WATER RESOURCES ON AND NEAR INDIAN LANDS IN NORTHEASTERN KANSAS AND SOUTHEASTERN NEBRASKA--STUDY DESCRIPTION

by Thomas J. Trombley and Joan F. Kenny

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CONVERSION FACTORS

Multiply	*By*	*To obtain*
mile	1.609	kilometer
square mile	2.590	square kilometer
acre	4,047	square meter
cubic foot per second	0.02832	cubic meter per second
acre-foot per year	1,233	cubic meter per year

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ABSTRACT

In October 1988, the U.S. Geological Survey began a 5-year study to evaluate the water resources in a 4,005-square-mile area of northeastern Kansas and southeastern Nebraska. Surface-water availability will be evaluated by estimating selected low-flow durations and frequencies at streamflow-gaging stations with 10 or more years of continuous records and by estimating the total reservoir-storage requirements to sustain flow in small drainage basins. Surface-water quality will be evaluated using graphs and statistical summaries of physical properties, inorganic and organic constituents, and fecal-indicator-bacteria concentrations.

Ground-water availability will be evaluated by defining aquifer geometry using information from about 1,800 wells. The results of aquifer tests will be used to estimate hydraulic properties of the aquifers. Ground-water quality will be evaluated using data from about 550 wells.

A general appraisal of the adequacy of water supplies in the study area to meet current demands will be made by comparing low flows with reported surface-water use and well yields with reported ground-water use. Nonpermitted diversions in the study area will be estimated using per-capita-consumption coefficients.

INTRODUCTION

Background

Increasing demand for and degradation of water supplies has increased concern about water-resource issues during the past few years. As a result, the Iowa Tribe of Kansas and Nebraska, the Kickapoo Tribe of Kansas, the Prairie Band of Potawatomi, and the Sac and Fox Tribe of Missouri are interested in developing the water resources in and around their respective treaty lands. Therefore, in October 1988, the U.S. Geological Survey, in cooperation with the U.S. Bureau of Indian Affairs and the four tribes, began a 5-year study to evaluate the water resources in an area of northeastern Kansas and southeastern Nebraska that includes the treaty lands of the four tribes. Information for the study will be useful to the Bureau of Indian Affairs, the tribes, and other Federal and State agencies involved in water-rights and water-management issues.

Purpose and Scope

This report presents a description of the 5-year study to assess the water resources in areas of northeastern Kansas and southeastern Nebraska that are of interest to the Iowa, Kickapoo, Potawatomi, and Sac and Fox Tribes. The primary objectives of the study are to describe and evaluate surface- and ground-water resources and water use in the study area. The objectives of the study are to be accomplished by: (1) compilation and analysis of available water data; (2) mapping of physical and hydrologic features in the study area, such as geology, soils, land use, surface drainage, aquifer boundaries, and location of current (1989-90) water appropriations using geographic information system (GIS) technology (the GIS maps or coverages will be used for grouping water data for further comparison and analysis); (3) defining of the flow and water quality in streams; and (4) defining water availability and quality in aquifers. Supplemental data, such as streamflow measurements, water-quality sampling, aquifer tests, and well inventories will be collected only as need and as funding permits.

DESCRIPTION OF STUDY AREA

The study-area boundaries (fig. 1), with the exception of the northern boundary (a township line), consist of hydrologic boundaries that include the treaty lands for the four Indian tribes. The 4,005-square-mile study area is drained by two river systems. The Big Nemaha and Wolf Rivers are part of the Missouri River

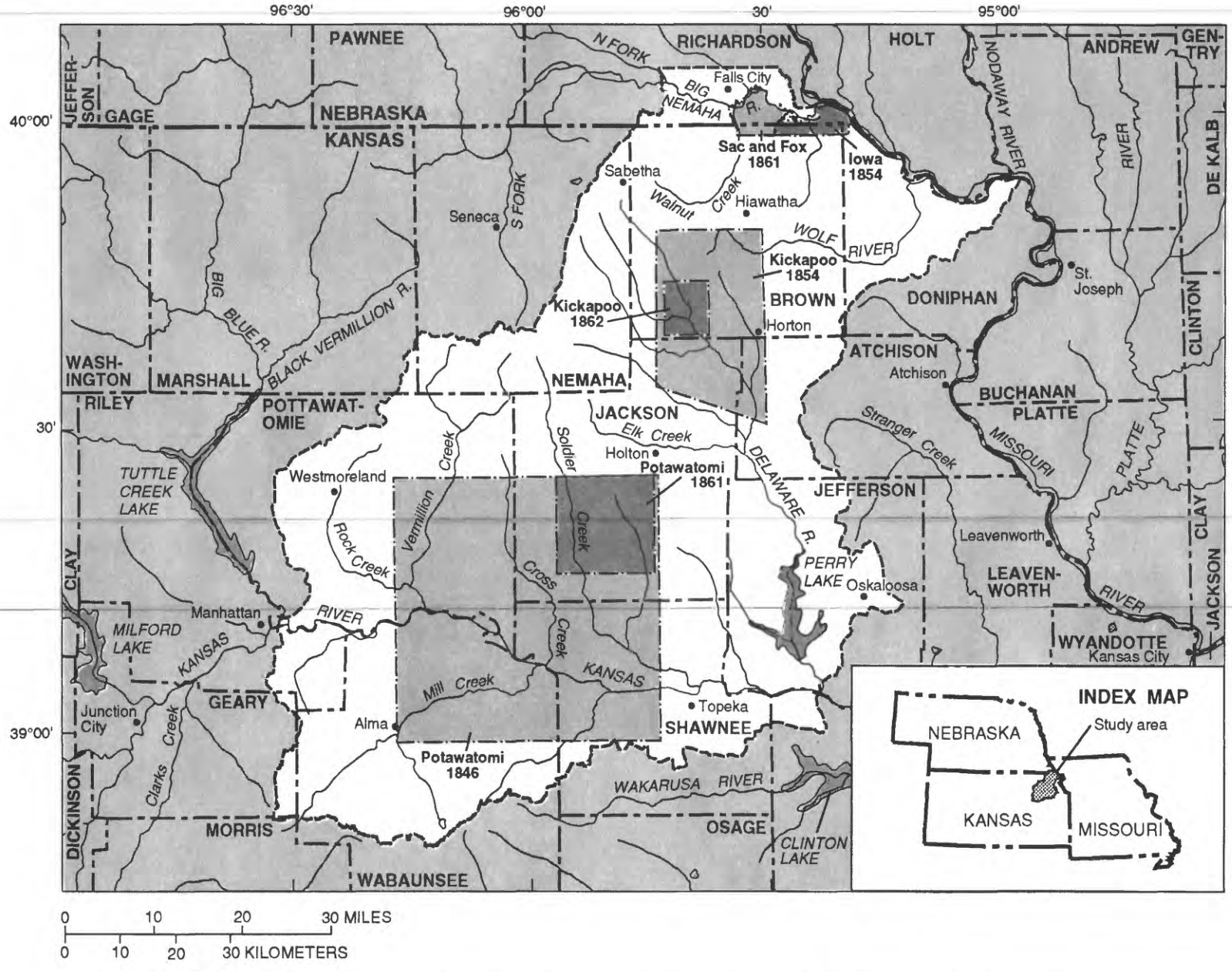

Figure 1. Location of study area and extent of Iowa, Kickapoo, Potawatomi, and Sac and Fox treaty lands.

basin. Vermillion Creek, Mill Creek, Soldier Creek, and the Delaware River are part of the Kansas River basin.

Geology

The study area is underlain primarily by Permian and Pennsylvanian rocks (Merriam, 1963) composed of interbedded limestone and shale. These rocks are overlain with glacial till, loess, and lacustrian and fluvial sediments. The pre-glacial drainage system was filled during glacial times with glacial deposits consisting mainly of basal gravel overlain by a complex of clay, silt, sand, and gravel that varies both vertically and laterally within short distances (Sinclair and others, 1990). Maps will be produced using GIS technology at a scale of 1:100,000 to show bedrock geology based on the 1:500,000-scale geologic map of Kansas (Kansas Geological Survey, 1964) and published geologic and geohydrologic maps (see Selected References). Surficial geology will be mapped using data obtained from the Kansas Geological Survey.

Climate

Variations in temperature and precipitation are primary indicators of climate. An evaluation of 30 years (1960-89) of monthly climatological data for Horton, Topeka, and the northeast Kansas climatic division of the National Oceanic and Atmospheric Administration will be used to summarize these variations within the study area. The location of the Horton and Topeka precipitation stations is shown in figure 2.

SURFACE-WATER RESOURCES

Two basic questions need to be addressed when evaluating water resources--first, "How does the quantity of water vary with location and time?" and, second, "How do the pertinent characteristics of water quality vary with location and time?"

Quantity

To evaluate surface-water quantity, it is necessary to know how much water is available without impoundments (lakes and ponds), how much is available with impoundments, and how much the availability changes with time. Of primary interest in this study is the availability of surface water during periods of low streamflow when demand is more likely to exceed supply; therefore, flooding and flood-related data will not be considered.

Water availability without impoundments will be evaluated using streamflow-gaging stations with 10 or more years of daily discharge records (fig. 2, table 1) to estimate selected low-flow durations and frequencies. At selected ungaged sites, water availability without impoundments will be estimated by interpolating streamflow discharge between two gaging stations or extrapolating upstream and downstream from a gaging-station site. At ungaged sites along Soldier Creek, Walnut Creek, and the Delaware River, far from a gaging station, several methods requiring low-flow discharge measurements will be investigated. Water availability with impoundments will be evaluated using the methods of a study by Carswell (1982) to estimate the total storage requirements to sustain gross reservoir outflow from small drainage basins.

Flow trends will be estimated using daily and monthly streamflow at selected stations to illustrate the temporal distribution of streamflow, indicating periods of critically low flow. Multiple regressions or nonparametric statistical tests will be used to estimate long-term trends in streamflow at selected sites.

Quality

Several aspects of surface-water quality need to be examined. Analysis of physical properties and inorganic constituents from historical data for about 90 sampling sites will be used to determine characteristics of the water and to indicate possible water-quality changes. These properties and constituents will include specific conductance, pH, dissolved-solids concentrations, and concentrations of calcium, magnesium, sodium, sulfate, chloride, nutrients (nitrate and ammonia), and metals (iron, manganese, and nickel). Analysis of organic-constituent concentrations in surface water will be used to indicate various types of contamination and will include total organic carbon, pesticides (such as atrazine and alachlor), and solvents (such as benzene).

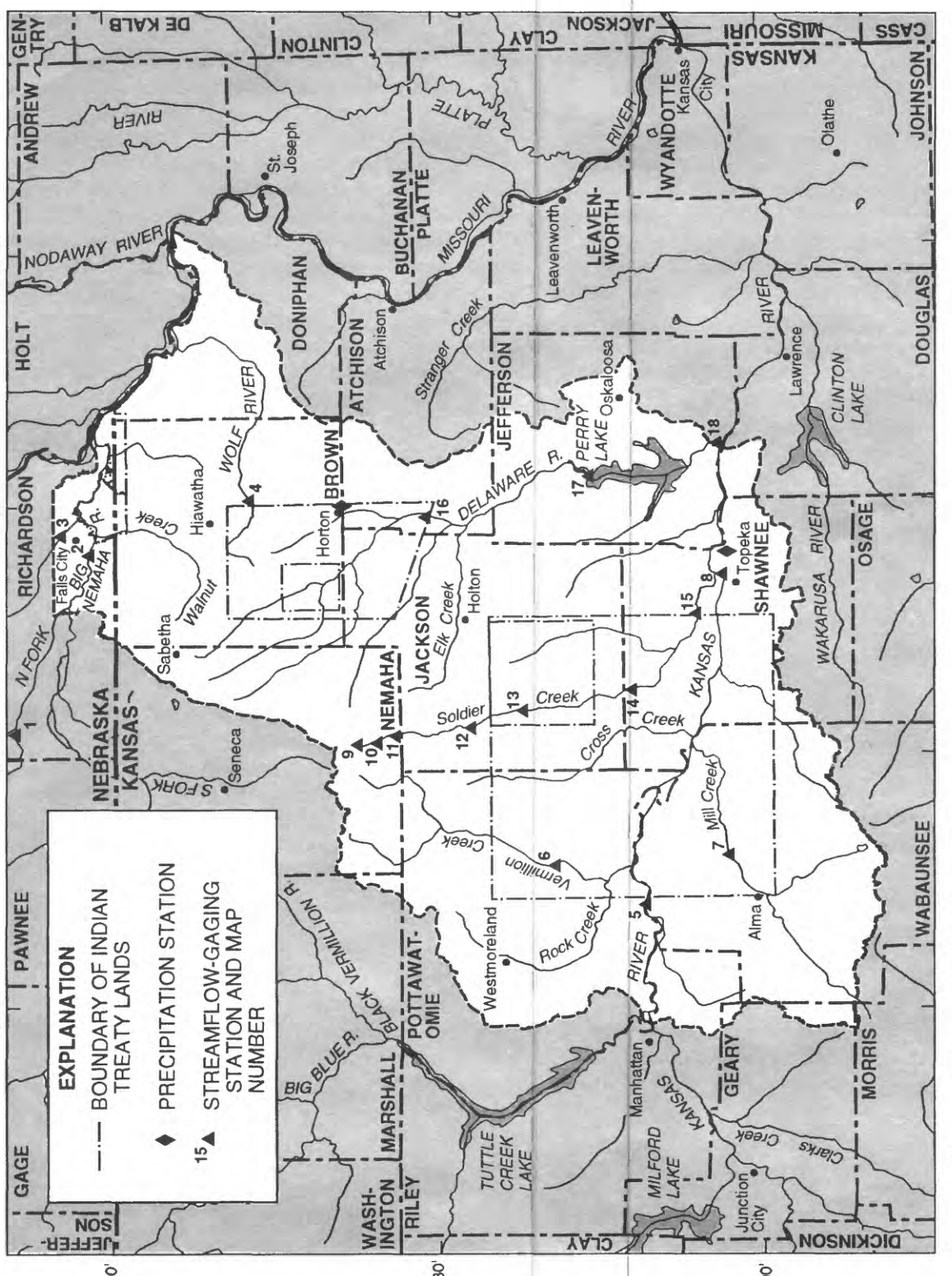

Figure 2. Location of precipitation stations and continuous-record streamflow-gaging stations with 10 or more years of daily discharge records.

Table 1. *Streamflow-gaging stations with 10 or more years of daily discharge records*

Map no. (fig. 2)	Site no.	Station name	Latitude	Longitude	Drainage area (square miles)
1	06814500	North Fork Big Nemaha River at Humbolt, Nebr.	400925	0955640	548
2	06815000	Big Nemaha River at Falls City, Nebr.	400200	0953530	1,340
3	06815500	Muddy Creek at Verdun, Nebr.	400840	0954310	186
4	06815600	Wolf River near Hiawatha, Kans.	394828	0952814	41.0
5	06887500	Kansas River at Wamego, Kans.	391152	0961816	55,280
6	06888000	Vermillion Creek near Wamego, Kans.	392100	0961310	243
7	06888500	Mill Creek near Paxico, Kans.	390344	0961052	316
8	06889000	Kansas River at Topeka, Kans.	390400	0953858	56,720
9	06889100	Soldier Creek near Goff, Kans.	393727	0955757	2.06
10	06889120	Soldier Creek near Bancroft, Kans.	393542	0955817	10.5
11	06889140	Soldier Creek near Soldier, Kans.	393357	0955745	16.9
12	06889160	Soldier Creek near Circleville, Kans.	392747	0955700	49.3
13	06889180	Soldier Creek near St. Clere, Kans.	392233	0955505	80.0
14	06889200	Soldier Creek near Delia, Kans.	391208	0955225	157
15	06889500	Soldier Creek near Topeka, Kans.	390600	0954327	290
16	06890100	Delaware River near Muscotah, Kans.	393117	0953157	431
17	06890500	Delaware River at Valley Falls, Kans.	392103	0952716	922
18	06891000	Kansas River at Lecompton, Kans.	390307	0952315	58,460

Map no. (fig. 2)	Daily discharge (cubic feet per second) Maximum	Minimum	Mean	Years of record	Period of record
1	24,600	0.07	200	38	October 1952 to September 1990
2	57,600	3	604	47	March 1944 to September 1990
3	14,300	1	66	20	October 1952 to September 1972
4	6,330	0	22.8	10	March 1961 to June 1970
5	393,000	116	4,988	72	January 1919 to September 1990
6	13,200	0	85.6	29	April 1936 to June 1946; January 1954 to June 1972
7	21,300	0	175	37	December 1953 to October 1989
8	458,000	170	5,560	73	June 1917 to May 1990
9	288	0	1.4	24	March 1964 to June 1987
10	672	0	2.5	25	March 1964 to June 1988
11	1,920	0	10.3	26	March 1964 to September 1989
12	5,830	0.03	32.6	26	March 1964 to September 1989
13	4,410	0.11	49.6	18	March 1964 to April 1981
14	14,800	0	97.6	31	October 1958 to September 1989
15	17,200	0	150	59	May 1929 to September 1932; August 1935 to September 1989
16	23,400	0.01	268	22	July 1969 to September 1989
17	55,200	0.01	386	46	June 1922 to September 1967
18	483,000	185	7,106	53	March 1936 to September 1989

Concentrations of fecal-indicator bacteria will be used to indicate possible contamination of water by human wastes. The U.S. Geological Survey water-quality data base (QWDATA) will be used to retrieve selected inorganic, nutrient, pesticide, and bacteria data for interpretive analysis.

Values of the properties and concentrations of the constituents will be described using graphs and statistical summaries. Time trends in constituent concentrations will be determined using nonparametric statistics (Iman and Conover, 1983), such as Kendall's tau, and parametric statistical methods, such as regression analysis.

Low-flow discharge was measured, and water-quality samples were collected at 23 stream sites during November 1988 (fig. 3, table 2). Results of this and other low-flow sampling investigations that might be conducted during the study will be used to evaluate the base-flow distribution of discharge and water quality.

GROUND-WATER RESOURCES

Ground-water resources in both major and minor aquifers in the study area will be evaluated. The major aquifers include the Kansas and Missouri River alluvial deposits and the pre-glacial buried valleys. Minor aquifers include bedrock aquifers, local alluvial aquifers, and glacial-drift aquifers.

Quantity

Ground-water quantity will be defined primarily using information contained in U.S. Geological Survey data bases. The Ground Water Site Inventory file (GWSI) includes well depth and water-level information for about 1,800 wells that will be used to define aquifer geometry in the study area, including thickness and areal extent. Results of aquifer tests for selected wells will be used to estimate the hydraulic properties of the aquifers and short-term water-yielding potential. The results of a modeling study of the Kansas River alluvium (R.J. Wolf, U.S. Geological Survey, written commun., 1990) will be used to estimate the sustained-yield potential of the Kansas River alluvial aquifer.

Quality

Ground-water quality will be evaluated using water-quality data from about 550 wells in the study area. The analysis will be similar to that of surface-water quality with the exception that fecal-bacteria concentrations will not be evaluated. Time trends in ground-water constituent concentrations will be evaluated using data from 13 wells that have been sampled annually since about 1976 (fig. 4, table 3) as part of the Kansas ground-water-quality monitoring network (Spruill, 1983).

WATER USE

Water rights in the State of Kansas are administered by the Kansas State Board of Agriculture, Division of Water Resources. Water rights are issued for 10 types of beneficial use--domestic, industrial, irrigation, municipal, stockwatering, recreation, hydroelectric-power generation, artificial recharge, hydraulic dredging, and contamination remediation. Thermoelectric-power generation is included with industrial use. Stockwatering water rights apply only to operations with more than 1,000 head of livestock. Water rights in the part of the study area in northeastern Kansas are grouped into irrigation, municipal, and "other" uses. The "other" category includes water rights for the remaining uses except for hydroelectric-power generation and artificial recharge, for which there are no water rights in the study area.

Water rights administered by the Division of Water Resources in the Kansas part of the study area included 994 points of diversion as of 1989. Of these diversions, 283 were from surface-water sources, and 711 were from ground-water sources. These numbers do not represent the total number of withdrawal points in the study area, only those with water rights. Numerous domestic wells and some other diversions, such as those on Indian lands, are not recorded because State water rights are not required.

The Nebraska Department of Water Resources maintains records of surface- and ground-water diversions for numerous designated uses. In the part of the study area in southeastern Nebraska, diversions from streams and registered wells were grouped into irrigation, municipal (including domestic and

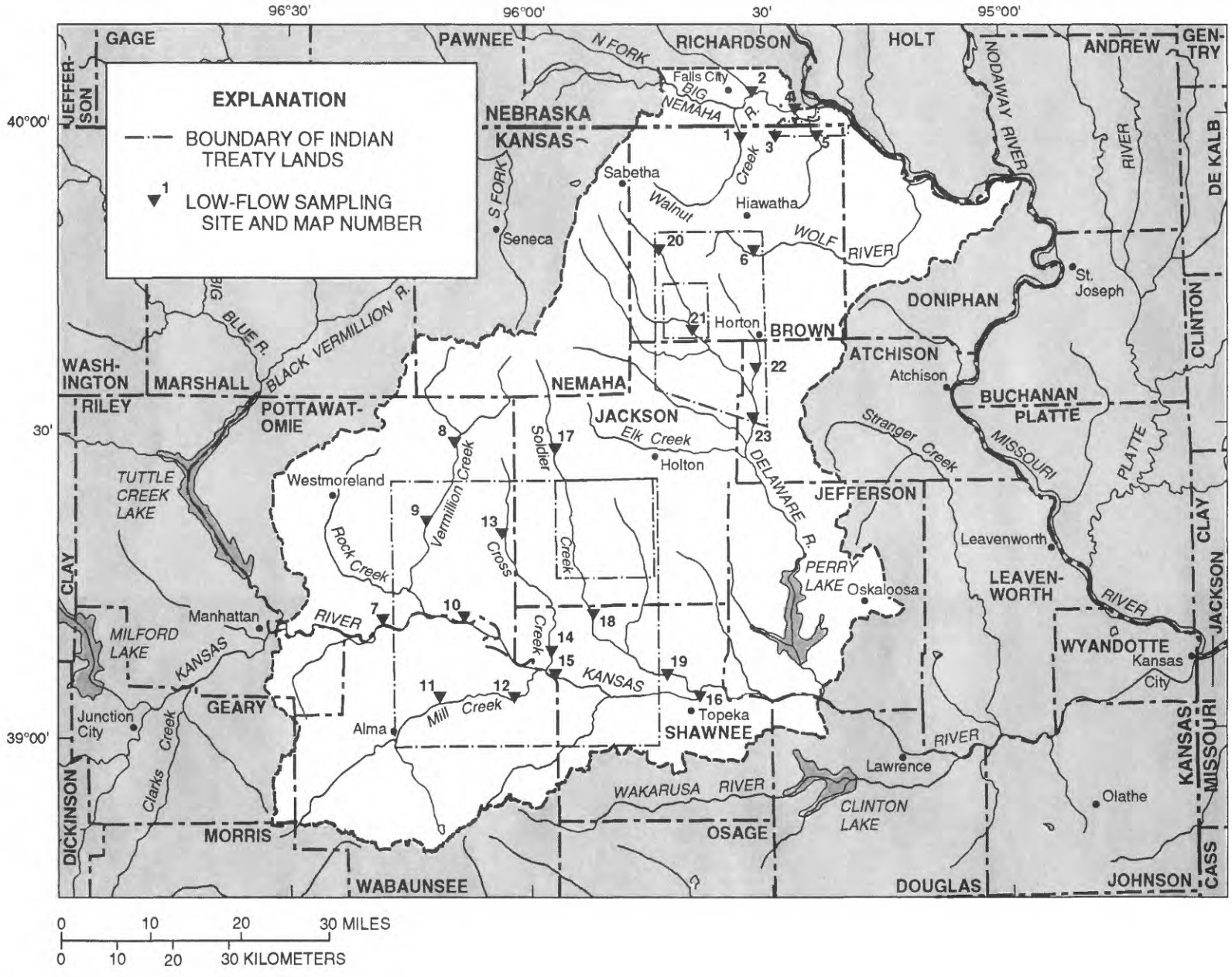

Figure 3. Location of low-flow stream sites sampled during November 1988.

Table 2. Low-flow water-quality sampling sites, November 1988

Map no. (fig. 3)	Site no.	Site name	Sample date
1	06815300	Walnut Creek at Reserve, Kans.	11-17-88
2	400234095311300	Big Nemaha River near Presto, Nebr.	11-17-88
3	395819095282700	Noharts Creek near Reserve, Kans.	11-17-88
4	400056095260500	Big Nemaha River near Rulo, Nebr.	11-17-88
5	395825095230000	Roys Creek near White Cloud, Kans.	11-17-88
6	394735095313000	Wolf River 4 miles south of Hiawatha, Kans.	11-17-88
7	06887500	Kansas River at Wamego, Kans.	11-16-88
8	392844096093500	Vermillion Creek near Onaga, Kans.	11-15-88
9	06888030	Vermillion Creek near Louisville, Kans.	11-15-88
10	06888350	Kansas River near Belvue, Kans.	11-15-88
11	06888500	Mill Creek near Paxico, Kans.	11-15-88
12	390356096021700	Mill Creek near Maple Hill, Kans.	11-15-88
13	391911096033500	Cross Creek near Emmett, Kans.	11-15-88
14	390820095571500	Cross Creek at Rossville, Kans.	11-15-88
15	06888705	Kansas River at Willard, Kans.	11-15-88
16	06889000	Kansas River at Topeka, Kans.	11-15-88
17	06889160	Soldier Creek near Circleville, Kans.	11-14-88
18	06889200	Soldier Creek near Delia, Kans.	11-14-88
19	06889500	Soldier Creek near Topeka, Kans.	11-14-88
20	394757095434300	Delaware River near Fairview, Kans.	11-17-88
21	06889990	Delaware River near Horton, Kans.	11-17-88
22	393551095312400	Little Delaware River near Muscotah, Kans.	11-17-88
23	06890100	Delaware River near Muscotah, Kans.	11-17-88

stock uses), and "other" uses. The "other" category consists primarily of water in storage. Of the 25 points of diversion recorded by the State in the Nebraska part of the study area in 1989, 16 were from surface-water sources, and 9 were from ground-water sources.

The largest number of State-authorized diversions in the study area is for irrigation use. The location of diversion points for irrigation is shown in figure 5 (multiple diversions might be located at or near the same place; therefore, maps showing the location of diversion points might contain overplots). There were 215 surface-water diversions and 454 ground-water diversions for irrigation in the Kansas part of the study area in 1989. In the Nebraska part of the study area, there were 13 surface-water diversions and 3 ground-water diversions for irrigation use. Virtually all of the ground-water diversions are located in the Kansas River alluvium. Most of the surface-water diversions in Kansas are located along major tributaries to the Kansas River--Rock, Vermillion, Cross, Mill, and Soldier Creeks, and the Delaware River and its tributary, Elk Creek. In Nebraska, surface-water diversions for irrigation use are located along the Big Nemaha River and its tributaries, including Walnut Creek.

The location of diversion points for municipal use in the study area is shown in figure 6. The municipal category of water use in Kansas includes cities, towns, rural water districts, and any other entity supplying water for public use. There were 22 surface-water and 185 ground-water diversions authorized in the Kansas part of the study area in 1989. Larger

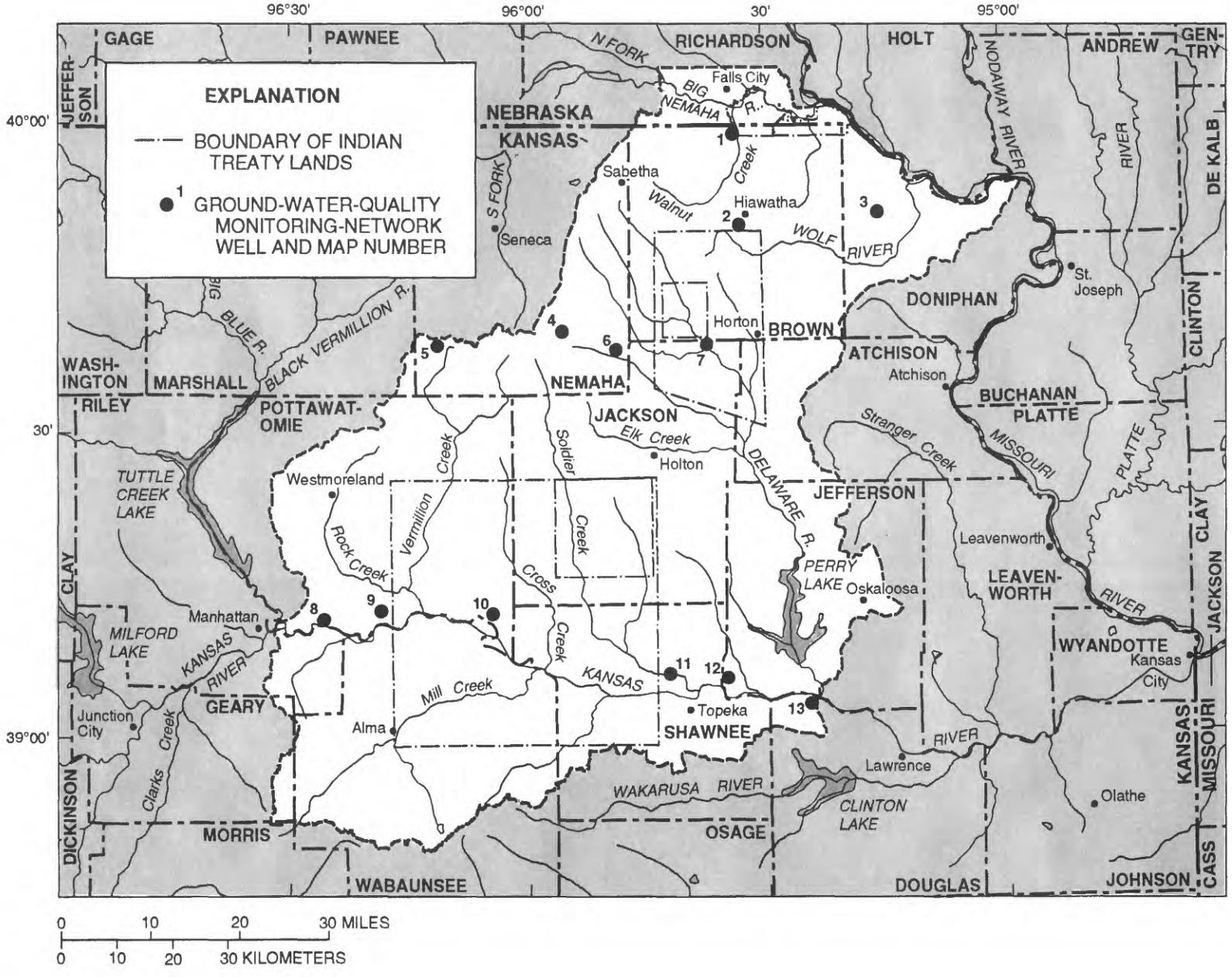

Figure 4. Location of ground-water-quality monitoring-network wells.

Table 3. *Kansas ground-water-quality monitoring-network wells*

[--, data not available]

Map no. (fig. 4)	Site no.	Local identification	Latitude	Longitude	Well use[1]	Water use[2]	County
1	395833095334401	01S 17E 07CBC 01	39° 58' 36"	095° 33' 45"	W	P	Brown
2	394939095324601	02S 17E 31DDC 01	39° 49' 40"	095° 32' 56"	W	P	Brown
3	395042095170401	02S 19E 27CBC 01	39° 50' 48"	095° 16' 57"	W	P	Doniphan
4	393959095554201	04S 13E 35BAA 01	39° 40' 00"	095° 55' 50"	W	P	Nemaha
5	393848096105101	05S 11E 03BCC 01	39° 38' 49"	096° 10' 52"	O	--	Nemaha
6	393755095490101	05S 14E 11ACC 01	39° 37' 56"	095° 48' 58"	W	P	Nemaha
7	393815095365901	05S 16E 10BBA 01	39° 38' 15"	095° 37' 00"	--	--	Jackson
8	391122096251801	10S 09E 09CDC 01	39° 11' 21"	096° 25' 13"	--	--	Pottawatomie
9	391200096181901	10S 10E 09ABC 01	39° 12' 01"	096° 18' 13"	O	--	Pottawatomie
10	391152096043304	10S 12E 09ADB 04	39° 11' 52"	096° 04' 36"	W	P	Pottawatomie
11	390551095421601	11S 15E 13BBC 01	39° 05' 58"	095° 42' 17"	W	P	Shawnee
12	390525095352701	11S 16E 13CBD 01	39° 05' 33"	095° 35' 28"	W	I	Jefferson
13	390308095240402	11S 18E 34BDA 02	39° 03' 13"	095° 24' 05"	W	P	Douglas

[1] Well use: W, withdrawal of water; O, observation.
[2] Water use: P, public supply; I, irrigation.

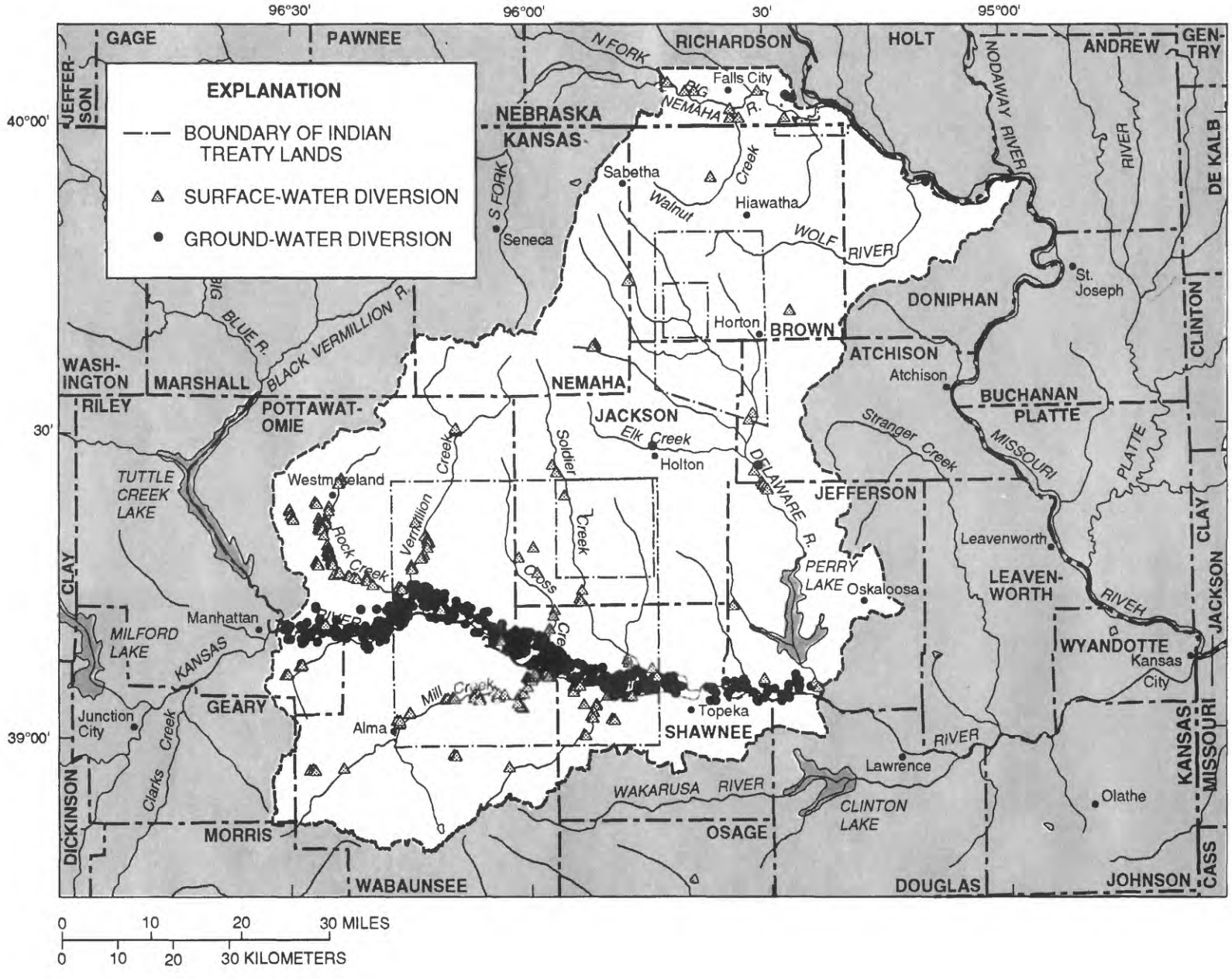

Figure 5. Location of authorized surface- and ground-water diversions for irrigation use, 1989.

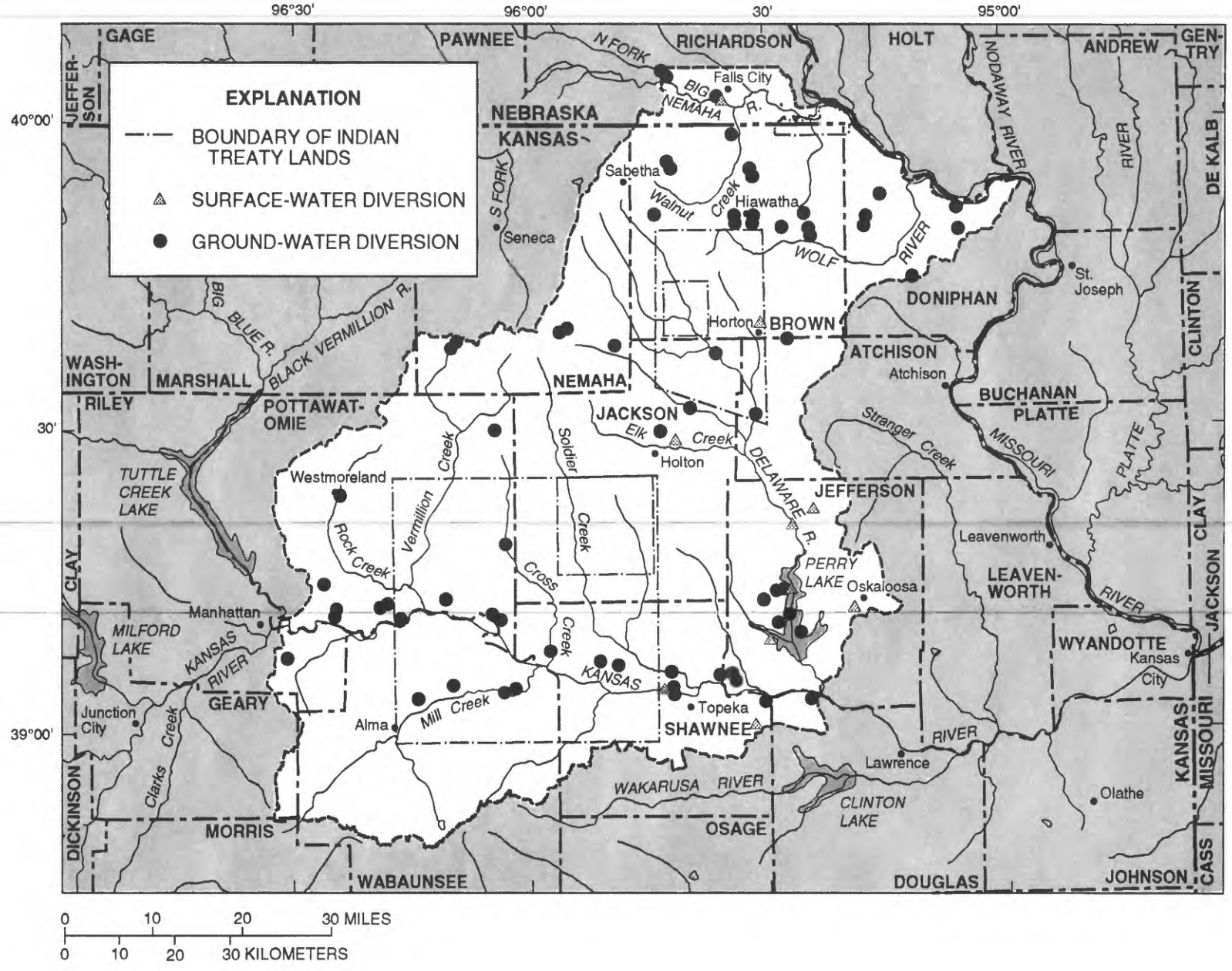

Figure 6. Location of authorized surface- and ground-water diversions for municipal use, 1989.

quantities of water are appropriated from surface water than from ground water. In the Nebraska part of the study area, there were one surface-water diversion and six ground-water diversions for municipal use.

Authorized diversion points for all other uses are shown in figure 7. In the Kansas part of the study area, there were 46 surface-water diversions and 72 ground-water diversions in 1989 for these other uses, which included domestic, industrial, stockwater, recreation, and thermoelectric-power generation. In the Nebraska part of the study area, there were two locations where surface water was used for storage.

A summary of diversions currently authorized by the Kansas Division of Water Resources and the Nebraska Department of Water Resources on Indian treaty lands is presented in table 4. Appropriations presented in table 4 are volumes of water that the States have approved for these water rights and do not necessarily equal volumes actually used. There are numerous water rights within the 1861 Potawatomi treaty lands, particularly for ground-water irrigation. Few State water rights are held on the Iowa, Kickapoo, and Sac and Fox treaty lands. The largest volumes of water appropriated on Indian lands are for municipal use, 90 percent of which is from surface water. Industrial use represents the next largest use, 67 percent of which is surface water. Thermoelectric-power generation accounts for much of the surface water appropriated for industrial use. There are numerous diversions to irrigate about 37,000 acres, most of which are located along the Kansas River.

Water-use reporting is required annually by the Kansas Division of Water Resources for all water rights. In Nebraska, number of acres irrigated is reported on a voluntary basis. Diversions in the study area for which water-use data are not available include those for rural domestic and stockwatering uses, those in Nebraska, and those on Indian treaty lands. Rural use will be approximated using population figures and per-capita-consumption coefficients. Per-capita-consumption coefficients will be derived from an analysis of water-use data reported to the Kansas Division of Water Resources by small communities in the area. Water use in the Nebraska part of the study area will be estimated using similar methods. Water use on Indian treaty lands will need to be evaluated with the assistance of the tribes. It is anticipated that most of the water used on the treaty lands is for public-supply, rural domestic, and stock uses.

Summaries of water use in the study area will be prepared. This information will be used to appraise the adequacy of water supplies for current demands and to evaluate the effects of certain water-quality issues on water use.

PRINCIPAL TOPICS OF STUDY

The principal topics to be described and evaluated during the study are outlined below:

- BACKGROUND
  - Historical development of area
  - Development of State Water Plans
- PHYSICAL SETTING
  - Geology
  - Climate
  - Land use
    - Population
    - Land use
      - Industrial land use
      - Agricultural land use
      - Hazardous waste and Superfund sites
- SURFACE-WATER RESOURCES
  - Quantity
    - Streamflow trends
    - Water availability without impoundment
    - Water availability with impoundment
  - Quality
    - Properties and major inorganic constituents
    - Metals
    - Pesticides and other organic constituents
    - Fecal indicator bacteria
- GROUND-WATER RESOURCES
  - Quantity
    - Major aquifers
      - Kansas River alluvium
      - Missouri River alluvium
      - Pre-glacial buried valleys
    - Minor aquifers
      - Bedrock
      - Local alluvial aquifers
    - Glacial drift
  - Quality
    - Properties and major inorganic constituents

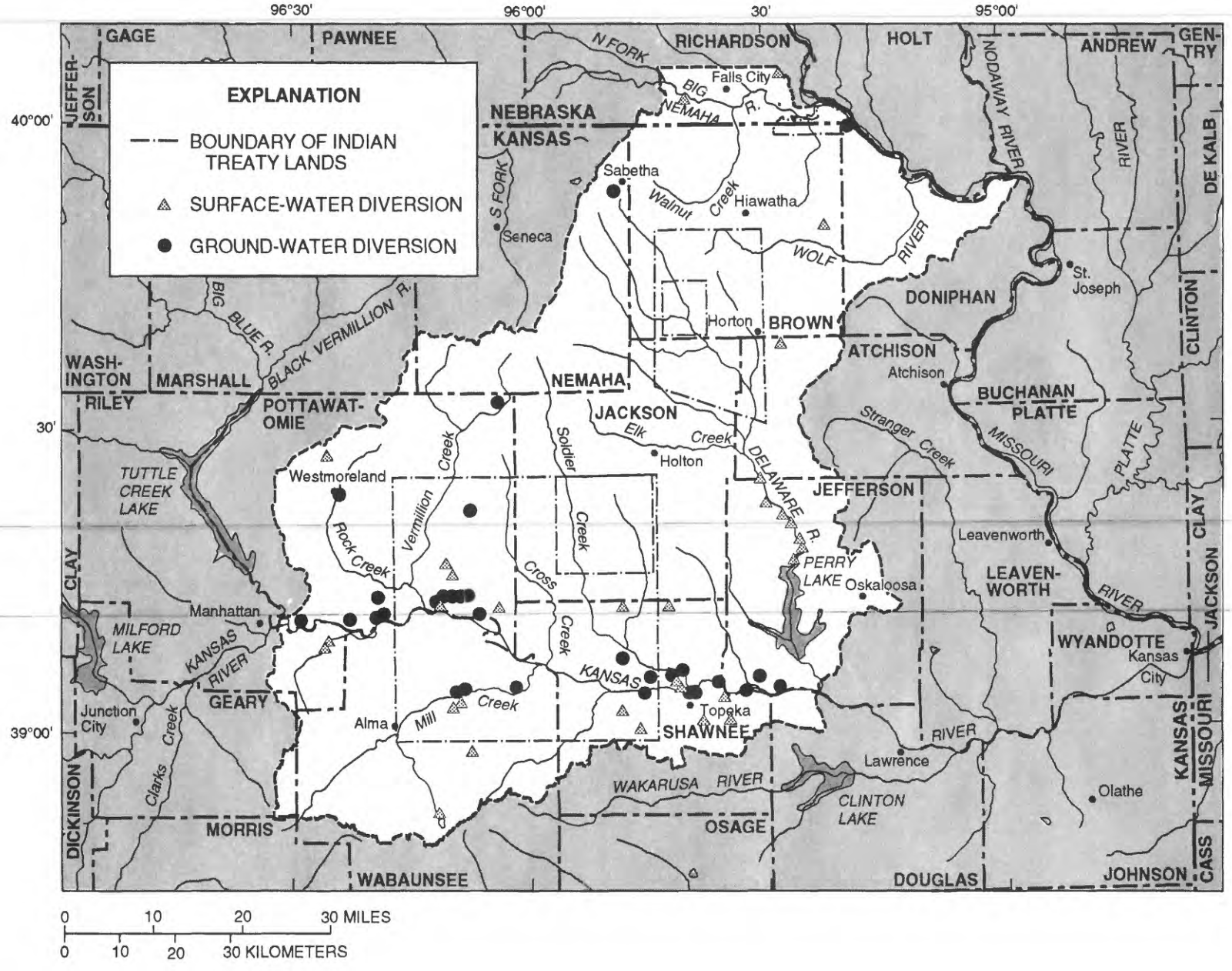

Figure 7. Location of authorized surface- and ground-water diversions for all uses other than irrigation and municipal uses, 1989.

Table 4. *Summary of diversions authorized on Indian lands (current boundaries) in northeastern Kansas and southeastern Nebraska*

[<, less than]

Tribe	Surface Water		Ground Water	
	Number of diversions	Appropriations (acre-feet per year)	Number of diversions	Appropriations (acre-feet per year)
Iowa				
Domestic	0	0	0	0
Industrial	0	0	0	0
Irrigation	2	5,575	0	0
Municipal	0	0	1	18
Stock	0	0	1	54
Recreation	0	0	0	0
Kickapoo				
Domestic	0	0	0	0
Industrial	0	0	0	0
Irrigation	1	145	0	0
Municipal	1	332	9	1,404
Stock	0	0	0	0
Recreation	0	0	0	0
Potawatomi				
Domestic	1	<1	1	3
Industrial	5	28,175	14	13,524
Irrigation	63	5,825	303	27,310
Municipal	7	49,409	30	3,864
Stock	1	235	1	11
Recreation	13	2,746	1	10
Sac and Fox				
Domestic	0	0	0	0
Industrial	0	0	0	0
Irrigation	6	4,742	0	0
Municipal	0	0	0	0
Stock	0	0	0	0
Recreation	0	0	0	0

ACRES ALLOWED TO BE IRRIGATED

	Surface water	Ground water
Iowa	539	0
Kickapoo	145	0
Potawatomi	6,866	29,248
Sac and Fox	546	0

Metals
Pesticides and other organic constituents
WATER USE
Appropriations
Nonappropriated use
Relation between water use, availability, and quantity

A work plan for completion of the major topics of study is shown in table 5. The major topics of study and the work plan may require revision during the course of study. Until the data are analyzed, the need for additional data or study cannot be fully assessed.

SUMMARY

In October 1988, the U.S. Geological Survey, in cooperation with the U.S. Bureau of Indian Affairs, the Iowa Tribe of Kansas and Nebraska, the Kickapoo Tribe of Kansas, the Prairie Band of Potawatomi, and the Sac and Fox Tribe of Missouri, began a 5-year study to evaluate the water resources in an area of northeastern Kansas and southeastern Nebraska that includes the treaty lands of the four tribes. The 4,005-square-mile study area is drained by two river systems. The Big Nemaha and Wolf Rivers are part of the Missouri River basin; Vermillion Creek, Mill Creek, Soldier Creek, and the Delaware River are part of the Kansas River basin.

The primary objectives of the study are to describe and evaluate surface- and ground-water resources and water use in the study area. These objectives will be accomplished by: (1) compilation and analysis of available water data; (2) mapping of physical and hydrologic features in the study area using GIS technology; (3) defining flow and water quality in streams; and (4) defining water availability and quality in aquifers.

Surface-water quantity during periods of low flow is of primary interest because demands are likely to exceed supply. Water availability without impoundments will be evaluated by estimating selected low-flow durations and frequencies at streamflow-gaging stations with 10 or more years of continuous record. Water availability with impoundments will be evaluated by estimating the total reservoir-storage requirements to sustain flow from small drainage basins. Flow trends will be estimated using multiple regression and nonparametric statistical tests.

Surface-water quality will be evaluated using graphs and statistical summaries of properties, inorganic and organic constituents, and fecal-indicator-bacteria concentrations. Results for 23 stream-site samples in November 1988 and from other sampling investigations that might be conducted during the study will be used to evaluate surface-water quality during base-flow conditions.

Ground-water availability will be evaluated by defining aquifer geometry using well depth and water-level information from about 1,800 wells. The results of aquifer tests will be used to estimate hydraulic properties of the aquifers. Ground-water quality will be evaluated using data from about 550 wells in the study area. Time trends in ground-water constituent concentrations will be evaluated using data from 13 wells that have been sampled annually since about 1976.

Water rights in Kansas are issued for 10 types of beneficial uses--domestic, industrial, irrigation, municipal, stockwatering, recreation, hydroelectric-power generation, artificial recharge, hydraulic dredging, and contamination remediation. A generalized appraisal of the adequacy of water supplies in the study area to meet current demands will be made by comparing low flows with reported surface-water use and well yields with reported ground-water use. Nonpermitted diversions in the study area will be estimated using per-capita-consumption coefficients and the assistance of the four tribes.

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Table 5. *Proposed work plan for study*

Task	Fiscal year			
	1990	1991	1992	1993
Background information	*** .	. . . .	. . . .	. . . .
Physical setting				
Geology	. . **	. . . .	. . . .	. . . .
Climate	. . **	. . . .	. . . .	. . . .
Land use	. . **	. . . .	** . .	. . . .
Surface-water resources				
Quantity				
Retrieve data	. . **	. . . .	. . . .	. . . .
Analyze flow data	. . . .	** . .	** . .	* . . .
Quality				
Retrieve data	. . **	. . . .	. . . .	. . . .
Analyze water-quality data	. . . .	****	** . .	* . . .
Ground-water resources				
Quantity				
Retrieve data/analysis	. . **	** . .	****	. . . .
Quality				
Retrieve data/analysis	. . **	** . .	****	. . . .
Water use	. . . .	** . .	****	. . . .
Reports				
Open file/progress reports	. . **	. . **	. . **	. . . .
Final project report				
First draft/staff overview	. . . .	. . . .	. . . *	** . .
Colleague review	. . .	. . . .	. . . .	. . * .
Regional review/approval	. . . .	. . . .	. . . .	. . . *

*, quarter year of directed work effort for task.
., quarter year with no directed work effort for task.

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