EXPLORATION FOR AREAS SUITABLE FOR GROUND-WATER DEVELOPMENT, CENTRAL CONNECTICUT VALLEY LOWLANDS, MASSACHUSETTS

By Bruce P. Hansen

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CONTENTS

ILLUSTRATIONS

(Plate is in pocket.)

TABLES

FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM OF UNITS (SI) METRIC CONVERSION FACTORS

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

Multiply inch-pound units	By	To obtain SI Units
	Length	
inch (in)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square foot (ft^2)	0.0929	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallons per minute (gal/min)	0.00379	cubic meter per minute (m^3/min)
million gallons per day (Mgal/d)	0.0438	cubic meter per second (m^3/s)
	Mass	
pound (lb)	0.4536	kilogram (kg)

Hydraulic Conductivity and Transmissivity

A, Hydraulic conductivity (K)

Feet per day	Meters per day	Gallons per day per square foot
1.0	0.305	7.48
3.28	1.0	24.5
0.134	0.041	1.0

B, Transmissivity (T)

Feet squared per day	Meters squared per day	Gallons per day per foot
1.0	0.0929	7.48
10.76	1.0	80.5
0.134	0.124	1.0

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ABSTRACT

Drillers' logs and geophysical borehole logs for a 25-square-mile section of the Connecticut River valley lowlands area of Amherst, Hadley, and Sunderland, Massachusetts, indicate that the area is underlain primarily by fine-grained lacustrine deposits. Nine test wells ranging in depth from 100 to 303 feet completely penetrate the unconsolidated valley fill. Geophysical logs indicate that the grain size of the lacustrine deposits changes from clay to silt or fine sand with increasing depth.

At six sites, seismic-refraction surveys indicate depths to bedrock ranging from 138 to 476 feet below land surface. The results of a continuous seismic-reflection profile on 10.8 miles of the Connecticut River indicate that fine-grained lake deposits in some areas, particularly from Hockanum Flat to just north of the Fort River, may be underlain by coarse-grained deposits. The deposits are located from 50 to 250 feet below the river surface, and range in thickness from 0 to 165 feet. Bedrock surface at a depth of 290 feet below the river surface (190 feet below sea level) also were detected.

A basal sand and gravel aquifer underlies the study area, but the deposits have limited and irregular areal extent. Large quantities of water capable of sustaining municipal supplies are withdrawn from some of these deposits. These aquifers may be continuous with previously mapped surficial ice-contact sand and gravel deposits. Areas that seem favorable for additional exploration for high-water-yielding sand and gravel deposits are mainly in the southern part of the area, between the Connecticut River and the Holyoke Range.

INTRODUCTION

In recent years, a number of communities in the central Connecticut River valley of Massachusetts have experienced frequent water-supply shortages. Amherst, in particular, has been plagued by persistent water-supply deficiencies, mainly the result of the rapid expansion of the University of Massachusetts, which accounts for over 50 percent of the Town's water consumption. The adjacent Towns of Hadley and Sunderland also have experienced intermittent water-supply deficiences.

Most of the municipal ground-water supplies in the central Connecticut River valley lowlands area are derived from glacial sand and gravel deposits that underlie glacial silt and clay deposits. Tighe and Bond (1973) reported that the basal sand and gravel deposits correspond to the location of a preglacial river valley that traverses the area. Walker and Caswell (1977) suggested that a basal layer of sand and gravel is present widely, but not everywhere, in the lowlands area.

The U.S. Geological Survey, in cooperation with the Massachusetts Division of Water Resources, began a detailed study of the unconsolidated deposits in part of the central Connecticut Valley lowlands. The objective of the study was to determine if the buried sand and gravel deposits are extensive, as suggested by preliminary data, and form a large, high-water-yielding ground-water resource in the valley. This report presents the results of that study.

Location

The study area is in the Connecticut River valley in central Massachusetts (fig. 1). It includes parts of the Towns of Sunderland in Franklin County and Amherst and Hadley in Hampshire County. The area covers about 25 mi^2 and is bordered on the north by the prominent Mount Toby highland, on the east by the rolling hills of the central uplands of Massachusetts, on the south by the Holyoke Range, and on the west by the Connecticut River. The flat lowlands range in elevation from 100 to 180 feet above sea level.

Previous Investigations

Surficial deposits are shown on maps of the Mount Holyoke and Mount Toby quadrangles by Balk (1957) and Jahns (1951). Bedrock geology is shown on maps of the Mount Holyoke and Mount Toby quadrangles by Balk (1957) and Willard (1951). Bedrock-surface contours are shown on maps of the Mount Toby and Mount Holyoke quadrangles by Londquist (1974, 1975) respectively. Walker and Caswell (1977) and Frimpter (1980) described the general ground-water conditions in the Connecticut River lowlands of Massachusetts. Tighe and Bond, consulting engineers, reported on ground-water testing in the Hockanum area of Hadley (1972) and discussed additional sources of supply for Amherst (1973). Almer Huntley, Jr., and Associates, Inc. (1974) described general ground-water conditions and results of ground-water testing in the Town of Hadley. Petersen and Maevsky (1962) and E. H. Walker and W. W. Caswell, III (U.S. Geological Survey, personal commun., 1977) provided well data.

Acknowledgments

The author wishes to thank the many local, State, and Federal government officials, well drillers, engineering-consulting firms, industrial concerns, and individual homeowners who provided data, assistance, and permission for test-well drilling and seismic work on their property. Rusty Tirey, Office of Marine Geology, U.S. Geological Survey, Woods Hole, Massachusetts, and F. P. Haeni, U.S. Geological Survey, Hartford, Connecticut, provided equipment and technical assistance and made a continuous seismic-reflection profile on the Connecticut River. Hadley town selectmen, refused to grant permission for any drilling or seismic work on town property, and successfully discouraged private landowners from granting similar permission.

HYDROGEOLOGY

Geology

The bedrock underlying most of the area consists of sandstones, conglomerates, shales, and some lava flows. These rocks formed during Triassic and Jurassic time in a north-south-trending valley bounded on the east by a major fault. The lowland is the result of preglacial erosion which cut more deeply into the Triassic and Jurassic sedimentary rock than the more resistant crystalline rocks of the bordering highlands and the Holyoke Range.

During the glacial period, the ice that advanced over this area rounded hills and deepened the bedrock valley in places. The ice deposited a discontinuous sheet of till, a heterogeneous mixture of rock fragments, ranging in size from boulders to clay, over the bedrock. As the glacial ice melted, streams of meltwater deposited sand and gravel along channels in the ice (eskers and kames) and in channels between the ice and adjacent hills (kame terraces).

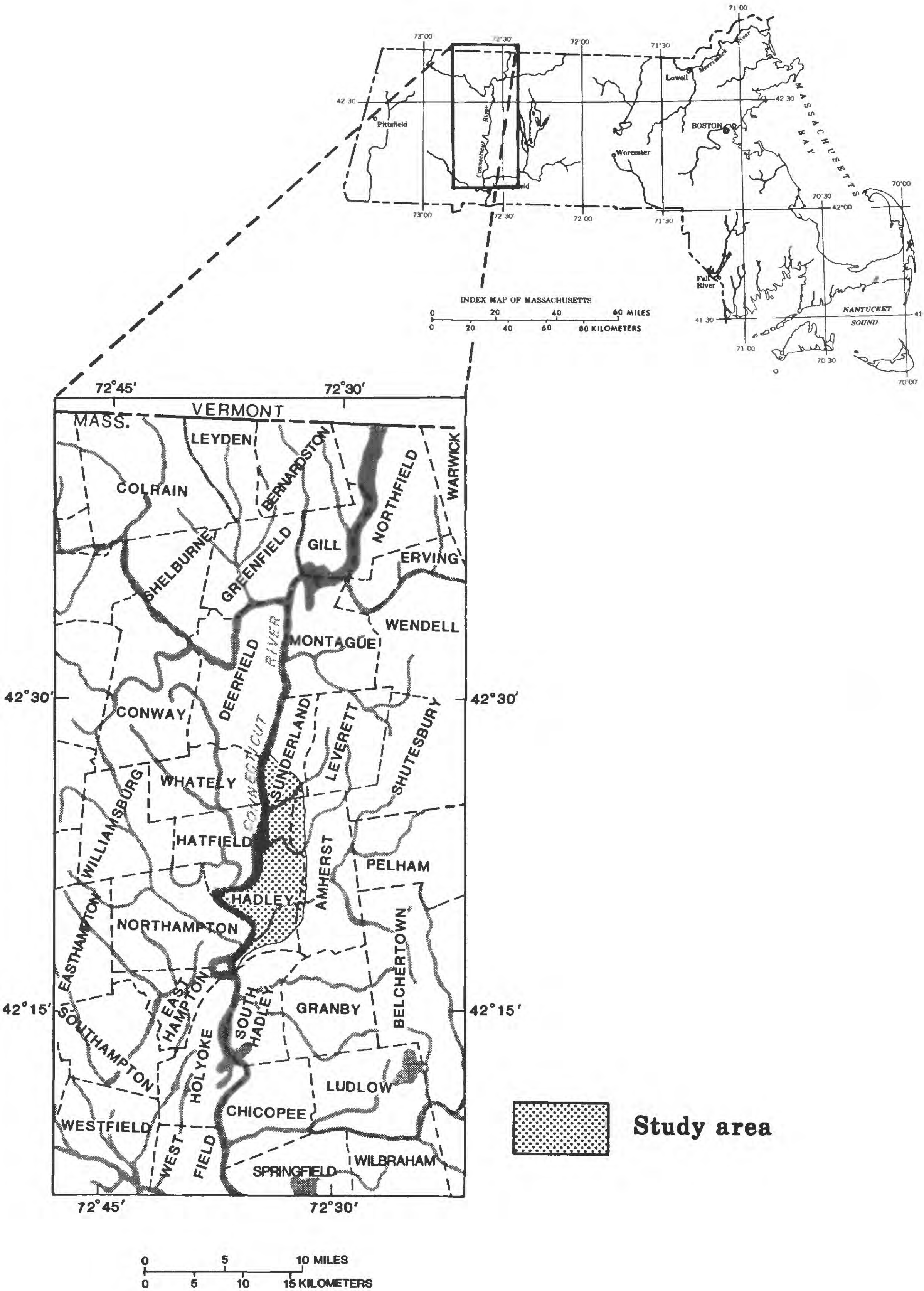


Figure 1.--Location of study area

During deglaciation and for some period after, the Connecticut River valley was occupied by "Lake Hitchcock," a large lake that formed behind a dam of glacial deposits in Connecticut. Lake-bed deposits of clay, silt, and fine sand occur beneath most of the lowlands that were occupied by Lake Hitchcock. These deposits are as thick as 476 feet where they fill the preglacial river channel and other glacially scoured areas. In places, these lake deposits overlap or bury sand and gravel deposits.

During the period that the glacial lake was draining, tributary streams from the valley sides spread alluvial deposits out into the receding lake. These deposits of sand and gravel cover the fine-grained lake-bottom deposits in places.

When Lake Hitchcock eventually drained, the Connecticut River eroded and meandered across parts of the former lake bottom creating the present wide terraces and flood plain. A layer of alluvial sand and some gravel, as much as 50 feet thick, caps these terraces and the flood plain. The distribution of surficial deposits and underlying bedrock formations is shown on the geologic maps of the Mount Toby (Balk, 1957) and Mount Holyoke (Jahns, 1951; Willard, 1951) quadrangles.

Ground-Water Development

Within the study area, large quantities of water are being withdrawn from buried deposits of sand and gravel. Withdrawal rates range from 190 to 1,080 gal/min. The location of 10 high-capacity wells and test wells are shown on plate 1, and data and logs are presented in tables A-1 and A-2 in the Appendix.

The aquifers along the northern boundary of the study area in Sunderland are deltaic deposits of sand and gravel that were deposited by glacial meltwater streams emptying into Lake Hitchcock from the adjacent highlands. Historically, ground-water development from the Sunderland delta was initially from natural and improved spring flows. Lowered spring flows in dry years, or the need for additional water, resulted in the development of wells which further lowered the natural water level and reduced spring flows which, in turn, resulted in the development of more wells to augment declining spring flows. The installed ground-water withdrawal capacity is about 4 Mgal/d, and the average yearly withdrawal is approximately 2.9 Mgal/d. Based on an estimated rate of ground-water recharge from precipitation of 1 Mgal/d for areas of stratified-drift deposits in New England, the 2 mi^2 area of stratified-drift deposits receives, on the average, about 2 Mgal/d of ground-water recharge. However, ground-water withdrawals (1981) exceed 2.9 Mgal/d. This level of pumping is being supported by recharge and by induced infiltration from a stream that flows across the area, as well as by leakage from less permeable materials adjacent to the aquifer. Based on measurements of stream runoff from two similar basins in western Massachusetts of approximately the same size (3.9 mi^2), it is estimated that recharge of 2 Mgal/d is available as induced infiltration from the stream. Thus, the total amount of estimated available water for the area is 4 Mgal/d, which is equal to the current withdrawal capacity. Withdrawals approaching the 4 Mgal/d capacity of the aquifer would cause further decreases in spring flow. During dry years, average recharge may be less than average withdrawal, and 4 Mgal/d might not be obtainable.

The small delta at the location of Sunderland well 50 is highly developed for its size. The public-supply well can pump 0.6 Mgal/d, and, in conjunction with direct pumpage from the stream crossing the area, serves as one source of supply to the Sunderland Water District system.

In Hadley, the aquifers are sand and gravel deposits that are overlain by varying thicknesses of silt and clay. These deposits are closely associated with, and most likely continuous with, nearby mapped surficial ice-contact sand and gravel deposits. The available pumping capacity of the area near Mount Warner is 1.5 Mgal/d from two public-supply wells (Hadley wells 15 and 16). Almer Huntley, Jr., and Associates, Inc. (1974) has reported that the two wells could be pumped to yield a total of 3 Mgal/d. It has also been reported that the water table near these wells has declined at a rate of about 1 foot per year since development began. The Hadley well 22 site has been developed to yield 2.8 Mgal/d from two public-supply wells. The drawdown data from a pump test at this site indicate that the aquifer is hydraulically connected to the Fort River—a source of induced recharge. In addition, ice-contact deposits just to the east serve as a recharge area. The site shown as Hadley well 19 has been tested but not developed. Analysis of available data from an aquifer test, and from test well drilling at this site, indicates that the aquifer may yield from 2 to 4 Mgal/d. The test data also indicate that there is a good hydraulic connection betweeen the aquifer at this site and the Connecticut River.

EXPLORATION METHODS AND RESULTS

Exploration to determine the areal extent of a basal sand and gravel aquifer was conducted from June 1981 through July 1982. Nine 7-inch diameter test holes were drilled using the mud rotary method. These test holes were geophysically logged and piezometers were installed. Seismic refraction surveys were conducted at six sites. A seismic reflection survey was run along 10.8 miles of the Connecticut River. The results of this exploration work are described in detail below.

Test Drilling

The drilling program was designed to explore previously untested areas having large thicknesses of unconsolidated material. Locations for drilling were selected based on available bedrock contour maps and availability of owner permission. Most of the test holes were located in the northern part of the area because of the unavailability of sites in the southern part of Hadley. Nine test wells (numbers 27, 29, 30, and 31 in Hadley and 65, 66, 67, 69, and 70 in Sunderland) were drilled, and range in depth from 100 to 303 feet. The locations of the test wells are shown on plate 1, and information about each well, including a lithologic log, is given in tables A-1 through A-3 in the Appendix. The lithologic logs are based on observations of the cuttings contained in the drilling mud and on split-spoon samples. In general, similar lithology was encountered, and is summarized in table 1.

Table 1.—Summary of geologic logs from test holes

Material	Description	Range in thickness (feet)
Alluvial deposits:	Layered fine sand to gravel; some silt. At six locations, 2-10 feet of clay was encountered at the surface.	10-49
Lake deposits:	Varved clay, silt, and very fine sand. Clay and silt predominate in the upper part of this sequence and grade to slightly coarser silt and very fine sand with depth.	17-274
Till:	Heterogeneous mixture of red clay, silt, sand and gravel.	0-5

Two exceptions to the above generalized description are worth noting. In test well Hadley W-27, a 50-foot layer of fine sand was found between 250 and 300 feet in depth. Also, Hadley 31 has thin lenses of silt and clay lake deposits that interfinger with sand and sand and gravel that may be outwash or thin alluvium deposited by streams entering the glacial lake during the period when it was draining.

Geophysical Logging

Geophysical logs aid in identification of lithologic boundaries, lithologic characteristics, and hydrologic properties. Geophysical logs are used as a supplement to the driller's descriptive log. SP (spontaneous potential), resistance, and natural-gamma-ray logs were made of each of the test holes drilled during the study.

SP is a measure of the voltage generated spontaneously by electrical-conductivity differences between drilling mud and formation water. SP is measured between an electrode moved through the borehole and another electrode connected to the ground surface. In unconsolidated material saturated with freshwater, the trace near the center of the log corresponds to silt and clay. Shifts to the left (negative) relate to other generally more permeable strata, such as sand or sand and gravel (fig. 2).

The resistance technique measures the resistance to flow of an electric current through earth materials between two electrodes moved through the borehole. Saturated clay formations have relatively low resistivity (trace to the left), and sand formations have relatively high resistivity (trace to the right); see figure 2.

Natural gamma ray logging measures the radiation of gamma rays from naturally occuring radioactive elements in subsurface formations (mainly potassium-40 in the unconsolidated materials deposited in Massachusetts). In most cases, clay contains more of these elements than sand or sand and gravel. The log of unconsolidated formations indicates clay-rich deposits at those depths where the gamma-ray intensity is high (trace right) and sand- or gravel-rich deposits where the intensity is low (trace left); see figure 2.

The geophysical logs of the test wells (figs. 2 and 3), generally correlate with the lithologic logs, but, in many cases, provide more detail. For example, the lithologic log of Sunderland W-67 (fig. 2) indicates the presence of fine sand and clay in layers from a depth of 30 to 55 feet. The geophysical logs of this same interval are interpreted to show that the clay is located at depths of 32 to 35 and 42 to 47 feet, the rest being fine sand.

A comparison of the geophysical logs of Hadley W-27 and the other test wells and the material recovered by several split-spoon samples indicates that the lake deposits penetrated in all but one of the other test wells may have more very fine or fine sand with depth than is indicated by the material logs alone. Neither the lithologic nor geophysical logs indicated any coarse-grained material at depth.

Seismic Surveys

Seismic refraction surveys were conducted at locations selected to locate and verify the presence of the thickest unconsolidated deposits, to determine the geologic setting of several test wells, and to provide velocity data to help interpret seismic reflection records. Surveys at six sites totaled 12,450 feet in length, and were interpreted by delay-time and ray-tracing techniques described by Scott and others (1972). The locations of the seismic lines are shown on plate 1, and the interpretive cross sections are shown in figure 4. Depths to bedrock from land surface range from 138 to 476 feet.

A continuous seismic-reflection profile was made from a boat over 10.8 miles of the Connecticut River from just south of Mount Warner to the Holyoke Range (plate 1). About 5.3 miles of good record and 2.9 miles of poor, but usable, record was obtained. Areas of poor or no data were due to either organic river-bottom deposits which blocked energy transmission, insufficient sound-source energy necessary to penetrate the full thickness of the unconsolidated deposits, or the masking of the shallow lithology on the record by strong multiples of river-bottom reflections. An interpreted cross section along the entire traverse of the reflection survey (fig. 5) shows an area of sand and gravel deposits, or till with some stratification, underlying fine-grained deposits between locations 23 and 32. The record and its interpretation for a portion of this area is shown in figure 6. The presence of these coarse deposits has not been verified by drilling. As shown on the cross section, the survey provided depth-to-bedrock information. A bedrock-surface elevation of 190 feet below sea level was recorded near station 22 on the traverse. Additional selected seismic reflection profiles are shown in figure 7.

FUTURE GROUND-WATER EXPLORATION

Plate 1 shows those areas where future ground-water exploration might discover additional coarse-grained deposits that have the potential for significant ground-water development. These areas have been delineated based on the location of present ground-water development, surficial geology, bedrock topography, and interpretation of seismic records. The best area for exploration lies just west and north of the Holyoke Range, between Hadley W-19 and W-22, where surficial sand and gravel is present on the east and the seismic record along the river indicates coarse-grained material at depth. The area east of Mount Warner, shown extending about 0.5 mile north and 1 mile south of Hadley W-15 and W-16, is based on present (1984) development, the presence of surficial sand and gravel, and the presence of a deep bedrock valley. The less favorable area, which extends from Mount Warner south to Hadley W-22, north of the Holyoke Range, also is underlain by a deep bedrock valley. The extent and potential of most of this area in the southern part of Hadley has not been assessed in this study.

Some of the ground water in Hadley has not been developed because it contains manganese, 0.35 mg/L (Tighe and Bond, 1972) and would have to be treated to meet drinking water standards (U.S. Environmental Protection Agency, 1975; 1977). Manganese and iron-bearing ground water has been developed in Massachusetts, but only where less expensive sources could not be found (Frimpter, 1973).

CONCLUSIONS

1. No areally extensive basal sand and gravel aquifer exists beneath the study area.

2. Limited, irregularly distributed, buried sand and gravel deposits capable of providing large quantities of ground water are present and have been developed.

3. The developed aquifer areas in Hadley may have the potential to be developed for additional ground-water withdrawals, but the water may have to be treated for iron. Data indicate that 2 to 5.5 Mgal/d of additional ground water could be pumped from the existing sites. Preliminary data show that additional areas in the southern part of Hadley may be underlain by coarse-grained deposits that have the potential for high capacity ground-water withdrawals. These areas may warrant further ground-water exploration.

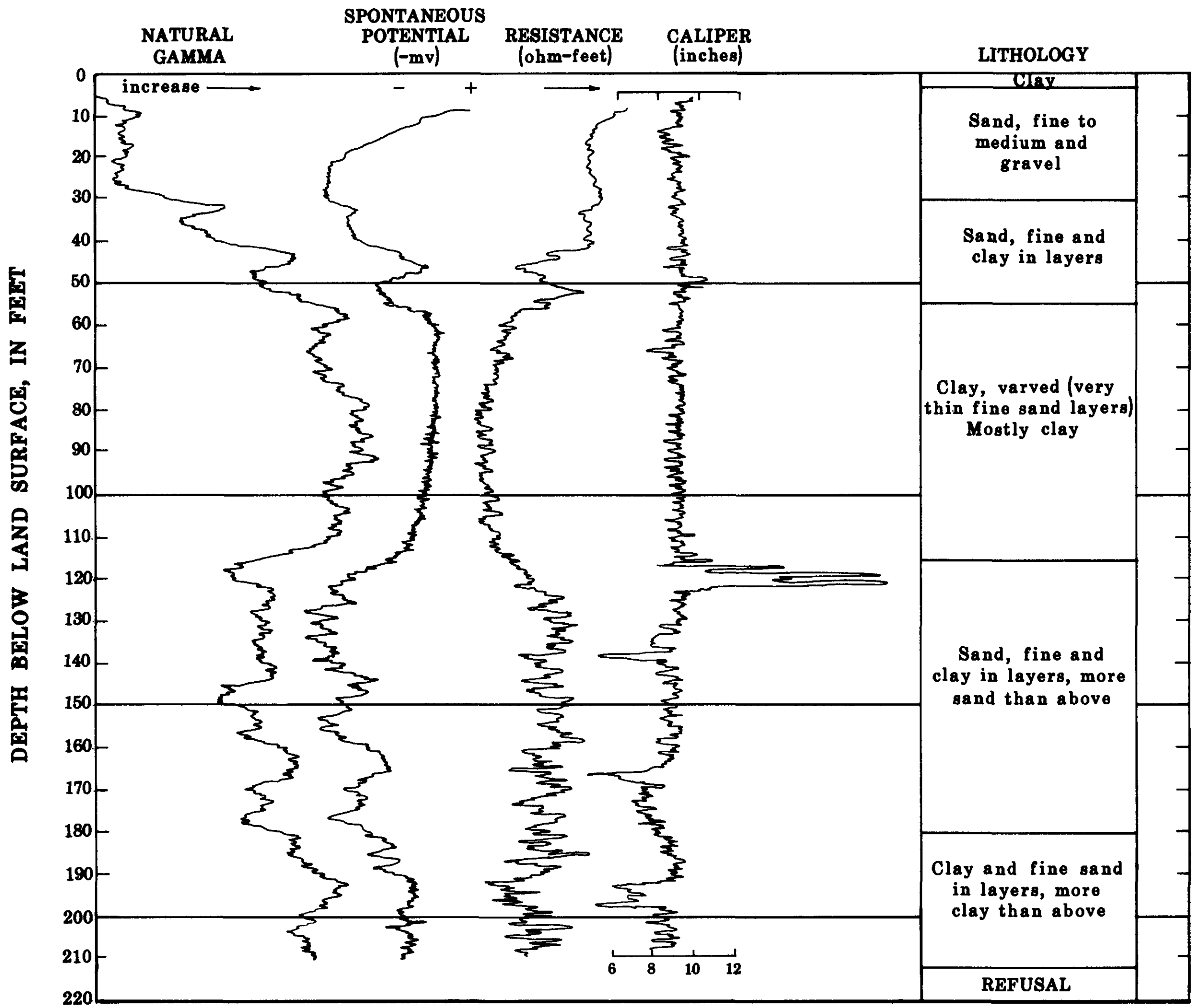
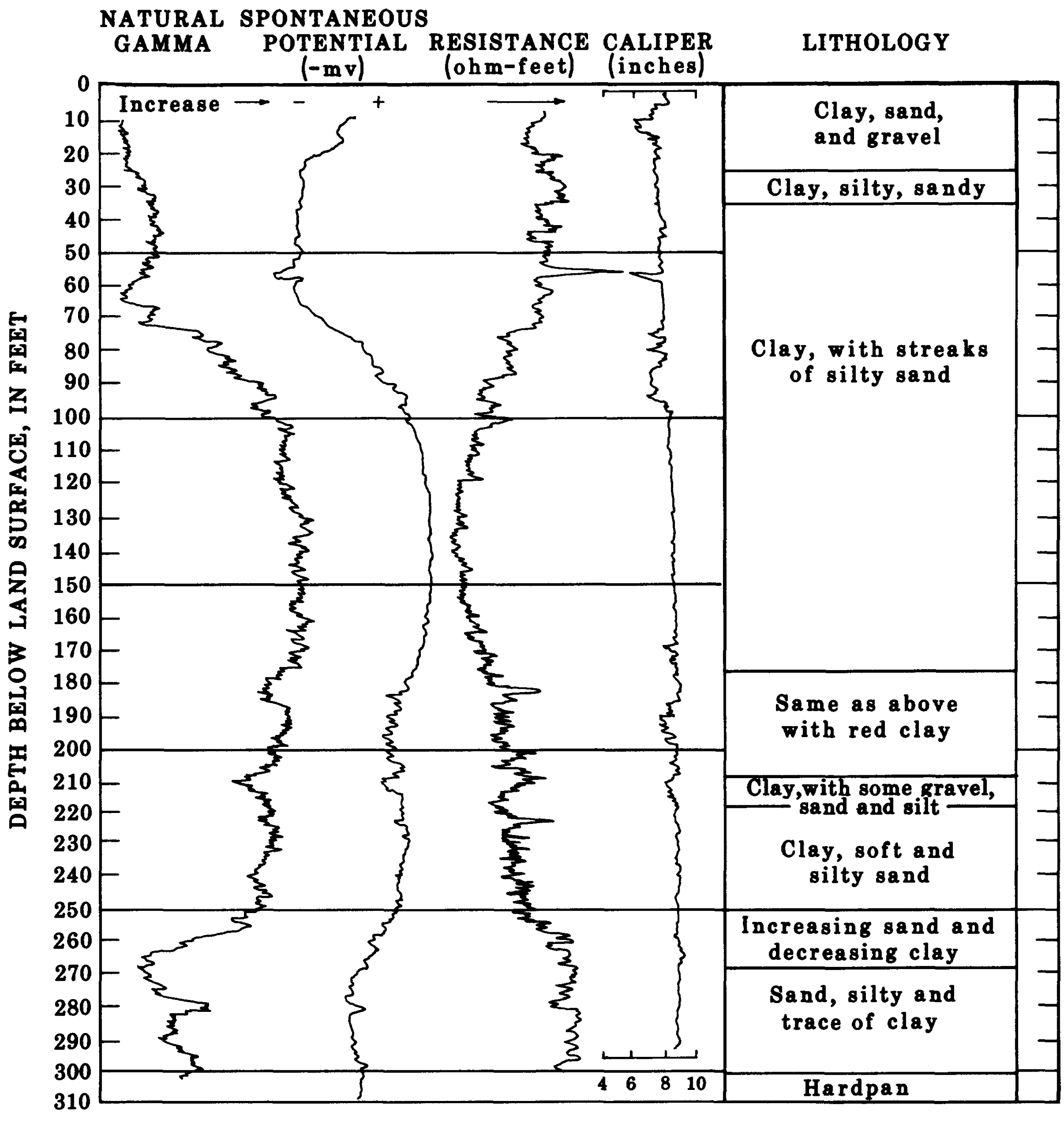
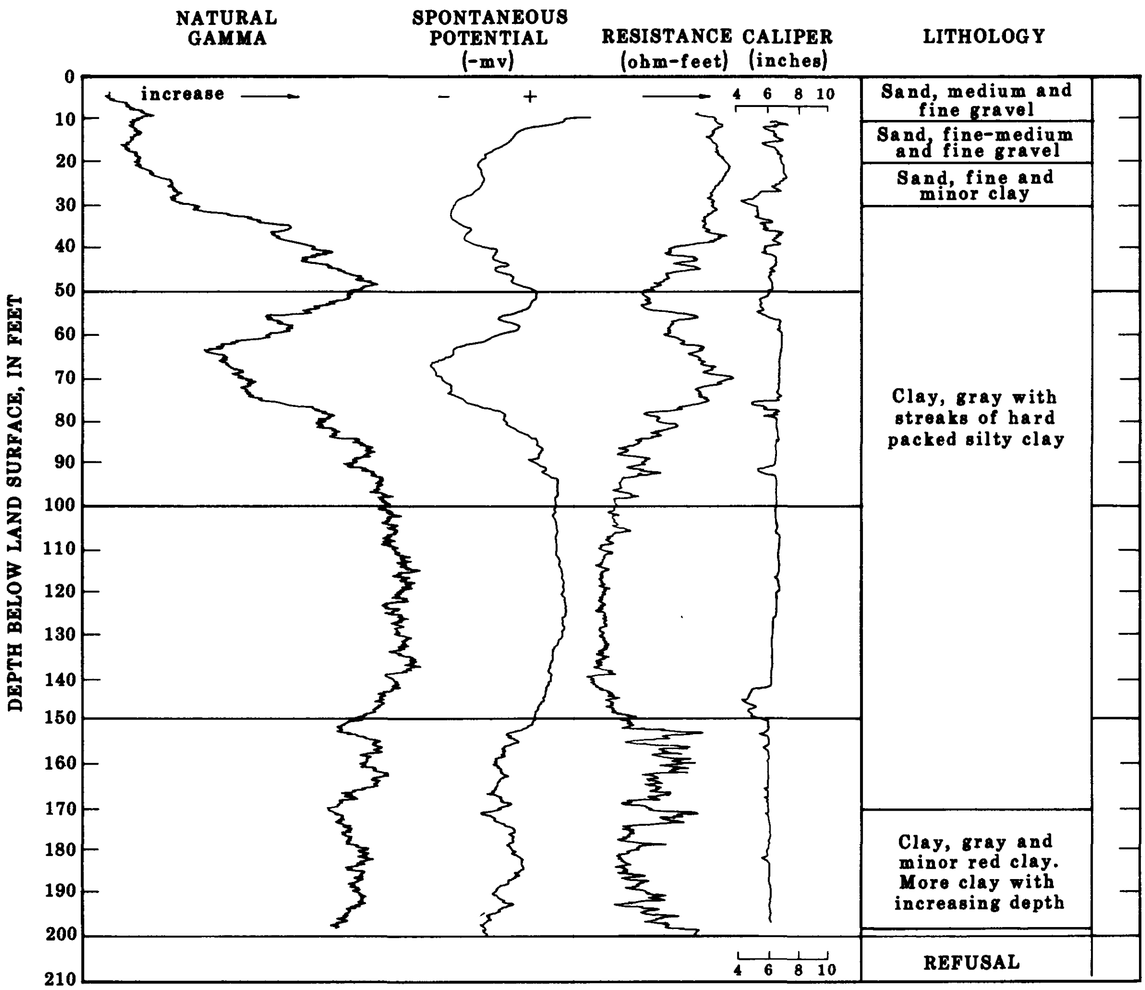


Figure 2.--Geophysical log of U.S. Geological Survey test well Sunderland W-67



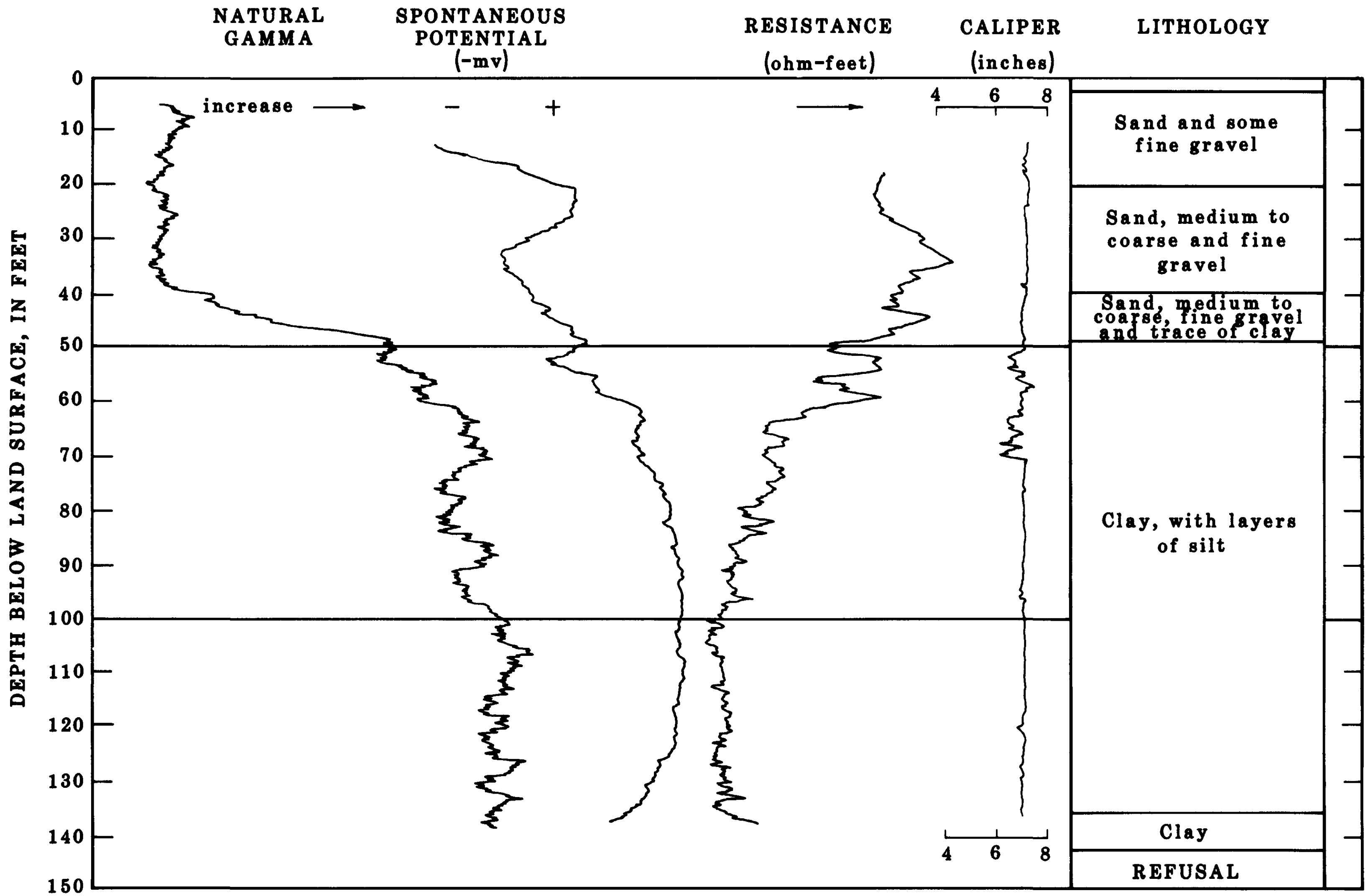
WELL HADLEY 27

Figure 3.--Geophysical logs of U.S. Geological Survey test wells



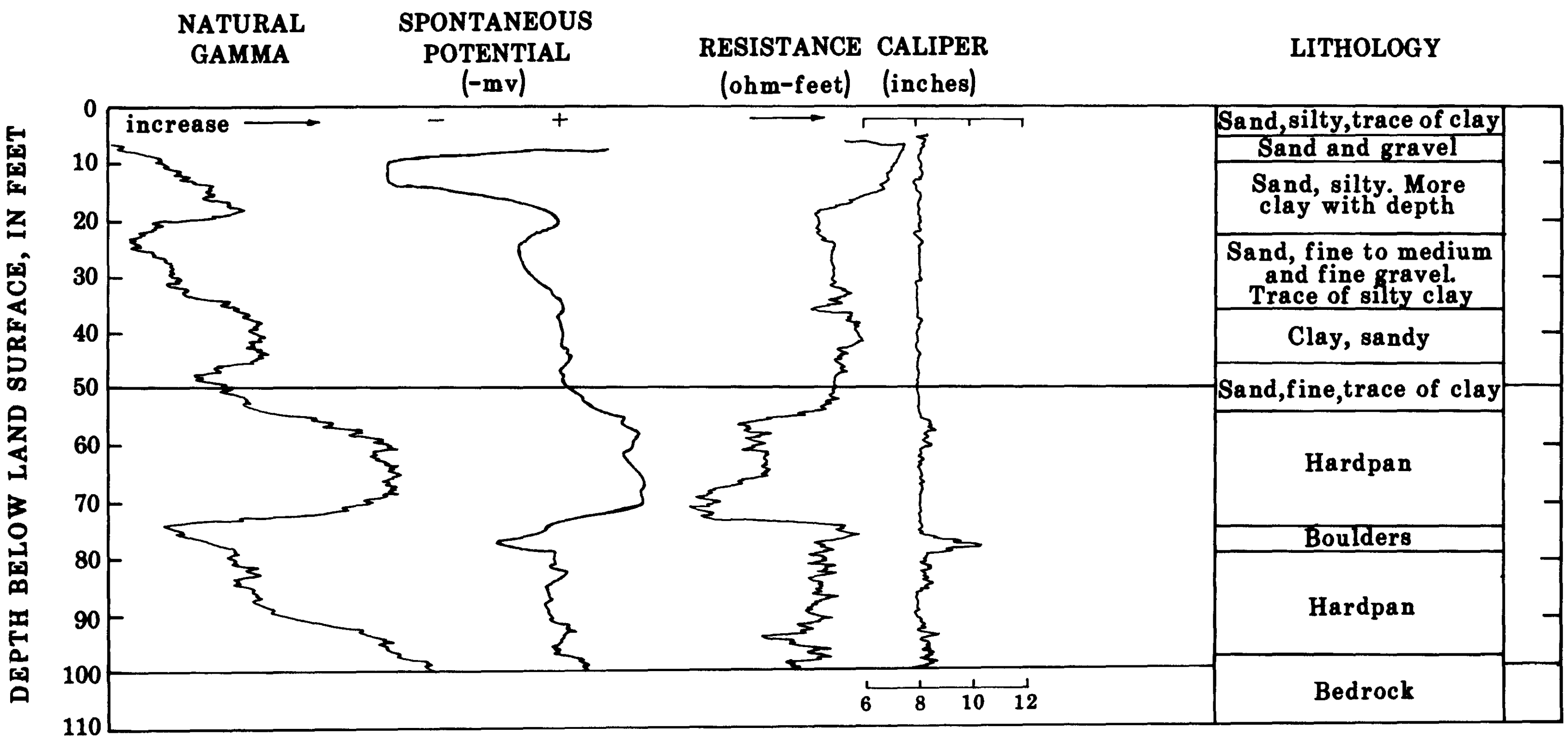
WELL HADLEY 29

Figure 3.--(continued)



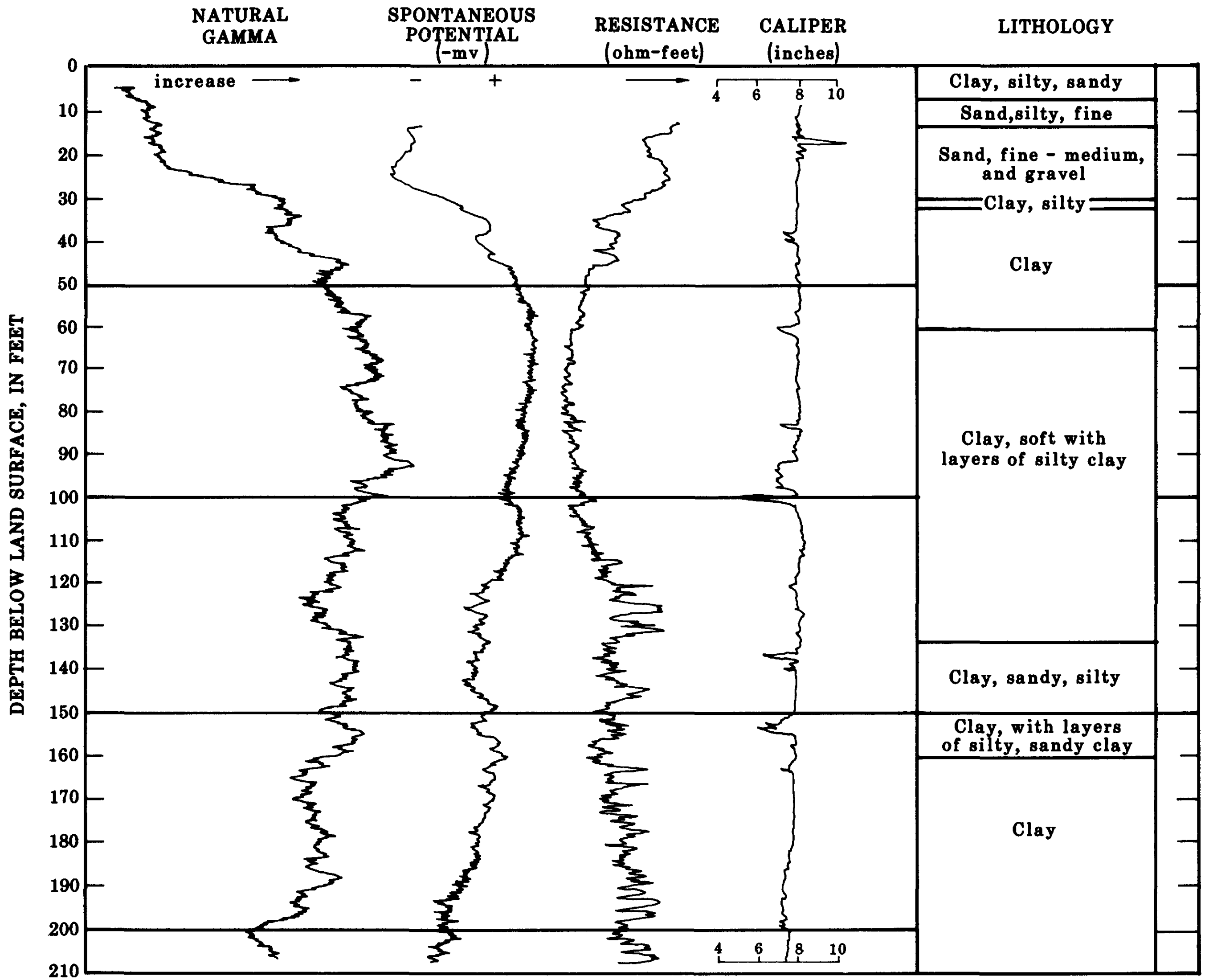
WELL HADLEY 30

Figure 3.--(continued)



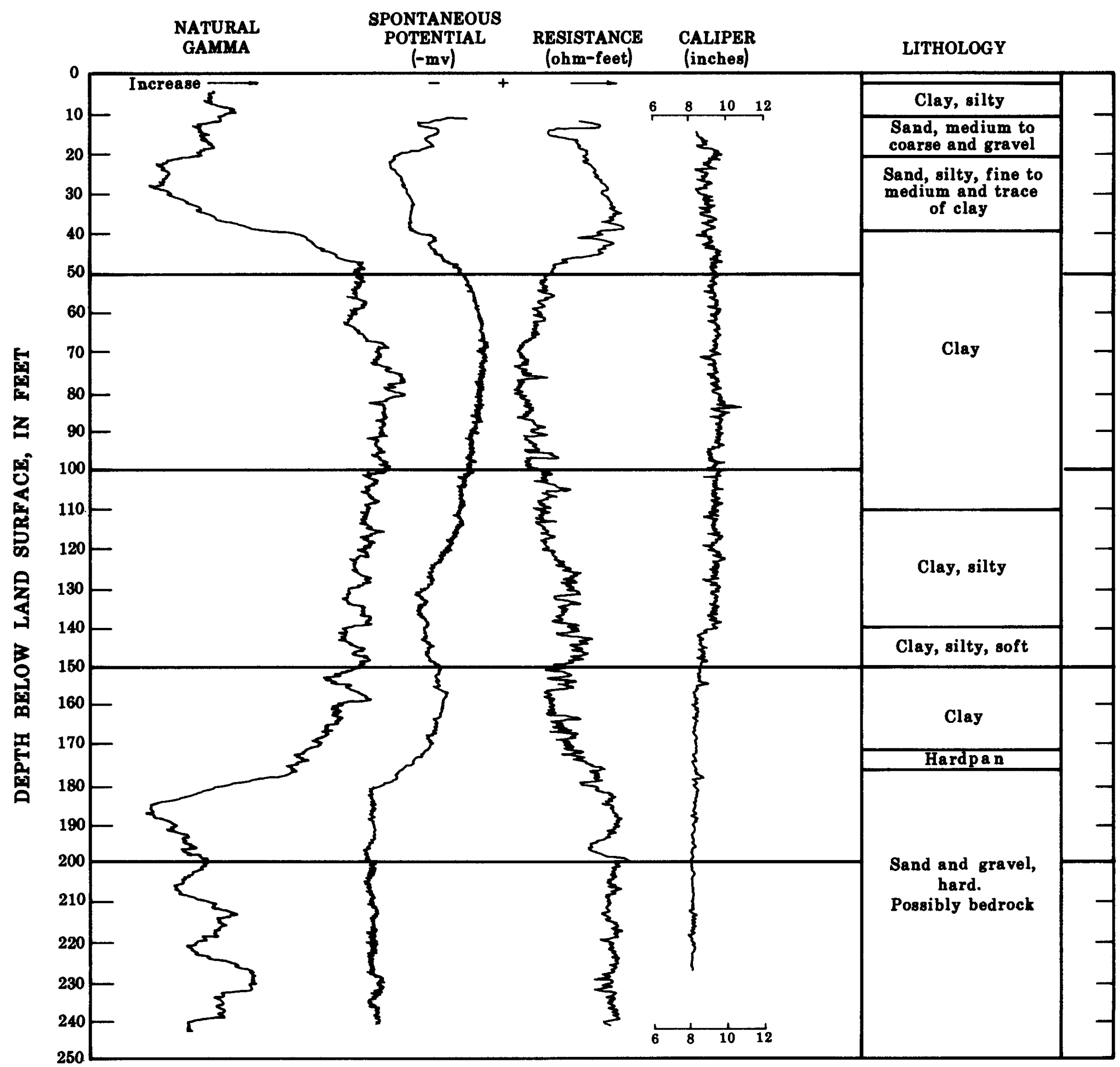
WELL HADLEY 31

Figure 3.--(continued)



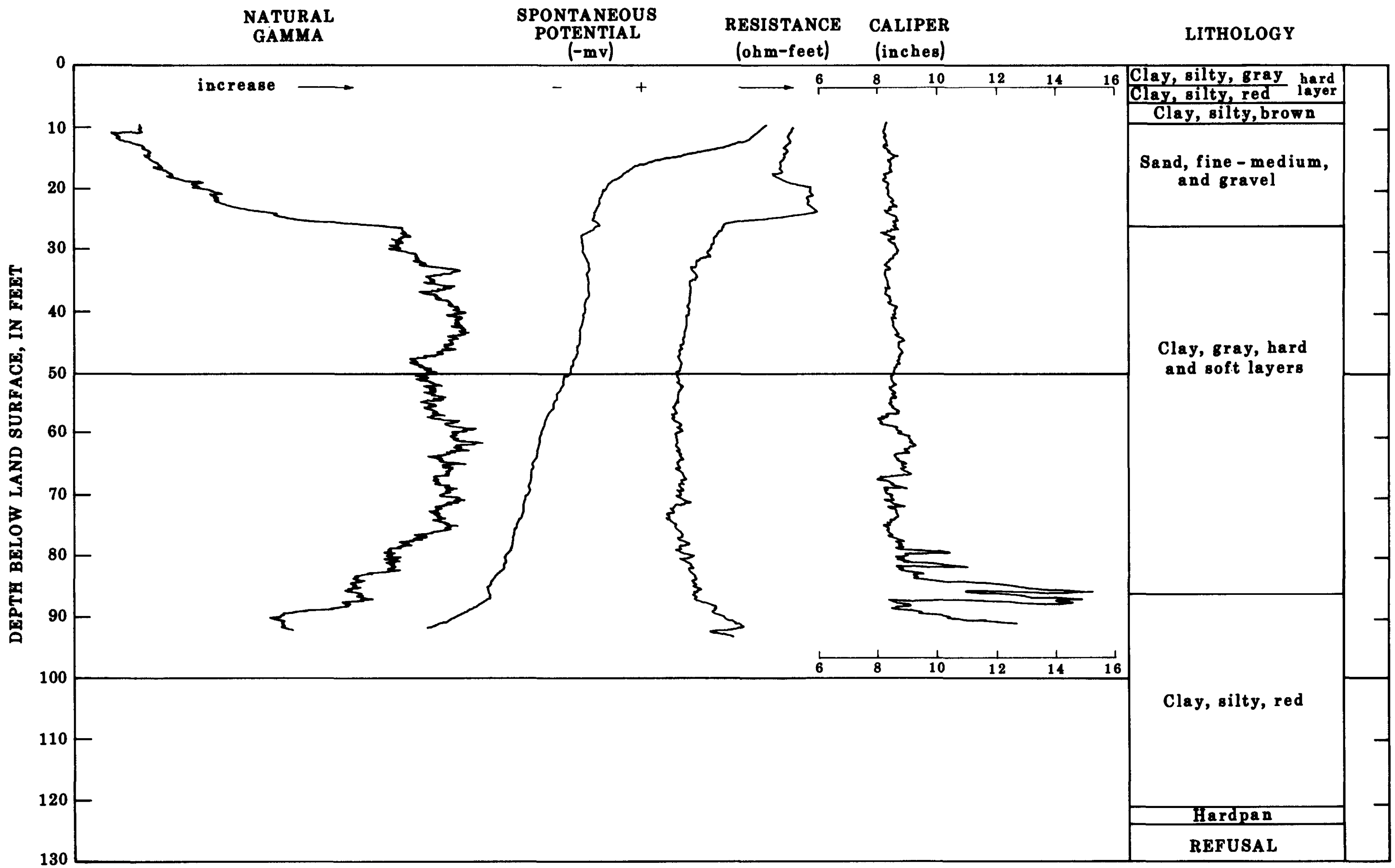
WELL SUNDERLAND 65

Figure 3.--(continued)



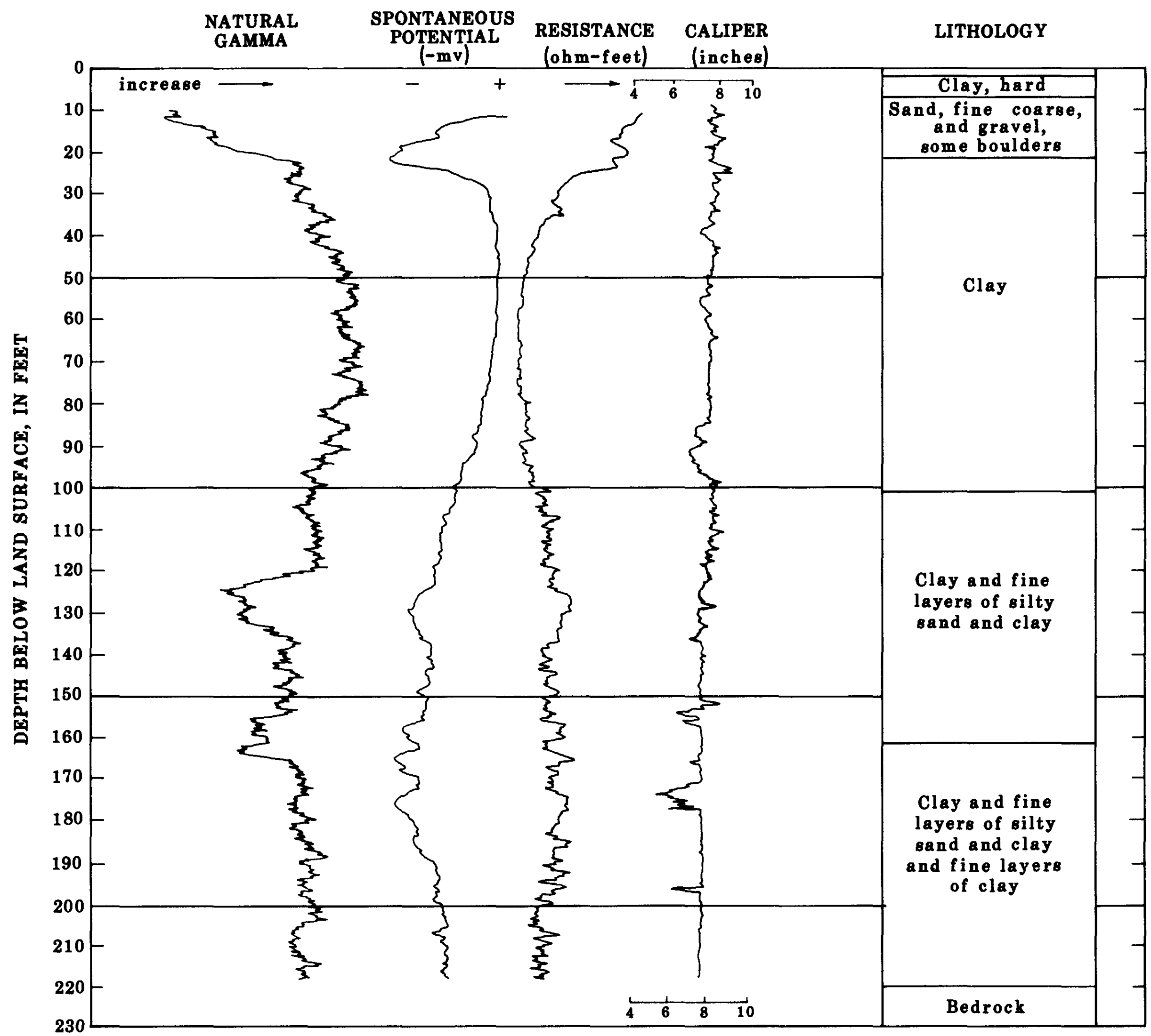
WELL SUNDERLAND 66

Figure 3.--(continued)



WELL SUNDERLAND 69

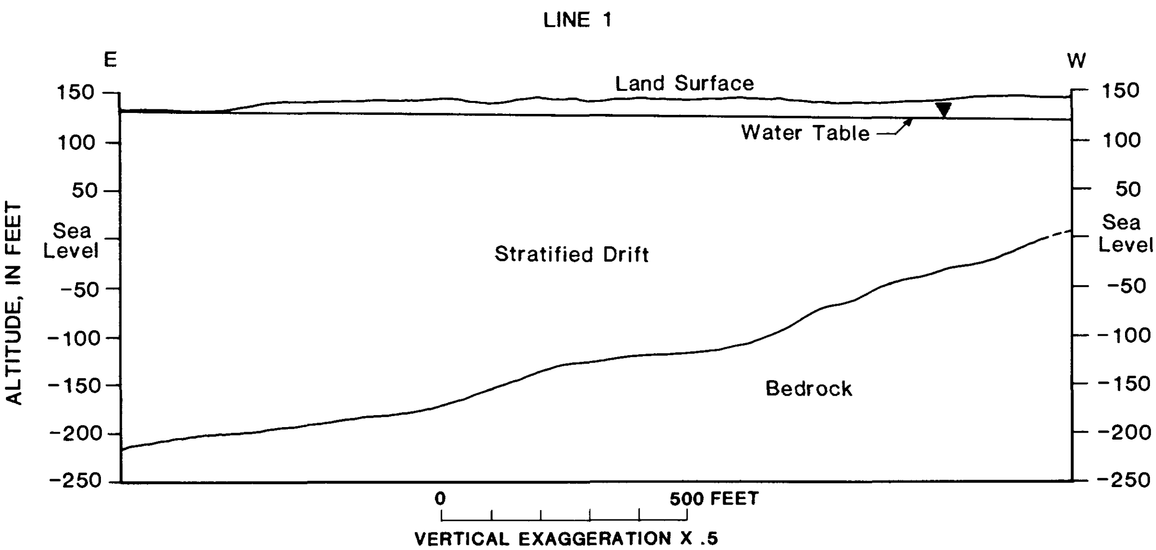
Figure 3.--(continued)



WELL SUNDERLAND 70

Figure 3.--(continued)

Hydrogeologic sections from seismic-refraction surveys conducted by the U.S. Geological Survey in 1982. Locations of individual profiles are shown in figure 2. Interpretation of field data based on a computer modeling technique described by Scott and others (1972).



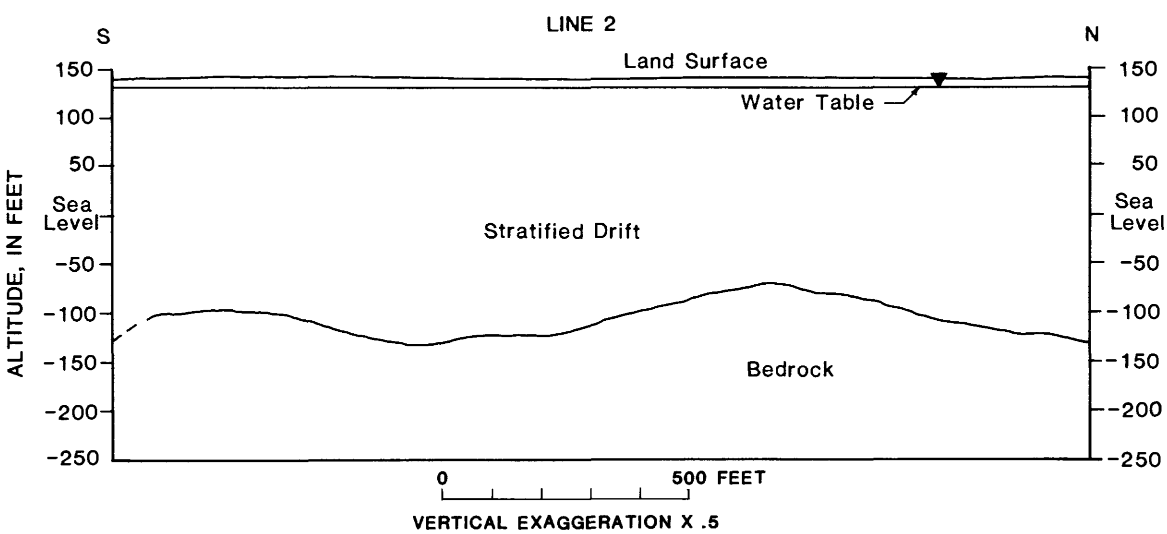
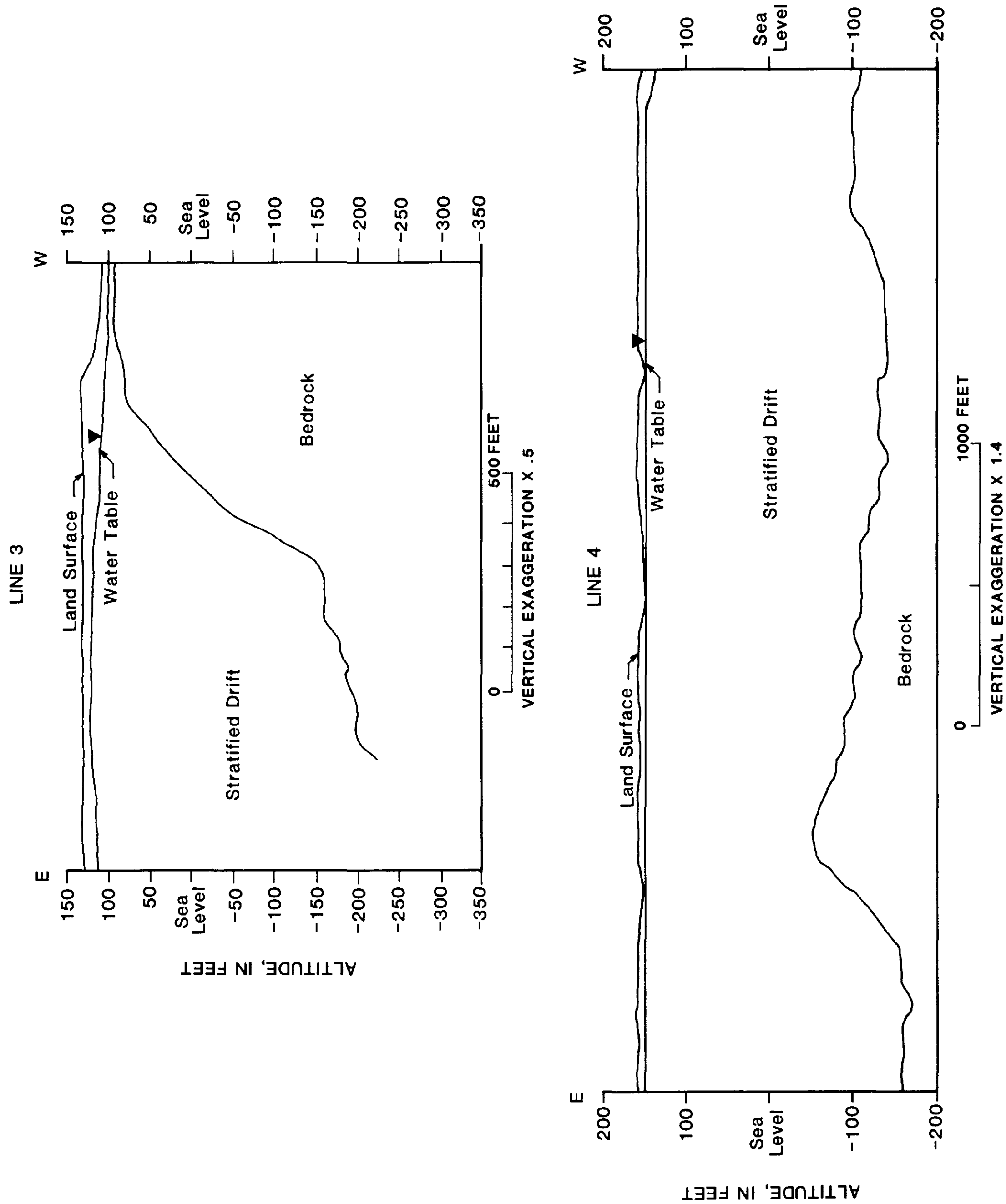


Figure 4.--Seismic-refraction profiles



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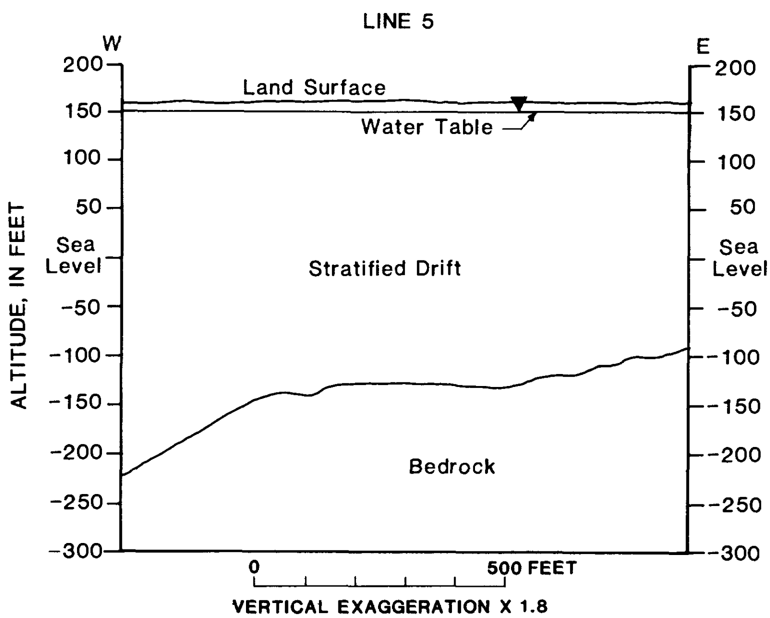

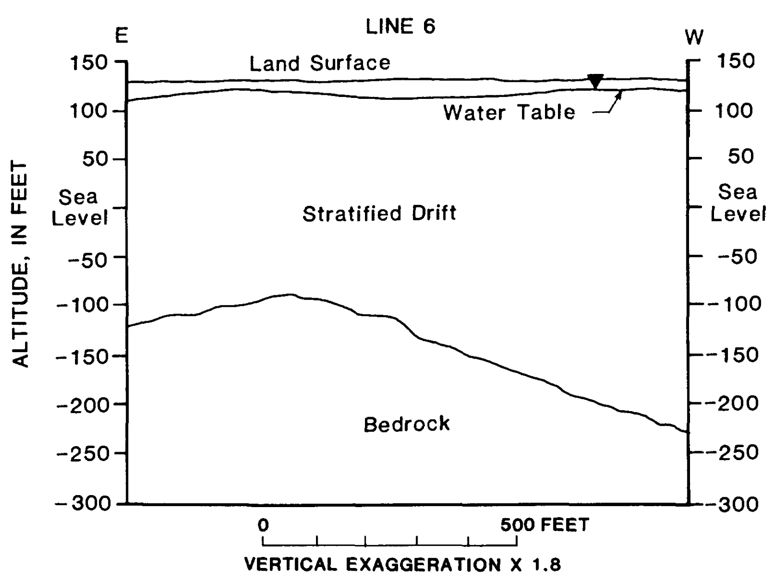

Figure 4.--(continued)

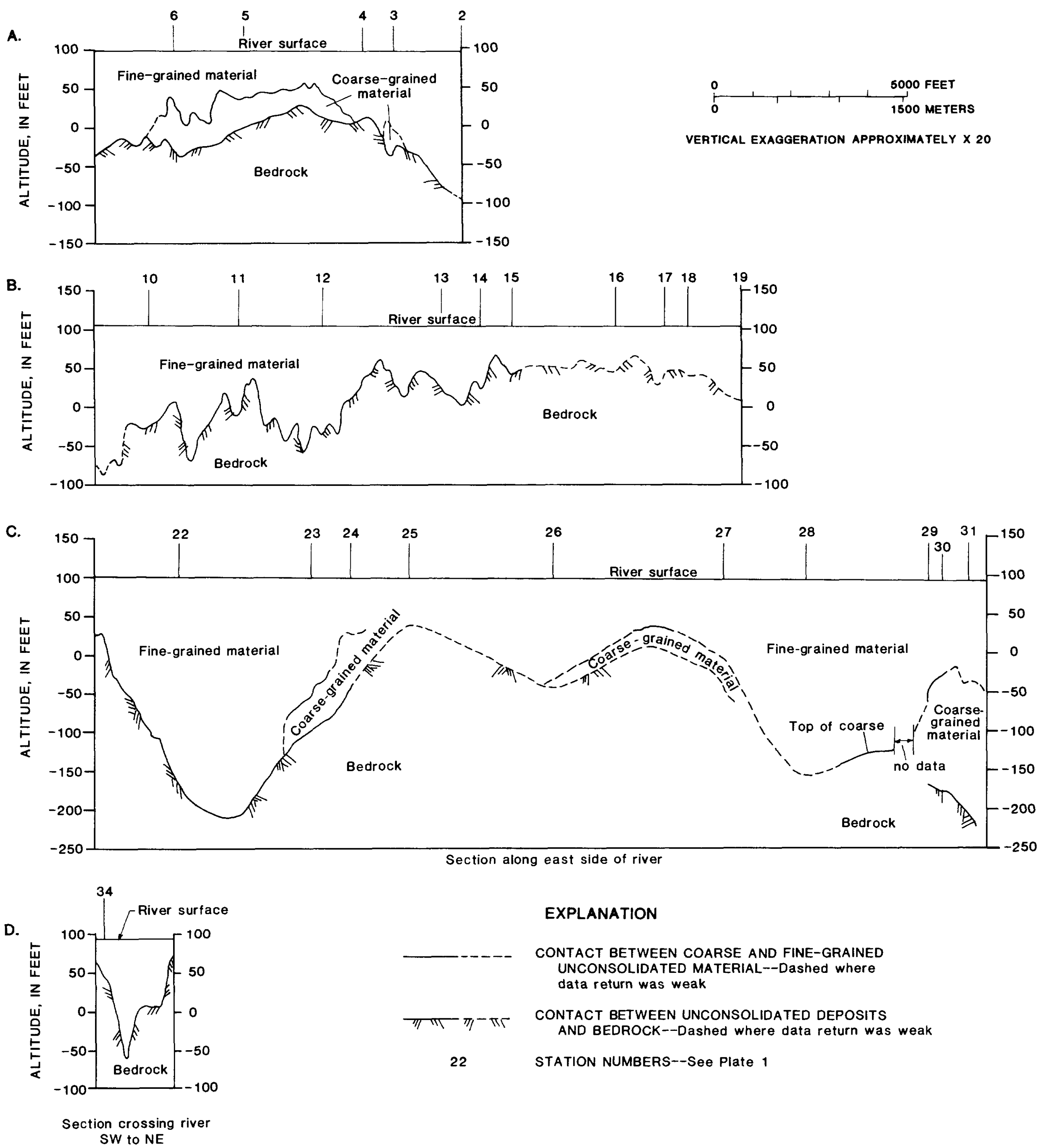

Figure 5.--Cross-section along traverse of seismic-reflection survey

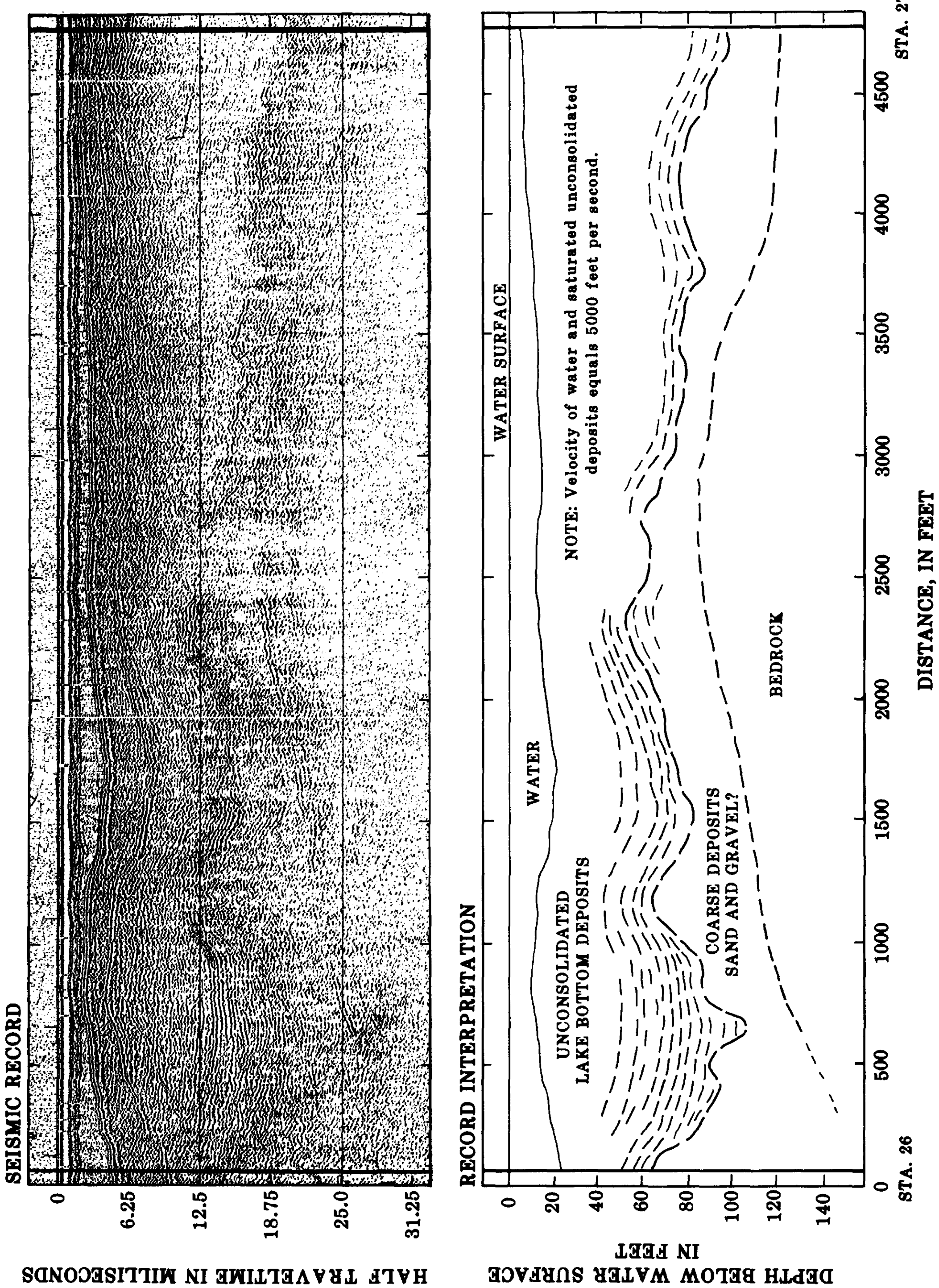

Figure 6.--Seismic-reflection profile

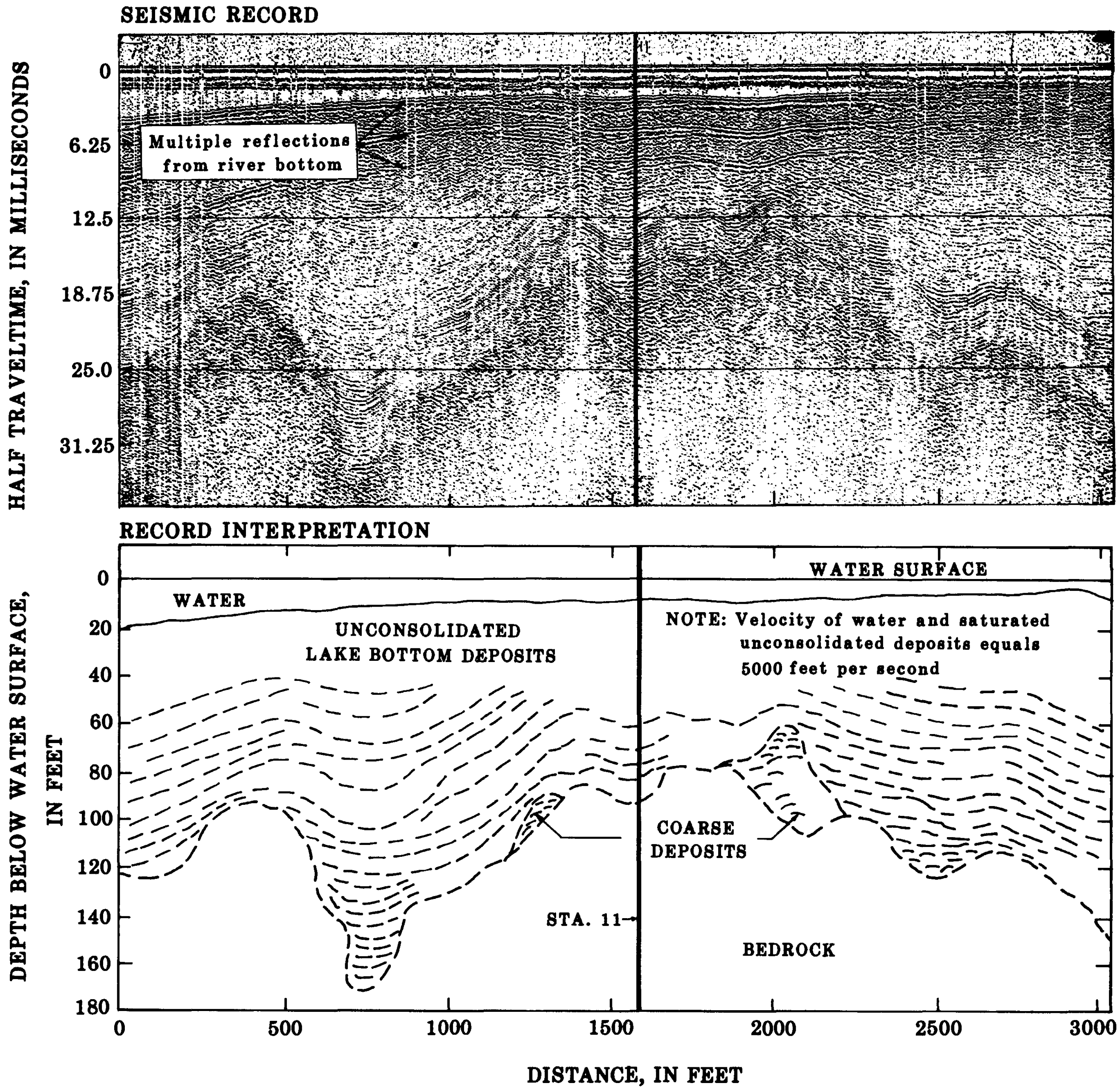

Figure 7.--Seismic-reflection profiles

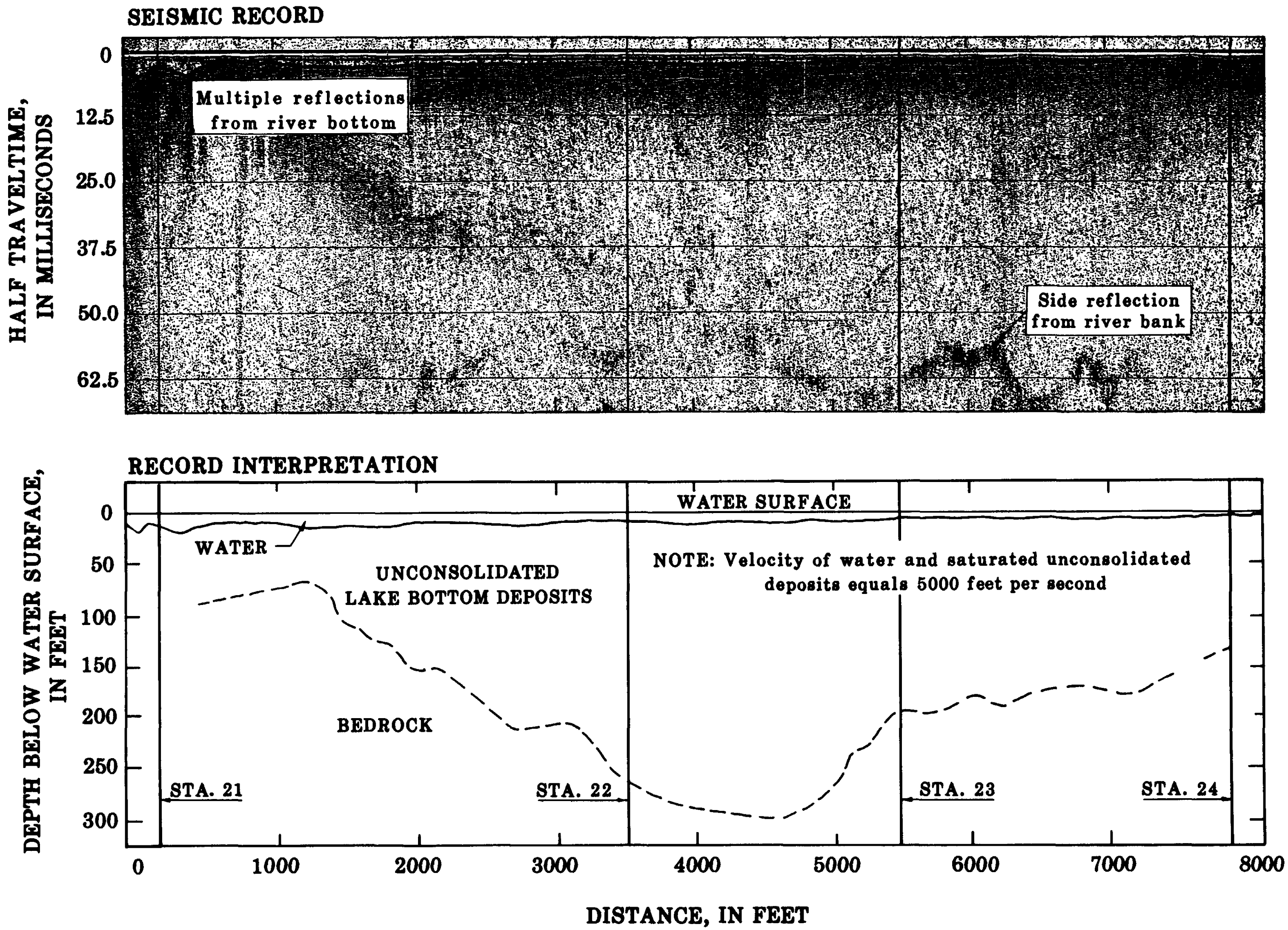

Figure 7.--(continued)

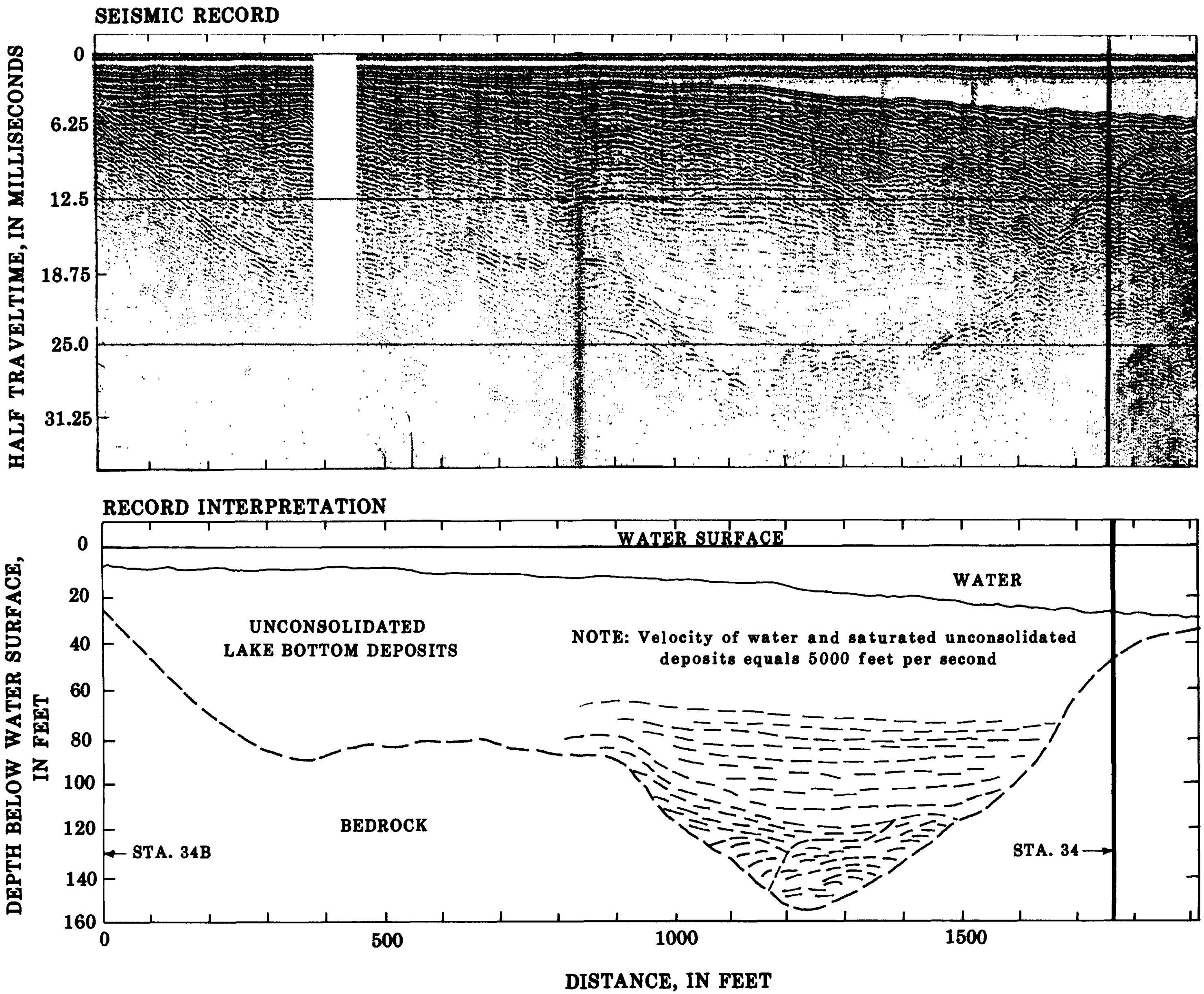

Figure 7.--(continued)

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APPENDIX

Table A-1.—Description of selected wells and borings

(Note: Not all data about a specific well may be stored in U.S. Geological Survey computer files, therefore, additional well information may be on file in the Massachusetts Subdistrict Office, Boston, Mass.)

Local number: Letter prefix indicates—B, bridge boring; W, well or test well (the "W" is omitted from plate 1 to conserve space); X, miscellaneous test boring.

Site ID: Last number is a sequential number for wells or borings in a 1-second grid.

Altitude of land surface: Altitudes are expressed in feet above National Geodetic Vertical Datum of 1929.

Owner: FISH & WILD, U.S. Fish and Wildlife Service; MA DV FISH, Massachusetts Division of Fisheries and Wildlife; and MDPW, Massachusetts Department of Public Works.

Well depth: Depth of finished well, in feet below land surface.

Use of site: O, observation; T, test hole; U, unused; W, water withdrawal; Z, destroyed.

Water level: Levels are given in feet below land surface; "+" indicates water level above land surface; F, flowing well; R, water level was reported to author; S, measurement by steel tape.

Finish: G, gravel pack with screen; O, open end; S, vertical screen; W, walled or shored; X, open hole in aquifer (generally cased to aquifer).

Discharge: R, the value was reported to author.

Water use: C, commercial; H, domestic; P, public supply; Q, aquaculture; S, stock.

Lithology of principal aquifer: Adjective symbols are C, coarse; F, fine; LTL, little; M, medium; SME, some; V, very. Lithology symbols are B, boulders; CL, clay; G and GRVL, gravel; S and SAND, sand; SDGL, sand and gravel.

Type of log available: Logs available in table 4—C, caliper log; E, electric log; J, gamma ray log. Logs available in table 2—D, driller's log; G, geologist's log.

Table A-1.--Description of selected wells and borings

LOCAL NUMBER	SITE-ID	ALTITUDE OF LAND SURFACE (FEET)	OWNER	USE OF SITE	DATE COM-PLETED	CONTRACTOR	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED
			AMHERST					
AIB 1	422119072311601	152	MDPW	T	--	--	--	--
AIB 2	422420072322001	147	MDPW	T	--	--	4.70 R	04/ /58
AIB 3	422451072321601	157	MDPW	T	--	--	1.50 R	04/ /58
AIB 4	422505072321201	158	MDPW	T	--	--	3.80 R	04/ /58
AIB 5	422430072322101	153	MDPW	T	--	--	8.25 R	04/ /58
AIB 6	422503072313901	172	MDPW	T	--	--	--	--
AIB 7	422232072304001	255	MDPW	T	--	MDPW	11.00 R	11/ /35
AIB 10	422443071314901	166	MDPW	T	--	--	4.10 R	02/ /41
AIW 6	422237072311501	320	PAPPAS, LOUIS	W	--	E.HARTLEY	--	--
AIW 7	422509072304301	300	RUXTON INC, D D	W	--	R.E.CHAPMAN	5.00 R	05/26/65
AIW 8	422528072301901	330	BALL, MYRON C	W	--	R.E.CHAPMAN	8.00 R	04/17/62
AIW 9	422537072304101	345	MANCHESTER, R L	W	--	R.E.CHAPMAN	9.00 R	03/ /44
AIW 10	422248072311001	285	ROWES, GARAGE	Z	--	--	--	--
AIW 12	421928072304101	172	STANLEY, ALBERT	W	--	--	15.00 R	01/ /51
AIW 13	421930072314301	250	HAMP. COLL.	W	--	R.E.CHAPMAN	10.00 R	08/ /68
AIW 14	421903072313001	245	EPSTEIN, SEYMOUR	T	--	R.E.CHAPMAN	39.50 R	06/26/59
AIW 22	422432072315301	185	COMINGS, ROBERT	W	--	R.E.CHAPMAN	--	--
AIW 23	422530072323501	160	AMHERST, TOWN	T	--	R.E.CHAPMAN	5.40 R	02/ /72
AIW 24	422547072311001	270	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
AIW 27	422425072322201	148	AMHERST, TOWN	T	--	R.E.CHAPMAN	6.40 R	12/ /71
AIW 45	422029072320101	137	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
AIW 46	422035072315601	140	AMHERST, TOWN	T	--	R.E.CHAPMAN	0.00 R	08/19/54
AIW 48	422035072314701	138	AMHERST, TOWN	T	--	R.E.CHAPMAN	0.00 R	08/19/54
AIW 50	422031072313501	135	AMHERST, TOWN	T	--	R.E.CHAPMAN	0.70+ R	08/19/54
AIW 51	422033072321201	138	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
AIW 52	422045072321601	140	AMHERST, TOWN	T	--	R.E.CHAPMAN	F	08/23/54
AIW 53	422031072312601	138	AMHERST, TOWN	T	--	R.E.CHAPMAN	F	08/23/54
AIW 54	422038072313101	138	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
AIW 55	422039072312401	145	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
AIW 56	422025072312701	145	AMHERST, TOWN	T	--	R.E.CHAPMAN	9.00+ R	08/24/54
AIW 57	422021072313301	155	AMHERST, TOWN	T	--	R.E.CHAPMAN	9.00+ R	05/16/57
AIW 58	422021072312901	145	AMHERST, TOWN	T	--	R.E.CHAPMAN	0.60+ R	08/26/54
AIW 61	422533072322601	160	ZWINAKIS, J	W	--	--	--	--
AIW 66	422535072322801	160	SKIBISKI	T	--	F.G.SULLIVAN	--	--
AIW 67	422534072323501	161	SKIBISKI	T	--	F.G.SULLIVAN	9.00 R	12/01/80
AIW 68	422518072323001	155	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
AIW 69	422518072323101	155	AMHERST, TOWN	T	--	R.E.CHAPMAN	2.00+ R	02/ /54
AIW 70	422444072314101	178	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
AIW 71	422443072312901	182	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
AIW 72	422449072312901	195	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
AIW 73	422453072322002	152	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
AIW 74	422452072321201	158	AMHERST, TOWN	T	--	R.E.CHAPMAN	4.33 R	03/12/54
AIW 75	422450072321801	157	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
AIW 76	422428072322201	148	AMHERST, TOWN	T	--	R.E.CHAPMAN	4.50 R	12/28/71
AIW 77	422420072321701	149	AMHERST, TOWN	T	--	R.E.CHAPMAN	0.00 R	09/06/72
AIW 78	422403072321501	145	AMHERST, TOWN	T	--	R.E.CHAPMAN	F	--
AIW 79	422403072322001	148	AMHERST, TOWN	T	--	R.E.CHAPMAN	F	03/ /73
AIW 80	422401072324801	151	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
AIW 81	422402072323301	154	AMHERST, TOWN	T	--	R.E.CHAPMAN	5.00 R	10/14/74
AIW 82	422404072320901	153	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
AIW 83	422539072321501	165	AMHERST, TOWN	T	--	R.E.CHAPMAN	5.79 R	07/12/76
AIW 84	422406072315501	165	AMHERST, TOWN	T	--	R.E.CHAPMAN	3.00 R	08/03/76

Table A-1.--Description of selected wells and borings (Continued)

LOCAL NUMBER	DEPTH DRILLED (FEET)	WELL DEPTH (FEET)	DEPTH TO FIRST OPENING (FEET)	FIN- ISH	DIS- CHARGE (GAL/MIN)	WATER USE	DEPTH TO AQUIFER (FEET)	LITHOLOGY OF PRINCIPAL AQUIFER	DEPTH TO BEDROCK (FEET)	DEPTH TO REFUSAL (FEET)	TYPE OF LOG AVAIL- ABLE
						AMHERST					
AIB 1	28.0	28.0	--	0	--	--	--	--	--	--	D
AIB 2	148.0	148.0	--	0	--	--	--	--	--	148	D
AIB 3	147.0	147.0	--	0	--	--	--	--	--	147	D
AIB 4	116.0	116.0	--	0	--	--	--	--	--	116	D
AIB 5	111.0	111.0	--	0	--	--	--	--	--	111	D
AIB 6	23.0	23.0	--	0	--	--	--	--	--	23	D
AIB 7	35.0	35.0	--	0	--	--	--	--	--	--	D
AIB 10	44.0	44.0	--	0	--	--	23	SDGL,SME B-44	--	--	D
AIW 6	470.0	470.0	96	X	28 R	H	--	--	96	--	--
AIW 7	725.0	725.0	90	X	12 R	H	--	--	79	--	--
AIW 8	480.0	480.0	30	X	0.25 R	H	--	--	16	--	--
AIW 9	164.0	164.0	33	X	5.0 R	H	--	--	28	--	--
AIW 10	33.0	33.0	--	--	--	--	--	--	33	--	--
AIW 12	325.0	325.0	67	X	5.3 R	H	--	--	56	--	--
AIW 13	615.0	615.0	45	X	1.0 R	H	--	--	38	--	--
AIW 14	190.0	190.0	70	--	7.0 R	--	--	--	58	--	D
AIW 22	215.0	215.0	19	X	1.8 R	H	--	--	12	--	--
AIW 23	126.0	126.0	--	S	75 R	--	0	SAND,M-C	--	126	D
AIW 24	15.0	15.0	--	0	--	--	--	--	--	15	D
AIW 27	105.0	28.0	23	--	65 R	--	0	SAND,M	--	105	D
AIW 45	79.0	79.0	--	S	22 R	--	60	SAND,M	--	79	D
AIW 46	42.0	42.0	32	S	75 R	--	30	GRVL	--	42	D
AIW 48	55.0	55.0	45	S	60 R	--	27	GRVL,M-C	--	55	D
AIW 50	70.0	70.0	40	S	60 R	--	40	GRVL,M-C	--	--	D
AIW 51	63.0	63.0	53	S	50 R	--	--	--	--	--	D
AIW 52	69.0	69.0	59	S	60 R	--	30	GRVL,C-40,M-C-69	--	--	D
AIW 53	82.0	82.0	--	0	20 R,F	--	50	GRVL	--	--	D
AIW 54	95.0	95.0	--	0	10 R	--	--	--	--	--	D
AIW 55	90.0	90.0	--	0	--	--	--	--	--	--	D
AIW 56	81.0	81.0	71	S	75 R	--	--	--	--	81	D
AIW 57	54.0	51.0	44	S	100 R	--	--	--	54	--	D
AIW 58	78.0	78.0	68	S	60 R	--	39	SAND	--	78	D
AIW 61	220.0	220.0	--	--	85	H	--	--	--	--	D
AIW 66	155.0	155.0	150	0	--	--	--	--	--	155	D
AIW 67	168.0	41.0	36	S	60 R	--	0	SDGL	--	168	D
AIW 68	161.0	161.0	--	0	--	--	--	--	--	--	D
AIW 69	147.0	147.0	137	S	30 R	--	--	--	--	--	D
AIW 70	25.0	25.0	--	0	--	--	--	--	--	--	D
AIW 71	21.0	21.0	--	0	--	--	--	--	--	--	D
AIW 72	95.0	95.0	--	0	--	--	--	--	--	--	D
AIW 73	136.0	136.0	--	0	--	--	--	--	--	--	D
AIW 74	43.0	43.0	33	S	60 R	--	0	SAND,M 0-43	--	--	D
AIW 75	171.0	171.0	--	0	--	--	0	SDGL	--	--	D
AIW 76	105.0	25.0	20	S	65	--	0	SAND,M	--	105	D
AIW 77	163.0	163.0	146	S	0.25	--	--	--	--	163	D
AIW 78	151.0	151.0	137	S	2.0 R	--	--	--	--	151	D
AIW 79	109.0	104.0	98	S	3.0 R	--	--	--	--	109	D
AIW 80	114.0	114.0	--	0	--	--	--	--	--	114	D
AIW 81	147.0	25.0	20	S	60 R	--	0	SAND,F	--	147	D
AIW 82	114.0	114.0	--	0	--	--	--	--	--	114	D
AIW 83	75.3	75.3	--	0	--	--	--	--	--	--	D
AIW 84	79.0	79.0	--	0	--	--	--	--	--	--	D

Table A-1.--Description of selected wells and borings (Continued)

LOCAL NUMBER	SITE-ID	ALTITUDE OF LAND SURFACE (FEET)	OWNER	USE OF SITE	DATE COM-PLETED	CONTRACTOR	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED
			DEERFIELD					
DFB 3	422805071351101	114	MDPW	T	--	--	--	--
DFW 60	422850071343501	132	UNIVERSITY OF MASS.	T	--	D.L.MAHER	30.50 R	09/16/80
DFW 61	422853071343501	132	UNIVERSITY OF MASS.	T	--	D.L.MAHER	25.58 R	09/17/80
DFW 62	422848071344601	139	UNIVERSITY OF MASS.	T	--	D.L.MAHER	36.83 R	09/18/80
			HADLEY					
HAB 1	422029072330201	135	MDPW	T	--	--	--	--
HAB 2	422308072335501	143	MDPW	T	--	MDPW	4.50	06/20/57
HAB 3	422314072322701	137	MDPW	T	--	MDPW	4.50 R	05/22/57
HAB 4	422224072323301	146	MDPW	T	--	--	6.50 R	05/22/57
HAB 5	422342072334301	137	MDPW	T	--	--	4.50 R	06/20/57
HAB 6	422241072323101	136	MDPW	T	--	--	3.00 R	05/22/57
HAW 1	421722072360901	145	KENDALL	W	--	BECKER	F	12/01/50
HAW 2	421727072361101	130	MELLELO	W	--	--	--	--
HAW 4	422349072331201	145	SANA, JOSEPH	W	--	OWNER	3.00	01/ /38
HAW 5	422223072334801	320	KENTFIELD, DAIRY	W	--	R.E.CHAPMAN	44.00 R	04/11/50
HAW 6	422316072345301	143	HADLEY, TOWN	W	--	OWNER	18.00	06/25/48
HAW 9	422005072364301	120	MASLAR, EVA	W	--	R.E.CHAPMAN	--	--
HAW 10	422113072341801	150	RUSSELL, GEORGE	W	--	R.E.CHAPMAN	40.00	--
HAW 11	422219072325501	195	KOPEC ALTER	W	--	R.E.CHAPMAN	48.00 R	07/ /48
HAW 12	422353072325001	152	ZALOT, FRANK	W	--	R.E.CHAPMAN	15.00 R	05/16/51
HAW 13	422257072344601	195	SCOTT, CLARENCE	W	--	R.E.CHAPMAN	8.00 R	02/ /47
HAW 14	422306072330501	144	KIELTC, JOHN G	W	--	R.E.CHAPMAN	7.00 R	09/ /49
HAW 15	422234072335401	145	HADLEY, TOWN	W	--	R.E.CHAPMAN	7.34 R	03/10/54
HAW 16	422230072335201	147	HADLEY, TOWN	W	09/24/63	R.E.CHAPMAN	27.50 RT	09/24/63
HAW 17	422151072324801	167	AMHERST, TOWN	T	--	R.E.CHAPMAN	4.50 R	12/ /71
HAW 18	422025072322001	140	AMHERST, TOWN	T	--	R.E.CHAPMAN	8.00+ R	12/ /71
HAW 19	421718072362301	110	HADLEY, TOWN	T	--	R.E.CHAPMAN	11.00 R	09/08/72
HAW 22	421956072345001	115	HADLEY, TOWN	T	--	F.G.SULLIVAN	9.70 R	11/04/74
HAW 23	421958072345101	115	HADLEY, TOWN	T	--	F.G.SULLIVAN	8.10 R	09/27/74
HAW 24	421959072344601	115	HADLEY, TOWN	T	10/07/74	F.G.SULLIVAN	--	--
HAW 26	421953072353801	108	HADLEY, TOWN	T	09/25/74	F.G.SULLIVAN	--	--
HAW 28	422517072335402	131	CON.CIGAR	T	--	LAYNE	--	--
HAW 29	422517072335401	131	CON.CIGAR	T	--	LAYNE	--	--
HAW 29	422509072330001	159	SZALA, EDWARD	T	--	LAYNE	--	--
HAW 30	422337072331301	150	SWARTZ, JOHN	T	--	LAYNE	--	--
HAW 31	422044072340901	130	BORAWSKI, ALEXANDER	T	--	LAYNE	--	--
HAW 32	421721072361501	108	HADLEY, TOWN	T	03/06/63	R.E.CHAPMAN	9.00 R	03/06/63
HAW 33	421724072361801	110	HADLEY, TOWN	T	--	R.E.CHAPMAN	--	--
HAW 34	421720072361801	100	HADLEY, TOWN	T	03/13/63	R.E.CHAPMAN	2.42 R	03/13/63
HAW 35	422301072321801	148	AMHERST, TOWN	T	--	R.E.CHAPMAN	2.10 R	04/19/72
HAW 36	422317072322501	139	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
HAX 1	422338072321701	149	UNIVERSITY OF MASS.	T	--	--	5.30 R	09/ /62
HAX 2	422307072322001	145	UNIVERSITY OF MASS.	T	--	--	4.10 R	09/ /62
			LEVERETT					
LSW 1	422722072313001	331	WEATHERBEE, R T	W	--	--	--	--
LSW 3	422643072315501	310	DUGUAY, WILLIAM	W	--	OWNER	2.00 S	06/ /48
LSW 6	422605072315201	310	KUZMESKI, WILLIAM	W	--	OWNER	18.00	06/ /48
LSW 9	422600072315301	310	BARTUSEWICH, A	W	--	OWNER	15.00 S	06/ /48
LSW 36	422746072310201	353	STARKWEATHER, W	W	--	R.E.CHAPMAN	F	09/ /66

Table A-1.--Description of selected wells and borings (Continued)

LOCAL NUMBER	DEPTH DRILLED (FEET)	WELL DEPTH (FEET)	DEPTH TO FIRST OPENING (FEET)	FIN-ISH	DIS-CHARGE (GAL/MIN)	WATER USE	DEPTH TO AQUIFER (FEET)	LITHOLOGY OF PRINCIPAL AQUIFER	DEPTH TO BEDROCK (FEET)	DEPTH TO REFUSAL (FEET)	TYPE OF LOG AVAIL-ABLE
						DEERFIELD					
DFB 3	109.0	109.0	--	--	--	--	--	--	--	--	D
DFW 60	131.0	131.0	--	0	--	--	--	--	--	131	D
DFW 61	127.0	127.0	--	0	--	--	--	--	--	127	D
DFW 62	119.0	119.0	--	0	--	--	--	--	--	119	D
						HADLEY					
HAB 1	23.0	23.0	--	--	--	--	--	--	--	23	D
HAB 2	129.0	129.0	--	0	--	--	--	--	--	129	D
HAB 3	112.0	112.0	--	--	--	--	76	SAND,F;V LTL CL	--	112	D
HAB 4	122.6	122.6	--	0	--	--	107	SDGL,MS-118;S+G-112	--	--	D
HAB 5	181.0	181.0	--	0	--	--	126	SAND,F	--	181	D
HAB 6	146.0	146.0	--	0	--	--	121	SAND,M RED	--	--	D
HAW 1	210.0	210.0	136	X	--	H	126	--	126	--	--
HAW 2	96.0	96.0	--	--	--	H	90	SDGL	--	--	D
HAW 4	15.0	15.0	--	W	--	H	0	--	--	--	--
HAW 5	190.0	190.0	186	X	50	S	0	SDGL,190+	--	--	--
HAW 6	25.0	25.0	--	0	--	H	--	--	--	--	--
HAW 9	40.0	40.0	35	S	60	H	0	--	--	--	--
HAW 10	175.0	175.0	--	X	8.0	H	54	--	54	--	--
HAW 11	264.0	264.0	63	X	3.0	H	56	--	56	--	--
HAW 12	305.0	305.0	150	X	16	H	140	--	140	--	--
HAW 13	140.0	140.0	36	X	10	H	20	--	20	--	--
HAW 14	148.0	148.0	68	X	9.0	H	62	--	62	--	--
HAW 15	228.0	226.0	203	S	550	P	65	SDGL,FS-200;CS&G-228	--	--	D
HAW 16	204.0	195.0	180	S	1080 0	P	135	--	204	--	D
HAW 17	105.0	28.0	23	S	65 R	--	0	SAND,M	--	105	D
HAW 18	65.0	65.0	--	S	65 R	--	42	SDGL,FS-MG	--	65	D
HAW 19	176.0	170.0	163	S	745	--	110	SDGL	176	--	D
HAW 22	116.0	116.0	101	S	752	--	45	SDGL,-116	--	--	D
HAW 23	106.0	106.0	101	S	5.0	--	0	SAND,M-C;SME G	--	106	D
HAW 24	110.0	110.0	105	S	70	--	0	SDGL,LTL SLT 45-55	--	110	D
HAW 26	143.0	143.0	--	0	--	--	--	--	--	143	D
HAW 28	303.0	64.0	61	G	--	--	--	--	--	--	--
HAW 29	303.0	267.0	267	G	--	--	--	--	302	--	D,E,J
HAW 29	200.5	23.0	20	G	--	--	--	--	200	--	D,E,J
HAW 30	139.0	33.0	30	G	--	--	--	--	139	--	D,E,J
HAW 31	100.0	23.0	20	G	--	--	--	--	--	--	D,E,J
HAW 32	133.0	133.0	127	S	15	--	125	SDGL	--	133	D
HAW 33	51.0	51.0	43	S	--	--	44	SDGL,M-CS&G	--	51	D
HAW 34	152.0	150.0	132	S	40 R	--	120	SAND,M-F;SME G	--	152	D
HAW 35	121.0	121.0	116	S	0.25	--	--	--	--	121	D
HAW 36	147.0	147.0	--	0	--	--	--	--	--	147	D
HAX 1	111.0	111.0	--	--	--	--	--	--	--	111	D
HAX 2	121.5	121.5	--	0	--	--	--	--	--	121	D
						LEVERETT					
LSW 1	150.0	150.0	--	--	--	H	--	--	--	--	--
LSW 3	8.0	8.0	--	--	--	H	--	--	--	--	--
LSW 6	24.0	24.0	--	0	--	H	--	--	--	--	--
LSW 9	16.0	16.0	--	0	--	H	--	--	--	--	--
LSW 36	325.0	325.0	181	X	4.0 F	H	54	--	54	--	--

Table A-1.--Description of selected wells and borings (Continued)

LOCAL NUMBER	SITE-ID	ALTITUDE OF LAND SURFACE (FEET)	OWNER	USE OF SITE	DATE COM-PLETED	CONTRACTOR	WATER LEVEL (FEET)	DATE WATER LEVEL MEASURED
			SUNDERLAND					
S6B 1	422602072324601	197	MDPW	T	--	MDPW	3.50 R	12/ /55
S6B 2	422717072340501	152	MDPW	T	--	--	3.50 R	12/ /55
S6B 3	422802072350401	97	MDPW	T	--	MDPW	--	--
S6W 1	422555072324201	193	RICE, F W	W	--	R.E.CHAPMAN	2.00 R	09/ /46
S6W 10	422647072350801	130	PETRAITIS, VIC	W	--	OWNER	18.00	04/06/50
S6W 13	422624072345001	132	WARNER, LOUIS	W	--	F.A.CHAMPLIN	4.00+ R	04/06/50
S6W 16	422635072343101	132	KULESSA, A H	W	--	--	18.00 S	03/31/50
S6W 18	422628072342301	131	FENSICK, MICHAEL	W	--	R.E.CHAPMAN	F	/ /49
S6W 39	422622072330401	170	MA DV FISH	W	05/15/61	R.E.CHAPMAN	0.50+ R	08/01/61
S6W 40	422614072325401	180	MA DV FISH	O	--	--	2.40+ S	08/05/57
S6W 41	422642072331301	220	BAGDON, LEON	U	--	OWNER	D	03/03/65
S6W 42	422639072331201	220	BAGDON, JOHN J	W	--	OWNER	43.00 S	03/03/65
S6W 50	422731072335401	200	SUNDERLAND, TOWN	W	--	R.E.CHAPMAN	2.00+ R	05/12/58
S6W 51	422655072333401	180	STAAB INC., R T	W	--	R.E.CHAPMAN	F	10/17/58
S6W 53	422816072340801	235	KOWALECK, ROBERT	W	--	R.E.CHAPMAN	40.00 R	01/28/63
S6W 54	422630072320801	270	--	T	--	R.E.CHAPMAN	--	--
S6W 55	422625072321401	255	AMHERST, TOWN	T	--	R.E.CHAPMAN	31.00 R	05/09/55
S6W 56	422615072323101	230	AMHERST, TOWN	T	--	R.E.CHAPMAN	20.00 R	05/10/55
S6W 57	422553072321401	200	MA DV FISH	T	--	R.E.CHAPMAN	F	05/12/55
S6W 58	422545072321501	170	MA DV FISH	T	--	R.E.CHAPMAN	F	05/13/55
S6W 59	422545072320101	220	MA DV FISH	T	--	R.E.CHAPMAN	F	05/16/55
S6W 60	422559072324901	185	AMHERST, TOWN	T	--	R.E.CHAPMAN	--	--
S6W 61	422603072324501	210	AMHERST, TOWN	T	--	R.E.CHAPMAN	1.00 R	06/07/55
S6W 62	422607072324201	205	SUNDERLAND WATER DIST.	W	--	R.E.CHAPMAN	20.41 R	12/02/81
S6W 63	422713072334401	195	CLIFFSIDE APTS	W	--	AETNA	--	--
S6W 64	422717072334701	200	CLIFFSIDE APTS	W	--	AETNA	--	--
S6W 65	422539072341101	138	CON. CIGAR	T	--	LAYNE	--	--
S6W 66	422622072345401	130	HEPBURN, HOWARD	T	--	LAYNE	--	--
S6W 67	422559072332401	160	LAURENITIS, ROBERT	T	--	LAYNE	--	--
S6W 68	422559072332402	160	LAURENITIS, ROBERT	T	--	LAYNE	--	--
S6W 69	422740072343001	138	SUNDERLAND, TOWN	T	--	LAYNE	--	--
S6W 70	422710072350901	125	SUNDERLAND, TOWN	T	--	LAYNE	--	--
S6W 71	422710072350902	138	SUNDERLAND, TOWN	T	--	LAYNE	--	--
S6W 72	422917072335801	145	--	T	--	D.L.MAHER	--	--
S6W 73	422916072340301	142	--	T	--	D.L.MAHER	--	--
S6W 74	422555072321701	195	MA DV FISH	T	--	F.G.SULLIVAN	12.20 R	01/19/81
S6W 75	422554072321301	195	MA DV FISH	T	--	F.G.SULLIVAN	8.66 R	12/03/80
S6W 76	422551072320901	195	MA DV FISH	T	--	F.G.SULLIVAN	8.17 R	12/09/80
S6W 77	422612072330901	159	MA DV FISH	T	--	F.G.SULLIVAN	20.17+ R	12/15/80
S6W 78	422609072325601	173	MA DV FISH	W	--	F.G.SULLIVAN	9.25+ R	12/30/80
S6W 79	422635072331401	172	ZAK	T	--	F.G.SULLIVAN	1.17 R	01/22/81
S6W 80	422627072332101	158	ZAK	T	--	F.G.SULLIVAN	--	--
S6W 81	422636072331801	165	ZAK	T	--	F.G.SULLIVAN	--	--
S6W 82	422636072332301	160	ZAK	T	--	F.G.SULLIVAN	--	--
S6W 83	422554072322101	180	FISH & WILD	W	07/ /73	R.E.CHAPMAN	--	--
S6W 84	422554072322102	180	FISH & WILD	W	07/ /73	R.E.CHAPMAN	--	--
S6W 85	422609072325401	180	MA DV FISH	W	05/ /57	R.E.CHAPMAN	--	--
S6W 86	422622072324401	215	WARNER BRO	W	--	--	20.62 R	12/02/81
S6W 87	422503072321201	235	WARNER BRO	O	12/03/81	F.G.SULLIVAN	34.80	12/03/81

Table A-1.--Description of selected wells and borings (Continued)

LOCAL NUMBER	DEPTH DRILLED (FEET)	WELL DEPTH (FEET)	DEPTH TO FIRST OPENING (FEET)	FIN- ISH	DIS- CHARGE (GAL/MIN)	WATER USE	DEPTH TO AQUIFER (FEET)	LITHOLOGY OF PRINCIPAL AQUIFER	DEPTH TO BEDROCK (FEET)	DEPTH TO REFUSAL (FEET)	TYPE OF LOG AVAIL- ABLE
					SUNDERLAND						
S6B 1	82.0	82.0	--	O	--	--	0	SDGL,S+G-42 C-FS-82	--	--	D
S6B 2	102.0	102.0	--	O	--	--	--	--	--	--	D
S6B 3	150.0	150.0	--	O	--	--	--	--	--	--	D
S6W 1	274.0	61.0	57	S	18	H	--	--	--	--	--
S6W 10	25.0	25.0	--	W	--	H	--	--	--	--	--
S6W 13	344.0	344.0	--	X	100 R	H	--	--	--	--	D
S6W 16	25.0	25.0	--	--	--	H	--	--	--	--	--
S6W 18	475.0	475.0	280	X	3.0 RF	H	--	--	270	--	--
S6W 39	90.0	72.5	63	G	520 O	Q	20	SDGL	--	--	D
S6W 40	30.0	--	--	S	--	--	--	--	--	--	--
S6W 41	40.0	40.0	0	W	--	--	--	--	--	--	--
S6W 42	44.0	44.0	0	W	--	H	--	--	--	--	--
S6W 50	97.0	97.0	82	G	425 O	P	0	SDGL,CL35-40,65-70	--	--	D
S6W 51	250.0	250.0	174	X	30	H	--	--	168	--	--
S6W 53	245.0	245.0	98	X	5.5	H	--	--	15	--	--
S6W 54	32.0	32.0	--	O	--	--	--	--	--	32	D
S6W 55	47.0	47.0	--	O	--	--	0	SDGL	--	47	D
S6W 56	50.0	50.0	40	S	50 R	--	0	GRVL,G,M&C	--	50	D
S6W 57	--	--	65	O	60	--	0	SDGL,+CL 10-35	--	--	D
S6W 58	--	--	110	S	0.25 R	--	--	--	--	--	D
S6W 59	130.0	130.0	--	S	35 R	--	--	--	--	--	D
S6W 60	195.0	195.0	--	O	--	--	--	--	--	--	D
S6W 61	378.0	70.0	50	S	266 R	--	--	--	376	--	D
S6W 62	79.0	79.0	64	G	407	P	0	SDGL,-69	--	--	--
S6W 63	240.0	240.0	--	X	60 R	C	--	--	--	--	--
S6W 64	280.0	280.0	--	X	60	C	--	--	--	--	--
S6W 65	206.0	24.0	21	G	--	--	--	--	206	--	D,E,J
S6W 66	243.0	23.0	20	G	--	--	--	--	177	--	D,E,J
S6W 67	211.0	122.0	119	G	--	--	--	--	211	--	D,E,J
S6W 68	211.0	27.0	24	G	--	--	--	--	--	--	--
S6W 69	123.0	18.0	18	G	--	--	--	--	123	--	D,E,J
S6W 70	220.0	124.0	124	G	--	--	--	--	120	--	D,E,J
S6W 71	220.0	21.0	18	G	--	--	--	--	--	--	--
S6W 72	142.0	142.0	--	X	--	--	--	--	--	142	D
S6W 73	139.0	139.0	--	O	--	--	--	--	--	139	D
S6W 74	110.0	65.0	59	S	250 O	--	0	SDGL,LTL CL	--	110	D,J
S6W 75	103.0	65.0	60	S	60	--	0	SDGL,CL 82-87	--	57	D
S6W 76	57.0	41.0	36	S	60	--	0	SDGL	--	--	D
S6W 77	160.0	110.0	100	S	20 R	--	55	SAND,SLTY;MS 97-112	--	192	D
S6W 78	192.0	78.0	73	S	60 R	Q	30	SDGL,65-80;REST F-MS	--	--	D
S6W 79	155.0	75.0	70	S	50 R	--	6	SAND,SME G-155	--	175	D
S6W 80	175.0	175.0	--	O	--	--	0	SDCL	--	--	D
S6W 81	165.0	90.0	85	S	--	--	14	SAND,F;SLTY;TR CL-165	--	--	D
S6W 82	120.0	120.0	--	O	--	--	--	--	--	--	D
S6W 83	58.5	58.5	39	S	150 O	Q	0	SDGL,-58	--	--	--
S6W 84	50.0	50.0	30	--	230	Q	0	SDGL,-50	--	--	--
S6W 85	70.0	70.0	50	S	190 R	Q	0	SDGL,-70+	--	--	--
S6W 86	53.0	53.0	--	--	--	--	0	SDGL,53+	--	--	--
S6W 87	50.0	50.0	45	S	--	--	0	SDGL,-50+	--	--	D

Table A-2.--Logs of selected wells and borings

(Depths are given in feet below land surface.)

	Depth
Amherst B-2.	
Loam and sand	0 - 6
Sand and gravel, medium, loose	6 - 16
Clay, soft, blue	16 - 134
Sand, medium, red; very little gravel	134 - 142
Sand and gravel, compact, red	142 - 148
Refusal	at 148
Amherst B-4.	
Loam, sand and gravel	0 - 2
Sand, fine, little clay; silt	2 - 8
Sand and gravel, coarse, loose, gray	8 - 13
Clay, soft, blue	13 - 108
Sand and gravel, coarse, gray	108 - 115
Sand; gravel; clay; boulders, compact, red	115 116
Refusal	at 116
Amherst B-5.	
Loam and dirty sand	0 - 8
Sand and gravel, coarse, loose, gray	8 - 12
Sand, medium, loose, gray	12 - 26
Clay, soft, blue	26 - 102
Sand, fine, gray; little clay	102 - 108
Sand; gravel and boulders, coarse, compact	108 - 111
Refusal	at 111
Amherst B-6.	
Loam; sand; gravel and boulders	0 - 1.4
Sand; gravel and boulders	1.4 - 11.2
Sand; gravel; mica; little clay; boulders, hard, blue	11.2 - 23
Refusal	at 23
Amherst B-10.	
Sand, loamy, soft	0 - 1.7
Sand; gravel and boulders, hard, dirty	1.7 - 8.5
Sand and clay, soft, dark	8.5 - 22.7
Sand, coarse, yellow; little gravel	22.7 - 28.5
Sand, yellow; coarse gravel; boulders, hard	28.5 - 44
Amherst W-45.	
Sand, fine, brown	0 - 10
Sand, coarse, gray	10 - 13
Clay	13 - 60
Sand, medium	60 - 79
Refusal	at 79
Amherst W-48.	
Silt, gray	0 - 4
Sand, coarse, gray	4 - 14
Clay	14 - 27
Gravel, medium to coarse	27 - 55
Refusal	at 55
Amherst W-52.	
Clay	0 - 20
Sand and clay	20 - 30
Gravel, coarse	30 - 40
Gravel, medium to coarse	40 - 69
Amherst W-54.	
Sand, gray	0 - 10
Clay	10 - 50
Sand and clay	50 - 95
Amherst W-57.	
Clay, brown	0 - 25
Sand, very fine; fine gravel, silty	25 - 30
Sand, fine	30 - 35
Sand and clay	35 - 40
Clay	40 - 44
Gravel, water-bearing	44 - 51
Hardpan	51 - 54
Ledge	at 54
Amherst W-61.	
Clay	0 - 86
Till	86 - 106
Sand, fine	106 - 133
Sand, fine; silt	133 - 137
Till; gravel streaks, silty.	137 - 153
Till, sandy	153 - 197
Amherst W-61 (Continued).	
Gravelly	197 - 209
Till	209 - 213
Gravel, water-bearing	213 - 220
Amherst W-67.	
Sand, medium, red	0 - 10
Sand, medium, red; gravel	10 - 42
Sand, medium, coarse, gray; gravel	42 - 58
Clay, gray	58 - 98
Sand, silty, red	98 - 168
Refusal	at 168
Amherst W-68.	
Sand and clay	0 - 90
Hardpan and clay	90 - 110
Sand and clay	110 - 144
Sand, fine	144 - 147
Clay	147 - 161
Bedrock	at 161
Amherst W-72.	
Gravel	0 - 6
Silt, brown	6 - 30
Silt, gray	30 - 95
Amherst W-74.	
Sand, medium	0 - 43
Amherst W-75.	
Gravel	0 - 10
Sand, medium	10 - 20
Clay	20 - 171
Amherst W-76.	
Sand, medium, gray	0 - 28
Clay, blue	28 - 105
Refusal	at 105
Amherst W-77.	
Sand, fine, gray	0 - 14
Clay, blue, gumble	14 - 133
Sand, fine, red; clay	133 - 147
Sand, coarse, red; clay	147 - 163
Refusal	at 163
Amherst W-79.	
Sand, fine to coarse, gray; some clay	0 - 7
Clay and silt	7 - 83
Clay, gray with red	83 - 97
Sand, fine to coarse, reddish brown	93 - 104
Same as above with red clay ball, drove harder	104 - 109
Refusal	at 109
Amherst W-80.	
Sand, fine, brown	0 - 96
Clay, blue	96 - 112
Sand, coarse, red; clay	112 - 114
Refusal	at 114
Amherst W-81.	
Sand, fine	0 - 28
Clay, blue	28 - 119
Clay, red	119 - 147
Refusal	at 147
Amherst W-82.	
Gravel, coarse and clay	0 - 7
Clay, blue	7 - 105
Clay, red; red sand	105 - 114
Refusal	at 114
Amherst W-83.	
Topsoil, sandy, dark	0 - 1
Clay, gray	1 - 49
Sand, fine, silty; clay	49 - 56
Clay, gray	56 - 70
Clay, red and gray	70 - 74
Sand, fine to medium; hardpan	74 - 75.2
Amherst W-84.	
Sand, fine; gray clay	0 - 5
Clay, gray	5 - 65
Hardpan; gray clay	65 - 79
Deerfield B-3. (West river bank)	
Sand, fine	0 - 1.5
Clay, soft, blue	1.5 - 50
Sand, fine; clay	50 - 86.5
Sand, fine, firm	86.5 - 99
Sand, hard, red	99 - 109
Deerfield B-3. (Middle of river)	
Sand and gravel	0 - 2
Clay, soft, blue	2 - 65.5
Sand, fine; little clay	65.5 - 100.6
Sand, sharp, firm, red	100.6 - 123.6
Sand, fine, hard, red; little clay	123.6 - 130.6
Deerfield W-60.	
Sand, fine, brown; silt	0 - 30
Clay, gray	30 - 90
Sand, fine, reddish; silt	90 - 121
Hardpan	121 - 131
Refusal	at 131
Deerfield W-62.	
Sand, fine, brown; clay	0 - 35
Clay, gray	35 - 90
Sand, fine, reddish; silt	90 - 110
Hardpan	110 - 119
Refusal	at 119
Hadley B-1.	
Sand and gravel	0 - 5
Sand, fine, gray-brown, compact; some clay and gravel	5 - 23
Refusal	at 23
Hadley B-2.	
Loam and sand	0 - 3.5
Sand, fine, gray	3.5 - 9
Clay, soft, blue	9 - 97
Sand, fine, red	97 129
Refusal	at 129
Hadley B-3.	
Loam and sand	0 6
Sand, medium, loose, gray	6 - 8
Clay, soft, blue	8 - 76
Sand, fine, red; very little clay	76 - 112
Refusal	at 112
Hadley B-4.	
Loam	0 - 2
Clay	2 - 12
Clay, blue, soft	12 - 31
Sand, fine, red; clay	31 - 107
Sand, medium, red; gravel; clay	107 - 118
Boulders	118 - 122
Hadley B-6.	
Loam	0 - 3
Clay, medium, yellow	3 - 6
Clay, soft, blue	6 - 43
Sand, fine, red; little clay	43 - 121
Sand, medium, red	121 - 140
Sand; gravel; boulders, coarse, compact	140 - 146
Hadley W-2.	
Clay	0 - 90
Gravel	90 - 96
Hadley W-15.	
Gravel	0 - 5
Clay, gray	5 - 65
Sand and silt	65 - 120
Sand and clay	120 - 190
Sand, coarse; clay	190 - 200
Sand, coarse	200 - 205
Gravel, coarse	205 - 228
Hadley W-16.	
Gravel fill	0 - 3
Clay, gray, soft	3 - 80
Sand, silty, red; clay	80 - 115
Sand, fine, silty	115 - 135
Clay; hardpan	135 - 140
Sand, fine gravel; some hardpan	140 - 145
Sand, fine; gravel, dirty	145 - 147
Sand; medium gravel	147 - 150
Gravel, medium; fine sand, water	150 - 160
Sand, fine to coarse	160 - 180
Gravel, medium to coarse	180 - 195
Gravel; clay	195 - 204
Refusal	at 204
Hadley W-17.	
Sand, medium	0 - 28
Clay, blue	28 - 105
Refusal	at 105

Table A-2.--Logs of selected wells and borings (Continued)

	Depth
Hadley W-18.	
Clay, hard	0 - 21
Gravel, medium; clay	21 - 35
Clay, hard	35 - 42
Sand, fine	42 - 49
Gravel, medium	49 - 56
Sand, medium	56 - 65
Refusal	at 65
Hadley W-19.	
Sand, dirty	0 - 10
Sand, coarse	10 - 20
Gravel, fine	20 - 30
Sand, coarse, dirty	30 - 40
Gravel, fine	40 - 50
Clay, stiff	50 - 90
Clay, silty	90 - 110
Gravel, fine; clay	110 - 120
Gravel; medium to fine	120 - 135
Sand, fine; silt	135 - 163
Gravel, coarse	163 - 168
Sand, fine	168 - 176
Ledge	at 176
Hadley W-22.	
Clay, sandy	0 - 4
Sand, medium	4 - 15
Sand, coarse	.15 - 24
Gravel, medium	24 - 34
Clay and stones	34 - 38
Gravel; traces of clay	38 - 45
Sand, coarse	45 - 50
Gravel, medium	50 - 56
Sand, coarse	56 - 65
Gravel, medium to coarse	65 - 104
Sand, coarse	104 - 110
Gravel, fine	110 - 116
Hadley W-26.	
Gravel, coarse; clay	0 - 10
Sand, fine; clay	10 - 20
Clay	20 - 115
Sand, silty; clay	115 - 140
Hardpan	140 - 143
Refusal	at 143
Hadley W-27.	
Topsoil	0 - 0.5
Clay, gray	.5 - 2
Sand and gravel; streaks of gray clay	2 - 10
Sand and gravel, medium to fine, brown	10 - 16
Sand and gravel, fine to coarse	16 - 25
Sand and gravel, reddish brown	25 - 28
Clay, silty, sandy, gray	28 - 38
Clay, gray; streaks of gray, silty sand	38 - 178
Clay, gray with red clay; some gray, silty sand	178 - 210
Clay, red and gray; some sand and silt; little gravel	210 - 220
Clay, very soft, more red; silty sand	220 - 250
Same but changing to more sand	250 - 270
Sand, silty, red; trace of clay	270 - 303
Refusal for wing bit	at 303
Hadley W-29.	
Sand gravel, fine to medium; fine gravel	0 - 10
Sand, fine to medium; fine gravel	10 - 20
Sand, fine, gray; trace of clay	20 - 30
Clay, gray; streaks of silty clay, hard packed	30 - 170
Clay, gray, trace of red; changing to more red less gray	170 - 198
Sand, silty, red; some fine gravel and clay	198 - 200
Refusal for wing bit	at 200
Hadley W-30.	
Topsoil	0 - 2
Sand, brown; some fine gravel	2 - 20
Sand, medium to coarse; fine gravel	20 - 39
Same; trace of clay	39 - 49
Clay, gray; streaks of silt	49 - 135
Clay, red	135 - 139
Refusal for wing bit	at 139

	Depth
Hadley W-31.	
Sand, silty, reddish; trace of clay	0 - 5
Sand and gravel, reddish	5 - 10
Sand, silty, reddish; trace of clay progressively more clay less sand	10 - 19
Clay, silty; streaks of red, sandy clay	19 - 23
Sand, fine to medium; fine gravel, silty	23 - 36
Clay, sandy, red	36 - 46
Sand, fine, red; trace of clay	46 - 54
Hardpan	54 - 74
Boulders	74 - 78
Hardpan, very hard streaks	78 - 97
Bedrock	97 - 100
Hadley W-34.	
Sand, fine, silty, gray	0 - 30
Clay	30 - 60
Sand, silty; clay	60 - 104
Sand, fine, gray	104 - 120
Sand, fine to medium	120 - 127
Sand, medium to coarse; some gravel near bottom	127 - 152
Refusal	at 152
Hadley W-35.	
Clay, hard, brown	0 - 22
Clay, gumbo, blue	22 - 90
Silt, fine, red; clay	90 - 114
Sand, medium, red	114 - 121
Refusal	at 121
Hadley X-1.	
Loam	0 - 1
Sand, fine	1 - 3
Clay, stiff	3 - 9
Clay, soft	9 - 108
Sand, fine, some gravel, very compact	108 - 111
Refusal	at 111
Hadley X-2.	
Loam; fine sand	0 - 3
Clay, stiff	3 - 8
Clay, soft	8 - 118
Sand, fine; some gravel, very compact	118 - 121.5
Refusal	at 121.5
Sunderland B-2.	
Sand, loamy	0 - 4
Sand and gravel, medium, loose	4 - 15
Sand, fine, loose	15 - 50
Sand, fine; little gravel, firm	50 - 65
Clay, soft, blue	65 - 95
Sand, medium, gray; little clay	95 - 102
Sunderland B-3.	
Sand and gravel	0 - 1
Clay, soft, blue	1 - 72.5
Clay; fine sand	72.5 - 106
Sand, fine, red	106 - 120
Sand, red, sharp, firm	120 - 144
Sand, sharp; little fine gravel	144 - 150
Sunderland W-39.	
Sand, clayey	0 - 20
Sand, brown	20 - 40
Sand, very fine	40 - 45
Gravel, medium	45 - 53
Sand, fine, dirty	53 - 58
Sand, medium, water-bearing	58 - 64
Gravel, water-bearing	64 - 66
Sand, medium to coarse, water-bearing	66 - 72.5
Sand, fine, silty; clay	72.5 - 90
Sunderland W-50.	
Sand and gravel	0 - 35
Clay and hardpan	35 - 40
Sand and gravel	40 - 65
Clay and sand	65 - 70
Sand and gravel	70 - 97
Sunderland W-54.	
Gravel, coarse	0 - 10
Gravel, medium	10 - 27
Hardpan	27 - 32
Refusal	at 32

	Depth
Sunderland W-55.	
Gravel, coarse	0 - 47
Refusal	at 47
Sunderland W-56.	
Gravel, coarse	0 - 30
Gravel, medium	30 - 40
Gravel, coarse	40 - 50
Refusal	at 50
Sunderland W-58.	
Silt, fine	0 - 10
Clay	10 - 60
Silt, fine, gray	60 - 100
Clay	100 108
Sand, fine, gray; some gravel	108 - 115
Sunderland W-59.	
Gravel	0 - 10
Clay	10 - 45
Sand, fine, brown	45 - 80
Silt and clay, brown	80 - 130
Refusal (no ledge)	at 130
Sunderland W-61.	
Topsoil	0 - 2
Gravel, coarse	2 - 15
Clay, yellow	15 - 25
Sand and clay	25 - 30
Clay	30 - 35
Sand, brown	35 - 55
Sand, coarse, brown	55 - 65
Sand, very fine	65 - 70
Sand and clay, very fine	70 - 155
Sand and clay, gray	155 - 290
Clay, red-brown	290 - 345
Gravel, red; red clay; hardpan	345 - 376
Red ledge	376 - 378
Sunderland W-65.	
Topsoil	0 - 0.5
Clay, silty, sandy, gray	.5 - 7
Sand, fine, silty, gray	7 - 13
Sand, fine to medium; gravel	13 - 30
Clay, silty, brown	30 - 31
Clay, gray	31 - 60
Clay, soft, gray; streaks of silty clay	60 - 134
Clay, sandy, silty	134 - 150
Clay, red and gray; some silty streaks	150 - 160
Clay, red; streaks of sandy clay	160 - 206
Refusal for wing bit	at 206
Sunderland W-66.	
Topsoil	0 - 3
Clay, silty	3 - 11
Sand and gravel, medium to coarse	11 - 21
Sand, fine to medium, silty gray	21 - 40
Clay	40 - 110
Clay, silty	110 - 140
Clay, silty, soft, gray	140 - 150
Clay, red	150 - 172
Hardpan	172 - 177
Sand and gravel, hard, red probably bedrock	177 - 243
Sunderland W-67.	
Clay, hard, gray; streaks of brown sand	0 - 3
Sand, fine brown-gray	3 - 7
Sand and gravel, fine to medium, gray	7 - 20
Sand and gravel, fine to medium; streaks of brown, silty sand	20 - 30
Clay, sandy, gray; streaks of gray clay	30 - 40
Clay, gray	40 - 110
Clay, gray; clay, silty, sandy, red and gray	110 - 137
Same as above but finer, more red	137 - 187
Clay, silty, sandy, red	187 - 211
Refusal for wing bit--bedrock?	at 211
Sunderland W-69.	
Clay, silty, gray	0 - 3
Hard	3 - 3.25
Clay, silty, red	3.25 - 6
Clay, silty, brown	6 - 9
Sand, fine to medium, gray-brown; gravel	9 - 26

Table A-2.--Logs of selected wells and borings (Continued)

	Depth
Sunderland W-69 (Continued).	
Clay, gray, hard and soft streaks	26 - 86
Clay, silty, gray, changing to red	86 - 120
Hardpan, red	120 - 123
Refusal for wing bit--bedrock?	at 123
Sunderland W-70.	
Topsoil	0 - 2
Clay, hard, gray	2 - 7
Sand and gravel, fine to coarse, reddish brown, some boulders	7 - 22
Clay, gray	22 - 102
Clay, red and gray; streaks of silty sand with clay	102 - 162
Same as above with streaks of hard clay	162 - 220
Refusal for wing bit--bedrock?	at 220
Sunderland W-72.	
Sand, fine to medium; gravel	0 - 28
Clay, gray; silt	28 - 142
Refusal	at 142
Sunderland W-74.	
Sand, medium-coarse; gravel	0 - 17
Sand, medium; gravel	17 - 32
Sand, medium	32 - 45
Sand, medium-coarse	45 - 55
Sand, medium; gravel	55 - 65
Sand, medium; clay	65 - 72
Sand, fine; gravel	72 - 92
Sand, medium; gravel; trace of clay	92 - 110
Refusal	at 110
Sunderland W-77.	
Sand, medium; gravel	0 - 25
Clay, red	25 - 55
Sand, silty, red	55 - 75
Sand, fine, red	75 - 83
Sand, silty, red	83 - 97
Sand, medium, red	97 - 112
Sand, silty, red	112 - 160
Sunderland W-78.	
Peat	0 - 8
Sand, medium; coarse gravel	8 - 18
Sand, medium; gravel	18 - 24
Clay; fine sand	24 - 30
Sand, medium	30 - 39
Sand, fine	39 - 50
Sand, medium	50 - 65
Sand, medium; gravel	65 - 80
Sunderland W-78 (Continued).	
Sand, fine to medium	80 - 115
Sand, medium	115 123
Sand, silty; clay	123 - 128
Sand, silty, red	128 - 192
Refusal	at 192
Sunderland W-80.	
Sand, fine; gravel	0 - 10
Sand, fine	10 - 18
Sand, fine; clay, gray	18 - 43
Sand, fine; trace of clay	43 - 75
Sand, silty, gray; trace of clay	75 - 100
Sand, fine, gray; trace of clay	100 - 130
Sand, silty; trace of clay	130 - 160
Sand, silty; clay	160 - 175
Refusal	at 175
Sunderland W-81.	
Sand, silty	0 - 10
Clay	10 - 14
Sand, fine	14 - 25
Sand, fine; trace of clay	25 - 80
Sand, fine to medium, gray	80 - 90
Sand, silty, gray; traces of clay	90 - 130
Sand, silty, gray; clay	130 - 165

Table A-3.--Particle-size distribution of lithologic samples from various depths in selected wells

Local no.	Sample depth (feet below lsd)	Sampling method	Percent of lithologic sample, by dry weight, passing through listed sieve (Top number is sieve size; bottom number is size of sieve opening, in millimeters)											
			0.62" 16	0.31" 8	5 4	10 2	18 1	35 0.5	60 0.25	120 0.125	230 0.0625	0.031	0.016	0.004
							HADLEY							
HAW 27	280	Split spoon	--	--	--	100	100	100	99	88	47	--	--	--
							SUNDERLAND							
S6W 65	120	Split spoon	--	--	100	100	99	98	96	93	84	--	--	--
S6W 65	200	Split spoon	--	--	--	--	100	100	99	98	77	--	--	--
S6W 66	20	Split spoon	100	99	99	97	92	77	19	6	4	--	--	--
S6W 67	130	Split spoon	--	--	--	--	100	100	100	98	86	67	51	32