United States
Environmental Protection
Agency

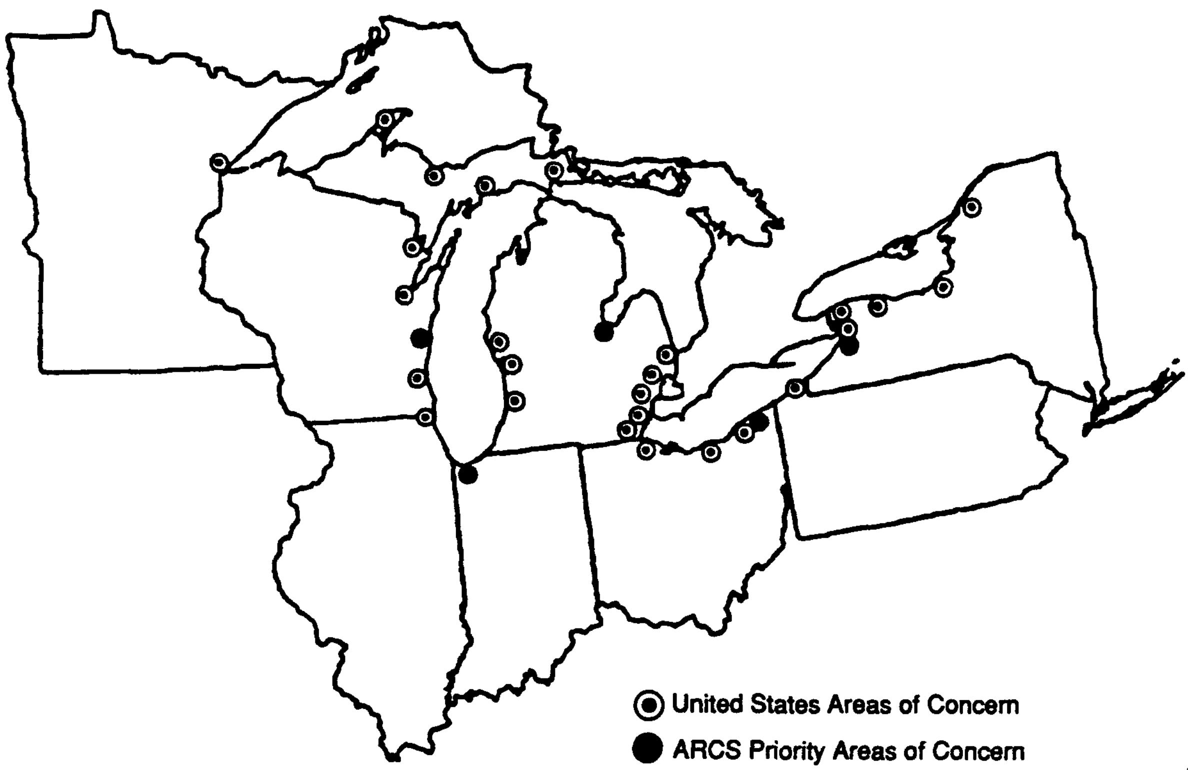
Great Lakes
National Program Office
77 West Jackson Boulevard
Chicago, Illinois 60604

EPA 905-R94-005
May 1994

EPA

Assessment and Remediation of Contaminated Sediments (ARCS) Program

MODEL DATA REQUIREMENTS AND MASS LOADING ESTIMATES FOR THE BUFFALO RIVER MASS BALANCE STUDY



Model Data Requirements and

Mass Loading Estimates for the Buffalo River

Mass Balance Study

Final Report - March, 1994

prepared for

United States Environmental Protection Agency
Great Lakes National Program Office
Marc L. Tuchman, Project Officer
77 West Jackson Blvd.
Chicago, IL 60604

prepared by

Joseph F. Atkinson, Tricia Bajak, Michael Morgante,
Stephen Marshall and Joseph V. DePinto

Great Lakes Program
Department of Civil Engineering
207 Jarvis Hall
State University of New York at Buffalo
Buffalo, New York 14260

DISCLAIMER

The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under Cooperative Agreement No. X995915-01-0 to the University at Buffalo. It has been subject to the Agency's peer and administration review, and it has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Environmental Protection Agency.

Summary

The Buffalo River (Buffalo, New York) is one of 43 Areas of Concern identified by the International Joint Commission in the Great Lakes basin. It was chosen for study under EPA's Assessment and Remediation of Contaminated Sediments (ARCS) program, Risk Assessment and Modeling (RAM) subgroup, and data were collected to estimate the loading sources and annual loading amounts for 11 different contaminants. Although present loadings are significantly reduced from historic levels, the sediments contain high concentrations of some materials and there is a concern for potential releases resulting from resuspension events. The contaminants of interest include total PCBs, chlordane, dieldrin, DDT, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, lead and copper. Total suspended solids loading is also calculated. Possible sources of contamination considered include upstream flows, industrial discharges, groundwater leaching, combined sewer overflows and resuspension of in-place contaminated sediments.

The river is known to act as a relatively efficient sediment trap, so that any contaminants adsorbed to particles transported into the river from upstream are likely to remain there. In fact, the major source for all the contaminants of interest was found to be the upstream tributary flows. Of course, loading to the water column from sediment resuspension is still unknown - estimates of the potential strength of that source will be evaluated after development of sediment transport and water quality models for the river. Estimates of export quantities from the system are also included, though these calculations have much greater uncertainty than the upstream values, due to the smaller data set available.

In addition to annual loading estimates, this report includes a calculation of several parameters needed to develop and apply general water quality and contaminant transport models to the river. These include primarily distribution (partition) coefficients for each of the contaminants of interest, as well as data for a number of conventional parameters. Annual and

monthly average flows are presented and data are provided for specifying upstream and downstream boundary conditions. The report is meant to provide a compilation of data useful for further modeling work on the Buffalo River conducted within the ARCS/RAM program, or for any other modeling application contemplated in the future.

Table of Contents

List of Figures

List of Tables

Nomenclature

C	suspended sediment concentration in area of concern
C_d	dissolved concentration
C_i	suspended sediment concentration in upstream tributary (indexed by i)
C_p	particulate concentration
F	correction factor for Parsons et al. (1963) relation
f_d	fraction dissolved
f_{oc}	fraction organic carbon
f_p	fraction particulate
I	precipitation
K'_d	measured partition (distribution) coefficient for dry weight solids (used for metals)
K_i	erodibility constant for tributary i
K'_{oc}	measured partition (distribution) coefficient, based on organic carbon (used for organics)
K_{ow}	octanol-water partition coefficient
[POC]	concentration of particulate organic carbon
Q_i	flowrate in tributary i
Q	total flowrate in area of concern
S	slope of relation used to calculate CSO loadings
W	load due to CSO discharge

1. Introduction

1.1. Project overview

The Buffalo River is fed from three main tributaries, Buffalo Creek, Cazenovia Creek and Cayuga Creek (Figure 1). From the confluence of Buffalo and Cazenovia Creeks the river meanders about 5.5 miles towards the west before discharging into Lake Erie, near the head of the Niagara River. The Buffalo River has played an important role in the industrial development of the city of Buffalo. These industries included grain mills, chemical and oil refineries and coke and steel mills, many of which are no longer operating. Unfortunately, the water and sediment quality of the river has suffered as a result of years of contaminant loading. In addition to industrial discharges, combined sewer overflows (CSOs) and leaching from inactive hazardous waste sites remain as potential sources for river contamination. Thirty-eight CSOs discharge to the river or lower Cazenovia Creek during storm conditions and these represent potential sources of organic and inorganic toxic contamination as well as BOD. There are currently 19 listed inactive hazardous waste disposal sites located within or adjacent to the river (NYSDEC, 1989). Polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), metals and cyanides have been detected in 12 of these sites and the potential for off-site migration has been confirmed or indicated at 4 of these sites.

In recent years there has been a desire to develop the river and its banks for greater public access and other uses. The New York State Department of Environmental Conservation (NYSDEC), for example, has recently upgraded the river's class "D" designation to class "C", meaning that the river waters are now believed to be suitable for fish propagation. Although present point source loadings have been reduced significantly from historic levels, possible contamination of the water column from resuspended bottom sediments represents a serious potential obstacle for further development and use of the river. This problem is exacerbated by a regular program of navigational dredging carried out by the U.S. Army Corps of Engineers (USACOE). This prevents a natural armoring effect from taking place and may also help to stir up contaminants on a periodic basis.

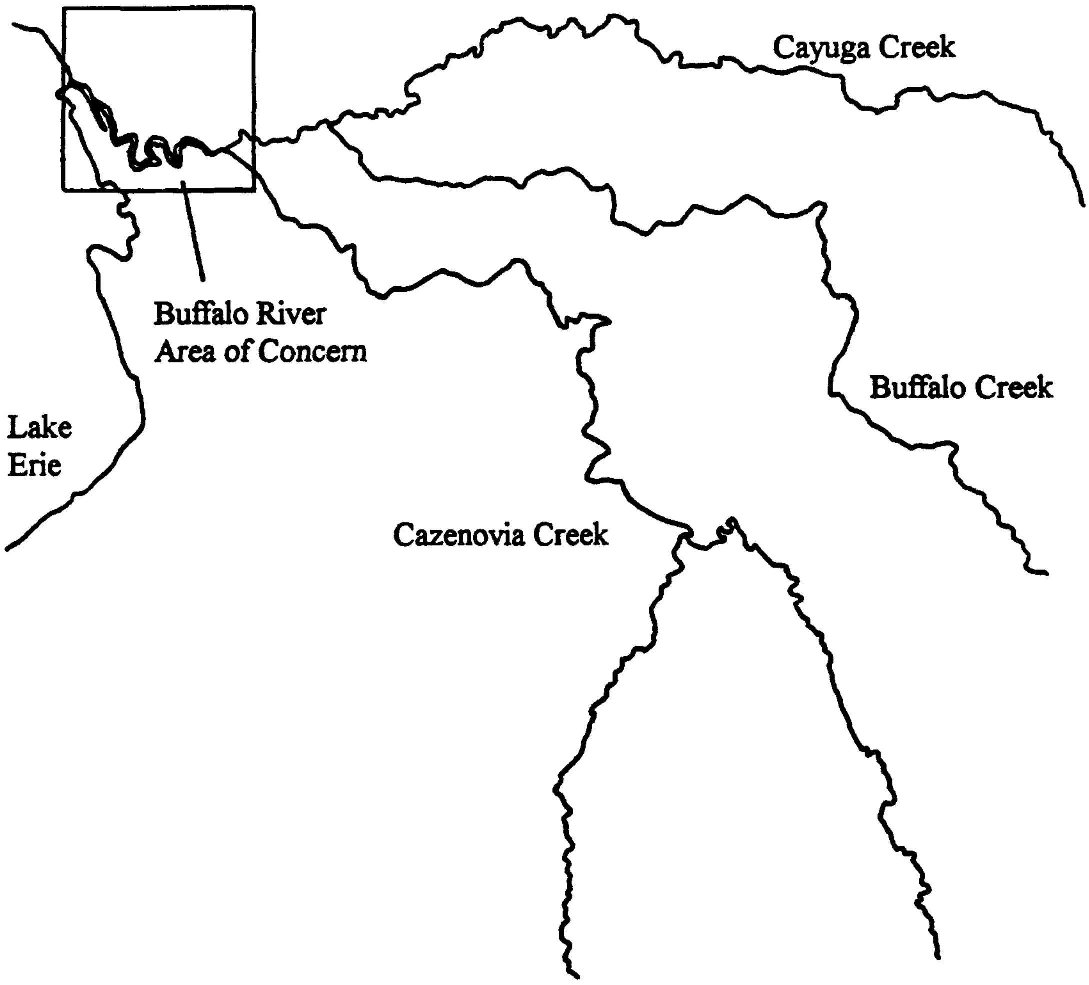


Figure 1. Location map for study area.

Because of the concern for in-place contaminants, the lower Buffalo River was listed by the International Joint Commission as one of 43 Areas of Concern (AOC) around the Great Lakes basin and it was chosen as a study site for EPA's ARCS program (GLNPO, 1991). This study has involved an intense data collection and water quality analysis effort. Sediment cores and water samples were taken for analyses for a number of constituents of interest (see section 1.2.).

The raw data collected during these surveys, as well as results of chemical analyses of the samples, have been collected and catalogued by EPA. The purpose of the present report is to summarize these data and, along with other information (described below), develop estimates for mass loading rates of various constituents of interest. These estimates may be used to evaluate the relative strength of various sources for pollutants of interest in the river, as indicated schematically in Figure 2. Upstream loadings are calculated on the basis of average daily flows and total suspended solids (TSS) concentrations, along with measured contaminant concentrations. Groundwater and combined sewer overflow (CSO) loadings are estimated on the basis of separate model calculations and industrial loadings are taken from the Buffalo River Remedial Action Plan prepared by the New York Department of Environmental Conservation (NYSDEC, 1989). Primarily, results are presented for use in water quality mass balance models which may be used to simulate the time history of toxics concentrations in the water column, sediments and biota of the river as a function of source inputs. This will be useful in evaluating system response to various remedial and/or regulatory actions that might be applied. Ultimately, it is desired to develop and apply an "integrated exposure-risk model" to estimate the risk to humans and wildlife via exposure to these concentrations. This model will include the following submodels:

1. <u>loading submodel</u>, to compute the spatial and temporal distribution of external inputs of contaminants to the river from both point and non-point sources;
2. <u>hydrodynamic transport submodel</u>;
3. <u>sediment transport submodel</u>;

4. physical-chemical toxics submodel, to incorporate the transport and sediment submodels into a framework that includes those processes affecting contaminant fluxes and reactions in the water column and sediments;
5. food chain bioaccumulation submodel, to calculate body burdens in various trophic levels of the food chain; and
6. risk analysis submodel for humans and key biota in the system.

Information in the present report will be useful mostly for the first four submodels. Available data are summarized in Chapter 3 and loading calculations are presented in Chapter 4, which concludes with a section outlining loading estimates for a "typical" year.

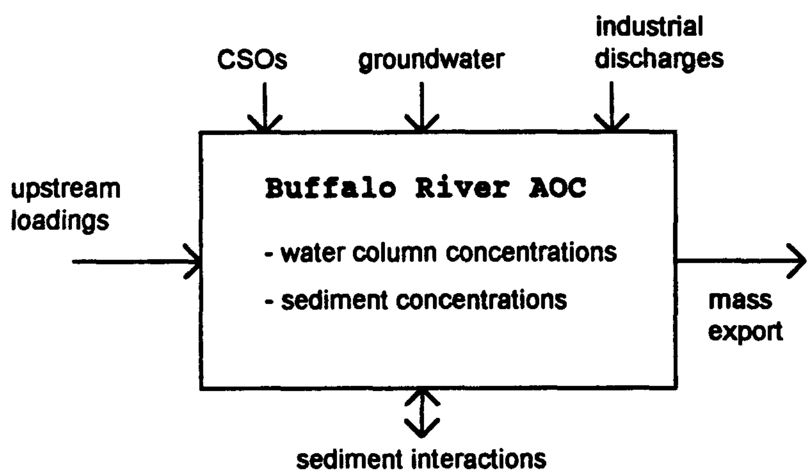


Figure 2. Schematic of general mass balance approach.

1.2. Parameters of interest, data sources

Primary parameters of interest are listed in Table 1. Field data were collected and analyzed for most of the contaminants by researchers at Buffalo State College. Other sources of information include the USACOE, NYSDEC, the National Oceanic and Atmospheric

Administration (NOAA), Buffalo Sewer Authority (BSA) and Canada Centre for Inland Waters (CCIW). A summary of available data is shown in Table 2.

Water column data for most of the conventional parameters were collected by researchers from NYSDEC (in a separate project) and from Buffalo State College. The DEC data were collected mostly during the summers of 1988 and 1990, with other metals and TSS data collected in December 1991 and spring 1992. Water column profiles were measured at about 10 different stations along the river. The Buffalo State data include water column profiles measured at the six ARCS sites (see below), with an intensive sampling effort over late spring to early fall, 1991. Because the main focus of the present report concerns pollutant loadings and mass balance modeling, the data reported here focuses primarily on the pollutants of interest, listed in Table 1. The main exception to this is in Section 3.2.1., which lists downstream boundary conditions (concentrations) for most of the conventional parameters of interest. These data are included here because they are not as readily available as the water column data.

Table 1. Parameters of interest for mass balance study.

Pollutants		Conventionals
CAHs:	Total PCBs	Sulfides
	Chlordane	Chlorides
	Dieldrin	Alkalinity
	p,p'-DDT	Hardness
		Suspended solids
PAHs:	Benzo(a)anthracene	TOC and DOC
	Benzo(b)fluoranthene	Dissolved oxygen
	Benzo(k)fluoranthene	Temperature
	Benzo(a)pyrene	Conductivity
	Chrysene	pH
		Fluorescence
Metals:	Lead	Velocity
	Copper	
	Iron	

Note: Abbreviations used in the above table (and elsewhere in this report) are as follows: CAH - chlorinated aromatic hydrocarbon; PCB - polychlorinated biphenyl; PAH - polychlorinated aromatic hydrocarbon; TOC - total organic carbon; DOC - dissolved organic carbon.

Data were collected for pollutant analyses as part of the ARCS project during two primary sampling periods each covering about a week during the fall of 1990 and spring of 1992. Specific sampling dates were October 18, 22, 27, 31, November 5, 9, 13, 1990, and April 4, 18 and 22, 1992. For the 1990 period samples were taken from 6 sites along the lower part of the river, as shown in Figure 3. Only sites 1, 3 and 6 were sampled during the 1992 period. Distances for each site relative to the river mouth are listed in Table 3.

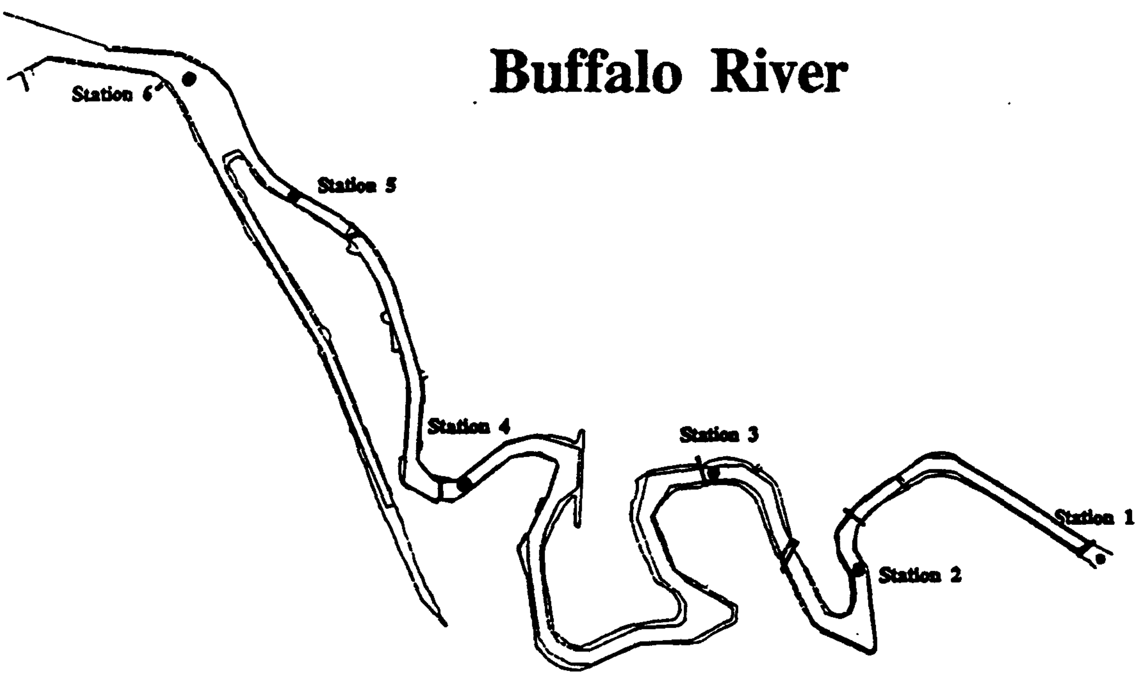


Figure 3. Water column sampling locations.

Table 2. Data summary - Buffalo River mass balance study.

Parameters	Location or matrix	Dates*
Gage data	Buffalo Harbor, 3 tributaries, water column	6/1/88-2/29/92
Hourly precipitation	Buffalo Airport	6/1/88-5/31/91
Monthly precipitation	7 stations, South Buffalo	1985-1991
Hourly surface observations	Buffalo Airport	6/1/88-9/30/90
Daily mean discharge	3 tributaries, water column	10/1/87-10/20/91
Conductivity, TSS, Temperature, Depth, DO, pH, Press., Fluor.	Buffalo River water column	assorted, '89-'92
PCBs, Pesticides, %Lipids	Carp stomachs	7/24/91
PAHs, Pesticides, PCBs	Sediment	8/1/90-9/30/90
Water quality data, metals	Sediment	8/1/90-9/30/92
PAHs, Pesticides, PCBs, metals, TSS, Water quality data	Buffalo River water column	Fall '90, Spring '92
BOD	Buffalo River water column	1991
Current velocity	Buffalo River water column	10/16/90-11/12/90
Overflow volume	CSOs	7/9/90-9/26/91
Event sampling	Buffalo River water column	3/91
Metals, TSS	Buffalo River and tributaries	12/91, spring '92
Industrial discharges (Buf. Color, PVS Chem.)	Buffalo River water column	6/1/88-7/31/91
Total discharge, Water surface elevations	Buffalo River water column	10/1/90-11/30/92
Cross sections	Buffalo River water column	various dates
Wind direction/speed	Buffalo Airport	1/1/77-5/31/88
Current rating table	3 tributaries, water column	
Soundings	Buffalo River water column	7/1/91-7/31/91, 5/1/92-5/31/92
USACOE dredging samples	Water Column	Summer '92

* A range of dates over which data were collected is reported; specific values may not be available for every day within the range.

Table 3. Sampling station locations.

Station	Distance upstream from river mouth (ft)	(km)
1	27,840	8.4
2	22,590	6.8
3	18,100	5.5
4	9,400	2.9
5	3,900	1.2
6	1,960	0.6

2. Conclusions

The annual loading calculations, summarized in Section 4.6 (Table 37), indicate relatively small loadings for most of the contaminants of interest. These estimates are based primarily on data obtained in the ARCS surveys, with the exception of metals loading. It was found that the upstream loading calculations for metals, based on the ARCS data, resulted in unreasonably high values when compared with data from other sources. The estimates reported here rely instead on data obtained by the NYSDEC (Litten and Anderson, 1992). For all contaminants of interest the dominant source was due to upstream flows draining the watershed. The major upstream loading was for metals. Upstream loading for lead (359 kg/yr) may be explained by atmospheric deposition and runoff from the upstream watershed, but the source for copper loading (933 kg/yr) is unknown. Compared with loadings due to industrial discharges and combined sewer overflows (330 and 110 kg/yr, respectively), this represents a major source. Loadings of PCBs and PAHs (from all sources) are between 1 - 4 kg/yr and insecticide loadings are less than 0.1 kg/yr. It is hypothesized that a possible source for upstream loadings is due to deposition which occurred as a result of the many years of steel and heavy industry operations conducted within and adjacent to the watershed for the Buffalo River AOC. Potential loading due to sediment resuspension into the water column is unknown at this time, though some information is presented to estimate the total mass of each contaminant in the sediments. Metals and PAHs appear to be the predominant problem there (see Table 14). Estimates for export fluxes are included, though there is greater uncertainty in these values due to the small number of data available.

2.1. Comment on data completeness, uncertainty in loading estimates

A large amount of data has been collected for the Buffalo River for purposes of evaluating water quality conditions and potential contamination risks and also to provide information for developing water quality models that may be used to further analyze contamination problems in the river. While some aspects of this data set are based on long records, many of the values reported here were developed from limited sources. For example, the flowrates are available from more than 45 years of record, but water column pollutant concentration data presented in Appendix B were obtained from two relatively short sampling periods. These data are not sufficient to draw firm conclusions regarding annual variations or even average values for the parameters of interest. There was a significant variation in values for some of these constituents during each of the sampling periods, and there is little consistency between corresponding values for the two periods (see Figures B1 and B13, for example). It is interesting to note that many of the parameters show higher water column concentrations for the 1992 data than for the 1990 data. This is particularly true for the PAHs. The only correlation indicated by the data appears to be with the higher flows, and corresponding higher suspended solids concentrations (see Table 20, for example). However, the relatively small data base precludes a firm conclusion at this point (e.g., there may be an inherent seasonal variation, concentrations may be a function of flowrate, industrial activities may change seasonally, etc.). This implies a certain variability in calculations for partition coefficients, though averaged values appear to be reasonable (Section 3.3). Data for downstream conditions were also scarce for some of the parameters, as noted in Section 3.2.1, and export estimates are based on only about 10 data points.

Uncertainties in adsorption characteristics in groundwater flows imply corresponding uncertainties in loading estimates from non-point sources (inactive hazardous waste sites). This is particularly true for metals loading. PAH loadings from the Buffalo Color site are believed to be reasonable. Groundwater loadings of PCBs and pesticides appear to be insignificant. Some refinement in these estimates may be possible when more data become available. Loadings from CSOs are based on model results and assumed concentrations for the various pollutants, so there is some inherent uncertainty in those loading estimates. Other point sources (industrial discharges) are well-documented (Table 24).

One other area of uncertainty, at least regarding mass loading estimates, concerns the potential for resuspension of contaminated sediments. Although sediment quality was analyzed at a number of locations along the river (Section 3.4), it is difficult to assess the erosion characteristics at different points. An attempt was made to predict areas more susceptible to erosion based on physical characteristics of the sediment (Section 4.3), but this showed an almost equal erosion potential along the entire AOC. Therefore, contamination risk from resuspended sediments will be analyzed only after a sediment transport model, which can account for variations in bottom shear stress, is applied to the river. A model of this type is currently being developed.

3. Model data requirements

In this section, raw and derived data are presented for developing water quality models of the river. These data are then used to develop loading estimates for the pollutants of interest in Section 4. Data available from the fall 1990 and spring 1992 surveys include the following parameters:

- conventionals
- water column profiles
- discharges
- dissolved and particulate metals
- dissolved and particulate organics

Representative values of chemical properties for the targeted pollutants, obtained from various standard sources, are listed in Table 4.

Table 4. Chemical properties of targeted pollutants.

Chemical	Water solubility (μg/l)	Henry's constant (atm-m^3/mole)	log K_{OW}
PCBs			
Total	0.46 - 7,000	9e-6 - 2.5e-4	4.33 - 7.13
Pesticides			
Chlordane	56	4.79e-5	6.0
Dieldrin	186	5.84e-5	5.32
p,p'-DDT	3.1	3.89e-5	6.13
PAHs			
Benzo(a)anthracene	44	8.42e-8	5.62
Benzo(a)pyrene	3.8	4.90e-7	6.52
Benzo(b)fluoranthene	14	1.19e-5	6.26
Benzo(k)fluoranthene	1 - 10*	5.45e-6	6.52
Chrysene	6	1.05e-6	6.09

* exact value is not available from common sources, but is estimated on the basis of values for similar compounds

3.1. Flows

The Buffalo River drainage basin comprises an area of approximately 408.6 square miles at the upstream study boundary. Included within this area are Buffalo Creek (146.2 square miles), Cayuga Creek (124.4 square miles), Cazenovia Creek (135.4 square miles) and 2.6 square miles of unsewered area between the junction of Buffalo Creek and Cayuga Creek and the junction of the Buffalo River and Cazenovia Creek.

A detailed study of available daily flow records for the Buffalo River basin was conducted by Meredith and Rumer (1987). In their study, average daily inflows to the Buffalo River at its confluence with Cazenovia Creek were synthesized from three United States Geological Survey (USGS) stream gages within the basin: Buffalo Creek at Gardenville, NY; Cayuga Creek near Lancaster, NY; and, Cazenovia Creek at Ebenezer, NY. The period of analysis was October 1940 through September 1985. Their report includes daily flow duration curves for the Buffalo River project area by month and discharge frequency curves for annual flow.

A typical year of average daily inflows to the study area was developed from the data compiled by Meredith and Rumer (1987). Average daily flows for each day of the year for the 45 years of record were first examined in terms of distribution of flow values. In order to provide an indication of the variability of flows throughout the year, average daily flow values for twelve randomly selected days of the year are shown in Appendix A, Figures A1 - A12. From these figures it can be seen that the flow values are not normally distributed, but are positively skewed. For this type of distribution, the arithmetic mean of the average daily values does not adequately represent the true central tendancy and the geometric mean provides better estimates for average conditions. Both means were calculated and shown in Figures 4 and 5 for comparison. The geometric mean (Figure 5) gives somewhat lower values since the weighting for extreme, but rare events is relatively small.

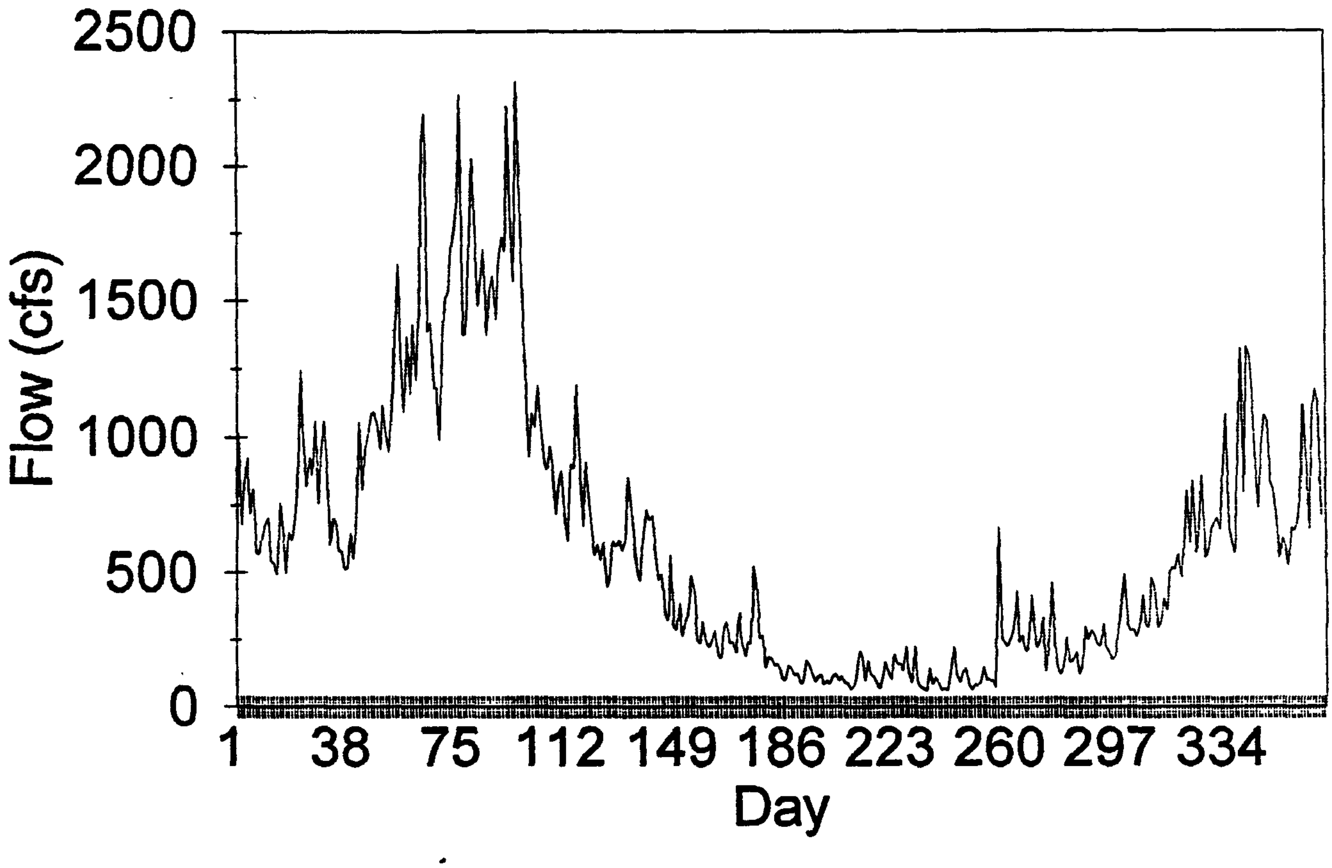


Figure 4. Average daily flows (arithmetic mean).

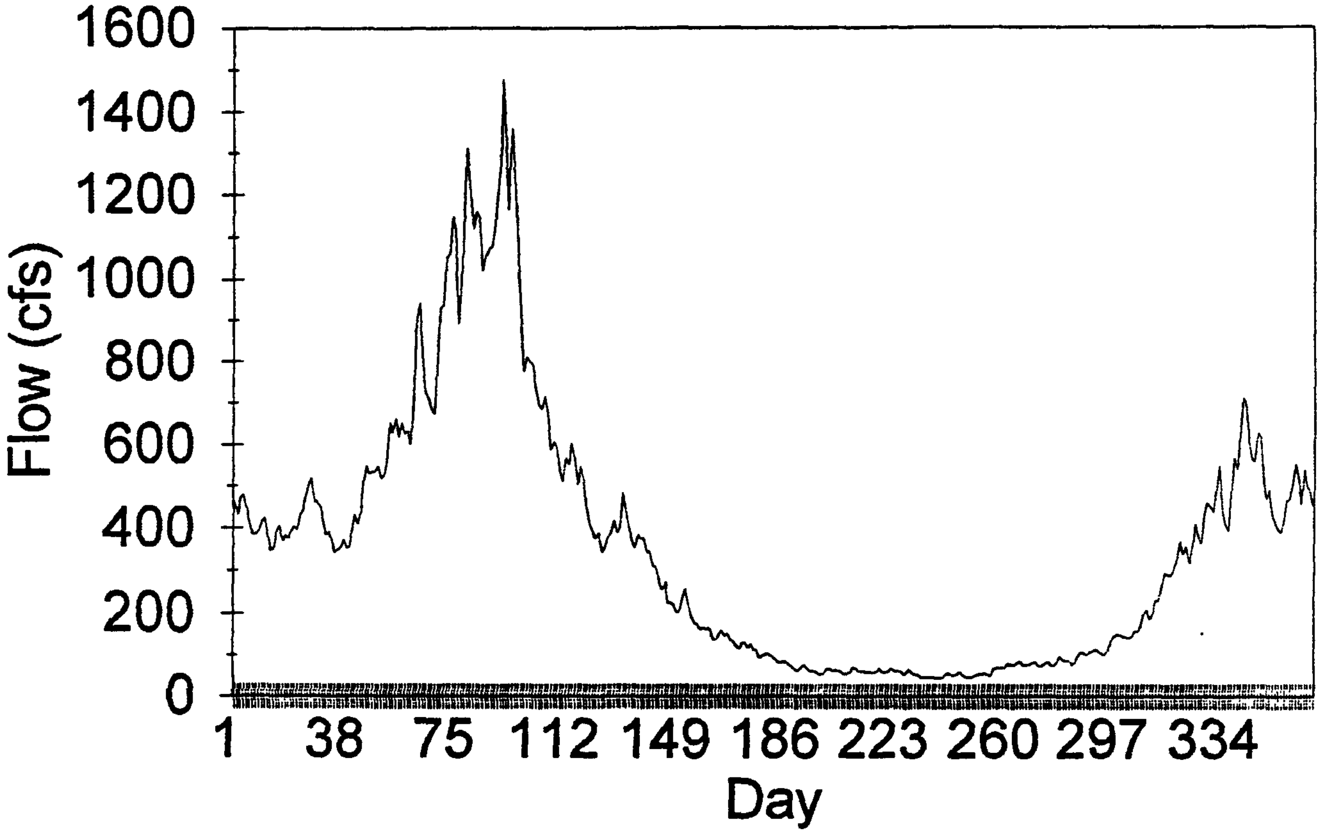


Figure 5. Average daily flows (geometric mean).

It should be noted that these flow values have been adjusted to account for the extra drainage areas located between the three gages and the AOC. According to a study by NYSDEC (Simon Litton, personal communication), an average adjustment is obtained by multiplying the sum of the three gage values by 1.19. Recently, a more detailed analysis by LTI which is based on flow areas determined from a geographic information system data base (Limno-Tech, Inc., personal communication) shows that the flows for each of the three tributaries should be multiplied by the following factors to adjust the gage data: Buffalo Creek - 1.05; Cayuga Creek - 1.33; Cazenovia Creek - 1.02 (see also eqns. 10 - 18). Meredith and Rumer (1987) adjusted the flows using a similar procedure, though the factors had slightly different values. The sum of the three adjusted flows is then the flowrate for the AOC. Monthly average (geometric mean) flows for each tributary are shown in Table 5, along with the adjusted total for the AOC. The LTI adjustment factors are used for calculating the total flows since it is believed that their values for contributing watershed areas are more accurate.

Table 5. Monthly average (geometric mean) flows.

	flowrate (cfs)			
Month	Buffalo Ck.	Cazenovia Ck.	Cayuga Ck.	Adjusted total
January	135	160	75	405
February	157	178	97	475
March	310	351	208	960
April	250	283	154	756
May	113	130	57	327
June	52	55	21	139
July	26	26	7	63
August	20	22	6	51
September	23	25	7	59
October	36	40	15	99
November	98	120	48	289
December	161	202	92	497

3.2. Water quality

Water samples were analyzed at Buffalo State College and detailed descriptions of analytical techniques and results are presented in a report currently under preparation by researchers at Buffalo State College. These data are summarized in the plots of Appendix B, which show measured concentrations for both sampling periods for each of the parameters of interest (Table 1). Iron concentrations are not shown since it was decided that iron was not a major concern in the river (some of the data for iron is included in other sections of this report).

3.2.1. Downstream boundary conditions

Downstream boundary condition data for the Buffalo River modeling project were obtained from the following sources:

- Niagara River Monitoring Reports - pollutant and suspended solids concentrations;
- STAR File, Ontario Ministry of the Environment - conventional constituents: hardness, alkalinity, pH, dissolved oxygen (DO), and chlorides;
- ARCS database - conductivity; and,
- Huang (1987) - temperature.

The data available from these sources are described below.

a) Priority Pollutants.

The available data on downstream boundary pollutant concentrations consist of four years of sampling data on the Niagara River at Fort Erie, 1986-87 through 1989-90. Table 6 summarizes the available data from these reports for both the dissolved fraction and suspended solids fraction for the priority pollutants of interest (CAHs and PAHs) and the total water concentration values for the metals of interest. Note that "non-detect" values are not included in the averages listed. The annual values were statistically derived from several samples taken during the indicated years. The data set has several gaps, especially in the water column data. Average values (arithmetic mean) over the period of record were computed because time trends could not be established from the relatively small data base.

Table 6. Pollutant concentrations, downstream boundary.

	Water Column Fraction					Suspended Solids Fraction				
	1986/87	1987/88	1988/89	1989/90	Avg	1986/87	1987/88	1988/89	1989/90	Avg
CAHs [ng/L]										
Total PCBs	2.90	—	—	—	2.9	1.00	0.489	0.674	0.426	0.6
g-Chlordane	—	—	—	—	—	—	—	—	—	—
-Chlordane	—	—	—	—	—	—	—	—	—	—
Dieldrin	0.319	0.319	0.289	0.286	0.3	0.0197	0.0317	0.0325	0.0331	0.03
p,p'-DDT	—	—	—	—	—	0.171	0.0989	0.0463	0.102	0.1
PAHs [ng/L]										
B(a)anthracene	0.186	0.126	0.262	—	0.2	1.50	1.24	2.37	1.02	1.5
B(b)fluoranthene	—	—	—	—	—	—	5.58	—	0.578	3.1
B(k)fluoranthene	—	—	—	—	—	—	4.41	—	0.837	2.6
B(a)pyrene	—	—	—	—	—	—	—	—	0.397	0.4
Chrysene	0.382	—	0.304	0.266	0.3	2.23	2.30	—	1.00	1.8
	Whole Water									
	1986/87	1987/88	1988/89	1989/90	Avg					
Metals: [mg/L]										
Lead	0.0014	0.00119	0.001765	0.000608	0.001					
Iron	0.460	0.359	0.985	0.251	0.5					
Copper	0.0016	0.00126	0.001743	0.001382	0.0					

b) <u>Conventionals</u>.

<u>Suspended solids</u> concentration data were available for the Niagara River at Fort Erie for approximately 45-50 sampling days from four years of record, 1986-87 through 1989-90. Approximately 3-5 concentration values were available for each month for each year of sampling. An average value of suspended solids concentration was computed for each month during each year and plots were made in order to examine annual seasonal trends for each year of record. These plots are shown in Appendix B, Figures B25 - B28. In general, suspended solids concentrations are highest during the period October through January, with lower concentrations typically observed the rest of the year. All suspended solids data values available for each month of the four year period of record were averaged and shown in Figure 6.

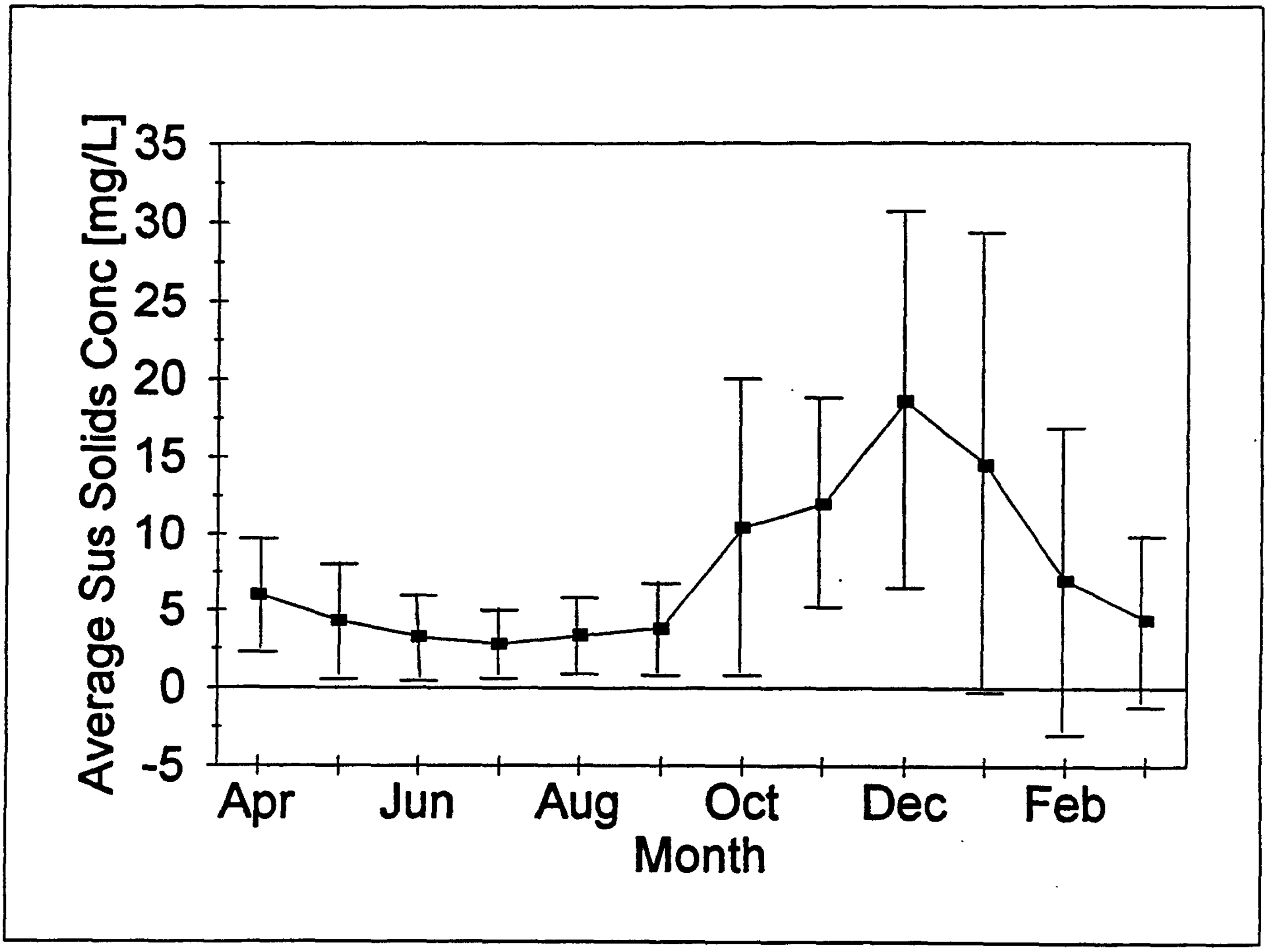


Figure 6. Average suspended solids concentration (1987 - 1990), downstream boundary.

Temperatures (mean monthly water surface) for the eastern basin of Lake Erie are available from Huang (1987). In that report, four earlier studies of long term surface water temperature trends in the eastern Lake Erie basin were examined and compared to temperature data available from the Buffalo Water Authority's intake pipe (period of record: 1946-1981). The final modified average monthly water surface temperatures for Lake Erie from that report are presented in Figure 7.

Dissolved Oxygen (DO) data were available from the STAR database file, obtained from CCIW, and also from measurements obtained by NYSDEC. The available data from the STAR database are limited and generally consist of a few values collected during the months of April through November during the 1960's and early 1970's. The NYSDEC data were measured in the summer months of 1988. These data are summarized in Table 7. Mean DO concentrations for each month were computed from these data and are shown in Figure 8. However, it should be noted that these data were probably not collected at exactly the same location.

Conductivity. Conductivity values were measured by NYSDEC during the summer of 1988. These data are summarized in Table 8.

Alkalinity, Hardness, Chlorides, pH -- Very limited data were available for these conventionals from the STAR File. The data available for chloride, hardness and alkalinity are summarized in Table 9. Data for pH are shown in Table 10. Mean monthly values were calculated for each of these parameters where possible and are presented in Figures 9 - 12.

Some conventional water quality data are also available from EPA's STORET file, but these are not included here because they are easily available directly from that data base.

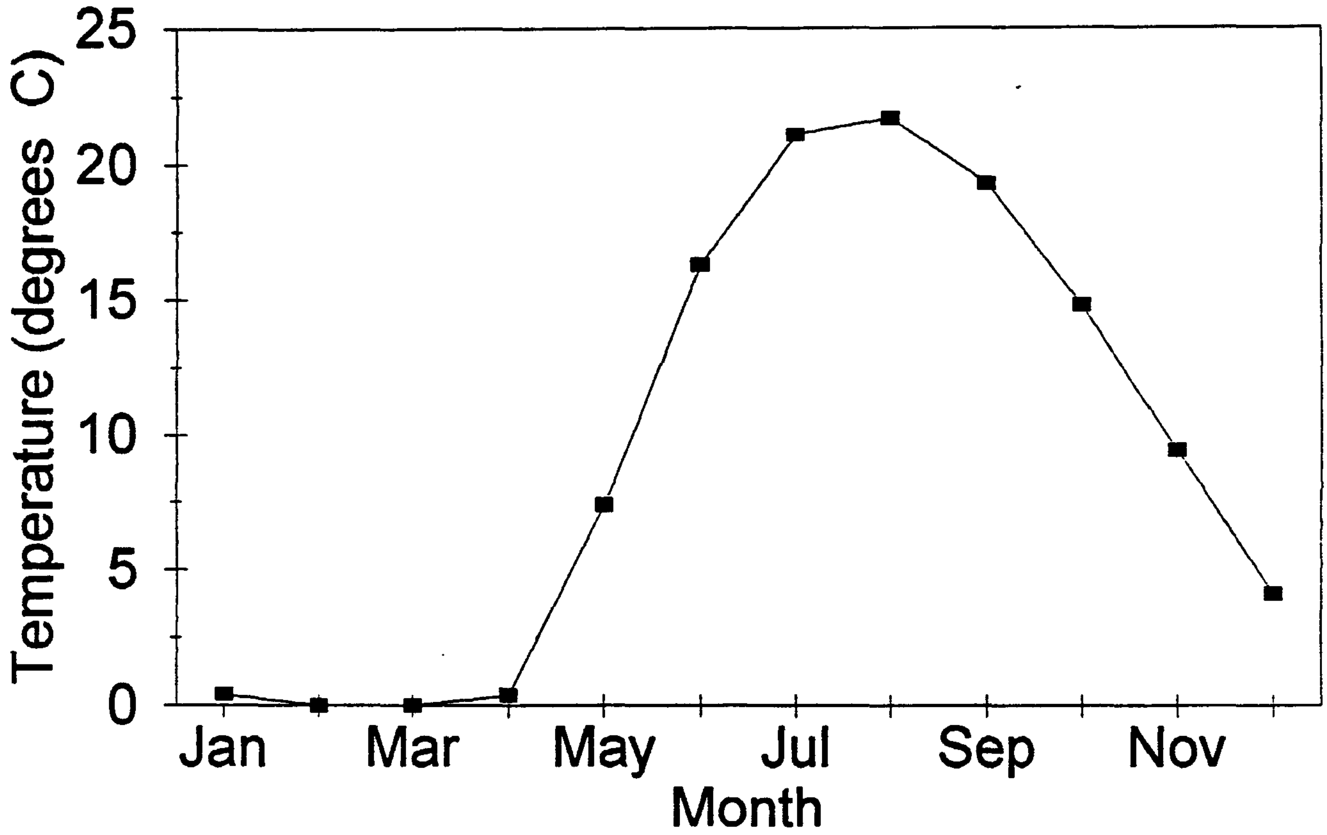


Figure 7. Average monthly surface temperature, Lake Erie at Buffalo.

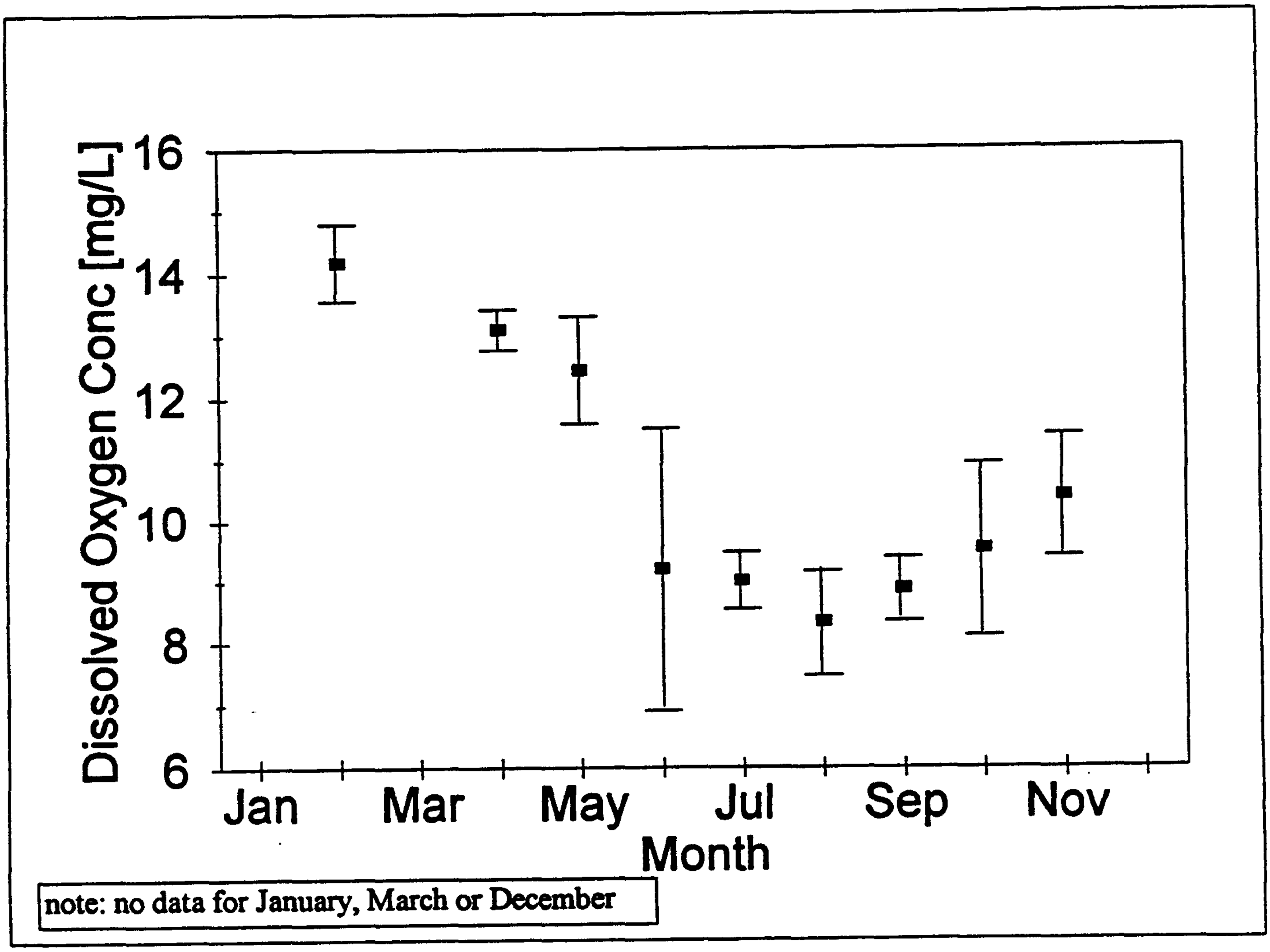


Figure 8. Average monthly DO concentration, downstream boundary.

Table 7. Dissolved oxygen data, downstream boundary.

Month	Date	(< 5m) DO Conc [mg/L]	(> 5m) DO Conc [mg/L]	Avg	Mon. Avg
FEB	2-6-69	14.6	13.7	14.2	14.2
APR	4-12-73	13.2	13.2	13.2	
	4-12-73	13.4	12.7	13.0	13.1
MAY	5-30-67	12.5	12.6	12.5	
	5-17-68	11.6	11.5	11.5	
	5-30-69	12.1	12.0	12.1	
	5-6-70	13.7	13.8	13.7	12.5
JUN	6-20-60	7.63	7.63	7.63	
	6-19-61	5.67	4.56	5.12	
	6-29-67	9.64	9.68	9.66	
	6-15-68	10.9	10.9	10.9	
	6-2-70	12.0	11.3	11.6	
	6-14-88*	—	—	9.73	
	6-15-88*	—	—	9.82	
	6-28-88*	—	—	9.18	9.21
JUL	7-25-60	8.38	8.64	8.51	
	7-21-61	9.04	9.64	9.34	
	7-10-67	9.72	8.68	9.2	
	7-31-67	9.2	9.2	9.2	
	7-29-68	8.97	8.95	8.96	
	7-5-71	9.27	9.17	9.22	
	7-25-73	9.14	9.26	9.20	
	7-25-73	9.79	9.74	9.77	
	7-12-88*	—	—	8.34	
	7-26-88*	—	—	8.34	9.01
AUG	8-15-60	6.90	6.95	6.93	
	8-24-61	8.77	9.05	8.91	
	8-14-66	8.47	8.39	8.43	
	8-21-67	8.46	8.46	8.46	
	8-1-70	9.63	9.59	9.61	
	8-17-71	9.04	8.88	8.96	
	8-22-84	8.64	8.70	8.67	
	8-29-88*	—	—	7.06	
	8-30-88*	—	—	7.81	8.32
SEP	9-27-60	7.85	7.95	7.90	
	9-11-67	9.39	8.87	9.13	
	9-28-68	9.09	8.99	9.04	
	9-23-70	9.09	9.11	9.10	
	9-28-72	9.1	9.15	9.13	8.86
OCT	10-25-60	6.58	8.68	7.63	
	10-2-61	10.5	9.57	10.1	
	10-2-67	9.64	9.39	9.52	
	10-30-67	10.4	11.23	10.8	
	10-15-69	9.60	9.57	9.59	9.52
NOV	11-15-60	8.40	8.24	8.32	
	11-5-68	10.5	10.5	10.5	
	11-23-71	10.9	10.8	10.8	
	11-14-72	10.9	11.0	10.9	
	11-7-73	10.6	10.7	10.7	
	11-7-73	11.1	11.3	11.2	10.4

SUMMARY

Month	DO Conc [mg/L]
February	14.2
April	13.1
May	12.5
June	9.21
July	9.01
August	8.32
September	8.86
October	9.52
November	10.4
December	—

* Data from ARCS database, NYSDEC (Lake Erie green buoy) and Coastguard Station; all other data from STAR file.

Table 8. Conductivity data, downstream boundary.

Month	Date	Average Conductivity (uS/cm)
June	6-14-88	288
	6-15-88	289
	6-28-88	289
July	7-11-88	295
	7-12-88	288
	7-26-88	286.6
August	8-29-88	317.9
	8-30-88	285.9
	Average	292.4

Table 9. Chloride, hardness and alkalinity, downstream boundary.

				Chloride, Filtered				
							SUMMARY	
Month	Date	(< 5m) mg/L Cl	(> 5m) mg/L Cl	Avg	Mon. Avg		Month	mg/L Cl
August	8-1-70	24.7	24.2	24.5			July	—
	8-17-71	24.2	24.1	24.2	24.3		August	24.3
September	9-23-70	24.9	24.1	24.5	24.5		Sepember	24.5
November	11-23-71	26.0	26.0	26.0	26.0		October	—
							November	26.0
				Hardness, Total Filtered				
							SUMMARY	
Month	Date	(< 10m) (mg/L	(> 10m) as CaCO3)	Avg	Mon Avg		Month	mg/L
May	5-30-67	125.0	—	125.0	125.0		January	—
June	6-29-67	127.8	—	127.8	127.8		February	—
July	7-10-67	132.7	—	132.7			March	—
	7-31-67	126.2	—	126.2			April	—
	7-29-68	133.2	130.7	132.0	130.3		May	125.
August	8-14-66	131.0	132.0	131.5			June	127.8
	8-21-67	130.9	—	130.9	131.2		July	130.3
September	9-11-67	132.8	—	132.8			August	131.2
	9-28-68	135.7	135.7	135.7	134.3		September	134.3
October	10-2-67	129.8	—	129.8			October	130.7
	10-30-67	129.8	—	129.8			November	—
	10-15-69	133.0	132.0	132.5	130.7		December	—

Alkalinity, Total Titrometric								
		(1 m)	(8 - 9 m)				SUMMARY	
Month	Date	(mg as	CaCO3)	Avg	Mon Avg		Month	mg
June	6-29-67	92.3	—	92.3	92.3		June	92.3
July	7-10-67	92.7	—	92.7			July	94.8
	7-31-67	97.6	—	97.6			August	91.4
	7-29-68	94.8	93.6	94.2	94.8		Sepember	93.1
Aug	8-21-67	91.4	—	91.4	91.4		October	94.2
Sep	9-11-67	91.9	—	91.9			November	—
	9-28-68	93.9	94.8	94.35	93.125		December	—
Oct	10-2-67	93.7	—	93.7				
	10-30-67	94.7	—	94.7	94.2			

Table 10. pH data, downstream boundary.

Month	Date	(1 m) pH	(4-5 m) pH	(8-10m) pH	Avg	Mon Avg		SUMMARY Month	pH
April	4-12-73	7.88	7.87	7.73	7.82			Apr	7.9
	4-12-73	7.95	7.94	7.9	7.93	7.87		Jun	8.3
June	6-14-88*	—	—	—	8.29			Jul	8.6
	6-15-88*	—	—	—	8.21			Aug	8.4
	6-28-88*	—	—	—	8.33	8.27		Sep	8.6
July	7-5-71	8.45	8.51	8.52	8.43			Nov	8.0
	7-25-73	8.79	8.8	8.79	8.79				
	7-25-73	8.88	8.88	8.88	8.88				
	7-12-88*	—	—	—	8.31				
	7-26-88*	—	—	—	8.38	8.57			
August	8-17-71	8.73	8.73	8.64	8.70				
	8-13-84	8.53	—	—	8.53				
	8-14-84	8.5	—	—	8.5				
	8-22-84	8.63	—	—	8.63				
	8-29-88*	—	—	—	7.84				
	8-30-88*	—	—	—	8.09	8.38			
September	9-28-72	8.65	8.63	8.62	8.63	8.63			
November	11-23-71	8.37	8.38	8.39	8.38				
	11-7-73	7.51	7.74	7.78	7.67				
	11-7-73	8.03	8.05	8.06	8.04	8.03			

* Data from ARCS Database, Lake Erie green buoy and Coastguard Station, all other data from STAR File.

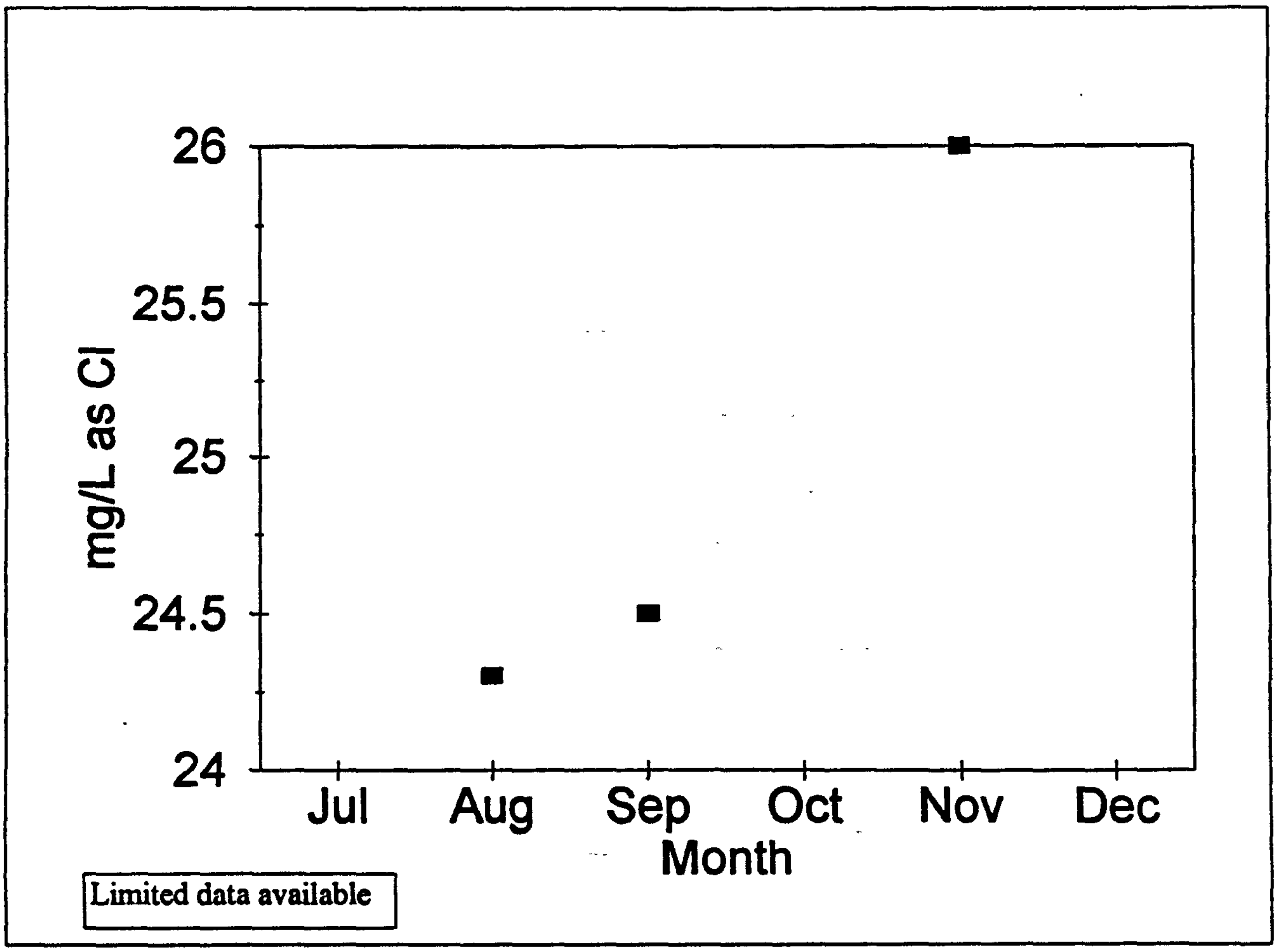


Figure 9. Chloride concentration, downstream boundary.

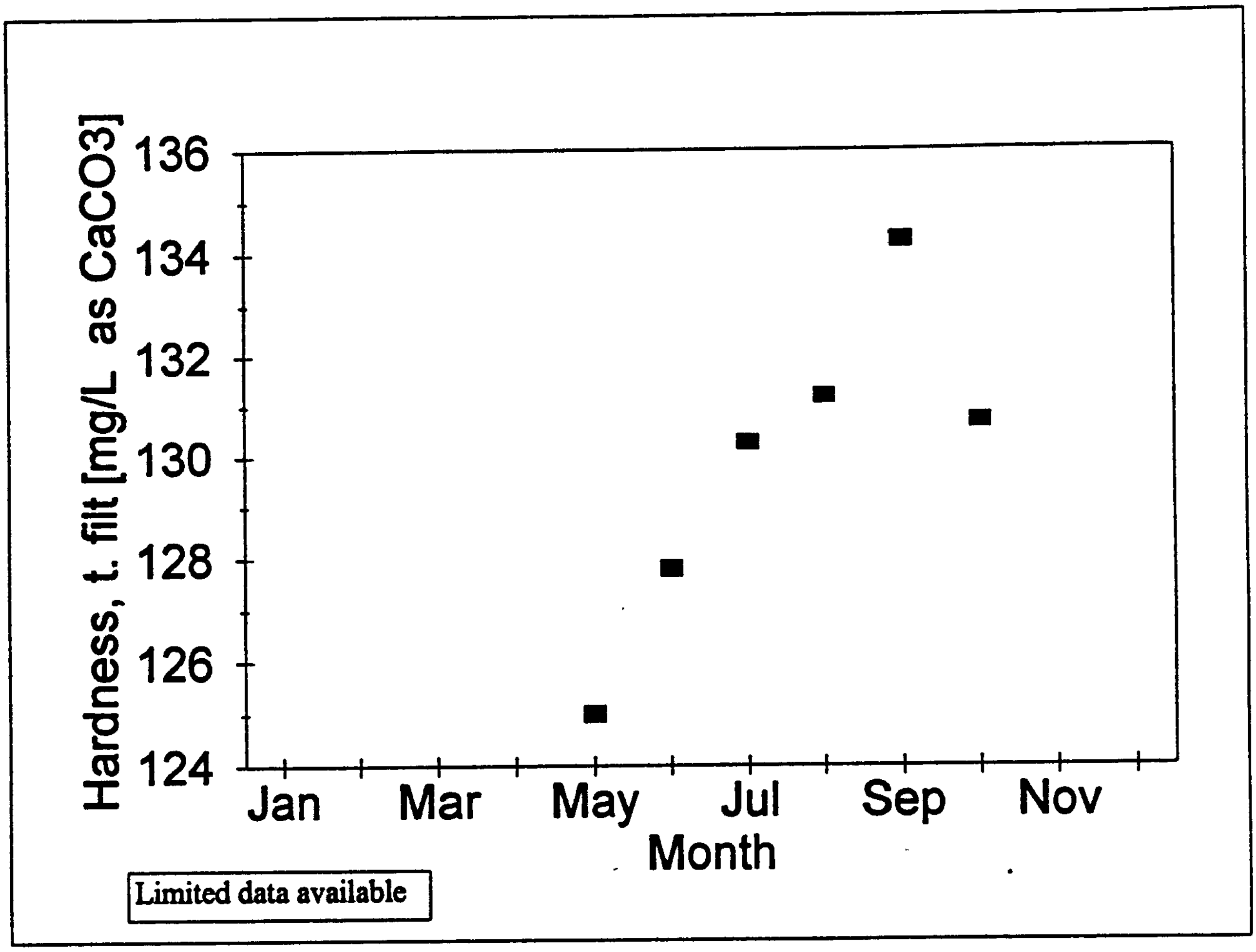


Figure 10. Hardness data, downstream boundary.

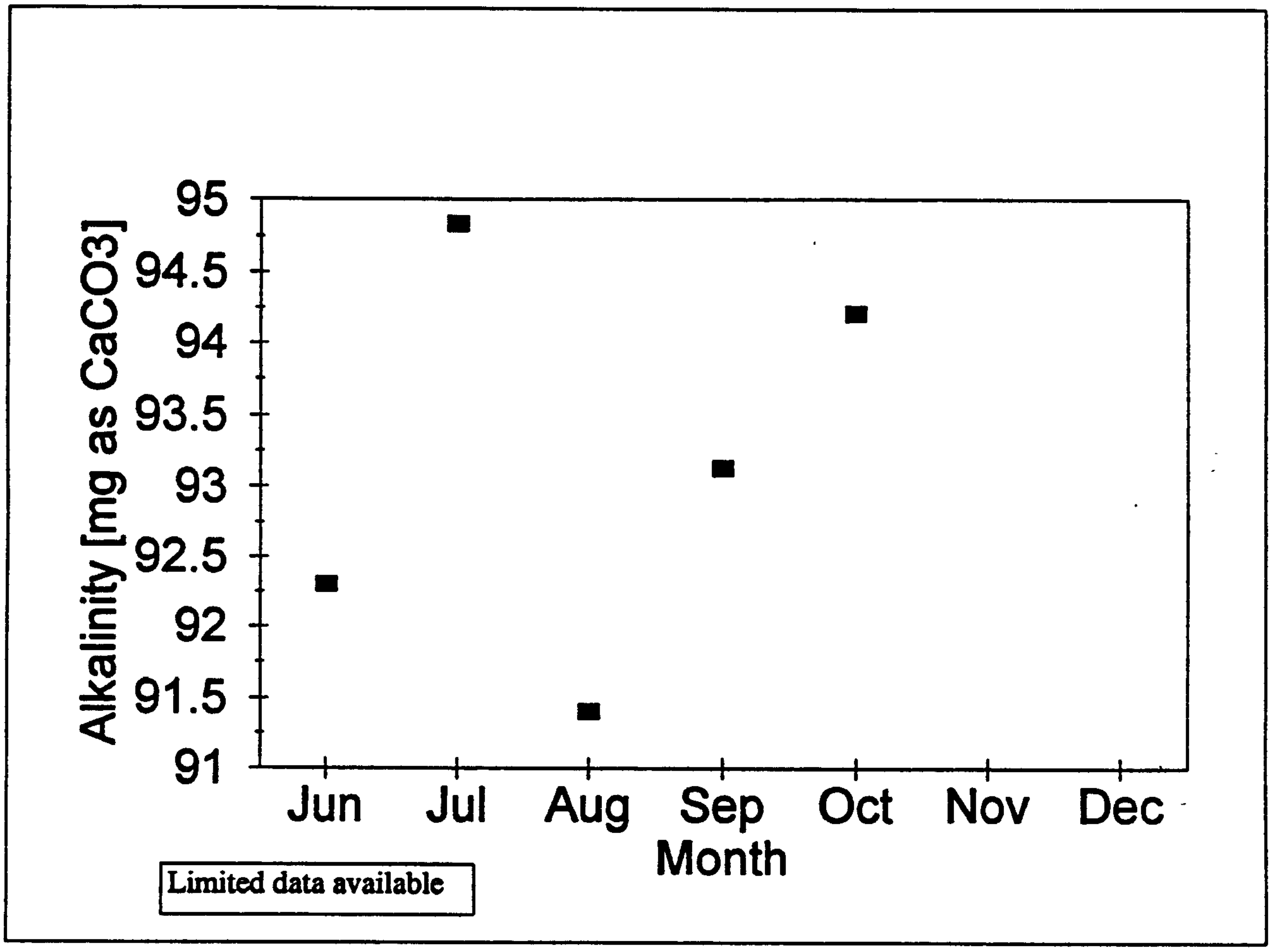


Figure 11. Alkalinity data, downstream boundary.

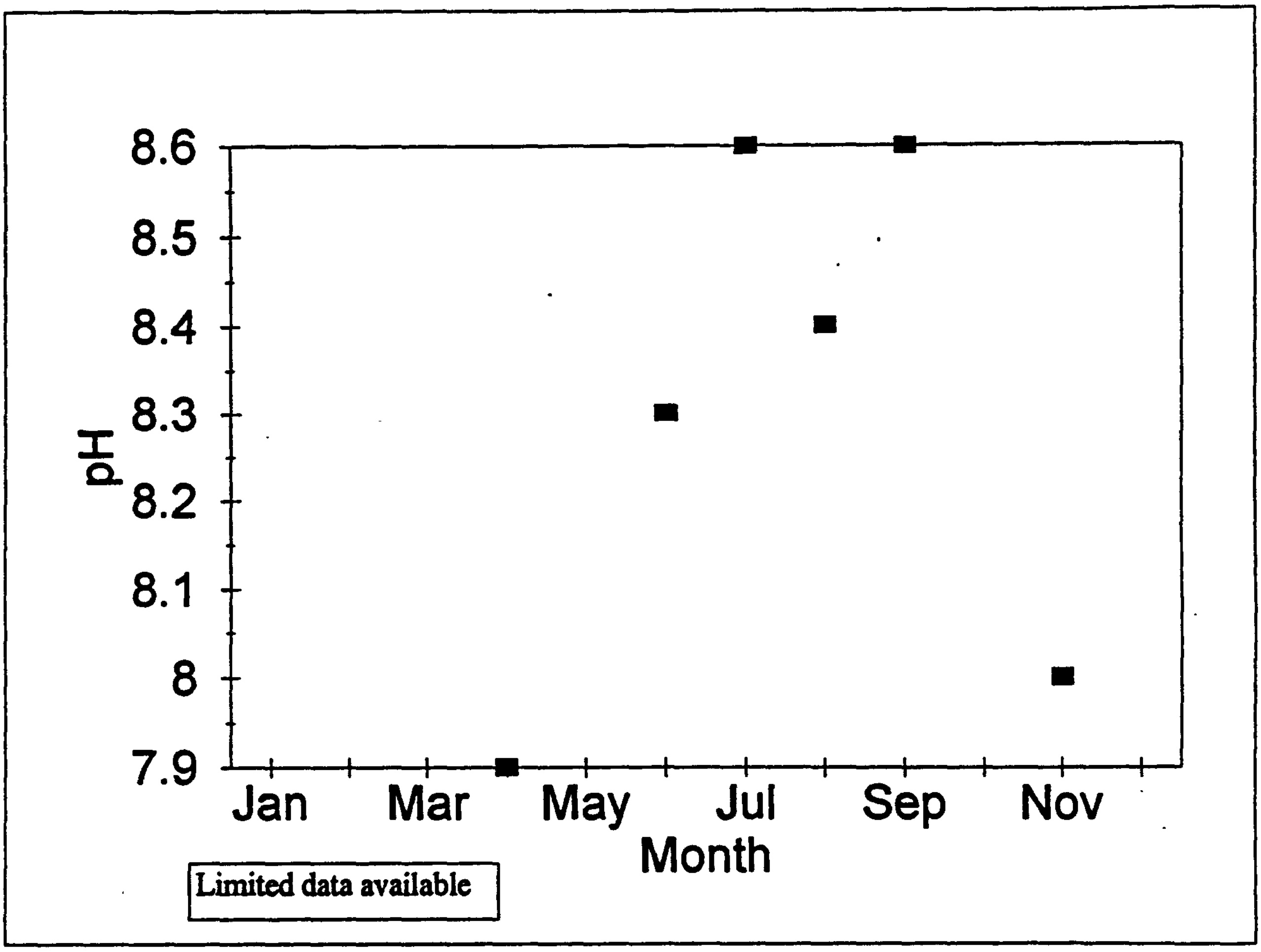


Figure 12. Average monthly pH, downstream boundary.

3.3. Partition coefficients

The water column data include concentrations of dissolved organic carbon (DOC), particulate organic carbon (POC) and total suspended solids (TSS) for each sample. The particulate (C_p) and dissolved (C_d) concentrations of total PCBs, 5 PAHs, 3 metals, and 4 pesticides were recorded for each sample as well. Most of the concentrations for the pesticides were below the detection limit. Total water column concentrations for all the parameters of interest are shown in the plots of Appendix B, as noted above. TSS concentrations are shown in Figures 13 - 15 for the fall sampling, spring sampling and overall data, respectively. In these figures, individual data points are shown as stars for each measurement location and average values are indicated as solid rectangles. These data allowed us to compute observed distribution coefficients for the above contaminants. These estimates approximate partition coefficients only if local equilibrium is assumed. This neglects possible kinetic interactions, but is the most reasonable approach, given the data available.

The fraction organic carbon (f_{oc}) was found by dividing the concentration of POC by the total suspended solids,

$$f_{oc} = \frac{[POC]}{C} \quad , \tag{1}$$

where [POC] = concentration of POC (mg organic carbon/L) and C = TSS concentration (mg dry weight solid/L). The field-observed partition coefficient for dry weight solids (K'_d) (L/kg d.w.) was calculated as follows:

$$K'_d = \frac{C_p}{CC_d} \quad . \tag{2}$$

K'_d values were computed for the metals. For the rest of the hydrophobic organic chemicals, the field-observed partition coefficient was computed on an organic carbon basis (K'_{oc}) (L/kg org.carbon),

$$K'_{oc} = \frac{K'_d}{f_{oc}} \qquad (3)$$

Calculations for the solids concentrations with respect to organic carbon content are summarized in Table 11 for PCBs, PAHs and pesticides of interest. The spatial variations of log K'_{oc} (log K'_d for metals) are shown in Appendix C, Figures C1 - C12.

Table 12 contains calculated values for the mean of the (log K'_{oc}) or (log K'_d) values for overall, spring '92, fall '90, and each of the 6 sampling sites. Standard deviations for the samples are also computed for overall, fall '90, and spring '92. Copies of spreadsheet calculations used to compute these values are included in Appendix C. It should be noted, however, that there are several computed values for f_{oc} which are greater than 1. This is an unrealistic value and appears to be a result of a problem with the raw data. These values are associated with times where the TSS is very low, and a small measurement error in TSS may be the source of the problem. These values were not used in subsequent calculations.

It was desired to determine the extent to which values of K'_{oc} could be predicted from the values of the octanol-water partition coefficient K_{ow}. This was done by first computing (log K'_{oc}) and comparing with values of (log K_{ow}) obtained from literature sources (Endicott et al., 1991; Hydroqual, 1984). These data are plotted in Figure 16. The straight line on this figure results from a linear regression analysis between (log K'_{oc}) and (log K_{ow}) and is written as

$$\log K'_{oc} = 1.12(\log K_{ow}) - 0.694 \quad , \qquad (4)$$

with $r^2 = 0.703$ ($p < 0.01$). This result is significant in that the slope of the regression is nearly equal to 1, while the intercept is reasonably close to 0, which suggests that (log K'_{oc}) may be predicted from the value of (log K_{ow}).

The fraction particulate (f_p) and fraction dissolved (f_d) values were also calculated, using

$$f_p = \frac{CK'_d}{1+CK'_d} \qquad \text{(for metals)} \qquad (5a)$$

or

$$f_p = \frac{K'_{oc}[POC]}{1+K'_{oc}[POC]} \qquad \text{(for organics)} \qquad (5b)$$

and

$$f_d = 1 - f_p \qquad (6)$$

Values for f_p are also included in Appendix C, Figures C13 - C24. Stream-wide average values are listed in Table 13.

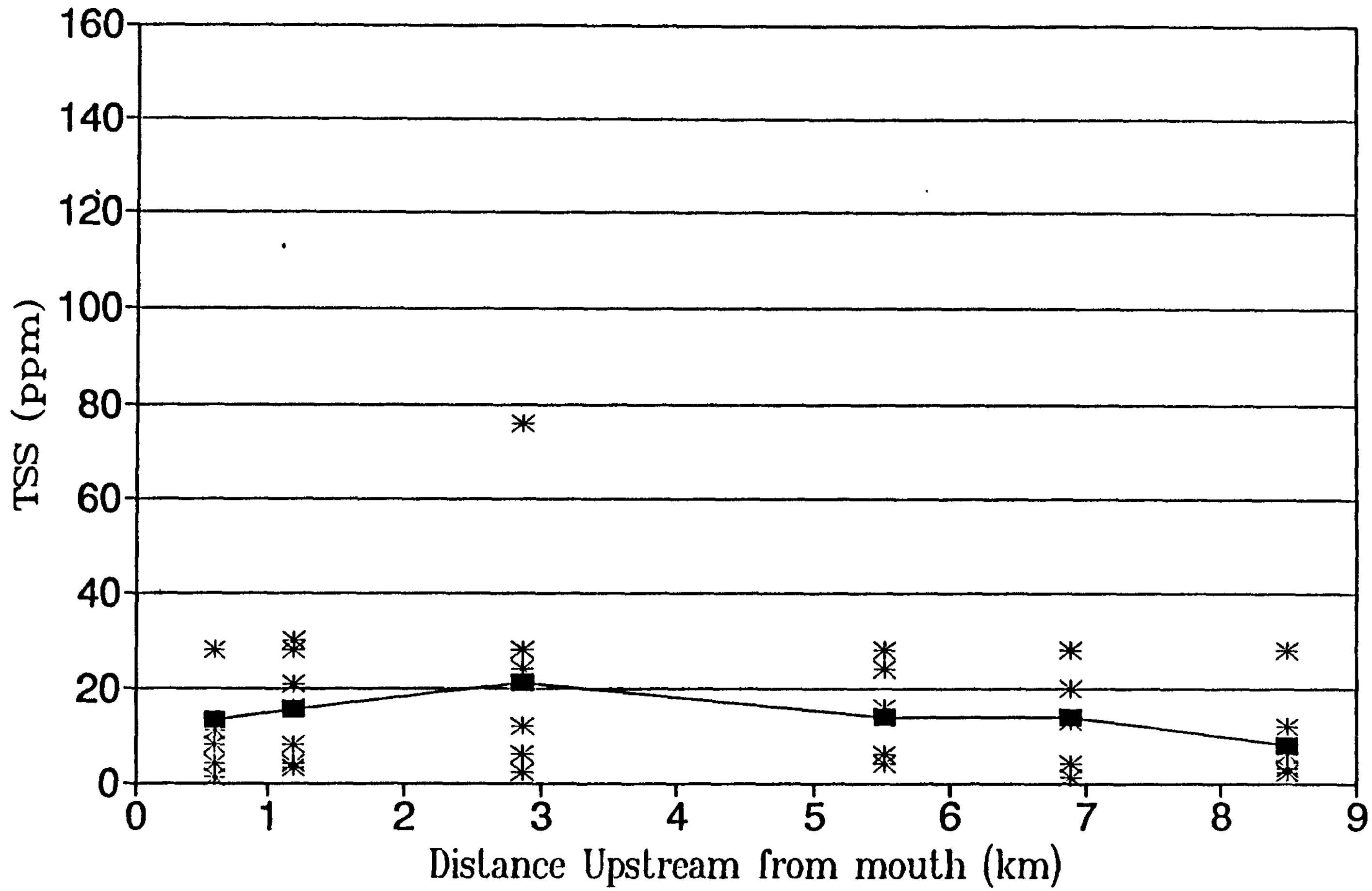


Figure 13. Longitudinal variation of TSS, fall 1990.

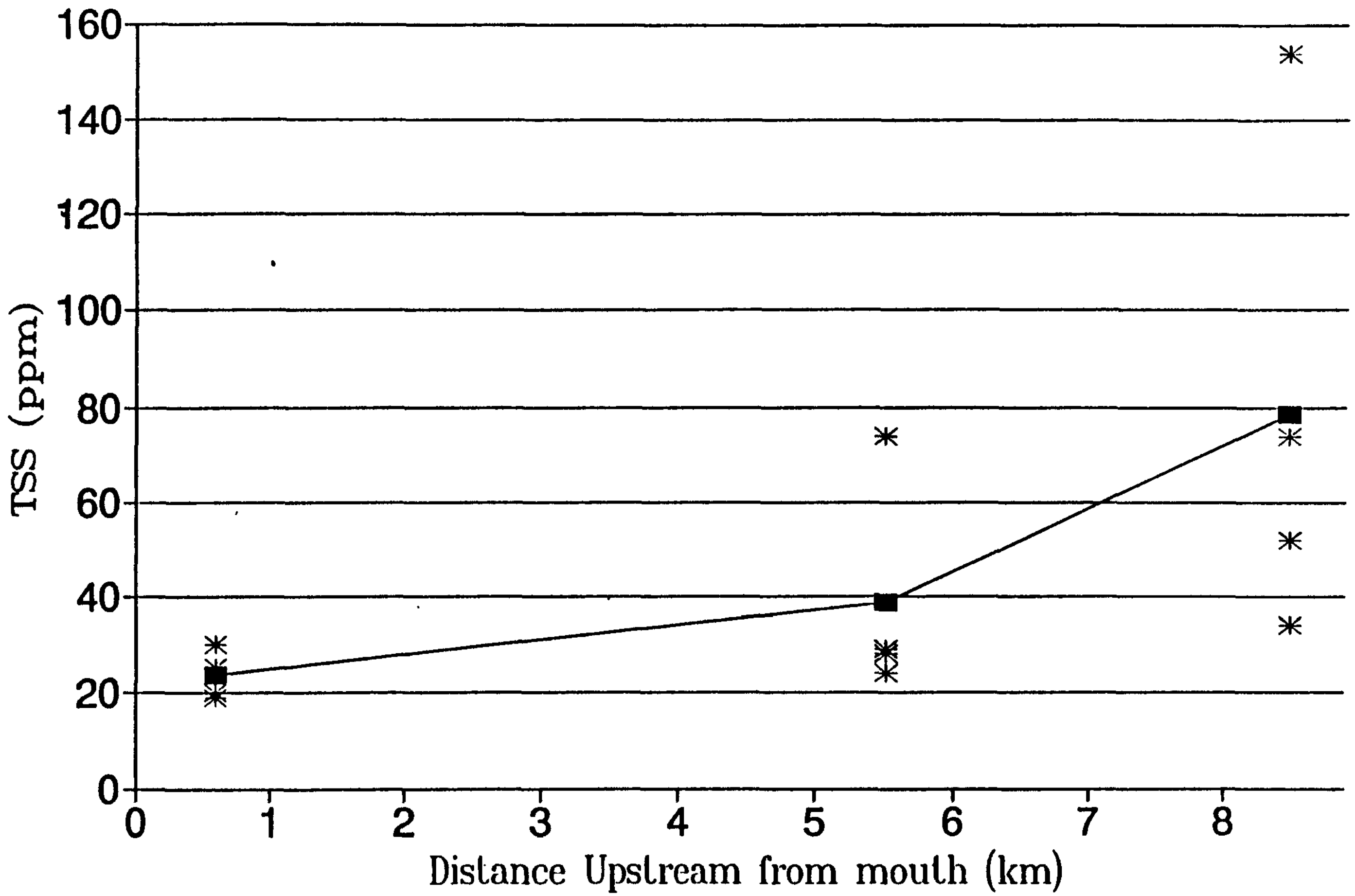


Figure 14. Longitudinal variation of TSS, spring 1992.

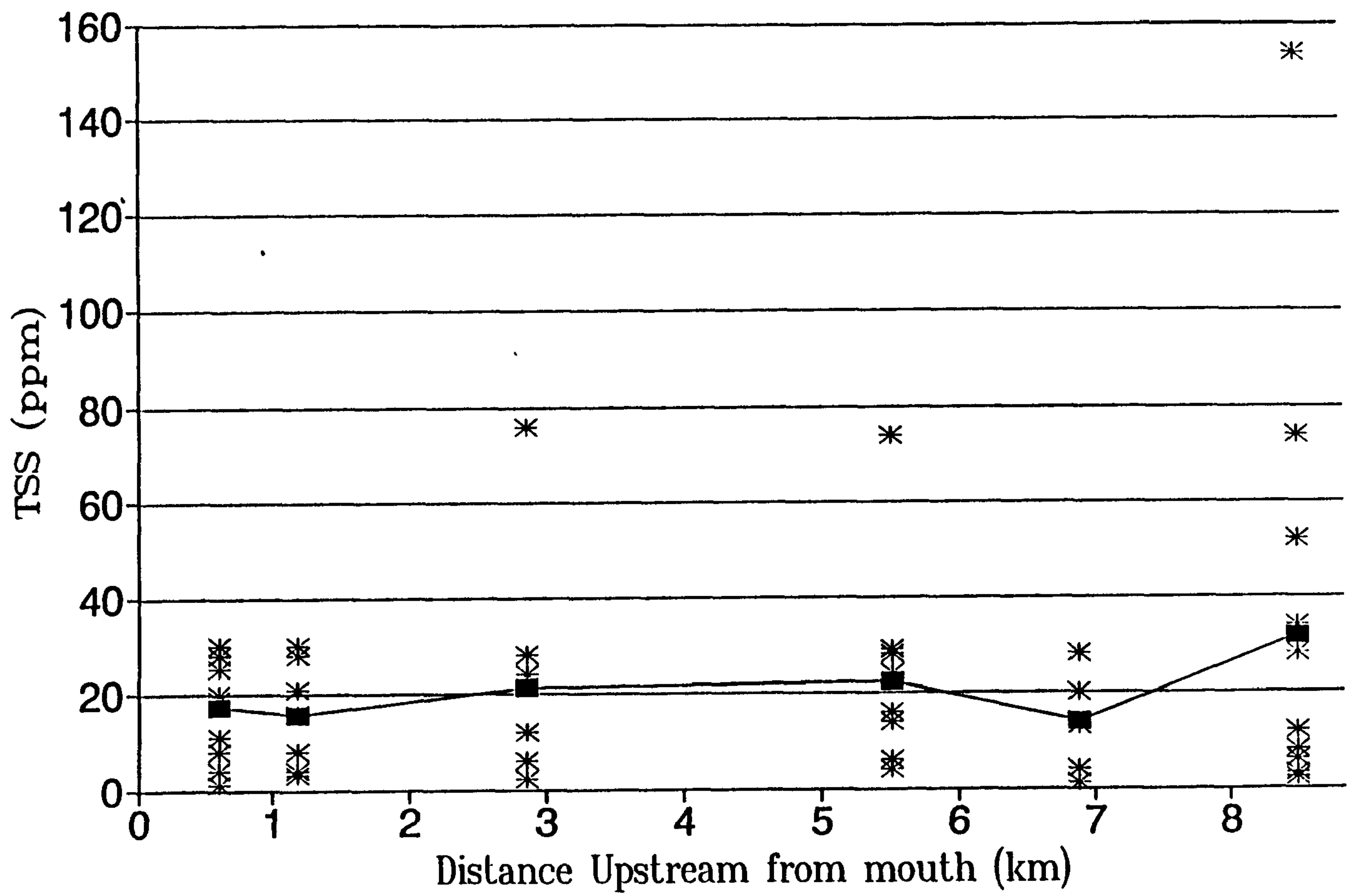


Figure 15. Longitudinal variation of TSS, overall data.

Table 11. Calculation of solids concentrations based on organic carbon content

BUFFALO RIVER (CF#320)
PCBs IN SEDIMENT SAMPLES

SAMPLE NUMBER	SPONSOR ID	total pcbs (ng/g d.w.)	Foc % dry wt.	Foc	total pcbs (ug/g o.c.)
320-1	BR30201C10	79.03	0.27	0.0027	29.27
320-2	BR30301C10	2595.31	2.3	0.023	112.84
320-3	BR30402C10	3364.77	2.7	0.027	124.62
320-4	BR30601C10	1057.22	1.8	0.018	58.73
320-5	BR30603C10	138.38	0.74	0.0074	18.70
320-6	BR30801C10	14830.50	4	0.04	370.76
320-7	BR30801C10	49935.16	5.4	0.054	924.73
320-8	BR30901C10	233.72	2.3	0.023	10.16
320-9	BR31302C10	1124.29	2.1	0.021	53.54
320-10	BR31402C20	649.32	2.3	0.023	28.23
320-11	BR31601CC1	316.49	2.2	0.022	14.39
320-12	BR31903C10	179.25	2	0.02	8.96
320-13	BR31903C10	8411.02	4.2	0.042	200.26
320-14	BR32003C10	10035.56	5.2	0.052	192.99
320-15	BR32102C10	137.85	2.3	0.023	5.99
320-16	BR32102C10	5135.21	3	0.03	171.17
320-17	BR32301C10	315.36	1.7	0.017	18.55
320-18	BR32501C10	767.77	1.7	0.017	45.16
320-19	BR332702C1	386.73	1.7	0.017	22.75
320-20	BR 32801C10	601.71	2	0.02	30.09
320-21	BR31301C10	415.74	1.8	0.018	23.10
320-22	BR33002C10	6341.76	5	0.05	126.84
320-23	BR33102C10	1961.20	1.9	0.019	103.22
320-24	BR33202C10	1700.59	2.2	0.022	77.30
320-25	BR33201C20	178.95	1.9	0.019	9.42
320-26	BR33201C20	43.90	2.1	0.021	2.09
320-27	BR33402C10	115.75	2.5	0.025	4.63
320-28	BR33402C10	1778.42	2.7	0.027	65.87
320-29	BR33501C10	525.84	1.9	0.019	27.68
320-30	BR33501C10	24486.84	7.1	0.071	344.89
320-31	BR33702C10	161.97	2.3	0.023	7.04
320-32	BR33702C10	181.48	1	0.01	18.15
320-33	BR3381C101	136.60	2	0.02	6.83
320-34	BR3381C104	2436.20	2.8	0.028	87.01
320-35	BR3410C101	219.17	2	0.02	10.96

Table 11 (continued)

GREAT LAKES (CF #320) BUFFALO RIVER
PAH CONCENTRATIONS IN SEDIMENT

		(Concentrations in ug/kg dry wt.)							(Concentrations in ug/kg o.c.)				
MSL Code	Sponsor I.D.	Benzo(a) Anthracene	Chrysene	Benzo(b) Fluoranthene	Benzo(k) Fluoranthene	Benzo(a) Pyrene	Foc % dry wt.	Foc	Benzo(a) Anthracene	Chrysene	Benzo(b) Fluoranthene	Benzo(k) Fluoranthene	Benzo(a) Pyrene
320-1	BR30201C101	74	117	97	73	78	0.27	0.0027	27559	43399	35917	27120	28249
320-2	BR30301C101	1558	1715	1324	1007	1318	2.3	0.023	67721	74571	57571	43802	57299
320-3	BR30402C101	2282	2617	1542	1245	1538	2.7	0.027	84534	96929	57123	46101	56976
320-4	BR30601C101	1154	1349	1139	897	1123	1.8	0.018	64096	74930	63282	49841	62371
320-5	BR30603C101	806	886	489	395	552	0.74	0.0074	108902	119763	66030	53379	74591
320-6	BR30801C101	1963	2530	1700	1050	1522	4	0.04	49082	63258	42492	26254	38054
320-7	BR30801C104	4647	6222	2467	1652	2195	5.4	0.054	86054	115225	45690	30594	40644
320-8	BR30901C101	358	541	506	386	412	2.3	0.023	15561	23506	22000	16784	17932
320-9	BR31302C101	2507	2776	1701	1469	1812	2.1	0.021	119386	132207	80987	69946	86266
320-10	BR31402C201	504	666	618	449	549	2.3	0.023	21893	29022	26866	19518	23866
320-11	BR31601C101	374	549	585	447	527	2.2	0.022	17016	24958	26581	20324	23947
320-12	BR31903C101	471	549	451	378	436	2	0.02	23552	27454	22566	18891	21806
320-13	BR31903C103	3926	4002	2556	2380	2688	4.2	0.042	93482	95297	60852	56662	63999
320-14	BR32003C101	14949	14177	11921	10721	13842	5.2	0.052	287478	272641	229253	206169	266199
320-15	BR32102C101	262	403	379	294	324	2.3	0.023	11405	17520	16475	12784	14091
320-16	BR32102C103	34660	28509	20623	20894	24577	3	0.03	1155996	950302	687429	696481	819231
320-17	BR32301C101	436	562	487	389	446	1.7	0.017	25629	33080	28633	22882	26264
320-18	BR32501C101	466	626	505	413	456	1.7	0.017	27427	36946	29713	24309	26844
320-19	BR32702C101	4851	4632	3772	3564	4450	1.7	0.017	285365	272500	221875	209637	261776
320-20	BR32801C101	924	1134	1046	795	992	2	0.02	46190	56693	52309	39756	49589
320-21	BR31301C101	714	866	805	670	794	1.8	0.018	39664	48135	44696	37207	44113
320-22	BR33002C103	5901	6472	3361	2636	3683	5	0.05	118012	129436	67210	52719	73651
320-23	BR33102C101	412	517	340	275	328	1.9	0.019	21673	27193	17869	14470	17256
320-24	BR33202C101	2602	3067	1242	962	1265	2.2	0.022	118268	139400	56440	43735	57487
320-25	BR33201C201	301	441	391	294	318	1.9	0.019	15865	23185	20570	15493	16761
320-26	BR33201C203	103	106	59	36	62	2.1	0.021	4892	5141	2795	1831	2952
320-27	BR33402C101	360	530	522	417	433	2.5	0.025	14397	21202	20864	16688	17312
320-28	BR33402C103	5349	5396	3414	3036	3786	2.7	0.027	198107	199658	126432	112440	140237
320-29	BR33501C101	472	671	747	530	624	1.9	0.019	24817	35314	39309	27905	32844
320-30	BR33501C103	6263	7732	4826	2819	4191	7.1	0.071	88208	108898	67966	39697	59029
320-31	BR33702C101	580	681	596	495	702	2.3	0.023	25226	29614	25994	21505	30511
320-32	BR33702C103	1537	1796	1333	1150	1617	1	0.01	153743	179616	133272	114990	161749
320-33	BR3361C101	401	573	567	441	474	2	0.02	20066	28637	28336	22037	23722
320-34	BR3361C104	21267	17857	14855	8786	13559	2.8	0.028	759541	637752	530549	313874	484235
320-35	BR3410C101	553	730	736	568	640	2	0.02	27671	36517	36754	28424	31977

Table 11 (continued)

PESTICIDES IN BUFFALO RIVER
IN SEDIMENT SAMPLES
(CF #320)

03/26/93

		(Concentrations in ug/kg dry weight)						(Concentrations in ug/kg org. carbon)			
						Foc	Foc				
SAMPLE NUMBER	SPONSOR ID	A-CHLORDAN	G-CHLORDAN	DIELDRIN	4,4'DDT			A-CHLORDAN	G-CHLORDAN	DIELDRIN	4,4'DDT
320-1	BR30201C101	2	2	2	2	0.27	0.0027	0.0054	0.0054	0.0054	0.00
320-2	BR30301C101	2	40	2	10	2.3	0.023	0.046	0.92	0.046	0.
320-3	BR30402C101	2	40	2	2	2.7	0.027	0.054	1.08	0.054	0.0
320-4	BR30601C101	10	20	2	10	1.8	0.018	0.18	0.36	0.036	0.
320-5	BR30603C101	2	10	2	2	0.74	0.0074	0.0148	0.074	0.0148	0.01
320-6	BR30801C101	2	100	100	20	4	0.04	0.08	4	4	0
320-7	BR30801C104	200	200	200	1000	5.4	0.054	10.8	10.8	10.8	[illegible]
320-8	BR30901C101	2	20	2	10	2.3	0.023	0.046	0.46	0.046	0.
320-9	BR31302C101	2	20	2	10	2.1	0.021	0.042	0.42	0.042	0.
320-10	BR31402C201	2	10	2	2	2.3	0.023	0.046	0.23	0.046	0.0
320-11	BR31601C101	2	20	2	10	2.2	0.022	0.044	0.44	0.044	0.
320-12	BR31903C101	2	20	2	10	2	0.02	0.04	0.4	0.04	0
320-13	BR31903C103	10	2	2	100	4.2	0.042	0.42	0.084	0.084	4
320-14	BR32003C101	20	10	10	2	5.2	0.052	1.04	0.52	0.52	0.1
320-15	BR32102C101	2	10	2	10	2.3	0.023	0.046	0.23	0.046	0.
320-16	BR32102C103	2	2	2	100	3	0.03	0.06	0.06	0.06	
320-17	BR32301C101	2	20	2	10	1.7	0.017	0.034	0.34	0.034	0.
320-18	BR32501C101	2	2	2	10	1.7	0.017	0.034	0.034	0.034	0.
320-19	BR32702C101	2	20	2	2	1.7	0.017	0.034	0.34	0.034	0.0
320-20	BR32801C101	2	10	2	2	2	0.02	0.04	0.2	0.04	0.
320-21	BR31301C101	2	20	2	2	1.8	0.018	0.036	0.36	0.036	0.0
320-22	BR33002C103	100	100	100	100	5	0.05	5	5	5	
320-23	BR33102C101	2	2	10	10	1.9	0.019	0.038	0.038	0.19	0.
320-24	BR33202C101	2	10	10	20	2.2	0.022	0.044	0.22	0.22	0.
320-25	BR33201C201	2	10	2	10	1.9	0.019	0.038	0.19	0.038	0.1
320-26	BR33201C203	2	2	2	2	2.1	0.021	0.042	0.042	0.042	0.0
320-27	BR33402C101	2	10	2	10	2.5	0.025	0.05	0.25	0.05	0.
320-28	BR33402C103	2	2	2	10	2.7	0.027	0.054	0.054	0.054	0.
320-29	BR33501C101	2	2	2	10	1.9	0.019	0.038	0.038	0.038	0.
320-30	BR33501C103	200	200	200	1000	7.1	0.071	14.2	14.2	14.2	[illegible]
320-31	BR33702C101	2	2	2	10	2.3	0.023	0.046	0.046	0.046	0.
320-32	BR33702C103	2	20	2	10	1	0.01	0.02	0.2	0.02	0
320-33	BR3381C101	2	20	2	10	2	0.02	0.04	0.4	0.04	0
320-34	BR3381C104	10	2	2	2	2.8	0.028	0.28	0.056	0.056	0.0
320-35	BR3410C101	2	10	2	10	2	0.02	0.04	0.2	0.04	0

Table 12. Summary calculations for log K'_{OC} and K'_d.

METALS --------	n	AVG TSS (mg/l)	LEAD K'd (l/kg)	LEAD log K'd	COPPER K'd (l/kg)	COPPER log K'd	IRON K'd (l/kg)	IRON log K'd
OVERALL	56	21.29	8.62E+05	5.27	1.84E+06	5.31	2.32E+05	5.08
s.d				0.78		0.96		0.54
Spring 92	12	46.94	1.44E+05	5.25	6.39E+04	4.59	9.12E+04	4.91
s.d				0.66		0.49		0.23
Fall 90	44	14.30	1.39E+06	5.58	2.58E+06	5.47	2.40E+05	5.09
s.d				0.72		0.96		0.60
Site 1	12	31.58	1.09E+06	5.04	2.85E+06	5.32	2.18E+05	5.08
Site 2	8	14	4.21E+06	5.62	4.55E+05	5.42	2.53E+05	5.11
Site 3	12	22.25	1.73E+06	5.90	9.71E+06	5.94	2.78E+06	6.00
Site 4	7	21.43	2.15E+06	5.76	7.17E+06	5.81	2.44E+05	5.05
Site 5	7	15.71	1.96E+06	5.77	1.91E+06	5.25	1.80E+05	4.99
Site 6	10	17.43	3.13E+05	5.24	1.49E+05	4.89	1.07E+05	5.00

PCBs --------	n	AVG TSS (mg/l)	Koc (l/kg)	log Koc
OVERALL	56	21.29	1.91E+07	6.44
s.d				1.00
Spring 92	12	46.94	4.22E+06	6.15
s.d				0.70
Fall 90	44	14.30	2.39E+07	6.53
s.d				1.07
Site 1	12	31.58	3.37E+06	5.79
Site 2	8	14	2.28E+06	5.44
Site 3	12	22.25	5.65E+06	6.40
Site 4	7	21.43	4.20E+07	7.34
Site 5	7	15.71	6.93E+07	7.36
Site 6	10	17.43	2.04E+06	6.25

Table 12 (continued)

PAHs -------	n	AVG TSS (mg/l)	B[a]a Koc (l/kg)	B[a]a log Koc	Chrysene Koc (l/kg)	Chrys. log Koc	B[b]f Koc (l/kg)	B[b]f log Koc	B[k]f Koc (l/kg)	B[k]f log Koc	B[a]p Koc (l/kg)	B[a]p log Koc
OVERALL	56	21.29	1.7E+06	5.66	3.8E+06	5.91	5.6E+06	6.33	9.6E+06	6.56	8.5E+06	6.56
s.d.				0.61		0.59		0.67		0.64		0.55
Spring 92	12	46.94	1.3E+06	5.96	3.5E+06	6.40	1.1E+07	6.70	1.4E+07	6.92	6.3E+06	6.71
s.d.				0.43		0.40		0.54		0.46		0.32
Fall 90	44	14.30	1.8E+06	5.84	4.2E+06	6.02	4.7E+06	6.16	7.4E+06	6.40	9.2E+06	6.51
s.d.				0.63		0.61		0.65		0.63		0.60
Site 1	12	31.58	2.2E+06	5.99	2.2E+06	6.20	4.8E+06	6.51	7.6E+06	6.74	9.2E+06	6.8
Site 2	8	14	1.3E+06	5.58	2.2E+05	5.34	4.0E+06	5.96	1.6E+06	6.01	2.7E+06	6.25
Site 3	12	22.25	8.9E+05	5.69	1.7E+06	5.97	1.0E+07	6.48	1.5E+07	6.76	3.0E+06	6.42
Site 4	7	21.43	2.7E+06	5.97	1.1E+07	6.47	1.3E+07	6.47	1.7E+07	6.74	3.2E+07	6.86
Site 5	7	15.71	2.2E+06	6.18	1.4E+06	6.02	1.3E+06	5.91	2.3E+06	6.17	3.6E+06	6.37
Site 6	10	17.43	4.1E+05	5.5	3.7E+06	6.29	5.1E+06	6.30	6.0E+06	6.43	4.9E+06	6.45

Pesticides -------	n	AVG TSS (mg/l)	G-CHL Koc (l/kg)	G-CHL log Koc	A-CHL Koc (l/kg)	A-CHL log Koc	DIELDRIN Koc (l/kg)	DIELD. log Koc	DDT Koc (l/kg)	DDT log Koc
OVERALL	56	21.29	9.22E+05	5.65	8.16E+05	5.62	4.77E+05	5.41	3.32E+06	6.20
s.d				0.57		0.52		0.64		0.66
Spring 92	12	46.94	1.58E+06	5.90	1.21E+06	5.74	2.42E+05	5.33	2.14E+06	6.06
s.d				0.65		0.71		0.25		0.55
Fall 90	44	14.30	6.67E+05	5.55	7.22E+05	5.78	5.76E+05	5.44	4.16E+06	6.31
s.d				0.51		0.47		0.73		0.73
Site 1	12	31.58	4.99E+05	5.64	6.13E+05	5.67	4.53E+05	5.45	5.37E+06	6.62
Site 2	8	14	1.02E+05	4.98	7.35E+05	5.3	2.61E+05	5.42	—	—
Site 3	12	22.25	1.10E+06	5.66	1.09E+06	6.31	5.78E+05	5.41	3.97E+06	6.07
Site 4	7	21.43	7.20E+05	5.7	9.72E+05	5.75	1.17E+06	5.94	6.20E+06	6.74
Site 5	7	15.71	1.28E+06	5.83	5.25E+05	5.59	3.17E+05	5.32	1.86E+06	6.18
Site 6	10	17.43	1.64E+06	5.93	8.80E+05	5.64	1.57E+05	5.16	1.20E+06	5.97

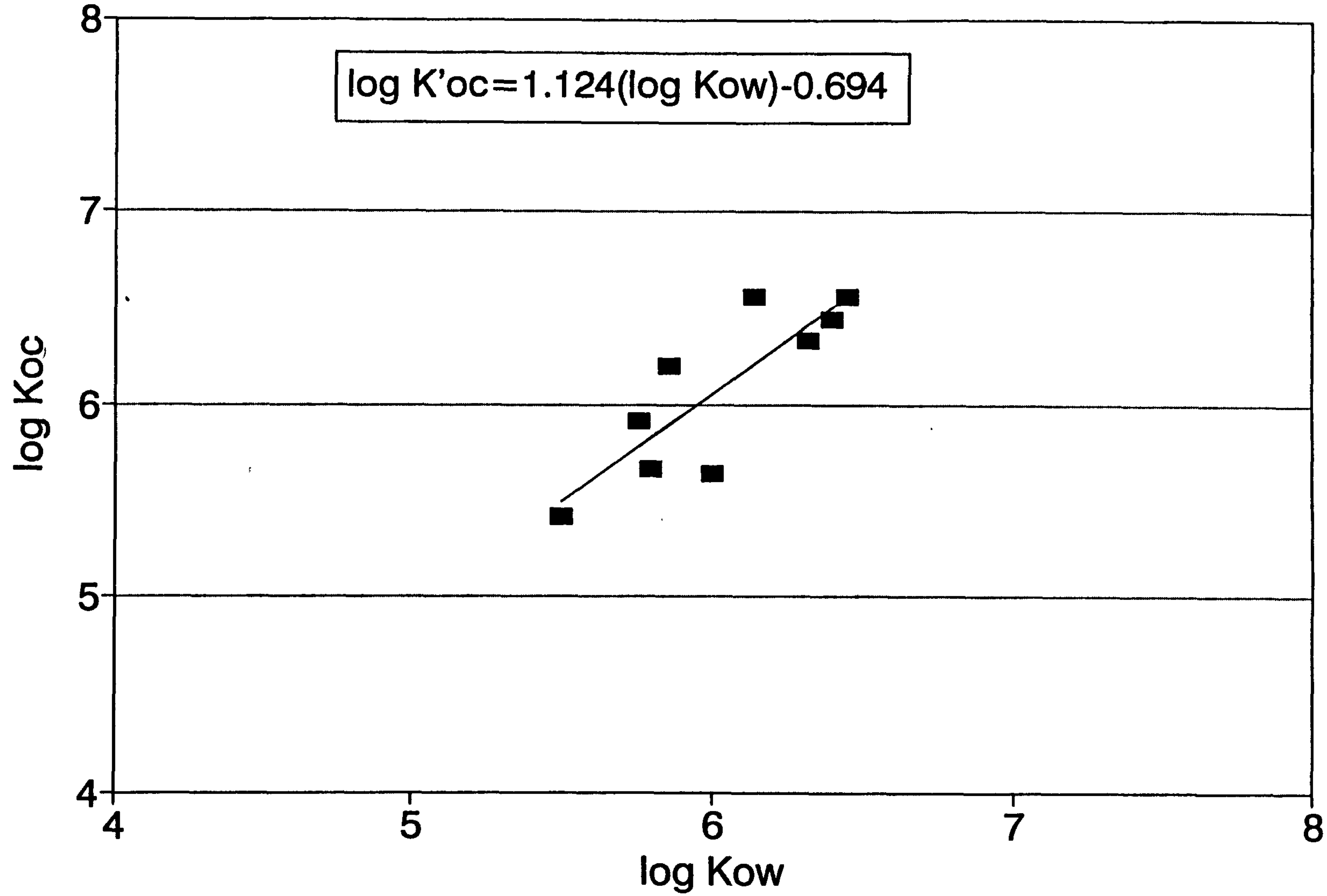


Figure 16. Relationship between log K'_{oc} and log K'_{ow}.

Table 13. Stream-wide average values for f_p.

Parameter	f_p
PCBs	0.75
A-Chlordane	0.50
G-Chlordane	0.55
Dieldrin	0.42
DDT	0.78
Benzo(a)anthracene	0.59
Benzo(b)fluoranthene	0.77
Benzo(k)fluoranthene	0.86
Benzo(a)pyrene	0.88
Chrysene	0.74
Lead	0.77
Copper	0.70

3.4. Spatial variability of sediment characteristics

The organic pollutants of interest (PCBs, PAHs, pesticides and metabolites) have been detected in bottom sediments of the Buffalo River (NYSDEC, 1989). In addition, inorganic pollutants of interest (metals and cyanides) have been detected in the water column of the river (NYSDEC, 1989). These parameters are known to sorb strongly to bottom sediments. These contaminants have a very low solubility in water and sorb strongly to organic matter associated with bottom sediments. While these bottom sediments are relatively immobile during periods of low to average flows, higher flow rates associated with snow melt or stormwater runoff may induce resuspension of the sediments. In addition, these events cause a much higher than normal sediment load to be transported from the upstream tributaries (see Section 4.1.1.).

Sediment cores were taken from 37 locations along the river bottom and several positions in the Buffalo Ship Canal (Figure 17). These locations include 10 master stations where a full range of parameters was analyzed, supplemented by reconnaissance, or indicator stations where selected parameters were measured. Details of the coring procedures, analyses and results are described in a report under preparation by AScI Corp. for the Great Lakes National Program Office (GLNPO) of EPA (Joe Rathbun, personal communication). According to that report, the average core length was 105" (267 cm). Relatively clean, brown silt was usually found in the upper foot or two, with oily silt beneath. Concentration data are reported as averages over the "upper sediment layer". This corresponds with the top 24" of the core. These data were combined with a digital map of the river to produce plots of contaminant concentrations at each measurement station, as shown in Appendix D. These figures give an indication of areas with relatively high concentration levels. For example, from Figures D11 and D12, there are several locations where metals concentrations are particularly high. These locations are mostly around the Buffalo Color Peninsula, though several high readings are also seen further downstream.

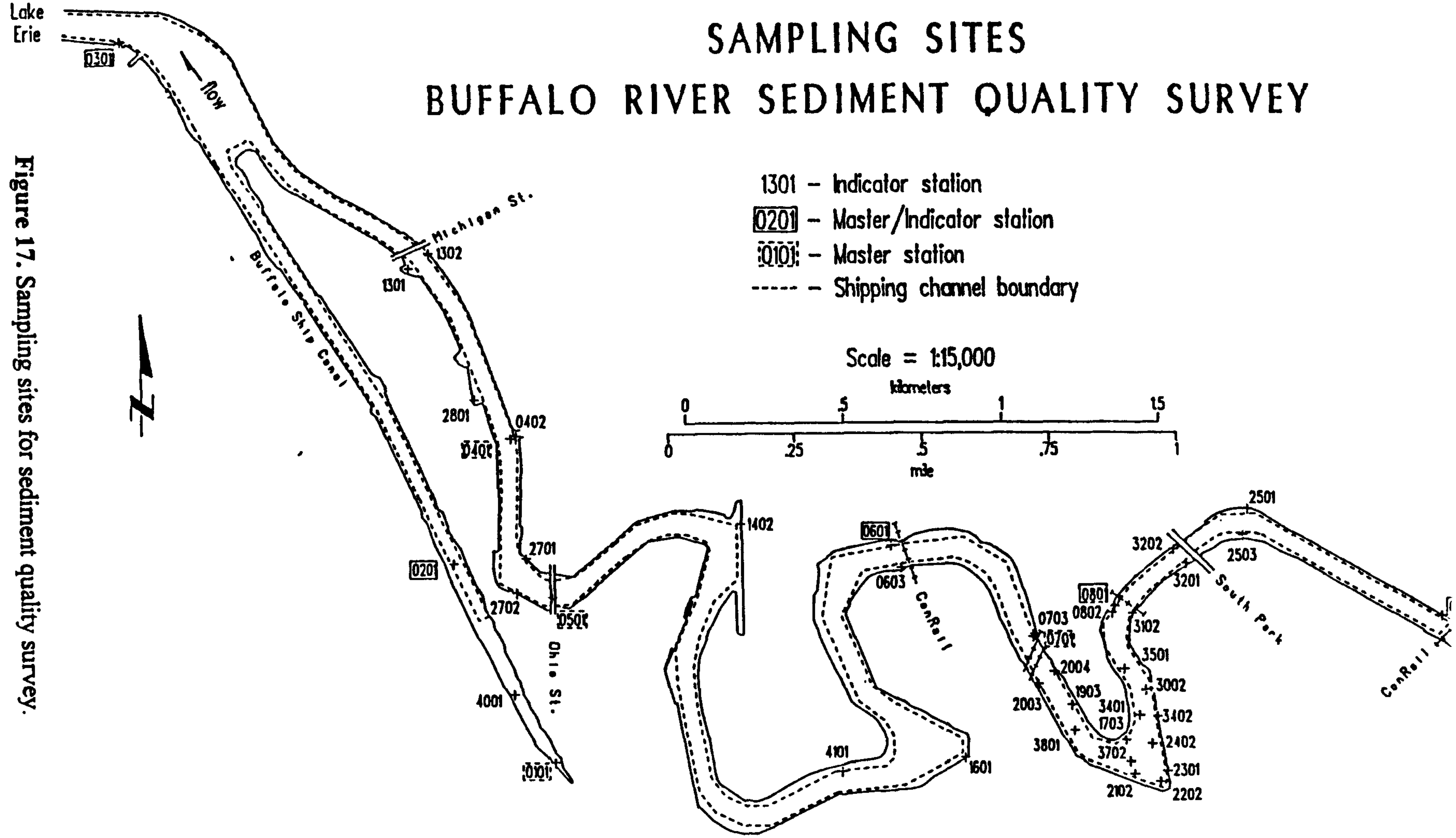


Figure 17. Sampling sites for sediment quality survey.

Estimates of the total in-place contaminant mass, Table 14, were made by spatially averaging the data shown in the figures of Appendix D. These calculations are meant to provide only an order-of-magnitude indication of the potential source represented by in-place contaminants, since the nature of the available data precludes the calculation of better mass estimates. Specifically, the data were sampled mostly from near-shore areas, with few measurements taken closer to the middle of the channel. The overall lack of finely spaced measurement points, along with the high degree of variability in the reported values, implies that simple averaging will not necessarily provide accurate mean values. Also, only the upper layer concentrations are reported, so the values in Table 14 do not reflect mass concentrations from depths below 24 in. or 24 cm.

Table 14. Contaminant mass in sediments.

Contaminant	Mass in upper sediment layer (kg)
PCBs	7.69
g-chlordane	0.32
a-chlordane	0.07
Dieldrin	0.06
DDT	0.26
Benzo(a)anthracene	16.17
Benzo(b)fluoranthene	17.68
Benzo(k)fluoranthene	14.34
Benzo(a)pyrene	17.99
Chrysene	19.77
Lead	1,399
Copper	1,408

4. Loading estimates

4.1. Upstream loading estimates

4.1.1. Suspended solids

Data. As noted above, transport of contaminants into the AOC is strongly dependent on sediment transport. Therefore, the ability to accurately predict suspended solids loadings to the AOC from upstream tributaries is an important component in the contaminant mass balance modeling effort. Suspended solids were measured as part of the data surveys conducted in 1990 and 1992 (Figures 13 - 15). The majority of these data, obtained from within the AOC, with the exception of data from the most upstream site (Site 1), are not useful for developing predictive relationships of upstream loadings to the AOC. However, data from Sites 2 - 6 can be used in validating solids transport modeling results within the AOC. Suspended solids and pollutant loadings from the upstream tributaries were therefore developed from TSS samples taken at several locations upstream of the Buffalo River/Cazenovia Creek confluence (at Highway 62) and at Site 1, and from water column samples taken at Site 1, which is about 2,000 ft. downstream of this confluence. A summary of available TSS data is listed in Table 15.

Table 15. Data availability for TSS

Site no. *	Period of record	No. of samples	Sampling location
120	7/89-4/90	42	Cazenovia Ck. at Cazenovia Parkway
119	7/89-9/90	44	Buffalo River at S. Ogden St.
105	1/90-7/92	41	Cazenovia Ck. at HWY 62 (Bailey Ave.)
104	1/90-7/92	48	Buffalo River at HWY 62 (Bailey Ave.)
Caz R/S1	3/92-4/92	4	(grab) Cazenovia Ck. at Northrup Rd.
Caz S/U2	3/92-4/92	4	(grab) Cazenovia Ck. at Cazenovia Pkwy.
BR S/U2	3/92-4/92	4	(grab) Buffalo River at S. Ogden St.
BC R/S2	3/92-4/92	4	(grab) Buffalo Ck. at N. Blossom Rd.
CAY R/S3	3/92-4/92	4	(grab) Cayuga Ck. at Lake Ave.
104	10/90-12/91	6	(grab) Buffalo River at HWY 62
1	10/90-4/92	12	Buffalo River AOC, Sampling Site 1

* Except for the last row, all site identification numbers refer to NYSDEC designations.

Reported TSS measurements do not normally include bed load transport. The bed load, also referred to as "unmeasured sediment discharge", is useful for predicting total solids load (Colby, 1957). However, this is not directly useful for predicting contaminant loading since the bed load consists mostly of larger particles while sorption occurs mainly to the smaller size fractions. Total sediment discharge rates were estimated for sites 1, 104 and 105 (Table 15) using the Colby (1957) relations, to provide some indication of total solids loading. The available data for Site 1 and calculated total sediment discharge rates are summarized in Table 16. In the following calculations for contaminant loadings, however, only the suspended loads are used.

Table 16. Upstream total sediment load, from Colby (1957) relation.

Total Sediment Discharge Calculations, Colby Relations
Buffalo River Mass Balance Modeling Project

Sampling Site #1, Buffalo River AOC

(1) Date	(2) Observed TSS (mg/L)	(3) Q (cfs)	(4) Buffalo Harbor WSEL (IGLD)	(5) Buffalo Harbor WSEL (NGVD)	(6) Cross Section Area (ft^2)	(7) Depth (ft)	(8) Width (ft)	(9) Velocity (ft/s)	(10) Relative Conc of Sands	(11) Availabil Ratio	(12) Ratio of Departure	(13) Curve C Un Sed D /ft width (ton/day)	(14) Unmeas Sediment Discharge (ton/day)	(15) Unmeas Sediment Discharge (mg/L)	(16) Total Sediment Discharge (mg/L)
10/18/90	8	1029	572.92	574.22	3460	14.42	239.9445	0.297399	50	0.16	0.5	1	119.9723	43.21861	51.21861
10/22/90	6	418	571.03	572.33	2962.867	12.53	236.4619	0.14108	50	0.12	0.48	1	113.5017	100.6541	106.6541
10/27/90	3	376	571.31	572.61	3036.517	12.81	237.0427	0.123826	50	0.06	0.32	1	75.85365	74.78147	77.78147
10/31/90	3	336	570.74	572.04	2886.588	12.24	235.8323	0.1164	50	0.06	0.32	1	75.46634	83.25674	86.25674
11/5/90	3	322	570.43	571.73	2805.047	11.93	235.1255	0.114793	50	0.06	0.32	1	75.24016	86.61622	89.61622
11/5/90	2	322	570.43	571.73	2805.047	11.93	235.1255	0.114793	50	0.04	0.28	1	65.83514	75.78919	77.78919
11/9/90	28	648	570.96	572.26	2944.455	12.46	236.3126	0.220075	50	0.56	1	1	236.3126	135.1815	163.1815
11/13/90	12	684	571.34	572.64	3044.408	12.84	237.1034	0.224674	50	0.24	0.65	1	154.1172	83.5219	95.5219
4/17/92	154	2592	571.73	573.03	3146.991	13.23	237.8678	0.823644	50	3.08	2.3	1	547.0959	78.24089	232.2409
4/17/90	52	2592	571.73	573.03	3146.991	13.23	237.8678	0.823644	50	1.04	1.4	1	333.0149	47.62489	99.62489
4/18/90	74	1678	571.57	572.87	3104.905	13.07	237.5597	0.540435	50	1.48	1.7	1	403.8515	89.21443	163.2144
4/22/90	34	1609	572.18	573.48	3265.355	13.68	238.6956	0.492749	50	0.68	1.1	1	262.5651	60.49039	94.49039

Notes:
(5) NGVD = IGLD + 1.3 ft
(10) Figure 7 (Colby, 1957)
(11) [(2)/(10)]
(12) Figure 8 (Colby, 1957)
(13) Figure 5 (Colby, 1957)
(14) [(8)*(12)*(13)]
(15) [(14)*370.6853/(3)]

Modified Parsons procedure for estimating TSS concentrations. A procedure for estimating TSS was reported in an early study by Parsons et al. (1963). Using data from 1953 - 1961, they developed a relation between suspended sediment concentration and discharge for each of the three tributary creeks,

$$C_i = K_i Q_i^{0.85} \quad , i = 1,2,3 \qquad (7)$$

where i = 1, 2, or 3 corresponds with Buffalo, Cayuga or Cazenovia Creek, respectively, C_i = suspended sediment concentration in tributary i (mg/L), K_i = "erodibility constant" for tributary i and Q_i = discharge in tributary i (cfs). Values for K_i are shown in Table 17.

Table 17. Watershed and seasonal variation in K_i (eq. 7).

Month	Buffalo Creek (i = 1)	Cayuga Creek (i = 2)	Cazenovia Creek (i = 3)
January	1.5	0.8	1.0
February	1.4	1.1	1.2
March	2.0	1.6	1.7
April	1.8	1.6	2.0
May	1.9	1.7	2.1
June	2.7	2.2	2.6
July	2.8	2.4	2.9
August	3.1	2.4	2.9
September	2.7	2.3	2.5
October	2.2	2.1	1.8
November	1.8	1.7	1.6
December	1.4	0.9	1.0

The total load to the AOC is obtained by summing,

$$QC = \sum_{i=1}^{3} Q_i C_i = \sum_{i=1}^{3} K_i Q_i^{1.85} \quad , \qquad (8)$$

where $Q = Q_1 + Q_2 + Q_3$ = total flow in Buffalo River and C = sediment concentration entering the river. The concentration C is then found by dividing the right hand side of (8) by Q.

In order to compare results from this equation with present observations, it was found that a correction factor had to be added due to the generally lower TSS values observed more recently. Thus,

$$C = \frac{F}{Q}\sum_{i=1}^{3} K_i Q_i^{1.85} \quad , \qquad (9)$$

where F = seasonally-dependent correction factor. Based on solids data listed above, values for F were calculated for all months except June, by comparing estimates using (9) with observed TSS. These values are shown in Table 18. A direct value for June was not estimated because measured TSS values were not available for that month. Instead, the value listed for June was obtained by averaging the values for May and July. Predicted concentrations using (9) are plotted vs. observed values in Figure 18. Although the comparison appears reasonable, it was felt that a relationship developed from the current data alone may be more appropriate due to changes in land use and erosive characteristics in the watershed from the time the Parsons et al. (1963) study was done.

Table 18. Values for correction factor in (9).

Month	Correction factor (F)
January	0.1
February	0.1
March	0.4
April	0.4
May	0.2
June	0.23
July	0.266
August	0.600
September	0.431
October	0.441
November	0.189
December	0.2

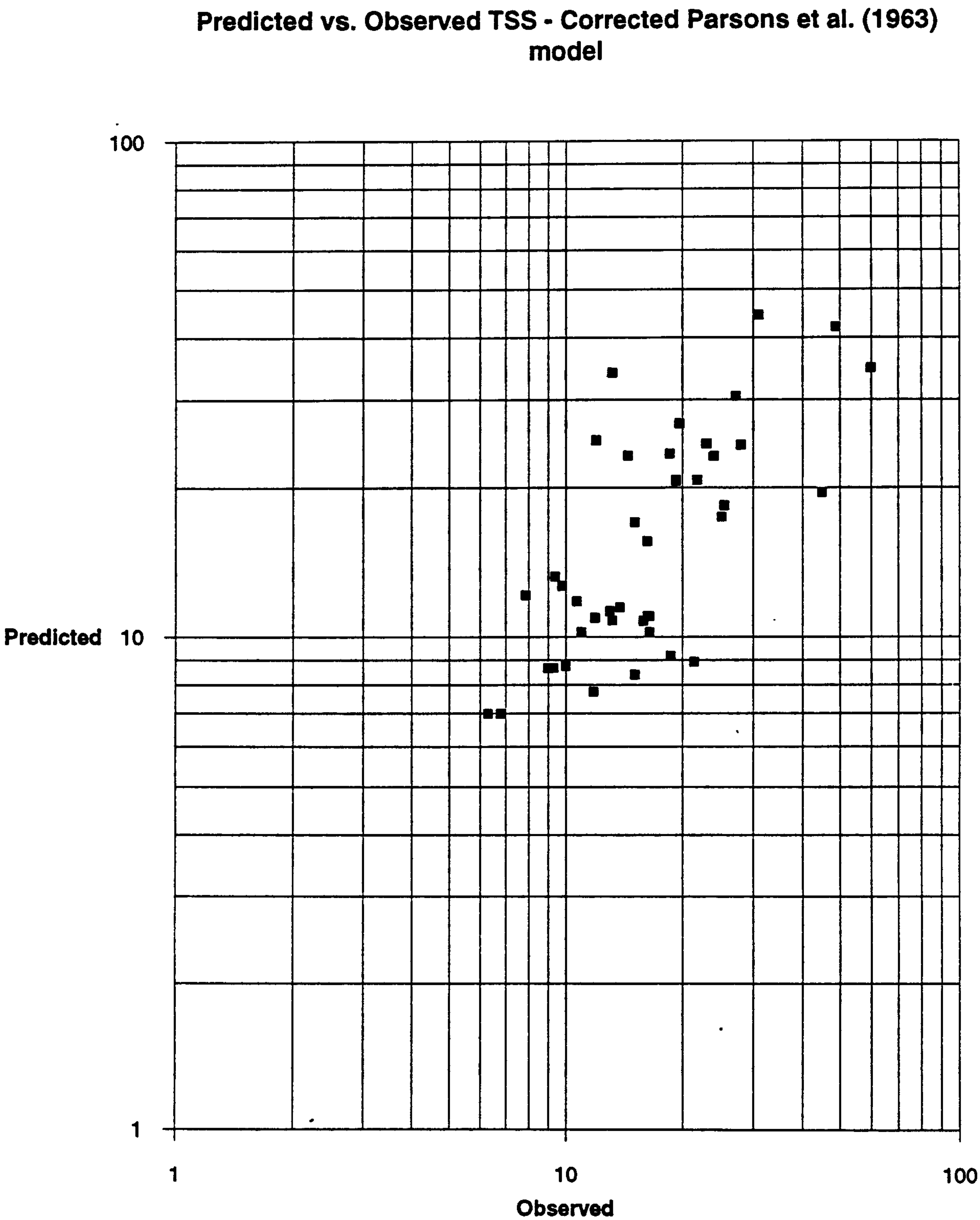


Figure 18. Relationship between observed and predicted TSS values.

Proposed procedure for estimating TSS. The TSS data described above were used to develop a relationship between TSS concentrations and discharge for the Buffalo River and its tributaries. For many of the TSS samples, actual discharge measurements at the time and location of sampling were available. This was true for all of the grab samples and also for some of the samples taken at Sites 104 and 105. In other cases, where discharge was not directly measured, discharge values from upstream USGS gages at the time closest to the sampling time were used to estimate the corresponding value at the sampling site.

First, total flow for Site 1 was estimated as

$$\text{(Site 1)} \qquad Q_{tot} = \left(\frac{149}{142}\right)Q_{bc} + \left(\frac{128}{96.4}\right)Q_{cay} + \left(\frac{138}{135}\right)Q_{caz} \qquad (10)$$

where Q_{bc}, Q_{cay} and Q_{caz} are the instantaneous measured discharges taken at the time closest to the sample time at the Buffalo Creek, Cayuga Creek and Cazenovia Creek gages, respectively, and the coefficients are ratios of total tributary drainage area at the confluence to the drainage area for each gage, as described in Section 3.1. When neither actual measured discharge nor time of sample were available, mean daily discharges for each of the gages on the sample day were used in (10) instead. For Sites 105 and 104 (Table 15), the following relations were used:

$$\text{(Site 105)} \qquad Q = \left(\frac{138}{135}\right)Q_{caz} \qquad (11)$$

$$\text{(Site 104)} \qquad Q = \left(\frac{149}{142}\right)Q_{bc} + \left(\frac{128}{96.4}\right)Q_{cay} \qquad (12)$$

Discharge estimates for Sites 120 and 119 were obtained in a similar fashion, using ratios of drainage areas,

$$\text{(Site 120)} \qquad Q = \left(\frac{136.5}{135}\right)Q_{caz} \qquad (13)$$

$$\text{(Site 119)} \qquad Q = \left(\frac{147.5}{142}\right)Q_{bc} + \left(\frac{128}{96.4}\right)Q_{cay} \qquad (14)$$

The appropriateness of using stream gage data in this manner to estimate instantaneous flows was investigated by calculating flows at times when measured flows were available. A comparison of measured discharge to calculated discharge showed that this procedure provides reasonable estimates. This procedure may not be reasonable, however, for locations further downstream where Lake Erie seiching affects the flows.

Correlation analyses. Once discharge estimates were obtained for each TSS sample, the data were examined in several ways. First, the data set from each station was analysed by assuming a power equation relationship of the form $TSS = aQ^b$, with TSS in mg/L and Q in cfs. The coefficients a and b were then determined using a best-fit linear equation to (log TSS) vs. (log Q). The regressions for data from all stations except 119 and 120 resulted in similar coefficient values with relatively high correlations (approximately 0.78 - 0.95). The data from stations 119 and 120 gave results quite different from each other as well as from the other stations. Upon examining the data, it was found that the values for these two stations were generally obtained during low flow periods while data from the other stations were for higher flows. It was concluded that data from each of the two main tributaries to the Buffalo River (i.e., Buffalo and Cazenovia Creeks) could be combined, by tributary, to obtain two relationships between TSS and Q; however, these relationships must account for differences between low and high flow periods.

The high flow data (all data except those from stations 119 and 120) were also lumped together by season and regression analyses were performed. The results showed no distinguishable seasonal trend in the relationship between TSS and Q.

Finally, all data were divided into two groups: Cazenovia Creek above the Buffalo River confluence and the Buffalo River and its tributaries above the confluence with Cazenovia Creek, including all low flow data from stations 119 and 120 (this latter grouping is hereafter referred to as "upstream Buffalo River"). These two sets of data are presented in Figures 19 and 20. The difference between the TSS vs. Q relationship in low and high flows is apparent from these plots. This phenomenon is believed to be associated with a stratified flow development occurring with low flows. It appears to be a reasonable approach to develop best-fit lines for each data set that distinguishes between low flow and high flow TSS concentrations.

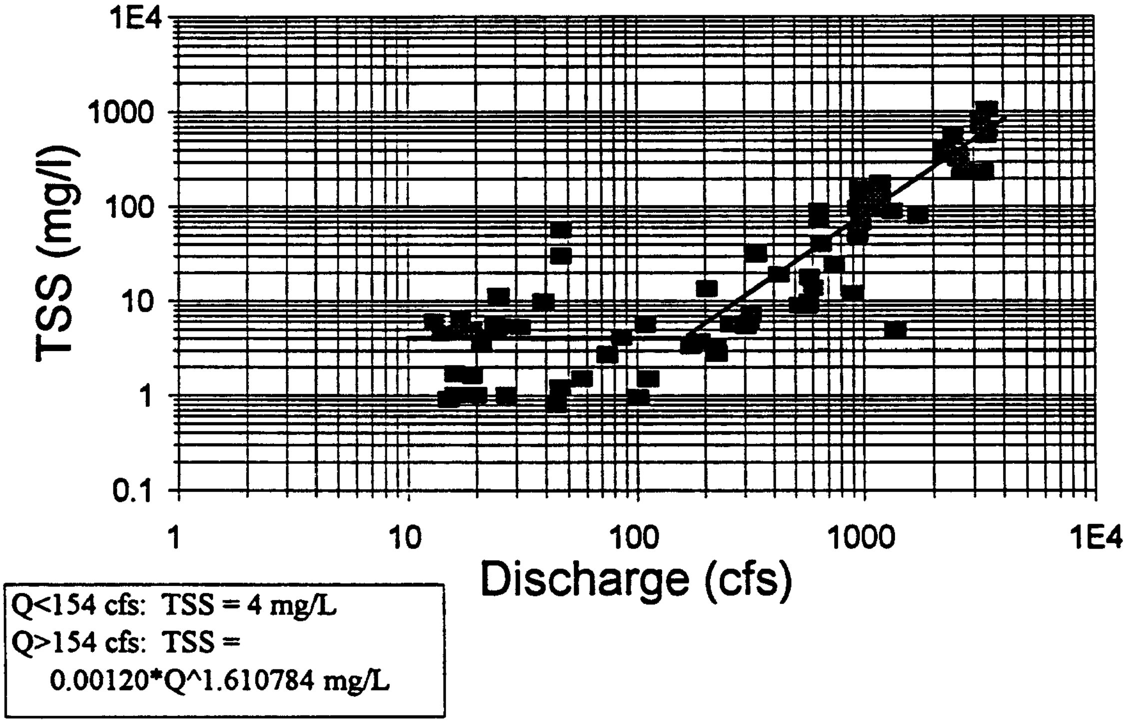


Figure 19. TSS vs. Q, for Cazenovia Creek

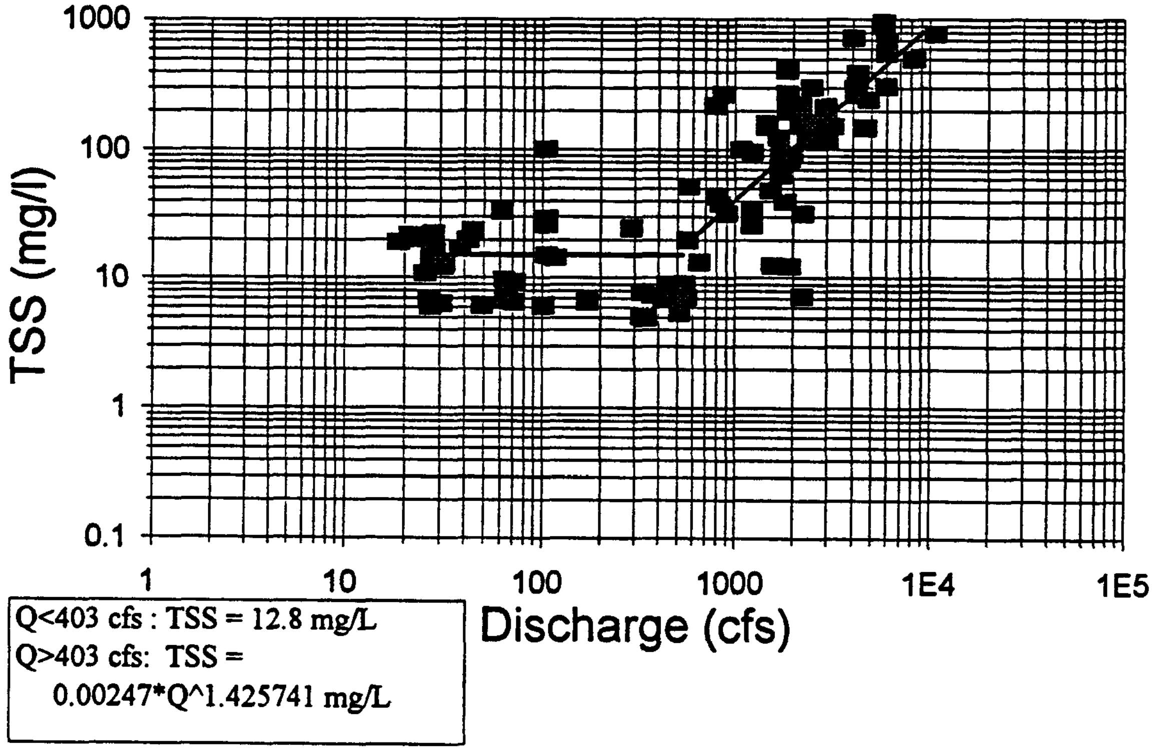


Figure 20. TSS vs. Q, for upstream Buffalo River

For each data set high flow data were regressed using all data above various selected low flow threshold values. The best-fit equation with the threshold value giving the highest correlation was then adopted for the high flows. The arithmetic average of (log TSS) was then computed for those values below the threshold value of Q. The point at which the high flow equation equals the low flow TSS value was then set as the threshold discharge between high and low flows (i.e., this represents the point of intersection for the two lines). For Cazenovia Creek a low flow threshold value of 165 cfs was determined, with a corresponding low flow TSS value of 4 mg/L, while for the Buffalo River tributaries the low flow threshold is 447 cfs, with a corresponding low flow TSS of 12.8 mg/L. The difference in low flow TSS values for these tributaries may explain in part the difference in power equation coefficients seen in the initial examination of individual station data from stations 119 and 120.

The resulting relationships for TSS as a function of flowrate are

(Cazenovia Creek) $TSS = 4.0(mg/L)$, $Q \leq 165$ cfs (15a)

$TSS = 0.00106Q^{1.61}(mg/L)$, $Q > 165$ cfs (15b)

where Q (cfs) is from (11), and

(Buffalo River tributaries) $TSS = 12.8(mg/L)$, $Q \leq 447$ cfs (16a)

$TSS = 0.00213Q^{1.43}(mg/L)$, $Q > 447$ cfs (16b)

where Q (cfs) is from (12). The correlation coefficients (r^2) for the above relations are as follows: (15b) 0.84, (16b) 0.64.

Statistical bias in regressions of log-transformed data. The regression model used to describe the relationship between TSS and discharge has the general form

$$\log TSS = B_o + B_1 \log Q + \varepsilon \quad (17)$$

where B_0 and B_1 are constants and ε is the error between the fitted line and the actual data. When this equation is back transformed to obtain power relations such as (15b) and (16b) the error term is omitted. Linear regression models involving non-transformed variables omit this term because the mean of the error terms is assumed to be zero. For transformed variables the mean of the error terms is zero in log units, but not in arithmetic units. Therefore, because the mean will not be zero after back transformation, the error term must be included in the resulting power relation,

$$TSS = 10^{(B_o+\varepsilon)} Q^{B_1} \quad (18)$$

where 10^{ε} is the bias correction term. If there is no error ($\varepsilon = 0$) then this term is equal to 1.

In order to estimate the appropriate bias correction for each relationship (eqns. 15b and 16b), the distributions of the regression residuals were examined (Newman, 1993). For each relationship, the regression residuals for the high flows were calculated and the frequency distributions were plotted, as shown in Figures 21 and 22. From these plots, it appears that the residuals are approximately normally distributed. The bias correction can then be estimated from (Havlicek and Crain, 1988; Newman, 1993)

$$\varepsilon = \frac{MSE}{2} \quad ,$$

$$MSE = \frac{\sum_{i=1}^{N} \varepsilon_i^2}{(N-2)} \quad (19)$$

where N is the number of observations. Resulting bias correction factors of 1.13 and 1.16 were obtained for Cazenovia Creek and the upstream Buffalo River tributaries, respectively.

Adopted relationships for TSS vs. discharge. The final relationships used to calculate TSS as a function of discharge are obtained by applying the bias correction factors to (15b) and (16b), resulting in

Cazenovia Creek) $\quad TSS = 0.00120 Q^{1.611} (mg/L)$, Q > 154 cfs (20)

(Buffalo River tributaries) $\quad TSS = 0.00247 Q^{1.426} (mg/L)$, Q > 403 cfs (21)

Note that the threshold values distinguishing between high and low-flow relations change slightly after applying the bias correction factors - the cut-off values in (20) and (21) also apply to (15a) and (16a).

Eqns. (15a), (16a), (20) and (21) thus form the basis for estimating TSS as a function of discharge in the two main tributaries which join to form the lower Buffalo River. These relations

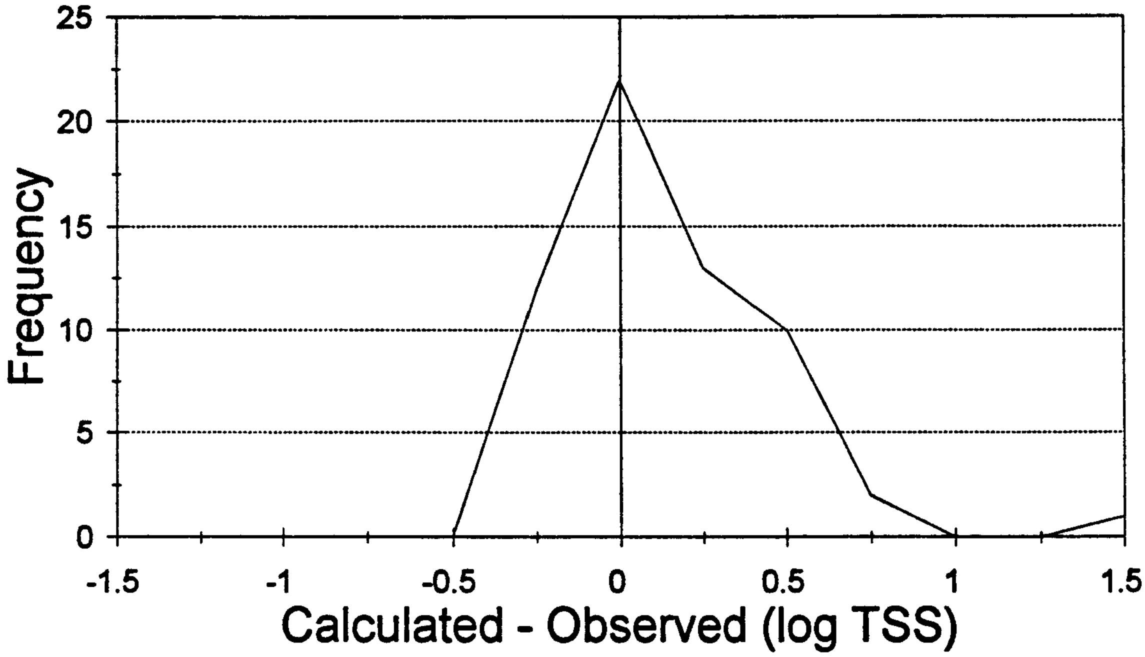


Figure 21. Frequency distribution of high flow regression residuals, Cazenovia Ck.

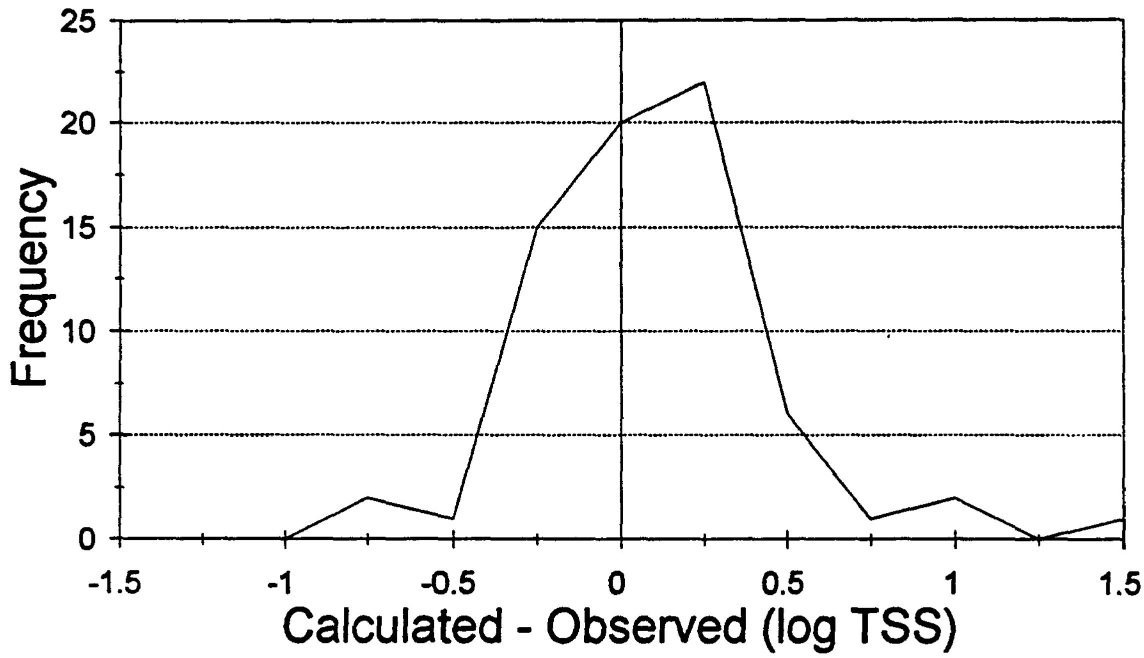


Figure 22. Frequency distribution of high flow regression residuals, upstream Buffalo River

are compared with data and plotted in Figures 23 and 24. The comparison appears to be reasonable and indicates that this approach is useful for estimating suspended sediment load to the AOC. Mass solids loading to the Buffalo River are obtained by adding computed mass loadings for each tributary. Time series of calculated upstream TSS loadings to the AOC are plotted for the three periods for which observed TSS data are available - Fall 1990, April 1991 and Spring 1992 - in Figures 25, 26 and 27, respectively. These plots also show a reasonably good fit for the TSS prediction equations. These relationships, along with water column data, can then be used to estimate contaminant mass loadings to the AOC from the upstream tributaries, as discussed in the following section.

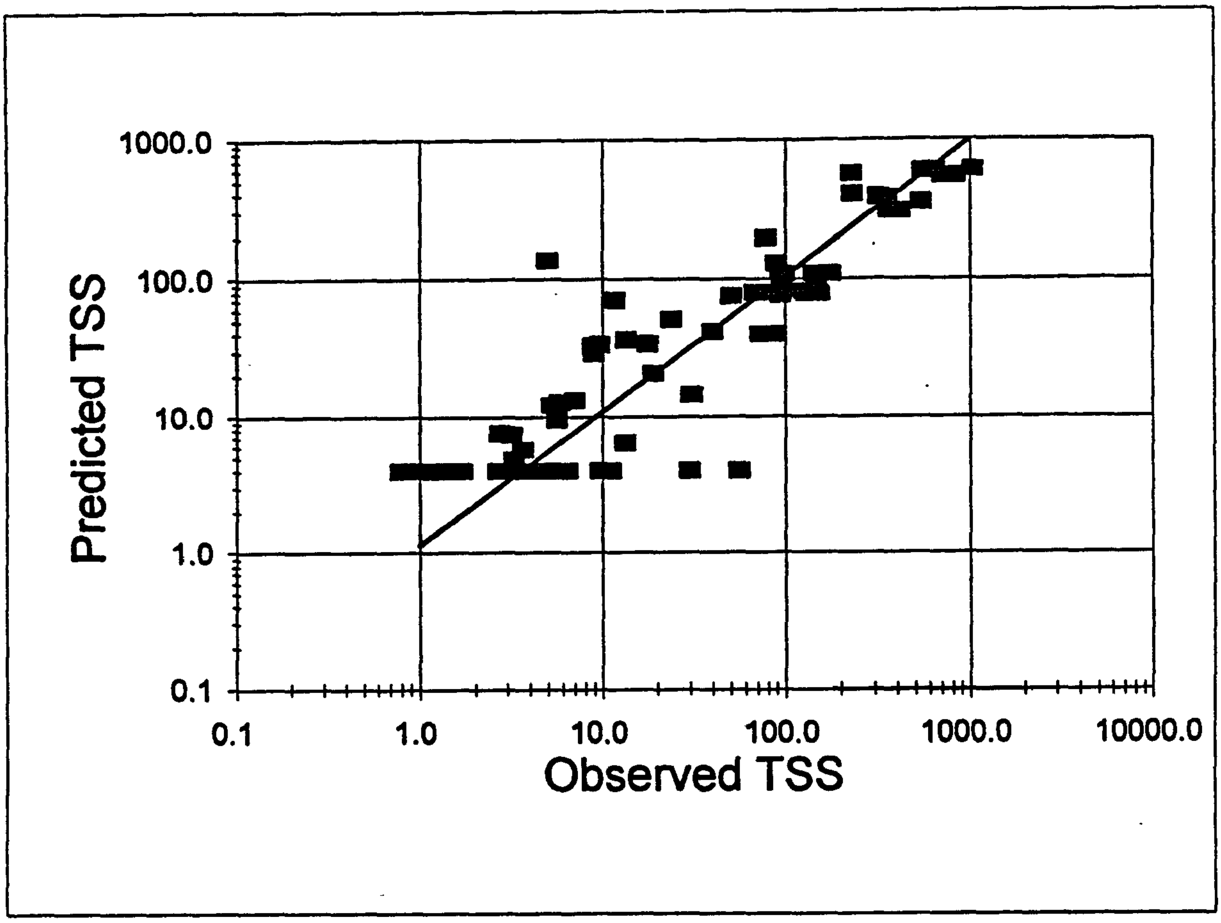


Figure 23. Comparison of predicted and measured TSS, Cazenovia Creek

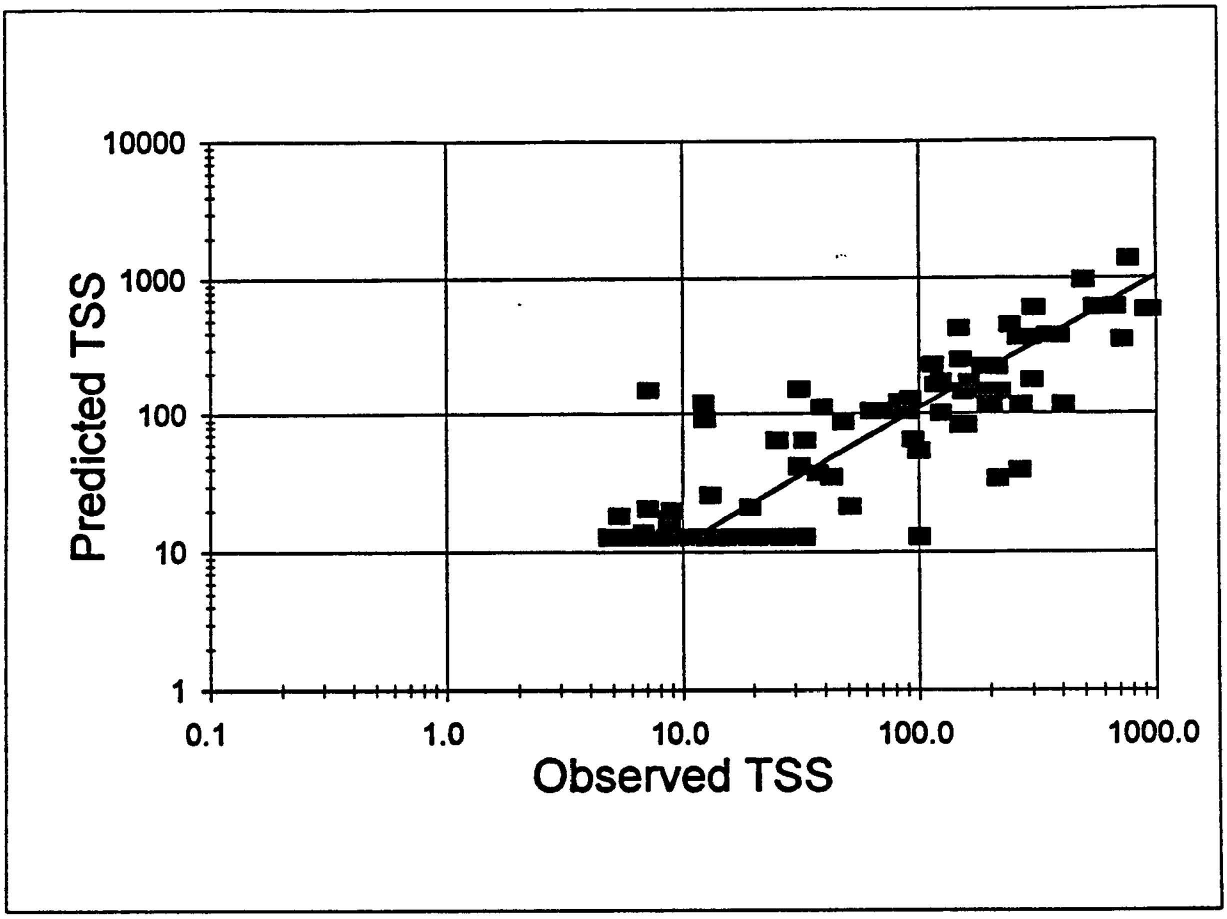


Figure 24. Comparison of predicted and measured TSS, upstream Buffalo River

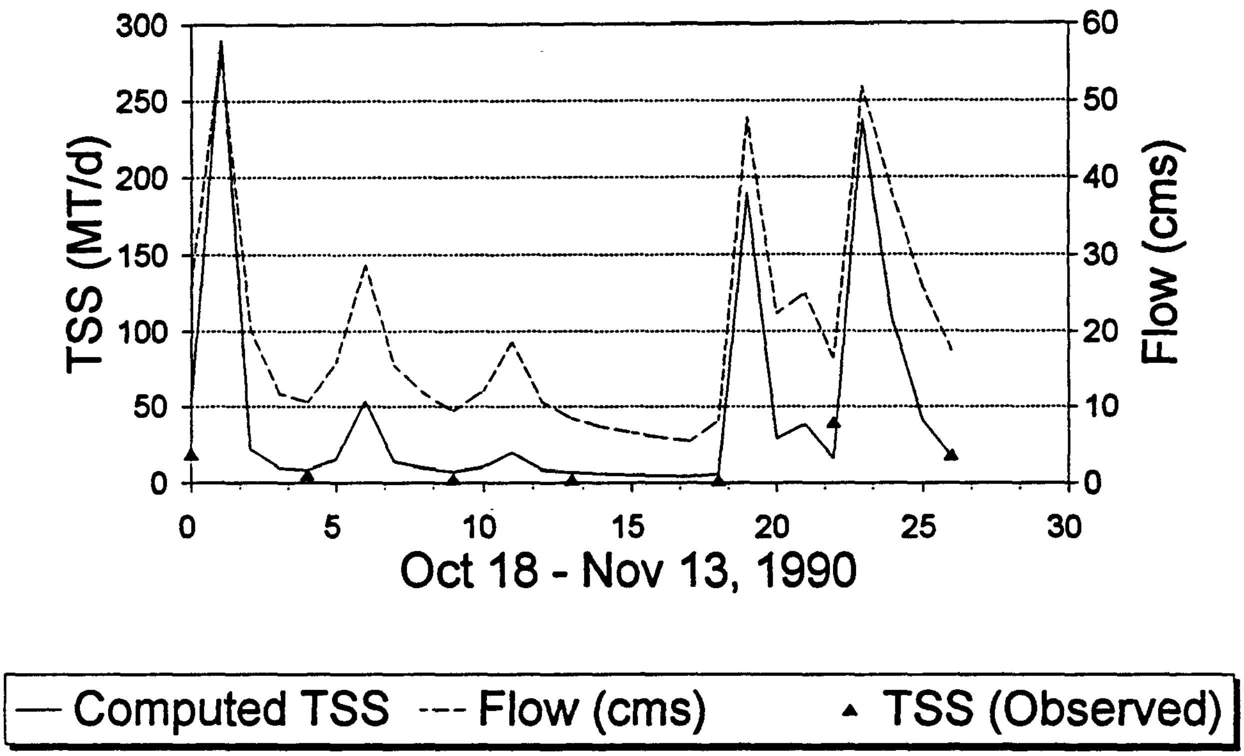


Figure 25. Upstream TSS loading, fall 1990

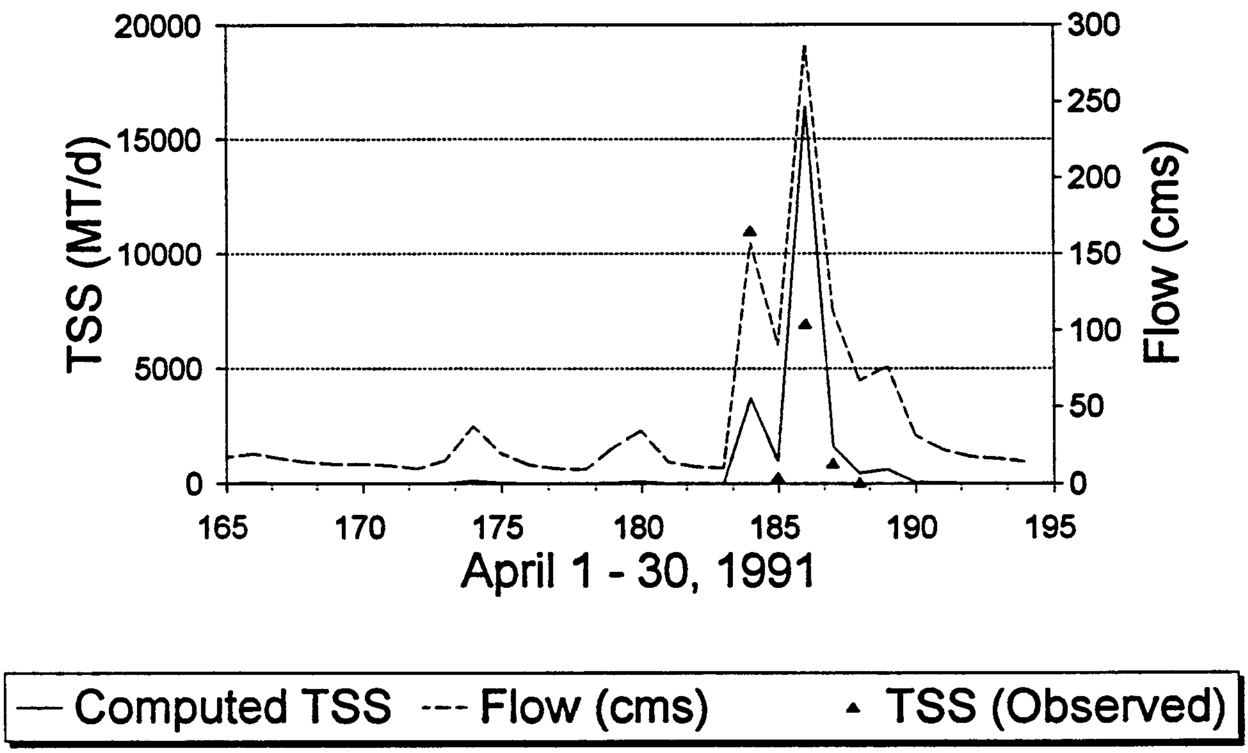


Figure 26. Upstream TSS loading, April 1991

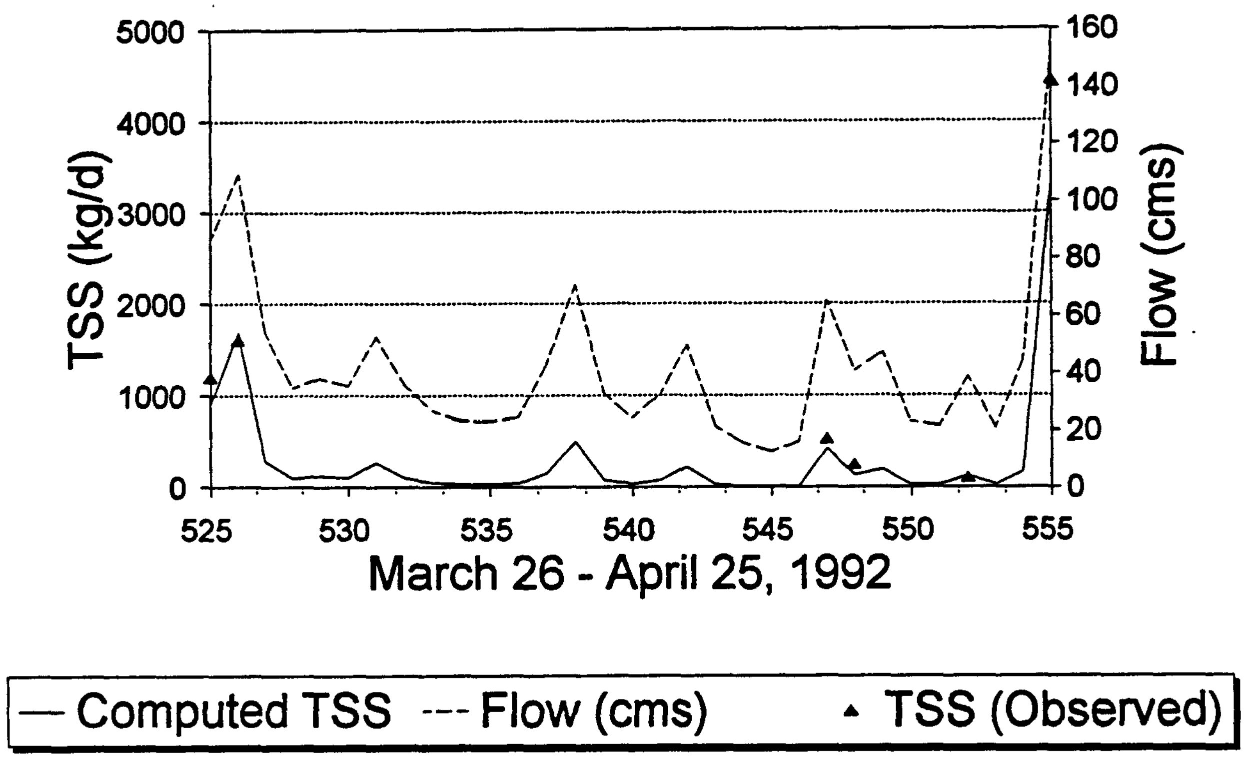


Figure 27. Upstream TSS loading, spring 1992

4.1.2. Contaminants

Coupled suspended sediment and water column data were available from four different sources, as summarized in Table 19.

Table 19. Availability of coupled sediment and water column data for contaminants.

Data set	Locations	Contaminants*	Period of record
ARCS	Sites 1 - 6, AOC	PCBs, PAHs, pesticides	Fall 1990, spring 1992
NYSDEC**	Various sites in AOC and upstream	PCBs, PAHs, metals	Fall 1990, spring 1992
ACOE***	Two sites in AOC	PCBs, PAHs, metals	Summer 1992
EPA STORET	Various sites in AOC and upstream	Metals	11/71 - 10/91

* Particulate and dissolved water column concentration data were available for all contaminants except metals, for which only total water column concentrations were available.
** Litten and Anderson (1992)
*** Data from 1992 dredging demonstration, obtained from Waterways Experiment Station (D. Averett, personal communication, 1993)

Measurements from Site 1 (ARCS data, upstream boundary of AOC) are shown in Table 20 for all contaminants except metals. The ARCS metals data showed unreasonably high concentrations, in comparison to all other available metals data, and were not used. Metals loadings were calculated from data obtained by the NYSDEC, as discussed below. For those dates on which the necessary data are available, sorbed pollutant concentrations can be estimated on the basis of the tabulated values and measured sediment discharge rates. The pollutant (particulate phase) load to the AOC during the period of study is then computed as the product of the pollutant concentration and the sediment discharge rate. These calculations are shown in Table 21. However, a more general approach was desired to develop relationships between sorbed pollutant concentrations and suspended sediment discharges (or concentrations) for the available pollutants of interest at the upstream limit of the AOC. Particulate and dissolved water column data for non-metals and total water column data for metals were examined in order to develop relationships for total pollutant loadings to the AOC, as described below.

Table 20. Upstream non-metal particulate concentrations.

(all data from ARCS, site 1)

date	TSS (mg/l)	flow (cfs)	conc. (mg/kg) PCB	Chlordane	Dieldrin	DDT	B(a)a	B(b)f	B(k)f	B(a)p	Chrysene
10/18/90	8	1029	0.633	1.53e-3	1.51e-3	1.51e-3	0	0	0	0	0
10/22/90	6	418	0.365	9.88e-3	6.65e-2	6.65e-2	1.65	2.75	0.933	2.36	3.16
10/27/90	3	376	0.081	0	1.49e-2	1.49e-2	0.652	1.08	0.253	0.661	0.946
10/31/90	3	336	0.183	4.83e-3	0	0	0.672	1.07	0.377	0.666	1.06
11/5/90	3	322	0.274	2.04e-2	1.81e-2	1.81e-2	2.19	4.02	1.47	2.62	3.38
11/5/90	2	322	1.645	3.13e-2	1.30e-4	1.30e-4	2.39	4.62	1.73	3.41	4.54
11/9/90	28	648	0.039	1.03e-3	1.35e-3	1.35e-3	0.096	0.188	0.059	0.115	0.156
11/13/90	12	684	0	1.19e-3	0	0	0.459	0.709	0.262	0.356	0.699
4/17/92	154	2592	0.013	8.40e-4	3.38e-4	6.40e-4	0.357	0.493	0.217	0.314	0.422
4/17/92	52	2592	0.024	3.83e-3	6.92e-4	1.08e-3	0.82	1.14	0.484	0.694	0.914
4/18/92	74	1678	0	6.92e-4	0	1.90e-4	0.115	0.205	0.078	0.119	0.27
4/22/92	34	1609	0.0191	2.29e-3	6.72e-4	1.34e-2	0.41	1.10	0.472	0.625	0.901

Table 21. Measured non-metal particulate pollutant loading rates.

date	loading rates (kg/day) solids	PCB	Chlordane	Dieldrin	DDT	B(a)a	B(b)f	B(k)f	B(a)p	Chrysene
10/18/90	2.00e4	1.27e-2	3.06e-5	3.06e-5	3.06e-5	0	0	0	0	0
10/22/90	6.09e3	2.22e-3	6.02e-5	4.05e-4	4.05e-4	1.00e-2	1.68e-2	5.68e-3	1.44e-2	1.92e-2
10/27/90	2.74e3	2.22e-4	0	4.09e-5	4.09e-5	1.79e-3	2.95e-3	6.93e-4	1.81e-2	2.59e-3
10/31/90	2.45e3	4.48e-4	1.18e-5	0	0	1.65e-3	2.61e-3	9.24e-4	1.63e-3	2.60e-3
11/5/90	2.35e3	6.45e-4	4.79e-5	4.24e-5	4.24e-5	5.14e-3	9.45e-3	3.46e-3	6.15e-3	7.93e-3
11/5/90	1.56e3	2.57e-3	4.88e-5	1.97e-7	1.97e-7	3.73e-3	7.21e-3	2.70e-3	5.32e-3	7.08e-3
11/9/90	4.41e4	1.74e-3	4.53e-5	5.93e-5	5.93e-5	4.23e-3	8.29e-3	2.60e-3	5.07e-3	6.88e-3
11/13/90	2.00e4	0	2.38e-5	0	0	9.16e-3	1.41e-2	5.23e-3	7.10e-3	1.39e-2
4/17/92	9.70e5	1.26e-2	8.11e-4	3.28e-4	6.20e-4	3.46e-1	4.78e-1	2.10e-1	3.05e-1	4.09e-1
4/17/92	3.28e4	7.83e-4	1.26e-4	2.27e-5	3.55e-5	2.69e-2	3.73e-2	1.59e-2	2.27e-2	2.99e-2
4/18/92	3.02e5	0	2.09e-4	0	5.76e-5	3.47e-2	6.19e-2	2.35e-2	3.59e-2	8.15e-2
4/22/92	1.33e5	2.63e-3	3.04e-4	8.93e-5	1.78e-3	5.45e-2	1.46e-1	6.27e-2	8.31e-2	1.20e-1

Particulate pollutant concentrations (non-metals). Correlation analyses were performed on the non-metal particulate pollutant data in mg (dry weight pollutant)/kg (dry weight TSS) versus TSS in mg (dry weight)/L. This was done for all non-metal pollutants of interest with water column data available from ARCS Site 1 only, and then for all data from Sites 1 - 6 together. In all cases, except for Dieldrin and DDT, the correlation coefficients were slightly higher for Site 1 data alone (N = 8-12, r = 0.60 - 0.90) than for the combined Site 1 - 6 data (N = 33 - 56, r = 0.55 - 0.88). However, due to the greater number of samples for the Site 1 - 6 data, all correlation coefficients for all pollutants have a higher level of significance (0.01 in all cases). Coupled suspended sediment and particulate water column concentrations for PCBs and PAHs were also available from the ACOE Dredging Demonstration Project. Therefore, the additional data (9 - 10 samples for each) were added to the ARCS (sites 1 - 6) data sets for PCBs and PAHs and regressions were performed. The regressions which included the dredging demo data resulted in higher correlation coefficients for all data sets except benzo(a) anthracene, which was slightly lower. However, all regressions using the dredging demo data provided correlations with a 0.01 level of significance. Data from NYSDEC (Litten and Anderson, 1992) for PCBs and PAHs were not used in these regressions because only one data sample was available for PCBs and the PAH data were reported only for total PAHs.

Prediction equations for particulate PCBs and all PAH pollutants were obtained from the combined ARCS Sites 1 - 6 and dredging demo data analyses. For pesticides, the prediction equations were obtained from the ARCS data set alone. Bias correction factors for the log-transformed data were then computed for all prediction equations assuming normally distributed residuals as described in Section 4.1.1. A sample plot showing the basic relationship is provided in Figure 28. The final adopted relationships for particulate pollutants versus TSS are as follows:

$$PCB_{particulate}\left(\frac{mg}{kg}\right) = 1.37\left(TSS_{total}^{-0.893}\right) \quad (22)$$

$$B[a]a_{particulate}\left(\frac{mg}{kg}\right) = 1.36\left(TSS_{total}^{-0.321}\right) \quad (23)$$

$$Chrysene_{particulate}\left(\frac{mg}{kg}\right) = 2.60\left(TSS_{total}^{-0.412}\right) \quad (24)$$

$$B[b]f_{particulate}\left(\frac{mg}{kg}\right) = 2.54\left(TSS_{total}^{-0.422}\right) \quad (25)$$

$$B[k]f_{particulate}\left(\frac{mg}{kg}\right) = 0.868\left(TSS_{total}^{-0.389}\right) \quad (26)$$

$$B[a]p_{particulate}\left(\frac{mg}{kg}\right) = 1.51\left(TSS_{total}^{-0.407}\right) \quad (27)$$

$$G\text{-}Chl_{particulate}\left(\frac{mg}{kg}\right) = 0.00635\left(TSS_{total}^{-0.617}\right) \quad (28)$$

$$A\text{-}Chl_{particulate}\left(\frac{mg}{kg}\right) = 0.0144\left(TSS_{total}^{-0.749}\right) \quad (29)$$

$$Dieldrin_{particulate}\left(\frac{mg}{kg}\right) = 0.0926\left(TSS_{total}^{-1.21}\right) \quad (30)$$

$$DDT_{particulate}\left(\frac{mg}{kg}\right) = 0.0848\left(TSS_{total}^{-1.14}\right) \quad (31)$$

where TSS_{total} (mg/l) is a flow weighted average of total upstream TSS concentration. The inverse relation with TSS shown in these regresssions is consistent with the observation that higher TSS demonstrates higher median particle size and larger particles carry lower mass-specific contaminant levels.

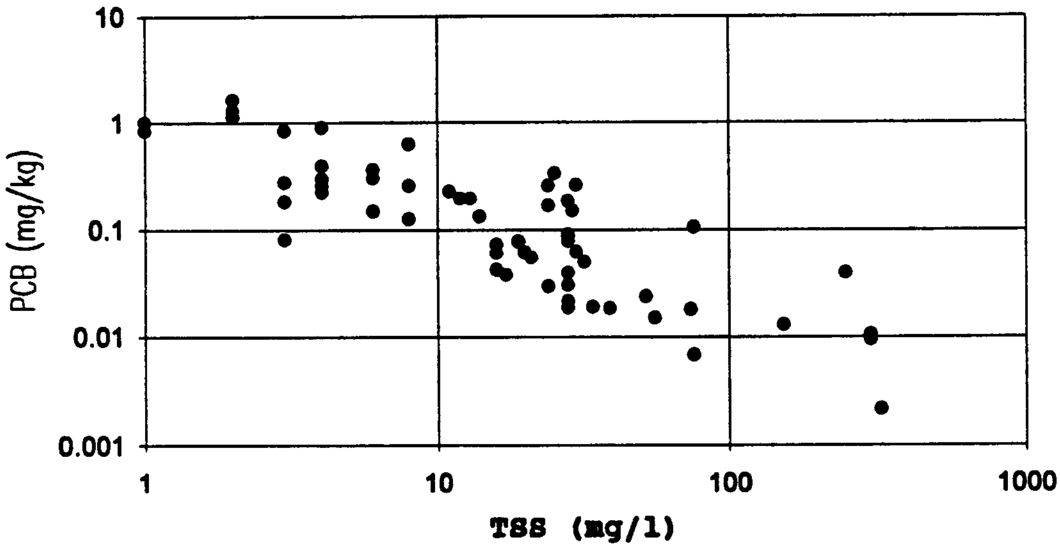


Figure 28. Sample plot of relationship between particulate concentration and TSS

Dissolved non-metal pollutant concentrations. The dissolved non-metal pollutant water column data for the ARCS data set (Sites 1-6) were examined in a similar manner as the particulate data. For these data, however, it was found that multiple linear regressions of dissolved pollutant versus Q (ft^3/s) and TSS (mg/L) generally provided better fits. For all non-metal pollutants, dissolved data from Site 1 alone resulted in higher correlations than the data from Sites 1 - 6 together. No significant relationships between dissolved pollutant concentration and Q and TSS were observed for the Site 1 - 6 data together. For the Site 1 data, all of the relationships derived were significant to at least the 0.1 level of significance (N = 7 - 12, r = 0.54 - 0.95), except those for PCBs, chlordane, dieldrin, and DDT. No significant relationship was observed between these four dissolved pollutants and Q and TSS. As with the particulate pollutants, dissolved water column data were available for PCBs and PAHs from the Dredging Demonstration project. NYSDEC data were not used for the same reason as stated earlier for particulates. There were fewer dissolved data samples for each pollutant (1 - 6 samples), and these were added to the Site 1 data for PCBs and PAHs to perform the multiple linear regressions. As with the Site 1 data alone, no significant relationships were observed for PCB as a function of Q and TSS. For the PAHs, the correlation coefficients for all constituents were lower with the addition of the dredging demo data, with levels of significance < 0.10. Therefore, prediction equations for dissolved PAHs were obtained from the ARCS data (Site 1) and arithmetic averages of all observed data for PCBs and pesticides are suggested for use in loading estimates. Again, bias correction factors for the log transformed data were calculated for each prediction equation as described in Section 4.1.1. The final adopted relationships for dissolved non-metal pollutant concentrations are:

$$PCB_{dissolved}\left(\frac{ng}{L}\right) = 0.670 \tag{32}$$

$$B[a]a_{dissolved}\left(\frac{ng}{L}\right) = 0.00036\left(Q_{total}^{1.56}\right)\left(TSS_{total}^{-0.406}\right) \quad (33)$$

$$Chrysene_{dissolved}\left(\frac{ng}{L}\right) = 0.0354\left(Q_{total}^{0.633}\right)\left(TSS_{total}^{0.0508}\right) \quad (34)$$

$$B[b]f_{diissolved}\left(\frac{ng}{L}\right) = 0.00419\left(Q_{total}^{0.981}\right)\left(TSS_{total}^{-0.19}\right) \quad (35)$$

$$B[k]f_{dissolved}\left(\frac{ng}{L}\right) = 0.00108\left(Q_{total}^{0.913}\right)\left(TSS_{total}^{-0.0993}\right) \quad (36)$$

$$B[a]p_{dissolved}\left(\frac{ng}{L}\right) = 0.00065\left(Q_{total}^{1.04}\right)\left(TSS_{total}^{-0.0993}\right) \quad (37)$$

$$G\text{-}Chl_{dissolved}\left(\frac{ng}{L}\right) = 0.0167 \quad (38)$$

$$A\text{-}Chl_{dissolevd}\left(\frac{ng}{L}\right) = 0.0254 \quad (39)$$

$$Dieldrin_{dissolved}\left(\frac{ng}{L}\right) = 0.0628 \quad (40)$$

$$DDT_{dissolved}\left(\frac{ng}{L}\right) = 0.0111 \quad (41)$$

where Q_{total} is the total adjusted tributary flow (eqn. 10) in cfs and TSS_{total} is the flow weighted average upstream TSS in mg/L.

Total non-metal pollutant concentrations. Total non-metal pollutant loading concentrations are obtained by adding the particulate and dissolved estimates using the appropriate unit conversion factors. Uncertainty in these estimates arises from sampling and measurement errors associated with the determination of the sorbed pollutant concentration and the suspended sediment concentration and the transfer of the relationship from the sampling site to other sites of interest. There are also inherent uncertainties involved in applying statistical regression equations when estimating concentrations. However, the above equations provide reasonable estimates, based on the limited data available.

Metals. Total metal concentration data (lead and copper) were available for several locations within the Buffalo River AOC and in the upstream tributaries with corresponding TSS concentration and stream discharge data as summarized in Table 22. Table 23 lists measured metals concentrations and loading rates, based on the NYSDEC data set noted in Table 22 (specifically, BR Bailey and flow weighted sums from BR S/U2 and CAZ S/U1).

Table 22. Summary of coupled suspended sediment and water column data for metals.

(data for lead and copper)

Data Set	Station	Location	No. Samples	Period of Record
NYSDEC*	Ohio St.	Buffalo River at Ohio Street	8 / 8	12/30/91, 3/26/92-4/25/92
	BR Bailey	Composite, Buffalo R. and Caz Creek at Bailey Avenue Bridges	1 / 1	12/30/91
	BR S/U2	Buffalo R. at S. Ogden Street	4 / 4	3/26/92-4/25/92
	BR R/S2	Buffalo R. at N. Blossom Rd.	4 / 4	3/26/92-4/25/92
	CAZ S/U1	Caz Creek at Caz Pkwy	4 / 4	3/26/92-4/25/92
	CAZ R/S1	Caz Creek at Northrup Rd.	4 / 4	3/26/92-4/25/92
	CAY R/S3	Cayuga Creek at Lake Ave.	4 / 4	3/26/92-4/25/92
ACOE**	-	Mobil Oil	14 / 14	Summer 1992
	-	Dead Man's Cove	7 / 7	Summer 1992
EPA-STORET	01031002	Buffalo River at Ohio Street	16 / 23	4/87-10/91
	01032213	Cay. Cr. at Bowen Rd. (Lanc.)	0 / 4	5/88-11/88
	01032311	Buffalo Cr. at Rt. 277 (Gard.)	0 / 4	5/88-11/88
	01032221	Cay. Cr. at Three Rod Rd (Alden)	1 /1	4/87-12/87

* Litten and Anderson (1992)

** 1992 Dredging demo data (D. Averett, personal communication, 1993)

Table 23. Upstream metals concentrations and loading rates.

Date	TSS (mg/l)	Flow (cfs)	Concentrations (mg/l)		Loading (kg/day)	
			lead	copper	lead	copper
12/30/91	118.6	2393	0.0063	0.0144	36.9	84.3
3/26/92	160.0	3465	0.0075	0.0091	63.6	77.2
4/1/92	40.0	2124	0.0018	0.0042	9.4	21.8
4/17/92	100.1	2992	0.0045	0.0051	32.9	37.3
4/25/92	271.1	7495	0.0087	0.0116	160	213

For non-metal pollutants, a generalized approach for estimating metals loadings to the AOC was desired; therefore, correlation analyses were performed on total lead and total copper concentrations (mg/l) versus TSS (mg/l). Regressions were first performed for the data from each site individually. Several of the individual stations provided significant relationships for metals vs. TSS, especially the upstream stations for data from NYSDEC (Litten and Anderson, 1992). Some stations provided no significant relationship at all. Regressions were then performed by grouping the station data in various ways such as all data upstream of the AOC, all data within the AOC, all data, Buffalo River tributaries upstream of Cazenovia Creek, Cazenovia Creek upstream Buffalo River, etc. Once again, several of these groupings provided significant relationships. The final relationships chosen for total lead and total copper were the ones which provided the highest level of significance with the greatest number of data points within the group. They were: lead - all upstream NYSDEC data plus the Dredging Demo-Mobil Oil data ($n=35$, $r=0.85$); and copper - all upstream NYSDEC data plus all EPA-STORET data for Cayuga Creek ($n=26$, $r=0.76$). Both relationships have a significance level of 0.01.

Total lead and copper loadings to the Buffalo River AOC from upstream tributaries can therefore be estimated using the following relationships, which include log-transform bias correction factors as discussed in Section 4.1.1:

$$Lead_{Total}\left(\frac{mg}{L}\right) = 2.66x10^{-4}\, TSS_{Tot}^{0.586} \qquad (42)$$

$$Copper_{Total}\left(\frac{mg}{L}\right) = 1.21x10^{-3} TSS_{Tot}^{0.367} \qquad (43)$$

where TSS_{tot} is in (mg/L).

4.2. Point sources

4.2.1. Industrial discharges

Industrial discharges to the Buffalo River are regulated by the NYSDEC. Currently there are 13 industrial wastewater discharges in the Buffalo River watershed and AOC. Two of the thirteen industries discharging to the AOC were identified in the Buffalo River Remedial Action Plan (NYSDEC, 1987) as supplying more than 0.1 lb/day (0.05 kg/day) of priority pollutants, while six others were noted as potential sources, though loadings in excess of 0.1 lb/day (0.05 kg/day) were not anticipated. The two industries are Buffalo Color Corporation and PVS Chemical. The RAP provided two years of loading data (1985-86 and 1986-87) for various pollutants from these facilities. In addition, EPA Permit Compliance System (PCS) discharge and loading data for these facilities were available from the NYSDEC for the period of June 1988 through July 1991. These data are summarized in Table 24.

Table 24. Summary of industrial discharges.

Facility	Parameter	Loading rates (kg/day) (1) (85-86)	(1) (86-87)	(2) (88-89)	(2) (89-90)	(2) (90-91)
Buffalo Color:	Chloroform	0.0	1.4	—	—	—
	Cyanide	0.23	0.0	—	—	—
	Lead*	0.0	0.23	< 0.18	< 0.18	< 0.14
	Nickel	0.18	0.0	< 0.59	< 0.59	< 0.59
	Zinc	0.36	0.77	—	—	—
	Aluminum	—	—	< 14.5	< 5.2	< 3.0
	Chromium	—	—	< 0.41	< 0.41	< 0.50
	Copper*	—	—	< 0.41	< 0.55	< 0.68
	Nitrobenzene	—	—	< 0.41	< 0.41	< 0.36
	Parachlorometa	—	—	< 0.41	< 0.41	< 0.36
	1,3 dichlorobenzene	—	—	< 0.41	< 0.41	< 0.36
	TOC*	—	—	77.3	85.9	67.3
	Total ammonia, -ium	—	—	1.8	3.0	4.5
	Total res. chlorine	—	—	—	—	8.8
PVS Chemical:	N-nitrosodiphenylamine	0.0	1.4	—	—	—
	Methylene chloride	0.0	0.08	—	—	—
	Chromium	0.68	0.0	—	—	—
	Copper*	0.41	0.0	—	—	0.36
	Zinc	2.5	0.0	—	—	—
	Phenols (4AAP)	0.0	0.64	—	—	—
	Cadmium	—	—	—	—	0.09
	Iron*	—	—	10.7	9.3	4.6
	Total Rec Phenolics	—	—	0.23	0.16	0.10
	TSS*	—	—	252	244	72.6
	Total res. Chlorine	—	—	—	—	5.2
	5-day BOD	—	—	< 152	< 47.0	< 39.4
	COD	—	—	< 440	< 305	< 98.2
	Oil and grease	—	—	< 51.6	< 43.2	< 20.2

* priority parameter of interest
(1) sampling data from NYSDEC, Remedial Action Plan; 24-hour annual composite (converted from lb/day)
(2) Permit Compliance System database, SPDES discharges, NYSDEC; "<" indicates that the reported value was computed using detection limits from the PCS database

4.2.2. Combined sewer overflows (CSOs)

As previously noted, there are a number of CSO outfall locations within the AOC. These are shown on the map of Figure 29. In an earlier study, Calocerinos & Spina Engineers (C&S, 1988), under contract to the Buffalo Sewer Authority (BSA), developed a hydraulic model of the combined sewer system of Buffalo. Phase I of that study began in 1977 and was completed in September, 1983. Various physical aspects of the sewer system were assessed, including the structural condition of pipes 36 inches or greater, the operation and physical condition of the two major outlying pump stations, the level of protection provided by CSOs against intrusion of extraneous flow into the system from receiving waterways, and the amount of deposition in various sewers throughout the system. Phase II of that study involved the actual model development.

In addition to the hydraulic model, the Phase II study included grab samples of discharges from several CSOs. Analyses were performed for conventional pollutants, heavy metals and some organics. Table 25 lists dates and locations of sampling points (at CSO discharge locations) and Table 26 lists the metals data from the C&S report. Table 27 lists concentrations for the PAHs and pesticides of interest obtained as part of the ARCS study.

Table 28 shows PCB concentrations. Due to the scarcity of these data, additional values were obtained from literature sources for comparison (Marsalek and Ng, 1989; Granier, et al., 1990) and are shown in Table 29. Values were also sought to supplement the data set for the other organics. These data are correlated with land use and may be used for the Buffalo River AOC as long as land use characteristics are known. The data in Tables 30 and 31 were taken from Jordan (1984) and list land use descriptions and associated concentrations for a number of the constituents of interest in the present study.

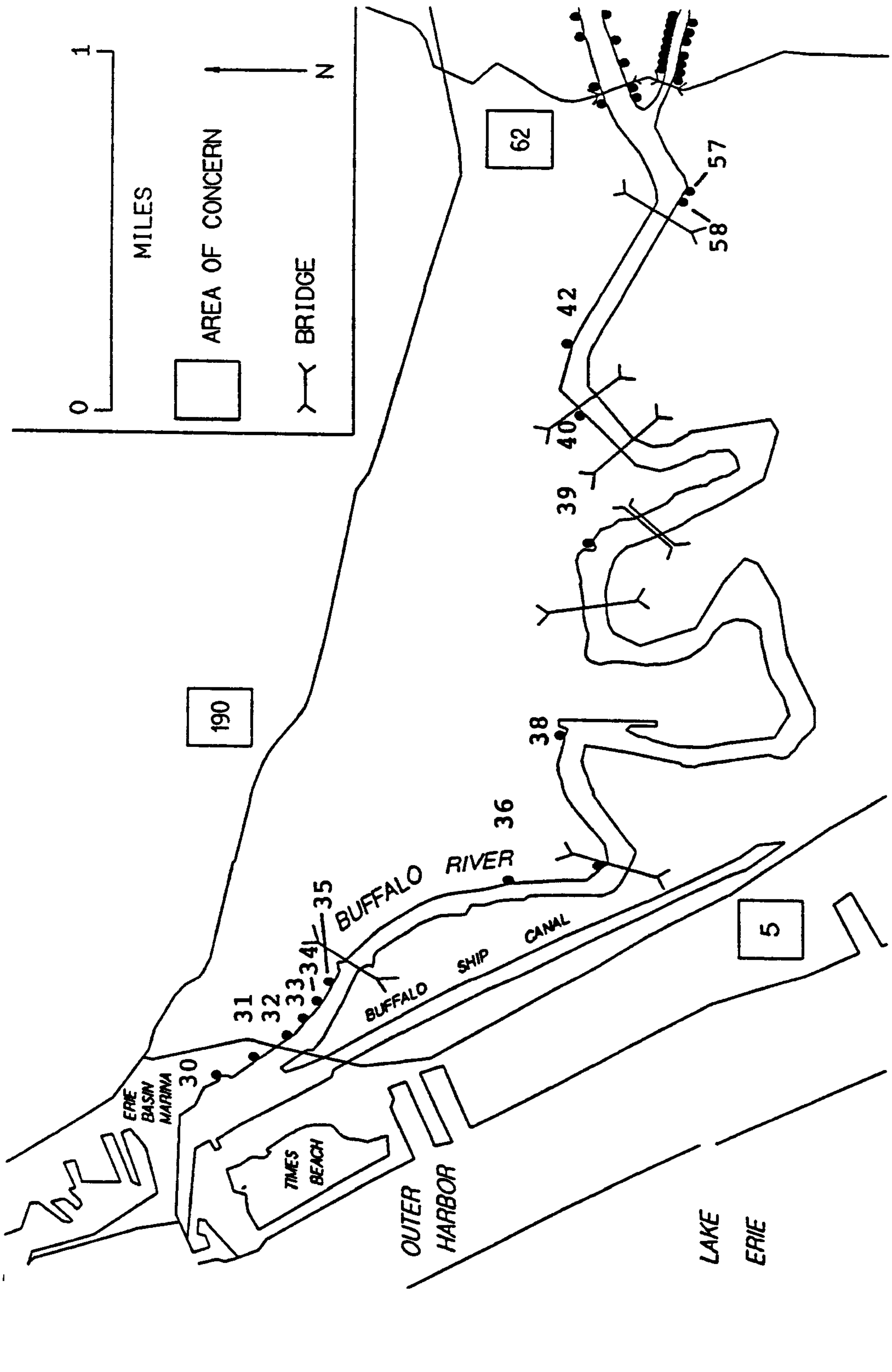


Figure 29. CSO outfall locations along Buffalo River AOC.

Table 25. CSO sampling dates and locations (from C&S, 1988).

Date	Location
5/16/88	Foot of Albany
5/19/88	BSA-Texas and Kerns
5/19/88	BSA-Old Bailey and Littell
5/16/88	Blank
5/16/88	Swan and Oak
5/16/88	BSA-Eagel and Emslie
5/16/88	Colorado and Scajaguada
5/16/88	BSA-Hamburg and Perry
5/16/88	Foot of Albany
5/16/88	Blank
4/30/88	BSA-Hamburg and Perry
4/30/88	Swan and Oak
4/29/88	Foot of Albany
4/29/88	Foot of Albany
4/30/88	Lafayette and Howard
4/30/88	Bailey and Scaj.
4/30/88	BSA-Old Bailey and Littell
4/30/88	BSA-Eagle and Emslie
4/30/88	Colorado and Scajaquada
4/30/88	BSA-South Buffalo Pump
4/30/88	BSA-South Legion
4/29/88	Mobil Oil
4/30/88	Cornelius Creek
4/30/88	BSA-Meterins Station
4/30/88	BSA-Texas and Kerns

Table 26. Metals data for CSOs (from C&S, 1988).

Calocerinos & Spina Metals Data			
Copper	Lead	Date	Site
0.26	ND	5/16/88	BSA - Cornelius Creek
0.10	ND	5/16/88	Baily & Scajaquada
0.13	ND	5/16/88	BSA - Eagel & Emslie
0.27	0.44	5/16/88	BSA - Hamburg & Perry
0.10	ND	4/30/88	BSA - Hamburg & Perry
0.08	ND	4/29/88	Foot of Albany
0.07	ND	4/29/88	Foot of Albany

* all concentrations in mg/l; ND - not detected

Table 27. PAHS and pesticides in CSOs of South Buffalo.

(dissolved phase)

Pollutant	Babcock 12/5/90	Cazenovia 12/5/90	Smith St. 12/5/90	Hamburg 12/5/90	Smith St. 8/9/91	Hamburg 8/9/91
gamma-Chlordane	BQL	BQL	BQL	BQL	0.253	0.105
alpha-Chlordane	BQL	BDL	BQL	BQL	0.179	0.106
Dieldrin	BDL	BDL	BDL	BDL	BQL	BQL
Benzo(a) anthracene	5.94	3.65	1.57	20.5	22.8	46.4
Benzo(b) fluoranthene	8.07	1.72	BQL	8.85	9.60	19.9
Benzo(k) fluoranthene	1.33	0.341	BQL	20.3	2.27	3.34
Benzo(a) pyrene	1.80	0.391	BQL	1.92	2.33	4.51
Chrysene	4.59	2.67	1.70	4.53	14.3	28.8
(particulate phase)						
gamma-Chlordane	0.153	BQL	0.676	0.0923	0.063	0.0423
alpha-Chlordane	0.144	BQL	0.708	0.0934	BQL	BQL
Dieldrin	BDL	BDL	BDL	BDL	BQL	1.41
Benzo(a) anthracene	7.45	3.55	134.8	1.87	34.0	17.3
Benzo(b) fluoranthene	10.2	6.17	144.2	1.89	29.4	21.3
Benzo(k) fluoranthene	3.45	2.16	68.2	0.603	20.5	5.24
Benzo(a) pyrene	5.46	3.59	147.1	0.612	43.2	6.91
Chrysene	9.86	5.05	182.1	4.26	34.3	22.2

* all units in ng/l of water; BQL - below quantitative limits; BDL - below detection limits

Table 28. PCB concentrations in CSOs in South Buffalo Sewer Districts.

District, date	dissolved *	particulate
Babcock, 12/5/90	BMDL	20.83
Hamburg, 12/5/90	23.3	152.66
Smith, 12/5/90	BMDL	99.03
Cazenovia, 12/5/90	BMDL	3.96
Smith, 8/9/91	BMDL	18.80
Hamburg, 8/9/91	BMDL	22.56

* all concentrations in ng/l water; BMDL - below machine detection limit

Table 29. Additional PCB data for CSOs.

PCB Data				
Concentration	Source	Land Use	Area	Source Key: 1 - Granier et al (1990) 2 - Marsalek and Ng (1989)
38-260 ng/L (130)	1	1	3	
90-2600 ng/L (633)	1	1	3	Land Use Key 1 - Residential 2 - Urban
36-2400 ng/L (625)	1	1	3	
30 ng/L	1	?	2	Area Key: 1 - CSO 2 - Runoff 3 - Stormwater Drainage
14 ng/L	1	?	2	
27-290 ng/L	1	?	2	
0.179 ug/L	2	2	1	
0.0269 ug/L	2	2	1	Values in parenthases are mean flow weighted conc.
0.0888 ug/L	2	2	1	
0.131 ug/L	2	?	?	
0.179 ug/L	2	1	1	
0.0 ug/L	2	1	1	
0.641 ug/L	2	1	1	

Table 30. Site characteristics for CSO data (from Jordan, 1984).

Code	Site	City	State	Catchment Area (acres)	Land Use
A	Ernest St. @ Allens	Providence	RI	65	Partly residential and highly industrial
B	Dexter St. @ Huntington	Providence	RI	300	Single family residential and scattered industrial
C	Lander St.	Seattle	WA	500	Light industrial and mixed commercial
D	Michigan St.	Seattle	WA	745	Heavy commercial and mixed industrial/residential
E	Branch St.	St. Louis	MO	2580	80% residential/commercial 13% industrial, 7% open
F	Prairie Ave.	St. Louis	MO	518	50% residential/commercial 40% industrial, 10% open
G	Phalen Creek	St. Paul	MN	870	Primarily multifamily res. and open space with some industrial/commercial
H	Eustis St.	St. Paul	MN	78	Light industry/commercial (soil is very impervious)

Table 31. Concentrations of parameters for sites of Table 27.

Pollutant	A	B	C	D	E	F	G	H
PCB-1016	ND	ND	1	ND	ND	ND	ND	ND
Benzo(a) anthracene	ND	ND	ND	ND	ND	ND	3	2
Benzo(b) fluoranthene	ND	ND	ND	ND	ND	ND	ND	1
Benzo(k) fluoranthene	ND	ND	ND	ND	1	ND	ND	3
Benzo(a) pyrene	ND	ND	ND	ND	ND	ND	ND	2
Lead	353	290	250	180	458	500	175	403
Copper	479	652	467	55	96	125	66	36
TSS (mg/L)	325	32	117	83	657	543	233	141
TOC (mg/L)	51	38	80	45	21	31	112	18

* all units in micrograms per liter unless otherwise noted; values reported are mean concentrations; ND - not detected

Unfortunately, the Phase II study by C&S considered the sewer collection system for the entire City of Buffalo, and did not focus specifically on outfalls to the Buffalo River AOC. In particular, many of the smaller outfalls to the Buffalo River were not included in their study, especially for the discharges to Cazenovia Creek (see Figure 29).

For the present study, a PC version of the SWMM model (PCSWMM4) was used to generate expected flows to the river from CSOs. This work is described in some detail by Irvine et al. (1993a). These flows were then combined with either measured data (such as Tables 26 - 28) or estimated concentrations (Tables 29 - 31) to obtain loading estimates. Although the loads due to those outfalls discharging within the AOC are of more direct interest when comparing the importance of various sources for the river, the results for the upstream outfalls provide an indication of the extent to which upstream loads may be attributed to CSOs. Marshall (1993) describes the modeling and loading calculations specifically for the upstream outfalls. In the following, results are presented separately for upstream and downstream CSO loads.

The CSO model was calibrated using data from one of the larger outfalls, at Babcock St., as described by Irvine et al. (1993b). It was then applied in two different modes. First, it was desired to estimate loadings due to a "typical" year of rainfall. After reviewing data available from the Buffalo Airport, precipitation data from 1990 were determined as a close approximation to the 30-year norms. The model was then run in a continuous mode using the data from that year. A total discharge of 620,000 m^3 was found for all outfalls, with 571,000 m^3 coming from the downstream outfalls alone (although smaller in number, the downstream outfalls contribute much more to the total CSO flows and associated pollutant loadings). The total loadings obtained in this exercise are summarized in Table 32.

Table 32. CSO loadings for typical year (1990)

Pollutant	Average concentration *	(kg/ yr) Upstream load	Downstream load (within AOC)
PCB	53.0	2.63e-3	2.34e-2
g-Chlordane	0.385	1.91e-5	1.69e-4
a-Chlordane	0.458	2.27e-5	2.02e-4
Dieldrin	1.41	6.96e-5	6.21e-4
B(a)a	50.0	2.48e-3	2.21e-2
B(b)f	45.2	2.23e-3	1.99e-2
B(k)f	22.2	1.10e-3	9.80e-3
B(a)p	36.7	1.82e-3	1.62e-2
Chrysene	52.4	2.59e-3	2.31e-2
Lead	326.1	16.2	144.0
Copper	247.0	12.3	109.1
TSS	266.4	13,210	117,620

* metals concentrations are in μg/l; TSS concentrations are in mg/l; all other concentrations are ng/l

In the second modeling approach it was desired to develop loading inputs that might result from different design storms, to provide information needed for long-term water quality modeling of the river. To do this, additional precipitation data were collected to describe storms which had mean return periods of 1, 2, 5, 10, 25 and 100 years. The CSO model was run for each of these storms to develop associated flow estimates which were combined with average concentrations to calculate pollutant loadings, as above. The overall procedure is described by Marshall (1993), who includes detailed calculations for each of the contaminants of interest. It was found that the total load from a CSO was reasonably well correlated with total precipitation from a storm. Figure 30 shows an example of this relationship. Similar curves were produced for each individual CSO, for each contaminant. In Figure 30, the total for all upstream CSOs has been added, since there is no need to separate effects of individual overflows in that region. As shown, there is a minimum precipitation at which a significant overflow will occur and it should be noted that there is some degree of uncertainty in choosing the minimum precipitation value. However, the model appears to reproduce loadings from large storms fairly well, which provide the majority of CSO loadings. For precipitation values above this minimum, the load is approximately linearly related to total storm precipitation. An equation of the following form was assumed to estimate loads:

$$W = (I - I_{min})S \tag{44}$$

where W = load (kg/day), I = total precipitation (in), I_{min} = minimum value for I at which overflow occurs and S = slope of the line relating W and I (as in Figure 30). Values for I_{min} and S are reported in Table 33 for each of the outfalls. These parameters may be used in (44) to estimate CSO loadings which would result from a storm with a given total precipitation.

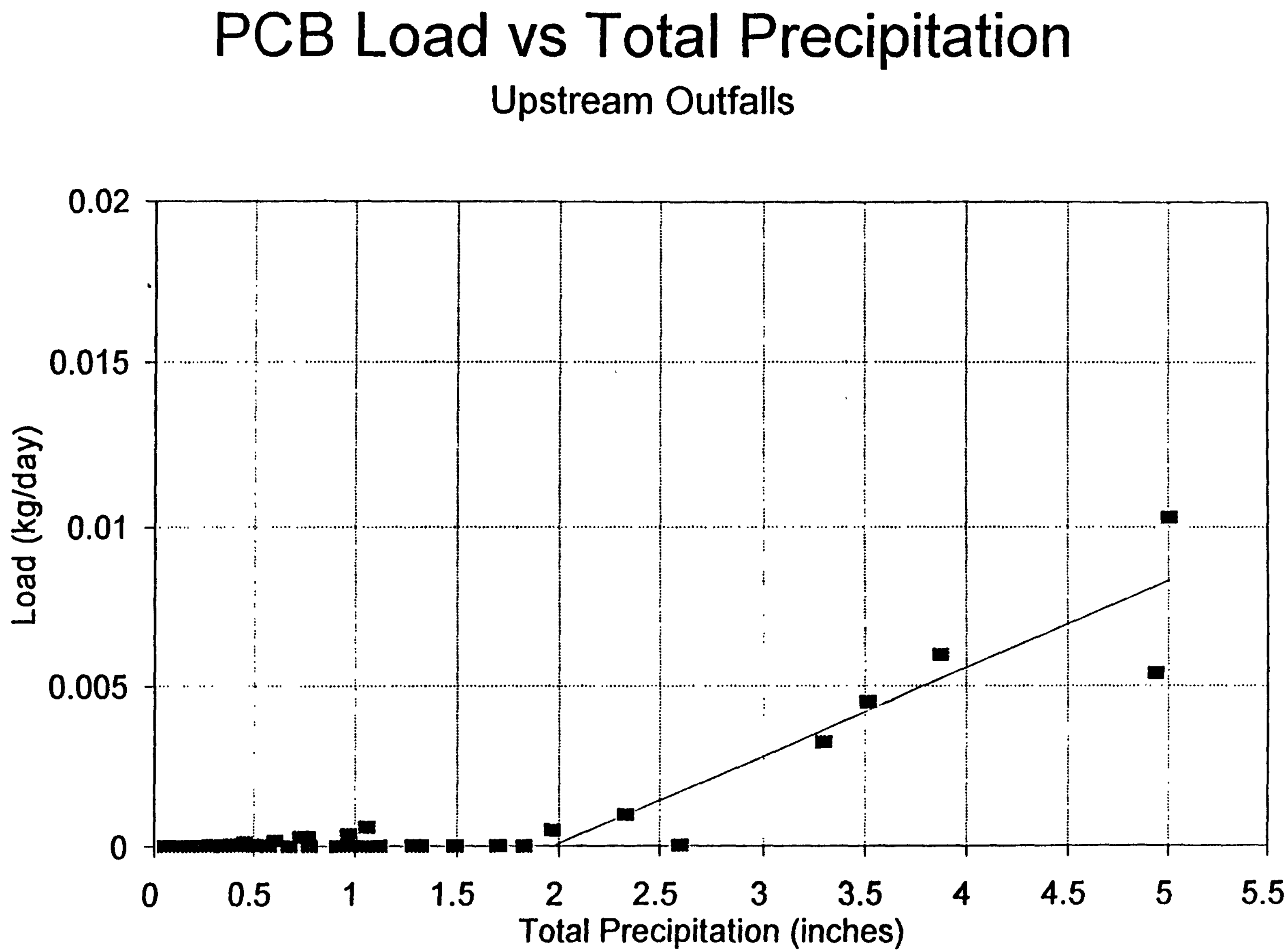


Figure 30. Example of CSO loading calculation as a function of storm precipitation

Table 33. Parameters for estimating CSO loadings

Outfall *	Upstream	57+58	30	31	32	33	34
I_{min} (in)	1.97	0.0	0.0	3.3	1.97	1.97	3.3
Pollutant	S ((kg/d)/in)						
PCB	2.75e-3	4.6e-4	1.69e-3	6.5e-6	1.0e-5	1.3e-5	5.1e-6
g-Chlor	2.0e-5	3.3e-6	1.2e-5	4.7e-8	7.3e-8	9.5e-8	3.7e-8
a-Chlor	2.4e-5	3.9e-6	1.5e-5	5.6e-8	8.7e-8	1.1e-7	4.4e-8
Dieldrin	7.3e-5	1.2e-5	4.5e-5	1.7e-7	2.7e-7	3.5e-7	1.3e-7
B(a)a	2.59e-3	4.3e-4	1.59e-3	6.1e-6	9.5e-6	1.2e-5	4.8e-6
B(b)f	2.34e-3	3.9e-4	1.44e-3	5.6e-6	8.6e-6	1.1e-5	4.3e-6
B(k)f	1.15e-3	1.9e-4	7.1e-4	2.7e-6	4.2e-6	5.5e-6	2.1e-6
B(a)p	1.9e-3	3.2e-4	1.17e-3	4.5e-6	7.0e-6	9.1e-6	3.5e-6
Chrysene	2.72e-3	4.5e-4	1.67e-3	6.4e-6	9.9e-6	1.3e-5	5.0e-6
Lead	16.9	2.80	10.4	0.0401	0.0619	0.0809	0.0312
Copper	12.8	2.12	7.88	0.0304	0.0468	0.0613	0.0236
TSS	13,820	2290	8496	32.8	50.5	66.1	25.5

Outfall *	35	36	36a	38	39	42
I_{min} (in)	2.33	3.3	1.83	1.83	1.49	0.0
Pollutant	S ((kg/day)/in)					
PCB	3.2e-5	6.1e-6	2.5e-4	1.9e-4	1.45e-3	1.1e-4
g-Chlor	2.4e-7	4.4e-8	1.8e-6	1.4e-6	1.1e-5	8.3e-7
a-Chlor	2.8e-7	5.3e-8	2.2e-6	1.6e-6	1.3e-5	9.9e-7
Dieldrin	8.6e-7	1.6e-7	6.7e-6	5.1e-6	3.9e-5	3.0e-6
B(a)a	3.1e-5	5.7e-6	2.4e-4	1.8e-4	1.37e-3	1.1e-4
B(b)f	2.8e-5	5.2e-6	2.1e-4	1.6e-4	1.24e-3	9.7e-5
B(k)f	1.4e-5	2.5e-6	1.1e-4	8.0e-5	6.1e-4	4.8e-5
B(a)p	2.2e-5	4.2e-6	1.7e-4	1.3e-4	1.01e-3	7.9e-5
Chrysene	3.2e-5	6.0e-6	2.5e-4	1.9e-4	6.1e-4	1.1e-4
Lead	0.20	0.0375	1.55	1.17	8.94	0.702
Copper	0.151	0.0284	1.17	0.888	6.77	0.532
TSS	163.0	30.6	1267	957.6	7303	573.7

* outfall identification numbers correspond with Irvine et al. (1993) and Marshall (1993) and generally increase upstream (see also Figure 29); all upstream outfalls are grouped together as explained in the text; outfalls 57 and 58 are grouped together because they are located very close to each other

4.3. Sediment resuspension potential and contamination risk

The risk of contamination from resuspended sediments is difficult to evaluate without a detailed sediment transport model. The figures of Appendix D indicate areas of particular concern for the targeted pollutants. In order to provide some indication of the degree to which the sediments would be susceptible to erosion, values for the dry fraction of wet weight of the sediment samples are plotted in Figure 31. This fraction is related to porosity and to the critical shear stress required to cause erosion. Higher porosity indicates a "looser" sediment and lower dry fraction corresponds with higher porosity. Therefore, areas with lower dry fraction values should be relatively more easily erodible. Unfortunately, from the data in Figure 31 it appears that the physical sediment characteristics do not show significant variations along the river bed.. Therefore, specific conclusions about contamination risk associated with erosion and resuspension of bottom sediments are not possible at this time and will have to be evaluated with the use of a sediment transport model.

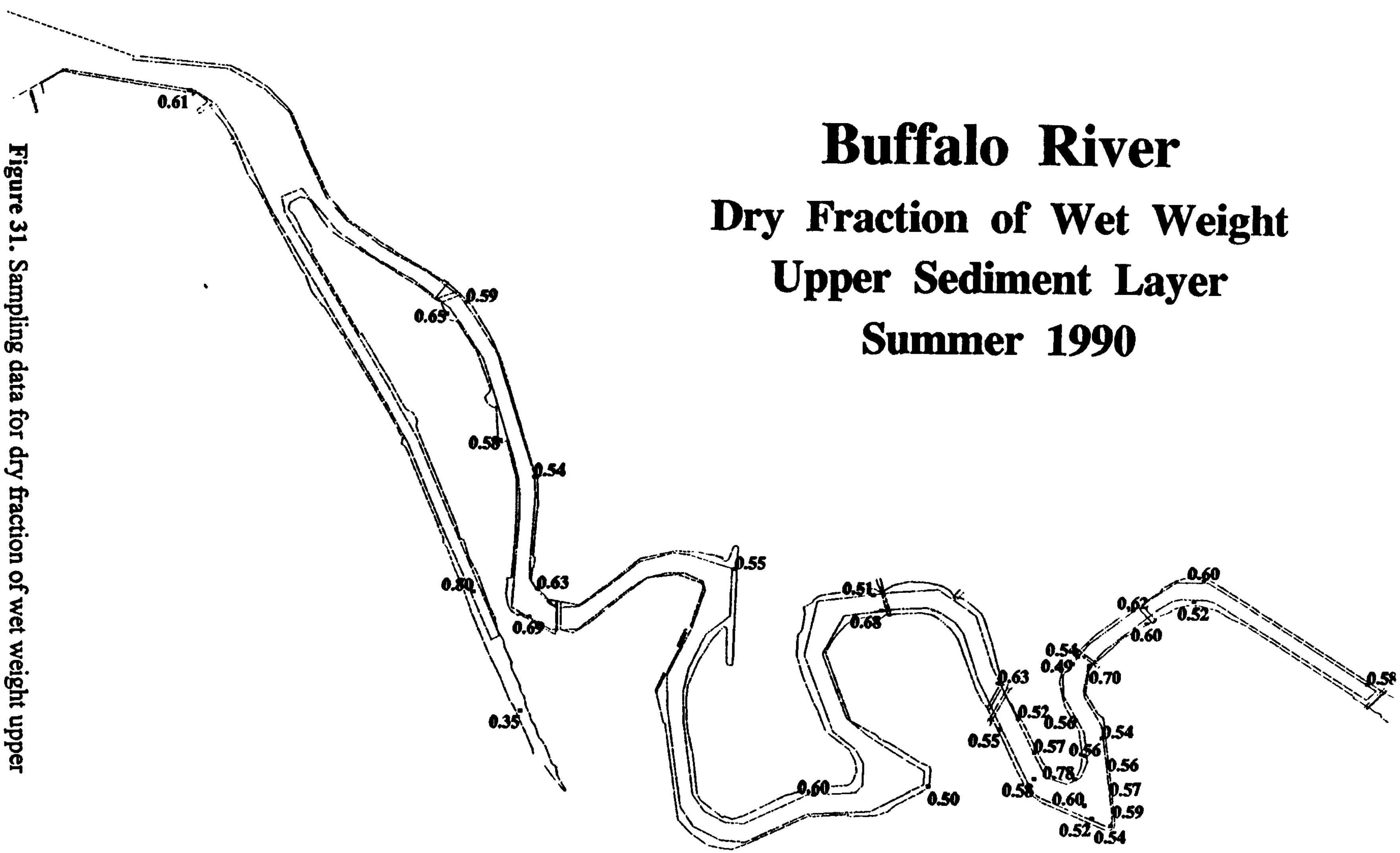


Figure 31. Sampling data for dry fraction of wet weight upper sediment layer, summer 1990.

One other measure of the potential for contamination by sediment resuspension is the amount of material contained in the upper sediment layer. These values were listed in Table 14. As previously noted, these values are meant only to indicate relative orders of magnitude for the contaminant mass contained within the sediments and do not necessarily represent the amount of mass that would be eroded by a given storm or over a particular time period.

4.4. Non-point sources (inactive hazardous waste sites)

Loadings from inactive hazardous waste sites were analyzed by Taylor (1991). Hazardous waste sites were identified in the Buffalo River RAP (NYSDEC, 1989), as shown in Figure 32. Loadings were estimated using analytical and mathematical groundwater transport models applied to six of these sites identified as potential contributors to pollution in the Buffalo River. These sites, along with identification numbers appearing in Figure 32, include Allied Chemical (004), Buffalo Color (012), Lehigh Valley Railroad (071), MacNaughton-Brooks (034), Madison Wire (036) and West Seneca Transfer Station (039). The last two sites in this list do not appear on Figure 32 since they are located slightly upstream of the AOC. Table 34, from Taylor (1991), summarizes those targeted pollutants associated with each of the six sites. Analyses were not completed for PCBs and pesticides since there was no indication of groundwater pollution of these contaminants.

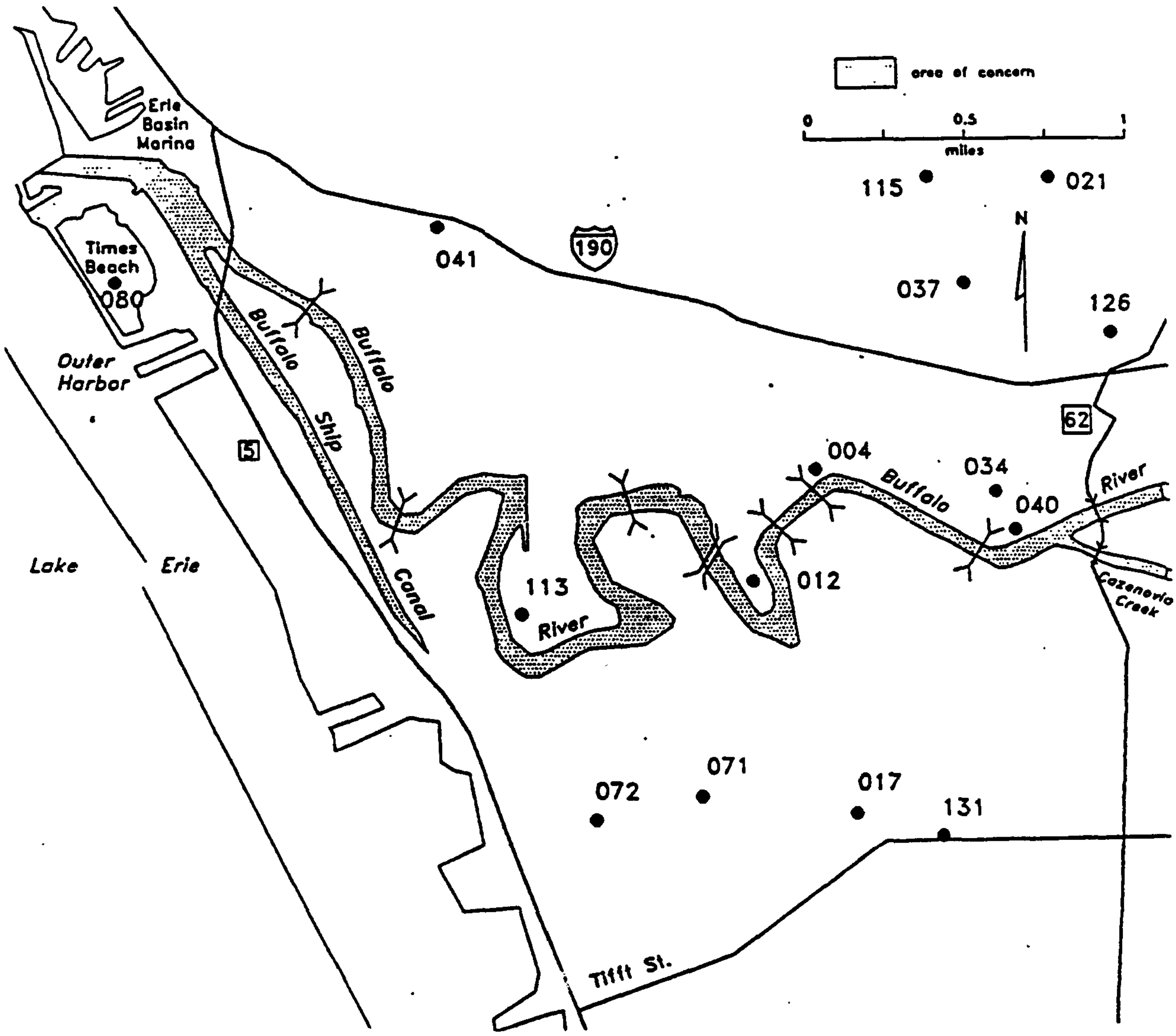


Figure 32. Inactive hazardous waste sites, from NYSDEC (1989).

Table 34. Summary of targeted pollutants associated with inactive hazardous waste sites (from Taylor, 1991).

Site	Organic pollutants	Inorganic pollutants
Allied Chemical		Iron, lead
Buffalo Color	PAHs	Copper, iron, lead
Lehigh Valley Railroad		Iron
MacNaughton-Brooks		Iron
Madison Wire		Copper, iron, lead
West Seneca Transfer		Iron, lead

Because of large uncertainties in the estimates obtained with the groundwater models (due to lack of sufficient data for estimating adsorption characteristics), Taylor reported a range of possible loading rates for each of the pollutants listed in Table 34. The maximum (steady-state) rates are listed in Table 35. Breakthrough curves were calculated for each of the pollutants and showed that steady-state transport was in fact not reached for any of the metals for periods well in excess of 1,000 years. Simulations for the Buffalo Color site were obtained only for 100 years, but these showed no indication of reaching steady state. Therefore, the values reported in Table 35 probably over-estimate the actual loadings, which may be a small fraction of the steady state values. For the Buffalo Color site, the situation is somewhat different due to the close proximity to the river. Here it is possible that steady-state may have been reached, especially for the PAHs where steady-state was predicted to be reached after about 15 years. The values for PAH loadings listed in Table 35 are therefore expected to be reasonable. Metals loadings from the Buffalo Color site are not reported in Table 34 since steady-state values were not obtained. However, for contamination times of the order of 50 years, the model predicts loadings of approximately 4 kg/yr for copper, 8 kg/yr for iron and 0.05 kg/yr for lead.

Table 35. Maximum (steady-state) loading rates from non-point sources (from Taylor, 1991).

	(kg/yr)							
Site	Copper	Iron	Lead	B(a)a	B(b)f	B(k)f	B(a)p	Chrys.
Allied Chemical		26.9	0.02					
Buffalo Color				0.22	0.07	0.01	0.02	0.03
Lehigh Val. RR		665						
MacNaughton		1,620						
Madison Wire	78.6	245	0.31					
West Seneca		1,340	2.09					

4.5. Export from system

It was desired to estimate annual export from the system for each of the contaminants of interest, in the same way upstream loadings were calculated in Section 4.1. However, there were only limited data available for downstream sites, compared with the data used for upstream calculations (particularly for relating TSS with flow). In addition, there was too much scatter in those data to allow development of reasonable regressions. For the estimates presented here the particulate concentrations for Site 6 (for non-metals) were converted to volumetric concentrations by multiplying them with the corresponding observed TSS values. The resulting values were then averaged and added to the averaged dissolved concentrations, also from the Site 6. These total concentrations were then multiplied by the total average annual flow, obtained from Table 5. Estimates of annual metals export were made using data available from the Ohio Street bridge (Litten and Anderson, 1992) and EPA-STORET data. Average values for lead (0.0067 mg/l) and copper (0.0076 mg/l) concentrations were multiplied by the average annual daily flow (343 cfs), obtained from Table 5. These values were then multiplied by 365 to obtain annual export estimates. Table 36 summarizes the results of the export calculations.

Table 36. Estimates for mass export from system

Parameter	Annual export (kg/yr)
PCBs	0.98
Chlordane	0.04
Dieldrin	0.04
DDT	0.01
Benzo(a)anthracene	6.30
Benzo(b) fluoranthene	6.68
Benzo(k)fluoranthene	2.36
Benzo(a)pyrene	3.19
Chrysene	7.46
Lead	2,052
Copper	2,323
TSS	5.33e6

4.6. Summary

4.6.1. "Typical" year

Referring to Figure 2, it is desired to estimate the total annual loading for each of the targeted pollutants to the AOC, from each of the various sources. Following the procedure outlined in Section 4.1.1, upstream TSS loadings were calculated for daily averaged flows (Section 3.1). Using values for both Q and TSS, dissolved and particulate loadings for each contaminant were calculated for each day, using eqns. (22 - 43), and summed to obtain total annual upstream loading estimates. The resulting values are listed in Table 37, which includes values for each of the sources noted in Figure 2, except for sediments. Sediment loading rates may be estimated only after application of a sediment transport model. Industrial point source loading values are taken from Table 24 and CSO loadings are taken from Table 32. Non-point source loadings are from Table 35 and export rates are reproduced from Table 36. Due to previously mentioned uncertainties in the groundwater loading estimates, each of the values in Table 35 for metals has been multiplied by 0.25 to provide estimates which are believed to be closer to actual (non-steady-state) values. The metals loadings estimated for the Buffalo Color site are also included in these estimates.

Table 37. Summary of annual loading estimates..

	Total annual loading (kg/yr)				
Parameter	Upstream	Industrial	CSOs *	Ground-water	Export
Total PCBs	0.77	---	0.02	---	0.98
Chlordane **	0.03	---	---	---	0.04
Dieldrin	0.04	---	---	---	0.04
p,p'-DDT	0.02	---	---	---	0.01
B(a)anthracene	3.06	---	0.02	0.22	6.30
B(b)fluoranthene	3.74	---	0.02	0.07	6.68
B(k)fluoranthene	3.78	---	0.01	0.01	2.36
B(a)pyrene	2.16	---	0.02	0.02	3.19
Chrysene	4.11	---	0.02	0.03	7.46
Lead	359	66.4	144.0	0.66	2,052
Copper	933	331.8	109.1	23.7	2,323
Total solids	5.50e7		1.18e5		5.33e6

* CSO loadings reported here are only for downstream outfalls
** a-chlordane and g-chlordane values are combined

Total solids entering and leaving the river are also estimated in Table 37, to provide a measure of the degree to which the river acts as a sediment trap. These values indicate that, on average, a large fraction of the incoming suspended sediment load remains within the river. A comparison of the upstream and export (downstream) loadings indicates that there may be additional sources for some of the contaminants along the AOC. Possibilities include CSOs (note that the CSO data are not very complete for contaminant concentrations and many values are inferred from literature sources), sediment release or other sources not accounted for. The metals data indicate that much more mass is leaving the system than entering. However, it should be noted that the upstream loading estimates are based on TSS loads calculated from monthly flows averaged over a 45-year record. Because the average monthly flows tend to be low, the TSS estimates are also low, resulting in low estimates for metals loading (this may also affect the other parameters). Export rates are based on an average concentrations based on a much smaller data set generally measured during higher flow events, which result in a higher export calculation. This affects the metals export much more than the other parameters because different data sets were used for the metals. The ARCS project will have to evaluate all sources in order to balance mass for these parameters.

5. References

Buffalo Sewer Authority (1988), Combined Sewer Overflow Inspection Points Within City of Buffalo, revised March, 1988.

Calocerinos & Spina Engineers (1988), Buffalo Combined Sewer Overflow Phase II Study, Report Number: C-36-1004-01-3, prepared for Buffalo Sewer Authority, Buffalo, NY, June.

Calocerinos and Spina (1977), Hertel Avenue Planning Area Infiltration/Inflow Analysis, Consulting Report, prepared for the Buffalo Sewer Authority Buffalo, New York, July.

Colby, B.R. (1957), Relationship of unmeasured sediment discharge to mean velocity. *Trans. Am. Geophys. Union* 38 (5), 708-719.

Endicott, D.D., W.L. Richardson, T.F. Parkerton, and D.M. DiToro (1991), A Steady State Mass Balance and Bioaccumulation Model for Toxic Chemicals in Lake Ontario. Final report to the Lake Ontario Fate of Toxics Committee. U.S. E.P.A. ERL-Duluth, LLRS, Grosse Ile, MI.

Granier, L., M. Chevreuil, A.M. Carru and R. Letolle (1990), Urban runoff pollution by organochlorines and heavy metals. *Chemosphere*, 21 (9), 1101-1107.

Havlicek, Larry L. and Ronald D. Crain (1988), Practical statistics for the physical sciences. American Chem. Soc., Washington, DC.

Huang (1987), "Analysis of Waterbody Surface Heat Exchange", Master of Science Thesis, Department of Civil Engineering, SUNY at Buffalo, Buffalo, New York.

Hydroqual, Inc., (1984), "Water-Sediment Partition Coefficients for Priority Metals", 11/82, included in: *Technical Guidance Manual for Performing Waste Load Allocations, Book II Streams and Rivers*, Chapter 3, Toxic Substances. U.S. E.P.A. 6/84.

Irvine, Kim N., Ellen J. Pratt and Stephen Marshall (1993a), Estimate of combined sewer overflow discharges to the Buffalo River Area of Concern. report to the US Environmental Protection Agency, Great Lakes National Program Office.

Irvine, K.N., B.G. Loganathan, E.J. Pratt and H.C. Sikka (1993b), Calibration of PCSWMM to estimate metals, PCBs and HCB in CSOs from an industrial sewershed. from *New Techniques for Modeling the Management of Stormwater Quality Impacts*, ed. W. James, Lewis Publ., Boca Raton, FL, chap. 10.

Jordan, E.C. Co. (1984), Combined sewer overflow toxic pollutant study. prepared for the U.S. Environmental Protection Agency, report EPA 440/1-84/304.

Litten, Simon and Bernadette Anderson (1993), An automated sampling system for trace contaminant load estimation - Buffalo River, Buffalo, NY, unpublished report, NYSDEC.

Marsalek, J. and H.Y.F. Ng (1989), Evaluation of pollution loadings from urban runoff nonpoint sources: Methodology and applications. *J. Great Lakes Res.* 15 (3), 444-451.

Marshall, Stephen (1993), Contaminant loading to the Buffalo River from combined sewer overflows. M. Eng. project, in preparation.

Meredith, Dale D. and Ralph R. Rumer (1987), Sediment dynamics in the Buffalo River. Report prepared for the NYSDEC, Department of Civil Engineering, State University of New York at Buffalo.

Newman, Michael C. (1993), Regression analyses of log-transformed data: Statistical bias and its correction. *Environmental Tech. Chem.* 12, 1129-1133.

NYSDEC (1989), Buffalo River Remedial Action Plan. Water Division, Buffalo Office.

Parsons, D.A., R.P. Apmann and G.H. Decker (1963), The determination of sediment yields from flood water sampling. Pub. no. 65, Intl. Assoc. Sci. Hydrology, 7-15.

Taylor, Stewart W. (1991), Pollutant loadings to the Buffalo River Area of Concern from inactive hazardous waste sites. Final report, prepared for U.S. Environmental Protection Agency, Great Lakes National Program Office, project no. X995024-01.

6. Appendices

The following appendices contain figures and tables (from spreadsheets) which document much of the water quality data available for the Buffalo River. Some of these data have been summarized, or presented in averaged form in the main document. Appendix A shows measured flowrates in the river throughout the year, based on 45 years of record compiled by Meredith and Rumer (1987). Appendix B summarizes contaminant water column concentrations obtained during the two ARCS sampling periods. Appendix C shows the spatial variation in calculated partition coefficients for each of the parameters of interest. Appendix D shows contaminant concentrations obtained in the sediments.

Appendix A. Buffalo River flowrates

List of Figures

(average daily flow frequency distribution curves for a random day in each month, based on data from 1940 - 1945; all flows in cfs)

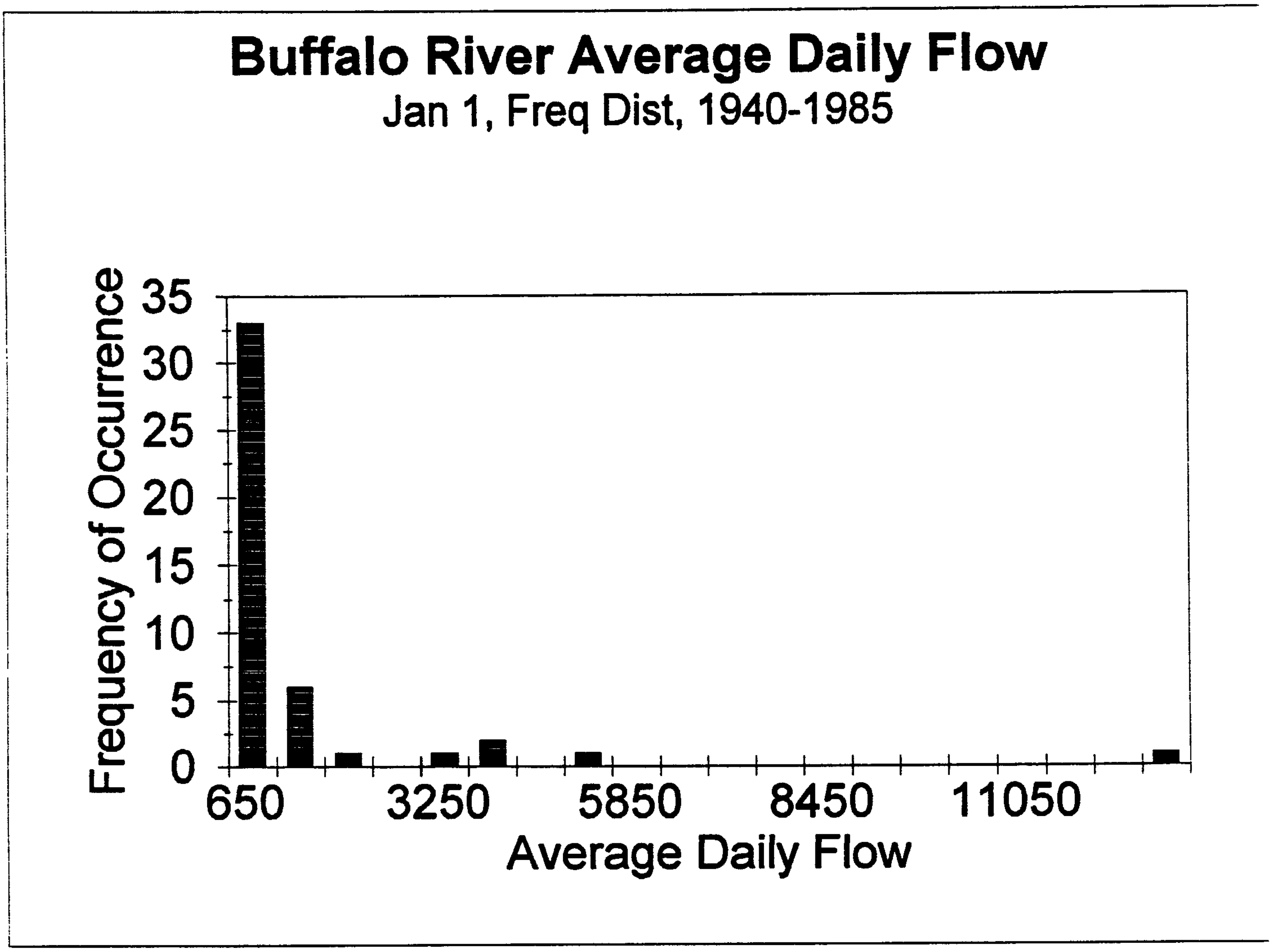
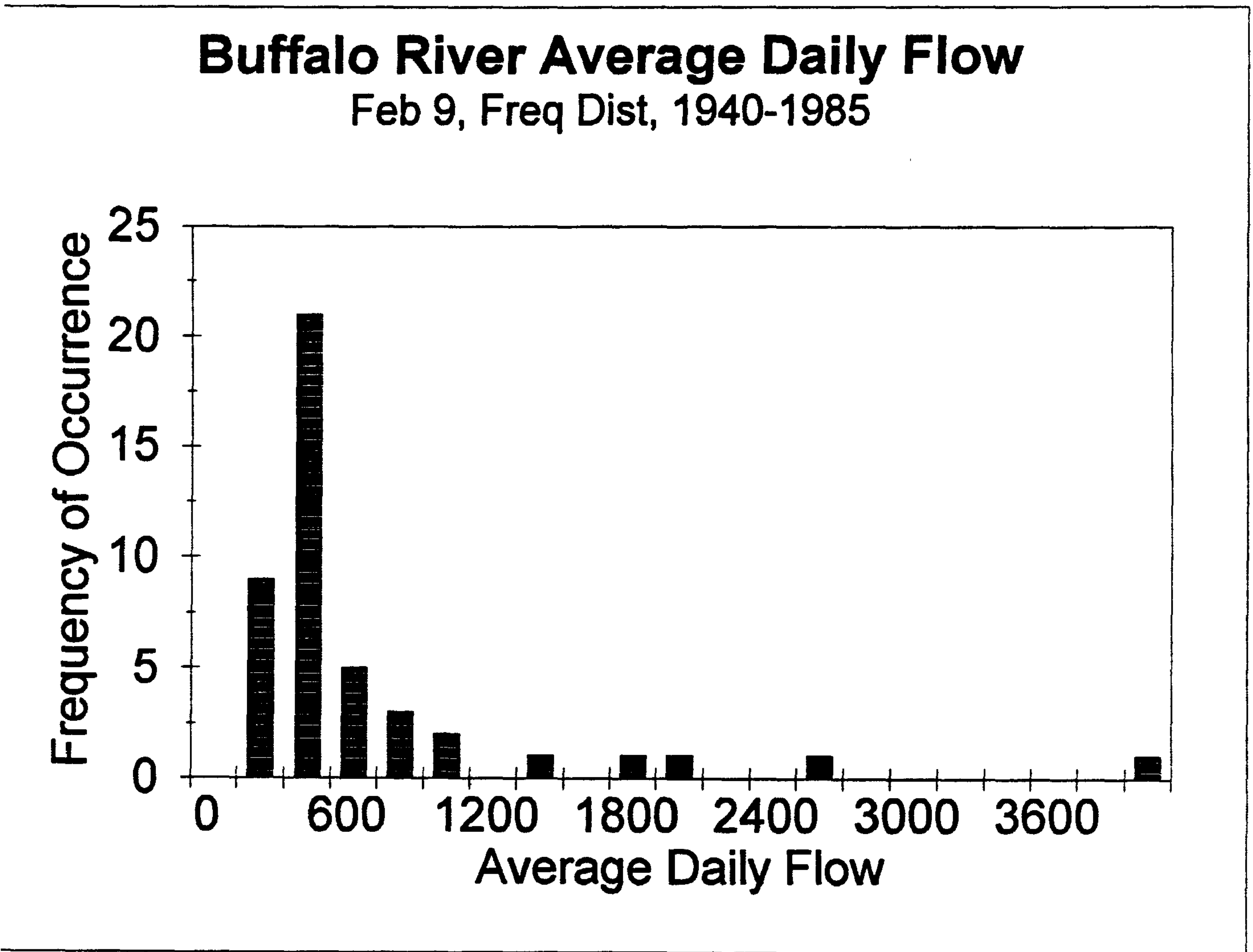
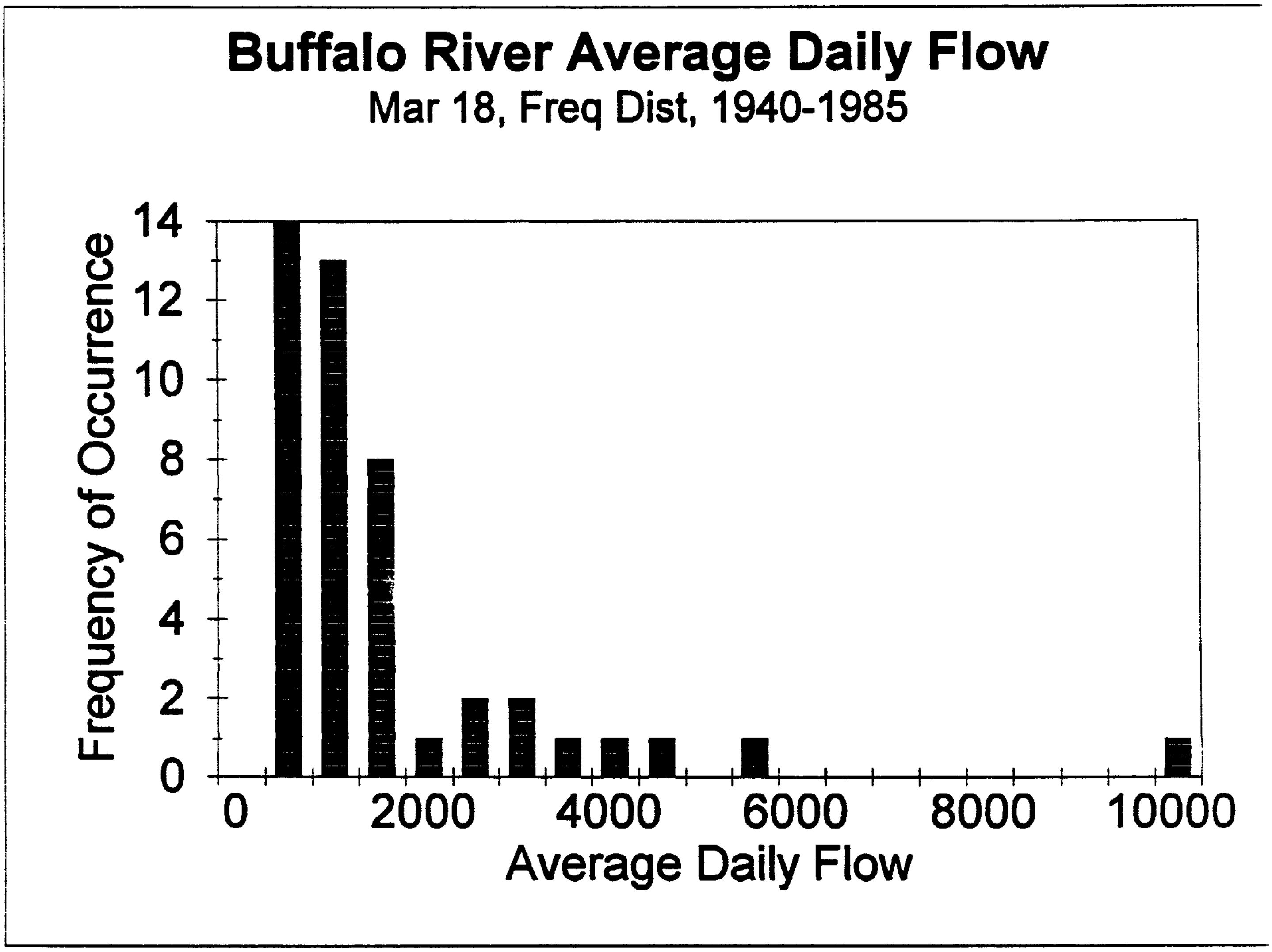

Buffalo River Average Daily Flow
Jan 1, Freq Dist, 1940-1985
Frequency of Occurrence
35
30
25
20
15
10
5
0
650
3250
5850
8450
11050
Average Daily Flow

Figure A1



Buffalo River Average Daily Flow
Feb 9, Freq Dist, 1940-1985
Frequency of Occurrence
25
20
15
10
5
0
0
600
1200
1800
2400
3000
3600
Average Daily Flow

Figure A2



Buffalo River Average Daily Flow
Mar 18, Freq Dist, 1940-1985
Frequency of Occurrence
14
12
10
8
6
4
2
0
0
2000
4000
6000
8000
10000
Average Daily Flow

Figure A3

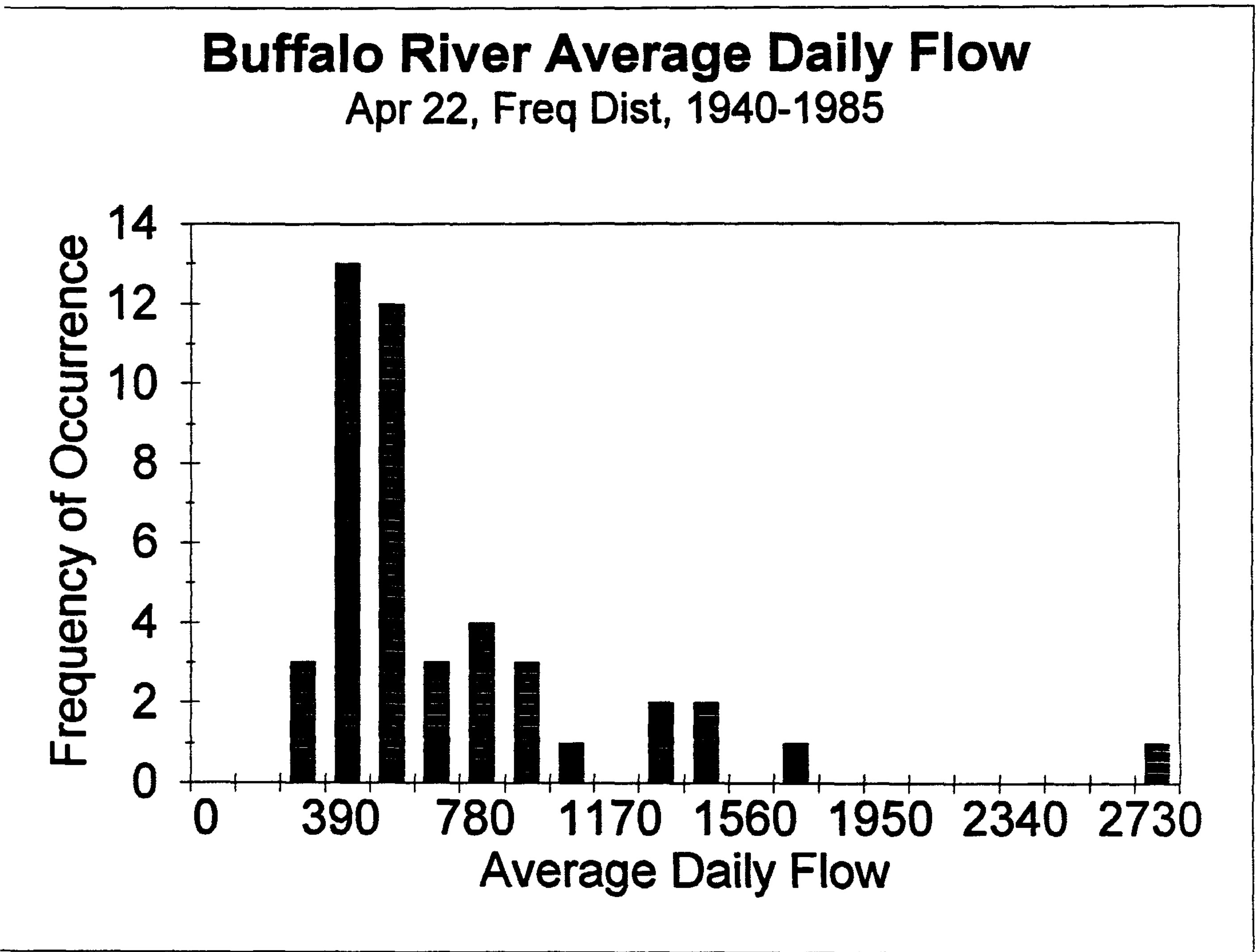
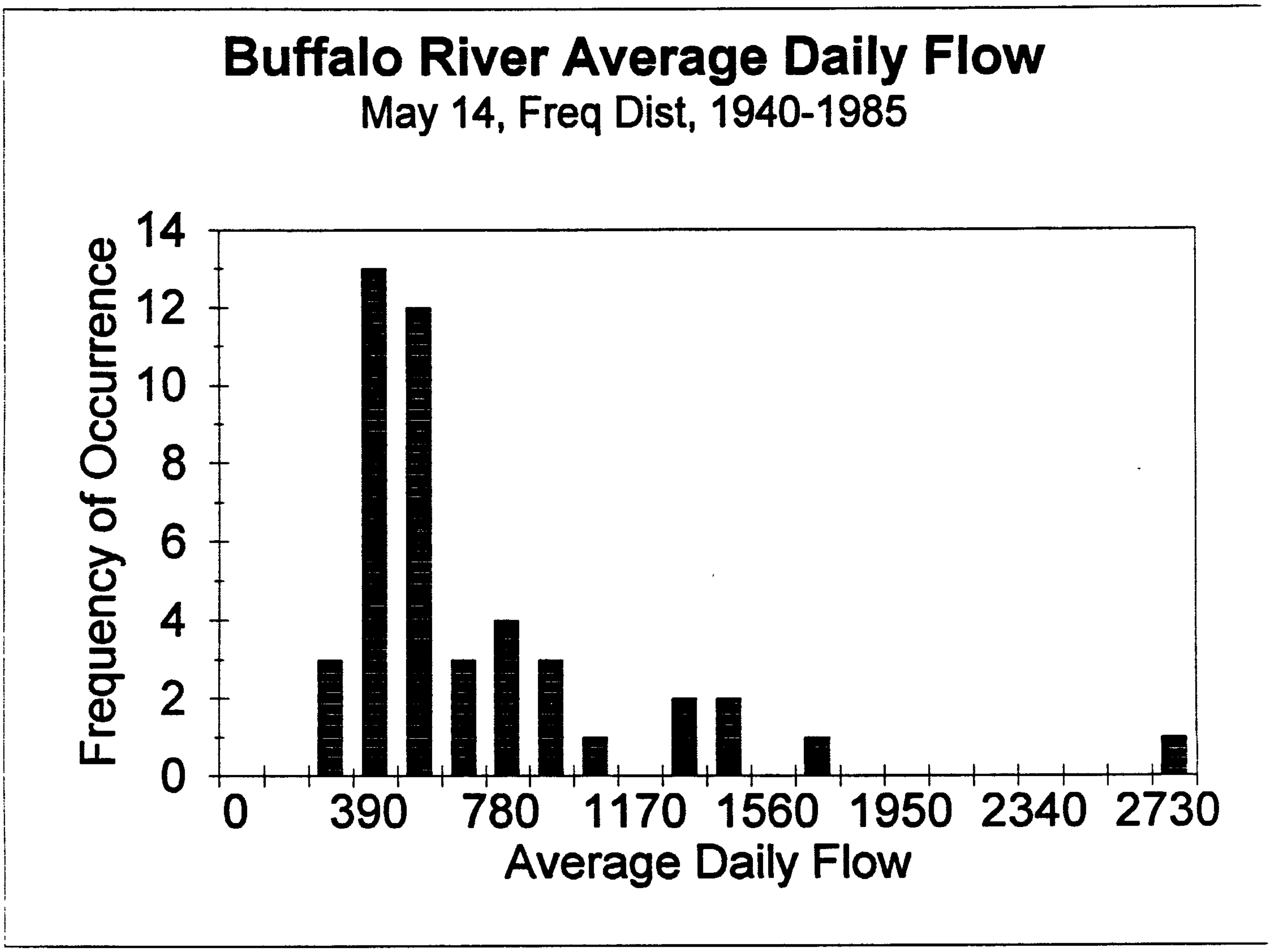

Buffalo River Average Daily Flow
Apr 22, Freq Dist, 1940-1985
Frequency of Occurrence
14
12
10
8
6
4
2
0
0
390
780
1170
1560
1950
2340
2730
Average Daily Flow

Figure A4



Buffalo River Average Daily Flow
May 14, Freq Dist, 1940-1985
Frequency of Occurrence
14
12
10
8
6
4
2
0
0
390
780
1170
1560
1950
2340
2730
Average Daily Flow

Figure A5

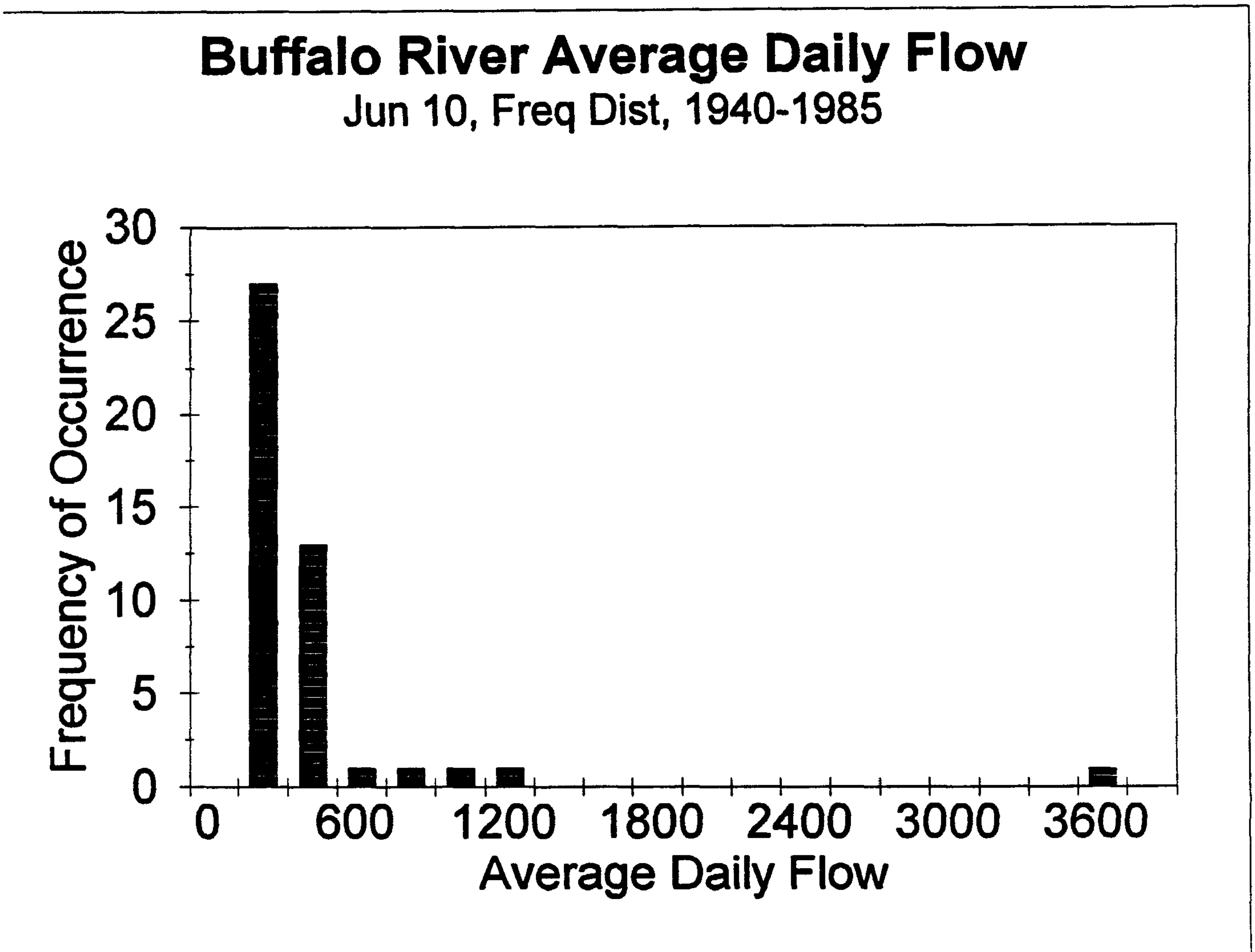
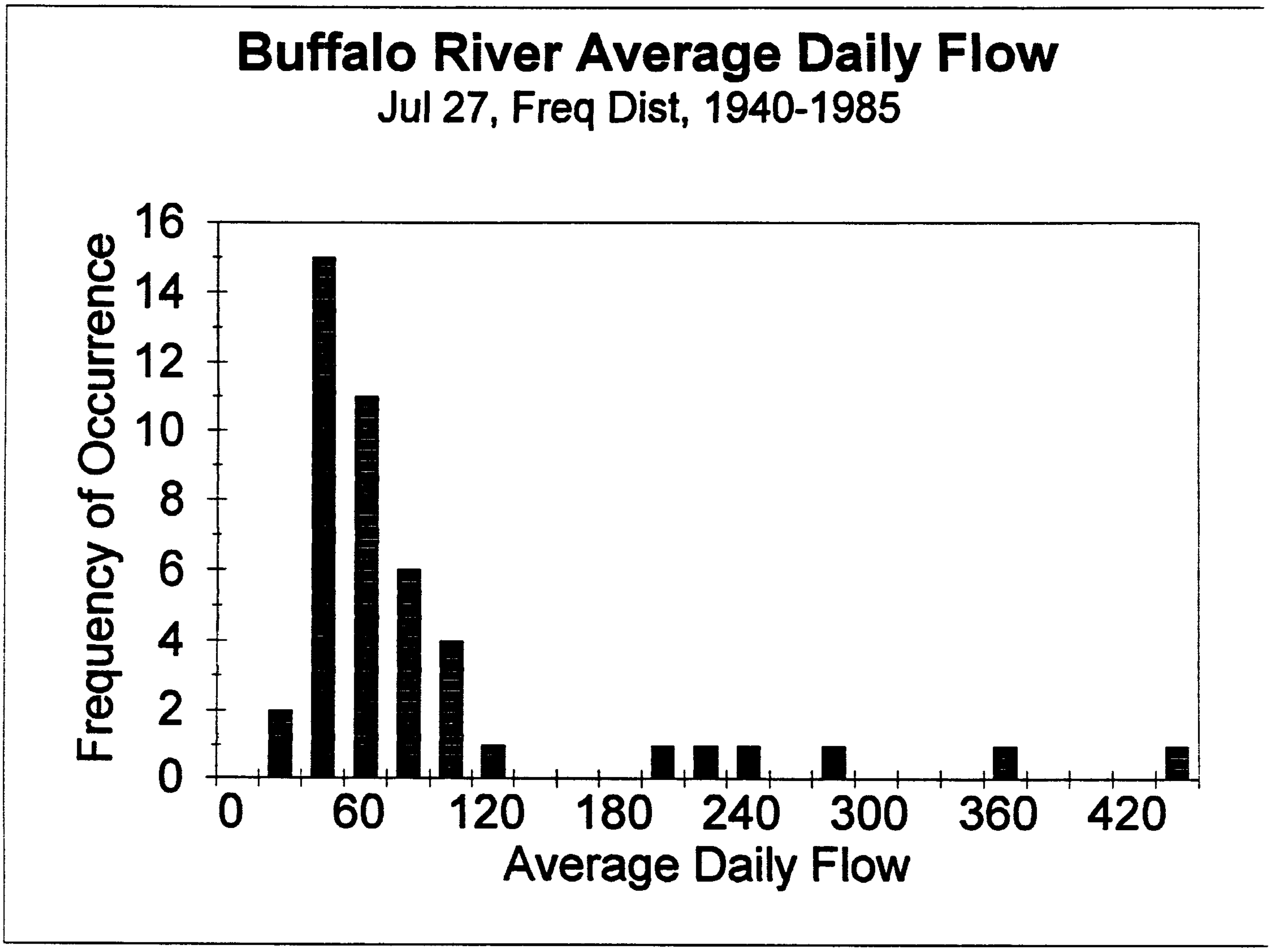

Buffalo River Average Daily Flow
Jun 10, Freq Dist, 1940-1985
Frequency of Occurrence
30
25
20
15
10
5
0
0
600
1200
1800
2400
3000
3600
Average Daily Flow

Figure A6



Buffalo River Average Daily Flow
Jul 27, Freq Dist, 1940-1985
Frequency of Occurrence
16
14
12
10
8
6
4
2
0
0
60
120
180
240
300
360
420
Average Daily Flow

Figure A7

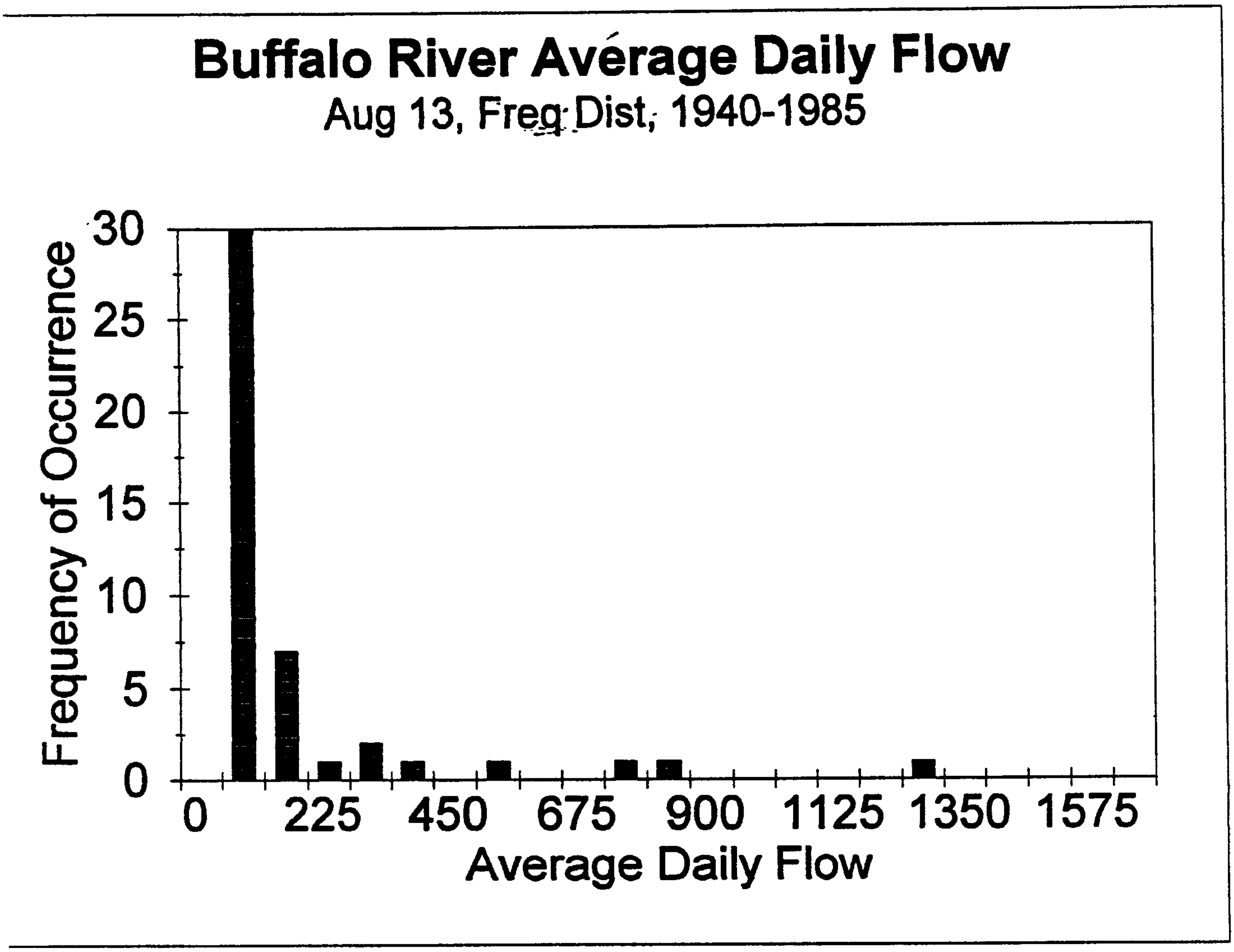

Buffalo River Average Daily Flow
Aug 13, Freq Dist, 1940-1985
Frequency of Occurrence
30
25
20
15
10
5
0
0
225
450
675
900
1125
1350
1575
Average Daily Flow

Figure A8

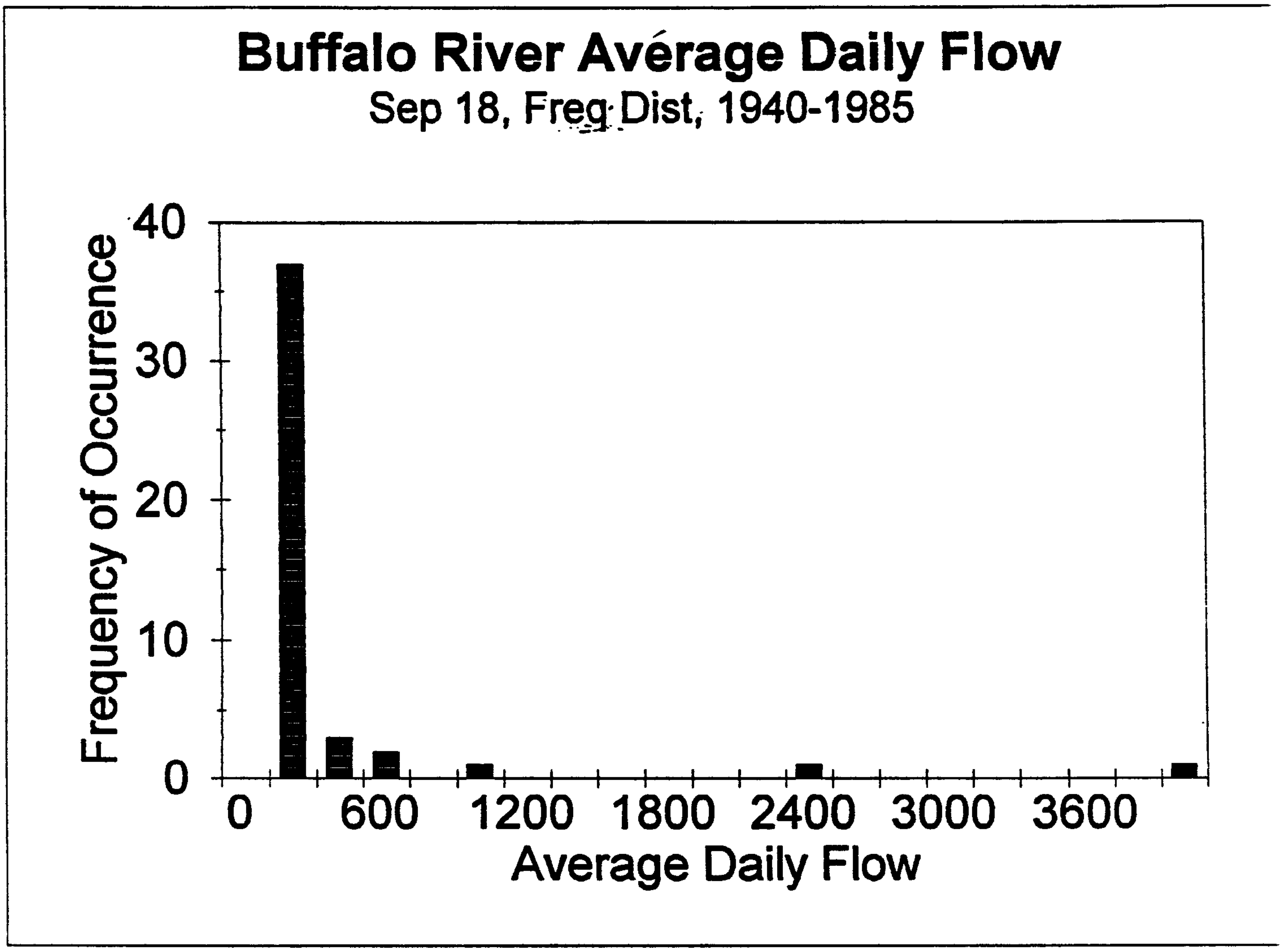
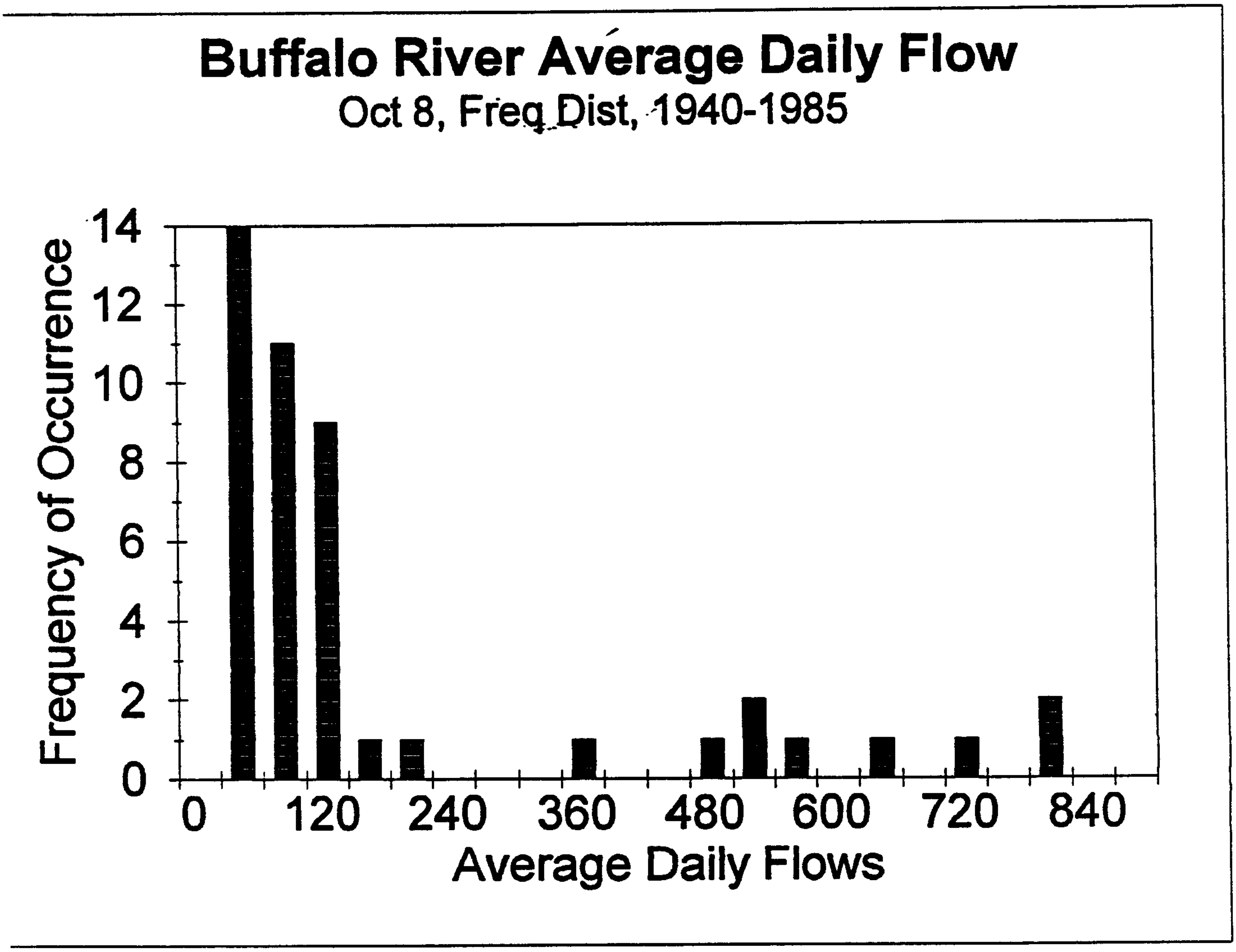

Buffalo River Avérage Daily Flow
Sep 18, Freq Dist, 1940-1985
Frequency of Occurrence
40
30
20
10
0
0
600
1200
1800
2400
3000
3600
Average Daily Flow

Figure A9



Buffalo River Average Daily Flow
Oct 8, Freq Dist, 1940-1985
Frequency of Occurrence
14
12
10
8
6
4
2
0
0
120
240
360
480
600
720
840
Average Daily Flows

Figure A10

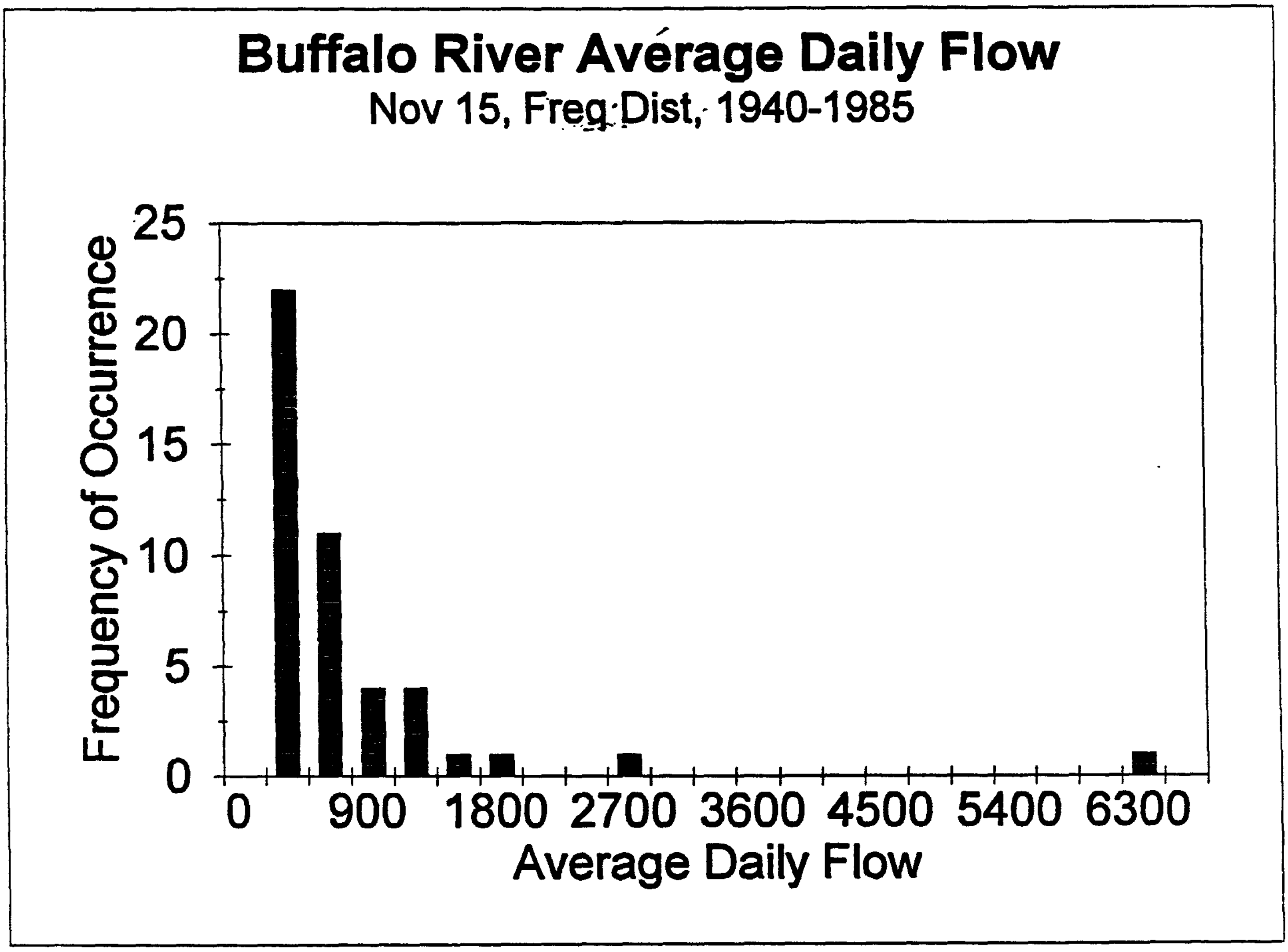
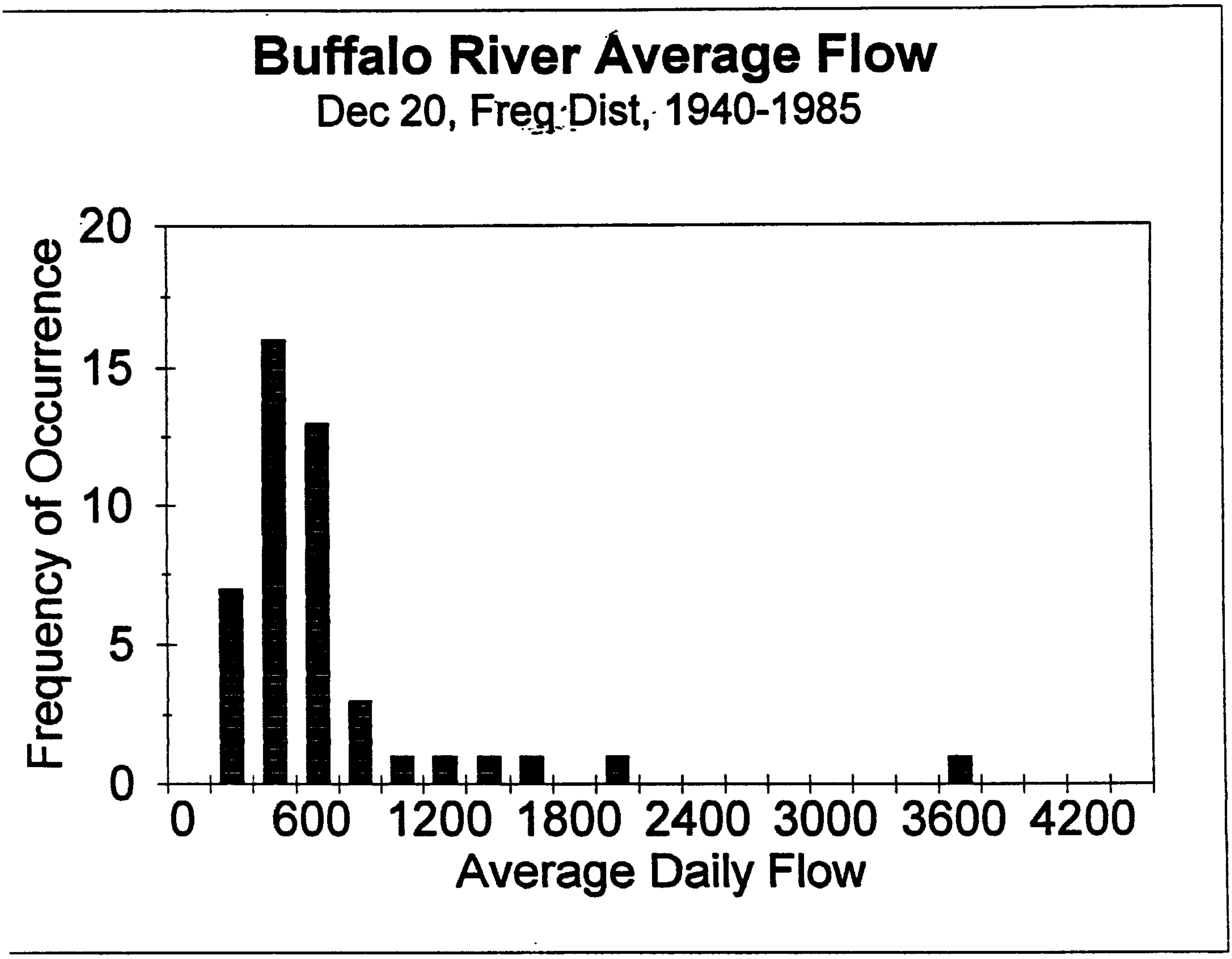

Buffalo River Average Daily Flow
Nov 15, Freq Dist, 1940-1985
Frequency of Occurrence
25
20
15
10
5
0
0
900
1800
2700
3600
4500
5400
6300
Average Daily Flow

Figure A11



Buffalo River Average Flow
Dec 20, Freq Dist, 1940-1985
Frequency of Occurrence
20
15
10
5
0
0
600
1200
1800
2400
3000
3600
4200
Average Daily Flow

Figure A12

Appendix B. Water quality data

List of Figures

Total PCBs Concentration

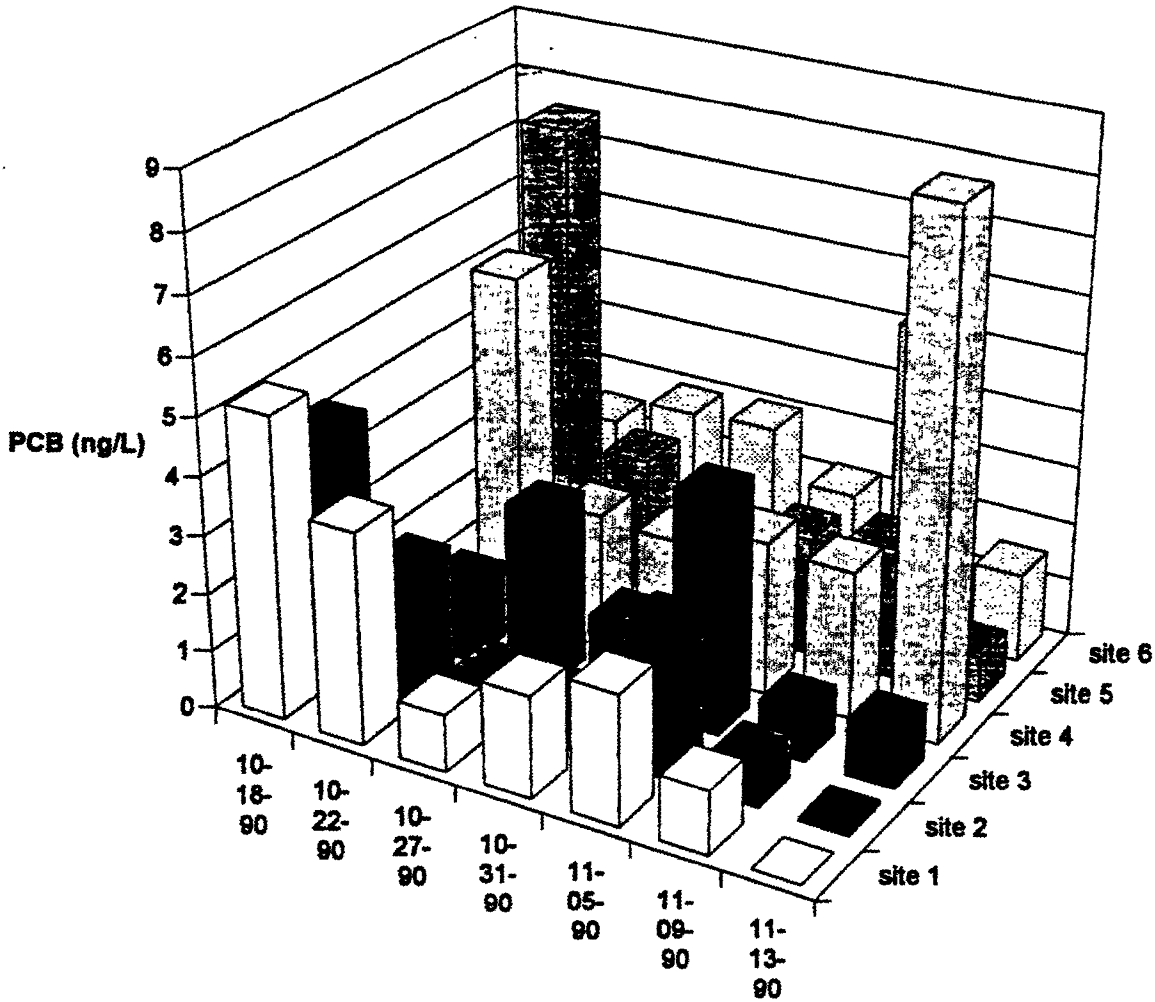


Figure B1

A-Chlordane Concentration

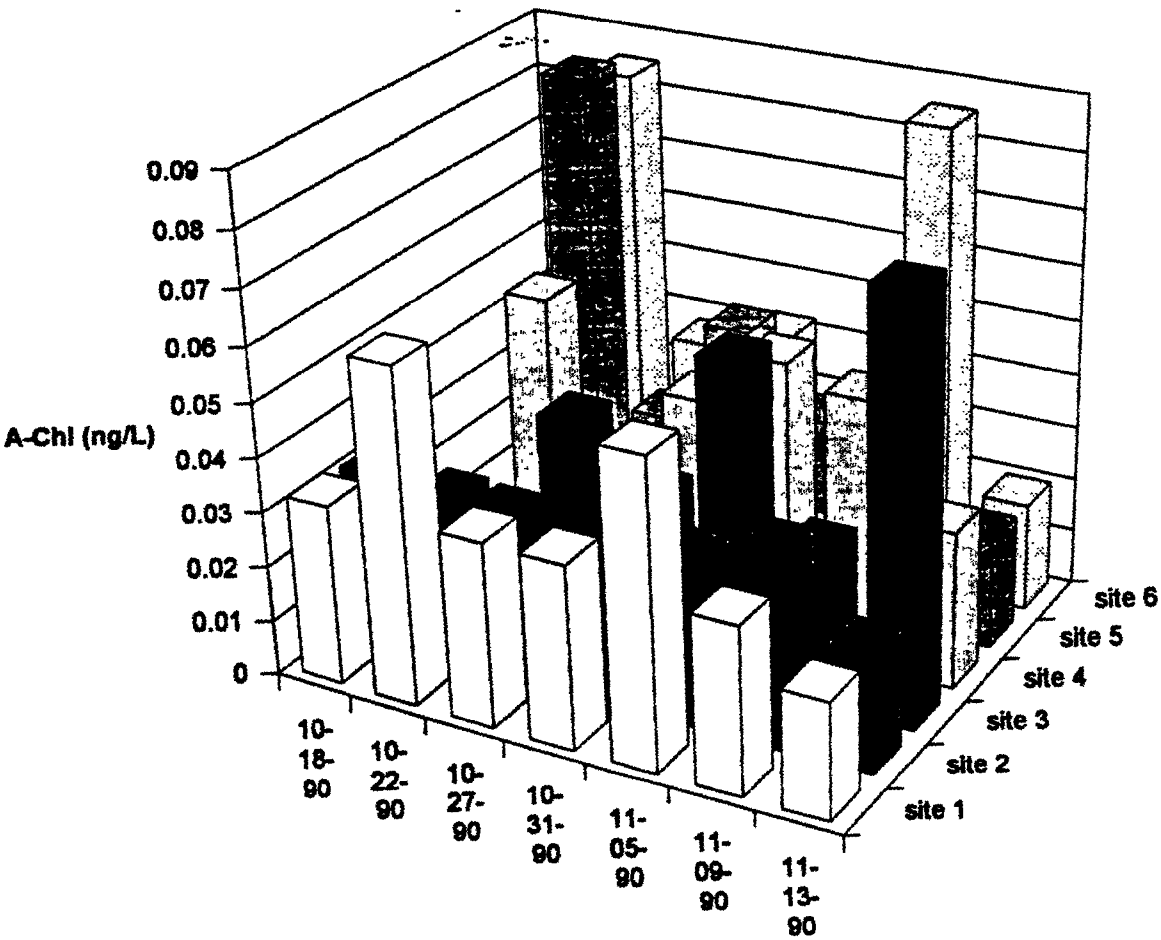


Figure B2

G-Chlordane Concentration

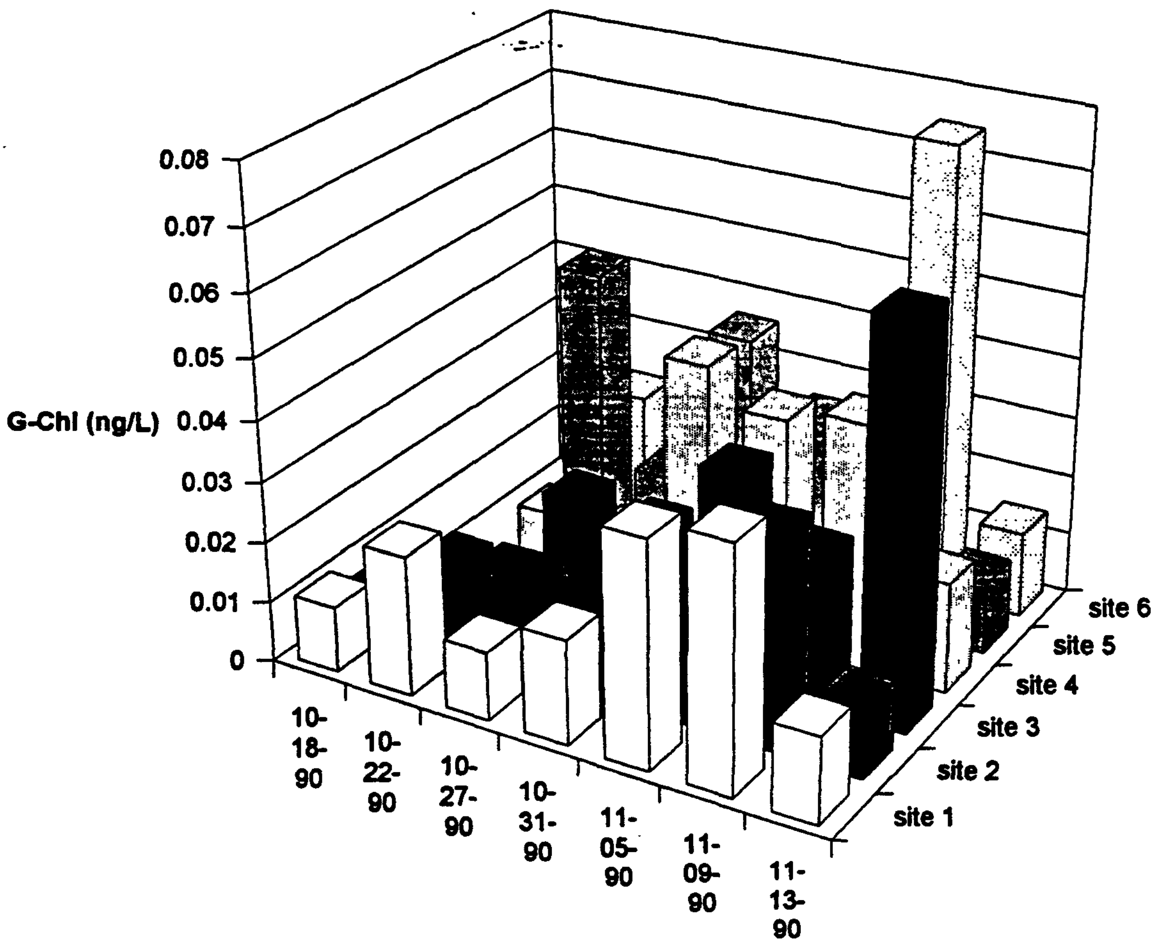


Figure B3

Dieldrin Concentration

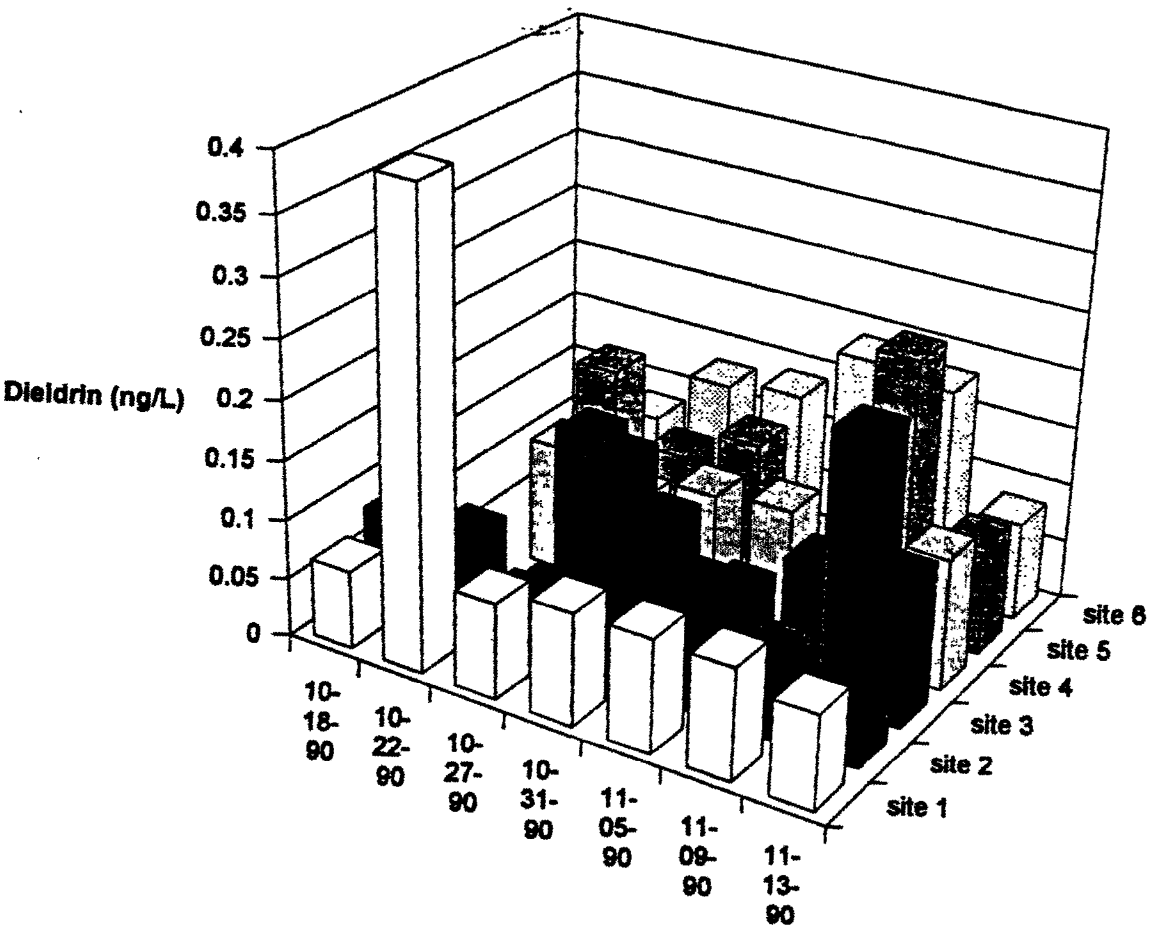


Figure E4

DDT Concentration

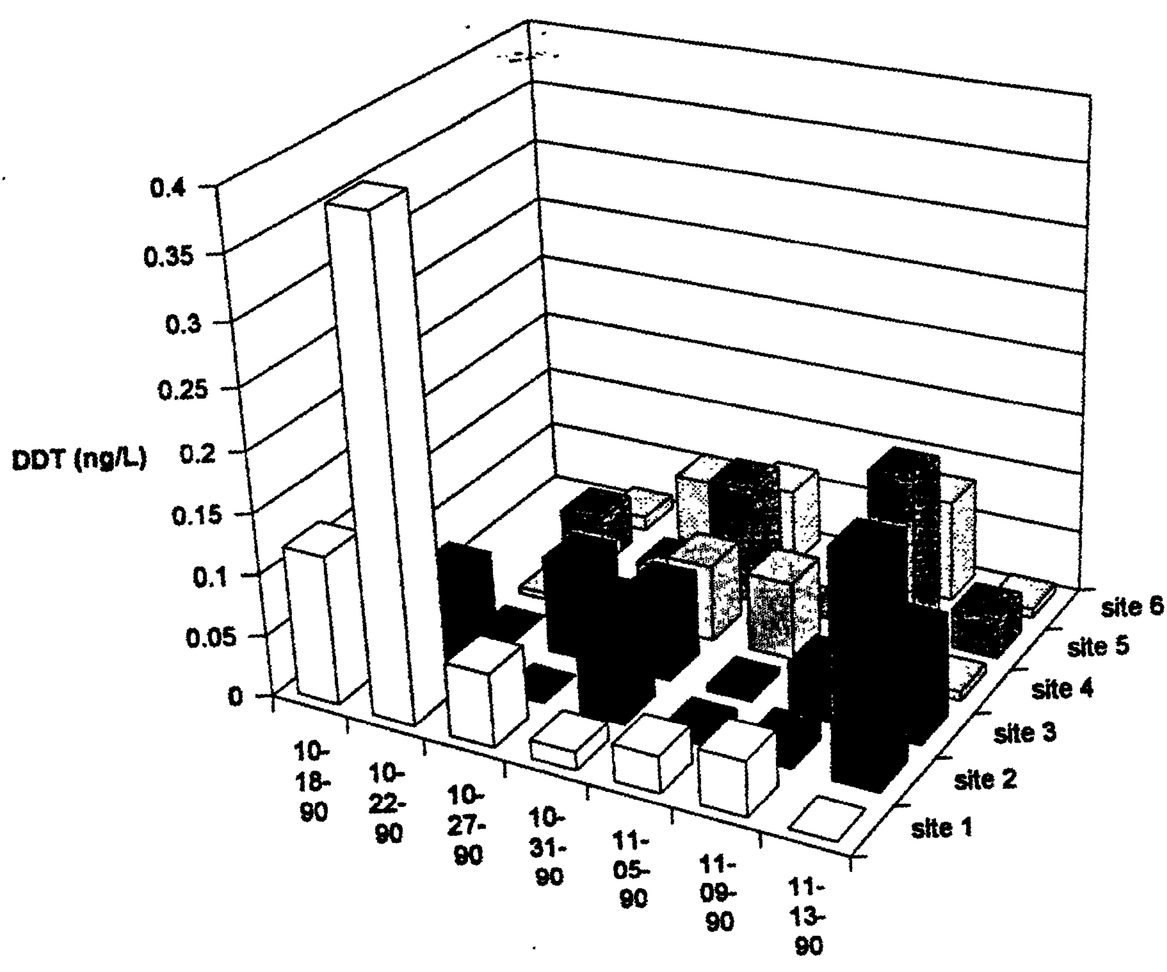


Figure B5

B[a]a Concentration

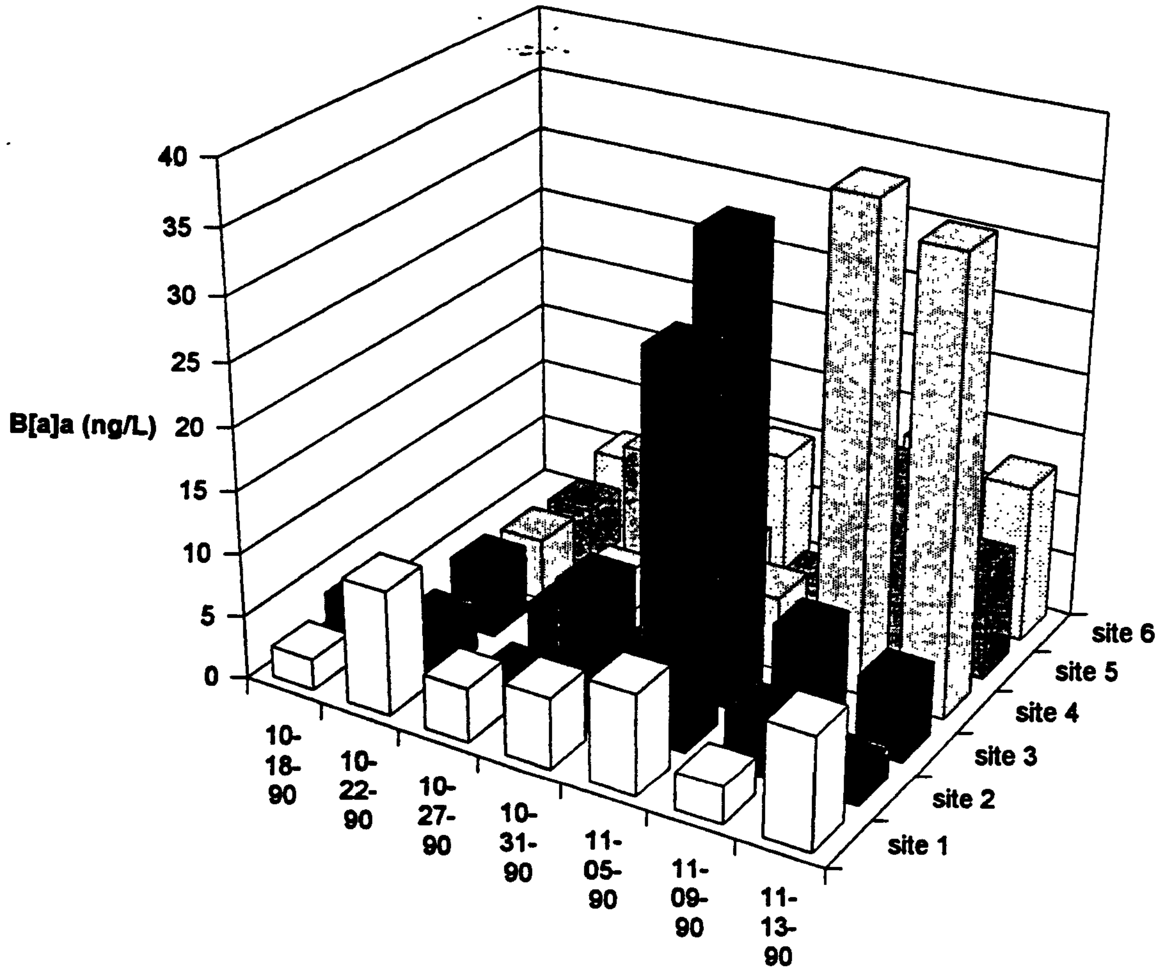


Figure B6

B[b]f Concentration

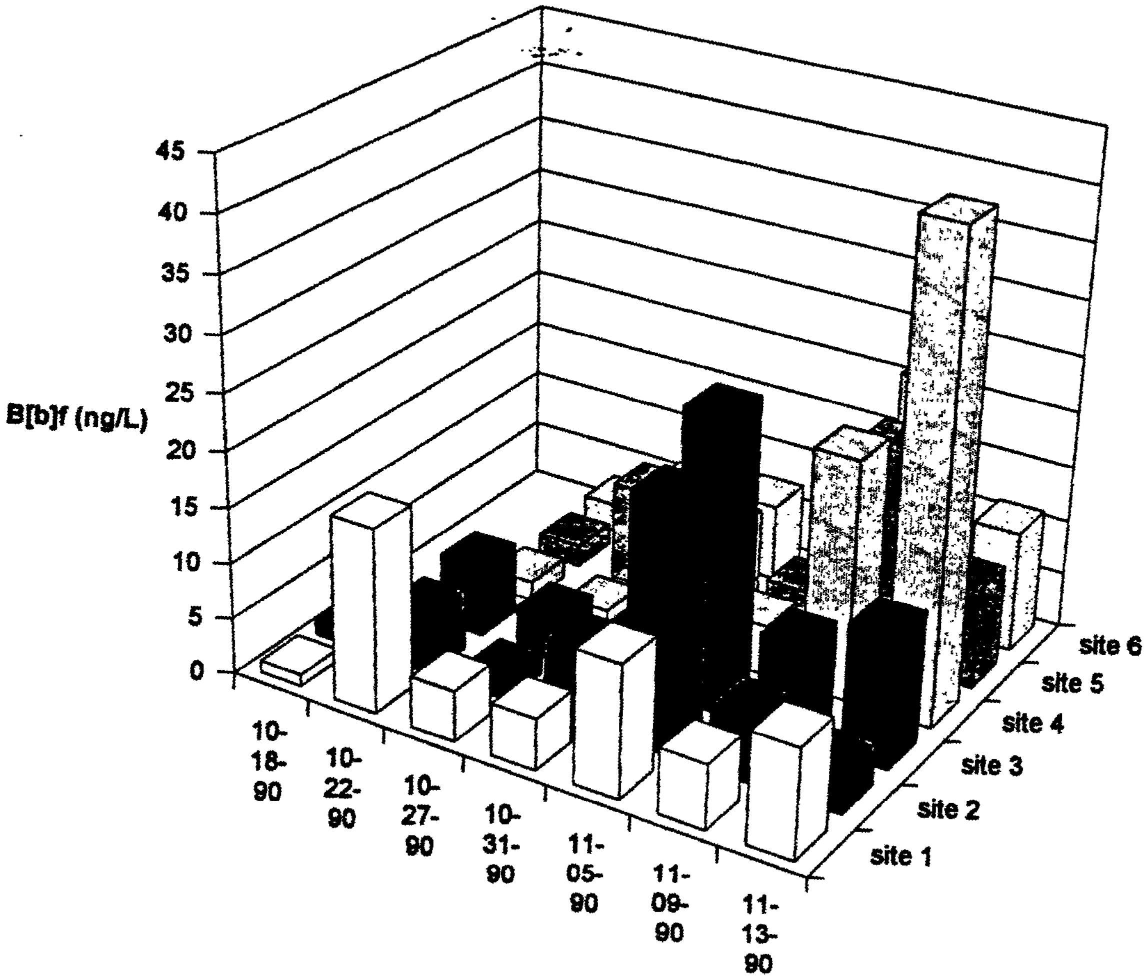


Figure B7

B[k]f Concentration

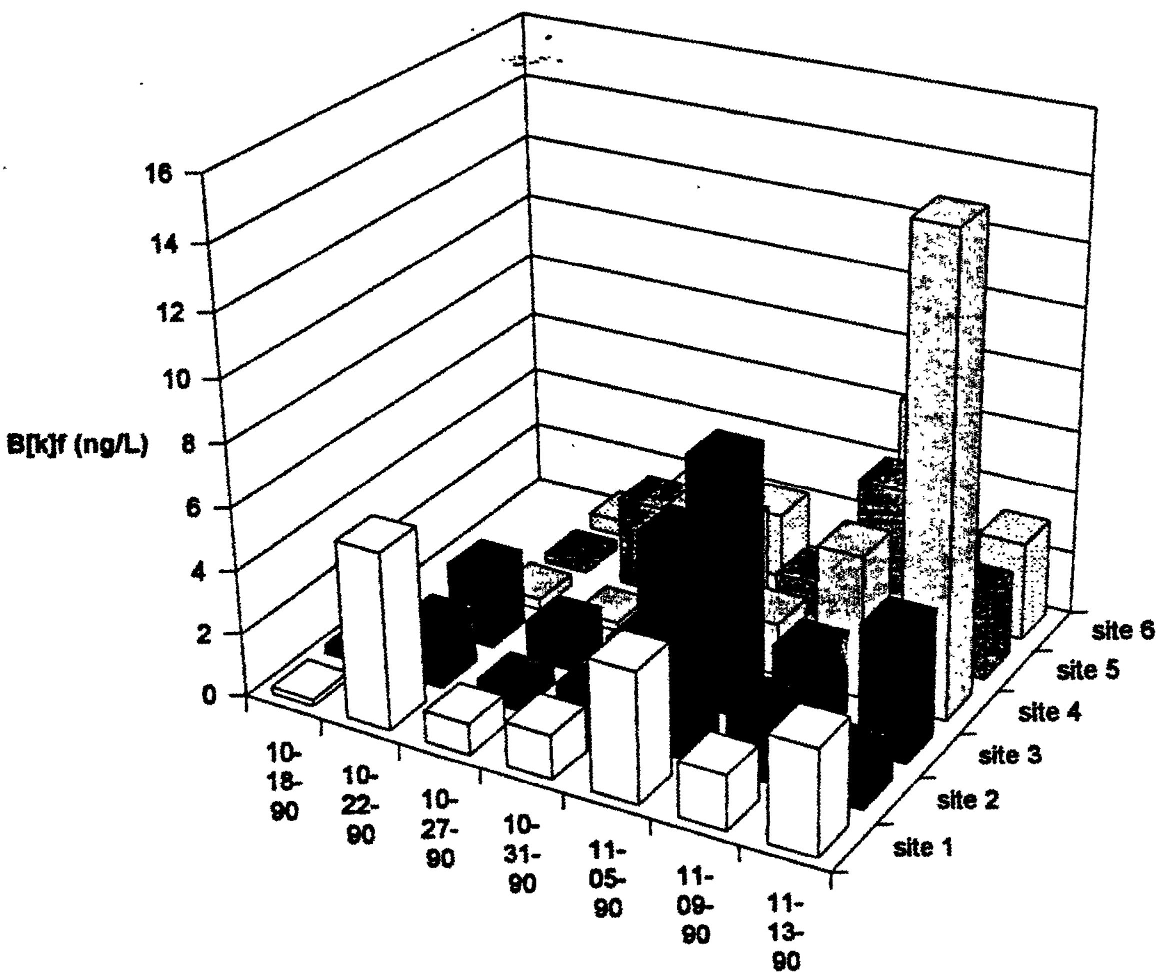


Figure B8

B[a]p Concentration

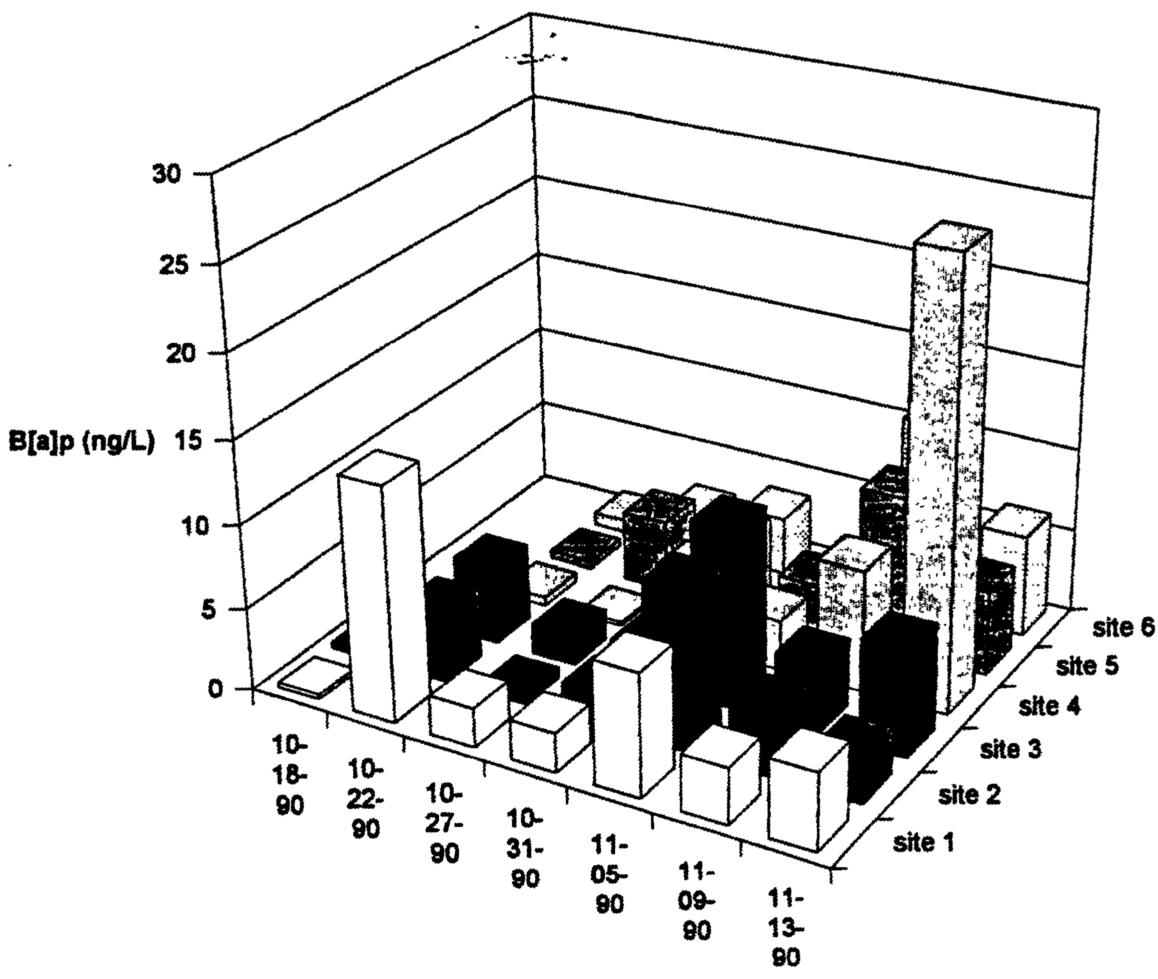


Figure B9

Chrysene Concentration

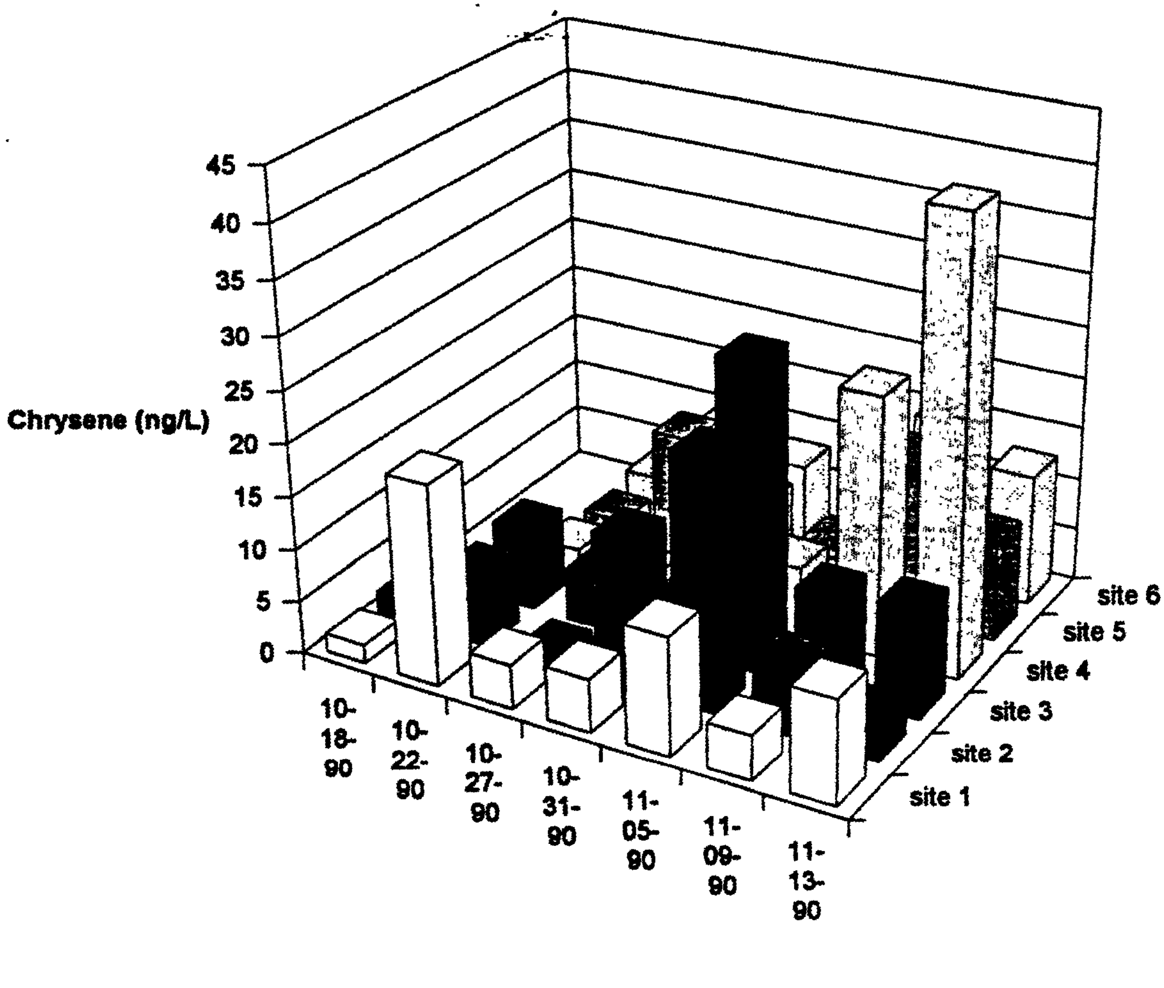


Figure B10

Lead Concentration

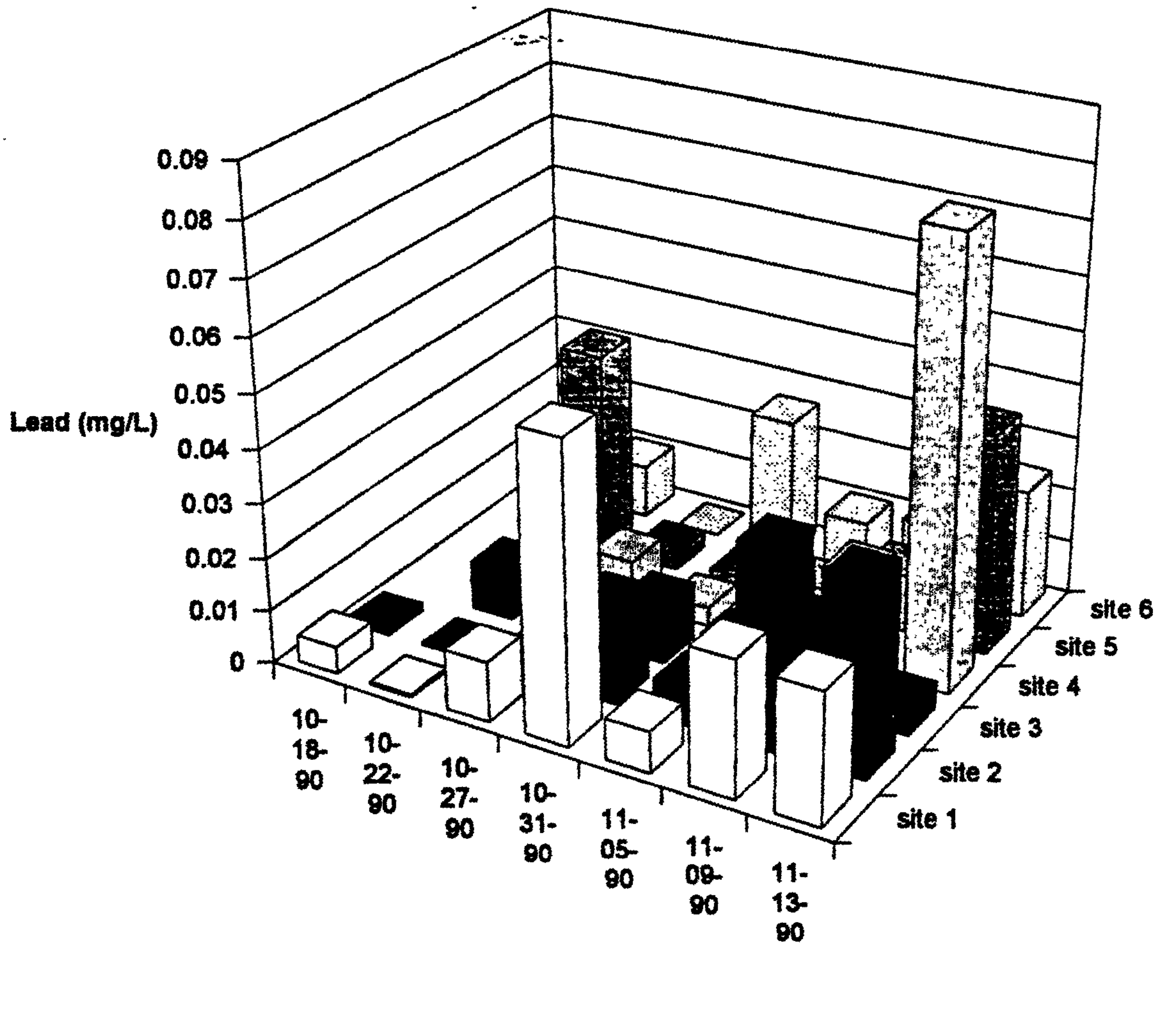


Figure B11

Copper Concentration

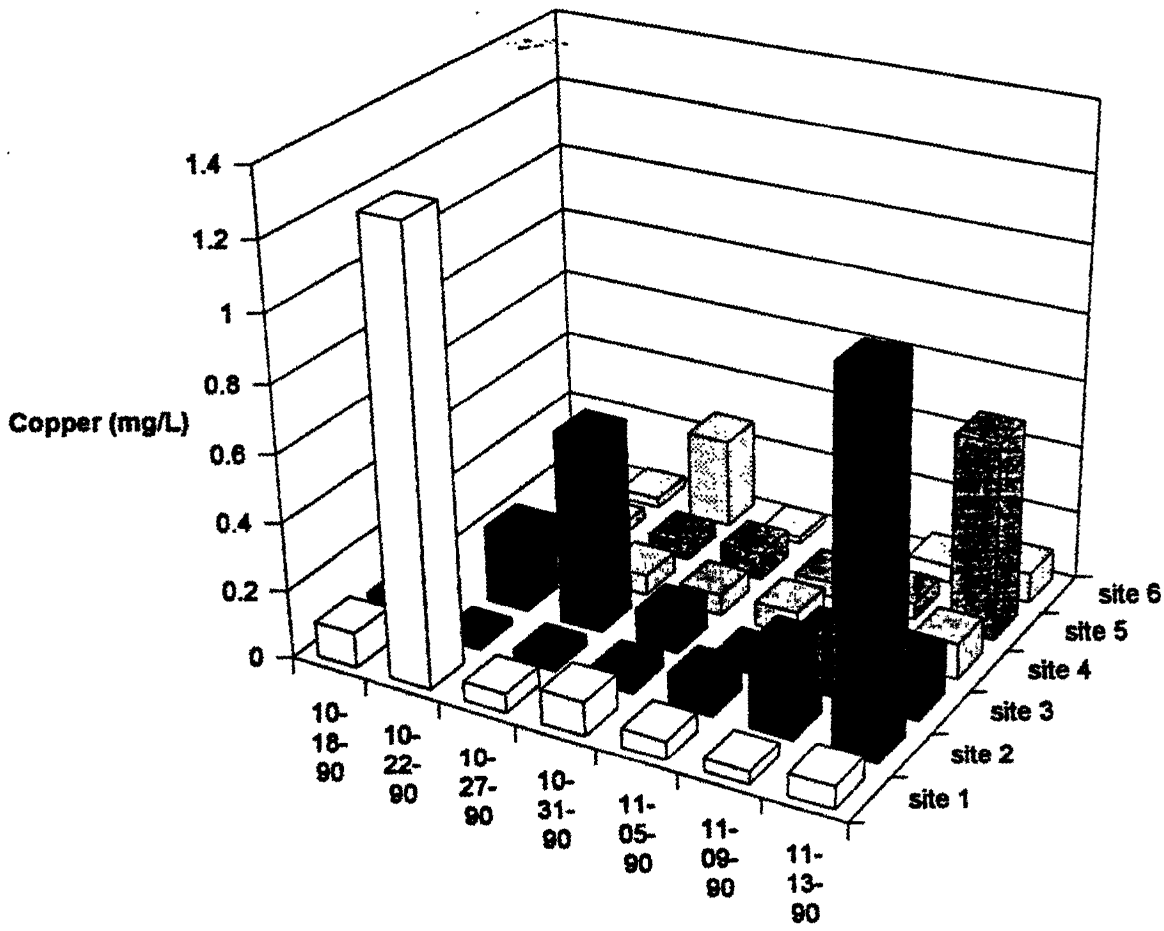


Figure B12

Total PCBs Concentration

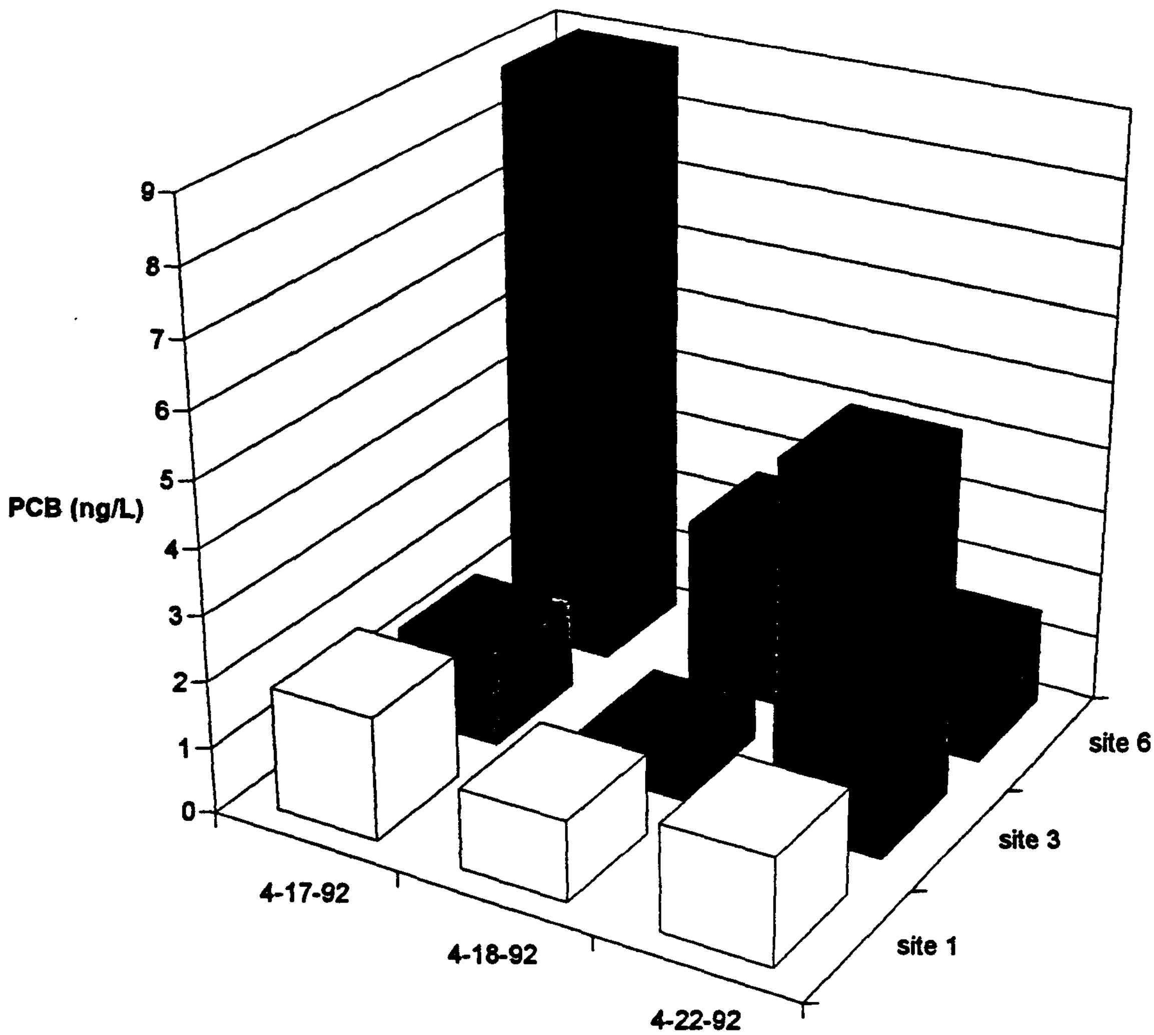


Figure B13

A-Chlordane Concentration

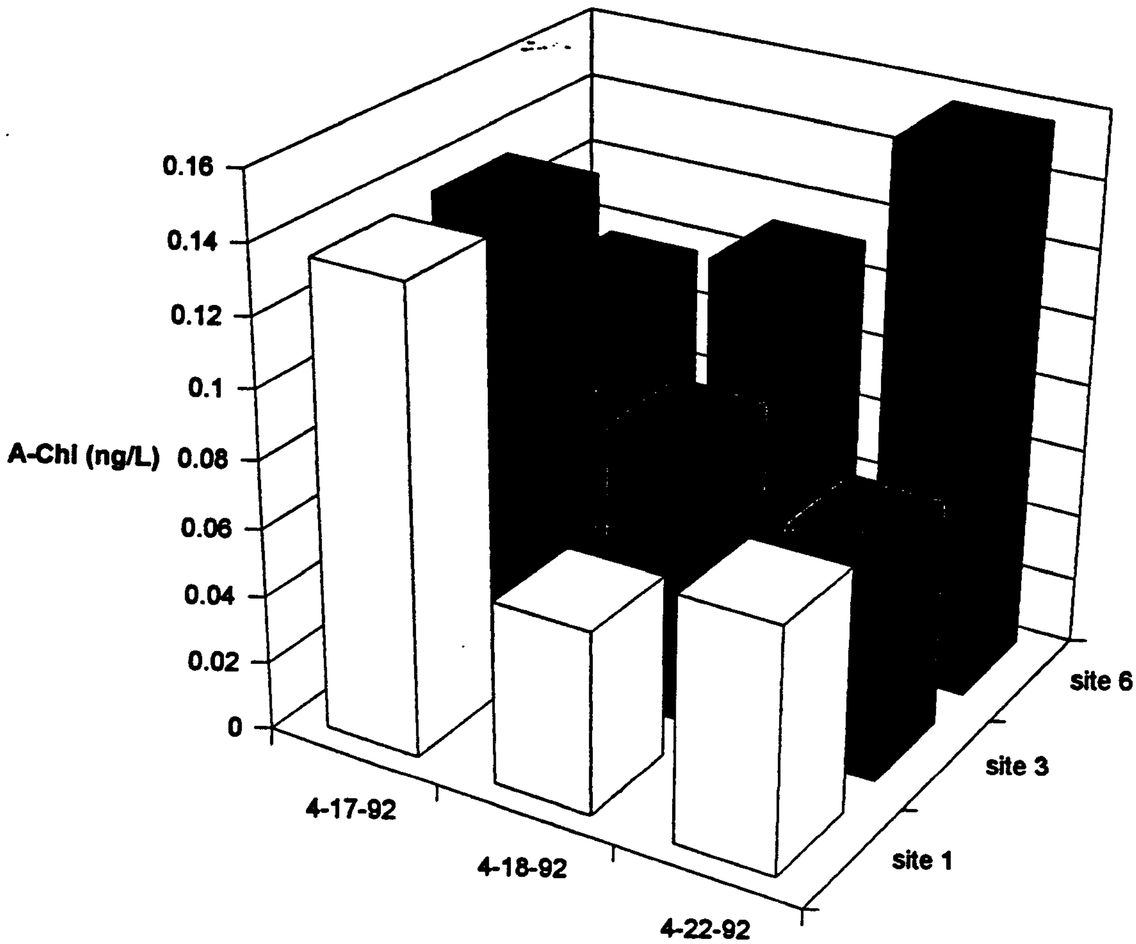


Figure B14

G-Chlordane Concentration

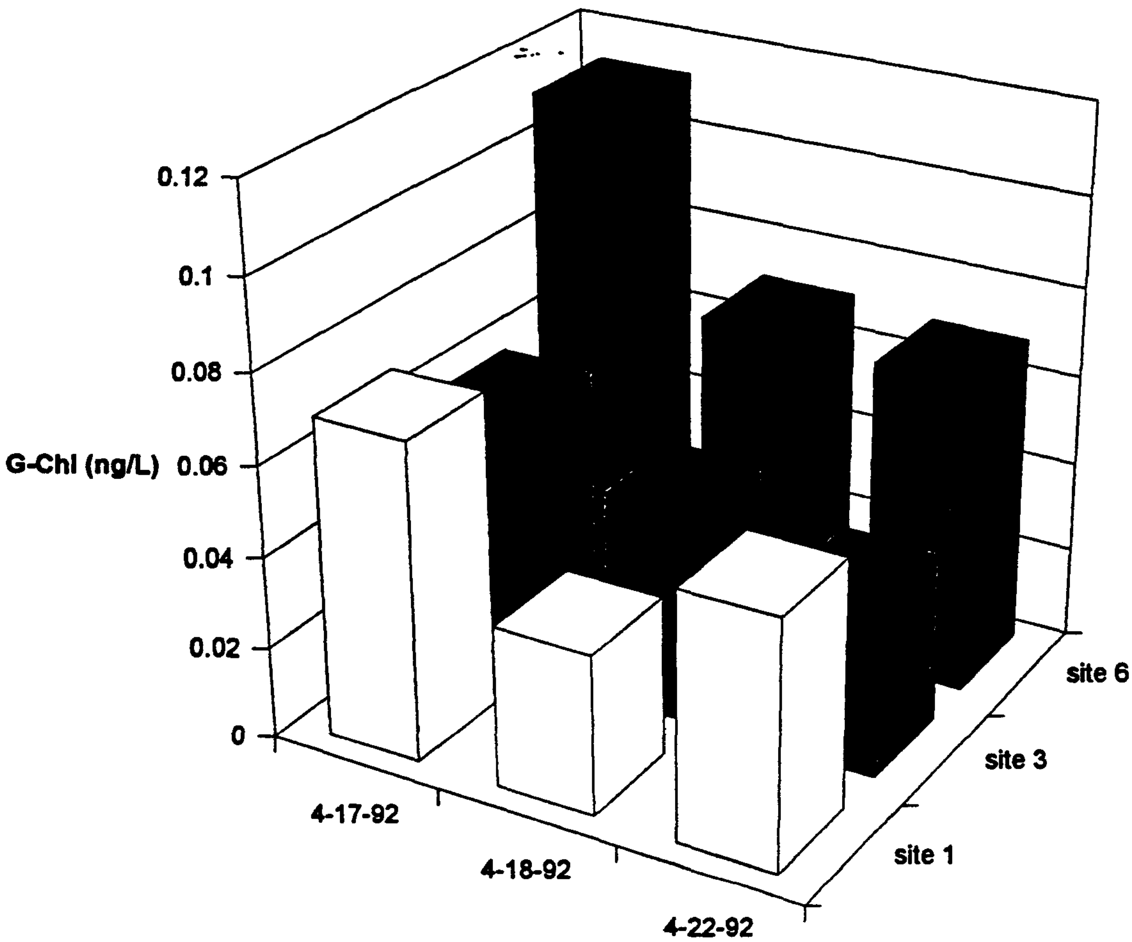


Figure B15

Dieldrin Concentration

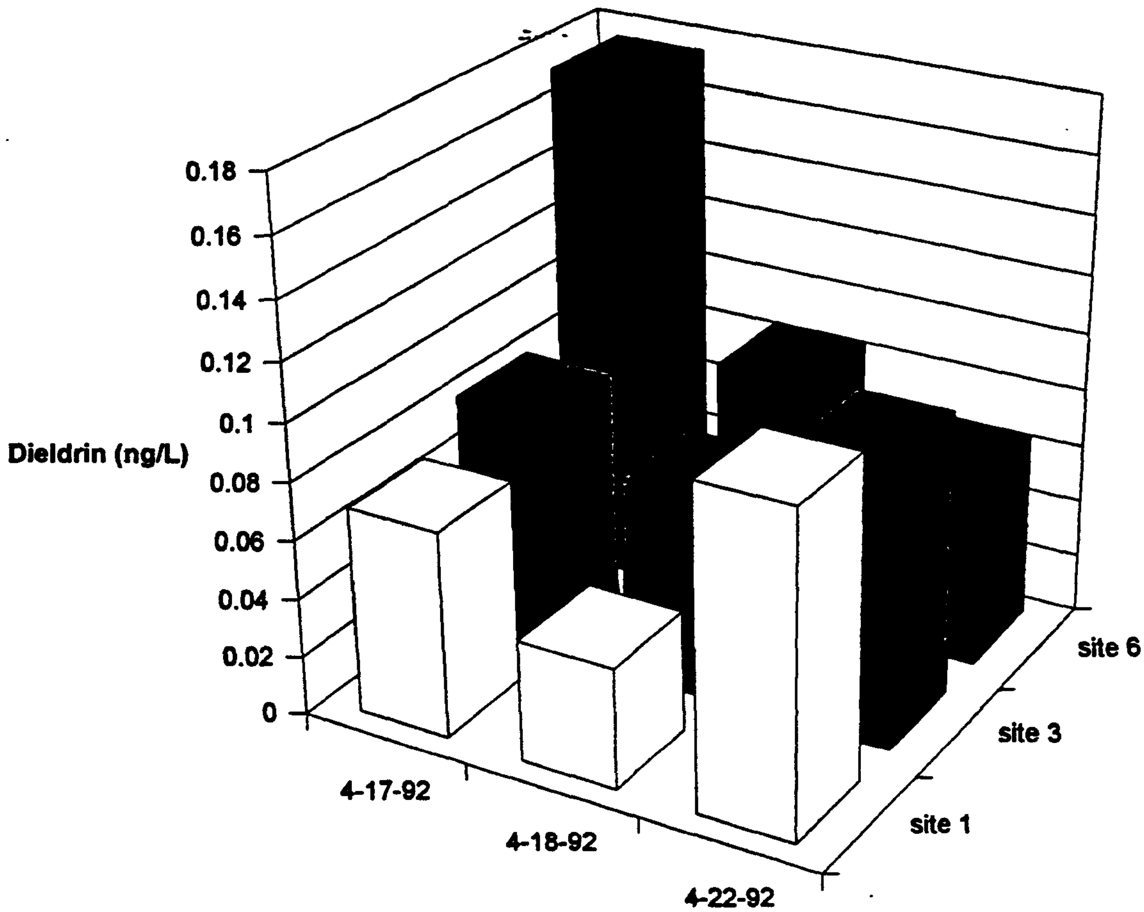


Figure B16

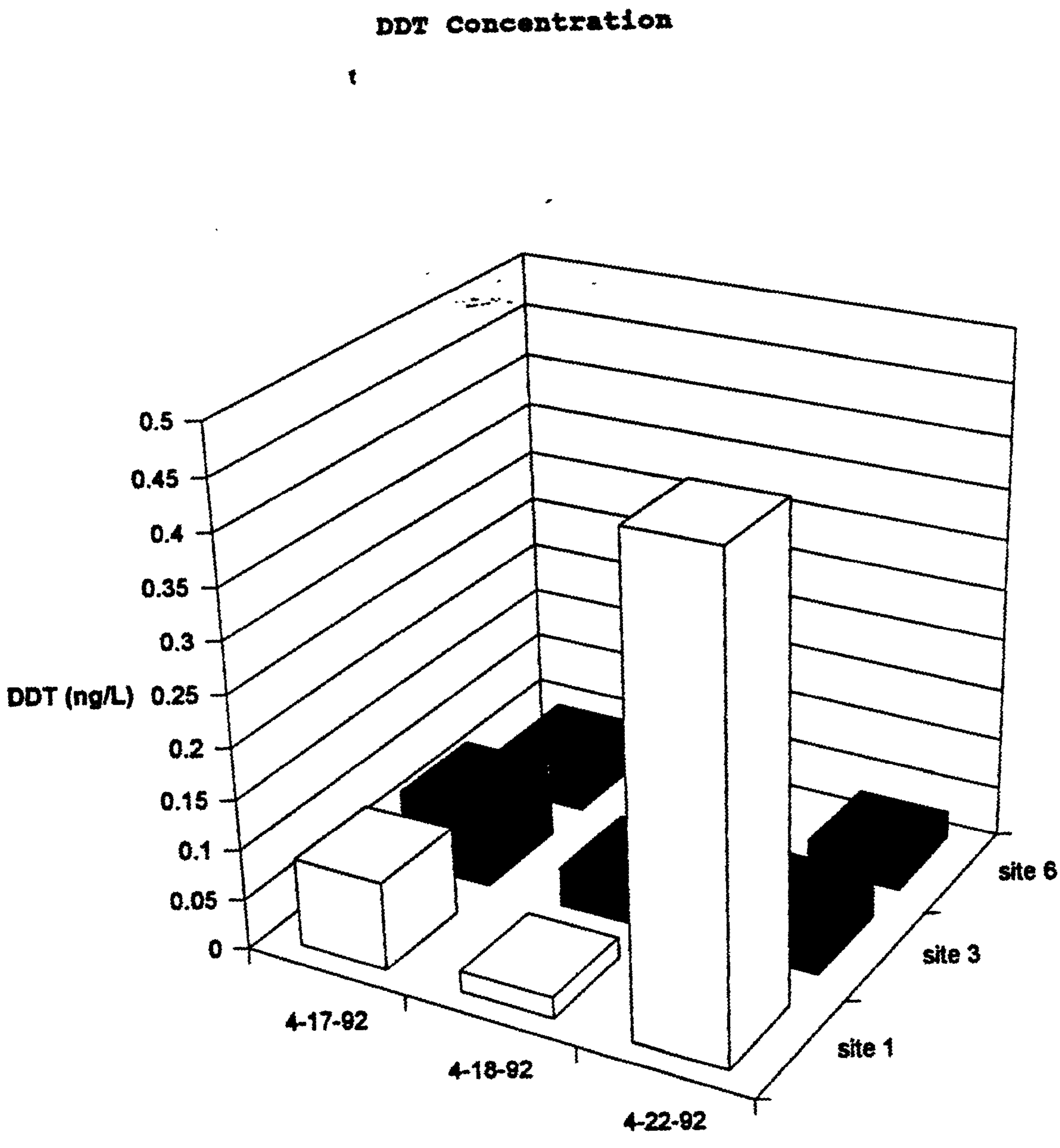

DDT Concentration
DDT (ng/L)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
4-17-92
4-18-92
4-22-92
site 1
site 3
site 6

Figure B17

B[a]a Concentration

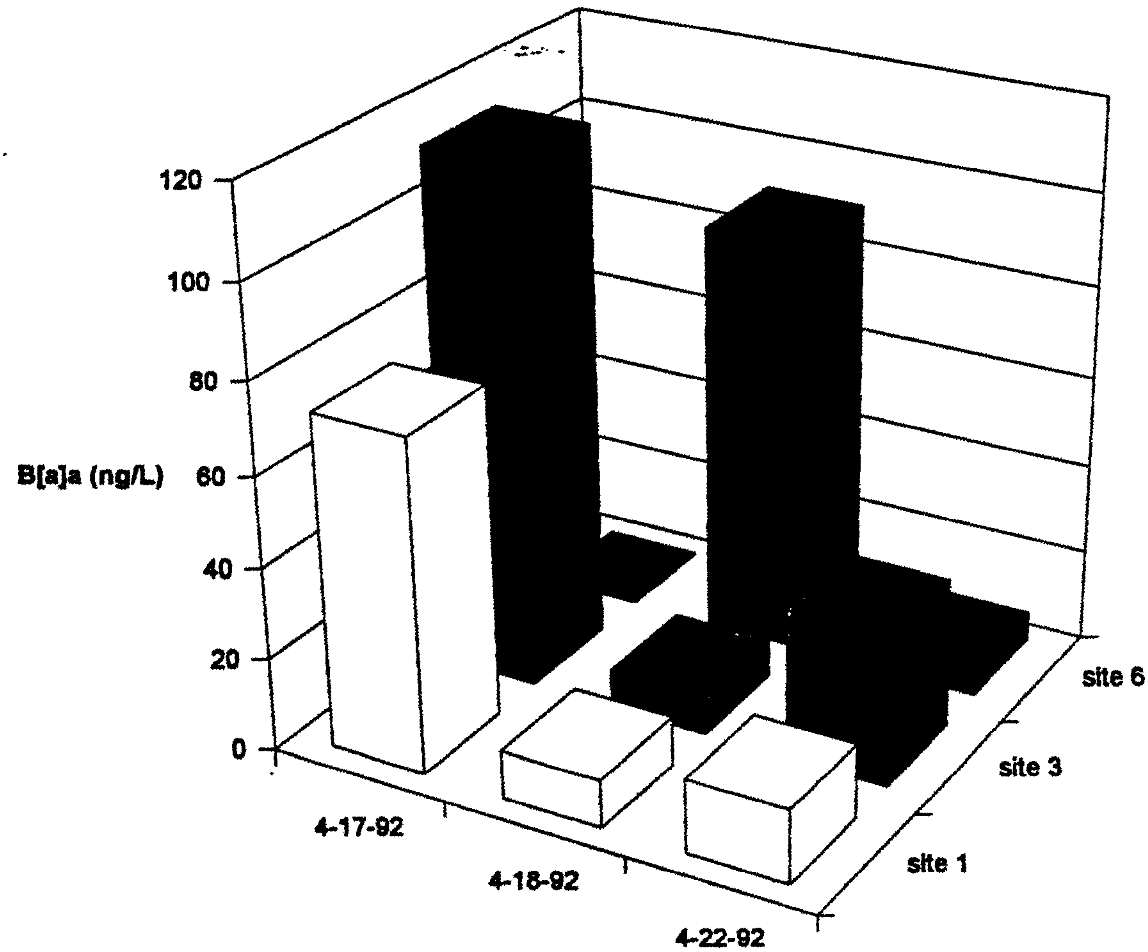


Figure B18

B[b]f Concentration

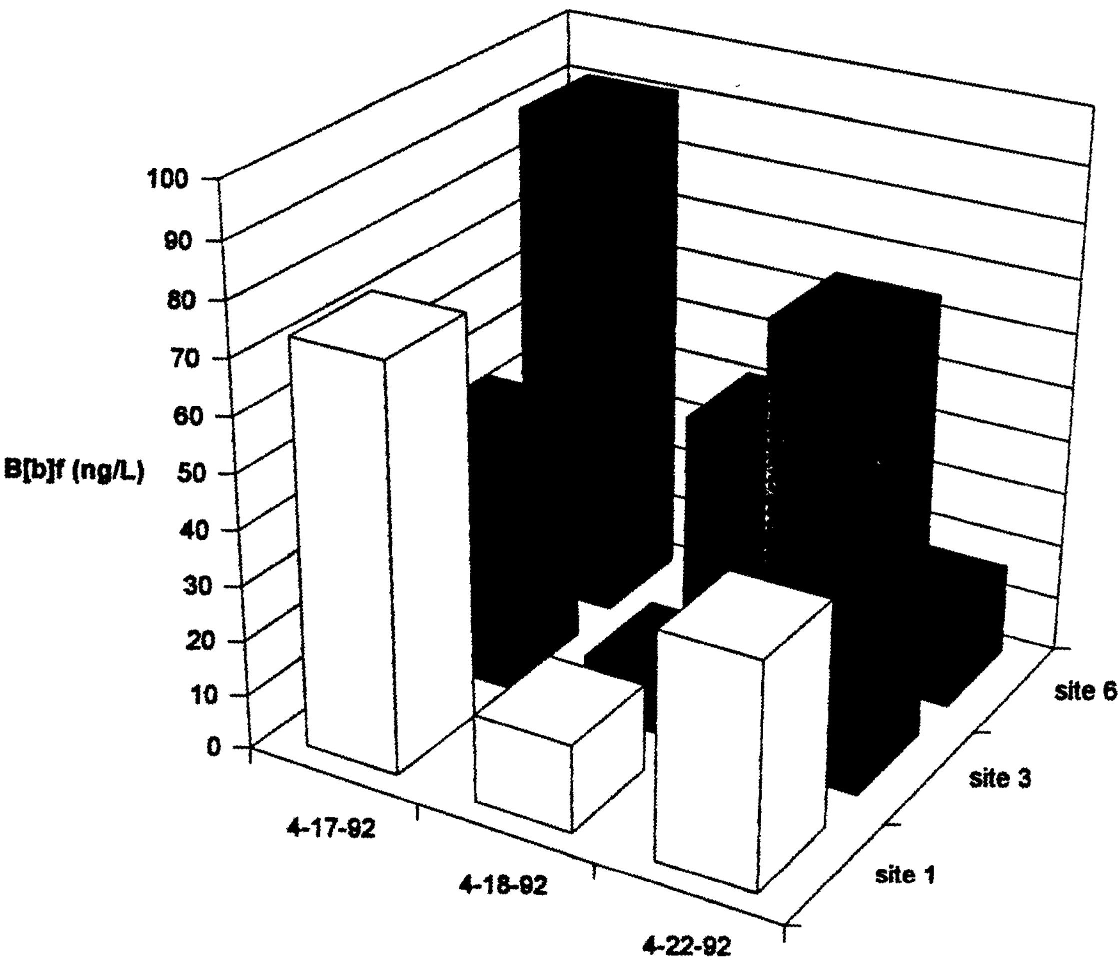


Figure B19

B[k]f Concentration

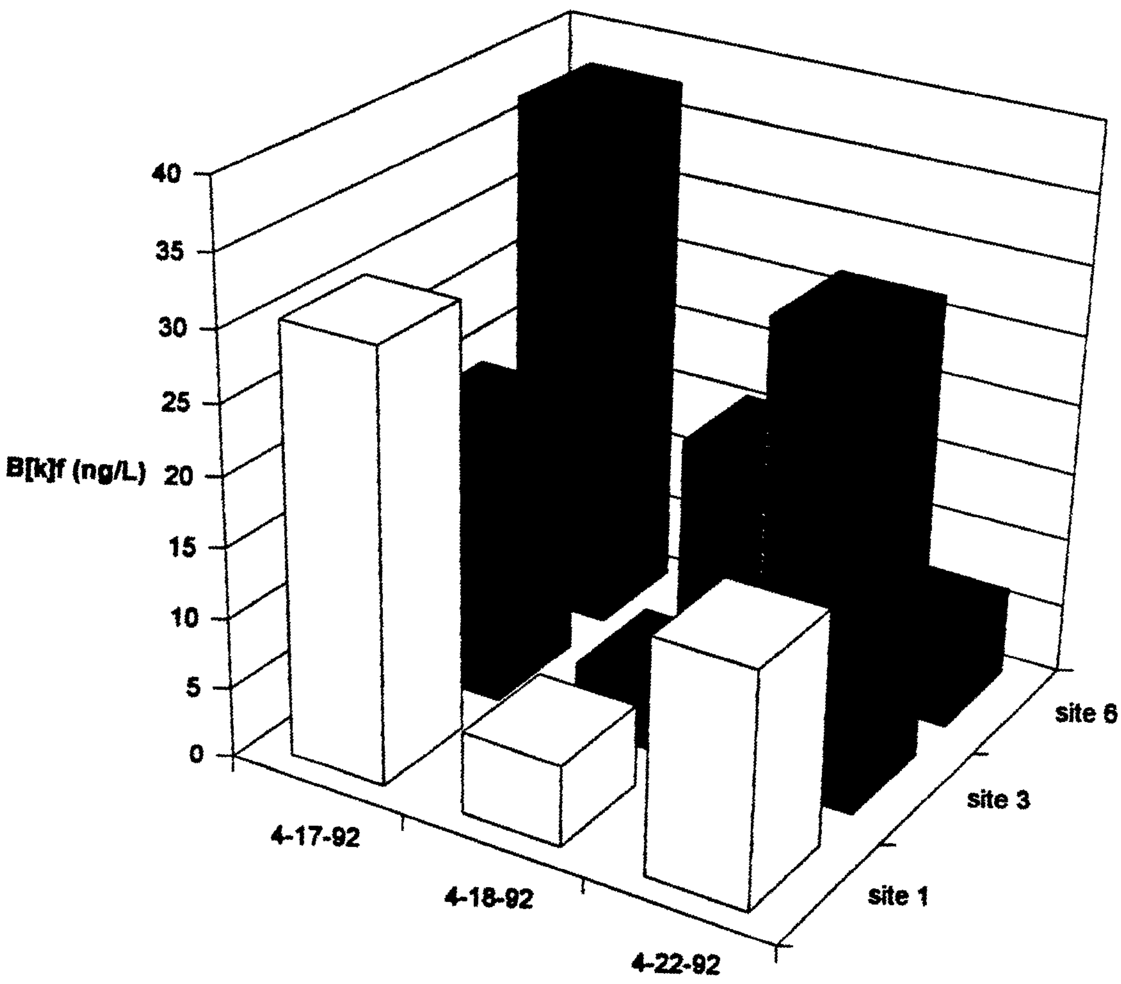


Figure B20

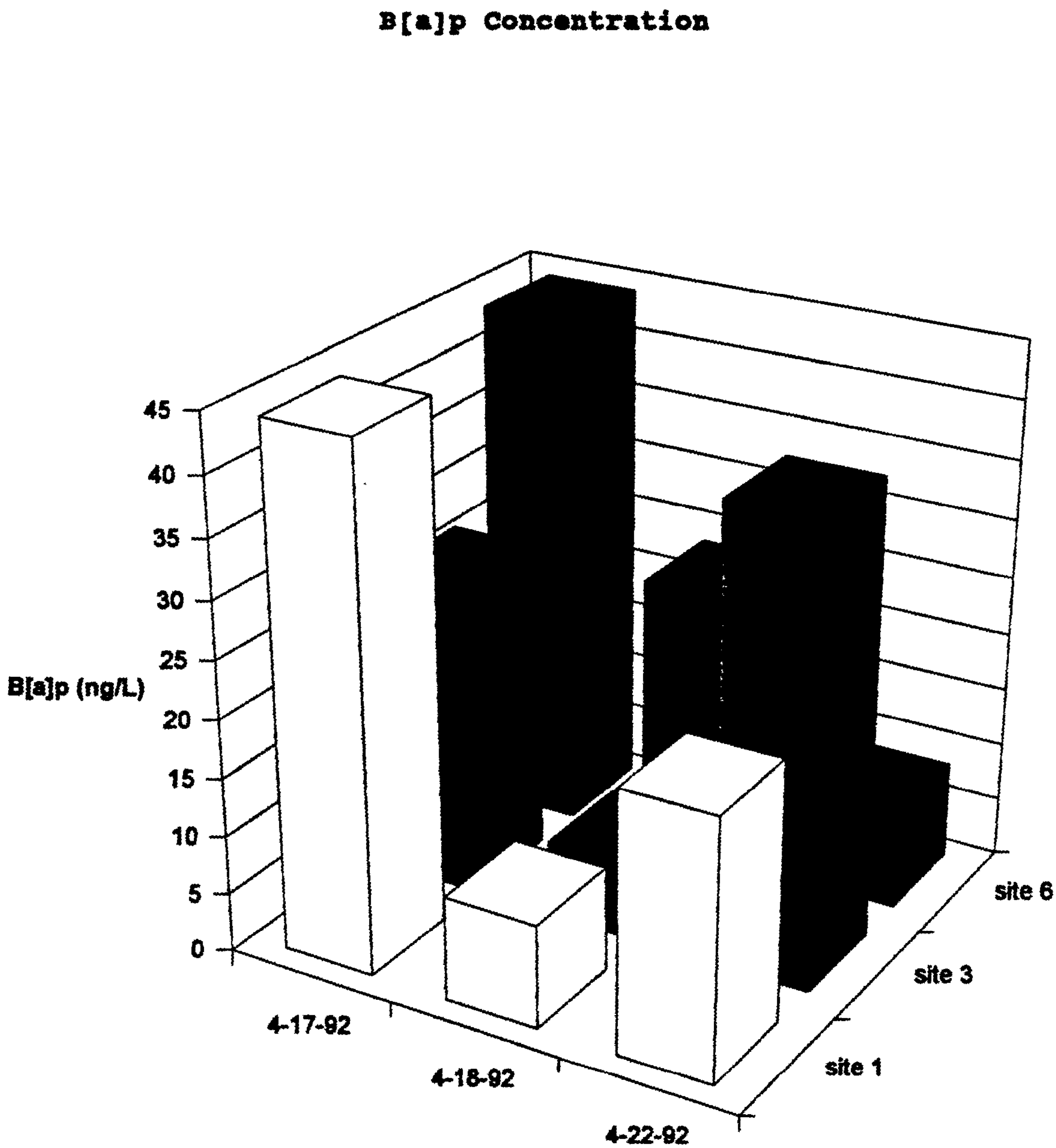

B[a]p Concentration
45
40
35
30
25
20
15
10
5
0
B[a]p (ng/L)
4-17-92
4-18-92
4-22-92
site 1
site 3
site 6

Figure B21

Chrysene Concentration

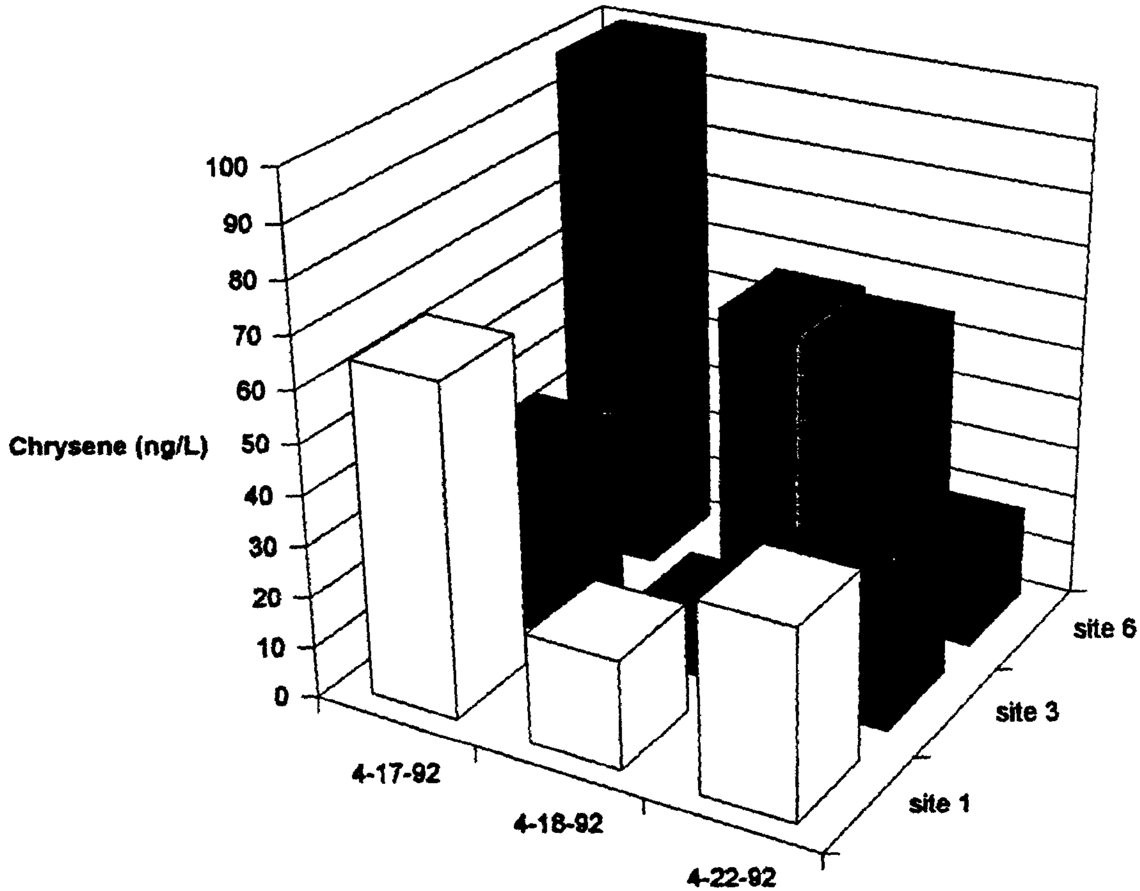


Figure B22

Lead Concentration

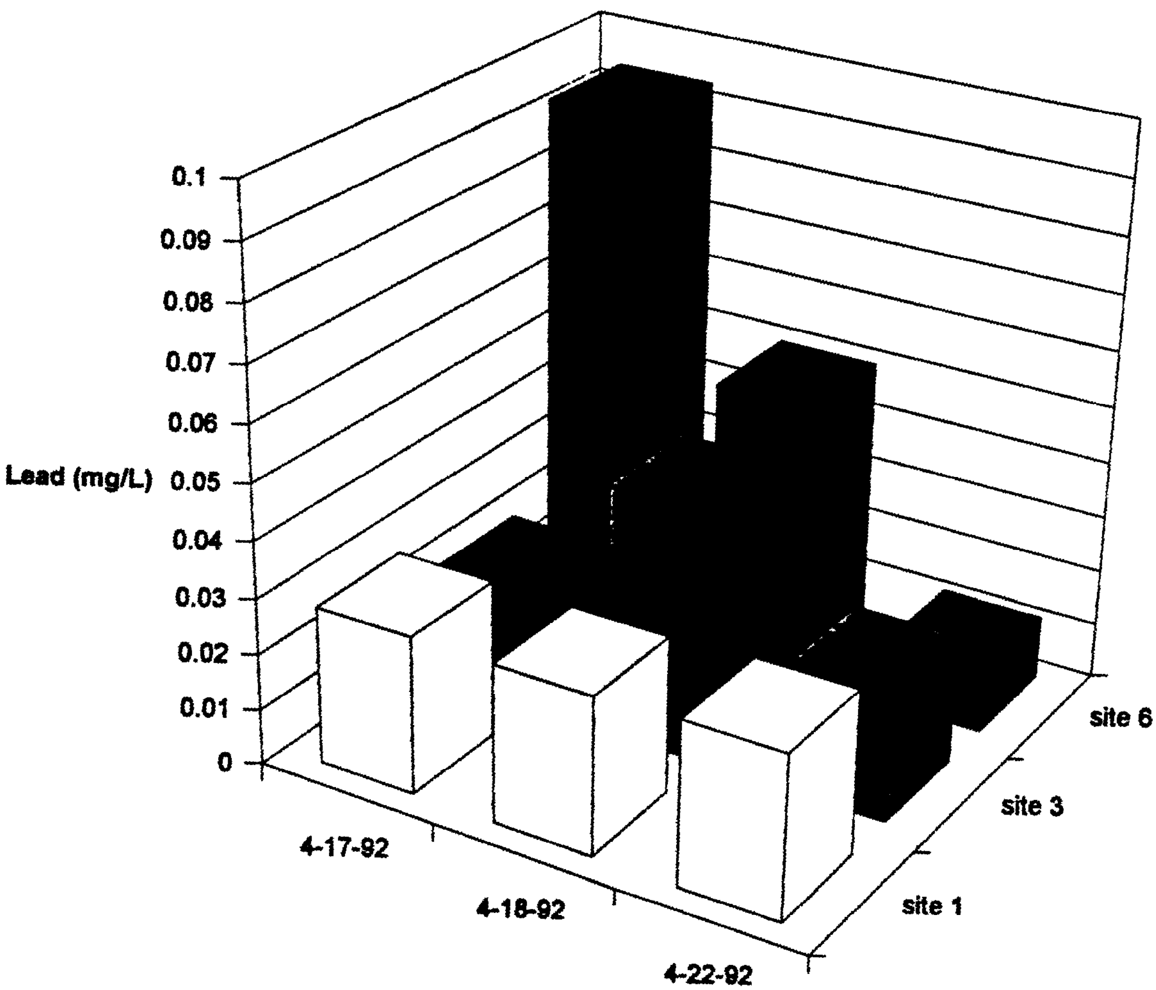


Figure B23

Copper Concentration

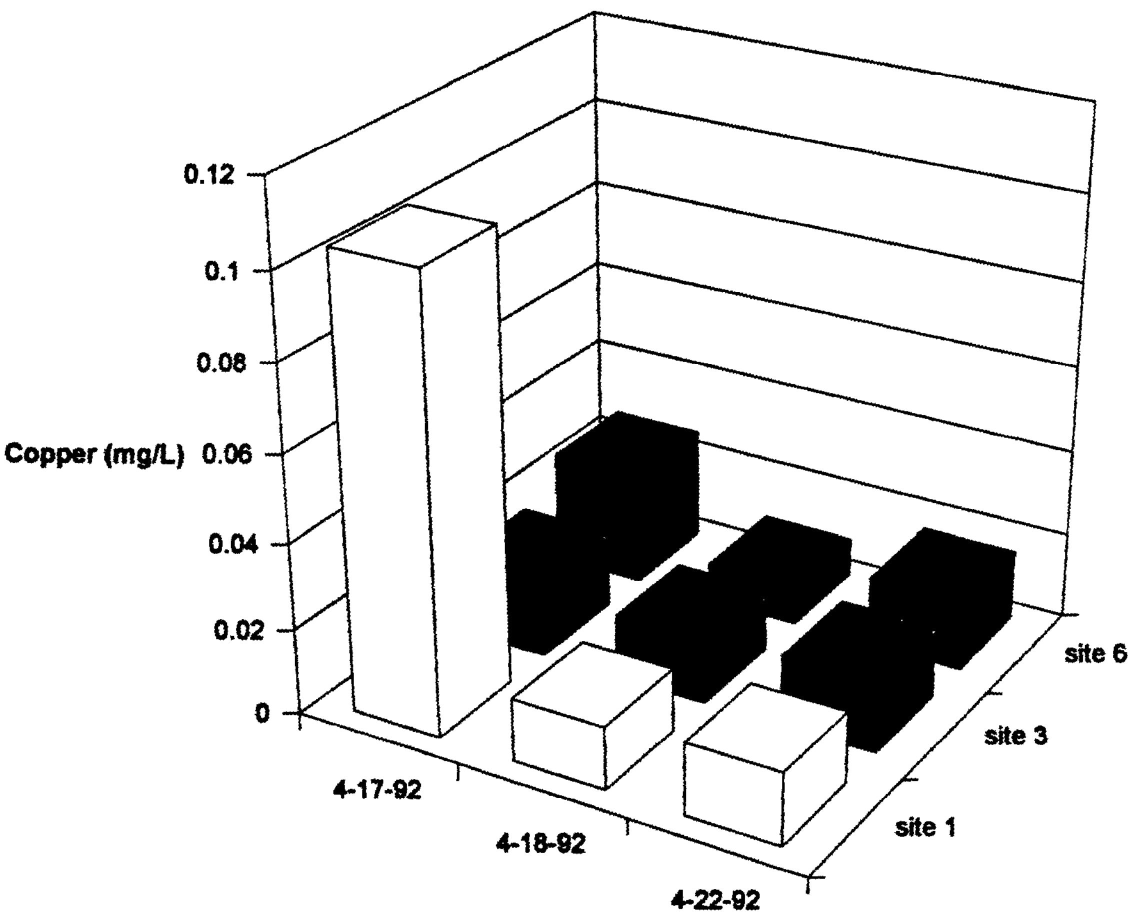


Figure B24

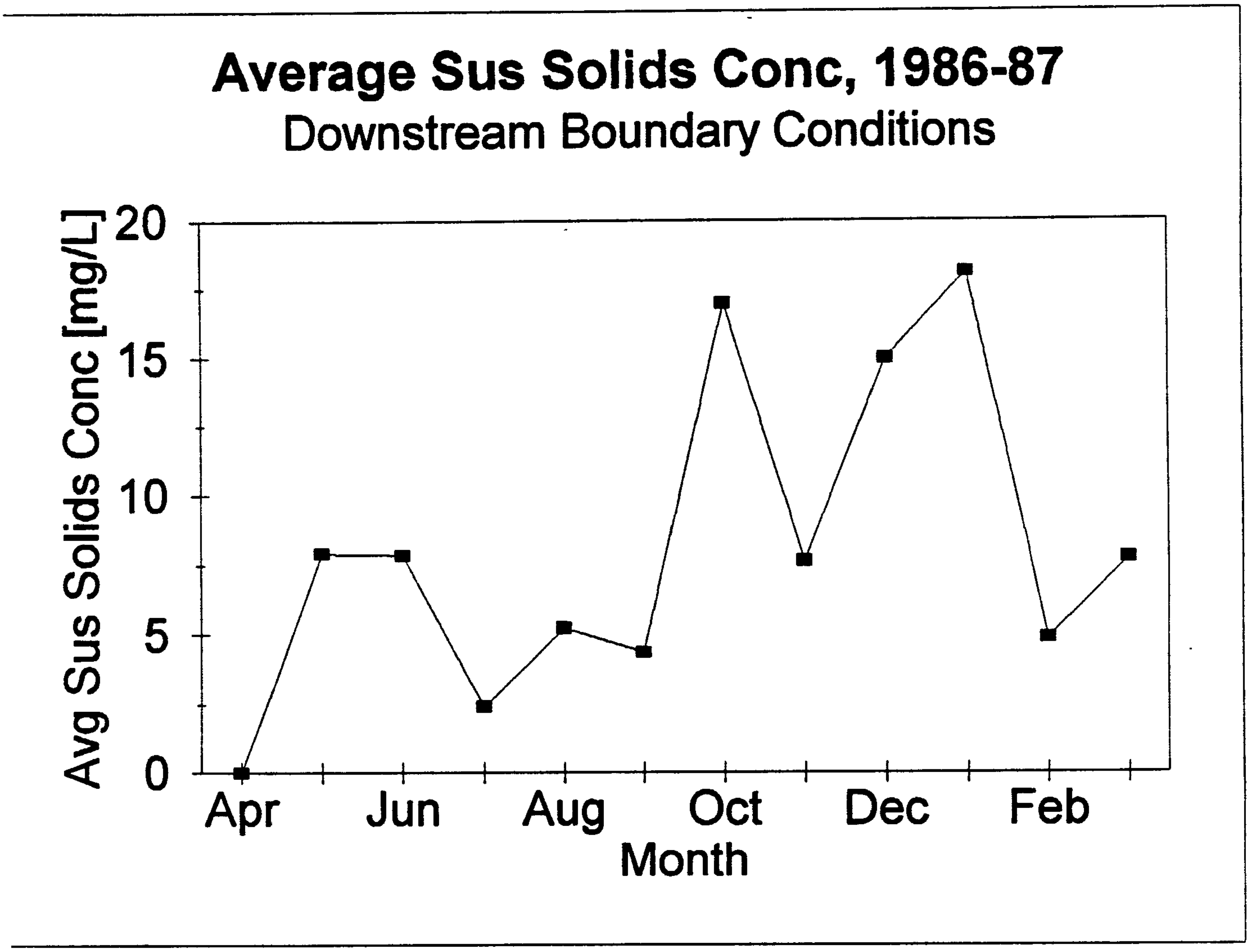

Average Sus Solids Conc, 1986-87
Downstream Boundary Conditions
Avg Sus Solids Conc [mg/L]
20
15
10
5
0
Apr
Jun
Aug
Oct
Dec
Feb
Month

Figure B25

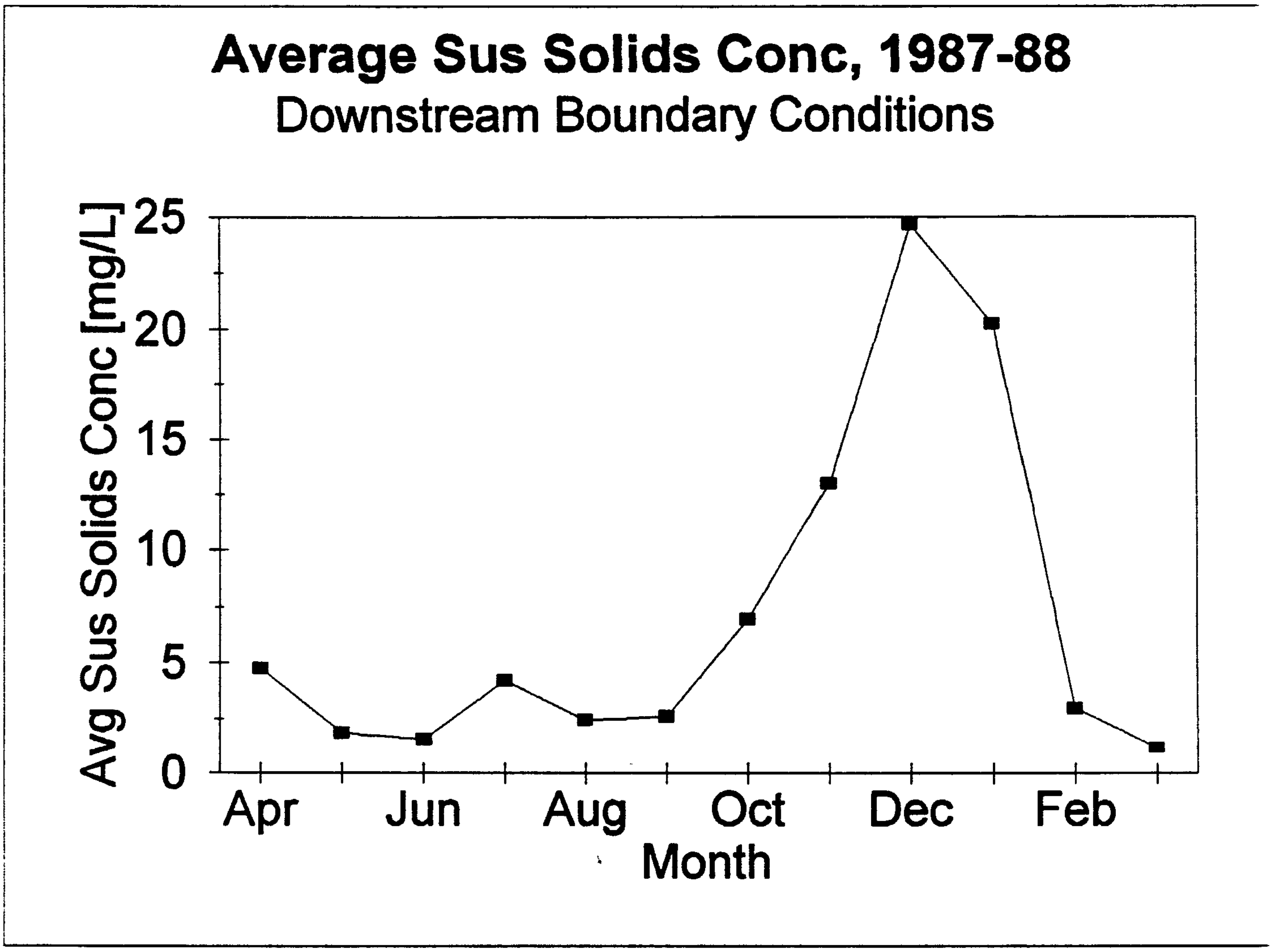

Average Sus Solids Conc, 1987-88
Downstream Boundary Conditions
Avg Sus Solids Conc [mg/L]
25
20
15
10
5
0
Apr
Jun
Aug
Oct
Dec
Feb
Month

Figure B26

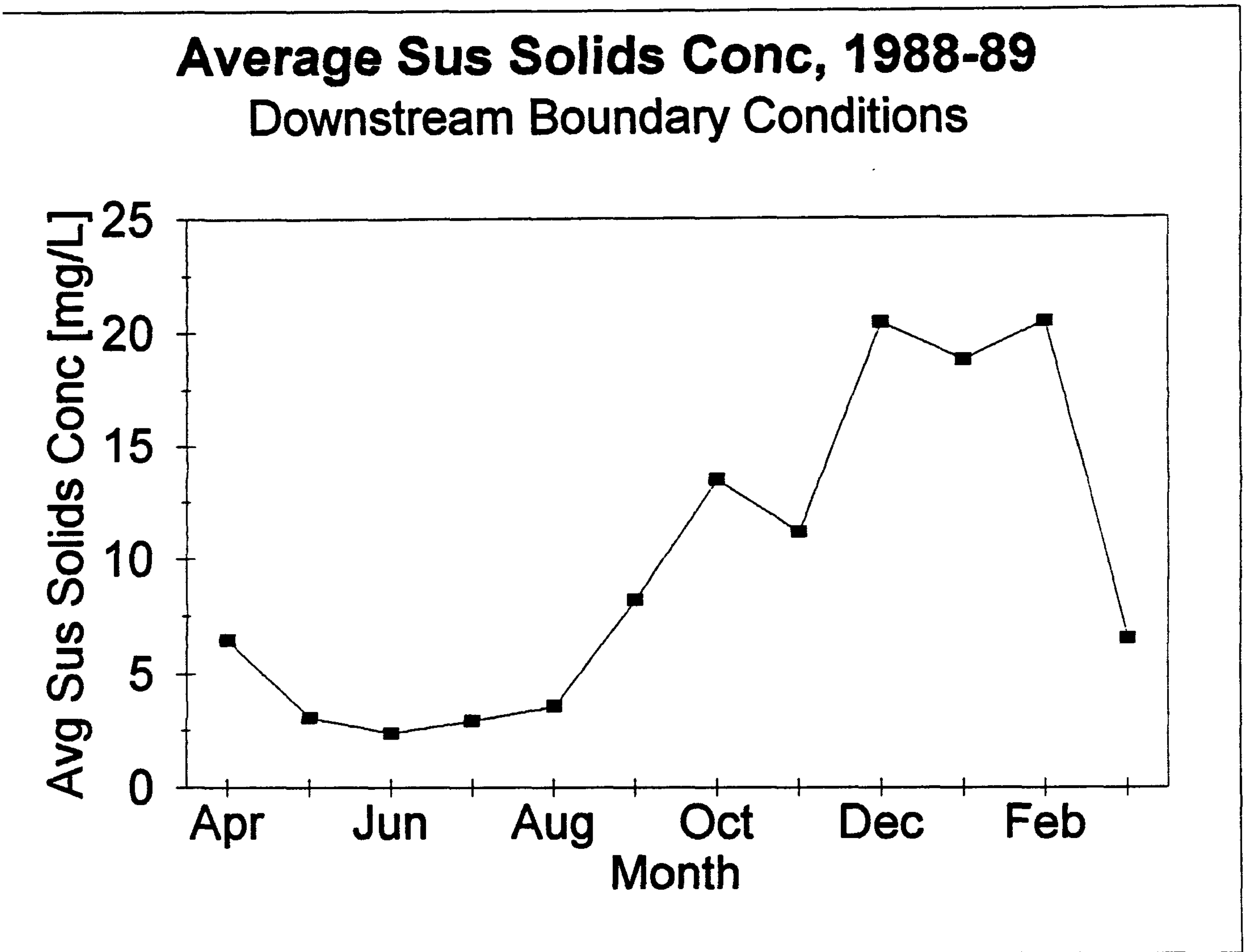
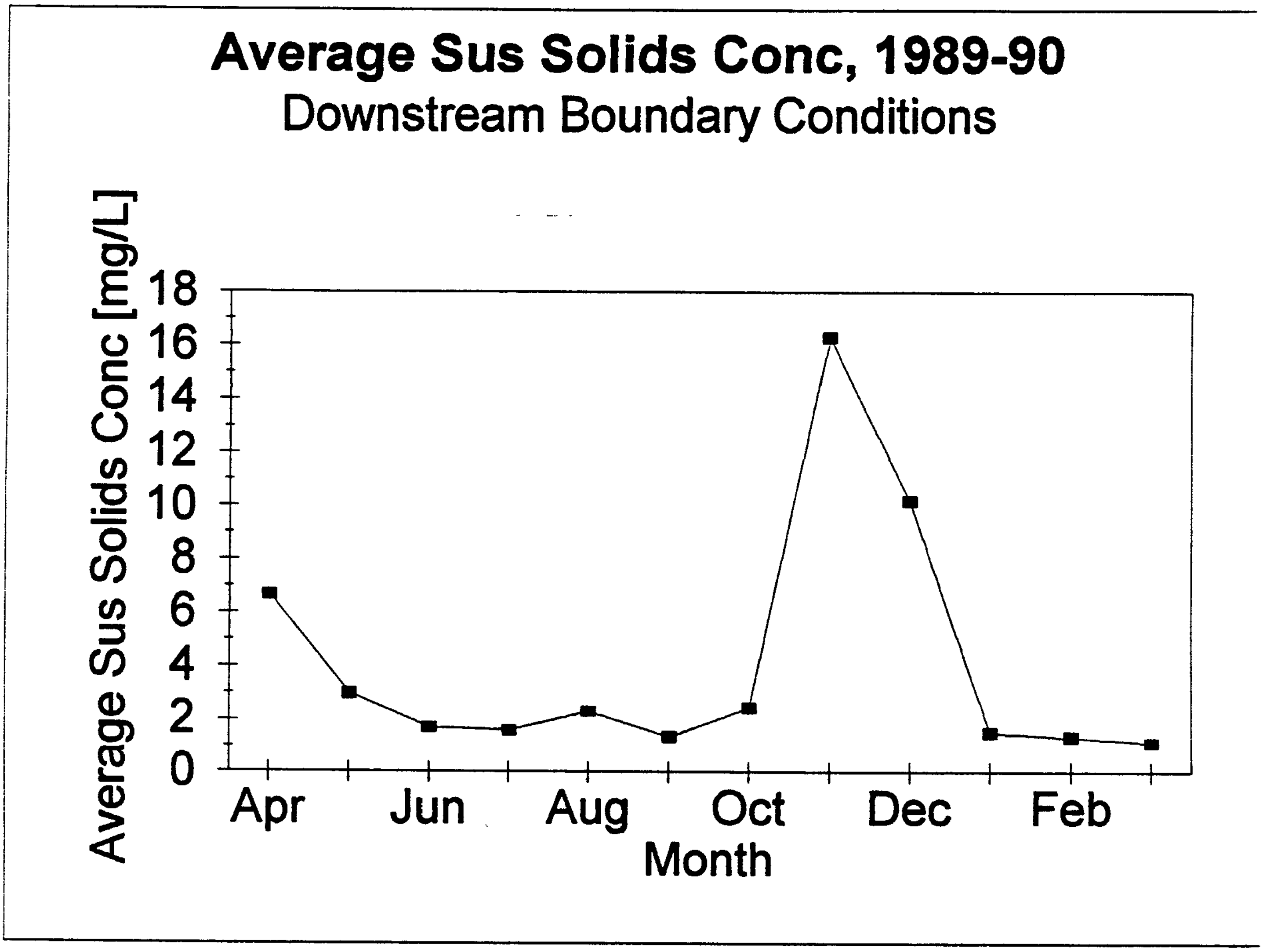

Average Sus Solids Conc, 1988-89
Downstream Boundary Conditions
Avg Sus Solids Conc [mg/L]
25
20
15
10
5
0
Apr
Jun
Aug
Oct
Dec
Feb
Month

Figure B27

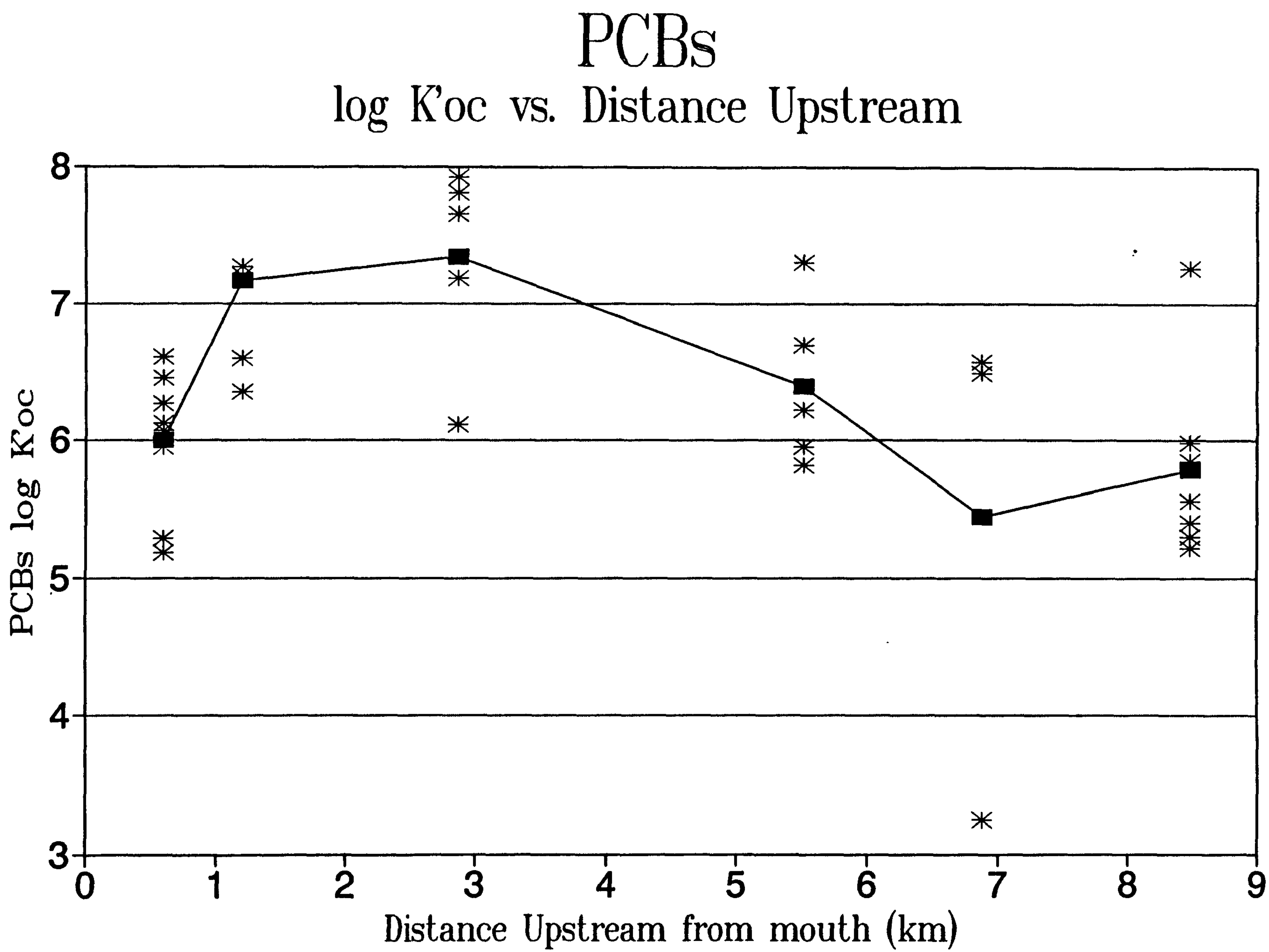


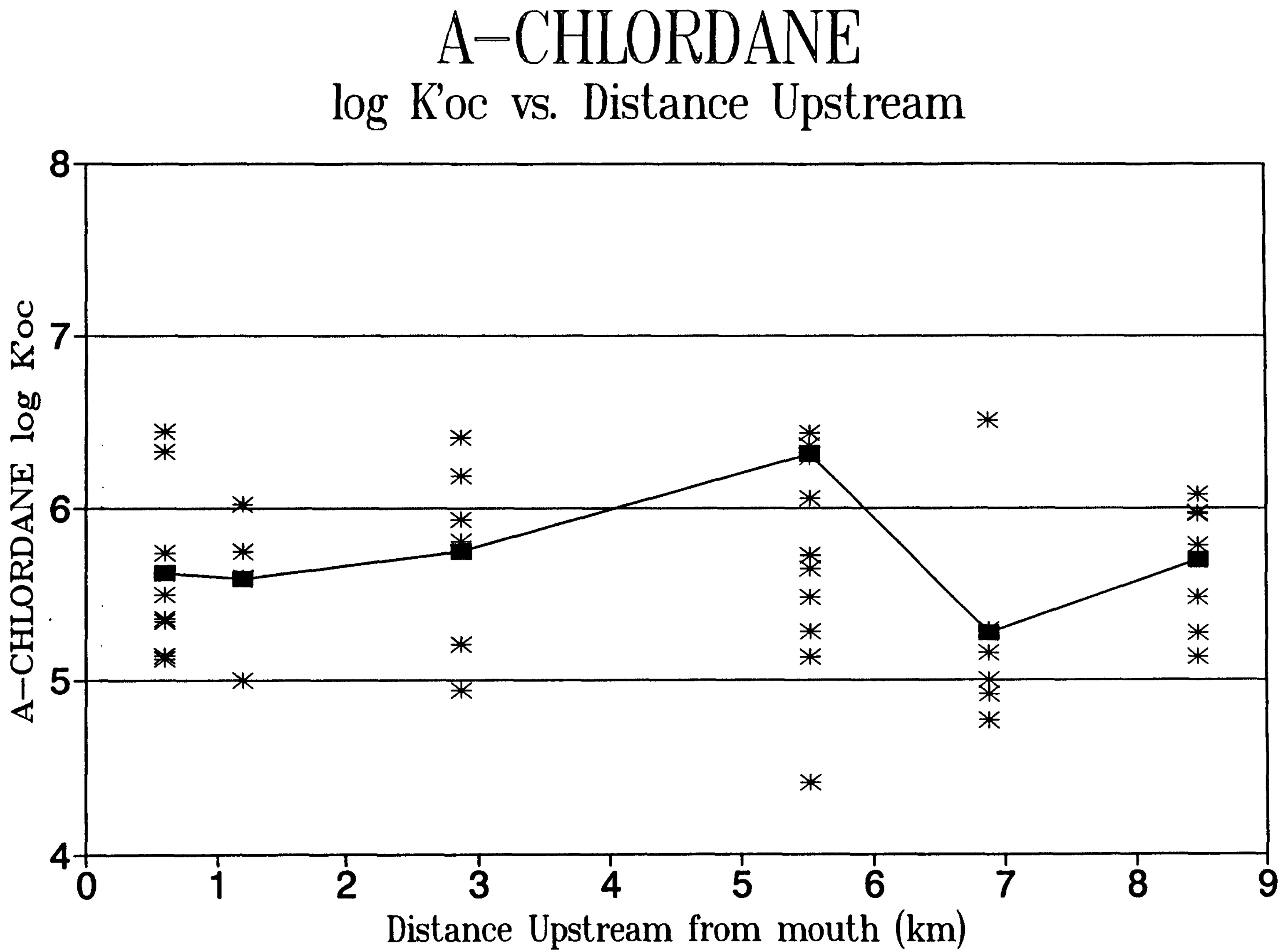
Average Sus Solids Conc, 1989-90
Downstream Boundary Conditions
Average Sus Solids Conc [mg/L]
18
16
14
12
10
8
6
4
2
0
Apr
Jun
Aug
Oct
Dec
Feb
Month

Figure B28

Appendix C. Partition coefficients

Figure C1


PCBs
log K'oc vs. Distance Upstream
PCBs log K'oc
8
7
6
5
4
3
0
1
2
3
4
5
6
7
8
9
Distance Upstream from mouth (km)



A-CHLORDANE
log K'oc vs. Distance Upstream
A-CHLORDANE log K'oc
8
7
6
5
4
0
1
2
3
4
5
6
7
8
9
Distance Upstream from mouth (km)

Figure C2

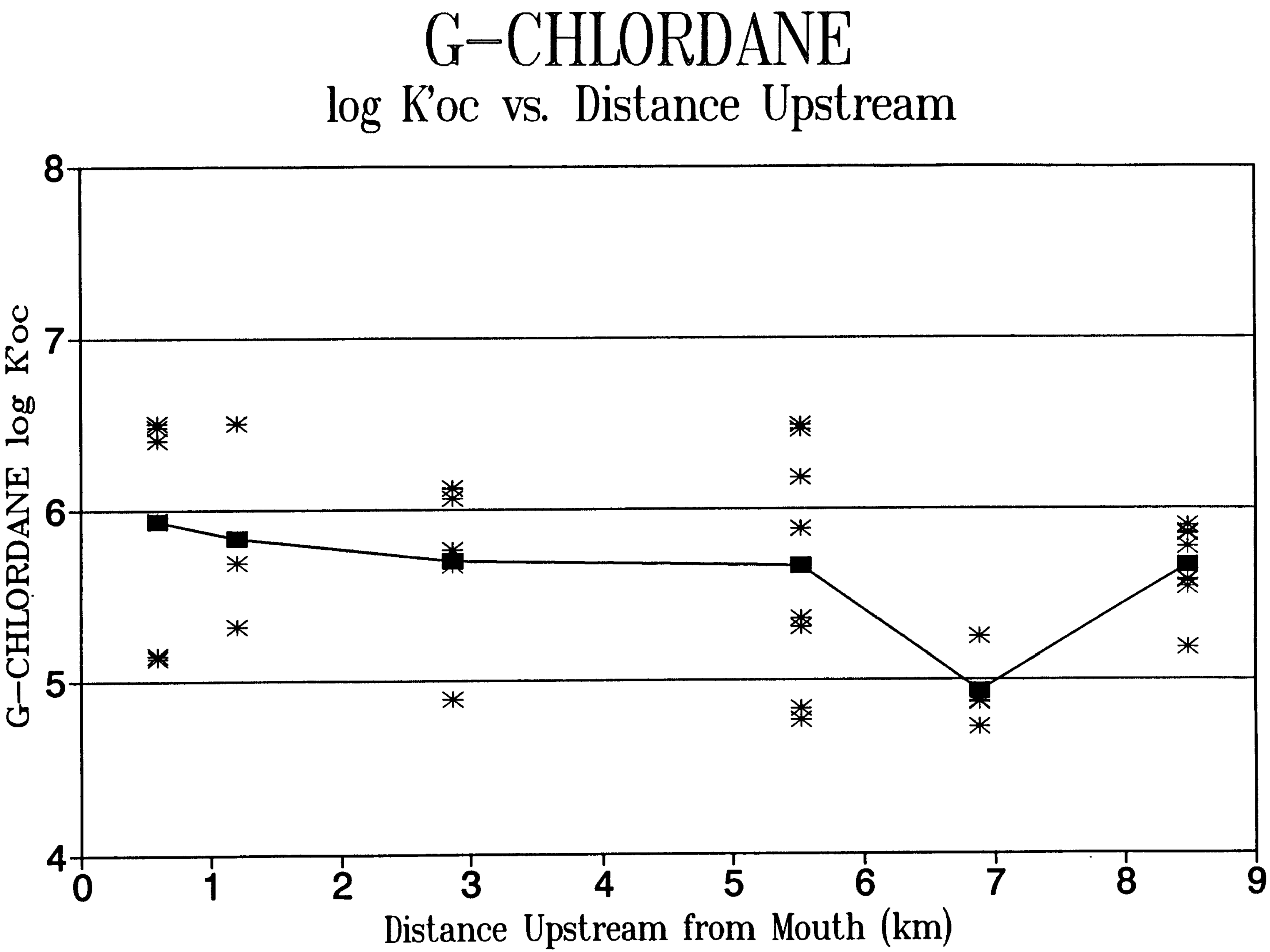
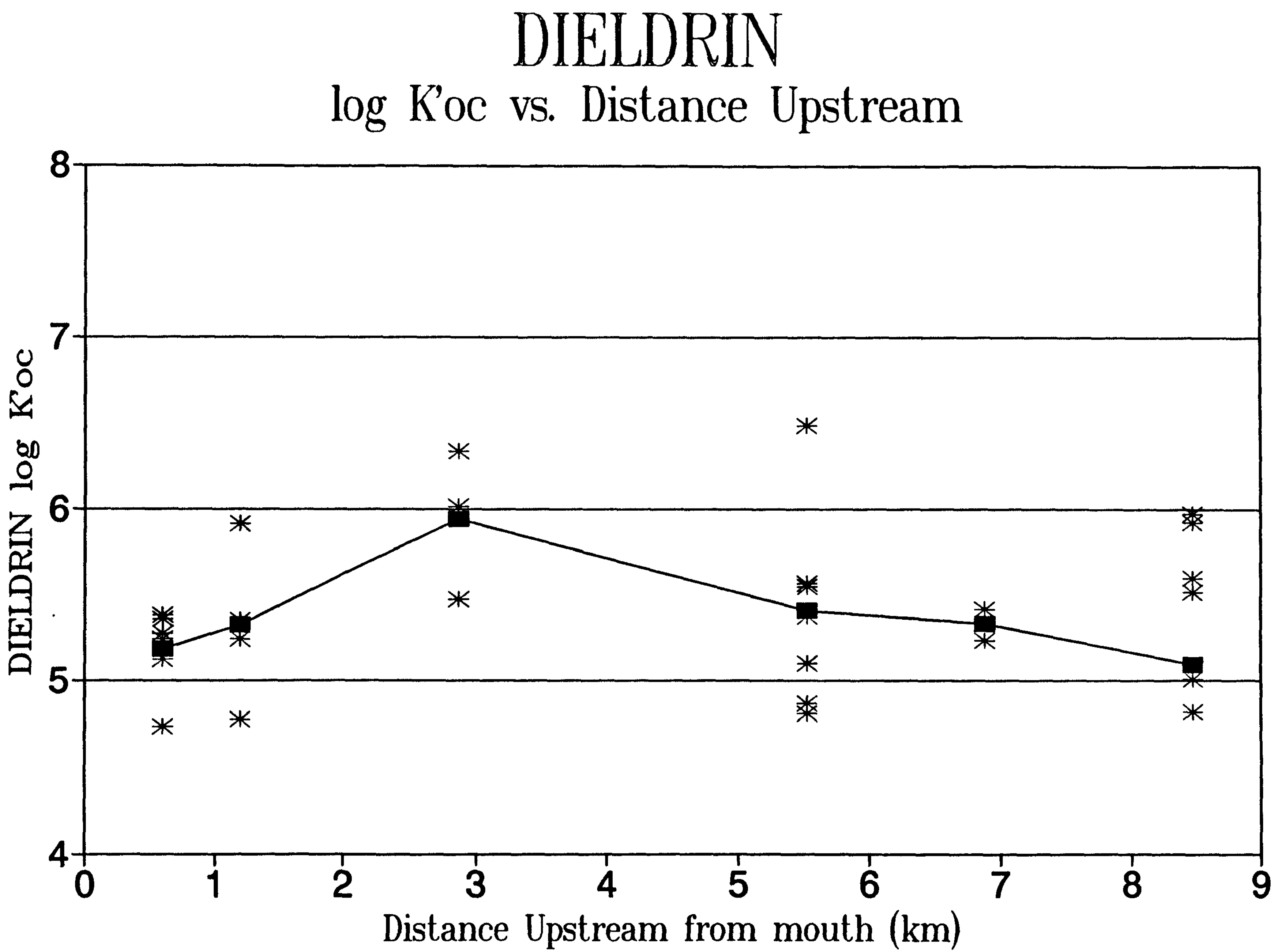
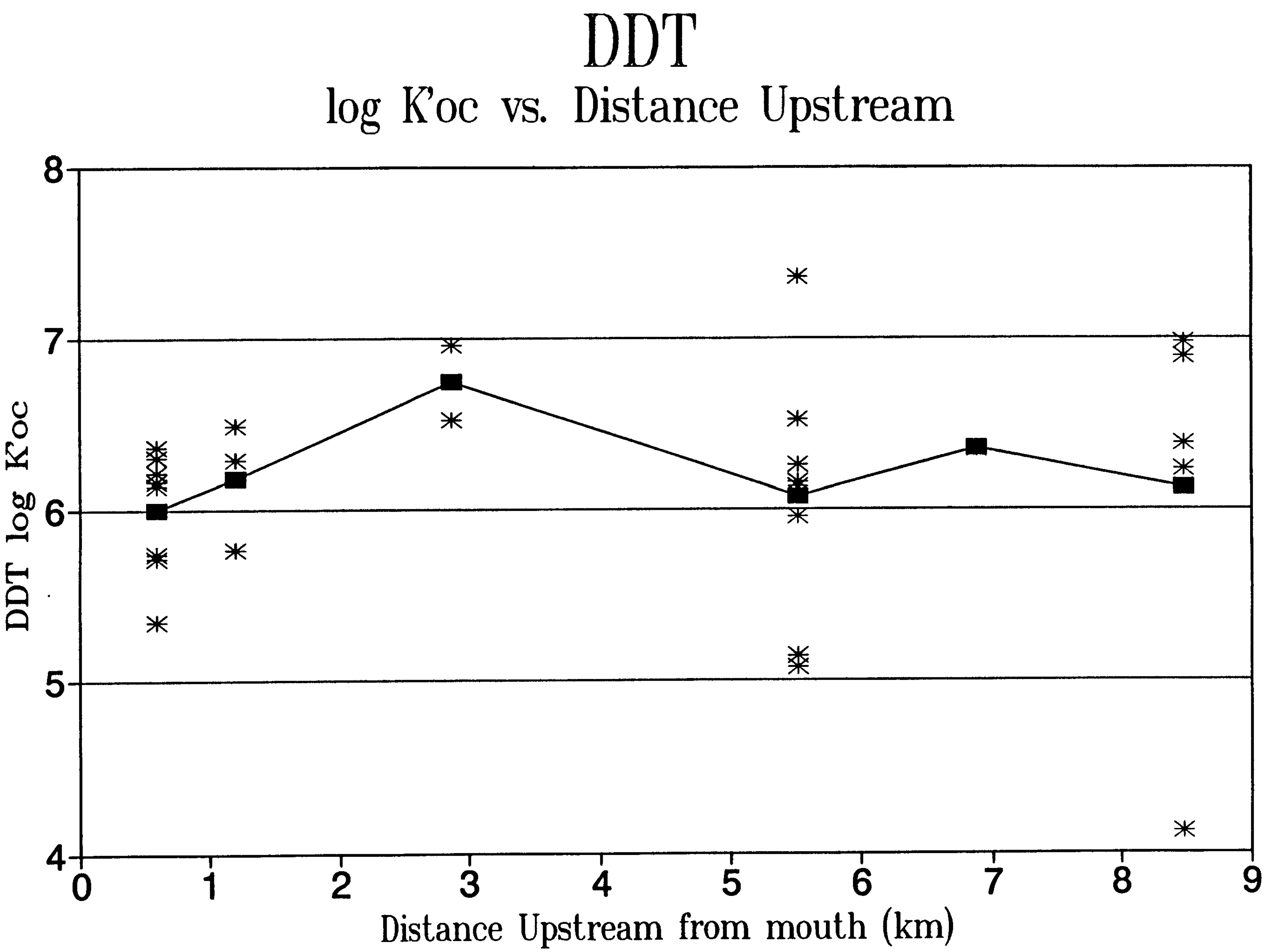

G-CHLORDANE
log K'oc vs. Distance Upstream
G-CHLORDANE log K'oc
Distance Upstream from Mouth (km)
8
7
6
5
4
0
1
2
3
4
5
6
7
8
9

Figure C3

Figure C4



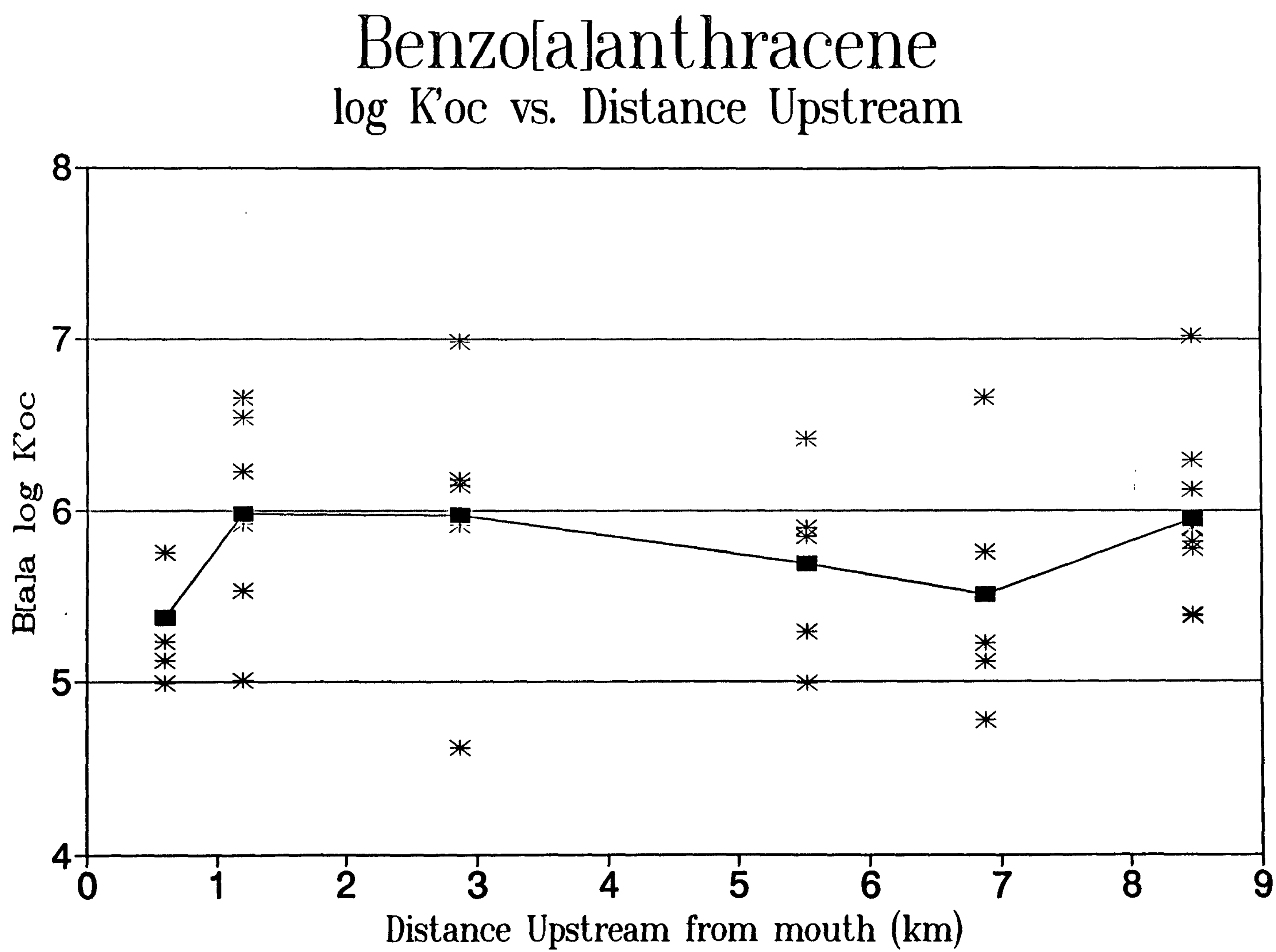
DIELDRIN
log K'oc vs. Distance Upstream
DIELDRIN log K'oc
Distance Upstream from mouth (km)
8
7
6
5
4
0
1
2
3
4
5
6
7
8
9



DDT
log K'oc vs. Distance Upstream
DDT log K'oc
Distance Upstream from mouth (km)
8
7
6
5
4
0
1
2
3
4
5
6
7
8
9

Figure C5

Figure C6



Benzo[a]anthracene
log K'oc vs. Distance Upstream
B[a]a log K'oc
Distance Upstream from mouth (km)
8
7
6
5
4
0
1
2
3
4
5
6
7
8
9

Benzo[b]fluoranthene

log K'oc vs. Distance Upstream

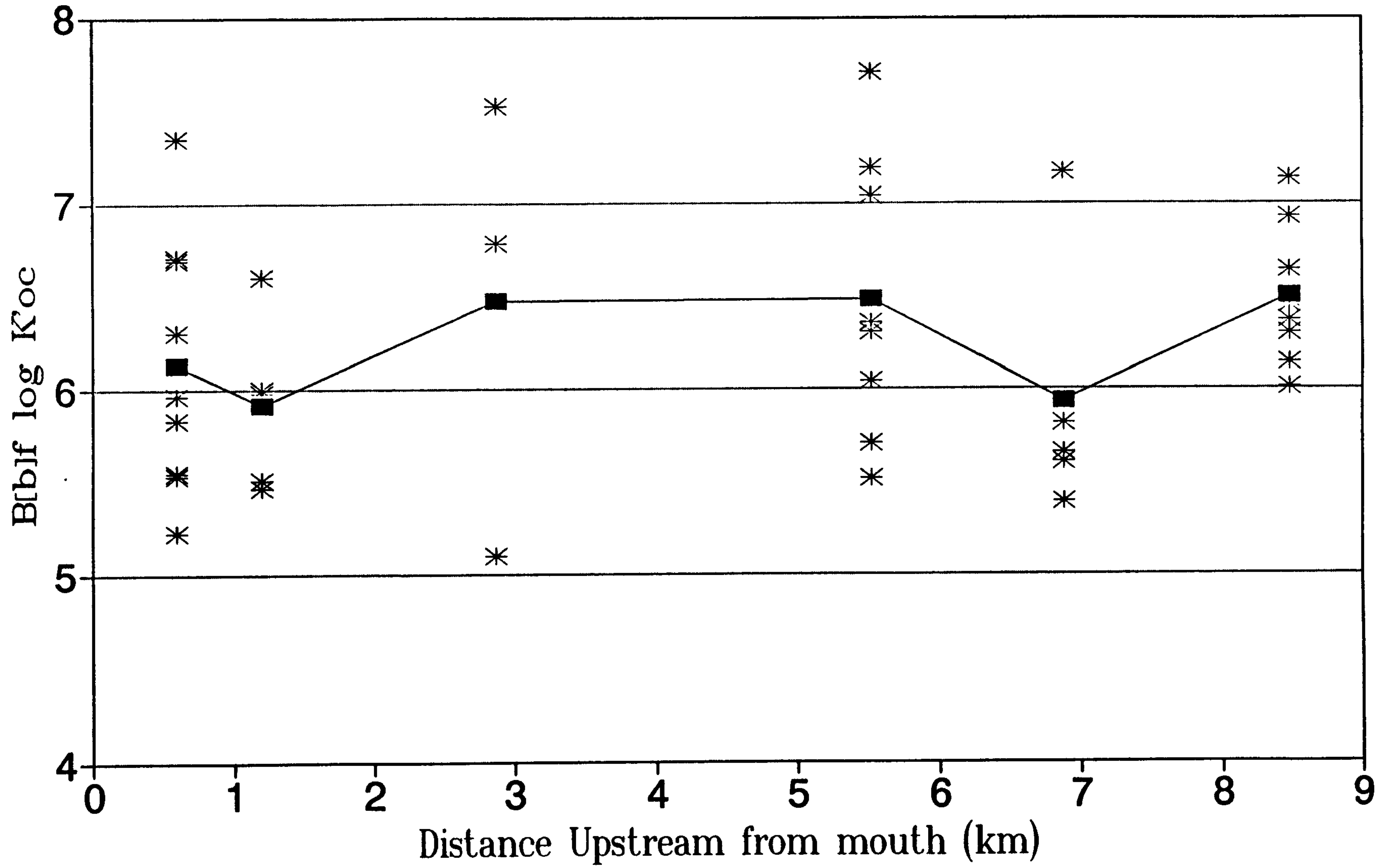
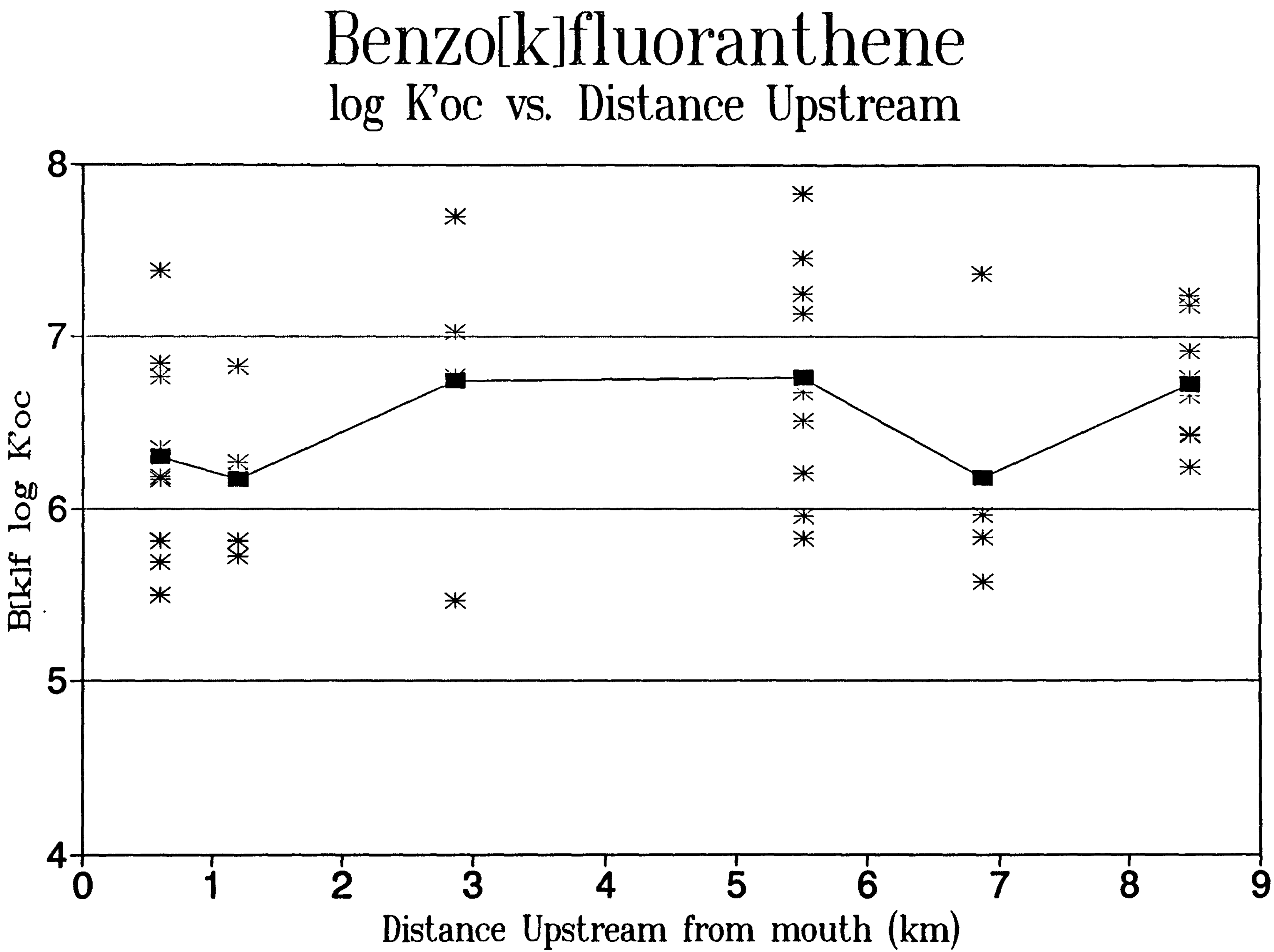
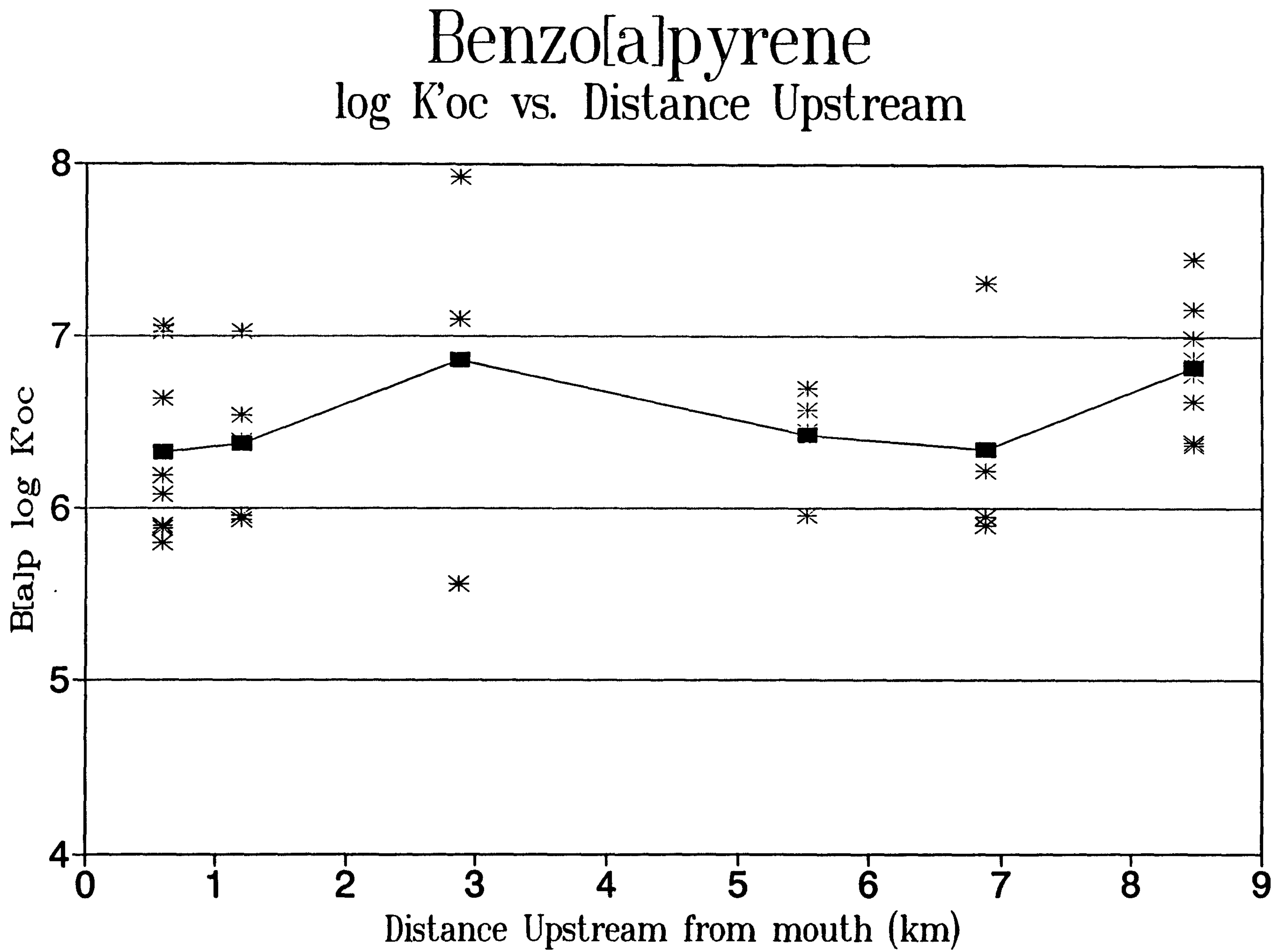


Figure C7



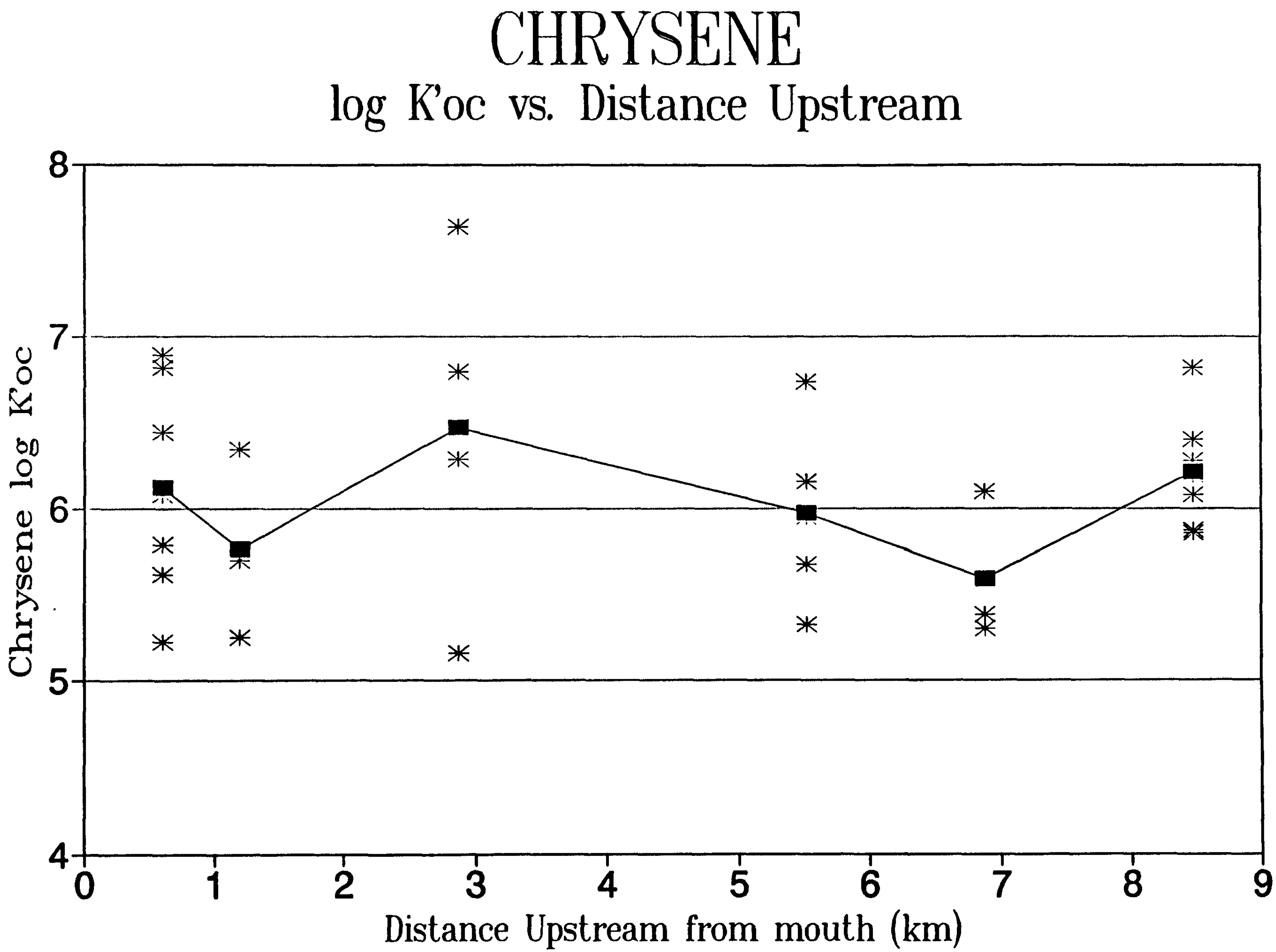
Benzo[k]fluoranthene
log K'oc vs. Distance Upstream
B[k]f log K'oc
8
7
6
5
4
0
1
2
3
4
5
6
7
8
9
Distance Upstream from mouth (km)

Figure C8



Benzo[a]pyrene
log K'oc vs. Distance Upstream
B[a]p log K'oc
8
7
6
5
4
0
1
2
3
4
5
6
7
8
9
Distance Upstream from mouth (km)

Figure C9



CHRYSENE
log K'oc vs. Distance Upstream
Chrysene log K'oc
8
7
6
5
4
0
1
2
3
4
5
6
7
8
9
Distance Upstream from mouth (km)

Figure C10

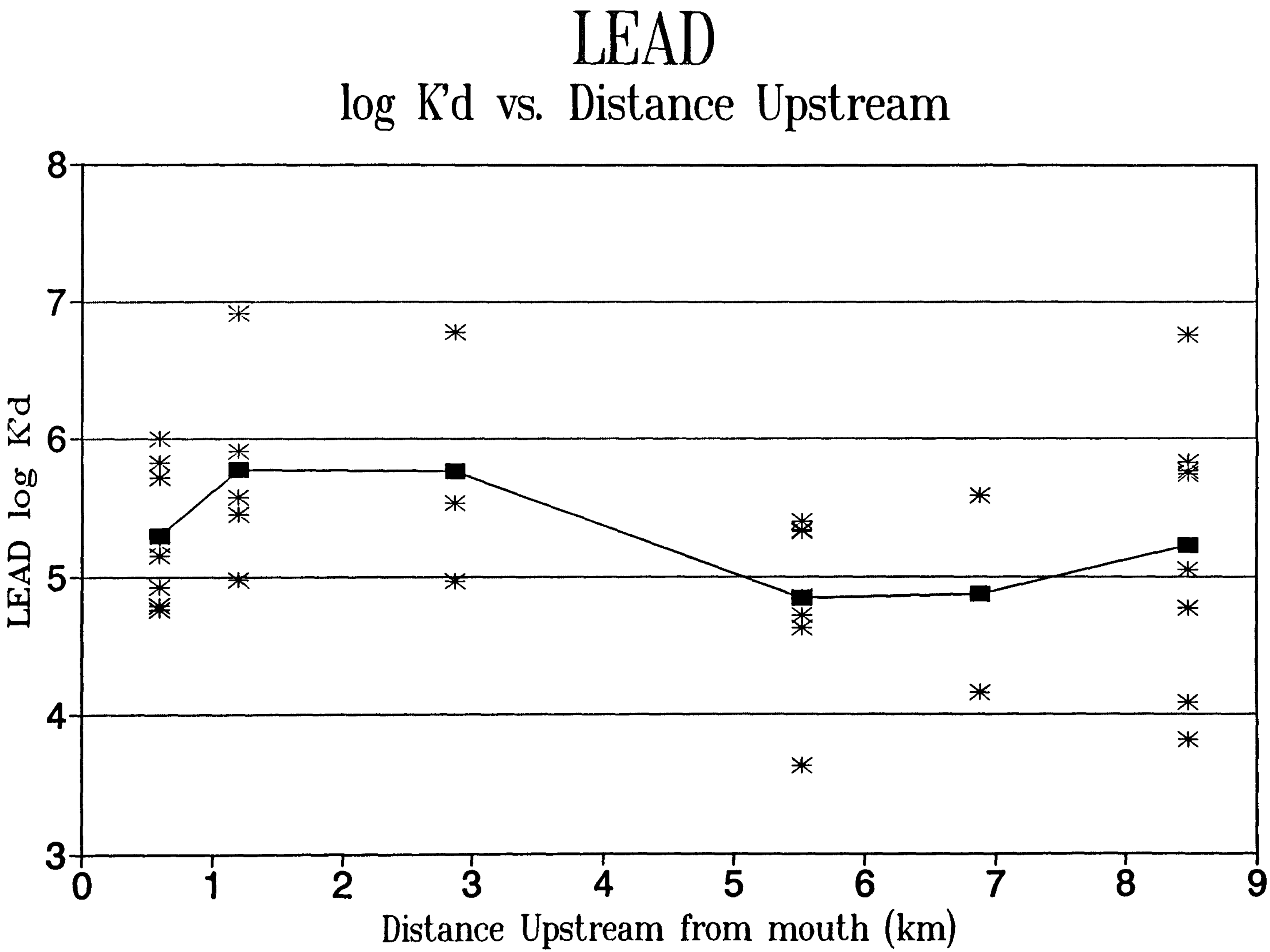

LEAD
log K'd vs. Distance Upstream
LEAD log K'd
Distance Upstream from mouth (km)
8
7
6
5
4
3
0
1
2
3
4
5
6
7
8
9

Figure C11

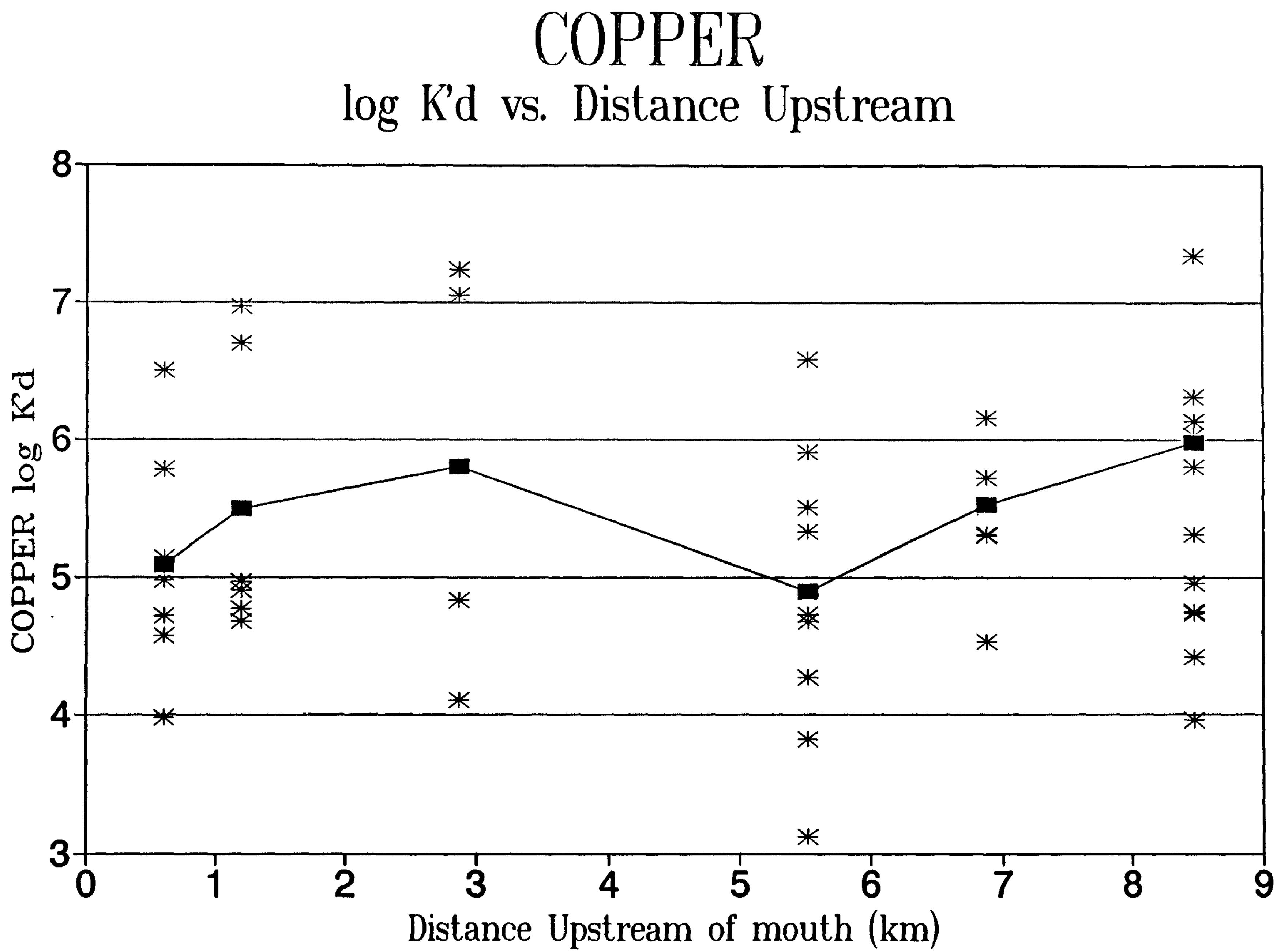

COPPER
log K'd vs. Distance Upstream
COPPER log K'd
Distance Upstream of mouth (km)
8
7
6
5
4
3
0
1
2
3
4
5
6
7
8
9

Figure C12

Fp vs. Distance Upstream from Mouth

PCBs

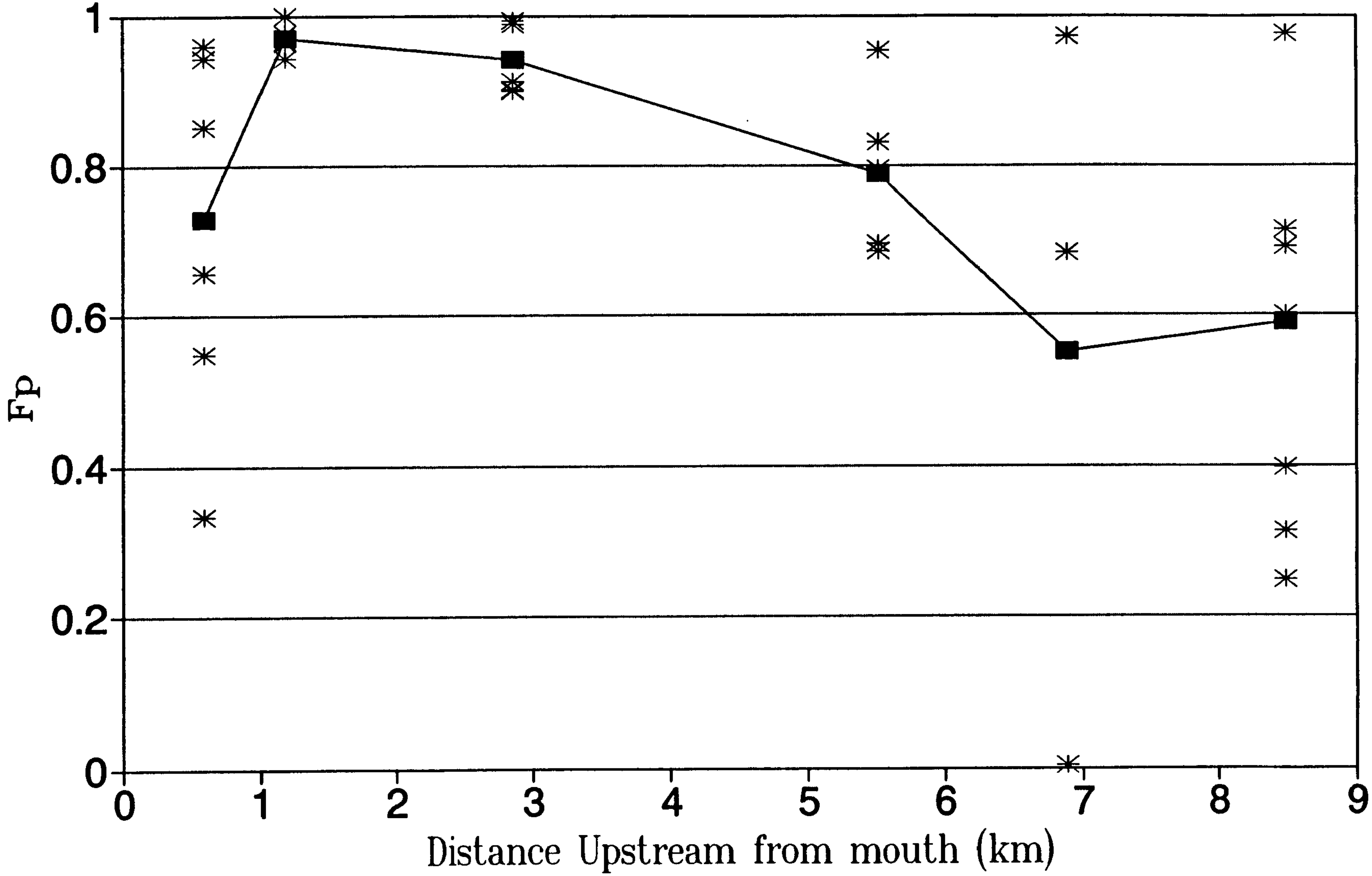


Figure C13

A-Chlordane

Fp vs. Distance Upstream from Mouth

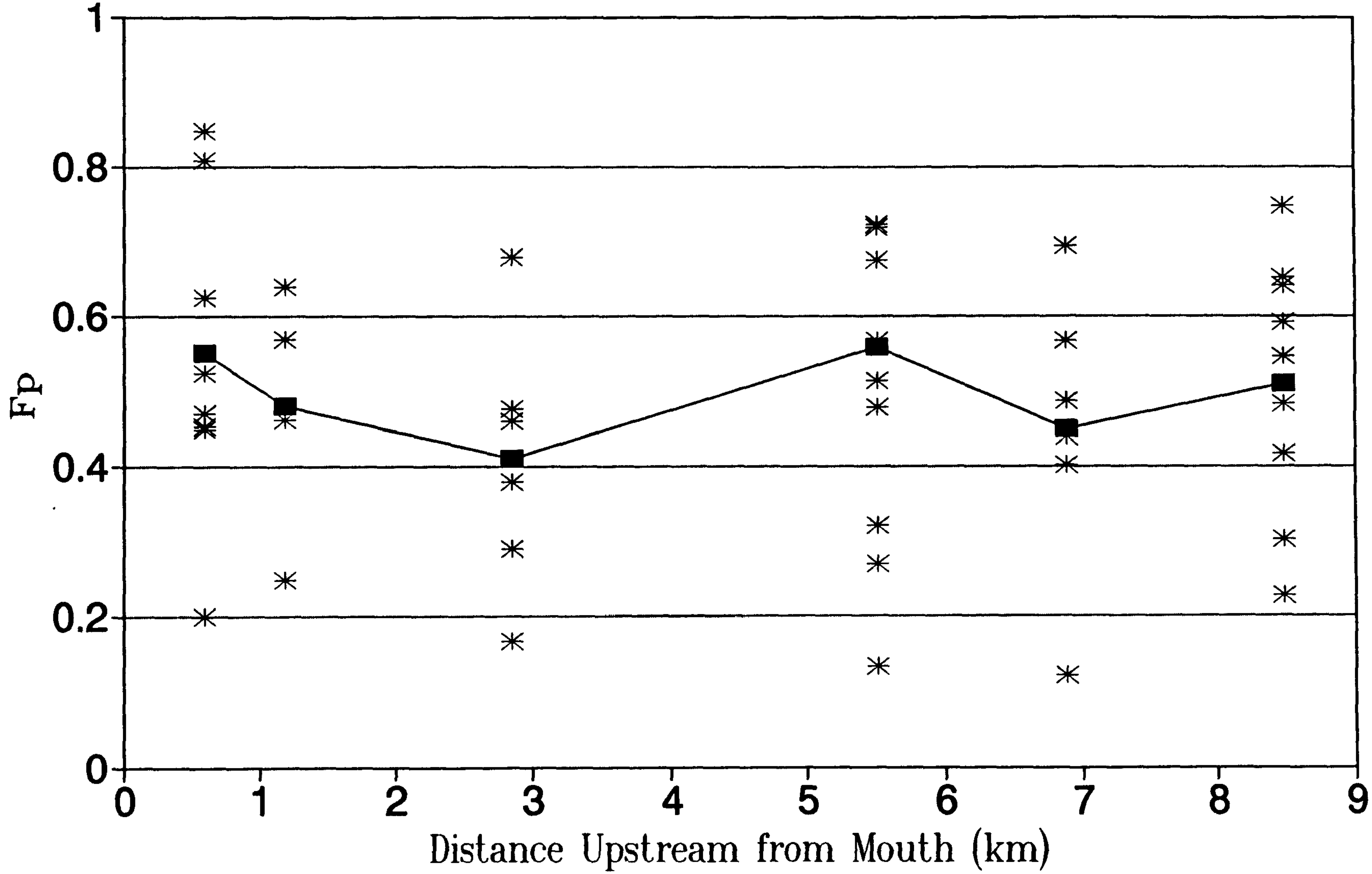


Figure C14

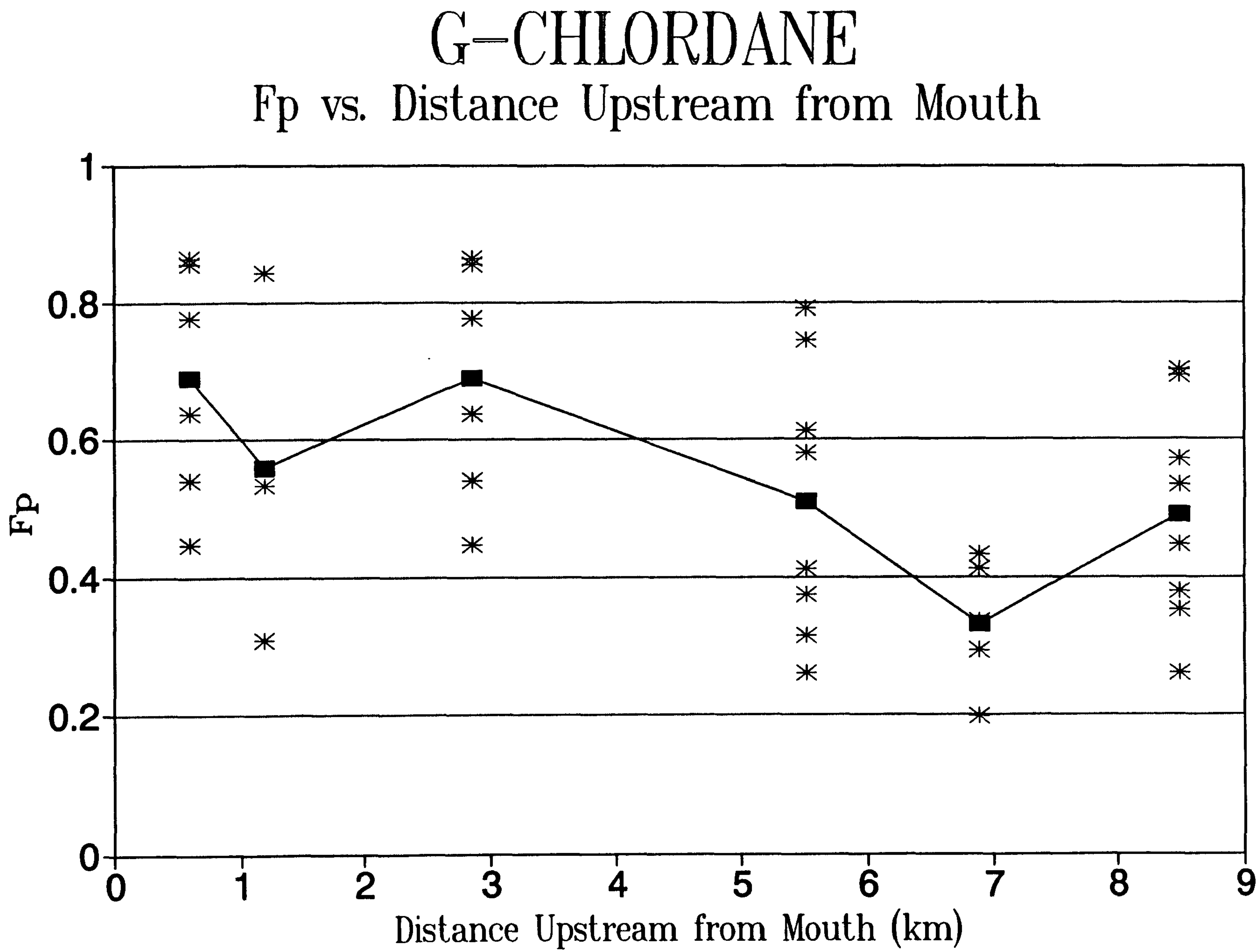
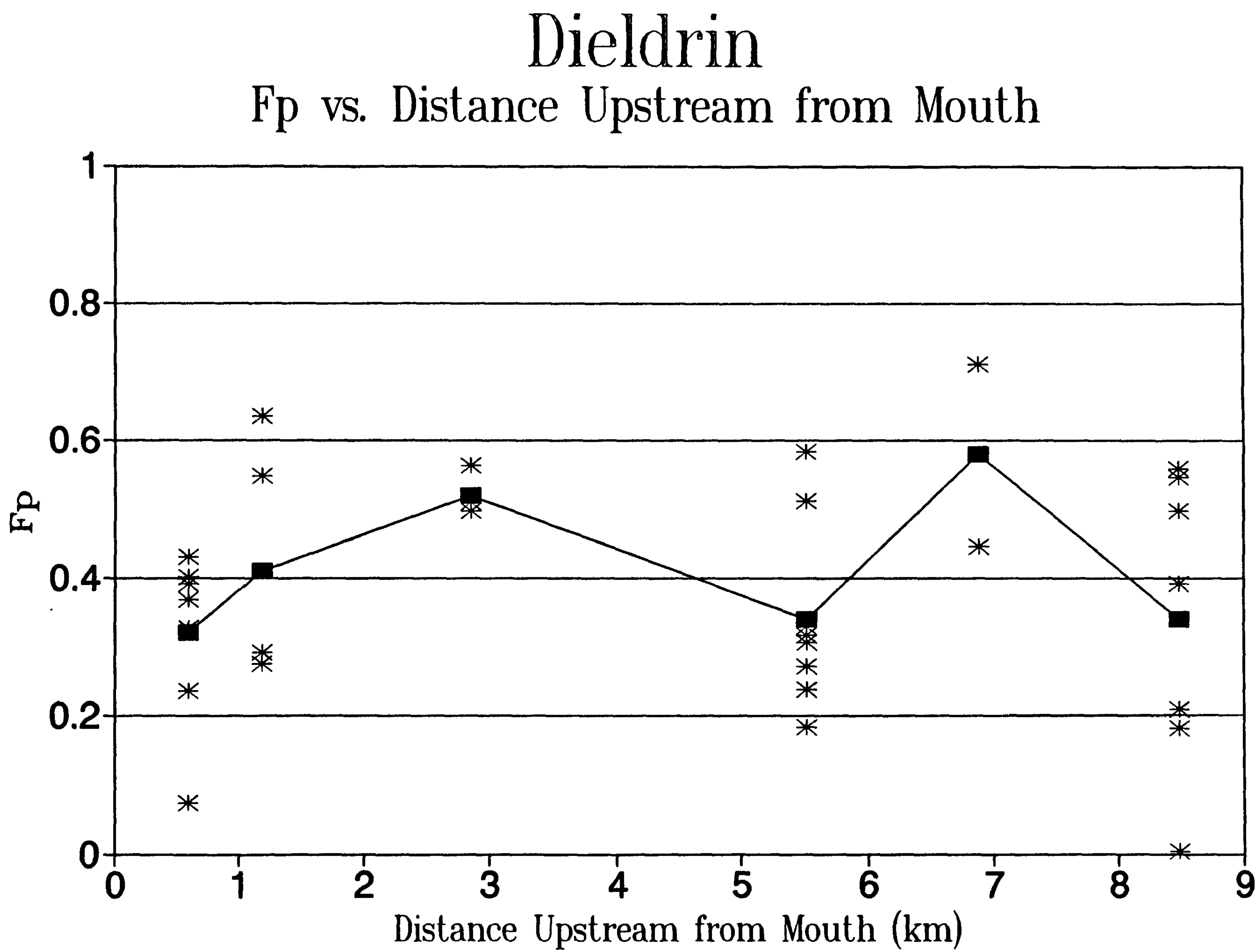

G-CHLORDANE
Fp vs. Distance Upstream from Mouth
Fp
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
7
8
9
Distance Upstream from Mouth (km)

Figure C15

Figure C16


Dieldrin
Fp vs. Distance Upstream from Mouth
Fp
Distance Upstream from Mouth (km)
0
0.2
0.4
0.6
0.8
1
0
1
2
3
4
5
6
7
8
9

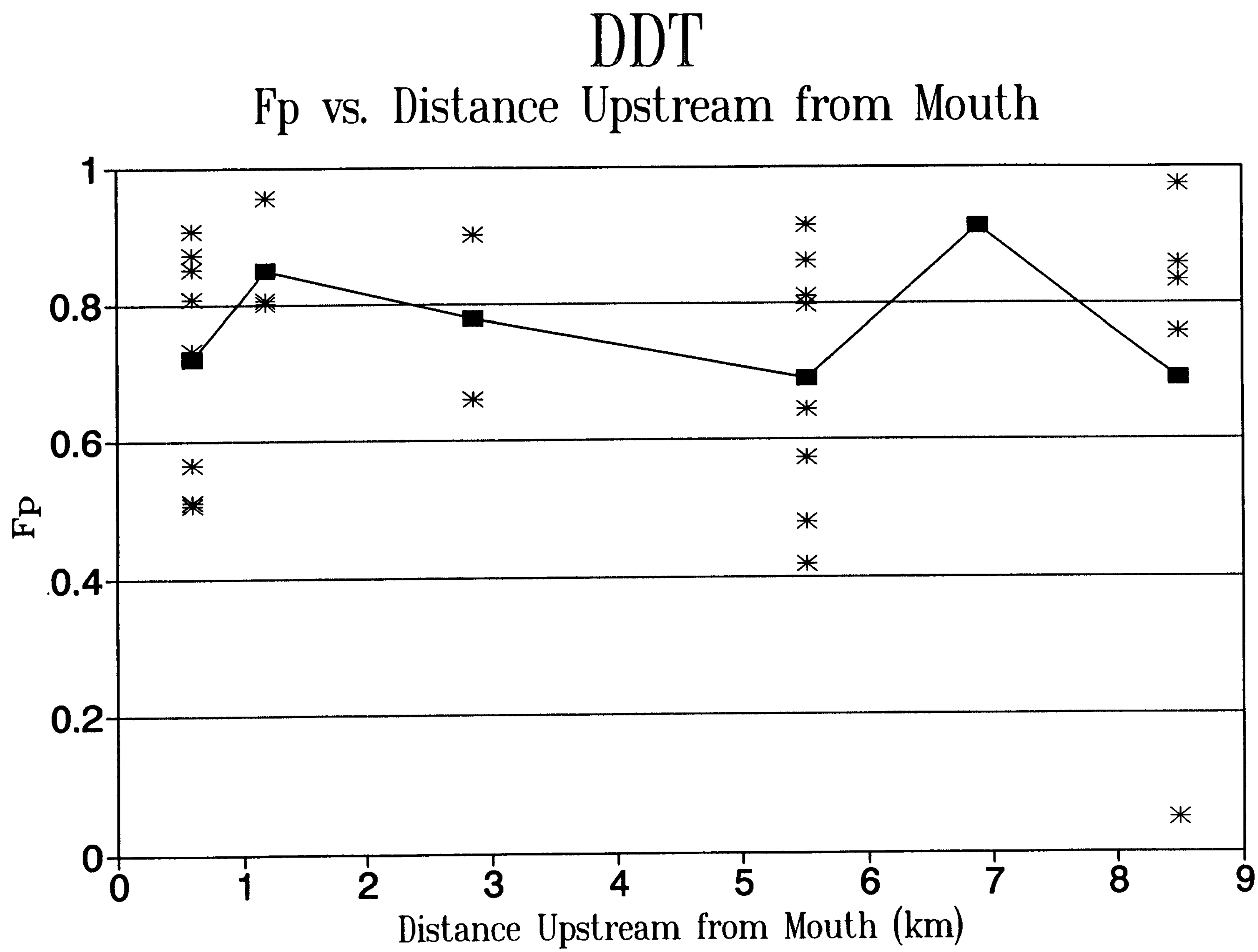

DDT
Fp vs. Distance Upstream from Mouth
Fp
0
0.2
0.4
0.6
0.8
1
0
1
2
3
4
5
6
7
8
9
Distance Upstream from Mouth (km)

Figure C17

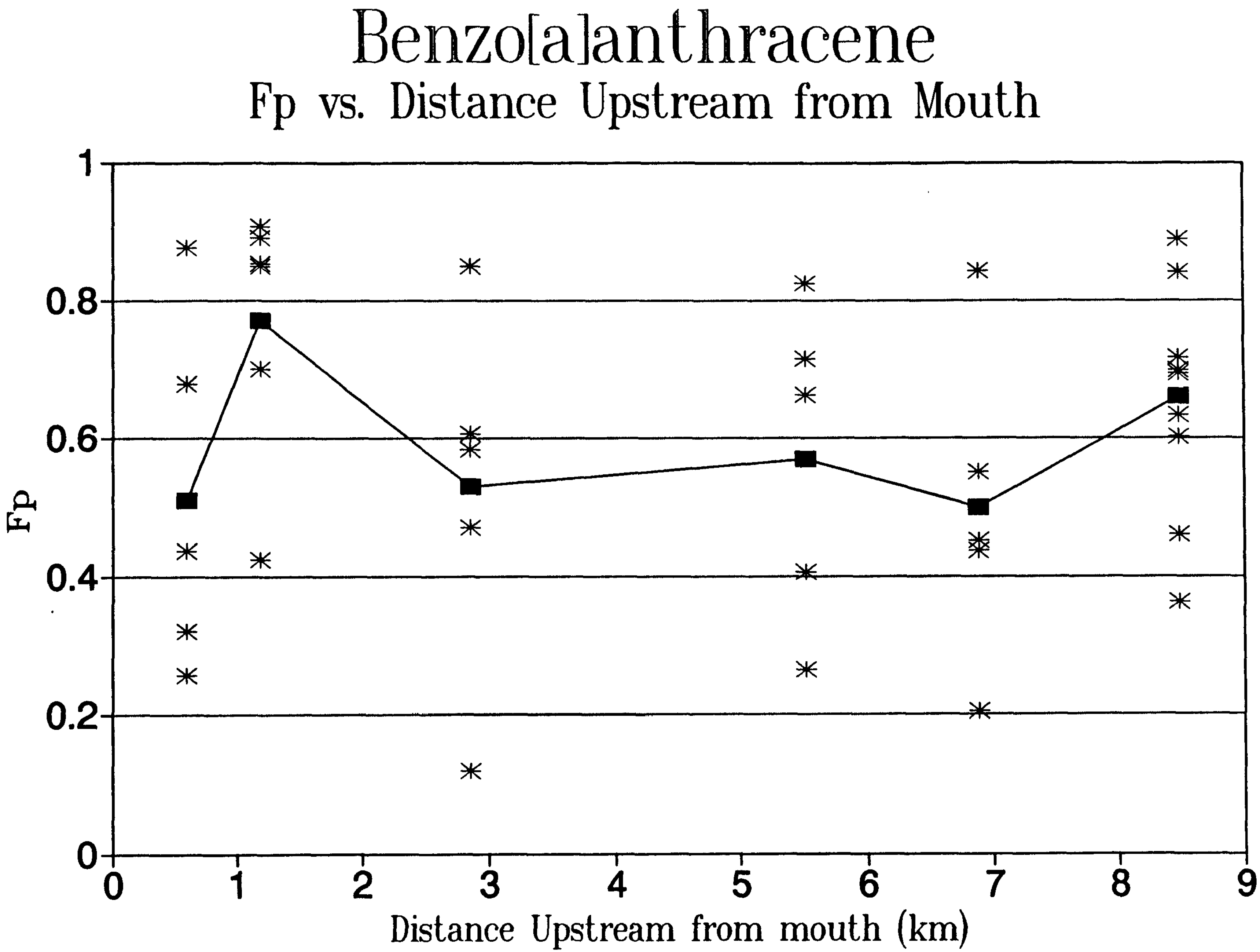
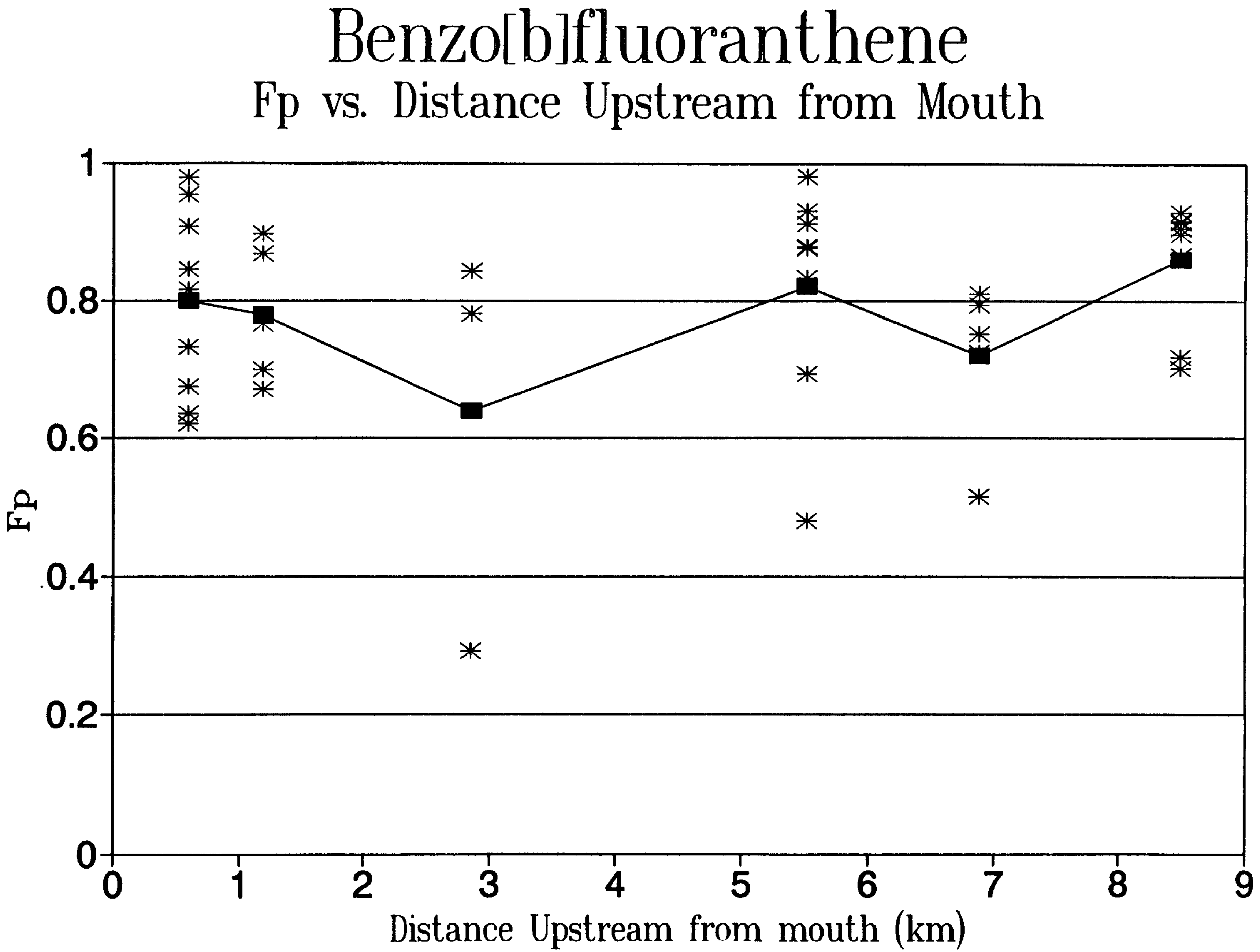

Benzo[a]anthracene
Fp vs. Distance Upstream from Mouth
Fp
0
0.2
0.4
0.6
0.8
1
0
1
2
3
4
5
6
7
8
9
Distance Upstream from mouth (km)

Figure C16



Benzo[b]fluoranthene
Fp vs. Distance Upstream from Mouth
Fp
0
0.2
0.4
0.6
0.8
1
0
1
2
3
4
5
6
7
8
9
Distance Upstream from mouth (km)

Figure C19

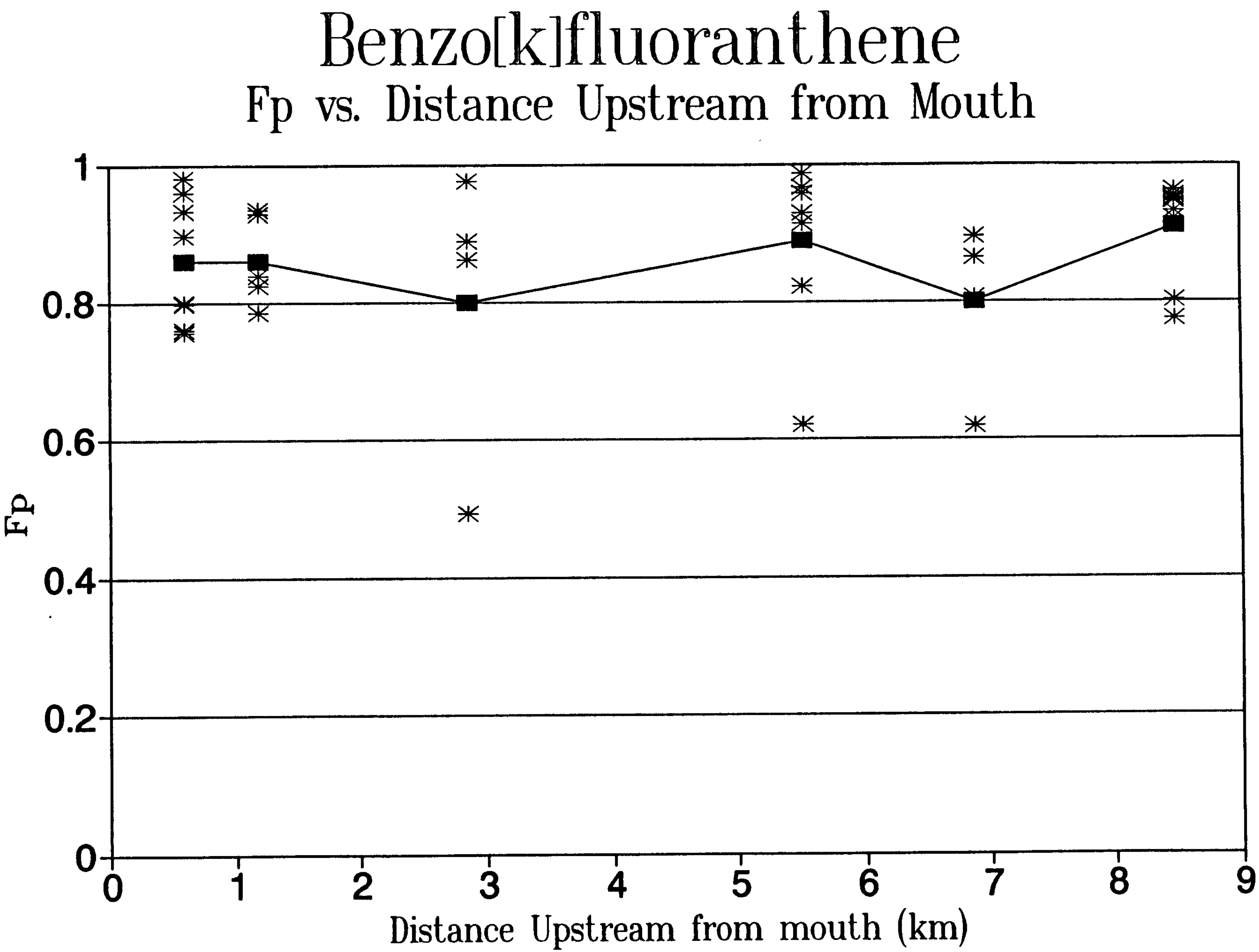

Benzo[k]fluoranthene
Fp vs. Distance Upstream from Mouth
Fp
0
0.2
0.4
0.6
0.8
1
0
1
2
3
4
5
6
7
8
9
Distance Upstream from mouth (km)

Figure C20

Benzo[a]pyrene

Fp vs. Distance Upstream from Mouth

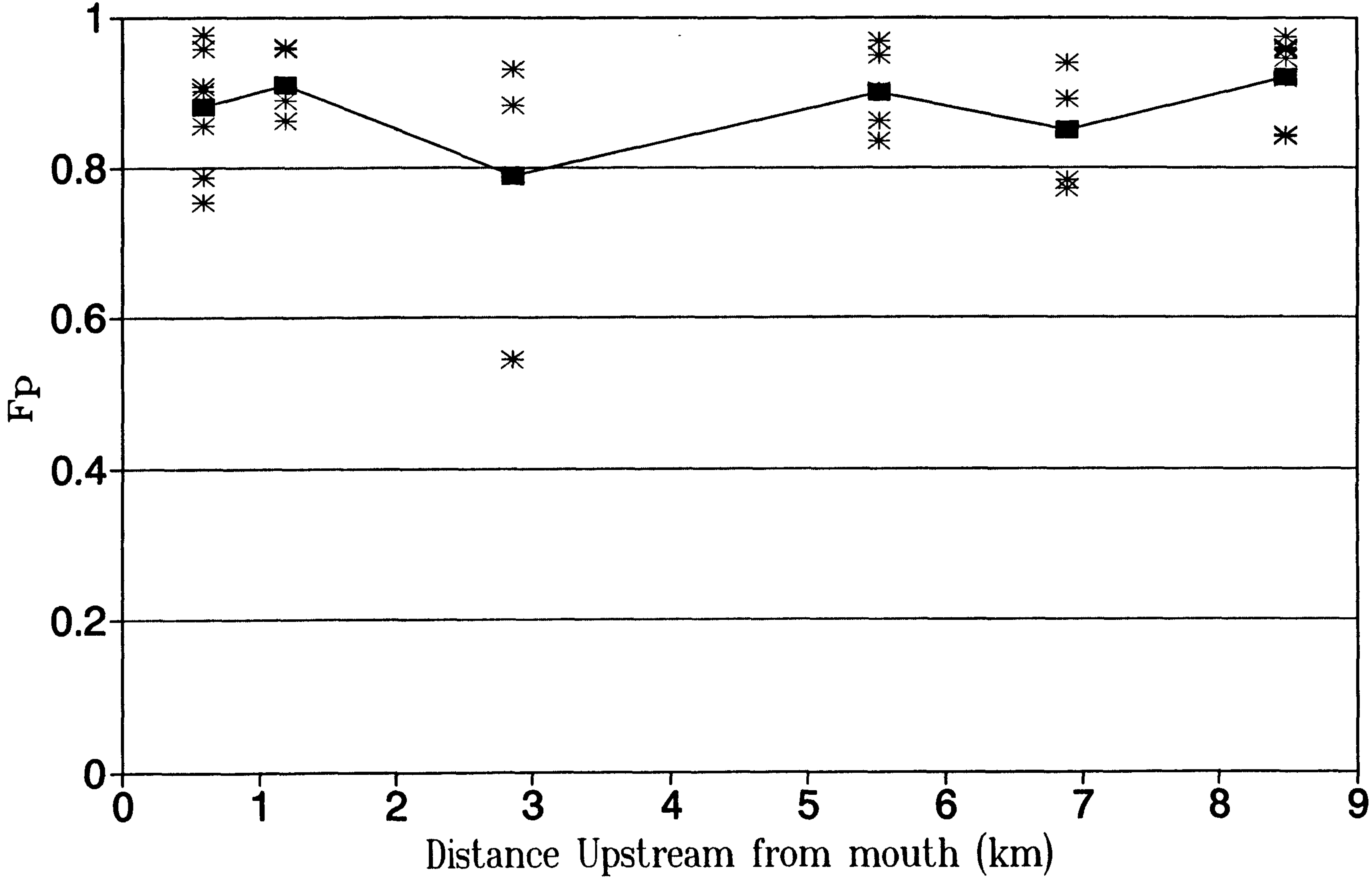


Figure C21

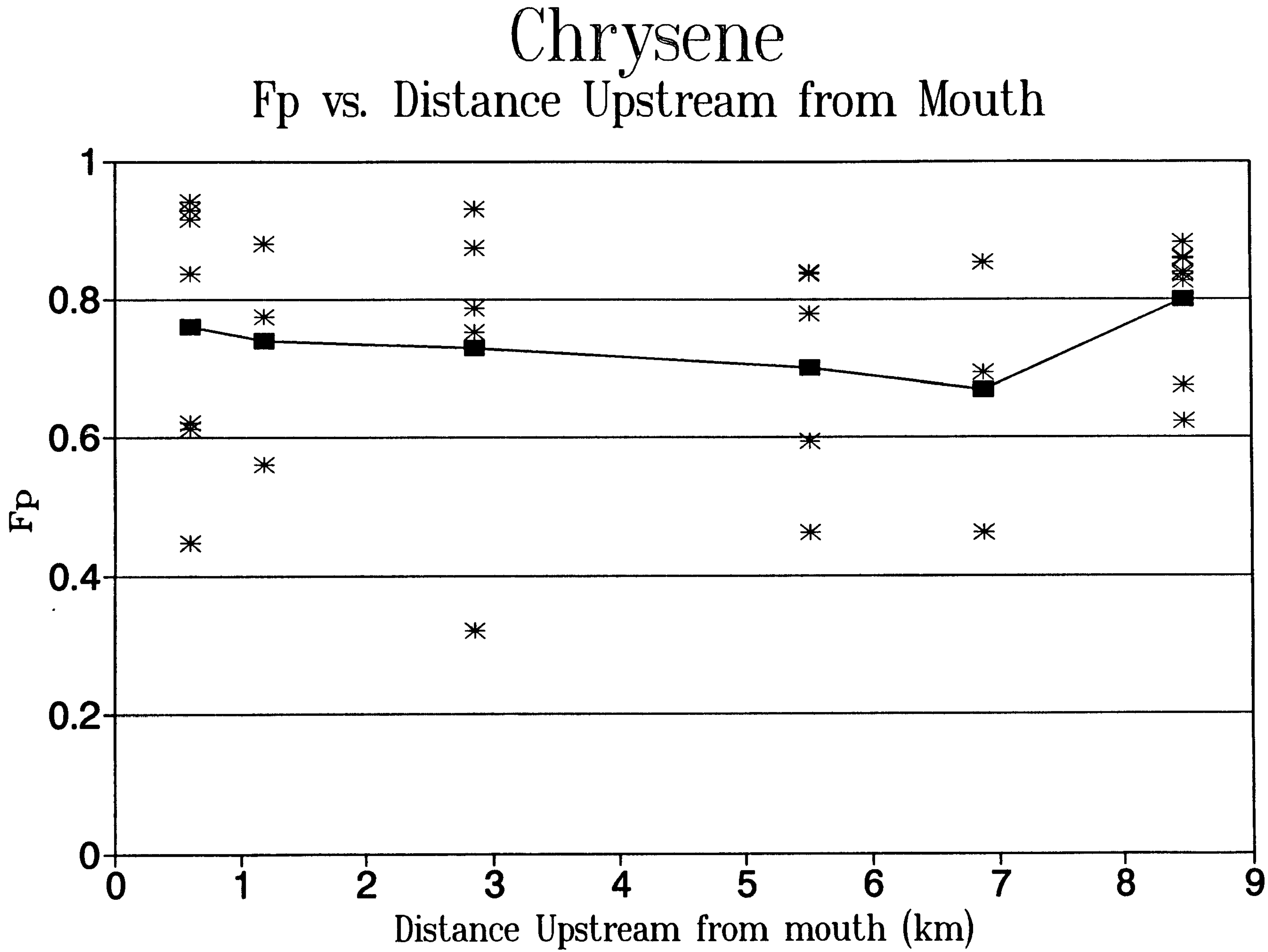

Chrysene
Fp vs. Distance Upstream from Mouth
Fp
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
7
8
9
Distance Upstream from mouth (km)

Figure C22

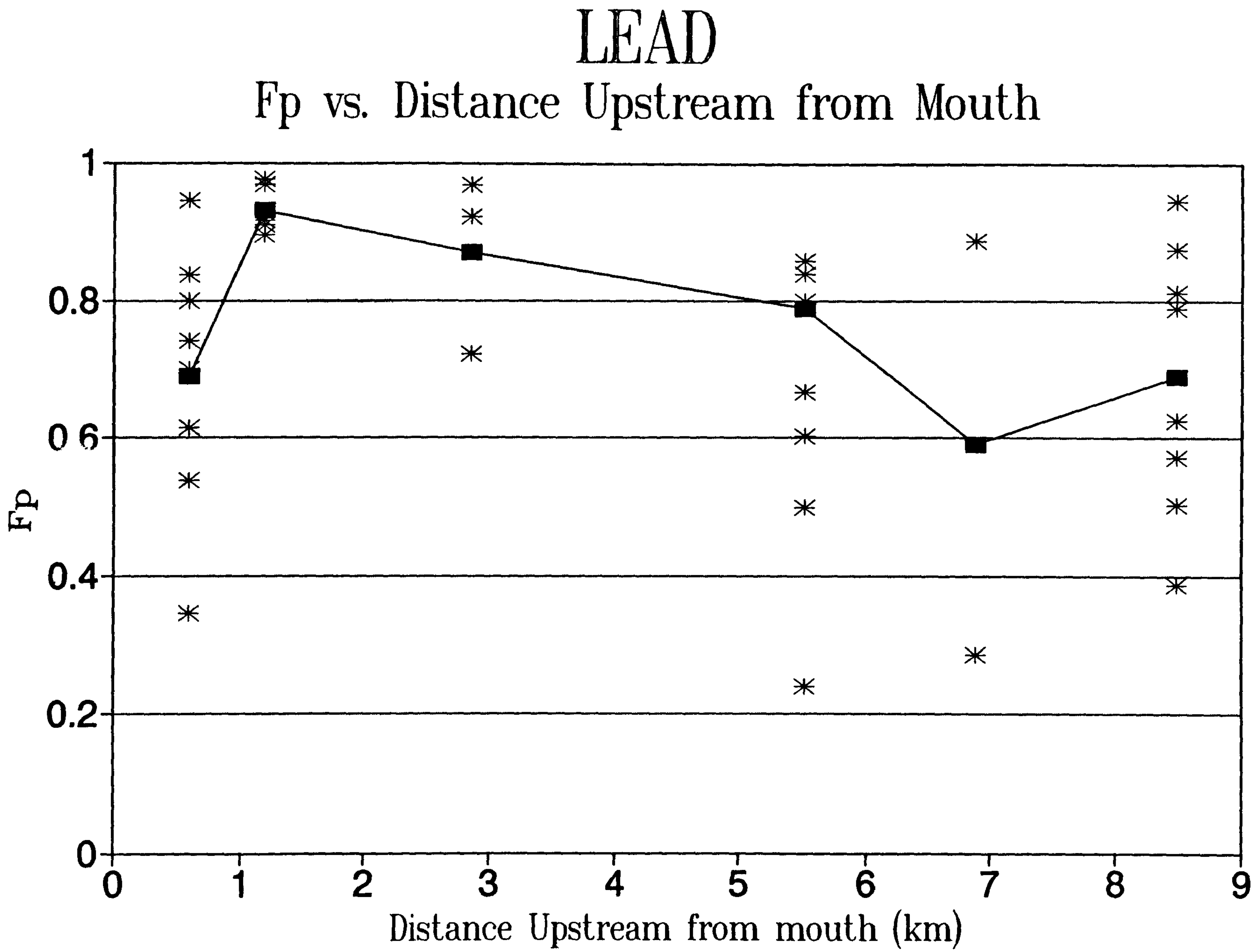
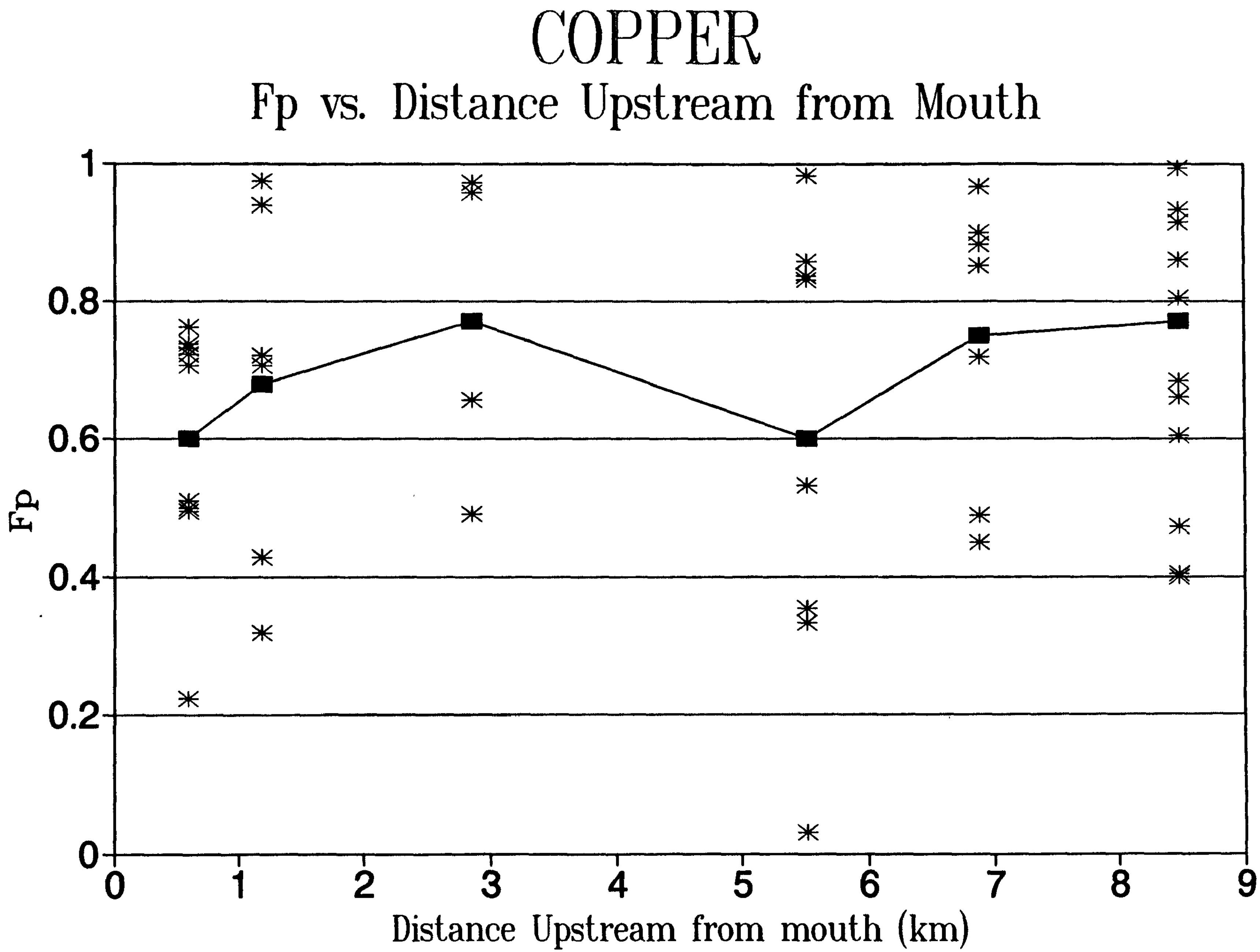

LEAD
Fp vs. Distance Upstream from Mouth
Fp
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
7
8
9
Distance Upstream from mouth (km)

Figure C23



COPPER
Fp vs. Distance Upstream from Mouth
Fp
0
0.2
0.4
0.6
0.8
1
0
1
2
3
4
5
6
7
8
9
Distance Upstream from mouth (km)

Figure C24

OVERALL BUFFALO RIVER PCBs Water Column

DATE	SIT	[DOC] (ppm)	[POC] (ppm)	TSS (ppm)	Foc	[PCB] part. (MG/KG)	[PCB] diss. (NG/L)	K'd (L/KG)	K'oc (L/KG)	log K'oc	Fp	Fd
4-17-92	1	10	3	154	0.0195	0.012964	BDL					
4-17-92	1	10	7	52	0.1346	0.023905	0.495789	4.82E+04	3.58E+05	5.554097	0.715	0.285
4-17-92	3	10	1	74	0.0135	0.018064	0.066651	2.71E+05	2.01E+07	7.302242	0.953	0.047
4-17-92	6	11	4	25.3	0.1581	0.332966	0.512002	6.50E+05	4.11E+06	6.614188	0.943	0.057
4-18-92	1	13	0	74	0.0000	BDL	1.23726					
4-18-92	3	12.6	1.3	28	0.0464	0.018732	BDL					
4-18-92	3	11.45	0.95	24	0.0396	0.02969	BDL					
4-18-92	6	16	2	30	0.0667	0.062532	0.699741	8.94E+04	1.34E+06	6.127259	0.728	0.272
4-22-92	1	10	4	34	0.1176	0.019078	0.980964	1.94E+04	1.65E+05	5.218301	0.398	0.602
4-22-92	3	9	6	29	0.2069	0.151131	1.12076	1.35E+05	6.52E+05	5.814088	0.796	0.204
4-22-92	6	13	6	20	0.3000	0.061651	BDL					
4-22-92	6	11	2	19	0.1053	0.077612	0.258848	3.00E+05	2.85E+06	6.45461	0.851	0.149
10-18-90	1	7.54	2.16	8	0.2700	0.633465	0.128303	4.94E+06	1.83E+07	7.262123	0.975	0.025
10-18-90	2	9.88	2.32	14	0.1657	0.001246	4.284309	2.91E+02	1.76E+03	3.244382	0.004	0.996
10-22-90	1	9.84	1.56	6	0.2600	0.364648	1.451364	2.51E+05	9.66E+05	5.985124	0.601	0.399
10-22-90	2	10.9	0.7	4	0.1750	0.397019	0.73414	5.41E+05	3.09E+06	6.489994	0.684	0.316
10-22-90	3	10.5	0.7	14	0.0500	0.132526	BDL					
10-22-90	3	10.5	0.9	6	0.1500	0.148472	BDL					
10-22-90	4	10.94	1.26	24	0.0525	0.255682	BDL					
10-22-90	5	12.5	1.7	30	0.0567	0.261626	0.289105	9.05E+05	1.60E+07	7.203297	0.964	0.036
10-22-90	6	12.74	0.46	28	0.0164	0.087273	BDL					
10-27-90	1	11	1.3	3	0.4333	0.080926	0.73427	1.10E+05	2.54E+05	5.405411	0.248	0.752
10-27-90	2	12.92	0.18	1	0.1800	0.836361	BDL					
10-27-90	3	7.02	2.48	16	0.1550	0.072406	0.52868	1.37E+05	8.84E+05	5.94625	0.687	0.313
10-27-90	3	7.64	2.96	4	0.7400	0.894211	0.72866	1.23E+06	1.66E+06	6.219684	0.831	0.169
10-27-90	4	6.07	8.23	12	0.6858	0.195111	BDL					
10-27-90	5	8.6	7.3	3	2.4333	0.840173	0.152905					
10-27-90	6	7.85	4.85	11	0.4409	0.227947	0.434155	5.25E+05	1.19E+06	6.075841	0.852	0.148
10-31-90	1	11.7	2.32	3	0.7733	0.182921	1.206006	1.52E+05	1.96E+05	5.292547	0.313	0.687
10-31-90	2	10.25	4.65	4	1.1625	BDL	0.772833					
10-31-90	3	10.96	0.46	4	0.1150	0.257697	0.448264	5.75E+05	5.00E+06	6.698876	0.697	0.303
10-31-90	4	12.11	0.59	2	0.2950	1.140409	0.255042	4.47E+06	1.52E+07	7.180627	0.899	0.101
10-31-90	4	11.84	0.16	6	0.0267	0.304222	0.175837	1.73E+06	6.49E+07	7.81211	0.912	0.088
10-31-90	5	7.64	2.16	21	0.1029	0.055164	0.02867	1.92E+06	1.87E+07	7.271993	0.976	0.024
10-31-90	6	11.24	2.58	1	2.5800	1.003402	2.00233					
11-05-90	1	8.65	3.21	3	1.0700	0.27441	0.365812					
11-05-90	1	8.27	3.81	2	1.9050	1.645333	BDL					
11-05-90	2	8	4.34	13	0.3338	0.194951	BDL					
11-05-90	3	7.35	1.83	24	0.0763	0.168515	BDL					
11-05-90	4	8.59	1.01	2	0.5050	1.310041	0.030976	4.23E+07	8.37E+07	7.922972	0.988	0.012
11-05-90	5	8.04	2.36	8	0.2950	0.256277	BDL					
11-05-90	6	9.29	1.37	4	0.3425	0.297365	0.975304	3.05E+05	8.90E+05	5.949488	0.549	0.451
11-09-90	1	8.46	0.77	28	0.0275	0.03943	BDL					
11-09-90	2	9.2	9.43	28	0.3368	0.021543	0.017004	1.27E+06	3.76E+06	6.575404	0.973	0.027
11-09-90	2	8.65	6.69	28	0.2389	0.030501	BDL					
11-09-90	3	7.04	6.91	28	0.2468	0.030266	BDL					
11-09-90	4	5.89	3.3	28	0.1179	0.090424	0.017032	5.31E+06	4.50E+07	7.653674	0.993	0.007
11-09-90	5	6.08	6.94	28	0.2479	0.078539	0.079553	9.87E+05	3.98E+06	6.600226	0.965	0.035
11-09-90	6	6.96	12.49	28	0.4461	0.184782	0.223482	8.27E+05	1.85E+06	6.268012	0.959	0.041
11-13-90	1	9.53	0.77	12	0.0642	BDL	BDL					
11-13-90	2	8.27	9.43	20	0.4715	BDL	0.075457					
11-13-90	3	2.41	6.69	16	0.4181	0.060459	BDL					
11-13-90	4	7.7	6.91	76	0.0909	0.10531	0.876159	1.20E+05	1.32E+06	6.121222	0.901	0.099
11-13-90	5	9.7	3.3	4	0.8250	0.222627	0.001131	1.97E+08	2.39E+08	8.377603	0.999	0.001
11-13-90	5	9.32	6.94	16	0.4338	0.042218	BDL					
11-13-90	6	7.19	12.49	8	1.5613	0.125163	0.521862					
				21.29			AVG=	9.20E+06	1.91E+07	6.44		
							LOG=	6.96	7.28			

Figure C25

OVERALL pesticides

DATE	SIT	G-CHL part. (NG/L)	G-CHL diss. (NG/L)	G-CHL K'd (L/KG)	G-CHL K'oc (L/KG)	G-CHL logK'oc	G-CHL Fp	G-CHL Fd	A-CHL part. (NG/L)	A-CHL diss. (NG/L)	A-CHL K'd (L/KG)	A-CHL K'oc (L/KG)	A-CHL logK'oc	A-CHL Fp	A-CHL Fd
4-17-92	1	0.038916	0.033802	7.48E+03	3.84E+05	5.58	0.535	0.465	0.089853	0.049953	1.17E+04	6.00E+05	5.78	0.643	0.357
4-17-92	1	0.067541							0.131827						
4-17-92	3	0.059267							0.136785						
4-17-92	6	0.087349	0.025154	1.37E+05	8.68E+05	5.94	0.776	0.224	0.045259	0.051331	3.49E+04	2.20E+05	5.34	0.469	0.531
4-18-92	1	0.020681	0.014754	1.89E+04					0.030504	0.023338	1.77E+04				
4-18-92	3	0.032525	0.008612	1.35E+05	2.91E+06	6.46	0.791	0.209	0.055972	0.02198	9.09E+04	1.96E+06	6.29	0.718	0.282
4-18-92	3	0.039557	0.013549	1.22E+05	3.07E+06	6.49	0.745	0.255	0.063184	0.024248	1.09E+05	2.74E+06	6.44	0.723	0.277
4-18-92	6	0.060368	0.010129	1.99E+05	2.98E+06	6.47	0.856	0.144	0.090062	0.021282	1.41E+05	2.12E+06	6.33	0.809	0.191
4-22-92	1	0.038468	0.016236	6.97E+04	5.92E+05	5.77	0.703	0.297	0.039221	0.032495	3.55E+04	3.02E+05	5.48	0.547	0.453
4-22-92	3	0.009851	0.02785	1.22E+04	5.90E+04	4.77	0.261	0.739	0.009003	0.058821	5.28E+03	2.55E+04	4.41	0.133	0.867
4-22-92	6	0.014022	0.017304	4.05E+04	1.35E+05	5.13	0.448	0.552	0.027862	0.033587	4.15E+04	1.38E+05	5.14	0.453	0.547
4-22-92	6	0.09199	0.014461	3.35E+05	3.18E+06	6.50	0.864	0.136	0.213958	0.038482	2.93E+05	2.78E+06	6.44	0.848	0.152
10-18-90	1	0.00483	0.00595	1.01E+05	3.76E+05	5.57	0.448	0.552	0.007409	0.025231	3.67E+04	1.36E+05	5.13	0.227	0.773
10-18-90	2	0.00212	0.005106	2.97E+04	1.79E+05	5.25	0.293	0.707	0.003789	0.027631	9.80E+03	5.91E+04	4.77	0.121	0.879
10-22-90	1	0.02295							0.036325	0.024922	2.43E+05	9.34E+05	5.97	0.593	0.407
10-22-90	2	0.0151							0.021015	0.00928	5.66E+05	3.24E+06	6.51	0.694	0.306
10-22-90	3	0.00401							0.006751	0.018307	2.63E+04	5.27E+05	5.72	0.269	0.731
10-22-90	3	0.01027							0.016117						
10-22-90	4	0	0.011717						0.009219	0.045597	8.42E+03	1.60E+05	5.21	0.168	0.832
10-22-90	5	0.03994	0.007439	1.79E+05	3.16E+06	6.50	0.843	0.157	0.057064	0.032167	5.92E+04	1.04E+06	6.02	0.640	0.360
10-22-90	6	0.01143	0.009753	4.19E+04	2.55E+06	6.41	0.540	0.460	0.017068	0.068044	8.96E+03	5.45E+05	5.74	0.201	0.799
10-27-90	1	0	0.011132						0	0.03339					
10-27-90	2	0	0.014929						0	0.021968					
10-27-90	3	0	0.008092						0.013194	0.027987	2.95E+04	1.90E+05	5.28	0.320	0.680
10-27-90	3	0.01446	0.024166	1.50E+05	2.02E+05	5.31	0.374	0.626	0.023856	0.018195	3.28E+05	4.43E+05	5.65	0.567	0.433
10-27-90	4	0	0.011281						0	0.021073					
10-27-90	5	0	0.015675						0	0.029555					
10-27-90	6	0.01105	0						0.019655	0.01785	1.00E+05	2.27E+05	5.36	0.524	0.476
10-31-90	1	0.00445	0.012599	1.18E+05	1.52E+05	5.18	0.261	0.739	0.010046	0.023254	1.44E+05	1.86E+05	5.27	0.302	0.698
10-31-90	2	0.00274	0.011002						0.007141	0.010684					
10-31-90	3	0.00906	0.012986	1.74E+05	1.52E+06	6.18	0.411	0.589	0.015978	0.015067	2.65E+05	2.30E+06	6.36	0.514	0.486
10-31-90	4	0.01491	0.043706	1.71E+05	5.78E+05	5.76	0.254	0.746	0.02631	0.028941	4.55E+05	1.54E+06	6.19	0.476	0.524
10-31-90	4	0.00495	0.023507	3.51E+04	1.32E+06	6.12	0.174	0.826	0.008608	0.021027	6.82E+04	2.56E+06	6.41	0.290	0.710
10-31-90	5	0.01311	0.029375	2.13E+04	2.07E+05	5.32	0.309	0.691	0.022572	0.026401	4.07E+04	3.96E+05	5.60	0.461	0.539
10-31-90	6	0	0.019082						0.018821	0.022986					
11-05-90	1	0.02247	0.009868						0.038683	0.013064					
11-05-90	1	0.02363	0.017782						0.038969	0.020707					
11-05-90	2	0	0.025143						0	0.030188					
11-05-90	3	0.02004	0.014547	5.74E+04	7.53E+05	5.88	0.579	0.421	0.039562	0.018983	8.68E+04	1.14E+06	6.06	0.676	0.324
11-05-90	4	0.02047	0.017501	5.85E+05	1.16E+06	6.06	0.539	0.461	0.024183	0.028335	4.27E+05	8.45E+05	5.93	0.460	0.540
11-05-90	5	0.01693	0.014743	1.44E+05	4.87E+05	5.69	0.535	0.465	0.020036	0.01515	1.65E+05	5.60E+05	5.75	0.569	0.431
11-05-90	6	0	0.016656						0	0.023917					
11-09-90	1	0.01402	0.025866	1.94E+04	7.04E+05	5.85	0.352	0.648	0.014776	0.015883	3.32E+04	1.21E+06	6.08	0.482	0.518
11-09-90	2	0.00976	0.014013	2.49E+04	7.39E+04	4.87	0.411	0.589	0.015893	0.020371	2.79E+04	8.27E+04	4.92	0.438	0.562
11-09-90	2	0.01502	0.02981	1.80E+04	7.53E+04	4.88	0.335	0.665	0.019524	0.014911	4.68E+04	1.96E+05	5.29	0.567	0.433
11-09-90	3	0.015	0.009485	5.65E+04	2.29E+05	5.36	0.613	0.387	0.019052	0.009162	7.43E+04	3.01E+05	5.48	0.675	0.325
11-09-90	4	0.02459	0.015896	5.52E+04	4.69E+05	5.67	0.607	0.393	0.033193	0.015699	7.55E+04	6.41E+05	5.81	0.679	0.321
11-09-90	5	0	0.019736						0	0.02656					
11-09-90	6	0.04762	0.026881	6.33E+04	1.42E+05	5.15	0.639	0.361	0.053265	0.031969	5.95E+04	1.33E+05	5.13	0.625	0.375
11-13-90	1	0.00531	0.008749	5.06E+04	7.88E+05	5.90	0.378	0.622	0.008998	0.012653	5.93E+04	9.24E+05	5.97	0.416	0.584
11-13-90	2	0.00487	0.006381	3.82E+04	8.09E+04	4.91	0.433	0.567	0.010476	0.011071	4.73E+04	1.00E+05	5.00	0.486	0.514
-90	3	0.01716	0.03741	2.87E+04	6.86E+04	4.84	0.314	0.686	0.036097	0.039375	5.73E+04	1.37E+05	5.14	0.478	0.522
-0	4	0.00673	0.012371	7.16E+03	7.87E+04	4.90	0.352	0.648	0.010717	0.017661	7.98E+03	8.78E+04	4.94	0.378	0.622
-0	5	0	0.011843						0.006581	0.020073	8.20E+04	9.93E+04	5.00	0.247	0.753
-90	5	0	0.008166						0	0.013055					
11-13-90	6	0	0.014055						0	0.019504					
			AVG=	9.83E+04	9.22E+05	5.65					1.10E+05	8.16E+05	5.62		
			log=	4.99	5.96						5.04	5.91			

Figure C26

OVERALL pesticides

DATE	SIT	DIELDRIN part. (NG/L)	DIELDRIN diss. (NG/L)	DIELDRIN K'd (L/KG)	DIELDRIN K'oc (L/KG)	DIELDRIN logK'oc	DIELDRIN Fp	DIELDRIN Fd	DDT part. (NG/L)	DDT diss. (NG/L)	DDT K'd (L/KG)	DDT K'oc (L/KG)	DDT logK'oc	DDT Fp	DDT Fd
4-17-92	1	0.052054	0.052846	6.40E+03	3.28E+05	5.52	0.496	0.504	0.098439	0.019574	3.27E+04	1.68E+06	6.22	0.834	0.16
4-17-92	1	0.035986							0.056326						
4-17-92	3	0.022609	0.061247	4.99E+03	3.69E+05	5.57	0.270	0.730	0.049409	0.027335	2.44E+04	1.81E+06	6.26	0.644	0.35
4-17-92	6	0.075646	0.099832	2.99E+04	1.89E+05	5.28	0.431	0.569	0.036714	0.006359	2.28E+05	1.44E+06	6.16	0.852	0.14
4-18-92	1		0.04144						0.014164	0.006242	3.07E+04				
4-18-92	3	0.020329	0.043893	1.65E+04	3.56E+05	5.55	0.317	0.683	0.013695	0.003218	1.52E+05	3.27E+06	6.52	0.810	0.19
4-18-92	3	0.013809	0.061777	9.31E+03	2.35E+05	5.37	0.183	0.817	0.034421	0.025641	5.59E+04	1.41E+06	6.15	0.573	0.42
4-18-92	6	0.027801	0.057364	1.62E+04	2.42E+05	5.38	0.326	0.674	0.027468	0.026652	3.44E+04	5.15E+05	5.71	0.508	0.49
4-22-92	1	0.022854	0.086989	7.73E+03	6.57E+04	4.82	0.208	0.792	0.45456	0.011942	1.12E+06	9.52E+06	6.98	0.974	0.02
4-22-92	3		0.098041						0.018531	0.025777	2.48E+04	1.20E+05	5.08	0.418	0.58
4-22-92	6		0.054604						0.011415	0.008756	6.52E+04	2.17E+05	5.34	0.566	0.43
4-22-92	6	0.017708	0.057681	1.62E+04	1.53E+05	5.19	0.235	0.765	0.026327	0.009549	1.45E+05	1.38E+06	6.14	0.734	0.26
10-18-90	1	0.0121	0.054685	2.77E+04	1.02E+05	5.01	0.181	0.819	0.0121						
10-18-90	2	0	0.082416						0						
10-22-90	1	0.39875							0.39875						
10-22-90	2	0.08693							0.08693						
10-22-90	3	0							0						
10-22-90	3	0							0						
10-22-90	4	0	0.106964						0	0.005311					
10-22-90	5	0.04137	0.108834	1.27E+04	2.24E+05	5.35	0.275	0.725	0.04137						
10-22-90	6	0.00606	0.076245	2.84E+03	1.73E+05	5.24	0.074	0.926	0.00606	0.005771	3.75E+04	2.28E+06	6.36	0.512	0.48
10-27-90	1	0.04481	0.037112	4.02E+05	9.29E+05	5.97	0.547	0.453	0.04481	0.01432	1.04E+06	2.41E+06	6.38	0.758	0.24
10-27-90	2	0	0.056181						0						
10-27-90	3	0.02971	0.095308	1.95E+04	1.26E+05	5.10	0.238	0.762	0.02971						
10-27-90	3	0.10166	0.097315	2.61E+05	3.53E+05	5.55	0.511	0.489	0.10166	0.025658	9.91E+05	1.34E+06	6.13	0.798	0.20
10-27-90	4	0	0.081549						0	0.006892					
10-27-90	5	0	0.092402						0	0.010652					
10-27-90	6	0.05113	0.079206	5.87E+04	1.33E+05	5.12	0.392	0.608	0.05113	0.005208	8.93E+05	2.02E+06	6.31	0.908	0.09
10-31-90	1	0	0.096105						0	0.014502					
10-31-90	2	0.08347	0.104155						0.08347	0.008103					
10-31-90	3	0.06367	0.045379	3.51E+05	3.05E+06	6.48	0.584	0.416	0.06367	0.00607	2.62E+06	2.28E+07	7.36	0.913	0.08
10-31-90	4	0.07704	0.059734	6.45E+05	2.19E+06	6.34	0.563	0.437	0.07704	0.03949	9.75E+05	3.31E+06	6.52	0.661	0.33
10-31-90	4	0	0.074851						0	0.007422					
10-31-90	5	0.0776	0.044329	8.34E+04	8.10E+05	5.91	0.636	0.364	0.0776	0.018543	1.99E+05	1.94E+06	6.29	0.807	0.19
10-31-90	6	0.05102	0.087522						0.05102	0.012061					
11-05-90	1	0.05415	0.042609						0.05415						
11-05-90	1	0.00025	0.09729						0.00025	0.004957					
11-05-90	2	0	0.10604						0	0.006862					
11-05-90	3	0	0.070288						0	0.004761					
11-05-90	4	0.05727	0.054996	5.21E+05	1.03E+06	6.01	0.510	0.490	0.05727	0.00623	4.60E+06	9.10E+06	6.96	0.902	0.09
11-05-90	5	0	0.054106						0						
11-05-90	6	0	0.187379						0	0.011246					
11-09-90	1	0.03767	0.058337	2.31E+04	8.39E+05	5.92	0.392	0.608	0.03767	0.006218	2.16E+05	7.87E+06	6.90	0.858	0.14
11-09-90	2	0	0.068199						0						
11-09-90	2	0	0.074684						0	0.031174					
11-09-90	3	0.03477	0.078702	1.58E+04	6.39E+04	4.81	0.306	0.694	0.03477	0.005576	2.23E+05	9.02E+05	5.96	0.862	0.13
11-09-90	4	0.07732	0.078562	3.51E+04	2.98E+05	5.47	0.496	0.504	0.07732						
11-09-90	5	0.12707	0.104759	4.33E+04	1.75E+05	5.24	0.548	0.452	0.12707	0.00601	7.55E+05	3.05E+06	6.48	0.955	0.04
11-09-90	6	0.07215	0.107295	2.40E+04	5.38E+04	4.73	0.402	0.598	0.07215	0.010454	2.46E+05	5.53E+05	5.74	0.873	0.12
11-13-90	1	0	0.060991						0						
11-13-90	2	0.18091	0.073531	1.23E+05	2.61E+05	5.42	0.711	0.289	0.18091						
11-13-90	3	0.04013	0.082118	3.05E+04	7.30E+04	4.86	0.328	0.672	0.04013	0.043444	5.77E+04	1.38E+05	5.14	0.480	0.52
11-13-90	4	0	0.112492						0	0.00718					
11-13-90	5	0	0.039726						0	0.011795					
11-13-90	5	0.04278	0.103753	2.58E+04	5.94E+04	4.77	0.292	0.708	0.04278	0.010568	2.53E+05	5.83E+05	5.77	0.802	0.19
11-13-90	6	0	0.09366						0	0.007933					
				1.04E+05	4.77E+05	5.41					6.01E+05	3.32E+06	6.20		
				5.02	5.68						5.78	6.52			

Figure C26 (cont.)

DATE	SIT	TSS (ppm)	[DOC] (ppm)	[POC] (ppm)	Foc	B[a]a part. (MG/KG)	B[a]a diss. (NG/L)	B[a]a K'd (L/KG)	B[a]a K'oc (L/KG)	B[a]a logK'oc	B[a]a Fp	B[a]a Fd
4-17-92	1	154	10	3	0.0195	0.357	23.63	1.51E+04	7.76E+05	5.89	0.699	0.301
4-17-92	1	52	10	7	0.1346	0.82	24.71	3.32E+04	2.47E+05	5.39	0.633	0.367
4-17-92	3	74	10	1	0.0135	1.536						
4-17-92	6	25.3	11	4	0.1581							
4-18-92	1	74	13	0	0.0000	0.115	2.21	5.20E+04				
4-18-92	3	28	12.6	1.3	0.0464	0.224						
4-18-92	3	24	11.45	0.95	0.0396	0.308	2.94	1.05E+05	2.65E+06	6.42	0.715	0.285
4-18-92	6	30	16	2	0.0667	3.019						
4-22-92	1	34	10	4	0.1176	0.41	2.64	1.55E+05	1.32E+06	6.12	0.841	0.159
4-22-92	3	29	9	6	0.2069	1.129						
4-22-92	6	20	13	6	0.3000	0.265						
4-22-92	6	19	11	2	0.1053	0.407						
10-18-90	1	8	7.54	2.16	0.2700		2.47561					
10-18-90	2	14	9.88	2.32	0.1657		3.74685					
10-22-90	1	6	9.84	1.56	0.2600	1.646						
10-22-90	2	4	10.9	0.7	0.1750	0.975						
10-22-90	3	14	10.5	0.7	0.0500	0.783						
10-22-90	3	6	10.5	0.9	0.1500							
10-22-90	4	24	10.94	1.26	0.0525		4.88836					
10-22-90	5	30	12.5	1.7	0.0567		4.57962					
10-22-90	6	28	12.74	0.46	0.0164		6.08329					
10-27-90	1	3	11	1.3	0.4333	0.652	2.29622	2.84E+05	6.55E+05	5.82	0.460	0.540
10-27-90	2	1	12.92	0.18	0.1800	0.674	0.81635	8.26E+05	4.59E+06	6.66	0.452	0.548
10-27-90	3	16	7.02	2.48	0.1550	0.238	1.94769	1.22E+05	7.88E+05	5.90	0.662	0.338
10-27-90	3	4	7.64	2.96	0.7400		1.75555					
10-27-90	4	12	6.07	8.23	0.6858		3.46727					
10-27-90	5	3	8.6	7.3	2.4333	1.559	6.33328					
10-27-90	6	11	7.85	4.85	0.4409	0.252	5.85154	4.31E+04	9.77E+04	4.99	0.321	0.679
10-31-90	1	3	11.7	2.32	0.7733	0.672	3.57488	1.88E+05	2.43E+05	5.39	0.361	0.639
10-31-90	2	4	10.25	4.65	1.1625	1.165	6.01586					
10-31-90	3	4	10.96	0.46	0.1150	0.418						
10-31-90	4	2	12.11	0.59	0.2950	1.329	2.9977	4.43E+05	1.50E+06	6.18	0.470	0.530
10-31-90	4	6	11.84	0.16	0.0267	0.696	2.71457	2.56E+05	9.61E+06	6.98	0.606	0.394
10-31-90	5	21	7.64	2.16	0.1029	0.209	0.44334	4.71E+05	4.58E+06	6.66	0.908	0.092
10-31-90	6	1	11.24	2.58	2.5800	2.525	7.34264					
11-05-90	1	3	8.65	3.21	1.0700	2.189	2.59643					
11-05-90	1	2	8.27	3.81	1.9050	2.39	2.10213					
11-05-90	2	13	8	4.34	0.3338	0.475	24.0203	1.98E+04	5.92E+04	4.77	0.205	0.795
11-05-90	3	24	7.35	1.83	0.0763	0.4	26.6318	1.50E+04	1.97E+05	5.29	0.265	0.735
11-05-90	4	2	8.59	1.01	0.5050	1.694	2.41183	7.02E+05	1.39E+06	6.14	0.584	0.416
11-05-90	5	8	8.04	2.36	0.2950	0.415	0.40415	1.03E+06	3.48E+06	6.54	0.891	0.109
11-05-90	6	4	9.29	1.37	0.3425	0.364	1.87478	1.94E+05	5.67E+05	5.75	0.437	0.563
11-09-90	1	28	8.46	0.77	0.0275	0.096	0.33613	2.86E+05	1.04E+07	7.02	0.889	0.111
11-09-90	2	28	9.2	9.43	0.3368	0.096	2.19888	4.37E+04	1.30E+05	5.11	0.550	0.450
11-09-90	2	28	8.65	6.69	0.2389	0.143						
11-09-90	3	28	7.04	6.91	0.2468	0.114	4.66987	2.44E+04	9.89E+04	5.00	0.406	0.594
1-09-90	4	28	5.89	3.3	0.1179	0.164	33.6245	4.88E+03	4.14E+04	4.62	0.120	0.880
1-09-90	5	28	6.08	6.94	0.2479	0.361	4.32327	8.35E+04	3.37E+05	5.53	0.700	0.300
1-09-90	6	28	6.96	12.49	0.4461	0.447	1.76966	2.53E+05	5.66E+05	5.75	0.876	0.124
11-13-90	1	12	9.53	0.77	0.0642	0.459	3.62166	1.27E+05	1.98E+06	6.30	0.603	0.397
11-13-90	2	20	8.27	9.43	0.4715	0.107	0.39569	2.70E+05	5.74E+05	5.76	0.844	0.156
11-13-90	3	16	2.41	6.69	0.4181	0.299	1.01592	2.94E+05	7.04E+05	5.85	0.825	0.175
11-13-90	4	76	7.7	6.91	0.0909	0.401	5.36129	7.48E+04	8.23E+05	5.92	0.850	0.150
11-13-90	5	4	9.7	3.3	0.8250	1.98	1.40597	1.41E+06	1.71E+06	6.23	0.849	0.151
11-13-90	5	16	9.32	6.94	0.4338	0.434	1.19437	3.63E+05	8.38E+05	5.92	0.853	0.147
11-13-90	6	8	7.19	12.49	1.5613	1.066	4.00944					
		21.29					AVG=	2.73E+05	1.70E+06	5.66		
							log=	5.44	6.23			

Figure C27

DATE	SIT	Chrysene part. (MG/KG)	Chrysene diss. (NG/L)	Chrysene K'd (L/KG)	Chrysene K'oc (L/KG)	Chrysene logK'oc	Chrysene Fp	Chrysene Fd	[illegible] part. (MG/KG)	[illegible] diss. (NG/L)	[illegible] K'd (L/KG)	[illegible] K'oc (L/KG)	[illegible] logK'oc	[illegible] Fp	[illegible] Fd
4-17-92	1	0.422	8.57	4.92E+04	2.53E+06	6.40	0.883	0.117	0.493	5.9	8.36E+04	4.29E+06	6.63	0.928	0.07
4-17-92	1	0.914	9.101	1.00E+05	7.46E+05	5.87	0.839	0.161	1.139	6.2	1.84E+05	1.36E+06	6.14	0.905	0.09
4-17-92	3	0.491							0.606	0.88	6.89E+05	5.10E+07	7.71	0.981	0.01
4-17-92	6	3.62	8.29	4.37E+05	2.76E+06	6.44	0.917	0.083	3.435	4.23	8.12E+05	5.14E+06	6.71	0.954	0.04
4-18-92	1	0.27	1.34	2.01E+05					0.205	0.783	2.62E+05				
4-18-92	3	0.355							0.334						
4-18-92	3	0.426	1.99	2.14E+05	5.41E+06	6.73	0.837	0.163	0.446	1.03	4.33E+05	1.09E+07	7.04	0.912	0.08
4-18-92	6	1.759	3.36	5.24E+05	7.85E+06	6.90	0.940	0.060	1.345	0.9	1.49E+06	2.24E+07	7.35	0.978	0.02
4-22-92	1	0.901	6.43	1.40E+05	1.19E+06	6.08	0.827	0.173	1.102	3.39	3.25E+05	2.76E+06	6.44	0.917	0.08
4-22-92	3	2.041	11.25	1.81E+05	8.77E+05	5.94	0.840	0.160	2.545	5.48	4.64E+05	2.24E+06	6.35	0.931	0.06
4-22-92	6	0.459							0.556	2.02	2.75E+05	9.17E+05	5.96	0.846	0.15
4-22-92	6	1.316	1.92	6.85E+05	6.51E+06	6.81	0.929	0.071	0.958	1.86	5.15E+05	4.89E+06	6.69	0.907	0.09
10-18-90	1		1.75327							1.06077					
10-18-90	2		2.22682							1.43076					
10-22-90	1	3.16							2.754						
10-22-90	2	1.716							1.374						
10-22-90	3	1.092							0.93						
10-22-90	3														
10-22-90	4		2.42034							1.72589					
10-22-90	5		1.84783							1.93811					
10-22-90	6		2.85334							2.58549					
10-27-90	1	0.946	1.36633	6.92E+05	1.60E+06	6.20	0.675	0.325	1.075	1.26048	8.53E+05	1.97E+06	6.29	0.719	0.28
10-27-90	2	1.249							1.456	0.55047	2.65E+06	1.47E+07	7.17	0.726	0.27
10-27-90	3	0.397	1.80085	2.20E+05	1.42E+06	6.15	0.779	0.221	0.363	1.16523	3.12E+05	2.01E+06	6.30	0.833	0.16
10-27-90	3		1.99319							0.86827					
10-27-90	4		1.4318							1.23482					
10-27-90	5	2.24	5.2289						2.109	2.71005					
10-27-90	6	0.392	5.33919	7.34E+04	1.67E+05	5.22	0.447	0.553	0.374	2.51252	1.49E+05	3.38E+05	5.53	0.621	0.37
10-31-90	1	1.062	1.92283	5.52E+05	7.14E+05	5.85	0.624	0.376	1.067	1.35501	7.87E+05	1.02E+06	6.01	0.703	0.29
10-31-90	2	3.011	2.06044						1.308	1.71416					
10-31-90	3	0.846							0.756	0.42626	1.77E+06	1.54E+07	7.19	0.876	0.12
10-31-90	4	2.296	1.24637	1.84E+06	6.24E+06	6.80	0.787	0.213	2.597	1.45663	1.78E+06	6.04E+06	6.78	0.781	0.21
10-31-90	4	1.369	1.16951	1.17E+06	4.39E+07	7.64	0.875	0.125	1.353	1.51213	8.95E+05	3.36E+07	7.53	0.843	0.15
10-31-90	5	0.348							0.33	0.79754	4.14E+05	4.02E+06	6.60	0.897	0.10
10-31-90	6	4.816	3.0301						4.419	2.52626					
11-05-90	1	3.376	1.66223						4.023	1.27021					
11-05-90	1	4.536	1.50734						4.621	1.0632					
11-05-90	2	0.834	12.6355	6.60E+04	1.98E+05	5.30	0.462	0.538	0.881	10.7334	8.21E+04	2.46E+05	5.39	0.516	0.48
11-05-90	3	0.558	15.6755	3.56E+04	4.67E+05	5.67	0.461	0.539	0.526	13.6152	3.86E+04	5.07E+05	5.70	0.481	0.51
11-05-90	4	2.464	1.61913	1.52E+06	3.01E+06	6.48	0.753	0.247	2.238						
11-05-90	5	0.599							0.525						
11-05-90	6	0.482	1.17854	4.09E+05	1.19E+06	6.08	0.621	0.379	0.585	0.8502	6.88E+05	2.01E+06	6.30	0.733	0.26
11-09-90	1	0.156							0.188	0.50419	3.73E+05	1.36E+07	7.13	0.913	0.08
11-09-90	2	0.169	2.07725	8.14E+04	2.42E+05	5.38	0.695	0.305	0.179	1.30608	1.37E+05	4.06E+05	5.61	0.793	0.20
11-09-90	2	0.214							0.191						
11-09-90	3	0.196	3.77529	5.24E+04	2.13E+05	5.33	0.595	0.405	0.21	2.60087	8.07E+04	3.27E+05	5.51	0.693	0.30
11-09-90	4	0.284	16.8005	1.69E+04	1.43E+05	5.16	0.321	0.679	0.226	15.3416	1.47E+04	1.25E+05	5.10	0.292	0.70
11-09-90	5	0.424	3.45548	1.23E+05	4.95E+05	5.69	0.775	0.225	0.599	2.546	2.35E+05	9.49E+05	5.98	0.868	0.13
11-09-90	6	0.563							0.653	4.12197	1.58E+05	3.55E+05	5.55	0.816	0.18
11-13-90	1	0.699	1.65746	4.22E+05	6.57E+06	6.82	0.835	0.165	0.709	1.30441	5.44E+05	8.47E+06	6.93	0.867	0.13
11-13-90	2	0.189							0.157	0.73414	2.14E+05	4.54E+05	5.66	0.811	0.18
11-13-90	3	0.629							0.647	1.4199	4.56E+05	1.09E+06	6.04	0.879	0.12
11-13-90	4	0.522	2.98096	1.75E+05	1.93E+06	6.28	0.930	0.070	0.567						
11-13-90	5	2.274	1.24512	1.83E+06	2.21E+06	6.35	0.880	0.120	1.711	2.07659	8.24E+05	9.99E+05	6.00	0.767	0.23
11-13-90	5	0.522							0.379	2.9742	1.27E+05	2.94E+05	5.47	0.671	0.32
11-13-90	6	1.299	2.00925						0.923	3.55034					
				4.54E+05	3.79E+06	5.91					5.62E+05	6.51E+06	6.33		
				5.66	6.58						5.75	6.81			

Figure C27 (cont.)

DATE	SIT	part. (MG/KG)	diss. (NG/L)	K'd (L/KG)	K'oc (L/KG)	logK'oc	Fp	Fd	part. (MG/KG)	diss. (NG/L)	K'd (L/KG)	K'oc (L/KG)	logK'oc	Fp	Fd
4-17-92	1	0.217	1.349	1.61E+05	8.26E+06	6.92	0.961	0.039	0.314	2.196	1.43E+05	7.34E+06	6.87	0.957	0.043
4-17-92	1	0.484	1.313	3.69E+05	2.74E+06	6.44	0.950	0.050	0.694	2.16	3.21E+05	2.39E+06	6.38	0.944	0.056
4-17-92	3	0.263	0.286	9.20E+05	6.80E+07	7.83	0.986	0.014	0.363						
4-17-92	6	1.421	1.526	9.31E+05	5.89E+06	6.77	0.959	0.041	1.706	1.022	1.67E+06	1.06E+07	7.02	0.977	0.023
4-18-92	1	0.078	0.195	4.00E+05					0.119	0.12	9.92E+05				
4-18-92	3	0.147	0.179	8.21E+05	1.77E+07	7.25	0.958	0.042	0.216						
4-18-92	3	0.196	0.367	5.34E+05	1.35E+07	7.13	0.928	0.072	0.291						
4-18-92	6	0.511	0.32	1.60E+06	2.40E+07	7.38	0.980	0.020	0.782						
4-22-92	1	0.472	0.77	6.13E+05	5.21E+06	6.72	0.954	0.046	0.625	0.896	6.98E+05	5.93E+06	6.77	0.960	0.040
4-22-92	3	1.083	1.1	9.85E+05	4.76E+06	6.68	0.966	0.034	1.3	1.277	1.02E+06	4.92E+06	6.69	0.967	0.033
4-22-92	6	0.242	0.55	4.40E+05	1.47E+06	6.17	0.898	0.102	0.305	0.66	4.62E+05	1.54E+06	6.19	0.902	0.098
4-22-92	6	0.367	0.499	7.35E+05	6.99E+06	6.84	0.933	0.067	0.499	0.413	1.21E+06	1.15E+07	7.06	0.958	0.042
10-18-90	1		0.22063							0.30142					
10-18-90	2		0.28766							0.36031					
10-22-90	1	0.933							2.359						
10-22-90	2	0.459							1.065						
10-22-90	3	0.343							0.664						
10-22-90	3														
10-22-90	4		0.36749							0.5107					
10-22-90	5		0.29868							0.45666					
10-22-90	6		0.49446							0.7722					
10-27-90	1	0.253	0.21975	1.15E+06	2.66E+06	6.42	0.775	0.225	0.861	0.37002	1.79E+06	4.12E+06	6.62	0.843	0.157
10-27-90	2	0.511	0.12326	4.15E+06	2.30E+07	7.36	0.806	0.194	0.551	0.15161	3.63E+06	2.02E+07	7.31	0.784	0.216
10-27-90	3	0.125	0.25037	4.99E+05	3.22E+06	6.51	0.889	0.111	0.196	0.34366	5.70E+05	3.68E+06	6.57	0.901	0.099
10-27-90	3		0.21072							0.30171					
10-27-90	4		0.27236							0.27753					
10-27-90	5	0.789	0.50296						1.226	0.59007					
10-27-90	6	0.144	0.49852	2.89E+05	6.55E+05	5.82	0.761	0.239	0.173	0.51302	3.37E+05	7.65E+05	5.88	0.788	0.212
10-31-90	1	0.377	0.27892	1.35E+06	1.75E+06	6.24	0.802	0.198	0.666	0.37434	1.78E+06	2.30E+06	6.36	0.842	0.158
10-31-90	2	0.327							0.524						
10-31-90	3	0.334	0.10165	3.29E+06	2.86E+07	7.46	0.929	0.071	0.566						
10-31-90	4	0.975	0.31118	3.13E+06	1.06E+07	7.03	0.862	0.138	1.512	0.4053	3.73E+06	1.26E+07	7.10	0.882	0.118
10-31-90	4	0.478	0.35939	1.33E+06	4.99E+07	7.70	0.889	0.111	0.851	0.38549	2.21E+06	8.28E+07	7.92	0.930	0.070
10-31-90	5	0.125	0.18105	6.90E+05	6.71E+06	6.83	0.935	0.065	0.201	0.18551	1.08E+06	1.05E+07	7.02	0.958	0.042
10-31-90	6	1.668	0.4209						2.649	0.85766					
11-05-90	1	1.474	0.24106						2.619						
11-05-90	1	1.728	0.19871						3.411	0.18347					
11-05-90	2	0.321	2.55584	1.26E+05	3.76E+05	5.58	0.620	0.380	0.572	2.19381	2.61E+05	7.81E+05	5.89	0.772	0.228
11-05-90	3	0.205	2.98823	6.86E+04	9.00E+05	5.95	0.622	0.378	0.376	1.77119	2.12E+05	2.78E+06	6.44	0.836	0.164
11-05-90	4	0.828							1.511						
11-05-90	5	0.208							0.349						
11-05-90	6	0.198	0.25482	7.78E+05	2.27E+06	6.36	0.757	0.243	0.338	0.22826	1.48E+06	4.32E+06	6.64	0.856	0.144
11-09-90	1	0.059	0.12279	4.80E+05	1.75E+07	7.24	0.931	0.069	0.115	0.14976	7.68E+05	2.79E+07	7.45	0.956	0.044
11-09-90	2	0.071	0.31349	2.26E+05	6.72E+05	5.83	0.864	0.136	0.12	0.40529	2.96E+05	8.79E+05	5.94	0.892	0.108
11-09-90	2	0.072							0.145						
11-09-90	3	0.077	0.46724	1.65E+05	6.68E+05	5.82	0.822	0.178	0.129	0.57966	2.23E+05	9.02E+05	5.96	0.862	0.138
11-09-90	4	0.079	2.2867	3.45E+04	2.93E+05	5.47	0.492	0.508	0.144	3.37095	4.27E+04	3.62E+05	5.56	0.545	0.455
11-09-90	5	0.179	0.38679	4.63E+05	1.87E+06	6.27	0.928	0.072	0.325	0.38253	8.50E+05	3.43E+06	6.54	0.960	0.040
11-09-90	6	0.213	0.98138	2.17E+05	4.87E+05	5.69	0.859	0.141	0.376	1.06914	3.52E+05	7.88E+05	5.90	0.908	0.092
11-13-90	1	0.262	0.26834	9.76E+05	1.52E+07	7.18	0.921	0.079	0.356	0.38369	9.28E+05	1.45E+07	7.16	0.918	0.082
11-13-90	2	0.064	0.14851	4.31E+05	9.14E+05	5.96	0.896	0.104	0.129	0.16966	7.60E+05	1.61E+06	6.21	0.938	0.062
11-13-90	3	0.231	0.3485	6.63E+05	1.59E+06	6.20	0.914	0.086	0.386	0.3299	1.17E+06	2.80E+06	6.45	0.949	0.051
11-13-90	4	0.192	0.35993	5.33E+05	5.87E+06	6.77	0.976	0.024	0.351						
11-13-90	5	0.562	0.43166	1.30E+06	1.58E+06	6.20	0.839	0.161	1.171	0.58546	2.00E+06	2.42E+06	6.38	0.889	0.111
11-13-90	5	0.129	0.56219	2.29E+05	5.29E+05	5.72	0.786	0.214	0.267	0.68132	3.92E+05	9.03E+05	5.96	0.862	0.138
11-13-90	6	0.312	0.63375						0.68	0.68906					
				8.63E+05	9.61E+06	6.56					1.05E+06	8.47E+06	6.56		
				5.94	6.98						6.02	6.93			

Figure C27 (cont.)

METALS Water Column

DATE	SIT	TSS (MG/L)	DOC (MG/L)	POC (MG/L)	Foc	LEAD DISS. (MG/L)	LEAD SUSP. (MG/L)	LEAD K'd (L/KG)	LEAD log K'd	LEAD Fp	LEAD Fd
4-17-92	1	154	10	3	0.0195	0.0102	0.0103	6.56E+03	3.82	0.502	0.498
4-17-92	1	52	10	7	0.1346	0.0222	0.014	1.21E+04	4.08	0.387	0.613
4-17-92	3	74	10	1	0.0135	0.0161	0.0051	4.28E+03	3.63	0.241	0.759
4-17-92	6	25.3	11	4	0.1581	0.0052	0.0884	6.72E+05	5.83	0.944	0.056
4-18-92	1	74	13	0	0.0000	0.0053	0.0229	5.84E+04	4.77	0.812	0.188
4-18-92	3	28	12.6	1.3	0.0464	0.006	0.036	2.14E+05	5.33	0.857	0.143
4-18-92	3	24	11.45	0.95	0.0396	0.0078	0.0406	2.17E+05	5.34	0.839	0.161
4-18-92	6	30	16	2	0.0667	0.0081	0.0418	1.72E+05	5.24	0.838	0.162
4-22-92	1	34	10	4	0.1176	0.0061	0.023	1.11E+05	5.04	0.790	0.210
4-22-92	3	29	9	6	0.2069	0.0092	0.0139	5.21E+04	4.72	0.602	0.398
4-22-92	6	20	13	6	0.3000	0.0029	0.0083	1.43E+05	5.16	0.741	0.259
4-22-92	6	19	11	2	0.1053	0.0054	0.0063	6.14E+04	4.79	0.538	0.462
10-18-90	1	8	7.54	2.16	0.2700	BDL	0.005				
10-18-90	2	14	9.88	2.32	0.1657	BDL	0.0015				
10-22-90	1	6	9.84	1.56	0.2600	BDL	0.0005				
10-22-90	2	4	10.9	0.7	0.1750	BDL	0.0005				
10-22-90	3	14	10.5	0.7	0.0500	BDL	0.01				
10-22-90	3	6	10.5	0.9	0.1500	BDL	0.009				
10-22-90	4	24	10.94	1.26	0.0525	BDL	0.0065				
10-22-90	5	30	12.5	1.7	0.0567	0.004	0.034	2.83E+05	5.45	0.895	0.105
10-22-90	6	28	12.74	0.46	0.0164	0.003	0.007	8.33E+04	4.92	0.700	0.300
10-27-90	1	3	11	1.3	0.4333	BDL	0.011				
10-27-90	2	1	12.92	0.18	0.1800	BDL	0.0035				
10-27-90	3	16	7.02	2.48	0.1550	BDL	BDL				
10-27-90	3	4	7.64	2.96	0.7400	BDL	BDL				
10-27-90	4	12	6.07	8.23	0.6858	BDL	0.0085				
10-27-90	5	3	8.6	7.3	2.4333	BDL	0.003				
10-27-90	6	11	7.85	4.85	0.4409	BDL	BDL				
10-31-90	1	3	11.7	2.32	0.7733	0.003	0.052	5.78E+06	6.76	0.945	0.055
10-31-90	2	4	10.25	4.65	1.1625	BDL	0.018				
10-31-90	3	4	10.96	0.46	0.1150	BDL	0.011				
10-31-90	4	2	12.11	0.59	0.2950	BDL	0.004				
10-31-90	4	6	11.84	0.16	0.0267	BDL	0.003				
10-31-90	5	21	7.64	2.16	0.1029	BDL	0.002				
10-31-90	6	1	11.24	2.58	2.5800	0.017	0.009				
11-05-90	1	3	8.65	3.21	1.0700	0.003	0.005				
11-05-90	1	2	8.27	3.81	1.9050	0.003	0.004				
11-05-90	2	13	8	4.34	0.3338	BDL	0.007				
11-05-90	3	24	7.35	1.83	0.0763	0.004	0.004	4.17E+04	4.62	0.500	0.500
11-05-90	4	2	8.59	1.01	0.5050	0.001	0.012	6.00E+06	6.78	0.923	0.077
11-05-90	5	8	8.04	2.36	0.2950	0.001	0.003	3.75E+05	5.57	0.750	0.250
11-05-90	6	4	9.29	1.37	0.3425	0.002	0.008	1.00E+06	6.00	0.800	0.200
11-09-90	1	28	9.53	0.77	0.0275	BDL	0.025				
11-09-90	2	28	8.27	9.43	0.3368	0.004	0.051	4.55E+05	5.66	0.927	0.073
11-09-90	2	28	2.41	6.69	0.2389	BDL	0.017				
11-09-90	3	28	7.7	6.91	0.2468	0.005	0.01	7.14E+04	4.85	0.667	0.333
11-09-90	4	28	9.7	3.3	0.1179	0.005	0.013	9.29E+04	4.97	0.722	0.278
11-09-90	5	28	9.32	6.94	0.2479	0.003	0.008	9.52E+04	4.98	0.727	0.273
11-09-90	6	28	7.19	12.49	0.4461	0.005	0.008	5.71E+04	4.76	0.615	0.385
11-13-90	1	12	9.53	0.77	0.0642	0.003	0.021	5.83E+05	5.77	0.875	0.125
11-13-90	2	20	8.27	9.43	0.4715	0.004	0.031	3.88E+05	5.59	0.886	0.114
11-13-90	3	16	2.41	6.69	0.4181	0.001	0.004	2.50E+05	5.40	0.800	0.200
11-13-90	4	76	7.7	6.91	0.0909	0.003	0.079	3.46E+05	5.54	0.963	0.037
11-13-90	5	4	9.7	3.3	0.8250	0.002	0.066	8.25E+06	6.92	0.971	0.029
11-13-90	5	16	9.32	6.94	0.4338	0.001	0.013	8.13E+05	5.91	0.929	0.071
11-13-90	6	8	7.19	12.49	1.5613	BDL	0.024				
AVG =		21.29						8.90E+05	5.27		
log value=								5.95			

Figure C28

Distribution Coefficient Analysis

METALS

DATE	SITE	COPPER DISS. (MG/L)	COPPER SUSP. (MG/L)	COPPER K'd (L/KG)	COPPER log K'd	COPPER Fp	COPPER Fd	IRON DISS. (MG/L)	IRON SUSP. (MG/L)	IRON K'd (L/KG)	IRON log K'd	IRON Fp	IRON Fd
4-17-92	1	0.007	0.098	9.09E+04	4.96	0.933	0.067	0.61	2.32	2.47E+04	4.39	0.792	0.208
4-17-92	1	0.009	0.0955	2.04E+05	5.31	0.914	0.086	0.5	2.14	8.23E+04	4.92	0.811	0.189
4-17-92	3	0.012	0.006	6.76E+03	3.83	0.333	0.667	0.48	2.2	6.19E+04	4.79	0.821	0.179
4-17-92	6	0.007	0.019	1.07E+05	5.03	0.731	0.269	0.43	0.87	8.00E+04	4.90	0.669	0.331
4-18-92	1	0.009	0.006	9.01E+03	3.95	0.400	0.600	0.28	0.93	4.49E+04	4.65	0.769	0.231
4-18-92	3	0.006	0.009	5.36E+04	4.73	0.600	0.400	0.3	1.15	1.37E+05	5.14	0.793	0.207
4-18-92	3	0.007	0.008	4.76E+04	4.68	0.533	0.467	0.32	1.06	1.38E+05	5.14	0.768	0.232
4-18-92	6	0.007	0.002	9.52E+03	3.98	0.222	0.778	0.39	1.51	1.29E+05	5.11	0.795	0.205
4-22-92	1	0.009	0.008	2.61E+04	4.42	0.471	0.529	0.33	0.79	7.04E+04	4.85	0.705	0.295
4-22-92	3	0.011	0.006	1.88E+04	4.27	0.353	0.647	0.46	0.95	7.12E+04	4.85	0.674	0.326
4-22-92	6	0.005	0.014	1.40E+05	5.15	0.737	0.263	0.2	0.44	1.10E+05	5.04	0.688	0.313
4-22-92	6	0.007	0.007	5.26E+04	4.72	0.500	0.500	0.21	0.58	1.45E+05	5.16	0.734	0.266
10-18-90	1	BDL	0.102					0.215	0.787	4.58E+05	5.66	0.785	0.215
10-18-90	2	0.009	0.067	5.32E+05	5.73	0.882	0.118	0.549	1.315	1.71E+05	5.23	0.705	0.295
10-22-90	1	0.01	1.306	2.18E+07	7.34	0.992	0.008	0.727	0.466	1.07E+05	5.03	0.391	0.609
10-22-90	2	0.011	0.009	2.05E+05	5.31	0.450	0.550	0.228	0.85	9.32E+05	5.97	0.788	0.212
10-22-90	3	0.007	0.379	3.87E+06	6.59	0.982	0.018	0.297	1.74	4.18E+05	5.62	0.854	0.146
10-22-90	3	0.012	0.059	8.19E+05	5.91	0.831	0.169	0.268	0.985	6.13E+05	5.79	0.786	0.214
10-22-90	4	BDL	0.065					0.314	1.687	2.24E+05	5.35	0.843	0.157
10-22-90	5	0.01	0.024	8.00E+04	4.90	0.706	0.294	0.959	1.143	3.97E+04	4.60	0.544	0.456
10-22-90	6	0.008	0.021	9.38E+04	4.97	0.724	0.276	0.353	1.414	1.43E+05	5.16	0.800	0.200
10-27-90	1	0.011	0.045	1.36E+06	6.13	0.804	0.196	0.227	0.519	7.62E+05	5.88	0.696	0.304
10-27-90	2	BDL	0.032					0.714	0.068	9.52E+04	4.98	0.087	0.913
10-27-90	3	BDL	1.128					0.46	0.378	5.14E+04	4.71	0.451	0.549
10-27-90	3	BDL	0.014					0.403	0.265	1.64E+05	5.22	0.397	0.603
10-27-90	4	BDL	0.06					0.545	0.078	1.19E+04	4.08	0.125	0.875
10-27-90	5	0.003	0.045					0.794	0.097				
10-27-90	6	BDL	0.267					0.484	0.379	7.12E+04	4.85	0.439	0.561
10-31-90	1	0.014	0.086	2.05E+06	6.31	0.860	0.140	0.364	0.511	4.68E+05	5.67	0.584	0.416
10-31-90	2	0.007	0.04					0.411	0.403				
10-31-90	3	BDL	0.103					0.187	0.699	9.34E+05	5.97	0.789	0.211
10-31-90	4	0.002	0.069	1.72E+07	7.24	0.972	0.028	0.259	0.36	6.95E+05	5.84	0.582	0.418
10-31-90	4	BDL	0.054					0.2	0.395	3.29E+05	5.52	0.664	0.336
10-31-90	5	BDL	0.079					0.299	0.857	1.36E+05	5.14	0.741	0.259
10-31-90	6	0.005	0.016					0.453	0.789				
11-05-90	1	0.017	0.033					0.438	0.343				
11-05-90	1	0.019	0.041					0.493	0.415				
11-05-90	2	0.027	0.069	1.97E+05	5.29	0.719	0.281	0.667	0.562	6.48E+04	4.81	0.457	0.543
11-05-90	3	0.032	0.001	1.30E+03	3.11	0.030	0.970	0.421	0.015	1.48E+03	3.17	0.034	0.966
11-05-90	4	0.003	0.068	1.13E+07	7.05	0.958	0.042	0.515	0.35	3.40E+05	5.53	0.405	0.595
11-05-90	5	0.032	0.015	5.86E+04	4.77	0.319	0.681	0.374	0.031	1.04E+04	4.02	0.077	0.923
11-05-90	6	0.024	0.058	6.04E+05	5.78	0.707	0.293	0.247	0.136	1.38E+05	5.14	0.355	0.645
11-09-90	1	0.015	0.023	5.48E+04	4.74	0.605	0.395	0.212	0.251	4.23E+04	4.63	0.542	0.458
11-09-90	2	0.021	0.02	3.40E+04	4.53	0.488	0.512	0.19	0.514	9.66E+04	4.99	0.730	0.270
11-09-90	2	0.046	0.414	3.21E+05	5.51	0.900	0.100	0.179	0.535	1.07E+05	5.03	0.749	0.251
11-09-90	3	0.023	0.138	2.14E+05	5.33	0.857	0.143	0.183	0.696	1.36E+05	5.13	0.792	0.208
11-09-90	4	0.022	0.042	6.82E+04	4.83	0.656	0.344	0.273	0.77	1.01E+05	5.00	0.738	0.262
11-09-90	5	0.014	0.036	9.18E+04	4.96	0.720	0.280	0.253	1.706	2.41E+05	5.38	0.871	0.129
11-09-90	6	0.025	0.026	3.71E+04	4.57	0.510	0.490	0.382	0.463	4.33E+04	4.64	0.548	0.452
11-13-90	1	0.04	0.027	5.63E+04	4.75	0.403	0.597	0.341	0.509	1.24E+05	5.09	0.599	0.401
11-13-90	2	0.036	1.038	1.44E+06	6.16	0.966	0.034	0.385	0.416	5.40E+04	4.73	0.519	0.481
11-13-90	3	0.026	0.134	3.22E+05	5.51	0.838	0.163	0.382	0.78	1.28E+05	5.11	0.671	0.329
11-13-90	4	0.054	0.052	1.27E+04	4.10	0.491	0.509	2.544	2.08	1.08E+04	4.03	0.450	0.550
11-13-90	5	0.028	1.038	9.27E+06	6.97	0.974	0.026	0.503	1.064	5.29E+05	5.72	0.679	0.321
11-13-90	5	0.056	0.042	4.69E+04	4.67	0.429	0.571	0.508	1.008	1.24E+05	5.09	0.665	0.335
11-13-90	6	0.044	0.043					0.656	0.442				
AVG =				1.82E+06	5.20					2.04E+05	5.05		
log value=				6.26						5.31			

Figure C28 (cont.)

Distribution Coefficient Analysis

METALS Water Column

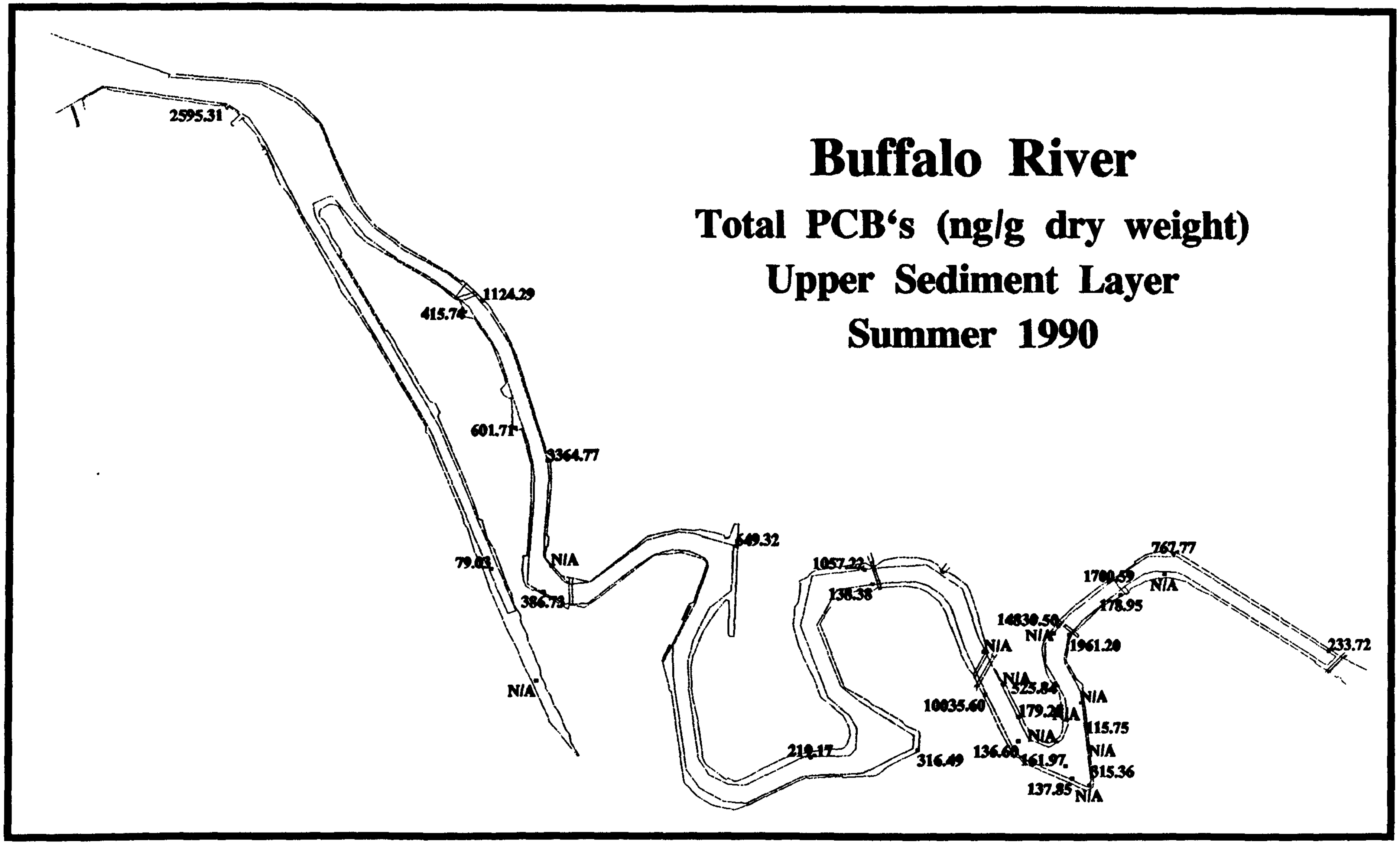
DATE	SIT	TSS (MG/L)	DOC (MG/L)	POC (MG/L)	Foc	LEAD DISS. (MG/L)	LEAD SUSP. (MG/L)	LEAD K'd (L/KG)	LEAD log K'd	LEAD Fp	LEAD Fd	COPPER DISS. (MG/L)	COPPER SUSP. (MG/L)	COPPER K'd (L/KG)	COPPER log K'd	COPPER Fp	COPPER Fd	IRON DISS. (MG/L)	IRON SUSP. (MG/L)	IRON K'd (L/KG)	IRON log K'd	IRON Fp	IRON Fd
4-17-92	1	154	10	3	0.0195	0.0102	0.0103	6.56E+03	3.82	0.502	0.498	0.007	0.098	9.09E+04	4.96	0.933	0.067	0.61	2.32	2.47E+04	4.39	0.792	0.208
4-17-92	1	52	10	7	0.1346	0.0222	0.014	1.21E+04	4.08	0.387	0.613	0.009	0.0955	2.04E+05	5.31	0.914	0.086	0.5	2.14	8.23E+04	4.92	0.811	0.189
4-17-92	3	74	10	1	0.0135	0.0161	0.0051	4.28E+03	3.63	0.241	0.759	0.012	0.006	6.76E+03	3.83	0.333	0.667	0.48	2.2	6.19E+04	4.79	0.821	0.179
4-17-92	6	25.3	11	4	0.1581	0.0052	0.0864	6.72E+05	5.83	0.944	0.056	0.007	0.019	1.07E+05	5.03	0.731	0.269	0.43	0.87	8.00E+04	4.90	0.669	0.331
4-18-92	1	74	13	0	0.0000	0.0053	0.0229	5.84E+04	4.77	0.812	0.188	0.009	0.006	9.01E+03	3.95	0.400	0.600	0.26	0.93	4.49E+04	4.65	0.769	0.231
4-18-92	3	28	12.8	1.3	0.0464	0.006	0.036	2.14E+05	5.33	0.857	0.143	0.006	0.009	5.36E+04	4.73	0.600	0.400	0.3	1.15	1.37E+05	5.14	0.793	0.207
4-18-92	3	24	11.45	0.95	0.0396	0.0078	0.0406	2.17E+05	5.34	0.839	0.161	0.007	0.008	4.76E+04	4.68	0.533	0.467	0.32	1.06	1.38E+05	5.14	0.768	0.232
4-18-92	6	30	16	2	0.0667	0.0081	0.0418	1.72E+05	5.24	0.838	0.162	0.007	0.002	9.52E+03	3.98	0.222	0.778	0.39	1.51	1.29E+05	5.11	0.795	0.205
4-22-92	1	34	10	4	0.1176	0.0061	0.023	1.11E+05	5.04	0.790	0.210	0.009	0.008	2.61E+04	4.42	0.471	0.529	0.33	0.79	7.04E+04	4.85	0.705	0.295
4-22-92	3	29	9	6	0.2069	0.0092	0.0139	5.21E+04	4.72	0.602	0.398	0.011	0.006	1.66E+04	4.27	0.353	0.647	0.46	0.95	7.12E+04	4.85	0.674	0.326
4-22-92	6	20	13	6	0.3000	0.0029	0.0083	1.43E+05	5.16	0.741	0.259	0.005	0.014	1.40E+05	5.15	0.737	0.263	0.2	0.44	1.10E+05	5.04	0.686	0.313
4-22-92	6	19	11	2	0.1053	0.0054	0.0063	6.14E+04	4.79	0.538	0.462	0.007	0.007	5.26E+04	4.72	0.500	0.500	0.21	0.58	1.45E+05	5.16	0.734	0.266
10-18-90	1	8	7.54	2.16	0.2700	BDL	0.005					BDL	0.102					0.215	0.787	4.56E+05	5.66	0.785	0.215
10-18-90	2	14	9.86	2.32	0.1657	BDL	0.0015					0.009	0.067	5.32E+05	5.73	0.882	0.118	0.549	1.315	1.71E+05	5.23	0.705	0.295
10-22-90	1	6	9.84	1.56	0.2600	BDL	0.0005					0.01	1.306	2.18E+07	7.34	0.992	0.008	0.727	0.466	1.07E+05	5.03	0.391	0.609
10-22-90	2	4	10.9	0.7	0.1750	BDL	0.0005					0.011	0.009	2.05E+05	5.31	0.450	0.550	0.226	0.85	9.32E+05	5.97	0.788	0.212
10-22-90	3	14	10.5	0.7	0.0500	BDL	0.01					0.007	0.379	3.87E+06	6.59	0.982	0.018	0.297	1.74	4.18E+05	5.62	0.854	0.146
10-22-90	3	6	10.5	0.9	0.1500	BDL	0.009					0.012	0.059	6.19E+05	5.91	0.831	0.169	0.266	0.965	6.13E+05	5.79	0.786	0.214
10-22-90	4	24	10.94	1.26	0.0525	BDL	0.0065					BDL	0.065					0.314	1.667	2.24E+05	5.35	0.843	0.157
10-22-90	5	30	12.5	1.7	0.0567	0.004	0.034	2.83E+06	5.45	0.895	0.105	0.01	0.024	6.00E+04	4.90	0.706	0.294	0.959	1.143	3.97E+04	4.60	0.544	0.456
10-22-90	6	28	12.74	0.46	0.0164	0.003	0.007	6.33E+04	4.92	0.700	0.300	0.006	0.021	9.36E+04	4.97	0.724	0.276	0.353	1.414	1.43E+05	5.16	0.800	0.200
10-27-90	1	3	11	1.3	0.4333	BDL	0.011					0.011	0.045	1.36E+06	6.13	0.804	0.196	0.227	0.519	7.62E+05	5.88	0.696	0.304
10-27-90	2	1	12.92	0.18	0.1800	BDL	0.0035					BDL	0.032					0.714	0.068	9.52E+04	4.98	0.087	0.913
10-27-90	3	16	7.02	2.48	0.1550	BDL	BDL					BDL	1.126					0.46	0.376	5.14E+04	4.71	0.451	0.549
10-27-90	3	4	7.64	2.96	0.7400	BDL	BDL					BDL	0.014					0.403	0.265	1.64E+05	5.22	0.397	0.603
10-27-90	4	12	6.07	8.23	0.6856	BDL	0.0065					BDL	0.06					0.545	0.076	1.19E+04	4.08	0.125	0.875
10-27-90	5	3	8.6	7.3	2.4333	BDL	0.003					0.003	0.045					0.794	0.097				
10-27-90	6	11	7.85	4.85	0.4409	BDL	BDL					BDL	0.267					0.484	0.379	7.12E+04	4.85	0.439	0.561
10-31-90	1	3	11.7	2.32	0.7733	0.003	0.052	5.78E+06	6.76	0.945	0.055	0.014	0.066	2.05E+06	6.31	0.860	0.140	0.364	0.511	4.66E+05	5.67	0.584	0.416
10-31-90	2	4	10.25	4.65	1.1625	BDL	0.016					0.007	0.04					0.411	0.403				
10-31-90	3	4	10.96	0.46	0.1150	BDL	0.011					BDL	0.103					0.187	0.699	9.34E+05	5.97	0.789	0.211
10-31-90	4	2	12.11	0.59	0.2950	BDL	0.004					0.002	0.069	1.72E+07	7.24	0.972	0.028	0.259	0.36	6.95E+05	5.84	0.582	0.418
10-31-90	4	6	11.64	0.16	0.0267	BDL	0.003					BDL	0.054					0.2	0.395	3.29E+05	5.52	0.664	0.336
10-31-90	5	21	7.64	2.16	0.1029	BDL	0.002					BDL	0.079					0.299	0.657	1.36E+05	5.14	0.741	0.259
10-31-90	6	1	11.24	2.56	2.5600	0.017	0.009					0.005	0.016					0.453	0.789				
11-05-90	1	3	8.65	3.21	1.0700	0.003	0.005					0.017	0.033					0.436	0.343				
11-05-90	1	2	8.27	3.81	1.9050	0.003	0.004					0.019	0.041					0.493	0.415				
11-05-90	2	13	8	4.34	0.3338	BDL	0.007					0.027	0.069	1.97E+05	5.29	0.719	0.281	0.667	0.562	6.46E+04	4.81	0.457	0.543
11-05-90	3	24	7.35	1.83	0.0763	0.004	0.004	4.17E+04	4.62	0.500	0.500	0.032	0.001	1.30E+03	3.11	0.030	0.970	0.421	0.015	1.46E+03	3.17	0.034	0.966
11-05-90	4	2	6.59	1.01	0.5050	0.001	0.012	6.00E+06	6.78	0.923	0.077	0.003	0.066	1.13E+07	7.05	0.958	0.042	0.515	0.35	3.40E+05	5.53	0.405	0.595
11-05-90	5	8	8.04	2.36	0.2950	0.001	0.003	3.75E+05	5.57	0.750	0.250	0.032	0.015	5.86E+04	4.77	0.319	0.681	0.374	0.031	1.04E+04	4.02	0.077	0.923
11-05-90	6	4	9.29	1.37	0.3425	0.002	0.008	1.00E+06	6.00	0.800	0.200	0.024	0.058	6.04E+05	5.78	0.707	0.293	0.247	0.136	1.36E+05	5.14	0.355	0.645
11-09-90	1	28	9.53	0.77	0.0275	BDL	0.025					0.015	0.023	5.46E+04	4.74	0.605	0.395	0.212	0.251	4.23E+04	4.63	0.542	0.458
11-09-90	2	28	8.27	9.43	0.3368	0.004	0.051	4.55E+05	5.66	0.927	0.073	0.021	0.02	3.40E+04	4.53	0.488	0.512	0.19	0.514	9.66E+04	4.99	0.730	0.270
11-09-90	2	28	2.41	6.69	0.2389	BDL	0.017					0.046	0.414	3.21E+05	5.51	0.900	0.100	0.179	0.535	1.07E+05	5.03	0.749	0.251
11-09-90	3	28	7.7	6.91	0.2468	0.005	0.01	7.14E+04	4.85	0.667	0.333	0.023	0.138	2.14E+05	5.33	0.857	0.143	0.183	0.696	1.36E+05	5.13	0.792	0.208
11-09-90	4	28	9.7	3.3	0.1179	0.005	0.013	9.29E+04	4.97	0.722	0.278	0.022	0.042	6.62E+04	4.83	0.656	0.344	0.273	0.77	1.01E+05	5.00	0.738	0.262
11-09-90	5	28	9.32	6.94	0.2479	0.003	0.008	9.52E+04	4.98	0.727	0.273	0.014	0.036	9.16E+04	4.96	0.720	0.280	0.253	1.706	2.41E+05	5.38	0.871	0.129
11-09-90	6	28	7.19	12.49	0.4461	0.005	0.008	5.71E+04	4.76	0.615	0.385	0.025	0.026	3.71E+04	4.57	0.510	0.490	0.362	0.463	4.33E+04	4.64	0.548	0.452
11-13-90	1	12	9.53	0.77	0.0642	0.003	0.021	5.83E+05	5.77	0.875	0.125	0.04	0.027	5.63E+04	4.75	0.403	0.597	0.341	0.509	1.24E+05	5.09	0.599	0.401
11-13-90	2	20	8.27	9.43	0.4715	0.004	0.031	3.86E+05	5.59	0.886	0.114	0.036	1.036	1.44E+06	6.16	0.966	0.034	0.365	0.416	5.40E+04	4.73	0.519	0.481
11-13-90	3	16	2.41	6.69	0.4181	0.001	0.004	2.50E+05	5.40	0.800	0.200	0.026	0.134	3.22E+05	5.51	0.838	0.163	0.362	0.76	1.26E+05	5.11	0.671	0.329
11-13-90	4	76	7.7	6.91	0.0909	0.003	0.079	3.46E+05	5.54	0.963	0.037	0.054	0.052	1.27E+04	4.10	0.491	0.509	2.544	2.06	1.06E+04	4.03	0.450	0.550
11-13-90	5	4	9.7	3.3	0.8250	0.002	0.066	8.25E+06	6.92	0.971	0.029	0.026	1.036	9.27E+06	6.97	0.974	0.026	0.503	1.064	5.29E+05	5.72	0.679	0.321
11-13-90	5	16	9.32	6.94	0.4336	0.001	0.013	6.13E+05	5.91	0.929	0.071	0.056	0.042	4.69E+04	4.67	0.429	0.571	0.506	1.006	1.24E+05	5.09	0.665	0.335
11-13-90	6	8	7.19	12.49	1.5613	BDL	0.024					0.044	0.043					0.656	0.442				
AVG =		21.29						6.90E+05	5.27					1.82E+06	5.20					2.04E+05	5.05		
log value=								5.95						6.26						5.31			

Figure C29

Appendix D. Sediment concentrations

List of Figures

(spatial variation of contaminant concentrations in upper sediment layer; "N/A" = not available)



Buffalo River
Total PCB's (ng/g dry weight)
Upper Sediment Layer
Summer 1990
2595.31
1124.29
415.74
601.71
3364.77
79.03
N/A
386.73
N/A
649.32
1057.22
138.38
219.17
316.49
10035.60
N/A
N/A
325.84
179.28
N/A
N/A
136.60
161.97
137.85
N/A
14830.50
N/A
1961.20
N/A
115.75
N/A
315.36
1700.59
N/A
178.95
767.77
233.72

Figure D1

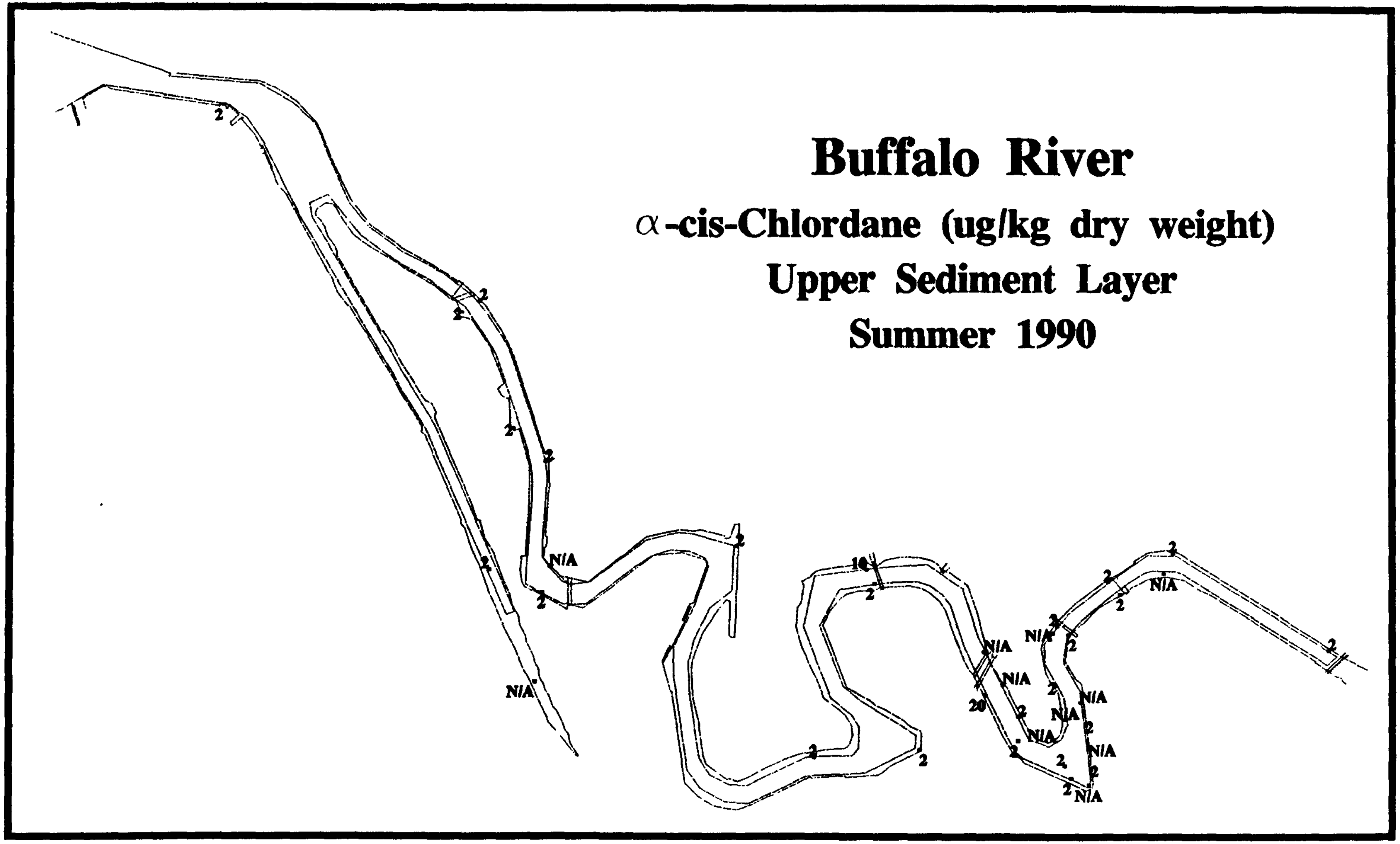

Buffalo River
α-cis-Chlordane (ug/kg dry weight)
Upper Sediment Layer
Summer 1990
2
2
2
2
2
N/A
2
2
N/A
2
10
2
2
2
N/A
2
2
N/A
N/A
2
N/A
20
2
N/A
N/A
2
N/A
2
2
N/A
2
2
N/A
2

Figure D2

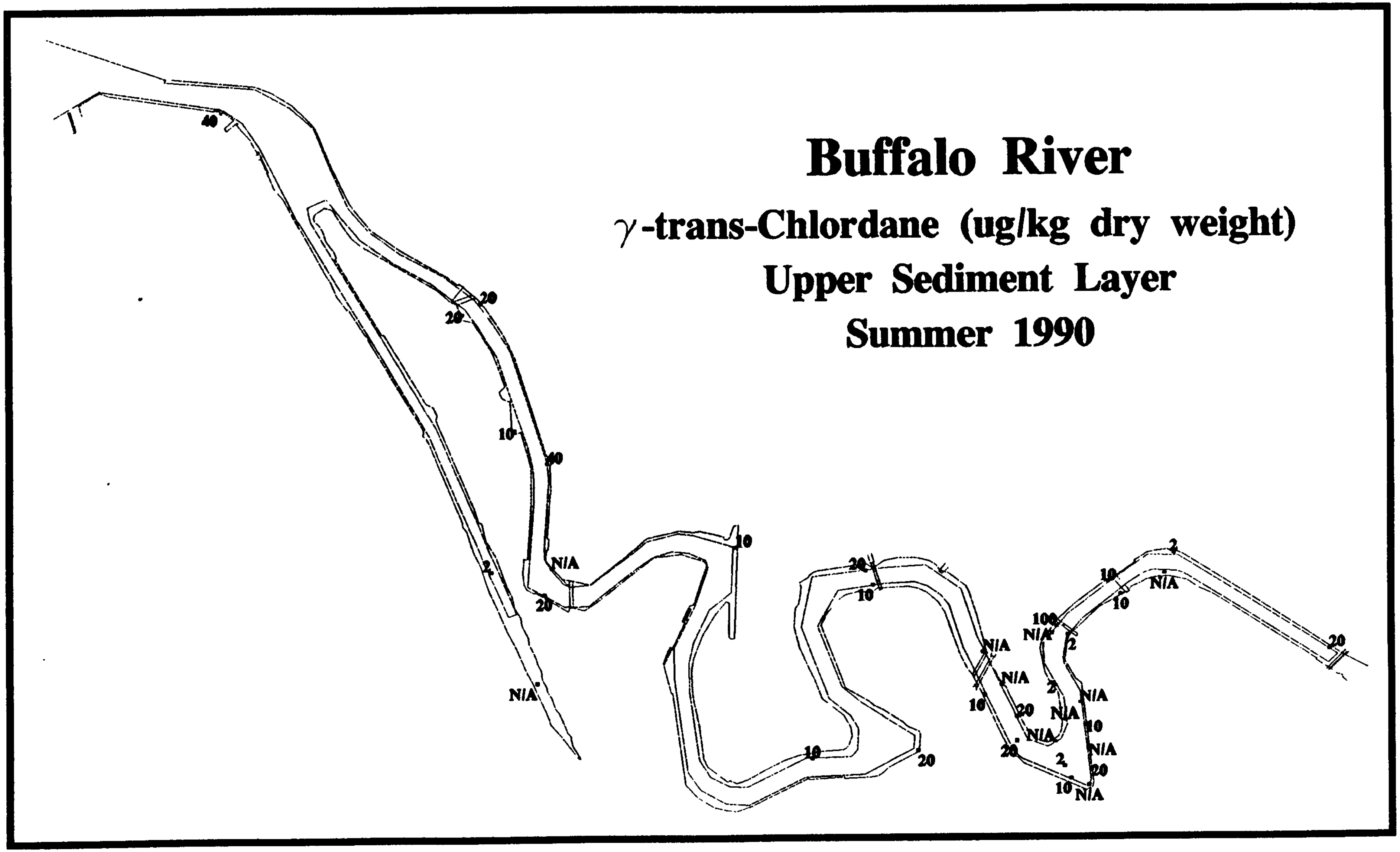

Buffalo River
γ-trans-Chlordane (ug/kg dry weight)
Upper Sediment Layer
Summer 1990

Figure D3

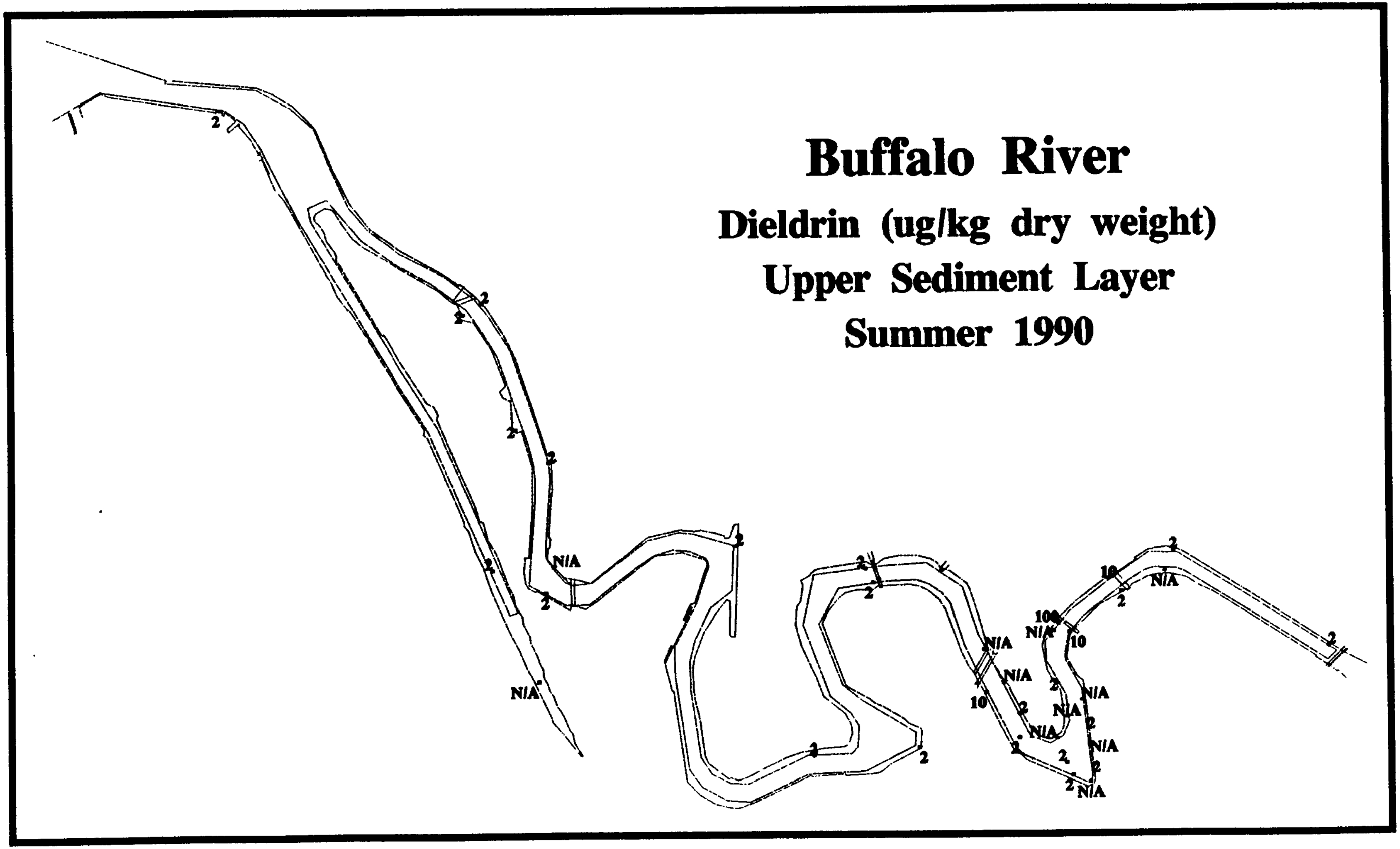
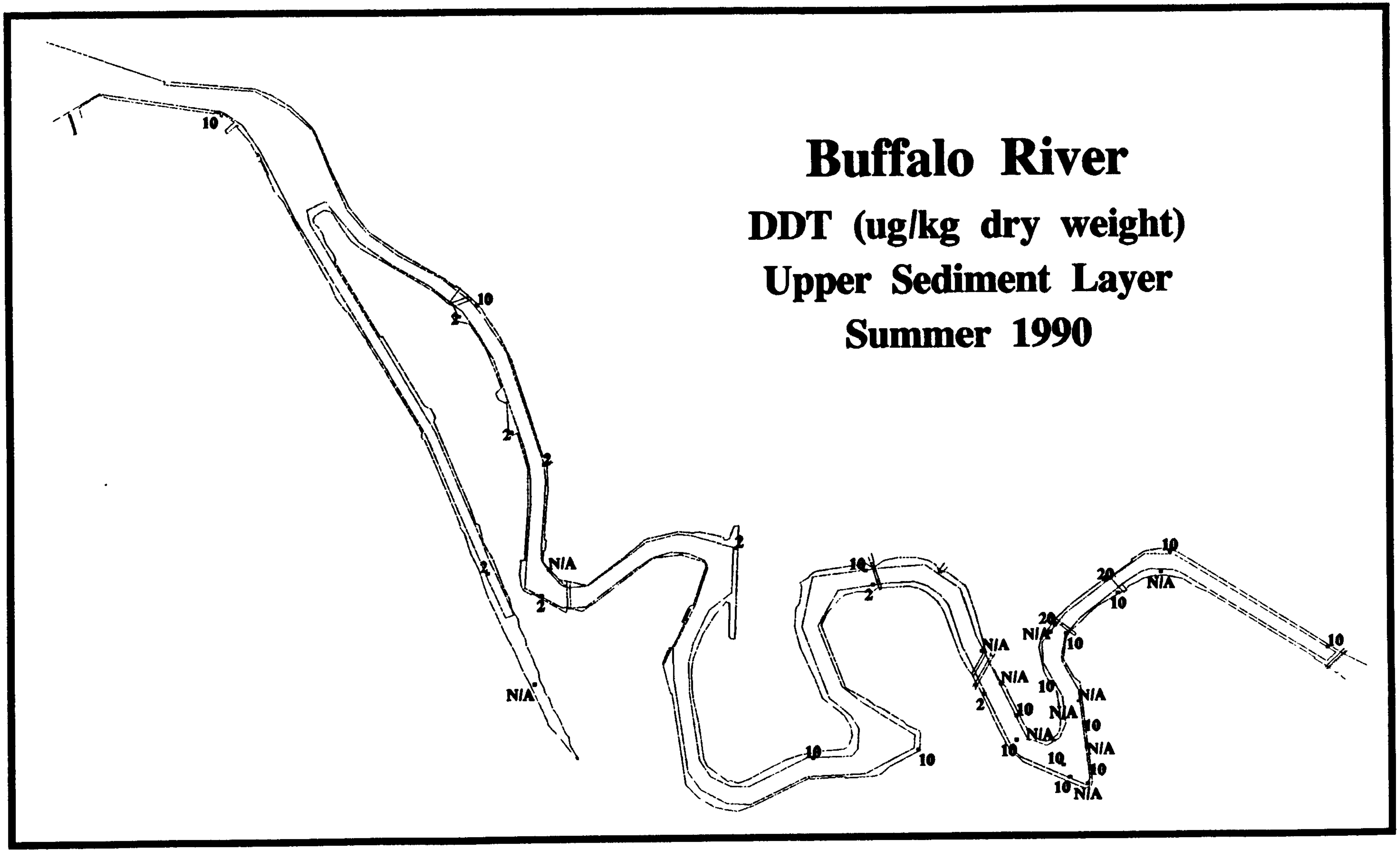

Buffalo River
Dieldrin (ug/kg dry weight)
Upper Sediment Layer
Summer 1990

Figure D4



Buffalo River
DDT (ug/kg dry weight)
Upper Sediment Layer
Summer 1990

Figure D5

Figure D6

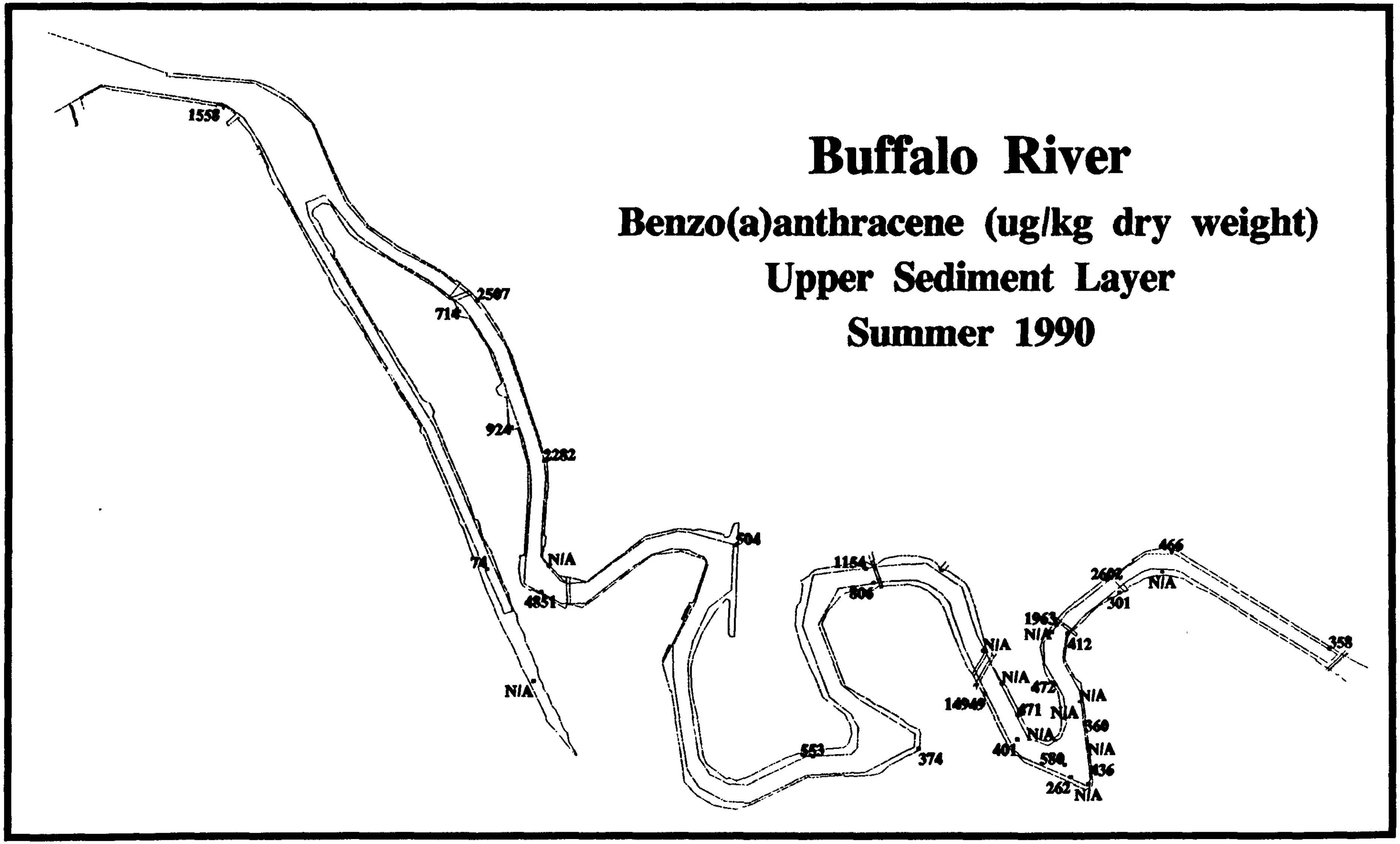
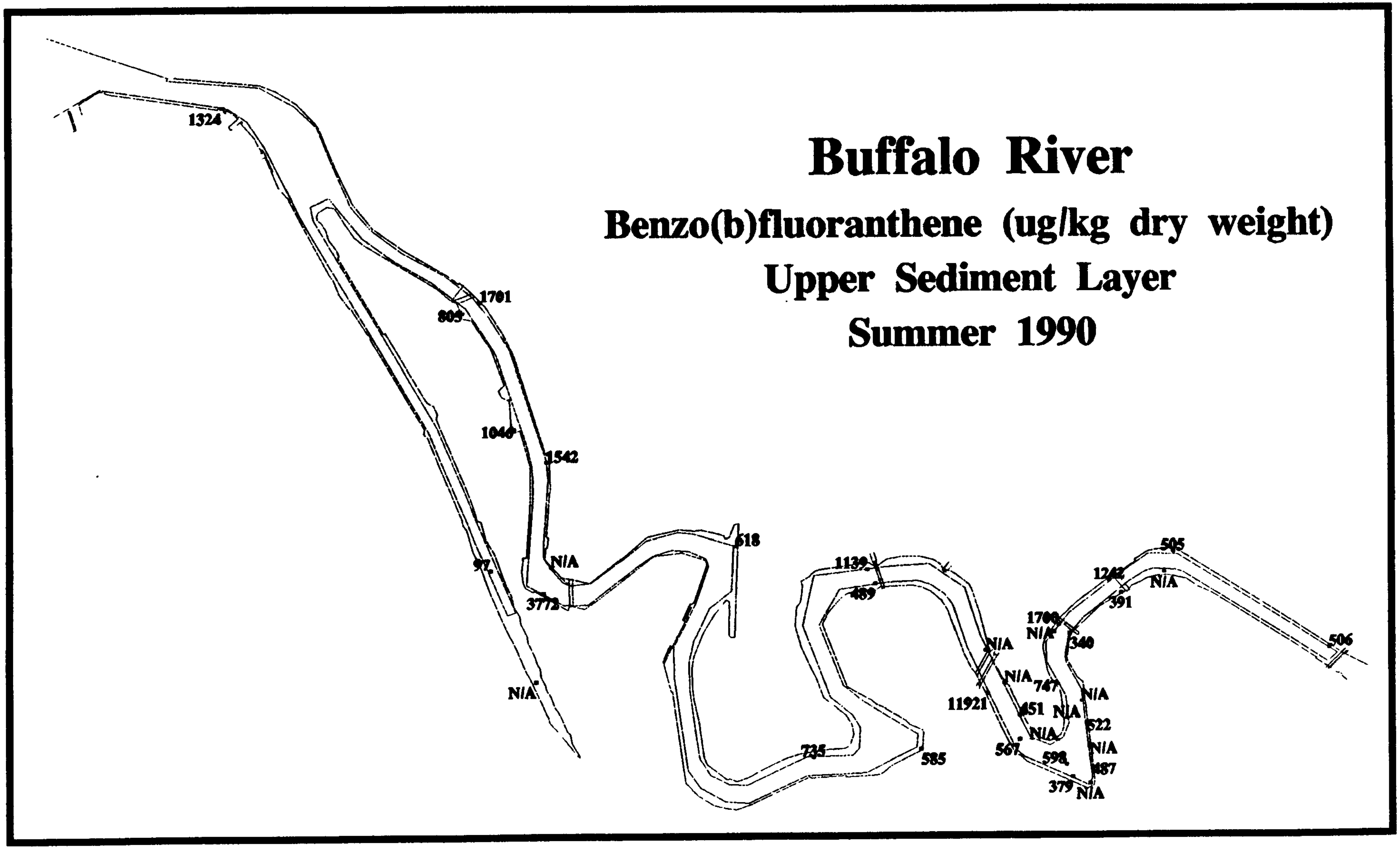

Buffalo River
Benzo(a)anthracene (ug/kg dry weight)
Upper Sediment Layer
Summer 1990
1558
2507
714
924
2282
71
N/A
4851
N/A
504
1164
806
553
374
466
2602
N/A
301
1963
N/A
412
358
N/A
14949
N/A
472
471
N/A
N/A
N/A
360
N/A
401
580
436
262
N/A

Figure D7



Buffalo River

Benzo(b)fluoranthene (ug/kg dry weight)

Upper Sediment Layer

Summer 1990

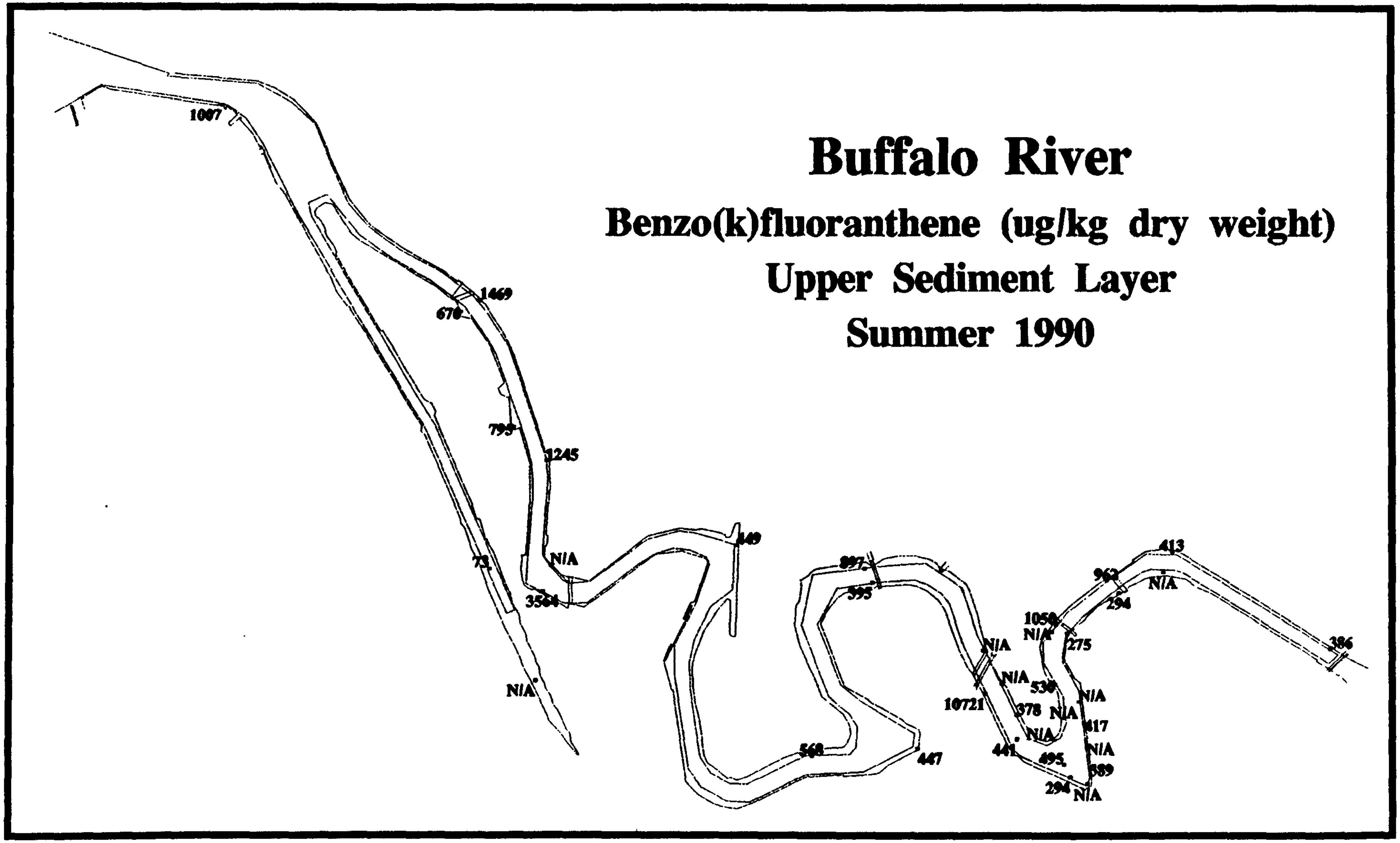

Buffalo River
Benzo(k)fluoranthene (ug/kg dry weight)
Upper Sediment Layer
Summer 1990
1007
1469
670
795
1245
N/A
73
3564
449
897
595
568
447
N/A
10721
413
962
N/A
294
1050
N/A
275
386
N/A
530
N/A
378
N/A
417
N/A
441
495
N/A
389
294
N/A

Figure D8

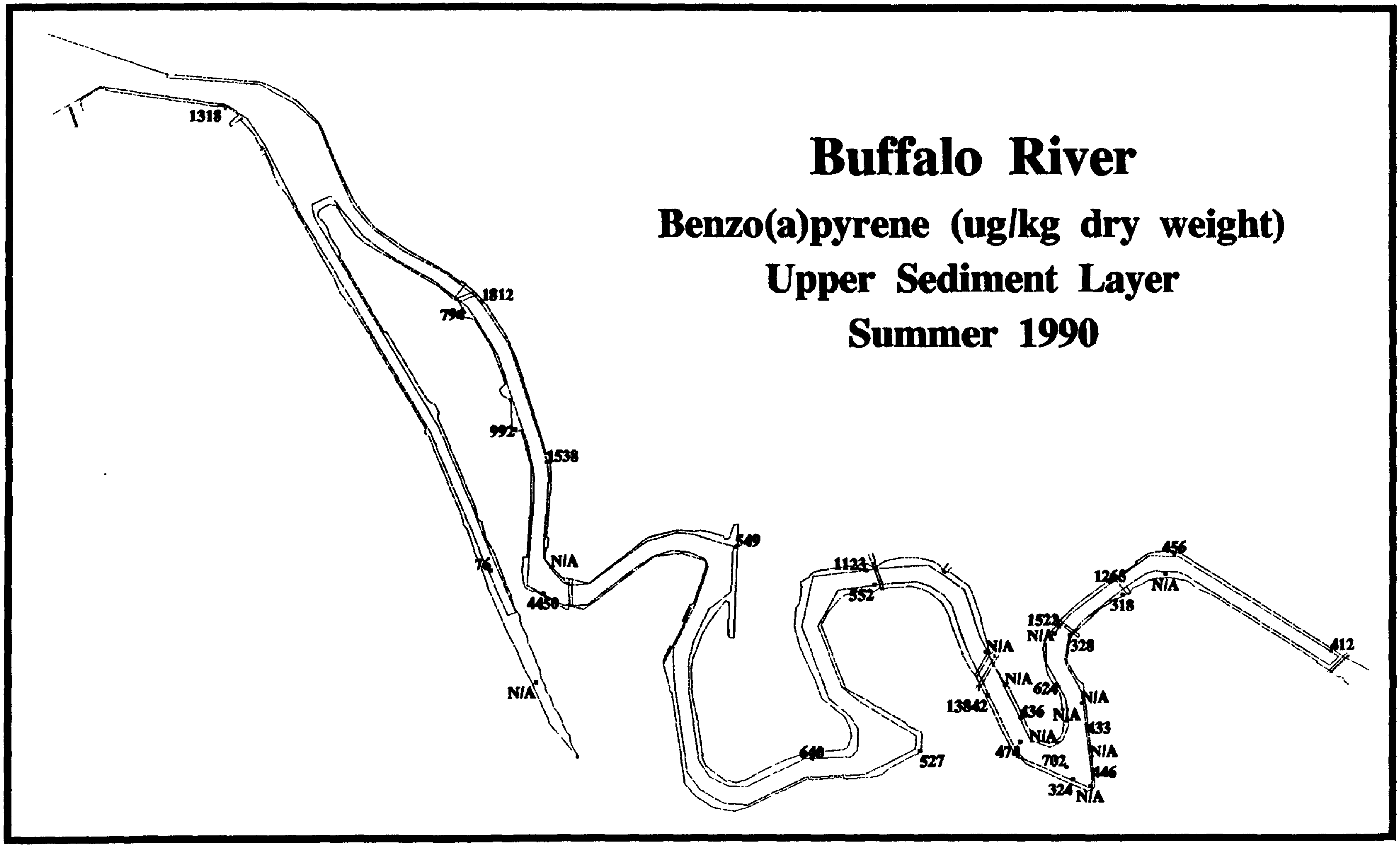

Buffalo River
Benzo(a)pyrene (ug/kg dry weight)
Upper Sediment Layer
Summer 1990
1318
1812
794
992
1538
N/A
76
4450
N/A
549
1123
552
640
527
13842
N/A
N/A
624
436
N/A
N/A
474
702
324
N/A
N/A
433
N/A
446
1522
N/A
328
1265
318
N/A
456
412

Figure D9

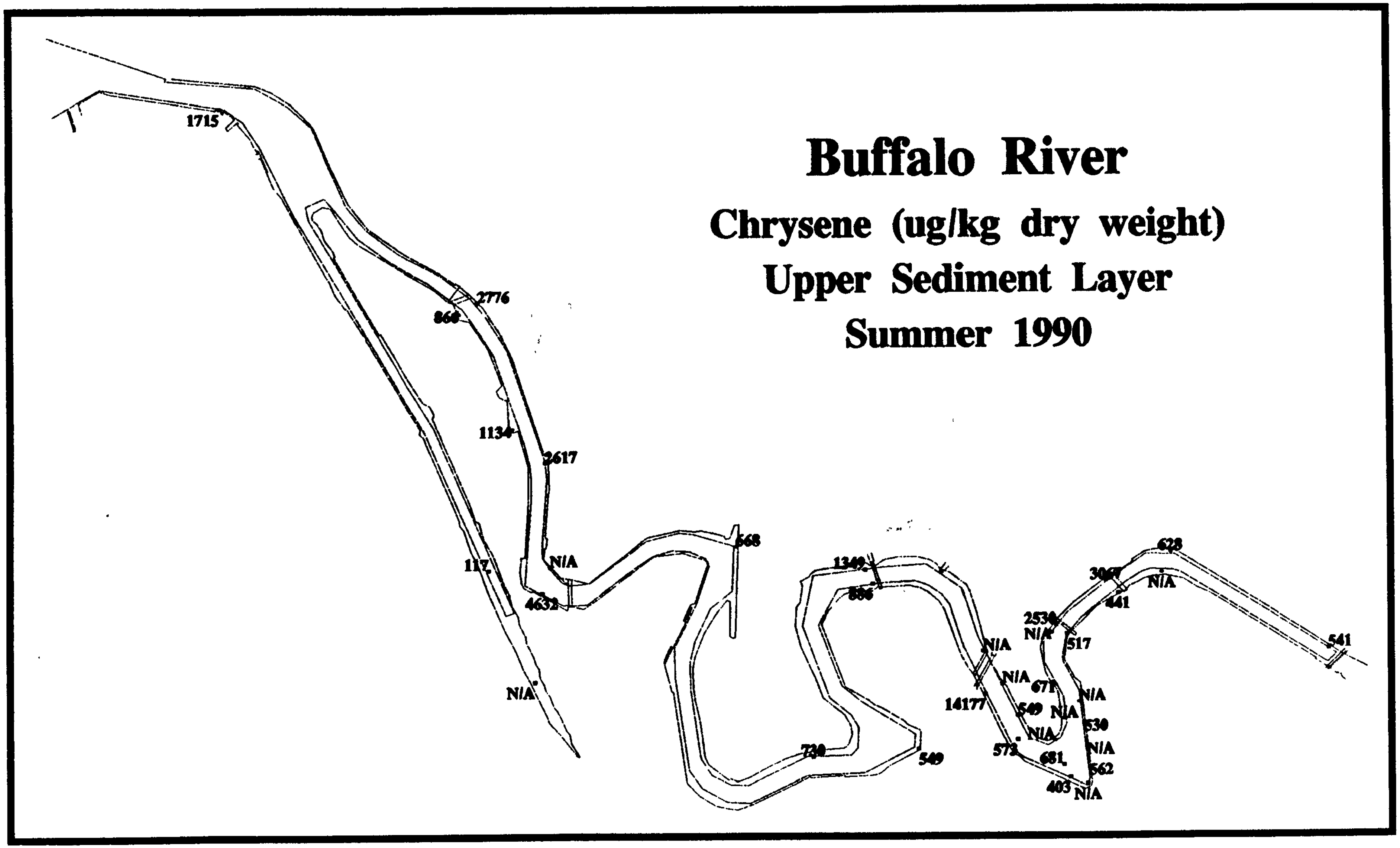

Buffalo River
Chrysene (ug/kg dry weight)
Upper Sediment Layer
Summer 1990
1715
2776
866
1134
2617
117
N/A
4632
N/A
668
1349
886
730
549
628
3067
N/A
441
2530
N/A
517
541
N/A
N/A
671
14177
549
N/A
N/A
530
N/A
573
681
N/A
562
403
N/A

Figure D10

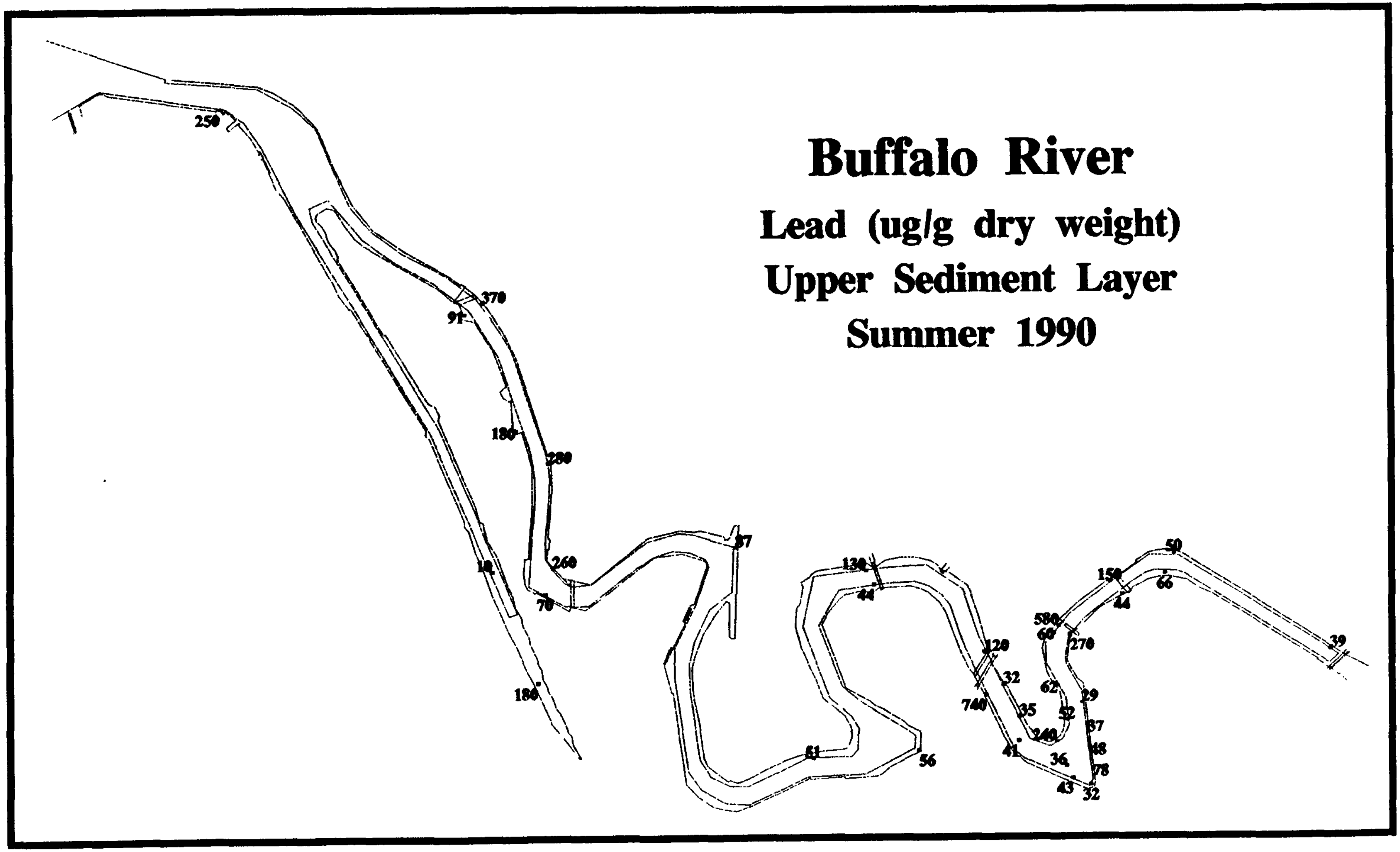

Buffalo River
Lead (ug/g dry weight)
Upper Sediment Layer
Summer 1990

Figure D11

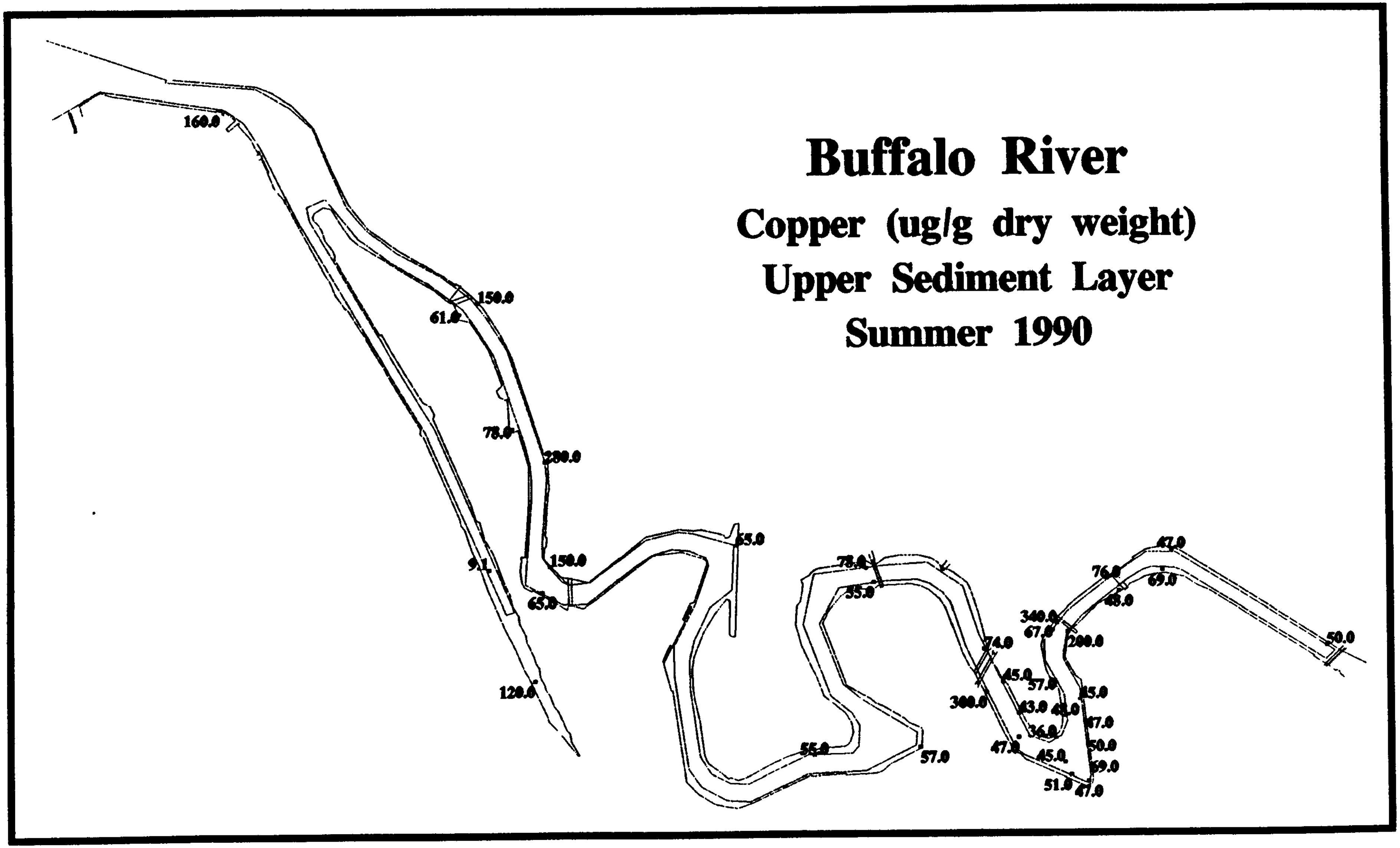

Buffalo River
Copper (ug/g dry weight)
Upper Sediment Layer
Summer 1990
160.0
150.0
61.0
78.0
150.0
9.1
65.0
120.0
55.0
78.0
55.0
55.0
57.0
74.0
300.0
45.0
57.0
43.0
41.0
36.0
47.0
45.0
51.0
47.0
69.0
50.0
47.0
45.0
200.0
340.0
67.0
76.0
48.0
47.0
69.0
50.0

Figure D12