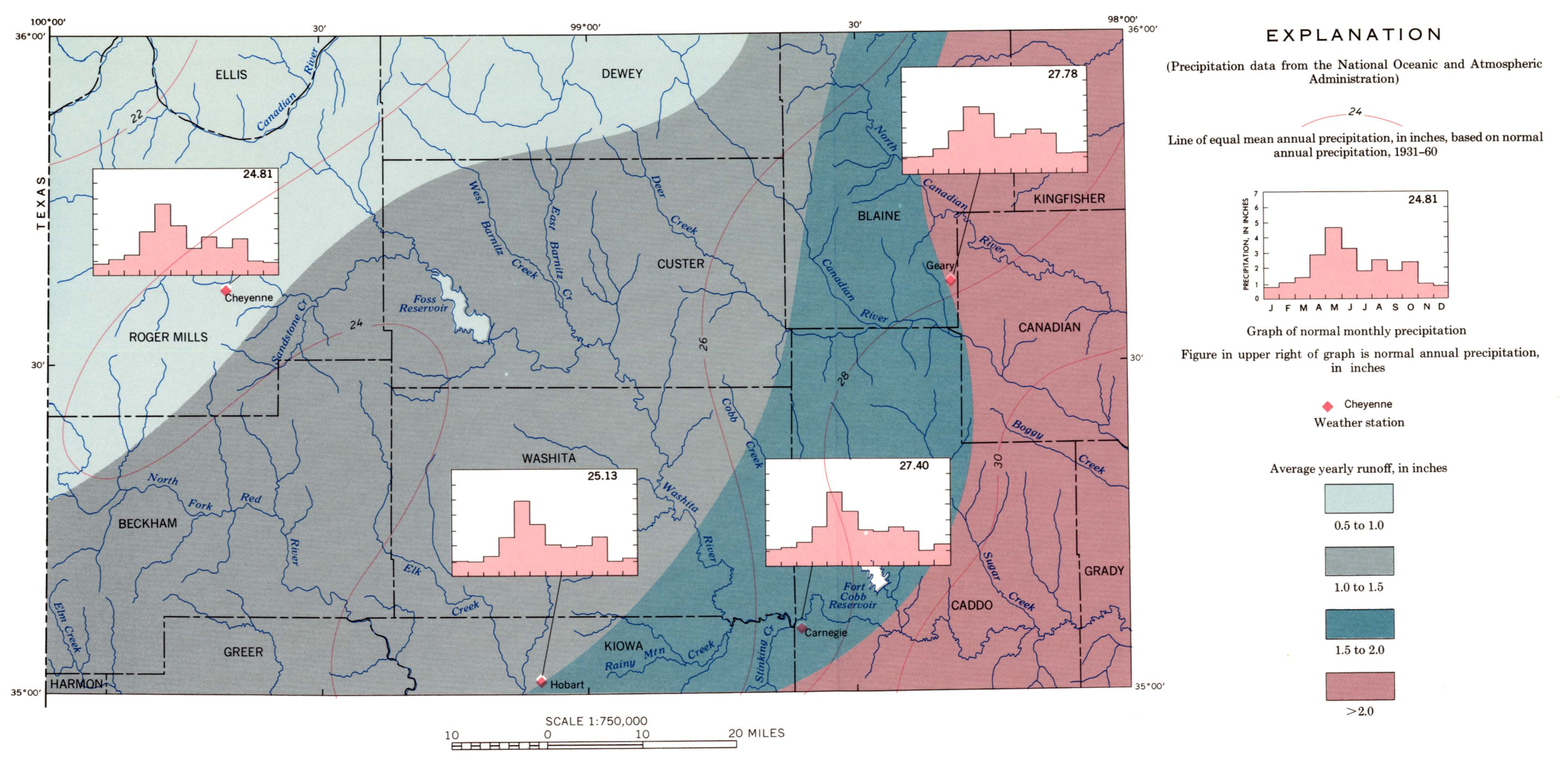

Figure 7. Map showing distribution of precipitation and runoff.

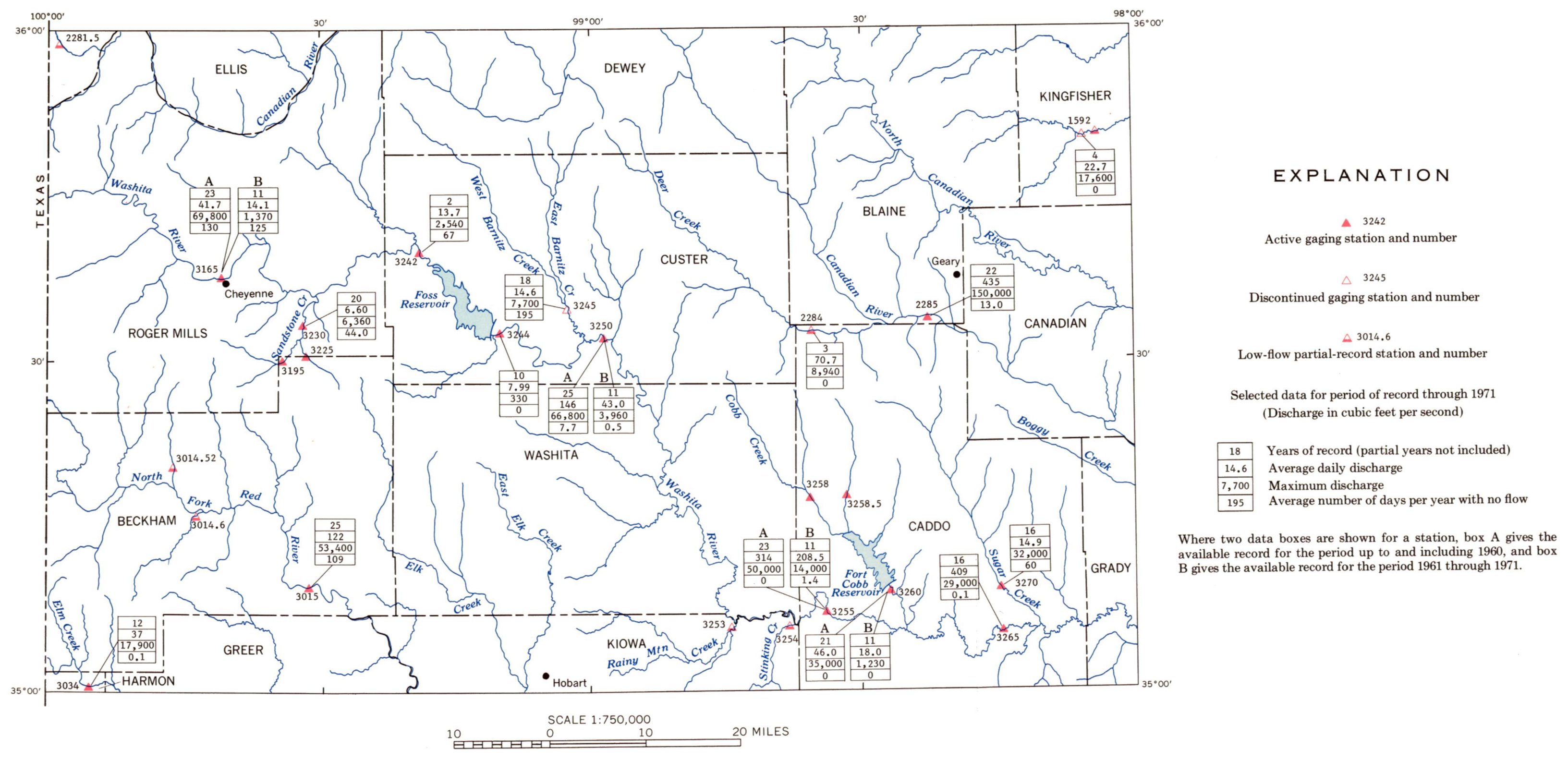

Figure 8. Map showing location of stream-gaging stations and citing selected streamflow data.

Table 1. — Surface-Water Stations in the Clinton Quadrangle

Station number[1]	Stream name and station location	Period of record (calendar years)
	Daily gaging stations	
7-1592	Kingfisher Creek near Kingfisher	1966-70
2284	Deer Creek at Hydro	1960-63
2285	Canadian River at Bridgeport	1944-64, 1970-
3015	North Fork Red River near Carter	1944-62, 1964
3034	Elm Fork of North Fork Red River near Carl	1959-
3165	Washita River near Cheyenne	1937-
3195	Sandstone Creek near Berlin	1952-
3225	East Branch Sandstone Creek near Elk City	1951-
3230	Sandstone Creek near Cheyenne	1951-
3242	Washita River near Hammon	1970-
3244	Washita River near Foss	1956-57, 1961-
3245	Barnitz Creek near Arapaho	1945-63
3250	Washita River near Clinton	1935-
3255	Washita River at Carnegie	1937-
3258	Cobb Creek near Eakly	1968
3258.5	Lake Creek near Eakly	1970-
3260	Cobb Creek near Fort Cobb (published as "Pond Creek near Ft. Cobb" prior to 1960)	1939-
3265	Washita River at Anadarko	1902-08, 1935-37, 1963-
3270	Sugar Creek near Gracemont	1955-
	Low-flow partial-record stations	
7-1592	Kingfisher Creek near Kingfisher	1971-
2281.5	Commission Creek near Grand	1965-66
2284	Deer Creek at Hydro (published as "Deer Creek near Hydro" prior to 1960)	1951-59, 1964-
3014.52	Starvation Creek near Prentiss	1965-
3014.6	Turkey Creek near Sayre	1965-
3253	Rainy Mountain Creek near Mountain View	1951-55, 1958-59, 1961
3254	Stinking Creek near Carnegie	1951-55, 1958-61

[1] From USGS national system of downstream order numbers.

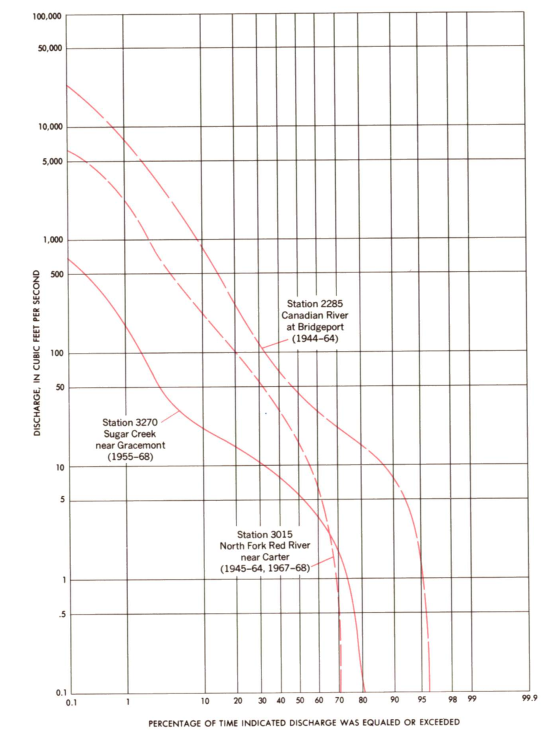

Figure 9. Flow-duration curves for selected streams.

PHYSIOGRAPHY AND CLIMATE

The Clinton quadrangle encompasses the red-bed plains of west-central Oklahoma. The predominant topography consists of rolling plains, moderate valley slopes, and upland slopes of 2 to 20 percent. Landforms range from sand dunes and steep-sloped cuestas in the northwest to narrow box canyons along streams in the east-central and southwestern parts of the region. The climate is semiarid, and the region is subject to long- and short-term droughts. The four seasons are distinct and are approximately of equal duration. Average temperatures range from about 38°F in January and February to above 80°F in July and August. Dry dusty winds and long periods of low humidity can occur almost any time of the year. The average annual lake evaporation varies from about 62 inches per year in the east to about 64 inches per year in the west.

AVAILABILITY OF SURFACE WATER

The mean annual precipitation in the Clinton quadrangle ranges from about 22 inches in the west to about 30 inches in the east (fig. 7). Monthly precipitation totals vary seasonally; the wettest period is normally during May and June, and the driest period normally occurs in the late fall and winter months. Often, significant rainfall occurs during intense but short-lived thunderstorms that are associated with squall-line activities ahead of fronts. These storms are common in the spring, less frequent during summer and early fall, and seldom occur in the winter.

Most precipitation never becomes surface runoff, because a large percentage of the precipitation is intercepted by evaporation and vegetation or is temporarily stored in local depressions. The intensity and frequency of storm occurrences influence the percentage of runoff that occurs from a given storm. Average annual runoff in the Clinton quadrangle ranges from about 0.75 inch per year (about 3.4 percent of average annual rainfall) in the west to 2.4 inches per year (about 8.3 percent of average annual rainfall) in the east (fig. 7).

Streamflow

Streamflow discharge is seasonal and correlates closely with the annual distribution of precipitation. Streamflow data are available for 19 gaging stations and 7 low-flow partial-record sites in the Clinton quadrangle (fig. 8). Prior to 1961, records of streamflow and major-reservoir contents were published in an annual series of U.S. Geological Survey Water-Supply Papers, *Surface Water Supply of the United States*. The records for Oklahoma are contained in part 7 of that series. The records for the 5-year period 1961-65 are contained in a 2-volume publication of the same series. Beginning with the 1961 water year, the U.S. Geological Survey has also published streamflow records separately for each state and released them through their district offices, primarily for local use.

Table 1 lists the names, locations, station numbers, and periods of published record available in the Water-Supply Papers for the daily-gaging stations and low-flow partial-record stations in the Clinton quadrangle.

Periods of no flow occur each year in every major stream in the quadrangle except for the lower half of the Washita River. A few secondary tributaries that drain areas of the Elk City Sandstone, Rush Springs Sandstone, Ogallala Formation, and terrace deposits have perennial base runoff most years. This runoff is related to the geology within each stream basin, because ground water is the source of base flow, and the volume of runoff is related to ground-water levels. Base runoff increases as ground-water levels rise and decreases as levels decline. Where ground-water levels decline below the stream bed, stream water may seep into the underlying rocks, thereby reducing or eliminating streamflow.

Flow-duration curves for three selected streams in the Clinton quadrangle show variations in streamflow that are typical of the region (fig. 9). These curves show the percentage of time that a given flow can be expected to be equaled or exceeded. For example, the flow of the Canadian River near Bridgeport equaled or exceeded 43 cfs (cubic feet per second) 50 percent of the time during 1944-64. The curve also shows that the flow was less than 0.1 cfs about 4 percent of the time.

Since about 1960, small reservoirs and ponds in and adjacent to the Clinton quadrangle have reduced the magnitude and frequency of high flows in all streams but the North Fork of the Red River. Figures 10 and 11 illustrate the decrease in the average monthly distribution of streamflow, using the Washita River at points near Cheyenne and near Carnegie as examples. When streamflow for the Washita River near Cheyenne during the period 1961-71 is compared to that of the 1938-60 period, a reduction of more than 60 percent is noted; near Carnegie, streamflow dropped almost 35 percent. In contrast, the average annual rainfall at Cheyenne from 1961-71 was only about 12 percent less than it was during the earlier period. Irrigation wells have been developed in the alluvium above the Cheyenne gaging station, and they may affect the base-flow distribution, but the extent of their effect has not been determined.

Lakes and Flood-Detention Reservoirs

The primary function of flood-detention reservoirs is the regulation of surface runoff to control flooding (and its attendant damage to agricultural and civic works downstream) and to reduce sediment loads in stream waters. Providing public recreational opportunities and wildlife habitats are secondary but important benefits to reservoir construction.

From 1952 to January 1972, 476 flood-detention reservoirs were completed in the Washita River basin by the U.S. Soil Conservation Service (fig. 12). Reservoirs regulate runoff from about 40 percent of the Washita River basin, which drains about 45 percent of the quadrangle. They have a cumulative storage capacity of 136,000 acre-feet of sediment and water and an additional cumulative capacity to regulate about 266,000 acre-feet of storm runoff. About 98 square miles of drainage area in the Timber Creek and Upper Elk Creek watersheds in the North Fork of the Red River basin is regulated by 23 flood-detention reservoirs. These reservoirs have a cumulative capacity for permanent storage of 4,500 acre-feet of sediment and water and an additional capacity to regulate 17,000 acre-feet of storm runoff (table 2).

Two major reservoirs, Foss and Fort Cobb, were built in the Washita basin by the U.S. Bureau of Reclamation to provide storage for irrigation, recreation, municipal, and flood-control water (fig. 12). Fort Cobb Reservoir was completed in 1959, and Foss Reservoir was completed in 1961. The 2 reservoirs have a combined storage capacity of about 336,000 acre-feet of water and a capacity to control about 244,000 acre-feet of flood water (table 2). High mineralization of the impounded water in Foss Reservoir makes it unsuitable as a municipal water supply, but the water is used for irrigation.

CHEMICAL QUALITY OF SURFACE WATER

Geology, streamflow characteristics, and man's activities all affect the chemical quality of surface water. However, in the Clinton quadrangle, chemical quality depends mostly on the abundance, solubility, and kinds of minerals making up the rocks in a stream basin, plus the variability of streamflow. Low population density, light industrialization, and an agricultural-based economy have minimized man's effect on surface-water quality in the quadrangle, although during low-flow periods discharge of municipal and industrial wastes may be a minor source of mineralization in a few streams.

Data collected and published by the U.S. Geological Survey provide a general description of the chemical quality of surface water at selected sites in the Clinton quadrangle. From 1941 through 1965, data were published in an annual series of Water-Supply Papers entitled *Quality of Surface Waters in the United States*. Records for Oklahoma are in part 7 of the series. Beginning with the 1965 water year, water-quality data have also been published in a series of annual releases on a state-by-state basis. Chemical-quality data given in these reports include information about concentrations of certain dissolved constituents, such as sodium, calcium, sulfate, and chloride, and characteristics such as hardness, sodium-adsorption ratio, specific conductance, and pH. Data on fluvial sediment and water temperature are also included in these reports. Fluvial-sediment information is given for suspended-sediment discharges and for particle-size distribution of suspended sediment and bed material. Water-temperature data are given only for daily observations.

The suitability of surface water for municipal supply and irrigation and the location of water-quality sampling stations are shown in figures 13 and 14. Determination of the suitability is based on chemical-quality characteristics during periods of low streamflow. A list of surface-water-quality stations and a record of the sampling period appear in table 3.

High mineralization makes water from most streams in the quadrangle unsuitable for municipal use during low-flow periods (fig. 13). Gypsum and halite from natural sources are the principal causes of mineralization. Within the Washita River basin, concentrations of sulfate generally are above 250 mg/l (milligrams per liter), and they sometimes exceed 2,000 mg/l in some streams. Also, chloride concentrations in Rainy Mountain and Stinking Creeks generally exceed the U.S. Public Health Service drinking-water standards of 250 mg/l. Water in the North Canadian River usually contains approximately equal concentrations of chloride and sulfate. In the Canadian River, sulfate concentrations generally are higher than chloride concentrations. In the North Fork of the Red River, chloride concentrations usually exceed recommended drinking-water standards. Stream water in the Elm Fork of the North Fork of the Red River is highly mineralized because of salt-water inflow from natural springs.

As figure 14 shows, water from many streams in the Clinton quadrangle is suitable for irrigation, providing good irrigation practices are followed. A summary of water quality as it relates to agriculture is contained in *Report of the Committee on Water-Quality Criteria*, released by the U.S. Federal Water Pollution Control Administration (1968, p. 144-184).

WATER USE

The amount of water used in the Clinton quadrangle during 1971 for municipal, industrial, rural-domestic, and irrigation purposes is estimated at 36 billion gallons, or about 110,000 acre-feet. Irrigation accounted for 33.2 billion gallons; municipal and industrial demand accounted for 1.8 billion gallons; and rural-domestic use accounted for about 1.0 billion gallons.

Ground water is the major source of water used in the quadrangle. Ground-water withdrawal for irrigation amounted to 28.9 billion gallons, or 87 percent of the total irrigation water used. More than 75 percent, 1.4 billion gallons, of the water used for municipal and industrial purposes was taken from ground-water sources. Rural-domestic use accounted for withdrawal of an additional 1.0 billion gallons of ground water.

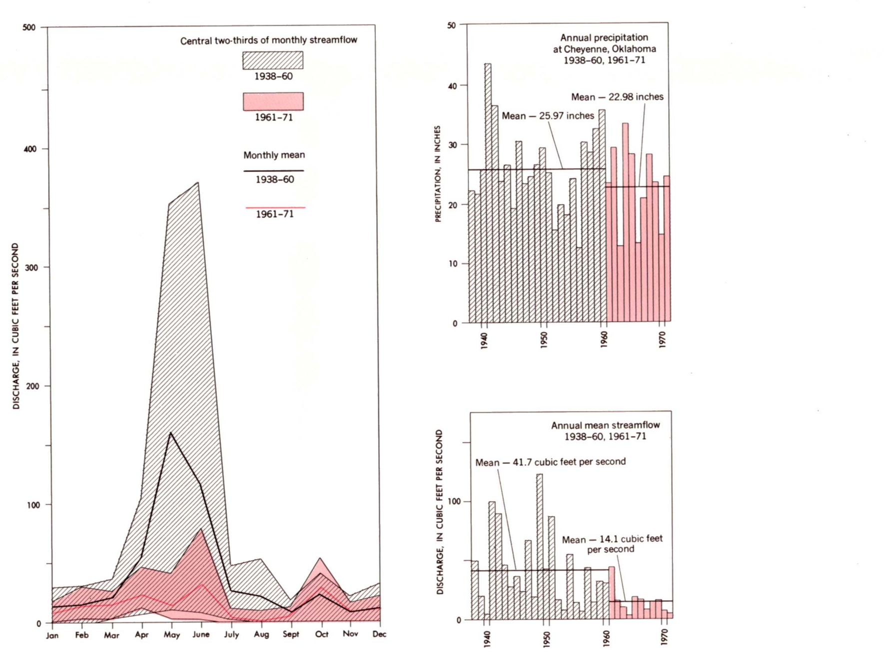

Figure 10. Streamflow distribution of Washita River near Cheyenne.

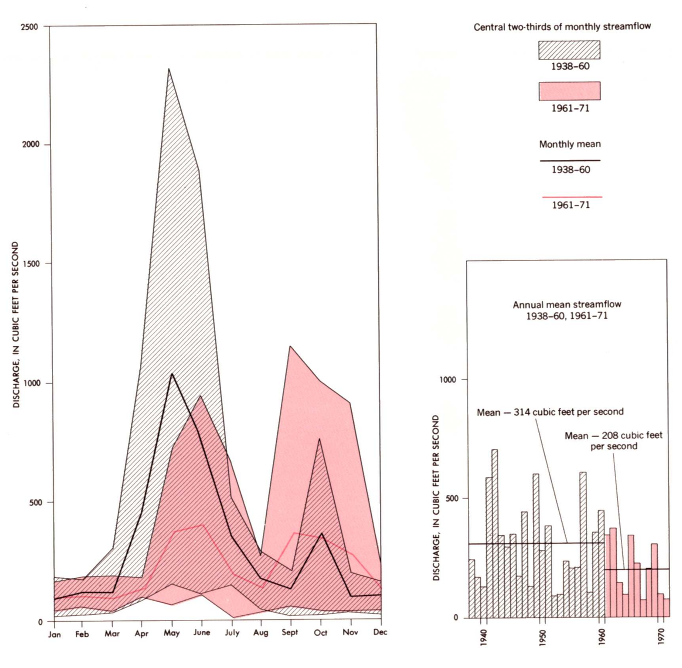

Figure 11. Streamflow distribution of Washita River near Carnegie.

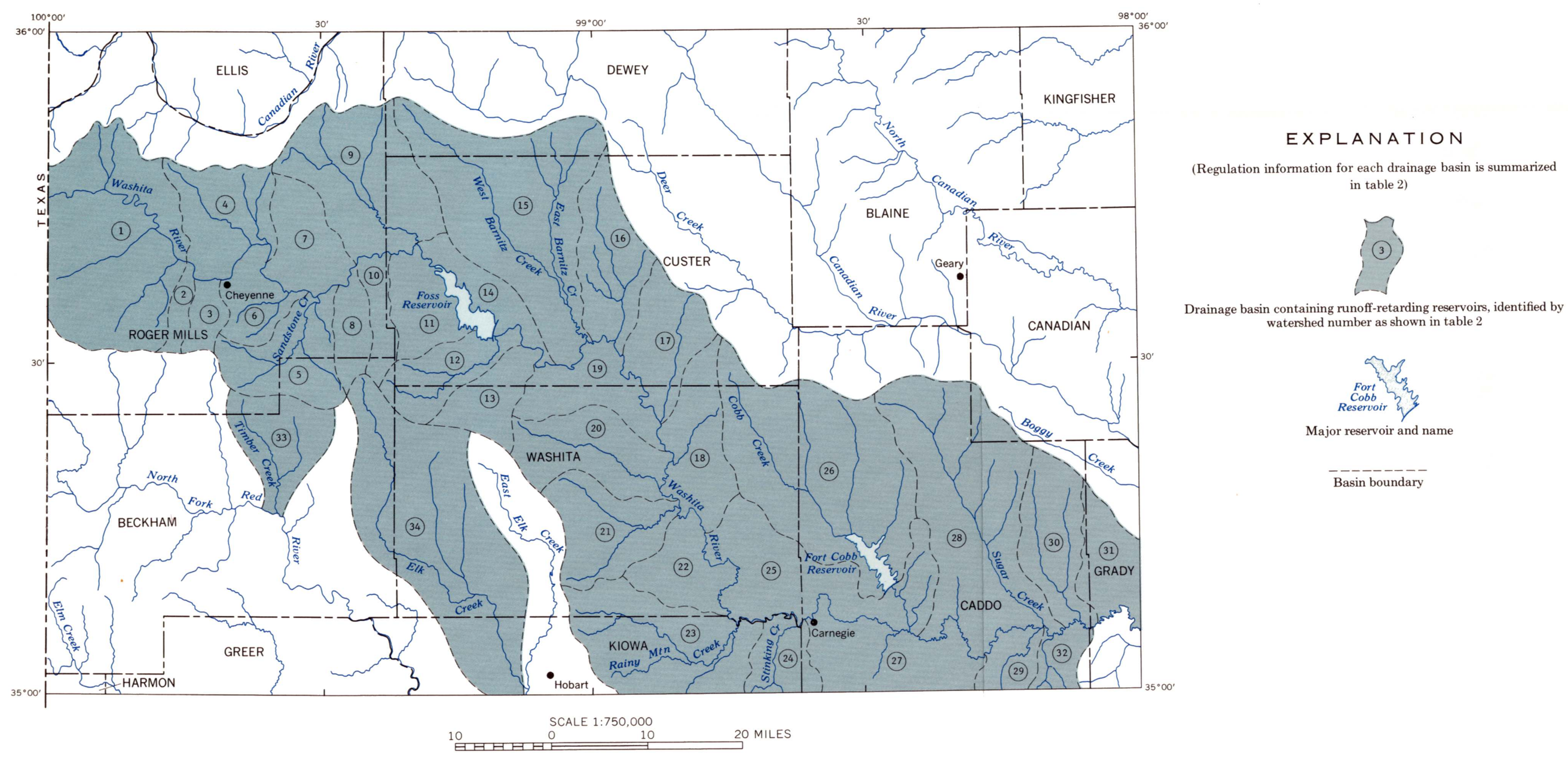

Figure 12. Map showing location of regulated tributaries and major reservoirs.

Table 2. — Reservoirs in the Clinton Quadrangle

Major Reservoirs

Station number	Reservoir	Maximum capacity (acre-feet)	Extremes of storage: Maximum content (acre-feet)	Date	Minimum content[1] (acre-feet)	Date
7-3243	Foss Reservoir	436,500	121,800	5/30/70	---	---
3259	Fort Cobb Reservoir	143,700	102,600	9/26/65	60,500	5/30/71

[1] Minimum since conservation pool was first filled.

Floodwater-Retarding Reservoirs[1]

Watershed number	Watershed name	Number of floodwater retarding structures	Year of completion[2]	Drainage area of watershed (square miles)	Drainage area regulated by structure (square miles)	Combined capacity at crest of principal spillway (acre-feet)	Total surface area at crest of principal spillway (acres)	Combined capacity at crest of emergency spillway (acre-feet)	Total surface area at crest of emergency spillway (acres)
	Washita River Basin								
1	Upper Washita River[3]	32	1964	275	180.39	8,889	839	30,300	2,202
2	Broken Leg Creek	3	1963	16.4	9.96	751	72	2,426	185
3	Sergeant Major Creek	6	1963	30.8	17.15	1,170	116	4,321	285
4	Dead Indian-Wildhorse Creeks	11	1964	101.35	62.20	4,448	404	14,985	1,028
5	Sandstone Creek	24	1952	107	72.46	7,217	655	24,631	1,622
6	Beaver Dam Creek	6	1970	43.16	17.78	1,583	185	4,342	375
7	Nine Mile Creek	18	1964	84.87	39.21	2,884	364	9,695	862
8	Big Kiowa Creek	6	1965	40.50	18.95	1,188	142	4,462	386
9	Quartermaster Creek	36	1962	192.78	104.10	5,956	730	23,150	1,964
	Planned	37	---	---	105.37	6,044	743	23,434	1,992
10	White Shield Creek	18	1964	27.16	11.34	718	123	2,943	346
	Planned	20	---	---	12.21	775	137	3,168	380
11	Panther Creek	6	1958	73.82	14.18	817	124	3,438	332
12	Soldier Creek	12	1970	69.92	39.68	2,664	285	9,379	808
13	Turkey Creek	12	1960	73.94	47.52	3,958	414	11,792	992
14	Butler laterals	5	1970	73.62	6.28	308	45	1,290	142
	Planned	8	---	---	11.45	551	83	2,325	252
15	Barnitz Creek	69	1959	279.18	150.42	14,491	1,728	41,612	3,745
	Planned	70	---	---	151.81	14,576	1,742	41,931	3,780
16	Beaver Creek	15	1968	88.45	53.08	3,760	438	13,209	1,162
	Planned	16	---	---	54.89	3,884	455	13,653	1,212
17	Bear Creek	7	1970	83.76	10.07	768	86	2,880	252
	Planned	10	---	---	55.17	2,686	232	11,805	777
18	Gyp Creek	0	---	112.23	---	---	---	---	---
	Planned	2	---	---	18.50	438	44	3,419	233
19	South Clinton laterals	10	1970	79.40	15.44	1,446	191	4,018	438
	Planned	17	---	---	31.50	2,537	330	7,586	804
20	Boggy Creek	36	1967	115.69	70.88	6,054	748	18,569	1,880
21	Cavalry Creek	29	1959	109.30	52.61	4,757	615	14,913	1,434
	Planned	31	---	---	56.74	5,189	682	16,005	1,561
22	Oak Creek	11	1969	72.49	34.54	2,588	299	9,839	750
23	Rainy Mountain Creek[4]	25	1969	328.06	93.29	4,032	672	21,245	2,287
	Planned	41	---	---	219.29	9,454	1,720	49,573	5,470
24	Saddle Mountain Creek[4]	7	1960	113.16	40.14	1,083	209	9,974	970
	Planned	14	---	---	54.10	1,598	294	13,623	1,321
25	Cowden laterals	5	---	127.94	7.62	446	56	1,993	175
	Planned	14	---	---	66.52	2,662	289	16,494	1,108
26	Cobb Creek (includes Fast Runner Creek)	10	1959	335.78	55.70	4,213	409	19,568	1,122
	Planned	12	---	---	108.18	6,446	683	30,527	2,055
27	Fort Cobb laterals[4]	0	---	121.13	---	---	---	---	---
	Planned	13	---	---	63.09	2,357	340	14,005	1,227
28	Sugar Creek	44	---	295.43	135.60	7,480	1,000	32,567	2,751
	Planned	46	---	---	142.52	7,892	1,068	34,331	2,914
29	Tonkawa Creek[4]	12	1970	47.9	18.72	1,336	145	4,879	536
30	Spring Creek[5]	1	1960	83.58	71.70	40,985	2,192	59,761	2,683
	Planned	2	---	---	72.50	41,035	2,200	59,987	2,706
31	Ionine Creek[4]	0	---	85.19	---	---	---	---	---
	Planned	17	---	---	31.42	2,336	393	8,980	1,061
32	Delaware Creek[4]	0	---	57.6	---	---	---	---	---
	Planned	4	---	---	31.37	2,081	256	10,958	791
	TOTAL COMPLETED	476	---	---	1,450.01	135,990	13,286	402,181	31,714
	TOTAL PLANNED	569	---	---	1,930.25	158,088	16,483	514,862	41,887
	North Fork Red River Basin								
33	Timber Creek	7	1963	65.16	44.6	975	163	9,262	779
34	Upper Elk Creek	16	1970	388	53.75	3,522	452	12,240	1,134
	Planned	47	---	---	213.95	9,340	1,487	41,796	4,182
	TOTAL COMPLETED	23	---	---	98.35	4,497	615	21,502	1,913
	TOTAL PLANNED	54	---	---	258.55	10,315	1,650	51,058	4,961

[1] Summary as of 1-1-72; data provided by U.S. Department of Agriculture Soil Conservation Service.
[2] Completion date of last floodwater-retarding reservoir constructed; further erosion control, land-treatment and planned reservoirs are still pending completion.
[3] Summary does not include about 385 square miles of drainage area in the State of Texas, in which 38 floodwater-retarding structures regulate 303 square miles.
[4] Includes watershed area outside quadrangle boundary.
[5] Includes 36,985 acre-feet of storage for municipal water supply.

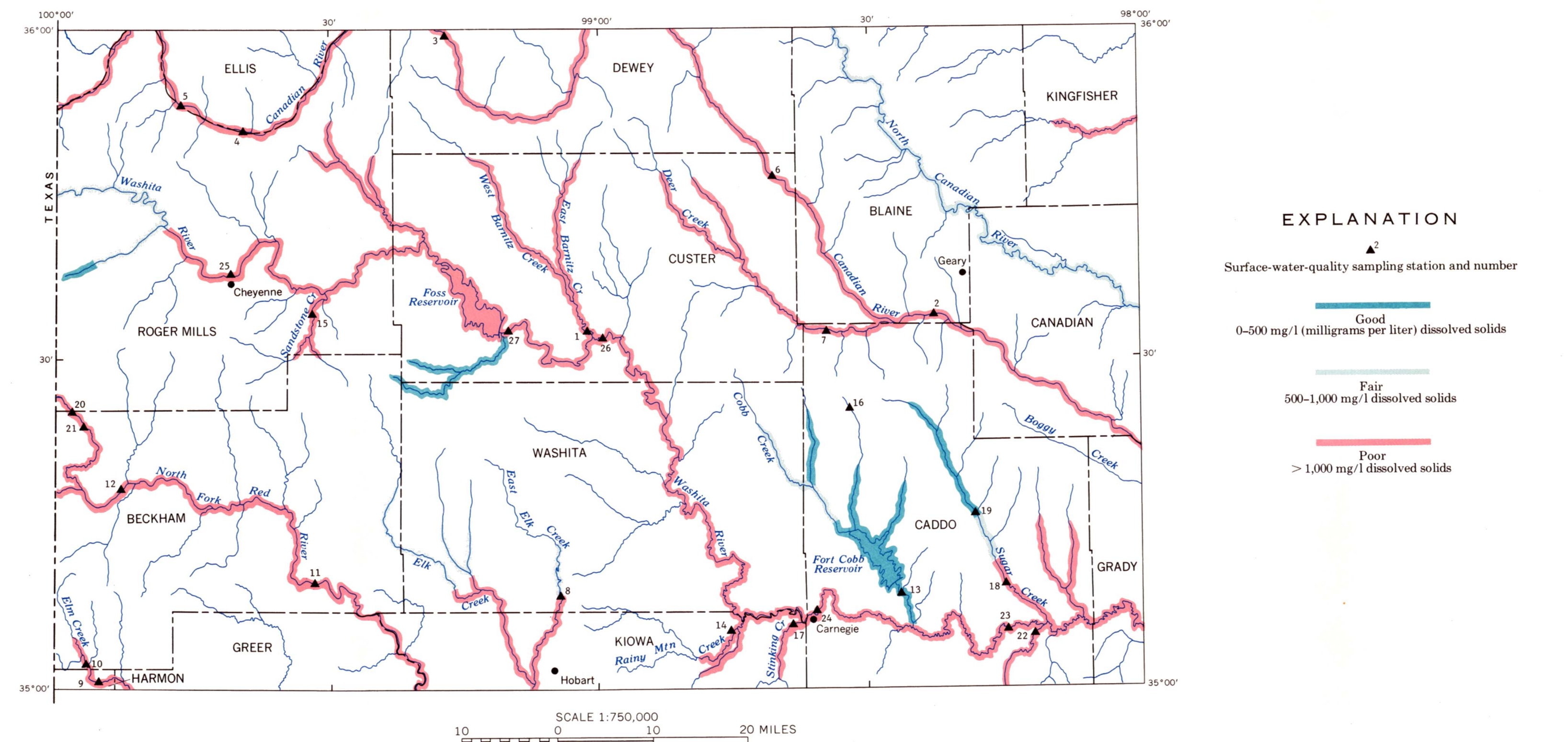

Figure 13. Map showing location of surface-water-quality sampling stations and suitability of surface water for municipal use (based on amounts of dissolved solids).

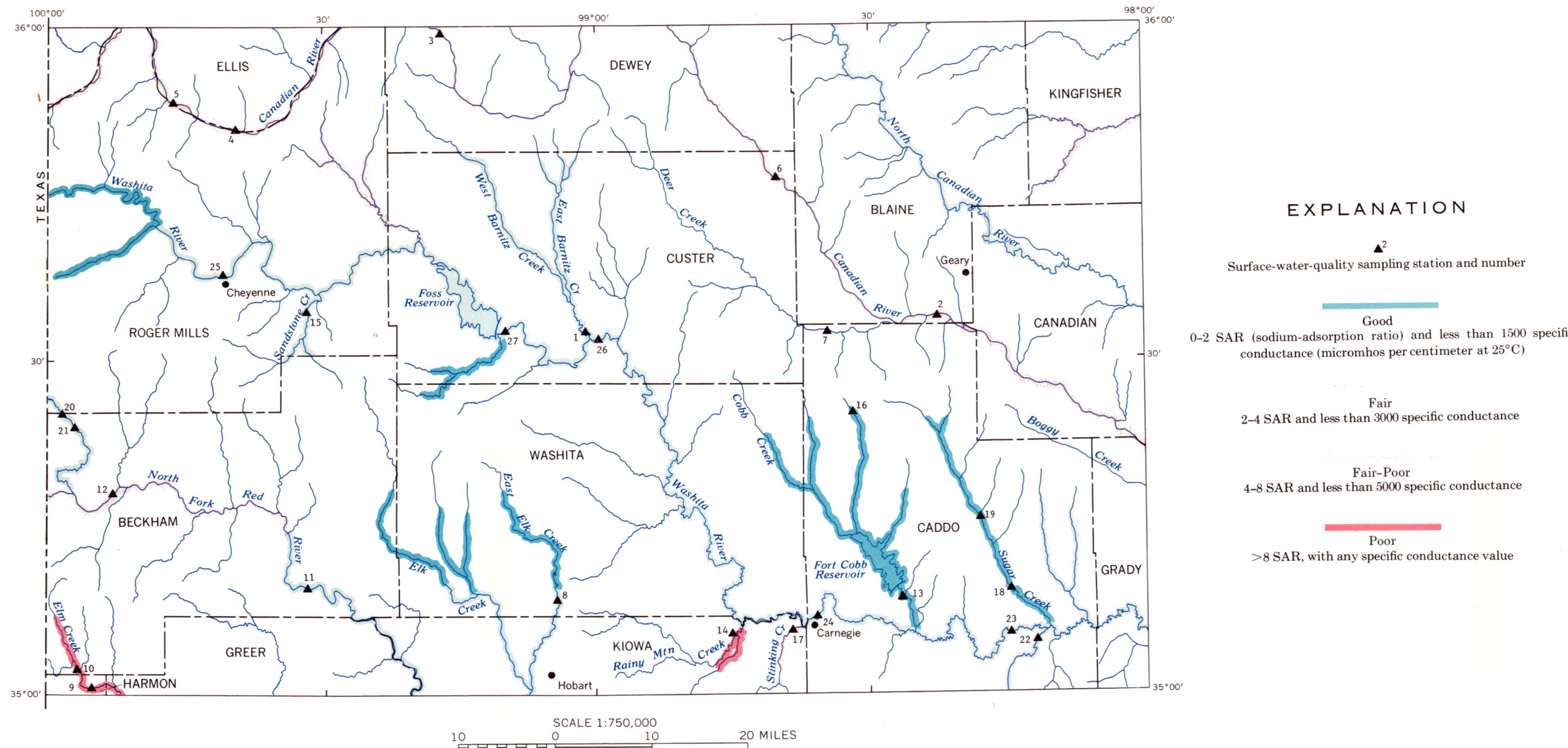

Figure 14. Map showing location of surface-water-quality sampling stations and suitability of surface water for irrigation (based on sodium-adsorption ratio and specific conductance).

Table 3. — Surface-Water-Quality Sampling Stations in the Clinton Quadrangle

Location number	Stream name and station location	Frequency of sampling: water year: number of analyses (given in parentheses[1])
1	Barnitz Creek near Arapaho	1952(4), 1955(1)
2	Canadian River at Bridgeport	1949-60(D), 1961(4), 1964(7)
3	Canadian River near Camargo	1952(1), 1953(3)
4	Canadian River near Cheyenne	1950(2), 1951(4)
5	Canadian River near Roll	1952(1), 1953(2), 1962(8), 1963(8)
6	Canadian River near Thomas	1952(1), 1953(2), 1961-63(D)
7	Deer Creek at Hydro (published as "Deer Creek near Hydro" prior to 1960)	1951(1), 1952(9), 1953(12), 1954(11), 1955(10), 1956(2), 1957(6), 1958(4), 1960(5), 1961(26), 1962(15), 1963(26)
8	East Elk Creek near Rocky	1961(2)
9	Elm Fork of North Fork Red River near Carl	1960(7), 1961(3), 1962(10), 1963(7), 1968(13)
10	Elm Fork of North Fork Red River at Salton crossing	1960(4), 1961(3)
11	North Fork Red River near Carter	1949(1), 1950(2), 1951(4), 1958(3), 1959(3), 1960(6), 1961(3), 1962(10), 1963(6), 1968(11)
12	North Fork Red River near Erick	1952(2), 1960(10), 1962(10), 1963(9)
13	Cobb Creek near Fort Cobb (published as "Pond Creek near Ft. Cobb" prior to 1960)	1947(12), 1948(12), 1950(2), 1951(5), 1952(9), 1953(6), 1954(9), 1955(8), 1956(8), 1957(7), 1958(3), 1960(6), 1963(18)
14	Rainy Mountain Creek near Mountain View	1952(5), 1953(3), 1954(7), 1955(2), 1958(4)
15	Sandstone Creek near Cheyenne	1951(1), 1952(3), 1957(4), 1958(4)
16	Spring Creek near Eakly	1961(4)
17	Stinking Creek near Carnegie	1952(4), 1953(4), 1954(7), 1955(2), 1958(7)
18	Sugar Creek near Anadarko	1949(1), 1950(3), 1951(3), 1952(5), 1953(5), 1954(8), 1955(4)
19	Sugar Creek near Gracemont	1956(7), 1957(3), 1958(3), 1959(3), 1960(2)
20	Sweetwater Creek near Texas line	1953(2), 1954(2)
21	Sweetwater Creek near Sweetwater	1952(4)
22	Tonkawa Creek near Anadarko	1968(D)
23	Washita River at Anadarko	1952(1), 1955(1), 1965-68(D)
24	Washita River at Carnegie	1948(2), 1949(3), 1950(2), 1951(4), 1952(6), 1953(6), 1954(1), 1955-68(D)
25	Washita River near Cheyenne	1950(2), 1951(5), 1952(4), 1953(4), 1960(2), 1961(10)
26	Washita River near Clinton	1953(1), 1958(3), 1960(2), 1961(5), 1962(2), 1963(10)
27	Washita River near Foss	1950(2), 1951(4), 1956(2), 1958(3)

[1] D, daily.

RECONNAISSANCE OF THE WATER RESOURCES OF THE CLINTON QUADRANGLE, WEST-CENTRAL OKLAHOMA

By
Jerry E. Carr and DeRoy L. Bergman
U.S. Geological Survey

1976

Cartographic preparation by Oklahoma Geological Survey