Geology and Ground- Water Resources of the Lower Lodgepole Creek Drainage Basin, Nebraska

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With a section on

CHEMICAL QUALITY OF THE WATER

By E. R. JOCHENS

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By L. J. Bjorklund

ABSTRACT

The area described is almost wholly in Nebraska and is the drainage basin of Lodgepole Creek from the Wyoming State line to the Colorado State line, a distance along the stream valley of about 95 miles. It covers about 1,950 square miles. The purposes of the study were to ascertain the characteristics, thickness, and extent of the water-bearing formations and to obtain and interpret data on the origin, quality, quantity, movement, availability, and use of ground water in the area.

The rocks exposed in the drainage basin are the Brule formation of Oligocene (Tertiary) age, the Ogallala formation of Pliocene (Tertiary) age, and alluvium of Pleistocene and Recent (Quaternary) age. The Brule formation is mainly a siltstone, which yields an average of 950 gallons per minute (gpm) to irrigation wells tapping its fractured zones or reworked material; the maximum reported discharge is 2,200 gpm. The Ogallala formation underlies most of the area. It consists of lenticular beds of clayey, silty, sandy, and gravelly materials and supplies water to all wells on the upland, including a few large-discharge wells, and to many irrigation and public-supply wells in the valley of Lodgepole Creek. The yield of irrigation wells tapping the Ogallala formation ranges from 90 to 1,600 gpm and averages about 860 gpm. The alluvium is present in the valleys of Lodgepole Creek and its tributaries and consists mainly of heterogeneous mixtures of silt, sand, and gravel, and lenticular bodies of these materials. Between the Colorado State line and Chappell, Nebr., irrigation wells derive most of their water from the alluvium. However, between Chappell and Sidney most of the irrigation wells tap both the alluvium and permeable zones in the underlying Brule formation, and in much of the valley west of Sidney, where the water table is beneath the bottom of the alluvium, irrigation wells derive water from the underlying Brule or Ogallala formations. Irrigation wells obtaining water chiefly from the alluvium have a yield ranging from 130 to 1,200 gpm, averaging about 770 gpm.

In the Lodgepole Creek valley below Sidney the depth to water generally is less than 20 feet and, in many places, less than 10. In much of this part of the area the water table extends to the land surface or to the root zone of the vegetation, and discharge by evapotranspiration is high. In the valley of Lodgepole Creek between Sidney and the Wyoming State line, the depth to water generally ranges from less than 10 feet near the stream to more than 100 along the edge of the valley. In the upland the depth to water ranges from about 80 to about 300 feet.

Recharge to the ground-water reservoir is derived chiefly from precipitation; other sources are seepage from irrigation systems and streams, and subsurface inflow of ground water. Water that infiltrates to the water table generally moves toward Lodgepole Creek in a downstream direction and is discharged into the stream through springs and seeps. However, within an area of at least 400 square miles in the northern part of the lower Lodgepole Creek drainage basin, ground water moves toward the valley of the North Platte River.

Water is discharged from the ground-water reservoir into streams, by evapotranspiration, through wells, and by subsurface outflow. During the 1951–52 water year about 13,000 acre-feet of ground water left the area as streamflow. An estimated 20,000 acre-feet of water annually is discharged by the transpiration of grasses and trees growing along the creek bottom, and about 1,000 acre-feet of water leaves as subsurface outflow.

During the period 1950–51 about 68,000 acre-feet of water was pumped from wells in the area for all uses. Of this amount, about 35,000 acre-feet in 1950 and 23,300 acre-feet in 1951 were used to irrigate about 15,560 and 15,790 acres. Nearly one-fourth of this water percolated back to the ground-water reservoir. These acreages, however, included about 2,100 acres irrigated in part with water diverted from Lodgepole Creek.

The 13,000 acre-feet of ground water that left the area as surface flow during the water year 1951–52 is excess or rejected ground water, and therefore this additional amount of ground water could be pumped without exceeding the available supply. The pumping of a greater amount of water would cause a decline of the water table and thereby lessen the quantity of ground water discharged by nonbeneficial vegetation. Large-discharge wells can be developed in almost any part of the lower Lodgepole Creek valley except in about a 5-mile stretch starting 7 miles upstream from Brownson. It is believed that maximum discharge probably has been reached in the heavily pumped area in the lower 10 miles of Sidney Draw. However, additional ground water could be pumped from the Ogallala formation throughout much of the upland. That part of the upland on both sides of Lodgepole Creek valley between Bushnell and Potter offers the best possibilities for future development of large-discharge wells in the Ogallala formation. The upland south of Lodgepole Creek valley from about 10 miles west of Sidney to about 5 miles east of Sidney and the upland in the vicinity of the Wyoming State line are the least favorable areas for large-discharge wells.

Ground water and surface water in the lower Lodgepole Creek drainage basin are similar in chemical character. Concentrations of dissolved chemical substances generally are low. The concentration of dissolved solids in 22 samples of ground water ranged from 217 to 473 parts per million (ppm). Three samples of surface water had concentrations that were within the range of the ground-water samples. Both surface water and ground water are moderately hard, both are low in percent sodium, and, in both, the bicarbonate ion predominates over other anions.

All the samples were rated as excellent to good for irrigation; none contained amounts of boron harmful to the most sensitive crops. Water in the report area generally is excellent for most purposes, although silica and hardness may present some problems if the water is used in steam boilers and water heaters. Most of the water meets the quality standards with respect to chemical characteristics as recommended by the U. S. Public Health Service for water used on interstate carriers.

INTRODUCTION

PURPOSE AND SCOPE OF THE INVESTIGATION

This investigation is one of several being made by the Geological Survey as part of the program of the Department of the Interior for the conservation, development, and use of the water resources of the Missouri River basin. This study was made at the request of the Bureau of Reclamation to ascertain the characteristics, thickness, and extent of the water-bearing formations in the lower Lodgepole Creek drainage basin in Nebraska, the origin, quality, quantity, movement, availability, and use of ground water in the area, and to bring up to date the information obtained by previous studies.

This report is based principally on field work done from September 1951 through July 1952. The study was under the general supervision of A. N. Sayre, chief of the Ground Water Branch of the Geological Survey, and G. H. Taylor, regional engineer in charge of ground-water investigations in the Missouri River basin, and under the immediate supervision of H. M. Babcock, district engineer for Wyoming. The quality-of-water study was made under the general supervision of S. K. Love, chief of the Quality of Water Branch of the Geological Survey, and P. C. Benedict, regional engineer in charge of quality-of-water studies in the Missouri River basin.

LOCATION AND EXTENT OF THE AREA

The area described is that part of the drainage basin of Lodgepole Creek east of the Wyoming-Nebraska State line, a distance of about 95 miles along the creek valley. It includes most of Cheyenne and Kimball Counties, about one-third of Deuel County, and a small part of Banner County in Nebraska, and a narrow strip along the northern part of Logan and Weld Counties, Colo. It covers an area of about 1,950 square miles, of which 1,825 is in Nebraska (figs. 1 and 2).

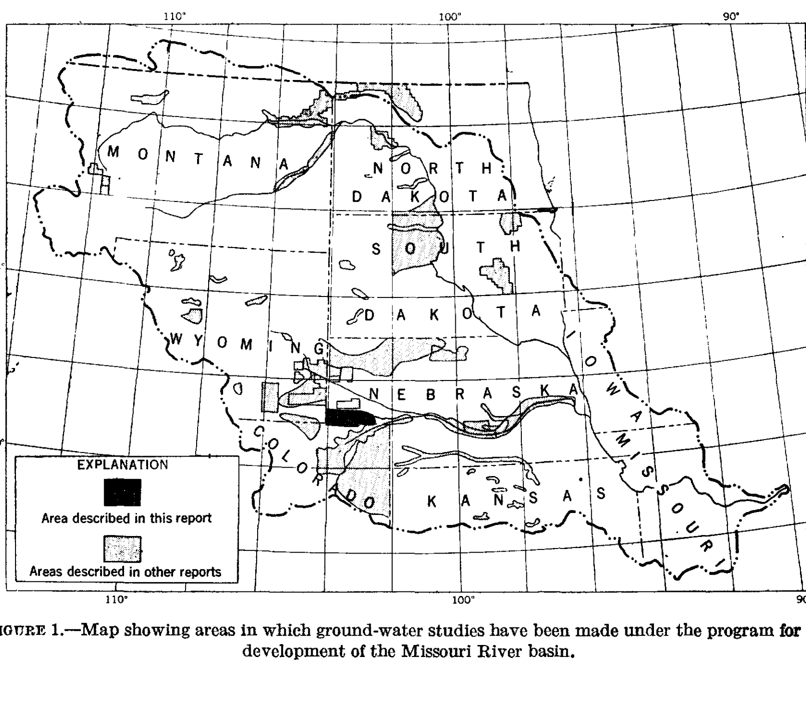

FIGURE 1.—Map showing areas in which ground-water studies have been made under the program for the development of the Missouri River basin.

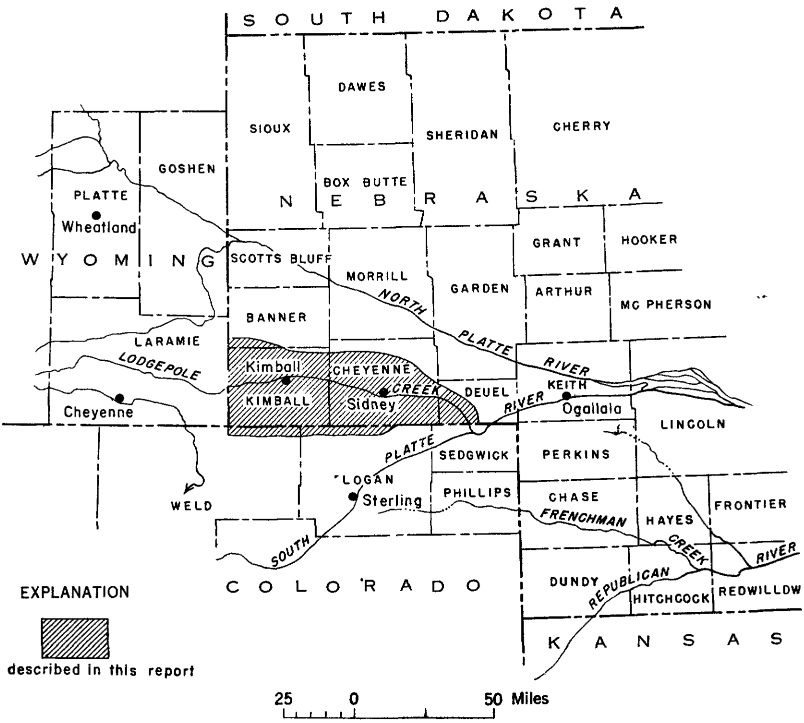

FIGURE 2.—Map of a part of Nebraska, Wyoming, and Colorado showing the part of Lodgepole Creek drainage basin described by this report.

PREVIOUS INVESTIGATIONS

Several investigations have been made of the geology and water resources of this and adjacent areas. These earlier studies proved very useful, and they are referred to frequently in this report. Darton (1903, 1905) made a reconnaissance of the geology and ground-water resources of the central Great Plains and western Nebraska. Meinzer (1917) described the geology, hydrology, and ground-water resources of the Lodgepole Creek valley in Wyoming and Nebraska and included data on wells and the results of chemical analyses of 22 water samples. The U. S. Department of Agriculture (1940) published a water-facilities area plan for the Lodgepole Creek watershed in Wyoming and Nebraska. Three publications by Condra and others (1943, 1947, and 1950) describe the geological section of Nebraska and indicate correlations with geologic formations in adjacent States.

METHODS OF INVESTIGATION

Records were obtained of 329 wells, including 274 used for irrigation, public supply, or industry and 55 used for domestic, stock, or other purposes. A few of these wells are a short distance outside the area.

An attempt was made to include all large-discharge wells in the inventory. Owners, tenants, and drillers were interviewed regarding wells and the character and thickness of the water-bearing formations tapped by them, and all available logs were collected. Detailed information regarding depth of well, depth to water, geologic source, discharge, drawdown, and acreage irrigated was collected for most of the irrigation wells. Measurements of the depth to water and the depth of the well were made with a steel tape, and a few measurements of pump discharge were made with a Hoff current meter. These measurements, other information, and reported data for those not measured are given in table 11.

The bimonthly measurement of the water level in 35 observation wells in the area was begun early in the investigation. These measurements and those made previously for most of the wells by the U. S. Geological Survey in cooperation with the Conservation and Survey Division of the University of Nebraska are included in this report. Chemical analyses were made of water samples collected from 21 wells and at 3 points on Lodgepole Creek. The altitude of the water level in 267 wells was determined instrumentally.

Also included in this report are an areal geologic map (pl. 1), geologic cross sections (pl. 2), a map showing the contour of the water table (pl. 3), a map showing location of wells and depth to water (pl. 4), and logs of test holes furnished by the Conservation and Survey Division of the University of Nebraska (table 9).

WELL-NUMBERING SYSTEM

All wells and test holes referred to are numbered according to their location within the U. S. Bureau of Land Management's survey of the area and are in the sixth principal meridian and baseline system. The first numeral of a well number denotes the township, the second the range, and the third the section in which the well is situated. The lowercased letters following the section number indicate the position of the well within the section. The first letter denotes the quarter section and the second letter the quarter-quarter section, or 40-acre tract. These subdivisions are designated *a, b, c,* and *d,* and the letters are assigned counterclockwise. If two or more wells are within the same quarter-quarter section, consecutive numbers, beginning with 1, follow the lowercased letters (fig. 3).

ACKNOWLEDGMENTS

Residents within the area were very cooperative in permitting measurements and giving information about their wells. Well drillers furnished logs of wells, depth, and other pertinent information. Oil and geophysical companies gave information helpful to the investigation. The Magnolia Oil Co. furnished topographic maps of the

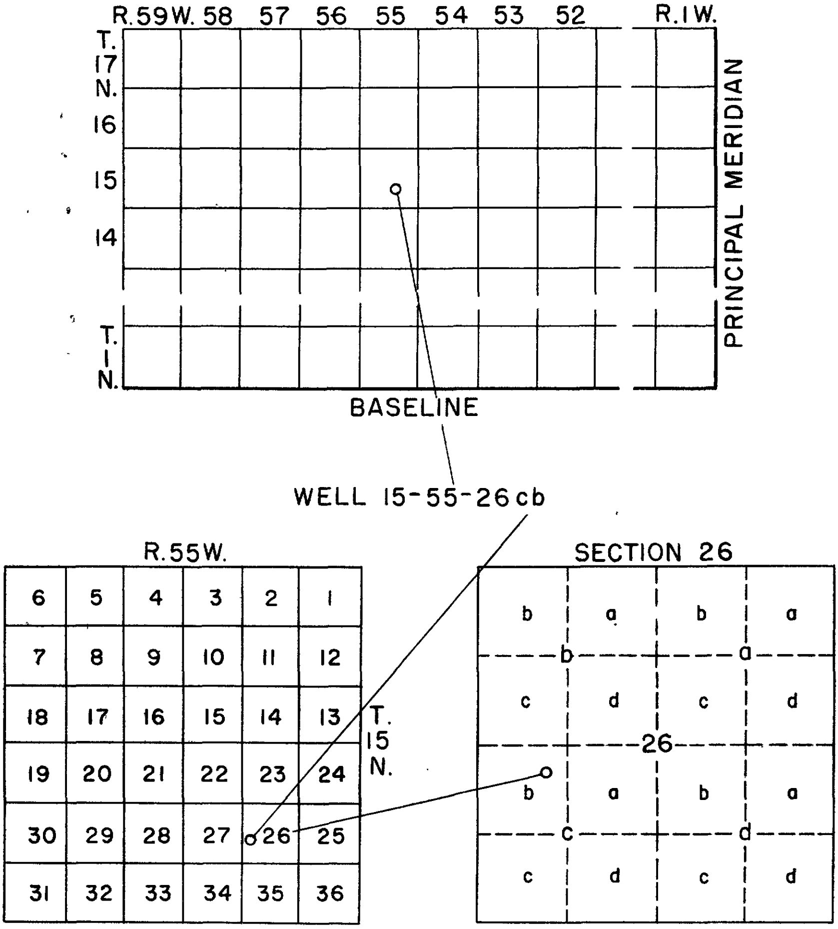

FIGURE 3.—Sketch showing well-numbering system.

southern part of Kimball County. The Wheatbelt Rural Electric Assoc. at Sidney, Nebr., and the Rural Electric Co. at Pine Bluffs, Wyo., supplied data on the amount of power used by electrically operated water pumps. The Department of Roads and Irrigation of the State of Nebraska, at Bridgeport, provided pertinent hydrologic data on Lodgepole Creek. The Conservation and Survey Division of the University of Nebraska furnished valuable geologic information.

GEOGRAPHY

TOPOGRAPHY AND DRAINAGE

The area described in this report is in the High Plains section of the Great Plains physiographic province. It includes the lower half of the Lodgepole Creek drainage basin, which is bounded on the north by the drainage basin of the North Platte River and on the south by the drainage basin of the South Platte River, into which Lodgepole Creek drains.

The lower Lodgepole Creek valley, formed by stream erosion and later partly filled by stream sedimentation, is a flat-bottomed, steep-sided trench similar to other valleys of the Great Plains. The sides of the valley are outcrops of the Ogallala and Brule formations, which stand in almost vertical escarpments in many places. The valley bottom averages about 1½ miles in width and lies 100 to 250 feet below the upland plain. Many tributary valleys, or draws, have been cut into the plain adjacent to the main valley. Sidney Draw valley, which is about 50 miles long and is the main tributary valley, resembles the lower Lodgepole Creek valley in that it is relatively flat bottomed and is bordered by steep walls.

The highest elevation in the area, which probably is also the highest in the State of Nebraska, is near the southwest corner of Kimball County and is 5,422 feet above mean sea level. This altitude was determined and reported by surveyors of the Magnolia Oil Co., and it supplants the previous assertion that the highest altitude in the State (5,340 feet) was in Banner County to the north.

Lodgepole Creek rises in the Laramie Mountains in Wyoming and flows in a general easterly direction through Wyoming, Nebraska, and Colorado for about 165 miles to its confluence with the South Platte River. The creek enters the area at the Wyoming-Nebraska State line at an altitude of about 4,990 feet and leaves the area near Ovid, Colo., at an altitude of about 3,560 feet. Hence the average gradient of the creek is 15 feet to the mile in this 95-mile stretch. A profile of the creek is shown in geologic section *A–A′* on plate 2. The creek maintains a perennial flow throughout most of its course. In several places, however, it disappears beneath the land surface and reappears downstream. This interesting phenomenon is discussed more fully under "Recharge" and "Discharge." Many of the tributaries to Lodgepole Creek are ephemeral streams that flow for only a short period after heavy precipitation

CLIMATE

The climate is characterized by relatively light precipitation, a high evaporation rate, and a wide range of temperature. The winters are cold, and the summers are short and hot. Recorded temperatures in the area have ranged from −30° F to slightly more than 100° F. In winter, cold waves are sometimes accompanied by blizzards and usually last from 3 days to a week.

A climatological station has been maintained by the U. S. Weather Bureau for 63 years at Kimball, for 53 at Lodgepole, for 30 at Potter, and for 23 at Sidney. A record of precipitation at Kimball and Lodgepole for 1931–51 is given in table 1. Normal monthly, seasonal, and annual precipitation and temperatures at the same stations are shown in table 2.

TABLE 1.—*Annual precipitation, in inches, at Kimball and Lodgepole, Nebr.*

Year	Kimball	Lodgepole	Year	Kimball	Lodgepole
1931	12.05	11.66	1942	24.60	22.88
1932	13.65	14.18	1943	14.35	13.83
1933	19.76	17.10	1944	21.89	18.58
1934	10.38	10.93	1945	21.70	25.17
1935	18.05	14.50	1946	17.57	17.07
1936	10.99	----------	1947	18.09	24.19
1937	13.60	10.31	1948	16.79	15.77
1938	23.91	20.79	1949	19.19	----------
1939	11.67	11.69	1950	14.40	18.44
1940	16.27	12.38	1951	21.57	23.20
1941	17.89	22.82			

TABLE 2.—*Normal monthly, seasonal, and annual temperature and precipitation at Kimball and Lodgepole, Nebr.*

	Kimball		Lodgepole	
	Temperature (°F)	Precipitation (inches)	Temperature (°F)	Precipitation (inches)
December	28.9	0.56	28.1	0.53
January	26.8	.41	26.3	.38
February	28.4	.59	28.1	.54
Winter	28.0	1.56	27.5	1.45
March	35.5	1.03	36.5	.96
April	45.5	2.09	47.2	2.34
May	55.0	2.67	56.8	2.78
Spring	45.3	5.79	46.8	6.08
June	65.2	2.49	66.6	2.65
July	71.8	2.30	73.5	2.32
August	70.2	1.81	72.3	2.03
Summer	69.1	6.60	70.8	7.00
September	61.0	1.18	62.5	1.36
October	48.9	.86	50.9	.93
November	36.5	.52	37.3	.57
Fall	48.8	2.56	50.2	2.86
Year	47.8	16.51	48.8	17.39

The normal annual precipitation at Kimball is 16.51 inches, and at Lodgepole it is 17.39 inches. About 80 percent of the precipitation falls as rain during the growing season, April through September. The summer rains generally occur as thunderstorms, which are usually sporadic and unevenly distributed. These storms sometimes are accompanied by strong winds and hail which cause much damage to crops. During 1951, evaporation from a class *A* land pan, in inches, at the U. S. Weather Bureau station at Bridgeport, about 25 miles north of Lodgepole Creek valley, was as follows: April, 4.68; May, 6.77; June, 6.18; July, 7.48; August, 6.97; September, 5.13; and October, 3.03. These values are believed to be representative of the evaporation rates in the report area.

The prevailing wind is from the north and northwest during the winter and from the south and southeast during the summer. Wind velocities generally are highest during the spring and lowest in late summer, although high winds may occur in any month of the year.

POPULATION, AGRICULTURE, AND INDUSTRY

About 16,000 persons reside in the area. Of these, 55 percent live in urban areas and the others in rural areas. Many of those living in the towns own and operate farms, and the majority of the residents make their living from agriculture. According to the 1950 census, the population of the three principal municipalities was as follows: Sidney, 4,912; Kimball, 2,048; and Chappell, 1,297.

Livestock and winter wheat are the principal agricultural products and are produced throughout the area. Crops requiring irrigation—sugar beets, alfalfa, potatoes, beans, grains, and pasture grass—are grown in the valley.

After the completion of the first producing oil wells in western Nebraska (in northern Cheyenne County) during June 1949, a gas well was completed in the vicinity of Huntsman in the Lodgepole Creek basin in early 1950. Many producing wells, both oil and gas, have been completed in the Lodgepole Creek drainage basin since the initial discovery. Most of the production is from the upper sandstone of the Dakota group at depths ranging from 4,400 to 7,000 feet below the land surface.[1]

GEOLOGY

SUMMARY OF STRATIGRAPHY

The rocks that crop out in the area are sedimentary and range in age from Oligocene (Tertiary) to Recent (Quaternary). The Brule formation of Oligocene age is the oldest exposed formation, and the alluvium of Pleistocene and Recent age is the youngest. The extent of the formations exposed in the area is shown on plate 1. A generalized section of these formations appears on page 10.

SUMMARY OF GEOLOGIC HISTORY

The following discussion of the geologic history of the region has been adapted from a report by Rapp, Warner, and Morgan (1953) on the geology and ground-water resources of an adjacent area in Laramie County, Wyo.

PALEOZOIC AND MESOZOIC ERAS

The sedimentary rocks of Paleozoic and Mesozoic age that underlie but do not crop out in the lower Lodgepole Creek drainage basin are

[1] Data regarding oil and gas wells obtained from E. C. Reed, director, Conserv. and Survey Div., Univ. Nebr. (oral communication).

Generalized section of the geologic formations exposed in the lower Lodgepole Creek drainage basin

System	Series	Formation	Thickness (feet)	Physical character	Water supply
Quaternary.	Pleistocene and Recent.	Alluvium.	0–70	Gravel, sand, and silt. Graded, unconsolidated, and lenticular.	Supplies large quantities of water to irrigation and public-supply wells in Deuel County.
Tertiary.	Pliocene.	Ogallala formation.	0–350+	Gravel, sand, silt, and clay beds. In part cemented with calcium carbonate.	Supplies large quantities of water to irrigation and public-supply wells in Cheyenne and Kimball Counties.
	Oligocene.	Brule formation.	300+	Siltstone, compact and brittle, pinkish or flesh colored. Locally, the formation contains vertical to nearly vertical fractures and lenticular beds of volcanic ash, sandstone, and fragments of reworked siltstone.	Generally a poor aquifer but locally yields a large supply from porous and fractured zones. Generally, largest yield is obtained from these zones where they are overlain by permeable saturated alluvium.

exposed or have been drilled through in adjacent areas to the south, west, and north. The following sketch of the pre-Tertiary geologic history of the region is based on data collected in the adjacent areas.

Pre-Cambrian rocks are directly overlain by Pennsylvanian strata, indicating that throughout pre-Pennsylvanian time either this area was a land surface or that any rocks deposited during that time were removed by erosion before deposition of the Pennsylvanian strata. Near the end of the Paleozoic era the Pennsylvanian sea advanced upon the area, and shoreline conditions prevailed. That era ended with a widespread emergence of the land, resulting in the formation of shallow basins and low plains with wide mud flats. The climate was arid.

In early Mesozoic time, during the Triassic period, gypsum and gypsiferous red clay and sand were laid down under prevailingly arid conditions. Local shallow basins and extensive mud flats predominated. Triassic time ended with extensive uplift, which, although not causing local deformation, resulted in general planation and, in some places, deep channeling. Encroachment by the sea again took place, and sand and clay beds (Sundance formation) were deposited along the shoreline. Marine conditions gave way to continental conditions, and fresh-water sand and clay (Morrison formation) were laid down. The abundance of dinosaur remains and carbonaceous matter in these sediments indicates that a humid climate prevailed during deposition. At the beginning of Early Cretaceous time there was some uplift, after which nearshore sediments (Dakota group) were deposited. Then the sea advanced again and, during the remainder of Early Cretaceous and most of Late Cretaceous time, several thousand feet of marine clay and sand (Colorado group, Pierre shale, and Fox Hills sandstone) were deposited. The sea again retreated and a considerable thickness of sand (Lance formation) was laid down. During this time, however, marine conditions recurred locally. The close of the Cretaceous period was characterized by extensive mountain making (the Laramide revolution).

CENOZOIC ERA

TERTIARY PERIOD

During the Tertiary period, repeated crustal uplift and erosion occurred in the Rocky Mountain region and resulted in recurrent deposition of material by streams in the plains region to the east. During a period of relative quiescence (Oligocene epoch), sedimentation occurred in a broad basin lying east of the mountains. These sediments (Brule formation) were composed of silt and volcanic ash, the latter being evidence of extensive volcanism, though at considerable distances from the report area. Later, during another period of

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quiescence (Miocene epoch), beds of fine sand and volcanic ash were laid down. Subsequently, these beds (Arikaree sandstone) were removed by rejuvenated streams which cut deeply into the underlying beds of silt and volcanic ash (Brule formation). This period of erosion was followed in the Pliocene epoch by the deposition of coarse material (Ogallala formation).

QUATERNARY PERIOD

Streams that had been rejuvenated as a result of crustal uplift at the close of the Tertiary period were enlarged by an increased supply of water during the Pleistocene epoch of the Quaternary period. The underlying Tertiary rocks were deeply eroded, and the process of the cutting and filling of channels was so widespread that gravel and sand were deposited in sheetlike beds. The principal streams eroded deeply into the bedrock, cutting and building terraces along their channels and depositing the alluvium that now underlies the flood plain and adjacent terraces. The approximate location, size, and areal extent of the ancestral valleys are shown on plate 1 by contour lines drawn on the pre-Quaternary erosional surface.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

The important water-bearing formations, which supply water to all wells in the area, are the Brule and Ogallala formations and the alluvium. Their outcrops are shown on plate 1. Rocks older than the Brule formation are either relatively impermeable or lie at such great depth below the land surface that they are not regarded as potential sources of water supply.

BRULE FORMATION

CHARACTER AND THICKNESS

The Brule formation of Oligocene age is a moderately hard, compact, brittle siltstone that locally may be sandy or argillaceous. According to Rapp, Visher, and Littleton (1956), the results of a particle-size analysis of six samples of the formation from the North Platte River valley in Goshen County, Wyo., 50 to 75 miles northwest of Kimball, Nebr., show an average grain size as follows:

	Diameter (millimeters)	*Percent by weight*
Clay	<0.004	19
Silt	.004 – .0625	70
Very fine sand	.0625– .125	9
Coarser than very fine sand	>.125	2

Fresh exposures of the formation are pinkish or flesh colored; however, weathered surfaces are light pink to almost white. The formation typically weathers into blocks and slabs.

Although the Brule formation appears to be massive, it has regular but indistinct bedding planes. Lenticular beds of volcanic ash, sandstone, and fragments of siltstone are present locally in the formation. Geologic cross sections (pl. 2) show that, in Cheyenne and Deuel Counties, a permeable zone in the Brule formation underlies parts of the valley of Lodgepole Creek and that of Sidney Draw. The zone is 10 to 15 feet thick and pinches out toward the sides of the valleys. Drillers report that most of the siltstone fragments obtained from this permeable zone are angular but that some are rounded. A study of the permeable zone in the Brule at the lower end of the Lodgepole Creek valley was made by McLaughlin during a ground-water study in the vicinity of Julesburg, Colo. McLaughlin (1948, p. 13) states:

> During the test drilling done by the town of Julesburg it was found that the "porous" zone consists of moderately well-rounded pebbles of reworked Brule clay, the pebbles ranging in diameter from less than half an inch to more than 2 inches. Inasmuch as the so-called "porous" zone is actually a deposit of coarse gravel that is confined to the zone underlying the alluvium, it perhaps should be considered a part of the alluvium. The material lying above the "porous zone," although doubtless reworked, resembles so closely the Brule clay from which it was derived that it cannot be readily distinguished from it.

Superficially, the Brule formation is cut vertically and along bedding planes by joints, which generally are small. Vertical to nearly vertical fractures cut the formation to unknown depths, some possibly extending completely through the formation. These fractures in many places are several inches wide and are capable of transmitting water readily to wells. Very likely these fractures constitute some of the permeable zones found in the stream valleys. Because fractures or groups of fractures constitute zones of weakness in the bedrock, they doubtless were the principal determining factor in the location of the watercourses in the area.

The total thickness of the Brule formation in this area probably exceeds 300 feet in many places. According to electric logs and samples, oil wells in the vicinity of Huntsman, Nebr., about 5 miles north of Sidney, disclosed 460 feet of White River beds. The lower 80 feet probably is the Chadron formation.[2]

DISTRIBUTION AND SURFACE FORM

The Brule formation underlies the entire area and crops out in prominent escarpments that consist of almost vertical cliffs capped by the more resistant Ogallala formation. These outcrops are near Pine Bluffs, Wyo., near Sidney, Nebr., and along the lower 10 miles of Sidney Draw valley. The ancestral valley of Lodgepole Creek is cut into the formation near the Wyoming State line and along the

[2] E. C. Reed, director, Conserv. and Survey Div., Univ. Nebr. (oral communication).

reach of the valley from a point about 6 miles east of Potter to the Colorado State line. The alluvium, which was deposited after the maximum downcutting of the valley, covers the Brule formation over much of these reaches of the valley. A profile of the valley is shown in section *A–A′* on plate 2.

WATER SUPPLY

Generally the Brule formation is relatively impermeable and yields little water to wells, but, where it is fractured or contains beds of siltstone fragments, its permeability is much greater. Such permeable zones are the principal source of water for many of the large-discharge wells in the Lodgepole Creek valley in the extreme western part of Kimball County, in the lower 10 miles of Sidney Draw valley, and in the Lodgepole Creek valley in central and eastern Cheyenne County and the adjacent part of Deuel County. These wells are reported to have yields that range from 125 to 2,200 gpm and average about 950 gpm.

OGALLALA FORMATION

CHARACTER AND THICKNESS

The Ogallala formation of Pliocene age consists of lenticular beds of clayey, silty, sandy, and gravelly materials, in part cemented with calcium carbonate. The cemented beds, or "mortar beds," are resistant to erosion and form prominent ledges. The gravel contained in the formation was derived from a great diversity of igneous, sedimentary, and metamorphic rocks in the mountains to the west, and consists of pebbles of quartz, quartzite, feldspar, gneiss, schist, sandstone, and granite. Many of the granitic pebbles are partly decomposed and easily broken. According to Wenzel and Waite (1941, p. 28), the Ogallala formation was laid down by desert-type streams that aggraded their channels, spilled over into new channels, and left a series of braided sand and gravel deposits and many shallow, temporary lakes in which silt and clay were deposited. The thickness of the Ogallala formation ranges from a featheredge where the formation has been completely cut by Lodgepole Creek to more than 350 feet beneath the upland.

DISTRIBUTION AND SURFACE FORM

The Ogallala formation underlies the entire area with the exception of those parts of the lower Lodgepole Creek valley and Sidney Draw Valley where erosion has completely cut through the Ogallala into the underlying Brule formation.

The clay, silt, sand, and gravel in the formation are easily eroded, except where sod covers the surface or where resistant cemented layers are present. Ledges composed of "mortar beds" are prominent in many places on both sides of the valley and cap the prominent bluffs near Sidney and Potter, Nebr., and near Pine Bluffs, Wyo. The formation is eroded into steep slopes on the sides of the lower Lodgepole Creek valley and some of its tributary valleys, but on the upland it is preserved as a broad, gently rolling plain where it has not been dissected by stream erosion.

WATER SUPPLY

The Ogallala formation is an important aquifer in much of the High Plains. It supplies water to all wells on the upland, including a few large-discharge wells, and to many public-supply and irrigation wells in the lower Lodgepole Creek valley. It is the only source of water for the towns of Bushnell, Kimball, Dix, and Potter. The 104 irrigation wells that derive all or part of their water from the Ogallala formation are reported to have yields that range from 90 to 1,600 gpm and average about 860 gpm.

ALLUVIUM

CHARACTER AND THICKNESS

The alluvium of the lower Lodgepole Creek valley and its tributaries consists mainly of heterogeneous mixtures or lenticular bodies of silt, sand, and gravel and contains some scattered pebbles, cobbles, and boulders. These materials were probably derived from erosion of the Ogallala formation during Pleistocene and Recent times. The alluvium generally is relatively thin, averaging about 25 feet in thickness in the valley bottom from the Wyoming State line to Chappell, Nebr. Downstream from Chappell the alluvium in the valley bottom is progressively thicker, and at the Colorado State line it has an average thickness of about 40 feet. The alluvium ranges in thickness from a featheredge at the margin of the valley to as much as 70 feet beneath terrace remnants. The alluvium in the tributary valleys is not a source of ground water, as it is thin and lies above the water table.

DISTRIBUTION AND SURFACE FORM

The alluvium underlies the flood plain and the two terraces that border the flood plain. The first terrace, which is about 10 to 20 feet above the flood plain, is well preserved throughout most of the valley. The second terrace, which is about 65 feet above the flood plain, is well preserved in Kimball County only, having been largely removed by erosion in Cheyenne and Deuel Counties. In some places the landward part of the terraces is covered by colluvial material, which was derived from the adjacent Ogallala formation and forms long, gentle slopes toward the creek.

WATER SUPPLY

Because the alluvium in the lower Lodgepole Creek valley is relatively thin, it is an important source of water for irrigation wells only where the water table is near the land surface. Between the Colorado State line and Chappell the alluvium is the chief source of supply to irrigation wells. Between Chappell and Sidney most of the irrigation wells are drilled through the alluvium and into permeable zones in the Brule formation, and water is derived from both formations. In much of the valley west of Sidney the water table lies below the bottom of the alluvium, and water is derived from the underlying Brule or Ogallala formation. The towns of Chappell and Lodgepole derive their municipal water supply from wells in the alluvium.

The yields of irrigation wells deriving water chiefly from the alluvium range from 130 to 1,200 gpm and average about 770 gpm.

GROUND WATER

In this area ground water is derived chiefly from the infiltration of precipitation and water used for irrigation. Some of the ground water eventually returns to the surface through seeps and springs or is discharged by wells or by evapotranspiration.

Generally, porous rocks below the water table are saturated. In the more permeable rocks, such as beds of sand and gravel in the alluvium and in the Ogallala formation, individual pore spaces are interconnected and are large enough that water moves freely through them under the force of gravity, but in the less permeable rocks, such as the siltstone, clay, and fine-grained sandstone of the Brule formation, the pores are so small that water moves through them slowly. In some areas, however, the Brule formation is broken by numerous fractures that freely transmit large quantities of water.

THE WATER TABLE

The water table is the upper surface of the zone of saturation, and its position is approximated by the water level in wells tapping an unconfined aquifer. The piezometric surface is an imaginary surface that coincides with the static water level in wells tapping an aquifer in which the water is under artesian pressure. If the piezometric surface is above the land surface, water will flow from the wells. Although both water-table and artesian conditions exist in the area, generally the water table is continuous with the piezometric surface and no attempt is made here to differentiate them.

SHAPE AND SLOPE

The water table is an irregular, fluctuating, sloping surface that transects the Brule and Ogallala formations and also the alluvium in topographically low areas. The irregularities in slope and direction of slope are caused by differences in thickness, permeability, and position of the aquifer and by the amount of water being transmitted locally. The fluctuations are caused by additions or withdrawals of water from the ground-water reservoir.

Ground water moves in the general direction of the slope of the water table (hydraulic gradient), and the rate of movement is proportional to that slope and to the permeability of the water-bearing material. The slope of the water table is shown on plate 3 by contour lines based on water-level measurements that were made during the fall and winter of 1951–52. Because the Brule formation is less permeable, on the whole, than the Ogallala formation and the alluvium, the water table generally is held at a higher elevation and has a steeper slope in the Brule than in the others.

In most of the area ground water moves toward Lodgepole Creek in a downstream direction and discharges into the creek through springs and seeps. Consequently, the creek is an effluent (gaining) stream for the greater part of its length. In several places, however, the water table lies below the creek bed, and the creek loses water to the ground-water reservoir. South of the lower 16 miles of Sidney Draw valley, and on both sides of the Lodgepole Creek valley near the Wyoming State line, where the Brule formation is topographically high and covered by a relatively thin mantle of the Ogallala formation, the water table slopes steeply into the valleys. From the vicinity of Kimball to the vicinity of Potter the saturated thickness of the Ogallala formation is about uniform beneath and on both sides of Lodgepole Creek valley, and the slope of the water table is relatively smooth and regular.

The Lodgepole Creek valley is several hundred feet higher topographically than the valley of the North Platte River (Sidney in the valley of Lodgepole Creek is about 400 feet higher than Bridgeport in the valley of the North Platte River); the water-table divide is nearer to the valley of Lodgepole Creek than is the topographic divide between the two valleys. Near Potter the water-table divide is only a little north of Lodgepole Creek, and in this vicinity the water table slopes away from the Lodgepole Creek valley toward the valley of the North Platte River. To determine the amount of ground water that flows from the lower drainage basin of Lodgepole Creek to the drainage basin of the North Platte River, however, would require much additional information on the configuration of the water table and on the permeability and total saturated thickness of the water-bearing formations.

The water-table divide between the lower valley of Lodgepole Creek and the valley of the South Platte River is thought to lie approximately on the Nebraska-Colorado State line and to coincide with the surface-drainage divide. These features are shown on a water-table contour map of Nebraska (Schreurs, 1954).

DEPTH TO WATER

The depth to water generally is related to the configuration of the land surface; usually the depth is greater where the land surface is high and least where the land surface is low. The depth to water is shown on plate 4.

In the Lodgepole Creek valley downstream from Sidney the depth to water generally is less than 20 feet; in many places it is less than 10 feet, and the capillary fringe of the water table extends either to the land surface or to the root zone of the vegetation. Therefore, the evapotranspiration rate is high.

In the Lodgepole Creek valley between Sidney and the Wyoming State line, the depth to water ranges from less than 10 feet near the stream to about 100 feet along the edge of the valley. The water table is continuous with the stream except for a stretch of about 11 miles upstream from 1 mile east of Potter; here the alluvium generally is dry, and the water table is as much as 40 feet below the creek. In Sidney Draw valley also the alluvium is dry, and the water table is in the underlying formations.

On the upland the depth to water ranges from about 80 feet, in areas where the Brule formation is topographically high and the overlying Ogallala formation is relatively thin, to about 300 feet where the Ogallala formation is relatively thick.

FLUCTUATIONS

The water table is not a stationary surface but fluctuates when discharge from and recharge to the ground-water reservoir are unequal; therefore, the magnitude of the fluctuations is dependent upon the net rate of depletion or replenishment of the ground-water reservoir. In this area the principal sources of recharge are the infiltration of precipitation and the seepage of irrigation water, and the principal means of discharge are natural drainage into surface outlets, evapotranspiration, and the withdrawal of water by pumping.

In order to study the fluctuations of the water table periodic measurements of the water level were made in 35 selected wells. These measurements are shown in table 10. In five of the wells periodic water-level measurements have been made for several years; measurements in one of the wells have been made since 1934. According to available data, no significant change in the water level in the area has occurred in recent years; however, the measurements indicate a rise of the water table during the nongrowing season and a decline during the growing and pumping season.

The maximum seasonal fluctuation of the water table occurs in the heavily pumped area along the valley of Sidney Draw, near its confluence with the valley of Lodgepole Creek, where water is derived from the Brule formation. Some well owners report a sharp decline in the yield of their wells toward the end of each pumping season, as a result of the decline in water level. The Brule formation contains less recoverable water in storage than is contained in equal volumes of the alluvium or Ogallala formation and hence is depleted more rapidly. After the pumping season, however, the depleted Brule formation is readily replenished by movement of water from the adjacent water-bearing materials through the permeable fracture zones in the formation.

RECHARGE

Recharge is the addition of water to the ground-water reservoir. In this area it is derived from precipitation, seepage from irrigation systems, seepage from streams, and subsurface inflow of ground water from the west. Sufficient data were not available to determine adequately the quantities of recharged to the ground-water reservoir from all sources, nor to determine the quantities of water withdrawn from the reservoir by all the different means of discharge. However, where sufficient data were available, computations or estimates of these quantities are given.

PRECIPITATION

Precipitation, as rain or snow is the source of practically all the recharge to the ground-water reservoir. Part of the precipitation leaves the area as runoff, part evaporates, part is used by vegetation, and part infiltrates to the water table. No attempt was made in this investigation to determine the amount of precipitation that reaches the ground-water reservoir, but it is thought to be only a small part of the total precipitation, probably no more than 5 percent.

IRRIGATION SYSTEMS

Both ground water and surface water are used for irrigation. The surface water is either diverted directly from Lodgepole Creek or released from the Oliver reservoir, about 3 miles east of Bushnell, or the Bennett reservoir, about 1 mile east of Kimball, both of which are on Lodgepole Creek. No records are available concerning the total amount of water that is diverted directly from the creek, but probably it is small compared to the amount released from the reservoirs, which was about 9,000 acre-feet in 1950. Most of the water diverted directly from the creek is used for irrigation of pastureland near the creek in Deuel County and eastern Cheyenne County. The water released from the reservoirs irrigates land on both sides of Lodgepole Creek between the Oliver reservoir and the town of Dix. Although data to make adequate computations were unavailable, it is estimated that about one-fourth of the water pumped from wells and about one-half of the surface water used for irrigation infiltrates to the ground-water reservoir from canals and irrigated fields. These estimates are based on the interpretation of irrigation seepage data given in a report on ground-water conditions in the Dutch Flats area, Nebraska (Babcock and Visher, 1951, p. 21–22).

STREAMS

Along most of its course Lodgepole Creek is an effluent stream; the gain in flow represents discharge from the ground-water reservoir. However, where the water table is below the creekbed, the creek is an influent, or losing, stream, and in such places it is a source of recharge to the ground-water reservoir. The longest stretch in which Lodgepole Creek is influent is the 17 miles from Bennett reservoir to about a mile east of Potter. The creek loses its perennial flow in the first 6 miles of this stretch and is dry, except during floods, for the remaining 11 miles. The water-bearing materials underlying this 17-mile stretch are thicker and more permeable than those underlying the adjacent upstream and downstream stretches and, consequently, are capable of transmitting the low flow of Lodgepole Creek. In the heavily pumped area near Sidney the water table is sufficiently lowered during the pumping season to cause the creek to become dry.

Cloudbursts generally cause Lodgepole Creek to flood several times each year. Because the creek follows a meandering course, the progress of the floods is impeded and much of the adjacent meadowland is inundated. Infiltration of the floodwater recharges the underlying ground-water reservoir. Local residents report that many floods thus are dissipated to a large extent before they reach the South Platte River. After the floods subside the water stored in the alluvium slowly seeps back into the stream.

Many streams that flow only in direct response to runoff from precipitation drain the upland and enter the lower valley of Lodgepole Creek. These include Sidney Draw, North Sidney Draw, Cow Creek, and many smaller streams, and they range in length from about 1 to more than 50 miles. Because the clean sand and gravel in the stream beds absorb water readily, these streams contribute much recharge to the ground-water reservoir. Frequently they have a large flow of water after a heavy rainfall, but in a relatively short distance the flow is entirely absorbed by the underlying alluvial material. The rapid rate of infiltration of these streams is illustrated in a draw north of Brownson where about 250,000 gallons per day (gpd) of chlorinated effluent from the sewage-disposal plant of the Sioux Ordnance Depot disappears into the ground within a quarter of a mile. The high water table under many of the larger tributaries indicates that the streams are a source of considerable recharge (pl. 3).

SUBSURFACE INFLOW

The ground-water reservoir is recharged to some extent by underflow into the area through the alluvium in the Lodgepole Creek valley and through the Ogallala formation. Underflow across the Wyoming-Nebraska State line is computed to be about 12.6 cubic feet per second (cfs), or about 9,100 acre-feet per year. Of this underflow, about 3.1 cfs (2,250 acre-feet per year) flows into the North Platte River drainage basin, and about 9.5 cfs (6,850 acre-feet per year) remains in the drainage basin of Lodgepole Creek. The underflow was determined as follows: From studies made in the Egbert-Pine Bluffs-Carpenter area (Rapp, Warner, and Morgan, 1953, p. 26), it was computed that the underflow through the alluvium at the Wyoming-Nebraska State line was 7.5 cfs, or five times the underflow at Bushnell, Nebr. By using an estimated coefficient of permeability of 650 gpd per square foot, a hydraulic gradient of 21 feet per mile, and a cross section 16 miles long and 15 feet thick, the underflow through the Ogallala formation in the upland north of the valley of Lodgepole Creek was computed to be 5.1 cfs. The coefficient of permeability was based on recent tests made of the Ogallala formation in the Frenchman Creek drainage basin in northeastern Colorado and southwestern Nebraska. The underflow across the State line south of the valley of Lodgepole Creek is thought to be negligible.

DISCHARGE

STREAMS

The flow of Lodgepole Creek throughout most of its course is largely derived from ground water. Usually the flow is very steady during late fall, winter, and early spring, but erratic during late spring, summer, and early fall as the result of local torrential storms, stream diversions, infiltration to the ground-water reservoir in heavily pumped areas, and evapotranspiration.

During the water year 1951–52 about 7,400 acre-feet of water flowed past Bushnell (table 3). Most of this water is derived from ground-water inflow in the 10-mile reach of Lodgepole Creek upstream from Bushnell (Rapp, Warner, and Morgan, 1953, p. 25). The creek continues to pick up ground water downstream from Bushnell to near Bennett reservoir, but no estimate of the amount was made.

During the water year 1951–52, 14,335 acre-feet of water left the area as surface flow (table 3). About 90 percent of the water leaving the area as streamflow probably represents ground-water discharge.

Thus, about 13,000 acre-feet was derived from ground-water discharge picked up by Lodgepole Creek downstream from Potter.

TABLE 3.—*Monthly runoff of Lodgepole Creek, in acre-feet, during water year 1951–52 at Bushnell, Nebr., and at the Colorado State line*

[From records of the Surface Water Branch of the U. S. Geological Survey obtained in cooperation with the Nebraska Department of Roads and Irrigation]

	Bushnell, Nebr.	*Colorado State line*
October	795	1,840
November	710	1,600
December	632	949
January	667	1,020
February	789	1,340
March	901	1,940
April	760	1,640
May	693	2,000
June	403	937
July	343	856
August	368	154
September	335	59
Total	7,396	14,335

EVAPOTRANSPIRATION

Ground water may be taken into the roots of plants directly from the zone of saturation, or from the capillary fringe above it, and discharged from the plants by the process known as transpiration; or it may be brought to the land surface by capillary action and discharged by evaporation. Most of the discharge of ground water by transpiration occurs where the depth to water is less than 20 feet, and most loss of ground water by evaporation occurs where the depth to water is less than 10 feet. Loss by both processes increases as the depth to water decreases. The combination of the two processes is known as evapotranspiration. The rate of evapotranspiration of ground water is high in the low, flat areas bordering Lodgepole Creek where the depth to water is less than 10 feet (pl. 4).

In the parts of the area where evapotranspiration of ground water occurs, grass is the principal water user; cottonwood and willow trees are the principal users in some localities, however.

No study was made during this investigation of the rate at which ground water is evaporated and transpired. In Scotts Bluff County, Nebr., which is about 50 miles to the north, the quantity of ground water evaporated and transpired from the zone of saturation in shallow-water areas has been estimated to be about 18 inches a year (Wenzel, Cady, and Waite, 1946, p. 118). If it is assumed that this estimate of 18 inches is applicable to the report area, about 20,000 acre-feet of ground water per year is discharged by evapotranspiration from the 13,000 acres beneath which the water table is shallow.

WELLS

In this area, about 40,000 acre-feet of water in 1950 and about 28,000 acre-feet of water in 1951 were pumped for irrigation, public, industrial, stock, and domestic uses. Of these amounts about 35,000 acre-feet in 1950 and about 23,000 acre-feet in 1951 were used for irrigation (see "Irrigation supplies"). Estimates of the quantity of water pumped for irrigation and public uses are presented under "Utilization." It has been estimated that nearly one-fourth of the total amount of water pumped each year is returned eventually to the ground-water reservoir.

SUBSURFACE OUTFLOW

Of the ground water leaving the lower Lodgepole Creek drainage basin as underflow, the greater part moves into the North Platte River drainage basin through the Brule and Ogallala formations; all other subsurface outflow enters the South Platte River valley through the Brule and Ogallala formations and the alluvium of Lodgepole Creek valley.

North of Lodgepole Creek, and south of the topographic divide between Lodgepole Creek and the North Platte River, there are two well-defined water-table divides—one in extreme western Kimball County and another extending eastward from Potter to the western boundary of Deuel County (pl. 3). It is not possible, from available evidence, to determine whether the two water-table divides are segments of one continuous divide or whether the two divides, if projected, would prove to be segments of two distinct divides. If there is only one continuous divide, then the ground water underlying at least 400 square miles of the lower Lodgepole Creek drainage basin moves toward and discharges by subsurface outflow into the North Platte River drainage basin. On the other hand, if the eastern water-table divide is a segment of a divide that crosses to the south side of Lodgepole Creek, then the area beneath which ground water moves toward the North Platte River drainage basin is considerably larger. However, additional and more detailed studies will be needed before the amount of northeastward outflow of ground water from the lower Lodgepole Creek drainage basin can be determined accurately.

In comparison, however, the subsurface outflow across the Colorado State line into the South Platte River valley is relatively small because the section through which underflow can occur is only about 4 miles wide and because the water-bearing beds are relatively thin. It is estimated that as much as 1,000 acre-feet of ground water annually moves into the South Platte River valley as underflow from the Lodgepole Creek valley. Of this amount, Bjorklund and Brown (1957) have estimated that 0.8 cfs (580 acre-feet) moves through the alluvium.

UTILIZATION

Information was obtained on 329 wells during the investigation. All known irrigation, public-supply, and industrial wells were visited, and all available data concerning them obtained. No attempt was made to secure data on all domestic and stock wells in the area, but a sufficient number were visited to collect information needed for this study. A few wells outside the drainage basin also were visited. Detailed data on all these wells are given in table 11, and their location is shown on plate 4.

IRRIGATION SUPPLIES

Most of the irrigation wells now in use in the area have been drilled since 1930, although a few wells were in existence in 1915 (Meinzer, 1917, p. 57–61). Most of the early wells were shallow, dug wells that have since been abandoned. A curve showing the cumulative number of wells constructed in the period 1925–51 is shown in figure 4.

Water for irrigation is derived from all three of the principal geologic sources of ground water, namely, the Brule and Ogallala formations and the alluvium of the Lodgepole Creek valley. These are described under "Geologic formations and their water-bearing properties."

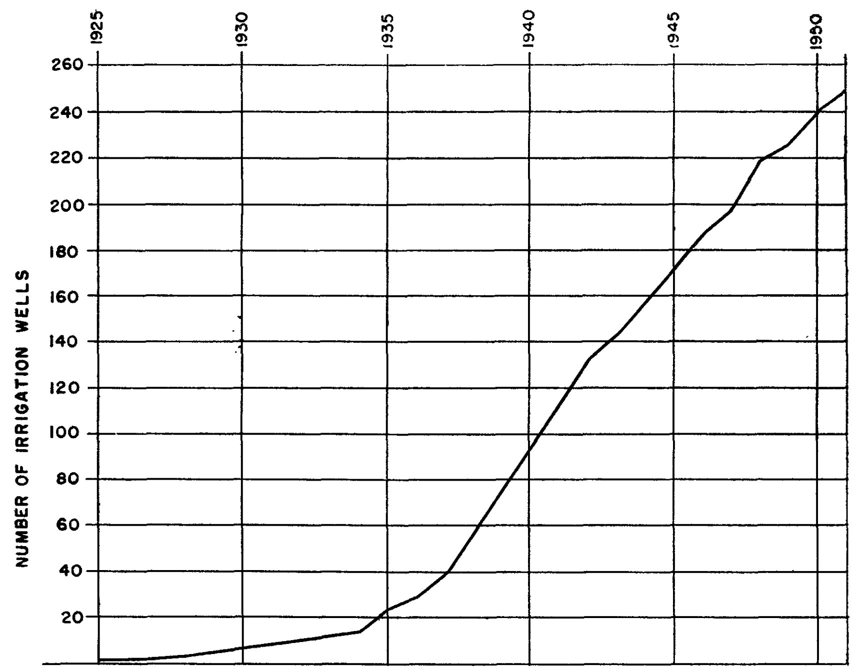

FIGURE 4.—Cumulative number of irrigation wells constructed in the lower Lodgepole Creek drainage basin, Nebraska, 1925–51.

The number of irrigation wells deriving water from each is given in table 4. Most of the irrigation wells are on the valley floors of Lodgepole Creek and Sidney Draw. There are a few wells, however, in the small tributary valleys and on the upland that are similar in yield and efficiency to the wells deriving water from the Ogallala formation in the lower Lodgepole Creek valley. However, these wells are more expensive to construct and operate because of the greater depth and greater pumping lift.

TABLE 4.—*Number of irrigation wells tapping different geologic formations*

Formation	Cheyenne County	Deuel County	Kimball County	Total
Brule formation	65		3	68
Ogallala formation	21		66	87
Alluvium	6	19		25
Brule formation and alluvium	45	6	1	52
Ogallala formation and alluvium	4		13	17
Total	141	25	83	249

METHODS OF DEVELOPMENT

Brule formation.—Irrigation wells tapping permeable fracture zones in the Brule formation in the lower Lodgepole Creek valley generally are drilled by cable-tool methods. After these permeable zones have been located by test drilling, a large-diameter hole (about 20 inches) is drilled. When the permeable zone is reached, usually at depths of 50 to 85 feet, drilling becomes easier and the water in the bailer generally becomes clear. A steel casing is used in the alluvium, but below it no casing is necessary. Where the alluvium is saturated, as in the vicinity of Lodgepole and Chappell, the casing is sometimes perforated to obtain water from this source also. By drilling additional holes a few feet from a well and by using a special offset drilling bit to connect them to the well at points below the water table, the yield of several of the wells tapping the Brule formation has been substantially increased.

Ogallala formation and alluvium.—The methods of constructing irrigation wells in the Ogallala formation and the alluvium are similar. After locating a permeable water-bearing sand or gravel by test drilling, a larger hole is drilled by either cable-tool or reverse hydraulic-rotary methods. Generally a perforated steel casing is lowered into the hole, and the annular space is packed with clean, screened gravel. The perforated parts of the casings are placed below the water table at positions that correspond to the more permeable zones in the water-bearing formation, and care is taken to omit perforations in zones of silt or fine sand.

Pumps and power.—Most of the irrigation wells are equipped with turbine pumps; a few of the older ones are equipped with centrifugal pumps.

The power needed for pumping water from a well is proportional to the rate of pumping and the height the water must be lifted to the point of discharge. Pumps in irrigation wells are driven by electric motors or internal-combustion engines that use diesel oil, gasoline, or butane gas for fuel. A summary of the wells using these different types of power is given in table 5.

TABLE 5.—*Number of irrigation wells equipped with different types of engines*

County	Type of power					
	Electric motor	Farm tractor	Stationary gasoline engine	Stationary diesel engine	Stationary butane engine	None
Cheyenne	63	24	38	6	1	9
Deuel	14	7	3	0	1	0
Kimball	65	8	3	4	1	2
Total	142	39	44	10	3	11

Nearly three-fifths of the irrigation wells are equipped with electric motors. Electrical energy is supplied by the Rural Electric Co. at Pine Bluffs, Wyo.; the Wheatbelt Rural Electric Assoc. at Sidney, Nebr.; and the Highline Electric Assoc. at Holyoke, Colo. In the Lodgepole Creek valley east of Sidney, where the depth to water in most of the irrigation wells is less than 20 feet, only 5-, 10-, or 15-horsepower motors are required, but in other parts of the area, where the general depth to water ranges from 20 to 100 feet, 15- to 40-horsepower motors are used. The power needed for sprinkling systems is about double that for gravity systems and is provided by larger motors or by the use of booster pumps in the sprinkling system.

Sprinkling systems.—Sprinkling systems are in use at 17 of the irrigation wells in this area. Most of these systems, which have been installed since 1948, are used to irrigate pastures and also land that is too rough or too permeable to permit efficient irrigation by conventional methods. About 975 acres is being irrigated in this way.

YIELDS OF WELLS

Reported yields of irrigation wells in the area range from 90 to 2,200 gpm, and the drawdown of the water level in the wells ranges from 2 to 70 feet. The range and average for both pump discharge and specific capacity of wells in the area are given in table 6. This table was compiled largely from reported data, as practically all the field work for this report was done during the nonirrigating season and only a few measurements of discharge and drawdown could be made. Because the discharge of newly drilled wells generally is measured after only a short period of pumping, which does not allow sufficient time for the drawdown of the water in the well to approximate equilibrium, the reported yields of wells generally are greater than the average seasonal yield. In heavily pumped areas the progressive decline of the water table during the pumping season results in reduced yields of wells.

TABLE 6.—*Discharge and specific capacity of irrigation wells tapping different geologic formations*

Geologic formation	Number of wells used in computation	Discharge (gallons per minute)		Number of wells used in computation	Specific capacity (gallons per minute per foot of drawdown)	
		Range	Average		Range	Average
Cheyenne County						
Brule formation	61	125-2,200	980	39	4-850	147
Ogallala formation	17	90-1,500	900	11	32-500	138
Alluvium	3	700-1,200	900	1		39
Brule formation and alluvium	32	300-2,000	990	27	12-800	90
Ogallala formation and alluvium	4	700-1,200	1,000	2	14- 17	16
Deuel County						
Alluvium	16	130-1,200	730	6	38-138	68
Brule formation and alluvium	6	600-1,460	1,000	5	12-245	81
Kimball County						
Brule formation	3	200 700	500	2	50- 60	55
Ogallala formation	58	350-1,600	880	41	10-400	62
Brule formation and alluvium	1		1,500			
Ogallala formation and alluvium	12	400-1,500	800	10	11-200	50
Summary of all wells used in computation						
	213	90-2,200	920	144	4-850	95

The specific capacities of irrigation wells in the area (the number of gallons per minute the well yields for each foot of drawdown) range from 4 to 850 and average 95. The specific capacities of wells vary with differences in their construction and development; under water-table conditions, the specific capacity varies also if the drawdown is more than a small fraction of the saturated thickness of the aquifer. However, a comparison of specific capacities is useful in estimating the relative efficiency of wells and the permeability of formations.

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QUANTITY OF WATER PUMPED

The total quantity of water pumped from irrigation wells in 1950–51 was estimated by determining the quantity pumped by electrically driven pumps and applying the average to all the irrigation wells in the area. The quantity of water pumped by electrically driven pumps was calculated by applying the ratio of power consumption to discharge as computed by Bjorklund and Brown (1957) for wells in the lower South Platte River valley. In the latter area it was ascertained that 2.38 kilowatt-hours of energy was required to lift 1 acre-foot of water a distance of 1 foot. The quantity of water pumped by each well was then computed by using the following equation:

$$Q=\frac{E}{2.38H}$$

where

Q=water pumped from well during the year, in acre-feet,
E=energy consumed at well during the year, in kilowatt-hours,
H=total pumping lift at well, in feet.

The computed amount of water pumped for irrigation during 1950–51 is given in table 7.

TABLE 7.—*Computed quantity of water pumped from irrigation wells, and acreage irrigated*

	1950	1951
Number of wells for which computations were made	87	108
Pumpage from these wells acre-feet	14,393	11,599
Average pumpage per well do	165	107
Number of irrigation wells pumped	213	218
Estimated total pumpage in area acre-feet	35,100	23,300
Total area irrigated [1] acres	15,560	15,790
Computed pumpage per acre acre-feet	2.26	1.48

[1] About 2,500 acres was irrigated in part with supplemental water diverted from Lodgepole Creek.

ACREAGE IRRIGATED

The acreage irrigated by water pumped from wells was determined during the field investigation by ascertaining from well owners or operators the number of acres irrigated by each well. This reported total acreage is given in table 7, and the acreage irrigated from individual wells is given in table 11.

About 2,100 acres of land in Kimball County is irrigated with water from the Oliver and Bennett reservoirs and 19 irrigation wells. Owners report that the wells supply about 60 percent of the irrigation water used in that part of the area. About 400 acres of land in Cheyenne and Deuel Counties is irrigated from small diversions from Lodgepole Creek supplemented by water from irrigation wells. In the lower part of Cheyenne County and in Deuel County the creek flow is so undependable during the growing season that farmers rely almost exclusively on wells to supply water for irrigation.

Nearly 975 acres of land is now irrigated by sprinkling systems installed at 17 wells in the area, and, judging from interest that is being shown in this method, it is likely that the acreage irrigated by sprinkling systems will be increased substantially in the future.

POSSIBLE FUTURE DEVELOPMENT

The amount of water that can be pumped from the ground-water reservoir without causing serious depletion depends upon the capacity of, and the recharge to, the ground-water reservoir. If water is withdrawn faster than it is replenished, the water level will decline and the reservoir eventually will become depleted. Water-level measurements in 35 observation wells, shown in table 10, indicate seasonal fluctuations due to pumping, but they do not reveal any significant downward trend of the water table; this indicates that the ground-water reservoir within the area is not being depleted at the present rate of withdrawal.

Because the flow of Lodgepole Creek is derived largely from ground-water discharge, it represents excess ground water in the drainage basin and almost equals the amount of water that could be used for additional development, if use of the water that leaves the area is disregarded. In the water year of 1951–52 this excess amounted to about 13,000 acre-feet.

Where the water table is near the land surface, the withdrawal of sufficient water to cause a lowering of the water table would result in reducing the amount of ground water lost by evapotranspiration, and the additional water thereby salvaged would be available for other use. The most favorable area for salvaging ground water in this way is in the Lodgepole Creek valley downstream from Sidney where the water table is near the land surface and the loss by evapotranspiration is large. Lowering the water table by pumping from wells not only would salvage water now lost through evapotranspiration but would help to alleviate waterlogging and thereby increase the productivity of the land. Of course, some of the ground water withdrawn for irrigation infiltrates back to the ground-water reservoir, and part of this return flow could be reused; however, some of it must be allowed to leave the area to prevent accumulation of salts in the soil and ground water.

Large-discharge wells probably can be drilled in almost any part of Lodgepole Creek valley except in a 5-mile stretch starting 7 miles upstream from Brownson. Several wells drilled for irrigation in this part of the valley have been unsuccessful because the zone of saturation in the alluvium is thin and the underlying Brule formation apparently has few, if any, permeable zones.

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Heavy pumping in the lower 10 miles of Sidney Draw valley results in a considerable seasonal decline of the water table. Many farmers report that well yields decrease rapidly toward the end of the pumping season and pumping has to be stopped at some wells. This would indicate that maximum development probably has been reached in this part of the area. The ground water is derived from permeable fracture zones in the Brule formation, and the amount of water in storage probably is not great. During the fall and winter, subsurface inflow of water from the adjacent Ogallala formation and infiltration of local precipitation raise the water table to the level of the prepumping season.

Additional large-discharge wells probably can be drilled on the upland because the Ogallala formation, which yields water to many irrigation wells in the valley, underlies all of the upland and is a potential source of irrigation water, especially in that part bordering the valley of Lodgepole Creek between Bushnell and Potter. This premise is supported by the facts that wells tapping the Ogallala formation in the lower Lodgepole Creek valley are productive, that the Ogallala formation has a greater saturated thickness in this part of the upland than in other parts, and that four irrigation wells have already been constructed in this part of the area.

Large-discharge wells also probably could be drilled on the upland south of Lodgepole Creek valley from Potter to a point about 10 miles west of Sidney and east from a point about 6 miles west of Sunol. Much test drilling, however, would be necessary to locate permeable zones in the saturated part of the Ogallala formation. A few unsuccessful attempts have been made to develop irrigation wells in the Ogallala formation north of the Lodgepole Creek valley east of Potter, but it is possible that continued exploration there will show that large-discharge wells can be drilled.

The upland south of the Lodgepole Creek valley, from a point about 10 miles west of Sidney to a point about 6 miles west of Sunol, and the upland in the vicinity of the Wyoming State line are the least favorable for drilling irrigation wells. In these areas the saturated section of the Ogallala formation is thin and probably would not yield sufficient water for large-discharge wells, although it yields enough water for domestic and stock use.

PUBLIC SUPPLIES

Water supplies for the eight municipalities in the area are obtained from wells. The average daily consumption totals about 3.2 million gallons. The water supply of these communities is described in downstream order from Bushnell to Chappell; populations, except for the Sioux Ordnance Depot, are from the 1950 census.

BUSHNELL

Water is supplied to the village of Bushnell, population 225, by a drilled well situated within the village limits. This well (15–57–32bb), which is 100 feet deep, obtains water from the Ogallala formation and delivers 350 gpm with a 5-foot drawdown. It is equipped with an electrically driven turbine pump that delivers water directly into the village mains and forces a reserve supply of water into a 50,000-gallon elevated steel tank located at the well site. A maximum operating pressure of 55 pounds per square inch is maintained. The average daily consumption is about 100,000 gallons; however, a maximum of about 200,000 gpd is used during the hot summer season. The water is not treated; the results of a chemical analysis of the water from this well are given in table 8.

KIMBALL

Kimball, population 2,048, receives its water supply from a battery of three drilled wells (15–55–30ad, 15–55–30ddl, and 15–55–32bc) that obtain water from the Ogallala formation and are situated within the Kimball city limits. An additional well (15–55–32ab) has been constructed and will be added to the city water-supply system. These wells are equipped with electrically driven turbine pumps that pump water directly into the city mains and force a reserve supply of water into a 50,000-gallon elevated steel tank. The city's average daily consumption is about 1 million gallons, but a maximum of about 3 million gpd is used during the hot summer season. The water is very hard but is not treated. The results of a chemical analysis of water from well 15–55–30ad are shown in table 8.

DIX

The village of Dix, population 270, receives its water supply from a drilled well within the village limits. The well (15–54–35ba) is 139 feet deep, obtains water from the Ogallala formation, and is equipped with an electrically driven turbine pump that delivers 160 gpm directly into the village mains. A reserve water supply is pumped into a 45,000-gallon elevated steel tank and an operating pressure ranging from 19 to 35 pounds per square inch is maintained in the distribution mains. The water is not treated. A chemical analysis of the water was made, and the results are given in table 8.

POTTER

Potter, population 421, is supplied by two drilled wells (14–52–5bd and 14–52–6aa) situated within the town limits. Each well is 97 feet deep, obtains water from the Ogallala formation, and is equipped with an electrically driven turbine pump and an auxiliary gasoline engine.

Water is pumped directly into the town mains, and a reserve supply is forced into a 75,000-gallon elevated steel tank, which maintains pressures ranging from 40 to 60 pounds per square inch at service outlets. In 1951 the total pumpage was 22 million gallons, but of this amount the Union Pacific Railroad Co. used 10 million gallons. The water is not treated. The results of a chemical analysis of the water from well 14–52–6aa are given in table 8.

SIOUX ORDNANCE DEPOT

The Sioux Ordnance Depot, including Ordville (population 1,482) and the dormitory area (population 443), is supplied mainly from three wells (14–50–18ba, 14–50–18bc1, and 14–50–18bc2) situated within the military reservation. These wells, which are 150 to 153 feet deep, obtain water from permeable zones in the Brule formation and are equipped with electrically driven turbine pumps and auxiliary gasoline engines. Water is pumped into a 1,250,000-gallon concrete underground tank, from there it is repumped into a 75,000-gallon elevated steel tank which maintains a working pressure ranging from 40 to 60 pounds per square inch at outlets. Consumption of water ranges from about 220,000 gpd during midwinter to about 620,000 gpd during the hot part of the summer and averages about 395,000 gpd. This includes water for both public and industrial use.

In addition, two wells (15–50–34da and 15–50–35ac) that have been drilled into the Ogallala formation furnish a supplementary supply. Use of well 15–50–34da has been temporarily discontinued, however, and well 15–50–35ac is used only occasionally. An effort was made to obtain the entire water supply from the Ogallala formation, but the water-bearing materials were not sufficiently permeable to yield the quantity of water desired. The results of a chemical analysis of the water from well 14–50–18ba are given in table 8. The water supply is chlorinated, and the effluent from the sewage-disposal plant also is chlorinated to prevent contamination of the ground-water reservoir.

SIDNEY

Sidney, population 4,912, is supplied by four drilled wells (14–49–31aa, 14–49–31ad, 14–49–31ba, and 14–49–31da) situated within the city limits. A fifth well (13–49–6aa), also within the city limits, has been constructed and will be added to the municipal system. These wells range in depth from 86 to 102 feet, and all obtain water from permeable zones in the Brule formation. Pump discharges are reported to range from 1,000 to 1,200 gpm and drawdowns from 3 to 12 feet. The wells are equipped with electrically driven turbine pumps that deliver water directly into the city mains and force a reserve supply into a 125,000-gallon elevated steel tank and a 500,000-gallon steel standpipe situated on a hill north of the city. Operating pressures ranging from 42 to 62 pounds per square inch are maintained at service outlets. The maximum daily consumption of water in gallons is about 1.5 million and the average is about 1 million; the Union Pacific Railroad Co. uses about 66,000 and other industries use about 40,000. No treatment, other than chlorination, is given the public supply. The results of a chemical analysis of a sample of water from well 14–49–31aa are shown in table 8.

LODGEPOLE

The village of Lodgepole, population 555, is supplied by three drilled wells (14–46–30cd, 14–46–31ba, and 14–46–31bd) situated within the village limits. The wells range in depth from 20 to 50 feet and obtain water from the alluvium of the Lodgepole Creek valley. Each well is equipped with an electrically driven turbine pump; discharges range from 160 to 350 gpm, and drawdowns from 5 to 8 feet. Water is pumped directly into the village mains, and reserve water is forced into two 12,000-gallon concrete tanks situated on a hillside north of the village. The maximum operating pressure at service outlets is 60 pounds per square inch. Maximum daily consumption is about 170,000 gallons, and the average daily consumption is about 135,000 gallons. The water is not treated. A chemical analysis of water from well 14–46–31ba is shown in table 8.

CHAPPELL

Chappell, population 1,297, is supplied by two drilled wells (13–45–15cc1 and 13–45–15cc2) situated within the city limits. Each well is 41 feet deep and obtains water from the alluvium of the Lodgepole Creek valley. The yields are reported to range from 400 to 900 gpm and the drawdowns from 4 to 7 feet. The wells are equipped with electrically driven turbine pumps that deliver water directly into the city mains and force a reserve supply into a 300,000-gallon elevated steel tank situated in the northern part of the city. Operating pressures from 48 to 54 pounds per square inch are maintained at service outlets. Total daily consumption ranges from about 160,000 gallons during midwinter to about 750,000 gallons during the hot summer. About 10,000 gallons is used each day to fill automatic flushing tanks in the sewer system, and about 1,350 gallons is sold to the Union Pacific Railroad Co. for use in locomotive boilers. The results of a chemical analysis of water from well 13–45–15cc2 are given in table 8. The city water supply is not treated.

DOMESTIC AND STOCK SUPPLIES

Most of the residents of the smaller towns and rural areas obtain domestic and stock water supplies from wells of small diameter that are equipped with cylinder pumps operated by windmill, by hand, or by small electric motors. Many of the homes in the area are equipped with distribution systems in which pressure is maintained by storage in elevated tanks or by electrically driven pumps. In Sidney Draw valley and the part of Lodgepole Creek valley in the vicinity of Sidney, ground water for domestic and stock use generally is obtained from the Brule formation; on the upland and in the Lodgepole Creek valley west of Potter, it is obtained from the Ogallala formation; and in the Lodgepole Creek valley between Potter and the Colorado State line, it is obtained from the alluvium. Chemical analyses of water from wells in various parts of the area are shown in table 8.

CHEMICAL QUALITY OF THE WATER

By E. R. Jochens

A study of the chemical quality of the water in the lower Lodgepole Creek drainage basin was made during the field season of 1952 to obtain general information on the quality of the water in relation to domestic use and irrigation. Some data obtained in 1948–49 also are included in this report. Samples of ground water were collected from representative wells in the alluvium and in the Ogallala and Brule formations, and samples of water from three points on Lodgepole Creek were collected for comparison with the ground water. The locations of all the sampling points are shown in figure 5. The chemical analyses of the water were made in the laboratory of the Geological Survey at Lincoln, Nebr.

Analytical results in this report are expressed in accordance with the methods commonly used by the U. S. Geological Survey (1952, p. 5–6):

The dissolved mineral constituents are reported in parts per million. A part per million is a unit weight of a constituent in a million unit weights of water. . . An equivalent per million is a unit chemical combining weight of a constituent in a million unit weights of water and is calculated by dividing the concentration in parts per million by the chemical combining weight of the constituents. For convenience in making this conversion the reciprocals of chemical combining weights of the most commonly reported constituents are given in the following table:

Constituent [Basic radicals]	Factor	Constituent [Acid radicals]	Factor
Iron (Fe^{++})	0.0358	Carbonate (CO_3^{--})	0.0333
Iron (Fe^{+++})	.0537	Bicarbonate (HCO_3^{-})	.0164
Calcium (Ca^{++})	.0499	Sulfate (SO_4^{--})	.0208
Magnesium (Mg^{++})	.0822	Chloride (Cl^{-})	.0282
Sodium (Na^{+})	.0435	Fluoride (F^{-})	.0526
Potassium (K^{+})	.0256	Nitrate (NO_3^{-})	.0161

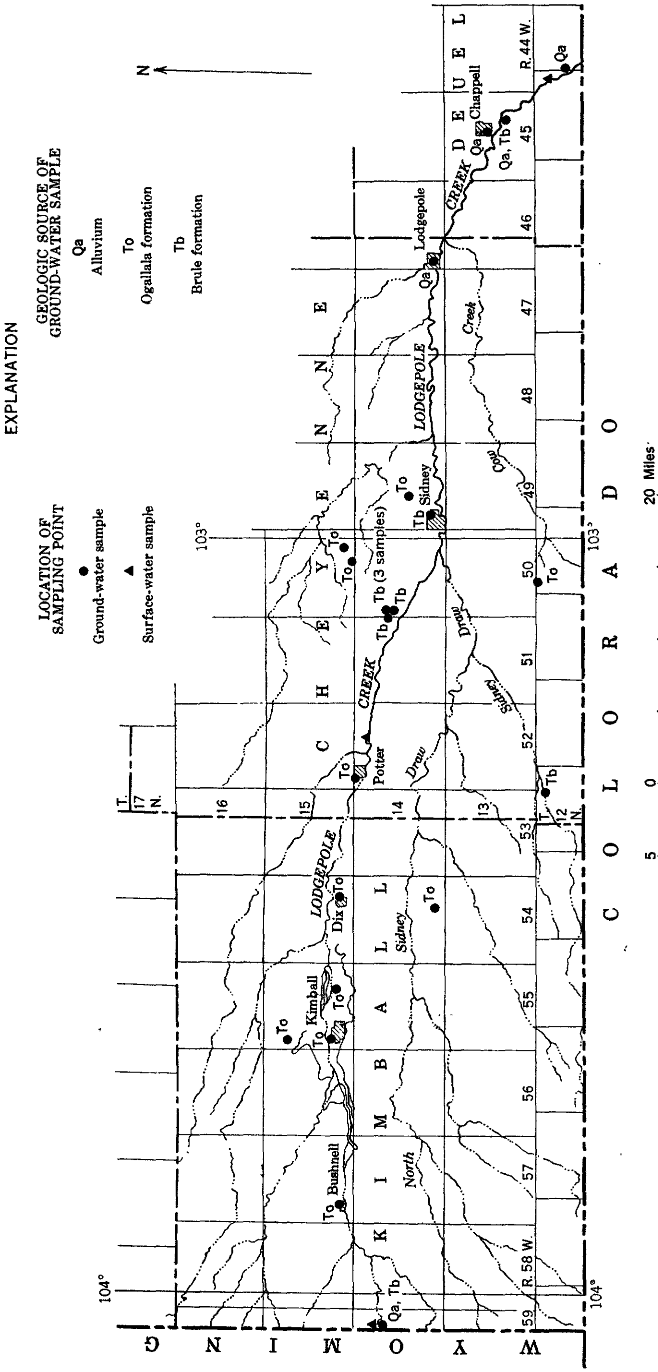

FIGURE 5.—Location of quality-of-water sampling points in the lower Lodgepole Creek drainage basin, Nebraska.

Results given in parts per million can be converted to grains per United States gallon by dividing by 17.12. A calculated quantity of sodium and potassium is given in some analyses and is the quantity of sodium needed in addition to the calcium and magnesium to balance against the acid radicles [radicals].

The total hardness, as calcium carbonate ($CaCO_3$), is calculated from the equivalents of calcium and magnesium . . . The hardness caused by calcium and magnesium (and other ions if significant) equivalent to the carbonate and bicarbonate is called carbonate hardness; the hardness in excess of this quantity is called noncarbonate hardness.

In the analyses of most waters used for irrigation, the quantity of dissolved solids is given in tons per acre-foot as well as in parts per million. Percent sodium has been computed for those analyses where sodium and potassium are reported separately by dividing the equivalents per million of sodium by the sum of the equivalents per million of calcium, magnesium, sodium, and potassium and multiplying the quotient by 100. In analyses where sodium and potassium were calculated and reported as a combined value, the value reported for percent sodium will include the equivalent quantity of potassium. In most waters of moderate to high concentration, the proportion of potassium is much smaller than that of sodium.

. . . Hydrogen-ion concentration (pH) is given as the negative logarithm of the number of moles of ionized hydrogen per liter of water.

Specific conductance, expressed as micromhos, is a measurement of the ability of the water to conduct an electrical current and is thus an indication of the ionized salts in solution.

Samples of ground and surface waters generally were low in mineralization but hard; the percent sodium was low. These properties ranged as follows:

Extremes and averages of chemical and physical properties

[3 surface-water and 23 ground-water samples]

Substance or property	*Maximum*	*Minimum*	*Average*
Specific conductance---------micromhos at 25° C--	662	306	457
Dissolved solids [1]---------------parts per million--	473	217	314
Hardness as $CaCO_3$------------parts per million--	270	118	180
Percent sodium----------------------------------	38	9	23

[1] 25 samples; one sample for well 14-50-18ba not analyzed for dissolved solids.

GROUND WATER

Samples of ground water were collected for chemical analysis from 3 wells in the alluvium, from 11 in the Ogallala formation, from 5 in the Brule formation (1 well sampled on 3 different dates), and from 2 in the alluvium and Brule undifferentiated. The results of the analyses are shown in table 8, and the geologic source of the water for each of the samples is shown in figure 5. The similarity of concentration in and composition of the water from the different sources can be observed from the table of analyses. The analyses are so much the same that the aquifers cannot be differentiated on the basis of the chemical quality of the water.

At present, oilfield wastes and brines have not affected the chemical quality of the ground water. However, pollution from this source is a possibility and should be guarded against.

DOMESTIC AND INDUSTRIAL USE

Ground water used for domestic purposes may contain different amounts of dissolved minerals. Some of these minerals, when present even in small amounts, are objectionable in water used in the home and may affect the health and economic welfare of the user. Standards for drinking water have been established by the U. S. Public Health Service (1946), and the observation of these standards is mandatory for public carriers in interstate commerce. However, people accustomed to drinking water that has an appreciably higher mineral content than prescribed by these standards often find less mineralized water unpalatable. The maximum limits of concentrations for some individual mineral constituents are given in table 8.

Water containing fluoride in excess of 1.5 ppm may cause permanent mottling of the enamel of the teeth if used for drinking by young children (Dean, 1936). However, the incidence of dental caries (decay of teeth) is decreased when approximately 1 ppm of fluoride is present in the water.

Nitrate in water often is an indication of pollution by sewage or other organic matter. Infants fed water that contains considerable nitrate may develop cyanosis, or "blueness." Comly (1945), Waring (1949), and Bosch and others (1950), have written articles on the occurrence of cyanosis in relation to nitrate in water. Pending further study, the National Research Council (Maxcy, 1950), through its committee on Sanitary Engineering and Environment, recommended that water from private sources having a nitrate (as NO_3) content in excess of 45 ppm be regarded as unsafe for infant feeding.

Iron and manganese in water are objectionable if present in quantities totaling about 0.3 ppm or more because they stain porcelain, enamel, and fabrics. In addition, they may cause turbidity in water and introduce an unpleasant taste.

Considerable calcium and magnesium in water may cause much expense and trouble in the home, although some calcium and magnesium are necessary to form a protective coating that will retard corrosion of metallic equipment. Scale formation reduces flow in hot-water pipes, and high hardness from calcium and magnesium salts requires the use of more soap. Water having a hardness (as $CaCO_3$) of more than 120 ppm may be classed as hard, and users may find it profitable to soften the water. Water having a hardness much in excess of 200 ppm may be expensive not only to soften but also to use untreated.

TABLE 8.—*Chemical analyses and other related measurements of ground and surface waters in the lower Lodgepole Creek drainage basin*

[Analytical results in parts per million except as indicated]

Location	Aquifer	Depth of well (feet)	Date	Temperature (° F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent sodium	Specific conductance (micromhos at 25° C)	pH
Cheyenne County																						
12-50-6ab	Ogallala formation	126.0	5/ 1/52	55	53	0.17	63	16	42	9.5	188	53	42	0.8	79	0.12	473	224	70	28	662	7.7
12-53-2bc	Brule formation	101	5/ 7/52	54	54	.08	47	10	12	5.5	191	5.0	3.5	.4	23	.04	264	159	2	14	369	7.7
14-46-31ba	Alluvium	35	5/20/52	50	51	.17	64	12	45	10	295	48	15	.7	7.4	.15	400	210	0	31	598	7.7
14-49-21cb	Ogallala formation	357	6/13/52	56	54	.12	34	8.5	20	7.8	178	14	3.5	.8	6.7	.04	239	120	0	25	328	7.7
14-49-31aa	Brule formation	102	5/15/52	54	50	.25	78	18	26	9.3	289	40	29	.5	13	.09	417	270	33	17	631	7.5
			9/14/48	53	51	.06	45	10	20		220	2.0	6.0	.6	4.4	------	288	153	0	22	360	8.1
14-50-18ba	do	150	5/13/52	54	46	----	----	-----	19	------	230	----	-----	---	----	------	-----	170	0	20	416	7.6
			6/25/52	53	40	.10	49	9.8	24		222	16	5.5	.6	7.8	------	274	163	0	24	403	8.2
14-50-18bc1	do	150	6/25/52	53	44	.08	52	11	23		233	18	6.0	.6	7.0	------	282	176	0	22	422	7.6
14-50-18bc2	do	153	6/25/52	53	43	.07	51	11	22		230	17	6.5	.7	6.7	------	282	174	0	22	418	7.6
14-52-6aa	Ogallala formation	97	5/13/52	54	50	.21	58	13	15	6.4	205	30	13	.5	23	.05	323	197	29	14	457	7.7
15-50-34da	do	300	9/14/48	46	60	.14	31	10	21		[1] 178	4.0	6.0	.9	4.8	------	272	118	0	28	314	8.3
15-50-35ac	do	310	6/26/52	52	53	1.4	31	10	34		180	28	6.0	.8	6.0	------	280	119	0	38	367	7.8
Deuel County																						
12-44-18bb	Alluvium	92	9/16/49	53	54	0.40	58	9.6	25	9.4	246	28	7.6	0.6	14	0.20	342	184	0	22	473	7.3
13-45-15cc2	do	41	5/16/52	54	46	.10	70	14	39	12	316	40	14	.7	9.6	.12	402	232	0	26	613	7.4
13-45-23cb2	Alluvium and Brule formation.	100	9/16/49	58	53	.16	54	14	48	13	320	35	12	.8	4.0	.30	404	193	0	33	571	7.3

Kimball County																						
14-54-34da	Ogallala formation	265.0	6/12/52	55	48	0.12	36	11	25	6.7	168	24	16	0.7	17	0.07	271	136	0	27	390	7.9
14-59-11dd	Alluvium and Brule formation.	84	6/12/52	51	44	.11	64	13	20	4.7	239	34	13	.8	12	.05	324	212	16	17	487	7.7
15-54-35ba	Ogallala formation	139	5/13/52	52	41	.10	68	15	35	6.1	274	50	21	.8	8.5	.06	382	230	5	24	589	7.5
15-55-7db	do	206.0	6/12/52	54	40	.28	40	10	6.5	4.0	154	8.0	8.5	.5	12	.04	217	141	15	9	306	7.9
15-55-26cc	do	124	5/22/52	54	51	.17	42	11	14	5.2	183	17	7.0	.7	11	.04	251	150	0	16	353	7.9
15-55-30ad	do	90	5/16/52	52	46	.30	64	14	28	7.4	285	30	12	.9	6.3	.06	350	219	0	21	532	7.5
15-57-32bb	do	100	5/21/52	52	49	.14	57	13	23	4.7	248	27	11	.8	8.1	.05	318	197	0	20	476	7.7
Surface water																						
Lodgepole Creek, half a mile east of Wyoming State line.			6/12/52	78	32	0.05	40	12	24		204	18	7.5	0.7	2.1	0.07	248	148	0	26	371	7.8
Lodgepole Creek, 2 miles east of Potter, Nebr.			6/12/52	69	47	.12	44	9.7	18		195	15	4.5	.5	6.6	.05	243	150	0	21	355	7.9
Lodgepole Creek, 2 miles north of Colorado State line.			6/13/52	76	44	.12	65	15	49		305	44	15	.8	11	.10	395	222	0	32	604	7.6
U. S. Public Health Service limits						[2] 0.3		125				250	250	1.5	[3] 45		[4] 500					

[1] Includes equivalent of 8 ppm of carbonate (CO_3).
[2] Iron plus manganese.
[3] National Research Council (Maxcy, 1950).
[4] 1,000 ppm permitted.

The chemical analyses of the samples collected in the area indicate that the ground water is hard but it is excellent in most other respects for domestic use. Two samples contained excessive amounts of iron. Local pollution was suggested by a sample that contained an excessive amount of nitrate together with an amount of chloride that was greater than normal.

Silica may present problems if the water is used for steam boilers or steam turbines. Silica concentrations ranged from 40 to 60 ppm in the 23 ground-water samples.

IRRIGATION

In accordance with the method of classification proposed by Wilcox (1948), water having a percent sodium of less than about 40 can be rated for irrigation on the basis of its specific conductance as follows:

Specific conductance (micromhos per centimeter at 25° C)	*Rating for irrigation*
Less than 750	Excellent to good
750–2,000	Good to permissible
2,000–3,000	Doubtful to unsuitable
More than 3,000	Unsuitable

The highest percent sodium in the samples of ground water collected in the area was 38, and the specific conductance ranged from 306 to 662. Hence, all the ground water sampled rated excellent to good for irrigation use. However, the surface water is more variable in chemical composition than the ground water, and the rating depends on flow conditions.

The tolerance of plants to boron has been studied by Eaton (1935) and Scofield (1936). Eaton rated plants according to their sensitivity to boron, and Scofield determined the limits of their tolerance to it. Of the 16 samples for which the content of boron was determined, all rated as excellent for irrigation of the most sensitive crops.

SURFACE WATER

Three samples of surface water were collected June 12–13, 1952, in connection with the study of the ground-water quality. Although these samples are not representative of the general surface-water quality, they give an indication of the type of surface water that entered, that was contained within, and that left the area during the period in which most of the ground-water samples were collected. The mean daily flow in Lodgepole Creek near Bushnell on June 12, 1952, was 6.2 cfs and at Ralton (in Deuel County, near the Colorado State line) on June 13, 1952, was 9.3 cfs. The similarity of the quality of the surface-water samples and the quality of the ground-water samples can be seen in table 8. However, surface water is more variable in composition than ground water because it is more commonly subject to changes in flow and pollution. It is noted that the water in Lodgepole Creek increased in mineralization in the stretch 2 miles east of Potter to 2 miles north of the Colorado State line. Part of this increase may be due to discharge of sewage into Lodgepole Creek by the towns of Sidney and Chappell.

SUMMARY AND CONCLUSIONS

Precipitation is the principal source of recharge to the ground-water reservoir in the area. Lesser amounts of recharge are derived from seepage from irrigation systems and streams and from subsurface inflow.

In the lower Lodgepole Creek drainage basin, ground water generally moves toward Lodgepole Creek in a downstream direction. However, in at least 400 square miles north of the creek valley the ground water moves northeastward toward the North Platte River.

Ground water is discharged by streams, evapotranspiration, wells, and subsurface outflow. During the 1951–52 water year about 13,000 acre-feet of ground water left the area as streamflow. It is estimated that about 20,000 acre-feet of water is discharged annually by evapotranspiration in areas of shallow water table in the Lodgepole Creek valley. It also is estimated that 40,000 acre-feet of water in 1950 and 28,000 acre-feet in 1951 was pumped from wells for irrigation, public supply, and industrial, stock, and domestic uses. The total amount of ground water discharged by subsurface outflow has not been determined.

In the lower Lodgepole Creek valley the depth to water ranges from less than 10 feet near the stream to about 100 feet along the edge of the valley. On the upland the water table is about 80 to 300 feet below the land surface.

The important water-bearing formations are the Brule and Ogallala formations and the alluvium. These supply water to all wells in the area. Of the 40,000 acre-feet of water pumped in 1950 and the 28,000 acre-feet pumped in 1951 about 35,000 and 23,000 acre-feet was used for irrigation. Most of the irrigation wells are in the valleys of Lodgepole Creek and its principal tributary, Sidney Draw.

The loss of considerable ground water from the Lodgepole Creek drainage basin by streamflow and by evapotranspiration where the water table is shallow is evidence that much greater use could be made of this resource, assuming no competing downstream uses of water now leaving the area. Additional withdrawal of ground water where the water table is shallow would serve the dual purpose of salvaging water now lost through evapotranspiration and of improving the crop-producing capacity of lands now waterlogged. Large-discharge wells probably could be constructed in almost any part of Lodgepole Creek valley except in a 5-mile stretch starting 7 miles upstream from Brownson. It is believed that the maximum development of ground water already has been reached in the lower 10 miles of Sidney Draw valley.

The Ogallala formation, which yields water to many irrigation wells in the valley of Lodgepole Creek and to a few in the upland, underlies all the upland and is a potential source of irrigation water in much of the area. The upland on both sides of Lodgepole Creek between Bushnell and Potter is the most favorable part of the area for drilling large-discharge wells in the Ogallala formation; the upland south of Lodgepole Creek valley from about 10 miles west of Sidney to about 5 miles east of Sidney and that in the vicinity of the Wyoming State line are the least favorable. However, because the water-bearing properties of the Ogallala formation vary considerably within short distances, test drilling should precede the selection of a site for a large-discharge well.

Complete and accurate records on the installation of additional large-discharge wells in the area, on the quantity of water withdrawn annually from the ground-water reservoir, and on the fluctuation of the water level in wells should be maintained and evaluated regularly in order to foretell possible or impending overdevelopment of the ground-water resources.

Samples of ground water from representative wells in the three major water-bearing formations show that the water is relatively uniform in total concentration of dissolved solids and percentage composition. Because of this similarity no differentiation of aquifers can be made on the basis of chemical quality of the water. The quality of the surface water in the area is also similar to that of the ground water. Samples generally were low in mineralization but hard; percent sodium and boron were low. The water is well suited for irrigation and, with the exception of hardness, satisfactory for domestic purposes.

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LOGS OF TEST HOLES AND WELLS

The logs of 111 test holes and wells, including 89 test holes drilled by the Conservation and Survey Division of the University of Nebraska, are arranged in numerical order and grouped by counties in table 9. The locations of test holes and wells used in constructing the cross sections and pre-Quaternary erosional surface are shown on plate 1. Logs entitled "sample logs" are for test holes from which rock cuttings were collected and studied by geologists working for the Conservation and Survey Division of the University of Nebraska. The "driller's logs" were obtained from drillers' records or from other sources.

TABLE 9.—*Logs of test holes and wells*

Cheyenne County

	Thickness (feet)	Depth (feet)
12-52-5aa. Sample log of test hole 59 in line *B-B'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,394 feet		
Silt, clayey, and sand; dark-brown to gray	5	5
Silt, clayey, light-brown to gray; contains sand and gravel	15	20
Gravel, fine to medium-coarse, pink	1	21
Clay, very silty, light pinkish-gray (Brule formation)	20	41
Clay, pink (Brule formation)	10	51
Clay, very silty, light pinkish-gray; very hard in lower 3 feet (Brule formation)	18	69
12-52-5da. Sample log of test hole 60 drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,397 feet		
Clay, silty, dark-brown to gray; contains some gravel	6	6
Clay, silty, to clayey silt, light-brown to gray	13	19
Clay, silty to very silty, light pinkish-gray (Brule formation)	20	39
Clay, very silty to clayey sandstone, light-gray to pinkish (Brule formation)	8	47
Clay, pink (Brule formation)	7	54
Clay, very silty, light pinkish-gray (Brule formation)	25	79
13-46-5aa. Sample log of test hole 8 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 3,808 feet		
Clay, silty, dark-brown to gray	8	8
Gravel, fine to medium, pink; contains coarse sand	16	24
Gravel, medium to coarse, pink	6	30
Clay, silty, indurated, light pinkish-gray (Brule formation)	40	70
Clay, very silty, softer, light pinkish-gray (Brule formation)	10	80
Clay, silty, indurated, light pinkish-gray (Brule formation)	15	95
Clay, indurated, pink (Brule formation)	4	99
13-47-17ab. Driller's log of test hole at site of irrigation well		
No sample	54	54
Clay	26	80
Gravel, good	26	106
Rock	1	107
13-50-1bc. Driller's log of test hole at site of irrigation well		
Topsoil	10	10
Dirt and sand	10	20
Hardpan or Brule formation (water at 32 ft)	12	32
Red rocks	6	38
Brule formation, tight	4	42
Brule formation, open	16	58
Brule formation, tight	22	80

TABLE 9.—*Logs of test holes and wells*—Continued

Cheyenne County—Continued

13-50-2cb Driller's log of test hole at site of irrigation well

	Thickness (feet)	Depth (feet)
Topsoil	10	10
Dirt and sand	10	20
Hardpan or Brule formation (water at 57 ft)	37	57
Brule formation, tight	20	77
Brule formation, open	4	81
Brule formation, tight	19	100

13-50-3bb. Driller's log of test hole at site of irrigation well. Surface altitude, 4,146 feet

	Thickness (feet)	Depth (feet)
Topsoil	10	10
Gravel	8	18
Hardpan or Brule formation (water at 36 ft)	18	36
Brule formation, tight	14	50
Brule formation, open	12	62
Brule formation, tight	38	100

13-50-3cb. Driller's log of test hole at site of irrigation well. Surface altitude, 4,159 feet

	Thickness (feet)	Depth (feet)
Topsoil	8	8
Gravel	6	14
Hardpan or Brule formation (water at 33 ft)	19	33
Brule formation, tight	4	37
Brule formation, open	23	60
Brule formation, tight	40	100

13-50-4ab. Driller's log of test hole at site of irrigation well. Surface altitude, 4,151 feet

	Thickness (feet)	Depth (feet)
Topsoil	12	12
Dirt and sand	8	20
Hardpan or Brule formation (water at 35 feet)	15	35
Brule formation, tight	5	40
Brule formation, open	20	60
Brule formation, tight	30	90

13-50-4ad. Sample log of test hole 20 in line *B-B'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,143 feet

	Thickness (feet)	Depth (feet)
Sand, silty, brown	2	2
Sand, fine to coarse, pink; and fine to medium gravel; contains some reworked Brule and Ogallala material	7	9
Gravel, fine to coarse, pink; contains much reworked Ogallala and Brule pebble material	10	19
Clay, silty, light pinkish-buff (Brule formation)	50	69

13-50-7cc. Sample log of test hole 43 in line *G-G'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,232 feet

	Thickness (feet)	Depth (feet)
Clay, silty, dark-brown to gray	5	5
Clay, silty, light-brown to gray to pinkish	11	16
Clay, silty, light pinkish-gray (Brule formation)	30	46
Clay, silty to very silty, light pinkish-gray (Brule formation)	10	56
Clay, silty to very silty, hard, pink (Brule formation)	13	69

13-51-1ad. Sample log of test hole 39 in line *G-G'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,242 feet

	Thickness (feet)	Depth (feet)
Clay, silty, and sand; dark-brown to gray	5	5
Silt, clayey, light-brown to gray	6	11
Gravel, fine to coarse, light-gray (Ogallala pebbles)	24	35
Clay, silty, light pinkish-gray (Brule formation)	30	65
Clay, very silty, light pinkish-gray (Brule formation)	11	76
Clay, indurated, pink (Brule formation)	43	119

TABLE 9.—*Logs of test holes and wells*—Continued

Cheyenne County—Continued

13-51-1da. Sample log of test hole 40 in line *G-G′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,227 feet

	Thickness (feet)	Depth (feet)
Sand and clayey silt; dark-brown to gray	8	8
Gravel, fine to coarse, light-gray and pink (Ogallala pebbles)	33	41
Clay, silty, light pinkish-gray (Brule formation)	22	63
Clay, very silty, light-gray to pinkish (Brule formation)	15	78
Clay, silty, partly indurated, pink; lost circulation at 80 feet (Brule formation)	21	99

13-51-1dd. Sample log of test hole 41 in lines *B-B′* and *G-G′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,214 feet

	Thickness (feet)	Depth (feet)
Silt, clayey, and sand; brownish-gray	8	8
Gravel, fine to coarse, light-gray (many Ogallala pebbles)	17	25
Clay, silty to very silty, light pinkish-gray (Brule formation)	35	60
Clay, silty, pink (Brule formation)	19	79

13-51-3ba. Sample log of test hole 46 drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,329 feet

	Thickness (feet)	Depth (feet)
Silt, clayey, sand; dark-brown to gray	2	2
Gravel, fine to coarse (Ogallala pebbles)	26	28
Clay, very silty, light pinkish-gray (Brule formation)	41	69
Sandstone, clayey, light pinkish-gray (Brule formation)	10	79
Clay, silty to very silty, light pinkish-gray (Brule formation)	10	89

13-51-4bc. Sample log of test hole 47 in line *J-J′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,315 feet

	Thickness (feet)	Depth (feet)
Silt, clayey, dark-brown to gray; contains gravel	2	2
Silt, clayey, light-brown to gray	5	7
Gravel, fine to very coarse, light-gray and pink	12	19
Clay, silty, light-gray to pinkish, and pink clay (Brule formation)	30	49
Clay, very silty, light-gray to pinkish, and pink clay (Brule formation)	20	69

13-51-4cc. Sample log of test hole 48 in line *J-J′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,282 feet

	Thickness (feet)	Depth (feet)
Clay, silty, dark-brown to gray	1	1
Silt, clayey, light-brown to gray, and gravel	3	4
Gravel, fine to coarse, light-gray and pink (Ogallala pebbles)	9	13
Clay, silty, light pinkish-gray (Brule formation)	17	30
Clay, very silty, light pinkish-gray, and hard, pink clay (Brule formation)	39	69

13-51-8da. Sample log of test hole 49 in line *J-J′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,271 feet

	Thickness (feet)	Depth (feet)
Silt, clayey, dark-brown to gray	1	1
Silt, clayey, light-brown to gray	9	10
Gravel, fine to coarse, light-gray (Ogallala and Brule pebbles)	4	14
Clay, very silty, light pinkish-gray (Brule formation)	20	34
Clay, very silty, and clay (Brule formation)	35	69

13-51-10ad. Sample log of test hole 45 in line *B-B′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,249 feet

	Thickness (feet)	Depth (feet)
Clay, silty, dark-brown to gray; contains sand and gravel	3	3
Silt, clayey, light-brown to gray	3	6
Gravel, fine to coarse, light-gray and pink (Ogallala pebbles in upper part and Brule pebbles in lower part)	13	19
Clay, silty to very silty, light-gray to pinkish (Brule formation)	10	29
Clay, very silty, light-gray to pinkish, and pink clay (Brule formation)	40	69

TABLE 9.—*Logs of test holes and wells*—Continued

Cheyenne County—Continued

	Thickness (feet)	Depth (feet)
13-51-10cd. Driller's log of test hole at site of irrigation well		
Topsoil	10	10
Dirt and sand	10	20
Hardpan or Brule formation (water at 43 ft)	23	43
Red rocks	20	63
Brule formation, open	3	66
Brule formation, tight	24	90
13-51-11ab. Driller's log of test hole at site of irrigation well. Surface altitude, 4,228 feet		
Topsoil	8	8
Gravel	4	12
Hardpan or Brule formation (water at 33 ft)	21	33
Brule formation, tight	15	48
Red rocks, hard	2	50
Brule formation, open	6	56
Brule formation, tight	44	100
13-51-11ba2. Driller's log of irrigation well. Surface altitude, 4,236 feet		
Topsoil	12	12
Dirt and sand	6	18
Hardpan or Brule formation (water at 40 ft)	22	40
Red rocks	10	50
Brule formation open	4	54
Red rocks, hard	3	57
Brule formation, tight	33	90
13-51-12ad. Sample log of test hole 42 in line *G-G'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,200 feet		
Sand, fine, gravel, and pebbles; contains many limy pebbles	2	2
Gravel, fine to coarse, and abundant pink pebbles, mainly limy	4	6
Sand, fine to coarse, pinkish-gray, and a little fine gravel; contains small limy pebbles	11	17
Clay, silty, light pinkish-buff (Brule formation)	39	56
Clay, very silty, light pinkish-buff (Brule formation)	33	89
13-51-13ac. Sample log of test hole 44 drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,245 feet		
Clay, silty, and sand; dark-brown to gray	1	1
Clay pebbles, silty, light pinkish-gray	8	9
Clay, silty, light pinkish-gray (Brule formation)	19	28
Clay, silty to very silty, light pinkish-gray (Brule formation)	20	48
Clay, very silty, light pinkish-gray, and pink indurated clay (Brule formation)	30	78
Clay, indurated, pink (Brule formation)	30	108
Clay, hard, pink (Brule formation)	11	119
13-51-15bb. Driller's log of irrigation well. Surface altitude, 4,258 feet		
Topsoil	8	8
Gravel	6	14
Hardpan or Brule formation	22	36
Red rocks	24	60
Brule formation, open (water)	2	62
Brule formation, tight	6	68
Brule formation, open (water)	2	70
Brule formation, tight	10	80

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TABLE 9.—*Logs of test holes and wells*—Continued

Cheyenne County—Continued

	Thickness (feet)	Depth (feet)
13-51-16cb. Sample log of test hole 51 in lines *J-J'* and *B-B'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,270 feet		
Silt, clayey, dark-brown	6	6
Gravel, fine to medium, pink (Ogallala pebbles)	2	8
Pebbles of Brule formation	11	19
Clay, silty to very silty, light pinkish-gray, and some pink clay (Brule formation)	30	49
Siltstone, clayey, to very silty clay, light pinkish-gray (Brule formation)	20	69
Sandstone, fine-grained, light pinkish-gray (Brule formation)	9	78
Clay, pink (Brule formation)	6	84
Sandstone, fine-grained, light pinkish-gray, and clay, pink (Brule formation)	10	94
Clay, pink, interbedded with pinkish-gray, silty clay (Brule formation)	22	116
13-51-17aa. Sample log of test hole 50 in line *J-J'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,268 feet		
Silt, clayey, dark-brown to gray	3	3
Silt, clayey, light-brown to gray	6	9
Gravel, coarse, light-gray (Ogallala pebbles)	2	11
Clay, very silty, light pinkish-gray, and pink clay (Brule formation)	28	39
Clay, very silty, light pinkish-gray, grading to clayey silt (Brule formation)	20	59
No samples, lost circulation at 60 feet; drilled smooth, steady, and slow (probably Brule formation)	10	69
13-51-19cb. Sample log of test hole 54 in line *H-H'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,328 feet		
Clay, silt, and sand; dark-brown to gray in upper part, light-brown to gray in lower part	6	6
Pebbles of Brule formation	3	9
Clay, silty, light pinkish-gray; coarse in lower part (Brule formation)	27	36
Clay, pink (Brule formation)	7	43
Clay, silty, light pinkish-gray (Brule formation)	19	62
Clay, pink; interbedded with silty clay (Brule formation)	7	69
13-51-21bb. Sample log of test hole 52 in line *J-J'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitnde, 4,279 feet		
Clay, silty, to clayey silt, brown to gray; contains some sand and gravel	10	10
Gravel, fine to medium, some coarse; pink	5	15
Clay, silty to very silty, light pinkish-gray (Brule formation)	24	39
Clay, pink (Brule formation)	10	49
Clay, silty, light pinkish-gray (Brule formation)	5	54
Clay, pink (Brule formation)	10	64
Clay, silty to very silty, light pinkish-gray (Brule formation)	5	69
13-51-21cb. Sample log of test hole 53 in line *J-J'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,295 feet		
Silt, clayey, to silty clay, dark-brown to gray; contains sand	4	4
Clay (reworked or weathered Brule formation)	5	9
Clay, silty, light pinkish-gray (Brule formation)	20	29
Clay, very silty, light pinkish-gray (Brule formation)	31	60
Sandstone, clayey, fine-grained, pinkish-gray (Brule formation)	7	67
Clay, hard, pink (Brule formation)	2	69
13-51-30bb. Sample log of test hole 55 in lines *H-H'* and *B-B'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,326 feet		
Clay, silty, dark-brown to gray; contains much sand and gravel	4	4
Gravel, medium to very coarse (Ogallala pebbles)	14	18
Clay, pink, and silty clay (Brule formation)	11	29
Clay, silty to very silty, light pinkish-gray (Brule formation)	30	59
No sample, lost circulation at 60 feet	10	69

TABLE 9.—*Logs of test holes and wells*—Continued

Cheyenne County—Continued

	Thickness (feet)	Depth (feet)
13-52-25da. Sample log of test hole 56 in line *H-H'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,330 feet		
Clay, silty, and sand; brownish-gray	17	17
Clay, silty, grading to very silty, light pinkish-gray (Brule formation)	21	38
Clay, pink (Brule formation)	5	43
Clay, very silty, grading to clayey sandstone, light-gray to pinkish (Brule formation)	5	48
Clay, pink (Brule formation)	7	55
Clay, silty to very silty, light pinkish-gray (Brule formation)	40	95
Clay, hard, pink, some interbedded silty clay in upper part (Brule formation)	24	119
13-52-31dc. Driller's log of test hole at site of irrigation well. Surface altitude, 4,468 feet		
Topsoil	15	15
Hardpan, loose	9	24
Hardpan or Brule formation (water at 61 ft)	37	61
Brule formation, tight	10	71
Brule formation, open	5	76
Brule formation, tight	24	100
13-52-36aa. Sample log of test hole 57 in line *H-H'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,334 feet		
Clay, silty, and sand; dark-brown to gray	3	3
Sand and gravel, fine to medium, pinkish-gray	2	5
Clay, silty, light pinkish-gray (Brule formation)	20	25
Clay, very silty, to clayey sandstone, light-gray to pinkish; contains some pink clay (Brule formation)	20	45
Clay, pink (Brule formation)	10	55
Clay, very silty, light-gray to pinkish (Brule formation)	11	66
Clay, pink (Brule formation)	3	69
13-52-36dd. Sample log of test hole 58 in line *H-H'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,358 feet		
Silt, clayey, light-brown to gray, dark in upper part	10	10
Clay, silty to very silty, light pinkish-gray (Brule formation)	40	50
Clay, pink (Brule formation)	10	60
Clay, very silty, pinkish-gray (Brule formation)	21	81
Clay, hard, pink (Brule formation)	6	87
Clay, silty, light pinkish-gray (Brule formation)	2	89
14-47-28bc. Sample log of test hole 10 in line *D-D'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 3,899 feet		
Sand, fine to coarse, brownish-gray; contains some gravel	5	5
Gravel, fine to medium-coarse; contains coarse sand	27	32
Clay, silty, light pinkish-gray (Brule formation)	77	109
14-47-32aa. Sample log of test hole 11 in lines *A-A'* and *D-D'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 3,892 feet		
Clay, silty, soft, medium-gray; soil at top	11	11
Gravel, fine to medium-coarse, pinkish; contains coarse sand	18	29
Clay, silty, indurated, light pinkish-gray (Brule formation)	70	99
14-47-33cb. Sample log of test hole 12 in line *D-D'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 3,916 feet		
Clay, silty, soft, brownish-gray (loess)	17	17
Sand, coarse, and fine gravel; pinkish	16	33
Clay, silty, light pinkish-gray (Brule formation)	76	109

TABLE 9.—*Logs of test holes and wells*—Continued

Cheyenne County—Continued

	Thickness (feet)	Depth (feet)
14-47-35aa. Sample log of test hole 9 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 3,849 feet		
Clay, silty, soft, dark-brown to gray (soil)	4	4
Clay, silty, soft, medium light-gray	3	7
Sand, fine to coarse, gray	2	9
Gravel, fine- to medium-grained, pink, and medium to coarse, gray sand	16	25
Clay, silty, indurated, light pinkish-gray (Brule formation)	68	93
Clay, very silty, light pinkish-gray (Brule formation)	3	96
Clay, pinkish (Brule formation)	13	109
14-48-26cc. Sample log of test hole 13 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 3,949 feet		
Clay, silty, brownish-gray	9	9
Sand, medium to coarse, and fine to medium-coarse gravel; pinkish-gray	9	18
Clay, silty, light pinkish-gray; lost circulation at 85 feet (Brule formation)	81	99
14-48-27cc. Driller's log of test hole at site of irrigation well. Surface altitude, 3,965 feet		
Topsoil	10	10
Gravel	8	18
Hardpan or Brule formation (water at 26 feet)	8	26
Brule formation, tight, or hardpan	64	90
Brule formation, open	6	96
Brule formation, tight	14	110
14-48-27dc. Driller's log of irrigation well		
Topsoil and clay	17	17
Gravel	8	25
Brule formation, solid	16	41
Brule formation, broken	52	93
14-48-29cb. Sample log of test hole 14 in line *E-E'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,000 feet		
Sand, silty, gravel, and pebbles; poorly sorted	2	2
Sand, silty, dark-brown	5	7
Silt, sandy, light brownish-buff	11	18
Sand, medium, to medium-coarse gravel; pink	9	27
Gravel, fine to coarse, pink; and many gray, limy pebbles	9	36
Sand, fine, to medium gravel; pinkish-gray; contains many limy pebbles	3	39
Clay, silty, light pinkish-buff (Brule formation)	17	56
14-48-32bb. Sample log of test hole 15 in lines *A-A'* and *E-E'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 3,997 feet		
Silt, sandy, brownish-gray in upper part; sand, fine to coarse in lower part	6	6
Sand, medium, to medium gravel; pink; contains reworked Brule clay	15	21
Clay, silty, light pinkish-buff (Brule formation)	98	119
14-48-32cc. Sample log of test hole 16 in line *E-E'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,027 feet		
Sand, silty, brown	2	2
Gravel, fine to medium, and abundant medium to coarse sand and some coarse gravel, pink; contains a little sandy silt, brownish-gray in lower part	15	17
Gravel, medium to coarse, pink, and a little medium to coarse sand and fine gravel	33	50
Sand, medium to coarse, pinkish-gray (a little reworked Ogallala in lower part)	24	74
Sand, coarse, and medium gravel, pink (some reworked Ogallala pebbles)	6	80
Clay, silty, light pinkish-buff; lost circulation at 84 feet (Brule formation)	19	99

TABLE 9.—*Logs of test holes and wells*—Continued

Cheyenne County—Continued

	Thickness (feet)	Depth (feet)
14-49-31ba. Driller's log of test hole at site of public-supply well. Surface altitude, 4,092 feet		
Topsoil	8	8
Gravel	12	20
Hardpan (water at 23 ft.)	3	23
Hardpan or Brule formation	32	55
Brule formation, open	12	67
Brule formation, tight	18	85
14-49-31cc. Sample log of test hole 19 in lines *A-A'* and *B-B'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,091 feet		
Sand, fine to coarse, pinkish-gray; contains some reworked Ogallala material	4	4
Gravel, fine to coarse, pink; contains considerable fine to coarse sand, slightly coarser in lower part	16	20
Silt, sandy, light pinkish-buff (Brule formation)	10	30
Silt, sandy, light-gray to grayish-buff (Brule formation)	20	50
Silt, sandy, light pinkish-buff; lost circulation at 55 feet (Brule formation)	29	79
14-49-33cc. Sample log of test hole 18 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,066 feet		
Sand, silty, dark brownish-gray	3	3
Sand, fine to medium, light pinkish-gray; contains some reworked Ogallala and Brule material	5	8
Gravel, fine to coarse, some pebbles, pink; abundant fine to coarse sand; contains a little reworked Ogallala and Brule material	4	12
Clay, silty, light pinkish-buff (Brule formation)	57	69
14-49-35bb. Sample log of test hole 17 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,048 feet		
Loam, silty, sandy, dark	3	3
Gravel, fine to coarse, a few pebbles, pink; contains some medium to coarse sand	27	30
Gravel, coarse, pink; abundant pebbles in lower part	9	39
Gravel, fine to coarse, pink; contains some sand, coarser in lower part	20	59
Clay, silty, light pinkish-buff; lost circulation at 73 feet (Brule formation)	40	99
14-50-18bc. Sample log of test hole 37 in line *G-G'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,210 feet		
Sand, medium to coarse, brownish-gray, some soil at top; contains fine to medium gravel	2	2
Gravel, fine to medium, somewhat coarser in lower part, pink	18	20
Clay, silty, very silty from 40-65 feet, light pinkish-buff (Brule formation)	45	65
Clay, pinkish-buff; lost circulation at 79 feet (Brule formation)	34	99
14-50-18ca. Sample log of test hole 36 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,200 feet		
Clay, silty, dark brownish-gray	4	4
Sand, coarse, and fine to medium gravel; pink	16	20
Clay, silty, pinkish-buff; lost circulation at 74 feet (Brule formation)	79	99
Clay, slightly silty, light pinkish-buff (Brule formation)	19	118
14-50-19cd. Driller's log of test hole at site of irrigation well. Surface altitude, 4,218 feet		
Topsoil	14	14
Dirt and sand	10	24
Hardpan or Brule formation (water at 46 ft)	22	46
Brule formation, tight	30	76
Brule formation, open	6	82
Brule formation, tight	28	110

TABLE 9.—*Logs of test holes and wells*—Continued

Cheyenne County—Continued

	Thickness (feet)	Depth (feet)
14-50-19d1. Sample log of test hole 33 drilled by Conservation and Survey Division of the University of Nebraska, 1934		
Loam, sandy	4	4
Loess, clayey	4	8
Sand and gravel	5	13
Clay (Brule formation)	22	35
14-50-19d2. Sample log of test hole 34 drilled by Conservation and Survey Division of the University of Nebraska, 1934		
Loam, sandy	4	4
Loess, clayey	1	5
Gravel (much Ogallala material)	7	12
Clay (Brule formation)	38	50
14-50-19d3. Sample log of test hole 35 drilled by Conservation and Survey Division of the University of Nebraska, 1934		
Loam, sandy; reworked Ogallala material in middle part	5	5
Clay, loose, light-brown	3	8
Gravel; contains some pieces of Ogallala material	6	14
Clay (Brule formation)	37	51
14-50-19dc. Driller's log of test hole at site of irrigation well		
Topsoil	10	10
Dirt and sand	5	15
Hardpan or Brule formation (water at 41 ft)	26	41
Brule formation, tight	11	52
Brule formation, open	5	57
Brule formation, tight	43	100
14-50-20cc1. Sample log of test hole 24 drilled by Conservation and Survey Division of the University of Nebraska, 1934		
Loam, sandy	1	1
Sand and gravel	2	3
Brule and Ogallala pebbles, and gravel	3	6
Clay, friable (Brule formation)	145	151
14-50-20cc2. Sample log of test hole 25 drilled by Conservation and Survey Division of the University of Nebraska, 1934		
Sand, and some clay	5	5
Gravel	2	7
Clay (Brule formation)	51	58
14-50-20cc3. Sample log of test hole 26 drilled by Conservation and Survey Division of the University of Nebraska, 1934		
Loam, sandy	2	2
Gravel	2	4
Clay (Brule formation)	67	71
14-50-20cc4. Sample log of test hole 27 drilled by Conservation and Survey Division of the University of Nebraska, 1934		
Gravel, coarse	3	3
Clay (Brule formation)	32	35

TABLE 9.—*Logs of test holes and wells*—Continued

Cheyenne County—Continued

	Thickness (feet)	Depth (feet)
14-50-20cc5. Sample log of test hole 28 drilled by Conservation and Survey Division of the University of Nebraska, 1934		
Loam, sandy	2	2
Sand and gravel	2	4
Clay (Brule formation)	71	75
14-50-20cc6. Sample log of test hole 29 drilled by Conservation and Survey Division of the University of Nebraska, 1934		
Loam, sandy	1	1
Sand and gravel	4	5
Clay (Brule formation)	43	48
14-50-20cc7. Sample log of test hole 30 drilled by Conservation and Survey Division of the University of Nebraska, 1934		
Loam, sandy	5	5
Clay (Brule formation)	73	78
14-50-20cc8. Sample log of test hole 31 drilled by Conservation and Survey Division of the University of Nebraska, 1934		
Loam, sandy	1	1
Loess, clayey; contains tiny flakes of mica	6	7
Gravel	8	15
Clay (Brule formation)	75	90
14-50-20cc9. Sample log of test hole 32 drilled by Conservation and Survey Division of the University of Nebraska, 1934		
Loam, sandy	3	3
Loess, clayey	2	5
Gravel	8	13
Clay (Brule formation)	124	137
14-50-28aa. Sample log of test hole 23 in line *F-F'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,175 feet		
Sand, fine to coarse, brownish-gray	5	5
Sand, fine to coarse, pinkish-gray; abundant fine gravel; contains many reworked Ogallala pebbles	4	9
Sand, fine, to medium gravel, poorly sorted, pinkish-gray; contains considerable reworked Ogallala pebbles	20	29
Gravel, fine to coarse, pink; abundant fine to coarse sand; contains a little reworked Ogallala material	14	43
Clay, silty, light pinkish-buff (Brule formation)	38	81
Clay, silty, light pinkish-buff; contains considerable interbedded dense, sticky clay (Brule formation)	18	99
14-50-34bb. Sample log test hole 22 in lines *A-A'* and *F-F'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,136 feet		
Silt, sandy, brownish-gray	5	5
Sand, medium, to medium gravel, some coarse gravel; pink	13	18
Clay, silty, light pinkish-buff; contains interbedded dense, sticky clay (Brule formation)	61	79

TABLE 9.—*Logs of test holes and wells*—Continued

Cheyenne County—Continued

	Thickness (feet)	Depth (feet)
14-50-34cb. Sample log of test hole 21 in line *F–F′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,154 feet		
Silt, sandy, brownish-gray	2	2
Silt, light-buff; contains scattered calcareous sand grains	5	7
Sand, fine, to coarse gravel, and pebbles, limy; poorly sorted	5	12
Clay, silty, light pinkish-buff (Brule formation)	30	42
Clay, silty, and clay, light pinkish-buff (Brule formation)	37	79
14-51-7bb. Sample log of test hole 63 in line *H–H′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,291 feet		
Sand, silty, dark-brown to gray	1	1
Gravel, fine, pink, and coarse sand	10	11
Gravel, fine to coarse, pink	11	22
Gravel, fine, pink, and coarse sand	14	36
Siltstone to sandstone, part limy, pinkish-gray and gray (Ogallala formation)	30	66
Siltstone, calcareous, hard, light-gray (Ogallala formation)	3	69
14-51-7bc. Sample log of test hole 62 in lines *A–A′* and *H–H′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,292 feet		
Clay, silty, dark-brown to gray	5	5
Gravel, fine to coarse, pink and dark; and sand	18	
Siltstone to sandstone, pinkish-gray; contains some light-gray limy pieces (Ogallala formation)	37	60
Siltstone pebbles, calcareous, light-gray (basal Ogallala)	7	67
Claystone, silty, light pinkish-gray (Brule formation)	30	97
Claystone, silty, light pinkish-gray, and pink claystone (Brule formation)	22	119
14-51-9ba. Sample log of test hole 61 in line *A–A′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,262 feet		
Clay, silty, dark brownish-gray	4	4
Sand, medium to coarse, gray; and fine to medium coarse, pink gravel	10	14
Clay, silty, indurated, light pinkish-gray (Brule formation)	49	63
Clay, very silty, light pinkish-gray (Brule formation)	10	73
Clay, silty, indurated, light pinkish-gray; some interbedded pink clay	36	109
14-51-13bb. Driller's log of test hole at site of irrigation well. Surface altitude, 4,218 feet		
Topsoil	6	6
Gravel	5	11
Clay (water at 41 ft)	30	41
Quicksand	6	47
Brule formation, tight, and red rocks	18	65
Brule formation, open	3	68
Brule formation, tight	42	110
14-51-24ac. Sample log of test hole 38 in line *G–G′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,190 feet		
Silt, sandy, light brownish-gray	2	2
Sand, fine to coarse, pink, and a little fine to coarse gravel; contains some limy pebbles and a little reworked Brule and Ogallala material in lower part	11	13
Clay, silty, light pinkish-buff (Brule formation)	36	49
14-52-1da. Sample log of test hole 64 in line *H–H′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,314 feet		
Clay, silty, dark-brown to gray, and sand	4	4
Sand, fine to coarse, gray, and gravel	13	17
Gravel, fine to medium-coarse, pink	6	23
Siltstone to sandstone, light-gray and pinkish-gray (Ogallala formation)	53	76
Siltstone to sandstone, very limy, hard (Ogallala formation)	2	78
Claystone, silty, light-gray to pinkish, in part nonsilty and pink (Brule formation)	31	109

TABLE 9.—*Logs of test holes and wells*—Continued

Cheyenne County—Continued

	Thickness (feet)	Depth (feet)
14-52-6da. Sample log of test hole 67 in lines *A-A'* and *K-K'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,376 feet		
Clay, silty, gray	2	2
Gravel, fine to medium-coarse, pink, and coarse, gray sand	16	18
Gravel, medium to coarse (many Ogallala pebbles)	13	31
Sandstone, silty, pinkish-gray (Ogallala formation)	29	60
Sandstone, silty, pinkish-gray, interbedded with calcareous siltstone, light-gray (Ogallala formation)	16	76
Sandstone, silty, pinkish-gray (Ogallala formation)	23	99
14-52-8b. Sample log of test hole 66 in line *K-K'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,404 feet		
Clay, silty, dark-gray	3	3
Sand, coarse, gray, and fine to medium gravel; contains reworked Ogallala pebbles, pink	11	14
Sandstone, silty, pinkish-gray (Ogallala formation)	10	24
Claystone, silty, micaceous, pinkish (Ogallala formation)	2	26
Sandstone, silty, light-gray and pinkish-gray (Ogallala formation)	7	33
Siltstone, sandy, calcareous, light-gray (Ogallala formation)	5	38
Siltstone, calcareous, light-gray to white (Ogallala formation)	2	40
Sandstone, silty, pinkish-gray (Ogallala formation)	10	50
Siltstone, calcareous, hard, light-gray to white (Ogallala formation)	5	55
Sandstone, silty, light-gray to pink (Ogallala formation)	39	94
Siltstone to limestone, hard, light-gray to white (Ogallala formation)	1	95
14-52-11c. Sample log of test hole 65 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,366 feet		
Clay, silty to sandy, dark-brown to gray in upper part, medium-gray in lower part	18	18
Gravel, composed of Ogallala pebbles	20	38
Siltstone to limestone, very hard, light-gray (Ogallala formation)	6	44
Siltstone to claystone, calcareous, softer, light-gray (Ogallala formation)	7	51
Sandstone, silty, soft, medium light-gray (Ogallala formation)	6	57
Siltstone to claystone, very calcareous, chalky, light-gray (Ogallala formation)	3	60
Sandstone, silty, soft, light-gray to pinkish (Ogallala formation)	30	90
Siltstone to claystone, calcareous, hard, light-gray (Ogallala formation)	13	103
Sandstone, silty, soft, medium light-gray (Ogallala formation)	6	109

Deuel County

	Thickness (feet)	Depth (feet)
12-44-7cb. Driller's log of test hole at site of irrigation well		
Loam, sandy	10	10
Sand, very fine	2	12
Sand and gravel (water at 12 ft)	3	15
Gravel, coarse	9	24
Clay, reddish	2	26
12-45-2da. Sample log of test hole 2 in line A-A' drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 3,610 feet		
Road fill	4	4
Clay, silty to sandy, dark-brown	3	7
Silt and clay, black; contains a little sand	1	8
Clay, silty, brown; contains some sand and fine gravel	1.5	9.5
Gravel, coarse, dark-red and some green	4.5	14
Gravel, coarse to fine, red	2	16
Gravel, fine, red	5	21
Clay, hard, pinkish-brown	5	26
Brule formation, very hard, pinkish-brown	3	29

TABLE 9.—*Logs of test holes and wells*—Continued

Deuel County—Continued

	Thickness (feet)	Depth (feet)
12-45-12cb. Sample log of test hole 1 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 3,614 feet		
Soil, silty, sandy, light-buff	7.5	7.5
Gravel, medium to coarse, red and gray; contains some lime gravel	8.5	16
Gravel, fine to medium to some coarse, red	12	28
Gravel, medium to coarse, red, some gray	6	34
Gravel, medium to coarse; contains large pebbles	5	39
Gravel, coarse; contains boulders	3	42
Brule clay, and pinkish gravel (Poor sample due to caving of gravel)	7	49
Clay, buff to pinkish	4	53
Clay, sandy, pinkish to bnff	4	57
13-44-31cc. Sample log of test hole 3 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 3,624 feet		
Soil, sandy, fine, dark-brown	4	4
Gravel, fine to coarse, red	6	10
Gravel, fine to medium, red	10	20
Gravel, fine to coarse, red	6	26
Gravel, red, slightly finer than above	2.5	28.5
Gravel, medium to coarse; contains a few chips of pinkish, hard, sandy clay	10.5	39
Clay, hard, compact, buff to pinkish (looks like Brule formation)	10	49
13-45-16cb. Driller's log of irrigation well		
Topsoil	9	9
Gravel	8	17
Sand, coarse	9	26
Gravel, hard	10	36
Sandstone, soft and hard	15	51
Sandstone, soft	25	76
Brule formation	29	105
13-45-22bb. Sample log of test hole 5 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 3,680 feet		
Loam, sandy, dark-brown	6.5	6.5
Gravel, fine to coarse, red	2.5	9
Gravel, medium to coarse; contains some dark sandy clay	4	13
Gravel, fine to medium to coarse, light-red	6	19
Gravel, fine to medium, red to pink	2	21
Clay, solid, buff, pinkish to gray; contains some lime	7	28
13-45-25cc. Sample log of test hole 4 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 3,648 feet		
Road fill; contains sand and silt	4.5	4.5
Silt, grayish-brown, and sand	6.5	11
Gravel, fine, some coarse, reddish	5	16
Gravel, fine to coarse, reddish	3	19
Gravel, fine to coarse, clear, yellow pink	3	22
Clay, sandy, compact, buff to pinkish	12	34
Clay, sandy, buff to pinkish	5	39
13-46-12bb. Sample log of test hole 7 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 3,756 feet		
Clay, silty, soft, dark-brown to gray; contains sand and gravel	2	2
Sand, coarse, gray, and fine to medium, pink gravel	10	12
Gravel, fine to medium-coarse, pink	8	20
Clay, silty, indurated, pinkish-gray (Brule formation)	15	35
Clay, very silty, indurated, pinkish-gray (Brule formation)	40	75
Clay, indurated, pink, and silty clay (Brule formation)	15	90

TABLE 9.—*Logs of test holes and wells*—Continued

Deuel County—Continued

	Thickness (feet)	Depth (feet)

13-46-12cc. Sample log of test hole 6 drilled by Conservation and Snrvey Division of the University of Nebraska, 1942. Surface altitude, 3,792 feet

Road fill	3	3
Gravel, fine to medium, red	10	13
Gravel, fine to medium, light-red	10	23
Gravel, fine to medium, red and blue	10	33
Gravel, very fine, red; contains some sand	1.5	34.5
Gravel, fine to medium; contains some Brule clay	9	43.5
Gravel, light to medium-red; contains lime mixture	6.5	50
Sandy material, very hard, light-buff	9	59

Kimball County

14-53-3aa. Sample log of test hole 68 in line *A-A′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,447 feet

Sand, silty, brown	6	6
Silt, and scattered sand grains; brownish-buff	4	10
Silt, sandy, soft, dark brownish-gray	7	17
Gravel, medium to coarse, pink, and sand, fine gravel and pebbles	13	30
Gravel, fine, pinkish-gray; contains abundant medium to coarse sand	19	49
Sandstone, silty, pinkish-gray; poor sample due to caving (Ogallala formation)	40	89

14-57-1aa. Sample log of test hole 82 in line *P-P′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,804 feet

Sand, fine to medium-coarse, brown to gray	3	3
Gravel, fine to coarse (Ogallala formation)	14	17
Sandstone, silty, medium light-gray; embedded pink clay pebbles (Ogallala formation)	19	36
Siltstone to sandstone, calcareous, indurated, light-gray (Ogallala formation)	7	43
Sandstone, silty, interbedded with calcareous siltstone (Ogallala formation)	9	51

14-58-2da. Sample log of test hole 85 in line *A-A′* drilled by Conservation and Survey Division of the University of Nebraska, 1942

Sand, and clayey silt; brown to gray	1	1
Silt, clayey, light-brown to gray	7	8
Gravel, fine to coarse, light-gray (largely Ogallala pebbles)	10	18
Siltstone, sandy, medium light-gray (Ogallala formation)	10	28
Sandstone, silty, medium light-gray (Ogallala formation)	20	48
Sandstone, silty, medium light-gray to pinkish (Ogallala formation)	61	109

14-58-8dc. Sample log of test hole 86 in line *A-A′* drilled by Conservation and Survey Division of the University of Nebraska, 1942

Sand, fine to coarse, brown to gray	2	2
Gravel, fine to coarse, pink; contains Brule pebbles	21	23
Clay, indurated, very silty, pink (Brule formation)	17	40
Clay, very silty, medium-gray to pinkish (Brule formation)	59	99

14-59-11aa. Sample log of test hole 89 in line *R-R′* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 5,050 feet

Clay, silty, silt, and sand; brown to gray	6	6
Gravel, medium to coarse, pink (Ogallala pebbles)	14	20
Gravel, fine, angular, pink; some fragments of calcareous siltstone and sandstone, light-gray; contains some light-gray clay	30	50
Gravel and sandstone; contains fragments of calcareous, light-gray siltstone	13	63
Clay, pink (Brule formation)	17	80
Clay, silty, hard, pinkish-gray (Brule formation)	8	88
Clay, very silty, hard, medium light-gray to pink (Brule formation)	21	109

TABLE 9.—*Logs of test holes and wells*—Continued

Kimball County—Continued

	Thickness (feet)	Depth (feet)
14-59-12bc. Sample log of test hole 88 in lines *A-A'* and *R-R'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,988 feet		
Loam, sandy	2	2
Soil, sandy, black; contains gravel and clay	7	9
(?)	7	16
Gravel, light to medium, and Brule formation	10	26
Brule clay and light to medium gravel	10	36
Brule clay or hardpan, and gravel	63	99
14-59-13bc. Sample log of test hole 87 in line *R-R'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 5,026 feet		
Loam, sandy	3	3
Gravel, fine to medium to coarse, and Brule formation or hardpan	10	13
Gravel, fine to medium to coarse; contains very little clay	7	20
Brule formation or hardpan, and fine to medium gravel	20	40
Brule formation or hardpan; contains some sand and gravel	10	50
Hardpan or Brule formation; contains a little light gravel	10	60
Brule formation or hardpan, and trace of sand	40	100
Brule formation or hardpan	9	109
15-53-32ca. Sample log of test hole 69 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,487 feet		
Silt, sandy, brown	5	5
Silt, sandy, light brownish-buff; many shell fragments and a few tiny gastropods; contains a little reworked Ogallala formation	6	11
Gravel, fine to coarse, pink; coarser and containing pebbles in lower part, some coarse sand in upper part	8	19
Sandstone, silty, noncalcareous, pinkish-tan (Ogallala formation)	16	35
Samples poor; probably silty sandstone, pinkish (Ogallala formation)	34	69
Siltstone, sandy, noncalcareous, gray to gray-buff	29	98
Siltstone, sandy, noncalcareous, gray-buff to buff (Ogallala formation)	13	111
Sandstone, silty, hard, very calcareous, grayish-white (Ogallala formation)	3	114
Sandstone, silty, indurated, slightly calcareous, gray to buff to pinkish (Ogallala formation)	5	119
15-54-27ad. Sample log of test hole 71 in lines *A-A'* and *L-L'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,513 feet		
Sand, fine to coarse, brownish-gray; silty at top	5	5
Sand, fine, to coarse gravel, poorly sorted, pink; contains a few pebbles in lower part	15	20
Sand, medium to coarse, pink, and a little fine sand and fine gravel; contains a few shell fragments; lost circulation at 24 to 26 feet	20	40
Sand, medium, and medium to coarse gravel, poorly sorted, pinkish-gray	10	50
Sand, medium to coarse, compact, pinkish-gray; contains a little fine to medium gravel in lower part	29	79
15-54-28cc. Sample log of test hole 72 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,559 feet		
Silt, sandy, dark brownish-gray	2	2
Silt, sandy, medium-gray	4	6
Gravel, fine to coarse, pink; contains some pebbles and medium to coarse sand; a little reworked Ogallala formation	6	12
Siltstone, sandy, noncalcareous, soft, pinkish-buff (Ogallala formation)	34	46
Siltstone, sandy, noncalcareous, pinkish-buff; contains some rootlet material in lower part (Ogallala formation)	34	80
Siltstone, sandy, very calcareous, hard, grayish-buff (Ogallala formation)	3	83
Sandstone, silty, noncalcareous, soft, pinkish-buff (Ogallala formation)	26	109

TABLE 9.—*Logs of test holes and wells*—Continued

Kimball County—Continued

	Thickness (feet)	Depth (feet)
15-54-35cb. Sample log of test hole 70 in line *L-L'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,582 feet		
Sand, silty, brownish-gray	5	5
Sand, silty, calcareous, brownish-buff	5	10
Gravel, medium to coarse, pink; contains abundant pebbles and many reworked Ogallala pebbles	3	13
Sandstone, silty, pinkish-tan; some interbedded gray siltstone; considerable gravel caving from above (Ogallala formation)	34	47
Siltstone, gray to buff to pinkish; a little rootlet material at 67 to 77 feet (Ogallala formation)	40	87
Siltstone, sandy, pinkish-tan (Ogallala formation)	22	109
15-55-22dc. Driller's log of irrigation well		
Topsoil, sandy	5	5
Clay	7	12
Sand and gravel	13	25
Gravel, coarse	22	47
Clay	30	77
15-55-25bb. Sample log of test hole 73 in lines *A-A'* and *M-M'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,596 feet		
Clay, silty, sandy, dark-gray in upper part and light-gray in lower part	8	8
Sand, medium to coarse, gray; and gravel, fine to medium, pink	12	20
Siltstone, calcareous, indurated, light-gray (Ogallala formation)	1	21
Sandstone, silty, pinkish-gray (Ogallala formation)	14	35
Siltstone to claystone, calcareous, indurated, light-gray (Ogallala formation)	2	37
Sandstone, silty, pinkish-gray (Ogallala formation)	3	40
Siltstone, calcareous, indurated, light-gray (Ogallala formation)	2	42
Sandstone, silty, pinkish-gray (Ogallala formation)	8	50
Siltstone, calcareous, indurated, light-gray; contains some interbedded sandstone (Ogallala formation)	12	62
Sandstone, silty, pinkish-gray; contains some pink clay (Ogallala formation)	7	69
Siltstone, calcareous, indurated, light-gray; contains some interbedded sandstone (Ogallala formation)	7	76
Sandstone, silty, pinkish-gray and light-gray; contains some pink clay (Ogallala formation)	10	86
Siltstone, calcareous, indurated, light-gray (Ogallala formation)	6	92
Sandstone, silty, pinkish-gray (Ogallala formation)	7	99
15-55-25cc. Sample log of test hole 74 in line *M-M'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,622 feet		
Sand, silty, dark-brown to gray	1	1
Clay, silty, gray	8	9
Gravel, fine to medium-coarse, pink; some sand	20	29
Sand, coarse, and fine to medium-coarse gravel; pink	8	37
Gravel, fine to medium-coarse, pink	3	40
Sand, coarse, and fine, angular gravel; pink; lost circulation between 39 and 49 feet	9	49
15-55-29db. Sample log of test hole 77 drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,694 feet		
Silt and sand, fine to coarse, brown to gray	14	14
Gravel, fine to coarse, pink (Ogallala pebbles)	24	38
Gravel, fine, angular, compact, pink (Ogallala formation?)	16	54
Siltstone and sandstone, micaceous, gray; contains some pink clay (Ogallala formation)	9	63
Siltstone, calcareous, sandy, hard, light-gray (Ogallala formation)	8	71
Sandstone, silty, pinkish-gray (Ogallala formation)	5	76
Siltstone, calcareous, sandy, hard, light-gray (Ogallala formation)	5	81
Sandstone, silty, light-gray and pinkish; some interbedded siltstone (Ogallala formation)	18	99
Sandstone, silty, light-gray and pinkish (Ogallala formation)	13	112
Siltstone and limestone, hard, light-gray to white (Ogallala formation)	1	113

TABLE 9.—*Logs of test holes and wells*—Continued

Kimball County—Continued

	Thickness (feet)	Depth (feet)
15-55-30aa. Sample log of test hole 79 in line *N-N'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,660 feet		
Sand, silty, dark-brown to gray	5	5
Silt, clayey and sandy, gray	13	18
Gravel, fine to medium-coarse, pink; and sand	17	35
Sandstone, silty, pinkish-gray (Ogallala formation)	14	49
Claystone to limestone, very hard, light-gray to white (Ogallala formation)	1	50
15-55-30ad. Sample log of test hole 78 in lines *A-A'* and *N-N'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,666 feet		
Silt and sand, dark-brown to gray	2	2
Gravel, fine to coarse, pink	12	14
Gravel, fine, angular, pink (Ogallala formation?)	24	38
Siltstone, calcareous, very hard, partly sandy, light-gray; some interbedded pinkish-gray, silty sandstone (Ogallala formation)	8	46
Sandstone, silty, pinkish-gray to buff (Ogallala formation)	3	49
Siltstone, chalky, calcareous, hard, white (Ogallala formation)	20	69
Sandstone, silty, pinkish-gray; some interbedded calcareous siltstone (Ogallala formation)	30	99
Sandstone, silty, pinkish-gray (Ogallala formation)	10	109
Clay, silty to very silty, medium light-gray to pinkish (Ogallala formation?)	10	119
15-55-30dd2. Driller's log of test hole at site of industrial well		
Topsoil and clay	13	13
Sand	26	39
Siltstone	9	48
Caliche	3	51
Sand and clay streaks	6	57
Clay, sandy, white	20	77
Caliche	2	79
Sand and clay	10	89
Sand, fine	2	91
Caliche	7	98
Sand, fine	1	99
Caliche	11	110
Sand, fine	29	139
Clay and caliche	12	151
Siltstone	20	171
Caliche	2	173
Clay, white	2	175
Sand, fine, loose	5	180
Sand, medium, and gravel	6	186
Clay, sandy, and siltstone	23	209
15-55-32cb. Sample log of test hole 76 in line *N-N'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,774 feet		
Clay, silty, and sand; dark-brown to gray	5	5
Sandstone, silty, pinkish-gray to buff (Ogallala formation)	24	29
Siltstone, calcareous, hard, sandy, medium light-gray (Ogallala formation)	5	34
Sandstone, silty, pinkish-gray (Ogallala formation)	15	49
Siltstone, calcareous, sandy, light-gray (Ogallala formation)	3	52
Gravel, fine, pink (Ogallala formation)	11	63
Sandstone, silty, pinkish-gray; gravel cave (Ogallala formation)	40	103
Siltstone, calcareous, hard, light-gray to pink (Ogallala formation)	6	109
15-55-33dc. Driller's log of irrigation well		
Topsoil	6	6
Sand, coarse, and clay	7	13
Siltstone, brittle	30	43
Sand, coarse, and clay	3	46
Chalk rock, brittle	2	48
Siltstone, soft, brittle	26	74
Sand, coarse, and clay	2	76
Sand rock	6	82
Sand and gravel	18	100
Clay, soft, brown	6	106
Sand, fine	6	112
Sand, coarse	42	154
Siltstone	6	160

TABLE 9.—*Logs of test holes and wells*—Continued

Kimball County—Continued

	Thickness (feet)	Depth (feet)
15-55-36cc. Sample log of test hole 75 in line *M-M'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,700 feet		
Silt, sandy, dark-brown to gray	11	11
Sandstone, silty, soft, buff (Ogallala formation)	13	24
Siltstone, calcareous, sandy, hard, light-gray (Ogallala formation)	1	25
Sandstone, silty, pinkish-gray (Ogallala formation)	6	31
Siltstone, calcareous, hard, sandy, light-gray (Ogallala formation)	2	33
Sandstone, silty, pinkish-gray (Ogallala formation)	23	56
Gravel, fine-grained, pink (Ogallala formation)	11	67
Sandstone, silty, pinkish-gray (Ogallala formation)	24	91
Siltstone, calcareous, hard, light-gray (Ogallala formation)	2	93
15-56-26cc. Sample log of test hole 80 in line *A-A'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,727 feet		
Clay, silty, sand, and gravel; dark-brown to gray	3	3
Gravel, fine to coarse, pink	20	23
Claystone, pink (Ogallala formation)	2	25
Sandstone, silty, partly calcareous, light-gray (Ogallala formation)	7	32
Siltstone to claystone, indurated, calcareous, light-gray to white (Ogallala formation)	3	35
Sandstone, silty, and calcareous siltstone; light-gray and pinkish-gray (Ogallala formation)	30	65
Sandstone, silty, pinkish-gray (Ogallala formation)	12	77
Claystone to limestone, hard, light-gray to white (Ogallala formation)	1	78
15-56-31bc. Sample log of test hole 81 in lines *A-A'* and *P-P'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,797 feet		
Silt, clayey, and sand; dark-brown to gray	2	2
Clay, silty, to clayey silt, gray	3	5
Gravel, medium to coarse (Ogallala pebbles)	11	16
Sandstone, silty, pinkish-gray; contains some pink clay (Ogallala formation)	2	18
Sandstone, silty, pinkish-gray; interbedded with light-gray, calcareous siltstone (Ogallala formation)	13	31
Sandstone, silty, pinkish-gray (Ogallala formation)	9	40
Sandstone, silty, pinkish-gray; interbedded with calcareous siltstone (Ogallala formation)	22	62
Claystone, pink; contains some silty sandstone (Ogallala formation?)	17	79
15-57-30dd. Sample log of test hole 84 in line *Q-Q'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,892 feet		
Silt, sand, and gravel; dark-brown to gray	6	6
Gravel, fine to coarse (Ogallala pebbles)	15	21
Sandstone, silty, pinkish-gray (Ogallala formation)	9	30
Siltstone, calcareous, indurated, light-gray (Ogallala formation)	1	31
Sandstone, silty, light-gray to pinkish; some interbedded calcareous, light-gray siltstone (Ogallala formation)	18	49
Sand, silty, pinkish-gray (Ogallala formation)	4	53
Siltstone, calcareous, indurated, light-gray (Ogallala formation)	1	54
15-57-31da. Sample log of test hole 83 in lines *A-A'* and *Q-Q'* drilled by Conservation and Survey Division of the University of Nebraska, 1942. Surface altitude, 4,847 feet		
Sand; contains a little loam	4	4
Sand, fine to medium, and gravel	5	9
Sand to fine to medium gravel; contains a little Brule formation and hardpan	9	18
Brule formation or hardpan, and fine to medium gravel	10	28
Brule formation or hardpan, and fine to medium gravel from above	9	37
Brule formation or hardpan, and gravel	6	43
Brule formation or hardpan, and a little light gravel	20	63
Brule formation or hardpan, and a little coarse sand	6	69
Brule formation or hardpan, and fine to medium gravel	10	79
Brule formation or hardpan, and medium gravel	10	89
Brule formation or hardpan, and a little coarse sand	10	99

TABLE 10.—*Water levels in observation wells*

Cheyenne County

Date	Water level	Date	Water level	Date	Water level
13-49-6aa					
Jan. 11, 1951	39.70	Nov. 19, 1951	39.72	May 29, 1952	38.09
Mar. 29	39.79	Jan. 23, 1952	39.76	July 15	40.39
May 22	40.43	Mar. 20	38.83		
13-50-3cb					
Jan. 10, 1951	47.73	Nov. 20, 1951	47.57	Mar. 20, 1952	46.53
Mar. 29	47.51	Dec. 11	47.33	May 23	46.29
May 22	48.87	Jan. 23, 1952	46.90	July 16	49.95
13-51-10aa					
Jan. 10, 1951	37.89	Nov. 20, 1951	37.60	May 23, 1952	36.55
Mar. 29	37.47	Jan. 16, 1952	37.30	July 16	40.40
May 22	38.46	Mar. 20	37.04		
14-47-26cb1					
July 28, 1940	20.28	June 20, 1947	18.41	Nov. 19, 1951	18.77
Nov. 9	20.82	June 22, 1950	19.51	Jan. 23, 1952	18.66
Oct. 25, 1941	20.16	Jan. 11, 1951	18.80	Mar. 18	18.64
Nov. 17, 1942	19.53	Mar. 28	18.32	May 29	18.39
Nov. 17, 1944	19.99	May 22	18.41	July 15	18.78
14-47-28cb					
Jan. 11, 1951	13.47	Nov. 6, 1951	12.82	Mar. 18, 1952	12.68
Mar. 29	13.53	Nov. 19	12.79	May 29	11.73
May 22	13.21	Jan. 23, 1952	13.03	July 15	12.91
14-47-31bb					
Jan. 12, 1951	5.57	Nov. 8, 1951	5.57	Mar. 18, 1952	5.39
Mar. 29	5.29	Nov. 19	5.67	May 29	5.09
May 22	5.47	Jan. 23, 1952	5.41	July 15	5.69
14-47-31bd					
Nov. 8, 1951	7.91	Jan. 23, 1952	8.06	May 29, 1952	7.10
Nov. 19	7.93	May 18	7.68	July 15	7.82
14-48-27cc					
Jan. 12, 1951	33.99	Nov. 19, 1951	34.97	Mar. 18, 1952	34.39
Mar. 29	33.77	Jan. 23, 1952	33.82	May 29	35.85
Nov. 14	35.05				
14-48-31dd					
Jan. 12, 1951	55.78	Nov. 15, 1951	57.80	May 29, 1952	56.95
Mar. 29	56.51	Jan. 23, 1952	56.72	July 15	57.05
May 22	56.43	Mar. 20	56.65		

TABLE 10.—*Water levels in observation wells*—Continued

Cheyenne County—Continued

Date	Water level	Date	Water level	Date	Water level
14-49-25cd					
Nov. 15, 1951	15.80	Mar. 20, 1952	15.17	July 15, 1952	15.77
Jan. 24, 1952	15.40	May 29	14.57		
14-49-34bb					
Jan. 12, 1951	25.12	Nov. 19, 1951	25.11	May 29, 1952	24.90
Mar. 29	25.07	Jan. 23, 1952	25.15	July 15	25.07
May 22	25.11	Mar. 20	25.15		
14-50-27cc					
Jan. 12, 1951	15.07	Nov. 19, 1951	15.46	May 23, 1952	13.87
Mar. 29	15.07	Jan. 23, 1952	14.76	July 16	15.25
May 22	14.98	Mar. 20	14.89		
14-50-35ac					
Jan. 12, 1951	35.08	Nov. 19, 1951	31.25	May 23, 1952	29.25
Mar. 29	30.07	Jan. 23, 1952	30.14	July 16	31.52
May 22	30.46	Mar. 20	29.61		
14-51-13bb					
Jan. 12, 1951	26.53	Nov. 20, 1951	25.62	May 23, 1952	24.58
Mar. 29	26.45	Jan. 23, 1952	25.98	July 16	25.92
May 22	26.59	Mar. 20	25.07		
14-52-5cb					
Sept. 4, 1934	27.78	Apr. 1, 1936	27.61	Apr. 6, 1940	28.17
Nov. 19	27.89	June 9	27.62	July 28	29.27
Jan. 10, 1935	27.80	Aug. 8	27.87	Nov. 9	28.28
Mar. 5	27.85	Aug. 29	27.77	June 22, 1950	29.89
Apr. 27	27.85	Dec. 3	27.76	Jan. 12, 1951	28.97
June 15	26.64	Apr. 7, 1937	27.91	Mar. 29	29.17
Aug. 20	27.29	June 24	28.74	May 22	29.46
Sept. 19	27.27	Aug. 12	28.60	Nov. 20	28.92
Oct. 26	27.35	Oct. 19	28.13	Jan. 24, 1952	29.01
Nov. 29	27.45	June 27, 1938	28.04	Mar. 26	29.07
Jan. 2, 1936	27.45	Oct. 27	27.82	July 16	31.03
Jan. 22	27 48	Dec. 6, 1939	28.10		
14-52-8bb					
Jan. 12, 1951	50.40	Nov. 20, 1951	50.21	Mar. 26, 1952	50.34
Mar. 28	50.24	Jan. 24, 1952	50.14	May 23	50.37
14-52-11ac					
Jan. 12, 1951	28.64	May 22, 1951	26.80	Jan. 24, 1952	27.26
Mar. 29	27.37	Nov. 20	28.60	July 16	25.72

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TABLE 10.—*Water levels in observation wells*—Continued

Deuel County

Date	Water level	Date	Water level	Date	Water level
13-45-23cb1					
Jan. 11, 1951	12.90	May 22, 1951	11.97	Jan. 23, 1952	12.41
Mar. 29	12.18	Nov. 19	11.84	Mar. 18	12.19
14-46-33dc2					
Jan. 11, 1951	14.01	Oct. 18, 1951	13.67	Mar. 18, 1952	13.20
Mar. 29	14.14	Nov. 19	13.46	May 29	13.02
May 22	13.41	Jan. 23, 1952	13.65	July 15	13.81

Kimball County

Date	Water level	Date	Water level	Date	Water level
14-58-18bc					
Mar. 29, 1951	66.81	Jan. 24, 1952	66.72	May 22, 1952	66.49
May 23	66.27	Mar. 25	66.66	July 17	66.78
Nov. 21	66.53				
14-59-1bb					
Jan. 12. 1951	81.67	Nov. 21, 1951	81.38	Mar. 25, 1952	81.48
Mar. 29	81.75	Jan. 24, 1952	81.55	May 22	81.40
May 23	81.41				
14-59-11dd					
Jan. 12, 1951	22.28	Nov. 21, 1951	22.03	May 22, 1952	21.69
Mar. 29	22.26	Jan. 24, 1952	22.16	July 17	22.69
May 23	21.99	Mar. 25	21.95		
15-53-31bb					
Jan. 12, 1951	46.26	Nov. 20, 1951	45.83	Mar. 26, 1952	44.75
Mar. 29	46.92	Jan. 24, 1952	45.25	May 23	45.01
May 23	46.71	Feb. 19	45.38	July 16	47.36
15-53-34cb					
Nov. 20, 1951	63.33	Mar. 26, 1952	63.97	July 16, 1952	63.77
Jan. 24, 1952	63.78	May 23	63.74		
15-54-26cb					
Jan. 12, 1951	24.95	Nov. 20, 1951	24.20	Mar. 26, 1952	22.49
Mar. 29	24.52	Jan. 24, 1952	23.64	May 23	23.64
May 23	25.35				
15-54-28bc					
Jan. 12, 1951	16.12	Nov. 20, 1951	18.48	Mar. 26, 1952	18.92
Mar. 29	18.47	Jan. 24, 1952	18.38	May 23	17.65
May 23	18.16				

TABLE 10.—*Water levels in observation wells*—Continued

Kimball County—Continued

Date	Water level	Date	Water level	Date	Water level
15-54-30dc					
Jan. 12, 1951	58.65	Dec. 10, 1951	57.03	Mar. 26, 1952	57.48
Mar. 29	58.80	Jan. 24, 1952	56.54	May 23	57.81
May 23	58.92				
15-55-17cc					
Jan. 10, 1935	92.54	Aug. 8, 1936	92.03	July 28, 1940	93.42
Mar. 5	92.81	Aug. 29	92.01	Nov. 9	94.36
Apr. 27	92.69	Dec. 3	92.82	Oct. 25, 1941	94.97
June 15	91.75	Apr. 7, 1937	93.12	Nov. 17, 1942	95.49
July 18	91.82	June 24	93.05	June 22, 1950	96.11
Aug. 20	91.82	Aug. 12	93.07	Mar. 29, 1951	95.86
Sept. 19	91.84	Oct. 19	93.34	May 23	95.71
Oct. 26	91.80	June 27, 1938	93.45	Nov. 21	95.65
Nov. 29	91.86	Oct. 27	93.69	Jan. 24, 1952	95.41
Jan. 2, 1936	91.58	June 13, 1939	93.79	Mar. 26	95.74
Jan. 22	91.68	Dec. 6	94.12	May 22	95.73
Mar. 31	91.85	Apr. 6, 1940	94.03	July 16	95.78
June 9	92.14				
15-55-26cc					
Jan. 2, 1936	40.47	Dec. 5, 1936	40.66	May 23, 1951	43.24
Jan. 22	40.69	Apr. 7, 1937	41.55	Nov. 20	41.39
Apr. 1	41.17	Oct. 19	41.30	Jan. 24, 1952	41.57
June 9	41.04	Jan. 12, 1951	42.71	Mar. 26	41.91
Aug. 8	41.33	Mar. 29	42.78	May 22	42.05
Aug. 29	41.38				
15-55-29db1					
Nov. 27, 1951	46.09	Mar. 26, 1952	46.67	July 16, 1952	47.16
Jan. 24, 1952	46.20	May 22	47.03		
15-56-25cb					
Jan. 12, 1951	20.82	Nov. 20, 1951	20.71	Mar. 26, 1952	20.55
Mar. 29	20.85	Jan. 24, 1952	20.44	May 22	23.23
May 23	20.83				
15-56-29ca					
Jan. 12, 1951	74.38	Nov. 20, 1951	72.35	May 22, 1952	73.02
Mar. 29	73.69	Jan. 24, 1952	72.44	July 17	73.24
May 23	73.56	Mar. 25	72.76		
15-56-32ac					
Jan. 12, 1951	20.89	Nov. 20, 1951	19.44	Mar. 25, 1952	20.36
Mar. 29	21.04	Jan. 24, 1952	20.10	May 22	19.96
May 23	20.87				
15-57-33ab					
Nov. 29, 1935	22.47	Apr. 7, 1937	22.30	Jan. 24, 1952	22.00
Jan. 2, 1936	22.41	Mar. 29, 1951	22.72	Mar. 25	21.85
Jan. 22	22.40	May 23	22.62	May 22	21.89
Mar. 31	22.15	Nov. 20	22.11	July 17	22.49
Dec. 3	22.64				
15-57-35bb					
Jan. 12, 1951	29.07	Nov. 20, 1951	29.50	May 22, 1952	24.52
Mar. 29	27.57	Jan. 24, 1952	27.50	July 17	29.97
May 23	26.69	Mar. 25	25.47		

TABLE 11.—*Record of wells*

Well number: See text for description of well-numbering system.
Type of well: Dn, driven well; Dr, drilled well; Du, dug well.
Depth of well: Measured depths are given in feet and tenths below measuring point; reported depths are given in feet below land surface.
Type of casing: C, concrete; P, metal pipe; N, none.
Character of material: G, gravel; S, sand; Sls, siltstone.
Geologic source: Qa, alluvium; Tb, Brule formation; To, Ogallala formation.
Type of pump: C, centrifugal; Cy, cylinder; T, turbine; N, none.
Type of power: B, butane engine; D, diesel engine; E, electric motor; G, gasoline engine; T, tractor; W, windmill; N, none.
Use of water: D, domestic; I, irrigation; In, industrial; O, observation; P, public supply; S, stock.

Measuring point: Bpb, bottom of pump base; Fs, floor surface; Hpb, hole in pump base; Idp, invert of discharge pipe; Ls, land surface; Tca, top of casing; Tce, top of casing, east well; Tpb, top of pump base; Tpc, top of pit curb; Tpp, top of pump platform; Tvp, top of vent pipe; Twc, top of well cover; Wlg, water-level gage.
Depth to water: Measured depths are given in feet, tenths, and hundredths; reported depths are given in feet.
Yield: M, measured; R, reported.
Remarks: Bw3, battery of 3 wells (or the number indicated); Ca, sample collected for chemical analyses; EoTb, ends on Brule formation; L, log at site of well is given in table 9; Pw, pit well; S, sprinkling system; Sw, supplementary water; Tb30, Brule formation at 30 feet (or the depth indicated); U, unused (number indicates time in years)

Well No.	Owner or tenant	Year drilled (19__)	Type of well	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Type of pump	Type of power	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below (−) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement	Yield (gallons per minute)	Drawdown (feet)	Acres irrigated	Remarks
										Cheyenne County										
12-49- 3ab	E. Meyer	---	Dr	187.0	6	P	S,G	To	Cy	W	S	Tca	+1.0	4,287.8	171.88	5- 1-52	-------	---	---	
50- 6ab	Charles Deaver	---	Dr	126.0	6	P	S,G	To	Cy	W	D	Tca	+ .5	4,385.4	89.27	5- 1-52	-------	---	---	Ca
51- 6aa	Charles Cady	36	Dr	350	6	P	Sls,S,G	To,Tb	Cy	W	D,S	Tca	0	4,475.9	83.83	5- 7-52	-------	---	---	
53- 1bb	E. H. Killham	39	Dr	235	24	P	Sls	Tb	T	G	I	Tvp	+1.5	4,474.5	61.62	1-22-52	1,000R	---	100	Tb17
2bc	James Vacik	39	Dr	101	24	P	Sls	Tb	T	G	I	Ls	------	4,504.6	38	-------	1,320M	---	75	Tb17,Ca
22aa	Not known	---	Dr	248.5	6	P	S,G	To	Cy	N	D,S	Tca	+ .5	4,685.5	227.30	5- 7-52	-------	---	---	U
13-46- 5bc	I. R. Goertzen	48	Dr	45	18	P	Sls,S,G	Tb,Qa	C	T	I	Tca	−5.0	3,829.1	7.35	10-24-51	840R	---	60	Bw3,Tb26
6ab	Harold From	48	Dr	90	18	P	Sls,S,G	Tb,Qa	T	B	I	Hpb	+ .2	3,829.3	12.62	10-24-51	500R	12	60	S
8bb	Arthur Bruns	25	Dr	19.5	16	P	S,G	Qa	C	T	I	Tce	+2.5	3,851.6	5.38	10-25-51	800R	---	23	Bw3
17cb	Frank Vosika	---	Dr	74.5	8	P	S,G	To	Cy	W	S	Hpb	+1.0	3,920.7	47.83	10-25-51	-------	---	---	
20cb	E. R. Stewart	05	Dr	197.0	6	P	S,G	To	Cy	W	D,S	Hpb	+ .7	4,053.1	180.32	10-25-51	-------	---	---	
47- 5cd	Joseph Zimola	---	Dr	183.5	6	P	S,G	To	Cy	W	D,S	Tca	+1.0	4,107.9	165.10	11- 7-51	-------	---	---	
17ab	Charles Oliverius	46	Dr	110	24-18	P	S,G	To	T	T	I	Tca	+1.0	4,020.5	68.62	11- 7-51	750R	14	50	L
48- 7aa	Mrs. E. L. Grabell	10	Dr	153.0	6	P	S,G	To	Cy	W	D,S	Tca	+ .7	4,173.7	150.73	11-28-51	-------	---	---	
36dd	James Houser, Sr.	---	Dr	178.0	6	P	S,G	To	Cy	W	D,S	Tca	+ .2	4,135.0	143.87	5- 1-52	-------	---	---	
49- 6aa	City of Sidney	49	Dr	100	18	P	Sls	Tb	T	T	P,O	Hpb	+2.0	4,104.7	41.72	11-19-51	-------	---	---	
6da	J. J. Treinen	51	Dr	165	18	P	Sls	Tb	T	E	I	Ls	------	4,135.3	72	-------	125R	28	2	S
8cb	S. C. Jensen	05	Dr	165.0	4	P	S,G	To	Cy	W	D,S	Twc	+1.0	4,296.8	117.20	4-15-52	-------	---	---	

18ba	City of Sidney	22	Dr	125.0	8	P	S,G	To	Cy	E	D	Twc	+1.0	4,292.3	91.67	4-15-52	4R	29		
50- 1ba	O. Albin Olson	49	Dr	90	18	P	Sls	Tb	T	G	I	Bpb	+1.0	4,114.7	13.25	11-30-51	800R	42	60	Tb22
1bc	Anna Olson	38	Dr	80	24	P	Sls	Tb	T	G	I	Bpb	0	4,137.1	35.51	12- 3-51	1,200R	20	60	L
2bc	J. Bright	39	Dr	80	18	P	Sls	Tb	T	D	I	Tca	+2.5	4,148.3	43.86	12-10-51			140	
2cb	P. Olson	42	Dr	95.5	18	P	Sls	Tb	T	G	I	Hpb	+0.5		52.52	12-12-51	1,300R	15	85	L
2db	do	42	Dr	93.8	18	P	Sls	Tb	T	G	I	Hpb	+1.0	4,138.2	34.59	12-12-51	1,400R	15	85	Tb30
3bb	Carl Olson	41	Dr	100	18	P	Sls	Tb	T	G	I	Ls		4,145.7	40		1,200R		65	L
3ca	do	40	Dr	100	18	P	Sls	Tb	T	G	I	Hpb	0		33.34	12-11-51	1,250R		100	L
3cb	do	43	Dr	100	18	P	Sls	Tb	T	G	I,O	Hpb	+1.0	4,160.3	48.33	12-11-51	1,100M		100	Tb35
3cc	do	44	Dr	99.0	18	P	Sls	Tb	T	G	I	Hpb	+1.0	4,163.5	52.63	12-11-51	800R		40	Tb35
3cd	do	45	Dr	100	18	P	Sls	Tb	T	G	I	Hpb	+1.0	4,165.5	55.98	12-12-51	1,150R		115	Tb35
3db	do	45	Dr	88.0	18	P	Sls	Tb	T	G	I	Hpb	+ .5		47.85	12-11-51	1,100R		80	Tb35
4ab	Everett Mohatt	41	Dr	90	30	P	Sls	Tb	T	E	I	Hpb	+ .3	4,151.0	35.66	12-12-51	1,200R	3	60	L
5aa	Charles Krueger	50	Dr	83.5	20	N	Sls	Tb	N	N	I	Ls		4,173.9	54.10	12-13-51	900R			Tb32,U1
5db	do	45	Dr	92	24	P	Sls	Tb	T	G	I	Hpb	+1.0	4,166.0	31.92	12-13-51	1,100R	18	100	Tb32
7bc	Oley Atkins	41	Dr	79.5	24	P	Sls	Tb	T	G	I	Hpb	+ .7	4,195.9	26.51	12-13-51	1,200R		120	
7cb	John Owens	38	Dr	90	24	P	Sls	Tb	T	E	I	Bpb	+1.3	4,201.2	31.57	12-13-51	800R	40	30	Tb30
27bb	Bert Walker	10	Dr	107.0	6	P	S,G	To	Cy	W	D,S	Bpb	+1.0	4,355.7	85.50	4-30-52				
51- 3db	A. M. Anderson	35	Dr	131.5	20	P	Sls	Tb	N	N	I	Tca	+1.0	4,263.8	49.94	1-18-52	600R	70		U5
10aa	Sam Chambers	44	Dr	95	22	P	Sls	Tb	T	G	I,O	Hpb	+1.3	4,252.4	38.60	1-16-52	700R	25	80	Tb12
10ab	Roy Anderson	39	Dr	95	20	P	Sls	Tb	T	G	I	Hpb	+1.0	4,256.0	39.65	1-17-52	1,100R	16	90	
10cd	Sam Chambers	41	Dr	90	20	P	Sls	Tb	T	G	I	Hpb	+1.0	4,250.4	42.20	1-17-52	1,125R	25	160	L
11ab	George Baird	41	Dr	100	24	P	Sls	Tb	T	E	I	Bpb	+ .2	4,228.0	34.30	12-18-51	1,300R	9	100	L
11ac	do	47	Dr	84	20	P	Sls	Tb	T	G	I	Bpb	+1.0		34.35	12-18-51	800R	25	75	Tb20
11ba1	N. W. Ladegard	41	Dr	100	18	P	Sls	Tb	T	E	I	Hpb	+1.0	4,243.1	37.57	12-19-51	500R	40	35	Tb25
11ba2	do	46	Dr	90	18	P	Sls	Tb	T	G	I	Hpb	+1.0		37.13	1-16-52	1,500R	2	125	L
12ac	George Baird	43	Dr	100	20	P	Sls	Tb	T	D	I	Hpb	+1.0	4,211.5	36.74	12-19-51	1,000R	20	75	Tb20
12bc	Guy Shaw	42	Dr	100	20	P	Sls	Tb	T	G	I	Ls		4,220.9	35		300R	40		U3
12ca	do	45	Dr	80	20	P	Sls	Tb	T	G	I	Ls		4,208.7	35		1,000R	20	70	Tb20
15bb	A. McMillen	39	Dr	80	20	P	Sls	Tb	T	E	I	Hpb	+1.0	4,259.3	40.62	1-17-52	1,500R	3	85	L
16aa	Warren Cunningham	44	Dr	90	18	P	Sls	Tb	T	G	I	Bpb	0	4,258.4	40.11	1-18-52	750R		50	
16dd	do	44	Dr	90	18	P	Sls	Tb	T	E	I	Hpb	+ .4	4,286.1	65.34	1-17-52	960R	4	100	
20cc	Ladegard and Anderson.	45	Dr	100	18	P	Sls	Tb	T	E	I	Hpb	+1.0	4,298.6	26.35	1-17-52	1,200R	3	130	Bw3
52-31dc	Leo O. Olsen	40	Dr	93.0	20	P	Sls	Tb	T	G	I	Hpb	+1.5	4,470.0	63.12	1-22-52	1,200R	20	40	L
36ac	C. L. Walters	46	Dr	100	24	P	Sls	Tb	T	D	I	Hpb	+1.3	4,345.5	47.49	1-22-52	750R	40	25	Bw3
36bb	do	45	Dr	100	24	P	Sls	Tb	T	G	I	Hpb	+ .7	4,343.6	33.45	1-22-52	900R	20	35	Bw5
53-14aa	Warren Nelson	36	Dr	250.0	6	P	S,G	To	Cy	W	D,S	Hpb	+ .3	4,637.4	233.60	5- 7-52				
14-46-20cd	H. C. Quinn	50	Dr	204.0	6	P	S,G	To	Cy	W	S	Tca	+ .7	4,023.8	190.60	10-25-51				
30cd	Village of Lodgepole	45	Dr	50	18	P	S,G	Qa	T	E	P	Ls			9		160R	5		EoTb
31ad	Irving Oberfelder	42	Dr	60.5	36	P	S,G	Qa	T	T	I	Tca	0	3,817.7	3.09	10-24-51			20	
31ba	Village of Lodgepole		Dr	35	18	P	S,G	Qa	T	E	P	Tca	+3.0	3,831.1	10.16	10-25-51	350R	8		EoTb,Ca
31bd	do	32	Dr	20	36	P	S,G	Qa	T	E	P	Tpp	+1.0	3,826.3	7.34	10-25-51	300R	8		EoTb
31ca	Ross Glassburn		Dr	14.5	24	P	S,G	Qa	T	G	I	Tca	0	3,823.7	5.03	10-25-51				U4
32ad	Mrs. Nellie Melton		Dr	27.5	8	P	S,G	Qa	Cy	W	S	Tca	+1.5	3,812.9	18.06	10-24-51				
47-21bc	J. A. Talich		Dr	175.0	6	P	S,G	To	Cy	W	D,S	Tca	0	4,045.1	170.65	11- 7-51				
25da	Fred F. Lehmkuhl		Dr	8.5	8	P	S,G	Qa	Cy	W	S	Tca	0	3,841.4	2.21	11- 7-51				
26cb1	University of Nebraska	40	Dn	29.0	1	P	S,G	Qa	N	N	O	Tca	+1.2	3,874.0	19.86	1-23-52				
26cb2	Bernard Dailey		Dr	72.5	24	P	Sls,S,G	Tb,Qa	T	T	I	Bpb	+ .5	3,868.9	13.84	10-31-51	800R	50	50	Tb22
26db	Ernest Wickard	39	Dr	90.3	20	P	Sls,S,G	Tb,Qa	T	T	I	Tca	+ .8	3,860.7	14.45	11- 6-51	1,200R	16	43	Tb22,S
27cb	Fred F. Lehmkuhl	41	Dr	80	24	P	Sls,S,G	Tb,Qa	T	T	I	Bpb	+ .2	3,873.7	6.24	11- 1-51			29	Tb25,U3
27cc	do	43	Dr	70	24	P	Sls,S,G	Tb,Qa	N	N	I	Tca	+1.5		11.05	11- 2-51				U9
27cd	do	43	Dr	71.8	24	P	Sls,S,G	Tb,Qa	T	T	I	Tca	+1.5	3,872.2	9.11	11- 2-51			60	Tb25,U3

TABLE 11.—*Record of wells*—Continued

Well No.	Owner or tenant	Year drilled (19..)	Type of well	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Type of pump	Type of power	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below (−) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement	Yield (gallons per minute)	Drawdown (feet)	Acres irrigated	Remarks
Cheyenne County—Continued																				
14-47-27da	Fred F. Lehmkuhl	42	Dr	80	24	P	Sls,S,G	Tb,Qa	T	G	I	Tca	0	3,873.9	14.39	11- 1-51	----	----	40	Tb25,U3
28cb	L. C. Barstow	42	Dr	80.5	18	P	Sls,S,G	Tb,Qa	T	E	I,O	Hpb	+1.0	3,898.0	13.82	11- 6-51	500R	50	40	Tb40
30cb	Firth Booth	38	Dr	90	30	P	Sls,S,G	Tb,Qa	T	E	I	Tca	0	3,920.3	5.75	11- 7-51	820R	12	55	Tb30
31bb	Emil Englert	40	Dr	85	30	P	Sls,S,G	Tb,Qa	T	E	I,O	Hpb	+1.0	3,921.0	6.57	11- 8-51	1,200R	40	28	
31bd	A. A. Fenske	44	Dr	73.5	30	P	Sls,S,G	Tb,Qa	T	E	I,O	Tca	+1.5	----	9.41	11- 8-51	960R	35	40	Tb25
34ac	Fred F. Lehmkuhl	42	Dr	80	24	P	Sls,S,G	Tb,Qa	T	T	I	Ls	----	----	18	----	1,200R	13	120	Tb25,U3
34cb	A. A. Fenske	45	Dr	100	30	P	Sls,S,G	Tb,Qa	T	E	I	Tca	+1.0	----	30.84	11- 2-51	----	----	40	Tb32,Bw5
34db	do	45	Dr	70.5	30	P	Sls,S,G	Tb,Qa	N	N	I	Tca	0	3,877.3	18.48	11- 2-51	----	----	120	Tb32,U7
35ab	Arthur Disney	50	Dr	80.3	30	P	Sls,S,G	Tb,Qa	T	T	I	Hpb	+.3	3,855.2	7.65	11- 1-51	1,700R	21	80	Tb26
35bc	J. R. Crabb	41	Dr	71.5	18	P	Sls,S,G	Tb,Qa	T	G	I	Hpb	+.5	3,865.5	12.64	10-31-51	900R	----	70	
35bd	Clayton Lindley	38	Dr	120	18	P	Sls,S,G	Tb,Qa	T	T	I	Ls	----	3,863.6	12	----	1,000R	30	70	
48- 2cc	Forrest Planck	----	Dr	153.0	6	P	S,G	To	N	N	D,S	Tca	+.5	4,152.5	119.96	11- 9-51	----	----	----	U
14bc	Joel Frerichs	----	Dr	156.0	8	P	S,G	To	Cy	W	D,S	Tpc	0	4,139.1	126.20	11-14-51	----	----	----	
17bc	Oscar Schlaman	16	Dr	170	4	P	S,G	To	Cy	W	D,S	Tca	+1.5	4,165.9	131.83	5- 1-52	3R	15	----	
18da	Albert Runion	20	Dr	151.0	6	P	S,G	To	Cy	W	D,S	Tpc	+.4	4,144.7	145.49	11-28-51	----	----	----	
25ba	Loomis Booth	39	Dr	90.5	22	P	Sls,S,G	Tb,Qa	T	G	I	Tca	+.5	3,972.9	52.52	11- 8-51	----	----	120	
25cc	Ben Vacik	35	Dr	92.0	36	P	Sls,S,G	Tb,Qa	T	T	I	Tca	+1.0	3,938.0	16.34	11- 9-51	1,100R	20	120	Tb26,Sw
25db1	Clinton Gade	40	Dr	81.0	24	P	Sls,S,G	Tb,Qa	N	N	I	Tca	+1.2	----	11.17	11- 8-51	----	----	----	U
25db2	do	46	Dr	56.0	30	P	Sls,S,G	Tb,Qa	T	T	I	Bpb	+1.0	3,934.8	15.97	11- 8-51	2,000R	5	75	
25dc	do	41	Dr	78.8	30	P	Sls,S,G	Tb,Qa	T	T	I	Tca	0	3,930.1	9.26	11- 8-51	----	----	25	
26cc	L. C. Barstow	40	Dr	100	30	P	Sls,S,G	Tb,Qa	T	E	I	Fs	+2.5	3,952.3	22.36	11-14-51	1,200R	40	100	Tb40,Bw2
26db	do	42	Dr	85.5	24	P	Sls,S,G	Tb,Qa	T	E	I	Tca	+.5	3,951.0	26.49	11- 9-51	600R	50	70	Tb42
27cc	Frank Portrey	----	Dr	110	18	P	Sls,S,G	Tb,Qa	T	E	I,O	Fs	+3.7	3,969.0	38.75	11-14-51	1,000R	----	114	L
27dc	Earl LaGrange	46	Dr	93	30-24	P	Sls,S,G	Tb,Qa	T	E	I	Hpb	+.5	----	31.30	11-14-51	1,100R	3	40	L
27dd	do	31	Dr	92.5	36	P	Sls	Tb	T	E	I	Tca	+2.5	----	28.93	11-14-51	800R	8	40	Tb30
28dc	W. F. Krueger	49	Dr	104	18	P	Sls,S,G	Tb,Qa	T	T	I	Hpb	+3.0	----	29.18	11-15-51	750R	40	40	Tb40,Sw
29bc	Earl Krueger	46	Dr	100	12	P	Sls,S,G	Tb,Qa	T	E	I	Hpb	+2.0	4,014.0	30.72	11-15-51	1,000R	20	50	Tb40
30cc	George Kavanaugh	43	Dr	55	30	P	S,G	Qa	T	G	I	Ls	----	4,007.1	4	----	1,200R	----	60	
31db	George Schnell	47	Dr	110	30	P	S,G	Qa,To	T	E	I	Hpb	+2.0	4,026.6	33.37	11-15-51	1,000R	58	40	EoTb
31dd	do	47	Dr	105.8	30	P	S,G	Qa,To	T	E	I,O	Hpb	+1.0	4,048.4	58.80	11-15-51	700R	50	40	EoTb
34ac	J. B. Bauer	40	Dr	100	18	P	Sls	Tb	T	E	I	Hpb	+2.0	3,967.0	38.07	11-14-51	2,200R	----	220	

34bb	Ronald Krueger	40	Dr	97.8	36	P	Sls	Tb	T	T	I	Bpb	+1.0	3,971.6	40.07	11-14-51	600R	----	30	Tb32
36bb	Grace Schultie	41	Dr	85	30	P	Sls,S,G	Tb,Qa	T	E	I	Hpb	+1.0	3,938.3	18.40	11- 8-51	1,400R	18	75	Tb30
49- 6aa	Guy Ferry	---	Dr	167.5	6	P	S,G	To	Cy	W	D,S	Tca	+ .5	4,289.8	146.67	4-29-52	--------	----	----	
21cb	M. V. Rapp	---	Dr	357	6	P	S,G	To	Cy	W	D,S	Tca	+1.0	4,237.4	146.98	4-29-52	--------	----	----	Ca
25cd	George Schnell	42	Dr	90	36	P	Sls,S,G	Tb,Qa	T	E	I,O	Hpb	+3.5	4,027.6	19.30	11-15-51	1,200R	38	60	Tb40
29cc	Bert Steel estate	38	Dr	125	18	P	Sls,S,G	Tb,Qa	T	E	I	Ls	------	--------	28	--------	700R	57	47	
31aa	City of Sidney	---	Dr	102	16	P	Sls	Tb	T	E	P	Hpb	+1.0	4,089.1	28.35	12- 4-51	1,000R	3	----	Ca
31ad	do	43	Dr	86	18	P	Sls	Tb	T	E	P	Hpb	+1.0	--------	27.19	12- 4-51	1,200R	4	----	
31ba	do	36	Dr	86	32	P	Sls	Tb	T	E	P	Tvp	+1.0	4,093.5	27.20	12- 4-51	1,050R	7	----	L
31cc	H. Van Aelstyn	48	Dr	78.2	24	P	Sls	Tb	T	T	I	Tca	+2.0	4,097.9	16.18	11-29-51	1,000R	19	20	
31da	City of Sidney	41	Dr	100	32.28	P	Sls	Tb	T	E	P	Hpb	+2.0	--------	20.29	12- 4-51	1,000R	12	----	Tb19
31dd1	C. B. Dorwart	43	Dr	80	24	P	Sls	Tb	T	E	I	Tca	+2.0	--------	27.66	2- 5-52	800R	----	40	
31dd2	do	40	Dr	80	24	P	Sls	Tb	T	E	I	Ls	------	--------	26	--------	400R	----	30	
32ab	City of Sidney	---	Dr	62.0	12	P	S,G	To	T	E	I	Tca	−16.0	4,069.7	11.58	12-11-51	--------	----	20	S
32cb	C. B. Dorwart	44	Dr	40	18	P	Sls	Tb	T	G	I	Hpb	+1.0	--------	19.29	2- 6-52	300R	----	7	
33cc	D. M. Boyd	46	Dr	85	20	P	Sls	Tb	T	E	I	Hpb	+ .5	4,068.6	14.88	11-29-51	1,000R	17	80	Tb32
33da	I. L. Pindell	46	Dr	100	18	P	Sls	Tb	T	G	I	Hpb	+1.0	4,055.8	14.98	11-28-51	850R	50	60	Tb25
34ad	J. B. Rutner	30	Dr	50	48	P	Sls,S,G	Tb,Qa	T	E	I	Tpp	+1.0	4,038.1	5.90	11-28-51	--------	----	25	
34bb	Harry Brewer	48	Dr	89.9	18	P	Sls	Tb	T	T	I,O	Hpb	+1.2	4,065.8	26.31	11-19-51	700R	----	4	Tb24
34cb	Bernard Beyer	44	Dr	100	20	P	Sls	Tb	T	D	I	Hpb	+1.0	4,055.6	14.48	11-28-51	850R	50	60	Tb25,Bw5
34db	do	48	Dr	100	20	P	Sls,S,G	Tb,Qa	T	T	I	Hpb	0	4,046.7	11.19	11-28-51	850R	50	100	Tb25,Bw5
35bb	John Peetz	48	Dr	99.5	20	P	Sls,S,G	Tb,Qa	T	T	I	Hpb	+1.0	4,041.7	12.94	11-27-51	1,400R	8	35	Tb30
36ca	George Schnell	47	Dr	68	24	P	S,G	Qa	T	E	I	Hpb	+1.0	--------	29.33	11-15-51	700R	18	40	EoTb
50-17cb1	B. E. Runge	37	Dr	150	18	P	Sls	Tb	T	E	I	Ls	------	--------	60	--------	1,500R	60	50	
17cb2	do	38	Dr	120	24	P	Sls	Tb	T	G	I	Ls	------	--------	70	--------	750R	60	30	
17cb3	do	49	Dr	126.5	20	P	Sls	Tb	N	N	I	Tca	+ .5	4,221.2	54.03	2- 1-52	750R	60	----	U3
18ba	U. S. Dept. of War	42	Dr	150	22	P	Sls	Tb	T	E	P,In	Wlg	+5.0	4,227.4	48	3-19-52	220R	28	----	Ca
18bc1	do	42	Dr	153	-----	P	Sls	Tb	T	E	P,In	Wlg	+5.0	4,217.5	46	3-19-52	500R	32	----	Ca
18bc2	do	42	Dr	153	19	P	Sls	Tb	T	E	P,In	Wlg	+5.0	4,211.8	40	3-19-52	750R	31	----	Ca
18da	Leon Fine	49	Dr	85.5	18	P	Sls,S,G	Tb,Qa	N	N	I	Tca	+ .5	4,226.9	49.58	2- 1-52	--------	----	----	U2
19cd	Mrs. M. Anderson	38	Dr	94.6	18	P	Sls	Tb	T	T	I	Tca	+2.0	4,220.2	54.14	2- 1-52	800R	----	----	U8,L
19db	John Schmitt	---	Dr	48.0	15	P	Sls,S,G	Tb,Qa	C	G	I	Tca	0	--------	7.01	1-25-52	300R	----	17	
19dc	do	41	Dr	100	18	P	Sls	Tb	T	G	I	Hpb	+1.0	4,209.5	43.02	1-25-52	1,000R	----	50	L
27cc	Henry Haupt	38	Dr	83.5	20	P	Sls,S,G	Tb,Qa	T	E	I,O	Tpb	+1.0	4,147.0	16.46	11-19-51	800R	50	100	
29ab	Martin Dimery	---	Dr	------	24	P	S,G	Qa	C	G	I	Tca	+1.0	4,164.2	3.80	1-25-52	--------	----	50	
34bb	N. W. Ladegard	42	Dr	100	18	P	Sls,S,G	Tb,Qa	T	E	I	Hpb	+1.0	4,140.6	10.12	12- 5-51	900R	10	47	Bw2
34cd	do	44	Dr	90	18	P	Sls	Tb	T	E	I	Hpb	+1.0	4,142.7	32.91	12- 5-51	1,200R	2	118	Tb25
34dc	do	50	Dr	96	18	P	Sls	Tb	T	E	I	Hpb	+1.5	--------	29.58	12- 5-51	1,200R	2	82	Tb25
35ab	Paul G. Hecker	41	Dr	80	20	P	Sls	Tb	T	D	I	Tca	0	--------	48.67	12- 3-51	600R	----	36	Tb48
35ac	Bert Steel estate	27	Dr	91.3	48-24	P	Sls,S,G	Tb,Qa	T	G	I,O	Tpp	+2.5	4,150.7	33.75	11-19-51	--------	----	40	
35ad	do	46	Dr	70	18	P	Sls,S,G	Tb,Qa	T	G	I	Hpb	+1.0	4,135.8	18.84	12- 5-51	--------	----	60	
35bb	Mrs. J. M. O'Connell	39	Dr	100	18	P	Sls	Tb	T	E	I	Hpb	+2.5	4,129.6	23.07	12-10-51	900R	17	48	
35cc	do	30	Dr	100	18	P	Sls	Tb	T	E	I	Bpb	+2.0	4,131.0	23.99	12- 7-51	1,200R	18	80	
35dc	Bert Steel estate	30	Dr	75.4	24	P	Sls	Tb	T	E	I	Tca	+1.0	4,122.9	20.02	12- 5-51	900R	16	60	
36ad	H. VanAelstyn	42	Dr	80	24	P	Sls	Tb	T	T	I	Ls	------	--------	15	--------	--------	----	25	
36bb	Bert Steel estate	43	Dr	------	-----	P	Sls	Tb	T	E	I	Hpb	+1.0	4,143.2	47.50	12- 5-51	--------	----	40	
36bc	O. Albin Olson	37	Dr	66	24	P	Sls	Tb	T	E	I	Hpb	+1.5	4,117.3	15.97	11-30-51	1,700R	2	125	Tb28
36bd	Cheyenne County	34	Du,Dr	85	48-24	P	Sls,S,G	Tb,Qa	T	E	I	Ls	------	--------	14	--------	600R	6	----	
36cb	Anna Olson	22	Du,Dr	54	144	C	Sls,S,G	Tb,Qa	T	E	I	Tpc	+ .5	--------	11.42	11-30-51	800R	18	50	Tb32
36cc	do	39	Dr	60	12	P	Sls,S,G	Tb,Qa	T	T	I	Tca	+1.0	4,111.9	9.56	11-30-51	800R	----	12	
36cd	O. Albin Olson	48	Dr	55	18	P	Sls,S,G	Tb,Qa	T	E	I	Tca	+1.0	4,111.7	10.12	11-30-51	1,600R	2	65	Tb22
51-11cc	C. H. Fuller	39	Dr	80	24	P	Sls	Tb	T	E	I	Tca	0	4,234.5	38.37	2- 6-52	--------	----	80	
12cb	G. H. Thompson	47	Dr	97.5	20	P	Sls	Tb	T	T	I	Hpb	+1.0	4,240.1	49.12	2-11-52	1,000R	----	35	

TABLE 11.—*Record of wells*—Continued

Well No.	Owner or tenant	Year drilled (19__)	Type of well	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Type of pump	Type of power	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below (−) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement	Yield (gallons per minute)	Drawdown (feet)	Acres irrigated	Remarks
Cheyenne County—Continued																				
14-51-13bb	G. H. Thompson	39	Dr	110	20	P	Sls	Tb	T	E	I,O	Tvp	+1.0	4,219.3	26.62	11-20-51	750R	----	40	L
52- 3bd	C. Herboldsheimer	43	Dr	102	18	P	S,G	To	T	E	I	Hpb	+ .5	4,381.9	48.22	2- 7-52	1,200R	10	100	
3cb	Francis Egging	43	Dr	60	18	P	S,G	To,Qa	T	E	I	Ls	------	4,360.0	15	--------	1,100R	----	120	
4aa	C. Herboldsheimer	42	Dr	100	18	P	S,G	To	T	E	I	Hpb	+1.5	4,384.2	50.23	2- 7-52	800R	25	50	
4bc	F. E. Willoughby	44	Dr	100	24	P	S,G	To	T	E	I	Hpb	+1.0	4,390.0	48.72	2- 8-52	850R	14	38	
4cb	Albert Nielsen	41	Dr	92	18	P	S,G	To	T	E	I	Bpb	+1.0	4,371.2	26.22	2- 7-52	1,100R	13	110	
4da	do	48	Dr	78	18	P	S,G	To	T	E	I	Tca	+2.5	4,356.0	17.59	2- 8-52	1,000R	9	70	
5bd	Town of Potter	38	Dr	97	24	P	S,G	To	T	E	P	Hpb	+2.0	-------	39.09	2- 8-52	360R	----	----	
5cb	Leonard J. Wheeler	28	Dr	55.1	18	P	S,G	To	T	E	I,O	Tpc	+ .7	-------	29.71	1-24-52	670M	15	18	
5cc	do	35	Dr	------	48	P	S,G	To	T	E	I	Hpb	+1.0	4,393.5	38.01	1-24-52	--------	----	65	
5db	Dean Hagemeister	38	Dr	90	20	P	S,G	To	T	E	I	Ls	------	-------	25	--------	1,500R	6	104	
6aa	Town of Potter	35	Dr	97	8	P	S,G	To	T	E	P	Hpb	+1.5	-------	59.42	2- 8-52	90R	----	----	Ca
6dd	Potter Rural Cemetery	45	Dr	110	8	P	S,G	To	T	E	I	Hpb	+ .5	4,393.6	37.62	2-12-52	90R	----	5	S
8bb	Lester Willoughby	48	Dr	75	20	P	S,G	To	T	E	I,O	Hpb	+1.0	4,406.7	51.21	11-20-51	--------	----	43	
10bd	Francis Egging	48	Dr	57	18	P	S,G	To,Qa	T	E	I	Tc	+2.0	-------	24.06	2- 7-52	1,200R	----	80	
11ac	Earl Johnson	49	Dr	42	18	P	S,G	To	T	G	I,O	Hpb	+1.0	4,342.4	29.60	11-20-51	800R	----	80	
19cd	G. D. Larson	48	Dr	142.0	18	P	S,G	To	N	N	I	Tca	+ .5	4,464.9	91.64	5- 7-52	1,200R	----	----	U3
53- 1cc	George A. Coulter	42	Dr	129	18	P	S,G	To	T	E	I	Hpb	+ .5	-------	94.45	2-12-52	1,000R	2	130	
1db	do	37	Dr	108	24	P	S,G	To	T	E	I	Bpb	+2.0	4,428.7	67.89	2-12-52	1,000R	5	100	
2bc	Howard Gunderson	40	Dr	130	18	P	S,G	To	T	E	I	Hpb	+1.0	4,475.9	106.53	2-14-52	800R	----	100	
2db	Harold Dana	35	Dr	162	18	P	S,G	To	T	E	I	Hpb	+1.0	4,463.4	96.72	2-14-52	1,000R	----	145	
15-48-30ac	Louis Miller	---	Dr	186.5	6	P	S,G	To	N	N	D,S	Tca	+ .5	4,175.0	164.74	5- 1-52	--------	----	----	U
49- 8bc	E. L. Myers	22	Dr	200.5	6	P	S,G	To	Cy	E	D,S	Tca	+ .5	4,259.8	188.50	4-29-52	--------	----	----	
50-34da	U. S. Dept. of War	48	Dr	300	12	P	S,G	To	N	N	P,I	------	------	-------			--------	----	----	Ca,U
35ac	do	42	Dr	310	12	P	S,G	To	T	G	In	Hpb	+1.5	4,332.7	176.74	3-19-52	200R	----	----	Ca
52- 7dc	Earl Anderson	50	Dr	352	18	P	S,G	To	T	D	I	Hpb	+1.0	4,563.1	214.86	2-12-52	900R	15	160	S
53-35dd	Cecil McKinney	50	Dr	73.7	18	P	S,G	To	T	E	I	Hpb	+1.0	4,420.3	58.71	2-14-52	700R	----	90	S
16-52-19dc	A. E. Jacobson	30	Dr	292.5	4	P	S,G	To	Cy	W	D,S	Tca	+ .5	4,625.0	283.98	5- 8-52	--------	----	----	
17-49-28dc	Mrs. Clara Clough	14	Dr	291.0	4	P	S,G	To	N	N	S	Tca	+ .5	4,259.6	287.15	4-29-52	--------	----	----	U

Deuel County

12-44- 7cb	Mrs. Marie Freeman	43	Dr	26	18	P	S,G	Qa	C	E	I	Tpc	+1.0	3,597.8	13.06	1-30-52	1,100R	----	45	Bw3, L
18bb	Paul Nass	48	Dr	92	18	P	S,G	Qa	T	E	I	Tca	0	3,590.7	11.34	1-31-52	1,200R	----	15	Tb30,Ca
18cd	H. H. Reese	36	Dr	38	18	P	S,G	Qa	T	E	I	Ls	------	3,579.6	11	--------	750R	18	180	
45- 2ac	Glenn LaSalle	35	Dr	28	50-24	P	S,G	Qa	T	T	I	Tca	+1.0	3,621.1	8.14	1-31-52	850R	13	50	EoTb
11aa	George Rabe	38	Du,Dr	34.0	14	P	S,G	Qa	C	G	I	Tpc	0	3,617.3	20.89	1-30-52	1,000R	----	----	U12
12ca	L. M. Freeman	44	Du	25	-----	N	S,G	Qa	C	T	I	Tpp	— .5	-------	7.50	1-30-52	650R	----	25	Pw
12db	do	47	Dr	32	18	P	S,G	Qa	T	E	I	Hpb	+1.0	3,598.0	9.26	1-30-52	950R	----	40	EoTb
12dd	Glen Paulsen	50	Dr	32	18	P	S,G	Qa	T	T	I	Tca	+1.0	-------	9.34	1-30-52	750R	20	33	EoTb
13aa	Mrs. L. Pheiffer	38	Dr	47	18	P	S,G	Qa	T	T	I	Idp	+2.0	3,593.3	11.92	1-31-52	500R	----	20	
13ad	Peter Jensen	48	Dr	56	18	P	Sls,S,G	Qa,Tb	T	E	I	Ls	------	-------	11	--------	800R	----	15	
13-45- 7cb	Howard McHatton	40	Dr	40	30	P	S,G	Qa	C	T	I	Tca	—9.0	-------	4.52	10-16-51	400R	----	----	U3
9aa	George McFee	23	Dr	196	4	P	S,G	To	Cy	W	D,S	Ls	------	3,897.1	180	--------	--------	----	----	
15cc1	City of Chappell	36	Dr	41	24	P	S,G	Qa	T	E	P	Tpp	—9.5	3,685.7	15.51	1-31-52	900R	7	----	EoTb
15cc2	do	43	Dr	41	18	P	S,G	Qa	T	E	P	Ls	------	-------	25	--------	400R	4	----	EoTb,Ca
16cb	W. H. Pyle	48	Dr	105	18	P	Sls,S,G	Qa,Tb	T	E	I	Bpb	+1.0	-------	7.57	10-17-51	975R	15	60	L
16dc	C. D. Brown	30	Dr	27	24	P	S,G	Qa	T	T	I	Idp	+2.0	3,697.3	14.12	10-11-51	--------	----	20	EoTb,U5
17ba1	Kenneth Ernhardt	48	Dr	80	18	P	S,G	Qa	T	T	I	Hpb	0	3,726.5	24.57	10-16-51	--------	----	----	U3
17ba2	George McFee	---	Dr	57.5	6	P	S,G	To	Cy	W	S	Tca	+1.0	3,743.2	40.23	10-16-51	--------	----	----	
23ab	Albert Williams	---	Dr	80	6	P	Sls,S,G	To,Tb	Cy	W	S	Tca	+ .5	3,698.0	45.65	12-14-48	--------	----	----	
23cb1	do	45	Dr	23	18	P	S,G	Qa	T	E	I,O	Tpp	+1.0	3,669.8	12.84	11-19-51	600R	10	12	EoTb
23cb2	do	46	Dr	100	18	P	Sls,S,G	Qa,Tb	T	E	I	Tca	+1.0	3,667.2	11.14	1-28-52	1,400R	30	50	Ca
23dd	do	44	Dr	102	18	P	Sls,S,G	Qa,Tb	T	E	I	Hpb	+1.0	3,668.0	15.39	1-28-52	600R	15	55	Tb30
25ca	Robert Newman	35	Dr	23.3	24	P	S,G	Qa	T	E	I	Tca	0	3,645.4	9.23	1-30-52	800R	----	50	Bw2,EoTb
26ac1	George Peterson	47	Dr	102	18	P	Sls,S,G	Qa,Tb	T	E	I	Hpb	+1.0	3,659.3	8.75	1-28-52	750R	64	56	Tb21
26ac2	do	48	Dr	90	18	P	Sls,S,G	Tb,Qa	T	E	I	Tca	0	3,657.0	6.43	1-28-52	1,460R	6	51	Tb21
27bb	Wayne Kayton	10	Dr	50.6	4	P	S,G	To	Cy	W	S	Tca	+1.0	3,715.9	42.62	10-11-51	--------	----	----	
34cb	Wilmer Castle	---	Dr	190.0	4	P	S,G	To	N	N	D,S	Tca	+ .5	3,842.8	170.59	10-10-51	--------	----	----	U
46- 1ac	H. C. Peterson	---	Dr	141.5	4	P	S,G	To	Cy	W	S	Tca	+1.0	3,875.7	131.84	10- 8-51	--------	----	----	
4ab	Myron Carlson	50	Dr	24	8	P	S,G	Qa	C	E	I	Tca	+1.5	-------	7.72	10-18-51	200R	----	20	EoTb,S
11aa	Fred Rocker	45	Dr	25	12	P	S,G	Qa	C	E	I	Tca	+1.5	3,751.5	7.40	10-17-51	130R	----	2	
11dd	E. E. Wilds	---	Dr	61.0	4	P	S,G	To	N	N	P	Tca	+ .3	3,799.8	46.46	10-17-51	--------	----	----	U
12ab	H. C. Peterson	---	Dr	------	4	P	S,G	To,Qa	Cy	W	S	Tca	0	3,748.2	5.50	10-17-51	--------	----	----	
12db	Wayne Peterson	51	Dr	60	18	P	S,G	Qa	T	B	I	Hpb	+4.0	3,734.6	8.62	10-16-51	--------	----	60	Bw2,S
14dd	H. C. Peterson	---	Dr	140.0	4	P	S,G	To	Cy	W	S	Tca	0	3,900.1	128.25	10-17-51	--------	----	----	
16ba	Dick Schlaman	18	Dr	141.0	4	P	S,G	To	Cy	W	D,S	Tca	+2.0	3,975.0	103.20	10-19-51	--------	----	----	
14-45-10bb	Mrs. Ada Mick	---	Dr	170.0	4	P	S,G	To	N	N	S	Tca	+1.5	3,899.3	161.65	4-14-52	--------	----	----	U
46-33cc	Myron Carlson	51	Dr	27	24	P	S,G	Qa	T	G	I	Tca	+ .5	3,799.1	9.49	10-18-51	1,100R	8	----	EoTb
33dc1	do	51	Dr	24	18	P	S,G	Qa	T	G	I	Tca	+ .5	3,789.8	8.49	10-18-51	700R	11	60	EoTb,Sw
33dc2	do	---	Dr	16.3	6	P	S,G	Qa	N	N	O	Tca	+1.0	3,796.3	14.67	10-18-51	--------	----	----	

Kimball County

12-56- 2aa	Mr. Menken	---	Dr	192.0	4	P	S,G	To	Cy	N	D,S	Tca	+2.0	4,984.4	191.50	5-19-52	--------	----	----	U
13-55-31cc	Elbert Lukesh	---	Dr	250.0	4	P	S,G	To	Cy	N	D,S	Tca	+ .5	4,981.3	234.45	5-19-52	--------	----	----	U
58- 8ab	C. H. Malm	25	Dr	219.5	6	P	S,G	To	Cy	W	D,S	Hpb	+1.0	5,284.5	201.47	5-22-52	--------	----	----	
14-53- 3ad	Dewey Lovell	48	Dr	144	18	P	S,G	To	T	E	I	Hpb	+1.5	-------	118.14	2-14-52	750R	10	110	
54-11cb	L. Young	---	Dr	237.5	4	P	S,G	To	Cy	W	D,S	Tca	+2.0	4,714.4	231.24	5-13-52	--------	----	----	
34da	Jess Farmer	44	Dr	265.0	6	P	S,G	To	Cy	W	D,S	Tca	+ .5	4,742.0	252.02	5-13-52	--------	----	----	Ca

TABLE 11.—*Record of wells*—Continued

Well No.	Owner or tenant	Year drilled (19..)	Type of well	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic source	Type of pump	Type of power	Use of water	Measuring point: Description	Measuring point: Distance above (+) or below (−) land surface (feet)	Measuring point: Height above mean sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement	Yield (gallons per minute)	Drawdown (feet)	Acres irrigated	Remarks
Kimball County—Continued																				
14-55-7aa	L. Siebenaler		Dr	281.0	4	P	S,G	To	Cy	W	S	Tca	+.5	4,928.8	271.21	5-12-52				U
20cc	Albert Petch		Dr	139.5	4	P	S,G	To	Cy	W	S	Tca	+2.0	4,808.8	126.96	5-19-52				
57-34cd	Don Norberg	37	Dr	127	18	P	S,G	To	T	D	I	Hpb	0	5,031.6	66.51	4-18-52	1,200R	25		U2
58-1cc	Clyde Gadeken	39	Dr	80	18	P	S,G	To	T	D	I	Hpb	+1.5	4,920.8	31.87	4-17-52			200	
18bc	Floyd Soule	39	Dr	125	18	P	Sls	Tb	T	E	I,O	Hpb	0	5,035.3	66.53	11-21-51	600R	10	20	
59-1bb	C. N. Nelson	40	Dr	170	24	P	Sls	Tb	T	E	I,O	Hpb	+1.0	5,070.2	82.38	11-21-51	200R		12	S
11dd	A. P. Mortensen	48	Dr	84	18	P	Sls,S,G	Qa,Tb	T	T	I,O	Hpb	+1.0	5,014.3	23.03	11-21-51	1,500R		65	Ca
14dc	do	39	Dr	100	18	P	Sls	Tb	T	E	I	Tca	0	5,064.5	63.67	4-17-52	700R	14	70	Tb20
15-53-30cb1	Arthur Kenton	44	Dr	60	18	P	S,G	To,Qa	T	E	I	Tca	0		20.71	2-19-52	1,500R	28	100	
30cb2	Arthur Kenton	50	Dr	120	18	P	S,G	To	T	E	I	Hpb	+1.0	4,514.4	49.01	2-19-52	800R	40	75	
31bb	Robert Gunderson	50	Dr	85	18	P	S,G	To	T	E	I,O	Hpb	+1.0	4,512.3	46.38	2-19-52	1,000R	10	110	
31cc	do	48	Dr	112.5	18	P	S,G	To	T	E	I	Hpb	+.5	4,548.2	88.18	2-19-52	700R	20	110	
32cc	Leslie Johnson	45	Dr	127	18	P	S,G	To	T	E	I	Hpb	+2.0	4,523.1	91.12	2-20-52	800R	25	80	S
33bd	Hahler estate	46	Dr	75	18	P	S,G	To	T	E	I	Tca	+1.0	4,462.3	44.90	2-15-52	750R		60	
33ca	do	40	Dr	78.5	18	P	S,G	To	N	N	I	Tca	+1.3	4,480.2	66.73	2-15-52	800R			U
33db	do	38	Dr	104.5	18	P	S,G	To	T	E	I	Tca	+.5	4,476.2	69.17	2-15-52	900R		100	
33dc	do	35	Dr	121.5	30-18	P	S,G	To	T	E	I	Bpb	+.5	4,477.8	88.84	2-15-52	850R	15	75	
34cb	Verne Johnson	40	Dr	100	30-18	P	S,G	To	T	E	I,O	Tca	0	4,459.9	63.33	11-20-51	680R		70	S
54-15dd	Dean L. Scheele		Dr	234.0	6	P	S,G	To	Cy	W	D	Tca	+.5	4,713.4	221.35	5-8-52				
25bc	Emery Horrum	50	Dr	78	18	P	S,G	To,Qa	T	E	I	Tca	+6.0		23.32	2-21-52	800R		66	
25cc	do	45	Dr	125	24-18	P	S,G	To	T	E	I	Hpb	+1.0		55.53	2-21-52	800R	15	100	
26bd	William Steele	42	Dr	68	18	P	S,G	To,Qa	T	E	I	Tca	+2.0	4,512.8	23.28	2-26-52	650R	30	70	S
26cb	do	45	Dr	64.0	24	P	S,G	To,Qa	T	E	I,O	Tca	+.5	4,512.6	24.70	11-20-51	850R		65	
26cd	Howard Gunderson	41	Dr	110	18	P	S,G	To	T	E	I	Hpb	+3.0	4,545.0	55.79	2-27-52	500R		35	
27cb	Frank Gotte	49	Dr	82	18	P	S,G	To	T	E	I	Hpb	+1.0	4,544.7	38.11	2-28-52	1,100R	9	65	
27da	Gail Russell	50	Dr	110	18	P	S,G	To	T	G	I	Hpb	+1.0	4,536.3	36.73	2-26-52	750R	10	45	
27dd	do	41	Dr	200	18	P	S,G	To	T	E	I	Hpb	+1.5	4,548.8	54.29	2-26-52	750R		45	
28bc	Vernon Atkins	41	Dr	100	18	P	S,G	To,Qa	T	E	I,O	Tca	+.5	4,543.3	18.98	11-20-51	847R	21	85	
30dc	Herbert Linn	39	Dr	105	24	P	S,G	To	T	E	I,O	Hpb	+1.0	4,621.3	58.03	12-10-51	700R	13	100	Sw
34ac	Ray Gunderson	40	Dr	147	24-18	P	S,G	To	T	E	I	Tca	+.5	4,581.3	94.05	2-21-52	850R	7	128	
35ba	Village of Dix	48	Dr	139	12	P	S,G	To	T	E	P	Ls			65		160R			Ca

35cb	Robert Gunderson	37	Dr	133.5	18	P	S,G	To	T	D	I	Tca	0	4,577.5	93.17	2-26-52	1,000R		135	
35dc	Gail Russell	40	Dr	150	18	P	S,G	To	T	D	I	Hpb	+.5	4,581.1	100.20	2-20-52	1,500R		135	
36ab	Howard Gunderson	38	Du,Dr		36-18	P	S,G	To	T	E	I	Hpb	+.5	4,515.6	46.52	2-26-52	700R		60	
36bb	Emery Horrum	45	Dr	125	24-18	P	S,G	To	T	E	I	Hpb	+.5	4,537.7	63.66	2-21-52	800R	16	100	
36cc	do	39	Dr	125	24-18	P	S,G	To	T	E	I	Tca	+2.0	4,558.0	81.74	2-21-52	930R	16	160	
36cd	do	42	Dr	125	24-18	P	S,G	To	T	E	I	Hpb	+.5	4,557.8	85.72	2-21-52	1,000R	16	160	
55- 7db	J. L. Young	13	Dr	206.0	4	P	S,G	To	Cy	W	D,S	Tca	+.5	4,847.9	187.53	5-14-52				Ca
8cb	Paul Mossberg		Dr	200.0	6	P	S,G	To	Cy	W	D,S	Ls			192					
17cc	Kimball Irrigation District	35	Dr	114.4	4	P	S,G	To	N	N	O	Tvp	+.8	4,740.4	96.45	11-21-51				
19aa	H. G. Phelps		Dr	130	18	P	S,G	To	T	E	I	Tca	0	4,718.5	69.38	3-13-52	600R			U1
19ac	A. L. Miller	43	Dr	110	18	P	S,G	To	T	E	I	Hpb	+1.0	4,711.7	59.67	3-13-52	850R	10	60	
19bb	M. J. Meistrell	45	Dr	147	18	P	S,G	To	T	T	I	Tca	+1.0	4,760.9	87.05	9-18-51	900R	22	40	Sw
19cb	Henry Raasch	47	Dr	89.5	18	P	S,G	To	T	T	I	Tca	+.5	4,723.7	56.97	3-13-52				U3
19db	Vernon Atkins	37	Dr	87	20	P	S,G	To	T	E	I	Tca	+1.0	4,699.7	42.00	3-13-52	700R	40	60	
22dc	Cree Aue	50	Dr	77	18	P	S,G	To,Qa	T	E	I	Hpb	+1.0	4,618.0	6.61	3- 6-52	1,000R	18	96	Sw,L
26cb	W. M. Rodman	50	Dr	90	18	P	S,G	To	T	E	I	Hpb	+1.0	4,644.2	36.25	2-28-52	1,600R	4	120	
26cc	Henry Meier	32	Dr	124	24	P	S,G	To	T	E	I,O	Tca	+.5	4,652.3	41.89	11-20-51	530M	15	70	Sw,Ca
27ba	W. M. Rodman	36	Dr	90	18	P	S,G	To,Qa	T	E	I	Hpb	+.5	4,641.7	30.05	2-28-52	1,000R	5	104	Sw
27cb	do	37	Dr	70.5	18	P	S,G	To	T	E	I	Hpb	+.5	4,662.3	40.53	3- 5-52	1,000R	9	179	Sw
27cc	J. O. Lobb	37	Dr	72	16	P	S,G	To	T	T	I	Hpb	0	4,670.4	42.20	3- 5-52	650R	18		U7
27cd	do	40	Dr	72	18	P	S,G	To	T	T	I	Hpb	0		36.20	3- 5-52	700R	12		U7
28ba	Frank Rasmussen	49	Dr	50	16	P	S,G	To,Qa	T	T	I	Hpb	+.5	4,661.9	26.73	3- 6-52			40	
28cb	Adam Ebel	50	Dr	87	18	P	S,G	To	T	E	I	Hpb	+1.0	4,689.2	51.81	3- 7-52			60	
28db	Walter Strauch	35	Dr	117	18	P	S,G	To	T	E	I	Tca	+.5	4,679.6	48.38	3-10-52	700R	25	100	Sw
28dc	Elton Jackson	35	Dr	110	18	P	S,G	To	T	E	I	Hpb	+1.0	4,690.6	64.36	3- 7-52			70	
29bc	City of Kimball	46	Dr	57	36-18	P	S,G	To	T	E	P	Ls			30		600R	8		
29bd	Henry Stahla	43	Dr	72	18	P	S,G	To	T	E	I	Bpb	+.5		47.76	3-10-52	700R	20	60	Sw
29cb	Albert Petsch		Dr	125	20	P	S,G	To	T	E	I	Hpb	0	4,697.2	49.67	3-13-52				U2
29db1	Gale Russell	50	Dr	85	18	P	S,G	To	T	G	I,O	Hpb	+1.0	4,688.7	47.09	11-27-51	1,000R		63	
29db2	do	47	Dr	95.5	15	P	S,G	To	N	N	I	Tca	+1.5	4,694.6	53.84	3-11-52	350R			Bw3,U5
30ad	City of Kimball	13	Dr	90	18	P	S,G	To	T	E	P	Ls			40		250R	8		Ca
30cc	do		Dr		18	P	S,G	To	Cy	E	I	Ls			70				13	S
30dd1	do	31	Dr	248	20	P	S,G	To	T	E	P	Ls			56		250R	14		
30dd2	Union Pacific R. R. Co	43	Dr	212	18	P	S,G	To	T	E	In	Hpb	+2.0	4,705.6	58.08	3-27-52	167R	19		L
32ab	City of Kimball	46	Dr	320	30	P	S,G	To	N	N	P	Tca	+1.0		77.12	3-12-52				U
32bc	do	33	Dr	280	18	P	S,G	To	T	E	P	Bpb	+2.0	4,729.9	81.34	3-12-52	500R			
33ad	Vernon E. Linn	46	Dr		18	P	S,G	To	T	E	I	Bpb	+1.5	4,717.7	90.51	3- 6-52	1,200R		160	Sw
33dc	August Stahla	51	Dr	164	18	P	S,G	To	T	T	I	Tca	+1.0	4,754.9	124.95	3- 7-52			110	Sw,L
34bd	Mrs. Herbert Herbert	44	Dr	126	18	P	S,G	To	T	E	I	Hpb	+1.0	4,716.5	94.32	3- 6-52	1,010R	8	137	Sw
35ac	Victor Ebel	40	Dr	101.5	18	P	S,G	To	T	E	I	Tca	+1.0	4,677.2	66.40	3- 6-52	600R		90	Sw
56-23db	William Phillips	48	Dr	136	20	P	S,G	To	T	E	I	Idp	+1.5		62.32	3-26-52	975R	60	103	Sw
24cc	Vowers Brothers	38	Dr	142	16	P	S,G	To	T	E	I	Idp	+1.5	4,746.6	50.05	3-26-52	1,000R	50	147	Sw,L
24db	William Novotny	46	Dr	132	16	P	S,G	To	T	E	I	Ls		4,747.0	60		600R	60	140	Sw
25ab	Robert Gerard	39	Dr	43	72	P	S,G	To,Qa	T	E	I	Bpb	+.5		17.23	3-27-52	400R	20	69	Sw
25cb	Vowers Brothers	40	Dr	46	18	P	S,G	To,Qa	T	E	I,O	Bpb	+1.5	4,707.3	22.05	3-26-52	680R	24	30	
27cb	Marion Heidemann	46	Dr	135	18	P	S,G	To	T	E	I	Tca	+.5	4,755.5	36.30	4- 3-52	1,125R	49	70	
28db	Phillip Schwindt	38	Dr	136	24	P	S,G	To	T	E	I	Hpb	+2.0	4,765.4	38.18	4- 2-52	1,500R	22	160	Sw
29ca	Vernou E. Linn	42	Dr	125.0	24	P	S,G	To	T	G	I,O	Tca	+1.0	4,814.8	73.35	11-20-51			60	
32ac	do	42	Dr	149	18	P	S,G	To,Qa	T	E	I,O	Tca	+1.0	4,758.5	20.44	11-20-51	550R	20	40	Sw
32bc	do	42	Dr	190	18	P	S,G	To,Qa	T	E	I	Tca	+1.0	4,771.3	24.44	4- 7-52	450R	40	30	
32cc	do	42	Dr	85	18	P	S,G	To	T	E	I	Tca	+2.0	4,773.9	24.50	4- 7-52	650R	40	77	

TABLE 11.—*Record of wells*—Continued

Well No.	Owner or tenant	Year drilled (19..)	Type of well	Depth of well (feet)	Diameter of well (inches)	Type of casing	Principal water-bearing bed		Type of pump	Type of power	Use of water	Measuring point			Depth to water level below measuring point (feet)	Date of measurement	Yield (gallons per minute)	Drawdown (feet)	Acres irrigated	Remarks
							Character of material	Geologic source				Description	Distance above (+) or below (−) land surface (feet)	Height above mean sea level (feet)						
	Kimball County—Continued																			
15-56-32cd	Vernon E. Linn	42	Dr	90	18	P	S,G	To	T	E	I	Hpb	+ .5	-------	49.61	4-7-52	1,000R	28	100	
33bc	Harold Quinn	41	Dr	102.5	18	P	S,G	To	T	E	I	Tca	+ .5	4,758.4	29.26	4-8-52	1,200R	----	90	Sw
34bd	John H. Ferguson	47	Dr	68	24	P	S,G	To	T	E	I	Ls	-----	-------	43	--------	1,000R	----	90	Sw
34cc	Phillip Stahla, Jr	36	Dr	88	16	P	S,G	To	T	E	I	Bpb	+ .5	4,768.3	43.69	4-3-52	700R	24	67	Sw
57-27bc	Bert Case	37	Dr	200+	24	P	S,G	To	T	E	I	Hpb	+ .5	4,894.7	93.22	4-16-52	1,200R	20	100	
32bb	Village of Bushnell	36	Dr	100	20	P	S,G	To	T	E	P	Tca	−6.0	4,866.0	26.83	5-21-52	350R	5	----	Ca
33ab	Matt Tomich	35	Dr	81	24	P	S,G	To	T	E	I,O	Hpb	+ .5	4,843.9	22.61	11-20-51	1,200R	25	70	
33dd	do	42	Dr	110	24	P	S,G	To	T	E	I	Tca	+ .5	4,860.5	39.69	4-16-52	700R	60	70	S
34bd	do	39	Dr	100	24	P	S,G	To	T	E	I	Hpb	+1.0	4,833.9	24.27	4-16-52	900R	60	100	S
34cb	do	37	Dr	150	24	P	S,G	To	T	E	I	Hpb	+1.0	4,848.3	36.33	4-16-52	1,000R	60	100	S
35bb	J. Singleton	39	Dr	80	24	P	S,G	To	T	E	I,O	Bpb	+1.5	4,834.4	31.00	11-20-51	--------	----	40	
36db	E. T. Forsling	38	Dr	60	18	P	S,G	To,Qa	T	E	I	Hpb	+2.0	4,768.6	1.72	4-8-52	900R	25	50	
59-12bc	Not known	---	Dr	91.2	4	P	S,G	To	N	N	D,S	Tca	+1.5	5,207.1	90.20	5-22-52	--------	----	----	U
26ad	do	---	Dr	93.5	6	P	S,G	To	Cy	W	S	Hpb	+1.5	5,125.4	90.70	5-22-52	--------	----	----	
16-54-6bc	Otto Beranick	38	Dr	80	18	P	S,G	To	T	B	I	Hpb	0	-------	42.47	5-14-52	1,200R	35	100	
34ad	Gale Turnbull	51	Dr	248	5	P	S,G	To	N	N	D	Tpc	0	4,697.0	183.72	5-8-52	--------	----	----	U
55-1dd	Paul Ostgren	47	Dr	94	20	P	S,G	To	T	T	I	Hpb	+ .5	-------	36.88	5-14-52	800R	20	55	
56-2cd	Ralph Dillon	---	Dr	238.0	6	P	S,G	To	Cy	N	D,S	Tca	+1.0	4,939.3	224.28	5-14-52	--------	----	----	U
25bb	A. H. Johnson estate	---	Dr	243.5	4	P	S,G	To	Cy	N	D,S	Hpb	+ .3	4,917.6	223.33	5-14-52	--------	----	----	U

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