PHYSICAL AND CHEMICAL DATA FROM TWO WATER-QUALITY SURVEYS OF STREAMS IN THE LEWISVILLE LAKE WATERSHED, NORTH-CENTRAL TEXAS, 1984 AND 1985

By
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INTRODUCTION

Physical and chemical water-quality data and nitrogen and phosphorus yields for 29 sites sampled in two synoptic surveys of streams within the Lewisville Lake watershed are presented in this report. The two synoptic surveys were conducted in March 1984 and March 1985, as a reconnaissance and assessment of water quality and nitrogen and phosphorus yields throughout the watershed. This work was cooperatively funded by the city of Dallas and the U.S. Geological Survey (USGS) as part of a hydrologic study to quantify nonpoint nutrient loads to Lewisville Lake.

WATERSHED DESCRIPTION

The Lewisville Lake watershed encompasses a 1,660 mi^2 area of rolling woodland, open prairie, rangeland, and farmland in north-central Texas including parts of Denton, Wise, Montague, Cooke, Grayson, and Collin Counties (fig. 1). The economy consists of small rural communities and various kinds of agriculture and animal husbandry businesses including horse and cattle ranches; dairy, sod, and cotton farms; and numerous seed and grain crops. Most of the watershed area is sparsely populated. The cities of Denton and Gainesville are the only urban centers in the watershed and account for a relatively small part of the total area (about 20 mi^2, or 1.2 percent). Although suburban development accounts for a relatively small part of the watershed, it is progressing rapidly in some areas adjacent to the lake (especially on the east and west sides). This development causes concerns about the potential adverse impacts on the water quality of the lake.

Denton, Gainesville, and many of the small rural communities throughout the watershed operate sewage treatment facilities that discharge either directly into the lake or into streams flowing to the lake (fig. 1). The largest facilities are operated by Denton and The Colony (a community on the east side of the lake) and routinely have a discharge ranging from 3 to 10 Mgal/d. All of the other facilities in the watershed are licensed to release less than 1 Mgal/d and most release considerably less, while some operate only intermittantly.

The watershed is comprised of four physiographic/land-resource regions having distinct associations of topography, soils, vegetation, and land uses (Austin, 1965), all of which may affect the quality of water flowing to the lake. These regions are noted in figure 1 and are delineated by boundaries of the various geologic outcrops and formations with which they are commonly associated (Bureau of Economic Geology, 1967). The underlying geologic formations in this part of Texas are Cretaceous in origin, sedimentary in nature, interlayered shales, sands, and limestones, and tilted downward to the southeast. Broad physiographic belts are formed where the western-most extensions of these formations come to oblique intersections with the surface. These physiographic belts cross the watershed from north to south and effect a similar orientation of land-resource regions across the watershed.

The four land-resource regions from west to east (and geologically oldest to youngest) are: (1) The West Cross Timbers, which is underlain by the Antler sands formation of the Trinity group; (2) the Grand Prairie, which is underlain by calcareous shales and argillaceous limestones of the Fredericksburg and Washita groups; (3) the East Cross Timbers, which is underlain by sandstones of the Woodbine formation; and (4) the Texas Blackland Prairie, which is underlain by calcareous shales of the Eagle Ford formation.

Outcrops of the sandstone formations underlying the East and West Cross Timbers regions tend to form low, rolling hills marked by deeply eroded and narrow stream channels with steep banks. Soils in both regions are typically ultisols or alfisols, of loamy or sandy-loam texture, light in color, well-drained, of moderate to good permeabilities, and may vary in depth from a few inches on rock promontories to several feet in broad shallow valleys (Ford and Pauls, 1980). The natural vegetation in these regions is a scrubby woodland of post oak, blackjack oak, and mesquite marking the western extent of the eastern forests of North America and a transition to the relatively more arid upland prairies of the west. Though the soils in these regions are generally fertile, their use in mechanized agriculture is limited somewhat by the ruggedness of the terrain. Consequently, much of the land remains woodland and wooded rangeland, or is converted to fruit or nut orchards.

The limestone and calcareous shale formations underlying the Texas Blackland prairie and the Grand Prairie regions of the watershed have formed nearly level peneplanes of grasslands having dark heavy soils and few trees except those growing along typically broad, shallow stream channels. The soils are mostly deep and well-mixed mollisols or vertisols, of high base saturation and clay content, with poor drainage, and moderate to poor permeabilities (Ford and Pauls, 1980). Generally, the soils of the Texas Blackland Prairie contain more clay, are more poorly drained, and are somewhat less permeable than those of the Grand Prairie region. Most of these two regions is extensively and intensively farmed leaving little or none of the natural prairie indigenous to the area.

Lewisville Lake is formed on the Elm Fork Trinity River. About 80 percent of the watershed is drained by five streams that range in size from about 130 mi^2 to nearly 400 mi^2. The largest of these, Elm Fork Trinity River, is joined by the second largest, Clear Creek, and the third largest, Isle du Bois Creek. Hickory and Little Elm Creeks enter the lake at the Hickory Creek and Little Elm arms from the west and east, respectively. Hickory Creek drains an area that is mostly of the Grand Prairie land-resource type. Clear Creek flows from the West Cross Timbers region, across a narrow stretch of Grand Prairie and through the East Cross Timbers region. Little Elm Creek drains the Texas Blackland Prairie region, and the Elm Fork Trinity River, and Isle du Bois Creek flow from a combination of prairie and cross-timbers regions. The remaining 20 percent of the watershed is comprised of the surface area of the lake and the land immediately adjacent to the lake, which is drained by numerous small streams having drainage areas of less than about 30 mi^2. Flow in all of the five principal streams is controlled to some degree by numerous flood-retention ponds, stock tanks, and small lakes. Ray Roberts Lake (a water-supply reservior built by the U.S. Army Corps of Engineers in 1987) controls all flow in the Elm Fork Trinity River and Isle du Bois Creek watersheds above the junction of Clear Creek. Average annual precipitation in the watershed area is about 32 in. Of this amount, about 5.2 in., or 16 percent, flows out of Lewisville Lake each year.

METHODS OF INVESTIGATION

Twenty-nine sites on streams within the Lewisville Lake watershed were selected for sampling (table 1). Included in the selection were sites on the headwaters and main stem of each of the major tributaries to the lake as well as a number of sites on some of the smaller tributaries draining directly into the lake. All of the sites were located at bridges or low-water crossings. Several sites were located at existing USGS steam-gaging stations where historical records of discharge and water quality were available.

For purposes of this report, each site is identified by a two-character alphanumeric symbol (fig. 1, table 1). The first character is a letter denoting the watershed. For example, "H" designates a sample site on Hickory Creek. The second character is a number indicating the downstream order of each site relative to other sites in the same principal drainage area. The number "1" identifies the upstream-most site or a site on the upstream-most tributary within each of the principal drainage areas. In table 1 a lower-case alphabetic character noted to the right of the drainage area for each of the sites indicates the dependence or independence of each site from others in the same principal drainage area. If two sites have a character in common, they also have some part of their drainage area above the sites in common. Eight of the 29 sites were located downstream from other sampling sites; thus they were not independent of one or more of the other sampling sites.

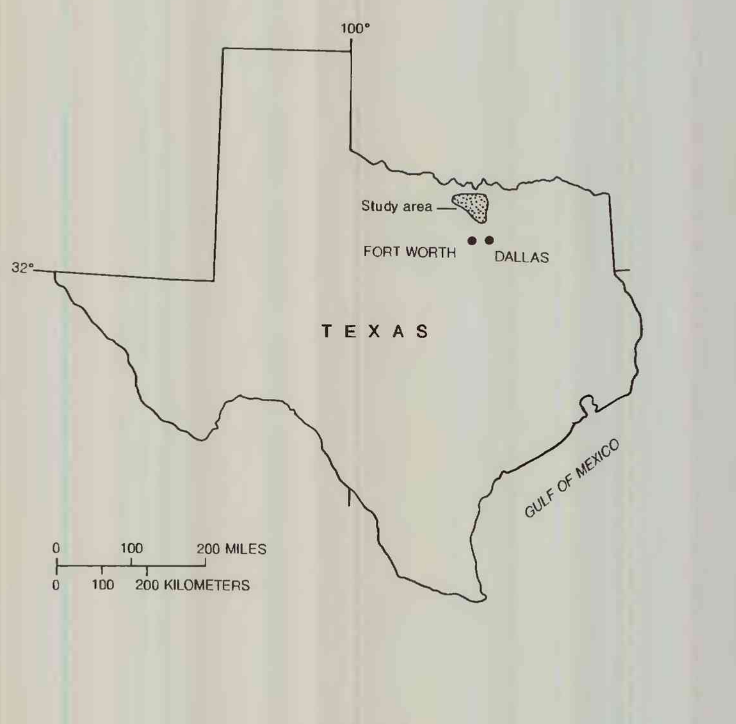
The objective in the selection of the dates for the surveys was to sample the streams during relatively high- and low-flow conditions. A comparison of discharges during the two surveys to flow duration curves (fig. 2) and daily discharge hydrographs (fig. 3) for three sites with historical discharge data, shows that flows during the low-flow survey were relatively high compared to long-term flow-duration characteristics and the range of flows experienced during the two study periods. This selection was necessary because of the problems inherent in synoptically sampling streams of very different drainage areas and hydrologic response characteristics. When larger streams are at low flow, for example, many of the smaller streams are dry. Sampling high-flow conditions on many of the smaller streams was also a problem because the high flow was associated with runoff, and its duration was too short to make synoptic sampling practicable. Flow at some sites was lower during the high-flow survey than during the low-flow survey. Consequently, for the purposes of this report, the terms "high flow" and "low flow" are intented to describe the results of the two surveys as relative to one another and may not be representative of high-flow or low-flow conditions for all sites compared to long-term flow-duration characteristics.

Each of the surveys was completed in one day. Discharge, specific conductance, pH, temperature, and dissolved oxygen were measured in the field and samples for analyses of nitrogen, phosphorus, and organic carbon were collected using standard USGS methods (Guy and Norman, 1970; Rantz and others, 1982). Immediately after collection, all samples were chilled and remained on ice until analyzed. Samples for nutrient analyses were also preserved by the addition of mercuric chloride salt. The Geological Survey Central Laboratory performed analyses for total organic carbon, nitrite plus nitrate, total Kjeldahl nitrogen, and total phosphorus using standard methods (Skougstad and others, 1979).

METRIC CONVERSIONS

The inch-pound units of measurements used in this report may be converted to metric (International System) units by using the following conversion factors:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.4	millimeter
square mile (mi^2)	2.590	square kilometer
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
cubic feet per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]
pounds per day per square mile [$(lbs/d)/mi^2$]	1.75135	kilograms per day per square kilometer [$(k/d)/km^2$]



LOCATION MAP

PHYSICAL AND CHEMICAL DATA

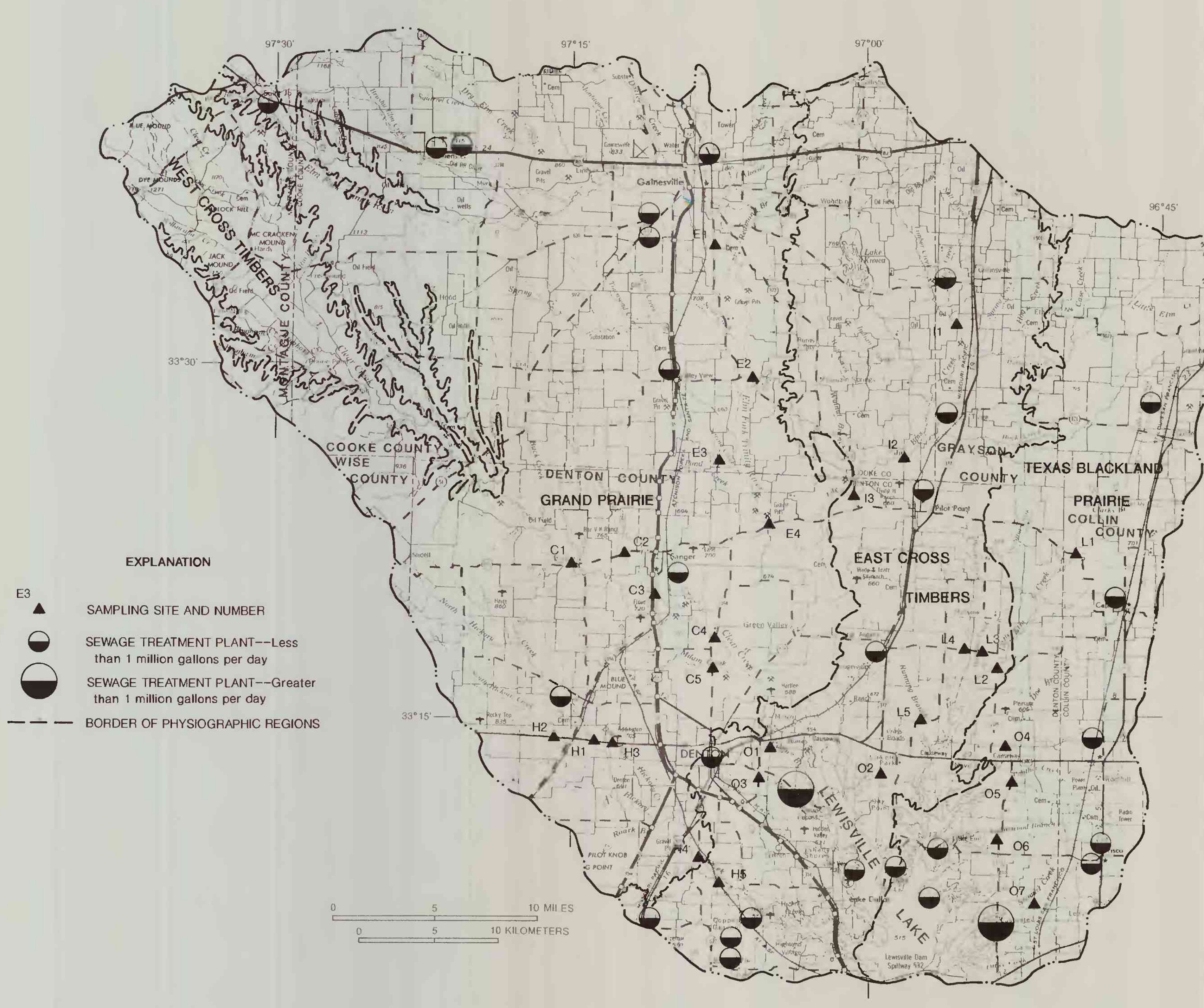


Figure 1.--Lewisville Lake watershed with sewage treatment plants, physiographic/land resources regions, and synoptic survey sites.

Table 1.-- Synoptic survey sites

[mi^2, square miles]

Site identi-fication	Name or location (USGS station number)	Drain-age area (mi^2)	Common drainage area within each watershed 1/	Latitude	Longitude
Hickory Creek watershed:					
H1	North Hickory Creek at U.S. Hwy. 380	39.4	a	33°13'58"	97°13'50"
H2	South Hickory Creek at U.S. Hwy. 380	20.1	b	33°14'09"	97°15'53"
H3	Dry Fork Hickory Creek at U.S. Hwy. 380	4.13	c	33°13'53"	97°13'00"
H4	Hickory Creek at Denton (08052780)	129.	abc	33°09'05"	97°08'29"
H5	Fincher Branch at county road	5.62	d	33°07'50"	97°07'35"
Clear Creek watershed:					
C1	Clear Creek at Farm Road 455	257	a	33°21'30"	97°15'01"
C2	Duck Creek at Farm Road 455	31.4	b	33°21'59"	97°12'13"
C3	Clear Creek near Sanger, Tx. (08051500)	295	ab	33°20'09"	97°10'41"
C4	Clear Creek at Farm Road 2164	323	ab	33°18'21"	97°07'44"
C5	Milam Creek at Farm Road 2164	12.4	c	33°17'05"	97°07'52"
Elm Fork Trinity River watershed:					
E1	Elm Fork Trinity River at Farm Road 2071	182	a	33°34'55"	97°07'48"
E2	Elm Fork Trinity River at Farm Road 922	265	a	33°29'18"	97°05'47"
E3	Spring Creek at county road	71.1	b	33°25'53"	97°07'32"
E4	Elm Fork Trinity River near Sanger (08050500)	381	ab	33°23'10"	97°05'06"
Isle du Bois Creek watershed:					
I1	Jordan Creek at county road	65.3	a	33°31'33"	96°55'28"
I2	Isle du Bois Creek at county road	205	a	33°25'55"	96°58'10"
I3	Isle du Bois Creek near Pilot Point (08051000)	266	a	33°24'24"	97°00'45"
Little Elm Creek watershed:					
L1	Little Elm Creek at Farm Road 455	46.7	a	33°21'54"	96°49'22"
L2	Little Elm Creek near Aubrey (08052700)	75.5	a	33°17'00"	96°53'32"
L3	Mustang Creek at Farm Road 428	22.2	b	33°17'46"	96°54'17"
L4	Pecan Creek near Aubrey (08052730)	32.2	c	33°17'51"	96°55'05"
L5	Running Branch at Farm Road 2931	2.79	d	33°14'53"	96°57'19"
Other streams flowing directly to Lake Lewisville:					
O1	Cooper Creek at county road	6.66	a	33°13'41"	97°04'54"
O2	Alyne Branch at Farm Road 424	7.02	b	33°12'29"	96°59'26"
O3	Pecan Creek at Farm Road 288	12.3	c	33°12'24"	97°05'00"
O4	Button Branch at county road	14.8	d	33°13'49"	96°52'55"
O5	Panther Creek at Farm Road 423	20.3	e	33°12'23"	96°52'48"
O6	Cottonwood Branch at Farm Road 423	9.45	f	33°09'53"	96°53'26"
O7	Stewart Creek at county road	8.73	g	33°07'12"	96°51'35"

1/ Indicates the independence of sites within each watershed (ie. sites having a letter in common have some drainage area in common).

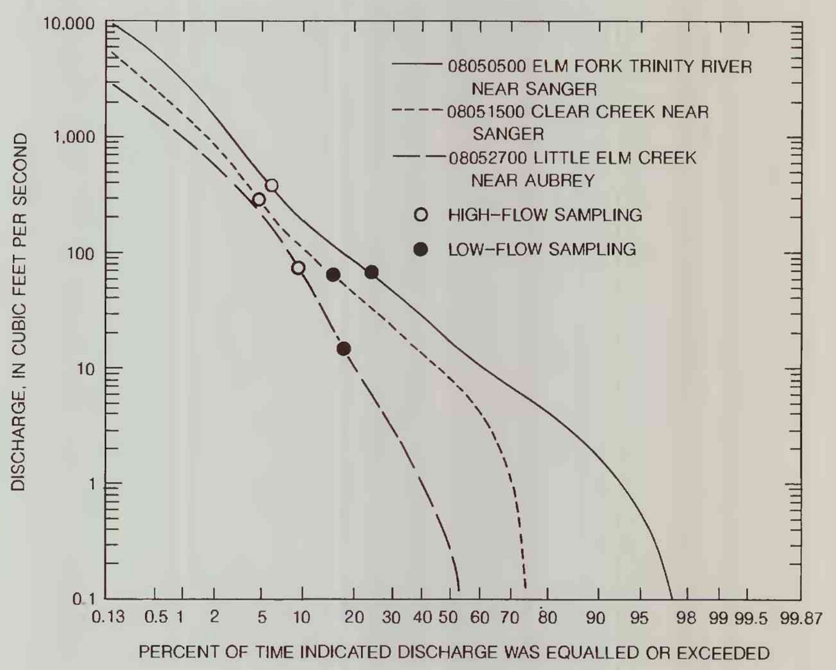


Figure 2.--Relation of discharges at three stream-gaging stations during each synoptic survey to long-term flow duration curves.

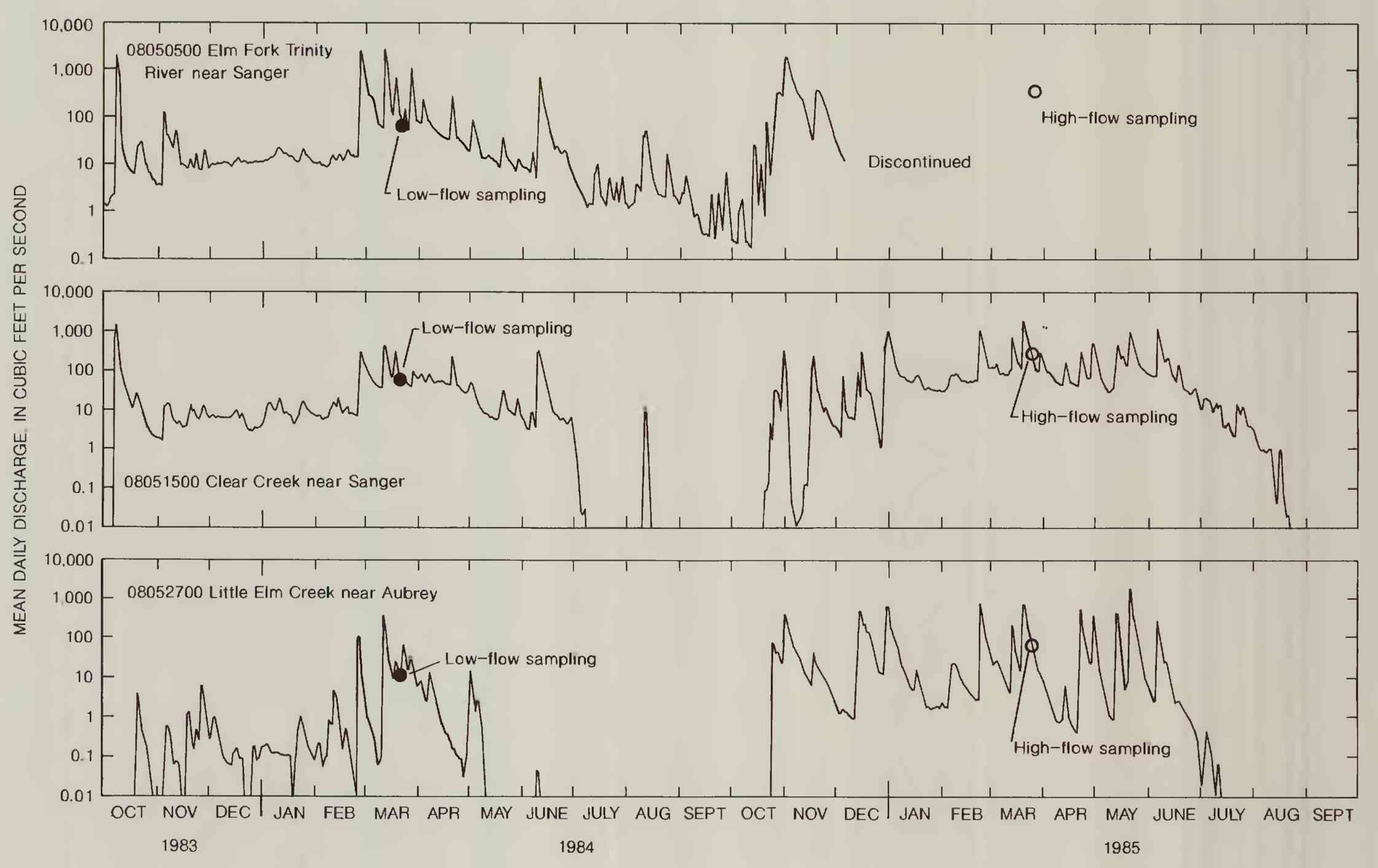


Figure 3.--Hydrographs for water-years 1984 and 1985 at three stream-gaging stations.

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