Prepared in cooperation with the U.S. Environmental Protection Agency

Inventory and Statistical Analysis of Sediment Data for Streams in Kentucky, 1950–2008

Scientific Investigations Report 2009–5035

U.S. Department of the Interior
U.S. Geological Survey

Cover photo. USGS site ID 03308500,
the Green River at Munfordville, Kentucky.

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KEN SALAZAR, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

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Conversion Factors

SI to Inch/Pound		
Multiply	**By**	**To obtain**
milligram (mg)	35.27	ounce, avoirdupois (oz)
liter (L)	0.2642	gallon (gal)

Concentrations of chemical constituents in water are given in milligrams per liter (mg/L).

Abbreviations

FNU	Formazin nephelometric units
NTU	Nephelometric turbidity units
NWIS	National Water Information System
p	Parameter
SSC	Suspended-sediment concentration
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
USGS	U.S. Geological Survey

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Abstract

Suspended sediment is a constituent of water that is monitored because of concerns about accelerated erosion, nonpoint contamination of water resources, and degradation of aquatic environments. Understanding the availability of monitored sediment data for streams in Kentucky is critical to planning future modeling and monitoring efforts. In order to assess the availability of sediment data for Kentucky, long-term records were obtained from the National Water Information System (NWIS) of the U.S. Geological Survey (USGS). Suspended-sediment concentration (SSC), the parameter traditionally measured and reported by the USGS, was statistically compared to turbidity and total suspended solids (TSS), two parameters that are considered surrogate data. Coincident observations of SSC with either turbidity or TSS were available for 42 sites. In combination with instantaneous streamflow, turbidity and TSS both proved to be significant indicators of SSC when data from all sites were used. Because of the perceived link between sediment and nutrient abundance in streams, sediment-parameter data at these sites were correlated to total-nitrogen and total-phosphorus concentrations. A significant relation (p-value < 0.05) was found between monitored nutrient concentrations and coincident sediment abundance, although there were no clear linear relations.

This compilation of data showed that SSC was monitored at 118 sites in Kentucky at some time between 1950 and 2008. As of March 2008, 9 sites were monitored for SSC in Kentucky (8 of which are new) down from a high of more than 60 SSC sites during the 1980s. Of these 118 SSC sites, 21 sites were also monitored for TSS; there are coincident records for both SSC and TSS at 6 sites. Forty-seven of these long-term water-quality sites were also monitored for turbidity; there are coincident records for SSC and turbidity at 42 sites, including all of those at which there are coincident data for TSS. The number of sites at which SSC and at least one other sediment parameter (TSS or turbidity) were monitored decreased from a high of 27 in 1987 to zero during the period 2001–2005.

Introduction

Water-quality data, including nitrogen and phosphorus concentrations, are used to model the contribution of individual streams to regional ecosystems to address concerns such as hypoxia in the Gulf of Mexico (Alexander and others, 2008). More recently, sediment is being included in this type of regional modeling (Schwarz, 2008). However, these regional modeling efforts are dependent upon the maintenance of long-term data-collection sites where the period of record encompasses changes in urban development and agricultural management, as well as potential climate change.

Three sediment parameters have been historically reported by the U.S. Geological Survey (USGS): suspended-sediment concentration (SSC), total suspended solids (TSS), and turbidity. Of these sediment parameters, SSC (National Water Information System (NWIS) parameter 80154 (p80154)) is preferred to TSS (p00530) because the analytical method for SSC has been shown to be the more precise and accurate method, resulting in less error in sediment-load estimates (Glysson and Gray, 2002). An intact sample is used to determine SSC, in contrast to an aliquot of the sample as used with TSS methods. In comparison to turbidity, SSC is accurate at all magnitudes of sediment concentration (milligram per liter). Turbidity (p00076), until recently, had an upper limit of approximately 1,000 nephelometric turbidity units (NTU) due to instrument limitations; turbidity also measures suspended materials in addition to sediment, including finely divided organic matter, plankton and other microscopic organisms, organic acids, and dyes (Anderson, 2005). Finally, use of different turbidimeter technologies can result in different turbidity measurements for the same environmental conditions or laboratory samples, yet all turbidity data were reported in the NWIS as a single parameter code, p00076, until 2005 (Miller, 2004); this complicates not only comparison of turbidity to SSC but also comparison of turbidity data among monitoring sites and data-collection periods (Sadar, 2002; Ziegler, 2002).

Although SSC is the preferred sediment parameter and is the one traditionally monitored by the USGS, measurement and reporting of additional sediment parameters can have substantial research benefits. Specifically, because TSS and turbidity are frequently reported by other agencies (for example, Kentucky Division of Water; *http://www.water.ky.gov/sw/swmonitor/*) the maintenance of multiparameter sediment sites enables extension of sediment modeling to more streams, including those of different orders and in different physiographic terranes. Consequently, it is important to understand the quantitative relation among these three sediment parameters. In order to maintain this ability to compare and contrast these different sediment parameters, it is critical that long-term records of all three parameters be available. The purpose of the data inventory and statistical analysis described in this report was to determine the availability of long-term sediment data for Kentucky and to quantify the relation among these three sediment parameters (SSC, TSS, and turbidity). The study was done in cooperation with the U.S. Environmental Protection Agency.

Methods

During January 2008, data were downloaded from the National Water Information System (NWIS; *http://waterdata.usgs.gov/nwis/rt*) for sites along Kentucky streams where long-term water-quality records were available. For purposes of this analysis, "long-term records" are defined as those from sites where 25 or more field visits had been made for collection of water-quality samples. Fewer than 25 sediment records may be available, however, if sediment was not on the sampling and analytical schedule for every field visit. The number of field visits per year depends on the particular site and sampling program.

From these retrieved observations, data for SSC (p80154), TSS (p00530), and turbidity (p00076) were inventoried in order to assess the abundance, history, and coordination of observations. Each sediment parameter was statistically described, and stepwise linear regression was used to develop a relation between SSC (the preferred parameter) and the surrogates TSS and/or turbidity using coincident observations (from the same site, day, and time) of the sediment parameters and instantaneous stream discharge (p00061). The correlation between individual sediment parameters, as well as to total nitrogen (p00600) and total phosphorus (p00665), was evaluated with scatterplots because of the perceived relation between sediment and nutrient abundance in streams; the significance of these correlations was tested with the Pearson's product-moment correlation coefficient. All statistical analyses were done with S-plus (Insightful Corporation, 2008).

Sediment Data Inventory

In Kentucky, SSC was monitored at 118 long-term sites between 1950 and 2008 [fig. 1 and table 1 (at the end of the report)]. More than 60 sites were monitored in the early 1980s; however, this number decreased to approximately 30 sites around 1982 and decreased again in the 1990s to less than 15 SSC sites (fig. 2). During the late 1990s, SSC was monitored at one site. As of December 2007, 10 sites were monitored for SSC in Kentucky. Of these 10 SSC sites, 8 are in watersheds that are the focus of recent interest (2007) by agencies that cooperate with the USGS in water-resources investigations (U.S. Environmental Protection Agency and Kentucky Division of Water). Collection of SSC data at the Green River at Munfordville, Ky. (USGS site ID 03308500, cover photo), was discontinued in February 2008. Currently, a long-term SSC record is maintained for the Tennessee River at Highway 60 near Paducah, Ky. (USGS site ID 03609750), at the confluence of the Tennessee and Ohio Rivers; flow at this site is regulated by the dam at Kentucky Lake, so high-discharge events, and the resultant sediment concentrations, are attenuated.

Total suspended sediment (TSS) was monitored at 21 of these 118 long-term sites where SSC was monitored (figs. 1 and 3 and table 1); 6 sites have coincident records for SSC and TSS (fig. 4). The number of TSS sites also peaked around 1980 with a maximum of 11. By 1990, TSS was no longer monitored by the USGS.

Turbidity was monitored at 47 of these 118 long-term sites (figs. 1 and 5 and table 1), and there are coincident records of SSC and turbidity at 42 of these sites (fig. 6), including all of those at which there are coincident data for TSS. The number of turbidity sites peaked in the mid-1980s with a maximum of 20. This number began to decrease in the late1980s and, by 2001, the last p00076 turbidity record was discontinued. During 2007, SSC and turbidity were coincidently monitored on the Tennessee River at Highway 60 near Paducah, Ky. (USGS site ID 03609750), and the Cumberland River at Smithland, Ky. (USGS site ID 03438500); however, these data are not included in this report because a different turbidity unit (p63676) was used. [Details on USGS changes in turbidity measurement and reporting can be found in Miller (2004) and documents referenced therein.]

The number of monitored sites where SSC and at least one other sediment parameter were reported ranged from a high of 25 in 1987 to a low of zero during 2001–5. As of March 2008, nine sites were sampled for SSC data, and turbidity was monitored at one of these sites, the Tennessee River at Highway 60 near Paducah, Ky. (USGS site ID 03609750).

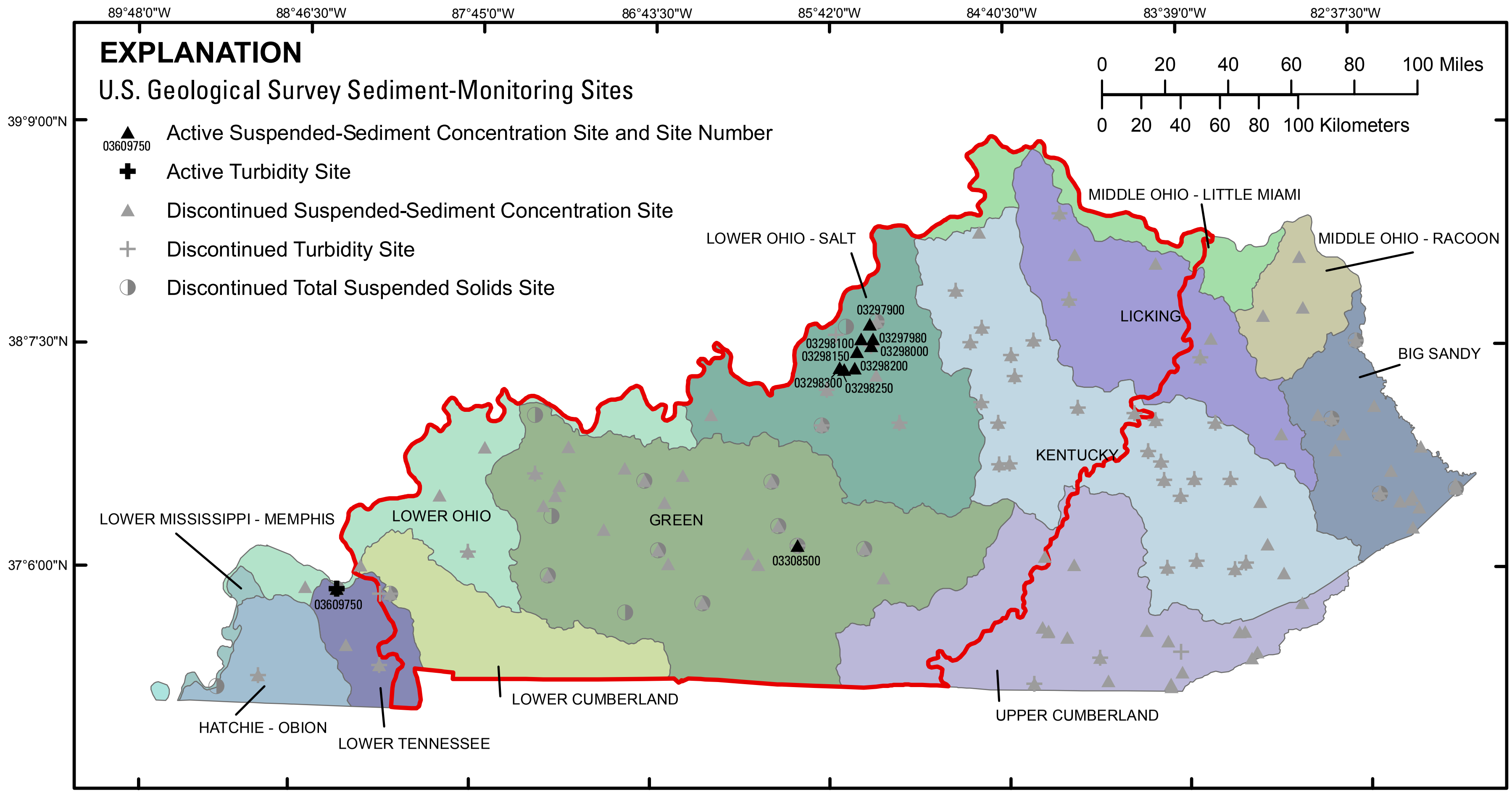


Figure 1. Distribution of historical U.S. Geological Survey sediment-monitoring sites across Kentucky for which there are long-term water-quality records and location of active sediment-monitoring sites at the end of 2007; these sites are also listed in table 1. Sites with coincident observations that are discussed in the text are indicated by coincident symbols and are noted in table 1. The thirteen hydrologic-unit-code 6 (HUC 6) basins are shown for reference. The Interior Plateau area of Kentucky (Ecoregion 71 of Woods and others, 2002) referred to in the text is outlined in red.

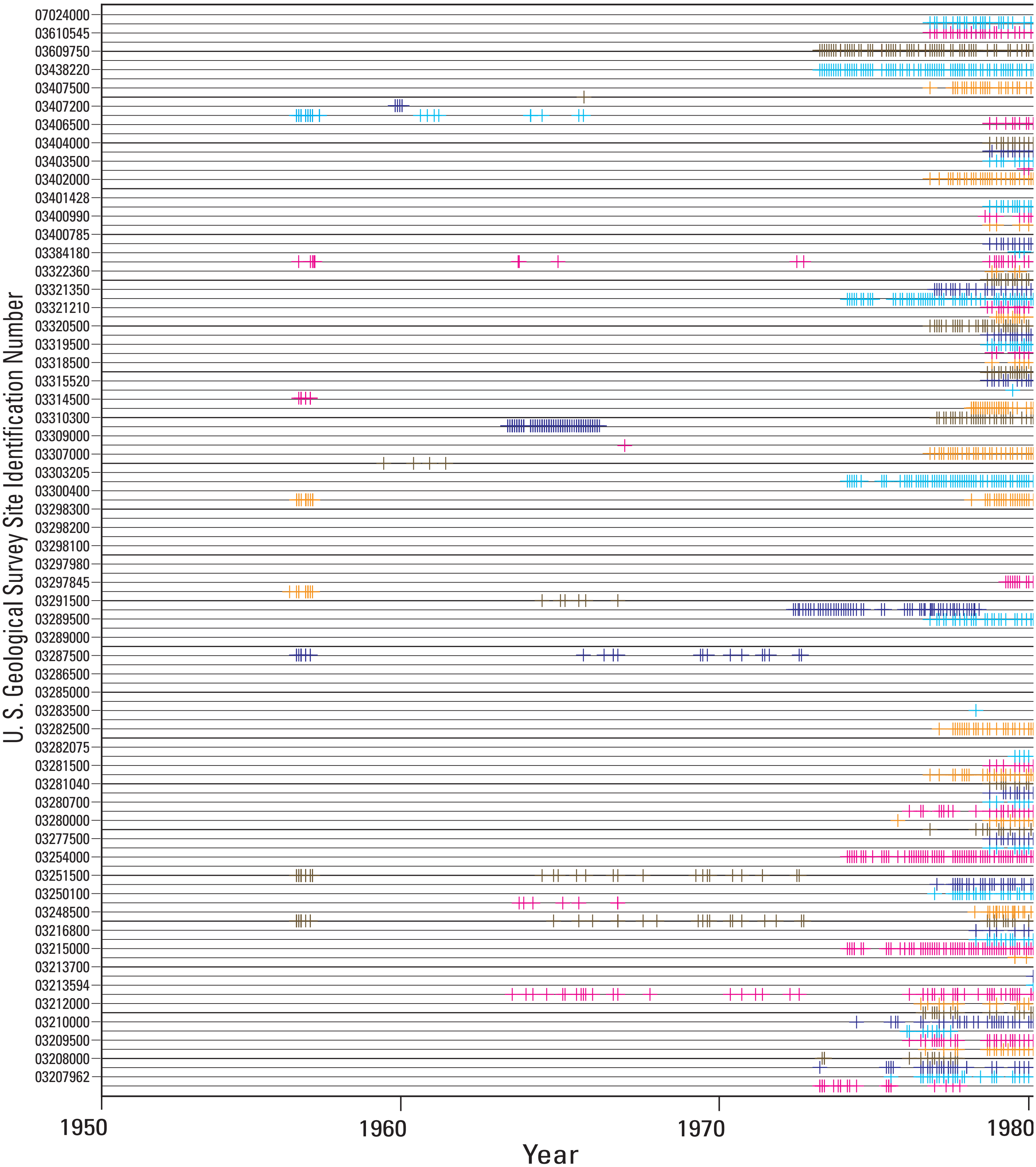
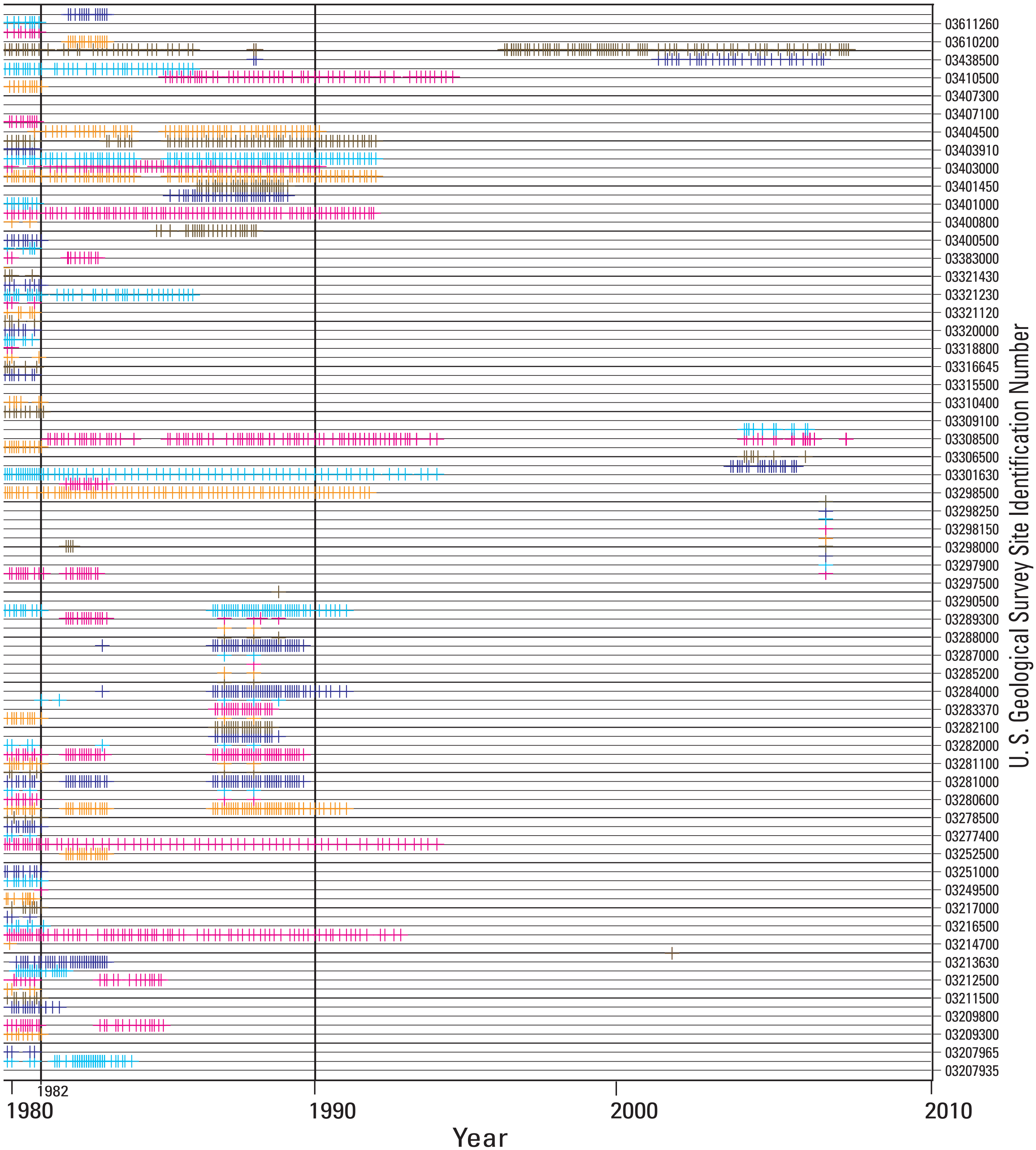


Figure 2. Sample-collection dates of suspended-sediment concentration at U.S. Geological Survey sites in Kentucky for which there are long-term water-quality records. The highest number of sites was monitored in the early 1980s; however, this number was halved by 1982 (shown by the first line). Some new sites were added in the mid-1980s, but the total number of sites was halved again



(to approximately 15) before 1990 (shown by the second line). The number of sites continued to decrease during the 1990s. At the end of 2007, 10 sites were being monitored in the Commonwealth; however, most of these have no long-term record. Each crosshatch (+) indicates a single sample date. Color in this figure is only to help the reader and is not meant to imply a difference between sites.

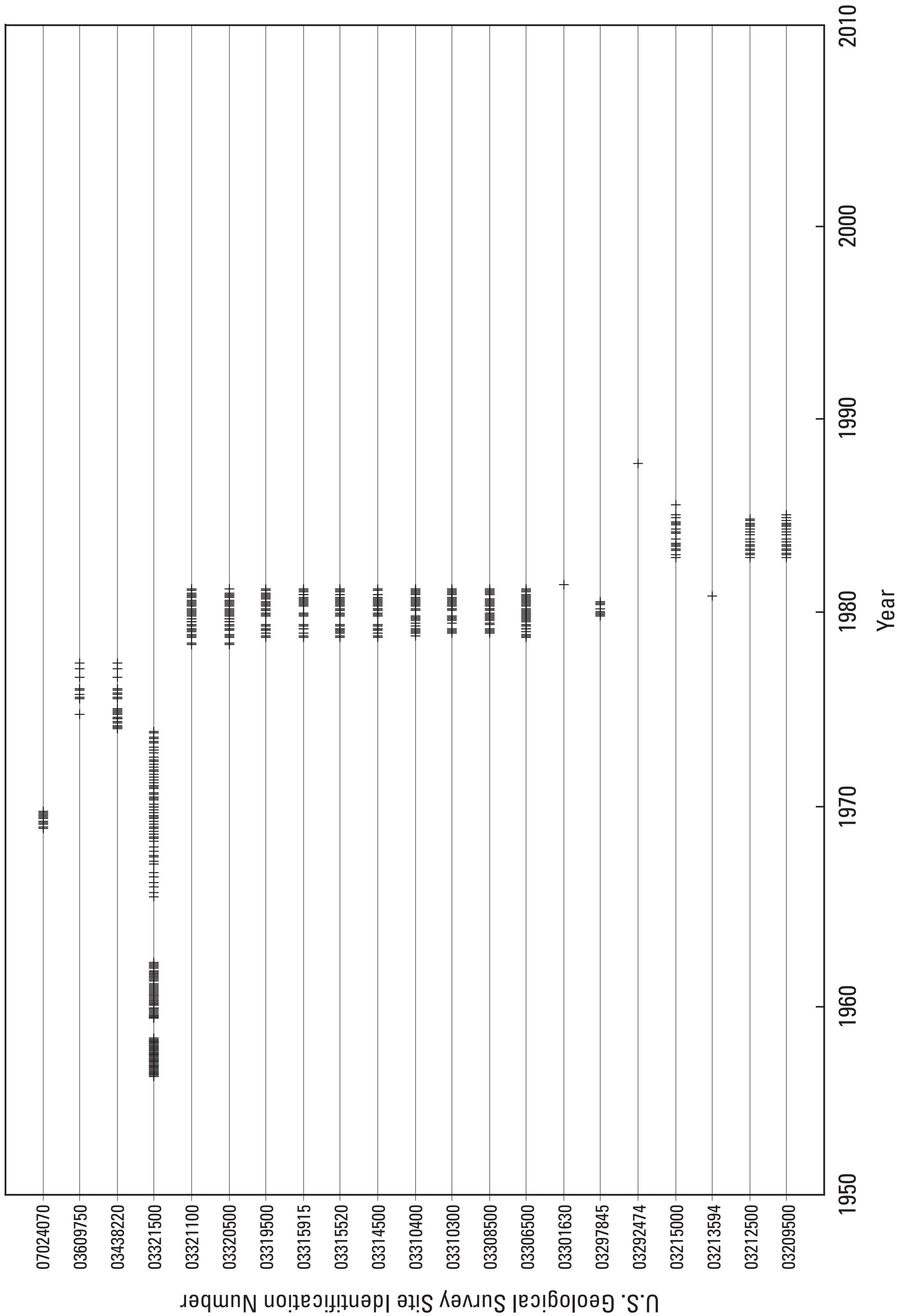


Figure 3. Sample-collection dates of total suspended solids at U.S. Geological Survey sites in Kentucky. The highest number of sites was monitored around 1980; however this number dwindled to zero by the end of the decade. At the end of 2007, no USGS sites were being monitored for total suspended solids in the Commonwealth. Each crosshatch (+) indicates a single sample date.

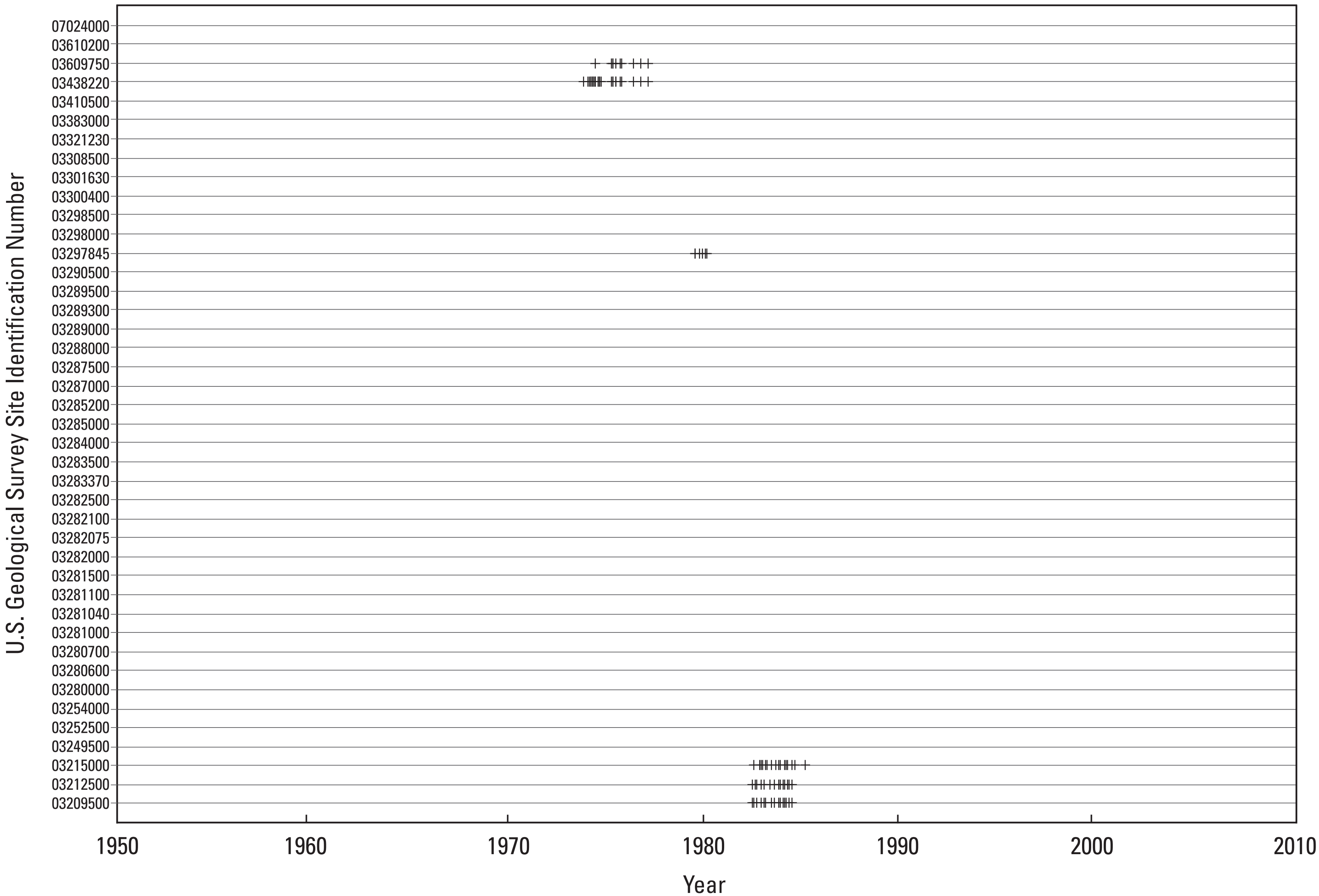


Figure 4. Coincident sample-collection dates of suspended-sediment concentration and total suspended solids at U.S. Geological Survey sites in Kentucky. For consistency with other figures, all sites for which at least two sediment parameters were monitored are included. Although six sites included both sediment parameters for over 10 years, at the end of 2007, there were no sites with this type of coincident data. Each crosshatch (+) indicates a single sample date.

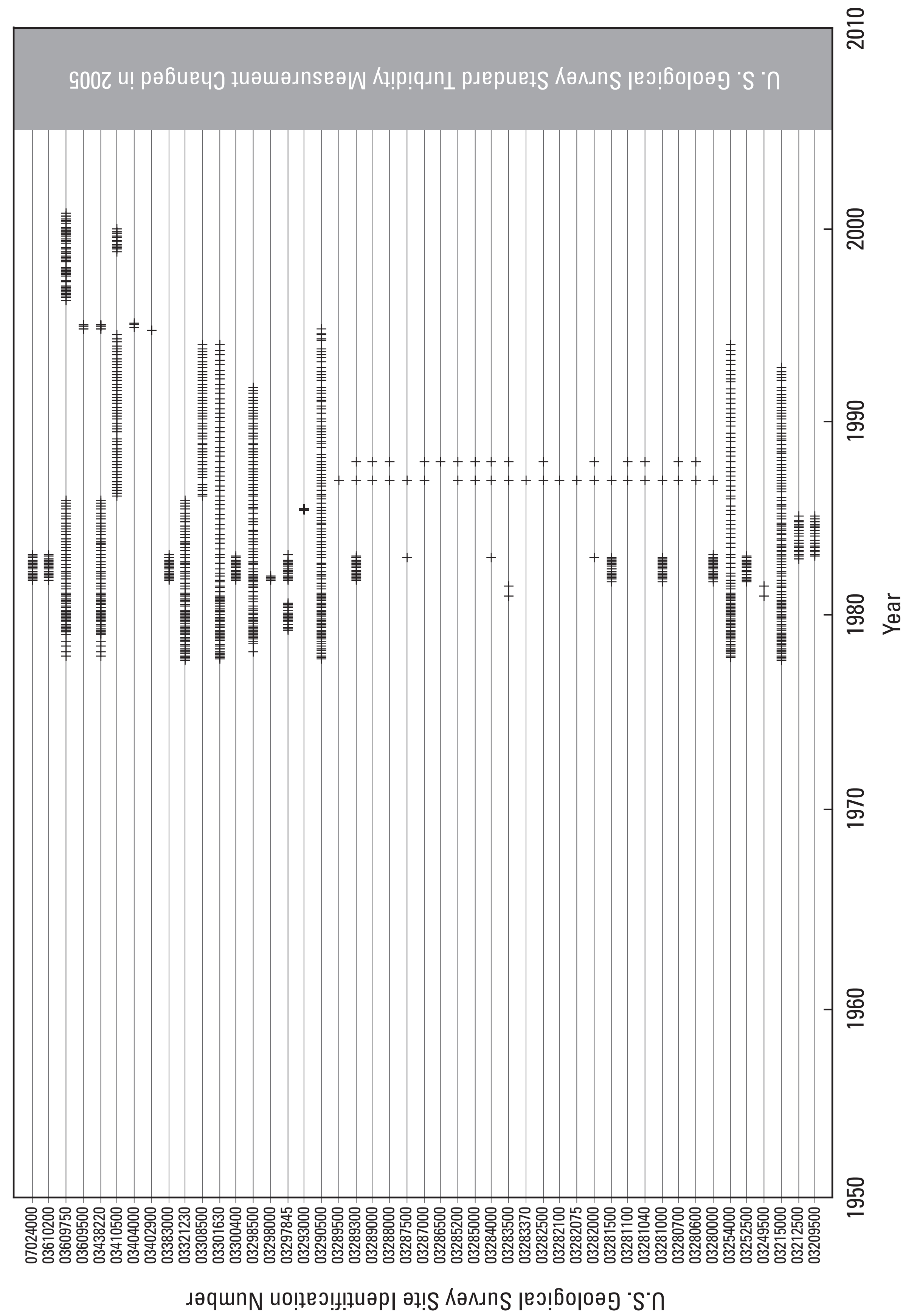


Figure 5. Sample-collection dates of turbidity at U.S. Geological Survey sites in Kentucky. The highest number of sites was monitored in the mid-1980s; however this number decreased soon after this peak and again in the mid-1990s. For consistency with other figures, the time period extends to 2008. However, the p00076 monitoring parameter was discontinued in 2005 (Miller, 2004). Each crosshatch (+) indicates a single sample date.

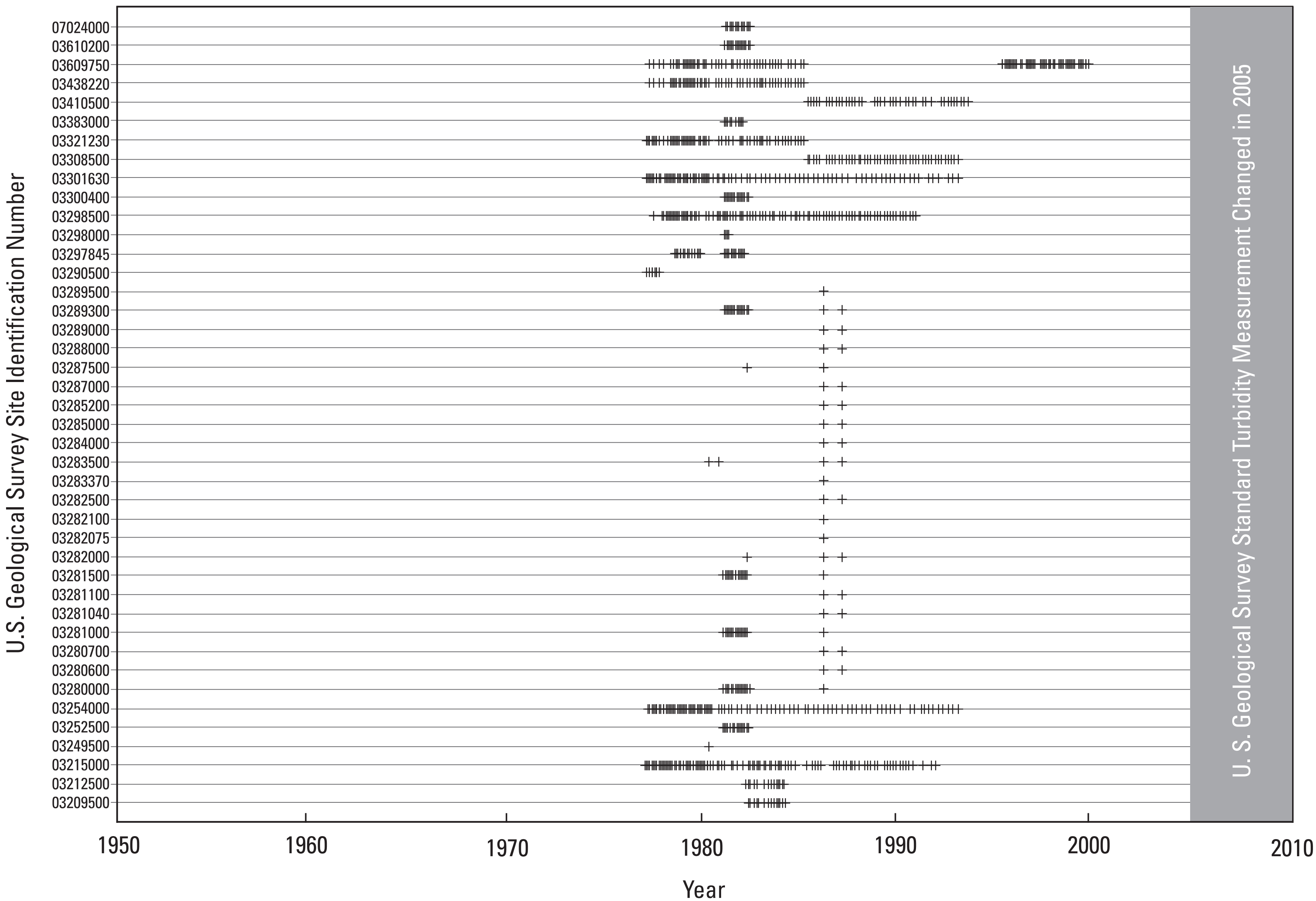


Figure 6. Coincident sample-collection dates of suspended-sediment concentration and turbidity at U.S. Geological Survey sites in Kentucky. For consistency with other figures, the time period extends to 2008. However, the p00076 monitoring parameter was discontinued in 2005 (Miller, 2004). Since the late 1970s, coincident suspended-sediment concentration and turbidity data were measured at 42 sites at least once. Each crosshatch (+) indicates a single sample date.

Statistical Analysis of Selected Sediment and Nutrient Parameters

Five water-quality parameters—SSC, TSS, turbidity, total nitrogen (TN), and total phosphorus (TP)—were statistically summarized to reveal any significant relation among them (table 2 and figs. 7–12). The nutrient parameters TN and TP were included in the statistical analysis because of the perceived relation between sediment and nutrient abundance in streams (as mentioned, for example, by Alexander and others, 2008). For the 42 stations at which there are coincident data for at least two sediment parameters, a Pearson's product-moment correlation was calculated. This analysis showed significant correlation between all pairs of sediment parameters and between the nutrient parameters. In addition, there was significant correlation between all sediment and nutrient parameters except for the total phosphorus and TSS pairing (fig. 12). The significance, however, is likely due to the large number of observations; visual inspection shows that none of the scatterplots shows a linear relation, and the correlations between sediment and nutrient parameters are all < 0.4. Correlation between water-quality parameters also was evaluated separately for those sites that are part of the Interior Plateau area of Kentucky (red outline in fig. 1), which includes the Bluegrass and Pennyroyal karst terranes (Ecoregion 71 of Woods and others, 2002). Results from this analysis were similar (fig. 12; correlation coefficients in parentheses), with significant correlation between sediment parameters and between nutrient parameters; however, for sites in the Interior Plateau area of Kentucky, the correlation between SSC and total phosphorus is the only significant relation between an individual sediment parameter and a nutrient parameter.

In order to quantify the significant correlations between SSC and the surrogates TSS and/or turbidity, coincident observations were used in stepwise linear regression (table 3). These coincident observations ranged from 1 to 400 mg/L suspended sediment (recorded as p80154, SSC). Previous researchers have shown a natural (or Napierian) logarithm transformation to make the regressions more rigorous (Galloway and others, 2005) and this was true when either TSS or turbidity were individually used to estimate SSC. For sites with coincident observations of all three sediment parameters, the combination of TSS, turbidity, and instantaneous discharge was the strongest estimator of SSC; in this case, the untransformed values were the most rigorous indicators.

Each of these regressions of SSC on TSS and turbidity (table 3) is highly significant, and all coefficients retained are significant at the 0.05 confidence level. Although this indicates a significant ability to estimate SSC for streams in Kentucky from the surrogates TSS and turbidity, this ability is strongest when coincident TSS and turbidity data are available. The TSS slope coefficient was expected to be close to 1 because SSC and TSS are reported with the same units and should quantify the same material. Finally, although the regression of SSC on turbidity is significant, the relatively low R^2 combined with the high number of observations suggests that estimates of SSC from this equation may be less accurate than those derived from TSS data.

Glysson and Gray (2002) noted that estimation of SSC sediment loads from other sediment parameters was most successful when data from individual stations were separated. Consequently, these regressions were assessed for all sites with ≥ 5 coincident observations of different sediment parameters (tables 4, 5, and 6). Although some of these regressions are more rigorous, not all of the regressions are significant, and there is no clear pattern of significance with respect to sample size or coefficient values. The resulting slope (β) coefficients also are inconsistent within each set of equations. Furthermore, site-specific analyses are prohibitive when trying to develop an SSC database for all of Kentucky due not only to the lack of coincident samples but also to the complexity of treating each site differently in regional modeling.

Table 2. Statistical summary of selected water-quality parameters for sites where suspended-sediment concentration and at least one other sediment parameter were coincidentally monitored.

[SSC, suspended-sediment concentration; TSS, total suspended solids; n, number of coincident observations, not the number of matched sites; p, parameter; mg/L, milligrams per liter; NTU, nephelometric turbidity units]

Parameter name and USGS NWIS parameter code	Unit	Mean	Standard deviation	Range	n
SSC – p80154	mg/L	161	413	0.9 to 10,600	2,429
TSS – p00530	mg/L	48	67	1 to 396	75
Turbidity – p00076	NTU	28	46	.2 to 350	943
Total nitrogen – p00600	mg/L	1.5	1.7	.2 to 26.0	1,333
Total phosphorus – p00665	mg/L	.2	.4	.0 to 8.0	1,488

Table 3. Regression of suspended-sediment concentration on total suspended solids, turbidity, and discharge.

[SSC, suspended-sediment concentration; TSS, total suspended solids; Q, instantaneous discharge; n, number of coincident observations, not the number of matched sites; ln, natural or Napierian logarithm; R^2, coefficient of determination for equation; *, regression significant at the 0.05 confidence level]

Equation	n	R^2	p-value
ln SSC = 0.43 + 0.940 ln TSS	73	0.76*	0.000
ln SSC = 1.59 + 0.638 ln Turbidity + 0.046 ln Q	933	.53*	.000
SSC = 7.5 + 0.73 TSS + 0.88 Turbidity + 0.006 Q	45	.92*	.000

Table 4. Regression of suspended-sediment concentration on total suspended solids for individual sites. Each regression takes the form ln SSC = intercept + β_{TSS} ln TSS.

[USGS, U.S. Geological Survey; ID, identification; β, slope coefficient; SSC, suspended-sediment concentration; TSS, total suspended solids; n, number of coincident observations, not the number of matched sites; ln, natural or Napierian logarithm; R^2, coefficient of determination for equation;*, coefficient is significant at the 0.05 confidence level]

USGS site ID	Intercept	β_{TSS}	n	R^2	p-value
03209500	1.31*	0.80*	14	0.81	0.000
03212500	1.27*	.76*	14	.95	.000
03215000	-.10	1.08*	13	.87	.000
03297845	-1.52	1.55*	6	.91	.003
03438220	.38	.88*	17	.38	.008
03609750	3.20*	-.16	9	.05	.570

Table 5. Regression of suspended-sediment concentration on turbidity and discharge for individual sites. Each regression takes the form ln SSC = intercept +$\beta_{Turbidity}$ ln Turbidity + β_Q ln Q.

[USGS, U.S. Geological Survey; ID, identification; β, slope coefficient; SSC, suspended-sediment concentration; Q, instantaneous discharge; n, number of coincident observations, not the number of matched sites; ln, natural or Napierian logarithm; R^2, coefficient of determination for equation; *, coefficient is significant at the 0.05 confidence level]

USGS site ID	Intercept	$\beta_{Turbidity}$	β_Q	n	R^2	p-value
03209500	1.92	0.27*	0.24	14	0.72	0.001
03212500	2.39	.49*	.08	14	.71	.001
03215000	-.43	.50*	.40*	99	.67	.000
03252500	.61	.75*	.11	17	.77	.000
03254000	.62	.43*	.27*	91	.53	.000
03280000	.78	1.16*	-.08	17	.95	.000
03281000	1.21	.40*	.20	17	.54	.005
03281500	1.41*	.94*	-.12	17	.83	.000
03289300	2.40*	.68*	-.27	19	.25	.096
03290500	-1.34	-.17	.73*	8	.96	.000
03297845	2.23*	.29*	.23*	28	.47	.000
03298500	.82*	.41*	.26*	94	.65	.000
03300400	.28	.79*	.12	16	.84	.000
03301630	1.96*	.35*	.22*	91	.52	.000
03308500	1.09	.62*	.13	47	.60	.000
03321230	.96	.19*	.30*	62	.36	.000
03383000	1.08	.71	.08	10	.51	.083
03410500	-.47	.41*	.30*	41	.54	.000
03438200	-2.72*	.05	.53*	56	.40	.000
03609750	-.39	.08	.25	107	.14	.000
03610200	1.42*	.64*	.15	14	.57	.010
07024000	1.75*	.63*	.02	614	.49	.000

Table 6. Regression of suspended-sediment concentration on total suspended solids, turbidity, and discharge for individual sites. Each regression takes the form SSC = intercept + β_{TSS} TSS + $\beta_{Turbidity}$ Turbidity + β_Q Q.

[USGS, U.S. Geological Survey; ID, identification; β, slope coefficient; SSC, suspended-sediment concentration; TSS, total suspended solids; Q, instantaneous discharge; n, number of coincident observations, not the number of matched sites; R^2, coefficient of determination for equation; *, coefficient is significant at the 0.05 confidence level]

USGS site ID	Intercept	β_{TSS}	$\beta_{Turbidity}$	β_Q	n	R^2	p-value
03209500	15.92*	0.57	1.14	0.01*	13	0.97	0.000
03212500	9.50	.82*	.75*	.00	14	.98	.000
03215000	1.35	.51	1.39	.01	12	.89	.000
03297845	-19.94	2.51	-.04	-.15	6	.95	.076

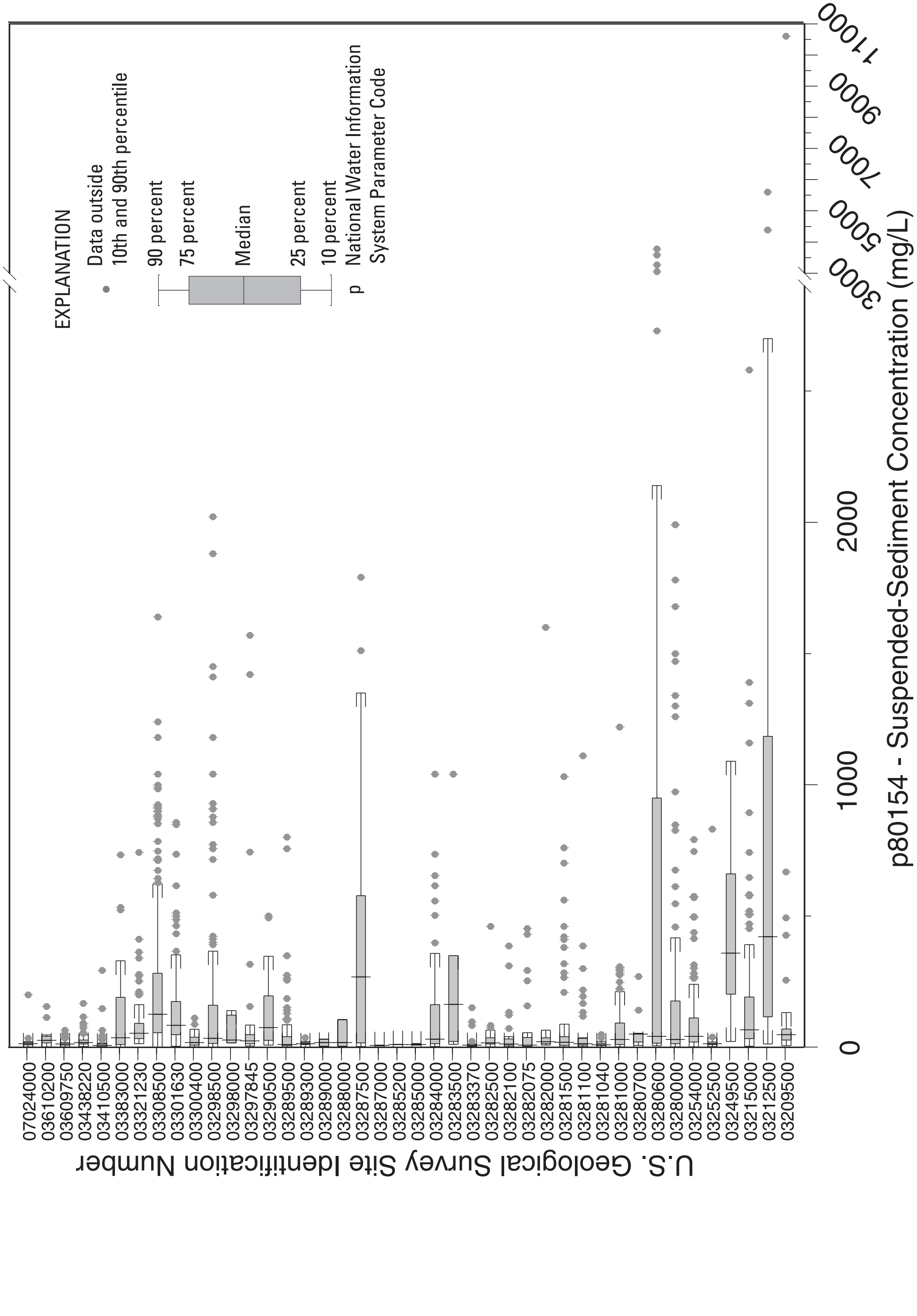


Figure 7. Suspended-sediment-concentration data for the 42 sites in Kentucky at which at least one other sediment parameter (total suspended solids or turbidity) was monitored.

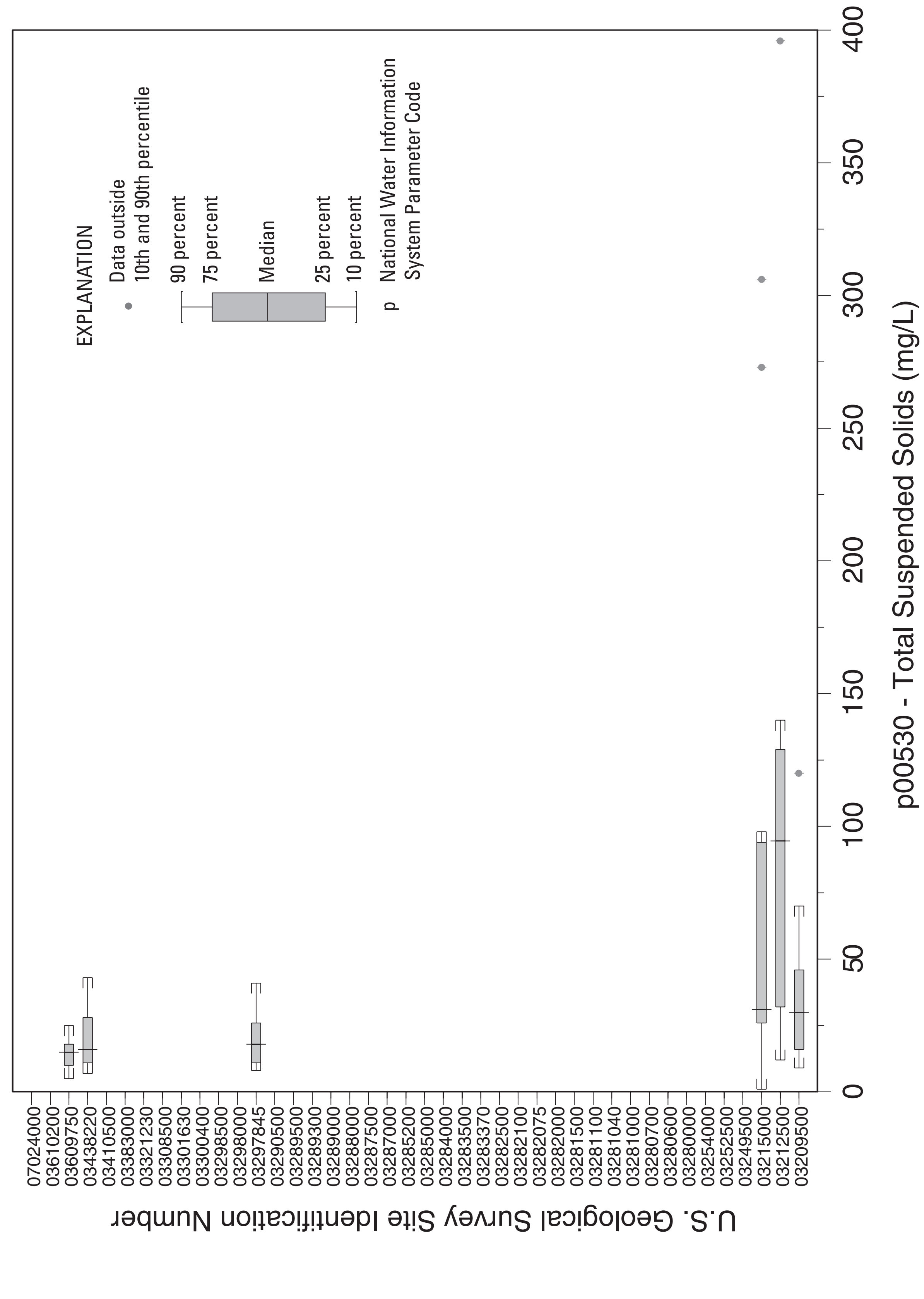


Figure 8. Suspended-solids data for the six sites in Kentucky at which suspended-sediment concentration was coincidentally monitored. For consistency, all 42 matched sites have been included.

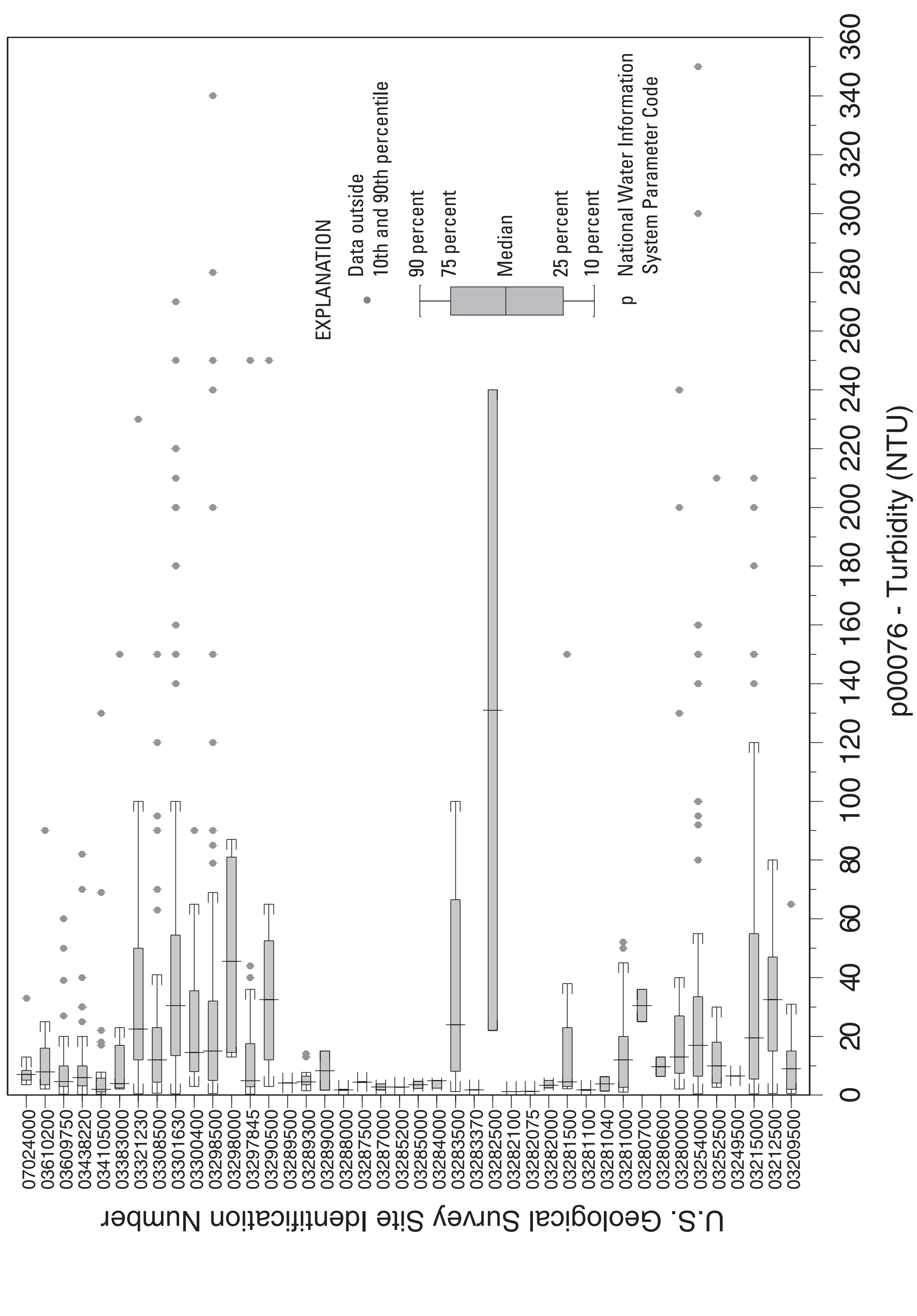


Figure 9. Turbidity data for the 42 sites in Kentucky at which suspended-sediment concentration was coincidentally monitored.

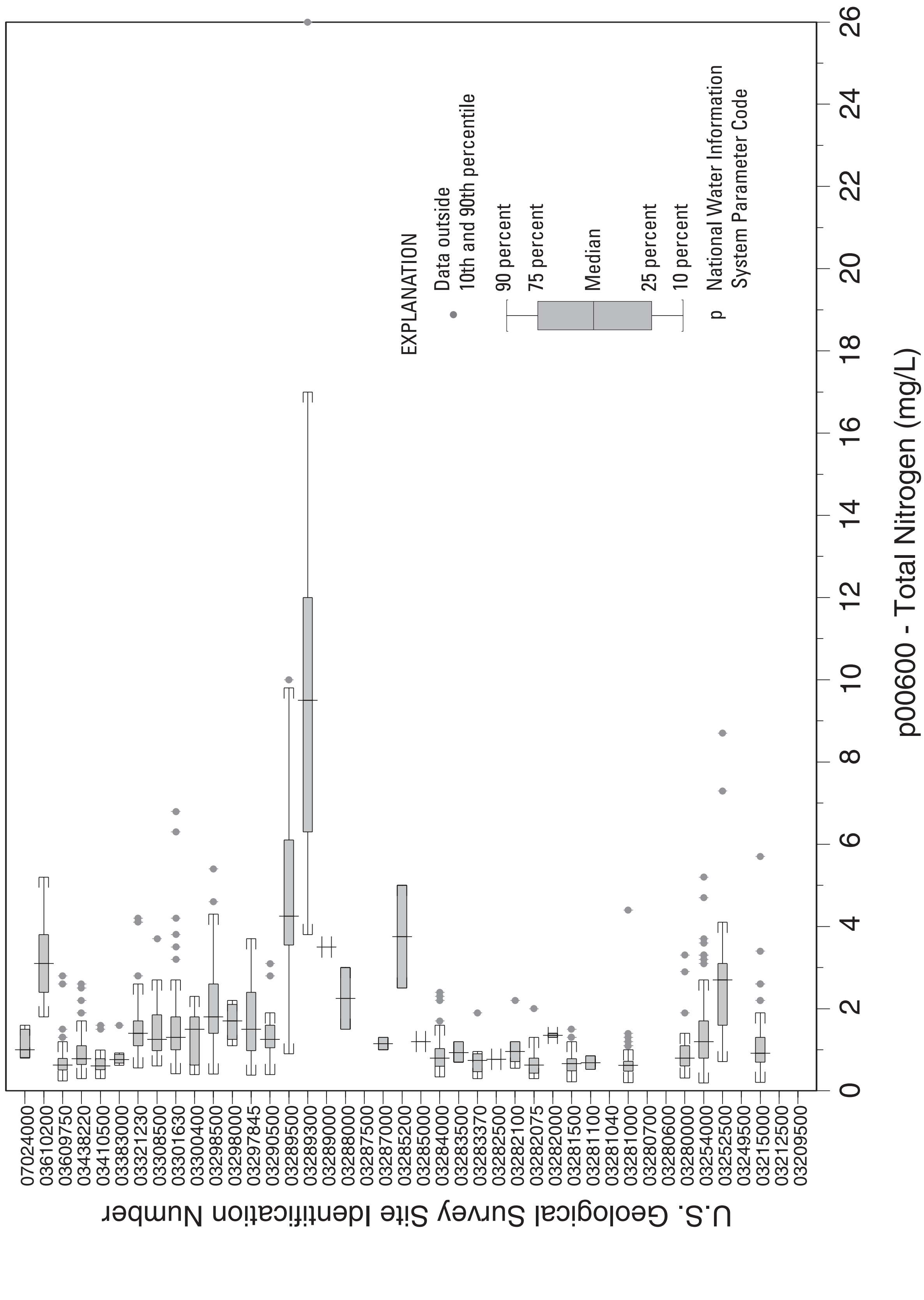


Figure 10. Total-nitrogen data for the 42 sites in Kentucky at which suspended-sediment concentration and at least one other sediment parameter were monitored.

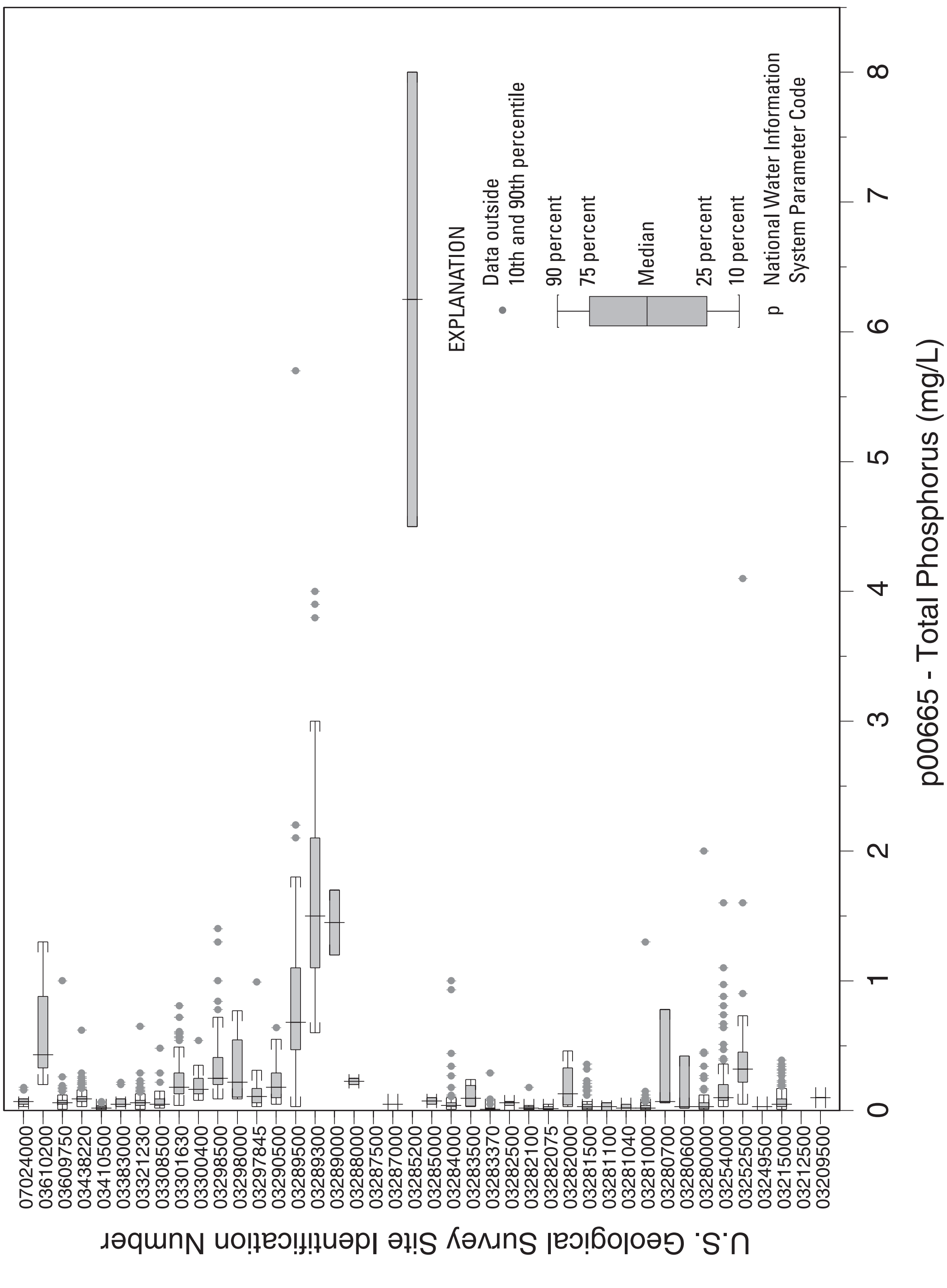


Figure 11. Total-phosphorus data for the 42 sites in Kentucky at which suspended-sediment concentration and at least one other sediment parameter were monitored.

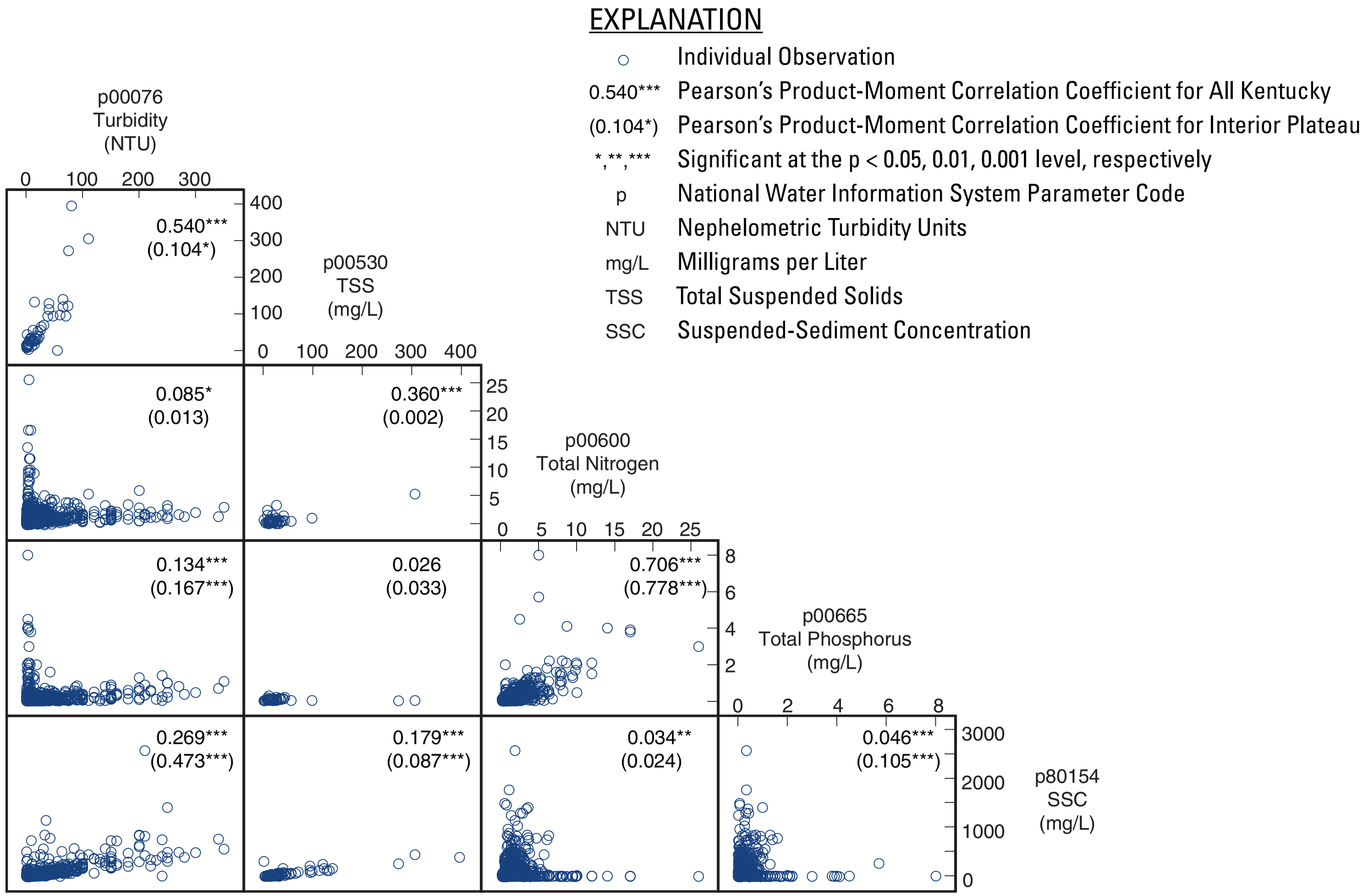


Figure 12. Scatterplot and Pearson's product-moment correlations of five water-quality parameters for each of the coincident observations discussed in the text. For the entire state, all but the total suspended solids-total phosphorus correlations are highly significant due to the large number of observations, even though the correlations are generally low. However, only the sediment parameters show clear linear relations.

Summary

An inventory and statistical analysis of sediment data for Kentucky streams was completed by the USGS, in cooperation with the U.S. Environmental Protection Agency, to assess the availability and quantify the statistical relations among suspended-sediment concentration (SSC) and the surrogate sediment parameters total suspended solids (TSS) and turbidity for the period 1950–2008. The relation of sediment parameters to total nitrogen and total phosphorus was also quantified. Suspended-sediment concentration is significantly correlated to the two surrogate sediment parameters of TSS and turbidity, as well as to total nitrogen and total phosphorus. On the basis of this analysis, TSS and turbidity both can be used to statistically estimate SSC for runoff events and stream reaches where no SSC data are available. However, this analysis also shows that estimation will be stronger by use of TSS, as opposed to turbidity, and that these data should be weighted accordingly in any modeling efforts for which SSC is the preferred method. The strongest statistical estimate results from a combination of TSS and turbidity data.

This inventory has illustrated that sediment monitoring of all types has declined in Kentucky since the maximum number of sites in the early 1980s (65, 11, and 20 sites for SSC, TSS, and turbidity, respectively). As of March 2008, SSC was monitored at nine sites; eight of these sites were started in 2007. The remaining site at which SSC was monitored is on a controlled stream reach, downstream from a reservoir, where high-flow events are attenuated. The result is that there are no remaining sites that can be used for modeling changes in sediment concentration due to climatic events or contemporary land-use changes, including urban development and agricultural management.

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Table 1. Long-term stations where at least one parameter was monitored. Matched sites, with coincident SSC observations, are indicated by an * next to the second parameter.

[USGS, U.S. Geological Survey; ID, identification; SSC, suspended-sediment concentration; TSS, total suspended solids; p, parameter code]

USGS site ID	Site name	SSC (p80154)	TSS (p00530)	Turbidity (p00076)	Total nitrogen (p00600)	Total phosphorus (p00665)
03207935	LICK CREEK AT LICK CREEK, KY	x				
03207962	DICKS FORK AT PHYLLIS, KY	x				
03207965	GRAPEVINE CREEK NEAR PHYLLIS, KY	x				
03208000	LEVISA FORK BELOW FISHTRAP DAM NEAR MILLARD, KY	x				
03209300	RUSSELL FORK AT ELKHORN CITY, KY	x				
03209500	LEVISA FORK AT PIKEVILLE, KY	x	x*	x*		x*
03209800	LEVISA FORK AT PRESTONSBURG, KY	x				
03210000	JOHNS CREEK NEAR META, KY	x				
03211500	JOHNS CREEK NEAR VAN LEAR, KY	x				
03212000	PAINT CREEK AT STAFFORDSVILLE, KY	x				
03212500	LEVISA FORK AT PAINTSVILLE, KY	x	x*	x*		
03213594	CAMP CREEK NEAR ARGO, KY	x	x			
03213630	RIGHT FORK HURRICANE CREEK NEAR STOPOVER, KY	x				
03213700	TUG FORK AT WILLIAMSON, WV	x				
03214700	ROCKCASTLE CREEK AT INEZ, KY	x				
03215000	BIG SANDY RIVER AT LOUISA, KY	x	x*	x*	x*	x*
03216500	LITTLE SANDY RIVER AT GRAYSON, KY	x				
03216800	TYGARTS CREEK AT OLIVE HILL, KY	x				
03217000	TYGARTS CREEK NEAR GREENUP, KY	x				
03248500	LICKING RIVER NEAR SALYERSVILLE, KY	x				
03249500	LICKING RIVER AT FARMERS, KY	x		x*		x*
03250100	NORTH FORK TRIPLETT CREEK NEAR MOREHEAD, KY	x				
03251000	NORTH FORK LICKING RIVER NEAR LEWISBURG, KY	x				
03251500	LICKING RIVER AT MCKINNEYSBURG, KY	x				
03252500	SOUTH FORK LICKING RIVER AT CYNTHIANA, KY	x		x*	x*	x*
03254000	LICKING RIVER AT BUTLER, KY	x		x*	x*	x*
03277400	LEATHERWOOD CREEK AT DAISY, KY	x				
03277500	NORTH FORK KENTUCKY RIVER AT HAZARD, KY	x				x
03278500	TROUBLESOME CREEK AT NOBLE, KY	x				
03280000	NORTH FORK KENTUCKY RIVER AT JACKSON, KY	x		x*	x*	x*
03280600	MIDDLE FORK KENTUCKY RIVER NEAR HYDEN, KY	x		x*		x*
03280700	CUTSHIN CREEK AT WOOTON, KY	x		x*		x*
03281000	MIDDLE FORK KENTUCKY RIVER AT TALLEGA, KY	x		x*	x*	x*
03281040	RED BIRD RIVER NEAR BIG CREEK, KY	x		x*		x*
03281100	GOOSE CREEK AT MANCHESTER, KY	x		x*	x*	x*
03281500	SOUTH FORK KENTUCKY RIVER AT BOONEVILLE, KY	x		x*	x*	x*
03282000	KENTUCKY RIVER AT LOCK 14 AT HEIDELBERG, KY	x		x*	x*	x*
03282075	BIG SINKING CREEK NEAR CRYSTAL, KY	x		x*	x*	x*
03282100	FURNACE FORK NEAR CRYSTAL , KY	x		x*	x*	x*

Table 1. Long-term stations where at least one parameter was monitored. Matched sites, with coincident SSC observations, are indicated by an * next to the second parameter —Continued

[USGS, U.S. Geological Survey; ID, identification; SSC, suspended-sediment concentration; TSS, total suspended solids; p, parameter code]

USGS site ID	Site name	SSC (p80154)	TSS (p00530)	Turbidity (p00076)	Total nitrogen (p00600)	Total phosphorus (p00665)
03282500	RED RIVER NEAR HAZEL GREEN, KY	x		x*	x*	x*
03283370	CAT CREEK NEAR STANTON, KY	x		x*	x*	x*
03283500	RED RIVER AT CLAY CITY, KY	x		x*	x*	x*
03284000	KENTUCKY RIVER AT LOCK 10 NEAR WINCHESTER, KY	x		x*	x*	x*
03285000	DIX RIVER NEAR DANVILLE, KY	x		x*	x*	x*
03285200	CLARKS RUN NEAR DANVILLE, KY	x		x*	x*	x*
03286500	KENTUCKY RIVER AT LOCK 7 AT HIGHBRIDGE, KY	x		x		
03287000	KENTUCKY RIVER AT LOCK 6 NEAR SALVISA, KY	x		x*	x*	x*
03287500	KENTUCKY RIVER AT LOCK 4 AT FRANKFORT, KY	x		x*		
03288000	NORTH ELKHORN CREEK NEAR GEORGETOWN, KY	x		x*	x*	x*
03289000	SOUTH ELKHORN CREEK AT FORT SPRING, KY	x		x*	x*	x*
03289300	SOUTH ELKHORN CREEK NEAR MIDWAY, KY	x		x*	x*	x*
03289500	ELKHORN CREEK NEAR FRANKFORT, KY	x		x*	x*	x*
03290500	KENTUCKY RIVER AT LOCK 2 AT LOCKPORT, KY	x		x*	x*	x*
03291500	EAGLE CREEK AT GLENCOE, KY	x				
03292474	GOOSE CREEK AT OLD WESTPORT RD NEAR ST MATTHEWS, KY		x			
03293000	MIDDLE-FORK BEARGRASS CREEK AT OLD CANNONS LANE AT LOUISVILLE, KY			x		
03297500	PLUM CREEK AT WATERFORD, KY	x				
03297845	FLOYDS FORK NEAR CRESTWOOD, KY	x	x*	x*	x*	x*
03297900	FLOYDS FORK NEAR PEWEE VALLEY, KY	x				
03297980	LONG RUN NEAR FISHERVILLE, KY	x				
03298000	FLOYDS FORK AT FISHERVILLE, KY	x		x*	x*	x*
03298100	POPE LICK AT POPE LICK ROAD NEAR MIDDLETOWN, KY	x				
03298150	CHENOWETH RUN AT GELHAUS LANE NEAR FERN CREEK, KY	x				
03298200	FLOYDS FORK NEAR MT WASHINGTON, KY	x				
03298250	CEDAR CREEK AT THIXTON ROAD NEAR LOUISVILLE, KY	x				
03298300	PENNSYLVANIA RUN AT MT WASHINGTON ROAD NEAR LOUISVILLE, KY	x				
03298500	SALT RIVER AT SHEPHERDSVILLE, KY	x		x*	x*	x*
03300400	BEECH FORK AT MAUD, KY	x		x*	x*	x*
03301630	ROLLING FORK NEAR LEBANON JUNCTION, KY	x	x	x*	x*	x*
03303205	SINKING CREEK NEAR LODIBURG, KY	x				
03306500	GREEN RIVER AT GREENSBURG, KY	x	x			
03307000	RUSSELL CREEK NEAR COLUMBIA, KY	x				
03308500	GREEN RIVER AT MUNFORDVILLE, KY	x	x	x*	x*	x*
03309000	GREEN RIVER AT MAMMOTH CAVE, KY	x				
03309100	WET PRONG BUFFALO CREEK NEAR MAMMOTH CAVE, KY	x				

Table 1. Long-term stations where at least one parameter was monitored. Matched sites, with coincident SSC observations, are indicated by an * next to the second parameter —Continued

[USGS, U.S. Geological Survey; ID, identification; SSC, suspended-sediment concentration; TSS, total suspended solids; p, parameter code]

USGS site ID	Site name	SSC (p80154)	TSS (p00530)	Turbidity (p00076)	Total nitrogen (p00600)	Total phosphorus (p00665)
03310300	NOLIN RIVER AT WHITE MILLS, KY	x	x			
03310400	BACON CREEK NEAR PRICEVILLE, KY	x	x			
03314500	BARREN RIVER AT BOWLING GREEN, KY	x	x			
03315500	GREEN RIVER AT LOCK 4 AT WOODBURY, KY	x				
03315520	GREEN RIVER AT ABERDEEN, KY	x	x			x
03315915	MUD RIVER NEAR HOMER, KY		x			
03316645	GREEN RIVER AT ROCKPORT, KY	x				
03318500	ROUGH RIVER AT FALLS OF ROUGH, KY	x				
03318800	CANEY CREEK NEAR HORSE BRANCH, KY	x				
03319500	ROUGH RIVER AT DUNDEE, KY	x	x			
03320000	GREEN RIVER AT LOCK 2 AT CALHOUN, KY	x				
03320500	POND RIVER NEAR APEX, KY	x	x			
03321100	POND RIVER NEAR SACRAMENTO, KY		x			
03321120	POND RIVER NEAR VANDETTA, KY	x				
03321210	CYPRESS CREEK NEAR CALHOUN, KY	x				
03321230	GREEN RIVER NEAR BEECH GROVE, KY	x		x*	x*	x*
03321350	SOUTH FORK PANTHER CREEK NEAR WHITESVILLE, KY	x				
03321430	PANTHER CREEK NEAR OWENSBORO, KY	x				
03321500	GREEN RIVER AT LOCK AND DAM 1 AT SPOTTSVILLE, KY		x			
03322360	BEAVERDAM CREEK NEAR CORYDON, KY	x				
03383000	TRADEWATER RIVER AT OLNEY, KY	x		x*	x*	x*
03384180	TRADEWATER RIVER NEAR SULLIVAN, KY	x				
03400500	POOR FORK AT CUMBERLAND, KY	x				
03400785	MARTINS FORK ABOVE SMITH, KY	x				
03400800	MARTINS FORK NEAR SMITH, KY	x				
03400990	CLOVER FORK AT HARLAN, KY	x				
03401000	CUMBERLAND RIVER NEAR HARLAN, KY	x				
03401428	BENNETTS FORK AT MIDDLESBORO, KY	x				
03401450	STONY FORK NEAR MOUTH AT MIDDLESBORO, KY	x				
03402000	YELLOW CREEK NEAR MIDDLESBORO, KY	x				x
03402900	CUMBERLAND RIVER AT PINE STREET BRIDGE AT PINEVILLE, KY			x		
03403000	CUMBERLAND RIVER NEAR PINEVILLE, KY	x				
03403500	CUMBERLAND RIVER AT BARBOURVILLE, KY	x				
03403910	CLEAR FORK AT SAXTON, KY	x				
03404000	CUMBERLAND RIVER AT WILLIAMSBURG, KY	x		x		x
03404500	CUMBERLAND RIVER AT CUMBERLAND FALLS, KY	x				
03406500	ROCKCASTLE RIVER AT BILLOWS, KY	x				
03407100	CANE BRANCH NEAR PARKERS LAKE, KY	x				
03407200	WEST FORK CANE BRANCH NEAR PARKERS LAKE, KY	x				

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USGS site ID	Site name	SSC (p80154)	TSS (p00530)	Turbidity (p00076)	Total nitrogen (p00600)	Total phosphorus (p00665)
03407300	HELTON BRANCH AT GREENWOOD, KY	x				
03407500	BUCK CREEK NEAR SHOPVILLE, KY	x				
03410500	SOUTH FORK CUMBERLAND RIVER NEAR STEARNS, KY	x		x*	x*	x*
03438220	CUMBERLAND RIVER NEAR GRAND RIVERS, KY	x	x*	x*	x*	x*
03438500	CUMBERLAND RIVER AT SMITHLAND, KY	x				
03609500	TENNESSEE RIVER NEAR PADUCAH, KY			x		
03609750	TENNESSEE RIVER AT HIGHWAY 60 NEAR PADUCAH, KY	x	x*	x*	x*	x*
03610200	CLARKS RIVER AT ALMO, KY	x		x*	x*	x*
03610545	WEST FORK CLARKS RIVER NEAR BREWERS, KY	x				
03611260	MASSAC CREEK NEAR PADUCAH, KY	x				
07024000	BAYOU DE CHIEN NEAR CLINTON, KY	x		x*	x*	x*
07024070	MISSISSIPPI RIVER AT HICKMAN, KY		x			
	Total Number of Sites	114	21	46	35	43

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