Streamflow and water quality monitoring on Mt. Mansfield

James Shanley and Jon Denner, U.S. Geological Survey, Montpelier, Vermont

Cooperators:

Tim Scherbatskoy, School of Natural Resources, University of Vermont
Carl Waite, School of Natural Resources, University of Vermont
M.S. students, School of Natural Resources, University of Vermont

Introduction: The Water Resources Division of the U.S. Geological Survey operates a network of stream gaging stations nationwide. This network provides a continuous long-term record of streamflow quantity which is valuable to hydrologic research as well as engineering applications. The Division also has expertise in water quality, and has an ongoing program to monitor the quality of U.S. streams and rivers. This tradition in water quantity and quality measurements has given rise to a more recent interest in watershed biogeochemical cycling; determination of hydrologic and chemical fluxes are important elements of such studies.

The USGS became active in the VMC in 1992. USGS participation helps to meet the need for water quantity and quality information in support of VMC ecosystem research, while at the same time it provides streamflow information in an area of Vermont that is otherwise poorly represented. It also marks one of the few high-elevation stream-gaging sites in the state.

On November 6, 1992, a reconnaissance sampling effort was made in the Browns River (6.1 sq. km) and Stevensville Brook (5.2 sq. km) watersheds, to collect preliminary data for the siting of the monitoring stations. Measurements of temperature, pH, and specific conductance were made. As a follow-up, 3 low-elevation sites (Browns River and two branches of Stevensville Brook) were sampled for full major ion analysis on November 13, 1992.

In general, waters draining the west slope of Mt. Mansfield are poorly buffered. Headwater streams at high elevation, in particular, are quite acidic (pH<5.0). This is attributed to the relatively unreactive quartz-mica-albite schist bedrock, limited thickness of overburden (glacial till), and limited soil development. Buffering increases as stream size increases. The extent of buffering is greater at Browns River than at Stevensville Brook. Low elevation areas are at pH 5.5 to 6.5, compared to near 7.0 at Browns River. It appears that significant neutralization in the Browns River watershed occurs in the lowest 20% of the basin. The lower alkalinities at Stevensville result from slightly higher sulfate and lower base cation concentrations relative to Browns River.

The low dissolved load of these streams implies a tight nutrient economy in the forested watersheds that they drain. Weathering rates are slow, and forest productivity may be limited by nutrient availability. The acidic character and elevated aluminum concentrations of these streams suggests a possible negative impact on aquatic fauna and forest health.

Nettle Brook, a small tributary to the North Branch of Stevensville Brook, was chosen as the initial site for a stream gaging station. The reconnaissance survey revealed this stream to be less acidic than other headwater streams at Mt. Mansfield, perhaps an indication of greater groundwater inputs. We felt that choosing this basin would provide the opportunity to study neutralization processes, because more acidic conditions probably prevail in the stream in its higher reaches. Also, the stream may be subject to episodic acidification during higher flows such as the spring snowmelt period. One advantage of the site is that other studies already are underway within the Nettle Brook basin for which hydrologic and chemical load information would be useful. A second benefit is that the findings at Nettle Brook will be directly interpreted and compared to ongoing biogeochemical and hydrologic research by the authors in streams of similar size and elevation (albeit very different geology) at Sleepers River near Danville, Vermont.

Objectives: The objectives of the project are to:
1) calculate an annual water budget, and thereby estimate evapotranspiration,
2) analyze individual storm events, i.e., the timing and quantity of runoff relative to precipitation inputs, to form a conceptual model of the hydrologic functioning of the watershed,
3) use chemistry and hydrology together to identify biogeochemical pathways,
4) quantify fluxes of major solutes in streamflow,
5) assess the degree of "nitrogen saturation" in the forest,
6) evaluate the susceptibility of the stream to acidification from atmospheric deposition and the threat of aluminum toxicity to fish, and
7) generalize findings to the Stevensville Brook and Browns River watersheds, based on reconnaissance work and scale considerations.

Methods: A site was chosen for weir construction on Nettle Brook, near its confluence with the north branch of Stevensville Brook. The weir was constructed in late September 1993 so that stream discharge measurements could begin in time for the start of the hydrologic water year on October 1.

A 90° V-notch weir was constructed of plywood with a plexiglass insert for the notch. Stage is logged electronically at 5-minute intervals with a potentiometer driven by a float in a stilling well adjacent to the weir. The datalogger and data storage module are housed in a small structure mounted on top of the well.

Solute budgets for the gaged watershed will be determined using data from the NADP (wet deposition) and NDDN (dry deposition) stations at Proctor Forest (inputs) and streamflow and stream chemistry data (outputs). Hydrologic and chemical data from the monitoring stations will establish a baseline for assessing the effects of global change, and will complement VMC ecosystem research projects on Mt. Mansfield.

At least 30 samples annually will be collected at each site, including monthly and selected high-flow samples. Samples will be analyzed for nutrients, major inorganic solutes, silica, aluminum, and dissolved organic carbon.

Results: The weir and stage recording equipment have been functioning well. The initial 3 months of flow data (October, November, and December 1993) have been error-checked and corrected. Corrections included minor adjustments for backwater from leaf and other tree debris (a typical autumn problem) and from ice. There were no discrepancies between observed and recorded stage during site visits, thus no additional adjustments to the record were necessary. The hydrograph for the first three months is given in fig. 1.

October was a wet month. Several storms with rainfall > 2 cm occurred. The stream showed the characteristic "flashy" response of a steep mountain catchment. This response is typified by the storm of October 16-17 (fig. 2). In that storm, 14.6 mm rain fell in 27 hours. The rain fell in several bursts of moderate intensity. In each case, the stream responded within 2 hours after the onset of rain, and the hydrograph peaked within 2 hours of peak rain intensity. If no additional rain occurs, the stream returns to base flow in 2-3 days (fig. 1).

November was relatively dry, although it had the three highest daily flows for the quarter. The high flows for November 5 and 6 resulted from rain on snow following a significant snowfall on November 2. The high flow at the end of November was caused by rain. December precipitation was primarily stored in the form of snow, thus stream discharge receded to winter baseflow conditions.

Stream samples were collected approximately monthly during the period but no analyses are available as yet.

Future plans: The stream gage on Nettle Brook is intended for long-term recording. Flow measurements in 1994 will be augmented by several additional measurements at the site, including air, water, and soil temperature at 5, 15, and 30 cm depth. During the winter period, snow depth and reflected shortwave radiation also will be measured and logged electronically. Stream sampling will be intensified to daily or twice daily during the main spring melt. Some samples of snow core and snowmelt water (from snowmelt lysimeters) also will be collected for analysis. A

minimum of monthly stream sampling will continue throughout the year; selected rain storms will be sampled intensively.

All samples will be analyzed for major cations and anions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, NO_3^{-}, SO_4^{2-}, Cl^{-}, alkalinity), Al, Si, DOC, and NH_4^{+}.During the summer, the spring runoff samples will be analyzed, and initial interpretations of the processes controlling stream flow and stream chemistry will be made. Dennis Daly, a M.S. candidate at UVM School of Natural Resources, will contribute to this interpretation in his directed study of nitrate export. Water and solute budgets for Water Year 1994 will be made after the water year ends in September.

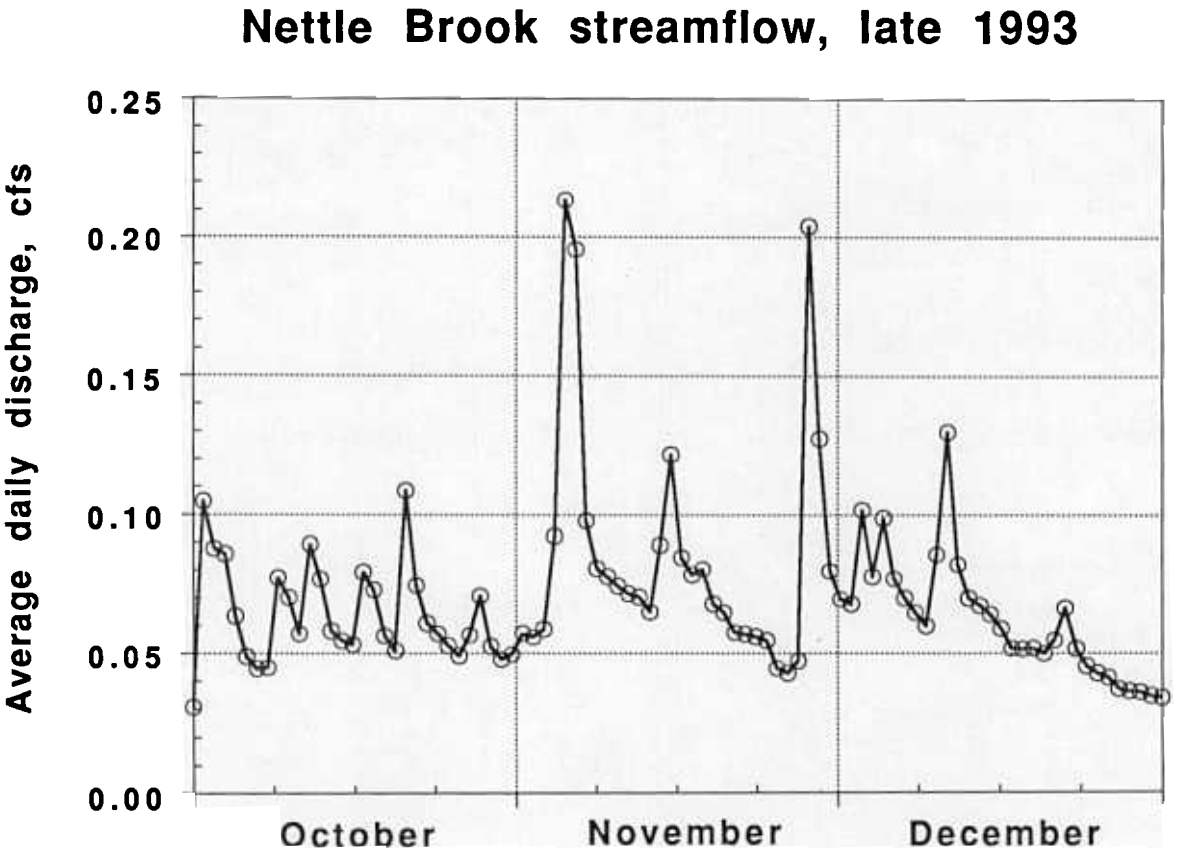

Figure 1. Daily average streamflow at Nettle Brook, October - December, 1993

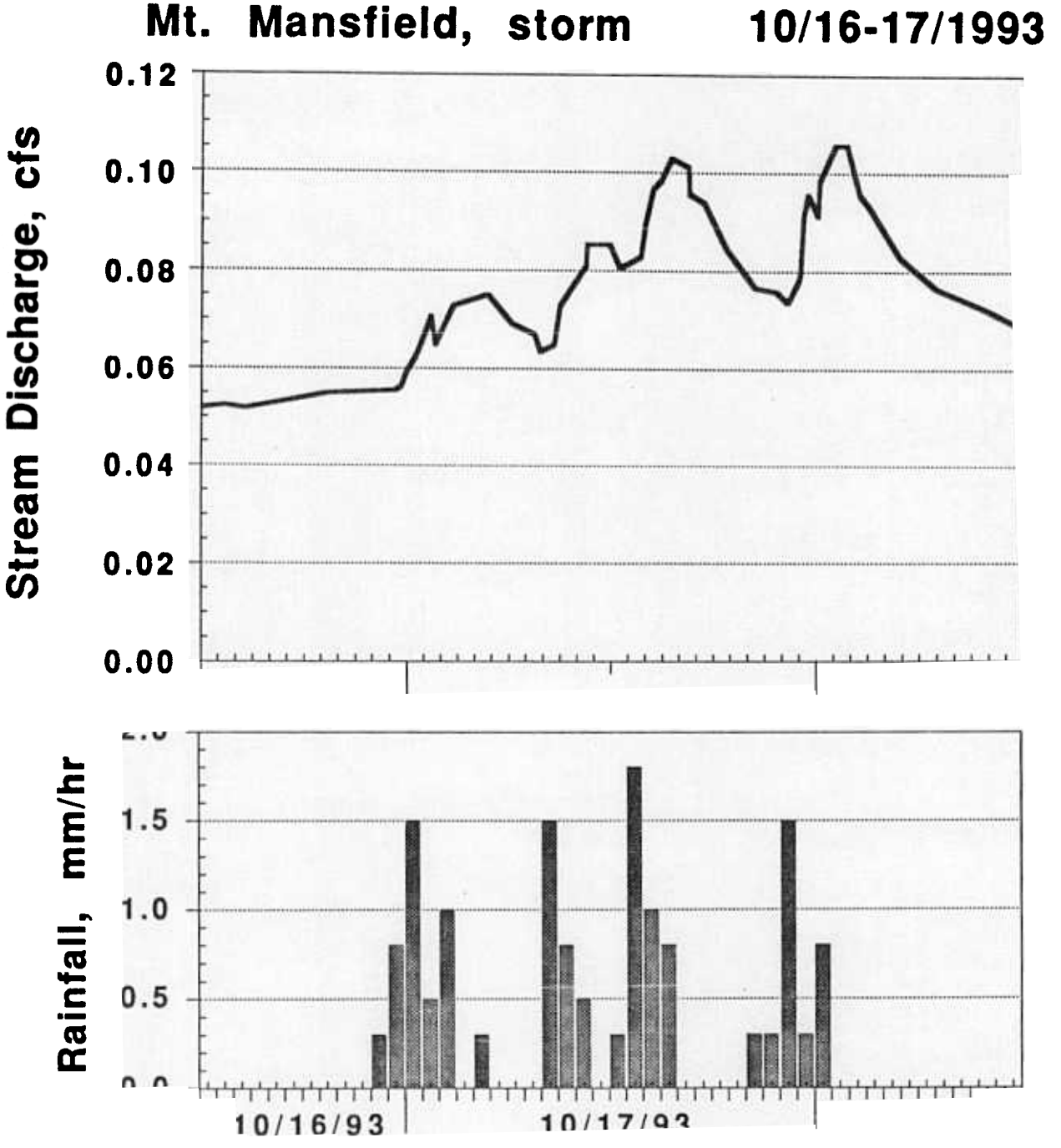

Figure 2. Response of Nettle Brook to rain storm of October 1993