



## Hydrologic Benchmark Network Stations in the Eastern U.S. 1963-95 (USGS Circular 1173-A)

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# Tallulah River near Clayton, Georgia (Station 02178400)

*This report details one of the approximately 50 stations in the Hydrologic Benchmark Network (HBN) described in the four-volume U.S. Geological Survey Circular 1173. The suggested citation for the information on this page is:*

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*All of the tables and figures are numbered as they appear in each circular. Use the navigation bar above to view the abstract, introduction and methods for the entire circular, as well as a map and list of all of the HBN sites. Use the table of contents below to view the information on this particular station.*

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## Site Characteristics and Land Use

The Tallulah River HBN Basin is in the Blue Ridge physiographic province in the northeast corner of Georgia ([Figure 10](#). *Map of the study area in the Tallulah River Basin and photograph of the basin landscape near Tate City, Georgia*). The basin drains 146 km<sup>2</sup> of steep, mountainous terrain that ranges in elevation from 573 m at the gage to

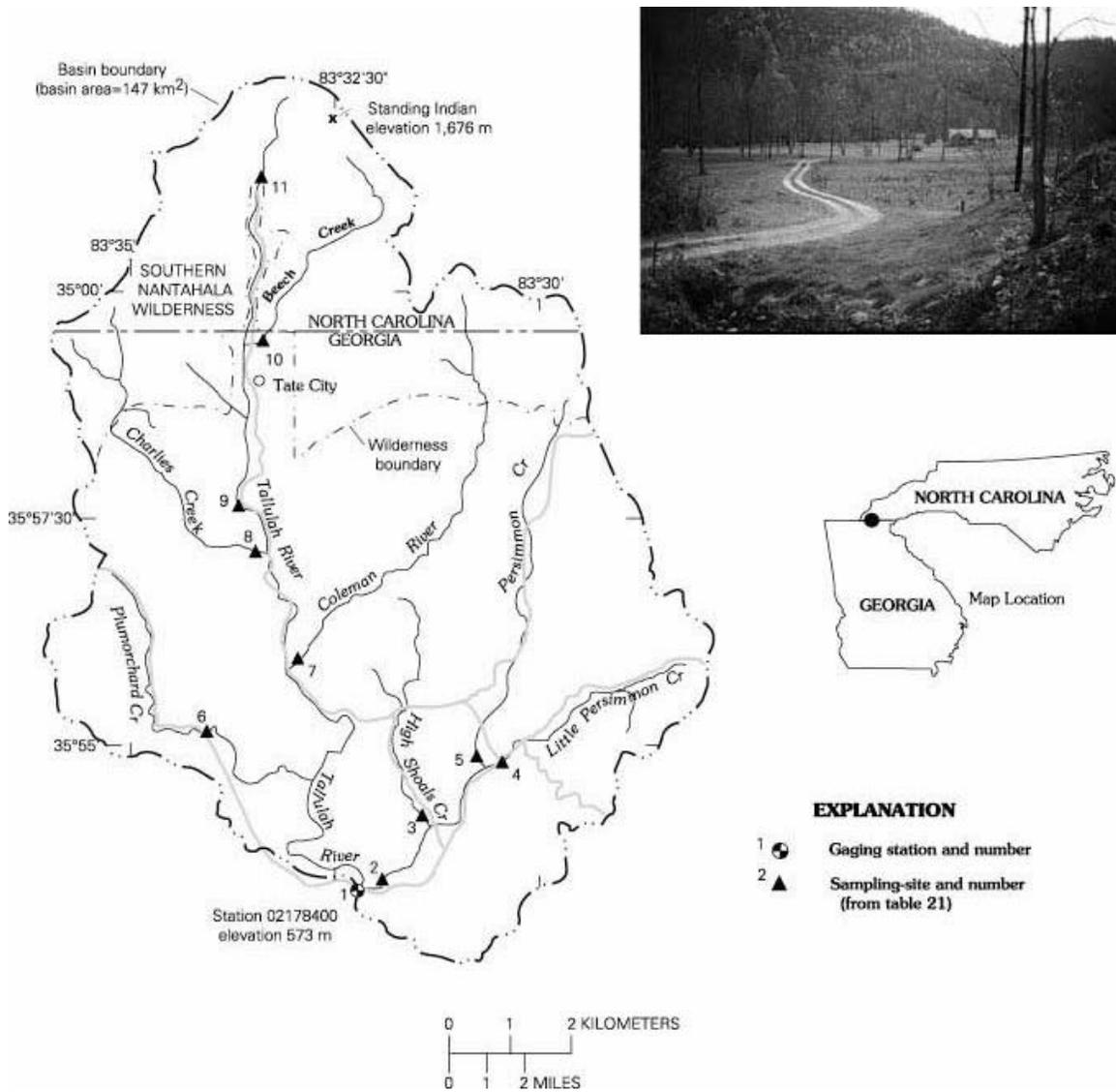


Figure 10. Map of the study area in the Tallulah River Basin and photograph of the basin landscape near Tate City, Georgia

1,676 m at the summit of Standing Indian Mountain. The USGS gaging station is 17 km west of Clayton, Ga., at latitude 34°53'25" and longitude 83°31'50". The Tallulah River is a south-flowing tributary of the Tugaloo River and discharges into Lake Burton reservoir about 2 km downstream from the gage. The reach of the main channel upstream from the gage is about 23 km long and has an average stream gradient of 3.8 m/km. The main channel is perennial, and flow varies strongly with season; mean monthly discharge ranged from 3.1 m<sup>3</sup>/s in September to 8.3 m<sup>3</sup>/s in March. Average annual runoff, of which between 5 and 20 percent occurs as stormflow (Swift and others, 1988), was 116 cm from 1964 to 1995 (U.S. Geological Survey, Water Resources Data, Georgia). Meteorological data have been collected since the 1930's at the Coweeta Experimental Forest, 10 km northeast of the basin (Swift and Waide, 1988). Climate of the area is characterized by mild temperatures and large precipitation amounts. Average monthly temperatures range from 3.3°C in January to 21.6°C in July. Average annual precipitation at Coweeta's main weather station (elevation = 685 m) is 182 cm and increases with elevation at a rate of about 5 percent per 100 m. Precipitation is greater in late winter and spring than in late summer and fall with March being the wettest month. Snow comprises as much as 10 percent of the annual precipitation, although heavy snows and long-lasting snow-packs are rare.

The basin lies in the Central Appalachian Broadleaf Forest ecoregion (Bailey and others, 1994). The four major vegetation communities in the area are distributed in a reasonably predictable pattern controlled by elevation and moisture (Day and others, 1988). The Northern Hardwood forest type is found on slopes and in coves at elevations above 1,200 m and is dominated by yellow birch, basswood, buckeye, northern red oak, yellow poplar, and black cherry. The cove hardwood forests grow primarily along moist ravines at elevations below 1,200 m and are dominated by yellow poplar and hemlock with smaller amounts of red maple, northern red oak, hickory, and black birch. The oak forest type is widely distributed on north-facing slopes at elevations below 1,200 m. Chestnut oak is the dominant species with variable amounts of scarlet oak, northern red oak, and white oak. The oak-pine community type, which is dominated by pitch pine and scarlet oak, is found at lower elevations on dry, south-facing slopes and ridgetops.

Most soils in the basin are classified as Ultisols and are mapped in the Tusquitee-Edneyville-Porters soil association, which includes steep, well-drained loamy soils formed in residuum weathered from schist and gneiss (Carson and Green, 1981). These soils are characterized by a reddish to grayish-brown surface layer of loam (20 cm) overlying a subsoil of yellowish-brown, sandy to clayey loam extending to a depth of 150 cm or more. Chemically, these soils have a high-organic matter content (5 to 15 percent), are moderately acidic (pH 4.74 to 5.13), and have low cation-exchange capacities (Swank and Crossley, 1988). The dominant soil minerals are detrital feldspar, biotite, and garnet and pedogenic kaolinite and gibbsite (Velbel, 1988).

The basin lies in the Southern Appalachian Blue Ridge geologic province and is underlain by rocks of late Proterozoic to early Paleozoic age belonging to the Richard Russell Formation and Coweeta Group (Peper and others, 1991; Hatcher, 1988). Both units contain gneiss, schist, amphibolite, and calc-silicate rocks, but the Richard Russell

Formation tends to be coarser grained and more migmatized than the Coweeta Group. The mineralogy of both units is similar and includes quartz, muscovite, biotite, plagioclase, garnet, hornblende, epidote, kyanite, staurolite, and sillimanite. A few lithologic units in the Richard Russell Formation contain sulfide-bearing schists. Extensive isovolumetric weathering of the bedrock has resulted in the formation of a porous, permeable mantle of saprolite over the bedrock that is generally believed to be the primary source of base flow to streams (Velbel, 1988).

The Tallulah River Basin drains parts of Towns and Rabun Counties in northeastern Georgia and Clay County in western North Carolina. Land in the basin is entirely in the boundaries of the Chattahoochee and Nantahala National Forests, of which 32 percent is in the Southern Nantahala Wilderness and 19 percent is privately owned. The main road into the basin enters near the gage and roughly parallels the main channel to within 2.5 km of the northern basin boundary. Paved and gravel roads provide access to most major tributaries, although travel in the wilderness is limited to foot trails. A portion of the Appalachian Trail follows most of the ridgeline in the northern one-half of the basin. The steep, heavily forested slopes make travel off roads and trails difficult.

Logging was important in the history of the area (Douglass and Hoover, 1988), and most of the basin probably was logged at least once prior to the establishment of the Chattahoochee and Nantahala National Forests in the mid-1930's. Current (1997) land cover in the National Forest is almost 100 percent forest, and the primary land-use activities are timber production and recreation. Timber harvesting in the basin during the past 10 years has averaged 140 ha annually (David Jensen, Forest Service, written commun., 1996). The method of cutting used prior to 1990 was largely clearcutting; however, seedtree, shelterwood, group selection, and single tree selection have become the standard during the past 5 years (David Jensen, written commun., 1996). Recreational use has increased significantly during the past 20 years, and campgrounds along the river are in high demand throughout the summer season. Roads are a major source of sediment loading to streams during storm events. During the last 5 years, the Forest Service has rebuilt bridges and paved or upgraded roads along drainages in an effort to reduce erosion of sediment to surface waters. The most substantial land-use change in the National Forest during the past 30 years was the designation of the Southern Nantahala Wilderness in 1984. Both the Chattahoochee and Oconee National Forests are in the process of revising their current management plans (David Jensen, written commun., 1996). These revisions may result in future increased areas of wilderness in the basin and provide Wild and Scenic designation for some segments of the Tallulah River upstream from the gage.

Private land in the basin is currently 78 percent forested, 17 percent cleared, and 5 percent residential (David Jensen, written commun., 1996) and is concentrated in the Persimmon Creek subbasin, along the valley floor near Tate City, and along the flood plain downstream from the Coleman River confluence. The primary land-use activities in these areas are cattle grazing and hay production with some poultry production, logging, and crop production. Three relatively new residential subdivisions are in the Persimmon Creek subbasin; two have about 20 new houses and the third is currently (1997) being

developed (David Jensen, written commun., 1996). There are several small prospects and mines in the basin, but all are inactive (Peper and others, 1991).

## Historical Water-Quality Data and Time-Series Trends

The Tallulah River gage was operated by the USGS as a discharge-only station until it was removed from the HBN in 1994. Water-quality samples were collected periodically at the gage from March 1967 through July 1990 as part of a USGS program to monitor pristine surface-water sites in Georgia (James McConnell, U.S. Geological Survey, oral commun., 1996). Samples were collected on a biannual schedule and were analyzed for a suite of chemical constituents similar to those measured at other HBN stations. Partial analyses for an additional 22 samples also are stored in NWIS. These samples were collected as part of a State water-quality assessment program and were analyzed at the Georgia Department of Natural Resources (James McConnell, oral commun., 1996). Daily discharge records for the Tallulah River (station 02178400) are available beginning in July 1964. Records of daily water temperature at the gage from September 1964 through September 1979 also are available.

Calculated ion balances for 48 samples with complete major ion analyses are shown in [Figure 11a](#) and [11b](#). *Temporal variation of discharge, field pH, major ion concentrations, and ion balance at Tallulah River, Georgia*. Ion balances ranged from -26 to +7 percent, and less than 65 percent of the samples had calculated values within the  $\pm 10$  percent range. This wide range of values reflects the difficulty in making precise analytical measurements at the low solute concentrations typical of this station. The average ion balance for all samples was -8.5 percent, and almost 90 percent had negative ion balances, indicating that the samples had an excess of measured anions over cations. Because stream samples at this station generally have low alkalinities, the apparent anion excess probably is because of an overestimation of alkalinity by the fixed-endpoint titration to pH 4.5 (Office of Water Quality Technical Memorandum No. 80.27, New Parameter Codes for pH, Alkalinity, Specific Conductance, and Carbonate/ Bicarbonate, issued September 19, 1980, at URL <http://water.usgs.gov/public/admin/memo/>). For waters with alkalinities around 100  $\mu\text{eq/L}$ , however, the endpoint pH is closer to 5.0, and titration to pH 4.5 may overestimate alkalinity by as much as 25  $\mu\text{eq/L}$  (Barnes, 1964). Because the average alkalinity and anion excess for this station were 140  $\mu\text{eq/L}$  and 30  $\mu\text{eq/L}$ , respectively, a bias in the laboratory alkalinity appears to be a reasonable explanation for the negative ion balances.

Time-series plots of the major dissolved constituents were inspected for evidence of method-related effects (fig. 11). Several patterns are evident in the sulfate and field pH records. For example, sulfate concentrations between 1970 and 1972 were all reported as less than or equal to 42  $\mu\text{eq/L}$  (2 mg/L), which was the reporting limit used by some USGS laboratories during this period of record. The two uncharacteristically high sulfate concentrations apparent near the end of the record are coincident with the use of a turbidimetric titration for sulfate analyses at the NWQL between March 1986 and December 1989 (Fishman and others, 1994). In 1989, the NWQL determined that sulfate

concentrations can be overestimated by this technique, and the method was changed to ion chromatography in 1990 (Office of Water Quality Technical Memorandum No. 90.04, Turbidimetric Sulfate Method, issued December 21, 1989, at URL <http://water.usgs.gov/public/admin/memo/>). The plot of field pH shows several uncharacteristically low values in the first one-half of the record. Interestingly, a similar pattern in field pH also was observed at the Falling Creek HBN station in Georgia (fig. 9). As suggested for that station, the pattern may have been caused by a change in field instrumentation. This is further supported by the fact that both stations were serviced by the same USGS field office.

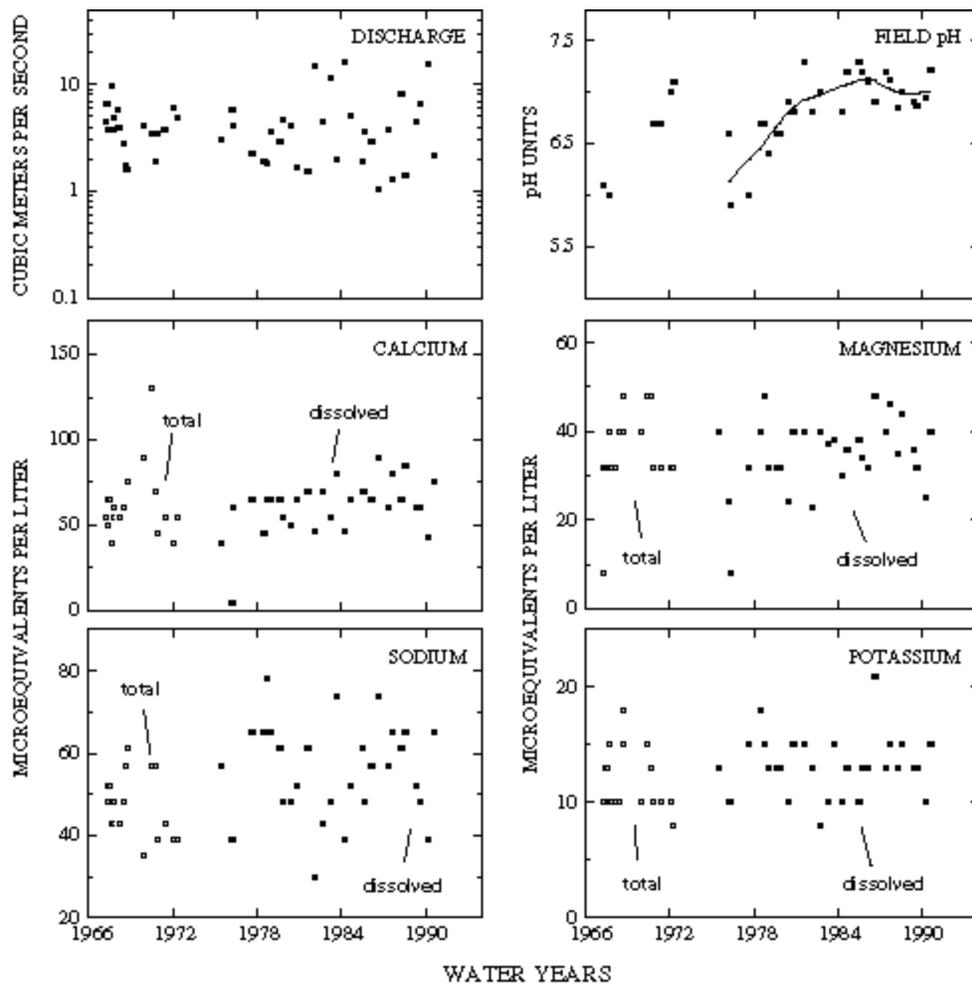


Figure 11a. Temporal variation of discharge, field pH, major ion concentrations, and ion balance at Tallulah River, Georgia.

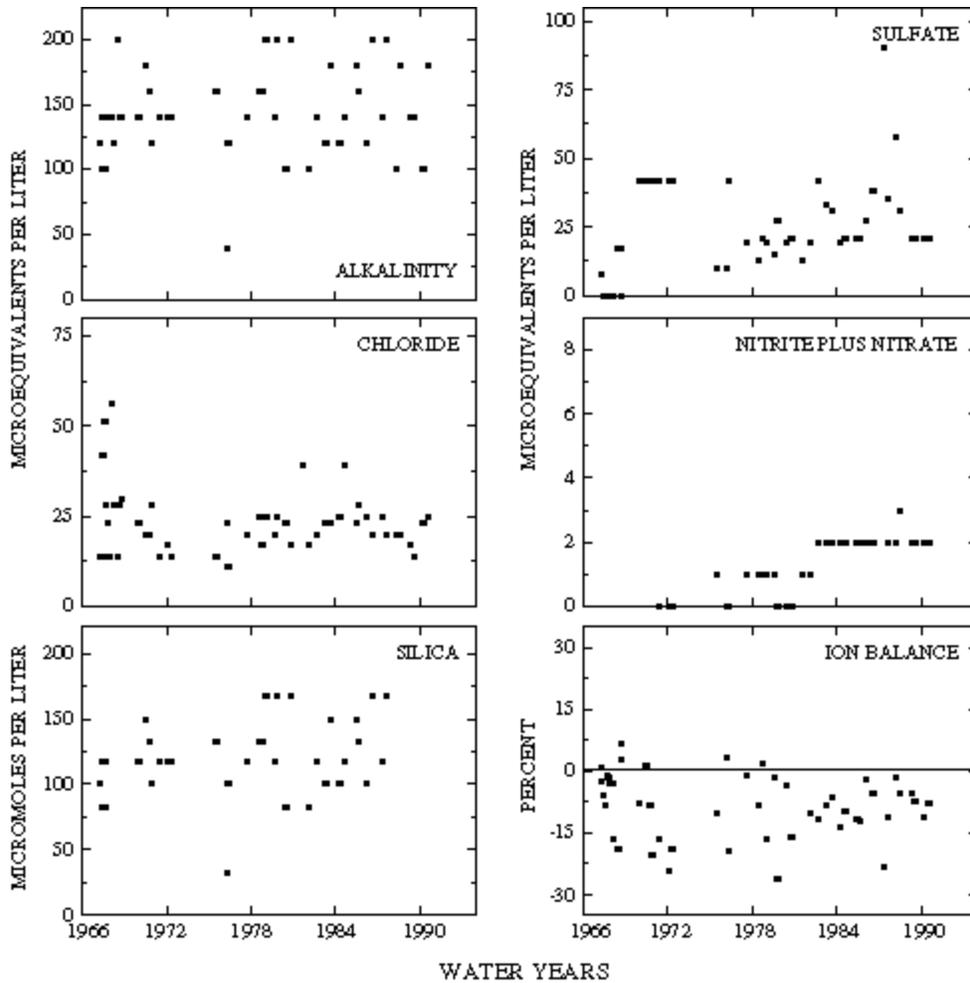


Figure 11b. *Temporal variation of discharge, field pH, major ion concentrations, and ion balance at Tallulah River, Georgia.- Continued.*

Table 18 gives median concentrations and ranges of major constituents in stream water collected at the gage and VWM concentrations in wet-only deposition measured at the Coweeta NADP station about 10 km northeast of the basin. Precipitation chemistry at the NADP station is dilute and slightly acidic, with a VWM pH of 4.6 for 17 years of record. The dominant cations in precipitation were hydrogen, which contributed 58 percent of the total cation charge, and ammonium and sodium, which contributed 18 and 13 percent, respectively. Sulfate was the dominant anion, accounting for 64 percent of the total anion charge, and nitrate and chloride accounted for 25 and 13 percent, respectively. The predominance of these ions indicates that precipitation in the basin is primarily a mixture of strong acids derived from anthropogenic emissions of sulfur and nitrogen compounds, which cause acid rain.

**Table 18. Minimum, first quartile, median, third quartile, and maximum values of physical properties and major ion concentrations measured in water-quality samples from Tallulah River, Georgia, March 1967 through July 1990, and volume-weighted mean concentrations in precipitation collected at the Coweeta Station, North Carolina**

[Concentrations in units of microequivalents per liter, discharge in cubic meters per second, specific conductance in microsiemens per centimeter at 25 degrees Celsius, and silica in micromoles per liter; n, number of stream samples; VWM, volume-weighted mean; inst., instantaneous; spec. cond., specific conductance; <, less than; --, not measured]

Parameter	Stream Water						Precipitation VMA <sup>a</sup>
	Minimum	First quartile	Median	Third quartile	Maximum	n	
Discharge	1.1	2.2	3.7	5.1	16	49	--
Spec. cond., field	12	15	17	20	25	49	--
pH, field	5.9	6.6	6.9	7.1	7.3	34	4.6 <sup>b</sup>
Calcium	<5.0	55	60	70	130	49	3.5
Magnesium	8.2	32	34	40	48	49	1.5
Sodium	30	43	52	61	78	49	5.4
Potassium	7.7	10	13	15	21	49	.5
Ammonium	<.7	.7	1.4	2.9	7.1	18	7.8
Alkalinity, laboratory	40	120	140	160	200	48	--
Sulfate	<8.3	<21	21	35	90	49	28
Chloride	11	17	22	25	56	49	5.6
Nitrite plus nitrate	<1.4	3.9	3.9	7.1	79	27	11 <sup>c</sup>
Silica	90	130	140	160	180	45	--

<sup>a</sup> Data are volume-weighted mean concentrations for 1978—94.

<sup>b</sup> Laboratory pH.

<sup>c</sup> Nitrate only.

Stream water in the Tallulah River is very dilute and poorly buffered; specific conductances ranged from 12 to 25  $\mu\text{S}/\text{cm}$  and alkalinities were generally between 120 and 160  $\mu\text{eq}/\text{L}$ . The major cations in stream water were calcium and sodium and alkalinity was the dominant anion. The primary source of base cations and alkalinity in stream water probably is weathering of silicate minerals in the underlying gneiss and schist. The median chloride concentration in stream water was 22  $\mu\text{eq}/\text{L}$ , which is about four times larger than the VWM concentration of 5.6  $\mu\text{eq}/\text{L}$  in precipitation. On the basis of the difference between average annual runoff and precipitation, evapotranspiration can account for no more than a threefold increase in the concentration of precipitation, indicating that a small amount of chloride may be derived from sources other than wet deposition. Swank and Waide (1988) determined that dry deposition from the atmosphere accounted for about 15 percent of the annual chloride input to streams that drain the nearby Coweeta Basin. Alternatively, weathering of hornblende in the bedrock also may contribute small amounts of chloride to surface waters (Peters, 1991), as would some human activities in the basin. The median concentration of sulfate in stream water (21  $\mu\text{eq}/\text{L}$ ) was smaller than the VWM concentration of 28  $\mu\text{eq}/\text{L}$  in wet precipitation. Considering that dry deposition of sulfate in the Southern Blue Ridge has been estimated to be comparable to that of wet deposition (Elwood and others, 1991), it appears that much of the atmospherically deposited sulfate is currently being retained in the basin. The primary mechanism probably is sulfate adsorption on soils, which also acts to buffer surface waters from the effects of acidic deposition (Elwood and others, 1991). The lower concentration of both nitrate and ammonium in stream water compared to precipitation indicates nitrogen also is strongly retained in the basin but also indicates that upstream agricultural activities do not have a substantial effect on nutrient concentrations in stream water at the gage.

The solute composition of stream water was further evaluated by analyzing correlations between solutes and stream discharge (table 19). Base cations, silica, and alkalinity had strong inverse correlations with discharge, which is consistent with a hydrologic system where weathering-enriched base flow is diluted by waters from shallow or surficial sources during periods of increased discharge. Among the ions, the highest degree of correlation was found between sodium and silica ( $\rho = 0.908$ ), which most likely reflects the weathering of feldspars in the underlying gneiss and schist. As expected, the atmospherically derived constituents showed little correlation with the major weathering products with the exception of a positive correlation between calcium and sulfate ( $\rho = 0.632$ ). Although most sulfate is retained in the basin soils, this association indicates that mobilization of sulfate from the basin may be causing the export of soil calcium to the stream (Johnson and Ruess, 1984).

**Table 19. Spearman rank correlation coefficients (rho values) showing the relation among discharge, pH, and major ion concentrations, Tallulah River, Georgia, 1980 through 1990**

[Q, discharge; Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; Alk, alkalinity; SO<sub>4</sub>, sulfate; Cl, chloride; Si, silica]

	Q	pH	Ca	Mg	Na	K	Alk	SO <sub>4</sub>	Cl
pH	-0.262								
Ca	-.682	0.500							
Mg	-.706	.518	0.632						
Na	-.834	.182	.566	0.688					
K	-.702	.137	.347	.583	0.734				
Alk	-.718	.308	.689	.735	.683	0.635			
SO <sub>4</sub>	-.385	.532	.632	.465	.184	.215	0.485		
Cl	.173	.387	-.067	.143	.036	.033	.105	-0.001	
Si	-.927	.235	.625	.744	.908	.687	.657	.267	-0.180

Results of the seasonal Kendall test for trends in discharge and major dissolved constituents are shown in table 20. Because many of the chemical analyses in the early part of the record are incomplete, trends were calculated only for the period 1976 through 1994. Statistically significant upward trends were observed for field pH at the 0.01 confidence level and calcium at the 0.05 confidence level. Trends in both constituents were similar for unadjusted and flow-adjusted concentrations, indicating that the trends are not driven by variations in stream discharge. The LOWESS curve for field pH reveals that most of the increase occurred in the late 1970's and early 1980's (fig. 11). As mentioned previously, field pH measurements during this period of record may have been affected by changes in analytical equipment. Thus, the trend in pH is more likely to have been caused by analytical bias than environmental change in the basin. The weak upward trend in calcium and lack of trends in other major constituents are inconsistent with long-term changes in stream chemistry observed at the nearby Coweeta Hydrologic Laboratory. Swank and Waide (1988) reported significant increases in stream- water sulfate and decreases in alkalinity and basin cations in several undisturbed streams at Coweeta. They suggested these changes in stream chemistry indicate that the capacity of these basins for retaining atmospheric sulfate and mobilizing base cations is beginning to decline. One explanation for the difference in trend results between the two sites is that the Tallulah River Basin may be less affected by acidic deposition because it drains a much larger area than the streams at Coweeta. Large basins offer a greater opportunity for buffering of acidic inputs as a result of longer residence times of waters in contact with soil and bedrock (Elwood and others, 1991). Alternatively, detection of trends in

stream-water chemistry of the Tallulah River may have been obscured by factors such as analytical bias and low sampling frequency.

**Table 20. Results of the seasonal Kendall test for trends in discharge and unadjusted and flow-adjusted pH and major ion concentrations, Tallulah River, Georgia, March 1976 through July 1990**

[Trends in units of microequivalents per liter per year, except discharge in cubic meters per second per year, pH in standard units per year, and silica in micromoles per liter per year; <, less than; --, not calculated]

Parameter	Unadjusted		Flow adjusted	
	Trend	p-value	Trend	p-value
Discharge	-0.01	0.929	--	--
pH, field	.08	.008	0.08	0.008
Calcium	1.6	.028	1.2	.030
Magnesium	.5	.168	.4	.199
Sodium	.4	.528	.2	.507
Potassium	<.1	.548	<.1	.825
Alkalinity, laboratory <sup>a</sup>	--	--	--	--
Sulfate	<.1	.365	( <sup>b</sup> )	--
Chloride	<.1	.385	( <sup>b</sup> )	--
Nitrite plus nitrate	( <sup>a</sup> )	--	--	--
Silica	.6	.561	.5	.268

<sup>a</sup> Insufficient data to calculate trend.

<sup>b</sup> Flow model not significant at  $\alpha = 0.10$ .

# Synoptic Water-Quality Data

Results of the surface-water synoptic sampling conducted October 27 and 28, 1991, are given in table 21; locations of sampling sites are shown in figure 10. Discharge at the gage was 2.0 m<sup>3</sup>/s compared to the median daily discharge of 2.7 m<sup>3</sup>/s for October (Lawrence, 1987), indicating that the basin was sampled during normal conditions for that time of year. Solute concentrations measured at the gage (site 1) during the synoptic sampling were generally between the median and third-quartile concentrations at the gage during the entire period of record (table 18). Tributary streams were similar in composition to the gage, with calcium and sodium the dominant cations and alkalinity the dominant anion. All samples had ion balances close to zero (range -2.5 to 4.9 percent), indicating that organic anions probably did not contribute significantly to the ionic content of stream water at the time of sampling.

**Table 21. Physical properties and major ion concentrations from surface-water sampling sites in the Tallulah River Basin, Georgia, collected October 27—28, 1991**

[Site locations shown in fig. 10; Q, discharge in cubic meters per second; SC, specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; Ca, calcium; Mg, magnesium; Na, sodium; K, potassium; Alk, alkalinity; SO<sub>4</sub>, sulfate; Cl, chloride; NO<sub>3</sub>, nitrate; concentrations in microequivalents; Si, silica in micromoles per liter; <, less than; --, not measured]

Site	Station number	Q	SC	pH	Ca	Mg	Na	K	Alk	Cl	NO <sub>3</sub>	SO <sub>4</sub>	Si	Criteria <sup>a</sup>	Remarks
1	02178400	1.98	20	7.12	65	41	57	15	150	20	1.4	15	153	--	--
2	345324083314500	.68	24	7.18	75	40	87	19	170	22	5.0	14	190	MT, LU	Agriculture
3	345407083305200	--	31	7.21	110	62	91	31	230	28	16	13	210	LU	Agriculture
4	345447083300300	--	24	7.17	65	37	110	18	170	22	4.3	19	230	LU	Agriculture
5	345448083300700	.28	21	7.21	65	30	78	18	150	22	2.9	12	180	LU	Agriculture
6	345509083335600	.14	14	6.87	41	24	43	11	89	17	<.7	11	120	MT	Rural residences
7	345549083324600	.23	13	6.94	33	19	43	11	83	17	<.7	12	120	MT	Forested
8	345706083331300	.22	15	7.06	44	22	48	13	98	16	<.7	11	130	LU	Forested
9	345739083332700	.40	21	7.20	85	37	57	14	150	17	<.7	33	150	LU	Downstream from Tate City
10	345924083332500	.040	23	7.12	110	33	57	13	160	11	<.7	42	140	BG	Sulfide mineralization
11	350043083332600	.053	20	7.13	90	23	61	13	140	16	<.7	25	140	LU	Wilderness

<sup>a</sup> Criteria used in selection of sampling sites: BG = bedrock geology, MT = major tributary, LU = land use.

Visual inspection of the synoptic data indicates that land-use activities explain most of the spatial variation in water quality at the time of the synoptic sampling. Although nitrate concentrations were extremely low at all the sampling sites (less than 17  $\mu\text{eq/L}$ ), only tributaries that drain areas of the basin with agricultural activities (sites 2–5) had detectable concentrations of nitrate. These sites also had slightly elevated concentrations of alkalinity, silica, sodium, potassium, and chloride compared to sites that drain largely undeveloped subbasins (sites 6–8, 10, and 11). For example, alkalinity averaged 180  $\mu\text{eq/L}$  and silica averaged 200  $\mu\text{eq/L}$  in the agricultural subbasins compared to 110  $\mu\text{eq/L}$  and 140  $\mu\text{eq/L}$ , respectively, in the forested subbasins. Chloride averaged 24  $\mu\text{eq/L}$  and sodium averaged 92  $\mu\text{eq/L}$  in the agricultural areas compared to 15  $\mu\text{eq/L}$  and 50  $\mu\text{eq/L}$ , respectively, in the forested subbasins. These differences in chemistry indicate that landscape disturbance related to agriculture and possibly septic tank leakage had a minor, although detectable, impact on the chemistry of surface waters during the sampling period. The impact of these disturbed areas on stream chemistry and sediment load, however, may increase disproportionately during periods of high runoff. Abandoned mines and prospects also may affect the chemistry of some surface waters in the basin. For example, Beech Creek (site 10), which was sampled downstream from a mapped mine and mineralized zone, had the highest sulfate and calcium concentration of the forested tributaries. The mine was not sampled during the synoptic sampling, but the slightly elevated concentrations measured in this tributary are consistent with the weathering sulfide minerals in the ore deposit.

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Velbel, M.A., 1988, Weathering and soil-forming processes, in Swank, W.T., and Crossley, D.A., Jr., eds., Forest hydrology and ecology at Coweeta: New York, Springer-Verlag, p. 93–102.

## Appendix A. List of Map References

### a. U.S. Geological Survey topographic maps:

- Dillard, Georgia-North Carolina (1: 24,000)
- Hightower Bald, Georgia-North Carolina (1: 24,000), gaging station on this quadrangle
- Rainbow Springs, North Carolina (1: 24,000)
- Toccoa, Georgia-South Carolina-North Carolina (1: 100,000)

### b. Geologic maps:

- Peper, J.D., Lesure, F.G., Cox, L.J., and D'Agostino, J.P., 1991, Geology, geochemistry, and mineral resource assessment of the Southern Nantahala Wilderness and adjacent roadless areas, Rabun and Towns Counties, Georgia, and Clay and Macon Counties, North Carolina: U.S. Geological Survey Bulletin 1883, 30 p.
- Hatcher, R.D., Jr., 1971, The geology of Rabun and Habersham Counties, Georgia: Geological survey of Georgia Bulletin 83.
- Hadley, J.B., and Nelson, A.E., 1971, Geologic map of the Knoxville quadrangle, North Carolina and Tennessee, and South Carolina: U.S. Geological Survey Miscellaneous Investigations Series Map I-654, scale 1: 250,000.

### c. Soil surveys:

- Carson, W.S., and Green, T.W., 1981, Soil survey of Rabun and Towns Counties, Georgia: U.S. Department of Agriculture Soil Conservation Service, p. 97, 76 folded plates.

### d. Other maps

- U.S. Department of Agriculture, 1986, Map of Chattahoochee National Forest, Georgia: U.S. Department of Agriculture Forest Service, Southern Region, scale 1: 126,720.
- U.S. Department of Agriculture, 1986, Map of Southern Nantahala Wilderness and Standing Indian Area, Chattahoochee and Nantahala National Forests, Georgia and North Carolina: U.S. Department of Agriculture Forest Service, Southern Region, scale 1: 126,720.

## Appendix B - NWIS Site-Identification Numbers

Table B-1. NWIS site identification numbers and site names for water-quality sampling sites.

Site	Identification Number	Site Name
1	02178400	TALLULAH RIVER CLAYTON GEORGIA
2	345324083314500	PERSIMMON CR BLW PERSIMMON
3	345407083305200	HIGH SHOALS CR NR PERSIMMON
4	345447083300300	LITTLE PERSIMMON CR NR PERSIMMON
5	345448083300700	PERSIMMON CR AB PERSIMMON
6	345509083335600	PLUM ORCHARD CR NR PERSIMMON
7	345549083324600	COLEMAN R NEAR TATE CITY
8	345706083331300	CHARLES CREEK NR TATE CITY
9	345739083332700	TALLULAH R BLW TATE CITY
10	345924083332500	BEECH CR NR TATE CITY
11	350043083332600	TALLULAH R AB TATE CITY

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