Department of Natural Resources
MARYLAND GEOLOGICAL SURVEY
Kenneth N. Weaver, Director

OPEN FILE REPORT NO. 88–02–4

SELECTED GEOHYDROLOGIC CHARACTERISTICS OF THE PATAPSCO AQUIFERS AT CHALK POINT, PRINCE GEORGES COUNTY, MARYLAND

by

Frederick K. Mack

Prepared in cooperation with the
United States Geological Survey and the
Maryland Power Plant Research Program

1988

CONVERSION FACTORS AND ABBREVIATIONS

For the convenience of readers who may prefer to use the International System (SI) of metric units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply inch-pound unit	By	To SI unit
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Volume	
gallon (gal)	3.785	liter (L)
	Flow	
gallon per minute (gal/min)	0.06308	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meters per second (m^3/s)
	Transmissivity	
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)
	Temperature	
degree Fahrenheit (°F)	°C = 5/9 (°F-32)	degree Celsius (°C)
	Specific Conductance	
micromho per centimeter at 25°Celsius (µmho/cm at 25°C)	1.000	microseimens per centimeter at 25° Celsius (µS/cm at 25°C)

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--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 of 1929".

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ABSTRACT

The Cretaceous Patapsco Formation at Chalk Point consists of thick beds of clay and silt that separate sandy intervals of varying lateral extent. Water-bearing characteristics of three sand layers, the tops of which are at depths of about 850 feet, 1,000 feet, and 1,500 feet, have been estimated by pumping tests. The estimated transmissivity of each was 570, 1,500, and 820 feet squared per day, respectively, at the sites tested.

Water levels in the "850-foot" sand declined from 10 feet above sea level to 17 feet below sea level from 1974 to 1986. Water levels in the "1,000-foot" sand, which has been pumped since 1975 at rates ranging from zero to 0.8 million gallons per day, have declined from 15 feet above sea level to 23 feet below sea level from 1973 to 1986. Water levels in the "1,500-foot" sand, which has not been pumped, have declined from 15 feet above sea level to 1 foot below sea level from 1973 through 1986.

Chemical analyses of water samples show that except for the slightly high concentrations of dissolved iron in the "850-foot" and "1,000-foot" sands, all constituents tested met the drinking-water standards of the U.S. Environmental Protection Agency.

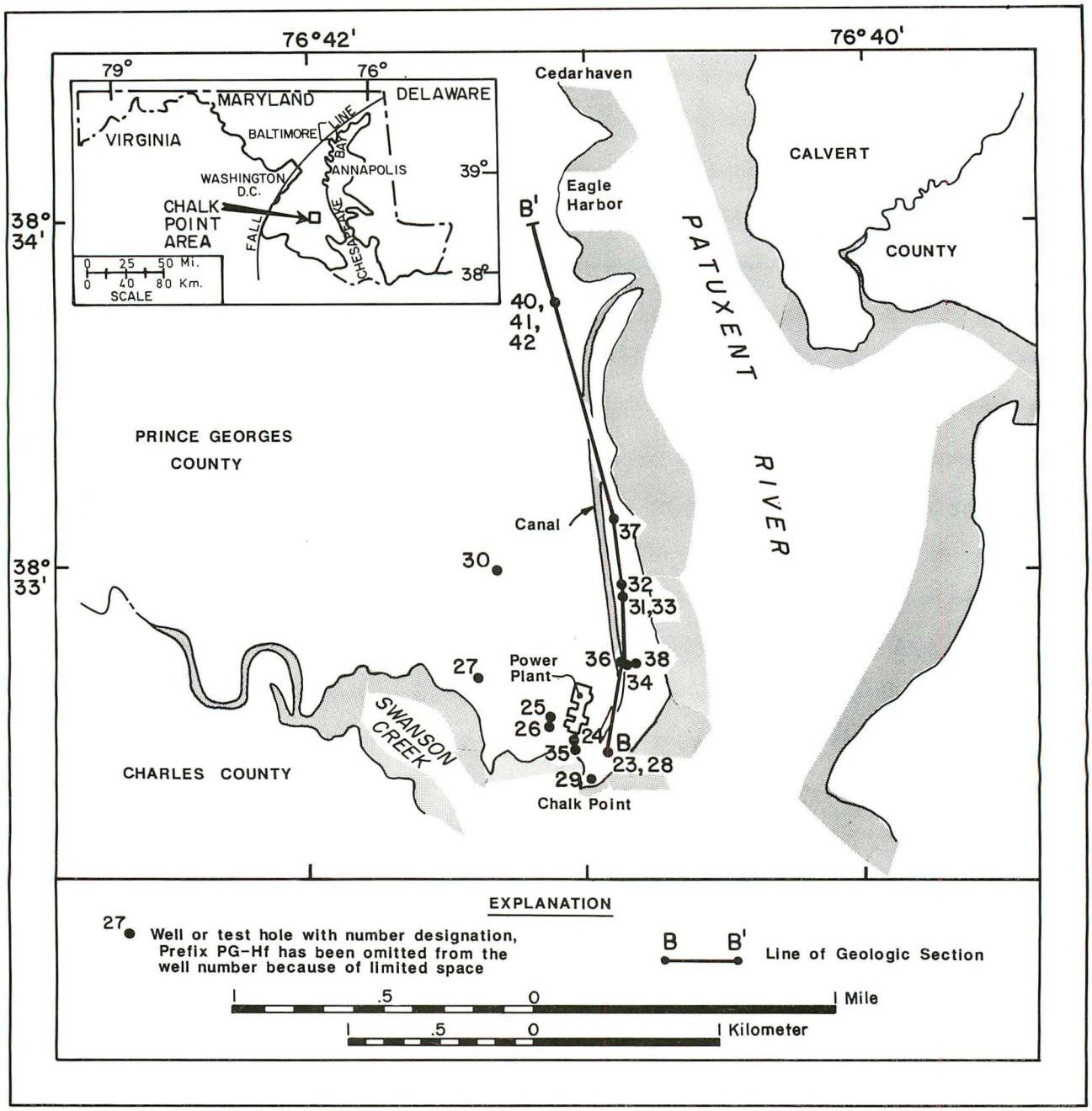


Figure 1. Locations of Chalk Point and geologic section B-B'.

INTRODUCTION

Background

In order to meet the increasing demand for water supplies in southern Maryland, all potential sources of ground water need to be considered. The Patapsco aquifers are potential sources that have not been highly stressed, but have supplied an average of 0.2 to 0.4 Mgal/d of water to the Chalk Point power plant of the Potomac Electric Power Company (PEPCO) since 1975 (see fig. 9). Chalk Point is located on the Coastal Plain of Maryland in southeastern Prince Georges County, is about 30 miles southeast of the Fall Line and Washington, D.C., and about 50 miles south of Baltimore, Md. (fig. 1).

Purpose and Scope

This report updates an earlier publication about the geohydrology of Chalk Point (Mack, 1976) by providing additional information about the Patapsco aquifers and by showing how water levels in wells tapping the aquifers have been affected by local and regional pumpage. Data regarding three Patapsco aquifers have been gathered at Chalk Point by test drilling, geophysical logging, pumping tests, and the monitoring of water levels at the plant since 1973. Daily values for quantities of water pumped from each well were furnished by PEPCO. This report has been prepared to make that information available to the public.

Data Collection

Hydrogeologic data for formations deeper than the Magothy aquifer at Chalk Point were obtained during the following sequence of events from 1972 to 1975:

1972 - Interest in the availability of water from the Patapsco Formation developed when supplies from the overlying Magothy aquifer became a limitation.

1973 - Test hole PG-Hf 31 was drilled to the top of crystalline rock, a depth of 2,454 ft, and then converted to a well screened in both the "1,000-foot" sand and the "1,500-foot" sand. A packer was installed to permit separate tests of each aquifer.

1973 - Observation well PG-Hf 32 was drilled 200 ft north of test hole PG-Hf 31, and was cased and screened in a way that permitted the separate measurement of water levels in both the "1,000-foot" and the "1,500-foot" sands. This well was used to monitor water-level changes in each of these sands as aquifer tests were conducted in them by pumping water from PG-Hf 31. Observation well PG-Hf 32 has been used since 1973 to monitor water-level trends since 1973.

1973 - Test hole PG-Hf 34 was drilled to 1,561 ft below land surface and geophysically logged to 1,270 ft at the site selected for production well PG-Hf 38.

1973 - Test hole PG-Hf 37 was drilled to 1,560 ft below land surface, geophysically logged to 520 ft, filled, and abandoned.

1974 - Production well PG-Hf 38 was drilled, screened in the "1,000-ft" sand, and tested.

1975 - Production commenced from well PG-Hf 38.

1975 - Observation well PG-Hf 40 was constructed with a screen in the "850-foot" sand. Monitoring of water levels in the well commenced.

Drilling and much of the well testing were done by Shannahan Artesian Well Company of St. Michaels, Maryland.

Selected Geophysical Data

Geophysical-logging methods provided much of the information used in this report. Table 1 shows types of geophysical logs available, intervals of the holes that were logged, and the organizations that conducted the logging. Copies of the most significant geophysical and driller's logs are presented at the end of this report. (See table 5, and figs. 14, 15, and 16).

GEOLOGIC SETTING

Geologic section A-A' (fig. 2) shows the relationship of Patapsco sands at Chalk Point to other Atlantic Coastal Plain sediments along a line extending from west of the Fall Line in Virginia to the Patuxent River. The section also shows that the Coastal Plain wedge is greater than 2,400 ft thick at Chalk Point, and that there are at least three relatively thin sand layers in the Patapsco Formation separated from one another and the overlying Magothy aquifer by thick beds of silt and clay.

Geologic section B-B' (fig. 3) presents greater detail of the geologic character of the Coastal Plain sediments of the Chalk Point area. It shows that the three major sand layers of the Patapsco Formation are present at depths of approximately 850 ft, 1,000 ft, and 1,500 ft below sea level. These sand beds have a relatively limited lateral extent. The section is based primarily on natural gamma logs for test holes drilled along a line extending northward about 1 1/2 miles from wells near the power plant (fig. 1). The logs record the natural radioactivity of the many layers of sediment penetrated by the individual drill holes. Deflections to the right on these logs indicate increasing radioactivity. Experience has shown that fine-grained sediments, such as silt and clay, generally are more radioactive than coarse-grained sediments, such as sand and gravel. Therefore, in examining the log of a specific well, those layers that cause the natural gamma trace to extend to the right are interpreted as being fine-grained

Table 1. Geophysical logs available for the Chalk Point area showing all or part of the Patapsco Formation

USGS Well No.	Date logged	Logged by[1]	Type of log[2]	Depth logged (feet)	Logged in: c = cased hole o = open hole	Amount of log presented in this report[3]	Figure number in this report
PG-Hf 31	3-27-73	USGS - T	SPR	0 - 675	o	n	-
		do.	GR	0 - 675	o	n	-
	4-27-73	do.	CR	0 - 1,130	cased from 0 to 681 ft open from 681 to 1,130 ft	n	-
	4-27-73	Birdwell Div.	MPR SP	650 - 1,132	o	p	7
		do.	BD	680 - 1,130	o	n	-
		do.	Cal	670 - 1,130	o	n	-
	4-28-73	do.	3DV	650 - 1,126	o	n	-
	4-29-73	do.	GR	0 - 1,600	cased from 0 to 681 ft open from 681 to 1,600 ft	n	-
		do.	Ntn	0 - 1,600	do.	p	10
	10-28-82	USGS - D	BT	1,320 - 1,175	c	n	-
		do.	T	0 - 1,608	c	n	-
		do.	Cal	0 - 1,608	c	n	-
		do.	BD	0 - 1,605	c	n	-
	12-06-84	USGS - T	GR	0 - 1,608	c	e	14
PG-Hf 34	10-10-73	do.	SPR	0 - 1,270	o	e	15
	10-10-73	do.	SP	0 - 1,270	o	e	15
	10-10-73	do.	GR	0 - 1,270	o	e	15
PG-Hf 40	11-06-74	do.	MPR	0 - 1,084	o	e	16
	11-06-74	do.	GR	0 - 1,084	o	e	16
	11-06-74	do.	SP	0 - 1,084	o	e	16
	11-06-74	do.	Cal	0 - 1,030	o	n	-

[1] USGS - T = U. S. Geological Survey, Towson Office; USGS - D = U. S. Geological Survey, Denver Office
[2] BD - bulk density, Cal - caliper, 3DV - 3 dimensional velocity, GR - natural gamma radioactivity, Ntn - neutron, BT - brine tracer flow, T - temperature, SP - spontaneous potential, SPR - single-point resistance, MPR - multi-point resistivity
[3] e - entire log, n - no log, p - partial log

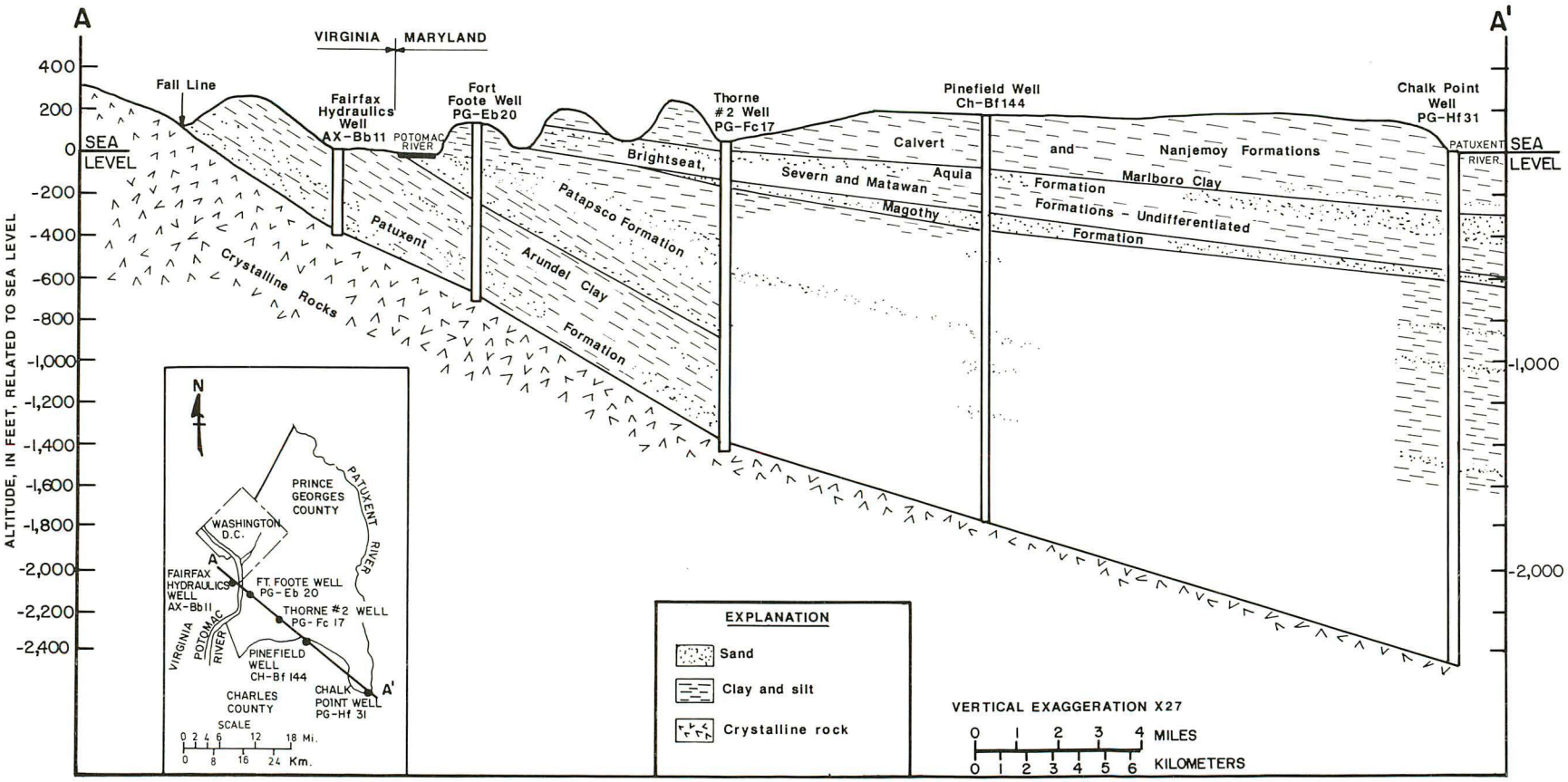


Figure 2. Geologic section A-A' from the Fall Line to the Patuxent River.

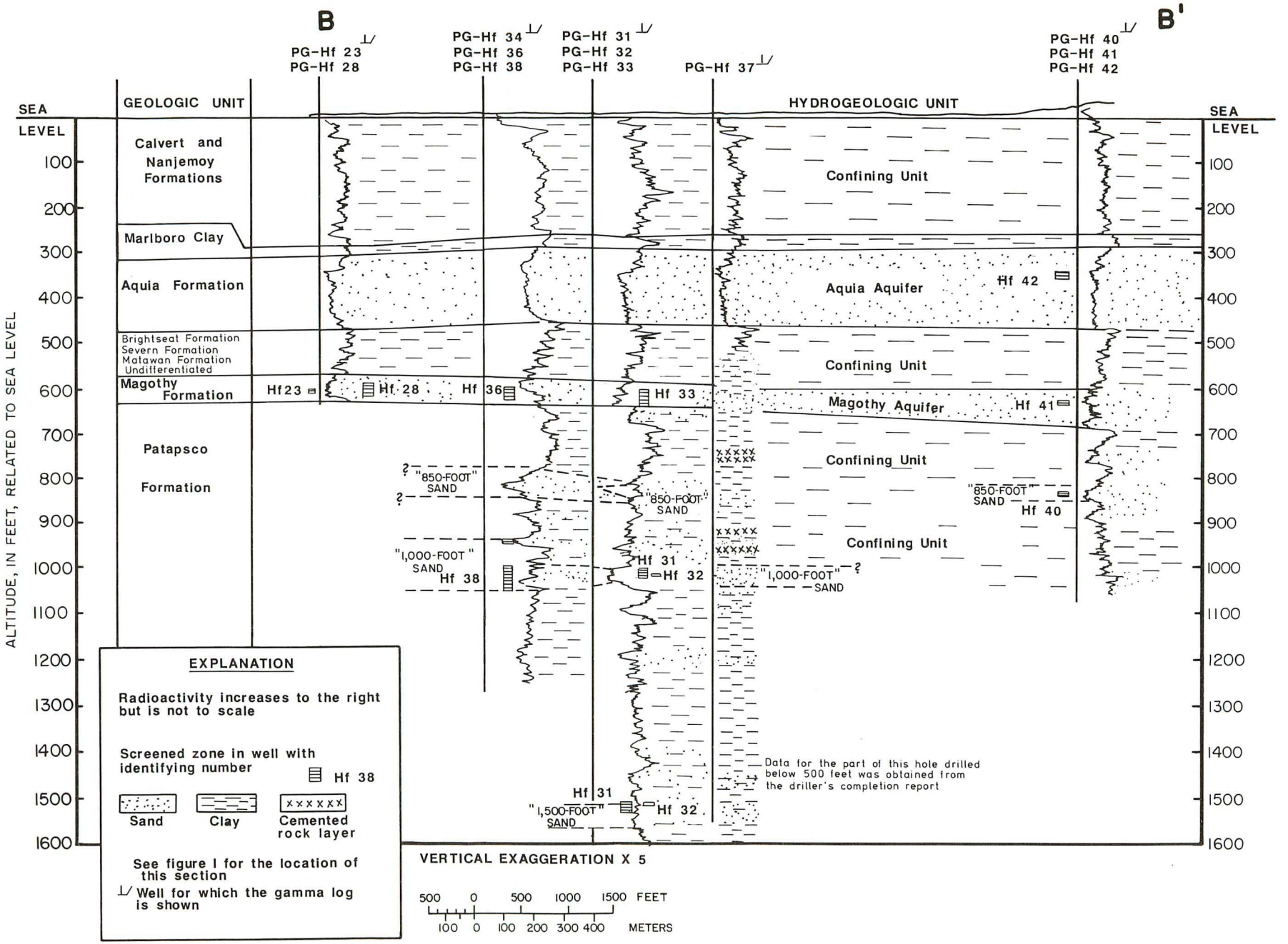


Figure 3. Geologic section B-B' of the Chalk Point area based primarily on gamma logs.

sediment, whereas traces extending to the left generally indicate sand or gravel. Descriptive logs for the test holes used to prepare section B-B' are given in table 5 (at back of this report). Most of the gamma logs were made to depths great enough to show some of the characteristics of the "1,000-foot" sand, but only one, PG-Hf 31, is deep enough to indicate the character of the "1,500-foot" sand.

GEOHYDROLOGY

The small lateral extent of some sand layers within the Patapsco Formation is a common characteristic of sediments deposited in fluvial continental environments. This characteristic makes it difficult to determine the extent of recharge to water-bearing sands. Viewed with regard to its hydrologic characteristics, the Patapsco Formation contains several significant layers of sand, some of which may be virtually isolated from all others and some of which are probably interconnected. The clay layers are confining beds that impede vertical and horizontal movement of water between individual sand beds of the Patapsco Formation and also impede the movement between Patapsco sand beds and the overlying Magothy Formation.

Although only three wells have been geophysically logged in the Patapsco Formation, analysis of available data suggests that the thickness of individual sand layers is quite variable. Therefore, prediction of the occurrence of specific water-bearing sands at sites not yet tested, is difficult.

The hydraulic characteristics of three of the thicker sand layers of the Patapsco Formation at Chalk Point were estimated by aquifer-test methods developed by Theis (1935) and Cooper and Jacob (1946). Drawdown data from observation well PG-Hf 32 were used to obtain values for the transmissivities and storage coefficients of the "1,000-foot" and "1,500-foot" sands. Using procedures described by Driscoll (1986), recovery data were used to estimate values for the transmissivity of the "850-foot" sand in well PG-Hf 40 and the "1,500-foot" sand in pumping well PG-Hf 31. The tests consisted of pumping each sand at a uniform rate for at least 24 hours, recording the drawdown and recovery of water levels at selected time intervals, and using the following formulas to estimate the transmissivities and storage coefficients for the aquifers:

$$T = \frac{35Q}{\Delta s}$$

where

T = transmissivity, in feet squared per day;

Q = discharge, in gallons per minute;

Δs (drawdown data) = drawdown, in feet of the water level in the observation well during one log cycle of a semilogarithmic plot of time in minutes as a function of drawdown; and

Δs (recovery data) = residual drawdown, in feet, of the water level in the pumping well during one log cycle of a semilogarithmic plot of t/t' as a function of residual drawdown where:

$$t/t' = \frac{\text{Time, in minutes, since pumping started}}{\text{Time, in minutes, since pumping stopped}}.$$

The formula used to determine values for the storage coefficient is expressed as follows:

$$S = \frac{2.25 \times T \times to}{r^2}$$

where

S = storage coefficient;

to = time intercept of zero axis, in days; and

r = distance from pumping well to the observation well, in feet.

Table 2 summarizes the pump test data for the Patapsco sands.

Aquifer Characteristics

"850-Foot" Sand

Stratigraphy

The thickness of the "850-foot" sand of the Patapsco Formation varies considerably over short lateral distances as may be seen in geologic section B-B' (fig. 3). The gamma logs indicate the combined thickness of the sand layers in the "850-foot" sand is at least 65 ft at well PG-Hf 34, about 10 ft at PG-Hf 31, and approximately 26 ft at well PG-Hf 40.

Hydraulic characteristics

Test hole PG-Hf 40, drilled to a depth of 1,095 ft, was the pilot hole for the cluster of observation wells constructed near Eagle Harbor for monitoring the effects of pumpage from the Aquia, Magothy, and Patapsco aquifers. It was originally intended that a well be screened in the "1,000-foot" sand to monitor pumpage from production well PG-Hf 38. However, the geologic data from PG-Hf 40 show, that there is no significant sand at 1,000 ft. As may be seen on the gamma-ray and resistivity logs for PG-Hf 40 (fig. 4), there are three distinct fining-upward sequences between depths 930 and 710 ft that grade from coarse basal sands, 10 to 20 ft thick, to finer-grained layers of silt and clay. These fining-upward sequences are characteristic of sedimentation in a fluvial depositional environment. The screen for PG-Hf 40 was set in the middle sequence because it contains the thickest sand and appeared to have the best water-bearing characteristics.

Table 2. Pump test data for three Patapsco aquifers at Chalk Point

Aquifer		Well pumped	Well observed	Date of test	Length of screen in the pumped well (feet)	Pumping rate (gal/min)	Type of water-level data analyzed	Transmissivity from aquifer tests (ft^2/d)		Storage coefficient from aquifer tests	Aquifer test curve plotted in figure number
Designation	Approximate depth below sea level (feet)	PG-Hf	PG-Hf					Each test	Average (rounded)		
"850-foot" sand	850	40	40	February 1975	20	21	Recovery in pumped well	570	570	---	5
"1,000-foot" sand	1,000	31	32	June 1973	27	80	Drawdown in observation well	1,077	1,500	0.000084	8A
		38	32	March 1974	67	513	do.	1,841		0.00016	8B
"1,500-foot" sand	1,500	31	31	June 1973	25	93	Recovery in pumped well	1,085	930	---	11
		31	32	June 1973	25	93	Drawdown in observation well	775		0.000086	11

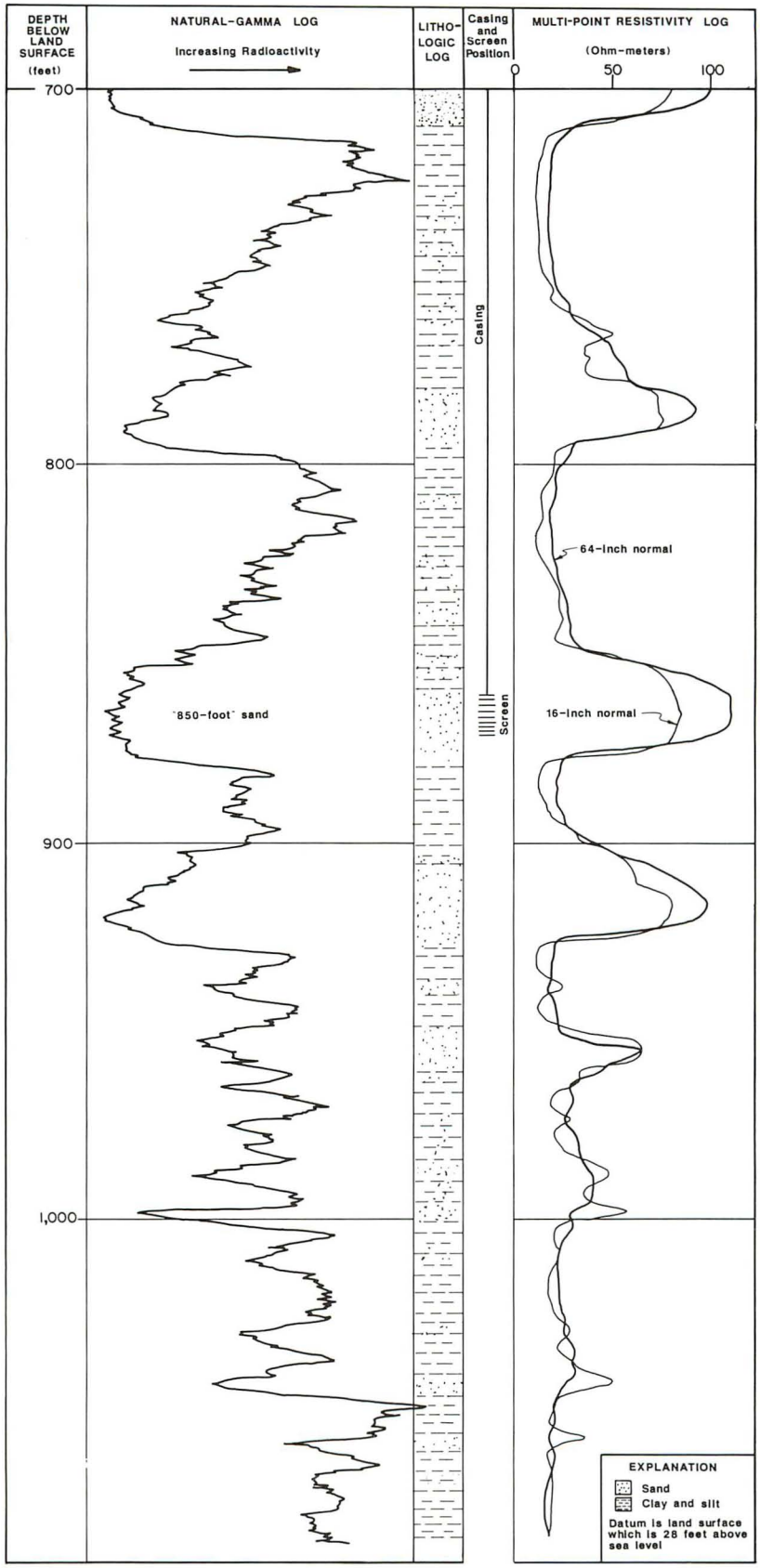


Figure 4. Geophysical logs showing details of the part of test hole PG-Hf 40 from 700 to 1,084 feet below land surface.

A pumping test of the "850-foot" sand was conducted in February 1975 by pumping well PG-Hf 40 at 21 gal/min for 24 hours. Water levels were measured during the drawdown and recovery phases of the test. The residual drawdown data is shown in figure 5. Calculations based on the data from the pumping test indicate the transmissivity of the screened sand is about 570 ft^2/d.

As may be seen on the graph of the residual drawdown data presented in figure 5, the water-level measurements made during the early parts of the test (larger t/t'values) fall on a very steep slope relative to the slope of the line defined by the later data (smaller t/t' values). This difference in slope is probably due to the low efficiency of the wells. The steep slope of the early recovery data represents the relatively rapid flow of water into the well to reach a level in the casing equivalent to the head in the aquifer outside the casing. Water levels measured during the first 26 minutes of recovery probably reflect heads during this transition period. The subsequent parts of the curve, the part after the head in the casing reached equilibrium with the head in the aquifer, are probably more representative of aquifer properties because very small quantities of water moved into the well.

Water levels in PG-Hf 40 have declined at a rather uniform rate since they were first measured at the time the well was completed in 1975. The hydrographs for this well (see fig. 6 of this report and fig. 10 of Mack, Wheeler, and Curtin, 1983) show that the water level in 1974 was 10 ft above sea level and that it declined to 17 ft below sea level by 1986. Some of the decline may be the result of a regional lowering of the potentiometric surface due to pumpage from the wells screened in the same zone several miles away. Another possible cause of the decline may be the upward leakage of water into the Magothy aquifer in response to water-level declines in the Magothy. Some of decline, however, appears to be related to pumpage from the "1,000-foot" sand. Comparison of the water levels and pumpage data plotted in figure 6 suggests that there may be a substantial hydrologic connection between the "850-foot" sand and the "1,000-foot" sand. For example, water-level rises that occurred in the "850-foot" sand in August 1977 and April 1979 match pumpage declines that occurred at the same time in the "1,000-foot" sand. The gravel pack of the production well, which is continuous from the base of the "1,000-foot" sand to the top of the "850-foot" sand, is a probable artificial hydrologic connection permitting movement of some water between the two sands. However, other parts of the graph show other trends such as the decline of water levels in the "850-foot" sand in June 1980, when pumpage from the "1,000-foot" sand was substantially reduced.

Chemical quality

A chemical analysis of water from the "850-foot" sand is presented in table 3. It shows that, except for the concentration of dissolved iron, which was 1,300 µg/L, all constituents tested met the drinking water standards of the U.S. Environmental Protection Agency (1977).

"1,000-Foot" Sand

All pumpage from the Patapsco Formation at Chalk Point has been from one well, PG-Hf 38, screened in the "1,000-foot" sand.

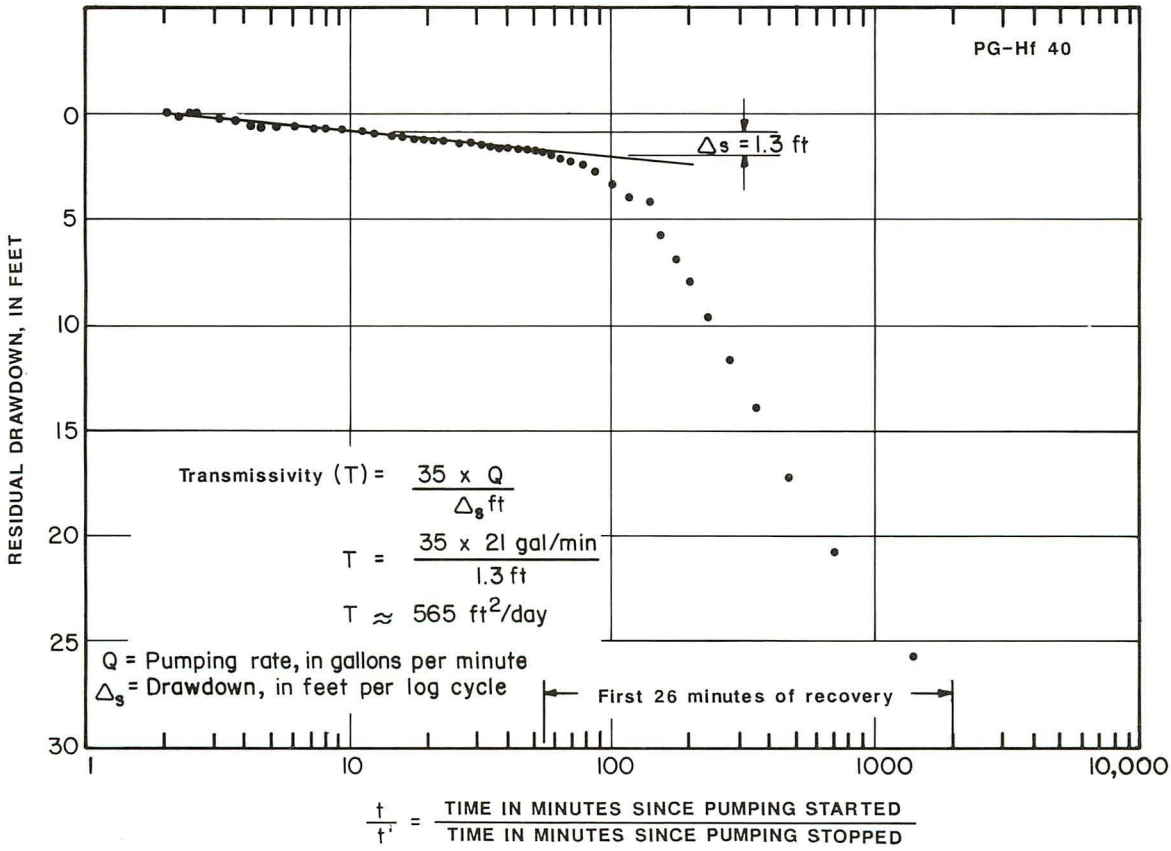


Figure 5. Residual drawdown data and transmissivity calculations for the February 1975 pumping test on well PG-Hf 40 tapping the "850-foot" sand.

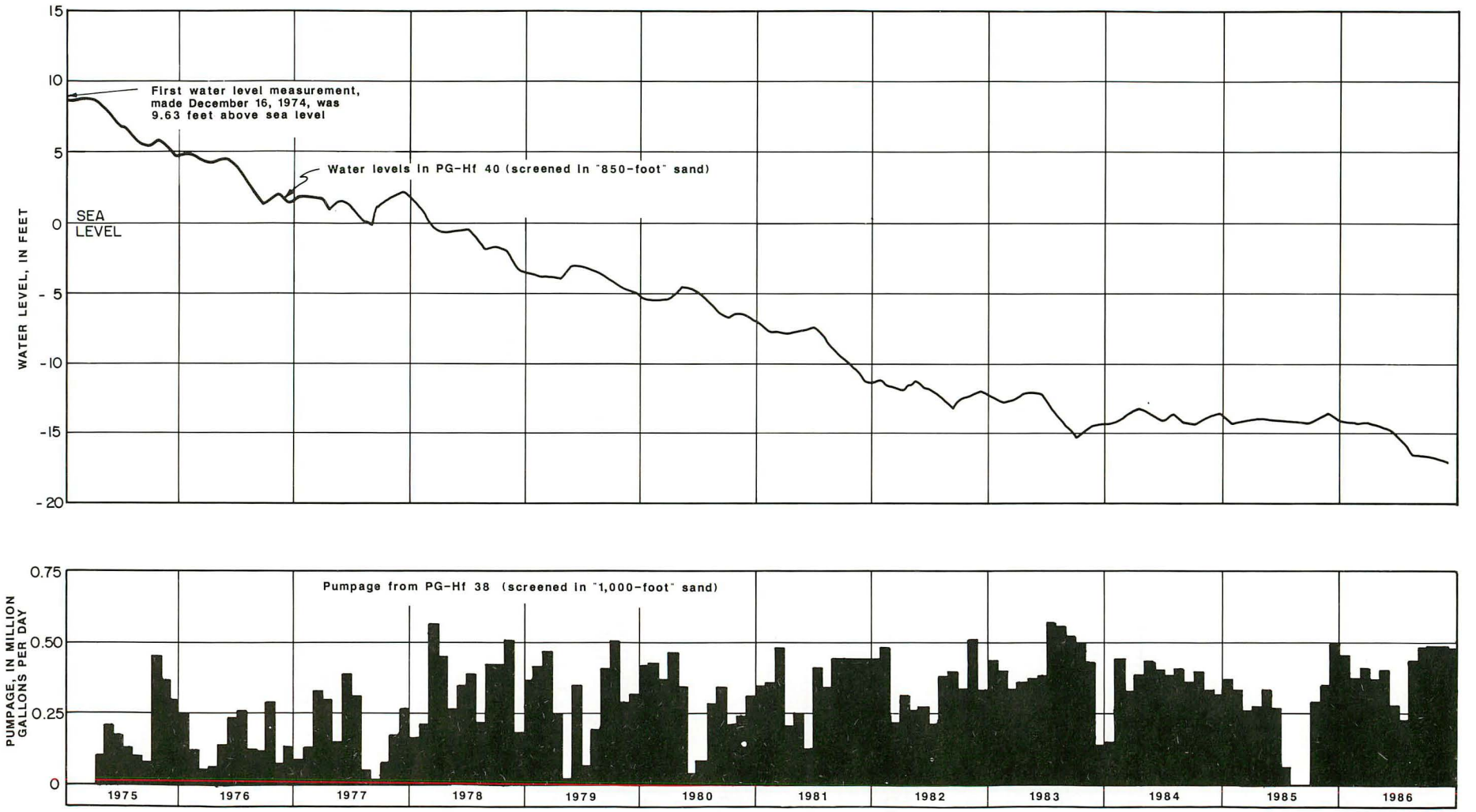


Figure 6. Water-level fluctuations in observation well PG-Hf 40, screened in the "850-foot" sand, and pumpage from production well PG-Hf 38, screened in the "1,000-foot" sand.

Table 3. Chemical analyses of ground-water samples from Patapsco aquifers at Chalk Point

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

	Test well PG-Hf 31	Test well PG-Hf 31	Production well PG-Hf 38	Production well PG-Hf 38	Observation well PG-Hf 40
Screen position (feet below sea level)	996 to 1,023	1,506 to 1,531	954 to 964 999 to 1,056	954 to 964 999 to 1,056	832 to 842
Date of collection	6-14-73	6-27-73	3-26-74	8-31-84	1-24-75
Analysis by	USGS	Penniman and Brown, Inc.	USGS	USGS	USGS
Aquifer designation	"1,000-foot" sand	"1,500-foot" sand	"1,000-foot" sand	"1,000-foot" sand	"850-foot" sand
Temperature (Degrees C)	22.0	--	--	24.0	21.5
Dissolved silica (SiO_2) (mg/L)	11	17.5	9.6	9.8	9.5
Total iron (Fe) (µg/L)	630	<100	180	770	1,300
Total manganese (Mn) (µg/L)	0.0	<50	80	9	20
Dissolved calcium (Ca) (mg/L)	13	--	14	14	23
Dissolved magnesium (Mg) (mg/L)	8.4	--	8.7	8.7	13
Dissolved sodium (Na) (mg/L)	23	--	24	21	15
Dissolved potassium (K) (mg/L)	9.2	--	10	9.1	8.3
Bicarbonate (HCO_3) (mg/L)	141	--	141	--	170
Carbonate (CO_3) (mg/L)	0	--	1	--	0
Dissolved sulfate (SO_4) (mg/L)	11.	<1.0	11	14	3.3
Dissolved chloride (Cl) (mg/L)	1.0	5.0	0.6	1.1	1.2
Dissolved fluoride (F) (mg/L)	0.4	--	0.3	0.3	0.8
Dissolved nitrate (NO_3) (mg/L)	0.18	--	--	--	--
Dissolved solids (sum of constituents) (mg/L)	147	153	149	--	158
Hardness (Ca, Mg) (mg/L)	67	5.7	71	--	110
Non-carbonate hardness (mg/L)	0	--	0	--	0
Specific conductance (µS/cm at 25°C)	245	--	256	250	--
pH	7.8	7.1	8.4	7.6	6.2

Stratigraphy

Section B-B' (fig. 3) shows that the combined thickness of the water-bearing beds in the "1,000-foot" sand of the Patapsco Formation ranges from at least 65 ft at production well PG-Hf 38, to 29 ft at test hole PG-Hf 31, to zero at PG-Hf 40. Figure 7, which includes geophysical logs of test hole PG-Hf 31 from depth 800 ft to 1,131 ft, shows the positions of the sand layers, the interbedded clay layers, and the well screen in the "1,000-foot" sand.

Hydraulic characteristics

Two pumping tests were conducted on the "1,000-foot" sand. For the first test, well PG-Hf 31 was pumped at 81 gal/min for 72 hours in June 1973. Water-level declines due to this pumping were observed in the pumped well and in observation well PG-Hf 32 located 200 ft to the north. Figure 1 shows locations of the wells. Water-level drawdown data obtained from the observation well during the test and presented in figure 8A indicate the transmissivity of the screened sand is about 1,100 ft^2/d and the storage coefficient is about 0.00008. Departures of the data points from the straight line between 10 and 100 minutes are probably due to fluctuations in the pumping rate during the drawdown phase of the pumping test. Departures in the later part of the curve may be due to tidal fluctuations in the nearby Patuxent River. This first test was completed before production well PG-Hf 38 was drilled.

The second test was made by pumping production well PG-Hf 38 at 500 gal/min for 24 hours in March 1974. The effect of that pumping was observed in observation well PG-Hf 32, 1,200 feet to the north, and in production well PG-Hf 38 itself. Water-level drawdown data obtained from the observation well during this test and presented in figure 8B indicate the transmissivity and storage coefficient of the combined sands screened in the "1,000-foot" sand by well PG-Hf 38 are about 1,800 ft^2/d and 0.00016, respectively.

Differences in estimated transmissivity values from the two tests are probably due in part to the differences in the way the pumped wells were screened and gravel packed (fig. 3). For the first test, only twenty-seven feet of observation well PG-Hf 31 were screened from 996 to 1,023 ft below sea level in the lower of two sandy zones. For the second test, a total of 67 feet of well PG-Hf 38 was screened in both the lower and an upper sand zone with screens set from 954 to 964 ft and from 999 to 1,056 ft below sea level. The gravel pack in the well extended up the annular space outside the casing to the "850-foot" sand. If the confining layer separating the upper and lower sand zones screened in PG-Hf 38 is relatively extensive, the value of 1,100 ft^2/d obtained from pumping well PG-Hf 31 during the first test is probably most representative of the transmissivity of the lower sand alone and the value of 1,800 ft^2/d obtained in the second test is probably representative of the combined transmissivity of both the upper and lower sands and possibly some of the overlying sands.

Water from the "1,000-foot" sand has been used by the power plant since 1975 to supplement supplies taken from the Magothy aquifer. Pumpage and random water-level measurements from well PG-Hf 38 are presented in figure 9.

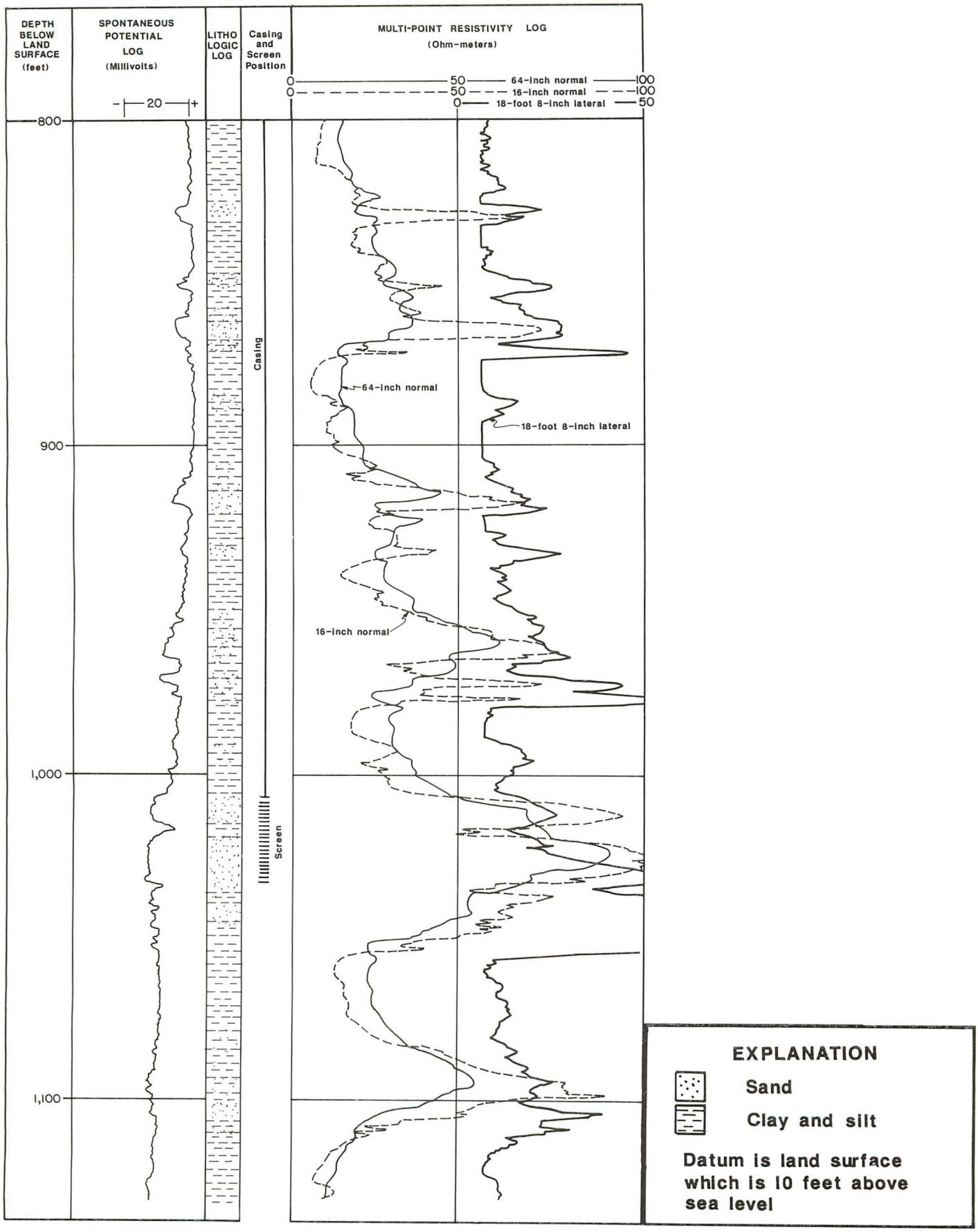
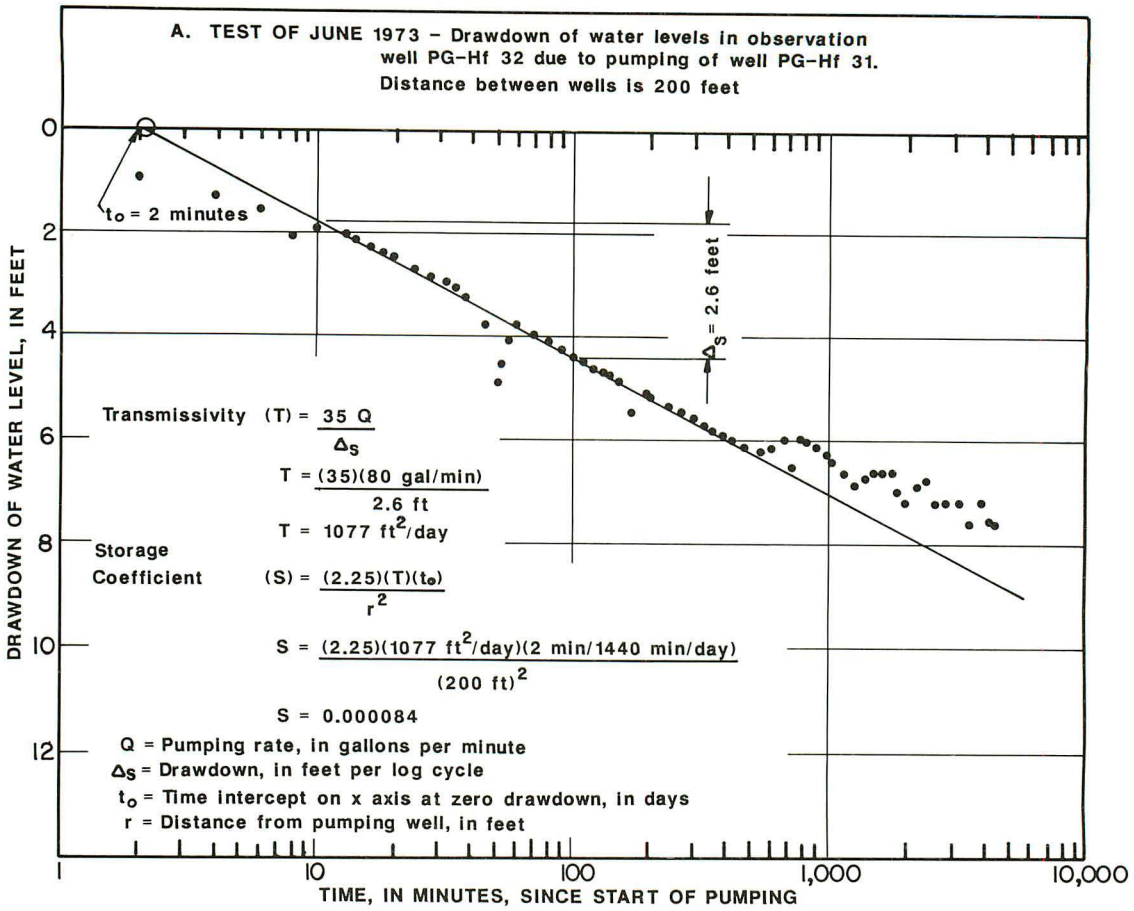


Figure 7. Geophysical logs showing details of the part of test hole PG-Hf 31 from 800 to 1,131 feet below land surface.



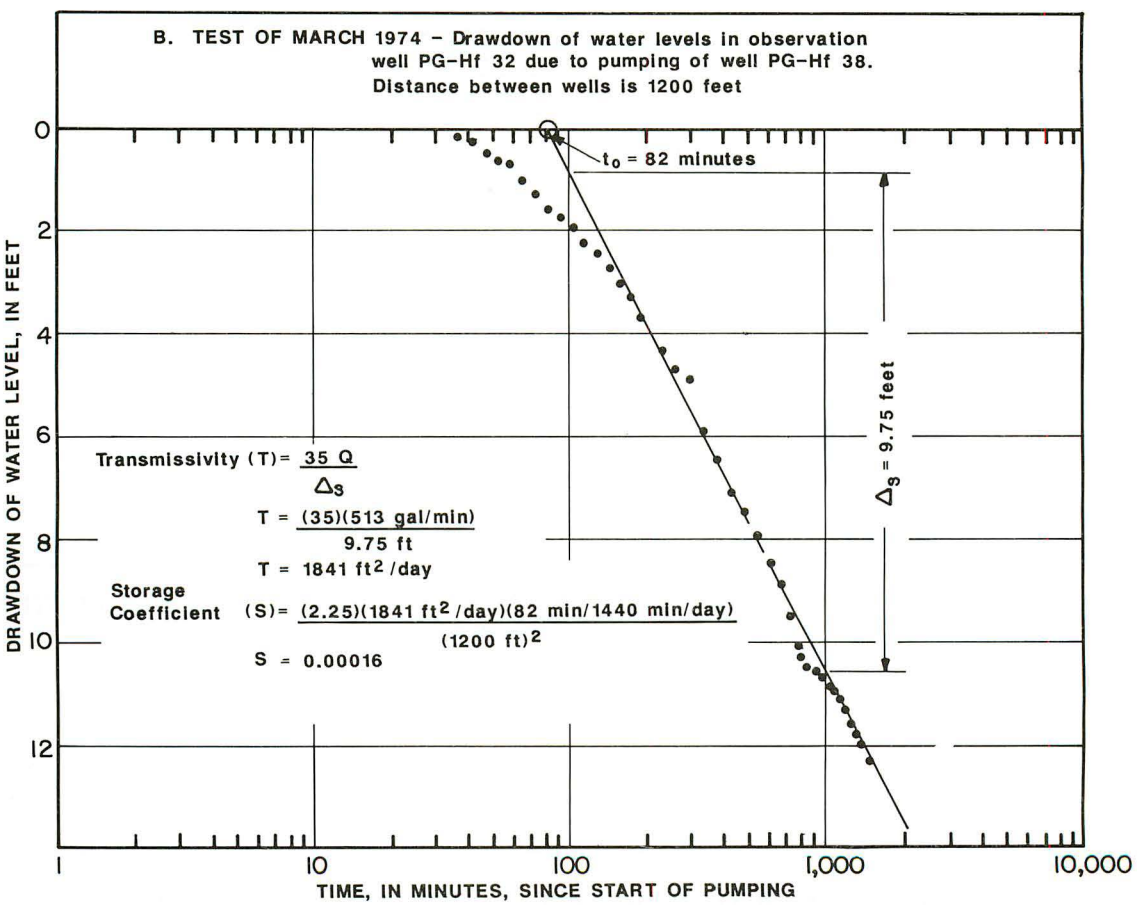


Figure 8. Aquifer test data and parameter calculations for observation well PG-Hf 32 during two pumping tests of the "1,000-foot" sand.

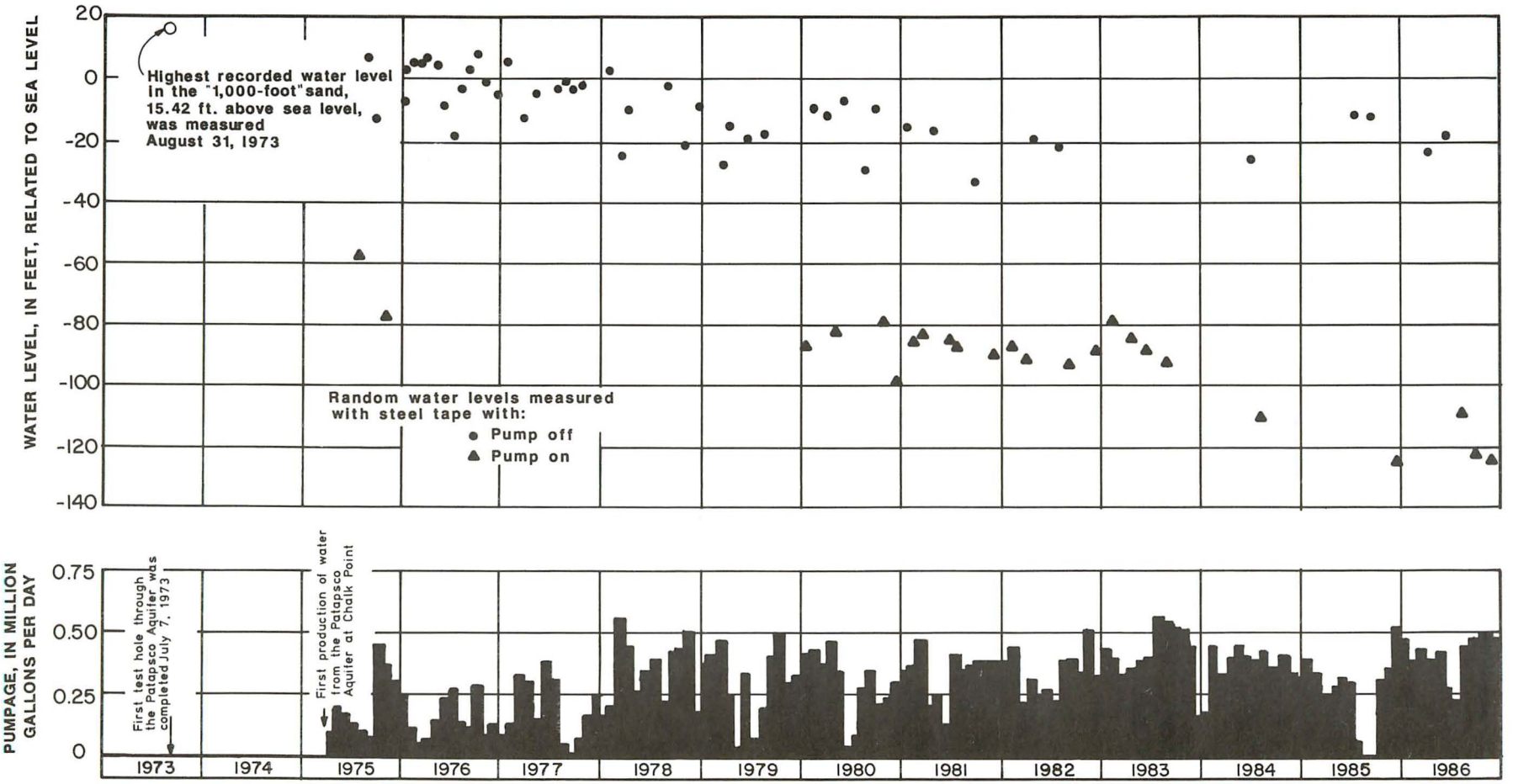


Figure 9. Water levels and pumpage from well PG-Hf 38, screened in the "1,000-foot" sand.

The hydrograph shows that since pumping began, monthly pumpage has ranged from zero to over 0.5 Mgal/d. The average rate of pumping has increased from about 0.2 Mgal/d in 1975 to over 0.4 Mgal/d in 1986. Some of the water-level measurements presented in figure 9 were made while the pump in PG-Hf 38 was running and some were made when the pump was off. Comparison of the pumping and non-pumping water levels in 1986 shows there was about 100 ft of drawdown when well PG-Hf 38 was pumping.

Random water levels measured in observation well PG-Hf 32 are presented in figure 12 with pumpage from production well PG-Hf 38. The graph shows a close correlation between pumpage and water levels as they declined from 15 ft above sea level in 1973 to 23 ft below sea level in 1986. However, during a period of more than 2 months in 1985, when no water was pumped from the aquifer at Chalk Point, water levels recovered to within 2 1/2 ft of sea level.

Graphs have been published of daily pumpage from well PG-Hf 38 since production from the Patapsco commenced in 1975 (Mack, Wheeler, and Curtin, 1983).

Chemical quality

The chemical analyses for water samples from the "1,000-foot" sand are presented in table 3. They show that, except for the concentration of iron, which was 770 µg/L, all constituents tested met the drinking water standards of the U.S. Environmental Protection Agency (1977).

"1,500-Foot" Sand

Stratigraphy

The "1,500-foot" sand of the Patapsco Formation has been penetrated and screened by wells PG-Hf 31 and PG-Hf 32, which are 200 ft from one another (fig. 1). Water has not been pumped from the "1,500-foot" sand since it was tested in 1973.

A neutron log and a gamma-ray log for the part of test hole PG-Hf 31 from depth 1,200 to 1,600 ft are given in figure 10. The gamma-ray log shows more natural radioactivity than is usually observed in the best aquifers, suggesting that the water-bearing properties of the "1,500-foot" sand are rather limited because they probably contain much fine-grained sediment. The deeper screen in well PG-Hf 31 is set from 1,506 to 1,531 ft below sea level.

Hydraulic characteristics

One pumping test was made on the "1,500-foot" sand. Observations of water-level changes were made in the pumped well, PG-Hf 31, and the observation well, PG-Hf 32, during the drawdown and recovery phases of the test. PG-Hf 31 was pumped at 78 gal/min for 72 hours. Data for the recovery phase of

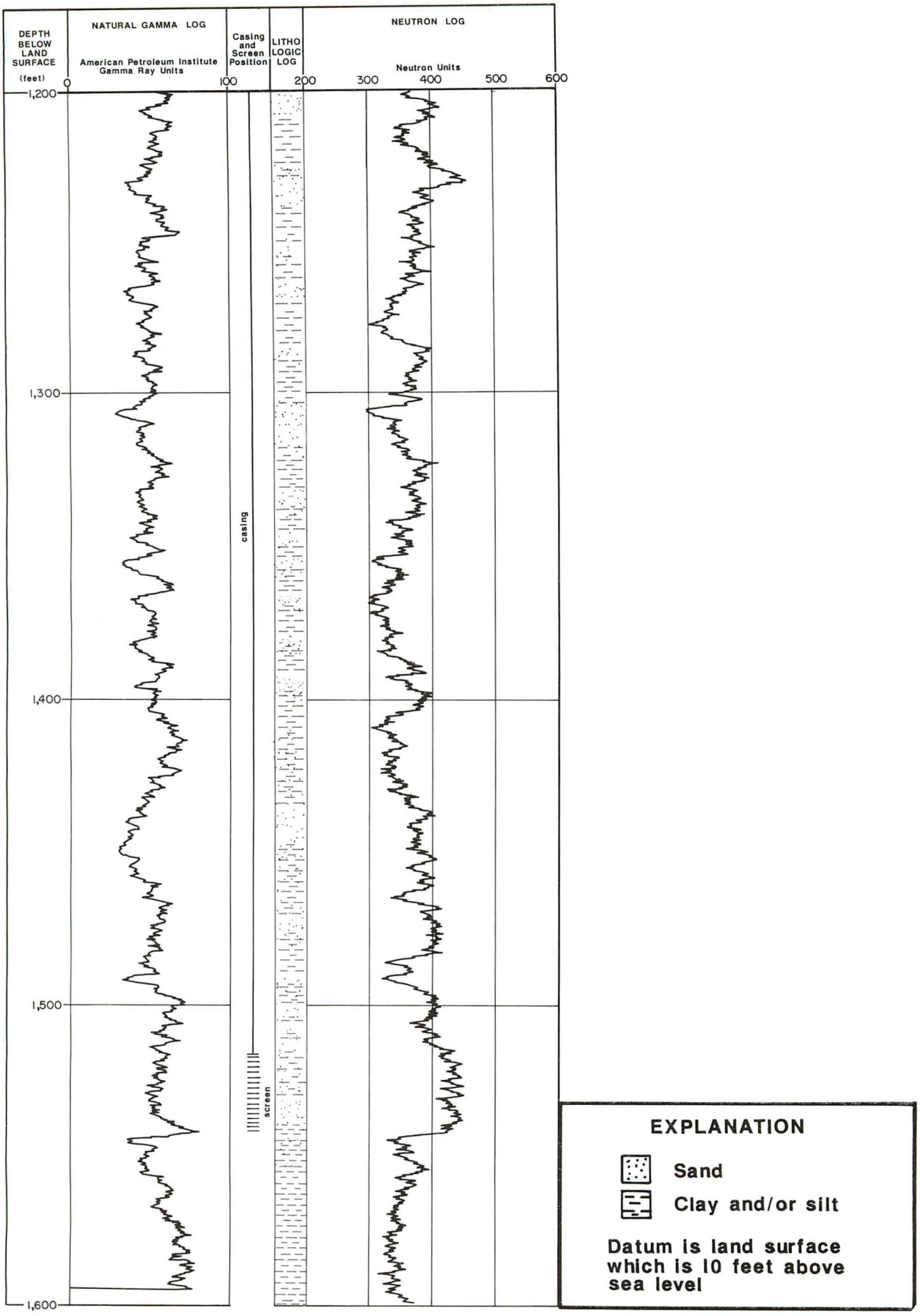


Figure 10. Geophysical logs showing details of the part of test hole PG-Hf 31 from 1,200 feet to 1,600 feet below land surface.

the test, plotted in figure 11, indicate the transmissivity of the 25-ft screened interval is in the range of 910 ft^2/d (well PG-Hf 31) to 720 ft^2/d (well PG-Hf 32).

Water levels in well PG-Hf 32, screened in the "1,500-foot" sand, were about 15 ft above sea level when the well was completed and tested in 1973. No water has been pumped from the "1,500-foot" sand in this area since the pumping test. Periodic readings made in well PG-Hf 32 since 1975 were used to prepare the upper hydrograph in figure 12, which shows a steady decline in water levels to about 5 ft above sea level in 1982 and a steeper decline to 1 ft below sea level by 1986. The decline may have been caused by pumping from the aquifer several miles away or by leakage upward through confining beds to the "1,000-foot" sand, where water levels are lower. The great thickness of several hundred feet and the probable low vertical hydraulic conductivity of confining beds suggests that upward leakage is not a major factor causing the decline.

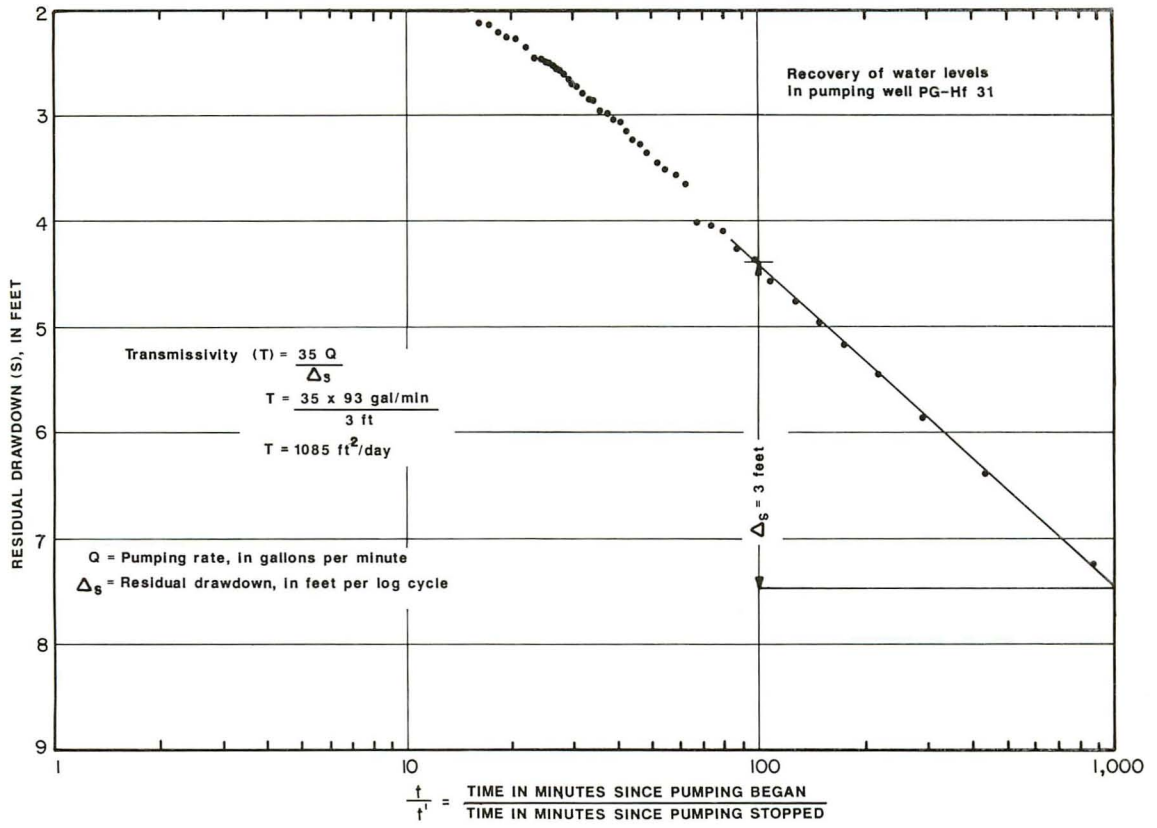
Chemical quality

The chemical analysis of water collected after 72 hours of test pumping the aquifer is presented in table 3. It shows that the water is softer (5 mg/L) and has slightly more silica (17.5 mg/L) than water from the other Patapsco sands at Chalk Point. Concentrations of all constituents tested met the drinking-water standards of the U.S. Environmental Protection Agency.

Interaquifer flow - Comparison of Water Levels of the Individual Aquifers

Graphs of pumpage from the "1,000-foot" sand and water levels measured in wells PG-Hf 32 ("1,000-foot" sand), PG-Hf 32 ("1,500-foot" sand), and PG-Hf 40 ("850-foot" sand) on a routine basis since 1975, are presented in figure 12. Earliest measured water levels for aquifers of the Patapsco Formation at Chalk Point were obtained in 1973 (table 4). They show that water levels in each sand have been declining at least since 1975 and that the greatest decline has occurred in the producing sand ("1,000-foot" sand). The declines are summarized as follows:

Sand designation	Static water levels above (+) or below (-) sea level			Amount of decline (ft)
	1973	1975	1986	
"850-foot"	Not yet drilled	+10	-17	>27
"1,000-foot"	+15	+8	-23	38
"1,500-foot"	+15	+12	-1	16



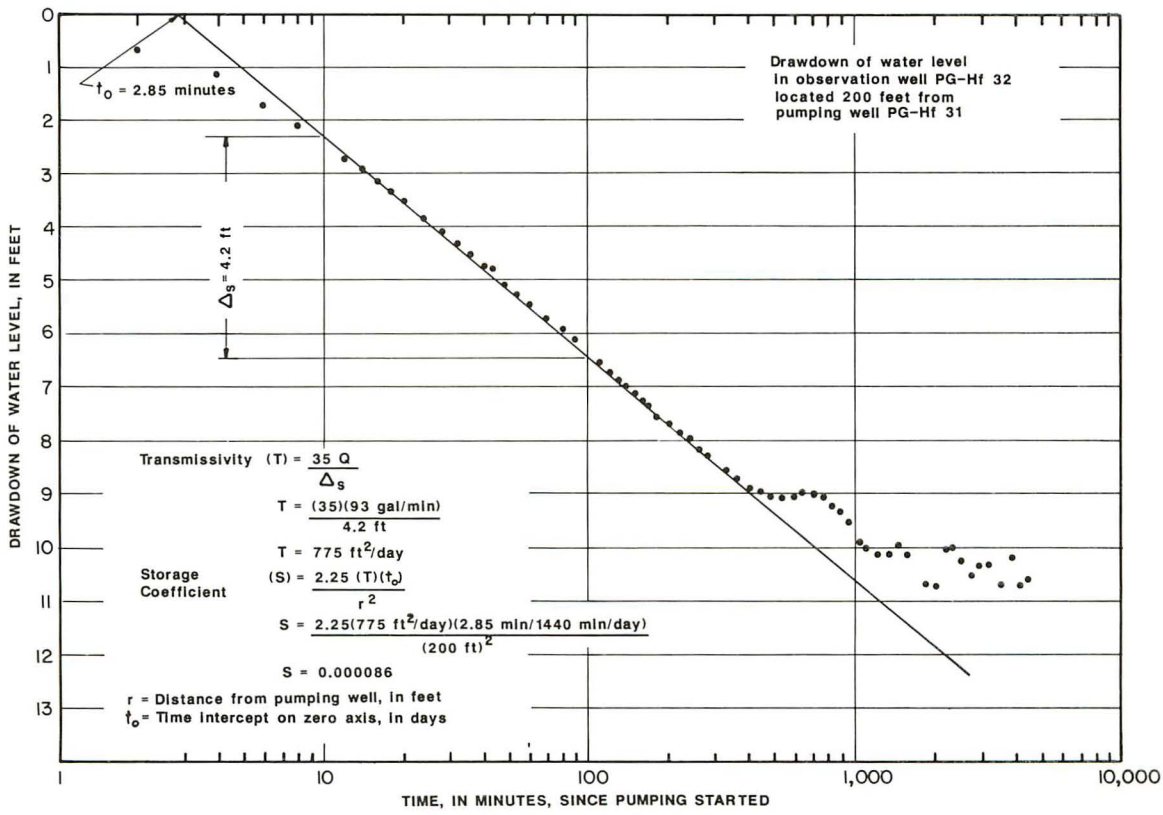


Figure 11. Aquifer test data and parameter calculations for wells PG-Hf 31 and PG-Hf 32 during the June 1973 pumping test of the "1,500-foot" sand.

Table 4. Data for selected wells and test holes at or near Chalk Point

USGS Well No. PG-Hf	State of Maryland Permit No.	Date Completed	Altitude of land surface (ft)	Screen position (ft below sea level)	Screen diameter (inches)	Depth reached by drilling (ft below land surface)	Aquifer
23	47061	1962	7	601 - 606	2	675	Magothy
24	47129	1962	8.2	404 - 409	2	454	Aquia
25	47062	1962	13.6	351 - 357	2	454	Aquia
26	49920	1963	14	591 - 621	6	638	Magothy
27	49921	1963	16	581 - 617	6	650	Magothy
28	51271	1963	6.8	587 - 616	6	640	Magothy
29	-	-	12	Not screened	-	-	Pleistocene
30	72-0047	1971	60	335 - 366	4	426	Aquia
31	73-0065	1973	10	996 - 1,023 1,506 - 1,531	4 4	2,453	Patapsco - "1,000-foot" sand Patapsco - "1,500-foot" sand
32	73-0065	1973	11	1,014 - 1,019 1,510 - 1,515	2 2	1,545	Patapsco - "1,000-foot" sand Patapsco - "1,500-foot" sand
33	73-0065	1973	11	585 - 628	10	639	Magothy
34	73-0140	1973	10	Not screened	-	1,561	-
35	72-0086	1972	11.2	388 - 419	4	430	Aquia
36	73-0140	1973	10	595 - 624	10	634	Magothy
37	73-0141	1973	10	Not screened	-	1,560	-
38	73-0172	1974	10	954 - 964 999 - 1,056	6	1,066	Patapsco - "1,000-foot" sand
39	73-0147	1973	165	Open hole 137 - 175	No Screen	340	Nanjemoy
40	73-0298	1975	28	832 - 842	4	1,095	Patapsco - "850-foot" sand
41	73-0297	1974	28	620 - 630	4	675	Magothy
42	73-0294	1974	28	339 - 349	4	395	Aquia

[1] Purpose of well: T = test of lithologic character; O = observation of water levels; P = production of water for power plant; D = domestic supply

Table 4. Data for selected wells and test holes at or near Chalk Point -- continued

Early water levels related to sea level (in ft)		Pumping Test Data				
Water level	Date	Pumping level related to sea level (in ft)	Pumping Rate (gal/min)	Date	Purpose of well[1]	Remarks
+28	5/16/62	-	-	-	T, O	First test hole to the Magothy aquifer at Chalk Point.
+18.75	5/16/62	-	-	-	T, O	First test hole and observation well in the Aquia Formation at Chalk Point.
+18.55	5/18/62	-	-	-	T, O	-
+27.2	2/08/63	-215	385	2/08/63	P	Owner's No. 2.
+25.7	6/09/63	-166	400	4/04/63	P	Owner's No. 3.
Flowing	5/16/63	-215	420	5/17/63	P	Owner's No. 1.
+0.5	4/04/63	-	-	-	D	Dug well source of water for the home at Chalk Point before PEPCO became owner.
+12	12/14/71	-30	63	12/14/71	P	Source of water for concrete "batch" plant.
+15.54 +15.85	6/11/73 5/16/73	-25.5 -35.7	80 78	6/14/73 6/28/73	T	Test hole drilled to basement. Deepest geophysical log to 1,608 feet.
+15.11 +15.58	8/23/73 8/23/73	-	-	-	O	Observation well used during pumping test on "1,000-foot" and "1,500-foot" sands.
-24	9/05/73	-195	511	9/05/73	P	Owner's No. 5.
-	-	-	-	-	T	Probe hole for testing "1,000-foot" sands. Filled, sealed and abandoned.
+9	5/15/72	-22.5	73	5/15/72	P, O	Used as source for sanitary facilities for construction workers until 1974.
-22	11/28/73	-191	506	11/28/73	P	Owner's No. 6A.
-	-	-	-	-	T	Geophysical log to 520 feet. Filled, sealed and abandoned.
3	3/13/74	-88	513	3/03/74	P	Owner's No. 6B.
+80	12/31/73	+15	5	12/31/73	D	Supply for home constructed by Hessick Investment Corp. on Christ Church Road, 3 miles northwest of the power plant.
+10	1/23/75	-80	21	1/24/75	O	Permanent observation well for monitoring the "850-foot" sand in the Patapsco Formation.
-5	1/13/75	-74	60	1/14/75	O	Permanent observation well for monitoring the Magothy aquifer.
+10	12/19/75	-81	60	12/20/75	O	Permanent observation well for monitoring the Aquia Formation.

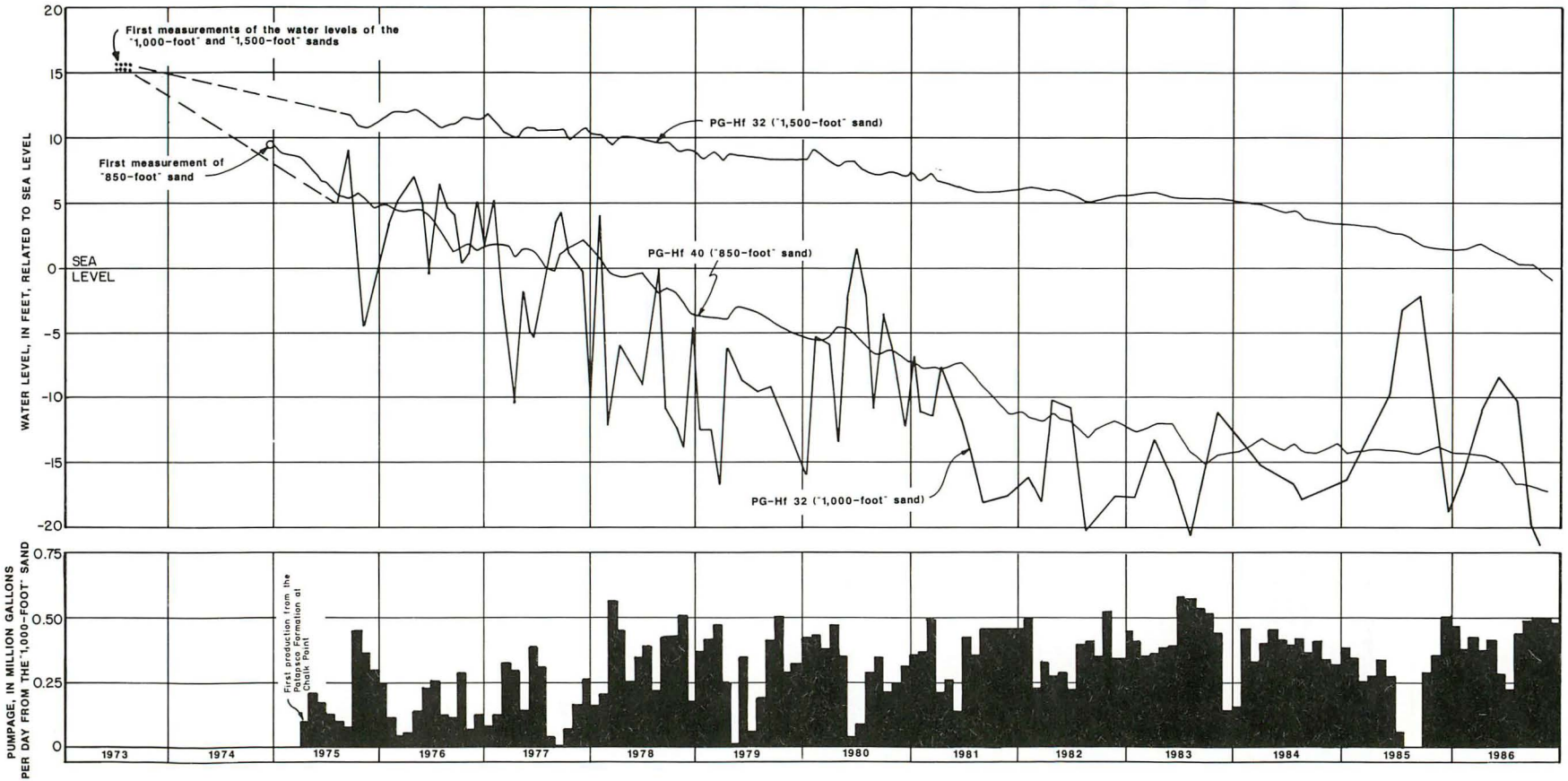


Figure 12. Water-level fluctuations in the "850-foot", "1,000-foot", and "1,500-foot" sands and pumpage from PG-Hf 38.

Comparison of the water-level and pumpage hydrographs presented in figure 12 shows that water levels in the "850-foot" sand, measured in well PG-Hf 40, were usually nearly as deep and sometimes even deeper than water levels in the "1,000-foot" sand, measured in well PG-Hf 32, which is much closer to pumping well PG-Hf 38. As mentioned in the section of this report describing the "850-foot" sand, there probably are hydrologic connections, both natural and artificial, between the two sands. Such connections would permit flow of water between the sands and help explain why water levels in the "850-foot" sand are nearly as deep as levels in the "1,000-foot" sand.

Water levels in the "1,500-foot" sand, were the highest of the three Patapsco sands monitored at Chalk Point. Although that sand is not pumped, there is known to be a small upward flow of water from it to the "1,000-foot" sand through well PG-Hf 31, which is screened in both the "1,000-foot" and "1,500-foot" sands. There is no packer in well PG-Hf 31 to prevent flow between the "1,000-foot" and "1,500-foot" sands.

Figure 13 shows water-level fluctuations that were caused in all three aquifers by tides in the nearby Patuxent River. Data in this illustration were obtained from continuous water-level recorders installed on the wells indicated. The fluctuations range from 0.4 to 0.6 ft/d.

SUMMARY

Geological data from test wells drilled along a north-south-trending 1 1/2-mile long line at Chalk Point indicate that the Patapsco Formation contains several thin sand layers that differ in lithologic character over relatively short distances. Hydrologic data obtained from the wells include transmissivity values, water levels, pumpage, and quality of water.

Transmissivity values of each of the three sands tested by pumping are probably representative of the thin sands of the Patapsco Formation. The transmissivity of the "850-foot" sand is approximately 570 ft^2/d; of the "1,000-foot" sand, approximately 1,800 ft^2/d at one site and 1,100 ft^2/d at another; and of the "1,500-foot" sand, approximately 820 ft^2/d.

Water levels in the three sands have been monitored since observation wells were completed in 1973 and 1975. They have declined 27 ft in the "850-foot" sand from 1974 to 1986, 38 ft in the "1,000-foot" sand from 1973 to 1986, and 16 ft in the "1,500-foot" sand from 1973 to 1986. Comparison of the hydrographs of water levels and pumpage indicates that there has been an interchange of water between the "850-foot" sand and the "1,000-foot" sand.

All pumpage from the Patapsco Formation at Chalk Point has been from the "1,000-foot" sand. Pumping commenced in 1975 at an average rate of about 0.2 Mgal/d and continued at that rate through 1977. From 1978 through 1986, the pumping rate ranged from 0.2 to 0.5 Mgal/d.

Chemical analyses of water samples from each of the aquifers show that, except for the slightly high concentrations of dissolved iron in the "850-foot" and "1,000-foot" sands, all constituents tested met the drinking water standards of the U.S. Environmental Protection Agency.

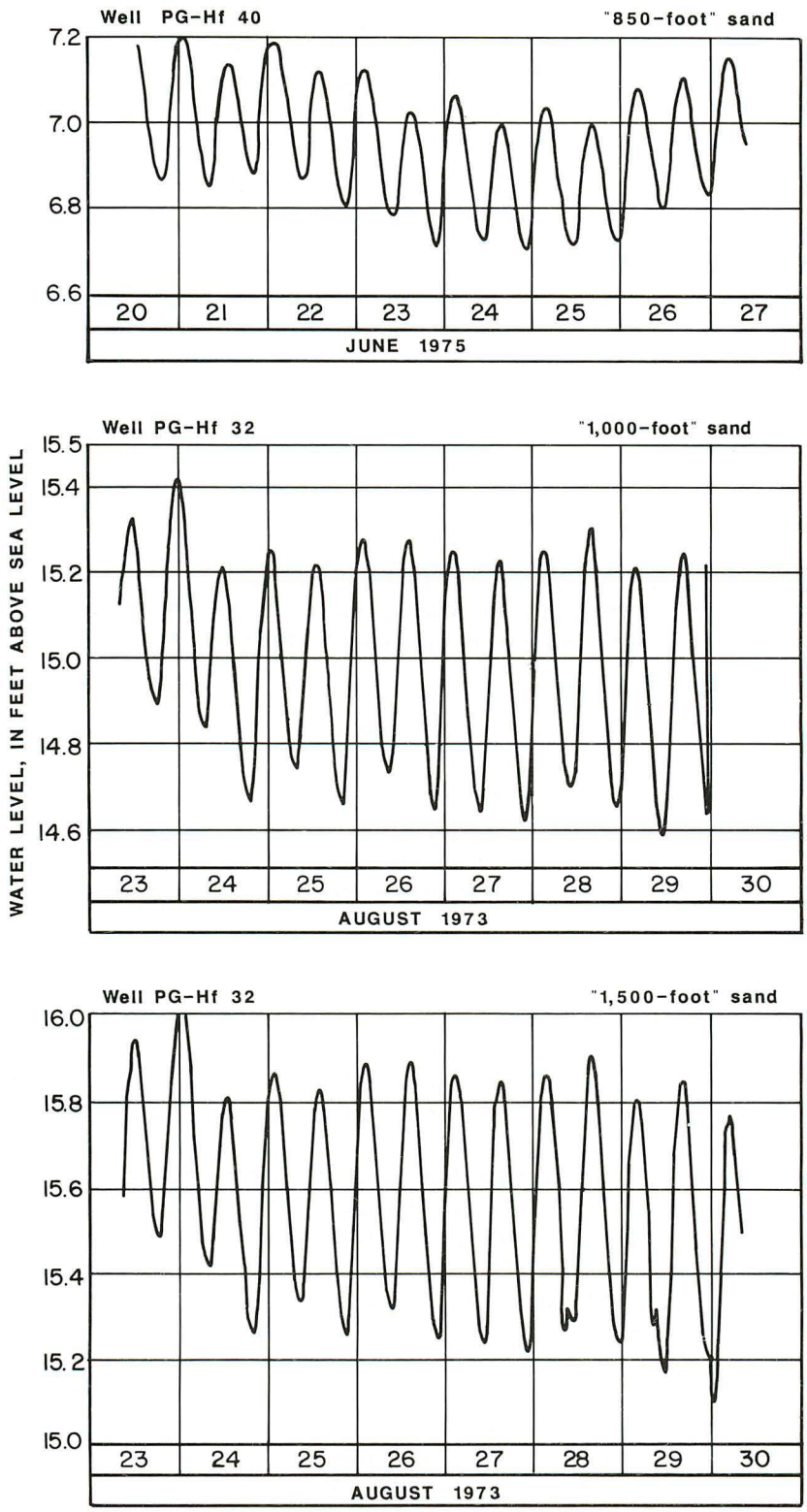


Figure 13. Water-level fluctuations in the "850-foot", "1,000-foot", and "1,500-foot" sands caused by tidal fluctuations in the nearby Patuxent River.

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Table 5. Drillers' logs and descriptions of cuttings from holes drilled into the Patapsco Formation at Chalk Point

[The column for depth gives the number of feet below land-surface datum of the base of the designated layer]

Well PG-Hf 31 (Altitude: 10 feet)

Lithology	Thickness (feet)	Depth (feet)
Fill	4	4
Sand and gravel	8	12
Clay and gravel	5	17
Clay, green	44	61
Clay, green with shells	59	120
Clay, green, sandy, glauconitic	178	298
Sand and fine gravel; light gray; fragments of calcareous sandstone and shells	157	455
Clay, green, sandy	137	592
Sand, gray, medium to coarse	14	606
Sand, gray, coarse to gravelly	33	639
Clay, predominantly red, but also brown and yellow	167	806
Clay, sandy, reddish-gray	18	824
Rock	.5	824.5
Clay, sandy, reddish-gray	22.5	847
Clay, sandy, gray and white	13	860
Sand, fine to medium, gray, clayey	6	866
Clay, white and gray	4	870
Clay, red and gray	30	900
Clay, white, gray, brown, red; and sand, very fine to fine, reddish-brown	105	1,005
Sand, fine to medium, whitish-tan, clean	6	1,011
Clay, sandy	2	1,013
Sand, medium to coarse, whitish-tan, clean	23	1,036
Clay, red, tough	53	1,089
Clay, gray, sandy	20	1,109
Clay, red and gray	68	1,177
Clay, gray; and sand, fine to medium brown	28	1,205
Clay, red and gray, sandy	81	1,286
Clay, red and white, sandy	40	1,326
Clay, red and gray, sandy	124	1,450
Sand, medium to coarse, gray-brown, clean	10	1,460
Clay, green	32	1,492
Clay, green, sandy	23	1,515
Sand, variegated, clean	26	1,541
Clay, red and green, tough	63	1,604
Clay, varicolored; and sand, fine to medium, brown	50	1,654
Clay, varicolored, tough	150	1,804
Clay, varicolored, sandy; and sand, medium to coarse, brown	52	1,856
Sand, medium to coarse, brown; and clay, sandy, white	19	1,875
Clay, varicolored, tough	81	1,956
Clay, varicolored, softer (sandy)	50	2,006
Sand, fine to medium, muddy, brown	20	2,026
Clay, varicolored, tough	170	2,196
Sand, fine to very fine, muddy	10	2,206
Clay, varicolored, tough	13	2,219
Rock	1	2,220
Clay, varicolored, softer (sandy)	17	2,237
Clay, varicolored, tough	69.5	2,306.5
Rock	.5	2,307
Clay, varicolored, soft (sandy)	33	2,340
Clay, varicolored, tough	10	2,350
Clay, varicolored, soft (sandy)	20	2,370
Sand, very fine to fine, micaceous	10	2,380
Clay, varicolored, soft (sandy)	10	2,390
Clay, varicolored, tough	20	2,410
Sand, medium, micaceous and clay	20	2,430
Clay, varicolored	17.75	2,447.75
Rock, hard	6	2,453.75

Table 5. Drillers' logs and descriptions of cuttings from holes drilled into the Patapsco Formation at Chalk Point -- continued

Well PG-Hf 32 (Altitude: 11 feet)

Lithology	Thickness (feet)	Depth (feet)
Landfill, sand, gravel and wood	10	10
River mud	20	30
Clay, green	310	340
Clay, with some sand, crusty	275	615
Sand, coarse, free, white and gray	25	640
Clay, tough, brown and yellow	57	697
Clay, tight, red	327	1,024
Sand, free, white, water-bearing	10	1,034
Clay, mixed, tight	72	1,106
Rock	.5	1,106.5
Clay with some sand, white	6.5	1,113
Clay, very tight, mixed	31	1,144
Clay with some sand, gray	8	1,152
Clay, tight, mixed	12	1,164
Clay, very tight, white and gray	123	1,287
Clay, mixed	160	1,447
Sand, free	9	1,456
Clay, tight	9	1,465
Clay with some sand	25	1,490
Clay, tight	11	1,501
Clay with some sand	15	1,516
Sand, free	13	1,529
Clay, green	6	1,535
Clay, tight	11	1,546

Well PG-Hf 34 (Altitude: 10 feet)

Lithology	Thickness (feet)	Depth (feet)
Sand and gravel	8	8
Clay, green	6	14
Sand and gravel	6	20
Clay, green	37	57
Clay, sandy, green	237	294
Sand, some clay, brown and black	36	330
Sand, crusty, cemented	45	375
Sand, some clean, some silt	32	407
Sand, uniform grain size, brown	42	449
Clay, sandy, green	84	533
Rock, hard	1	534
Clay, sandy, green	71	605
Sand, coarse, white	29	634
Clay, variegated	302	936
Rock	1	937
Clay, sandy	22	959
Sand, fine, white	16	975
Clay, tough, red	28	1,003
Sand, fine, white, with some clay	64	1,067
Rock, hard	1	1,068
Clay, variegated	368	1,436
Sand, fine, white, with thin layers of clay	18	1,454
Clay, tough	52	1,506
Sand, fine, white	12	1,518
Clay, very tough	43	1,561

Table 5. Drillers' logs and descriptions of cuttings from holes drilled into the Patapsco Formation at Chalk Point -- continued

Well PG-Hf 37 (Altitude: 10 feet)

Lithology	Thickness (feet)	Depth (feet)
Clay and gravel, sandy brown	16	16
Clay, green	33	49
Clay, green, some shell	41	90
Clay, sandy, green	214	304
Sand, brown and black	5	309
Sand, brown and black, some clay	27	336
Sand, crust-cemented	34	370
Sand, free and tight	34	404
Sand, free, brown	44	448
Clay with some sand, green	139	587
Sand and clay	18	605
Sand	47	652
Clay with some sand	5	657
Clay, red	80	737
Rock	1.5	738.5
Clay, tight	7	745.5
Rock	.5	746
Clay, tight, brown	81	827
Clay with some sand	48	875
Clay, tight, red	42	917
Rock	1	918
Clay with some sand	40	958
Sand, free and fine	6	964
Rock	.8	964.8
Clay	3.2	968
Sand, fine and free	2	970
Clay, red	5	975
Clay, and some sand, very free	23	998
Sand, fine and free	8	1,006
Sand, fine and free; some clay streaks, free	5	1,011
Sand, fine and free, white	5	1,016
Sand, fine, free	7	1,023
Sand, fine; one or two clay streaks, free	8	1,031
Sand, fine and free	5	1,036
Clay, tight	13	1,049
Sand, fine, fairly free, white	3	1,052
Clay, tight	4	1,056
Clay with some sand	72	1,128
Clay, tight	12	1,140
Clay, hard, red	38	1,178
Clay with some sand	12	1,190
Clay, tight	15	1,205
Clay with some sand	52	1,257
Clay, tight	67	1,324
Clay, soft	27	1,351
Clay, tough	82	1,433
Sand and clay, mushy	26	1,459
Clay, tight	53	1,512
Clay, and very free, fine sand	2	1,514
Sand, medium coarse with clay streaks	10	1,524
Clay, tight	36	1,560

Table 5. Drillers' logs and descriptions of cuttings from holes drilled into the Patapsco Formation at Chalk Point -- continued

Well PG-Hf 40 (Altitude: 28 feet)

Lithology	Thickness (feet)	Depth (feet)
Clay, olive green and tan streaks	20	20
Clay, olive green	40	60
Clay, dark green, and some shell	20	80
Sand, fine, dark green, and some shell	40	120
Sand, fine, dark green	20	140
Clay, dark green with sand, coarse and white, glauconite	20	160
Sand, coarse, light gray, and glauconite	80	240
Sand, coarse, glauconite, green	20	260
Clay, glauconite, green	20	280
Sand, coarse, glauconite, and some shell and gray-green clay	20	300
Sand, coarse, light gray and light red clay	20	320
Sand, coarse, white to green, glauconite, with red clay	40	360
Sand, coarse and cemented, black and white, with shell and red clay with trace of glauconite	60	420
Sand, medium to coarse, white, glauconite, with shell and light gray clay	60	480
Clay, dark blue-gray with some shell	20	500
Clay, some red, some blue gray with traces of glauconite	20	520
Clay, red and black, with green, cemented sand with shell	20	540
Sand, cemented, black, white, and green, and shell with some red clay	20	560
Clay, red and gray, and some fine to medium black sand	40	600
Clay, medium gray, lignite and medium to coarse, light gray sand	20	620
Sand, fine, light gray, abundant lignite, and some light gray clay	20	640
Sand, medium to coarse, light gray, with lignite	40	680
Sand, medium to coarse, quartz with some glauconite	34	714
Clay, pink to orange and light gray-green	46	760
Clay, pink to orange and white with fine, glauconitic sand	40	800
Clay, red and tan with some fine, glauconitic sand	40	840
Clay, dark gray to red with some medium coarse, glauconitic sand	20	860
Clay, red to dark gray, with some fine glauconitic sand	20	880
Clay, red to dark gray, with some medium glauconitic sand	20	900
Clay, light gray to red with some medium to fine, glauconitic sand and some wood	60	960
Bit sample, dark gray sandy clay		
Clay, light gray with some medium to fine glauconitic sand	40	1,000
Clay, medium gray with some fine, glauconitic sand	20	1,020
Clay, red, with some fine, glauconitic sand	75	1,095

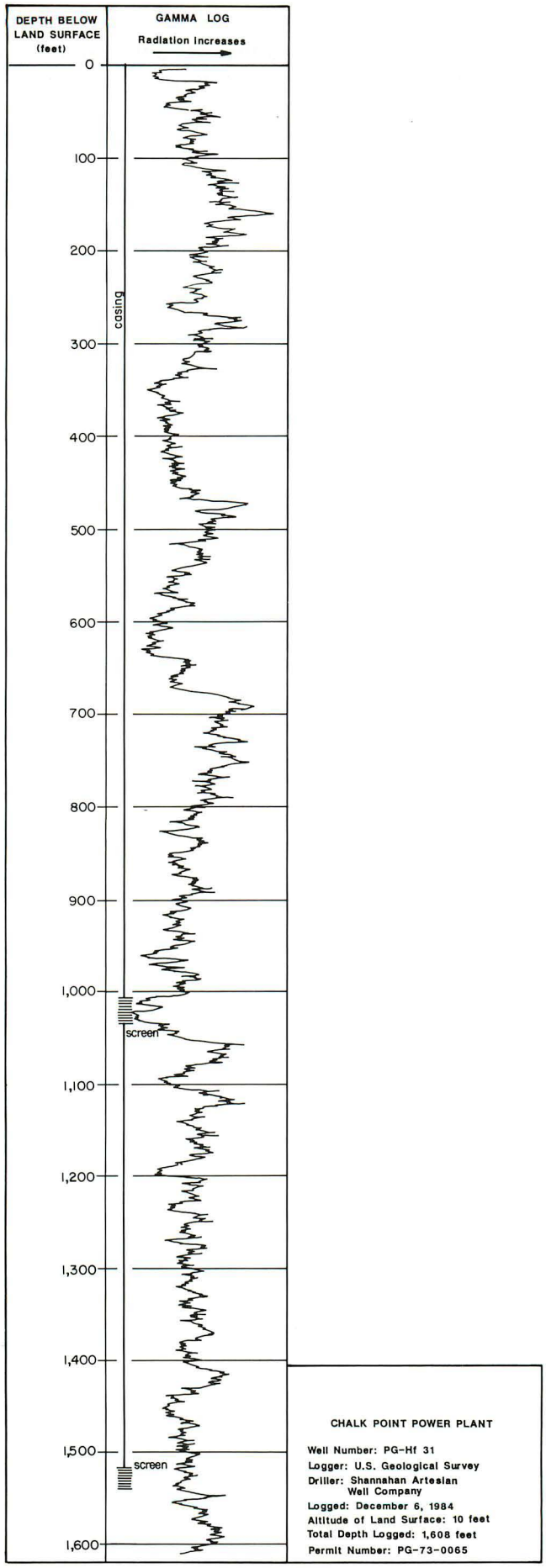

Figure 14. Natural gamma log and screen positions for test hole PG-Hf 31.

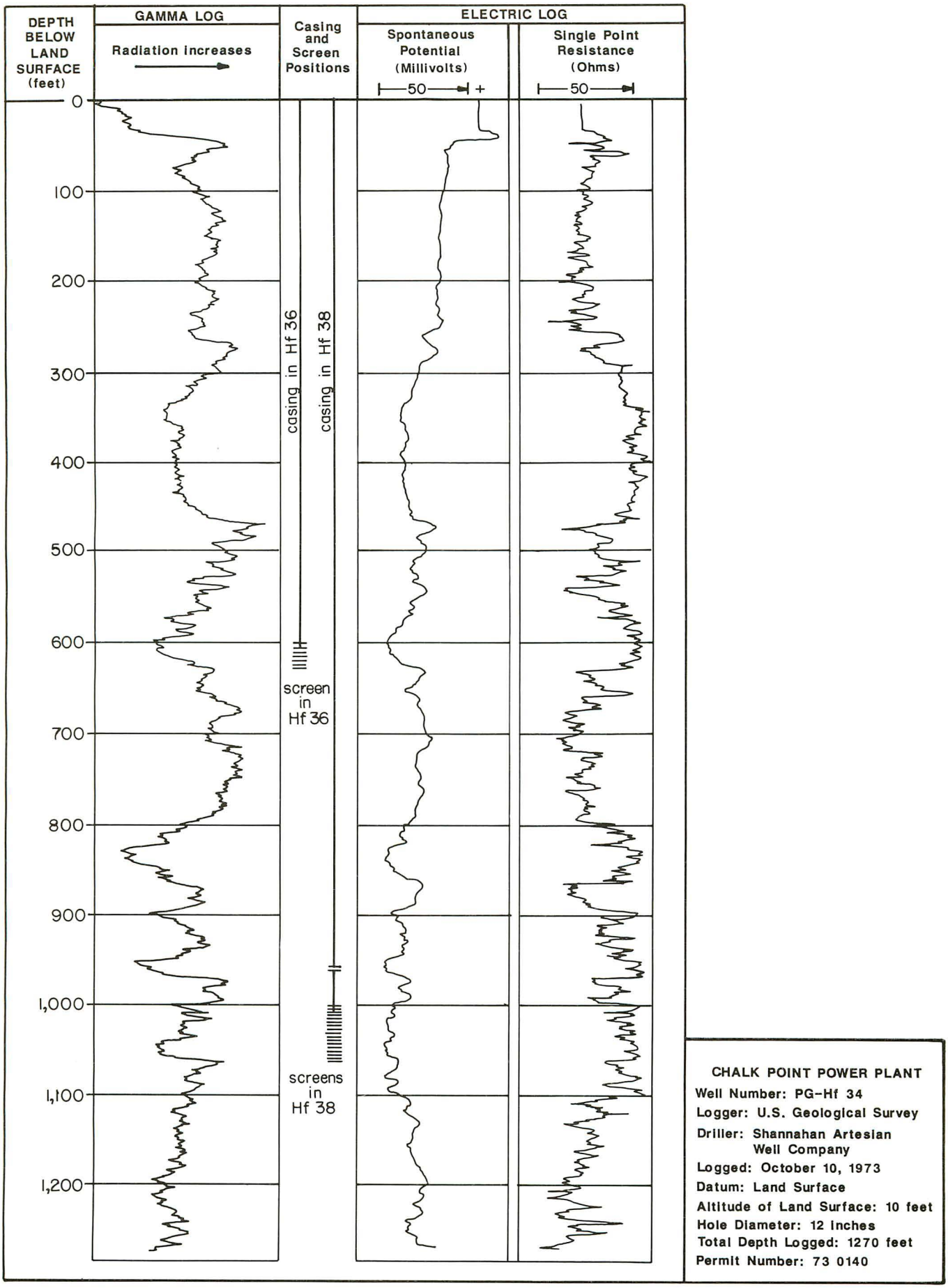

Figure 15. Geophysical logs for test hole PG-Hf 34 and the screen positions for production wells PG-Hf 36 and PG-Hf 38 at the same site.

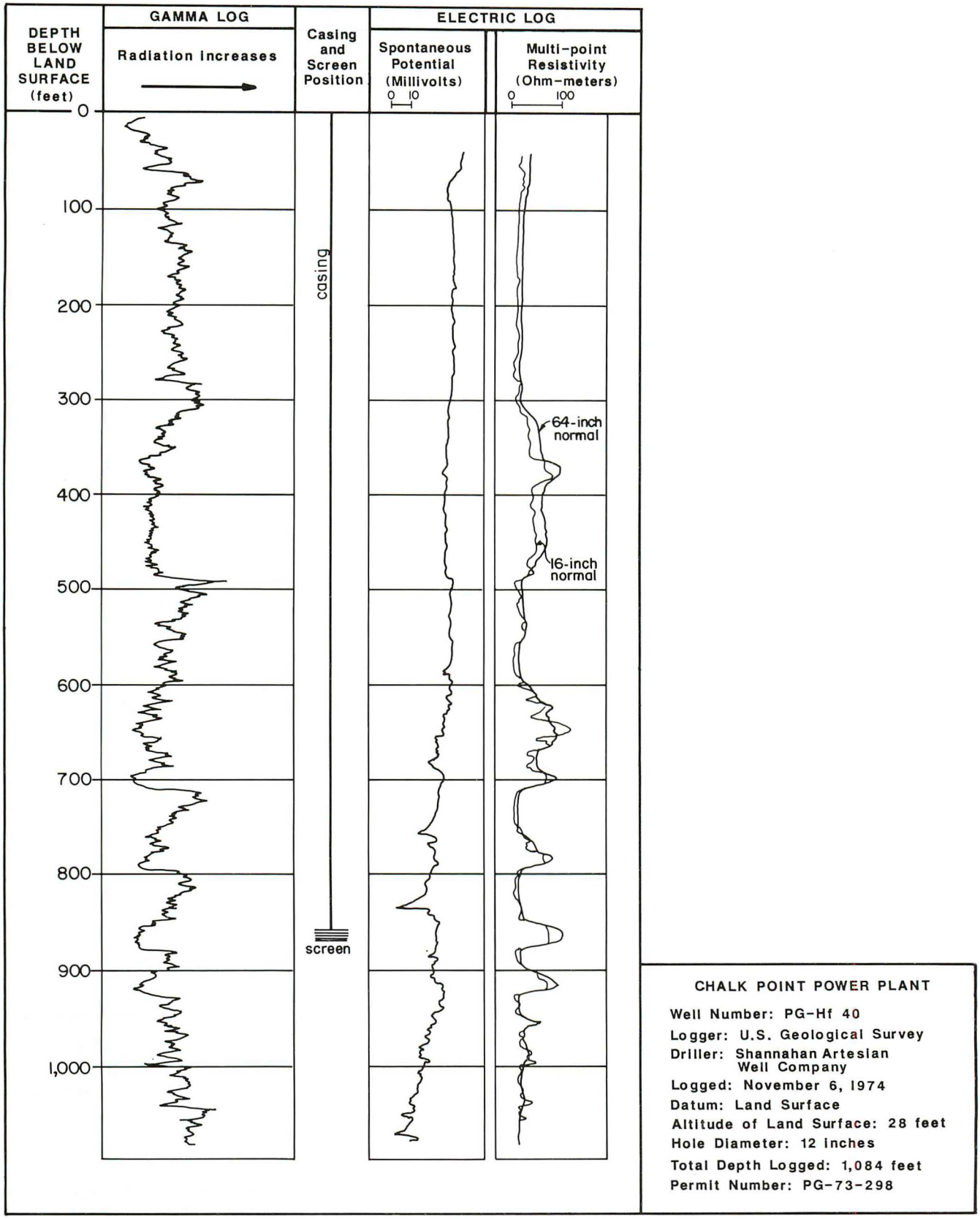

Figure 16. Geophysical logs and the screen position for test well PG-Hf 40.

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