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Site Specific Water Quality Assessment:
Leon Creek, Texas

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SITE SPECIFIC WATER QUALITY ASSESSMENT: LEON CREEK, TEXAS

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OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
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I. INTRODUCTION

Increasing use of metals in manufacturing and chemical industries has caused a measurable rise in ambient toxic metal concentrations in industrial discharges (Spaulding and Ogden 1968). As a result, many of our nation's receiving surface waters contain elevated levels of metals. Primary sources of most toxic metals include industrial and municipal sewage treatment plant (publicly owned treatment works) discharges, mine drainage, and atmospheric precipitation (Spaulding and Ogden 1968; EPA 1979).

The effluent and sludge of many publicly owned treatment works (POTWs) are known to contain high metal concentrations (Dewalle and Chian 1980). This has been assumed to result from industrial wastewater discharges to POTWs. However, high metal concentrations have also been found in POTWs which do not receive industrial wastes.

Results from recent sampling of a wide spectrum of POTW effluents (U.S. Geological survey data; Sverdrup and Parcel and Associates, Inc. 1977; Dewalle and Chian 1980) showed that the concentration of several toxic metals in receiving streams exceeded freshwater aquatic life criteria recommended by the U.S. Environmental Protection Agency (U.S. EPA 1976). In many cases, levels were of sufficient magnitude to suggest that the biological communities of many of the nation's surface waters could be experiencing severe impacts. However, undocumented reports have claimed that substantial populations of aquatic life (fish, invertebrates, plants) exist in a healthy condition in waters containing concentrations in excess of the recommended criteria.

Prompted by this apparent contradiction the EPA Office of Water Regulations and Standards (OWRS) issued a directive to document the water and biological quality that exist in selected streams receiving POTW discharges. Later, as other important sources of metals were identified, the program was expanded to include the investigation of mining and industrial discharges. The toxic metals program was based on the following study objectives:

1. To document the concentration and distribution of toxic metals in selected streams receiving discharges from publicly owned treatment works (POTWs), mining, and industrial wastes.

2. To determine the biological state of receiving waters when the aquatic life criteria for toxic metals are exceeded. This included sampling and analyzing fish, benthic invertebrates, and periphyton communities.

3. To report the extent to which criteria levels were observed to be exceeded.

4. To develop explanatory hypotheses when healthy biota exist where criteria are exceeded.

The project was undertaken as a cooperative effort by EPA's Environmental Monitoring Systems Laboratory, Las Vegas, Nevada (EMSL-LV) and the Environmental Research Laboratories at Corvallis, Oregon (ERL-Corvallis) and Duluth, Minnesota (ERL-Duluth). EMSL-LV designed the project and supervised the field investigation in cooperation with University of Nevada, Las Vegas (UNLV) personnel. Laboratories at ERL-Duluth and ERL-Corvallis performed static bioassay tests to assess the toxicity of whole and filtered water samples from each stream investigated.

From a list of approximately 200 candidate streams, 50 were selected for a preliminary field survey. The list was then narrowed to 15 streams (Table 1) which received mining, industrial, or municipal discharges. Streams were selected to provide broad geographical representation and a range of watershed characteristics and uses, pollution sources, water quality characteristics, biota, and habitats. Field sampling for biological, physical, and chemical water quality information was conducted from July 28 to November 10, 1980. Figure 1 illustrates the general approach to each study site. In each river, a control site was sampled upstream from a discharge point, and transects were established downstream from the discharge to define impact and subsequent recovery zones.

Individual study sites were chosen according to the following criteria:

1. Toxic metal concentrations upstream from effluent discharges were below current water quality criteria.

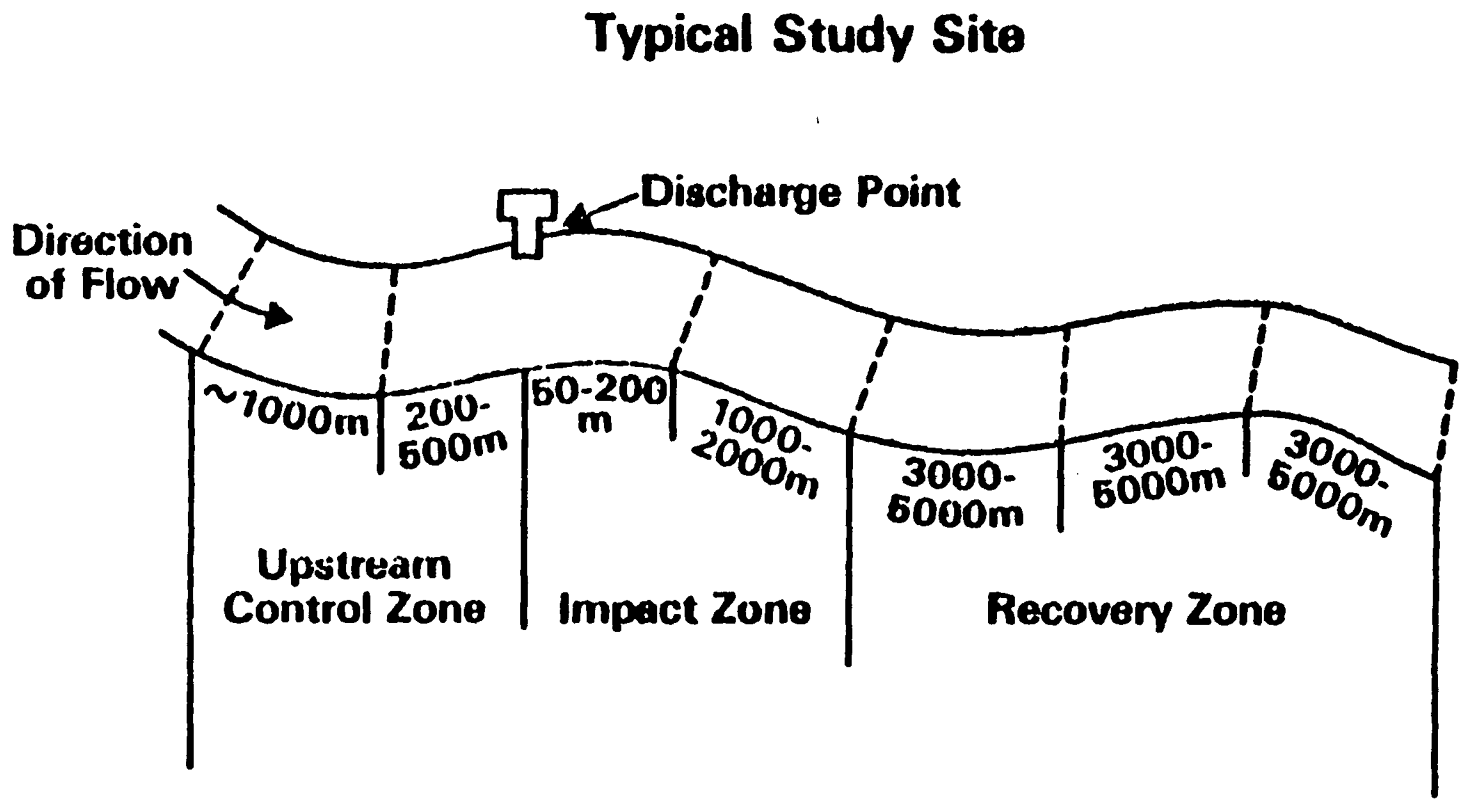
2. Metal concentrations in receiving waters after complete mixing with effluent discharge were 5 to 10 times greater than the water quality criteria.

Data from the 1980 toxic metals project will be presented in 15 separate reports discussing each river system; a summary project report will follow the

TABLE 1. 1980 STUDY LOCATIONS, TYPES OF DISCHARGES, AND METALS PRESENT IN EXCESS OF EPA RECOMMENDED AQUATIC LIFE CRITERIA*

Pollution Source Stream	Metal(s)
Mining	
Prickly Pear Creek, Montana	Copper, Zinc, Cadmium
Silver Bow Creek, Montana**	Copper, Cadmium, Zinc
Slate River, Colorado	Copper, Zinc, Silver, Cadmium
Tar Creek, Oklahoma	Zinc, Cadmium, Silver, Lead
Red River, New Mexico	Copper, Cadmium
Industrial	
Leon Creek, Texas	Chromium, Nickel
Little Mississinewa River, Indiana	Lead, Chromium
Public Owned Treatment Works (POTW)	
Bird Creek, Oklahoma	Arsenic, Selenium
Cedar Creek, Georgia	Chromium, Silver
Maple Creek, South Carolina	Chromium
Irwin Creek, North Carolina	Chromium, Zinc, Nickel, Lead
Blackstone River, Massachusetts	Cadmium, Lead
Mill River, Ohio	Nickel
Cayadutta Creek, New York	Chromium, Cadmium
White River, Indiana	Copper

*In most cases the acute criteria were exceeded (U.S. EPA 1976); chronic criteria were exceeded in all cases.
**Also receives POTW discharge.



Each transect consists of:

- 5 replicates for biological samples
- Electrofishing 100 meters of stream reach
- 3 replicates for tissue, sediment and water samples
- 1 twenty-four hour composite water sample
- 8 three hour integrated water samples

Total number of samples per transect

= 37
+ 45 hydrolab measurements (9 parameters x 5 replicates)

Figure. 1. Generalized diagram of the field sampling approach.

individual basin studies. This report addresses data collected in Leon Creek, Texas.

II. METHODS

Five sampling stations were established in Leon Creek (Figure 2) and sampled from November 5 to November 8, 1980. One station was sampled in the control zone (161), two stations (162 and 163) were located in the impacted zone, and two stations (164 and 165) were located in the recovery zone. Detailed discussions of the various sampling methodologies follow:

CHEMICAL

Water

Field Collection

To determine the water quality characteristics of Leon Creek, horizontal and vertical profiles of pH, conductivity, temperature, dissolved oxygen (DO), and reduction/oxidation (redox) potential were measured at each station with a Hydrolab 4041 water quality measurement system. Other field measurements included: turbidity with a Hach nephelometer, and chlorine with a Hach field chlorine kit. Triplicate grab samples were collected at each site mid-depth between surface and bottom, preserved appropriately for each analysis as specified in U.S. EPA (1979b) and APHA (1980), and shipped to EMSL-LV for analysis. Filtering of grab samples (0.45 μm filter) for total and dissolved metal fractions analysis was completed on site within approximately three hours of the time of collection. All samples were acidified with Ultrex nitric

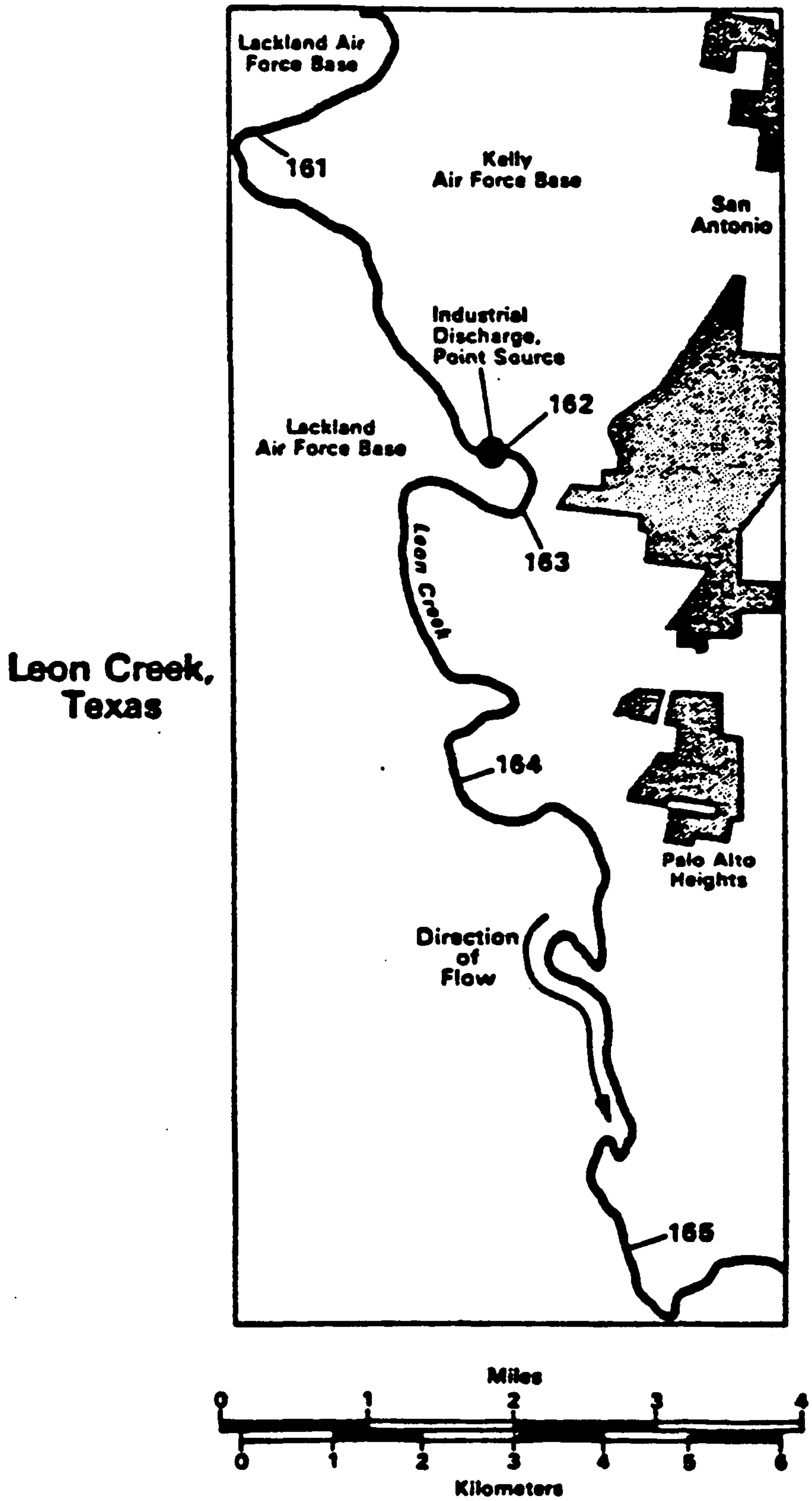


Figure 2. Station locations on Leon Creek, Texas.

acid to a pH of <2.0, and shipped to UCLA's Laboratory of Biomedical and Environmental Science for ICAP analysis. In addition to the manual grabs an ISCO sampler collected 24-hour composite samples at one hour intervals for metal analyses. Three one-hour samples of 100 ml each were composited in a 450 ml sample vessel; thus, eight three-hour composite samples were collected at each station. Samples were acidified with Ultrex nitric acid and shipped to UCLA for ICAP analysis.

Laboratory Analysis

Table 2 lists the parameters and methods used for laboratory analyses of water quality in Leon Creek.

Sediments

Field Collection

Streambed sediments were collected in Leon Creek to determine the extent to which metals entering from the Kelly AFB industrial discharge accumulate in sediments. Backwater pool areas, when available, were sampled at each station. Sediment cores were collected with a WILDCO 2" (5 cm) brass core sampler fitted with a plastic core liner and egg shell core catcher. A series of shallow core samples were collected from the submerged root zone along a stream bank. When necessary, several shallow core samples were collected to fill one core tube replicate. Three replicate core samples were collected from each of the five stations and shipped to EMSL-LV for ICAP analyses.

Laboratory Analysis

It has long been known that different particle sizes have different affinities for metals and other positive ions (Namminga and Wihlm 1977;

TABLE 2. LABORATORY CHEMICAL ANALYSIS OF STREAM WATER QUALITY PARAMETERS

	Parameter	Reference
A.	Automated Analyses (Technicon Auto Analyzer; all values in mg/l)	
	Total phosphate	U.S. EPA 1979b Method 365.1
	Ortho phosphate	U.S. EPA 1979b Method 365.1
	Hydrolysable phosphate	U.S. EPA 1979b Method 365.1
	Kjeldahl nitrogen	U.S. EPA 1979b Method 351.1
	Total Ammonia (NH_4)	U.S. EPA 1979b Method 350.1
	Nitrates + nitrites	U.S. EPA 1979b Method 353.1
	Total alkalinity	U.S. EPA 1979b Method 310.2
B.	Additional Parameters (mg/l)	Reference
	Total Ca + Mg hardness*	APHA (1980) p. 195
	Total organic carbon (carbon analyzer)	U.S. EPA 1979b Method 415.1
	Total residues	U.S. EPA 1979b Method 160.3
	Suspended residues	U.S. EPA 1979b Method 160.1
	Total sulfate	U.S. EPA 1979b Method 375.1
	Total cyanide	U.S. EPA 1979b Method 335.2
C.	Spectrum of selected total metals - ICAP** Cu, Cd, Zn, As, Ni, Ag, Cr, Se, Ca, Mg, Al, Pb (μg/l)	Alexander and McAnulty 1981
	Total recoverable	U.S. EPA 1979b
	Filtered through 0.45 μm	U.S. EPA 1979b
Composite samples from mixing zone (ISCO) (metal analyses: ICAP μg/l)		Alexander and McAnulty 1981

* Calculations from measured Ca and Mg concentrations.
** ICAP = Inductively Coupled Argon Plasma emission spectroscopy.

McDuffie et al. 1976), and that the most important particle sizes known to sorb positive ions range from fine sand down to clay. For this reason preliminary tests were conducted in the laboratory prior to final sediment analyses to determine the particle size range sorbing the most metals and expressing the least among-replicate variability. Whole samples and 100, 250, and 400 mesh seived sub-samples from Prickly Pear Creek, Montana, sediments were previously analyzed for total recoverable metal (EPA 1981). Based on this experiment, 400 mesh (64 μm) particle sizes contained the most metal per gram sample and exhibited the least replicate variation.

Replicate core samples from Leon Creek were shipped to EMSL-LV, oven dried at 100°C to complete dryness, and sieved through a 400 mesh (64 μm) stainless steel sieve. Each sample was then divided into four equal portions. A 1-gram subsample was then used for the acid extraction. An extraction medium of 5 mls of HCl and 0.5 mls H_2SO_4 in 50 mls of water was found to be the most effective extraction solvent (EPA 1981). These solution subsamples were then placed in 20 dram scintillation vials and sent to UCLA for ICAP analyses (Alexander and McAnulty 1981).

BIOLOGICAL

Biological monitoring in Leon Creek met three specific goals:

1. To identify and determine the background distribution of algal, invertebrate, and fish species;

2. To determine if biological communities exhibit measurable changes in relation to distance from point sources; and

3. To determine metal concentrations in plant and fish tissues as an indication of sublethal and potentially lethal impacts to the biota, and to provide insight into the fate of various metals.

Table 3 summarizes the biological parameters measured, collection techniques, and analytical methods. A more detailed description of the methods used to sample and analyze each parameter is discussed below.

Macroinvertebrates

Field Collection

The Standardized Traveling Kick Method (STKM) (Pollard and Kinney 1979) was used to collect invertebrate samples in Leon Creek. Three replicates were collected at each site using a 30-mesh triangular dip net with a mouth opening of 25 cm x 25 cm x 25 cm and a length of 76 cm. Kick sampling was standardized by the investigator holding a net in the water in front of him for 30 seconds while traveling approximately four meters downstream vigorously kicking the substrate. This sampled an area approximately 0.75 x 4 meters (3 m^2).

After collection, samples were washed through a 30 mesh sieve-bottom bucket, placed in a white enamel pan, and field-sorted to major taxonomic groups. Field extraction of animals from each sample was checked by another field team member as a quality control measure. This QA check involved scanning the sorting pan until no additional macroinvertebrates were observed for two minutes of continuous scanning. Sorted invertebrates and any unsorted samples were preserved in the field with approximately 10 percent formalin and returned to EMSL-LV for final processing.

TABLE 3. SUMMARY OF BIOLOGICAL PARAMETERS SAMPLED IN LEON CREEK AND ASSOCIATED METHODS

Tissue Concentrations of Toxic Metals	Ecological Indicators
Aquatic Macrophytes (Representative species at each station, analyzed by DC arc spectroscopy)	Periphyton (Unit area periphyton scrape from natural rock substrate)
	Species identification
Root tissue	Relative abundance counts
Leaves and stems	
	Invertebrates (Standardized Traveling Kick Method)
Fish (Seining, electrofishing, analyzed by DC arc spectroscopy	
	Species identification
Gill	Relative abundance counts
Muscle	
Liver	Fish (Seining, electrofishing)
Kidney	
Gonad*	Species identification
Brain*	Relative abundance
Eye*	Length/weight relationships
Whole body**	

* Selected individuals from locations with extremely high metal concentrations.

** Whole fish were analyzed in small specimens.

Laboratory Analysis

Collected benthic invertebrates were identified to the lowest possible taxonomic level and counted at UNLV. Laboratory quality assurance sorting criteria were the same as for field sorting when additional sorting was required. Some members of the order Diptera were only identified to the sub-family level (e.g., Chironominae) and members of the Oligochaeta were keyed only to class. A reference collection of identified specimens is stored at the laboratory, and samples were submitted to the University of Idaho for taxonomic verifications by C. E. Hornig.

Macroinvertebrate data were compiled and stored in a local PDP 1170 computer system where various mathematical and statistical computations were made. Invertebrate data analyses for Leon Creek consisted of: 1) total number of individuals (standing crop), 2) total number of taxa (species richness), and 3) relative species abundance.

Plants

Periphyton

Field Collection

Periphyton was collected from riffle zone rock substrates. Replicate rocks from each station were selected in areas of uniform flow and velocity within the riffle. Algae growing onto or attached to rocks (epilithic) were sampled within a circular area of 3772 mm^2, the boundaries delineated by a flexible rubber ring. The rubber ring was placed on top of rocks which had been removed from the river and placed into shallow enamel pans. The area within the ring boundary was scraped with a razor blade and stiff nylon brush into a 500 ml glass jar. This procedure was repeated for each replicate sample at each station. Each replicate volume was then adjusted to a standard volume by adding distilled water. Acid-lugols preservative was added to each sample to produce a final concentration of 1-5 percent (v/v) depending upon algal biomass present.

Laboratory Analysis

Counting and identification procedures included two analysis steps: 1) one subsample was acid-cleaned for diatom species identifications and proportional counts, and b) the second subsample was examined with an inverted microscope to count and identify non-diatoms and obtain a total count of all viable diatom frustules to convert proportional diatom counts to cells/mm.

A. Diatom Proportional Count

One 10-20 ml sub-sample was removed with a wide-bore pipette and placed into a 25 ml Erlenmeyer flask; five ml of concentrated nitric acid (HNO_3) was then added. Flasks were placed on a heating plate inside a fume hood, and samples were mildly boiled for approximately 5 minutes or until sample color became clear. This procedure oxidized sample organic material and broke up gelatinous material, leaving the silica diatom frustules. Each subsample was then centrifuged for 5 minutes. The supernatent was decanted and the centrifuge tube refilled with distilled water. This procedure was repeated two additional times to remove any remaining HNO_3. After final centrifugation, one or two drops of concentrated sample were placed on a cover glass and mounted with Hyrax™ mounting media. The edge of the slide was sealed with clear fingernail polish.

Counting Procedure

Diatoms were identified and counted at 1000x magnification (oil emersion) with an Olympus BHT phase contrast microscope. Long counts of 5000-10000 diatoms or more, such as are recommended by Patrick (1977), are far too time consuming for most water quality studies; hence, we scanned random strips until at least 300 diatom cells were counted and identified (Weitzel 1979). Counting fewer diatoms (300) provides reliable results (Weber 1973) and compares well with longer counts of 1000 diatoms (Castenholtz 1960).

B. Non-Diatom Count

A 0.05 to 2.0 ml subsample was introduced into a Wild™ plate chamber. Strips were scanned across the entire counting chamber diameter under 100-400X magnification using an Olympus IMT inverted microscope. All non-diatoms were counted and identified during this step as well as total viable diatom frustule number. If excess clumping was evident, the sample was placed in a "sonifier" unit to break up clumps and filaments.

Calculations

(1) Counting accuracy = $2 \cdot \frac{100}{\sqrt{n}}$ (Lund et al. 1958)

(2) Cell abundance (cells mm^{-2}) = $\frac{(A_c)\ (V_s)\ (X_i, X_D)}{(L_s)\ (W_s)\ (N_s)\ (V_a)\ (A_s)}$

where

A_c = area of counting plate chamber (510 mm^2)

V_s = volume of sample (ml)

X_i = counts of non-diatom species

X_D = total count of viable diatom frustules

L_s = length of strip counted (25 mm)

W_s = width of strip(s) counted (mm)

N_s = number of strip(s) counted (1,2,3,4)

V_a = volume of subsample (0.05-2.0 ml)

A_s = area of rock scraped as delineated by rubber ring (3772 mm^2)

n = number of diatom frustules counted

Total diatom abundance was converted to relative abundance of each species by [formula 2] x $\frac{N_i}{N_D}$

where

N_i = number of occurrences of each species in the proportional count

N_D = total number of diatom frustules counted in the proportional count

Macrophyte Tissues

Field Collection

Macrophytes from the family Graminacea were collected for tissue analysis from banks where the root zone was in contact with stream water. Random samples from the whole plant (leaves, stems, and roots) were collected in triplicate from each station. These samples were frozen and shipped to EMSL-LV with dry ice.

Laboratory Analysis

Macrophyte samples were thawed, roots and stems were separated at the soil surface level, and each of the parts was washed three times in distilled water.

Each washing consisted of placing the sample in a 16 oz Nalgene bottle, filling to 1/3 volume, and agitating for one minute. All plant samples were oven dried at 80°C to complete dryness, placed in plastic 20 dram vials, and homogenized with a Model 8000 Mixer Mill (Spex Industries Inc.). Approximately 1 gm samples were then placed in 20 dram scintillation vials and sent to UCLA for analysis by DC Arc Spectrometry (Alexander and McAnulty 1981).

Fish

Community Census

Fish samples taken in this study were qualitative collections with emphasis placed on presence or absence of various fish species upstream and downstream from the primary discharge. Sampling was conducted by electrofishing with a backpack shocker. All fish were identified, weighed, and measured in the field.

Tissues

Field Collection

Mature fish from a variety of families were collected from each station where available; each was frozen, and shipped with dry ice to EMSL-LV. The fish were later thawed; liver, gill, muscle, and kidney tissues were dissected from each fish. Brain, gonad, and eye tissues were also extracted to compare metal accumulation in various tissues.

Laboratory Analysis

Triplicate samples of approximately 1 gm from each tissue type were freeze dried and sent to UCLA's Laboratory of Biomedical and Environmental

Science for DC Arc Spectrometry analysis (Alexander and McAnulty 1981). At UCLA each of 3 subsamples was individually weighed and analyzed for metal content.

Bioassays

Field Collection

Water samples from stations 161 and 162 were collected in 5 gallon cubitainers, packed in ice, and shipped to ERL-Duluth for bioassay.

Laboratory Analysis

Bioassays were conducted on whole water samples. The Duluth work consisted of experiments on: 1) an activity index of bluegill sunfish (*Lepomis macrochirus*); 2) acute toxicity to *Daphnia magna*; 3) immobilized enzymes; and 4) chlorophyll *a* fluorescence.

III. RESULTS AND DISCUSSION

CHEMICAL

Water Quality

Several publications have identified some water quality parameters which may alter metal toxicity in controlled laboratory bioassays (Lloyd and Herbert 1962; Nishikowa and Tabata 1969; Brown et al. 1974; Shaw and Brown 1974; Waiwood and Beamish 1978; Howarth and Sprague 1979; Miller and Mackay 1980). These factors include hardness, alkalinity, pH, temperature, and turbidity from dissolved or particulate matter. An attempt was made to accurately characterize water quality in Leon Creek by identifying and quantifying as many parameters as feasible (Appendix A). Metal data both from mid-depth grab samples and ISCO 24-hour automatic collections (to provide information on diel changes) are included in Appendix A.

Water samples were analyzed for total and dissolved metal concentrations and compared to EPA (1980) recommended acute criteria for aquatic life based upon water hardness (Table 4). Total silver, cadmium, and chromium concentrations exceeded recommended criteria in the impact zone downstream from station 161, presumably due to the discharge from Kelly Air Force Base. Increased nutrient concentrations and decreased dissolved oxygen levels and percent saturation were also evident immediately downstream from the discharge (Table 5), indicating substantial quantities of organic materials are entering Leon Creek.

TABLE 4. COMPARISON OF MEAN TOTAL CONCENTRATIONS OF SELECTED METALS VERSUS CALCULATED ACUTE WATER QUALITY CRITERIA FOR AQUATIC LIFE. Mean values based on grab and ISCO samples combined.

	Stations				
	Control	Impact		Recovery	
	161	162	163	164	165
Hardness (mg/l)	383	247	253	300	410
Metal (μg/l)					
Total Cadmium					
Actual ($\bar{x}$)*	6.8	22.7	23.1	6.2	5.0
Criterion	12	8	8	10	13
Total Lead					
Actual ($\bar{x}$)	157.6	239.6	193.1	136.0	127.1
Criterion	885	519	535	658	962
Total Silver					
Actual ($\bar{x}$)	46.0	79.9	77.9	16.0	15.5
Criterion	41	19	20	27	46
Total Arsenic					
Actual ($\bar{x}$)	85.4	311.7	276.4	145.6	112.0
Criterion	440	440	440	440	440
Total Copper					
Actual ($\bar{x}$)	14.7	49.9	48.5	3.0	3.4
Criterion	78	52	53	62	83
Total Chromium					
Actual ($\bar{x}$)	4.6	31.7	54.0	3.2	2.4
Criterion	19	12	12	15	20

* Means represent three or more analytical replicates unless otherwise indicated.

TABLE 5. MEAN CONCENTRATIONS OF SELECTED WATER QUALITY PARAMETERS (mg/l) AND PERCENT OXYGEN SATURATION AT EACH STATION IN LEON CREEK, TEXAS.

	Stations				
	Control	Impact		Recovery	
	161	162	163	164	165
$\bar{x}$ Dissolved Oxygen*	6.43	5.43	3.79	8.06	6.73
% O_2 Saturation	70.0	65.0	43.0	89.0	72.0
$\bar{x}$ Ortho Phosphorus	0.050	0.150	0.360	0.217	0.070
$\bar{x}$ Total Phosphorus	0.020	0.135	0.322	0.193	0.057
$\bar{x}$ Kjeldahl Nitrogen	0.262	0.490	0.675	0.448	0.297
$\bar{x}$ Total Organic Carbon	3.65	7.25	13.90	3.20	9.45

*Means represent three or more analytical replicates unless otherwise indicated.

Ambient metal concentrations were highest in the impact zone (Station 163), then decreased in the two downstream recovery zone sites (164 and 165), often to lower concentrations than were found in the upstream control. In some cases ambient metal concentrations apparently declined between the control and first impact zone stations. The reason for the anomaly is not known.

Analysis of variance (ANOVA) and Bartlett's test for homogeneity of variances were performed to test for significant differences between stations for six ambient total metals in Leon Creek. In the case of chromium, ANOVA parametric assumptions for normality and heterogeneity of variances were unable to be met (indicated by Bartlett's test), so a Kruskal-Wallis ANOVA by ranks (Siegel 1956) was used to test for significant differences (Table 6). When ANOVA f-ratios indicated significant differences ($p=0.05$) in metal concentrations, the Student-Newman-Keuls (SNK) stepwise multiple range test was calculated (Sokal and Rohlf 1981) to determine between which of the six stations differences occurred. For all six metals examined, station 163 contained significantly ($p=0.05$) greater ambient concentrations than any other site (Table 7).

The dissolved fraction of metals has long been implicated as being the most toxic form to aquatic life. This has been demonstrated by toxicity tests (Shaw and Brown 1974; Howorth and Sprague 1978; Carlson unpublished data) and several treatments of species equilibrium models (Pagenhopf et al. 1974; Andrew et al. 1977; McCrady and Chapman 1979; Chapman unpublished data). These models correlate metal toxicity with the free ion concentrations as well as the presence of carbonate (CO_3^{--}) or hydroxide (OH^-) molecular forms.

Ambient total and dissolved metal concentrations were compared for key metals at all stations in Leon Creek (Table 8). A sizable percentage (84-100%)

TABLE 6. SIGNIFICANCE LEVELS OF BARTLETT'S TEST, ANOVA F-RATIOS, AND KRUSKAL-WALLIS ANOVA BY RANKS FOR TEST OF DIFFERENCES BETWEEN STATIONS FOR AMBIENT TOTAL METAL CONCENTRATIONS, LEON CREEK, TEXAS.

Total Metal	Bartlett's	ANOVA	Kruskal-Wallis
Cadmium	NS	***	
Chromium	*		**
Arsenic	NS	***	
Copper	NS	***	
Lead	NS	***	
Silver	NS	***	

* p=0.05
** p=0.01
*** p=0.001

of total metal concentrations occurred in the dissolved fraction at all stations except 164, with a much smaller fraction sorbed or chelated by suspended particulate matter. At Station 164, the dissolved metal fraction was much lower for all metals examined except copper, ranging from 0-64% of the total. Increased mean concentrations of nonfilterable residues (from 40 mg/l at Station 161 to 130 mg/l at station 163) and suspended particulate matter in the discharge probably account for lower dissolved metal concentrations in the water column at this point.

It should be noted that in some cases, mean dissolved metal concentrations apparently exceed mean total metals (Table 8). This anomaly generally occurs 1) when metal concentrations such as cadmium and lead, are near or below instrument detection limits, or 2) when confidence intervals around the dissolved and total metal means are overlapping, indicating there is no

TABLE 7. STUDENT-NEWMAN-KEULS STEPWISE MULTIPLE RANGE TEST (SNK) OF AMBIENT TOTAL METAL CONCENTRATIONS, LEON CREEK, TEXAS. Nonsignificant ($p=0.05$) subsets of group means are indicated by horizontal lines.

	Stations				
	Control	Impact		Recovery	
Metal	161	162	163	164	165
Arsenic					
$\bar{x}$ (μg/l)	85.4	65.7	363.2	145.6	129.5
SNK					
Cadmium					
$\bar{x}$ (μg/l)	6.8	4.2	28.3	6.2	4.0
SNK					
Chromium					
$\bar{x}$ (μg/l)	4.7	13.5	63.8	3.2	*
SNK					
Copper					
$\bar{x}$ (μg/l)	14.7	28.2	57.8	3.0	2.0
SNK					
Lead					
$\bar{x}$ (μg/l)	157.7	45.3	262.2	136.0	96.0
SNK					
Silver					
$\bar{x}$ (μg/l)	46.0	34.5	102.8	16.0	7.5

*Total chromium ambient data missing at this site.

TABLE 8. MEAN TOTAL AND DISSOLVED CONCENTRATIONS OF SELECTED METALS (µg/l) (grab samples only) AT EACH STATION IN LEON CREEK, TEXAS. Numbers enclosed in parentheses are 95% confidence intervals.*

	Station				
	161	162	163	164	165
Hardness (mg/l)	383	247	253	300	410
	Silver (Detection Limit = 12)				
Total	46.0 (18.8)	34.5 (27.7)	102.8 (32.6)	16.0 (7.7)	7.5 (18.9)
Dissolved	48.2 (17.0)	40.2 (10.5)	106.2 (18.3)	7.0 (17.9)	10.0 (0)**
% Dissolved	100	100	100	44	100
	Cadmium (Detection Limit = 7.5)				
Total	6.8 (1.9)	4.2 (4.2)	28.3 (2.9)	6.2 (2.1)	4.0 (0)
Dissolved	8.3 (2.0)	12.5 (2.0)	34.7 (4.1)	2.5 (2.8)	4.2 (1.6)
% Dissolved	100	100	100	40	100
	Lead (Detection Limit = 120)				
Total	157.7 (37.5)	45.3 (21.4)	262.2 (52.9)	136.0 (42.7)	96.0 (46.0)
Dissolved	163.0 (39.2)	111.3 (38.9)	323.5 (40.6)	87.6 (53.6)	135.7 (32.0)
% Dissolved	100	100	100	64	100
	Arsenic (Detection Limit = 110)				
Total	85.4 (38.0)	65.7 (143.1)	363.2 (144.8)	145.6 (76.6)	129.5 (175.0)
Dissolved	83.0 (77.3)	127.6 (93.0)	443.0 (93.6)	77.4 (36.2)	118.5 (71.0)
% Dissolved	97	100	100	53	92
	Chromium (Detection Limit = 5)				
Total	4.7 (1.6)	13.5 (4.5)	63.8 (3.4)	3.2 (0.5)	NS
Dissolved	6.2 (1.7)	11.3 (1.6)	56.8 (3.5)	0**	NS
% Dissolved	100	84	89	0	
	Copper (Detection Limit = 11)				
Total	14.7 (4.4)	28.2 (3.0)	57.8 (3.9)	3.0 (5.0)	2.0 (8.7)
Dissolved	19.8 (4.7)	32.0 (3.8)	66.5 (7.0)	3.2 (1.6)	5.0 (4.2)
% Dissolved	100	100	100	100	100

*Confidence intervals that overlap indicate total and dissolved metal mean concentrations are not significantly ($p=0.05$) different.
**Based on only two data points. All other means based on three or more analytical replicates.

significant (p=0.05) difference between them.

Except for chlorine, the remaining general water quality parameters (e.g., pH, conductivity) were at levels within the expected range for natural southwestern streams (Appendix A). Reported chlorine values, however, are high, ranging from 30-80 times above the EPA recommended criterion. These high values are even reported for the control zone which receives minimal pollution impact and contains aquatic biota representative of a diverse and healthy community. This apparent anomaly may be attributable to field measurement techniques rather than actual elevated chlorine values in the area. This methodology is currently being reevaluated at EMSL-LV by comparisons of data from a Hach chlorine kit and standard EPA chemical analysis procedures (U.S. EPA 1979b).

Sediments

Kruskal-Wallis one-way analysis of variance by ranks was performed to test differences between stations for 10 metals in sediment samples. When ANOVA f-ratios indicated significant differences (p=0.05) in metal concentrations, the SNK multiple range test was calculated to determine between which of the five stations differences occurred (Table 9).

ANOVA f-ratios indicated significant differences (p = 0.05) between stations based upon mean sediment (lead, silver, aluminum, and selenium) concentrations. The data indicated no significant differences between stations in mean sediment concentrations of cadmium, copper, nickel, zinc, chromium, and arsenic.

The SNK tests for lead, silver, aluminum, and selenium in the sediments

TABLE 9. STUDENT-NEWMAN-KEULS STEPWISE RANGE TEST (SNK) OF MEAN TOTAL CONCENTRATIONS OF SELECTED METALS IN SEDIMENT SAMPLES, LEON CREEK, TEXAS. Statistically nonsignificant (p=0.05) subsets of group means are indicated by horizontal lines.

	Stations				
	Control	Impact		Recovery	
Metal	161	162	163	164	165
Lead					
$\bar{x}$ (mg/kg)	237.6	663.0	1057.1	910.4	155.9
SNK					
Aluminum					
$\bar{x}$ (mg/kg)	13942.2	12152.8	6896.3	8982.5	6531.1
SNK					
Selenium					
$\bar{x}$ (mg/kg)	11.7	17.8	44.1	0.3	0.3
SNK					
Silver					
$\bar{x}$ (mg/kg)	1.9	28.7	122.2	33.4	2.1
SNK					

did not reveal consistent up- to downstream patterns of distribution, although Station 163 sediments tended to contain significantly higher metal concentrations than did the control site. A possible explanation for the inconsistency observed is that metal concentrations in the sediments of Leon Creek are of sufficient magnitude to have saturated the sediments. A steady-state system may exist which is not affected by the relatively small additional input of metals from Kelly AFB. Metal saturation could result from continuous nonpoint discharges into Leon Creek upstream from the control site (161), including possible runoff from a hazardous waste disposal site, and from storm drains near roads and freeways.

BIOLOGICAL

Macroinvertebrates

There were 49 macroinvertebrate taxa collected in Leon Creek during the 1980 fall sampling effort (Table 10). Benthic populations were compared at all stations (Appendix B) throughout the river to assess the impact of elevated metal concentrations and organic pollutants on biological communities in Leon Creek below Kelly AFB.

Upstream Control Station (161)

Aproximately 60% (28 taxa) of the total taxa found in Leon Creek were collected at the control site (Table 10). Specimens from the six mayfly genera found in the river were reported at this station, including one mayfly, *Isonychia* sp., not found at any other site. Three other genera (*Rhagovelia* sp., *Hyalella azteca*, and *Cheumatopsyche* sp.) were also only collected at this site. Macroinvertebrate populations at the control site (Figure 3) were

TABLE 10. DISTRIBUTION AND RELATIVE ABUNDANCE OF MACROINVERTEBRATE TAXA, NOVEMBER 1980, LEON CREEK, TEXAS. A=Abundant (61-100%), VC=Very Common (31-60%), C=Common (6-30%), O=Occasional (1-5%), R=Rare (<1%).

Taxa	Stations 161	162	163	164	165
Ephemeroptera					
Siphlonuridae					
Isonychia sp.	R				
Leptophlebiidae					
Paraleptophlebia sp.	R				R
Baetidae					
Baetis sp.	C				O
Tricorythidae					
Tricorythodes sp.	R				O
Leptohyphes sp.	R				R
Caenidae					
Caenis sp.	O				R
Odonata					
Gomphidae					
Ophiogomphus sp.	R			R	O
Libellulidae					
Brechmorhoga mendax					R
Calopterygidae					
Hetaerina sp.					R
Coenagrionidae					
Argia sp.	O			O	C
Megaloptera					
Corydalidae					
Corydalus sp.					O
Hemiptera					
Gerridae					
Gerris sp.					
Veliidae					
Rhagovelia sp.	R				
Trichoptera					
Hydropsychidae					
Hydropsyche sp.					R
Cheumatopsyche sp.	O				
Smicridea fasciatella	R			R	C
Hydroptilidae					
Hydroptila sp.	O		R	O	R
Leucotrichia sp.					R
Alisotrichia sp.					R
Helicopsychidae					
Helicopsyche sp.	R			R	O

continued

TABLE 10. Continued

Taxa	Stations 161	162	163	164	165
Diptera					
Chironomidae					
Tanypodinae	O	R	R	O	O
Chironominae	C	R	R	C	C
Orthocladiinae	C	O	O	C	C
Simuliidae					
Simuliium sp.				R	R
Ceratopogonidae					
Palpomyia sp.	R			R	
Atrichopogon sp.				R	
Empididae				R	
Lepidoptera					
Pyralidae					
Parargyractis sp.	O			R	O
Coleoptera					
Elmidae					
Microcylloepus pusillus lodingi	R		R	R	O
Heterelmis vulnerata	R				C
Stenelmis sp.	C		R	C	O
Stenelmis crenata				R	
Elsianus texanus					R
Dryopidae					
Helichus sp.					R
Psephenidae					
Psephenus sp.	R			R	R
Hydracarina					
Sperchonidae					
Sperchon sp.					R
Hydrobatidae					
Atractides sp.					R
Amphipoda					
Talitridae					
Hyalella azteca	O				
Nephropsidea					
Astacidae	R	R	R	R	R
Turbellaria	R	R	R	R	
Nematoda	R				R

continued

TABLE 10. Continued

Taxa	Stations 161	162	163	164	165
Oligochaeta	0	A	A	C	0
Hirudinea	0			0	
Gastropoda					
Planorbidae					
Ferrissia sp.				0	R
Helisoma/*Gyraulus* complex		R	R	R	
Physidae					
Physa sp.		R			R
Pelecypoda					
Sphaeriidae					
Sphaerium sp.			R	R	
Corbiculidae					
Corbicula fluminea				0	

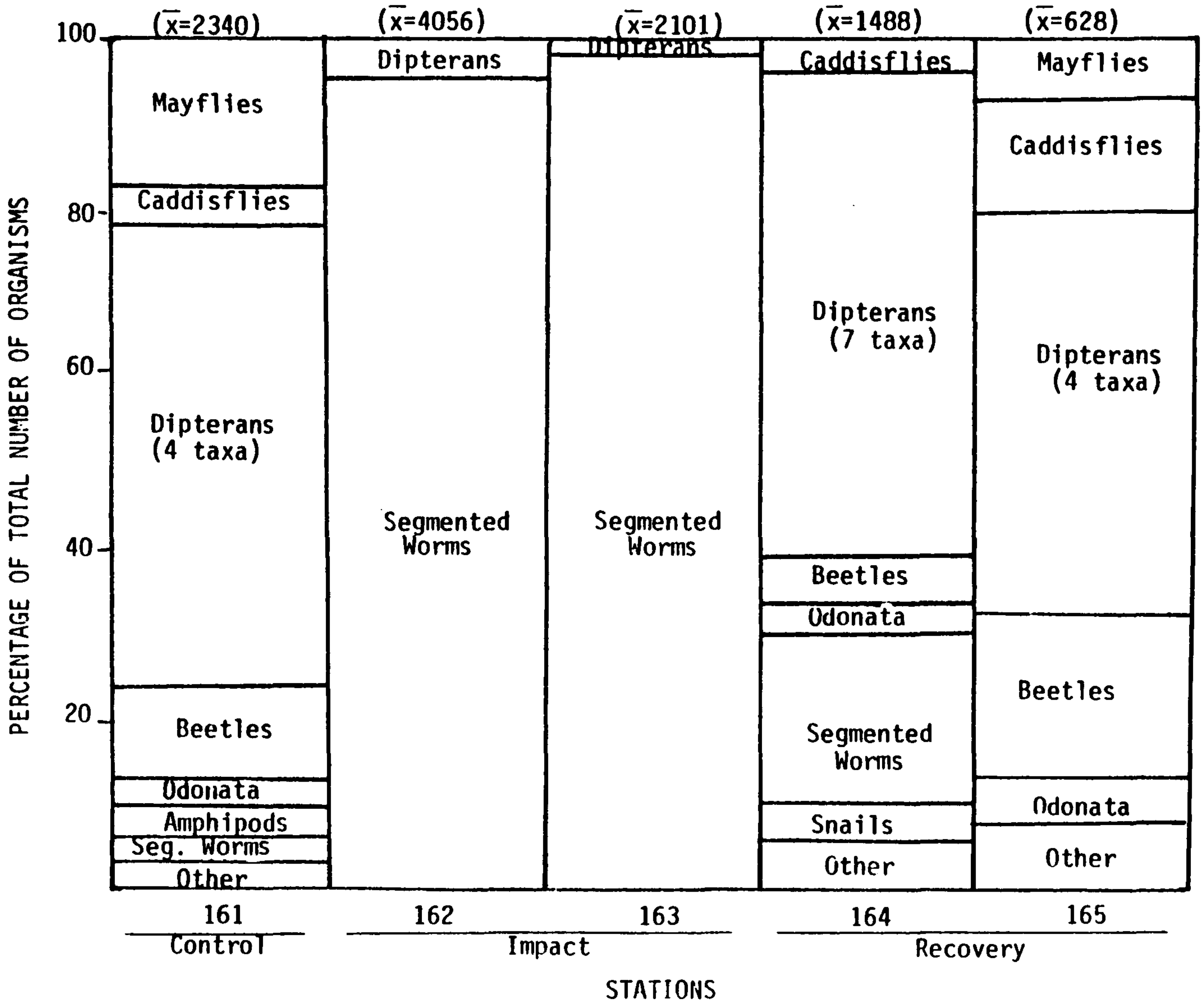


Figure 3. Percent composition of major macroinvertebrate groups at stations in Leon Creek, Texas. (Numbers at the top of each station indicate mean number of organisms per replicate sample.)

numerically dominated by dipterans, primarily chironomid midges.

A one-way ANOVA was used to test differences between stations using macroinvertebrate standing crop, species richness, and Shannon-Wiener diversity (Southwood 1978). Patterns of differences between stations were tested using SNK multiple range procedure (Sokal and Rohlf 1981). The control zone station was significantly different (p=0.05) with respect to total number of taxa and diversity among the two impact zone sites (162 and 163) and the furthest downstream recovery zone station (165), but not significantly different from the first recovery zone station (164) (Table 11). Standing crop was not significantly different among stations except for the first impact zone site (162), which had significantly (p=0.05) higher counts than the other sampling locations. It should be noted that diversities used in calculating the ANOVAs and SNKs were based upon midge taxonomy only to the subfamily level.

Impact Zone (Stations 162 and 163)

Total invertebrate numbers at the first impact site were almost double those in the control zone (Table 11 and Figure 4). However, species richness at both impact stations decreased to one-thirds of the control. Further, more than 95 percent of the total number were oligochaetes. Oligochaetes were not identified below class level. Nevertheless, cursory examination of the samples from the impact zone revealed the vast majority of the oligochaete population to be Tubificidae. There were no mayfly or dragonfly/damselfly species collected in the impact zone. No caddisflies or aquatic beetles were found at the upstream impact station (162), and, in fact, Station 162 was the only site in the river where two species of elmid beetles (*Microcylloepus pusillus lodingi* and *Stenelmis* sp.) and one caddisfly species (*Hydroptila* sp.) were not collected. The few dipterans collected in the impact zone were primarily orthoclad midges.

TABLE 11. STUDENT-NEWMAN-KEULS STEPWISE MULTIPLE RANGE TEST (SNK) OF MACROINVERTEBRATE MEAN TOTAL COUNTS (STANDING CROP), MEAN NUMBER OF TAXA (SPECIES RICHNESS), AND SHANNON-WIENER DIVERSITY INDICES AT EACH STATION IN LEON CREEK, TEXAS. Nonsignificant (p=0.05) subsets of group means are indicated by vertical lines.

		Mean Total Count		Mean # of Taxa		Diversity	
	Station	$\overline{x}$	SNK	$\overline{x}$	SNK	$\overline{x}$	SNK
Upstream Control Zone	161	2340.0		23.0		3.2193	
Impact Zone	162	4056.0		7.3		0.3390	
	163	2101.3		7.3		0.2653	
Recovery Zone	164	1488.0		21.0		3.0577	
	165	628.0		28.7		3.5383	

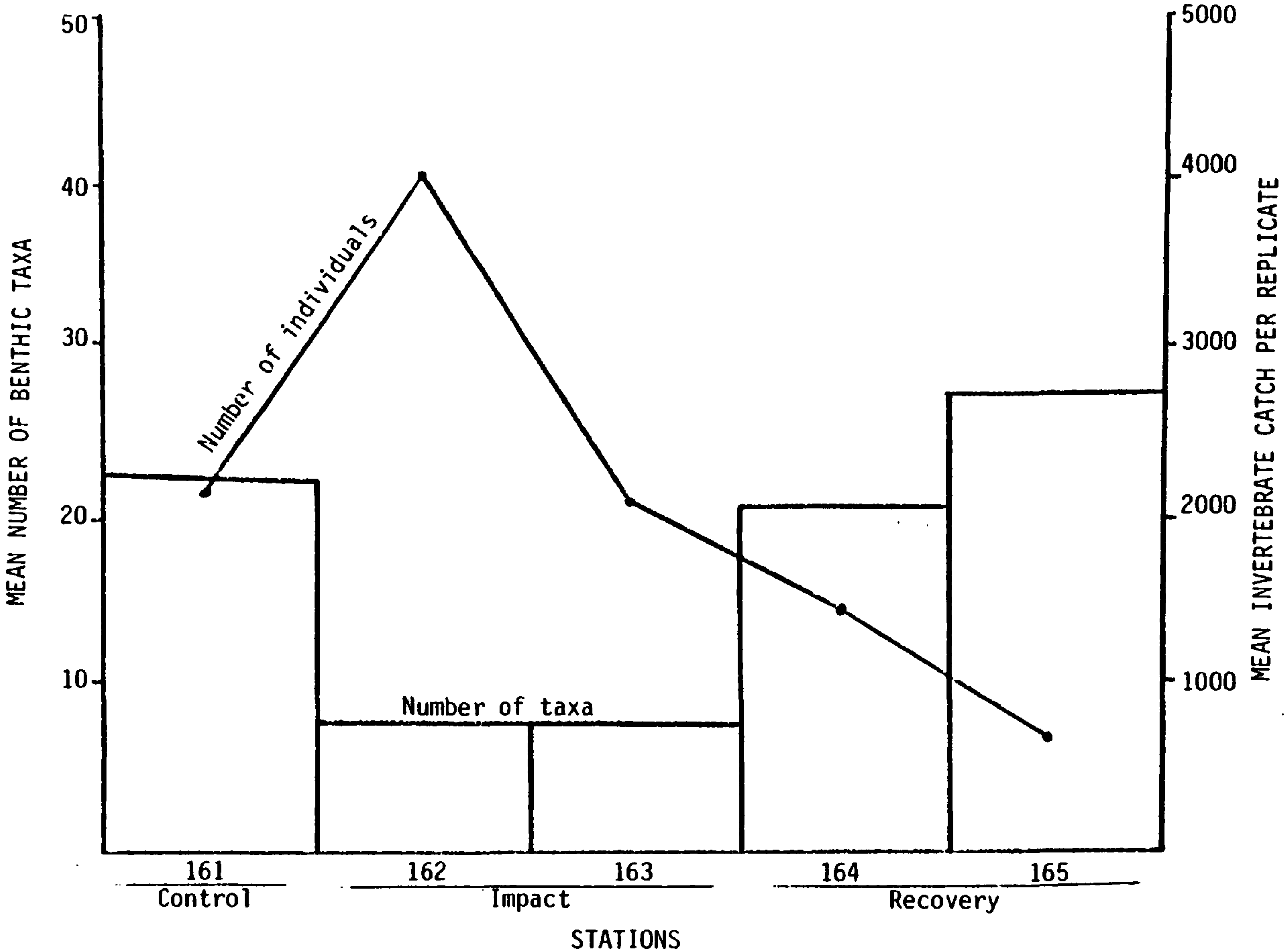


Figure 4. Mean number of benthic taxa and mean count per replicate at all stations, Leon Creek, Texas.

Both stations in the impact zone were significantly (p=0.05) different with respect to total number of taxa and species diversity than any other site in the river, but not significantly different from one another (Table 11).

Recovery Zone (Stations 164 and 165)

Mayflies did not reappear at the first recovery zone station (164) and oligochaetes were still common (18% of total counts); in other respects, the taxonomic distribution of macroinvertebrates greatly resembled that found in the upstream control site. Midges remained numerically dominant. Several additional dipteran species were found at Station 164 that had not been collected upstream, including the biting fly, Atrichopogon sp., and members of the family Empididae, which were not found at any other site in the river. The clam, Corbicula fluminea, was also collected only at this site.

Station 165, located nine miles downstream from the Kelly AFB discharge, was more diverse than the control site. There were 34 taxa here, 10 of which were not collected at any other site. Five of the six mayfly genera collected upstream were found. Mean organism counts per replicate were only one-quarter those of the control. Turbellarians were collected at every station in the river except for Station 165.

Chironomid midges (all three subfamilies), crawfish (Astacidae), and oligochaetes were the only taxa collected at every station in Leon Creek. A number of taxa, including Ophiogomphus sp., Argia sp., Smicridae fasciatella, Helicopsyche sp., Paragyractis sp., and Psephenus sp., reappeared at both recovery zone stations after disappearing in the impact zone. Leeches (Hirudinea) were found both in the control and upstream recovery zone sites, but were absent in the impact zone and downstream recovery stations.

Caution must be used, however, in interpreting these distributions since they only represent a single sampling round. For example, preliminary data (Miller and Melancon, unpublished data) from macroinvertebrate samples collected during September 1981 in Leon Creek showed a much higher species diversity in the impact zone (Station 162) than was observed during 1980. Furthermore, these 1981 samples at Station 162 were numerically dominated by orthoclad midges and Physa snails, not by oligochaetes as was so striking during 1980. These differences are not necessarily surprising considering such factors as seasonality, changing physical/chemical and discharge conditions, and the spatial patchiness of macroinvertebrates. They do illustrate, however, the need to establish baseline data, with at least seasonal macroinvertebrate collections, when using biological parameters for impact monitoring.

Changes in the 1980 benthic species composition were also compared to mean concentrations of trace metals in Leon Creek. The literature describes a number of environmental factors which influence trace metal toxicity to aquatic organisms (Tabata 1969; Karbe et al. 1975; LaBounty et al. 1975; Luoma and Bryan 1978). Included among those factors are: the concentration, valence, and form in which metals exist in the water column; exposure duration of the animal; stream discharge and flow velocity; chemical characteristics of the water, especially hardness, pH, and dissolved oxygen; and the nature, condition, and life stage of the organism. Some organisms are especially sensitive to elevated concentrations of metals, for example, oligochaetes, leeches, crustaceans, and mollusks (Brinkhurst 1965; Hynes 1965; LaBounty et al. 1975) while others are more tolerant, although relative toxicity of metals to aquatic insects varies widely with differing taxa (Warnick and Bell 1969; Phillips and Russo 1978).

In Leon Creek, the impact zone silver, cadmium, and chromium concentrations increased to several times above EPA acute water quality criteria recommended for local aquatic life based upon water hardness (Table 4). These increases correlate (Spearman-Rank r_s=0.87; Siegel 1956) to the decrease in mean number of benthic taxa (Figure 5), although because of small sample size the correlation is not statistically significant. Increased metal concentrations also correlate (r_s=0.7-0.9) with increased total invertebrate counts. This is of particular importance considering that elevated invertebrate numbers in the 1980 impact zone samples are primarily due to tubificid oligochaetes. The literature contains many examples of oligochaetes found in abundance below sources of organic pollution (Brinkhurst 1964; Brinkhurst 1965; Brinkhurst and Kennedy 1965; Aston 1973). Tubificid worms contain red blood pigments and can survive and reproduce in very low oxygen tensions for considerable periods of time, while predators (e.g., leeches, bottom-dwelling fish) and competitors may be eliminated. Goodnight and Whitely, working in midwestern streams, have built a pollution index system based on the percentage of tubificids in a total population (in Aston 1973). In their system, benthic communities with more than 80 percent tubificids indicated a high degree of organic enrichment or industrial pollution. Oligochaetes are typically highly sensitive, however, to poisonous metals (Brinkhurst 1965). These data, when analyzed with respect to ambient oxygen and nutrient levels in Leon Creek, suggest that during 1980, metals may have affected the aquatic biota less than organic pollutants. However, there are some anomalies. For example, the common caddisflies *Hydropsyche* sp. and *Cheumatopsyche* sp. have been reported to be tolerant to low dissolved oxygen and elevated nutrient concentrations (Roback 1965; Klotz 1977). These genera were collected in Leon Creek but were not found in the impact zone, suggesting metal concentrations may be toxic to them. Field notes indicate a similar substrate (cobble riffle) and flow for all stations; therefore, the

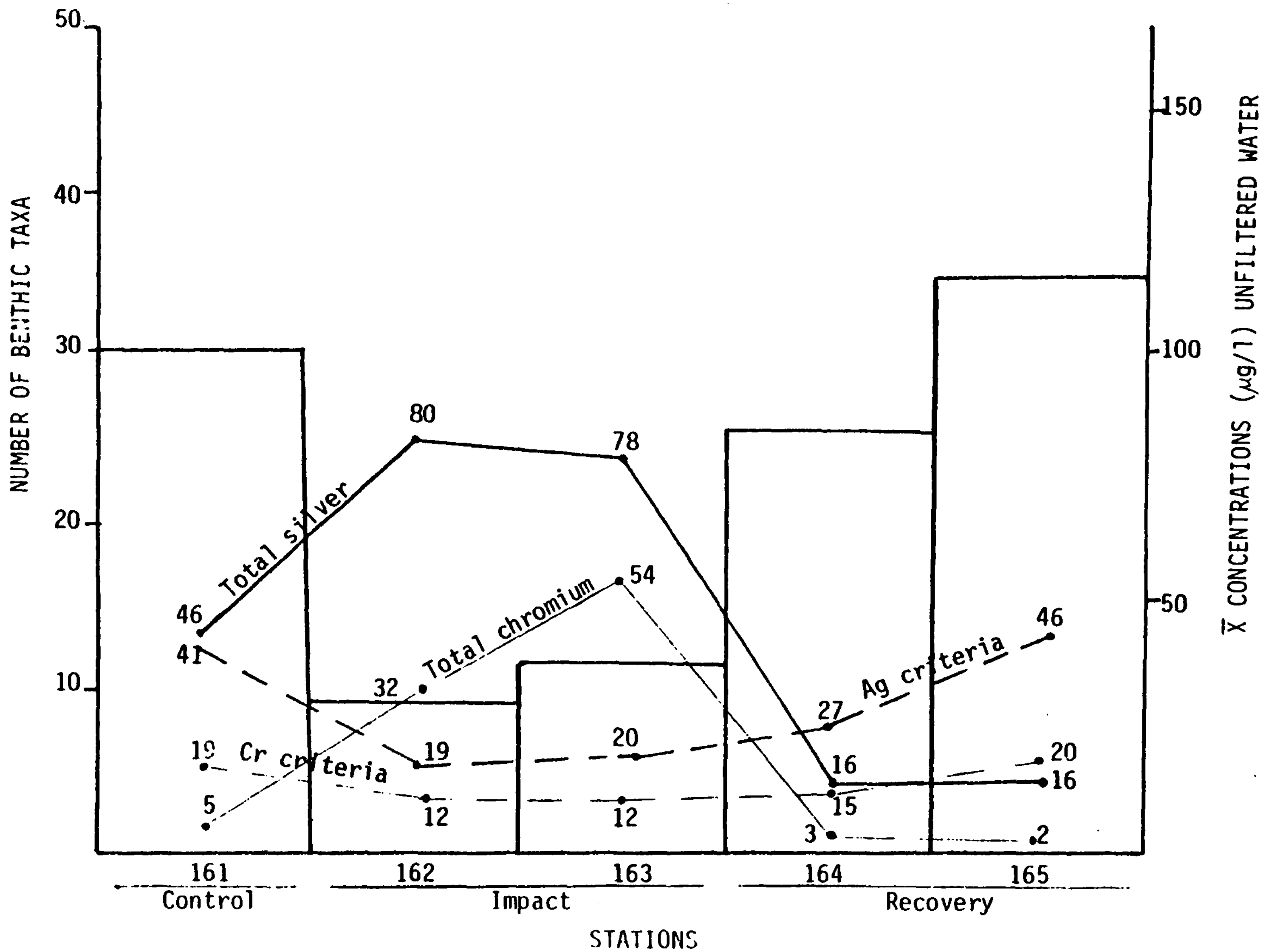


Figure 5. Comparison of benthic species richness in Leon Creek, Texas, mean concentrations of total chromium and silver, and calculated chromium and silver water quality criteria.

absence of expected species may relate more to chemical characteristics than to physical differences between stations. Some mayfly species are highly sensitive to elevated silver concentrations (Nehring 1976: reported in Herricks and Buikema 1977); this may partially account for the total absence of mayflies.

Plants

Periphyton

The periphyton community is an important component of the biological structure of a stream and has been isolated as one of the better monitors of water quality and stream conditions (Weitzel 1979). Periphyton is defined as the assemblage of plants attached to or found growing on a substrate (Weitzel 1979). Terms used to describe the type of substrate include:

Epilithic - growing on rocks
Epipelic - growing on mud or sediments
Epiphytic - growing on plants
Epizoic - growing on animals
Epidendric - growing on wood
Epipsammic - growing on sand surfaces

The periphyton community may contain a vast number of species including diatoms, blue-greens, and green algae. A diatom community may consist of three to four hundred species living together in a relatively small area at any point in time in the benthos of unpolluted streams (Patrick 1978).

Healthy streams usually have high species numbers, each with relatively small populations. A stream perturbation, such as toxic metal pollution, may alter community composition. Change may be expressed in several ways: species richness, number of individuals, or kinds of species. Metal pollution may reduce species diversity and increase total algal abundance, with a few species becoming extremely common (Miller et al 1982). Shifts in species composition from diatoms to filamentous greens or unicellular greens and blue-green algae have also been reported (Patrick 1949). The types of shifts are dependent upon the effects of various kinds of pollution (Patrick 1977).

Diatom tolerance to heavy metals include strains ranging from sensitive to very resistant. Metal resistance of only a few algae have been studied both in the laboratory and in the field (Whitton and Say 1975). Results of these studies have not been consistent. For example, a laboratory study of *Nitzschia palea* (Steemann-Nielsen and Wium-Anderson 1970) indicated that this diatom is very sensitive to soluble copper in the absence of any chelating agent. However, Palmer (1977) included it in a list of tolerant species 'indicative' of copper pollution. Since many environmental factors other than metal concentrations may influence a given habitat, heavy metals could be considered to restrict species distributions but not to define them (Foster 1982).

Diatoms are also useful indicators of water quality for the following reasons:

1. With their secure means of attachment to substrates, diatoms may be less subject to drift than invertebrates and are good indicators of conditions at collection locations.

2. A short generation time allows diatoms to better reflect conditions

immediately prior to sampling, instead of integrating long-term effects.

3. Diatoms mounts may be stored for many years, permitting re-examination at any later time.

4. Diatoms are ubiquitous on stream bottoms.

5. They are easy to collect in sufficient quantity to meet statistical requirements.

6. Diatoms have a wide and well documented (Lowe 1974) range of environmental requirements and pollution tolerances for many taxa.

Diatoms dominated the periphyton assemblage (Appendix C) in Leon Creek both in number of taxa and cell abundance during the period sampled from November 5-8, 1980 (Figure 6). One hundred and one diatom taxa (Bacillariophyceae) were identified (Table 12). The environmental requirements of the important taxa are presented in Table 13. Greens (Chlorophyta) and blue-greens (Cyanophyta) were less common, contributing ten and two taxa, respectively (Table 14). Representatives of Euglenophyta (euglenoids), Pyrrhophyta (dinoflagellates), and Cryptophyta (cryptomonads) were also observed in low numbers and with few representatives. This assemblage, however, may not be indicative of periphyton composition during other seasons since the algal community undergoes seasonal change in composition and abundance.

A comparison of control, impact, and recovery zone stations follows:

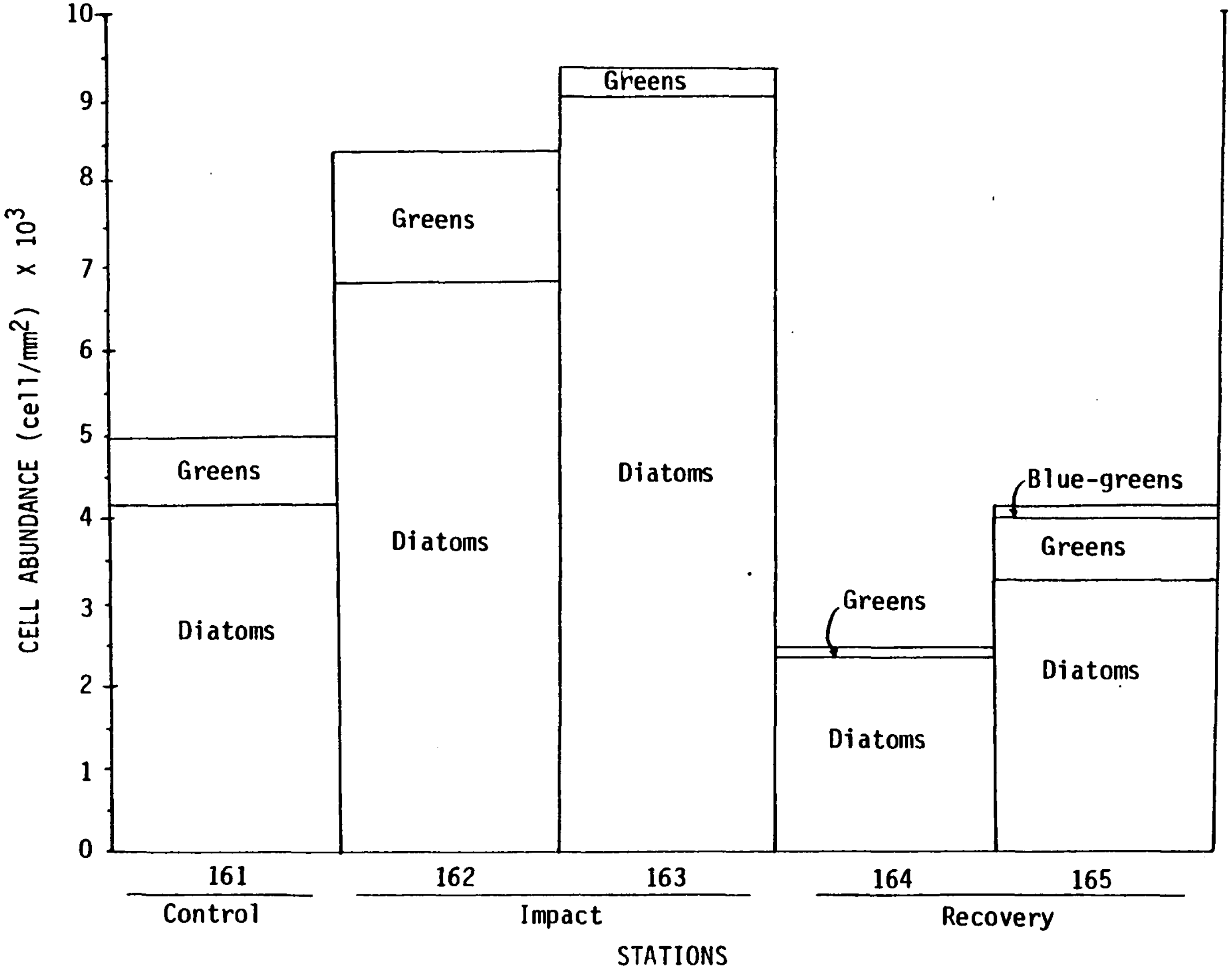


Figure 6. Periphyton cell abundance and algal group composition in Leon Creek, Texas.

TABLE 12. LIST OF DIATOM TAXA AND RELATIVE ABUNDANCE IN LEON CREEK, TEXAS. A=Abundant (61-100%), VC=Very Common (31-60%), C=Common (6-30%), O=Occasional (1-5%), and R=Rare (<1%).

	Stations				
	Control	Impact		Recovery	
Taxa	161	162	163	164	165
Bacillariophycae					
Centrales					
Biddulphia laevis				C	O
Cyclotella meneghiniana	R	R	R	R	R
Cyclotella stelligera	R	R	O		R
Cyclotella pseudostelligera		R	O		
Melosira varians	R	R		O	
Thallassiosira fluviatillis	R			O	O
Terpsinoe americana			R	O	VC
Fragilariaceae					
Fragilaria spp.			O		
Fragilaria brevistrata					R
Synedra rumpens	R				
Synedra ulna		C			R
Synedra ulna var. oxyrhynchus f. medio-contracta	R	O		C	C
Synedra ulna var. contracta			R		
Synedra gallonii				O	
Eunotiaceae					
Eunotia pectinalis		R			
Eunotia naegelii	R				
Achnanthaceae					
Achnanthes lanceolata			R	R	
Achnanthes minutissima	O		R	O	
Achnanthes affinis	R				
Cocconeis placentula			R		
Cocconeis placentula var. euglypta	R			O	C
Cocconeis placentula var. lineata					R
Naviculaceae					
Amphipleura pellucida	R				
Diploneis spp.		R		R	
Diploneis elliptica			R		
Diploneis oblongella					R

continued

TABLE 12. Continued

	Stations				
	Control	Impact		Recovery	
Taxa	161	162	163	164	165
Naviculaceae (Cont.)					
Gyrosigma spp.	R			R	
Gyrosigma nodiferum	0				
Gyrosigma obscurum	R				
Navicula spp.	R	R	0		R
Navicula rhynchocephala			R	0	R
Navicula tripunctata var. *schizomoides*			R	R	0
Navicula pupula		R	0		
Navicula pupula var. *rectangularis*					0
Navicula cryptocephala	R		0	R	0
Navicula cryptocephala var. *veneta*	R	R			
Navicula minima		R	R	R	
Navicula subminuscula		R	R	C	0
Navicula gastrum	R			R	
Navicula graciloides	C		R	C	0
Navicula symmetrica	R			R	R
Navicula mutica var. *tropica*	C	R	R		R
Navicula confervacea	0	C		R	
Navicula heufleri var. *leptocephala*				R	
Navicula notha	0				
Navicula pygmaea			0		R
Navicula secreta var. *apiculata*	R				
Navicula mutica var. *stigma*	R	0	C	0	
Navicula viridula var. *rostellata*	R				
Navicula sanctaecrucis	0		0	0	C
Navicula cuspidata			R	R	R
Navicula tenera				R	0
Pinnularia spp.	R		R		
Pinnularia abaujensis				R	
Pinnularia biceps	R		R		
Pleurosigma delicatulum	R				

continued

TABLE 12. Continued

	Stations				
	Control	Impact		Recovery	
Taxa	161	162	163	164	165
Gomphonemaceae					
Gomphonema parvulum	C	R		0	0
Gomphonema subclavatum var. *mexicanum*	C			C	R
Gomphonema subclavatum	R				
Gomphonema brasiliense	0		C	0	R
Gomphonema tenellum					0
Cymbellaceae					
Amphora spp.				R	R
Amphora ovalis	0			0	
Amphora ovalis var. *pediculus*			R		
Amphora coffeiformis				0	
Cymbella spp.					R
Cymbella minuta	0	R			
Cymbella minuta var. *pseudogracilis*	R				
Cymbella sinuata			R		
Nitzschiaceae					
Bacillaria paradoxa	0	R	R	0	
Hantzschia amphioxys		R			
Nitzschia spp.	0	R	0	R	
Nitzschia dissipata	0	0		R	
Nitzschia frustulum var. *perpusilla*				R	
Nitzschia hantzschiana		R	R		
Nitzschia palea	R	VC	C	R	
Nitzschia fonticola		R	0		
Nitzschia amphibia	C	0	C	C	0
Nitzschia hungarica	0	R		R	R
Nitzschia ignorata		0	R		
Nitzschia filiformis			0		
Nitzschia faciculata	R				
Nitzschia tryblionella var. *levidensis*	R			R	R
Nitzschia tryblionella var. *debilis*		R	0		
Nitzschia elliptica		R		R	
Nitzschia kutzingiana		0	C		0

continued

TABLE 12. Continued

	Stations				
	Control	Impact		Recovery	
Taxa	161	162	163	164	165
Nitzschiaceae (Cont.)					
Nitzschia capitellata			C	R	R
Nitzschia accedens			R		
Nitzschia obtusa var. *scalpelliformis*	R	0	0	R	0
Nitzschia lorenziana			R	R	0
Nitzschia sigma	R				
Nitzschia tryblionella var. *victoriae*	R				
Nitzschia apiculata	0			0	
Nitzschia gandersheimiensis	R				
Nitzschia hybrida	R				
Surirellaceae					
Cymatopleura solea				R	
Surirella angustata	R	R		R	R
Surirella ovalis	0				
Surirella robusta			R	R	
Surirella suecica				0	
Surirella ovata var. *crumena*				R	

TABLE 13. REPORTED ENVIRONMENTAL REQUIREMENTS, INCLUDING pH RANGE AND HEAVY METAL TOLERANCE OF THE IMPORTANT DIATOM TAXA OBSERVED IN LEON CREEK, TEXAS.

Taxa	Distribution and Environmental Requirements
Biddulphia laevis Ehr.	Fresh to brackish water form (Lowe 1974); restricted to waters of moderately high conductivity and alkalinity (Czarnecki and Blinn 1978). pH requirements: optimum over 8.5; occurring at pH around 7 (Lowe 1974).
Cocconeis placentula Ehr.	Cosmopolitan; calcium indifferent; characteristic of waters that have not been exposed to pollutants to zones where oxidation of organic load is proceeding (Lowe 1974); tolerant to phenolic wastes (Palmer 1977); characteristic of slow moving water (Hostetter and Stoermer 1968). pH requirements: range 4.7-8.0 (Lowe 1974); optimum 8.0.
Gomphonema brasiliense Grun.	Seems to prefer warm water of moderate conductivity (Patrick and Reimer 1975). pH requirements: circumneutral.
Gomphonema parvulum Kütz.	Cosmopolitan; a facilitative nitrogen heterotroph; calcium and iron indifferent (Lowe 1974); eutrophic species (Symoens 1957); attains high abundances in running waters below effluents of organic wastes (Backhaus 1968); characteristic of excessively polluted "polysaprobic" water (Lange-Bertalot 1979). pH requirements: range 4.2-9.0 (Lowe 1974); optimum 7.8-8.2.
Navicula confervacea (Kütz.) Grun.	Seems to prefer soft to warm water (Patrick and Reimer 1966). pH requirements: range 5.0-8.4 (Lowe 1974); optimum 8.4.
Navicula graciloides A. Mayer	Prefers fresh to slightly brackish water (Czarnecki and Blinn 1978). pH requirements: circumneutral (Patrick and Reimer 1966).
Navicula sanctaecrucis Ostr.	Slightly brackish water or fresh water with very high mineral content (Patrick and Reimer 1966).
Navicula mutica var. stigma Patr.	Temperate water form, usually occurring between 15° and 30°C (Patrick and Reimer 1966).

continued

TABLE 13. Continued.

Taxa	Distribution and Environmental Requirements
Nitzschia amphibia Grun.	Facultative nitrogen heterotroph; tolerates small amounts of salt; occurring over a temperature range from 0° to 30°C (Lowe 1974); can exist with high reproductive rates in heavily polluted "*alpha-mesosaprobic" waters (Lange-Bertalot 1979). pH requirements: range 4.0-9.3 (Lowe 1974); optimum slightly greater than 8.5.
Nitzschia capitellata Hust.	Fresh to brackish water form (Hustedt 1930); obligate nitrogen heterotroph (Lowe 1974). pH requirements: range 7.0-9.2 (Lowe 1974); optimum 7.3-7.8.
Nitzschia kutzingianum Hilse	pH requirements: range 6.4-8.4 (Lowe 1974); optimum 7.5-7.8.
Nitzschia palea (Kütz) W. Smith	Cosmopolitan; a very good indicator of pollution, an obligate nitrogen heterotroph; euryoxybiont, calcium indifferent; tolerates a wide span of ecological conditions; occurring over a temperature range from 0° to 30°C (Lowe 1974); tolerant of excessively polluted "*polysaprobic" waters (Lange-Bertalot 1979). pH requirements: range 4.2-9.0 (Lowe 1974); optimum 8.4. Heavy metal tolerance: tolerates relatively large amounts of copper (1.5 mg/l) and chromium (Schröder 1939 and Blum 1957).
Synedra ulna (Nitz.) Ehr.	Cosmopolitan; great ecological span; prefers dirty water; calcium indifferent; unsuitable as an ecological indicator (Lowe 1974). pH requirements: range 5.7-9.0 (Lowe 1974); optimum 7-8 (Cholnoky 1968). Heavy metal tolerance: Fairly resistant to 1 mg/l Zn but killed by 2 mg/l Zn (Williams and Mount 1965).
Synedra ulna var. oxyrhnchus Kütz.	pH requirements: range 6.6-7.9 (Lowe 1974).
Terpsinoe americana (Bailey) Ralfs.	Marine, brackish and fresh water form (Boyer 1927).

* alpha-mesosaprobic; BOD less than 13 mg/l oxygen, and less than 75 percent oxygen deficit.

polysaprobic; BOD greater than 22 mg/l oxygen, and oxygen deficit greater than 90 percent.

TABLE 14. LIST OF ALGAL TAXA (EXCLUSIVE OF DIATOMS) AND RELATIVE ABUNDANCE IN LEON CREEK, TEXAS. A=Abundant (61-100%), VC=Very Common (31-60%), C=Common (6-30%), O=Occasional (1-5%), and R=Rare (<1%).

	Stations				
	Control	Impact		Recovery	
Taxa	161	162	163	164	165
Chlorophyta					
Colonies	C				
Filaments	VC	VC		A	VC
Chlorococcales					
Coelastrum microporum		C			
Scenedesmus spp.	O				
Scenedesmus quadricauda		O			
Scenedesmus abundans		C			
Scenedesmus dimorphus		C			
Zygnematales					
Mougeotia spp.	C		VC		
Siphonocladales					
Cladophora spp.	VC		VC	C	VC
Zygnematales					
Spirogyra spp.		O			
Closterium spp.		O		O	O
Cosmarium spp.	O	R			
Euglenophyta					
Euglenales					
Euglena spp.			O		
Phacus spp.				C	
Pyrrhophyta					
Dinokontae					
Peridinium spp.			O		
Cryptophyta					
Cryptomonadaceae					
Cryptomonas spp.				O	
Cyanophyta					
Oscillatoriales					
Oscillatoria spp.	R	R	C		
Phormidium spp.					C

Upstream Control Station (161)

The diatoms *Gomphonema parvulum*, *Navicula mutica* var. *stigma*, *Nitzschia amphibia*, and *Navicula graciloides* were common, each contributing more than 5 percent of total cell abundance (Figure 7). Cell abundances were not converted to cell volume or biomass. Relative size differences between species are, therefore, not reflected with these data, since each taxon receives equal numerical representation, regardless of frustule size.

Total cell abundance for all observed algal groups at station 161 was 4969 cells/mm^2 (Figure 8); diatoms contributed 85 percent of total abundance (Figure 6). Green algae contributed 14 percent, with unidentified colonies and filaments, *Scenedesmus* spp., *Mougeotia* sp., *Cladophora* sp., and *Cosmarium* spp. present. Mean diatom species diversity of 4.17 and mean total diatom taxa of 52.5 were higher here than in any other station (Table 14).

Impact Zone (Stations 162 and 163)

Total cell abundance increased to 8338 and 9336 cells/mm^2 at Stations 162 and 163, respectively. Mean concentrations of total silver and chromium also increased to several times above the EPA acute water quality criteria recommended for local aquatic life based on hardness (Figure 8).

Nitzschia palea was common at both stations and contributed 47 percent to total cell abundance at Station 162 (Figure 7). *N. palea* predominates in "polysaprobic" waters with BOD_5 greater than 22 mg O_2/l and an oxygen-saturation deficit greater than 90 percent (Lange-Bartalot 1979). This taxon is also a facultative nitrogen heterotroph (Table 13). Observed dissolved oxygen concentration in Leon Creek decreased from 6.43 mg O_2/l at Station 161 to 5.43 and 3.79 mg O_2/l at Stations 162 and 163, respectively (Table 5). This observed

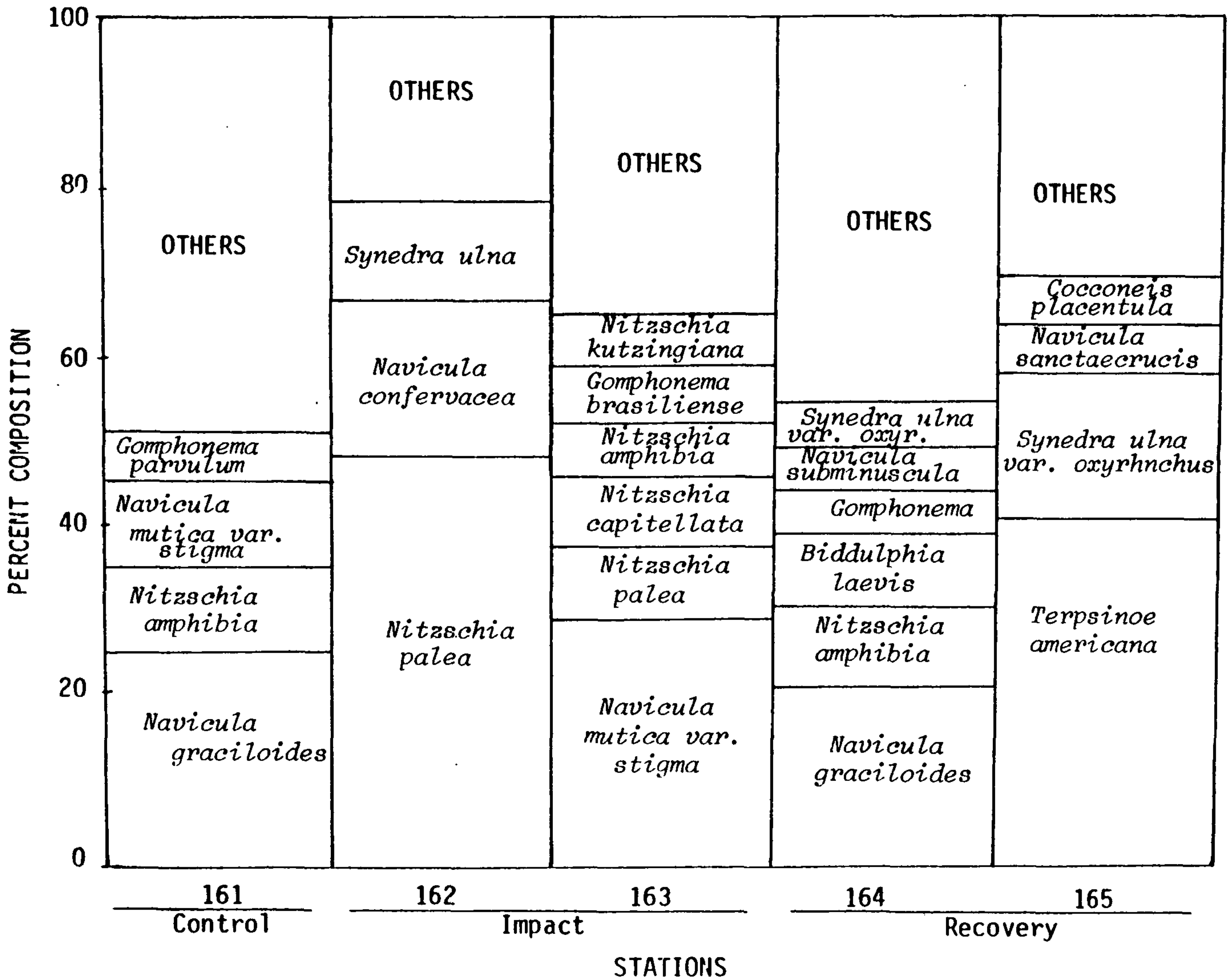


Figure 7. Percent composition of diatom species contributing greater than five percent to total cell abundance in Leon Creek, Texas.

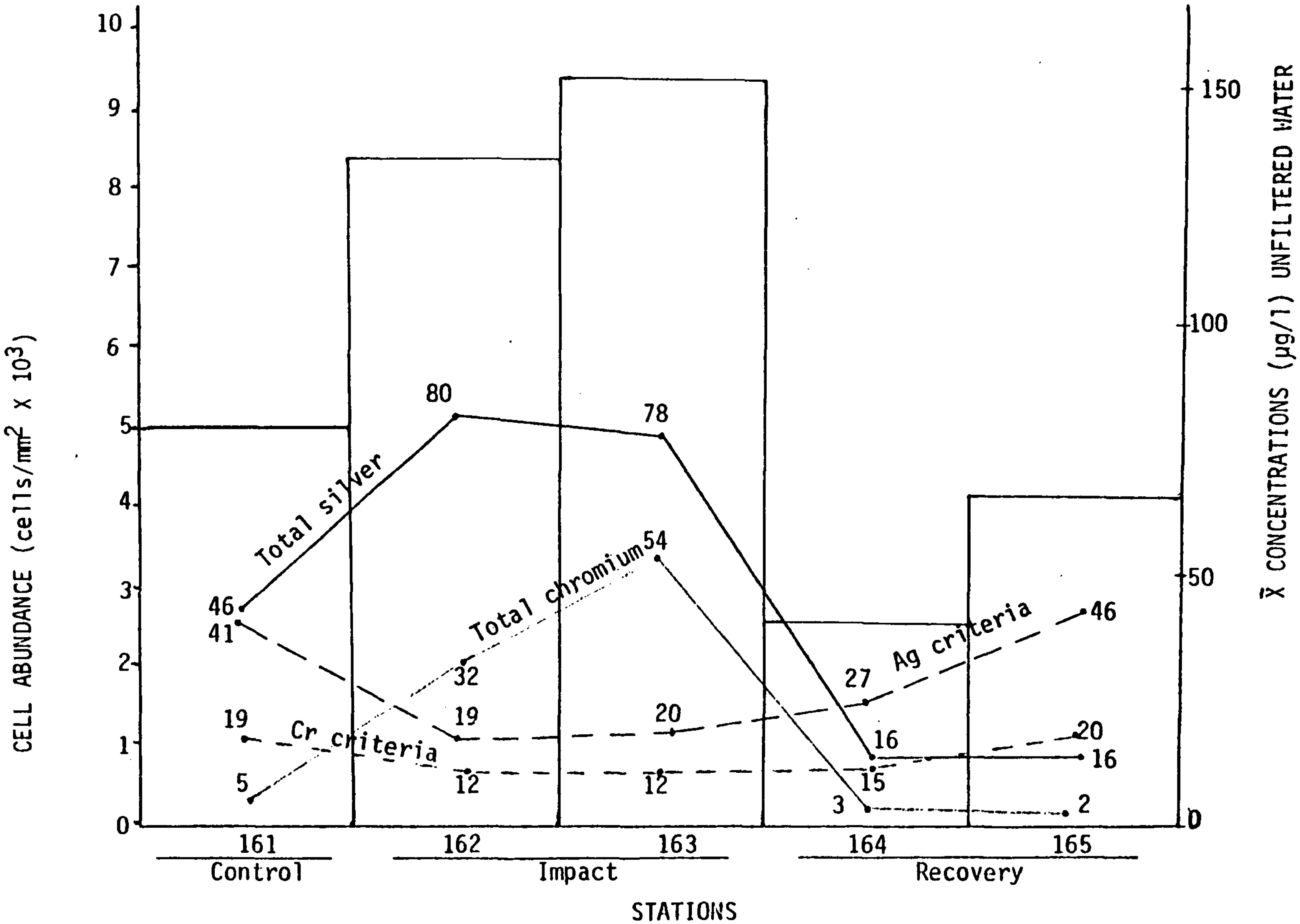


Figure 8. Periphyton cell abundance (cells/mm^2 x 10^3) in Leon Creek, Texas, mean concentrations of total silver and chromium, and calculated silver and chromium water quality criteria.

oxygen concentration decrease suggests organics entering Leon River upstream from Station 162 are creating an oxygen deficit. Mean number of diatom taxa (28) and species diversity (2.66) were lowest at Station 162 (Table 15).

A one-way analysis of variance (ANOVA) was used to test differences at each station with respect to total number of diatom taxa, total diatom abundance (cells/mm^2), and mean Shannon-Wiener diversity (Table 15). No significant difference ($p=0.05$) was observed in total diatom abundance between stations. Significant differences ($p=0.05$) between stations were found with respect to total number of taxa and species diversity. Patterns of difference between stations were tested using SNK multiple range procedure. The total number of diatom taxa at Station 162 and species diversity were significantly lower ($p=0.05$) than the control zone station (161). However, no significant difference ($p=0.05$) was observed in the number of taxa or species diversity between Station 163 and Station 161.

Nitzschia tryblionella var. debilis, N. ignorata, N. fonticola, N. hantzschiana, Navicula pupula, and Cyclotella pseudostelligera were observed only in this zone and were not present at any other station (Table 12). The environmental requirements of these taxa are not completely known; however, it appears that N. pupula and C. pseudostelligera are "indifferent" to most chemical and physical parameters (Lowe 1974).

Recovery Zone (Stations 164 and 165)

Cell abundance decreased to 2365 and 4084 cells/mm^2 at Stations 164 and 165, respectively (Figure 8). Mean silver and chromium concentrations decreased to below EPA acute water quality criteria recommended for local aquatic life based on hardness (Figure 8).

TABLE 15. STUDENT-NEWMAN-KEULS STEPWISE MULTIPLE RANGE TEST (SNK) OF TOTAL NUMBER OF DIATOM TAXA, SHANNON-WIENER DIVERSITY AND TOTAL DIATOM ABUNDANCE (cells/mm^2) IN LEON CREEK, TEXAS. Nonsignificant (p=0.05) subsets of group means are indicated by vertical lines.

	Station	Total # of Taxa		Total Abundance		Diversity	
		$\bar{x}$	SNK	$\bar{x}$	SNK	$\bar{x}$	SNK
Control	161	52.5		4206		4.1649	
Impact	162	28.0		6769		2.6647	
	163	40.5		8981		3.9780	
Recovery	164	36.0		2335		4.2275	
	165	35.5		3128		3.4624	

Species composition changed somewhat: Nitzschia spp. were less abundant here than in the impact zone. Terpsinoe americana and Biddulphia laevis appeared either as common or very common components and were not abundant at other stations (Table 12). Both species have been reported from brackish water, while B. laevis is restricted to waters of moderately high conductivity and alkalinity (Table 13). Cocconeis placentula and Synedra ulna var. oxyrhynchus f. medio-contracta were more abundant than in the other stations. Number of diatom taxa were not significantly different ($p=0.05$) at stations downstream from Station 163 in the impact zone than at the control zone (Station 161). Neither were species diversity differences found between the two zones.

A summary of the Leon Creek periphyton data shows diatoms contributed the greatest relative abundance at each station. No significant differences were observed between impact, recovery or control zones. Total diatom cell abundance (cells/mm^2) was somewhat higher in the impact zone but differences between stations were not statistically significant. Mean number of total diatom taxa and mean species diversity were lowest at Station 162 where mean total silver and chromium concentrations were several times greater than EPA acute water quality criteria. Highest diversity and greatest mean number of taxa were observed in the control zone but, again, were not significantly different from the impact zone. Analysis of individual species also did not reveal any sharp contrasts. The diatoms Cyclotella meneghiniana and Nitzschia obtusa var scalpelliformis were present at every station while Nitzschia tryblionella var. debilis, N. ignorata, N. fonticola, N. hantzschiana, Navicula pupula, and Cyclotella pseudostelligera were observed only in the impact zone. Nitzschia palea, a taxon characteristic of organically polluted waters (Table 13), was common in the impact zone (Stations 162 and 163) where dissolved oxygen concentrations were lowest. This may suggest the influence of both organics and metals to the periphyton in Leon Creek. However, long term studies are necessary to evaluate changes over seasons for an annual period. The use of artificial substrates would also eliminate some variability resulting from differences in natural rock substrata. Further testing is necessary to help understand the apparent complex relationships between metal pollution and organics on species composition of the algal community in Leon Creek.

Macrophyte Tissues

Copper concentrations in control zone roots and whole plant tissues were consistently lower than those in the impact zone (Appendix E). Copper concentrations in leaf and stem tissues decrease in the recovery zone while root and whole plant samples remained relatively high.

Similar trends were observed for chromium, with greatest metal accumulation reported at Station 163. Lead data are missing for control zone samples and data from the impact and recovery zones are so variable that no trends could be detected. Silver concentrations showed very slight increase at Station 163 but all values were consistently low.

All metals examined in plant tissues from Leon Creek were present in concentrations exceeding values generally reported in the open literature for similar contaminated areas. For example, Mudrock and Capobianco (1979) found Elodea canadensis, Scirpus sp., and Typha sp. to contain 10-19 μg/g dry weight copper, 14-40 μg/g zinc, and 5-17 μg/g lead. Grasses (Graminaceae) from Leon Creek, however, contained root copper concentrations ranging from 1.1 μg/g in the control zone to 255.4 μg/g at Station 163. In leaves and stems, copper concentrations ranged from 1.1 μg/g to 32.8 g/g; whole plant concentrations ranged from 8.0 μg/g in the control zone to 77.3 μg/g in the impact zone.

White (1976) reported that ambient copper concentrations of 161 μg/l and lead concentrations of 5 μg/l resulted in 108 μg/g copper and 47.4 μg/g lead in _Equisetum_ roots, and 13 μg/g copper and 5.59 μg/g lead in above ground parts.

Except for one sample, chromium concentrations in plant tissues were similar to values reported in the literature. Above-ground parts from Leon Creek had concentrations as high as 32.8 μg/g in the impact zone. Mudrock and Capobianco (1979) reported above ground parts of _Iridaceae_ sp., _Scirpus_ sp., and _Typha_ sp. from a contaminated area to have chromium concentrations of 6.9, 2.5, and 3.8 μg/g, respectively.

Fish

Community Census

Fish were primarily collected in this study to analyze tissue metal concentrations. However, the following species in Leon Creek were reported from qualitative observations and fish collections during electroshocking: gizzard shad (_Dorosoma cepedianum_), Mexican tetra (_Astyanax fasciatus mexicanus_), carp (_Cyprinus carpio_), channel catfish (_Ictalurus punctatus_), sailfin molly (_Poecilia latipinna_), bluegill (_Lepomis macrochirus_), and Rio Grande perch (_Cichlasoma cyanoguttatum_). No single species of fish was present at all stations. Thus, these species represent a diverse and typical fish community of small southern streams. This may be significant considering that acute and chronic criteria values for several metals (Table 4) were exceeded within every zone.

Tissues

The distribution and relative abundance of the fish in Leon Creek were highly variable. Tissues from several fish species were collected and analyzed at each station; the species selection depended upon their presence and abundance at each station.

The fact that acute and chronic criteria for several metals were exceeded throughout the control, impact, and recovery zones (Table 4) suggests the presence of nonpoint source metal contributions to Leon Creek. The indication of this metal source is also reflected in the fish tissue samples (Appendix D) which show little evidence of bioaccumulation of metals above control zone values.

Despite ambient concentrations in excess of recommended criteria cadmium values in the fish tissues were generally non-detectable. Copper concentrations were at or below values reported for gill, liver, kidney, and muscle tissues in a laboratory exposure of 9.4 μg/l (McKim and Bonoit 1974) and 49 μg/l (Brungs et al. 1973).

Except for gill tissue, chromium concentrations were generally non-detectable. Gill concentrations were measurable but remained at relatively low levels (0.8-9.9 μg/g). Knoll and Fromm (1960) reported accumulation of hexavalent chromium in trout livers and kidney to concentrations of 8 and 16 μg/g, respectively, in 24 days of exposure to 2.5 mg/l hexavalent chromium. Thus, although ambient chromium concentrations in Leon Creek exceed recommended criteria in the impact zone, they appear to be not high enough to cause fish tissue accumulation.

Ambient silver concentrations in Leon Creek exceeded the recommended acute criteria, suggesting silver toxicity and accumulation could be occurring. However, a paucity of data exists on silver concentrations in Leon Creek fish tissues. This is probably due to analytical limitations. Ambient concentration of silver in Prickly Pear Creek, Montana, were found as high as 45 µg/l, but no appreciable accumulation occurred in various trout tissues (Miller et al. 1982), with trout gill tissue ranging only up to 0.45 µg/g silver, and liver tissues containing as much as 7.5 µg/g. Ambient silver concentrations in Leon Creek were measured at nearly two times those in Prickly Pear Creek yet gill concentration ranged up to only 0.8 µg/g, and liver concentration ranged up to 1.8 µg/g. Coleman and Cearley (1974) reported similar tissue values in largemouth bass and bluegills.

It is possible that silver is extremely toxic at very low tissue concentrations. This is supported by the low LC50 values reported in the literature (Davies et al. 1978). Furthermore, the relatively low tissue values reported for Leon Creek may be related to bioavailability of silver. The LC50 values reported by Davies et al. (1978) were much lower than concentrations found in Leon Creek, yet several species were reported at each station. Davies et al. (1978) reported that the various inorganic compounds of silver have varying toxicity. Furthermore, a comparison of total and 0.45 µ filtrate of Leon Creek water revealed that up to 50 percent of the ambient silver in Leon Creek may be sorbed to particulate.

The chemical speciation and partitioning of the metals in Leon Creek may reduce the bioavailability uptake and toxicity of metals, and thus may be responsible for the presence of fish where seemingly toxic concentrations of metals exist. Physiological acclimation to metals may also be partially responsible for this discrepency. Additional work is warrented to identify the importance of metal speciation and acclimation in reducing metal toxicity.

Bioassay

The ambient total metal concentrations for silver, cadmium, and chromium in water samples from the Leon Creek impact zone (162 and 163) were in excess of the acute maximum criteria for aquatic life (Table 4), suggesting that water from the station would be acutely lethal to sensitive aquatic organisms. Bioassays conducted at Duluth on whole water samples from the control (161) and impact zone (162) stations, however, did not yield any results indicative of toxicity except for the enzyme inhibition test conducted on water from Station 161 (Appendix E). These results further suggest that metal toxicity is not the major pollution problem in Leon Creek.

IV. CONCLUSIONS

1. Concentrations of silver, cadmium, and chromium exceeded EPA recommended acute criteria in the impact zone downstream from the Kelly Air Force Base. Increased nutrient concentrations, and decreased dissolved oxygen levels and percent saturation were also observed, indicating substantial quantities of organic materials were entering Leon Creek.

2. The data indicate no significant differences ($p=0.05$) between stations in mean sediment concentrations of most metals examined in Leon Creek. It is suggested that metal concentrations in the sediments are sufficiently high to have reached a steady-state saturation point that is not affected by the relatively small additional input of metals from Kelly AFB. This saturation could be a result of continuous nonpoint discharges into Leon Creek upstream of the control site.

3. Macroinvertebrate and periphyton data from the impact zone suggest that, during 1980 sampling, ambient metal concentrations may have affected the aquatic biota less than the organic pollutants from Kelly AFB.

4. Improvement of various indices (species richness, diversity) of macroinvertebrate community health was observed in the recovery zone as compared to the impact zone. However, caution should be used in interpreting these distributions since they only represent a single sampling round; preliminary data from 1981 indicate substantially different macroinvertebrate populations than were observed during 1980 sampling.

V. RECOMMENDATIONS

1. Additional monitoring to identify organic components in discharges to Leon Creek, and to quantify the fate, persistance, and biological effects of organic toxicants, is recommended.

2. A site-specific study to examine the relationship between biological communities (macroinvertebrates, periphyton) and the combined metal/organic pollution in Leon Creek is needed. The protocol, "Field Testing of Measurement Methods for Stream Surveys" (EPA 1982) could be used in this evaluation.

3. Additional work is recommended to identify the role of metal speciation and acclimation in reducing metal toxicity to fish populations in Leon Creek.

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APPENDIX A

WATER CHEMISTRY SUMMARY DATA

STORET RETRIEVAL DATE 82/03/01

16161231
29 23 30.0 098 36 30.0 5
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
/TYPA/AMBNT/FISH/STREAM/TISSUE 11EPATH 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574621-0084104

DATE FROM TO	TIME OF DAY	DEPTH FEET	01025 CADMIUM CD,DISS UG/L	01027 CADMIUM CD,TOT UG/L	01049 LEAD PB,DISS UG/L	01051 LEAD PB,TOT UG/L	01075 SILVER AG,DISS UG/L	01077 SILVER AG,TOT UG/L	01000 ARSENIC AS,DISS UG/L	01002 ARSENIC AS,TOT UG/L	01030 CHROMIUM CR,DISS UG/L	01034 CHROMIUM CR,TOT UG/L
80/11/07	09 00	0000	10	5	166	121	59.0	18.0	85	58	6	4
	09 02	0000	11	7	232	213	76.0	36.0		54	9	6
	09 04	0000	8	9	149	141	40.0	67.0	59	83	6	6
	09 06	0000	6	5	141	179	35.0	41.0	38	108	4	3
	09 08	0000	7	9	124	168	36.0	55.0	150	124	6	6
	09 10	0000	8	6	166	124	43.0	59.0			6	3

DATE FROM TO	TIME OF DAY	DEPTH FEET	01040 COPPER CU,DISS UG/L	01042 COPPER CU,TOT UG/L
80/11/07	09 00	0000	25	17
	09 02	0000	18	8
	09 04	C000	21	19
	09 06	0000	20	14
	09 08	0000	23	18
	09 10	0000	12	12

STORET RETRIEVAL DATE 82/03/01

/TYPA/AMBNT/FISH/STREAM/TISSUE

16162231
29 21 30.0 098 34 30.0 4
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574622-0084106

DATE FROM TO	TIME OF DAY	DEPTH FEET	01025 CADMIUM CD,DISS UG/L	01027 CADMIUM CD,TOT UG/L	01049 LEAD PB,DISS UG/L	01051 LEAD PB,TOT UG/L	01075 SILVER AG,DISS UG/L	01077 SILVER AG,TOT UG/L	01000 ARSENIC AS,DISS UG/L	01002 ARSENIC AS,TOT UG/L	01030 CHROMIUM CR,DISS UG/L	01034 CHROMIUM CR,TOT UG/L
80/11/06	13 30	0000	15	5	85	47	33.0	62.0	124	131	10	18
	13 32	0000	13	5	121	53	38.0	72.0	71		10	18
	13 34	0000	14	1	102		38.0	25.0	202	44	13	9
	13 36	0000	12	1	98	36	30.0	7.0	38		10	10
	13 38	0000	10		181		44.0	14.0	203	22	13	10
	13 40	0000	11	9	81		58.0	27.0			12	16
	13 31											
CP(T)-03	AVE	0000		14		75		46.0		38		47
80/11/06	15 31											
	14 31											
CP(T)-03	AVE	0000		13		49		39.0				51
80/11/06	16 31											
	15 31											
CP(T)-03	AVE	0000		13		9		43.0		16		41
80/11/06	17 31											
	16 31											
CP(T)-03	AVE	0000		12		28		21.0		71		43
80/11/06	18 31											
	17 31											
CP(T)-03	AVE	0000		34		379		107.0		624		51
80/11/06	19 31											
	18 31											
CP(T)-03	AVE	0000		24		211		78.0		242		43
80/11/06	20 31											
	22 31											
CP(T)-03	AVE	0000		26		315		74.0		343		37
80/11/07	00 31											
80/11/06	23 31											
CP(T)-03	AVE	0000		24		313		77.0		189		32
80/11/07	01 31											
	00 31											
CP(T)-03	AVE	0000		25		202		80.0		419		34
80/11/07	02 31											
	01 31											
CP(T)-03	AVE	0000		21		211		69.0		239		31
80/11/07	03 31											

STORET RETRIEVAL DATE 82/03/01

/TYPA/AMBNT/FISH/STREAM/TISSUE

16162231
29 21 30.0 098 34 30.0 4
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574622-0084106

DATE FROM TO	TIME OF DAY	DEPTH FEET	01040 COPPER CU,DISS UG/L	01042 COPPER CU,TOT UG/L
80/11/06	13 30	0000	33	31
	13 32	0000	28	30
	13 34	0000	34	30
	13 36	0000	36	24
	13 38	0000	34	29
	13 40	0000	27	25
	13 31			
CP(T)-03	AVE	0000		35
80/11/06	15 31			
	14 31			
CP(T)-03	AVE	0000		31
80/11/06	16 31			
	15 31			
CP(T)-03	AVE	0000		32
80/11/06	17 31			
	16 31			
CP(T)-03	AVE	0000		44
80/11/06	18 31			
	17 31			
CP(T)-03	AVE	0000		71
80/11/06	19 31			
	18 31			
CP(T)-03	AVE	0000		57
80/11/06	20 31			
	22 31			
CP(T)-03	AVE	0000		55
80/11/07	00 31			
80/11/06	23 31			
CP(T)-03	AVE	0000		46
80/11/07	01 31			
	00 31			
CP(T)-03	AVE	0000		51
80/11/07	02 31			
	01 31			
CP(T)-03	AVE	0000		38
80/11/07	03 31			

STORET RETRIEVAL DATE 82/03/01

16162231
29 21 30.0 098 34 30.0 4
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN

/TYPA/AMBNT/FISH/STREAM/TISSUE

11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574622-0084106

DATE FROM TO	TIME OF DAY	DEPTH FEET	01025 CADMIUM CD,DISS UG/L	01027 CADMIUM CD,TOT UG/L	01049 LEAD PB,DISS UG/L	01051 LEAD PB,TOT UG/L	01075 SILVER AG,DISS UG/L	01077 SILVER AG,TOT UG/L	01000 ARSENIC AS,DISS UG/L	01002 ARSENIC AS,TOT UG/L	01030 CHROMIUM CR,DISS UG/L	01034 CHROMIUM CR,TOT UG/L
80/11/07	02 31											
CP(T)-03	AVE	0000		31		337		111.0		469		45
80/11/07	04 31											
	03 31											
CP(T)-03	AVE	0000		29		273		110.0		348		43
80/11/07	05 31											
	04 31											
CP(T)-03	AVE	0000		26		296		118.0		460		35
80/11/07	06 31											
	05 31											
CP(T)-03	AVE	0000		30		283		93.0		363		31
80/11/07	07 31											
	06 31											
CP(T)-03	AVE	0000		24		326		115.0		399		31
80/11/07	08 31											
	07 31											
CP(T)-03	AVE	0000		25		264		93.0		366		32
80/11/07	09 31											
	08 31											
CP(T)-03	AVE	0000		31		277		97.0		376		43
80/11/07	10 31											
	09 31											
CP(T)-03	AVE	0000		26		230		97.0		289		41
80/11/07	11 31											
	10 31											
CP(T)-03	AVE	0000		29		307		94.0		348		34
80/11/07	12 31											
	11 31											
CP(T)-03	AVE	0000		26		326		105.0		286		34
80/11/07	13 31											
	12 31											
CP(T)-03	AVE	0000		25		264		90.0		394		34
80/11/07	14 31											
	13 31											
CP(T)-03	AVE	0000		23		334		81.0		328		31
80/11/07	15 31											

STORET RETRIEVAL DATE 82/03/01

16162231
29 21 30.0 098 34 30.0 4
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574622-0084106

/TYPA/AMBNT/FISH/STREAM/TISSUE

DATE FROM TO	TIME OF DAY	DEPTH FEET	01040 COPPER CU,DISS UG/L	01042 COPPER CU,TOT UG/L
80/11/07	02 31			
CP(T)-03	AVE	0000		62
80/11/07	04 31			
	03 31			
CP(T)-03	AVE	0000		44
80/11/07	05 31			
	04 31			
CP(T)-03	AVE	0000		51
80/11/07	06 31			
	05 31			
CP(T)-03	AVE	0000		57
80/11/07	07 31			
	06 31			
CP(T)-03	AVE	0000		53
80/11/07	08 31			
	07 31			
CP(T)-03	AVE	0000		43
80/11/07	09 31			
	08 31			
CP(T)-03	AVE	0000		69
80/11/07	10 31			
	09 31			
CP(T)-03	AVE	0000		48
80/11/07	11 31			
	10 31			
CP(T)-03	AVE	0000		56
80/11/07	12 31			
	11 31			
CP(T)-03	AVE	0000		65
80/11/07	13 31			
	12 31			
CP(T)-03	AVE	0000		61
80/11/07	14 31			
	13 31			
CP(T)-03	AVE	0000		55
80/11/07	15 31			

STORET RETRIEVAL DATE 82/03/01

16162231
29 21 30.0 098 34 30.0 4
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
/TYPA/AMBNT/FISH/STREAM/TISSUE
11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574622-0084106

DATE FROM TO	TIME OF DAY	DEPTH FEET	01025 CADMIUM CD,DISS UG/L	01027 CADMIUM CD,TOT UG/L	01049 LEAD PB,DISS UG/L	01051 LEAD PB,TOT UG/L	01075 SILVER AG,DISS UG/L	01077 SILVER AG,TOT UG/L	01000 ARSENIC AS,DISS UG/L	01002 ARSENIC AS,TOT UG/L	01030 CHROMIUM CR,DISS UG/L	01034 CHROMIUM CR,TOT UG/L
80/11/07	14 31											
CP(T)-03	AVE	0000		24		219		86.0		255		28
80/11/07	16 31											
	15 31											
CP(T)-03	AVE	0000		22		226		88.0		254		28
80/11/07	17 31											
	16 31											
CP(T)-03	AVE	0000		20		151		75.0		359		22
80/11/07	18 31											
	17 31											
CP(T)-03	AVE	0000		24		234		93.0		275		25
80/11/07	19 31											
80/11/08	04 31											
CP(T)-03	AVE	0000		33		349		93.0		458		28
80/11/08	06 31											
	05 31											
CP(T)-03	AVE	0000		31		326		101.0		348		28
80/11/08	07 31											
	06 31											
CP(T)-03	AVE	0000		32		371		85.0		494		35
80/11/08	08 31											
	07 31											
CP(T)-03	AVE	0000		33		315		107.0		452		37
80/11/08	09 31											
	08 31											
CP(T)-03	AVE	0000		29		285		113.0		431		26
80/11/08	10 31											
	09 31											
CP(T)-03	AVE	0000		27		328		105.0		345		28
80/11/08	11 31											
	10 31											
CP(T)-03	AVE	0000		30		324		106.0		419		31
80/11/08	12 31											
	11 31											
CP(T)-03	AVE	0000		28		294		100.0		328		32
80/11/08	13 31											

STORET RETRIEVAL DATE 82/03/01

16162231
29 21 30.0 098 34 30.0 4
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574622-0084106

/TYPA/AMBNT/FISH/STREAM/TISSUE

DATE FROM TO	TIME OF DAY	DEPTH FEET	01040 COPPER CU,DISS UG/L	01042 COPPER CU,TOT UG/L
80/11/07	14 31			
CP(T)-03	AVE	0000		54
80/11/07	16 31			
	15 31			
CP(T)-03	AVE	0000		52
80/11/07	17 31			
	16 31			
CP(T)-03	AVE	0000		58
80/11/07	18 31			
	17 31			
CP(T)-03	AVE	0000		50
80/11/07	19 31			
80/11/08	04 31			
CP(T)-03	AVE	0000		59
80/11/08	06 31			
	05 31			
CP(T)-03	AVE	0000		61
80/11/08	07 31			
	06 31			
CP(T)-03	AVE	0000		66
80/11/08	08 31			
	07 31			
CP(T)-03	AVE	0000		61
80/11/08	09 31			
	08 31			
CP(T)-03	AVE	0000		61
80/11/08	10 31			
	09 31			
CP(T)-03	AVE	0000		57
80/11/08	11 31			
	10 31			
CP(T)-03	AVE	0000		57
80/11/08	12 31			
	11 31			
CP(T)-03	AVE	0000		66
80/11/08	13 31			

STORET RETRIEVAL DATE 82/03/01

/TYPA/AMBNT/FISH/STREAM/TISSUE

16163231
29 21 00.0 098 34 30.0 5
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574623-0084111

DATE FROM TO	TIME OF DAY	DEPTH FEET	01025 CADMIUM CD,DISS UG/L	01027 CADMIUM CD,TOT UG/L	01049 LEAD PB,DISS UG/L	01051 LEAD PB,TOT UG/L	01075 SILVER AG,DISS UG/L	01077 SILVER AG,TOT UG/L	01000 ARSENIC AS,DISS UG/L	01002 ARSENIC AS,TOT UG/L	01030 CHROMIUM CR,DISS UG/L	01034 CHROMIUM CR,TOT UG/L
80/11/06	09 00	0000	27	33	264	339	85.0	121.0	368	501	53	63
	09 02	0000	35	30	330	311	125.0	134.0	426	331	57	66
	09 04	0000	36	27	303	217	97.0	127.0	606	461	62	69
	09 06	0000	35	25	381	224	110.0	106.0	414		59	63
	09 08	0000	37	27	326	239	93.0	66.0	475	307	54	62
	09 10	0000	38	28	337	243	127.0	63.0	369	216	56	60
	09 01											
CP(T)-03	AVE	0000		38		326		109.0		554		66
80/11/06	11 01											
	10 01											
CP(T)-03	AVE	0000		35		264		101.0		256		67
80/11/06	12 01											
	11 01											
CP(T)-03	AVE	0000		42		290		109.0		391		78
80/11/06	13 01											
	12 01											
CP(T)-03	AVE	0000		33		275		86.0		208		75
80/11/06	14 01											
	13 01											
CP(T)-03	AVE	0000		36		251		70.0		369		85
80/11/06	15 01											
	14 01											
CP(T)-03	AVE	0000		36		262		74.0		325		84
80/11/06	16 01											
	15 01											
CP(T)-03	AVE	0000		32		202		83.0		332		79
80/11/06	17 01											
	16 01											
CP(T)-03	AVE	0000		34		207		95.0		222		81
80/11/06	18 01											
	17 01											
CP(T)-03	AVE	0000		24		64		45.0		285		57
80/11/06	19 01											
	18 01											
CP(T)-03	AVE	0000		33		164		76.0		227		63
80/11/06	20 01											

STORET RETRIEVAL DATE 82/03/01

16163231
29 21 00.0 098 34 30.0 5
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574623-0084111

/TYPA/AMBNT/FISH/STREAM/TISSUE

DATE FROM TO	TIME OF DAY	DEPTH FEET	01040 COPPER CU,DISS UG/L	01042 COPPER CU,TOT UG/L
80/11/06	09 00	0000	59	53
	09 02	0000	61	61
	09 04	0000	64	59
	09 06	0000	66	54
	09 08	0000	73	62
	09 10	0000	76	58
	09 01			
CP(T)-03	AVE	0000		61
80/11/06	11 01			
	10 01			
CP(T)-03	AVE	0000		71
80/11/06	12 01			
	11 01			
CP(T)-03	AVE	0000		78
80/11/06	13 01			
	12 01			
CP(T)-03	AVE	0000		78
80/11/06	14 01			
	13 01			
CP(T)-03	AVE	0000		78
80/11/06	15 01			
	14 01			
CP(T)-03	AVE	0000		75
80/11/06	16 01			
	15 01			
CP(T)-03	AVE	0000		83
80/11/06	17 01			
	16 01			
CP(T)-03	AVE	0000		80
80/11/06	18 01			
	17 01			
CP(T)-03	AVE	0000		64
80/11/06	19 01			
	18 01			
CP(T)-03	AVE	0000		67
80/11/06	20 01			

STORET RETRIEVAL DATE 82/03/01

16163231
29 21 00.0 098 34 30.0 5
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
/TYPA/AMBNT/FISH/STREAM/TISSUE
11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574623-0084111

DATE FROM TO	TIME OF DAY	DEPTH FEET	01025 CADMIUM CD,DISS UG/L	01027 CADMIUM CD,TOT UG/L	01049 LEAD PB,DISS UG/L	01051 LEAD PB,TOT UG/L	01075 SILVER AG,DISS UG/L	01077 SILVER AG,TOT UG/L	01000 ARSENIC AS,DISS UG/L	01002 ARSENIC AS,TOT UG/L	01030 CHROMIUM CR,DISS UG/L	01034 CHROMIUM CR,TOT UG/L
80/11/06	19 01											
CP(T)-03	AVE	0000		11		55		24.0		159		41
80/11/06	21 01											
	20 01											
CP(T)-03	AVE	0000		8		85		37.0				43
80/11/06	22 01											
	21 01											
CP(T)-03	AVE	0000		7		96		22.0		147		32
80/11/06	23 01											
	22 01											
CP(T)-03	AVE	0000		7		55		10.0				34
80/11/07	00 01											
80/11/06	23 01											
CP(T)-03	AVE	0000		2		58				94		24
80/11/07	01 01											
	00 01											
CP(T)-03	AVE	0000				21						24
80/11/07	02 01											
	01 01											
CP(T)-03	AVE	0000								77		12
80/11/07	03 01											
	02 01											
CP(T)-03	AVE	0000		0								12
80/11/07	04 01											
	03 01											
CP(T)-03	AVE	0000		0						66		31
80/11/07	05 01											
	04 01											
CP(T)-03	AVE	0000		6								35
80/11/07	06 01											

STORET RETRIEVAL DATE 82/03/01

16163231
29 21 00.0 098 34 30.0 5
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574623-0084111

/TYPA/AMBNT/FISH/STREAM/TISSUE

DATE FROM TO	TIME OF DAY	DEPTH FEET	01040 COPPER CU,DISS UG/L	01042 COPPER CU,TOT UG/L
80/11/06	19 01			
CP(T)-03	AVE	0000		22
80/11/06	21 01			
	20 01			
CP(T)-03	AVE	0000		7
80/11/06	22 01			
	21 01			
CP(T)-03	AVE	0000		10
80/11/06	23 01			
	22 01			
CP(T)-03	AVE	0000		9
80/11/07	00 01			
80/11/06	23 01			
CP(T)-03	AVE	0000		13
80/11/07	01 01			
	00 01			
CP(T)-03	AVE	0000		3
80/11/07	02 01			
	03 01			
CP(T)-03	AVE	0000		10
80/11/07	05 01			
	04 01			
CP(T)-03	AVE	0000		8
80/11/07	06 01			

STORET RETRIEVAL DATE 82/03/01

16164231
29 20 00.0 098 35 00.0 5
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
/TYPA/AMBNT/FISH/STREAM/TISSUE 11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574624-0084114

DATE FROM TO	TIME OF DAY	DEPTH FEET	01025 CADMIUM CD,DISS UG/L	01027 CADMIUM CD,TOT UG/L	01049 LEAD PB,DISS UG/L	01051 LEAD PB,TOT UG/L	01075 SILVER AG,DISS UG/L	01077 SILVER AG,TOT UG/L	01000 ARSENIC AS,DISS UG/L	01002 ARSENIC AS,TOT UG/L	01030 CHROMIUM CR,DISS UG/L	01034 CHROMIUM CR,TOT UG/L
80/11/05	12 00	0000	2	8	83	190	5.0	7.0	80	187		3
	12 02	0000	1	8	49	130	15.0	13.0	34	174	0	3
	12 04	0000	8	8	139	181		21.0	100	201	0	4
	12 06	0000	2	5	124	92	1.0	22.0	66			3
	12 08	0000	1	4		121		17.0	107	113		3
	12 10	0000	1	4	43	102				53		

DATE FROM TO	TIME OF DAY	DEPTH FEET	01040 COPPER CU,DISS UG/L	01042 COPPER CU,TOT UG/L
80/11/05	12 00	0000	3	1
	12 02	0000	4	
	12 04	0000		5
	12 06	0000	2	
	12 08	0000	4	3

STORET RETRIEVAL DATE 82/03/01

16165231
29 17 00.0 098 34 00.0 5
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
/TYPA/AMBNT/FISH/STREAM/TISSUE
11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574625-0084116

DATE FROM TO	TIME OF DAY	DEPTH FEET	01025 CADMIUM CD,DISS UG/L	01027 CADMIUM CD,TOT UG/L	01049 LEAD PB,DISS UG/L	01051 LEAD PB,TOT UG/L	01075 SILVER AG,DISS UG/L	01077 SILVER AG,TOT UG/L	01000 ARSENIC AS,DISS UG/L	01002 ARSENIC AS,TOT UG/L	01030 CHROMIUM CR,DISS UG/L	01034 CHROMIUM CR,TOT UG/L
80/11/05	10 40	0000	6		149				221			
	10 42	0000	5		115				21			
	10 44	0000	4		124	72			143	120		
	10 46	0000	2		192	70		6.0	87	77		
	10 48	0000	5	4	113	121	10.0		145	286		
	10 50	0000	3	4	121	121	10.0	9.0	94	35		
	10 41											
CP(T)-03	AVE	0000		9		175				169		
80/11/05	12 41											
	11 41											
CP(T)-03	AVE	0000		5		179				31		
80/11/05	13 41											
	12 41											
CP(T)-03	AVE	0000		6		262		11.0		165		3
80/11/05	14 41											
	13 41											
CP(T)-03	AVE	0000		4		102		11.0		34		
80/11/05	15 41											
	14 41											
CP(T)-03	AVE	0000		3		134		32.0		176		4
80/11/05	16 41											
	15 41											
CP(T)-03	AVE	0000		2		147		39.0		28		
80/11/05	17 41											
	16 41											
CP(T)-03	AVE	0000		5		205		10.0		95		0
80/11/05	18 41											
	17 41											
CP(T)-03	AVE	0000				34		12.0				
80/11/05	19 41											
	18 41											
CP(T)-03	AVE	0000				30		2.0		29		
80/11/05	20 41											
	20 41											
CP(T)-03	AVE	0000				19		1.0		99		
80/11/05	22 41											

STORET RETRIEVAL DATE 82/03/01

16165231
29 17 00.0 098 34 00.0 5
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574625-0084116

/TYPA/AMBNT/FISH/STREAM/TISSUE

DATE FROM TO	TIME OF DAY	DEPTH FEET	01040 COPPER CU,DISS UG/L	01042 COPPER CU,TOT UG/L
80/11/05	10 44	0000	6	
	10 46	0000	3	0
	10 48	0000	6	6
	10 50	0000		0
	11 41			
CP(T)-03	AVE	0000		2
80/11/05	13 41			
	13 41			
CP(T)-03	AVE	0000		0
80/11/05	15 41			
	14 41			
CP(T)-03	AVE	0000		0
80/11/05	16 41			
	15 41			
CP(T)-03	AVE	0000		1
80/11/05	17 41			
	16 41			
CP(T)-03	AVE	0000		4
80/11/05	18 41			
	19 41			
CP(T)-03	AVE	0000		1
80/11/05	21 41			
	21 41			
CP(T)-03	AVE	0000		0
80/11/05	23 41			
	22 41			
CP(T)-03	AVE	0000		9
80/11/06	00 41			
80/11/05	23 41			
CP(T)-03	AVE	0000		5
80/11/06	01 41			
	00 41			
CP(T)-03	AVE	0000		14
80/11/06	02 41			
	01 41			
CP(T)-03	AVE	0000		3
80/11/06	03 41			

STORET RETRIEVAL DATE 82/03/01

16165231
29 17 00.0 098 34 00.0 5
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
/TYPA/AMBNT/FISH/STREAM/TISSUE 11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574625-0084116

DATE FROM TO	TIME OF DAY	DEPTH FEET	01025 CADMIUM CD,DISS UG/L	01027 CADMIUM CD,TOT UG/L	01049 LEAD PB,DISS UG/L	01051 LEAD PB,TOT UG/L	01075 SILVER AG,DISS UG/L	01077 SILVER AG,TOT UG/L	01000 ARSENIC AS,DISS UG/L	01002 ARSENIC AS,TOT UG/L	01030 CHROMIUM CR,DISS UG/L	01034 CHROMIUM CR,TOT UG/L
80/11/05	21 41											
CP(T)-03	AVE	0000		1		19						
80/11/05	23 41											
	22 41											
CP(T)-03	AVE	0000		6		202		6.0		204		
80/11/06	00 41											
80/11/05	23 41											
CP(T)-03	AVE	0000		4		126						
80/11/06	01 41											
	00 41											
CP(T)-03	AVE	0000		7		141		12.0		236		
80/11/06	02 41											
	01 41											
CP(T)-03	AVE	0000		9		181		37.0		101		2
80/11/06	03 41											
	02 41											
CP(T)-03	AVE	0000		8		205		26.0		146		3
80/11/06	04 41											
	03 41											
CP(T)-03	AVE	0000		5		124		14.0		32		2
80/11/06	05 41											
	04 41											
CP(T)-03	AVE	0000		5		166		29.0		174		4
80/11/06	06 41											
	05 41											
CP(T)-03	AVE	0000		4		87		6.0		3		2
80/11/06	07 41											

STORET RETRIEVAL DATE 82/03/01

16165231
29 17 00.0 098 34 00.0 5
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574625-0084116

/TYPA/AMBNT/FISH/STREAM/TISSUE

DATE FROM TO	TIME OF DAY	DEPTH FEET	01040 COPPER CU,DISS UG/L	01042 COPPER CU,TOT UG/L
	03 41			
CP(T)-03	AVE	0000		1
80/11/06	05 41			
	04 41			
CP(T)-03	AVE	0000		7
80/11/06	06 41			
	05 41			
CP(T)-03	AVE	0000		5
80/11/06	07 41			

STORET RETRIEVAL DATE 82/02/01

16161231
29 23 30.0 098 36 30.0 5
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574621-0084104

/TYPA/AMBNT/FISH/STREAM/TISSUE

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00094 CNDUCTVY FIELD MICROMHO	00299 DO PROBE MG/L	00400 PH SU	00410 T ALK CACO3 MG/L	00500 RESIDUE TOTAL MG/L	00530 RESIDUE TOT NFLT MG/L	00612 UN-IONZD NH3-N MG/L	00623 KJELDL N DISS MG/L	00630 NO2&NO3 N-TOTAL MG/L
80/11/07	09 00	0000	16.7	1190	7.4	7.01	193	600	47	0.000	0.300	3.10
	09 01	0000					193	587	46	0.000	0.260	3.10
	09 02	0000					214	610	32	0.000	0.270	3.40
	09 03	0000					216	593	60	0.000	0.280	3.30
	09 04	0000					109	589	13	0.000	0.200	3.10
	09 10	0000	16.8	1170	6.5	7.07						
	09 20	0000	17.0	1120	6.1	6.99						
	09 30	0000	17.0	1120	6.1	6.97						
	09 40	0000	17.0	1090	6.0	6.94						

DATE FROM TO	TIME OF DAY	DEPTH FEET	00669 PHOS-TOT HYDRO MG/L P	00680 T ORG C C MG/L	50060 CHLORINE TOT RESD MG/L	50064 CHLORINE FREE AVL MG/L	82078 TURBIDIT Y FIELD NTU
80/11/07	09 00	0000	0.020	2.7	0.60	9.30	
	09 01	0000	0.020	4.6			
	09 02	0000	0.020				
	09 03	0000	0.020				
	09 04	0000	0.020				
	09 10	0000			0.70	0.05	9.3

STORET RETRIEVAL DATE 82/02/01

/TYPA/AMBNT/FISH/STREAM/TISSUE

16162231
29 21 30.0 098 34 30.0 4
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574622-0084106

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00094 CNDUCTVY FIELD MICROMHO	00299 DO PROBE MG/L	00400 PH SU	00410 T ALK CACO3 MG/L	00500 RESIDUE TOTAL MG/L	00530 RESIDUE TOT NFLT MG/L	00612 UN-IONZD NH3-N MG/L	00623 KJELDL N DISS MG/L	00630 NO2&NO3 N-TOTAL MG/L
80/11/06	13 10	0000	22.0	1080	4.8	7.01						
	13 20	0000	22.5	1130	5.6	7.04						
	13 30	0000	22.6	1130	5.7	7.10	150	390	19	0.130	0.560	3.10
	13 31	0000					151	409	35	0.130	0.470	3.10
	13 32	0000					152	406	25	0.110	0.510	2.70
	13 33	0000					153	395	31	0.110	0.450	2.60
	13 34	0000					152	407	11	0.120	0.460	2.50
	13 35	0000					153	399	55	0.120	0.490	2.50
	13 40	0000	22.0	1080	5.5	6.97						
	13 50	0000	21.7	1070	5.4	7.00						
	14 00	0001	21.7	1070	5.6	7.05						
	14 10	0000	22.4	1110	5.4	7.14						

DATE FROM TO	TIME OF DAY	DEPTH FEET	00669 PHOS-TOT HYDRO MG/L P	00680 T ORG C C MG/L	50060 CHLORINE TOT RESD MG/L	50064 CHLORINE FREE AVL MG/L	82078 TURBIDIT Y FIELD NTU
80/11/06	13 10	0000			0.80	0.06	3.1
	13 20	0000			0.80	0.06	3.1
	13 30	0000	0.130	4.4			3.1
	13 31	0000	0.120	10.1			
	13 32	0000	0.140				
	13 33	0000	0.140				
	13 34	0000	0.140				
	13 35	0000	0.140				

STORET RETRIEVAL DATE 82/02/01

16163231
29 21 00.0 098 34 30.0 5
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
/TYPA/AMBNT/FISH/STREAM/TISSUE 11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574623-0084111

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00094 CNDUCTVY FIELD MICROMHO	00299 DO PROBE MG/L	00400 PH SU	00410 T ALK CACO3 MG/L	00500 RESIDUE TOTAL MG/L	00530 RESIDUE TOT NFLT MG/L	00612 UN-IONZD NH3-N MG/L	00623 KJELDL N DISS MG/L	00630 NO2&NO3 N-TOTAL MG/L
80/11/06	09 00	0000	19.4	920	4.0	6.75	235	424	119	0.260	0.710	2.50
	09 01	0000					236	479	124	0.260	0.680	2.50
	09 02	0000					234	492	129	0.250	0.690	2.50
	09 03	0000					235	481	134	0.250	0.710	2.50
	09 04	0000					233	487	126	0.250	0.610	2.20
	09 05	0000					234	491	135	0.250	0.650	2.30
	09 10	0000	19.4	900	3.6	6.86						
	09 20	0000	19.4	910	3.8	6.88						
	09 30	0000	19.4	910	3.8	6.88						
	09 40	0000	19.5	910	3.8	6.88						

DATE FROM TO	TIME OF DAY	DEPTH FEET	00669 PHOS-TOT HYDRO MG/L P	00680 T ORG C C MG/L	50060 CHLORINE TOT RESD MG/L	50064 CHLORINE FREE AVL MG/L	82078 TURBIDIT Y FIELD NTU
80/11/06	09 00	0000	0.340	16.2	0.40	0.03	4.2
	09 01	0000	0.330	11.6			
	09 02	0000	0.330				
	09 03	0000	0.320				
	09 04	0000	0.280				
	09 05	0000	0.330				
	09 10	0000			0.40	0.03	4.2
	09 20	0000					6.3

STORET RETRIEVAL DATE 82/02/01

16164231
29 20 00.0 098 35 00.0 5
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
11EPATH 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574624-0084114

/TYPA/AMBNT/FISH/STREAM/TISSUE

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00094 CNDUCTVY FIELD MICROMHO	00299 DO PROBE MG/L	00400 PH SU	00410 T ALK CACO3 MG/L	00500 RESIDUE TOTAL MG/L	00530 RESIDUE TOT NFLT MG/L	00612 UN-IONZD NH3-N MG/L	00623 KJELDL N DISS MG/L	00630 NO2&NO3 N-TOTAL MG/L
80/11/05	12 00	0000	18.0	900	8.0	7.19	226	448	174	0.000	0.670	3.20
	12 01	0000					226	469	167	0.010	0.530	3.20
	12 02	0000					227	475	74	0.010	0.500	1.90
	12 03	0000					227	466	97	0.010	0.330	1.90
	12 04	0000					229	485	133	0.000	0.360	2.60
	12 05	0000					230	457	132	0.000	0.300	2.60
	12 10	0000	17.8	890	8.1	7.18						
	12 20	0000	17.7	890	8.2	7.17						
	12 30	0000	17.7	890	8.0	7.16						
	12 40	0000	17.7	890	8.0	7.15						

DATE FROM TO	TIME OF DAY	DEPTH FEET	00669 PHOS-TOT HYDRO MG/L P	00680 T ORG C C MG/L	50060 CHLORINE TOT RESD MG/L	50064 CHLORINE FREE AVL MG/L	82078 TURBIDIT Y FIELD NTU
80/11/05	12 00	0000	0.210	4.5	0.30	0.04	0.9
	12 01	0000	0.210	1.9			
	12 02	0000	0.200				
	12 03	0000	0.170				
	12 04	0000	0.200				
	12 05	0000	0.170				
	12 10	0000			0.30	0.04	0.9
	12 20	0000					0.9

STORET RETRIEVAL DATE 82/02/01

16165231
29 17 00.0 098 34 00.0 5
SAN ANTONIO TEXAS BEXAR COUNTY
48029 TEXAS BEXAR
WESTERN GULF 120600
GUADELUPE LAVACA AND SAN ANTONIO BASIN
/TYPA/AMBNT/FISH/STREAM/TISSUE 11EPATM 810124
0001 FEET DEPTH CLASS 00 CSN-RSP 0574625-0084116

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00094 CNDUCTVY FIELD MICROMHO	00299 DO PROBE MG/L	00400 PH SU	00410 T ALK CACO3 MG/L	00500 RESIDUE TOTAL MG/L	00530 RESIDUE TOT NFLT MG/L	00612 UN-IONZD NH3-N MG/L	00623 KJELDL N DISS MG/L	00630 NO2&NO3 N-TOTAL MG/L
80/11/05	10 00	0000	16.2	1130	6.6	7.34						
	10 10	0000	16.2	1130	6.8	7.37						
	10 20	0000	16.1	1130	6.4	7.38						
	10 30	0000	16.1	1130	6.9	7.39						
	10 40	0000	16.1	1130	6.9	7.39	248	580	29	0.030	0.440	1.50
	10 41	0000					250	586	83	0.010	0.300	1.50
	10 42	0000					246	588	70	0.010	0.270	1.50
	10 43	0000					246	588	80	0.010	0.240	1.50
	10 44	0000					186	578	90	0.010	0.260	1.70
	10 45	0000					188	580	103	0.000	0.270	1.70

DATE FROM TO	TIME OF DAY	DEPTH FEET	00669 PHOS-TOT HYDRO MG/L P	00680 T ORG C C MG/L	50060 CHLORINE TOT RESD MG/L	50064 CHLORINE FREE AVL MG/L	82078 TURBIDIT Y FIELD NTU
80/11/05	10 00	0000			0.30	0.04	5.6
	10 10	0000			0.30	0.04	5.6
	10 20	0000					5.6
	10 40	0000	0.060	11.6			
	10 41	0000	0.050	7.3			
	10 42	0000	0.060				
	10 43	0000	0.060				
	10 44	0000	0.060				
	10 45	0000	0.050				

APPENDIX B

MACROINVERTEBRATE CENSUS DATA

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 7, 1980
STATION: LACKLAND AND KELLY AFB, 4 MI UPSTREAM INDUST DISCH, (161) SUBSTATION: 231
SAMPLER TYPE: 30 SECOND KICK - 30 MESH TRIANGULAR NET (6)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: CHARLIE KEEHAN (53)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
EPHEMEROPTERA					
SIPHLONURIDAE					
ISONYCHIA SP. (530)	1 - 3	4.	0.	0.	4.
LEPTOPHLEBIIDAE					
PARALEPTOPHLEBIA SP. (1010)	1 - 3	20.	0.	0.	20.
BAETIDAE					
BAETIS SP. (1240)	1 - 3	624.	360.	68.	1052.
TRICORYTHIDAE					
TRICORYTHODES SP. (2010)	1 - 3	12.	0.	0.	12.
LEPTOHYPHES SP. (2110)	1 - 3	0.	4.	0.	4.
CAENIDAE					
CAENIS SP. (2710)	1 - 3	28.	72.	16.	116.
ODONATA-ANISOPTERA					
GOMPHIDAE					
OPHIOGOMPHUS SP. (4700)	1 - 3	0.	0.	4.	4.
ODONATA-ZYGOPTERA					
COENAGRIONIDAE					
ARGIA SP. (5310)	1 - 3	92.	84.	44.	220.
HEMIPTERA					
VELIIDAE					
RHAGOVELIA SP. (6170)	1 - 3	0.	4.	4.	8.
TRICHOPTERA					
HYDROPSYCHIDAE					
CHEUMATOPSYCHE SPP. (6630)	1 - 3	148.	16.	12.	176.
SMICRIDEA FASCIATELLA (6660)	1 - 3	0.	4.	0.	4.
HYDROPTILIDAE					
HYDROPTILA SP. (7710)	1 - 3	44.	28.	28.	100.
HELICOPSYCHIDAE					
HELICOPSYCHE SP. (8210)	1 - 3	0.	0.	4.	4.
DIPTERA					
CHIRONOMIDAE					
-ALL- (10510)	1 - 3	124.	68.	20.	212.
CHIRONOMIDAE, S-FAMILY TANYPODINAE					
-ALL- (10610)	1 - 3	88.	44.	24.	156.
CHIRONOMIDAE, S-FAMILY-CHIRONOMINAE					
-ALL- (12110)	1 - 3	972.	508.	488.	1968.

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 7, 1980
STATION: LACKLAND AND KELLY AFB, 4 MI UPSTREAM INDUST DISCH. (161) SUBSTATION: 231
SAMPLER TYPE: 30 SECOND KICK - 30 MESH TRIANGULAR NET (6)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: CHARLIE KEENAN (53)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
DIPTERA					
CHIRONOMIDAE, S-FAM ORTHOCLADIINAE					
-ALL- (14110)	1 - 3	872.	320.	300.	1492.
CERATOPOGONIDAE					
PALPOMYIA GROUP (18040)	1 - 3	4.	0.	0.	4.
LEPIDOPTERA					
PYRALIDAE					
PARARGYRACTIS SP. (19510)	1 - 3	32.	8.	12.	52.
COLEOPTERA					
ELMIDAE					
MICROCYLLOEPUS PUSILLUS LODINGI (19721)	1 - 3	12.	20.	4.	36.
HETERELMIS VULNERATA (19881)	1 - 3	28.	8.	4.	40.
STENELMIS SP. (19960)	1 - 3	304.	220.	92.	616.
PSEPHENIDAE					
PSEPHENUS SP. (20993)	1 - 3	4.	0.	0.	4.
AMPHIPODA					
TALITRIDAE					
HYALELLA AZTECA (41060)	1 - 3	44.	184.	92.	320.
NEPHROPSIDEA					
ASTACIDAE					
-ALL- (45710)	1 - 3	0.	4.	16.	20.
TURBELLARIA					
-ALL- (49010)	1 - 3	0.	20.	0.	20.
NEMATODA					
-ALL- (50610)	1 - 3	16.	0.	0.	16.
OLIGOCHAETA					
-ALL- (59010)	1 - 3	52.	40.	96.	188.
HIRUDINEA					
-ALL- (62510)	1 - 3	36.	32.	44.	112.
TOTAL FOR 29 SPECIES BY REPLICATE:	1 - 3	3560.	2048.	1372.	
TOTAL FOR 3 REPLICATES, 29 SPECIES:		6980.			

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 6, 1980
STATION: 50 YDS DOWNSTREAM KELLY AFB INDUSTRIAL DISCHARGE (162) SUBSTATION: 331
SAMPLER TYPE: 30 SECOND KICK - 30 MESH TRIANGULAR NET (6)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: CHARLIE KEENAN (53)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
DIPTERA					
CHIRONOMIDAE					
CHIRONOMIDAE PUPAE-ALL (10520)	1 - 3	24.	12.	16.	52.
CHIRONOMIDAE, S-FAMILY TANYPODINAE					
-ALL- (10610)	1 - 3	12.	8.	4.	24.
CHIRONOMIDAE, S-FAMILY-CHIRONOMINAE					
-ALL- (12110)	1 - 3	12.	8.	24.	44.
CHIRONOMIDAE, S-FAM ORTHOCLADIINAE					
-ALL- (14110)	1 - 3	128.	76.	120.	324.
NEPHROPSIDEA					
ASTACIDAE					
-ALL- (45710)	1 - 3	4.	0.	0.	4.
NEMATODA					
-ALL- (50610)	1 - 3	8.	4.	36.	48.
OLIGOCHAETA					
-ALL- (59010)	1 - 3	5000.	2936.	3696.	11632.
GASTROPODA					
PLANORBIDAE					
HELISOMA/GYRAULUS COMPLEX (63810)	1 - 3	0.	0.	4.	4.
PHYSIDAE					
PHYSA SP. (64310)	1 - 3	8.	0.	28.	36.

TOTAL FOR 9 SPECIES BY REPLICATE: 1 - 3 5196. 3044. 3928.

TOTAL FOR 3 REPLICATES, 9 SPECIES: 12168.

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 6, 1980
STATION: ROSEVALLEY RANCH, 0.5 MI D.S. KELLY AFB INDUST DISCH. (163) SUBSTATION: 231
SAMPLER TYPE: 30 SECOND KICK - 30 MESH TRIANGULAR NET (6)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: CHARLIE KEENAN (83)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE 2ND LEVEL REFERENCE GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
TRICHOPTERA					
HYDROPTILIDAE					
HYDROPTILA SP. (7710)	1 - 3	4.	0.	0.	4.
DIPTERA					
CHIRONOMIDAE					
CHIRONOMIDAE PUPAE-ALL (10520)	1 - 3	12.	0.	0.	12.
CHIRONOMIDAE, S-FAMILY TANYPODINAE					
-ALL- (10610)	1 - 3	4.	8.	0.	12.
CHIRONOMIDAE, S-FAMILY-CHIRONOMINAE					
-ALL- (12110)	1 - 3	12.	4.	4.	20.
CHIRONOMIDAE, S-FAM ORTHOCLADIINAE					
-ALL- (14110)	1 - 3	44.	24.	8.	76.
COLEOPTERA					
ELMIDAE					
MICROCYLLOEPUS PUSILLUS (19720)	1 - 3	4.	0.	0.	4.
STENELMIS SP. (19960)	1 - 3	12.	0.	0.	12.
NEPHROPSIDEA					
ASTACIDAE					
-ALL- (45710)	1 - 3	8.	8.	8.	24.
NEMATODA					
-ALL- (50610)	1 - 3	0.	4.	16.	20.
OLIGOCHAETA					
-ALL- (59010)	1 - 3	1936.	2412.	1764.	6112.
GASTROPODA					
PLANORBIDAE					
HELISOMA SP. (63020)	1 - 3	4.	0.	0.	4.
PELECYPODA					
SPHAERIIDAE					
SPHAERIUM SP. (65020)	1 - 3	0.	4.	0.	4.

TOTAL FOR 12 SPECIES BY REPLICATE: 1 - 3 2040. 2464. 1800.

TOTAL FOR 3 REPLICATES, 12 SPECIES: 6304.

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (018) DATE: NOVEMBER 5, 1980
STATION: SUMMERSET ROAD AT I-35, 3.5 MI DOWNSTREAM DISCHARGE (164) SUBSTATION: 231
SAMPLER TYPE: 30 SECOND KICK - 30 MESH TRIANGULAR NET (6)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: CHARLIE KEENAN (53)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE 2ND LEVEL REFERENCE GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
ODONATA-ANISOPTERA					
GOMPHIDAE					
OPHIOGOMPHUS SP. (4700)	1 - 3	2.	4.	12.	18.
ODONATA-ZYGOPTERA					
COENAGRIONIDAE					
ARGIA SP. (5310)	1 - 3	46.	60.	58.	164.
TRICHOPTERA					
HYDROPSYCHIDAE					
SMICRIDEA FASCIATELLA (6660)	1 - 3	4.	0.	2.	6.
HYDROPTILIDAE					
HYDROPTILA SP. (7710)	1 - 3	36.	72.	42.	150.
HELICOPSYCHIDAE					
HELICOPSYCHE SP. (8210)	1 - 3	0.	0.	2.	2.
DIPTERA					
CHIRONOMIDAE					
-ALL- (10510)	1 - 3	90.	204.	136.	430.
CHIRONOMIDAE, S-FAMILY TANYPODINAE					
-ALL- (10610)	1 - 3	32.	48.	70.	150.
CHIRONOMIDAE, S-FAMILY-CHIRONOMINAE					
-ALL- (12110)	1 - 3	232.	236.	276.	744.
CHIRONOMIDAE, S-FAM ORTHOCLADIINAE					
-ALL- (14110)	1 - 3	362.	444.	528.	1334.
SIMULIIDAE					
SIMULIUM SP. (17530)	1 - 3	4.	4.	10.	18.
CERATOPOGONIDAE					
PALPOMYIA GROUP (18040)	1 - 3	0.	0.	2.	2.
ATRICHOPOGON SP. (18070)	1 - 3	2.	0.	0.	2.
EMPIDIDAE					
-ALL- (18210)	1 - 3	4.	8.	14.	26.
LEPIDOPTERA					
PYRALIDAE					
PARARGYRACTIS SP. (19510)	1 - 3	2.	0.	0.	2.
COLEOPTERA					
ELMIDAE					
MICROCYLLOEPUS PUSILLUS LODINGI (19721)	1 - 3	4.	0.	2.	6.

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 5, 1980
STATION: SUMMERSET ROAD AT I-35, 3.8 MI DOWNSTREAM DISCHARGE (164) SUBSTATION: 231
SAMPLER TYPE: 30 SECOND KICK - 30 MESH TRIANGULAR NET (6)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: CHARLIE KEENAN (53)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
COLEOPTERA					
ELMIDAE					
STENELMIS SP. (19960)	1 - 3	78.	92.	90.	260.
STENELMIS CRENATA (19980)	1 - 3	0.	0.	2.	2.
PSEPHENIDAE					
PSEPHENUS SP. (20993)	1 - 3	2.	0.	0.	2.
NEPHROPSIDEA					
ASTACIDAE					
-ALL- (45710)	1 - 3	2.	0.	2.	4.
NEMATODA					
-ALL- (50610)	1 - 3	0.	0.	6.	6.
OLIGOCHAETA					
-ALL- (59010)	1 - 3	194.	292.	296.	782.
HIRUDINEA					
-ALL- (62510)	1 - 3	4.	4.	22.	30.
GASTROPODA					
ANCYLIDAE					
FERRISSIA SP. (63610)	1 - 3	40.	80.	90.	210.
PLANORBIDAE					
HELISOMA/GYRAULUS COMPLEX (63810)	1 - 3	0.	4.	2.	6.
PELECYPODA					
SPHAERIIDAE					
SPHAERIUM SP. (65020)	1 - 3	6.	12.	2.	20.
CORBICULIDAE					
CORBICULA SP. (66000)	1 - 3	30.	36.	32.	98.

TOTAL FOR 26 SPECIES BY REPLICATE:	1 - 3	1176.	1608.	1680.
TOTAL FOR 3 REPLICATES, 26 SPECIES:		4464.		

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 5, 1980
STATION: HWY 16 S, 9 MILES DOWNSTREAM KELLY AFB INDUST DISCH (165) SUBSTATION: 331
SAMPLER TYPE: 30 SECOND KICK - 30 MESH TRIANGULAR NET (6)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: CHARLIE KEENAN (83)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
EPHEMEROPTERA					
LEPTOPHLEBIIDAE					
PARALEPTOPHLEBIA SP. (1010)	1 - 3	1.	5.	4.	10.
BAETIDAE					
BAETIS SP. (1240)	1 - 3	19.	21.	36.	76.
TRICORYTHIDAE					
TRICORYTHODES SP. (2010)	1 - 3	8.	28.	4.	40.
LEPTOHYPHES SP. (2110)	1 - 3	0.	0.	1.	1.
CAENIDAE					
CAENIS SP. (2710)	1 - 3	2.	9.	0.	11.
ODONATA-ANISOPTERA					
GOMPHIDAE					
OPHIOGOMPHUS SP. (4700)	1 - 3	5.	7.	2.	14.
LIBELLULIDAE					
BRECHMORHOGA MENDAX (4880)	1 - 3	0.	0.	1.	1.
ODONATA-ZYGOPTERA					
CALOPTERYGIDAE					
HETAERINA SP. (5130)	1 - 3	0.	6.	2.	8.
COENAGRIONIDAE					
ARGIA SP. (5310)	1 - 3	16.	80.	25.	121.
MEGALOPTERA					
CORYDALIDAE					
CORYDALUS SP. (5710)	1 - 3	9.	22.	30.	61.
TRICHOPTERA					
HYDROPSYCHIDAE					
HYDROPSYCHE SPP. (6560)	1 - 3	0.	1.	0.	1.
SMICRIDEA FASCIATELLA (6660)	1 - 3	45.	83.	77.	205.
HYDROPTILIDAE					
HYDROPTILA SP. (7710)	1 - 3	3.	7.	0.	10.
LEUCOTRICHIA SP. (8010)	1 - 3	3.	2.	0.	5.
ALISOTRICHIA SP. (8020)	1 - 3	0.	6.	5.	11.
HELICOPSYCHIDAE					
HELICOPSYCHE SP. (8210)	1 - 3	10.	1.	1.	12.
DIPTERA					
CHIRONOMIDAE					
-ALL- (10510)	1 - 3	38.	43.	25.	106.

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 5, 1980
STATION: HWY 16 S, 9 MILES DOWNSTREAM KELLY AFB INDUST DISCH (165) SUBSTATION: 331
SAMPLER TYPE: 30 SECOND KICK - 30 MESH TRIANGULAR NET (6)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: CHARLIE KEENAN (53)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
DIPTERA					
CHIRONOMIDAE, S-FAMILY TANYPODINAE					
-ALL- (10610)	1 - 3	2.	14.	2.	18.
CHIRONOMIDAE, S-FAMILY-CHIRONOMINAE					
-ALL- (12110)	1 - 3	159.	235.	69.	463.
CHIRONOMIDAE, S-FAM ORTHOCLADIINAE					
-ALL- (14110)	1 - 3	105.	130.	72.	307.
SIMULIIDAE					
SIMULIUM SP. (17530)	1 - 3	0.	0.	1.	1.
LEPIDOPTERA					
PYRALIDAE					
PARARGYRACTIS SP. (19510)	1 - 3	4.	9.	1.	14.
COLEOPTERA					
ELMIDAE					
MICROCYLLOEPUS PUSILLUS LODINGI (19721)	1 - 3	17.	28.	18.	63.
HETERELMIS VULNERATA (19881)	1 - 3	57.	113.	32.	202.
STENELMIS SP. (19960)	1 - 3	18.	34.	22.	74.
ELSIANUS TEXANUS (20001)	1 - 3	1.	2.	1.	4.
DRYOPIDAE					
HELICHUS SP. (20310)	1 - 3	0.	1.	0.	1.
PSEPHENIDAE					
PSEPHENUS SP. (20993)	1 - 3	1.	1.	2.	4.
HYDRACARINA					
SPERCHONIDAE					
SPERCHON SP. (21510)	1 - 3	1.	2.	0.	3.
HYGROBATIDAE					
ATRACTIDES SP. (21700)	1 - 3	0.	5.	0.	5.
NEPHROPSIDEA					
ASTACIDAE					
-ALL- (45710)	1 - 3	1.	4.	0.	5.
NEMATODA					
-ALL- (50610)	1 - 3	0.	0.	1.	1.
OLIGOCHAETA					
-ALL- (59010)	1 - 3	6.	16.	2.	24.
GASTROPODA					
ANCYLIDAE					
FERRISSIA SP. (63610)	1 - 3	1.	0.	0.	1.
PHYSIDAE					
PHYSA SP. (64310)	1 - 3	0.	0.	1.	1.
TOTAL FOR 35 SPECIES BY REPLICATE:	1 - 3	532.	915.	437.	
TOTAL FOR 3 REPLICATES, 35 SPECIES:		1884.			

APPENDIX C

PERIPHYTON CENSUS DATA

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 7, 1980
STATION: LACKLAND AND KELLY AFB, 4 MI UPSTREAM INDUST DISCH. (161) SUBSTATION: 231
SAMPLER TYPE: UNIT AREA PERIPHYTON SCRAPE (30)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: KEN MOOR (60)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
BACILLARIOPHYCEAE					
NAVICULACEAE					
NAVICULA MUTICA VAR. TROPICA (77860)	1 - 3	598.	582.	66.	1247.
NAVICULA CONFERVACEA (77900)	1 - 3	142.	138.	16.	296.
NAVICULA NOTHA (77930)	1 - 3	110.	107.	12.	230.
NAVICULA SECRETA VAR. APICULATA (77970)	1 - 3	16.	15.	2.	33.
NAVICULA MUTICA VAR. STIGMA (77980)	1 - 3	47.	46.	5.	98.
NAVICULA VIRIDULA VAR. ROSTELLATA (77990)	1 - 3	16.	15.	2.	33.
NAVICULA SANTAECRUCIS (78000)	1 - 3	94.	92.	10.	197.
PINNULARIA SPP. (78820)	1 - 3	31.	31.	3.	66.
PINNULARIA BICEPS (78960)	1 - 3	16.	15.	2.	33.
PLEUROSIGMA DELICATULUM (79110)	1 - 3	47.	46.	5.	98.
GOMPHONEMACEAE					
GOMPHONEMA PARVULUM (80510)	1 - 3	354.	345.	39.	738.
GOMPHONEMA SUBCLAVATUM VAR. MEXICANUM (80530)	1 - 3	409.	398.	45.	853.
GOMPHONEMA SUBCLAVATUM (80550)	1 - 3	39.	38.	4.	82.
GOMPHONEMA BRASILIENSE (80710)	1 - 3	63.	61.	7.	131.
CYMBELLACEAE					
AMPHORA OVALIS (81040)	1 - 3	157.	153.	17.	328.
CYMBELLA MINUTA (81510)	1 - 3	134.	130.	15.	279.
CYMBELLA MINUTA VAR. PSEUDOGRACILIS (81610)	1 - 3	47.	46.	5.	98.
NITZSCHIACEAE					
BACILLARIA PARADOXA (83020)	1 - 3	126.	123.	14.	263.
NITZSCHIA SPP. (84000)	1 - 3	150.	146.	17.	312.
NITZSCHIA DISSIPATA (84020)	1 - 3	94.	92.	10.	197.
NITZSCHIA PALEA (84050)	1 - 3	47.	46.	5.	98.
NITZSCHIA AMPHIBIA (84070)	1 - 3	653.	636.	72.	1362.
NITZSCHIA HUNGARICA (84100)	1 - 3	142.	138.	16.	295.
NITZSCHIA FACICULATA (84170)	1 - 3	16.	15.	2.	33.
NITZSCHIA TRYBLIONELLA VAR. LEVIDENSIS (84200)	1 - 3	47.	46.	5.	98.
NITZSCHIA OBTUSA VAR. SCALPELLIFORMIS (84260)	1 - 3	8.	8.	1.	16.
NITZSCHIA SIGMA (84280)	1 - 3	16.	15.	2.	33.
NITZSCHIA TRYBLIONELLA VAR. VICTORIAE (84290)	1 - 3	31.	31.	3.	66.
NITZSCHIA APICULATA (84300)	1 - 3	142.	138.	16.	299.
NITZSCHIA GANDERSHEIMIENSIS? (84310)	1 - 3	31.	31.	3.	66.

PROJECT: TOXIC METALS PROJECT (TM)   AREA: RIVER SYSTEM NOT DESIGNATED (015)   DATE: NOVEMBER 7, 1980
STATION: LACKLAND AND KELLY AFB, 4 MI UPSTREAM INDUST DISCH, (161)   SUBSTATION: 231
SAMPLER TYPE: UNIT AREA PERIPHYTON SCRAPE (30)
NUMBER OF REPLICATES: 3   FIELD BIOLOGIST: KEN MOOR (60)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
BACILLARIOPHYCEAE					
NITZSCHIACEAE					
NITZSCHIA HYBRIDA (84320)	1 - 3	16.	15.	2.	33.
SURIRELLACEAE					
SURIRELLA ANGUSTATA (85210)	1 - 3	47.	46.	5.	98.
SURIRELLA OVALIS (85220)	1 - 3	78.	77.	9.	164.
CYANOPHYTA					
OSCILLATORIALES					
OSCILLATORIA SPP. (92000)	1 - 3	0.	0.	18.	18.
TOTAL FOR 58 SPECIES BY REPLICATE:	1 - 3	7247.	6775.	885.	
TOTAL FOR 3 REPLICATES, 58 SPECIES:		14907.			

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (019) DATE: NOVEMBER 6 , 1980
STATION: 50 YDS DOWNSTREAM KELLY AFB INDUSTRIAL DISCHARGE (162) SUBSTATION: 231
SAMPLER TYPE: UNIT AREA PERIPHYTON SCRAPE (30)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: KEN MOOR (60)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
CHLOROPHYTA					
FILAMENTS (40)	1 - 3	1720.	206.	0.	1926.
CHLOROCOCCALES					
COELASTRUM MICROPORUM (18020)	1 - 3	1376.	0.	0.	1376.
SCENEDESMUS QUADRICAUDA (18880)	1 - 3	0.	0.	116.	116.
SCENEDESMUS ABUNDANS (18910)	1 - 3	275.	0.	0.	275.
SCENEDESMUS DIMORPHUS (18920)	1 - 3	826.	0.	39.	864.
ZYGNEMATALES					
SPIROGYRA SPP. (27320)	1 - 3	0.	65.	0.	65.
CLOSTERIUM SPP. (29000)	1 - 3	34.	4.	10.	48.
COSMARIUM SPP. (29320)	1 - 3	0.	4.	0.	4.
BACILLARIOPHYCEAE					
CENTRALES					
MELOSIRA VARIANS (63870)	1 - 3	63.	22.	16.	101.
CYCLOTELLA MENEGHINIANA (64110)	1 - 3	16.	5.	4.	25.
CYCLOTELLA STELLIGERA (64130)	1 - 3	16.	5.	4.	25.
CYCLOTELLA PSEUDOSTELLIGERA (64150)	1 - 3	48.	16.	12.	76.
FRAGILARIACEAE					
SYNEDRA ULNA (72130)	1 - 3	1379.	473.	342.	2194.
SYNEDRA ULNA VAR. OXYRHYNCHUS F. MEDIO-C (72200)	1 - 3	539.	185.	134.	858.
EUNOTIACEAE					
EUNOTIA PECTINALIS (73650)	1 - 3	16.	5.	4.	25.
NAVICULACEAE					
DIPLONEIS SPP. (76720)	1 - 3	16.	5.	4.	25.
NAVICULA SPP. (77520)	1 - 3	79.	27.	20.	126.
NAVICULA PUPULA (77590)	1 - 3	48.	16.	12.	76.
NAVICULA CRYPTOCEPHALA VAR. VENETA (77640)	1 - 3	63.	22.	16.	101.
NAVICULA MINIMA (77650)	1 - 3	16.	5.	4.	25.
NAVICULA SUBMINUSCULA (77760)	1 - 3	48.	16.	12.	76.
NAVICULA MUTICA VAR. TROPICA (77860)	1 - 3	48.	16.	12.	76.
NAVICULA CONFERVACEA (77900)	1 - 3	2489.	853.	618.	3960.
NAVICULA MUTICA VAR. STIGMA (77980)	1 - 3	396.	136.	98.	631.
GOMPHONEMACEAE					
GOMPHONEMA PARVULUM (80510)	1 - 3	95.	33.	24.	151.
CYMBELLACEAE					
CYMBELLA MINUTA (81510)	1 - 3	16.	5.	4.	25.

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 6 , 1980
STATION: SO TOS DOWNSTREAM KELLY AFB INDUSTRIAL DISCHARGE (162) SUBSTATION: 231
SAMPLER TYPE: UNIT AREA PERIPHYTON SCRAPE (30)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: KEN MOOR (60)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
BACILLARIOPHYCEAE					
NITZSCHIACEAE					
BACILLARIA PARADOXA (83020)	1 - 3	32.	11.	8.	50.
HANTZSCHIA AMPHIOXYS (83430)	1 - 3	16.	5.	4.	25.
NITZSCHIA SPP. (84000)	1 - 3	63.	22.	16.	101.
NITZSCHIA DISSIPATA (84020)	1 - 3	206.	71.	51.	328.
NITZSCHIA HANTZSCHIANA (84040)	1 - 3	79.	27.	20.	126.
NITZSCHIA PALEA (84050)	1 - 3	6040.	2069.	1501.	9610.
NITZSCHIA FONTICOLA (84060)	1 - 3	16.	5.	4.	25.
NITZSCHIA AMPHIBIA (84070)	1 - 3	143.	49.	35.	227.
NITZSCHIA HUNGARICA (84100)	1 - 3	16.	5.	4.	25.
NITZSCHIA IGNORATA (84110)	1 - 3	143.	49.	35.	227.
NITZSCHIA TRYBLIONELLA VAR. LEVIDENSIS (84200)	1 - 3	111.	38.	28.	177.
NITZSCHIA ELLIPTICA (84220)	1 - 3	16.	5.	4.	25.
NITZSCHIA KUTZINGIANA (84230)	1 - 3	317.	109.	79.	504.
NITZSCHIA OBTUSA VAR. SCALPELLIFORMIS (84260)	1 - 3	143.	49.	35.	227.
SURIRELLACEAE					
SURIRELLA ANGUSTATA (85210)	1 - 3	32.	11.	8.	50.
CYANOPHYTA					
OSCILLATORIALES					
OSCILLATORIA SPP. (92000)	1 - 3	34.	0.	0.	34.
TOTAL FOR 42 SPECIES BY REPLICATE:	1 - 3	17028.	4652.	3335.	
TOTAL FOR 3 REPLICATES, 42 SPECIES:		25015.			

PROJECT: TOXIC METALS PROJECT (TM)   AREA: RIVER SYSTEM NOT DESIGNATED (015)   DATE: NOVEMBER 5, 1980
STATION: ROSEVALLEY RANCH, 0.5 MI D.S. KELLY AFB INDUST DISCH. (163)   SUBSTATION: 231
SAMPLER TYPE: UNIT AREA PERIPHYTON SCRAPE (30)
NUMBER OF REPLICATES: 3   FIELD BIOLOGIST: KEN MOOR (60)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
CHLOROPHYTA					
ZYGNEMATALES					
MOUGEOTIA SPP. (26800)	1 - 3	410.	0.	0.	410.
SIPHONOCLADALES					
CLADOPHORA SPP. (27000)	1 - 3	0.	0.	483.	483.
EUGLENOPHYTA					
EUGLENALES					
EUGLENA SPP. (37000)	1 - 3	41.	0.	0.	41.
PYRRHOPHYTA					
DINOKONTAE					
PERIDINIUM SPP. (44800)	1 - 3	0.	48.	0.	48.
BACILLARIOPHYCEAE					
CENTRALES					
CYCLOTELLA MENEGHINIANA (64110)	1 - 3	11.	26.	40.	77.
CYCLOTELLA STELLIGERA (64130)	1 - 3	45.	104.	161.	309.
CYCLOTELLA PSEUDOSTELLIGERA (64150)	1 - 3	101.	233.	362.	696.
TERPSINOE AMERICANA (67340)	1 - 3	6.	13.	20.	39.
FRAGILARIACEAE					
FRAGILARIA SPP. (70760)	1 - 3	118.	272.	422.	812.
SYNEDRA ULNA VAR. CONTRACTA (72400)	1 - 3	34.	78.	121.	232.
ACHNANTHACEAE					
ACHNANTHES LANCEOLATA (74540)	1 - 3	11.	26.	40.	77.
ACHNANTHES MINUTISSIMA (74600)	1 - 3	22.	52.	80.	155.
COCCONEIS PLACENTULA (74830)	1 - 3	6.	13.	20.	39.
NAVICULACEAE					
DIPLONEIS ELLIPTICA (76730)	1 - 3	34.	78.	121.	232.
NAVICULA SPP. (77520)	1 - 3	45.	104.	161.	309.
NAVICULA RHYNCHOCEPHALA (77540)	1 - 3	11.	26.	40.	77.
NAVICULA TRIPUNCTATA VAR. SCHIZONMOIDES (77570)0)	1 - 3	11.	26.	40.	77.
NAVICULA PUPULA (77590)	1 - 3	112.	259.	402.	773.
NAVICULA CRYPTOCEPHALA (77630)	1 - 3	45.	104.	161.	309.
NAVICULA MINIMA (77650)	1 - 3	11.	26.	40.	77.
NAVICULA SUBMINUSCULA (77760)	1 - 3	22.	52.	80.	155.
NAVICULA GRACILOIDES (77770)	1 - 3	34.	78.	121.	232.
NAVICULA MUTICA VAR. TROPICA (77860)	1 - 3	34.	78.	121.	232.

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 5, 1980
STATION: ROSEVALLEY RANCH, 0.5 MI D.S. KELLY AFB INDUST DISCH. (163) SUBSTATION: 231
SAMPLER TYPE: UNIT AREA PERIPHYTON SCRAPE (30)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: KEN MOOR (60)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
BACILLARIOPHYCEAE					
NAVICULACEAE					
NAVICULA PYGMAEA (77960)	1 - 3	134.	311.	483.	928.
NAVICULA MUTICA VAR. STIGMA (77980)	1 - 3	1108.	2566.	3980.	7654.
NAVICULA SANTAECRUCIS (78000)	1 - 3	67.	156.	241.	464.
NAVICULA CUSPIDATA (78010)	1 - 3	11.	26.	40.	77.
PINNULARIA SPP. (78820)	1 - 3	11.	26.	40.	77.
PINNULARIA BICEPS (78960)	1 - 3	11.	26.	40.	77.
GOMPHONEMACEAE					
GOMPHONEMA BRASILIENSE (80710)	1 - 3	241.	557.	864.	1662.
CYMBELLACEAE					
AMPHORA OVALIS VAR. PEDICULUS (81060)	1 - 3	11.	26.	40.	77.
CYMBELLA SINUATA (81530)	1 - 3	11.	26.	40.	77.
NITZSCHIACEAE					
BACILLARIA PARADOXA (83020)	1 - 3	22.	52.	80.	155.
NITZSCHIA SPP. (84000)	1 - 3	56.	130.	201.	387.
NITZSCHIA HANTZSCHIANA (84040)	1 - 3	22.	52.	80.	155.
NITZSCHIA PALEA (84050)	1 - 3	353.	817.	1266.	2435.
NITZSCHIA PONTICOLA (84060)	1 - 3	67.	156.	241.	464.
NITZSCHIA AMPHIBIA (84070)	1 - 3	285.	661.	1025.	1972.
NITZSCHIA IGNORATA (84110)	1 - 3	6.	13.	20.	39.
NITZSCHIA FILIFORMIS (84140)	1 - 3	45.	104.	161.	309.
NITZSCHIA TRYBLIONELLA VAR. DEBILIS (84210)	1 - 3	45.	104.	161.	309.
NITZSCHIA KUTZINGIANA (84230)	1 - 3	235.	544.	844.	1624.
NITZSCHIA CAPITELLATA (84240)	1 - 3	347.	804.	1246.	2397.
NITZSCHIA ACCEDENS (84250)	1 - 3	22.	52.	80.	155.
NITZSCHIA OBTUSA VAR. SCALPELLIFORMIS (84260)	1 - 3	56.	130.	201.	387.
NITZSCHIA LORENZIANA (84270)	1 - 3	11.	26.	40.	77.
SURIRELLACEAE					
SURIRELLA ROBUSTA (85240)	1 - 3	11.	26.	40.	77.
CYANOPHYTA					
OSCILLATORIALES					
OSCILLATORIA SPP. (92000)	1 - 3	82.	0.	0.	82.
TOTAL FOR 48 SPECIES BY REPLICATE:	1 - 3	4433.	9082.	14493.	
TOTAL FOR 3 REPLICATES, 48 SPECIES:		28008.			

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 5, 1980
STATION: SUMMERSET ROAD AT I-35, 3.5 MI DOWNSTREAM DISCHARGE (164) SUBSTATION: 231
SAMPLER TYPE: UNIT AREA PERIPHYTON SCRAPE (30)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: KEN MOOR (60)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
CHLOROPHYTA					
FILAMENTS (40)	1 - 3	0.	70.	0.	70.
SIPHONOCLADALES					
CLADOPHORA SPP. (27000)	1 - 3	6.	0.	0.	6.
ZYGNEMATALES					
CLOSTERIUM SPP. (30000)	1 - 3	4.	0.	0.	4.
EUGLENOPHYTA					
EUGLENALES					
PHACUS SPP. (37500)	1 - 3	4.	3.	0.	7.
CRYPTOPHYTA					
CRYPTOMONADACEAE					
CRYPTOMONAS SPP. (47900)	1 - 3	4.	0.	0.	4.
BACILLARIOPHYCEAE					
CENTRALES					
MELOSIRA VARIANS (63870)	1 - 3	10.	16.	156.	182.
CYCLOTELLA MENEGHINIANA (64110)	1 - 3	1.	1.	10.	12.
THALLASSIOSIRA FLUVIATILIS (66210)	1 - 3	6.	10.	93.	109.
BIDDULPHIA LAEVIS (66340)	1 - 3	32.	51.	488.	571.
TERPSINOE AMERICANA (67340)	1 - 3	9.	13.	124.	146.
FRAGILARIACEAE					
SYNEDRA ULNA VAR. OXYRHYNCHUS F. MEDIO-C (72200)	1 - 3	24.	37.	352.	413.
SYNEDRA GALLONII (72410)	1 - 3	11.	17.	166.	195.
ACHNANTHACEAE					
ACHNANTHES LANCEOLATA (74540)	1 - 3	1.	2.	21.	24.
ACHNANTHES MINUTISSIMA (74600)	1 - 3	4.	7.	62.	73.
COCCONEIS PLACENTULA VAR. EUGLYPTA (74840)	1 - 3	9.	14.	135.	158.
NAVICULACEAE					
DIPLONEIS SPP. (76720)	1 - 3	1.	1.	10.	12.
GYROSIGMA SPP. (77120)	1 - 3	1.	2.	21.	24.
NAVICULA RHYNCHOCEPHALA (77540)	1 - 3	6.	9.	83.	97.
NAVICULA TRIPUNCTATA VAR. SCHIZONMOIDES (77570)0)	1 - 3	1.	2.	21.	24.
NAVICULA CRYPTOCEPHALA (77630)	1 - 3	2.	3.	31.	36.
NAVICULA MINIMA (77650)	1 - 3	1.	1.	10.	12.
NAVICULA SUBMINUSCULA (77760)	1 - 3	21.	33.	311.	365.
NAVICULA GRACILOIDES (77770)	1 - 3	85.	134.	1276.	1495.

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 7, 1980
STATION: LACKLAND AND KELLY AFB, 4 MI UPSTREAM INDUST DISCH. (161) SUBSTATION: 231
SAMPLER TYPE: UNIT AREA PERIPHYTON SCRAPE (30)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: KEN MOOR (60)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
CHLOROPHYTA					
COLONIES (30)	1 - 3	0.	0.	196.	196.
FILAMENTS (40)	1 - 3	1065.	0.	0.	1065.
CHLOROCOCCALES					
SCENEDESMUS SPP. (18860)	1 - 3	0.	74.	0.	74.
ZYGNEMATALES					
MOUGEOTIA SPP. (26800)	1 - 3	120.	0.	0.	120.
SIPHONOCLADALES					
CLADOPHORA SPP. (27000)	1 - 3	0.	773.	0.	773.
ZYGNEMATALES					
COSMARIUM SPP. (29320)	1 - 3	0.	37.	0.	37.
BACILLARIOPHYCEAE					
CENTRALES					
MELOSIRA VARIANS (63870)	1 - 3	16.	15.	2.	33.
CYCLOTELLA MENEGHINIANA (64110)	1 - 3	16.	15.	2.	33.
CYCLOTELLA STELLIGERA (64130)	1 - 3	16.	15.	2.	33.
THALLASSIOSIRA FLUVIATILIS (66210)	1 - 3	16.	15.	2.	33.
FRAGILARIACEAE					
SYNEDRA RUMPENS (72120)	1 - 3	8.	8.	1.	16.
SYNEDRA ULNA VAR. OXYRHYNCHUS F. MEDIO-C (72200)	1 - 3	24.	23.	3.	49.
EUNOTIACEAE					
EUNOTIA NAEGELII (73680)	1 - 3	16.	15.	2.	33.
ACHNANTHACEAE					
ACHNANTHES MINUTISSIMA (74600)	1 - 3	142.	138.	16.	296.
ACHNANTHES AFFINIS (74650)	1 - 3	24.	23.	3.	49.
COCCONEIS PLACENTULA VAR. EUGLYPTA (74840)	1 - 3	16.	15.	2.	33.
NAVICULACEAE					
AMPHIPLEURA PELLUCIDA (75520)	1 - 3	16.	15.	2.	33.
GYROSIGMA SPP. (77120)	1 - 3	16.	15.	2.	33.
GYROSIGMA OBSCURUM (77130)	1 - 3	157.	153.	17.	328.
NAVICULA SPP. (77520)	1 - 3	31.	31.	3.	66.
NAVICULA CRYPTOCEPHALA (77630)	1 - 3	16.	15.	2.	33.
NAVICULA CRYPTOCEPHALA VAR. VENETA (77640)	1 - 3	16.	15.	2.	33.
NAVICULA GRACILOIDES (77770)	1 - 3	1496.	1456.	166.	3117.
NAVICULA SYMMETRICA (77850)	1 - 3	47.	46.	5.	98.

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 5, 1980
STATION: SUMMERSET ROAD AT I-35, 3.5 MI DOWNSTREAM DISCHARGE (164) SUBSTATION: 231
SAMPLER TYPE: UNIT AREA PERIPHYTON SCRAPE (30)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: KEN MOOR (60)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
BACILLARIOPHYCEAE					
NAVICULACEAE					
NAVICULA SYMMETRICA (77850)	1 - 3	3.	4.	41.	49.
NAVICULA CONFERVACEA (77900)	1 - 3	2.	3.	31.	36.
NAVICULA HEUFLERI VAR. LEPTOCEPHALA (77910)	1 - 3	1.	2.	21.	24.
NAVICULA MUTICA VAR. STIGMA (77980)	1 - 3	6.	9.	83.	97.
NAVICULA SANTAECRUCIS (78000)	1 - 3	7.	11.	104.	122.
NAVICULA CUSPIDATA (78010)	1 - 3	1.	1.	10.	12.
NAVICULA TENERA (78020)	1 - 3	3.	4.	41.	49.
PINNULARIA ABAUJENSIS (78940)	1 - 3	1.	1.	10.	12.
GOMPHONEMACEAE					
GOMPHONEMA PARVULUM (80510)	1 - 3	10.	15.	145.	170.
GOMPHONEMA SUBCLAVATUM VAR. MEXICANUM (80530)	1 - 3	25.	39.	373.	438.
GOMPHONEMA BRASILIENSE (80710)	1 - 3	11.	17.	166.	195.
CYMBELLACEAE					
AMPHORA SPP. (81020)	1 - 3	1.	1.	10.	12.
AMPHORA OVALIS (81040)	1 - 3	15.	23.	218.	255.
AMPHORA COFFEIFORMIS (81070)	1 - 3	12.	19.	176.	207.
NITZSCHIACEAE					
BACILLARIA PARADOXA (83020)	1 - 3	11.	17.	166.	198.
NITZSCHIA SPP. (84000)	1 - 3	1.	1.	10.	12.
NITZSCHIA DISSIPATA (84020)	1 - 3	1.	1.	10.	12.
NITZSCHIA FRUSTULUM VAR. PERPUSILLA (84030)	1 - 3	1.	1.	10.	12.
NITZSCHIA PALEA (84050)	1 - 3	3.	4.	41.	49.
NITZSCHIA AMPHIBIA (84070)	1 - 3	34.	54.	508.	596.
NITZSCHIA HUNGARICA (84100)	1 - 3	1.	1.	10.	12.
NITZSCHIA TRYBLIONELLA VAR. LEVIDENSIS (84200)	1 - 3	3.	5.	53.	61.
NITZSCHIA ELLIPTICA (84220)	1 - 3	2.	3.	31.	36.
NITZSCHIA CAPITELLATA (84240)	1 - 3	1.	2.	21.	24.
NITZSCHIA OBTUSA VAR. SCALPELLIFORMIS (84260)	1 - 3	1.	2.	21.	24.
NITZSCHIA LORENZIANA (84270)	1 - 3	1.	1.	10.	12.
NITZSCHIA APICULATA (84300)	1 - 3	7.	11.	104.	122.
SURIRELLACEAE					
CYMATOPLEURA SOLEA (85110)	1 - 3	1.	1.	10.	12.
SURIRELLA ANGUSTATA (85210)	1 - 3	2.	3.	31.	36.

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 5, 1980
STATION: SUMMERSET ROAD AT I-35, 3.5 MI DOWNSTREAM DISCHARGE (164) SUBSTATION: 231
SAMPLER TYPE: UNIT AREA PERIPHYTON SCRAPE (30)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: KEN MOOR (60)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
BACILLARIOPHYCEAE					
SURIRELLACEAE					
SURIRELLA ROBUSTA (85240)	1 - 3	1.	2.	21.	24.
SURIRELLA SUECICA (85260)	1 - 3	6.	10.	93.	109.
SURIRELLA OVATA VAR. CRUMENA (85270)	1 - 3	1.	2.	21.	24.

TOTAL FOR 55 SPECIES BY REPLICATE: 1 - 3 418. 702. 5975.

TOTAL FOR 3 REPLICATES, 55 SPECIES: 7094.

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 8, 1980
STATION: HWY 16 S, 9 MILES DOWNSTREAM KELLY AFB INDUST DISCH (165) SUBSTATION: 331
SAMPLER TYPE: UNIT AREA PERIPHYTON SCRAPE (30)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: KEN MOOR (60)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE / 2ND LEVEL REFERENCE / GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
CHLOROPHYTA					
FILAMENTS (40)	1 - 3	0.	0.	1043.	1043.
SIPHONOCLADALES					
CLADOPHORA SPP. (27000)	1 - 3	11.	500.	626.	1136.
ZYGNEMATALES					
CLOSTERIUM SPP. (29000)	1 - 3	0.	33.	0.	33.
BACILLARIOPHYCEAE					
CENTRALES					
CYCLOTELLA MENEGHINIANA (64110)	1 - 3	1.	45.	24.	70.
CYCLOTELLA STELLIGERA (64130)	1 - 3	1.	30.	16.	47.
THALLASSIOSIRA FLUVIATILIS (66210)	1 - 3	3.	90.	48.	141.
BIDDULPHIA LAEVIS (66340)	1 - 3	5.	219.	117.	341.
TERPSINOE AMERICANA (67340)	1 - 3	58.	2487.	1331.	3876.
FRAGILARIACEAE					
FRAGILARIA BREVISTRATA (70900)	1 - 3	0.	15.	8.	23.
SYNEDRA ULNA (72130)	1 - 3	1.	30.	16.	47.
SYNEDRA ULNA VAR. OXYRHYNCHUS F. MEDIO-C (72200)	1 - 3	17.	723.	387.	1128.
ACHNANTHACEAE					
COCCONEIS PLACENTULA VAR. EUGLYPTA (74840)	1 - 3	7.	301.	161.	470.
COCCONEIS PLACENTULA VAR. LINEATA (74850)	1 - 3	0.	15.	8.	23.
NAVICULACEAE					
DIPLONEIS OBLONGELLA (76770)	1 - 3	1.	45.	24.	70.
NAVICULA SPP. (77520)	1 - 3	0.	15.	8.	23.
NAVICULA RHYNCHOCEPHALA (77540)	1 - 3	0.	8.	4.	12.
NAVICULA TRIPUNCTATA VAR. SCHIZONOIDES (77570)0)	1 - 3	3.	90.	48.	141.
NAVICULA PUPULA VAR. RECTANGULARIS (77600)	1 - 3	1.	60.	32.	94.
NAVICULA CRYPTOCEPHALA (77630)	1 - 3	3.	90.	48.	141.
NAVICULA SUBMINUSCULA (77760)	1 - 3	1.	60.	32.	94.
NAVICULA GRACILOIDES (77770)	1 - 3	4.	101.	97.	202.
NAVICULA SYMMETRICA (77850)	1 - 3	0.	8.	4.	12.
NAVICULA MUTICA VAR. TROPICA (77860)	1 - 3	1.	45.	24.	70.
NAVICULA PYGMAEA (77940)	1 - 3	0.	15.	8.	23.
NAVICULA SANTAECRUCIS (78000)	1 - 3	9.	384.	206.	599.
NAVICULA CUSPIDATA (78010)	1 - 3	1.	30.	16.	47.
NAVICULA TENERA (78020)	1 - 3	4.	151.	81.	235.

PROJECT: TOXIC METALS PROJECT (TM) AREA: RIVER SYSTEM NOT DESIGNATED (015) DATE: NOVEMBER 5, 1980
STATION: HWY 16 S, 9 MILES DOWNSTREAM KELLY AFB INDUST DISCH (165) SUBSTATION: 331
SAMPLER TYPE: UNIT AREA PERIPHYTON SCRAPE (30)
NUMBER OF REPLICATES: 3 FIELD BIOLOGIST: KEN MOOR (60)
NOTE: NOT APPLICABLE (0)

RAW DATA TABLES

1ST LEVEL REFERENCE 2ND LEVEL REFERENCE GENUS/SPECIES	REPLICATES	COUNTS			TOTAL FOR SP.
BACILLARIOPHYCEAE					
GOMPHONEMACEAE					
GOMPHONEMA PARVULUM (80510)	1 - 3	6.	271.	145.	423.
GOMPHONEMA SUBCLAVATUM VAR. MEXICANUM (80530)	1 - 3	1.	45.	24.	70.
GOMPHONEMA BRASILIENSE (80710)	1 - 3	0.	8.	4.	12.
GOMPHONEMA TENELLUM (80730)	1 - 3	4.	166.	89.	258.
CYMBELLACEAE					
AMPHORA SPP. (81020)	1 - 3	0.	8.	4.	12.
CYMBELLA SPP. (81500)	1 - 3	0.	15.	8.	23.
NITZSCHIACEAE					
NITZSCHIA AMPHIBIA (84070)	1 - 3	2.	75.	40.	117.
NITZSCHIA HUNGARICA (84100)	1 - 3	1.	30.	16.	47.
NITZSCHIA TRYBLIONELLA VAR. LEVIDENSIS (84200)	1 - 3	1.	30.	16.	47.
NITZSCHIA KUTZINGIANA (84230)	1 - 3	2.	90.	48.	141.
NITZSCHIA CAPITELLATA (84240)	1 - 3	0.	8.	4.	12.
NITZSCHIA OBTUSA VAR. SCALPELLIFORMIS (84260)	1 - 3	1.	60.	32.	94.
NITZSCHIA LORENZIANA (84270)	1 - 3	1.	60.	32.	94.
SURIRELLACEAE					
SURIRELLA ANGUSTATA (85210)	1 - 3	0.	15.	8.	23.
CYANOPHYTA					
OSCILLATORIALES					
PHORMIDIUM SPP. (93000)	1 - 3	0.	0.	656.	656.

TOTAL FOR 42 SPECIES BY REPLICATE: 1 - 3 152. 6554. 5546.

TOTAL FOR 3 REPLICATES, 42 SPECIES: 12253.

APPENDIX D

TISSUE METAL ANALYSIS SUMMARY DATA

MEAN SILVER CONCENTRATIONS (ppm), LEON CREEK, TEXAS, IN VARIOUS PLANT TISSUES. MEANS ARE BASED ON THREE ANALYTICAL REPLICATES UNLESS OTHERWISE INDICATED.

Station	Roots	Leaves and Stems	Whole Plant
161	0.2	0.2K	0.3
	0.5	0.2K	0.5
	0.4	0.4	0.6
162	0.4	0.4	0.9
	0.7	0.6	1.1
	0.4	0.4	1.1
163	1.7	0.7	4.4
	1.7	0.4	1.3
	1.2	0.9	1.2
164	0.6	0.3	0.7
	0.5	0.6	0.9
	0.3	0.4	
	0.7	0.5	
165	0.8	0.5	0.2
	0.6	0.6	
	0.4	0.4	
	0.4	0.5	
		0.3	

K = value known to be less than indicated (one or more replicates less than detection limits).

MEAN LEAD CONCENTRATIONS (ppm), LEON CREEK, TEXAS, IN VARIOUS PLANT TISSUES. MEANS ARE BASED ON THREE ANALYTICAL REPLICATES UNLESS OTHERWISE INDICATED.

Station	Roots	Leaves and Stems	Whole Plant
161	-	-	7.8**
162	2.8	7.8	14.5
	37.5	ND**	36.1
		3.2	24.9
163	50.6	17.3	299.9
	112.1	9.6	27.1
	33.9	4.0*	13.9
164	11.6	4.9	3.2
	28.2	4.3*	32.3
	61.7	46.3	
		7.5*	
165	67.5	5.2*	19.2
	2.3K*	1.8*	
	8.4	-	
	18.4	12.0	
	8.6	18.0	

* = 2 replicates only.
** = 1 replicate only.
ND = not detectable.
K = value known to be less than indicated (one or more replicates less than detection limits).

MEAN CHROMIUM CONCENTRATIONS (ppm), LEON CREEK, TEXAS, IN VARIOUS PLANT TISSUES. MEANS ARE BASED ON THREE ANALYTICAL REPLICATES UNLESS OTHERWISE INDICATED.

Station	Roots	Leaves and Stems	Whole Plant
161	0.4K*	3.0	ND*
	4.1	ND	0.8*
			3.0
162	2.8	1.7	42.2
	23.9	2.4	15.0
	1.2		32.0
163	71.3	121.7	587.6
	72.9	6.8	86.4
	49.7	9.3	30.2
164	11.6	1.8	6.3
	8.1	0.4K	19.2
	15.2	10.4	
	2.4	1.6	
165	8.1	11.7	12.2
	2.2	7.5	
	10.1	0.6K	
	7.5		

* = 2 replicates only.
ND = not detectable.
K = value known to be less than indicated (one or more replicates less than detection limits).

MEAN COPPER CONCENTRATIONS (ppm), LEON CREEK, TEXAS, IN VARIOUS PLANT TISSUES. MEANS ARE BASED ON THREE ANALYTICAL REPLICATES UNLESS OTHERWISE INDICATED.

Station	Roots	Leaves and Stems	Whole Plant
161	5.1	2.8	7.6
	4.7	1.1	8.0
	1.1	5.4	8.9
162	16.6	9.1	65.0
	26.2	4.1	73.5
	12.4	8.2	77.3
163	61.5	32.8	286.3
	255.4	30.1	96.2
	88.6	25.2	87.1
164	24.8	7.5	25.8
	25.1	4.3	48.2
	22.0	11.7	
		8.6	
165	52.2	4.5	29.9
	18.9	3.9	
	27.3	1.5	
	28.9	20.2	
	14.1	27.6	

MEAN CHROMIUM CONCENTRATIONS (ppm), LEON CREEK, TX, IN VARIOUS FISH TISSUES. MEANS ARE BASED ON THREE REPLICATES UNLESS OTHERWISE INDICATED.

Station	Eyes	Brain	Gill	Muscle	Liver	Heart	Kidney	Whole Fish
161	0.3K**	-	1.6	ND**	-	-	-	19.8
			2.6					23.5
			0.5**					5.2
			1.1*					3.4
			2.2*					8.6
			0.8*					4.9*
								5.3
								0.5*
								2.0K
								5.4
								3.7
								5.1
								7.9
162	-	-	0.5	-	0.9*	0.6**	0.5K*	54.5
			3.5				0.5K	61.1
			9.9					71.9
								88.3
								14.2
								6.9
163	-	-	5.8	-	-	1.4**	-	89.1
								96.0
								119.6
								5.2
164	-	-	-	-	-	-	-	-
165	-	-	1.9*	-	ND**	-	-	4.6
			1.2*		11.6K*			7.8
			1.6					3.5
			2.8					45.4
								61.2
								61.5
								15.5

* = 2 replicates only.
** = 1 replicate only.
ND = not detectable.
K = value known to be less than indicated (one or more replicates below detection limits).

MEAN LEAD CONCENTRATIONS (ppm), LEON CREEK, TX, IN VARIOUS FISH TISSUES. MEANS ARE BASED ON THREE REPLICATES UNLESS OTHERWISE INDICATED.

Station	Eyes	Brain	Gill	Muscle	Liver	Heart	Kidney	Whole Fish
161	8.1**	35.9**	6.6	-	4.1**	-	11.0	56.9
			55.1				19.1	66.7
			34.7				84.0	12.4
			25.1					15.4*
			27.2					21.7
			3.3K*					17.6K
								16.8
								3.7**
								12.0K
								21.2
								13.1
								6.2
								7.4
162	-		13.6	-	-	4.4**	1.7**	16.0
			18.8				1.9**	32.2
			39.1					17.9*
								48.4
								6.8
								9.9
163	-		11.4	-	-	13.7**	-	70.9
								63.8
								71.7
								4.9
164	-	-	-	-	-	-	-	-
165	ND**		2.1**	-	ND**	4.4	22.8	3.7**
			7.0*		4.8**		11.1*	2.2*
			66.1					5.3*
			32.8					13.4
								16.7
								21.5
								2.6*

* = 2 replicates only.
** = 1 replicate only.
ND = not detectable.
K = value known to be less than indicated (one or more replicates below dectecion limits).

MEAN SILVER CONCENTRATIONS (ppm), LEON CREEK, TX, IN VARIOUS FISH TISSUES. MEANS ARE BASED ON THREE REPLICATES UNLESS OTHERWISE INDICATED.

Station	Eyes	Brain	Gill	Muscle	Liver	Heart	Kidney	Whole Fish
161	0.3K	0.9	0.8	0.6K	0.5	0.4K	0.2K*	0.5
	0.9	0.8	0.6	0.7	0.7	0.8	0.4K	0.4K
	0.7	1.1	0.5	0.5	0.4	0.9	0.3	0.2*
	0.6*	0.5	0.7	0.4	0.5	0.8*	0.5	
	0.4	0.5	0.1	0.4		0.8	0.3K*	
	0.3		0.8	0.4		0.6		
	0.3			0.7		0.4**		
	1.6*					0.8*		
162	0.9	0.7	0.8	0.8	0.9	1.1	1.2	3.5
	0.6	0.9	0.5	0.6	0.7	0.9*	0.9	3.6
	0.6	0.7	0.7	0.6K		1.4*	0.8	3.0
								2.4
								1.0
								0.5
163	0.4	0.4	0.3K	0.3*	0.6	0.8	0.7	3.4
								3.3
								3.6
								0.6
164	-	-	-	-	-	-	-	-
165	0.2	0.3*	0.2K	0.2K	0.3	0.8*	0.4	ND**
	0.5	ND*	0.2K	0.2K*	1.8	0.4**	ND*	3.0
	0.4	ND**		0.5K	1.0	0.7	0.7	2.9
	0.5	0.4		0.3K			0.2	3.3
								0.8

* = 2 replicates only.
** = 1 replicate only.
ND = not detectable.
K = value known to be less than indicated (one or more replicates below detection limits).

MEAN COPPER CONCENTRATIONS (ppm), LEON CREEK, TX, IN VARIOUS FISH TISSUES. MEANS ARE BASED ON THREE REPLICATES UNLESS OTHERWISE INDICATED.

Station	Eyes	Brain	Gill	Muscle	Liver	Heart	Kidney	Whole Fish
161	ND*	0.8	0.4	0.4**	10.3	14.2	2.3	18.9
	1.0	4.6	11.2	0.5	39.0	34.1	8.4	13.7
	0.9	6.7	2.6	0.4K*	2.0	34.8	22.4	6.3
	1.6	5.7	4.3	ND	8.0	44.9*	21.3	2.6
	0.6	9.9	1.9	0.3K*		32.4	3.1	22.1
	0.4K	12.4	0.4K			22.6		5.8
	0.4*	1.2				15.1**		2.4
	0.6	3.6				7.2*		4.7
								27.5
								116.7
								6.8
								13.2
								79.3
162	1.6	ND*	9.3	2.3K	16.0	34.2	16.6	154.4
	1.2	2.0	2.0	ND	12.7	20.8*	11.3	168.5
	0.8	9.0	2.7	ND**		38.3*	17.1	135.8
								26.9
								18.6
								5.3
163	3.7	2.1	2.6	0.6K	29.2	37.3	23.2	225.6
								226.6
								264.8
								15.8
164	-	-	-	-	-	-	-	-
165	0.4K	1.5	0.5K	ND**	18.3	13.1*	5.3	3.6
	1.1	4.0	0.9	0.9K	9.4	14.7*	9.6	22.9
	4.6	20.6	3.8	0.8K*	80.4	8.1	19.9	30.8
	0.5	6.5	4.1		18.2	9.6	10.2	171.9
								123.4
								161.0
								12.3

* = 2 replicates only.
** = 1 replicate only.
ND = not detectable.
K = value known to be less than indicated (one or more replicates below detection limits).

APPENDIX E

SUMMARIZED BIOASSAY RESULTS: DULUTH

COMPARISON OF FOUR TOXIC RESPONSES TO 30 AMBIENT WATER SAMPLES. Sample numbers relate to stations from 15 rivers sampled during the 1980 toxic metals project.

	Sample Number	Daphnia Toxicity	Enzyme Inhibition	Fish Ventilation Index	Algal Toxicity
	011				
	013	+	+	+	+
	021	+	+		+
	023		+		
	034				
	035	+	+		+
	042		+		
	045		+	+	
	051				
	054				+
	061		+		
	066		+		+
	073		+	ND*	+
	074		+	ND	
	081	+			+
	082	+	+	+	+
	092		+	+	
	094	+	+	+	+
	012	+		+	
	103	+		+	+
	111				
	114				
	121			+	
	122			+	+
	132				
	133	+		+	+
	142	+		ND**	+
	143	+		ND**	+
Leon Creek	161		+		
	162				

+ Positive response indicated.
* No data.
** Stress evident but unable to quantify.