CHANGES IN WATER QUALITY OF MICHIGAN STREAMS NEAR URBAN AREAS, 1973-84

by D. J. Holtschlag

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DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
6520 Mercantile Way, Suite 5
Lansing, MI 48911

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CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS AND ABBREVIATIONS

For the use of those readers who may prefer to use metric (International System) units rather than inch-pound units, the conversion factors for the terms used in this report are listed below.

Multiply inch-pound units	By	To obtain metric unit
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.59	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon per minute (gal/min)	0.06308	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
	Mass	
pound, avoirdupois (lb)	453.6	gram (g)
ton, short	0.9072	megagram (Mg)
	Temperature	
degree Fahrenheit (°F)	°C = 5/9 (°F-32)	degree Celsius (°C)

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ABSTRACT

Monthly water-quality monitoring of streams was begun by Michigan Department of Natural Resources in 1973 to (1) determine temporal and spatial variability, (2) detect long-term trends, and (3) describe changes in water quality near urban areas. This report provides a statistical analysis and summary of data collected from 1973 through 1984. Concentrations and discharges of nine commonly measured water-quality constituents and specific conductance are examined. Twenty-three sites on inland streams (streams draining basins wholly within Michigan) and 20 sites on Detroit River are discussed. The changes in water quality in 9 rivers near 12 urban areas in Michigan's southern Lower Peninsula and the relation between streamflow and selected water-quality characteristics, including phosphorus, chloride, sulfate, nitrogen, specific conductance, and solid residues are described.

Results show that the median dissolved-solids concentration in Clinton River downstream from Pontiac exceed Michigan's 1986 stream water-quality standard. Among inland streams, constituent concentrations and discharges generally were greatest in Saginaw River and least in Grand River upstream from Jackson. Upstream from Detroit, constituent concentrations in Detroit River did not differ appreciably across the Windmill Point Transect; downstream from Detroit, at the Fermi Transect across Detroit River, most constituent concentrations were higher near the American and Canadian shorelines. Among urban areas, greatest changes in constituent concentrations occurred in the Grand River near Jackson, in the Clinton River near Pontiac, and in the Tittabawassee River near Midland; the least changes in constituent concentrations occurred in the Saginaw River near Saginaw, in Detroit River near Detroit and the Kalamazoo River near Battle Creek. Greatest changes in constituent discharges occurred in the Detroit River near the Detroit area; the least occurred in the Chippewa River near Mount Pleasant.

Of the 230 regressions between streamflow and constituent concentrations in inland streams, about 73 percent were significant at the 5-percent level. The degree of the correlation and nature of the relation varied among sites and constituents. Generally, higher streamflows were associated with lower concentrations. Changes in streamflow and changes in constituent concentrations near urban areas were correlated in 57 percent of the 120 analyses. Generally, higher changes in streamflow were associated with lower changes in concentrations.

INTRODUCTION

Background

The Michigan Department of Natural Resources (MDNR) operates an urban water-quality network on streams to (1) determine spatial and temporal variability, (2) detect long-term trends, and (3) describe the changes in water quality near urban areas. Data collected at network sites represent a composite of natural and cultural influences upstream. These data provide managers with regional water-quality information rather than information about particular sources of constituents. This report was developed with funding from the MDNR Surface Water Quality Division.

Purpose and Scope

The purpose of this report is to statistically analyze stream water quality data obtained between 1973 and 1984 in order to (1) describe water quality of streams with respect to concentrations and discharges of 10 selected water quality characteristics at 43 sites, (2) describe changes in concentrations and discharges of constituents occurring near 12 urban areas, (3) describe relations between streamflow and concentrations, and (4) identify trends in water-quality data.

Acknowledgements

Acknowledgement is made to personnel of the Surface Water Quality Division of the Michigan Department of Natural Resources for their assistance and cooperation.

METHODS

Sample Collection and Analysis

Data used in this study were based on water-quality samples collected monthly by MDNR at monitoring sites upstream and downstream from urban areas. Most samples were obtained between 8 am and 5 pm on Monday through Friday. This systematic sampling procedure could result in a biased estimate of concentration and discharges if weekend or nighttime water-quality characteristics differ from those most frequently sampled. For purposes of this report, samples were assumed to be representative of average daily water quality. Water samples were collected using a Van Dorn[1] sampler or similar device. Sample preservation and chemical analysis were conducted according to U.S. Environmental Protection Agency (USEPA) approved methodology. Concentration and streamflow data at each site were obtained from the USEPA's storage and retrieval system (STORET) in March 1985. Data collection, begun at most monitoring sites by 1973, was continuing in 1985.

The urban water-quality monitoring network includes 23 sites on inland streams (streams draining basins wholly within Michigan) and 20 sites along 2 Detroit River transects. At inland stream sites, located upstream and down-

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[1] Use of brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

stream from 11 of the urban areas (fig. 1), water-quality samples were collected at mid-river at a depth of 1 foot below the water surface. Samples were assumed to represent the average water quality through the cross section. Streamflow at inland sites was determined by MDNR using drainage area adjustment factors applied to active U.S. Geological Survey gaging stations (table 1). The adjustment factors and active gaging stations varied somewhat during the period of sample collection.

For the Detroit River, 10 sites along each of 2 transects (fig. 2) were sampled at a depth of 1 foot below the water surface. Because the 10 sites along each transect were located at the deciles of flow distribution (U.S. Army Corps of Engineers, 1975), the average concentration of the 10 sites represent the streamflow-weighted average concentration for each transect. Streamflow was computed using a hydrodynamic simulation model developed by Quinn and Hagman (1977). The two transects are separated by a distance of 26.9 mi (miles). The intervening drainage area includes 658 mi^2 (square miles) in southeastern Michigan, including part of the City of Detroit, and 221 mi^2 of southwestern Ontario, Canada including part of the City of Windsor, Ontario. Adjacent American and Canadian urban areas have a combined population of about 5,200,000.

Statistical Analysis

Flow-Adjustment of Concentration Data

Typically, the concentration of a given constituent is related to streamflow (fig. 3). Flow-adjusted concentration (FAC) is the difference (residual) between the measured concentration and the average concentration expected for a particular streamflow. A procedure discussed by Smith, Hirsch, and Slack (1982) was used to estimate the flow-adjusted concentrations. This procedure uses linear regression analysis to estimate the relation between streamflow and concentration. The general form of the relation used in these investigations is expressed by the following:

$$\hat{C}=a+b \cdot f(Q) \qquad (1)$$

where $\hat{C}$ is estimated concentration,
a is an intercept parameter estimated by least-squares regression,
b is a slope parameter estimated by least-squares regression,
Q is daily mean streamflow,

f(Q) is one of the following functional forms:

- Q for a linear model,
- $\ln Q$ for a semi-logarithmic model,
- $1/Q$ for an inverse model, and
- $1/(1+BQ)$ for a hyperbolic model, where B is a positive constant.

The FAC was computed as the measured concentration (C), minus the estimated concentration (C). Model selection was based on: (1) the greatest fraction of variance explained; (2) the least standard error of estimate, and (3) visual inspection of plots of FAC at a function of C, and (4) plots of C versus C. FAC trend analysis was conducted only for regression models which

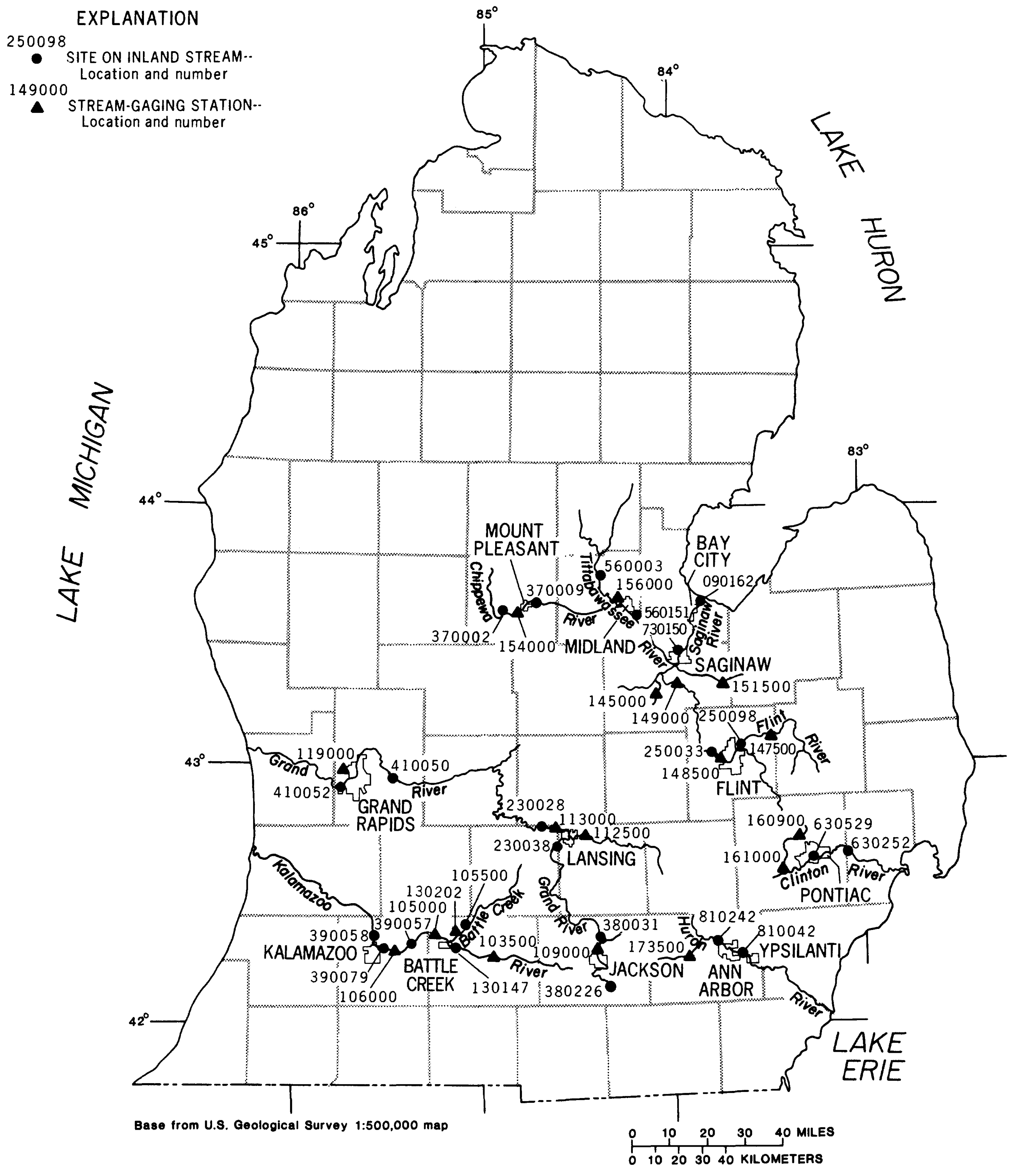

Figure 1.--Location of water-quality monitoring sites on inland streams in the Lower Peninsula of Michigan.

Table 1.--Water-quality sites and gaging stations on inland streams

STORET number	River	Urban area	Location description	Drainage area (square miles)	USGS[1] Gaging station number(s)
090162	Saginaw	Saginaw (downstream)	Sec. 21, Bangor Tps. Bay County, at Midland Street bridge.	6,280	04145000 04149000 04151500 04156000
130147	Kalamazoo	Battle Creek (upstream)	Sec. 8, Emmet Tps., Calhoun County at Raymond Road bridge.	539	04103500 04105500
130202	Battle Creek	Battle Creek (upstream)	Sec.21, Pennfield Tps., Calhoun County, at Nine Mile Road bridge.	183	04105000
230028	Grand	Lansing (downstream)	Sec.3, Delta Tps., Eaton County, at Webster Road bridge.	1,270	04113000
230038	Grand	Lansing (upstream)	Sec.2, Windsor Tps., Eaton County, at Creyts Road bridge.	743	04113000 04112500
250033	Flint	Flint (downstream)	Sec.31, Mount Morris Tps., Genesee County, at Elms Road bridge.	966	04148500
250098	Flint	Flint (upstream)	City of Flint, Genesee County, at Carpenter Road bridge.	610	04147500
370002	Chippewa	Mt. Pleasant (upstream)	Sec.21, Union Tps., Isabella County, at Lincoln Road bridge.	402	04154000
370009	Chippewa	Mt. Pleasant (downstream)	Sec.1, Union Tps., Isabella County, at Isabella Road bridge.	414	04154000
380031	Grand	Jackson (downstream)	Sec.35, Rives Tps., Jackson County at Maple Grove Road bridge.	375	04109000
380226	Grand	Jackson (upstream)	Sec.35, Summit Tps., Jackson County, at Draper Road bridge.	41	--
390057	Kalamazoo	Battle Creek (downstream)	City of Augusta, Kalamazoo County, at G Avenue bridge.	990	04106000
390058	Kalamazoo	Kalamazoo (downstream)	Sec.22, Cooper Tps., Kalamazoo County, at D Avenue bridge.	1,250	04106000
390079	Kalamazoo	Kalamazoo (upstream)	City of Comstock, Kalamazoo County, at River Street bridge.	1,010	04106000
410050	Grand	Grand Rapids (upstream)	Sec.7, Ada Tps., Kent County, at Knapp Street bridge.	4,470	04119000
410052	Grand	Grand Rapids (downstream)	City of Grandville, Kent County, at M-11 Highway bridge.	4,980	04119000
560003	Tittabawassee	Midland (upstream)	Sec.24, Jerome Tps., Midland County at old US-10 Highway bridge.	1,018	04156000
560151	Tittabawassee	Midland (downstream)	Sec.2, Ingersoll Tps., Midland County, at Gordonville Road bridge.	2,448	04156000
630252	Clinton	Pontiac (downstream)	Sec.29, Avon Tps., Oakland County at Hamlin Road bridge.	125	04161000
630529	Clinton	Pontiac (upstream)	Sec.21, Waterford Tps., Oakland at M-59 Highway bridge.	79.2	04160900
730150	Saginaw	Saginaw (upstream)	Sec.35, Saginaw Tps., Saginaw County at Center Street bridge.	6,280	04145000 04149000 04151500 04156000
810042	Huron	Ann Arbor (downstream)	Sec.32, Superior Tps., Washtenaw County, at Superior Road bridge.	824	04174500
810242	Huron	Ann Arbor (upstream)	Sec.17, Ann Arbor Tps., Washtenaw County, at Huron Bridge Park.	729	04174500

[1] U.S. Geological Survey

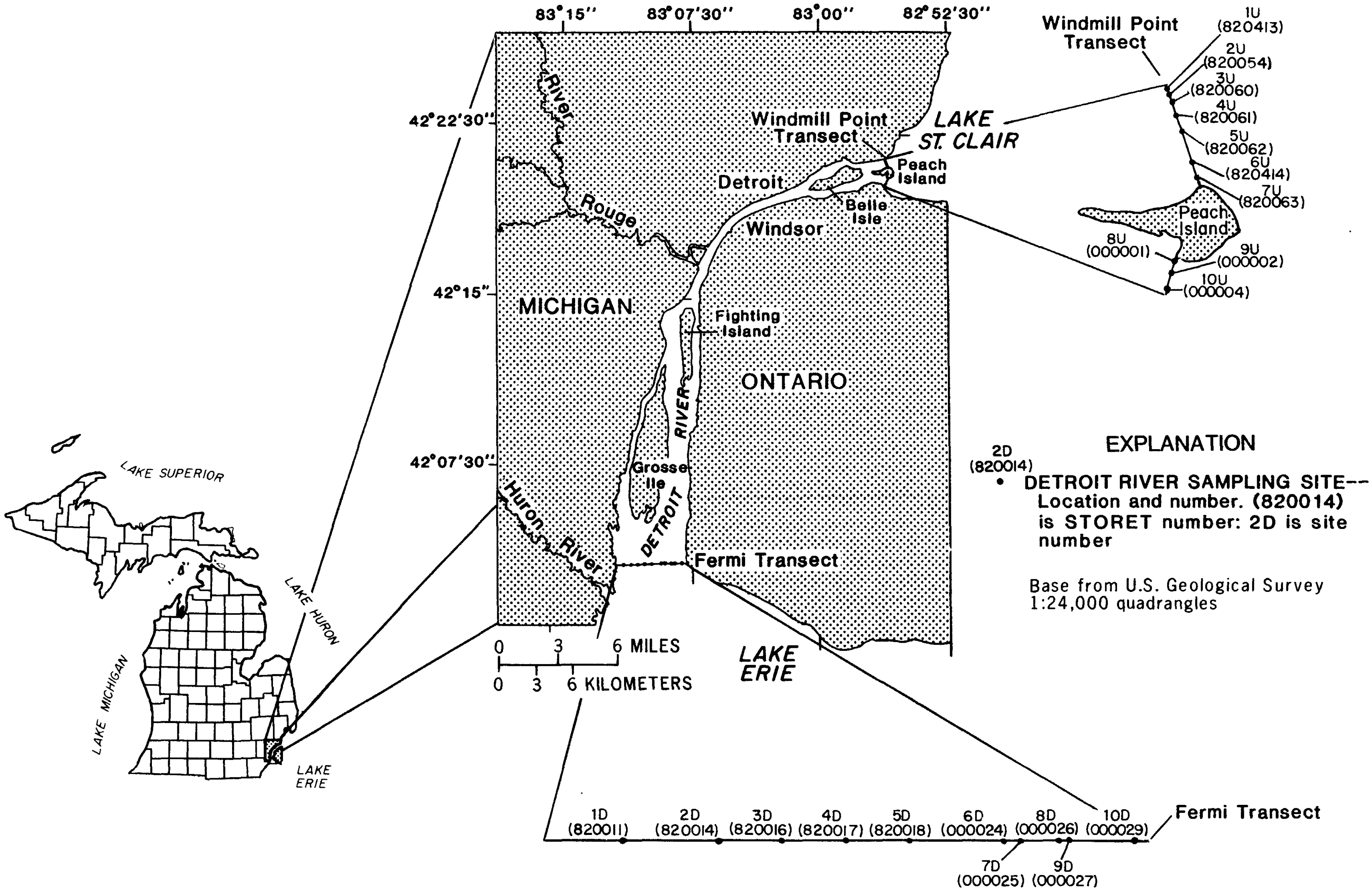

Figure 2.--Location of water-quality monitoring sites on the Detroit River.

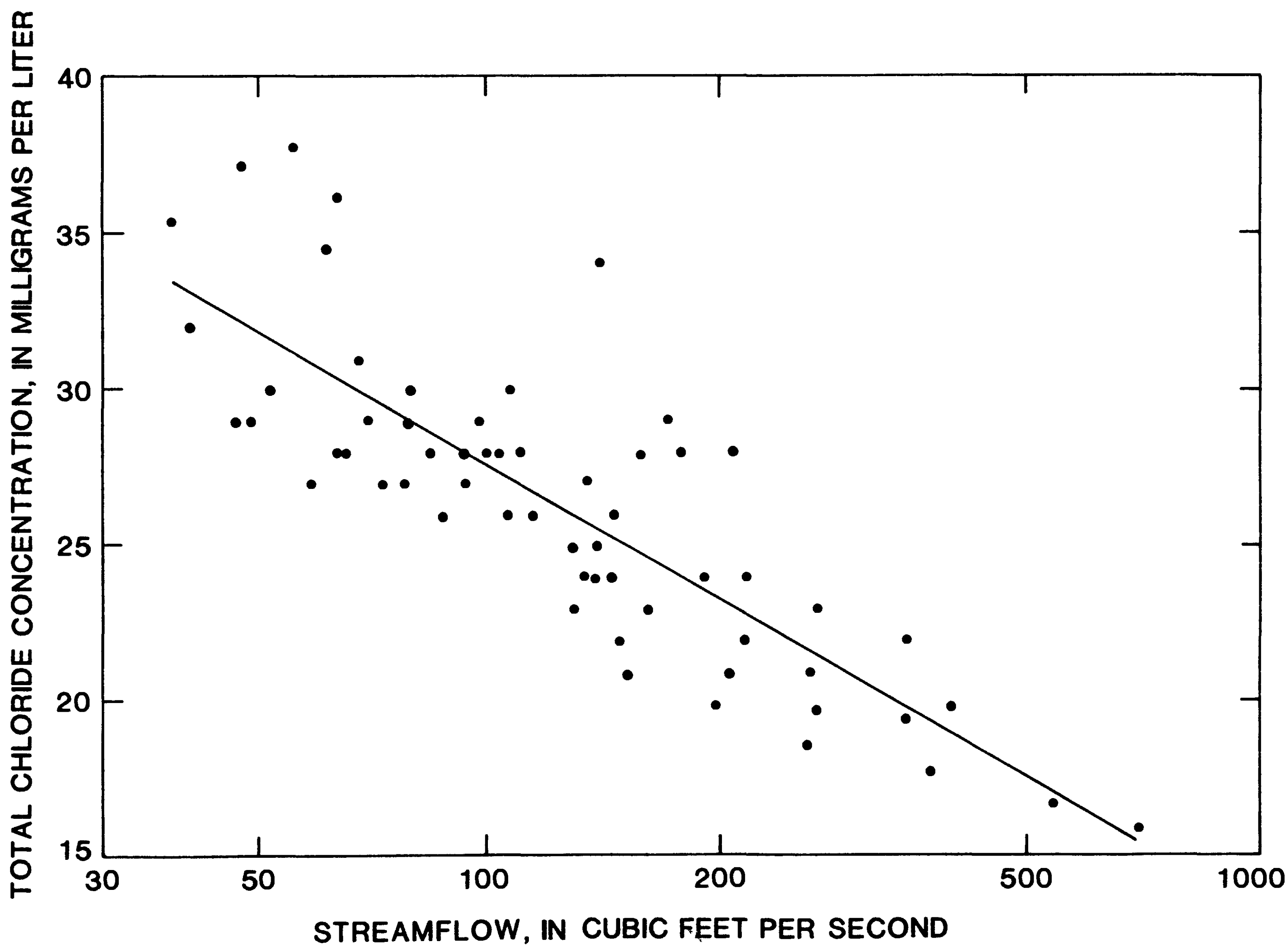

Figure 3.--Relation of chloride concentration to streamflow at Battle Creek upstream from Battle Creek.

were found to be significant at the 5-percent level. Occasionally, the number of FAC values were less than the number of concentration values because of missing streamflow records.

Trend Analysis

Trends in water-quality data occur for many reasons, including changes in waste-treatment facilities and land-use within the basin. Unless time trends are identified and necessary adjustments are made, data summaries may average the past conditions with substantially different recent conditions. Such historical averages may be of little value to water-quality managers attempting to understand or control current water-quality conditions. The purpose of the trend analysis was to increase the usefulness of water-quality data by ensuring that the summarized data represents water-quality conditions as they existed at the end of 1984.

In this study, trends in water-quality data were classified as either abrupt changes (step trends) or constant-rate changes (linear trends). Identification of step trends were based on inspection of constituent time-series plots (fig. 4), rather than statistical inference, because of the lack of information concerning the timing of the discontinuities before examining the time series data. Records showing one or more step trends were divided into two periods. The earlier period contains all data up to the most recent step trend; the later period contains the more recent data after the last step trend. Data summaries were based on the later period of record, where step trends occurred.

Monotonic (linear and nonlinear) trends were identified using a modified Seasonal Kendall's Test (Hirsch and Slack, 1984). Plots were inspected to determine whether linear approximations were appropriate. Records showing linear trends were adjusted using the Seasonal Kendall Slope Estimator (Hirsch and others, 1982) so that the effect of the time trend was removed and data summaries reflect conditions at the end of the time series. The magnitude of the adjustment varied over the period of record; larger adjustments (in absolute value) were applied to data obtained early in the data-collection period. Smaller adjustments were applied to more recent data (fig. 5). Records showing periods of nonlinear changes in the average concentration with time were separated into two periods; the earlier period contains the data having a nonlinear trend.

The concentrations of water-quality characteristics commonly vary with the season of the year (fig. 6). In order to eliminate seasonal effects, only concentrations means in the same month of the year were compared. For example, comparison of a January value with a May value would not contribute any information about the existence of a trend. Thus, the seasonal test for trend is based on all pairs of data which are multiples of 12 months.

GENERAL DESCRIPTION OF WATER-QUALITY CHARACTERISTICS AND STANDARDS

Nine water-quality constituents and specific conductance were selected by MDNR for evaluation in this study. The following table gives data related to each characteristic. Constituent concentrations are important in determining the suitability of water for maintaining desirable aquatic life and in

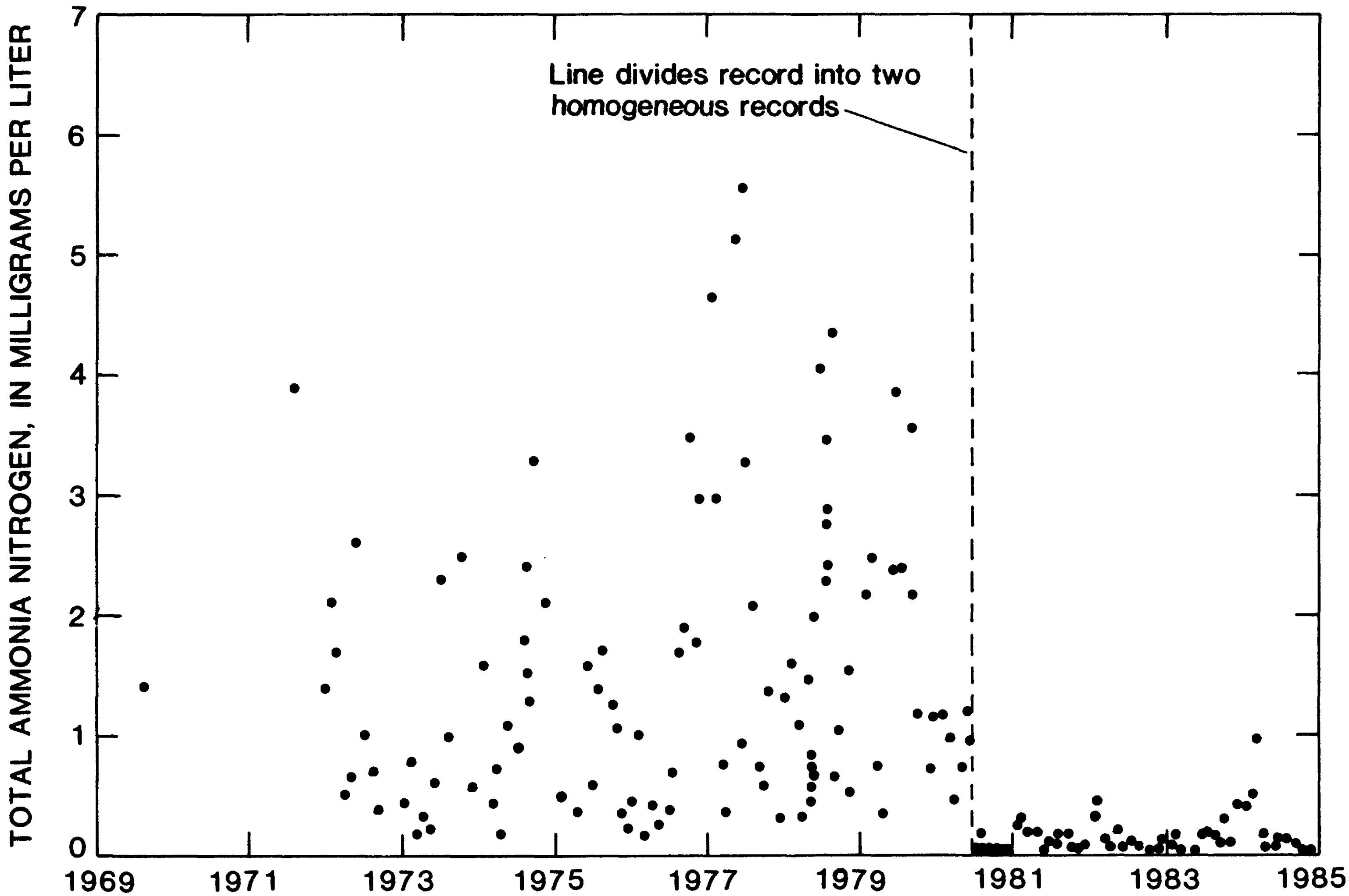

Figure 4.--Step trend in ammonia nitrogen concentration at Flint River downstream from Flint.

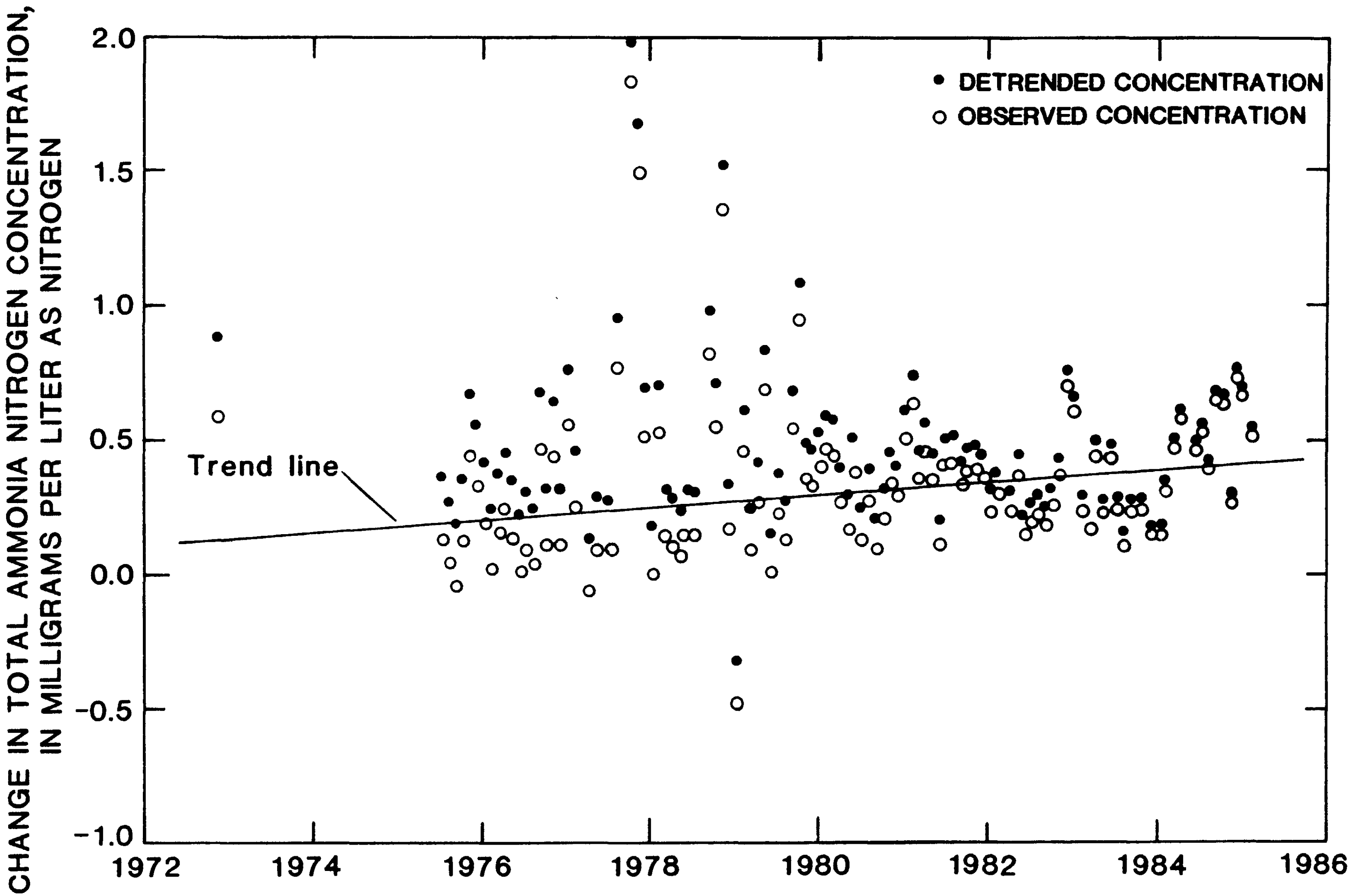

Figure 5.--Linear trend in ammonia nitrogen concentration changes near Kalamazoo.

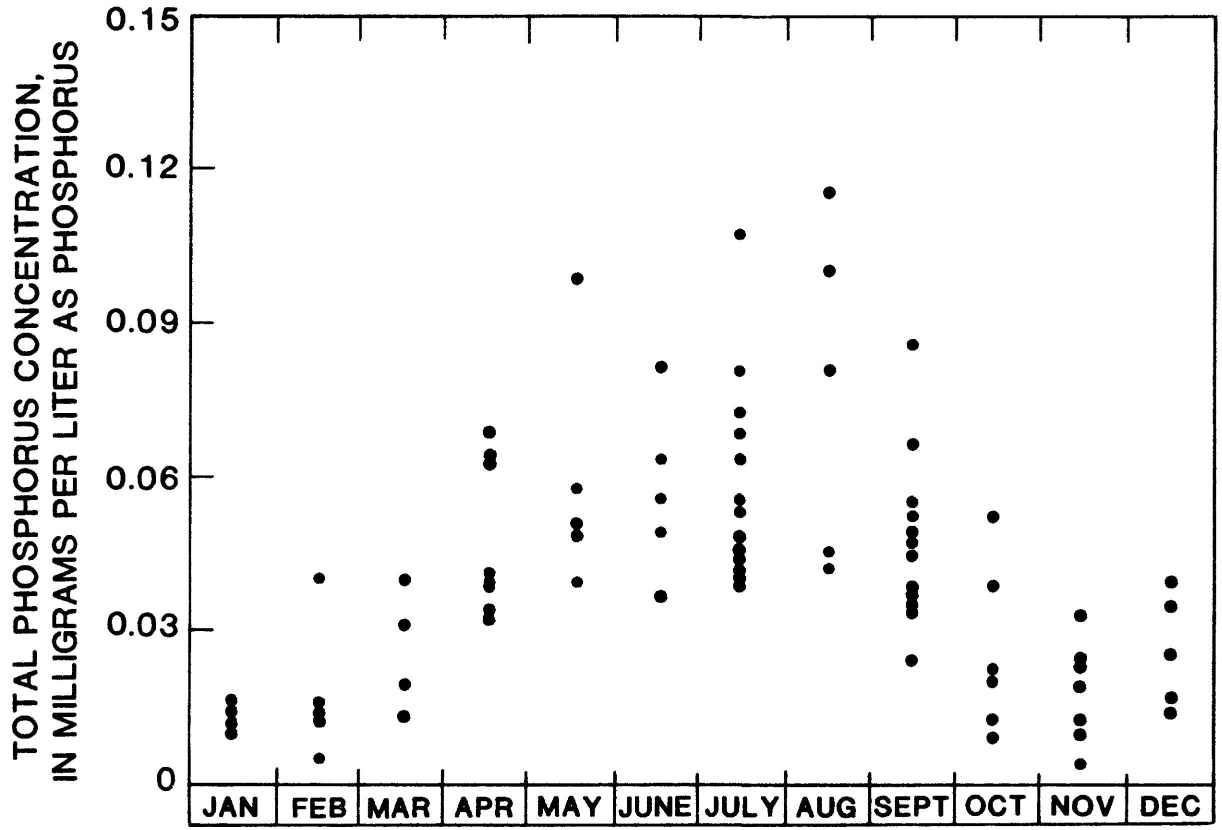

Figure 6.--Seasonal variation in phosphorus concentration at Kalamazoo River upstream from Kalamazoo.

Table 2.--Water-quality characteristics

[Average length of record is based on current homogeneous period only. All values for lower detection limit are in milligrams per liter except for specific conductance which is microsiemens per centimeter at 25 degrees Celsius. Lower detection limit based on analytical procedures currently in use by MDNR]

			Percentage of values less than detection limit		Average length of record (years)	
STORET number	Characteristic	Lower detection	Inland streams	Detroit River	Inland streams	Detroit River
00665	Total phosphorus as P (mg/L)	0.003	0	0	8.3	7.7
00940	Total chloride (mg/L)	.20	0	0	10.4	12.6
00945	Total sulfate as SO_4 (mg/L)	1.0	0	0	4.3	4.0
00625	Total organic plus ammonia nitrogen as N (mg/L)	.05	0	0	5.8	8.7
00610	Total ammonia nitrogen as N (mg/L)	[a].005	0.6	7.1	8.8	9.5
00630	Total nitrate plus nitrite nitrogen as N (mg/L)	.005	.2	<.1	8.5	12.0
00095	Specific conductance (µS/cm at 25° C)	2.0	0	0	10.3	9.1
00500	Total solids residue on evaporation at 105° C (mg/L)	20.0	[b]0	[b]0	10.3	11.4
47004	Dissolved-solids residue on evaporation at 180° C (mg/L)	20.0	0	0	9.1	13.6
00530	Nonfilterable-solids residue on evaporation at 105° C (mg/L)	4.0	4.3	5.4	10.3	17.0

[a] Detection limit lowered from 0.02 mg/L to 0.005 mg/L after July 1975.
[b] Calculated values reported after May 1977.

indicating the usefulness of the stream water for domestic, agricultural, and manufacturing purposes. The water-quality characteristics are discussed in the following paragraphs.

Phosphorus

Phosphorus is present in natural waters and in wastewaters as soluble phosphate, and is suspended in particles of detritus and bodies of aquatic organisms. The breakdown and erosion of phosphorus-bearing minerals in soil and rock formations, decaying plant and animal material, agricultural and domestic fertilizers, synthetic detergents, treated sewage effluents, and leaking septic systems contribute phosphorus to streams. Phosphorus is of concern because it promotes eutrophication. Of the major nutrients, phosphorus is the one most frequently limiting plant growth in lakes (Wetzel, 1975). To prevent accelerated eutrophication, total phosphates as phosphorus should not exceed 0.05 mg/L (milligrams per liter) in any stream at the point where it enters a lake or reservoir (U.S. Environmental Protection Agency, 1976). A desired goal for the prevention of plant nuisances in streams not discharging directly to lakes or impoundments is 0.1 mg/L total phosphorus (Mackenthun, 1973).

Chloride

Chloride is a major inorganic anion in natural water. Chlorides leach from soils and from rock formations into streams. Other significant sources of chloride include deicing salt, sewage effluents, industrial wastes, and oil field brines. High chloride concentrations give water a salty taste, and contribute to corrosion of metals. Standards of the Michigan Water Resources Commission (1986) require that public water-supplies not exceed 125 mg/L of chloride as a monthly average; when public supplies are withdrawn from the Great Lakes or connecting channels, chloride may not exceed 50 mg/L as a monthly average.

Sulfate

Sulfate is a major inorganic anion that enters water from soils and from rock formations. Sulfate has a cathartic effect upon humans when present in excessive amounts. The maximum recommended sulfate concentration in drinking water is 250 mg/L (U.S. Environmental Protection Agency, 1977b).

Nitrogen

Common nitrogen forms in streams include organic nitrogen, ammonia nitrogen, nitrate, and nitrite nitrogen. Nitrogen transformations from one form to another can occur as the result of biological and chemical processes. Sources of organic nitrogen include proteins, peptides, nucleic acids, urea, and numerous synthetic organic materials. Analytically, organic plus ammonia nitrogen are commonly determined together and reported as Kjeldahl nitrogen, a term that reflects the technique used in their determination.

Ammonia is naturally present in streams as a biodegradation product of compounds containing organic nitrogen and as a result of the hydrolysis of urea. It may also be produced by reduction of nitrate under anaerobic conditions. Total ammonia nitrogen includes both un-ionized ammonia (NH_3), and the ammonium ion (NH_4). Nitrate is an essential nutrient for many photosynthetic autotrophs and in some cases has been identified as a growth-limiting nutrient. In addition to nitrate's role in promoting eutrophication, excessive amounts in drinking water may cause methemoglobinemia. The maximum recommended concentration of nitrate as nitrogen in drinking water is 10 mg/L (U.S. Environmental Protection Agency 1977a).

Nitrite is an intermediate state of nitrogen in the reduction-oxidation reaction between ammonia and nitrate. Oxidation and reduction may occur in waste-water treatment plants, water-distribution systems, and streams.

Specific Conductance and Dissolved Solids

Specific conductance is an electrical property of water related to the concentration and type of ionized substances in the water. Measurements of specific conductance are commonly used to estimate dissolved-solids concentration. The relation between specific conductance and dissolved-solids concentration was similar for waters of inland streams. Linear regression equations of the following form were used to describe the relation between specific conductance and dissolved-solids concentration:

$$\hat{DS} = a + b \cdot SC \qquad (2)$$

where $\hat{DS}$ is the estimated dissolved-solids concentration, in milligrams per liter;

SC is specific conductance, in µS/cm (microsiemens per centimeter at 25° Celsius);

a is an intercept parameter estimated by least-squares regression;

and

b is a slope parameter estimated by least-squares regression.

Specific conductance is highly correlated with dissolved-solids concentration for the streams studied in Michigan (table 3). The average coefficient of determination (r-squared) was 0.99. The average intercept values (parameter, 'a') tended to be near zero. The average ratio (slope parameter, 'b') of dissolved-solids concentration to specific conductance is 0.65. Therefore, for the sites studied in this analysis, the dissolved-solids concentration (in mg/L) can be estimated with a high degree of accuracy by multiplying specific conductance (in µS/cm) by 0.65.

Solid Residues

Analysis of solids, as residue on evaporation, were conducted for total, dissolved, and nonfilterable solids. Total-solids concentration is calculated as the sum of dissolved solids and nonfilterable (suspended) solids. A wide variety of inorganic and organic materials are encountered in the analysis of solids. Waters having high solids generally are of inferior palatability and are unsuitable for many industrial applications. In addition, waters with a high nonfilterable-solids concentration may be aesthetically unsatisfactory for some purposes. The Michigan Water Resources Commission (1986) limits dissolved-solids concentration of streams to 500 mg/L as a monthly average.

Table 3.--Relation between specific conductance and dissolved-solids concentration at sites on inland streams

$$\hat{DS} = a + b \cdot SC$$

where $\hat{DS}$ is the estimated dissolved-solids concentration, in milligrams per liter;

SC is specific conductance, in µS/cm (microsiemens per centimeter at 25 degrees Celsius);

a is an intercept parameter estimated by least-squares regression;

and

b is a slope parameter estimated by least-squares regression.

STORET number	Linear equation coefficients: Intercept (a)	Linear equation coefficients: Slope (b)	Coefficient of determination	Standard error of estimate (mg/L)	Number of observations
090162	-1.31	0.653	0.998	3.97	177
130147	.17	.648	.979	4.51	64
130202	6.74	.640	.972	7.43	61
230028	.51	.649	1.000	1.27	60
230038	-.32	.650	1.000	.57	47
250033	2.52	.647	.995	5.61	135
250098	1.27	.648	.986	5.68	110
370002	-3.83	.658	.991	1.96	55
370009	-.45	.650	.996	2.26	81
380031	-1.95	.653	.997	5.00	127
380226	1.80	.646	.994	1.98	113
390057	3.63	.642	.986	4.69	84
390058	9.76	.634	.994	3.08	126
390079	.61	.649	.999	.84	106
410050	-.25	.650	1.000	.44	104
410052	.01	.660	1.000	.59	128
560003	.68	.648	.969	1.29	76
560151	.15	.650	1.000	.80	49
630252	-3.28	.654	.994	6.92	148
630529	1.34	.648	.996	2.19	109
730150	-.04	.651	.999	3.77	112
810042	1.38	.647	.958	8.67	132
810242	4.32	.643	.995	2.21	105

WATER QUALITY AT SITES ON INLAND STREAMS AND DETROIT RIVER

Constituent Concentrations and Streamflow

A summary of concentration and streamflow data was prepared for each inland stream and Detroit River site. Statistics reported include the mean; standard deviation; minimum value; 25th-, 50th-, and 75th-percentile; and maximum value (tables 4, 5 and 6). To permit comparison of sites for conditions existing at the end of 1984, only the most recent period of records containing step trends were included; effects of linear time trends were removed.

Inland Streams

Inland streams included in this analysis were: Battle Creek, Chippewa River, Clinton River, Flint River, Grand River, Huron River, Kalamazoo River, Saginaw River, and Tittabawassee River. The variation in water quality among the 23 sites on inland streams are ranked by median concentrations and shown on figures 7 to 17, at end of report. Higher-ranked sites are generally associated with impaired water quality. Several sites consistently occurred in the low- and high-five rankings for the 10 constituents investigated. The two sites on Saginaw River (090162 and 730150), occurred in the high-five rankings for 90 and 70 percent of the constituents analyzed, respectively. The site on Grand River upstream from Jackson (380226) occurred in the low-five rankings for 100 percent of the constituents analyzed. The site on Chippewa River upstream from Mount Pleasant (370002), occurred in the low-five rankings for 80 percent of the constituents analyzed. Variability in the rankings is indicated by the fact that 11 sites occurred one or more times in the low-five rankings, where 14 sites occurred one or more times in the high-five rankings. This variability indicates the intercorrelation among constituents.

Median phosphorus concentrations exceed 0.1 mg/L at both sites on Saginaw River (090162 and 730150), and sites downstream from Lansing (230028), Flint (250033), and Kalamazoo (390058). Median total ammonia nitrogen concentrations exceed 0.2 mg/L at sites downstream from Saginaw (090162), Kalamazoo (390058), Grand Rapids (410052), and Midland (560151). Median dissolved-solids concentrations exceed Michigan water-quality standards downstream from Pontiac (630252). No site had a median concentration which exceeds Michigan Water Resources Commission (1986) standard for chloride or USEPA drinking water standards (1977a, 1977b) for nitrate nitrogen or sulfate. No general Michigan or USEPA standard or criteria have been established for total organic plus ammonia nitrogen, total solids, specific conductance, and nonfilterable solids. The variability of median concentrations among inland stream sites are shown on figures 18 to 20.

Grand River basin is the second largest river basin in Michigan, draining 5,572 mi^2. Water quality of Grand River is monitored at six inland stream sites and streamflow is measured at three U.S. Geological Survey gaging stations. Grand River flows from east to west through the urban areas of Jackson, Lansing, and Grand Rapids before flowing into Lake Michigan (fig. 1). Data from the MDNR network was used to describe changes in water quality and streamflow throughout 75 percent of the river's 213 mile length.

Table 4.--Constituent concentrations and related data for sites on inland streams

[Results are in mg/L (milligrams per liter) except for specific conductance which is reported as µS/cm at 25° C (microsiemens per centimeter at 25 degrees Celsius).]

				Percentage of samples in which values are less than or equal to those shown					Step trend[1]		Linear trend[2]	
STORET number	Mean (mg/L)	Standard deviation (mg/L)	Minimum (mg/L)	25 (mg/L)	50 (mg/L)	75 (mg/L)	Maximum (mg/L)	Years of record	Date (year/month)	Earlier period	Probability level	Slope (mg/L/yr)
						Total phosphorus concentration						
090162	0.144	0.068	0.073	0.107	0.138	0.171	0.540	5	80/07	H[3]	0.055	--
130147	.053	.040	.012	.026	.047	.064	.290	6	--	--	.502	--
130202	.061	.031	.012	.040	.052	.079	.153	6	--	--	.016	-0.006
230028	.162	.067	.070	.106	.156	.210	.400	5	80/01	H	.545	--
230038	.056	.054	.003	.024	.050	.081	.343	11	--	--	.001	-.011
250033	.152	.063	.072	.097	.140	.200	.340	5	80/07	H	.103	--
250098	.049	.029	.003	.028	.043	.065	.148	11	--	--	.018	-.004
370002	.043	.040	.010	.020	.031	.048	.260	6	--	--	.559	--
370009	.069	.081	.003	.024	.048	.090	.455	9	--	--	.000	-.008
380031	.135	.164	.003	.044	.099	.177	1.58	14	--	--	.005	-.009
380226	.030	.027	.005	.015	.023	.037	.260	10	--	--	1.00	--
390057	.082	.048	.003	.046	.073	.103	.275	10	--	--	.000	-.005
390058	.204	.116	.060	.129	.177	.230	.720	14	--	--	.536	--
390079	.064	.053	.003	.030	.056	.080	.448	10	--	--	.000	-.004
410050	.081	.040	.018	.053	.078	.103	.213	10	--	--	.001	-.003
410052	.093	.056	.024	.058	.078	.103	.273	4	81/01	H	.008	-.008
560003	.032	.012	.014	.022	.030	.040	.065	6	--	--	.790	--
560151	.061	.038	.003	.031	.051	.083	.172	5	--	--	.015	-.008
630252	.097	.069	.034	.054	.082	.103	.420	7	78/01	H	.823	--
630529	.017	.009	.008	.011	.016	.020	.055	7	78/01	H	.016	-.001
730150	.111	.056	.030	.064	.102	.146	.258	5	80/07	H	.005	-.009
810042	.081	.110	.003	.036	.061	.098	1.24	14	--	--	.002	-.004
810242	.027	.016	.004	.017	.025	.032	.105	10	--	--	.000	-.001
						Total chloride concentation						
090162	80.3	32.7	19.8	53.0	76.5	102	220	2	--	--	.157	--
130147	29.3	4.34	20.4	26.8	29.0	31.7	48.2	6	--	--	.006	0.697
130202	26.3	4.91	16.1	23.0	27.0	29.0	37.6	6	--	--	.219	--
230028	49.8	17.2	22.5	36.0	47.2	61.0	110	12	--	--	.720	--
230038	42.9	14.1	19.0	31.0	41.8	52.8	82.5	11	--	--	.480	--
250033	59.5	24.7	24.0	45.0	54.0	66.0	220	13	--	--	.936	--
250098	28.6	4.64	17.4	26.0	29.0	31.0	42.0	11	--	--	.109	--
370002	18.5	2.80	8.94	16.6	19.4	20.1	24.1	6	--	--	.000	-.500
370009	26.0	8.12	9.31	21.5	25.0	28.8	69.6	9	--	--	.000	-.500
380031	54.8	27.1	20.0	35.0	47.0	71.0	154	14	--	--	.650	--
380226	13.5	1.24	10.4	12.8	13.5	14.6	17.0	10	--	--	.000	.300
390057	35.8	7.13	21.7	30.8	36.2	40.5	54.2	10	--	--	.000	.750
390058	35.7	7.99	17.0	29.0	36.0	42.0	62.0	14	--	--	.116	--
390079	31.6	6.14	20.9	27.8	31.5	35.1	61.1	10	--	--	.030	.381
410050	33.1	6.88	19.1	28.8	33.1	36.0	61.7	10	--	--	.041	.314
410052	38.6	10.3	17.0	31.0	39.0	46.0	66.0	13	--	--	.374	--
560003	15.9	2.46	8.00	14.4	16.0	17.5	22.0	6	--	--	.751	--
560151	96.8	56.4	23.0	56.0	77.0	130	209	5	--	--	.576	--
630252	105	32.7	49.0	86.0	100	118	310	13	--	--	.744	--
630529	57.4	6.47	45.5	53.5	56.3	60.2	95.6	12	--	--	.002	1.00
730150	84.5	39.8	16.7	55.5	79.0	110	220	12	--	--	.827	--
810042	56.9	12.5	37.5	48.3	55.6	62.7	139	14	--	--	.013	1.00
810242	47.5	4.60	34.7	45.1	47.5	50.8	62.8	10	--	--	.000	1.33
						Total sulfate concentration						
090162	51.6	9.27	19.0	47.3	53.0	59.0	66.5	5	--	--	.072	--
130147	53.5	57.7	35.4	41.2	44.8	47.7	421	4	--	--	.014	2.00
130202	60.5	14.7	35.0	52.0	60.0	68.0	115	4	--	--	.316	--
230028	62.3	14.2	37.0	51.1	61.4	69.6	110	6	--	--	.009	-2.73

See footnotes at end of table

Table 4.--Constituent concentrations and related data for sites on inland streams--Continued

STORET number	Mean (mg/L)	Standard deviation (mg/L)	Minimum (mg/L)	Percentage of samples in which values are less than or equal to those shown: 25 (mg/L)	50 (mg/L)	75 (mg/L)	Maximum (mg/L)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (mg/L/yr)
Total sulfate concentration--Continued												
230038	56.7	13.2	32.7	50.4	54.8	63.8	100	7	--	--	.016	-1.92
250033	56.0	7.68	37.8	50.6	56.4	62.5	69.8	4	--	--	.014	2.72
250098	43.9	8.31	28.0	38.0	43.0	49.0	62.0	4	--	--	.094	--
370002	28.5	4.59	19.0	26.0	28.0	31.0	43.0	4	--	--	.293	--
370009	32.3	4.75	23.0	29.0	32.0	36.0	46.0	4	--	--	.124	--
380031	62.6	14.2	42.0	50.0	60.0	73.0	101	4	--	--	.205	--
380226	35.4	7.50	22.5	31.2	34.3	37.8	55.8	4	--	--	.000	4.00
390057	48.5	6.26	38.4	44.3	48.5	53.4	65.9	4	--	--	.014	2.00
390058	56.6	5.49	44.9	53.4	57.8	59.9	67.1	4	--	--	.004	3.00
390079	46.5	5.00	36.7	43.6	46.6	49.6	60.2	4	--	--	.004	2.50
410050	49.2	9.25	24.0	44.0	50.0	54.0	72.5	4	--	--	.147	--
410052	53.9	9.59	31.0	50.0	56.0	59.0	72.8	4	--	--	.280	--
560003	29.0	6.76	16.5	24.0	27.9	33.0	46.0	4	--	--	.386	--
560151	44.2	10.1	21.0	37.5	43.0	49.0	68.0	4	--	--	.072	--
630252	55.6	13.8	27.0	46.0	54.0	62.0	97.0	5	--	--	.605	--
630529	28.7	3.27	21.0	27.0	29.0	31.7	33.9	4	--	--	.202	--
730150	53.0	10.8	17.0	47.4	53.0	60.0	72.0	4	--	--	.515	--
810042	53.9	5.62	40.4	49.2	55.7	58.0	63.4	4	--	--	.012	2.00
810242	49.0	5.64	38.4	45.3	49.5	52.7	63.4	4	--	--	.047	1.83
Total organic plus ammonia nitrogen concentration (as nitrogen)												
090162	1.54	0.335	0.970	1.30	1.50	1.72	2.60	5	80/07	H	0.478	--
130147	.670	.245	.280	.500	.610	.810	1.80	6	--	--	.056	--
130202	.621	.212	.212	.456	.602	.781	1.15	6	--	--	.005	-0.050
230028	1.09	.354	.671	.901	1.01	1.18	2.91	5	80/01	H	.026	-.071
230038	1.12	.310	.590	.930	1.10	1.25	3.00	11	--	--	.318	--
250033	1.39	.328	.870	1.20	1.35	1.60	2.70	5	80/07	H	.437	--
250098	1.11	.256	.740	.880	1.10	1.30	2.00	6	--	--	.061	--
370002	.593	.216	.380	.455	.530	.660	1.70	6	--	--	.666	--
370009	.577	.275	.168	.406	.509	.680	1.56	5	--	--	.001	-.097
380031	1.02	.272	.624	.849	.974	1.16	2.12	6	--	--	.001	-.067
380226	.655	.250	.360	.475	.585	.775	1.50	6	--	--	.268	--
390057	.903	.269	.430	.740	.825	1.00	1.80	6	--	--	.304	--
390058	1.31	.422	.234	1.07	1.24	1.52	2.73	6	--	--	.035	-.090
390079	.632	.211	.253	.491	.607	.779	1.24	6	--	--	.001	-.049
410050	.874	.270	.346	.684	.876	1.03	1.46	6	--	--	.009	-.045
410052	1.02	.443	.454	.795	.912	1.19	3.36	5	--	--	.001	-.100
560003	.631	.170	.310	.502	.640	.740	1.10	6	--	--	.774	--
560151	1.16	.344	.640	.940	1.10	1.35	2.05	5	--	--	.554	--
630252	1.04	.304	.590	.830	.950	1.20	2.00	5	--	--	.358	--
630529	.647	.100	.490	.570	.650	.700	1.00	6	--	--	.522	--
730150	1.47	.377	.900	1.20	1.50	1.70	2.40	5	80/07	H	.723	--
810042	.967	.319	.566	.740	.882	1.13	1.95	5	--	--	.005	-.051
810242	.711	.189	.090	.610	.690	.760	1.60	5	--	--	.496	--
Total ammonia nitrogen concentration (as nitrogen)												
090162	.349	.221	.050	.225	.310	.400	1.26	5	80/07	H	.382	--
130147	.069	.072	.005	.031	.047	.082	0.470	6	--	--	.384	--
130202	.060	.062	.005	.026	.038	.063	.290	6	--	--	.118	--
230028	.182	.185	.015	.060	.134	.220	.894	5	80/01	H	.762	--
230038	.141	.158	.005	.033	.081	.205	.809	11	--	--	.236	--
250033	.178	.168	.020	.075	.139	.199	1.00	5	80/07	H	.202	--
250098	.088	.099	.005	.015	.044	.137	.450	11	--	--	.407	--
370002	.048	.056	.010	.023	.034	.054	.406	6	--	--	.034	.002
370009	.135	.122	.005	.042	.111	.206	.478	9	--	--	.000	-.009
380031	.245	.207	.010	.100	.176	.320	1.05	14	--	--	.700	--
380226	.042	.040	.008	.019	.031	.048	.320	10	--	--	.013	.001
390057	.103	.086	.006	.047	.080	.124	.510	10	--	--	.086	--

See footnotes at end of table

Table 4.--Constituent concentrations and related data for sites on inland streams--Continued

STORET number	Mean (mg/L)	Standard deviation (mg/L)	Minimum (mg/L)	Percentage of samples in which values are less than or equal to those shown: 25 (mg/L)	50 (mg/L)	75 (mg/L)	Maximum (mg/L)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (mg/L/yr)
						Total ammonia nitrogen concentration--Continued						
390058	.531	.277	.147	.360	.459	.645	2.04	14	--	--	.010	.018
390079	.099	.078	.005	.046	.080	.126	.500	10	--	--	.356	--
410050	.073	.111	.005	.010	.031	.089	.720	10	--	--	.435	--
410052	.318	.200	.022	.161	.300	.430	1.09	13	--	--	.681	--
560003	.065	.033	.022	.044	.057	.079	.220	6	--	--	.000	.007
560151	.275	.219	.010	.120	.240	.370	1.08	5	--	--	.576	--
630252	.142	.197	.005	.027	.085	.180	1.28	7	78/01	H	.395	--
630529	.093	.140	.010	.043	.080	.114	1.61	12	--	--	.703	--
730150	.225	.201	.019	.091	.174	.265	1.06	5	80/07	H	.081	--
810042	.336	.634	.005	.005	.151	.478	4.95	14	--	--	.027	-.039
810242	.083	.108	.005	.015	.044	.112	.760	10	--	--	.161	--
						Total nitrate plus nitrite nitrogren concentration (as nitrogen)						
090162	1.66	.945	.330	1.00	1.50	2.21	4.70	5	80/07	L[4]	1.00	--
130147	1.54	.279	1.00	1.34	1.49	1.76	2.09	6	--	--	.001	.065
130202	1.01	.552	.300	.595	.760	1.35	2.40	6			1.00	--
230028	1.95	.589	.820	1.50	1.97	2.40	3.35	5	80/01	L	.880	--
230038	1.04	.582	.115	.637	.914	1.30	3.20	11	--	--	.529	--
250033	2.64	.815	1.15	2.08	2.42	3.08	5.76	5	80/07	L	.002	.220
250098	.534	.532	.021	.087	.274	.904	2.23	11	--	--	.043	.006
370002	.795	.551	.180	.516	.689	.851	3.63	6	--	--	.034	.030
370009	.858	.578	.377	.629	.722	.941	4.89	9	--	--	.000	.021
380031	1.58	.936	.290	.880	1.31	1.92	4.30	12	--	--	.910	--
380226	.305	.142	.061	.207	.272	.398	.850	10	--	--	.000	.013
390057	1.09	.325	.341	.895	1.02	1.22	2.79	8	--	--	.000	.027
390058	.924	.274	.329	.722	.918	1.08	1.59	12	--	--	.010	.023
390079	.842	.378	.082	.589	.863	1.11	1.72	10	--	--	.000	.024
410050	1.48	.866	.147	.765	1.44	2.06	4.49	10	--	--	.013	.053
410052	1.10	.775	.053	.475	.980	1.60	3.00	12	--	--	.066	--
560003	.367	.688	.029	.119	.283	.420	5.93	6	--	--	.001	.018
560151	.915	.730	.051	.280	.820	1.20	3.20	5	--	--	.852	--
630252	3.29	1.78	1.02	2.00	2.87	4.20	9.45	7	78/01	L	.243	--
630529	.118	.081	.005	.059	.107	.170	.344	12	--	--	.001	-.011
730150	1.58	1.00	.149	.720	1.40	2.25	4.20	6	80/07	L	.930	--
810042	.955	.376	.452	.674	.843	1.14	2.20	12	--	--	.012	.033
810242	.333	.301	.009	.119	.260	.460	1.90	10	--	--	.340	--
						Specific conductance						
090162	704	129	270	623	713	785	1,140	12	--	--	0.980	--
130147	562	47.3	375	540	570	590	655	6	--	--	.079	--
130202	614	69.5	405	574	625	658	749	6	--	--	.156	--
230028	682	95.9	473	623	688	741	955	12	--	--	.583	--
230038	653	84.3	420	594	663	715	813	11	--	--	.963	--
250033	664	125	395	585	648	705	1,360	13	--	--	.880	--
250098	586	71.2	388	543	571	612	768	11	--	--	.007	5.00
370002	448	30.7	370	435	450	461	530	6	--	--	.231	--
370009	485	59.1	275	453	490	520	625	9	--	--	.178	--
380031	696	146	430	585	670	788	1,090	14	--	--	.473	--
380226	482	41.1	340	460	485	515	565	10	--	--	.821	--
390057	608	55.3	424	578	620	646	728	10	--	--	.000	5.00
390058	602	59.8	380	560	610	645	720	13	--	--	.292	--
390079	576	44.7	479	540	582	604	676	10	--	--	.012	3.75
410050	588	68.7	366	552	583	625	740	10	--	--	.011	3.45
410052	591	85.6	365	548	600	650	800	13	--	--	.054	--
560003	404	50.6	285	376	400	435	505	6	--	--	.054	--
560151	730	206	310	590	725	865	1,260	5	--	--	.852	--
630252	779	138	370	688	770	845	1,530	13	--	--	.629	--
630529	598	49.0	501	568	587	618	858	12	--	--	.003	5.00

See footnotes at end of table

Table 4.--Constituent concentrations and related data for sites on inland streams--Continued

STORET number	Mean (mg/L)	Standard deviation (mg/L)	Minimum (mg/L)	Percentage of samples in which values are less than or equal to those shown: 25 (mg/L)	50 (mg/L)	75 (mg/L)	Maximum (mg/L)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (mg/L/yr)
					Specific conductance--Continued							
730150	731	175	245	645	725	818	1,600	12	--	--	.919	--
810042	624	63.2	465	590	620	658	940	14	--	--	.121	--
810242	624	43.9	530	603	620	638	877	10	--	--	.000	7.14
					Total solids concentration (residue at 105° C)							
090162	486	71.7	265	440	482	530	760	12	--	--	.977	--
130147	392	26.2	275	381	396	405	434	6	--	--	.001	4.50
130202	406	45.4	267	383	412	434	491	6	--	--	.156	--
230028	456	51.9	322	431	460	488	588	12	--	--	.198	--
230038	436	47.3	312	409	435	472	555	11	--	--	1.00	--
250033	434	80.0	223	392	418	455	845	13	--	--	.016	-4.50
250098	374	47.4	175	349	366	395	488	11	--	--	.057	--
370002	296	43.5	20.0	291	298	311	379	6	--	--	1.00	--
370009	341	84.1	21.0	313	331	353	841	9	--	--	.357	--
380031	472	101	280	396	456	525	827	14	--	--	.516	--
380226	321	26.5	226	308	326	340	376	10	--	--	.033	--
390057	412	36.4	294	394	420	435	485	10	--	--	.000	4.00
390058	405	40.9	290	379	411	432	499	13	--	--	.241	--
390079	382	27.7	320	362	387	400	460	10	--	--	.030	2.07
410050	409	39.7	249	391	411	436	492	10	--	--	.001	3.27
410052	431	49.7	265	409	438	459	589	13	--	--	.029	3.35
560003	263	34.7	106	248	265	284	325	6	--	--	.039	-1.75
560151	490	145	198	399	481	569	926	5	--	--	.621	--
630252	522	82.3	358	467	518	557	1,010	13	--	--	.783	--
630529	392	47.7	20.0	374	388	410	560	12	--	--	.026	3.20
730150	504	107	218	454	501	556	1,050	12	--	--	.956	--
810042	418	42.2	293	394	416	441	617	14	--	--	.215	--
810242	405	32.9	234	391	403	415	564	10	--	--	.000	3.86
					Dissolved-solids concentration (residue at 180° C)							
090162	448	90.4	176	405	463	509	618	12	--	--	.923	--
130147	381	30.0	258	369	388	399	433	6	--	--	.019	4.38
130202	400	45.1	263	377	408	428	487	6	--	--	.137	--
230028	450	60.0	318	411	459	484	597	6	--	--	.030	5.50
230038	411	62.3	250	380	416	465	527	4	--	--	.222	--
250033	433	84.2	257	386	421	461	884	11	--	--	.792	--
250098	381	47.9	254	352	372	399	501	10	--	--	.000	3.50
370002	291	20.5	240	283	292	300	344	6	--	--	.340	--
370009	312	36.4	179	293	315	335	384	9	--	--	.183	--
380031	451	92.1	280	382	434	512	708	12	--	--	.396	--
380226	312	26.8	221	299	315	334	367	10	--	--	.680	--
390057	393	38.6	277	365	403	418	474	8	--	--	.001	3.38
390058	392	41.4	274	364	400	422	468	13	--	--	.738	--
390079	363	30.2	293	343	366	387	422	9	--	--	.230	--
410050	370	47.0	228	344	370	400	462	10	--	--	.111	--
410052	387	58.4	237	358	393	424	520	12	--	--	.189	--
560003	263	33.0	185	246	262	287	328	6	--	--	.062	--
560151	474	143	202	379	462	545	907	5	--	--	.921	--
630252	512	88.3	240	458	506	556	994	11	--	--	.470	--
630529	389	33.5	326	367	381	406	557	11	--	--	.015	3.20
730150	475	117	159	424	480	531	1,040	11	--	--	.874	--
810042	408	42.6	302	384	407	429	611	12	--	--	.232	--
810242	404	29.2	343	390	401	414	568	9	--	--	.000	4.31

See footnotes at end of table

Table 4.--Constituent concentrations and related data for sites on inland streams--Continued

STORET number	Mean (mg/L)	Standard deviation (mg/L)	Minimum (mg/L)	Percentage of samples in which values are less than or equal to those shown: 25 (mg/L)	50 (mg/L)	75 (mg/L)	Maximum (mg/L)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (mg/L/yr)
Nonfilterable-solids concentration (residue at 105° C)												
090162	29.5	25.0	1.00	14.5	26.0	36.5	210	12	--	--	0.330	--
130147	11.3	9.01	1.00	4.00	10.0	15.0	37.0	6	--	--	.946	--
130202	6.36	4.39	1.00	4.00	5.00	7.50	22.0	6	--	--	.512	--
230028	14.1	12.3	1.00	4.86	12.0	19.6	64.5	12	--	--	.020	-0.606
230038	10.8	9.86	1.00	3.67	8.81	15.4	57.9	11	--	--	.025	-.500
250033	22.2	54.3	1.00	1.00	8.47	24.6	406	5	80/07	H	.002	-2.10
250098	13.6	10.8	1.00	5.00	12.0	18.0	67.0	11	--	--	.254	--
370002	16.8	45.0	2.00	5.00	8.00	13.5	340	6	--	--	.709	--
370009	33.7	86.3	1.00	8.00	15.0	26.0	662	9	--	--	.600	--
380031	17.8	16.9	1.00	5.00	14.0	26.0	119	14	--	--	.549	--
380226	10.4	7.75	2.85	4.90	7.15	14.4	35.8	10	--	--	.013	.333
390057	13.5	9.22	1.00	7.00	11.0	19.0	45.0	10	--	--	.551	--
390058	15.5	10.4	1.00	8.00	13.5	22.0	72.0	12	--	--	1.00	--
390079	10.4	7.40	1.00	4.00	9.00	15.0	37.0	10	--	--	.843	--
410050	21.5	14.7	1.00	8.50	21.0	31.0	68.0	10	--	--	.223	--
410052	24.7	19.3	1.00	11.0	23.5	30.5	104	13	--	--	.605	--
560003	8.87	5.69	1.00	4.00	8.00	13.0	24.0	6	--	--	1.00	--
560151	16.6	13.1	2.00	7.50	14.0	21.0	64.0	5	--	--	.493	--
630252	13.3	22.0	1.00	3.55	8.18	14.9	142	13	--	--	.005	-.714
630529	6.16	8.45	1.00	2.67	4.39	6.89	70.0	12	--	--	.003	-.333
730150	26.1	22.3	1.00	10.1	25.5	37.8	128	12	--	--	.035	-.833
810042	14.4	12.1	1.00	5.50	11.5	19.5	68.0	14	--	--	.503	--
810242	5.70	4.31	1.00	3.00	4.50	7.00	24.0	10	--	--	.090	--

[1] Step trend indicates that an abrupt change in the average concentration of a constituent was detected during the period of record. Summary statistics were based only on data following the date of the step trend.
[2] Linear trend indicates that a gradual change in average concentration during the period of record collection was detected. The concentration data was adjusted to reflect conditions at the end of 1984 using an adjustment which decreased in absolute value as a linear function of time.
[3] H indicates that the average concentration during the earlier period was higher.
[4] L indicates that the average concentration during the earlier period was lower.

Table 5.--Daily mean streamflow and related data at sites on inland streams

[Streamflow is reported in ft³/s (cubic feet per second).]

STORET number	Mean (mg/L)	Standard deviation (mg/L)	Minimum (mg/L)	Percentage of samples in which values are less than or equal to those shown: 25 (mg/L)	50 (mg/L)	75 (mg/L)	Maximum (mg/L)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (mg/L/yr)
						Daily mean streamflow						
090162	5,020	5,740	849	1,730	3,040	5,680	36,200	12	--	--	.901	--
130147	483	251	217	308	410	583	1,420	6	--	--	.944	--
130202	155	122	39.0	78.3	129	184	687	6	--	--	.320	--
230028	951	837	113	321	633	1,220	4,130	12	--	--	.913	--
230038	582	453	78.0	219	415	736	2,070	11	--	--	.272	--
250033	713	820	73.0	255	406	835	5,720	13	--	--	.297	--
250098	367	390	10.0	135	215	483	2,300	11	--	--	.773	--
370002	332	197	140	219	274	374	1,110	6	--	--	.019	8.60
370009	360	290	84.0	187	271	3,990	1,800	9	--	--	.603	--
380031	298	223	49.0	131	239	408	1,370	14	--	--	.380	--
380226	53.4	29.3	6.98	32.8	48.7	69.6	171	8	--	--	.022	2.80
390057	960	542	168	588	799	1,110	3,090	10	--	--	.495	--
390058	1,180	650	203	744	972	1,460	3,910	14	--	--	.179	--
390079	913	478	355	594	743	1,070	2,690	10	--	--	.816	--
410050	3,740	3,240	930	1,660	2,340	4,820	17,000	10	--	--	.096	--
410052	4,320	4,010	113	1,850	2,630	5,770	23,900	13	--	--	.615	--
560003	1,640	3,380	216	615	809	1,260	27,600	6	--	--	.000	68.6
560151	2,130	2,130	445	863	1,500	2,450	10,600	5	--	--	.373	--
630252	132	76.8	37.0	77.5	115	164	410	12	--	--	.216	--
630529	51.6	37.0	5.10	26.5	42.5	71.5	176	12	--	--	.119	--
730150	4,980	6,060	825	1,540	3,040	4,950	36,200	12	--	--	.821	--
810042	567	489	39.0	233	429	714	2,920	14	--	--	.478	--
810242	470	418	58.0	203	365	577	2,580	10	--	--	.671	--

[1] Step trend indicates that an abrupt change in the average concentration of a constituent was detected during the period of record. Summary statistics were based only on data following the date of the step trend.

[2] Linear trend indicates that a gradual change in average concentration during the period of record collection was detected. The concentration data was adjusted to reflect conditions at the end of 1984 using an adjustment which decreased in absolute value as a linear function of time.

Table 6.--Constituent concentrations at sites on Detroit River

[Results are in mg/L (milligrams per liter) except for specific conductance which is reported as µS/cm at 25° C (microsiemens per centimeter at 25 degrees Celsius).]

Site number	STORET number	Mean (mg/L)	Standard deviation (mg/L)	Minimum (mg/L)	Percentage of samples in which values are less than or equal to those shown: 25 (mg/L)	50 (mg/L)	75 (mg/L)	Maximum (mg/L)	Years of record	Step trend[1]: Date (year/month)	Step trend[1]: Earlier period	Linear trend[2]: Probability level	Linear trend[2]: Slope (mg/L/yr)
							Total phosphorus concentration						
1U	820413	0.013	0.008	0.002	0.008	0.011	0.016	0.038	8	77/01	H[3]	0.005	-0.001
2U	820059	.012	.008	.003	.008	.011	.014	.042	8	77/01	H	.002	-.001
3U	820060	.015	.006	.003	.011	.014	.017	.036	8	77/01	H	.302	--
4U	820061	.011	.004	.003	.009	.011	.013	.023	8	77/01	H	.304	--
5U	820062	.011	.005	.002	.007	.010	.012	.027	8	77/01	H	.401	--
6U	820414	.013	.008	.004	.008	.011	.015	.049	8	77/01	H	.922	--
7U	820063	.014	.012	.004	.009	.011	.016	.071	8	77/01	H	.464	--
8U	000001	.017	.014	.003	.010	.013	.019	.087	8	77/01	H	.922	--
9U	000002	.020	.011	.007	.012	.017	.022	.060	8	77/01	H	.354	--
10U	000004	.024	.015	.005	.016	.019	.029	.079	8	77/01	H	.434	--
1D	820011	.056	.027	.027	.039	.049	.061	.174	6	79/01	H	.834	
2D	820014	.019	.009	.004	.011	.016	.026	.045	6	79/01	H	.020	-.003
3D	820016	.017	.008	.004	.012	.016	.019	.038	6	79/01	H	.025	-.001
4D	820017	.014	.006	.003	.010	.014	.018	.033	8	77/01	H	.048	-.001
5D	820018	.014	.007	.006	.010	.012	.019	.036	8	77/01	H	.023	-.001
6D	000024	.015	.005	.005	.011	.015	.018	.029	8	77/01	H	.209	--
7D	000025	.015	.005	.006	.011	.014	.017	.028	8	77/01	H	.091	--
8D	000026	.018	.008	.007	.012	.015	.021	.051	8	77/01	H	.289	--
9D	000027	.019	.010	.009	.012	.017	.021	.064	8	77/01	H	.411	--
10D	000029	.026	.012	.013	.018	.021	.028	.077	8	77/01	H	.055	--
							Total chloride concentration						
1U	820413	8.42	2.83	4.57	6.85	7.90	9.02	26.7	14	--	--	.020	-.121
2U	820059	8.17	2.66	3.94	6.64	7.50	8.92	24.7	18	--	--	.012	-.108
3U	820060	7.80	2.09	3.88	6.48	7.27	8.59	16.9	18	--	--	.024	-.065
4U	820061	6.66	1.60	1.31	5.89	6.46	7.47	17.1	18	--	--	.001	-.111
5U	820062	6.60	1.14	3.89	5.75	6.36	7.28	9.84	18	--	--	.000	-.111
6U	820414	7.19	1.22	5.21	6.30	7.07	7.94	12.9	14	--	--	.042	-.061
7U	820063	6.82	1.34	4.36	5.84	6.67	7.38	12.6	18	--	--	.001	-.144
8U	000001	7.81	1.25	5.00	7.00	7.70	8.20	13.2	14	--	--	.303	--
9U	000002	7.75	1.78	5.05	6.56	7.33	8.49	14.7	18	--	--	.010	-.147
10U	000004	8.60	2.26	5.33	7.14	7.93	9.55	16.0	18	--	--	.011	-.136
1D	820011	13.1	4.17	7.25	10.2	12.4	15.4	25.9	8	77/01	H	.005	-.735
2D	820014	10.8	2.09	8.20	9.55	10.4	11.3	19.0	8	77/01	H	.598	--
3D	820016	9.35	1.59	6.80	8.32	9.10	9.85	15.9	8	77/01	H	.470	--
4D	820017	7.82	1.08	6.10	7.15	7.60	8.20	12.4	8	77/01	H	1.00	--
5D	820018	7.47	.871	6.00	7.00	7.40	7.90	11.6	8	77/01	H	.054	--
6D	000024	6.83	.721	5.54	6.36	6.65	7.29	9.40	8	77/01	H	.001	-.167
7D	000025	7.67	.725	6.20	7.30	7.50	7.90	9.80	6	79/01	H	.363	--
8D	000026	8.14	1.72	5.90	7.12	7.51	8.57	13.3	6	79/01	H	.001	-.500
9D	000027	9.93	4.74	5.09	7.60	8.57	10.2	29.0	6	79/01	H	.003	-.786
10D	000029	29.1	11.9	8.00	20.0	26.0	36.0	70.0	18	--	--	.514	--
							Total sulfate concentration						
1U	820413	17.1	2.63	14.0	16.0	17.0	18.0	29.0	4	--	--	.442	--
2U	820059	17.0	2.27	14.0	16.0	17.0	17.9	27.0	4	--	--	.374	--
3U	820060	16.6	1.43	14.0	16.0	17.0	17.7	19.0	4	--	--	.502	--
4U	820061	16.3	1.65	14.0	15.3	16.0	17.0	21.0	4	--	--	.901	--
5U	820062	15.8	0.990	13.0	15.0	16.0	16.0	18.0	4	--	--	.692	--
6U	820414	16.3	2.13	14.0	15.3	16.0	16.0	25.0	4	--	--	.897	--

See footnotes at end of table

Table 6.--Constituent concentrations at sites on Detroit River--Continued

Site number	STORET number	Mean (mg/L)	Standard deviation (mg/L)	Minimum (mg/L)	Percentage of samples in which values are less than or equal to those shown: 25 (mg/L)	50 (mg/L)	75 (mg/L)	Maximum (mg/L)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (mg/L/yr)
					Total sulfate concentration--Continued								
7U	820063	16.3	2.26	14.0	15.0	16.0	16.0	25.0	4	--	--	1.00	--
8U	000001	16.4	2.53	11.0	15.0	16.0	17.0	25.0	4	--	--	.709	--
9U	000002	17.1	2.71	13.0	16.0	16.5	18.0	29.0	4	--	--	.801	--
10U	000004	18.3	3.88	14.0	16.0	17.0	19.5	31.0	4	--	--	.331	--
1D	820011	20.8	3.69	17.0	18.8	19.5	22.0	34.0	4	--	--	.076	--
2D	820014	18.0	1.70	15.0	17.0	17.3	19.0	23.0	4	--	--	1.00	--
3D	820016	17.3	1.54	14.0	16.1	17.0	18.0	22.0	4	--	--	.900	--
4D	820017	16.5	1.31	15.0	15.4	16.0	17.0	20.0	4	--	--	.245	--
5D	820018	16.4	1.44	14.0	15.5	16.0	17.3	20.0	4	--	--	.106	--
6D	000024	16.4	1.19	14.0	15.9	16.0	17.0	20.0	4	--	--	1.00	--
7D	000025	16.4	1.10	15.0	16.0	16.0	17.0	20.0	4	--	--	.795	--
8D	000026	16.6	1.72	14.0	15.9	16.5	17.0	23.0	4	--	--	1.00	--
9D	000027	16.9	2.10	14.0	16.0	16.3	17.6	25.0	4	--	--	.798	--
10D	000029	18.1	2.15	15.0	16.8	18.0	19.0	24.0	4	--	--	.709	--
					Total organic plus ammonia nitrogen concentration (as nitrogen)								
1U	820413	0.283	0.072	0.170	0.237	0.270	0.320	0.490	10	--	--	0.939	--
2U	820059	.274	.070	.150	.220	.260	.320	.440	10	--	--	.400	--
3U	820060	.254	.069	.110	.207	.250	.300	.490	10	--	--	.322	--
4U	820061	.228	.067	.120	.185	.215	.260	.460	10	--	--	.108	--
5U	820062	.204	.054	.110	.170	.190	.247	.410	10	--	--	.084	--
6U	820414	.221	.063	.090	.170	.220	.260	.420	10	--	--	.168	--
7U	820063	.220	.064	.090	.180	.210	.252	.430	10	--	--	.939	--
8U	000001	.236	.067	.080	.190	.225	.270	.480	10	--	--	.702	--
9U	000002	.270	.094	.100	.210	.240	.312	.610	10	--	--	.879	--
10U	000004	.304	.106	.170	.230	.292	.347	.830	10	--	--	.421	--
1D	820011	.614	.137	.361	.518	.603	.663	1.09	10	--	--	.001	-0.022
2D	820014	.461	.125	.284	.387	.435	.510	1.01	10	--	--	.003	-.014
3D	820016	.362	.114	.099	.278	.355	.433	.730	10	--	--	.019	-.010
4D	820017	.242	.091	.012	.184	.215	.292	.500	10	--	--	.005	-.012
5D	820018	.228	.085	.098	.175	.213	.257	.585	10	--	--	.029	-.008
6D	000024	.205	.065	.086	.166	.199	.226	.467	10	--	--	.035	-.006
7D	000025	.231	.055	.140	.190	.220	.260	.470	10	--	--	.632	--
8D	000026	.248	.061	.160	.200	.235	.277	.490	10	--	--	.397	--
9D	000027	.261	.072	.150	.210	.250	.297	.510	10	--	--	.686	--
10D	000029	.339	.166	.160	.265	.310	.372	1.50	10	--	--	.131	--
					Total ammonia nitrogen concentration (as nitrogen)								
1U	820413	.015	.013	.005	.009	.010	.014	.062	8	77/01	H	.000	.001
2U	820059	.014	.010	.004	.009	.011	.013	.075	8	77/01	H	.000	.001
3U	820060	.012	.010	.004	.008	.009	.013	.058	8	77/01	H	.000	.001
4U	820061	.011	.007	.003	.007	.009	.011	.040	8	77/01	H	.001	.001
5U	820062	.009	.006	.003	.006	.008	.010	.039	8	77/01	H	.006	.001
6U	820414	.009	.006	.003	.006	.007	.009	.040	8	77/01	H	.004	.001
7U	820063	.010	.006	.002	.006	.008	.011	.033	8	77/01	H	.026	.000
8U	000001	.008	.007	.001	.004	.006	.009	.039	8	77/01	H	.086	--
9U	000002	.010	.007	.003	.007	.008	.011	.039	8	77/01	H	.025	.001
10U	000004	.015	.007	.006	.010	.012	.018	.039	8	77/01	H	.000	.001
1D	820011	.359	.092	.091	.295	.350	.410	.700	8	77/01	H	.270	--
2D	820014	.228	.049	.152	.193	.220	.255	.380	8	77/01	H	.701	--
3D	820016	.167	.080	.020	.109	.163	.220	.450	18	--	--	.219	--
4D	820017	.073	.058	.004	.029	.053	.099	.240	18	--	--	.413	--
5D	820018	.035	.024	.004	.018	.031	.045	.146	8	77/01	H	.103	--
6D	000024	.016	.010	.002	.009	.013	.020	.044	8	77/01	H	.110	--
7D	000025	.012	.008	.002	.007	.009	.014	.037	8	77/01	H	.467	--
8D	000026	.012	.009	.001	.007	.009	.013	.040	8	77/01	H	.663	--
9D	000027	.018	.008	.005	.013	.016	.022	.042	8	77/01	H	.039	.001

See footnotes at end of table

Table 6.--Constituent concentrations at sites on Detroit River--Continued

Site number	STORET number	Mean (mg/L)	Standard deviation (mg/L)	Minimum (mg/L)	Percentage of samples in which values are less than or equal to those shown: 25 (mg/L)	50 (mg/L)	75 (mg/L)	Maximum (mg/L)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (mg/L/yr)
					Total nitrate plus nitrite nitrogen concentration (as nitrogen)								
1U	820413	.325	.103	.156	.254	.315	.370	.777	12	--	--	.002	.015
2U	820059	.311	.100	.129	.243	.294	.342	.727	12	--	--	.004	.011
3U	820060	.273	.076	.073	.225	.274	.317	.524	12	--	--	.026	.006
4U	820061	.288	.071	.091	.259	.283	.327	.533	12	--	--	.006	.006
5U	820062	.316	.149	.111	.266	.291	.336	1.45	12	--	--	.008	.005
6U	820414	.362	.221	.189	.278	.312	.369	1.72	12	--	--	.001	.008
7U	820063	.375	.236	.150	.288	.316	.384	1.82	12	--	--	.001	.008
8U	000001	.378	.225	.203	.279	.332	.394	1.82	12	--	--	.002	.009
9U	000002	.387	.404	.046	.220	.275	.360	2.70	12	--	--	.052	--
10U	000004	.563	.514	.127	.296	.379	.616	3.13	12	--	--	.017	.014
1D	820011	.314	.102	.190	.250	.290	.330	.750	12	--	--	.055	--
2D	820014	.324	.103	.220	.272	.300	.344	1.05	12	--	--	.022	.005
3D	820016	.320	.064	.235	.276	.304	.346	.540	12	--	--	.012	.005
4D	820017	.322	.071	.233	.274	.296	.347	.668	12	--	--	.001	.006
5D	820018	.313	.088	.048	.265	.296	.347	.812	12	--	--	.006	.005
6D	000024	.339	.109	.227	.278	.302	.366	.885	12	--	--	.001	.007
7D	000025	.350	.140	.168	.272	.306	.374	1.02	12	--	--	.003	.006
8D	000026	.393	.243	.179	.280	.324	.384	1.73	12	--	--	.006	.007
9D	000027	.421	.270	.199	.284	.333	.419	1.73	12	--	--	.004	.008
10D	000029	.429	.268	.193	.285	.329	.439	1.72	12	--	--	.007	.007
					Specific conductance								
1U	820413	227	20.7	200	215	220	235	355	11	--	--	0.098	--
2U	820059	224	19.4	195	215	220	230	345	11	--	--	.149	--
3U	820060	219	12.6	195	210	215	225	270	11	--	--	.066	--
4U	820061	215	9.17	195	210	215	220	245	11	--	--	.140	--
5U	820062	215	11.0	198	210	215	220	275	11	--	--	.532	--
6U	820414	218	16.7	197	210	215	220	315	11	--	--	.174	--
7U	820063	218	16.4	194	210	215	220	310	11	--	--	.232	--
8U	000001	219	16.9	197	210	215	223	315	11	--	--	.086	--
9U	000002	227	22.2	200	215	224	230	355	11	--	--	.106	--
10U	000004	238	33.1	205	220	230	240	375	11	--	--	.094	--
1D	820011	268	25.1	220	250	260	280	355	11	--	--	.112	--
2D	820014	239	16.8	215	230	235	240	300	11	--	--	.366	--
3D	820016	230	14.8	210	220	230	233	280	11	--	--	.767	--
4D	820017	221	9.59	200	215	220	225	245	11	--	--	.860	--
5D	820018	217	8.39	200	213	216	222	240	11	--	--	.647	--
6D	000024	218	8.54	205	215	218	220	255	11	--	--	.880	--
7D	000025	222	11.7	200	215	220	225	265	11	--	--	.439	--
8D	000026	229	13.2	210	224	225	230	290	6	79/01	H	.378	--
9D	000027	240	21.6	210	228	235	245	320	6	79/01	H	.620	--
10D	000029	290	40.0	220	260	290	310	435	11	--	--	.147	--
					Total solids concentration (residue at 105° C)								
1U	820413	159	22.2	134	148	153	163	253	12	--	--	.784	--
2U	820059	154	20.5	92.0	146	150	158	257	12	--	--	.920	--
3U	820060	151	16.3	116	144	148	155	255	12	--	--	.074	--
4U	820061	147	12.0	100	142	147	152	211	12	--	--	.484	--
5U	820062	148	13.3	112	144	146	152	205	12	--	--	.555	--
6U	820414	152	17.7	112	144	148	154	243	12	--	--	.686	--
7U	820063	152	18.8	126	143	148	156	246	12	--	--	.976	--
8U	000001	154	21.2	112	144	149	156	242	12	--	--	.932	--
9U	000002	160	23.9	116	149	155	165	273	12	--	--	.902	--
10U	000004	172	29.5	138	154	162	179	284	12	--	--	.877	--
1D	820011	190	25.7	151	173	186	200	296	12	--	--	.066	--
2D	820014	169	22.9	108	156	163	174	283	12	--	--	.081	--

See footnotes at end of table

Table 6.--Constituent concentrations at sites on Detroit River--Continued

Site number	STORET number	Mean (mg/L)	Standard deviation (mg/L)	Minimum (mg/L)	Percentage of samples in which values are less than or equal to those shown: 25 (mg/L)	50 (mg/L)	75 (mg/L)	Maximum (mg/L)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (mg/L/yr)
					Total solids concentration--Continued								
3D	820016	162	13.6	144	154	159	164	221	12	--	--	.115	--
4D	820017	155	13.1	128	149	153	158	216	12	--	--	.379	--
5D	820018	152	12.1	108	146	152	156	214	12	--	--	.340	--
6D	000024	152	11.9	120	148	151	155	213	12	--	--	.486	--
7D	000025	156	13.0	126	148	153	163	209	12	--	--	.302	--
8D	000026	162	16.6	144	153	159	164	239	6	79/01	H	.529	--
9D	000027	170	23.7	140	158	165	171	251	6	79/01	H	.726	--
10D	000029	205	32.0	147	181	201	218	300	12	--	--	.304	--
					Dissolved-solids concentration (residue at 180° C)								
1U	820413	150	21.6	119	140	145	153	253	14	--	--	.217	--
2U	820059	147	19.6	86.0	140	143	152	248	14	--	--	.332	--
3U	820060	145	17.7	108	136	140	149	249	14	--	--	.198	--
4U	820061	142	14.7	96.0	136	140	144	220	14	--	--	.323	--
5U	820062	141	15.0	108	136	140	143	220	14	--	--	.398	--
6U	820414	143	15.7	81.0	136	140	146	205	14	--	--	.509	--
7U	820063	143	14.3	105	136	140	146	202	14	--	--	.465	--
8U	000001	144	16.2	101	136	140	146	205	14	--	--	.077	--
9U	000002	149	19.5	110	140	146	151	259	14	--	--	.335	--
10U	000004	155	23.3	125	143	150	160	256	14	--	--	.123	--
1D	820011	167	20.0	137	156	163	173	278	14	--	--	.037	-1.43
2D	820014	158	20.1	101	150	153	160	275	14	--	--	.132	--
3D	820016	152	13.0	113	145	150	154	212	14	--	--	.377	--
4D	820017	145	11.4	122	140	143	148	207	14	--	--	.700	--
5D	820018	143	10.9	106	138	142	146	205	14	--	--	.910	--
6D	000024	143	10.7	115	139	143	146	205	14	--	--	.810	--
7D	000025	146	12.3	113	140	143	150	201	14	--	--	.371	--
8D	000026	151	14.7	136	146	146	150	231	6	79/01	H	.695	--
9D	000027	158	18.8	136	148	153	159	241	6	79/01	H	.441	--
10D	000029	193	31.6	133	172	189	205	318	14	--	--	.956	--
					Nonfilterable-solids concentration (residue at 105° C)								
1U	820413	9.92	5.70	1.00	6.00	9.00	12.0	33.0	14	--	--	0.098	--
2U	820059	6.33	7.57	1.00	1.98	5.29	8.44	41.9	18	--	--	.004	-0.500
3U	820060	7.46	6.57	1.00	3.88	6.18	8.60	50.4	18	--	--	.024	-.222
4U	820061	6.53	5.08	1.00	3.43	5.41	8.74	27.3	18	--	--	.016	-.250
5U	820062	9.73	6.95	1.00	5.00	8.25	12.0	40.0	18	--	--	.121	--
6U	820414	9.96	8.49	1.00	5.00	7.50	12.5	50.0	14	--	--	.472	--
7U	820063	10.5	9.88	1.00	5.00	8.00	12.0	66.0	18	--	--	.485	--
8U	000001	10.4	10.3	1.00	5.00	9.00	12.0	87.0	14	--	--	.703	--
9U	000002	13.5	12.1	1.00	6.00	10.0	16.0	71.0	18	--	--	.176	--
10U	000004	18.4	19.1	1.00	8.50	13.0	23.0	163	18	--	--	.214	--
1D	820011	11.4	9.57	1.00	6.46	9.45	13.2	54.5	18	--	--	.031	-.345
2D	820014	7.20	7.08	1.00	2.82	5.42	10.3	45.4	18	--	--	.001	-.556
3D	820016	7.06	5.77	1.00	3.40	6.44	10.4	27.8	18	--	--	.001	-.500
4D	820017	7.33	6.56	1.00	3.52	6.48	10.5	35.4	18	--	--	.008	-.500
5D	820018	6.92	6.15	1.00	2.81	6.27	9.35	28.4	18	--	--	.004	-.500
6D	000024	9.72	5.31	1.00	6.00	9.00	12.0	32.0	14	--	--	.605	--
7D	000025	8.43	6.71	1.00	4.31	7.41	10.6	39.8	18	--	--	.013	-.326
8D	000026	11.4	5.88	1.00	8.00	11.0	14.0	32.5	14	--	--	.555	--
9D	000027	11.1	9.12	1.00	5.60	8.90	13.2	48.5	18	--	--	.016	-.300
10D	000029	16.4	12.3	1.00	10.0	14.0	18.0	90.0	18	--	--	.085	--

[1] Step trend indicates that an abrupt change in the average concentration of a constituent was detected during the period of record. Summary statistics were based only on data following the date of the step trend.

[2] Linear trend indicates that a gradual change in average concentration during the period of record collection was detected. The concentration data was adjusted to reflect conditions at the end of 1984 using an adjustment which decreased in absolute value as a linear function of time.

[3] H indicates that the average concentration during the earlier period was higher.

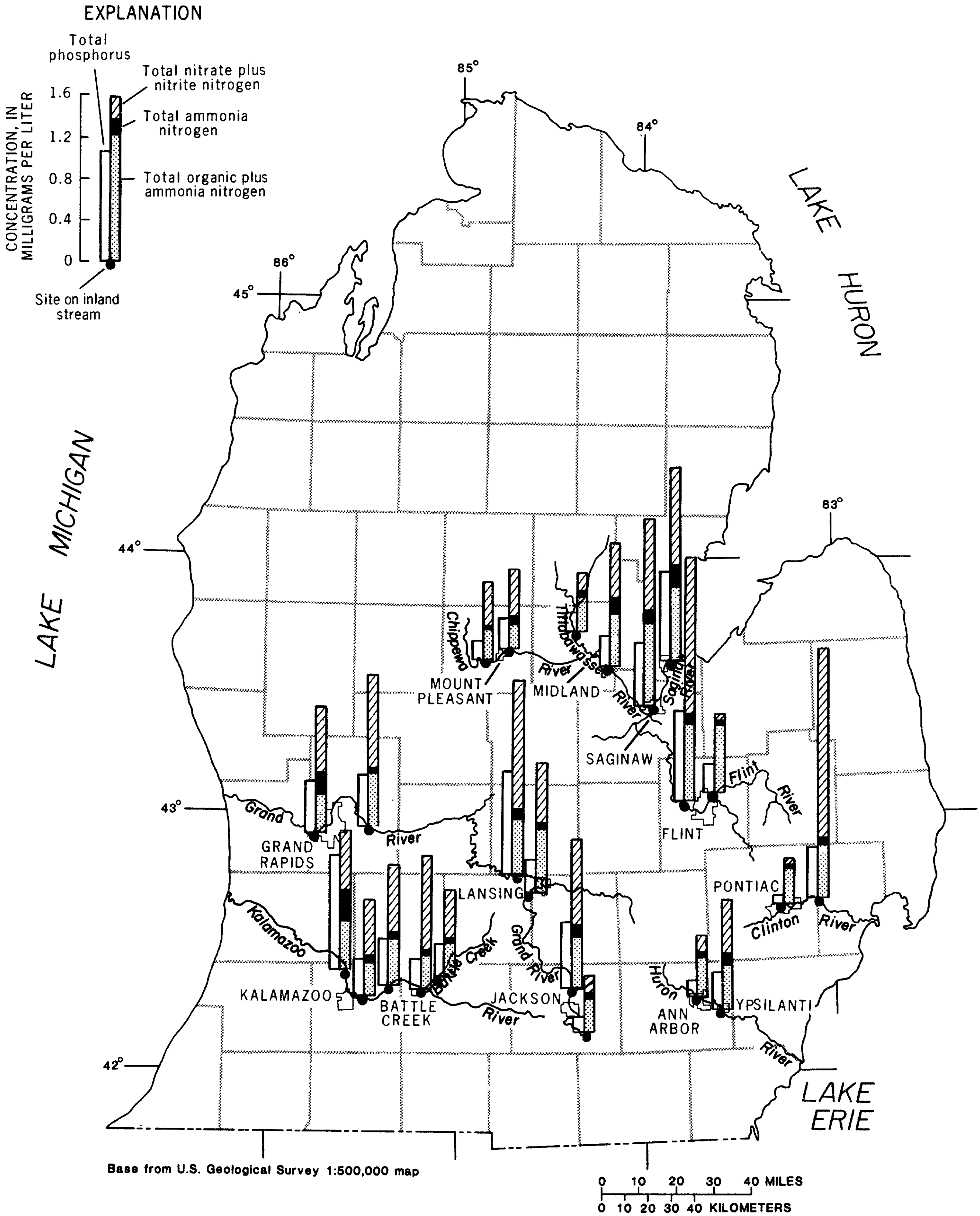

Figure 18.--Sites on inland streams in the Lower Peninsula of Michigan and variation of median total phosphorus and nitrogen concentrations.

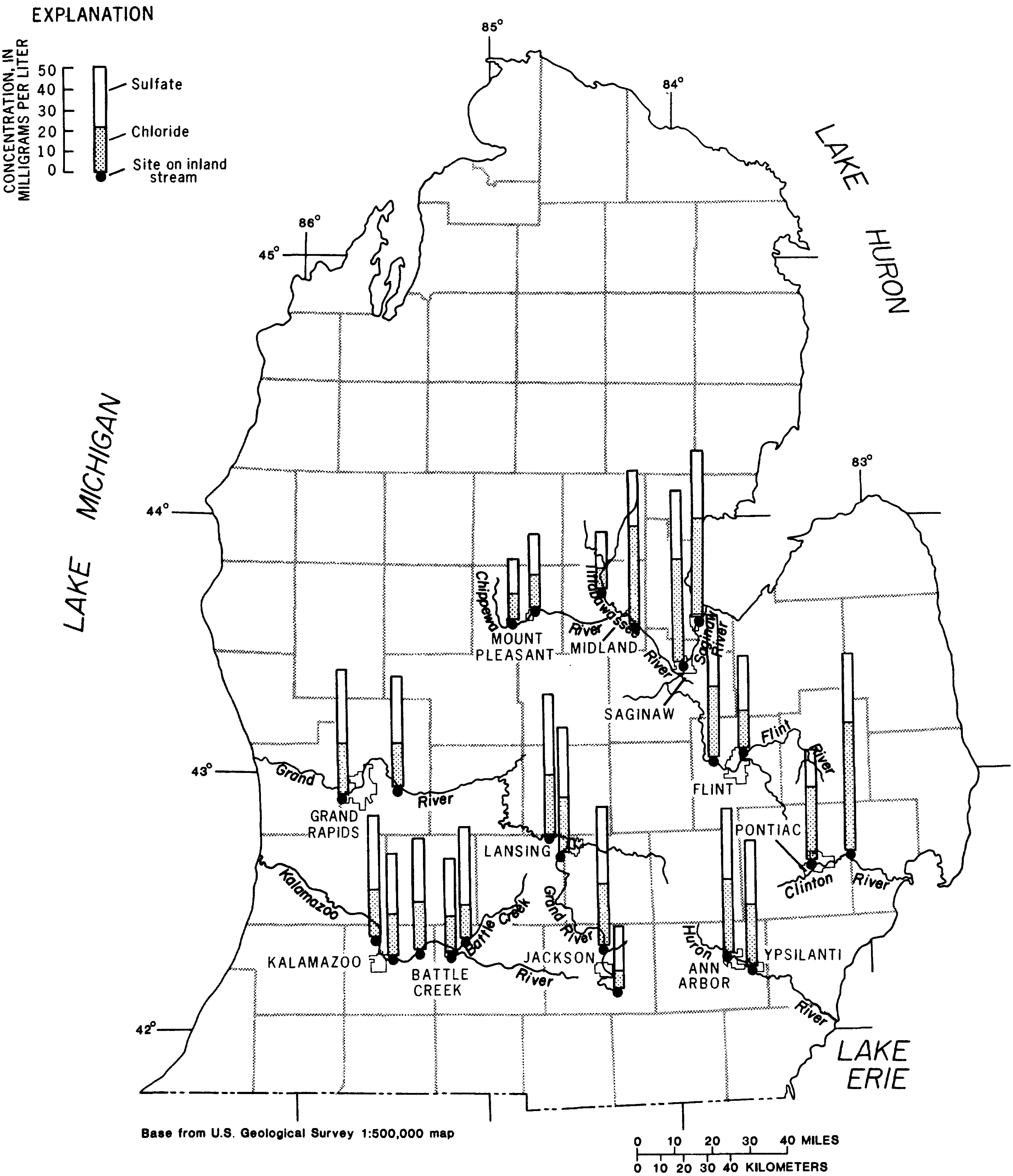

Figure 19.--Sites on inland streams in the Lower Peninsula of Michigan and variation of median total chloride and sulfate concentrations.

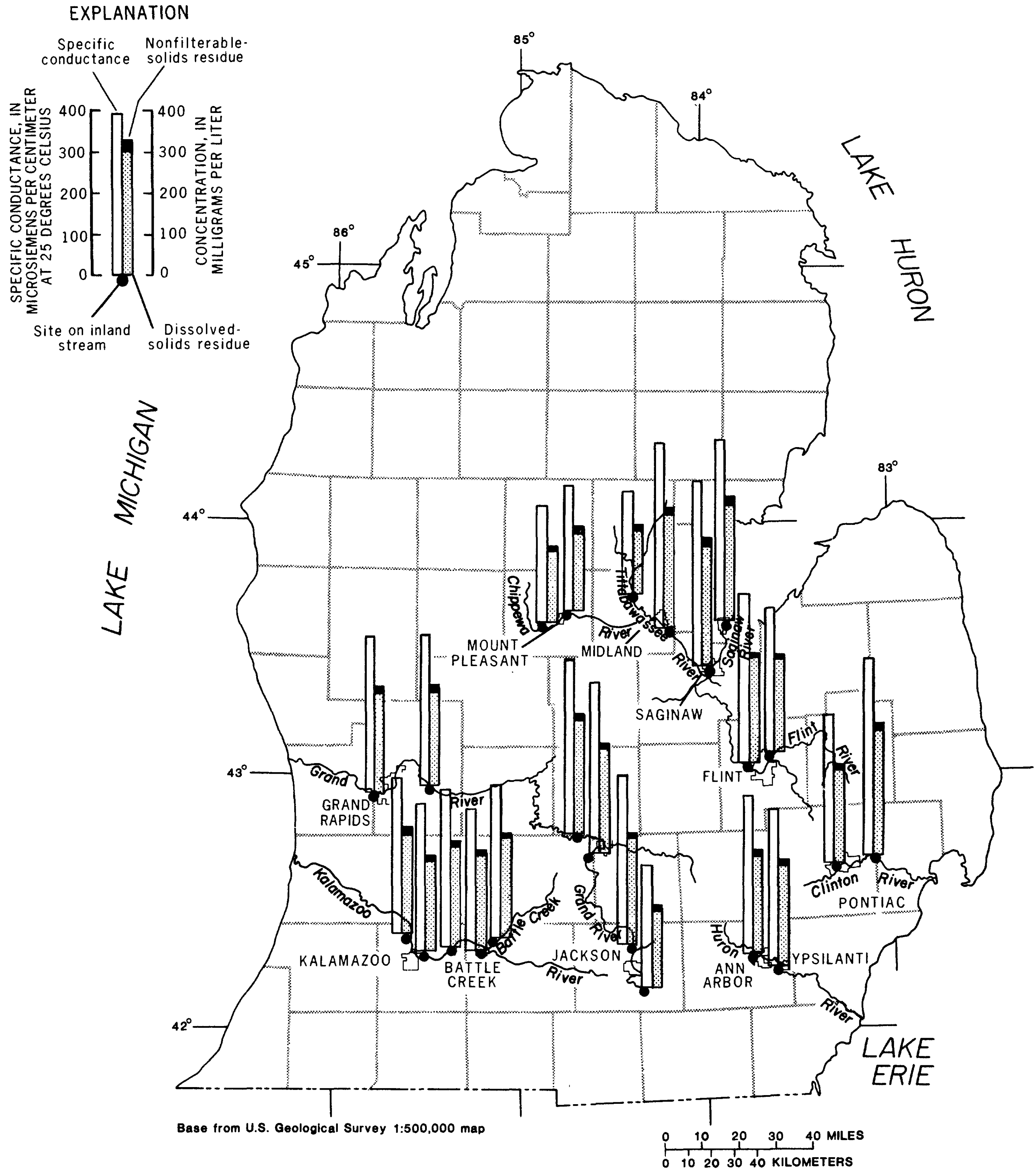

Figure 20.--Sites on inland streams in the Lower Peninsula of Michigan and variation of median specific conductance and solids concentrations.

Concentrations generally increased within urban areas and decreased between urban areas along Grand River (figs. 21-31, at end of report). On the figures, the mouth of Grand River at Lake Michigan is taken as river mile 0.0. Minimum concentrations of all constituents occur at the site upstream from Jackson (380226). Phosphorus and total organic plus ammonia nitrogen concentrations increased in Jackson. Total ammonia nitrogen concentrations increased in the urban areas. The greatest increase in median ammonia nitrogen concentration occurred in Grand Rapids. Correspondingly, total nitrate plus nitrite nitrogen concentrations decreased in Grand Rapids while increasing in Jackson and Lansing.

Dissolved solids, total solids, and specific conductance, followed a similar pattern of increasing within urban areas and decreasing between urban areas. Concentrations of nonfilterable solids, however, increased between Lansing and Grand Rapids. Total sulfate concentrations also increased within urban areas, and decreased between urban areas. Streamflow increased downstream throughout the reach. Therefore, greater changes in concentrations occur for a particular load at upstream sites.

Detroit River

The variation of concentrations at sites along the two transects on Detroit River are shown on figures 32 to 41, (at end of report). Concentrations tended to be higher at the downstream (Fermi) transect. Median concentrations of total ammonia nitrogen at two sites (820011 and 820014), near the American shoreline at the downstream transect, exceed 0.2 mg/L. Also, with the exception of nitrate plus nitrite nitrogen, and nonfilterable solids, the cross-channel distribution of concentrations changed from nearly uniform at upstream (Windmill Point) transect to concave at the downstream transect. Minimum concentrations at the downstream transect tended to be near the center of flow distribution, with concentrations increasing toward the American and Canadian shorelines.

Constituent Discharges

Discharge indicates the weight of constituents passing a stream transect in a unit of time. In this study, discharges were computed by multiplying daily mean streamflow, in cubic feet per second, by constituent concentration, in milligrams per liter (mg/L), and converted to tons per day using a 0.002697 conversion factor. The discharges were not integrated with flow duration statistics and therefore generally do not provide an unbiased estimate of the annual discharges. Annual discharges would probably be higher than values indicated by average instantaneous discharges, particularly where streamflow and concentration data are highly correlated. Summary statistics represent only the characteristics of the instantaneous discharge data.

Inland Streams

A summary of discharge data was prepared for each inland site. Statistics reported include the mean, standard deviation, minimum, 25th-, 50th-, and 75th-percentile, and maximum value (table 7). To permit comparison of sites, only the most recent period of records containing step trends were included; effects of linear time trends were removed.

Table 7.--Constituent discharges at sites on inland streams

[Discharges are in tons/d (tons per day).]

STORET number	Mean (tons/d)	Standard deviation (tons/d)	Minimum (tons/d)	Percentage of samples in which values are less than or equal to those shown: 25 (tons/d)	50 (tons/d)	75 (tons/d)	Maximum (tons/d)	Years of record	Step trend[1]: Date (year/month)	Step trend[1]: Earlier period	Linear trend[2]: Probability level	Linear trend[2]: Slope (tons/d/yr)
					Total phosphorus discharge							
090162	2.64	7.45	0.454	0.794	1.10	1.87	52.7	5	80/07	H[3]	0.053	--
130147	0.080	0.098	.008	.025	0.062	0.102	0.618	6	--	--	.436	--
130202	.027	.027	.001	.010	.018	.032	.117	6	--	--	.028	-0.002
230028	.413	.397	.052	.187	.272	.444	1.96	5	80/01	H	.817	--
230038	.131	.149	.000	.040	.075	.162	.907	11	--	--	.006	-.008
250033	.191	.336	.023	.057	.091	.202	2.35	5	80/07	H	.023	.019
250098	.076	.109	.001	.021	.038	.086	.744	11	--	--	.164	--
370002	.049	.107	.004	.012	.020	.039	.761	6	--	--	.058	--
370009	.099	.181	.000	.029	.046	.085	1.26	9	--	--	.000	-.053
380031	.073	.061	.000	.035	.061	.104	.385	14	--	--	.006	-.006
380226	.004	.004	.000	.002	.003	.006	.033	10	--	--	.027	<.001
390057	.218	.177	.000	.093	.168	.283	.797	10	--	--	.001	-.014
390058	.478	.260	.049	.312	.413	.602	1.61	14	--	--	.014	-.014
390079	.176	.189	.005	.075	.134	.239	1.70	10	--	--	.010	-.007
410050	1.15	1.40	.138	.347	.574	1.10	6.94	10	--	--	1.00	--
410052	1.80	2.17	.382	.563	.885	1.57	8.39	4	81/01	H	.081	--
560003	.135	.270	.020	.045	.058	.112	2.08	6	--	--	.001	.005
560151	.543	.920	.090	.190	.277	.494	5.71	5	--	--	.276	--
630252	.032	.037	.007	.015	.018	.030	.228	6	78/01	H	.728	--
630529	.002	.002	.000	.001	.002	.003	.011	7	78/01	H	.101	--
730150	1.99	4.01	.377	.737	1.16	1.68	28.3	5	80/07	H	.407	--
810042	.117	.189	.000	.029	.069	.133	1.77	14	--	--	.023	-.005
810242	.048	.073	.004	.016	.028	.052	.628	10	--	--	.095	--
					Total chloride discharge							
090162	770	496	243	453	612	904	3,190	12	--	--	.322	--
130147	33.4	13.1	17.7	23.1	30.4	38.8	74.4	6	--	--	.559	--
130202	9.82	5.37	3.54	6.14	8.52	12.5	29.8	6	--	--	.944	--
230028	102	62.7	20.2	49.9	87.1	132	334	12	--	--	1.00	--
230038	53.1	25.7	17.1	31.3	46.7	66.9	134	11	--	--	.238	--
250033	97.6	92.6	14.3	39.3	75.4	121	576	13	--	--	.144	--
250098	26.9	26.2	.917	10.5	16.6	35.1	149	11	--	--	.966	--
370002	16.2	9.07	4.42	10.5	13.8	19.0	49.2	6	--	--	.197	--
370009	25.8	14.0	6.80	15.6	22.0	30.7	72.8	9	--	--	.347	--
380031	36.0	12.0	16.1	27.2	32.5	42.6	81.9	14	--	--	.050	0.500
380226	1.81	.914	.270	1.17	1.69	2.43	5.08	10	--	--	.004	.110
390057	72.7	25.6	9.97	57.2	65.9	81.6	181	10	--	--	.100	--
390058	104	37.3	13.7	77.7	97.7	122	271	14	--	--	.348	--
390079	68.2	29.9	29.9	48.3	59.3	81.1	217	10	--	--	.097	--
410050	317	188	119	190	246	390	1,010	10	--	--	.010	7.25
410052	372	224	10.6	218	301	489	1,100	13	--	--	.247	--
560003	72.2	168	9.96	26.1	35.0	52.6	1,410	6	--	--	.004	2.94
560151	375	161	37.0	264	362	463	724	5	--	--	.488	--
630252	31.8	21.9	3.42	17.1	26.3	38.4	160	12	--	--	.029	-.730
630529	6.62	4.19	.932	3.71	6.06	8.87	20.9	12	--	--	.215	--
730150	752	414	183	429	669	925	2,650	12	--	--	.730	--
810042	66.9	46.5	6.94	32.2	55.1	85.0	277	14	--	--	.977	--
810242	51.9	34.6	8.45	28.7	44.4	64.3	183	10	--	--	.025	1.06
					Total sulfate discharge							
090162	651	492	135	259	475	828	1,990	5	--	--	.244	--
130147	63.4	67.4	19.6	32.8	48.5	64.9	438	4	--	--	.098	--
130202	23.4	16.1	6.46	11.0	18.9	29.9	77.8	4	--	--	.507	--
230028	167	127	29.7	68.2	134	201	496	6	--	--	.151	--
230038	96.1	69.4	15.7	41.2	76.8	127	282	7	--	--	.441	--
250033	78.1	65.1	10.9	30.2	63.2	103	323	4	--	--	.198	--
250098	38.7	33.2	4.41	14.7	29.8	52.7	181	4	--	--	.198	--

See footnotes at end of table

Table 7.--Constituent discharges at sites on inland streams--Continued

STORET number	Mean (tons/d)	Standard deviation (tons/d)	Minimum (tons/d)	Percentage of samples in which values are less than or equal to those shown: 25 (tons/d)	50 (tons/d)	75 (tons/d)	Maximum (tons/d)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (tons/d/yr)
					Total sulfate discharge--Continued							
370002	26.6	17.8	8.90	14.1	20.5	29.8	76.2	4	--	--	1.00	--
370009	30.4	19.2	10.9	16.4	24.0	34.1	77.7	4	--	--	1.00	--
380031	52.5	26.0	13.3	35.2	48.7	64.8	120	4	--	--	.906	--
380226	3.04	2.50	.077	1.67	2.39	3.69	11.6	4	--	--	.802	--
390057	107	54.4	43.5	65.2	93.2	129	270	4	--	--	.479	--
390058	146	71.8	69.2	93.6	130	166	368	4	--	--	.345	--
390079	102	53.7	40.6	63.4	88.4	120	268	4	--	--	.637	--
410050	494	314	157	261	361	695	1,410	4	--	--	.702	--
410052	599	359	207	308	455	807	1,510	4	--	--	.702	--
560003	168	452	12.3	28.9	65.2	150	2,960	4	--	--	.184	--
560151	233	170	60.9	103	177	274	812	4	--	--	.816	--
630252	18.6	9.57	6.95	13.2	16.3	21.8	51.9	4	--	--	.141	--
630529	3.48	2.64	.426	1.16	3.40	4.75	12.6	4	--	--	.056	--
730150	647	496	142	274	506	828	2,200	4	--	--	.911	--
810042	73.4	57.0	9.75	26.7	60.6	102	252	4	--	--	.432	--
810242	60.9	49.0	7.05	21.8	48.8	85.2	214	4	--	--	.581	--
					Total organic plus ammonia nitrogen discharge (as nitrogen)							
090162	20.8	31.7	5.38	9.05	13.7	19.6	224	5	80/07	H	0.311	--
130147	.985	.795	.177	.449	.741	1.22	3.84	6	--	--	.316	--
130202	.370	.341	.045	.144	.256	.453	1.80	6	--	--	.189	--
230028	3.84	3.83	.442	1.70	2.72	4.22	22.0	5	80/01	H	.700	--
230038	1.76	1.56	.210	.711	1.27	2.17	10.7	11	--	--	.410	--
250033	1.49	2.08	.000	.215	.787	2.12	12.4	5	80/07	H	.009	-0.260
250098	1.05	1.000	.091	.445	.641	1.36	4.48	6	--	--	.144	--
370002	.584	.743	.124	.254	.386	.605	4.98	6	--	--	.146	--
370009	.804	.827	.211	.417	.600	.897	5.67	5	--	--	.716	--
380031	1.01	.587	.280	.517	.834	1.34	2.47	6	--	--	.791	--
380226	.084	.067	.001	.040	.068	.120	.310	6	--	--	.661	--
390057	2.24	1.40	.505	1.25	1.87	2.52	7.20	6	--	--	.817	--
390058	4.62	1.97	.985	3.42	4.12	5.47	11.2	6	--	--	.665	--
390079	1.85	1.25	.299	1.01	1.53	2.08	6.47	6	--	--	.031	-.090
410050	12.1	11.7	2.27	4.91	6.84	13.0	62.3	6	--	--	.709	--
410052	16.3	13.3	4.38	8.14	11.1	19.9	74.4	5	--	--	.105	--
560003	2.72	5.60	.231	.626	1.01	2.50	39.9	6	--	--	.327	--
560151	6.44	6.63	1.90	3.31	4.55	7.32	40.0	5	--	--	.606	--
630252	.336	.230	.098	.203	.267	.422	1.47	5	--	--	.531	--
630529	.078	.051	.009	.041	.076	.109	.270	6	--	--	.683	--
730150	17.9	22.2	5.40	9.05	13.1	17.3	156	5	80/07	H	.167	--
810042	1.35	1.22	.000	.560	1.17	1.69	6.17	5	--	--	.036	-.130
810242	1.01	.904	.097	.426	.716	1.21	4.06	5	--	--	.674	--
					Total ammonia nitrogen discharge (as nitrogen)							
090162	4.34	6.99	.447	1.78	3.31	4.18	48.8	5	80/07	H	.355	--
130147	.100	.139	.001	.026	.062	.137	1.00	6	--	--	.620	--
130202	.022	.025	.001	.006	.017	.029	.162	6	--	--	.944	--
230028	.458	.603	.009	.111	.268	.637	4.12	5	80/01	H	.939	--
230038	.181	.223	.003	.054	.115	.235	1.88	11	--	--	.842	--
250033	.285	.411	.017	.088	.163	.314	2.29	5	80/07	H	.485	--
250098	.091	.166	.000	.009	.033	.098	1.09	11	--	--	.706	--
370002	.055	.158	.007	.013	.027	.045	1.18	6	--	--	.002	<0.010
370009	.149	.184	.000	.059	.120	.190	1.51	9	--	--	.008	<-.010
380031	.140	.097	.005	.070	.115	.192	.704	14	--	--	.908	-
380226	.005	.007	.000	.001	.003	.005	.040	10	--	--	.025	<.010
390057	.251	.195	.009	.103	.204	.342	.906	10	--	--	.315	-
390058	1.26	.524	.234	.884	1.18	1.53	3.03	14	--	--	.030	.030
390079	.250	.220	.001	.092	.202	.367	1.19	10	--	--	.221	--
410050	1.09	2.91	.000	.054	.231	1.14	23.3	10	--	--	.460	--
410052	2.81	2.19	.010	1.77	2.39	3.36	20.5	13	--	--	.607	--
560003	.238	.808	.031	.052	.080	.153	6.68	6	--	--	.000	.010

See footnotes at end of table

Table 7.--Constituent discharges at sites on inland streams--Continued

STORET number	Mean (tons/d)	Standard deviation (tons/d)	Minimum (tons/d)	Percentage of samples in which values are less than or equal to those shown: 25 (tons/d)	50 (tons/d)	75 (tons/d)	Maximum (tons/d)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (tons/d/yr)
Total ammonia nitrogen discharge--Continued												
560151	1.17	1.55	.164	.484	.853	1.18	10.6	5	--	--	1.00	--
630252	.040	.062	.000	.005	.021	.047	.355	6	78/01	H	.296	--
630529	.008	.012	.000	.001	.005	.009	.117	12	--	--	.015	<-.010
730150	2.69	5.95	.000	.221	1.83	2.66	41.6	5	80/07	H	.013	-.150
810042	.422	.432	.000	.080	.263	.770	1.84	14	--	--	.010	-.040
810242	.115	.209	.000	.011	.057	.151	1.50	10	--	--	.134	--
Total nitrate plus nitrite nitrogen discharge (as nitrogen)												
090162	24.7	27.1	1.11	6.10	12.7	32.0	124	5	80/07	L[4]	.782	-
130147	1.62	.797	.643	1.05	1.40	2.07	4.95	6	--	--	.178	-
130202	.497	.637	.050	.134	.276	.616	3.52	6	--	--	.620	--
230028	5.56	5.26	.687	1.96	3.84	6.50	22.5	5	80/01	L	.939	--
230038	1.90	2.27	.053	.586	1.10	2.21	13.3	11	--	--	.146	--
250033	1.78	1.58	.000	.840	1.32	2.27	8.03	5	80/07	L	.014	-0.280
250098	.731	1.36	.001	.013	.133	.849	8.23	11	--	--	.702	-
370002	.775	.961	.111	.267	.442	.852	4.74	6	--	--	.006	.020
370009	.913	1.06	.152	.335	.521	.905	4.82	9	--	--	.028	.020
380031	1.11	1.03	.102	.581	.786	1.09	6.81	12	--	--	.457	--
380226	.040	.031	.004	.020	.032	.049	.153	10	--	--	.000	<.010
390057	2.49	1.90	.178	1.32	1.99	3.17	14.1	8	--	--	.674	--
390058	2.63	2.00	.169	1.33	2.13	3.51	12.6	12	--	--	.842	--
390079	1.96	1.64	.001	.719	1.59	2.67	7.92	10	--	--	.195	--
410050	18.0	22.7	.499	3.57	9.00	22.2	105	10	--	--	.026	.300
410052	18.3	24.7	.236	2.17	8.98	22.8	126	12	--	--	.705	--
560003	1.50	3.87	.013	.339	.618	1.19	30.5	6	--	--	.000	.670
560151	7.20	10.4	.067	.960	2.89	8.95	54.9	5	--	--	.766	--
630252	.865	.220	.224	.718	.886	.986	1.42	6	78/01	L	.082	--
630529	.019	.031	.000	.001	.011	.024	.162	12	--	--	.003	<-.010
730150	23.9	27.9	.880	3.38	13.2	34.0	137	5	80/07	L	.231	--
810042	1.06	1.13	.100	.407	.663	1.22	7.85	12	--	--	.143	--
810242	.621	1.07	.002	.055	.247	.559	7.47	10	--	--	.270	--
Total solids discharge (residue at 105° C)												
090162	5,900	5,720	1,230	2,440	4,000	6,710	10,700	12	--	--	0.956	--
130147	481	217	228	321	425	573	1,230	6	--	--	.884	--
130202	157	92.8	45.1	87.9	138	190	495	6	--	--	.620	--
230028	1,100	857	149	422	801	1,450	4,530	12	--	--	.779	--
230038	627	404	113	285	505	847	1,940	11	--	--	.180	--
250033	864	1,060	91.8	323	580	1,020	9,930	13	--	--	.115	--
250098	352	351	9.87	139	219	476	2,240	11	--	--	.799	--
370002	267	149	110	177	230	318	833	6	--	--	.040	7.47
370009	346	450	4.76	175	256	352	4,080	9	--	--	.775	--
380031	333	178	94.1	189	305	427	1,040	14	--	--	.628	--
380226	43.9	24.6	5.21	26.8	40.9	58.4	151	10	--	--	.040	2.00
390057	968	410	154	663	874	1,140	2,220	10	--	--	.819	--
390058	1,240	552	189	846	1,090	1,510	3,160	13	--	--	.189	--
390079	891	406	357	615	772	1,100	2,380	10	--	--	.451	--
410050	4,160	2,660	1,370	2,270	3,130	5,490	13,700	10	--	--	.020	93.6
410052	4,390	3,270	122	2,090	3,190	6,080	17,000	13	--	--	.336	--
560003	1,200	2,780	160	417	600	891	23,200	6	--	--	.002	46.4
560151	2,400	1,550	684	1,420	1,980	2,680	7,640	5	--	--	1.00	--
630252	179	99.1	60.0	112	151	223	542	12	--	--	.138	--
630529	50.6	34.8	5.93	27.5	42.6	69.6	171	12	--	--	.124	--
730150	5,740	5,040	1,140	2,370	4,370	6,410	26,800	12	--	--	.758	--
810042	611	471	50.0	262	501	787	2,520	14	--	--	.658	--
810242	475	384	50.6	207	391	605	2,110	10	--	--	.224	--

See footnotes at end of table

Table 7.--Constituent discharges at sites on inland streams--Continued

STORET number	Mean (tons/d)	Standard deviation (tons/d)	Minimum (tons/d)	Percentage of samples in which values are less than or equal to those shown: 25 (tons/d)	50 (tons/d)	75 (tons/d)	Maximum (tons/d)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (tons/d/yr)
Dissolved-solids discharge (residue at 180° C)												
090162	5,570	4,780	1,160	2,280	3,890	6,490	20,900	12	--	--	.959	--
130147	465	205	222	315	408	556	1,180	6	--	--	.723	--
130202	155	91.8	44.6	85.2	136	189	487	6	--	--	.832	--
230028	1,350	958	190	544	1,170	1,720	3,980	6	--	--	.121	--
230038	784	441	111	422	732	1,050	1,810	4	--	--	.096	--
250033	727	710	90.6	285	536	869	4,330	11	--	--	.536	--
250098	344	338	9.74	138	210	459	2,000	10	--	--	.835	--
370002	271	136	112	181	241	308	753	6	--	--	.020	11.7
370009	289	175	103	171	243	331	869	9	--	--	.529	--
380031	315	173	93.2	179	285	397	1,030	12	--	--	.232	--
380226	43.0	24.2	5.15	26.5	40.2	56.7	149	10	--	--	.040	1.97
390057	931	412	144	635	816	1,060	2,140	8	--	--	.643	--
390058	1,180	555	174	777	1,030	1,440	2,930	13	--	--	.671	--
390079	861	407	329	584	741	1,060	2,290	9	--	--	.218	--
410050	3,990	2,510	1,320	2,260	2,880	5,110	13,100	10	--	--	.004	117
410052	4,070	3,130	112	1,890	2,810	5,830	15,700	12	--	--	.127	--
560003	1,190	2,790	153	433	596	854	23,200	6	--	--	.004	51.8
560151	2,300	1,330	628	1,380	2,030	2,610	6,780	5	--	--	1.00	--
630252	161	84.7	60.0	103	140	192	497	10	--	--	.756	--
630529	44.9	29.5	5.72	23.6	39.1	57.5	154	11	--	--	.780	--
730150	5,210	4,250	1,060	2,090	4,050	6,200	22,800	11	--	--	.635	--
810042	587	465	47.9	257	469	737	2,510	12	--	--	.803	--
810242	514	385	62.7	261	423	633	2,190	9	--	--	.019	10.2
Nonfilterable-solids discharge (residue at 105° C)												
090162	723	2,110	3.71	88.0	161	410	20,500	12	--	--	.493	--
130147	16.6	18.5	0.631	4.86	10.1	19.5	88.3	6	--	--	.944	--
130202	2.51	2.20	.213	0.889	1.91	3.24	11.2	6	--	--	.944	--
230028	55.9	77.2	1.73	10.7	22.6	69.2	389	12	--	--	.106	--
230038	24.1	32.7	1.64	6.94	12.0	28.0	175	11	--	--	.289	--
250033	34.5	46.0	1.18	6.18	14.8	42.3	199	5	80/07	H	.055	--
250098	16.0	29.9	.135	2.02	7.17	16.5	242	11	--	--	.494	--
370002	12.5	19.1	.744	2.89	5.08	9.19	90.8	6	--	--	1.00	--
370009	61.0	349	.801	5.79	9.45	21.3	3,210	9	--	--	.838	--
380031	12.1	11.7	.270	3.56	7.90	17.9	52.3	14	--	--	.555	--
380226	1.14	.948	.153	.552	.729	1.37	4.75	10	--	--	.003	0.070
390057	34.3	29.7	2.61	13.1	22.9	46.6	163	10	--	--	.943	--
390058	47.3	37.9	2.39	19.5	38.0	64.5	226	12	--	--	.190	--
390079	23.8	19.2	1.60	9.65	19.3	32.1	101	10	--	--	.560	--
410050	237	320	4.05	44.7	138	285	2,000	10	--	--	.156	--
410052	300	398	4.40	68.6	168	348	2,340	13	--	--	.335	--
560003	32.3	58.5	.000	5.41	10.2	26.4	296	6	--	--	.055	--
560151	133	244	5.39	19.9	50.5	136	1,090	5	--	--	.606	--
630252	6.46	11.5	.000	.741	2.53	7.51	67.5	12	--	--	.016	-.250
630529	.641	1.27	.000	.000	.301	.982	9.17	12	--	--	.011	-.090
730150	584	1,300	3.59	94.9	176	412	8,300	12	--	--	.860	--
810042	24.2	39.9	.502	4.22	10.9	27.5	363	14	--	--	.417	--
810242	8.52	16.8	.307	1.71	4.39	9.07	142	10	--	--	.121	--

[1] Step trend indicates that an abrupt change in the average discharge of a constituent was detected during the period of record. Summary statistics were based only on data following the date of the step trend.

[2] Linear trend indicates that a gradual change in average discharge during the period of record collection was detected. The discharge data was adjusted to reflect conditions at the end of 1984 using an adjustment which decreased in absolute value as a linear function of time.

[3] H indicates that the average discharge during the earlier period was higher.

[4] L indicates that the average discharge during the earlier period was lower.

The variation in discharges for sites on inland streams were ranked by median discharge and are shown on figures 42 to 50 (at end of report). Stream-flow and discharge estimates for the site on Tittabawassee River upstream from Midland (560003) and the site on Grand River downstream from Jackson (380031) may be less accurate than at other sites because of the greater distances between the water-quality and streamflow monitoring sites. Sites consistently occurring in the high-five rankings include those on Saginaw River (090162 and 730150), and Grand River at Grand Rapids (410050 and 410052). Sites occurring in all of the low-five rankings include those upstream from Battle Creek (130202), Jackson (380226), and Pontiac (630529). Variability in ranking of discharge was less than ranking of concentration. Lower variability corresponds to higher intercorrelation among constituents. Only seven sites occurred one or more times in both the high- and low-five ranking for the discharges analyzed.

Detroit River

Summaries of Detroit River discharge data were prepared by transect rather than by individual sites (table 8) to correspond with available streamflow data. For each transect, an average concentration, based on the concentration measured on the same day at each of the ten sites, was multiplied by the corresponding daily average streamflow and a units adjustment factor. Minor differences in the number of samples at upstream and downstream transects occurred.

Relations Between Constituent Concentrations and Streamflow

The relation between streamflow and concentration of a constituent at a site may help to identify the source of a constituent. For example, a high positive correlation between concentration and streamflow may indicate that surface runoff is a major factor effecting the concentration of a constituent; a high negative correlation may indicate a continuous constant point source. Lack of correlation may indicate that both processes are effecting concentrations. Although identification of the source of constituents was beyond the scope of this study, the relation between streamflow and concentration was described in order to develop the flow-adjusted concentration (FAC) data. The FAC was used together with concentration and discharge data to enhance the trend analysis.

Inland Streams

Of the 230 regressions of constituent concentration and streamflow at sites on inland streams, 72.6 percent (table 9) were significant at the 5-percent level. Of the functional forms used to describe the concentration-streamflow relation, 40.7 percent were linear, 26.3 percent were semilogarithmic, 21.0 percent were inverse, and 12.0 percent were hyperbolic. A negative correlation between concentration and streamflow was found in 77.8 percent of the correlations significant at the 5-percent level. All significant correlations at sites on inland streams between streamflow and chloride, sulfate, specific conductance, total solids, and dissolved solids were negative; both positive and negative correlations were found between streamflow and phosphorus, nitrogen forms, and nonfilterable solids.

Table 8.--Constituent discharges at Detroit River Transects

[Discharges are in tons/d (tons per day).]

Transect	Mean (tons/d)	Standard deviation (tons/d)	Minimum (tons/d)	Percentage of samples in which values are less than or equal to those shown: 25 (tons/d)	50 (tons/d)	75 (tons/d)	Maximum (tons/d)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (tons/d/yr)
Total phosphorus discharge												
Windmill	8.98	4.46	4.20	6.11	8.40	10.3	27.3	7	79/01	H[3]	--	--
Fermi	13.0	4.41	7.24	9.51	12.4	15.1	28.7	7	79/01	H	--	--
Total chloride discharge												
Windmill	4,490	773	2,400	4,150	4,350	4,650	7,490	6	79/01	H	--	--
Fermi	6,570	1,120	4,660	5,520	6,520	7,290	9,810	7	79/01	H	--	--
Total sulfate discharge												
Windmill	9,280	1,310	4,860	8,730	9,240	9,820	12,400	6	--	--	--	--
Fermi	9,620	1,140	5,620	9,410	9,560	9,860	12,200	6	--	--	--	--
Total organic plus ammonia nitrogen discharge												
Windmill	139	30.5	74.5	114	132	166	207	12	--	--	--	--
Fermi	199	36.9	128	171	195	229	304	12	--	--	--	--
Total ammonia nitrogen discharge (as nitrogen)												
Windmill	6.63	3.60	3.07	4.58	5.56	6.41	19.5	9	77/01	H	0.004	0.42
Fermi	50.7	11.4	32.4	43.8	48.1	55.1	106	9	77/01	H	--	--
Total nitrate plus nitrite nitrogen discharge (as nitrogen)												
Windmill	206	89.4	103	151	181	225	612	14	--	--	.008	5.51
Fermi	203	70.8	129	160	178	214	531	14	--	--	.015	3.41
Total solids discharge (residue at 105° C)												
Windmill	86,900	10,200	43,900	81,800	85,600	90,800	126,000	15	--	--	--	--
Fermi	94,600	10,000	52,500	88,700	93,100	98,300	129,000	15	--	--	--	--
Dissolved-solids discharge (residue at 180° C)												
Windmill	82,200	9,760	41,200	77,300	80,900	85,700	122,000	15	--	--	--	--
Fermi	88,700	9,210	44,900	83,600	87,300	93,400	125,000	15	--	--	--	--
Nonfilterable-solids discharge (residue at 105° C)												
Windmill	5,500	3,300	1,370	3,450	4,810	6,560	24,100	15	--	--	--	--
Fermi	6,590	3,670	1,120	4,560	5,990	7,530	26,100	15	--	--	--	--

[1] Step trend indicates that an abrupt change in the average discharge of a constituent was detected during the period of record. Summary statistics were based only on data following the date of the step trend.

[2] Linear trend indicates that a gradual change in average discharge during the period of record collection was detected. The discharge data was adjusted to reflect conditions at the end of 1984 using an adjustment which decreased in absolute value as a linear function of time.

[3] H indicates that the average discharge during the earlier period was higher.

Table 9.--Relations between constituent concentrations and streamflow at sites

[Results are in mg/L (milligrams per liter) except for specific conductance which is reported as μS/cm at 25° C (microsiemens per centimeter at 25 degrees Celsius).]

STORET number	Flow analysis	Phosphorus total (mg/L as P)	Chloride, total (mg/L as Cl)	Sulfate, total (mg/L as SO_4)	Nitrogen, organic plus ammonia total (mg/L as N)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, nitrate plus nitrite total (mg/L as N)	Specific conductance, (μS/cm at 25 deg. C)	Solids, residue at 105 deg. C total (mg/L)	Solids, residue at 180 deg. C dissolved (mg/L)	Solids, residue at 105 deg. C nonfilterable (mg/L)
						Sites on inland streams					
090162	model	lin[a]	log[b]	lin	inv[c]	nfr[d]	inv	hyp[e]	log	hyp	lin
	corr	+[f]	-[g]	-	-	na[h]	+	-	-	-	+
	R2	0.350	0.568	0.238	0.169	na	0.303	0.604	0.546	0.720	0.435
130147	model	log	lin	nfr	inv	log	nfr	lin	lin	log	inv
	corr	-	-	na	+	+	na	-	-	-	+
	R2	.150	.333	na	.328	0.083	na	.313	.371	.366	.088
130202	model	nfr	log	lin	inv	nfr	log	hyp	hyp	hyp	nfr
	corr	na	-	-	+	na	+	-	-	-	na
	R2	na	.693	.118	.480	na	.235	.765	.778	.767	na
230028	model	inv	log	log	nfr	nfr	nfr	hyp	lin	lin	lin
	corr	-	-	-	na	na	na	-	-	-	+
	R2	.335	.545	.362	na	na	na	.561	.485	.669	.115
230038	model	inv	log	log	nfr	lin	log	hyp	lin	hyp	lin
	corr	-	-	-	na	-	+	-	-	-	+
	R2	.115	.739	.172	na	.019	.148	.675	.607	.774	.029
250033	model	inv	log	nfr	hyp	nfr	inv	hyp	hyp	hyp	nfr
	corr	-	-	na	-	na	-	-	-	-	na
	R2	.236	.138	na	.090	na	.750	.224	.068	.203	na
250098	model	nfr	lin	nfr	nfr	nfr	hyp	lin	lin	lin	lin
	corr	na	-	na	na	na	+	-	-	-	+
	R2	na	.108	na	na	na	.226	.111	.068	.134	.046
370002	model	lin	lin	nfr	lin	lin	log	lin	nfr	lin	lin
	corr	+	-	na	+	+	+	-	na	-	+
	R2	.341	.220	na	.410	.276	.236	.218	na	.218	.165
370009	model	nfr	log	nfr	nfr	log	inv	lin	nfr	lin	nfr
	corr	na	-	na	na	-	+	-	na	-	na
	R2	na	.223	na	na	.074	.087	.510	na	.539	na
380031	model	inv	inv	hyp	inv	log	inv	log	log	log	lin
	corr	-	-	-	-	-	-	-	-	-	-
	R2	.375	.809	.719	.170	.243	.441	.809	.760	.798	.060
380226	model	nfr	nfr	nfr	log	nfr	nfr	lin	lin	lin	nfr
	corr	na	na	na	+	na	na	-	-	-	na
	R2	na	na	na	.088	na	na	.063	.075	.069	na
390057	model	nfr	lin	nfr	nfr	nfr	nfr	lin	lin	lin	nfr
	corr	na	-	na	na	na	na	-	-	-	na
	R2	na	.460	na	na	na	na	.578	.571	.570	na
390058	model	log	lin	inv	log	log	log	lin	lin	lin	inv
	corr	-	-	-	-	-	+	-	-	-	-
	R2	.221	.478	.152	.260	.206	.155	.482	.535	.494	.050

[a] lin indicates linear model used to describe relationship between streamflow and constituent.
[b] log indicates logarithmc model used to describe relationship between streamflow and constituent.
[c] inv indicates inverse model used to describe relationship between streamflow and constituent.
[d] nfr indicates concentation is not flow related at the 5 percent level of significance.
[e] hyp indicates hyperbolic model used to describe relationship between streamflow and constituent.
[f] + indicates positive correlation between streamflow and constituent.
[g] - indicates negative correlation between streamflow and constituent.
[h] na indicates that analysis is not applicable.

Table 9.--Relations between constituent concentrations and streamflow at sites--Continued

STORET number	Flow analysis	Phosphorus total (mg/L as P)	Chloride, total (mg/L as Cl)	Sulfate, total (mg/L as SO_4)	Nitrogen, organic plus ammonia total (mg/L as N)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, nitrate plus nitrite total (mg/L as N)	Specific conductance, (µS/cm at 25 deg. C)	Solids, residue at 105 deg. C total (mg/L)	Solids, residue at 180 deg. C dissolved (mg/L)	Solids, residue at 105 deg. C nonfilterable (mg/L)
Sites on inland streams--Continued											
390079	model	nfr	lin	nfr	nfr	nfr	inv	lin	lin	lin	inv
	corr	na	-	na	na	na	+	-	-	-	-
	R2	na	.231	na	na	na	.302	.230	.396	.284	.097
410050	model	lin	lin	lin	lin	lin	log	lin	lin	lin	nfr
	corr	+	-	-	+	+	+	-	-	-	na
	R2	0.311	0.322	0.138	0.061	0.125	0.462	0.402	0.427	0.404	na
410052	model	log	hyp	lin	inv	hyp	log	lin	lin	lin	nfr
	corr	-	-	-	-	-	+	-	-	-	na
	R2	.115	.533	.230	.103	.218	.424	.431	.448	.441	na
560003	model	nfr	nfr	nfr	nfr	nfr	inv	log	nfr	log	nfr
	corr	na	na	na	na	na	-	-	na	-	na
	R2	na	na	na	na	na	.152	.060	na	.054	na
560151	model	inv	log	log	inv	log	log	log	log	log	lin
	corr	-	-	-	-	-	+	-	-	-	+
	R2	.093	.501	.505	.465	.170	.511	.584	.483	.574	0.156
630252	model	nfr	inv	log	nfr	nfr	inv	inv	inv	inv	inv
	corr	na	-	-	na	na	-	-	-	-	+
	R2	na	.167	.268	na	na	.779	.294	.295	.330	.096
630529	model	nfr	log	nfr	nfr	log	lin	inv	inv	log	nfr
	corr	na	-	na	na	-	+	-	-	-	na
	R2	na	.479	na	na	.183	.065	.262	.308	.288	na
730150	model	inv	log	lin	inv	nfr	inv	hyp	hyp	hyp	lin
	corr	-	-	-	-	na	+	-	-	-	+
	R2	.159	.490	.284	.434	na	.297	.483	.427	.501	.177
810042	model	inv	log	nfr	nfr	nfr	inv	lin	lin	lin	nfr
	corr	-	-	na	na	na	-	-	-	-	na
	R2	.305	.300	na	na	na	.467	.346	.256	.320	na
810242	model	lin	log	nfr	lin	nfr	hyp	lin	lin	lin	lin
	corr	+	-	na	+	na	+	-	-	-	+
	R2	.073	.318	na	.101	na	.412	.150	.081	.117	.076
Detroit River Transects											
Windmill	model	nfr	nfr	nfr	nfr	lin	lin	nfr	nfr	nfr	nfr
	corr	na	na	na	na	+	-	na	na	na	na
	R2	na	na	na	na	.046	.070	na	na	na	na
Fermi	model	nfr	nfr	nfr	nfr	lin	lin	inv	nfr	nfr	nfr
	corr	na	na	na	na	-	-	-	na	na	na
	R2	na	na	na	na	.094	.033	.045	na	na	na

The correlation between streamflow and concentration varied, depending on constituent and site. Dissolved solids and specific conductance were most strongly related to streamflow; all 23 regression equations were significant at the 5-percent level and these had a coefficient of determination of 0.41 (dissolved solids) and 0.40 (specific conductance). Total sulfate was the constituent least related to streamflow; only 11 regression equations were significant at the 5-percent level and these had an average value of 0.29 for the coefficient of determination.

Two sites on Tittabawassee River showed the greatest and least constituent correlation with streamflow. At the upstream site (560003), only three constituents were significantly correlated with streamflow; the average variation explained by these three was 8.8 percent. At the downstream site (560151) all 10 regression equations were significant at the 5 percent level and these had an average coefficient of determination of 0.40.

Detroit River

For Detroit River samples, streamflow and the average concentration along a transect were generally unrelated (table 9). Of the 20 regression equations between concentrations and streamflow, only five were significant at the 5-percent level, and these only explained an average of 5.8 percent of the total variation. This lack of correlation between streamflow and concentration is related to the extended retention of constituents in the upper Great Lakes which reduces the event responsiveness of the system. Because of the generally low correlation between streamflow and concentration in Detroit River, a trend analysis was not conducted on the flow-adjusted concentrations.

Trends

Inspection of time-series plots of concentration data revealed 22 step trends at sites on inland streams. Most of these trends occurred in phosphorus (31.8 percent) and in the three forms of nitrogen (63.6 percent). For sites on Detroit River, 52 step trends were identified in concentration data. All sites on both Detroit River transects had lower phosphorus concentrations after 1977. Step trends were also common in these records for total ammonia nitrogen and total chloride. Step trends, identified in concentration time series plots, were applied to the discharge and FAC data.

Linear trends were identified in concentration, discharge, and FAC data at sites (table 10). Comparison of linear trends in nine constituent concentrations and discharges for sites on inland streams indicate the following: (1) no trend occurs in either concentration or discharge (51.7 percent), (2) a trend occurs in concentration but not discharge (25.6 percent), (3) a trend occurs in discharge but not in concentration (7.7 percent), (4) a trend occurs in both concentration and discharge (15 percent), and (5) a trend in both concentration and discharge agree in the direction of the trend (93.6 percent). Two cases indicated a trend in concentration with a different algebraic sign than the trend in discharge. A negative trend in total-solids concentration at Tittabawassee River upstream from Midland (site 560003) was associated with a positive trend in streamflow to create a positive trend in discharge. A positive trend was identified in total nitrate plus nitrite nitrogen concentration at Flint River downstream from Flint (site 250033), while a negative trend in discharge was indicated. No trends were identified in streamflow or FAC for this case.

Table 10.--Trends in constituent concentration, constituent discharge, and flow-adjusted constituent concentration at sites

[Results are in mg/L (milligrams per liter) except for specific conductance which is reported as µS/cm at 25° C (microsiemens per centimeter at 25 degrees Celsius).]

STORET number	Flow analysis	Phosphorus total (mg/L as P)	Chloride, total (mg/L as Cl)	Sulfate, total (mg/L as SO_4)	Nitrogen, organic plus ammonia total (mg/L as N)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, nitrate plus nitrite total (mg/L as N)	Specific conductance, (µS/cm at 25 deg. C)	Solids, residue at 105 deg. C total (mg/L)	Solids, residue at 180 deg. C dissolved (mg/L)	Solids, residue at 105 deg. C nonfilterable (mg/L)	Streamflow ft³/s
090162	conc[a]	o[b]	o	o	o	o	o	o	o	o	o	o
	disc[c]	o	o	o	o	o	o	na[d]	o	o	o	na
	FAC[e]	-	-	o	o	*[f]	o	o	o	o	o	na
130147	conc	o	0.697	2.00	o	o	0.065	o	4.50	4.38	o	o
	disc	o	o	o	o	o	o	na	o	o	o	na
	FAC	-[g]	+[h]	*	-	o	*	+	+	+	o	na
130202	conc	-0.006	o	o	-0.050	o	o	o	o	o	o	o
	disc	-.002	o	o	o	o	o	na	o	o	o	na
	FAC	*	+	o	o	*	o	+	+	+	*	na
230028	conc	o	o	-2.73	-.071	o	o	o	o	5.50	-0.606	o
	disc	o	o	o	o	o	o	na	o	o	o	na
	FAC	o	o	-	*	*	*	o	+	o	-	na
230038	conc	-.011	o	-1.92	o	o	o	o	o	o	-.500	o
	disc	-.008	o	o	o	o	o	na	o	o	o	na
	FAC	-	o	-	*	o	o	o	o	+	-	na
250033	conc	o	o	2.72	o	o	.220	o	-4.50	o	-2.10	o
	disc	-.019	o	o	-.261	o	-.280	na	o	o	o	na
	FAC	o	o	*	o	*	o	o	-	o	*	na
250098	conc	-.004	o	o	o	o	.006	5.00	o	3.50	o	o
	disc	o	o	o	o	o	o	na	o	o	o	na
	FAC	*	o	*	*	*	o	+	o	+	o	na
370002	conc	o	-.500	o	o	0.002	.030	o	o	o	o	8.62
	disc	o	o	o	o	.002	.022	na	7.47	11.7	o	na
	FAC	o	-	*	o	o	o	o	*	o	o	na
370009	conc	-.008	-.500	o	-.097	-.009	.021	o	o	o	o	o
	disc	-.052	o	o	o	-.005	.015	na	o	o	o	na
	FAC	*	-	*	*	-	+	o	*	o	*	na
380031	conc	-.009	o	o	-.067	o	o	o	o	o	o	o
	disc	-.007	.500	o	o	o	o	na	o	o	o	na
	FAC	-	+	o	-	o	o	o	o	o	o	na
380226	conc	o	.300	4.00	o	.001	.013	o	o	o	.333	2.80
	disc	<.001	.112	o	o	.001	.003	na	2.00	1.97	.073	na
	FAC	*	*	*	o	*	*	o	o	o	*	na
390057	conc	-.005	.750	2.00	o	o	.027	5.00	4.00	3.38	o	o
	disc	-.014	o	o	o	o	o	na	o	o	o	na
	FAC	*	+	*	*	*	*	+	+	+	*	na
390058	conc	o	o	3.00	-.090	.018	.023	o	o	o	o	o
	disc	-.014	o	o	o	.032	o	na	o	o	o	na
	FAC	-	o	o	-	+	+	o	o	o	o	na
390079	conc	-.004	.381	2.50	-.049	o	.024	3.75	2.07	o	o	o
	disc	-.007	o	o	-.092	o	o	na	o	o	o	na
	FAC	*	+	*	*	*	o	+	+	+	o	na

[a] conc indicates slope of constituent level and time trend, in (mg/L)/yr
[b] o indicates no trend at the 5 percent level of significance
[c] disc indicates slope of discharge-time trend, in (tons/d)/yr
[d] na indicates analysis not applicable to the specific constituent
[e] FAC indicates direction of flow adjusted constituent and time trend
[f] * indicates constituent level not related to streamflow rate
[g] - indicates flow-adjusted constituent trend negative
[h] + indicates flow-adjusted constituent trend positive

Table 10.--Trends in constituent concentration, constituent discharge, and flow-adjusted constituent concentration at sites--Continued

STORET number	Flow analysis	Phosphorus total (mg/L as P)	Chloride, total (mg/L as Cl)	Sulfate, total (mg/L as SO_4)	Nitrogen, organic plus ammonia total (mg/L as N)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, nitrate plus nitrite total (mg/L as N)	Specific conductance, (μS/cm at 25 deg. C)	Solids, residue at 105 deg. C total (mg/L)	Solids, residue at 180 deg. C dissolved (mg/L)	Solids, residue at 105 deg. C nonfilterable (mg/L)	Streamflow ft^3/s
410050	conc	-0.003	0.314	o	-0.045	o	0.053	3.45	3.27	o	o	o
	disc	o	7.25	o	o	o	.297	na	93.3	117	o	na
	FAC	o	+	o	-	o	o	+	+	+	*	na
410052	conc	-.008	o	o	-.100	o	o	o	3.35	o	o	o
	disc	o	o	o	o	o	o	na	o	o	o	na
	FAC	-	+	o	-	o	+	+	+	+	*	na
560003	conc	o	o	o	o	0.007	.018	o	-1.75	o	o	68.6
	disc	.005	2.94	o	o	.010	.067	na	46.4	51.3	o	na
	FAC	*	*	*	*	*	o	o	*	o	*	na
560151	conc	-.008	o	o	o	o	o	o	o	o	o	o
	disc	o	o	o	o	o	o	na	o	o	o	na
	FAC	-	o	o	o	o	o	o	o	o	o	na
630252	conc	o	o	o	o	o	o	o	o	o	-0.714	o
	disc	o	-.730	o	o	o	o	na	o	o	-.251	na
	FAC	*	o	o	*	*	-	o	o	o	-	na
630529	conc	-.001	1.00	o	o	o	-.011	5.00	3.20	3.20	-.333	o
	disc	o	o	o	o	.001	-.002	na	o	o	-.087	na
	FAC	*	+	*	*	o	-	+	+	+	*	na
730150	conc	-.009	o	o	o	o	o	o	o	o	-.833	o
	disc	o	o	o	o	-.147	o	na	o	o	o	na
	FAC	-	o	o	o	*	o	o	o	o	o	na
810042	conc	-.004	1.00	2.00	-.051	-.039	.033	o	o	o	o	o
	disc	-.005	o	o	-.131	-.036	o	na	o	o	o	na
	FAC	-	+	*	*	*	o	o	o	o	*	na
810242	conc	-.001	1.33	1.83	o	o	o	7.14	3.86	4.31	o	o
	disc	o	1.06	o	o	o	o	na	o	10.2	o	na
	FAC	-	+	*	o	*	o	+	+	+	o	na

At sites where concentrations were related to streamflow, a comparison of linear trends in concentration and FAC indicate: (1) no trends in concentration or FAC (50.9 percent), (2) a trend in concentration but not FAC (7.8 percent), (3) a trend in FAC but not in concentration (12 percent), (4) a trend in both concentration and FAC (29.3 percent), and (5) all cases showing a trend in concentration and FAC agreed in the direction of the trend.

Most sites showed no linear time trends in concentrations, discharges, or FAC; however, a higher percentage showed trends than would be expected by pure chance (table 11). More positive than negative trends were identified at sites on inland streams, while more negative trends were identified in Detroit River sites. More trends were identified among FAC and fewer trends among discharges than were identified among concentrations.

Table 11.--Trend-test results at sites

Number of station-constituent pairs				
	Negative trend	No trend	Positive trend	Number tested
Sites on inland streams				
Concentration	38	160	55	253
Load	20	160	27	207
Flow-adjusted concentration .	27	98	42	167
Sites on Detroit River				
Concentration	36	135	29	200

Percentage of station-constituent pairs			
	Negative trend	No trend	Positive trend
Sites on inland streams			
Concentration	15.0	63.3	21.7
Load	9.7	77.3	13.0
Flow-adjusted concentration .	16.2	58.7	25.1
Sites on Detroit River			
Concentration	18.0	67.5	14.5
Distribution under the null hypothesis (no trend)	2.5	95.0	2.5

CHANGES IN WATER QUALITY NEAR URBAN AREAS

For the purpose of this study, changes in water quality near an urban area[2] were computed using sites upstream and downstream from an urban area as paired samples. Although the assumptions underlying the paired sampling methodology were not strictly satisfied because of the operational difficulties involved in routinely sampling the same plume of water at the downstream and upstream sites, the expected error would be negligible if the system was in steady state. The steady-state requirement is satisfied as long as changes in concentration and streamflow at both downstream and upstream sites are small during the sampling interval.

For urban areas drained by a single inland stream, changes in concentration were computed as the differences in concentration between the downstream and upstream sites, based on samples collected at both sites on the same day. For urban areas where two upstream tributaries were sampled, a weighted average upstream concentration was determined that was proportional to the daily-mean streamflow at the upstream sites. Positive changes in concentration indicate that water at sites upstream from an urban area had lower constituent concentrations than water at the corresponding downstream site.

Sampling sites on the Detroit River transects were located at the deciles of flow distribution across the channel. Therefore, changes in concentration were computed as the differences between the average concentration at the 10 sites on the upstream transect (Windmill Point) and the average concentration at the 10 sites on the downstream transect (Fermi). Positive changes in concentrations indicate higher average concentrations at the downstream transect. Sources of constituents were not identified in this study.

Generally, changes in concentration and discharge near urban areas and the differences between summary statistics of concentration and discharge at individual sites upstream and downstream from urban areas do not exactly match. The reason such differences occur is that usually fewer paired samples were available than total samples at either site. Despite the somewhat fewer number of samples, the analysis of paired samples more accurately reflects the changes near urban areas.

Changes in Constituent Concentrations

Changes in concentrations between sites upstream and downstream from urban areas were ranked by median values and are shown on figures 51 to 61 (at end of report). Table 12 shows summary statistics of changes in concentrations and streamflow. Higher ranked values indicate greater impacts by urban areas on water quality. Urban areas consistently occurring in the high-three rankings include Jackson, Pontiac, and Midland with a frequency of 80-, 70-, and 70-percent, respectively. Areas consistently occurring in the low-three rankings include Saginaw, Detroit, and Battle Creek with a frequency of 80-, 70-, and 60-percent, respectively. Eight areas occurred one or more times in both the high- and low-three rankings for the characteristics analyzed.

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[2] Urban area names used in this report describe geographic areas rather than political entities or subdivisions.

Table 12.--Changes in constituent concentrations near urban areas

[Concentrations are in mg/L (milligrams per liter) except for specific conductance which is reported as µS/cm at 25° C (microsiemens per centimeter at 25 degrees Celsius).]

Urban area	Mean (mg/L)	Standard deviation (mg/L)	Minimum (mg/L)	Percentage of samples in which values are less than or equal to those shown: 25 (mg/L)	50 (mg/L)	75 (mg/L)	Maximum (mg/L)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (mg/L/yr)
Total phosphorus concentration												
Ann Arbor	0.045	0.040	-0.072	0.018	0.041	0.066	0.228	10	--	--	0.014	-0.002
Battle Creek	.040	.044	-.069	.020	.036	.055	.271	6	--	--	.613	--
Flint	.094	.058	.011	.042	.087	.132	.277	5	80/07	H[3]	.106	--
Grand Rapids	.022	.041	-.058	.002	.015	.027	.202	4	81/01	H	.272	--
Jackson	.106	.065	.020	.057	.093	.140	.312	10	--	--	.700	--
Kalamazoo	.121	.111	-.260	.064	.091	.147	.584	10	--	--	.708	--
Lansing	.071	.054	.013	.033	.056	.091	.318	5	80/01	H	.156	--
Midland	.021	.038	-.037	-.007	.021	.031	.163	4	--	--	.019	-.007
Mt. Pleasant	-.003	.027	-.044	-.019	-.004	.007	.116	6	--	--	.000	-.017
Pontiac	.077	.067	.004	.035	.060	.083	.393	7	78/01	H	.591	--
Saginaw	.002	.052	-.141	-.015	.004	.025	.250	5	80/07	H	.446	--
Detroit	.007	.008	-.023	.005	.007	.010	.031	6	79/01	H	.885	--
Total chloride concentration												
Ann Arbor	9.91	9.65	-.817	4.68	7.95	12.9	75.4	10	--	--	.007	-.400
Battle Creek	9.12	4.22	2.34	6.42	8.22	10.6	26.0	6	--	--	.036	.719
Flint	28.7	16.4	.000	18.5	26.0	34.5	114	10	--	--	.938	--
Grand Rapids	5.76	6.25	-10.3	1.31	5.31	10.0	21.9	10	--	--	.026	-.500
Jackson	44.0	26.2	10.0	25.1	35.8	59.9	140	10	--	--	.102	--
Kalamazoo	6.07	3.68	-12.7	4.01	5.76	8.28	13.3	10	--	--	.024	-.250
Lansing	8.01	9.63	-14.0	4.00	6.00	9.90	59.0	11	--	--	.775	--
Midland	76.6	61.8	4.11	35.3	57.0	109	282	4	--	--	1.00	--
Mt. Pleasant	5.89	3.17	-6.00	4.00	5.91	7.66	15.0	6	--	--	.232	--
Pontiac	53.8	32.1	-6.00	35.0	47.0	65.0	260	12	--	--	.320	--
Saginaw	-3.41	29.2	-158	-16.8	-1.00	8.00	133	11	--	--	.106	--
Detroit	3.78	1.87	.130	2.37	3.93	4.84	8.06	6	79/01	H	.203	--
Total sulfate concentration												
Ann Arbor	4.47	3.35	-6.00	3.00	5.00	7.00	10.0	4	--	--	1.00	--
Battle Creek	-.215	2.02	-3.80	-1.76	-.185	.800	5.87	4	--	--	.736	--
Flint	4.45	4.94	-16.0	3.00	4.00	7.00	16.0	4	--	--	1.00	--
Grand Rapids	4.67	3.75	-8.00	3.00	5.00	7.00	12.3	4	--	--	.629	--
Jackson	38.6	12.9	5.00	30.0	36.0	47.0	70.0	4	--	--	.300	--
Kalamazoo	-3.45	2.38	-11.8	-4.50	-3.00	-2.00	1.00	4	--	--	.641	--
Lansing	4.58	4.94	-4.38	1.54	3.54	6.54	19.8	6	--	--	.034	-1.00
Midland	14.2	10.1	-18.5	10.3	13.4	17.3	41.8	4	--	--	1.00	--
Mt. Pleasant	3.89	2.59	-6.00	3.00	4.00	5.00	10.0	4	--	--	.459	--
Pontiac	26.9	13.8	-5.00	18.0	26.0	34.2	67.0	4	--	--	.096	--
Saginaw	-1.31	8.55	-11.0	-5.00	-3.00	.300	45.0	4	--	--	.401	--
Detroit	.656	.871	-2.10	.350	.700	1.20	2.54	6	--	--	.287	--
Total organic plus ammonia nitrogen concentration (as nitrogen)												
Ann Arbor	.435	.366	-.130	.200	.309	.489	1.76	6	--	--	.077	--
Battle Creek	.196	.231	-.218	.089	.161	.279	1.22	6	--	--	.269	--
Flint	.312	.303	-.301	.150	.300	.430	1.72	5	80/07	H	.232	--
Grand Rapids	.258	.195	-.100	.105	.210	.400	0.759	5	--	--	.440	--
Jackson	.452	.289	-.097	.296	.409	.540	1.72	6	--	--	.040	-.042
Kalamazoo	.835	.395	.040	.545	.749	1.07	2.14	6	--	--	.442	--
Lansing	.253	.212	-.200	.115	.250	.344	.899	5	80/01	H	.813	--
Midland	.495	.299	.067	.300	.445	.676	1.22	4	--	--	.795	--

See footnotes at end of table

Table 12.--Changes in constituent concentrations near urban areas--Continued

Urban area	Mean (mg/L)	Standard deviation (mg/L)	Minimum (mg/L)	Percentage of samples in which values are less than or equal to those shown: 25 (mg/L)	50 (mg/L)	75 (mg/L)	Maximum (mg/L)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (mg/L/yr)
Total organic plus ammonia nitrogen concentration--Continued												
Mt. Pleasant	.036	.162	-.163	-.026	.014	.064	.784	6	--	--	.002	-.062
Pontiac	.399	.298	-.340	.200	.350	.529	1.29	6	--	--	.051	--
Saginaw	.094	.303	-.700	-.100	.100	.200	1.10	6	--	--	.112	--
Detroit	.109	.066	-.059	.068	.102	.139	.317	10	--	--	.098	--
Total ammonia nitrogen concentration (as nitrogen)												
Ann Arbor	.142	.282	-.616	-.024	.041	.219	1.10	5	80/01	H	.010	-.029
Battle Creek	.047	.100	-.183	.003	.014	.072	.487	6	--	--	.220	--
Flint	.081	.160	-.120	.012	.041	.110	.970	5	80/07	H	.396	--
Grand Rapids	.194	.134	.009	.076	.199	.286	.565	10	--	--	1.00	--
Jackson	.176	.202	-.176	.051	.100	.263	.938	10	--	--	.027	-.007
Kalamazoo	.462	.297	-.315	.279	.414	.567	2.00	10	--	--	.001	.023
Lansing	.065	.128	-.113	-.015	.043	.118	.520	5	80/01	H	1.00	--
Midland	.180	.166	-.020	.042	.160	.273	.750	4	--	--	.435	--
Mt. Pleasant	-.016	.068	-.129	-.063	-.030	.009	.185	6	--	--	.001	-.048
Pontiac	.062	.186	-.119	-.020	.006	.083	1.16	7	78/01	H	.447	--
Saginaw	.145	.228	-.610	.030	.089	.220	1.51	12	--	--	.555	--
Detroit	.085	.024	.046	.069	.081	.097	.178	9	77/01	H	1.00	--
Total nitrate plus nitrite nitrogen concentration (as nitrogen)												
Ann Arbor	0.774	0.508	0.128	0.384	0.585	0.983	2.07	5	80/01	L[4]	0.042	0.077
Battle Creek	-.274	.139	-.714	-.345	-.249	-.198	0.185	6	--	--	.279	--
Flint	1.41	1.09	.100	.703	.942	2.00	5.39	5	80/07	L	.127	--
Grand Rapids	-.055	.166	-.520	-.115	-.074	.000	.500	10	--	--	.120	--
Jackson	.994	.711	-.140	.588	.853	1.20	4.02	10	--	--	.054	--
Kalamazoo	.100	.166	-.463	.005	.070	.165	.634	10	--	--	.026	.004
Lansing	.944	.481	-.119	.675	.849	1.16	2.45	5	80/01	L	.239	--
Midland	.352	.835	-3.35	.000	.312	.670	2.31	4	--	--	.795	--
Mt. Pleasant	.209	.110	-.139	.175	.199	.261	.481	6	--	--	.007	.048
Pontiac	2.86	2.07	-.310	1.46	2.18	3.84	11.7	7	78/01	L	.055	--
Saginaw	.036	.504	-2.90	-.139	.050	.259	1.50	12	--	--	.232	--
Detroit	.011	.094	-.463	.000	.018	.036	.272	14	--	--	.052	--
Specific conductance												
Ann Arbor	45.4	35.3	-35.0	27.5	45.0	60.0	260	10	--	--	.071	--
Battle Creek	18.9	28.8	-51.1	6.08	13.5	25.9	122	6	--	--	.071	--
Flint	99.7	65.5	-90.0	60.0	92.5	135	340	11	--	--	.487	--
Grand Rapids	32.9	39.3	-160	15.0	30.0	50.0	230	10	--	--	.504	--
Jackson	211	121	35.0	120	178	278	605	10	--	--	.132	--
Kalamazoo	53.6	30.9	-80.0	35.0	50.0	70.0	125	10	--	--	.128	--
Lansing	33.3	48.9	-165	15.0	40.0	56.3	200	11	--	--	.414	--
Midland	305	219	-166	200	244	404	997	4	--	--	.795	--
Mt. Pleasant	33.6	19.0	-30.0	27.0	35.0	45.0	95.0	6	--	--	.061	--
Pontiac	211	128	-210	148	205	273	945	12	--	--	.599	--
Saginaw	-25.9	121	-845	-70.0	-17.5	25.0	545	12	--	--	.212	--
Detroit	13.4	9.46	-17.0	8.65	13.0	17.4	46.0	6	79/01	H	.609	--
Total solids concentration (residue at 105° C)												
Ann Arbor	50.9	20.5	-9.14	42.5	49.3	56.7	133	10	--	--	.010	4.75
Battle Creek	17.2	19.0	-18.9	7.50	14.9	24.4	89.2	6	--	--	.279	--
Flint	78.7	43.4	-48.0	54.0	72.0	106	225	11	--	--	.132	--
Grand Rapids	24.4	27.7	-45.0	10.3	20.0	38.5	185	10	--	--	.773	--
Jackson	149	85.0	28.0	85.5	130	193	492	10	--	--	.057	--
Kalamazoo	40.1	21.4	-64.0	28.5	38.5	50.0	121	10	--	--	.130	--
Lansing	25.6	34.1	-122	10.3	31.5	45.8	96.0	11	--	--	.499	--

See footnotes at end of table

Table 12.--Changes in constituent concentrations near urban areas--Continued

Urban area	Mean (mg/L)	Standard deviation (mg/L)	Minimum (mg/L)	Percentage of samples in which values are less than or equal to those shown			Maximum (mg/L)	Years of record	Step trend[1]		Linear trend[2]	
				25 (mg/L)	50 (mg/L)	75 (mg/L)			Date (year/month)	Earlier period	Probability level	Slope (mg/L/yr)
Total solids concentration--Continued												
Midland	204	145	-85.9	141	170	274	652	4	--	--	.892	--
Mt. Pleasant	27.9	19.7	-28.0	19.5	27.0	33.0	111	6	--	--	.235	--
Pontiac	148	78.8	-5.00	104	142	185	626	12	--	--	.833	--
Saginaw	-18.8	86.4	-558	-47.0	-14.0	12.0	346	11	--	--	.263	--
Detroit	10.0	10.8	-27.9	6.65	11.4	14.9	32.1	7	79/01	H	.513	--
Dissolved-solids concentration (residue at 180° C)												
Ann Arbor	29.2	24.2	-25.0	17.0	29.0	39.0	168	9	--	--	.058	--
Battle Creek	12.1	18.1	-33.4	3.91	9.23	17.3	76.9	6	--	--	.071	--
Flint	65.0	42.7	-58.0	39.5	59.5	87.5	221	9	--	--	.173	--
Grand Rapids	21.8	26.7	-104	10.0	20.0	36.0	149	9	--	--	.296	--
Jackson	113	77.5	-19.6	55.3	97.5	148	364	9	--	--	.021	-5.20
Kalamazoo	34.2	20.6	-52.0	23.0	32.0	45.0	81.0	9	--	--	.311	--
Lansing	20.0	25.5	-59.0	9.00	23.0	33.0	94.0	4	--	--	.541	--
Midland	202	142	-108	132	174	272	648	4	--	--	.496	--
Mt. Pleasant	21.6	12.9	-23.0	17.5	22.0	28.5	62.0	6	--	--	.052	--
Pontiac	114	81.5	-144	74.7	108	149	570	9	--	--	.019	-5.75
Saginaw	-44.6	83.2	-588	-64.5	-31.6	-15.8	331	9	--	--	.015	-5.00
Detroit	8.59	6.75	-11.1	5.30	8.85	11.5	29.4	7	79/01	H	1.00	--
Nonfilterable-solids concentration (residue at 105° C)												
Ann Arbor	7.29	8.06	-3.00	1.00	5.00	10.5	38.0	10	--	--	.837	--
Battle Creek	4.33	7.63	-19.1	-1.00	3.04	8.66	21.5	6	--	--	.130	--
Flint	6.51	17.1	-45.0	-1.00	2.00	13.0	67.0	5	80/07	H	.154	--
Grand Rapids	3.56	13.8	-38.0	-2.00	1.00	5.75	63.0	10	--	--	.401	--
Jackson	6.82	14.0	-12.3	-2.40	3.06	14.1	94.5	10	--	--	.018	-.500
Kalamazoo	-5.33	9.17	-44.0	-9.00	-4.00	.000	12.0	5	--	--	.100	--
Lansing	3.97	9.49	-48.5	.000	2.50	7.50	44.0	11	--	--	.100	--
Midland	-1.47	10.4	-24.9	-8.04	-3.56	.263	27.6	4	--	--	.009	-2.77
Mt. Pleasant	8.04	10.0	-5.00	1.00	6.00	11.0	45.0	6	--	--	.304	--
Pontiac	8.83	20.7	-71.0	1.50	5.00	11.5	129	12	--	--	.105	--
Saginaw	-1.88	21.1	-70.0	-11.0	-2.00	4.00	136	11	--	--	.077	--
Detroit	1.62	6.05	-32.2	-.150	1.60	4.75	27.6	15	--	--	.955	--

[1] Step trend indicates that an abrupt change in the average concentration of a constituent was detected during the period of record. Summary statistics were based only on data following the date of the step trend.

[2] Linear trend indicates that a gradual change in average concentration during the period of record collection was detected. The concentration data was adjusted to reflect conditions at the end of 1984 using an adjustment which decreased in absolute value as a linear function of time.

[3] H indicates that the average concentration during the earlier period was higher.

[4] L indicates that the average concentration during the earlier period was lower.

The low ranking for changes in concentrations in the Saginaw area may be effected by unsteady flow conditions of Saginaw River. Flow measurements and simulations have shown extended periods of reverse flow (Holtschlag, 1981). These conditions permit water from Saginaw Bay to mix with river water in the lower Saginaw River channel and lower concentrations at the downstream site (090162). Therefore, changes in concentration between the upstream and downstream sites (730150 and 090162) may not accurately reflect urban-area discharges.

Changes in Constituent Discharges

Changes in discharges between sites upstream and downstream from urban areas are shown in table 13. Larger changes in discharge are generally associated with the larger urban areas. Estimates for the changes in streamflow and discharge in some urban areas may be less accurate than at other urban areas. For example, gaging station 04109000, used to estimate streamflow, is distant from the water-quality site on Grand River downstream from Jackson (380031). Also, different methods for estimating streamflow are used at sites downstream and upstream from Jackson; gaging station 04156000, used to estimate streamflow, is distant from the water-quality site on Tittabawassee River upstream from Midland (560003). Changes in discharges in the Detroit area ranked first among changes in discharges for all urban areas examined, but because of scale limitations, are not included in figures 62 to 70 (at end of report). The Grand Rapids area occurred in 90 percent of the high-three rankings. Areas consistently occurring in the low-three rankings include Mount Pleasant, 90-percent frequency, and Ann Arbor, Pontiac, and Saginaw, all with a 60 percent frequency. Six areas occurred one or more times in both the high- and low-three rankings.

Relations Between Changes in Constituent Concentrations and Streamflow

Equations relating changes in constituent concentrations with changes in streamflow near urban areas were significant, at the 5-percent level, in 56.7 percent of the 120 cases examined (table 14). Of the functional forms used to describe these relations, 13.2 percent were linear, 29.4 percent were semilogarithmic, 36.8 percent were inverse, and 20.6 percent were hyperbolic. Generally changes in constituent concentrations and streamflow were negatively correlated (94.1 percent). Negative correlations between changes in streamflow and changes in concentration were determined for all constituents except phosphorus and nonfilterable-solids concentration, which showed both positive and negative correlations near different urban areas.

Trends

Twenty-two step trends were identified for changes in constituent concentrations in seven urban areas. Step trends were most common in records of phosphorus and nitrogen. All constituents (except nitrate plus nitrite nitrogen) having step trends, had higher concentrations during the earlier period of record. Nitrate plus nitrite nitrogen concentrations were lower during earlier periods and are thought to increase in later periods because of augmented waste-treatment processing which effects the conversion of ammonia to the nitrate plus nitrite nitrogen form.

Table 13.--Changes in constituent discharges near urban areas

[Discharges are in tons/d (tons per day).]

Urban area	Mean (tons/d)	Standard deviation (tons/d)	Minimum (tons/d)	Percentage of samples in which values are less than or equal to those shown: 25 (tons/d)	50 (tons/d)	75 (tons/d)	Maximum (tons/d)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (tons/d/yr)
Total phosphorus discharge												
Ann Arbor	0.084	0.138	-0.095	0.032	0.052	0.092	1.18	10	--	--	0.282	--
Battle Creek	.127	.113	-.185	.062	.111	.177	0.626	6	--	--	.718	--
Flint	.197	.324	.048	.092	.115	.183	2.36	5	80/07	H[3]	.058	--
Grand Rapids	.409	.560	-.860	.118	.186	.505	1.98	4	81/01	H	.261	--
Jackson	.091	.044	.026	.059	.082	.114	.223	8	--	--	.296	--
Kalamazoo	.316	.219	-.811	.214	.304	.424	1.02	10	--	--	.841	--
Lansing	.241	.264	-.178	.119	.164	.232	1.13	5	80/01	H	.872	--
Midland	.307	.629	-.394	.062	.119	.248	2.75	4	--	--	.435	--
Mt. Pleasant	.016	.031	-.111	.003	.012	.025	.110	6	--	--	.000	-0.010
Pontiac	.029	.037	.006	.013	.016	.026	.222	7	78/01	H	.643	--
Saginaw	.637	3.47	-.779	-.114	.074	.316	24.4	5	80/07	H	.857	--
Detroit	4.12	4.39	-13.0	2.88	3.64	5.39	17.6	6	79/01	H	.772	--
Total chloride discharge												
Ann Arbor	19.9	16.4	4.96	10.9	16.3	22.5	130	10	--	--	.257	--
Battle Creek	31.3	17.3	-53.6	25.7	30.3	37.8	106	6	--	--	.097	--
Flint	64.4	66.0	11.3	27.1	52.4	76.0	497	10	--	--	.102	--
Grand Rapids	93.1	42.2	-63.6	69.3	87.0	116	234	10	--	--	.888	--
Jackson	37.1	10.7	19.4	29.0	34.1	42.2	72.9	8	--	--	.003	1.26
Kalamazoo	28.6	16.1	-86.5	21.7	28.2	35.1	64.6	10	--	--	.010	-.949
Lansing	44.1	36.8	-75.5	18.8	35.9	59.6	153	11	--	--	.376	--
Midland	288	152	17.7	176	295	340	667	4	--	--	.594	--
Mt. Pleasant	4.92	4.08	-5.79	2.74	5.11	6.76	17.0	6	--	--	.048	-.507
Pontiac	28.4	19.5	6.27	16.5	23.4	32.7	155	12	--	--	.360	--
Saginaw	28.8	182	-256	-88.4	14.1	91.6	1,120	11	--	--	.486	--
Detroit	2,150	1,090	18.9	1,310	2,220	2,720	4,770	6	79/01	H	.310	--
Total sulfate discharge												
Ann Arbor	12.8	9.31	-2.32	5.11	12.1	18.4	42.6	4	--	--	.424	--
Battle Creek	30.7	13.0	12.9	19.7	28.3	39.6	64.5	4	--	--	.736	--
Flint	39.9	37.6	-5.51	13.7	34.6	50.4	201	4	--	--	.076	--
Grand Rapids	104	64.7	-21.8	62.4	88.9	132	343	4	--	--	.220	--
Jackson	51.1	25.6	12.8	32.8	47.2	62.9	115	4	--	--	.798	--
Kalamazoo	43.9	19.2	16.0	32.1	38.9	48.7	110	4	--	--	.312	--
Lansing	72.5	60.2	-2.66	27.5	56.2	87.4	263	6	--	--	.343	--
Midland	88.8	154	-146	34.4	71.3	136	711	4	--	--	.056	--
Mt. Pleasant	3.65	2.69	-4.69	2.28	3.13	4.79	11.3	4	--	--	1.00	--
Pontiac	12.6	7.23	4.20	7.78	10.7	13.8	36.9	4	--	--	.033	-1.58
Saginaw	.051	147	-207	-58.9	-10.7	10.1	810	4	--	--	.112	--
Detroit	436	376	-224	272	375	758	1,400	6	--	--	.243	--
Total organic plus ammonia nitrogen discharge (as nitrogen)												
Ann Arbor	.490	.511	-.124	.141	.370	.681	2.45	6	--	--	.032	-.078
Battle Creek	.875	.799	-2.68	.546	.788	1.16	3.86	6	--	--	.825	--
Flint	.971	1.71	-.394	.120	.495	1.29	11.6	5	80/07	H	.049	-.120
Grand Rapids	4.14	3.00	-1.65	2.55	3.66	4.66	18.5	5	--	--	.706	--
Jackson	.942	.552	.275	.477	.822	1.27	2.32	6	--	--	.436	--
Kalamazoo	2.48	1.50	-5.88	1.86	2.44	3.11	5.70	6	--	--	.340	--
Lansing	1.78	2.31	-2.79	.641	1.14	1.91	11.3	5	80/01	H	.261	--
Midland	4.82	4.20	-2.47	3.00	4.17	5.69	22.7	4	--	--	.009	1.53
Mt. Pleasant	.098	.134	-.093	.024	.064	.132	.566	6	--	--	.000	-.052
Pontiac	.257	.214	-.001	.137	.194	.329	1.37	6	--	--	.876	--
Saginaw	2.76	9.54	-3.20	-.634	.766	2.43	68.3	6	--	--	.657	--
Detroit	50.6	60.5	-45.2	23.9	40.2	61.5	460	10	--	--	.049	-3.13

See footnotes at end of table

Table 13.--Changes in constituent discharges near urban areas--Continued

Urban area	Mean (tons/d)	Standard deviation (tons/d)	Minimum (tons/d)	Percentage of samples in which values are less than or equal to those shown: 25 (tons/d)	50 (tons/d)	75 (tons/d)	Maximum (tons/d)	Years of record	Step trend[1]: Date (year/month)	Earlier period	Linear trend[2]: Probability level	Slope (tons/d/yr)
Total ammonia nitrogen discharge (as nitrogen)												
Ann Arbor	.211	.297	-.138	-.020	.120	.370	.972	5	80/01	H	.033	-.049
Battle Creek	.136	.178	-.259	.037	.075	.199	.719	6	--	--	.279	--
Flint	.206	.328	-.023	.050	.109	.219	1.93	5	80/07	H	.932	--
Grand Rapids	1.78	2.03	-17.8	1.42	1.99	2.43	4.52	10	--	--	.322	--
Jackson	.141	.103	.022	.071	.113	.188	.677	8	--	--	.787	--
Kalamazoo	1.12	.526	-.720	.830	1.05	1.39	3.16	10	--	--	.001	.065
Lansing	.237	.384	-.281	.017	.107	.316	2.24	5	80/01	H	.872	--
Midland	.642	.632	-.678	.261	.480	.855	2.64	4	--	--	.435	--
Mt. Pleasant	.041	.089	-.378	-.003	.047	.092	.282	6	--	--	.000	-.028
Pontiac	.033	.060	-.008	.001	.013	.035	.342	7	78/01	H	.082	--
Saginaw	1.19	1.54	-2.49	.368	1.04	1.57	9.18	12	--	--	.820	--
Detroit	49.0	22.1	29.7	39.1	45.5	52.5	188	8	77/01	H	.805	--
Total nitrate plus nitrite nitrogen discharge (as nitrogen)												
Ann Arbor	0.502	0.312	-0.138	0.248	0.490	0.672	1.50	5	80/01	L[4]	0.179	--
Battle Creek	.173	.781	-4.91	.073	.225	.445	1.54	6	--	--	.718	--
Flint	2.06	1.15	.720	1.39	1.79	2.45	8.05	5	80/07	L	.072	--
Grand Rapids	.555	3.47	-17.2	-.227	.336	1.19	18.4	10	--	--	.373	--
Jackson	1.04	.879	.073	.596	.783	.988	5.78	8	--	--	.847	--
Kalamazoo	.500	.490	-2.87	.309	.491	.705	2.01	10	--	--	.138	--
Lansing	3.40	3.77	-4.66	1.06	2.33	3.70	16.5	5	80/01	L	.521	--
Midland	4.41	9.33	-7.55	-.065	.838	5.23	49.4	4	--	--	.435	--
Mt. Pleasant	.133	.206	-.631	.091	.114	.142	1.26	6	--	--	.000	0.019
Pontiac	.844	.213	.220	.699	.872	.975	1.35	7	78/01	L	.164	--
Saginaw	.268	7.34	-43.6	-.944	.304	2.22	20.5	12	--	--	.241	--
Detroit	42.2	298	-259	.108	11.7	25.6	2,640	14	--	--	.078	--
Total solids discharge (residue at 105°)												
Ann Arbor	108	82.7	19.0	55.5	91.7	124	456	10	--	--	0.541	--
Battle Creek	314	129	13.5	231	281	398	624	6	--	--	.941	--
Flint	422	471	-12.5	164	278	514	3,520	11	--	--	.136	--
Grand Rapids	685	462	40.6	403	516	826	2,720	10	--	--	.045	11.4
Jackson	351	147	89.6	242	307	429	809	8	--	--	.000	16.8
Kalamazoo	260	119	-3.60	181	225	312	774	10	--	--	.003	-7.17
Lansing	425	408	-89.0	137	295	552	1,900	11	--	--	.345	--
Midland	1,400	1,290	-37.7	662	1,180	1,660	6,760	4	--	--	1.00	--
Mt. Pleasant	30.6	18.0	-19.0	19.0	28.9	39.5	86.8	6	--	--	.476	--
Pontiac	124	71.8	15.7	72.8	109	150	479	12	--	--	.421	--
Saginaw	619	2,060	-268	-80.2	62.1	292	14,900	11	--	--	.635	--
Detroit	7,190	3,740	108	4,940	6,970	8,700	18,200	6	79/01	H	.458	--
Dissolved-solids discharge (residue at 180°)												
Ann Arbor	92.3	67.0	17.9	44.4	79.2	114	411	9	--	--	.763	--
Battle Creek	294	120	-13.6	217	265	376	596	6	--	--	.712	--
Flint	360	402	-12.9	143	267	432	3,040	9	--	--	.487	--
Grand Rapids	627	350	101	394	504	792	1,820	9	--	--	.008	13.2
Jackson	337	139	88.9	237	290	413	777	8	--	--	.000	16.2
Kalamazoo	231	107	4.33	163	204	270	635	9	--	--	.009	-8.04
Lansing	520	474	-87.2	161	389	610	1,590	4	--	--	.398	--
Midland	1,320	1,100	14.1	696	1,150	1,640	5,950	4	--	--	1.00	--
Mt. Pleasant	25.4	13.7	-14.6	16.2	26.6	34.4	66.4	6	--	--	.139	--
Pontiac	111	62.1	31.4	69.3	96.8	135	440	9	--	--	.575	--
Saginaw	284	848	-265	-82.9	51.6	302	6,370	9	--	--	.371	--
Detroit	5,460	2,540	728	3,940	5,120	6,610	12,700	6	79/01	H	.937	--

See footnotes at end of table

Table 13.--Changes in constituent discharges near urban areas--Continued

Urban area	Mean (tons/d)	Standard deviation (tons/d)	Minimum (tons/d)	Percentage of samples in which values are less than or equal to those shown			Maximum (tons/d)	Years of record	Step trend[1]		Linear trend[2]	
				25 (tons/d)	50 (tons/d)	75 (tons/d)			Date (year/month)	Earlier period	Probability level	Slope (tons/d/yr)
Nonfilterable-solids discharge (residue at 105° C)												
Ann Arbor	13.8	27.8	-2.60	1.26	4.97	15.7	220	10	--	--	.906	--
Battle Creek	17.3	22.8	-32.8	4.11	10.9	27.6	87.1	6	--	--	.829	--
Flint	15.6	40.7	-17.3	-4.92	-.593	17.9	172	5	80/07	H	.005	-2.72
Grand Rapids	90.0	212	-249	-4.32	19.1	95.1	1,190	10	--	--	.082	--
Jackson	11.6	10.0	.672	3.74	8.09	15.9	51.0	8	--	--	.008	0.388
Kalamazoo	21.1	26.2	-48.7	6.20	14.7	28.5	139	5	--	--	1.00	--
Lansing	31.2	57.4	-27.6	2.62	10.8	35.1	319	11	--	--	.330	--
Midland	80.8	216	-51.8	-5.18	14.3	41.8	837	4	--	--	.298	--
Mt. Pleasant	5.90	7.77	-6.44	.806	3.69	10.4	33.8	6	--	--	.692	--
Pontiac	5.96	9.52	-2.38	1.04	2.61	6.87	62.5	12	--	--	.056	--
Saginaw	218	1,320	-181	-49.7	.000	28.1	13,300	11	--	--	1.00	--
Detroit	2,400	3,190	-257	650	1,750	3,230	20,700	15	--	--	.676	--

[1] Step trend indicates that an abrupt change in the average discharge of a constituent was detected during the period of record. Summary statistics were based only on data following the date of the step trend.

[2] Linear trend indicates that a gradual change in average discharge during the period of record collection was detected. The discharge data was adjusted to reflect conditions at the end of 1984 using an adjustment which decreased in absolute value as a linear function of time.

[3] H indicates that the average discharge during the earlier period was higher.

[4] L indicates that the average discharge during the earlier period was lower.

Table 14.--Relations between changes in constituent concentrations and streamflow near urban areas

[Concentrations are in mg/L (milligrams per liter) except for specific conductance which is reported as µS/cm at 25° C (microsiemens per centimeter at 25 degrees Celsius).]

Urban area	Flow analisis	Phosphorus total (mg/L as P)	Chloride, total (mg/L as Cl)	Sulfate, total (mg/L as SO_4)	Nitrogen, organic plus ammonia total (mg/L as N)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, nitrate plus nitrite total (mg/L as N)	Specific conductance, (µS/cm at 25 deg. C)	Solids, residue at 105 deg. C total (mg/L)	Solids, residue at 180 deg. C dissolved (mg/L)	Solids, residue at 105 deg. C nonfilterable (mg/L)
Ann Arbor	model	inv[a]	log[b]	log	lin[c]	nfr[d]	hyp[e]	log	inv	log	lin
	corr	-[f]	-	-	-	na[g]	-	-	-	-	+[h]
	R2	0.066	0.143	0.364	0.076	na	0.692	0.174	0.138	0.168	0.042
Battle Creek	model	nfr	lin	nfr	nfr	nfr	nfr	nfr	nfr	nfr	nfr
	corr	na	-	na	na	na	na	na	na	na	na
	R2	na	.210	na	na	na	na	na	na	na	na
Flint	model	hyp	log	lin	nfr	nfr	hyp	hyp	log	hyp	nfr
	corr	-	-	-	na	na	-	-	-	-	na
	R2	.106	.098	.491	na	na	.657	.248	.041	.214	na
Grand Rapids	model	nfr	inv	inv	inv	inv	inv	inv	inv	inv	nfr
	corr	na	-	-	-	-	-	-	-	-	na
	R2	na	.557	.162	.243	0.587	.109	.199	.191	.202	na
Jackson	model	hyp	hyp	hyp	inv	log	inv	hyp	hyp	hyp	lin
	corr	-	-	-	-	-	-	-	-	-	-
	R2	.472	.681	.530	.462	.286	.297	.694	.649	.692	.049
Kalamazoo	model	inv	log	inv	log	inv	inv	inv	inv	inv	nfr
	corr	-	-	-	-	-	-	-	-	-	na
	R2	.173	.139	.323	.183	.207	.229	.199	.186	.199	na
Lansing	model	hyp	log	log	nfr	nfr	nfr	lin	nfr	nfr	log
	corr	-	-	-	na	na	na	-	na	na	+
	R2	.462	.033	.205	na	na	na	.022	na	na	.079
Midland	model	nfr	log	log	inv	log	nfr	log	log	log	nfr
	corr	na	-	-	-	-	na	-	-	-	na
	R2	na	.478	.377	.490	.434	na	.590	.536	.599	na
Mount Pleasant	model	inv	nfr	inv	nfr	nfr	nfr	nfr	nfr	lin	inv
	corr	-	na	-	na	na	na	na	na	-	-
	R2	.094	na	.170	na	na	na	na	na	.101	.094
Pontiac	model	lin	inv	hyp	nfr	nfr	hyp	log	inv	log	lin
	corr	+	-	-	na	na	-	-	-	-	+
	R2	.072	.101	.367	na	na	.521	.223	.244	.251	.122
Saginaw	model	min[i]	nfr	min	min	nfr	nfr	nfr	nfr	nfr	nfr
	corr	na	na	na	na	na	na	na	na	na	na
	R2	na	na	na	na	na	na	na	na	na	na
Detroit	model	nfr	nfr	nfr	nfr	nfr	nfr	nfr	nfr	nfr	nfr
	corr	na	na	na	na	na	na	na	na	na	na
	R2	na	na	na	na	na	na	na	na	na	na

[a] inv indicates inverse model used to describe relationship between streamflow and constituent.
[b] log indicates logarithmc model used to describe relationship between streamflow and constituent.
[c] lin indicates linear model used to describe relationship between streamflow and constituent.
[d] nfr indicates concentation is not flow related at the 5 percent level of significance.
[e] hyp indicates hyperbolic model used to describe relationship between streamflow and constituent.
[f] - indicates negative correlation between streamflow and constituent.
[g] na indicates that analysis is not applicable.
[h] + indicates positive correlation between streamflow and constituent.
[i] min indicates number of data points below minimum needed to develop relationship.

Comparison of trends (table 15) in the changes in nine constituent concentrations and discharges in 12 urban areas indicate: (1) no trend in concentrations or discharges in 66.7 percent of the 108 cases studied, (2) a trend in concentration but not in discharge (13 percent), (3) a trend in discharge but not in concentration (12 percent), (4) a trend in both concentration and discharge (8.3 percent), and (5) two of the nine cases showing a trend in both concentration and discharge indicated a negative trend in concentration and a positive trend in discharge. The positive trend in streamflow in Jackson was associated with a negative trend in concentration of dissolved solids and nonfilterable solids and resulted in a positive trend in discharge.

Changes in concentrations and changes in streamflow were unrelated, for measurements made on the same day, in 43.3 percent of the 120 analysis. Of the remaining cases, comparison of trends in concentrations and FAC indicated: (1) no trend in concentration or FAC (60.3 percent), (2) a trend in concentration but not FAC (14.7 percent), (3) a trend in FAC but not concentration (16.2 percent), (4) a trend in both concentration and FAC (8.8 percent), and (5) all cases showing a trend in both concentration and FAC agreed in algebraic sign.

Most urban areas showed no time trends in concentrations, discharges, or FAC; however, a higher percentage showed trends than would be expected than by pure chance (table 16). More negative trends were identified near urban areas. More trends were identified among FAC and fewer trends among discharges than were identified among concentrations.

Table 15.--Trends in changes of constituent concentration, constituent discharge, and flow-adjusted constituent concentration near urban areas

[Concentrations are in mg/L (milligrams per liter) except for specific conductance which is reported as µS/cm at 25° C (microsiemens per centimeter at 25 degrees Celsius).]

Urban area	Flow analysis	Phosphorus total (mg/L as P)	Chloride, total (mg/L as Cl)	Sulfate, total (mg/L as SO_4)	Nitrogen, organic plus ammonia total (mg/L as N)	Nitrogen, ammonia total (mg/L as N)	Nitrogen, nitrate plus nitrite total (mg/L as N)	Specific conductance, (µS/cm at 25 deg. C)	Solids, residue at 105 deg. C total (mg/L)	Solids, residue at 180 deg. C dissolved (mg/L)	Solids, residue at 105 deg. C nonfilterable (mg/L)	Streamflow ft^3/s
Ann Arbor	conc[a]	-0.002	-0.400	o[b]	o	-0.029	0.077	o	4.75	o	o	o
	disc[c]	o	o	o	-0.078	-.049	o	na[d]	o	o	o	na
	FAC[e]	-[f]	-	o	-	*[g]	o	-	o	-	o	na
Battle Creek	conc	o	.71B	o	o	o	o	o	o	o	o	o
	disc	o	o	o	o	o	o	na	o	o	o	na
	FAC	*	+[h]	*	*	*	*	*	*	*	*	na
Flint	conc	o	o	o	o	o	o	o	o	o	o	o
	disc	o	o	o	-.120	o	o	na	o	o	-2.72	na
	FAC	o	o	o	*	*	o	o	-	o	*	na
Grand Rapids	conc	o	-.500	o	o	o	o	o	o	o	o	o
	disc	o	o	o	o	o	o	na	11.4	13.2	o	na
	FAC	*	o	o	o	o	o	o	o	o	*	na
Jackson	conc	o	o	o	-.042	-.027	o	o	o	-5.20	-.500	18.5
	disc	o	1.26	o	o	o	o	na	16.8	16.2	.388	na
	FAC	-	o	o	o	o	-	o	o	o	o	na
Kalamazoo	conc	o	-.250	o	o	.023	.004	o	o	o	o	-5.40
	disc	o	-.949	o	o	.065	o	na	-7.17	-8.04	o	na
	FAC	o	-	o	o	o	o	-	-	-	*	na
Lansing	conc	o	o	-1.00	o	o	o	o	o	o	o	o
	disc	o	o	o	o	o	o	na	o	o	o	na
	FAC	o	o	-	*	*	*	o	*	*	-	na
Midland	conc	-.006	o	o	o	o	o	o	o	o	-2.77	o
	disc	o	o	o	1.53	o	o	na	o	o	o	na
	FAC	*	o	o	o	o	*	o	o	o	*	na
Mount Pleasant	conc	-.017	o	o	-.062	-.048	.048	o	o	o	o	o
	disc	-.010	-.507	o	-.052	-.028	.019	na	o	o	o	na
	FAC	-	*	o	*	*	*	*	*	-	o	na
Pontiac	conc	o	o	o	o	o	o	o	o	-5.75	o	o
	disc	o	o	-1.58	o	o	o	na	o	o	o	na
	FAC	o	o	o	*	*	o	o	o	o	o	na
Saginaw	conc	o	o	o	o	o	o	o	o	-5.00	o	o
	disc	o	o	o	o	o	o	na	o	o	o	na
	FAC	*	*	*	*	*	*	*	*	*	*	na
Detroit	conc	o	o	o	o	o	o	o	o	o	o	o
	disc	o	o	o	-3.13	o	o	na	o	o	o	na
	FAC	*	*	*	*	*	*	*	*	*	*	na

[a] conc indicates slope of constituent level and time trend, generally in (mg/L)/year
[b] o indicates no trend at the 5 percent level of significance
[c] disc indicates slope of discharge-time trend, in tons/day/year
[d] na indicates analysis not applicable to the specific constituent
[e] FAC indicates direction of flow adjusted constituent and time trend
[f] - indicates flow-adjusted constituent trend negative
[g] * indicates constituent level not related to streamflow rate
[h] + indicates flow-adjusted constituent trend positive

Table 16.--Trend-test results near urban areas

Number of urban area-constituent pairs

	Negative trend	No trend	Positive trend	Number tested
Urban area changes				
Concentration	18	107	7	132
Discharge	13	86	9	108
Flow-adjusted concentration .	16	51	1	68

Percentage of urban area-constituent pairs

	Negative trend	No trend	Positive trend
Urban area changes			
Concentration	13.6	81.1	5.3
Load	12.0	79.7	8.3
Flow-adjusted concentration .	23.5	75.0	1.5
Distribution under the null hypothesis (no trend)	2.5	95.0	2.5

SUMMARY AND CONCLUSIONS

Michigan Department of Natural Resources maintains 23 urban water-quality monitoring sites on inland streams (streams draining basins in Michigan) and 20 sites on Detroit River. The sites on inland streams are located upstream and downstream from 12 urban areas in Michigan's Lower Peninsula. Sites on Detroit River are located at the Windmill Point and Fermi Transects, which are upstream and downstream from the Detroit area. Twelve years of monthly water-quality data for 9 constituents were analyzed, including phosphorus; chloride; sulfate; organic, ammonia, and nitrate plus nitrite nitrogen; and total, dissolved, and nonfilterable-solids residues. Specific conductance was also analyzed.

The water quality of streams was analyzed to (1) characterize the concentration and discharge of selected chemical constituents, (2) characterize the change in concentration and discharge near urban areas on the basis of paired stations upstream and downstream from urban areas, (3) describe the relation between streamflow and concentrations, and (4) detect trends in water-quality data.

Time-series plots were used to identify step trends (abrupt changes) in the average concentration of constituents at each site. Only the most recent past of a record with a step trend was used to characterize water-quality conditions. The plots revealed 22 step trends at sites on inland streams, 52 at sites on Detroit River, and 7 near urban areas. Most step trends occurred in records of phosphorus and nitrogen. Constituent concentrations were higher during earlier periods of record for all records showing step trends except for ammonia nitrogen which was lower.

Records that had a monotonic trend in average concentration with time were identified by using the nonparametric Seasonal Kendall Test. The adequacy of a linear approximation to the monotonic trend was determined by inspection of a plot of the time-series data. Where a linear approximation to the trend was appropriate, the Seasonal Kendall Slope Estimator was used to adjust the data in order for data summaries to reflect current conditions. The adjustment varied over the period of record; larger adjustments (in absolute value) were applied to data obtained early in the data-collection period and smaller adjustments were applied to more recent data. Periods of record that exhibited nonlinear trends were considered nonhomogeneous and were divided into two periods-- an earlier and later period. The earlier period contained the nonlinear trend; data summaries were computed on the later period.

Data from most sites and urban areas showed no linear time trend in constituent concentration, constituent discharge, or flow-adjusted constituent concentration. Occurrence of a trend in concentration was generally associated with a trend in discharge and flow-adjusted concentration. More trends were identified among flow-adjusted concentrations than among concentrations; fewer trends were identified among discharge data.

Data summaries for concentrations and discharges reflect current (end of 1984) conditions. For inland streams, Saginaw River generally had the greatest constituent concentrations and discharges; Grand River upstream from Jackson ranked among the least constituent concentrations and discharges. Median dissolved-solids concentrations for Clinton River downstream from

Pontiac exceed Michigan's 1986 stream-water quality standard. Upstream from Detroit, constituent concentrations of Detroit River did not differ appreciably across Windmill Point Transect. However, downstream from Detroit at the Fermi Transect, most constituent concentrations of Detroit River were greater near the American and Canadian shorelines. Greatest changes in constituent concentrations generally occurred in the Grand River near Jackson, the Clinton River near Pontiac, and the Tittabawassee River near Midland; smallest changes in constituent concentrations occurred in Saginaw River near Saginaw, Detroit River near Detroit, and Kalamazoo River near Battle Creek. Maximum change in constituent discharges occurred in Detroit River near Detroit for all constituents. Among urban areas along inland streams, greatest changes in constituent discharges occurred in Grand River near Grand Rapids while the least changes in constituent discharges occurred in Chippewa River near Mount Pleasant.

Streamflow and constituent concentrations were correlated at most (73-percent) sites on inland streams but few (15 percent) sites on Detroit River. At inland sites, higher streamflows were generally (78 percent) associated with lower constituent concentrations. In urban areas, changes in streamflow and changes in constituent concentrations were related in 57 percent of the analyses; greater changes in streamflows were generally (94.1 percent) associated with smaller changes in constituent concentration.

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page 59 follows

ILLUSTRATIONS

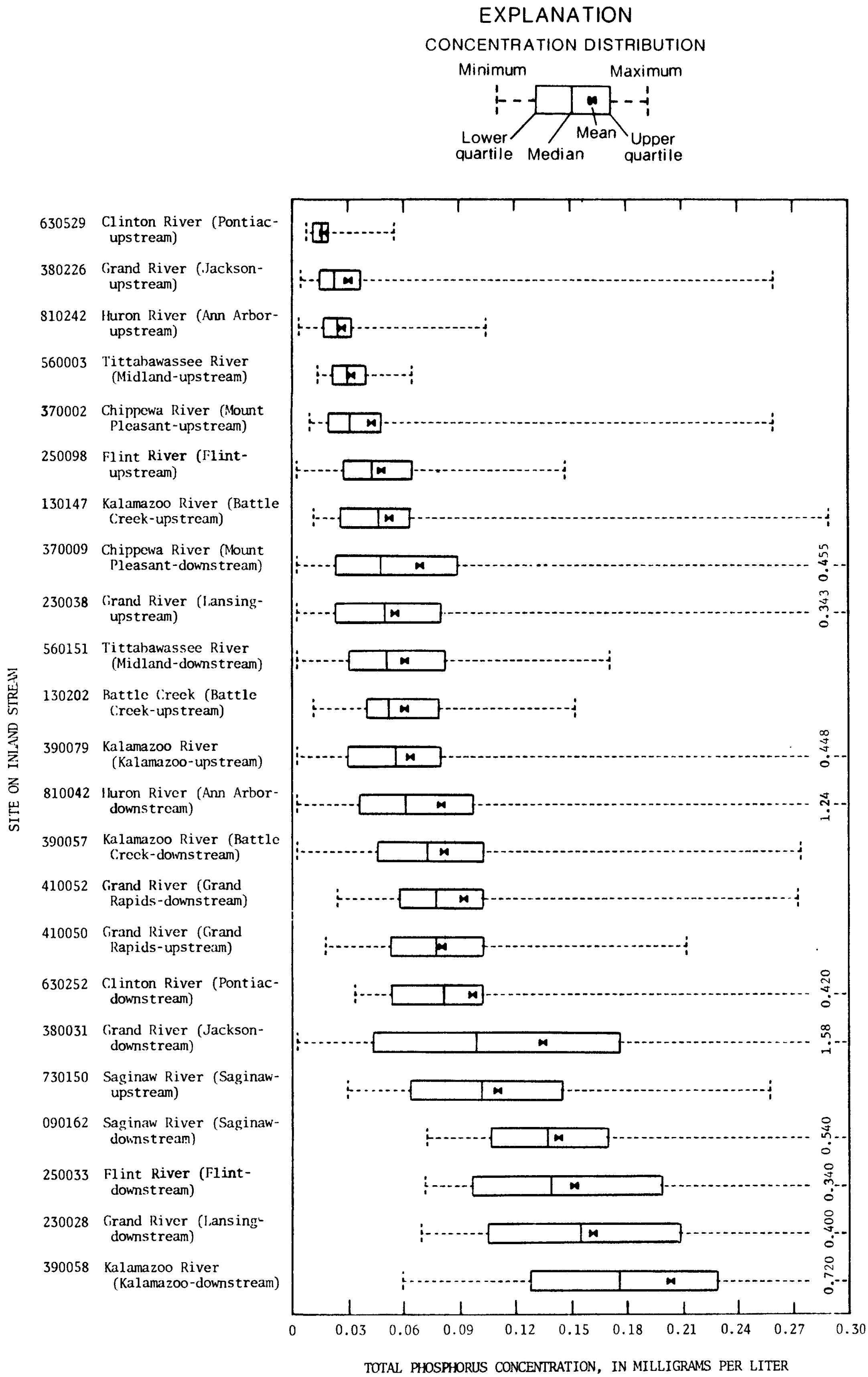


Figure 7.--Sites on inland streams and variation of total phosphorus concentration.

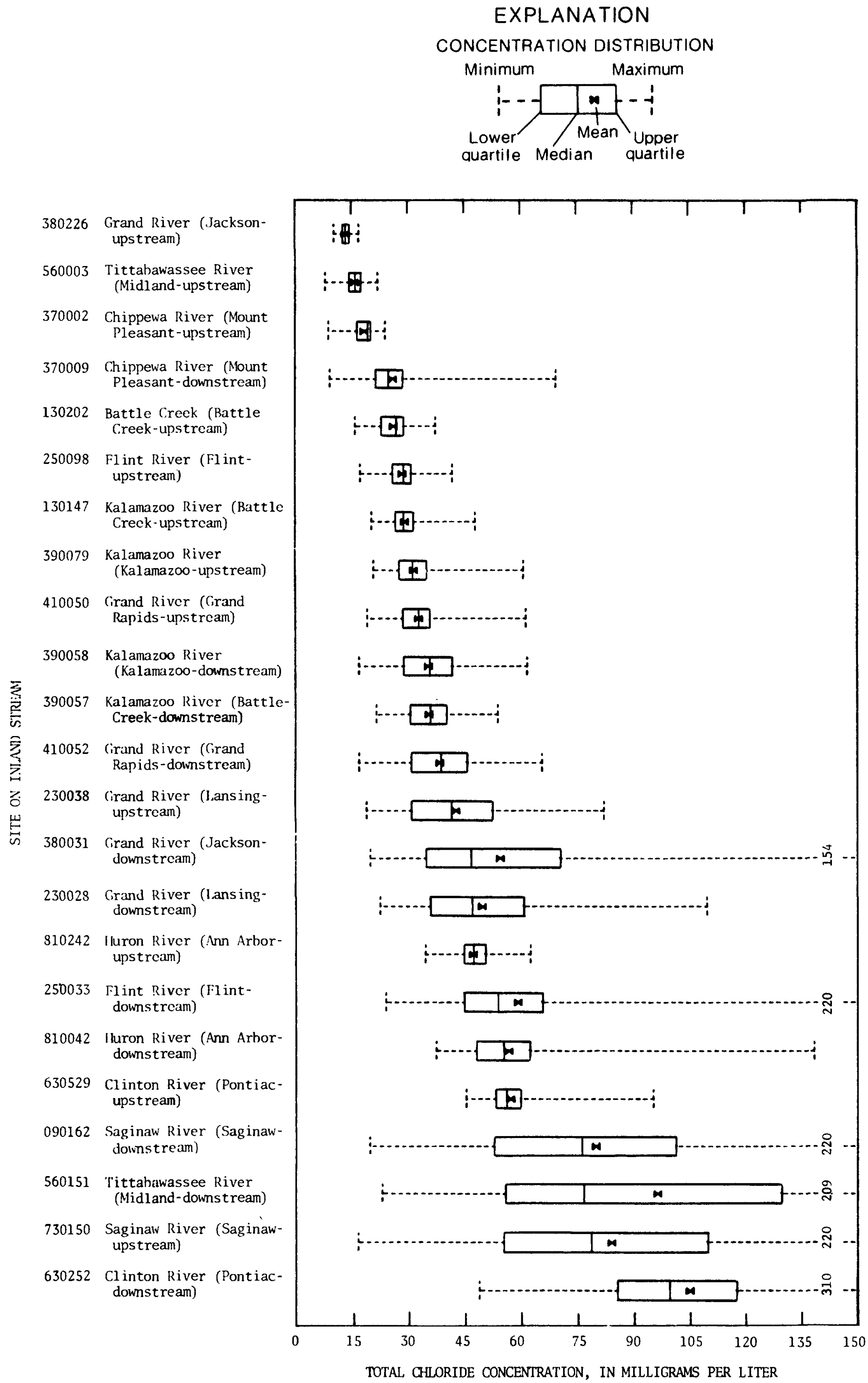


Figure 8.--Sites on inland streams and variation of total chloride concentration.

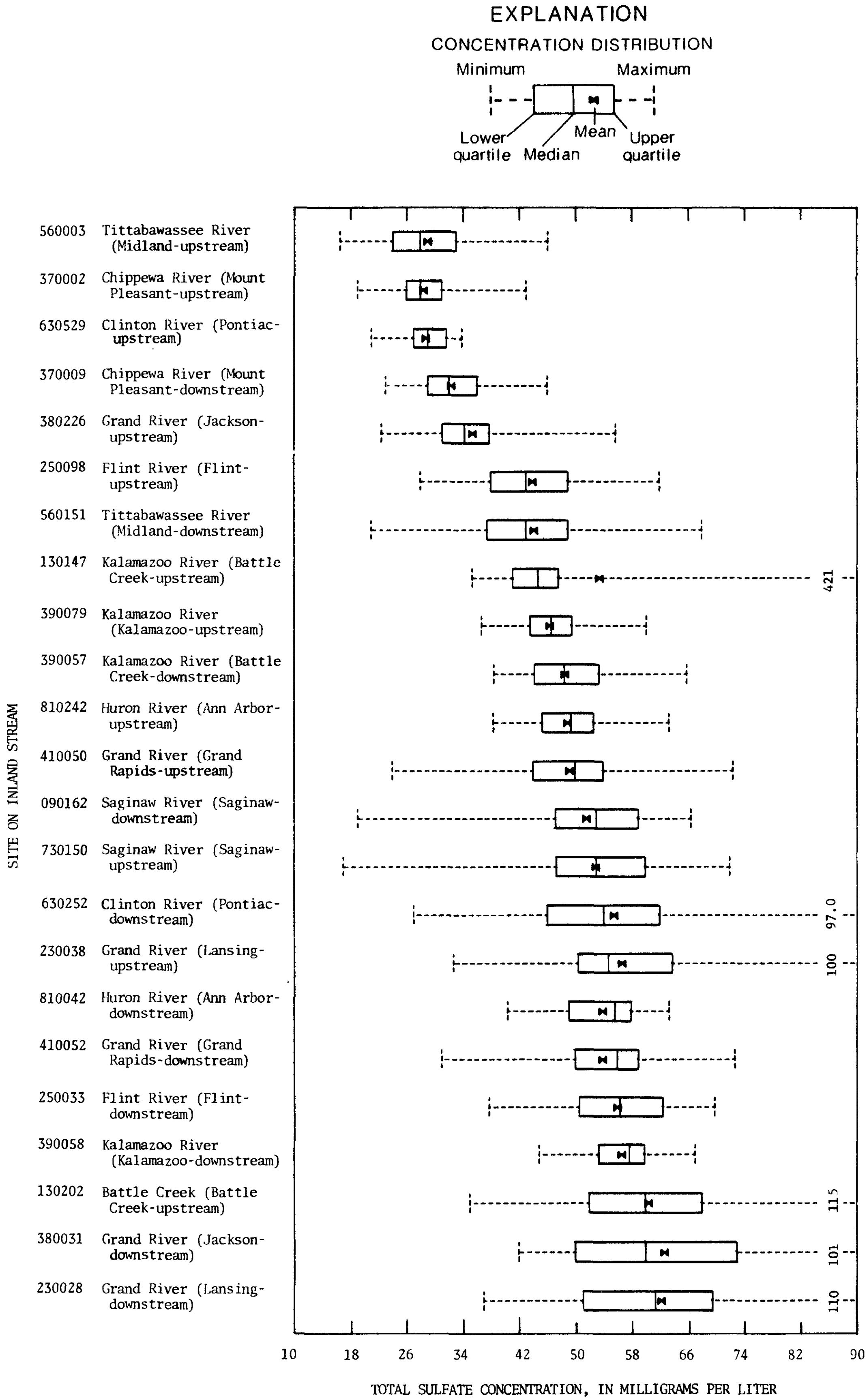


Figure 9.--Sites on inland streams and variation of total sulfate concentration.

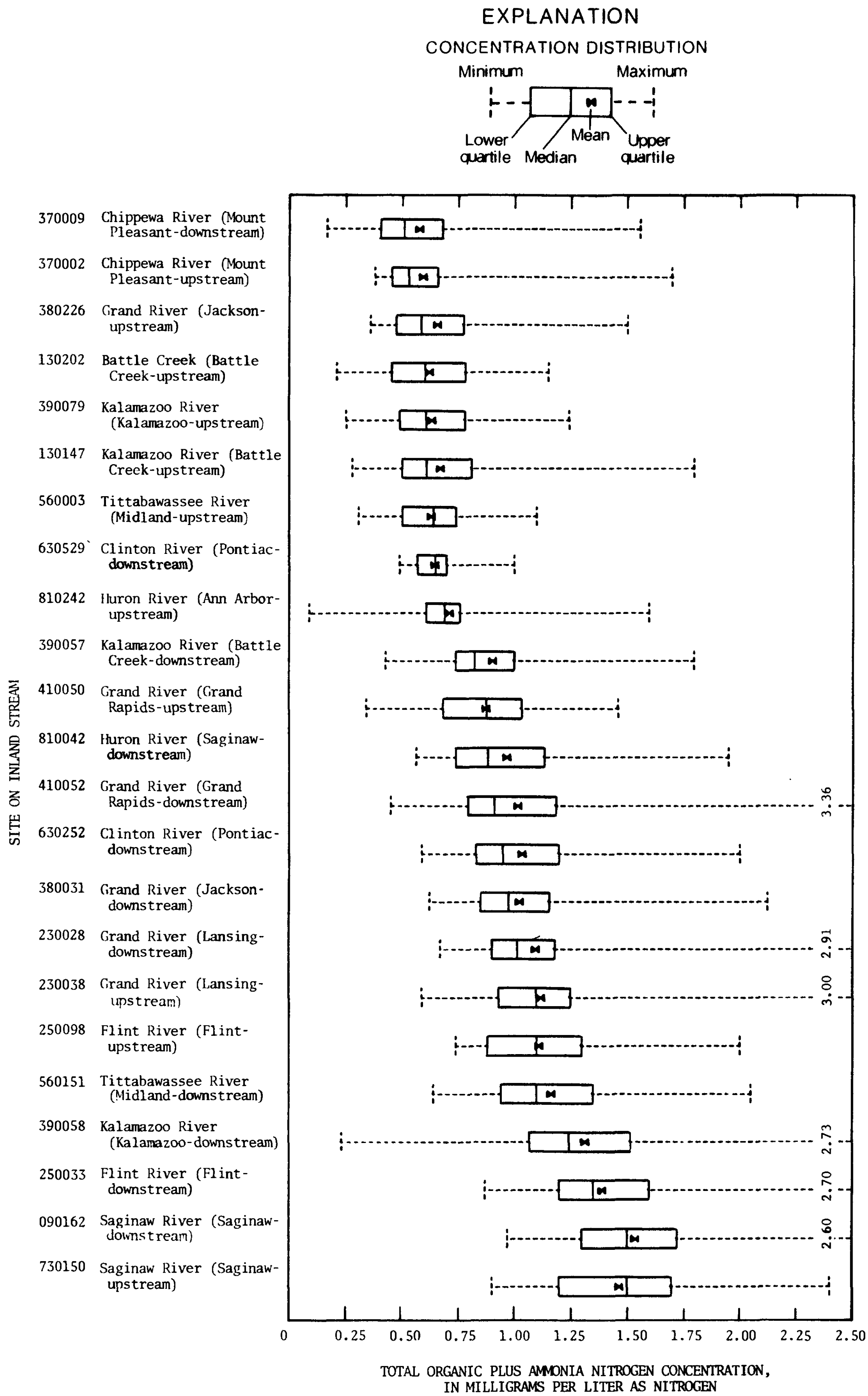


Figure 10.--Sites on inland streams and variation of total organic plus ammonia nitrogen concentration.

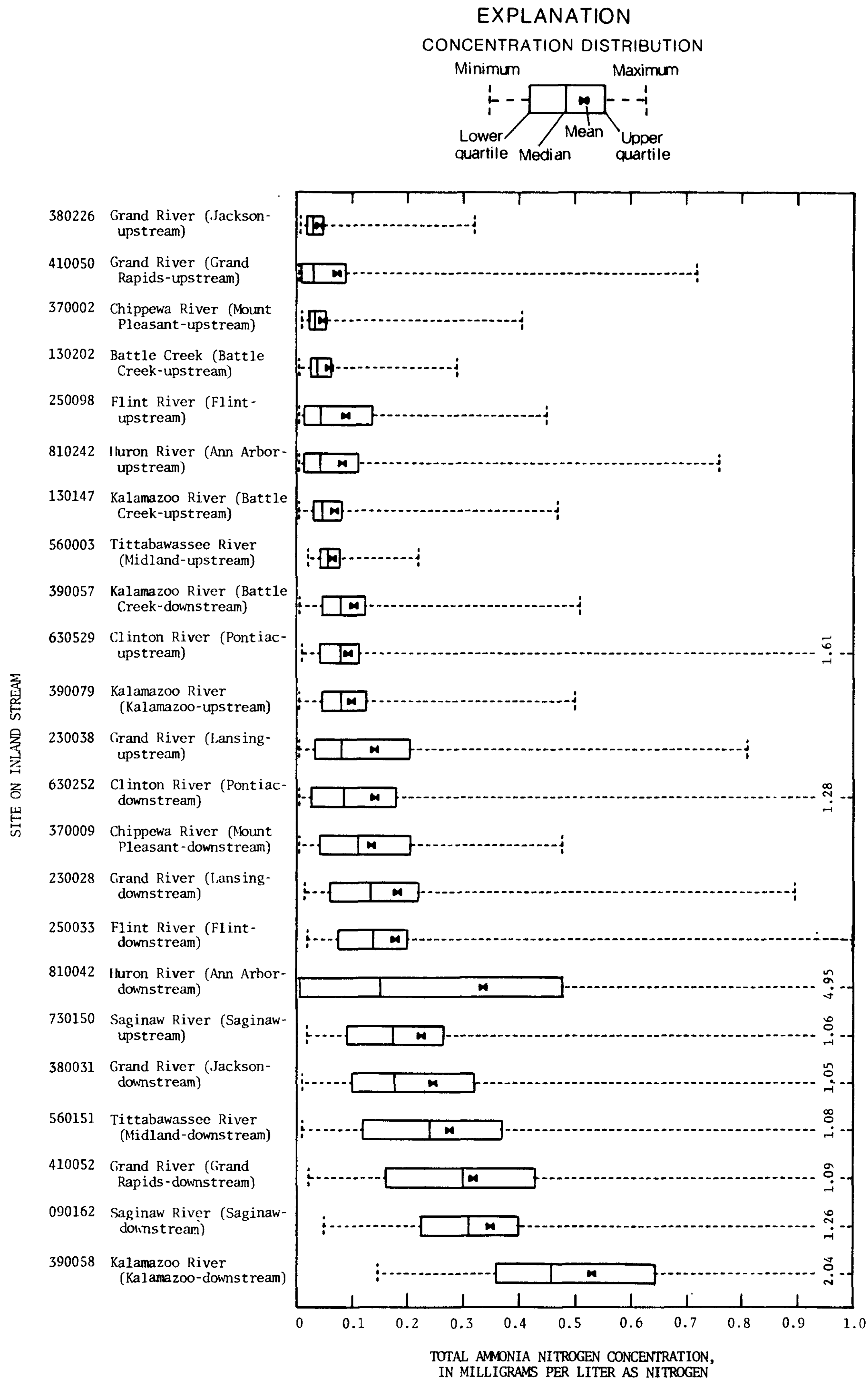


Figure 11.--Sites on inland streams and variation of total ammonia nitrogen concentration.

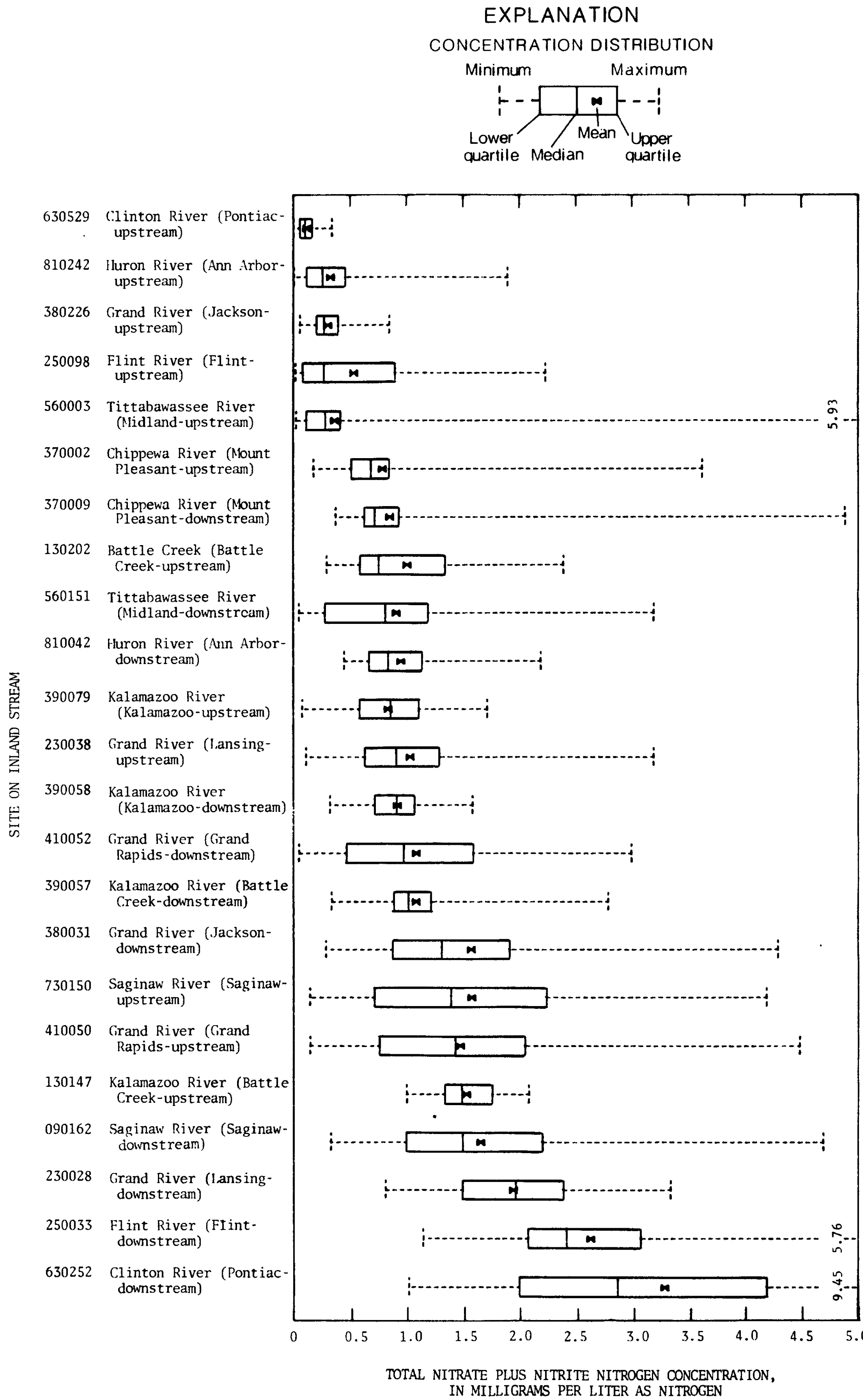


Figure 12.--Sites on inland streams and variation of total nitrate plus nitrite nitrogen concentration.

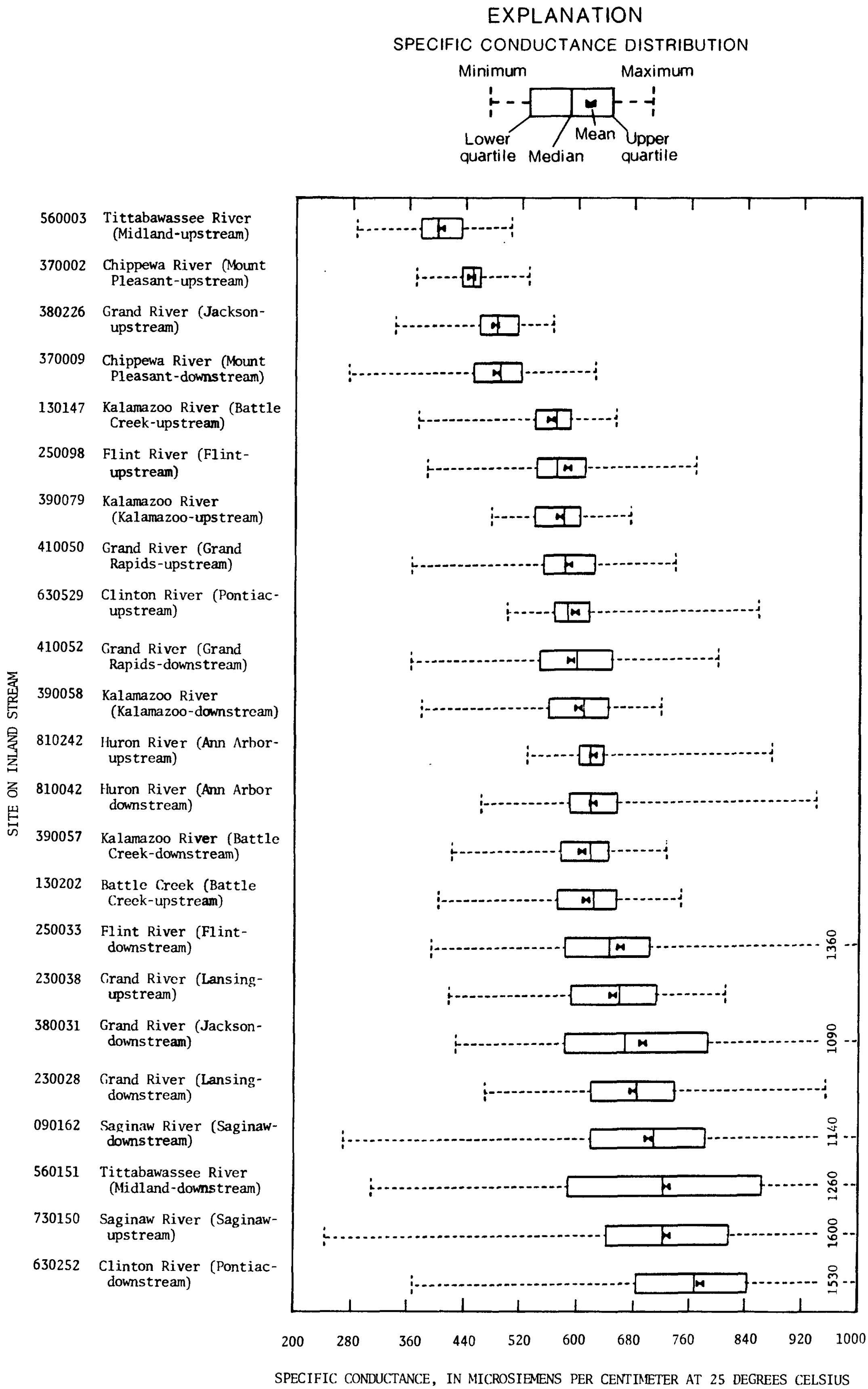


Figure 13.--Sites on inland streams and variation of specific conductance.

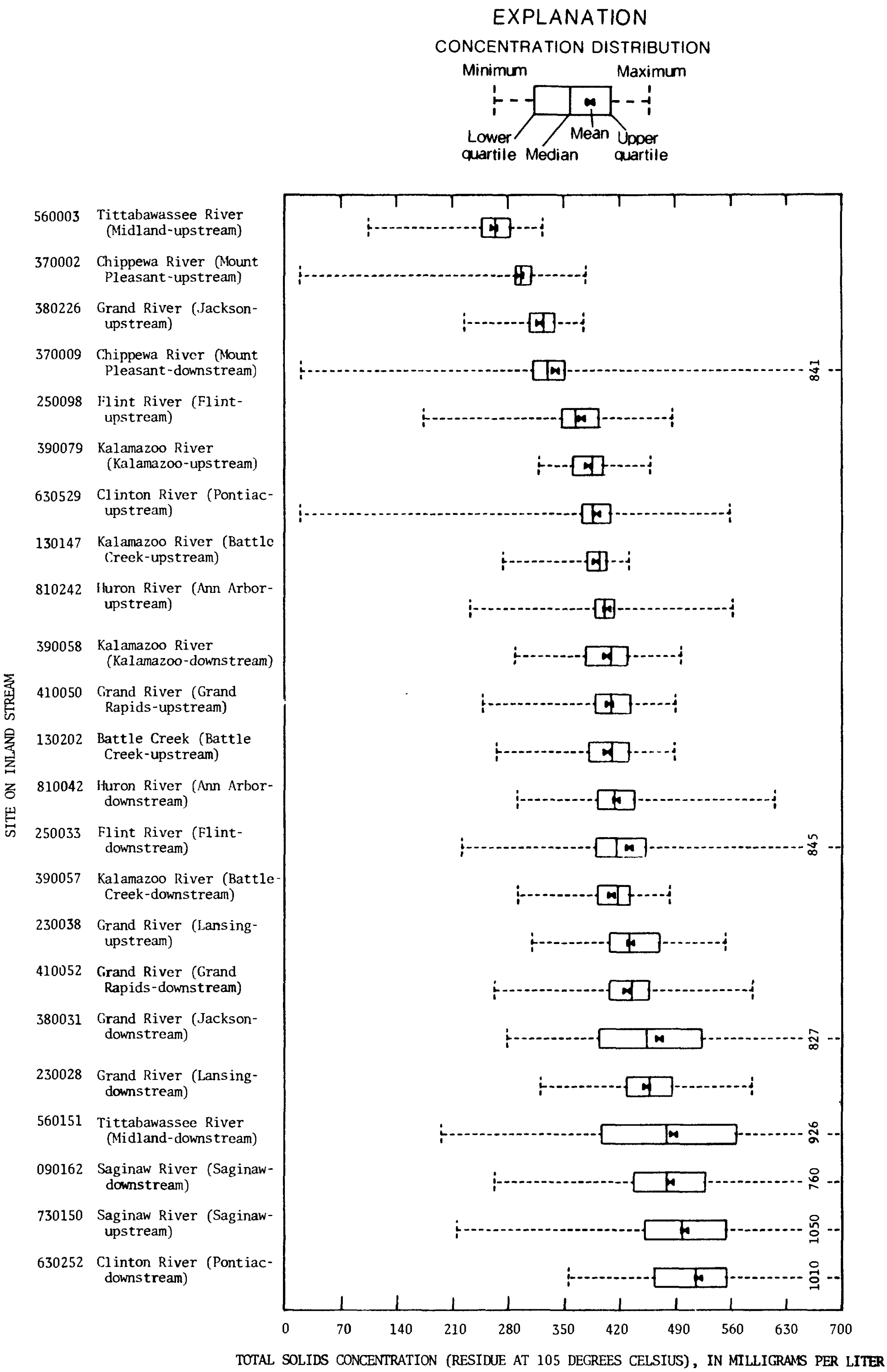


Figure 14.--Sites on inland streams and variation of total solids concentration.

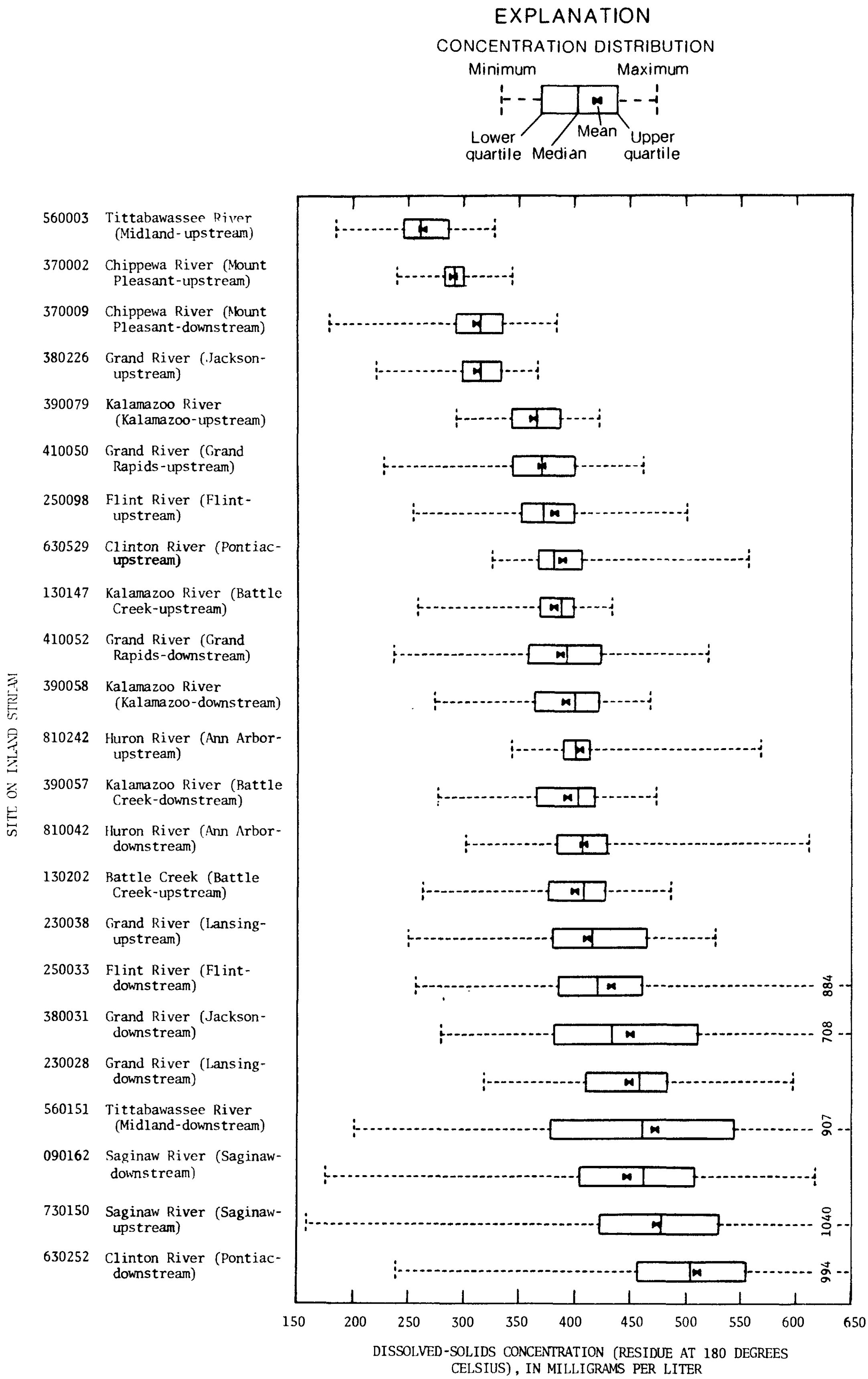


Figure 15.--Sites on inland streams and variation of dissolved-solids concentration.

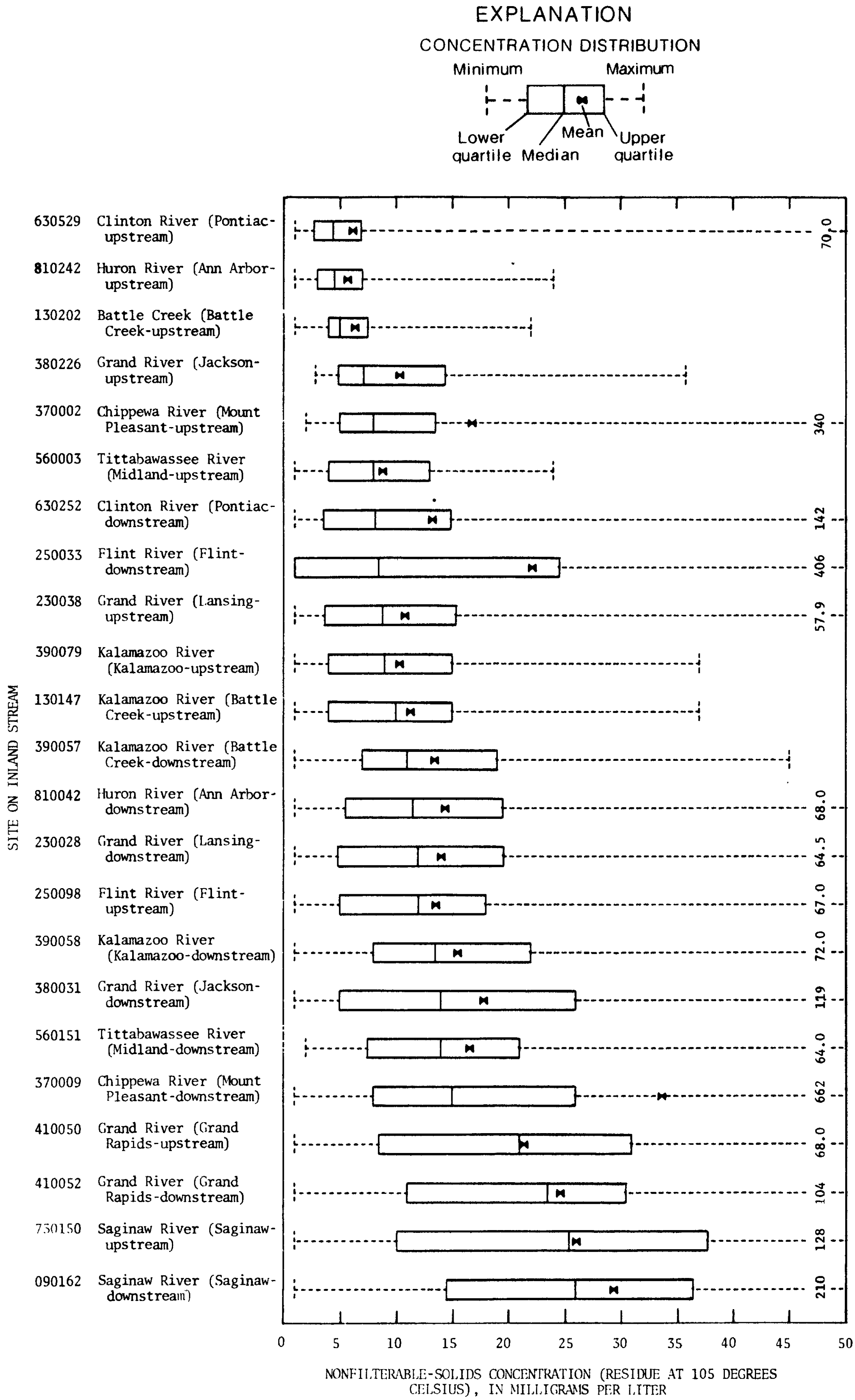


Figure 16.--Sites on inland streams and variation of nonfilterable-solids concentration.

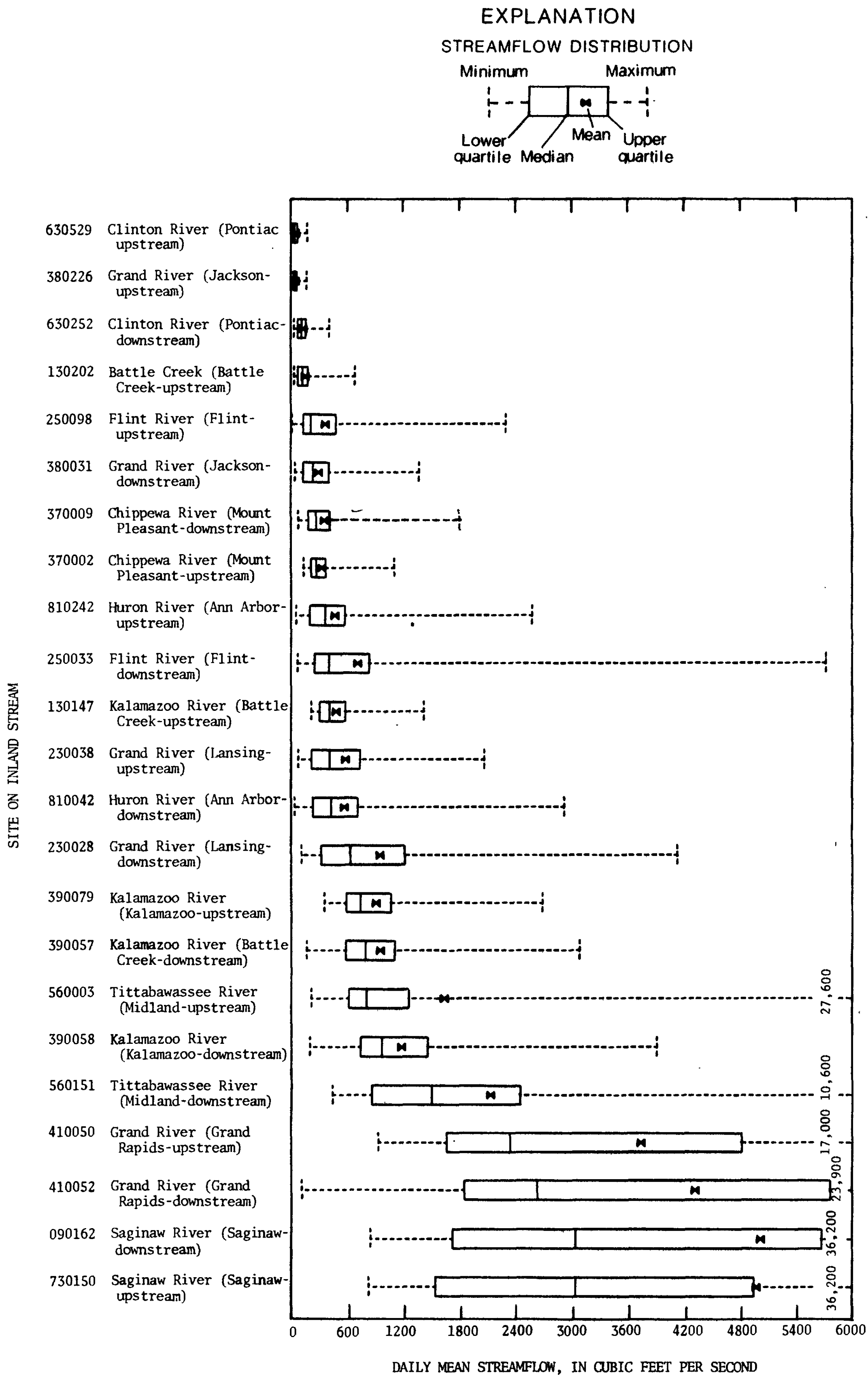


Figure 17.--Sites on inland streams and variation of streamflow.

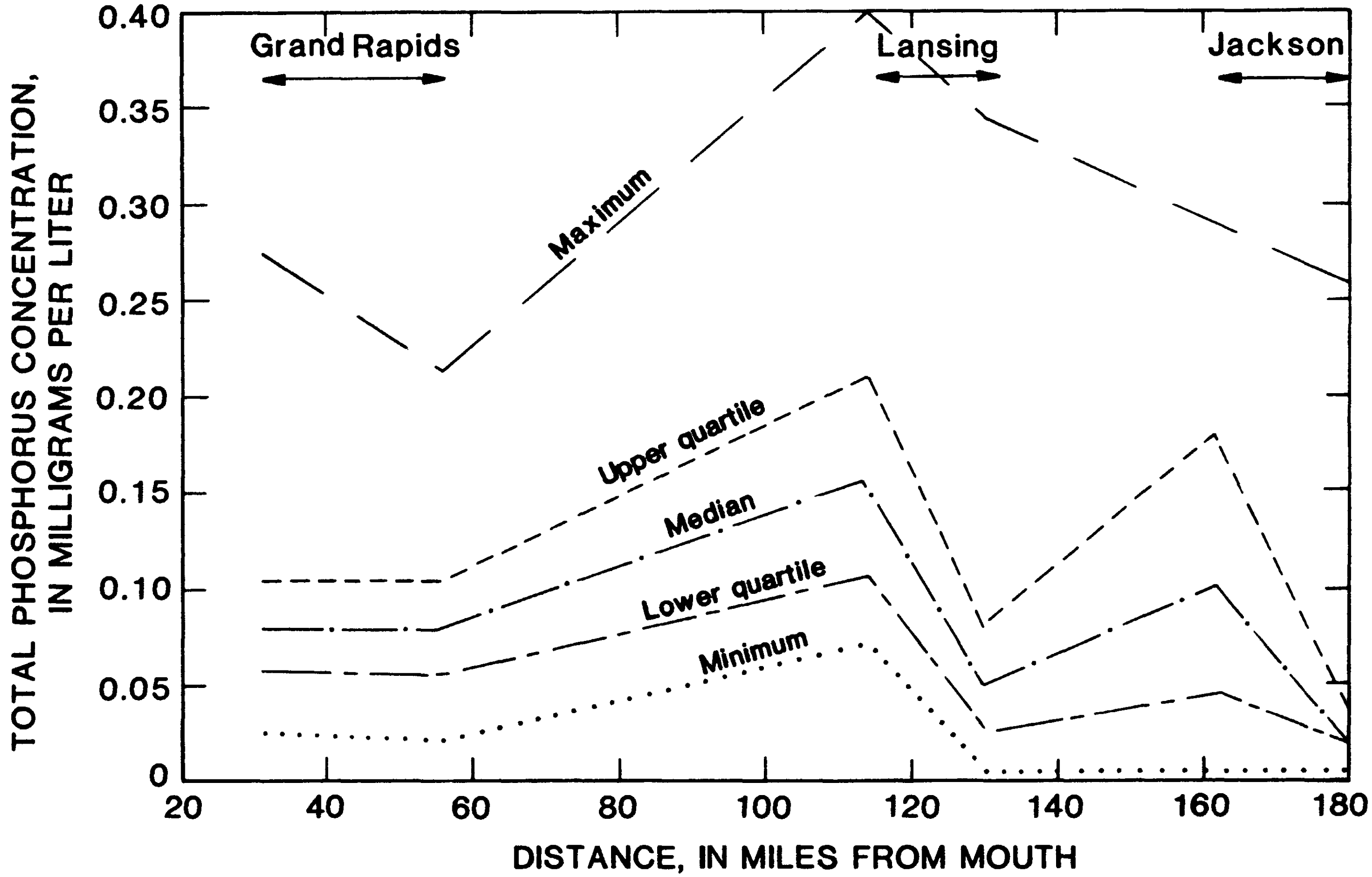


Figure 21.--Urban areas along Grand River and changes in total phosphorus concentration.

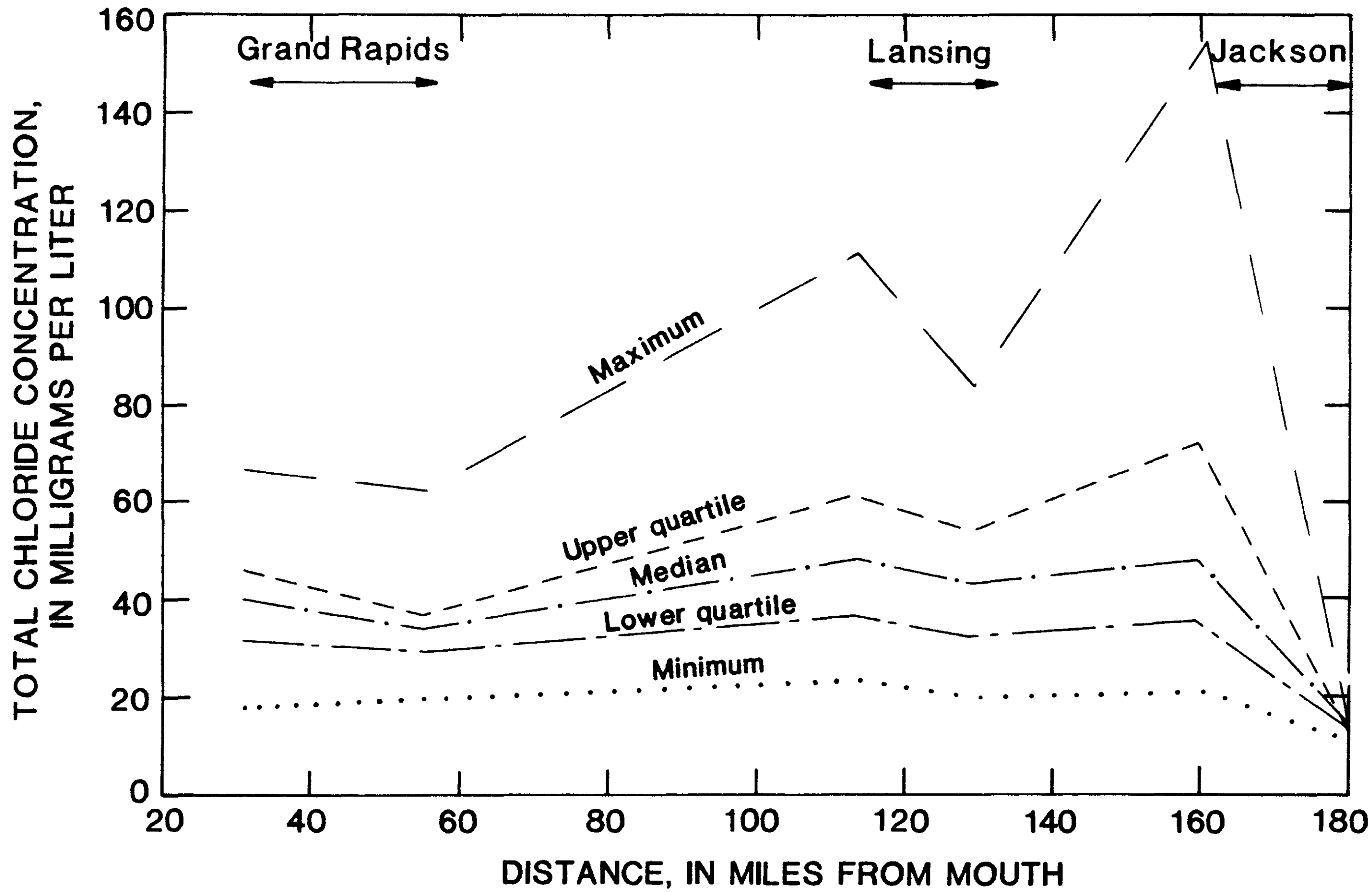


Figure 22.--Urban areas along Grand River and changes in total chloride concentration.

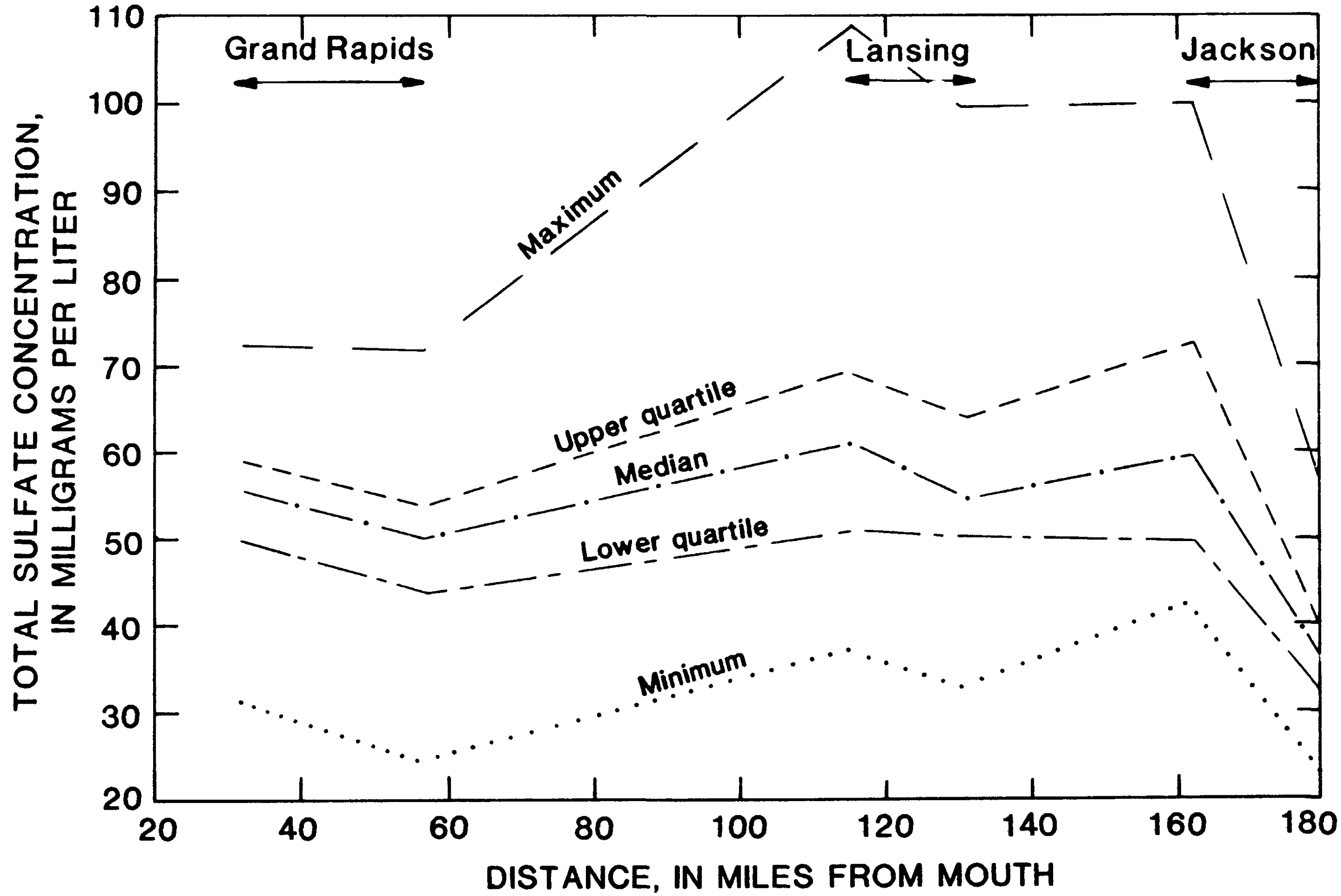


Figure 23.--Urban areas along Grand River and changes in total sulfate concentration.

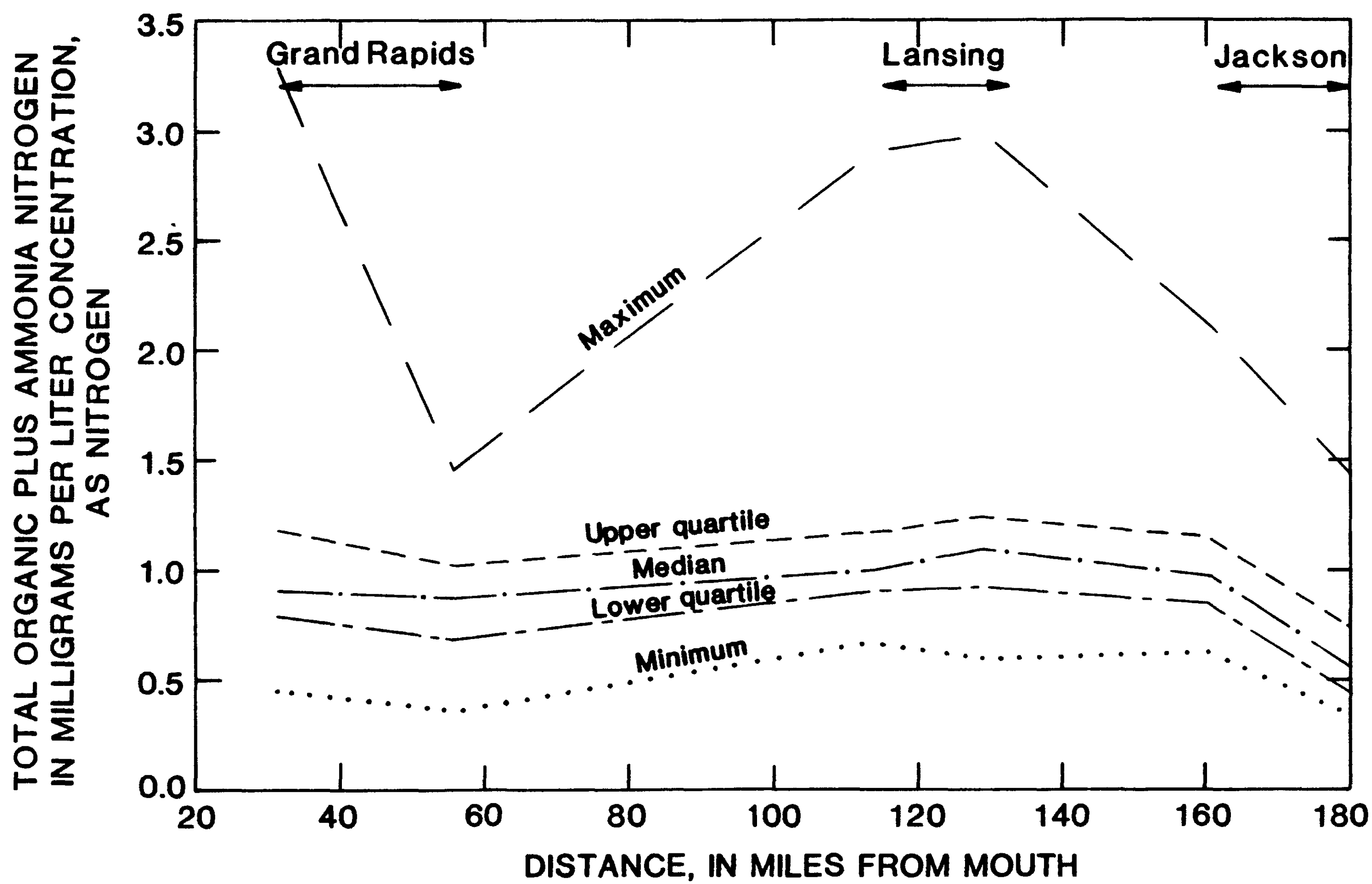


Figure 24.--Urban areas along Grand River and changes in total organic plus ammonia nitrogen concentration.

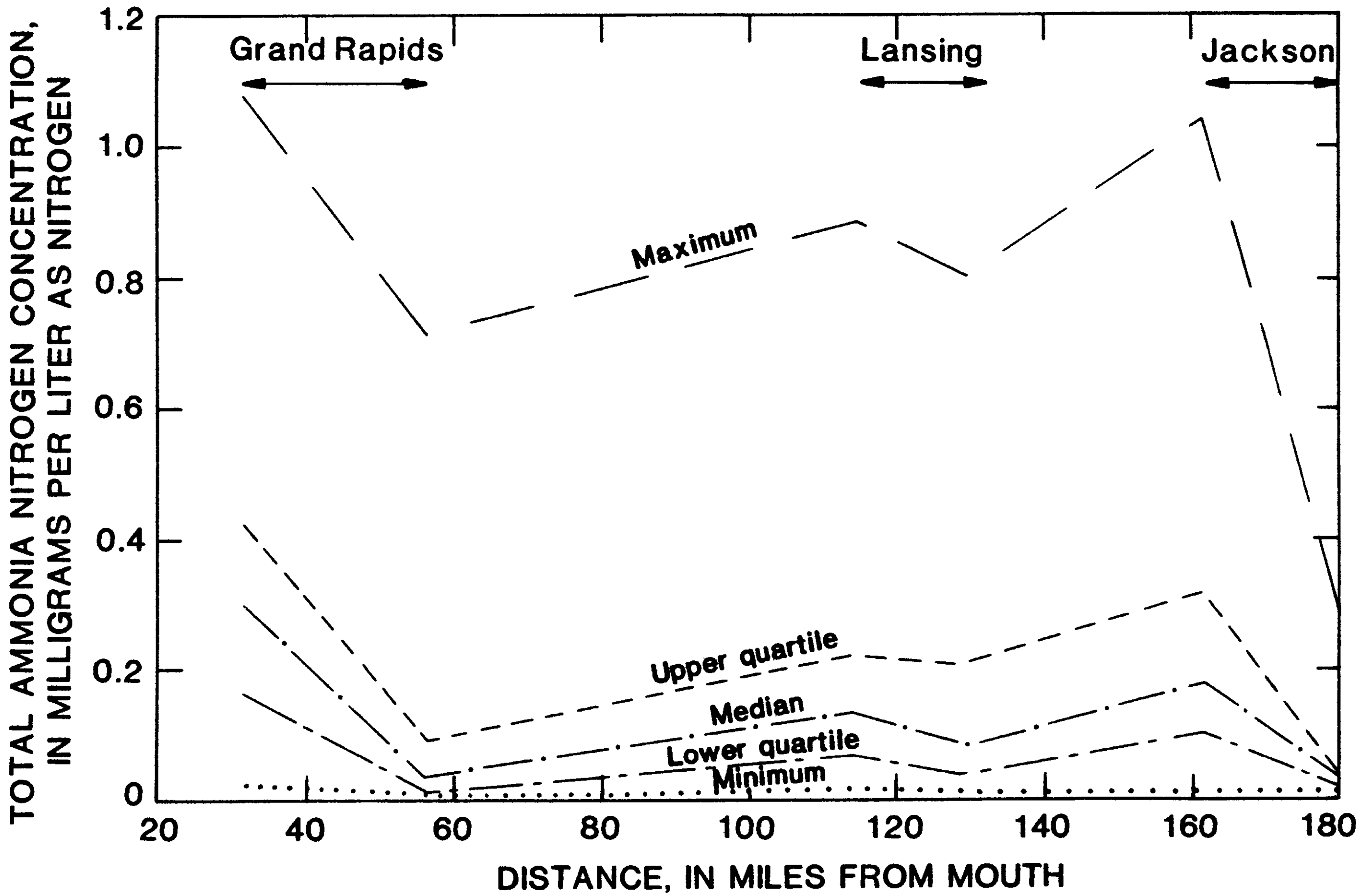


Figure 25.--Urban areas along Grand River and changes in total ammonia nitrogen concentration.

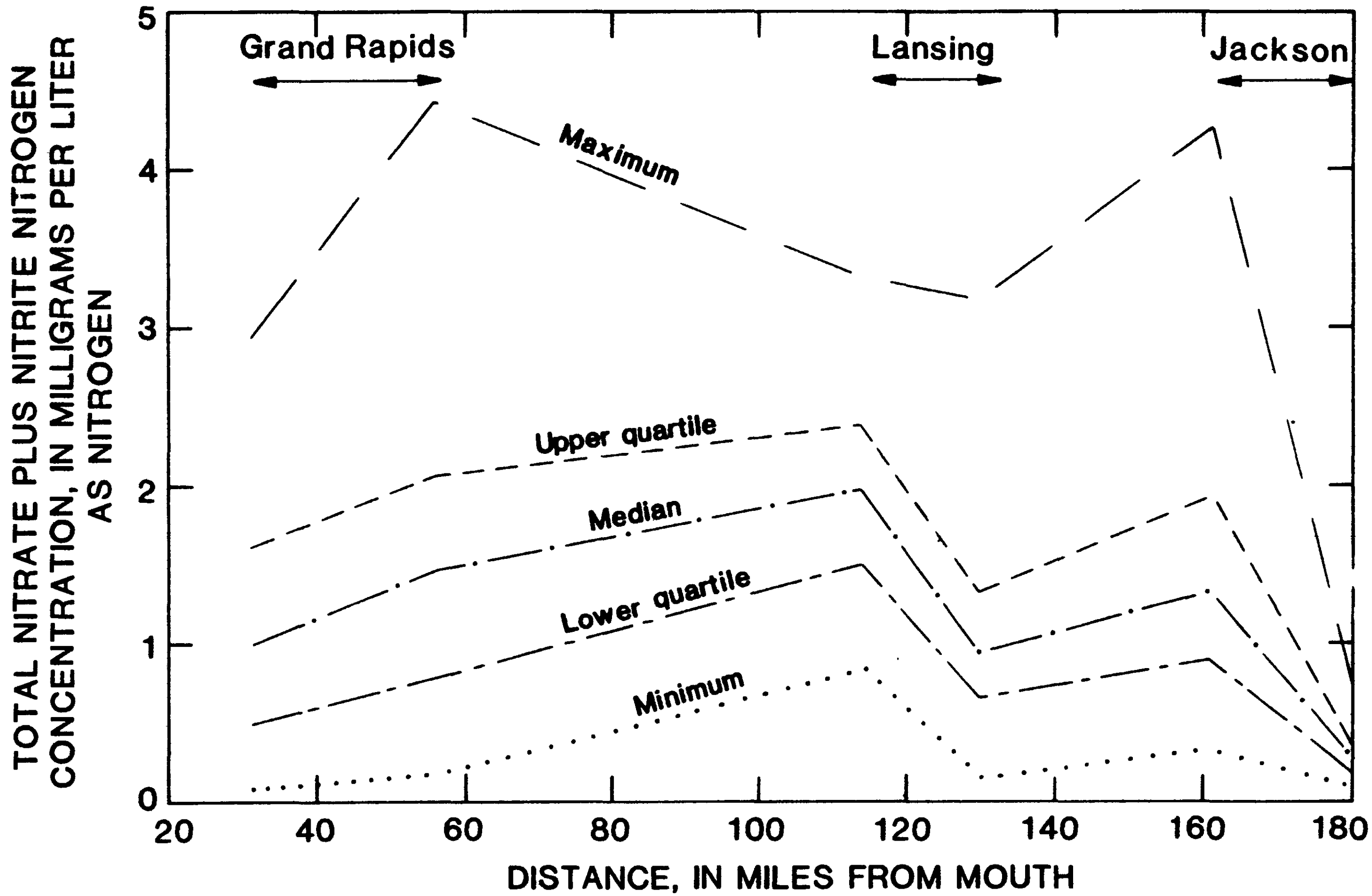


Figure 26.--Urban areas along Grand River and changes in total nitrate plus nitrite nitrogen concentration.

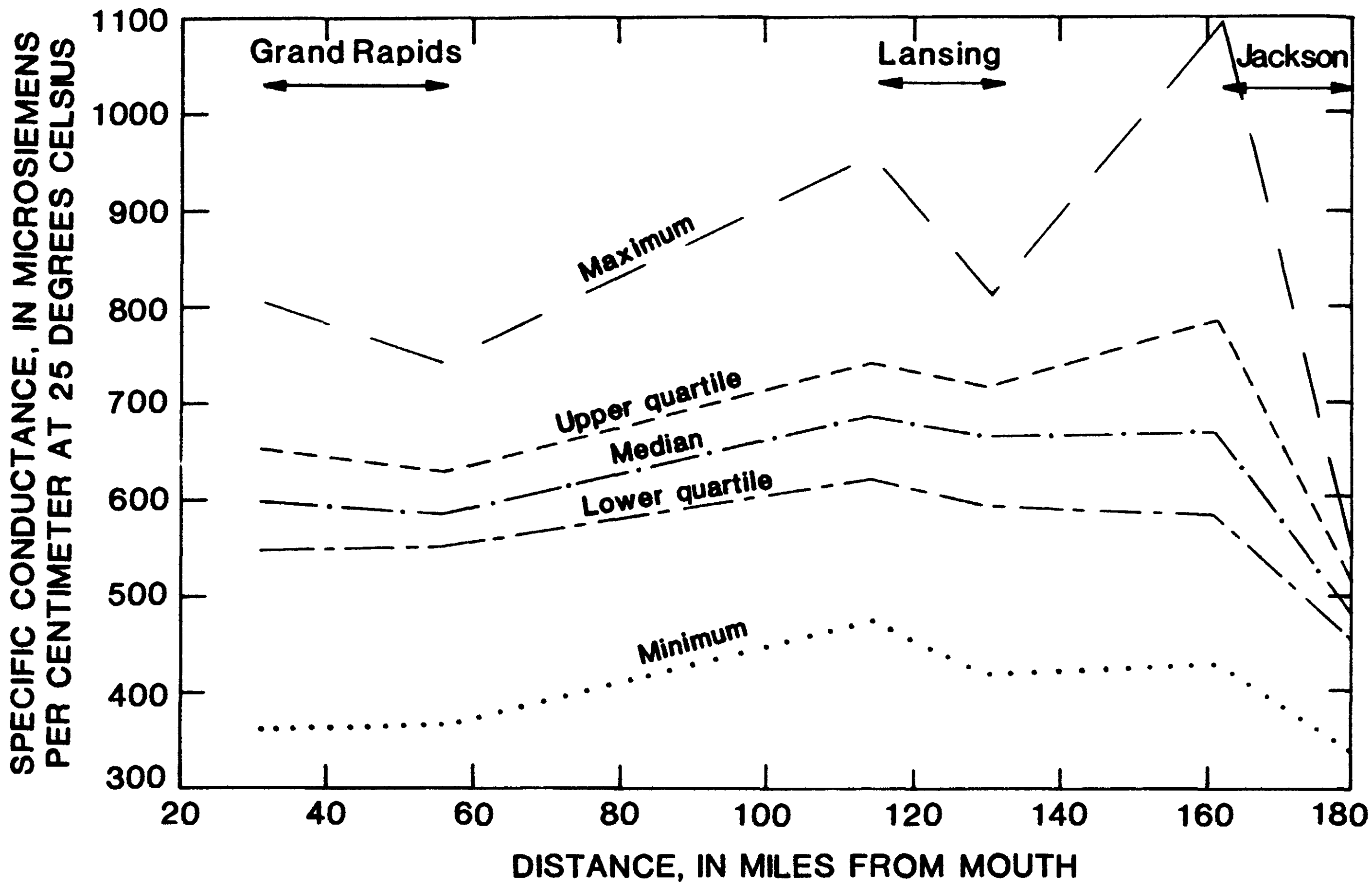


Figure 27.--Urban areas along Grand River and changes in specific conductance.

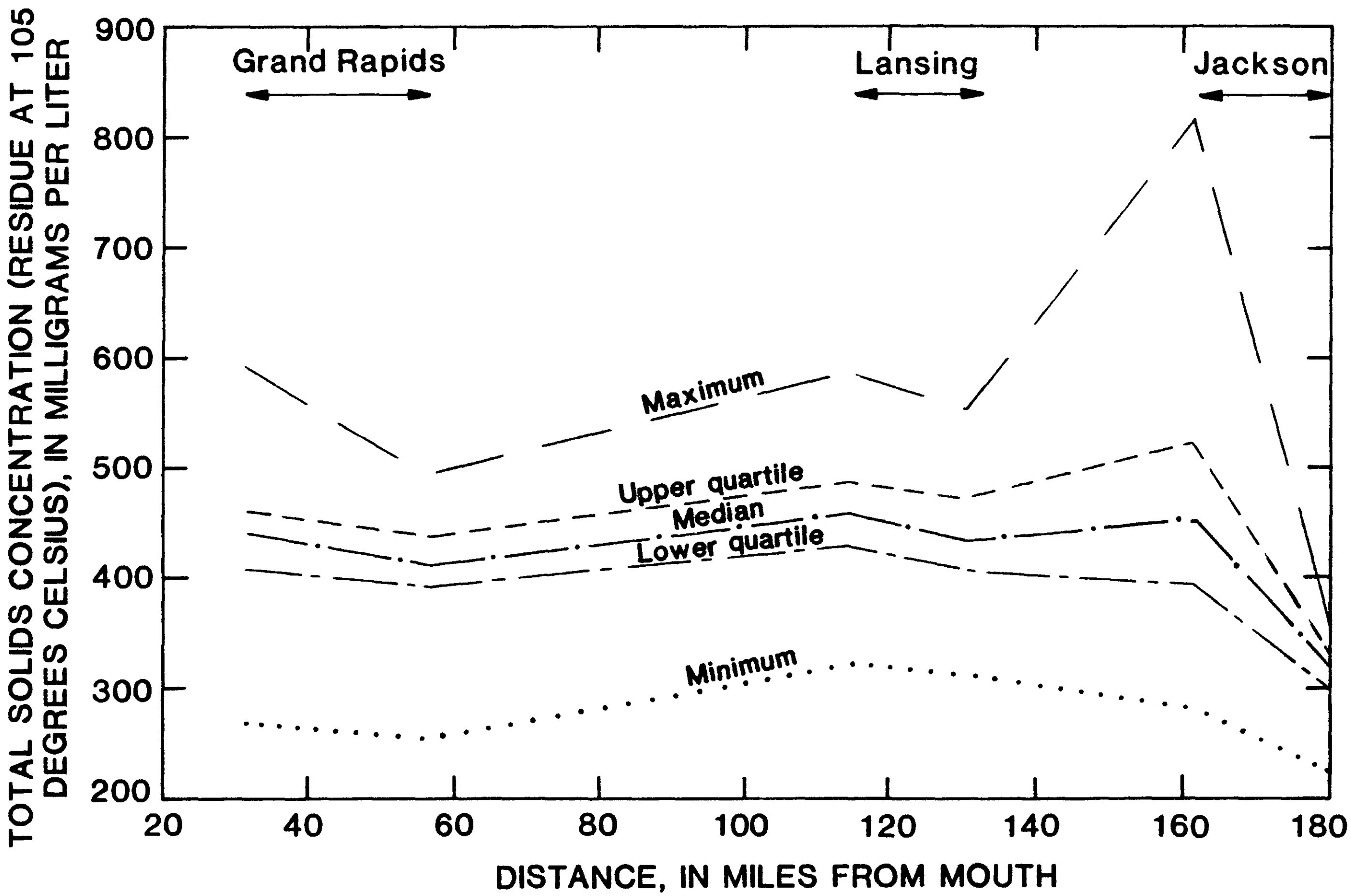


Figure 28.--Urban areas along Grand River and changes in total solids concentration.

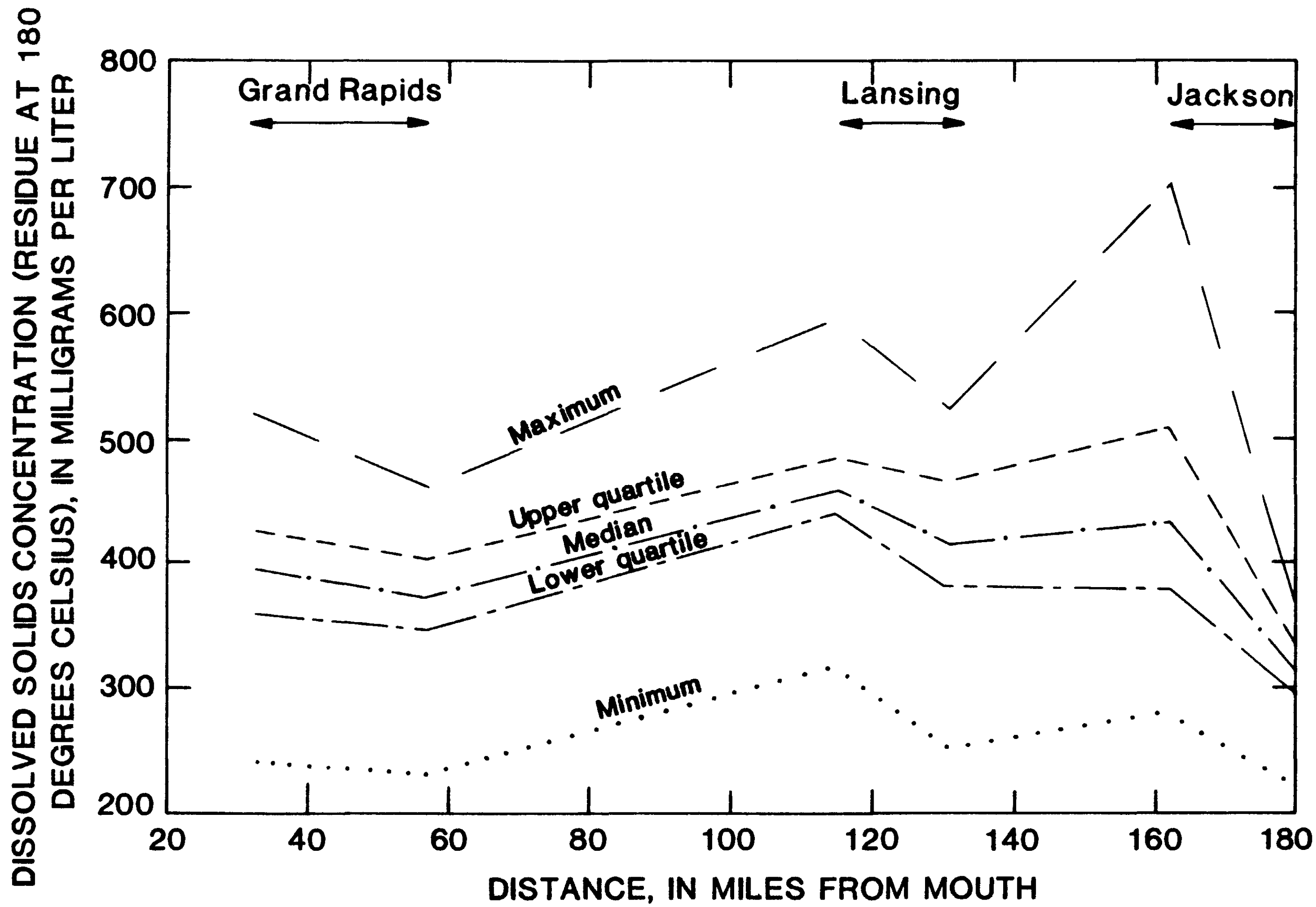


Figure 29.--Urban areas along Grand River and changes in dissolved-solids concentration.

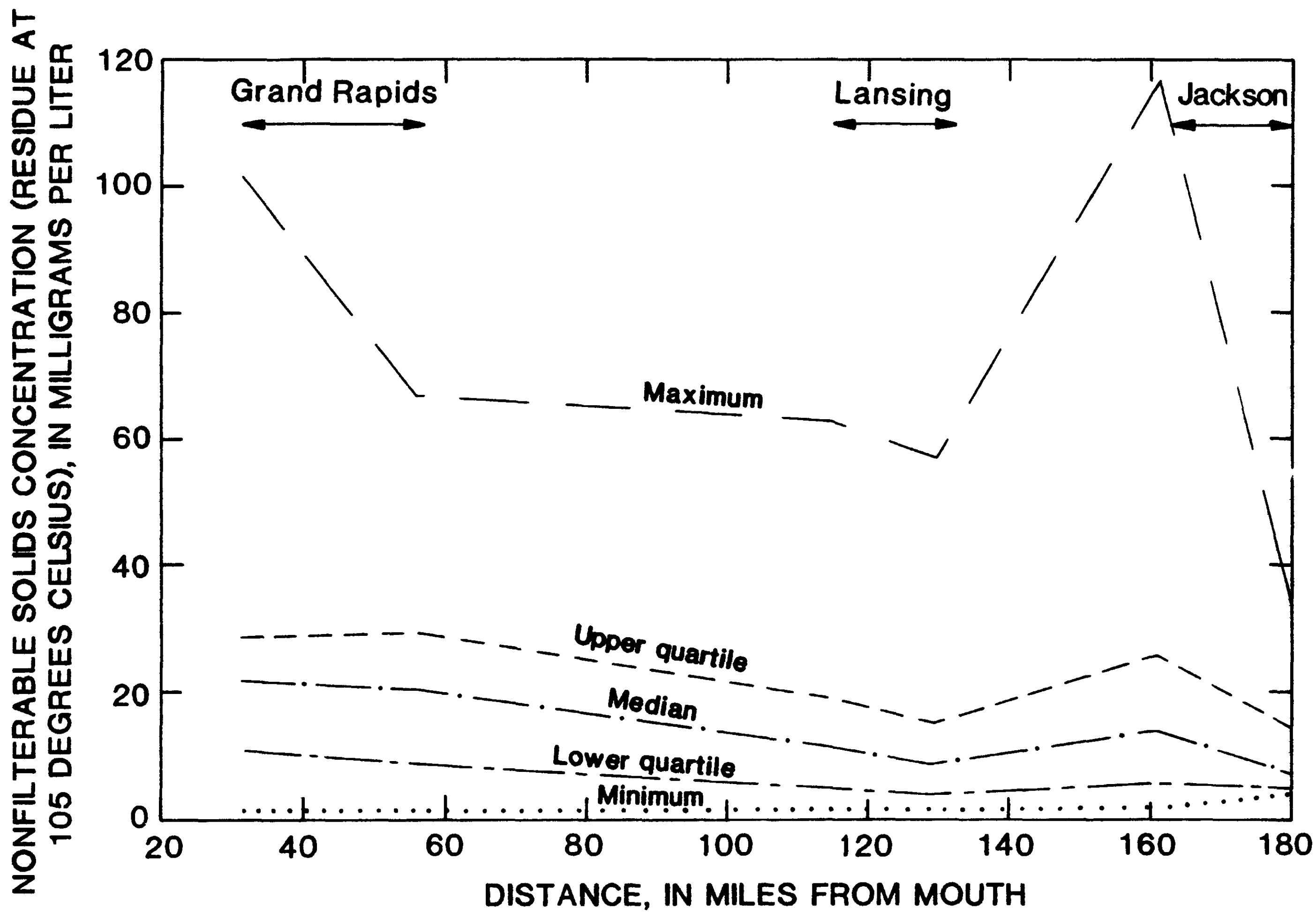


Figure 30.--Urban areas along Grand River and changes in nonfilterable-solids concentration.

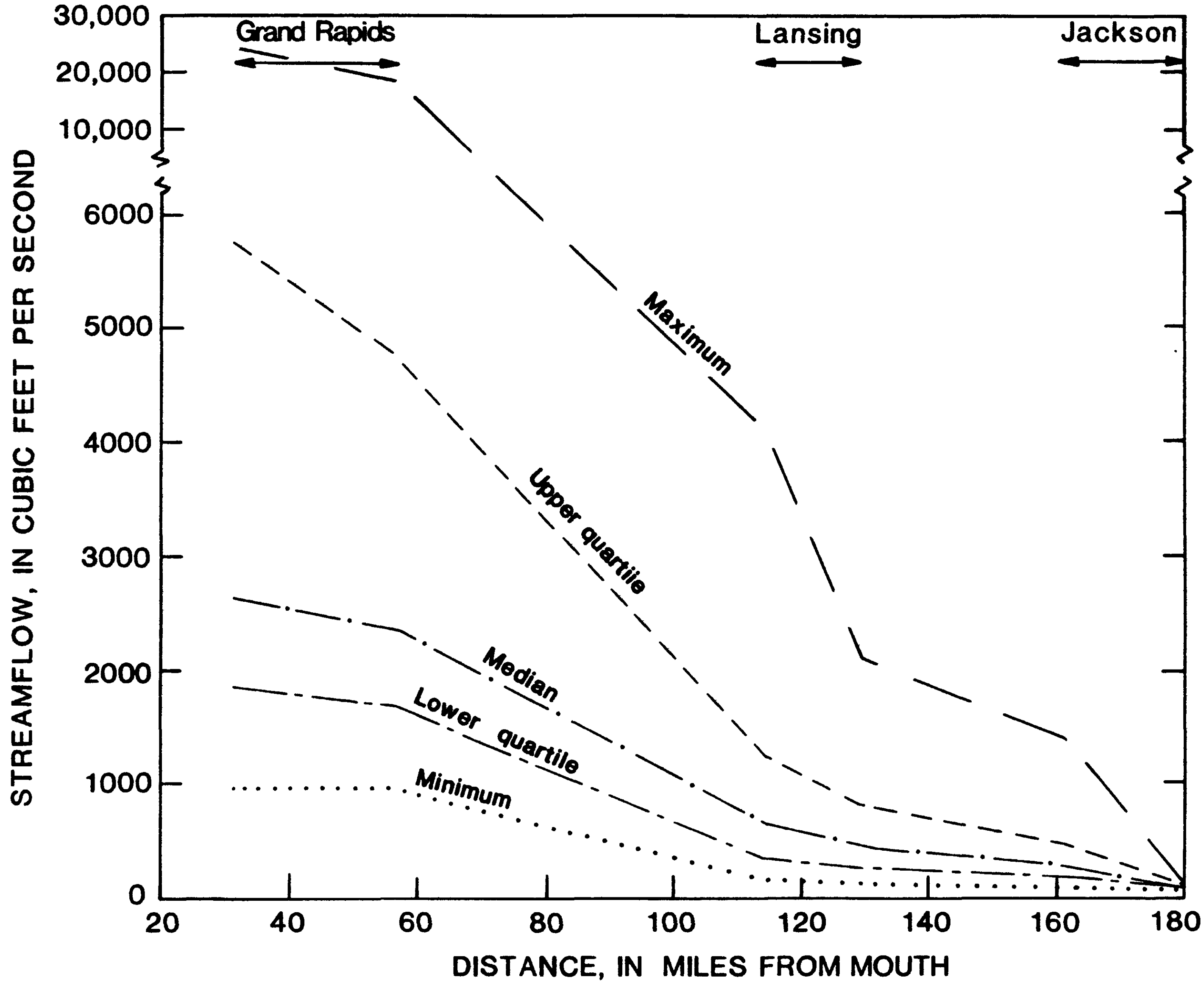


Figure 31.--Urban areas along Grand River and changes in streamflow.

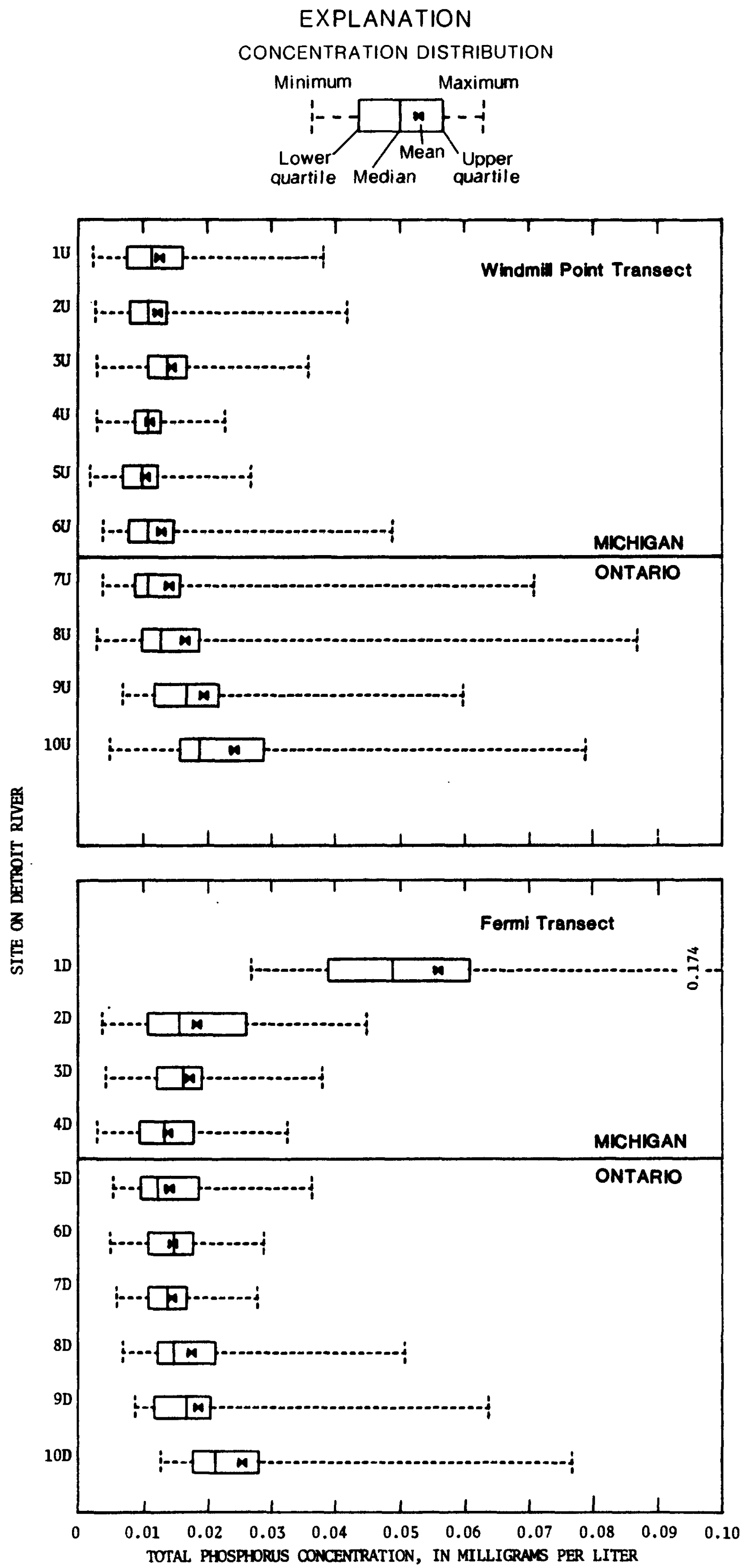


Figure 32.--Sites on Detroit River and variation of total phosphorus concentration.

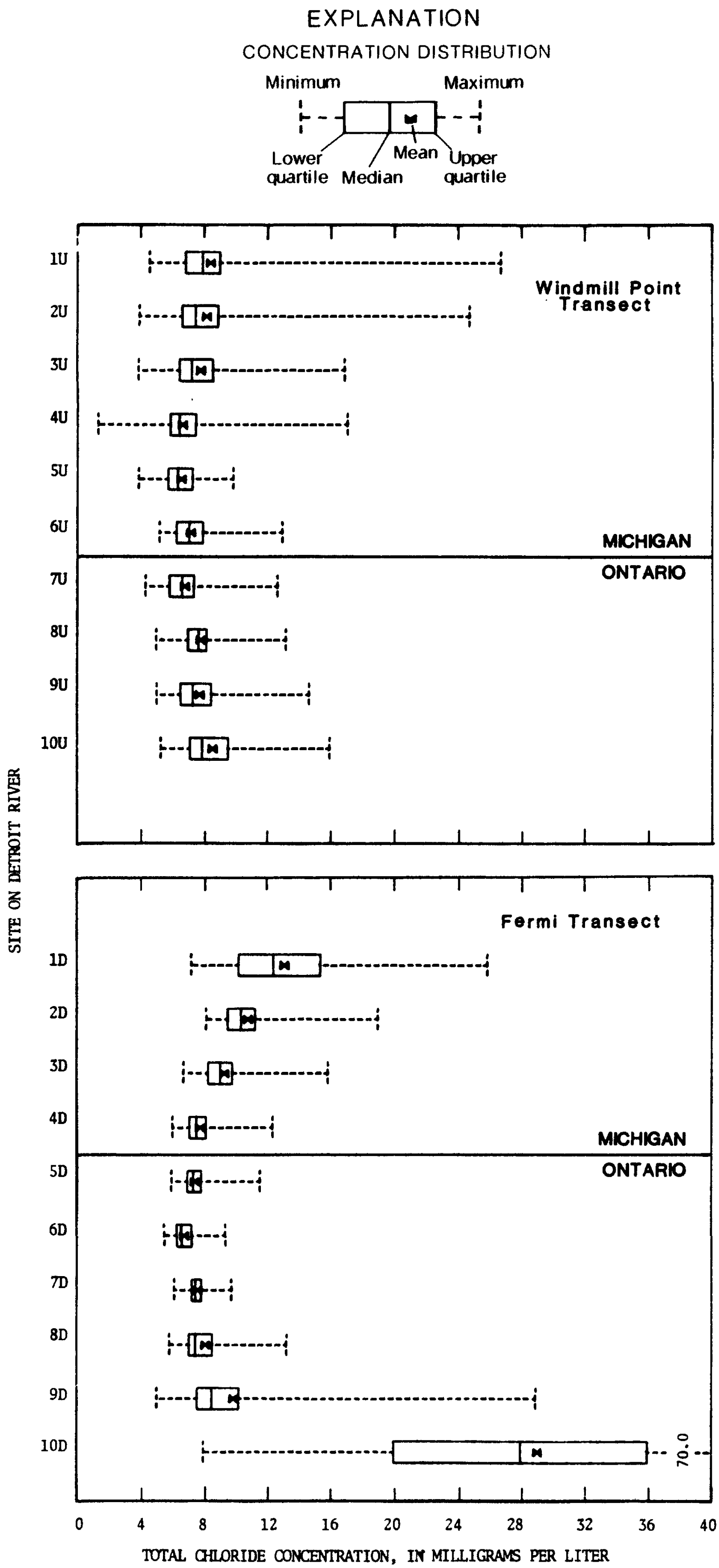


Figure 33.--Sites on Detroit River and variation of total chloride concentration.

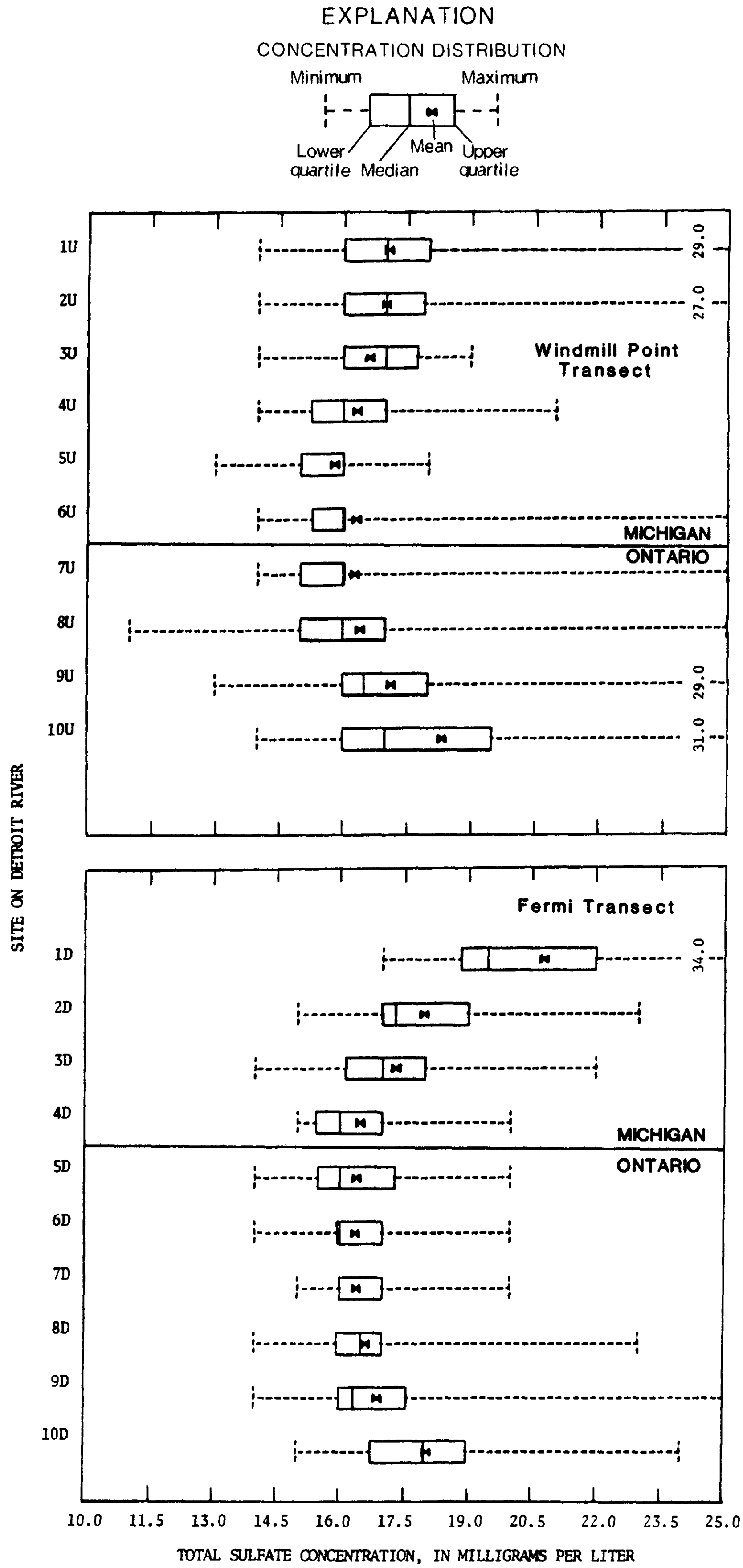


Figure 34.--Sites on Detroit River and variation of total sulfate concentration.

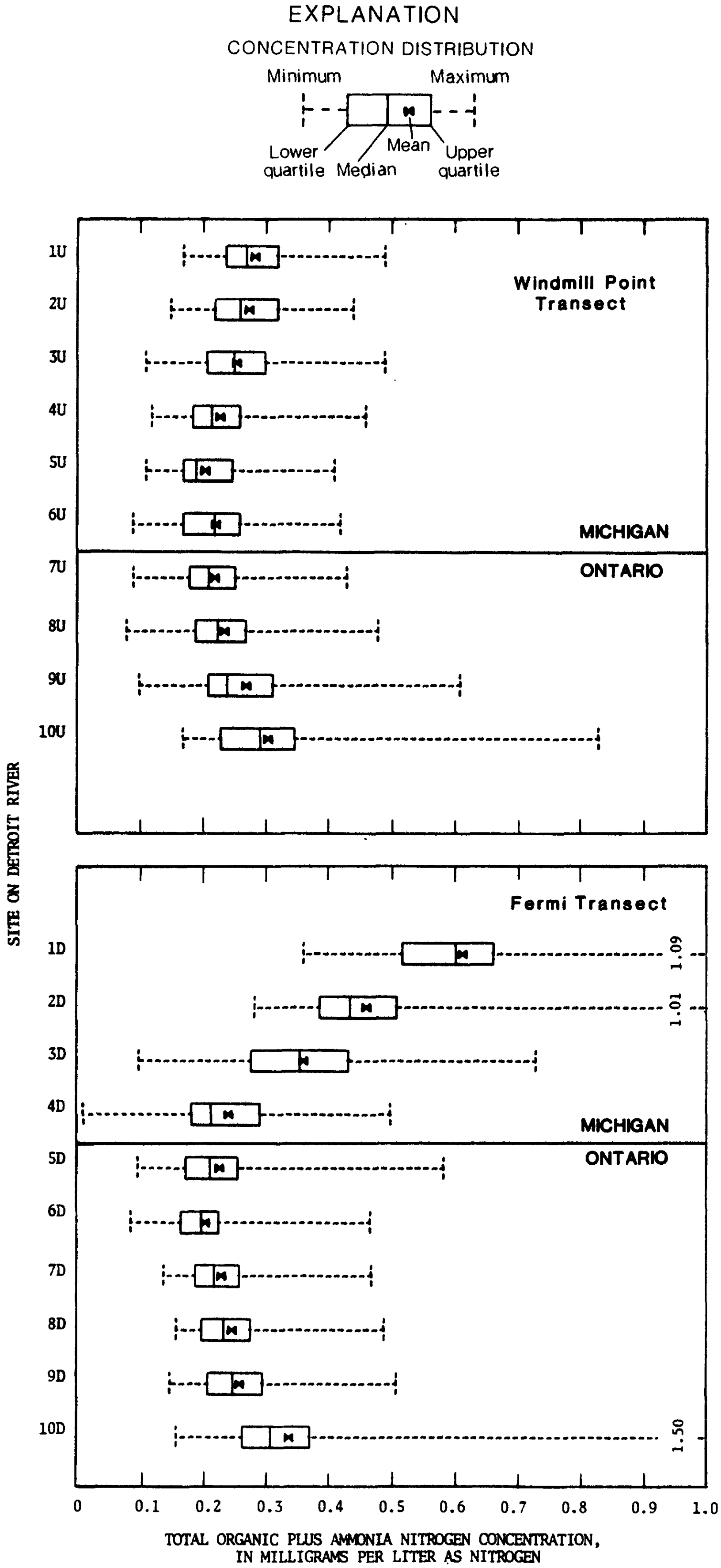


Figure 35.--Sites on Detroit River and variation of total organic plus ammonia nitrogen concentration.

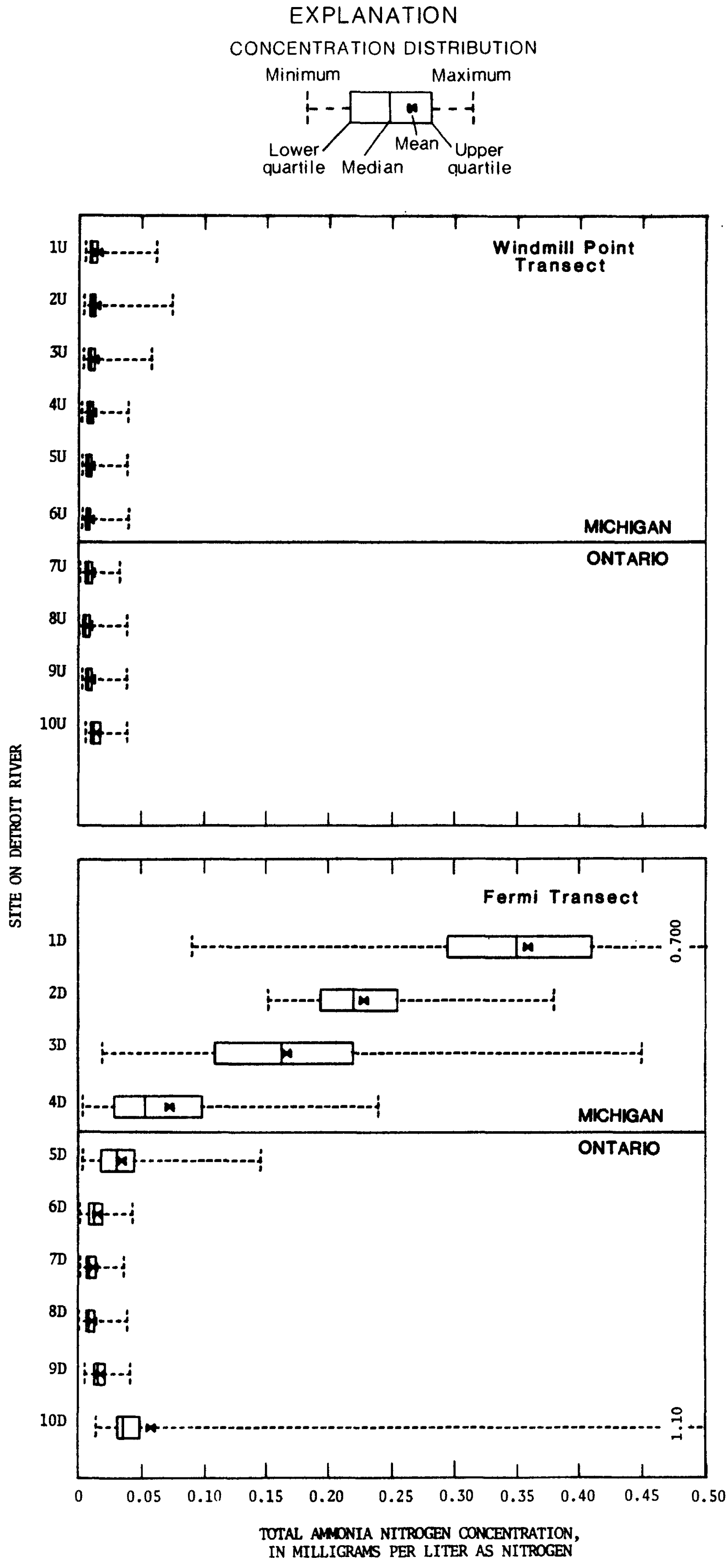


Figure 36.--Sites on Detroit River and variation of total ammonia nitrogen concentration.

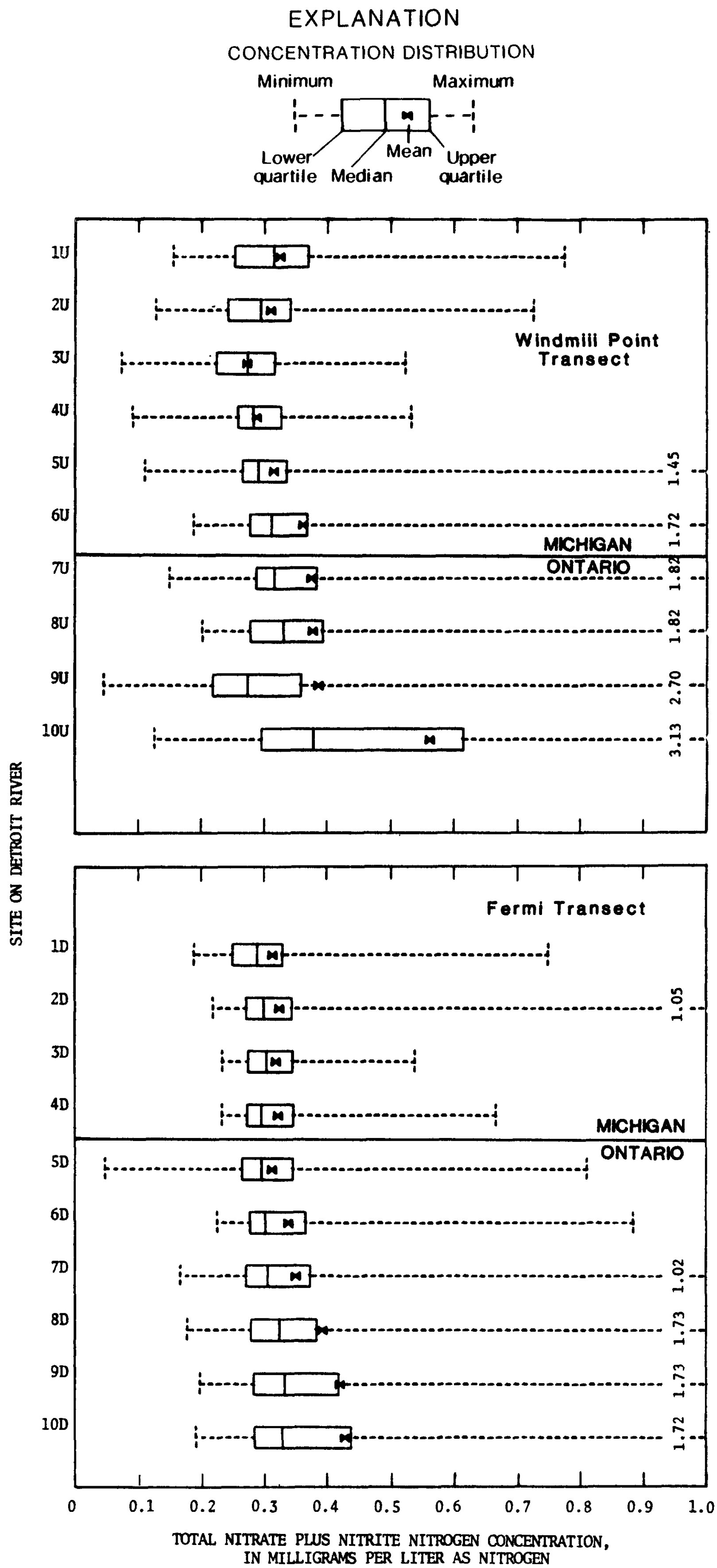


Figure 37.--Sites on Detroit River and variation of total nitrate plus nitrite nitrogen concentration.

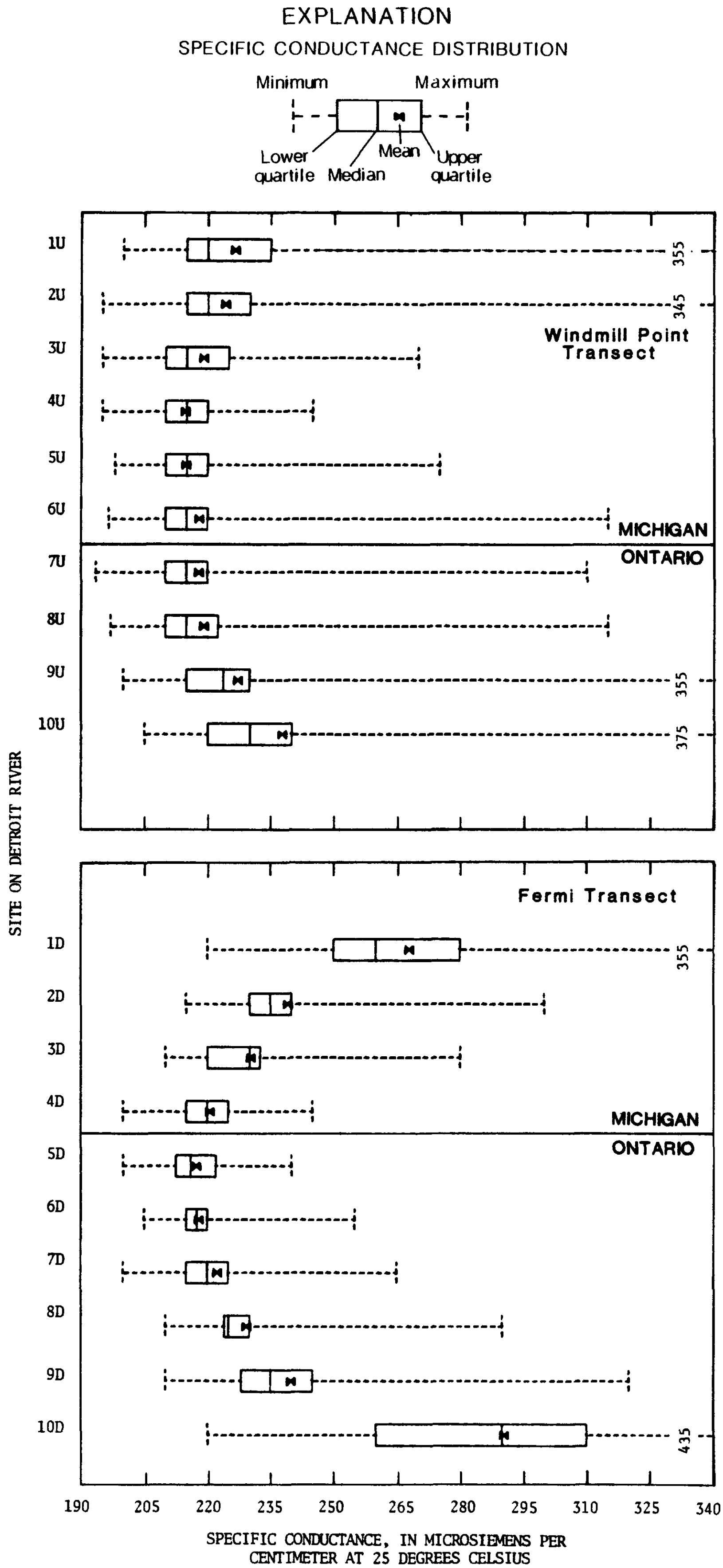


Figure 38--Sites on Detroit River and variation of specific conductance.

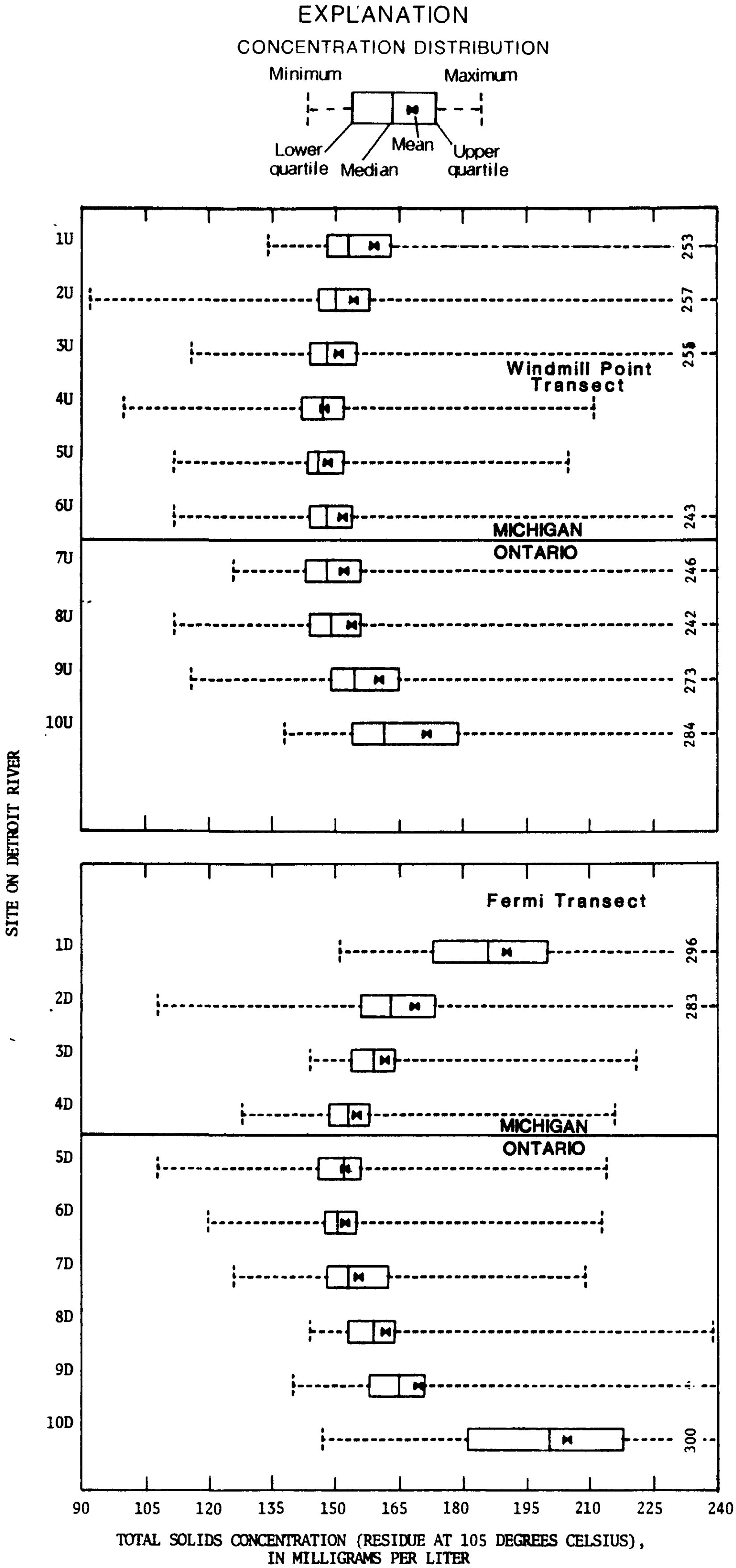


Figure 39.--Sites on Detroit River and variation of total solids concentration.

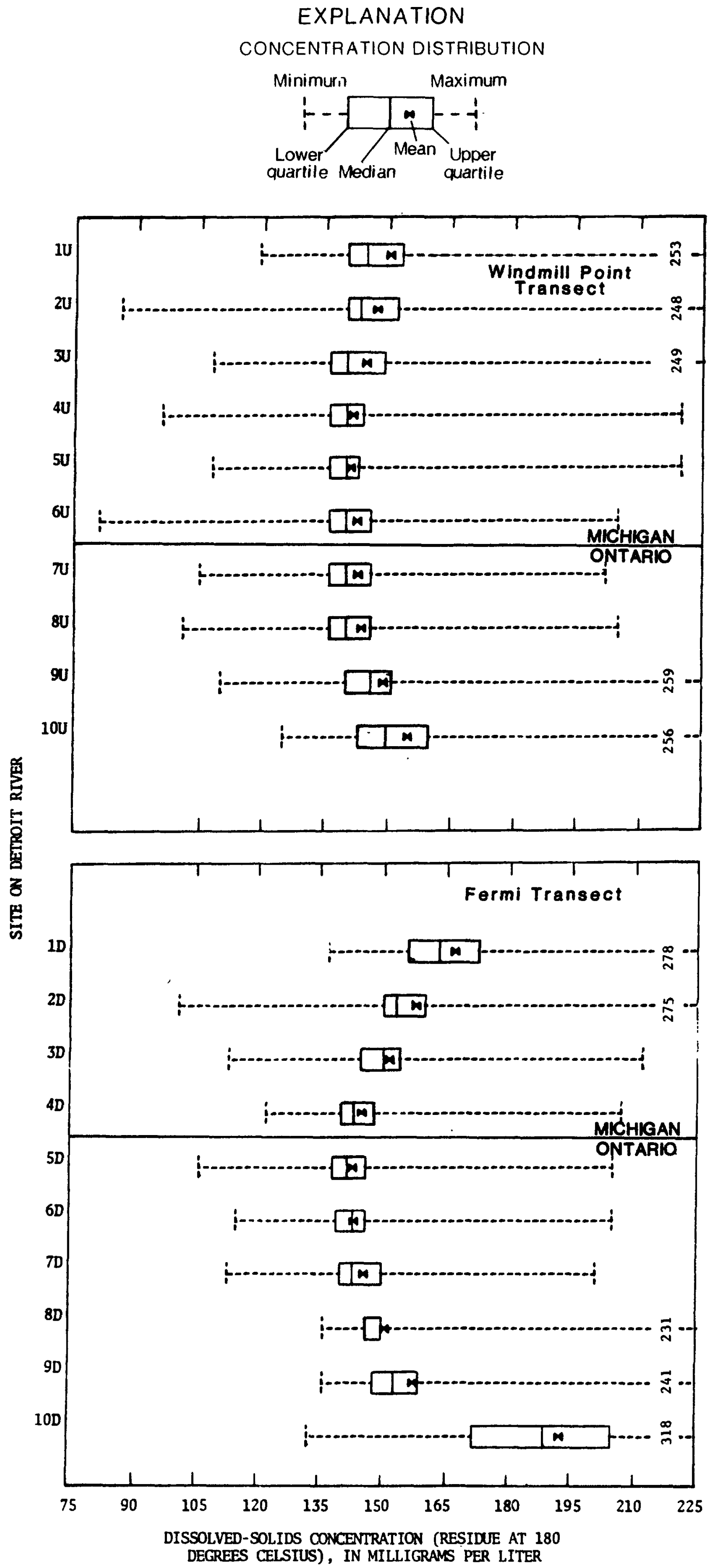


Figure 40.--Sites on Detroit River and variation of dissolved-solids concentration.

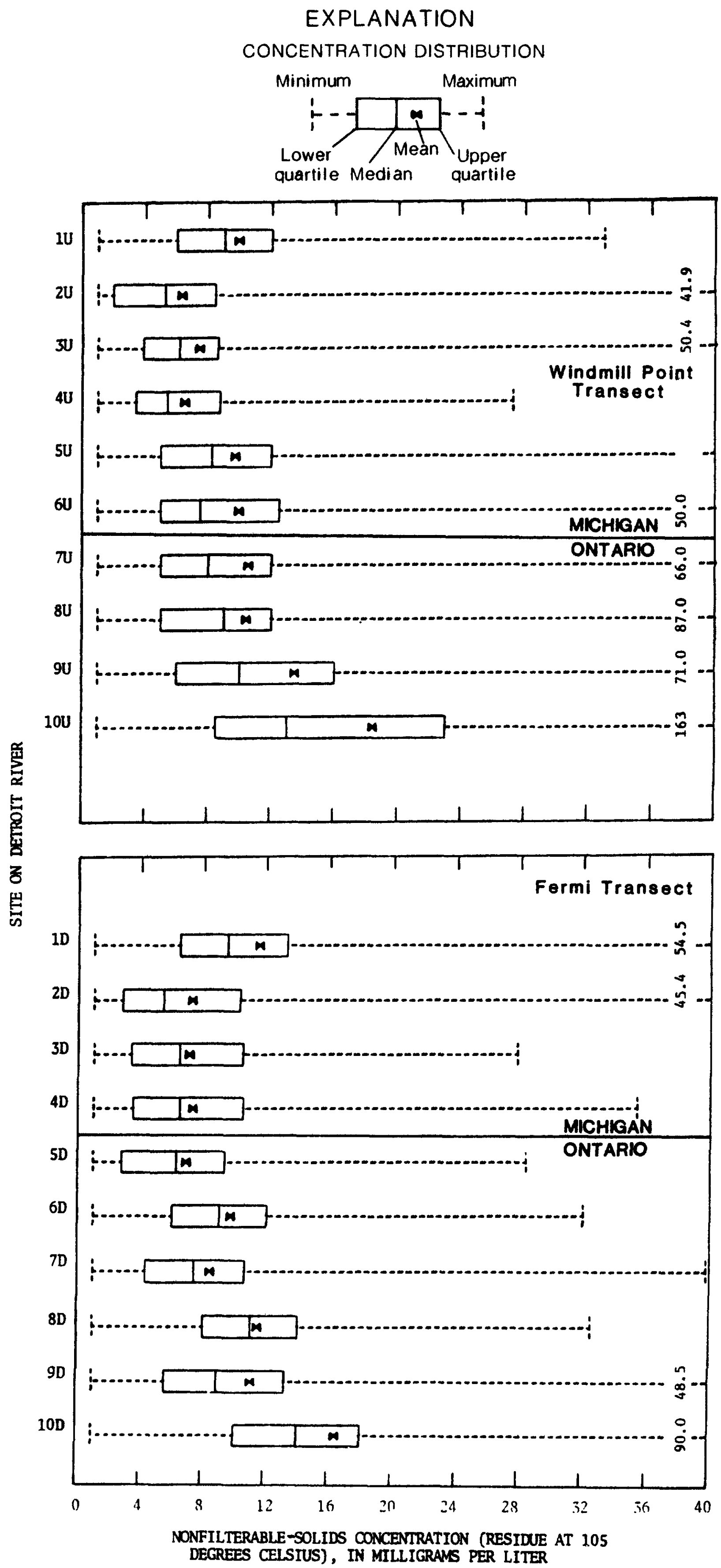


Figure 41.--Sites on Detroit River and variation of nonfilterable-solids concentration.

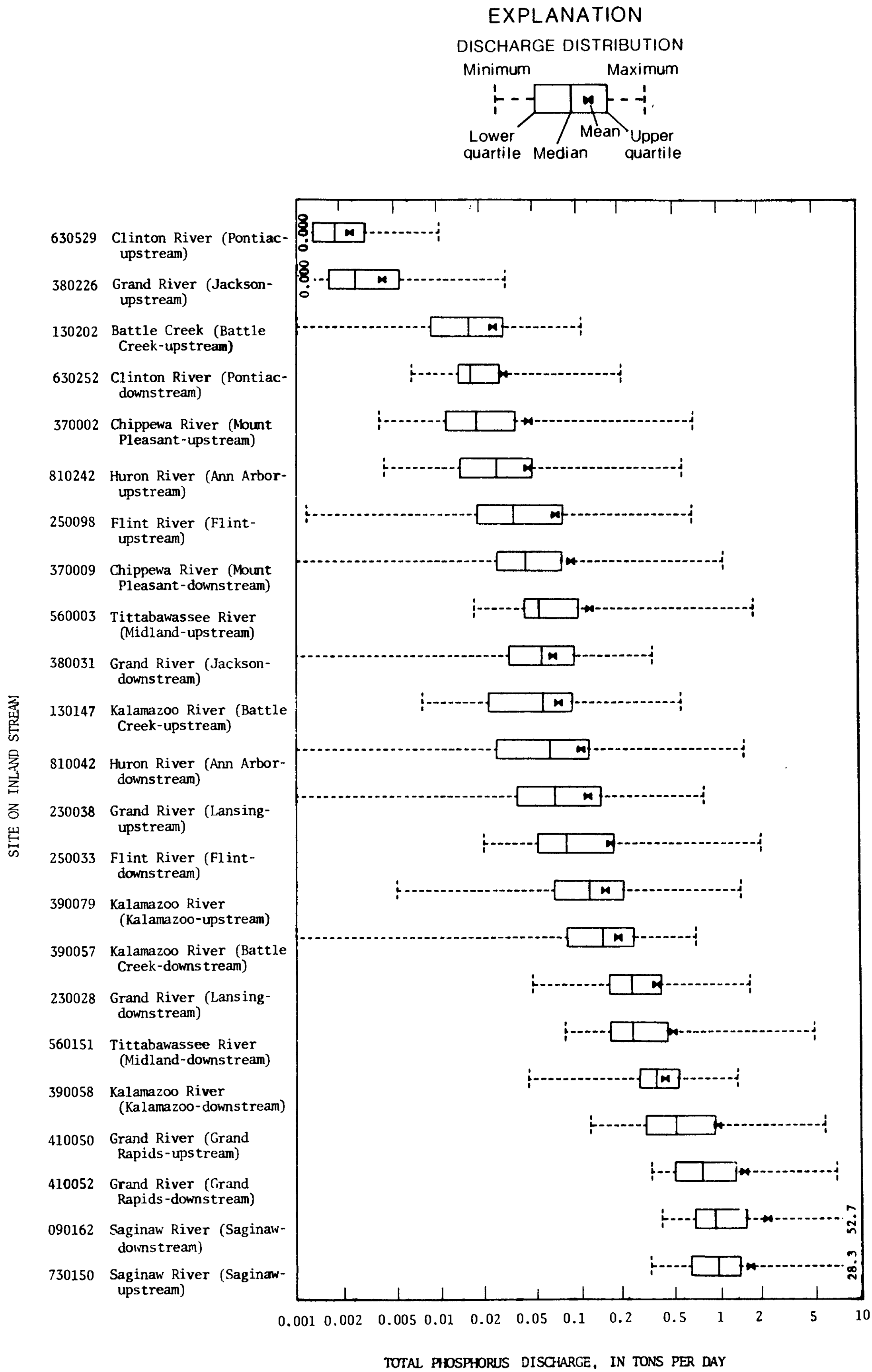


Figure 42.--Sites on inland streams and variation of total phosphorus discharge.

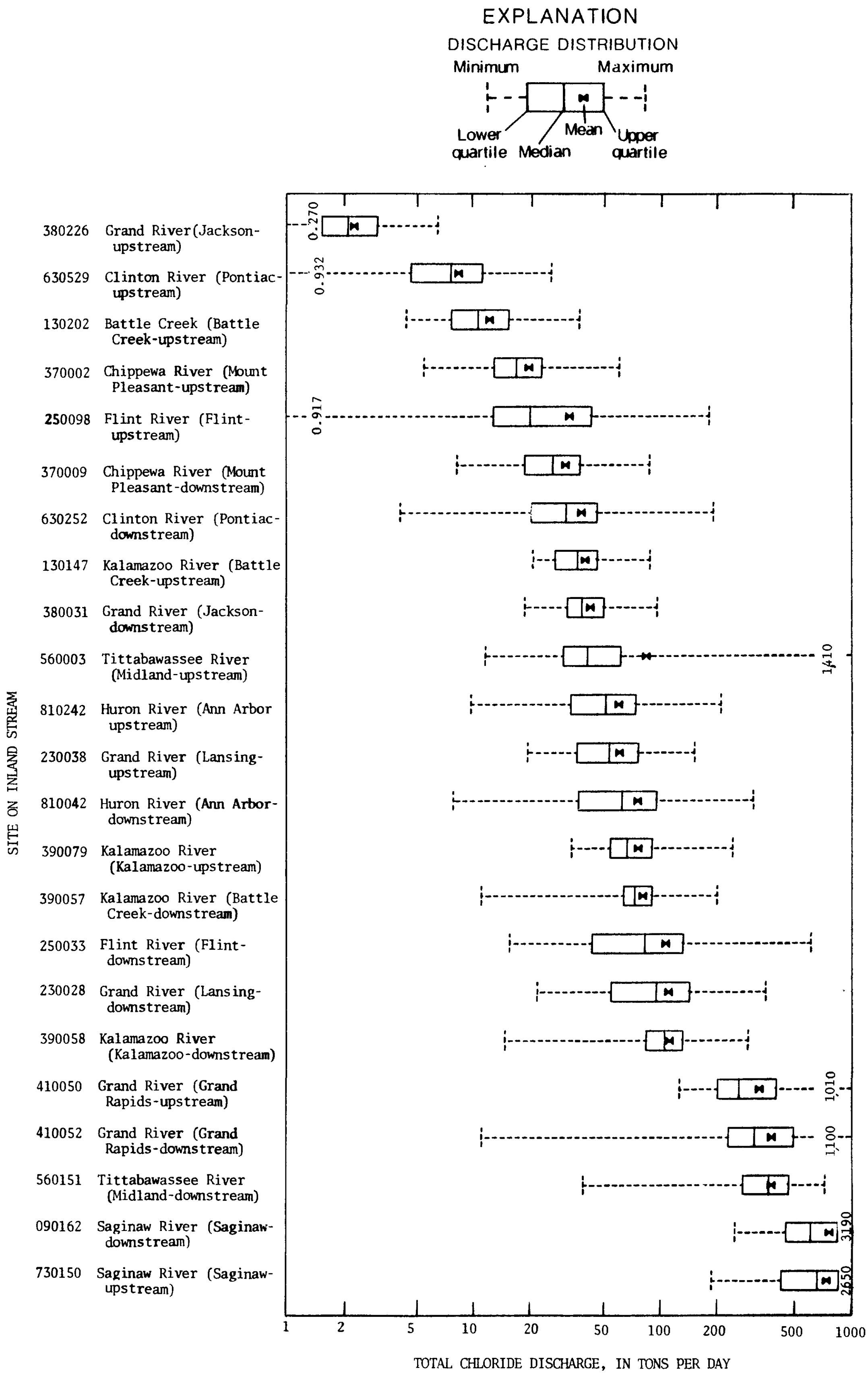


Figure 43.--Sites on inland streams and variation of total chloride discharge.

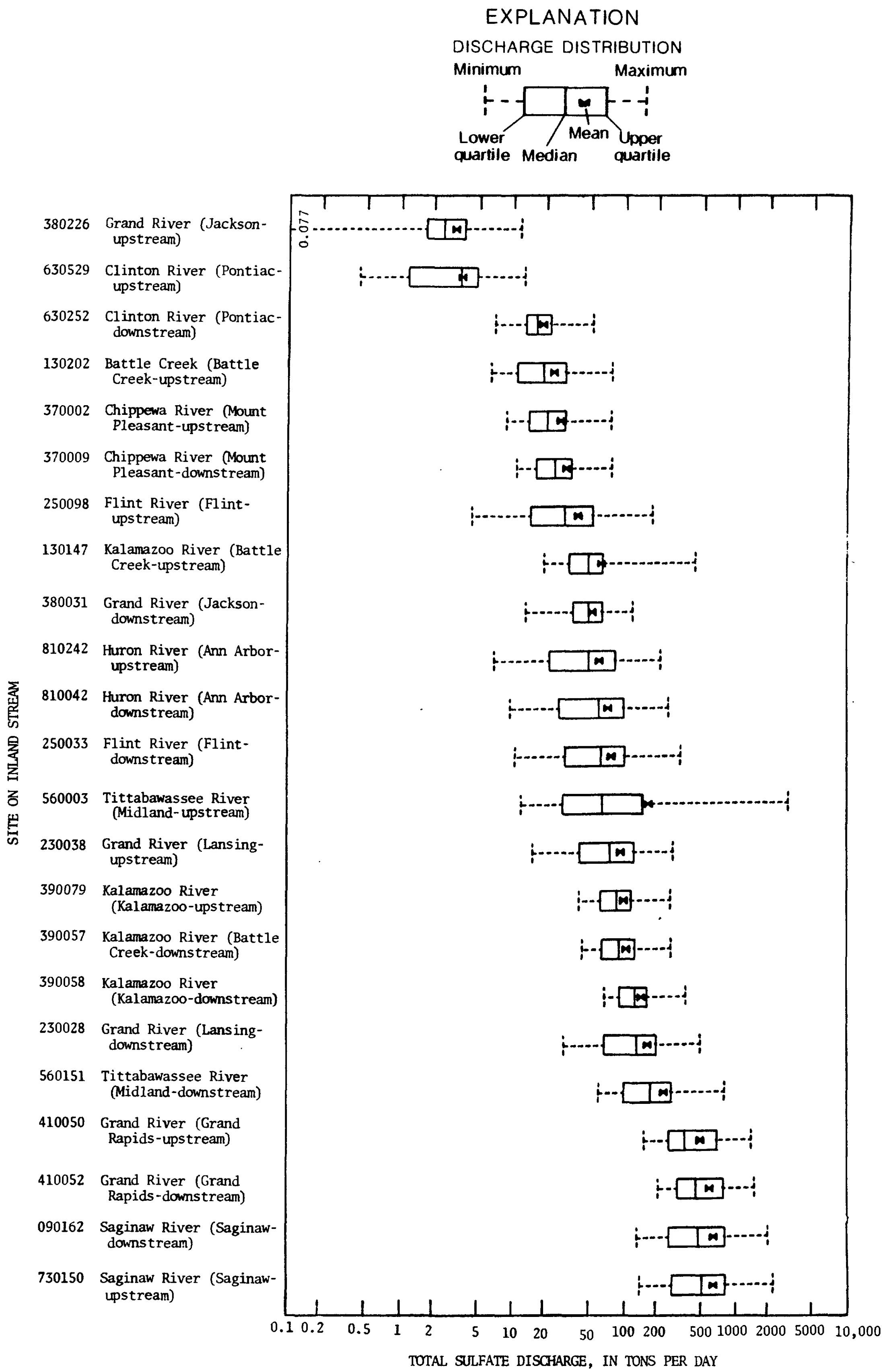


Figure 44.--Sites on inland streams and variation of total sulfate discharge.

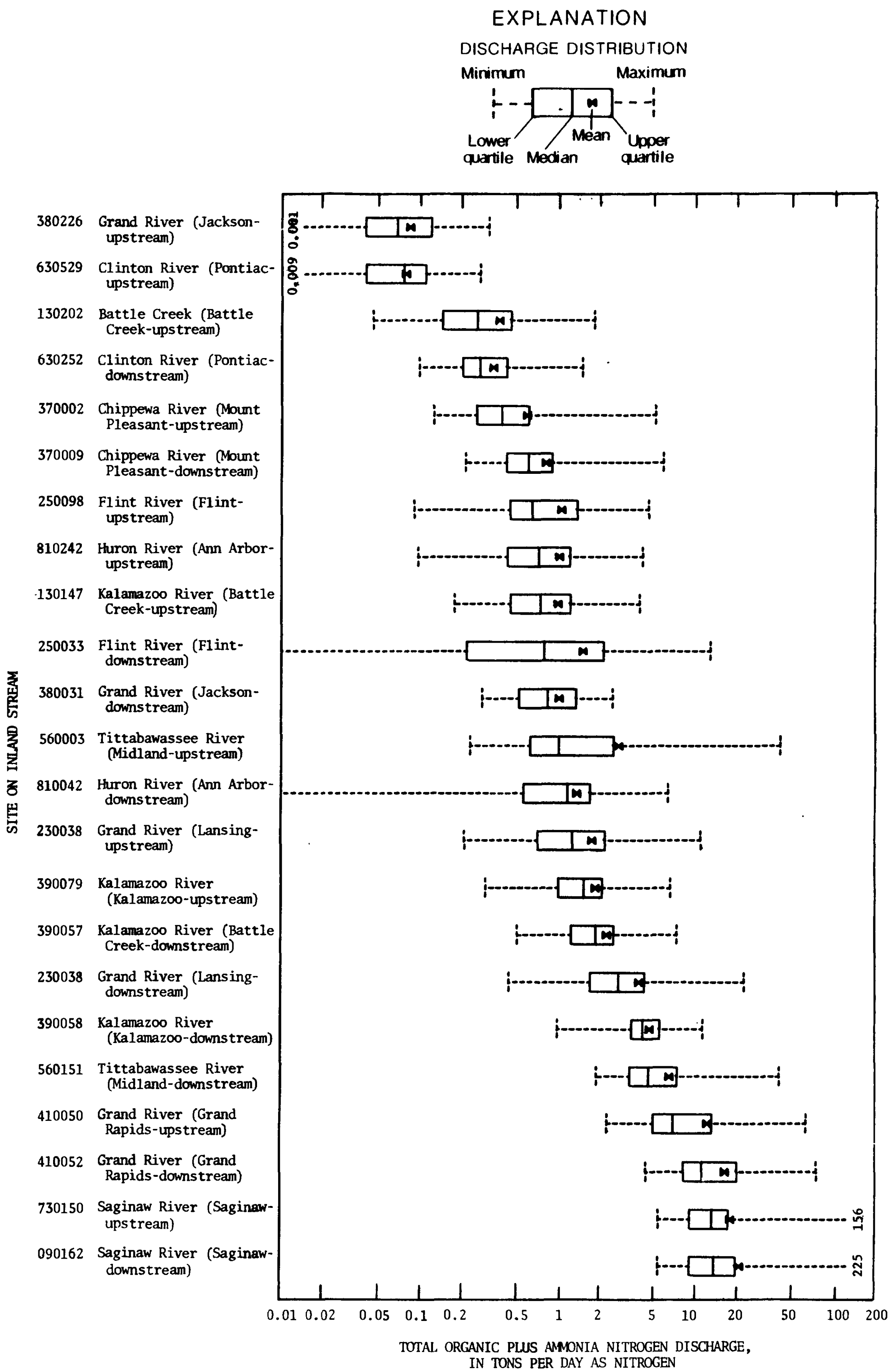


Figure 45.--Sites on inland streams and variation of total organic plus ammonia nitrogen discharge.

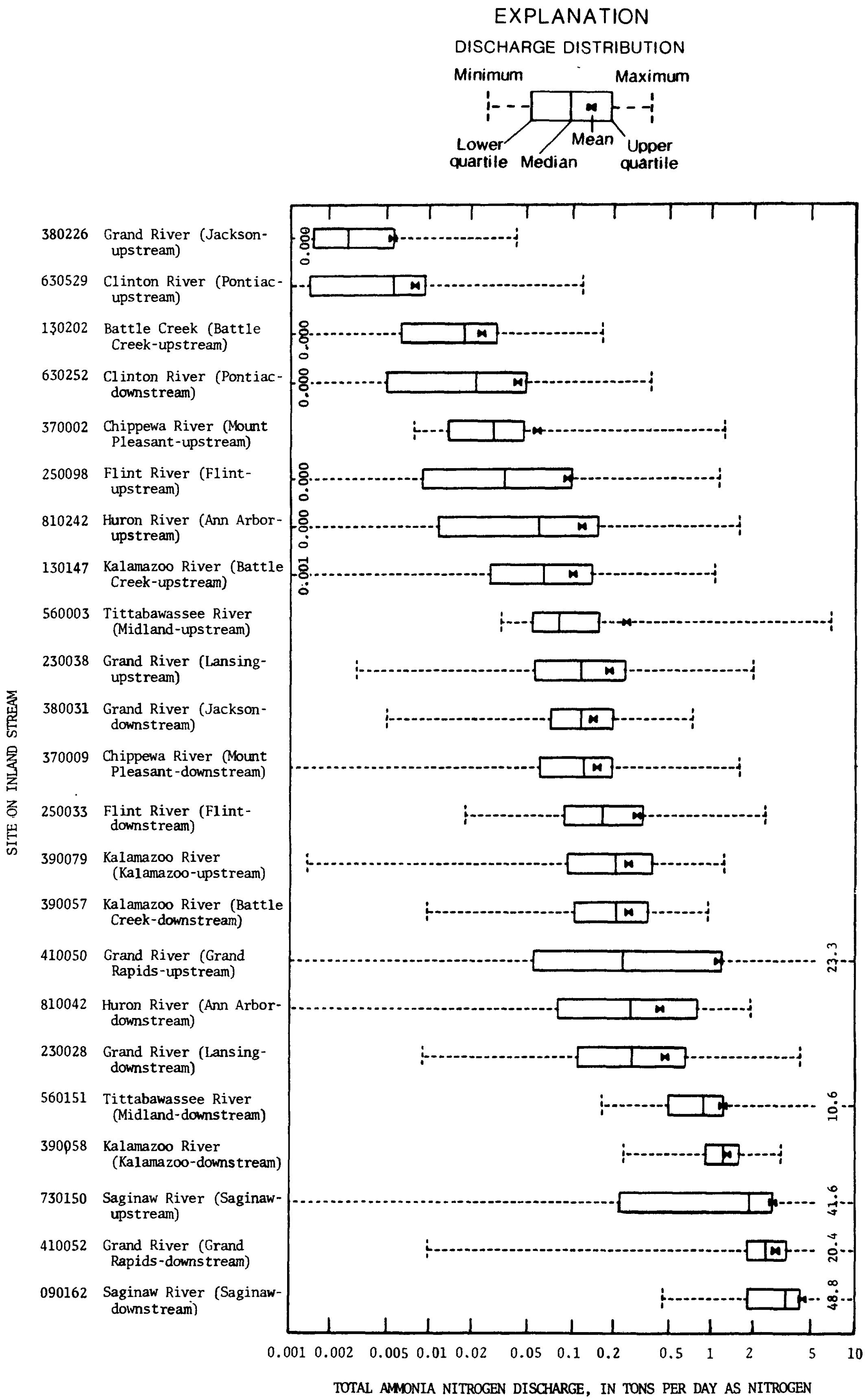


Figure 46--Sites on inland streams and variation of total ammonia nitrogen discharge.

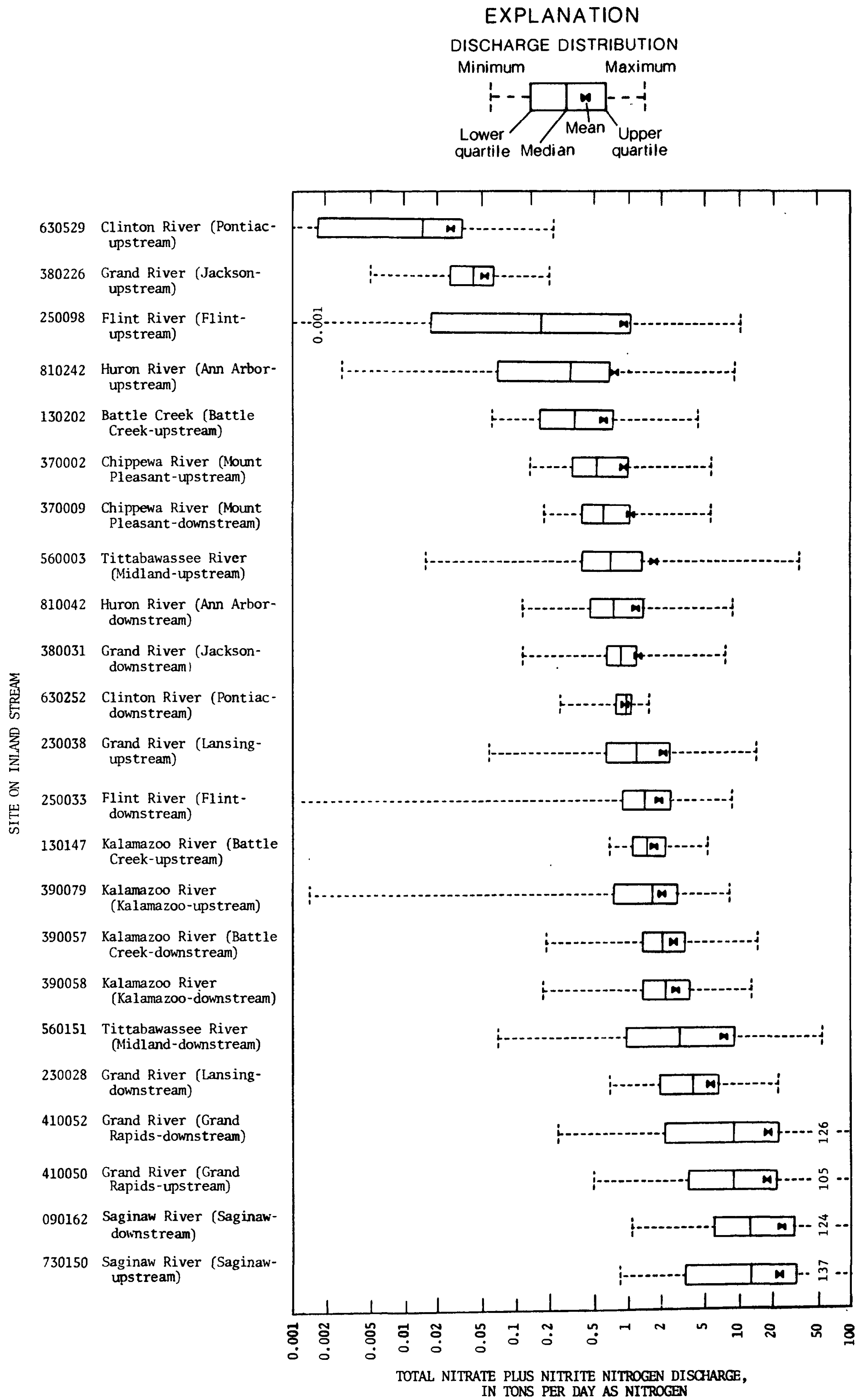


Figure 47.--Sites on inland streams and variation of total nitrate plus nitrite nitrogen discharge.

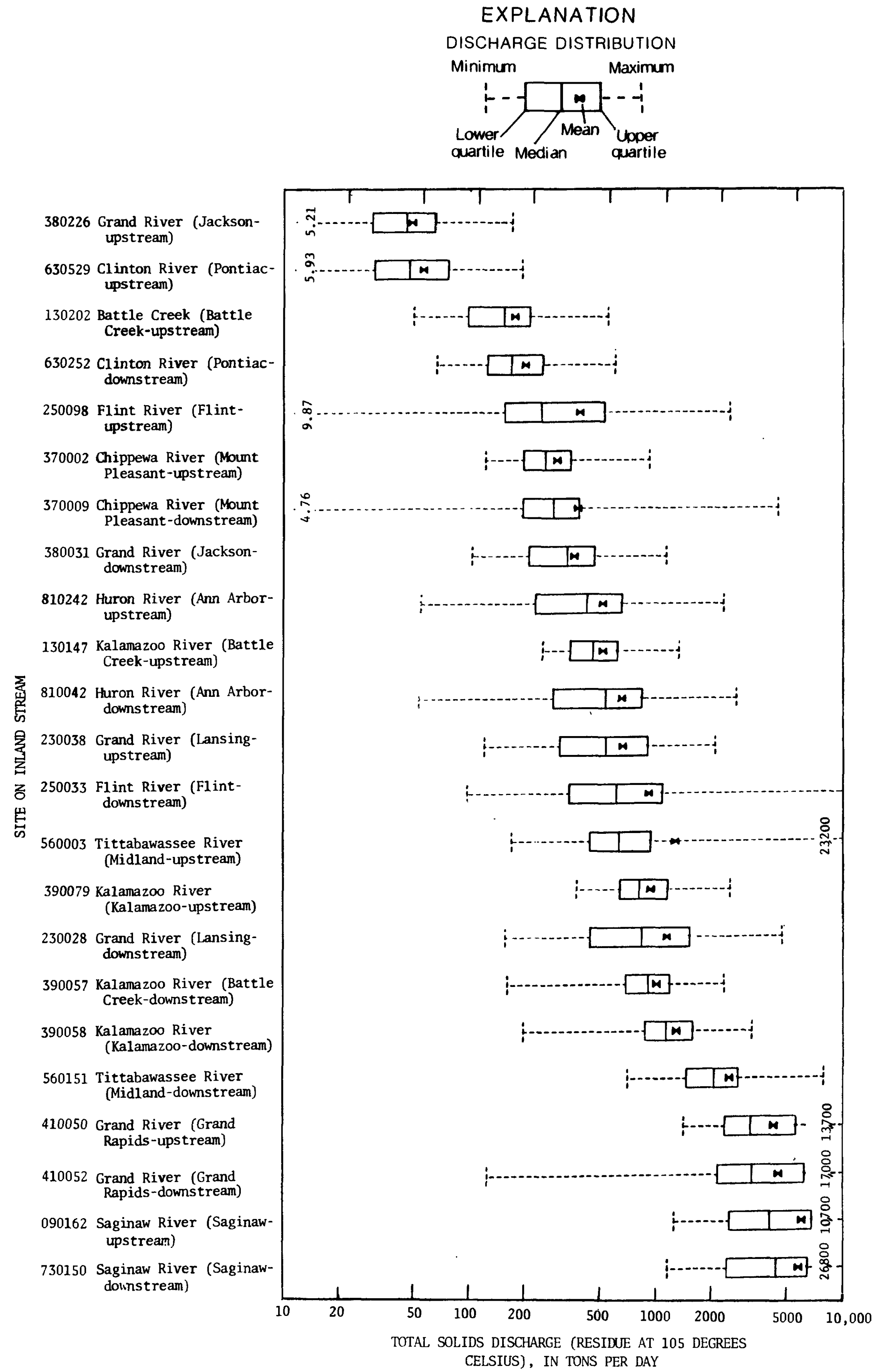


Figure 48.--Sites on inland streams and variation of total solids discharge.

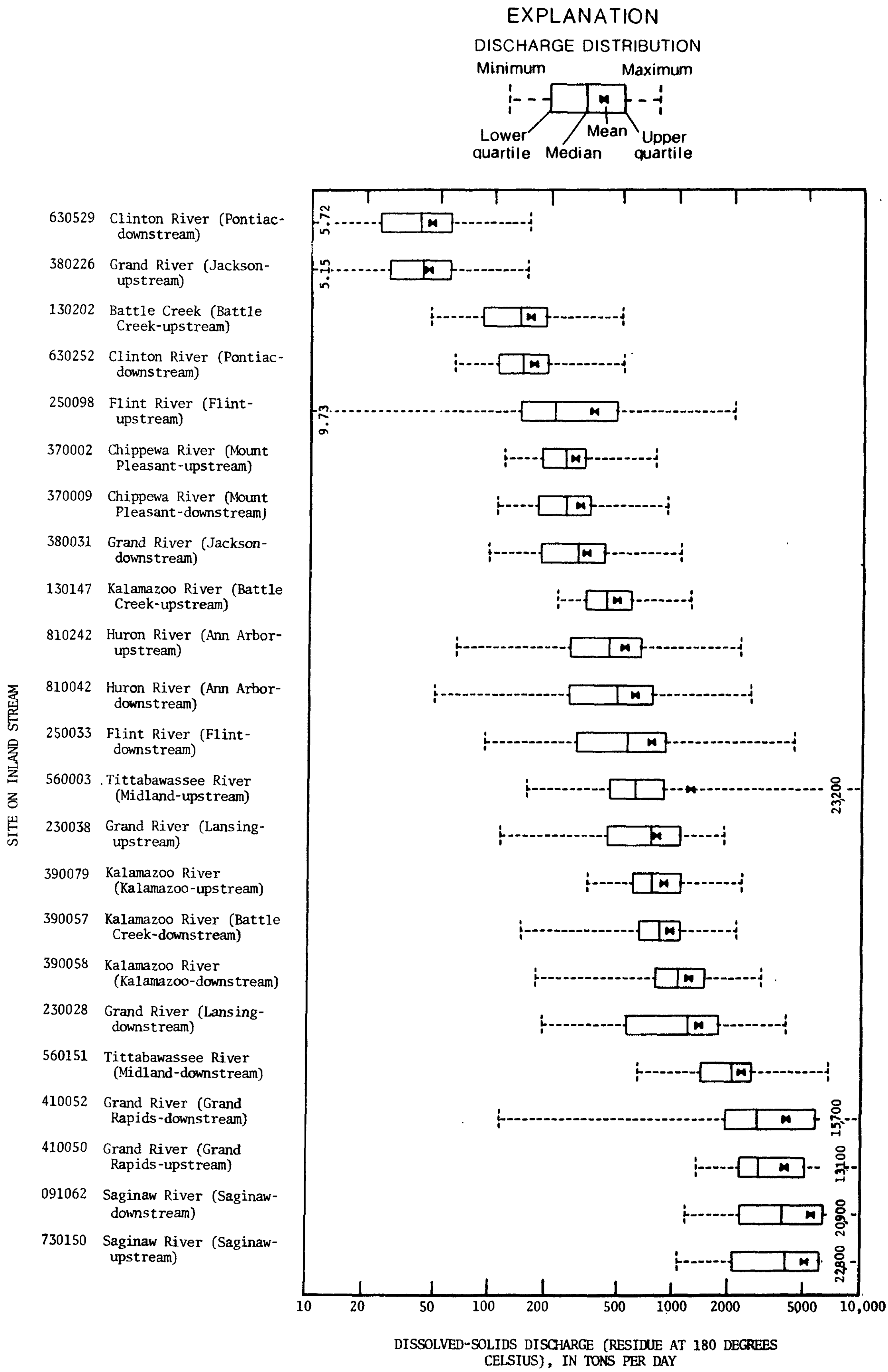


Figure 49.--Sites on inland streams and variation of dissolved-solids discharge.

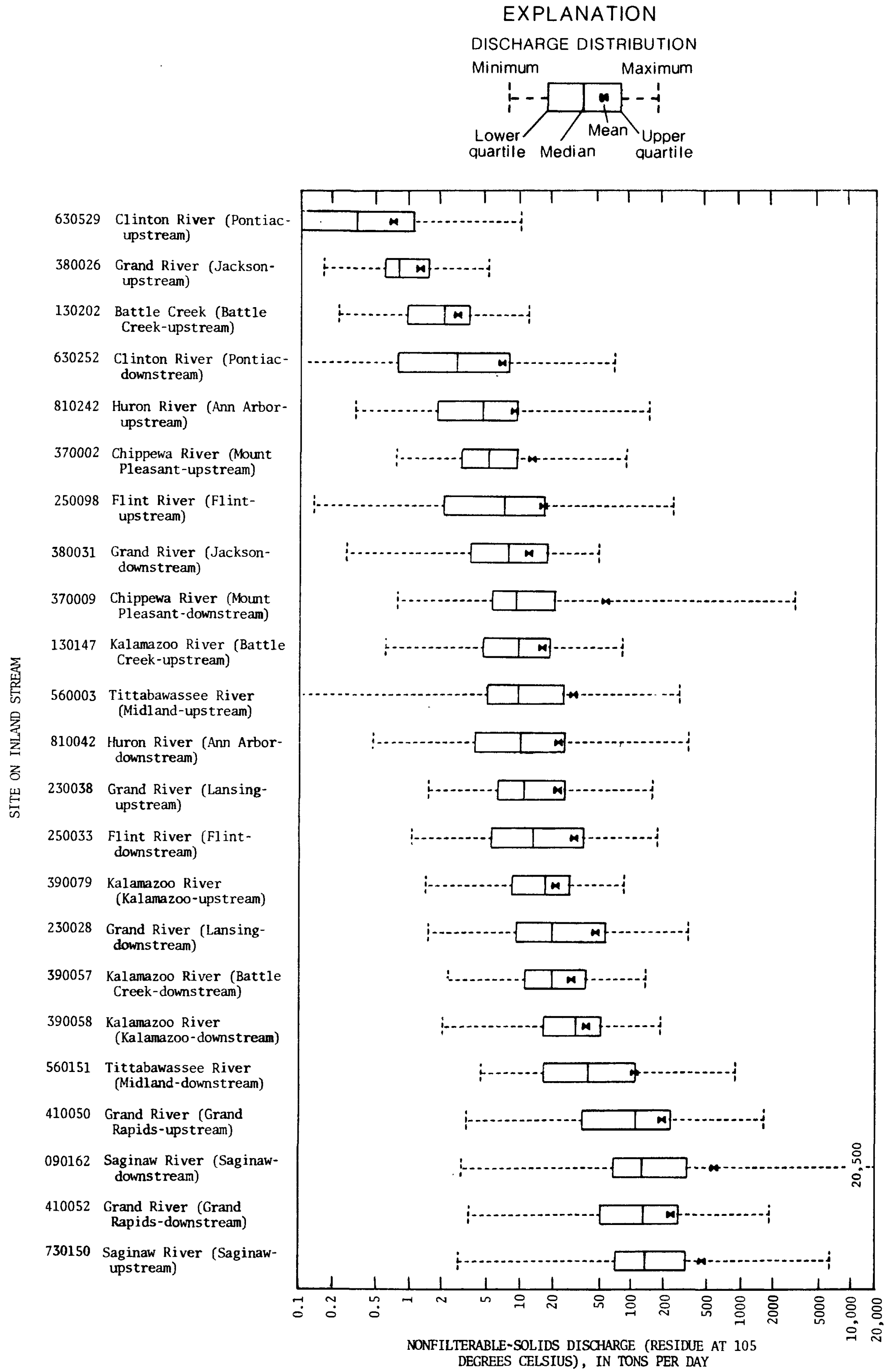


Figure 50.--Sites on inland streams and variation of nonfilterable-solids discharge.

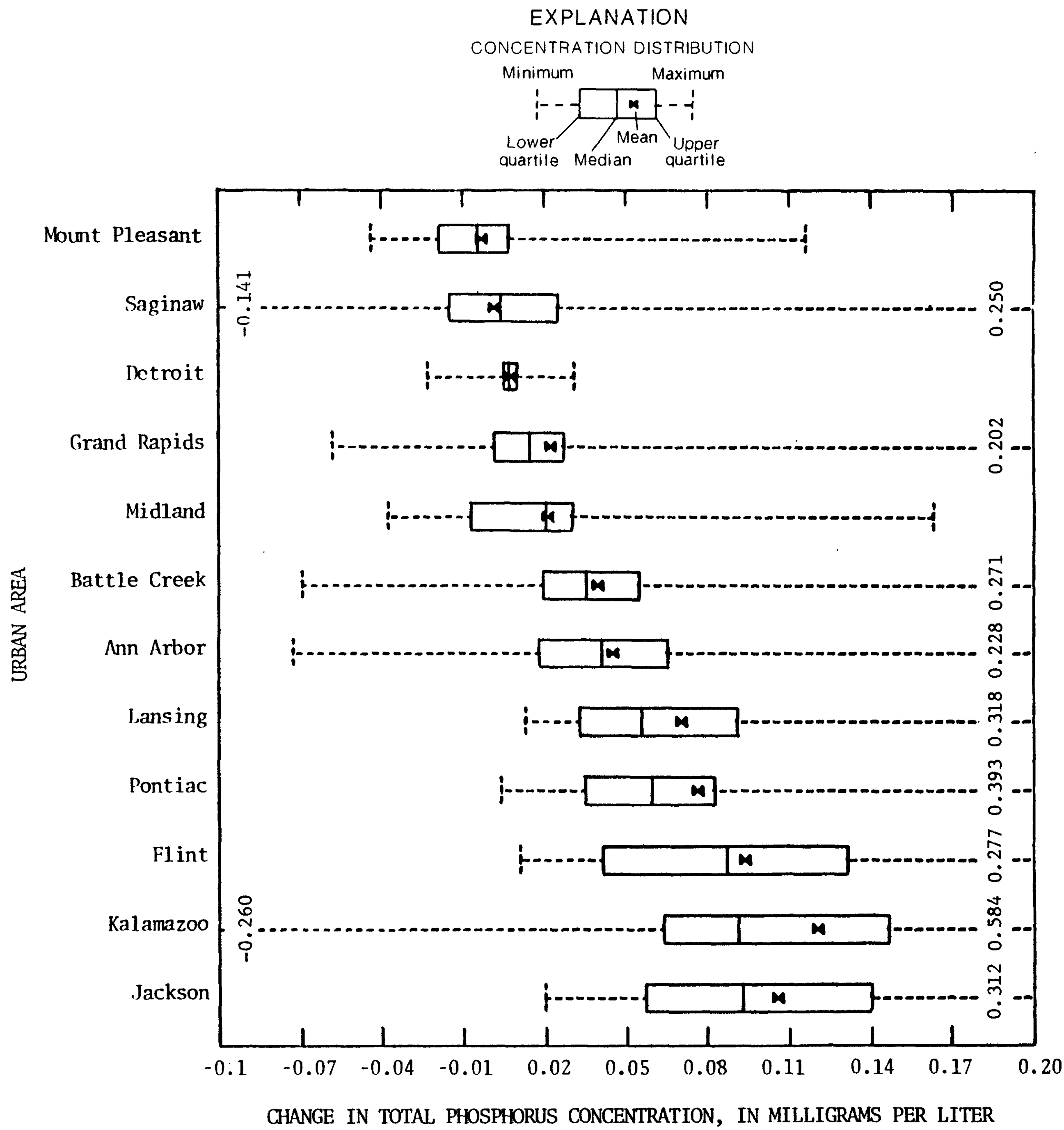


Figure 51.--Urban areas and variation of changes in total phosphorus concentration.

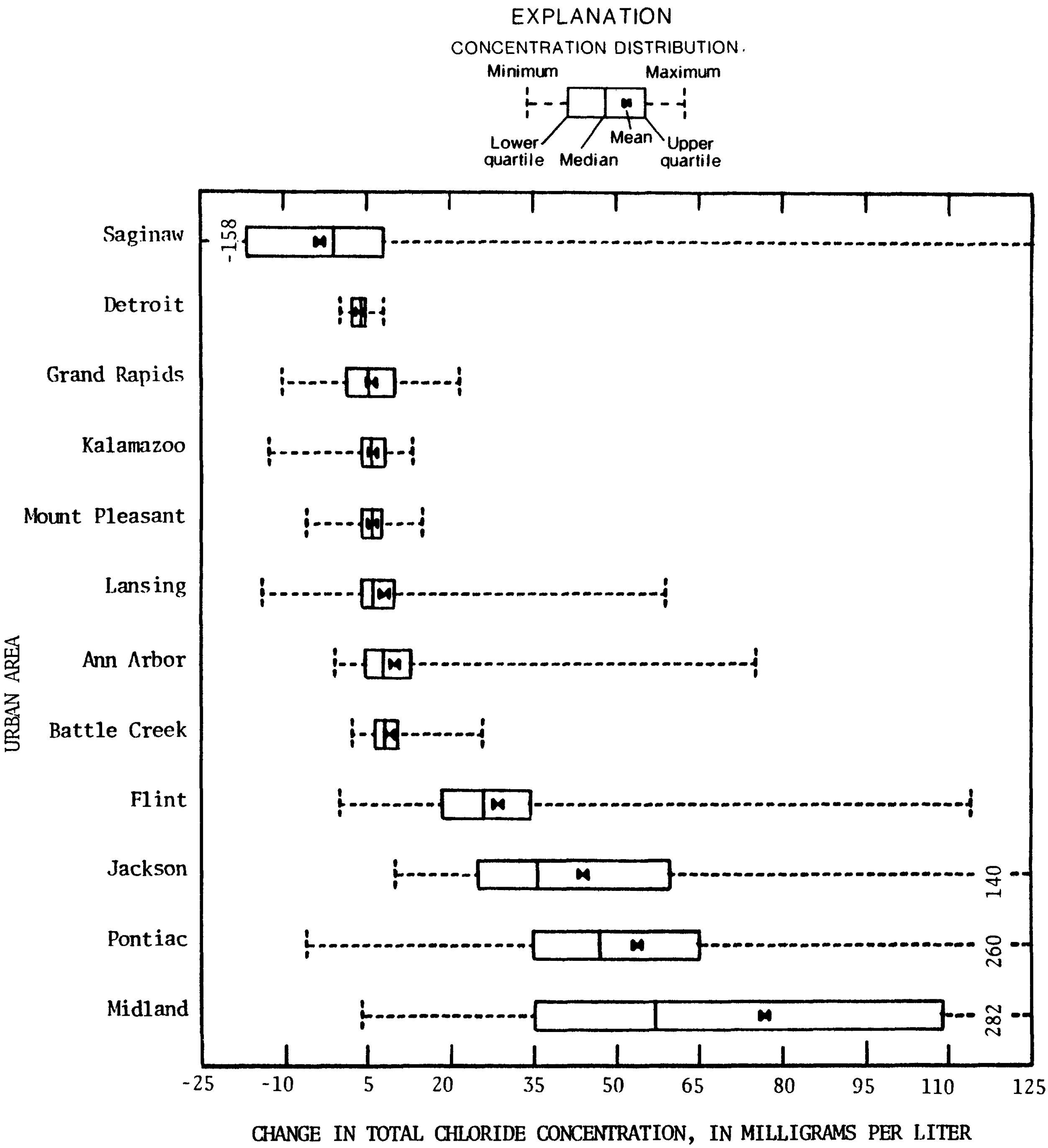


Figure 52.--Urban areas and variation of changes in total chloride concentration.

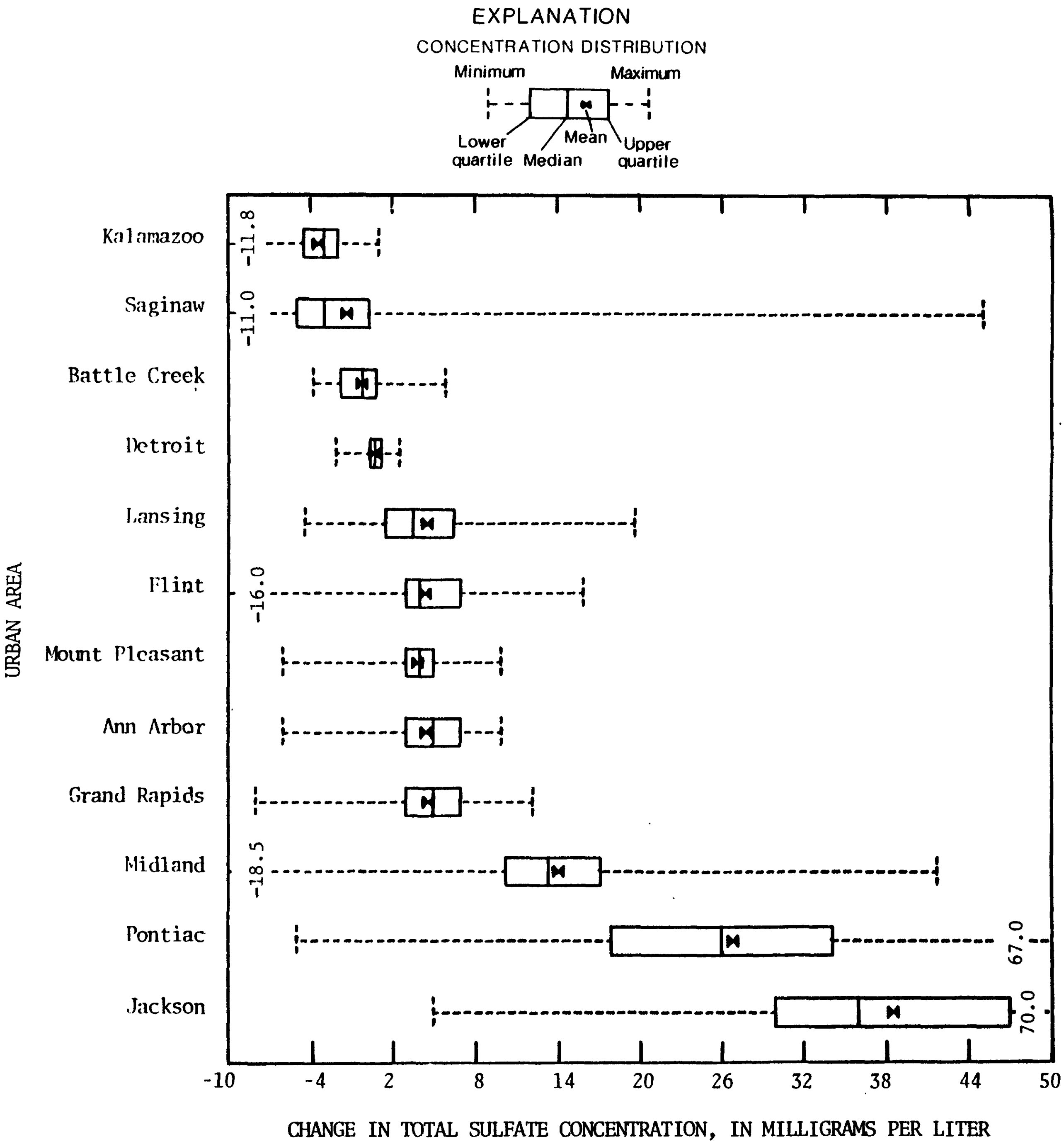


Figure 53.--Urban areas and variation of changes in total sulfate concentration.

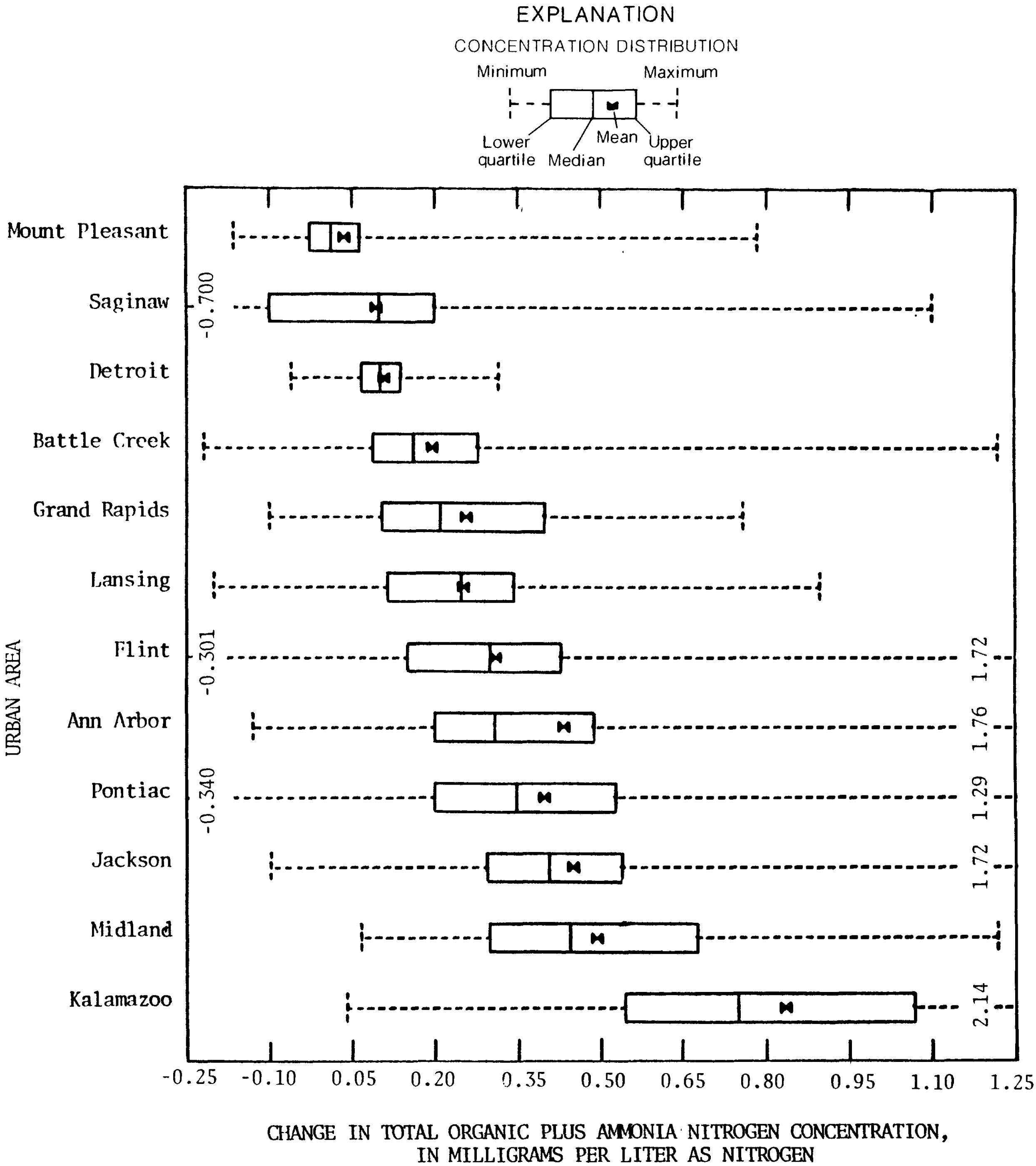


Figure 54.--Urban areas and variation of changes in total organic plus ammonia nitrogen concentration.

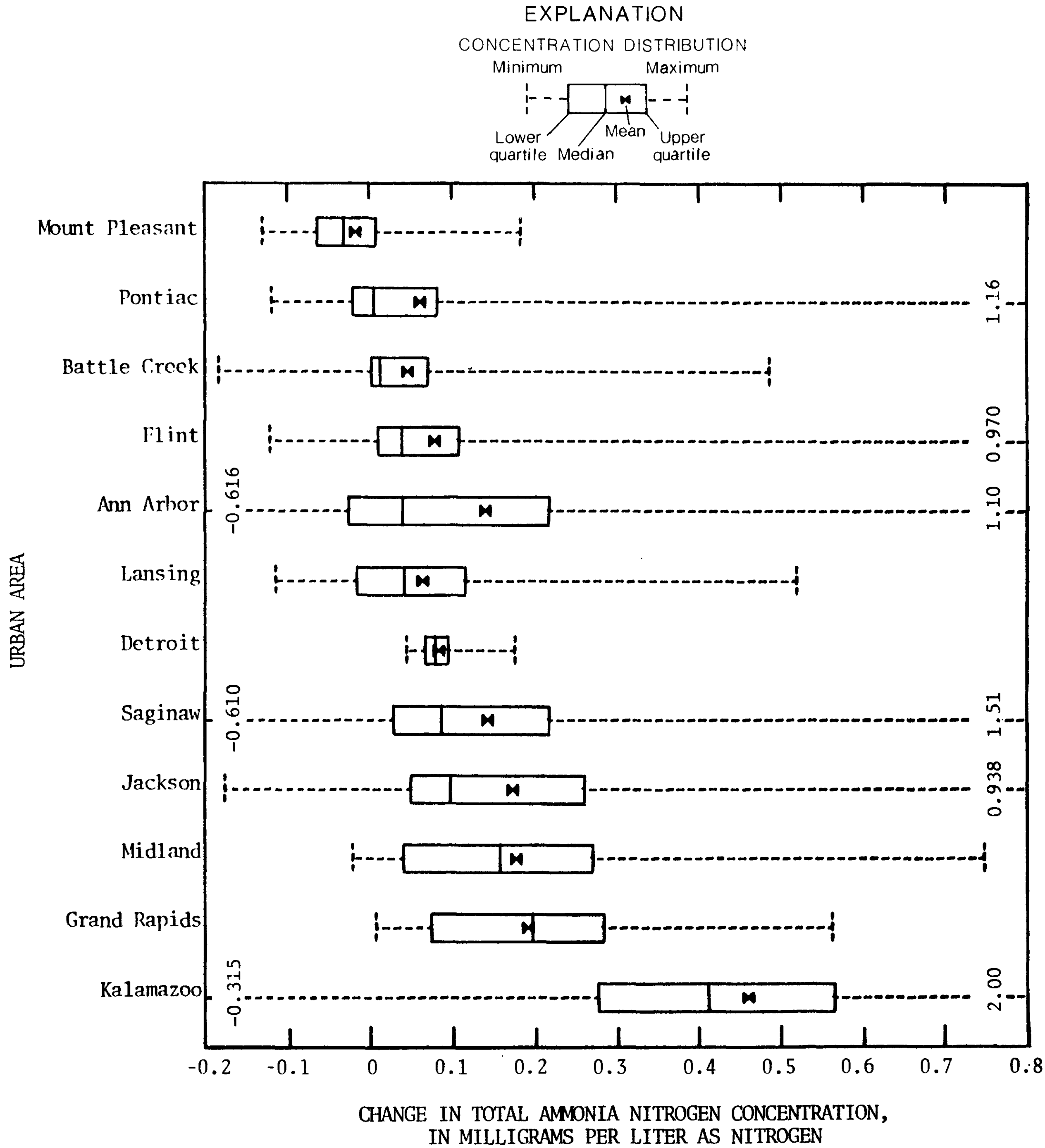


Figure 55.--Urban areas and variation of changes in total ammonia nitrogen concentration.

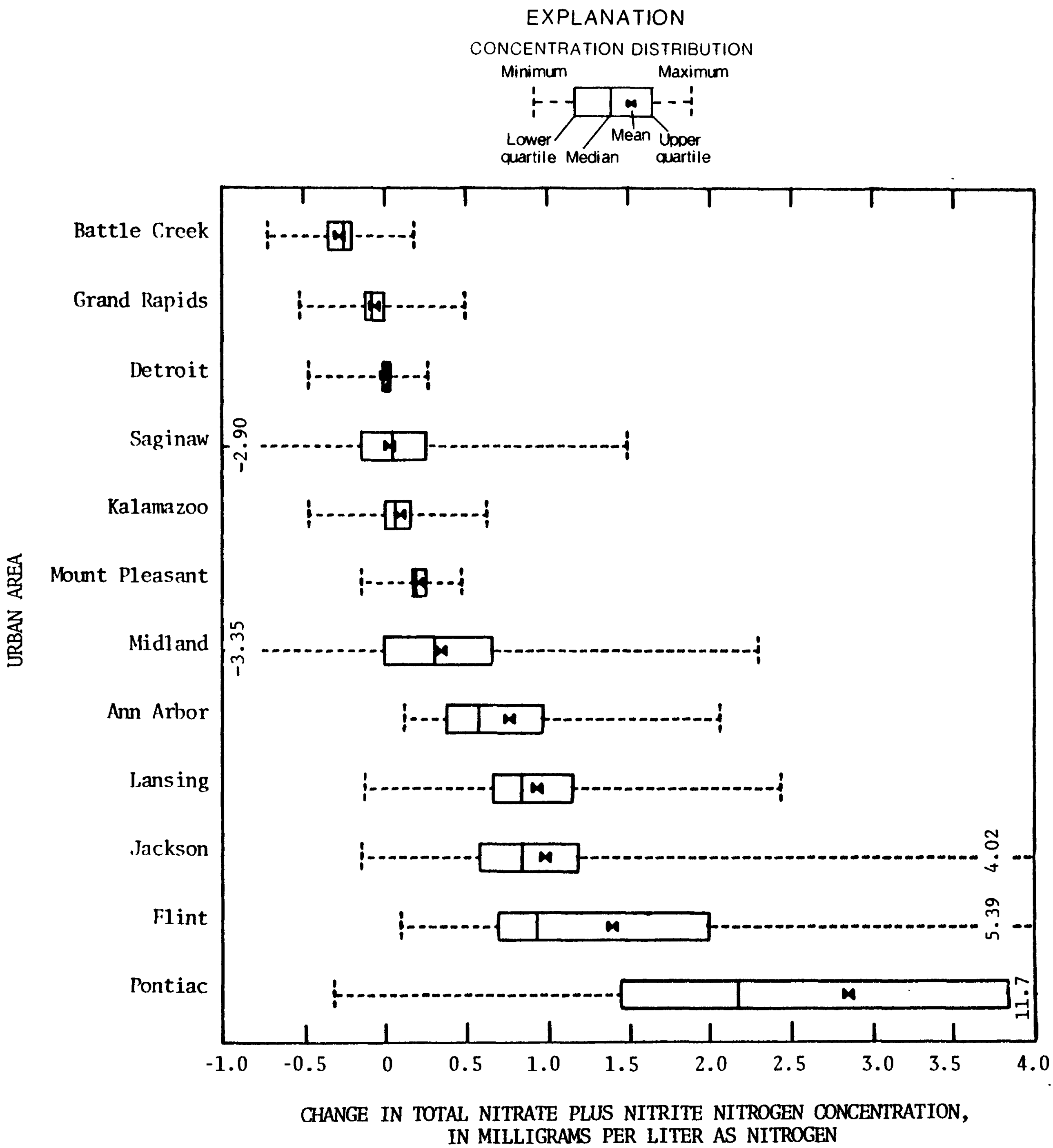


Figure 56.--Urban areas and variation of changes in total nitrate plus nitrite nitrogen concentration.

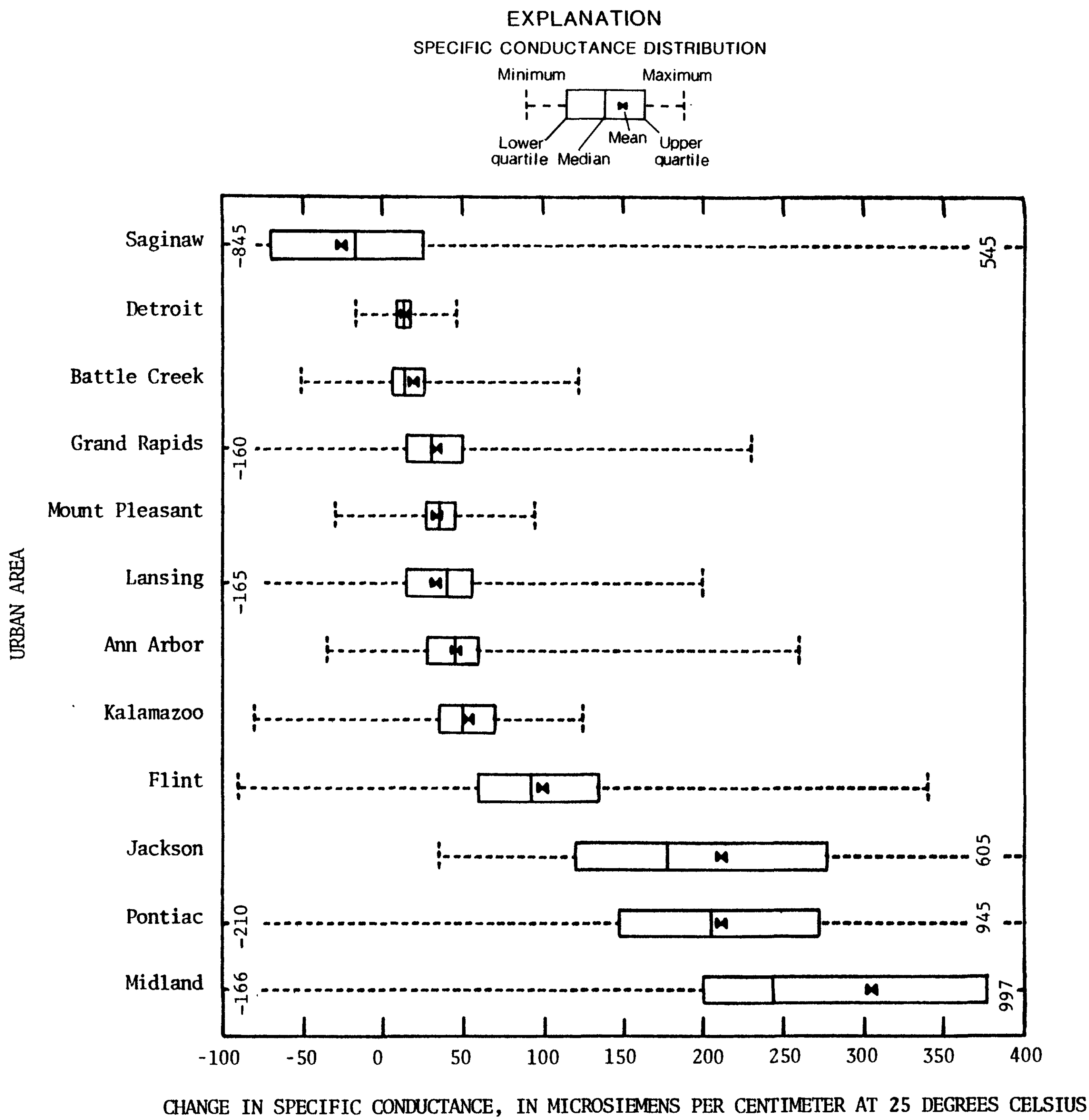


Figure 57.--Urban areas and variation of changes in specific conductance.

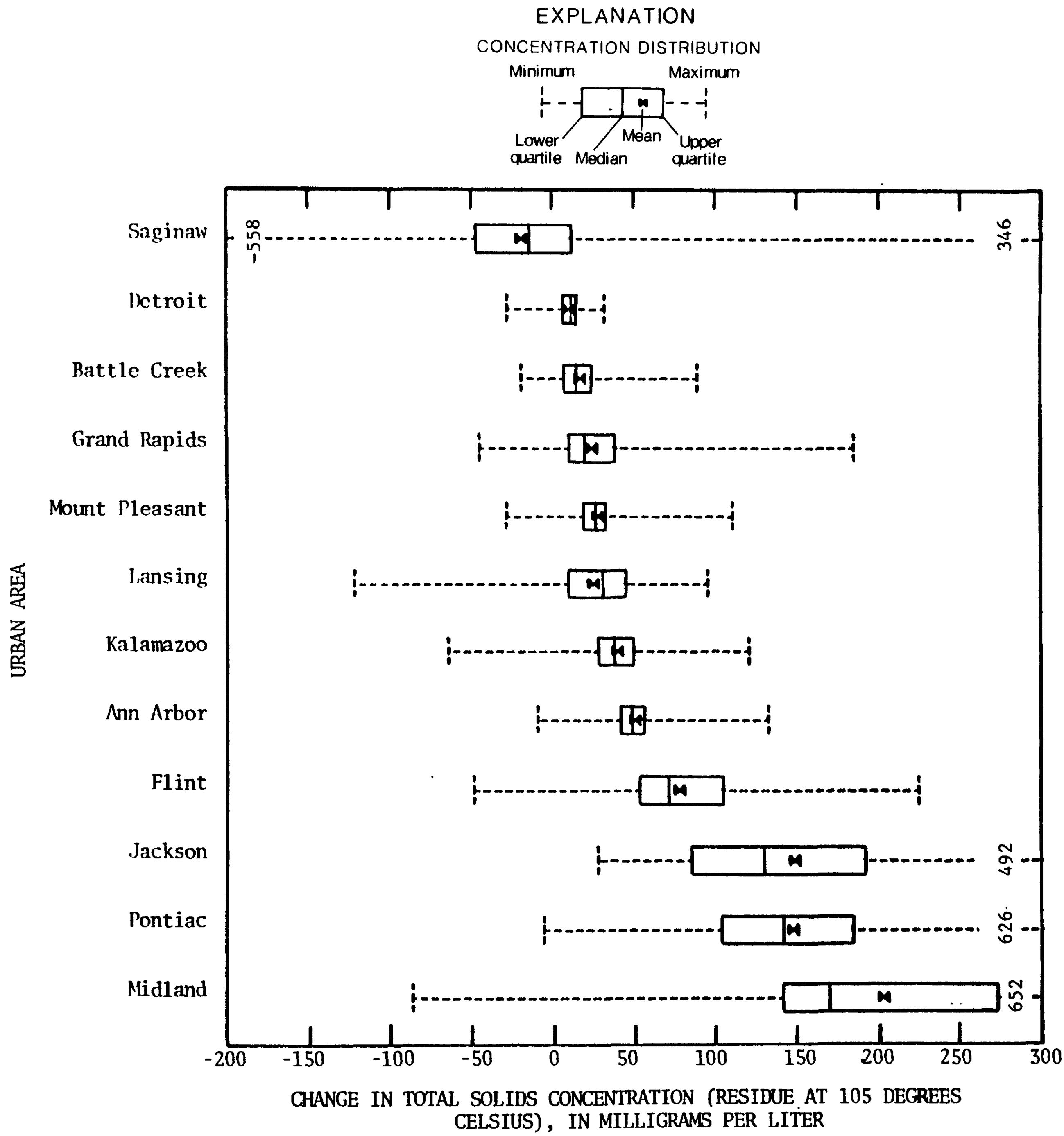


Figure 58.--Urban areas and variation of changes in total solids concentration.

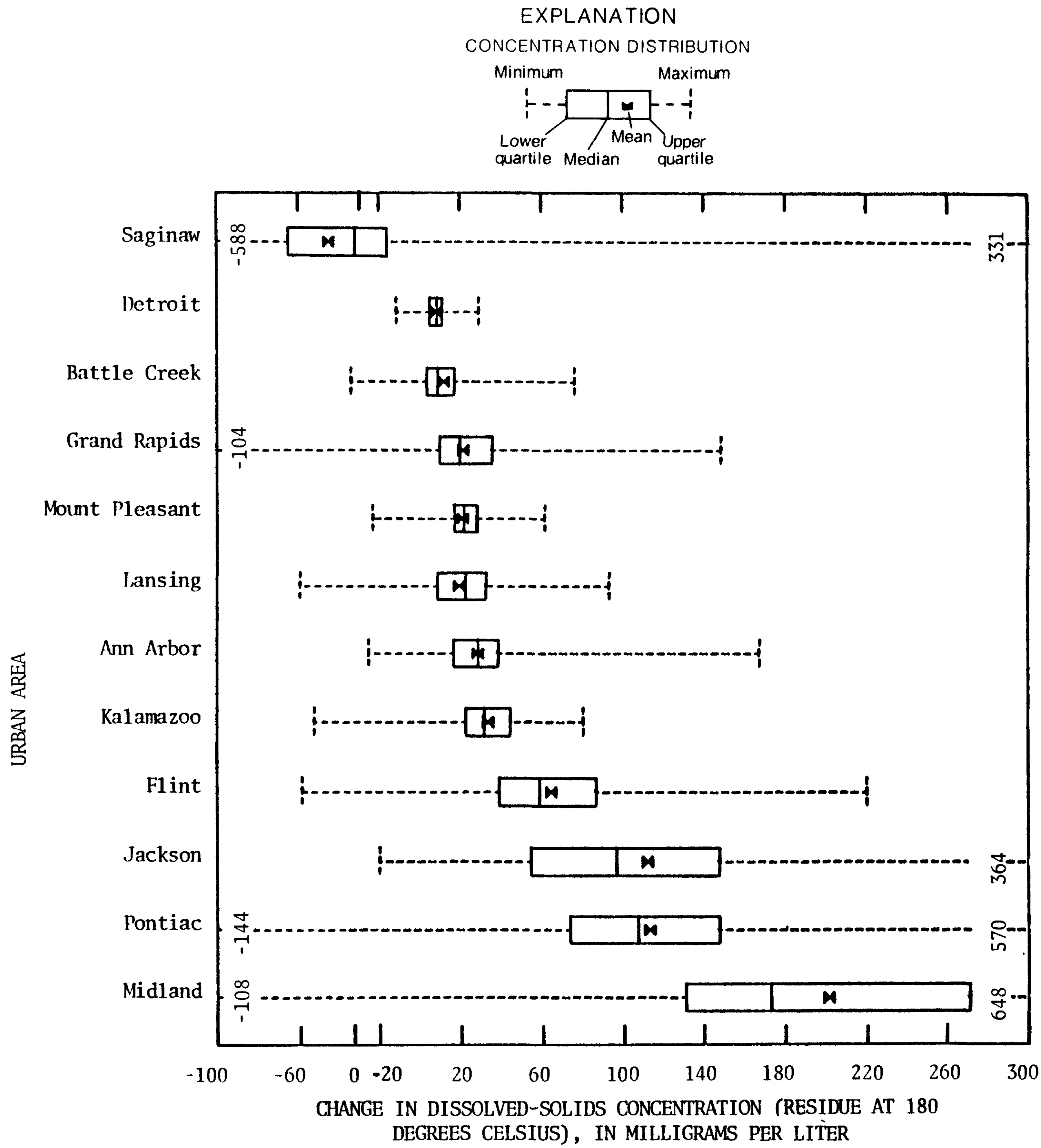


Figure 59.--Urban areas and variation of changes in dissolved-solids concentration.

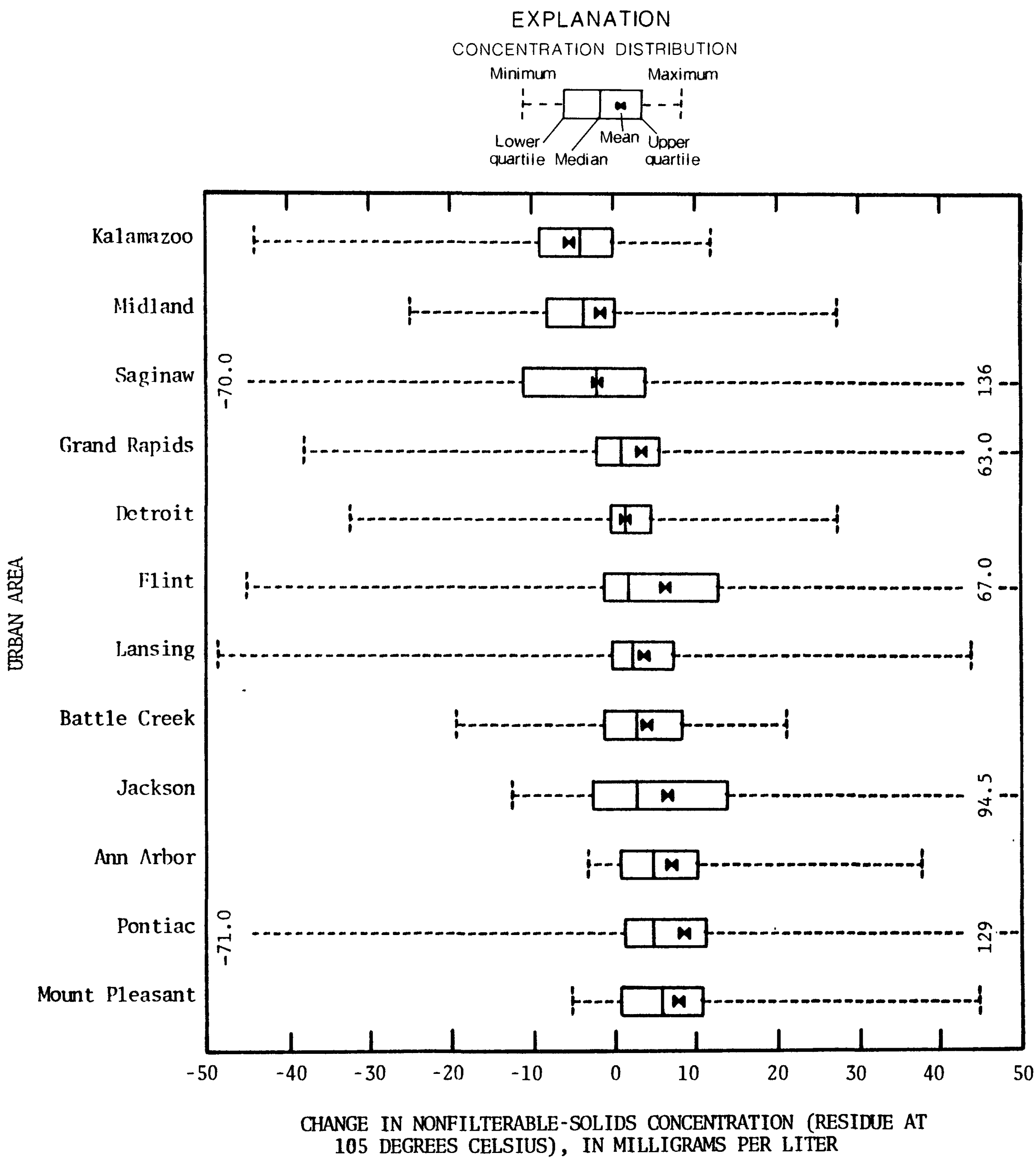


Figure 60.--Urban areas and variation of changes in nonfilterable-solids concentration.

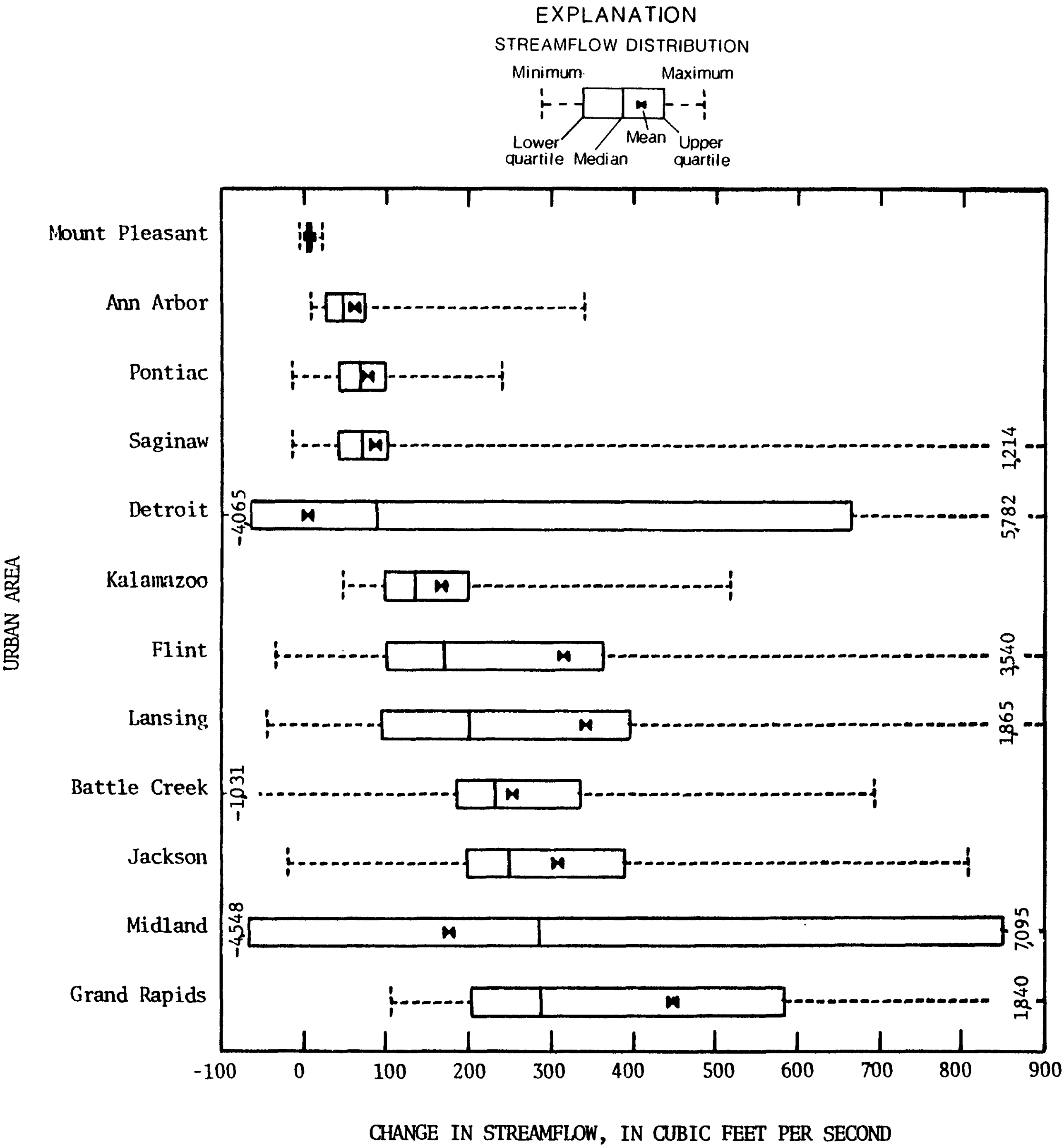


Figure 61.--Urban areas and variation of changes in streamflow.

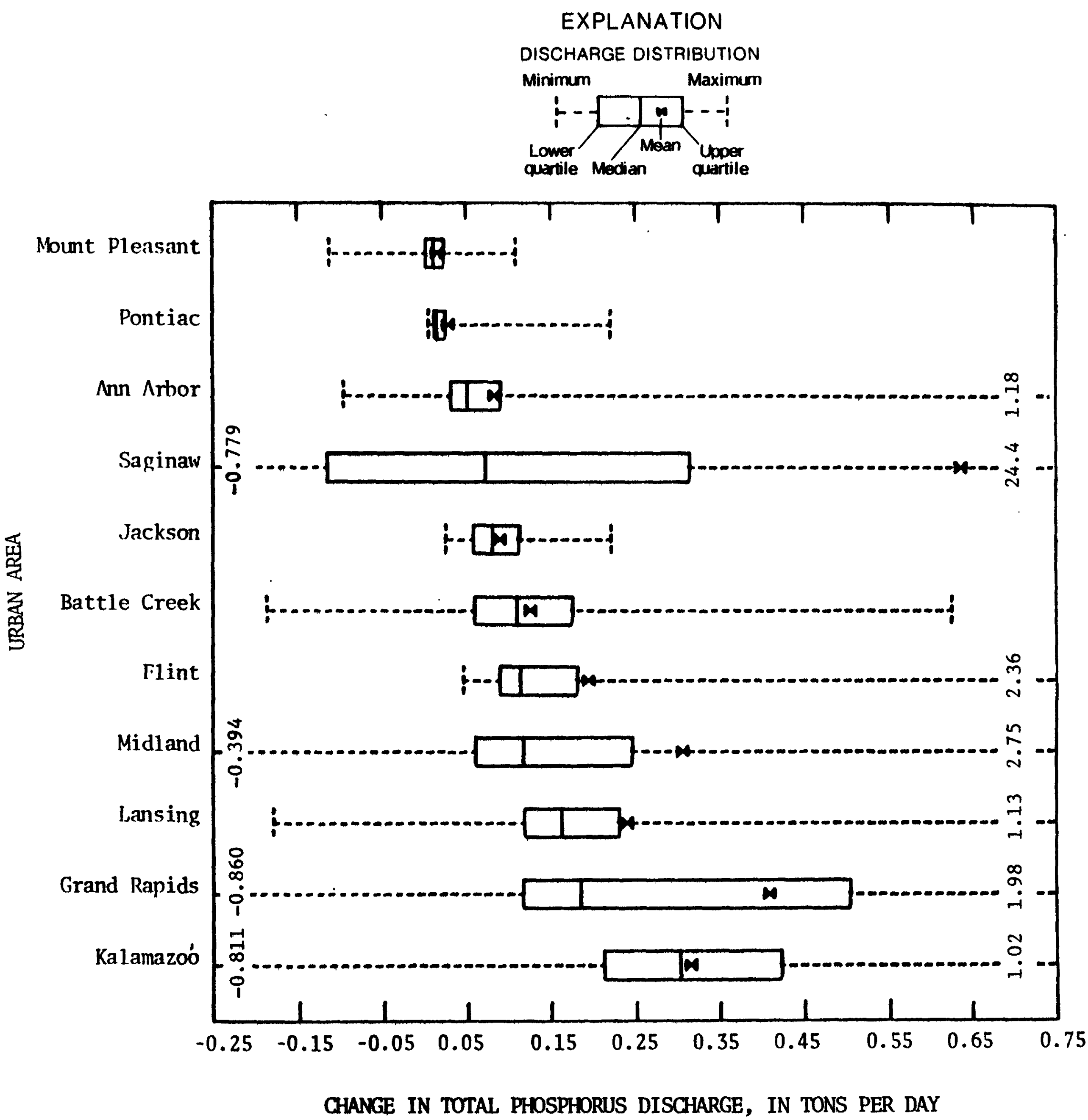


Figure 62.--Urban areas and variation of changes in total phosphorus discharge.

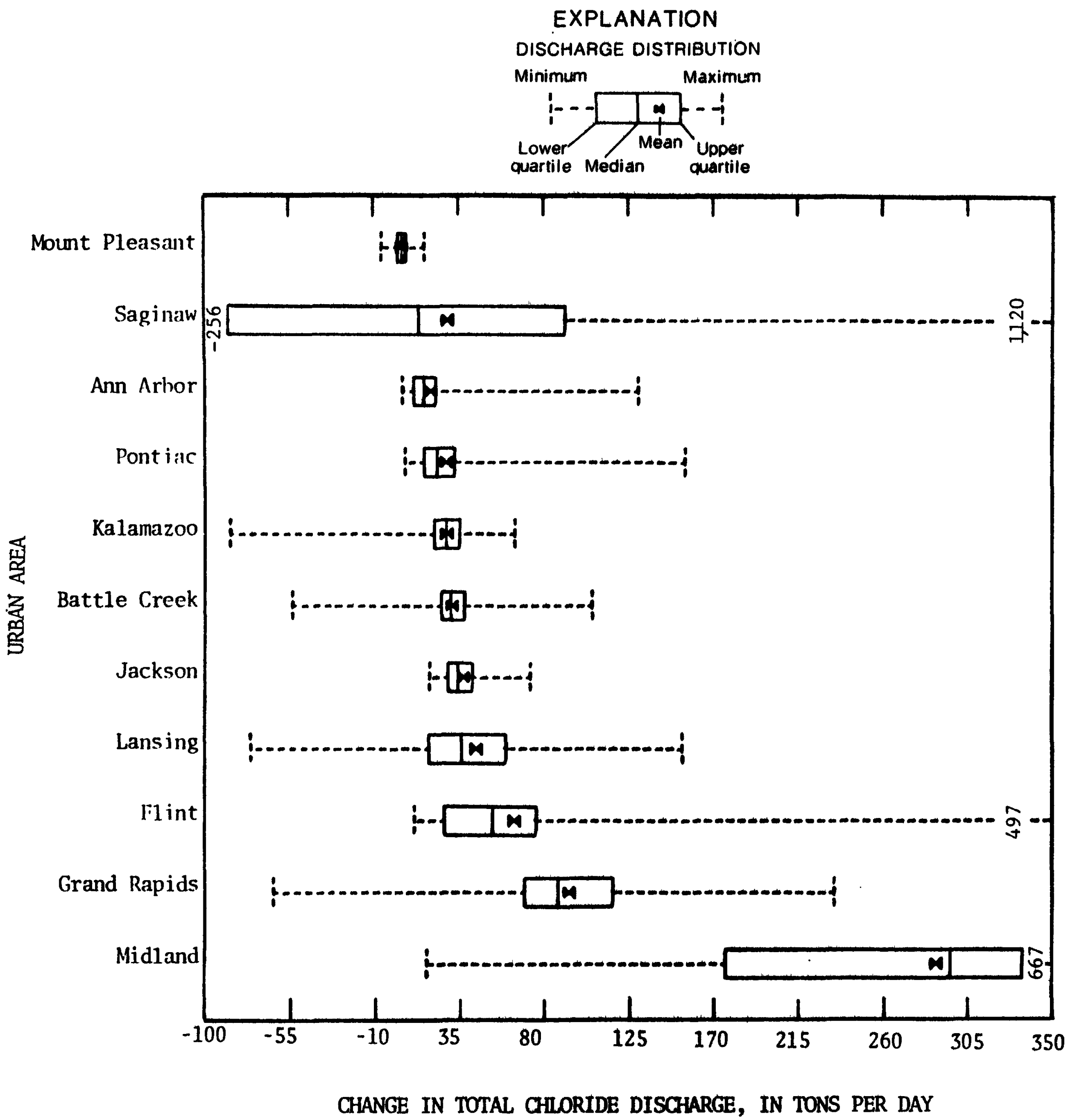


Figure 63.--Urban areas and variation of changes in total chloride discharge.

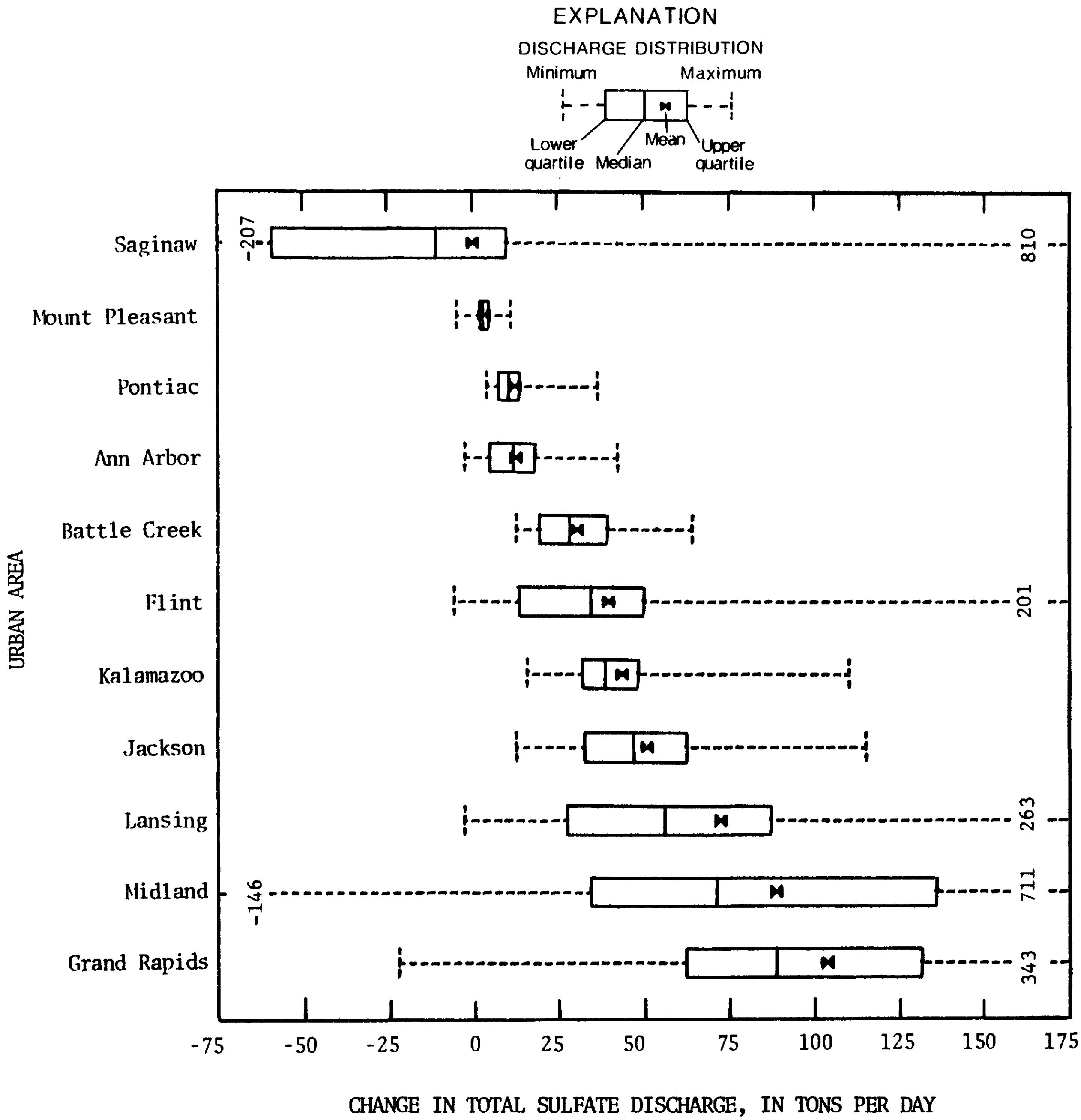
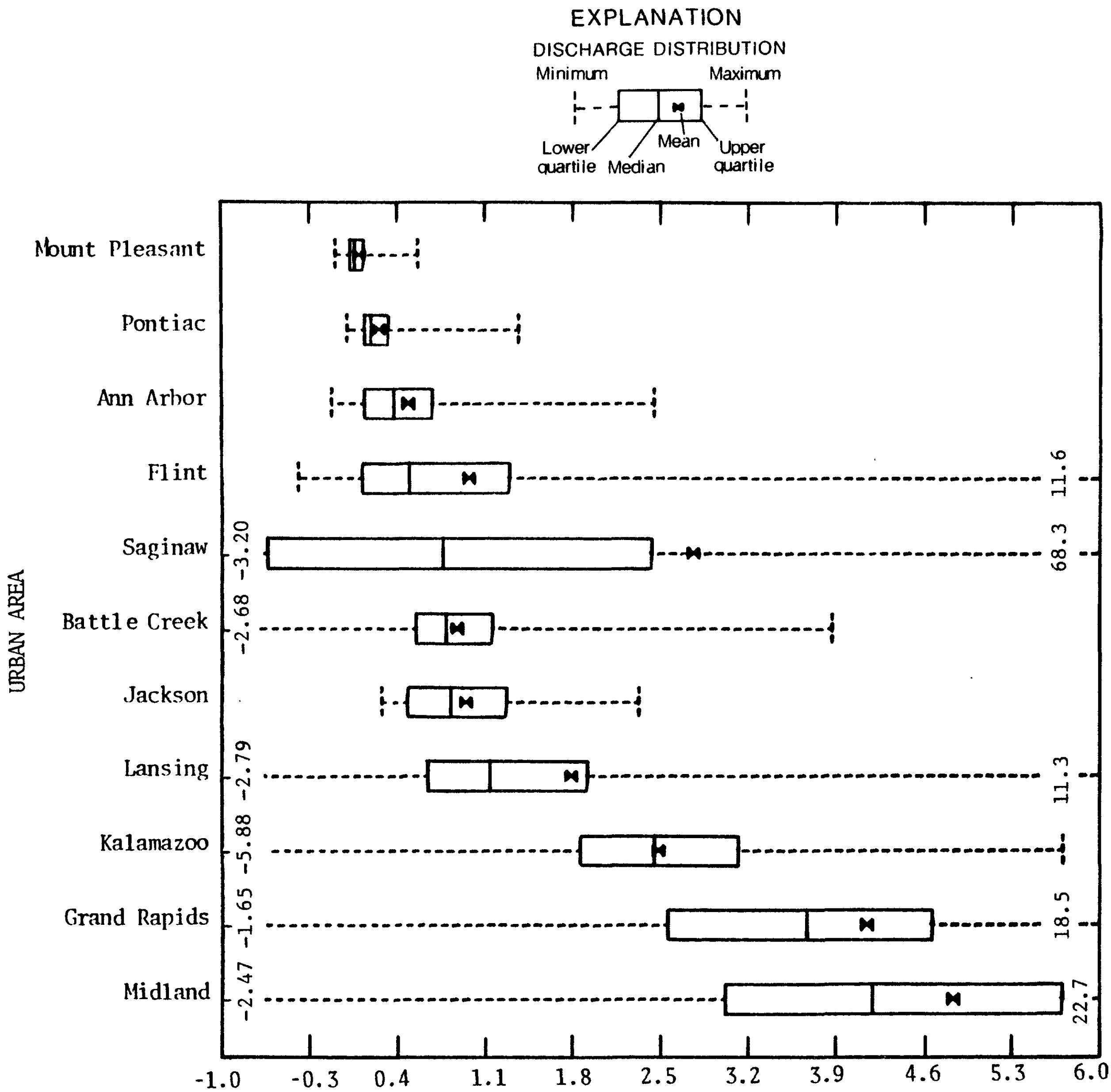


Figure 64.--Urban areas and variation of changes in total sulfate discharge.



CHANGE IN TOTAL ORGANIC PLUS AMMONIA NITROGEN DISCHARGE, IN TONS PER DAY AS NITROGEN

Figure 65.--Urban areas and variation of changes in total organic plus ammonia nitrogen discharge.

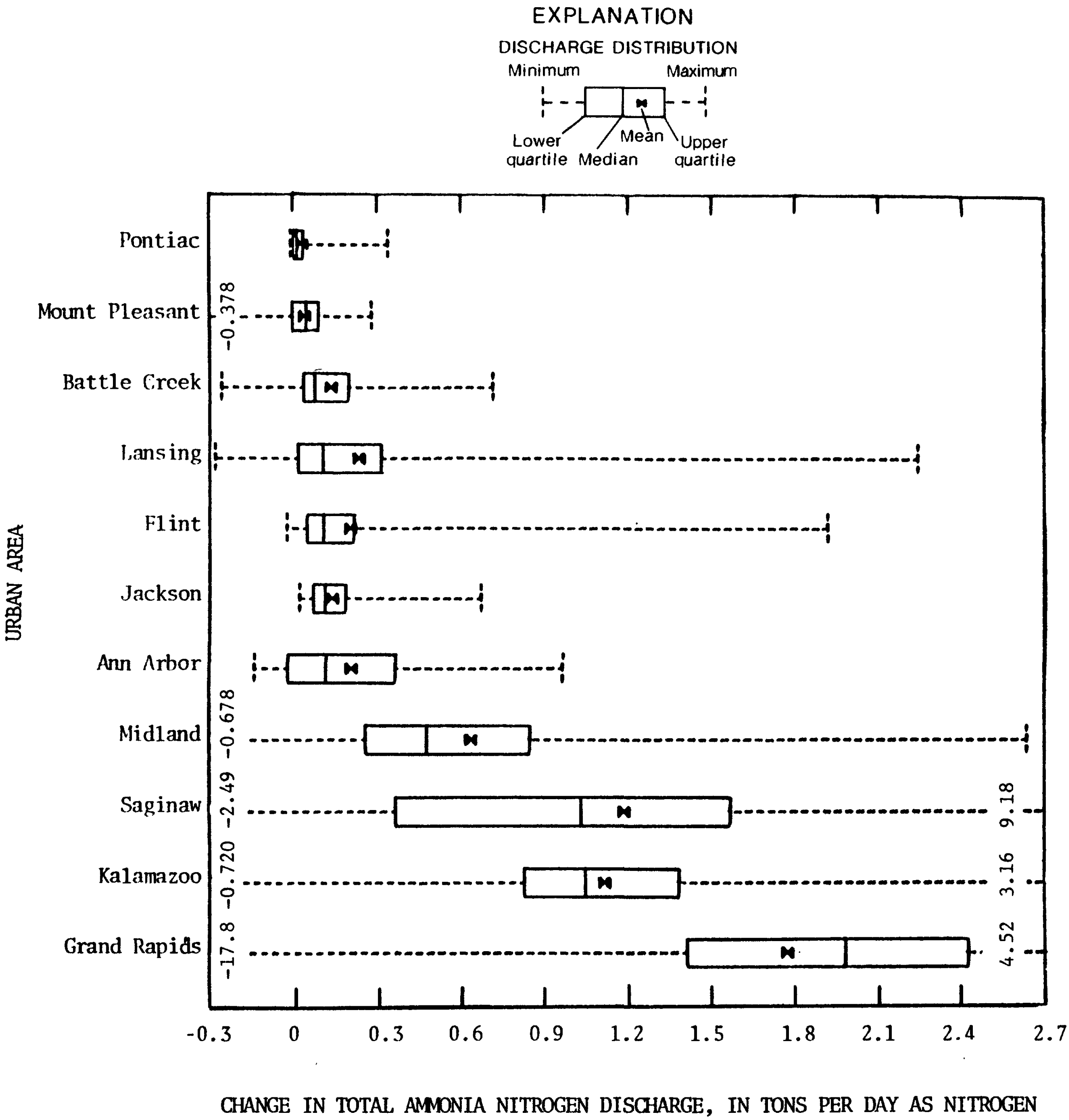


Figure 66.--Urban areas and variation of changes in total ammonia nitrogen discharge.

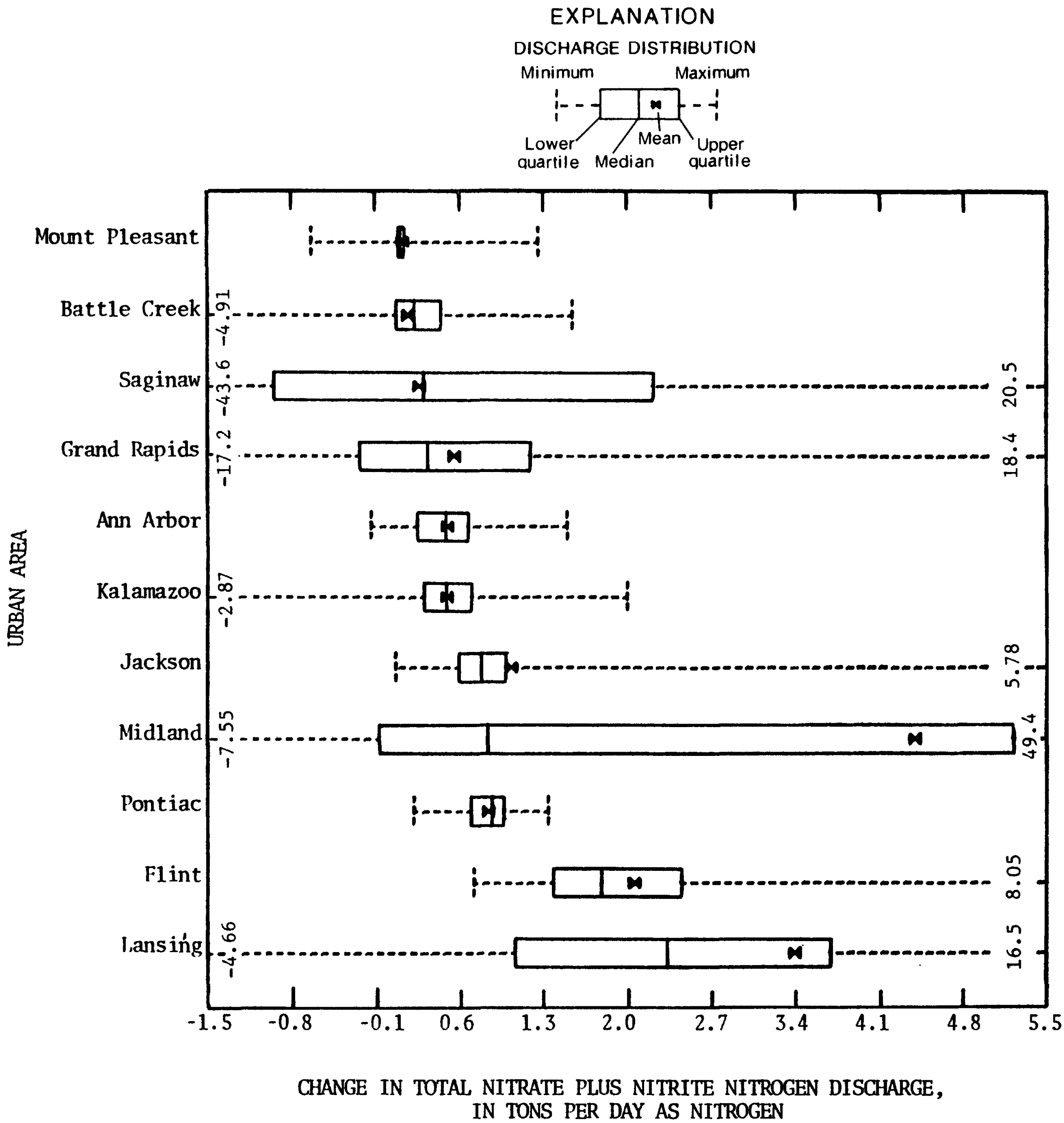


Figure 67.--Urban areas and variation of changes in total nitrate plus nitrite nitrogen discharge.

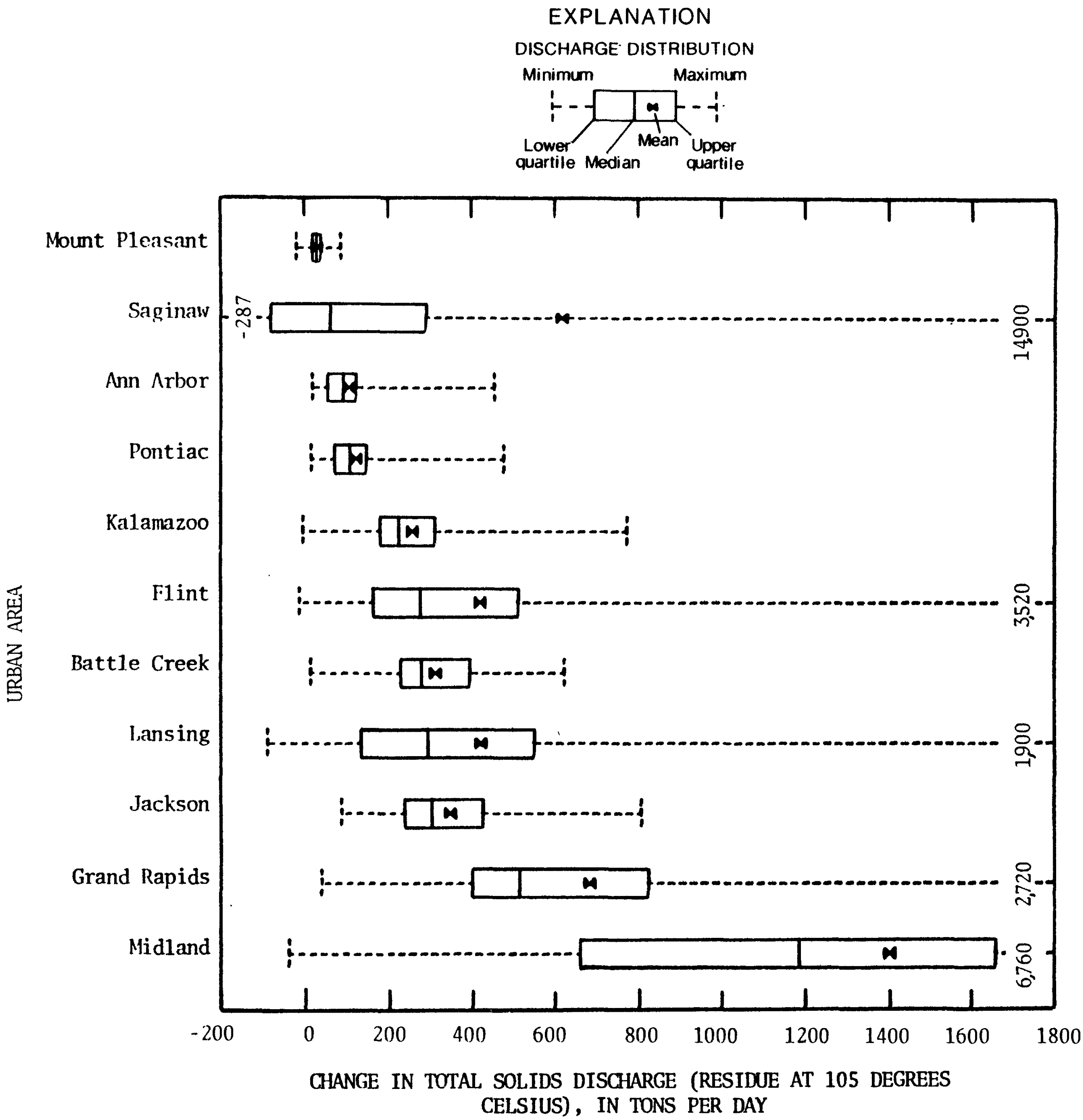


Figure 68.--Urban areas and variation of changes in total solids discharge.

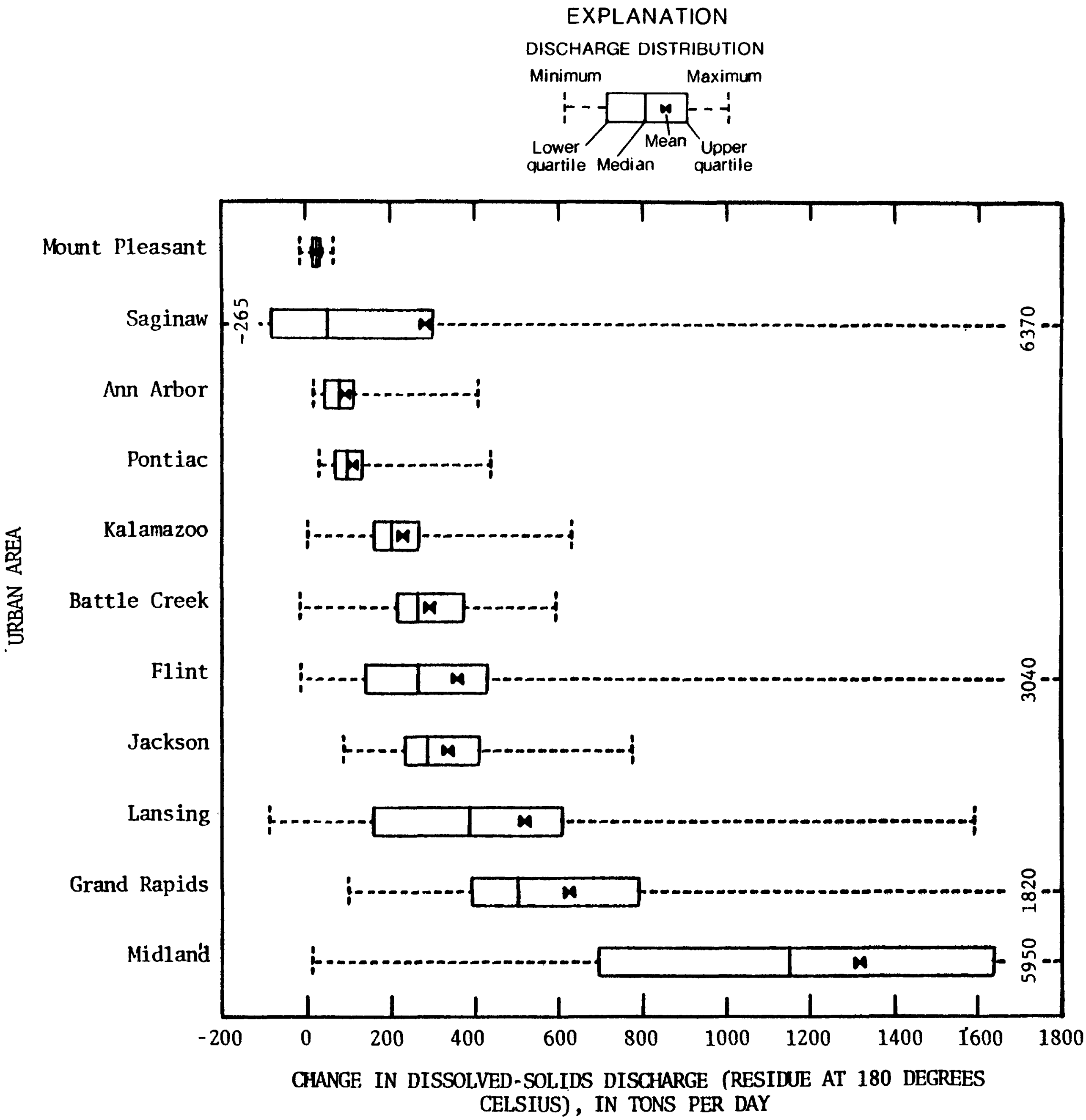


Figure 69.--Urban areas and variation of changes in dissolved-solids discharge.

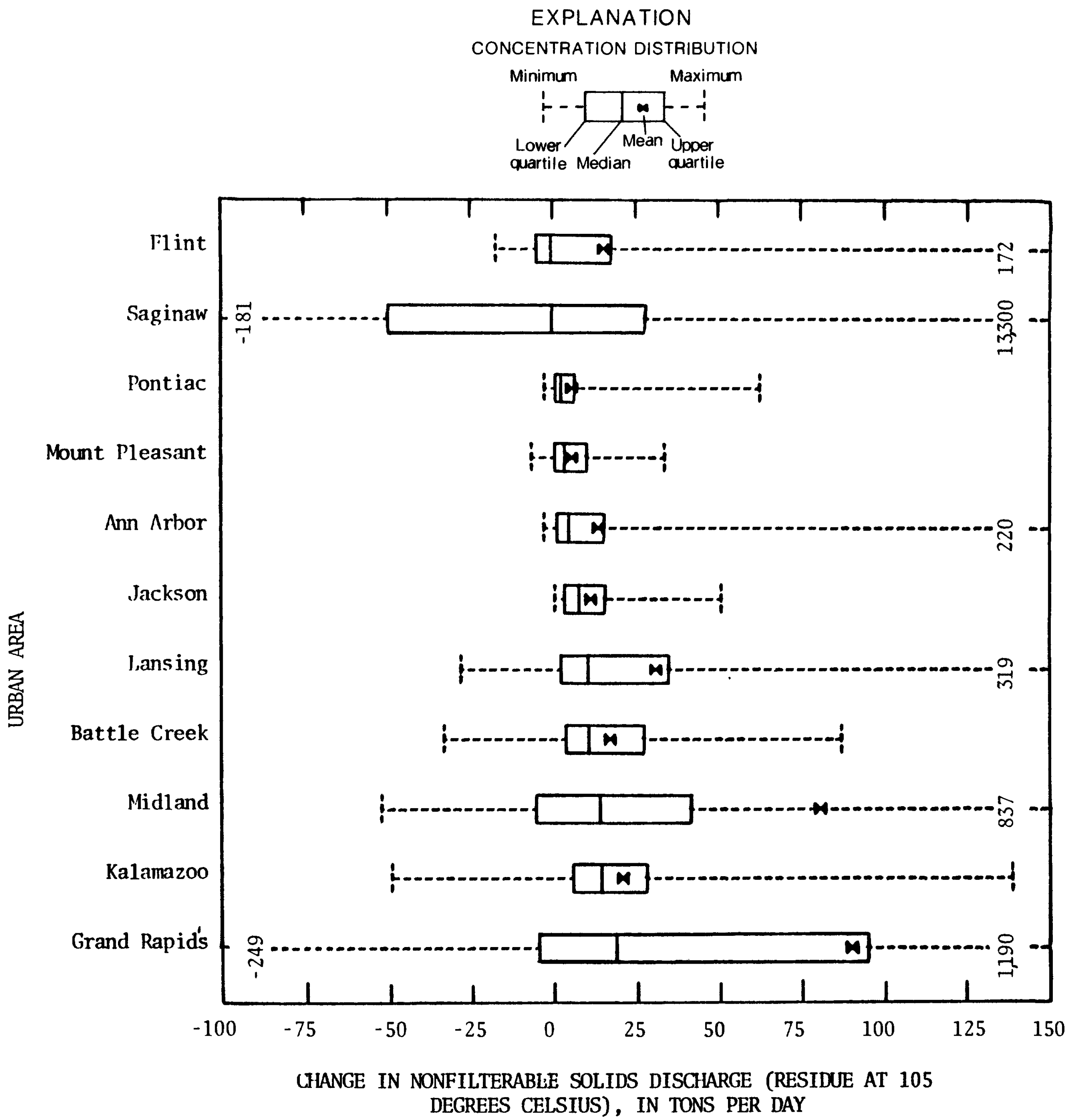


Figure 70.--Urban areas and variation of changes in nonfilterable-solids discharge.

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