Sediment Monitoring of Mill Creek, Rankin County, Mississippi

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ABSTRACT

Mill Creek in Rankin County, Mississippi, drains an 11 square mile watershed and flows into Pelahatchie Bay of the Ross Barnett Reservoir. Higher than expected sediment yields from Mill Creek have required that dredging operations in the affected areas be completed on 3-year intervals rather than the 10-year intervals which were planned when the reservoir was constructed.

A study of sediment yields during four storms in 1998 indicated that some areas of the watershed had significantly higher yields than other areas of similar size. In 2006, the U.S. Geological Survey, in cooperation with the Rankin County Board of Supervisors, began collecting streamflow and sediment concentration data at three locations in the watershed. The data are being collected to monitor the effects of structural improvements installed by Rankin County to reduce the volume of sediment flowing from Mill Creek into Pelahatchie Bay. Two locations were sampled as part of the 1998 study, allowing a comparison of the discharge-sediment concentration relation for the two time periods. The third sampling location will provide information on the sediment concentrations in the runoff from a primarily undeveloped area.

Keywords: sediment, runoff, streamflow

Introduction

The U.S. Geological Survey (USGS), in cooperation with the Rankin County Board of Supervisors (Rankin County), has developed and is implementing a monitoring program to collect streamflow and suspended-sediment data at selected locations in the Mill Creek Watershed in Rankin County, Mississippi. Data currently are being collected at four locations in the watershed. Two of the monitoring locations were selected, in part, based on results from a 1998 study (Runner, 1998) that indicated some areas of the watershed had significantly higher sediment yields than other areas of similar or larger size.

Data are being collected in support of the County's efforts to reduce the amount of sediment that is flowing from the Mill Creek Watershed into Pelahatchie Bay of the Ross Barnett Reservoir (fig. 1). Results of the monitoring program will be used to assist in the selection of the location and type of sediment reduction efforts that will be implemented in the watershed. The data will also be used to evaluate the effects of the work after it has been completed.

Higher than expected sediment yields from Mill Creek require more frequent (3-year intervals rather than the 10-year intervals) dredging activities in Pelahatchie Bay than were originally planned. The dredging is necessary to maintain the viability of that part of the Bay as a recreational water body for boaters and fishermen. The increased dredging activity also diverts financial resources that might have been used in other areas of the Reservoir.

Purpose and Scope

This report describes the current (spring 2007) status of the monitoring effort, describes planned additions to the monitoring program, and presents results of data collection and preliminary analysis thus far.

The Mill Creek Watershed is located in Rankin County, Mississippi, and flows into Pelahatchie Bay of the Ross Barnett Reservoir (fig.1). The watershed is approximately 11.1 square miles and is a mixture of forest, residential, commercial, and agricultural land use. Data collection began in August 2006 and will continue through September 2008.

Data currently (2007) are being collected at four locations (fig. 2) in the watershed: Mill Creek at Highway 25 (USGS station number 02485574), Mill Creek Tributary No. 1 at Grants Ferry Road (USGS station number 02485577), Mill Creek at Castlewoods Boulevard (USGS station number 02485573), and Mill Creek Tributary No. 5 at Woodlands Drive (USGS station number 0248557250). Data collection consists of the operation of continuous stream-discharge stations and the collection of suspended-sediment data during runoff events.

In addition to the continuous monitoring stations, discrete streamflow- and sediment-data will be collected during runoff events at additional locations, one on Mill Creek and several on small tributaries (fig. 2). A summary of the existing, historic, and proposed monitoring locations and their basin characteristics is shown in table 1.

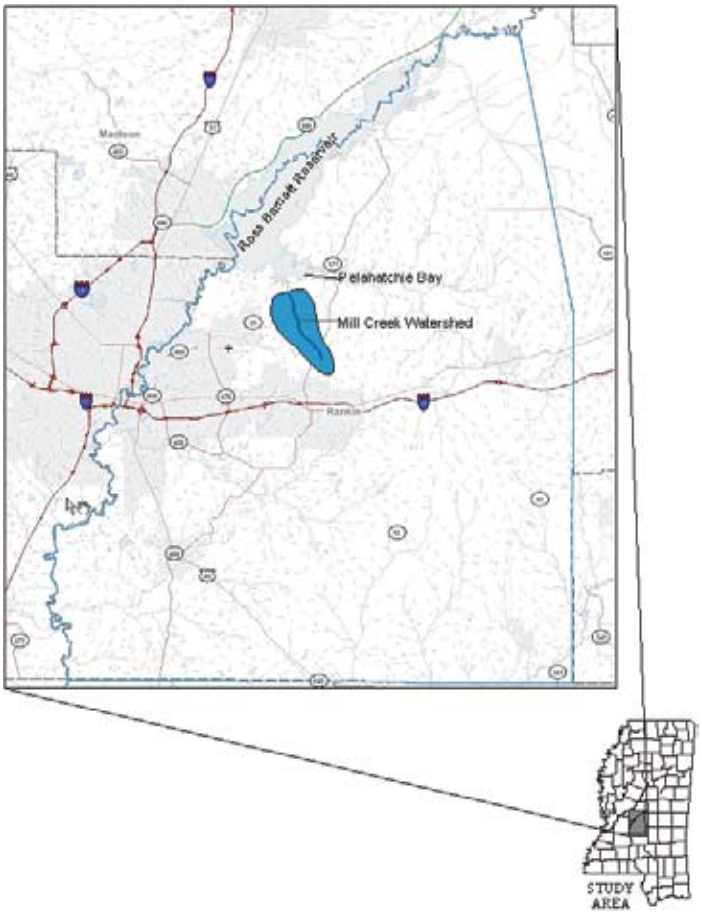

Figure 1. Location of Mill Creek watershed in Rankin County, Mississippi.

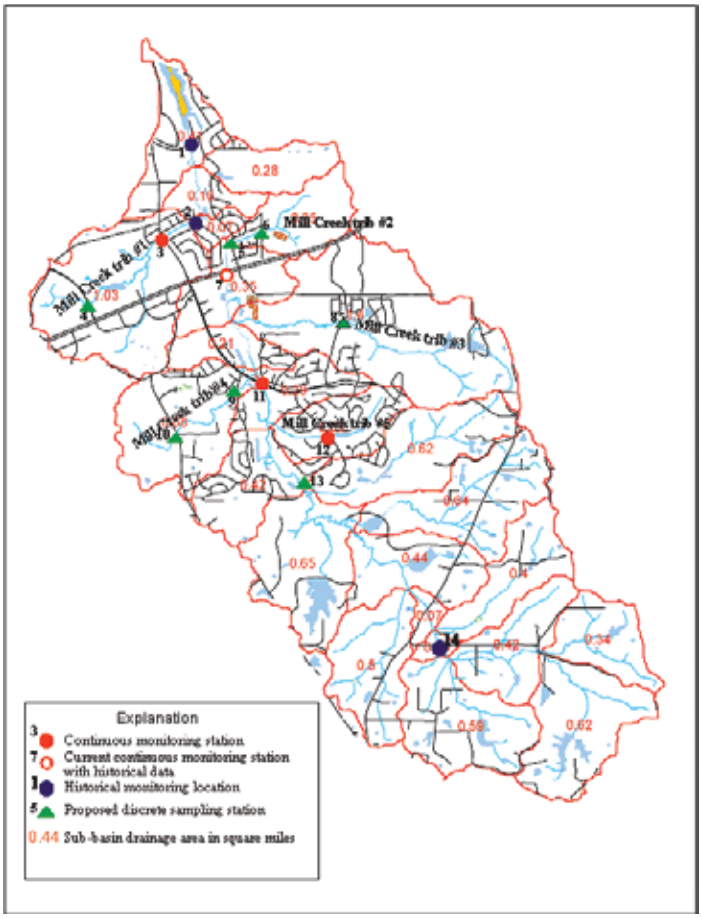

Figure 2. Location of current, historical, and proposed monitoring sites in the Mill Creek Watershed in Rankin County, Mississippi.

Table 1. Monitoring locations in the Mill Creek Watershed in Rankin County, Mississippi [DA, drainage area; mi², square miles; L, stream length; mi, miles; S, channel slope from 10 to 85 percent of length; Percent is percent of total drainage area].

Fig. 2 map no.	Monitoring location and site name	DA (mi²)	L (mi)	S (ft/ml)	Percent	Remarks
1	Mill Creek at Spillway Rd.	11.1	6.65	15.3	100.0	Sampled in 1998
2	Mill Creek Trib. #1	1.03	1.51	34.5	9.3	Sampled in 1998
3	Mill Creek Trib #1 at Grants Ferry Rd.	0.94	1.20	41.1	8.5	Current real-time site
4	Mill Creek Trib. #1 Site B	0.23	0.45	59.3	2.1	Proposed synoptic sampling site
5	Mill Creek Trib. #2 Site A	0.34	0.99	82.2	3.1	Proposed synoptic sampling site
6	Mill Creek Trib. #2 Site B	0.30	0.76	124.6	2.7	Proposed synoptic sampling site
7	Mill Creek at Hwy 25	8.92	5.63	17.1	80.5	Sampled in 1998, Current real-time site
8	Mill Creek Trib. #3 sampling site	0.98	1.54	36.4	8.8	Proposed synoptic sampling site
9	Mill Creek Trib. #4 Site A	0.62	1.21	43.0	5.6	Proposed synoptic sampling site
10	Mill Creek Trib. #4 Site B	0.26	0.65	65.6	2.3	Proposed synoptic sampling site
11	Mill Creek at Castlewoods Blvd.	6.37	4.65	18.6	57.5	Current real-time site
12	Mill Creek Trib. #5 sampling site	0.21	0.70	68.6	1.9	Current real-time site
13	Mill Creek at Golf Course	5.32	3.82	20.6	48.0	Proposed synoptic sampling site
14	Mill Creek at Coon Hunters Rd.	1.92	2.09	36.9	17	Sampled in 1998

Data Collection

Stream Discharge

Stream discharge data are computed by using measured water-level, or stage, and a stage-discharge relation. Stage data are collected at the continuous monitoring stations by using a non-submersible pressure transducer to measure the water level, and a data-collection platform to record the data. Data are measured and recorded every 15 minutes and transmitted via satellite to the USGS office in Jackson, MS.

Streamflow measurements over the range of stage are made to develop a relation between stage and discharge. The resulting relation is used to compute the instantaneous discharge at the monitoring location.

Suspended Sediment Concentration

Water samples at the monitoring stations are collected by the USGS during site visits, and by automatic pumping samplers during runoff events. The USGS collects depth- and width-integrated water samples using methods and equipment described in USGS technical publications (Guy and Norman, 1970; Wilde, 1998). Automatic samplers installed at the continuous monitoring locations are activated when the stage exceeds a preset threshold. After activation, the

sampler collects a water sample at a preset time interval. The threshold and sampling interval is unique to each site and is based on the range in stage and duration of the hydrographs. The water samples are sent to the USGS sediment laboratory in Baton Rouge, La., for analysis to determine the concentration of sediment in the water. The concentrations for the integrated samples are compared to the results of the samples collected by the pumping samplers to determine correction coefficients that are applied to adjust the pumped samples to better represent the average concentration in the stream.

Suspended Sediment Discharge

Sediment discharge is the product of the concentration and the stream discharge. It represents the rate at which the sediment is passing a specific transect of the stream and is generally expressed in units of tons per day (t/d):

$$Qs_n = C_n * Q_n * 0.0027 \qquad (1)$$

where:

Qs_n = Instantaneous sediment discharge, in tons per day;

C_n = Instantaneous sediment concentration, in milligrams per liter;

Q_n = Instantaneous stream discharge, in cubic feet per second;

0.0027 = Unit conversion factor.

Sediment load is the sum of the sediment discharges weighted by time. It represents the total volume of sediment passing a specific transect of the stream and generally is expressed in units of tons (t).

Sediment yield is the total sediment load at a particular transect divided by the drainage area above that point on the stream. It represents the average volume of sediment that is generated from a unit area of the drainage basin. Sediment yield generally is expressed in units of tons per square mile (t/mi^2).

Land Use

In January 2006, Rankin County purchased high-resolution photography for the Mill Creek Watershed. This photography was analyzed using USGS software to delineate and classify land-use in the watershed. This software creates data sets compatible with popular graphical information system (GIS) software which was then used to determine the percentage of the watersheds and sub-watersheds in the various land-use categories. A summary of the land use data obtained from the 2006 photography is included in table 2.

Data Results

To date, more than 400 water samples have been collected at the continuing monitoring stations, and laboratory results for samples collected through the end of October 2006 have been received. A summary of the October samples is presented in table 3.

On October 16 and 17, 2006, the Mill Creek Watershed received approximately 2.1 inches of rain in a 24-hour period. Sediment loads for this event for both Mill Creek at Highway 25 and Mill Creek Tributary No. 1 were computed using GCLAS (Graphical Constituent Loading Application Software). Figures 3 and 4 show the streamflow- and sediment- concentration hydrographs for the two monitoring locations. A summary of the data collected for each station is listed in table 4. For the two days of the event, 207 tons of sediment flowed from Mill Creek at Highway 25, and 180 tons moved from Mill Creek Tributary No. 1. These loads represent sediment yields of 23.2 and 191 tons per square mile respectively (table 4).

The data also indicate Mill Creek Tributary No.1 experienced a small rise on October 18, 2006, where the sediment concentration was greater than 2,000 mg/L for a substantial part of the day (fig. 4). The computed sediment load on Mill Creek Tributary No. 1 for October 18 was 11 tons, with a daily mean streamflow and sediment concentration of 2.3 ft^3/s and 1,020 mg/L, respectively.

Suspended sediment loads computed from the October 2006 sediment samples were compared to results from a

Table 2. Land-use catagories and percent of watershed of land-use data for locations in the Mill Creek Watershed. [DA, drainage area]						
Monitoring location and site name	**DA (mi^2)**	**Forest**	**Urban**	**Barren**	**Open Water**	**Range-grassland**
Mill Creek at Spillway Rd.	11.1	58	19	9	2	12
Mill Creek Trib. #1	1.03	22	15	57	1	5
Mill Creek Trib #1 at Grants Ferry Rd.	0.94	24	7	62	1	5
Mill Creek Trib. #1 Site B	0.23	0	12	88	0	0
Mill Creek Trib. #2 Site A	0.34	90	8	1	1	0
Mill Creek Trib. #2 Site B	0.30	96	1	2	1	0
Mill Creek at Hwy 25	8.92	62	18	3	2	15
Mill Creek Trib. #3 sampling site	0.98	53	20	2	2	23
Mill Creek Trib. #4 Site A	0.62	66	14	10	0	10
Mill Creek Trib. #4 Site B	0.26	73	1	21	0	5
Mill Creek at Castlewoods Blvd.	6.37	64	15	3	2	16
Mill Creek Trib. #5 sampling site	0.21	4	95	0	0	1
Mill Creek at Golf Course	5.32	70	4	4	3	19
Mill Creek at Coon Hunters Rd.	1.92					

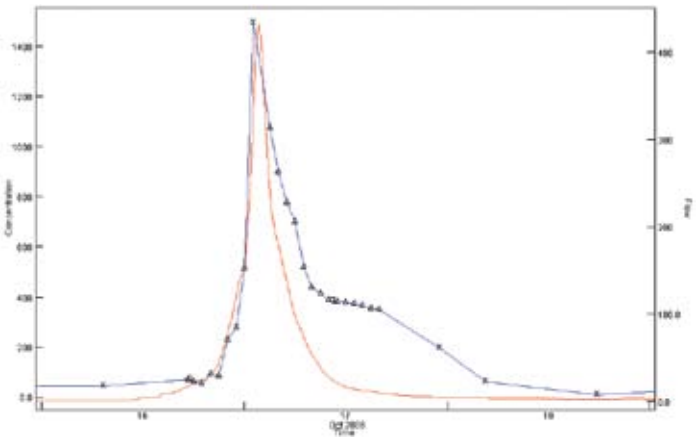

Figure 3. GCLAS plot showing discharge- and sediment-concentration hydrographs for Mill Creek at Highway 25, October 16 – 18, 2006.

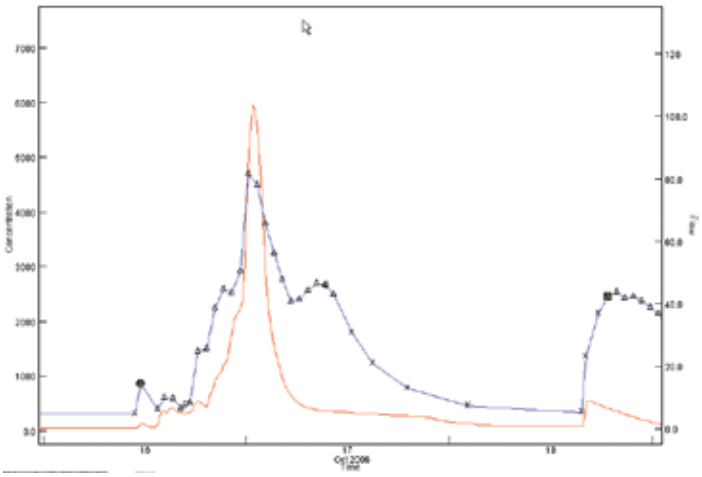

Figure 4. GCLAS plot showing discharge- and sediment-concentration hydrographs for Mill Creek Tributary #1 at Grants Ferry Rd., October 16 – 18, 2006.

1998 sediment study (Runner, 1998) for the same locations. During the 1998 study, samples were collected at the Highway 25 monitoring location and on Tributary #1 at a bridge downstream from the current monitoring location.

A preliminary review of the data suggests that, for Mill Creek at Highway 25, the stream discharge-sediment load relation is about the same in 2006 as it was in 1998 (fig. 5). The data for Mill Creek Tributary #1 at Grants Ferry Road indicate that for a given streamflow, there is more sediment in transport now than there was in 1998 (fig. 6).

Summary

In response to higher than expected sediment deposition from Mill Creek in Rankin County into Pelahatchie Bay of the Ross Barnett Reservoir, the Rankin County Board of Supervisors initiated an effort to reduce erosion in the Mill Creek watershed and the subsequent transport of the eroded material into Pelahatchie Bay. To support Rankin County's efforts, the U.S. Geological Survey is collecting streamflow and sediment concentration data at locations in the Mill Creek watershed. Data have been collected at two monitoring locations

Table 3. Results of sampling at Mill Creek monitoring stations in October 2006 [ft^3/s, cubic feet per second; mg/L, milligrams per liter; t/d, tons per day; Min., minimum; Max., maximum].

Monitoring station	Number of Samples	Sampled stream discharge (ft^3/s)		Suspended-sediment concentration (mg/L)		Suspended-sediment discharge (t/d)	
		Min.	Max.	Min.	Max.	Min.	Max.
Mill Creek at Highway 25	85	5.7	250	47	1040	1.8	668
Mill Creek Trib. No 1 at Grants Ferry Road	95	<1	96	324	6460	1.1	1140

Table 4. Summary of streamflow and suspended sediment concentration data collected at Mill Creek at Highway 25 and Mill Creek Tributary No. 1 at Grants Ferry Rd., October 16 and 17, 2006 [ft^3/s, cubic feet per second; mg/L, milligrams per liter].

Monitoring station	Maximum streamflow (ft^3/s)	Maximum concentration (mg/L)	Daily-mean streamflow Oct. 16/17 (ft^3/s)	Daily-mean concentration Oct. 16/17 (mg/L)	Sediment load (tons)	Sediment yield (tons/mi^2)
Mill Creek at Highway 25	432	1040 @ 238 ft^3/s	18 / 74	79 / 513	207	23.2
Mill Creek Trib. No 1 at Grants Ferry Road	104	4590 @ 88 ft^3/s	12 / 15	890 / 1970	180	191

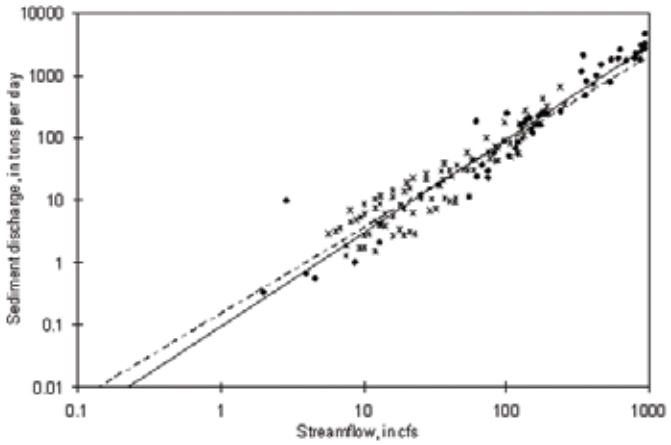

Figure 5. Comparison of the streamflow - suspended-sediment-discharge relation for data collected at Mill Creek at Highway 25 in 1998 and 2006.

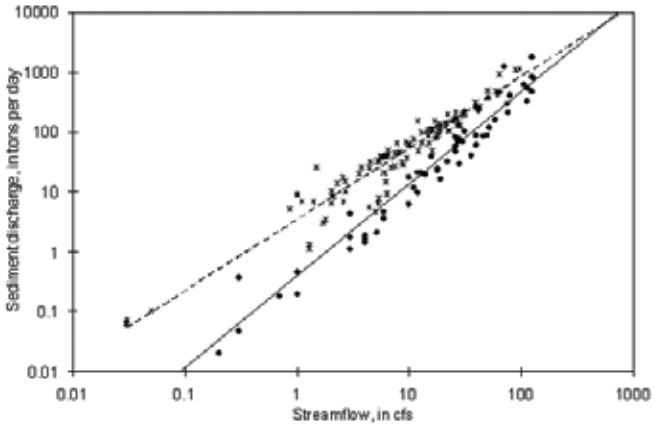

Figure 6. Comparison of the streamflow - suspended-sediment-discharge relation for data collected at Mill Creek Tributary No. 1 in 1998 and 2006.

since October 2006 and additional monitoring is planned for the future. Data will be used to compute sediment loads in Mill Creek and some of its tributaries, determine areas of the watershed that contribute more sediment than others, thus making them candidates for structural improvements, and monitor the effectiveness of the structural improvements and best management practices that are implemented in the watershed.

Preliminary results from data collected during October 2006 have been compared to data collected in 1998. These data suggest that the sediment yields in some areas of the watershed are higher now than they were at the time of the earlier study.

References

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