A STUDY OF THE EFFECTS OF A RAIN STORM UPON THE MAJOR CHEMICAL CONSTITUENTS OF THE PECONIC RIVER, LONG ISLAND, NEW YORK

John P. Choynowski* and Martin A.A. Schoonen
Earth and Space Sciences Department,
State University of New York at Stony Brook,
Stony Brook, NY 11794-2100.

This study shows the contrast in response to a rain storm between the heavily forested upper stretches of the Peconic River and the lower stretch of the river near the town of Riverhead. At Schultz Road near the headwaters of the river an increase in the concentration of the major constituents is observed, whereas near Riverhead a decrease is observed. Although it is difficult to establish what causes the increase in the major constituents near the headwaters, it is most likely due to a combination of throughfall and groundwater mixing with riverwater. The dilution observed at the Riverhead Gauge is caused by the mixing of rain with the river and a second source of water more dilute than the riverwater before the storm. This second source is most likely displaced groundwater.

INTRODUCTION

The Peconic River is an east-west trending river with an approximate length of 15 miles (NYDEC, 1985), located in the largely undeveloped core of the central Pine Barrens of eastern Suffolk County, Long Island, New York. The headwaters of the Peconic River are poorly defined. Much of the water in the upper stretches of the river is derived from wetlands west of William Floyd Parkway and a series of north-south trending ponds east of Schultz Road (Englebright, 1992). However, toward the east, the Peconic River becomes a gaining stream (Warren et al., 1968). Hence, the river receives much of its water from ground water seeping into the stream channel. The flow of the river is controlled by eight dams (NYDEC, 1985). In the lower streches of the river, the dams transform the river from a narrow stream into a broad, shallow, slow moving river. A dam in the town of Riverhead prevents seawater from entering the lower stretches of the river.

The objective of this study is to determine the effect a storm event has on the concentration of major constituents in river water. This is of importance in understanding the hydrological behavior of the watershed. During and/or following a storm event in a watershed, a temporary increase in streamflow, i.e., stormflow, is observed. The stormflow may be derived from (1) direct precipitation into the stream channel, (2) run off, (3) flow through the vadoze zone (interflow), and (4) displaced groundwater (Fetter, 1994; Dunne and Black, 1970). By determining the composition of waters that may contribute to the stormflow as well as the chemical composition of the river itself it is possible to constrain the relative importance of each type of contributing water.

METHODS

To achieve our objective, we monitored the chemical composition of the Peconic River before, during and following a rain storm. In addition, wet and dry precipitation sample was collected at Brookhaven National Laboratory. Two monitoring sites were chosen. The first site is where Schultz Road crosses the river, near the headwaters of the river. The second site is the USGS Riverhead Gauge, about 0.5 miles upstream from the town of Riverhead. There are some important differences between these sites besides the fact that the Schultz Road site is in the upper stretches of the river, while the Riverhead Gauge is near the mouth of the river. The Schultz Road site is heavily vegetated with red maples, which are

* Present address: 960 Calvert Road, Rising Sun, MD 21911.

common along the banks of the Peconic River (Richard,1992). In contrast, the Riverhead Gauge site is characterized by a significant widening of the Peconic River to the extent that only an insignificant portion of the river is covered by foliage. The wide open area of the Peconic, also referred to as Peconic Lake, constitutes an area of approximately 0.06 square miles. The land use around Peconic Lake is mostly for residential housing.

At both sites streamwater samples were collected before, during, and for 5 days after tropical storm Danielle passed through the region on September 26, 1992. In addition, samples were taken from a shallow observation well near the Peconic River at Schultz Road. This well, made of PVC pipe with a 2.5 inch diameter, is located approximately 15 feet south of the river, and is 2.5 feet deep. The baseline sample was collected approximately 17 hours preceding the beginning of the storm, and three days after the previous most recent rain event (9/22/92). Samples were collected at each location twice on the day of the storm; one sample in the morning and a second sample in the late afternoon or evening. After the first day, the sampling frequency was just one sample per day. The last sample was taken six days after the storm. No rain precipitated on those days except for 0.03 inches that fell on 9/27/92.

Temperature, pH, Eh, and conductivity were measured *in situ*. All samples were titrated for alkalinity, and filtered within 48 hours using 0.45 µm membrane filters. A Dionex 2000i Ion Chromatograph (IC) was used to determine Chloride (Cl), Sulfate (SO_4), and Nitrate (NO_3) concentrations. A Spectraspan SSVB direct-current argon plasma emission spectrometer (DCP-AES) was used to used to determine Sodium (Na), Potassium (K), Calcium (Ca), Magnesium (Mg), and Iron (Fe) concentrations.

The rate of precipitation and total amount of precipitation was recorded at Brookhaven National Laboratory. In addition, our collegue Craig Brown collected a wet and dry precipitation sample at Brookhaven National Laboratory for this study. We also obtained the total amount of precipitation recorded at Riverhead. Hourly discharge rates and stage height data for the Riverhead gauge were provided by the USGS-Water Resources Division in Syosset.

RESULTS

Tropical storm Danielle approached Long Island from the south. Precipitation began at 2:45 A.M. on 9/26/92 and ended at 1:15 P.M. on the same day. BNL recorded a total amount of precipitation of 0.60 inches, while the Riverhead Resources Farm recorded 0.69 inches of precipitation. This difference in amounts of precipitation occurred because the storm trended towards Riverhead and therefore, it may have rained there for a longer period of time. Tables 1 and 2 list the concentration for the ions and ion balances respectively for wet and dry precipitation. The wet precipitation was collected on 9/27/92. The pH of the rain was 4.59. The ion balance percentage of the wet precipitation is -11.3% (see table 1). The surplus of anions may be due to an incorrect, high pH reading, or the presence of significant amounts of NH_4^+. An inaccurate pH reading could be significant because unlike the riverwater samples the H+ ion plays a large role in determining the amount of cations in rainwater. For example, a pH of only 0.2 less would practically place the ion balance within 5.0% of being balanced. NH_4+ was not analyzed for, but it may be important. Between 1979 and 1987, the yearly average NH_4+ concentration in precipitation at BNL ranged from 7 to 18 *u*M (Dana and Barchet, 1989).

Table 1: Ionic Concentrations of Wet and Dry Precipitation in (*u*M).

	HCO_3	SO_4	NO_3	Cl	NA	Ca	Mg	K	Fe
Wet	37.1	16.1	0.40	105.7	81.3	3.4	10.0	5.5	0.3
Dry	0	28.0	25.2	106.7	96.4	17.8	16.0	21.1	0.4

Table 2: Ionic Charge Balance of Wet and Dry Precipitation Samples

Precipitation	Sum. Cations	Sum. Anions	Ion Balance %
Wet	139.8	175.4	-11.30
Dry	185.9	187.9	-0.54

There is significant lag between the rise in the gauge height and the peak of the precipitation. As seen in Fig. 1, the increase in gauge height is reached after precipitation ceased. The streamflow remains elevated for almost 30 hours after the end of the storm.

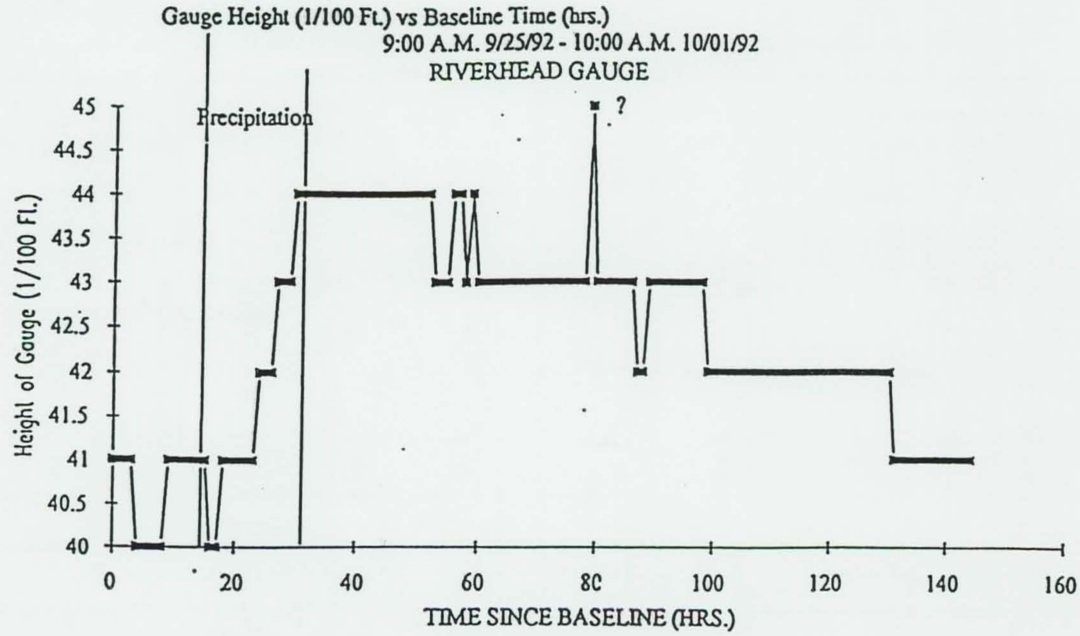

Figure 1: The increase in gauge height at Riverhead due to precipitation from tropical storm Danielle is plotted against baseline time. Note that most of the precipitation occurred between hours 20 and 25 (see, Choynowski, 1992). Discharge rates are given in Choynowski (1992).

While tropical storm Danielle had a significant effect on the streamflow of the river, it had only a minor effect on the concentrations of the major constituents in the water. However, interestingly, the two monitoring sites responded differently. As shown in Fig. 2 and 3, dilution is observed to take place simultaneously for the Na, Cl, Ca, Mg, and K ions at the Riverhead Gauge. Sulfate shows an overall dilution, although the sample collected during the storm shows a slight increase. The dilution of these ions coincides with the rain event as these samples were collected during the middle of the storm and at the end of the storm. In contrast to Riverhead, the data for the Peconic River at Schultz Road show an increase in concentration for SO_4, Cl, Na, K, and Mg within three hours after the precipitation ceased (see Fig. 4 and 5). Although determined, changes in HCO_3^- concentrations were not evaluated because these are dependent upon pH and not conservative. Also NO_3, Fe, and K were analyzed but not used in evaluating the sources of water, because there was considerable uncertainty in these data. Among the three parameters measured in the field, pH, Eh, and conductivity, only the Eh shows a significant change. This is shown in Figure 6.

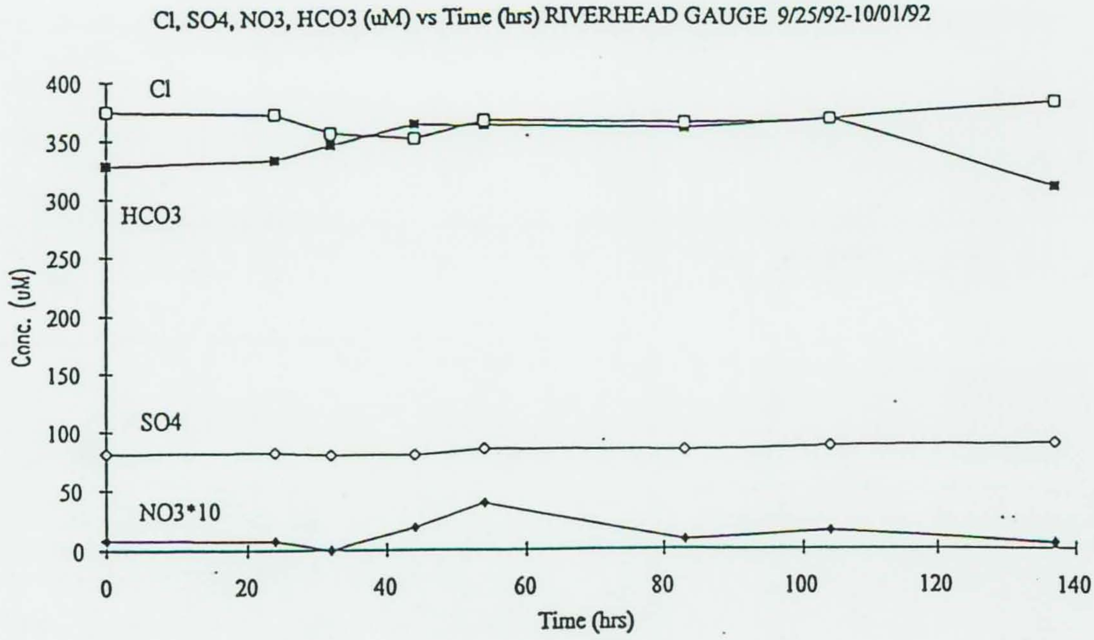

Figure 2: Riverhead Gauge anions vs Time: The concentrations in the anions are plotted against the time the samples were drawn since baseline, at Riverhead.

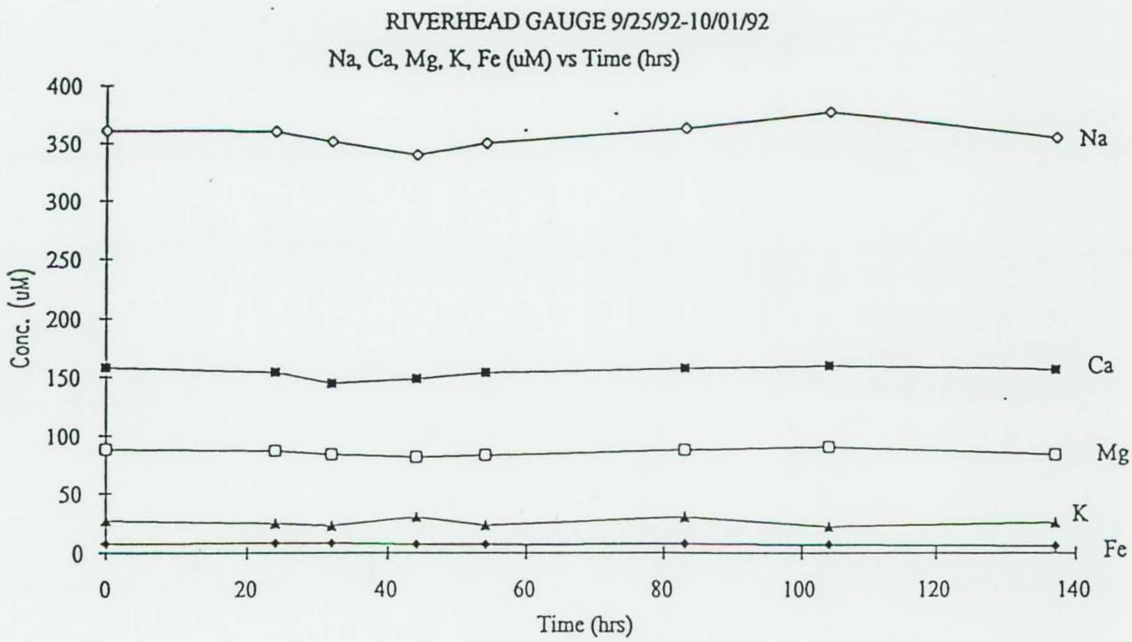

Figure 3: Riverhead Gauge cations vs Time: The concentrations in the cations are plotted against the time the samples were drawn since baseline, at Riverhead.

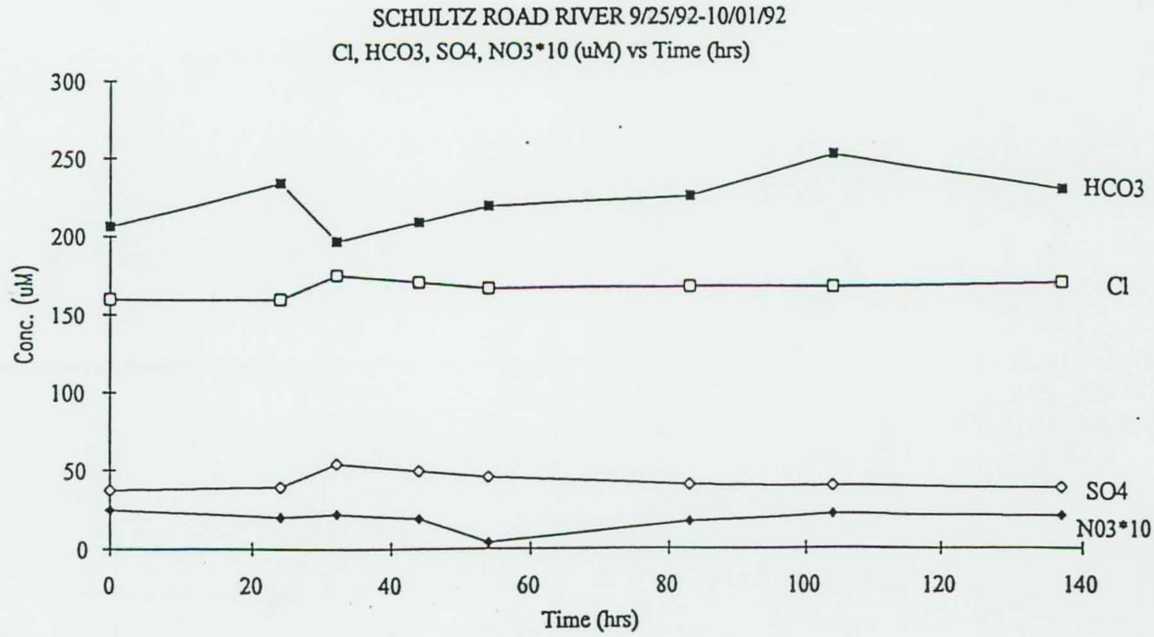

Figure 4: Schultz Road River anions vs Time: The concentrations in the anions are plotted against the time the samples were drawn since baseline, at Schultz Road.

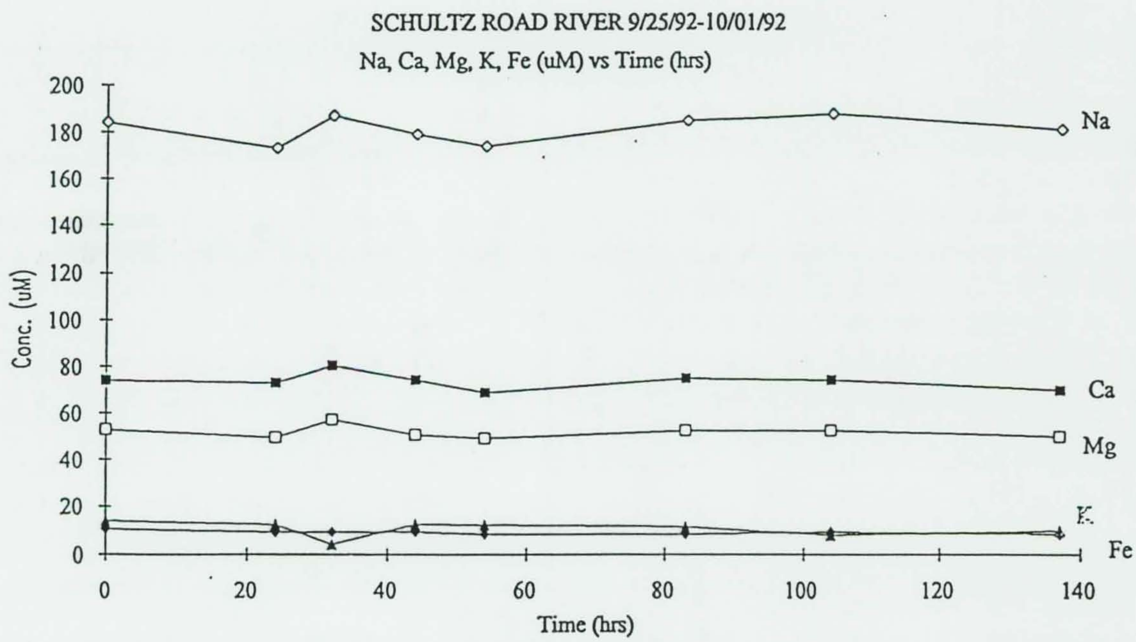

Figure 5: Schultz Road River cations vs Time: The concentrations in the cations are plotted against the time the samples were drawn since baseline, at Schultz Road.

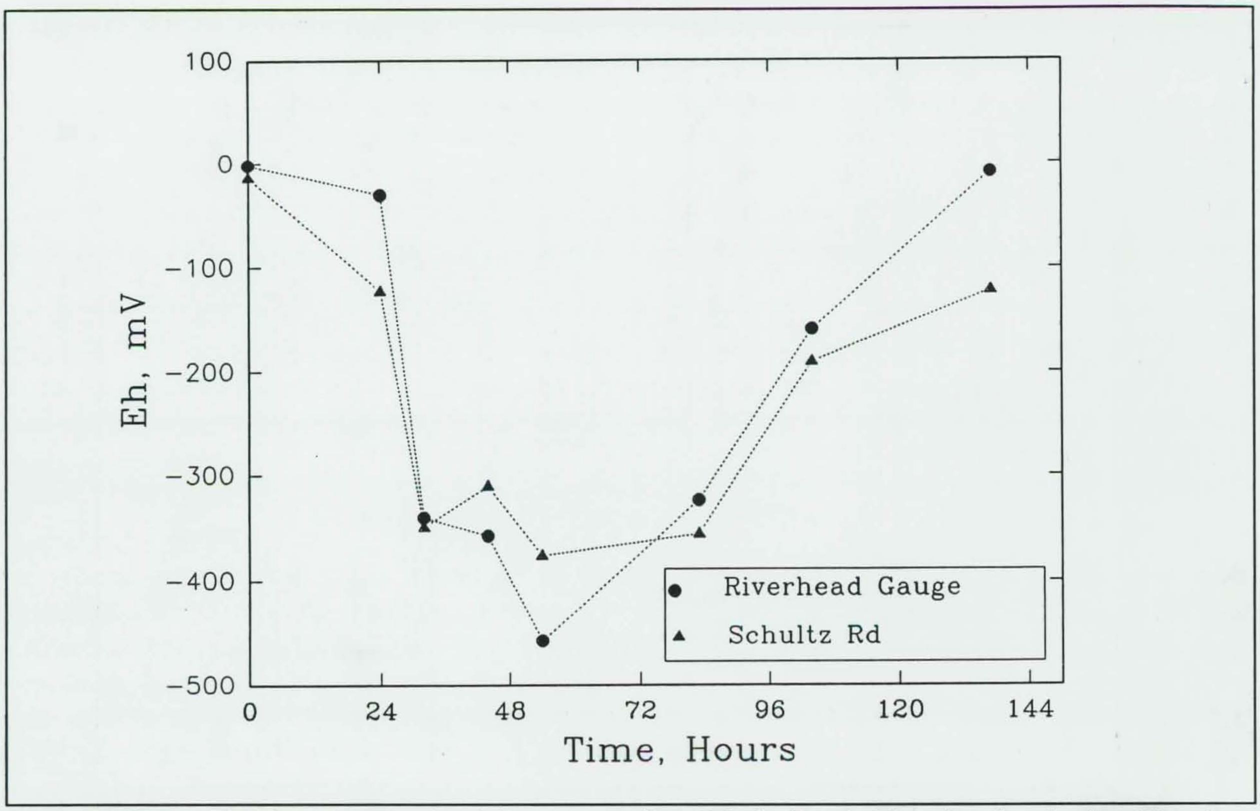

Figure 6. Changes in Eh at the Riverhead Gauge as well as Schultz Road. Note that the absolute Eh values are typically meaningless, but it is clear that there is a significant drop in the Eh of the water.

DISCUSSION

The dilution of the Peconic River at Riverhead indicates that the river receives a significant amount of more dilute water. The three obvious sources are rain, run off, and interflow. Based on a mass balance calculation, dilution by direct precipitation can be ruled out as a significant source (Choynowski, 1992). The second source, run off, is probably not very important because the gauge height lags the peak of the preciptation by almost a half day (Dunne and Black, 1970). In addition, a mass balance calculation shows that run off originating from the area immediately along Peconic Lake would account for no more than a 0.8% dilution (Choynowski, 1992). The contribution of interflow is more difficult to evaluate. Water flowing through the vadose zone will be retarded with respect to over land flow (Dunne and Black, 1970). Hence, this would be consistent with the lag time observed in the gauge height (Beven et al., 1982). However, interflow requires the presence of a less permeable layer above the watertable. There is no evidence for an extensive less permeable layer at this site and with the groundwater table at depths less than 10 ft it is more likely that the bulk of the infiltrating water reaches the watertable. In addition, a significant contribution of water via interflow is inconsistent with the observed rapid drop in Eh. Interflow water is expected to be oxic, i.e., high Eh. Hence, a significant amount of more reduced water, i.e., low Eh, must be entering the river. The only obvious source of reduced water is groundwater. Because Eh is not a conservative parameter, it is not possible to constrain the amount of ground water that may be entering the river based on changes in Eh. However, river water is generally more concentrated in dissolved solids than shallow groundwater due to evapotranspiration (Berner et al., 1987). Therefore, the observed dilution could be due to mixing of river water with shallow ground water. The increased discharge of groundwater into the river is caused by an increase in the water table and a steepening of the hydraulic gradient toward the stream. The steeper hydraulic gradient forces more ground water into the river than under normal baseflow conditions (Fetter, 1994). Essentially, what the chemical data indicate is that the infiltration of rainwater appears to displace groundwater.

In contrast to the dilution at Riverhead, an increase in the concentration of major constituents is observed at Schultz Road. Hence, more concentrated water must be mixing with the river water at Schultz Road (see Fig. 4 and 5. Again a significant drop in Eh is observed which indicates the discharge of reduced ground water into the river. However, our well data show that the ground water at Schultz Road is less concentrated than the river water (Choynowski, 1992). Hence, simple mixing of the ground water and river water would result in a dilution. One source of water that is possibly more concentrated than the riverwater is throughfall, i.e., rain that has passed through the canopy (Berner et al., 1987). Trees are very effective collectors of aerosols, such as seasalt aerosols (see Table 1), which will be washed off when it rains. At Schultz Road the entire stream channel is below a canopy of red maples. Therefore, it is possible that the minor increase in major constituent concentration is due to throughfall. Unfortunately, without an analysis of the throughfall it is impossible to constrain the relative importance of this source of water.

CONCLUSIONS

The results of this study indicate that a typical rain storm will have only a minor effect on the major constituent chemistry of the Peconic River. The stormflow is mainly due to groundwater entering the stream channel. Direct precipitation in the stream channel, interflow and run off are additional, but minor sources. A subtle difference is seen in the response of the major constituent chemistry between the upper stretches and the lower streches of the river. In the upper streches, a minor increase in concentrations is seen which may be due to throughfall entering the river besides groundwater. In the lower stretches, a slight dilution is observed which may be due to mixing of groundwater and riverwater.

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