

GAINING, LOSING, AND DRY STREAM REACHES AT BEAR CREEK VALLEY, OAK RIDGE, TENNESSEE MARCH AND SEPTEMBER 1994

By John A. Robinson and Reavis L. Mitchell, III

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To Obtain
foot (ft)	0.3048	meter
acre	0.4047	square hectare
square mile (mi ²)	2.590	square kilometer
mile (mi)	1.609	kilometer
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second

Sea level: In this report “sea level” refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of first-order level nets of the United States and Canada, formally called Sea Level Datum of 1929.

Gaining, Losing, and Dry Stream Reaches at Bear Creek Valley, Oak Ridge, Tennessee, March and September 1994

By John A. Robinson *and* Reavis L. Mitchell, III

ABSTRACT

A study was conducted to delineate stream reaches that were gaining flow, losing flow, or that were dry in the upper reaches of Bear Creek Valley near the Y-12 Plant in Oak Ridge, Tennessee. The study included a review of maps and discharge data from a seepage investigation conducted at Bear Creek Valley; preparation of tables showing site identification and discharge and stream reaches that were gaining flow, losing flow, or that were dry; and preparation of maps showing measurement site locations and discharge measurements, and gaining, losing, and dry stream reaches. This report will aid in developing a better understanding of ground-water and surface-water interactions in the upper reaches of Bear Creek.

INTRODUCTION

The Oak Ridge Reservation (ORR) is located in East Tennessee in the western part of the Valley and Ridge Physiographic Province. The 58,000-acre ORR is bounded on the northeast, southeast, and southwest by the Clinch River, and on the northwest by Blackoak Ridge (McMaster, 1967). The three major facilities within the ORR are Y-12, a research, development, and production center; X-10, the Oak Ridge National Laboratory (ORNL), a research and development center; and K-25, the Gaseous Diffusion Plant (ORGP), a production center that was closed in 1986.

During 1994 the U.S. Geological Survey (USGS), in cooperation with the U.S. Department of

Energy, conducted a seepage investigation in Bear Creek Valley (Robinson and Johnson, 1996). In 1995, a second study was started to quantify changes in streamflow to delineate gaining, losing, and dry stream reaches in the headwater streams in Bear Creek Valley. Information provided by this report is intended to aid the Y-12 Environmental Restoration Program, Groundwater Operable Units Remedial Investigations Project, to develop a better understanding of ground-water and surface-water interactions in a part of the ORR.

The study involved (1) a review of maps and discharge data from a seepage investigation conducted in Bear Creek Valley; (2) preparation of tables showing site identification and discharge and stream reaches that were gaining flow, losing flow, or that were dry; and (3) preparation of maps showing measurement site locations and discharge measurements, and gaining, losing, and dry stream reaches. All discharge data used in this report were collected during high base flow conditions, March 14 through March 19, 1994, and low base flow conditions, September 9 through September 19, 1994, at Bear Creek Valley, Oak Ridge, Tennessee.

Study Area

The study area is bounded by Pine Ridge on the northwest, Chestnut Ridge on the southeast, North Tributary 9 (NT9) on the southwest, and the Y-12 Plant on the northeast (fig. 1). Bear Creek Valley southwest of the Y-12 Plant is drained by two streams: Bear Creek, which exits Bear Creek Valley through a water gap in Pine Ridge, and Grassy Creek, which discharges to the Clinch River. The 1,125 acres within the

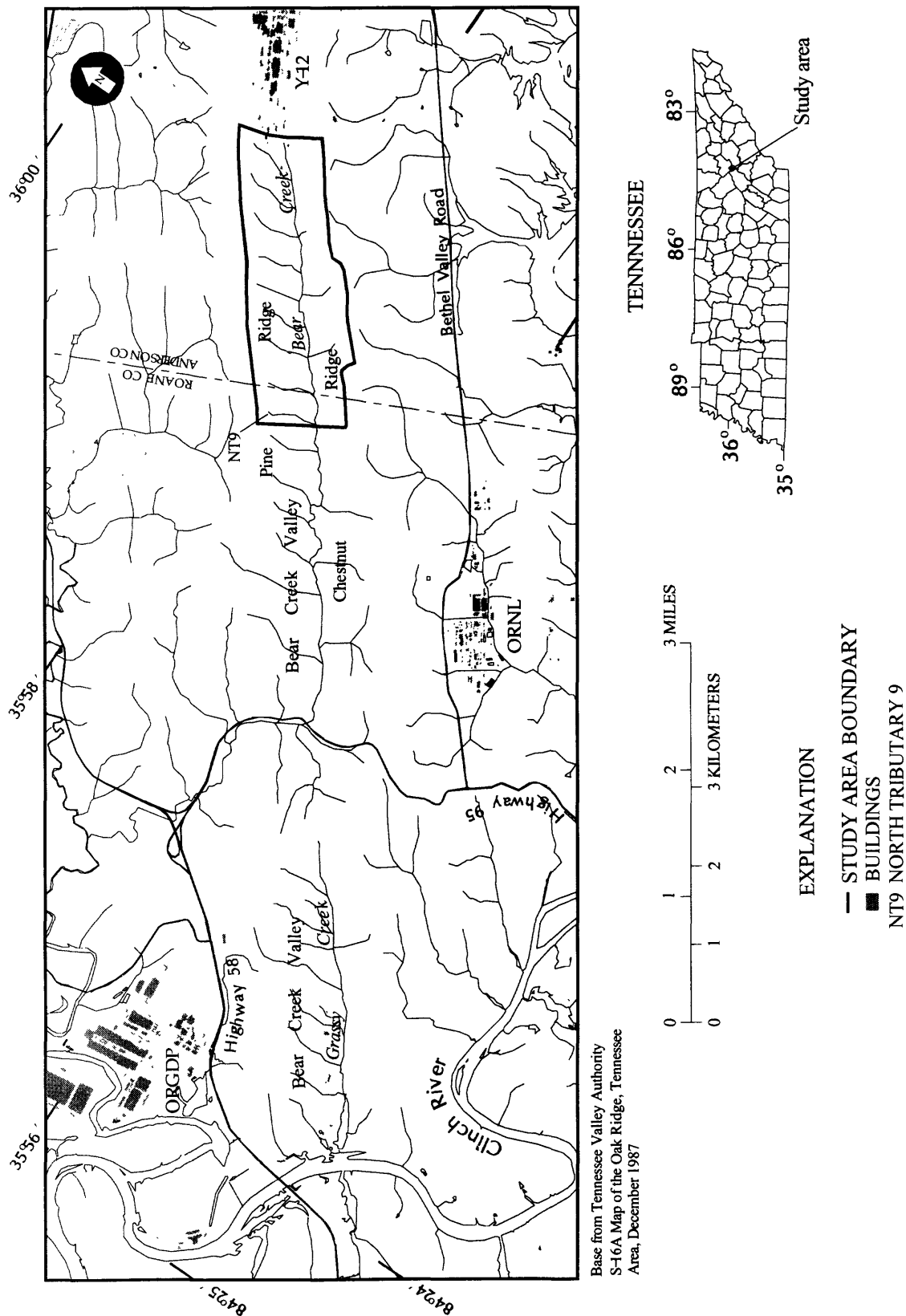


Figure 1. Location of the study area in Bear Creek Valley, Oak Ridge, Tennessee.

study area include the uppermost part of Bear Creek and many tributaries north and south of Bear Creek (fig. 2). The main tributaries to the north of Bear Creek include North Tributary 1 (NT1) through NT8. The main tributaries to the south of Bear Creek include South Tributary 1 (ST1) through ST4 and South Spring 1 (SS1) through SS6. In addition to Bear Creek and the main tributaries, many unnamed sub-tributaries exist throughout the study area.

Previous Investigation

During 1994 the USGS, in cooperation with the U.S. Department of Energy, conducted a seepage investigation in Bear Creek Valley, in which the Y-12 Plant is located (Robinson and Johnson, 1996). The study involved three phases of activity: (1) a reconnaissance to inventory and map seeps, springs, and stream measurement sites; (2) the measurement of discharge and water-quality characteristics under high base flow conditions; and (3) the measurement of discharge and water-quality characteristics under low base flow conditions. The seepage investigation was conducted on Bear Creek and Grassy Creek. Discharge measurements were made along streams and tributaries in the basins of these two streams, southwest of the Y-12 Plant. In order to gain a better understanding of flow paths in the upper reaches of Bear Creek, discharge measurements from the previous investigation were used in this report to quantify changes in streamflow and to delineate stream reaches which are classified as gaining flow, losing flow, or dry.

GAINING, LOSING, AND DRY STREAM REACHES

For the purposes of this study, stream reaches were classified as gaining flow (gaining), losing flow (losing), or dry. Changes in streamflow between two adjacent sites on the same stream, plus any flow from contributing tributaries, were used to determine if the flow was gaining or losing along that stream reach. To identify reaches that gain or lose flow, as opposed to apparent differences due to measurement error, the following criteria were used: for streamflow of less than 0.1 cubic foot per second (ft^3/s), a change in flow of more than 25 percent of total flow was used to determine if the flow was increasing or decreasing; for streamflow equal to or greater than $0.1 \text{ ft}^3/\text{s}$, a change

in flow of 10 percent was used as the criterion. If two adjacent stream measurement sites had zero flow, these stream reaches were classified as dry. Stream reaches were classified as having no change in flow if the change in streamflow was zero or less than 10 percent for total flow greater than $0.1 \text{ ft}^3/\text{s}$ or less than 25 percent for total flow between 0.01 and $0.1 \text{ ft}^3/\text{s}$. If two adjacent stream measurement sites had equal flow rates or the difference in flow rates were in the above specified range, these stream reaches had no change in flow. In many instances, discharge was measured at only one site along a stream reach. These single sites along stream reaches may contribute flow to a stream or tributary. Many of the stream reaches in the study area were unobserved as a result of safety concerns or limited access. Discharge was measured at 229 sites in the study area (fig. 3). Site numbers and discharge values are presented in table 1. Changes determined for both high base flow and low base flow conditions, measurement sites, discharge, and stream classification under both conditions are shown on plate 1 at the back of the report.

High Base Flow

Discharge measurements along upper Bear Creek and its tributaries were collected during high base flow from March 14 through March 19, 1994 (Robinson and Johnson, 1996). During high base flow, discharge measurements for Bear Creek ranged from 0.02 to $2.01 \text{ ft}^3/\text{s}$; however, site 1490, on a small tributary to Bear Creek, had a discharge of $0.01 \text{ ft}^3/\text{s}$ (table 1, plate 1). No dry stream reaches were observed along Bear Creek during high base flow. Gaining stream reaches occurred near NT2, NT3, NT5, NT7, and NT8, with gains in flow from 0.09 to $0.51 \text{ ft}^3/\text{s}$. Stream reaches losing flow in the range of 0.13 to $1.34 \text{ ft}^3/\text{s}$ occurred near NT1, NT2, NT3, NT4, NT5, NT6, and NT7 (table 2).

The discharge measurements along the north tributaries were $0.16 \text{ ft}^3/\text{s}$ or less with the exception of measurements of 1.10 and $1.16 \text{ ft}^3/\text{s}$ along NT3 near Bear Creek (table 1, plate 1). All tributaries north of Bear Creek had gaining and losing stream reaches. All north tributaries, except NT3, NT7, and NT8, had dry stream reaches. For most of the tributaries north of Bear Creek, gains in flow were in the range of 0.01 to $0.15 \text{ ft}^3/\text{s}$ (table 2), except for a section of NT3, which had the largest measured gain in flow of $1.07 \text{ ft}^3/\text{s}$. Losses in flow for the north tributaries ranged from 0.01 to $0.22 \text{ ft}^3/\text{s}$ (table 2).

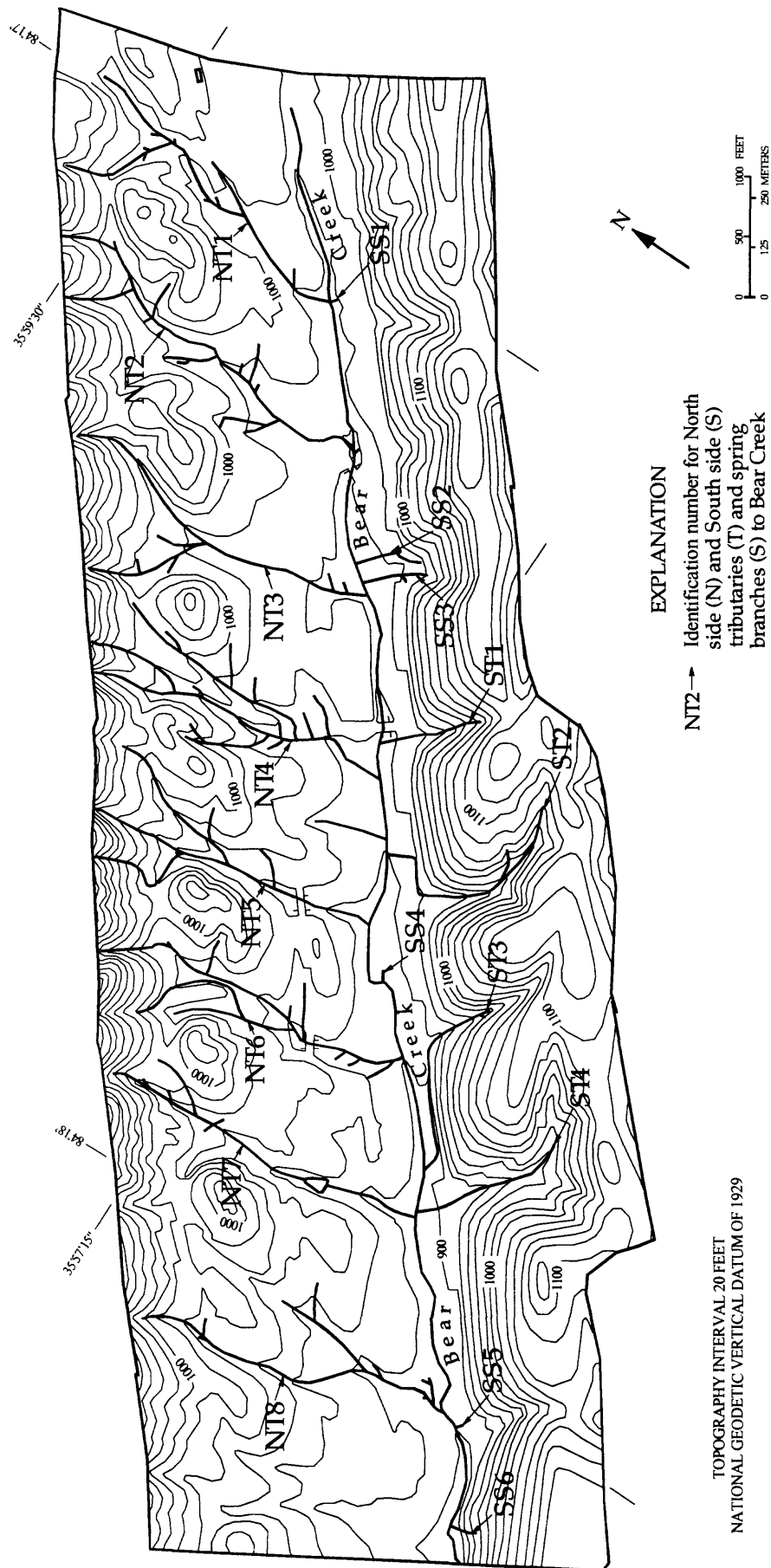


Figure 2. Stream locations and identification numbers for Bear Creek tributaries.

Discharge measurements along the south tributaries ST1, ST2, and ST4 were mostly zero with the exception of ST3 (table 1, plate 1). Discharge measurements along ST3 ranged from less than 0.02 to 0.44 ft³/s. Stream reaches along ST3 were gaining flow and losing flow in the range of 0.07 to 0.36 ft³/s (table 2). One dry stream reach was observed along ST2. The south spring tributaries, SS1 through SS6, which may contribute flow to Bear Creek, were mostly single sites with discharge measurements in the range of 0.01 to 0.44 ft³/s (table 1). A section of south spring tributary SS2 had a gain in flow of 0.03 ft³/s (table 2).

Low Base Flow

Discharge measurements along upper Bear Creek and its tributaries were collected during low base flow from September 9 through September 29, 1994 (table 1, plate 1). Discharge measurements along Bear Creek ranged from 0 to 0.29 ft³/s. Gaining and losing stream reaches occurred along this section of Bear Creek (table 3). Streamflow gains and losses

along Bear Creek were generally in the range of 0.01 to 0.10 ft³/s. The section of Bear Creek near NT4, NT5, and NT6 remained dry. One gaining stream reach along Bear Creek near NT8 had an increase in flow of 0.15 ft³/s.

Most sites on tributaries north of Bear Creek were dry or had flow of 0.01 ft³/s. Only one site on NT8 had a discharge of 0.02 ft³/s (table 1, plate 1). North tributaries NT1, NT4, and NT5 had gains and losses in flow of 0.01 ft³/s. North tributaries NT6 and NT8 had gains and losses of 0.02 ft³/s.

South tributaries ST1, ST2, and ST4 remained dry during low base flow and ST3 had two discharge measurements of 0.03 and 0.13 ft³/s (table 1, plate 1). Two gaining reaches occurred along ST3. The south spring tributaries SS1, SS4, and SS6 were dry. South spring tributaries SS2, SS3, and SS5 had discharges of 0.02 ft³/s, 0.01 ft³/s, and 0.10 ft³/s, respectively. A stream reach along south spring SS3 was gaining flow at 0.01 ft³/s, and SS5 was a contributing reach to Bear Creek.

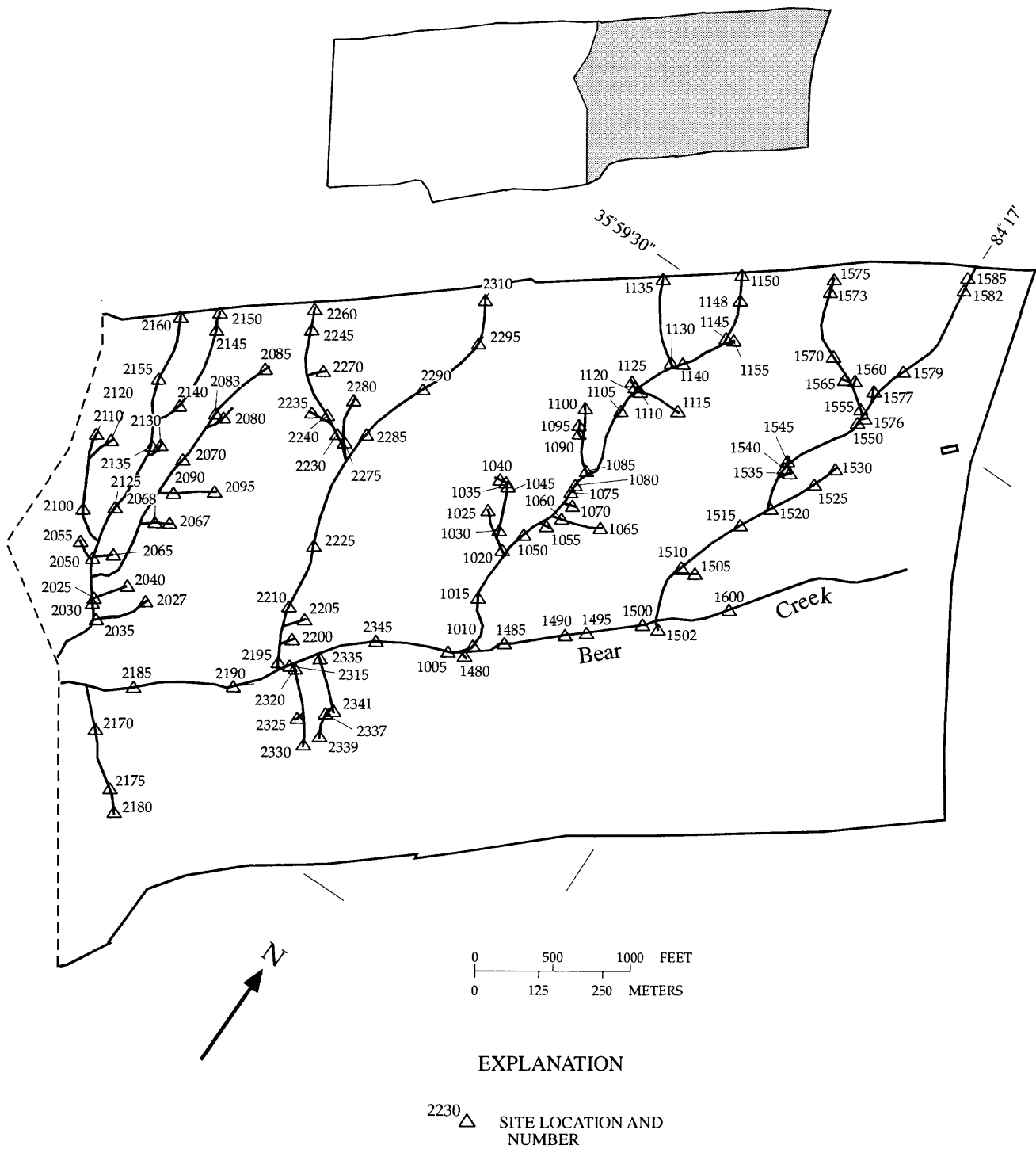


Figure 3. Location of stream sites in the study area—Continued.

Table 1. Discharge data during high base flow, March 14 through March 19, 1994, and low base flow, September 9 through September 29, 1994 at Bear Creek Valley, Oak Ridge, Tennessee

[All discharge values in cubic feet per second; HBF, high base flow; LBF, low base flow]

Site			Site			Site		
Discharge			Discharge			Discharge		
number	HBF	LBF	number	HBF	LBF	number	HBF	LBF
Bear Creek			Tributaries to NT1			North Tributary 3 (NT3)		
1490	0.01	0.00	1560	0.00	0.00	2310	0.00	0.00
1480	0.16	0.00	1555	0.04	0.00	2295	0.04	0.00
1600	0.22	0.02	1545	0.00	0.00	2290	0.05	0.00
1500	0.30	0.01	1535	0.00	0.00	2285	0.04	0.00
1495	0.31	0.02	1530	0.00	0.00	2225	0.03	0.00
3310	0.36	0.00	1525	0.01	0.00	2210	1.10	0.00
3040	0.39	0.00	1520	0.00	0.00	2195	1.16	0.00
3285	0.40	0.00	1505	0.01	0.00			
3190	0.14	0.00				Tributaries to NT3		
2345	0.44	0.02	North Tributary 2 (NT2)			2280	0.01	0.00
1485	0.44	0.04	1155	0.02	0.00	2275	0.01	0.00
3185	0.50	0.00	1140	0.03	0.00	2270	0.01	0.00
1005	0.57	0.02	1105	0.16	0.00	2260	0.00	0.00
2015	0.64	0.00	1085	0.06	0.00	2245	0.02	0.00
3170	0.64	0.00	1080	0.00	0.00	2240	0.02	0.00
3045	0.69	0.00	1075	0.15	0.00	2235	0.01	0.00
2185	0.70	0.00	1070	0.00	0.00	2230	0.03	0.00
3005	0.76	0.07	1055	0.00	0.00	2205	0.00	0.00
4630	0.79	0.07	1050	0.13	0.00	2200	0.00	0.00
4525	0.80	0.00	1015	0.15	0.00			
4520	0.89	0.00	1010	0.16	0.00	North Tributary 4 (NT4)		
2190	0.90	0.04				2135	0.07	0.00
4530	0.93	0.08	Tributaries to NT2			2125	0.04	0.00
4400	1.06	0.04	1150	0.01	0.00	2050	0.00	0.00
2315	1.08	0.00	1148	0.02	0.00	2030	0.10	0.01
4110	2.01	0.29	1145	0.03	0.00	2020	0.10	0.00
			1135	0.01	0.00			
North Tributary 1 (NT1)			1130	0.04	0.00	Tributaries to NT4		
1585	0.00	0.00	1125	0.00	0.00	2160	0.01	0.01
1582	0.03	0.00	1120	0.00	0.00	2155	0.04	0.01
1579	0.02	0.00	1115	0.00	0.00	2150	0.00	0.00
1550	0.09	0.01	1110	0.01	0.00	2145	0.00	0.00
1540	0.10	0.00	1100	0.03	0.00	2140	0.01	0.00
1515	0.13	0.01	1095	0.00	0.00	2130	0.01	0.00
1510	0.14	0.00	1090	0.00	0.00	2120	0.00	0.00
			1065	0.00	0.00	2110	0.00	0.00
Tributaries to NT1			1060	0.02	0.00	2100	0.02	0.00
1577	0.00	0.00	1045	0.01	0.00	2095	0.00	0.00
1576	0.00	0.00	1040	0.00	0.00	2090	0.00	0.00
1575	0.00	0.00	1035	0.00	0.00	2085	0.00	0.00
1573	0.00	0.00	1030	0.01	0.00	2083	0.00	0.00
1570	0.00	0.00	1025	0.01	0.00	2080	0.00	0.00
1565	0.01	0.00	1020	0.01	0.00	2070	0.00	0.00

Table 1. Discharge data during high base flow, March 14 through March 19, 1994, and low base flow, September 9 through September 29, 1994 at Bear Creek Valley, Oak Ridge, Tennessee--continued

Site			Site			Site		
Discharge			Discharge			Discharge		
number	HBF	LBF	number	HBF	LBF	number	HBF	LBF
Tributaries to NT4			North Tributary 6 (NT6)			North Tributary 8 (NT8)		
2068	0.09	0.00	3110	0.02	0.00	4480	0.04	0.01
2067	0.00	0.00	3080	0.07	0.00	4475	0.00	0.02
2065	0.01	0.00	3070	0.09	0.00	4430	0.08	0.01
2055	0.00	0.00	3060	0.01	0.00	4405	0.09	0.01
2040	0.00	0.00	3050	0.08	0.00			
2035	0.00	0.00				Tributaries to NT8		
2027	0.00	0.00	Tributaries to NT6			4505	0.00	0.00
2025	0.00	0.00	3155	0.00	0.00	4495	0.00	0.00
			3150	0.01	0.00	4490	0.01	0.00
North Tributary (NT4A)			3145	0.01	0.01	4455	0.03	0.01
2010	0.00	0.00	3140	0.00	0.00	4450	0.01	0.00
2006	0.00	0.00	3135	0.00	0.00	4445	0.00	0.00
2005	0.00	0.00	3130	0.00	0.00	4440	0.01	0.01
			3120	0.01	0.00	4435	0.04	0.00
North Tributary 5 (NT5)			3115	0.00	0.00	4425	0.00	0.00
3280	0.03	0.00	3105	0.01	0.00	4420	0.01	0.01
3275	0.03	0.01	3100	0.01	0.00	4415	0.00	0.00
3270	0.03	0.01	3095	0.01	0.00	4410	0.02	0.01
3240	0.03	0.00	3090	0.01	0.00			
3200	0.12	0.00	3085	0.00	0.00	South Tributary 1 (ST1)		
3195	0.10	0.00	3078	0.00	0.00	2180	0.00	0.00
3190	0.14	0.00	3075	0.01	0.00	2175	0.00	0.00
			3065	0.01	0.00	2170	0.00	0.00
Tributaries to NT5			3055	0.00	0.00			
3198	0.00	0.00	North Tributary 7 (NT7)			South Tributary 2 (ST2)		
3202	0.00	0.00	4620	0.02	0.00	3305	0.00	0.00
3205	0.00	0.00	4615	0.00	0.00	3300	0.00	0.00
3210	0.03	0.00	4610	0.02	0.00	3290	0.01	0.00
3215	0.00	0.00	4605	0.00	0.00			
3225	0.00	0.00	4600	0.00	0.00	Tributaries to ST2		
			4595	0.06	0.00	3295	0.00	0.00
Tributaries to NT5			4590	0.00	0.00			
3265	0.00	0.00	4585	0.00	0.00	South Tributary 3 (ST3)		
3260	0.01	0.00	4580	0.07	0.00	3035	0.01	0.00
3255	0.00	0.00	4545	0.10	0.00	3025	0.37	0.00
3250	0.01	0.00	4540	0.07	0.00	3015	0.44	0.03
3245	0.01	0.00	4535	0.06	0.00	3010	0.36	0.13
32235	0.00	0.00						
3230	0.00	0.00	North Tributary 8 (NT8)			Tributaries to ST3		
			4515	0.01	0.00	3030	0.00	0.00
North Tributary 6 (NT6)			4510	0.01	0.00	3020	0.00	0.00
3165	0.02	0.00	4500	0.02	0.00			
3160	0.02	0.01	4485	0.04	0.01	South Tributary 4 (ST4)		
3125	0.04	0.01				4125	0.00	0.00

Table 1. Discharge data during high base flow, March 14 through March 19, 1994, and low base flow, September 9 through September 29, 1994 at Bear Creek Valley, Oak Ridge, Tennessee--continued

Site number	Discharge	
	HBF	LBF
South Tributary 4 (ST4)		
4120	0.00	0.00
South Spring 1 (SS1)		
1502	0.07	0.00
South Spring 2 (SS2)		
2335	0.22	0.02
2341	0.23	0.02
Tributaries to SS2		
2337	0.06	0.00
2339	0.03	0.00
South Spring 3 (SS3)		
2320	0.17	0.01
2330	0.12	0.00
Tributaries to SS3		
2325	0.05	0.00
South Spring 4 (SS4)		
3175	0.13	0.00
3180	0.13	0.00
South Spring 5 (SS5)		
4115	0.44	0.10
South Spring 6 (SS6)		
4105	0.01	0.00

Table 2. Stream reach classification during high base flow at Bear Creek Valley, Oak Ridge, Tennessee, March 14 through March 19, 1994

[All discharge measurements in cubic feet per second]

Site		Stream reach		Change in discharge	Site		Stream reach		Change in discharge		
number		class- ification			number		class- ification				
Upstream	Downstream				Upstream	Downstream					
Bear Creek					North Tributary 1 (NT1)						
1600	1500	losing flow		-0.14	1565	--	contributing site		--		
1500	1495	no change in flow		0.00	1576	--	contributing site		--		
1495	1485	gaining flow		0.12	1577	--	contributing site		--		
1485	1005	losing flow		-0.44	1545	--	contributing site		--		
1005	2345	losing flow		-0.13	1540	--	contributing site		--		
2345	2315	gaining flow		0.25	1505	--	contributing site		--		
2315	2190	losing flow		-1.34	North Tributary 2 (NT2)						
2190	2185	losing flow		-0.20	1150	1148	gaining flow		0.01		
2185	2015	losing flow		-0.16	1148	1145	gaining flow		0.01		
2015	3310	losing flow		-0.28	1155	1140	losing flow		-0.02		
3310	3285	no change in flow		0.00	1135	1130	gaining flow		0.03		
3285	3190	losing flow		-0.26	1140	1105	gaining flow		0.08		
3190	3185	gaining flow		0.26	1115	1110	gaining flow		0.01		
3185	3175	losing flow		-0.37	1125	1120	dry		0.00		
3175	3170	gaining flow		0.38	1105	1080	losing flow		-0.22		
3170	3045	no change in flow		0.00	1100	1085	gaining flow		0.03		
3045	3040	losing flow		-0.26	1095	1090	dry		0.00		
3040	3005	no change in flow		0.00	1080	1075	gaining flow		0.15		
3005	4630	no change in flow		0.00	1075	1050	losing flow		-0.04		
4630	4530	gaining flow		0.38	1065	1060	gaining flow		0.02		
4530	4525	losing flow		-0.13	1050	1015	no change in flow		0.00		
4525	4520	gaining flow		0.09	1040	1035	dry		0.00		
4520	4400	gaining flow		0.17	1045	1030	no change in flow		0.00		
4400	4110	gaining flow		0.51	1025	1020	losing flow		-0.01		
North Tributary 1 (NT1)					1015	1010	no change in flow		0.00		
1585	1582	gaining flow		0.03	1070	--	contributing site		--		
1582	1579	losing flow		-0.01	1055	--	contributing site		--		
1579	1550	gaining flow		0.03	North Tributary 3 (NT3)						
1575	1573	dry		0.00	2310	2295	gaining flow		0.04		
1573	1570	dry		0.00	2295	2290	no change in flow		0.00		
1570	1555	gaining flow		0.03	2290	2285	no change in flow		0.00		
1550	1540	no change in flow		0.00	2285	2225	losing flow		-0.05		
1530	1525	gaining flow		0.01	2225	2210	gaining flow		1.07		
1525	1520	losing flow		-0.01	2210	2195	no change in flow		0.00		
1520	1515	gaining flow		0.03	2260	2245	gaining flow		0.02		
1515	1510	no change in flow		0.00	2245	2240	losing flow		-0.01		
1560	--	contributing site		--	2240	2230	no change in flow		0.00		

Table 2. Stream reach classification during high base flow at Bear Creek Valley, Oak Ridge, Tennessee, March 14 through March 19, 1994--continued

[All discharge measurements in cubic feet per second]

Site		Stream reach		Change in discharge	Site		Stream reach		Change in discharge		
number		class- ification	ification		number		class- ification	ification			
Upstream	Downstream				Upstream	Downstream					
North Tributary 3 (NT3)					North Tributary 5 (NT5)						
2280	2275	no change in flow	0.00		3200	3195	losing flow	-0.02			
2270	--	contributing site	--		3265	3260	dry	0.01			
2235	--	contributing site	--		3260	3255	losing flow	-0.01			
2205	--	contributing site	--		3255	3250	gaining flow	0.01			
2200	--	contributing site	--		3235	3230	dry	0.00			
North Tributary 4 (NT4)					3230	3225	dry	0.00			
2150	2145	dry	0.00		3225	3210	gaining flow	0.03			
2145	2140	gaining flow	0.01		3202	3198	dry	0.00			
2160	2155	gaining flow	0.03		3245	--	contributing site	--			
2155	2135	gaining flow	0.02		North Tributary 6 (NT6)						
2135	2125	losing flow	-0.04		3165	3160	no change in flow	0.00			
2125	2050	losing flow	-0.07		3160	3155	losing flow	-0.02			
2050	2030	no change in flow	0.00		3155	3140	losing flow	-0.01			
2030	2020	no change in flow	0.00		3140	3145	gaining flow	0.01			
2110	2100	gaining flow	0.02		3145	3120	losing flow	-0.04			
2085	2083	dry	0.00		3120	3115	losing flow	-0.01			
2083	2070	dry	0.00		3115	3110	gaining flow	0.02			
2095	2090	dry	0.00		3110	3080	gaining flow	0.05			
2067	2068	gaining flow	0.09		3080	3070	no change in flow	0.00			
2040	2035	dry	0.00		3070	3050	no change in flow	0.00			
2027	2025	dry	0.00		3100	3095	no change in flow	0.00			
2080	--	contributing site	--		3105	3095	losing flow	-0.01			
2130	--	contributing site	--		3135	3130	dry	0.00			
2120	--	contributing site	--		3130	3125	gaining flow	0.04			
2055	--	contributing site	--		3065	3060	no change in flow	0.00			
2065	--	contributing site	--		3150	--	contributing site	--			
North Tributary 4A (NT4A)					3085	--	contributing site	--			
2010	2006	dry	0.00		3078	--	contributing site	--			
2006	2005	dry	0.00		3075	--	contributing site	--			
North Tributary 5 (NT5)					3055	--	contributing site	--			
3280	3275	no change in flow	0.00		North Tributary 7 (NT7)						
3275	3270	no change in flow	0.00		4620	4610	no change in flow	0.00			
3270	3240	losing flow	-0.02		4610	4580	no change in flow	0.00			
3240	3205	losing flow	-0.06		4580	4545	gaining flow	0.03			
3205	3200	gaining flow	0.12		4545	4540	losing flow	-0.03			
					4540	4535	no change in flow	0.00			
					4600	4595	gaining flow	0.06			

Table 2. Stream reach classification during high base flow at Bear Creek Valley, Oak Ridge, Tennessee, March 14 through March 19, 1994--continued

[All discharge measurements in cubic feet per second]

Site		Stream reach		Change in discharge
number		class- ification	Change in	
Upstream	Downstream			
North Tributary 7 (NT7)				
4605	--	contributing site	--	
4585	--	contributing site	--	
4590	--	contributing site	--	
North Tributary 8 (NT8)				
4515	4510	no change in flow	0.00	
4510	4500	gaining flow	0.01	
4500	4485	no change in flow	0.00	
4485	4480	no change in flow	0.00	
4480	4435	no change in flow	0.00	
4435	4430	gaining flow	0.04	
4430	4405	no change in flow	0.00	
4455	4440	losing flow	-0.03	
4445	4450	gaining flow	0.01	
4120	4410	gaining flow	0.02	
4430	4505	no change in flow	0.00	
4490	--	contributing site	--	
4495	--	contributing site	--	
4475	--	contributing site	--	
4425	--	contributing site	--	
4415	--	contributing site	--	
South Tributary 1 (ST1)				
2180	2175	dry	0.00	
2175	2170	dry	0.00	
South Tributary 2 (ST2)				
3305	3300	dry	0.00	
3300	3290	gaining flow	0.01	
3295	--	contributing site	--	
South Tributary 3 (ST3)				
3035	3025	gaining flow	0.36	
3025	3015	gaining flow	0.07	
3015	3010	losing flow	-0.08	
3020	--	contributing site	--	
South Tributary 4 (ST4)				
4120	4125	dry	0.00	
South Spring 1 (SS1)				
1502	--	contributing site	--	

Site		Stream reach		Change in discharge
number		class- ification	Change in	
Upstream	Downstream			
South Spring 2 (SS2)				
2341	2335	no change in flow	0.00	
2339	2337	gaining flow	0.03	
South Spring 3 (SS3)				
2330	2320	no change in flow	0.00	
2335	--	contributing site	--	
South Spring 4 (SS4)				
3180	--	contributing site	--	
South Spring 5 (SS5)				
4115	--	contributing site	--	
South Spring 6 (SS6)				
4105	--	contributing site	--	

Table 3. Stream reach classification during low base flow at Bear Creek Valley, Oak Ridge, Tennessee, September 9 through September 29, 1994

[All flow measurements in cubic feet per second]

Bear Creek				North Tributary 1 (NT1)			
Site		Stream reach		Site		Stream reach	
number		class-	Change in	number		class-	Change in
Upstream	Downstream	ification	discharge	Upstream	Downstream	ification	discharge
1600	1500	losing flow	-0.01	1565	--	contributing site	--
1500	1495	gaining flow	0.01	1576	--	contributing site	--
1495	1485	gaining flow	0.02	1577	--	contributing site	--
1485	1005	losing flow	-0.02	1545	--	contributing site	--
1005	2345	no change in flow	0.00	1540	--	contributing site	--
2345	2315	losing flow	-0.05	1505	--	contributing site	--
2315	2190	gaining flow	0.04				
2190	2185	losing flow	-0.04	North Tributary 2 (NT2)			
2185	2015	dry	0.00	1150	1148	dry	0.00
2015	3310	dry	0.00	1148	1145	dry	0.00
3310	3285	dry	0.00	1155	1140	dry	0.00
3285	3190	dry	0.00	1135	1130	dry	0.00
3190	3185	dry	0.00	1140	1105	dry	0.00
3185	3175	dry	0.00	1115	1110	dry	0.00
3175	3170	dry	0.00	1125	1120	dry	0.00
3170	3045	dry	0.00	1105	1080	dry	0.00
3045	3040	dry	0.00	1100	1085	dry	0.00
3040	3005	losing flow	-0.06	1095	1090	dry	0.00
3005	4630	no change in flow	0.00	1080	1075	dry	0.00
4630	4530	no change in flow	0.01	1075	1050	dry	0.00
4530	4525	losing flow	-0.08	1065	1060	dry	0.00
4525	4520	dry	0.00	1050	1015	dry	0.00
4520	4400	gaining flow	0.03	1040	1035	dry	0.00
4400	4110	gaining flow	0.15	1045	1030	dry	0.00
North Tributary 1 (NT1)				1025	1020	dry	0.00
1585	1582	dry	0.00	1015	1010	dry	0.00
1582	1579	dry	0.00	1070	--	contributing site	--
1579	1550	no change in flow	0.00	1055	--	contributing site	--
1575	1573	dry	0.00	North Tributary 3 (NT3)			
1573	1570	dry	0.00	2310	2295	dry	0.00
1570	1555	dry	0.00	2295	2290	dry	0.00
1550	1540	losing flow	-0.01	2290	2285	dry	0.00
1530	1525	dry	0.00	2285	2225	dry	0.00
1525	1520	dry	0.00	2225	2210	dry	0.00
1520	1515	gaining flow	0.01	2210	2195	dry	0.00
1515	1510	losing flow	-0.01	2260	2245	dry	0.00
1560	--	contributing site	--	2245	2240	dry	0.00
				2240	2230	dry	0.00

Table 3. Stream reach classification during low base flow at Bear Creek Valley, Oak Ridge, Tennessee, September 9 through September 29, 1994--continued

Site		Stream reach		Change in	Site		Stream reach		Change in
number		class-ification	discharge		number		class-ification	discharge	
Upstream	Downstream				Upstream	Downstream			
North Tributary 3 (NT3)					North Tributary 5 (NT5)				
2280	2275	dry	0.00		3260	3255	dry	0.00	
2270	--	contributing site	--		3255	3250	dry	0.00	
2235	--	contributing site	--		3235	3230	dry	0.00	
2205	--	contributing site	--		3230	3225	dry	0.00	
2200	--	contributing site	--		3225	3210	dry	0.00	
North Tributary 4 (NT4)					3202	3198	dry	0.00	
2150	2145	dry	0.00		3245	--	contributing site	--	
2145	2140	dry	0.00		North Tributary 6 (NT6)				
2160	2155	no change in flow	0.00		3165	3160	gaining flow	0.01	
2155	2135	losing flow	-0.01		3160	3155	losing flow	-0.01	
2135	2125	dry	0.00		3155	3140	dry	0.00	
2125	2050	dry	0.00		3140	3145	gaining flow	0.01	
2050	2030	gaining flow	0.01		3145	3120	losing flow	-0.02	
2030	2020	losing flow	-0.01		3120	3115	dry	0.00	
2110	2100	dry	0.00		3115	3110	dry	0.00	
2085	2083	dry	0.00		3110	3080	dry	0.00	
2083	2070	dry	0.00		3080	3070	dry	0.00	
2095	2090	dry	0.00		3070	3050	dry	0.00	
2067	2068	dry	0.00		3100	3095	dry	0.00	
2040	2035	dry	0.00		3105	3095	dry	0.00	
2027	2025	dry	0.00		3135	3130	dry	0.00	
2080	--	contributing site	--		3130	3125	gaining flow	0.01	
2130	--	contributing site	--		3065	3060	dry	0.00	
2120	--	contributing site	--		3150	--	contributing site	--	
2055	--	contributing site	--		3085	--	contributing site	--	
2065	--	contributing site	--		3078	--	contributing site	--	
North Tributary 4A (NT4A)					3075	--	contributing site	--	
2010	2006	dry	0.00		3055	--	contributing site	--	
2006	2005	dry	0.00		North Tributary 7 (NT7)				
North Tributary 5					4620	4610	dry	0.00	
3280	3275	gaining flow	0.01		4610	4580	dry	0.00	
3275	3270	no change in flow	0.00		4580	4545	dry	0.00	
3270	3240	losing flow	-0.01		4545	4540	dry	0.00	
3240	3205	dry	0.00		4540	4535	dry	0.00	
3205	3200	dry	0.00		4600	4595	dry	0.00	
3200	3195	dry	0.00		4605	--	contributing site	--	
3265	3260	dry	0.00		4585	--	contributing site	--	

Table 3. Stream reach classification during low base flow at Bear Creek Valley, Oak Ridge, Tennessee, September 9 through September 29, 1994--continued

Site number		Stream reach class-	Change in
Upstream	Downstream	ification	discharge
North Tributary 7 (NT7)			
4590	--	contributing site	--
North Tributary 8 (NT8)			
4515	4510	dry	0.00
4510	4500	dry	0.00
4500	4485	gaining flow	0.01
4485	4480	no change in flow	0.00
4480	4435	losing flow	-0.02
4435	4430	losing flow	-0.01
4430	4405	losing flow	-0.01
4455	4440	no change in flow	0.00
4445	4450	dry	0.00
4420	4410	gaining flow	0.01
4430	4405	losing flow	0.01
4490	--	contributing site	--
4495	--	contributing site	--
4475	--	contributing site	--
4425	--	contributing site	--
4415	--	contributing site	--
South Tributary 1 (ST1)			
2180	2175	dry	0.00
2175	2170	dry	0.00
South Tributary 2 (ST2)			
3305	3300	dry	0.00
3300	3290	dry	0.00
2175	--	contributing site	--
South Tributary 3 (ST3)			
3035	3025	dry	0.00
3025	3015	gaining flow	0.03
3015	3010	gaining flow	0.10
3020	--	contributing site	--
South Tributary 4 (ST4)			
4120	4125	dry	0.00
South Spring 1 (SS1)			
1502	--	contributing site	--

Site number		Stream reach class-	Change in
Upstream	Downstream	ification	discharge
South Spring 2 (SS2)			
2341	2335	no change in flow	0.00
2339	2337	dry	0.00
South Spring 3 (SS3)			
2330	2320	gaining flow	0.01
2335	--	contributing site	--
South Spring 4 (SS4)			
3180	--	contributing site	--
South Spring 5 (SS5)			
4115	--	contributing site	--
South Spring 6 (SS6)			
4105	--	contributing site	--

SUMMARY

In 1995 the U.S. Geological Survey, in cooperation with the U.S. Department of Energy, began a study to delineate stream reaches that were gaining flow, losing flow, or that were dry within a 1,125-acre study area which includes the uppermost part of Bear Creek and many tributaries north and south of Bear Creek. Discharge data from a seepage investigation at Bear Creek Valley, Oak Ridge, Tennessee, are presented in this report. The classification of stream reaches are based on discharge data at 229 sites along upper Bear Creek and its tributaries. These data were collected during high base flow, from March 14 through March 19, 1994, and during low base flow, from September 9 through September 29, 1994.

To identify reaches that gain or lose flow, the following criteria were used: for streamflow of less than 0.1 cubic foot per second (ft^3/s), a change in flow of more than 25 percent of total flow was used to determine if the flow was increasing or decreasing; for streamflow equal to or greater than $0.1 \text{ ft}^3/\text{s}$, a change in flow of 10 percent was used as the criterion. If two adjacent stream measurement sites had zero flow, these stream reaches were classified as dry.

During high base flow, discharge measurements for Bear Creek ranged from 0.01 to $2.01 \text{ ft}^3/\text{s}$. Gaining and losing stream reaches occurred along Bear Creek in the range of 0.09 and $0.51 \text{ ft}^3/\text{s}$ and 0.13 to $1.34 \text{ ft}^3/\text{s}$, respectively. No dry stream reaches were observed along Bear Creek during high base flow. The discharge measurements along the north tributaries ranged from less than 0.01 to $1.16 \text{ ft}^3/\text{s}$. All tributaries north of Bear Creek had gaining and losing stream reaches. Gains in flow for the north tributaries were in

the range of 0.01 to $1.07 \text{ ft}^3/\text{s}$, and losses in flow were in the range of 0.01 to $0.22 \text{ ft}^3/\text{s}$. Discharge measurements along the south tributaries were mostly less than $0.25 \text{ ft}^3/\text{s}$, with the exception of ST3 and ST5. Dry stream reaches were observed along ST1, ST2, and ST4. The south spring tributaries, SS1 through SS6, were mostly single sites with discharge measurements in the range of 0 to $0.44 \text{ ft}^3/\text{s}$.

During low base flow, discharge measurements along Bear Creek ranged from 0.00 to $0.29 \text{ ft}^3/\text{s}$. Streamflow gains and losses along Bear Creek were generally in the range of 0.01 to $0.10 \text{ ft}^3/\text{s}$. The section of Bear Creek near NT4, NT5, and NT6 remained dry. Two stream reaches along Bear Creek near NT7 were losing flow (0.06 and $0.08 \text{ ft}^3/\text{s}$). One gaining stream reach along Bear Creek near NT8 had an increase of flow of $0.15 \text{ ft}^3/\text{s}$. Only one site in the north tributaries had a discharge of $0.02 \text{ ft}^3/\text{s}$. All other sites were dry or had a discharge of $0.01 \text{ ft}^3/\text{s}$. North tributaries NT2, NT3, and NT7 were dry. South tributaries ST1, ST2, and ST4 remained dry during low base flow, and ST3 had discharge measurements of 0.03 and $0.13 \text{ ft}^3/\text{s}$. South spring tributaries SS2, SS3, and SS5 had discharges of $0.02 \text{ ft}^3/\text{s}$, $0.01 \text{ ft}^3/\text{s}$, and $0.10 \text{ ft}^3/\text{s}$, respectively.

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