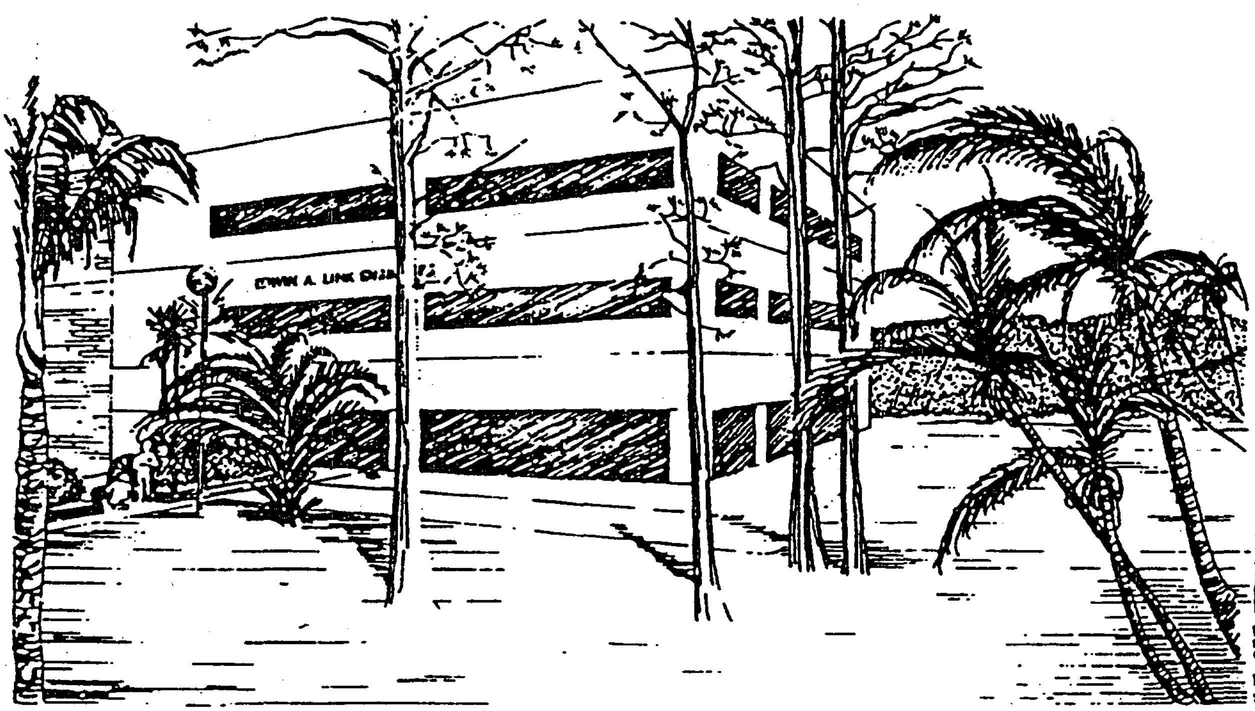
Special Publication SJ 90-SP2

Final Report to the St. Johns River Water Management District

PARTICULATE NUTRIENT AND METAL INVESTIGATIONS IN THE TURKEY CREEK WATERSHED



John H. Trefry, Robert P. Trocine, Simone Metz,
Nenad Iricanin and Naichi Chen
Department of Oceanography & Ocean Engineering
Florida Institute of Technology, Melbourne, Florida 32901

June 1989

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF FIGURES (CONTINUED)

LIST OF TABLES

ACKNOWLEDGEMENTS

We thank Joel Steward, John Higman and Dean Vanderbleek of the St. Johns River Water Management District for their help in the field and for useful discussions about Turkey Creek. Support from Steve Schropp and Fred Calder of the Florida Department of Environmental Regulation for companion studies of particulate nutrients was critical to completion of the project. We have enjoyed our collaboration with Forrest Dierberg, Patana Thavipoke and Brad Lewis of FIT throughout the field and laboratory aspects of the work, especially in the dark and the rain and the mud at the more remote areas of the creek. Our discussions with John Windsor and Diane Barile of FIT have greatly increased our understanding and appreciation of this system. We appreciate the efforts of Gary Garrison and his staff at the Water Control District of South Brevard for accommodating us so willingly. We also thank Janet Fleeker for assistance in producing the final report. Support for this research was obtained from the St. Johns River Water Management District and the Florida Department of Environmental Regulation.

EXECUTIVE SUMMARY

The future success of growth and development along the Indian River Lagoon, Florida, is linked to protection and wise management of its abundant natural resources. Unfortunately, many creeks and the lagoon are presently being stressed by a variety of adverse environmental conditions. Inputs of soil and nutrients from various tributaries of the lagoon have led to a build-up of muck sediments in some areas. At present, we have inadequate knowledge about the origins of these negative inputs to the lagoon. This study was designed to provide us with information about the quantities, composition and sources of suspended matter to Turkey Creek, an important tributary of the Indian River Lagoon.

To address our goal, we established a physical and chemical monitoring network at 11 sites in Turkey Creek from March 1, 1988 through February 28, 1989. We focused on both non-storm and storm flow conditions. Non-storm samples were collected bi-weekly. Four storm events of varying magnitudes were also sampled during the study. Samples of suspended matter were collected to determine levels of total suspended solids (TSS), as well as concentrations of particulate carbon, nitrogen, phosphorus, silicon, aluminum, iron, potassium, sodium, calcium, magnesium, copper, manganese and lead.

Concentrations of TSS typically ranged from 2-7 mg/L during non-storm periods. These values are most likely higher than natural, historic levels for this area, but do not constitute a muddy creek. A direct relationship was found between gravimetric TSS measurements and more rapidly obtainable turbidity values. Using this relationship, an equation was developed to calculate TSS from turbidity. This equation nicely facilitates quantitative

determinations of sediment loading from turbidity data.

In general, particulate carbon, nitrogen and phosphorus values follow trends for suspended solids; however, the pattern is quite complex. Particles may carry 10 to >50% of the total carbon, nitrogen or phosphorus load on some occasions and thus the role of particles in nutrient transport to the Indian River Lagoon can be important, especially in storm events.

Concentrations of major elements in suspended matter from Turkey Creek varied directly with one another, increasing or decreasing as a function of the amount of organic matter present. The iron content of particles in Turkey Creek can be as high as 10-20%, relative to 4-5% iron in average continental crust. This anomaly is believed to be related to ancient deposits and diagenetic processes in the watershed. Particulate silicon and aluminum values are quite uniform throughout the creek. In fact, the silicon/aluminum ratio of 3.1 ± 0.3 is in close agreement with the ratio of 3.4 for average continental crust. Element to aluminum ratios are used to identify and track sediment sources and movement throughout the creek because aluminum is less subject to chemical weathering than other elements and because aluminum is a predictable and stable component of silts and clays. Overall, the major element data and metal/aluminum ratios show the importance of soil inputs from the southwestern portion of the watershed where extensive areas are undergoing development.

Concentrations of particulate copper in Turkey Creek ranged from 2-1160 $\mu g/g$, relative to values for average continental crust of about 50 $\mu g/g$. Upland areas of the creek had natural copper levels. The onset of copper contamination was observed near the water control structure on the C-1 canal. A major peak in copper levels was observed in the area of Troutman Boulevard.

Specific sources for this copper are not conclusively known. A probable source of the copper-contaminated particles is sediments from the Turkey Run tributary that served as a major sink for metals discharged from an industrial wastewater treatment plant. The treatment plant discontinued discharge to surface waters in 1986; nevertheless, contaminated sediments can continue to be a source of copper.

The downstream distribution of copper and other trace metals in Turkey Creek is used to show the relative importance of particle inputs from various locations to the final composition of suspended matter being delivered to the Indian River Lagoon. For example, even though the copper content of particles in the Troutman Boulevard area is very high, particle transport from this area is low enough that no effect is observed on copper levels downstream.

Particulate lead concentrations were above natural levels throughout the creek. Highest levels were observed in sites near well-traveled roads and in the Troutman Boulevard area. The primary source of lead to most areas is automobile emissions; however, non-point discharges may have an influence at some sites.

Runoff of suspended sediments increased dramatically during major (>10 cm) rain events. For example, TSS values at one site in the southwestern area of the creek rose from about 3 mg/L during normal flow to almost 500 mg/L during a 15 cm rainfall event in January 1989. Such high flow in January 1989 carried 240 metric tons of sediment through the creek in a 72-hour period. Such transport during a major storm event is equivalent to the amount of suspended sediment carried through Turkey Creek during 2-4 years of normal, non-storm flow. Rainfall of <5 cm had no effect on sediment transport.

During this study we have carefully obtained a sizeable amount of data for Turkey Creek. Then, using that data base, we have answered several questions relating to the sources, transport and fate of suspended particles in Turkey Creek. The data and concepts evolved can also be used for future questions and management decisions. Clearly, some of the muck problems in the Indian River Lagoon can be traced to poor soil conservation practices and nutrient runoff from upland areas in the Turkey Creek watershed.

INTRODUCTION

The natural beauty of the east coast of Florida is reflected in its many waterways and creeks as well as in the splendor of the Indian River Lagoon and the Atlantic Ocean. Continued growth and economic development in this area are linked to future protection and wise management of these natural resources. Unfortunately, many creeks and the Indian River Lagoon are presently being stressed by a variety of adverse environmental conditions. Turbidity is high, water quality is low, seagrass growth has declined and the bottom of the lagoon is covered with a patchwork of muck.

Development of sound management, policy and engineering decisions for the above concerns is dependent on a strong scientific data base. At present, we have inadequate knowledge of the sources of materials carried to the Indian River Lagoon and where they are deposited. Once we know where problem materials are coming from and where they are going, then corrective measures can be initiated.

Previous studies have made preliminary identifications of some areas where muck and potential pollutants are being deposited in the lagoon (Project MUCK; Trefry _et_ _al_., 1987). Muck is the black, organic-rich sediment found on the bottom of the lagoon in some locations. This muck contributes to the high turbidity in the system and thus to the decline of water quality, seagrass beds and fisheries resources. Muck is also one of the sources of noxious smells often reported along the lagoon. By studying the composition of muck, we have determined that uncontrolled soil runoff is a major contributor to muck deposits (Trefry _et_ _al_., 1987). Decaying plant debris fertilized by sewage and runoff nutrients is also an important component. Muck sometimes contains high levels of potential pollutants such as mercury (Hg), copper (Cu) and lead (Pb). By identifying the major problem sites for muck we can help make plans to remove it and reclaim portions of the lagoon. An ongoing muck survey throughout the lagoon will soon provide us with a first order picture of the problem.

In addition to knowing where sediment runoff is accumulating, we also need to identify the sources of soil, dust, and plant debris entering the lagoon. Once these muck sources are known, the responsible agencies and municipalities can help prevent additional soil losses and inputs of uncontrolled runoff to the lagoon. At present, we do not have adequate data to identify the origins of various negative inputs to the lagoon. This study provides us with a start on that process by determining the quantities, composition and sources of suspended matter to Turkey Creek, an important tributary of the Indian River Lagoon. The results of this study will be generally applicable to other tributaries of the Indian River Lagoon and will help provide information required to develop a management scheme for land-use activities, stormwater runoff and maintenance of water quality throughout the system. Such information is critical to the future health of habitats and fisheries in Turkey Creek and the Indian River Lagoon.

To help determine the quantities, composition and sources of suspended particles to Turkey Creek and adjacent major canals, we established a physical and chemical monitoring network from March 1, 1988 through February 28, 1989. We focused on both non-storm and storm flow conditions. Storm-event sampling is critical to understanding the total quantities of suspended matter delivered to Turkey Creek and to calculating the relative importance of non-storm versus storm transport of suspended matter.

SAMPLE SITES

We sampled at 11 stations in the Turkey Creek watershed as shown on Figure 1 and described below. These stations were chosen to provide representative coverage of agricultural, industrial, and municipal areas as well as lesser developed portions of the watershed. This project complemented a study of Turkey Creek by the State of Florida Department of Environmental Regulation and the St. Johns River Water Management District which focused on dissolved and particulate nutrients. Our sampling sites were as follows:

TUS was located just west of Route 1 in the eastern extremities of Turkey Creek. This site provided data for the final, integrated suspended sediment to be delivered to the Indian River Lagoon. When the water column was stratified or when the water was deeper than 1.5 m, two samples were collected at site TUS, with TUSA designated as the surface sample and TUSB as the near-bottom sample.

TC2 was located just upstream from the western end of Turkey Lake, off the western dock on the property of Lillian and Russell Gheer (1300 Miller Street) who graciously offered access to the site. Sampling at this location provided data for an integrated sample upstream of the marinas and main basin of the lower creek.

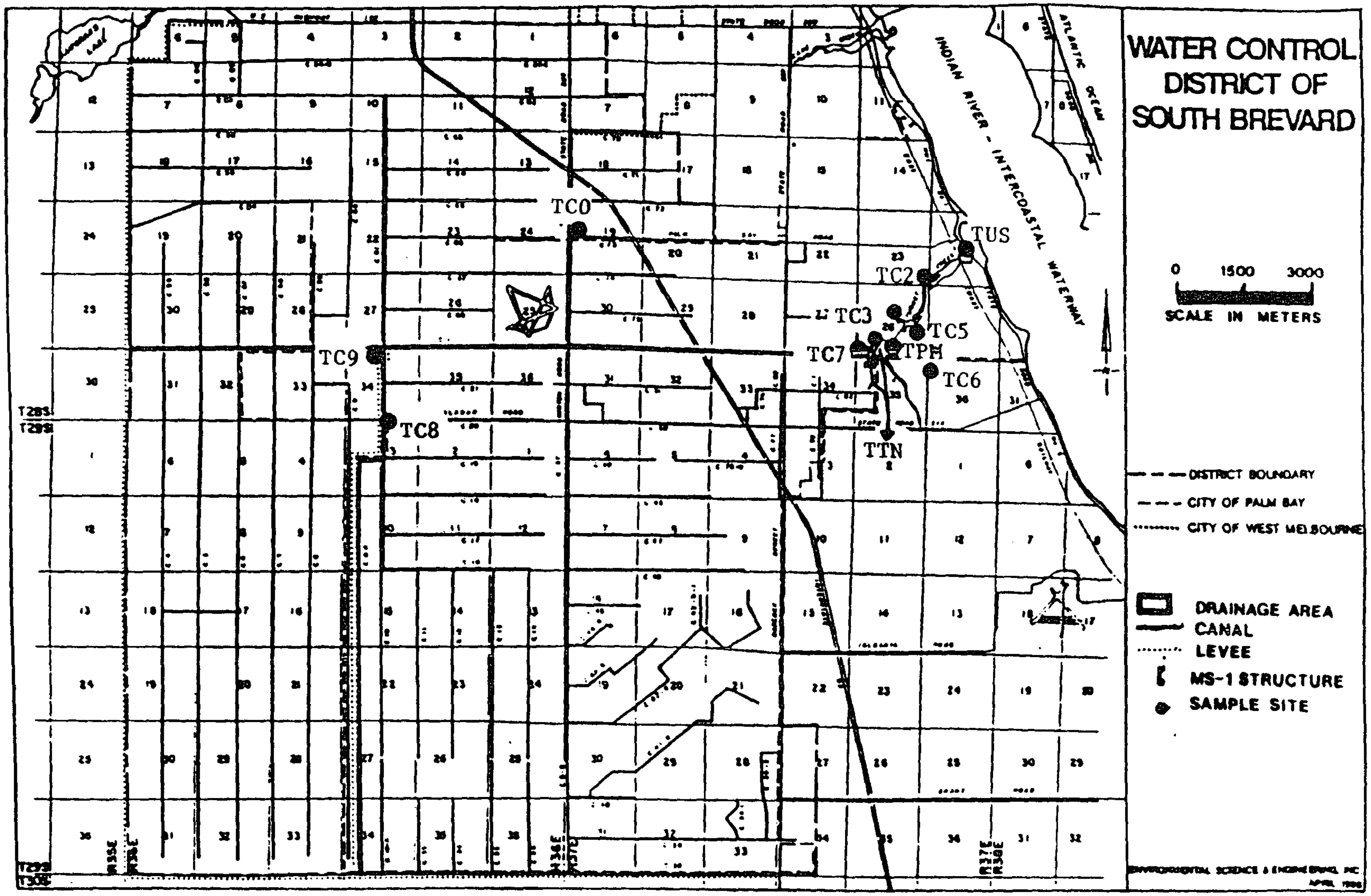


Figure 1. Map showing sampling sites for study of suspended matter in Turkey Creek.

<u>TC3</u> was located in the main downstream tributary of the creek, just upstream of an adjoining creek near Troutman Boulevard. The site is at the end of Sunswept Avenue on the east side of the road before the "round" house.

<u>TTN</u> was located on Troutman Boulevard downstream from industrial and previous wastewater sources.

<u>TPM</u> was located below a bridge crossing Port Malabar Boulevard and is coincident with a U.S.G.S. hydrology gauging station. Here, water is sampled which flows through a natural area after leaving the flood control structure of the Water Control District of South Brevard.

<u>TC5</u> was located along the south side of Port Malabar Boulevard in a canal which flows under the road into the beginning of a canal referred to as the New Jersey Waterway. A water level staff gauge was present at this site.

<u>TC6</u> was located under a bridge constructed for the Brook Hollow residential development. This site monitors the ongoing development. A water level staff gauge was also present at this site.

<u>TC7</u> was located in the C-1 canal just upstream of the flood control structure for the Water Control District of South Brevard. Greater than 90% of the water from the Turkey Creek watershed passes through the control structure. Gauging equipment was available at this location.

<u>TC8</u> was located on the C-10 canal, upstream of the C-1 canal at the Malabar Road bridge, site of a U.S.G.S. gauging station. This location provided a measure of inputs from a developing (≈30%) residential area. Upstream of this site, an extensive residential development project is underway.

<u>TC9</u> was situated on the C-1 canal, 400 m west of where C-10 and C-62 intersect with C-1. This site is at a U.S.G.S. gauging station and helps determine the suspended matter signal from mainly agricultural inputs.

<u>TC0</u> was located in the Minton Road canal at the north side of the intersection at Emerson and Minton Roads where a U.S.G.S. gauging station is situated. This site measures inputs from a more developed residential area and construction at I-95.

PROJECT STRATEGY

The non-storm sampling plan included biweekly collection of duplicate water samples at eleven of the locations listed above and triplicate samples at two of the eleven sampling sites. The choice of the triplicate sites varied from month to month to eventually test variability in more detail at each location. Samples from each site where the water depth was <1.5 m were taken at mid-depth. When the water depth was >1.5 m or if the water column was stratified, which only occurred at TUS, water samples were taken at 0.5 m below the surface (TUSA) and about 0.5 m above the bottom (TUSB).

Storm-event sampling is critical to understanding the total quantities of suspended matter delivered to Turkey Creek and to calculating the relative importance of non-storm versus storm transport of suspended matter. Water samples were collected in duplicate during four storm events over the 12-month study period. We collected storm-flow samples at Stations TCO, TC9, TC8, TC7 and TPM to provide good coverage of major source areas and sites coincident with other planned studies of Turkey Creek. Samples were collected three times during the first 24 h of the storm event and every 12 hours until suspended matter concentrations returned to within normal background levels.

At each site and water depth where suspended matter samples were collected, we also made field measurements of temperature, salinity, conductivity, dissolved oxygen and pH. Water samples for suspended matter were collected in carefully acid-washed, conventional polyethylene bottles. Suspended matter was recovered by filtration through 0.4 μm pore size Nuclepore filters as described in the methods section. Total suspended matter concentrations (TSM in mg/liter) were determined gravimetrically. Then, particle concentrations of Fe, Al, Si, Ca, Na, Mg, K, C, N, P, Mn, Cu, and Pb were determined. We also measured turbidity (in NTU) using a standard turbidimeter in the laboratory.

From the data base generated we have been able to determine:

1. The mathematical relationship between turbidity and total suspended matter. This allows future investigators to make rapid turbidimeter measurements and quantitative estimates of sediment transport.
2. The major element composition of suspended particles carried by the various creek systems. This information allows us to estimate the fraction of the particulate matter that is organic, aluminosilicate or quartz sand.
3. The trace metal load of the suspended matter from various sectors of Turkey Creek. This will help identify sources of contaminants to the system.
4. Source area for suspended particles carried by the system selected based on elemental ratios.
5. The relative importance of non-storm versus storm events to suspended sediment transport.

METHODS

Water samples were collected using a side-mounted Van Dorn bottle. Special care was taken to acid-wash the sampling bottle and keep it free from contact with potential contaminant sources. Field measurements specified in the previous section were made using a Hydrolab in-situ sensor by scientists from the St. Johns River Water Management District.

Conventional polyethylene bottles were used to collect water for suspended matter and for trace metals from the sampling bottle. These bottles were washed with concentrated HNO_3, followed by 0.01 N HNO_3 and then rinsed well with distilled, deionized water (DDW). Water for C, N and P was collected in acid-washed glass bottles.

Water filtration was carried out in a laminar flow hood in a clean room at the FIT Chemical Oceanography Laboratory. For suspended matter and metal analyses, we used 47 mm diameter, 0.4 μm pore size, Nuclepore membrane filters which had been washed in warm 3N HNO_3 and rinsed with DDW. Each filter was weighed three times prior to filtration in a humidity and temperature controlled environment with a polonium anti-static device in place. The membrane filter was mounted on an acid-washed glass filtration system and as much water as possible was filtered. We have tried to have at least 1-2 mg of suspended matter on each filter. Following filtration, each sample was rinsed with three aliquots of pH adjusted (pH 8) DDW to remove any residual salts. The filters were air-dried in our clean room and reweighed three times. Total suspended matter concentrations were determined by dividing the mass on the filter by the volume of water filtered. Samples for particulate carbon and nitrogen determinations were filtered through pre-combusted (550°C) 0.4 μm pore size, 13 mm diameter Gelman glass fiber filters. Samples for particulate phosphorus were processed through 47 mm diameter, 0.4 μm pore size Nuclepore filters.

Turbidity measurements were made in the laboratory using a Hach Turbidimeter and standards supplied by the manufacturer. Samples were shaken thoroughly, not vigorously, just prior to each determination.

Suspended matter samples for major element and trace metal analysis were digested in stoppered Teflon test tubes using HNO_3 and HF. The membrane filters were placed in the tubes and small amounts of acid (100-500 μm) were added. The tubes were sealed and heated to 80°C. We also digested milligram quantities of U.S. National Bureau of Standards estuarine sediment (SRM 1646) as a check on the accuracy of our analyses. Table 1 shows good comparisons between our analyses and the reported values for the NBS standards. Such checks are critical to establishing the validity of the data. The triplicate field samples provided a measure of our precision.

The final digest was diluted to 6-10 ml and analyzed by atomic absorption spectrophotometry (AAS) using our Perkin-Elmer 4000 instrument equipped with an HGA-400 heated graphite atomizer and an AS-40 auto-sampler. Concentrations of Al, Si, Fe, Na, Ca, Mg and K were determined by flame AAS. Analyses for Cu and Pb were by flameless AAS.

Analysis for particulate carbon and nitrogen was carried out using a Carlo Erba NA 1500 NCS analyzer by direct insertion of the glass fiber filter into the heating chamber for complete combustion at 2000°C. A variety of standards were used to check instrument calibration.

Table 1. Results for analyses of U.S. National Bureau of Standards Estuarine Sediment - Standard Reference Material #1646.

Element	Certified Concentration	Experimental Concentration*
Fe	3.35 ± 0.10 %	3.39 ± 0.06 %
Al	6.25 ± 0.20 %	6.12 ± 0.16 %
Ca	0.83 ± 0.03 %	0.81 ± 0.04 %
Mg	1.09 ± 0.08 %	1.14 ± 0.04 %
Cu	18 ± 3 μg/g	19.7 ± 1.6 μg/g
Pb	28.2 ± 1.8 μg/g	26.2 ± 1.6 μg/g
Mn	375 ± 20 μg/g	386 ± 6 μg/g
	Reference Concentration	
Si	31 %	30 ± 1 %
Na	2.0 %	2.0 ± 0.1 %
K	1.4 %	1.6 ± 0.2 %

* n = 19 replicates

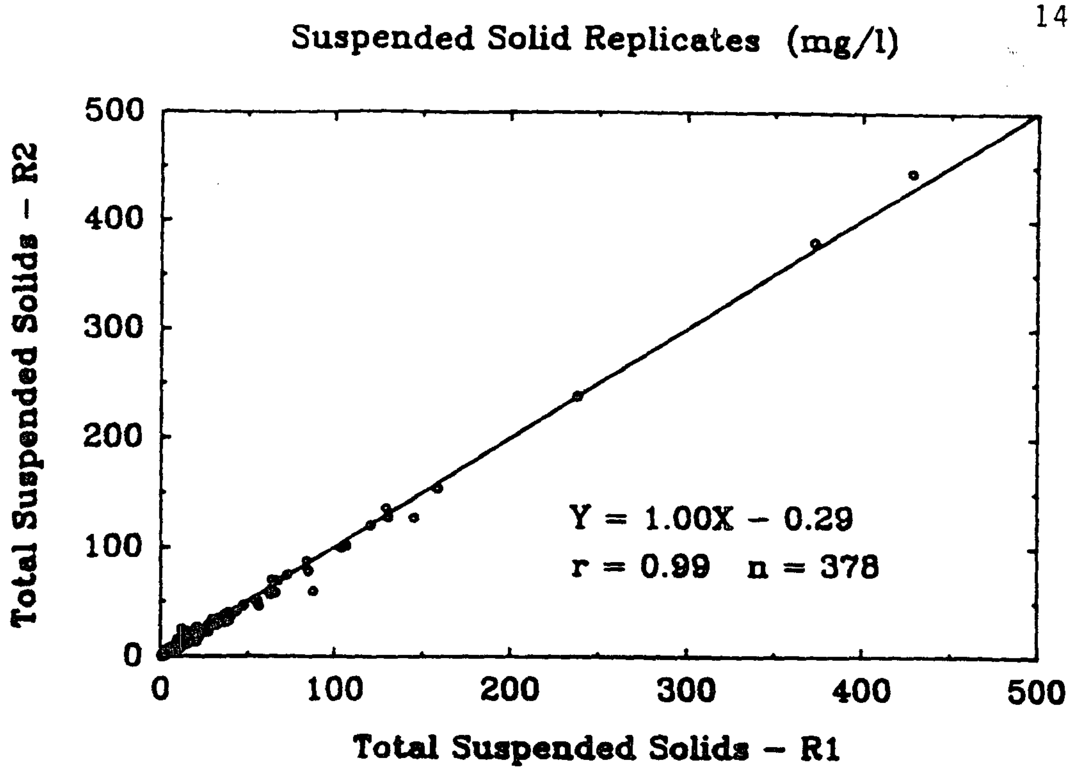
RESULTS AND DISCUSSION

Data Overview & Turbidity vs. Total Suspended Matter

Concentrations of total suspended solids along with particulate carbon (C), nitrogen (N) and phosphorus (P) have been measured in duplicate samples collected biweekly during non-storm conditions for one year from 11 locations in Turkey Creek, Florida. Concentrations of particulate iron (Fe), aluminum (Al), silicon (Si), magnesium (Mg), sodium (Na), potassium (K), manganese (Mn), copper (Cu) and lead (Pb) were also measured monthly at 11 locations in Turkey Creek. In addition, four rain events were sampled over 2-3 day periods at 5 of the regular locations. Thus, the total data set provides a coherent picture of the temporal and spatial distribution of these particulate nutrients, major elements and trace metals in the Turkey Creek watershed under normal and storm conditions.

A copy of the data set is attached and a disk containing the data on DBASE III (File TURKEY2.DBF) has been sent to the St. Johns River Water Management District. In addition to our particulate data, the hard copy and disk contain the dissolved nutrient data obtained by Dierberg et al. (Florida Institute of Technology) and Steward et al. (St. Johns River Water Management District).

Replicate samples were taken throughout the study at each location. Overall excellent agreement was observed between replicates (R1 and R2). Figures 2 and 3 show plots of R1 versus R2 for Total Suspended Solids (TSS), particulate carbon, particulate nitrogen and particulate phosphorus. Correlation coefficients for these plots are generally >0.95, showing the close agreement. However, on some occasions, significant differences were observed between replicates. This was especially true at station TC0 where



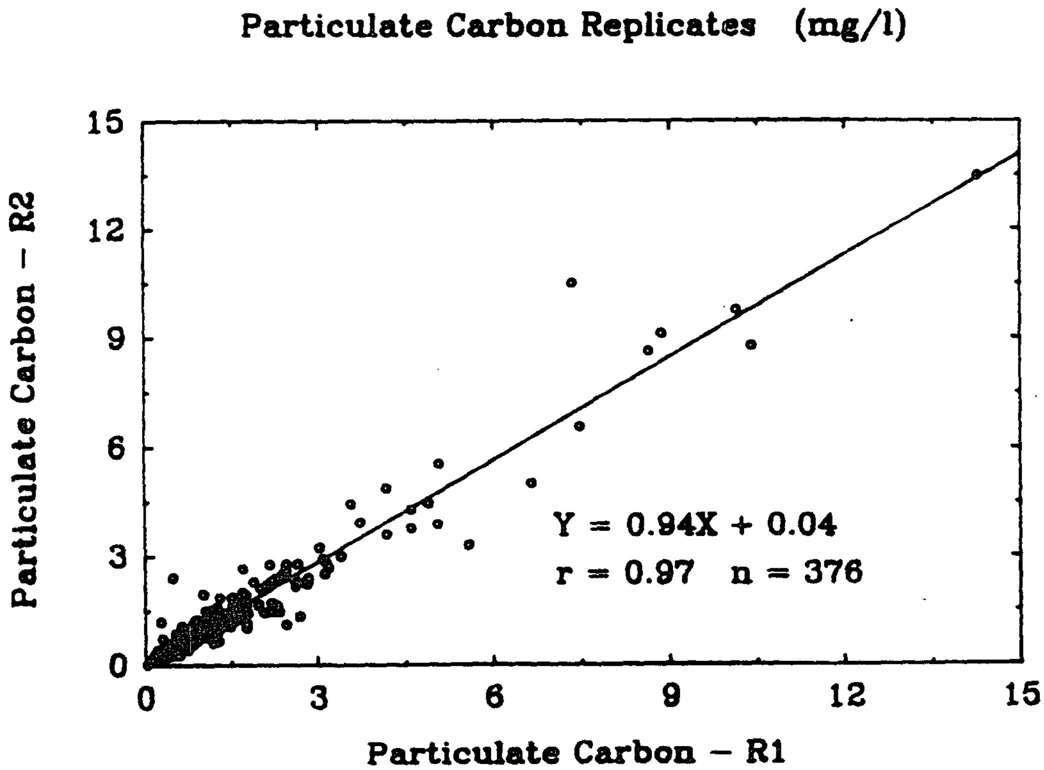
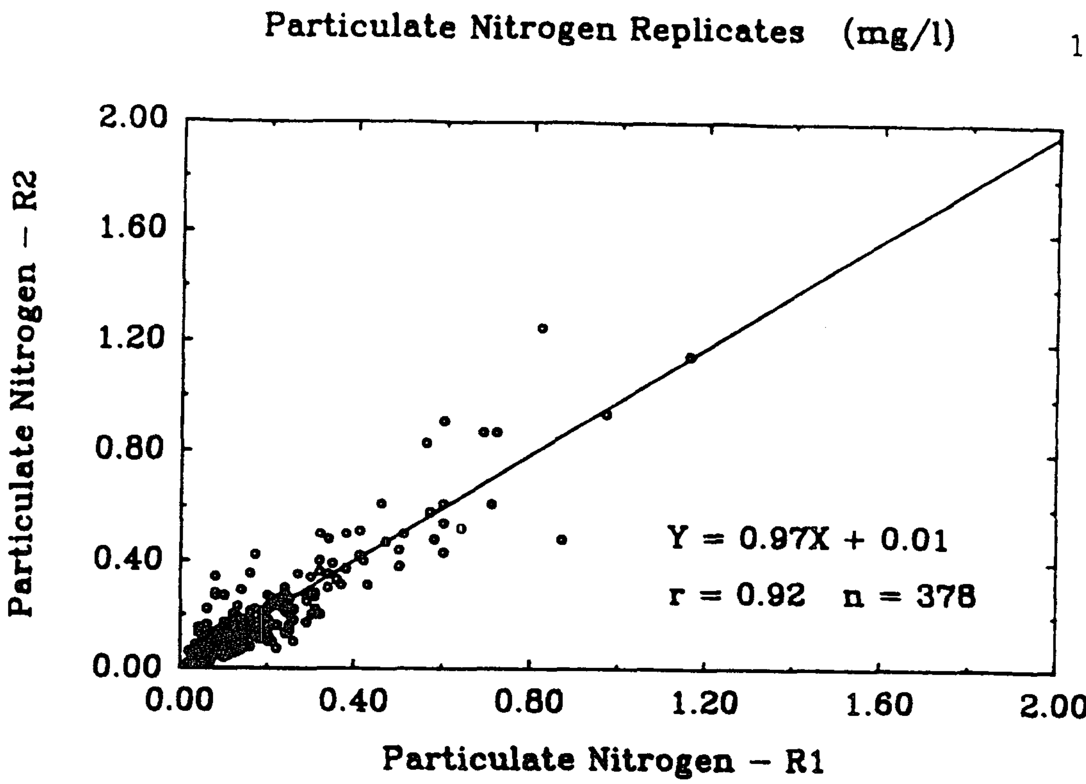


Figure 2. Scatter plots showing comparisons of replicate samples (R1 and R2) for Total Suspended Solids (TSS) and particulate carbon.



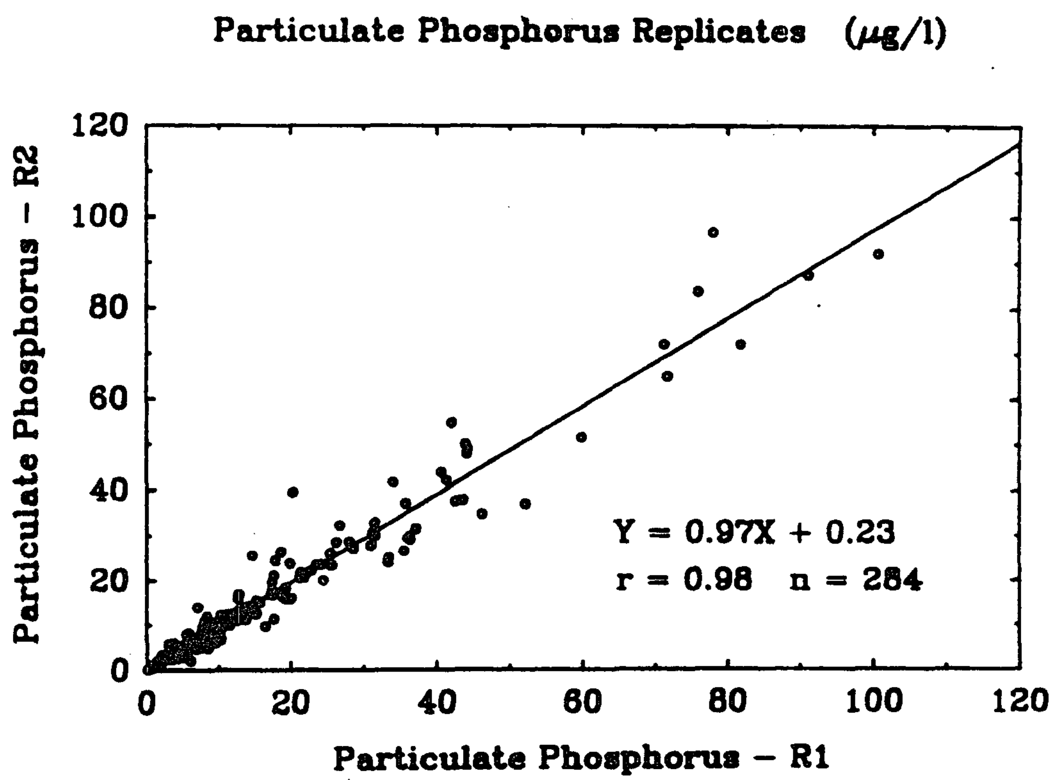


Figure 3. Scatter plots showing comparisons of replicate samples (R1 and R2) for particulate nitrogen and particulate phosphorus.

two small canals joined, with one always being more turbid than the other. Thus, values for TCO were sometimes skewed, even when the sample bottles were side-by-side in the water. Samples of near-bottom water from station TUSB were also subject to some variability in concentrations of suspended solids, most likely due to resuspension of fine-grained bottom deposits. Finally, occasional variations were observed from the shallow waters (<0.5 m) at TC5 and TC6. Overall, the comparisons between replicates were good enough that an average is used for each station and sample period. Such a rigorous replication program is probably not necessary for Turkey Creek in the future.

In addition to measuring TSS, we also measured suspended solids concentrations by turbidimetry. A linear relationship was observed between the two parameters (Figures 4 and 5). Equation 1 was derived from Figure 4 for non-storm events and enables one to estimate the concentrations of suspended solids from the more readily obtainable turbidimeter measurements. The relationship shown in Figure 4 spans a modest range of TSS values from

$$\text{Suspended Solids} = (2.3 \times \text{Turbidity}) - 3.8 \qquad \text{(Eq. 1)}$$

non-storm conditions. Some scatter is observed in the data set; however, the overall relationship will provide a first approximation of TSS values from turbidity data.

The TSS versus turbidity relationship is a bit stronger for the storm samples (Figure 5) because of the larger ranges in values for both parameters and because of the more unifrom particle composition during storm flow. Equation 2 shows the mathematical relationship between suspended solids and turbidity for storm events. The storm curve shows a one-third reduction in

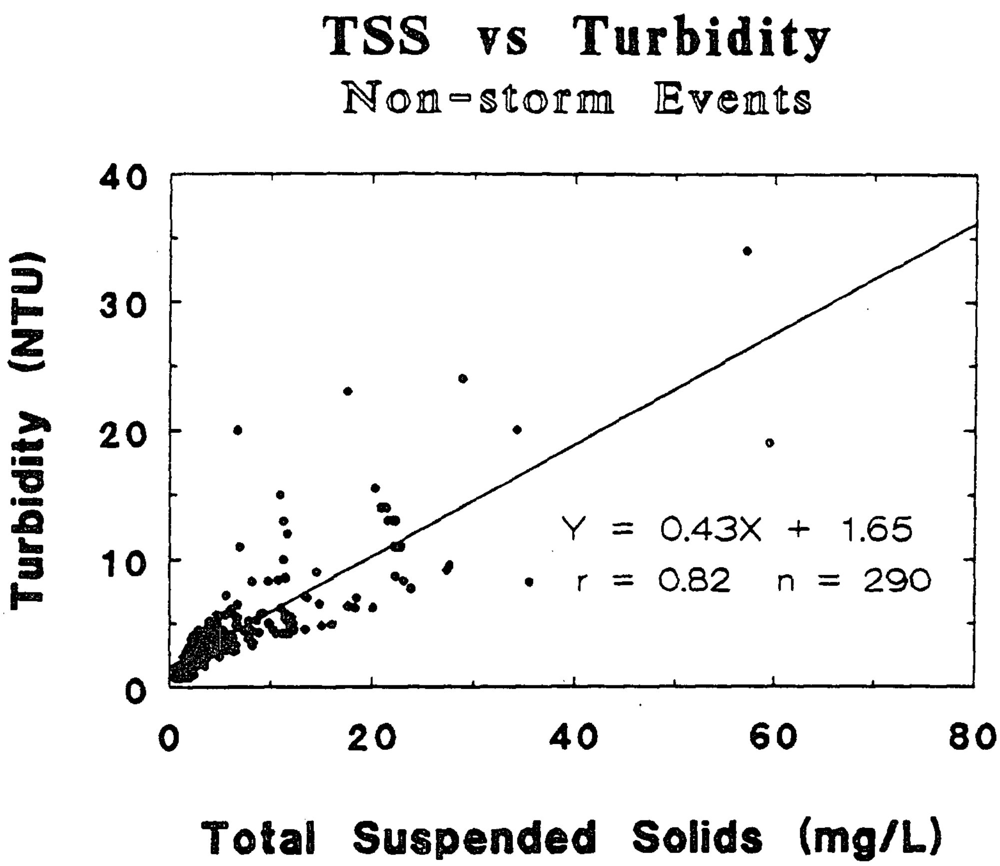


Figure 4. Scatter plot showing linear relationship between turbidity (in NTU) and total suspended solids (TSS) for non-storm events.

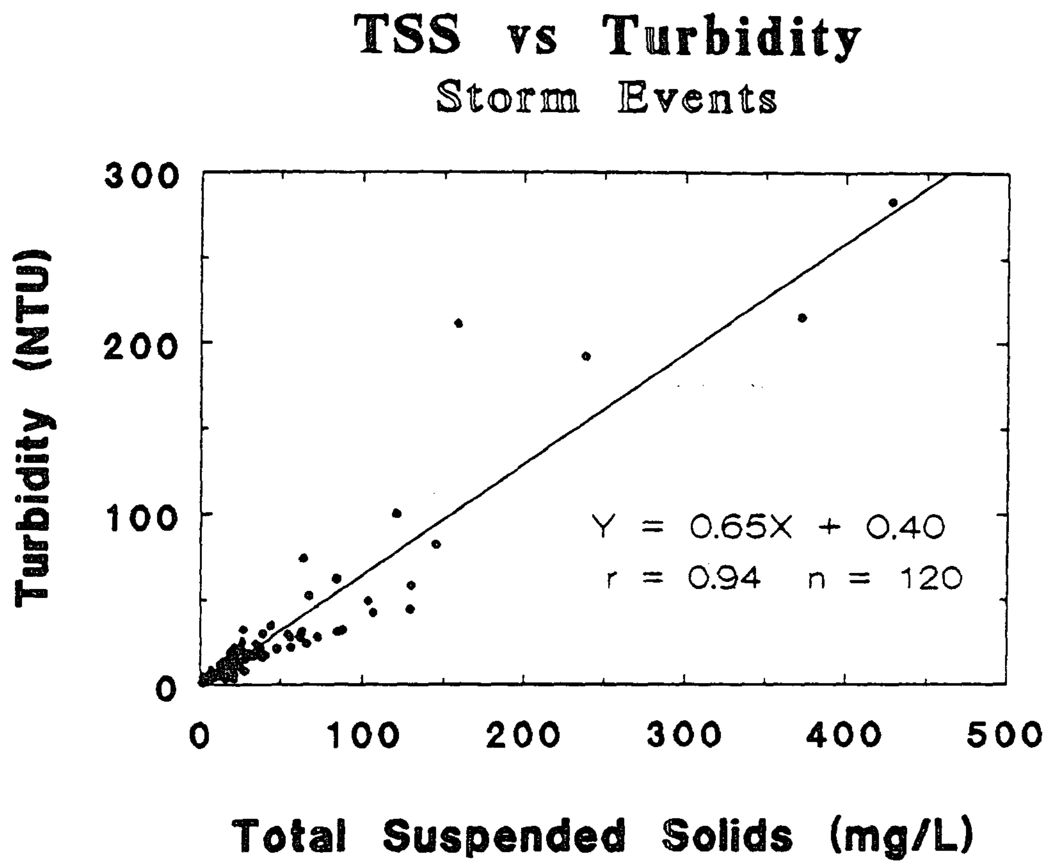


Figure 5. Scatter plot showing linear relationship between turbidity (in NTU) and total suspended solids (TSS) for storm events.

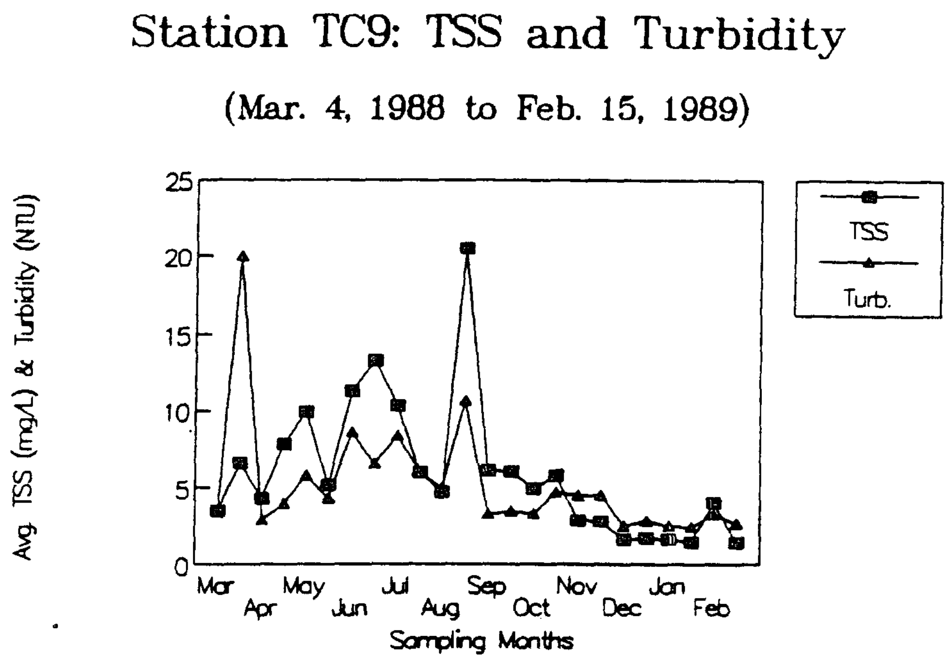
slope for the storm data set. An equation for the overall data set is

$$\text{Suspended Solids} = \{1.5 \times \text{Turbidity}\} - 0.6 \qquad \text{(Eq. 2)}$$

almost the same as that for the storm samples because the high storm values control the relationship. At this time, Eq. 1 is probably best for non-storm conditions and Eq. 2 is best suited for storm flow. Calibrated turbidity values provide a useful and rapid means for estimating sediment loads.

As suggested in Figures 4 and 5, some significant differences occur in TSS between storm and non-storm events. These will be discussed in more detail in subsequent sections and only a general overview as it relates to TSS values is given here. Concentrations of TSS showed relatively minor variations at a given site for each of the biweekly samples collected during non-storm periods. Data from Stations TC9, TC7, TPM and TUSA are used to give an overview of the results in Figures 6-9. Values for TSS during non-storm flow typically ranged from 2-7 mg/L. Exceptions to this trend are found for the March 18, 1989 data because a storm event preceeded the sampling trip by a couple of days. A similar observation occurs for the August 17, 1988 period.

Values for TSS during storm periods were as high 428 mg/L (Figure 4) with storm TSS values typically an order-of-magnitude higher (Figure 10). Similar increases were observed for the other particulate parameters such as carbon and nitrogen (Figures 6-9) to be discussed later. We will now address the five tasks identified on page 8: Major Elements, Trace Metals, Particulate Nutrients and Storm Events. The Results and Discussion presented here can be used, combined with work by the St. Johns River Water Management District, to address present as well as future research and management issues.



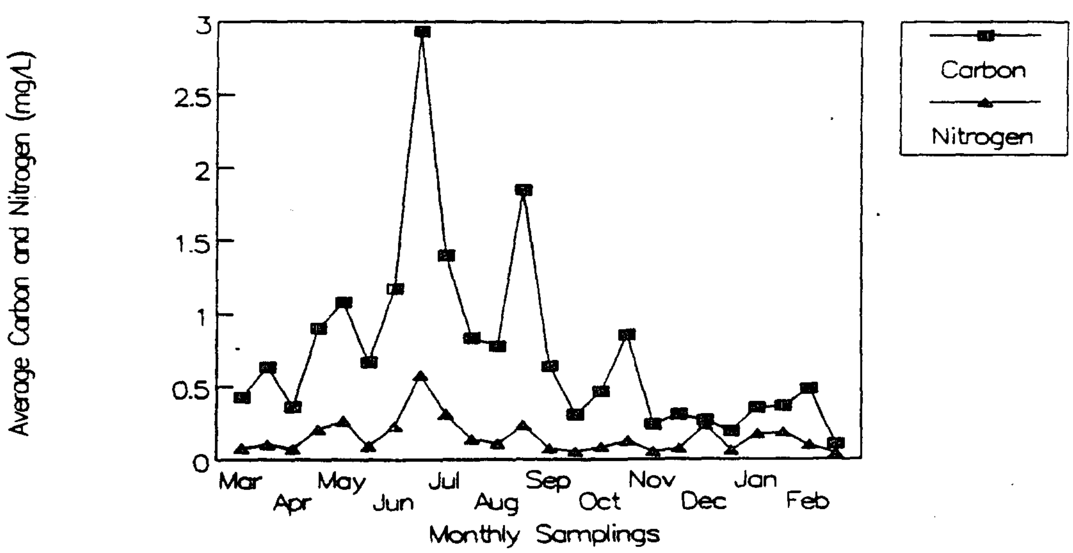
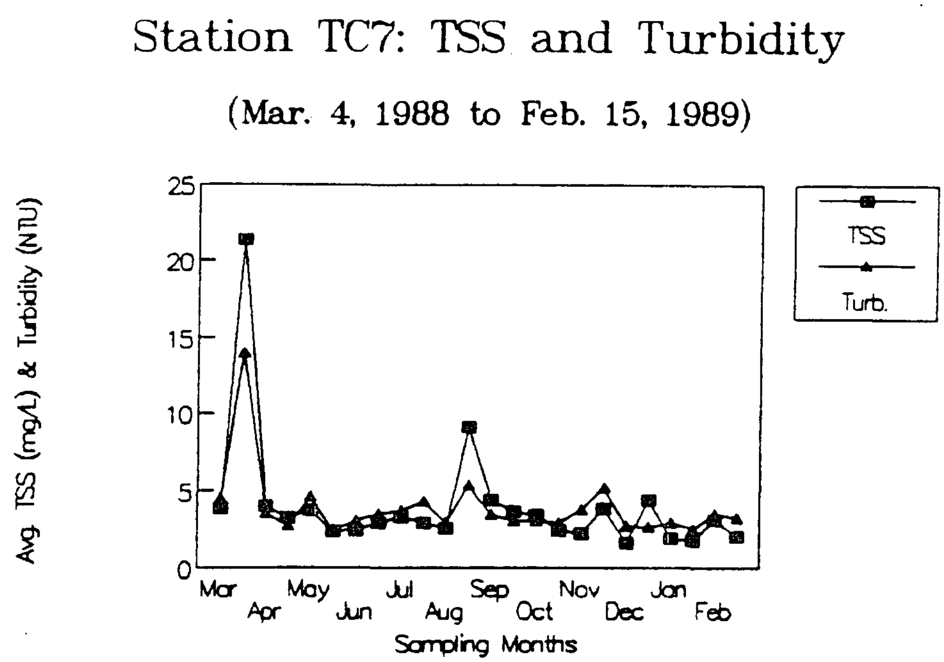


Figure 6. Graphs showing Total Suspended Solids, turbidity and particulate carbon and nitrogen data for station TC9 for biweekly samples.



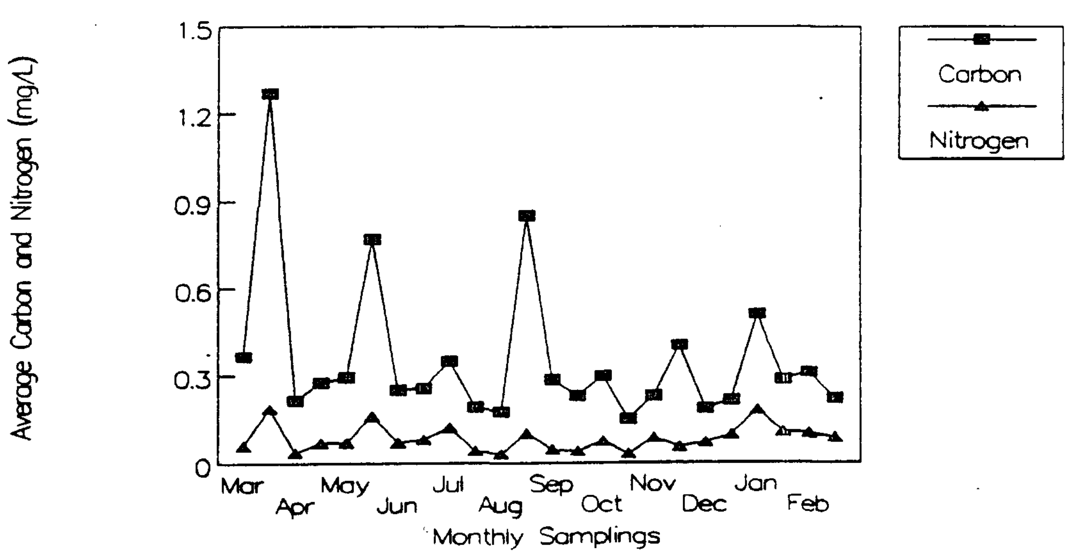
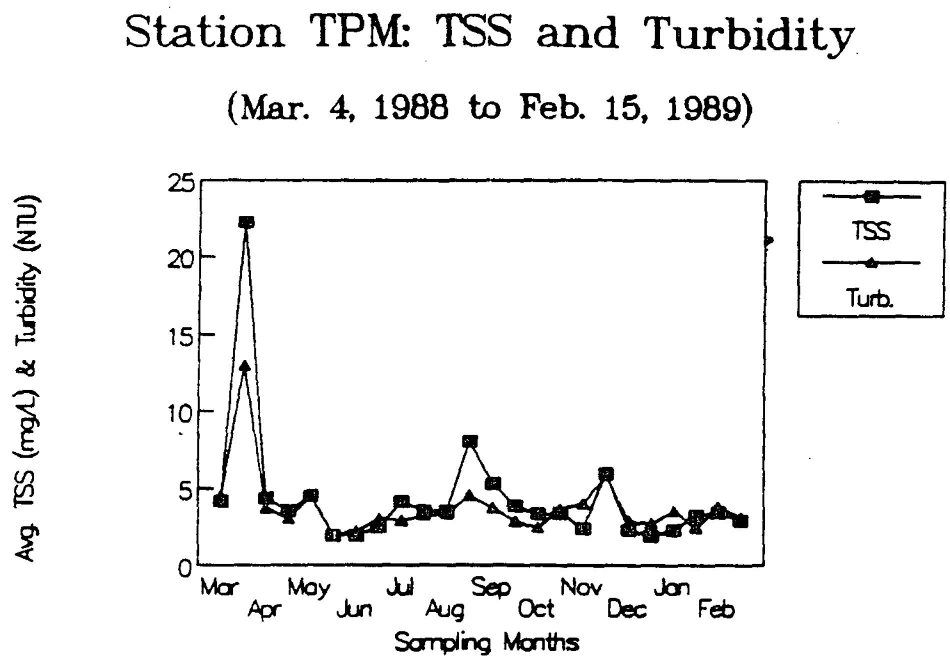


Figure 7. Graphs showing Total Suspended Solids, turbidity and particulate carbon and nitrogen data for station TC7 for biweekly samples.



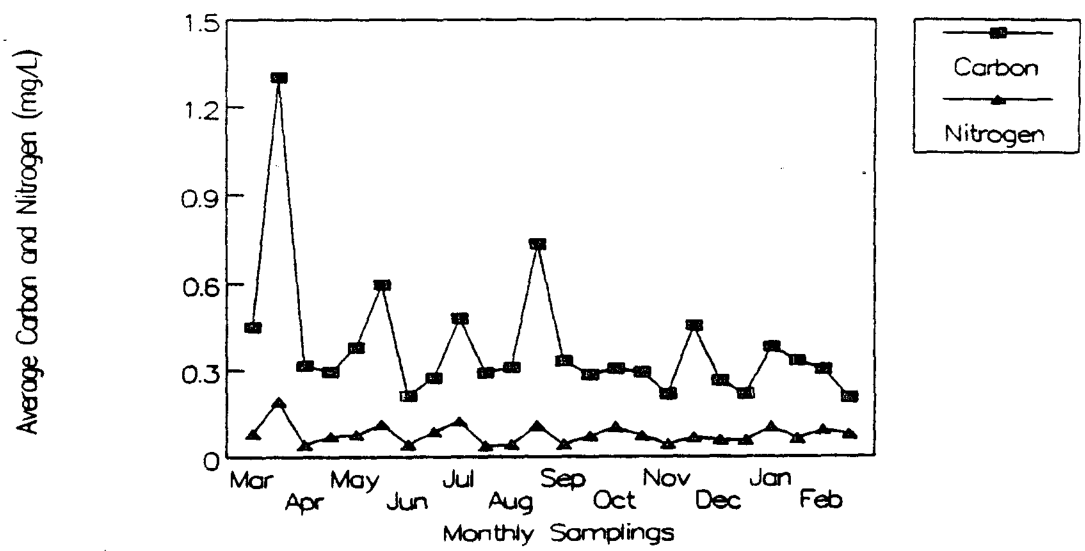
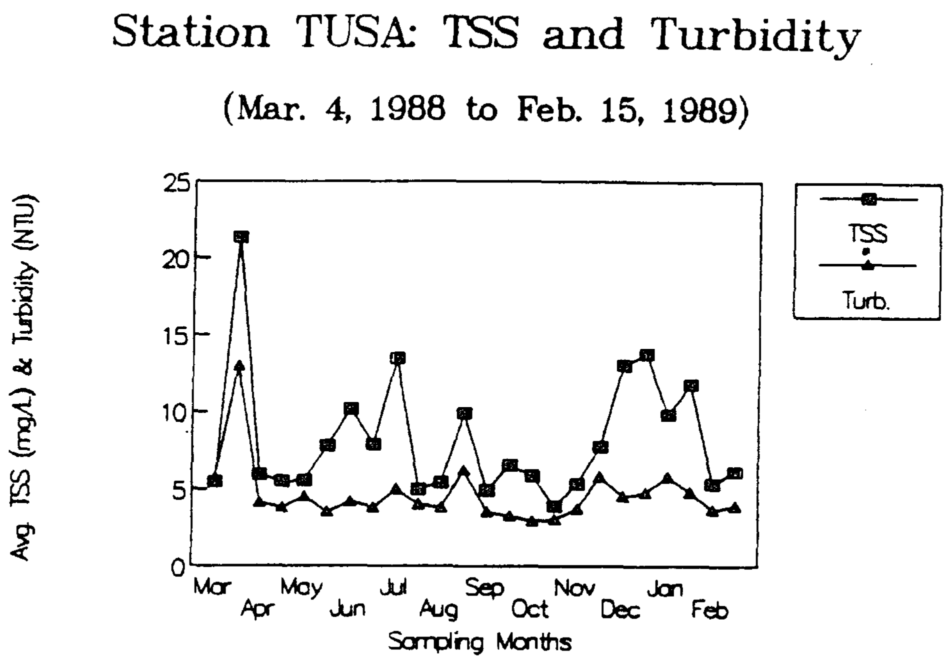


Figure 8. Graphs showing Total Suspended Solids, turbidity and particulate carbon and nitrogen data for station TPM for biweekly samples.



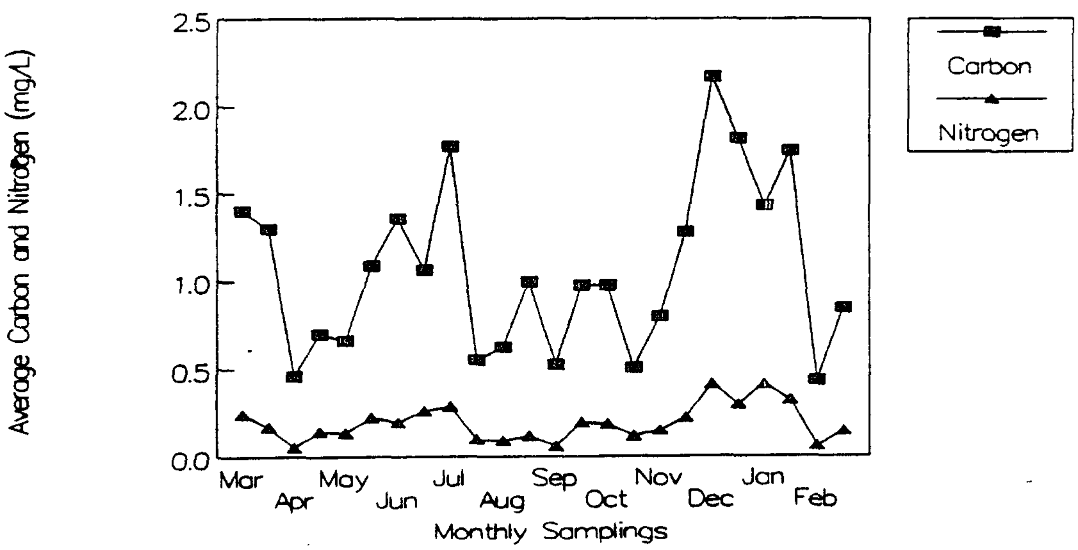


Figure 9. Graphs showing Total Suspended Solids, turbidity and particulate carbon and nitrogen data for station TUSA for biweekly samples.

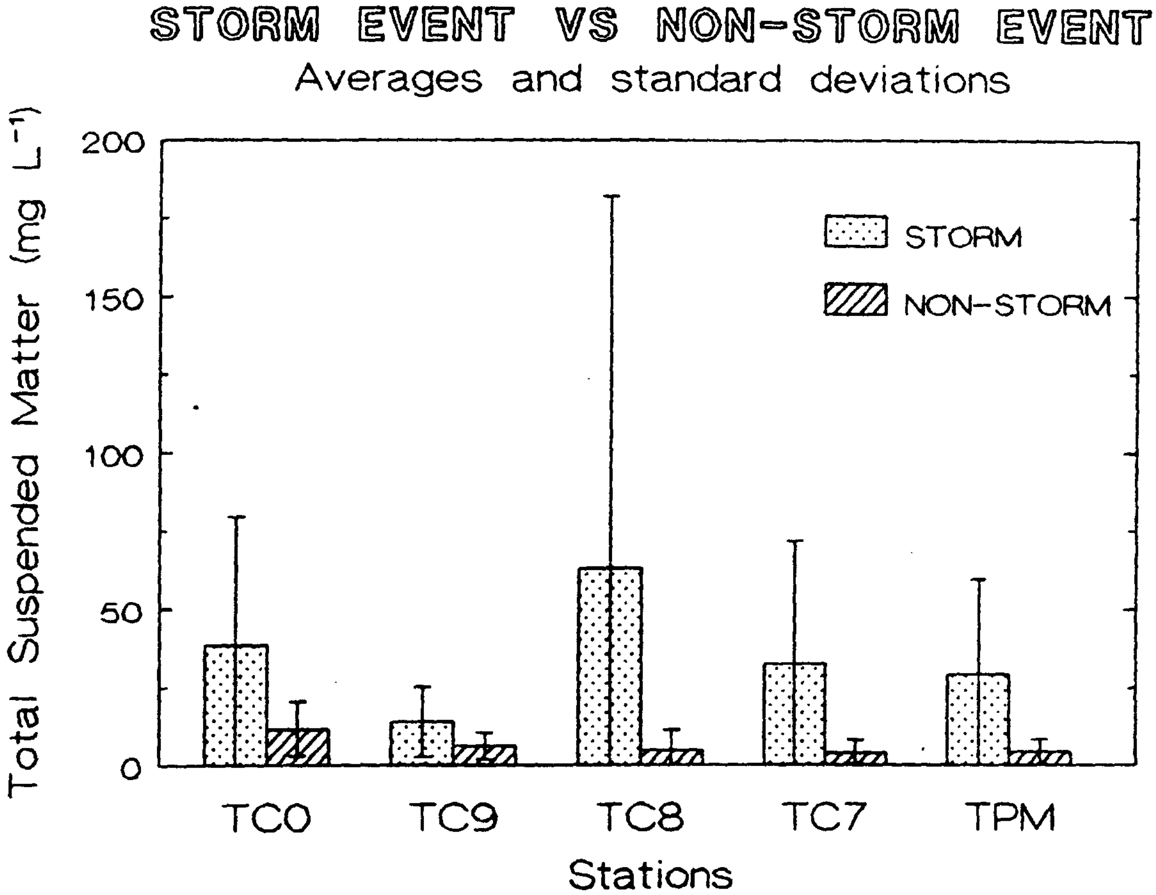


Figure 10. Histograms showing total suspended solids concentrations for storm and non-storm events from stations TC0, TC9, TC8, TC7 and TPM.

Major Elements: Non-Storm Samples

Suspended matter samples were collected monthly at 11 stations and analyzed for the major elements Fe, Al, Si, Ca, Mg, Na and K. The complete data set is given in the Appendix. A summary of annual mean concentrations for each element during non-storm periods by station is provided in Table 2. Discussion of these data will focus on monthly distributions at selected sites (TC9, TC7, TPM and TUSA) to provide a representative overview of the annual cycle. Then, a discussion of intersite comparisons will follow. This final picture identifies the influence of various particle inputs along the creek to the composite material carried to the mouth of Turkey Creek and on into the Indian River lagoon.

Concentrations of major elements in field replicates from a given station generally agree well with better than 10% coefficient of variance. The most noteworthy differences in replicates occur for samples from station TC0 as mentioned previously.

Concentrations of the major elements in suspended matter from Turkey Creek usually vary directly relative to one another, increasing or decreasing as a function of the organic matter present. In suspended matter samples rich in organic matter, the concentrations of major elements will be lower than in samples with a low organic matter content. This general trend can be seen by perusal of the data in Table 2 and in Figure 11. In general for Turkey Creek, during low flow, TSS values are lower and the particles in suspension are more organic rich with lower percentages of major elements. At increased water flow, more suspended matter with an increased content of sand and silt are put

Table 2. Summary of particulate data for non-storm samples from Turkey Creek.

	Fe	Al	Si	Ca	Mg	Na	K	Mn	Cu	Pb
	(% of particle content)							(µg/g)		
TUS A	6.27	4.54	14.40	1.47	0.80	0.15	0.37	865	54	38
TC 2	9.33	3.87	11.54	1.84	0.41	0.08	0.20	535	43	27
TC 3	10.39	4.01	11.97	2.03	0.34	0.09	0.22	489	45	32
TTN	2.31	2.28	8.13	1.66	0.35	0.14	0.27	807	543	79
TPM	10.57	4.26	11.93	2.03	0.37	0.25	0.21	443	46	27
TC 5	3.72	2.48	7.29	0.82	0.36	0.30	0.14	53	25	47
TC 6	3.66	1.90	9.96	1.29	0.30	0.25	0.19	1021	29	22
TC 7	9.77	3.45	10.01	1.75	0.28	0.10	0.21	305	37	22
TC 8	9.21	4.17	13.51	3.43	0.37	0.09	0.24	211	20	19
TC 9	13.00	3.02	10.51	1.63	0.34	0.14	0.25	264	18	22
TC 0	12.04	3.68	10.58	2.05	0.28	0.06	0.15	101	12	46
Mean ± Std. Dev.	8.21 ±3.63	3.42 ±0.88	10.89 ± 2.10	1.82 ±0.65	0.38 ±0.14	0.15 ±0.08	0.22 ±0.06	463 ±320	79 ±154	35 ±18

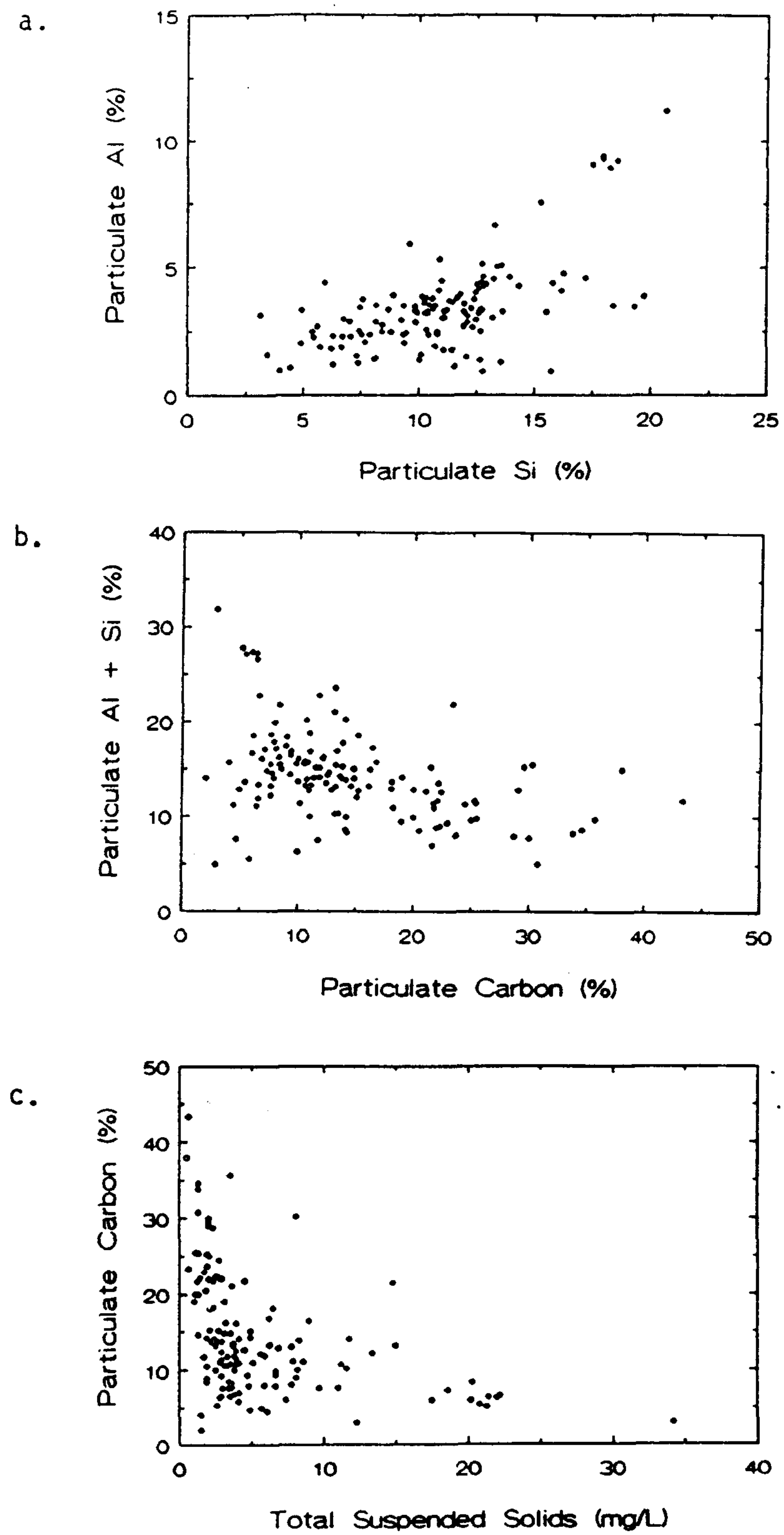
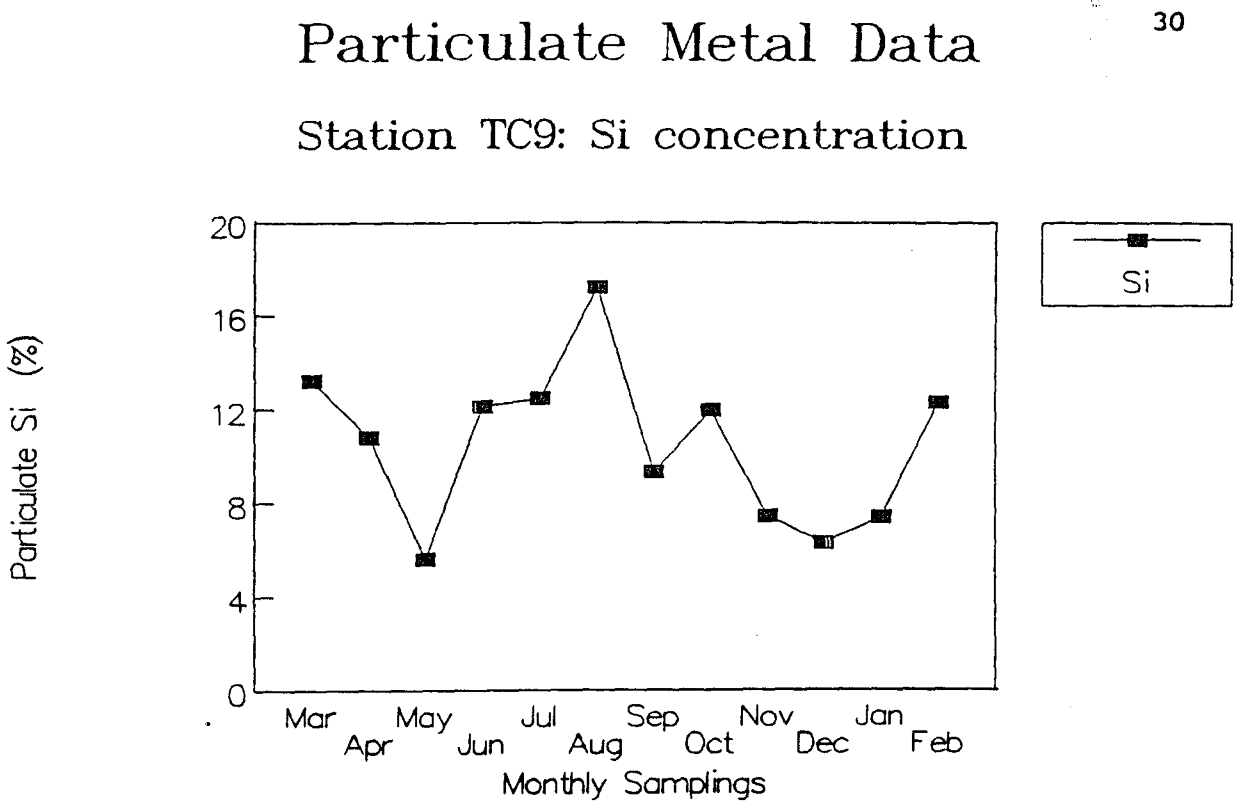


Figure 11. Scatter plots showing (a) particulate Al vs Si, (b) Al + Si vs carbon, and (c) carbon vs total suspended solids.

into suspension and the relative percentages of major elements increases with concurrent decreases in organic matter content. This general observation can be used to understand most of the specific trends seen in the monthly and storm samples.

Silicon is the most abundant element, except for oxygen, in continental crust and is the primary component of quartz sand (SiO_2) and clay (aluminosilicates) transported through Turkey Creek. Overall, the Si content of suspended particles from Turkey Creek during normal sampling periods averaged a consistent 11 ± 2% (Table 2). This value is significantly lower than that for continental crust (27% Si) or pure quartz sand (46% Si). The trend of lower Si values results from high levels of organic matter (typically 25-40%), which dilute the silicate and aluminosilicate material.

The monthly samples for site TC9 show considerable variability in particulate Si concentrations ((Figure 12). These variations are generally consistent with changes in TSS and organic carbon ((Figure 5, p. 18). Particulate Si values for site TC7 (Figures 13) are somewhat more consistent, with the major exception of a March 16, 1988, rain event when increased silt and sand were being transported. Much less variability is found for the TSS data from sites TPM and TC7 (Figures 6 and 7; p. 19 and 20) due to their locations along active transport routes of the creek where buildup of fine-grained sediment does not occur. Data from site TUSA show a large range of about 10-20% Si over the annual cycle (Figure 15). The variations in Si covary well with TSS values (Figure 8, p. 21) with higher Si content when TSS values are high. The TSS values for TUSA are more variable than found at most other sites in the creek, the result of several factors that influence turbidity at this site including wind, boat traffic and muck sediments in the area.



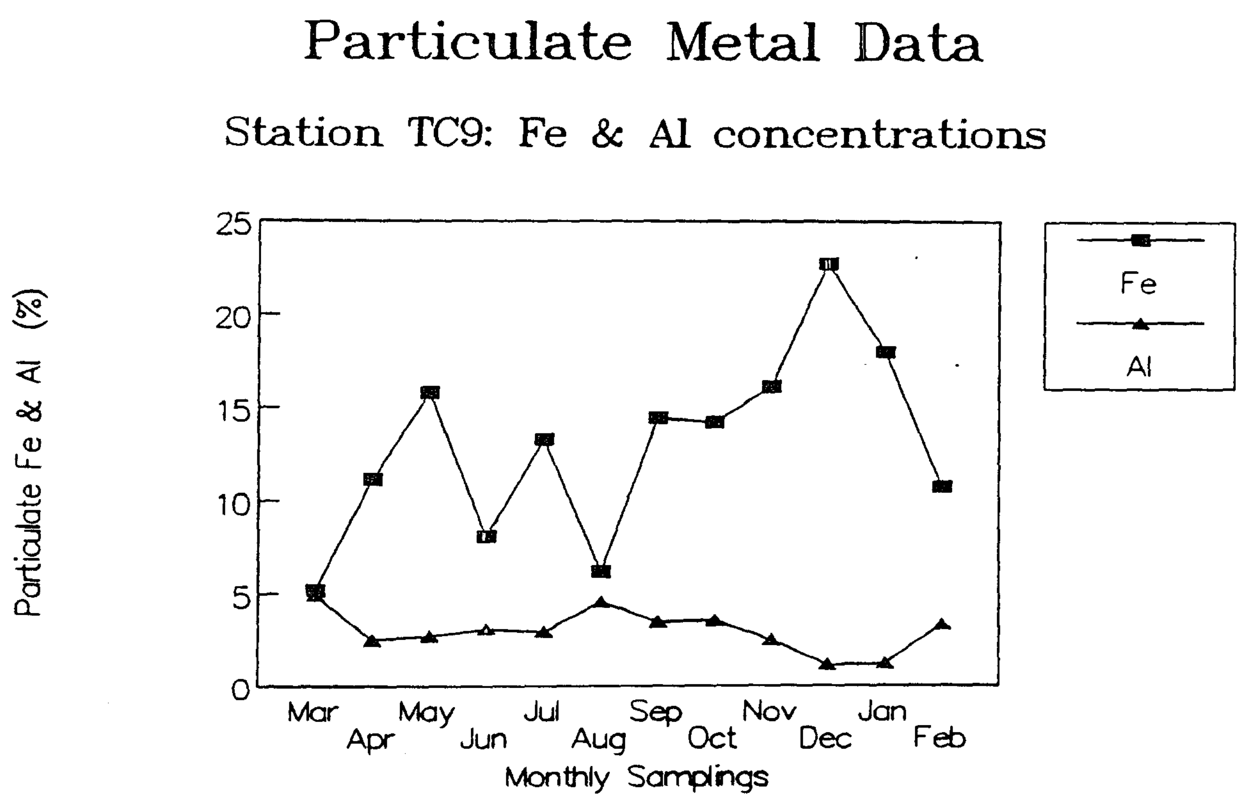
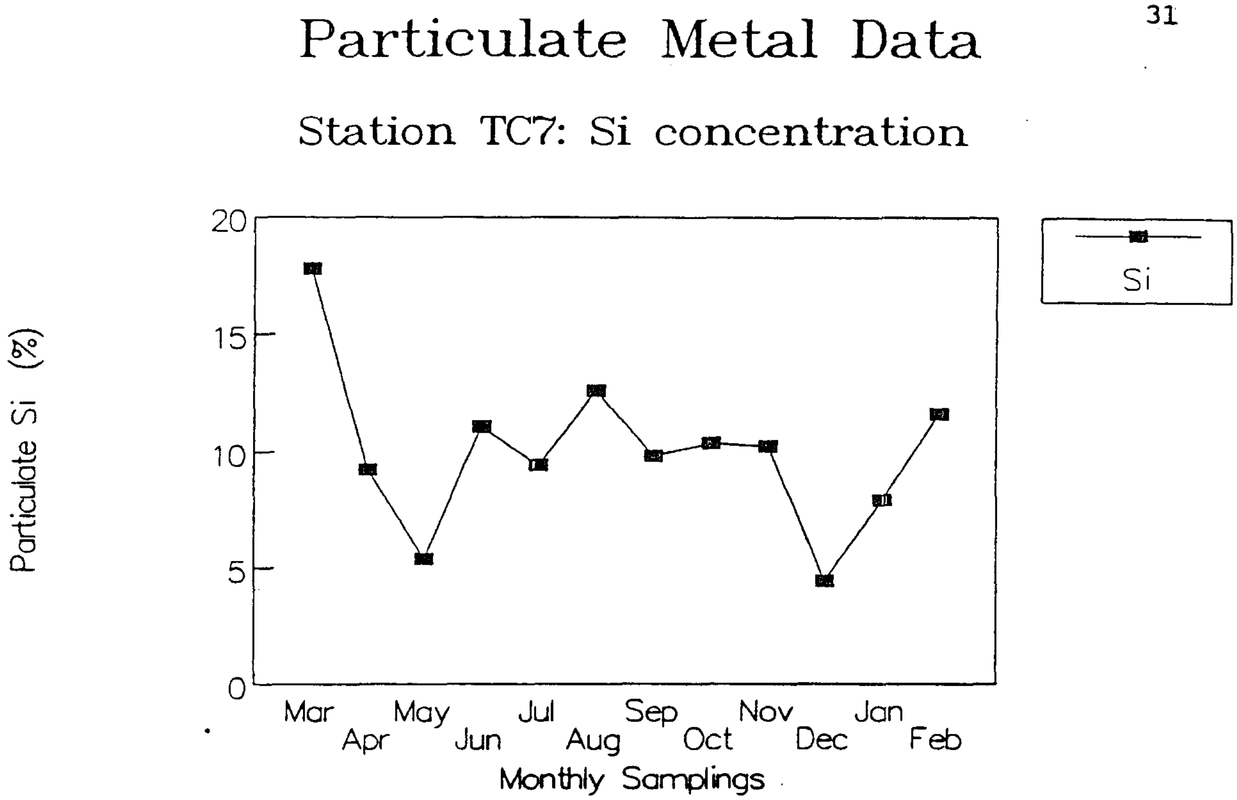


Figure 12. Graphs showing particulate Si, Fe and Al data for monthly samples from station TC9.



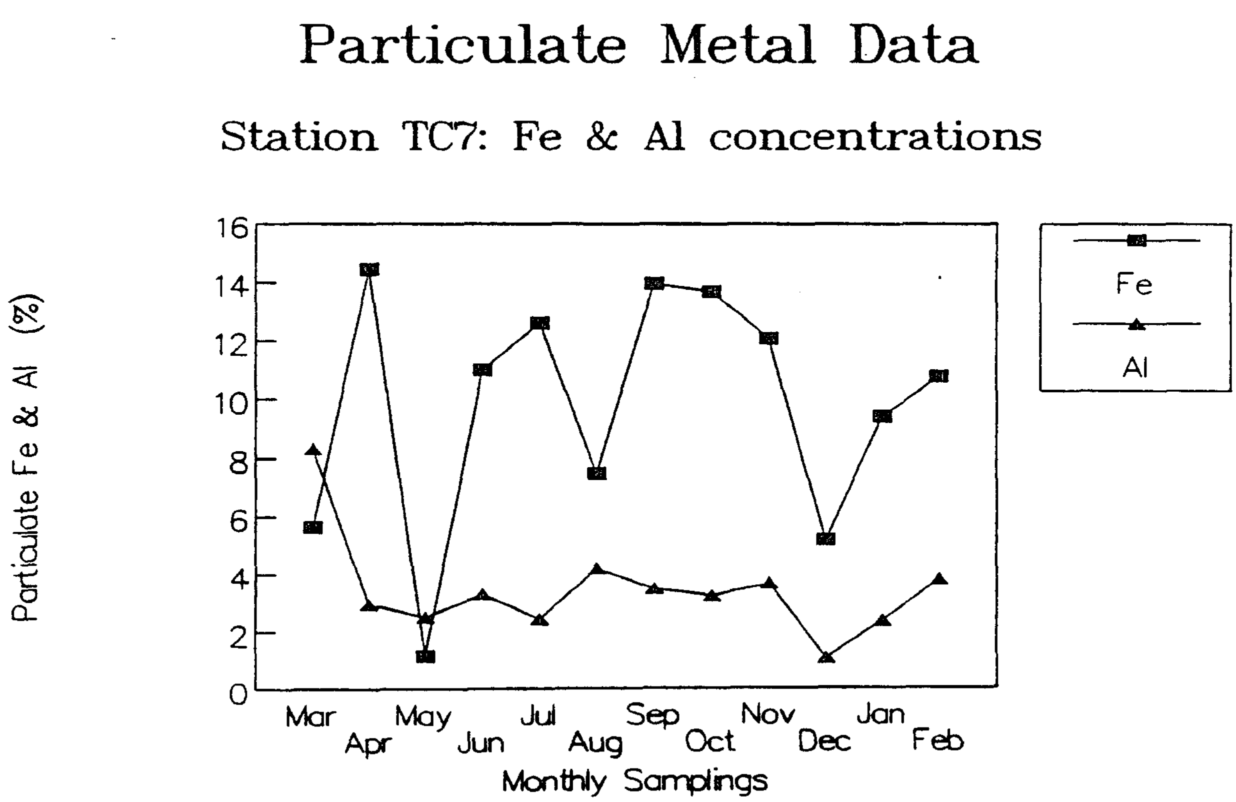
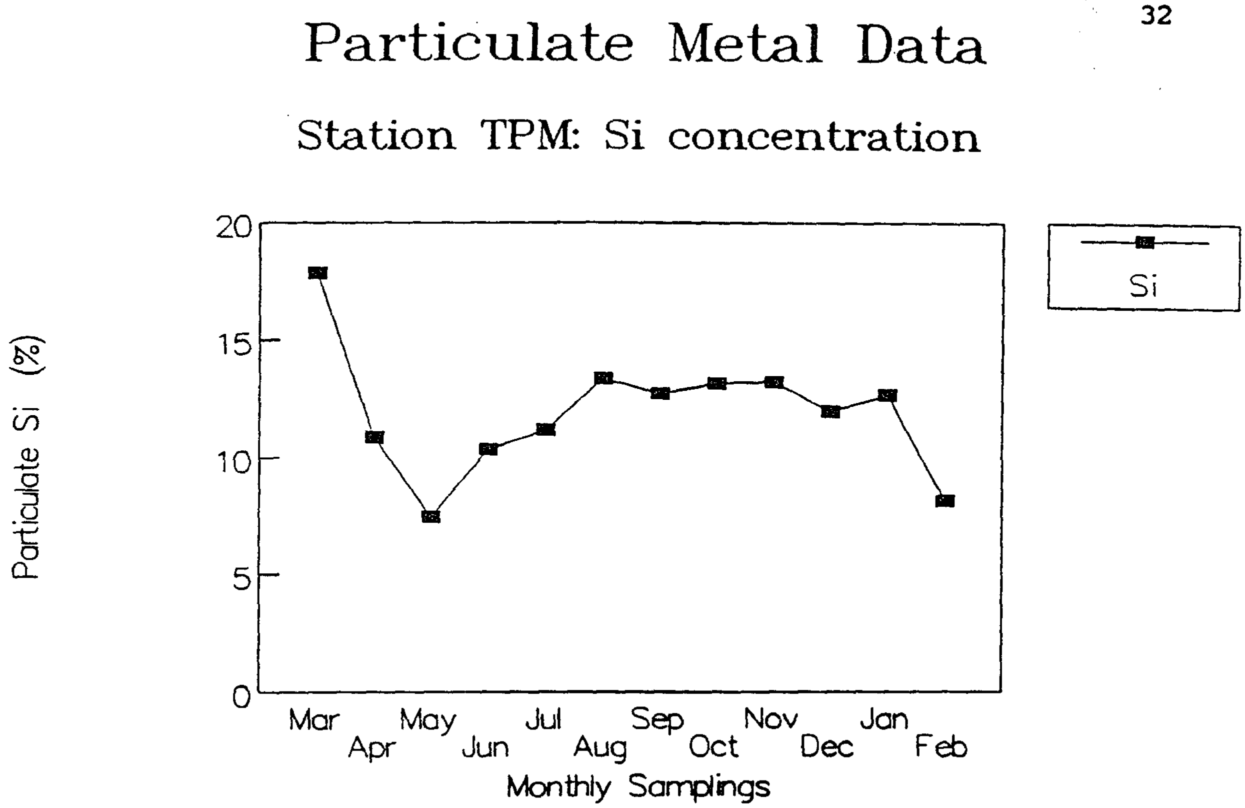


Figure 13. Graphs showing particulate Si, Fe and Al data for monthly samples from station TC7.



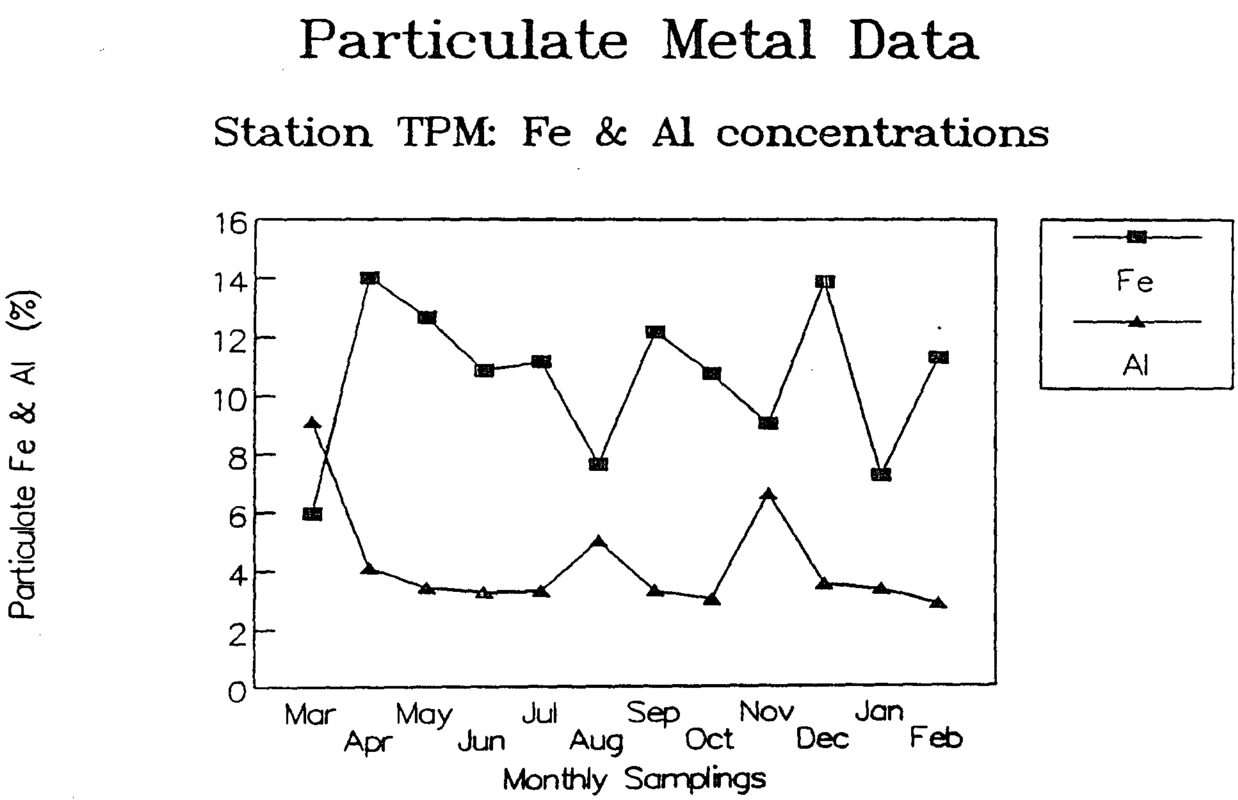
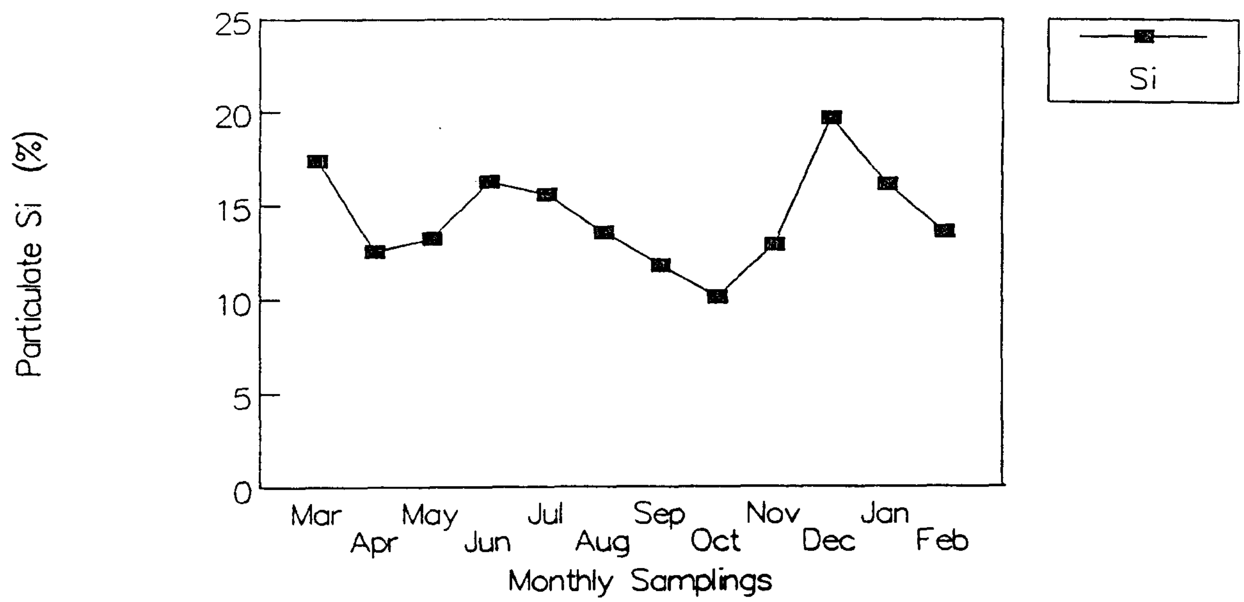


Figure 14. Graphs showing particulate Si, Fe and Al data for monthly samples from station TPM.

Particulate Metal Data

Station TUSA: Si concentration



Particulate Metal Data

Station TUSA: Fe & Al concentrations

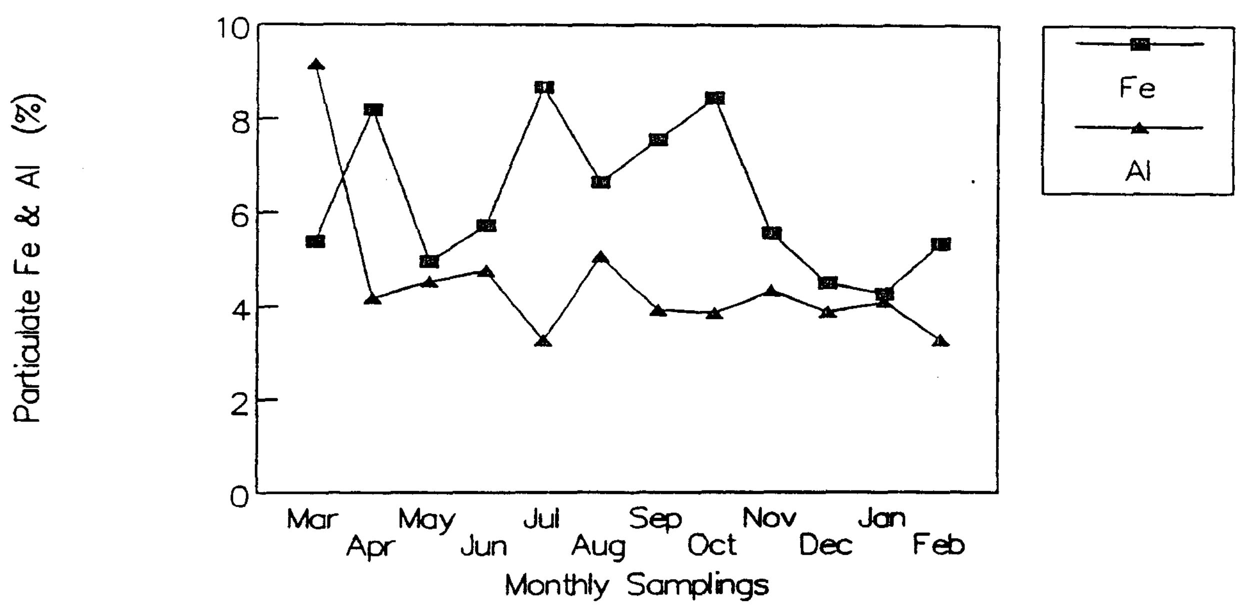
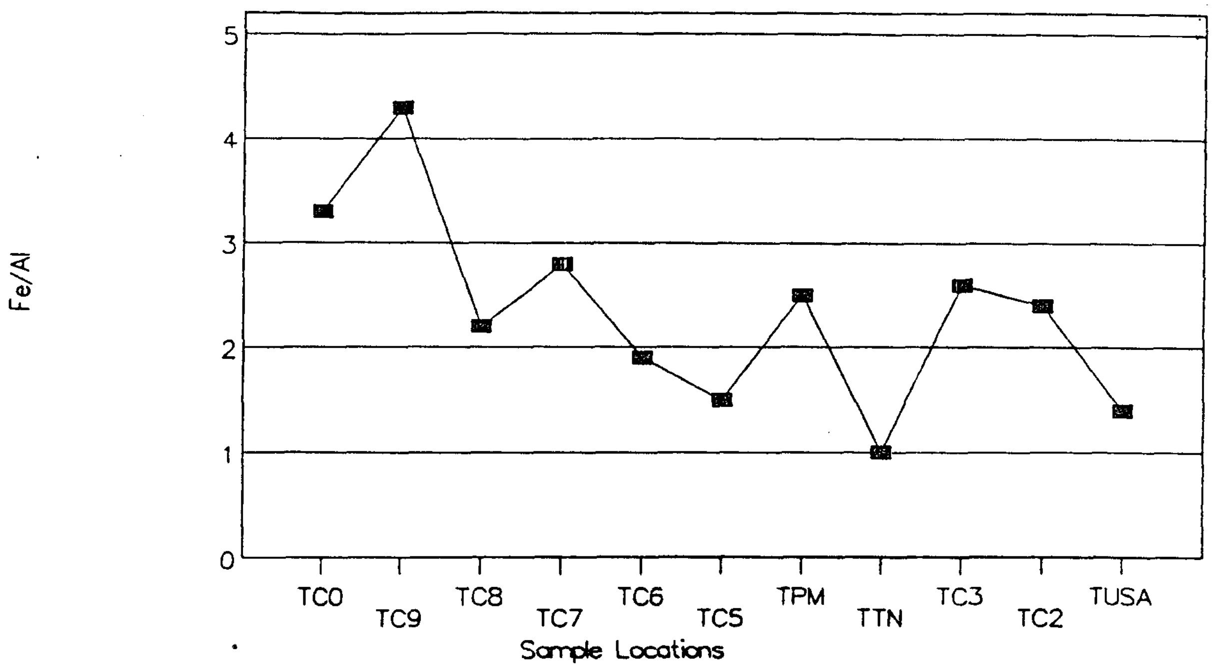


Figure 15. Graphs showing particulate Si, Fe and Al data for monthly samples from station TUSA.

Aluminum concentrations in non-storm particles from Turkey Creek show an overall uniformity similar to that for Si (Table 2). As was the case for Si, the particulate Al content (3.4 ± 0.9%) is low relative to average continental crust (8.2% Al) due to the abundance of organic matter. Concentrations of Al show some of the same trends observed for Si; however, excursions from the mean are less common because Al is associated primarily with clays and Si is a component of clays, quartz sand and certain phytoplankton such as diatoms (Figures 12-15). Aluminum concentrations are commonly used as a reference to normalize concentrations of other elements. The use of Al is favored because Al is less subject to chemical weathering than other elements and because Al is a primary component of fine-grained clays and silt. Ratios of metals to Al will be used in subsequent discussions to follow the trends of other metals.

Iron concentrations in suspended matter from non-storm periods were highly variable as a function of station with many values in the range of 10-20% Fe, relative to 4-5% Fe in continental crust. These Fe-rich particles sharply contrast with the low Si and Al content of the suspended solids from Turkey Creek and are one dramatic and unusual observation from our data set. The highest particulate Fe values were found at upstream stations, especially TC 9 (Figure 12). A basin-wide overview of the Fe distribution is best shown by the Fe/Al annual means for each site (Figure 16). Relative to continental crust with an Fe/Al ratio of 0.5, suspended matter samples from throughout Turkey Creek have Fe/Al ratios averaging 1 to >4. This Fe enrichment is greatest at stations TC9 and TC0 (Figure 16). We can only speculate on possible mechanisms for this Fe enrichment. Much of the soil material in the



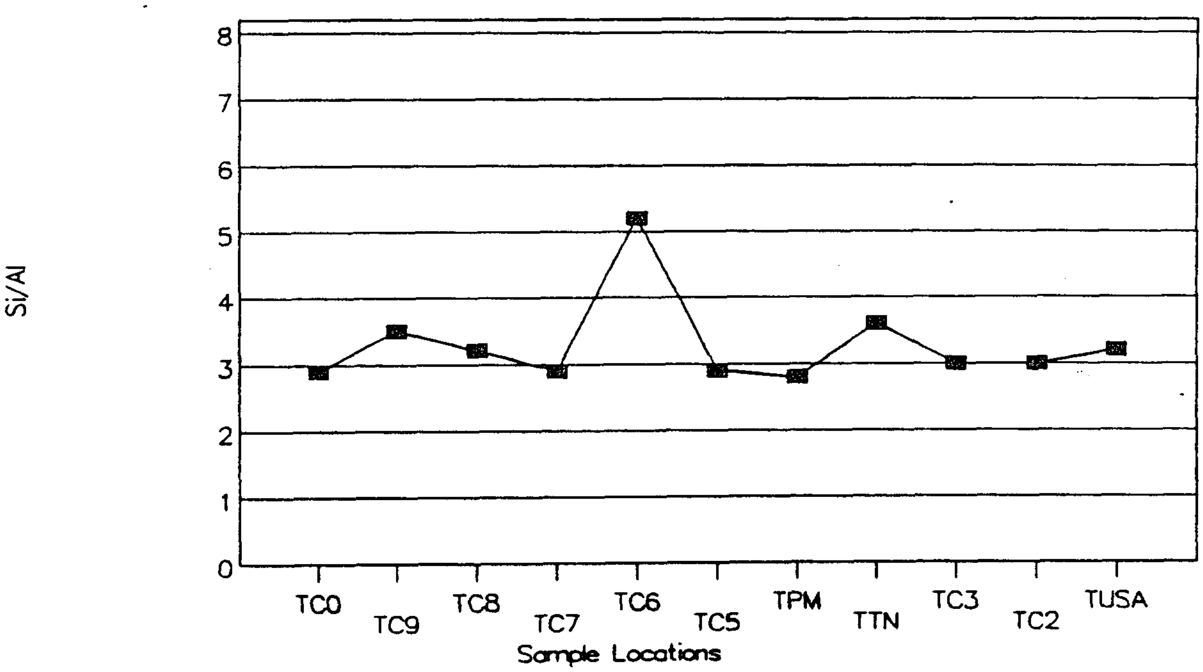


Figure 16. Graphs showing the Fe/Al and Si/Al ratios for each site based on annual averages.

upper basin is Fe-rich material deposited during the Pleistocene. Iron is very susceptible to remobilization and transport under reducing or anoxic conditions. Low pH and high dissolved organic matter concentrations also help support mobilization of Fe in natural waters. Thus, at some time in the past, Fe has been released from subsurface or adjacent sediments and deposited in the upper reaches of Turkey Creek. The high Fe/Al signal observed at TC9, and to a lesser degree at TC0 and TC8, is traceable throughout the the creek to site TUSA where the Fe/Al ratio is still >1. The Fe enrichment has no obvious deleterious effect and is a natural phenomenon.

Previous sediment samples collected in the Indian River Lagoon at the mouth of Turkey Creek (Trefry et al., 1987) do not show this Fe enrichment with Fe/Al ratios of about 0.5. This observation supports the concept that much of the muck deposits in the Indian River Lagoon are due to storm loadings. Use of the various element/Al ratios to identify and track sediment inputs is discussed in more detail later in the report.

In contrast to Fe, the Si/Al ratio for suspended matter throughout Turkey Creek averages a uniform 3.1 ± 0.3 (Figure 16), in close agreement with an Si/Al ratio of 3.4 for average continental crust. The Si/Al ratio varies very little throughout the Turkey Creek watershed. One exception at site TC6 most likely results from an increased quartz sand component in this residential sandy area.

Sometimes within a drainage basin, the elemental signature of the suspended particles can vary from one tributary to another. Such differences can provide tracers of particle movement throughout the system. For example, the Si/Al ratio at TC6 (Figure 16) is distinct and can be used to follow material from that area as it moves through the system. In this instance, sediment inputs from TC6 are too small to influence the Si/Al ratio downstream.

In a similar fashion, the Fe/Al ratios can be used to trace the Fe-rich particles from upstream stations TC0, TC9 and TC8 (Table 3). After the confluence of these tributaries at TC7, the Fe/Al ratio is 2.8. Assuming for the moment that inputs to TC7 from TC0 are small, we estimate that a 30% contribution of material from TC9 (Fe/Al = 4.3) and a 70% input from TC8 (Fe/Al = 2.2) would yield the ratio observed at TC7 (Table 3). The Fe/Al ratio at TC7 is consistent with that at TPM, TC3 and TC2, the main stations downstream. We will show more clearly in the trace metal data that even strong "signatures" for particles from TC6, TC5 and TTN do not influence the main bolus of suspended matter being transported downstream during non-storm conditions. The change in the Fe/Al ratio at TUSA suggests another influence at this site, one that could be related to resuspended muck sediments.

Data for K and Na can be used to complement the perspective gained from Si and Fe concentrations. The K/Al and the Na/Al ratios for sites TC8 and TC9 can again be used in a 7:3 proportion to derive the respective ratios at TC7 (Table 3). This proportion in sediment source areas is certainly consistent with more extensive development at present in the southwestern portion of the watershed than to the west and northwest. The K/Al ratio at TC7 is also consistent at main downstream sites TPM, TC3 and TC2 (Figure 17), in support of the idea that the main sediment input during non-storm conditions is from

Table 3. Average metal/Al ratios for non-storm suspended matter samples from Turkey Creek.

	Fe/Al	K/Al	Na/Al	Ca/Al	Ca/Mg	Si/Al
TUS A	1.4	0.082	0.033	0.32	1.8	3.2
TC2	2.4	0.052	0.021	0.48	4.5	3.0
TC3	2.6	0.054	0.022	0.51	6.0	3.0
TTN	1.0	0.118	0.061	0.73	4.7	3.6
TPM	2.5	0.049	0.059	0.48	5.5	2.8
TC5	1.5	0.056	0.121	0.33	2.3	2.9
TC6	1.9	0.100	0.132	0.68	4.3	5.2
TC7	2.8	0.061	0.029	0.51	6.2	2.9
TC8	2.2	0.058	0.022	0.82	9.3	3.2
TC9	4.3	0.083	0.046	0.54	4.8	3.5
TCO	3.3	0.041	0.016	0.56	7.3	2.9

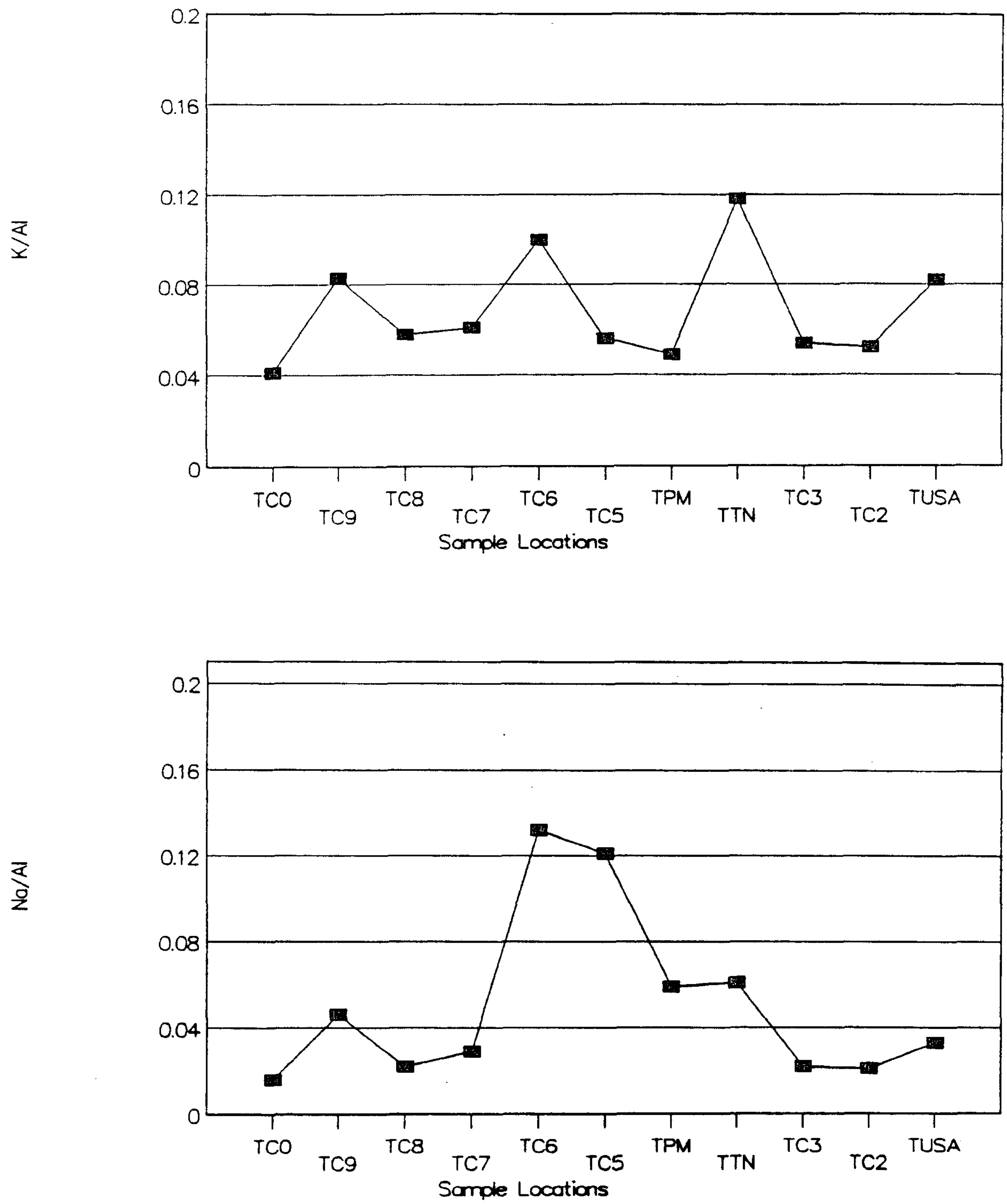


Figure 17. Graphs showing the K/Al and Na/Al ratios for each site based on annual averages.

the upland areas and that material from TC0 amounts to only a small fraction of the total suspended sediment reaching the C-1 canal during non-storm runoff. A strong Na/Al ratio at TC6 and TC5 marks these particles with a distinct fingerprint. As an interesting aside, the K/Al and Na/Al ratios for Turkey Creek (Table 3) are much lower than values for average continental crust of 0.26 and 0.28, respectively. The low ratios in Turkey Creek result from a combination of less felsic source rocks and more intense chemical weathering in this system.

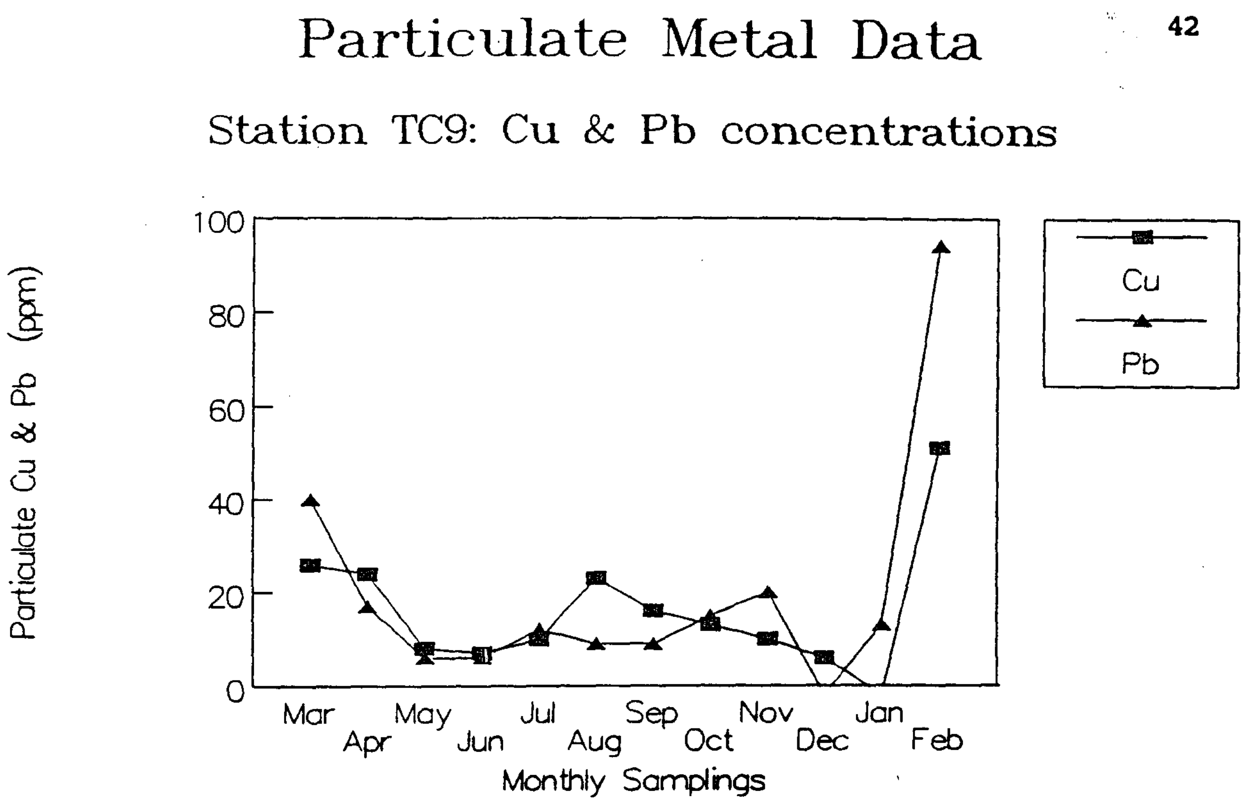
The Ca/Al and Ca/Mg ratios for suspended matter from Turkey Creek (Table 3) are comparable or somewhat higher than crustal ratios of 0.5 and 1.8, respectively. This draining basin is somewhat more Ca-rich, consistent with local limestone abundances.

Trace Metals: Non-Storm Samples

Three metals, Cu, Mn and Pb, were chosen to provide an overview of the distribution of trace elements in Turkey Creek and to evaluate possible contamination. Copper is used in a variety of industrial applications, as a herbicide, in anti-fouling paints for boats, and it is present in municipal waste. Lead is most commonly introduced into the environment from automobile emissions and industrial discharges. Manganese does not typically behave as a contaminant, but rather can serve as an indicator of redox conditions in a sedimentary system.

Copper concentrations in suspended particles from Turkey Creek range from as low as 2 or 3 $\mu g/g$ on occasion at some upstream stations to as high as 1160 $\mu g/g$ at site TTN. These values bracket average continental crust and mean sediment Cu concentrations of 50 and 33 μg/g, respectively. Particulate Cu concentrations at upstream sites TC0, TC9 (Figure 18) and TC8 are at natural levels. Observed variations at these sites are generally small and are related to the organic matter and clay content of the particles. By sites TC7 and TPM, Cu concentrations are generally higher at 10-90 μg/g (Figures 19 and 20). Throughout the year, very high particulate Cu concentrations were found for site TTN (Figure 21). These concentrations are 5 to >25 times above natural levels and possibly result from past inputs to the Troutman Boulevard area. Downstream of the site TTN, particulate Cu levels are lower at 40-60 μg/g.

An overview of the average Cu/Al ratios for each site (Figure 23) more clearly shows the trends described above. We assume that natural Cu/Al ratios for this area are between 4 and 6 ($x\ 10^4$). Thus, upstream stations show no evidence of Cu contamination. As we move down along the C-1 canal to TC7, the particulate Cu levels, and thus the Cu/Al ratios, are above natural levels. This addition of Cu to the system is small and may result from a combination of Cu treatments (herbicides) for control of vegetation and various non-point sources. As we move farther downstream, the average Cu/Al ratio for site TTN jumps off the chart at 238×10^4. However, no measureable influence of the elevated Cu levels at site TTN can be seen downstream (Figure 23). The data show that the particle flux from the Troutman Boulevard area is either not being transported downstream or that it is very small relative to the particle load of the main creek. A similar explanation can be made for the lack of



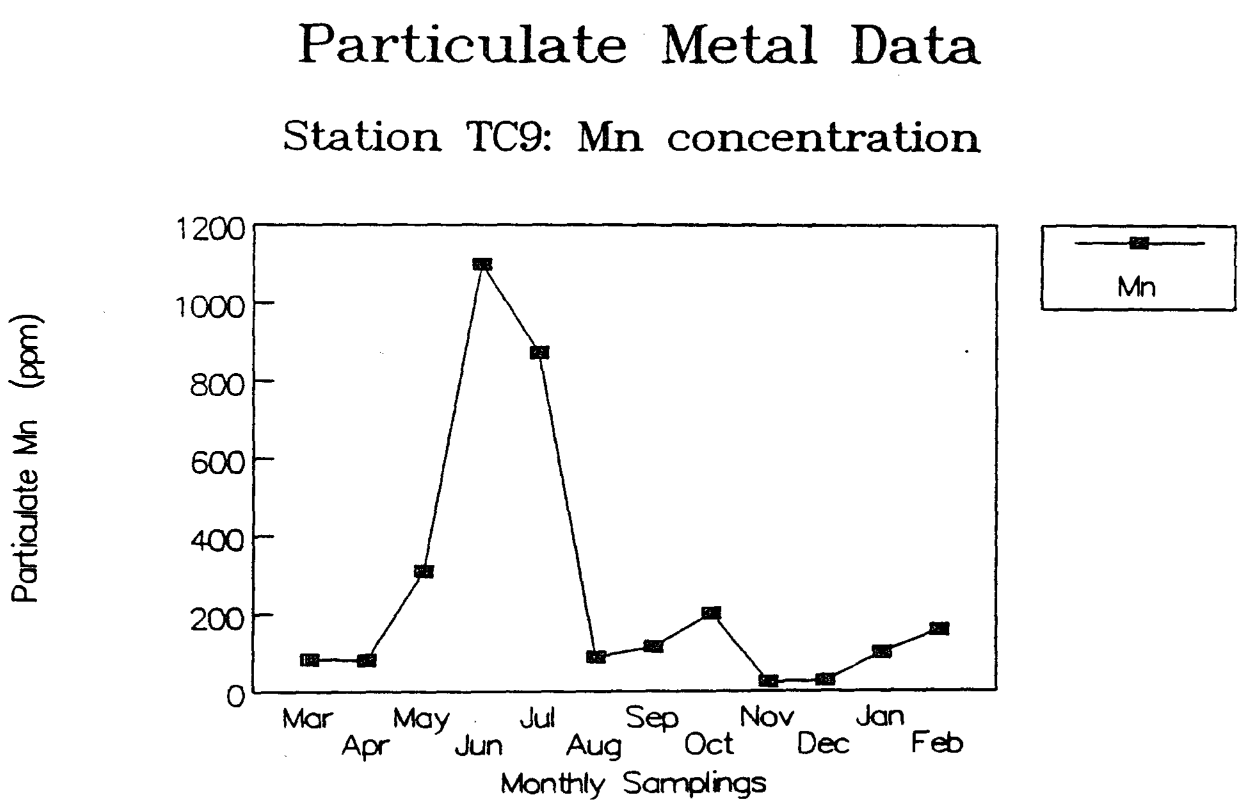


Figure 18. Graphs showing Cu, Pb and Mn concentrations for suspended particles from station TC9.

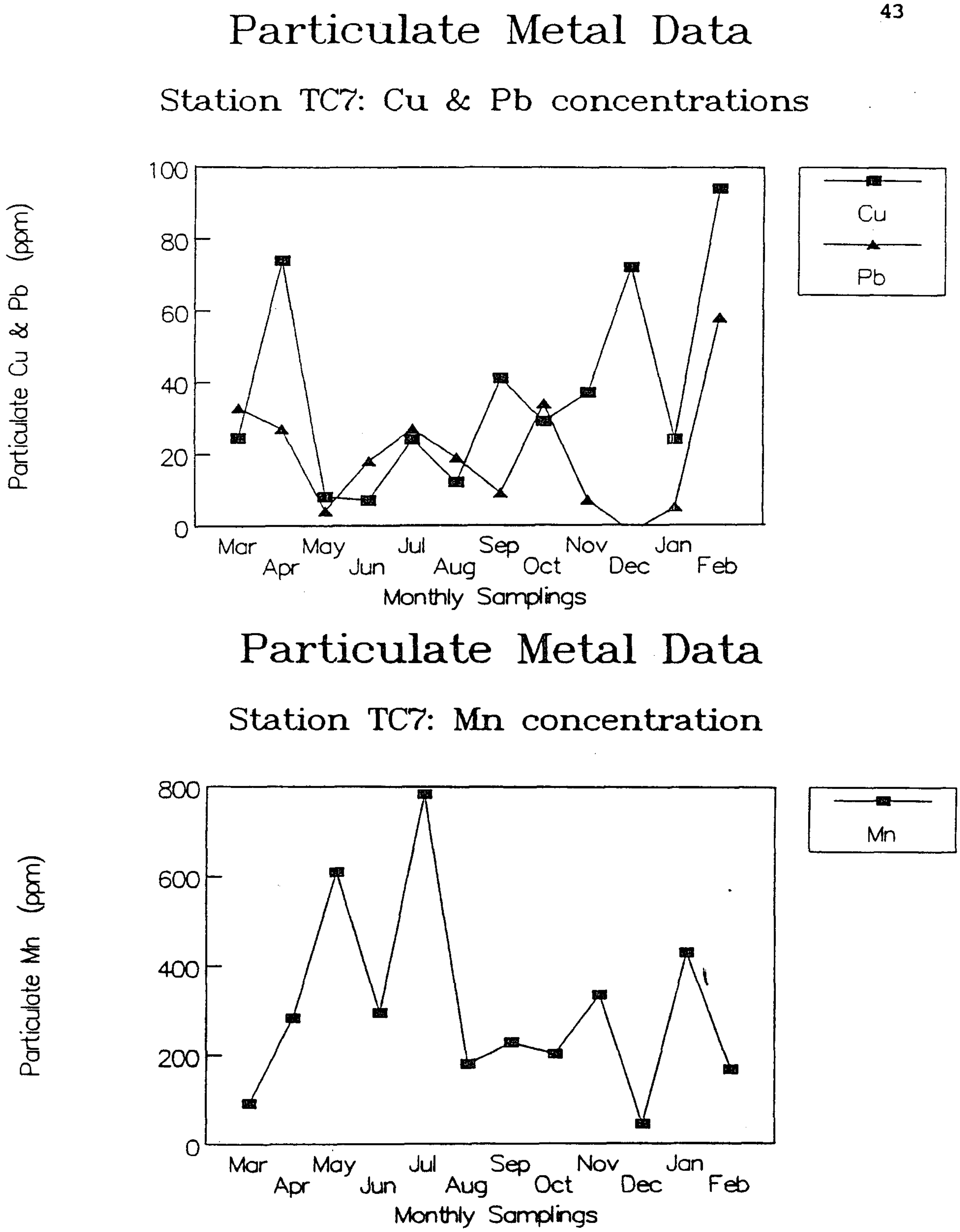
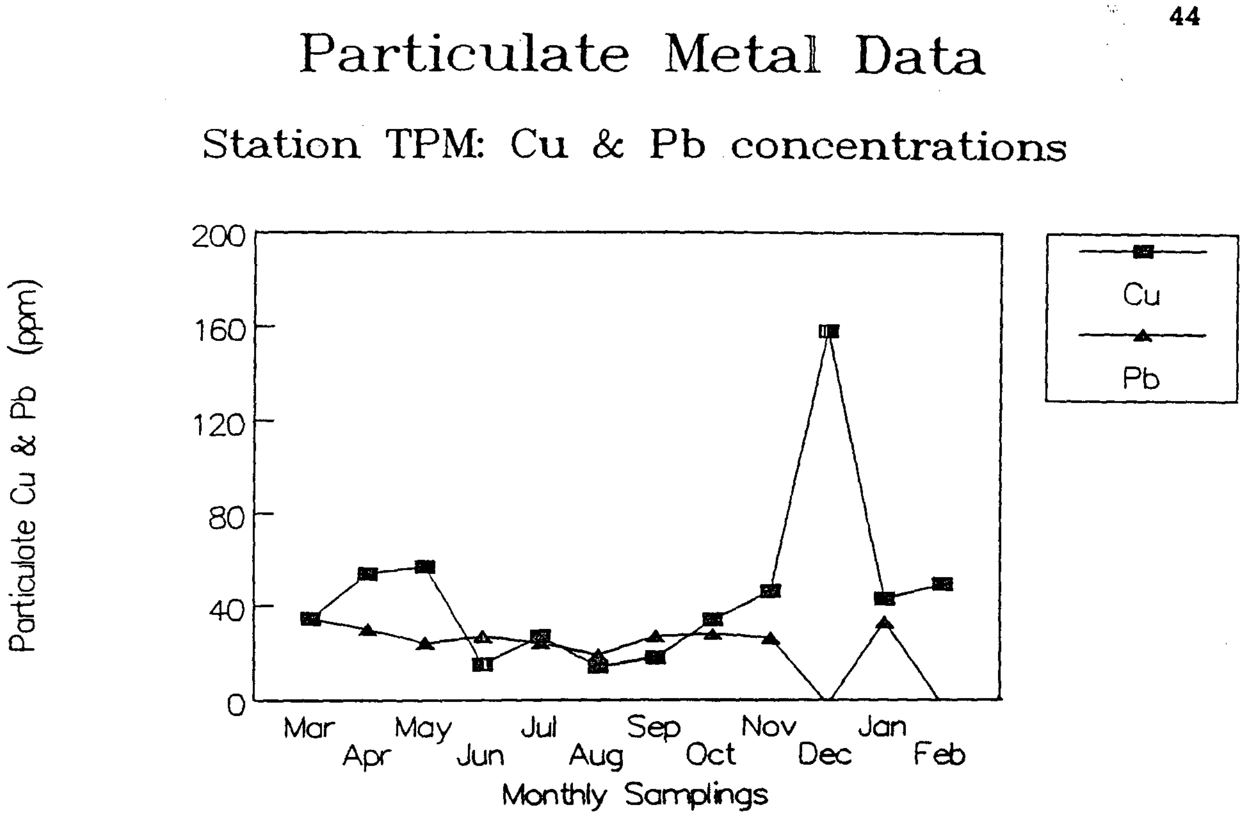


Figure 19. Graphs showing Cu, Pb and Mn concentrations for suspended particles from station TC7.



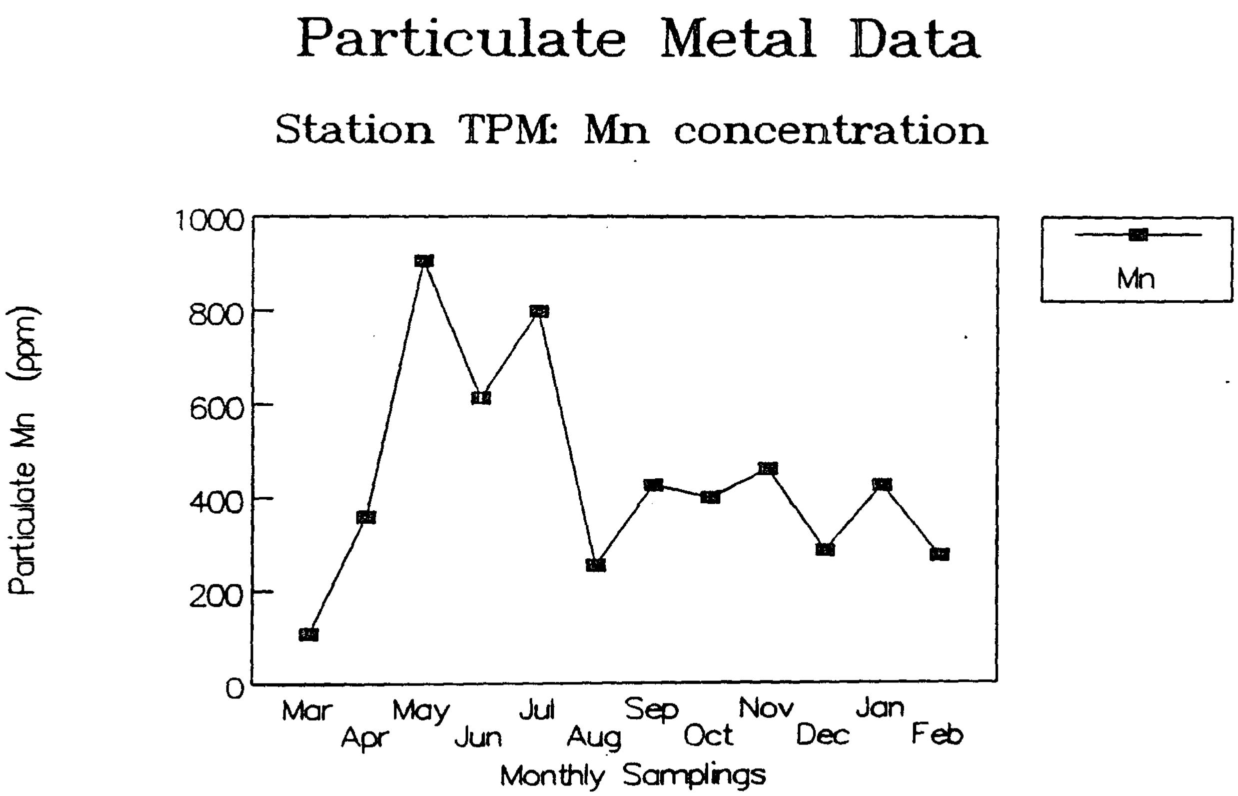
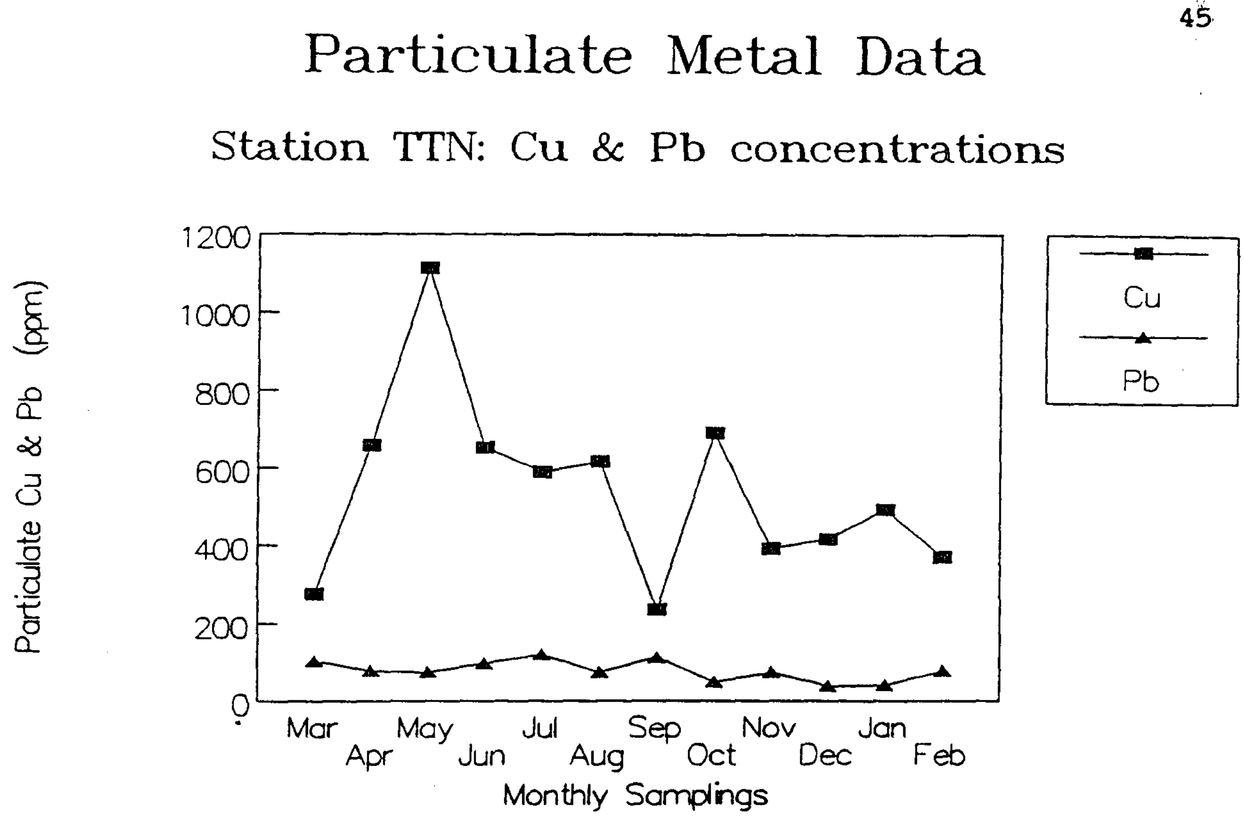


Figure 20. Graphs showing Cu, Pb and Mn concentrations for suspended particles from station TPM.



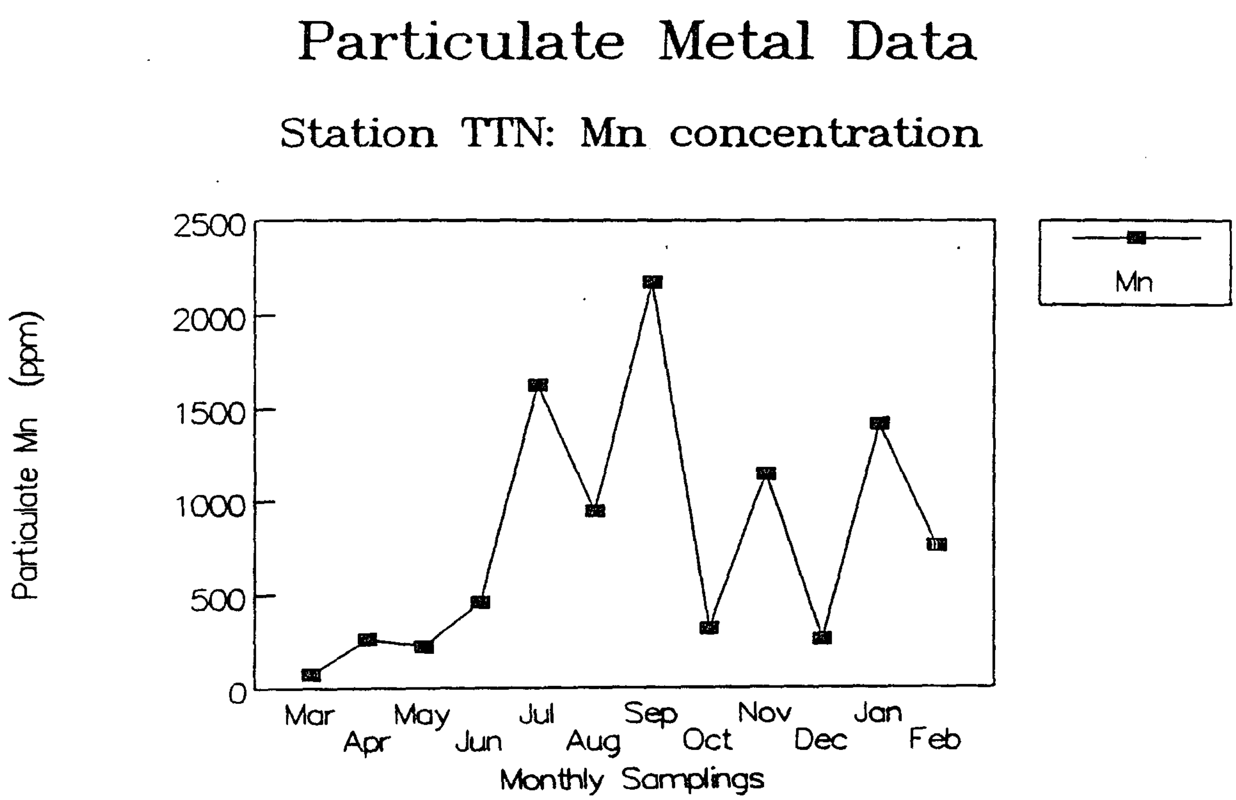
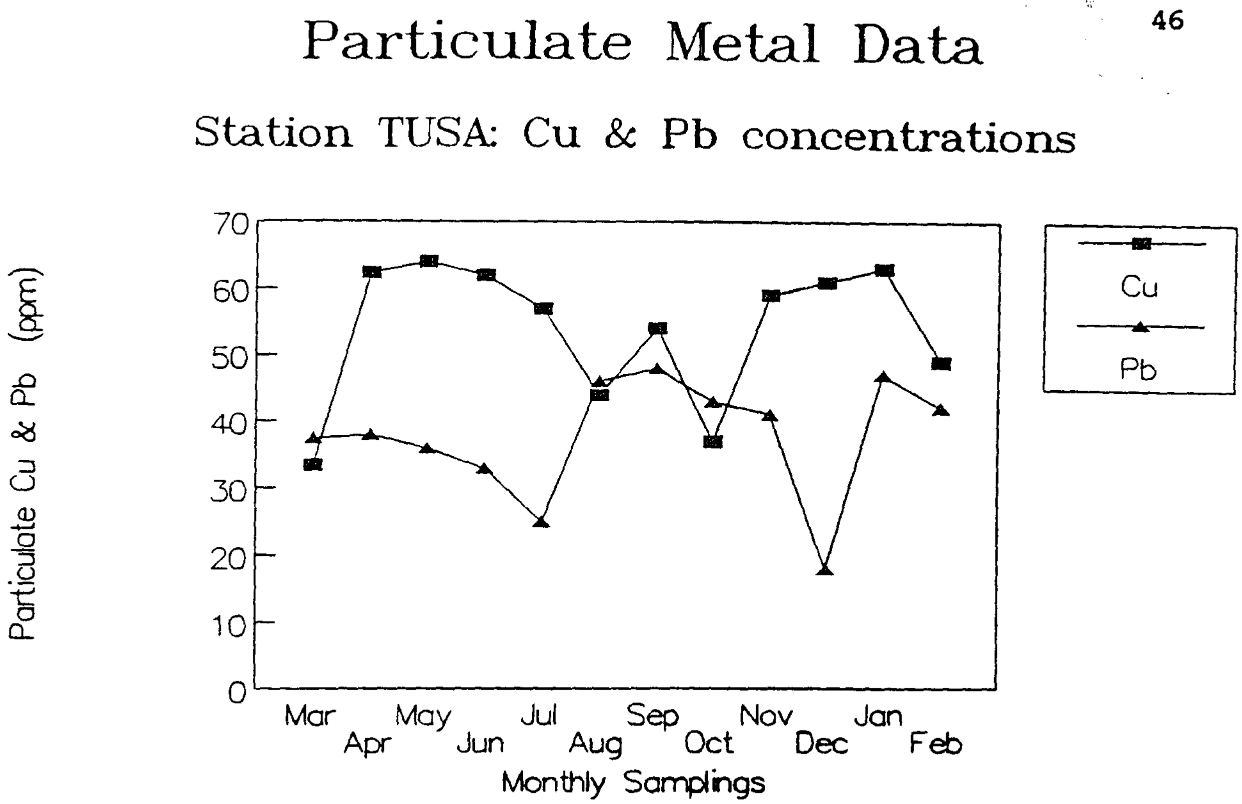


Figure 21. Graphs showing Cu, Pb and Mn concentrations for suspended particles from station TTN.



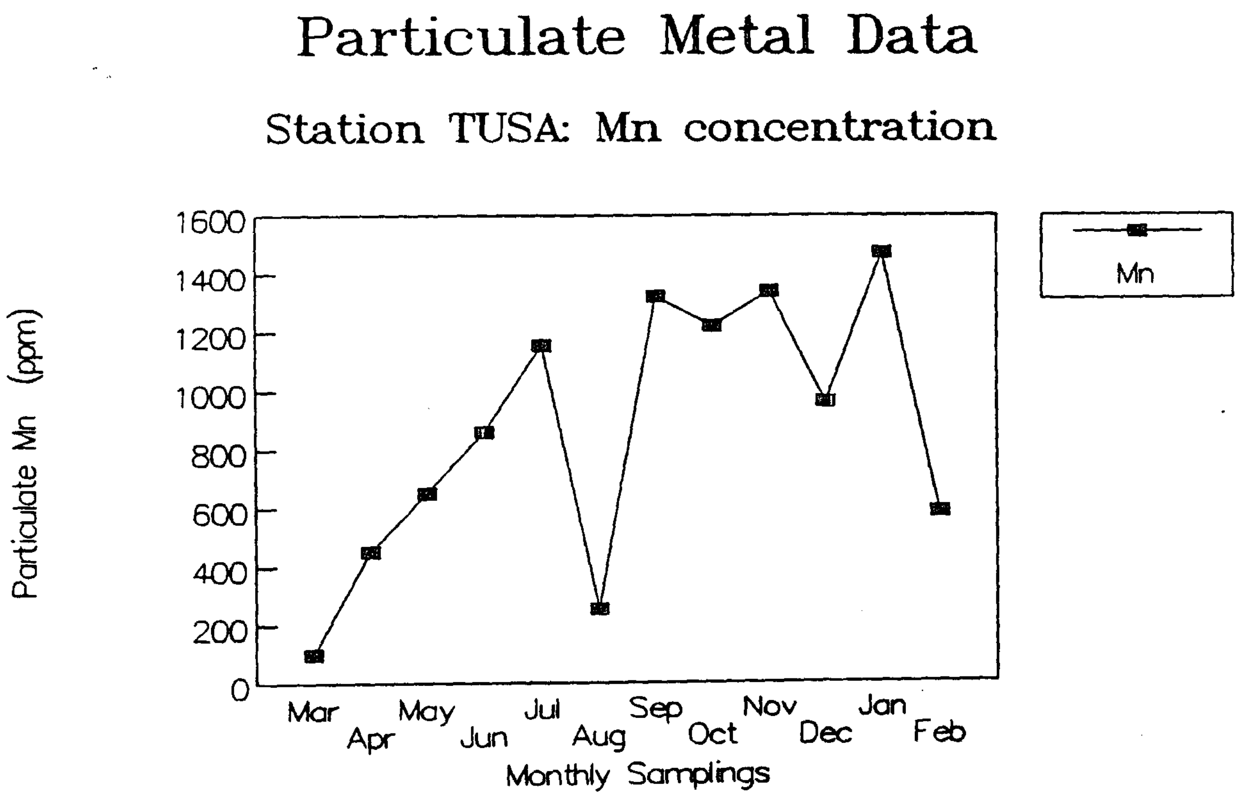


Figure 22. Graphs showing Cu, Pb and Mn concentrations for suspended particles from station TUSA.

influence of the higher Cu/Al ratio for the small tributary at site TC6. Glascock (1987) observed the same trend from her study of sediment Cu content in Turkey Creek (Figure 24). Sediment Cu concentrations in the Troutman Boulevard area were 243 and 543 $\mu g/g$; however, downstream values were 4-9 $\mu g/g$. Glascock (1987) did see some evidence for Cu contamination near marinas adjacent to US 1. There is subtle evidence for an increase in the Cu/Al ratio for site TUSA. Overall, the Cu/Al signal developed at site TC7 is unaltered along the main creek right to the mouth.

Lead concentrations of particles from Turkey Creek show some similarities and some differences relative to Cu. Throughout the entire watershed, particulate Pb concentrations and the Pb/Al ratio are above natural levels. Upstream sites TC8 and TC9 have the least Pb contamination (Figures 18 and 23), probable because these sites are removed from direct inputs of Pb from roadside runoff. In contrast, Pb levels for suspended particles collected from site TC0 (Figure 23) are well above natural levels. This site is adjacent to a well-traveled intersection with substantial influence from highway runoff.

In the C-1 canal at site TC7, the Pb signal is a composite of the upstream sources with a Pb/Al ratio intermediate of that for stations TC8 and TC9. Downstream of TC7, site TTN shows a very high Pb/Al ratio (Figure 23) due to industrial and municipal inputs. Higher Pb/Al ratios are also observed at sites TC5 and TC6. However, we see the same downstream trend observed for Cu, namely that the signal developed at site TC7 is carried through TPM and on to the lower creek sites where the Pb/Al ratio is similar and 3-4 times above natural levels.

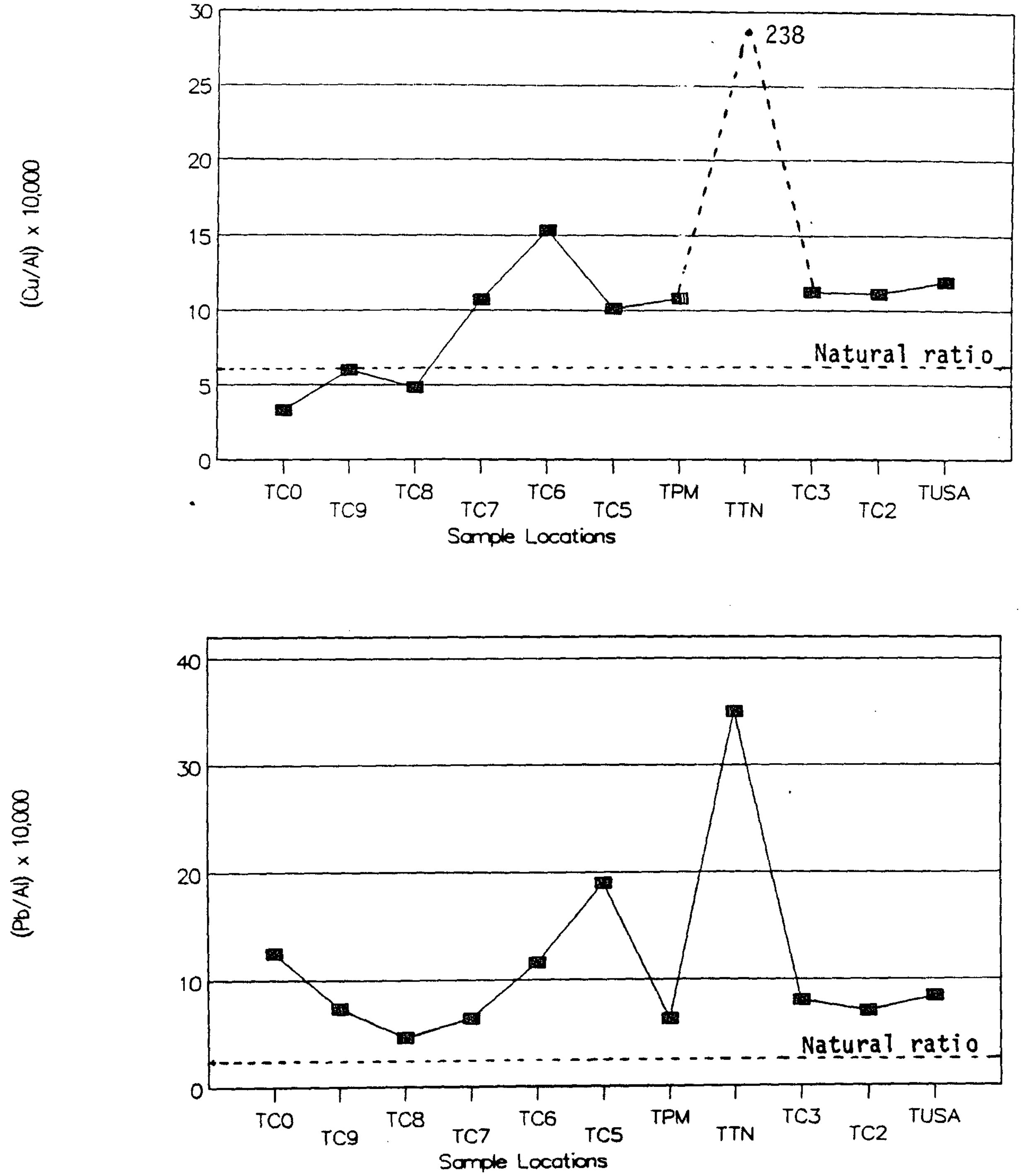


Figure 23. Graph showing the Cu/Al and Pb/Al ratios for each site based on annual averages.

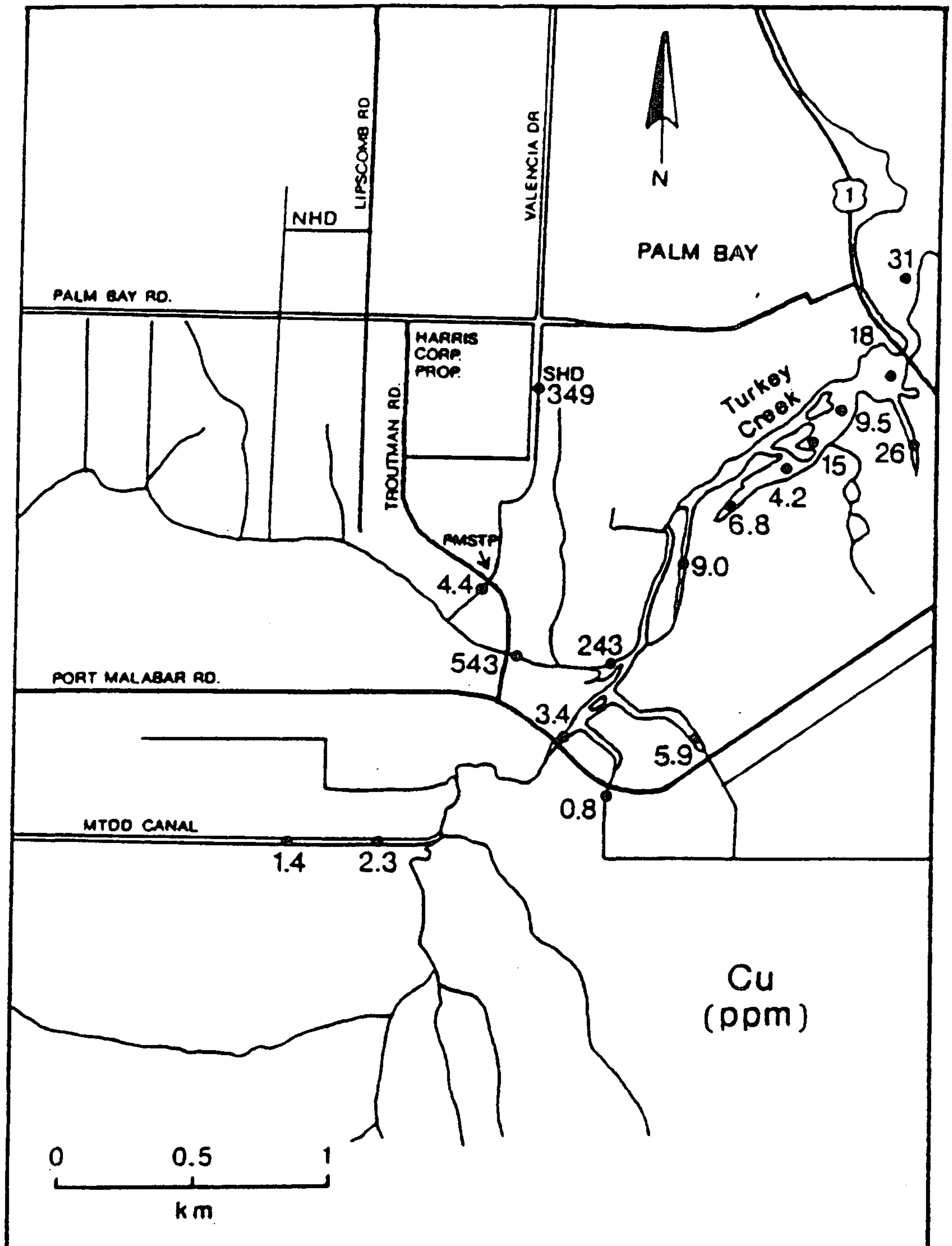


Figure 24. Distribution of Cu in sediments from Turkey Creek (from Glascock, 1987).

Particulate manganese values can be quite variable over an annual cycle at a given site. For example, at TC9 (Figure 18, p. 42), particulate Mn values are <200 μg/g for most of the year. Then, during May, June and July, a sharp increase occurs. A similar trend is seen at sites TC0, TC8, TC7 (Figure 19), TPM (Figure 20) and TTN (Figure 21). In some cases, the increase in particulate Mn coincides with an increase in organic matter content. One plausible explanation for this trend is release of dissolved Mn to the water column from upland areas during times when reducing conditions develop in submerged soil and sediment. The onset of reducing conditions is spurred by increased bacterial activity (a function of temperature increase and more abundant organic matter), and warmer, less oxygen-bearing waters. In this scenario, dissolved Mn is released to the water column where it oxidizes and becomes particulate Mn during late spring and early summer. This trend suggests that redox conditions throughout the system have a seasonal cycle. The cycle is tied to the organic content of suspended particles and most likely can be extrapolated to other redox-sensitive chemical species.

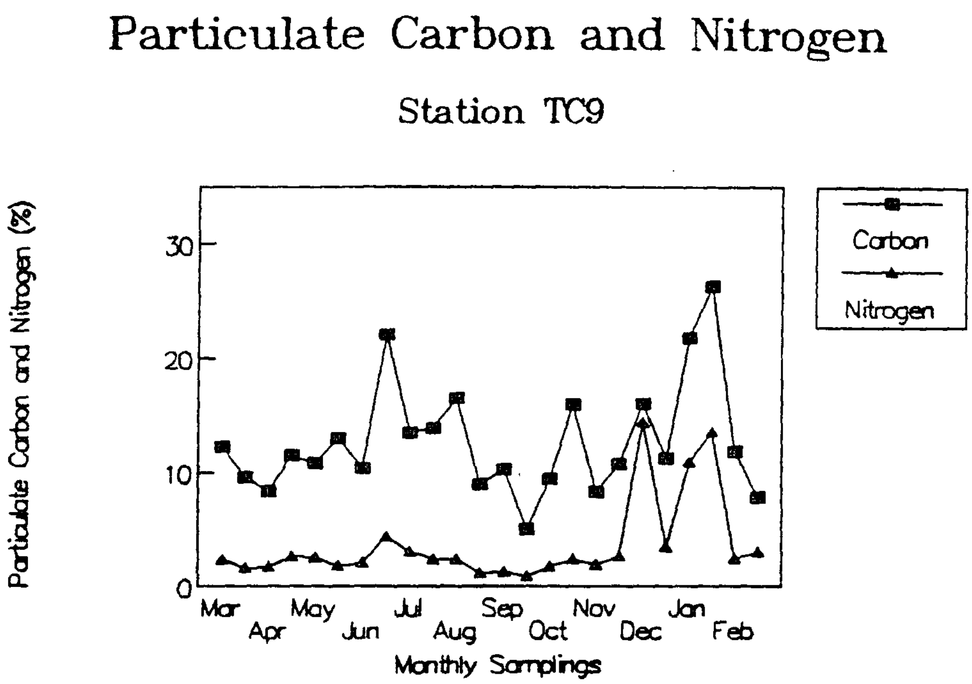
Particulate Nutrients: Non-Storm Samples

The particle-bound fraction of carbon, nitrogen and phosphorus carried by rivers and creeks can be a significant percentage of the total transport. Thus, we included particulate nutrients in this study of Turkey Creek. Data for particulate carbon and nitrogen (in mg/L) for sites TC9, TC7, TPM and TUSA are shown in Figures 5-8 (pp. 18-21). Particulate carbon and nitrogen values vary considerably during the non-storm, annual cycle. In general, particulate

C and N (as mg/L) follow the trends for suspended solids. Suspended solids transport is in turn related to runoff, stream flow, seasonal practices in agriculture and construction, and elapsed time between rain events.

In contrast with the particulate nutrient data on a mg/L basis, the weight percent C, N and P content of the particles is more uniform in the non-storm samples (Figures 25-28). At TC7 and TPM, the % carbon and nitrogen are rather uniform, except for samples collected during low flow in late May and late December (Figures 26 and 27). At these times, very small amounts of suspended silts and clays are being transported and thus the organic fraction becomes a proportionally higher percent of the total. This trend can be seen on Figure 11c (p. 27) where some of the highest % C values are found at the lowest TSS concentrations and vice versa. Very high % particulate C, N and P values are observed at TC9 during the summer. This may be related to upstream increases in productivity and they can be followed downstream as discussed in the particulate Mn section.

The % of total carbon and nitrogen carried with particles shows a complex trend that varies with TSS values and season. Figure 11c (p. 27) shows that the highest percent carbon values occur at TSS values of <5 mg/L and that the % carbon is lower when TSS levels are >15 mg/. However, the trend has many complex exceptions. One example of the importance of particle transport shows that at site TC0 when TSS = 57.1 mg/L, the percent of total C, N and P in the particulate fraction was 16, 35, and 55%, respectively. The relationship of percent C, N and P with TSS values follows only the very general trend described and varies under certain conditions, especially storm events, to be described in the next section.



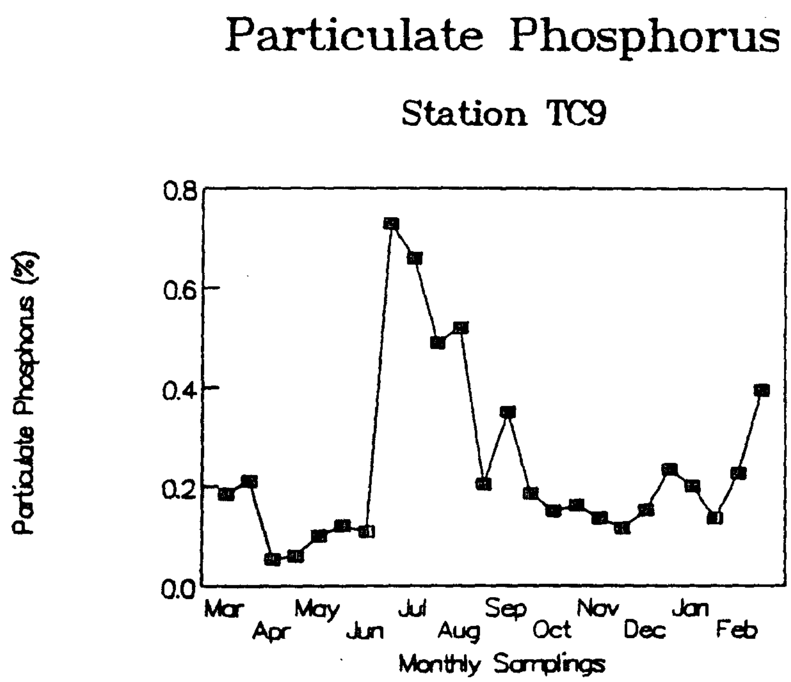
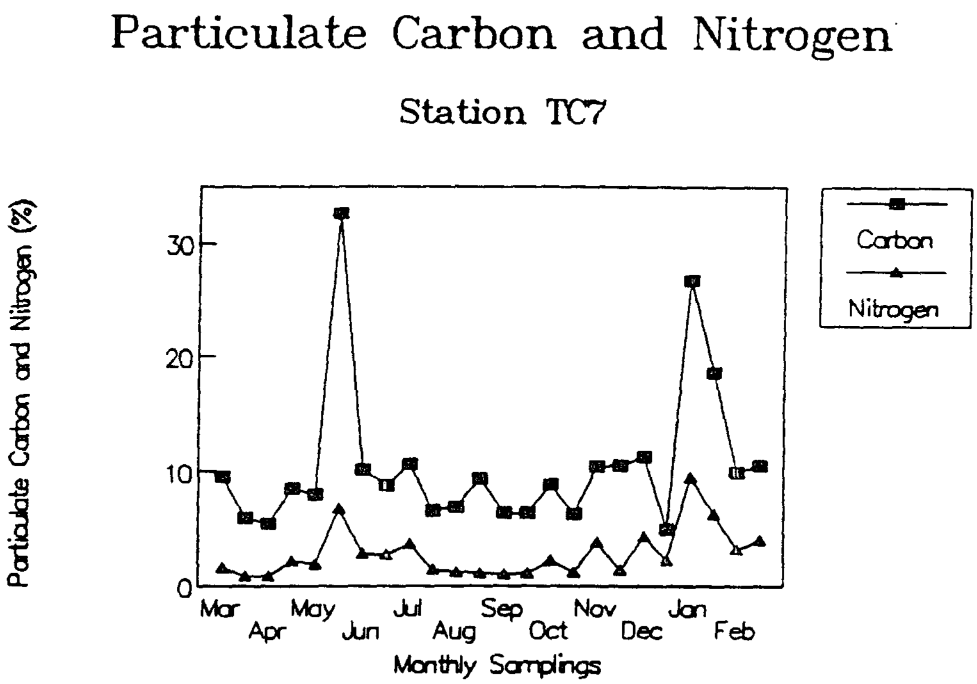


Figure 25. Graphs showing % carbon, nitrogen and phosphorus in suspended solids from site TC9.



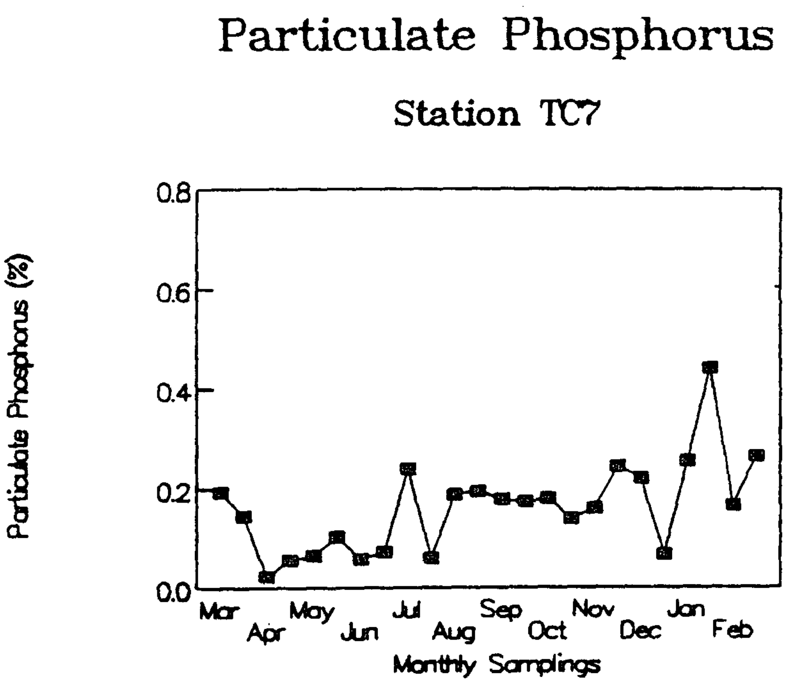
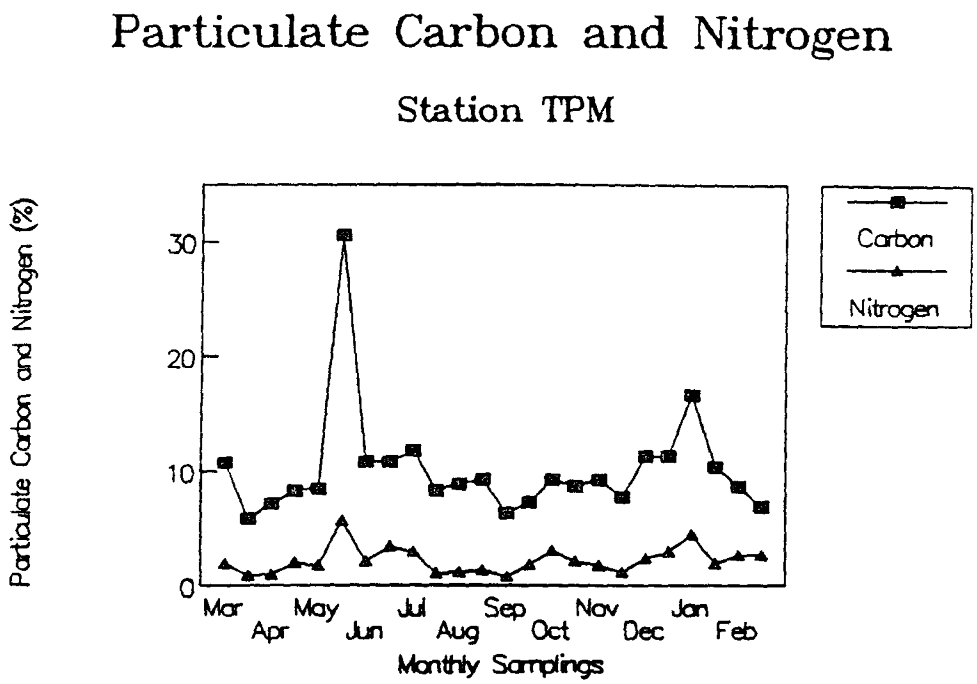


Figure 26. Graphs showing % carbon, nitrogen and phosphorus in suspended solids from site TC7.



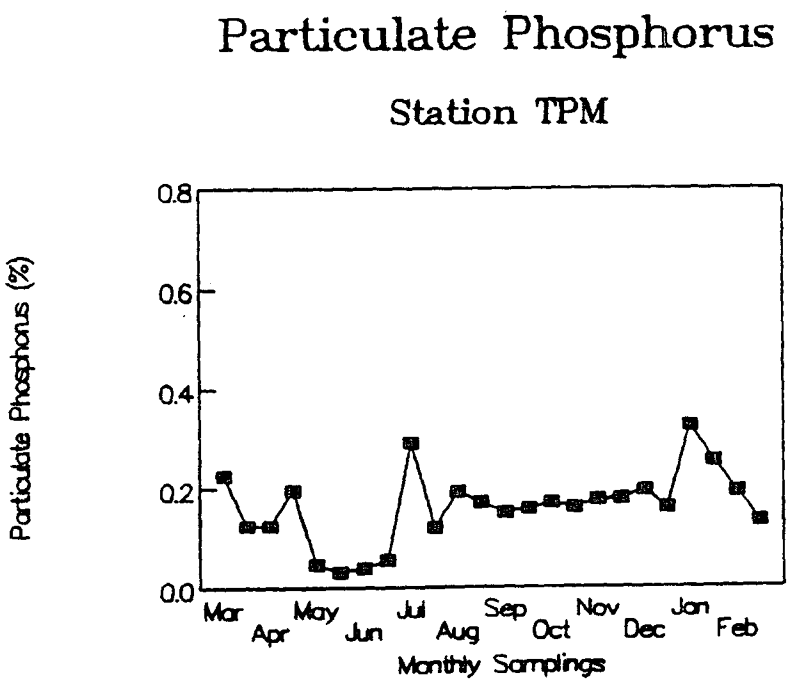
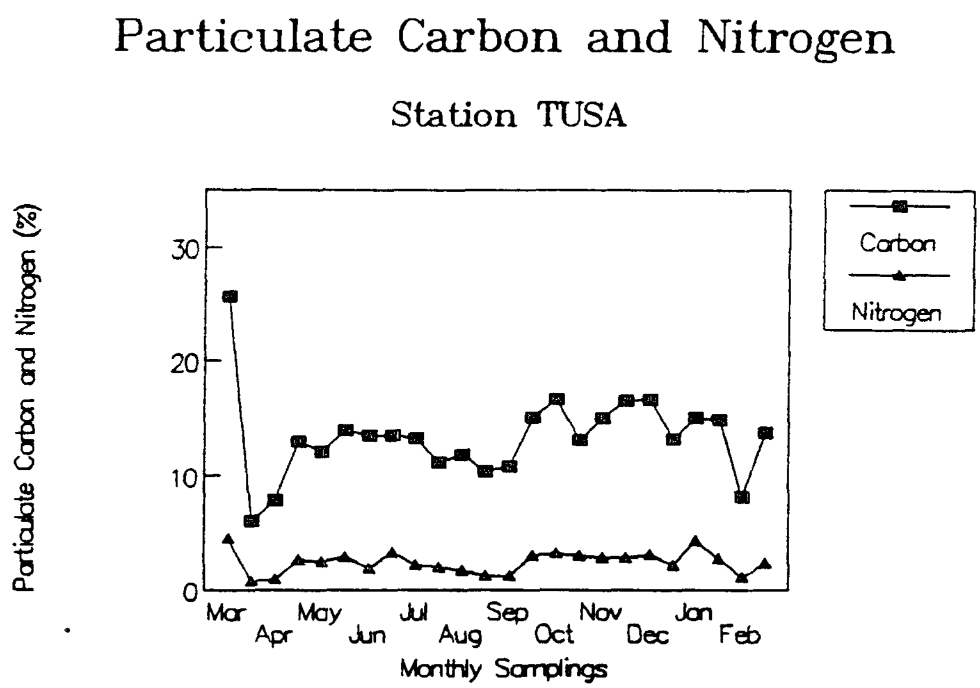


Figure 27. Graphs showing % carbon, nitrogen and phosphorus in suspended solids from site TPM.



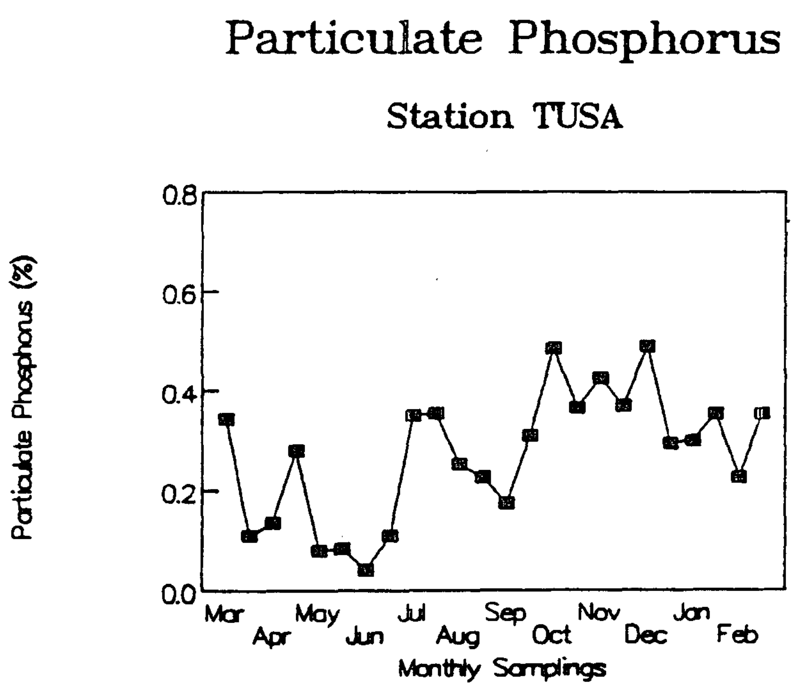
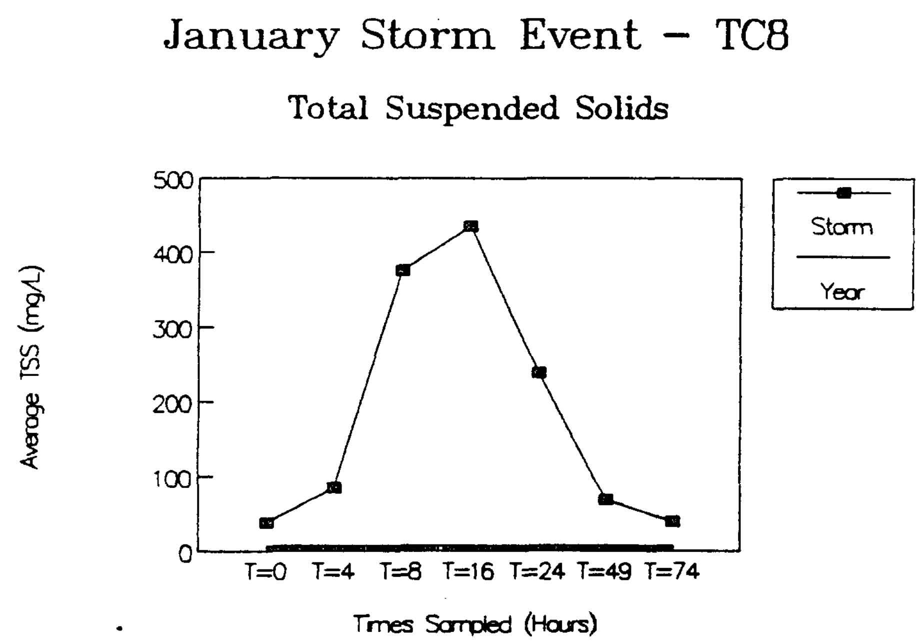


Figure 28. Graphs showing % carbon, nitrogen and phosphorus in suspended solids from site TUSA.

Storm Events

Runoff of suspended sediments can be dramatically increased during rain events. Thus, the storm component of sediment transport is an important part of the annual cycle. During this program we were able to collect data from four storm events to obtain a spectrum of rainfall intensities. The first rain event (July 10-12, 1988) was small at 0.3-2.8 cm. The second rain event was along the southern end of Tropical Storm Keith on November 23-26, 1988. Rainfall in the drainage basin during this event was 2.5-5.3 cm, a bit lower than predicted because we were on the fringes of the storm. The third event was exciting and the type of event that moves soil from the creek to the lagoon. Rainfall for our January 19-21, 1989 event ranged from 15.0-16.8 cm at the various gauging locations. The final runoff event was sampled from March 3-6, 1989 as part of a 7.4-8.4 cm rainfall.

To show the role of storm events on transport of suspended sediments, we will contrast the big-event (15-16.8 cm rainfall) in January 1989 with the smaller (2.5-5.3 cm rainfall) November 1988 storm and non-storm periods. Data for the January 1989 storm event (Figures 29-31) show that we began sampling before the peak in stage height and 8-16 hours before maximum levels of TSS and particulate carbon and nitrogen. The increase in TSS at TC8 is extraordinary as background levels of about 3 mg/L rose to almost 500 mg/L. This site is close to an area of residential development where several square miles of soil lay exposed.



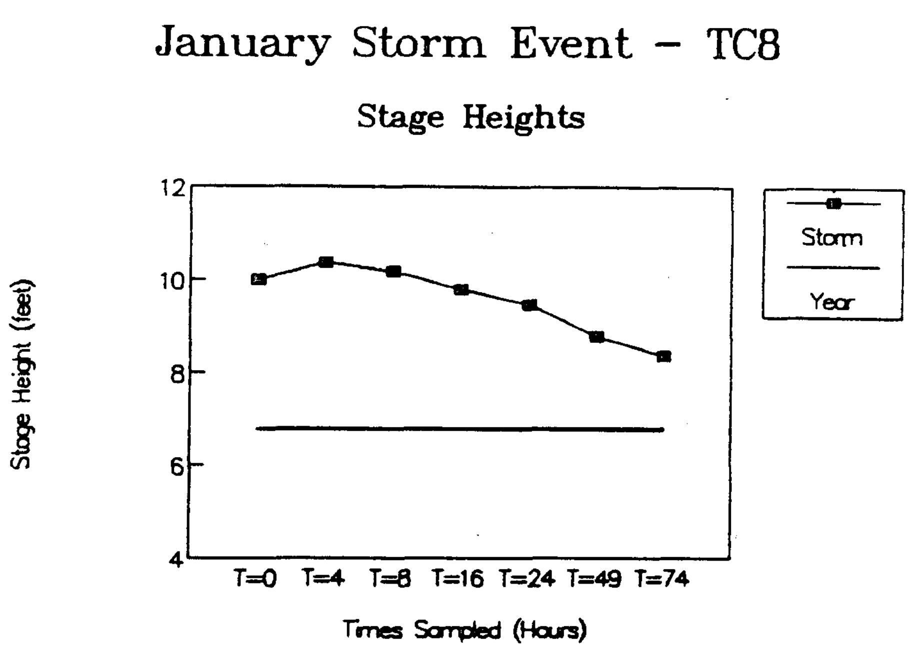


Figure 29. Graphs showing concentrations of total suspended solids and stage height at station TC8 during the January 1989 storm event.

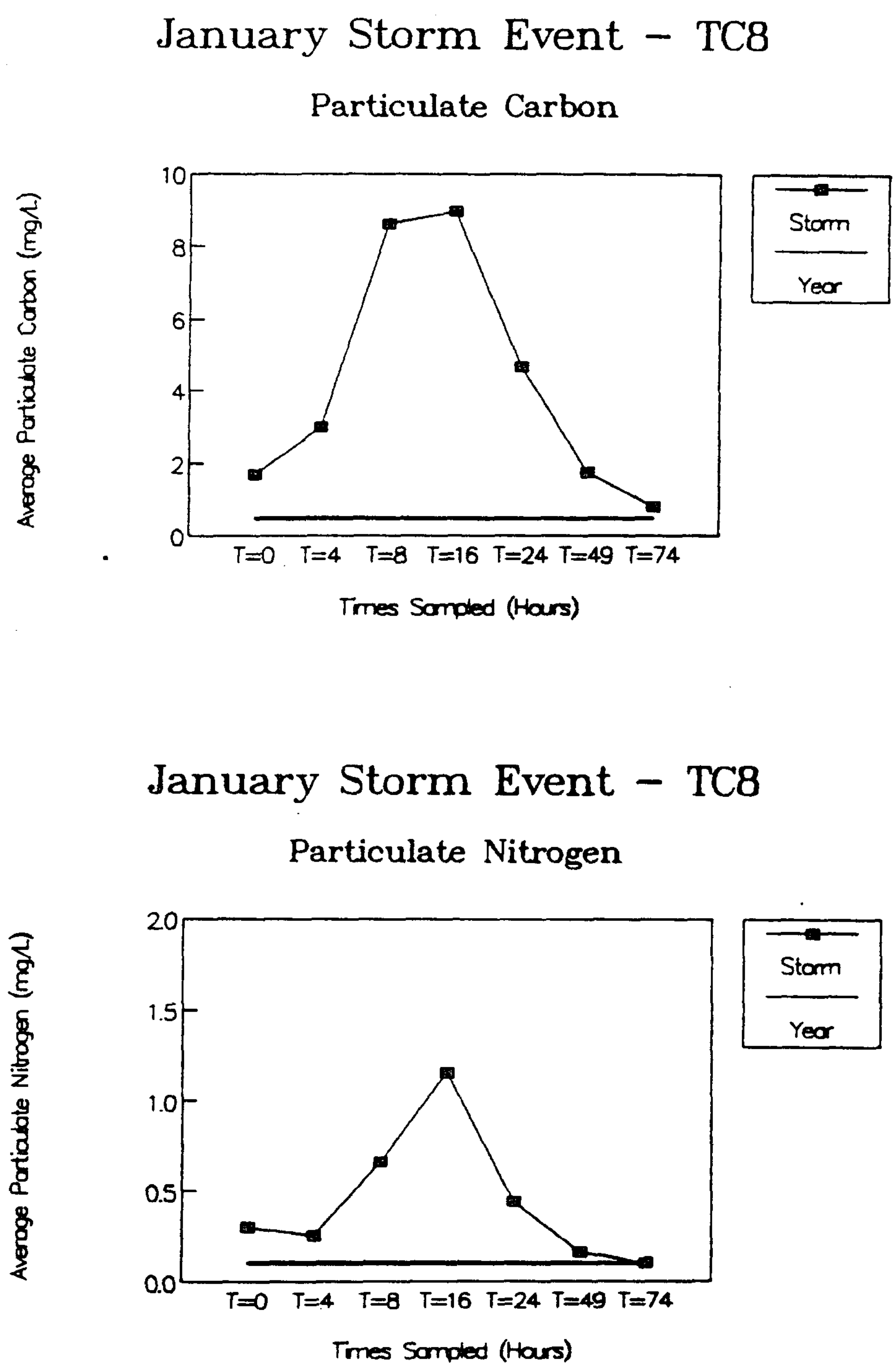


Figure 30. Graphs showing concentrations of particulate C and N at station TC8 during the January 1989 storm event.

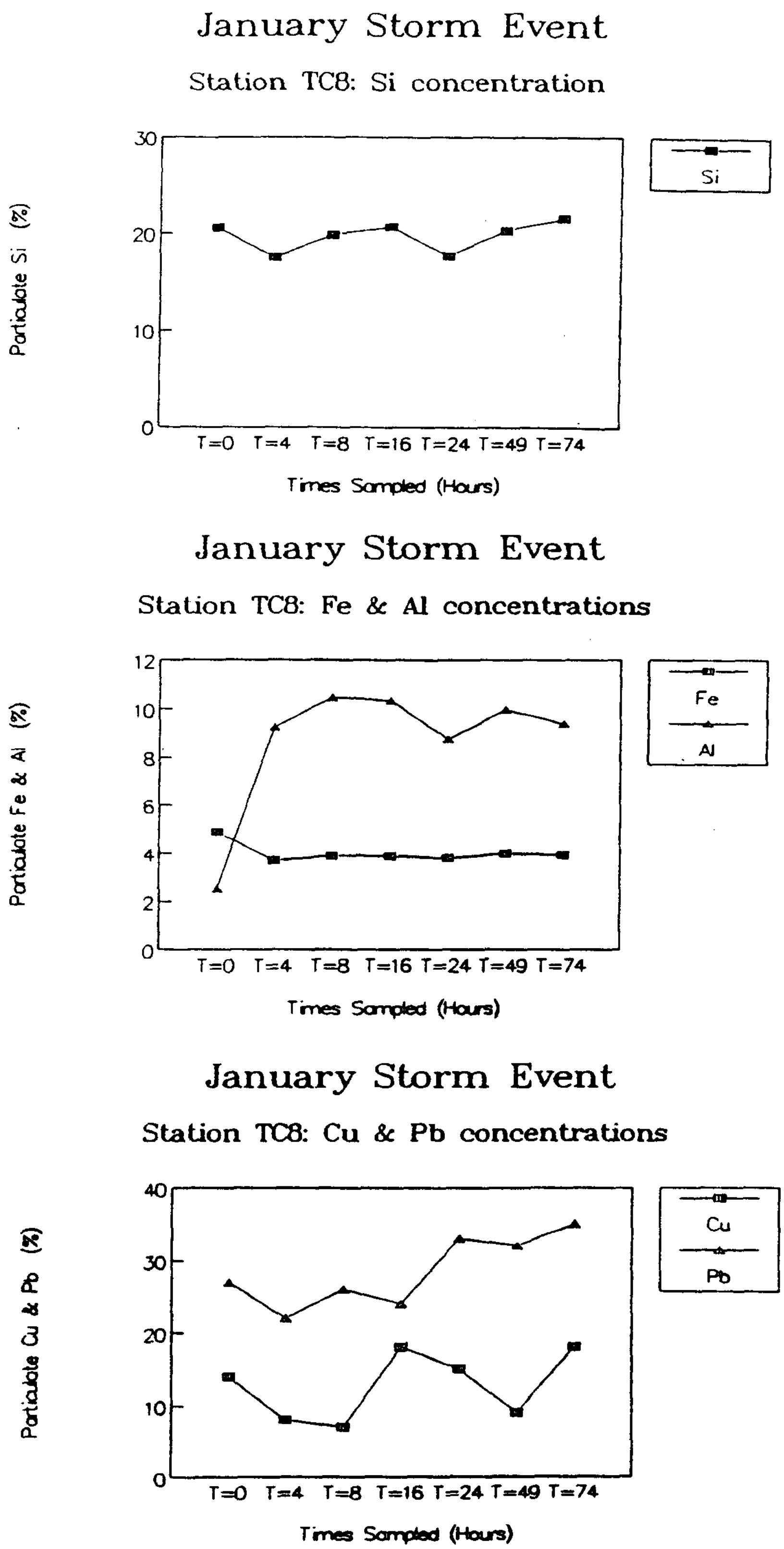


Figure 31. Graphs showing concentrations of Si, Fe, Al, Cu and Pb in suspended solids at site TC8 during the January 1989 storm event.

We estimate that 240 metric tons of suspended sediment were transported past station TC8 over a 72-hour period during the January 1989 storm event (Table 4). This sediment burden is almost 500 times greater than during a non-storm 72-hour period or during a 2-5 cm rainfall event (November 1988, Table 4). Thus, rainfall at a magnitude of 15 cm can move a mass of suspended sediment equivalent to what is transported over 2-4 years of normal flow.

Relative to site TC8, sediment transport during the January 1989 storm at stations TC9 and TCO (Table 4) is small. Most of the sediment carried past the flood control structure at TC7 would seem to have originated in the southwest quadrant of Palm Bay. The somewhat lower sediment transport value for TC7, relative to TC8, most likely results from (1) less accurate flow data from TC7, (2) variations in the cross-sectional distribution of TSS, and (3) sedimentation in the canal between TC8 and TC7. Sediment transport values at station TPM are more compatible with the TC8 values; however, the data set for the USGS flow gauge at TPM is incomplete for the January storm period. Without doubt, development upstream of TC8 has a dramatic influence on sediment transport in Turkey Creek.

Fluxes of particulate carbon and nitrogen increased greatly during the January 1989 storm event (Figure 30). Relative to normal particulate carbon concentrations of <1 mg/L, values rose to >8 mg/L. Some changes in elemental composition also occurred over a 72-hour period. Concentrations of particulate Si at TC8 increased from normal 10-15% levels to a near-uniform 20% during the high runoff (Figure 31). The aluminum content of the suspended sediment jumped from tupical values of 2-5% to 9-10%. Both of these changes reflect a decrease in the organic character of the suspended matter to more

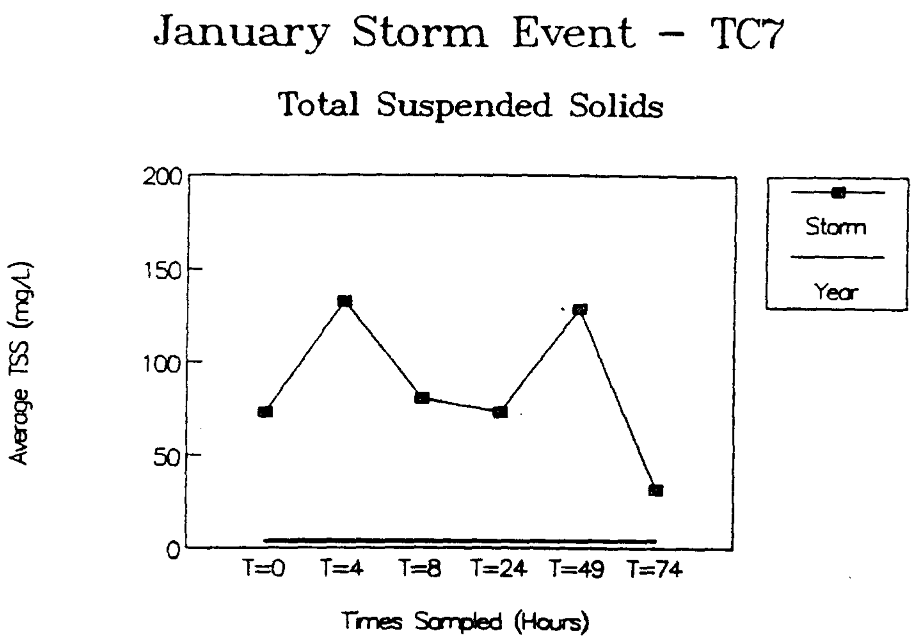
Table 4. Estimates of suspended sediment transport during storm and non-storm periods.

Time Period	Site	Water Flow ($x10^3$ L/sec)	TSM (mg/L)	Sediment Transport (metric tons)
January 1989 (15-16.8 cm rain)	TC8	3.0 to 7.7	37 to 428	240 tons/72 h
	TC9	5.0 to 9.0	4 to 39	30 tons/72 h
	TCO	0.13 to 0.51	8 to 145	3 tons/72 h
	TC7	8.5 to 12.2	11 to 130	180 tons/72 h
	TPM	≈16	14 to 107	>260 tons/72 h
November 1988 (2.5-5.3 cm rain)	TC8	0.6	1.2 to 4.3	0.5 tons/72 h
	TC7	1.6 ± 0.4	7 ± 2	3 tons/72 h
Annual Non-Storm	TC8	≈0.6	≈3	0.5 tons/72 h
	TC7	≈1.2	≈4	1.2 tons/72 h

clay and silt-containing particles. Concentrations of particulate Cu and Pb remained low throughout the storm (Figure 31). These natural levels for Cu and Pb result from erosion and transport of uncontaminated, natural soil material during the extensive runoff.

Increased concentrations of TSS at TC7 during the January 1989 storm event contrast sharply with non-storm levels (Figure 32) as TSS values of 50-130 mg/L greatly exceed levels of ≈4 mg/L during non-storm periods. An interesting bimodal distribution in TSS, and to a lesser degree stage height (Figure 32), suggests that a second pulse of water moved through the control structure later in the event. As observed for station TC8, particulate Si and Al concentrations at TC7 increased by a factor of 2-3 during the storm runoff (Figure 33 versus Figure 13, p. 31), the result of an increase in the silt and clay make-up of the suspended matter. A marked dip in the % Si and Al (Figure 33) matches well with a decrease in TSS values. The Cu content of the suspended matter decreased during the event; however, the Pb content increased during the final 24-hour period (Figure 33). An initially high Cu value may be related to a Cu source near TC7. For Pb, we may be seeing a slight delay in runoff of upstream particles from roadways. Lag times for water and particle transport from roadside areas into and through the Turkey Creek sytem are not well known, but are times 4-16 hours are reasonable.

A direct comparison of TSS values for the four storm events at stations TC8 and TC7 is given in Figures 34-37. The July and November 1988 rainfalls were 0.3-2.8 and 2.5-5.3 cm, respectively. At these small rainfalls, only small or sometimes indistinguishable changes in suspended sediment levels were observed (Figures 34 and 36). Rainfall at <5 cm tends to just soak in with



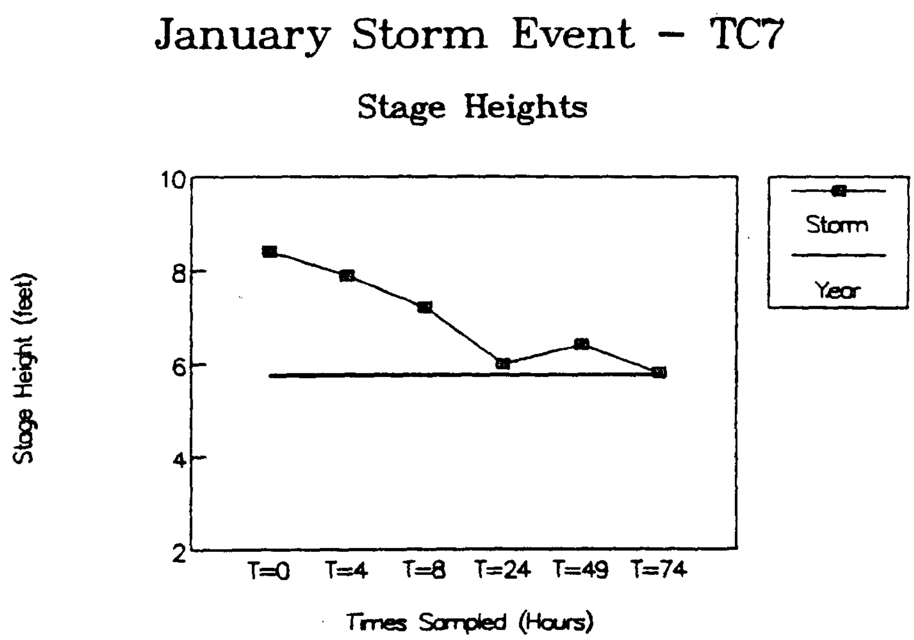


Figure 32. Graphs showing concentrations of total suspended solids and stage heights at station TC7 during the January 1989 storm event.

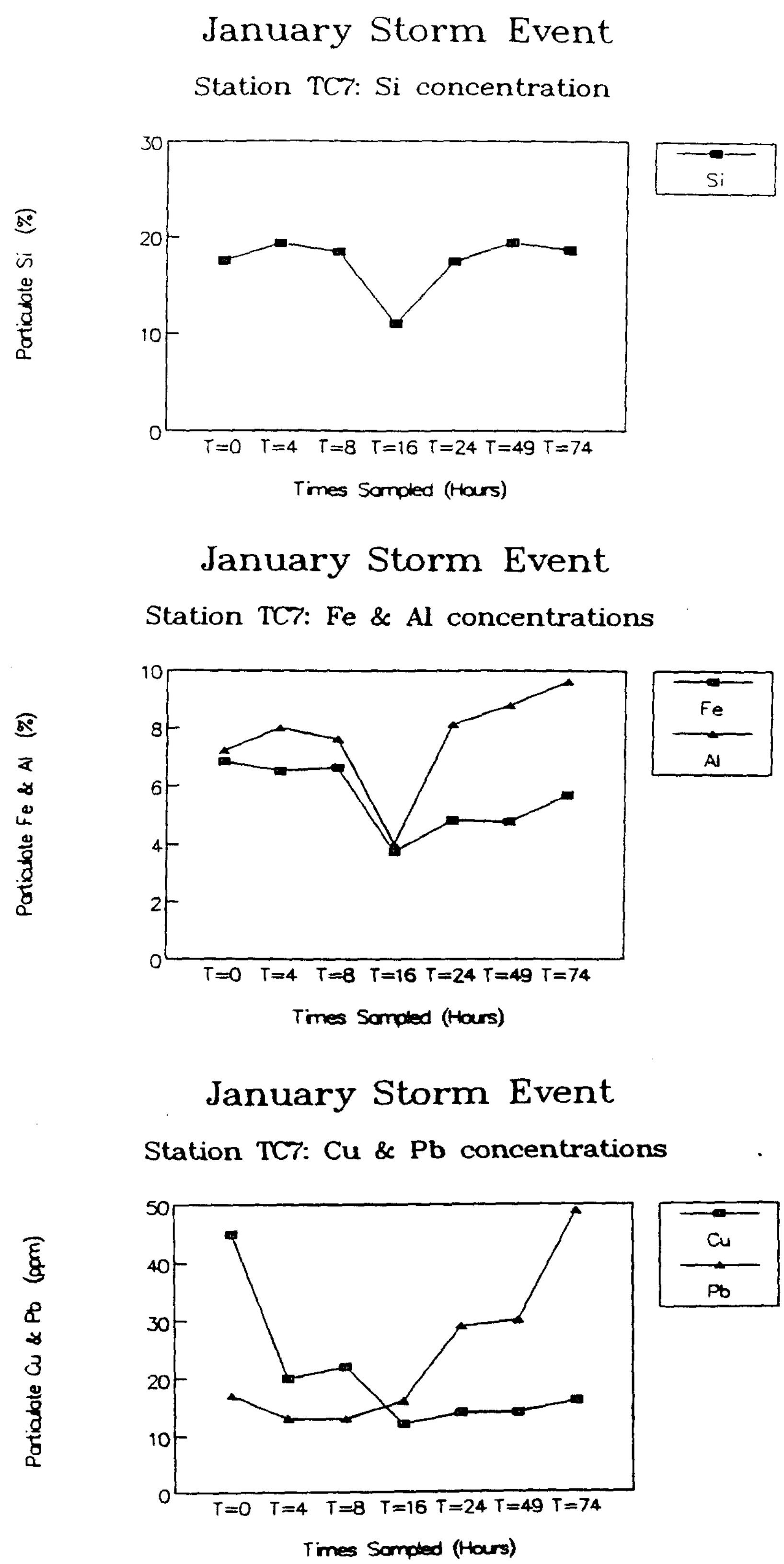
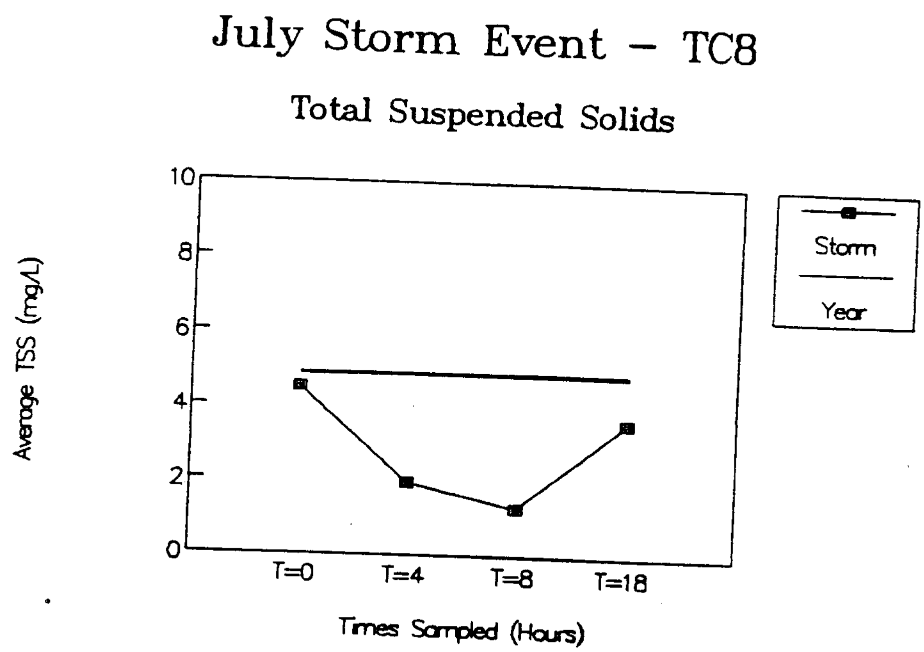


Figure 33. Graphs showing concentrations of Si, Fe, Al, Cu and Pb in suspended solids at site TC7 during the January 1989 storm event.



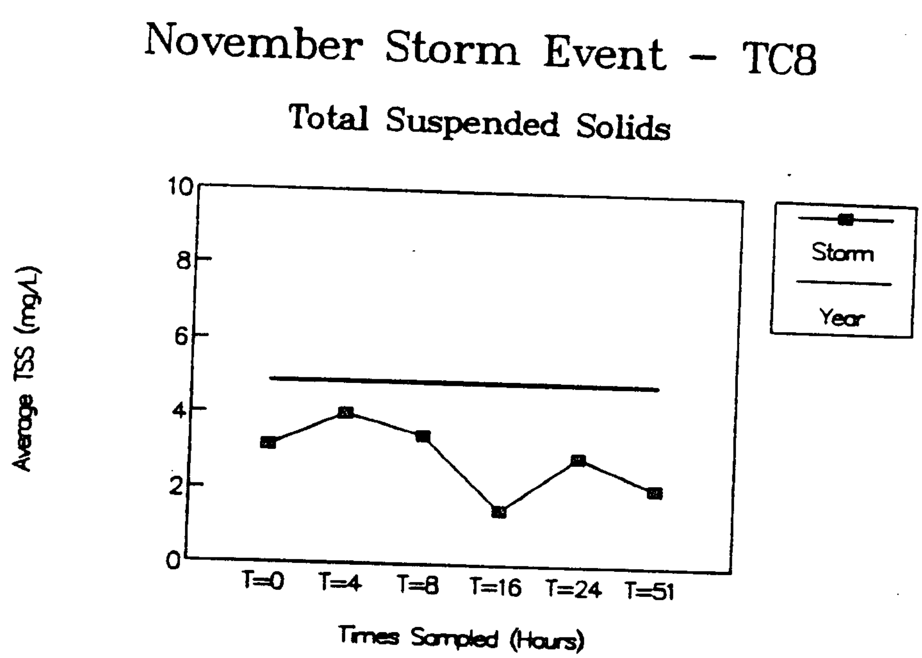
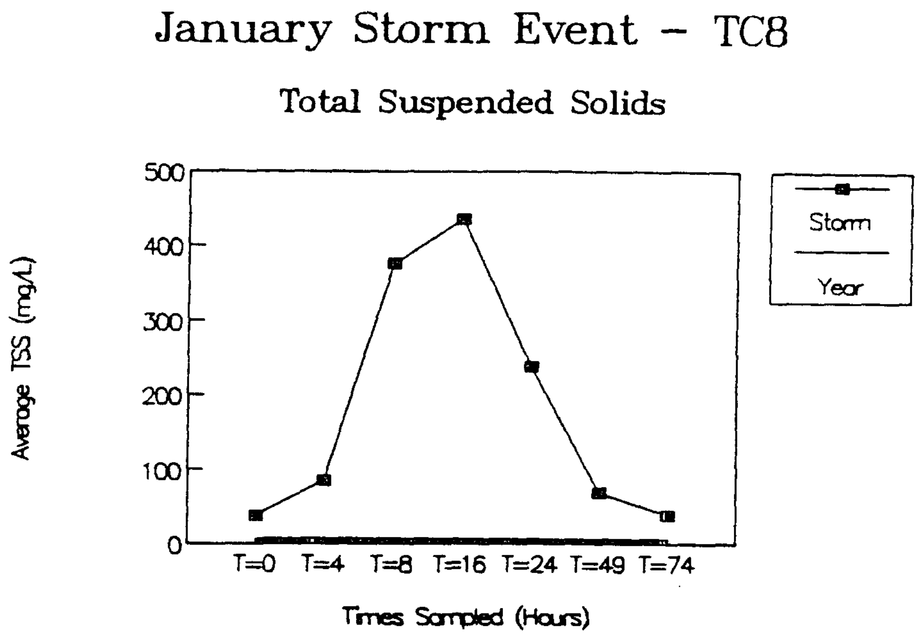


Figure 34. Graphs showing concentrations of total suspended solids for station TC8 for the July and November 1988 storm events.



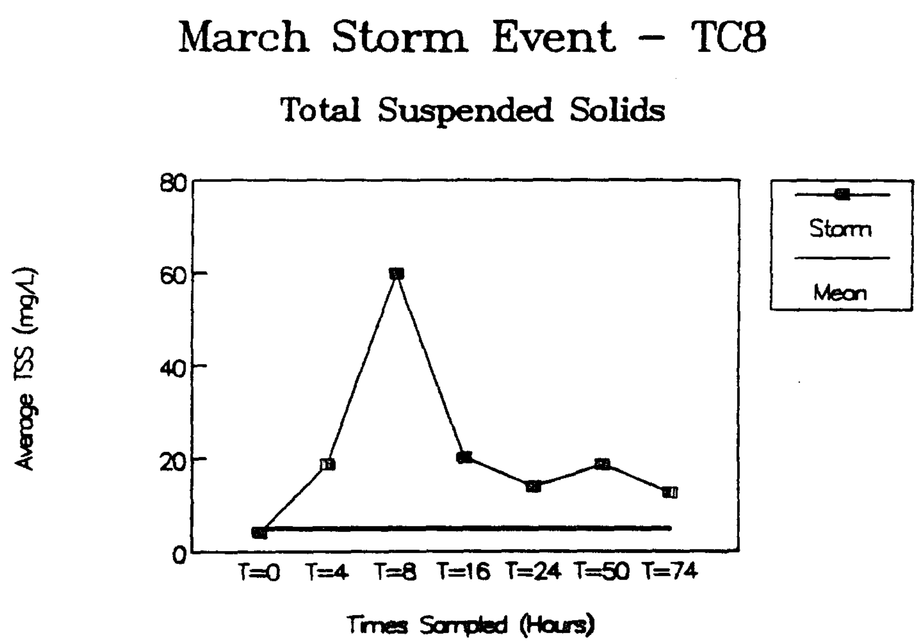
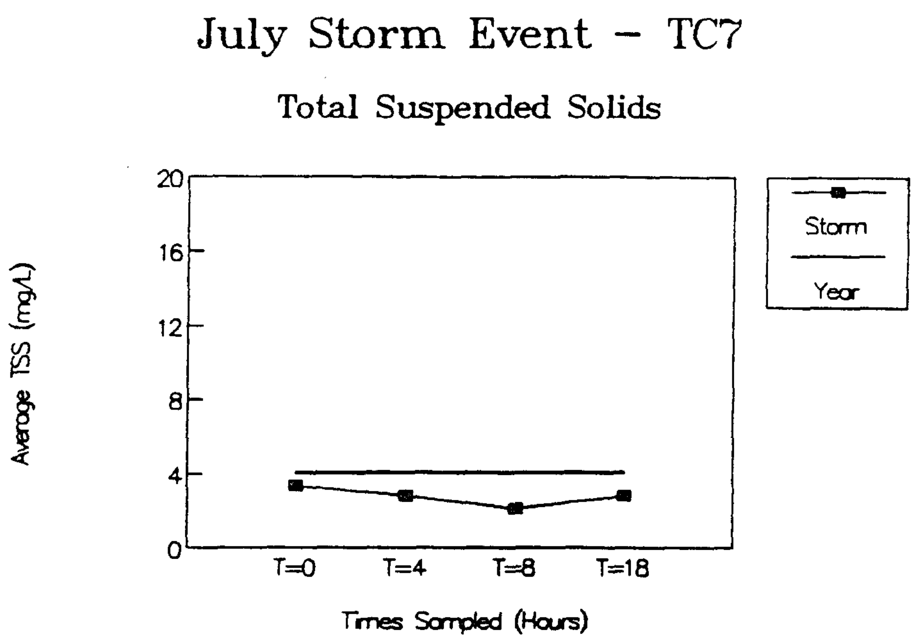


Figure 35. Graphs showing concentrations of total suspended solids for station TC8 for the January and March 1989 storm events.



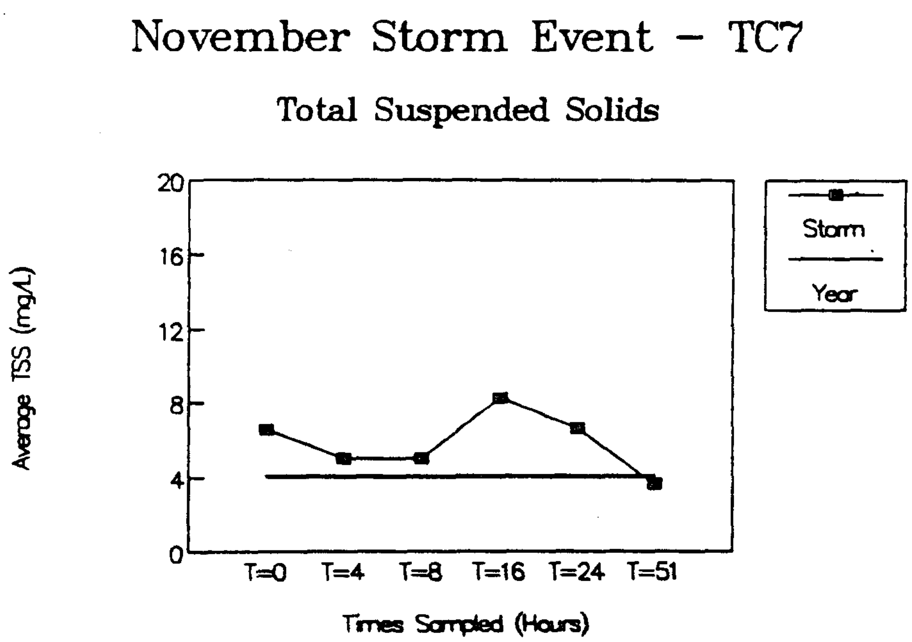
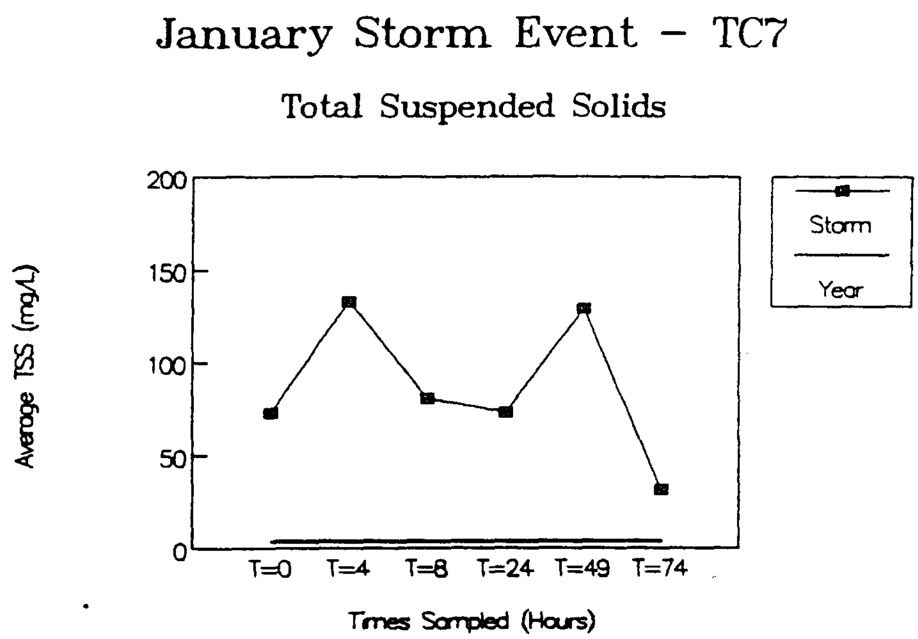


Figure 36. Graphs showing concentrations of total suspended solids for station TC7 for the July and November 1988 storm events.



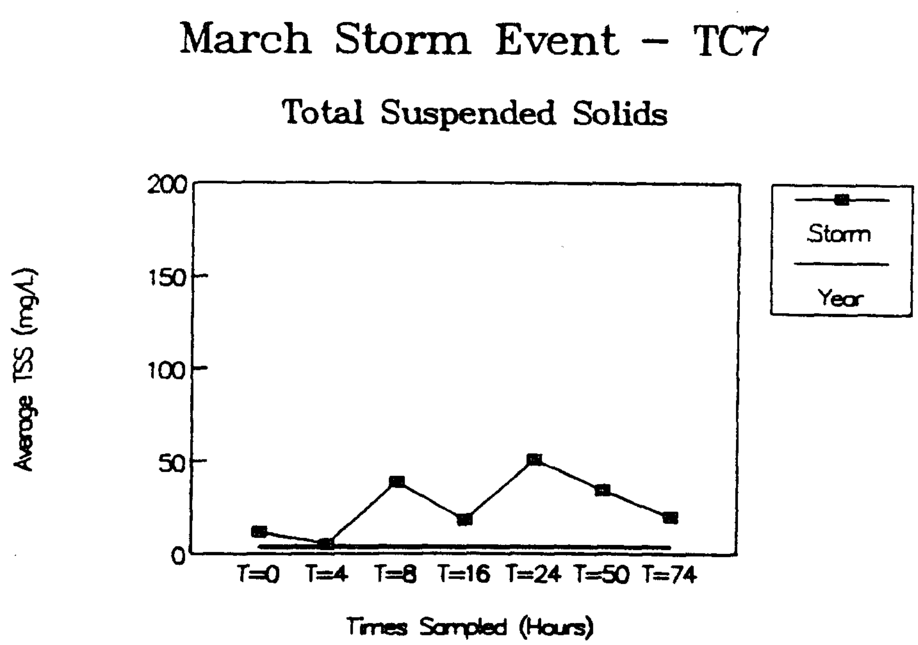


Figure 37. Graphs showing concentrations of total suspended solids for station TC7 for the January and March 1989 storm events.

little runoff, especially when a dry period has preceeded the rain. In contrast, the November 1989 storm with 15-16.8 cm of rain and the March 1989 storm with 7.4-8.4 cm led to sizeable increases in suspended sediment. The >15 cm rainfall yields a tremendous sediment runoff, one which is not just proportionally higher, relative to rainfall, than observed for the 7-8 cm rain event. Thus, the major storm (Table 4) clearly plays a lion's role in transporting sediment through Turkey Creek.

SUMMARY AND CONCLUSIONS

To determine the sources, transport and fate of suspended sediments in Turkey Creek, Florida, we established a physical and chemical monitoring network at 11 sites in Turkey Creek from March 1, 1988 through February 28, 1989. We focused on both non-storm and storm flow conditions. Non-storm samples were collected bi-weekly. Four storm events of varying magnitudes were also sampled during the study. Samples of suspended matter were collected to determine levels of total suspended solids (TSS), as well as concentrations of particulate carbon, nitrogen, phosphorus, silicon, aluminum, iron, potassium, sodium, calcium, magnesium, copper, manganese and lead.

Concentrations of TSS typically ranged from 2-7 mg/L during non-storm periods. These values may be higher than natural, historic levels for this area, but do not constitute a muddy creek. A direct relationship was found between gravimetric TSS measurements and more rapidly obtainable turbidity values. Using this relationship, an equation was developed to calculate TSS from turbidity. This equation nicely facilitates quantitative determinations of sediment transport from turbidity data.

In general, particulate carbon (C), nitrogen (N) and phosphorus (P) values follow trends for suspended solids; however, the pattern is complex. Particles may carry 10 to >50% of the total C, N or P load on occasions and thus the role of particles in nutrient transport to the Indian River Lagoon can be important, especially in storm events.

Concentrations of major elements in suspended matter from Turkey Creek varied directly with one another, increasing or decreasing as a function of the amount of organic matter present. The iron (Fe) content of particles in Turkey Creek can be as high as 10-20%, relative to 4-5% Fe in average continental crust. This anomaly is believed to be related to ancient deposits and diagenetic processes in the watershed. Particulate silicon (Si) and aluminum (Al) values are quite uniform throughout the creek. In fact, the Si/Al ratio of 3.1 ± 0.3 is in close agreement with the ratio of 3.4 for average continental crust. Element to Al ratios are used to identify and track sediment sources and movement throughout the creek because Al is less subject to chemical weathering than other elements and because Al is a predictable and stable component of silts and clays. Overall, the major element data show the importance of soil inputs from the southwestern portion of the watershed where extensive areas are undergoing residential development.

Concentrations of particulate copper (Cu) in Turkey Creek ranged from 2-1160 $\mu g/g$, relative to values for average continental crust of about 50 $\mu g/g$. Upland areas of the creek had natural Cu levels. The onset of Cu contamination was observed near the water control structure on the C-1 canal. A major peak in Cu levels was observed in the area of Troutman Boulevard. Sources of Cu may include, but not be restricted to herbicides and sediments contaminated from former industrial and municipal waste discharges.

Particulate lead (Pb) concentrations were above natural levels throughout the creek. Highest levels were observed in sites near well-traveled roads and in the Troutman Boulevard area. The primary source of Pb to most areas is probably automobile emissions; however, industrial and municipal discharges may have had an influence at some sites. The downstream distribution of trace metals is used to show the relative importance of particle inputs from various locations to the final composition of suspended matter being delivered to the Indian River Lagoon. For example, even though the Cu content of particles in the Troutman Boulevard area is very high, particle transport from this area is low enough that no effect is observed on Cu levels downstream.

Runoff of suspended sediments increased dramatically during major (>5 cm) rain events. For example, TSS values at one site in the southwestern area of the creek rose from about 3 mg/L during normal flow to almost 500 mg/L during a 15 cm rainfall event in January 1989. During a 72 hour period in January 1989, 240 metric tons of sediment were carried through the creek. This magnitude of sediment transport during a major storm event is equivalent to the amount of suspended sediment carried through Turkey Creek during 2-4 years of normal, non-storm flow. Rainfall of <5 cm had essentially no effect on sediment transport.

During this study we have carefully obtained a sizeable amount of data for Turkey Creek. Then, using that data base, we have answered several questions relating to the sources, transport and fate of suspended particles in Turkey Creek. The data and concepts evolved can also be used for future questions and management decisions. Clearly, some of the muck problems in the Indian River Lagoon can be traced to poor soil conservation practices and nutrient runoff from upland areas in the Turkey Creek watershed.

REFERENCES

Glascock, C.J. (1987). Trace metal geochemistry of sediments from Turkey Creek, Florida. M.S. Thesis, Florida Institute of Technology, Melbourne, Florida, 50 pp.

Trefry, J.H., Stauble, D.K, Sisler, M.A., Tiernan, D., Trocine, R.P., Metz, S., Glascock, C.J. and Bader, S.F. (1987). Origin, composition and fate of organic-rich sediments in coastal estuaries, Project MUCK. Final Report to the Florida Sea Grant College and the State of Florida Department of Environmental Regulation (Project R/IRL-2), 103 pp.

APPENDIX

1. Data for Total Suspended Solids, Major Elements and Trace Metals.

2. Data for Particulate and Dissolved Nutrients available upon request from the authors or the St. Johns Water Management District, Palatka, Florida.

PARTICULATE METAL DATA: TURKEY CREEK PROJECT
Department of Oceanography & Ocean Engineering
Florida Institute of Technology
Dr. John H. Trefry, Principal Investigator

Station ID	Rep.	Date	Sample Number	TSM mg/L	Fe (%)	Al (%)	Si (%)	Ca (%)	Mg (%)	Na (%)	K (%)	Mn ppm	Cu ppm	Pb ppm
TUS 0.5m	R1	03/16/88	1	21.40	5.40	9.07	17.51	1.45	0.56	0.04	0.26	100	37	39
TUS 0.5m	R2	03/16/58	2	21.40	5.38	9.27	17.29	1.49	0.55	0.06	0.25	98	30	36
TC2	R1	03/16/88	3	20.20	5.66	9.42	17.94	1.42	0.54	0.04	0.24	98	25	38
TC2	R2	03/16/88	4	21.50	5.41	9.33	17.70	1.52	0.56	0.06	0.25	96	27	33
TC3	R1	03/16/88	5	21.30	5.80	9.22	18.57	1.58	0.56	0.08	0.29	106	29	42
TC3	R2	03/16/88	6	21.40	5.85	9.30	18.54	1.58	0.56	0.08	0.26	106	24	40
TTN	R1	03/16/88	7	5.90	2.30	3.81	10.31	1.55	0.39	0.41	0.17	76	266	109
TTN	R2	03/15/88	8	5.90	2.29	3.85	9.66	1.65	0.30	0.18	0.20	82	287	97
TTN	R1	03/16/88	9	22.00	6.01	9.29	17.95	1.60	0.56	0.04	0.25	106	30	34
TPM	R2	03/16/88	10	22.60	5.97	8.96	17.81	1.66	0.55	0.05	0.26	109	39	35
TC5	R1	03/16/88	11	3.70	2.11	3.15	3.13	0.52	0.30	0.05	0.05	11	12	31
TC6	R1	03/16/88	12	8.20	2.34	4.40	5.92	0.96	0.42	0.05	0.16	151	29	23
TC7	R1	03/16/88	13	20.80	6.05	8.94	18.23	1.65	0.54	0.05	0.26	94	25	35
TC7	R2	03/16/88	14	21.90	5.26	7.70	17.37	0.97	0.29	0.06	0.24	91	24	31
TC8	R1	03/16/88	15	34.20	4.77	11.21	20.67	1.17	0.59	0.05	0.28	85	12	42
TC8	R2	03/15/88	16	33.80	4.85	11.09	20.19	1.18	0.59	0.05	0.29	92	10	49
TC9	R1	03/16/88	17	6.70	4.69	4.32	12.52	1.03	0.31	0.02	0.20	79	25	31
TC9	R2	03/16/88	18	6.50	5.63	5.48	13.95	1.14	0.41	0.02	0.20	87	27	49
TC0	R1	03/16/88	19	22.20	8.13	7.55	15.24	1.29	0.38	0.03	0.18	45	10	52
TC0	R2	03/16/88	20	20.00	8.24	7.79	14.95	1.30	0.37	0.06	0.18	46	12	61
TUS 0.5m	R1	04/20/88	21	5.60	8.19	3.75	12.39	1.22	0.83	-1.00	0.29	461	62	40
TUS 0.5m	R2	04/20/88	22	5.33	8.26	4.35	12.76	1.18	0.78	0.23	0.30	458	71	34
TUS 0.5m	R3	04/20/88	23	5.93	8.14	4.48	12.42	1.15	0.74	0.23	0.29	436	54	40
TUS 1m	R1	04/20/88	24	11.20	4.78	5.68	18.95	1.30	1.70	0.61	0.52	700	63	34
TC2	R1	04/20/88	25	3.93	10.67	2.49	12.67	1.39	0.42	0.12	0.20	359	35	24
TC3	R1	04/20/88	26	3.53	13.17	3.41	12.26	1.75	0.24	-2.00	0.22	391	49	36
TTN	R1	04/20/88	27	2.35	2.55	2.05	9.39	1.42	0.31	0.07	0.32	268	623	79
TTN	R2	04/20/88	28	2.25	2.73	2.36	10.58	1.50	0.32	0.11	0.35	251	743	76
TTN	R3	04/20/88	29	2.25	2.42	2.10	9.63	1.31	0.30	0.07	0.33	275	614	81
TPM	R1	04/20/88	30	3.40	14.02	4.11	10.87	1.79	0.27	-2.00	0.20	358	54	30
TC5	R1	04/20/88	31	1.93	6.20	3.53	8.18	0.64	0.15	0.10	0.18	14	35	81
TC6	R1	04/20/88	32	2.06	7.09	2.57	10.35	1.08	0.30	0.03	0.15	594	43	37
TC7	R1	04/20/88	33	3.40	14.43	2.95	9.26	1.46	0.20	-2.00	0.18	283	74	27
TC8	R1	04/20/88	34	4.46	10.80	2.70	11.94	1.84	0.22	0.01	0.25	293	19	20
TC9	R1	04/20/88	35	7.87	11.15	2.49	10.80	1.22	0.30	-2.00	0.19	82	24	17
TC0	R1	04/20/88	36	9.66	15.25	4.48	10.99	1.44	0.23	-2.00	0.13	76	20	42
TUS 0.5m	R1	05/18/88	37	8.13	4.95	4.54	13.23	0.87	1.08	0.16	0.30	652	64	36
TUS 1m	R1	05/18/88	38	16.00	4.11	4.67	16.72	1.11	1.61	0.22	0.45	834	57	34
TC2	R1	05/18/88	39	3.07	8.93	3.22	12.01	1.32	0.47	0.13	0.20	705	23	35
TC3	R1	05/18/88	40	2.20	10.71	3.05	11.10	1.42	0.34	0.12	0.11	706	24	38
TTN	R1	05/18/88	41	2.30	2.09	3.52	10.71	1.58	0.52	0.18	0.23	226	1163	84
TTN	R2	05/18/88	42	2.60	1.75	3.76	10.48	1.62	0.53	0.17	0.21	225	1079	70
TTN	R3	05/18/88	43	2.00	1.39	3.49	9.76	1.60	0.48	0.17	0.20	226	1098	72
TPM	R1	05/18/88	44	2.00	12.68	3.44	7.47	1.46	0.33	0.15	0.18	905	57	24
TC5	R1	05/18/88	45	4.93	4.32	3.35	4.93	0.53	0.24	0.04	0.07	17	19	67
TC6	R1	05/18/88	46	1.33	2.21	1.89	5.73	0.45	0.31	0.13	0.14	1112	14	41
TC7	R1	05/18/88	47	2.27	1.17	2.50	5.41	1.20	0.23	0.07	0.14	610	8	4

PARTICULATE METAL DATA: TURKEY CREEK PROJECT

Department of Oceanography & Ocean Engineering
Florida Institute of Technology
Dr. John H. Trefry, Principal Investigator

Station ID	Rep.	Date	Sample Number	TSM mg/L	Fe (%)	Al (%)	Si (%)	Ca (%)	Mg (%)	Na (%)	K (%)	Mn ppm	Cu ppm	Pb ppm
TC8	R1	05/18/88	48	4.90	10.04	3.36	8.69	2.77	0.33	0.06	0.17	234	11	13
TC9	R1	05/18/88	49	4.93	15.80	2.71	5.60	1.31	0.32	0.06	0.14	311	8	6
TC0	R1	05/18/88	50	13.40	9.00	5.33	10.90	1.97	0.32	0.09	0.21	231	18	53
TC0	R2	05/18/88	51	8.20	11.06	5.11	9.20	1.80	0.30	0.08	0.19	203	0	71
TC0	R3	05/18/88	52	12.40	9.30	5.21	10.96	1.92	0.29	0.09	0.20	231	15	65
TUS 0.5m	R1	06/15/88	53	7.80	5.72	4.77	16.25	1.66	0.82	0.04	0.53	862	62	33
TUS 1m	R1	06/15/88	54	18.40	4.15	5.03	17.92	1.57	1.39	0.12	0.50	768	55	33
TC2	R1	06/15/88	55	2.93	9.90	3.03	11.02	2.10	0.37	0.06	0.15	719	16	30
TC2	R2	06/15/88	56	3.00	9.83	3.07	9.80	2.11	0.37	0.07	0.15	752	12	33
TC2	R3	06/15/88	57	3.13	9.20	2.88	9.42	1.88	0.35	0.05	0.17	709	15	26
TC3	R1	06/15/88	58	2.07	12.55	2.87	9.85	2.08	0.31	0.03	0.21	732	26	45
TTN	R1	06/15/88	59	1.85	-2.00	1.88	6.66	1.30	0.30	0.02	0.18	460	653	99
TPM	R1	06/15/88	60	2.47	10.87	3.29	10.38	2.04	0.32	0.03	-2.00	614	15	27
TC5	R1	06/15/88	61	2.47	2.16	2.98	6.76	0.86	0.33	0.03	-2.00	35	8	64
TC6	R1	06/15/88	62	3.47	1.46	1.92	10.71	1.36	0.32	0.09	0.17	1022	11	24
TC7	R1	06/15/88	63	2.93	10.99	3.30	11.10	1.79	0.30	0.10	0.20	295	7	18
TC8	R1	06/15/88	64	3.20	8.05	2.85	12.11	3.40	0.34	0.02	-2.00	163	3	9
TC8	R2	06/15/88	65	3.20	7.70	2.83	12.09	3.36	0.32	0.02	-2.00	161	4	8
TC8	R3	06/15/88	66	2.93	7.95	3.06	12.42	4.02	0.38	0.02	-2.00	174	4	8
TC9	R1	06/15/88	67	14.80	8.06	3.10	12.12	1.35	0.36	0.03	0.44	1100	7	6
TC0	R1	06/15/88	68	11.20	12.27	4.39	15.79	1.99	0.30	0.04	0.22	208	3	44
TC0 t=0	R1	07/10/88	69	20.00	6.66	5.58	18.29	2.75	0.36	0.05	0.18	103	13	117
TC9 t=0	R1	07/10/88	70	7.40	13.77	3.72	14.67	1.86	0.43	0.04	0.23	444	2	13
TC8 t=0	R1	07/10/88	71	4.20	8.47	4.77	13.47	2.82	0.39	0.06	0.11	288	-2	5
TC7 t=0	R1	07/10/88	72	3.70	10.52	3.16	10.06	1.90	0.25	0.01	-2.00	599	2	1
TPM t=0	R1	07/10/88	73	4.00	11.45	3.87	11.06	2.30	0.37	0.01	0.12	488	8	3
TC0 t=4	R1	07/11/88	74	14.90	6.52	8.45	17.68	1.49	0.48	0.05	0.23	127	3	49
TC9 t=4	R1	07/11/88	75	4.60	17.20	2.61	8.27	1.80	0.35	0.05	0.17	847	6	8
TC8 t=4	R1	07/11/88	76	1.80	9.78	3.20	10.66	2.05	0.30	0.02	-2.00	220	-2	-2
TC7 t=4	R1	07/11/88	77	2.90	12.16	2.68	9.69	1.62	0.25	0.15	0.27	619	2	4
TPM t=4	R1	07/11/88	78	3.40	10.32	2.85	10.63	1.86	0.28	0.24	0.27	1247	3	5
TC0 t=8	R1	07/11/88	79	26.70	4.19	6.11	12.86	10.13	0.38	0.10	0.22	92	12	36
TC9 t=8	R1	07/11/88	80	4.70	16.92	2.70	8.00	1.80	0.34	0.23	0.26	522	58	12
TC8 t=8	R1	07/11/88	81	1.13	9.14	1.89	8.11	2.13	0.28	0.10	0.64	215	-2	-2
TC7 t=8	R1	07/11/88	82	2.10	14.33	3.34	16.10	2.64	0.47	1.63	0.48	814	16	21
TPM t=8	R1	07/11/88	83	3.00	11.47	3.47	11.33	2.37	0.34	0.20	0.37	1665	2	23
TC0 t=18	R1	07/11/88	84	25.90	6.41	8.85	16.24	1.95	0.46	0.07	0.23	124	10	49
TC9 t=18	R1	07/11/88	85	7.90	11.76	3.37	14.61	1.74	0.38	0.33	0.39	460	40	9
TC8 t=18	R1	07/11/88	86	3.40	9.58	3.48	18.49	3.90	0.35	0.15	0.28	407	-2	8
TC7 t=18	R1	07/11/88	87	2.73	12.99	3.19	9.25	1.94	0.29	0.12	0.41	619	28	11
TPM t=18	R1	07/11/88	88	3.73	11.44	3.40	11.38	2.44	0.39	0.31	0.30	2645	54	13
TUS 0.5m	R1	07/20/88	89	5.13	8.67	3.27	15.53	1.88	0.57	0.07	0.28	1155	57	25
TUS 1m	R1	07/20/88	90	23.00	4.39	4.88	20.61	1.47	1.59	0.15	0.53	1539	45	25
TC2	R1	07/20/88	91	3.80	11.52	3.65	11.47	2.25	0.33	0.04	0.22	945	25	18
TC3	R1	07/20/88	92	3.33	11.32	3.21	12.58	2.18	0.28	0.06	0.31	860	30	23
TC3	R2	07/20/88	93	3.73	10.90	3.29	11.07	2.09	0.29	0.07	0.33	863	27	25
TC3	R3	07/20/88	94	3.47	11.54	3.46	11.07	2.13	0.31	0.07	0.32	849	28	21

PARTICULATE METAL DATA: TURKEY CREEK PROJECT
Department of Oceanography & Ocean Engineering
Florida Institute of Technology
Dr. John H. Trefry, Principal Investigator

Station ID	Rep.	Date	Sample Number	TSM mg/L	Fe (%)	Al (%)	Si (%)	Ca (%)	Mg (%)	Na (%)	K (%)	Mn ppm	Cu ppm	Pb ppm
TTN	R1	07/20/88	95	2.65	2.62	2.47	8.81	1.73	0.39	0.12	0.33	1628	591	121
TPM	R1	07/20/88	96	3.60	11.16	3.34	11.21	2.19	0.29	0.08	0.34	798	27	24
TC5	R1	07/20/88	97	2.93	2.33	2.03	4.91	0.99	0.30	1.17	0.25	34	22	35
TC5	R2	07/20/88	98	3.07	2.36	1.84	5.36	0.99	0.31	1.17	0.22	36	22	36
TC5	R3	07/20/88	99	3.87	2.05	1.76	5.54	0.94	0.29	1.12	0.21	43	26	30
TC6	R1	07/20/88	100	1.20	2.67	1.60	10.10	1.27	0.16	0.20	0.20	1044	29	11
TC7	R1	07/20/88	101	2.87	12.59	2.44	9.46	1.77	0.19	0.14	0.22	785	24	27
TC8	R1	07/20/88	102	4.47	4.32	2.50	8.43	2.85	0.28	0.12	0.22	523	7	6
TC9	R1	07/20/88	103	6.20	13.30	2.96	12.47	1.58	0.60	0.08	0.26	871	10	12
TC0	R1	07/20/88	104	17.50	11.80	0.94	15.72	1.58	0.33	0.07	0.17	98	9	38
TUS 0.5m	R1	08/17/88	105	11.00	6.64	5.08	13.56	2.31	0.55	0.07	0.24	254	44	46
TC2	R1	08/17/88	106	7.80	7.06	4.43	12.71	2.16	0.40	0.08	0.20	186	24	23
TC2	R2	08/17/88	107	8.70	6.91	4.73	12.59	2.37	0.40	0.09	0.20	194	21	29
TC2	R3	08/17/88	108	7.10	7.07	4.60	12.25	2.09	0.41	0.08	0.18	182	20	19
TC3	R1	08/17/88	109	7.40	7.47	4.62	13.92	2.02	0.38	0.06	0.20	279	34	21
TC3	R2	08/17/88	110	7.90	7.46	4.52	13.16	2.32	0.40	0.08	0.19	237	34	18
TC3	R3	08/17/88	111	5.80	8.14	5.11	12.95	2.25	0.43	0.09	0.18	231	34	21
TTN	R1	08/17/88	112	2.00	4.42	2.27	5.46	1.74	0.40	0.12	0.08	947	617	74
TPM	R1	08/17/88	113	8.10	7.66	5.03	13.37	1.88	0.37	0.05	0.17	254	14	19
TC5	R1	08/17/88	114	2.40	11.47	1.59	3.43	1.05	0.27	0.12	0.06	77	-2	47
TC6	R1	08/17/88	115	1.30	6.43	2.31	6.30	1.77	0.35	0.10	0.09	1225	14	31
TC7	R1	08/17/88	116	8.60	7.46	4.19	12.61	2.18	0.36	0.05	0.18	180	12	19
TC8	R1	08/17/88	117	6.67	6.15	5.13	12.73	3.82	0.40	0.08	0.21	131	19	26
TC9	R1	08/17/88	118	20.30	6.18	4.59	17.20	1.41	0.12	0.36	0.18	90	23	9
TC0	R1	08/17/88	119	11.60	14.41	3.75	7.59	2.87	0.27	0.06	0.18	74	14	32
TUS 0.5m	R1	09/21/88	120	6.20	7.54	3.94	11.79	1.49	0.84	0.06	0.32	1322	54	48
TUS 1m	R1	09/21/88	121	13.40	4.18	5.08	15.92	1.52	1.54	0.09	0.47	1575	51	33
TC2	R1	09/21/88	122	4.80	11.04	3.39	10.63	2.22	0.40	-2.00	0.20	515	27	24
TC2	R2	09/21/88	123	4.73	10.70	2.83	10.81	2.06	0.47	-2.00	0.13	441	37	33
TC2	R3	09/21/88	124	4.47	12.15	3.57	11.10	2.43	0.38	-2.00	0.16	535	29	30
TC3	R1	09/21/88	125	4.07	12.29	4.28	12.79	2.65	0.37	-2.00	0.20	414	23	23
TC3	R2	09/21/88	126	3.67	13.39	4.72	12.15	2.26	0.26	-2.00	0.16	438	31	30
TC3	R3	09/21/88	127	4.00	13.74	4.23	12.54	2.62	0.37	-2.00	0.19	458	31	32
TTN	R1	09/21/88	128	1.95	3.09	1.47	8.16	1.38	0.30	-2.00	0.31	2176	236	114
TPM	R1	09/21/88	129	3.80	12.17	3.33	12.73	2.32	0.31	-2.00	0.11	427	18	27
TC5	R1	09/21/88	130	1.40	2.57	2.09	7.70	1.13	0.92	-2.00	-2.00	75	-2	38
TC6	R1	09/21/88	131	1.10	2.41	1.50	12.04	1.29	0.26	-2.00	-2.00	890	44	11
TC7	R1	09/21/88	132	3.53	13.95	3.49	9.85	2.42	0.33	-2.00	0.16	228	41	9
TC8	R1	09/21/88	133	4.73	8.53	4.02	12.46	4.25	0.33	-2.00	0.17	318	66	6
TC9	R1	09/21/88	134	5.70	14.48	3.51	9.35	2.23	0.41	-2.00	0.10	116	16	9
TC0	R1	09/21/88	135	6.10	13.02	2.76	8.44	2.63	0.19	-2.00	0.05	121	20	45
TUS 0.5m	R1	10/19/88	136	3.53	8.44	3.87	10.15	1.63	0.70	0.49	0.29	1222	37	43
TUS 1m	R1	10/19/88	137	11.30	4.26	4.24	16.61	1.66	1.73	0.27	0.57	1550	56	53
TC2	R1	10/19/88	138	3.13	10.74	3.38	9.86	1.96	0.45	0.05	0.22	886	34	18
TC2	R2	10/19/88	139	2.67	11.42	3.97	10.78	2.04	0.51	0.07	0.21	1027	35	25
TC2	R3	10/19/88	140	2.93	12.08	3.56	10.82	1.82	0.38	0.08	0.25	903	37	19
TC3	R1	10/19/88	141	2.60	11.30	3.28	11.95	1.83	0.30	0.13	0.22	524	21	30

PARTICULATE METAL DATA: TURKEY CREEK PROJECT
Department of Oceanography & Ocean Engineering
Florida Institute of Technology
Dr. John H. Trefry, Principal Investigator

Station ID	Rep.	Date	Sample Number	TSM mg/L	Fe (%)	Al (%)	Si (%)	Ca (%)	Mg (%)	Na (%)	K (%)	Mn ppm	Cu ppm	Pb ppm
TC3	R2	10/19/88	142	2.60	11.58	3.27	11.80	1.91	0.33	0.12	0.21	543	26	30
TC3	R3	10/19/88	143	3.33	11.29	3.25	11.20	1.95	0.35	0.20	0.26	522	29	28
TTN	R1	10/19/88	144	1.33	2.18	1.78	11.05	1.47	0.47	0.26	0.31	320	691	50
TPM	R1	10/19/88	145	3.60	10.74	3.03	13.18	2.37	0.55	1.13	0.19	400	34	28
TC5	R1	10/19/88	146	1.47	2.65	1.41	8.07	0.60	0.23	0.41	-2.00	107	21	37
TC6	R1	10/19/88	147	1.00	4.14	1.37	12.64	2.31	0.47	1.15	0.20	1399	32	21
TC7	R1	10/19/88	148	2.60	13.67	3.24	10.40	2.24	0.34	0.12	0.38	203	29	34
TC8	R1	10/19/88	149	2.73	10.48	4.28	14.30	4.58	0.41	0.08	0.28	189	14	18
TC9	R1	10/19/88	150	6.73	14.22	3.59	11.97	1.92	0.39	0.22	0.26	202	13	15
TC0	R1	10/19/88	151	12.30	4.14	0.98	3.97	0.91	0.10	0.01	0.07	36	5	19
TUS 0.5m	R1	11/16/88	152	9.00	5.55	4.34	12.90	1.44	1.20	0.11	0.40	1340	59	41
TUS 1m	R1	11/16/88	153	22.10	4.36	4.62	16.11	1.29	1.63	0.14	0.49	1534	53	30
TC2	R1	11/16/88	154	4.07	9.84	3.60	10.26	1.52	0.51	0.11	0.20	622	59	16
TC2	R2	11/16/88	155	3.93	10.00	3.47	9.74	1.69	0.36	0.08	0.21	626	62	13
TC2	R3	11/16/88	156	4.20	10.03	3.67	10.31	1.60	0.37	0.11	0.18	597	65	17
TC3	R1	11/16/88	157	3.93	10.67	3.79	10.60	2.01	0.31	0.16	0.23	617	42	21
TC3	R2	11/16/88	158	3.73	10.56	3.99	10.43	2.17	0.34	0.16	0.21	599	46	19
TC3	R3	11/16/88	159	3.80	10.45	3.61	10.54	1.96	0.33	0.17	0.24	606	45	29
TTN	R1	11/16/88	160	1.85	2.01	1.82	6.20	1.40	0.22	-2.00	0.35	1149	393	75
TPM	R1	11/16/88	161	5.93	9.07	6.65	13.25	1.72	0.44	0.16	0.27	462	46	26
TC5	R1	11/16/88	162	3.90	2.77	2.37	9.35	0.94	0.30	0.15	0.24	82	41	38
TC6	R1	11/16/88	163	0.60	3.23	1.78	11.42	1.25	0.16	0.09	-2.00	1223	-2	15
TC7	R1	11/16/88	164	3.87	12.06	3.66	10.25	2.08	0.33	0.13	0.21	336	37	7
TC8	R1	11/16/88	165	3.27	9.60	3.47	19.31	5.07	0.37	0.10	0.24	145	-2	7
TC9	R1	11/16/88	166	2.80	16.16	2.53	7.44	1.63	0.29	0.05	0.17	26	10	20
TC0	R1	11/16/88	167	18.60	10.30	1.29	13.53	1.83	0.40	0.09	0.22	126	7	64
TC0 t=0	R1	11/23/88	168	158.60	2.22	4.04	8.20	23.24	0.31	0.20	0.17	54	12	95
TC9 t=0	R1	11/23/88	169	5.20	10.38	6.18	15.09	1.68	0.44	0.20	0.27	56	10	47
TC8 t=0	R1	11/23/88	170	3.20	8.09	3.24	11.62	4.18	0.22	0.07	0.25	171	13	9
TC7 t=0	R1	11/23/88	171	6.27	11.16	4.05	13.52	2.08	0.32	0.02	0.25	268	36	30
TPM t=0	R1	11/23/85	172	4.80	9.10	3.10	10.61	1.71	0.23	0.01	0.21	445	33	18
TC0 t=4	R1	11/23/88	173	64.00	2.84	4.16	8.87	18.33	0.33	0.15	0.16	53	28	75
TC9 t=4	R1	11/23/88	174	4.80	10.24	4.75	13.59	2.16	0.43	0.67	0.23	108	44	35
TC8 t=4	R1	11/23/88	175	4.27	6.78	2.89	9.36	3.03	0.21	-2.00	0.26	165	30	20
TC7 t=4	R1	11/23/38	176	4.67	11.85	4.12	14.22	2.62	0.30	-2.00	0.21	241	37	13
TPM t=4	R1	11/23/88	177	3.20	17.84	6.36	20.27	3.40	0.47	0.02	0.39	839	50	37
TC0 t=8	R1	11/23/88	178	20.20	1.64	7.10	12.49	6.11	0.74	0.07	0.20	63	24	90
TC9 t=8	R1	11/23/88	179	6.20	6.65	3.57	13.60	2.66	0.30	0.61	0.22	93	14	10
TC8 t=8	R1	11/23/88	180	3.60	8.64	2.90	12.34	4.16	0.21	0.04	0.31	274	11	11
TC7 t=8	R1	11/23/88	181	5.27	10.76	3.63	12.90	2.13	0.25	0.03	0.23	207	43	17
TPM t=8	R1	11/23/88	182	5.93	9.68	4.25	14.01	2.36	0.37	0.14	0.27	570	39	17
TC0 t=16	R1	11/23/88	183	22.00	5.85	7.89	13.96	3.67	0.41	0.06	0.23	62	11	92
TC9 t=16	R1	11/24/88	184	1.80	16.09	7.35	18.26	2.94	0.51	0.35	0.44	130	38	32
TC8 t=16	R1	11/24/88	185	1.20	14.02	4.17	13.17	3.69	0.40	-2.00	0.34	308	28	31
TC7 t=16	R1	11/24/88	186	8.13	8.98	4.78	14.44	4.21	0.43	0.11	0.24	274	30	10
TPM t=16	R1	11/24/88	187	4.93	10.54	4.48	12.60	2.62	0.45	0.18	0.22	748	27	4
TC0 t=24	R1	11/24/88	188	17.70	5.93	8.37	14.07	4.13	0.49	0.06	0.23	88	14	54

PARTICULATE METAL DATA: TURKEY CREEK PROJECT
Department of Oceanography & Ocean Engineering
Florida Institute of Technology
Dr. John H. Trefry, Principal Investigator

Station ID	Rep.	Date	Sample Number	TSM mg/L	Fe (%)	Al (%)	Si (%)	Ca (%)	Mg (%)	Na (%)	K (%)	Mn ppm	Cu ppm	Pb ppm
TC9 t=24	R1	11/24/88	189	2.70	8.28	4.31	10.97	1.63	0.43	0.09	0.23	139	8	-2
TC8 t=24	R1	11/24/88	190	2.93	8.89	3.07	12.65	4.30	0.29	0.10	0.19	253	10	10
TC7 t=24	R1	11/24/88	191	6.40	9.39	3.83	14.08	2.72	0.33	0.10	0.22	278	22	14
TPM t=24	R1	11/24/88	192	4.93	9.51	4.03	12.94	3.55	0.39	0.13	0.24	531	22	14
TC0 t=51	R1	11/25/88	193	20.80	6.85	9.61	14.80	2.44	0.50	0.08	0.23	162	7	46
TC9 t=51	R1	11/25/88	194	1.60	13.28	3.18	9.07	1.93	0.35	0.09	0.24	549	16	-2
TC8 t=51	R1	11/25/88	195	2.07	10.44	2.67	10.04	3.80	0.27	0.18	0.19	979	29	39
TC7 t=51	R1	11/25/88	196	3.60	14.44	3.84	10.89	2.47	0.37	0.06	0.20	476	33	16
TPM t=51	R1	11/25/88	197	4.27	12.09	4.06	11.76	2.99	0.38	0.07	0.21	836	33	23
TUS 0.5m	R1	12/20/88	198	15.00	4.51	3.89	19.73	1.21	0.21	0.21	0.51	963	61	18
TUS 1m	R1	12/20/88	199	59.40	4.41	5.03	20.04	1.34	0.06	0.20	0.58	499	65	15
TC2	R1	12/20/88	200	2.90	10.72	3.55	10.45	2.28	0.45	0.05	0.18	403	131	5
TC2	R2	12/20/88	201	3.10	10.89	3.40	10.75	2.03	0.45	0.13	0.23	341	134	8
TC2	R3	12/20/88	202	3.30	9.70	2.93	10.65	2.04	0.38	0.07	0.22	352	134	13
TC3	R1	12/20/88	203	2.90	10.51	3.23	10.29	2.35	0.33	0.03	0.19	416	122	5
TC3	R2	12/20/88	204	3.20	9.05	2.97	10.22	2.16	0.31	0.05	0.16	393	133	15
TC3	R3	12/20/88	205	2.70	10.36	3.77	11.65	2.64	0.38	0.09	0.26	434	146	21
TTN	R1	12/20/88	206	2.00	0.96	1.54	7.31	2.19	0.30	0.06	0.27	265	416	40
TPM	R1	12/20/88	207	1.90	13.89	3.56	11.97	2.06	0.35	0.54	0.19	287	158	-2
TC5	R1	12/20/88	208	1.30	3.04	2.66	12.34	1.22	0.77	0.80	0.14	66	44	45
TC6	R1	12/20/88	209	0.50	4.80	1.38	10.03	1.62	0.47	0.47	-2.00	881	-2	-2
TC7	R1	12/20/88	210	4.10	5.18	1.09	4.44	0.84	0.14	0.12	0.09	45	72	-2
TC8	R1	12/20/88	211	0.60	19.86	3.53	18.38	5.55	0.59	-2.00	-2.00	161	26	-2
TC9	R1	12/20/88	212	1.70	22.72	1.20	6.28	2.41	0.31	0.17	0.59	29	6	-2
TC0	R1	12/20/88	213	8.10	17.00	5.93	9.58	1.89	0.31	0.04	0.12	42	7	40
TUS 0.5m	R1	01/18/89	214	11.50	4.27	4.10	16.17	1.38	1.24	0.09	0.79	1472	63	47
TUS 1m	R1	01/18/89	215	17.60	3.99	4.30	16.17	1.24	1.41	0.12	0.53	1161	55	30
TC2	R1	01/18/89	216	3.70	7.65	3.31	9.83	1.78	0.39	0.09	0.25	662	43	20
TC2	R2	01/18/89	217	3.60	7.66	3.48	9.86	1.84	0.42	0.05	0.25	607	-1	16
TC2	R3	01/18/89	218	3.60	8.03	3.54	10.16	1.81	0.45	0.07	0.24	677	43	21
TC3	R1	01/18/89	219	3.10	8.88	3.71	11.30	2.59	0.38	0.04	0.30	504	66	24
TC3	R2	01/18/89	220	3.00	9.01	3.76	11.83	2.78	0.39	0.09	0.31	527	63	28
TC3	R3	01/18/89	221	3.50	8.13	3.23	11.19	2.59	0.35	0.10	0.29	476	69	26
TTN	R1	01/18/89	222	1.70	1.20	2.29	7.08	3.00	0.32	0.22	0.30	1417	495	41
TPM	R1	01/18/89	223	3.80	7.28	3.37	12.68	3.10	0.34	0.03	0.26	428	43	33
TC5	R1	01/18/89	224	3.60	2.95	2.36	7.56	0.93	0.28	0.16	0.22	100	26	38
TC6	R1	01/18/89	225	1.10	2.53	1.14	11.54	1.54	0.35	0.14	0.39	2064	-2	7
TC7	R1	01/18/89	226	2.50	9.40	2.36	7.92	1.81	0.27	0.10	0.33	431	24	5
TC8	R1	01/18/89	227	2.00	9.53	2.37	10.43	3.51	0.33	0.29	0.26	230	-2	23
TC9	R1	01/18/89	228	1.30	17.98	1.26	7.38	2.48	0.34	0.25	-2.00	101	-2	13
TC0	R1	01/18/89	229	6.90	14.66	3.91	8.90	2.92	0.33	0.12	0.18	109	12	38
TC0 t=0	R1	01/22/89	230	145.20	2.97	6.42	14.30	12.19	0.39	0.13	0.20	71	24	137
TC9 t=0	R1	01/22/89	231	38.60	5.72	8.32	16.40	1.46	0.60	0.05	0.25	175	17	15
TC8 t=0	R1	01/22/89	232	37.40	4.88	2.51	20.57	1.77	0.60	0.05	0.32	114	14	27
TC7 t=0	R1	01/22/89	233	87.80	6.84	7.23	17.60	4.03	0.55	0.05	0.27	222	45	17
TPM t=0	R1	01/22/89	234	65.80	5.94	6.54	17.62	2.63	0.52	0.07	0.29	277	40	16
TC0 t=4	R1	01/22/89	235	33.00	3.58	5.83	17.34	5.15	0.37	0.08	0.26	66	30	102

PARTICULATE METAL DATA: TURKEY CREEK PROJECT
Department of Oceanography & Ocean Engineering
Florida Institute of Technology
Dr. John H. Trefry, Principal Investigator

Station ID	Rep.	Date	Sample Number	TSM mg/L	Fe (%)	Al (%)	Si (%)	Ca (%)	Mg (%)	Na (%)	K (%)	Mn ppm	Cu ppm	Pb ppm
TC9 t=4	R1	01/22/89	236	24.80	5.27	8.15	16.87	1.10	0.54	0.04	0.28	170	12	14
TC8 t=4	R1	01/22/89	237	84.00	3.70	9.24	17.58	6.70	0.64	0.08	0.31	81	8	22
TC7 t=4	R1	01/22/89	238	129.40	6.52	8.01	19.39	3.03	0.59	0.09	0.31	166	20	13
TPM t=4	R1	01/22/89	239	106.60	5.85	8.14	18.78	2.51	0.58	0.05	0.30	174	21	18
TC0 t=8	R1	01/22/89	240	34.20	3.58	8.97	15.07	3.78	0.47	0.07	0.27	72	23	70
TC9 t=8	R1	01/22/89	241	19.40	4.99	5.76	16.75	1.03	0.52	0.02	0.31	150	18	16
TC8 t=8	R1	01/22/89	242	372.40	3.88	10.47	19.86	4.27	0.72	0.07	0.37	72	7	26
TC7 t=8	R1	01/22/89	243	84.80	6.64	7.61	18.49	2.56	0.56	0.04	0.30	147	22	13
TPM t=8	R1	01/22/89	244	62.40	6.37	7.98	18.60	2.06	0.57	0.04	0.30	151	21	15
TC0 t=16	R1	01/22/89	245	15.40	3.87	6.21	15.84	2.39	0.41	0.06	0.28	54	35	56
TC9 t=16	R1	01/22/89	246	15.60	5.23	6.30	15.16	1.31	0.46	0.03	0.29	144	26	15
TC8 t=16	R1	01/22/89	247	428.00	3.86	10.33	20.68	3.98	0.78	0.06	0.37	65	18	24
TC7 t=16	R1	01/22/89	248	72.60	3.75	4.02	11.07	1.04	0.34	0.06	0.18	84	12	16
TPM t=16	R1	01/22/89	249	47.60	10.84	11.86	31.89	3.66	0.98	0.09	0.46	248	36	41
TC0 t=24	R1	01/23/89	250	12.20	4.83	5.61	16.28	1.68	0.35	0.02	0.28	38	42	105
TC9 t=24	R1	01/23/89	251	14.00	4.56	4.93	15.85	0.92	0.42	0.12	0.25	113	29	21
TC8 t=24	R1	01/23/89	252	237.80	3.73	8.73	17.71	3.37	0.68	0.06	0.32	70	15	33
TC7 t=24	R1	01/23/89	253	130.20	4.85	8.14	17.48	1.98	0.42	0.06	0.36	116	14	29
TPM t=24	R1	01/23/89	254	103.60	5.00	9.51	18.87	1.87	0.70	0.05	0.36	117	14	27
TC0 t=49	R1	01/24/89	255	8.80	7.20	6.30	14.59	2.58	0.42	0.03	0.28	33	16	97
TC9 t=49	R1	01/24/89	256	6.00	4.30	5.40	15.75	1.36	0.54	0.19	0.39	203	-2	30
TC8 t=49	R1	01/24/89	257	67.40	3.96	9.97	20.33	2.63	0.72	0.07	0.33	81	9	32
TC7 t=49	R1	01/24/89	258	29.80	4.80	8.80	19.42	1.83	0.67	0.14	0.35	93	14	30
TPM t=49	R1	01/24/89	259	32.20	4.03	7.31	17.38	1.28	0.60	0.08	0.31	79	12	23
TC0 t=74	R1	01/25/89	260	7.60	10.39	4.08	11.60	2.35	0.31	0.04	0.45	49	9	75
TC9 t=74	R1	01/25/89	261	4.00	4.67	4.77	16.69	1.31	0.45	0.91	0.60	111	42	40
TC8 t=74	R1	01/25/89	262	39.00	3.90	9.37	21.55	1.47	0.66	0.07	0.36	79	18	35
TC7 t=74	R1	01/25/89	263	11.20	5.70	9.63	18.65	1.77	0.55	0.24	0.32	88	16	49
TPM t=74	R1	01/25/89	264	13.60	5.05	6.69	17.14	1.91	0.54	0.09	0.54	100	13	28
TUS 0.5m	R1	02/15/89	265	6.30	5.33	3.28	13.61	1.11	1.00	0.24	0.28	588	49	42
TUS 1m	R1	02/15/89	266	11.90	4.29	4.44	17.68	1.11	1.36	0.23	0.43	426	70	41
TC2	R1	02/15/89	267	4.10	7.59	2.85	9.88	1.65	0.27	-2.00	0.13	325	67	67
TC2	R2	02/15/89	268	4.40	7.65	2.93	9.52	1.68	0.28	-2.00	0.17	322	-1	-1
TC2	R3	02/15/89	269	3.60	8.19	3.11	10.40	1.63	0.29	-2.00	0.20	351	73	74
TC3	R1	02/15/39	270	3.00	10.33	3.24	9.95	1.72	0.30	-2.00	0.19	365	58	70
TC3	R2	02/15/89	271	2.90	9.32	2.83	10.18	1.76	0.26	-2.00	0.19	334	58	60
TC3	R3	02/15/89	272	3.40	9.52	3.13	9.55	1.59	0.27	-2.00	0.16	323	52	56
TTN	R1	02/15/89	273	2.60	2.37	2.29	6.72	1.08	0.34	0.03	0.32	758	372	78
TPM	R1	02/15/89	274	2.80	11.30	2.88	8.17	1.79	0.28	-2.00	0.13	276	49	-1
TC5	R1	02/15/19	275	6.50	2.17	2.39	10.80	0.45	0.18	-2.00	0.06	18	25	48
TC6	R1	02/15/89	276	1.30	4.13	0.92	12.75	0.56	0.08	-2.00	-2.00	644	45	26
TC7	R1	02/15/89	277	1.90	10.74	3.81	11.65	1.94	0.29	-2.00	-2.00	168	94	58
TC8	R1	02/15/89	278	1.90	8.49	4.63	12.78	2.12	0.28	-2.00	0.31	58	22	31
TC9	R1	02/15/89	279	1.50	10.78	3.38	12.28	0.90	0.32	-2.00	-2.00	161	51	94
TC0	R1	02/15/89	280	4.90	13.69	2.89	7.03	3.30	0.21	-2.00	0.11	51	23	66
TC0 t=0	R1	03/03/89	281	120.80	2.61	5.07	10.77	19.24	0.41	0.17	0.19	68	19	121
TC9 t=0	R1	03/03/89	282	37.10	5.07	10.22	20.91	1.45	0.70	0.04	0.32	84	10	33

PARTICULATE METAL DATA: TURKEY CREEK PROJECT
Department of Oceanography & Ocean Engineering
Florida Institute of Technology
Dr. John H. Trefry, Principal Investigator

Station ID	Rep.	Date	Sample Number	TSM mg/L	Fe (%)	Al (%)	Si (%)	Ca (%)	Mg (%)	Na (%)	K (%)	Mn ppm	Cu ppm	Pb ppm
TC8 t=0	R1	03/03/69	283	3.90	5.02	8.15	18.02	3.75	0.53	0.04	0.37	122	30	68
TC7 t=0	R1	03/03/89	284	5.70	6.73	5.88	15.41	2.72	0.54	-2.00	0.28	184	33	72
TPM t=0	R1	03/03/89	285	13.80	6.54	5.67	14.00	2.02	0.46	0.02	0.30	775	23	32
TC0 t=4	R1	03/03/89	286	21.40	4.99	5.33	12.23	6.54	0.35	0.10	0.27	64	27	102
TC9 t=4	R1	03/03/89	287	37.20	4.40	9.80	18.45	2.66	0.71	0.07	0.37	86	14	33
TC8 t=4	R1	03/03/89	288	19.20	5.30	7.85	16.70	1.99	0.56	0.04	0.37	100	13	34
TC7 t=4	R1	03/03/89	289	40.40	5.39	7.29	16.08	2.24	0.64	0.04	0.36	223	24	28
TPM t=4	R1	03/03/89	290	39.40	5.84	6.02	15.39	2.30	0.53	0.05	0.32	379	22	20
TC0 t=8	R1	03/03/89	291	43.80	3.74	8.12	14.98	6.75	0.43	0.09	0.26	50	16	82
TC9 t=8	R1	03/03/89	292	22.80	6.38	6.03	15.18	2.20	0.53	0.03	0.30	162	16	22
TC8 t=8	R1	03/03/89	293	63.20	2.15	8.01	18.78	2.95	0.60	0.06	0.33	203	12	25
TC7 t=8	R1	03/03/89	294	14.50	4.33	7.11	14.90	3.22	0.57	0.06	0.33	103	14	35
TPM t=8	R1	03/03/89	295	54.80	5.10	8.49	18.51	2.64	0.63	0.05	0.33	175	14	27
TC0 t=16	R1	03/03/89	296	18.80	4.31	7.54	14.01	3.14	0.44	0.10	0.28	553	29	97
TC9 t=16	R1	03/03/89	297	27.40	7.67	5.02	14.36	1.40	0.44	0.08	0.27	39	21	19
TC8 t=16	R1	03/03/89	298	22.00	2.96	6.00	12.87	9.39	0.49	0.18	0.29	254	15	23
TC7 t=16	R1	03/03/89	299	56.40	5.73	7.66	18.67	3.12	0.57	0.04	0.31	169	11	30
TPM t=16	R1	03/03/89	300	55.80	5.42	7.65	18.34	3.01	0.55	0.02	0.28	160	10	30
TC0 t=24	R1	03/04/89	301	25.60	4.49	8.47	16.27	2.59	0.46	0.16	0.27	50	11	80
TC9 t=24	R1	03/04/89	302	20.80	7.36	5.04	13.69	1.28	0.42	0.01	0.22	118	12	15
TC8 t=24	R1	03/04/89	303	14.00	3.40	6.96	16.88	5.68	0.55	0.06	0.34	120	21	40
TC7 t=24	R1	03/04/89	304	38.00	5.80	6.01	16.15	3.10	0.46	0.05	0.27	145	27	21
TPM t=24	R1	03/04/89	305	28.40	5.75	5.87	16.49	2.37	0.47	0.04	0.26	162	11	25
TC0 t=50	R1	03/05/89	306	4.80	10.61	6.50	13.03	2.87	0.36	-2.00	-2.00	27	32	111
TC9 t=50	R1	03/05/89	307	15.40	6.05	4.10	12.94	1.62	0.39	-2.00	0.20	76	21	15
TC8 t=50	R1	03/05/89	308	18.80	3.40	6.46	15.47	5.67	0.54	0.14	0.31	76	11	25
TC7 t=50	R1	03/05/89	309	19.80	5.71	5.07	15.69	2.65	0.41	0.02	0.28	98	17	25
TPM t=50	R1	03/05/89	310	18.00	5.70	4.64	15.46	2.27	0.44	0.02	0.29	126	16	37
TC0 t=74	R1	03/06/89	311	5.60	7.69	2.93	7.41	2.28	0.21	-2.00	-2.00	13	-2	61
TC9 t=74	R1	03/06/89	312	20.60	6.04	3.97	11.20	1.41	0.34	-2.00	0.18	80	24	20
TC8 t=74	R1	03/06/89	313	12.80	3.21	4.71	13.26	6.60	0.38	0.02	0.31	69	15	30
TC7 t=74	R1	03/06/89	314	9.00	5.63	4.22	12.20	2.84	0.38	-2.00	0.28	57	41	23
TPM t=74	R1	03/06/89	315	12.00	6.02	4.74	14.64	2.63	0.41	-2.00	0.31	135	17	20