V-A: Water Quality Assessment

The following discussion of water quality assessment in the Batavia Kill watershed will be limited to two physical characteristics that are easily measured in water samples: turbidity and total suspended solids. Turbidity is an optical property of water. It is a measure of the light-scattering and absorption properties of molecules and particles suspended in water.

A "nephelometric turbidimeter" or "nephelometer" is commonly used to determine turbidity. This instrument passes a beam of light through a water sample and the instrument's microprocessor calculates a ratio of the signals from a transmitted light detector and a detector at a 90° angle from the transmitted beam of light to register a turbidity reading (Hach Company 1999). Turbidity is reported in "Nephelometric Turbidity Units" or NTUs. Turbidity is influenced not only by the amount of particles in the sample, but also the shape, size, and color of the particles.

Total suspended solids are a measure of suspended sediment concentration, expressed as a weight per volume (in milligrams per liter or mg/L). For this analysis, water samples were collected by filling a sample bottle (1 L) and filtering the water/sediment mixture through a glass fiber filter that is dried and weighed prior to filtration of a sample. The filter is oven dried to a constant weight at 103-105° C and the increase in filter weight represents the total suspended solids (Standard Methods 1998). Some colloidal and clay-sized particles pass through the filter due to their small particle sizes.

Although the relationship between turbidity and total suspended solids is positive (as turbidity increases, the amount of suspended particles also increases) this relationship depends on the source of the material, and is affected by both the composition and color of the particles (Walling and Webb 1992). It is therefore more informative to examine both turbidity and total suspended solids as indicators of the effects of suspended sediment on water quality rather than attempting to substitute one measurement for another. For this reason, both turbidity and total suspended solids have been key variables monitored in studies of water quality on the Batavia Kill.

1. IMPORTANCE OF WATER QUALITY INDICATORS

Local concerns about streambank and bed erosion can be better addressed if trouble areas are identified and managed to minimize losses. Additionally, the amount of material suspended in the water is important from a water supply perspective because suspended particles interfere with disinfection (in this case, with chlorination). New York City's water supply is unfiltered and must meet stringent federal standards for turbidity. During periods with high runoff, the reservoir system allows the fine particles to dissipate by dilution and settling. It is, however, more desirable to stop the sediment loss and transport at upstream sources. From a biological viewpoint, high sediment concentrations interfere with fish spawning success, can clog fish gills and reduce the invertebrate population that is part of a healthy, balanced stream community, as well as reduce light availability for phytoplankton and plant life.

Fine sediments are also known to facilitate the transport of other undesirable substances, such as bacteria, viruses, protozoa, nutrients (specifically phosphorus and nitrogen), metals, and organic compounds that are absorbed onto the surface of sediment particles. Increases in turbidity have been linked to waterborne illnesses caused by microorganisms such as *Giardia* and *Cryptosporidium* (USEPA 1999). So from several perspectives, there are advantages to controlling sediment loss and transport in a stream.

2. SELECTION OF THE BATAVIA KILL FOR BMP PILOT STUDIES

Focus on in-stream sources of sediment and high levels of turbidity in the Batavia Kill began with a concern over turbidity on a larger scale in the Catskill region of the New York City watershed. The importance of developing a strategy to reduce turbidity and improve water quality in streams and reservoirs was identified by USEPA in the *Filtration Avoidance Determination of December 1993* (FAD of 1993). This determination identified turbidity as a threat to long-term compliance with the raw water turbidity requirements of the Surface Water Treatment Rule (SWTR).

Picture of sampling house

Figure V-1

The FAD mandated that NYCDEP "identify watershed characteristics and activities which may have an adverse effect on source water quality" and pointed to the need for hydrological studies and water quality sampling of turbidity for use in modeling to "predict the impact of sources of contamination on downstream water quality" (1993). Special attention to stream water quality and management intervention in the Batavia Kill subbasin began in 1993, and was the subject of several documents or "deliverables" submitted by NYCDEP to USEPA.

NYCDEP responded to the Filtration Avoidance Determination by expanding their sampling program to meet the conditions of filtration avoidance and increased its water quality monitoring efforts to better characterize sources of turbidity on a regional scale. In the Catskill system (the Ashokan and Schoharie reservoir basins), synoptic surveys of turbidity and total suspended solids began in 1993 and continued through 1997. In 1993, 47 monitoring sites were established in the Catskill system, and in the following year monitoring was increased to 89 sites. By October 1995, more than 7,500 samples had been collected in total. These samples were analyzed for turbidity and total suspended solids. Water quality data were used to make estimates of suspended solids loads from streams near their confluences with the main streams (Esopus and Schoharie Creeks) that enter the Catskill system reservoirs.

Each tributary was ranked according to its relative contribution to turbidity levels and suspended sediment loads. Samples were collected as “grab samples” [discrete samples collected by filling a 1 liter (L) sample bottle with stream water] rather than using equipment that is traditionally employed to collect integrated suspended sediment samples. The general assumption was that grab samples would give a representation of the “wash load” of very fine suspended particles that are the principal source of turbidity in Catskill Mountain headwater streams. Eight tributaries to Esopus Creek and Schoharie Creek (6 in the Ashokan basin and 2 in the Schoharie basin) were ranked from highest to lowest suspended sediment discharge and turbidity for three seasons. The Batavia Kill subbasin, which represents 23% of the total area of the Schoharie Reservoir basin, had the highest suspended solids load calculated in 2 out of 3 seasons (1993-1994) (NYCDEP 1994).

Water quality sampling results were taken into consideration when selecting the Batavia Kill as a site for a pilot study of BMP implementation (NYCDEP 1995). Other criteria that entered into the selection of the Batavia Kill included a review of the Greene County Stream Inventory and input from the Greene County Soil and Water Conservation District, which identified more than 25 stream bank failures on the Batavia Kill (GCSWCD 1983).

3. FUTURE MONITORING

There are no quantitative action levels for turbidity or suspended sediment in streams. However, New York State has narrative standards for turbidity (“no increase that will cause a substantial visible contrast to natural conditions”) and for suspended, colloidal, and settleable solids (“none from sewage, industrial wastes or other wastes that will cause deposition or impair the waters for their best usages” (from 6NYCRR, Part 703.2, cited in NYCDEP 2001).

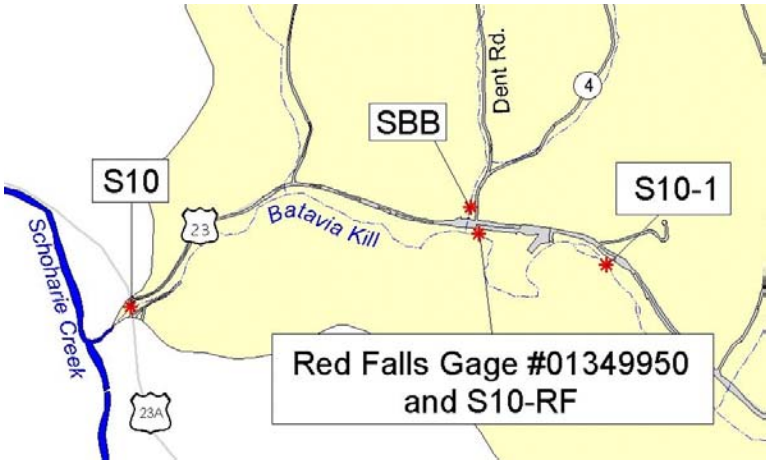


Figure V-2: Turbidity/TSS monitoring locations for the Red Falls demonstration site.

A plan is in place for NYCDEP to monitor the effectiveness of Best Management Practices (BMPs) on the Batavia Kill in the reach between sites S10-1 (upstream) and S10 (downstream) of a major sediment source area in this lower reach of the Batavia Kill, near Red Falls (NYCDEP 2001) **(Figure V-2)**.

This plan is a refinement of previous storm sampling strategies used from 1995 through 2000, and uses a systematic process for triggering sample collection with the use of state-of-the-art data loggers (CR10X, Campbell Scientific), pressure transducers for recording stream stage height, a tipping bucket rain gage, and automatic samplers at 3 sites (from upstream to downstream: S10-1, S10-RF, and S10, shown in Figure 1) that pump a sample into a collection bottle on the streambank. The monitoring goal is to characterize 10 storms per year, both before and after BMP construction. This approach is expected to provide sufficient data to evaluate stream management activities below Red Falls and determine whether there is a measurable improvement in water quality after stream restoration.

4. WATER QUALITY MONITORING RESULTS

Historical water quality data for storm events monitored on the Batavia Kill from 1995 through 2000 were reviewed. A few examples are given here to illustrate differences seen above and below the restoration sites in the Red Falls reach prior to BMP construction. Water quality monitoring prior to 1993 was solely based on fixed-frequency sampling at 2-week intervals.From 1993 to 1997, synoptic sampling (based on single samples collected daily during the period of selected rain events) was added to the water quality monitoring program for the specific purpose of doing a regional evaluation of turbidity and total suspended solids.

Beginning in 1995 and continuing to the present time, storm event sampling was added to the stream monitoring program. A comparison of synoptic and storm event results for the period from 1995 through 2000 is given in NYCDEP's *Quality Assurance Project Plan for Evaluation Of Stream Channel Stabilization Best Management Practices On The Batavia Kill by the Catskill District Hydrology Program* (2001). Mean values for turbidity and total suspended solids are markedly higher when storms are sampled through the hydrograph, and the necessity of sampling during the period of peak flow is illustrated in these comparisons.

Generalizations about Sampling in Years prior to 2001.

Storm event sampling was initiated at the beginning of a rain or rain/snowmelt runoff event where an appreciable increase in stream discharge is anticipated (J. Mayfield, personal communication). Since accurate weather predictions are difficult to make, the range in events monitored and the timing of sampling in the initial years of storm event monitoring did not always result in capturing the largest runoff events or a full representation of the storm hydrograph. Increasing sophistication in the use of programmable data loggers used in concert with rain gages and stage recorders has improved NYCDEP's ability to sample storm events effectively and efficiently in recent years (as described in the current *Quality Assurance Plan for the Batavia Kill*: NYCDEP 2001).

Ideally, the storm event is sampled from the onset at or near baseflow through the rising and falling limb of the hydrograph (a graph of stream discharge or flow over time; it is sometimes preferred that a measure of stream stage, the height above a known datum be used, because as streamflow changes, there are shifts and corrections that must be applied to correct for changes in the stream as it rises and recedes during a runoff event). This kind of intensive monitoring was deemed as the best way to evaluate water quality impacts of high flows (J. Mayfield personal communication).

A plot of all available data from 1993 through 2000 for turbidity (Figure 2a) and total suspended solids (Figure 2b) for the Batavia Kill outflow site (S10) above the confluence with Schoharie Creek shows how the use of storm event monitoring beginning in 1997 captured the peaks in sediment transport that could not otherwise be detected by single periodic samples. Synoptic sampling was done during rain events in 1993-1997, and although sampling was biased to focus on the high turbidity and suspended solids concentrations, maximum values are remarkably lower because hydrograph peaks were not captured using this approach.

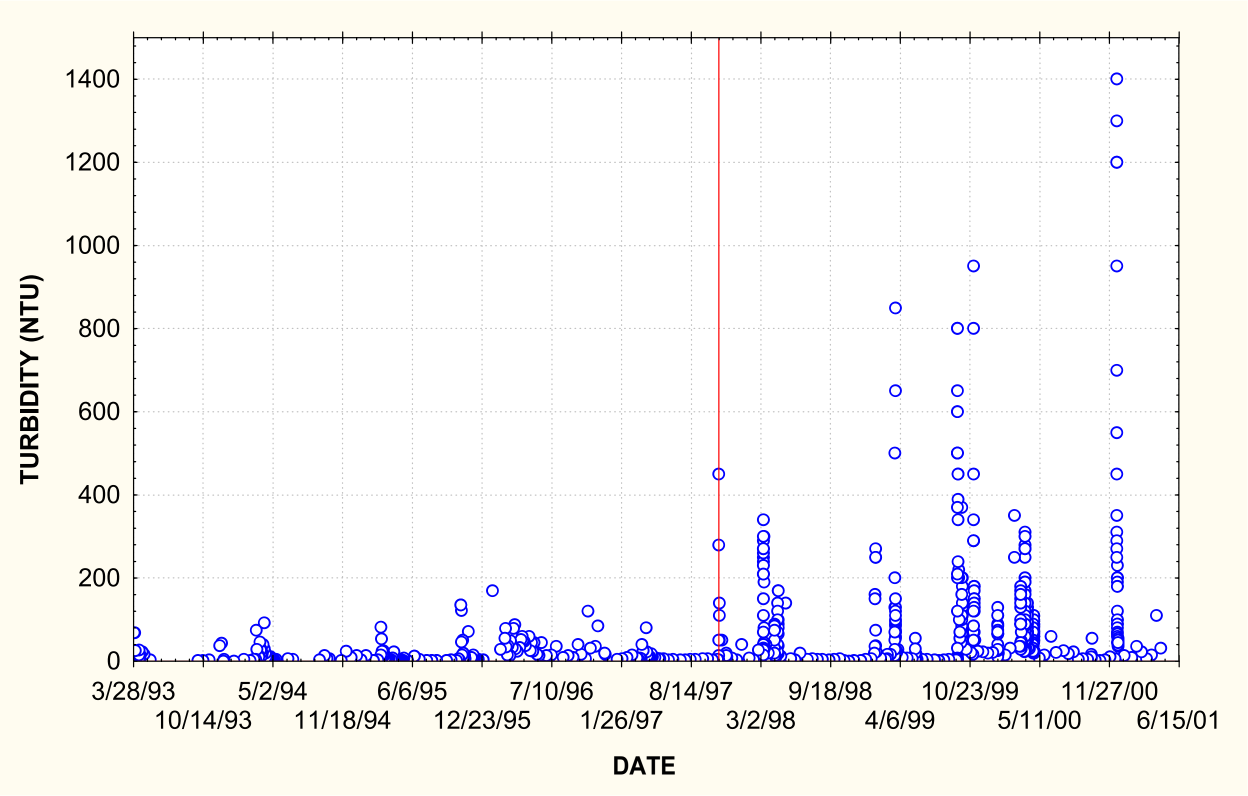


Figure V-3: Historical turbidity data for site S10 (terminal site) on the Batavia Kill.

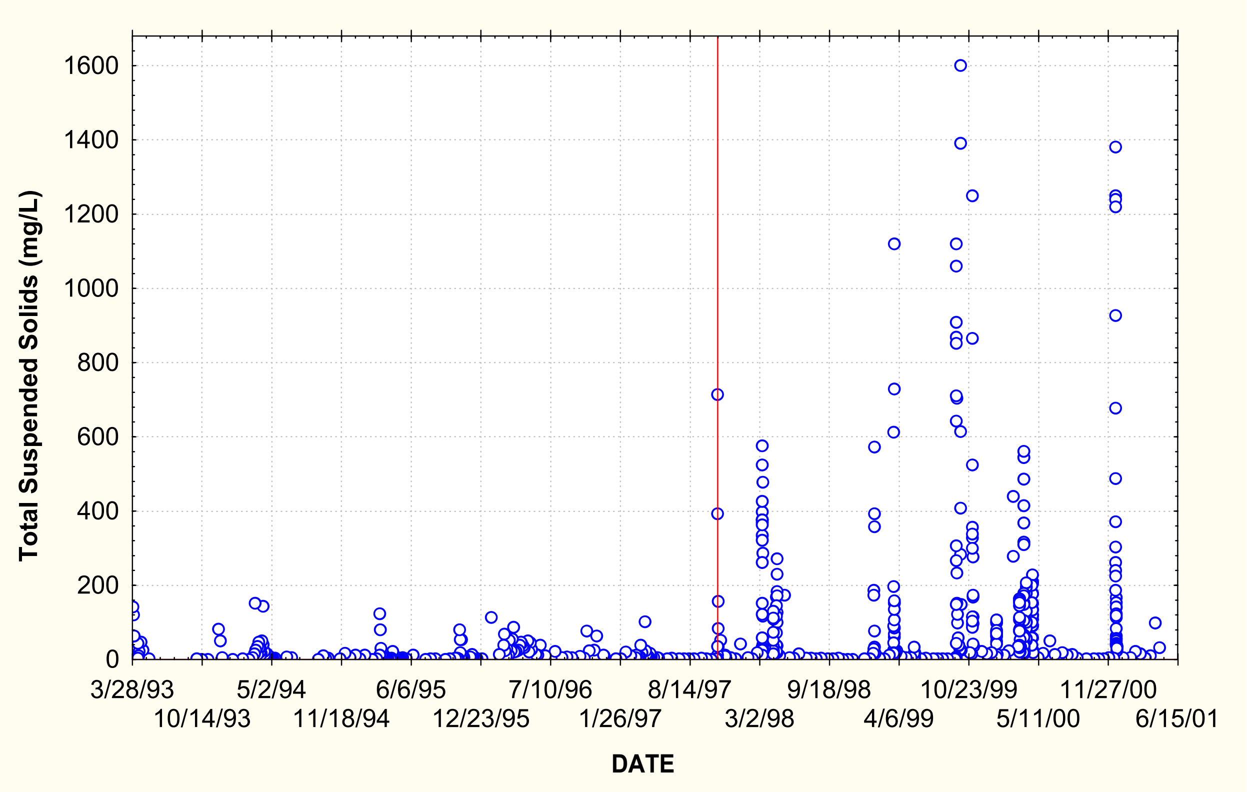
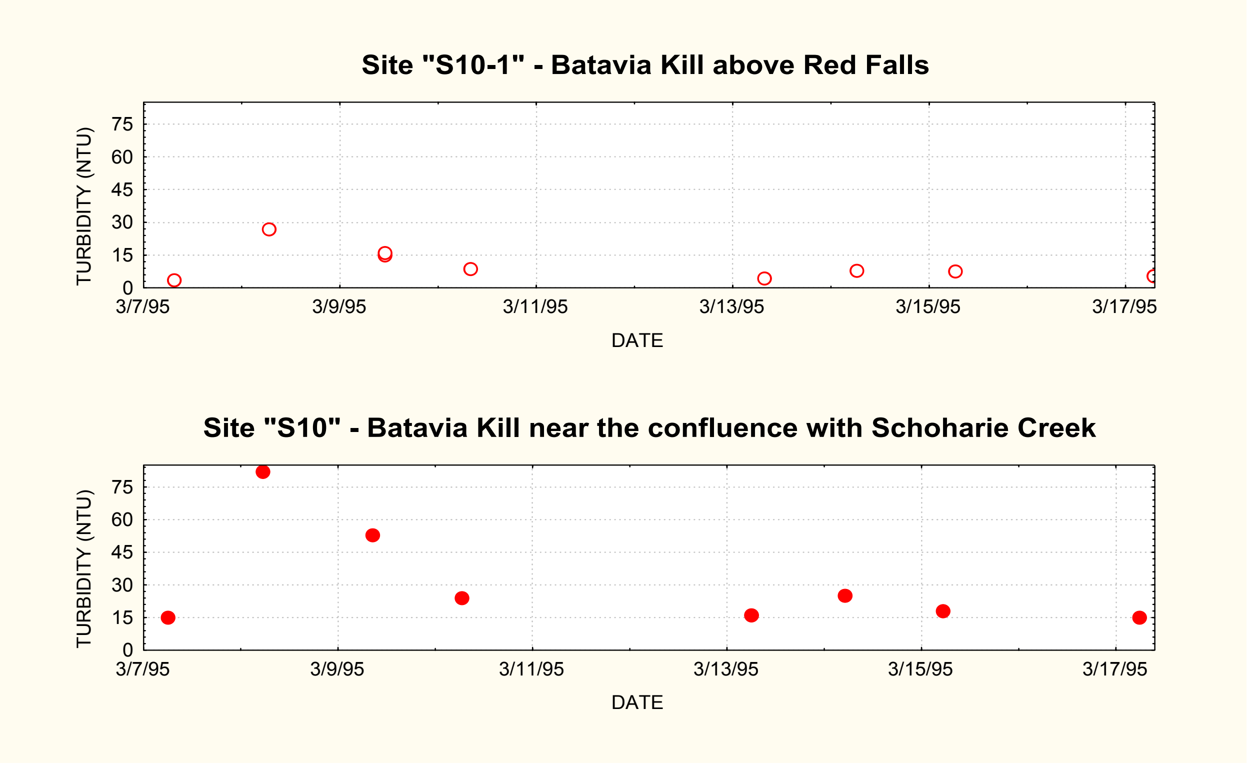


Figure V-4: Historical Total Suspended Solids (TSS) data for site S-10 on the Batavia Kill.

For the Batavia Kill, one storm event was monitored in 1995 (Figures 3a, 3b). No data for stream discharge were summarized for this period, which preceded the installation of a U.S. Geological Survey (USGS) stream gage at Red Falls in 1997. Grab samples were physically collected without the use of autosamplers and additional sampling sites were monitored from the headwaters in Maplecrest to the outflow in Prattsville, both on the mainstem of the Batavia Kill and in selected tributaries, and there was a general pattern of increasing turbidity in downstream sites. This storm had a moderate effect on turbidity (maximum of 82 NTU) and total suspended solids (123.7 mg/L) at Site S10, the farthest downstream site.

In 1996, greater emphasis was given to the tributaries of Esopus Creek, and consequently, storm sampling was not done on the Batavia Kill in that year. Storm event monitoring was expanded to include the Schoharie basin in 1997, with the Batavia Kill as the primary focus for that basin (other sites include S5I, a terminal site on Schoharie Creek in Prattsville above its inflow to the Schoharie Reservoir and S7I, the Bear Kill; a description of these sites is given in NYCDEP 1997).

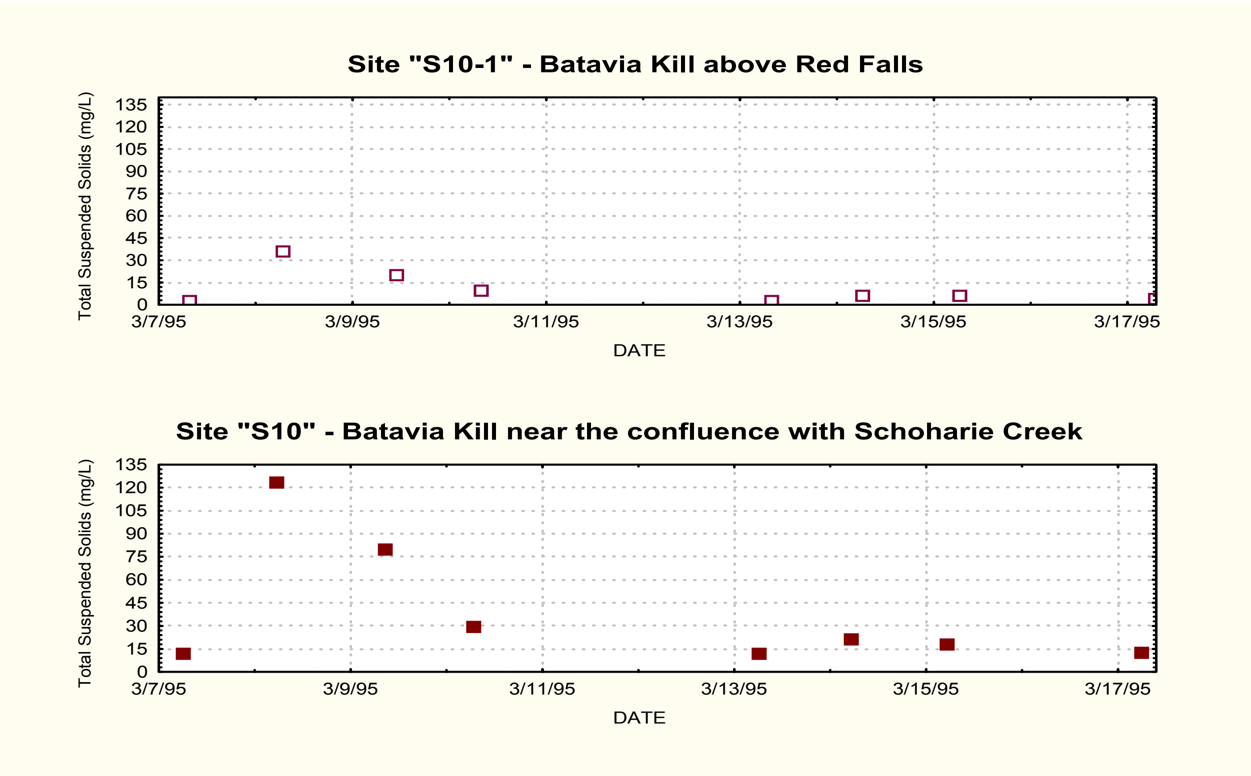
Figure V-5: Conditions with high turbidity and TSS are common on the Batavia Kill as seen in this photo 2 days after Tropical Storm Floyd Sept. 1999


Site "S10-1" - Batavia Kill above Red Falls

Site "S10" - Batavia Kill near the confluence with Schoharie Creek

Figure V-6: Turbidity above and below Red Falls, March 1995.

Storm Water Quality Monitoring Results from 1997 through 2000


Site "S10-1" - Batavia Kill above Red Falls

Site "S10" - Batavia Kill near the confluence with Schoharie Creek

Figure V-7: Total Suspended Solids above and below Red Falls, March 1995.

Data summarized here will focus on the reach of the Batavia Kill above and below Red Falls between the towns of Ashland and Prattsville. Although additional upstream sites were monitored, a total of three sites will be discussed for the purpose of examining the differences in sediment concentration and turbidity levels in the Red Falls reach.

Sites shown in Figure 1 include: S10 (Batavia Kill near the confluence with Schoharie Creek) which has a drainage area of 72.8 mi^2 and where stream discharge measurements are done by NYCDEP; S10-RF (Batavia Kill at Red Falls, corresponding with USGS stream gage #01349950, Batavia Kill at Red Falls near Prattsville NY) which has a drainage area of 68.6 mi^2; and S10-1 (Batavia Kill above Red Falls) which has a drainage area of 68.1 mi^2 and where stream discharge is determined by applying an adjustment to the discharge data reported for the USGS gage at Red Falls.
A single fall runoff event is characterized for 3 sites in 1997 (Figure 4). There is a progressive increase in turbidity from upstream to downstream sites. A similar pattern is seen for turbidity and total suspended solids for other events in subsequent years, and the magnitude of differences is dependent on stream discharge, with greater differences seen at higher flows. Some consideration was given to whether monitoring water quality at the Red Falls site was necessary to detect differences between upstream and downstream sites. Red Falls was monitored in 1997 for this single event and in 1999 for 3 out of 5

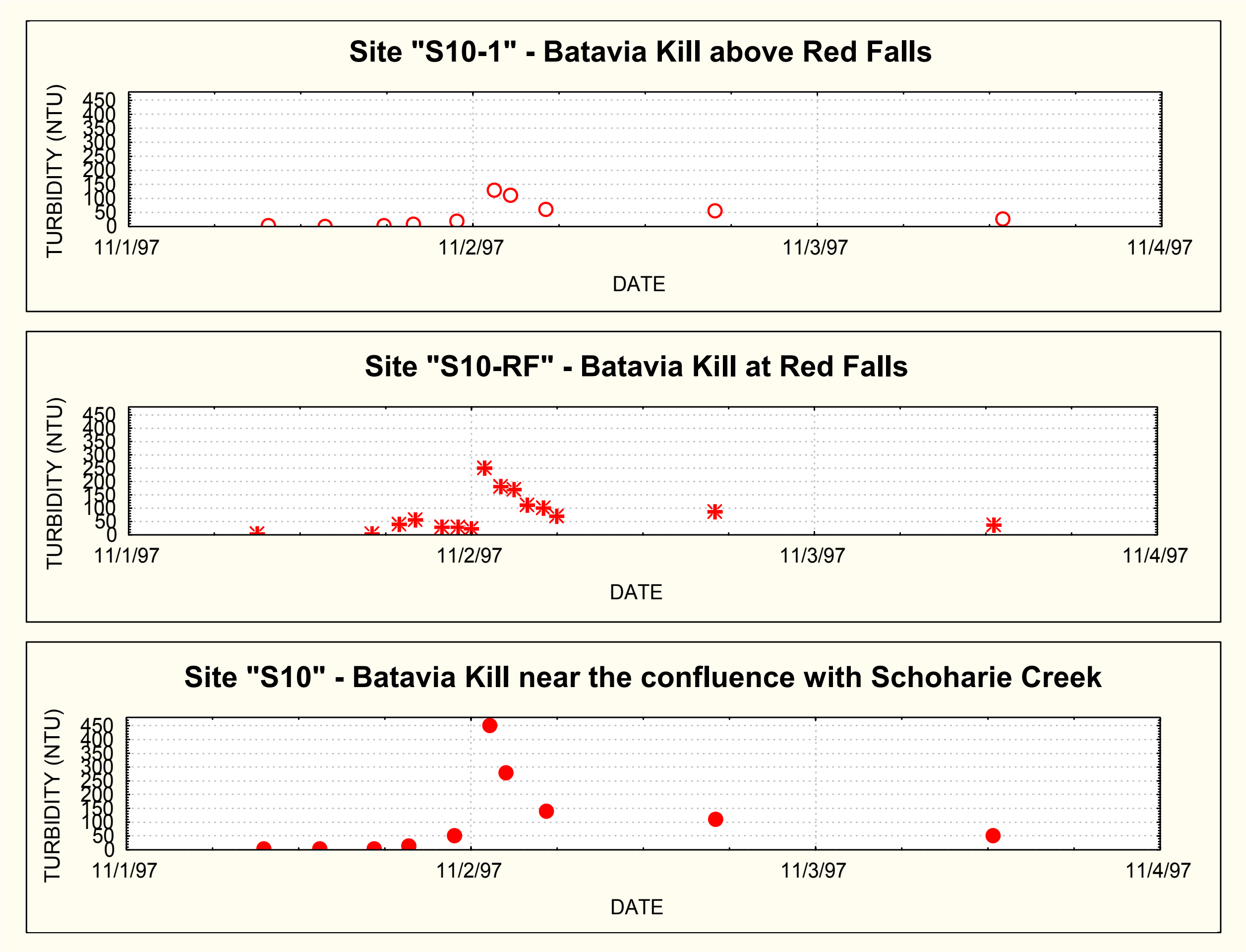


Figure V-8: Turbidity above, at , and below Red Falls November 1997.

monitored events. In most cases, a gradient of turbidity levels and concentration of suspended solids was seen from upstream to downstream sites. Continued monitoring at Red Falls (S10-RF) is planned for 2002 and beyond (NYCDEP 2001).

In 1998, 3 spring runoff events were monitored at 2 sites (S10-1 and S10) in the spring. In 1999, 5 events (1 winter, 2 spring, 2 fall) were monitored at 2-3 sites (S10-1, S10-RF, S10). Hurricane Floyd (September 1999) was a flood of record and discharge at the Red Falls USGS gage was 16,800 cfs (cubic feet per second). Due to equipment problems, water quality samples were not collected during the peak storm flow. In 2000, 6 events (1 winter, 4 spring, and 1 late fall event) were monitored at 2 sites (S10-1 and S10). Two additional examples of storms monitored in 2000 are shown in (Figures 5a, 5b, 6a, 6b). The second example from December 2000 had the highest turbidity (1400 NTU) on record for the site below Red Falls (S10).

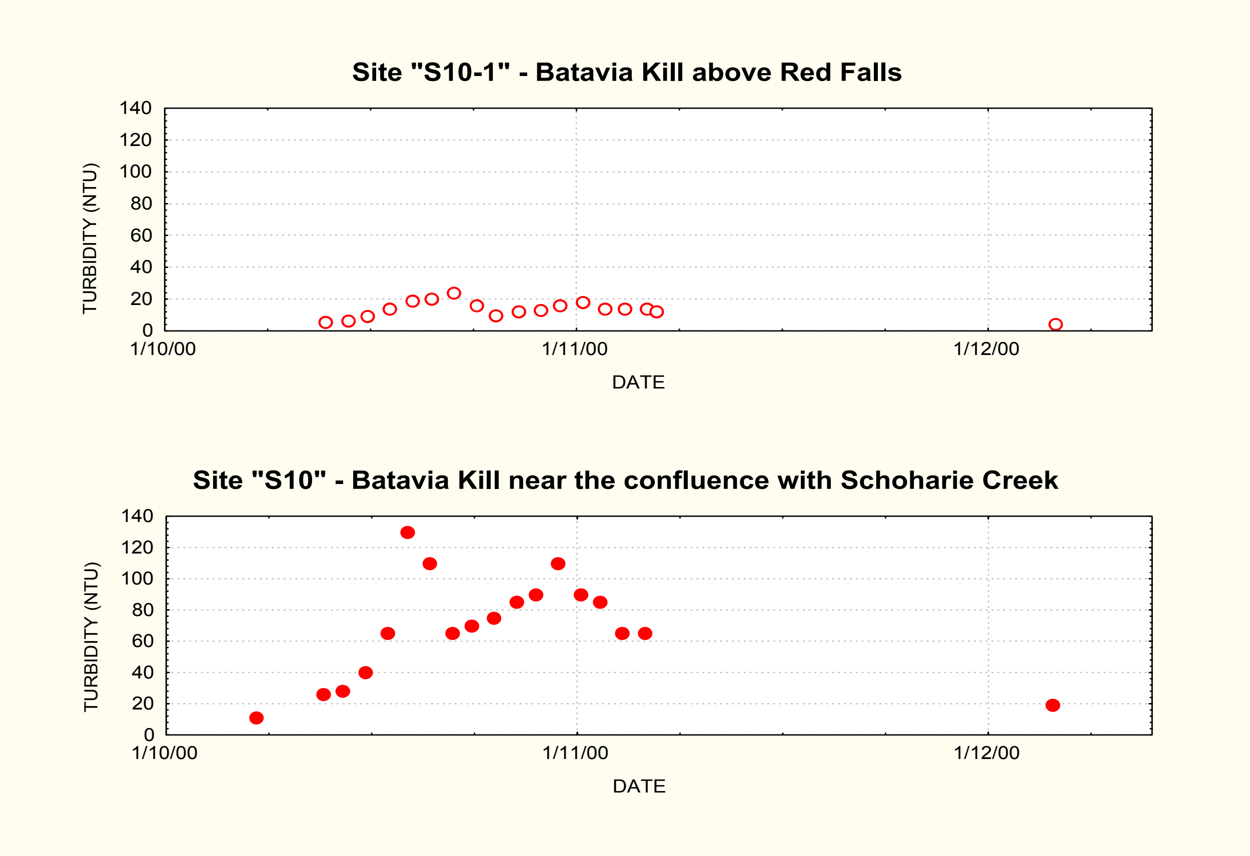


Figure V-9: Turbidity above and below Red Falls, January 2000.

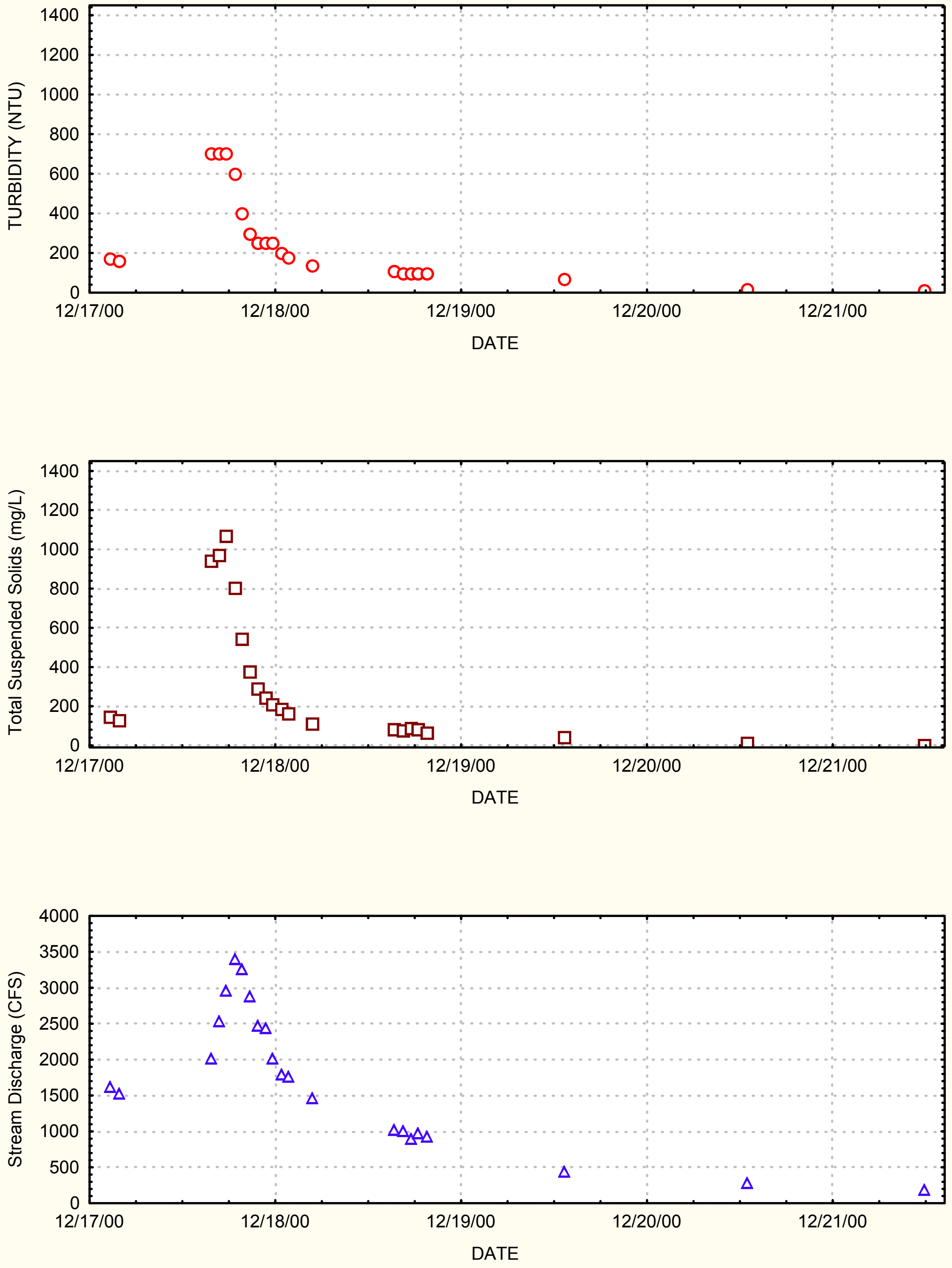


Figure V-10: Turbidity, Total Suspended Solids and Stream Discharge above Red Falls December 2000.

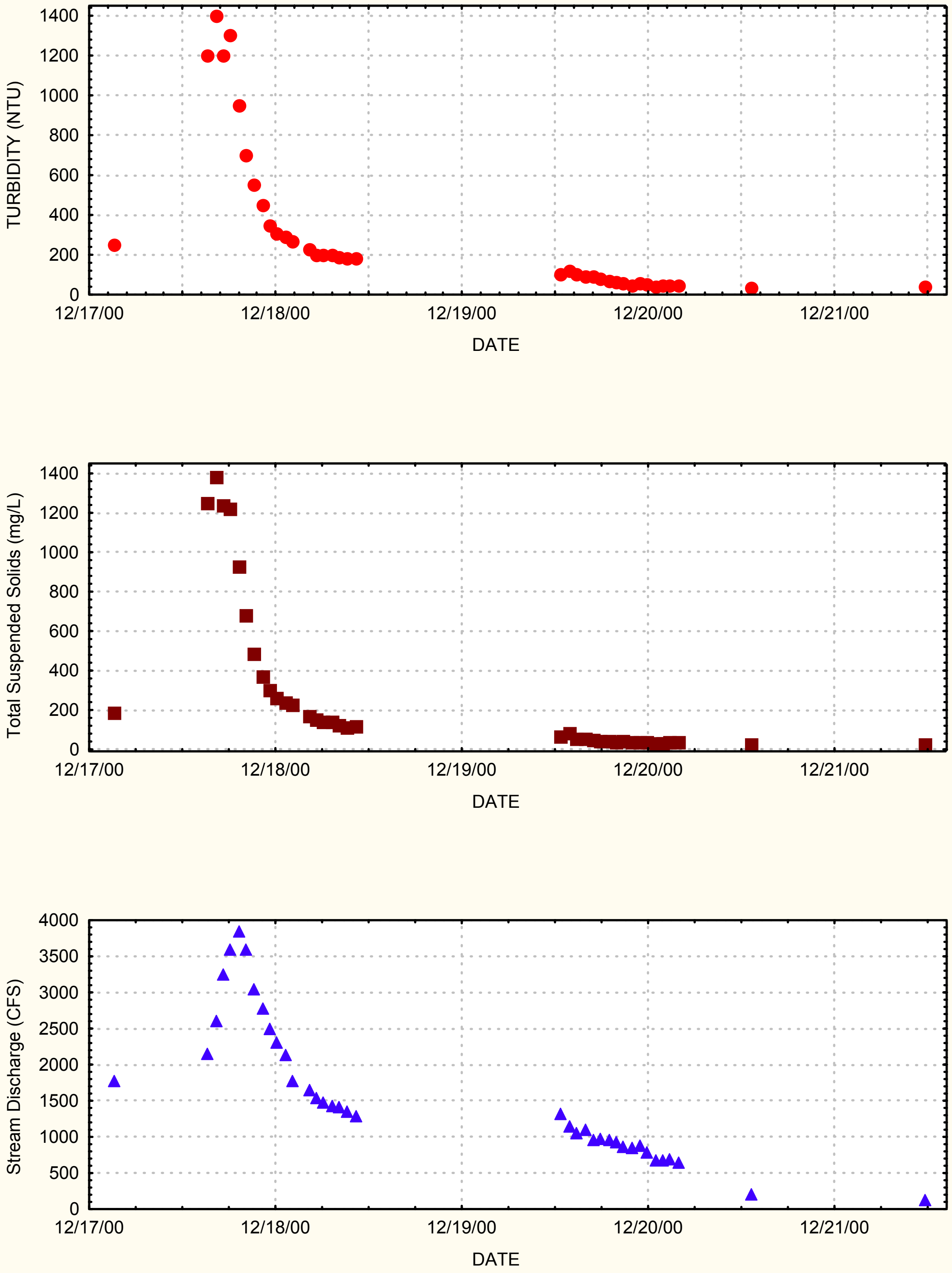


Figure V-11: Turbidity, Total Suspended Solids, and Stream Discharge below Red Falls December 2000.

Examples of storms monitored to date show the extreme variability in the magnitude of rainfall/snowmelt runoff events and the corresponding response of the stream. A review of the available data through 2000 reinforces the importance of measuring multiple events in a year to ensure that sufficient data are collected to make a comparison between before and after BMP implementation. The current NYCDEP water quality monitoring plan (NYCDEP 2001) is expected to provide adequate data to evaluate the water quality benefits of the stream restoration projects in the Red Falls reach of the Batavia Kill.