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UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

GEOHYDROLOGIC DATA FOR TEST WELL USW H-6 YUCCA MOUNTAIN AREA, NYE COUNTY, NEVADA

by

R. W. Craig, R. L. Reed, and R. W. Spengler

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By

R. W. Craig,[1] R. L. Reed,[2] and R. W. Spengler[1]

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CONVERSION TABLE

For use of readers who prefer to use inch-pound units, conversion factors for terms used in this report are listed below:

Multiply	*By*	*To obtain inch-pound*
millimeter	0.03937	inch
meter	3.281	foot
kilometer	0.6214	mile
liter	0.2642	gallon
liter per second	15.85	gallon per minute
microsiemens per centimeter at 25° Celsius	1.000	micromho per centimeter at 25° Celsius
degree Celsius	°F = 1.8°C+32	degree Fahrenheit
microgram per liter	[1]1.0	part per billion
milligram per liter	[1]1.0	part per million

[1]Approximate.

National Geodetic Vertical Datum of 1929 (NGVD)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Mean Sea Level; it is referred to as sea level in this report.

GEOHYDROLOGIC DATA FOR TEST WELL USW H-6
YUCCA MOUNTAIN AREA, NYE COUNTY, NEVADA

by R. W. Craig, R. L. Reed, and R. W. Spengler

ABSTRACT

This report presents the following data for test well USW H-6: drilling operations, lithology, availability of borehole geophysical logs, water levels, future availability of core analyses, water chemistry, pumping tests, and packer-injection tests. The well is one of a series of test wells drilled in and near Yucca Mountain adjacent to the Nevada Test Site, Nye County, Nevada, in cooperation with the U.S. Department of Energy. These investigations are part of the Nevada Nuclear Waste Storage Investigations to identify suitable sites for underground storage of high-level radioactive wastes.

Test well USW H-6 was drilled to a total depth of 1,220 meters. Rocks penetrated are predominantly ash-flow tuffs. Lava was encountered from 877 to 1,126 meters. The composite static water level is approximately 526 meters below land surface. The well was pumped during two periods. Maximum drawdown was about 18 meters after pumping for 4,822 minutes at 28 liters per second, and 12 meters after pumping for 2,226 minutes at 27 liters per second. A boreholeflow survey showed that 91 percent of the water withdrawn from the well came from the depth intervals from 616 to 631 meters, and from 777 to 788 meters.

INTRODUCTION

The U.S. Geological Survey has been conducting investigations at Yucca Mountain, Nevada, to determine the hydrologic and geologic suitability of the site for storing high-level nuclear waste in an underground mined repository. These investigations are part of the Nevada Nuclear Waste Storage Investigations being done by the U.S. Geological Survey in cooperation with the U.S. Department of Energy, Nevada Operations Office. Test drilling has been a principal method of investigation. This report presents geohydrologic and drill-hole data from test well USW H-6.

Test well USW H-6 is located in Nye County, Nevada, approximately 145 km northwest of Las Vegas in the southern part of the State (fig. 1). The well was drilled west of the part of Yucca Mountain being considered as a possible repository, on the eastern edge of Crater Flat (fig. 2). The well site is in a small easterly draining canyon, which is tributary to a larger southerly draining canyon adjacent to a large fault scarp (Lipman and McKay, 1965). Location of the site is Nevada State Coordinate System Central Zone N 763,299 ft and E 544,075 ft. Altitude of land surface at the well site is 1,302 m above sea level.

Test well USW H-6 is one in a series of geohydrologic test wells designed specifically for hydrologic testing. The well was sited west of the fault scarp primarily to determine if geohydrologic conditions in test wells east of the fault scarp extended to the west.

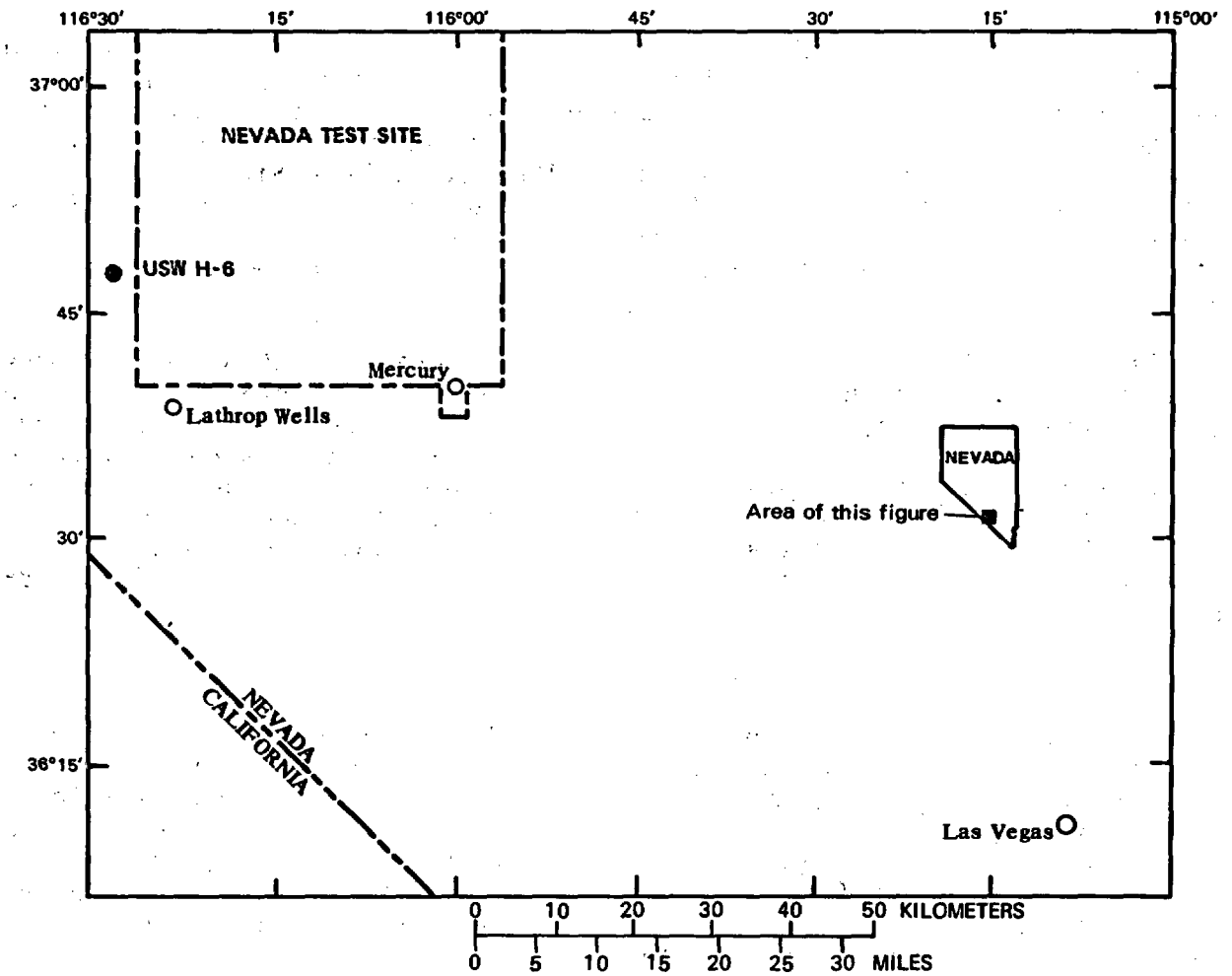

Figure 1.--Location of test well USW H-6.

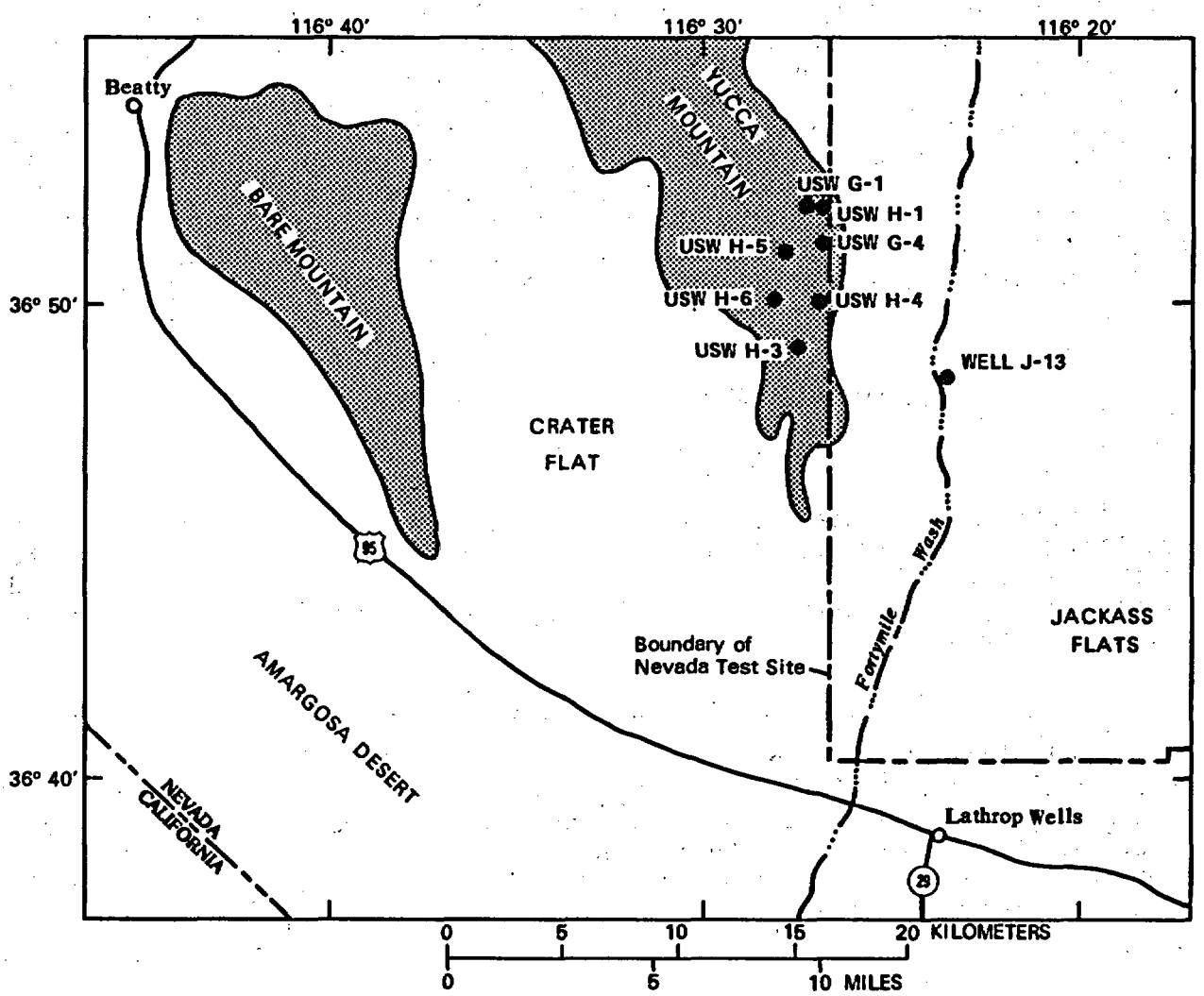

Figure 2.--Geographic features and other wells in vicinity of test well USW H-6.

DRILLING OPERATIONS

Drilling of well USW H-6 began on August 7, 1982. A total depth of 1,220 m was reached on September 30, 1982. The hole was rotary-drilled, using an air-foam fluid consisting of air, detergent, and water rather than drilling mud to minimize infilling of pores and fractures. Lithium chloride was added to all water used in drilling operations as well as water used during packer-injection testing. Concentrations of lithium in fluid returns or water samples were used to indicate if fluids sampled were contaminated by drilling or testing fluids or were indicative of formation water. A total of 67 m was cored at selected intervals from 333 to 1,220 m. No unusual drilling problems were encountered. Circulation was lost for about 30 minutes at 1,130 m. Well construction is shown in figure 3. A directional survey indicates that the maximum hole deviation is 1.5°. The bottom survey station, at 1,204 m, shows the hole deviation is 16 m from the vertical at a direction of N 88° 21' W. A detailed drilling history is contained in the files of the engineering firm, Fenix and Scisson, Inc., Las Vegas, Nevada (consultant of U.S Department of Energy).

LITHOLOGIC SAMPLING AND WELL LOGGING

Lithologic log

The rocks penetrated in test well USW H-6, as determined from rock-bit cuttings and core, are predominantly volcanic tuffs, with the exception of the depth interval 877 to 1,126 m, where lava was encountered. A detailed lithologic log is presented in table 1; complete designations of formation and member are shown.

Geophysical well logs

Geophysical logs were made in test well USW H-6 to confirm well construction, to help define lithologic contacts, to measure water levels, to obtain data on porosity and fractures, and to measure the diameter of the open hole. The logs were used to help select intervals for hydrologic testing. A summary of geophysical logs recorded in the well and the depth intervals logged are shown in table 2.

Table 1.--*Lithologic log of test well USW H-6*

[m=meters; mm=millimeters]

Stratigraphic and lithologic description	Thickness of interval (meters)	Depth to bottom of interval[1] (meters)
Alluvium of Quaternary age, boulders, gravel, sand; predominantly composed of densely welded Tiva Canyon Member of the Paintbrush Tuff, a few fragments are partly coated with caliche.	9.1	9.1
Paintbrush Tuff of Tertiary age		
Tiva Canyon Member		
Tuff, ash-flow, brownish-gray, grayish-red, densely welded, devitrified; less than 2 percent phenocrysts (sanidine).	48.8	57.9
Tuff, ash-flow, dusky-yellowish-brown, moderately welded (?); vitric (vitrophyre); abundant black glass shards.	3.1	61.0
Tuff, ash-flow, light-brown and dark-yellowish-orange, partially welded, vitric (partially argillic; less than 2 percent phenocrysts; abundant black and dark-yellowish-orange glass shards).	18.3	79.3
Bedded tuff (unnamed)		
Tuff, bedded, ash-fall, white, vitric	3.0	82.3
Pah Canyon Member		
Tuff, ash-flow, moderate-orange-pink, nonwelded, vitric; pumice, very-pale-orange, vitric; conspicuous biotite (ash-fall may be present from 88.4-91.4 m).	9.1	91.5
Topopah Spring Member		
Tuff, ash-flow, light-brown, nonwelded, vitric; mostly light-brown, vitric pumice; pale-reddish-brown and black vitrophyric lithic fragments (?).	9.1	100.6
Tuff, ash-flow, moderate-reddish-brown, (densely-welded, vitrophyre).	0.6	101.2(?)

Table 1.--*Lithologic log of test well USW H-6*--Continued

[m=meters; mm=millimeters]

Stratigraphic and lithologic description	Thickness of interval (meters)	Depth to bottom of interval[1] (meters)
Paintbrush Tuff of Tertiary Age--Continued		
Topopah Spring Member--Continued		
Tuff, ash-flow, grayish-red, densely welded, devitrified; 10 percent (?) phenocrysts (abundant bronze biotite).	2.4	103.6(?)
Tuff, ash-flow, grayish-red, moderately welded, vapor phase; pumice, grayish-red(?), vapor phase (bit cuttings very fine grained).	24.4	128.0
Tuff, ash-flow, light-brown-gray to very-light-gray, densely welded, devitrified; possible lithophysal zone(?).	70.1	198.1
Tuff, ash-flow, light-brown and grayish-red (mottled) densely welded, devitrified; less than 1 percent phenocrysts; conspicuous mottled appearance of bit cuttings between 268.2 and 359.7 m suggesting a possible lithophysal zone(?).	172.8	370.9
Tuff, ash-flow, black, vitrophyre; upper part of subunit altered to light brown and moderate brown; may be zeolites(?).	27.4	339.3
Tuff, ash-flow, grayish-brown to moderate-yellowish-brown, partially welded to nonwelded, vitric, abundant black glass shards; base identified in television camera videotape observations.	11.0	410.3
Bedded tuff (unnamed)		
Tuff, ash-fall, bedded, reworked, light-olive-gray, moderate-brown, light-brownish-gray, vitric, slightly to moderately indurated(?); predominantly composed of pumice; sparse brownish-gray, medium-light-gray, and medium-dark-gray vitrophyric lithic fragments; beds range in thickness from 30-37 mm; beds dip 7-10°.	9.2	419.5

Table 1.--*Lithologic log of test well USW H-6*--Continued

[m=meters; mm=millimeters]

Stratigraphic and lithologic description	Thickness of interval (meters)	Depth to bottom of interval[1] (meters)
Rhyolite Lavas and Tuffs of Calico Hills		
Tuffaceous beds of Calico Hills		
Tuff, ash-flow, moderate-reddish-orange, light-brown, non-to-partially welded, vitric; pumice, grayish-orange-pink, light-gray, very-light-gray, yellowish-gray, vitric, particles range in size from 3 mm to 60 mm; less than 2 percent phenocrysts (sanidine); sparse brownish-gray rhyolitic lithic fragments and light gray to black vitrophyre lithic fragments. (Bedded tuff interval from 432.2-432.4 m, moderate-pink to grayish-orange-pink, moderately indurated, vitric, dominantly pumice fragments, rare brownish-gray, rhyolitic lithic fragments). (Television camera videotape observations suggest the base of the interval is 444.4 m).	24.9	444.4
Tuff, bedded, reworked, moderate-orange-pink, grayish-yellow, pale-yellowish-brown; dominantly zeolitic and argillic pumice fragments; lower 3 m well sorted.	14.0	458.4
Crater Flat Tuff of Tertiary age		
Prow Pass Member		
Tuff, ash-flow, pale-yellowish-brown, partially welded, vitric; pumice, grayish-yellow and very-pale-orange, vitric, particles 1-20 mm in size; 5 to 7 percent phenocrysts of quartz, sanidine, plagioclase, biotite, and pyroxene; rare grayish red volcanic and moderate-reddish-brown mudstone lithic fragments, commonly less than 10 mm in size.	11.0	469.4
Tuff, ash-flow, pale-yellowish-brown and grayish-orange-pink, partially welded, devitrified and vapor-phase crystallization; pumice, light-gray, light-brownish-gray, vapor-phase crystallization, particles commonly less than 20 mm in size; 10 percent phenocrysts (sanidine, plagioclase, quartz, biotite), abundant minute biotite flakes concentrated in pumice fragments; sparse pale-reddish-brown mudstone lithic fragments, commonly less than 5 mm in size, as large as 10 mm.	42.7	512.1

Table 1.--*Lithologic log of test well H-6*--Continued

Stratigraphic and lithologic description	Thickness of interval (meters)	Depth to bottom of interval[1] (meters)
Crater Flat Tuff--Continued		
Prow Pass Member--Continued		
Tuff, ash-flow, yellowish-gray, grayish-orange-pink, light-olive gray, partially welded, devitrified, zeolitic(?); pumice, moderate-orange-pink, grayish-yellow, zeolitic(?); 5 to 10 percent phenocrysts, biotite rich; sparse moderate-reddish-brown mudstone lithic fragments; bit cutting samples extremely small and difficult to describe.	25.9	538.0(?)
Bedded tuff (unnamed)		
Tuff, bedded, reworked, moderate-reddish-brown and yellowish-gray, dominantly composed of moderate pink pumice fragments, zeolitic (?) and sub-rounded phenocrysts.	9.1	547.1(?)
Bullfrog Member		
Tuff, ash-flow, grayish-orange-pink, non-to-partially welded(?), devitrified, pumice, very-light-gray and very-pale-orange; biotite rich; bit cutting samples extremely small.	4.6	551.7
Tuff, ash-flow, pale-yellowish-brown and very-light-brownish-gray, partially welded, vapor-phase crystallization; pumice, medium-light-gray, light-brownish-gray, and medium-gray, vapor-phase crystallization; 15 percent phenocrysts (sanidine, plagioclase, quartz, biotite); very rare moderate-brown rhyolitic lithic fragments.	30.5	582.2
Tuff, ash-flow, olive-gray and brownish-gray, partially welded, devitrified; pumice, light-brownish-gray, devitrified; 10 percent phenocrysts (sanidine, plagioclase, quartz, biotite, hornblende); rare moderate-reddish-brown mudstone lithic fragments and moderate-brown rhyolitic lithic fragments.	18.3	600.5(?)

Table 1.--*Lithologic log of test well USW H-6*--Continued

Stratigraphic and lithologic description	Thickness of interval (meters)	Depth to bottom of interval[1] (meters)
Crater Flat Tuff--Continued		
Bullfrog Member--Continued		
Tuff, ash-flow, light-brown and pale-brown, partially to moderately welded, devitrified; pumice, medium-light-gray, light-brown, devitrified; 15 percent phenocrysts (sanidine, quartz, plagioclase, biotite, hornblende); rare pale-reddish-brown mudstone lithic fragments.	51.2	651.7
Tuff, ash-flow, grayish-orange, moderate-yellowish-brown, and grayish-yellow, partially to nonwelded, devitrified, moderately altered; (estimates based on x-ray analysis suggest more than 30 percent mordenite/clinoptilolite and less than 10 percent montmorillonite[2]); pumice, grayish-orange and pale-yellowish-orange, devitrified, altered; 10 percent phenocrysts of sanidine, plagioclase, quartz, biotite; bit cutting samples contaminated from 658.4 to 673.6 m.	26.5	678.2
Bedded tuff (unnamed)		
Tuff, bedded, reworked, light-brown, slightly indurated; pumice, grayish-yellow and grayish-pink, subrounded, moderately sorted.	9.1	687.3
Tram Member		
Tuff, ash-flow, moderate-orange-pink to light-brown, nonwelded (?), devitrified; pumice, very-pale-orange, grayish-yellow, slightly zeolitic (?); 15 percent phenocrysts (quartz, sanidine, plagioclase, biotite).	16.8	704.2
Tuff, ash-flow, yellowish-gray, grayish-orange, and light-brownish-gray, devitrified, dominantly vapor phase crystallization; commonly less than 10 mm in length; 10 percent phenocrysts (quartz, sanidine, plagioclase, biotite); rare to sparse grayish-red, light brown, olive-gray, and greenish-gray, rhyolitic to intermediate volcanic lithic fragments, commonly less than 15 mm in size, as large as 40 mm; bit cutting samples extremely fine from 771.1-801.6 m, and 804.7 to 810.8 m.	106.7	810.8(?)

Table 1.--*Lithologic log of test well USW H-6*

Stratigraphic and lithologic description	Thickness of interval (meters)	Depth to bottom of interval[1] (meters)
Crater Flat Tuff--Continued		
Tram Member--Continued		
Tuff, ash-flow, yellowish-gray and light-olive-gray, nonwelded, zeolitic and argillic; estimates based on x-ray analysis suggest more than 40 percent mordenite/clinoptilolite and less than 10 percent montmorillonite; pumice, pale-greenish-yellow and grayish-yellow, zeolitic, commonly less than 10 mm in length; 10 percent phenocrysts of quartz, sanidine, plagioclase, and biotite; notable increase in lithic fragments (about 10-15 percent of rock), olive gray, brownish-gray, moderate-reddish-brown, and dark gray, rhyolitic to intermediate, range in size from 2 to 30 mm; bit cutting samples extremely fine from 816.9-832.1 m.	63.7	874.5
Bedded tuff (unnamed)		
Tuff, reworked, moderate red to grayish-red, moderately indurated; pumice, sparse, white to grayish-orange-pink, zeolitic (?).	2.7	877.2
Lava		
Lava, pale-yellowish-green, light-greenish-gray, pale green, and dusky-yellow-green, dacitic (?), altered to smectite and zeolites; estimates based on x-ray analysis indicate 40 percent clinoptilolite/mordenite; 30 to 40 percent phenocrysts (plagioclase, abundant biotite and hornblende).	60.1	937.3
Lava, brownish-gray, greenish-gray, dacitic (?), vitric (decrease in alteration); estimates based on x-ray analysis suggest 20 percent mordenite; 30-40 percent phenocrysts (plagioclase, biotite, hornblende).	13.7	951.0
Lava, pale-red, grayish-red, light-olive-gray to olive-gray, devitrified (slightly altered); estimates based on x-ray analysis suggest less than 10 percent montmorillonite; 30-40 percent phenocrysts (plagioclase, biotite, hornblende).	56.1	1,007.1(?)

Table 1.--*Lithologic log of test well USW H-6*--Continued

Stratigraphic and lithologic description	Thickness of interval (meters)	Depth to bottom of interval[1] (meters)
Crater Flat Tuff--Continued		
Lava--Continued		
Lava, pale-red, slight increase in alteration, dacitic(?).	62.8	1,069.9
Lava, olive-gray and brownish-gray, devitrified, dacitic(?).	19.8	1,089.7
Lava, blackish-gray, dacitic, vitrophyre; 30 percent phenocrysts (plagioclase, biotite, hornblende).	19.8	1,109.5
Lava, greenish-gray to light-greenish-gray, dacitic, vitric (slightly altered, alteration increases downward); 30 percent phenocrysts of plagioclase, biotite, hornblende).	16.4	1,125.9(?)
Bedded tuff (unnamed)		
Tuff, reworked (tuffaceous sandstone), pale-brown, fine-grained, well-sorted, well-rounded, few pumice fragments, slightly zeolitic; contains approximately 20 percent mordenite based on x-ray analysis.	4.3	1,130.2(?)
Lithic Ridge Tuff		
Tuff, ash-flow, light-olive-gray and greenish-gray, partially welded, zeolitic and argillic; pumice, olive-gray and light-greenish-gray, argillic and zeolitic, commonly 5 to 30 mm in length; 10 percent phenocrysts (quartz, sanidine, plagioclase, biotite, and sphene); sparse light-brownish-gray, olive-gray, and brownish-gray volcanic lithic fragments, commonly 5 to 30 mm in size.	34.1	1,164.3
Tuff, ash-flow, greenish-gray, non-to-partially welded, moderately zeolitic, contains approximately 30 percent analcime based on x-ray analysis; pumice, greenish-gray, pale-green, highly argillic and zeolitic, commonly 5 to 20 mm in size; 10 percent pheno-crysts (sanidine, plagioclase, quartz, biotite,		

Table 1.--*Lithologic log of test well USW H-6*--Continued

Stratigraphic and lithologic description	Thickness of interval (meters)	Depth to bottom of interval[1] (meters)
Lithic Ridge Tuff--Continued		
and sphene); increase in lithic fragments, about 5 to 10 percent, grayish-black, brownish-black, olive-gray, brownish-gray, rhyolitic to intermediate, commonly 5 to 35 mm.	55.6	1,219.9
	TOTAL DEPTH	1,219.9

[1]Depth to bottom of interval is reported to 0.1 meter to correspond to the thickness of intervals; actual depths are probably ±0.5 meter.

[2]X-ray analyses by P. D. Blackmon (U.S. Geological Survey).

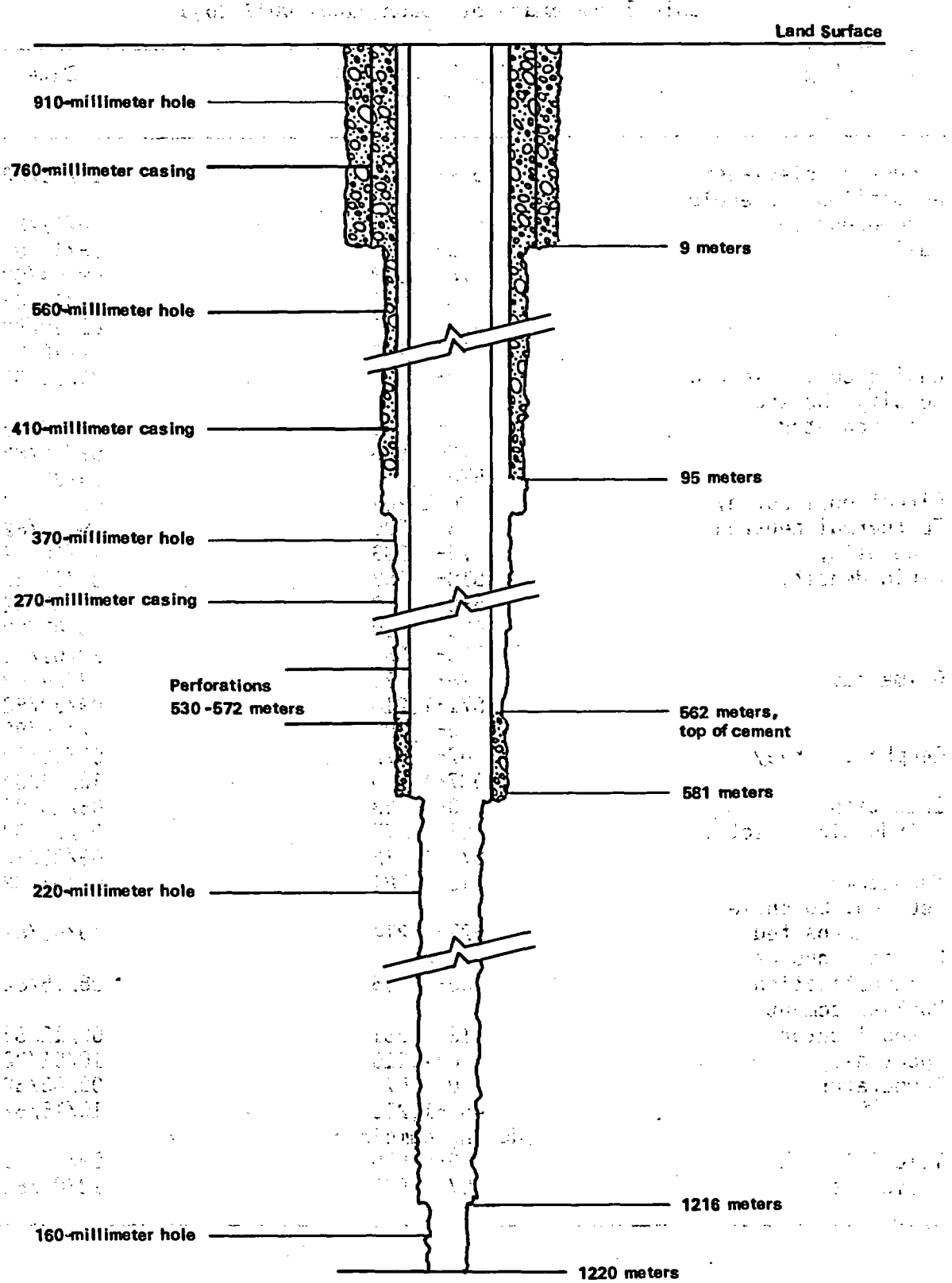

Figure 3.--Well construction.

Table 2.--*Summary of geophysical well logs*

Log	Depth interval (meters)	Date
Acoustic televiewer	579-1,204	11/02/82
Acoustilog, borehole compensated	581-1,212	10/01/82
Caliper	0- 95	08/13/82
	76- 578	09/04/82
	0- 600	09/13/82
	564-1,211	09/30/82
	564-1,202	12/16/82
Casing collar locator	0- 586	09/12/82
Density, borehole compensated	0- 95	08/13/82
	76- 578	09/04/82
	570-1,213	09/30/82
Directional survey	0-1,204	09/29/82
Epithermal neutron porosity	76- 580	09/07/82
	76- 593	12/16/82
Fluid density	518- 557	09/03/82
	518- 533	09/05/82
	518- 539	09/07/82
	518- 533	10/01/82
Gamma ray	76- 579	09/04/82
	571-1,214	09/30/82
	0-1,203	12/16/82
Geophone survey	107- 572	09/05/82
	587-1,210	10/02/82
Induction	0- 93	08/13/82
Induction-electric	91- 577	09/04/82
	575-1,212	09/30/82
Magnetometer	210- 581	09/07/82
Neutron, borehole compensated	527-1,214	10/01/82
Nuclear annulus investigation	85- 95	08/15/82
Nuclear cement top locator	512- 581	09/12/82
Spectralog	0-1,215	10/01/82
Temperature	0- 579	09/05/82
	457-1,215 (during pumping)	10/15/82
Television camera video tape	0- 515	09/04/82
	607- 907	12/02/82

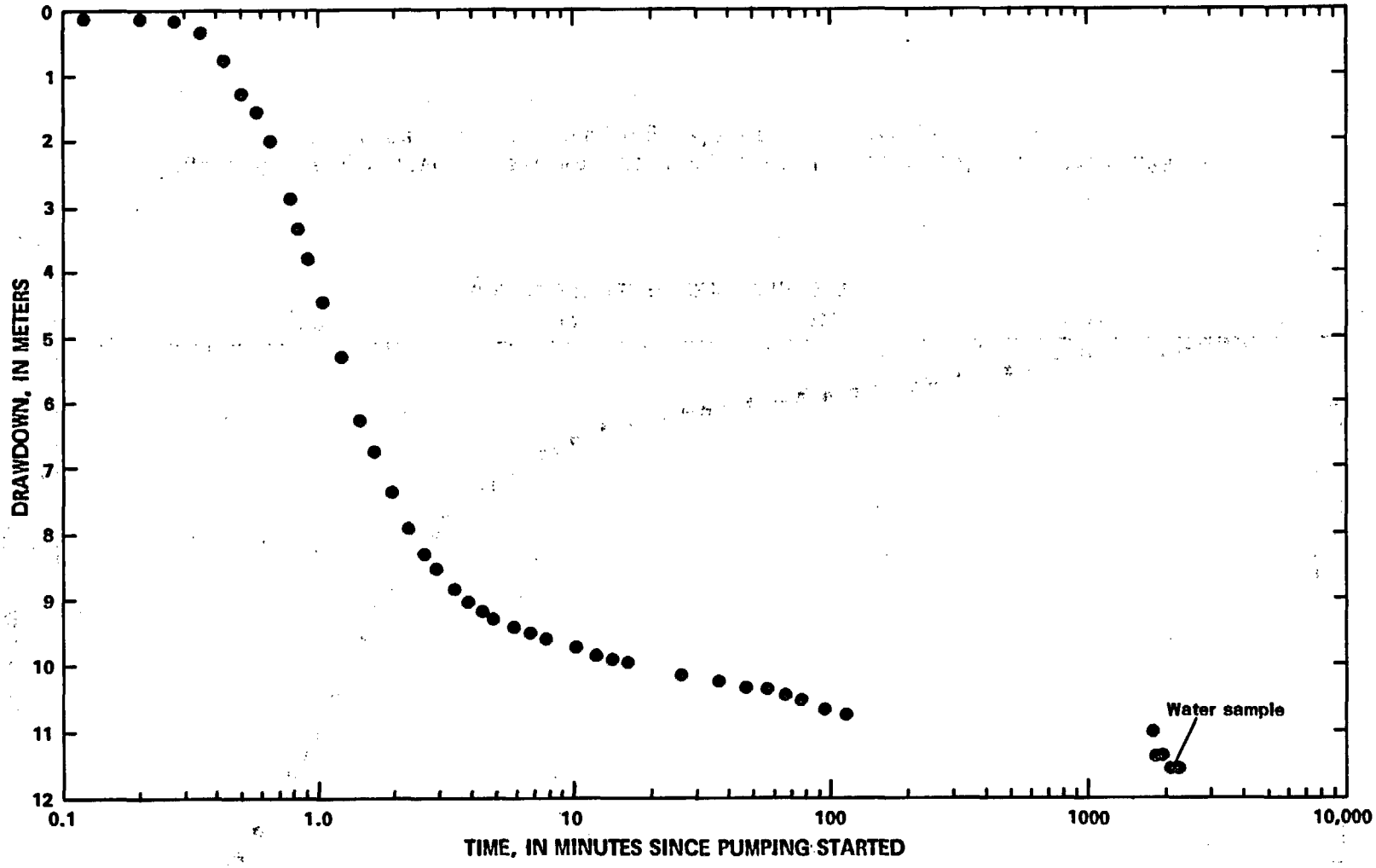

Figure 5. Water-level drawdown, pumping test 2, depth interval from 526 to 1,220 meters, at a pumping rate of 27 liters per second.

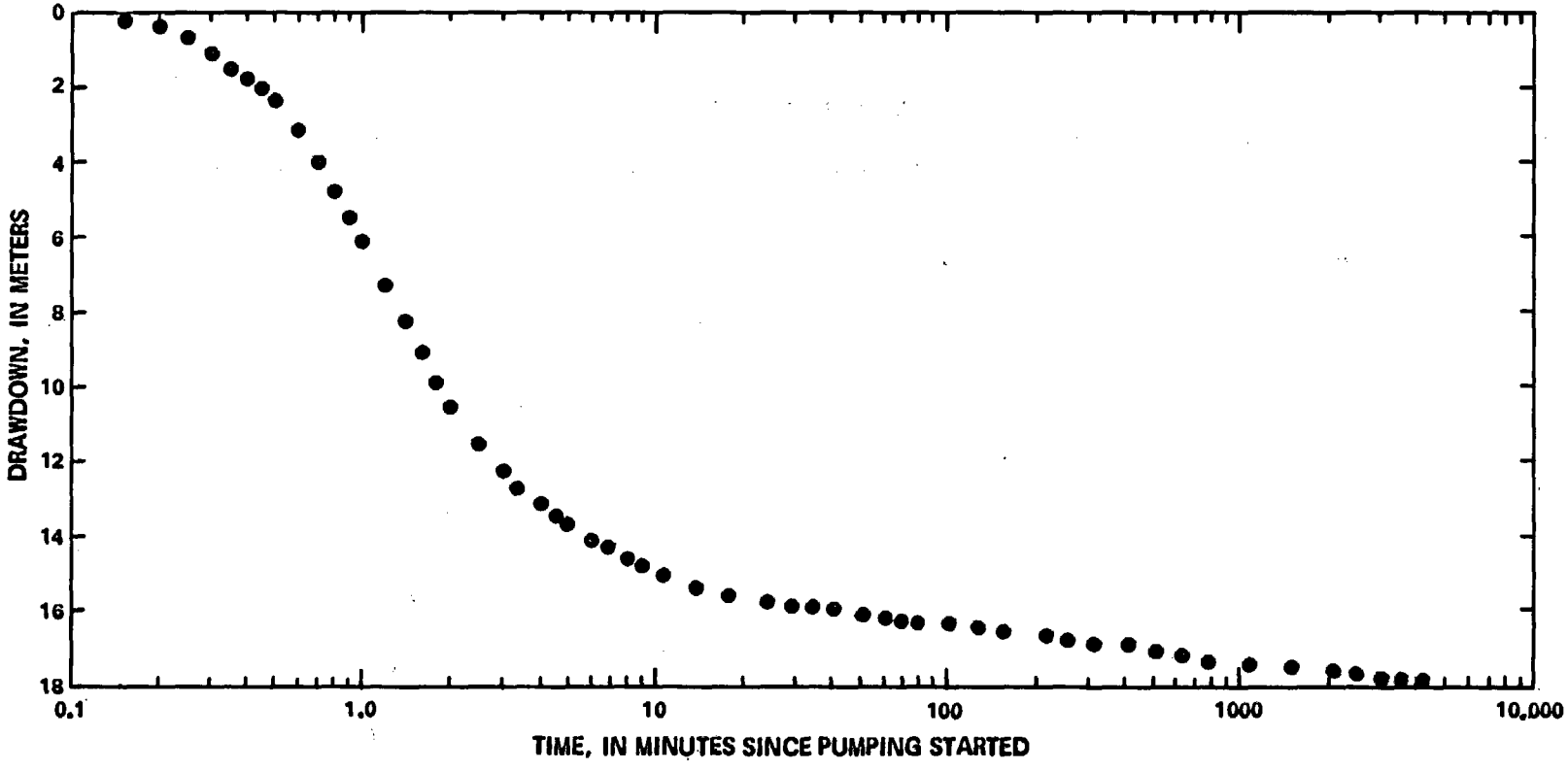

Figure 4.--Water-level drawdown, pumping test 1, depth interval from 526 to 1,220 meters, at a pumping rate of 28 liters per second.

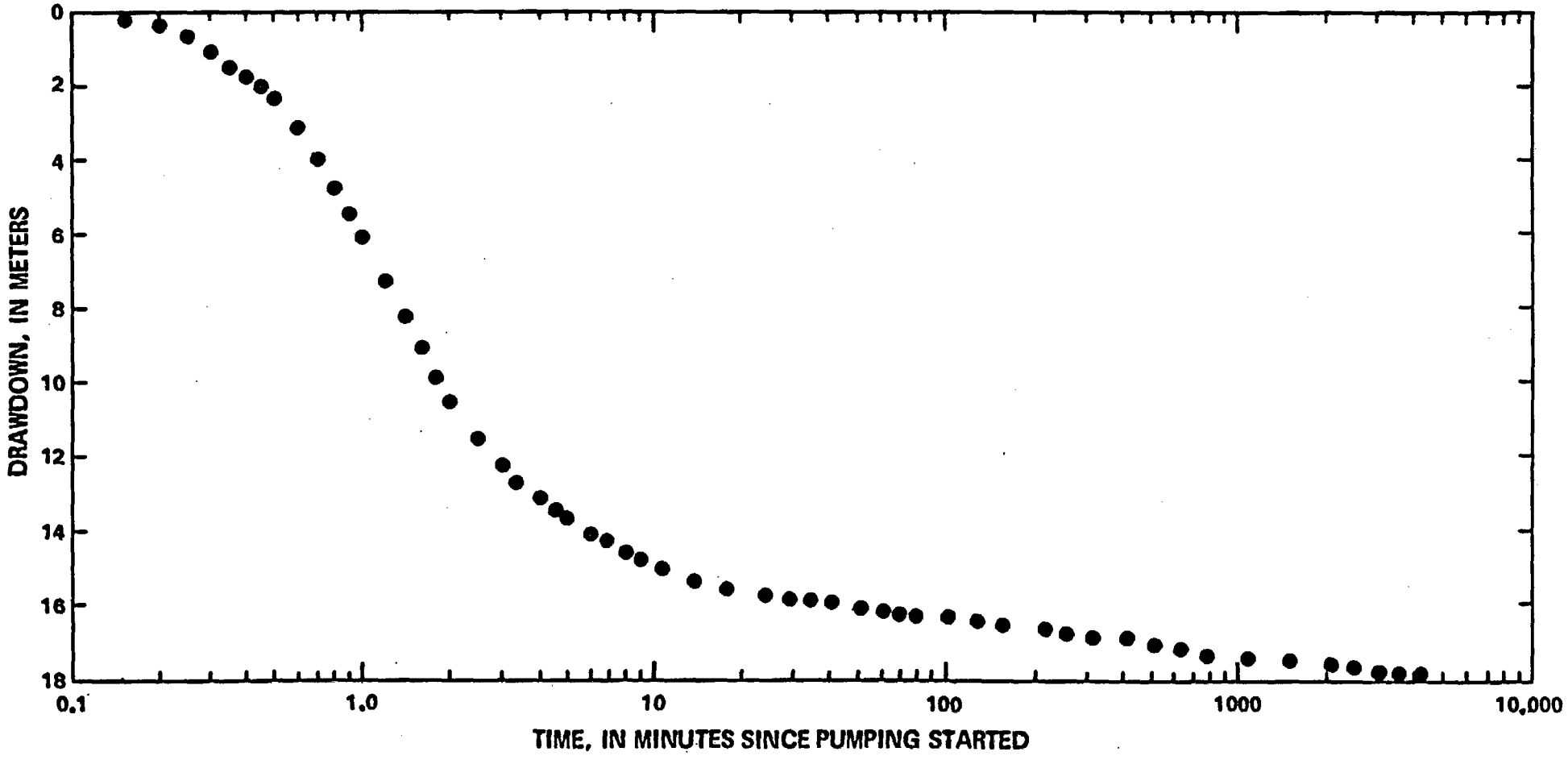

Figure 4.--Water-level drawdown, pumping test 1, depth interval from 526 to 1,220 meters, at a pumping rate of 28 liters per second.

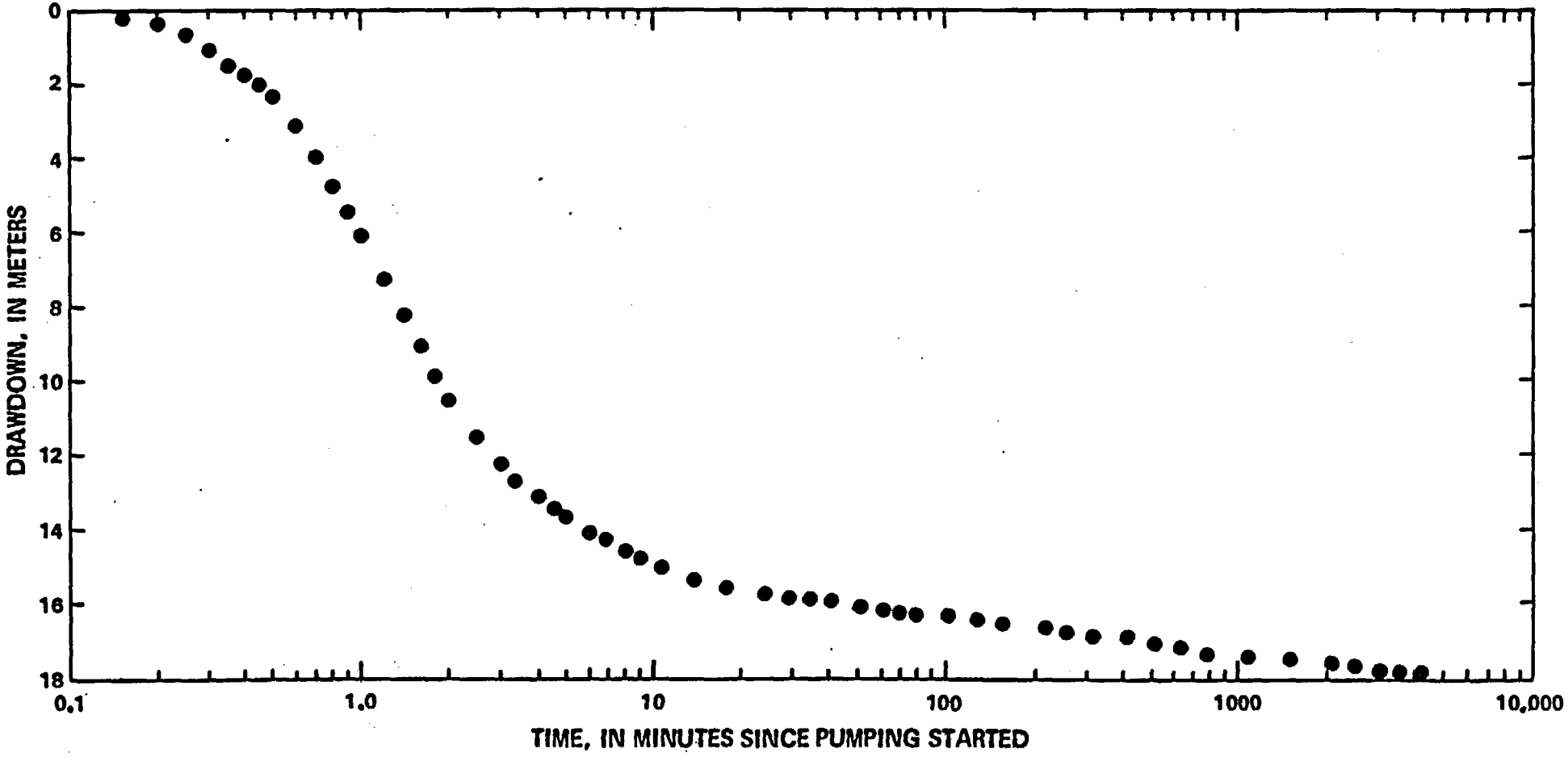

Figure 4.--Water-level drawdown, pumping test 1, depth interval from 526 to 1,220 meters, at a pumping rate of 28 liters per second.

Tests on Core Samples

Cores totaling 67 m were taken from the hole in the depth interval 333 to 1,220 m (table 3). Core samples were submitted to the U.S. Geological Survey laboratory and to Holmes and Narver Materials Testing Laboratory (contractor for U.S. Department of Energy) for analyses of density, matrix porosity, pore saturation, and pore-water content. Hydraulic conductivities are to be measured in samples from the saturated part of the hole. Results of these laboratory analyses are not available as of October 1983.

Table 3.--*Summary of cored intervals*

Depth interval[1] (meters)	Length of core (meters)	Length of core recovered (meters)
332.5- 339.5	7.0	4.4
342.9- 345.6	2.7	2.7
349.6- 356.3	6.7	5.2
417.0- 422.8	5.8	5.0
431.9- 435.6	3.7	3.7
460.2- 463.2	3.0	3.0
509.0- 512.0	3.0	3.0
554.7- 560.8	6.1	6.1
624.8- 626.9	2.1	2.1
716.3- 721.8	5.5	5.5
871.1- 874.1	3.0	2.8
914.4- 917.4	3.0	3.0
971.1- 974.1	3.0	2.8
1,036.3-1,039.3	3.0	3.0
1,097.3-1,100.3	3.0	3.0
1,158.2-1,161.2	3.0	2.9
1,216.1-1,219.8	3.7	3.7
TOTAL	67.3	61.9

[1]Depths are reported to 0.1 meter to correspond to the length of core; actual depths are probably ±0.5 meter.

HYDROLOGIC TESTING AND WATER SAMPLING

Water Levels

Water levels were measured in the well to determine a composite static water level. The composite static water level was 526 m below land surface (776 m above sea level), after the well was completed at a total depth of 1,220 m. Water-level measurements are listed in table 4. The measurements made September 4, 5, and 7, 1982, are representative of the composite static water level when the depth of the well was 583 m.

Pumping Tests

Two pumping tests for drawdown and recovery were conducted in the well. Although the well was open to a total depth of 1,220 m, the borehole-flow survey described below showed no flow below 803 m. The effective production interval was 526 to 803 m. The pump was installed with the pump intake at 552 m, and the bottom of the monitoring tube at 575 m. The casing, which extends to 581 m, is perforated in five intervals; 530 to 536 m, 540 to 549 m, 552 to 561 m, 564 to 567 m, and 569 to 572 m.

During the first pumping test, the well was pumped at 28 L/s for 4,822 minutes; this test was ended prematurely by mechanical failure. No drawdown data past 4,184 minutes or recovery data were obtained, because the water-level monitoring tool was removed from the hole in preparation for the borehole-flow survey. Drawdown-versus-time data for pumping test 1 are shown in figure 4. Pumping test 2 ran for 2,226 minutes at 27 L/s. Drawdown-versus-time data for the second test are shown in figure 5. No data are available for the interval from 116 to 1,789 minutes, because the monitoring instrument was removed to allow access for the borehole-flow survey tool. Recovery of the water level in the well was monitored at the end of pumping. Results are shown in figure 6 as residual drawdown (recovery) versus time.

Table 4.--*Water-level measurements*

Date	Depth interval (meters)	Depth to water (meters)	Method
09/04/82	525- 583	525.4	Television camera
09/05/82	525- 583	527	Fluid density log
09/07/82	525- 583	527	Fluid density log
10/01/82	525-1,220	525	Fluid density log
10/06/82	525-1,220	526.0	Float switch
10/07/82	525-1,220	526.0	Float switch
10/17/82	525-1,220	525.8	Float switch
10/20/82	525-1,220	526.0	Float switch
03/31/83	525-1,220	526.0	Float switch

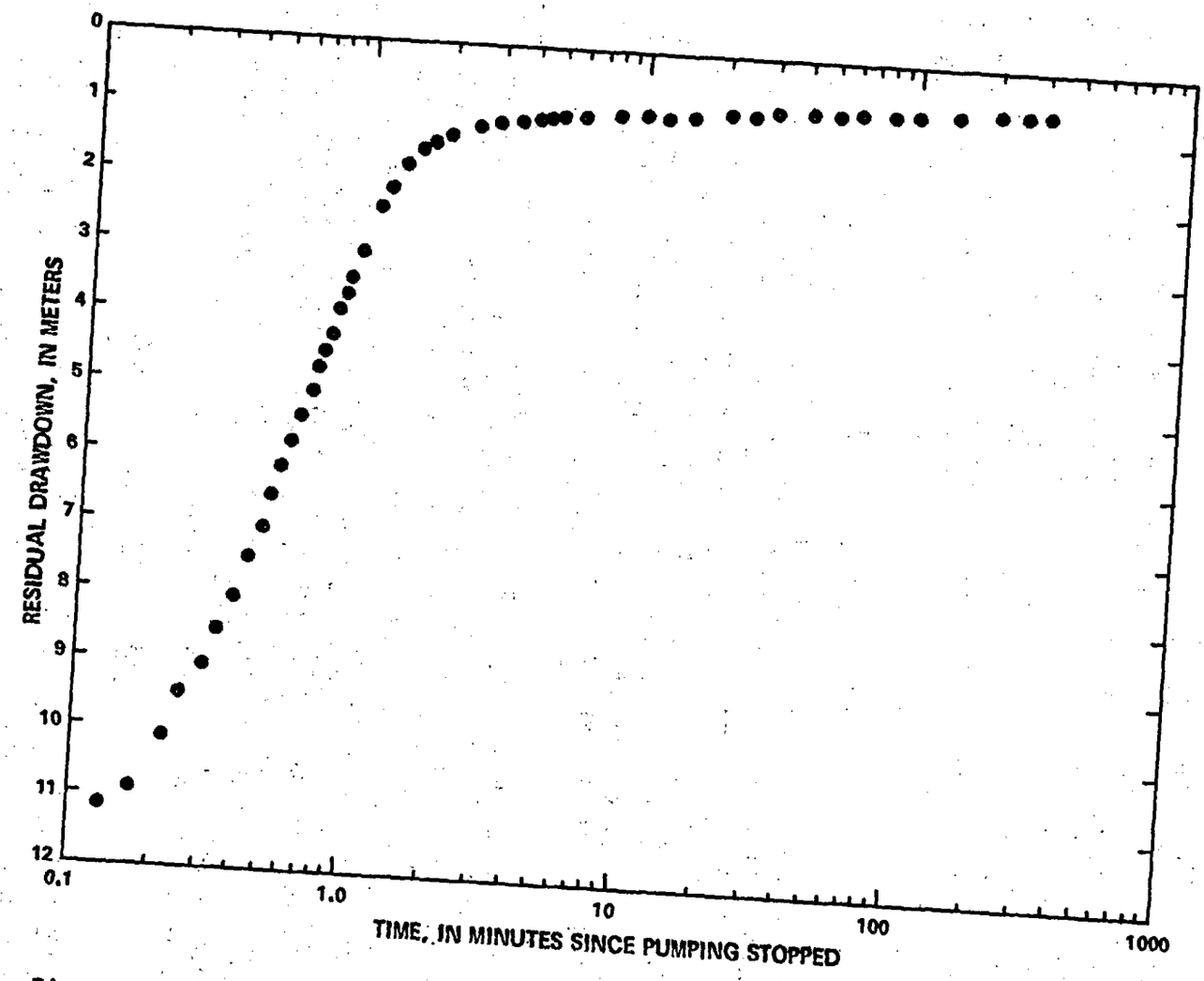

Figure 6.--Water-level recovery, pumping test 2, depth interval from 526 to 1,220 meters.

Borehole-flow Survey

A borehole-flow survey was made during pumping test 2. The survey was made to detect intervals of fluid entrance into the borehole. Small quantities of radioactive iodine-131 were injected into the water column at selected depths. Time required for the iodine-131 to move between two gamma-ray detectors, a known distance apart, was converted to a velocity. The cross-sectional area of the hole was determined by use of a caliper log. The product of the velocity and the cross-sectional area gave a rate of flow past a particular depth. The tool was moved through the hole as required to define the intervals of water production. A more complete description of the technique for the survey is found in Blankennagel (1967). Depth and corresponding stratigraphy versus percentage of total flow are shown in figure 7. The survey showed that 91 percent of the water withdrawn from the well came from the depth intervals from 616 to 631 m, and from 777 to 788 m. No measureable flow (greater than about 0.05 L/s) was detected below 803 m.

Packer-injection Tests

Packer-injection tests were conducted in various intervals of the well to: (1) Obtain data on the distribution of hydraulic head in the well, and (2) obtain data for future determination of the distribution of transmissivity in the well. The intervals to be tested were isolated from the remainder of the borehole by use of inflatable straddle-packers. Tests were conducted either on the interval between the packers or on the interval from the bottom packer to the bottom of the well. Water was injected by filling tubing that was connected to the packer tool, and then opening the tool to either the between-packer-interval or below-packer interval, as appropriate.

Data for these tests are summarized in table 5. The decline of water level during each test, presented as the ratio of the hydraulic head above the static water level at a given time (H) to the hydraulic head above the static water level at time of injection (H_o) versus time since injection began, is shown in figures 8-18. Height of the water column is shown on the right side of the graph as meters above static water level. Most tests were started with a full tube of water, with hydraulic head about 5 m above land surface. Tests of intervals expected to slowly dissipate the water column used about one-half of the water in the tube. These intervals were those that showed little or no production of fluid during borehole-flow survey. The hydraulic head above static water level at time of injection for each test is shown in figures 8 to 18 as the value equivalent to a H/H_o ratio of 1.

Chemical Analysis of Water

A composite water sample was obtained near the end of pumping test 2. At the time of sampling, approximately 1.2×10^7 L of fluid had been withdrawn from the well during the combined pumping of the tests. Results of the analysis of the water sample are shown in table 6. The uncorrected carbon-14 age of the water is 14,600 years before present (16.3 percent modern).

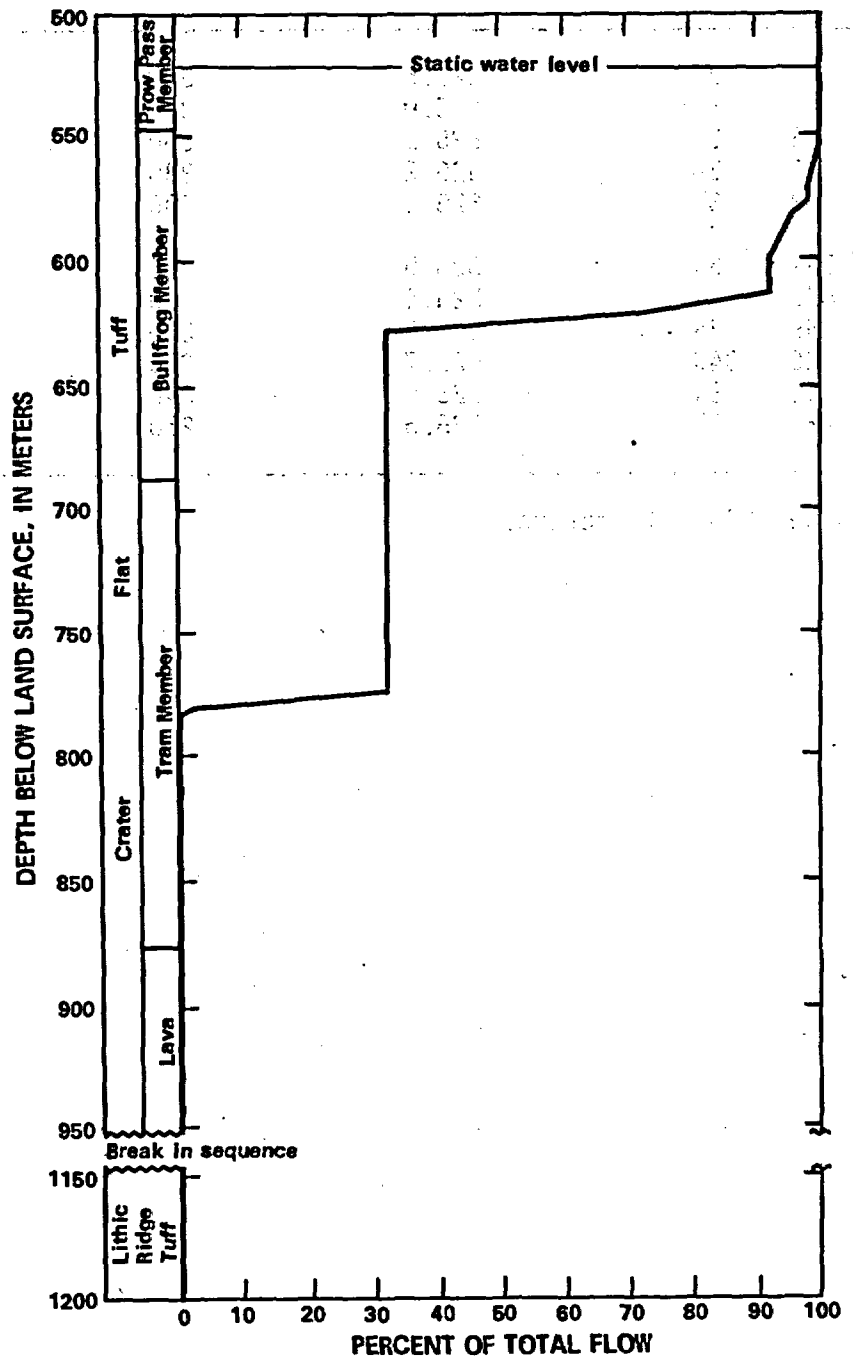

Figure 7.--Borehole-flow survey, showing percent of pumping rate produced by intervals.

Table 5.--*Summary of packer-injection tests*

Test No.	Interval tested: Depth (meters)	Interval tested: Length (meters)	Static water level, approximate depth (meters)	Average hole diameter[1] (millimeters)	Test duration (minutes)
1	581- 607	26	525.6	300	256
2	606- 640	34	526.0	330	120
3	649- 683	34	526.2	330	600
3A	649- 683	34	526.2	330	720
4	686- 753	67	526.4	300	180
5	753- 787	34	526.5	290	34
6	804- 838	34	525.4 +	290	340
7	835- 869	34	525.5	270	240
8	871-1,220	349	525.7	250	290
9	1,118-1,152	34	526.0	240	240
10	1,155-1,220	65	526.5	250	620

[1]Bit diameter 220 millimeters.

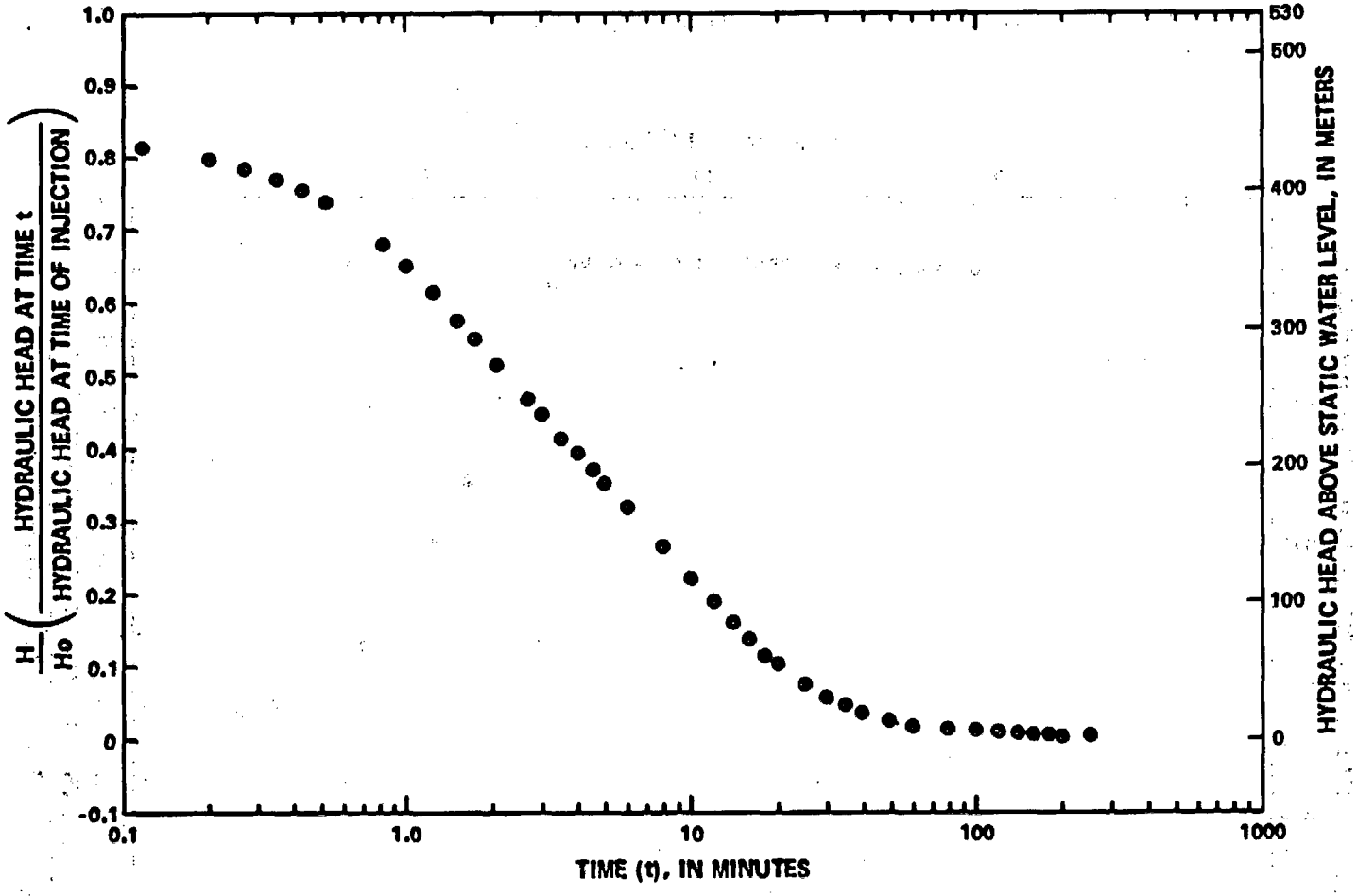

Figure 8.--Packer-injection test 1, depth interval from 581 to 607 meters.

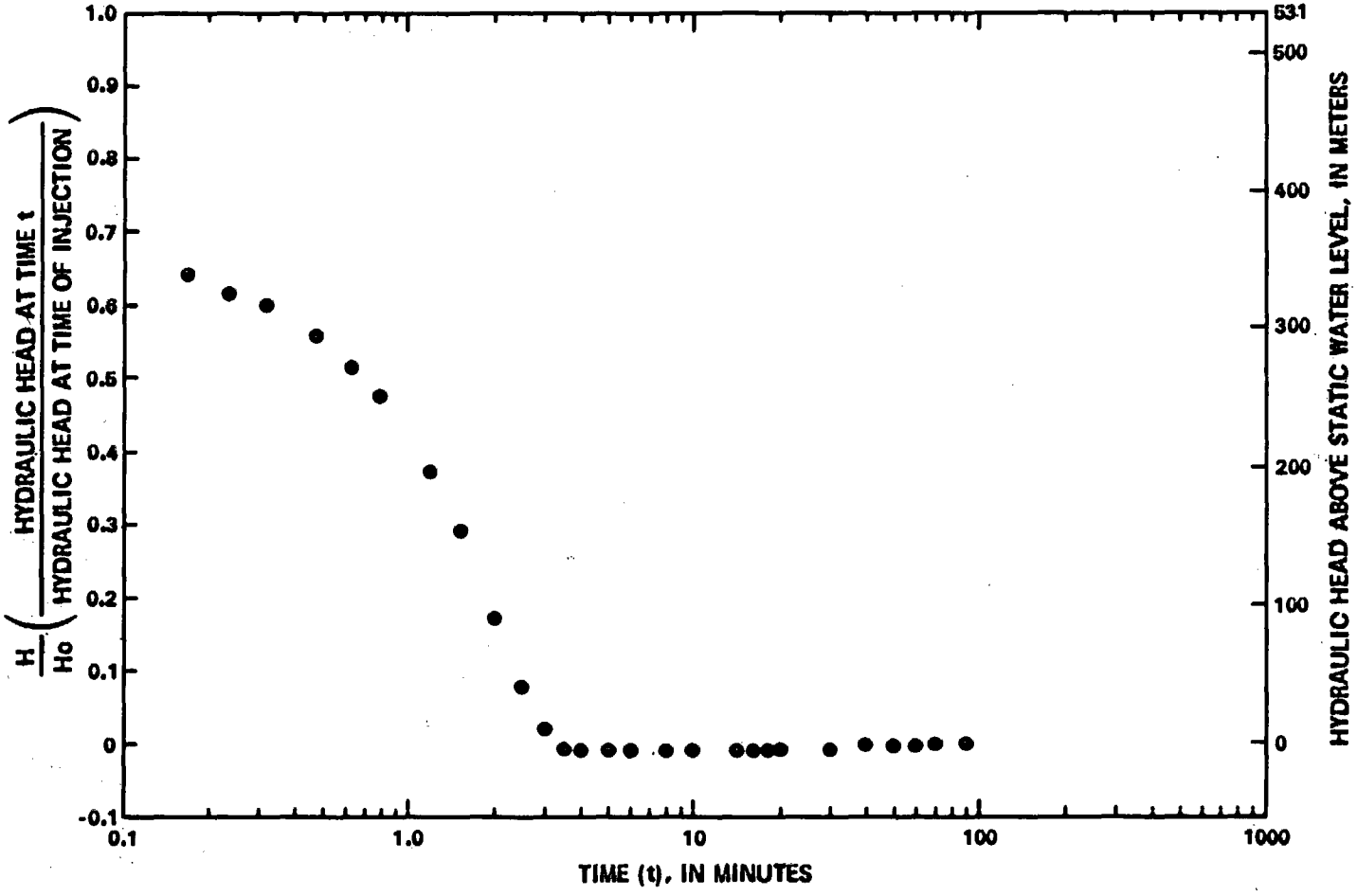

Figure 9.--Packer-injection test 2, depth interval from 606 to 640 meters.

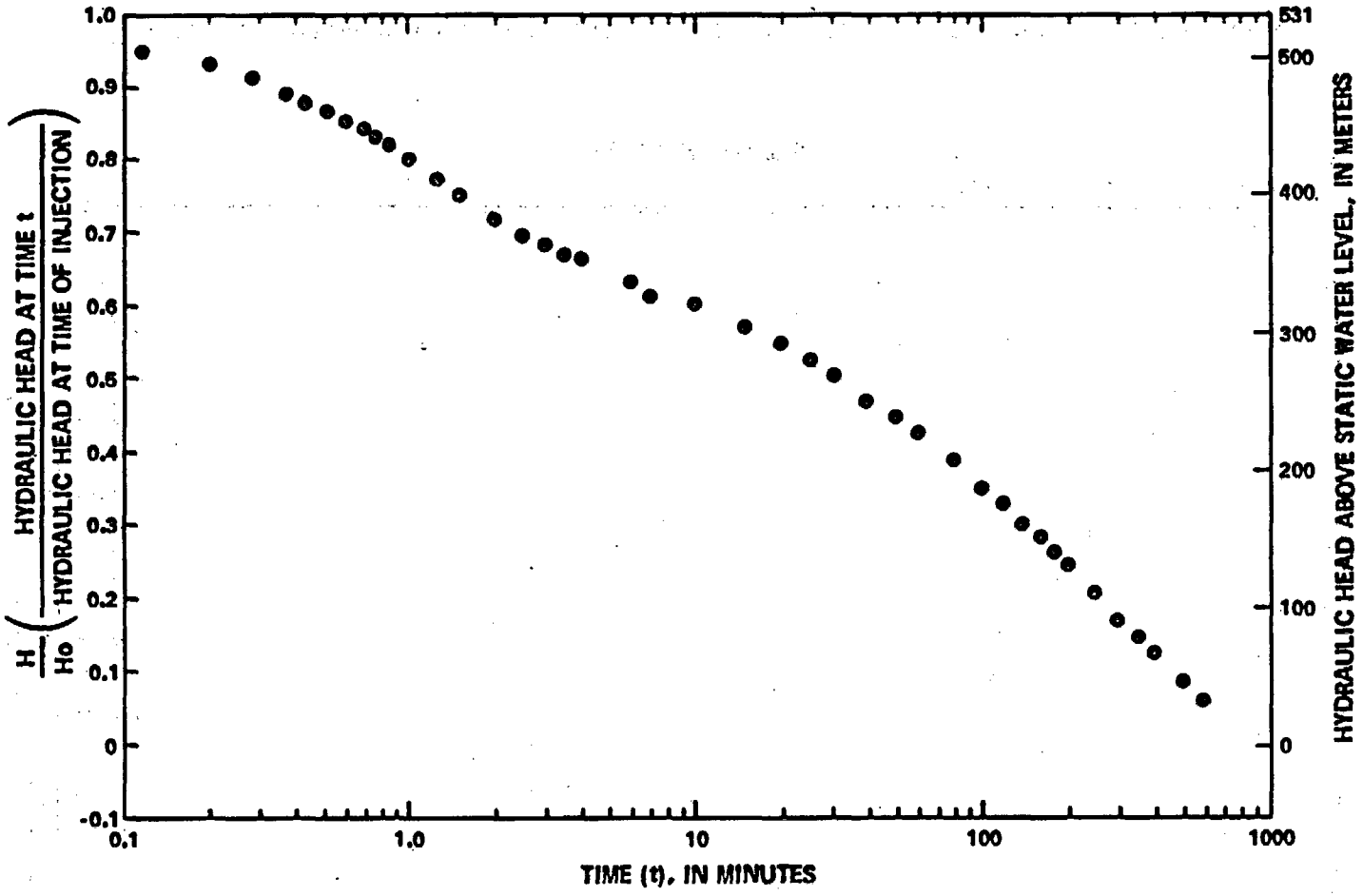

Figure 10.--Packer-injection test 3, depth interval from 649 to 683 meters.

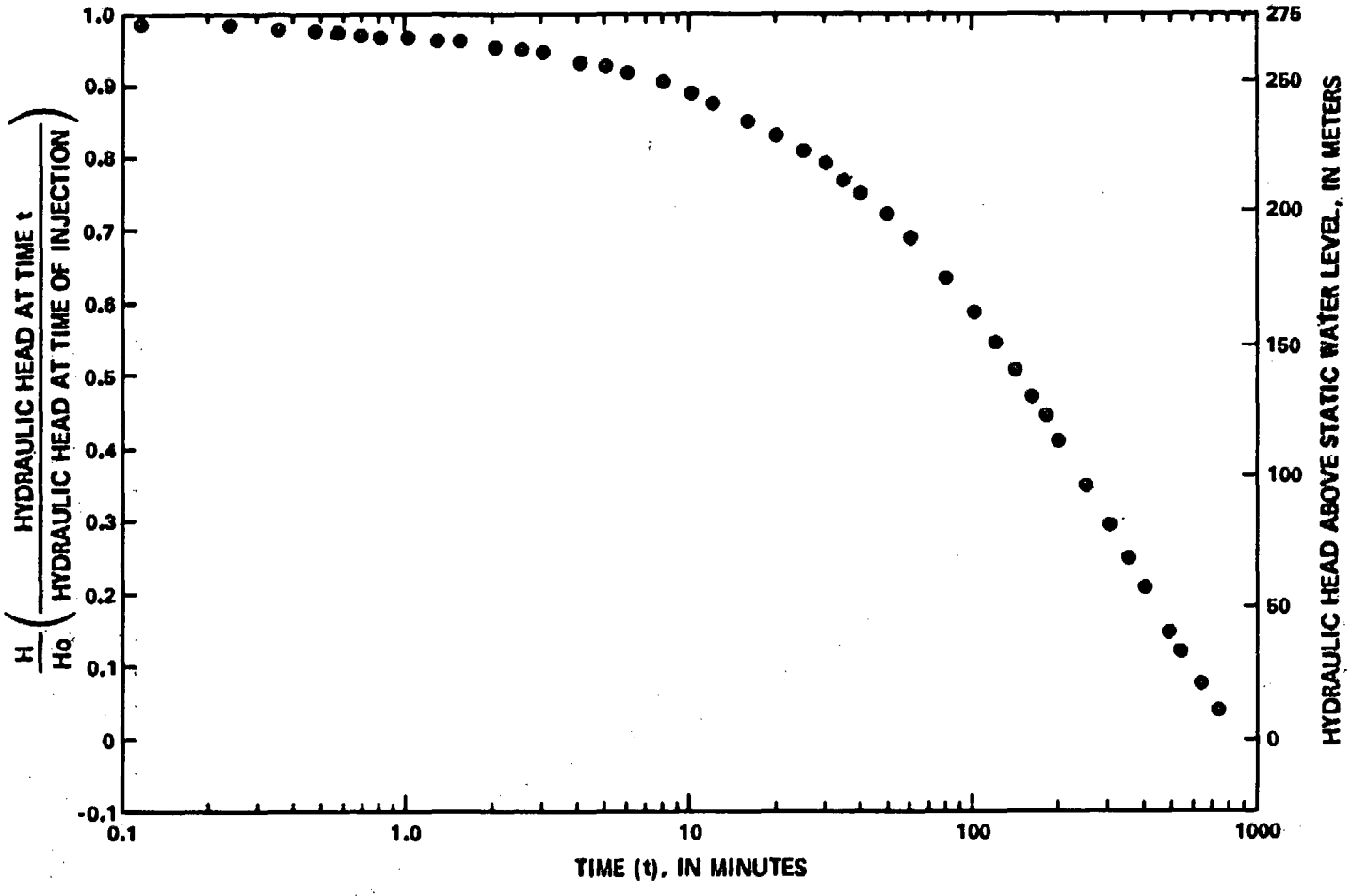

Figure 11.--Packer-injection test 3A, depth interval from 649 to 683 meters.

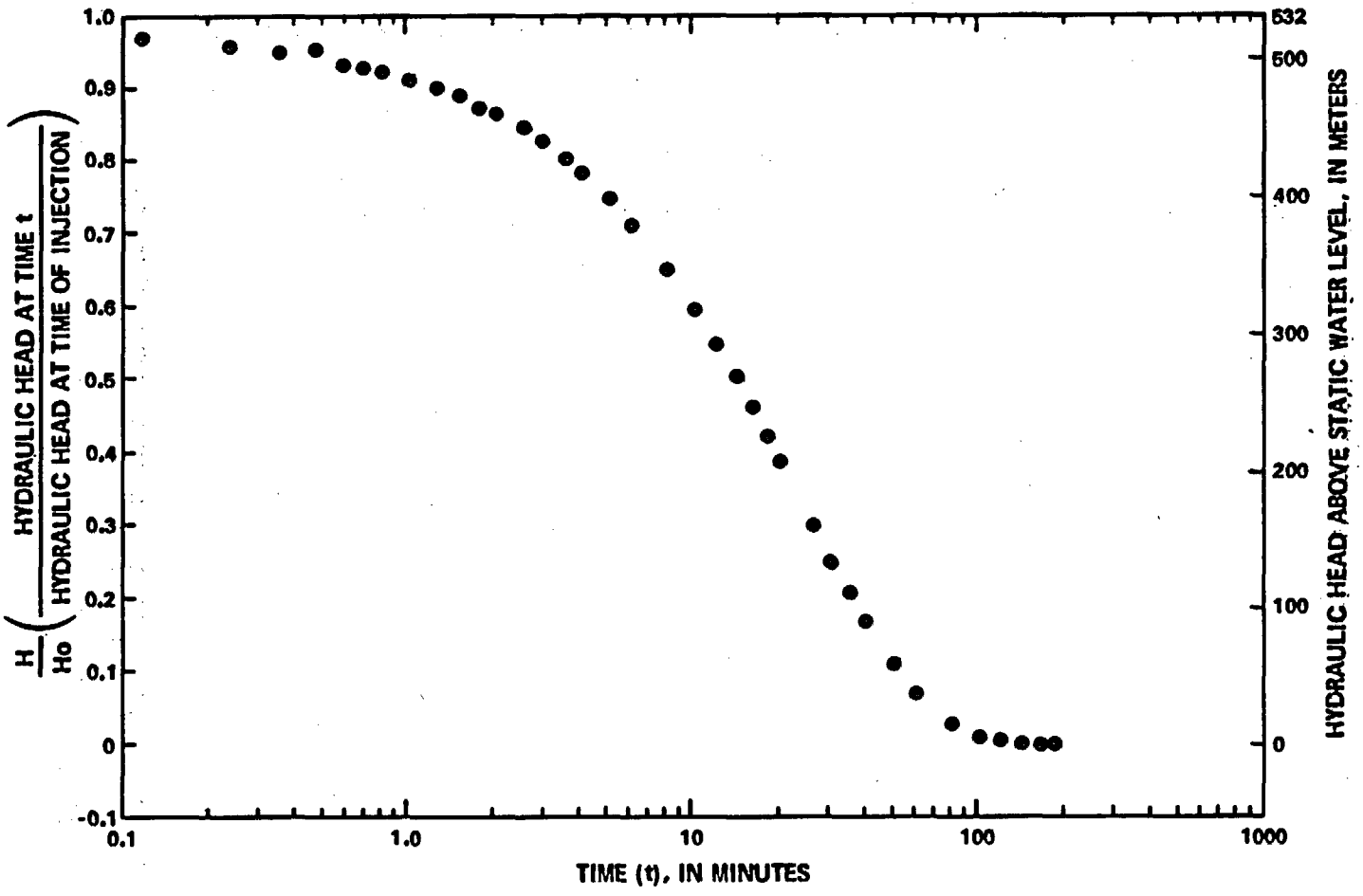

Figure 12.--Packer-injection test 4, depth interval from 686 to 753 meters.

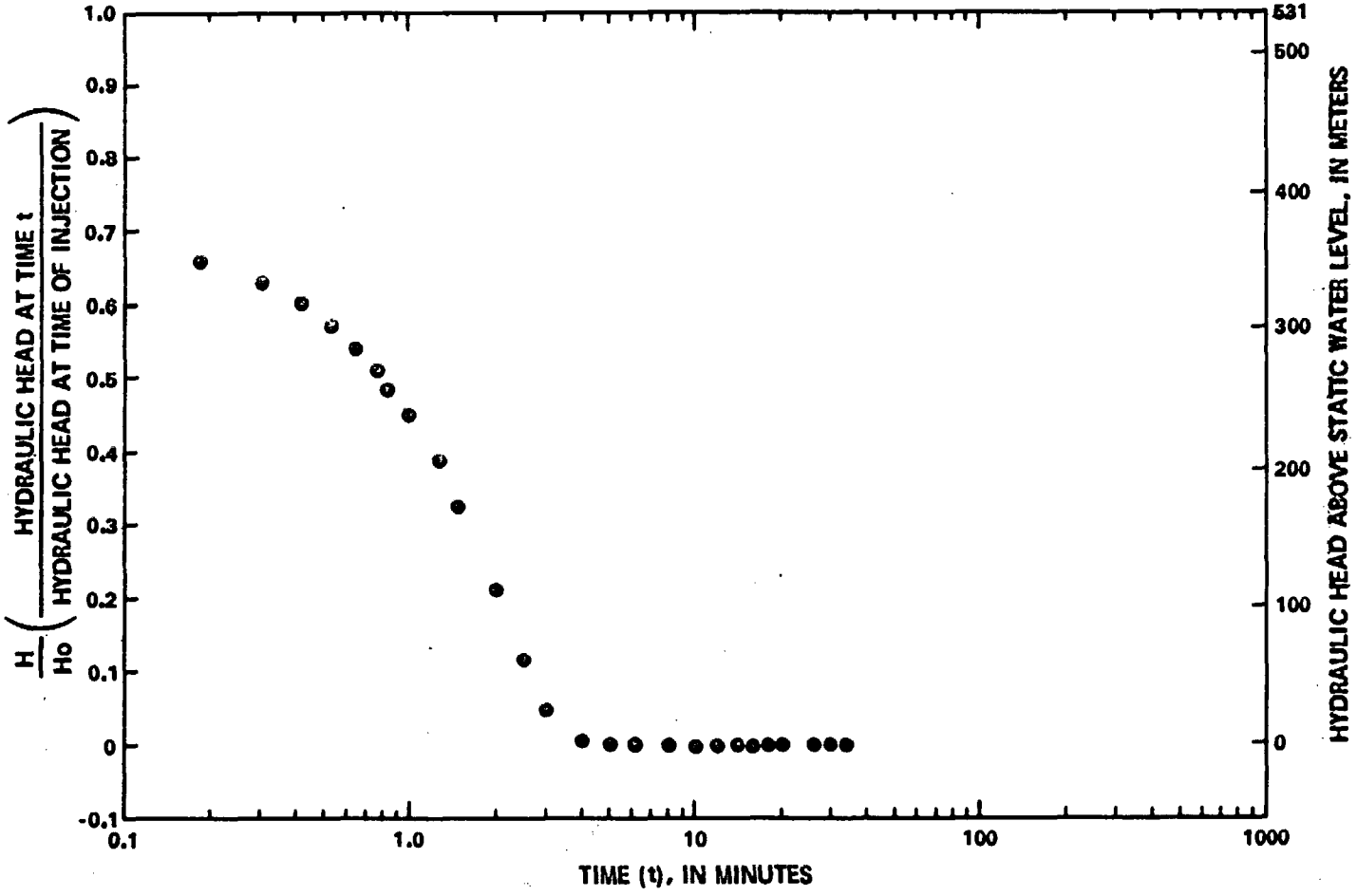

Figure 13.--Packer-injection test 5, depth interval from 753 to 787 meters.

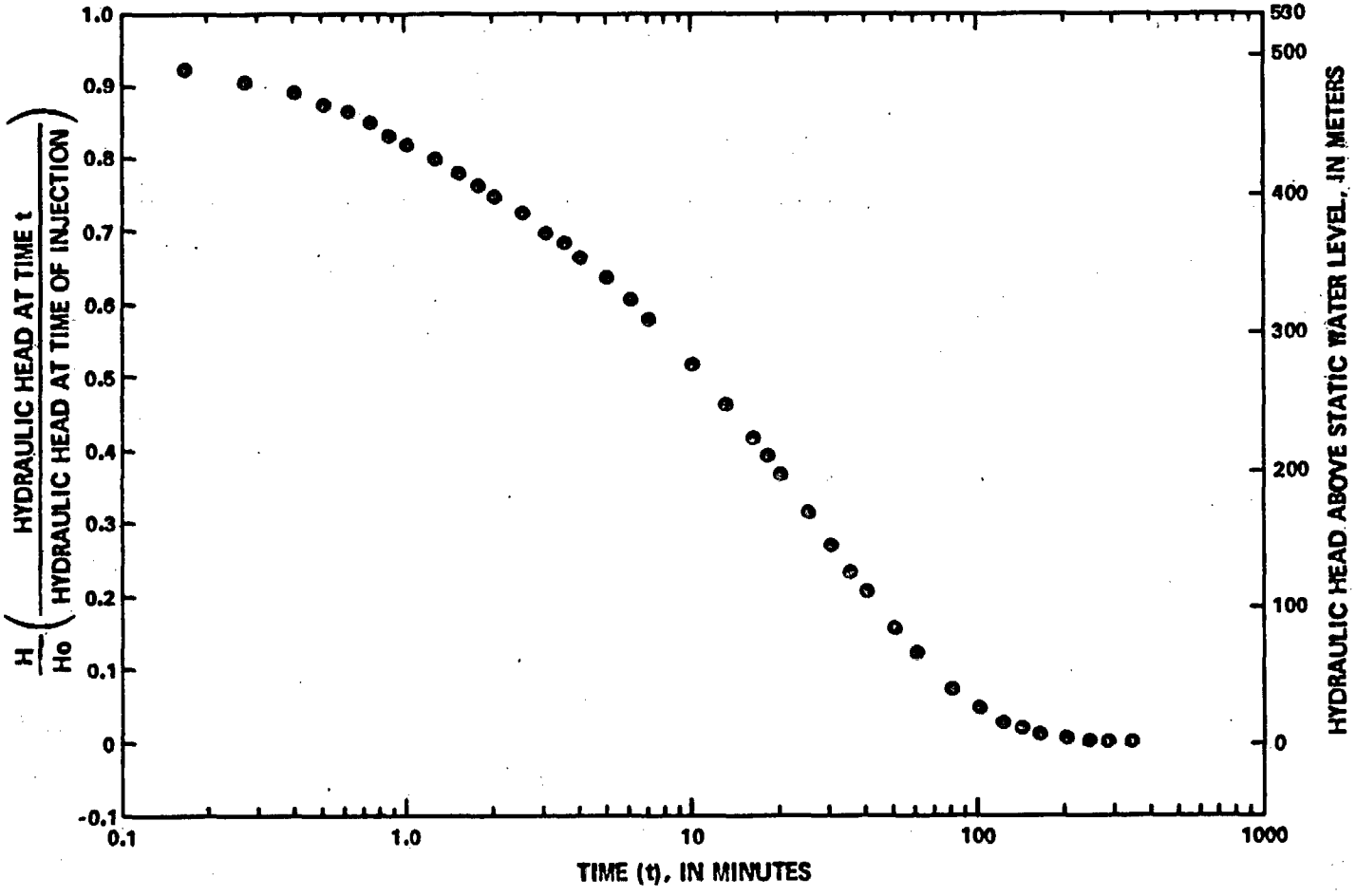

Figure 14.--Packer-injection test 6, depth interval from 804 to 838 meters.

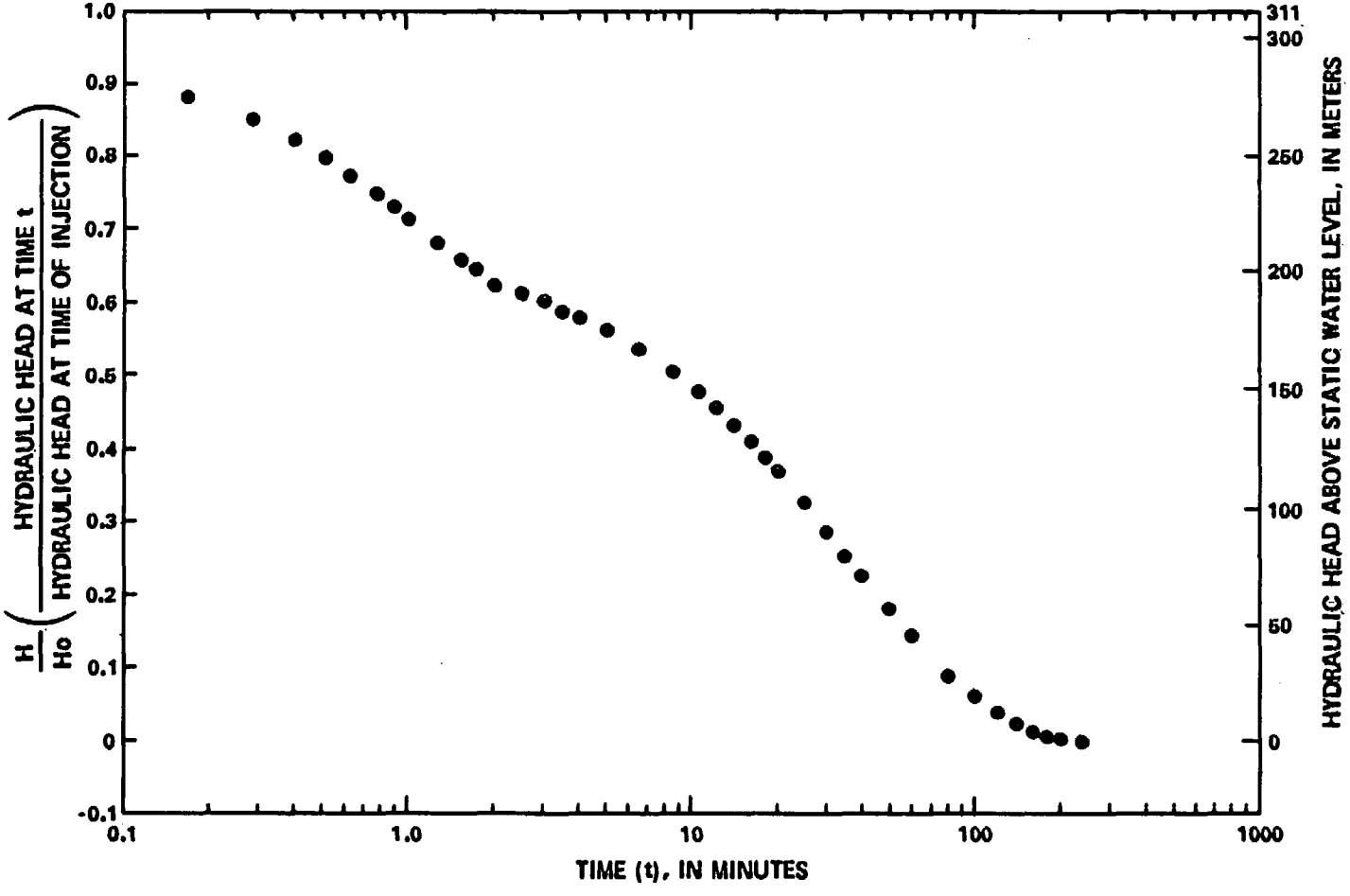

Figure 15.--Packer-injection test 7, depth interval from 835 to 869 meters.

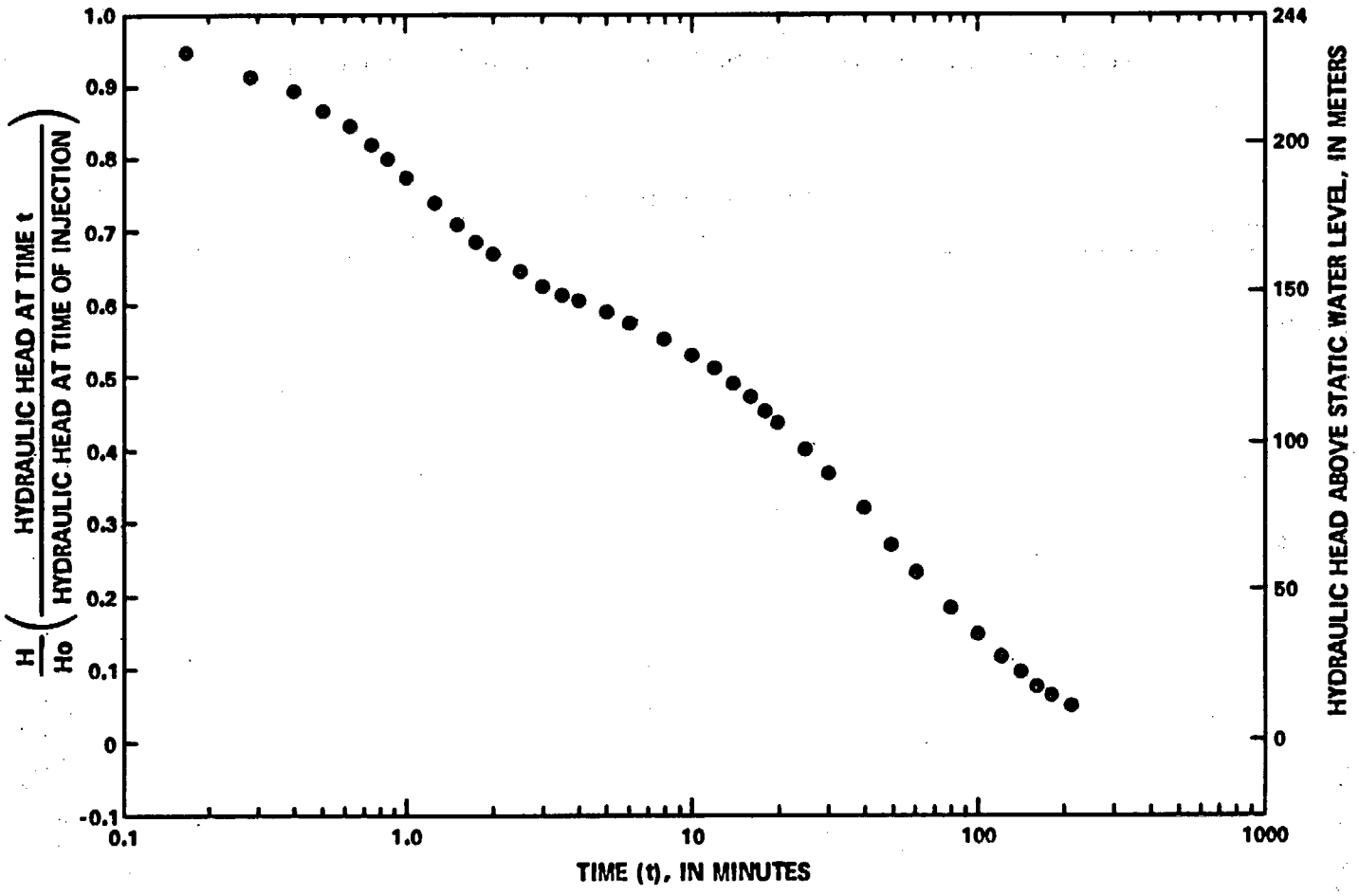

Figure 16.--Packer-injection test 8, depth interval from 871 to 1,220 meters.

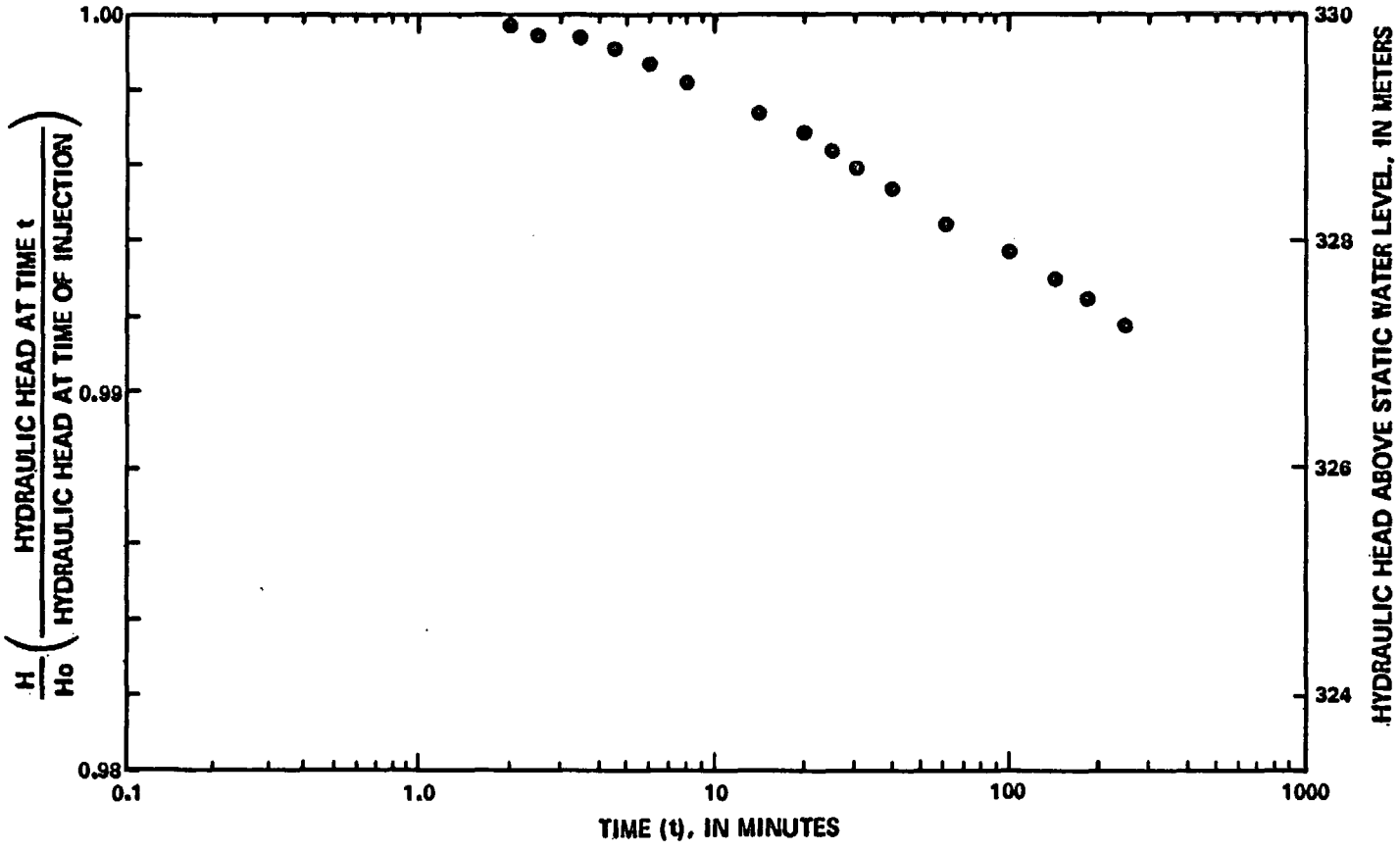

Figure 17.--Packer-injection test 9, depth interval from 1,118 to 1,152 meters.

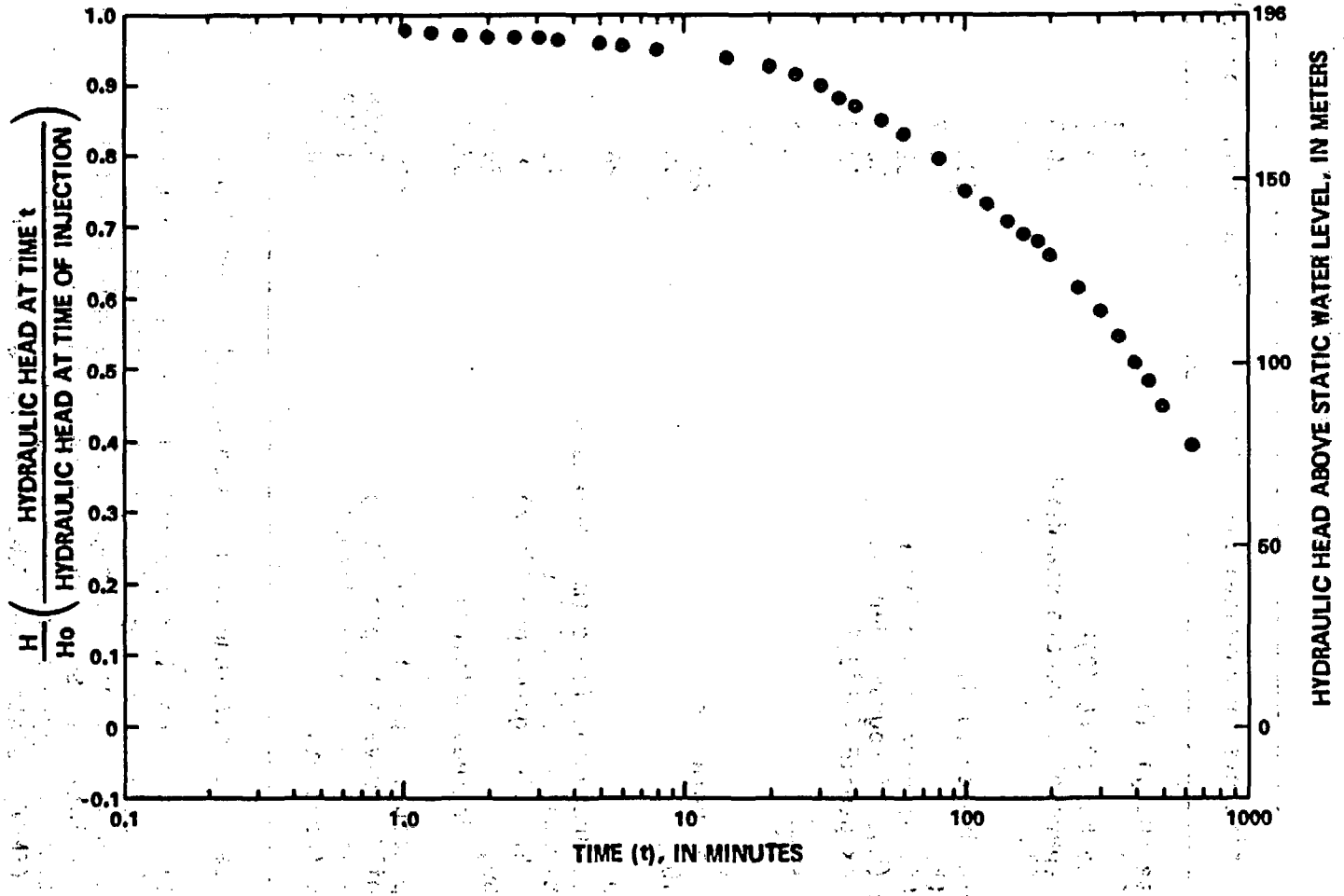

Figure 18.--Packer-injection test 10, depth interval from 1,155 to 1,220 meters.

Table 6.--*Results of chemical analysis*[1] *of water sample obtained during pumping of depth interval from 526 to 1,120 meters*

[All units are milligrams per liter unless otherwise indicated; date of collection, 10/16/82]

Chemical constituents or physical properties	Concentration or value
Bicarbonate (HCO_3), field	182
Calcium (Ca)	4.1
Carbon-13/carbon-12 ($\delta^{13}C$)[2]	-7.5
Carbon-14 (percent of modern standard)	16.3
Chloride (Cl)	7.6
Deuterium/hydrogen ($\delta^{2}H$)[3]	-106
Flouride (F)	4.7
Lithium (Li, micrograms per liter)	82
Magnesium (Mg, micrograms per liter)	90
Oxygen-18/oxygen-16 ($\delta^{18}O$)[4]	-13.8
pH, laboratory	8.3
pH, field	8.1
Potassium (K)	1.3
Residue on evaporation	263
Silica (SiO_2)	48
Sodium (Na)	86
Specific conductance, field (microsiemens per centimeter at 25° Celsius)	379
Strontium (Sr, micrograms per liter)	8
Sulfate (SO_4)	29
Temperature (degrees Celsius)	37.8
Tritium (picocuries per liter)	<10
Cations (milliequivalents per liter)	3.996
Anions (milliequivalents per liter)	4.053
Difference (percent)	-0.71

[1] Chemical analysis made by U.S. Geological Survey laboratory, Denver, Colorado.

[2]Deviation of carbon-13/carbon-12 ratio of sample from Peedee belemnite standard (PDB) relative to PDB, in parts per thousand.

[3]Deviation of deuterium/hydrogen ratio of sample from standard mean ocean water (SMOW) relative to SMOW, in parts per thousand.

[4]Deviation of oxygen-18/oxygen-16 ratio of sample from standard mean ocean water (SMOW) relative to SMOW, in parts per thousand.

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