

## **Synoptic Survey Results For Four Storm Events**

### Background: Sediment and Sixmile Creek

Sixmile Creek is a major tributary to southern Cayuga Lake; the stream drains a watershed area of approximately 52 square miles and enters the Cayuga Inlet about one mile upstream of Cayuga Lake. The Creek is the source of public water supply for the City of Ithaca and portions of the Town of Ithaca.

Sixmile Creek transports a substantial sediment load, leading to its placement on the State and Federal list of impaired waterbodies. Elevated concentrations of suspended sediment may degrade water clarity, interfere with the biological community, and complicate water treatment. Moreover, suspended sediments may carry other contaminants, among them metals, pesticides, and nutrients.

The source of the sediment transported by the Sixmile Creek has been the focus of investigation, notably the October 2003 Flood Mitigation Needs Assessment report by Milone and MacBroom Inc. (MMI) of Cheshire CT completed for the Tompkins County Planning Department. The findings of the MMI report indicate that the vast majority of the sediment originates within the stream channel itself. That is, runoff from developed areas, agricultural fields, and roadways is only a minor component of the stream's sediment load. Erosion of the stream bed and banks is the major source. This is a consequence of the underlying geologic formations and past land use practices. The watershed was cleared for agricultural use in the 19<sup>th</sup> century and sediment eroded from the landscape was stored in the streambed. Now much of the watershed is reforested, and external sediment load has diminished.

This general conclusion makes intuitive sense to long-term observers of the stream. Channel migration is evident in several areas. Professor Dan Karig has documented lateral migration upstream of German Cross Road. Several properties in the Town of Caroline (known as the Barille site) are threatened by severe bank erosion.

As explained in the MMI report, Sixmile Creek is responding in a predictable manner to the physical environment. The significant drop in elevation from the stream headwaters in Dryden (elevation 1650 ft) to the lake (elevation 382 ft) is a source of potential energy. Under present land use conditions the watershed is relatively stable and well-vegetated; consequently, the landscape is not a significant source of sediment. The stream's potential energy is not used up in transporting sediment originating in the watershed. Instead, the potential energy is used to erode and transport particles from the stream bed and channel.

Sixmile Creek's meandering can also be explained in terms of energy dynamics. The stream migrates laterally and becomes more sinuous to dissipate more energy in a shorter distance. This serves to decrease the stream's slope. The underlying geology of the area plays an important role; the lakebed deposits of silts and clay left behind by glaciations are highly erodible. In many areas the stream has eroded its streambed to reach bedrock or a resistant till layer.

Overall, a number of factors interact to affect the stream's sediment load. Slope, depth to bedrock, and soil type are among the most important. Typical of larger streams, these characteristics vary along the length of Sixmile Creek. The MMI team segmented Sixmile Creek into a series of nine reaches to analyze and describe the factors affecting sediment transport within the reaches. The reaches sequence from downstream to upstream.

### The Nine Stream Reaches Defined by MMI

- (1) Cayuga Inlet to Van Natta's Dam
- (2) Van Natta's Dam to Burns Road
- (3) Burns Road to Banks Road
- (4) Banks Road to Middaugh Road
- (5) Middaugh Road to Valley Road near VandeMark Road
- (6) Valley Road near VandeMark Road to Boiceville Road
- (7) Boiceville Road to Creamery Road
- (8) Creamery Road to Six Hundred Road
- (9) Six Hundred Road to Headwaters in Dryden

City of Ithaca Investigations

The City of Ithaca has received state and federal matching grants for projects designed to improve management of riparian areas within Six Mile Creek. As part of this study, the City and its project team (EcoLogic LLC of Cazenovia NY, the Cayuga Lake Watershed Network, and John Heintz P.E. of IEDC) completed a forest inventory along the riparian corridor, performed in-stream sampling of aquatic habitat and benthic macroinvertebrates, and defined priority areas.

An in-stream monitoring program is part of the City's workplan. In 2004 the City team completed four synoptic surveys to measure the concentration of suspended sediment and total phosphorus during high flow conditions. Synoptic surveys are designed to collect samples at multiple locations within the watershed at approximately the same time. These surveys can provide scientists and resource managers with information regarding how a stream responds to a given hydrologic event. Segments with active erosion would be expected to transport a high sediment load. In segments with depositional areas (such as the reservoirs) the suspended sediment load will decrease. The synoptic surveys completed in Sixmile Creek incorporated stations within the stream reaches as defined by MMI.

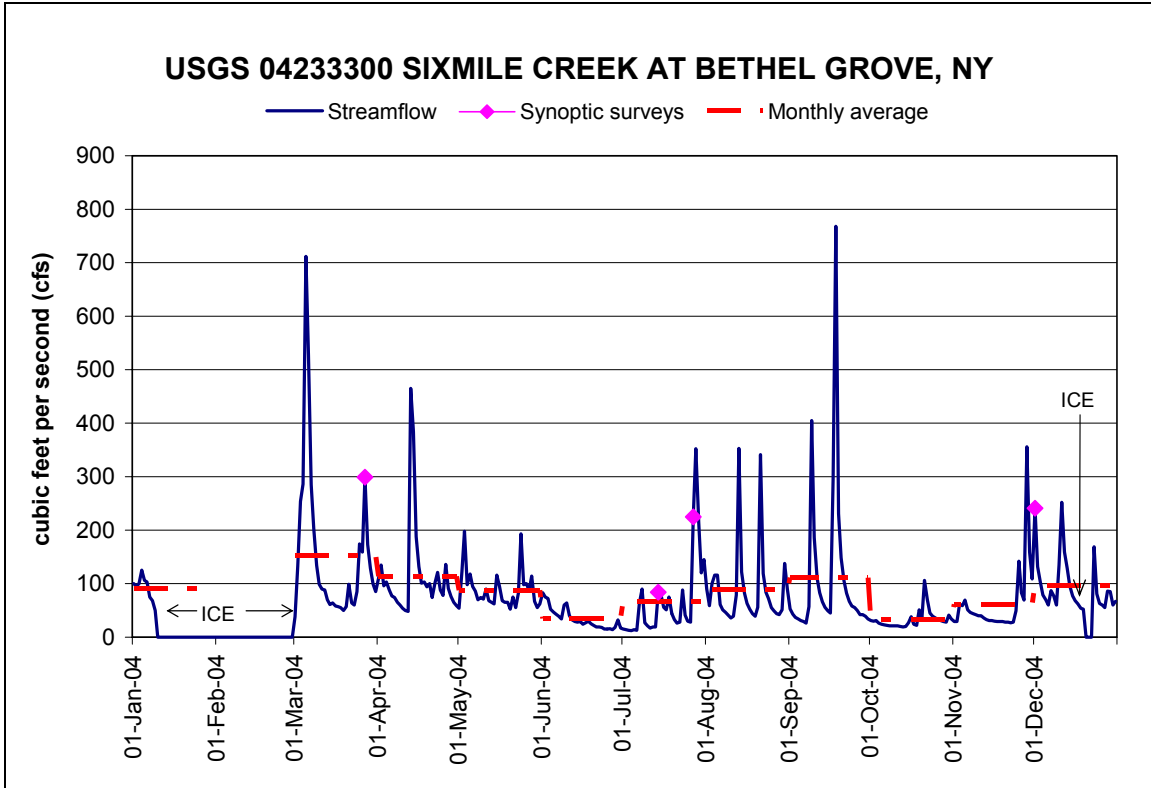
Samples were collected by staff of the Cayuga Lake Watershed Network and trained volunteers. Laboratory analysis of the suspended sediment was completed by the City of Ithaca; phosphorus analyses were completed by Community Science Institute, Inc. (CSI). The Watershed Network staff tracked streamflow using the real-time USGS gage at Bethel Grove. A high flow event was defined as one standard deviation above the monthly mean discharge ([Table 1](#)).

Table 1  
Definition of High Flow Events

Month	Monthly Mean Discharge (cfs)	Standard Deviation (cfs)	Threshold for High Flow Event (cfs)
January	82.9	61.45	144.35
February	90.9	26.98	117.88
March	105	41.02	146.02
April	110	55.14	165.14
May	77.1	57.61	134.71
June	49.9	29.82	79.72
July	20.1	13.2	33.3
August	12.9	14.28	27.18
September	14	7.5	21.5
October	21.8	15.58	37.38
November	44.3	38.58	82.88
December	61.8	55.73	117.53

### Sampling Completed in 2004

The four synoptic survey events completed in 2004 are denoted on the hydrograph included as [Figure 1](#). It is clear from the hydrograph that 2004 was a wet year in Tompkins County. The four sampling events successfully captured high flow conditions.



[Figure 1](#). Hydrograph of Sixmile Creek discharge, Jan 1 – Dec 31, 2004.

### Results: Sediment Concentration

Results of the 2004 synoptic surveys are presented in [Table 2](#). Note that the MMI designation of stream reaches proceeds from downstream (reach 1) to upstream (reach 9). The data plots are formatted to display the concentrations and loads of total phosphorus (TP) and total suspended sediment (TSS) from upstream to downstream (left to right) using a scale of river miles (distance from headwaters). Designated MMI reach numbers are also included in the data table for clarity.

Note that the concentration of sediment in the stream water increases in the middle reaches; these are the areas associated with active lateral migration of the stream and bank erosion. It is interesting to note that the concentration of suspended sediment does not measurably decrease between German Cross Road and Burns Road. This finding indicates that the City's siltation dam is not operating as a depositional area. Improvements and restoration of this area planned for 2005 are designed to increase the capacity of the siltation pond and alter the water circulation to enhance sediment deposition.

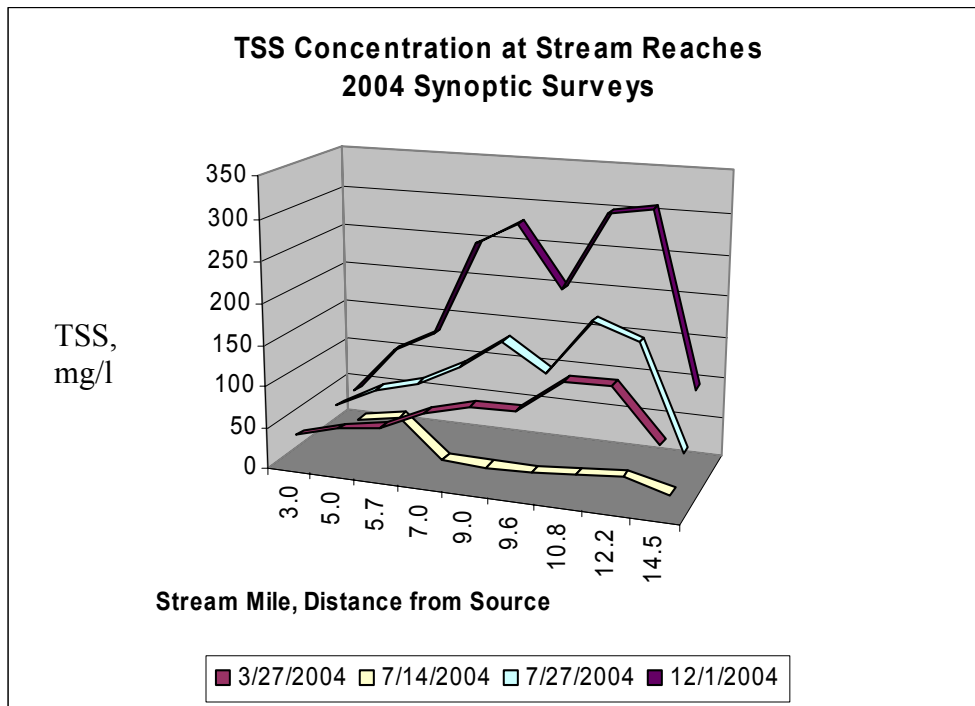
Sediment concentrations decline significantly between Burns Road and Giles St. This result indicates that the downstream impoundments are functioning to remove sediment.

**TABLE 2**

Results of Total Suspended Sediment Measurements, Synoptic Surveys

MMI Reach Designation	Distance from Source (mi)	Sampling Site	Total Suspended Sediment, mg/l			
			3/27/04	7/14/04	7/27/04	12/01/04
9	3	Six Hundred Rd.	37.9	N/A	39.6	42.1
8	5	Creamery Rd.	52.7	45.4	66.0	101.4
7	5.7	Boiceville Rd.	61.8	55.1	80.1	127.8
6	7	Valley Rd.	85.4	10.3	108.2	247.3
5	9	Middaugh Rd.	99.1	7.2	145.5	276.8
4	9.6	Banks Rd.	100.2	8.6	112.9	200.8
3	10.8	German Cross Rd.	142.0	11.6	181.2	297.2
2	12.2	Burns Rd.	142.1	16.8	160.7	305.7
1	14.5	Giles St.	82.1	3.4	34.4	93.3

The suspended sediment data from the synoptic surveys are plotted in [Figure 2](#).



[Figure 2](#). Suspended sediment concentration measured during four synoptic surveys.

Results: TP Concentration

Total phosphorus concentrations were also measured on the water samples collected during the 2004 synoptic surveys. These results are summarized in [Table 3](#). The analysis of total phosphorus

(P) includes the following fractions: dissolved organic, dissolved inorganic, particulate inorganic, and particulate organic.

**TABLE 3**

Results of Total Phosphorus Measurements, Synoptic Surveys

MMI Reach Designation	Distance from Source (mi)	Sampling Site	Total Phosphorus, mg/l			
			3/27/04	7/14/04	7/27/04	12/01/04
9	3	Six Hundred Rd.	0.058	0.009	0.044	0.07
8	5	Creamery Rd.	0.09	0.021	0.152	0.258
7	5.7	Boiceville Rd.	0.076	0.012	0.132	0.252
6	7	Valley Rd.	0.061	0.016	0.101	0.195
5	9	Middaugh Rd.	0.069	0.01	0.121	0.254
4	9.6	Banks rd.	0.064	0.018	0.105	0.199
3	10.8	German Cross Rd.	0.045	0.05	0.065	0.118
2	12.2	Burns Rd.	0.036	0.052	0.072	0.116
1	14.5	Giles St.	0.032	0.021	0.056	0.058

It is evident from comparing the data presented in Tables 2 and 3 that the phosphorus and sediment concentrations are closely coupled in Sixmile Creek. A linear regression between the two data sets (plotted in Figure 3) demonstrates this strong relationship. This indicates that the total P measured in the samples is associated with the particulate fraction, indicating that dissolved P is very low. This finding is consistent with the watershed’s land use. There are no permitted point source discharges to Sixmile Creek and active agriculture tends to be remote from the stream. Stormwater runoff from the City (which would be measured at Site 1) does not appear to measurably increase dissolved phosphorus. However, the watershed downstream of Giles St is urbanized and there are additional stormwater discharges to the Creek before it reaches the Cayuga Inlet.

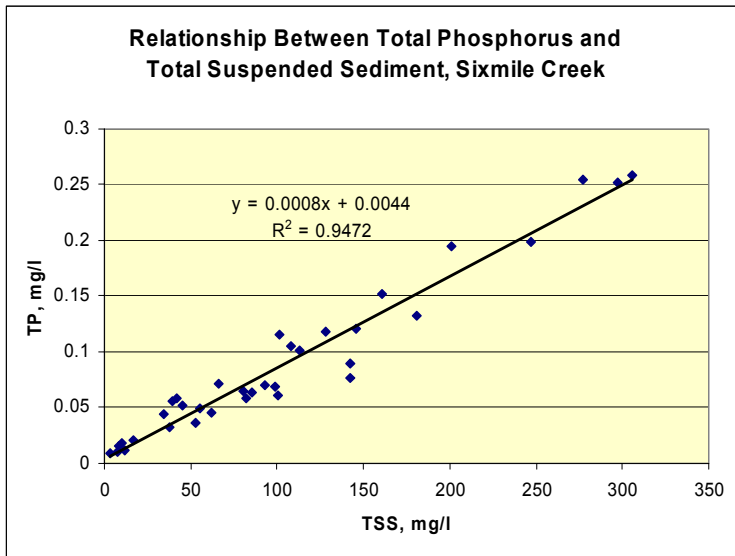


Figure 3. Regression of total suspended sediment and total phosphorus data from synoptic surveys, all stations, all dates.

Results: Loading Estimates

Loads of TSS and TP transported by Sixmile Creek during the survey were estimated using discharge data from the USGS gages. These loading calculations are only estimates, as they are based on a single grab sample collected during each of the high flow event. Concentration of suspended sediment can vary greatly over the course of a single storm event.

The loads of TSS and TP estimated for each of the four sampling events are displayed in [Figures 4-7](#).

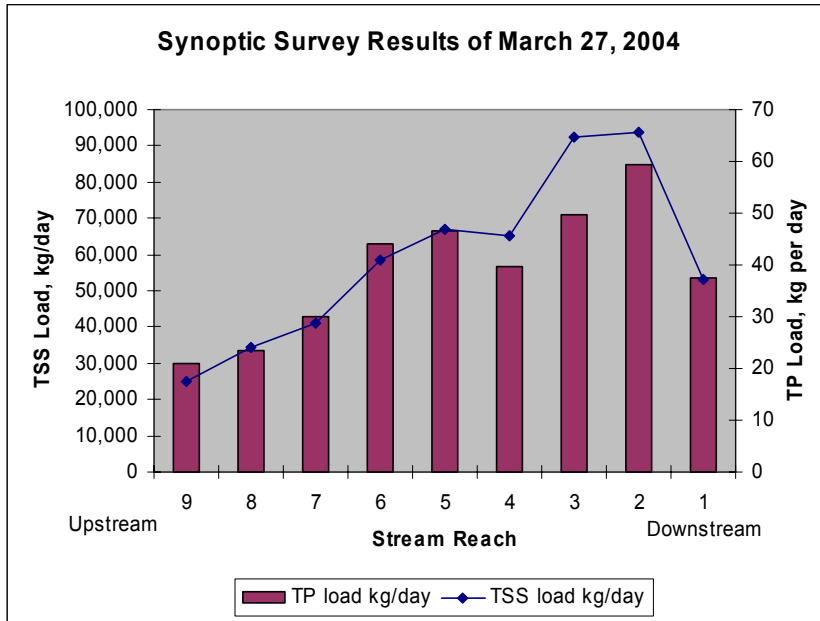


Figure 4. TP load (instantaneous) calculated based on March 27, 2004 event

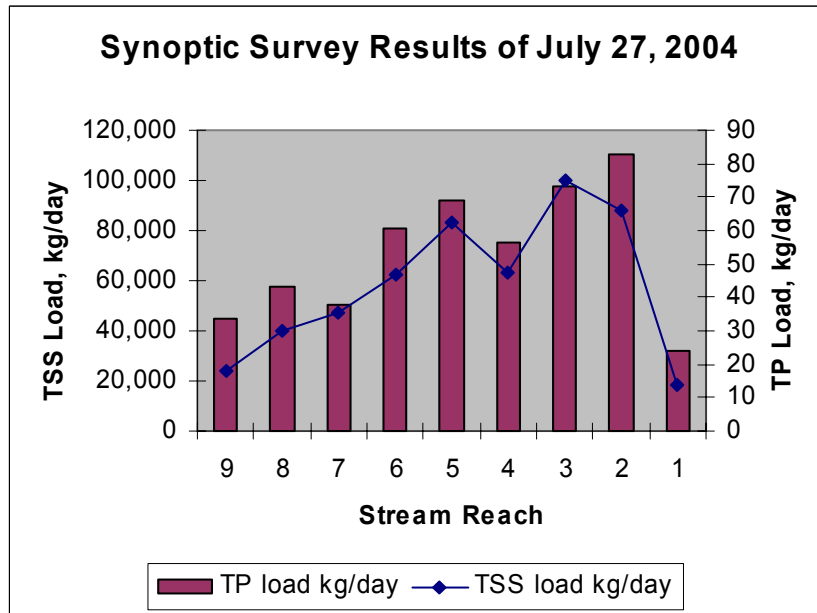


Figure 5. TP load (instantaneous) calculated based on July 27, 2004 event

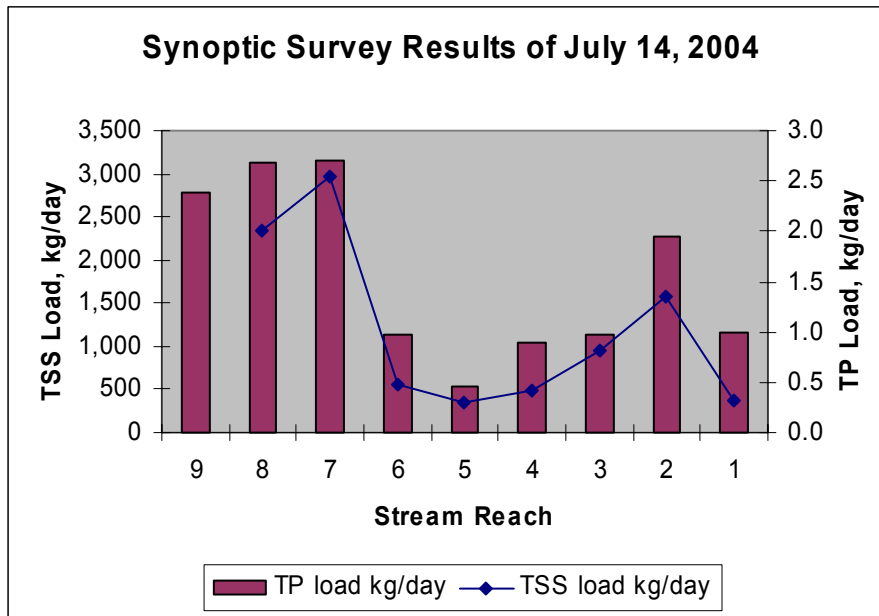


Figure 6 TP load (instantaneous) calculated based on July 14, 2004 event (incomplete storm)

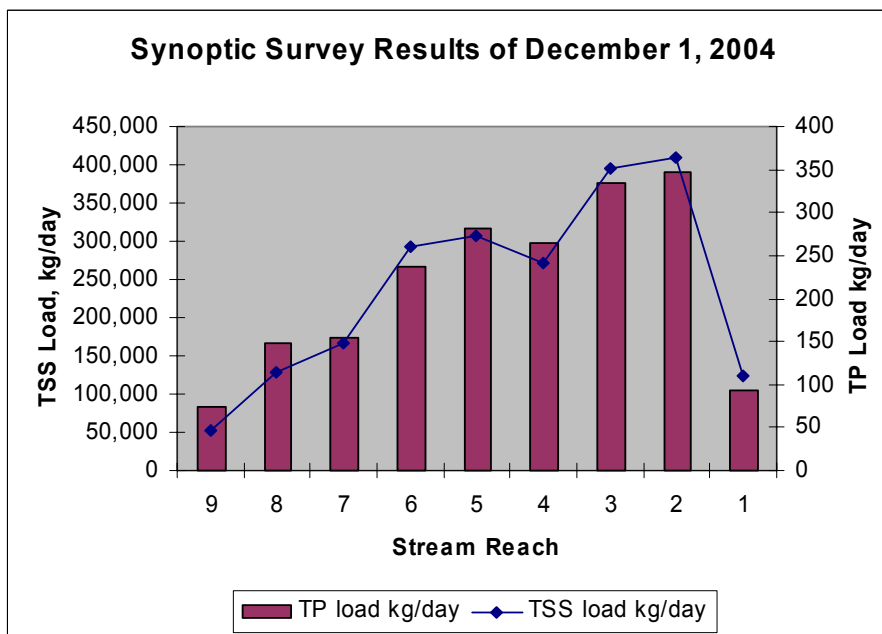


Figure 7. TP load (instantaneous) calculated based on Dec.1, 2004 event

With the exception of the July 14, 200 event, the synoptic surveys were conducted when stream levels were high, at or approaching bank full conditions. Most sediment is transported under these conditions. The loading pattern for the July 14, 2004 event differs from the other three events; upstream reaches were affected by the storm while the middle reaches were not. Field records from this event confirm that the storm of July 14 did not occur throughout the entire watershed. This dataset should be considered less representative than the others. Note the different scale of TSS and TP loading for the four events.

### Summary

The four surveys completed in 2004 illustrate how the stream reaches respond to precipitation and high flow events. The results confirm that sediment erosion and transport are significant in the stream's middle reaches. Phosphorus concentration is associated with the sediment fraction. The City of Ithaca's siltation basin is not reducing sediment concentration in the stream, thus confirming the need for renovation and improvements to this site. The downstream reservoirs are capturing sediments eroded from the watershed.