INTRODUCTION

The U.S. Geological Survey (USGS), in cooperation with the Cheyenne and Arapaho Tribes, conducted the present study to determine the vulnerability to contamination of ground water beneath tribal lands within the 3,991-acre Concho Reserve in Canadian County, Oklahoma (map A).

Purpose and Scope

The purpose of this project is to provide information on the hydrologic characteristics of the aquifer and sources of potential ground-water contamination needed to make improvement and protection-planning decisions. Cheyenne-Arapaho tribal managers are planning to improve and protect the public water supply of the Concho Reserve. These plans include a possible relocation the existing well field. Ground-water wells in this well field within the Reserve produce water for public use.

This report gives the results of field reconnaissance observations, provides a compilation of hydrologic data from files of the USGS, and includes data on ground-water hydrology and geology of the area within and adjacent to the Concho Reserve. Current land use and potential sources of contamination of ground water are identified. Tables of water-quality data from 1943 through 1980 have been compiled from files of the USGS. The location of the study area is shown on figure 1.

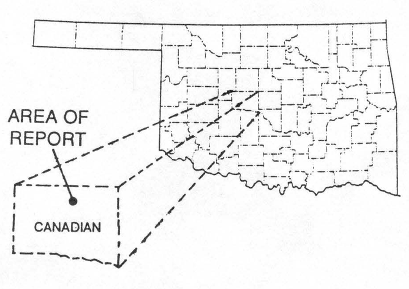


Figure 1.—Location of study area.

Previous Studies

Mogg, Schoff, and Reed (1960) described the ground-water resources of Canadian County, Oklahoma. Records of well and test-hole data, results of chemical analyses of ground water, analyses of aquifer tests and test-hole cores, and estimates of annual recharge are included in their report. Contour maps showing bedrock elevations, the static water-table elevation, the thickness of alluvial and terrace deposits, and the saturated thickness of alluvial deposits are presented in the report. Their report contains hydrologic data and available ground-water-quality analyses for alluvial and terrace deposits along the North Canadian River in Canadian County. Many of the data contained in their report were collected in the alluvium within and adjacent to the Concho Reserve.

Christenson (1983) studied the hydrologic system of the alluvial and terrace deposits along the North Canadian River to determine the maximum annual yield of ground water. His report describes the use of a digital model to simulate the hydrologic system of the alluvial and terrace aquifer along the North Canadian River valley from Canton Dam, located 85 river miles upstream from the Concho Reserve, to Lake Overholser, located 23 river miles downstream from the Concho Reserve.

Jacobsen and Reed (1949) compiled information to the end of 1943 on the ground-water resources of the Oklahoma City area. Their report contains a discussion of the hydrologic properties of the North Canadian River alluvium and low terraces, including Pleistocene terrace deposits in the vicinity of Lake Overholser. Comparison of maps by Jacobsen and Reed (1949) with maps by Mogg, Schoff, and Reed (1960, pl. I) shows that alluvial and terrace deposits in the Lake Overholser area are lithologically similar to deposits on the Concho Reserve.

An appraisal of the potential impact of agricultural practices in the vicinity of the current water-supply wells of the Concho Reserve was conducted by the Oklahoma Department of Agriculture (written commun. to the Cheyenne-Arapaho Tribes, 1989). This survey did not include water-quality analyses, and therefore did not identify existing contamination. A recommended action was to monitor for the pesticides Glean[1] and 2,4-D by water-quality analysis of samples from the Cheyenne-Arapaho wells during early spring months.

Acknowledgments

Cooperation extended by members of the Cheyenne-Arapaho Tribe Public Works Department in obtaining local information and access to tribal land is sincerely appreciated. Special thanks are extended to Mr. Melvin Roman Nose and Mr. Robert Wilson of the Cheyenne-Arapaho Tribes. This study was funded by a U.S. Environmental Protection Agency Region 6 grant under the Multi-Media Assistance Program NI-006423-01-1.

Methods of Study

Data from previous hydrologic studies of areas in and surrounding the Concho Reserve and from nearby areas having similar geologic and hydrologic characteristics were reviewed, as were existing geologic maps and hydrologic data in the files of the USGS. Field work for this report included documentation of current land uses, reconnaissance of existing springs and seeps draining the terrace within the Reserve, an inventory of ground-water wells in and adjacent to the Concho Reserve, and identification of potential sources of ground-water contamination within the Reserve.

Explanation of the Local Identifier

Locations of data sites are specified by latitude and longitude to the nearest second and by a local identifier based upon the Oklahoma public-land survey. Local identifiers include the township and range followed by the section number and a series of letters that designate the quarter-section subdivisions from largest to smallest. A sequence number is added to make each local identifier unique. As illustrated in figure 2, the public-land survey description of the site indicated by the dot is NW 1/4 NW 1/4 NW 1/4 sec. 19, T. 13 N., R. 07 W.; the USGS local identifier is 13N-07W-19 BBB. If the sequence number is 1, the complete identifier is 13N-07W-19 BBB 1.

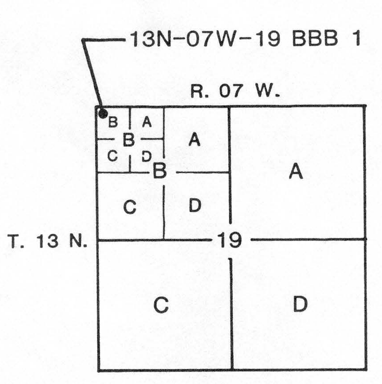


Figure 2.—Local identifier numbering sequence.

PHYSIOGRAPHY

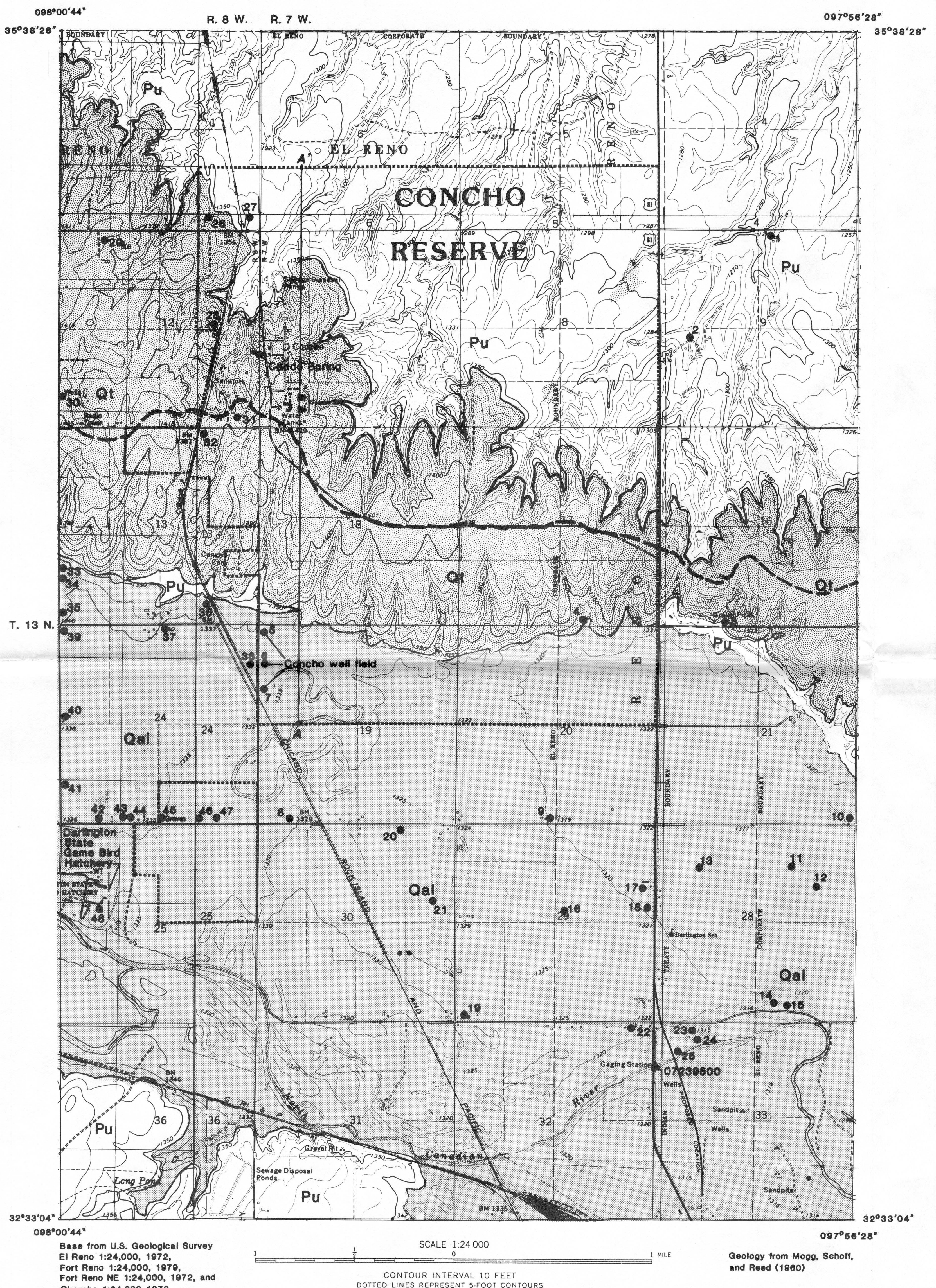
The Concho Reserve covers 3,991 acres in the Central Redbed Plains region of Canadian County, Oklahoma. The Reserve lies along a prominent drainage divide between the Cimarron River to the north and the North Canadian River to the south. Land-surface altitudes vary from 1,258 feet above the National Geodetic Vertical Datum of 1929 (NGVD) along a streambed at the northern boundary of the Reserve to about 1,430 feet at the crest of the drainage divide. The area north of the drainage divide is upland prairie dissected by many deeply eroded gullies and small streams. The area south of the drainage divide is upland prairie with many small valleys that only extend to the alluvial floodplain within the southern part of the study area. A land-surface profile *A–A′* extending from the south boundary of the Concho Reserve to the north boundary of the Reserve across the highest part of the drainage divide within the Reserve is shown on figure 3. The location of the profile is shown on map A.

LAND USE

The Reserve includes 2,710 acres of pasture, 1,209 acres of cropland, and 72 acres of roads (Cross and Associates, Inc, Norman, Okla., written commun., 1975). Tribal administrative buildings, small repair and maintenance shops, warehouses, a childrens' day-care facility, and about 20 residences and structures of the inactive Concho Indian school occupy the west-central side of the tract. Commercial locations are a Bingo Hall located in the gymnasium of the inactive school and a tribal smoke shop located at the eastern entrance to the Reserve. A small hog farm and grain-storage bins are located near the center of the Reserve. An abandoned hydroponics installation is located near the southwest corner of the Reserve.

Vegetation in the study area varies from natural grasses to cultivated farm land (W.E. Puckett, Soil Conservation Service, Stillwater, Okla., written commun., July 21, 1992). The alluvial valley along the southern part of the Reserve is mostly irrigated land. Winter wheat is the principal crop, but corn, alfalfa, sorghum, and lawn grasses are grown in the area also. Most of the central upland area within the Reserve is improved grassland except for an east-west-trending strip of cropland located south of the Cimarron-North Canadian River drainage divide. Tracts of native short prairie grasses and non-irrigated agricultural land are characteristic of the northern part of the Reserve. Grassland areas are primarily used for grazing. Small stock ponds are located along both sides of the drainage divide. Phreatophytes are present within the area (Mogg, Schoff, and Reed, 1960, p. 55). Phreatophytes (generally cedars, scrub oak, plum thickets, and native trees) are scarce over much of the area and generally are located near small contact springs or seeps in the upper riparian areas of small stream valleys. However, a dense growth of phreatophytes exists along the western edge of the Reserve within depressions resulting from long-abandoned sand-mining operations. Phreatophytes also are present along a northward-flowing tributary to the Cimarron River that has eroded a steep-sloped narrow valley through most of the terrace to near the drainage divide of the Cimarron and North Canadian Rivers. The general distribution of grassland, cropland, and brush within and surrounding the Concho Reserve is shown on map B.

[1]Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government



Map A.—Geology and ground-water well locations in the area of the Concho Reserve.

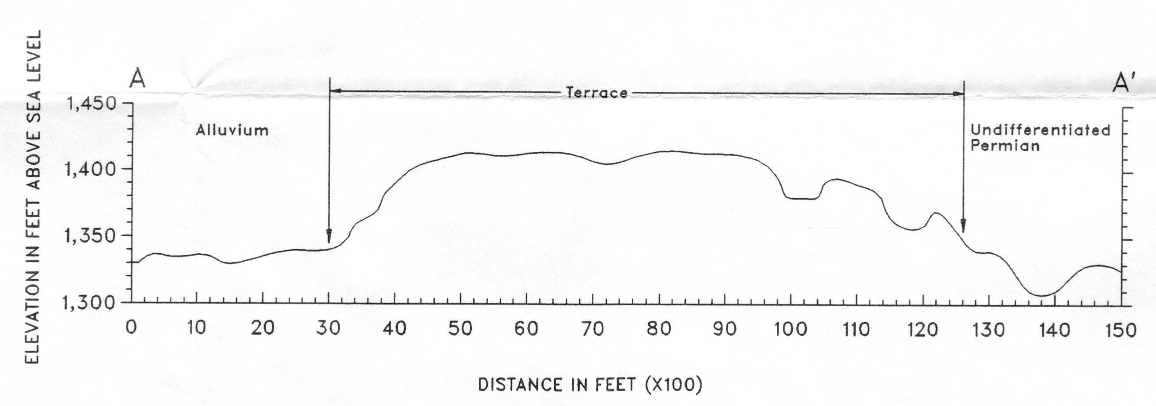


Figure 3.—Land-surface profile and surficial geology extending from the south boundary (*A*), to the north boundary (*A′*) of the Concho Reserve. Surficial geology from Mogg, Schoff, and Reed (1960).

Table 1. Selected records of wells and test holes in and adjacent to the Concho Reserve

[Depth of well and water levels are reported as depth in feet below land-surface datum. Principal aquifer codes: 110ALVM, synonymous with North Canadian River alluvium as used in this report; 112TRRCH, high terrace deposits; 313ELRN, synonymous with Permian undifferentiated rocks as used in this report. Source of depth data: D, drillers' reports; L, logs; O, owner; R, reported; S, U.S. Geological Survey; Water-level status: P, pumping; S, nearby pumping; Water-level method: R, reported; S, steel tape; T, electric tape; Use of water: H, domestic; I, irrigation; N, industrial; P, Public supply; S, livestock; U, unused; --, no data]

Site number on map A	Local well number	Site-ID	Aquifer code	Altitude of land surface (feet)	Depth of well (feet)	Source of depth data	Water level (feet)	Water-level date	Water-level status	Water-level method	Primary use of water
1	13N–07W–09 ABB 1	353724097565801	313ELRN	1250	15.5	S	3.29	04–07–92	--	S	H
2	13N–07W–09 CBA 1	353657097572201	313ELRN	1270	--	--	1.70	04–07–92	S	T	S
3	13N–07W–16 CDC 1	353544097565201	313ELRN	1350	68.8	S	3.58	04–07–92	--	S	U
4	13N–07W–17 DCC 1	353543097575601	112TRRCH	1335	27	S	13.72	05–06–92	--	S	U
5	13N–07W–19 BBB 1	353527097591901	110ALVM	1335	40	S	11.33	04–06–92	--	S	P
6	13N–07W–19 BBC 1	353531097593901	110ALVM	1335	44	S	8.40	05–06–92	--	S	P
7.	13N–07W–19 BCB 1	353524097593601	110ALVM	1315	45	R	--	--	--	--	P
8	13N–07W–19 CCD 1	353701097590101	110ALVM	1334.7	47	L	18	00–00–19	--	R	U
9	13N–07W–20 CDD 1	353700097580002	110ALVM	1323.5	36	L	12	00–00–19	--	R	U
10	13N–07W–21 DDD 1	353701097570101	110ALVM	1322.3	40	L	9.75	00–00–19	--	R	U
11	13N–07W–28 ABD 1	353437097564301	110ALVM	1318	--	--	40.5	07–14–80	P	S	I
12	13N–07W–28 ADB 1	353432097564901	--	1315	50	D	15	03–20–73	--	R	I
13	13N–07W–28 BBD 1	353436097571601	110ALVM	1320	47	D	12	03–00–80	--	R	I
14	13N–07W–28 DCC 1	353403097565301	110ALVM	1320	48	D	12	11–29–73	--	R	I
15	13N–07W–28 DCD 1	353402097564901	--	1320	44	D	8	05–15–85	--	R	P
16	13N–07W–29 ACC 1	353426097580001	110ALVM	1325	48	D	16	05–30–79	--	R	S
17	13N–07W–29 ADA 1	353429097573501	110ALVM	1320	43	D	15	09–25–72	--	R	I
18	13N–07W–29 ADD 1	353425097573601	110ALVM	1320	47	D	15	09–23–72	--	R	I
19	13N–07W–29 CCC 1	353500097580001	110ALVM	1328.56	25.5	S	18.72	03–30–42	--	--	U
20	13N–07W–30 ABA 1	353500097590001	110ALVM	1330.4	38	L	14	00–00–19	--	R	U
21	13N–07W–30 ADD 1	353429097584401	110ALVM	1325	45	D	15	05–09–80	--	R	N
22	13N–07W–32 AAB 1	353356097574601	110ALVM	1325	--	--	21.00	04–07–92	--	S	H
23	13N–07W–33 BBA 1	353353097571901	110ALVM	1315	--	--	20.00	04–07–92	--	S	H
24	13N–07W–33 BBA 2	353352097571801	110ALVM	1315	--	--	17.20	04–07–92	--	S	H
25	13N–07W–33 BBD 1	353350097572301	110ALVM	1315	--	--	20.35	04–07–92	--	S	U
26	13N–08W–01 DCC 1	353729098000701	112TRRCH	1350	11.70	S	1.98	04–07–92	--	S	U
27	13N–08W–01 DDD 1	353728097594401	112TRRCH	1350	53	D	18	02–07–84	--	R	N
28	13N–08W–12 ACC 1	353700098000701	110ALVM	1380	30.34	S	8.12	04–07–92	--	S	H
29	13N–08W–12 BBA 1	353714098003401	112TRRCH	1410	34.9	R	19.65	01–27–54	--	S	S
30	13N–08W–12 CCB 1	353643098004401	112TRRCH	1423	37.8	S	29.06	04–23–80	--	S	U
31	13N–08W–12 DDD 1	353637097594301	112TRRCH	1405	86.0	S	21.62	05–06–92	--	S	U
32	13N–08W–13 ABA 1	353632098000001	110ALVM	1402	10.6	S	3.65	01–27–54	--	S	U
33	13N–08W–13 CBC 1	353610098004301	110ALVM	1348.7	47	L	17	00–00–19	--	R	U
34	13N–08W–13 CCB 2	353550098004001	110ALVM	1345	40	R	23	00–00–47	--	R	P
35	13N–08W–13 CCC 1	353545098003501	110ALVM	1345	41	R	--	--	--	--	P
36	13N–08W–13 DCD 1	353547098000001	110ALVM	1340.4	40	L	15	00–00–19	--	R	U
37	13N–08W–24 ABB 1	353534098001001	110ALVM	1345.9	49	L	28	00–00–19	--	R	U
38	13N–08W–24 ADA 1	353527097594401	110ALVM	1339.7	47	L	25	00–00–19	--	R	U
39	13N–08W–24 BBB 1	353540098004101	110ALVM	1347.1	46	L	18	00–00–19	--	R	U
40	13N–08W–24 BCC 1	353517098004101	110ALVM	1343.6	46.5	L	16	00–00–19	--	R	U
41	13N–08W–24 CCB 1	353500098004101	110ALVM	1336	47	L	18	01–05–49	--	R	U
42	13N–08W–24 CCD 1	353453098003301	110ALVM	1336	55	S	22	07–00–54	--	S	I
43	13N–08W–24 CDC 1	353451098002101	110ALVM	1341.2	44	L	15	00–00–19	--	R	U
44	13N–08W–24 CDC 2	353452098002201	110ALVM	1341	54	O	24	05–00–53	--	R	I
45	13N–08W–24 DCC 1	353454098001201	110ALVM	1335	43.5	S	15.26	04–07–92	--	S	H
46	13N–08W–24 DCD 1	353452098000701	110ALVM	1336.5	45	L	17	00–00–19	--	R	U
47	13N–08W–24 DDC 1	353452097573401	110ALVM	1336.1	44	L	18	00–00–19	--	R	U
48	13N–08W–25 BCD 1	353426098003201	112TRRCH	1335	43	D	15	12–19–79	--	R	S

Revised table—12/8/93

EXPLANATION

Qal

ALLUVIUM

Silt, clay, sand, and gravel. Generally the more permeable deposits are below the water table. Water from alluvial deposits is generally hard and contains excessive amount of sulfate in some areas

Qt

TERRACE DEPOSITS

Silt, clay, sand, and gravel in variable proportions with predominantly fine-grained sand. Yields good-quality water for domestic use in some areas of Canadian County

QUATERNARY

Pu

UNDIFFERENTIATED PERMIAN ROCKS OF THE EL RENO GROUP

Reddish-brown shale, siltstone, and fine-grained sandstone, with thin layers of gypsum and dolomite. Well yields sufficient for domestic and stock use can generally be obtained. In some areas the water is highly mineralized

PERMIAN

BOUNDARY OF THE CONCHO RESERVE

DRAINAGE DIVIDE—Separates North Canadian and Cimarron River drainage areas

A ——— A′

LOCATION OF LAND-SURFACE PROFILE (fig. 3)

•21

GROUND-WATER WELL—Number by well is well site number listed in table 1

SPRING

▲07239500

STREAM-GAGING STATION—Number is station identification number

CLIMATE

The study area has a dry subhumid climate. Average annual precipitation is about 29.50 inches (Department of Commerce, monthly summaries). Precipitation is greatest during spring and early summer months and least during late summer and winter months. Consecutive years of lower-than-normal rainfall are common, when annual precipitation is only 55 to 60 percent of average. Average wind velocity is 12 miles per hour. Winds generally are from the south except during winter months, when frequent regional weather fronts from the north and northwest pass through the area. Average annual pan evaporation is 61 inches.

GEOLOGY

In the Concho Reserve, Permian rocks of the El Reno Group are overlain partially by Quaternary terrace deposits along a topographic drainage divide running east to west across the Reserve (map A) (Mogg, Schoff, and Reed, 1960, pl. I). Alluvial deposits of the North Canadian River are present along the southern edge of the area. Permian rocks of the area are locally referred to as red beds because of their reddish-brown to red color. Red beds within the study area are described as a single unit in this report and are not differentiated by formation.

The Permian red-bed sequence within the study area consists of alternating layers of marine deposits ranging from reddish-brown silty clay shale and reddish-brown silty shale to fine-grained sandstone with interbedded evaporites (Mogg, Schoff, and Reed, 1960, p. 23–28). The red beds are exposed over the northeast third of the study area and along a road cut above the North Canadian River alluvium near the southwest corner of the main Reserve area.

Terrace deposits are probably of Pleistocene age and overlie the red beds along the drainage divide between the Cimarron River and the North Canadian River (Mogg, Schoff, and Reed, 1960, p. 35–41). These deposits are mainly lenticular beds of silt, sand, and clay with some gravel near the base. Because of insufficient data, accurate estimates of the thickness of terrace deposits throughout the Reserve cannot be made. Field observations indicate that the thickness varies from a thin veneer along the edges of the deposits to a maximum of about 60 feet in a small area near the water towers on the west-central edge of the Reserve. Field observations suggest that the average terrace thickness over the Reserve is about 30 feet.

Alluvial deposits form a strip about half a mile wide within the southern boundary of the study area (Mogg, Schoff, and Reed, 1960, p. 41–45). These deposits are a segment of the 2.5–mile wide North Canadian River alluvial valley. The alluvial deposits are not uniform, but are composed of interfingering lenses of silt, clay, and fine to coarse sand and gravel. Alluvial deposits of the North Canadian River are the principal source of municipal, industrial, and irrigation water supplies in Canadian County (Mogg, Schoff, and Reed, 1960).

HYDROLOGY

Surface Water

The Concho Reserve lies along the drainage divide between the Cimarron River, about 22 miles to the north, and the North Canadian River, about 2.5 miles to the south. There are no perennial streams within the Reserve. Surface water flowing north of the divide to the Cimarron River is conveyed by many deep, narrow tributaries that have eroded upstream to near the drainage divide and have removed much of the terrace deposit that overlies the Permian rocks. Surface water flowing south of the divide is conveyed by many smaller valleys that extend only to the adjacent alluvium of the North Canadian River, where water ponds and subsequently percolates into the alluvium or is lost to evaporation and transpiration.

The availability of surface water within the boundaries of the Reserve is limited to impoundment in small stock ponds during periods of direct surface runoff. Drainage areas above these ponds are small and provide only enough direct surface runoff to maintain storage in ponds for stock and wildlife use.

Springs

Small springs and seeps within the Reserve are ephemeral and discharge ground water in response to seasonal variations in precipitation and evapotranspiration. Small springs and seeps are present near the contact of the terrace with the less permeable Permian rocks near the upper end of most tributaries draining the north slope of the Reserve. Similar seeps are located along the south slope of the terrace within the Reserve above two small stock ponds and along a road cut where the terrace-red bed contact is exposed. Ground water from the terrace probably recharges the alluvium along the terrace-alluvium contact where red beds are not exposed.

Caddo Spring (see map A), which is the only named spring within the Reserve, is of historical significance to the Cheyenne-Arapaho Tribes (Melvin Roman Nose, personal commun., 1992). Caddo Spring is a depression spring located on a steep hillside of a stream valley. The most significant ground-water outflow within the Reserve is to a small wetland area below Caddo Spring. The wetland is formed behind the remains of a small earthen dam beside the stream. This outflow is probably from several small springs at the base of the more permeable terrace deposits within the wetted area in addition to the discharge from Caddo Spring a short distance upstream. Total outflow from this wetted area was estimated to range from 20 to 30 gallons per minute from March through July 1992. The discharge from Caddo Spring was no more than 5 percent of the total outflow during this period, and there was no flow at times.

LAND-USE AND GROUND-WATER DATA, CHEYENNE-ARAPAHO TRIBES, CONCHO RESERVE, CANADIAN COUNTY, OKLAHOMA

By

D.L. Bergman and M.E. Savoca

1993

Aquifers and Ground-Water Availability within the Reserve

An aquifer is any geologic unit that has the capability of storing water and yielding usable amounts of the stored water to wells (Lohman and others, 1972). The capability of various rock units to store and deliver water to wells varies widely. The term "aquifer" is related to the amount of water or yield needed to satisfy the requirement of the intended use of the water. For instance, a geologic formation that has the capability of delivering limited amounts of water, but enough to satisfy the water requirements of single households or livestock, is considered an aquifer for that purpose. If, however, the intended use of water from the same geologic unit required more water than the unit is capable of delivering, this same unit is not considered an aquifer for that purpose.

Permian rocks in the vicinity of the Concho Reserve yield limited amounts of water to wells (Mogg, Schoff, and Reed, 1960, p. 23–38). Water from these rocks may be highly mineralized. The principal use of ground water from Permian rocks is for livestock and for a few farmsteads north of the Reserve. Available data show little or no probability of developing wells in Permian rocks that will yield sufficient water of suitable quality for the Concho Reserve public water supply.

Terrace deposits along the upland drainage divide between the Cimarron River and the North Canadian River in Canadian County contain water of the best quality within the county (Mogg, Schoff, and Reed, 1960, p. 39–41). Terrace deposits are a minor aquifer in areas where well yields are sufficient to meet the requirements of farmsteads. Terrace deposits within the Concho Reserve are too limited in extent and too thin to store sufficient quantities of water for dependable yields to wells.

Alluvial deposits along the North Canadian River are the major source of ground water in Canadian County (Mogg, Schoff, and Reed, 1960, p. 41–45). The alluvium provides most of the municipal, industrial, and irrigation water for the area. Well yields of 100 to 300 gallons per minute are common and some wells have been developed with yields of more than 500 gallons per minute. Water from the alluvium is hard. Minerals in solution are deposited on well screens and may be deposited in the pore spaces of sediments, resulting in deterioration of wells. Selected data for wells and test holes within and surrounding the study area are listed in table 1; well locations are shown on map A.

Characteristics of the Alluvial Aquifer

Alluvium of the North Canadian River is the principal aquifer within the Concho Reserve. The alluvium extends along a half-mile-wide strip 2 miles long within the southern part of the Reserve and is the present source of water for the Reserve.

The average thickness of the alluvium in an area extending from near U.S. Highway 81 west to near the Darlington State Game Bird Hatchery is from 45 to 38 feet (Mogg, Schoff, and Reed, 1960). Alluvial deposits are about 45 feet thick within the present Concho Reserve well field located near the western edge of the Reserve.

The water table generally is the upper surface of the zone of saturation. When recharge exceeds discharge, the water table rises. Conversely, when discharge exceeds recharge the water table lowers. According to Mogg, Schoff, and Reed (1960), the saturated thickness of alluvium along the southern boundary of the Reserve averaged about 33 feet. The water table within the present Concho Reserve well field has been observed at land surface during extremely wet periods. Occasionally, surface runoff ponds within the well-head area following intense rainfall. In May 1992, the saturated thickness of the alluvial aquifer penetrated by well 13N-07W-19 BBC 1 within the Concho well field was 36 feet.

Lines of equal elevation of the water table within the alluvial aquifer reported by Mogg, Schoff and Reed, (1960) are shown on map B. Ground-water movement is perpendicular to these contour lines in a downstream (east-southeasterly) direction. The water-table contours indicate that ground-water movement ranges from almost parallel to slightly towards the North Canadian River. An exception occurs during periods of high streamflow, when infiltration from the stream recharges the alluvium. A slight downstream bowing of the contours near the alluvium-terrace contact indicates the probability of some recharge into the alluvium from the terrace or red-bed boundary. The water-table slope of the alluvial aquifer within the Concho Reserve is about 5 feet per mile.

The potential of this aquifer to receive, store, and transmit water to pumping wells has been evaluated by specific-capacity measurements and aquifer tests (Mogg, Schoff, and Reed, 1960). In addition to these well tests, test-hole core samples were analyzed to determine the distribution and range of potential permeability in the alluvium. These data, when combined with the knowledge of local climate and the ability of the aquifer to receive and store water, can be used to make an appraisal of the well-yield capabilities of the aquifer.

Maximum yields from wells of identical construction and depth may vary from well to well because of variability in the physical characteristics of the alluvial deposits. Therefore, well-yield data from a single well may not be indicative of potential well yields for all locations. However, aquifer tests and pumping tests at a variety of sites may provide information on the range of well yields to be expected.

Data obtained from aquifer tests of wells located near the Concho Reserve were published by Mogg, Schoff, and Reed (1960). Wells used for the aquifer tests were located in 13N-07W-33, about 1 mile southeast of the Reserve boundary and in 13N-08W-24, about 3/4 mile southwest of the current Concho well field. Data from these tests, and specific capacity data and core-sample analyses from many small test holes drilled through the alluvium to the top of the underlying red beds were used to obtain average aquifer characteristics applicable to the alluvial deposits along the southern edge of the Concho Reserve. These characteristics are:

Aquifer characteristics	Average value
[Data from Mogg, Schoff, and Reed (1960)]	
Specific yield[1]	0.15
Hydraulic conductivity[2]	134 feet per day
Safe yield	270 acre-feet per year per square mile

[1] Equivalent to coefficient of storage used by Mogg, Schoff, and Reed (1960).
[2] Equivalent to coefficient of permeability expressed in gallons per day per square foot used by Mogg, Schoff, and Reed (1960).

Water Quality

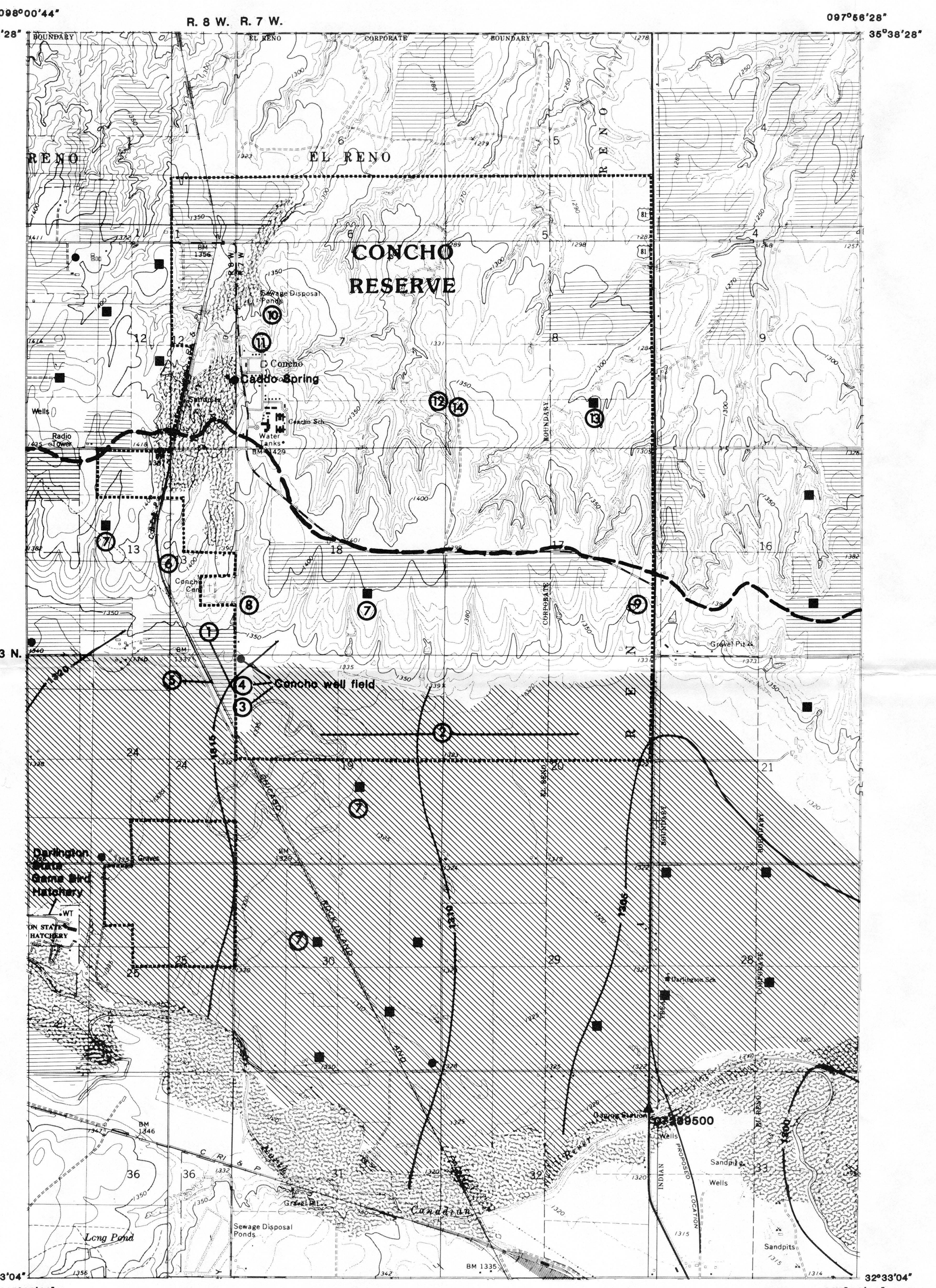
Ground-water quality within an aquifer is directly related to the type and quantity of minerals and gasses contained within the aquifer and within surrounding rocks that recharge the aquifer. Most recharge to ground water in the alluvium is from precipitation and infiltration of streamflow from the river. The quality of ground water in the alluvium is similar to the quality of water in the North Canadian River. Ground water in the alluvium is generally a hard to very hard calcium magnesium bicarbonate type. Total dissolved solids are generally less than 1,000 milligrams per liter. Ground water within the terrace has about one-third the hardness of that within the alluvium. Recharge to the terrace is from precipitation. Ground-water-quality analyses from files of the U.S. Geological Survey for the area within and near the Concho Reserve are shown in table 2. Sampled well locations are shown on map B.

AQUIFER VULNERABILITY

Ground water within the Concho Reserve is vulnerable to contamination because of the large permeability of the aquifer. The permeable alluvial and terrace deposits in and surrounding the Concho Reserve area readily accept and transport pollutants. Various pollutants can be introduced from industrial, agricultural, and domestic sources in the recharge area that make the water unsuitable for many uses. Sampling and analysis of the current ground-water quality within and adjacent to the Concho Reserve was not within the scope of this study.

Water-supply wells for the Concho Reserve are shown on map A and in table 1 as site numbers 5, 6, and 7. Water samples colleced by the Oklahoma State Health Department from two of these public water-supply wells within the Concho Reserve well field were analyzed for 56 volatile organic carbon compounds (VOC) on January 14 and February 18, 1992. Analyses were performed by the Oklahoma State Environmental Laboratory of the Oklahoma State Health Department in accordance with U.S.Environmental Protection Agency method 502.2 (U.S. Environmental Protection Agency, 1988). This method was used to analyze for the presence of VOC compounds with detection limits of 0.5 microgram per liter (µg/L) or greater. No VOC were detected. Below is a a listing of compounds included in the analyses.

Benzene	1,1,1,2-Tetrachloroethane
Bromobenzene	1,1,2,2-Tetrachloroethane
Bromoform	1,1,1-Trichcloroethane
Chlorobenzene	1,1,2-Trichcloroethane
1,2-Dichlorobenzene	C-1,2-Dichloroethene 1,3-
Dichlorobenzene	1,1-Dichloroethene
1,4-Dichlorobenzene	Tetrachloroethylene
Ethyl benzene	Trichloroethene
N-Butylbenzene	Dichlorodibromomethane
N-Propylbenzene	Dichlorodifluoromethane
Isopropylbenzene	Trichlorofluoromethane
SEC-Butylbenzene	Napthalene
T-Butylbenzene	1,2-Dibromo-3-chloropropane
1,2,3-Trichlorobenzene	1,2-Dichloropropane
1,2,4-Trichlorobenzene	1,3-Dichloropropane
1,2,4-Trimethylbenzene	2,2-Dichloropropane
1,3,5-Trimethylbenzene	1,2,3-Trichloropropane
Methyl bromide	1,1-Dichloropropene
Hexachlorobutadiene	C-1,3-Dichloropropene
Carbontetrachloride	Dichloropropene
Chloroethane	T-1,3-Dichloropropene
Chloroform	Styrene
Methyl chloride Toluene	
Methylene chloride	P-Isopropyltoluene
1,2-Dibromoethane	Vinyl chloride
1,1-Dichloroethane	Xylene
1,2-Dichlorethane	M & P Xylene
1,2-Dichlorethene, (TRN)	O-xylene



Base from U.S. Geological Survey
El Reno 1:24,000, 1972,
Fort Reno 1:24,000, 1979,
Fort Reno NE 1:24,000, 1972, and
Okarche 1:24,000 1972

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Water-table contours from Mogg, Schoff, and Reed (1960)

Map B.—General land use and locations of potential sources of ground-water contamination within the Concho Reserve.

Table 2. Selected chemical analyses of ground water for selected wells and a spring within and near the Concho Reserve

[µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; deg. C, degrees Celsius]

Site identification number	Local number	Date	Specific conductance (µS/cm)	Hardness, total (mg/L as $CaCO_3$)	Alkalinity[1] (mg/L $CaCO_3$)	Calcium dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Solids, residue at 180 deg. C, dissolved (mg/L)
353358097583801	13N-07W-30 DDD 1	07-28-80	2,700	700	550	140	84	870	200	1.2	2,180
353452098002201	13N-08W-24 CDC 2	07-04-58	1,640	690	404	170	65	330	120	.8	1,120
353527097591901	13N-07W-19 BBB 1	04-16-43	865	430	264	110	36	200	15	.7	565
353545098003502	[2]13N-08W-13 BC 1	04-16-43	222	85	54	22	7.2	19	50	.4	130
353714098003401	13N-08W-12 BBA 1	02-20-54	339	110	41	29	8.5	29	12	.3	251

[1] Alkalinity collected as a whole water, fixed end point titration.
[2] Spring.

Revised table—12/8/93

Table 3.—*Sources of potential contamination to ground water within the Cheyenne-Arapaho Reserve*

Map number	Description	Remarks
1	Paved road and road cut	Conveys surface runoff, which may contain material from accidental transportation spills, animal remains or animal matter, and roadside dumping, directly into the well-head area where it ponds until infiltrated or evaporated.
2	Agricultural land	Most of the alluvium is irrigated agricultural land where pesticides, herbicides, and fertilizers are applied. Some cropland is located within 100 feet of the Concho well field.
3	Present water-supply wells	Located in low area where the water table is at ground level during wet periods. Well heads may be inundated by surface runoff that ponds in well field at times.
4	Abandoned and unplugged wells in present well field and at nearby unused hydroponics installation	Provides open conveyance into the aquifer.
5	Railroad	Possibility of accidental spills and herbicide use along right-of-way within the recharge area of the Concho Reserve well field.
6	A horse boarding corral and septic tanks from about 20 homes	Possibility of bacteria and nutrient introduction into the terrace and to surface runoff that drains into the recharge area of the Concho Reserve well field.
7	Oil and gas wells and storage tanks	Possibility of surface spill or structural failure contaminating aquifer recharge areas.
8	Stock pond in pasture	Discharges seepage and runoff containing animal waste onto alluvium at well field.
9	Small sewage lagoon serving smoke shop	Possibility of bacteria and nutrient introduction into the terrace.
10*	Concho sewage lagoon	Possibility of bacteria and nutrient introduction on the red beds and into streamflow of a tributary to the Cimarron River.
11*	Mechanical repair shops	Possibility of contaminating terrace with petroleum waste products: gasoline, solvents, and other hydrocarbons.
12*	Hog farm building and pen area with small waste lagoon	Possibility of bacteria and nutrient introduction on red beds and into a tributary of the Cimarron River by surface runoff.
13*	Oil and gas well with storage tanks	Possibility of surface spills on red beds and into a tributary of the Cimarron River.
14*	Grain storage bins	Possibility of introducing fumigant and insect-control material into ground water.

* Locations within the Concho Reserve that do not present a threat of ground-water contamination south of the Cimarron-North Canadian River divide.

EXPLANATION

NATURAL GRASSLANDS AND IMPROVED PASTURES

NON-IRRIGATED CROPLAND

IRRIGATED CROPLAND

TREES AND BRUSH

BOUNDARY OF THE CONCHO RESERVE

DRAINAGE DIVIDE—Separates North Canadian and Cimarron River drainage areas

1310 CONTOUR LINE—Showing altitude of the water table in the alluvium (Mogg, Schoff, and Reed, 1960)

(5) LOCATION OF POTENTIAL SOURCES OF GROUND-WATER POLLUTION—Number corresponds to site number in table 3

SPRING

OIL AND GAS WELL

▲07239500 STREAM-GAGING STATION—Number is station identification number

SOURCES OF CONTAMINATION

Identification and evaluation of potential sources of ground-water contamination is necessary for proper land use, land management, and zoning in areas of ground-water recharge and in areas of existing and future well sites. Currently, application of methyl parathion by aerial spraying and Glean are the predominate pesticides, and ammonium nitrate is the principal fertilizer applied in the agricultural areas of the alluvium (Fred Escott, Escott Aerial Spraying Inc., El Reno, Okla., personal commun., 1992). In at least two instances, fecal coliform bacteria were detected in water samples from the Concho Reserve well field (Oklahoma State Health Department State Environmental laboratory, written communs., 1989 and 1990). The source of contamination was not identified, but the presence of coliform bacteria is indicative of contamination occurring from and near land surface. Potential sources of ground-water contamination have been identified within and adjacent to the Concho Reserve. Several of these sources are not within the ground-water recharge area of the present well field and none are documented as actual sources of ground-water pollution. Potential sources of ground-water contamination are identified in table 3. Locations of potential sources of ground-water contamination are shown on map B.

SUMMARY

The location of the present Concho Reserve water-supply wells makes the well-head recharge area vulnerable to several potential sources of contamination. Contaminants carried by ponded surface runoff in the well-head area are the principal danger. Some analyses of ground water from the water-supply wells in past years contained fecal coliform bacteria, an indication of pollution from or near the land surface. The degradation of ground-water quality from other potential sources of contamination identified in this report has not been documented. Ground-water-quality analyses from the Concho Reserve water-supply wells would be required to determine if contaminants are present.

Relocation of the existing Concho Reserve water-supply wells is currently being considered by Reserve managers. The proposed location of the wells is about half a mile east of the present well field in an area that would not be subject to ponding of surface runoff around the well heads during wet periods. The proposed location would afford increased protection from catastrophic road or railroad spills. The proposed well relocation would place a greater part of the well-head recharge area within the Concho Reserve jurisdiction and simplify management of land-use practices within the recharge area.

The magnitude and extent of possible contamination of ground water from activities of man within Concho Reserve tribal lands has not been determined. The determination of current ground-water quality in wells at selected sites within the recharge area of the Tribe's water-supply wells would help identify the existence of contaminants at the wells and delineate potential contaminant plumes. Periodic water-quality monitoring at existing and future well locations would help maintain quality control over the public water supply.

DEFINITION OF TERMS

[From Meinzer, 1923, and Lohman and others, 1972]

Aquifer: A body of rock that is sufficiently permeable to conduct ground water and to yield economically significant quantities of water to wells and springs.

Contact spring: A gravity spring flowing from a lithologic contact where a more permeable rock overlies a less permeable rock.

Depression spring: A gravity spring flowing where the water table is intercepted by a steeply sloping land surface.

Drainage basin: The land area within a topographic divide from which surface runoff drains into a particular stream system.

Drainage divide: A boundary line along a topographic high that separates adjacent drainage basins.

Ephemeral spring: A spring that does not flow continually.

Hydraulic conductivity: The rate of flow in cubic feet per day through a cross section of one square foot under a unit hydraulic gradient, at the prevailing temperature.

Phreatophytes: Plants that obtain their water supply from the water table by means of a deep root system.

Safe yield: The amount ground water that can be withdrawn from an aquifer without exceeding recharge to the aquifer.

Saturated thickness: The saturated zone extending from the water table down to the base of an aquifer.

Specific capacity: An expression of the productivity of a well calculated by dividing the pumping rate of a well by the water-level drawdown.

Specific yield: A ratio of the volume of water a rock or soil will yield by gravity drainage to the volume of rock or soil.

Water table: The water surface in an unconfined aquifer or confining bed at atmospheric pressure. The water table is determined by measuring standing water levels in non-pumping wells.

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