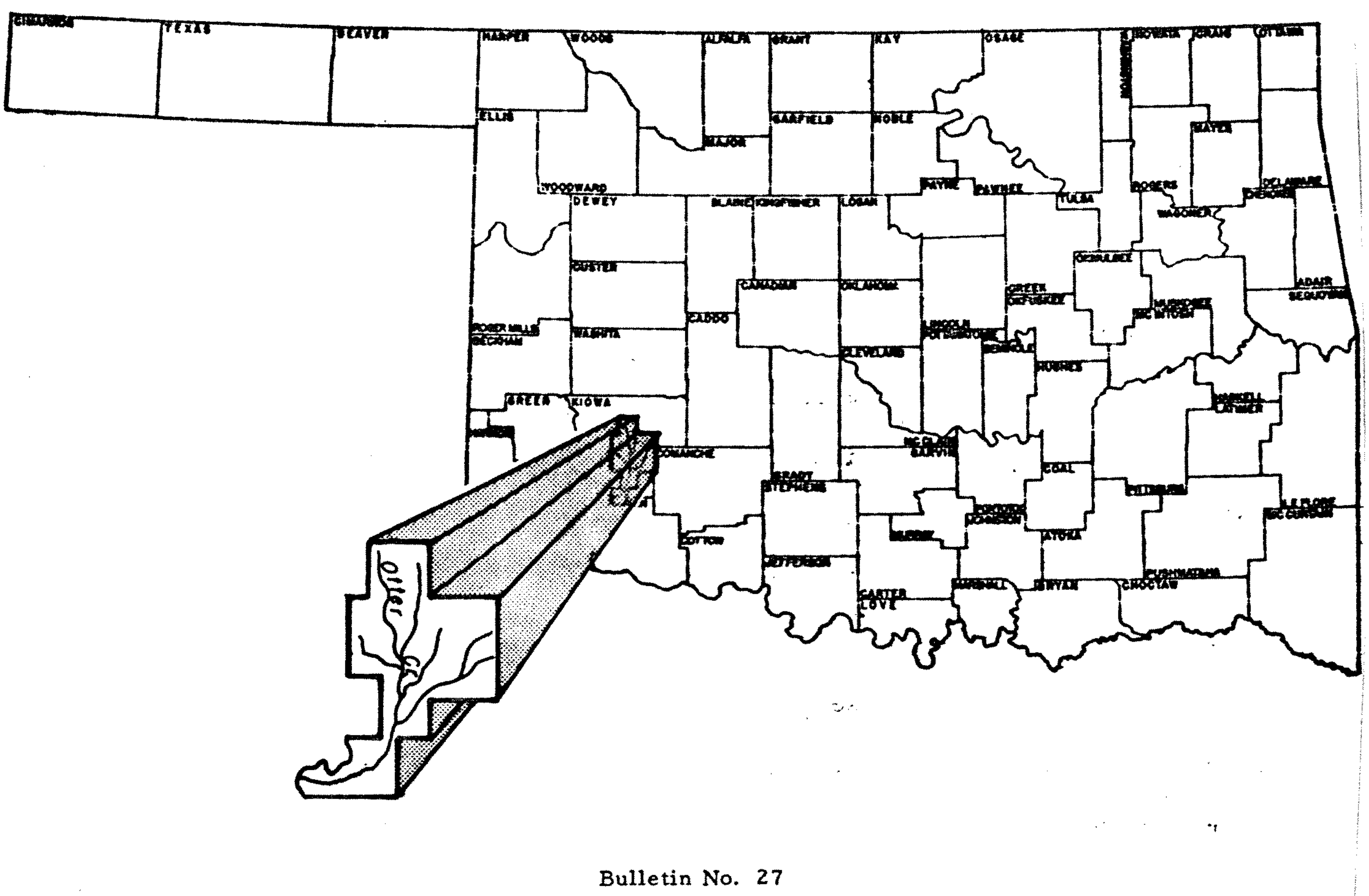
In The Alluvium Of
Ground Water
Otter Creek Basin,
Oklahoma



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The investigation on which this report is based was made from December 1960 to February 1961 by the U.S. Geological Survey in cooperation with the Oklahoma Water Resources Board. A report that briefly described the ground-geology of the alluvial deposits in the Otter Creek basin was released to the open file in August 1961. The original purpose of the investigation was to provide information for use by the State in establishing water rights in the basin. Because it contains information on the availability of ground water that may be useful in planning and developing the area, the report has been published by the Oklahoma Water Resources Board.

Oklahoma Water Resources Board

GROUND WATER IN THE ALLUVIUM OF OTTER CREEK BASIN, OKLAHOMA

By

Jerrald R. Hollowell

Open-File Report
Prepared by the U.S. Geological Survey
in cooperation with
the Oklahoma Water Resources Board

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By Jerrald R. Hollowell

ABSTRACT

Otter Creek basin comprises 287 square miles in Kiowa, Comanche, and Tillman Counties. The basin is not typical of southwestern Oklahoma in that it includes massive mountains and scattered knobs and peaks of the Wichita Mountains. Alluvium covers much of the southern half of the basin but is restricted to the major tributary valleys in the northern half. The upper part of the alluvium is predominantly silt and clay; the lower part is predominantly very fine to medium sand and has a basal stratum of coarse sand and gravel. The average thickness of the flood-plain deposit is about 37 feet. The flood-plain deposits and terrace deposits in the southern part of the basin occur together in the subsurface as an integral unit. Principal recharge to the flood-plain deposits is through infiltration of precipitation and surface runoff, and through percolation from adjoining aquifers, principally the terrace deposits. Principal discharge from the flood-plain deposits is through seepage into Otter Creek by transpiration by vegetation, and by pumping from wells. The city of Snyder pumps about 200,000 gallons per day (gpd) from the alluvium of East Otter Creek during the winter and spring, and about 400,000 gpd during the summer and fall. Irrigation is concentrated principally on the flood plain common to both Otter Creek and North Fork Red River.

INTRODUCTION

Purpose and Scope

This report illustrates and describes the alluvial geology and the hydrologic properties of the alluvial deposits in Otter Creek basin. The bedrock geology is described briefly also. The limits of the flood-plain alluvium of Otter Creek basin were mapped. The purpose of this investigation was to map and describe the alluvial deposits in Otter Creek basin and to explain the occurrence, movement, and use of ground water in the alluvial deposits.

Location and General Features of the Basin

Otter Creek rises in and drains the southwestern part of the Wichita Mountains in Kiowa and Comanche Counties, Okla. The Otter Creek basin is a 287 square-mile area that lies principally in Kiowa County and extends into northwest Tillman and Comanche Counties (fig. 1). The basin, shaped like South America, is about 30 miles long and 18 miles wide at its widest part. Its altitude ranges from 1,260 to 2,400 feet above mean sea level. Its relief is not typical of southwestern Oklahoma. Isolated ridges, peaks, and knobs of granite and gabbroic rocks protrude through the nearly level plains to heights up to 500 feet.

West Otter Creek heads in central Kiowa County at an altitude of about 1,560 feet. It flows south 22 miles to its confluence with East Otter Creek in sec. 9, T. 2 N., R. 17 W (fig. 3). East Otter Creek heads in the Wichita Mountains in northwestern Comanche County at an altitude of about 2,100 feet. It flows southwest about 17 miles to its confluence with West Otter Creek. From this confluence Otter Creek flows south and west 15 miles to join the North Fork Red River, sec. 23, T. 1 N., R. 19 W., in Tillman County.

The population of the basin according to the 1960 Census was about 4,000. The principal city, Snyder, in the southern part of the basin (fig. 3), has a population of 1,663. Other cities are Roosevelt and Mountain Park with populations of 495 and 403, respectively.

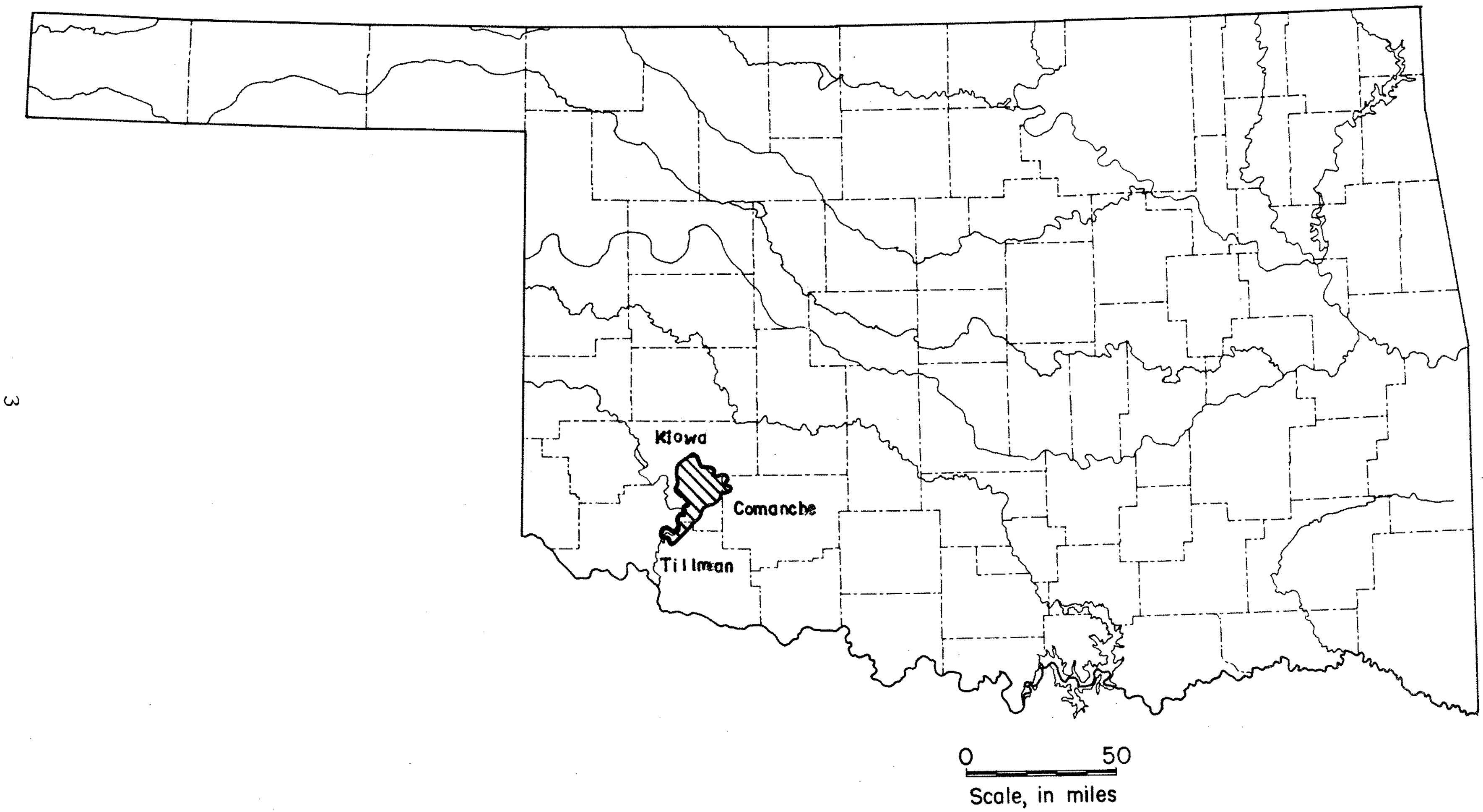


Figure 1.--Index map showing location of Otter Creek basin, Oklahoma.

Well and Test-Hole Numbering System

All wells and test holes referred to in this report are identified by a location number used in Oklahoma by the U.S. Geological Survey and the Oklahoma Water Resources Board. The location number describes the geographic location of the well or test hole, based on the Federal system of public-land surveys. It indicates the location of the well or test hole to the nearest 10-acre tract when the well can be located that precisely. The location number consists of a series of numbers and letters corresponding to the township, range, section, and tract within a section, in that order, as illustrated in figure 2. For instance, the number 1N-18W-1cba refers to a well in T. 1 N., R. 18 W., sec. 1, and located in the NE$\frac{1}{4}$NW$\frac{1}{4}$SW$\frac{1}{4}$ of the section.

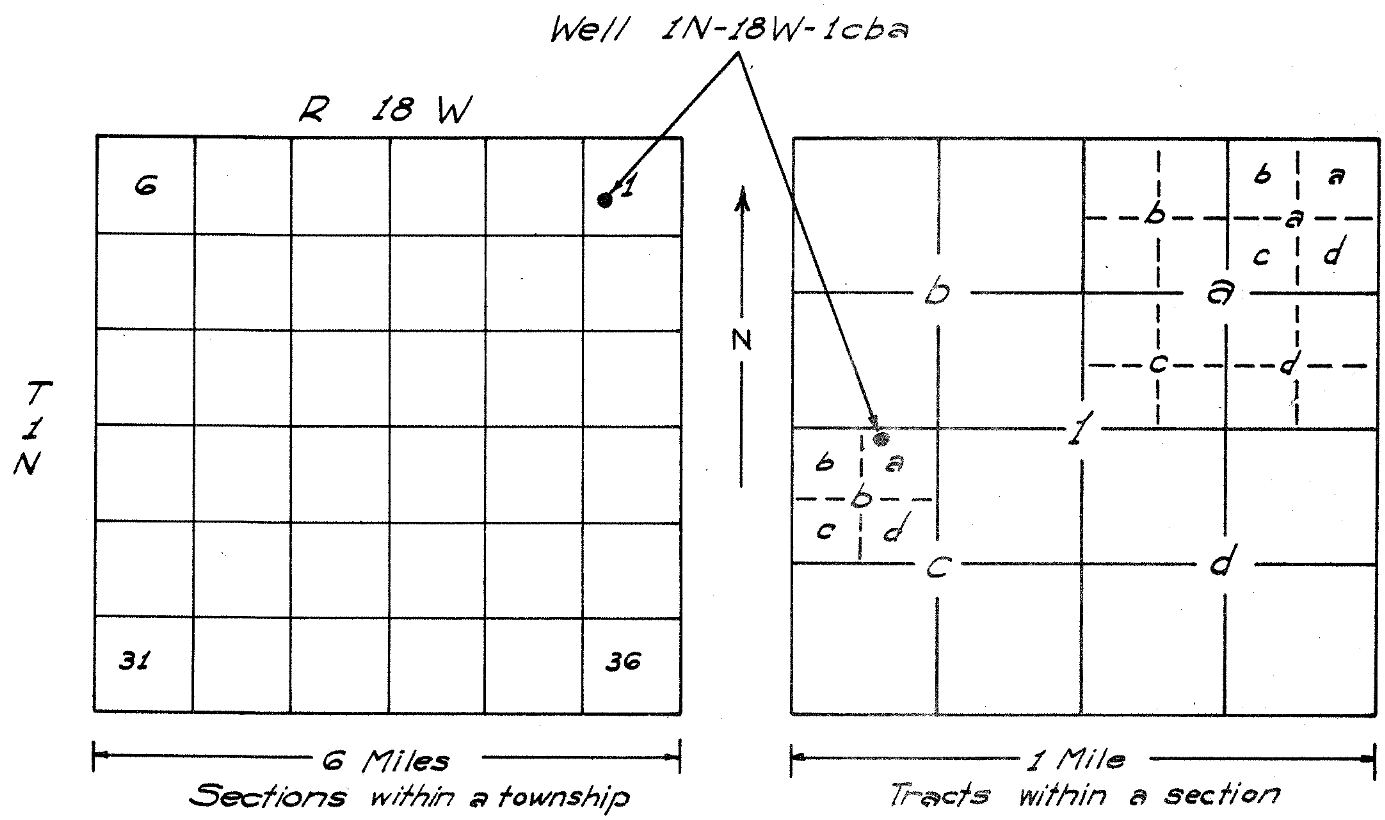


Figure 2.--Diagram illustrating well and test-hole numbering system.

GEOLOGY

Precambrian Rocks

The bedrock in Otter Creek basin is composed of Precambrian igneous and Permian sedimentary rocks (fig. 3). The Precambrian granitic and gabbroic rocks form barren domelike hills and mountains that rise abruptly 5 to 500 feet above the plains. In much of the basin these hills are only partly exposed above the plain. No wells are known to obtain water directly from the Precambrian rocks, but along the flanks of the mountains some water is obtained from younger deposits composed chiefly of granitic fragments.

Permian Rocks

The Permian rocks exposed throughout the basin belong to the Wichita Formation (fig. 3), which consists of interbedded reddish-brown and light-gray silt, shale, and very fine- to medium-grained sandstone, that is locally gypsiferous. A characteristic feature of the Wichita Formation is the greenish-gray mottling on freshly broken surfaces of silt and shale beds. This feature is useful in distinguishing weathered red beds from overlying terrace deposits of similar lithology. No wells are known to obtain large amounts of water from this formation, but, locally, small amounts of water may be obtained from the lenticular sandstone beds. Eight municipal wells of the city of Roosevelt tap this formation. Their yield is small and inadequate for the citys's needs during the summer.

Quaternary Deposits

Alluvial deposits are made up of materials deposited by flowing water. In the Otter Creek area they have been subdivided into terrace deposits of Pleistocene age and flood-plain deposits of Recent age (figs. 3 and 4). Alluvial deposits of Quaternary age cover most of the southern half of the Otter Creek drainage basin. In the northern half of the basin the alluvial deposits are restricted to the major tributary stream valleys as shown in figure 3.

Terrace Deposits

Terrace deposits of Pleistocene age are alluvial deposits at some height above the present flood plain, and which underlie abandoned former flood plains. The deposits consist of interbedded lenses of clay, silt, sand, and gravel. They are widespread throughout the southern part of the basin, flanking Otter Creek flood plain and surrounding the granite mountains (fig. 3).

Terrace deposits in the northern part of the basin are isolated and thin. On the surface, terrace deposits are difficult to discern from deeply weathered Permian bedrock, and in many areas the only distinction is the topographic relief. The extensive terrace deposits in the extreme southern part of the basin have a maximum thickness of at least 76 feet and possibly more; their average thickness is about 42 feet (Barclay and Burton, 1953, p. 10) and the lower part contains about 20 feet of sand and gravel. These deposits are the principal aquifer in Tillman County and supply large amounts of water for irrigation and municipal supplies as well as supplying domestic needs.

In sec. 12, T. 1 N., R. 18 W., and sec. 7, T. 1 N., R. 17 W., the terrace deposits wedge out against a bedrock high that borders the flood plain (fig. 3). The terrace deposits flanking the flood plain in T. 2 N. average about 20 feet throughout the rest of the basin. The terrace deposits are a principal aquifer in Kiowa County and where they are thickest are tapped for irrigation and municipal supply. In Tps. 4 and 5 N. thin terrace deposits are extensive along minor tributary valleys (fig. 3) where they yield small amounts of water adequate for domestic supply. Test drilling in sec. 2, T. 4 N., R. 18 W., found the terrace deposits about 25 feet thick and containing only a few feet of saturated material.

Flood-Plain Deposits

In the Otter Creek basin the alluvial deposits of Recent age are confined to the flood plains, strips of relatively smooth land that border the principal streams. This alluvium consists of stream-laid deposits that generally can be divided into two parts, the upper predominantly silt and clay and the lower predominantly sand and gravel. The upper deposits are light gray to dark brown, are generally sandy, and locally contain shell fragments. The lower deposits are reddish brown to gray. Generally the alluvial deposits grade gradually downward from silt to sand to gravel and the gravel lies on bedrock. However, in some places the silt and sand are interbedded. Relative thicknesses of these upper and lower units are shown in figures 4-6. The principal source of the alluvial deposits is the igneous rocks of the nearby Wichita Mountains. However, much of the finer material was derived from the fine-grained sandstone, silt, and clay of the Permian sedimentary rocks surrounding the mountains (fig. 3). The age of the subsurface deposits cannot be determined, thus part of the alluvial fill beneath the flood plains may be of equivalent age to the terrace deposits.

The alluvial valley of East Otter Creek is about 13 miles long and half a mile or less in width. In well 3N-17W-34dac the alluvium is 52 feet thick and contains 18 feet of basal sand. It thins upstream and at Mountain Park is 23 feet thick and contains only 3 feet of basal sand. The flood-plain deposits are the principal aquifer along the valley, being tapped principally by domestic- and stock-supply wells. However, in the lower reach of the valley, where it is thickest, it is the source of Snyder's municipal-water supply.

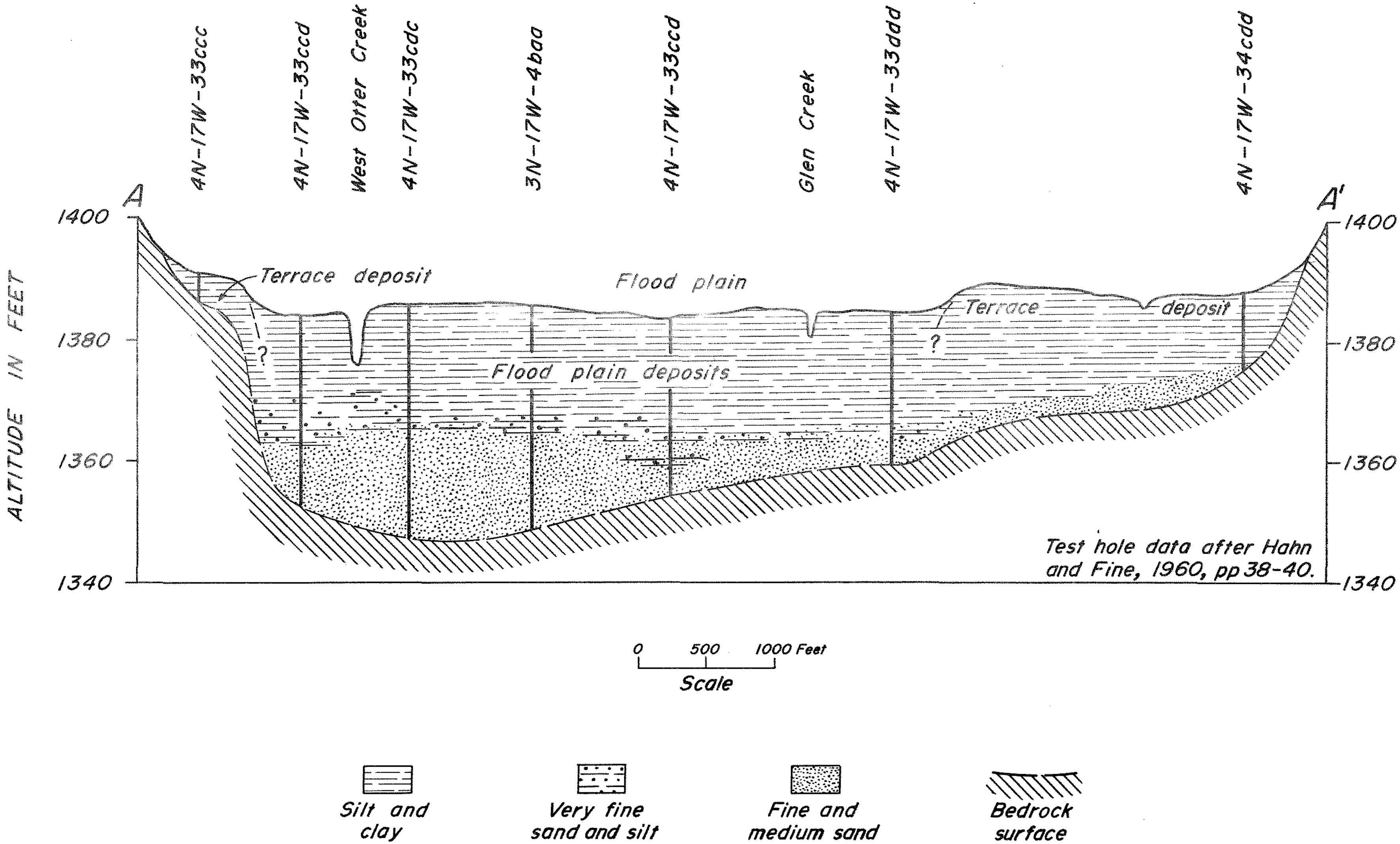
The alluvial valley of West Otter Creek consists of three segments separated by massive mountains. From north to south these segments are:

(1) A narrow valley in Tps. 4 and 5 N., R. 17 W., that is about $4\frac{1}{2}$ miles long and half a mile wide and narrows upstream. The source of the alluvium of this segment is entirely fine-grained sedimentary rock. The alluvium contains only a few feet of basal sand; therefore, its potential for water-supply development is limited to a few domestic and stock supplies.

(2) A nearly flat valley in Tps. 3 and 4 N., R. 17 W., that is about a mile wide and 3 miles long. The thickness of the flood-plain deposits in this segment ranges from 5 to 46 feet and averages about 30 feet. The upper silt and clay ranges in thickness from 11 to 42 feet and averages about 22 feet. The basal sand and gravel ranges in thickness from 2 inches to 27 feet and averages about 8 feet (Hahn, and Fine, 1960, p. 36-43). Geologic section A-A' (fig. 4) shows the valley fill to consist of extensive flood-plain deposits flanked by a narrow terrace deposit, both bounded and underlain by sedimentary bedrock. In this segment the flood-plain deposits are the principal aquifer; they are tapped by four irrigation wells.

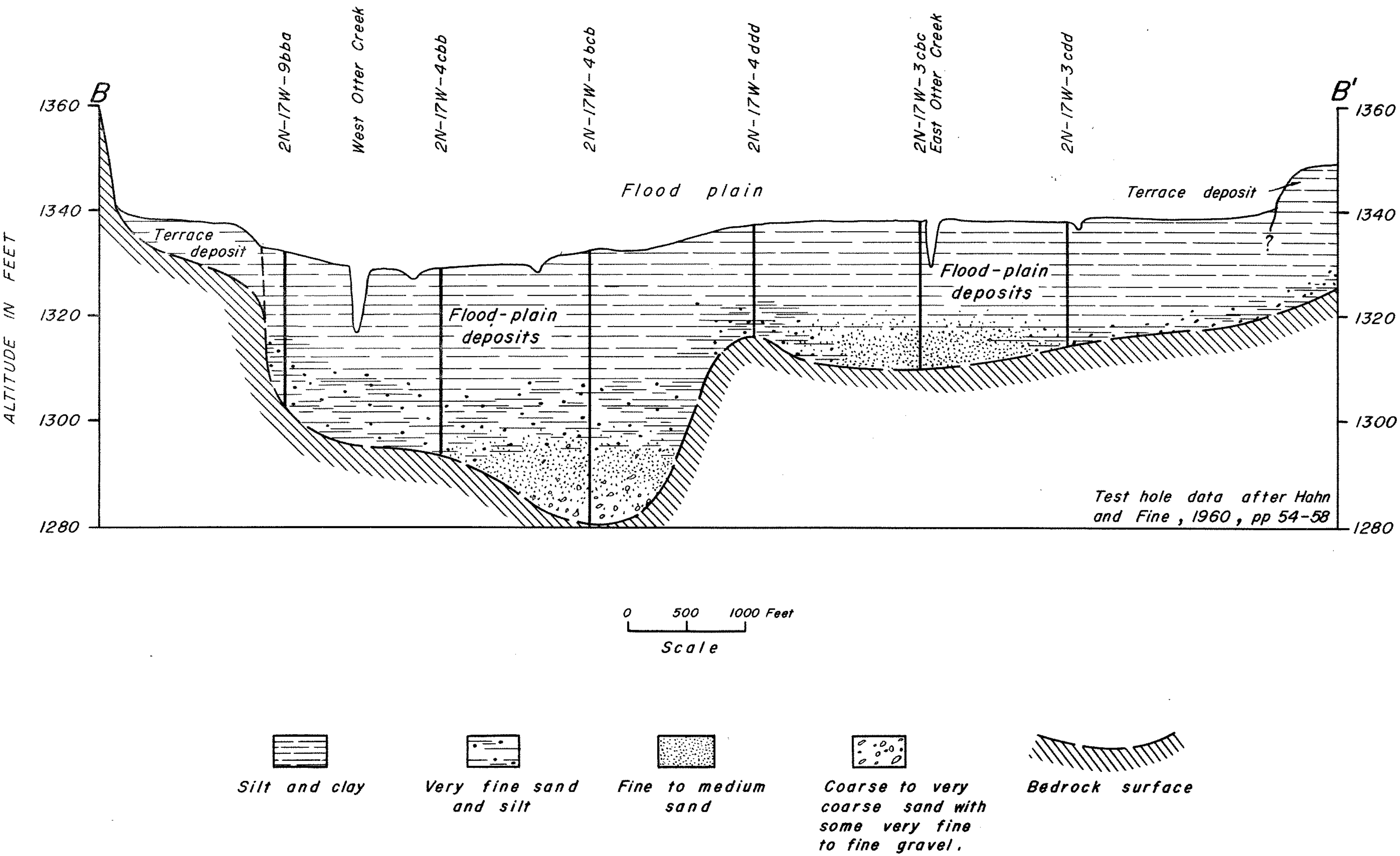
(3) A nearly flat valley in Tps. 2 and 3 N., R. 17 W. (fig. 3), that is about half a mile wide and 7 miles long. In this segment the thickness of the flood-plain deposits ranges from 20 to 66 feet and averages about 43 feet. The thickness of the upper silty part ranges from 6 to 45 feet and averages about 22 feet. The thickness of the basal sandy part ranges from 1 to 50 feet and averages about 21 feet. Where coarse sand and gravel occur, the coarse zone ranges in thickness from 1 to 39 feet and averages about 9 feet (Hahn, and Fine, 1960, p. 43-61). Geologic section B-B' (fig. 5) through the flood plains of East Otter Creek and West Otter Creek shows that the flood-plain deposits are confined by bedrock to the west and flanked by terrace deposits to the east. In this segment flood-plain deposits are the principal aquifer and they are tapped by 7 irrigation and 2 industrial wells.

From the confluence of East and West Otter Creeks, Otter Creek traverses a broad flood plain bounded on the north, east, and south by terrace deposits (fig. 3). The flood-plain deposits range in thickness from 18 to 54 feet and average about 40 feet. The upper part is predominately silt and sandy silt, and ranges in thickness from a few inches to 45 feet and averages about 14 feet. The lower part consists of sand and gravel and ranges in thickness from 1 to 50 feet and averages about 26 feet. These lower deposits are predominantly medium to very coarse sand but contain very fine and fine gravel. This is the most prolific aquifer in the basin and it is tapped by 75 known irrigation wells or



Line of cross section shown on figure 3

Figure 4. Geologic cross section A-A'



Line of cross section shown on figure 3.

Figure 5. Geologic cross section B-B'

well systems. Geologic section C-C' (fig. 6) shows the flood plain bounded on the north by sand dunes and on the south by terrace deposits. Because the terrace deposits were laid down by ancient streams that traversed the area they are similar to the deposits laid down by the present stream system. Although there is a difference in age and altitude, these two units have similar physical and water-bearing properties, and together form a single aquifer.

Dune Sand

Dune sand is an eolian deposit of Pleistocene or Recent age consisting of very fine to medium sand and silt. Dunes flank the north side of Otter Creek in a strip about a mile wide along the lower $5\frac{1}{2}$ miles of its course where the creek flows westward. The dunes range from 5 to 30 feet in height and overlie alluvial deposits (fig. 6). The principal source for the dune sand is the nearby flood plain of North Fork Red River.

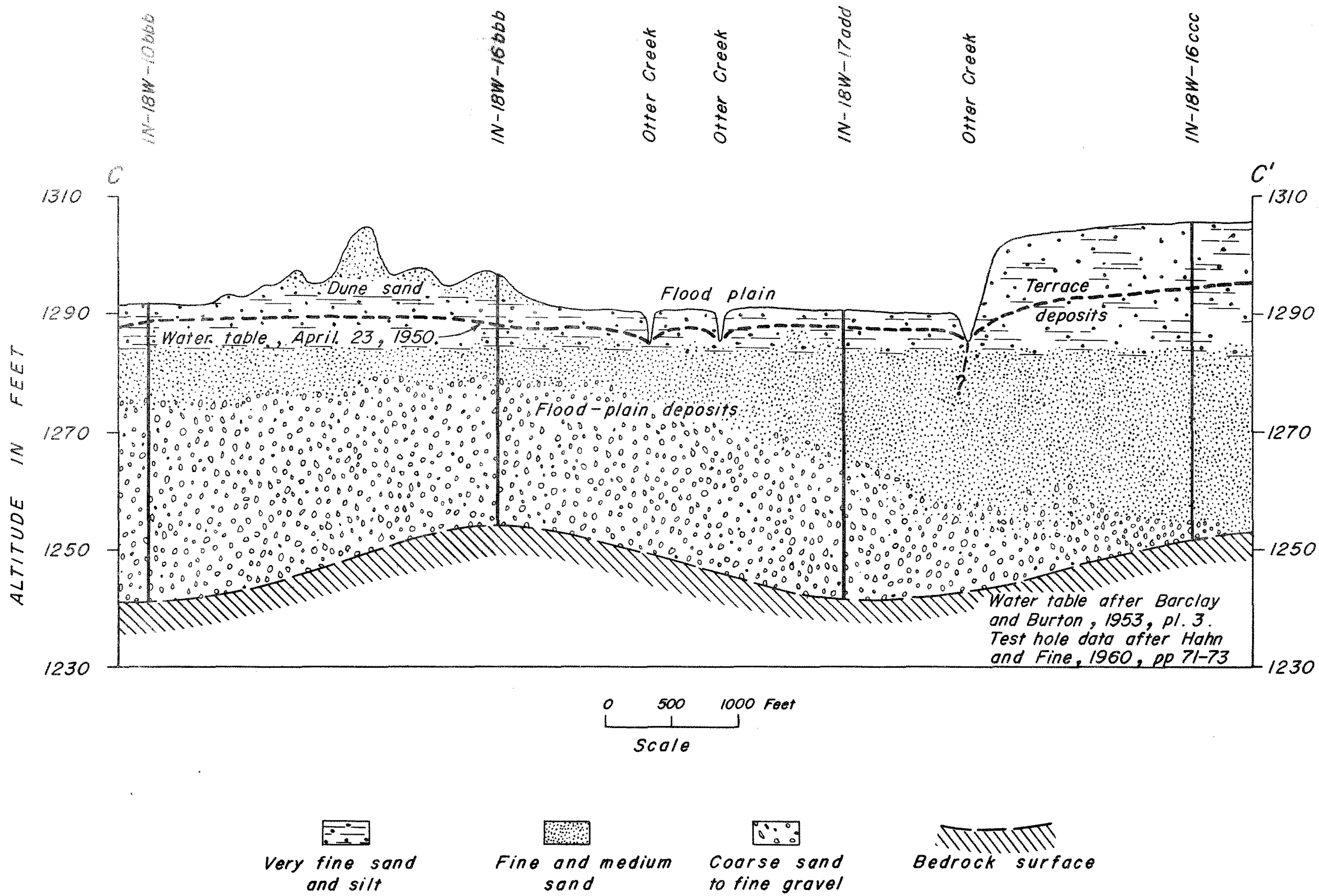
GROUND WATER IN THE ALLUVIUM

Ground water is water below the land surface and in the zone of saturation. In this report ground water is restricted to the flood-plain deposits of Otter Creek basin by impermeable bedrock except in the southern part. There the flood-plain deposits and the terrace deposits form an integral unit in the subsurface (figs. 5 and 6) and ground water is restricted to both flood-plain and terrace deposits.

Movement

The ground water is continually moving from areas of recharge to areas of discharge. The upper surface of the zone of saturation, termed the water table, is about 10 feet below the flood plain of Otter Creek. Fluctuations of the water table are caused chiefly by irregularities in rates of recharge and discharge of ground water.

Fluctuation of the water table in the flood-plain deposits is illustrated by the monthly hydrograph of observation well 1N-18W-1cba in Tillman County (fig. 7). The water table rises to a high level in response to heavy precipitation; the water level declines sharply during July, August, or September in response to pumping for irrigation and transpiration by plants. The prolonged decline of the water level during 1956 was due to drought.



Line of cross section shown on figure 3

Figure 6. Geologic cross section C-C'

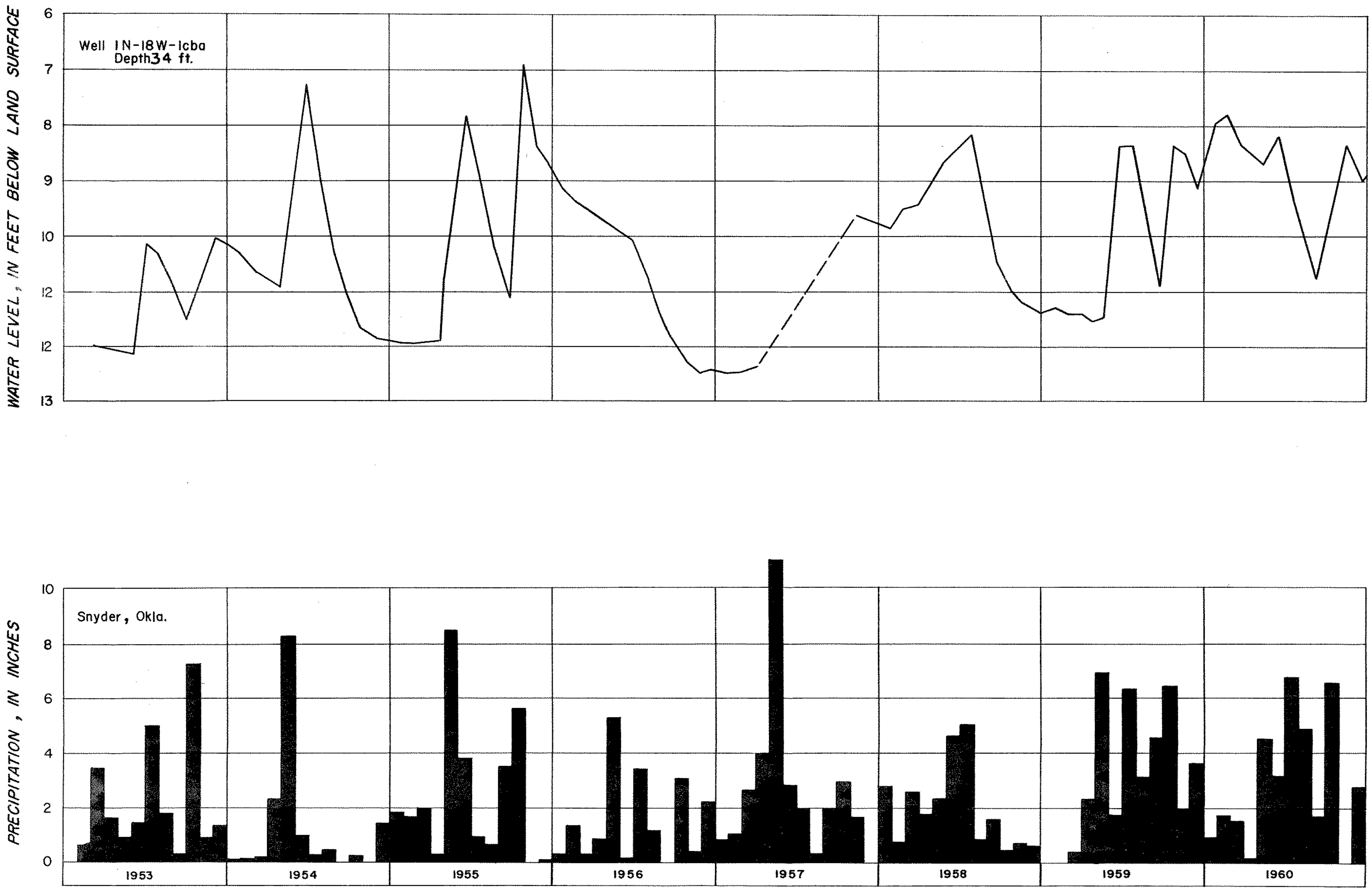


Figure 7--Hydrograph of observation Well 1N-18W-1cba, Tillman County, and monthly precipitation at Snyder.

Recharge

Recharge, the replenishment of ground water to the alluvium, is from one or more of several sources--precipitation directly on the flood plain, surface runoff from outside the flood-plain area, overflow from Otter Creek, and application of excessive irrigation water. Other lesser sources are bank infiltration from Otter Creek during a higher than average stream stage and lateral percolation into the flood-plain deposits from adjacent deposits.

Surface drainage is not well developed on much of the flood plain, so precipitation and overland runoff from the adjacent highlands is a principal source of recharge. The sandy soil favors a relatively high rate of infiltration, and recharge occurs rapidly in the sand-dune and adjacent areas in the southern part of the basin. Recharge from precipitation in this area is illustrated by the rapid rise of the water level in well 1N-18W-1cba in response to precipitation as shown on figure 7.

Another major source of recharge to the flood-plain deposits is percolation from the flanking terrace deposits. Recharge occurs continually due to the higher position of the water table in the terrace deposits relative to the water table in the flood-plain deposits.

Discharge

Ground water is continually being discharged through one or more of several ways--by seepage into stream channels, percolation into adjacent aquifers, transpiration by plants, evaporation from the saturated zone, and pumping of wells.

Discharge occurs as ground water seeps into a stream whose surface is lower than the water table. This seepage is responsible for stream flow during periods when there is no surface runoff and occurs at all times except during high stream flow when the water table is lower than the stream bed. Seepage from the terrace deposits that flank the south side of Otter Creek along the lower 6 miles of its course was computed to be about 2,400,000 gpd (gallons per day) using figures obtained by Barclay and Burton (1953, p. 20). This is sufficient to maintain perennial flow along this reach of Otter Creek.

Some discharge of ground water may take place through percolation into sandstone aquifers in the Permian rocks underlying and bordering the alluvium. Only under unusual conditions would the ground water from the flood-plain deposits percolate into the terrace deposits. This could happen only if pumping from the terrace deposits was heavy enough to draw the water table below that of the flood-plain deposits.

A large amount of ground water is discharged by transpiration from the heavy growth of trees and brush lining the banks of the creeks and covering uncultivated areas of the flood plain, especially by phreatophytes (cottonwood, willow, and alfalfa).

Ground water is discharged also by evaporation directly from the zone of saturation where the water table is within a few feet of the land surface. This discharge from the alluvium is small because the depth to the water table at most places is too great to permit evaporation.

The discharge of ground water from the flood-plain deposits by pumping is heavy in Tps. 1 and 2 N. but is negligible north of U.S. Highway 6. The greatest discharge of ground water from the flood-plain deposits is for irrigation south of U.S. Highway 62 (fig. 3). The common well installation, a group of sandpoint wells connected by a manifold to a centrifugal pump, is reported to yield as much as 900 gpm (gallons per minute), however, most wells yield 150 to 350 gpm.

About 370 acre-feet of ground water is pumped annually for the Snyder municipal supply. Two wells, 3N-17W-34dac1 and 34 dac2, tapping the alluvium of East Otter Creek (fig. 3), supply about 200,000 gpd during the winter and spring and about 400,000 gpd during the summer and fall. This adequately supplies about 600 metered and 200 unmetered customers, except during prolonged periods of extremely hot weather, when water consumption increases.

Roosevelt Monument Co. is the principal industrial user of ground water in the Otter Creek basin. Two wells, 2N-17W-4cac and cdb, are pumped on a work-week basis and discharge about 10 and 20 gpm, respectively.

Irrigation and municipal use constitute the principal discharge by pumping from the terrace deposits flanking Otter Creek in the southern part of the basin. Yields from irrigation wells in the terrace deposits are reported to be as much as 700 gpm. Mountain Park obtains its municipal supply from a privately owned well, 3N-17W-27ddd, that is reported to yield 225 gpm. Roosevelt obtains its municipal supply from 9 wells in sec. 2, T. 4 N., R. 18 W. (fig. 3), of which 1 well that taps the terrace deposits is reported to yield about 10 gpm.

CONCLUSIONS

As written in the Oklahoma Statutues "water flowing in underground streams with ascertainable beds and banks" refers to the ground water in the saturated portion of the alluvial fill deposited by the present stream system. In part of Otter Creek basin, where the flood-plain deposits are bounded and underlain by impermeable bedrock, the banks are clearly ascertainable. In the southern part of Otter Creek basin, where the flood-plain deposits are bounded by terrace deposits that have similar geologic and hydrologic characteristics in the subsurface, the banks are not ascertainable. The terrace deposits, being topographically higher than the flood-plain deposits, contribute ground water continually to the flood-plain deposits (fig. 6). Thus the "water flowing in underground streams" is arbitrarily restricted to the water in the flood-plain deposits that is moving downstream. Only by lowering the water level in the terrace deposits (by heavy and continuous pumpage) could the relation between ground water in the flood-plain deposits and ground water in the terrace deposits be altered. For this reason, the alluvial deposits of the flood plain have been differentiated from the terrace deposits as though the topographic break separating them was formed by "ascertainable beds and banks" in the subsurface.

Near the confluence of Otter Creek with the North Fork Red River, the creek and river share an alluvial flood plain some 27 square miles in area (fig. 3). Any delineation of the individual flood plains and drainage basins could be made only on the basis of topographic relief and would be arbitrary. The only hydrologic distinction that could be made would be to define the ground-water divide between the ground water moving toward Otter Creek and toward North Fork Red River. This would require a more detailed study of the water table than was possible during this investigation.

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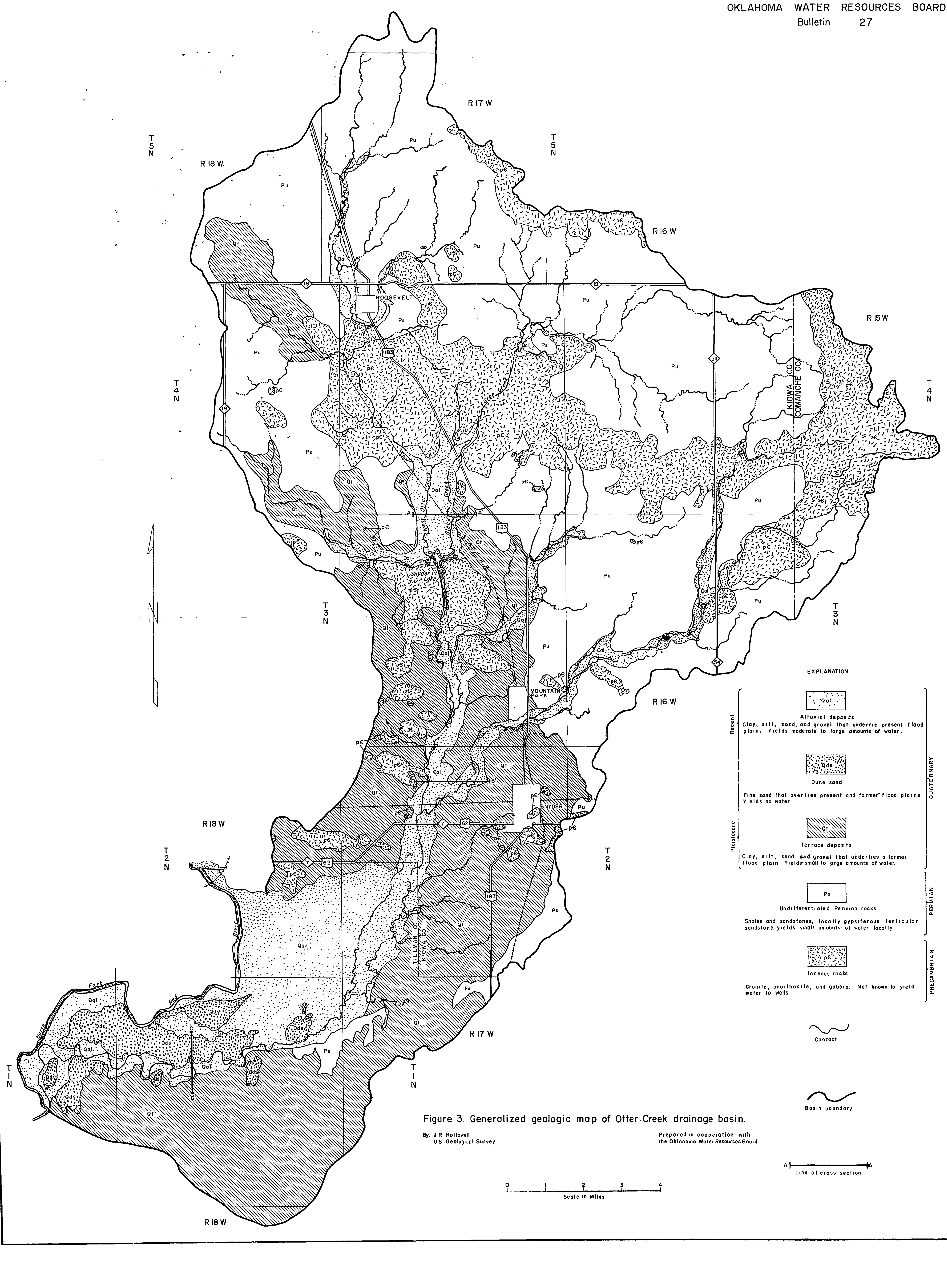

Figure 3. Generalized geologic map of Otter-Creek drainage basin.

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Prepared in cooperation with
the Oklahoma Water Resources Board