WATER QUALITY DATA ANALYSIS FOR COLORADO RIVER

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This report presents analyses of time trends and the spatial distribution of baseflow water quality along the Colorado River between Mansfield Dam and the USGS streamflow gaging station at Farm Road 973. The data used in these analyses are from the U.S. Geological Survey (USGS)/City of Austin Cooperative Monitoring Program. These data represent baseflow conditions. Baseflow data are defined as those collected during non-storm event periods. Table 1 is a listing of the sampling sites and the period of record for each of the sites.

This study is related to a previous report, Lake Austin/Town Lake Water Quality Data Analysis[1] published in 1984 by the Watershed Management Division of Public Works. In that report Lake Austin and Town Lake water quality were evaluated using USGS, NURP[2], and City of Austin Water and Wastewater Department data.

Conclusions

1. Data for water quality constituent concentrations, when transformed to logarithm, are normally distributed. This implies that the normal distribution regression and correlation models[3] can be formulated for trend analysis.

2. For most constituents, there are no significant time trends for the sampling sites below Longhorn Dam (Colorado River at U.S. Highway 183 and Farm Road 973). There are significant increasing time trends for TKN at the Highway 183 (HWY 183) site, and for NO_3 at Farm Road 973 (FM 973).

3. Data are insufficient for time trends analysis for all sampling sites between Mansfield Dam and Longhorn Dam.

4. For the sampling site at FM 973 the concentrations for some water quality constituents such as BOD, NO_3, NH_3, TKN and TP are significantly higher during winter (December to February) than during other seasons. Wastewater discharges above this sampling point are less diluted during winter due to lower releases from upstream reservoirs.

5. In general, the water quality at the FM 973 sampling site is significantly different from that of upstream stations. The concentrations for BOD, NO_3, NH_3, TKN and TP are significantly higher due to discharges of treated sewage entering the Colorado River above this sampling site. The concentration of fecal coliform, however, is significantly less than that of the sampling site at HWY 183.

6. Along the river between Mansfield Dam and the Hwy 183 sampling site, there is no significant spatial variation in concentration among sampling sites for most water quality parameters. Fecal coliform, however, increases significantly between Tom Miller Dam and the Lamar Street Bridge. This is possibly due to sewage/septic system leakage in tributary watersheds upstream from the sampling site at the Lamar Street Bridge. Dissolved oxygen concentration tends to increase from below Mansfield Dam to Tom Miller Dam.

Details of Study

This study used baseflow (non-storm event) water quality data collected under the USGS/City of Austin Cooperative Monitoring Program. The non-storm event condition is considered to exist when less than 0.05 inch rainfall occurs on the day of data collection, or when less than 0.5 inch or 1 inch rainfall occurs one or two days before the data collection. It should be noted that, very few storm event water quality data have been collected for the Colorado River under the USGS/City Cooperative Program. The USGS sampling sites and period of record for the data are listed in Table.1. The water quality parameters being considered include biochemical oxygen demand (BOD), fecal coliform (FeCol), total suspended solids (TSS), total dissolved solids (TDS), nitrate nitrogen (NO_3), ammonia nitrogen (NH_3), total kjeldahl nitrogen (TKN), total phosphorous (TP), and total organic carbon (TOC).

The time trend and spatial variation for each water quality parameter were studied. Statistical methods and SAS[4] computer programs were used. The sampling distributions of concentration data and their logarithmic transformations for each parameter were examined. In general, the log-transformed concentration data can be fitted to normal distributions. The goodness of fit to normal distributions is judged by examining the normal probability plot and a test-statistic specified by the SAS program: Shapiro-Wilk W statistic when $N \leq 50$ or Kolomogorov D statistic when $N > 50$, where n is the number of non-missing values.

The geometric means of concentration values for each year for each parameter were regressed on time (years) for examination of time trend. Regression equations were developed. The residual plots from the regression were examined. The residuals or errors are independent from the dependent and independent variables and are normally distributed. The independent variable, time, is a known constant (i.e., representing a specific year). Therefore, the regression equations are considered as normal error regression and normal correlation models[3]. The regression and the corresponding correlations can be tested for statistical significance without complexity. The F-distribution and Student's - t tests were used to determine if there are any significant regressions or trends. A probability level of 0.05 was chosen for tests of significance on the trend. This means that the probability of a statement concerning a trend being wrong is about 5%, i.e., it is about 95% confident that a statement concerning the trend is right. If a trend is significant at less than the 0.05 level, it must be significant at 0.05 level.

The data for sampling sites below Longhorn Dam are sufficient for time trend analysis. There are eleven and sixteen years of water quality data, respectively, for sampling sites at HWY 183 and FM 973. There are also several measurements for each year of the sampling. No significant trend was found except an increasing trend for TKN at HWY 183 and an increasing trend for NO_3 at FM 973. Linear regressions on TKN and NO_3 are shown in Figures 1 and 2. Significant spatial differences in constituent concentrations exist between the two sampling sites. The concentrations for BOD, NO_3, NH_3, TKN, and TP at site FM 973 are significantly higher than these at site HWY 183 as shown in Table 2. On the other hand, the fecal coliform count at site FM 973 is significantly lower. No significant difference exists for TSS, TDS, and TOC. Discharges of treated sewage from the City's three wastewater treatment plants (Walnut Creek, Govalle, and Hornsby treatment plants) enter the Colorado river between the two sampling sites. The concentrations of nutrient parameters (such as NO_3, NH_3, TKN, and TP) and BOD for site FM 973 are significantly higher during winter months (December to February). In these months, less water is released from upstream lakes as compared to the release during the other seasons, and therefore, the water quality constituents are less diluted by the flow.

The available data for all sampling sites above Longhorn Dam do not show any time trends. Statistically speaking, the data are insufficient for trend analysis. There are only about seven years of data and only one or two measurements for some of the seven years. Along the Colorado River from below Mansfield Dam to HWY 183 the spatial variations (or trend) on concentration are not significant except for a few cases

(Table 2 and Figures 3-8). The cold water released from the hypolimnion of Lake Travis has low dissolved oxygen (DO) concentration. The concentration rises (Figure 3) as the flow moves downstream because of reaeration and and photosynthetic oxygen production[1]. This phenomenon is more prominent in the summer months. There is a significant increase in fecal coliform between Tom Miller Dam and the sampling site at Lamar Street Bridge (Figure 4). This increase is possibly due to sewage/septic leakage from upstream tributary watersheds above the Lamar Street Bridge. For example, leakage in municipal sewer lines upstream from Barton Spring[5] were located and repaired in 1982. There are also some increases (at about .10 significant level) in nutrient parameters such as NH_3, TKN and TP along the length of Town Lake (Figures 6-8). Long term effects of urban runoff may contribute to these increases. The results of the trend and spatial variation study generally agree with these of the previously published Lake Austin/Town Lake report.

REFERENCES

1. City of Austin, "Lake Austin/Town Lake Water Quality Analysis", prepared by Watershed Management Division, Public Works Department, February 1984.

2. Engineering Science, "The Final Report of Nationwide Urban Runoff Program in Austin, Texas", prepared for City of Austin, January 1983.

3. Neter, J. and etc., "Applied Linear Regression Models", Richard D. Irwin, Inc., Illinois 1983.

4. SAS Institute, "SAS User's Guide: Basics and Statistics", Version 5 Ed., Cary, North Carolina, 1985.

5. City of Austin, "Barton Spring Water Quality Trend Analysis", Prepared by Watershed Management Division, Public Works Department, October 1985.

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Table 1. Sampling Sites and Period of Record

Sampling Sites	Lake Austin Below Manafield Dam	Lake Austin at Coppers Landing	Lake Austin at Metrop. Park	Lake Austin above Tom Miller Dam	Town Lake at Red Bud Isle	Town Lake at Lamar Bridge	Town Lake above Longhorn Dam	Colorado River at Hwy 183	Colorado River at FM 973
USGS Identific.	Gaging Sta. 08154510	Site E_c	Site C_c	Site A_c	Site E_c	Site D_c	Site A_c	Gaging Sta. 08158000	Gaging Sta. 08158650
Period of Record	1980-1984	1978-1983	1978-1983	1978-1983	1978-1983	1978-1983	1978-1983	1974-1984	1968-1984
Sampling Depth (Feet)	-	1	1	1	1	1	1	-	-

tbl1/gcc

Table 2. Mean Concentration of Water Quality Constituents Along Colorado River

		LAKE AUSTIN				TOWN LAKE			BELOW TOWN LAKE		
Constituent	Mean	Below Mansf.Dam	Coppers Landing	Metrop. Park	Tom Miller Dam	Red Bud Isle	Lamar Bridge	Longhorn Dam	Hwy 183	FM 973	Spatial*** Trend
FeCol	A.M.	-	4	18	20	15	707	129	340	341	
	G.M.	-	2	6	11	12	91	71	117	62	S_1
DO	A.M.*	6.3**	8.3	8.1	9.0	8.3	8.0	7.6	9.3	8.6	
	G.M.	6.0	7.5	7.8	8.8	8.2	7.7	7.5	8.6	8.3	S_2
BOD	A.M.	.64	.43	.43	.87	.62	.50	.58	.69	2.9	
	G.M.	.61	.40	.37	.86	.51	.34	.52	.59	1.7	S_3
NO_3	A.M.	.14	.15	-	.13	.12	.24	.21	.24	1.1	
	G.M.	.13	.10	-	.07	.11	.18	.17	.17	.65	S_3
NH_3	A.M.	.05	.04	.07	.08	.02	.04	.05	.05	.60	
	G.M.	.04	.04	.03	.03	.02	.03	.05	.04	.31	S_3
TKN	A.M.	.55	.57	.59	.59	.42	.43	.55	.63	1.8	
	G.M.	.51	.43	.47	.53	.34	.36	.45	.54	1.3	S_3
TP	A.M.	.02	.01	.01	.01	.01	.02	.01	.03	.99	
	G.M.	.02	.01	.01	.01	.01	.02	.02	.02	.47	S_3
TOC	A.M.	-	2.4	-	3.1	4.3	-	2.8	5.4	5.6	
	G.M.	-	3.2	-	3.1	4.0	-	2.8	4.0	5.1	NS
TSS	A.M.	-	-	-	-	-	-	-	4	11	
	G.M.	-	-	-	-	-	-	-	3	8	NS
TDS	A.M.	-	-	-	-	-	-	-	291	309	
	G.M.	-	-	-	-	-	-	-	291	308	NS

* A.M. means arithmatic mean; G.M. means geometric mean.
** All units are in mg/l except fecal coliform which is col./100ml.
***Only geometric means were used for trend analysis.
S_1 - significant increasing trend between Mansfield Dam and Hwy 183; significant decreasing trend between Hwy 183 and FM 973.
S_2 - significant increasing trend between Mansfield Dam and Tom Miller Dam
S_3 - significant increasing trend between Hwy 183 and FM 973.
NS - no significant trend.

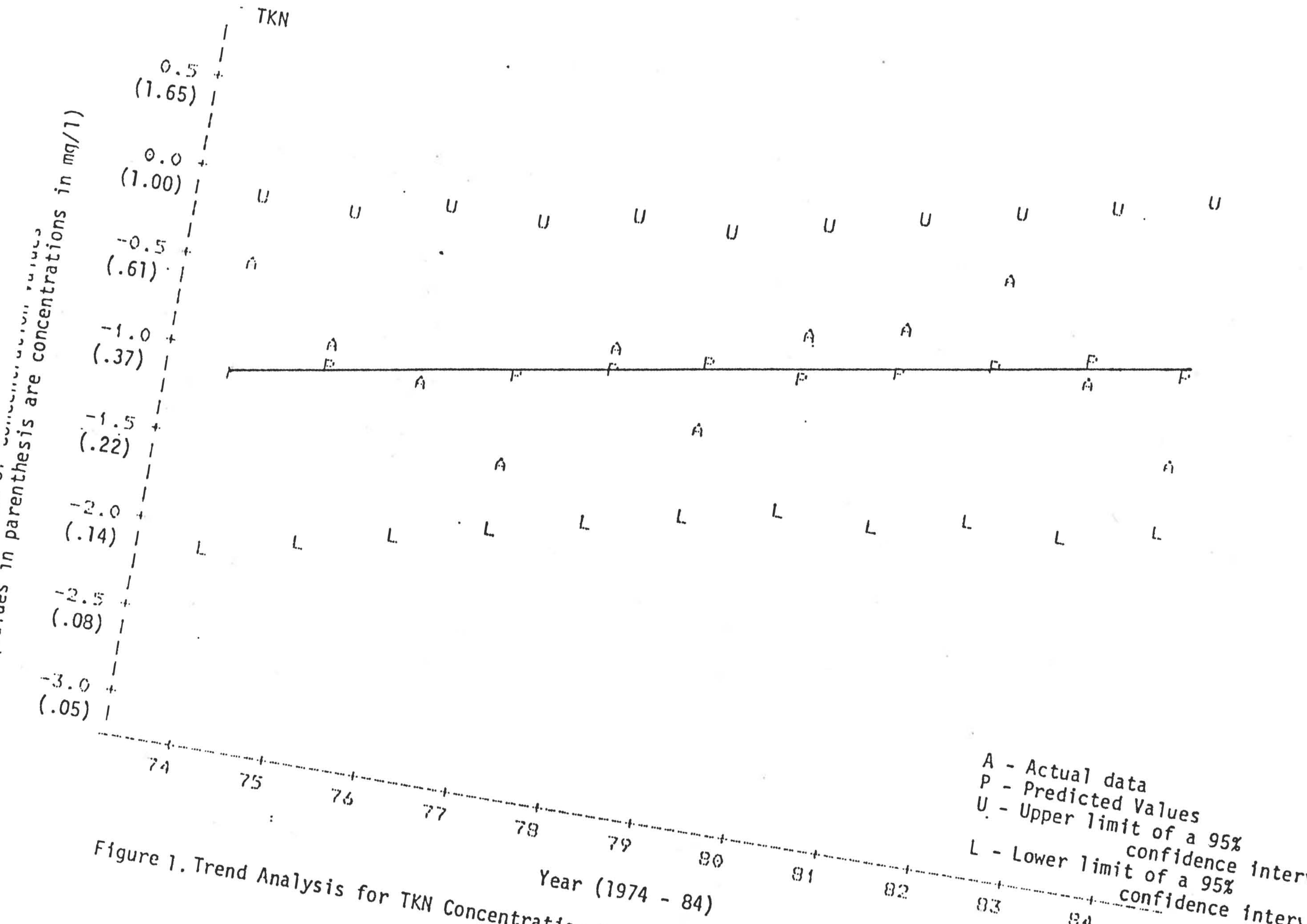

Figure 1. Trend Analysis for TKN Concentration Data for Colorado River at HWY

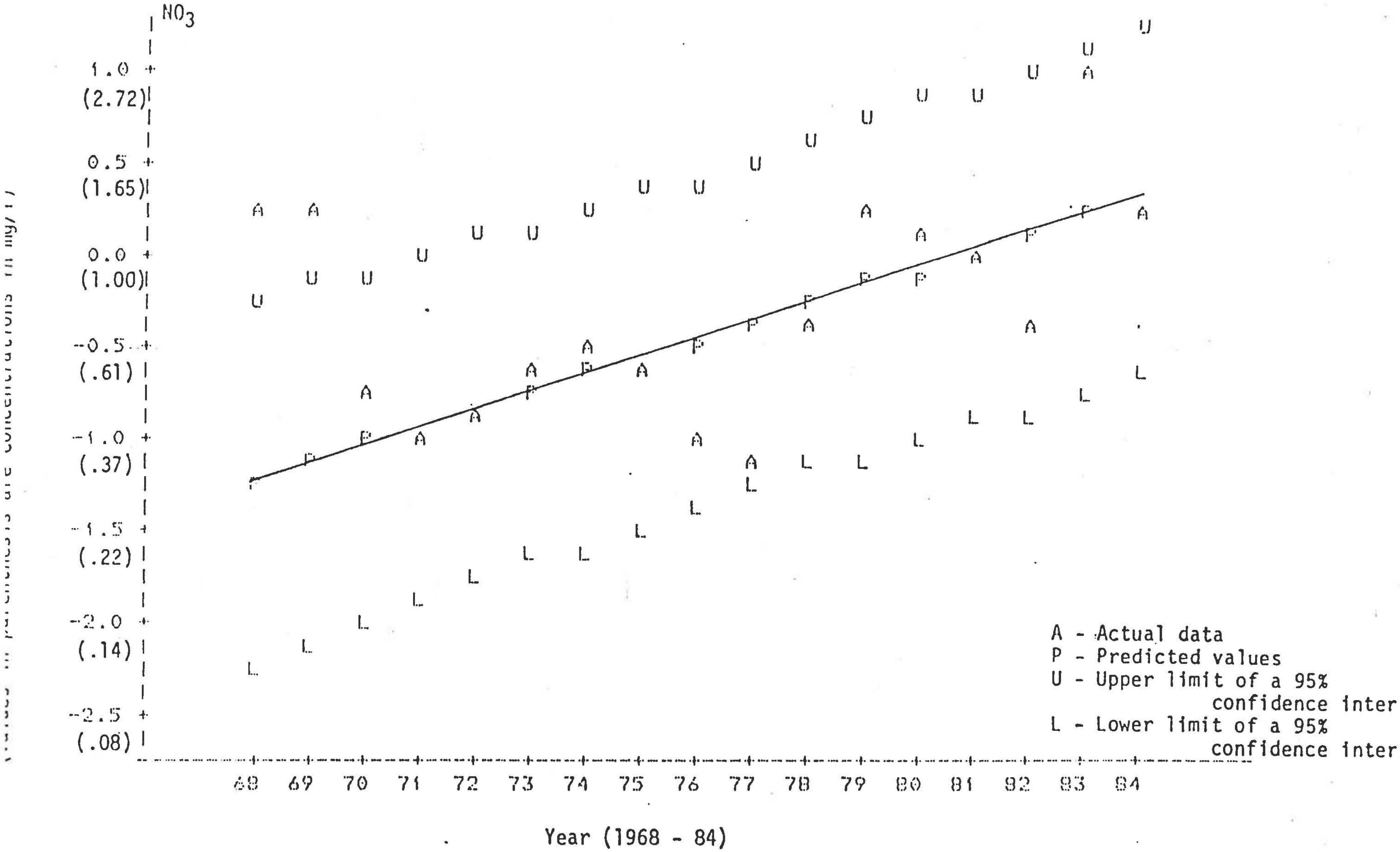

Figure 2. Trend Analysis for NO_3 Concentration Data for Colorado River at FM 973

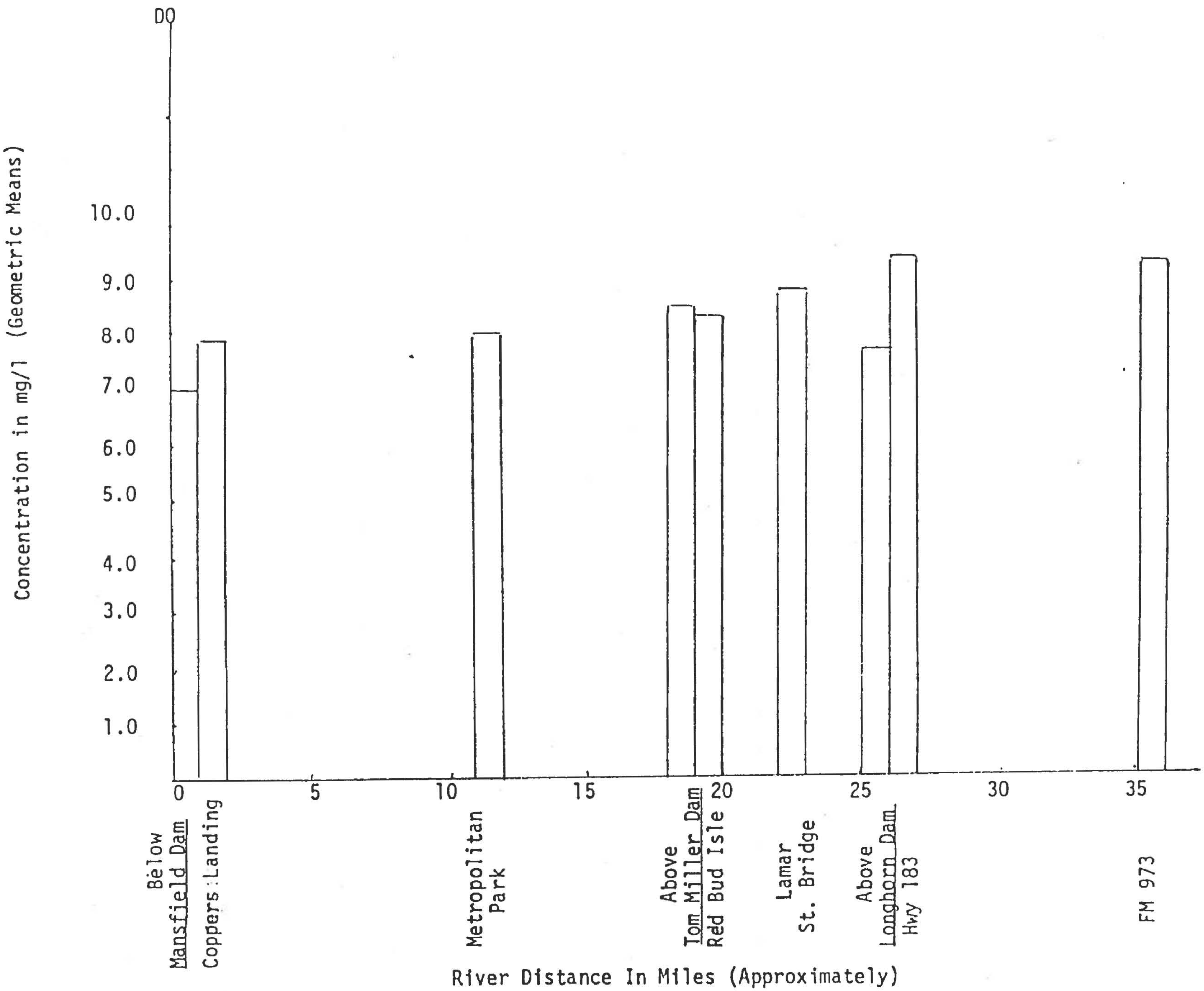

Figure 3. Spatial Distribution of DO Concentration Along Colorado River

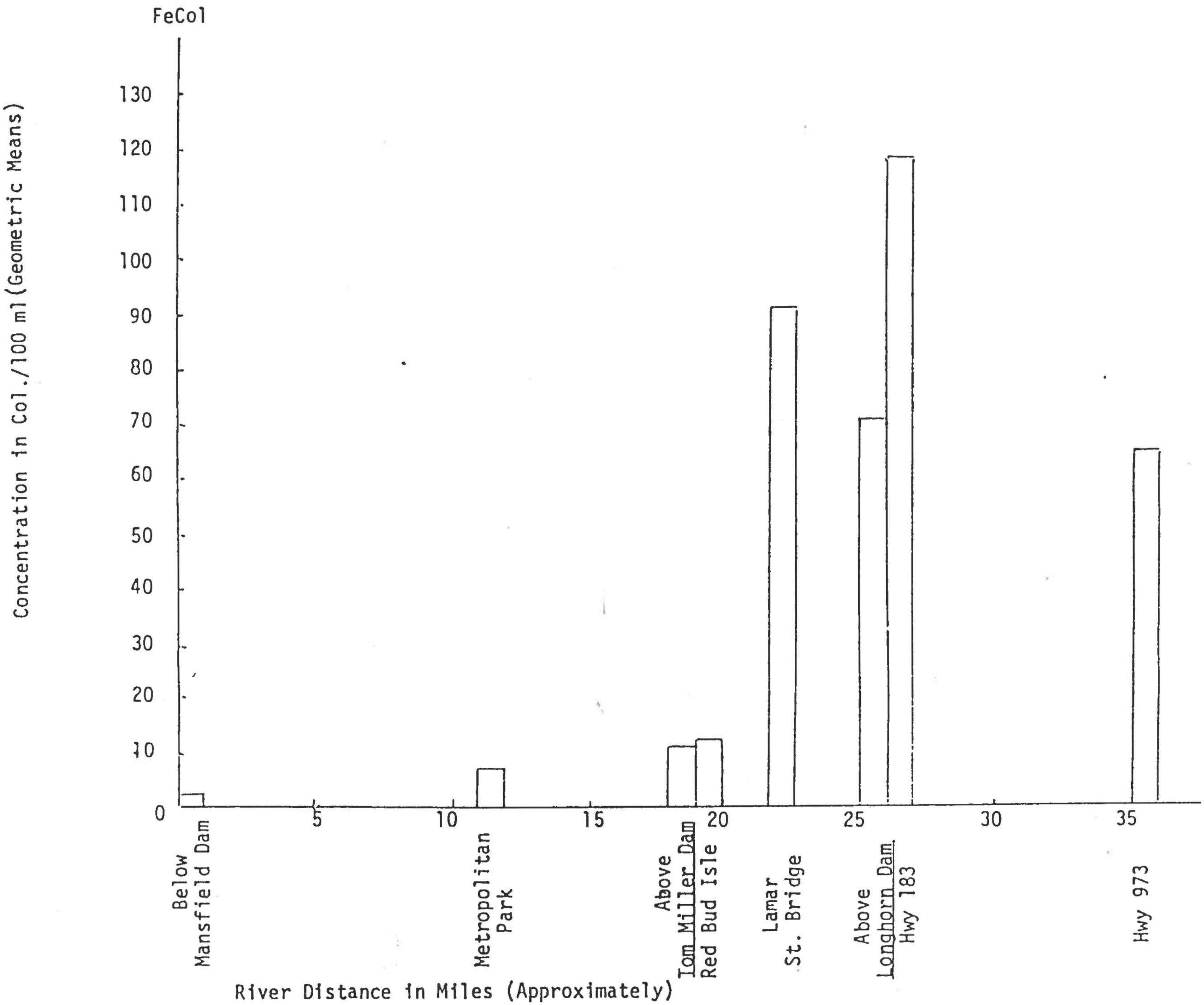

Figure 4. Spatial Distribution of Fecol Coliform Concentration Along Colorado River

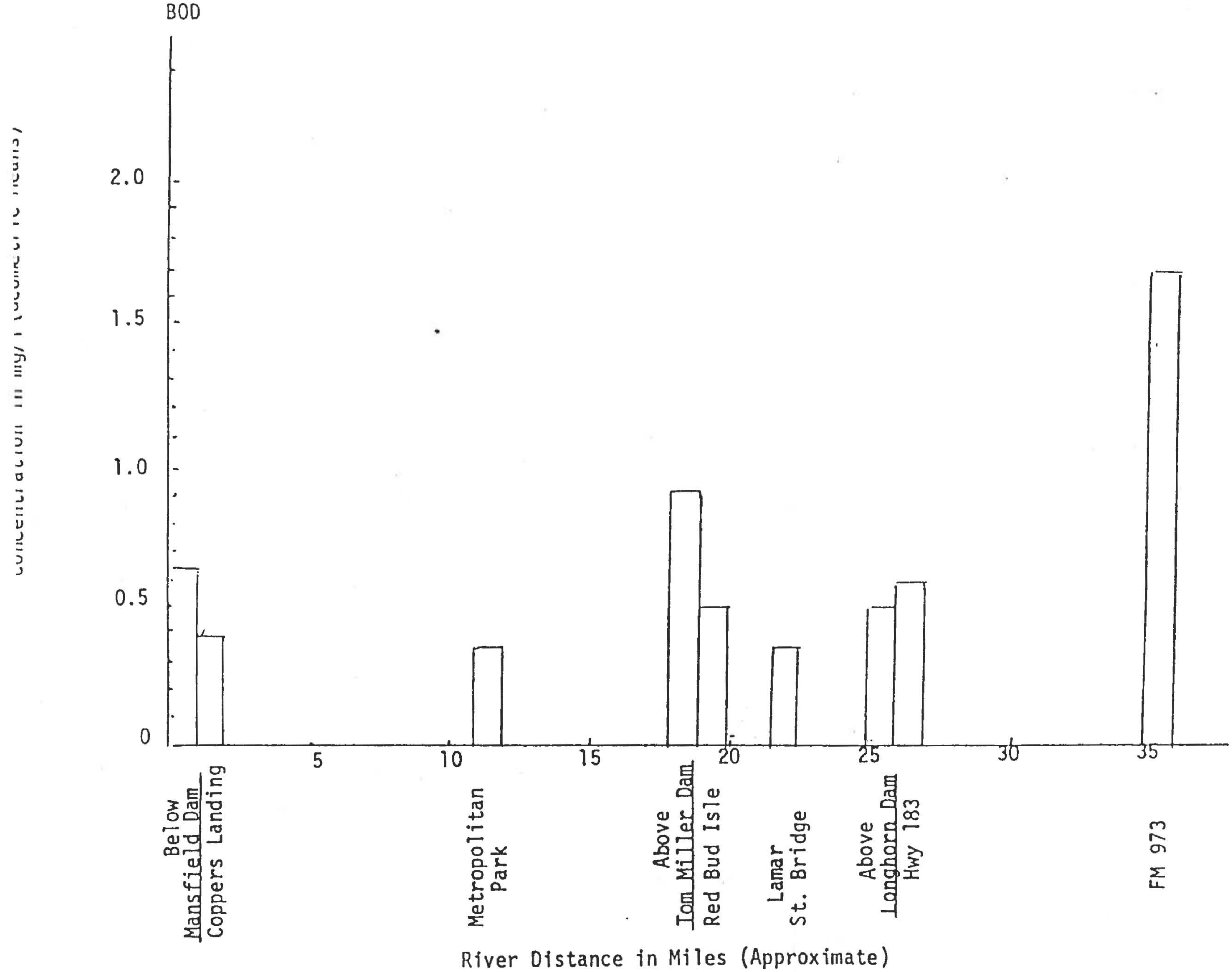

Figure 5. Spatial Distribution of BOD Concentration along Colorado River

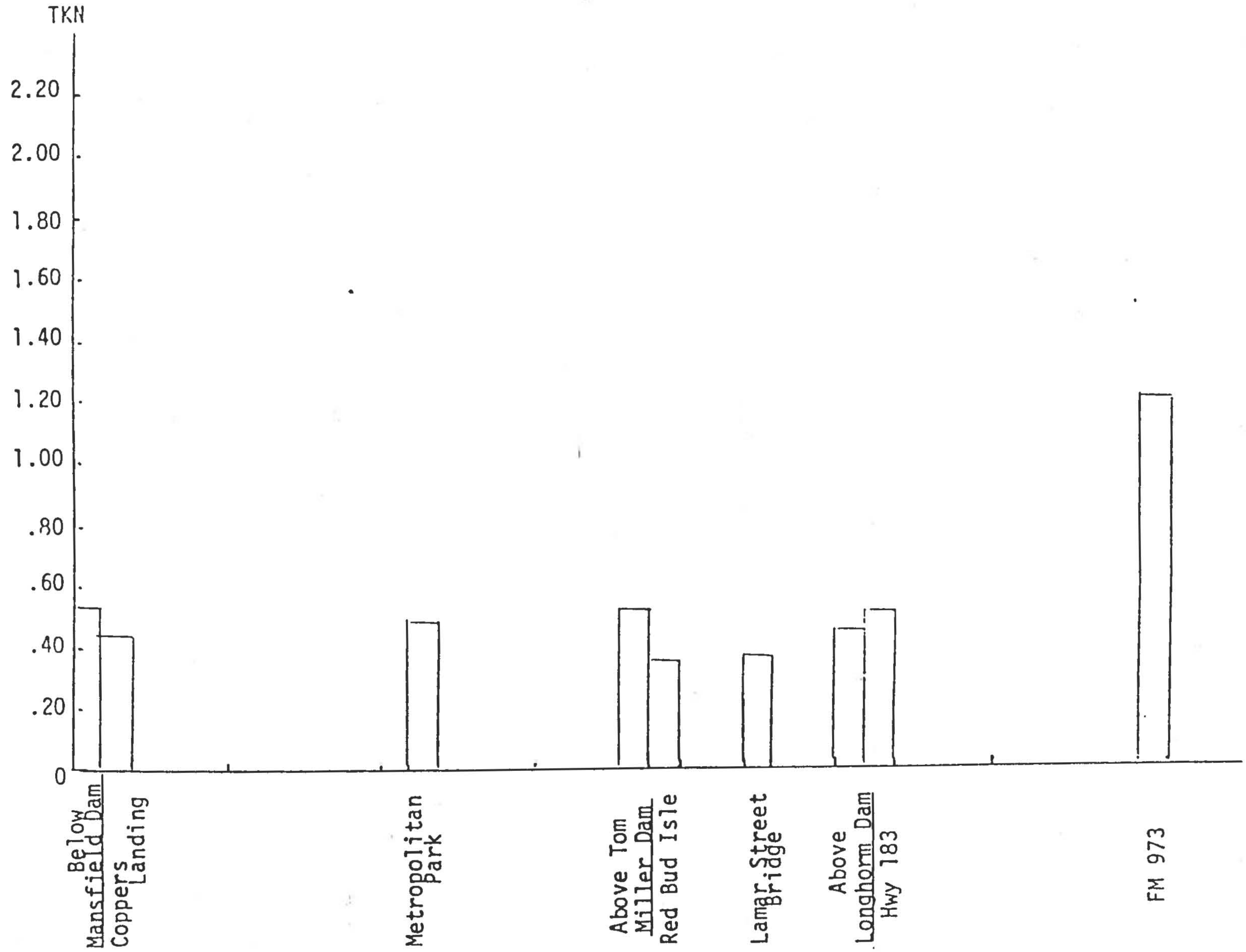

Figure 7. Spatial Distribution of TKN Concentration Along Colorado River

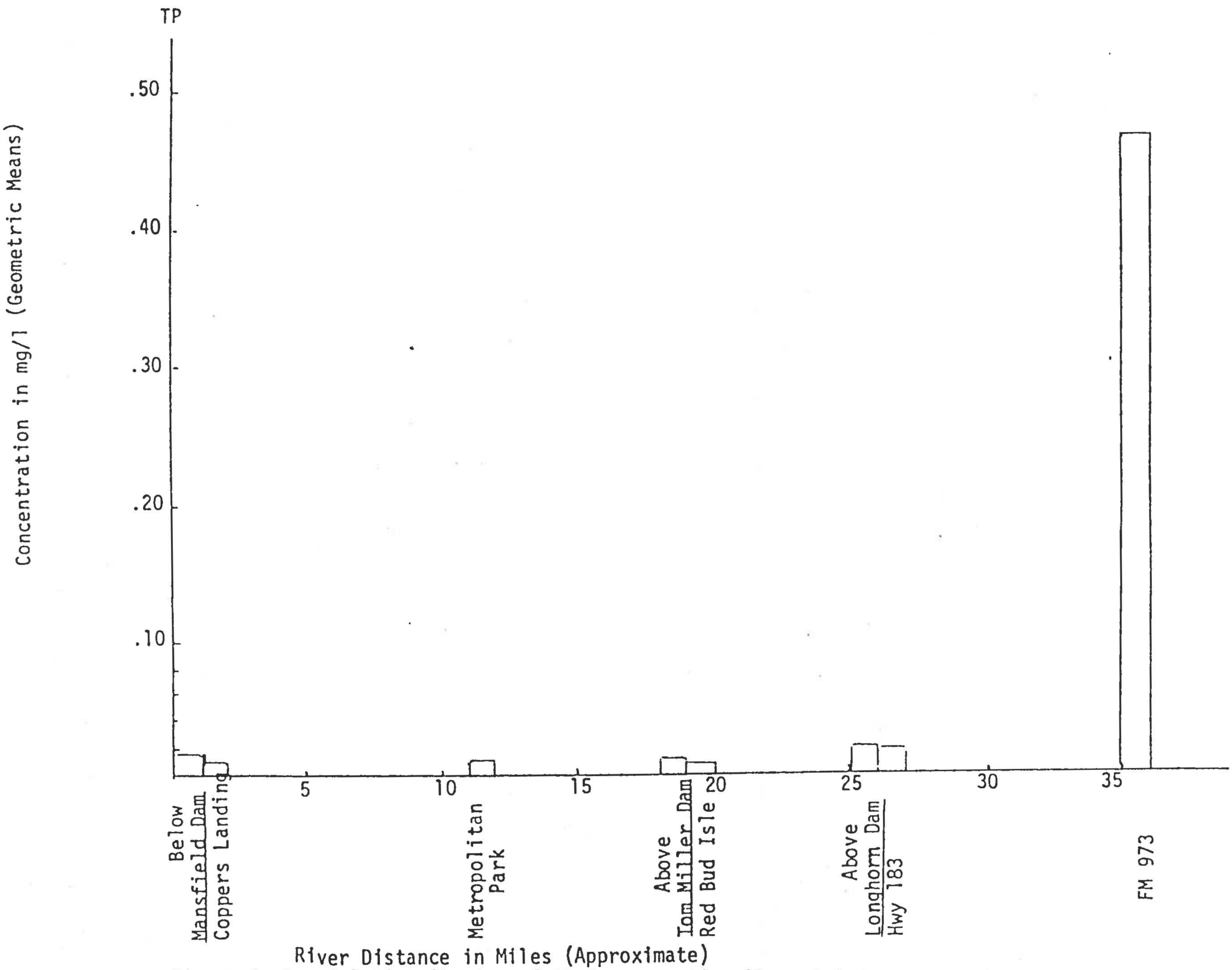

Figure 8. Spatial Distribution of TP Concentration Along Colorado River

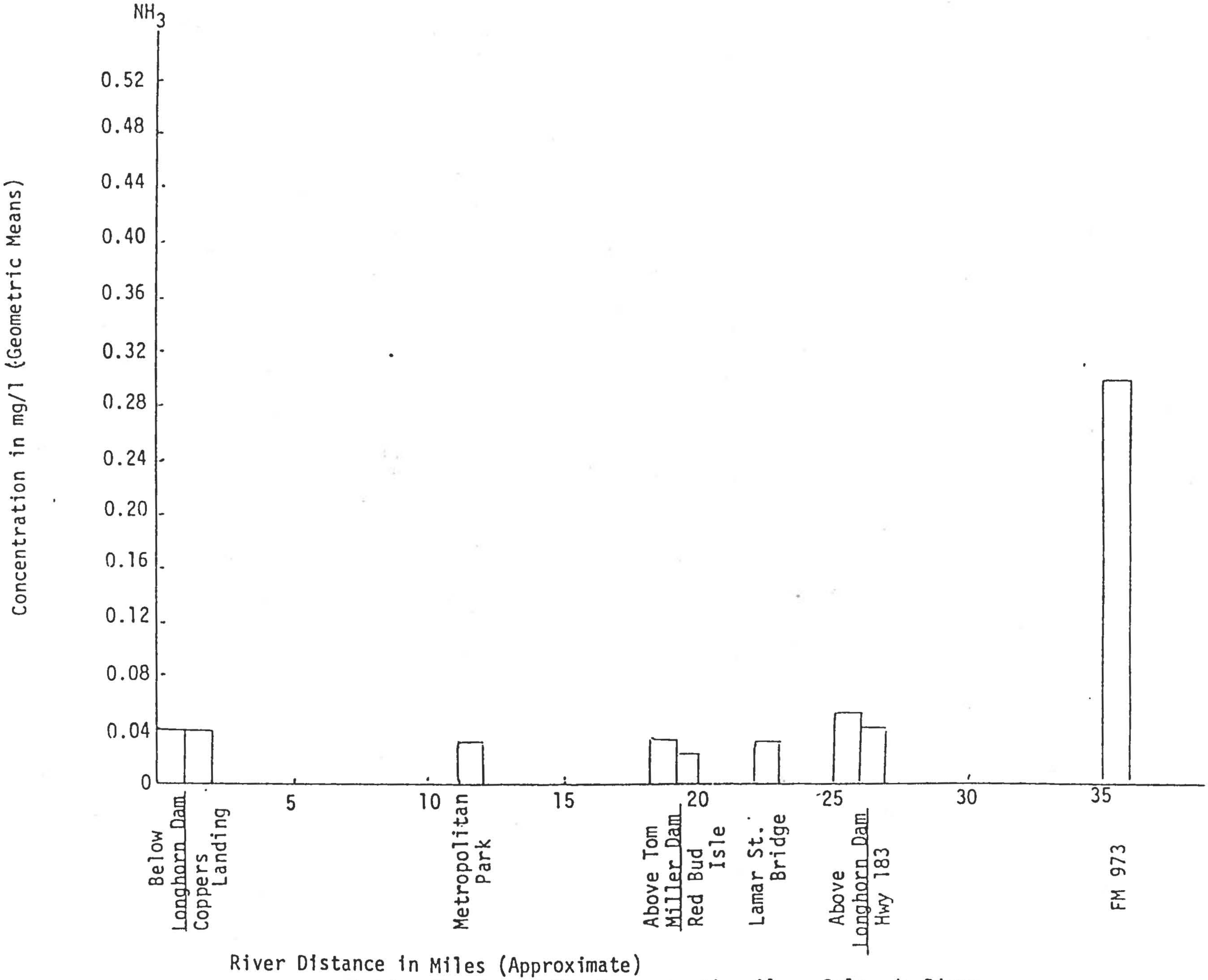

Figure 6. Spatial Distribution of NH_3 Concentration Along Colorado River