UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resources Division

HYDROLOGIC INVESTIGATIONS AT WYTHEVILLE NATIONAL FISH HATCHERY NO. 2 MAX MEADOWS, VA., 1976 to 1979

By

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OPEN-FILE REPORT 82-686

Prepared in cooperation with the

VIRGINIA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION

Marion, Virginia

1982

UNITED STATES DEPARTMENT OF THE INTERIOR

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CONTENTS

	Page
Abstract	1
Introduction	2
Highway construction history	5
Physical setting of study area	6
Description of monitoring sites	6
Significance of data	9
Summary and conclusions	22
References	23

ILLUSTRATIONS

Figure 1.	Map showing location of Glade Creek basin, Wytheville National Fish Hatchery No. 2 and surrounding area	3
2.	Map showing location of monitoring sites and Wytheville National Fish Hatchery No. 2	4
3.	Photograph of the Glade Creek monitoring site facing upstream	7
4.	Photograph of Boiling Spring facing upstream	10
5-8.	Hydrographs of average daily discharge and turbidity at West Spring and Boiling Spring, and daily precipitation at the Glade Creek monitoring site	
	5. 1976 Calendar year	11
	6. 1977 Calendar year	12
	7. 1978 Calendar year	13
	8. 1979 Calendar year	14

Page

Figure 9. Hydrograph of hourly values of discharge and turbidity of Boiling Spring and precipitation at the Glade Creek monitoring site, April 3-6, 1977 17

10. Graph showing water temperatures measured in Glade Creek basin and mean monthly air temperature for the study area 19

TABLE

Table 1. Mean and range in concentrations of chemical constituents in ground-water samples from Wytheville Fish Hatchery No. 2, Max Meadows, Va., June 1976 to March 1979 21

CONVERSION OF MEASUREMENT UNITS

The following factors may be used to convert the Inch-pound units published in this report to International System (SI) of metric units.

To convert from	Multiply by	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow	
gallon per minute (gal/min)	.06309	liter per second (L/s)
cubic feet per second (ft^3/s)	.02832	cubic meters per second (m^3/s)

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ABSTRACT

Construction of a section of Interstate Highway 77 through Glade Creek basin in Wythe County, southwestern Virginia, raised concern about its effect on two springs and a well that supply water to a fish hatchery in the basin. Discharge of Glade Creek and the two springs, turbidity of the springs, water levels in the well, water temperature, and chemical quality of the springs and well were monitored during construction and for 6 months after completion of the highway. Analyses of the data showed no trends, anomalies, or changes in quality of water that could be related either to construction activities or to the presence and use of the completed highway.

INTRODUCTION

Construction of Interstate Highway 77 through the Glade Creek drainage basin in Wythe County, southwest Virginia, was begun in 1976 and completed in 1978 (figs. 1 and 2). The U.S. Fish and Wildlife Service, which operates the Wytheville National Fish Hatchery No. 2 near the mouth of the basin, was concerned that highway construction might adversely affect two springs and a well that supply water to the hatchery. This concern was twofold: first, that contaminated, sediment-laden runoff from the construction zone might enter the ground-water system and be discharged through the springs or be pumped from the well; and second, that blasting and earth-moving operations might affect the recharge zones and flow paths of the ground-water system, causing a reduction in spring flow or well yield. Any degradation in water quality or decrease in the water supply would affect the operation of the hatchery.

The water-supply sources at the hatchery were monitored during construction and for 6 months after completion of the segment of the highway in the basin. Data were collected on the discharge and turbidity of the two springs (Boiling Spring and West Spring), the flow of Glade Creek, and precipitation at the Glade Creek site. Chemical analyses were made of water samples from the springs and the well, and water temperatures were measured periodically at all the monitoring sites.

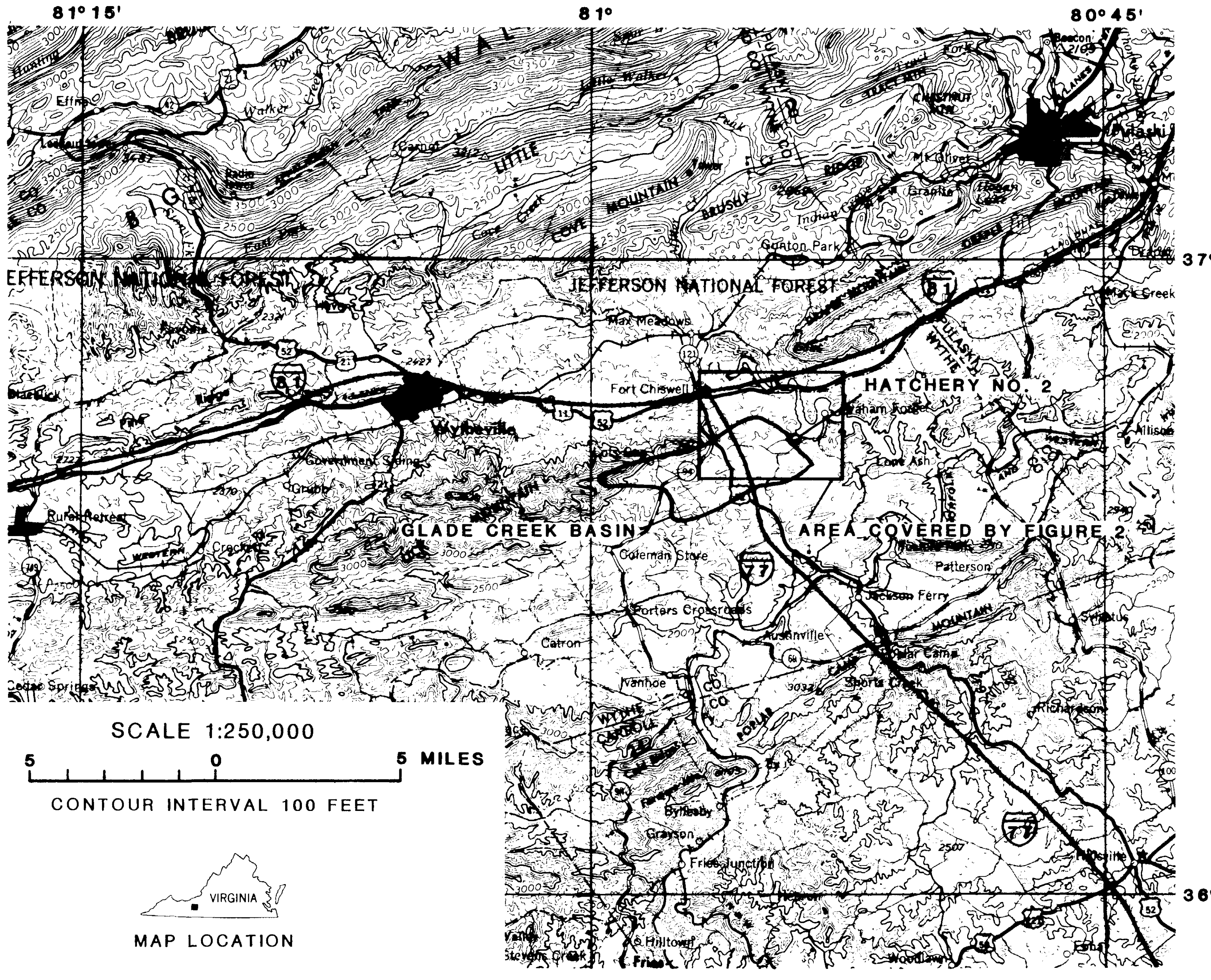

Figure 1. -- Location of Glade Creek Basin and Wytheville National Fish Hatchery No. 2.

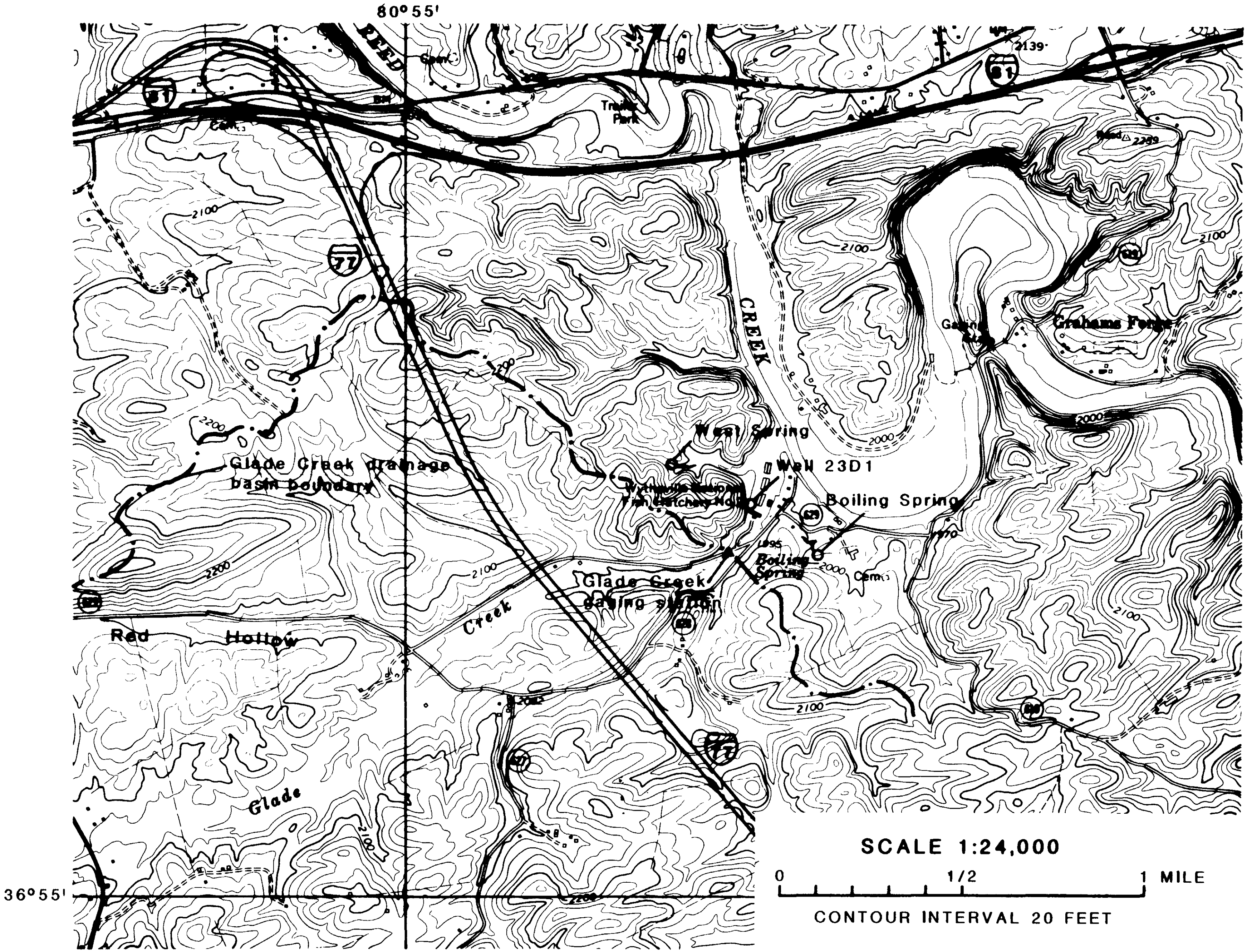

Figure 2. -- Location of monitoring sites and Wytheville National Fish Hatchery No. 2.

This report is an analysis and summary of the data collected by the U.S. Geological Survey at the springs and water-supply well at the Wytheville Hatchery between May 1976 and September 1979. Data for all the monitoring sites have been published in annual water-resources data reports by the U.S. Geological Survey (1976-79) under the following site numbers and names: 03166800 Glade Creek at Grahams Forge, Va., 03166880 West Spring at National Fish Hatchery near Grahams Forge, Va., 03166900 Boiling Spring at National Fish Hatchery near Grahams Forge, Va., and 365557080535801 (local no. 23D1) National Fish Hatchery Well near Grahams Forge, Va. Locations of the data-collection sites are shown in figure 2.

HIGHWAY CONSTRUCTION HISTORY

In September 1976, construction was started on Interstate 77 from its junction with Interstate 81, southward through Glade Creek basin (figs. 1 and 2). About 2 miles of Interstate 77 passes through the Glade Creek basin. Construction through the basin required excavations of 5 to 60 feet in depth and 200 to 1,500 feet in length. Major blasting and earth-moving activities were completed by the fall of 1977, and the new segment of the highway was opened to traffic on Dec. 4, 1978.

PHYSICAL SETTING OF STUDY AREA

Glade Creek basin consists mostly of moderately rolling farm and pasture land, except for the slope of Lick Mountain in the northwestern part. Altitudes range from 1,960 to 3,390 feet above sea level [1], but most relief ranges from 150 to 200 feet. Twenty-two percent of the basin is forested. The area is underlain by complexly folded and faulted sedimentary rocks, and calcareous rocks (dolomite and siltstone) are present throughout the basin (Calvin and Hobbs, eds., 1963); limestone and silty limestone are dominant south of Glade Creek. Sandy siltstone underlies the immediate area of the Wytheville Hatchery.

DESCRIPTION OF MONITORING SITES

In May 1976, two recorders were installed on Glade Creek near the entrance to the hatchery (fig. 3) to collect rainfall and streamflow data. The streamflow recorder gaged a drainage area of 7.15 square miles, most of which lies upstream from Interstate 77.

The supply well at the hatchery is 8 inches in diameter, 400 feet deep, and cased to 116 feet below land surface. The

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[1] The term "sea level" now is used to refer to National Geodetic Vertical Datum of 1929 (NGVD of 1929). NGVD of 1929 is a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level."

Figure 3. -- Photograph of the Glade Creek monitoring site facing upstream.

well penetrates varicolored, friable, sandy siltstone of the Lower Cambrian Rome (Waynesboro) Formation (R.C. Wilkenloh, Virginia Division of Mineral Resources, written commun., 1964). The well driller reported that the major water-bearing zone was penetrated near the bottom of the well and that water flowed at the land surface at the completion of drilling. The well was pumped at 45 gallons per minute for 24 hours; drawdown at the end of the test was 35 feet below the prepumping level. The water level in the well was measured periodically, and water samples were collected for chemical analysis about every three months during the study. The quality of the well water is critical because it is used to hatch eggs and to raise young trout until they are moved to outside ponds and raceways.

West Spring (fig. 2) flows from fractured rock that is typical of the siltstone in this area. A water-level (stage) recorder was installed on the spring so that discharge could be determined, and turbidity was also monitored automatically. The turbidimeter has an alarm to warn when turbidity reaches a level harmful to fish. The entire flow of the spring is piped into raceways in which trout are raised until they are stocked in local streams.

Boiling Spring (fig. 2) flows from an opening in limestone and silty limestone. The water originally "boiled" from a small outlet, hence the name. The spring has been enclosed by a concrete box and a building that houses two pumps (fig. 4). One pump is operated continuously to pump water to the hatchery raceways. The second pump is reserved for emergency use. A recorder installed in the pump house obtained data to determine the overflow of the spring (water that is not pumped to the hatchery). A record was kept of the water pumped to the hatchery so that the total flow of the spring could be calculated. Turbidity and water-level recorders identical to those at West Spring were operated at Boiling Spring.

SIGNIFICANCE OF THE DATA

Graphs of mean daily discharge of Boiling and West Springs, turbidity of the two springs, and daily precipitation at the Glade Creek monitoring site are shown in figures 5-8. Because precipitation is distributed fairly evenly throughout the year, the general seasonal variation in spring flow probably reflects differences in rates of evapotranspiration (ET), between growing and nongrowing seasons. Flows are highest during late winter and early spring, when vegetation is dormant and low ET rates do not significantly reduce potential ground-water recharge. No anomalies or trends on the hydrographs can definitely be related to construction activities or to the effect of the completed highway.

The geohydrology of the Glade Creek basin is not known in enough detail to determine precisely the hydraulic

Figure 4. -- Photograph of Boiling Spring facing upstream.

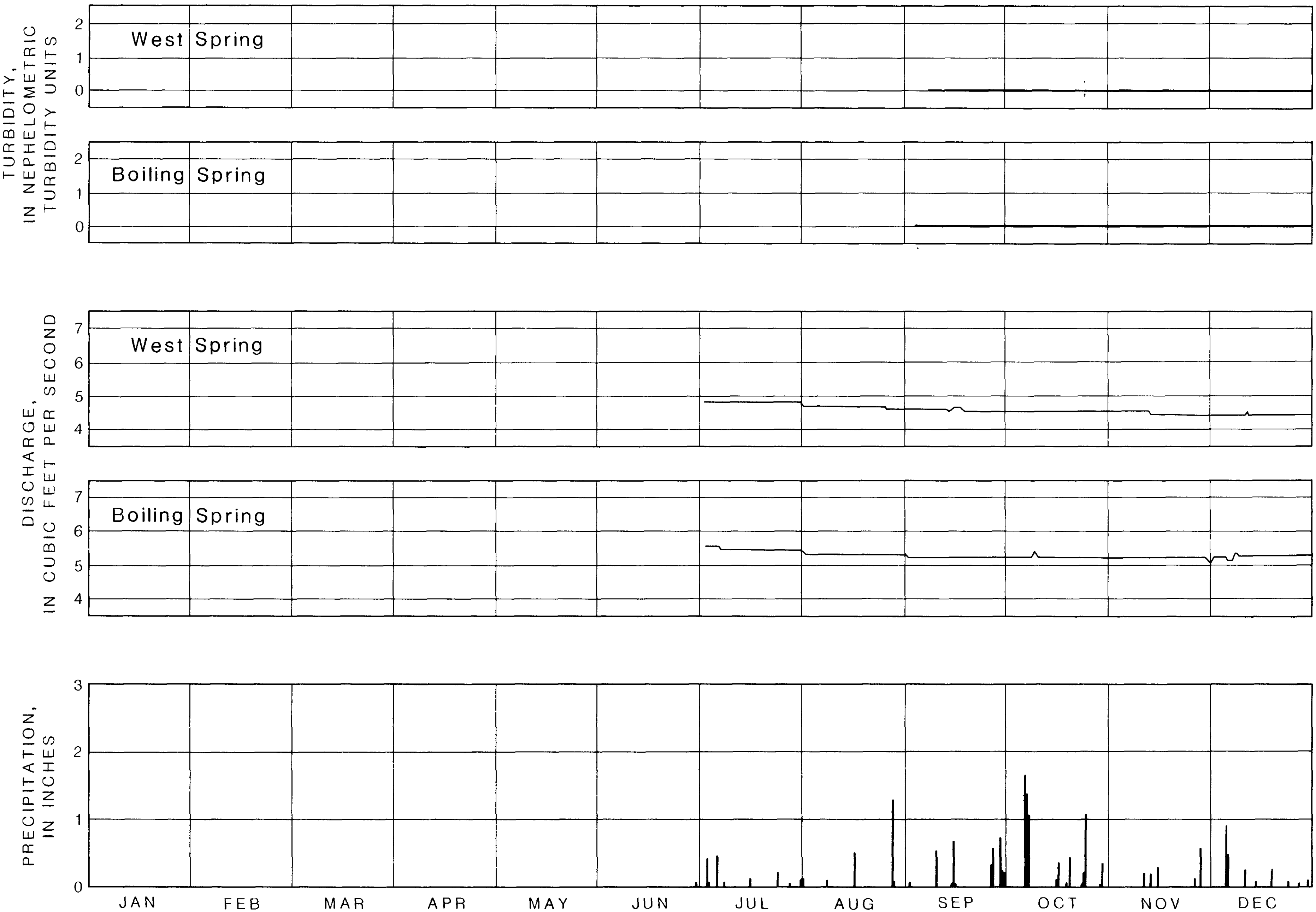

Figure 5. -- Average daily discharge and turbidity at West Spring and Boiling Spring, and daily precipitation at the Glade Creek monitoring site, 1976 calendar year.

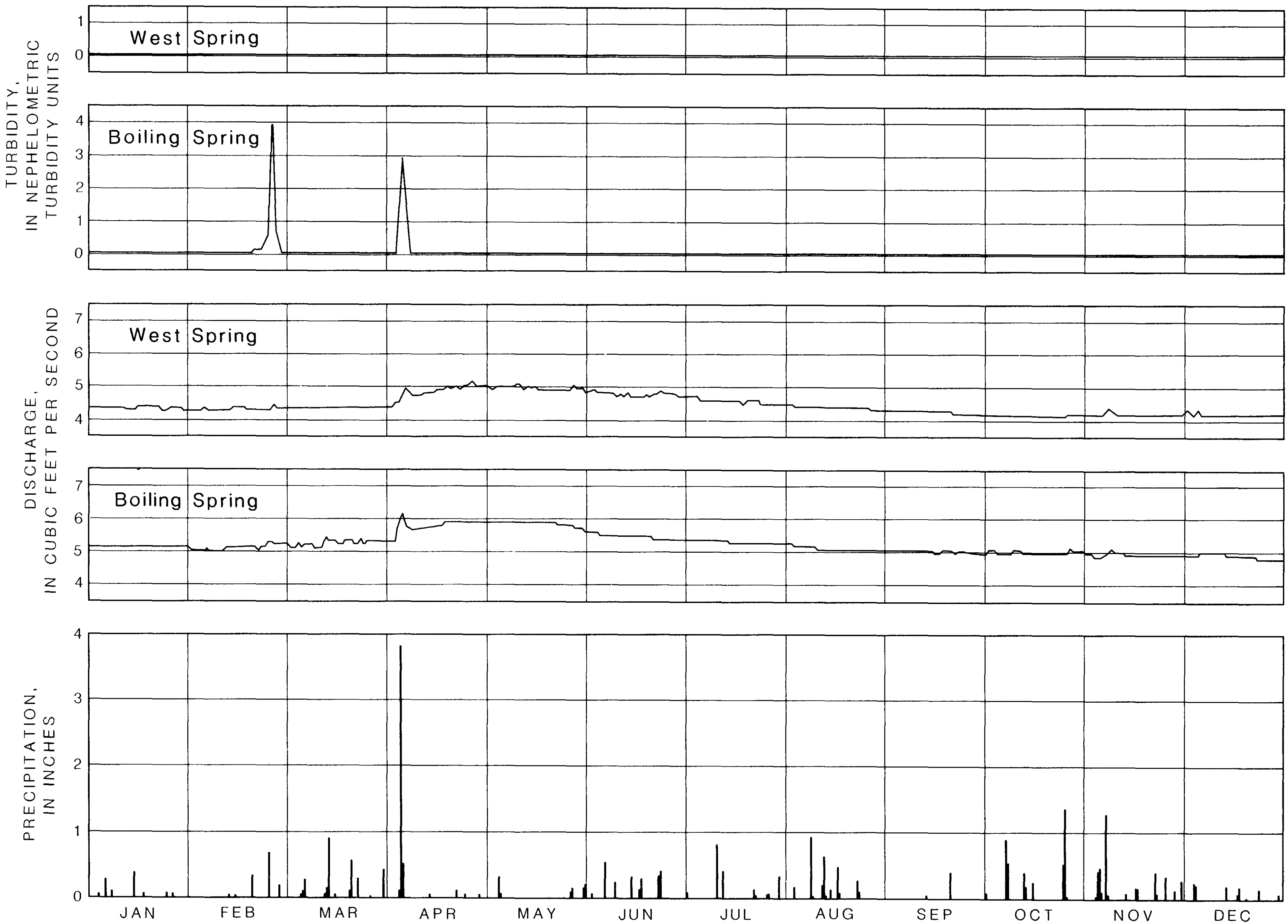

Figure 6. -- Average daily discharge and turbidity at West Spring and Boiling Spring, and daily precipitation at the Glade Creek monitoring site, 1977 calendar year.

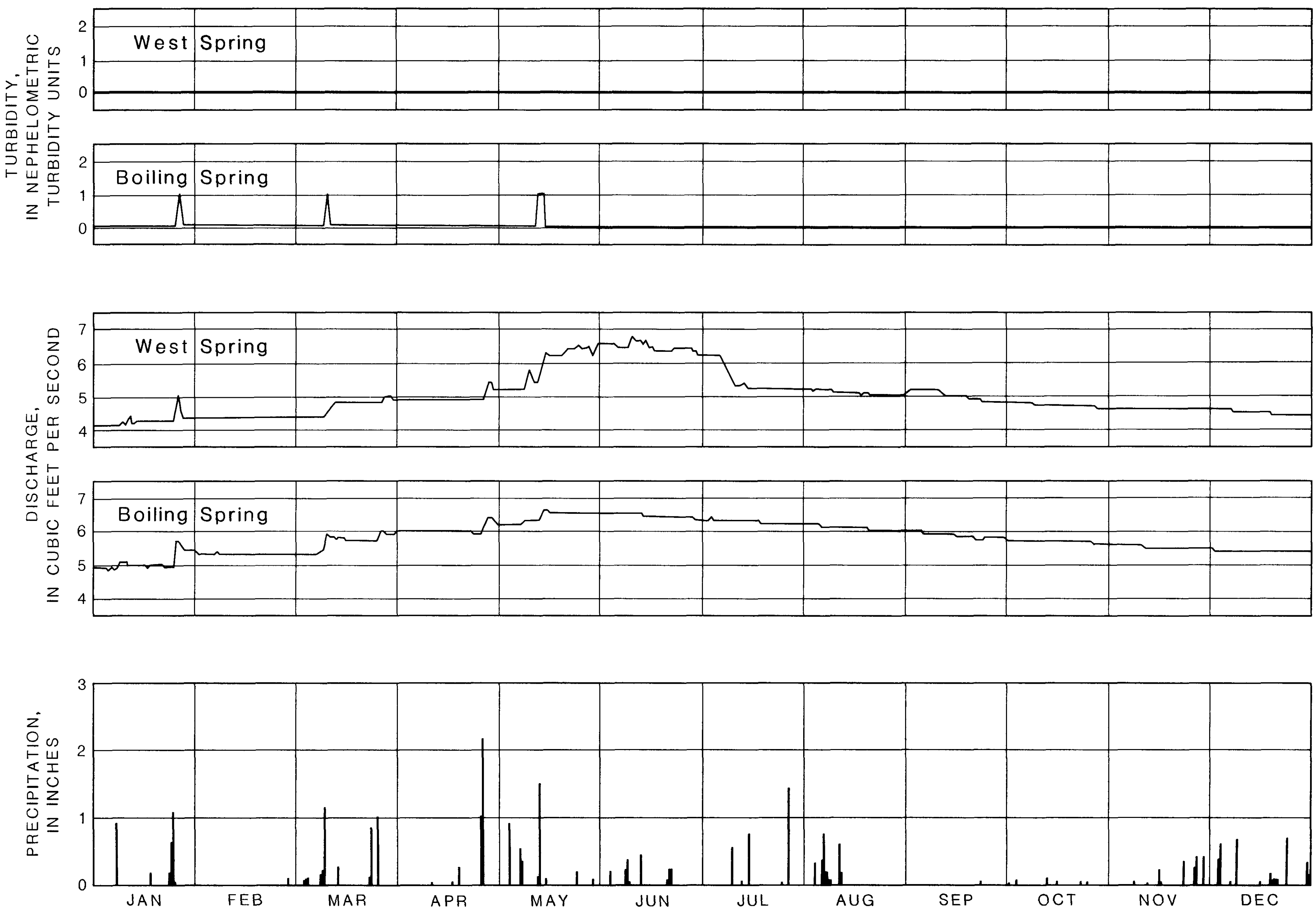

Figure 7. -- Average daily discharge and turbidity at West Spring and Boiling Spring, and daily precipitation at the Glade Creek monitoring site, 1978 calendar year.

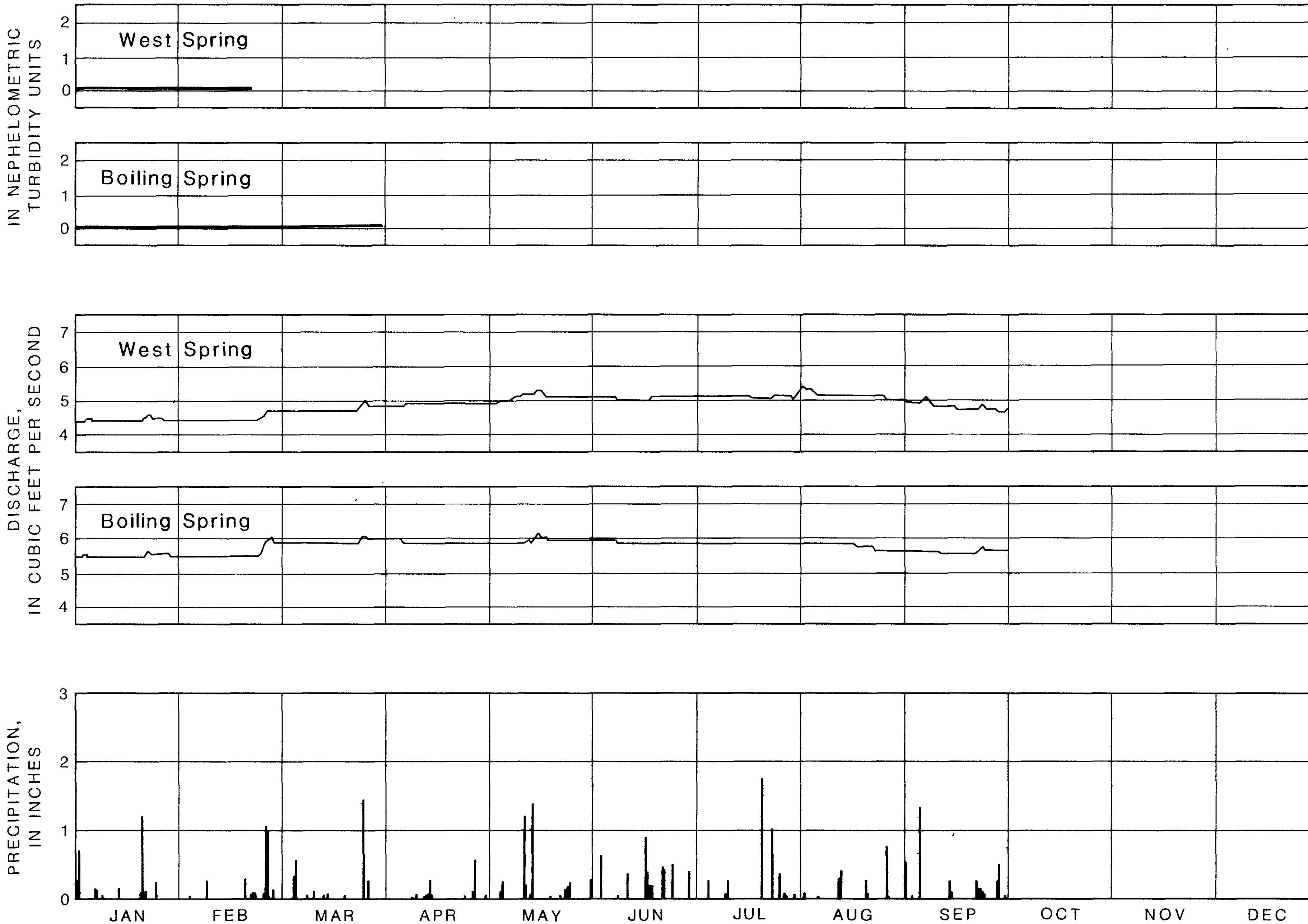

Figure 8. -- Average daily discharge and turbidity at West Spring and Boiling Spring, and daily precipitation at the Glade Creek monitoring site, 1979 calendar year.

connection between the recharge area(s) and the discharge at Boiling and West Springs. However, the location of the springs in the lower part of the basin and their relatively uniform discharge (except for seasonal variation), indicate a long flow path from source to outlet. The hydrographs show a time lag of from 1 to 2 days, depending on the seasonal differences in basin conditions (vegetation and ground cover) and rainfall intensity, between rainfall peaks and peaks in mean daily discharge at the springs. This rather short time lag could be the effect of a pressure wave caused by the increment of head added by the recharge from precipitation. Within a few days after recharge, the springs return to a more normal flow rate as the recharge pulse is damped out along the flow path. However, "temporary" peaks in flow at both springs did last for several days as late as the end of June in both 1977 and 1978 (figs. 6 and 7).

The plot of mean daily values of turbidity at West Spring (figs. 5-8) is a virtually flat trace, with no peaks or troughs evident. However, during the period of record, instantaneous turbidity values reached 1.5 NTUs (nephelometric turbidity units); the mean value was 0.2 NTU.

The turbidity graphs for Boiling Spring are not quite so featureless as those for West Spring. Five turbidity peaks, coincident with or lagging slightly behind peaks in flow, were recorded at Boiling Springs (figs. 6 and 7). An instantaneous maximum turbidity level of 14.5 NTUs was recorded on Feb. 24, 1977. This value was below the critical level required to activate the alarm system. The relationship between discharge and turbidity of Boiling Spring and local precipitation is shown in figure 9. The fluctuation in turbidity for this period is typical of the other aforementioned peaks--coincident with peaks in flows of the spring and lagging slightly behind the period of maximum rainfall. The 6-hour time lag between rainfall peaks and turbidity peaks (fig. 9) on Apr. 4-5, 1977, indicates a very rapid response of the spring's flow system to intense rainfall (about 4 inches within 24 hours).

The occurrence of turbidity peaks at Boiling Spring but not at West Spring may be due to geologic and hydrologic differences between the two springs. Boiling Spring is south of Glade Creek, where limestone and silty limestone are the dominant rock types; siltstone is present in the vicinity of West spring, which is north of the creek. The turbidity peaks at Boiling Springs may be caused by flushing pockets of fine clayey sediment in solution-enlarged joints, fractures, and bedding-plane partings in the limestone. This material is deposited during periods of low-velocity flow, and some of it is removed during brief periods of high-velocity flow. Whatever the mechanism, the periods of relatively high flow last only a few days. These periods of relatively high turbidity are probably not related to the construction of Interstate 77, although in the absence of a

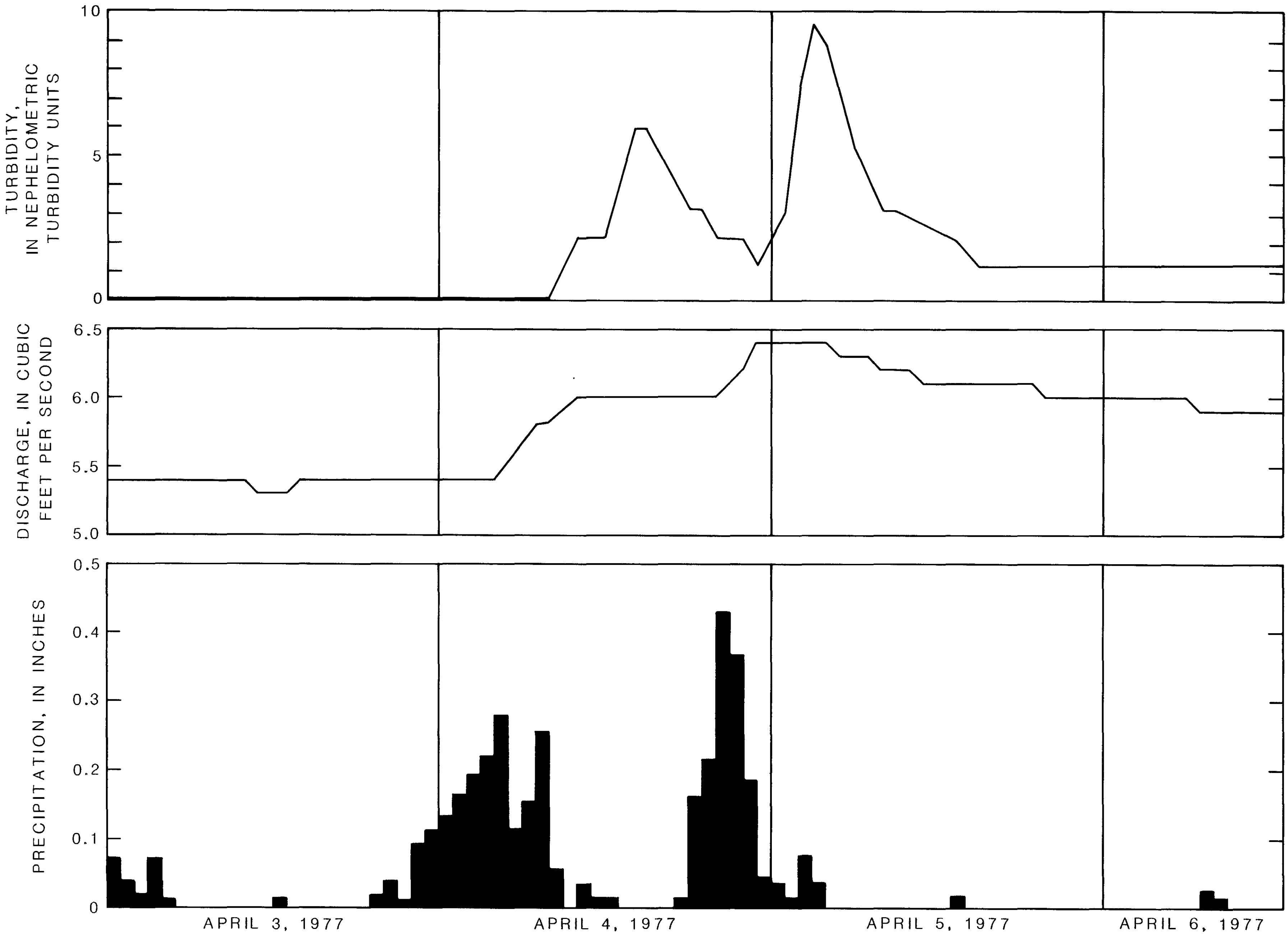

Figure 9. -- Hourly values of discharge and turbidity of water from Boiling Spring, and precipitation at the Glade Creek monitoring site.

long preconstruction record of turbidity, this statement is not conclusive. The water level in the supply well at the hatchery was measured periodically. Levels ranged from 0.17 feet to 5.47 feet below land surface. There were no apparent trends or changes in water levels that could be attributed to highway construction. The variation seemed to be due either to differences in the pumping schedule before each measurement or to seasonal changes in ground-water recharge.

Water temperature was measured during each visit to the Glade Creek, West Spring, and Boiling Spring monitoring sites and when water-quality samples were collected from the hatchery well. The water temperatures are plotted in figure 10 along with mean monthly air temperature for the area. The ground-water temperatures are relatively constant (11.5 to 13.5°C) compared with those of surface water, which vary greatly seasonally (from near freezing to nearly 30°C). The stable ground-water temperatures indicate a long subsurface flow path, intimate contact with the source rocks, and little or no "short circuit" to the surface-water system in the Glade Creek basin.

Water samples were collected from the water-supply well at the hatchery and from the two springs at about every three months during the study. Chemically, the water from the springs and the well are almost identical, with the exception of the concentration of dissolved iron. Results

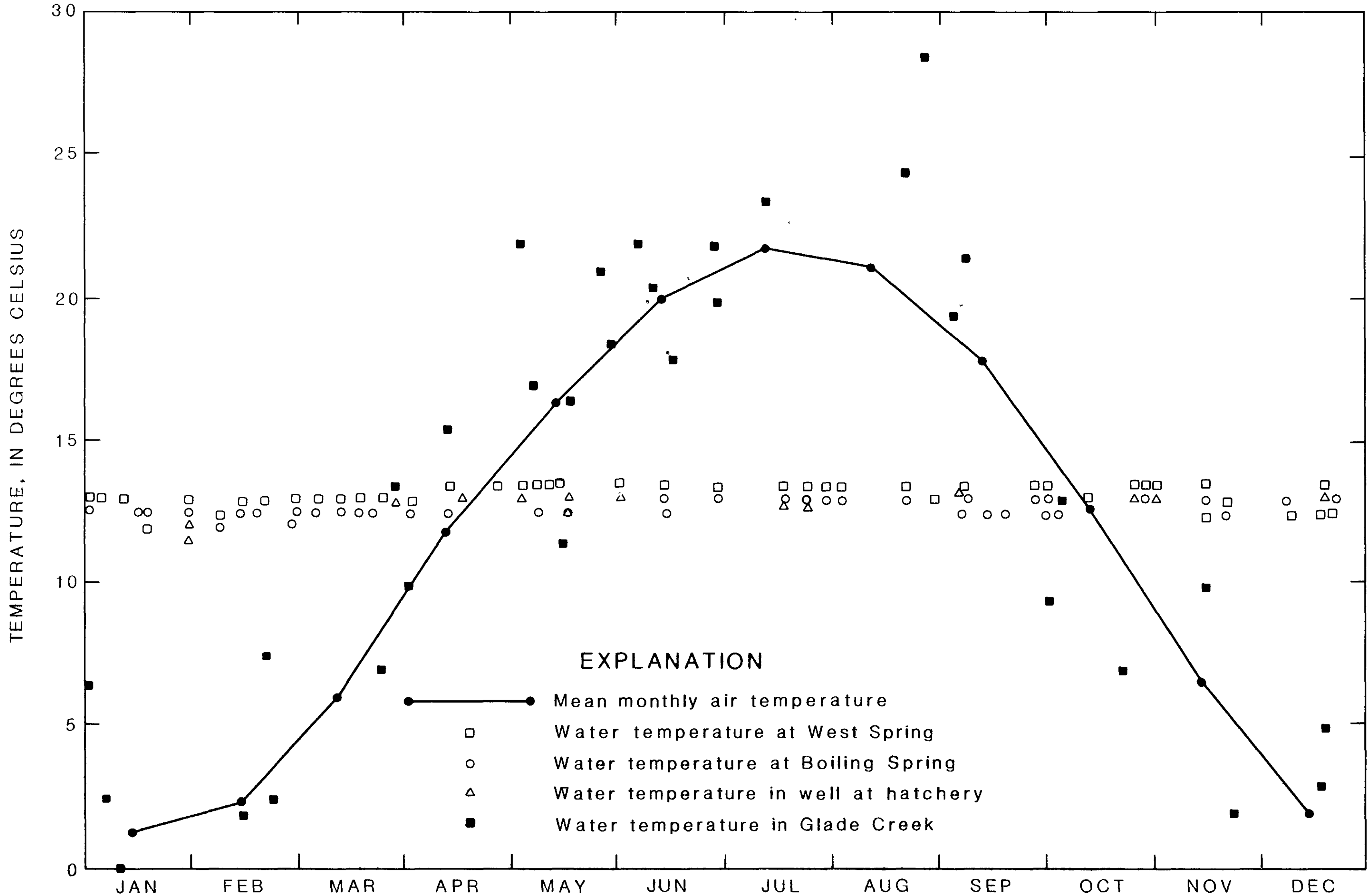

Figure 10. -- Water temperatures measured in the Glade Creek basin and mean monthly air temperature for the study area.

of chemical analyses of the samples (Table 1) indicate that all constituents tested fall well within recommended drinking water standards (U.S. Environmental Protection Agency, 1977). No changes in water quality were detected during the study.

Table 1.--Mean and range in concentrations of chemical constituents in ground-water samples from Wytheville Fish Hatchery No. 2, Max Meadows, VA, June 1976 to March 1979

Values are in milligrams per liter, except as noted

Constituent and/or property	Well 23D1 11 samples		West Spring 12 samples		Boiling Spring 12 samples		Maximum concentration recommended for drinking water 1/
	Mean	Min - Max	Mean	Min - Max	Mean	Min - Max	
Calcium (Ca)	22.0	21.0 - 23.0	25.0	24.0 - 26.0	23.0	23.0 - 25.0	
Magnesium (Mg)	15.0	15.0 - 16.0	15.0	14.0 - 15.0	14.0	14.0 - 14.0	125
Sodium (Na)	0.6	0.4 - 0.9	0.6	0.3 - 1.2	0.6	0.4 - 0.8	250
Potassium (K)	1.7	1.4 - 3.0	1.6	1.3 - 3.3	1.6	1.4 - 2.3	
Bicarbonate (HCO_3)	137.0	130.0 - 140.0	137.0	110.0 - 142.0	132.0	129.0 - 140.0	
Sulfate (SO_4)	2.4	1.2 - 3.3	2.2	1.1 - 2.8	1.9	1.1 - 3.0	250
Chloride (Cl)	1.2	0.3 - 2.4	1.0	0.5 - 2.7	1.0	0.5 - 1.7	250
Flouride (F)	0.1	0.1 - 0.1	0.1	0.0 - 0.1	0.1	0.0 - 0.1	1.5 2/
Nitrogen (NO_2 + NO_3 diss. as N)	0.18	0.01 - 0.24	0.22	0.07 - 0.29	0.20	0.02 - 0.30	10
Phosphorous (ortho diss. as P)	0.01	0.00 - 0.03	0.01	0.00 - 0.01	0.01	0.00 - 0.01	
Phosphate (ortho diss. as PO_4)	0.04	0.00 - 0.09	0.01	0.00 - 0.03	0.02	0.00 - 0.03	
Iron (diss. as Fe in micrograms/liter)	15.0	0.0 - 50.0	11.0	0.0 - 60.0	8.0	0.0 - 20.0	300
Hardness (as $CaCO_3$)	119.0	110.0 - 120.0	123.0	120.0 - 130.0	120.0	120.0 - 120.0	
Dissolved Solids 3/	115.0	104.0 - 123.0	116.0	105.0 - 126.0	112.0	106.0 - 127.0	500
Specific Conductance (micromhos/cm at 25°C)	218.0	205.0 - 228.0	222.0	218.0 - 230.0	209.0	180.0 - 254.0	
Color (Platinum-cobalt units)	4.0	0.0 - 10.0	4.0	0.0 - 10.0	4.0	0.0 - 10.0	
Temperature (°C)	12.9	11.5 - 13.5	13.2	12.0 - 13.5	12.9	12.5 - 13.0	

1/ U.S. Environmental Protection Agency, 1976, Quality criteria for water.
2/ Recommended limits for fluoride vary according to the annual average maximum daily air temperature. These limits apply only to naturally occurring fluoride.
3/ Residue on evaporation at 180°C.

SUMMARY AND CONCLUSIONS

The discharge records for West Spring and Boiling Spring from July 1976 through September 1979 show no apparent trends, anomalies, or changes that can be directly related to constructing Interstate 77. Turbidity peaks at Boiling Spring, although sporadic, closely followed local rainfall. The peaks could not be correlated with construction activity. The turbidity record for West Spring shows practically no variation. The chemical quality of water from the hatchery well and the two springs showed no significant change during the study.

The data compiled do not indicate that constructing Interstate 77 affected the two springs or the supply well at the Wytheville National Fish Hatchery No. 2. However, because of a lack of equivalent preconstruction data, on flow and turbidity, it cannot be stated positively that no change took place in the hydrologic regime of the springs and well. As a result of this study, it is safe to assume the operations at the hatchery have been insignificantly affected.

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