ESTIMATION OF TRENDS IN SURFACE-WATER CHARACTERISTICS FOR HICKAHALA AND PETERS (LONG) CREEKS OF THE YAZOO RIVER BASIN DEMONSTRATION EROSION CONTROL PROJECT, NORTH-CENTRAL MISSISSIPPI, 1986-95

Michael S. Runner and Richard A. Rebich
U. S. Geological Survey
Pearl, Mississippi

INTRODUCTION

In 1985, the U.S. Geological Survey (USGS) began collecting data for the Demonstration Erosion Control (DEC) project in north-central Mississippi. The project is part of a multi-agency program for the planning, construction, and evaluation of measures to alleviate flooding and erosion in the Bluff Hills of the upper Yazoo River Basin. Since 1985, stream discharge data, sediment samples, and water-quality samples have been collected at selected sites in the DEC study area by USGS personnel, station observers, and automatic samplers.

A 1993 investigation indicated possible trends in surface-water discharge, suspended-sediment concentration, and sediment discharge at some of the DEC sites (Rebich 1993). Further investigations at Hotopha and Otoucalofa Creeks indicated decreasing trends for flow-adjusted sediment discharge for both sites, despite the increasing trends in stream discharge for both sites (Rebich 1995). These results indicated possible changes in features within the basin that contributed to the decrease in sediment discharge. This report presents trend analyses for daily mean values of stream discharge, suspended-sediment concentration, and sediment discharge for Hickahala Creek near Senatobia and Peters (Long) Creek near Pope.

Site Description and Data-Collection Activities

Hickahala Creek near Senatobia and Peters (Long) Creek near Pope are located in the Yazoo River drainage basin in north-central Mississippi (Figure 1). The drainage areas for the sites are 121 and 79.2 square miles, respectively. The drainage basins consist primarily of agricultural, range, and forest lands, with minimal urban area. The Peters Creek Basin has some surface-mining activity approximately 5 miles upstream from the gage. These sites were selected to be part of the DEC project because their watersheds have shown large losses of soil and agricultural chemicals, characteristic of agricultural watersheds in that geographic region. Streams in these basins generally create unstable, deeply incised channels which are subject to substantial upland and channel erosion.

Data collection began at Hickahala Creek in January 1986 with continuous stream discharge and sediment sampling. Sediment samples are collected by USGS personnel, station observers, and PS-69 automated sediment samplers. Similar data collection at Peters Creek began in December 1986.

USGS personnel make discharge measurements at both sites every 6 weeks and collect sediment samples every 3 weeks. Additional discharge measurements and sediment samples are collected during storm events. Discharge measurements are used to establish stage-discharge ratings for each station and to monitor shifts in the ratings. More than 115 discharge measurements for Hickahala Creek and more than 100 for Peters Creek have been made. Station observers collect single-vertical sediment samples and record stage readings three times per week and during storm events. PS-69 automatic samplers collect samples at a single point in the stream cross section and are triggered to collect samples when the stage exceeds a preset level, generally 1 to 1.5 feet above normal low stage. The sampling frequency of the automatic samplers depends on the rate of change in stage; thus, samples are collected more frequently on the rising limb of the storm hydrograph than on the falling limb. This sampling pattern is necessary for a better definition of the first flush of sediment during a storm event, which is when the highest suspended-sediment concentrations are most likely to occur. Concentration coefficients can be applied to both point samples and single-vertical samples to relate them to multi-vertical samples, which give a more accurate description of the actual sediment concentration of a complete cross section. On well mixed streams, concentrations for point and single vertical samples are generally representative of the average concentration in the entire cross section and the correction coefficient is near 1.0 (Vanoni 1977). The sampling procedures used are those described by Guy and Norman (1970). Approximately 6,100 suspended-sediment samples at Hickahala Creek and 3,600 at Peters Creek have been collected during the period of record. Sediment samples are analyzed and the concentration stored in USGS data files. The instantaneous concentrations are used, along with instantaneous stream discharge values to calculate the sediment discharge from the basins using the USGS sediment discharge computation program SEDCALC. Daily mean values for stream discharge, suspended-sediment concentration, and sediment discharge for all DEC sites are published annually by the Mississippi District and are also stored in the USGS data base.

TREND ANALYSES OF STREAM DISCHARGE AND SEDIMENT DATA

Trend analyses of stream discharge, suspended-sediment concentration, and sediment discharge data are necessary to aid in the evaluation of the effectiveness of management techniques used to control erosion, sedimentation, and flooding. Management techniques include agricultural management practices, field-level, sediment-retention structures, low-flow control structures in streams, bank stabilization measures, and sediment retention ponds.

Trend Analyses Procedures

For these analyses, the Seasonal Kendall Test was used to test for trends in stream discharge, suspended-sediment concentration, and sediment discharge, as was done by Rebich (1993). These analyses were performed by using five replicate subsets of the total data set. Subsets were used because the total data set was too large to perform the Seasonal Kendall Test. Replication was necessary to verify the precision of the trend results.

The hypothesis of the Seasonal Kendall Test is that no trend exists for the time series of data tested. For each test there is an associated "p-value" which reflects the probability of detecting a trend if the data were randomly ordered. The p-value associated with each test is compared to a selected level of significance. If the p-value is less than the selected level of significance, the hypothesis of no trend is rejected. For these analyses, a level of significance of 0.1 was selected. The Seasonal Kendall Slope Estimator was also calculated to indicate the magnitude and direction of trends.

Flow Adjustment Techniques

A strong correlation exists between stream discharge and suspended-sediment concentration. Suspended-sediment concentration and sediment discharge generally increase with increased stream discharge. To increase the chance of detecting trends in the suspended-sediment concentration and sediment discharge data, the effect of the variability of stream discharge should be removed.

To remove the effect of stream discharge on suspended-sediment concentration and sediment discharge, flow adjusted values were calculated. For this report, the flow-adjusted value is a residual value computed by subtracting a predicted daily mean value from an actual daily mean value. The predicted daily mean values are computed from a mathematical expression describing the relation between stream discharge and suspended-sediment concentration or sediment discharge based on the entire data set. The mathematical technique selected for this analysis to describe these relations is a locally-weighted scatterplot smooth (LOWESS, Helsel and Hirsch 1992).

Analytical Results

Trend results were considered significant if the p-value from the test was less than 0.1, as stated earlier, and if results were replicated between subsets. However, several of the test results had p-values that were slightly greater than 0.1 but were close enough to consider the possible existence of trends in the data. Graphical analyses of each data subset were also used to support the existence of trends.

Trend analyses of the Hickahala Creek data indicated consistent and statistically significant trends for some subsets of all five parameters (Table 1). Stream-discharge data indicated about a 2 percent per year increase over the period of record. Graphical analyses of the stream discharge data supported the statistical results. Suspended-sediment concentration data showed an increase of approximately 4 to 5 percent per year over the same period. The sediment discharge data showed an increasing trend of approximately 0.5 percent per year for the period of record. For the flow-adjusted suspended-sediment concentration and sediment-discharge data, only two of the five subsets had p-values less that 0.1; although trends could possibly exist in the flow-adjusted sediment data, no conclusions can be made because the results could not be replicated. A possible explanation as to why the results could not be replicated is that the variance in the sediment data was due to factors other than stream discharge. However, the graphical analyses of the flow-adjusted sediment discharge data plotted versus time show a decreasing trend for the latter part of the period of record, which is reflected in the smoothed line through the data in Figure 2.

Trend analyses of the Peters Creek data provided consistent and statistically significant results only in the stream discharge data, which showed about a 1 percent increase per year. Graphical analyses of the stream discharge data supported the statistical results. Consistent and statistically significant results in the unadjusted and flow-adjusted sediment data could not be replicated. However, the graphical analyses of flow-adjusted sediment discharge data plotted versus time show a decrease for the latter part of the period of record reflected in the smoothed line in Figure 3, similar to the flow-adjusted sediment discharge data for Hickahala Creek.

SUMMARY

The Demonstration Erosion Control (DEC) project is a multi-agency program to evaluate flood control and erosion management techniques in the upper Yazoo River Basin in north-central Mississippi. The U.S. Geological Survey has been collecting stream discharge and sediment data since 1985 as part of the DEC project. Data have been collected at Hickahala Creek near Senatobia and Peters (Long) Creek near Pope since 1986. Preliminary trend analyses indicated possible trends in the data from both sites.

Statistical and graphical analyses were performed to detect trends in stream discharge, suspended-sediment concentration, and sediment discharge. The Seasonal Kendall Test for trend and the Seasonal Kendall Slope Estimator were used to detect trends and to indicate direction and slope of trend lines. Flow-adjusted values were computed to eliminate the effect of the variability of stream discharge on suspended-sediment concentration and sediment discharge data.

Analyses indicated statistically significant increasing trends in stream discharge existed at both Hickahala and Peters Creek. Graphical analyses of the stream-discharge data from both sites supported the statistical results. Increasing trends for suspended-sediment concentration and sediment discharge were indicated for Hickahala Creek. No trends were detected in suspended-sediment concentration and sediment discharge for Peters Creek. Trends in the flow-adjusted sediment data for both Hickahala Creek and Peters Creek could not be replicated. However, graphical analyses indicated that the flow-adjusted sediment discharge data appear to decrease for the latter part of the period of record at both sites.

REFERENCES

Guy, H. P., and V. W. Norman. 1970. Field methods for measurement of fluvial sediment.: U.S. Geological Survey Techniques of Water-Resources Investigation, book 3, chapter c2.

Helsel, D. R., and R. M. Hirsch. 1992. Statistical methods in water research. New York: Elsevier.

Rebich, R. A. 1993. Preliminary summaries and trend analyses of stream discharge and sediment data for the Yazoo Basin Demonstration Erosion Control Project, north-central Mississippi, July 1985 through September 1991. U.S. Geological Survey Water Resources Investigations Report 93-4068.

Rebich, R. A. 1995. Estimation of sediment-discharge reduction for two sites of the Yazoo River Basin Demonstration Erosion Control Project, north-central Mississippi, 1985-94. U.S. Geological Survey Water-Resources Investigations Report 95-4198.

Vanoni, V. A. 1977. Sediment engineering: ASCE-Manuals and Reports on Engineering Practice- no. 54.

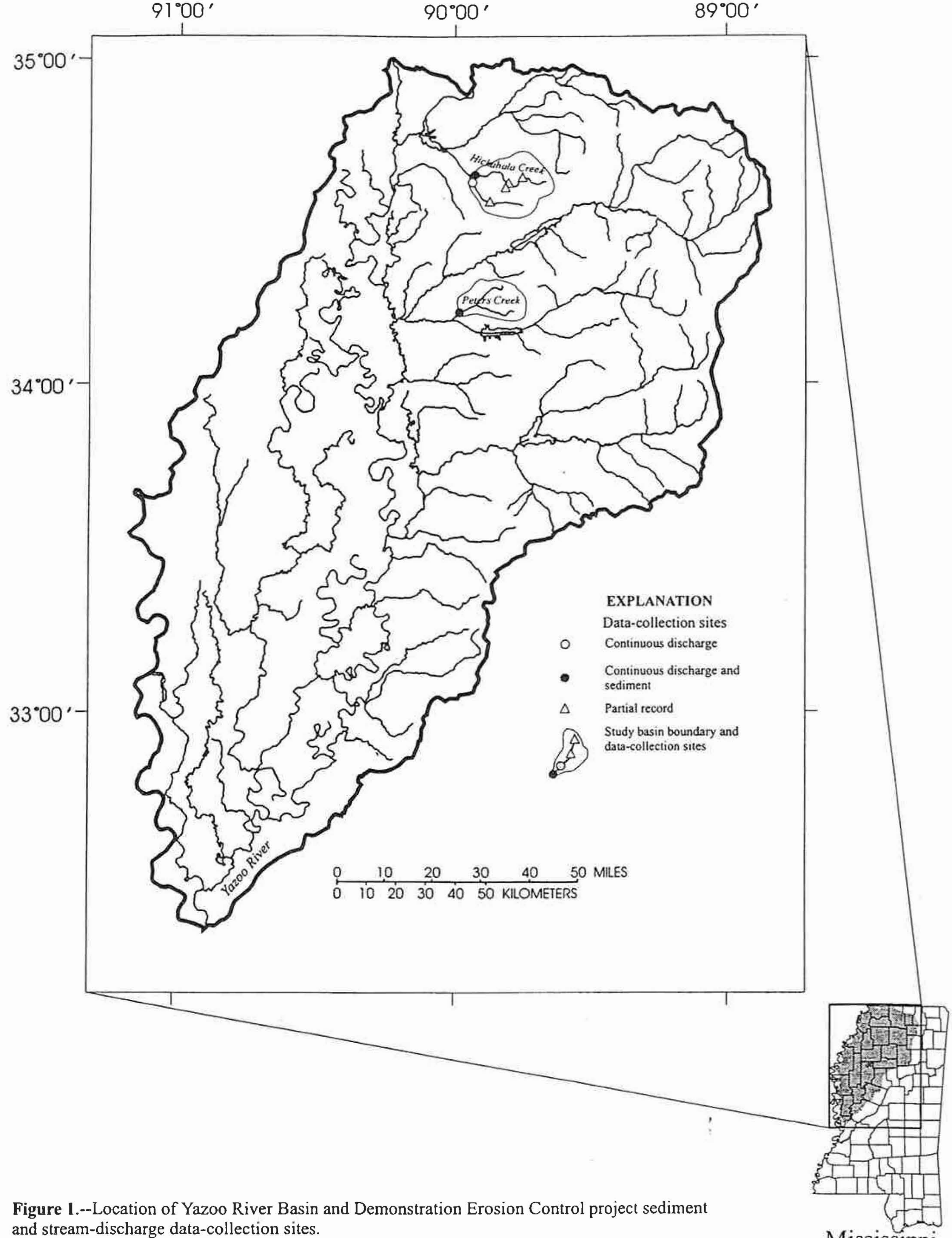

Figure 1.--Location of Yazoo River Basin and Demonstration Erosion Control project sediment and stream-discharge data-collection sites.

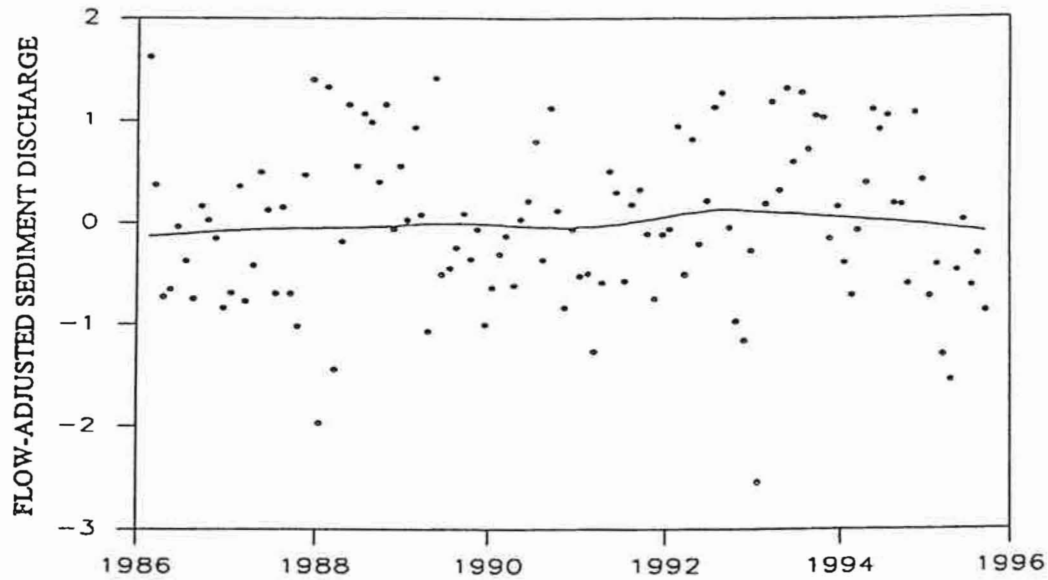

Figure 2.—Flow-adjusted sediment discharge data (subset 3) and smoothed line for Hickahala Creek near Senatobia for the period January 1986 through September 1995.

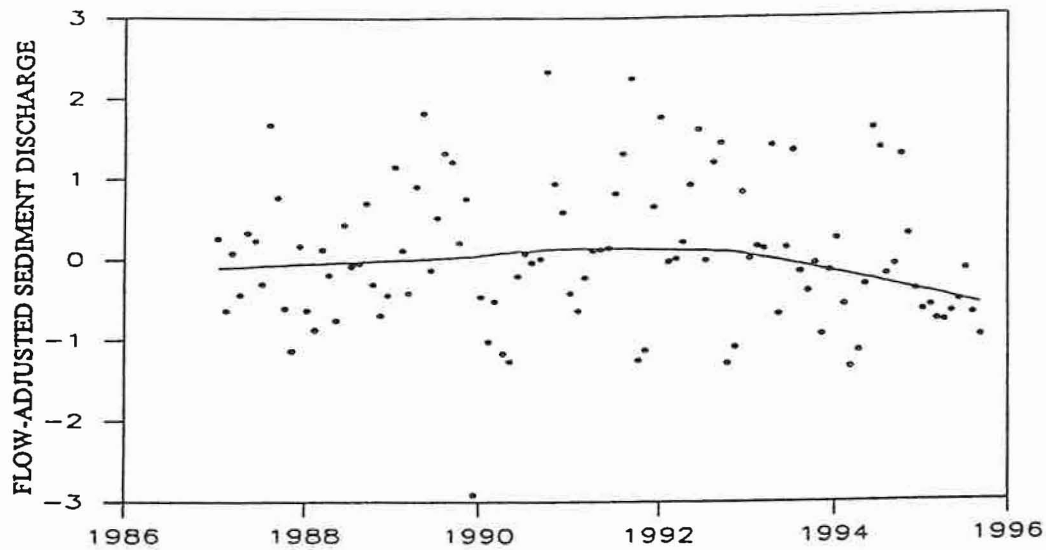

Figure 3.—Flow adjusted sediment discharge data (subset 2) and smoothed line for Peters (Long) Creek near Pope for the period December 1986 through September 1995.

Table 1.—Results of Seasonal Kendall trend tests on subsets of unadjusted and flow-adjusted daily mean values for Demonstration Erosion Control Project stations (statistically significant trends appear in bold)

Data	Subset	Flow Adjustment	p-value	Slope Estimate (percent per year)
HICKAHALA CREEK NEAR SENATOBIA (10 YEARS OF DATA)				
Stream discharge	1	not applicable	**0.01**	**2.3**
Stream discharge	2	not applicable	**0.00**	**2.4**
Stream discharge	3	not applicable	**0.01**	**2.0**
Stream discharge	4	not applicable	**0.01**	**2.0**
Stream discharge	5	not applicable	**0.01**	**2.3**
Sediment concentration	1	unadjusted	**0.07**	**5.5**
Sediment concentration	2	unadjusted	**0.02**	**3.5**
Sediment concentration	3	unadjusted	0.16	1.9
Sediment concentration	4	unadjusted	**0.08**	**4.0**
Sediment concentration	5	unadjusted	**0.02**	**5.1**
Sediment concentration	1	adjusted	**0.08**	**7.3**
Sediment concentration	2	adjusted	0.26	3.0
Sediment concentration	3	adjusted	0.92	0.0
Sediment concentration	4	adjusted	0.38	4.1
Sediment concentration	5	adjusted	**0.06**	**7.3**
Sediment discharge	1	unadjusted	**0.03**	**0.8**
Sediment discharge	2	unadjusted	**0.01**	**0.5**
Sediment discharge	3	unadjusted	**0.07**	**0.4**
Sediment discharge	4	unadjusted	**0.02**	**0.8**
Sediment discharge	5	unadjusted	**0.02**	**0.8**
Sediment discharge	1	adjusted	**0.05**	**8.3**
Sediment discharge	2	adjusted	0.20	4.1
Sediment discharge	3	adjusted	0.88	1.0
Sediment discharge	4	adjusted	0.22	5.1
Sediment discharge	5	adjusted	**0.08**	**6.2**
PETERS (LONG) CREEK NEAR SENATOBIA (9 YEARS OF DATA)				
Stream discharge	1	not applicable	**0.07**	**0.7**
Stream discharge	2	not applicable	0.24	1.0
Stream discharge	3	not applicable	**0.10**	**0.8**
Stream discharge	4	not applicable	0.12	0.9
Stream discharge	5	not applicable	0.16	0.7
Sediment concentration	1	unadjusted	0.43	-0.6
Sediment concentration	2	unadjusted	0.76	-0.2
Sediment concentration	3	unadjusted	0.19	-0.9
Sediment concentration	4	unadjusted	0.32	-1.0
Sediment concentration	5	unadjusted	0.71	-0.5
Sediment concentration	1	adjusted	0.54	-3.9
Sediment concentration	2	adjusted	0.77	-2.0
Sediment concentration	3	adjusted	**0.08**	**-6.8**
Sediment concentration	4	adjusted	**0.03**	**-16.5**
Sediment concentration	5	adjusted	**0.03**	**5.1**
Sediment discharge	1	unadjusted	0.86	0.02
Sediment discharge	2	unadjusted	0.87	-0.01
Sediment discharge	3	unadjusted	0.64	-0.01
Sediment discharge	4	unadjusted	0.96	0.0
Sediment discharge	5	unadjusted	0.82	-0.14
Sediment discharge	1	adjusted	0.57	-3.0
Sediment discharge	2	adjusted	0.73	-2.0
Sediment discharge	3	adjusted	0.20	-5.8
Sediment discharge	4	adjusted	**0.08**	**-6.8**
Sediment discharge	5	adjusted	0.34	-3.9