Department of Natural Resources
Resource Assessment Service
MARYLAND GEOLOGICAL SURVEY
Jeffrey P. Halka, Acting Director

BASIC DATA REPORT NO. 22

HYDROGEOLOGIC DATA FROM SIX TEST WELLS IN THE UPPER PATAPSCO AND LOWER PATAPSCO AQUIFERS IN SOUTHERN MARYLAND

by

Nadine Calis and David D. Drummond

Prepared in cooperation with the
Boards of County Commissioners of
Calvert, Charles, and St. Mary's Counties
and the
United States Department of the Interior
Geological Survey

2008

State of Maryland

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Governor

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ABSTRACT

Six exploratory test wells were drilled in Southern Maryland to obtain hydrogeologic data for the Upper Patapsco and Lower Patapsco aquifers. Information collected from the test wells includes lithologic descriptions of sediments; biostratigraphic analyses using fossil pollen, spores, and plankton; geophysical logs; hydraulic characteristics; water-quality analyses; and water-level data. The hydrogeologic data were used in a regional study of the water-supply potential of the Coastal Plain aquifers in Calvert, Charles, and St. Mary's Counties, Maryland. This report documents the hydrogeologic data collected from the wells, and includes brief descriptions of associated drilling, construction, and data-collection procedures.

INTRODUCTION

Six exploratory test wells were drilled to depths of about 1,650 feet (ft) into the Upper Patapsco and Lower Patapsco aquifers between April 2001 and March 2003 (fig. 1). The test wells were drilled in order to obtain hydrogeologic data for the Patapsco aquifer system in Southern Maryland. The test-well drilling program was part of a regional study to assess the water-bearing potential of the aquifer system in Calvert, Charles, and St. Mary's Counties. Two wells were drilled in each county. The results of the regional study are presented in a summary administrative report (Drummond, 2005) and in a comprehensive final report (Drummond, 2007).

Location of Study Area and Test Wells

The study area comprises three counties in Southern Maryland: Calvert, Charles, and St. Mary's. This area is bounded by the Chesapeake Bay to the east, the Potomac River to the south and west, and Anne Arundel and Prince George's Counties to the north (fig. 1). The Commonwealth of Virginia lies across the Potomac River, and Washington, D.C. is about 15 miles (mi) to the north. The total land area of the three counties is 1,037 square miles (mi^2).

Well locations were chosen to provide hydrogeologic information where it was previously lacking, and to provide long-term monitoring of water levels. Wells CA Db 96 and CH Cg 24 were screened in the Upper Patapsco aquifer, and wells CA Fd 85, CH Bg 17, SM Bc 39, and SM Dd 72 were screened in the Lower Patapsco aquifer. Well numbers comprise a county prefix (CA for Calvert, CH for Charles, and SM for St. Mary's), a two-letter designation for the 5-minute latitude/longitude grid within each county, and a sequential number assigned to wells as they were inventoried within each 5-minute quadrangle. Curtin and Dine (1995) provide a full explanation of the well-numbering system, and include maps showing the 5-minute quadrangle grid for each county in Southern Maryland.

Hydrogeologic Setting

The study area lies completely within the Coastal Plain province of Maryland. Coastal Plain geologic formations consist of layers of sand, silt, clay, and gravel that generally become deeper and thicker to the southeast, and overlie a basement complex of largely crystalline bedrock. Sand and gravel layers form aquifers, which provide water to wells; clay and silt layers form confining units, which limit flow between the aquifers and provide storage for the aquifer system. Aquifers and confining units penetrated by the test wells are shown in the generalized hydrogeologic section in figure 2, and the hydrogeologic characteristics of these units are briefly described in table 1.

Aquifers penetrated by the test wells include (from shallow to deep) the Surficial, Piney Point, Aquia, Magothy, Upper Patapsco, and Lower Patapsco aquifers. Intervening confining units include the Chesapeake, Nanjemoy, Brightseat, Upper Patapsco, Middle Patapsco, and Arundel confining units. The Surficial aquifer is used by some older, shallow wells throughout the study area. The Piney Point and Aquia aquifers are used predominantly in Calvert and St. Mary's Counties. The Magothy, Upper Patapsco, and Lower Patapsco aquifers are currently used primarily in Charles County, but are being developed in Calvert and St. Mary's Counties.

The Patuxent aquifer, which is the deepest freshwater aquifer in Southern Maryland, underlies the Arundel confining unit, and rests on the bedrock surface beneath most of the study area. The Patuxent aquifer is currently used for water supply only in the northwestern part of the study area, and was not included in this study.

The deepest well drilled in Southern Maryland, at Lexington Park, reached bedrock at 2,623 ft below land surface or 2,515 ft below sea level (Hansen and Wilson, 1984). At this site (and perhaps elsewhere in the study area) the Patuxent aquifer may be underlain by thin remnants of the Waste Gate Formation, a brackish-water, silty sand that rests on the bedrock surface. The Waste Gate Formation thins updip to zero-thickness by onlap of younger units, and is largely restricted to the lower Delmarva Peninsula. Neither the Waste Gate Formation nor the underlying bedrock units are considered potential water sources in Southern Maryland (tab. 1).

Acknowledgments

Cooperative funding for this study was provided by the County Commissioners of Calvert, Charles, and St. Mary's Counties; the Maryland Department of Natural Resources; and the U.S. Department of the Interior, Geological Survey. Additional funding was provided by the Chesapeake Ranch Water Company[1]. Sites for test-well drilling were provided by the Calvert County Department of Public Works, Charles County Public Schools, Chesapeake Ranch Water Company, Maryland Department of Natural Resources, and the St. Mary's County Metropolitan Commission.

Field data were collected by Nadine Calis, Karen Jennings, Brandon Fewster, Barbara Cooper, and David Bolton, all of the Maryland Geological Survey. Stephen Curtin, of the U.S. Geological Survey, performed geophysical logging of some test wells. Donajean Appel of the Maryland Geological Survey assisted in preparation of the tables and other aspects of the report. The report was reviewed by Donajean Appel, David Bolton, Harry Hansen, and Claire Richardson of the Maryland Geological Survey, and Michael Smigaj of the U.S. Geological Survey (USGS). Special thanks go to the homeowners in Calvert, Charles, and St. Mary's Counties who patiently endured around-the-clock test-drilling operations in their neighborhoods.

WELL DRILLING AND CONSTRUCTION

Test-well borings were drilled to depths ranging from 1,600 to 1,667 ft below land surface (tab. 2), using the direct rotary method. Wells CA Db 96, CH Bg 17, and SM Dd 72 were drilled by A. C. Schultes of Maryland, Inc., and wells CA Fd 85, CH Cg 24, and SM Bc 39 were drilled by Sydnor Hydrodynamics, Inc. Drill cuttings were collected at changes of drill rods (20-foot intervals), and in some wells, samples were also collected at mid-rod lengths (10-foot intervals). Descriptions of sediments were recorded by the well drillers (tabs. 3 through 8),

[1] The Chesapeake Ranch Water Company changed its name to The Chesapeake Water Association in November, 2004. The community of Chesapeake Ranch Estates is generally referred to as Chesapeake Ranch in this report.

based on drill cuttings and the response of the drilling rig to different sediment types. Drilling fluid was circulated for up to several hours to allow drill cuttings to reach the surface before proceeding to the next depth interval; however, some recirculation and mixing of sediments between intervals was unavoidable.

After each borehole was drilled to final depth, the drilling fluid was thinned and geophysical logs were run. Screen intervals were determined based on sediment logs and geophysical logs. The test wells were constructed with 4-inch diameter steel casing and 4-inch wire-wound stainless steel well screens. Diagrams showing well construction features are shown in figures 3 through 5. The boreholes for the two Upper Patapsco wells (CA Db 96 and CH Cg 24), were plugged below the well screens to prevent flow between the Upper and Lower Patapsco aquifers. Screened intervals were gravel packed, and the annular space outside the well casings was grouted using either cement grout or a mix of cement and bentonite. A ten-foot section of blank casing was installed below the deepest screen section in each well to allow settling of sediment without clogging the well screen. The 4-inch well casing was extended about 2 ft above land surface. After the grout was properly cured, each well was developed using compressed air and high-pressure jetting to remove fine-grained material from the well casing and screen openings.

In wells CA Db 96 and CH Cg 24, which were screened in the Upper Patapsco aquifer, the sandy intervals that were eventually screened were exposed to drilling fluid for extended periods of time as the boreholes were drilled to final depth. The sands screened in well CH Bg 17 were also exposed to drilling fluid for an extended period due to well-construction problems. These time periods ranged up to several weeks, and probably resulted in extensive invasion of the sands with drilling fluid, and led to difficulties in thoroughly developing the wells. Incomplete well development may have decreased well yields in these wells.

An aquifer test was performed for each well, and water samples were collected for chemical analyses during the pumping phase of the aquifer test. Drilling equipment was then removed and the drill site restored to previous conditions. A 6-inch steel protective casing was cemented in place to protect the 4-inch well casing from damage, and was extended about 3 ft above land surface. The altitude of the top of each well casing was surveyed from a nearby benchmark, except for well CH Bg 17, which was surveyed from a stream gage that had previously been surveyed for altitude. Land-surface elevation at some wells was altered during final grading in site restoration. Land-surface elevation at well CA Db 96 may also have been altered during construction of a highway bypass for Prince Frederick. Grading is not expected to affect the altitude of the top of the well casing, which was used as a datum for water-level measurements.

HYDROGEOLOGIC DATA

Lithologic Descriptions

Descriptive lithologic logs of drill cuttings were recorded by geologists on site (tabs. 9 through 14). Samples were washed using a 250-micron sieve, examined with a hand lens and described. Selected samples were examined in detail in the laboratory using a binocular microscope. Samples were dried, stored in envelopes, and archived. Color designations (e.g. 7.5YR 3/4) were made on moist material using Munsell soil color charts (Munsell Color Company, 1975). The on-site lithologic logs were aggregated for similar intervals into composite lithologic descriptions (tabs. 9 through 14). Original on-site logs are on file at the Maryland Geological Survey. Depths are in feet below land surface; dimensions of sediment grains, fossils, and rock fragments are in millimeters (mm). Formation determinations are based on lithologic data, geophysical logs, palynological data, regional cross sections, and structure-contour maps. Consequently, not all formation contacts correspond to changes in lithology in the on-site logs.

Most of the sediment samples were contaminated with up-hole material because of mixing in the fluid column and recirculation through the mud pump. In addition, much of the clayey material was pulverized by the drill bit and combined with the drilling fluid, and is under-represented in the descriptions of drill cuttings. These problems tend to increase with drilling depth. In particular, glauconite grains (and to a lesser extent shell fragments) were present in most of the samples; however, glauconite has not been documented in the Magothy or Patapsco Formations in outcrops or core holes in Maryland. It is likely that the occurrence of glauconite and shell fragments in samples from these formations is a result of recirculation and contamination from shallower intervals (particularly the Aquia and Piney Point Formations) where glauconite is common. For these reasons, drill cuttings, no matter how carefully collected and described, are not fully representative of in situ sediment materials, and should be used with caution.

Geologist's logs (tabs. 9 through 14) of the Patapsco Formation show extreme lithologic variability. The Upper Patapsco and Lower Patapsco aquifers contain significant clay and silt proportions, both intermixed and interlayered with the sands. The Upper Patapsco and Middle Patapsco confining units contain significant sandy layers, some of which may be used for water supply. Fine-grained sediments exhibit a wide range of textures and colors. Coarse-grained sediments range from fine sand to coarse gravel (and possibly pebbles and cobbles), and range in color from gray to reddish-brown. Sands are predominantly iron-stained quartz grains, but include a wide variety of accessory grains, and some cemented intervals.

Palynologic Analyses

Selected sediment samples were analyzed for fossil pollen, spore, and plankton assemblages to estimate age and depositional environment of the selected intervals. These palynologic analyses aided in the correlation of hydrogeologic units throughout the study area. Unwashed sediment samples were sent to Dr. Gilbert Brenner (Consulting Palynologist, New Paltz, New York) for analysis. Because drill cuttings were used in the analysis (core samples were not obtained during drilling), samples were significantly contaminated with material from shallower intervals, and age dating was based on the first occurrence of diagnostic forms, working downward in the section. The palynologic analyses in tables 15 through 18 are edited from Dr. Brenner's reports, in which the Arundel and Patapsco Formations are subdivided into five palynozones based on criteria discussed in Brenner (1963) and Doyle and Robbins (1977). In this system, the Arundel Formation is subdivided into Palynozones I and IIA, and the Patapsco Formation is subdivided into Palynozones IIB, IIC, and III.

The sediment samples used for palynologic analysis were selected from four of the six test wells, and ranged in depth from 520 to 1,650 ft below land surface. Seven of the 32 samples were barren (did not yield datable palynomorphs). Age determinations ranged from Paleocene (Aquia Formation) to Lower Cretaceous, Early Albian, Palynozone I (Arundel Formation). Shallower intervals were not selected for analysis because the biostratigraphy of these intervals has already been established (Hansen, 1996).

Geophysical Logs

Geophysical logs were run in the uncased boreholes after they were drilled to final depth. Geophysical logs shown in figures 6 through 11 include natural gamma, spontaneous potential, multi-point resistivity (including 16-inch and 64-inch electrode spacings) and single-point resistance. Other logs were run on some wells, including 8-inch resistivity, 32-inch resistivity, and lateral resistivity, and are on file at the Maryland Geological Survey. The spontaneous-potential log for well CA Db 96 shows an atypical signature, and appears to have malfunctioned for this well. The geophysical logs for wells CA Db 96 and CH Bg 17 (figs. 12 and 14) were run by A. C. Schultes; logs for wells CA Fd 85, CH Cg 24 and SM Bc 39 (figs. 13, 15 and 16) were run by Sydnor Hydrodynamics; the log for well SM Dd 72 (fig. 17) was run by USGS.

Geophysical logs can be used to determine generalized sediment types in boreholes. Gamma radiation generally is higher in clays and silts, and lower in sands and gravels; resistivity and resistance generally are lower in clays and silts, and higher in sands and gravels. The logs were used to determine optimal intervals for screening the test wells. Additionally, the logs were used in conjunction with geophysical logs from other wells in the region for stratigraphic correlation and sand-thickness estimates (Drummond, 2007).

Aquifer Tests

After each test well was constructed and developed, an aquifer test was performed, which included a 24-hour constant-discharge pumping phase followed by a 24-hour recovery phase. The discharge rate was held constant for each test within a few gallons per minute (gpm). Discharge was monitored using an orifice meter, and checked periodically using a totalizing flow meter, and a 55-gallon barrel and stopwatch. Withdrawal rates in the six wells ranged from 56.3 to 82.5 gpm, and specific capacities ranged from 1.51 to 4.52 gallons per minute per foot (gpm/ft) (tab. 2). Graphs showing drawdown and recovery data for the six aquifer tests are shown in figures 12 through 17.

Transmissivities calculated using the Cooper-Jacob straight-line method (Drummond, 2007) for the Upper Patapsco aquifer range from 380 to 1,100 feet squared per day (ft^2/d), and for the Lower Patapsco aquifer range from 200 to 4,000 ft^2/d (tab. 2). Analysis was complicated in four of the six wells (CA Db 96, CA Fd 85, CH Bg 17, and SM Dd 72) by significant nonlinearities in the semi-logarithmic plots. The nonlinearities are attributed primarily to heterogeneity in aquifer sediments and variable thickness of sand layers. Drummond (2007) provides a detailed discussion of the interpretation of aquifer-test results.

Water-Quality Analyses

Water samples for chemical analysis were obtained from an in-line spigot for each well during the last several hours of the withdrawal phase of the aquifer test. Chemical analyses were performed by the USGS for all wells, and also by private laboratories for all wells except SM Dd 72. Field personnel from the Maryland Geological Survey, USGS, and the private laboratories collected the water samples and performed field tests for pH, alkalinity, and specific conductance. Well CA Db 96 was resampled on February 4, 2003 because of a misplaced sample bottle in the initial sampling. Chemical analyses performed by the USGS laboratory are shown in table 19.

Water-quality analyses included major ions, nutrients, iron, manganese, fluoride, arsenic, radon, and selected field parameters (pH, alkalinity, and specific conductance). Water quality in all of the test wells appears to be suitable for most purposes, including human consumption. No U.S. Environmental Protection Agency Maximum Contaminant Levels (MCL's) were exceeded in the analyses, although not all regulated constituents were tested. The Secondary Maximum Contaminant Levels (SMCL's) for iron (300 micrograms per liter [μg/L]) and manganese (50 μg/L) were exceeded only in well CA Db 96. Arsenic concentrations were 0.3 μg/L for wells CA Db 96 and CH Cg 24, which are screened in the Upper Patapsco aquifer, and were below detection limits (0.2 to 0.3 μg/L) for the wells screened in the Lower Patapsco aquifer. Total dissolved solids (residue on evaporation at 180° C) for the six test wells ranged from 127 to 267 milligrams per liter (mg/L).

Water Levels

Automatic water-level recorders were installed on the test wells, which recorded water levels at intervals of 15 minutes (SM Bc 39), 30 minutes (CH Bg 17), or 60 minutes (CA Db 96, CA Fd 85, CH Cg 24, and SM Dd 72) until removal in August 2005. Hand-held water-level measurements were obtained during site visits to service the recorders, and continue on a semi-annual basis. Minimum daily water levels from automatic measurements and hand-held measurements are shown in figures 18 through 20.

Water levels measured in the test wells between July 2001 and September 2007 range from 14.38 to 61.81 ft below sea level. Water levels in all of the test wells show steady declines over their periods of record, and the rates of decline range from about 1.2 feet per year (ft/yr) in wells CA Fd 85 and SM Dd 72, both screened in the Lower Patapsco aquifer, to about 2.8 ft/yr in well CH Bg 17, also screened in the Lower Patapsco aquifer. Water levels in all wells display barometric fluctuations, and well SM Dd 72 displays a semi-diurnal tidal fluctuation. Well SM Dd 72 is about ½ mile from Breton Bay, which is a tidal estuary. Wells CA Db 96 and CH Cg 24, both screened in the Upper Patapsco aquifer, display distinct seasonal water-level fluctuations of about one foot, that are probably caused by seasonal variations in pumpage. The other wells, all screened in the Lower Patapsco aquifer, display less distinct seasonal water-level fluctuations.

CONCLUSIONS

Six test wells drilled into the Upper Patapsco and Lower Patapsco aquifers provide hydrogeologic data that are critical in the regional analysis of the water-bearing potential of the Coastal Plain aquifer system in Southern Maryland. Sampling of sediments and aquifer testing indicate extreme variability in lithology and hydraulic properties of these aquifers. Geophysical logs and palynologic analyses were used to define the extent and characteristics of the Patapsco aquifers and confining units in areas of Southern Maryland where data were sparse. These data also facilitated correlation with equivalent hydrogeologic units in other areas of Maryland and adjoining states. Water-quality testing indicates that water in the Upper and Lower Patapsco aquifers is of good quality and can probably be used for most purposes. Water-level monitoring in the test wells has helped define potentiometric surfaces in the Patapsco aquifers, and indicates downward trends ranging from about 1.2 to 2.8 ft/yr.

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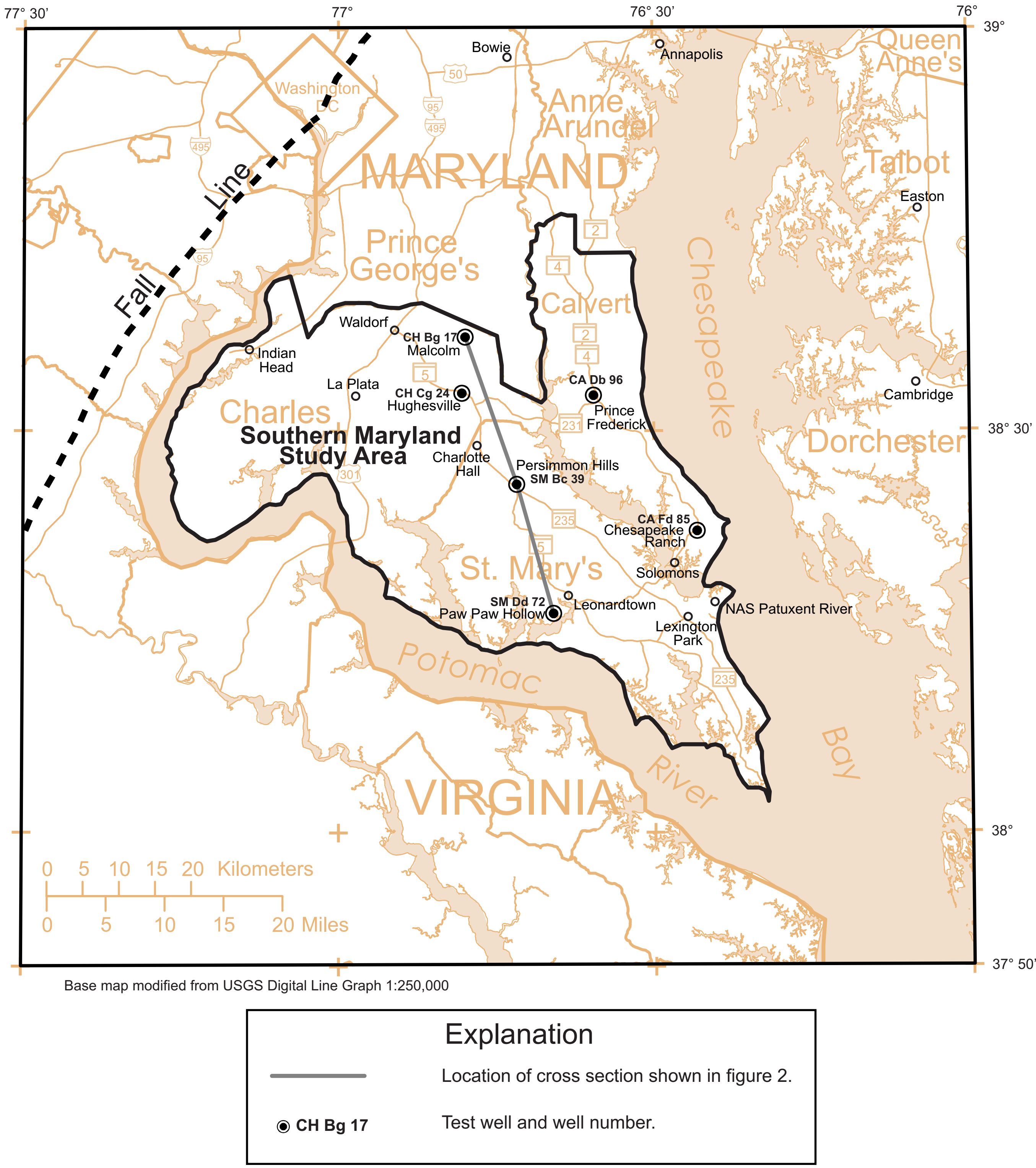


Figure 1. Location of the study area, test wells, and hydrogeologic section in Southern Maryland.

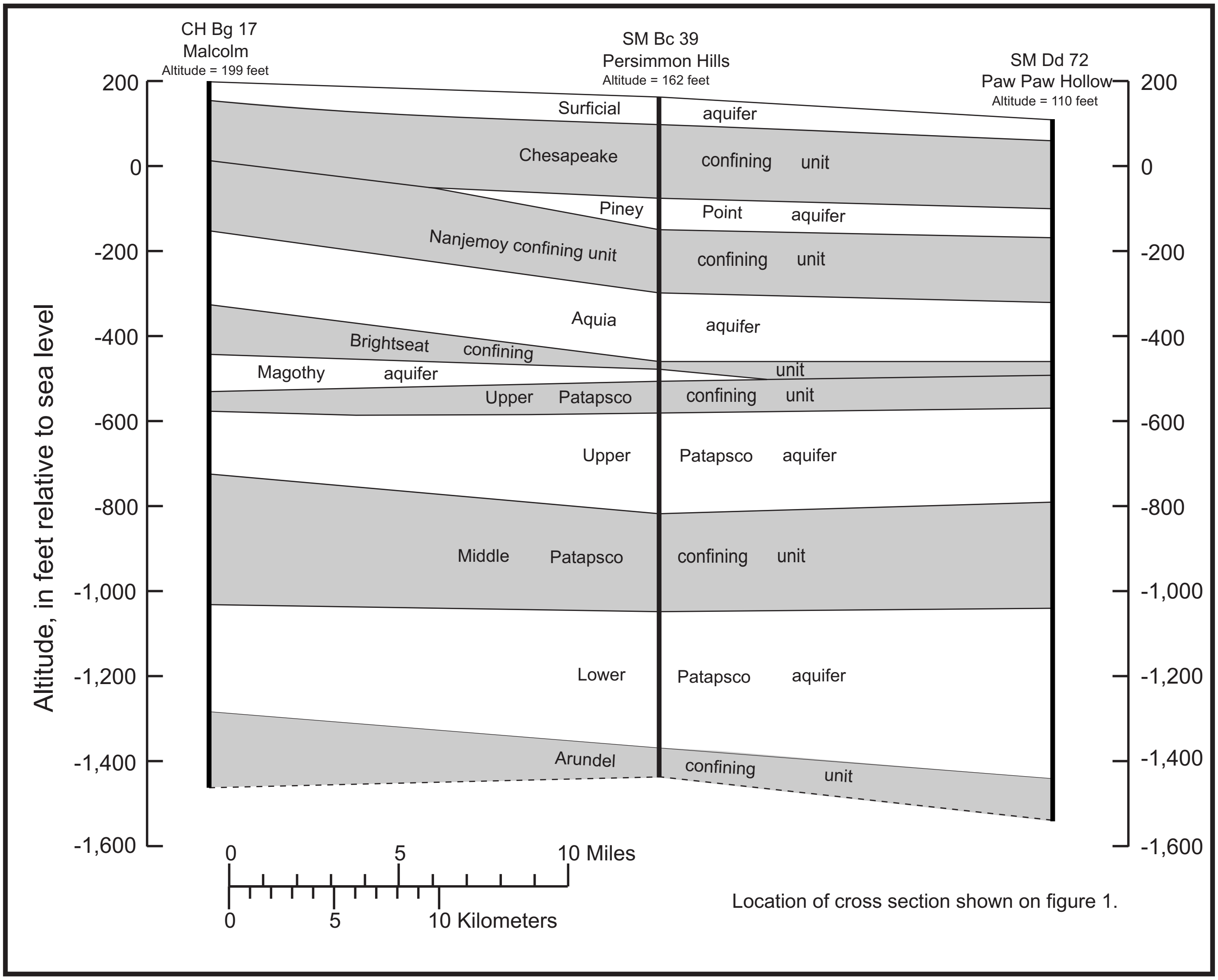
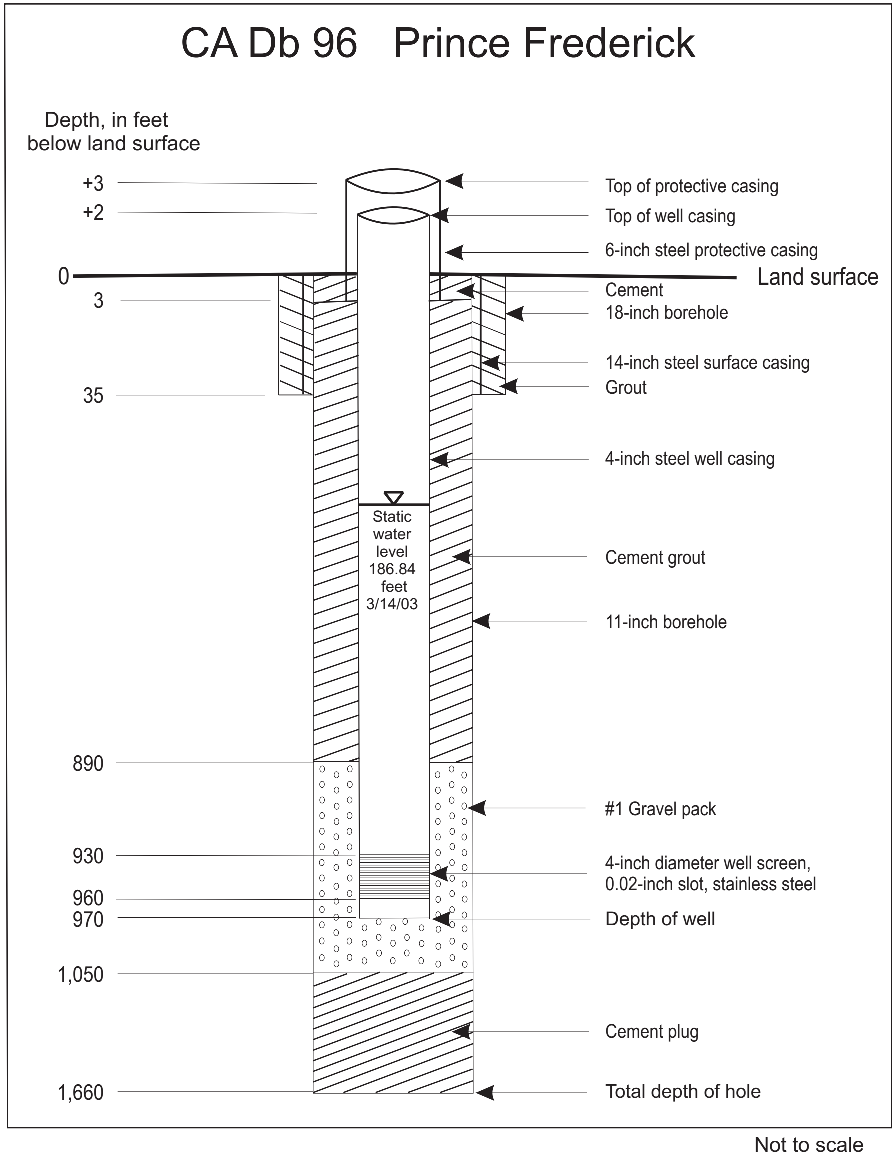


Figure 2. Generalized hydrogeologic cross section, from Malcolm to Paw Paw Hollow.



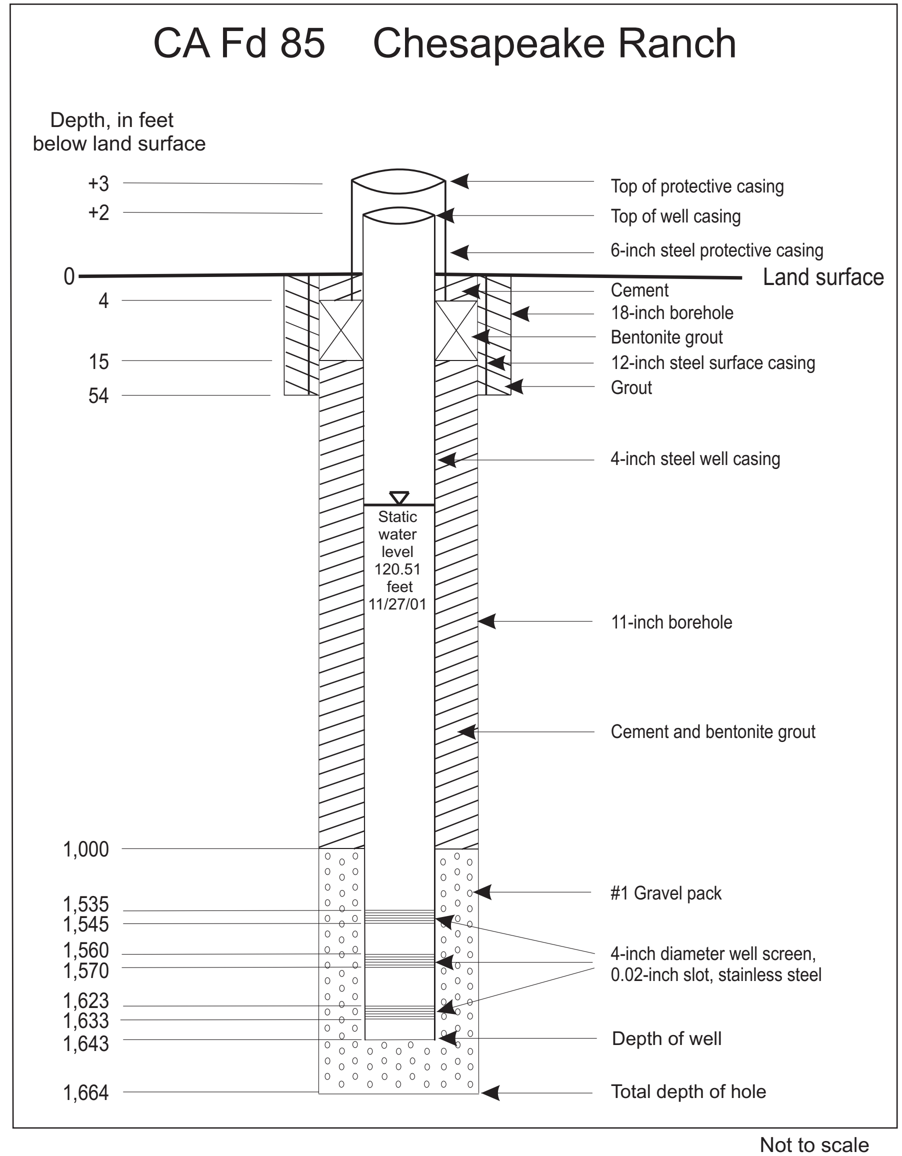


Figure 3. Diagrams showing construction features of test wells CA Db 96 and CA Fd 85.

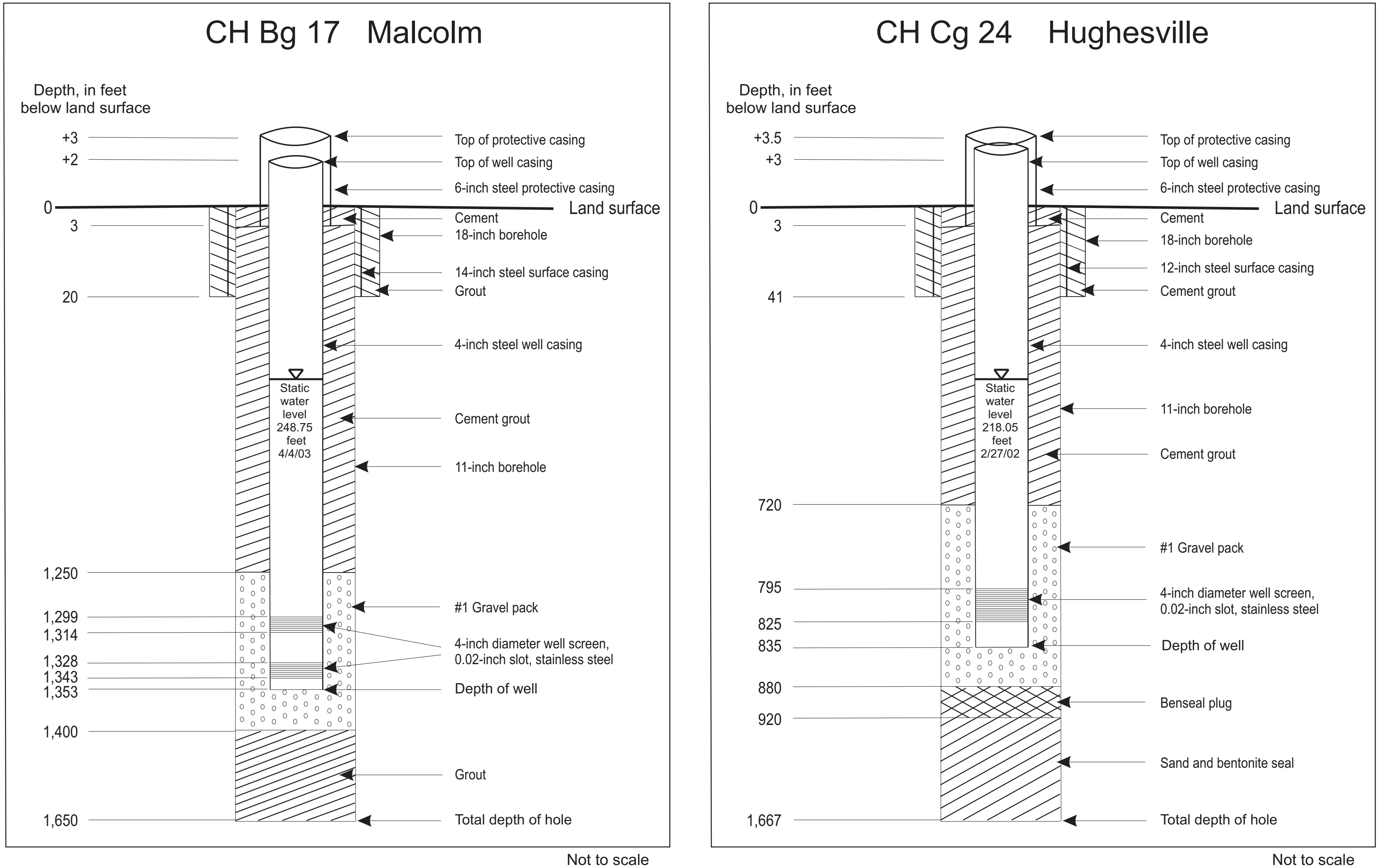
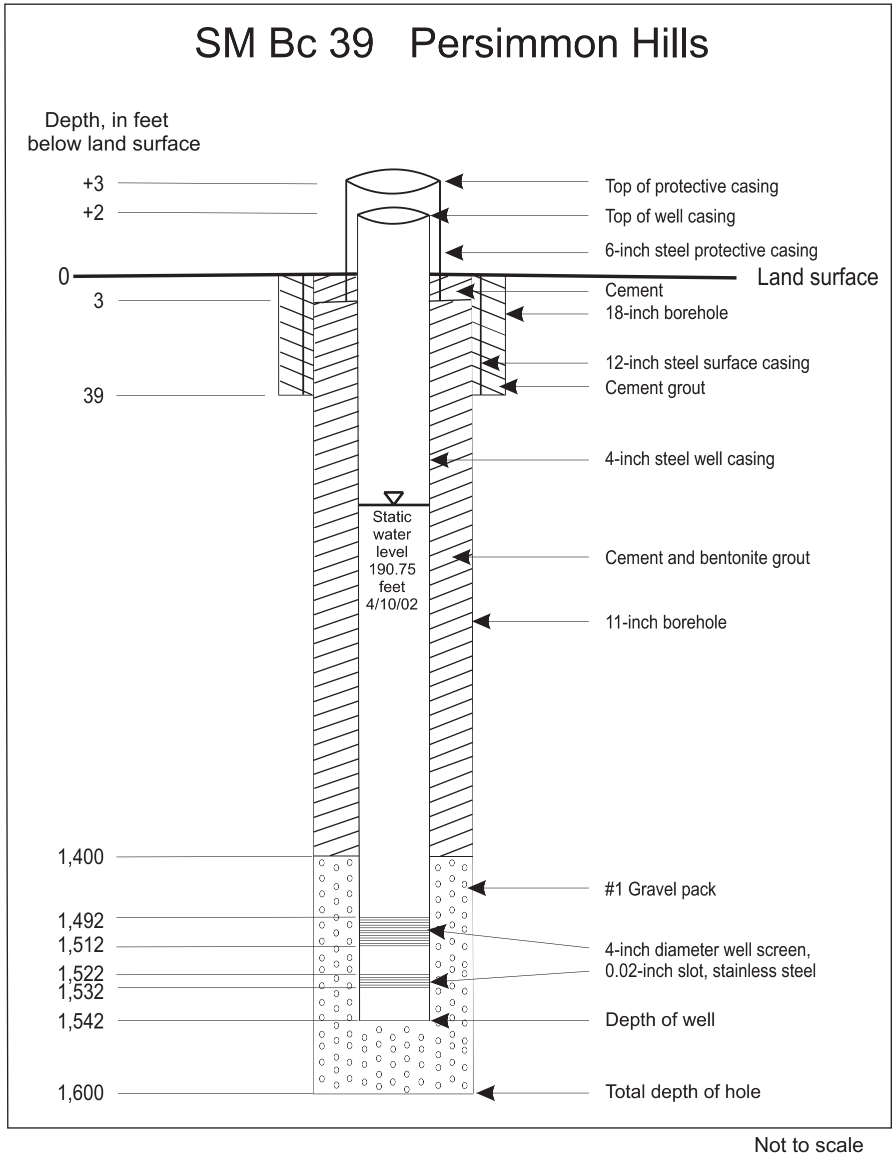


Figure 4. Diagrams showing construction features of test wells CH Bg 17 and CH Cg 24.



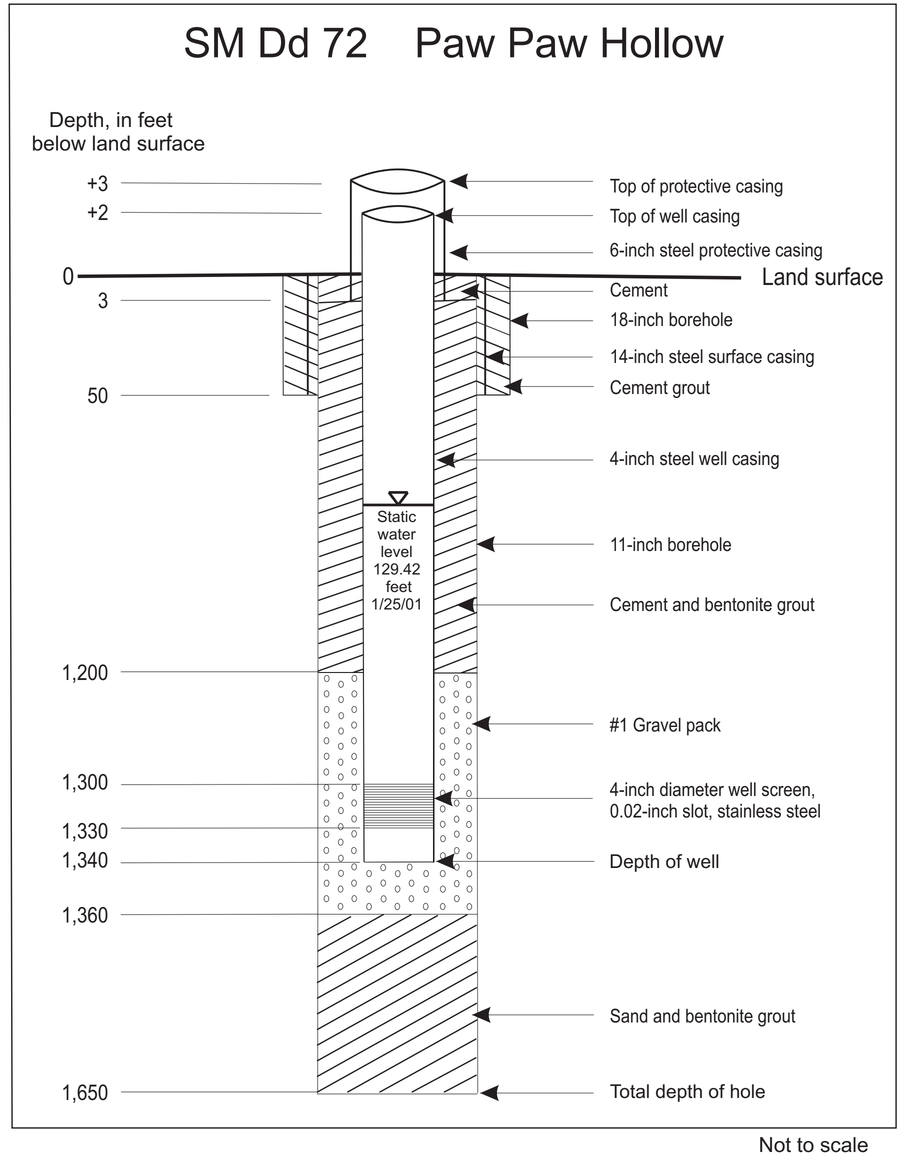


Figure 5. Diagrams showing construction features of test wells SM Bc 39 and SM Dd 72.

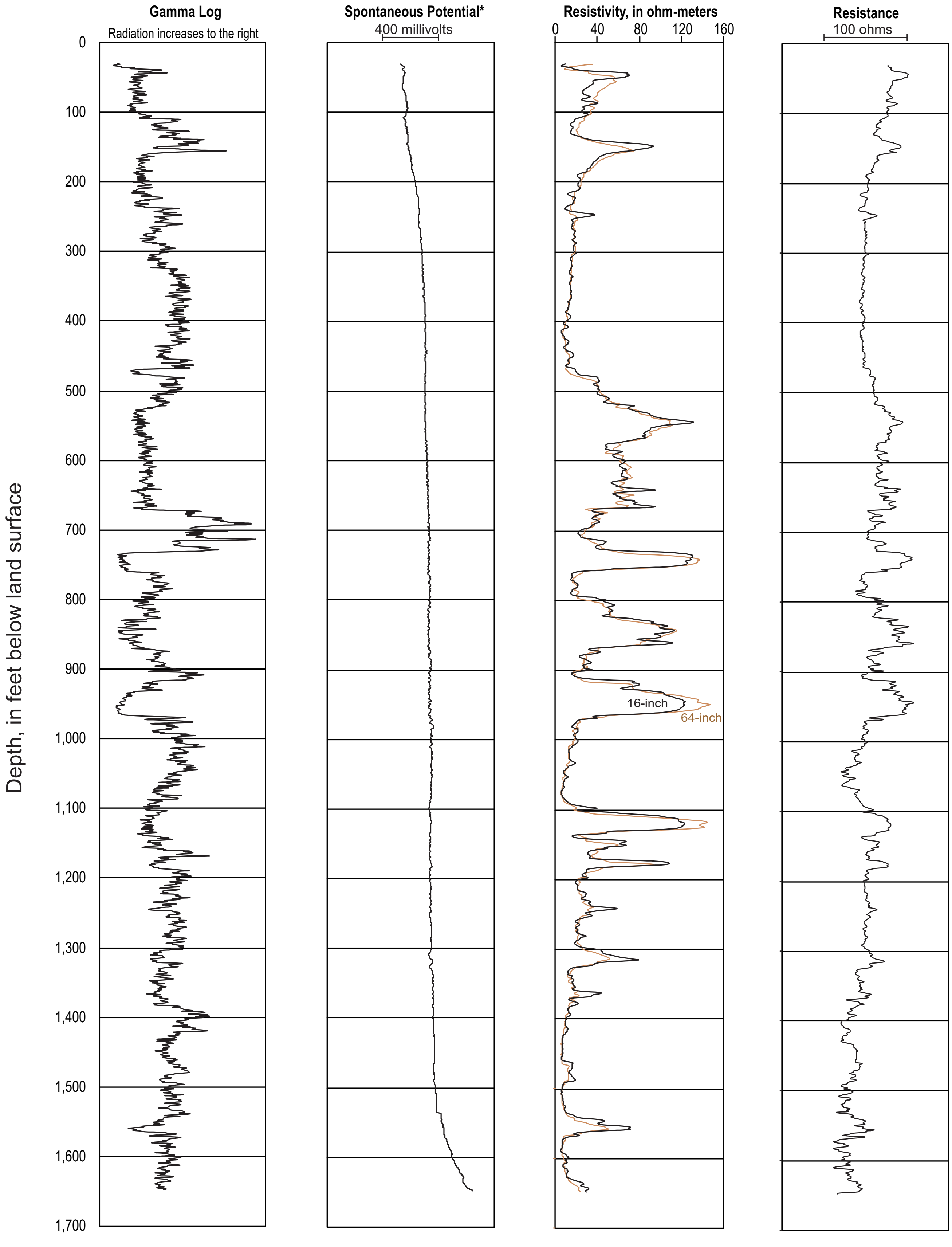


**Figure 6. Geophysical logs for test well CA Db 96, at Prince Frederick.
(* The spontaneous potential tool appears to have malfunctioned for this log.)**

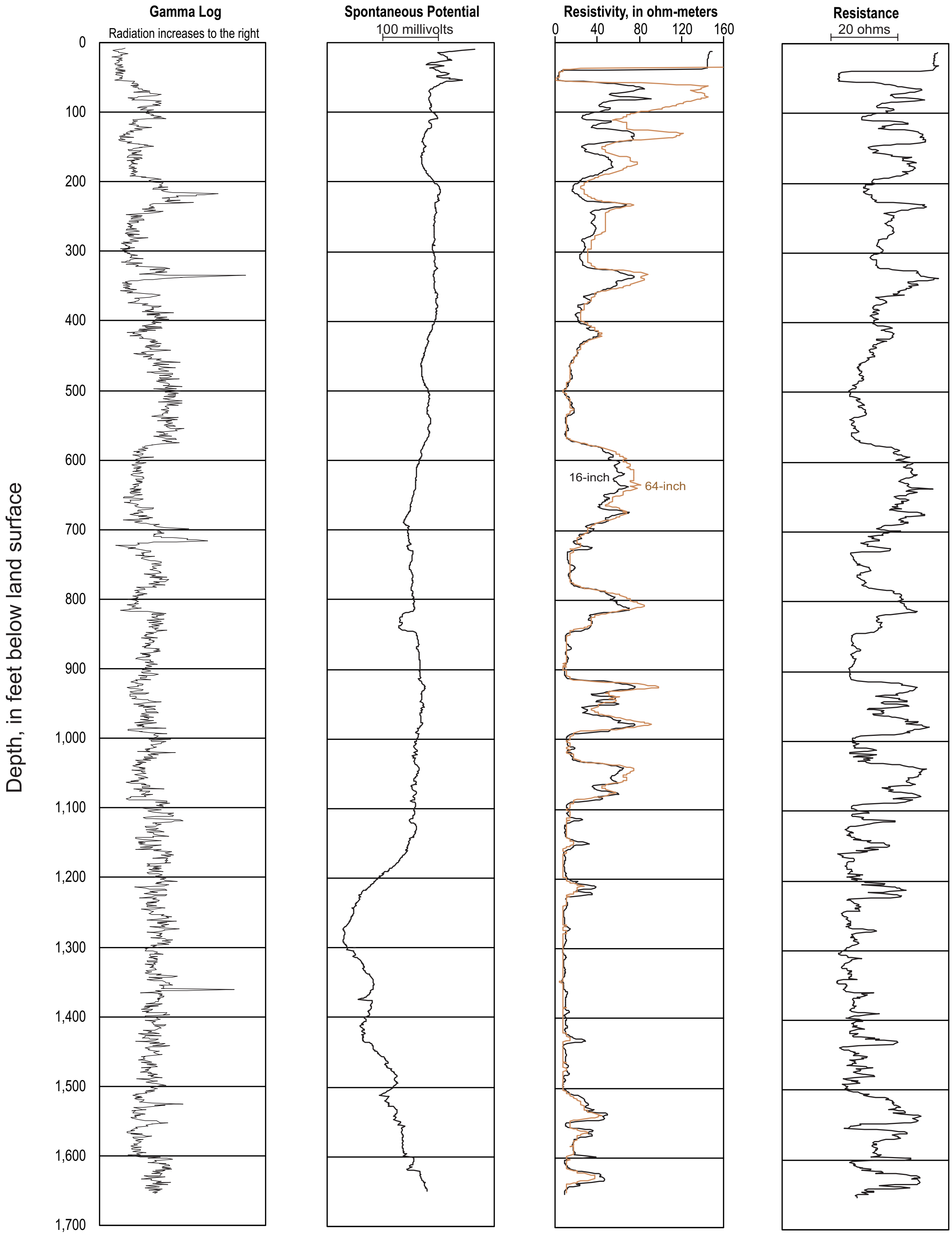


Figure 7. Geophysical logs for test well CA Fd 85, at Chesapeake Ranch.

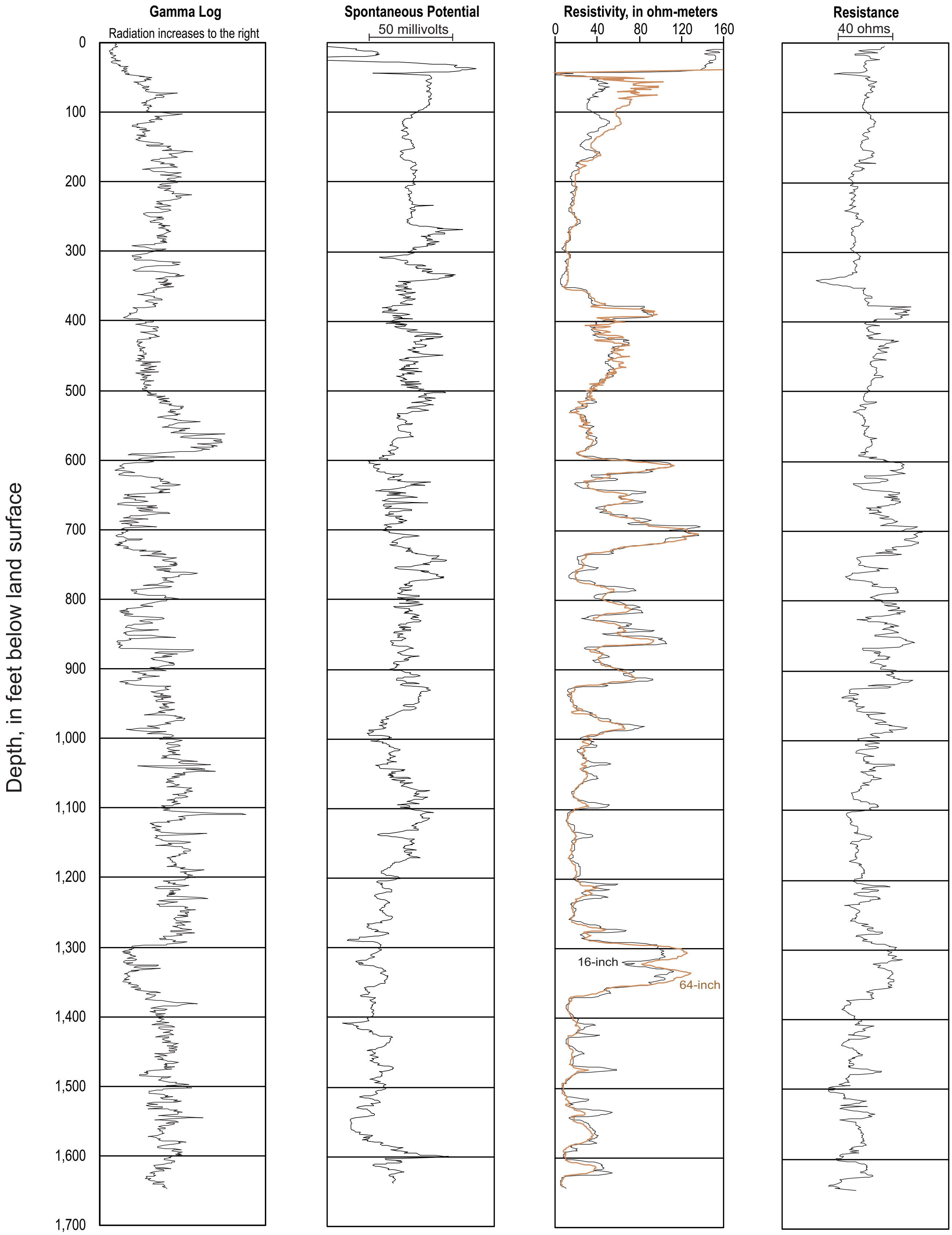


Figure 8. Geophysical logs for test well CH Bg 17, at Malcolm.

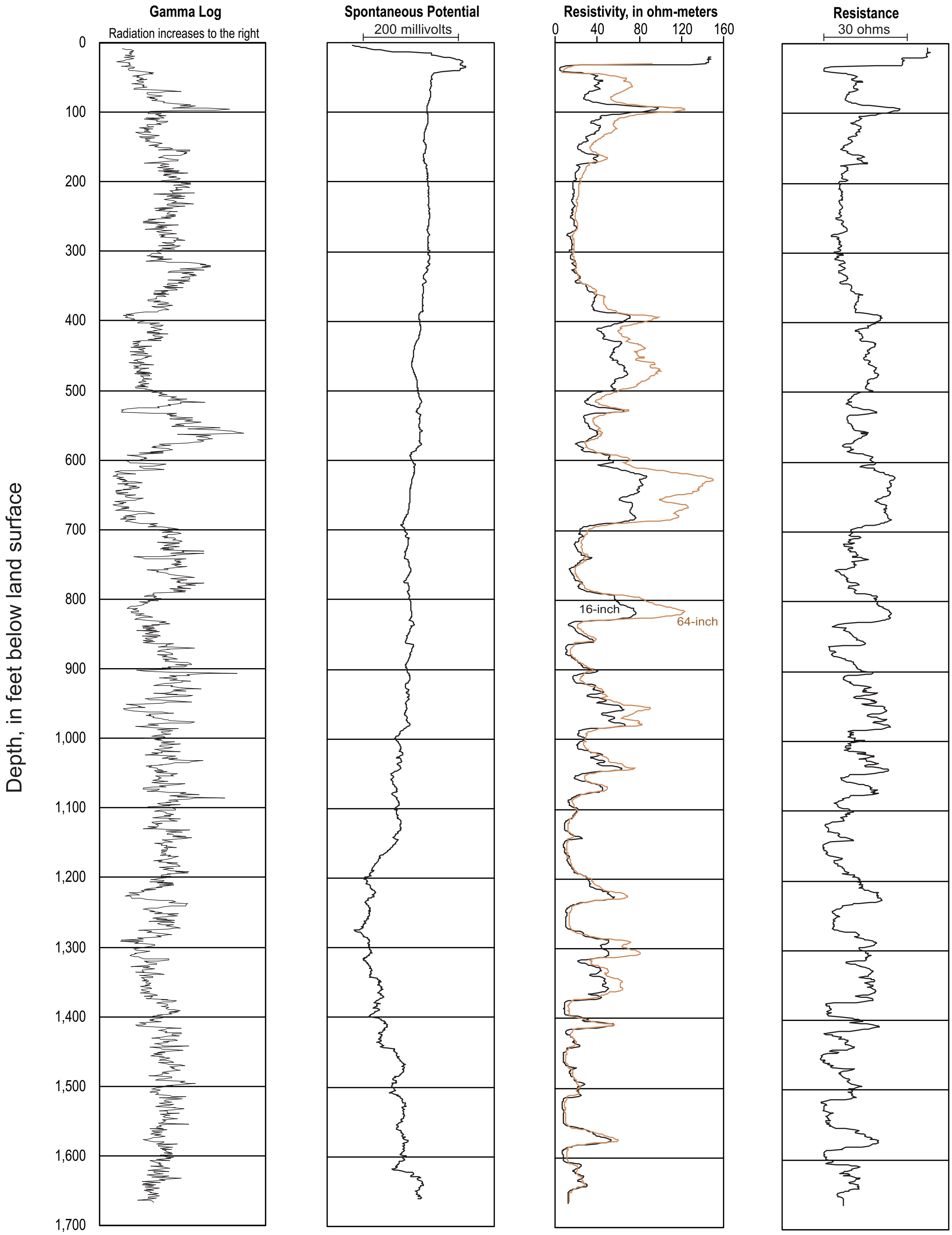


Figure 9. Geophysical logs for test well CH Cg 24, at Hughesville.

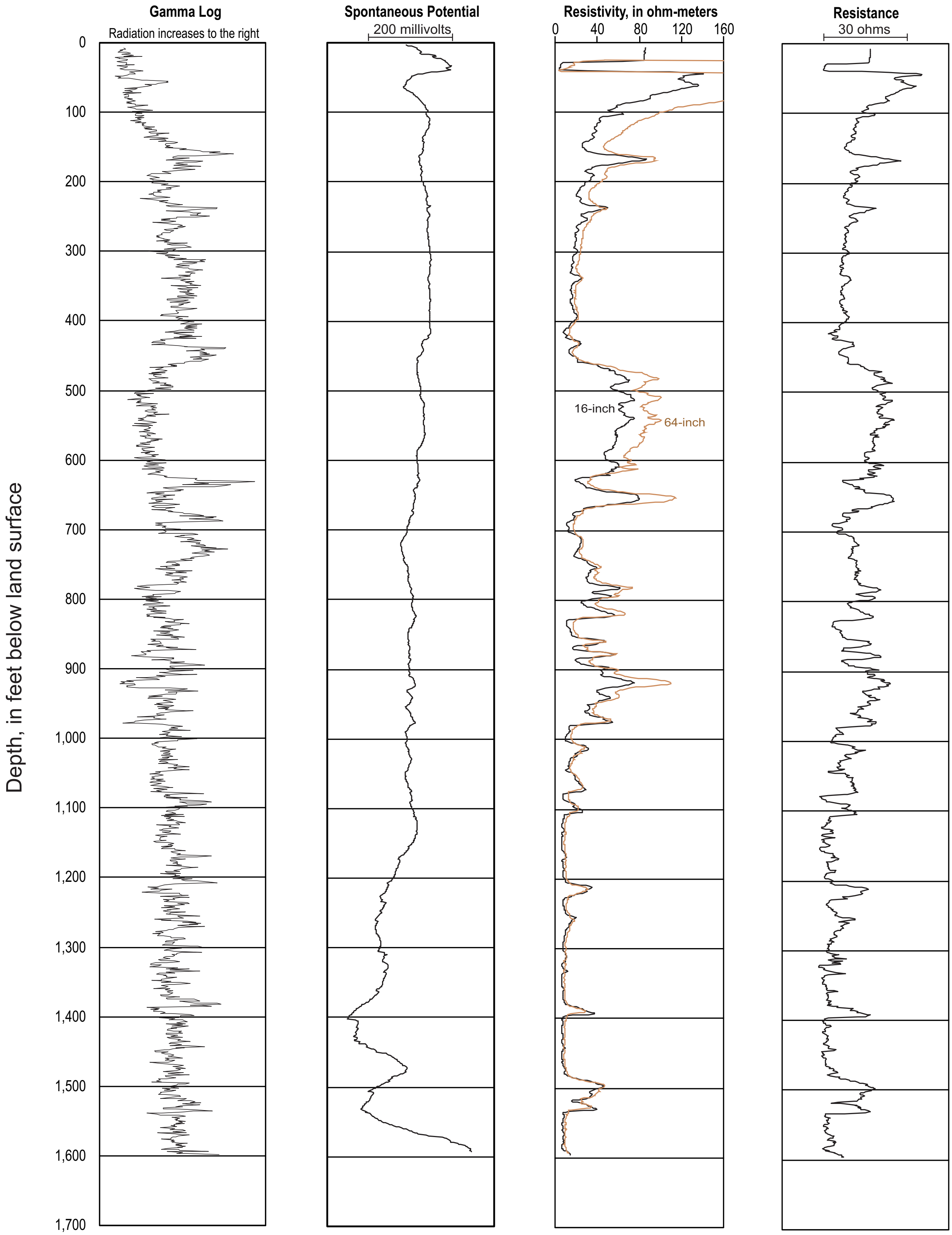


Figure 10. Geophysical logs for test well SM Bc 39, at Persimmon Hills.

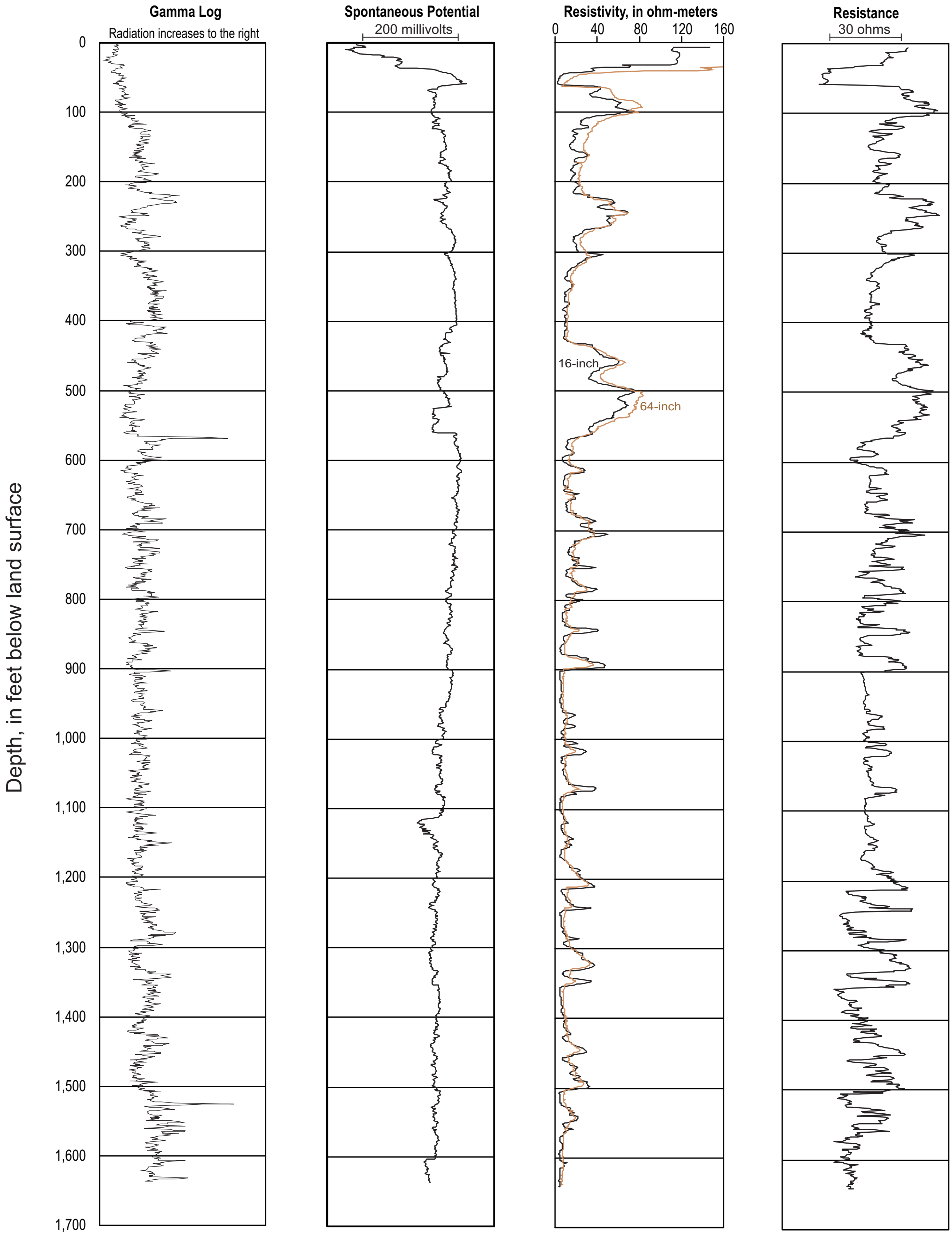


Figure 11. Geophysical logs for test well SM Dd 72, at Paw Paw Hollow.

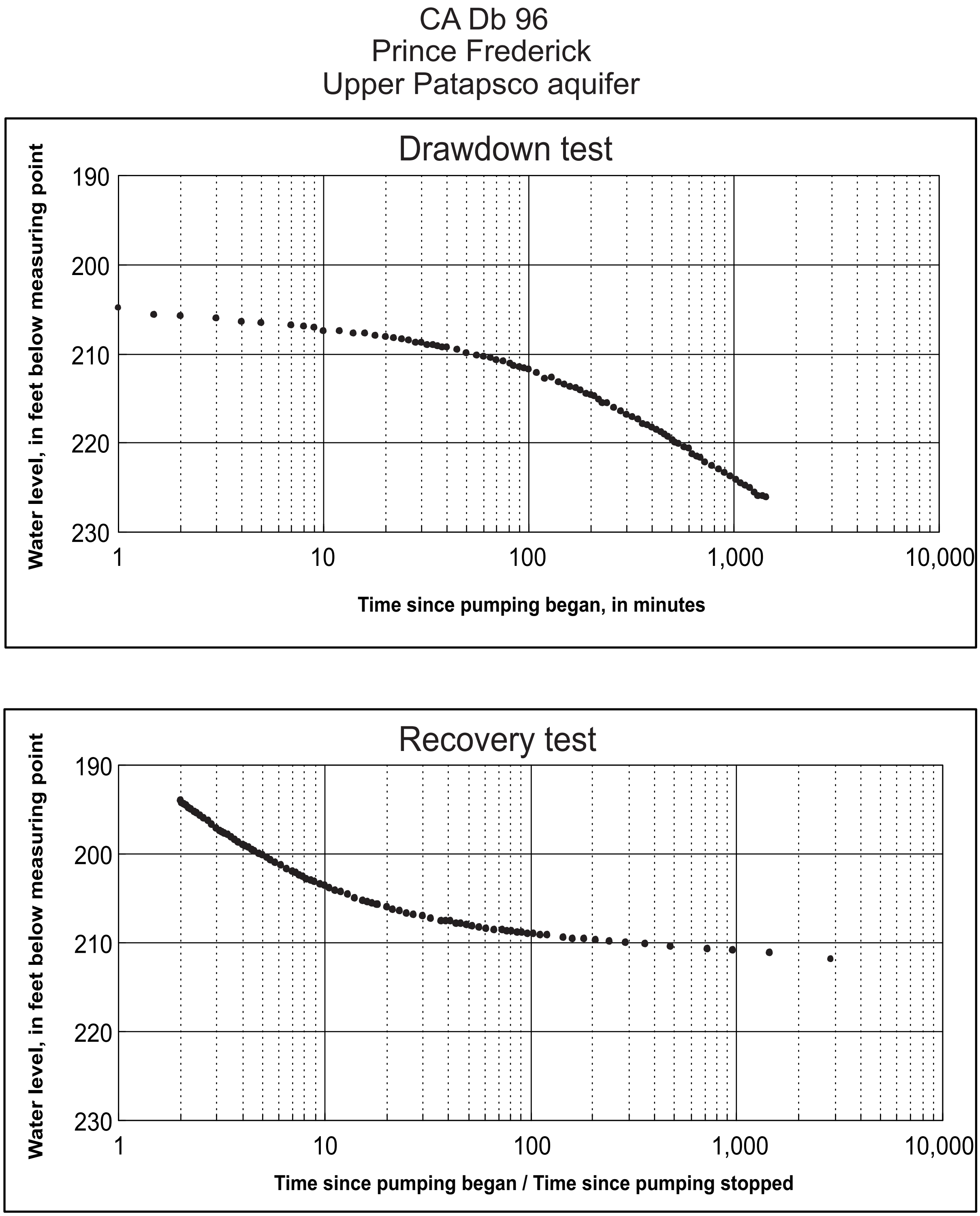


Figure 12. Drawdown and recovery data for aquifer test of test well CA Db 96.

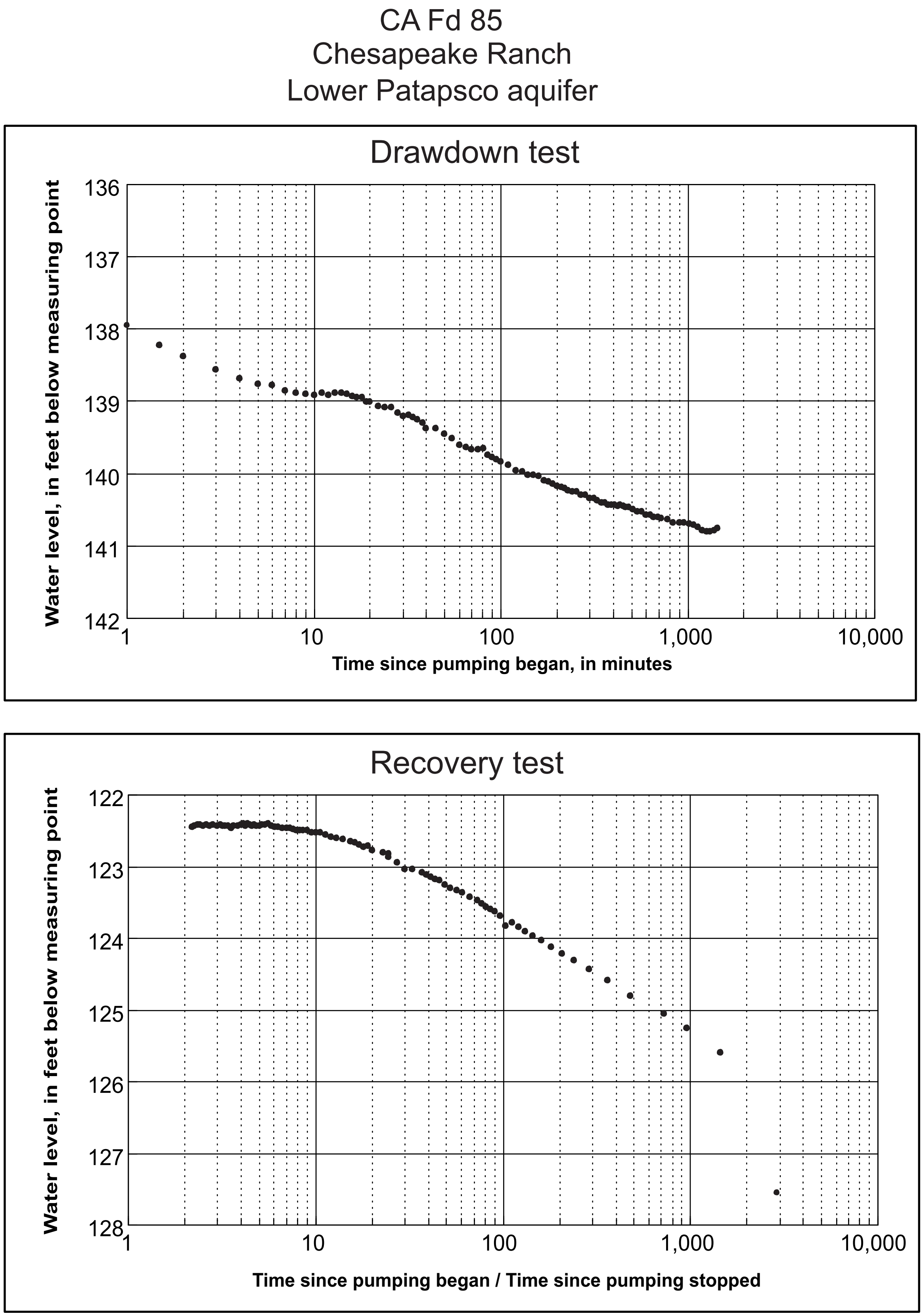


Figure 13. Drawdown and recovery data for aquifer test of test well CA Fd 85.

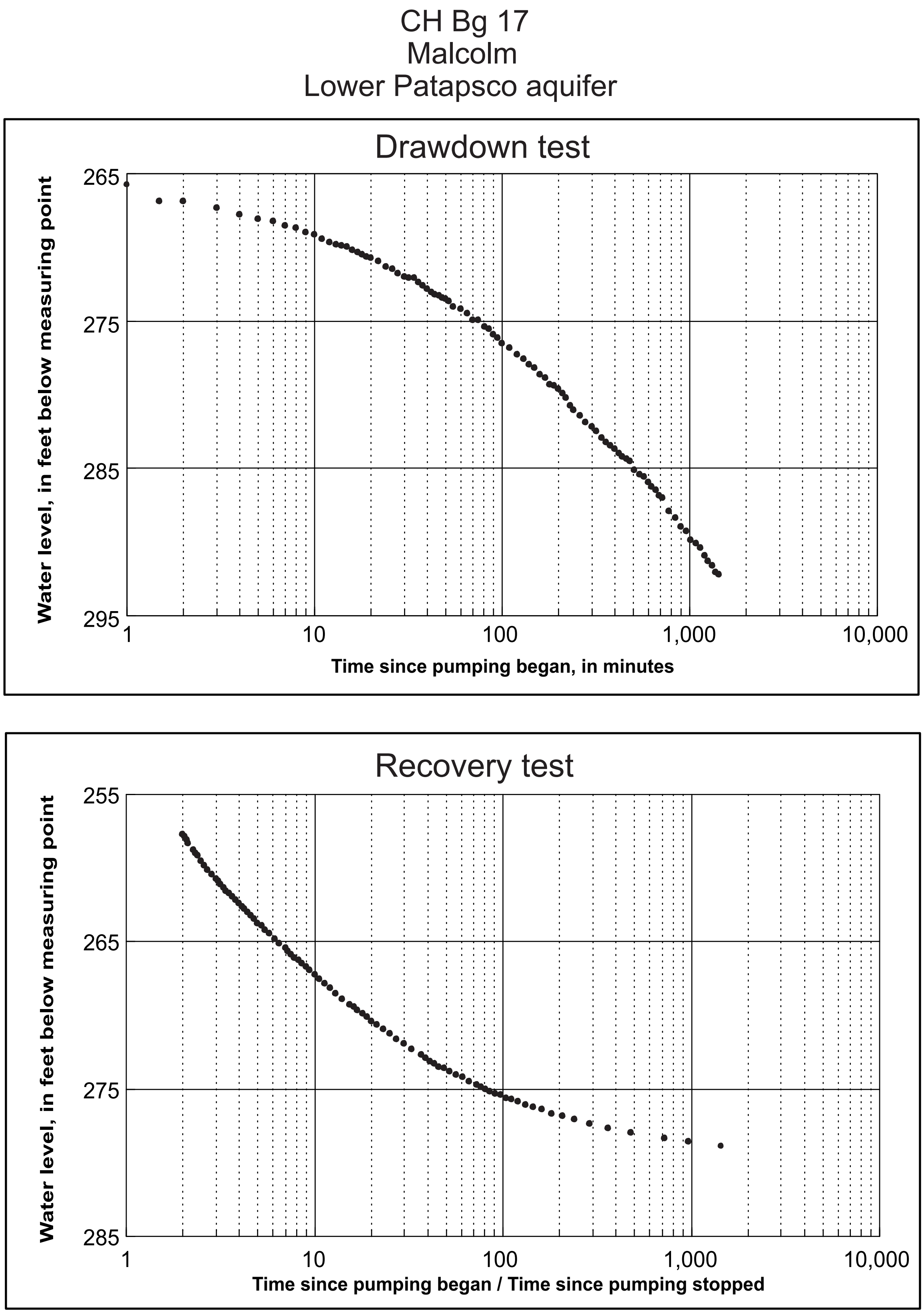
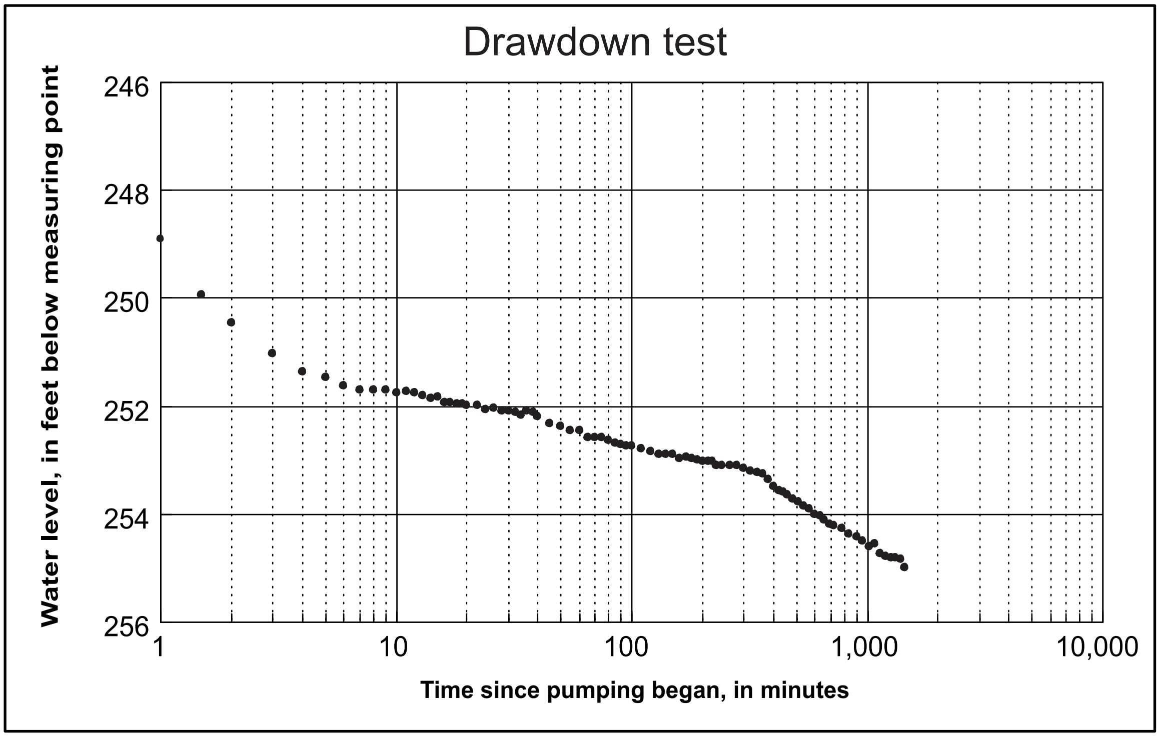


Figure 14. Drawdown and recovery data for aquifer test of test well CH Bg 17.

CH Cg 24
Hughesville
Upper Patapsco aquifer



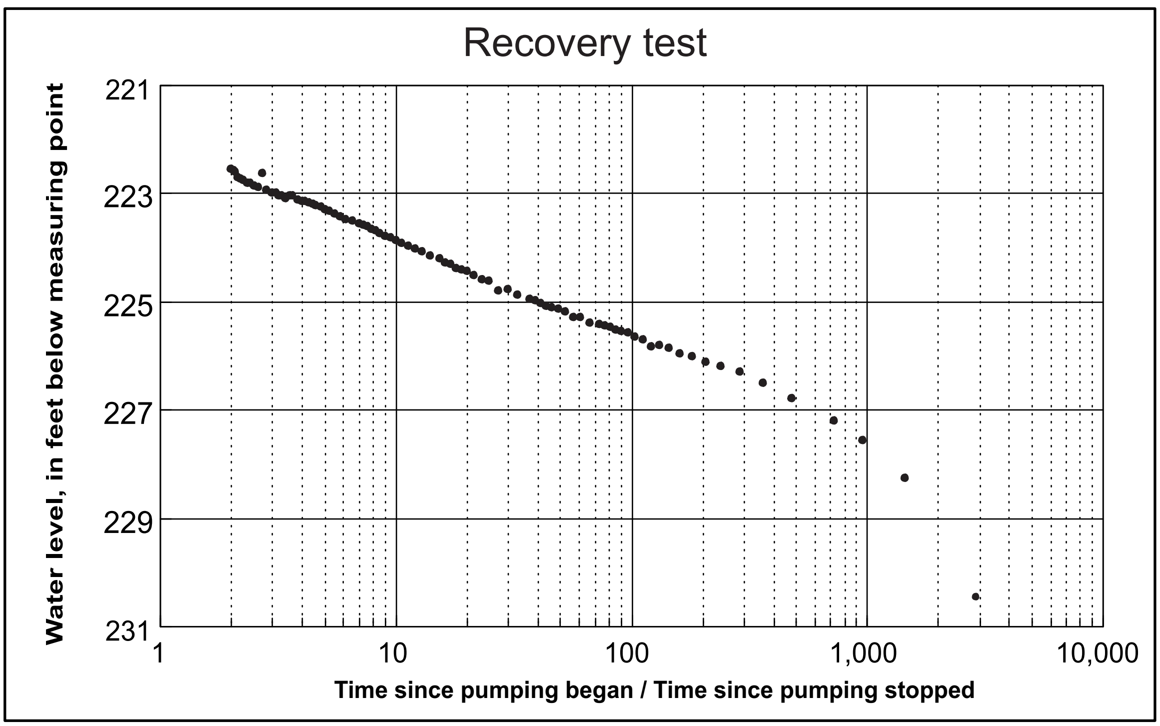
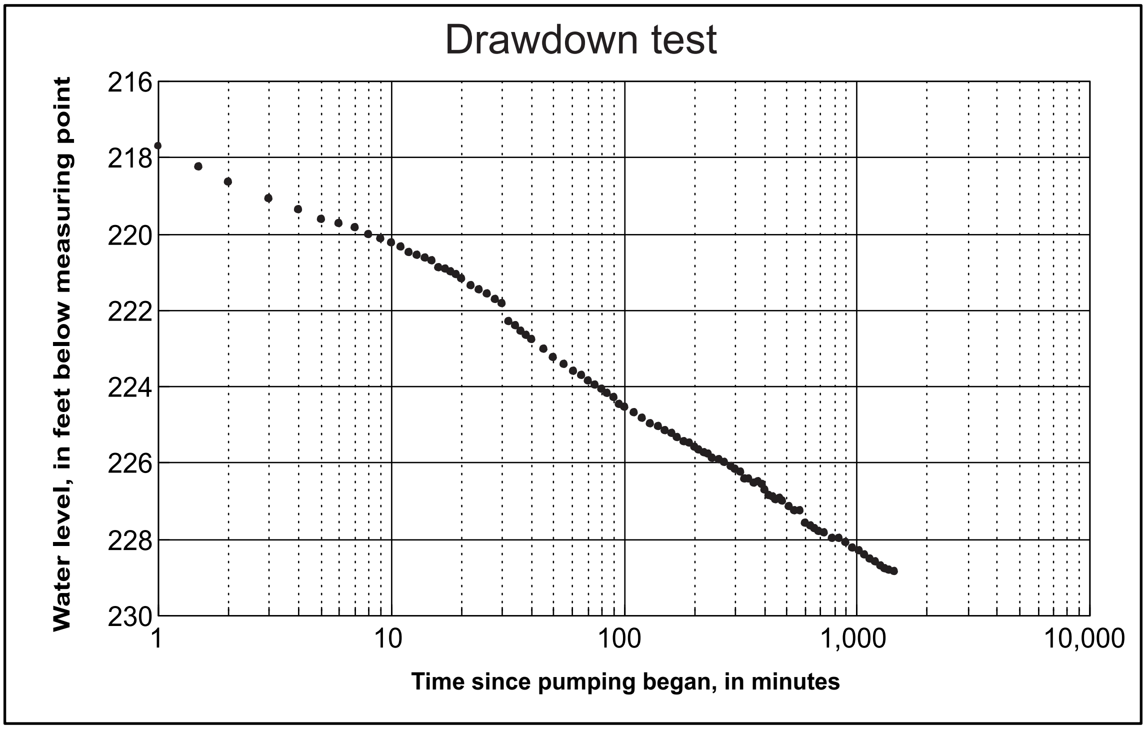


Figure 15. Drawdown and recovery data for aquifer test of test well CH Cg 24.

SM Bc 39
Persimmon Hills
Lower Patapsco aquifer



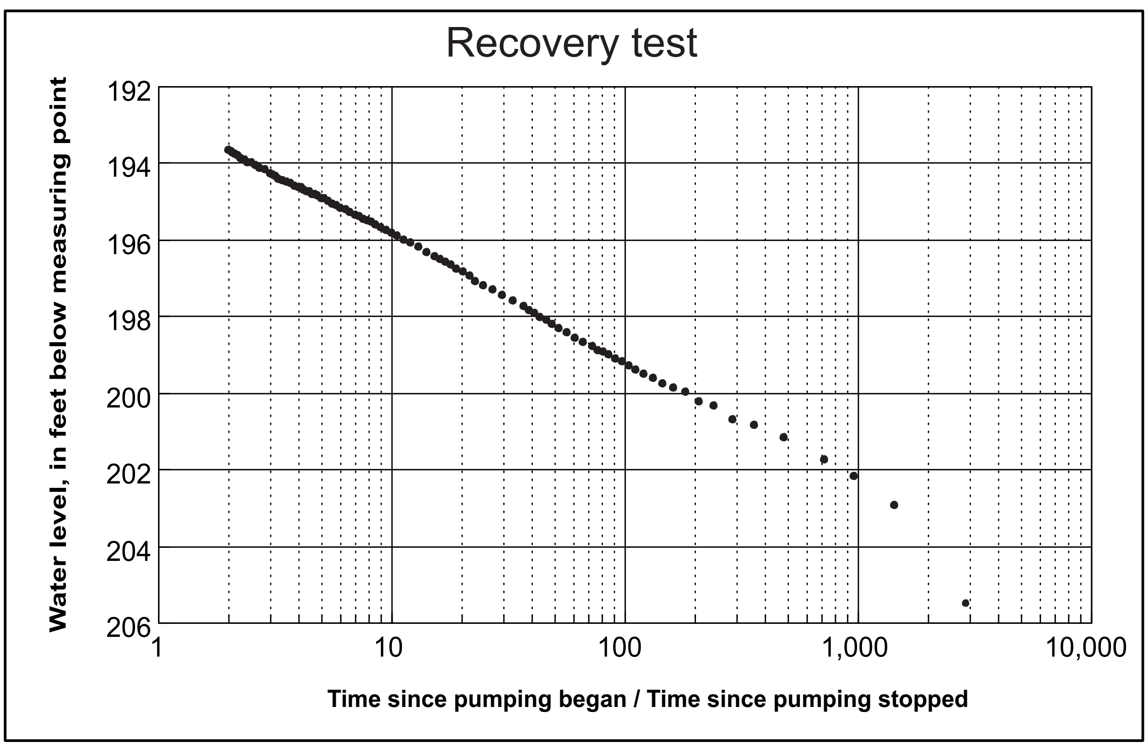


Figure 16. Drawdown and recovery data for aquifer test of test well SM Bc 39.

SM Dd 72
Paw Paw Hollow
Lower Patapsco aquifer

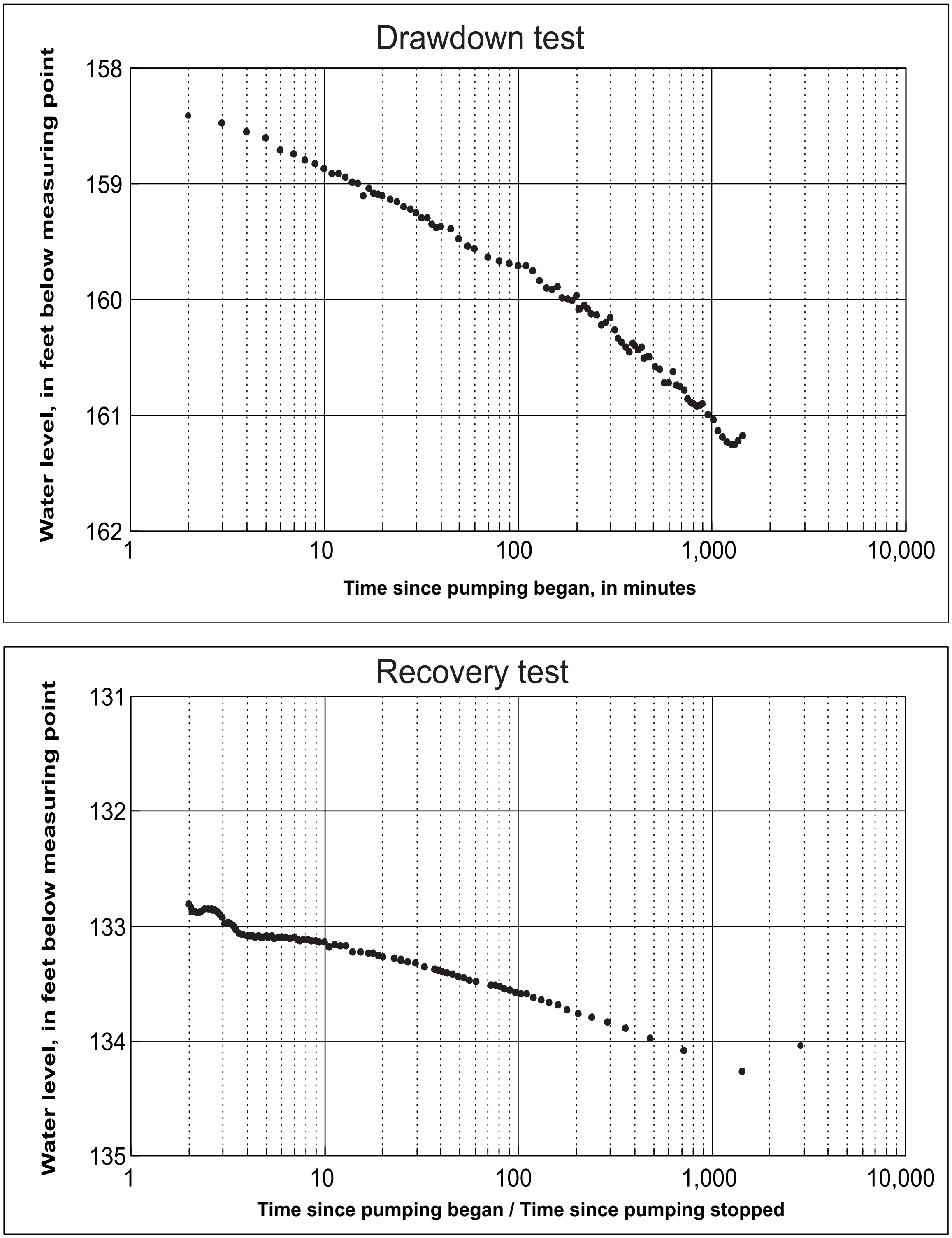


Figure 17. Drawdown and recovery data for aquifer test of test well SM Dd 72.

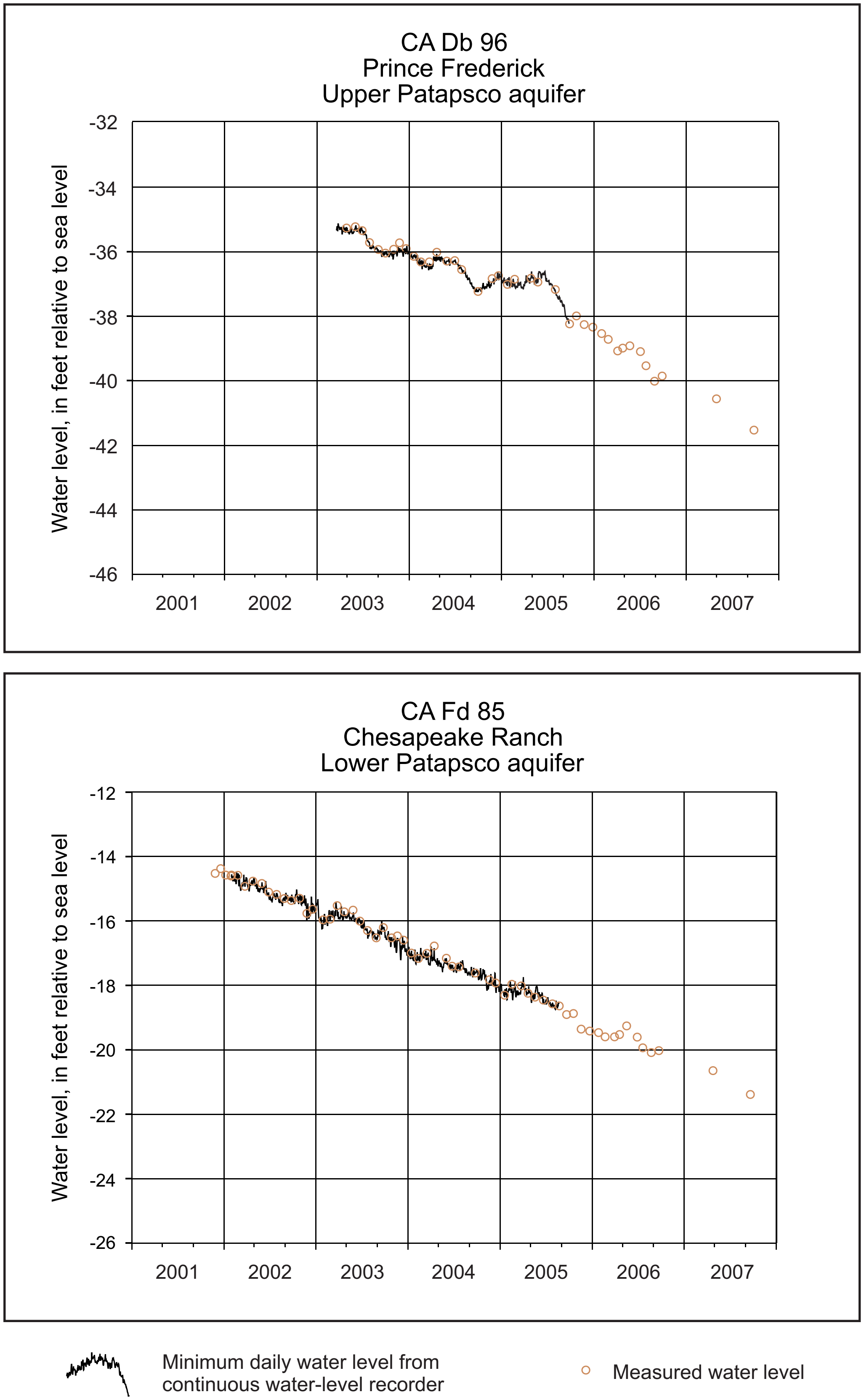


Figure 18. Hydrographs of test wells CA Db 96 and CA Fd 85, in Calvert County.

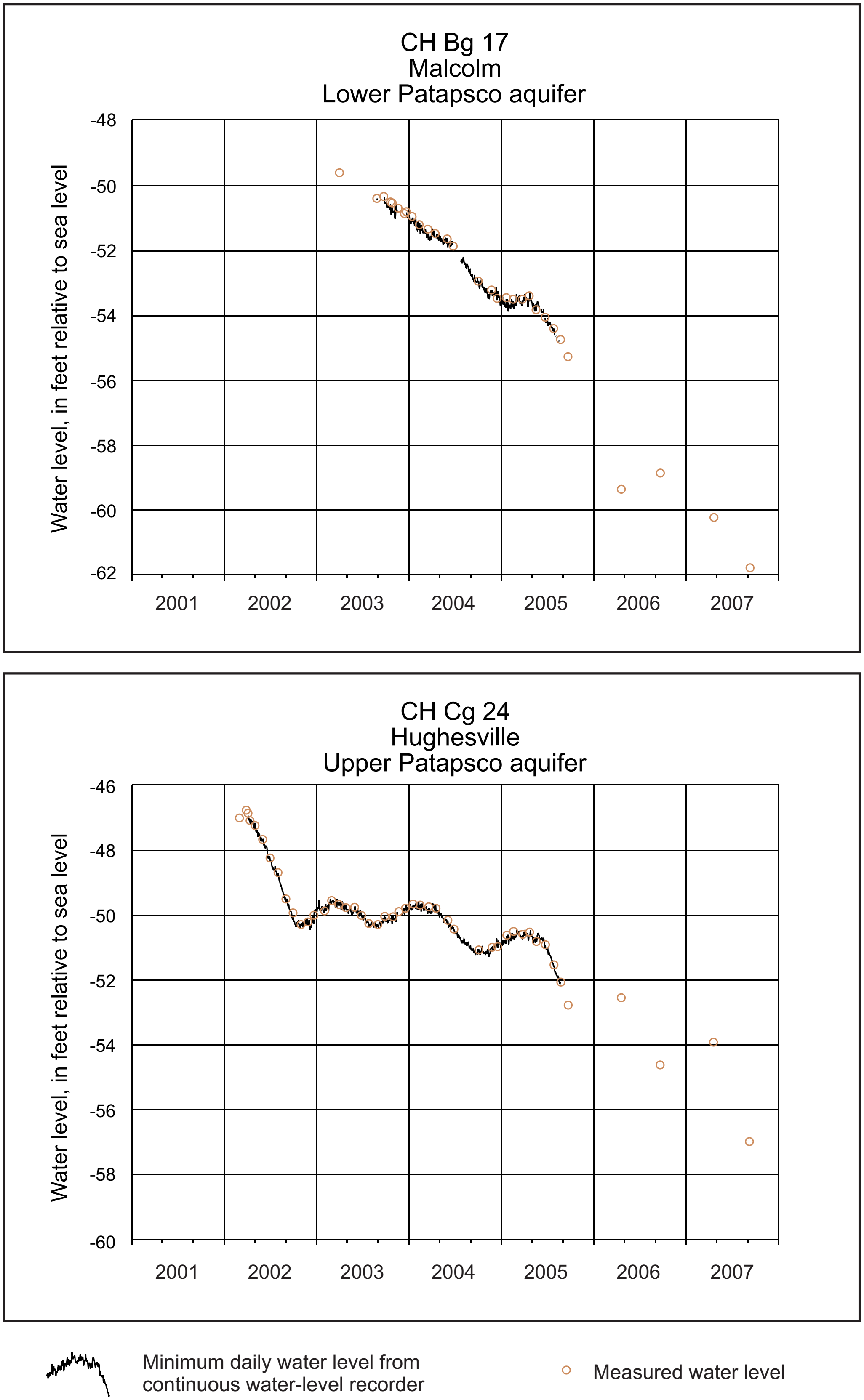


Figure 19. Hydrographs of test wells CH Bg 17 and CH Cg 24, in Charles County.

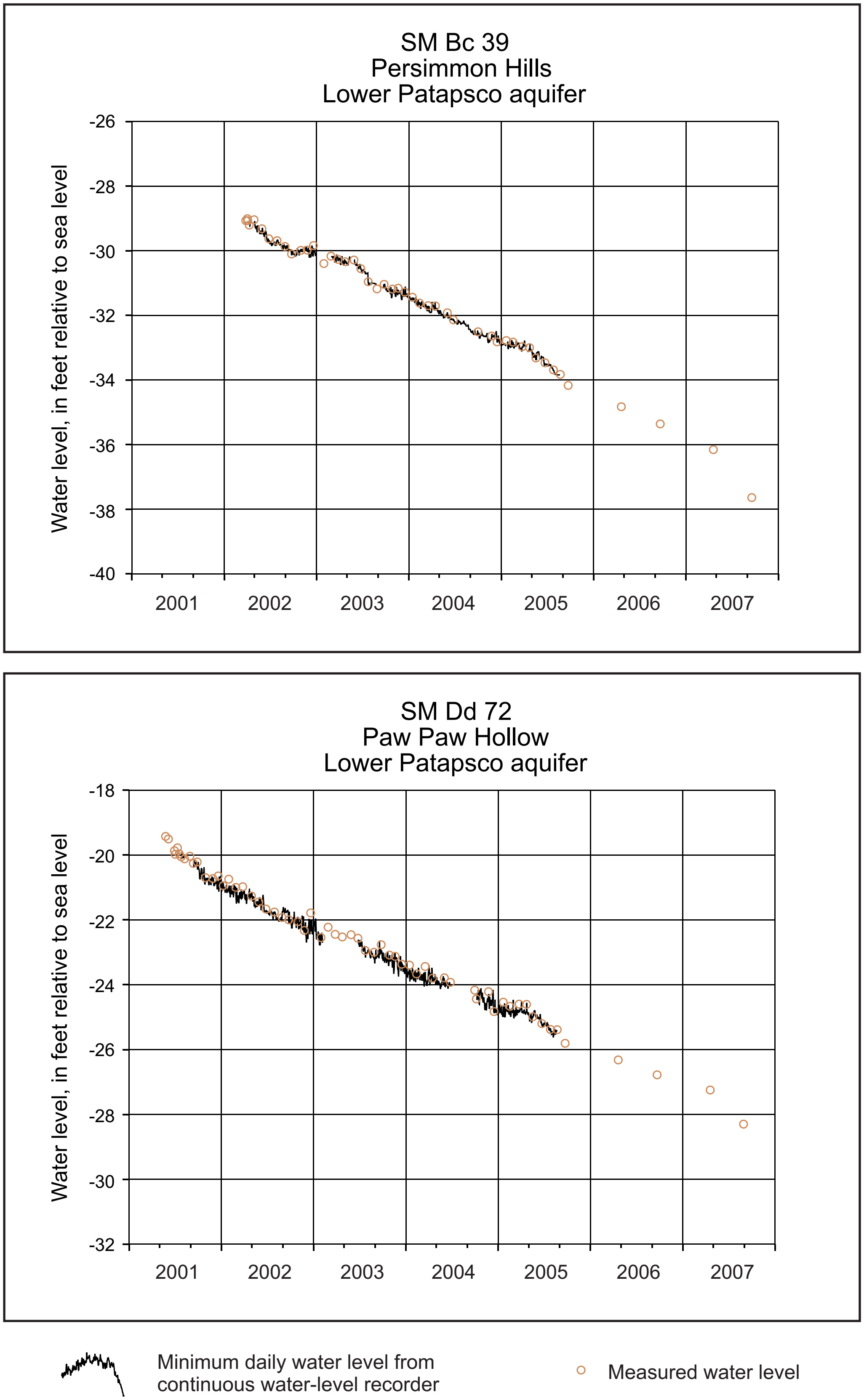


Figure 20. Hydrographs of test wells SM Bc 39 and SM Dd 72, in St. Mary's County.

Table 1. Geologic and hydrostratigraphic units of Southern Maryland

[Modified from Hansen and Wilson, 1984; McCartan, 1989; and Hansen, 1996; Fm, formation; queried (?) where uncertain]

ERATHEM	SYSTEM	SERIES	FORMATION (GROUP)	FORMATION	THICKNESS (feet)	LITHOLOGY	HYDROSTRATIGRAPHIC UNIT
CENOZOIC	QUATERNARY	Holocene & Pleistocene		Lowland deposits	0-150	Sand, gravel, sandy clay, and clay.	SURFICIAL AQUIFER
	NEOGENE	Pliocene		Upland deposits	0-85	Irregularly stratified cobbles, gravel, sand, and clay lenses.	
				Yorktown Fm. (?)	0-20	Fine-grained glauconitic sand.	CHESAPEAKE CONFINING UNIT
		Miocene	Chesapeake Group	Eastover Fm. (?)	0.5-40	Clayey silt with thin laminae of silt, clay, or sand.	
				St. Marys Fm.	0-335	Sand, clayey sand, and sandy clay; fossiliferous and diatomaceous.	
				Choptank Fm.			
				Calvert Fm.			
	PALEOGENE	Oligocene		Old Church Fm. (?)	0-5	Patchy distribution; clayey, glauconitic sand.	PINEY POINT AQUIFER
		Eocene	Pamunkey Group	Piney Point Fm.	0-90	Sand, slightly glauconitic, with intercalated indurated layers; fossiliferous.	
				Nanjemoy Fm.	0-240	Glauconitic sand with clayey layers.	NANJEMOY CONFINING UNIT
		Paleocene		Marlboro Clay	0-30	Pink and gray clay.	
				Aquia Fm.	30-205	Glauconitic, greenish to brown sand with indurated layers; fossiliferous.	AQUIA AQUIFER
				Brightseat Fm.	0-40	Gray to dark-gray micaceous silty and sandy clay.	BRIGHTSEAT CONFINING UNIT
MESOZOIC	CRETACEOUS	Upper	Monmouth Group Matawan Group	Formations undifferentiated	0-135	Sandy clay and sand, dark gray to black, with minor glauconite; fossiliferous.	
				Magothy Fm.	0-230	Light gray to white sand and fine gravel with interbedded clay layers; contains pyrite and lignite. Includes two sand units in southern Anne Arundel County where the formation is thickest.	MAGOTHY AQUIFER
		— ? —	Potomac Group	Patapsco Fm.	0-1,200	Interbedded sand, clay, and sandy clay; color variegated, but chiefly hues of red, brown, and gray; consists of several sandy intervals that function as separate aquifers.	Patapsco aquifer system: UPPER PATAPSCO CONFINING UNIT UPPER PATAPSCO AQUIFER MIDDLE PATAPSCO CONFINING UNIT LOWER PATAPSCO AQUIFER
		Lower		Arundel Fm.	0-400	Red, brown, and gray clay; in places contains ironstone nodules, carbonaceous remains, and lignite.	ARUNDEL CONFINING UNIT
				Patuxent Fm.	100-650	Interbedded gray and yellow sand and clay; kaolinized feldspar and lignite common. Locally clay layers predominate.	PATUXENT AQUIFER
				Waste Gate Fm. (?)	32*	Light gray to gray, tan, fine to medium, clayey sands and clayey silts; feldspathic.	Not a fresh-water aquifer
PALEOZOIC PRECAMBRIAN	Undifferentiated pre-Cretaceous consolidated-rock basement				Unknown	Igneous and metamorphic rocks; sandstone and shale.	NOT RECOGNIZED

* at Lexington Park

Table 2. Construction and yield characteristics of the six test wells

[deg, degree; min, minute; sec, second; ft, feet; gal/min, gallons per minute; (gal/min)/ft, gallons per minute per foot; ft^2/d, feet squared per day; Md., Maryland]

Well number	State permit number	Location	Latitude Longitude (deg min sec)	Driller	Date completed	Altitude of land surface (ft above sea level)	Depth of hole (ft below land surface)
CA Db 96	CA-94-4191	Prince Frederick	38 32 44 76 35 42	A.C. Schultes of Md.	12/12/2002	151.56	1,660
CA Fd 85	CA-94-3305	Chesapeake Ranch	38 22 36 76 25 54	Sydnor Hydrodynamics	11/14/2001	105.98	1,664
CH Bg 17	CH-94-5325	Malcolm	38 37 06 76 47 54	A.C. Schultes of Md.	3/3/2003	199.16	1,660
CH Cg 24	CH-94-4194	Hughesville	38 32 54 76 48 14	Sydnor Hydrodynamics	1/16/2002	171.04	1,667
SM Bc 39	SM-94-3921	Persimmon Hills	38 26 05 76 43 02	Sydnor Hydrodynamics	3/18/2002	161.54	1,600
SM Dd 72	SM-94-3616	Paw Paw Hollow	38 16 26 76 39 34	A.C. Schultes of Md.	5/16/2001	109.99	1,650

			Pumping test				
Well number	Screened intervals[1] (ft below land surface)	Aquifer	Discharge (gal/min)	Static level (ft below land surface)	Drawdown at 24 hours (ft)	Specific capacity ([gal/min]/ft)	Trans-missivity (ft^2/d)
CA Db 96	930-960	Upper Patapsco	73.2	190.66	35.49	2.06	380
CA Fd 85	1,535-1,545 1,560-1,570 1,623-1,633	Lower Patapsco	82.5	120.51	18.24	4.52	2,700
CH Bg 17	1,299-1,314 1,328-1,343	Lower Patapsco	60.4	253.21	39.98	1.51	200
CH Cg 24	795-825	Upper Patapsco	56.3	219.25	33.90	1.66	1,100
SM Bc 39	1,492-1,512 1,522-1,532	Lower Patapsco	66.3	190.61	35.72	1.86	640
SM Dd 72	1,300-1,330	Lower Patapsco	70.0	131.00	28.51	2.46	4,000

[1]All casing and screen intervals are 4-inch diameter; well depth is 10 ft greater than deepest screen interval; also see figures 3, 4, and 5 for construction features.

Table 3. Driller's log of drill cuttings for test well CA Db 96

CA Db 96
Prince Frederick

Description of drill cuttings	Depth to bottom (feet below land surface)	Description of drill cuttings	Depth to bottom (feet below land surface)
Topsoil	2	Hard shell and sand	669
Fine to medium tan sand	7	Sand and shell with clay	677
Tan clay	14	Sand with cemented sand and shell with red clay	701
Fine sand with clay	21	Gray clay with fine sand	719
Tan clay	27	Gray sand with lignite and clay, pink clay with lignitic fine sand, fine sand with pink and gray lignite(?)	833
Gray clay	44	Coarse to medium sand, red and white clay	938
Gray sand and shell with clay	73	Coarse to medium sand with lignite and red clay	964
Gray clay and shell	86	Red clay, some sand	1,078
Hard shell and sand	88	Medium to fine sand with red clay	1,138
Sand and shell	95	Coarse to medium sand with gray clay	1,167
Green clay with shell	142	Gray clay with fine medium sand	1,183
Hard layer	143	Hard brown and gray clay, red clay	1,243
Gray sand and shell	182	Medium to fine sand and gray clay, red clay with fine sand	1,331
Green clay and shell with fine sand	243	Hard layer	1,332
Gray sand and shell with clay and pepper sand	379	Multi-colored clay with fine sand and hard layers	1,457
Green clay and pepper sand	409	Clay with fine sand	1,660
Light gray clay	426		
Sand with gray clay	512		
Coarse sand with cement sand	545		
Medium to fine sand and cement sand	597		
Gray clay with medium to fine sand, shell and cement sand layers	637		
Medium sand with clay	650		

Table 4. Driller's log of drill cuttings for test well CA Fd 85

CA Fd 85
Chesapeake Ranch

Description of drill cuttings	Depth to bottom (feet below land surface)	Description of drill cuttings	Depth to bottom (feet below land surface)
Sand	20	Shell, rock, brown clay, sand	830
White sand	32	Brown clay and sand	860
Gray clay, sand and gravel	70	Brown gray clay, some sand	870
Sticky gray clay, coarse rock	80	Sandy brown and gray clay	894
Sticky gray clay, sand, rock	90	Sticky brown clay	914
Sticky gray clay	110	Red brown gray clay	920
Gray and green clay	120	Fine sand, some clay	930
Green clay and shells	140	Fine sand, coarse rock	940
Sandy green clay and shells	200	Fine sand, some clay	950
Sticky green clay	230	Fine sand, brown and gray clay	960
Green clay, shell and sand	240	Fine sand, sandy clay	990
Sandy green clay and shells	270	Sand, green and gray clay	1,000
Sandy green clay	280	Sticky brown and gray clay	1,020
Green clay and shells	290	Sandy gray clay	1,090
Green clay and some shells	310	Fine sand	1,120
Sticky green clay and some rock	320	Sandy brown clay	1,190
Green clay, shell and rock	330	Fine brown sand and clay	1,200
Sandy green clay and rock	340	Fine brown sand	1,220
Green clay, black sand, shell	350	Fine brown sand, mixed clay	1,240
Green clay, rock and shell	360	Sand and brown, gray clay	1,250
Black sand and green clay	370	Fine sand, some brown clay	1,260
Gravel and coarse sand	380	Fine brown sand	1,270
Coarse sand and gray clay	390	Fine sand, some clay	1,290
Sandy gray clay	410	Sandy and sticky brown clay	1,380
Black sand and gray clay	460	Hard brown and red clay	1,390
Black sand and green clay	530	Sandy and sticky brown clay	1,460
Fine black sand and green clay	540	Fine sand, gray clay, shell, rock	1,470
Black sand and gray clay	590	Fine sand, sandy gray clay	1,480
Black sandy gray clay	625	Fine brown sand, some clay	1,490
Fine sand, coarse rock	630	Fine sand	1,500
Fine sand, green/gray clay mix	640	Fine sand, sandy gray clay	1,520
Fine sand, clay mix, shells, rock	660	Fine sand	1,540
Sandy gray clay, shell, rock	680	Fine sand, some clay	1,550
Shell, rock, sand	692	Coarse sand, some clay	1,570
Gray clay	730	Fine white sand	1,580
Hard green clay	740	Brown clay and sand	1,610
Hard green and red clay	750	Brown and gray clay, sand, wood	1,630
Mixed clay, coarse rock	774	Sand and wood	1,640
Sandy red clay	790	Wood and brown clay	1,650
Sandy red clay mixed	800	Brown clay	1,664
Fine sand, mixed clay	820		

Table 5. Driller's log of drill cuttings for test well CH Bg 17

CH Bg 17
Malcolm

Description of drill cuttings	Depth to bottom (feet below land surface)	Description of drill cuttings	Depth to bottom (feet below land surface)
Topsoil	1	Fine to medium sand	728
Sandy clay	16	Medium to coarse sand	752
Tan sand with gravel	42	Red and white clay with lignite	774
Gray clay with fine sand	154	Coarse sand with lignite	792
Gray sand and shells with clay	172	Clay with sand and lignite	847
Hard shell layer	174	Sand with clay	893
Gray sand and shells with clay, sand with clay and pepper sand, gray clay with sand	352	Clay with fine sand	957
Gray sand with little white and tan clay	378	Hard layers with clay and sand	963
Hard shell layer	380	Red clay with fine sand-slow drilling	1,027
Sand with cemented sand	412	Multi-colored clay with fine sand	1,198
Medium sand	428	Fine sand with clay	1,210
Fine to medium sand cemented sand	439	Sand without clay streaks	1,220
Clay with sand and shells	514	Clay with sand streaks	1,230
Hard layer	517	Sand with clay streaks	1,327
Fine to medium sand with clay	588	Hard layer	1,328
Hard layer	589	Clay and sand	1,352
Fine to medium sand with lignite	633	Sand, clay, and lignite	1,447
Red and white clay with lignite and sand	642	Sand with clay streaks	1,515
		Fine to medium sand	1,660

Table 6. Driller's log of drill cuttings for test well CH Cg 24

CH Cg 24
Hughesville

Description of drill cuttings	Depth to bottom (feet below land surface)	Description of drill cuttings	Depth to bottom (feet below land surface)
White sand and red clay	10	Sandy yellow gravel (?)	730
Red clay and white sand	20	Sandy brown clay	740
White sand and gray and red clay	30	Red clay sand	750
Gray clay	40	Red clay	760
Gray clay and gravel	50	Red clay and coarse gravel	770
Gravel, shell, fine sand, green clay	60	Sandy red clay	790
Green clay	65	Sandy clay, some red clay	800
No record	110	Sandy red clay	820
Gray clay, fine sand, shells mixed	120	Fine sand, red and brown clay	850
Fine sand, gray clay, shells	160	Fine sand, brown clay, and rock	870
Gray clay, shells, and fine black sand	170	Fine sand and brown and gray clay	880
Green sandy clay, shell, coarse gravel	180	Brown sandy clay	890
Green sandy clay, shell	190	Brown and red clay, some gravel	900
Green sandy clay, coarse rock	200	Brown clay and gravel	910
Black sandy green clay and shell	230	Brown and gray clay, sandy	920
Black sandy green clay	260	Mixed clay, brown, red, coarse gravel	930
Black sandy green clay and shell	270	Sand, some brown clay and shell	940
Fine black sand and gray clay	310	Brown and gray clay, sand	950
Fine black sand, gray clay, and gravel	320	Sand, brown clay	960
Fine black sand, red and gray clay, gravel	330	Sand, some brown clay	970
Fine black sand, red and gray clay	380	Fine sand	990
Fine black sand, red and gray clay, shell rock	410	Sandy brown and gray clay	1,030
No record	440	Sandy gray clay	1,050
Sandy green clay	450	Sandy gray and red clay	1,058
Sandy green and gray clay	460	No record	1,122
Sandy green clay and shell rock	470	Hard brown clay	1,129
Sandy green and gray clay and shell	490	Sandy brown clay and hard brown clay	1,150
Sand and shell	520	Hard brown clay	1,170
Sand, gray clay, and shell	530	Sandy and hard red clay	1,180
Coarse sand and shell	540	Hard red clay	1,190
Sandy gray clay, shell	550	Hard clay	1,200
Fine sand, red and gray clay, and shells	580	Sand	1,210
Fine sand, gray clay and shells	590	Sandy clay	1,220
Fine sand, red and gray clay, and shells	620	Rock	1,230
Fine sand, red and gray clay, and coarse sand	630	Sand	1,240
Coarse sand	690	Hard gray clay	1,254
Coarse sand and sticky yellow clay	720	Hard clay	1,262
Sticky yellow clay and sand	724	Fine sand, some clay	1,270
		Fine sand	1,360
		Fine sand and gray clay	1,460
		Fine sand, some clay	1,470
		Fine sand and clay	1,480

Table 6. Continued

CH Cg 24—Continued

Description of drill cuttings	Depth to bottom (feet below land surface)	Description of drill cuttings	Depth to bottom (feet below land surface)
Fine sandy clay	1,490	Clay and fine sand	1,560
Fine sand and clay	1,510	Hard red and green clay and fine sand	1,620
Clay and sand	1,540	Fine sand	1,640
Clay and sand	1,550	Clay and sand	1,667

Table 7. Driller's log of drill cuttings for test well SM Bc 39

SM Bc 39
Persimmon Hills

Description of drill cuttings	Depth to bottom (feet below land surface)	Description of drill cuttings	Depth to bottom (feet below land surface)
Red clay	40	Red clay	891
Clay and shells	50	Sand and red clay	910
Green clay and shells	70	Brown and red clay, fine sand	970
Green and gray clay, shell, rock	80	Red clay and fine sand	1,010
Green clay, sand, shell, rock	90	Red and brown clay, coarse sand	1,020
Green clay and shell	110	Red clay, coarse rock	1,030
Sandy clay and shell	120	Coarse rock, some red and gray clay	1,050
Green clay and shell	130	Green and gray, sandy clay	1,060
Green clay, sand, shell, coarse rock	140	Green and gray, fine sandy clay	1,070
Brown and gray hard clay	170	Green and gray, red sandy clay	1,080
Hard gray clay	220	Red and green sandy clay	1,090
Gray clay	280	Sandy gray clay	1,110
Hard gray clay	290	Brown clay and sand	1,130
Black sand, green and gray clay	320	Red and gray clay	1,150
Black sand and gray clay	390	Red clay	1,160
Gray clay	460	Red and gray clay, fine sand	1,170
Brown and green clay	470	Brown and red clay, coarse sand	1,180
Shell rock, brown and green clay	480	Brown and red clay	1,210
Green clay, fine sand, shell rock	490	Green and gray clay, fine sand	1,220
Shell rock and green clay	510	Fine and coarse sand	1,230
Sandy green clay and shell rock	520	Fine, sandy brown clay	1,240
Shell rock and green clay	580	Sandy, brown and gray clay	1,250
Sandy green clay	600	Sandy, lime green clay	1,260
Rock and green clay	610	Lime green and red clay, sand	1,270
Green clay, sand, rock	620	Red and brown clay and sand	1,290
Rock and gray clay	630	Brown clay	1,310
Sandy gray clay	640	Brown and gray clay	1,320
Gray clay and coarse sand	650	Gray clay	1,330
Coarse sand	670	Gray, green clay, some sand	1,340
Coarse sand and tough red clay	680	Sandy, brown and gray clay	1,350
Brown and red clay	710	Sandy brown clay	1,370
Mixed red clay, sand	720	Brown clay and fine sand	1,380
Yellow and gray clay	750	Fine sand	1,410
Hard gray clay	770	Fine sand, hard red and brown clay	1,420
Gray clay and fine sand	800	Hard red and brown clay	1,430
Gray and lime green clay, fine sand	830	Sand	1,520
Clay	850	Green clay and fine sand	1,530
Sand	865	Fine sand, hard brown and red clay	1,540
Red clay	870	Red, brown clay	1,580
Sand	882	Red, brown and green clay	1,600

Table 8. Driller's log of drill cuttings for test well SM Dd 72

SM Dd 72
Paw Paw Hollow

Description of drill cuttings	Depth to bottom (feet below land surface)	Description of drill cuttings	Depth to bottom (feet below land surface)
Gravel with red clay	7	Clay gray/white	862
Fine to coarse tan sand	30	Fine to medium sand	881
Hard layer	31	Fine sand and clay	894
White clay	40	Fine to coarse sand with clay and lignite	948
Large gravel with fine tan sand	46	Multi-colored clay with sand	1,045
Tan and gray clay	53	Fine to medium sand with clay	1,053
Gray sand and shell with clay	112	Multi-colored clay, hard	1,118
Green clay with fine sand and shell	235	Multi-colored clay with medium to fine sand	1,128
Gray sand and shell	250	Multi-colored clay, hard	1,151
Cemented sand and shell with clay	252	Fine to medium sand with clay	1,169
Hard shell layer	284	Fine to medium sand	1,193
Black sand and shell with clay	425	Multi-colored clay, hard	1,219
Pink clay	433	Fine white sand	1,228
Brown/black sand with shell	577	Red and gray clay	1,248
Clay with sand and shell	626	Coarse to medium sand	1,335
Hard multi-colored clay	642	Multi-colored clay, hard	1,392
Fine to medium gray sand with clay	660	Fine to medium sand with clay	1,434
Hard multi-colored clay	676	Fine to medium sand with clay and lignite	1,485
Fine to medium sand with clay and lignite	721	Gray and white clay	1,496
Hard layer	722	Dirt and sand with clay	1,504
Clay with fine sand and lignite	747	Fine to medium sand	1,542
Sand, fine to medium	753	Clay, hard, slow drilling	1,583
Clay with fine sand	764	Fine to medium sand	1,590
Medium sand with clay	797	Clay with fine, silty sand	1,650
Hard layer	798		
Clay with fine sand	844		

Table 9. Composite lithologic description of drill cuttings for test well CA Db 96

[ft, feet; mm, millimeter; %, percent; <, less than;
Color designations are based on Munsell Color Charts (Munsell Color Company, Inc., 1975)]

CA Db 96
Prince Frederick
Altitude: 152 ft above sea level

Depth, in feet below land surface	Description
	Surficial aquifer
0-60	Sand, fine to medium, quartz, mostly clear colorless and frosted, subangular; abundant fragments of iron-cemented sandstone, dark brown (7.5YR 3/4); clay, brownish yellow (10YR 6/8), sandy, grading into dark greenish gray, (Gley 1 4/10GY), silty; shell fragments (40-60 ft), mostly off white and gray.
	Chesapeake confining unit
60-270	Clay, brownish yellow (10YR 6/8), sandy, dark greenish gray, (Gley 1 4/10GY) and olive clay (Gley 1 4/10Y and 5Y 4/2); shells, white and gray, with some *Turritella* shells (150-180 ft) and sparse fragments of dark reddish brown (2.5YR 2.5/3) translucent shell material, slightly calcareous interbedded with sand, medium-grained, clayey, quartz clear colorless and green-stained, subangular; (130-180 ft); trace fine lignite; fragments of black phosphate nodules 2-3 mm, molds and fish teeth, slightly calcareous (230-240 ft); shark's tooth 230-240 ft.
	Piney Point aquifer
270-320	Sand, fine to coarse, quartz clear, green and yellow-stained, subrounded to subangular; glauconite (20-80%), subrounded to botryoidal, black to medium greenish gray; abundant shell material; rare pyrite; clay, very dark gray cemented clasts, very dark greenish gray (Gley 1 3/10Y), sandy, glauconitic (300-310 ft), greenish gray (Gley 1 5/10GY), slightly silty (310-420 ft., and trace pink clay (290-300 ft).
	Nanjemoy confining unit
320-450	Sand, fine to coarse, quartz, clear, green and yellow-stained, subrounded to subangular; glauconite (30-80%), subrounded to botryoidal, black to medium greenish gray; some shell material; rare pyrite; interbedded clay, very dark greenish gray (Gley 1 3/10Y), greenish gray (Gley 1 5/10GY), silty and brown (7.5YR 4/2), sandy; trace shells and mica.
450-475	(Marlboro Clay, 450-475 ft, determined from geophysical log.)
	Aquia aquifer
475-670	Sand, fine to coarse, quartz clear, colorless, white, yellow and green-stained, angular to subrounded; glauconite (70-80%), black, green, sparse brown and olive, botryoidal and oblong; clay, silty to sandy, micaceous, greenish gray (Gley 1 5/10GY), brown (7.5YR 4/2 and 5/4), light green, and dark greenish gray (Gley 1 4/10GY); abundant shell fragments (640-670 ft.), punctuate brachiopods, internal *Turritella* molds, some corallites filled with green glauconite; rare pyrite, phosphate nodules, and cemented sandstone, non-calcareous and calcareous.
	Brightseat confining unit
670-730	Clay, greenish black (Gley 1 2.5/10Y), glauconitic, soft with sparse chips of brown (7.5YR 4/2); abundant lignite from 720 to 740 ft, beds of sand from 712-720 ft and from 730-740 ft.

Table 9. Continued

CA Db 96—Continued

Depth, in feet below land surface	Description
	Magothy aquifer
730-780	Sand, coarse to very coarse, quartz clear, colorless, white frosted, rose, green and yellow- stained grains, subrounded to subangular, abundant lignite, sparse pyrite.
	Upper Patapsco confining unit
780-830	Clay, dark gray (5YR 4/1), sandy; sand, medium-grained, quartz, clear colorless and frosted, glauconite (10%), black, botryoidal; sparse fragments of fine sandstone, brown (10YR 5/3), with sparse fine lignite, calcite cement, pyrite, mica, shell fragments.
	Upper Patapsco aquifer (with minor confining layers)
830-880	Sand, fine to very coarse, quartz mostly clear colorless, frosted, some yellow, rose, lavender and green-stained grains, subangular to subrounded; glauconite (10-15%), mostly black, botryoidal with some olive, green, and brown, oblong; beige cemented sandstone, non-calcareous and calcareous, with fine lignite; some iron-cemented grains; sparse shells; sparse clay chips, mostly dark gray (5YR 4/1), sandy; gravel (6 mm), quartz, multi-colored; common lignite (some partly pyritized); some pyrite and muscovite; sparse iron-cement, calcite-cement and shells.
880-940	Clay, gray (7.5YR 6/1), silty, glauconitic, red (2.5YR 4/6), sandy, dark gray (5YR 4/1), silty to sandy (900-920 ft), and sparse dark greenish gray (Gley 1 4/10GY), slightly sandy, from 920-940 ft; gravel, up to 7 mm, multi-colored; sand, fine to coarse, quartz, mostly clear colorless, frosted and smoky, subrounded to subangular, with glauconite (10-15%), black, green, olive and brown, botryoidal and oblong; abundant spherical, beige/white, sandstone aggregates, non-calcareous, 1-3 mm in diameter; common lignite and pyrite, some iron-cement.
940-980	Sand, tan, fine to coarse, quartz mostly clear colorless, frosted and smoky, subangular to subrounded; glauconite (7-15%), black, botryoidal, green, olive, oblong; lignite pyrite, sparse gravel sandstone aggregates; some clay chips, dark gray (5YR 4/1), plus brown (7.5YR 5/2). Geophysical log indicates predominantly clay from 970-1,000 ft.
	Middle Patapsco confining unit (with minor aquifer layers)
980-1,075	Clay, multi-colored, dark greenish gray (Gley 1 4/10Y), gray (7.5YR 6/1), silty, very dark greenish gray (Gley 1 3/10GY), dark gray (10YR 4/1), and greenish black (Gley 1 2.5/10Y), and reddish brown (2.5YR 4/4); abundant sandstone aggregates, spherical, light gray/white, some iron-stained; sand, medium to coarse, variable, with quartz, mostly clear colorless, subangular to subrounded; glauconite (10%), black, green, and brown, botryoidal; ironstone and limonite; partly pyritized lignite; sparse muscovite and pyrite; sparse shell fragments.
1,075-1,115	Clay, multi-colored, mottled, greenish gray (Gley 1 6/10Y), dark reddish brown (2.5YR 3/4), weak red (10YR 4/2), dark grayish brown (10YR 4/2); sand (1,095-1,115 ft), medium-grained, mostly clear colorless quartz, some frosted with abundant muscovite and sparse chlorite; glauconite (7%), black, olive, brown, botryoidal; rare pyrite and sandstone.
1,115-1,195	Sand, medium to coarse, quartz, mostly clear colorless, frosted, sparse lavender and yellow-stained, angular to subangular, sandstone fragments (1,135-1,195 ft), muscovite, glauconite, black and green, botryoidal and oblong (5-10% of sand), fine lignite and pyritized lignite, pyrite; some gravel, ironstone and rare shell fragments from 1,155-1,195 ft; clay, multi-colored and mottled, as above, with dark brown (7.5YR 3/2) and greenish gray (Gley 1 6/5GY) clay.

Table 9. Continued

CA Db 96—Continued

Depth, in feet below land surface	Description
	Middle Patapsco confining unit (with minor aquifer layers)—Continued
1,195-1,235	Clay, multi-colored, predominantly weak red (10R 4/3), brown (7.5YR 4/3) and dark gray (7.5YR 4/1), reddish brown (5YR 4/4 to 2.5YR 4/4), and other colors; sand, fine to coarse, quartz, mostly clear colorless, frosted, some yellow, brown and lavender, with glauconite (7% of sand), black, botryoidal, lignite, muscovite, pyrite and some sandstone.
	Lower Patapsco aquifer (with confining layers)
1,235-1,540	Clay, sandy, multi-colored and mottled, mostly reddish brown (5YR 3/1), silty, micaceous, greenish gray (Gley 1 6/5GY), micaceous and other colors (browns, reds, grays, white and yellow); sand, fine to coarse, mostly medium-grained, quartz clear colorless, frosted, some yellow, blue and lavender-stained grains, subangular to subrounded, glauconite (5-15%), black and green, botryoidal and oblong; common sandstone fragments, muscovite, lignite, iron-cement and some iron oxides; sparse pyrite, calcareous grains, chlorite, gravel, and shell fragments.
1,540-1,660	Sand, fine to coarse, quartz, clear colorless, frosted, some lavender and yellow grains, subangular to subrounded, with glauconite (10-15%), black, with some green, olive and brown grains, botryoidal and oblong; iron-cement; spherical and angular sandstone pieces, muscovite, sparse calcite-cemented grains; rare pyritized lignite and pyrite; trace shell fragments; clay, multi-colored, very dark gray (10YR 3/1), silty, dark gray (10YR 4/1), silty to sandy, dark reddish brown chips (2.5YR 3/3), dense, and other shades of gray, brown and weak red; mostly brown (7.5YR 4/3) clay from 1,548-1,590 ft.

Table 10. Composite lithologic description of drill cuttings for test well CA Fd 85

[ft, feet; mm, millimeter; %, percent; <, less than;
Color designations are based on Munsell Color Charts (Munsell Color Company, Inc., 1975)]

CA Fd 85
Chesapeake Ranch
Altitude: 106 ft above sea level

Depth, in feet below land surface	Description
	Surficial aquifer
0-50	Sand, red, white and gray; no samples available.
50-70	Sand, medium to gravel, red and gray, quartz clear, frosted, iron and yellow-stained grains, subrounded; some lithic and dark brown-red conglomerate clasts; sparse pyrite-cemented grains; clay, silty to fine sandy, light gray to dark gray (10YR 7/2, Gley 1 4/N).
	Chesapeake confining unit
70-130	Clay, dark greenish gray (Gley 1 4/10GY & 10Y), silty to sandy; weathered shells, white, beige, gray, brown, and black and some molds; some sand, fine to medium, quartz, clear colorless, frosted and smoky (some with black inclusions), subangular to subrounded; altered glauconite (<5%), fine, black and greenish brown, botryoidal and oblong.
130-160	Shells, white, beige, brown, gray and black, mostly bivalves, some *Chesapectins* and internal molds; clay, dark greenish gray (Gley 1 4/10Y), fine to very coarse sandy; trace sand, fine to medium, quartz, mostly clear colorless with some iron and yellow-stained grains, subangular to well-rounded, some fine, black grains and calcite-cemented sand; trace gravel, mostly quartz, clear, frosted and yellow-stained.
160-330	Clay, mostly dark greenish gray (Gley 1 4/10Y), with some olive gray (5Y 4/2), and olive brown (2.5Y 4/4); weathered shell fragments; two shark's teeth 3-4 mm long; some sand, clear colorless quartz, some with black inclusions, and yellow, green and iron-stained grains, subrounded to well rounded; sparse calcite-cemented sand and fine black grains; sparse glauconite, rare lignite.
	Piney Point aquifer
330-370	Sand, very dark greenish gray (Gley 1 3/10Y), fine to coarse, quartz, clear colorless, green-stained and blue frosted, subrounded to subangular; glauconite (10%), fine to medium, black, botryoidal (350-370 ft); abundant shell material and calcite-cemented fragments; some clay, dark greenish gray (Gley 1 4/10Y), fine sandy, greenish gray (Gley 1 5/5GY), and olive gray (5Y 4/2).
370-390	Sand, medium to very coarse, poorly sorted quartz, clear colorless, white, yellow and brown-stained; sandstone, calcareous; abundant glauconite (30-40%), fine to medium, black, botryoidal; gravel, quartz, subangular to subrounded; some clay, mostly glauconitic matrix, greenish gray (Gley 1 5/5GY) and some light greenish gray (Gley 1 7/5GY); shells, white, tan, some black and gray (380-390 ft).
	Nanjemoy confining unit
390-440	Clay, dark greenish gray (Gley 1 3/5GY and 3/10Y)), glauconitic, sandy; sand, fine to coarse, clear colorless, yellow, brown and green, subrounded; abundant glauconite (65-75%), brown, greenish brown, green and black, botryoidal; muscovite and cemented sandstone, calcareous (390-420 ft); gravel, clear, white, yellow, green and brown-stained quartz; sparse shell material, white and dark gray.
440-480	Sand, medium to very coarse, quartz, clear colorless, frosted, yellow and green-stained, subrounded to subangular; glauconite (60-80%), medium-grained, black and some dark olive green, botryoidal; sparse muscovite; gravel up to 4 mm, quartz, mostly frosted, yellow-brown and

Table 10. Continued

CA Fd 85—Continued

Depth, in feet below land surface	Description
	Nanjemoy confining unit—Continued
	clear colorless, subrounded to well-rounded; sparse clay clasts, dark olive gray (5Y 3/2), silty, glauconitic, micaceous; sparse shell material.
480-570	Clay, very dark greenish gray (Gley 1 3/10Y), glauconitic sandy, dark greenish gray (Gley 1 4/10GY); glauconite (80-90%), fine to coarse, black, botryoidal; some sand, increasing with depth, fine to coarse, quartz, clear colorless, frosted and green-stained, subrounded to subangular; sparse shell material and gravel.
	Marlboro Clay
570-580	Clay, pink to brown (2.5 YR 5/3), silty, micaceous.
	Aquia aquifer
580-650	Sand, medium to very coarse, quartz, clear colorless, frosted, green, brown and yellow-stained, subangular to subrounded; abundant glauconite (60-70%), fine to medium, black, greenish brown, brown and green, botryoidal and oblong, some goethite pellets, orange-brown; abundant quartz gravel; clay, dark greenish gray (Gley 1 4/10Y and 4/5GY) and olive gray (5Y 4/2), silty to glauconitic sandy, weak red (2.5YR 5/2), silty to sandy, micaceous, and chips of greenish gray (Gley 1 5/5GY), dense and micaceous (640-650 ft); some shell material and calcite cement.
650-700	Sand, fine to coarse, quartz, clear colorless, frosted, green, yellow and brown-stained, subrounded to subangular; abundant glauconite (50%), black, brown, some greenish brown and green, botryoidal and oblong; common muscovite and cemented sandstone, calcareous; some shell fragments, *Foraminifera* and bryozoans; some clay layers, dark greenish gray (Gley 1 4/10Y), glauconitic sandy and greenish gray (Gley 1 5/10Y), micaceous, dense; cemented sandstone 690-700 ft.
	Brightseat confining unit
700-716	Clay, mostly very dark greenish gray (Gley 1 3/5GY), glauconitic, sandy with calcareous grains, chips of greenish gray (Gley 1 5/10Y), silty, micaceous and some dark reddish gray (5YR 4/2), silty, micaceous; abundant glauconite (60%), fine, black, botryoidal and rounded; abundant fragments of cemented sandstone, calcareous; trace quartzose sand, medium-grained; sparse shell fragments.
	Upper Patapsco confining unit
716-780	Clay, variable, weak red (10R 5/2), very dark greenish gray (Gley 1 3/10Y), micaceous and dark grayish brown (2.5Y 4/2), sandy; abundant sand, medium to very coarse, quartz, clear colorless, frosted, lavender and yellow-stained, subangular to angular; trace glauconite, medium to coarse, black, brown and greenish brown, botryoidal and oblong; sparse lignite, pyrite, gravel, shell fragments and indurated sandstone, light yellowish brown (2.5Y 6/4), non-calcareous.
	Upper Patapsco aquifer (with minor confining layers)
780-850	Sand, fine to coarse, quartz, clear colorless, frosted, white, yellow, brown and some lavender, subangular to well rounded; glauconite (<10%), fine to medium, mostly black with some green and brown, botryoidal (decreases with depth); common lignite from 810-830 ft, some partly pyritized; ironstone and spherical, hard to moderately indurated sandstone, yellowish brown; sparse mica (muscovite and biotite); clay, brown (10YR 4/2), sandy, greenish gray (Gley 2

Table 10. Continued

CA Fd 85—Continued

Depth, in feet below land surface	Description
	Upper Patapsco aquifer (with minor confining layers)—Continued
	5/10G) silty to medium sandy, micaceous; dark greenish gray (Gley 1 4/10Y), glauconitic sandy; sparse shell material and gravel from 800-820 ft with pebbles up to 25 mm; sandstone from 830-850 ft, reddish gray (5YR 5/2) to yellowish, grayish brown with sparse dark reddish brown (5YR 3/3), moderately indurated.
850-920	Clay, reddish gray (5YR 5/2), sandy, some greenish gray (Gley 1 4/10Y), silty to medium sandy, glauconitic, dark grayish brown (10YR 4/2), slightly sandy (860-890 ft), reddish brown (5YR 4/3), fine to medium sandy, and sparse dark red (2.5YR 3/3), dense (850-890 ft); some sand, fine to medium, variable quartz, subangular to subrounded; sparse glauconite, medium-grained, green and black; sparse gravel.
920-990	Sand, fine to coarse, mostly clear colorless quartz with some lavender, frosted green, and yellow-stained quartz, subrounded to subangular, common muscovite and lignite; clay is mostly greenish gray (Gley 1 5/5GY), sandy, with common lignite and some brown (10YR 4/3) clay.
990-1,030	Clay, dark grayish brown (2.5Y 5/1), fine to medium sandy and sparse red brown clay (2.5YR 3/2) from 1,010-1,020 ft and dark gray (2.5Y 4/1), silty to fine sandy and very dark gray (Gley 1 3/N), fine sandy, micaceous from 1,020-1,030 ft, interbedded with sand, tan, fine to coarse, multi-colored quartz, subangular to subrounded, with common black botryoidal glauconite and lignite, some cemented sandstone, iron cement and muscovite.
1,030-1,090	Sand, greenish gray (Gley 1 5/10Y), fine to medium, quartz, mostly clear colorless, lavender and green-stained (with bright green inclusions), subrounded to subangular, common lignite, muscovite; interbedded layers of greenish gray clay (Gley 1 6/10Y), sandy, dark greenish gray (Gley 1 4/10Y) and sparse very dark greenish gray (Gley 1 3/5GY) clay.
	Middle Patapsco confining unit (with minor aquifer layers)
1,090-1,200	Clay, variable, brown (7.5YR 4/3), dark grayish brown (2.5Y 4/2), dark gray (2.5Y 4/1), dark grayish brown (2.5Y 4/2), reddish brown (5YR 4/4), greenish gray (Gley 1 5/5GY); sparse glauconite, fine, black, botryoidal; intermixed sand, medium to coarse, quartz, clear colorless, white, smoky, lavender, yellow and green-stained; subangular to subrounded; glauconite (<7%), medium, black and sparse brown, botryoidal; sparse ironstone, pyrite, limonite, and muscovite; some cemented sandstone, non-calcareous.
1,200-1,220	Sand, gray, fine to medium, quartz, clear colorless, yellow and brown-stained, subangular, with common iron-cemented grains; glauconite, fine, black; reddish brown grains, subangular to angular, rare pyrite; interbedded clay, reddish brown (2.5Y 4/2) and dark grayish brown (10YR 4/2).
1,220-1,500	Clay, sandy, mixed olive brown (2.5Y 4/3), dark grayish brown (2.5Y 4/2), dark gray (2.5Y 4/1), dark greenish gray (Gley 1 4/5GY), dark reddish brown (2.5Y 3/4) and other colors; intermixed sand, tan, mostly medium-grained, quartz, multi-colored, subrounded; some glauconite, medium-grained, black, brown and rare green, botryoidal; sparse sandstone fragments with iron-cement, mica, goethite pellets, pyrite, lignite and muscovite.

Table 10. Continued

CA Fd 85—Continued

Depth, in feet below land surface	Description
	Lower Patapsco aquifer (with minor confining layers)
1,500-1,664	Sand, medium to coarse, tan-gray, quartz, mostly clear colorless, yellow, lavender, blue, green and brown-stained, subrounded, abundant dark reddish-brown iron-cemented grains, sparse glauconite, black, botryoidal; sparse muscovite, cemented calcareous sandstone, gravel and pyrite; layers of clay, light gray to white interlayered with reddish brown (5YR 4/3), greenish gray (Gley 1 5/10Y), sandy and dark greenish gray (Gley 1 4/10Y) clay.

Table 11. Composite lithologic description of drill cuttings for test well CH Bg 17

[ft, feet; mm, millimeter; %, percent; <, less than;
Color designations are based on Munsell Color Charts (Munsell Color Company, Inc., 1975)]

CH Bg 17
Malcolm
Altitude: 199 ft above sea level

Depth, in feet below land surface	Description
	Surficial aquifer
0-40	Gravel, quartz, mostly white, frosted with some medium dark gray, yellow, rose and orange grains, well rounded to subangular, some sharp broken pieces, up to 5 mm across; some sand and sandstone fragments, rounded.
	Chesapeake confining unit
40-180	Clay, dark greenish gray (Gley 1 4/10Y) and dark olive gray (5Y 3/2), and very dark greenish gray (Gley 1 3/10Y), micaceous; gravel (4-9 mm), quartz, white and yellow; sand (10-20%), fine to very coarse, quartz, mostly clear colorless and frosted, subangular, fine lignite, some shell fragments, beige and translucent brown, sparse glauconite, lignite, internal molds (*Turritella*), phosphate nodules, limonite; cemented sandstone (160-180 ft), very dark greenish gray (3/10Y), non-calcareous.
	Nanjemoy confining unit
180-340	Sand, clayey, fine to coarse, mostly medium-grained, quartz, clear colorless, frosted, white and sparse green-stained and lavender, angular to subrounded; glauconite (30-80%), fine, black, some green and brown, botryoidal and subrounded; sparse pyrite and muscovite; abundant cemented sandstone, very dark greenish gray and dark greenish gray, calcareous and non-calcareous; some shell fragments, *Turritella* molds and echinoid spicules; sparse gravel; clay, very dark to dark greenish gray (Gley 1 3-4/10Y and 5/5GY).
340-350	(Marlboro Clay, 340-350 ft, determined from geophysical log.)
	Aquia aquifer
350-520	Sand, fine to coarse, mostly medium-grained, quartz, clear colorless, green-stained, some frosted, subangular to subrounded; glauconite (70-80%), black and brown, botryoidal, fine; muscovite, calcareous sandstone, olive green-gray, dark beige and non-calcareous sandstone fragments; sparse pyrite (260-300 ft); gravel, decreasing downhole, mostly quartz, white, frosted, yellow, beige and some pink, sparse chert; sparse shell fragments, lignite; clay, very dark, dark and greenish gray (Gley 1 3-4/10Y and 5/5GY) and brown clay (7.5YR 5/2), greenish black (Gley 2.5/10Y) glauconitic clay; common fragments of calcareous sandstone from 400 to 500 ft.
	Brightseat confining unit
520-640	Sand, clayey, medium to coarse, quartz, clear colorless, green, yellow and brown-stained, subrounded; glauconite (50-70%), black, brown and green, botryoidal and oblong; some cemented glauconitic sand, grayish, calcareous and lignite (500-600 ft); common gravel, phosphate pellets, coarse to very coarse, black and brown, subrounded to oblong, up to 8 mm long, slightly calcareous; mica; common shells, mostly light colored; rare shark and porpoise teeth; clay, very dark gray (Gley 1 3-4/10Y) to greenish gray (Gley 1 5/10GY), and sparse brown (7.5YR 4.5/3), sandy; clay becoming mostly very dark greenish gray (Gley 1 3/5GY) toward bottom of interval.

Table 11. Continued

CH Bg 17—Continued

Depth, in feet below land surface	Description
	Magothy aquifer
640-730	Sand, gray, medium to very coarse, quartz, clear colorless and frosted, sparse yellow, brown, lavender and rose, subangular to subrounded; sparse lignite, glauconite, black, botryoidal; pyrite, sandstone clasts, muscovite; some shells and sparse gravel; sparse clay (680-700 ft), olive brown and dark greenish gray, both sandy.
	Upper Patapsco confining unit
730-775	Sand, clayey, medium to very coarse, quartz, mostly clear colorless and white frosted, with rose and yellow grains; some gravel with sparse feldspar; glauconite, fine, black, brown and olive, rare pyrite, sparse lignite, sparse sandstone clasts, and shells; clay, reddish brown (5YR 5/3), and very dark greenish gray (Gley 1 3/10Y).
	Upper Patapsco aquifer (with minor confining layers)
775-920	Sand, fine to coarse, quartz, mostly clear and white frosted, with some orange, yellow-stained grains; sandstone aggregates, well-rounded, non-calcareous, light to dark brown (7.5YR 6/3 to 3/3), some iron-stained, coarse to very coarse; sandstone fragments, non-calcareous; glauconite (10%), fine, black; sparse lignite, pyrite; gravel, up to 6 mm, multi-colored, quartz and feldspar; sparse shell fragments; interbedded clay layers, light reddish brown (5YR 6/3), white, grayish brown (10YR 5/2), and light yellowish brown (2.5Y 6/3).
	Middle Patapsco confining unit (with minor aquifer layers)
920-1,000	Clay, multi-colored, mostly dark gray (5Y 4/1), some light olive brown (2.5Y 5/4), dark reddish gray (5YR 4/2), yellowish brown (10YR 5/4), and greenish gray (Gley 1 5/10Y); abundant lignite; sparse sand, muscovite, gravel.
1,000-1,020	Clay, mottled, weak red (10R 4/4), grayish brown (10YR 4.5/2), very dark greenish gray (Gley 1 3/10Y); sand, medium to coarse; abundant lignite; sparse shell fragments.
1,020-1,050	Clay, gray (10YR 5/1), sandy, dark gray (2.5Y 4/1), micaceous, dark reddish gray (5YR 4/2), silty, dark greenish gray (Gley 1 4/5GY), micaceous, abundant dark grayish brown (2.5Y 4/2); sand, fine to coarse, quartz, mostly clear colorless, frosted, yellow and brown-stained, subrounded to rounded, sparse glauconite, black and brown, botryoidal and subrounded; beige sandstone fragments, mostly spherical; common lignite, pyrite, muscovite, and iron-cement; sparse shells and gravel.
1,050-1,070	Sand, medium to coarse, mixture of clear quartz, sandstone aggregates; fine, black botryoidal glauconite, common pyrite, gravel; clay, mixed, grays, browns, red.
1,070-1,110	Clay, mixed dark greenish gray (Gley 4/1), reddish brown (5YR 4/3) and weak to dusky red (10R 3.5/3), with some white and gray clay; sand, medium-grained, clear quartz, subrounded to subangular, rounded sandstone aggregates, common pyrite, abundant lignite; sparse glauconite.
1,110-1,230	Clay, mottled, mostly brown (7.5YR 4/3-4), red (10R 4/6), some dark gray (2.5Y 4/1 and Gley 4/N), sparse light olive brown (2.5Y 5/4), silty and very dark greenish gray clay (Gley 13/10Y); sand, medium-grained, as above; less lignite; sparse shells, gravel and muscovite.

Table 11. Continued

CH Bg 17—Continued

Depth, in feet below land surface	Description
	Lower Patapsco aquifer
1,230-1,480	Sand, gray-tan, medium to very coarse, mostly clear quartz, subangular to subrounded; some white frosted, yellow, green, rose and lavender grains; interspersed lignite, muscovite, rare biotite, quartz gravel (up to 8 mm) and pebbles up to 15 mm; fine to medium sandstone aggregates, and iron-cemented sandstone (1,250-1,270 ft and 1,330-1,350 ft); sparse glauconite, pyrite, and pyritized lignite; interbedded clay, variegated, predominantly grays and reddish-browns, shades of yellowish brown, red-brown, gray, white, yellow and pink.
	Arundel confining unit
1,480-1,660	Sand, medium to coarse, gray, as above; clay, multi-colored, mostly greenish gray (Gley 1 5/5GY), yellow (2.5Y 7/6) and dark reddish brown (5YR 4/3). Geophysical logs indicate mostly clay in this interval.

Table 12. Composite lithologic description of drill cuttings for test well CH Cg 24

[ft, feet; mm, millimeter; %, percent; <, less than;
Color designations are based on Munsell Color Charts (Munsell Color Company, Inc., 1975)]

CH Cg 24
Hughesville
Altitude: 171 ft above sea level

Depth, in feet below land surface	Description
	Surficial aquifer
0-50	Sand, fine to very coarse, quartz, clear colorless, frosted, yellow and brown-stained, very angular to well-rounded; feldspar and lithic grains; gravel with pebbles up to 15 mm; abundant lignite; interbedded clay, yellow brown (10YR 5/6), very sandy, olive brown (2.5Y 4/4) at 10-20 ft, very sandy, some dark olive gray (5Y 3/1), dark brown-black (2.5Y 2.5/1), dark gray (5Y 4.5/1).
	Chesapeake confining unit
50-130	Clay, olive gray (5Y 4/2), very silty, light olive brown (2.5Y 5/4) from 120-130 ft and rare black clay (5Y 2.5/1), micaceous at 110-120 ft; sand, very fine to very coarse, quartz, clear colorless and brown-stained, subangular to well-rounded; abundant shell fragments; some gravel, opaque, tan and red-brown, with pebbles up to 25 mm.
130-150	Clay, olive (5Y 4/4), silty; sand, very fine grading into coarse, clear colorless quartz and opaque grains, well rounded to subangular; some shells.
150-170	Clay, dark olive gray (5Y 3/2), sandy, olive gray (5Y 4/2), silty, dark greenish gray (Gley 1 4/10Y), fine sandy, and some black clay, at 160-170 ft, (Gley 1 2.5/1), sandy; abundant shell fragments, some partly cemented; sand, quartz, clear colorless, frosted, white, pink, yellow, lavender and iron-stained, subangular to well-rounded; sparse gravel.
170-180	Shells, clear, white, gray and black; sand, very coarse to granular, quartz, frosted white, frosted pink, clear colorless, iron, pink and yellow-stained, subangular; some calcite-cemented grains; rare chert; clay, dark olive gray (5Y 3/2), silty to fine sandy.
180-210	Sand, fine to coarse, quartz, mostly clear colorless, subrounded to subangular; abundant gravel, coarse to very coarse, quartz, white, clear, yellow with sparse pink and lavender grains and chert; abundant shell fragments, *Turritella* shells and internal molds, *Chesapectins* and other bivalves with internal molds; common glauconite (10-20%), black and green, botryoidal; brownish-red and greenish-black iron oxides (limonite and hematite?); clay, dark olive gray (5Y 3/2), and very dark greenish gray (Gley 1 3/10Y), glauconitic and micaceous.
	Nanjemoy confining unit
210-400	Clay, sandy, greenish black (Gley 1 2.5/5GY), and greenish gray (Gley 1 5/5GY); sand, medium to coarse, quartz, clear, colorless, green-stained; glauconite (40%), black, botryoidal; some mica; sparse shell fragments with foraminifera, bryozoans and a shark tooth fragment; calcite-cemented layers 250-260 ft and 390-400 ft.
400-410	Sandstone, calcified, glauconitic; sand, medium to coarse, quartz, mostly clear colorless, white, yellow and green frosted, subangular; abundant glauconite (35%), black and green, botryoidal and sparse brown, oblong; clay, greenish gray (Gley 1 5/10Y), and some very dark greenish gray (Gley 1 3/10Y); some shells and bryozoan fragments.
410-420	Clay, predominately olive (5Y 4/3) and some greenish gray (Gley 1 5/10Y) and dark greenish gray (Gley 1 4/10Y); sand, very fine to medium, glauconitic.
	Marlboro Clay
420-430	Clay, weak red (2.5YR 5/2).

Table 12. Continued

CH Cg 24—Continued

Depth, in feet below land surface	Description
	Aquia aquifer
430-460	Sandstone, calcified, glauconitic; sand, medium to coarse, quartz, clear colorless, white, brown, yellow and green-stained, subangular to subrounded; glauconite (40-50%), black, brown and greenish brown, botryoidal and oblong; common shells, mostly bivalves and some gravel up to 15 mm; clay, dark greenish gray (Gley 1 4/10Y), some light olive brown (2.5Y 5/4) and some dark greenish brown (10YR 4/2).
460-510	Sand, fine to coarse, quartz, clear colorless, white, brown, yellow and green-stained, subrounded to subangular, iron oxides and brown opaque grains; abundant shell fragments, mostly light colored bivalves, sparse foraminifera and bryozoans; glauconite (30-50%), black, brownish green and brown, botryoidal and oblong; abundant sandstone fragments, calcified, glauconitic; common gravel with pebbles up to 20 mm; clay, multi-colored from brown and olive to greenish gray and dark gray, silty, micaceous and glauconitic.
	Brightseat Formation
510-620	Clay, greenish black (Gley 1 2.5/10Y), very dark greenish gray (Gley 1 3/10Y), to gray (2.5Y 5/1); some sand, fine to coarse, quartz, mostly clear colorless (some with black inclusions) and some yellow-stained, frosted, lavender and green-stained, subrounded to subangular; glauconite (60%), fine to coarse, black, botryoidal; some mica, shells and multi-colored gravel; sparse shells, molds, calcified sandstone, pyrite, and lignite.
	Magothy aquifer
620-700	Sand, medium to very coarse, quartz, clear colorless, with frosted white, pink, yellow, lavender, and orange-stained grains; some black glauconite from 710-720 ft; interspersed lignite, pyrite, shell fragments and calcite-cemented grains; sandstone, cemented, calcareous, fine to medium, black (5Y 2.5/1) from 620-650 ft; gravel, very coarse to pebble sized, multi-colored quartz grains; interbedded clay grading downwards from dark gray (5Y 4/1), greenish black (Gley 1 2.5/10Y), olive yellow (2.5Y 6/6) to brown (10YR 4/3).
	Upper Patapsco confining unit
700-780	Clay, dark gray (5Y 4/1), brown (7.5YR 5/4), gray (5Y 5/1), olive yellow (2.5Y 6/6), silty; sand, medium-grained, quartz with black and green glauconite, lignite, non-calcareous sandstone and shell fragments; abundant gravel, sparse pyrite, lignite.
	Upper Patapsco aquifer
780-870	Sand, medium-grained, quartz clear, colorless, white, lavender, yellow, and green-stained, subangular to subrounded; glauconite, fine, black, botryoidal; reddish brown iron oxides; sandstone, sparse pyrite, lignite, mica and shell fragments; clay, reddish brown (2.5YR 4/4), sandy, very dark gray (2.5Y 3/1), silty to fine sandy, micaceous and some very dark greenish gray (Gley 1 3/10Y) from 810-850 ft, sandy; sparse shell fragments, cemented grains and lignite.
	Middle Patapsco confining unit
870-940	Clay, light greenish gray (Gley 1 7/10Y), reddish brown (5YR 4/3), brown (7.5YR 4/3), very dark gray (5Y 3/1), olive yellow (5Y 6/6); interbedded sand, medium to very coarse, quartz clear, colorless, brown and yellow-stained, subrounded to subangular with sparse gravel, glauconite, lignite.

Table 12. Continued

CH Cg 24—Continued

Depth, in feet below land surface	Description
	Middle Patapsco confining unit—Continued
940-1,000	Sand, medium to coarse, quartz, clear colorless, white, smoky, lavender and yellow-stained, subangular; lignite; abundant sandstone pieces, gray, non-calcareous; sparse pyrite; clay, dark red, and brown (10YR 4/3), sandy.
1,000-1,010	Sandstone, gray, fine-grained, cemented, non-calcareous, with some unconsolidated sand; abundant lignite, sparse pyrite, glauconite; gravel; trace clay, dark reddish gray (10R 4/1).
1,010-1,100	Clay, olive brown (2.5Y 4/3), light olive brown (2.5Y 5/3), very dark greenish gray (Gley 1 3/10GY), and brown (10YR 4/3); interbedded sand, medium to very coarse, quartz, clear colorless, frosted, lavender, yellow, green and orange-stained, subangular to subrounded, with sparse calcite-cemented grains; gravel up to 35 mm, frosted quartz, white, pink, orange, gray and black, some chert; sparse fragments of calcite-cemented glauconitic sandstone, lignite, pyrite and glauconite.
1,100-1,200	Clay, mostly reddish brown and brown (10YR 4/3), with some very dark greenish gray (Gley 1 3/10GY) and light gray (10YR 7/2), sandy; sand, very fine to very coarse, quartz, mostly clear colorless, some white frosted and yellow-stained, subangular to subrounded; abundant lignite; common well-rounded white sandstone clasts; sparse pyrite.
	Lower Patapsco aquifer
1,200-1,514	Sand, medium to very coarse, quartz, multi-colored, mostly clear colorless with black granular inclusions, green-gray and lavender-stained, and some opaque grains, subrounded to subangular; iron-cemented sandstone, 1,360-1,370 ft; common muscovite, lignite, pyrite, glauconite; interspersed quartz gravel, quartz, with pebbles up to 20 mm; interbedded multi-colored clay, dark greenish gray (Gley 1 3/10GY), brown (7.5YR4/4), sandy, dark olive gray (5Y 3/2), reddish brown (5Y 3/2), dark yellowish brown (10YR 4/3-4).
	Arundel confining unit
1,514-1,667	Clay, multi-colored, brown (10YR 4/3), dark greenish gray, dark grayish brown (10YR 4/2), dark yellowish brown (10YR 4/4), and other colors; interbedded sands, medium to coarse, quartz, clear colorless, some with black inclusions, white, frosted, lavender, yellow and brown-stained, subrounded to subangular; common glauconite, fine, black, botryoidal; some iron-cemented sandstone; sparse pyrite, gravel.

Table 13. Composite lithologic description of drill cuttings for test well SM Bc 39

[ft, feet; mm, millimeter; %, percent; <, less than;
Color designations are based on Munsell Color Charts (Munsell Color Company, Inc., 1975)]

SM Bc 39
Persimmon Hills
Altitude: 162 ft above sea level

Depth, in feet below land surface	Description
	Surficial aquifer
0-65	Sand and gravel, reddish yellow (7.5YR 6/6), fine sand to gravel up to 30 mm, quartz, mostly clear colorless, frosted, red-stained and some smoky grains, rounded to angular, some feldspar grains; abundant fragments of reddish-brown iron-cemented sand; some clay, yellow brown (7.5 YR 5/6), sandy and brownish yellow (10YR 6/6), sandy.
	Chesapeake confining unit
65-238	Clay, dark greenish gray (Gley 1 4/10Y and Gley 1 4/5 GY), and brownish yellow, (10YR 6/6), silty and sandy; abundant shell fragments; interspersed sand, fine to medium, quartz, mostly clear colorless with black inclusions, and some white, green, yellow and brown-stained grains, subangular to subrounded, fragments of iron-cemented sand; gravel up to 13 mm; sparse lignite.
	Piney Point aquifer
238-312	Sand, clayey, fine to very coarse, quartz, clear colorless, green and yellow-stained, abundant glauconite (40%), greenish black, botryoidal; abundant clay, dark olive gray (5Y 3/2) and very dark gray (5Y 3/1), silty, glauconitic; common muscovite; gravel up to 20 mm; some cemented sandstone, calcareous, grayish-brown (290-300 ft).
	Nanjemoy confining unit
312-450	Clay, very dark greenish gray (Gley 1 3/10Y), dark olive gray (5Y 3/2), glauconitic and some dark grayish brown clay (2.5Y 4/2); some interspersed sand, medium to very coarse, quartz, clear colorless and green-stained, subrounded to subangular; abundant glauconite (80%), green and black, botryoidal; some shells and gravel; sparse muscovite.
	Marlboro Clay
450-460	Clay, weak red (2.5YR 5/2), trace yellowish brown (10YR 6/6).
	Aquia aquifer
460-510	Sand, highly glauconitic, medium to coarse, quartz, clear colorless, green and yellow-stained, white frosted, angular; abundant glauconite (50-80%), mostly black with some green and brown, botryoidal; some shells and gravel; sparse clay, very dark greenish gray (Gley 1 3/10Y), glauconitic, dark greenish gray (Gley 1 4/10Y), glauconitic and micaceous, some brown (7.5YR 4/3), glauconitic and some olive (5Y 5/3); sparse pyrite; cemented sandstone 500-510 ft, sparse shell fragments.
510-540	Clay, sandy, dark greenish gray (Gley 1 4/10Y), and brown (7.5YR 4/3); sand, quartz, clear colorless, green and yellow-stained, subangular to subrounded; glauconite (50%), black, botryoidal and brown, oblong; cemented sandstone fragments, calcareous, white and beige, well-rounded to subangular, glauconitic; shells, beige, gray and white, bivalves and echinoids.
540-570	Sand, medium to coarse, quartz, clear colorless and yellow-stained, subangular to subrounded; glauconite (30-40%), black, botryoidal and yellowish brown, rounded, some coarse reddish-brown, subrounded grains; abundant shell fragments and cemented sandstone, calcareous; sparse

Table 13. Continued

SM Bc 39—Continued

Depth, in feet below land surface	Description
	Aquia aquifer—Continued
	foraminifera; sparse clay, olive gray (5Y 4/2), sandy and greenish black (Gley 1 2.5/10Y) and reddish gray (2.5YR 5/1).
570-600	Clay, greenish black (Gley 1 2.5/10Y) with interspersed glauconitic sand and some reddish gray (2.5YR 5/1) and reddish yellow (5YR 6/6); sand, medium to coarse, quartz, clear colorless and yellow-stained, subangular to subrounded, glauconitic; common cemented sandstone, calcareous.
600-620	Sand, medium to coarse, quartz, clear colorless and yellow-stained, subangular to subrounded; glauconite (40%), black, botryoidal and brown, oblong; sparse glauconitic clay, very dark greenish gray (Gley 1 3/GY), olive (5Y 4/3), some yellowish brown (10YR 5/6), and pale green (Gley 1 6/5GY); some calcite-cemented glauconitic sand; shells, mostly white, beige and gray; sparse gravel.
	Brightseat confining unit
620-640	Clay, sandy, mostly very dark greenish gray (Gley 1 3/10Y), and some light olive brown (2.5Y 5/4); sand, medium-grained, quartz, clear colorless, frosted and yellow-stained, subangular; glauconite (40%), medium to coarse, black, botryoidal; some cemented sandstone, calcareous; sparse shells and gravel.
	Magothy aquifer
640-670	Sand, medium to coarse, quartz, clear colorless, frosted, white, lavender and smoky, subangular; clay (common 640-650 ft), very dark greenish gray (Gley 1 3/10Y) and very dark gray (5Y 3/1); some lignite, pyrite, shells, and gravel.
	Upper Patapsco confining unit
670-740	Clay, pale yellow (5Y 8/2), laminated with strong brown (7.5YR 5/8), with some greenish gray and reddish brown; interbedded sand, tan, medium to coarse, quartz, clear colorless, frosted, white, lavender and smoky, subangular, abundant lignite, some pyrite; sparse black glauconite; fragments of non-calcareous sandstone, grayish-green; sparse gravel, shells.
	Upper Patapsco aquifer
740-980	Sand, medium to coarse, clear colorless, frosted, white, lavender and yellow-stained quartz, subangular to subrounded; interbedded clay, dark greenish gray (Gley 1 4/5GY), some pale yellow laminated with brownish yellow clay (10YR 6/8), some gray (7.5YR 5.1), and mixed browns (7.5YR 7/4 to 7.5YR 4/3); abundant lignite and pyrite; sandstone fragments, non-calcareous, in brown clayey matrix; sparse glauconite, black, botryoidal.
	Middle Patapsco confining unit
980-1,210	Clay, various colors, brown (7.5YR 4/4), grayish brown (2.5Y 5/2), dark brown (7.5YR 3/2), olive gray (5Y 5/2), gray (5Y 5/1), and greenish gray (Gley 1 6/10Y); interbedded sand, fine to coarse, quartz, mostly clear colorless with green, lavender, frosted and yellow-stained grains; sparse pyritized lignite, muscovite, gravel up to 20 mm, mostly frosted white and yellow quartz; cemented sandstone, non-calcareous (1,000-1,010 ft).

Table 13. Continued

SM Bc 39—Continued

Depth, in feet below land surface	Description
	Lower Patapsco aquifer (with confining units)
1,210-1,250	Sand, medium to very coarse, quartz, clear colorless, lavender, smoky and green-stained, some with black inclusions, subrounded to angular; clay, brown (7.5YR 4/3), slightly sandy, gray (5Y 5/1), sandy and some brownish yellow, very sandy; gravel up to 9 mm; sparse glauconite; fragments of non-calcareous, cemented sandstone and reddish brown iron oxides, lignite.
1,250-1,360	Clay, various colors, olive brown (2.5Y 4/3), brown (7.5YR 4/3), olive gray (5Y 4/2), dark reddish brown (2.5YR 3/4); some sand, medium-grained, quartz, mostly clear colorless, subrounded to subangular; cemented sandstone aggregates, white, mostly spherical, non-calcareous; sparse lignite, muscovite, and gravel up to 13 mm.
1,360-1,390	Sand, medium to coarse, quartz, clear colorless with black inclusions, some white, lavender, and yellow-stained, angular to subangular; abundant clay, pale yellow (5Y 8/2) laminated with brownish yellow (10YR 6/6), and dark brownish yellow (10YR 6/6), dark grayish brown (10YR 4/2), and very dark greenish gray (Gley 1 3/5GY), and small chips of dark reddish brown (5YR 3/3); sparse lignite, dark brown and black iron-cemented aggregates, gravel, mostly quartz, non-calcareous sandstone aggregates.
1,390-1,480	Clay, various colors, greenish gray (Gley 1 6/10Y), reddish gray (5YR 5/2), weak red (2.5YR 5/2), dusky red, brown (7.5YR 4/3), with some mottling; common sand, medium to very coarse, multi-colored quartz, subrounded; common pyritized lignite; sparse gravel from 1,470-1,480 ft.
1,480-1,530	Sand, medium to very coarse, quartz, clear colorless with frosted white, smoky, green and yellow-stained grains and sparse lavender grains, subrounded to subangular; interbedded clay, sandy, mostly dark yellowish brown (10YR 4/4) and reddish brown (5YR 4/3) with other colors; some brown, red and black iron-cemented aggregates from 1,510-1,530 ft; sparse gravel up to 15 mm, white, yellow opaque; sparse shell fragments.
	Arundel confining unit
1,530-1,600	Clay, yellowish brown (10YR 5/4), dark grayish brown (2.5Y 4/2), reddish brown (5YR 4/4), and dark greenish gray (Gley 1 4/10Y); sparse sand.

Table 14. Composite lithologic description of drill cuttings for test well SM Dd 72

[ft, feet; mm, millimeter; %, percent; <, less than;
Color designations are based on Munsell Color Charts (Munsell Color Company, Inc., 1975)]

SM Dd 72
Paw Paw Hollow
Altitude: 110 ft above sea level

Depth, in feet below land surface	Description
	Surficial aquifer
0-30	Sand, red (10R 4/6) and yellowish brown (10YR 4/6), fine to very coarse, quartz, rose, blue, smoky, white, milky, angular to subrounded; feldspar, coarse to very coarse, white, very angular to rounded; lignite.
30-40	Clay, gray, sandy; sparse sand, tan, coarse to very coarse, quartz, clear colorless, white, rose, blue, subrounded; trace lignite.
40-50	Gravel, brownish yellow, up to 20 mm, quartz and feldspar, subangular to well rounded.
	Chesapeake confining unit
50-120	Clay, dark greenish gray (5GY 4/1), silty; abundant shell material, including small clams and *Turitella* fragments; abundant sand, fine to medium, quartz, clear colorless, subrounded; sandstone fragments, reddish brown (90-100 ft); abundant shell material, including small clams and turitella fragments; common lignite and muscovite.
120-210	Clay, olive gray (5Y 4/2), silty; sparse lignite.
	Piney Point aquifer
210-280	Sand, medium to coarse, quartz, mostly clear colorless with some smoky, pink, green, and orange-stained grains, some iron-stained, subrounded to rounded; common glauconite, fine to medium, botryoidal, black and light green; abundant shell material; abundant calcite-cemented sandstone fragments; rare pyrite.
	Nanjemoy confining unit
280-430	Clay, olive gray (5Y 5/2) and dark greenish gray (5GY 4/1); common sand (280-320 ft), fine to coarse, quartz, clear colorless, smoky, green and iron-stained, subrounded to rounded; abundant glauconite (60-90%), black, botryoidal, green and brown, rounded and oblong; common shell material (340-420 ft), sparse muscovite.
	Marlboro Clay
430-437	Clay, reddish gray (5YR 5/2), with some fine sand.
	Aquia aquifer
437-570	Sand, fine to coarse, quartz, clear colorless, white, green and iron-stained, subangular to subrounded, some calcite-cemented grains; abundant glauconite (30-40%), fine to coarse, black, botryoidal, light green, greenish brown and brown; clay, grayish brown, olive gray, dark olive gray, dark greenish gray and other colors; common iron-hydroxides (limonite/goethite), red-brown and yellow-brown, rounded; common shell material; sparse pyrite and muscovite, *foraminifera* (*Nodosaria*).

Table 14. Continued

SM Dd 72—Continued

Depth, in feet below land surface	Description
	Brightseat confining unit
570-600	Clay, dark gray (5Y 4/1) and dark grayish-brown (10YR 4/2), sandy; glauconite (30%), fine to medium, black, green and brown, botryoidal; sparse calcite-cemented sandstone fragments, goethite pellets, pyrite, muscovite and shells.
	Upper Patapsco confining unit
600-680	Clay, very dark greenish gray to greenish gray (Gley 1 3/10GY-5/GY), light olive gray (5Y 6/2), reddish brown (2.5YR 4/3) and other colors, silty; interbedded sand, fine to coarse, quartz, clear colorless, milky, purple, tan and iron-stained, subrounded to rounded; glauconite (10%), fine to medium, black, green and brown, botryoidal; some coarse lignite, trace muscovite, pyrite, goethite pellets, and shell fragments.
	Upper Patapsco aquifer (with minor confining layers)
680-900	Sand, fine to coarse, quartz, mostly clear colorless with some pink, purple, green, milky, and blue grains, subangular to rounded; common glauconite, fine to medium, black and green, botryoidal; interbedded clay, dark greenish gray to greenish gray (Gley 1 4/5GY-5/GY), olive gray (5Y 5/2), reddish brown (2.5YR 4/3), brown (7.5YR 5/3) and other colors, silty; common lignite; sparse calcite-cemented sandstone, muscovite, pyrite, goethite pellets, and shell fragments.
	Middle Patapsco confining unit (with minor aquifer layers)
900-1,150	Clay, light to dark gray, brown (7.5YR 5/3), greenish gray (Gley 1 5/GY), light reddish brown (2.5YR 4/3), and white, silty; interbedded sand, fine to coarse, quartz, clear colorless, milky, purple, yellow and green-stained, angular to subangular; common glauconite, medium-grained, black and brown, botryoidal; trace pyrite, muscovite, lignite, and goethite.
	Lower Patapsco aquifer (with confining layers)
1,150-1,250	Sand, fine to coarse, quartz, clear colorless, milky, purple, yellow and green-stained, subrounded to subangular; trace glauconite, lignite and muscovite; some clay, as above.
1,250-1,300	Clay, multi-colored, mostly olive gray (5Y 4/2), fine sandy; some medium reddish brown and medium greenish gray; sand, fine to very coarse, quartz, mostly clear colorless with some lavender and green-stained grains, subrounded to rounded; glauconite (30%), medium to coarse, black, botryoidal; trace calcite, lignite, pyrite, siltstone, goethite and muscovite.
1,300-1,350	Sand, fine to very coarse, quartz, mostly clear colorless and green-stained, subrounded; clay, very hard, olive gray (5Y 4/2) and reddish brown pieces.
1,350-1,410	Clay, dense, reddish brown, pinkish brown and gray; some sand, medium to coarse, quartz, mostly clear colorless; glauconite (10%), medium to coarse, black, botryoidal; sparse muscovite and feldspar; trace pyrite, lignite and calcareous sandstone (1,370-1,390 ft).
1,410-1,450	Sand, fine to medium, quartz, clear colorless, purple and blue, subrounded to rounded, with sparse muscovite, feldspar and glauconite; interlayered clay, reddish brown, dark and light gray and greenish gray; trace pyrite, lignite and calcite-cemented grains.
1,450-1,550	Sand, medium to coarse, quartz, mostly clear colorless with some purple and green-stained grains, rounded to subrounded; sparse muscovite, pyrite, lignite and glauconite; interlayered with clay, reddish brown, gray, dark gray and other colors.

Table 14. Continued

SM Dd 72—Continued

Depth, in feet below land surface	Description
	Arundel confining unit
1,550-1,650	Clay, reddish brown, light gray and some greenish-gray clay; sand, medium to coarse, quartz, mostly clear colorless with some white, purple and green-stained grains, rounded to subrounded; glauconite (20-25%), medium to very coarse, black, botryoidal; some feldspar, pyrite, lignite and muscovite; some calcite-cemented grains.

Table 15. Palynologic analysis of selected drill-cutting samples for test well CA Db 96

[Gilbert J. Brenner, Ph.D., written communication, 2003; ft, feet; Fm., formation]

CA Db 96
Prince Frederick

Except for the sample at 780-800 ft (Upper Cretaceous/Magothy) most of the samples were not the preferred lithology for organic microfossil recovery. The lithotype of most of the samples were coarse-grained, clayey sands and gravels, their light brown color indicating an oxidizing environment at the time of deposition. The cutting samples were also contaminated at each level with uphole material. The processing approach was to use high resolution recovery with pipette decanting at each step, instead of the usual manual decanting method. As a result of this careful methodology, a single slide of each sample containing enough palynomorphs to pick tops for dating was achieved. Only the sample at 880-900 ft, was totally devoid of organic residue.

600-620 feet
Stratigraphic Determination: Paleocene
Formation: Aquia
Lithology: Glauconitic, clayey sand with shell fragments.
Paleoecology: Marine

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation	Frequency[1]
Pollen and Spores:		
Nudopollis terminalis	Paleocene to Lower Eocene (as in well PG Df 35)	R
Nudopollis thiergarti	Aquia Fm.	O

Discussion: *Nudopollis* is characteristic of the Paleocene of Maryland and the Gulf Coast (Fairchild and Elsik, 1969). In Maryland *N. thiergarti* is believed to be restricted to the Aquia Formation (Patricelli, 1977).

700-720 feet
Stratigraphic Determination: Upper Cretaceous (Maestrichtian [?])
Formation: Monmouth (?)
Lithology: Glauconitic, silty clay.
Paleoecology: Marine

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation	Frequency
Pollen and Spores:		
Rugubivesiculites reductus	Patapsco Fm. to Monmouth Fm.	O
Rugubivesiculites rugosus	Patapsco Fm. to Monmouth Fm.	A
Cicatricosisporites spp.	Typical of Cretaceous horizons	R

Discussion: Although there are very few palynomorphs in this sample, the occurrence of several well-preserved grains of two species of the *Rugubivesiculites* suggests that this horizon is in the Upper Cretaceous. In New Jersey *Rugubivesiculites reductus* is more common in the Monmouth Group (Maestrichtian) than the Matawan Group (Campanian).

[1] Subjective abundance scheme (Specimens per slide):
R (rare) = 1 to 2; O (occasional) = 3 to 5; C (common) = 5 to 10; A (abundant) = More than 10

CA Db 96—Continued

700-720 feet (continued)

This sample also contains several grains of *Cicatricosisporites*, the appearance of which is more characteristic of horizons below the Paleocene.

780-800 feet
Stratigraphic Determination: Upper Cretaceous (Santonian)
Formation: Magothy
Lithology: Grey, silty clay.
Paleoecology: Nonmarine

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation	Frequency
Pollen and Spores:		
Plicapollis sp. F Christopher, 1979	Magothy Fm.	R
Pseudoplicapollis longiannulata	Middle Magothy Fm.	R
Rugubivesiculites rugosus	Patapsco Fm. to Monmouth Fm.	A
Tricolporate Type 6 of Doyle, 1969 (Fig. 5J, K)	Magothy Fm.	R

Discussion: First occurrence of *Normapolles* angiosperm pollen that is typical for the Magothy Formation. The common occurrence of *Pseudoplicapollis longiannulata* and *Plicapollis sp. F* of Christopher (1979) places this sample in the middle Magothy (Santonian Stage) about the level of the Amboy Stoneware Clay Member from the Raritan Basin of New Jersey. The characteristic *Normapolle* associations that are distinctive for the Upper Magothy of New Jersey are not found in this sample.

880-900 feet BARREN

1,000-1,015 feet
Stratigraphic Determination: Upper Cretaceous (Lower Cenomanian)
Formation: Upper Patapsco, Zone III
Lithology: Yellow arkosic, silty sand with some clay matrix.
Paleoecology: Nonmarine

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation	Frequency
Pollen and Spores:		
Rugubivesiculites rugosus	Patapsco Fm. to Monmouth Fm.	A
Tricolpopollenites sp. E Doyle and Robbins, 1977	Zone III	O
Tricolporopolenites sp. B Doyle and Robbins, 1977	Zone III	A
Tricolporoidites sp. B Doyle and Robbins, 1977	Zone III	O

Discussion: Several palynomorphs restricted to Zone III of the Patapsco Formation are present.

Table 15. Continued

CA Db 96—Continued

1,235-1,240 feet
Stratigraphic Determination: Cretaceous (Albian or Lower Cenomanian [?])
Formation: Patapsco, Zone II or III (?)
Lithology: Yellow arkosic, silty sand with some clay matrix.
Paleoecology: Nonmarine

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation	Frequency
Pollen and Spores:		
Rugubivesiculites reductus	Patapsco Fm. to Monmouth Fm.	O
Taurocusporites segmentus	Zones II-III	R
Tricolporopolenites sp. B Doyle and Robbins, 1977	Zone III	A

Discussion: The sample could be assigned to either palynomorph Zone II or III, depending on whether *tricolporopolenites sp. B* is an up-hole contaminant or not.

1,340-1,360 feet
Stratigraphic Determination: Lower Cretaceous (Albian)
Formation: Patapsco, Zone IIB
Lithology: Yellow arkosic, silty sand with some clay matrix; phytomacerals high in vitrain and fusain.
Paleoecology: Nonmarine

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation	Frequency
Pollen and Spores:		
Abietinaepollenites minimus Brenner, 1963	Zone IIB	R
Appendicisporites babsae Brenner, 1963	Reported only in Zone II	R
Converrucosisporites proxigranulatus	Zones I-II	R
Tricolporopolenites sp. B Doyle and Robbins, 1977	Zone III	A
Tricolporopollenites distinctus	Zones IIC- III	R
Klukisporites variegatus	Zones I-II	R
Rugubivesiculites rugosus	Common in Zones IIC-III	0

Discussion: *Appendicisporites babsae* is found only in Zone II and *Abietinaepollenites minimus* is found only in Zone IIB. The other forms have concurrent ranges that also indicate Zone II. *Tricolporopollenites sp. B* occurs as a contaminant.

1,440-1,460 feet
Stratigraphic Determination: Lower Cretaceous (Albian)
Formation: Patapsco, Zone IIB
Lithology: Yellow arkosic, silty sand with some clay matrix; phytomacerals high in vitrain and fusain.
Paleoecology: Nonmarine

Table 15. Continued

CA Db 96—Continued

1,440-1,460 feet (continued)

Diagnostic Palynomorphs	**Atlantic Coastal Plain Range or Formation**	**Frequency**
Pollen and Spores:		
Cicatricosisporites aralica	Zones I-II	R
Cicatricosisporites subrotundus	Zone IIB	R
Tricolporopolenites sp. B Doyle and Robbins, 1977	Zone III	R
Trilobosporites crassus	Zone IIB	R
Platysaccus megasaccus	Zones I-II	R

Discussion: The sample contains spores restricted to Zone IIB of the Patapsco Formation. Up-hole contaminants from Zone III and younger intervals are also present.

1,520-1,540 feet

Stratigraphic Determination: Lower Cretaceous (Albian)
Formation: Patapsco, Zone IIB
Lithology: Yellow arkosic, silty sand with some clay matrix; phytomacerals high in vitrain and fusain.
Paleoecology: Nonmarine

Diagnostic Palynomorphs	**Atlantic Coastal Plain Range or Formation**	**Frequency**
Pollen and Spores:		
Cirratriradites spinulosus	Zones I-II	R
Cingulatisporites reticingulus	Zones I-II	R
Clavatipollenites hughesii	Zones I-II	R
Tricolpites albiensis	Zone IIB	R

Discussion: The presence of *Tricolpites albiensis* places this sample in Zone IIB.

1,590-1,610 feet

Stratigraphic Determination: Lower Cretaceous (Upper Aptian [?] to Lower Albian)
Formation: Arundel Formation or Lower Patapsco Formation
Lithology: Yellow arkosic, silty sand with some clay matrix; phytomacerals high in vitrain and fusain.
Paleoecology: Nonmarine

Diagnostic Palynomorphs	**Atlantic Coastal Plain Range or Formation**	**Frequency**
Pollen and Spores:		
Cicatricosisporites australiensis	Zones I-II	O
Cirratriradites spinulosus	Zones I-II	R

Table 15. Continued

CA Db 96—Continued

1,590-1,610 feet (continued)

Discussion: This sample has very few palynomorphs. The appearance of several grains of *Cicatricosisporites australiensis* suggests a Zone I correlation. Schizeaceous spores are more typical of Zone I than Zone II of the Potomac Group in Maryland. Zone III pollen from the Upper Patapsco Formation also occurs in the sample, most likely as an up-hole contaminant.

Table 16. Palynologic analysis of selected drill-cutting samples for test well CH Cg 24

[Gilbert J. Brenner, Ph.D., written communication, 2002; ft, feet; Fm., formation]

CH Cg 24
Hughesville

520-530 feet
Stratigraphic Determination: Paleocene (Danian [?])
Formation: Brightseat (?)
Paleoecology: Marine

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation	Frequency[1]
Pollen and Spores:		
Momipites tenuipollis	Maestrichtian to Eocene	O
	(most common in Paleocene)	C
Thomsonipollis magnificus	Paleocene	O
Pteridoidea sp. 2	Lower Aquia Fm. to Marlboro Clay (as in well PG Df 35)	
Maceopolipollenites tenuipolus	Paleocene	R
Castanea crenataeformis	Common in Paleocene-Eocene	A
Nudopollis terminalis	Paleocene to Lower Eocene (as in well PG Df 35)	R
Dinoflagellates:		
Acritarch Type 2	Lower Paleocene (Danian)	C
Deflandrea dilwynensis	Paleocene	R
Pterospermopsis ginginensis	Upper Cretaceous (Upper Senonian to Paleocene)	O

Discussion: The diagnostic palynomorphs present suggest a Paleocene age. Elsewhere in Maryland (well AA De 100) *Acritarch Type 2* has been found in the Brightseat Formation.

550-560 feet
Stratigraphic Determination: Upper Cretaceous (Campanian [?])
Formation: Upper Matawan or Monmouth
Paleoecology: No dinoflagellates found, but sample is poor in palynomorphs

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation	Frequency
Pollen and Spores:		
Rugubivesiculites reductus	Patapsco Fm. to Monmouth Fm.	C
Rugubivesiculites rugosus	Patapsco Fm. to Monmouth Fm.	O
Momipites tenuipollis	Maestrichtian – Eocene (most common in Paleocene)	C
Tricolpites parvus (Waanders, 1974)	Monmouth Fm. of New Jersey	R
Holkopollenites chemardensis (Fairchild and Elsik, 1969)	Monmouth Fm. of New Jersey and Maestrichtian to Paleocene of the Gulf Coast	R

[1] Subjective abundance scheme (Specimens per slide):
R (rare) = 1 to 2; O (occasional) = 3 to 5; C (common) = 5 to 10; A (abundant) = More than 10

Table 16. Continued

CH Cg 24—Continued

550-560 feet (continued)

Discussion: Although there are few palynomorphs, the common occurrence of two species of the *Rugubivesiculites* with specimens in good condition, suggests that these grains are not reworked, and that the sample is truly Cretaceous in age.

610-620 feet

Stratigraphic Determination: Upper Cretaceous (Lower Campanian [?])
Formation: Lower Matawan
Paleoecology: Marine
Palynological Recovery: Poor

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation	Frequency
Pollen and Spores:		
Araucariacites australis	Late Albian to Maestrichtian	O
Pseudoplicapollis cuneata	Morgan Cliffwood beds (Magothy Fm.) to Merchantville Fm. in New Jersey	C
Vacuopollis sp. 1 (Groot, Penny and Groot, 1961)	Magothy Fm.	R
Species *CP3B* (Wolfe, 1976)	Lower Campanian	R
Dinoflagellates:		
Tanyosphaeridium variecalum	Santonian to Campanian	R
Hystrichosphaeridium stellatum	Santonian to Campanian	O

Discussion: *Normapolles*, distinctive of the upper Magothy Fm., are not found in this marine sample. However, the common occurrence of *Pseudoplicapollis cuneata*, which is recorded as characteristic of the uppermost Magothy (Morgan Cliffwood beds) in New Jersey (Christopher, 1979), suggests that this is a Matawan horizon close to the Magothy and the Santonian/Campanian boundary. Palynomorph CP3B has only been found by Wolfe (1976) in the Lower Campanian.

Table 17. Palynologic analysis of selected drill-cutting samples for test well SM Bc 39

[Gilbert J. Brenner, Ph.D., written communication, 2002; ft, feet; Fm., formation]

SM Bc 39
Persimmon Hills

600-610 feet
Stratigraphic Determination: Paleocene (?)
Formation: Aquia (?)
Paleoecology: Marine
Palynological Recovery: Poor

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation	Frequency[1]
Pollen and Spores:		
Modern or Miocene Contaminants:		
Pinus sp.		
Salix sp.		
Betula sp.		
Quercus		
Tilia		
Ambrosia		
Acer		
Grass pollen		
Fossil Pollen and Dinoflagellates:		
Pollen:		
Momipites tenuipollis	Maestrichtian – Eocene (most common in Paleocene)	O
Castanea crenataeformis	Common in Paleocene to Eocene	C
Nudopollis sp.	Paleocene to Eocene	R
Dinoflagellates:		
Deflandrea phosphorica Eisenack	Paleocene to Eocene (Aquia Fm. and Nanjemoy Fm.)	R

Discussion: Fossil palynomorphs are rare in this sample. The major portion of the pollen content is from modern or perhaps Miocene horizons. A well preserved specimen of the dinoflagellate, *Deflandrea phosphorica*, and the two above fossil pollen types suggests a Paleocene age for this sample.

[1] Subjective abundance scheme (Specimens per slide):
R (rare) = 1 to 2; O (occasional) = 3 to 5; C (common) = 5 to 10; A (abundant) = More than 10

Table 17. Continued

SM Bc 39—Continued

620-630 feet

Stratigraphic Determination: Paleocene or Upper Cretaceous (Maestrichtian)
Formation: Aquia/Brightseat undivided or Monmouth if Cretaceous grains are in place
Paleoecology: Shallow Marine
Palynological Recovery: Poor

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation	Frequency
Pollen and Spores:		
Modern or Miocene Contaminants:		
Pinus sp.		
Carya		
Ilex		
Betula sp.		
Quercus		
Tilia		
Ambrosia		
Tertiary Pollen and Dinoflagellates:		
Pollen:		
Alnus verus	Upper Paleocene to Recent	R
Bombacaeidites nacientoensis Elsik, 1974	Paleocene	R
Castanea crenataeformis	Common in Paleocene and Eocene	C
Momipites tenuipollis	Maestrichtian to Eocene (most common in Paleocene)	R
Cretaceous Pollen:		
Araucariacites australis	Late Albian to Maestrichtian	O
Rugubivesiculites reductus	Patapsco Fm. to Monmouth Fm.	C
Dinoflagellates:		
Micrhystridium sp.	Wide Range	O

Discussion: This sample contains a mixture of pollen assemblages from different ages:

1. Modern or possibly Miocene pollen contaminants
2. Paleocene forms
3. The last occurrence of *Rugubivesiculites reductus* (Patapsco Fm. to Monmouth Fm.) and *Araucariacites australis* (Late Albian to Maestrichtian).

There is only one poorly preserved grain of *Rugubivesiculites reductus* and one grain of *A. australis*. Either these two forms, which are rare in this sample, are reworked from the Cretaceous beds below, or are in place and indicate a Cretaceous age for this sample. It is possible that the Cretaceous-Tertiary contact is either within or close to the sample interval (620-630 ft). This sample has poor palynological recovery, and as cuttings rather than a core sample, the age determination is uncertain. There are no dinoflagellates (not even fragments) other than the acritarch *Michystridium*, which may be an indication of brackish conditions.

Table 17. Continued

SM Bc 39—Continued

<u>640-650 feet</u>
Stratigraphic Determination: Upper Cretaceous (upper Santonian [?] to Campanian)
Formation: Magothy or Matawan
Paleoecology: Marine
Palynological Recovery: Fair

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation	Frequency
The following forms are believed to be Paleocene uphole contaminants:		
Deflandrea phosphoritica		
Castanea types		
Momipites tenuipolis		
Nudopollis sp.		
Cretaceous Pollen:		
Araucariacites australis	Late Albian to Maestrichtian	O
Minorpollis sp.	Magothy Fm. to Monmouth Fm.	C
Rugubivesiculites reductus	Patapsco Fm. to Monmouth Fm.	C
Species *NP-2* (Wolfe, 1976)	Upper Matawan Fm. to Monmouth Fm.	
Cretaceous Dinoflagellates:		
Cyclonephelium distinctum	Valanginian to Campanian	
Microdinium setosum	Monmouth Fm. – Brightseat Fm.	
Microdinium sp. A (Benson, 1976)	Monmouth Fm.	
Xenascus ceratiodes Lentin and Williams	Santonian to Campanian	
Micrhystridium sp.	Wide Range	
Tanyosphaeridium varieclumum	Santonian to Campanian	

<u>Discussion</u>: This is the only sample of the three from this well that contains several distinctly Upper Cretaceous forms. No forms from the Patapsco or Raritan have been found in SM Bc 39 at 640-650 ft. As in the above two samples, pollen from modern and Miocene horizons contaminate this sample. In Lentin and Williams (1973, 1981) the dinoflagellates *Xenascus ceratiodes,* and *Tanyosphaeridium varieclumum* are reported from the Santonian and Campanian stages of the Grand Banks off Canada (Williams and Brideaux, 1975).

Table 18. Palynologic analysis of selected drill-cutting samples for test well SM Dd 72

[Gilbert J. Brenner, Ph.D., written communication, 2001; ft, feet; Fm., formation]

SM Dd 72
Paw Paw Hollow

600-620 feet
Stratigraphic Determination: Lower Cretaceous (Albian)
Formation: Upper Patapsco, Zone IIB or IIC (?)
Palynological Recovery: Very Poor

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation	Frequency[1]
Angiosperm Pollen:		
Tricolporopollenites sp. E (?) (Doyle and Robbins, 1977)	Zone III (?)	
Spores:		
Taurocusporites reduncus (Bolkhovitina)	Zone I – III	
Taurocusporites spackmani Brenner	Zones IIB – III	
Cicatricosisporites patapscoensis Brenner	Zones IIB	
Cicatricosisporites aralica (Bolkhovitina)	Zones I – II	
Uphole Contamination:		
Dinoflagellate Cysts:		
Deflandrea phosphorica *Eisenack*	Eocene – Oligocene	
Paleocene Angiosperm Pollen:		
Fragment of *Nudopollis sp.*	Paleocene	
Modern Angiosperm Pollen:		
Juglands sp.		
Liriodendron sp.		
Salix sp.		
Betula sp.		
Grass pollen		
Modern Gymnosperm Pollen:		
Pinus sp.		

Discussion: This sample contains several species typical of Zone IIB or IIC in the Upper Patapsco. If so, a poorly preserved grain of what looks like *Tricolporopollenites sp E (?)* Doyle and Robbins (1977), diagnostic of the uppermost Zone III of the Patapsco, is an uphole contaminant.

640-660 feet BARREN

	Atlantic Coastal Plain Range or Formation
Uphole Contamination:	
Dinoflagellate Cysts:	
Deflandrea phosphorica Eisenack	Eocene – Oligocene

[1] Subjective abundance scheme (Specimens per slide):
R (rare) = 1 to 2; O (occasional) = 3 to 5; C (common) = 5 to 10; A (abundant) = More than 10

Table 18. Continued

SM Dd 72—Continued

640-660 feet (continued)

	Atlantic Coastal Plain Range or Formation
Uphole Contamination:	
Modern Angiosperm Pollen:	
Juglands sp.	
Salix sp.	
Betula sp.	
Grass pollen	
Modern Gymnosperm Pollen:	
Tsuga canadensis	
Pinus sp.	

660-680 feet BARREN

680-700 feet BARREN

720-740 feet
Stratigraphic Determination: Lower Cretaceous (Albian)
Formation: Upper Patapsco, Zone IIB (?) or IIC
Paleoecology: Nonmarine
Palynological Recovery: Poor

Diagnostic Palynomorphs	**Atlantic Coastal Plain Range or Formation**
Angiosperm Pollen:	
Tricolpopollenites micromunus	Zones IIA – IIC
Tricolpopollenites minutus	Zones IIA – IIC
Tricolporoidites sp. A (Doyle and Robbins, 1977)	Zone IIC
Spores:	
Appedicisporites segmentus	Zone II
Appendicisporites potomacensis	Zones IIB – IIC

Discussion: First large influx of wood (fusain and vitrain from the top down) suggesting an increase in nonmarine conditions.

760-780 feet BARREN

930-950 feet BARREN

Table 18. Continued

SM Dd 72—Continued

950-970 feet
Stratigraphic Determination: Lower Cretaceous (Albian)
Formation: Patapsco, Zone IIB
Paleoecology: Nonmarine
Palynological Recovery: Poor

Diagnostic Palynomorphs	**Atlantic Coastal Plain Range or Formation**
Spores:	
Cicatricosisporites patapscoensis Brenner	Zone IIB
Densoisporites perinatus	Zones I – II

1,070-1,090 feet
Stratigraphic Determination: Lower Cretaceous (Albian)
Formation: Lower Patapsco, Zone IIA (?)
Paleoecology: Nonmarine
Palynological Recovery: Poor

Diagnostic Palynomorphs	**Atlantic Coastal Plain Range or Formation**
Angiosperm Pollen:	
Tricolpopollenites micromunus	Most common in Zone IIA
Gymnosperm Pollen:	
Araucariacites australis	Most common in Zone II
Alisporites bilateralis	Zones I – II
Classopollis torosus	Zones I – II
Spores:	
Appendicisporites potomacensis	Zones I –II
Cicatricosisporites spp.	Zones I – II
Densoisporites perinatus	Zones I – II
Psilatriletes radiatus	Zones I – II (more common in Zone II)
Reticulatisporites dupliexinous	Zones I – II
Paleocene-Eocene Contaminants:	
Dinoflagellate Contaminant:	
Deflandrea phosphoritica	Eocene
Angiosperm Fossil Pollen Contaminant:	
Castanea crenataeformis	Common in Paleocene
Modern Angiosperm Pollen:	
Lilia sp.	
Tilia sp.	
Ambrosia sp.	
Modern Gymnosperm Pollen:	
Pinus sp.	

Discussion: No Zone IIB spores present, only forms that are found in all zones of the Patapsco. This is the common situation in Zone IIA.

Table 18. Continued

SM Dd 72—Continued

1,110-1,130 feet
Stratigraphic Determination: Lower Cretaceous (Albian)
Formation: Lower Patapsco, Zone IIA (?)
Paleoecology: Nonmarine
Palynological Recovery: Poor

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation
Angiosperm Pollen:	
Brenneropollis peroreticulatus	Zones I – II (more common in the Arundel and lower Patapsco Formations)
Gymnosperm Pollen:	
Classopollis torosus	Zones I – II
Spores:	
Microreticulatus crassiexinous Brenner	Zones I – II
Converrucosisporites proxigranulatus	Zones I – II

Discussion: No Zone IIB spores have been found in this sample. *Brenneropollis* is a common palynomorph in the Lower Patapsco.

1,130-1,150 feet
Stratigraphic Determination: Lower Albian / lower Patapsco, Zone IIA
Formation: Lower Patapsco, Zone IIA
Paleoecology: Estuarine to marine
Palynological Recovery: Good

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation
Angiosperm Pollen:	
Tricolpopollenites micromunus	Common in Zones IIA – IIBC
Tricolpopollenites minutus	Common in Zones IIA / IIA-IIC
Gymnosperm Pollen:	
Classopollis torosus	Zones I – II
Alisporites bilateralis	Zones I – II
Araucariacites australis	Most common in Zone II
Spores:	
Trilobosporites marylandensis	Zones I – II
Cicatricosisporites hallei	Zones I – II
Taurocusporites segmentatus	Zones I – II
Dinoflagellates:	
Aptea polymorpha Eisenack	Barremian to Albian
Cyclonephelium cf. distinctum	Hauterivian to Campanian
Leptodinium alectrolophum	Barremian to Aptian
Paleohystrichophora cf. infusorioides Deflandre, 1935	Albian to Campanian

Table 18. Continued

SM Dd 72—Continued

1,130-1,150 feet (continued)

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation
Modern Angiosperm Pollen:	
Lilia sp.	
Tilia sp.	
Grass pollen	
Modern Gymnosperm Pollen:	
Pinus sp.	

Discussion: An assemblage of spores and pollen restricted to Zone IIB of the Patapsco has not been found in this sample. Small *Tricolpates* common in Zone IIA have been found. Several well preserved Cretaceous dinoflagellate genera of previously unpublished species indicate an estuarine to marine environment for this sample. The dinoflagellates suggest a Lower Cretaceous age (Eisenack, 1958; Davey and others, 1966; Millioud, 1975; Williams, 1978).

1,330-1,350 feet

Stratigraphic Determination: Lower Cretaceous (Lower Albian)
Formation: Lower Patapsco, Zone IIA (?)
Paleoecology: Marine
Palynological Recovery: Very Poor

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation
Angiosperm Pollen:	
Brenneropollis peroreticulatus	Zones I – II (more common in the Arundel and Lower Patapsco Formations)
Gymnosperm Pollen:	
Classopollis torosus	Cretaceous
Spores:	
Apiculatisporis asymmetricus	
Cicatricosisporites spp.	Zones I – II
Densoisporites perinatus	Zones I – II
Zonalapollenites trilobatus	Zones I – II
Dinoflagellates:	
Fragment of *Paleohystrichophora sp.*	Cretaceous
Modern Angiosperms:	
Betula	
Lilia sp.	
Tilia sp.	
Grass pollen	
Modern Gymnosperm Pollen:	
Pinus sp.	

Table 18. Continued

SM Dd 72—Continued

1,550-1,570 feet
Stratigraphic Determination: Lower Cretaceous (Lower Albian)
Formation: Arundel, Zone I (?)
Paleoecology: Nonmarine
Palynological Recovery: Very Poor

Diagnostic Palynomorphs	**Atlantic Coastal Plain Range or Formation**
Spores:	
Cicatricosisporites brevilaesuratus Couper	Zone I
Cicatricosisporites spp.	More common in Zone I
Gymnosperm Pollen:	
Exesisporites tumulus	More common in Zone I

Discussion: *Cicatricosisporites brevilaesuratus* has only been found in Zone I of the lower Potomac Group. The other spore and pollen types listed are found in Zone II, but are more abundant in Zone I. Their dominance in Zone I assemblages is a characterizing feature. The sample lacks species restricted to Zone II (Patapsco Formation).

1,570-1,590 feet
Stratigraphic Determination: Lower Cretaceous (Lower Albian)
Formation: Arundel, Zone I (?)
Paleoecology: Nonmarine
Palynological Recovery: Very Poor

Diagnostic Palynomorphs	**Atlantic Coastal Plain Range or Formation**
Spores:	
Cicatricosisporites brevilaesurites	Zone I
Gymnosperm Pollen:	
Araucariacites australis	Zones I – II
Uphole Contaminant from Zone II:	
Angiosperm Pollen:	
Tricolpopollenites minutus	Zones IIA – IIC

Discussion: *Cicatricosisporites brevilaesurites* has only been found in Zone I of the lower Potomac Group.

Table 18. Continued

SM Dd 72—Continued

1,590-1,610 feet
Stratigraphic Determination: Lower Cretaceous (Lower Albian)
Formation: Arundel, Zone I (?)
Paleoecology: Nonmarine
Palynological Recovery: Poor

Diagnostic Palynomorphs	Atlantic Coastal Plain Range or Formation
Spores:	
Cicatricosisporites brevilaesuratus Couper	Zone I
Clavatisporites hughesii	Zone I in the absence of tricolpates
Gymnosperm Pollen:	
Classopollis torosus	Most common in Zone I
Modern Angiosperm Pollen:	
Acer sp.	
Tilia sp.	
Betula sp.	
Modern Gymnosperm Pollen:	
Larix sp.	
Picea sp.	

Discussion: *Cicatricosisporites brevilaesurites* has only been found in Zone I of the lower Potomac Group.

1,650 feet BARREN

Explanation and references for palynologic analyses, Tables 15-18

[Modified from Gilbert J. Brenner, Ph.D., written communication, 2001, 2002, and 2003]

Cuttings were received in plastic bags containing drilling mud, and were unwashed. Samples were centrifuged to remove all the water from the remaining sediment. Each sample was then processed to extract all organic content (pollen and spores) by heavy liquid separation. The amount of palynological material was, in general, sparse so that several processing runs were required to concentrate enough palynological residue necessary for at least one microscope slide per sample. Uphole palynological contamination was found, upon microscopic examination, to be extensive. For example, samples from Cretaceous horizons were generally contaminated with Paleocene pollen, Eocene dinoflagellates, and abundant modern pollen and spores.

Dating was based on the first occurrence of diagnostic forms working downward in the sample sequence.

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Table 19. Water-quality analyses for six test wells in Southern Maryland

[deg C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 degrees Celsius; @, at; mg/L, milligrams per liter; µg/L, micrograms per liter; pCi/L, picoCuries per liter; <, less than; E, estimated; --, not reported]

Well number	Date	pH, field	Temperature (deg C)	Specific conductance (µS/cm)	Total dissolved solids, (residue @180 deg C)	Sodium (mg/L)	Potassium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sulfate (mg/L as SO_4)	Alkalinity (mg/L as $CaCO_3$)
Upper Patapsco aquifer											
CA Db 96	2/4/2003	7.0	18.5	240	127	12.1	10.4	13.9	9.13	3.9	110
CH Cg 24	1/29/2002	7.3	19.8	281	164	48.3	7.24	6.63	3.03	8.6	131
Lower Patapsco aquifer											
CA Fd 85	11/28/2001	8.7	25.2	414	264	102	1.7	1.08	0.261	13.6	213
CH Bg 17	3/4/2003	8.0	20.6	240	152	54.2	3.21	1.09	0.512	5.8	119
SM Bc 39	3/28/2002	8.4	26	297	188	69.9	0.98	0.4	0.139	10	147
SM Dd 72	5/15/2001	8.3	22.5	420	267	97.2	1.26	0.45	0.189	15.2	207

Well number	Chloride (mg/L)	Fluoride (mg/L)	Iron (µg/L)	Manganese (µg/L)	Arsenic (µg/L)	Nitrite plus nitrate (mg/L as N)	Phosphorus (mg/L)	Total organic carbon (mg/L)	Silica (mg/L as SiO_2)	Radon-222 (pCi/L)	Gross alpha-particle activity (pCi/L)	Gross beta-particle activity (pCi/L)
Upper Patapsco aquifer												
CA Db 96	0.94	0.39	4,900	89	0.3	<0.06	0.1	E0.4	9.1	150	7	17
CH Cg 24	2.05	0.4	267	15.1	0.3	<0.05	0.10	3.4	10.5	230	3	8
Lower Patapsco aquifer												
CA Fd 85	2.07	0.4	105	12.5	<0.2	<0.05	0.1	E0.4	13.5	140	2.2	1.8
CH Bg 17	0.78	1.26	204	13.9	<0.3	<0.06	0.18	E0.3	10.2	330	<2	4
SM Bc 39	2.29	0.7	126	9.3	E0.1	<0.05	0.36	E0.4	15.7	630	<2	<3
SM Dd 72	2.03	0.72	49	8.1	<0.2	<0.05	0.16	4.2	14.5	--	1.4	1.0

A message to Maryland's citizens

The Department of Natural Resources (DNR) seeks to serve the citizens of Maryland by balancing preservation and enhancement of the State's resources with prudent extraction and utilization policies. This publication provides information that will increase your understanding of how DNR strives to reach that goal through the earth science assessments conducted by the Maryland Geological Survey.

Martin O'Malley
Governor

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