MISSISSIPPI DELTA SURFACE WATER QUALITY, A SUMMARY

Karrie Pennington
USDA Natural Resources Conservation Service
Stoneville, Mississippi

INTRODUCTION

The Delta Water Supply Study was initiated by request to USDA Natural Resources Conservation Service (NRCS) from the YMD Joint Water Management District (YMD) and Delta Soil and Water Conservation Districts (SWCD) to determine the feasibility of maintaining water quality standards for streams and rivers set by the Mississippi Department of Environmental Quality (MSDEQ) and stabilizing the groundwater levels in the Mississippi River Alluvial Aquifer.

The Mississippi River Alluvial Aquifer, which supplies water for approximately 12,500 currently used agricultural wells in the Delta, is experiencing long-term declines in groundwater levels. These declines are a potential threat to continued agricultural industry stability in the region because a ready supply of high quality water is necessary to the industry in three major areas. First, groundwater is essential to the catfish industry in the Delta. Second, this water supply also makes possible the highly water dependent rice industry. Third, the ability to irrigate stabilizes long term yield levels by increasing the likelihood of producing a crop when rainfall is deficient. Farmers in the Southeast have traditionally relied upon the 50 plus inches of rainfall received most years to produce a crop. The fact that rainfall doesn't come when ordered has caused many farmers to invest in irrigation technology. These are relatively recent innovations in Mississippi with catfish and rice production as well as irrigation water use increasing dramatically since 1970. We can expect to maintain and see continued growth in the agricultural industry, the lifeblood of the Delta, only with adequate water supplies.

Groundwater level declines have also resulted in decreased baseflows of some interior streams and rivers. Low baseflows pose a threat to human health and safety if there is insufficient water to dilute permitted effluent loadings from wastewater treatment plants and industries. Fish can also be influenced by low flows. The loss of adequate fisheries' habitat may result in loss of species diversity and cause population declines. Poor water quality also decreases a fish's ability to survive in low water conditions. Research to determine how specific changes in water quality influence warm water fisheries is needed (Waters 1995).

The water quality survey portion of this study was designed to provide background data for existing water quality in the major interior waterways in order to predict how adding water to supplement flows will influence overall water quality. The objective of the sampling program was to chart water quality changes in response to the currently existing changes in stream flow and predict or monitor how proposed managed additions to stream flows will influence water quality. This effort was started in October of 1993 and is funded through October 1996. Sampling through major hydrologic events was not possible due to resource limitations. Monthly sampling at specific sites was chosen to prevent the bias that limited event sampling could induce. Accurate background pictures cannot be developed without dry period data, so all months were sampled. Ideally, monitoring would continue indefinitely to establish long term patterns or trends in water quality and monitor the effects of implemented practices. Realistically, all studies involve completion time tables and budget constraints, both of which are not conducive to permanent monitoring efforts.

The augmentation and increased use of surface water to maintain flows and take pressure off the alluvial aquifer will potentially benefit agriculture and aquatic organism populations, as well as safeguard water quality and supplies for urban areas and wildlife. Stream flow augmentation may be a practical solution to the problem of water supplies in the Delta.

METHODOLOGIES

Sampling was done in the second or third week in each month. No attempt was made to bracket rainfall, irrigation periods, or any other event. First year sampling included eight locations along the length of Deer Creek from Greenville to Valley Park. Monthly sampling on ten additional sites, two each, on the Sunflower River, Coldwater River, Bogue Phalia, Quiver River, and one each at Yazoo Pass and Mill Creek began June 1994. Six Deer Creek sites were dropped in October 1995 and one additional site on both the Bogue Phalia and Quiver River and two additional sites on the Sunflower River were added. We now have data from 22 locations representing the major internal Delta waterways (Figure 1).

Water samples were obtained using a Wildco 2 liter sampler with a weighted messenger to trigger closure. At each site, the sampler was rinsed in the surface water to be sampled, moved to an undisturbed site, and lowered to collect a sample representing the surface foot of water. All sites were sampled from bridges. One liter samples were placed in a cooler on ice for subsequent analysis at the USDA NRCS Jamie Whitten Plant Materials Center Laboratory in Coffeeville, Mississippi (PMC). A second, 100 mL, sample was transfered to sterile containers and placed in a cooler on ice for coliform analysis at Davis Research Laboratory in Avon, Mississippi. Water analysis included total kjeldahl nitrogen (TKN), nitrate plus nitrite nitrogen, total and orthophosphorus (TP and OP), alkalinity, total and suspended solids (TS and TSS), and total and fecal coliforms. On site measurements of dissolved oxygen (DO), pH, temperature, conductivity, and total dissolved solids (TDS) were made using a Corning Checkmate 90 meter and sensor system. On site turbidities were determined using a HACH P2000 turbidity meter. All on site samples were tested in triplicate.

Tape downs from the sampling point for stream stage, estimates of odor and color, and the general condition of the areas were recorded at each site visit.

During June and September of 1994 and July of 1995, four liter water samples for pesticide analysis were collected at each site using the sampler twice and emptying into individual four liter glass bottles. These samples were immediately iced for delivery to the Mississippi State Chemical Laboratory (MSCL) for analysis of 88 pesticides. Tests included chemicals grouped by MSCL into five categories. There were 19 Nitrogen-Phosphorus pesticides, 27 chlorinated pesticides, 11 pesticides used primarily on cotton, 12 chlorinated acids and phenols, and 19 herbicides that did not fit into any of the other categories.

RESULTS AND DISCUSSION

Dissolved oxygen (DO) levels remained above the 5 ppm standard, set by MSDEQ as necessary for fish survival, (MSDEQ 1992) during most sampling periods. Monthly averages of DO at all sample sites, except Deer Creek, (Figure 2a) are near the critical level from May to August when water temperatures are high. Samples from Deer Creek at Leland (Figure 2b) neared or fell below the critical level in July through October. Saturated DO levels were calculated using a regression equation for the relationship between DO and temperature. The equation was developed using data from a chart of saturated DO values at varying temperatures in water at atmospheric pressure with low salt content (APHA 1989). The equation is:

$$\text{Saturated DO} = -0.22\ (\text{temperature } ^\circ\text{C}) + 13.84,\ r^2 = 0.97.$$

Saturated DO values are correspondingly lower at higher temperatures. Dissolved oxygen deficit (DOD), calculated as the difference between theoretical maximum saturated DO values and measured DO, ranged between 1 and 3 ppm for the sites represented in Figure 2a, and between -0.5 to 4.1 ppm for the Deer Creek site represented in Figure 2b. DOD levels below 4 ppm are considered adequate for healthy fish populations (USGS 1993). The Leland site approaches problem values in April and August through October. Care should be taken in interpretation of this data. Single time grab samples and monthly averages cannot adequately portray the diurnal fluctuations in DO actually experienced by the current fish population. These data do allow us to determine the seasons during which water added to the streams may be beneficial for their aeration potential.

Conductivity values ranging from 69 to 880 microSm^{-1}, 0.04 to 0.56 parts per thousand (ppt), are not a problem in terms of the environment or human health and safety. The salt content of fresh water is approximately 0.5 ppt. Concentrations of nitrate plus nitrite nitrogen exceeded the 1 ppm standard set by MSDEQ in 33 of 343 samples or 10 percent of the samples. The range of pH values from 6.5 to 8.5 SU is not problematic. Fecal coliform levels at all sites did not violate standards set by MSDEQ for fish and wildlife waters (MSDEQ 1992).

Turbidity, total solids, and total phosphorus reach maximum levels during winter and early spring runoff (Figure 3a; b). Concentrations of total phosphorus do, at some time during the year, exceed the 0.3 ppm standard set by MSDEQ for waters designated as fish and wildlife streams (MSDEQ 1992). Concentrations of total phosphorus exceeded the 0.3 ppm standard in 131 of 343 samples or 38 percent of the samples. Linear regression analysis for data from the Sunflower River, Coldwater River, Bogue Phalia, and Quiver River for total phosphorus as a function of turbidity resulted in coefficients of determination ranging from 0.48 to 0.88. Analysis at the same sites for total phosphorus as a function of total solids (TS) resulted in coefficients of determination ranging from 0.006 to 0.88. When total dissolved solids (TDS) were a significant component of TS, coefficients of determination were reduced. Elimination of TDS from total solids by subtraction changed the coefficient of determination range to 0.63 to 0.91. Linear regression analysis for data from Deer Creek at Leland for total phosphorus as a function of turbidity resulted in a coefficient of determination of 0.87. Analysis for total phosphorus as a function of TS minus TDS resulted in a coefficient of determination of 0.90.

These data strongly support the assumption that high sediment inflow into receiving waters is associated with a corresponding inflow of total phosphorus. This is a clear indication that sediment erosion control, in addition to preserving valuable farm land, would reduce the total phosphorus lost to receiving waters in the Delta. Phosphorus is often the limiting nutrient in eutrophication of lakes and streams. A method that prevents phosphorus from entering these waters could slow the rate of eutrophication of Delta streams and lakes.

Total Kjeldahl Nitrogen (TKN) follows a similar relationship to TP and TS or turbidity but less consistently. This inconsistency occurs because nitrogen, unlike phosphorus, in receiving waters is often associated with dissolved and total organic components rather than mineral components of the system. Concentrations of TKN at all sites do, for much of the year, exceed the 1.0 ppm standard set by MSDEQ for waters designated as fish and wildlife streams (MSDEQ 1992). Concentrations of TKN exceeded the 1 ppm standard in 214 of 343 samples or 62 percent of the samples. Linear regression analysis of TKN as a function of turbidity for the Sunflower River, Coldwater River, Bogue Phalia, and Quiver River produced coefficients of determination that ranged from 0.06 to 0.69. Analysis at the same sites for TKN as a function of TS ranged from 0.0003 to 0.64. Coefficients of determination for TKN as a function of TDS ranged from 0.06 to 0.46. Elimination of TDS from total solids by subtraction changed the coefficient of determination range to 0.04 to 0.63. Linear regression analysis for Deer Creek at Leland of TKN as a function of turbidity produced a coefficient of determination of 0.72. Analysis for TKN as a function of TS-TDS produced a coefficient of determination of 0.68.

As expected, the relationship between TKN and any of the indicators of solids in the water and the influence of TDS were more variable than the phosphorus relationships. This is consistent with the differing chemistries of phosphorus and nitrogen in soil and aquatic systems. Solids in the water could account for variations in phosphorus at the 0.6 or greater level 69 % of the time. Solids in the water could account for variations in TKN at the 0.6 or greater level only 23 % of the time. Reductions in sediment load would be expected to significantly reduce TKN inflow to receiving waters about one fourth of the time.

None of the water samples tested to date contain pesticides at levels to cause concern to EPA or FDA with environmental or human health issues. Deer Creek water samples collected by grab sampling at 8 locations on Deer Creek June 1994 (Table 1) and September 1994 (Table 2) and grab samples collected from Deer Creek, Coldwater River, Sunflower River, Quiver River, Bogue Phalia, Mill Creek, and Yazoo Pass during July 1995 (Table 3), were tested for 88 pesticides at the Mississippi State Chemical Laboratory. Eleven herbicides were detected in the June samples, ten herbicides and one defoliant were detected in the September samples, and ten herbicides, two insecticides, and one PCB were detected in the July samples. All of the herbicides exhibit a low to very low toxicity to fish, birds, and mammals (Meister 1994; MCES; WSSA 1989). The defoliant is highly toxic to birds. The insecticides are not a problem at the levels detected. The actual levels of herbicides, insecticides, and defoliant detected were at the ppb level and well below any value that would cause harm to fish, birds, and mammals including humans (USEPA 1989). Tests included the groups reported in the methods section, 19 Nitrogen-Phosphorus pesticides (6 detected), 27 chlorinated pesticides (3 detected), 11 chemicals commonly used on cotton (1 detected), 12 chlorinated acids and phenols (3 detected), and the 19 additional herbicides (6 detected). It is important to note that there were 190 quantifiable detections in 2,464 tests or a detection of chemicals in only 7.7 % of the tests and none of these were at or near harmful levels.

Pesticide analyses of all fish, sediment, and some water samples were in progress at the writing of this summary. Results will be presented in a future paper.

Mention of a laboratory or product in this paper does not constitute a recommendation for use by the U.S. Department of Agriculture Natural Resources Conservation Service. Names of commercial products and laboratories are included for the benefit of the reader and do not imply endorsement or preferential treatment by the U.S. Department of Agriculture Natural Resources Conservation Service. All programs and services of the U.S. Department of Agriculture Natural Resources Conservation Service are offered on a nondiscriminatory basis without regard to race, color, national origin, religion, sex, marital status, or handicap.

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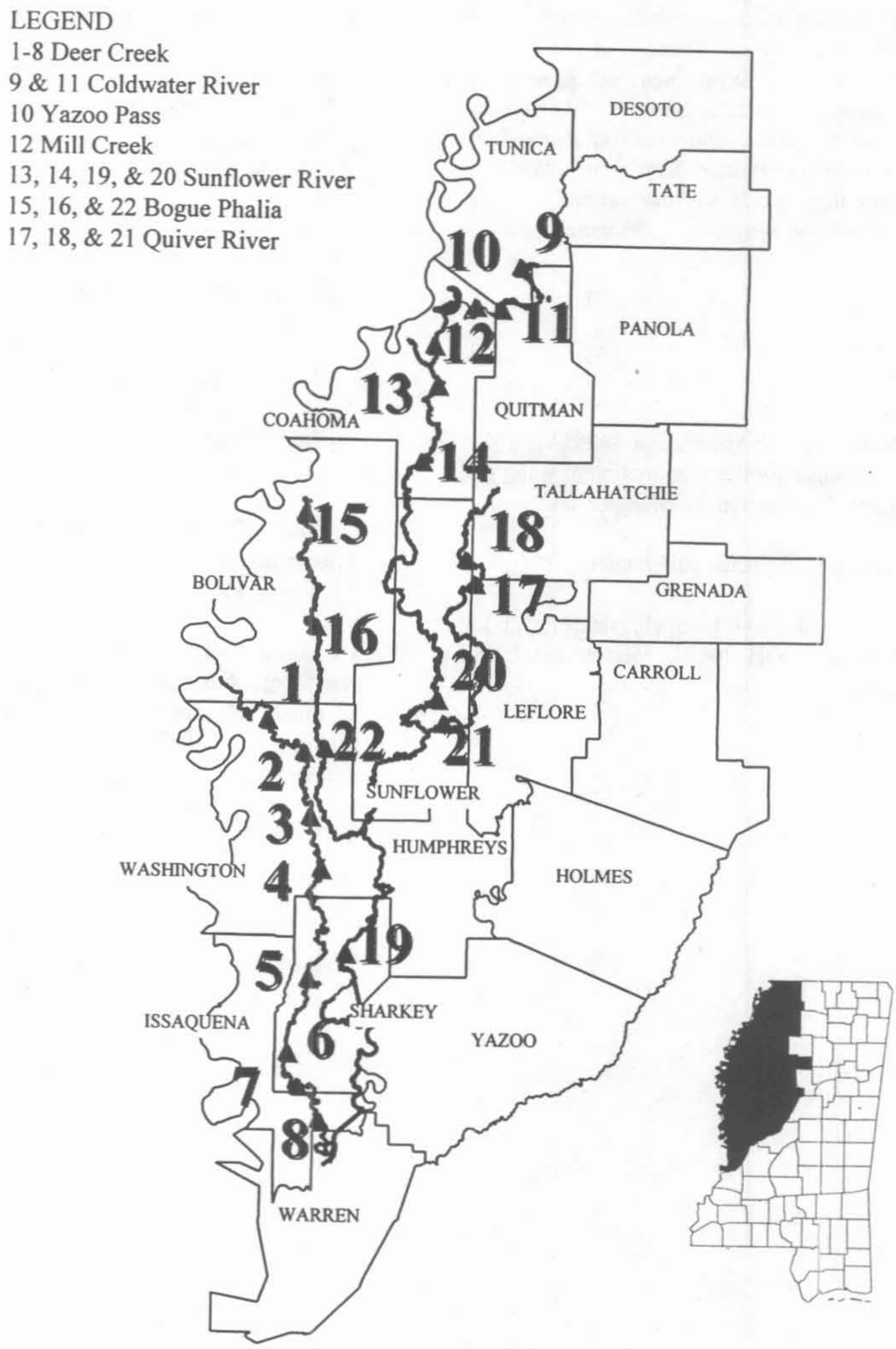
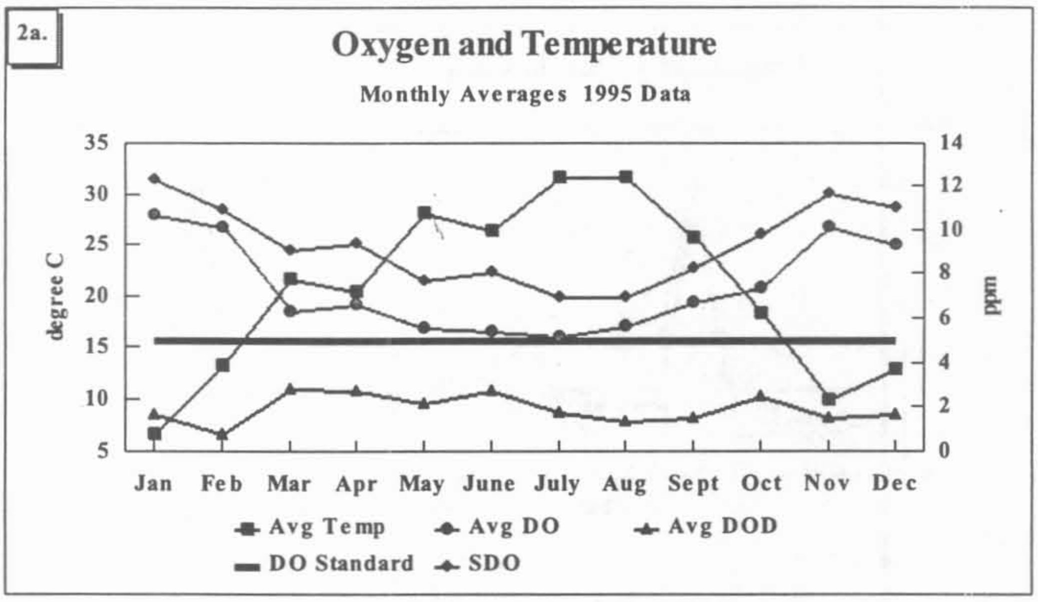


Figure 1. Mississippi Delta NRCS Water Quality Sampling Sites



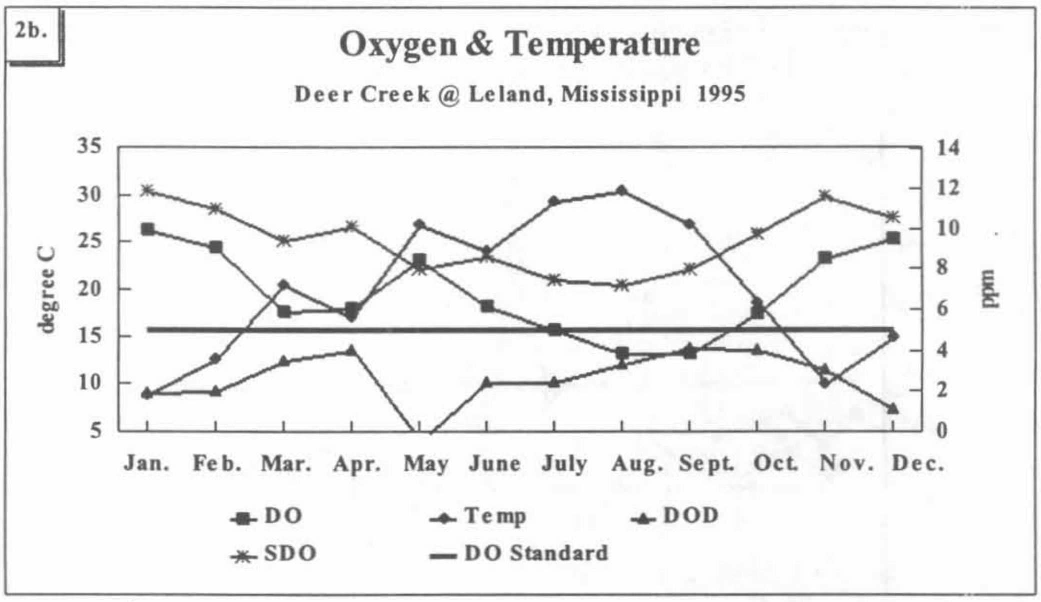
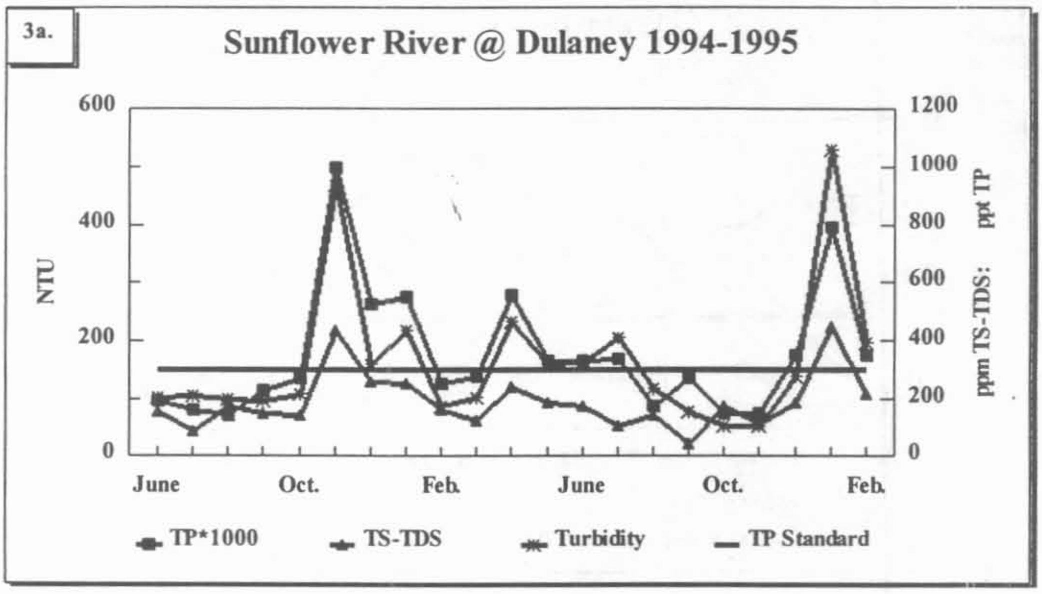


Figure 2a & b: Relationship between measures of oxygen (dissolved oxygen DO; dissolved oxygen deficit DOD; saturated dissolved oxygen SDO) and temperature as monthly averages for Coldwater River, Sunflower River, Quiver River, and Bogue Phalia for 1995 data (2a) and monthly values for Deer Creek at Leland (2b).



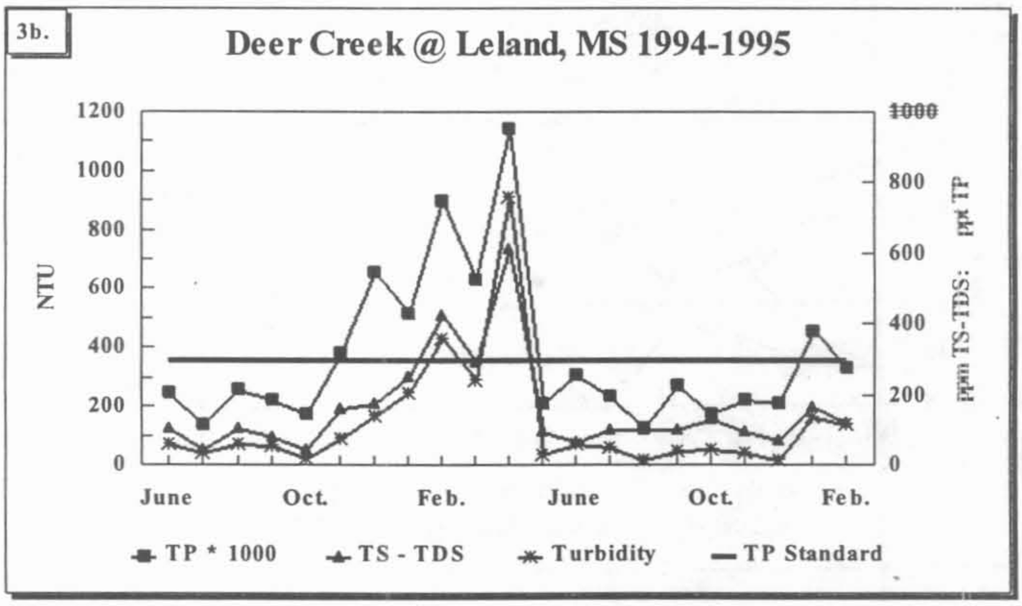


Figure 3a & b. Relationship between turbidity, total solids (TS) adjusted for total dissolved solids (TDS), and total phosphorus (TP) (expressed as ppt to adjust for scale) for the Sunflower River at Dulaney (3a) and Deer Creek at Leland (3b).

Table 1. Pesticides detected in water samples collected on Deer Creek, June 19, 1994. Note that only detections are included in the tables. There were 704 tests done in June with 51 detections or 7 % of the tests.

Location	**1	2	3	4	5	6	7	8
Compound	ppb							
1. Atrazine	5.32	0.95	2.13	2.6	* ND	ND	ND	1.42
2. Bromacil	ND	ND	ND	ND	ND	ND	0.45	ND
3. Metolachlor	2.04	2.16	1.29	1.82	1.01	1.08	ND	ND
4. Metribuzin	0.23	0.84	0.49	0.06	0.06	0.23	ND	ND
5. Zorial	1.61	2.3	1.87	0.93	2.28	6.09	8.6	1.66
6. Acifluorfen	1.04	ND	0.1	ND	ND	ND	ND	ND
7. Bentazon	1.86	ND	1.1	ND	ND	ND	ND	ND
8. Dicamba	0.08	0.1	0.1	0.08	0.07	0.07	ND	0.07
9. Cyanazine	1.86	ND	ND	ND	ND	ND	ND	ND
10. Diuron	0.37	0.47	0.79	ND	0.74	1.3	3.1	0.28
11. Fluometron	4.3	6.7	8.1	4.1	1.9	1.3	ND	ND
* ND, none detected								
**1. Greenville, 2. Leland, 3. Arcola, 4. Hollandale, 5. Rolling Fork, 6. Cary, 7. Onward, 8. Valley Park								

Table 2. Pesticides detected in water samples collected on Deer Creek, September 12, 1994. Note that only detections are included in the tables. There were 704 tests done in September with 45 detections or 6 % of the tests.

Location	**1	2	3	4	5	6	7	8
Compound	ppb							
1. Atrazine	1	1	ND	1.8	* ND	ND	ND	ND
5. Zorial	0.12	0.11	0.2	0.23	0.27	0.31	0.78	0.51
6. Acifluorfen	ND	ND	0.15	0.04	0.05	0.06	ND	ND
8. Dicamba	ND	ND	ND	ND	0.32	ND	ND	ND
9. Cyanazine	1	2	ND	1.4	1.7	3.3	ND	1
10.Diuron	0.36	0.77	0.5	0.6	0.81	2.7	1.36	0.23
11.Fluometron	0.31	0.55	0.49	0.04	0.74	0.72	0.39	0.7
12. Linuron	ND	ND	ND	ND	ND	ND	0.26	0.34
13. Swep	ND	ND	ND	ND	ND	ND	0.26	ND
14. Trebufos	0.01	ND	0.01	0.01	0.01	ND	ND	ND
*ND, None Detected								
**1. Greenville, 2. Leland, 3. Arcola, 4. Hollandale, 5. Rolling Fork, 6. Cary, 7. Onward, 8. Valley Park								

Table 3. Pesticides detected in water samples collected at Deer Creek, Coldwater River, Yazoo Pass, Mill Creek, Sunflower River, Quiver River and Bogue Phalia during July 1995. Note that only detections are included in the table. There were 1056 tests done with 94 quantifiable detections or 9 % of the tests.

Location	** 2	7	9	10	11	12	13	14	15	16	17	18
Compound	ppb											
3. Metolachlor	* ND	ND	ND	ND	ND	ND	0.26	ND	0.26	ND	3.1	1.3
4. Metribuzin	0.07	ND	0.03	0.02	0.32	1.1	0.04	0.09	0.07	0.17	0.18	0.05
5. Zorial	0.67	0.98	0.12	0.15	0.19	1.2	0.32	0.73	1.2	0.57	0.48	0.12
6. Acifluorfen	1.4	ND	1.2	0.16	1.1	0.05	0.11	1.8	1.3	2.3	0.71	1.6
7. Bentazon	1.5	ND	3.2	0.22	2.8	0.18	0.17	3.9	2	3.2	2.7	4.5
9. Cyanazine	3.5	8.1	1.7	1.7	1.1	2.1	trace	3.9	3.2	15	trace	2.6
10. Diuron	1.7	4.9	0.22	trace	trace	0.28	trace	0.41	0.22	2.1	trace	trace
11. Fluometron	2.7	13	1.2	1.7	0.73	1.9	0.68	2.2	1.2	15	0.3	3.6
15. Disulfoton sulfone	0.12	0.86	ND	ND	ND	ND	ND	0.22	1.2	0.55	0.1	0.13
16. 4,4 DDE	0.01	ND	ND	ND	ND	ND	0.01	ND	ND	ND	ND	ND
17. PCB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.5
18. Pendimethalin	ND	ND	ND	ND	0.02	ND	ND	ND	ND	ND	ND	ND
19. 2,4-D	0.18	trace	trace	trace	0.11	ND	ND	0.16	ND	0.31	0.15	0.17

* ND, none detected
** 2. Deer Creek, Leland; 7. Deer Creek, Onward; 9. Coldwater River, Hally Rd; 10. Yazoo Pass @ Rich; 11. Coldwater River, Brahan RD; 12. Mill Creek; 13. Sunflower River, Farrel-Eagle Nest Rd; 14. Sunflower River, Dulaney; 15. Bogue Phalia, Hwy 32; 16. Bogue Phalia, Hwy 446; 17. Quiver River, Drew; 18. Quiver River, Parchman (see figure 1)