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GROUND-WATER EXPLORATION, BEAVER CREEK VALLEY NEAR KENAI, ALASKA

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Prepared in Cooperation with the City of Kenai
and the Kenai Peninsula Borough

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INTRODUCTION

The results of the ground-water investigation for the city of Kenai are presented in this report. The investigation included an analysis of ground-water potential in the vicinity of Kenai, Alaska (fig. 1), and a test-drilling program in the Beaver Creek valley near Kenai (fig. 2). As a result of the test drilling, a ground-water source was located and a successful production well was drilled.

This report summarizes the results of this exploration program and includes the data and conclusions concerning selection of the test-drilling sites, the results of the testing program, and some suggestions relative to further exploration for ground water in the area and the future management of water supply.

Purpose and Scope of Investigation

The purposes of this investigation were (1) to locate a ground-water source capable of yielding 650 gpm (gallons per minute) sustained average flow, or 3,000 gpm for 10 hours fire demand; (2) to evaluate the water-bearing properties of the aquifers in the completed wells; and (3) to determine the chemical quality of water from the exploration wells.

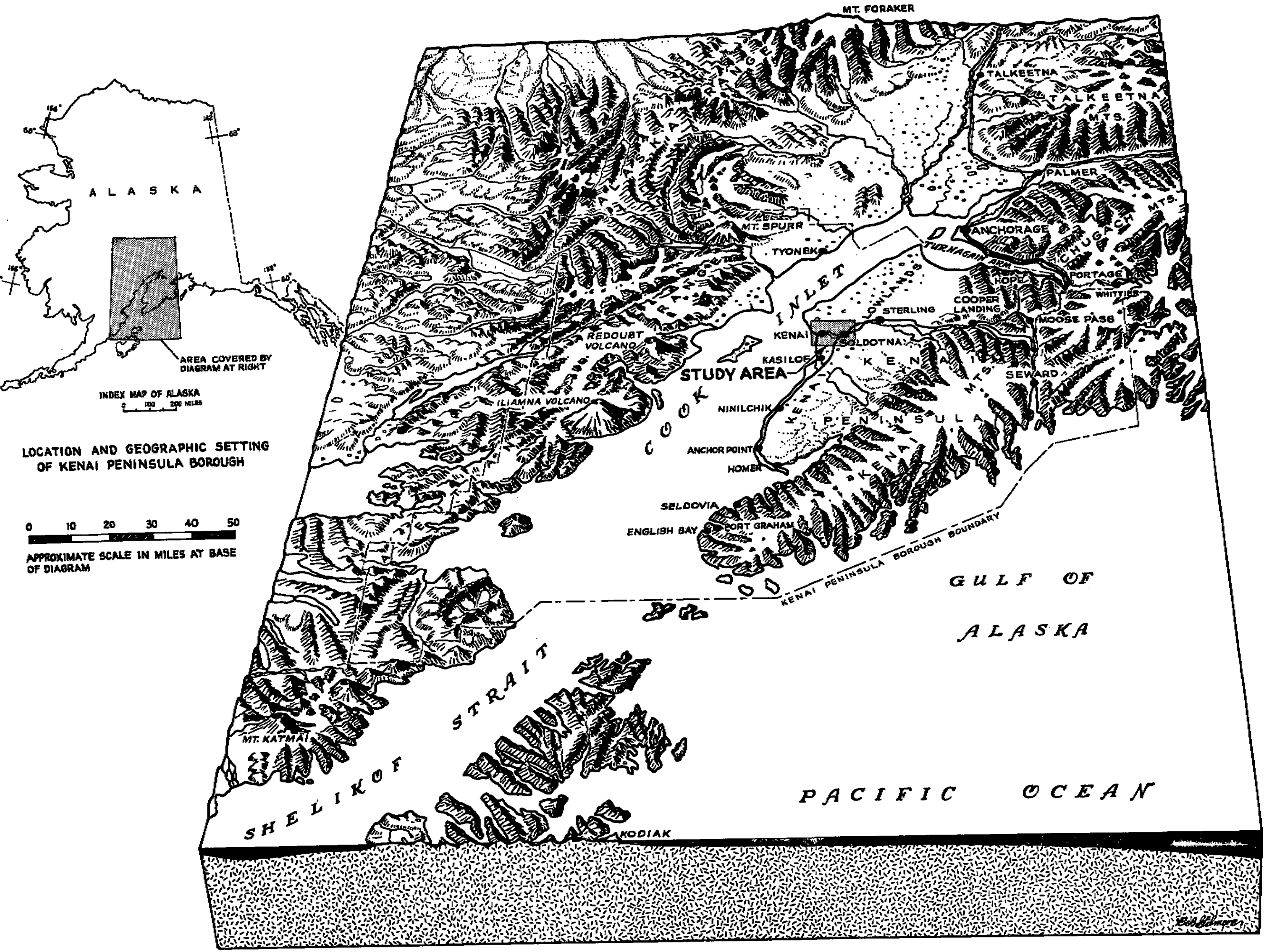

Figure 1.--Location of Kenai, Alaska, and area of present investigation.

Since July 1967, the U.S. Geological Survey, in cooperation with the Kenai Peninsula Borough has conducted a water-resources study of the Kenai Borough. During the summers of 1969 and 1970, the scope of the borough study was expanded and a cooperative program with the city of Kenai was initiated to make a reconnaissance ground-water exploration of the Beaver Creek valley near Kenai (fig. 2). The scope of the 1969 summer program included drilling two test wells (test wells 1 and 2) in what was believed to be the most favorable part of the valley for the development of ground water. During the summer of 1970, three test wells were programmed to delineate the western edge of the aquifer and the closest point to the city where high-capacity wells could be anticipated. These objectives were fulfilled after the second well (test well 4) was drilled, and the third planned test well was therefore not drilled. Following completion of the 1970 test-drilling program, Adams, Corthell, Lee, Wince, and Associates designed and supervised the drilling of a production well. Throughout the entire planning, test drilling, and production-well testing, the Geological Survey acted in an advisory role to the city of Kenai.

Methods of Investigation

During the study of the Kenai Peninsula Borough and prior to the test-drilling program in Beaver Creek valley, ground-water conditions in the Kenai area had been defined in general terms. Included in this general definition were an inventory of existing wells, the collection and analysis of drillers' logs, the augering of shallow test holes, the geophysical logging of selected wells, the mapping of surficial geology, and an analysis of the chemical quality of ground water. These data were evaluated to delineate the most promising areas for test drilling. Test wells were then drilled at the selected locations shown in figure 2.

The formations penetrated during drilling were sampled, and the cuttings and cores were analyzed for particle-size distribution, permeability, and for the presence of clay and microfossils. The resulting test holes were logged geophysically using natural gamma, gamma-gamma, and neutron-epithermal-neutron techniques followed by borehole flow tests employing flowmeter brine-injection techniques. Water samples were collected and either analyzed in the field for selected water-quality parameters or sent to the laboratory for analysis. In addition, aquifer tests were performed on the test wells as they were completed and on a production well.

Geohydrologic Setting

The Kenai area is underlain by unconsolidated deposits as mapped in figure 2. They are stratified sedimentary deposits of glacial origin. They have been subdivided using existing maps, aerial photographs, well logs, field inspection of landforms, and surficial expression. The units include drift, outwash-plain deposits, coastal-plain deposits, deltaic deposits, abandoned-channel deposits, and alluvium.

Not all unconsolidated deposits in the study area can be classified precisely owing to the complex nature of the sedimentation and the scope of geologic mapping and interpretation. Nevertheless, at most places the unconsolidated deposits as mapped differ from each other in form, physical characteristics, and water-bearing properties. Although the map of unconsolidated-deposits represents only the sediments as seen at the surface, in most places the general hydrogeologic conditions at the surface extend to depths greater than 100 feet.

Geologic units most favorable for ground-water development within the study area include the outwash-plain deposits and the abandoned-channel deposits. The drift and deltaic deposits have been suitable sources for industrial and municipal wells in North Kenai and Soldotna, but have not

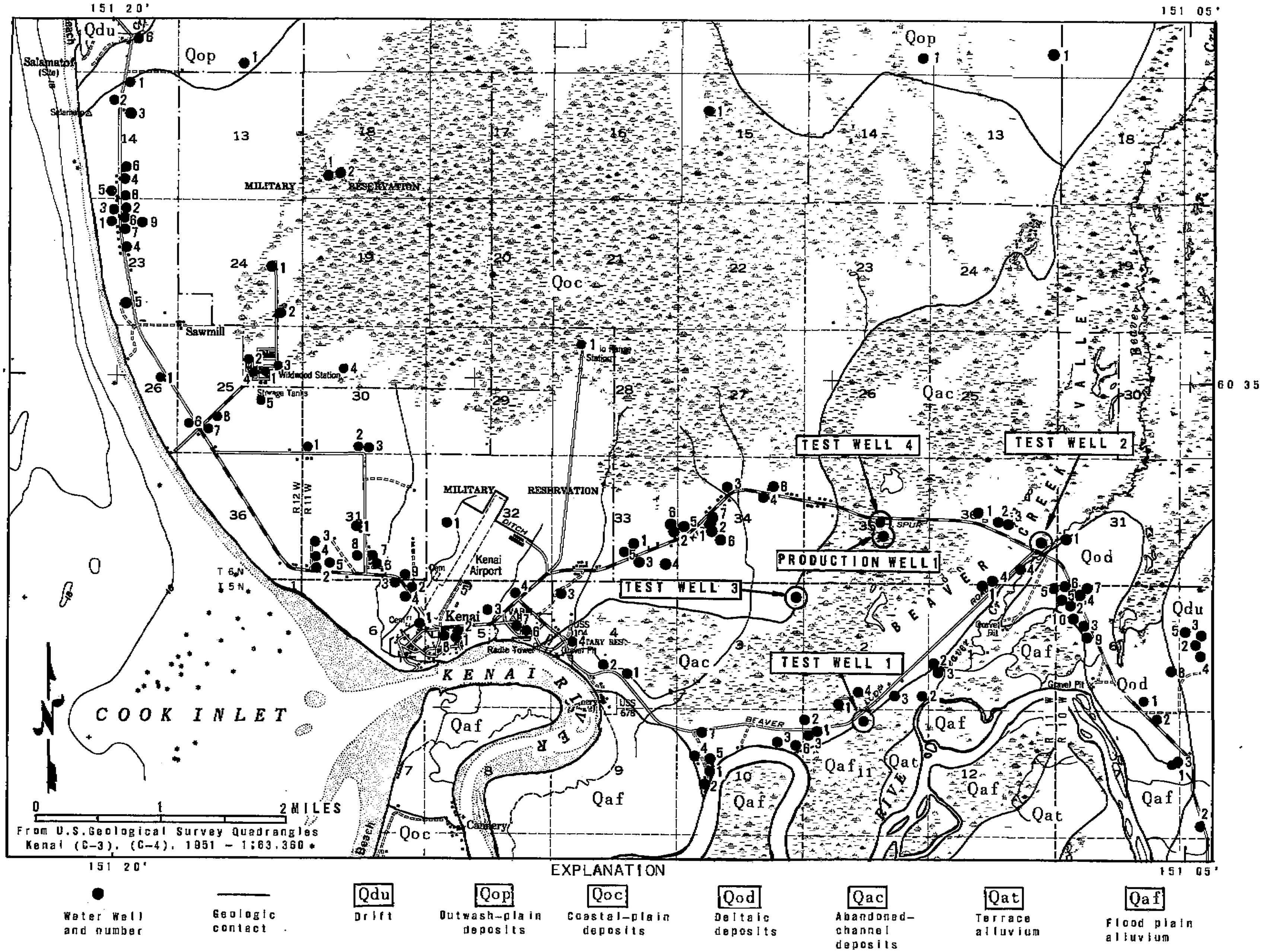

Figure 2.--Kenai area showing Quaternary unconsolidated deposits and location of selected water and test wells.

proven suitable within the study area. The coastal-plain deposits are generally unfavorable because of the large quantities of fine-grained sand, silt, and clay. The alluvium is generally too thin to be considered a favorable water-bearing unit, but may prove suitable for infiltration galleries adjacent to the Kenai River. Buried outwash deposits may provide suitable aquifers beneath the alluvium.

Selection of Test-Drilling Sites

The coastal-plain deposits upon which the city of Kenai is located were rejected as a potential source of municipal ground water on the basis of available well data. These deposits consist of an upper sand unit, ranging in thickness from 40 to 100 feet overlying a predominantly silt and clay unit at least 600 feet thick.

Prior to this exploration and development program, the city of Kenai obtained its municipal supply from the upper sand unit. A few private wells produced water from sand and gravel aquifers within the silt and clay unit at depths ranging from 180 to 250 feet. Yields of as much as 180 gpm have been obtained at Wildwood Station from the upper sand unit, and as much as 50 gpm from permeable zones within the silt and clay unit. Water from the upper sand unit contains as much as 8.2 mg/l (milligrams per liter) of iron, and 70 percent of the samples contain more than 1 mg/l of iron. Water from the deeper units contains excessive amounts of dissolved minerals and organic materials.

From the study of the geology and hydrology of the area, two areas were selected as being favorable for exploration: (1) the abandoned-channel deposits and (2) the outwash-plain deposits adjacent to Beaver Creek valley.

The abandoned-channel deposits of the Beaver Creek valley were thought to have a good water-bearing potential for high-capacity wells because geologic data indicated that the ancestral Beaver Creek valley was a major drainage course during past geologic history. This evidence showed that well-sorted sand and gravel could have been deposited within this drainage during the melting of the glaciers in the Kenai lowlands. This supposition was verified by good yields from several domestic wells completed in favorable water-bearing materials. The water quality was also excellent, although a few wells had chloride contents greater than 250 mg/l.

The outwash-plain deposits adjacent to the Beaver Creek valley have been little explored. One auger well (well 1, T. 6 N., R. 11 W., sec. 12, fig. 2) penetrated 70 feet of water-bearing coarse sandy gravel and the quality of water was good. Because of similarities between this area and areas of proven yield, the possibility was good for finding artesian aquifers in these deposits within 300 feet of the surface.

The exploration program was initiated in the abandoned-channel deposits of the Beaver Creek valley. The outwash-plain deposits adjacent to Beaver Creek valley were not tested as part of this exploration program.

SUMMARY OF TEST RESULTS - BEAVER CREEK VALLEY

Description of Water-Bearing Material

The geologic formations penetrated in all test and production wells were similar. However, the geology is too complex to allow precise correlation between wells. Three major units were distinguishable: an upper surficial unit of water-bearing sand and gravel; a middle confining unit of clay, silt, silty sand, and cemented gravel; and a lower unit of sand and gravelly sand that constitutes the major confined aquifer.

The surficial deposits range in thickness from 15 to 80 feet. They contain large quantities of water, but the water contains objectionable concentrations of iron.

The middle confining unit of interbedded clay, silt, silty sand, and cemented gravel is in sharp contact with the surficial unit but grades into the underlying confined aquifer.

The lower unit consists of interbedded fine to coarse well-sorted sand and sandy gravel containing some clay and silt layers, and is characterized by large quantities of coal and wood fragments within the water-bearing unit. In test well 3 the total aquifer thickness was only 6 feet, but in test well 2 the thickness was more than 135 feet. In test well 3 the last 90 feet penetrated were in predominantly fine material yielding very little water. All the other test and production wells did not fully penetrate the water-bearing unit; the unit did grade with depth to predominantly fine sand, silty sand, and interbeds of clay and silt.

A more complete description of the sediments penetrated by the test and production wells is presented in figures 3 through 7, which are composites of driller, geological, and geophysical logs compared to a well construction diagram; and in table 1, which includes results of the laboratory sample analyses. Apparent inconsistencies in the diagrams between lithologic logs, water-yielding zones, and casing perforations may be explained at least in part by the limitations inherent in the logging techniques.

Hydraulic Tests

The physical properties of the materials making up the confined aquifer and adjacent confining beds were determined by laboratory and field tests.

Hydraulic conductivity, a measure of the rate of water flow through a porous medium, was determined in the laboratory for selected samples (table 2). Hydraulic conductivity of materials making up the confined aquifer was determined on repacked drill-cutting samples and ranged from 5.4×10^{-1} to 23.2 m day^{-1} (meters per day), equivalent to a field

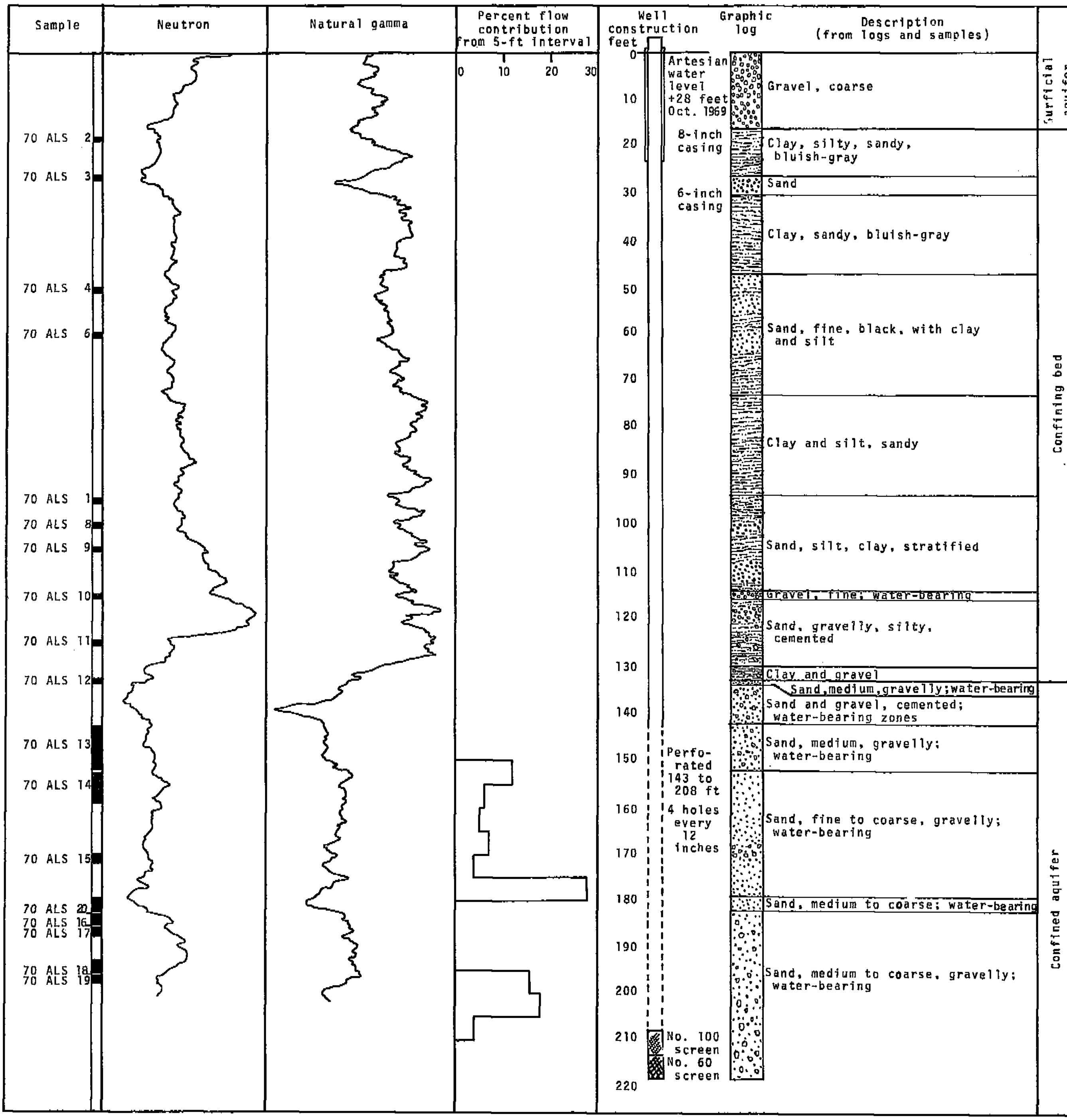

Figure 3.--Composite logs and well construction diagram of test well 1.

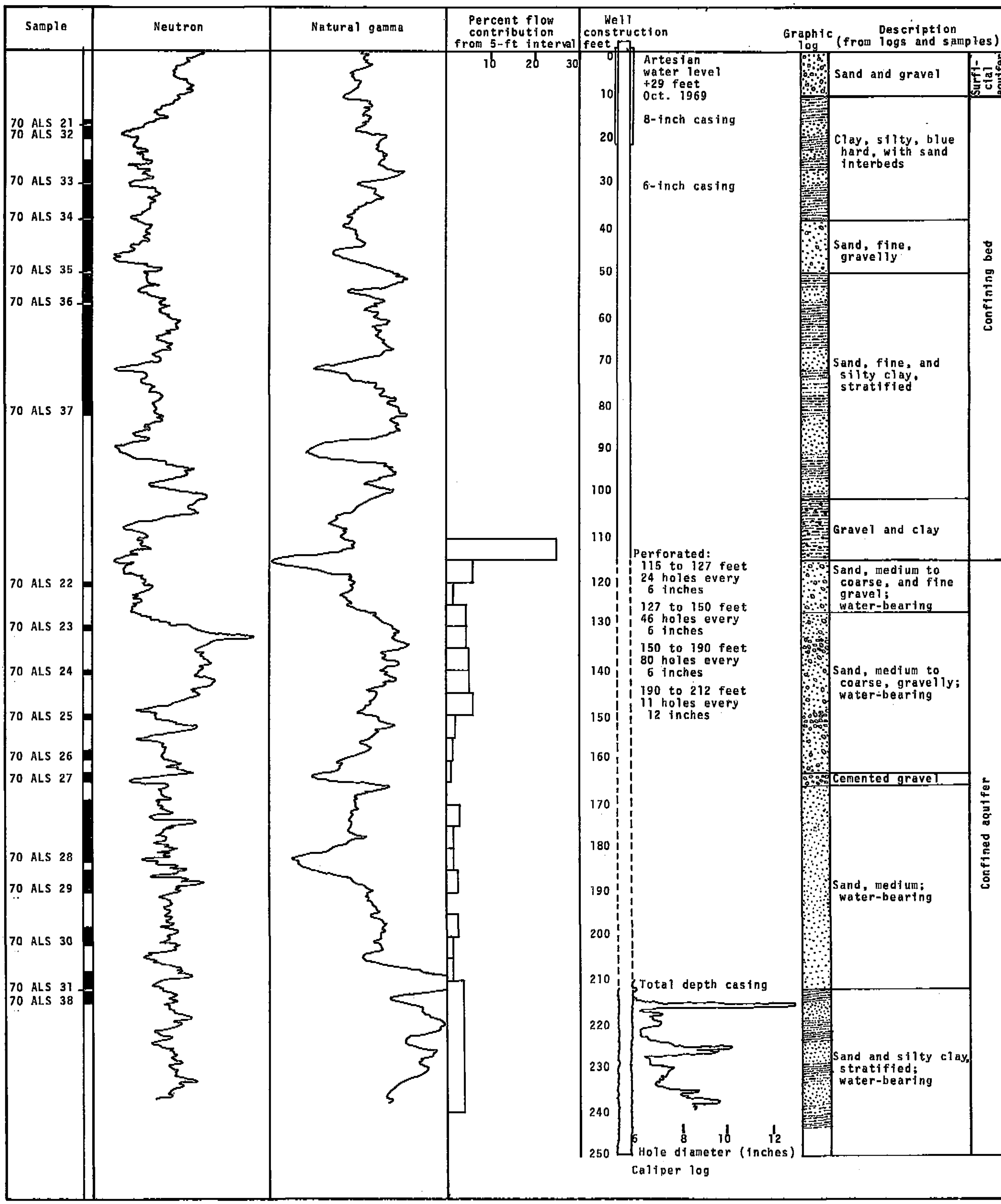

Figure 4.--Composite logs and well construction diagram of test well 2.

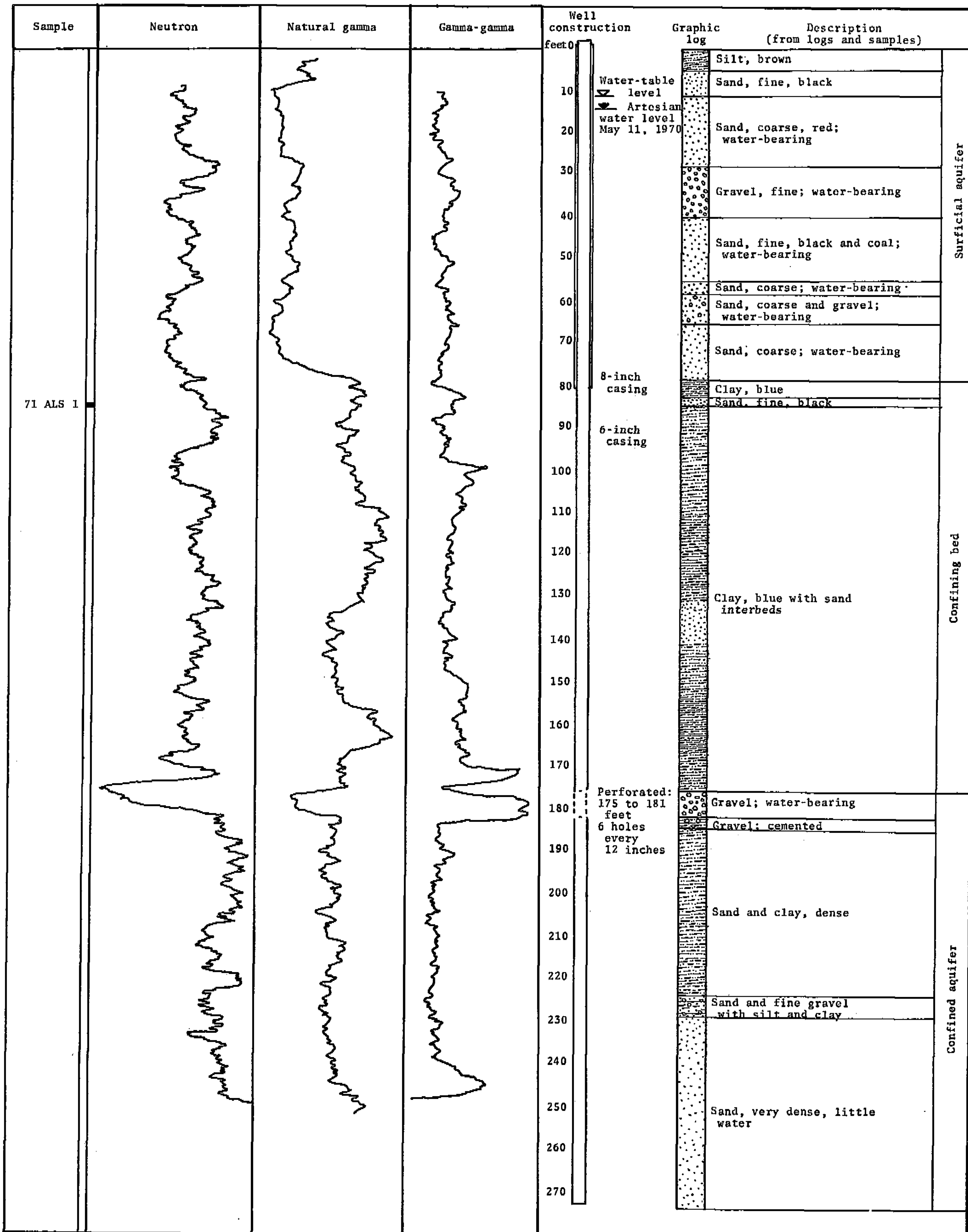

Figure 5.--Composite logs and well construction diagram of test well 3.

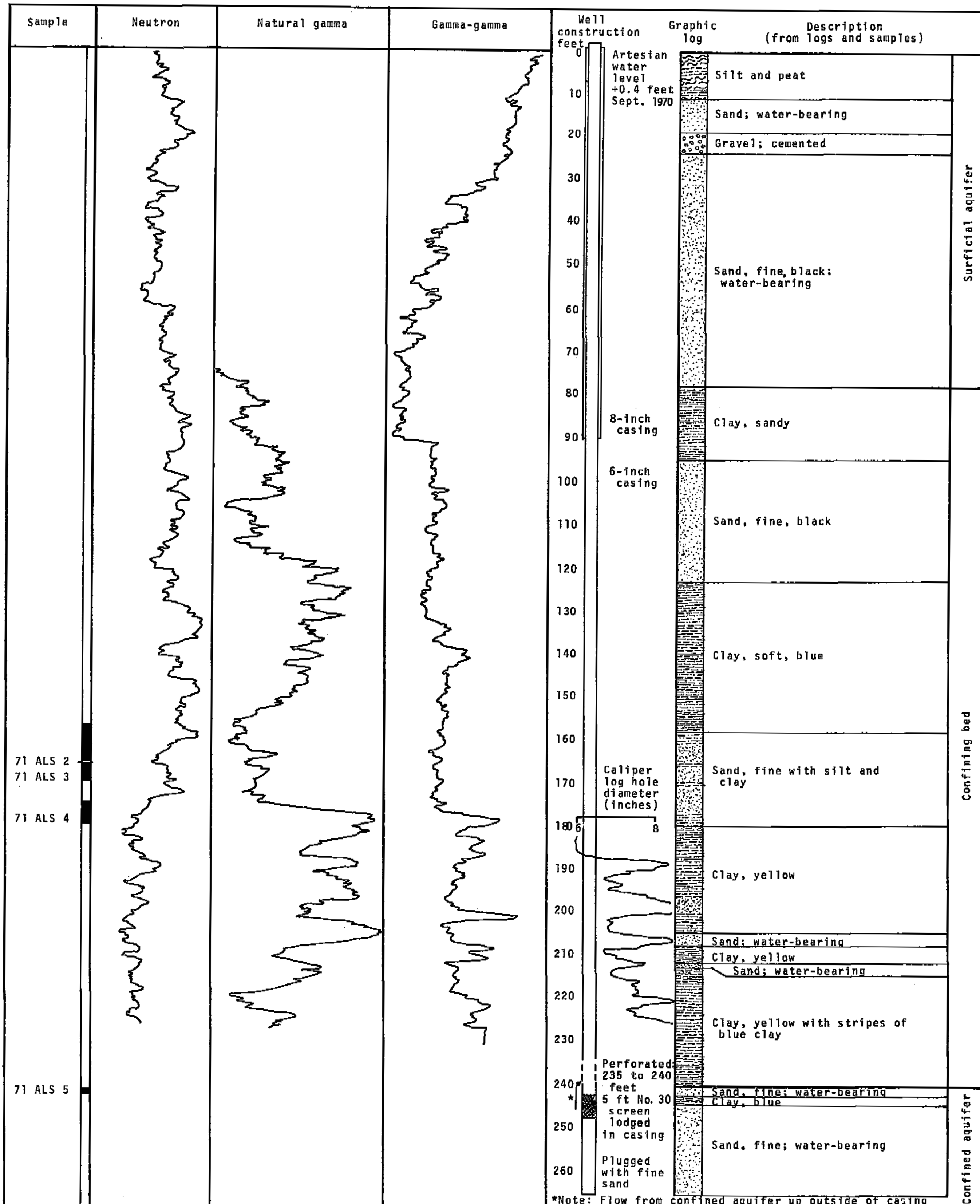

Figure 6.--Composite logs and well construction diagram of test well 4.

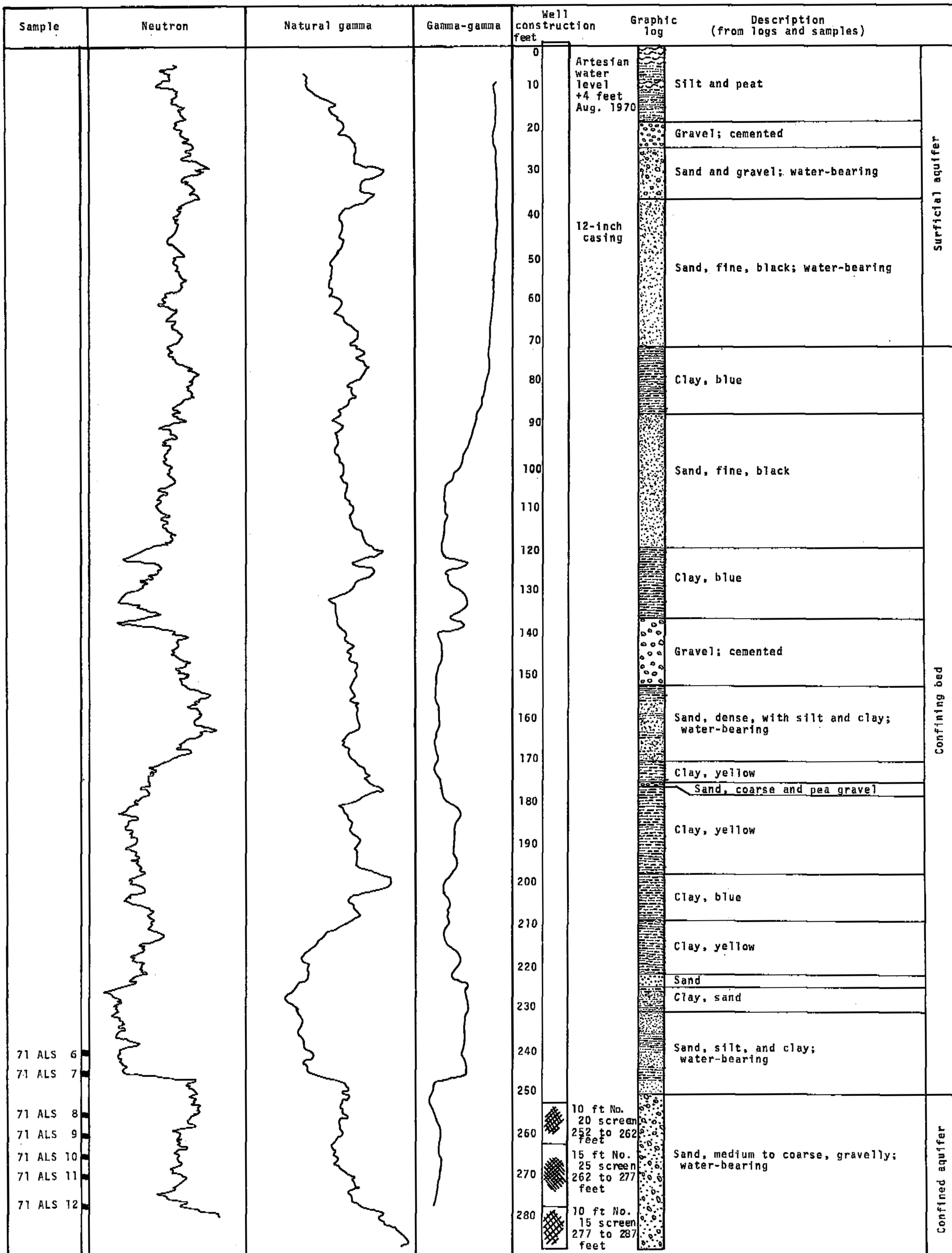

Figure 7.--Composite logs and well construction diagram of production well 1.

Table 1.--*Particle-size analyses of selected samples from test and production wells.*
(Analyses by U.S. Geological Survey)

Sample depth (feet)	Hydrologic laboratory sample	Percent of sample by weight of size indicated (millimeters)										
		Clay	Silt	Sand					Gravel			
		<0.004	0.004-.0625	Very fine 0.0625-.125	Fine 0.125-.25	Medium 0.25-.5	Coarse 0.5-1.0	Very coarse 1.0-2.0	Very fine 2.0-4.0	Fine 4.0-8.0	Medium 8.0-16.0	Coarse 16.0-32.0
						Test well 1						
60- 61	70 ALS 6	5.2	15.9	30.5	41.7	6.5	0.0	0.2	0.0	0.0	0.0	0.0
95- 96	70 ALS 1	16.5	18.1	24.4	38.3	1.9	0.6	0.2	0.0	0.0	0.0	0.0
100-101	70 ALS 8	9.8	17.8	21.3	44.2	6.3	0.6	0.0	0.0	0.0	0.0	0.0
125-126	70 ALS 11	3.6	5.8	5.9	27.1	28.0	8.5	8.6	7.7	4.1	0.8	0.0
133-134	70 ALS 12	1.7		1.5	17.8	52.9	17.9	4.9	1.5	0.7	1.1	0.0
143-152	70 ALS 13	2.0		1.3	17.1	50.0	12.1	4.4	5.3	5.1	1.7	0.9
153-159	70 ALS 14	3.0		3.0	20.9	57.7	10.4	1.8	1.9	0.9	0.4	0.0
170-172	70 ALS 15	1.5		1.0	8.8	24.7	11.7	5.9	10.2	14.1	14.4	7.8
183-186	70 ALS 16	2.8		2.5	10.7	24.8	20.9	11.4	19.0	7.7	0.1	0.0
186-188	70 ALS 17	0.2		0.2	3.0	24.9	62.0	5.7	2.0	1.6	0.4	0.0
193-196	70 ALS 18	3.2		2.5	19.3	46.4	23.0	4.5	1.1	0.1	0.0	0.0
196-198	70 ALS 19	0.9		0.6	6.8	34.4	26.7	8.9	11.9	7.4	1.9	0.6
180-183	70 ALS 20	2.6		2.8	17.1	47.5	25.8	2.8	0.9	0.3	0.1	0.0
						Test well 2						
16- 17	70 ALS 21	19.7	24.8	6.3	12.1	19.2	13.1	4.8	0.0	0.0	0.0	0.0
25- 30	70 ALS 33	16.4	38.3	2.3	15.4	12.5	2.3	1.1	4.2	3.7	1.9	1.8
38- 50	70 ALS 35	3.2	3.4	5.3	53.0	7.8	5.2	3.8	4.6	5.2	2.9	5.4
57- 82	70 ALS 37	9.6	23.9	28.2	31.7	5.4	0.4	0.4	0.4	0.0	0.0	0.0
120-121	70 ALS 22	1.5		1.3	5.1	41.7	39.3	6.4	1.7	1.9	1.2	0.0
130-131	70 ALS 23	3.9		2.8	11.3	36.7	32.9	5.8	3.1	3.1	0.4	0.0
140-141	70 ALS 24	1.5		0.6	4.3	21.4	22.5	10.7	13.9	17.1	6.3	1.6
150-151	70 ALS 25	4.5		4.4	16.6	20.3	12.3	8.9	10.2	9.2	4.0	9.8
158-160	70 ALS 26	0.2		0.5	11.4	40.8	13.1	7.4	8.5	11.4	6.8	0.0
163-165	70 ALS 27	3.1		2.1	11.1	21.2	23.1	18.1	14.5	6.5	0.3	0.0
169-183	70 ALS 28	0.6		1.1	27.7	62.6	5.5	0.7	0.4	0.7	0.7	0.0
185-190	70 ALS 29	1.1		1.8	31.2	44.4	3.4	2.3	3.6	5.8	5.6	0.7
198-202	70 ALS 30	4.6		4.1	22.8	64.4	2.9	0.2	0.3	0.4	0.2	0.0
208-212	70 ALS 31	4.9		4.3	27.0	60.1	2.9	0.4	0.1	0.2	0.0	0.0
212-215	70 ALS 38	34.7	54.5	3.6	2.4	1.1	1.6	1.5	0.3	0.2	0.0	0.0
						Test well 3						
84	71 ALS 1	39.4	46.1	1.2	8.5	2.8	0.6	0.2	0.1	0.2	0.4	0.7
						Test well 4						
157-165	71 ALS 2	14.5		14.4	48.1	21.8	1.2	0.0	0.0	0.0	0.0	0.0
165-170	71 ALS 3	8.5		5.5	29.5	53.9	2.4	0.2	0.0	0.0	0.0	0.0
175-180	71 ALS 4	11.1		4.6	53.2	29.4	1.7	0.0	0.0	0.0	0.0	0.0
242-243	71 ALS 5	5.1		6.0	73.2	15.2	0.4	0.2	0.0	0.0	0.0	0.0
						Production well 1						
250	71 ALS 6	6.2		3.3	31.6	39.3	12.0	1.3	1.7	2.7	1.9	0.0
255	71 ALS 7	4.8		1.2	24.2	44.2	8.8	4.2	5.2	4.2	2.2	1.0
265	71 ALS 8	2.4		0.1	7.8	38.4	19.3	7.5	7.6	9.8	7.1	0.0
270	71 ALS 9	3.6		2.2	15.0	53.6	14.1	3.8	2.9	2.9	1.9	0.0
275	71 ALS 10	3.0		3.2	14.1	40.2	14.5	4.3	7.9	8.5	3.3	1.0
280	71 ALS 11	3.3		2.5	24.1	59.1	2.3	1.3	2.1	2.6	2.5	0.0
287	71 ALS 12	3.8		3.5	28.0	54.9	4.4	1.2	0.8	1.2	0.9	1.2

Table 2.--*Hydraulic properties of selected samples from test and production wells.*

Sample depth (feet)	Hydraulic conductivity	Field coefficient of permeability	Remarks
	Meters per day	Gallons per day per square foot	
Test well 1			
95- 96	9.7×10^{-2}	2.4	Drive sample; repacked for test
153-159	5.4	130	Drill cuttings; repacked for test
183-186	1.6	390	Drill cuttings; repacked for test
196-198	23.2	570	Drill cuttings; repacked for test
180-183	8.6	210	Drill cuttings; repacked for test
Test well 2			
16- 17	7.1×10^{-4}	0.017	Drive sample; run undisturbed
120-121	5.4×10^{-1}	13	Drill cuttings; repacked for test
140-141	11.3	280	Drill cuttings; repacked for test
158-160	17.5	430	Drill cuttings; repacked for test
169-183	14.3	350	Drill cuttings; repacked for test
198-202	2.7	66	Drill cuttings; repacked for test
Test well 3			
84- 85	2.2×10^{-4}	0.0054	Drive sample; run undisturbed
Test well 4			
242-243	7.6	186	Drill cuttings; repacked for test
Production well 1			
250	5.8	142	Drill cuttings; repacked for test
255	5.9	145	Drill cuttings; repacked for test
265	10.8	265	Drill cuttings; repacked for test
270	7.8	191	Drill cuttings; repacked for test
275	10.3	252	Drill cuttings; repacked for test
280	11.9	292	Drill cuttings; repacked for test
287	11.0	270	Drill cuttings; repacked for test

coefficient of permeability of 13 to 570 gpd per ft^2 (gallons per day per square foot). This range can be considered to be low to moderately permeable, but great caution needs to be exercised in applying results on repacked samples. Hydraulic conductivity, determined by using borehole flow-testing equipment, within each test well was variable. The most permeable units were gravelly sand. However, the less permeable sand units transmit large quantities of water because they are thick. Hydraulic conductivity of the materials within the confining beds ranged from 2.2×10^{-4} to 9.7×10^{-2} m day^{-1} (permeability ≈ 0.0054 gpd per ft^2 to 2.4 gpd per ft^2). Even these low hydraulic conductivities allow a large amount of leakage toward the unconfined surficial deposits under the present head relationship. However, increased ground-water development of the confined aquifer could induce leakage from the surficial deposits to the confined aquifer.

Field hydraulic tests measuring transmissivity and storage coefficient are summarized in table 3. Maximum measured discharges and specific capacities are also included, but may not reflect the true potential yield because of differences imposed by casing size, well construction, and effectiveness of development and pumping techniques. Transmissivity, a measure of the rate at which water flows through a vertical strip of the aquifer 1-foot wide extending through the full saturated thickness under a unit hydraulic gradient, was determined by maintaining constant discharge in the test well and measuring drawdown in the test or observation well. Transmissivity ranged from 4,000 to 9,900 ft^2 day^{-1} (square feet per day) (30,000 to 74,000 gpd per ft). Transmissivities in excess of 1,300 ft^2 day^{-1} (10,000 gpd per ft) are generally considered to be adequate for most industrial or municipal purposes.

Table 3.--*Summary of hydraulic tests.*

Well number	Diam-eter (inches)	Well construction	Maximum discharge	Specific capacity [1/] (gpm per ft of drawdown)	Transmissivity (gpd per ft)	Storage coefficient
Test well 1	6	Open hole, 208-212 feet	600[2/]	20	35,000[4/]	
		Perforated casing 143-206 feet	600[2/]	22	30,000[5/]	
Test well 2	6	Perforated 115-212 feet; open hole, 212-240 feet	1,100[3/]	29	73,500[5/]	
Test well 3	6	Perforated 177-182 feet	60[6/]			
Test well 4	6	Open hole, 191-245 feet	400[7/]			
Production well 1	12	Screened 252 to 287 feet	850[8/]	8.5[10/]	46,000[9/]	7.5×10^{-4}[9/]

1/ After 24 hours flow or pumping.

2/ Natural flow estimated by head on 6-inch pipe.

3/ Well pumped by air lift and discharge measured by flow through rectangular weir; 700 gpm natural flow estimated by head on 6-inch pipe.

4/ Average transmissivity determined from drawdown data in flowing well using Theis nonequilibrium well formula and Jacob modified nonequilibrium formula.

5/ Average transmissivity determined from drawdown data using Theis nonequilibrium well formula and Jacob modified nonequilibrium formula, and from recovery data using the relationship between residual drawdown and the ratio of time since flow was started to time after flow was stopped, t/t'.

6/ Bailer test.

7/ Well pumped by air lift and discharge measured by barrel and stopwatch.

8/ Well pumped with turbine pump and discharge measured by orifice plate.

9/ Transmissivity and storage coefficient determined from drawdown data of the observation well (test well 4) using the Theis nonequilibrium well formula.

10/ This low specific capacity is the result of incomplete development of the well and partial penetration of the aquifer.

The transmissivity values for test wells 1 and 2 (figs. 7-8) were determined from measurements of drawdown or recovery during the flowing tests of these wells. During the pump test of production well 1 (fig. 9), test well 4 was used as an observation well to record changes in head. This test provided a good record by which to analyze storage coefficient (fig. 10), which is the volume of water released or taken into storage per unit of surface area of the aquifer per unit change in head. The measured storage coefficient, 7.5×10^{-4}, is typical for a confined aquifer. In most confined aquifers, values are in the range of 10^{-5} to 10^{-3}, indicating that even moderate withdrawals of water will cause pressure changes over extensive areas.

The shape of the time-drawdown curves (figs. 8-12) during constant-discharge tests is related to the aquifer geometry and the position of hydraulic boundaries. If the slope of the time-drawdown curve is generally constant, as in figures 8 and 9; or if the data plot on the type curve, as in figure 12, the test is said to be unaffected by boundary conditions. But, when the slope of the curve steepens with time and changes markedly, as in figure 10, an impervious hydraulic boundary condition may be the cause. This implies, when geologic information is also considered, that the eastern edge of the confined aquifer may coincide with the eastern limit of the abandoned-channel deposits and that water inflow from this direction is reduced by an impermeable boundary. No boundaries were detected during the test of production well 1; possibly another production well could be drilled west of production well 1.

The hydraulic tests provide information that can be used to calculate (1) rate of lowering of water level with time at any place within the cone of depression and (2) shape and position of the cone of depression at a given time within the area tested. For example, the drawdown of water level in the confined aquifer at various distances from the pumped

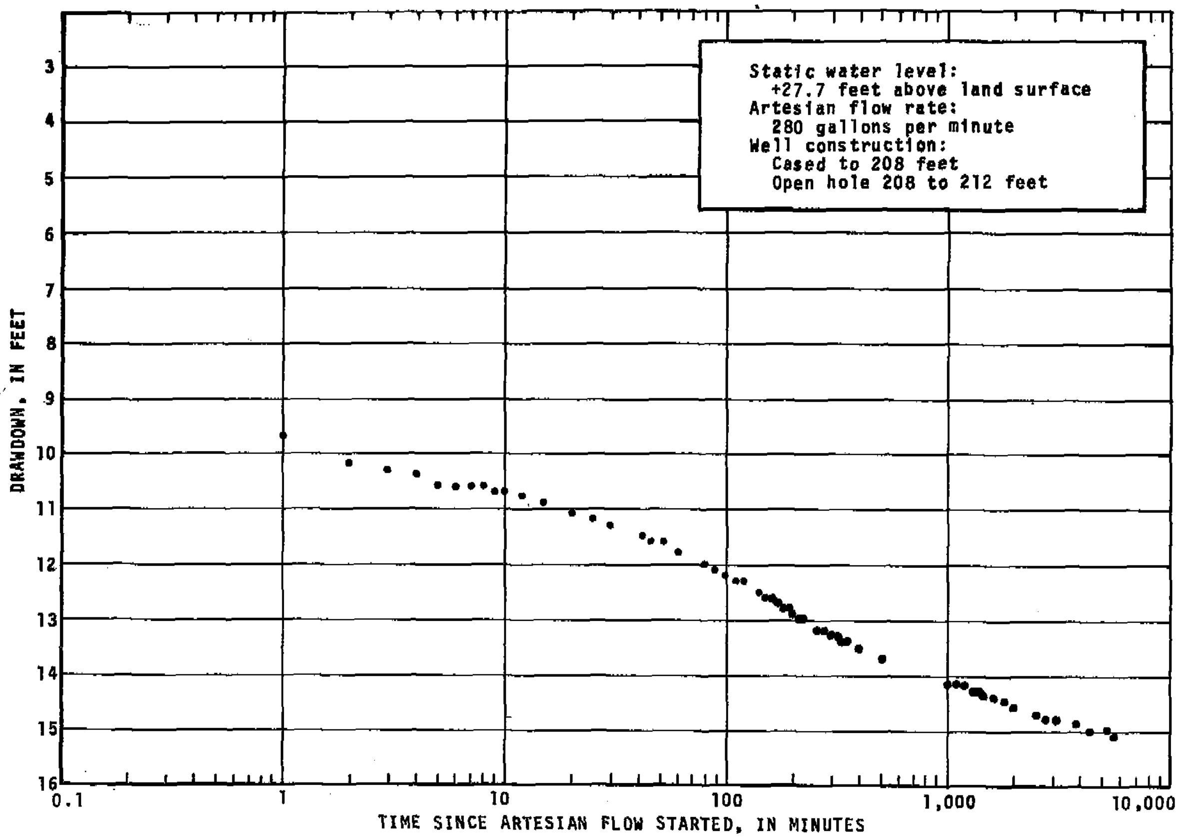

Figure 8.--Time-drawdown curve test well 1, June 23 to 27, 1969.

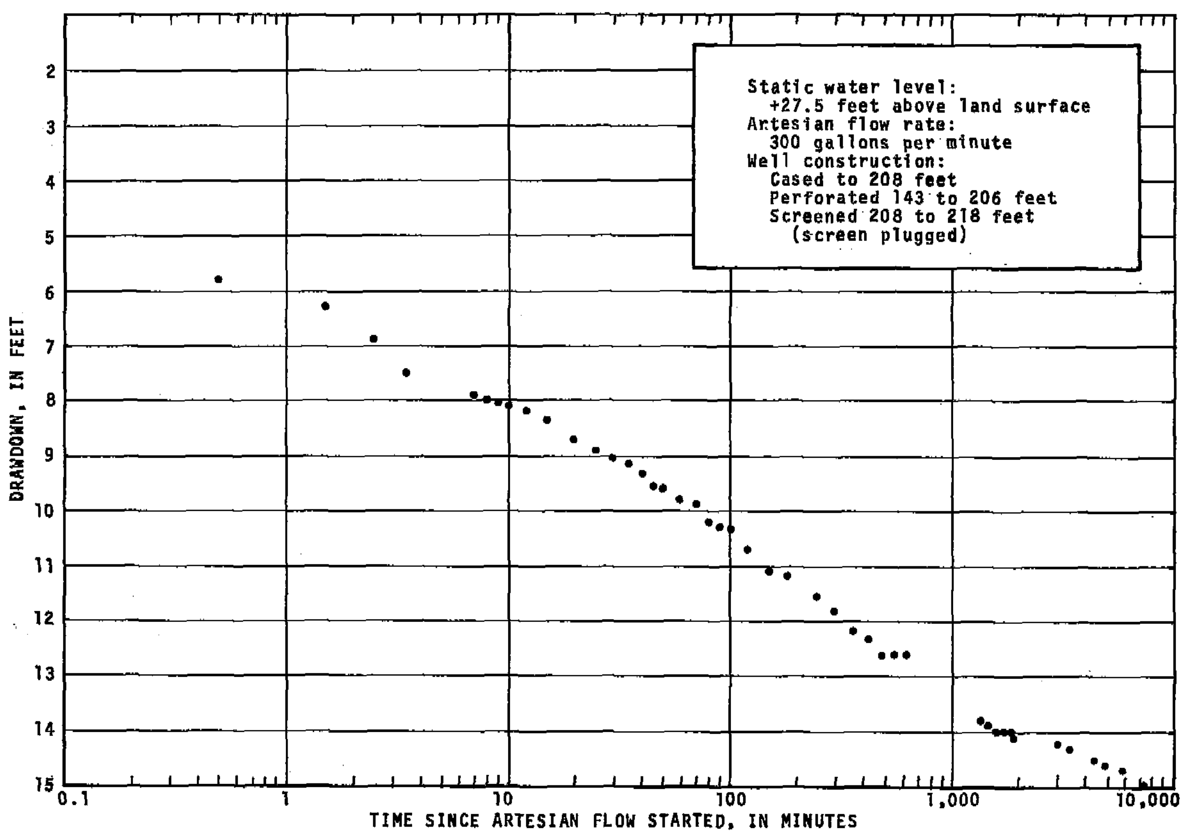

Figure 9.--Time-drawdown curve test well 1, September 25 to 30, 1969.

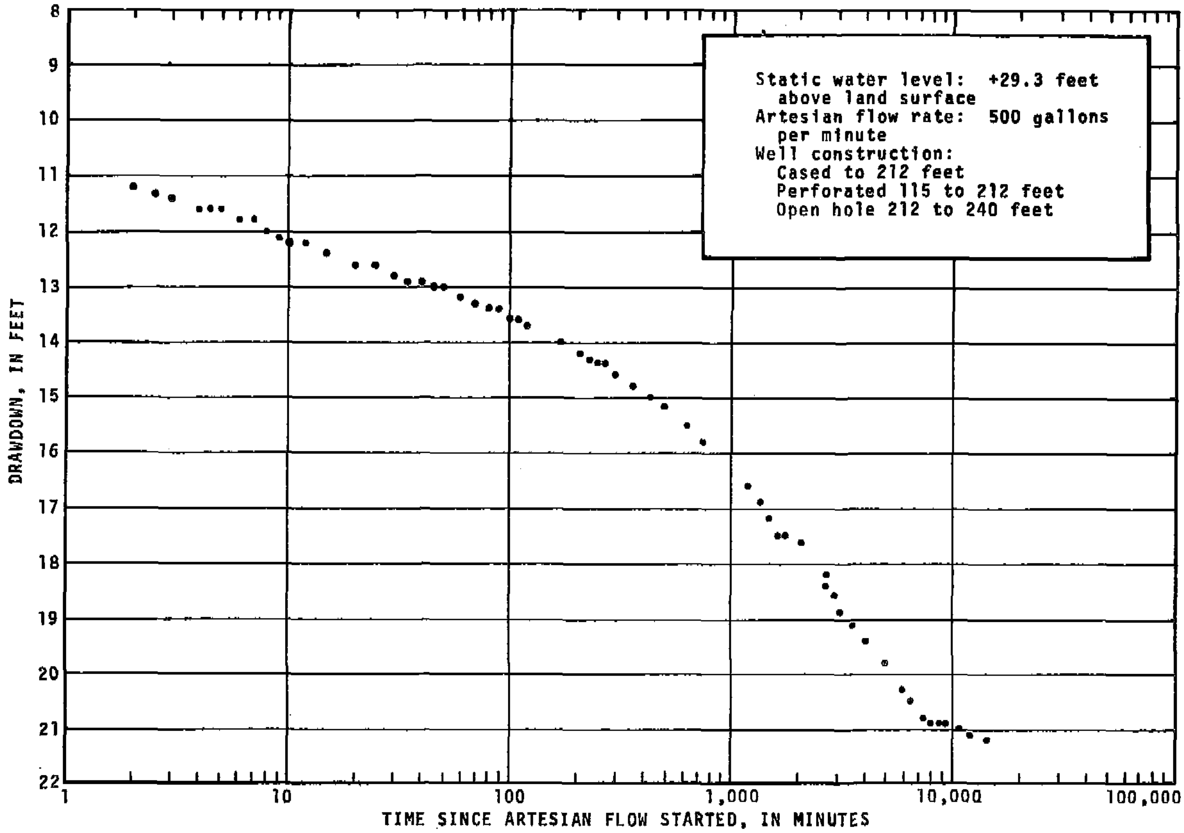

Figure 10.--Time-drawdown curve test well 2, July 14 to 24, 1969.

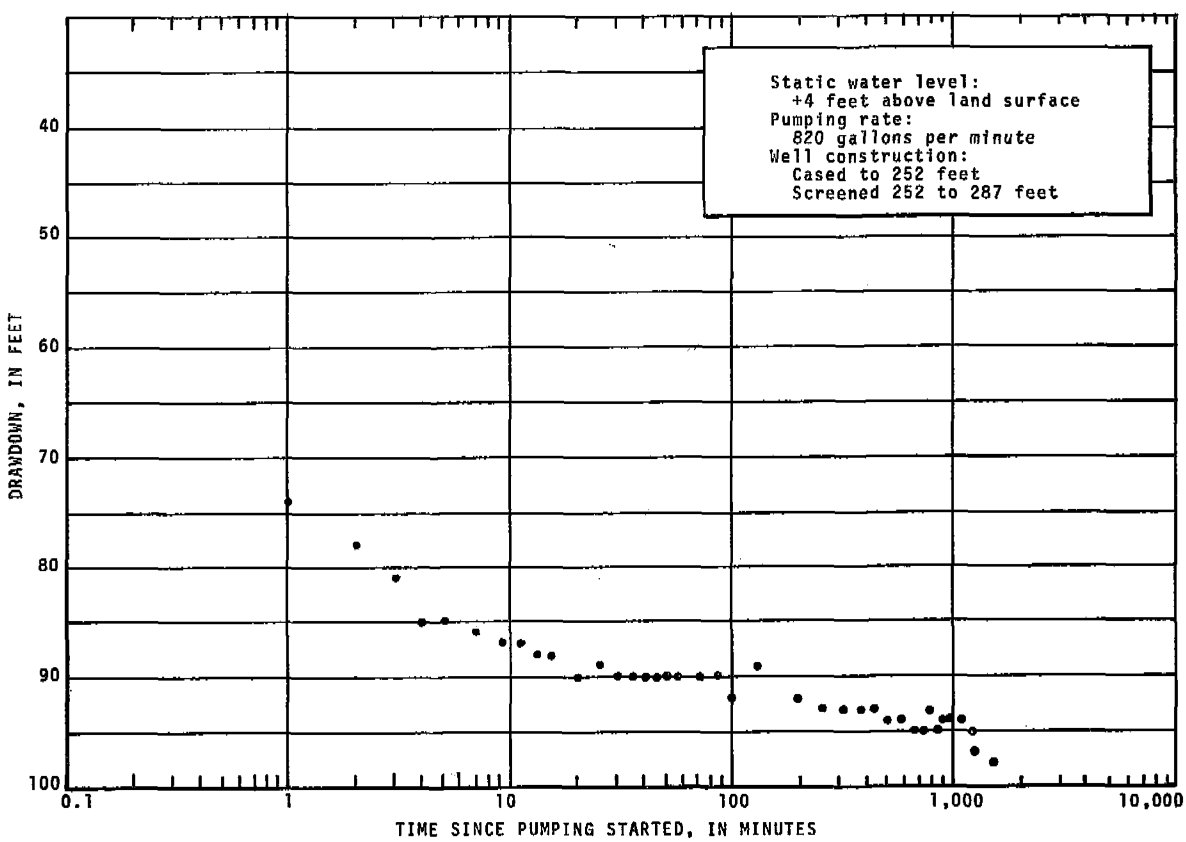

Figure 11.--Time drawdown curve production well 1, August 11 to 12, 1970.

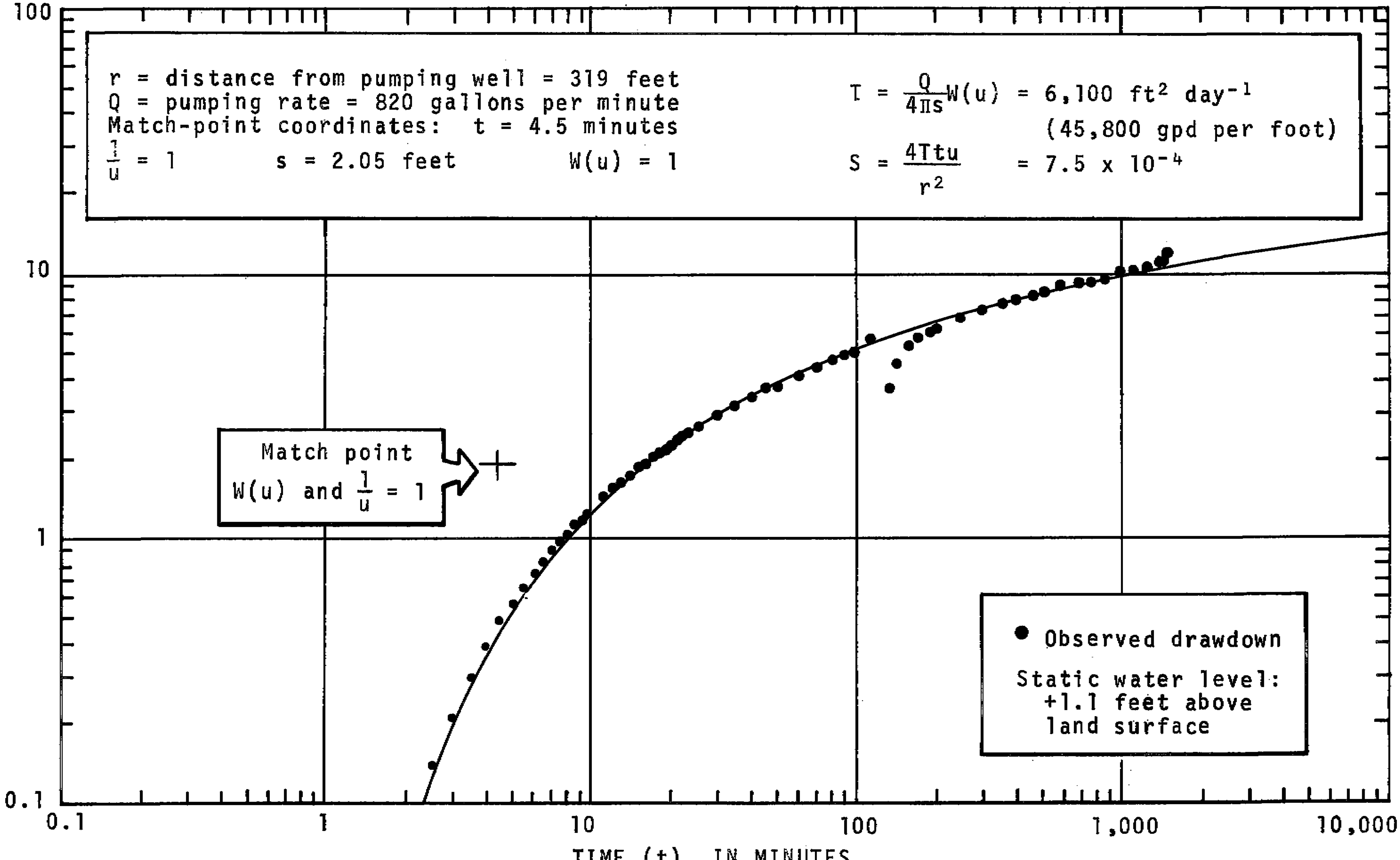

Figure 12.--Logarithmic plot of drawdown data in the observation well (test well 4) during pumping of production well 1, August 11 to 12, 1970.

well in Beaver Creek valley can be predicted using the values of transmissivity and storage coefficient and knowledge of boundary conditions determined from the hydraulic tests in this area. Figure 13a is a graph of predicted decline in water level at a distance, r, from production well 1 after pumping from storage for t days. Some assumptions made in preparing the graphs are: (1) the aquifer is areally homogeneous and infinite in extent; (2) transmissivity and storage coefficient as determined from the test of production well 1 are representative of the aquifer; (3) the well is pumped at a continuous rate of 500 gpm; and (4) all water pumped is taken from storage. Figure 13b is a graph showing predicted decline in water level at various distances from production well 1 after pumping specified quantities for 1 day. These graphs can be used to predict optimum spacing of wells when used in conjunction with economic and engineering considerations beyond the scope of this report.

On the basis of the available aquifer-test data, the city of Kenai should be able to obtain the required 650 gpm sustained average flow or 3,000 gpm for 10 hours from two or three properly spaced and constructed wells in the Beaver Creek valley.

Quality of Ground Water

The water from all wells was of the sodium bicarbonate type and of good quality (table 4). Iron content ranged from 0.08 to 0.80 mg/l, which is low for the Kenai area. The water samples ranged in hardness from 1 to 95 mg/l. Some of the samples had a slight hydrogen sulfide odor and an amber color.

In all test and production wells, except test well 1, the quality of water was similar throughout the drilled interval. The water from test well 1 had the highest chloride content, which also increased with depth of drilling. This well is located within a zone of salty ground

Table 4.--*Chemical analyses of water from wells in Beaver Creek valley.*
(Analyses by U.S. Geological Survey)

Date of collection	Sampling depth (feet)	Temperature (°C)	Silica (SiO_2) (mg/l)	Iron (Fe) (mg/l)	Calcium (Ca) (mg/l)	Magnesium (Mg) (mg/l)	Sodium (Na) (mg/l)	Potassium (K) (mg/l)	Bicarbonate (HCO_3) (mg/l)	Sulfate (SO_4) (mg/l)	Chloride (Cl) (mg/l)	Fluoride (F) (mg/l)	Nitrate (NO_3) (mg/l)	Dissolved solids (calculated) (mg/l)	Hardness as $CaCO_3$ (mg/l)	Specific conductance (micromhos at 25°C)	pH	Color
Test well 1																		
June 10, 1969 1/	152	4	42	0.52	4.8	6.4	40	9.8	136	0	15	0.2	0.1	185	35	254	8.3	10
June 17, 1969 1/	208	4	43	.55	13	15	54	11	168	0	52	.2	.1	282	95	449	8.0	--
September 30, 1969 2/	143-206	--	41	.80	8.5	15	57	9.6	164	0.8	60	.1	.2	273	83	430	8.0	10
Test well 2																		
June 19, 1969 1/	115	--	34	--	3.8	2.5	46	4.6	144	0	2.1	.5	.1	160	20	225	8.3	5
July 24, 1969 3/	115-240	4	40	.08	4.6	4.0	39	4.9	137	0	2.8	.6	.4	163	28	218	8.4	5
August 21, 1969 1/	115-246	--	39	.32	5.2	6.0	2.7	5.7	128	0	2.8	.2	.1	150	40	202	8.1	10
Test well 3																		
May 1, 1970 4/	265	--	5.3	--	8.2	4.8	44	8.9	147	7.7	12	.3	.3	164	40	280	7.5	10
May 12, 1970 5/	177-182	3	33	.44	16	5.2	39	5.6	176	0	3.2	.5	.1	190	62	274	8.0	5
Test well 4																		
May 20, 1970 6/	241-243	3.5	44	.38	0.3	0.3	52	2.6	136	0	0.7	.5	.6	162	1	217	8.2	--
Production well 1																		
August 12, 1970 7/	253-287	4	46	.14	5.4	5.9	24	4.8	113	1.6	1.4	.4	.5	144	38	182	7.9	10

1/ Sampled from flowing well.
2/ Sampled after 5 days of flow at 300 gpm.
3/ Sampled after 10 days of flow at 500 gpm with open hole from 212 to 240 feet and perforated casing from 115 to 212 feet.
4/ Sampled from bailer; sample turbid.
5/ Sampled after 1 hour of pumping at 15 gpm.
6/ Sampled after 4 hours of pumping at 400 gpm.
7/ Sampled after 24 hours of pumping at 920 gpm.

water that is known to occur near the Cook Inlet shoreline and in some of the deeper wells inland from the coast. Test well 1 is near wells numbers 4 and 5 (T. 5 N., R. 11, sec. 10. fig. 2), which have chloride contents of 446 and 400 mg/l, respectively. The boundary of the salty water is not accurately known.

FUTURE POTENTIAL FOR GROUND-WATER DEVELOPMENT

Efficient development and utilization of the ground-water resources in the Beaver Creek valley will require continued exploration drilling and testing programs, followed by properly engineered production wells and a realistic program of well-field management.

Design of Exploration and Testing Program

A continuing exploration and testing program should have a two-fold purpose: (1) to locate sites suitable for production wells, and (2) to delineate the extent and geohydrologic character of the ground-water reservoir.

Areas considered favorable for continued exploration occur within the unit mapped as abandoned-channel deposits (fig. 2); specifically, the following areas bear consideration: (1) between test wells 1 and 2 and 2 and 4, (2) north of the Kenai Spur highway, and (3) between production well 1 and the western boundary of the abandoned-channel deposits.

Each proposed production well should be preceded by a test well to evaluate the ground-water potential and to eliminate the expense of drilling an unsuccessful production well. The test well would provide data to be used to efficiently design the production well and to serve as an observation well during the aquifer testing. The hydraulic information thus acquired is essential in the future design of the water-supply system and in its operation and management.

The predicted distance-drawdown curves for production well 1 (fig. 13) together with engineering and economic considerations can be used as a guide in selecting the spacing of test sites for additional production wells. The known physical and hydrologic characteristics of the Beaver Creek aquifer probably will allow the development of a fairly close-spaced system of wells. This suggestion is supported by the predicted distance-drawdown curve of production well 1 and by the fact that there are approximately 250 feet of available drawdown.

Well Construction and Development

The effective design and construction of additional successful production wells in Beaver Creek valley should take into account the fact that most of the sediments are fine grained--sand interbedded with silt and clay and contain many fragments of wood and coal.

The thin beds of fine-grained sand in the Beaver Creek aquifers may be capable of yielding large amounts of water to wells, but the beds are difficult to screen and to develop. During the drilling of test well 2, for example, the stratified sandy clay and sand unit from 210 to 250 feet produced very little water. However, after development the geophysical logs showed that the uncased hole had remained open between 210 and 240 feet and that this lower unit was contributing approximately 25 percent (fig. 4) of the well discharge. Consequently, the successful drilling and completion of wells in these materials will require careful well construction, screening, and development.

During the drilling of test wells 1 and 2, great quantities of wood and coal fragments washed to the surface. Approximately 12 hours after test well 2 had been screened between 208 and 218 feet, the discharge decreased by one-half. After perforating between 143 and 206 feet, the flow returned to maximum. Exploration showed no flow from the screened

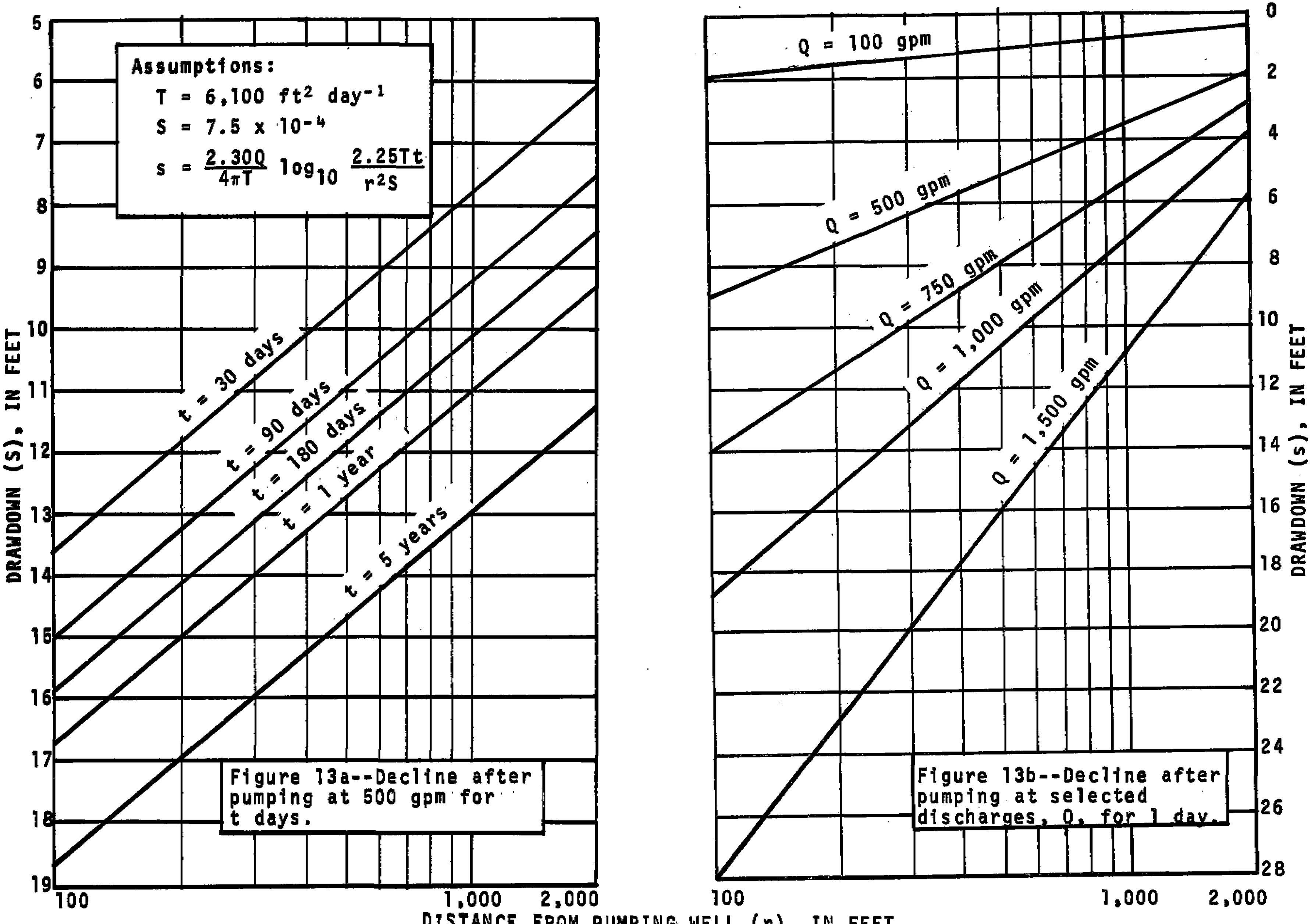

Figure 13.--Predicted decline in water level in Beaver Creek valley (at distance, r, from production well 1 after pumping from storage).

section after perforation and, from previous experience, the driller reasoned that the screens had been plugged by wood and coal fragments. An easy solution to removal of wood and coal from the screen mesh or periphery is not readily apparent. This problem deserves further study.

WELL-FIELD MANAGEMENT

Proper management of ground-water resources in Beaver Creek valley requires continued monitoring activities and a refinement of hydrologic concepts. Continuous records should be kept of all withdrawals of ground water and of water-level changes in selected observation and production wells. Samples of ground water for chemical analysis should be collected periodically from wells along the Kenai River and Cook Inlet. Data-collection activities should continue and records should be obtained on any new test well or pumping test. Data gained from drilling and testing additional wells throughout the valley followed by monitoring of the water-level decline associated with pumping these wells will help to establish the optimum pumping schedules for the well field and to design for further expansion. As more data are acquired, consideration should be given to the construction of a model of the ground-water system. This will help to predict the future response of this system to use.

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