PRELIMINARY APPRAISAL OF GROUND WATER IN AND NEAR THE ANCESTRAL MISSOURI RIVER VALLEY, NORTHEASTERN MONTANA

By Gary W. Levings

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UNITED STATES DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS

The following factors can be used to convert inch-pound units in this report to the International System (SI) of Units.

Multiply inch-pound unit	By	To obtain SI unit
acre	4,047	square meter
acre-foot	1,233	cubic meter
foot	0.3048	meter
gallon per minute	0.06309	liter per second
gallon per minute per foot	0.2070	liter per second per meter
inch	25.40	millimeter
mile	1.609	kilometer
square mile	2.590	square kilometer

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by the equation:

$$°F = 9/5\ (°C) + 32$$

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ABSTRACT

A preliminary appraisal was conducted in the vicinity of the ancestral Missouri River valley in northeastern Montana to describe the ground-water resources and to establish a data base for the area. The data base then could be used for future evaluation of possible changes in water levels or water quality.

In this area, consolidated aquifers are the Upper Cretaceous Fox Hills-lower Hell Creek aquifer and the overlying Paleocene Fort Union Formation. Unconsolidated aquifers are Pleistocene terrace gravel and glacial deposits and Holocene alluvium. Aquifers are recharged by precipitation, infiltration of streamflow, and possibly leakage from lakes and potholes. Ground water moves from topographically higher areas toward the ancestral valley, then along the ancestral valley to the southwest. Water is discharged from aquifers by evapotranspiration, springs and seeps, movement directly into streams and lakes, and wells. Average well yields are greatest for irrigation wells completed in outwash gravel (886 gallons per minute).

Eighteen wells were completed in various aquifers to monitor potential long-term changes in water levels and water quality. Observed water levels declined about 2 feet or less during the study (1982-85). Chemical analysis of ground-water samples indicated that concentrations of some dissolved constituents exceeded U.S. Environmental Protection Agency primary and secondary standards for drinking water used for public supply.

INTRODUCTION

Background

In late 1980 and 1981, 15 center-pivot irrigation systems were installed near Dagmar and Coalridge, in northeastern Montana. The wells for these center-pivot systems, along with three previously drilled irrigation wells, were thought to be completed in gravel deposits of the ancestral Missouri River valley. The effects of ground-water withdrawal from these wells on water levels in the area was of major concern to some residents.

Purpose and Scope

This report describes the results of a preliminary appraisal of ground water in the vicinity of the ancestral Missouri River valley. The study was conducted from 1982 through the spring of 1985 by the U.S. Geological Survey in cooperation with the Montana Bureau of Mines and Geology, U.S. Bureau of Indian Affairs, and U.S. Fish and Wildlife Service. The primary objective of the investigation was to describe the ground-water resources of the area including occurrence, recharge, movement, discharge, well yields, water-level fluctuations, and water quality. A secondary objective was to inventory wells and to case test holes that could be monitored after this study to determine potential effects of continued or changed ground-water withdrawals on water levels and water quality of the affected aquifers.

From 1982 to 1984, 125 wells were inventoried and 75 water samples were collected for chemical analysis. Measurement of water levels in a network of 18 observation wells was begun in the fall of 1982. In 1983 and 1984, discharge was measured at most of the irrigation wells. A test-drilling program was started in the summer of 1984. Several of the test holes were cased and developed, and water-quality samples were collected. These wells were added to the observation-well network and four wells were equipped with recorders. The applicability of using surface geophysical techniques to determine depth to bedrock in the ancestral Missouri River valley was tried at three test-hole locations but was not successful.

Location and Extent of Study Area

The 600-square-mile study area is located in southeastern Sheridan and extreme northeastern Roosevelt Counties in northeastern Montana (fig. 1). The communities of Medicine Lake, Homestead, Dagmar, Coalridge, and Westby are included in the area. The study area includes that part of the ancestral Missouri River valley from near Homestead to the North Dakota State line.

Precipitation

The region is semiarid; the average annual precipitation, based on 37 years of record, is 13.5 inches at Medicine Lake 3SE and 13.8 inches at Westby. Most of the precipitation generally occurs during the spring and summer from intense, localized rainstorms. Bar graphs of annual precipitation for 1948-84 show that precipitation has been less than average during 6 of the last 8 years at Medicine Lake and 5 of the last 8 years at Westby (fig. 2).

Location-Numbering System

In this report, locations are numbered according to geographic position within the rectangular grid system used by the U.S. Bureau of Land Management (fig. 3). The location consists of as many as 14 characters. The first three characters specify the township and its position north (N) of the Montana Base Line. The next three characters specify the range and its position east (E) of the Montana Principal Meridian. The next two characters are the section number. The next one to four characters designate the quarter section (160-acre tract), quarter-quarter section (40-acre tract), quarter-quarter-quarter section (10-acre tract), and quarter-quarter-quarter-quarter section (2.5-acre tract), respectively, in which the well is located. The subdivisions of the section are designated A, B, C, and D in a counterclockwise direction, beginning in the northeast quadrant. The last two digits form a sequence number based on the order of inventory of wells or test holes in the same 2.5-acre tract. For example, well 30N55E16BBBA01 is the first well inventoried in the NE1/4NW1/4NW1/4NW1/4 sec. 16, T. 30 N., R. 55 E.

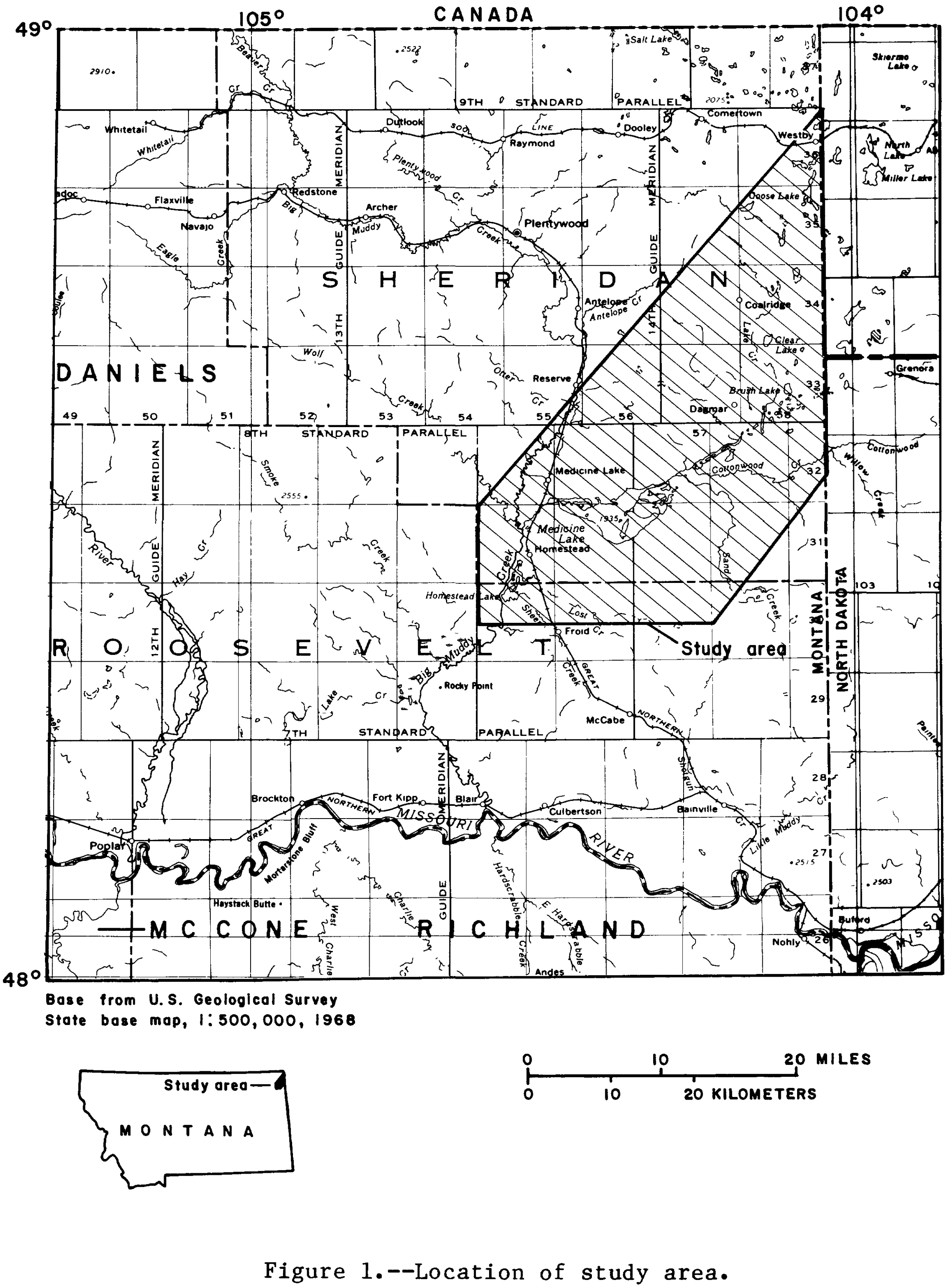

Figure 1.--Location of study area.

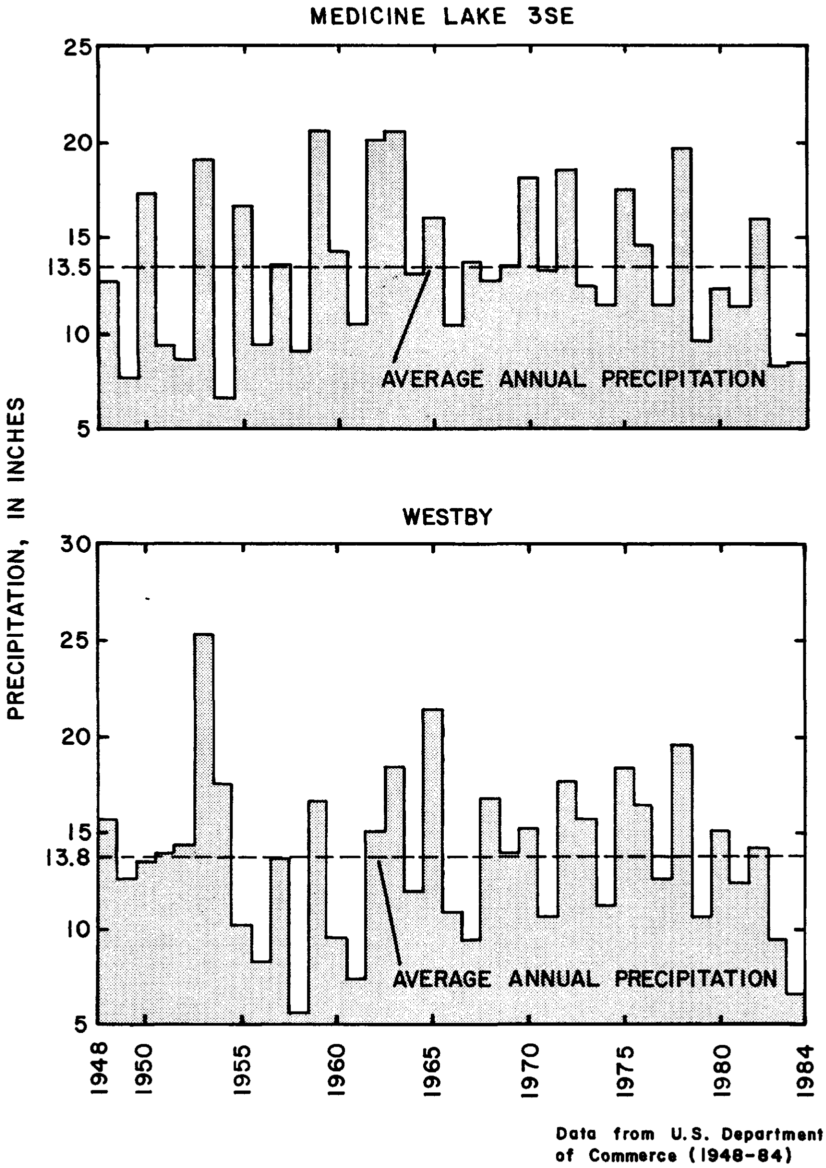

Figure 2.--Annual precipitation for Medicine Lake 3SE and Westby, 1948-84.

GEOLOGIC SETTING

The study area lies in the glaciated section of the Missouri Plateau of the Great Plains Province (Fenneman, 1931). The glacial geology of the study area is discussed in detail by Alden (1932), Witkind (1959), Howard (1960), Colton (1963), Hansen (1967), and Freers (1970). Only a synopsis of the history of the extremely complex glacial events that led to the abandonment of the ancestral Missouri River valley is discussed herein.

The present course of the Missouri River from Poplar to the east is anomalous and represents the course of an ice-marginal stream formed near the southern limit of glaciation. The pre-glacial or ancestral drainage is indicated topographically by a broad swale that extends across the upland from near Poplar through Medicine

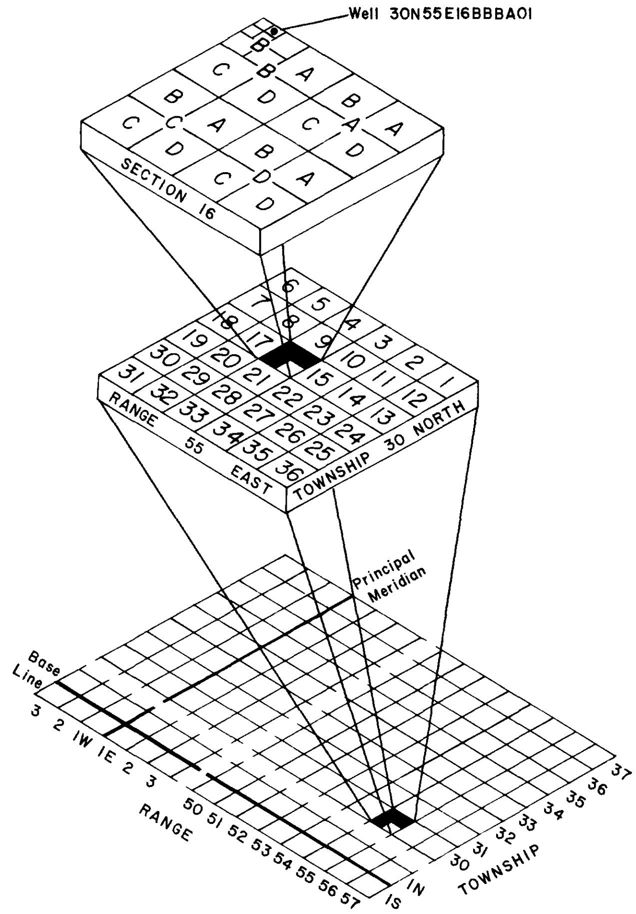

Figure 3.--Location-numbering system.

Lake and Grenora, North Dakota. The ancestral drainage continued into Canada and eventually emptied into Hudson Bay. The topographic map of the bedrock surface (consolidated units) for the study area (pl. 1) shows the location and general configuration of the ancestral valley of the Missouri River as determined from well and test-hole data.

As the ice advanced from the north, it occupied the ancestral valley of the Missouri River and dammed the river. The ice blockage created a glacial lake that eventually overflowed and eroded several ice-marginal channels, resulting in the present course of the Missouri River. For a detailed discussion of the events, the reader is referred to Howard (1960, p. 77).

Consolidated Units

Only data for geologic units above the Bearpaw Shale of Late Cretaceous age are presented in this report (table 1). The Bearpaw is a 1,100- to 1,200-foot thick section of gray shale with some bentonite.

Table 1.--*Generalized stratigraphic column of geologic formations in the study area*

System	Series	Group or formation		Thickness (feet)	General lithologic character
Quaternary	Holocene	Alluvium and colluvium		0-50±	Fine- to coarse-grained flood-plain deposits of Big Muddy Creek valley and major tributaries; consist mostly of silt and sand with gravel lenses. Also include slope-wash deposits on hillsides and in valleys consisting chiefly of locally derived silt, sand, and gravel.
	Pleistocene	Glacial deposits		0-300±	Unconsolidated glacial till, glacial lakebed deposits, and poorly to well-sorted clay, silt, sand, and gravel in various types of glacio-fluviatile deposits. Also include outwash gravel of pre-glacial or inter-glacial periods which may be, in part, buried by till, and contain a large percentage of limestone and dolomite.
		Terrace gravel		0-100±	Brown gravel containing sparse glacial erratics overlain, in places, by till. Consists of 95 percent brown quartzite pebbles derived from the Flaxville Formation, and less than 5 percent glacial erratics consisting of limestone, dolomite, and igneous and metamorphic rocks transported from Canada.
Tertiary	Paleocene	Fort Union Formation		800±	Well-sorted and well-stratified gray clay, bentonitic gray clay, brown carbonaceous clay, mudstone, lignite, buff siltstone, gray silty limestone concretions, shale, olive-gray sand, and buff calcareous sandstone. Marked lateral variation in lithology.
Cretaceous	Upper Cretaceous	Montana Group	Hell Creek Formation	250±	Well-stratified sequence of shale, siltstone, sandstone, and carbonaceous shale. Overall appearance is somber greenish gray. Lower 50 to 100 feet is predominantly medium-tan sand, locally cemented to sandstone. A few quartzite pebbles occur in basal 50 feet.
			Fox Hills Sandstone	100±	Consists of an upper sandstone unit, 50 to 80 feet thick, underlain by a transitional marine shale unit 35 feet thick. Lower unit consists of thin-bedded, well-laminated shale grading to siltstone in upper part. Upper sandstone contains numerous concretions. Upper part of formation removed by erosion in many places before deposition of Hell Creek Formation.
			Bearpaw Shale	1,100-1,200	Dark-olive-gray, slightly fissile, semiconsolidated jointed clayey shale. Contains several kinds of hard ellipsoidal concretions, many containing marine fossils. A few sandy beds present in the upper part. Thin bentonite seams present in some shale zones; bentonite also is disseminated throughout some zones.

Overlying the Bearpaw Shale is a section of sandstone, shale, and siltstone identified as the Fox Hills Sandstone and Hell Creek Formation, both also of Late Cretaceous age. These units have a combined thickness of about 350 feet in the study area and occur at depths ranging from 600 to 1,100 feet below land surface.

The youngest consolidated unit in the study area is the Fort Union Formation of Paleocene age. The Fort Union consists largely of interbedded clay, mudstone, shale, siltstone, sandstone, and lignite coal. These lithologic units change laterally and intertongue. The thickness of the Fort Union varies considerably within the study area because much of the upper part of the formation has been removed by erosion, particularly along the axis of the ancestral valley of the Missouri River. Maximum thickness is probably 800 feet, with a minimum of 300-400 feet underlying the deepest parts of the ancestral valley. Isolated outcrops of the Fort Union occur along the banks of Big Muddy Creek, along the bluffs south of Medicine Lake, and in the Coalridge area.

Unconsolidated Units

The valley of the ancestral Missouri River has been filled with alternating deposits of sand, silt, and clay from lakebed deposits; gravel from pre-glacial terraces within the valley; gravel from outwash channels; and glacial till. These individual units form a heterogeneous valley-fill deposit. Individual units are lenticular in nature, thickening and thinning considerably within short lateral distances. Subsurface correlation of individual units from point to point is difficult and generally is not possible with available data.

The study area is underlain by a mantle of till interbedded with outwash channels. The thickness of the till is variable. The till is absent in some areas and is as much as 300 feet thick in some parts of the ancestral valley. In most of the area, the thickness of the till is probably only a few tens of feet. The till is predominantly a clay and silt matrix, with scattered pebbles and cobbles, and in some areas contains boulders.

As the glaciers retreated to the north, several outwash channels were formed. These are topographically low areas, and their surface expression is shown on the topographic map of the bedrock surface (pl. 1).

The youngest deposits in the study area are alluvium and colluvium found along the major streams. These deposits vary in thickness within the stream valleys. Maximum thicknesses of 50 feet occur along Big Muddy Creek.

GROUND-WATER RESOURCES

Occurrence

Water can be obtained from six geohydrologic units in the study area, in ascending order: (1) the Fox Hills-lower Hell Creek aquifer, (2) the Fort Union Formation, (3) terrace-gravel layers, (4) glacial till, (5) outwash gravel, and (6) alluvial deposits. Inventory data for wells and test holes in these units are summarized in table 6 at the back of the report. The location of wells and test holes is shown on the potentiometric-surface map (pl. 2).

The Fox Hills Sandstone and lower part of the Hell Creek Formation form a hydraulically connected unit known throughout eastern Montana as the Fox Hills-lower Hell Creek aquifer. Only well 31N56E19ABAA01 is completed in the aquifer. In this well, which is 1,160 feet deep, the top of the Fox Hills-lower Hell Creek aquifer is about 1,000 feet below land surface. A "trickle" of water reportedly flows from this artesian well.

Sandstone and coal seams in the Fort Union Formation are major sources of domestic and stock water in the study area. Twenty-four inventoried wells are completed in the Fort Union. These wells range in depth from 88 to 413 feet and average 217 feet. The depth is dependent on location within the study area because the ancestral Missouri River valley has been eroded into the Fort Union. Wells completed in the Fort Union are generally deeper in the ancestral valley than in those areas where the Fort Union is covered only by a thin veneer of glacial deposits.

Several remnant terrace-gravel layers are found within the glacial deposits that filled the ancestral Missouri River valley. These terrace-gravel layers commonly can be differentiated from outwash gravel by the large percentage (as much as 95 percent) of chert and quartz pebbles. The terrace-gravel layers are either reworked and redeposited Flaxville Gravel of late Tertiary age or gravel substantially younger in age than the Flaxville. These gravels were present in most of northeastern Montana prior to the glacial period. The terrace-gravel layers occur at different altitudes in the ancestral valley. The areal extent and thickness, which may vary from a few feet to several tens of feet, can be determined best by test drilling. Results of test drilling during this study indicate that a terrace gravel generally occurs at or near the base of the ancestral Missouri River valley. In the study area, several wells are completed in the basal ancestral gravel, and several test holes were drilled and cased as part of the study. Seventeen wells are completed in terrace gravel. They range in depth from 172 to 350 feet and average 250 feet.

Most of the study area contains a veneer of glacial material, primarily till. The amount of water produced by the glacial till is small because of the relatively large percentage of silt and clay, which are very fine grained. Twenty-four inventoried wells are completed in the till. These wells range in depth from 30 to 327 feet and average 126 feet.

Within and overlying the glacial till are significant thicknesses of sand and gravel. These deposits are in outwash channels that formed in front of melting glaciers. They vary from narrow, shallow channels to channels more than a mile in width and as much as 150 feet deep, such as the Dagmar and Grenora channels (pl. 3). The surficial boundaries of the Dagmar, Stady, Grenora, and Coalridge outwash channels are shown on plate 3. Outwash channels may be covered by glacial till, with no topographic depression showing at the land surface. Outwash gravel can be identified in drill cuttings by the large percentage (greater than 40 percent) of limestone and dolomite pebbles. The outwash gravel is the source of water for all the existing irrigation wells in the study area. In the study area 52 wells are completed in the outwash gravels. These wells range in depth from 30 to 220 feet and average 111 feet.

The depositional nature of both the terrace and outwash gravel is indicated on the map showing altitude of the deepest gravel penetrated during drilling of the well or test hole (pl. 3). All available logs were used as a source of data; therefore, some locations have not been checked onsite.

Scattered throughout the area, particularly along Big Muddy Creek, are isolated deposits of alluvium. Alluvial deposits do not constitute a significant aquifer in the study area. Only six wells are completed in this unit.

Recharge

Recharge to the aquifers in the study area is from infiltration of precipitation, infiltration of streamflow, and possibly leakage from lakes and potholes. The amount of precipitation infiltration differs from place to place depending on the type of surficial deposits, topography, and vegetation. In spring and summer when runoff from snowmelt or rainfall is significant, major streams in the study area may recharge the ground-water system along segments of their length. Although some water from lakes and potholes might leak into the ground-water system, the magnitude of the leakage is unknown. Generally, the accumulation of fine-grained sediments on the bottoms of lakes and potholes restricts downward movement of water; thus, the amount of leakage probably is minimal.

Movement

The direction of water movement can be inferred from contours connecting the altitude of static water level at wells (pl. 2). Some water levels are anomalous and were not considered in contouring; they are possibly caused, in part, by isolated clay and till layers that function as confining beds.

The potentiometric-surface map indicates the general direction of movement to be from the topographically higher areas toward the ancestral valley and then along the ancestral valley from northeast to southwest. Thus, water is moving into the area from North Dakota and is moving out of the study area along the present valley of Big Muddy Creek.

Discharge

Water is discharged from aquifers by evapotranspiration, by springs and seeps, by movement directly into stream channels in localized areas and lakes, and by wells. Discharge by evapotranspiration occurs along the streams where the water table is near land surface. Contact springs and seeps occur along slopes where the Fort Union crops out. In these outcrop areas, clay layers prevent downward movement of water and force it to move laterally until it discharges through springs and seeps. Water is also moving through the ancestral Missouri River valley near Homestead and out of the study area.

Ground-water pumpage for domestic use has been relatively constant for many years. Based on per capita use, an estimated 150-175 acre-feet is withdrawn yearly for domestic use. Ground-water withdrawal for irrigation has only recently become a major component of total ground-water discharge. Estimates of ground-water pumpage from irrigation wells for 1975-84 are listed in table 2. The estimates are based on a measured or reported discharge of each irrigation well and an annual electric-consumption rate.

Table 2.--*Estimated ground-water pumpage for irrigation use, 1975-84*

Year	Pumpage (acre-feet)
1975	16
1976	100
1977	600
1978	425
1979	700
1980	825
1981	2,700
1982	2,575
1983	3,150
1984	4,150

Well Yield and Specific Capacity

The reported yield of a well determined by pumping, bailing, or blowing with air is not always a measure of sustainable well yield unless the drawdown in the well is measured and water is withdrawn for a significant period of time. If those data are available, a reliable specific capacity of the well can be determined.

Specific capacity is the yield, in gallons per minute, divided by the water-level drawdown, in feet. The length of a specific-capacity test can vary from a few minutes to several hours, but results are more reliable the longer the test. Reported or measured yields and specific capacities of wells for different aquifers are given in table 3. Based on the limited data available, wells completed in terrace gravels and outwash have the largest specific capacities. The range of specific capacities is an indication of the heterogeneity of the different aquifer units.

Water-Level Fluctuations

Water levels in several wells were measured periodically during the study. Hydrographs for selected wells in outwash gravels (fig. 4) show that water levels declined slightly (about 2 feet or less) from June 1982 to April 1985. Possible reasons for the decline are ground-water withdrawals from nearby irrigation wells or less than normal precipitation during the past several years, or both.

During 1984, 18 observation wells were installed in outwash gravels, terrace gravels, and the Fort Union Formation. Four of the wells completed in outwash gravels are presently (1985) equipped with recorders to monitor water levels continuously. The other wells are measured periodically.

Table 3.--*Well yields and specific capacities*

Geohydrologic unit	Reported or measured yield (gallons per minute)				Specific capacity (gallons per minute per foot)			
	Maximum	Minimum	Average	Number of wells	Maximum	Minimum	Average	Number of wells
Alluvial deposits (nonirrigation well)	2.4	2.4	2.4	1	--	--	--	--
Outwash gravel (irrigation wells)	1,210	644	886	13	175	18	93	7
Outwash gravel (nonirrigation wells)	50	14	25	14	23	.2	9.2	14
Glacial till (nonirrigation wells)	10	6	8	4	.5	.2	.4	3
Terrace gravel (nonirrigation wells)	51	8	20	9	29	.2	6.7	9
Fort Union Formation (nonirrigation wells)	20	1.3	6.4	9	.7	.05	.2	8

GROUND-WATER QUALITY

Chemical Analyses

Laboratory analyses of chemical constituents are available for water samples from 84 wells (tables 7 and 8 at the back of the report). These analyses are for samples collected in 1978 or later, with the exception of four analyses of samples collected in 1947 and 1948. Onsite specific conductance can be used to estimate the quantity of dissolved solids in water where a laboratory analysis is not available. The ratio of dissolved solids to onsite specific conductance has been calculated for each aquifer and is tabulated below:

Aquifer	Ratio	Number of samples
Alluvial deposits	0.61	3
Outwash gravel	.64	44
Glacial till	.68	15
Terrace gravel	.64	9
Fort Union Formation	.65	15
Fox Hills-lower Hell Creek	.64	2

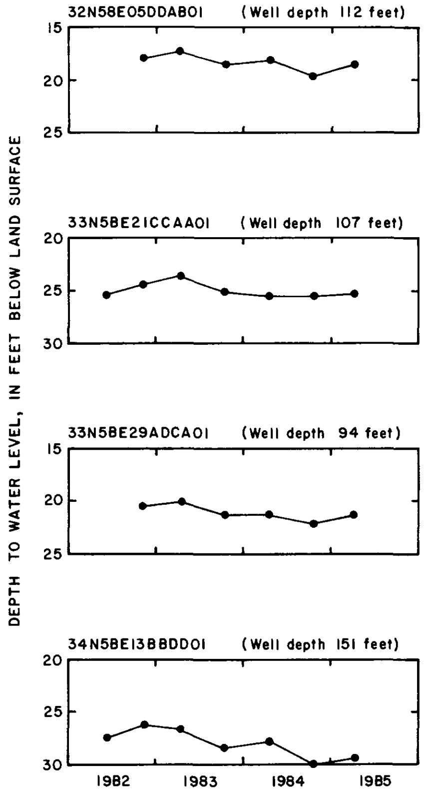

Figure 4.--Hydrographs of selected wells completed in outwash gravel, 1982-85.

To obtain an estimate of dissolved-solids concentration in water from an aquifer in the study area, multiply specific conductance by the corresponding ratio.

To illustrate water type at the sampled wells, chemical-constituent diagrams are shown on plate 4. They depict the dissolved concentrations of the predominant cations and anions contained in the water sample. For the convenience of comparing the ions, concentrations have been converted from milligrams per liter to milliequivalents per liter (Hem, 1970).

Specific aquifers commonly have water that is chemically similar throughout and thus exhibit typical patterns for the chemical-constituent diagrams. However, examination of the chemical-constituent diagrams shows that water from the various aquifers in the study area has a diverse quality. Water from the Fox Hills-lower Hell Creek aquifer is a sodium chloride bicarbonate type, based on two samples from one well. Water from the Fort Union Formation and terrace gravel is generally a sodium bicarbonate type. In glacial till, water samples contain mostly mixtures of calcium, magnesium, bicarbonate, and sulfate. Most samples of water from outwash gravel contain principally sodium or calcium and bicarbonate. Water in alluvial deposits contains principally sodium, calcium, bicarbonate, and sulfate based on analysis of three samples.

Suitability of Water for Domestic and Public-Supply Use

Generally, the larger the quantity of dissolved constituents in water, the less suitable it is for human consumption. The U.S. Environmental Protection Agency (1977; 1979) has established primary and secondary standards for drinking water used for public supply. The maximum contaminant levels (concentrations) for drinking water, according to these standards, are given in tables 4 and 5 for variables analyzed in this study.

Table 4.--*Primary drinking-water standards*[1]

Contaminant	Maximum contaminant level	
	Milligrams per liter	Micrograms per liter
Arsenic	0.05	50
Cadmium	.010	10
Chromium	.05	50
Lead	.05	50
Nitrate (as N)	10	--
Selenium	.01	10
Silver	.05	50
Fluoride	[2] 2.4	--

[1]From U.S. Environmental Protection Agency (1977).

[2]Maximum contaminant level (concentration) of fluoride is dependent on annual average of the maximum daily temperatures for water-supply location. A contaminant level of 2.4 milligrams per liter is appropriate for the study area.

Table 5.--*Secondary drinking-water standards*[1]

[mg/L, milligrams per liter; µg/L, micrograms per liter]

Contaminant	Maximum contaminant level
Chloride	250 mg/L
Copper	1 mg/L (1,000 µg/L)
Iron	0.3 mg/L (300 µg/L)
Manganese	0.05 mg/L (50 µg/L)
pH	6.5-8.5
Solids, dissolved	500 mg/L
Sulfate	250 mg/L
Zinc	5 mg/L

[1]From U.S. Environmental Protection Agency (1979).

Four constituents in the samples analyzed (tables 7 and 8)--cadmium, lead, selenium, and fluoride--exceed the primary drinking-water standards. Cadmium exceeded the limit in two analyses, lead in one analysis, and selenium and fluoride in three analyses. Excessive fluoride in drinking water may produce objectionable dental fluorosis. The concentrations of cadmium, lead, and selenium that exceed primary drinking-water standards are significant in that they have a potential for toxicity. Information on the occurrence of cadmium and selenium in the water is too incomplete to enable detailed explanations for the observed concentrations. Large concentrations of lead commonly are caused by corrosion of lead plumbing and are not necessarily due to naturally occurring lead in untreated waters.

The constituents that most commonly exceeded the secondary standards are iron, manganese, sulfate, and dissolved solids. These are constituents that primarily affect the esthetic qualities of the water; however, at concentrations considerably larger than the standards, health degradation, as well as esthetic degradation, may occur.

Excessive concentrations of iron and manganese impart a bitter taste to drinking water and cause pronounced staining. Concentrations of sulfate exceeding 250 mg/L (milligrams per liter) are likely to result in objectionable taste and laxative effects. Excess concentrations of sulfate can be tolerated, but individuals drinking the water for the first time may experience adverse physiological effects and may require time to become acclimated to drinking the water. Dissolved solids, a measure of the total dissolved mineral content of the water, is a general indication of the acceptability of the water. Excessive dissolved-solids concentrations commonly are associated with excessive hardness, objectionable taste, mineral deposition, or corrosion (U.S. Environmental Protection Agency, 1979).

Hardness of water, expressed as an equivalent quantity of calcium carbonate ($CaCO_3$), is caused principally by dissolved calcium and magnesium. The following ranges are used to classify water hardness (Durfor and Becker, 1964):

Range in hardness as $CaCO_3$, in milligrams per liter	Description
0-60	Soft
61-120	Moderately hard
121-180	Hard
More than 180	Very hard

Hardness values for ground water in the study area ranged from 8 to 1,400 mg/L (table 7). Average values of hardness for each aquifer are as follows:

Aquifer	Number of samples	Average hardness, in milligrams per liter
Alluvial deposits	3	427
Outwash gravel	44	396
Glacial till	15	831
Terrace gravel	9	278
Fort Union Formation	15	241
Fox Hills-lower Hell Creek	2	16

Suitability of Water for Irrigation Use

Dissolved solids in irrigation water, commonly referred to as salinity hazard, generally present the principal water-quality threat to crops. Salinity hazards from dissolved solids also are dependent on physical factors such as soil type, drainage conditions, and crop type. The maximum limit of dissolved solids for best crop growth is considered to be about 1,000 mg/L, but by using selective irrigation practices this value can be increased. If sodium and boron constitute substantial percentages of the dissolved solids, additional hazards are present.

Large concentrations of sodium in water constitute a hazard to soils by causing accumulation of exchangeable sodium ions, resulting in soils of little permeability and poor tilth. If the proportion of sodium in water is large, the sodium hazard is large; conversely if calcium and magnesium predominate, the hazard is small. A measure of the sodium hazard (sodium-adsorption ratio or SAR) is defined as:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{(Ca^{+2}) + (Mg^{+2})}{2}}}$$

where ion concentrations are expressed in milliequivalents per liter.

Plots of SAR values versus specific conductance for analyses from five aquifers are shown in figure 5. Five analyses from the Fort Union Formation and two from the Fox Hills-lower Hell Creek aquifer could not be plotted because the SAR values were more than 32 (see table 7). The data show considerable scatter for SAR but the salinity values plot primarily in the high range. Based on the classification diagrams in figure 5, water from outwash gravel generally would be suitable for irrigation. Water from the terrace gravel or the Fort Union Formation in many instances would be unsuitable because of the high sodium hazard.

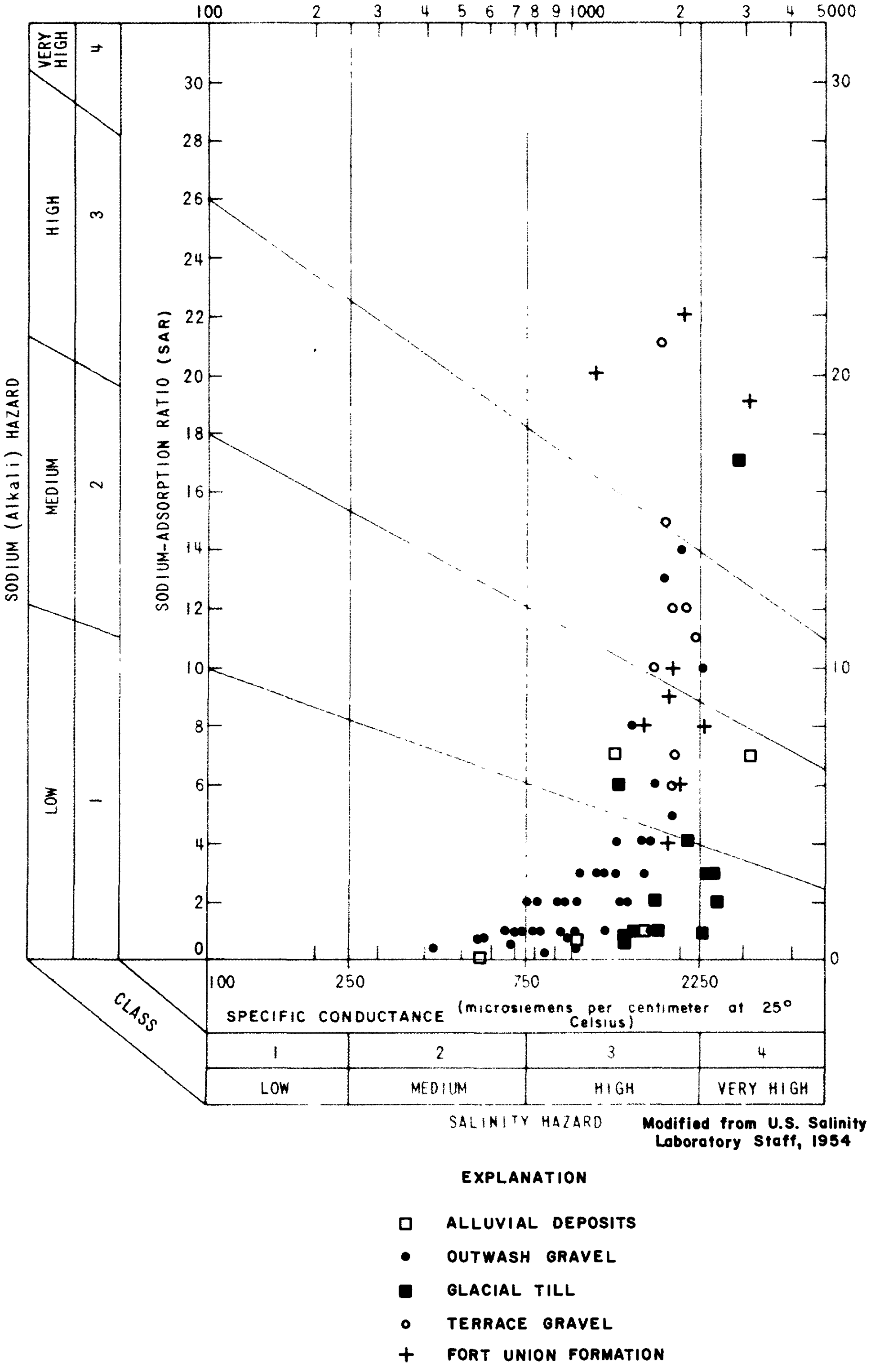

Figure 5.--Salinity- and sodium-hazard classification of water for irrigation use.

SUMMARY

Consolidated units above the Upper Cretaceous Bearpaw Shale include, in ascending order, the Fox Hills Sandstone, Hell Creek Formation, and Fort Union Formation. Unconsolidated pre-glacial terrace deposits and glacial deposits mantle the consolidated units in most of the study area. The youngest deposits are principally alluvial deposits along major streams.

Most of the units above the Bearpaw Shale are aquifers. The Fox Hills Sandstone and the lower part of the Hell Creek Formation form a hydraulically connected unit known as the Fox Hills-lower Hell Creek aquifer. Only one well is completed in this aquifer in this area; a "trickle" of water is reported to flow from the well, which is 1,160 feet deep. Average of reported and measured yields from nonirrigation wells, in gallons per minute, are about 6.4 for the Fort Union Formation, 20 for terrace gravel, 8 for glacial till, 25 for outwash gravel, and 2.4 for alluvial deposits. The average yield of 13 irrigation wells completed in outwash gravel is 886 gallons per minute.

Recharge to the aquifers is from infiltration of precipitation, infiltration of streamflow, and possibly leakage from lakes and potholes. A potentiometric-surface map indicates that the general direction of movement of water within the aquifers is from topographically higher areas toward the ancestral Missouri River valley, and then along the ancestral valley to the southwest. Water is discharged from aquifers by evapotranspiration, springs and seeps, movement directly into stream channels in localized areas and lakes, and by pumping wells. The withdrawal of ground water for irrigation use has only recently become a major component of total ground-water discharge.

Water levels were measured periodically in 18 observation wells completed in the Fort Union Formation, terrace gravel, and outwash gravel. The measurements indicate that water levels declined slightly during the study (1982-85), possibly in response to ground-water withdrawals from nearby irrigation wells and(or) less than normal precipitation during the past several years.

Based on analyses of water samples from various aquifers, most water in the area is suitable for human consumption. Some chemical constituents in the water, however, exceeded the standards established by the U.S. Environmental Protection Agency for drinking water for public supply. Cadmium, lead, selenium, and fluoride each exceeded the primary standards in at least one sample, and iron, manganese, sulfate, and dissolved solids were the constituents that most commonly exceeded sup- the secondary standards. Water from outwash gravel is the most suitable source of ply for irrigation use on the basis of specific conductance and sodium-adsorption ratio.

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SUPPLEMENTAL DATA

Table 6.--*Records of wells and test holes*

[Location number--numbering system described in text. Type of site--W, well; X, test hole. Use of site--O, observation; T, test; U, unused; W, withdrawal; Z, destroyed. Use of water--H, domestic; I, irrigation; P, public supply; S, stock, U, unused; Z, other. Depth of well, in feet below land surface. Bottom of casing, in feet below land surface. Top of perforated or screened interval--in feet below land surface. Geohydrologic unit (aquifer in well or deepest unit penetrated in test hole)--110ALVM, alluvial deposits; 112OTSH, outwash gravel; 112TILL, glacial till; 112ALVM, terrace gravel; 125FRUN, Fort Union Formation; 211FHHC, Fox Hills-lower Hell Creek aquifer. Altitude of land surface, in feet above sea level. Water level--in feet above (+) or below (no sign) land surface; F, flowing. Method of water-level measurement--G, pressure gage; R, reported; S, steel tape; T, electric tape. Type of log available--D, driller's; G, geologist's. Onsite specific conductance--in microsiemens per centimeter at 25 °Celsius. --, no data]

Location number (pl. 2)	Type of site	Date well constructed (month/ day/year)	Use of site	Use of water	Depth of well (feet)	Diameter of casing (inches)	Bottom of casing (feet)	Top of perforated or screened interval (feet)	Geohydrologic unit
30N55E01ACA01	X	06/30/1981	T	--	205	--	--	--	112TILL
30N55E01BAB01	W	07/23/1981	U	--	208	12	178	178	112ALVM
30N55E01DDDD01	W	05/29/1947	Z	--	190	4	--	--	112ALVM
30N55E03AAAA01	W	10/12/1984	T	--	186	2	186	167	112ALVM
30N55E10DDDD01	W	10/11/1984	T	--	147	2	116.50	84	112OTSH
30N55E16BBBA01	W	11/20/1983	O	--	172	4	106	106	112ALVM
30N56E05DAAA01	X	06/24/1984	Z	--	148	--	--	--	125FRUN
30N56E05DDDD01	X	06/23/1984	Z	--	148	--	--	--	112OTSH
30N56E11BACD01	W	02/01/1964	W	H	146	4	143.75	--	125FRUN
31N55E07CBCB01	W	--/--/1922	W	H	52	4	52	--	112TILL
31N55E12DAAA01	X	08/28/1948	T	--	99	--	--	--	125FRUN
31N55E13DDDD01	X	06/04/1947	T	--	195	--	--	--	112ALVM
31N55E18DBAB01	W	--	W	H	50	24	40	--	112TILL
31N55E23DCCD01	W	10/22/1975	W	H	213	4	210	210	112ALVM
31N55E24AAAA01	X	06/03/1947	T	--	95	--	--	--	112ALVM
31N55E25DDDD01	W	05/28/1947	Z	--	295	4.75	--	--	112ALVM
31N55E29AABD01	W	--	W	S	50	4	50	6	110ALVM
31N55E35CBDB01	W	08/01/1944	W	H	60	24	40	40	112TILL
31N55E36DDDD01	W	05/28/1947	Z	--	215	4.25	--	--	112TILL
31N56E06BDDB01	X	08/02/1948	T	--	165	--	--	--	125FRUN

Altitude of land surface (feet)	Water level (feet)	Method of water-level measurement	Date water level measured (month/day/year)	Discharge (gallons per minute)	Date discharge measured (month/day/year)	Type of log available	Onsite specific conductance (micro-siemens)
1,987	--	--	--	--	--	D	--
1,958	37	R	07/23/1981	--	--	D	--
1,988	12.35	S	06/03/1947	--	--	D	--
1,946	13.64	S	10/16/1984	33	10/15/1984	G	1,940
1,973	26.02	S	10/16/1984	20	10/15/1984	G	2,280
1,935	--	--	--	--	--	G	--
2,084	--	--	--	--	--	G	--
2,110	--	--	--	--	--	G	--
2,010	66.52	S	07/02/1983	4.5	02/01/1964	D	2,860
2,100	--	--	--	--	--	--	860
2,101	--	--	--	--	--	G	--
2,039	--	--	--	--	--	D	--
2,057	26.57	S	09/02/1982	--	--	--	1,800
1,975	40.84	S	07/20/1983	9.2	07/20/1983	D	1,920
2,037	--	--	--	--	--	D	--
1,970	20.98	S	06/07/1947	--	--	D	--
1,936	F	--	08/08/1983	2.4	08/08/1983	--	1,320
1,940	11.09	S	08/27/1982	--	--	--	2,450
1,990	17.10	S	06/12/1947	--	--	D	--
2,033	95.3	R	08/02/1948	--	--	G	--

Table 6.--*Records of wells and test holes*--Continued

Location number (pl. 2)	Type of site	Date well constructed (month/day/year)	Use of site	Use of water	Depth of well (feet)	Diameter of casing (inches)	Bottom of casing (feet)	Top of perforated or screened interval (feet)	Geohydrologic unit
31N56E17ADDB01	W	07/16/1970	W	H	170	4	170	166	125FRUN
31N56E18BCBC01	W	10/01/1924	W	H	160	4	--	--	125FRUN
31N56E19AAAC01	W	04/01/1970	W	H	350	4	337	330	125FRUN
31N56E19ABAA01	W	--/--/1970	W	S	1,160	4	1,160	850	211FHHC
31N56E19ABBB01	W	--/--/1970	W	U	316	4	315	311	125FRUN
31N56E19CDC01	X	06/23/1981	T	--	185	--	--	--	--
31N56E19DAC01	X	06/29/1981	T	--	205	--	--	--	--
31N56E19DDD01	X	06/27/1981	T	--	220	--	--	--	--
31N56E20CCA01	X	06/29/1981	T	--	155	--	--	--	--
31N56E20DDDC01	W	09/15/1953	W	H	240	4	240	--	125FRUN
31N56E21CCCC01	X	06/14/1984	Z	U	223	--	--	--	125FRUN
31N56E22BAB01	X	02/24/1981	T	--	200	--	--	--	--
31N56E22CCA01	X	05/01/1981	T	--	155	--	--	--	--
31N56E22DBB01	X	02/23/1981	T	--	203	--	--	--	--
31N56E24CCDD01	W	07/01/1947	W	H	36	24	36	--	112TILL
31N56E28CCCC01	X	06/07/1947	--	--	410	--	--	--	112TILL
31N56E29DDDD01	X	06/21/1984	Z	U	368	--	--	--	125FRUN
31N56E30BBBB01	W	05/29/1947	Z	--	203	1.50	81	--	112OTSH
31N56E32BAAB01	W	08/01/1910	W	H	153	4	153	--	112TILL
31N56E33CABB01	X	06/25/1984	Z	--	323	--	--	--	125FRUN
31N56E33CCCC01	X	06/22/1984	Z	U	360	--	--	--	125FRUN
31N56E33CCCD01	W	09/22/1984	O	--	350	4	350	264	112ALVM
31N57E01BACA01	W	09/01/1981	W	U	125	5.50	125	115	112OTSH
31N57E03DBBB01	W	07/01/1965	W	S	160	4	--	--	112OTSH
31N57E09ABAD01	W	06/22/1983	W	S	220	4	220	211	112OTSH
31N57E09CCBC01	W	07/15/1902	W	H	60	24	60	--	112OTSH
31N57E17ABDC01	W	07/27/1965	W	S	141	4	141	--	112TILL
31N57E20ABDA01	W	05/01/1945	W	S	95	24	95	--	112TILL
31N57E28DCBC01	W	09/01/1971	W	S	265	4	265	--	112ALVM
31N57E34CDDC01	W	--/--/1909	W	S	90	24	90	--	112TILL
31N58E09CBCD01	W	--/--/1945	W	S	120	4	120	--	125FRUN
31N58E32CBCB01	W	09/24/1981	W	S	50	5	50	45	112TILL
31N59E06CCCA01	W	10/01/1954	W	H	110	4.50	--	--	125FRUN
32N55E25ABCB01	W	--	W	P	40	--	--	24	110ALVM
32N56E05DADB01	W	--/--/1910	W	P	30	24	--	--	112OTSH

Altitude of land surface (feet)	Water level (feet)	Method of water-level measurement	Date water level measured (month/day/year)	Discharge (gallons per minute)	Date discharge measured (month/day/year)	Type of log available	Onsite specific conductance (microsiemens)
2,025	96.11	S	08/28/1982	--	--	D	1,900
2,096	140.49	S	09/07/1982	--	--	--	2,100
2,062	100	R	04/01/1970	9	04/--/1970	D	2,650
2,050	F	--	08/24/1978	--	--	D	3,650
2,048	100.05	T	08/21/1978	5	--/--/1970	D	--
2,025	--	--	--	--	--	D	--
2,044	--	--	--	--	--	D	--
2,043	--	--	--	--	--	D	--
2,067	--	--	--	--	--	D	--
2,091	131.42	S	09/07/1982	--	--	D	1,950
2,092	--	--	--	--	--	G	--
2,005	--	--	--	--	--	D	--
2,015	--	--	--	--	--	D	--
1,998	--	--	--	--	--	D	--
2,012	15.22	S	08/27/1982	--	--	--	1,290
2,100	--	--	--	--	--	D	--
2,102	--	--	--	--	--	G	--
2,009	57.32	S	06/07/1947	--	--	D	1,250
2,054	92.77	S	09/03/1982	--	--	--	2,000
2,102	--	--	--	--	--	G	--
2,108	--	--	--	--	--	G	--
2,106	124.37	S	10/15/1984	--	--	G	--
1,997	25.02	S	07/19/1983	24	08/12/1984	D	1,000
1,975	31.30	S	08/23/1982	--	--	--	1,020
1,968	19.43	S	07/18/1983	14	06/22/1983	D	840
1,990	3.60	S	08/23/1982	--	--	--	700
2,003	16	R	07/27/1965	10	07/27/1965	D	--
2,048	60	R	12/01/1963	--	--	--	--
2,090	112.50	T	08/24/1978	12	09/01/1971	D	2,140
2,206	39.88	S	08/30/1982	--	--	--	1,300
2,067	38.18	S	08/30/1982	--	--	--	3,100
2,095	F	--	--	--	--	D	2,620
2,130	100	R	--/--/1982	--	--	--	2,300
1,950	--	--	--	--	--	--	3,270
2,025	7.81	S	08/21/1948	--	--	--	1,050

Table 6.--*Records of wells and test holes*--Continued

Location number (pl. 2)	Type of site	Date well con- structed (month/ day/year)	Use of site	Use of water	Depth of well (feet)	Diam- eter of casing (inches)	Bottom of casing (feet)	Top of perfo- rated or screened inter- val (feet)	Geo- hydro- logic unit
32N56E12CBBA01	W	--/--/1910	W	H	106	6	106	--	125FRUN
32N56E17CCCB01	W	04/15/1982	W	H	200	8	--	--	125FRUN
32N56E19BDDD01	W	06/30/1980	W	H	223	4	223	218	112ALVM
32N56E20CCCC01	W	04/02/1975	W	H	240	4	240	237	112ALVM
32N56E28BBBC01	X	09/13/1948	T	--	50	--	--	--	112TILL
32N56E29AAAA01	X	08/30/1984	Z	--	250	--	--	--	112ALVM
32N56E29DCBC01	X	09/10/1948	T	--	50	--	--	--	112TILL
32N56E29DDDD01	W	09/19/1984	T	--	233	2	233	213	112ALVM
32N56E29DDDD02	W	09/19/1984	T	--	118	2	118	110	112OTSH
32N56E31ADDD01	X	08/06/1948	T	--	190	--	--	--	112TILL
32N56E31BBBB01	X	06/06/1947	O	--	95	--	--	--	112TILL
32N56E31BBBB02	W	06/08/1947	Z	--	225	1.50	144	--	112ALVM
32N56E31BCCC01	X	06/04/1947	O	--	230	--	--	--	112TILL
32N56E31CCCC01	X	05/30/1947	O	--	210	--	--	--	112TILL
32N56E31DAAC01	X	08/02/1948	T	--	180	--	--	--	112TILL
32N56E32BAAB01	X	08/20/1948	T	--	148	--	--	--	112TILL
32N56E32BBDB01	X	09/08/1948	T	--	66	--	--	--	112TILL
32N56E33BCDC01	W	10/09/1976	W	Z	82	5	75	75	112TILL
32N56E33BCDC02	X	05/27/1972	T	U	500	--	--	--	125FRUN
32N57E09A01	X	08/06/1981	T	--	140	--	--	--	--
32N57E09ADD01	X	08/06/1981	T	--	140	--	--	--	--
32N57E09DCCB01	W	--	W	H	--	--	--	--	--
32N57E21CBD01	X	10/09/1982	T	--	110	--	--	--	--
32N57E22AAAA01	X	06/11/1984	Z	U	223	--	--	--	125FRUN
32N57E26BBBB01	X	06/10/1984	Z	U	218	--	--	--	112OTSH
32N57E26CBBB01	X	06/13/1984	Z	U	147	--	--	--	112OTSH
32N57E26CBBB02	W	07/17/1984	O	U	247	4	270	227	112ALVM
32N57E26CBBB03	W	07/18/1984	O	U	150	4	150	125	112OTSH
32N57E34ABB01	X	09/01/1981	T	--	125	--	--	--	--
32N57E35BBBC01	X	05/28/1984	Z	U	333	--	--	--	125FRUN
32N57E35CCCB01	X	05/29/1984	Z	U	323	--	--	--	125FRUN
32N58E04DBBD01	W	07/23/1984	O	U	318	4	318	303	125FRUN
32N58E04DBBD02	W	07/25/1984	O	U	143	4	143	126	112OTSH
32N58E05DDAB01	W	09/13/1980	W,O	I	112	12	92	92	112OTSH
32N58E06DCAA01	W	09/10/1980	W	I	94	12	74	74	112OTSH

Altitude of land surface (feet)	Water level (feet)	Method of water-level measurement	Date water level measured (month/day/year)	Discharge (gallons per minute)	Date discharge measured (month/day/year)	Type of log available	Onsite specific conductance (microsiemens)
2,110	100	R	--	--	--	--	2,150
1,960	13.67	S	08/21/1982	--	--	--	2,050
1,959	29.26	S	07/20/1983	9.2	07/20/1983	D	1,740
1,985	47.34	S	08/21/1978	20	04/02/1975	D	1,860
1,997	--	--	--	--	--	G	--
1,998	--	--	--	--	--	G	--
2,025	--	--	--	--	--	G	--
1,984	50.65	T	10/14/1984	--	--	G	1,700
1,984	49.44	T	10/14/1984	--	--	G	1,970
1,952	18.4	R	08/06/1948	--	--	G	--
1,968	--	--	--	--	--	D	--
1,968	33.09	S	06/12/1947	--	--	D	1,980
1,936	2.40	S	06/07/1947	--	--	D	--
1,937	3.62	S	06/07/1947	--	--	D	--
1,944	9.2	R	08/02/1948	--	--	G	--
1,972	37.8	R	08/20/1948	--	--	G	--
1,993	--	--	--	--	--	G	--
1,940	14.78	S	11/05/1982	--	--	D	2,110
1,940	--	--	--	--	--	D	--
2,049	--	--	--	--	--	D	--
2,035	--	--	--	--	--	D	--
2,062	100	R	08/20/1982	--	--	--	2,900
1,975	--	--	--	--	--	D	--
1,952	--	--	--	--	--	G	--
1,950	--	--	--	--	--	G	--
1,951	--	--	--	--	--	G	--
1,951	.55	S	07/18/1984	23	08/10/1984	D	1,850
1,951	5.43	S	08/10/1984	26	08/11/1984	D	1,720
1,955	--	--	--	--	--	D	--
1,948	--	--	--	--	--	G	--
1,985	--	--	--	--	--	G	--
1,977	6.70	S	07/26/1984	--	--	G	2,000
1,977	24.28	S	07/26/1984	25	08/10/1984	D	1,400
1,974	18.00	S	11/05/1982	820	07/02/1984	D	1,480
1,995	39.10	S	11/05/1982	--	--	D	1,700

Table 6.--*Records of wells and test holes*--Continued

Location number (pl. 2)	Type of site	Date well con- structed (month/ day/year)	Use of site	Use of water	Depth of well (feet)	Diam- eter of casing (inches)	Bottom of casing (feet)	Top of perfo- rated or screened inter- val (feet)	Geo- hydro- logic unit
32N58E10CCCC01	W	08/28/1984	O	--	101	4	92	92	112OTSH
32N58E12DDCC01	W	--/--/1955	W	H	275	4	275	--	125FRUN
32N58E13DDDB01	W	04/22/1961	W	Z	298	4.12	295	--	112ALVM
32N58E22CBBC01	W	--	W	S	225	5	--	--	125FRUN
32N58E26ADDB01	W	06/06/1961	Z	--	297	4	297	--	112ALVM
32N58E27BCCC01	W	09/18/1984	O	--	270	4	270	175	112ALVM
32N58E31CBDD01	W	11/01/1947	W	H	17	--	--	--	110ALVM
32N59E04DDDD01	X	05/26/1984	Z	U	373	--	--	--	125FRUN
32N59E08BCBA01	W	--/--/1944	U	--	90	--	--	--	112TILL
32N59E09DDBC01	W	08/01/1983	W	--	413	5	413	393	125FRUN
32N59E19BDBC01	W	08/12/1963	U	--	291	4.50	286	286	125FRUN
32N59E29CBD01	X	08/29/1981	T	--	200	--	--	--	--
33N56E02ACAB01	W	10/10/1970	W	H	327	4	325	318	112TILL
33N56E10DBCD01	W	--/--/1910	W	H	30	18	30	--	112TILL
33N56E26DDDC01	W	07/01/1915	W	H	127	--	--	--	112TILL
33N56E28CBCD01	W	--/--/1935	U	--	153	4	--	--	125FRUN
33N56E28DAAD01	W	--	U	--	50	--	--	--	112TILL
33N56E29BBBB01	W	05/26/1978	W	S	217	4	203	203	125FRUN
33N56E31BBBC01	W	09/15/1975	W	H	88	5	88	--	125FRUN
33N56E33ABAB01	W	--	U	--	--	--	--	--	--
33N57E05ACBC01	W	--/--/1910	W	H	30	48	30	--	110ALVM
33N57E06CBBD01	W	--/--/1908	W	H	287	6	287	--	112TILL
33N57E12CDBD01	W	06/22/1954	W	H	110	4	110	--	112TILL
33N57E17BACA01	W	07/10/1974	W	H	76	24	76	--	112OTSH
33N57E22DCCA01	W	--	W	H	235	5	235	--	112TILL
33N57E33CDDC01	W	10/10/1956	W	H	90	4	105	--	112TILL
33N58E01ABAB01	W	09/01/1925	W	H	153	5	153	--	112TILL
33N58E05ACAA01	W	--	W	H	6	60	6	--	110ALVM
33N58E06CBDC01	W	07/01/1909	W	H	128	5	128	--	112TILL
33N58E09CDDA01	W	--	W	H	30	--	--	--	112OTSH
33N58E14CCA01	X	01/29/1981	T	--	175	--	--	--	--
33N58E14CDD01	X	09/25/1981	T	--	170	--	--	--	--
33N58E17ABBA01	W	--	W	H	40	5	40	--	112OTSH
33N58E17ADDD01	W	07/30/1984	O	U	130	4	130	97	112OTSH
33N58E18DDB01	X	--/--/1981	T	--	150	--	--	--	--

Altitude of land surface (feet)	Water level (feet)	Method of water-level measurement	Date water level measured (month/day/year)	Discharge (gallons per minute)	Date discharge measured (month/day/year)	Type of log available	Onsite specific conductance (microsiemens)
2,008	56.93	S	11/30/1984	--	--	G	--
2,004	44.40	S	08/18/1982	--	--	--	1,640
2,040	60	R	04/22/1961	15	04/22/1961	D	2,230
1,990	34.29	S	08/16/1982	--	--	--	1,880
1,990	18	R	06/06/1961	8	06/06/1961	D	--
2,012	51.46	S	11/30/1984	--	--	G	--
1,975	11.37	S	08/23/1982	--	--	--	1,950
2,050	--	--	--	--	--	G	--
2,010	48.39	S	08/18/1982	--	--	--	--
2,072	83.59	S	05/27/1984	20	08/01/1983	D	--
2,020	91	R	08/12/1963	4	08/12/1963	D	--
2,035	--	--	--	--	--	D	--
2,225	188.09	S	08/22/1978	9	10/10/1970	D	1,550
2,201	12.56	S	09/06/1982	--	--	--	1,550
2,140	124.78	S	08/25/1982	--	--	--	2,600
2,128	133.44	S	09/06/1982	--	--	--	--
2,130	6.41	S	09/07/1982	--	--	--	--
2,120	156	R	05/26/1978	2.5	05/26/1978	D	1,940
1,985	60	R	09/15/1975	--	--	--	2,700
2,130	11.30	S	09/07/1982	--	--	--	--
2,030	18.21	S	08/25/1982	--	--	--	560
2,250	265	R	--/--/1908	7	--	--	1,460
2,082	83.28	S	08/15/1982	--	--	--	1,680
2,145	62.19	S	08/25/1982	--	--	--	880
2,070	70	R	08/20/1982	--	--	--	1,700
2,067	67.90	S	08/24/1982	--	--	--	2,300
2,042	44.94	S	08/24/1982	--	--	--	1,350
2,015	2.12	S	08/16/1982	--	--	--	5,040
2,095	92.53	S	08/17/1982	--	--	--	1,060
1,990	4.65	S	08/13/1982	--	--	--	1,230
2,025	--	--	--	--	--	D	--
1,985	--	--	--	--	--	D	--
2,018	18	R	--	--	--	--	720
1,992	12.23	S	08/09/1984	26	08/09/1984	G	730
2,018	--	--	--	--	--	D	--

Table 6.--*Records of wells and test holes*--Continued

Location number (pl. 2)	Type of site	Date well constructed (month/day/year)	Use of site	Use of water	Depth of well (feet)	Diameter of casing (inches)	Bottom of casing (feet)	Top of perforated or screened interval (feet)	Geohydrologic unit
33N58E20DDB01	X	01/15/1981	T	--	110	--	--	--	--
33N58E21BCA01	X	01/16/1981	T	--	150	--	--	--	--
33N58E21CCAA01	W	09/23/1980	W,O	I	107	12	107	87	112OTSH
33N58E23AADB01	W	05/01/1955	W	H	67	6	67	--	112TILL
33N58E23BAB01	X	09/24/1981	T	--	140	--	--	--	--
33N58E23CBCA01	W	--	U	--	65	4	--	--	--
33N58E23CBCA02	W	08/01/1984	O	U	150	4	150	110	112OTSH
33N58E23CCAA01	W	04/06/1981	W	I	147	12	147	127	112OTSH
33N58E23CCAA02	X	01/28/1981	T	--	125	--	--	--	--
33N58E24AAAA01	W	08/21/1984	O	--	178	4	178	163	112OTSH
33N58E25AAAA01	X	05/15/1984	Z	U	397	--	--	--	125FRUN
33N58E25AAAA02	W	08/22/1984	T	--	340	2	340	328	112ALVM
33N58E25AAAA03	W	08/24/1984	O	--	150	4	140	138	112OTSH
33N58E28CBBA01	W	07/25/1984	O	U	130	4	130	77	112OTSH
33N58E29ADCA01	W	09/17/1980	W,O	I	94	12	94	74	112OTSH
33N58E29ADDB01	W	07/25/1984	O	U	98	4	98	74	112OTSH
33N58E29ADDB02	W	07/30/1984	O	U	330	4	330	290	125FRUN
33N58E30ACAA01	W	09/18/1980	W	I	150	12	120	120	112OTSH
33N58E32CCAA01	W	09/26/1980	W	I	91	12	71	71	112OTSH
33N58E33DACB01	W	--/--/1962	W	S	143	4	--	--	125FRUN
33N58E36AADD01	X	05/17/1984	Z	U	348	--	--	--	125FRUN
33N58E36DDDD01	X	05/23/1984	Z	U	323	--	--	--	125FRUN
34N56E24ABCC01	W	--/--/1915	W	H	341	4	341	--	125FRUN
34N57E20CADC01	W	10/12/1962	W	H	300	4	297	--	112TILL
34N58E01BDD01	X	--	T	--	140	--	--	--	--
34N58E06CCCB01	W	06/01/1973	W	H	183	5	164	--	125FRUN
34N58E11DBAB01	W	08/07/1984	O	U	130	4	130	100	112OTSH
34N58E12CBBB01	X	08/04/1984	Z	--	339	4	339	--	125FRUN
34N58E13AAAD01	W	08/08/1984	O	U	180	4	180	150	112OTSH
34N58E13AAAD02	W	08/09/1984	O	U	105	4	105	96	112OTSH
34N58E13BBDD01	W	11/12/1980	W,O	I	151	12	131	131	112OTSH
34N58E13CDBB01	W	06/02/1981	W	I	154	12	134	134	112OTSH
34N58E14AAAA01	W	--	W	U	28	--	--	--	110ALVM
34N58E14ACAA01	W	10/02/1980	W	I	126	12	106	106	112OTSH
34N58E14BDDD01	W	--/--/1974	W	I	90	12	70	70	112OTSH

Altitude of land surface (feet)	Water level (feet)	Method of water-level measurement	Date water level measured (month/day/year)	Discharge (gallons per minute)	Date discharge measured (month/day/year)	Type of log available	Onsite specific conductance (micro-siemens)
2,002	--	--	--	--	--	D	--
2,000	--	--	--	--	--	D	--
1,995	25.67	S	06/09/1982	957	08/17/1983	D	823
2,010	40	R	--	--	--	--	2,300
1,985	--	--	--	--	--	D	--
2,010	39.36	S	11/06/1982	--	--	--	--
2,010	38.98	S	09/30/1984	23	08/09/1984	G	1,550
1,992	21.54	S	11/05/1982	--	--	D	2,010
1,998	--	--	--	--	--	D	--
2,007	29.11	S	11/30/1984	--	--	G	--
1,992	--	--	--	--	--	G	--
1,992	+1.74	G	10/15/1984	51	10/15/1984	G	2,940
1,992	19.46	S	11/30/1984	--	--	G	--
1,985	21.78	S	07/26/1984	27	08/08/1984	D, G	1,260
1,992	20.86	S	11/06/1982	882	08/17/1983	D	952
1,990	23.68	S	07/26/1984	27	08/08/1984	D	690
1,990	15.22	S	08/08/1984	--	--	D	2,050
1,995	22.75	S	11/05/1982	837	06/12/1984	D	1,060
1,985	33.09	S	08/16/1982	950	08/18/1983	D	805
1,995	29.85	S	08/18/1982	--	--	--	1,980
1,973	--	--	--	--	--	G	--
1,998	--	--	--	--	--	G	--
2,380	338	R	--/--/1915	1.3	08/29/1979	--	1,040
2,320	244	R	10/12/1962	6	10/12/1962	D	1,490
2,058	--	--	--	--	--	D	--
2,193	103.25	S	08/08/1983	--	--	D	1,180
2,060	18.98	S	08/08/1984	25	08/08/1984	D, G	1,650
2,050	--	--	--	--	--	G	--
2,095	59.10	S	08/11/1984	--	--	G	--
2,098	101.60	S	08/11/1984	--	--	G	--
2,065	27.66	S	06/13/1982	825	08/17/1983	D	776
2,100	55.30	S	06/13/1982	644	08/17/1983	D	1,060
2,064	24.23	S	04/06/1983	--	--	--	--
2,059	22.80	S	11/05/1982	950	07/02/1984	D	1,380
2,058	17.58	S	11/05/1982	804	08/17/1983	--	1,040

Location number (pl. 2)	Type of site	Date well con- structed (month/ day/year)	Use of site	Use of water	Depth of well (feet)	Diam- eter of casing (inches)	Bottom of casing (feet)	Top of perfo- rated or screened inter- val (feet)	Geo- hydro- logic unit
34N58E14CBDD01	W	05/05/1977	W	I	151	12	125	125	112OTSH
34N58E14DBDD01	W	06/26/1980	W	I	98	12	75	75	112OTSH
34N58E18BCBB01	W	08/13/1975	W	S	142	4	138	138	125FRUN
34N58E20DAAA01	W	08/10/1984	O	U	110	4	110	83	112OTSH
34N58E21DCCD01	W	--	W	H	104	4	104	--	112OTSH
34N58E22AACC01	W	11/05/1980	W	I	104	12	92	73	112OTSH
34N58E23BBBB01	W	11/07/1980	W	I	86	12	86	66	112OTSH
34N58E26ADAB01	W	--/--/1967	W	H	118	4	114	114	112OTSH
34N58E29CDBA01	W	10/23/1980	W	I	81	12	61	61	112OTSH
34N58E29DBC01	X	--	T	--	126	--	--	--	--
34N58E29DCA01	X	--	T	--	120	--	--	--	--
34N58E29DCB01	X	--	T	--	118	--	--	--	--
34N58E29DCBA01	W	09/10/1981	W	I	122	12	102	102	112OTSH
34N58E29DDB01	X	09/04/1981	--	--	155	--	--	--	--
35N58E01AAC01	X	06/02/1976	T	--	180	--	--	--	--
35N58E01AADA01	W	--	W	I	45	12	--	--	112OTSH
35N58E01ACB01	X	10/11/1982	T	--	125	--	--	--	--
35N58E01ACDA01	W	--	W	I	32	12	--	--	112OTSH
35N58E01ADC01	W	06/03/1976	O	--	40	1.25	25	25	--
35N58E01ADC02	X	--	T	--	140	--	--	--	--
35N58E01ADDA01	W	--	W	I	48	12	--	--	112OTSH
35N58E01CAC01	X	06/03/1976	--	--	120	--	--	--	--
35N58E01DAB01	X	06/02/1976	T	--	200	--	--	--	--
35N58E01DAB02	X	10/13/1982	T	--	35	--	--	--	--
35N58E01DABB01	W	10/12/1982	T	--	30	2	30	23	112OTSH
35N58E01DAD01	X	06/02/1976	T	--	120	--	--	--	--
35N58E01DAD02	X	--	T	--	200	--	--	--	--
35N58E01DAD03	X	10/11/1982	T	--	50	--	--	--	--
35N58E01DBAA01	W	10/16/1982	W	I	33	12	33	13	112OTSH
35N58E01DBDD01	W	--	W	I	39	12	--	--	112OTSH

Altitude of land surface (feet)	Water level (feet)	Method of water-level measurement	Date water level measured (month/day/year)	Discharge (gallons per minute)	Date discharge measured (month/day/year)	Type of log available	Onsite specific conductance (microsiemens)
2,059	17.10	S	11/05/1982	877	08/17/1983	D	1,200
2,062	22.62	S	11/05/1982	1,210	06/12/1984	D	765
2,191	118.48	S	08/08/1983	3.5	08/13/1975	D	--
2,040	10.29	S	08/11/1984	25	08/11/1984	G	1,380
2,080	48.77	S	08/18/1982	--	--	--	590
2,045	6.70	S	06/13/1982	900	08/17/1983	D	940
2,045	12.34	S	06/13/1982	866	08/17/1983	D	814
2,065	44.16	T	08/21/1978	16	07/24/1976	D	1,070
2,032	13.91	S	11/06/1982	--	--	D	970
2,033	--	--	--	--	--	D	--
2,033	--	--	--	--	--	D	--
2,033	--	--	--	--	--	D	--
2,033	13.78	S	04/08/1983	--	--	--	960
2,040	--	--	--	--	--	D	--
2,100	--	--	--	--	--	D	--
2,078	13.80	S	04/08/1983	--	--	--	760
2,105	--	--	--	--	--	D	--
2,073	7.51	S	04/08/1983	--	--	--	--
2,065	--	--	--	--	--	D	--
2,065	--	--	--	--	--	D	--
2,078	14.49	S	04/08/1983	--	--	--	830
2,180	--	--	--	--	--	D	--
2,070	--	--	--	--	--	D	--
2,070	--	--	--	--	--	D	--
2,068	3.52	S	04/08/1983	--	--	D	--
2,105	--	--	--	--	--	D	--
2,105	--	--	--	--	--	D	--
2,105	--	--	--	--	--	D	--
2,068	4.72	S	04/08/1983	--	--	D	1,870
2,065	4.20	S	04/08/1983	--	--	--	--

Table 6.--*Records of wells and test holes*--Continued

Location number (pl. 2)	Type of site	Date well constructed (month/day/year)	Use of site	Use of water	Depth of well (feet)	Diameter of casing (inches)	Bottom of casing (feet)	Top of perforated or screened interval (feet)	Geohydrologic unit
35N58E01DDA01	X	10/11/1982	T	--	50	--	--	--	--
35N58E01DDA02	X	10/11/1982	T	--	110	--	--	--	--
35N58E01DDB01	X	--	T	--	155	--	--	--	--
35N58E01DDC01	X	10/14/1982	T	--	35	--	--	--	--
35N58E02BDA01	X	--	T	--	80	--	--	--	--
35N58E24AAAA01	W	05/12/1982	O	U	200	1.25	92	90	112OTSH
35N58E24DDDD01	W	05/25/1982	O	U	73	1.25	58	55	112OTSH
35N58E36CBBB01	W	07/04/1983	W	S	108	5	107	87	112OTSH
36N58E23BACA01	W	07/30/1977	W	S	175	3	175	166	125FRUN
36N58E36D01	X	01/18/1981	T	--	160	--	--	--	--

Altitude of land surface (feet)	Water level (feet)	Method of water-level measurement	Date water level measured (month/day/year)	Discharge (gallons per minute)	Date discharge measured (month/day/year)	Type of log available	Onsite specific conductance (microsiemens)
2,105	--	--	--	--	--	D	--
2,105	--	--	--	--	--	D	--
2,080	--	--	--	--	--	D	--
2,080	--	--	--	--	--	D	--
2,080	--	--	--	--	--	D	--
2,092	41.03	S	06/08/1982	--	--	D	575
2,065	16.48	S	05/25/1982	--	--	D	1,750
2,075	--	--	--	50	07/04/1984	D	1,650
2,162	58	R	07/30/1977	8	07/30/1977	D	2,780
2,115	--	--	--	--	--	D	--

Table 7.--*Common-constituent concentrations in water from wells*

[Constituents are dissolved and values are reported in milligrams per liter, except as indicated. Geologic unit--110ALVM, alluvial deposits; 112OTSH, outwash gravel; 112TILL, glacial till; 112ALVM, terrace gravel; 125FRUN, Fort Union Formation; 211FHHC, Fox Hills-lower Hell Creek aquifer. Agency analyzing sample--30010, Montana Bureau of Mines and Geology; 38002, North Dakota State Water Commission; 80020, U.S. Geological Survey. Abbreviations: microsiemens, microsiemens per centimeter at 25 °Celsius; °C, degrees Celsius]

Location number (pl. 4)	Date of sample (year-month-day)	Geo-hydro-logic unit	Onsite spe-cific con-duct-ance (micro-siemens)	Onsite pH (stand-ard units)	Temper-ature (°C)	Hard-ness (as $CaCO_3$)	Calcium (Ca)	Magne-sium (Mg)	Sodium (Na)
30N55E03AAAA01	84-10-15	112ALVM	1,940	7.3	8.5	500	100	60	310
30N55E10DDDD01	84-10-15	112OTSH	2,280	7.5	7.5	420	95	45	460
31N55E18DBAB01	82-09-02	112TILL	1,800	7.4	8.5	860	180	100	67
31N55E23DCCD01	83-07-20	112ALVM	1,920	7.7	9.5	210	41	25	400
31N55E29AABD01	83-08-08	110ALVM	1,320	7.5	8.0	240	48	28	240
31N55E35CBDB01	82-08-27	112TILL	2,450	7.3	8.0	1,100	210	140	190
31N56E17ADDB01	82-08-28	125FRUN	1,900	7.0	9.5	750	150	90	260
31N56E18BCBC01	48-08-20	125FRUN	2,030	7.6	--	590	100	82	320
	82-09-07	125FRUN	2,100	7.3	9.0	470	65	75	330
31N56E19ABAA01	78-08-24	211FHHC	3,650	8.7	16.0	16	4.4	1.1	800
	82-06-11	211FHHC	2,710	8.5	11.0	15	4.5	.80	810
31N56E20DDDC01	82-09-07	125FRUN	1,950	8.8	8.5	8	2.3	.46	450
31N56E24CCDD01	82-08-27	112TILL	1,290	7.1	--	700	180	61	26
31N56E30BBBB01	47-06-06	112OTSH	1,250	--	11.0	380	75	46	150
31N57E01BACA01	84-08-12	112OTSH	1,000	7.3	9.0	460	120	42	40
31N57E09ABAD01	83-07-18	112OTSH	840	7.5	10.0	380	87	40	62
31N57E09CCBC01	82-08-23	112OTSH	700	7.3	9.0	330	73	36	20
31N57E28DCBC01	78-08-24	112ALVM	2,140	9.3	11.0	230	33	35	400
31N57E34CDDC01	82-08-30	112TILL	1,300	7.2	--	730	170	73	26
31N58E09CBCD01	82-08-30	125FRUN	3,100	7.6	8.0	260	49	33	680
31N59E06CCCA01	82-08-30	125FRUN	2,300	7.3	8.5	450	82	60	380
32N55E25ABCB01	82-06-11	110ALVM	3,270	8.1	6.5	750	150	92	420
32N56E05DADB01	48-08-21	112OTSH	438	7.3	--	230	56	22	10
	82-09-07	112OTSH	1,050	7.5	11.0	520	110	59	18
32N56E17CCCB01	82-08-20	125FRUN	2,050	8.2	9.0	83	12	13	460
32N56E20CCCC01	78-08-21	112ALVM	1,860	8.1	10.5	86	13	13	440
32N56E29DDDD01	84-10-14	112ALVM	1,700	7.6	9.0	250	49	30	360
32N56E29DDDD02	84-10-14	112OTSH	1,970	7.5	8.0	670	140	77	260
32N56E31BBBB02	47-06-08	112ALVM	1,980	--	14.5	440	90	53	320
32N56E33BCDC01	82-06-11	112TILL	2,110	8.1	8.0	590	130	63	220
32N57E26CBBB02	84-08-10	112ALVM	1,850	8.0	10.0	150	32	17	400
32N57E26CBBB03	84-08-11	112OTSH	1,720	7.4	8.5	480	110	51	210
32N58E04DBBD01	84-08-10	125FRUN	2,000	8.3	10.0	12	2.6	1.3	580
32N58E04DBBD02	84-08-10	112OTSH	1,400	--	8.5	570	130	62	99
32N58E05DDAB01	82-08-12	112OTSH	1,480	7.3	8.5	580	130	61	130
32N58E06DCAA01	82-08-12	112OTSH	1,700	7.3	8.5	840	170	100	82
32N58E12DDCC01	82-08-18	125FRUN	1,640	7.4	10.0	270	48	36	310
32N58E13DDDB01	78-08-26	112ALVM	2,230	7.8	10.0	320	63	40	440
32N58E22CBBC01	82-08-16	125FRUN	1,880	7.8	9.0	310	62	38	350
33N56E02ACAB01	78-08-22	112TILL	1,550	7.3	9.5	750	150	90	78

Sodium-adsorption ratio (SAR)	Potassium (K)	Bicarbonate, (HCO_3)	Carbonate, (CO_3)	Alkalinity (as $CaCO_3$)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Silica (SiO_2)	Solids, sum of constituents	Nitrogen, as nitrate (N)	Agency analyzing sample (code number)
6	5.7	940	--	--	400	4.7	0.20	23	1,400	0.02	30010
10	6.2	870	--	--	680	7.3	.20	19	1,700	.05	30010
1	5.5	--	--	--	620	87	.20	16	1,200	--	80020
12	5.0	1,000	0.0	--	250	20	1.2	18	1,300	.22	30010
7	3.4	700	.0	--	160	4.9	.50	12	840	.02	30010
3	8.3	--	--	--	570	41	.50	16	1,700	--	80020
4	9.5	--	--	--	570	6.0	.20	13	1,600	--	80020
6	1.6	800	--	660	480	4.0	.00	14	1,400	--	80020
7	8.1	--	--	--	420	5.3	.20	6.8	1,400	--	80020
92	3.0	940	--	830	3.1	710	.60	13	2,000	.02	30010
96	2.0	1,040	.0	880	.1	690	2.9	12	2,000	.43	30010
74	2.2	--	--	--	210	4.0	1.7	6.8	1,200	--	80020
.4	7.0	530	.0	--	250	20	.30	27	840	1.6	30010
3	10	570	--	--	220	4.0	.00	15	800	--	80020
.8	5.5	560	.0	--	87	1.2	.30	31	600	2.0	30010
1	4.3	620	.0	--	2.4	1.6	.60	21	520	.03	30010
.5	5.0	--	--	--	41	1.6	.50	28	410	--	80020
12	6.0	750	--	650	400	6.0	2.7	15	1,300	1.6	30010
.4	5.0	500	.0	--	240	20	.20	21	840	9.4	30010
19	5.8	--	--	--	790	16	1.1	11	2,100	--	80020
8	9.1	--	--	--	440	5.3	.50	12	1,500	--	80020
7	10	790	.0	680	870	140	.60	19	2,100	.65	30010
.3	.80	190	--	150	44	3.6	.00	51	280	--	80020
.4	14	--	--	--	280	6.2	.30	26	640	--	80020
22	3.5	--	--	--	12	89	2.3	8.6	1,200	--	80020
21	4.0	1,120	--	920	.4	76	2.7	10	1,100	.10	30010
10	4.1	1,190	--	--	8.8	23	1.2	19	1,100	.02	30010
5	6.3	1,080	--	--	290	40	.20	27	1,400	.03	30010
7	16	810	--	--	420	30	1.0	12	1,300	--	80020
4	6.0	1,000	.0	840	200	41	.50	27	1,200	.04	30010
15	3.7	1,090	.0	--	89	30	.30	16	1,100	.05	30010
4	5.0	780	.0	--	300	3.4	.10	26	1,100	.03	30010
75	1.7	1,410	.0	--	3.3	87	.10	10	1,400	.04	30010
2	4.8	650	.0	--	270	2.4	.10	25	910	.04	30010
2	5.0	--	--	--	310	5.4	.20	25	970	--	80020
1	6.7	--	--	--	510	6.6	.20	22	1,200	--	80020
8	3.4	--	--	--	11	13	.80	27	970	--	80020
11	4.0	1,290	--	1,060	170	18	.80	28	1,400	1.4	30010
9	3.7	--	--	--	11	9.2	.80	26	1,100	--	80020
1	6.0	610	--	500	400	3.0	.10	22	1,100	.10	30010

Table 7.--*Common-constituent concentrations in water from wells*--Continued

Location number (pl. 4)	Date of sample (year-month-day)	Geo-hydro-logic unit	Onsite spe-cific con-duct-ance (micro-siemens)	Onsite pH (stand-ard units)	Temper-ature (°C)	Hard-ness (as $CaCO_3$)	Calcium (Ca)	Magne-sium (Mg)	Sodium (Na)
33N56E26DDDC01	82-08-25	112TILL	2,600	6.8	--	1,400	260	190	180
33N56E29BBBB01	80-10-14	125FRUN	1,940	8.4	9.5	11	2.8	.90	500
33N56E31BBBC01	82-09-06	125FRUN	2,700	7.5	9.0	81	16	10	670
33N57E05ACBC01	82-08-25	110ALVM	560	7.4	--	290	75	26	2.1
33N57E06CBBD01	78-08-23	112TILL	1,460	7.1	9.0	750	170	79	54
33N57E12CDBD01	82-08-15	112TILL	1,680	7.2	--	860	160	110	73
33N57E17BACA01	82-08-15	112OTSH	880	7.2	10.0	460	110	46	8.3
33N57E22DCCA01	82-08-20	112TILL	1,700	7.1	8.0	770	170	85	94
33N57E33CDDC01	82-08-24	112TILL	2,300	7.2	--	1,000	180	140	180
33N58E01ABAB01	82-08-24	112TILL	1,350	7.4	8.0	260	59	28	210
33N58E06CBDC01	82-08-17	112TILL	1,060	7.1	8.0	560	130	59	34
33N58E09CDDA01	82-08-13	112OTSH	1,230	7.4	--	420	64	62	120
33N58E17ABBA01	82-08-19	112OTSH	720	7.2	--	300	72	28	44
33N58E17ADDD01	84-08-09	112OTSH	730	7.8	8.0	280	68	26	42
33N58E21CCAA01	82-06-09	112OTSH	823	7.6	8.5	330	74	36	69
33N58E23AADB01	82-08-24	112TILL	2,300	7.0	9.0	1,300	320	110	70
33N58E23CBCA02	84-08-09	112OTSH	1,550	7.7	8.0	240	53	27	270
33N58E23CCAA01	82-06-09	112OTSH	2,010	7.6	9.0	180	40	20	410
	84-08-09	112OTSH	1,850	7.8	8.5	170	38	19	390
33N58E25AAAA02	84-10-13	112ALVM	2,940	7.2	9.0	320	62	40	680
33N58E28CBBA01	84-08-08	112OTSH	1,260	6.9	9.0	480	110	50	51
33N58E29ADCA01	82-06-13	112OTSH	952	7.3	8.5	470	100	53	68
33N58E29ADDB01	84-08-08	112OTSH	690	7.5	9.0	260	62	27	39
33N58E29ADDB02	84-08-09	125FRUN	2,050	8.7	11.0	10	2.5	1.0	500
33N58E30ACAA01	84-06-12	112OTSH	1,060	7.3	8.0	480	100	54	67
33N58E32CCAA01	82-08-16	112OTSH	805	7.3	8.0	310	74	31	52
33N58E33DACB01	82-08-18	125FRUN	1,980	7.2	9.0	280	61	32	380
34N57E20CADC01	78-08-19	112TILL	1,490	7.2	9.5	840	190	88	31
34N58E06CCCB01	83-08-08	125FRUN	1,180	7.7	9.0	34	7.2	4.0	270
34N58E11DBAB01	84-08-08	112OTSH	1,650	7.1	8.5	460	110	48	210
34N58E13BBDD01	82-06-13	112OTSH	776	7.8	8.5	390	90	39	79
34N58E13CDBB01	82-06-13	112OTSH	1,060	8.0	8.0	500	120	48	96
34N58E14ACAA01	82-08-13	112OTSH	1,380	7.2	8.0	420	95	44	160
34N58E14BDDD01	82-08-12	112OTSH	1,040	7.3	8.0	370	87	38	96
34N58E14CBDD01	82-08-12	112OTSH	1,200	7.3	8.5	380	86	39	130
34N58E14DBDD01	82-08-13	112OTSH	765	7.4	8.0	310	73	31	50
34N58E20DAAA01	84-08-11	112OTSH	1,380	7.1	7.5	460	100	48	130
34N58E21DCCD01	82-08-19	112OTSH	590	7.5	8.0	250	61	24	27
34N58E22AACC01	82-06-13	112OTSH	940	8.5	8.5	340	80	35	92
34N58E23BBBB01	82-06-13	112OTSH	814	8.8	8.5	300	69	31	72
34N58E26ADAB01	78-08-21	112OTSH	1,070	7.7	8.5	360	80	38	110
34N58E29CDBA01	82-08-19	112OTSH	970	7.2	8.5	350	80	37	77
34N58E29DCBA01	82-08-19	112OTSH	960	7.3	8.0	330	79	32	80
35N58E01AADA01	83-07-14	112OTSH	760	8.7	8.0	260	66	24	62
35N58E01DBAA01	83-07-14	112OTSH	1,870	8.1	7.5	510	130	46	190
35N58E24AAAA01	82-06-08	112OTSH	575	7.9	10.0	250	62	23	26
35N58E24DDDD01	82-06-08	112OTSH	1,750	7.7	10.0	400	99	37	250
35N58E36CBBB01	84-06-12	112OTSH	1,650	7.2	8.5	560	140	55	150

Sodium-ad-sorp-tion ratio (SAR)	Potas-sium (K)	Bicar-bonate, (HCO_3)	Car-bonate, (CO_3)	Alka-linity (as $CaCO_3$)	Sulfate (SO_4)	Chlo-ride (Cl)	Fluo-ride (F)	Silica (SiO_2)	Solids, sum of consti-tuents	Nitro-gen, as nitrate (N)	Agency ana-lyzing sample (code number)
2	9.0	850	.0	--	1,100	13	.40	18	2,200	1.1	30010
69	2.7	--	--	960	69	41	.30	5.8	1,200	--	80020
33	4.7	--	--	--	210	24	1.2	9.6	1,700	--	80020
.0	1.0	300	.0	--	9.0	2.7	.10	13	310	7.3	30010
.9	5.0	610	--	500	350	5.0	.10	22	990	.10	30010
1	6.0	630	.0	--	510	4.5	.20	19	1,200	.42	30010
.2	3.7	--	--	--	93	5.1	.30	19	500	--	80020
2	6.1	--	--	--	340	3.2	.20	24	1,100	--	80020
3	8.0	830	.0	--	730	7.0	.40	18	1,700	.06	30010
6	5.2	--	--	--	200	9.5	.50	22	850	--	80020
.6	5.1	550	.0	--	84	3.4	.20	20	600	.11	30010
3	12	530	.0	--	200	23	.50	28	770	.20	30010
1	4.0	350	.0	--	88	1.8	.10	26	440	.11	30010
1	3.8	350	.0	--	89	1.8	.10	27	430	.09	30010
2	5.0	400	.0	320	130	32	.30	26	570	.08	30010
.9	7.0	--	--	--	850	24	.30	24	1,700	--	80020
8	4.1	840	.0	--	140	9.6	.20	25	950	.10	30010
14	4.0	1,060	.0	860	150	49	1.1	20	1,200	.11	30010
13	4.0	1,010	.0	--	150	29	.20	20	1,100	1.6	30010
17	6.6	1,680	--	--	360	31	.20	23	2,000	.03	30010
1	4.9	320	.0	--	86	180	.20	27	670	.07	30010
1	5.0	540	.0	460	190	4.0	.20	26	720	.49	30010
1	3.4	340	.0	--	80	1.6	.10	27	410	.13	30010
70	2.2	1,170	.0	--	75	40	.10	12	1,200	.38	30010
1	4.5	540	.0	--	190	5.0	.20	27	710	.29	30010
1	4.8	--	--	--	98	3.3	.20	28	440	--	80020
10	5.6	--	--	--	280	41	.70	27	1,300	--	80020
.5	8.0	760	--	620	260	3.6	.20	26	980	.10	30010
20	3.0	550	.0	--	150	3.3	.30	22	720	.04	30010
4	5.6	680	.0	--	370	5.2	.20	27	1,100	.12	30010
2	3.0	440	.0	360	200	4.5	.20	28	670	.02	30010
2	5.0	500	.0	410	290	5.2	.20	24	840	.26	30010
4	5.0	--	--	--	290	6.4	.20	28	900	--	80020
2	4.1	--	--	--	200	5.4	.20	25	680	--	80020
3	4.4	--	--	--	230	6.7	.20	29	770	--	80020
1	3.1	--	--	--	130	3.3	.20	27	490	--	80020
3	5.4	580	.0	--	270	2.5	.20	28	880	.13	30010
.8	3.3	--	--	--	64	2.1	.20	27	340	--	80020
2	4.0	440	.0	340	190	4.2	.30	27	650	.16	30010
2	3.0	400	.0	360	150	3.0	.30	27	560	.21	30010
3	4.0	500	--	410	170	5.2	.30	22	680	.20	30010
2	4.9	--	--	--	180	3.6	.20	25	610	--	80020
2	5.6	--	--	--	170	2.6	.20	27	610	--	80020
2	3.7	250	.0	--	120	57	.08	20	470	.01	30010
4	5.8	280	.0	--	110	400	.08	24	1,100	2.6	30010
.7	4.2	300	.0	--	65	3.7	.30	23	350	--	38002
6	8.7	500	.0	--	510	29	.30	23	1,200	--	38002
3	5.7	600	.0	--	390	8.1	.20	28	1,100	.04	30010

Table 8.--*Miscellaneous-constituent concentrations in water from wells*

[Constituents are dissolved and values are reported in micrograms per liter. Geologic unit--110ALVM, alluvial deposits; 112OTSH, outwash gravel; 112TILL, glacial till; 112ALVM, terrace gravel; 125FRUN, Fort Union Formation; 211FHHC, Fox Hills-lower Hell Creek aquifer. Agency analyzing sample--30010, Montana Bureau of Mines and Geology; 38002, North Dakota State Water Commission; 80020, U.S. Geological Survey. Symbol: <, constituent present at concentration smaller than detection limit of applied analysis]

Location number	Date of sample (year-month-day)	Geo-logic unit	Alum-inum (Al)	Arsenic (As)	Beryl-lium (Be)	Boron (B)	Cad-mium (Cd)	Chro-mium (Cr)	Copper (Cu)	Iron (Fe)
30N55E03AAAA01	84-10-15	112ALVM	<30	13	--	270	<2	<2	2	160
30N55E10DDDD01	84-10-15	112OTSH	40	1	--	210	<2	<2	6	150
31N55E18DBAB01	82-09-02	112TILL	--	<1	0.7	130	<1	<10	<10	5
31N55E23DCCD01	83-07-20	112ALVM	--	--	--	--	--	--	--	2,700
31N55E29AABD01	83-08-08	110ALVM	--	--	--	--	--	--	--	290
31N55E35CBDB01	82-08-27	112TILL	--	--	--	--	--	--	--	250
31N56E17ADDB01	82-08-28	125FRUN	--	<1	.9	560	<1	10	<10	1,300
31N56E18BCBC01	48-08-20	125FRUN	--	--	--	280	--	--	--	160
	82-09-07	125FRUN	--	--	--	--	--	--	--	8,700
31N56E19ABAA01	78-08-24	211FHHC	--	--	--	2,200	--	--	--	130
	82-06-11	211FHHC	<30	--	--	2,200	<2	<2	<2	30
31N56E20DDDC01	82-09-07	125FRUN	--	--	--	--	--	--	--	230
31N56E24CCDD01	82-08-27	112TILL	<30	0	--	100	<2	8	17	20
31N56E30BBBB01	47-06-06	112OTSH	--	--	--	400	--	--	--	3,300
31N57E01BACA01	84-08-12	112OTSH	--	--	--	--	--	--	--	3,400
31N57E09ABAD01	83-07-18	112OTSH	--	--	--	--	--	--	--	2,600
31N57E09CCBC01	82-08-23	112OTSH	--	--	--	370	--	--	--	4,600
31N57E28DCBC01	78-08-24	112ALVM	--	--	--	--	--	--	--	1,100
31N57E34CDDC01	82-08-30	112TILL	70	<1	--	160	10	20	24	10
31N58E09CBCD01	82-08-30	125FRUN	--	--	--	430	--	--	--	740
31N59E06CCCA01	82-08-30	125FRUN	--	--	--	530	--	--	--	1,300
32N55E25ABCB01	82-06-11	110ALVM	<30	--	--	660	<2	<2	31	250
32N56E05DADB01	48-08-21	112OTSH	--	--	--	20	--	--	--	0
	82-09-07	112OTSH	--	--	--	--	--	--	--	6
32N56E17CCCB01	82-08-20	125FRUN	--	14	1.0	460	<1	<10	<10	1,900
32N56E20CCCC01	78-08-21	112ALVM	--	--	--	--	--	--	--	350
32N56E29DDDD01	84-10-14	112ALVM	<30	12	--	250	<2	<2	<2	97
32N56E29DDDD02	84-10-14	112OTSH	<30	22	--	240	<3	<3	7	240
32N56E31BBBB02	47-06-08	112ALVM	--	--	--	330	--	--	--	2,400
32N56E33BCDC01	82-06-11	112TILL	<30	--	--	290	<2	<2	25	5,600
32N57E26CBBB02	84-08-10	112ALVM	<30	--	--	250	<2	<2	<2	780
32N57E26CBBB03	84-08-11	112OTSH	--	--	--	--	--	--	--	5,500
32N58E04DBBD01	84-08-10	125FRUN	--	--	--	--	--	--	--	59
32N58E04DBBD02	84-08-10	112OTSH	--	--	--	--	--	--	--	3,100
32N58E05DDAB01	82-08-12	112OTSH	--	17	.8	410	<1	10	<10	1,200
32N58E06DCAA01	82-08-12	112OTSH	--	--	--	250	--	--	--	96
32N58E12DDCC01	82-08-18	125FRUN	--	--	--	--	--	--	--	1,700
32N58E13DDDB01	78-08-26	112ALVM	--	--	--	--	--	--	--	2,800
32N58E22CBBC01	82-08-16	125FRUN	--	<1	<.5	--	<1	10	<10	76
33N56E02ACAB01	78-08-22	112TILL	--	--	--	250	--	--	--	2,500
33N56E26DDDC01	82-08-25	112TILL	140	<1	--	360	13	20	44	20
33N56E29BBBB01	80-10-14	125FRUN	--	--	--	--	--	--	--	880
33N56E31BBBC01	82-09-06	125FRUN	--	--	--	--	--	--	--	460
33N57E05ACBC01	82-08-25	110ALVM	<0	<1	--	<50	<9	<10	18	<2
33N57E06CBBD01	78-08-23	112TILL	--	--	--	--	--	--	--	3,700

Lead (Pb)	Lith-ium (Li)	Manga-nese (Mn)	Molyb-denum (Mo)	Nick-el (Ni)	Sele-nium (Se)	Sil-ver (Ag)	Stron-tium (Sr)	Ti-tanium (Ti)	Vana-dium (V)	Zinc (Zn)	Zir-conium (Zr)	Agency ana-lyzing sample (code number)
--	61	67	<20	<10	<1	<2	1,300	10	<1	<3	<4	30010
--	84	750	<20	<10	<1	<2	940	10	<1	<3	<4	30010
<100	--	<1	--	<100	140	--	--	--	--	55	--	80020
--	--	120	--	--	--	--	--	--	--	--	--	30010
--	--	59	--	--	--	--	--	--	--	--	--	30010
--	--	350	--	--	--	--	--	--	--	--	--	80020
<100	--	58	--	<100	<1	--	--	--	--	17	--	80020
--	--	--	--	--	--	--	--	--	--	--	--	80020
--	--	130	--	--	--	--	--	--	--	--	--	80020
--	140	<10	--	--	--	--	220	--	--	--	--	30010
<40	120	<1	<20	<10	<1	<2	200	2	<1	70	<3	30010
--	--	5	--	--	--	--	--	--	--	--	--	80020
20	80	1,000	<20	<10	<1	5	1,200	20	13	80	6	30010
--	--	--	--	--	--	--	--	--	--	--	--	80020
--	--	210	--	--	--	--	--	--	--	--	--	30010
--	--	290	--	--	--	--	--	--	--	--	--	30010
--	--	350	--	--	--	--	--	--	--	--	--	80020
--	100	40	--	--	--	--	--	--	--	--	--	30010
20	80	42	<20	<10	47	14	1,400	20	21	160	30	30010
--	--	120	--	--	--	--	--	--	--	--	--	80020
--	--	30	--	--	--	--	--	--	--	--	--	80020
<40	50	1,800	<20	<10	<1	<2	800	<1	23	10	<3	30010
--	--	--	--	--	--	--	--	--	--	--	--	80020
--	--	2	--	--	--	--	--	--	--	--	--	80020
<100	--	32	--	<100	<1	--	--	--	--	7	--	80020
--	<10	820	--	--	--	--	--	--	--	--	--	30010
--	31	44	<20	<10	<1	<2	680	2	<1	6	<4	30010
--	44	91	<20	<10	<1	<2	1,100	20	<1	<3	<4	30010
--	--	--	--	--	--	--	--	--	--	--	--	80020
60	40	67	<20	<10	<1	<2	990	50	<1	30	<3	30010
--	47	40	<20	<10	--	<2	460	<1	<1	<3	<4	30010
--	--	200	--	--	--	--	--	--	--	--	--	30010
--	--	15	--	--	--	--	--	--	--	--	--	30010
--	--	250	--	--	--	--	--	--	--	--	--	30010
<100	--	170	--	100	<1	--	--	--	--	9	--	80020
--	--	470	--	--	--	--	--	--	--	--	--	80020
--	--	31	--	--	--	--	--	--	--	--	--	80020
--	30	50	--	--	--	--	--	--	--	--	--	30010
<100	--	85	--	<100	<1	--	--	--	--	7	--	80020
--	50	170	--	--	--	--	2,000	--	--	--	--	30010
44	110	3	<20	10	24	21	3,500	40	26	60	40	30010
--	--	30	--	--	--	--	--	--	--	--	--	80020
--	--	30	--	--	--	--	--	--	--	--	--	80020
19	10	1	<20	<10	<1	<13	270	8	<14	80	<20	30010
--	40	140	--	--	--	--	--	--	--	--	--	30010

Table 8.--*Miscellaneous-constituent concentrations in water from wells*--Continued

Location number	Date of sample (year-month-day)	Geologic unit	Aluminum (Al)	Arsenic (As)	Beryllium (Be)	Boron (B)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Iron (Fe)
33N57E12CDBD01	82-08-15	112TILL	70	<1	--	240	7	10	25	320
33N57E17BACA01	82-08-25	112OTSH	--	--	--	160	--	--	--	28
33N57E22DCCA01	82-08-20	112TILL	--	--	--	--	--	--	--	20,000
33N57E33CDDC01	82-08-24	112TILL	90	9	--	390	13	20	26	12,000
33N58E01ABAB01	82-08-24	112TILL	--	19	<1.0	490	<1	<10	<10	3,100
33N58E06CBDC01	82-08-17	112TILL	<30	1	--	140	<2	<2	12	530
33N58E09CDDA01	82-08-13	112OTSH	<30	3	--	180	<2	2	8	430
33N58E17ABBA01	82-08-19	112OTSH	<30	8	--	100	2	4	7	2,700
33N58E17ADDD01	84-08-09	112OTSH	--	--	--	--	--	--	--	2,500
33N58E21CCAA01	82-06-09	112OTSH	<30	--	--	150	<2	<2	9	2,100
33N58E23AADB01	82-08-24	112TILL	--	--	--	--	--	--	--	13,000
33N58E23CBCA02	84-08-09	112OTSH	<30	--	--	270	<2	<2	<2	1,500
33N58E23CCAA01	82-06-09	112OTSH	<30	--	--	210	<2	<2	2	1,000
	84-08-09	112OTSH	<30	--	--	200	<2	<2	<2	1,100
33N58E25AAAA02	84-10-13	112ALVM	<30	16	--	280	<2	<2	3	110
33N58E28CBBA01	84-08-08	112OTSH	<30	--	--	130	<2	<2	5	5,200
33N58E29ADCA01	82-06-13	112OTSH	<30	--	--	230	<2	<2	14	3,400
33N58E29ADDB01	84-08-08	112OTSH	--	--	--	--	--	--	--	2,600
33N58E29ADDB02	84-08-09	125FRUN	--	--	--	--	--	--	--	380
33N58E30ACAA01	84-06-12	112OTSH	--	--	--	--	--	--	--	100
33N58E32CCAA01	82-08-16	112OTSH	--	--	--	270	--	--	--	3,800
33N58E33DACB01	82-08-18	125FRUN	--	--	--	--	--	--	--	3,900
34N57E20CADC01	78-08-19	112TILL	--	--	--	--	--	--	--	1,100
34N58E06CCCB01	83-08-08	125FRUN	--	--	--	--	--	--	--	310
34N58E11DBAB01	84-08-08	112OTSH	--	--	--	--	--	--	--	5,100
34N58E13BBDD01	82-06-13	112OTSH	<30	--	--	250	<2	4	18	3,800
34N58E13CDBB01	82-06-13	112OTSH	<30	--	--	270	<2	<2	23	870
34N58E14ACAA01	82-08-13	112OTSH	--	21	<.5	520	<1	<10	<10	4,200
34N58E14BDDD01	82-08-12	112OTSH	--	--	--	210	--	--	--	2,800
34N58E14CBDD01	82-08-12	112OTSH	--	--	--	--	--	--	--	3,400
34N58E14DBDD01	82-08-13	112OTSH	--	--	--	150	--	--	--	2,800
34N58E20DAAA01	84-08-11	112OTSH	<30	--	--	340	<2	<2	6	4,800
34N58E21DCCD01	82-08-19	112OTSH	--	--	--	280	--	--	--	2,200
34N58E22AACC01	82-06-13	112OTSH	<30	--	--	220	<2	<2	8	2,800
34N58E23BBBB01	82-06-13	112OTSH	<30	--	--	170	<2	<2	11	2,400
34N58E26ADAB01	78-08-21	112OTSH	--	--	--	220	--	--	--	350
34N58E29CDBA01	82-08-19	112OTSH	--	--	--	410	--	--	--	2,400
34N58E29DCBA01	82-08-19	112OTSH	--	6	<.5	230	<1	<10	<10	3,400
35N58E01AADA01	83-07-14	112OTSH	--	--	--	--	--	--	--	320
35N58E01DBAA01	83-07-14	112OTSH	<30	--	--	80	<2	2	38	1,600
35N58E24AAAA01	82-06-08	112OTSH	--	--	--	50	--	--	--	900
35N58E24DDDD01	82-06-08	112OTSH	--	--	--	100	--	--	--	2,900
35N58E36CBBB01	84-06-12	112OTSH	--	--	--	--	--	--	--	2,700

Lead (Pb)	Lithium (Li)	Manganese (Mn)	Molybdenum (Mo)	Nickel (Ni)	Selenium (Se)	Silver (Ag)	Strontium (Sr)	Titanium (Ti)	Vanadium (V)	Zinc (Zn)	Zirconium (Zr)	Agency analyzing sample (code number)
30	80	34	<20	30	9	12	2,500	20	21	4,600	20	30010
--	--	160	--	--	--	--	--	--	--	--	--	80020
--	--	440	--	--	--	--	--	--	--	--	--	80020
41	100	230	<20	<10	<1	15	3,200	30	15	2,600	20	30010
<100	--	210	--	<100	<1	--	--	--	--	92	--	80020
40	45	410	<20	10	<1	<2	1,300	10	3	88	<3	30010
16	50	530	<20	<10	<1	5	320	6	7	10	6	30010
13	20	300	<20	<10	<1	4	510	6	4	9	6	30010
--	--	310	--	--	--	--	--	--	--	--	--	30010
50	30	290	<20	<10	<1	<2	570	<1	<1	<4	<3	30010
--	--	1,200	--	--	--	--	--	--	--	--	--	80020
--	39	71	<20	<10	--	<2	660	<1	<1	<3	<4	30010
<40	50	43	<20	<10	<1	<2	560	<1	<1	<4	<3	30010
--	49	42	<20	<10	--	<2	610	<1	<1	<3	<4	30010
--	54	510	40	<10	<1	<2	880	7	<1	8	<4	30010
--	23	430	<20	<10	--	<2	720	10	<1	<3	<4	30010
<40	30	340	<20	<10	<1	<2	1,000	10	<1	<4	<3	30010
--	--	310	--	--	--	--	--	--	--	--	--	30010
--	--	9	--	--	--	--	--	--	--	--	--	30010
--	--	340	--	--	--	--	--	--	--	--	--	30010
--	--	300	--	--	--	--	--	--	--	--	--	80020
--	--	220	--	--	--	--	--	--	--	--	--	80020
--	40	940	--	--	--	--	--	--	--	--	--	30010
--	--	8	--	--	--	--	--	--	--	--	--	30010
--	--	170	--	--	--	--	--	--	--	--	--	30010
<40	30	290	<20	<10	<1	<2	650	8	<1	<4	<3	30010
<40	40	540	<20	<10	<1	<2	810	40	<1	<4	<3	30010
<100	--	120	--	<100	<1	--	--	--	--	10	--	80020
--	--	320	--	--	--	--	--	--	--	--	--	80020
--	--	95	--	--	--	--	--	--	--	--	--	80020
--	--	280	--	--	--	--	--	--	--	--	--	80020
--	54	470	<20	<10	--	<2	1,100	8	<1	<3	<4	30010
--	--	330	--	--	--	--	--	--	--	--	--	80020
<40	30	280	30	<10	<1	<2	550	30	<1	<4	<3	30010
<40	30	250	30	<10	<1	<2	490	30	<1	<4	<3	30010
--	40	650	--	--	--	--	730	--	--	--	--	30010
--	--	480	--	--	--	--	--	--	--	--	--	80020
<100	--	270	--	<100	<1	--	--	--	--	7	--	80020
--	--	460	--	--	--	--	--	--	--	--	--	30010
<40	77	660	<20	<10	--	<2	340	30	6	<3	<4	30010
--	--	540	--	--	--	--	--	--	--	--	--	38002
--	--	350	--	--	--	--	--	--	--	--	--	38002
--	--	200	--	--	--	--	--	--	--	--	--	30010