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GEOLOGICAL SURVEY CIRCULAR 201

GROUND-WATER RESOURCES OF THE RAPID VALLEY UNIT CHEYENNE DIVISION SOUTH DAKOTA

By A. J. Rosier

WITH A SECTION ON THE SURFACE WATERS OF RAPID VALLEY

By L. J. Snell

Prepared as part of a program of the
Department of the Interior for
Development of the
Missouri River Basin

UNITED STATES DEPARTMENT OF THE INTERIOR
Oscar L. Chapman, Secretary

GEOLOGICAL SURVEY
W. E. Wrather, Director

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GROUND-WATER RESOURCES OF THE RAPID VALLEY UNIT CHEYENNE DIVISION, SOUTH DAKOTA

WITH A SECTION ON THE SURFACE WATERS OF RAPID VALLEY

ABSTRACT

The Rapid Valley unit is in Pennington County, S. Dak., and extends from the east city limits of Rapid City southeastward for 21 miles along Rapid Creek.

The bedrock formations that underlie the region are chiefly marine in origin, and they generally dip eastward from the center of the Black Hills uplift. The exposed formations are of Cretaceous age and consist of the Greenhorn limestone, the Carlile shale, the Niobrara formation, and the Pierre shale. The Pierre shale, which underlies the unconsolidated flood plain and terrace deposits in much of the region, is exposed in the erosional slopes along the south side of the valley and in the deeper draws on the north side. The areas in which the other formations are exposed are relatively small and are restricted to the western part of the region.

Four terraces are present on the north side of Rapid Creek. The lowest terrace and the flood plain in the western half of the region are irrigated at the present time, and the two lower terraces and the flood plain in the eastern half have been proposed for irrigation.

Abundant supplies of ground water occur in the flood plain and terrace deposits where they are now irrigated. Because the water-bearing materials consist of interfingering layers of differing permeability, the ground water is under water-table conditions in some places whereas it is confined in others. Locally, where there is a confining layer below other water-bearing materials or where a confining layer is itself saturated, the ground water may occur under both water-table and artesian conditions. Seepage from irrigation canals, which is the principal source of recharge, causes high ground-water levels from June to November; as a result, parts of the areas have become waterlogged. In the parts of the region that are not now affected by irrigation, the surface of the ground water is only a few feet above the bedrock surface and 6 ft to 42 ft below land surface; its position is relatively constant throughout the year.

Harmful concentrations of salt in the soil are in part due to evaporation of ground water. These are found only locally in the Rapid Valley region and do not present a serious problem at this time. It is thought, however, that the fine-grained materials underlying the Rapid terrace may contain sufficient salt to cause detrimental salt accumulations in the soil if the proposed irrigation causes ground-water levels to rise close to the surface.

Lining of the irrigation canals would reduce the amount of seepage and would effect a lowering of ground-water levels. If irrigation practices are extended to other areas, drainage facilities will be necessary both to avoid aggravating the existing conditions of waterlogging and to prevent the waterlogging of other low-lying lands.

The flow of Rapid Creek is affected by a variety of conditions. A few miles west of Rapid City, where Rapid Creek flows over the Englewood and Pahasapa limestones and the Minnelusa sandstone, there is a loss of about 8 cfs of water in a distance of a few miles. In the 3-mile reach of Rapid Creek between the Canyon Lake stream-gaging station and the Rapid City stream-gaging station, there is a gain of about 20 cfs; much of this gain in flow may be attributed to the inflow from

INTRODUCTION

Location and extent of the region

The Rapid Valley unit, which covers about 71 sq mi, is in Pennington County in southwestern South Dakota (see fig. 1); it extends from the eastern edge of Rapid City southeastward for 21 miles along Rapid Creek where the creek flows through the low foothills on the east-southeast flank of the Black Hills.

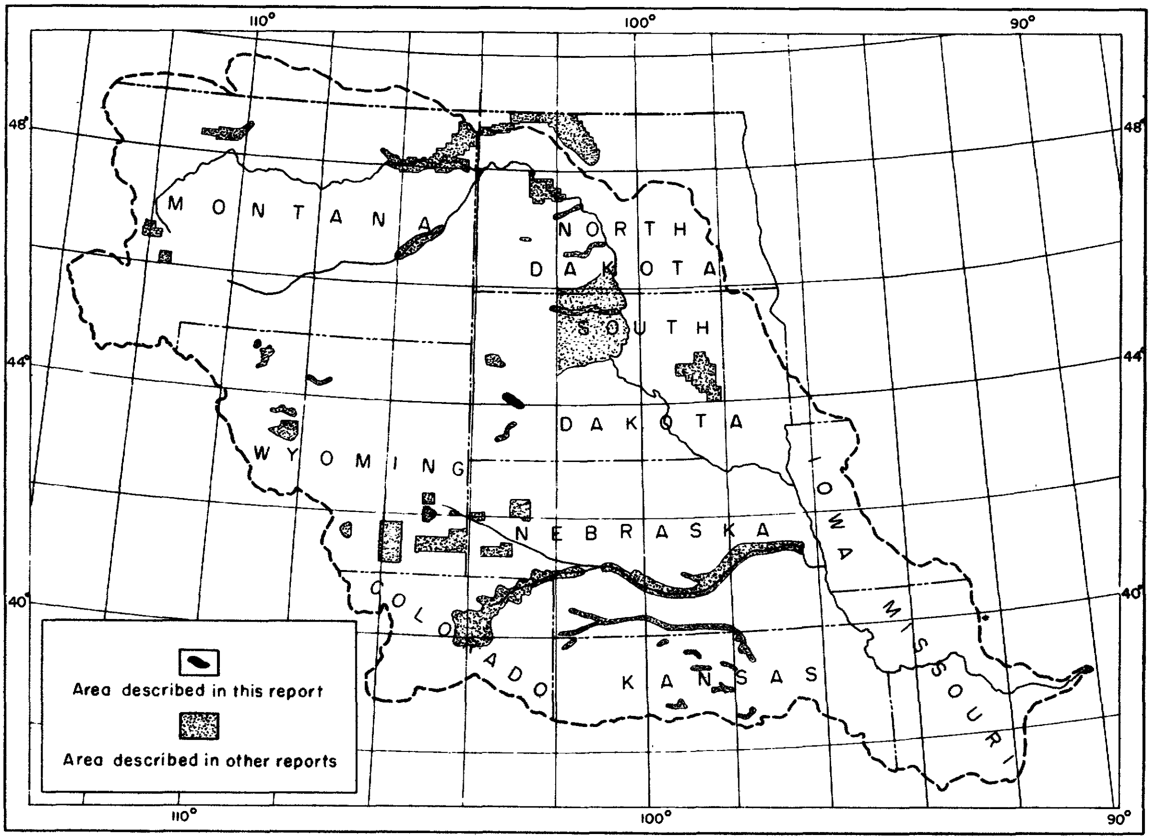

Figure 1.--Map of the Missouri River basin showing areas in which ground-water studies have been made under the Missouri Basin development program.

Cleghorn and Jackson springs and to the addition of water from the State-owned cement plant. In the Rapid Valley unit, the flow of the creek during the irrigation season is affected largely by the amount of water diverted for irrigation. The irrigation canals act as bypass channels, much of the water being returned to Rapid Creek by way of spillage into normally dry tributary creek channels and by movement through ground-water bodies that discharge into Rapid Creek.

(See figs. 1 and 4.) Rapid Creek drains a part of the area of metamorphic rocks in the Black Hills, and it follows a southeasterly course to its confluence with the Cheyenne River.

Purpose and scope of the investigation

The investigation on which this report is based is one of several that are being made by the Ground Water Branch of the Geological Survey as a part of the program of the U. S.

Department of the Interior for development of the resources of the Missouri River basin.

The purpose of this investigation was to assemble data from which areas in the Rapid Valley unit that are either waterlogged or in danger of becoming waterlogged could be delineated and to determine the probable reasons for the high ground-water levels.

This report, which describes the area that is being irrigated and the adjacent area that may be irrigated, includes a description of the geology and topography and a discussion of basic data pertaining to the occurrence of ground water. The field investigation was made between June 15 and November 10, 1949.

During the course of the field study a geologic map of the region was prepared, an inventory of domestic and stock wells and springs was made, and a water-level measurement program was begun.

The study was made under the general direction of A. N. Sayre, chief of the Ground Water Branch, U. S. Geological Survey, and G. H. Taylor, regional engineer in charge of ground-water studies under the Missouri River basin development program. G. A. LaRocque, Jr., district engineer in charge of Missouri Basin ground-water investigations in North and South Dakota, supervised the work.

Acknowledgments

Special acknowledgment is due all those who contributed to the success of this investigation. P. C. Jones and R. L. Solheim of the U. S. Bureau of Reclamation were especially helpful and cooperative during the course of the field work; Dr. J. P. Gries, professor of geology, South Dakota School of Mines and Technology, supplied much helpful advice and information; A. R. Denison, chief geologist for the Amerada Petroleum Corp., furnished logs of shot holes drilled by that corporation; and residents of the region and other persons supplied much helpful information.

Well-numbering system

Wells, springs, and test holes are numbered in this report according to their location within the land subdivisions of the Bureau of Land Management survey of the area. The first letter of a well number indicates the quadrant of the base line and the principal meridian system in which the well is located; the northeast and southeast quadrants, in both of which the Rapid Valley unit lies, are designated A and D, respectively. The first numeral of a well number indicates the township, the second one or two numbers the range, and the third one or two numbers the section in which a well is located. The lower-case letters following the section number indicate the location of the well within the section. The first letter denotes the quarter section (160-acre tract), the second the quarter-quarter section (40-acre tract), and the third the quarter-quarter-quarter section, or 10-acre tract. The letters are assigned in a counterclockwise direction, beginning in the northeast quarter of the section, quarter-quarter section, or quarter-quarter-quarter section. For non-uniform sections, the southeast corner is used to measure off the units of the sections. Thus, 10- or 40-acre tracts along the west row and north tier of the section may be larger or smaller than 10 or 40 acres in size. If more than one well is in a 10-acre tract, consecutive numbers beginning with 1 are added to the well numbers. A graphical explanation of this method of well identification is shown in figure 2.

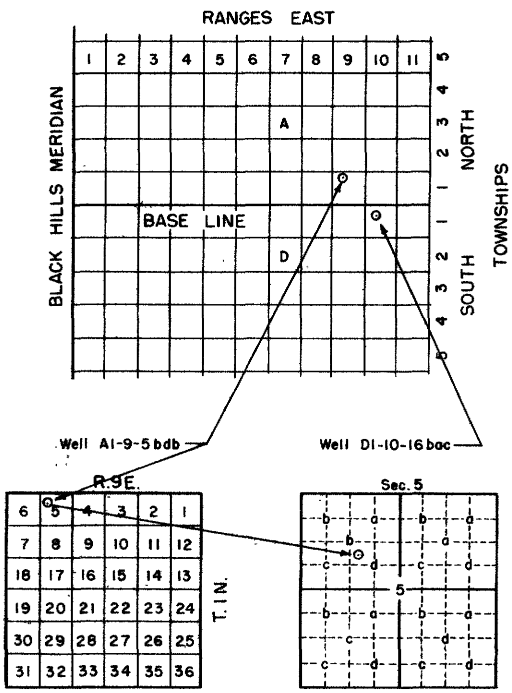

Figure 2.--Sketch showing well-numbering system.

Precipitation

Precipitation in the Rapid Valley unit ranges from an average of 17.5 in. a year at the western edge to an average of about 16.6 in. a year at the eastern edge of the region. There are no precipitation stations, but a continuous record has been maintained at Rapid City since 1888. The average annual precipitation for the period 1888-1948 is 17.52 in. The annual precipitation and the cumulative departure from average precipitation for the Rapid City station are shown graphically in figure 3. The value of 16.6 in. of precipitation per year for the eastern edge of the region was interpolated from the map (fig. 4) that shows average annual precipitation in southwestern South Dakota for the period 1930-48.

The graph of the cumulative departure from average precipitation shows that precipitation

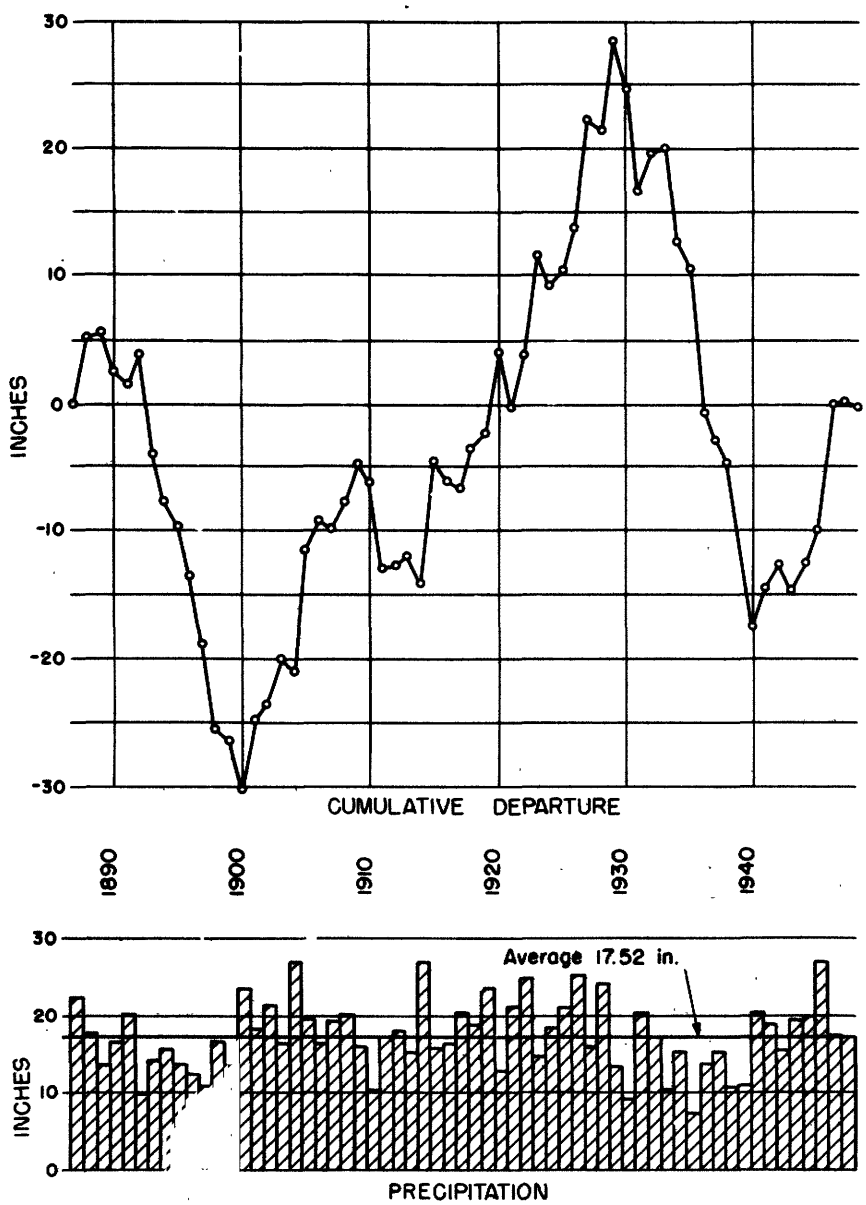

Figure 3.--Annual precipitation and cumulative departure from average precipitation at Rapid City, S. Dak., 1888-1948.

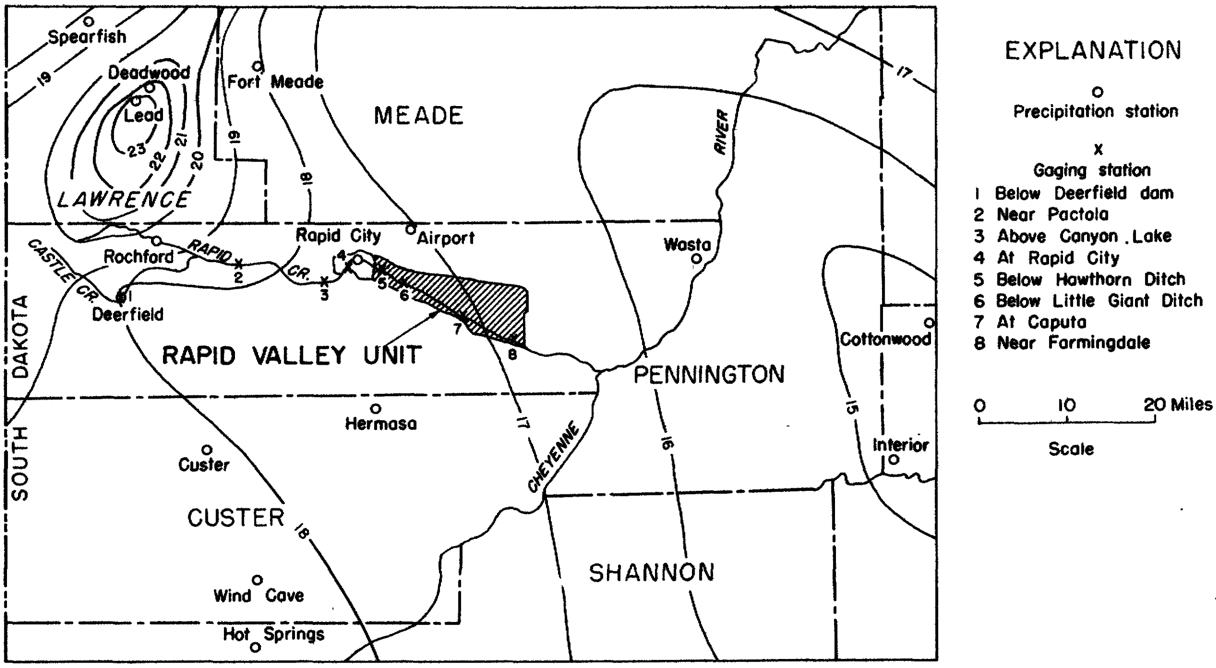

Figure 4.--Map of part of southwestern South Dakota showing average annual precipitation, in inches, for the period 1930-48 and location of gaging stations on Castle and Rapid Creeks.

was generally below average for the periods 1890 to 1900 and 1930 to 1940 and generally above average from 1901 to 1929 and from 1941 to 1947. The total deficiency in precipitation for the period 1930 to 1940 was the greatest for the period of record.

GEOLOGY

Previous studies

The stratigraphy and structure of the central Black Hills were described and mapped by Darton and Paige (1925),[1] and their report was used in the preparation of the geologic map included with this report. The terrace deposits were described and mapped by Fillman (1929) and Plumley (1948), and their reports were used in the naming of the terrace deposits as shown on plate 1. In recent years the Amerada Petroleum Corp. of Tulsa, Okla., drilled seven shot holes in conjunction with their seismic surveys within the area; the logs of these holes are included in this report.

[1] See page 18 for list of references cited.

Topography and structure

The Black Hills uplift was developed in a thick section of beds that are chiefly of marine origin. This uplift, which is a large dome-shaped anticline about 125 miles long and 60 miles wide, trends nearly northwest. The schists, gneisses, and granites, which were the basement rocks underlying the sedimentary strata, were raised above the level of the surrounding plains during the period of uplift. The sedimentary strata have been completely eroded from the central Black Hills; their eroded edges now encircle the elevated core. The diagrammatic cross section (fig. 5) illustrates the general relations. In the vicinity of the Black Hills, these sedimentary formations dip sharply away from the central core, but a few miles away from the Black Hills they retain their original nearly horizontal position. The areas where the softer shale formations crop

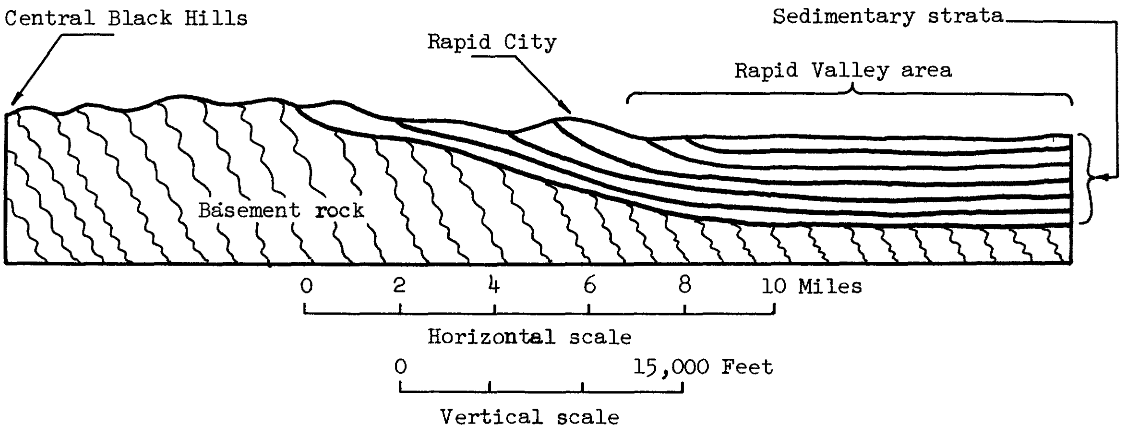

Figure 5.--Diagrammatic cross section of a part of the Black Hills showing relationship between the basement rocks and the overlying sedimentary strata, which have a total thickness of 5,000 ft and which were once continuous across the dome.

out now form valleys that encircle the Black Hills; the most conspicuous of these valleys is called the "Race Track." Erosion of the basement rocks has produced the ridges and peaks of the central Black Hills, of which the highest, Harney Peak, is 7,242 ft above mean sea level.

After the initial uplift of the Black Hills area, meandering streams that drained the area reduced the surrounding foothills to a peneplane. Materials that were eroded from the mountainous areas were deposited on this surface. Further uplift and consequent rejuvenation of the streams left a part of these deposits as the highest terraces in the region. On the east flank of the Black Hills, repetition of the cycle of deposition and subsequent erosion by the persistently southward-shifting streams shaped the present-day stream valleys.

The log of a deep water well drilled at the Rapid City Airport during 1942 has been published (Gries, 1943). This well, which is known as Rapid City Airport well 2, is in the NW$\frac{1}{4}$ sec. 13, T. 2 N., R. 8 E.

The Fall River sandstone has an eastward dip of 20° where exposed 7 miles west of Rapid City Airport well 2. Its altitude in well 2 is 2,100 ft lower than in the area; hence the apparent dip between the two is 3°. Between Rapid City Airport wells 1 and 2 (located in the NE$\frac{1}{4}$ sec. 18, T. 2 N., R. 9 E.) the same formation dips eastward at the rate

Log of Rapid City Airport well 2
(Altitude of land surface about 3,200 ft above sea-level datum)
(Abridged)

	Thickness (feet)	Depth (feet)
Top of Kelly bushing to cellar floor............	14	14
Pierre shale: shale, medium- to dark-gray, highly bentonitic toward base...	611	625
Niobrara formation: shale, highly bentonitic, calcareous, medium- to dark-gray....................	195	820
Carlile shale: shale, silty, calcareous, medium-gray....................	370	1,190
Greenhorn limestone: shale, silty, calcareous; streaks of limestone.............	110	1,300
Graneros shale: shale, micaceous, medium- to dark-gray; bentonite seam; silty streaks; sandstone, fine, white (Newcastle sandstone member)........	805	2,105
Fall River sandstone: sandstone; gray to white. (Water, derived from the 2,095 to 2,170-ft level, rose 1,740 ft in the drill stem in 32 min.).........	45	2,150

Log of Rapid City Airport well 2--Continued

	Thickness (feet)	Depth (feet)
Fuson shale: siltstone, clay, and sandstone, buff, yellow and pink..........	105	2,255
Lakota sandstone: sandstone, clay, and siltstone (Water rose 2,227 ft in the drill stem in 33 min. After 7-in. casing was set and well plugged back to the Lakota, casing was shot-perforated between 2,195 and 2,320 ft, and water then rose to within 110 ft of the land surface)...................	135	2,390
Morrison formation: clay, silty to sandy, varicolored.................	230	2,620
Unkpapa sandstone: sandstone, silty, glauconitic; white clay partings......	80	2,700
Sundance formation: sandstone; some argillaceous shale...................	320	3,020
Spearfish formation: siltstone and clay, brick-red to brown; some sandy beds	340	3,360
Minnekahta limestone: limestone, dense to finely crystalline, gray to cream-colored...........	50	3,410
Opeche formation: shale, silty, with basal sandstone, red to brown......	120	3,530
Minnelusa sandstone: dolomite, sandstone, and shale. (Water, derived from the 3,778 to 3,825-ft level, rose 3,118 ft in the drill stem in 30 min.)...................	675	4,205
Pahasapa (Madison) limestone: limestone and dolomite, medium crystalline....................	231	4,436

of only 50 ft to the mile, or 0.5°. From the airport eastward to the Gypsy's Hunter well, which is 45 miles east of Rapid City Airport well 1, the dip averages 26 ft to the mile, or 0.3°. The top of the Minnekahta limestone dips about 35 ft to the mile, or 0.4°, between the two airport wells.

Stratigraphy

Bedrock formations.--The oldest formations exposed in the Rapid Valley region are those of the Cretaceous system. These formations from oldest to youngest are the Greenhorn limestone, the Carlile shale, the Niobrara formation, and the Pierre shale.

The Greenhorn limestone consists of alternate beds of shale and limestone. The limestone, which is characterized by the fossil pelecypod Inoceramus labiatus, is thin-bedded and contains considerable clay and some sand; on exposure it hardens and breaks into thin pale-buff slabs, most of which show impressions of the distinctive fossil. The average thickness of the formation in the area where the rocks crop out is about 90 ft. A distinct break separates the Greenhorn limestone from the underlying shales, but its upper beds grade into the overlying Carlile shale. It is exposed in the Cyclone Canal, 3 miles southeast of Rapid City. It is, apparently, almost impermeable.

The Carlile shale, which is about 400 ft thick, is mostly gray shale but contains several thin hard beds of buff sandstone. There are many oval-shaped concretions near the top. This formation is poorly exposed in the dry creek bottoms in the northwest corner of the area. It is too dense to yield appreciable amounts of water.

The Niobrara formation is about 200 ft thick and is composed of soft shaly limestone, or impure chalk, which contains some clay and fine sand, and beds of limy shale. Unweathered exposures are light gray, and weathered exposures are yellow or buff. This formation may yield small quantities of water.

The Pierre shale, which is the youngest bedrock formation in the area, is about 1,200 ft thick. Fresh exposures of this formation are dark bluish gray, and weathered exposures are light brown. North of Rapid Creek it is continuously exposed along the slopes of the small north-facing bluffs. Because of their greater resistance to weathering, lenses of limestone, which are about 1,000 ft above the base of the formation, form low conical buttes where that part of the formation is exposed to erosion. The Pierre shale is almost impermeable.

Terrace deposits.--Rapid Creek valley, like the valleys of most of the creeks that flow eastward from the Black Hills, is characterized by an asymmetrical north-south profile. The north-facing slopes are steeper than the terraced, south-facing slopes. This is probably due to the generally persistent southward shifting of the creek, which has left terrace deposits on the north side of the valley and steep erosional slopes on the south side.

In the Rapid Creek valley, four distinct terraces are present north of Rapid Creek. Fillman (1929) differentiated and named the three highest: Mountain Meadow (Tertiary), Rapid (Quaternary), and Sturgis (Quaternary). Plumley (1948) differentiated and named the younger Farmingdale terrace (Quaternary). The outline of the terrace deposits as mapped by the author shows the approximate maximum extent of terrace deposits that have a substantial thickness, whereas Plumley's map shows the outline of the upper terrace surface, or about the minimum extent of the terrace deposits. Thus the maps of the author and of Plumley are not necessarily in agreement.

The Mountain Meadow stage is believed by Plumley (1948) to have ended during the middle part of Oligocene time after an uplift of 2,000 to 3,000 ft in the central Black Hills, 250 ft in the foothills, and 20 to 30 ft in the Badlands that are east of the foothills. The present-day stream valleys were carved in the central Black Hills on this uplifted surface. While the streams that flowed eastward from the Black Hills were cutting these valleys, they also meandered across the foothills and thus reduced them to a peneplane. The surface of the alluvial material that was deposited on this peneplane is the Mountain Meadow terrace. After the formation of the Mountain Meadow surface, the streams were confined to the valleys. Later uplift and consequent rejuvenation of the streams resulted in the formation of the three additional and distinctive terraces.

The Mountain Meadow surface consists of flat-topped divides on the interstream areas adjacent to the east side of the Black Hills. This terrace is not shown on the geologic map (pl. 1), but it is present to the north of the Rapid Valley unit. The location of the other three terraces is shown on the geologic map; the Rapid and Sturgis terraces are extensive areas in the Rapid Valley unit whereas the Farmingdale terrace is present only in the southeast corner of the region.

In the south part of secs. 8 and 9, T. 1 S., R. 10 E., Plumley shows a remnant of the Farmingdale terrace; if there is such a remnant, the author was not able to locate or distinguish it.

Each of the terraces and also the present flood plain of Rapid Creek are underlain by unconsolidated lenticular deposits of gravel, clay and sand. (See table 2.) The gravel immediately overlying the bedrock seems to be continuous and ranges in thickness from a few inches to about 35 ft. The average thickness of the terrace deposits is between 35 and 45 ft. Erosion has completely removed the terrace deposits in the deeper draws and has exposed the shale bedrock.

In many places, the terrace deposits are a source of shallow ground water.

During the formation of each successive terrace, an alluvial fan was formed on the surface of the adjacent flood plain at the mouth of each of the many draws that dissect the higher terraces. These fans are composed of gravels that were eroded from the higher terraces and of finer materials that were derived from the shale bedrock. In general, the coarser materials (boulders and coarse gravel) are at the base and the finer materials near the surface of the fans. The finer materials of some of them apparently have been removed by erosion.

Alluvium.--The alluvium consists of interfingering lenses of gravel, sand, and clay and a basal layer of sand and gravel that seems to be essentially continuous. The thickness of the alluvium beneath most of the flood plain is between 12 and 30 ft; in the draws the thickness generally is less than 10 ft. All the wells in the flood plain area obtain water from the alluvium.

HYDROLOGY

Ground water

Source, occurrence, and movement.--During part of 1949 the water table or piezometric surface beneath about 4,300 acres of the 10,740 acres of irrigated land in the Rapid

Valley unit was within 5 ft of the land surface. (See pl. 2.) Landowners have reported that this condition has existed generally since irrigation was begun. Many stockmen consider the high-water level to be advantageous because it promotes the growth of hay with little or no need for irrigation. Other stockmen, however, and those who desire to raise crops other than hay, wish to have the water levels lowered because the land is too moist for necessary farming operations--plowing, cultivation, and harvesting. Collectively the greater number of landowners seem to favor the higher-water levels provided the height of the water table does not interfere with the usual farming operations.

Measurements of ground-water levels in wells indicate that the water table and piezometric surfaces fluctuate within a fairly wide range. (See tables 3 and 4.) However, these fluctuations do not seem to be related primarily to precipitation, which averages about 16.6 in. a year, but rather to be caused by seepage from the irrigation canals and from water spread on the land for irrigation purposes.

Water generally flows in the canals from May to November, although it may be diverted in April after a winter of subaverage precipitation. Because the canals are not lined, the greatest water losses are where the canals cut into the more permeable material along the lips of the terraces or into the alluvium of the larger draws. The stretches where the greatest water loss from the canals probably occurs are shown by dashed lines on plate 2. Between Iowa Ditch and Hawthorn Ditch, the principal source of ground water is seepage from Iowa Ditch. In the remainder of the Sturgis terrace that is irrigated by water from Hawthorn Ditch, the source of ground water is seepage from Iowa and Hawthorn Ditches and seepage from irrigation water. It seems that the latter is only a small fraction of the ground-water recharge to the unconsolidated deposits that underlie the Sturgis terrace. The flood plain aquifers are recharged by seepage from Rapid Creek, seepage from the irrigation canals on the flood plain, underflow of ground water from the higher-lying terraces, waste irrigation water from the higher-lying terraces, and seepage from irrigation on the flood plain.

The ground water north of Rapid Creek generally moves in a southeasterly direction, largely following the slope of the bedrock surface. (See pl. 1.) Ground water in the aquifer of the Sturgis terrace deposits is unconfined. The ground water in the main aquifer that underlies the flood plain is unconfined at the toe of the Sturgis terrace. However it is locally confined toward Rapid Creek, and one or more semicontinuous water-bearing lenses may overlie the main aquifer. The water in some of the perched or semi-perched aquifers may be locally confined under artesian pressure.

The ground water south of Rapid Creek moves generally in a northeasterly direction, conformably with the slope of the bedrock surface. (See pl. 1.) The main aquifer, which is probably continuous with that north of the creek, apparently is locally confined, and one or more semicontinuous water-bearing lenses may also overlie the main aquifer. The water in some of the perched or semiperched aquifers may be locally confined.

As the clays or sandy clays that overlie and underlie the perched or semiperched aquifers generally are slightly permeable, vertical movement of the ground water through them is possible. In order to determine whether the hydraulic pressure differs within a vertical section of the alluvium or terrace deposits, groups of three or four observation wells were installed at 12 locations. (See pl. 2.) Each such installation is referred to as a piezometric station. The diameter of the wells is three-fourths of an inch and the wells are spaced 1 ft apart. The depths of the wells at each piezometric station are 4.5, 9.0, 13.5 and 18.0 ft, respectively, below land surface. The measuring points of the wells at each station are in the same horizontal plane.

During the winter of 1949-50, the water level in some of the shallower wells was higher than that in the deeper wells. Soon after water was diverted to the irrigation canals, the water level in the deeper wells rose to approximately the same or to a slightly higher altitude than that of the water level in the adjacent shallower wells. This marked change in the relative position of the water levels and the relatively greater fluctuation of the water level in the deeper wells indicates that conditions for recharge to and discharge from the deeper aquifer are more favorable, and that the transmissibility of the deep aquifer is probably greater than that of the more shallow ones. The water-level fluctuations in the wells at four typical piezometric stations are shown in figure 6.

Excess ground water that is transmitted to the flood plain from the higher terraces is a factor in the overburdening of aquifers that underlie the flood plain and in the consequent waterlogging of much of the land. If the materials of which the alluvial deposits are composed were homogeneous and sufficiently thick and permeable, the excess ground water would be transmitted through the deposits without causing waterlogging of the land. However, as the alluvium is composed of a basal gravel that ranges widely in transmissibility and is generally overlain by lenses of clay, sand, and gravel that also range widely in permeability, thickness, and extent, the water-bearing materials cannot transmit the amount of ground-water recharge at a sufficiently rapid rate to prevent

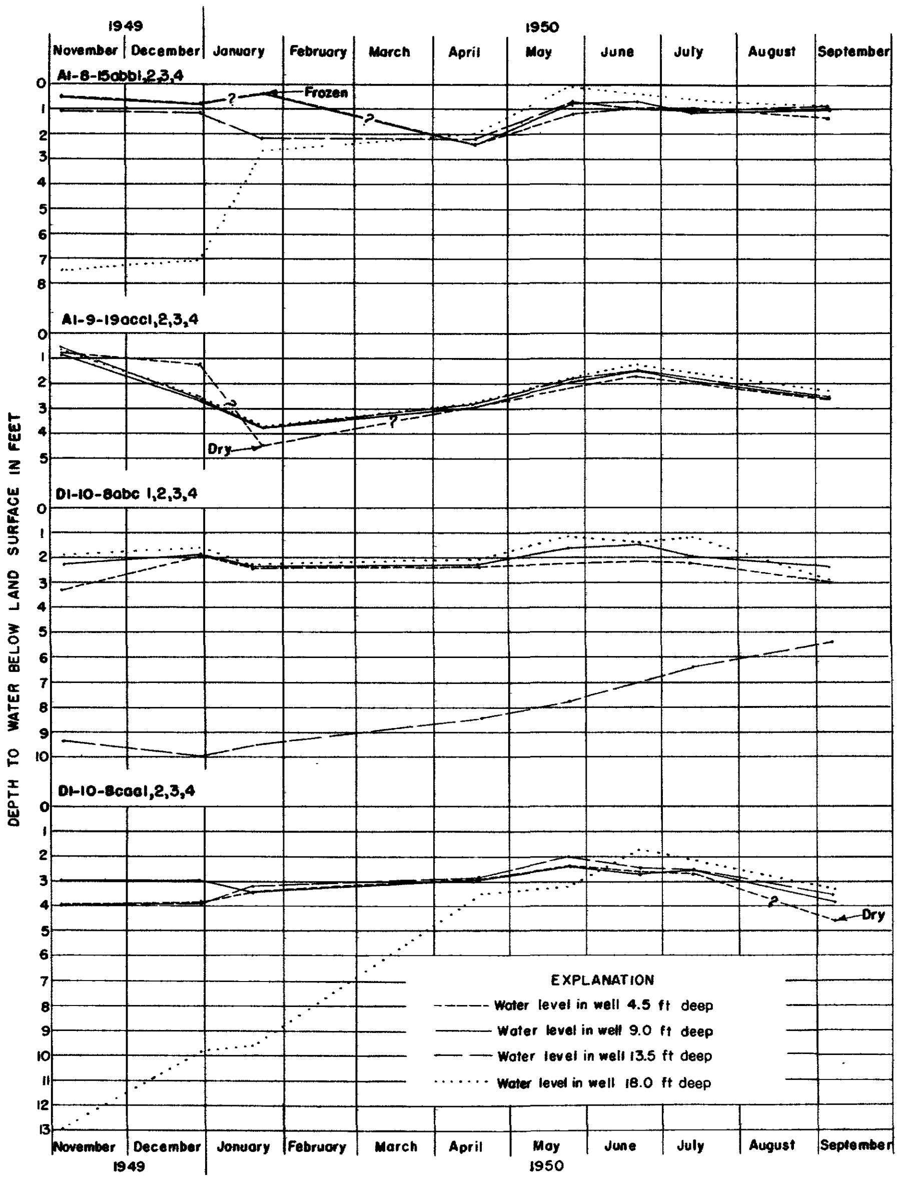

Figure 6.--Hydrographs of water-level fluctuations in observation wells at four piezometric stations, Rapid Valley unit, South Dakota.

either a rise in the water table or an increase in the hydrostatic pressure. Wherever water is confined in the discontinuous sand or gravel lenses, the hydrostatic pressure forces the water through the slightly permeable confining beds in the direction of least confinement. Thus the waterlogging of an area or part of an area may be the result of the movement into the area of either confined or unconfined ground water or both.

In the nonirrigated areas that are underlain by terrace deposits, the water table is generally only slightly above the shale bedrock (from 15 to 40 ft below the land surface). Precipitation that falls in the region is the only source of recharge to the aquifers in these terrace deposits. In some areas the upper few feet of the bedrock formations may also yield water to wells.

Fluctuations of the water level.--During the summer and early fall, the seepage of water from the unlined irrigation canals and the infiltration of excess irrigation water generally maintains the water table or piezometric surface at undesirably high levels in much of the area. In January 1950, several months after 1949 irrigation operations had been stopped on the Sturgis terrace, the decline of the water table from the summer high levels ranged from about 1 ft at the lip of the terrace to about 28 ft along the northern edge of the terrace. In the area that is underlain by alluvium, the decline of the water table or piezometric surface ranged from about 0.5 ft to about 8 ft. Superimposed on the seasonal fluctuations of ground-water levels due to seepage from the canals are the fluctuations due to groundwater underflow and to recharge from precipitation, from the creek, and from irrigation.

Hydrographs of the water-level fluctuations from August 1949 to September 1950 in seven wells along a north-south line from the Hawthorn Ditch to Rapid Creek in T. 1 N., R. 8 E., are shown in figure 7. A profile along the same line (fig. 8) shows the position of the water table in January and June 1950. Hydrographs of the water-level fluctuations in four additional wells are shown in figure 9.

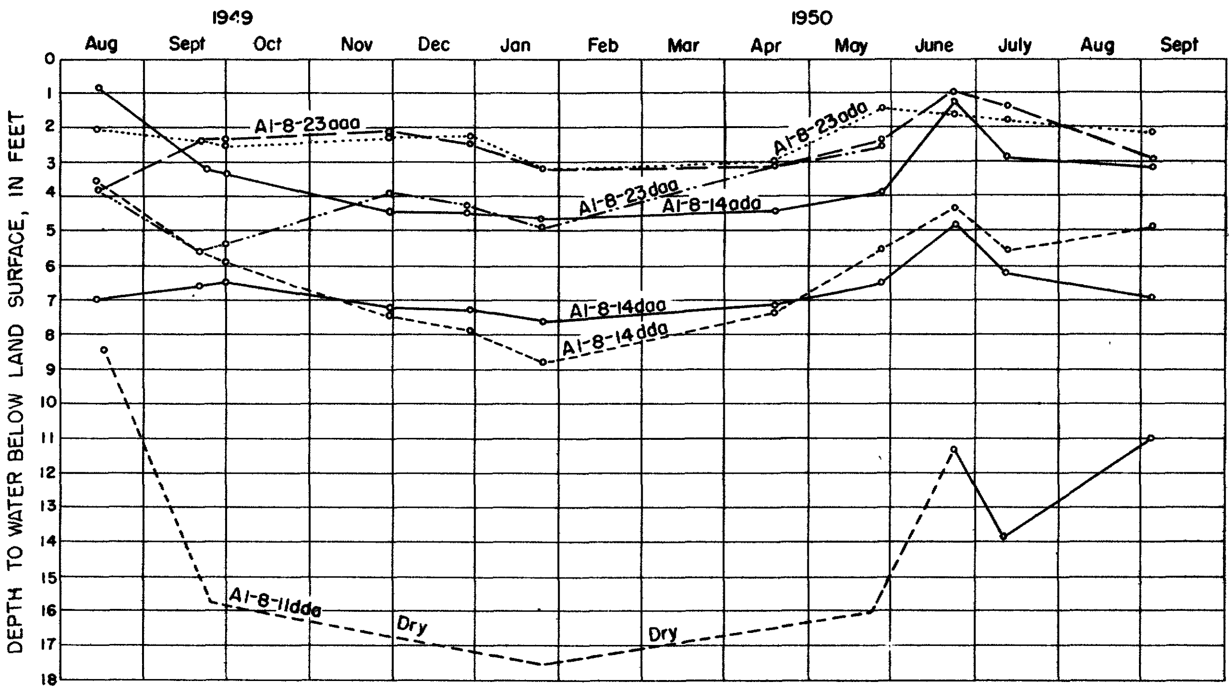

Figure 7.--Hydrographs showing fluctuations of the water level in seven wells in the Rapid Valley unit, South Dakota.

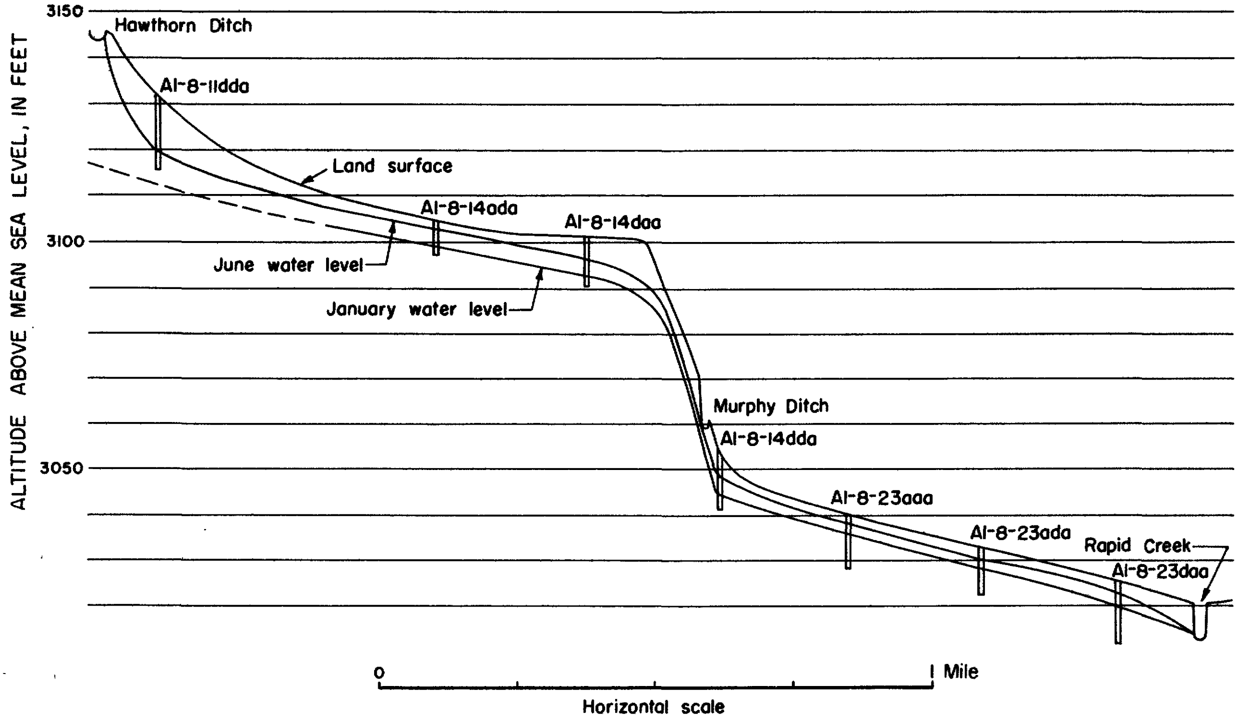

Figure 8.--Profile of the irrigated area in T. 1 N., R. 8 E., Rapid Valley unit, South Dakota, showing position of water table in January and June 1950.

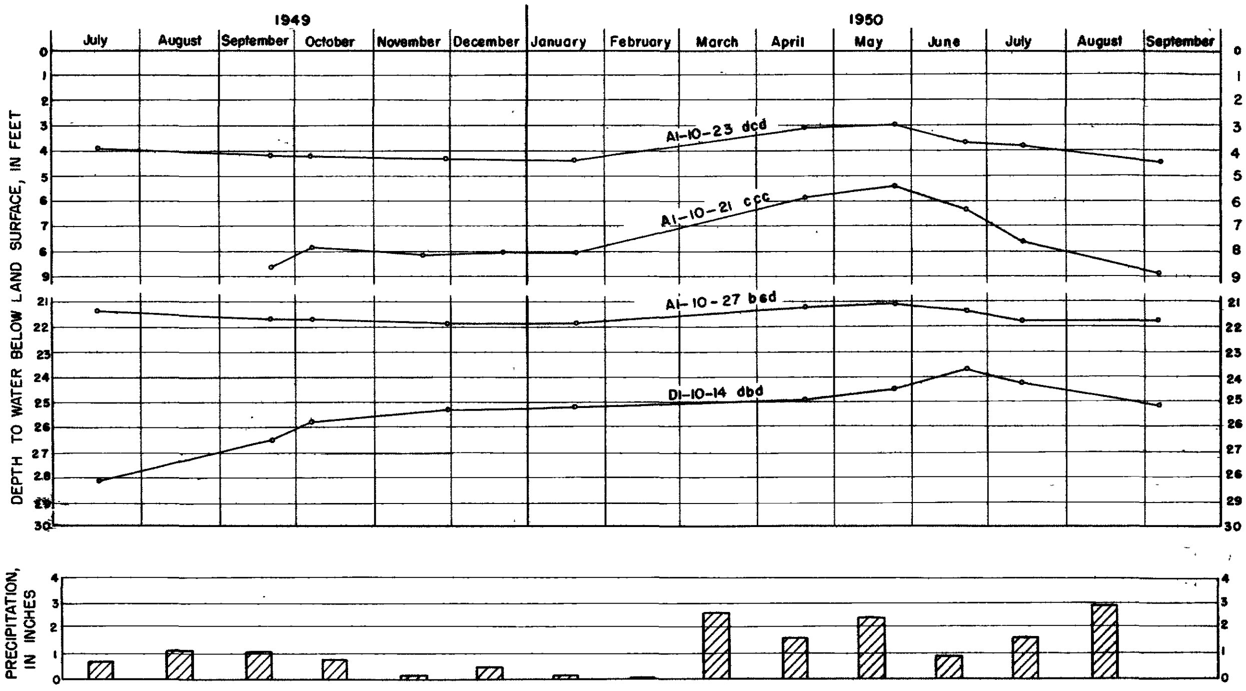

Figure 9.--Hydrographs showing fluctuations of the water level in four wells in the Rapid Valley unit and precipitation at the Rapid City Airport, S. Dak.

Salt deposition.--When, for long periods, the surface of the ground water is sufficiently shallow that evaporation occurs, the dissolved salts in the ground water become concentrated at or close below the land surface. Harmful concentrations of salts are only in a few localized areas in the Rapid Valley unit, despite the fact that the ground-water surface is at a shallow depth in large areas in the unit. A low original content of salt in the water-bearing materials and the leaching by seepage from irrigation water of those salts that were present in the soil may account for the lack of harmful salt concentrations in the waterlogged areas during the 50- to 60-yr period since the irrigation ditches were constructed.

The extension of irrigation to the remaining part of the Sturgis terrace probably will not create harmful concentrations of salt for at least a similar period, and any concentrations that may appear when this part of the terrace is first irrigated are likely to exist only until the salts are leached from the underlying materials by seepage of irrigation water.

The materials underlying the Rapid terrace are finer-grained than those that underlie the Sturgis terrace and may contain a greater concentration of detrimental salts. As a result, irrigation of this terrace may eventually cause the development of alkaline soils in areas where the water table rises to a level that is close below the land surface.

Present and potential use.--At the present time the principal use of ground water in the Rapid Valley unit is for domestic purposes and for the watering of stock. Only three wells are being used to obtain water for irrigation. (See table 5.) Much additional use of the ground water of the flood plain deposits could be made without exceeding the rate of replenishment of the aquifer or aquifers; not only could more water be made available for irrigation, but the increased withdrawals would result in a lowering of the water table in the waterlogged areas.

Many landowners report that their wells yield 180 gpm on a sustained basis; larger yields probably could be obtained if pumps of greater capacity were installed, and also if the wells were of more efficient design and construction.

It is estimated that 10,000 acre-ft of the gain of 11,000 acre-ft in stream flow between Rapid City and Farmingdale between May and September in both 1948 and 1949 is from ground-water sources. Hence an average 10,000 acre-ft a year is the greatest amount of ground water that is recoverable for use on a sustained basis within the area at the present time (disregarding the effect on stream flow and the legal problems related thereto, and not taking into account the part of the 10,000 acre-ft that might reenter the streams as return flow).

Lowering the water table in the waterlogged areas would reduce losses that result from evaporation and transpiration. This would represent a net increase in the amount of ground water that could be developed, so that the maximum would be more than the 10,000 acre-ft per year mentioned above.

The amount of ground water that is available for further use, the rate at which the water may be withdrawn from the aquifer, and the best means for removal of excess ground water may be determined by detailed studies. Though detailed hydrologic studies may show that a quantity of water is available for diversion, the legal aspects of such a diversion would also have to be explored.

Surface waters of Rapid Creek valley

By Leonard J. Snell

Precipitation is generally greater and is more evenly distributed throughout the year in the central Black Hills than it is along the foothills. In the spring, the snow cover of the central Black Hills melts slowly and much of this moisture penetrates the ground surface and moves downward to the zone of saturation. For example, in spite of the heavy snows of 1949, the discharge of Castle Creek during April, as measured at the gaging station above Deerfield Reservoir (see fig. 4), was less than double that of the period of low flow from December through March. This temporary retention of runoff is due presumably to the thick vegetal and humus cover and to the very numerous beaver dams that are present on all tributaries, both of which tend to decrease the maximum runoff during the spring break-up and during periods of heavy rains and to increase the minimum runoff during the drier periods of the year.

The Deerfield Reservoir on Castle Creek, which is a tributary of Rapid Creek, has a spillway altitude of 5,908 ft above sea-level datum and has a usable storage capacity of 15,140 acre-ft. An agreement among Rapid City, the Rapid Valley Conservancy District, and the U. S. Bureau of Reclamation, gives the city prior right to the use of the first 7,000 acre-ft and the Conservancy District the right to the remainder. A minimum flow of 2 cfs is maintained below the reservoir in order to sustain aquatic life in Castle Creek.

foothills. This loss in stream flow occurs primarily in the area where the Englewood and Pahasapa limestones and the Minnelusa sandstone crop out. (See fig. 10.) Many of the streams have a well-sustained flow upstream from the outcrop area, and all, except Rapid Creek, may become completely dry in the approximately 3-mile stretch that is underlain by the Englewood and Pahasapa limestones and the Minnelusa sandstone. The stream-flow records for Rapid Creek from June 1945 to July 1947, which were obtained by the Geological Survey in cooperation with the State of South Dakota, indicate that losses in this

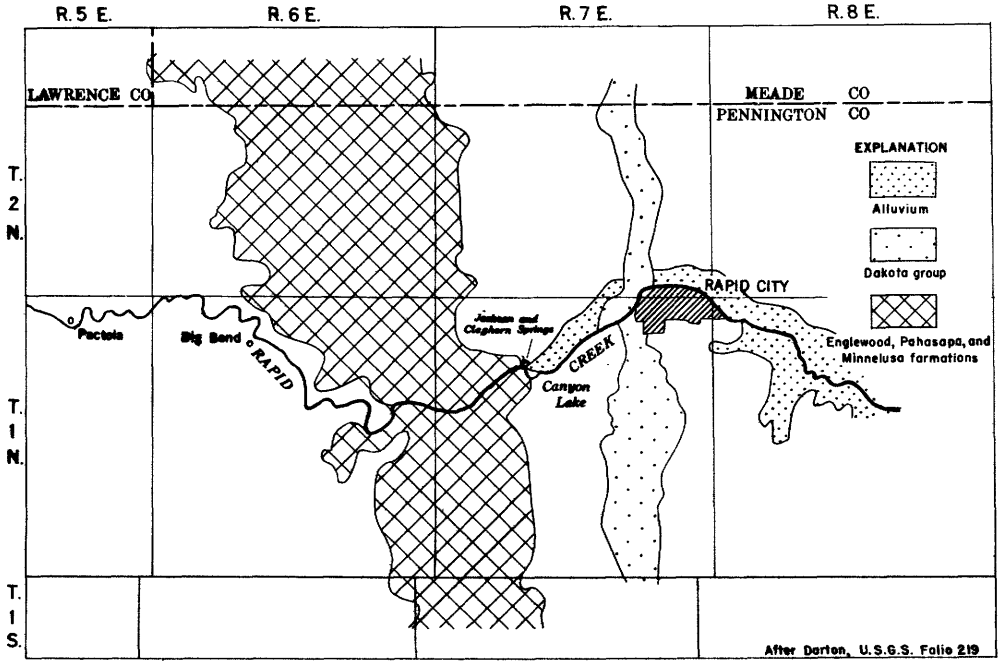

Figure 10.--Geologic sketch map of a part of the Black Hills.

The drainage area of Rapid Creek at the stream-gaging station near Pactola is 315 sq mi, and the drainage area of Rapid Creek above Canyon Lake is 379 sq mi (fig 4). Although the size of the drainage areas differs considerably, the low-water flows at the two stations generally are in close agreement except when local rains may cause a temporary rise at either station. During extended periods of low runoff, in spite of the 20 percent greater drainage area, the flow at the station above Canyon Lake is less than the flow near Pactola; this was true during a part of 1949 and 1950. The first studies of the area indicated that all streams flowing east from the Black Hills lose considerable water to the permeable sedimentary formations over which they flow before they reach the

stretch at times may exceed 10 cfs. The Bureau of Reclamation made a study prior to the construction of Deerfield Dam in 1939 that indicated a loss for Rapid Creek of about 7 cfs between Big Bend and Jackson Springs. The Geological Survey made a series of six discharge measurements in 1948 and one in 1949; these indicated a loss of about 5 cfs between the Lockhart Ranch and Jackson Spring. An average loss of 8 cfs has been tentatively accepted as approximately correct for this segment of Rapid Creek where the losses are measurable.

Jackson and Cleghorn Springs, which are above Canyon Lake and upstream from the State-owned fish hatchery, have a combined flow of approximately 14 cfs. Cleghorn Spring supplies the water for the fish hatchery, and Jackson Spring is one of the sources of water for Rapid City. For a few days in 1949, Jackson Spring was pumped at the rate of 9 cfs; it was observed that this pumpage affected Cleghorn Spring, which is about 150 ft to the north. A discharge measurement made below the hatchery on October 21, 1947, indicated a flow of 9½ cfs from Cleghorn Spring into Rapid Creek. Because the gain from the springs is nearly twice the estimated average loss from the creek, it is questionable whether the loss from the stream is the source of water for these springs. Part of the spring flow may be water from the Minnelusa sandstone or other formations.

The flow of Rapid Creek increases between the gaging station above Canyon Lake and Rapid City station. (See table 1.) Records for the 1947-48 water year indicate a gain of 22 cfs, for 1948-49 a gain of 25 cfs, and for 1949-50 a gain of 23 cfs; this gain includes the return flows from Leedy and Bennett Ditches and the natural runoff from South Canyon, Red Dale Gulch, and other catchment areas, as well as water from Jackson and Cleghorn Springs and waste water from the State-owned cement plant (about 3 cfs), which obtains its water from wells. Other relatively small springs in the Canyon Lake area contribute an estimated 2 cfs of additional inflow.

The effluent from the Rapid City sewage treatment plant enters Rapid Creek about 800 ft downstream from the gaging station on Rapid Creek below Hawthorn Ditch. The average measured flow through the plant is approximately 4½ cfs. According to city officials, the flow is sometimes 50 percent greater than the amount of water pumped through the municipal water system. This indicates that considerable ground water may seep into the sewer lines.

In addition to the above-mentioned stream-gaging stations, there are also stations on Rapid Creek below Little Giant Ditch near Rapid City, at Caputa, and near Farmingdale.

The stream-flow records for the various stream-gaging stations correlate closely for periods when there is no water diversion; however, considerable inflow occurs between gaging stations during the irrigation season. (See figs. 11 and 12.) Slight losses occur during the late autumn and winter months; some of this loss may be due to the freezing of some of the water and is regained during the spring break-up period. Local residents report that during dry years Rapid Creek has been dry at Farmingdale, but that the flow was continuous at Caputa. Recent stream-flow records substantiate the fact that losses do occur in that reach during part of the year. The reverse has been true when return flows of ground and surface water between Caputa and Farmingdale have been sufficient to cause a 10 cfs increase in flow at the lower station. Many canals remain full of water whether or not irrigation is in progress; in other canals the diverted water that is not used for irrigation is returned to the creek by means of surface drains or by percolation through the relatively pervious underlying materials.

The total diversions, the net flow after diversions, and the gains or losses between Rapid Creek gaging stations for the 1948 and 1949 water years are shown in table 1. The following peculiarities in the gains and losses in the flow of Rapid Creek are evident: the small gain (1948 water year) and small loss (1949 water year) between the station at Pactola and the station above Canyon Lake, the large gain in the 3-mile stretch from the station above Canyon Lake to the Rapid City gage, and the greater gains during the irrigation season (compared to the nonirrigation season) between the gaging station below Hawthorn Ditch and the gaging station near Farmingdale.

The actual discharge at each station, the diversions between gaging stations, and the computed net discharge after diversions are shown in figures 11 and 12; in addition, the cumulative diversion below Rapid City is indicated and is compared with the cumulative gain or loss between stations. The total amount of water diverted below Rapid City during September 1948 exceeded the flow at Rapid City by 1,130 acre-ft, or by more than one-third. (See fig. 11.) The cumulative gain during a month follows the same general trend as the cumulative diversions.

During the irrigation season, the inflow from outside the irrigated area is practically nonexistent; therefore the accumulated gains must be attributed to the surface return of unused water that was diverted for irrigation purposes (including that applied to the land in excess of field percolation capacity) and to ground-water seepage from irrigated lands.

Table 1.--Runoff, in acre-feet, at gaging stations in Rapid Creek basin, South Dakota, for water years ending September 30, 1948 and 1949

[Unpublished records, subject to revision]

Gaging station	Drainage area (square miles)	Year ending Sept.30, 1948 Total Oct.-Apr.	Year ending Sept.30, 1948 Total May-Sept.	Year ending Sept.30, 1948 Total Year	Year ending Sept.30, 1949 Total Oct.-Apr.	Year ending Sept.30, 1949 Total May-Sept.	Year ending Sept.30, 1949 Total Year
1. Castle Creek below Deerfield Dam[1]	95	2,818	3,247	6,065	2,994	3,689	6,683
2. Rapid Creek near Pactola[2]	315	13,630	15,450	29,080	14,570	17,050	31,620
3. Diversions	...	0	0	0	0	0	0
4. Gain (+) or loss (-) (line 6-2-3)	64	+1,100	+1,210	+2,310	-590	-800	-1,390
5. Net outflow	...	14,730	16,660	31,390	13,980	16,250	30,230
6. Rapid Creek above Canyon Lake[3]	379	14,730	16,660	31,390	13,980	16,250	30,230
7. Diversions[4]	...	(2,228)	(2,627)	(4,855)	(2,598)	(3,195)	(5,793)
8. Gain (+) (line 10-6)	31	+9,470	+6,600	+16,070	+10,490	+7,000	+17,490
9. Net outflow	...	24,200	23,260	47,460	24,470	23,250	47,720
10. Rapid Creek at Rapid City[3]	410	24,200	23,260	47,460	24,470	23,250	47,720
11. Diversions	...	1,623	5,311	6,934	1,551	5,377	6,928
12. Gain (+)	11	+1,483	+861	+2,344	+1,961	+1,887	+3,848
13. Net outflow	...	24,060	18,810	42,870	24,880	19,760	44,640
14. Rapid Creek below Hawthorn Ditch[3]	421	24,060	18,810	42,870	24,880	19,760	44,640
15. Diversions	...	1,572	7,737	9,309	2,212	7,786	9,998
16. Gain (+) or loss (-)	22	-338	+3,252	+2,914	+1,398	+1,987	+3,385
17. Net outflow	...	22,150	14,325	36,475	24,066	13,961	38,027
18. Rapid Creek below Little Giant Ditch[3]	443	22,150	14,325	36,475	24,066	13,961	38,027
19. Diversions	...	739	4,790	5,529	1,275	4,455	5,730
20. Gain (+)	65	+1,769	+4,048	+5,817	+3,559	+4,635	+8,194
21. Net outflow	...	23,180	13,583	36,763	26,350	14,141	40,491
22. Rapid Creek at Caputa[3]	508	23,180	13,583	36,763	26,350	14,141	40,491
23. Diversions	...	0	0	0	0	0	0
24. Gain (+)	...	+270	+2,970	+3,240	+3,150	+2,589	+5,739
25. Net outflow	...	23,450	16,553	40,003	29,500	16,730	46,230
26. Rapid Creek near Farmingdale[5]	...	23,450	16,553	40,003	29,500	16,730	46,230
Rapid City to Farmingdale (Rapid Valley unit)							
27. Total diversions	...	3,934	17,838	21,772	5,038	17,618	22,656
28. Total gain[6]	...	3,184	11,131	14,315	10,068	11,098	21,166
29. Difference = Crop use, transpiration, and evaporation. (Line 28-27)[7]	...	-750	-6,707	-7,457	+5,030	-6,520	-1,490

1 Period - last day of previous month to next to last day of month.

2 Period - next to last day of previous month to second to last day of month.

3 Period - calendar month.

4 Most of the water that is diverted into Leedy and Bennett Ditches is returned to Rapid Creek by surface channels above the gaging station at Rapid City; not included in computations as a loss.

5 Period - second day of month to first day of next month.

6 Part of the total gain probably is derived from the storage as ground water of irrigation water that was diverted during the preceding year or years.

7 This is a minimum difference and includes neither the part of direct precipitation that is lost by evapotranspiration nor the part that becomes ground-water recharge.

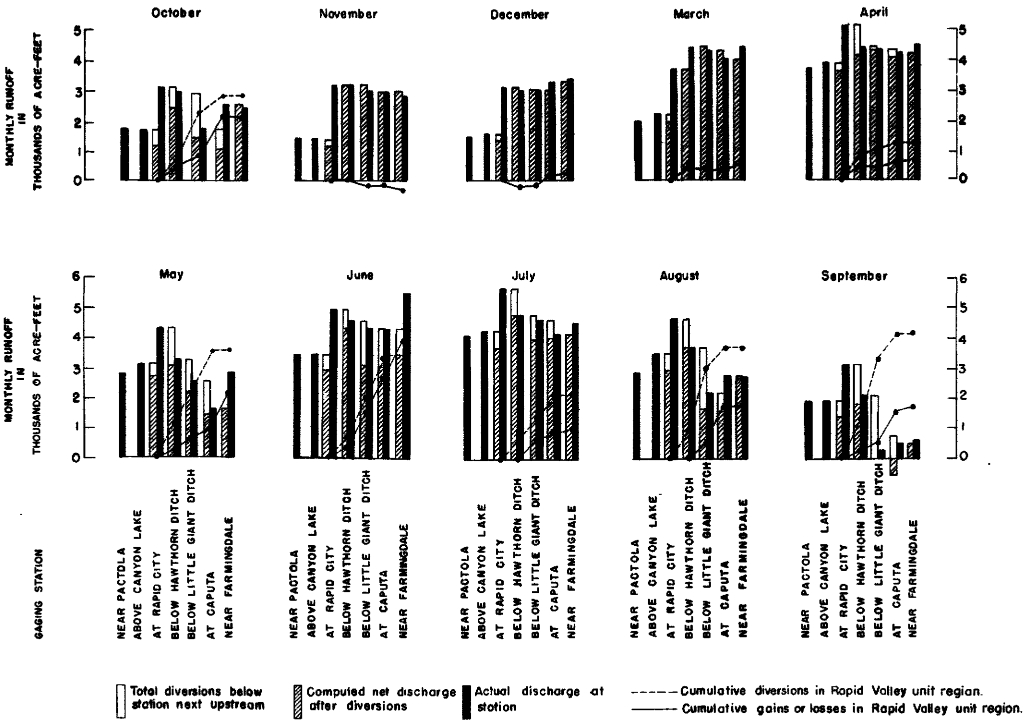

Figure 11.--Total monthly runoff and diversions for Rapid Creek, S. Dak., 1947-48.

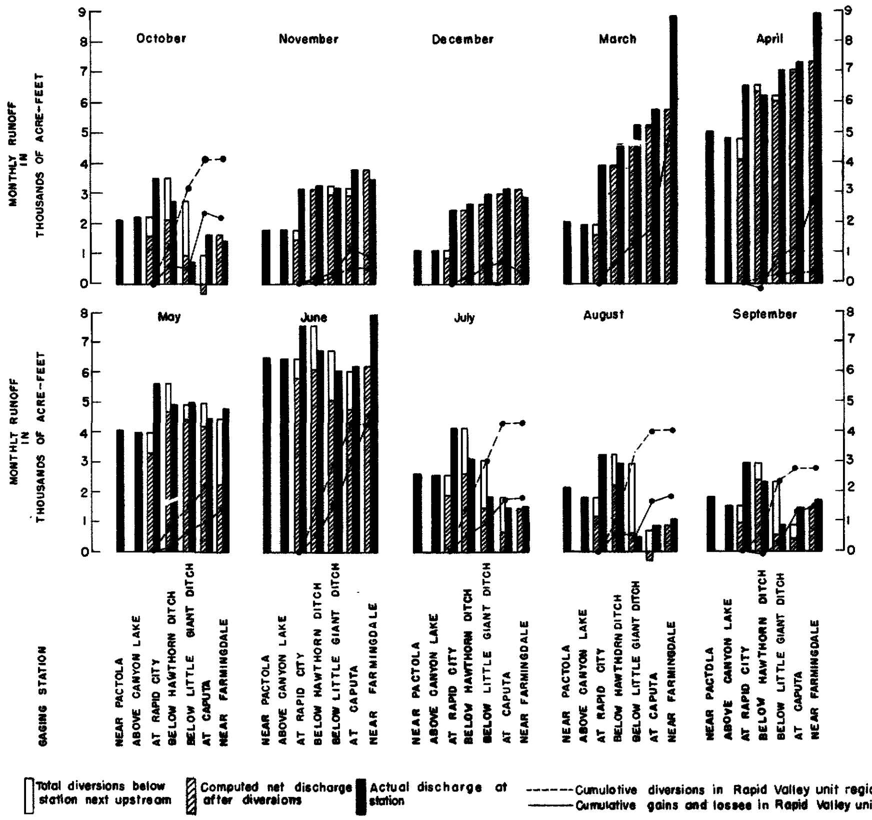

Figure 12.--Total monthly runoff and diversions for Rapid Creek, S. Dak., 1948-49.

CONCLUSION

At the present time much of the irrigated land in the Rapid Valley region is waterlogged. This condition is caused by leakage from unlined irrigation canals that traverse highly permeable deposits and by the application of irrigation water in excess of the transmission capacity of the natural drains and of the underlying aquifers. The waterlogging will become a problem that may be more widespread and serious if irrigation is extended to the new areas. A part of the irrigation water that will be applied to the higher terraces will seep downward through the now unsaturated underlying materials and eventually will reach the aquifers that underlie the lower lands, especially the flood-plain area, where it will probably cause waterlogging. Springs and seeps will appear along the lips of the terraces and along the contact of the terrace deposits with the underlying shale in many of the deeper draws. The alluvial deposits of the draws will be recharged by the discharge of the springs and seeps and will transmit water to the alluvial fans, which will transmit water to the flood-plain alluvium. Most of the larger draws will probably have flowing streams during the irrigation period.

Ditch losses can be reduced by lining the canals, especially where they are in gravel beds or in other highly permeable materials. Waterlogging of present areas could be reduced by construction of an adequate and integrated system of surface and subsurface drains. Such a system of drains would be used advantageously for the problem areas of this additional area for which irrigation is contemplated. This should be done either prior to or concurrent with further development and enlargement of the irrigated area. The lining of canals and the construction of adequate surface and subsurface drains would make more water available for the irrigation of additional lands not now under consideration. Drainage of the region cannot be accomplished completely without some system for the effective relief of the hydrostatic pressure in the basal gravels.

A much more detailed ground-water investigation of the Rapid Valley region is necessary if adequate drainage facilities are to be designed. The investigation should include the determination of the configuration of the underlying shale surface and the extent of various aquifers; the determinations of the permeability and transmissibility of the terrace-deposit and flood-plain aquifers; determinations of the quantity of ground water in storage and determination of the type of drainage measures that would best control and conserve the available water supply.

It is reported that no harmful salt concentrations exist in the Rapid Valley unit. Extension of irrigation to the remaining portion of the Sturgis terrace should not cause serious permanent concentrations of salt here or in the adjacent lower lands in the future. However, as the terrace deposits underlying the Rapid terrace are composed of finer materials and may possibly contain greater amounts of detrimental salts, a detailed study should be made of this area to determine if alkaline problems will accompany irrigation.

Further studies should be made to determine the quantitative potentialities of the water sources. It is estimated that a sustained yield of more than 10,000 acre-ft a year could be developed under the present irrigation regimen. Even if the water table were lowered as a result of improved irrigation and drainage facilities, a ground-water supply of 5,000 to 10,000 acre-ft might still be developed.

Measurement of the flow of Rapid Creek at gaging stations within the Rapid Valley unit indicates a large fluctuation in flow along the course of the creek during the irrigation season. This fluctuation largely reflects the withdrawal of water from the creek for irrigation use, the flow into the creek of waste water from irrigation, and ground-water seepage that has resulted directly from irrigation.

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Table 2.--Logs of test holes in the Rapid Valley unit, South Dakota

	Thickness (feet)	Depth (feet)
A1-8-4dad. 75 ft south of Iowa Canal on section line		
Clay, light-brown	6	6
Cobbles	.5	6.5
Clay, light-brown to yellow, some sand partings	6.5	13
Gravel with coarse sand (water bearing)	....	....
A1-8-10acd. 175 ft south of Hawthorn Canal on quarter-section line		
Clay, dark-brown	3	3
Clay, light-tan	1.5	4.5
Clay, light-tan with some yellow mottling	1.5	6
Gravel and sand; coarser with depth	2	8
Cobbles	....	....
(Water encountered at depth of 5 ft; rose to 2.74 ft below land surface.)		
A1-8-10adb. 200 ft north of Hawthorn Canal on quarter-section line		
Clay, dark-brown	4	4
Clay, yellow	3	7
Gravel and coarse sand	2	9
(Water encountered at depth of 6 ft; rose to 4.78 ft below land surface.)		
A1-8-11dda. 225 ft south of Hawthorn Canal, 25 ft west of section line		
Gumbo, black	1.5	1.5
Clay, light-brown	4.5	6
Cobble	1	7
Clay, yellow, with a few partings of sand	5	12

Table 2.--Logs of test holes in the Rapid Valley unit, South Dakota--Continued

	Thickness (feet)	Depth (feet)
A1-8-11dda--Continued		
Cobbles	1	13
Sand(?)	2	15
(Water encountered at depth of 12 ft; rose to 8.49 ft below land surface.)		
A1-8-14ada. NE corner of quarter-quarter section		
Gumbo, black	2	2
Clay, yellowish-brown	2	4
Cobbles	.5	4.5
(Water encountered in cobbles; rose to 0.92 ft below land surface.)		
A1-8-14daa. NE corner of quarter section		
Gumbo, black	1	1
Clay, brown	1.5	2.5
Clay, grayish-brown	3.5	6
Clay, red to dark-brown; some iron oxide covered pebbles	1.5	7.5
Cobbles	....	....
(Water level 7.06 ft below land surface.)		
A1-8-14dda. NE corner of quarter-quarter section		
Clay, dark-brown	3	3
Clay, tan, with gravel lens 6 in. thick at depth of 5.4 ft	2.4	5.4
Clay, tan; contains small pebbles at base	6.1	11.5
Cobbles	.5	12
(Water encountered at depth of 5.3 ft; rose to 3.54 ft below land surface.)		
A1-8-15abb. 75 ft south of intersection of State Route 40 and section-line road		
Gumbo, black to brown	3	3
Clay, yellow	2	5
Cobbles in a clay matrix	1	6
Clay, yellow, with partings of fine sand	2.5	8.5
Cobbles	1.1	9.6
(Water encountered at depth of 4 ft; rose to 1.75 ft below land surface.)		

Table 2.--Logs of test holes in the Rapid Valley unit, South Dakota--Continued

	Thickness (feet)	Depth (feet)
A1-8-23ada. NE corner of quarter-quarter section		
Gumbo, black to brown.....	2	2
Clay, yellow, grading downward into fine sand..	3.5	5.5
Sand, fine...............	1	6.5
Sand, coarse.............	1.5	8
Cobbles..................	2	10
(Water encountered at depth of 3.4 ft; rose to 2.11 ft below land surface.)		
A1-8-23daa. NE corner of quarter-quarter section		
Gumbo, black.............	1	1
Clay, reddish-brown.......	2	3
Clay, dark-brown..........	2	5
Clay, brick-red...........	1	6
Clay, grayish-brown and mottled red.............	2	8
Clay, gray and mottled yellow..................	1	9
Sand, fine...............	4	13
Cobbles at...............	....	13
(Water level 3.89 ft below land surface.)		
A1-9-7dcc.[1] SW corner of quarter section		
Clay.....................	10	10
Gravel, boulders, and sand	25	35
Shale....................	10	45
A1-9-8cdc.[1] SW corner of quarter-quarter section		
Gravel and boulders.......	20	20
Shale....................	15	35
A1-9-8ddc.[1] SW corner of quarter section		
Shale at.................	....	45
A1-9-9cdc.[1] SE corner of quarter section		
Clay and gravel...........	20	20
Shale....................	35	55
A1-9-10cdd.[1] SE corner of quarter section		
Clay and gravel...........	20	20
Gravel and boulders.......	15	35
A1-9-16aab.[1] NW corner of quarter-quarter section		
Clay.....................	16	16
Gravel and boulders.......	6	22

[1] **From Amerada Petroleum Corp.**

Table 2.--Logs of test holes in the Rapid Valley unit, South Dakota--Continued

	Thickness (feet)	Depth (feet)
A1-9-19bcb. NW corner of quarter-quarter section		
Clay.....................	7	7
Cobbles..................	5	12
(Water level 1.47 ft below land surface.)		
A1-9-34aca. SW corner of stockyard		
Clay, dark-brown..........	7	7
Clay, light-brown, with sand lenses.............	2	9
Clay, light-brown, with sand and small pebbles...	2.5	11.5
Cobbles at...............	....	11.5
(Water encountered at depth of 7.5 ft; rose to 6.8 ft below land surface.)		
A1-9-35bbc. NE corner of stockyard		
Gumbo, black to dark-brown	6	6
Clay, light-brown, with partings of sand.........	5.5	11.5
Cobbles at...............	....	11.5
(Water encountered at depth of 5.5 ft; rose to 2.5 ft below land surface.)		
A1-9-35bcb. SW corner of stockyard		
Clay, dark-gray to brown..	6	6
Loam, sandy, reddish-brown	6	12
Shale, dark-gray..........	1.5	13.5
Cobbles at...............	....	13.5
(Water encountered at depth of 6.0 ft; rose to 4.0 ft below land surface.)		

Table 3.--Measurements of the water level at piezometric stations in the Rapid Valley unit, South Dakota

[Feet below land-surface datum]

Date	Well no. and depth			
	1 (4.2)	2 (9.0)	3 (12.8)	4 (17.0)
A1-8-10dad1, 2, 3, 4. Measuring points are 1.15 ft above land surface and 3,141.2 ft above mean sea level				
Nov. 4, 1949	Dry	4.65	4.63	10.89
Dec. 29	Dry	6.04	6.27	9.78

Table 3.--Measurements of the water level at piezometric stations in the Rapid Valley unit, South Dakota--Continued

Date	Well no. and depth			
	1 (4.5)	2 (9.0)	3 (13.5)	4 (17.0)
A1-8-15aba1, 2, 3, 4. Measuring points are 0.35 ft above land surface and 3,098.4 ft above mean sea level				
Nov. 4, 1949	2.93	2.87	2.91	15.14
Dec. 29	3.44	3.41	4.09	12.18
Jan. 23, 1950	Dry	5.69	5.61	15.89
Apr. 17	Dry	5.36	5.43	14.86
May 26	Dry	3.72	3.85	13.88
June 21	2.97	2.96	3.49	13.42
July 12	3.49	3.17	3.23	13.09
Sept. 5	3.09	2.62	2.59	12.05
A1-8-15abb1, 2, 3, 4. Measuring points are 1.1 ft above land surface and 3,090.1 ft above mean sea level				
Nov. 4, 1949	0.46	0.47	1.03	7.43
Dec. 29	.77	.73	1.12	7.07
Jan. 23, 1950	a .37	a .37	2.16	2.68
Apr. 17	2.38	2.46	2.12	1.99
May 26	1.14	.76	.69	.09
June 21	.95	.69	1.02	.53
July 12	.95	1.16	1.14	.52
Sept. 5	1.35	1.02	.89	.88
A1-8-15bda1, 2, 3. Measuring points are 1.0 ft above land surface and 3,075.0 ft above mean sea level				
Nov. 4, 1949	Dry	5.23	8.05	.....
Dec. 29	Dry	5.78	8.15	.....
Jan. 23, 1950	Dry	5.81	8.17	.....
A1-9-19abd1, 2, 3. Measuring points are 0.95 ft above land surface and 3,048 ft above mean sea level				
Nov. 4, 1949	Dry	5.96	8.91	.....
Dec. 29	Dry	7.59	8.29	.....
Jan. 23, 1950	Dry	Dry	Dry	.....
June 21	Dry	Dry	10.23	.....
Sept. 5	Dry	6.01	9.19	.....
A1-9-19acc1, 2, 3, 4. Measuring points are 1.3 ft above land surface and 3,017.3 ft above mean sea level				
Nov. 4, 1949	0.72	0.79	0.54	0.63
Dec. 29	1.25	2.67	2.58	2.46
Jan. 23, 1950	Dry	3.79	3.71	3.68
Apr. 17	2.91	2.88	2.79	2.81
May 26	2.09	1.93	1.74	1.69
June 21	1.70	1.51	1.47	1.26

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Table 3.--Measurements of the water level at piezometric stations in the Rapid Valley unit, South Dakota--Continued

Date	Well no. and depth			
	1 (4.5)	2 (9.0)	3 (13.5)	4 (17.0)
A1-9-19acc1, 2, 3, 4--Continued				
July 13, 1950	2.07	1.92	1.81	1.66
Sept. 5	2.64	2.61	2.49	2.37
A1-9-19dbc1, 2, 3. Measuring points are 1.1 ft above land surface and 3,004.1 ft above mean sea level				
Nov. 4, 1949	1.83	1.80	1.39	.....
Dec. 29	1.52	1.48	1.45	.....
Jan. 23, 1950	2.43	2.53	2.57	.....
Apr. 17	2.23	2.27	2.21	.....
May 26	2.07	2.12	2.09	.....
June 21	1.88	1.92	1.87	.....
July 13	1.91	1.83	1.63	.....
A1-9-19dcd1, 2, 3. Measuring points are 0.7 ft above land surface and 2,995.7 ft above mean sea level				
Nov. 4, 1949	4.73	4.46	8.62	.....
Dec. 29	Dry	4.84	4.99	.....
Jan. 23, 1950	Dry	5.01	5.13	.....
Sept. 5	.....	5.37	.....	.....
A1-9-28caa1, 2, 3. Measuring points are 0.7 ft above land surface and 2,965.7 ft above mean sea level				
Nov. 4, 1949	Dry	5.78	5.32	.....
Dec. 29	Dry	5.03	5.47	.....
Jan. 20, 1950	Dry	5.47	5.67	.....
A1-9-28cad1, 2, 3, 4. Measuring points are 0.8 ft above land surface and 2,961.8 ft above mean sea level				
Nov. 4, 1949	Dry	5.44	5.49	14.71
Dec. 29	Dry	6.18	6.07	9.48
Jan. 20, 1950	Dry	6.27	6.21	8.68
Sept. 9	Dry	4.73	3.96	4.74
D1-10-8abc1, 2, 3, 4. Measuring points are 0.5 ft above land surface and 2,863.5 ft above mean sea level				
Nov. 4, 1949	3.28	2.25	9.32	1.86
Dec. 29	1.97	1.88	9.93	1.57
Jan. 19, 1950	2.41	2.33	9.48	2.24
Apr. 18	2.31	2.26	8.41	2.01
May 24	2.28	1.52	7.76	1.14
June 22	2.13	1.49	6.91	1.37
July 13	2.23	1.92	6.33	1.16
Sept. 6	3.00	2.39	5.37	2.90

Table 3.--Measurements of the water level at piezometric stations in the Rapid Valley unit, South Dakota--Continued

Date	Well no. and depth 1 (4.5)	2 (9.0)	3 (13.5)	4 (17.0)
D1-10-8caa1, 2, 3, 4. Measuring points are 0.5 ft above land surface and 2,863.5 ft above mean sea level				
Nov. 4, 1949	.....	3.00	3.99	12.97
Dec. 29	3.81	2.94	3.87	9.76
Jan. 19, 1950	3.47	3.38	3.22	9.47
Apr. 18	2.91	2.92	2.83	3.48
May 24	2.40	2.39	2.03	3.12
June 22	2.61	2.71	2.47	1.69
July 13	2.57	2.58	2.51	2.06
Sept. 6	Dry	3.82	3.57	3.28
D1-10-8cac1, 2, 3, 4. Measuring points are 0.5 ft above land surface and 2,864.5 ft above mean sea level				
Nov. 4, 1949	Dry	4.89	4.44	9.53
Dec. 29	Dry	4.11	4.10	9.48
Jan. 19, 1950	Dry	4.17	4.15	8.23
Apr. 18	.....	.....	3.67	8.04
May 24	.....	.....	3.10	8.44
June 22	.....	.....	3.61	8.26
July 13	.....	.....	3.56	7.82
Sept. 6	.....	.....	4.55	7.65

Table 4.--Measurements of the water level in observation wells in the Rapid Valley unit, South Dakota

[Feet below land-surface datum]

Date	Water level	Date	Water level
A1-8-3aad			
June 24, 1949	0.02	Jan. 30, 1950	0.37
Oct. 3	.11		
A1-8-3ccc			
June 24, 1949	4.02	Nov. 30, 1949	8.29
Sept. 19	4.13	Jan. 30, 1950	9.22
Oct. 3	7.25		
A1-8-3cdd			
June 24, 1949	8.33	Apr. 17, 1950	35.17
Sept. 19	18.99	May 26	36.46
Oct. 3	28.64	June 21	35.37
Nov. 30	31.89	July 12	35.28
Jan. 30, 1950	33.10	Sept. 5	29.89
A1-8-3ddc			
June 24, 1949	7.58	Oct. 3, 1949	28.21

Table 4.--Measurements of the water level in observation wells in the Rapid Valley unit, South Dakota--Continued

Date	Water level	Date	Water level
A1-8-4ccc			
June 23, 1949	3.40	Oct. 3, 1949	3.08
Sept. 19	3.13	Jan. 30, 1950	4.78
A1-8-4dad			
Aug. 23, 1949	13.93	Apr. 17, 1950	Dry
Sept. 19	14.13	May 26	Dry
Oct. 3	14.31	June 21	Dry
Dec. 28	14.37	July 12	Dry
Jan. 30, 1950	16.21	Sept. 5	12.82
A1-8-4dcd			
June 24, 1949	10.64	Jan. 30, 1950	13.11
Oct. 3	11.96		
A1-8-5bcc			
June 22, 1949	7.87	Apr. 17, 1950	10.66
Sept. 19	7.23	May 26	9.56
Oct. 3	10.91	June 21	9.17
Nov. 30	10.88	July 12	9.97
Jan. 30, 1950	11.13	Sept. 5	10.63
A1-8-5bdb1			
June 22, 1949	0.32	Oct. 3, 1949	5.92
Sept. 19	3.31	Jan. 3, 1950	6.89
A1-8-5bdb2			
June 22, 1949	3.50	Oct. 3, 1949	11.30
Sept. 19	5.67	Jan. 30, 1950	14.27
A1-8-5cab			
June 23, 1949	6.62	Oct. 3, 1949	9.08
Sept. 19	7.17	Jan. 30, 1950	11.81
A1-8-5cdb			
June 23, 1949	9.79	Jan. 30, 1950	12.23
Oct. 3	11.07		
A1-8-5cdc			
June 23, 1949	3.98	Jan. 30, 1950	6.66
Oct. 3	5.01		
A1-8-8aaa			
June 27, 1949	7.11	Jan. 30, 1950	9.73
Oct. 3	8.62		
A1-8-8aab1			
June 27, 1949	9.29	Apr. 17, 1950	12.51
Sept. 19	9.73	May 26	12.22
Oct. 3	11.02	June 21	8.23
Nov. 30	12.17	July 12	7.74
Jan. 30, 1950	13.23	Sept. 5	8.54

Table 4.--Measurements of the water level in observation wells in the Rapid Valley unit, South Dakota--Continued

Date	Water level	Date	Water level
A1-8-8aab2			
June 27, 1949	11.06	Jan. 30, 1950	12.17
Oct. 3	11.32		
A1-8-8aad			
June 27, 1949	11.28	Oct. 3, 1949	10.95
Sept.19	10.71	Jan. 30, 1950	12.61
A1-8-9abc			
Sept.24, 1949	5.42	Dec. 29, 1949	9.11
Oct. 3	8.19	Jan. 30, 1950	10.02
A1-8-9abd			
June 23, 1949	18.41	May 26, 1950	25.99
Oct. 3	19.51	June 21	17.83
Nov. 30	24.87	July 12	18.89
Jan. 30, 1950	25.14	Sept. 5	18.32
Apr. 17	25.14		
A1-8-9adb			
June 24, 1949	6.30	Nov. 30, 1949	11.44
Oct. 3	9.87	Jan. 30, 1950	12.73
A1-8-9bca			
June 27, 1949	11.21	Jan. 30, 1950	11.78
Oct. 3	10.35		
A1-8-9cab			
June 27, 1949	11.22	Jan. 30, 1950	12.07
Oct. 3	11.44		
A1-8-9cbb1			
June 27, 1949	10.24	Jan. 30, 1950	11.48
Oct. 3	10.97		
A1-8-9cbb2			
June 27, 1949	6.78	Jan. 30, 1950	7.31
Oct. 3	6.58		
A1-8-9cbc			
June 27, 1949	5.13	Jan. 30, 1950	6.09
Oct. 3	5.57		
A1-8-10aaa			
June 24, 1949	6.20	Oct. 3, 1949	29.26
Sept.19	21.71	Jan. 30, 1950	30.19
A1-8-10acd			
Aug. 23, 1949	2.62	Dec. 28, 1949	4.53
Sept.19	3.97	Jan. 30, 1950	5.64
Oct. 3	4.08		

Table 4.--Measurements of the water level in observation wells in the Rapid Valley unit, South Dakota--Continued

Date	Water level	Date	Water level
A1-8-10adb			
Aug. 23, 1949	4.78	Dec. 29, 1949	7.14
Sept.19	6.49	Jan. 30, 1950	8.33
Oct. 3	6.90		
A1-8-10bab			
June 24, 1949	12.11	Jan. 30, 1950	15.73
Oct. 3	14.47		
A1-8-10cbc			
June 29, 1949	4.77	Jan. 30, 1950	7.12
Oct. 3	6.89		
A1-8-10ccb			
June 29, 1949	4.45	Jan. 30, 1950	6.88
Oct. 3	5.78		
A1-8-11abc			
June 24, 1949	2.25	Oct. 3, 1949	3.23
Sept.19	2.16	Jan. 24, 1950	4.66
A1-8-11ccd			
June 24, 1949	11.39	Jan. 24, 1950	12.76
Oct. 4	10.42		
A1-8-11cdd1			
June 29, 1949	4.90	Jan. 24, 1950	4.92
Oct. 4	4.71		
A1-8-11dad			
June 29, 1949	21.74	Oct. 3, 1949	22.27
Sept.19	22.10	Jan. 24, 1950	27.61
A1-8-11dda			
Aug. 16, 1949	8.49	Apr. 17, 1950	Dry
Sept.19	Dry	May 26	Dry
Oct. 3	Dry	June 21	11.28
Nov. 30	Dry	July 12	13.77
Dec. 29	Dry	Sept. 5	11.02
Jan. 24, 1950	Dry		
A1-8-12ccc			
June 29, 1949	0.60	Oct. 3, 1949	3.74
Sept.19	3.27	Jan. 23, 1950	5.63
A1-8-13aac			
June 29, 1949	9.18	Oct. 4, 1949	15.70
A1-8-13cad			
Oct. 13, 1949	6.61	Jan. 23, 1950	7.55
Dec. 29	7.18		

Table 4.--Measurements of the water level in observation wells in the Rapid Valley unit, South Dakota--Continued

Date	Water level	Date	Water level
	A1-8-13dcd		
July 1, 1949	15.64	Jan. 23, 1950	18.98
Oct. 4	16.91		
	A1-8-14aaa		
June 29, 1949	3.47	Jan. 23, 1950	6.61
Oct. 3	4.98		
	A1-8-14ada		
Aug. 15, 1949	0.92	Apr. 17, 1950	4.37
Sept.19	3.23	May 26	3.84
Oct. 3	3.42	June 21	1.20
Nov. 30	4.48	July 12	2.78
Dec. 28	4.51	Sept. 5	3.05
Jan. 23, 1950	4.72		
	A1-8-14bbc		
June 30, 1949	9.92	Jan. 24, 1950	13.51
Oct. 4	11.76		
	A1-8-14ccd		
June 30, 1949	5.52	Jan. 23, 1950	8.96
Oct. 3	7.56		
	A1-8-14daa		
Aug. 14, 1949	7.06	Apr. 17, 1950	7.18
Sept.19	6.61	May 26	6.46
Oct. 3	6.53	June 21	4.84
Nov. 30	7.19	July 12	6.16
Dec. 29	7.31	Sept. 5	6.92
Jan. 23, 1950	7.61		
	A1-8-14dbb		
July 19, 1949	7.65	Jan. 23, 1950	10.46
Oct. 4	9.24		
	A1-8-14dda		
Aug. 14, 1949	3.59	Apr. 17, 1950	7.37
Sept.19	5.58	May 26	5.52
Oct. 3	5.96	June 21	4.30
Nov. 30	7.44	July 12	5.48
Dec. 28	7.90	Sept. 5	4.81
Jan. 23, 1950	8.74		
	A1-8-15abb		
Aug. 24, 1949	1.75	Dec. 28, 1949	0.60
Sept.19	.51	Jan. 23, 1950	.83
Oct. 3	.48		
	A1-8-15add		
Oct. 3, 1949	2.68	Dec. 28, 1949	4.01
Nov. 30	3.84	Jan. 23, 1950	3.89

Table 4.--Measurements of the water level in observation wells in the Rapid Valley unit, South Dakota--Continued

Date	Water level	Date	Water level
	A1-8-15add--Continued		
Apr. 17, 1950	4.79	July 12	2.02
May 26	1.93	Sept. 5	2.81
June 21	1.72		
	A1-8-15cbc		
Sept.26, 1949	2.19	Apr. 17, 1950	2.47
Oct. 3	1.77	May 26	2.23
Nov. 30	2.08	June 21	1.87
Dec. 28	2.19	July 12	2.30
Jan. 23, 1950	2.41	Sept. 5	3.06
	A1-8-15dca		
June 30, 1949	0.13	Jan. 23, 1950	1.15
Oct. 3	.17		
	A1-8-16aaa		
June 29, 1949	11.38	Oct. 3, 1949	11.25
	A1-8-16ada		
Sept.26, 1949	6.83	Apr. 17, 1950	8.41
Oct. 3	6.79	May 26	7.87
Nov. 30	7.64	June 21	7.62
Dec. 28	8.07	July 12	6.58
Jan. 23, 1950	8.51	Sept. 5	6.23
	A1-8-22daa		
June 30, 1949	9.76	Nov. 30, 1949	17.63
Sept.19	14.01	Jan. 23, 1950	19.26
Oct. 3	14.36		
	A1-8-23aaa		
Aug. 15, 1949	3.87	Apr. 17, 1950	3.11
Sept.19	2.41	May 26	2.27
Oct. 3	2.44	June 21	.99
Nov. 30	2.19	July 12	1.34
Dec. 29	2.41	Sept. 5	2.90
Jan. 23, 1950	3.32		
	A1-8-23ada		
Aug. 14, 1949	2.11	Apr. 17, 1950	3.03
Sept.19	2.42	May 26	1.42
Oct. 3	2.55	June 21	1.61
Nov. 30	2.28	July 12	1.74
Dec. 28	2.28	Sept. 5	2.14
Jan. 23, 1950	3.24		
	A1-8-23bbc		
June 30, 1949	3.63	Jan. 20, 1950	4.61
Oct. 3	4.32		

Table 4.--Measurements of the water level in observation wells in the Rapid Valley unit, South Dakota--Continued

A1-8-23daa

Date	Water level	Date	Water level
Aug. 14, 1949	3.89	Dec. 28, 1949	4.27
Sept.19	5.51	Jan. 23, 1950	4.83
Oct. 3	5.43	Apr. 17	3.19
Nov. 30	3.92	May 26	2.41

A1-8-24aba

Date	Water level	Date	Water level
July 1, 1949	9.40	Jan. 20, 1950	10.02
Oct. 4	9.47		

A1-8-24cac

Date	Water level	Date	Water level
June 30, 1949	9.36	Jan. 23, 1950	10.43
Oct. 4	9.31		

A1-8-24dbb1

Date	Water level	Date	Water level
June 30, 1949	9.07	Oct. 4, 1949	9.11

A1-8-26aba

Date	Water level	Date	Water level
June 30, 1949	10.90	Jan. 23, 1950	13.59
Oct. 4	12.19		

A1-9-7ccd

Date	Water level	Date	Water level
June 29, 1949	3.36	Oct. 4, 1949	3.61
Sept.20	3.60	Jan. 23, 1950	4.83

A1-9-9ccd

Date	Water level	Date	Water level
July 1, 1949	1.68	Oct. 5, 1949	0.71
Sept.20	.91	Jan. 23, 1950	1.41

A1-9-11ddd

Date	Water level	Date	Water level
Aug. 29, 1949	12.98	Jan. 23, 1950	13.34
Oct. 5	12.56		

A1-9-12ccc

Date	Water level	Date	Water level
Aug. 29, 1949	6.48	Nov. 30, 1949	6.43
Sept.19	6.51	Jan. 23, 1950	6.83
Oct. 6	6.59		

A1-9-13bba

Date	Water level	Date	Water level
Aug. 29, 1949	10.48	Oct. 6, 1949	10.51
Sept.19	10.39	Jan. 23, 1950	9.02

A1-9-19bbb

Date	Water level	Date	Water level
July 1, 1949	9.77	May 26, 1950	18.02
Oct. 5	14.35	June 21	17.61
Nov. 30	18.56	July 13	17.77
Jan. 23, 1950	19.17	Sept. 5	14.95
Apr. 17	18.71		

A1-9-19bcb

Date	Water level	Date	Water level
Sept.14, 1949	1.47	Nov. 30, 1949	2.38
Oct. 3	2.31	Dec. 28	2.47

Table 4.--Measurements of the water level in observation wells in the Rapid Valley unit, South Dakota--Continued

A1-9-19bcb--Continued

Date	Water level	Date	Water level
Jan. 23, 1950	4.11	June 22, 1950	2.37
Apr. 17	3.72	July 13	2.02
May 26	3.29	Sept. 5	1.61

A1-9-19cbc

Date	Water level	Date	Water level
June 30, 1949	7.49	May 26, 1950	6.72
Oct. 5	7.66	June 22	7.41
Nov. 30	7.35	July 12	7.64
Jan. 23, 1950	7.53	Sept. 6	7.47
Apr. 17	7.49		

A1-9-19dbc

Date	Water level	Date	Water level
Sept. 7, 1949	2.10	Dec. 28, 1949	2.21
Oct. 5	2.17		

A1-9-19dda

Date	Water level	Date	Water level
July 1, 1949	9.27	Jan. 23, 1950	9.63
Oct. 5	9.31		

A1-9-20dcb

Date	Water level	Date	Water level
Aug. 12, 1949	13.47	Nov. 30, 1949	14.94
Oct. 5	13.61	Jan. 20, 1950	17.31

A1-9-21abb

Date	Water level	Date	Water level
Aug. 14, 1949	2.38	Jan. 20, 1950	3.43
Oct. 5	2.76		

A1-9-26ddd

Date	Water level	Date	Water level
Aug. 24, 1949	10.16	Nov. 30, 1949	10.54
Sept.19	10.21	Dec. 28	10.67
Oct. 6	10.63		

A1-9-27ddb

Date	Water level	Date	Water level
Sept. 7, 1949	12.65	May 26, 1950	16.17
Oct. 3	14.51	June 22	13.21
Nov. 30	16.78	July 13	12.77
Jan. 20, 1950	18.27	Sept. 6	12.62
Apr. 17	17.44		

A1-9-28cbb

Date	Water level	Date	Water level
Oct. 13, 1949	6.35	May 26, 1950	4.64
Nov. 30	6.87	June 22	4.37
Dec. 28	7.13	July 13	4.17
Jan. 20, 1950	6.99	Sept. 6	5.97
Apr. 17	6.18		

A1-9-28dac

Date	Water level	Date	Water level
July 1, 1949	17.22	Jan. 20, 1950	21.54
Oct. 5	16.61		

Table 4.--Measurements of the water level in observation wells in the Rapid Valley unit, South Dakota--Continued

Date	Water level	Date	Water level
	A1-9-28dda		
July 26, 1949	11.98	Apr. 17, 1950	11.83
Sept.20	9.17	May 26	11.77
Oct. 5	9.32	June 22	11.54
Nov. 30	12.42	July 13	11.73
Jan. 20, 1950	14.19	Sept. 6	11.88
	A1-9-29bad		
July 1, 1949	2.69	Jan. 20, 1950	3.94
Oct. 5	2.71		
	A1-9-29cda		
Oct. 13, 1949	8.12	Jan. 20, 1950	7.58
Dec. 28	8.29		
	A1-9-29ddd		
Oct. 13, 1949	9.65	May 26, 1950	7.89
Nov. 30	7.52	June 22	7.49
Dec. 28	8.37	July 13	7.57
Jan. 20, 1950	7.49	Sept. 6	7.52
Apr. 17	7.77		
	A1-9-33bca		
Oct. 13, 1949	8.88	Jan. 20, 1950	11.66
Dec. 29	9.41		
	A1-9-34aca		
Sept.14, 1949	7.62	Jan. 20, 1950	7.20
Oct. 3	6.57	Apr. 17	7.01
Nov. 30	6.38	May 26	6.94
Dec. 28	6.24		
	A1-9-35adc		
July 13, 1949	4.29	Nov. 30, 1949	5.91
Oct. 5	5.80	Jan. 19, 1950	7.57
	A1-9-35baa		
July 13, 1949	7.42	Oct. 5, 1949	8.17
Sept.18	8.01	Jan. 20, 1950	9.31
	A1-9-35bbc		
Sept.14, 1949	3.16	Apr. 17, 1950	2.67
Oct. 3	3.17	May 26	2.43
Nov. 30	3.39	June 22	2.37
Dec. 28	3.51	July 13	3.46
Jan. 19, 1950	4.92	Sept. 6	3.87
	A1-9-35bcb		
Sept.14, 1949	8.12	Dec. 28, 1949	3.83
Oct. 3	2.39	Jan. 19, 1950	4.41

Table 4.--Measurements of the water level in observation wells in the Rapid Valley unit, South Dakota--Continued

Date	Water level	Date	Water level
	A1-9-35cdd		
July 13, 1949	6.63	Jan. 19, 1950	7.43
Oct. 5	6.69		
	A1-10-17ccc		
July 12, 1949	9.62	Apr. 17, 1950	6.96
Sept.20	9.37	May 26	5.59
Oct. 5	9.41	June 21	6.63
Nov. 30	8.94	July 13	5.99
Jan. 19, 1950	8.68	Sept. 6	8.25
	A1-10-18ccd		
Aug. 29, 1949	26.11	Oct. 3, 1949	26.20
Sept.19	26.17	Jan. 19, 1950	26.22
	A1-10-20bcb		
July 13, 1949	2.34	Oct. 6, 1949	1.98
Sept.20	2.17	Jan. 19, 1950	2.21
	A1-10-21ccc		
Sept.20, 1949	8.65	Apr. 18, 1950	5.94
Oct. 6	7.87	May 24	5.38
Nov. 19	8.51	June 21	6.35
Dec. 20	8.11	July 13	7.51
Jan. 18, 1950	8.09	Sept. 6	8.79
	A1-10-22ccc		
July 13, 1949	38.36	Oct. 6, 1949	38.93
Sept.20	38.58	Jan. 18, 1950	37.83
	A1-10-22dcd		
July 13, 1949	16.26	Oct. 6, 1949	16.27
Sept.19	16.31	Jan. 18, 1950	15.38
	A1-10-23dcd		
July 13, 1949	3.97	Apr. 17, 1950	3.08
Sept.20	4.07	May 24	2.97
Oct. 6	4.19	June 21	3.72
Nov. 29	4.37	July 13	3.88
Jan. 18, 1950	4.47	Sept. 6	4.39
	A1-10-27bad		
July 13, 1949	21.39	Apr. 18, 1950	21.17
Sept.20	21.60	May 24	21.04
Oct. 6	21.62	June 21	21.39
Nov. 29	21.94	July 13	21.67
Jan. 18, 1950	21.97	Sept. 6	21.62
	A1-10-27cbc		
July 14, 1949	10.97	Oct. 6, 1949	10.61
Sept.19	11.12	Nov. 29	13.14

Table 4.--Measurements of the water level in observation wells in the Rapid Valley unit, South Dakota--Continued

Date	Water level	Date	Water level
A1-10-27cbc--Continued			
Jan. 18, 1950	13.22	June 21, 1950	10.83
Apr. 18	11.33	July 13	11.03
May 24	10.05	Sept. 6	11.98
A1-10-31cdd			
July 19, 1949	11.08	Oct. 6, 1949	12.37
Sept.20	12.32	Jan. 19, 1950	12.32
A1-10-34aaa			
July 14, 1949	21.88	Oct. 6, 1949	21.92
A1-10-34bba			
July 14, 1949	17.41	Apr. 18, 1950	18.07
Sept.20	17.45	May 24	17.76
Oct. 6	17.51	June 21	17.77
Nov. 29	18.90	July 13	17.97
Jan. 18, 1950	19.19	Sept. 6	18.66
D1-9-1ada			
July 13, 1949	11.95	Apr. 17, 1950	15.82
Sept.20	13.87	May 26	15.73
Oct. 6	14.19	June 22	14.11
Nov. 30	14.18	July 13	12.87
Jan. 19, 1950	15.62	Sept. 6	13.09
D1-9-1daa			
July 11, 1949	7.29	Oct. 6, 1949	10.18
Sept.20	9.42	Jan. 19, 1950	11.05
D1-9-1ddd			
July 11, 1949	12.19	Oct. 6, 1949	14.22
Sept.20	13.81	Jan. 19, 1950	13.32
D1-9-2daa			
July 13, 1949	9.59	Oct. 6, 1949	9.72
D1-10-3ada			
July 14, 1949	10.04	Oct. 6, 1949	9.97
Sept.20	9.92		
D1-10-5cbd			
July 11, 1949	23.89	Apr. 17, 1950	34.41
Sept.20	29.78	May 26	34.43
Oct. 6	30.12	June 22	27.74
Nov. 30	27.80	July 13	26.83
Jan. 19, 1950	34.37	Sept. 6	28.06
D1-10-5ccc			
Oct. 5, 1949	12.66	May 26, 1950	Dry
Nov. 30	11.77	June 22	Dry
Dec. 28	13.07	July 13	Dry
Jan. 19, 1950	12.16	Sept. 6	Dry
D1-10-6bdb			
July 19, 1949	12.54	Jan. 19, 1950	13.86
Oct. 6	12.31		

Table 4.--Measurements of the water level in observation wells in the Rapid Valley unit, South Dakota--Continued

Date	Water level	Date	Water level
D1-10-6dad			
July 11, 1949	16.50	Jan. 19, 1950	17.63
Oct. 6	16.44		
D1-10-8abc			
July 27, 1949	4.39	May 24, 1950	3.17
Oct. 6	2.68	June 21	2.67
Nov. 30	2.53	July 13	2.84
Jan. 19, 1950	2.76	Sept. 6	3.68
Apr. 18	3.07		
D1-10-8add			
July 11, 1949	13.10	Oct. 6, 1949	11.41
Sept.19	12.58	Jan. 19, 1950	12.41
D1-10-8bcc			
Oct. 5, 1949	6.71	Dec. 28, 1949	8.11
D1-10-8cda			
Sept. 5, 1949	4.05	Dec. 28, 1949	3.53
Oct. 6	3.48	Jan. 19, 1950	3.23
D1-10-9aca			
July 19, 1949	2.32	Jan. 18, 1950	2.26
Oct. 6	2.21		
D1-10-9bca			
July 11, 1949	9.11	Jan. 19, 1950	11.32
Oct. 6	9.17		
D1-10-9cdd			
Sept.26, 1949	1.92	May 24, 1950	[a]0.40
Oct. 6	1.86	June 21	.14
Nov. 30	.01	July 13	.22
Dec. 28	1.44	Sept. 6	1.56
Apr. 18, 1950	[a].19		
D1-10-10cbc			
Sept.28, 1949	3.76	Apr. 18, 1950	Dry
Oct. 6	3.47	May 24	Dry
Nov. 30	Dry	June 21	3.61
Dec. 28	Dry	July 13	3.58
Jan. 18, 1950	Dry	Sept. 6	3.44
D1-10-14dbd			
July 14, 1949	28.19	Apr. 18, 1950	24.93
Sept.20	26.57	May 24	24.54
Oct. 6	25.84	June 21	23.68
Nov. 29	25.23	July 13	24.11
Jan. 18, 1950	25.22	Sept. 6	25.07
D1-10-15bba			
July 11, 1949	7.78	Oct. 6, 1949	7.79

[a] Feet above land-surface datum.

Table 5.--Records of wells and springs in the Rapid Valley unit, South Dakota

Type of well: B, bored, Dn, driven; Du, dug; J, jetted; Dr, drilled; Sp, perennial spring; Spi, spring during irrigation season.
Depth of well: Measured depths in feet and tenths; reported depths in feet.
Type of casing: Br, brick; C, concrete tile; CP, culvert pipe; P, pipe; R, rock; T, clay tile; W, wood.
Geologic source: Kp, Pierre shale; Qal, alluvium; Qrt, Rapid terrace deposits; Qst, Sturgis terrace deposits.
Method of lift: C, centrifugal; Cy, cylinder; P, jet pump.
Use of water: D, domestic; F, fire fighting; I, irrigation; In, industrial; O, observation; S, stock.
Measuring point: Tc, top of cover; Tca, top of casing; Tp, top of pipe. Altitudes interpolated from topographic maps.
Depth to water: Measured depths in feet, tenths, and hundredths; reported depths in feet.

Well no.	Owner or tenant	Type of well	Depth of well (feet)	Diameter of well (inches)	Type of casing	Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement (1949)
A1-8-3aad	A. Gluyas..............	Du	14.1	48	R	Qrt	Cy	S	Tc	2.8	3,217.8	2.82	6-24
3ccc	Bolman.................	Du	16.4	54	R	Qst	P	D	Tc	2.3	3,167.3	6.32	6-24
3cdd	E. C. DeGeest..........	Du	36.7	36	T	Qst	Cy	D,S	Tc	.0	3,179.0	8.33	6-24
3ddc	A. Gluyas..............	Du	44.9	72	R	Qst	Cy	D,S	Tca	.5	3,195.5	8.08	6-24
4cbd	R. Johnson.............	...	....	...	..	...	..	....	...	...	....	.....	
4ccc	J. Williams............	Du	13.9	48	C	Qal	P	D,S	Tc	1.1	3,135.1	4.50	6-23
4dad	U. S. Geol. Survey.....	J	18.0	3/4	P	Qst	..	O	Tp	2.6	3,186.6	16.53	8-23
4dcd	A. Walters.............	B	28.6	30	CP	Qst	P	D,S	Tca	.0	3,171.0	10.64	6-24
5bcc	....	Du	12.6	31	R	Qal	..	D,S	Tc	3.3	3,170.3	11.17	6-22
5bdb1	S. A. Fillingham.......	Du	10.4	48	W	Qal	P	S	Tc	.9	3,187.9	1.22	6-22
5bdb2	K. Levy................	Du	11.2	44	CP	Qal	P	D	Tca	2.0	3,186.0	5.50	6-22
5cab	.....do................	Du	16.9	60	W	Qal	P	D,S	Tc	-5.2	3,154.8	1.42	6-23
5cac	M. Bach................	D	24	6	CP	Qal	P	D	...	...	3,150	12	6-23
5cdb	M. Storrs..............	Du	15.1	14	CP	Qal	P	D,S	Tc	.8	3,150.8	10.59	6-23
5cdc	F. W. Merritt..........	Du	15.5	44	CP	Qal	P	D,S	Tca	1.0	3,146.0	4.98	6-23
5cdd	Sewage Disposal Plant..	Du	16	48	T	Qal	P	In	...	...	3,142	8	6-23
8aaa	E. A. Gates............	Du	12.2	30	..	Qal	Cy	D	Tc	.3	3,133.3	7.41	6-27
8aab1	.....do................	Du	20.6	42	C	Qal	C	D,In	Tca	.7	3,134.7	9.99	6-27
8aab2	.....do................	Du	15.0	30	..	Qal	Cy	D,S	Tc	.4	3,135.4	11.46	6-27
8aac	F. Apa.................	Du	22	48	C	Qal	P	D	...	...	3,137	18	6-27
8aad	C. Jackson.............	Du	16.3	48	C	Qal	P	D,S	Tc	.7	3,132.7	11.98	6-27
8adb	....	...	....	...	..	...	..	....	...	...	....	.....	

9aaa	D. A. Williams.........	Du	....	10	..	Qal	P	S	...	...	3,155	6	6-24
9abc	U. S. Geol. Survey.....	Du	14.0	3/4	P	Qal	..	O	Tp	.6	3,122.6	6.02	9-24
9abd	School................	Du	26.0	24	C	Qal	Cy	D	Tc	.9	3,130.9	19.31	6-23
9adb	H. Parson.............	Du	14.3	24	C	Qal	..	S	Tca	.5	3,120.5	6.80	6-24
9bca	C. Hayes..............	Du	15.6	40	T	Qal	P	S	Tc	.9	3,125.9	12.11	6-27
9cab	C. E. Morris..........	Du	13.5	38	R	Qal	P	D	Tc	.8	3,116.8	12.02	6-27
9cbb1	C. Casselman..........	Du	12.7	60	R	Qal	C	I	Tc	.5	3,115.5	10.74	6-27
9cbb2	W. Newcomb............	Du	9.2	15	CP	Qal	P	D	Tca	7.0	3,124	13.78	6-27
9cbb3	M. Fillingham.........	Du	16	60	C	Qal	P	D,S	...	...	3,113	13	6-27
9cbc	Slator................	Du	6.0	24	CP	Qal	Cy	D	Tc	2.2	3,117.2	7.33	6-27
10aaa	C. E. Balcom..........	Du	17.2	48	Br	Qst	Cy	D,S	Tc	1.0	3,179	7.20	6-24
10acd	U. S. Geol. Survey.....	J	9.0	3/4	P	Qst	..	O	Tp	2.2	3,147.2	4.82	8-23
10adb	.....do...............	Dn	9.0	3/4	P	Qst	..	O	Tp	2.3	3,151.3	7.08	8-23
10bab	Etzler................	Du	43.2	...	..	Qst	Cy	D,S	Tc	1.0	3,165.0	13.11	6-24
10cbb	W. Hallis.............	Du	12	36	..	Qal	P	S,I	...	...	3,108	6	6-24
10cbc	Remmerent.............	Du	11.9	36	W	Qal	P	S,I	Tc	.9	3,106.9	5.67	6-29
10ccb	B. Lewis..............	Du	24.3	40	R	Qal	Cy	D,S	Tc	.5	3,108.5	4.95	6-29
10ddc	....	Sp	....	...	..	...	..	....	...	...	....	.....	
11abc	Mahlon & Haines........	Du	23.8	72	R	Qst	Cy	D,S	Tc	2.0	3,174.0	4.25	6-24
11ccd	Haines................	Du	16.6	42	Br	Qst	P	D,S	Tc	1.0	3,126.0	12.39	6-29
11cdd1	C. Knapp..............	Du	9.6	24	C	Qst	P	D,S	Tca	2.5	3,120.5	7.40	6-29
11cdd2	....	Sp	....	...	..	...	..	....	...	...	....	.....	
11dad	J. Harth..............	B	34.0	24	C	Qst	Cy	D,S	Tc	1.0	3,146.0	22.74	6-29
11dda	U. S. Geol. Survey.....	Du	15	3/4	P	Qst	..	O	Tp	3.2	3,136.2	11.69	8-16
12ccc	Wilsey................	Du	4.0	36	R	Qst	P	D,S	Tc	.7	3,116.7	1.30	6-29
12dcd	R. W. Morris..........	Du	28.0	38	R	Qrt	P	D,S	Tc	.0	3,155.0	22.77	6-29
13aac	C. E. Morris..........	Du	20.5	28	R	Qrt	Cy	D,S	Tc	.2	3,155.2	9.38	6-29
13bdc	....	Spi	....	...	..	...	..	....	...	...	....	.....	
13cab	....	Spi	....	...	..	...	..	....	...	...	....	.....	
13cac	....	Spi	....	...	..	...	..	....	...	...	....	.....	
13cad	U. S. Geol. Survey.....	Dn	11.5	3/4	P	Qal	..	O	Tp	.7	3,070.7	7.31	10-13
13cba	....	Spi	....	...	..	...	..	....	...	...	....	.....	
13cbb1	G. Bitz...............	Du	10	48	C	Qst	P	D,S	Tc	...	3,100	8	6-30
13cbb2	....	Spi	....	...	..	...	..	....	...	...	....	.....	
13cbd	....	Spi	....	...	..	...	..	....	...	...	....	.....	
13dcd	E. Deluridge..........	Du	22.4	40	C	Qst	Cy	S	Tc	.3	3,081.3	15.94	7-11
14aaa	R. E. Marsh...........	Du	8.4	...	..	Qst	P	D,S	Tc	1.0	3,114.0	4.47	6-29
14ada	U. S. Geol. Survey.....	Dn	6.5	3/4	P	Qst	..	O	Tp	2.5	3,106.5	3.42	8-15
14bbc	D. Murphy.............	Du	15.3	30	Br	Qst	P	D,S	Tca	1.0	3,111.0	10.92	6-30
14ccd	J. Birnhoun...........	Du	17.5	24	R	Qal	P	D,S	Tc	.9	3,050.9	6.42	6-30
14daa	U. S. Geol. Survey.....	Dn	10	3/4	P	Qst	..	O	Tp	3.8	3,105.8	10.86	8-15

Table 5.--Records of wells and springs in the Rapid Valley unit, South Dakota--Continued

Well no.	Owner or tenant	Type of well	Depth of well (feet)	Diameter of well (inches)	Type of casing	Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement (1949)
A1-8-14dbb	....	Du	12.9	48	R	Qal	P	D,S	Tc	1.0	3,076.0	8.65	7-19
14dda	U. S. Geol. Survey.....	Dn	12	3/4	P	Qal	..	O	Tp	1.4	3,056.4	4.99	8-14
15abb	.....do...............	Dn	9.6	3/4	P	Qal	..	O	Tp	2.8	3,093.8	4.55	8-24
15add	.....do...............	Dn	7.0	3/4	P	Qal	..	O	Tp	2.0	3,084.0	4.68	10- 3
15cbc	.....do...............	Dn	12.0	3/4	P	Qal	..	O	Tp	.7	3,078.7	2.89	9-26
15dca	Taylor.................	Dr	35	6	CP	Qal	P	D	...	...	3,066	10	6-30
15dcb	.....do...............	Du	4.3	48	CP	Qal	P	D,S	Tc	2.0	3,067.0	2.13	6-30
16aaa	R. Hibbs..............	Du	24	24	..	Qal	Cy	D,S	Tc	.5	3,095.5	11.88	6-29
16ada	U. S. Geol. Survey.....	Dn	12	3/4	P	Qal	..	O	Tp	.7	3,087.7	7.53	9-26
22daa	V. Jeppson............	Dr	18.0	15	C	Qal	..	D	Tca	1.1	3,051.1	10.86	6-30
23aaa	U. S. Geol. Survey.....	Dn	12.0	3/4	P	Qal	..	O	Tp	.7	3,039.7	4.57	8-15
23ada	.....do...............	Dn	10.0	3/4	P	Qal	..	O	Tp	3.7	3,035.8	5.81	8-14
23bbc	Morris................	Du	9.5	36	R	Qal	Cy	D,S	Tc	.5	3,040.5	4.13	6-30
23daa	U. S. Geol. Survey.....	Dn	13.5	3/4	P	Qal	..	O	Tp	2.2	3,029.2	6.09	8-14
24aba	C. E. Morris..........	Du	14.0	18	CP	Qal	P	D,S	Tc	.4	3,043.4	9.80	7- 1
24cac	A. Jones..............	Du	12.5	18	CP	Qal	P	D,S	Tca	-5.0	3,016.0	4.36	6-30
24dbb1	....	Du	9.0	18	C	Qal	P	D,S	Tca	-3.0	3,019	6.07	6-30
24dbb2	....	Sp	.....	...	..	...	..	....	...	...	....	.....	
26aba	L. A. Withee..........	Du	16.3	24	R	Qal	Cy	S	Tc	1.1	3,030.1	12.00	6-30
26cbc	F. Morris.............	Dr	48.5	6	CP	...	Cy	D,S	Tc	.5	....	4.72	6-30
A1-9-7ccd	....	Du	14.5	23	CP	Kp	Cy	S	Tca	2.6	3,152.6	5.96	6-29
7dcc	Amerada Petroleum Corp.	Dr	45	...	..	...	..	....	...	...	....	.....	
8cdc	.....do...............	Dr	35	...	..	...	..	....	...	...	3,185	.....	
8ddc	.....do...............	Dr	45	...	..	...	..	....	....	...	....	.....	
9ccd	....	Du	2.0	20	CP	Qal	..	S	Tca	1.7	....	3.38	7- 1
9cdc	Amerada Petroleum Corp.	Dr	55	...	..	...	..	....	...	...	....	.....	
10cdd	.....do...............	Dr	35	...	..	...	..	....	...	...	....	.....	
10ddd	.....do...............	Dr	37	...	..	...	..	....	...	...	....	.....	
11ddd	....	Du	27.4	48	R	Qrt	Cy	S	Tc	1.2	....	14.18	8-29
12ccc	....	Du	20.4	48	R	Qrt	Cy	S	Tc	.0	....	6.48	8-29

13bba	....	Du	24.2	72	R	Qrt	Cy	D,S	Tc	.0	....	10.48	8-29
16aab	Amerada Petroleum Corp.	Dr	22	...	..	...	..	....	...	...	....	.....	
18bcd	H. Morris.............	Du	18	15	C	Qrt	P	D,S	...	.0	3,112.0	.00	6-29
19bbb	A. P. Frank...........	Du	32.0	48	R	Qst	P	D,S	Tc	.0	3,067.0	9.77	7- 1
19bcb	U. S. Geol. Survey.....	Dn	12.0	3/4	P	Qal	..	O	Tp	1.6	3,029.6	3.07	9-14
19cbc	....	Du	9.4	36	R	Qal	..	S	Tc	.7	3,010.7	8.19	6-30
19dbc	U. S. Geol. Survey.....	Dn	4.8	...	..	Qal	..	O	Tc	.0	3,002.0	2.10	9- 7
19dda	A. Heavlin.....	Du	14.8	18	R	Qal	Cy	D,S	Tc	.5	3,003.5	9.77	7- 1
20dcb	....	Du	18.7	50	R	Qal	..	S	Tc	.0	3,019.0	13.47	8-12
21abb	....	Du	8.3	48	R	Qal	..	S	Tc	.0	3,088.0	2.38	8-14
25cbb	....	Sp	....	...	..	...	..	....	...	...	....	.....	
26add	....	Sp	....	...	..	...	..	....	...	...	....	.....	
26ddd	U. S. Geol. Survey.....	Dn	13.5	3/4	P	Qst	..	O	Tp	.0	2,976.0	10.16	8-24
27ddb	....	Du	27.2	40	R	Qal	..	S	Tc	.9	2,963.9	13.55	9- 7
28cbb	U. S. Geol. Survey.....	Dn	9.0	3/4	P	Qal	..	O	Tp	.6	2,969.6	6.95	10-13
28dac	Hokom.................	Du	27.1	40	R	Qal	..	D	Tc	.8	2,977.8	18.02	7- 1
28dda	.....do...............	Du	18.2	24	CP	Qal	Cy	S	Tc	1.0	2,966.0	12.98	7-26
29bad	L. C. Myers...........	Du	5.0	48	CP	Qal	P	S	Tc	1.4	2,984.4	4.09	7- 1
29cda	U. S. Geol. Survey.....	Dn	13.5	3/4	P	Qal	..	O	Tp	.6	2,974.6	8.72	10-13
29ddd	.....do...............	Dn	13.5	3/4	P	Qal	..	O	Tp	.6	2,970.6	10.25	10-13
33bca	.....do...............	Dn	13.5	3/4	P	Qal	..	O	Tp	.6	2,965.6	9.48	10-13
34aca	.....do...............	Dn	12.0	3/4	P	Qal	..	O	Tp	2.3	2,936.3	9.92	9-14
35adc	W. H. Jones...........	Du	14.6	36	CP	Qal	Cy	S	Tc	1.3	2,926.3	5.59	7-13
35baa	L. Jones..............	Du	12.5	...	..	Qal	Cy	S	Tc	.0	2,950.0	7.42	7-13
35bbc	U. S. Geol. Survey.....	Dn	13.5	3/4	P	Qal	..	O	Tp	2.5	2,939.5	5.66	9-14
35bcb	.....do...............	Dn	13.5	3/4	P	Qal	..	O	Tp	1.8	2,932.8	9.92	9-14
35cdd	J. Lutheron...........	Du	13.9	24	CP	Qal	Cy	D,S	Tc	.4	2,920.4	7.03	7-13
A1-10-17ccc	....	Du	18.2	40	R	Kp	..	S	Tca	.5	3,153.5	10.12	8-12
18ccd	....	Du	26.8	72	R	Qrt	..	D,S	Tc	.0	3,170.0	26.11	8-29
19ddc	D. Dingeman...........	Dn	52	24	C	Qrt	..	D,S	...	...	3,105	42	7-13
20bcb	C. Crisman............	Du	14.5	24	CP	Kp	Cy	D,S	Tc	2.0	3,127.0	4.34	7-13
21ccc	....	Du	15.2	24	CP	Kp	Cy	S	Tc	1.2	3,088.2	9.85	9-20
22ccc	B. A. Dockins.........	Du	44.0	48	R	Qrt	Cy	D,S	Tc	.5	3,137.5	38.86	7-13
22dcd	G. Aggar..............	Du	59.4	24	CP	Qrt	P	D,S	Tc	2.0	3,124.0	18.26	7-13
22dda	....	Sp	....	...	..	...	..	....	...	...	....	.....	
23dcd	....	Du	8.7	...	..	Qal	Cy	S	Tc	1.0	3,125.0	4.97	7-13
25bcc	C. Forest.............	Du	28	36	R	Qrt	P	D,S	...	...	3,093	26	7-14
26bcb1	....	Sp	....	...	..	...	..	....	...	...	....	.....	
26bcb2	....	Sp	....	...	..	...	..	....	...	...	....	.....	
26cba	....	Sp	....	...	..	...	..	....	...	...	....	.....	
26cdc	....	Sp	....	...	..	...	..	....	...	...	....	.....	

Table 5.--Records of wells and springs in the Rapid Valley unit, South Dakota--Continued

Well no.	Owner or tenant	Type of well	Depth of well (feet)	Diameter of well (inches)	Type of casing	Geologic source	Method of lift	Use of water	Measuring point: Description	Measuring point: Height above land surface (feet)	Measuring point: Altitude above mean sea level (feet)	Depth to water level below measuring point (feet)	Date of measurement (1949)
A1-10-27bad	....	Du	38.0	24	CP	Qrt	Cy	S	Tc	1.5	3,108.5	22.89	7-13
27cbc	....	Du	21.0	50	R	Qrt	Cy	S	Tc	.0	3,063.0	10.97	7-14
29bcd	....	Sp	....	...	..	...	..	....	...	...	....	.....	
31cdd	S. E. Swanson..........	Du	19.1	48	R	Qal	Cy	D,S	Tc	1.0	2,931.0	12.08	7-19
34aaa	H. Kilman.............	Du	39.0	36	R	Qrt	Cy	D,S	Tc	.3	3,050.3	22.18	7-14
34bba	....	Du	23.7	24	R	Kp	Cy	....	Tc	.3	3,040.3	17.71	7-14
D1-9-1ada	Community of Caputa....	Du	19.4	60	R	Qal	..	F	Tc	.0	2,903.0	11.95	7-13
1daa	Sanders................	Du	13.8	36	..	Qal	Cy	D	Tc	.3	2,895.3	7.59	7-11
1ddd	J. Sanders.............	Du	17.1	48	R	Qal	P	D,S	Tc	.2	2,893.2	12.39	7-11
2daa	W. Lemben.............	Du	14.4	50	R	Qal	Cy	D,S	Tc	.6	2,916.6	10.19	7-13
D1-10-3ada	Hanawinckel............	Du	19.0	24	CP	Qrt	P	D,S	Tca	1.4	3,001.4	11.44	7-14
5cbd	L. O. Wisehart.........	Du	40.0	50	R	Qst	P	D,S	Tc	.0	2,920.0	23.89	7-11
5ccc	U. S. Geol. Survey.....	Dn	16.3	3/4	P	Qal	..	O	Tp	1.7	2,882.7	14.36	10- 5
6bdb	Sterrett...............	Du	28.7	40	R	Qal	P	D,S	Tc	.0	2,909.0	12.54	7-19
6dad	W. Hart................	Du	31.4	50	R	Qal	Cy	D,S	Tc	1.0	2,911.0	17.50	7-11
8abc	....	Du	10.0	48	Br	Qal	..	S	Tc	1.5	2,865.5	5.89	7-27
8add	H. C. Hamm.............	Du	18.9	30	R	Qal	Cy	D	Tc	.3	2,867.3	13.40	7-11
8bcc	U. S. Geol. Survey.....	Dn	13.5	3/4	P	Qal	..	O	Tp	.6	2,872.6	7.31	10- 5
8cda	.....do................	Dn	13.5	3/4	P	Qal	..	O	Tp	.7	2,861.7	4.75	9- 5
8cdd	....	Sp	....	...	..	...	..	....	...	...	....	.....	
8ddc	....	Sp	....	...	..	...	..	....	...	...	....	.....	
8ddd	....	Sp	....	...	..	...	..	....	...	...	....	.....	
9aca	Taylor.................	Du	13.5	36	R	Qal	Cy	D,S	Tc	1.1	2,859.1	3.42	7-19
9bca	J. Huntington..........	Du	24.6	30	T	Qal	P	D,S	Tc	-4.6	2,868.4	4.51	7-11
9cdd	U. S. Geol. Survey.....	Dn	7.0	3/4	P	Qal	..	O	Tp	2.0	2,835.0	3.92	9-26
10cbc	.....do................	Dn	8.5	3/4	P	Qal	..	O	Tp	3.4	2,848.4	7.16	9-28
14dbd	Community of Farmingdale	Du	29.2	36	W	Qal	Cy	....	Tc	1.2	2,778.2	29.39	7-14
15bba	Hammerquist............	Du	11.4	18	C	Qal	P	D	Tc	1.9	2,807.9	9.68	7-11
16bac	....	Sp	....	...	..	...	..	....	...	...	....	.....	
16bbd	....	Sp	....	...	..	...	..	....	...	...	....	.....	
D1-11-19cb	A. Balman..............	Du	18.0	30	C	Qal	Cy	D,S	Tc	2.2	....	13.72	7-20
28cb	....	Du	9.8	48	R	Qal	..	....	Tc	.2	....	6.44	7-20
28cc	....	Du	17.1	36	C	Qal	Cy	S	Tc	.5	....	14.24	7-20
29bc	E. H. Taylor...........	Du	13.5	30	C	Qal	Cy	S	Tc	1.0	....	12.20	7-20

GEOLOGIC MAP OF RAPID VALLEY UNIT, SOUTH DAKOTA SHOWING CONTOUR LINES ON THE WATER TABLE OR PIEZOMETRIC SURFACE, OCTOBER 1949

TOPOGRAPHIC MAP OF THE RAPID VALLEY UNIT, SOUTH DAKOTA
SHOWING LOCATION OF VELLS AND SPRINGS AND AREAS WHERE DEPTH
TO WATER TABLE OR PIEZOMETRIC SURFACE IS LESS THAN 5 FEET
OCTOBER 1949