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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Federal Center, Denver, Colorado 80225

HYDRAULIC TESTING OF HOLE UA-1-HTH-1, AMCHITKA ISLAND, ALASKA

(Amchitka-32)

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Amchitka-32
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ABSTRACT

Hole UA-1-HTH-1 was drilled and hydraulically tested in July and August 1971. The elevation of land surface at the site is 50.13 meters (164.48 feet) above mean sea level.

Total depth of the hole was 1,054 meters (3,458 feet) but, because of borehole erosion and bridging, only about 198 meters (650 feet) of the hole was hydraulically tested with straddle packers. Some information was obtained on the lower part of the hole by use of the pressure recorders which are used with the straddle packers.

The heads below land surface in that part of the hole tested with straddle packers ranged from 3.9 meters (12.7 feet) in the interval 80.5 to 125.0 meters (264 to 410 feet), the uppermost zone tested with straddle packers, to 5.7 meters (18.6 feet) in the interval 227.4 to 278.6 meters (746 to 914 feet), the lowermost part of the hole tested with straddle packers. The composite static water level obtained following a pumping test was 5.5 meters (18.0 feet). The composite head below 278.6 meters (914 feet), determined from a pressure recorder, was about 12.2 meters (40 feet). The head distribution indicates a decreasing head with depth.

Water samples were collected from two intervals for chemical, radiochemical, and C-14 analysis. The unadjusted age of water in the interval 183.5 to 234.7 meters (602 to 770 feet) was determined to be 8,410 years, and for the interval 227.4 to 278.6 meters (746 to 914 feet) was 17,880 years. After adjustment the ages of the waters may be less; however, they would still be in the thousands of years and the relative difference probably would still be real.

INTRODUCTION

Hydraulic testing and water sampling in hole UA-1-HTH-1 was done during August 1971 to supplement and improve knowledge of the hydrology in the area of the Cannikin site for better prediction of direction and velocity of ground-water movement. This report presents the basic data obtained during the hydraulic testing of UA-1-HTH-1.

The proximity of UA-1-HTH-1 to the Cannikin site, the drilling and testing so near the scheduled time for execution of the Cannikin event, and the difficulties incurred by bridging and hole erosion during drilling and testing reduced the time available for adequate testing. Additional data could have been obtained had more time been available.

Procedure for hydraulic tests

Geophysical logs were made after UA-1-HTH-1 was drilled to total depth. Drilling mud was then displaced with clear water and a pump was installed to remove the drilling mud from the formation and to conduct a pumping test. A tracejector log was made during pumping. The pump was then stopped and the water-level recovery was measured.

A caliper log was then made in preparation for testing the hole using straddle packers. The hole was bridged at about 305 m (1,000 ft) with a large caved zone just above the bridge.

Selected intervals of the hole were then isolated, tested, and sampled by using inflatable straddle packers. The intervals to be tested are normally selected according to hole condition, lithology, geophysical logs, and drilling reports. However, because of the small amount of hole remaining to be tested, only hole conditions were considered. Four intervals were successfully tested using 51 m (168 ft) of spacing between straddle packers. Water was swabbed from each interval through the tubing until all drilling fluid had been removed from the formation. Samples of formation water were then collected if the formation was sufficiently permeable to yield good samples.

HYDRAULIC TESTING OF HOLE UA-1-HTH-1

Well history

Hole UA-1-HTH-1 is at coordinates N. 5,705,280.04 m, and E. 646,725.31 m, Universal Transverse Mercator Grid, zone 60. Land surface at this site is 50.13 m (164.48 ft) above mean sea level.

The drilled depth of the hole was 1,054 m (3,458 ft). The casing consisted of 27.3-cm ($10\frac{3}{4}$-inch) pipe installed and cemented in place from 0 to 80.5 m (264 ft) below land surface. The hole was drilled with a 24.4-cm ($9\frac{5}{8}$-inch) bit from the bottom of the casing to total depth and left open. Holes UAe-1 and UA-1, located about 1,066.8 m (3,500 ft) south of UA-1-HTH-1, had significant loss of drilling mud during the drilling of the interval 609.6 to 1,036.3 m (2,000 to 3,400 ft). There was no reported mud loss when drilling this interval in hole UA-1-HTH-1. After total depth was reached and the geophysical logs were completed, the hole bridged at about 432.8 m (1,424.4 ft). The bridge was drilled through and while cleaning out the bottom of the hole the bit became stuck and two drill collars and bit were left in the hole. The addition of the bit and drill collars at the bottom of the hole decreased the depth of the hole to about 1,023.5 m (3,401.7 ft) below land surface.

The drilling mud was then displaced with water and the hole bridged again at about 318.5 m (1,045.1 ft). Because of the poor condition of the hole below this depth and the possibility of losing additional drilling tools in the hole, the bridge was not drilled out at this time.

After the hydraulic testing was completed, the hole was cleaned out to the top of the drill collars, at 1,032 m (3,385 ft) below land surface, and cemented from the bottom up to 427 m (1,400 ft). Heavy drilling mud was left in the hole from the top of the cement upward to land surface.

Intervals tested and sampled

The following intervals in hole UA-1-HTH-1 were tested:

Depth below land surface (meters)	(feet)
80.5-125.0	264-410
128.3-179.5	421-589
183.5-234.7	602-770
227.4-278.6	746-914

These test intervals and a generalized summary of hydrology, lithology, and hole construction are presented in figure 1. Samples of water were obtained during swabbing from intervals 183.5 to 234.7 m (602 to 770 ft) and 227.4 to 278.6 m (746 to 914 ft).

The water samples were analyzed chemically, radiochemically, and for C-14 age dating. The analysis of the samples for chemical and radiochemical content have not been completed and results will be

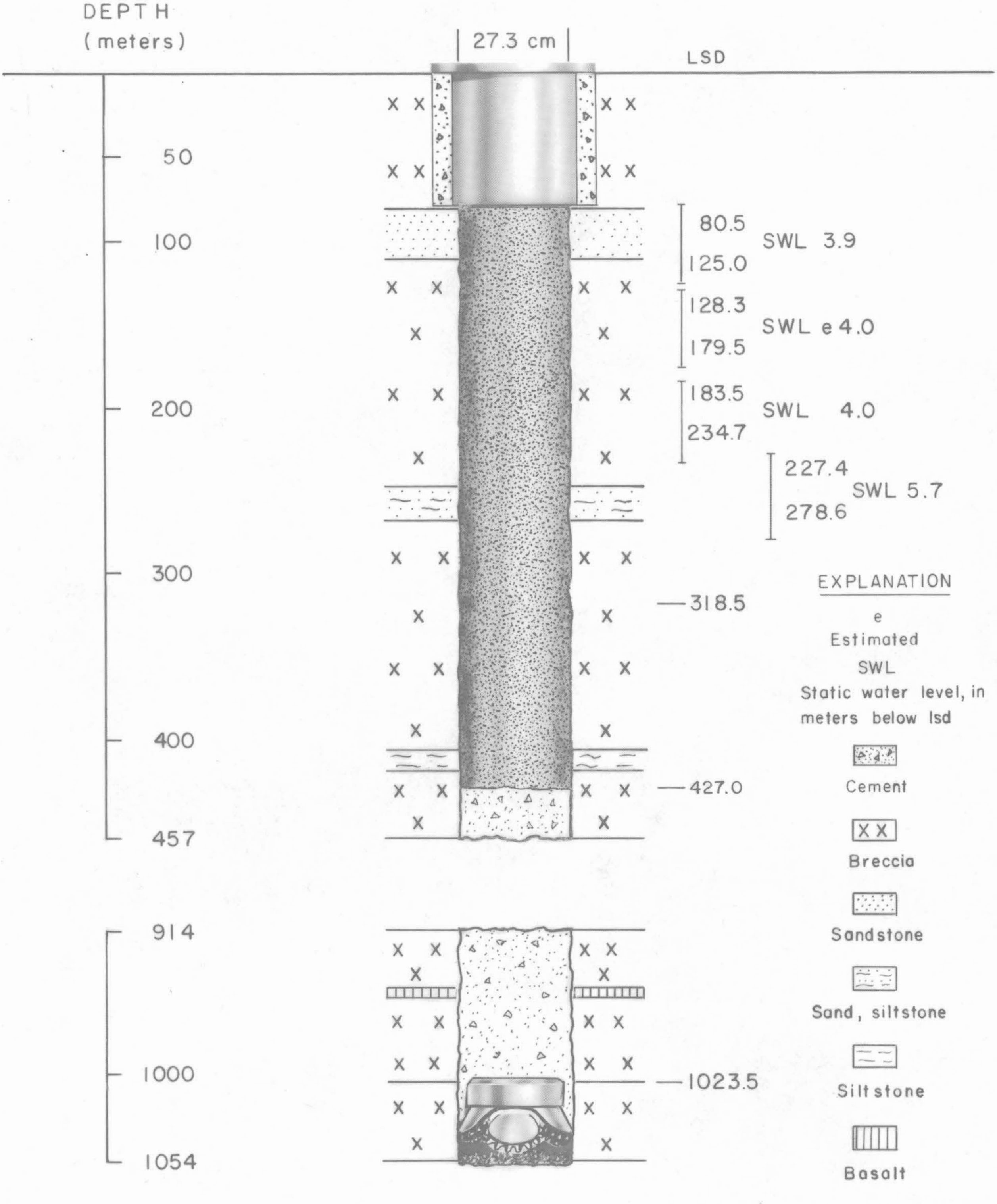

Figure 1.--Construction diagram, lithology and summary of hydraulic tests, hole UA-1-HTH-1, Amchitka Island, Alaska.
(Lithology from L.M. Gard and R.H. Morris, written commun.)

given in a later report. The C-14 age dating of water from the two intervals is partially completed. The unadjusted age of water in the interval 183.5 to 234.7 m (602 to 770 ft) was determined to be 8,410 years and for interval 227.4 to 278.6 m (746 to 914 ft), 17,880 years. Although the ages given are unadjusted and when adjusted may be less, the ages would still be in the thousands of years and the relative difference probably would be similar.

Vertical distribution of head

Table 1 gives the head for those intervals tested in hole UA-1-HTH-1. The highest head measured was in the uppermost interval tested, 80.5 to 125.0 m (264 to 410 ft), and the lowest head measured was in the lowermost interval tested, 227.4 to 278.6 m (746 to 914 ft). During the hydraulic testing with straddle packers, pressure recorders were emplaced above, between, and below the packers to indicate any passage of fluid around the packers during testing. Heads were determined from the pressure recorders emplaced below the packers and are presented in table 1.

Pumping test

After displacing the drilling mud in the borehole, a pump was installed to remove the drilling mud from the formation and to determine the transmissivity of the aquifers. The pump intake was set at 158 m (519 ft) below land surface. The hole was pumped for about 24 hours at an average rate of about 458 m^3pd (cubic meters per day) or 84 gpm (gallons per minute). About 458 m^3 (cubic meters) or 121,000 gallons

Table 1.--Head distribution in hole UA-1-HTH-1, Amchitka Island, Alaska

Interval tested		Depth of pressure recorder		Pressure			Static water level	
m below lsd	ft below lsd	m below lsd	ft below lsd	reported (psi)	m	ft	m below lsd	ft below lsd
80.5-125.0	264-410	--	--	--	--	--	[1]3.9	[1]12.7
128.3-179.5	421-589	--	--	--	--	--	e4.0	e13
183.5-234.7	602-770	--	--	--	--	--	[1]4.0	[1]13.2
227.4-278.6	746-914	--	--	--	--	--	[1]5.7	[1]18.6
80.5-1,005.8	264-3,300±	--	--	--	--	--	[2]5.5	[2]18.0
182.6-1,005.8±	599-3,300±	187.1	614	257.8	181.7	596	[3]5.4	[3]18
237.7-1,005.8±	780-3,300±	242.3	795	331.9	233.8	767	[3]8.5	[3]28
281.6-1,005.8±	924-3,300±	286.2	939	393.1	276.8	908	[3]9.4	[3]31

e Estimated.

[1] Measured.

[2] Composite water level measured following pumping test.

[3] Approximate values determined from pressure recorders emplaced below the packers.

of fluid were removed from the hole. The final specific conductance of the water removed from the hole was 1,800 micromhos per cm at 25°C (Celsius).

Table 2 is a tabulation of the water-level drawdown during pumping and of the water-level recovery after the pump had stopped. Figure 2 is a plot of the water-level recovery after the pump was stopped. The transmissivity of the rocks penetrated by the uncased part of the hole was 14.6 m^3pd per m (cubic meters per day per meter) or 1,180 gpd per ft (gallons per day per foot).

Tracejector survey

Table 3 gives the results of a tracejector survey conducted while pumping at a rate of 458 m^3pd (84 gpm). The survey shows that about 40 percent of the discharge was through a bridge at about 427 m (1,400 ft). The remainder of the inflow to the well bore was distributed uphole to the bottom of the casing.

Table 2.--Drawdown and recovery of water level during pumping test of hole UA-1-HTH-1, Amchitka Island, Alaska

(Measuring point 3.75 meters above land surface)

Date	Time (Military)	Elapsed time (minutes)		Depth to water below M.P. (meters)	Discharge (gpm)
		Pumping	Recovery		
8-21-71	0325			9.20	
	0335			9.14	
	0345			9.15	
		Generator malfunction			
	0830			9.26	
		Started pump to check generator then stop pump			
	1916			10.75	
	1919	Start pump			
		.25		13.29	
		.50		15.22	
		.75		17.75	
		1		19.63	
		1.50		23.80	e130
		2		27.76	
		2.50		31.43	
		3		35.07	
		4		41.72	
		5		47.65	
		6		52.48	
		7		56.52	
		8		59.92	
		9		62.88	125
		10		65.35	
		11		67.63	
		12		69.80	
		14		73.59	
		16		75.14	108
	1937	17 Pump stopped			
		42		20.62	
	2002	42 Start pump			
		43		23.68	
		44		26.93	67
		45		29.44	
		46		33.40	85
		47		36.92	
		48		39.72	
		49		42.17	
		50		44.34	
		55		51.67	85
		60		55.00	
		70		59.14	83
		80		60.29	

Table 2.--Drawdown and recovery of water level during pumping test of hole UA-1-HTH-1, Amchitka Island, Alaska--Continued

(Measuring point 3.75 meters above land surface)

Date	Time (Military)	Elapsed time (minutes)		Depth to water below M.P. (meters)	Discharge (gpm)
		Pumping	Recovery		
8-21-71	2045	90	Pump off		
	2047	92	Pump on		
		90		54.74	
	2100	100		59.60	
	2110	110		61.04	82
		125		61.01	
		135		61.00	82
	2145	145		61.03	
	2355	275		58.28	82
8-22-71	0030	310		58.62	83
	0100	340		58.27	81
	0130	370		58.08	82
	0200	400		58.30	83
	0230	430		55.83	74
	0300	460		56.10	77
	0330	490		55.95	79
	0400	520		56.20	79
	0430	550		55.95	80
	0500	580		56.57	81
	0530	610		56.46	79
	0600	640		57.22	82
	0630	670		55.80	78
	0655	700		56.22	80
	0840	805		56.30	79
	0915	840		56.30	78
	0930	855		56.34	79
	1000	885	Start tracejector		84
	1240	1045			84
	1520	1205	Finish tracejector		
	1533	1218		65.72	83
	1700	1305		64.30	90
	1930	1455		63.50	89
	2000	1485		63.73	89
	2004		Pump off		
			.50	59.86	
			.75	57.79	
			1	56.32	
			1.50	53.09	
			2	50.22	
			2.50	47.59	
			3	45.39	
			4	41.13	
			5	38.36	
			6	36.08	
			7	34.18	

Table 2.--Drawdown and recovery of water level during pumping test of hole UA-1-HTH-1, Amchitka Island, Alaska--Continued

(Measuring point 3.75 meters above land surface)

Date	Time (Military)	Elapsed time (minutes)		Depth to water below M.P. (meters)	Discharge (gpm)
		Pumping	Recovery		
8-22-71			8	32.52	
			9	31.05	
			10	29.86	
			12	28.01	
			14	26.82	
			16	25.62	
			18	24.68	
			20	23.52	
			22	22.64	
			24	21.72	
			26	20.98	
			28	20.44	
			30	19.97	
			35	19.00	
			40	18.32	
			50	17.57	
			60	17.08	
	2114		70	16.73	
	2124		80	16.48	
	2134		90	16.21	
	2144		100	16.02	
	2204		120	15.62	
	2224		140	15.32	
	2244		160	15.04	
	2304		180	14.80	
	2324		200	14.56	
8-23-71	0014		250	14.07	
	0104		300	13.67	
	0154		350	13.34	
	0244		400	13.05	
	0334		450	12.80	
	0424		500	12.59	
	0604		600	12.17	
	0653		649	12.01	
	0842		758	11.70	
	1200		956	11.30	
	1534		1170	11.08	
	1900		1376	10.84	
	1924		1400	10.82	
	2104		1500	10.69	
	2244		1600	10.60	

Table 2.--Drawdown and recovery of water level during pumping test of hole UA-1-HTH-1, Amchitka Island, Alaska--Continued

(Measuring point 3.75 meters above land surface)

Date	Time (Military)	Elapsed time (minutes)		Depth to water below M.P. (meters)	Discharge (gpm)
		Pumping	Recovery		
8-24-71	0024		1700	10.58	
	0204		1800	--	
	0344		1900	10.45	
	0524		2000	10.37	
	0604		2040	10.35	
	0810		2166	10.34	
	0844		2200		
	1044		2300		

e Estimated.

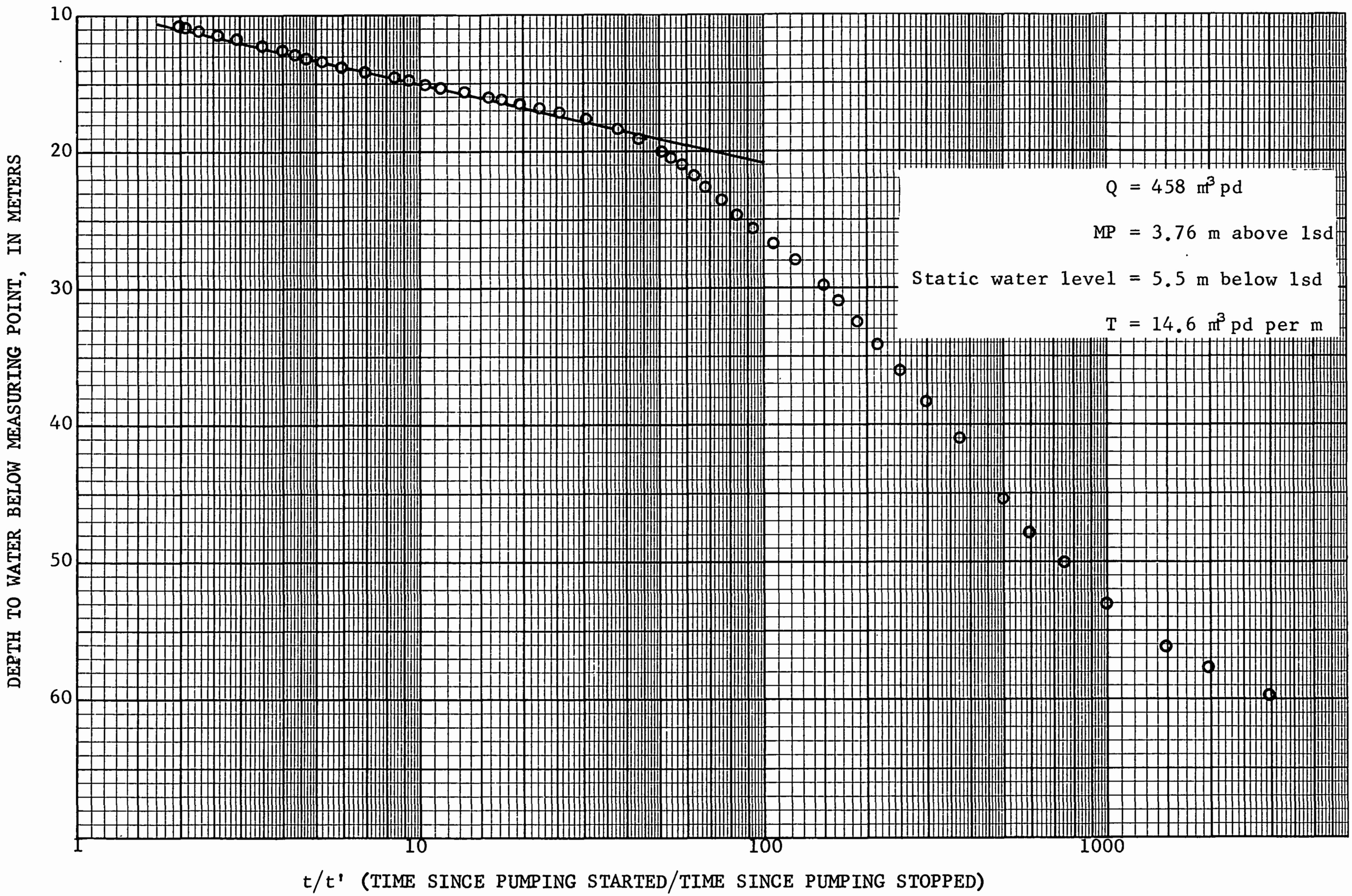

Figure 2.--Recovery of water level after pumping test of hole UA-1-HTH-1, Amchitka Island, Alaska.

Table 3.--Summary of tracejector survey of hole UA-1-HTH-1, Amchitka Island, Alaska

Interval		Inflow[1/]		Percent of flow
m below lsd	ft below lsd	m^3pd	gpm	
[2/]80.5-182.9	[2/]264-600	70.9	13	15.5
182.9-210.3	600-690	65.4	12	14.3
210.3-304.8	690-1,000	49.1	9	10.7
304.8-341.4	1,000-1,120	38.2	7	8.3
341.4-359.7	1,120-1,180	49.1	9	10.7
359.7-1,005.8±	1,180-3,300±	185.3	34	40.5
		458.0	84	100.0

[1/]Pumping rate 458 m^3pd (84 gpm).

[2/]Bottom of casing at 80.5 m (264 ft) below lsd.

METHOD OF ANALYSIS OF TEST DATA

The following formula was used to compute the transmissivity (T) from pumping-test recovery data;

$$T = \frac{2.30Q}{4\pi s} \log_{10} \frac{t}{t'}$$

where

T = transmissivity of the formation (cubic meters per day per meter),

s = residual drawdown (meters),

t = time since pumping began (minutes),

t' = time since pumping stopped (minutes),

Q = pumping rate (cubic meters per day).

Over one log cycle, $\log_{10} t/t'$ becomes unity; then,

$$T = \frac{2.30Q}{4\pi \Delta s} .$$

A type-curve method for determining the transmissivity of an aquifer that is applicable to testing of selected intervals in deep wells was introduced by Cooper and others (1967). This analysis involves an instantaneous charge of water to a well.

The static water level is near the surface in UA-1-HTH-1 and the results obtained from an instantaneous charge of water to an isolated interval are not satisfactory. In order to simulate the instantaneous charge of water and still obtain good data for analysis, the following procedure was applied.

Once the packers were in place and inflated, water was removed from the tubing to a depth of about 122 to 152 m (400 to 500 ft) depending on the depth of the top packer. The ports between the packers were then opened which permitted fluid to flow from between the packers into and up the tubing. The fluid recovery in the tubing was measured and tabulated.

The type curves (fig. 3) are derived by plotting H/H_o versus $\beta = Tt/r_c^2$ (a dimensionless time parameter) for values of $\alpha = r_s^2 S/r_c^2$ where

H_o = water level in tubing below initial head in aquifer immediately after injection, in meters

H = water level in tubing below initial head in aquifer, in meters, at time, t, in days

T = transmissivity, in cubic meters per day per meter

r_c = radius of injection tubing, in meters

r_s = radius of open hole, in meters

S = storage coefficient.

Once a value of T is obtained, hydraulic conductivity, K, can be calculated by the equation

$$K = T/b$$

where K is in cubic meters per day per square meter and b = thickness of the tested interval, in meters.

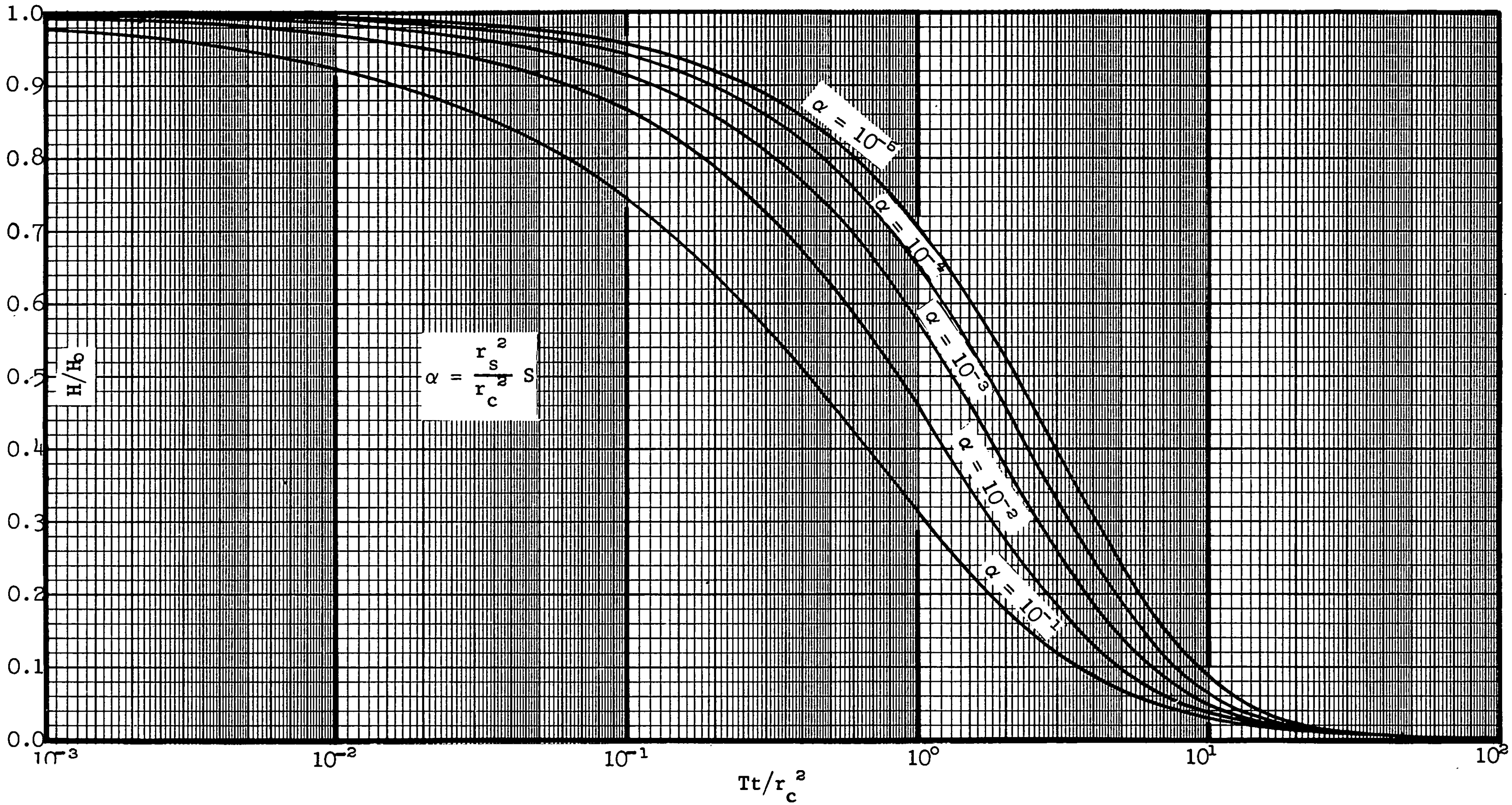

Figure 3.--Type curves for instantaneous charge in well of finite diameter.

Hydraulic characteristics

The analysis of test data obtained from individual intervals in hole UA-1-HTH-1 are presented in figures 4 to 6. The following parameters were constant for all intervals tested in hole UA-1-HTH-1: volume of tubing = 0.243 gallons per linear ft = 0.0030 m^3 per linear m; r_c = 1.22 in. = 0.0310 m.

A summary of hydraulic-test data obtained from hole UA-1-HTH-1 is tabulated in table 4.

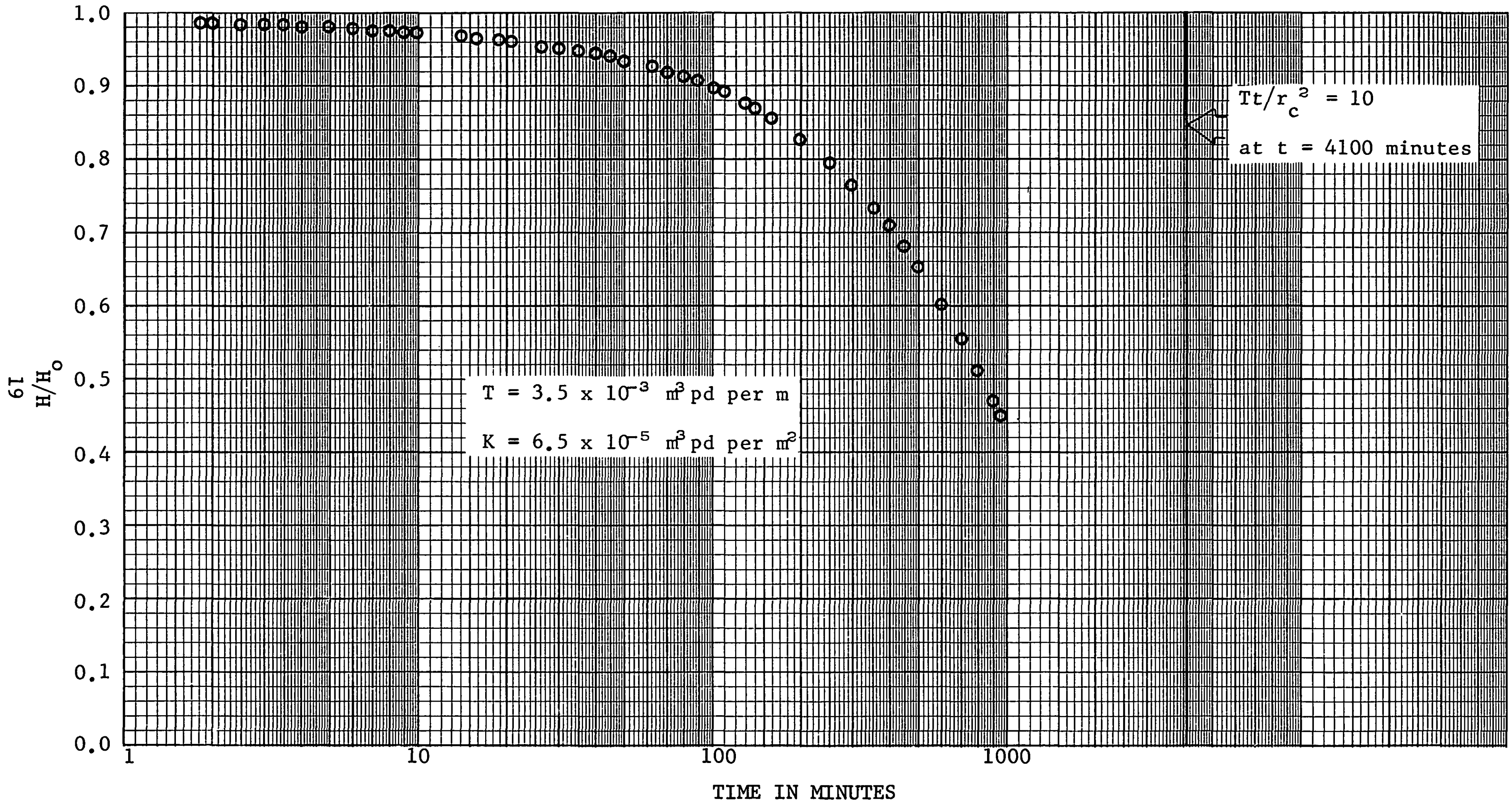

Figure 4.--Recovery test of interval 128.3 to 179.5 m (421 to 589 ft), hole UA-1-HTH-1, type-curve analysis.

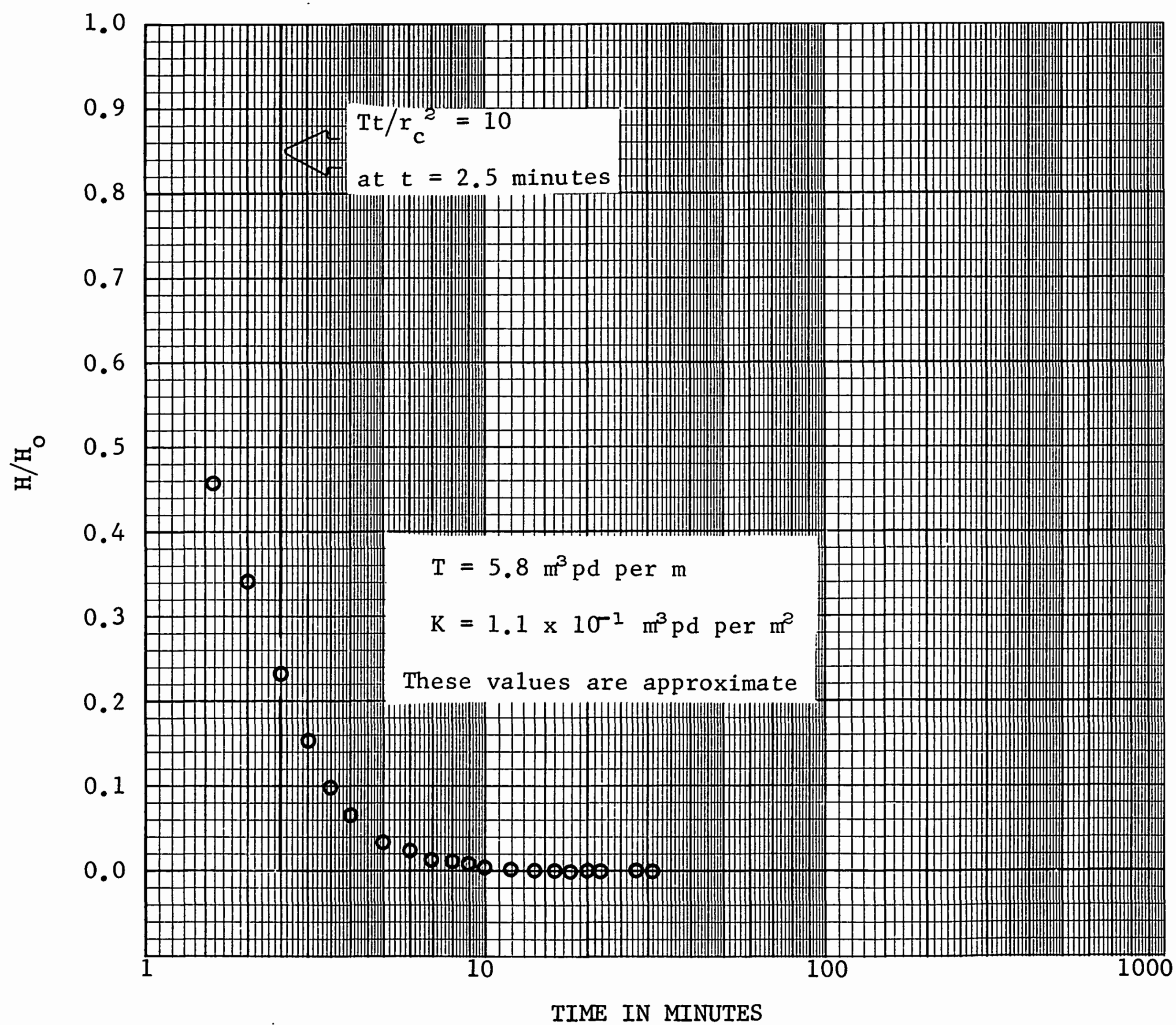

Figure 5.--Recovery test of interval 183.5 to 234.7 m (602 to 770 ft), hole UA-1-HTH-1, type-curve analysis.

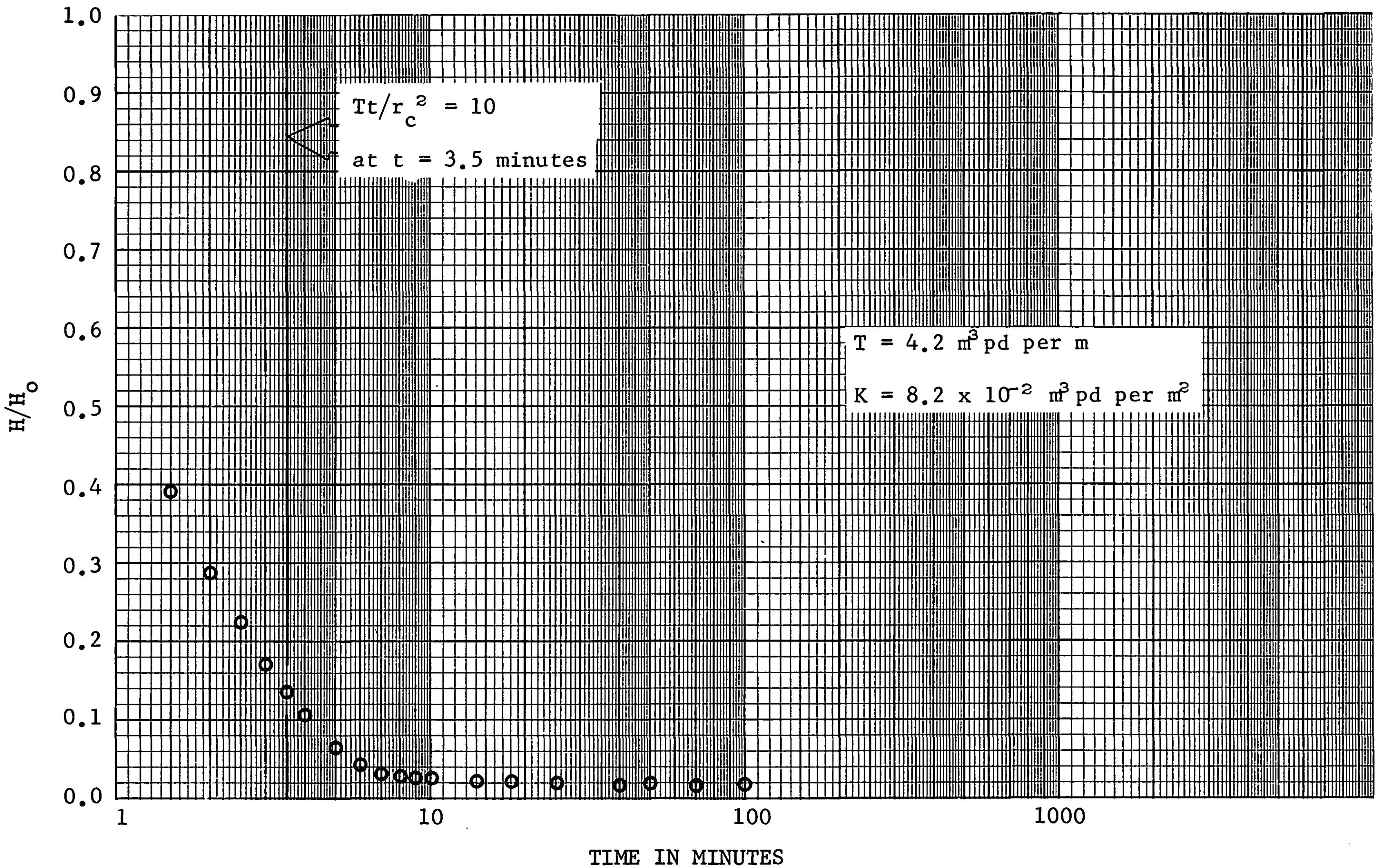

Figure 6.--Recovery test of interval 227.4 to 278.6 m (746 to 914 ft), hole UA-1-HTH-1, type-curve analysis.

Table 4.--Summary of hydraulic testing in hole UA-1-HTH-1, Amchitka Island, Alaska

Interval tested below lsd		Static water level below lsd		Specific conductance	Packer bypass	Transmissivity		Hydraulic conductivity		Remarks
m	ft	m	ft	(micromhos per cm at 25°C)		m^3pd per m	gpd per ft	m^3pd per m^2	gpd per ft^2	
80.5-125.0	264-410	3.9	12.7	--	--	--	--	--	--	--
128.3-179.5	421-589	e4.0	e13	--	No	3.5×10^{-3}	28.2×10^{-2}	6.5×10^{-5}	15.9×10^{-4}	--
183.5-234.7	602-770	4.0	13.2	590	No	5.8	467	1.1×10^{-1}	26.9×10^{-1}	114 m^3 (30,000 gallons) swabbed. Water samples collected.
227.4-278.6	746-914	5.7	18.6	800	No	4.2	338	8.2×10^{-2}	20×10^{-1}	265 m^3 (70,000 gallons) swabbed. Water samples collected.
80.5-1,005.8±	264-3,300±	5.5	18.0	1,800	--	14.4	11.6×10^{2}	--	--	473 m^3 (125,000 gallons) pumped.

e Estimated.

REFERENCE CITED

Cooper, H. H., Jr., Bredehoeft, J. D., and Papadopulos, I. S., 1967, Response of a finite-diameter well to an instantaneous charge of water: Water Resources Research, v. 3, no. 1, p. 263-269.

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J. B. Kirkwood, Columbus, Ohio

Desert Research Institute, Reno, Nevada:

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Environmental Protection Agency:

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E. A. Kari, Portland, Oregon
R. C. Scott, San Francisco, California

Environmental Research Corporation, Las Vegas, Nevada:

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Fenix & Scisson, Inc.:

Grant Bruesch, Mercury, Nevada
M. H. May, Las Vegas, Nevada

Holmes & Narver, Inc., Las Vegas, Nevada:

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The Spink Corporation of Nevada, Las Vegas, Nevada:

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U.S. Army Corps of Engineers, Alaska District, Anchorage, Alaska:

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U. S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi:

Library

U.S. Bureau of Mines, Denver, Colorado:

P. L. Russell

U.S. Department of Commerce, Auke Bay, Alaska:

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U.S. Department of Interior, Bureau of Sport Fisheries and Wildlife, Anchorage, Alaska:

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U.S. Geological Survey:

Library, Denver, Colorado
Library, Menlo Park, California
Library, Washington, D.C.

U.S. Geological Survey, Mercury, Nevada:

Geologic Data Center (15)

U.S. Geological Survey, Washington, D.C.:

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