RECONNAISSANCE OF THE GROUND-WATER, SURFACE-WATER SYSTEM IN THE ZEKIAH SWAMP RUN BASIN, CHARLES AND PRINCE GEORGES COUNTIES, MARYLAND

By Herbert T. Hopkins, Gary T. Fisher, and Laurence J. McGreevy

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CONVERSION FACTORS AND ABBREVIATIONS

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

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.4	millimeter (mm)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.59	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon per minute (gal/min)	0.06309	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celcius (°C) as follows:

$$°C = 5/9\ (°F - 32)$$

National Geodetic Vertical Datum of 1929 (NGVD of 1929): The reference surface to which relief features and altitude data are related, and formerly called mean sea level, is referred to as sea level.

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ABSTRACT

The water table in the alluvium of the Zekiah Swamp Run valley is above stream level during most of the year and the alluvial aquifer contributes water to the stream. During the summer, however, high evapotranspiration sometimes lowers the water table below the stream level. Water then moves from the stream to the alluvium and, at times, reaches of the stream become dry. Pumping from the confined aquifers has caused water levels to decline several tens of feet, which has increased the downward gradient between the water-table aquifer and the underlying confined aquifers. Three synoptic surveys of base flow show areal and temporal variations in stream discharge, pH, specific conductance, dissolved oxygen, and temperature. April 1984 base flows were high (141 cubic feet per second, ft^3/s, at the Route 6 gage) because of high precipitation during March. July 1983 base flows were low (2.35 ft^3/s at the Route 6 gage) and showed significant loss of streamflow because of high antecedent evapotranspiration.

Estimates of inflow and outflow of the Zekiah Swamp Run basin above Route 6 during the 1984 water year include: Precipitation, 50.21 inches; stream outflow, 20.10 inches; shallow ground-water underflow, 0.1 inch; and evapotranspiration, 33 inches. A streamflow budget of a 5.1 mi^2 area of the valley of Zekiah Swamp Run between Routes 5 and 6, during the synoptic surveys, shows a gain in streamflow of 6 ft^3/s during the April 1984 survey and a loss of almost 5 ft^3/s during the July 1983 survey.

INTRODUCTION

Zekiah Swamp is a large natural hardwood swamp located in Charles County, southern Maryland (fig. 1). The swamp occupies a steep-sided valley about 15 mi long and is more than a mile wide in places. It is drained by Zekiah Swamp Run, a freshwater, nontidal stream that becomes Allens Fresh Run at tidewater, which, in turn, becomes the Wicomico River. (See pl. 1.) In recent years, residential and commercial development in and adjacent to the Zekiah Swamp Run basin has been rapid and extensive. Hydrologic effects of land-use changes

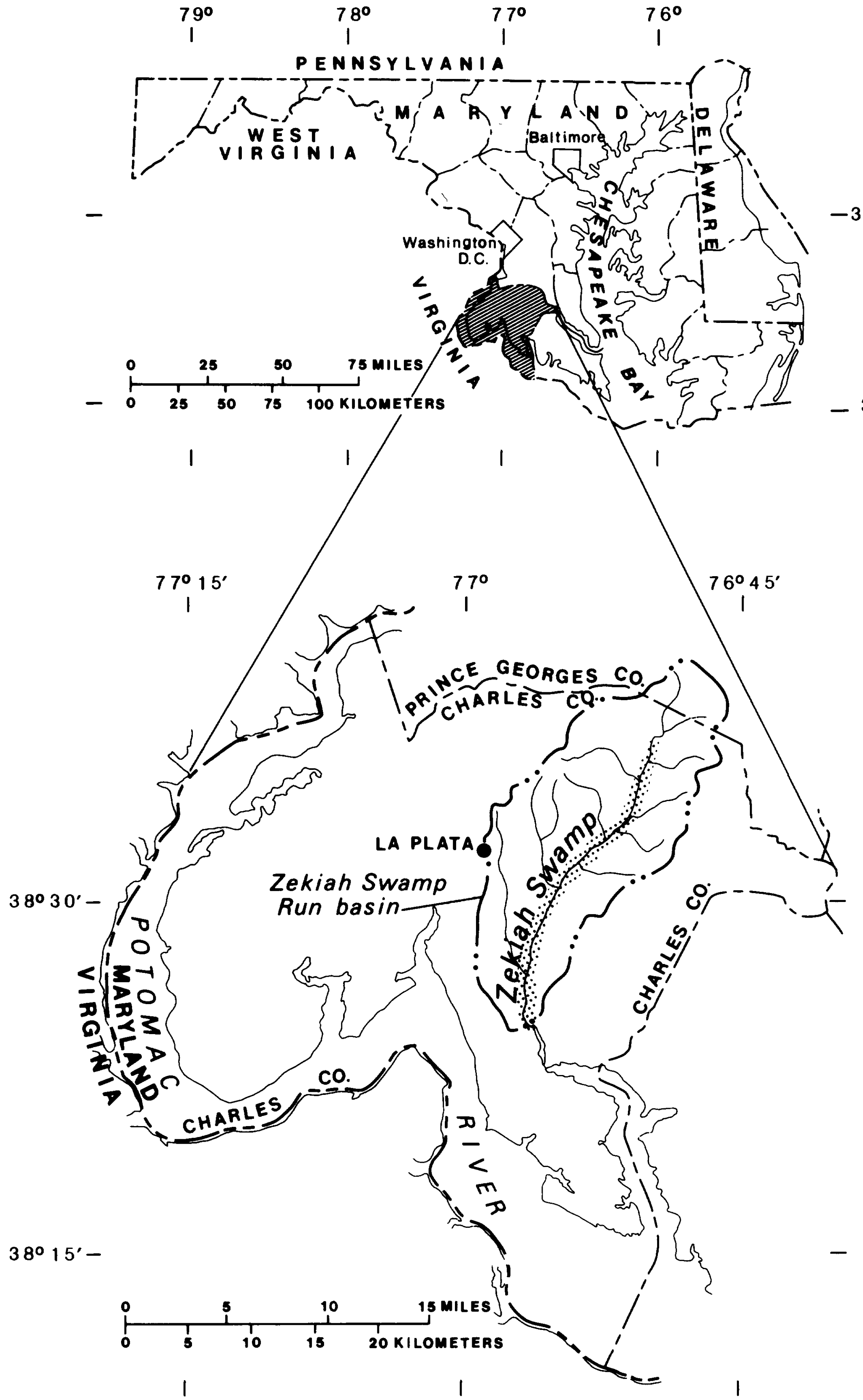


Figure 1.-- Location of Zekiah Swamp and Zekiah Swamp Run basin

and increased water demand associated with this development pose a potential threat to the stability of the swamp. State and local agencies are concerned about the preservation of Zekiah Swamp and it was designated an area of critical concern by the State of Maryland in 1981.

Purpose and Scope

This report presents results of a reconnaissance of the ground-water, surface-water system of the Zekiah Swamp Run basin. The report discusses general concepts of the hydrologic system and presents data collected during the study. The report describes sources of water in the Zekiah Swamp Run basin and gives estimates of inflow and outflow quantities.

Field work for the investigation began in May 1983 and continued through December 1984. Previous work in the area was reviewed; available geologic, hydrologic, and meteorological data were assembled and evaluated. One continuous-record gaging station and three staff gages were established at bridge crossings on Zekiah Swamp Run. Synoptic base-flow surveys were made in May 1983, July 1983, and April 1984. During the surveys, stream discharge, pH, specific conductance, dissolved oxygen, and temperature were measured at 12 sites on Zekiah Swamp Run and its tributaries.

Five test wells were drilled to determine the thickness of valley fill and to obtain water levels. Continuous water-level recorders were operated on four of the test wells; the fifth was measured monthly.

Locations of data-collection sites are shown on plate 1. Records of wells referred to in this report are given in the appendix (table 8). Logs of test wells and highway borings are also in the appendix (tables 9 and 10).

Climate

The climate in the Zekiah Swamp Run basin is moderately humid, with a mean daily temperature of 55.8°F and a mean annual precipitation of 42.62 in. at the National Weather Service station one mile west of La Plata, Md., for the period 1951 through 1980. Mean monthly temperatures vary from 34.6°F in January, to 75.9°F in July. Most precipitation is in the form of rainfall, although frozen forms can occur during the winter.

Figure 2 compares 1951-80 normal monthly precipitation at La Plata to monthly totals for the study period. The distribution of mean monthly precipitation is fairly uniform throughout the year; the lowest is 2.88 in. in February and the highest is 4.92 in. in August. Extreme variations in monthly precipitation, however, do occur. For example, the precipitation in March 1984 was 6.72 in., about double the 30-year mean. At the other extreme, only 1.24 in. of rain fell during June 1983, which was about one-third of the mean.

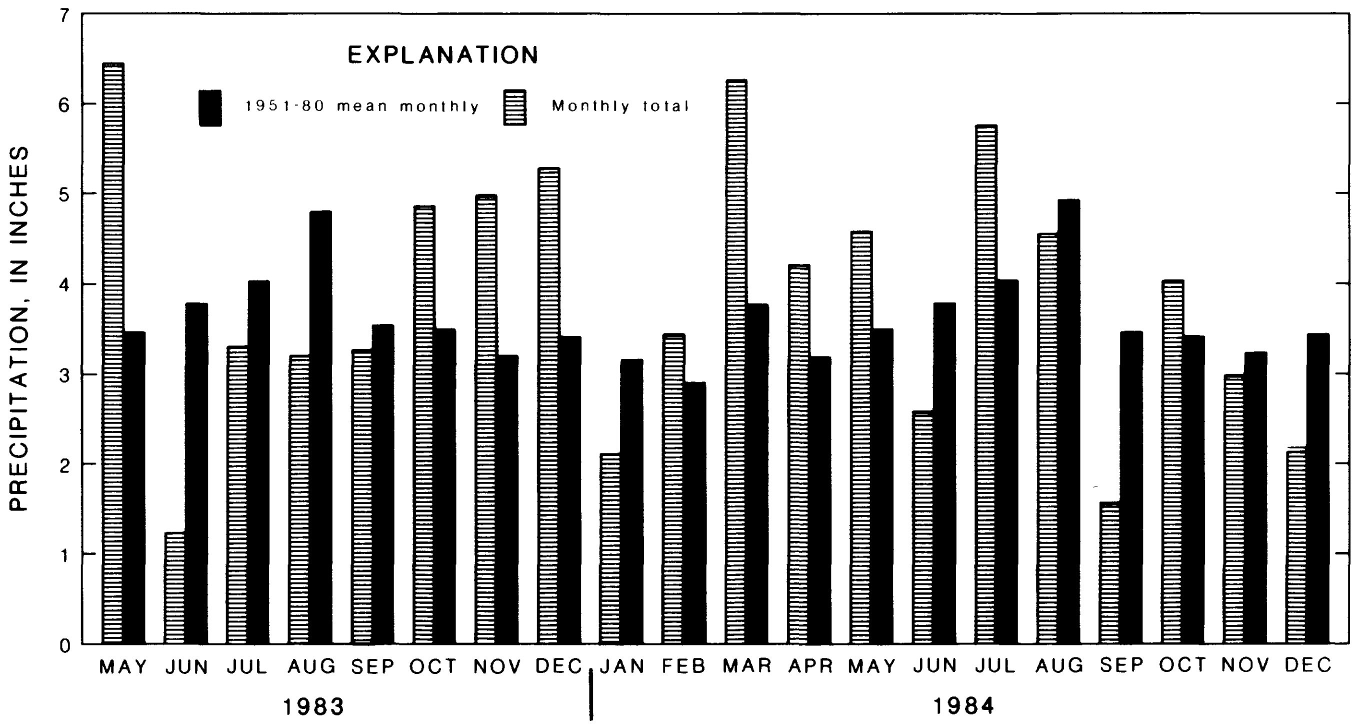


Figure 2.-- Monthly precipitation at La Plata, Md., May 1983 to December 1984 compared to 1951-80 means.

Acknowledgments

This report was prepared in cooperation with the Tri-County Council for Southern Maryland, the Coastal Resources Division of the Maryland Tidewater Administration, and the Maryland Geological Survey. The authors express their appreciation to other agencies that provided assistance in conducting this study, particularly the Charles County Departments of Planning and Public Works, and the U.S. Soil Conservation Service. In particular, the assistance of Steve Bunker, formerly of the Tri-County Council for Southern Maryland, is gratefully acknowledged. The test drilling services contracted by the Coastal Resources Division and carried out by the Water Resources Administration were essential for the successful completion of the study. The services of volunteer observers in obtaining daily gage heights are also gratefully appreciated.

HYDROGEOLOGIC SETTING

Zekiah Swamp Run basin is in the Atlantic Coastal Plain physiographic province. Unconsolidated Coastal Plain units of interlayered clay, silt, sand, gravel, and shell beds dip gently to the southeast beneath the area. These unconsolidated units are underlain by consolidated crystalline basement rock at depths ranging from about 1,500 to 2,000 ft below sea level (Brown and

Table 1.--Hydrogeologic units, Zekiah Swamp Run basin

System	Series	Geologic unit	Water-bearing characteristics
Quaternary	Holocene and Pleistocene	Alluvium	Sand, gravel, and silt with some clay; water bearing
Tertiary	Pliocene	Upland deposits	Gravel, sand, silt, and clay; tan, reddish-brown, yellow, and orange; water bearing
	Miocene	Calvert Formation	Clay, sandy clay, and silty sand; green, blue, and gray; fosiliferous. Generally not an aquifer in this area
	Eocene	Nanjemoy Formation and Marlboro Clay undifferentiated	Sand, fine, silt, clay, and shells; glauconitic; green to black; pink to gray Marlboro Clay at base of unit. Not an aquifer in this area
	Paleocene	Aquia Formation	Sand, shells, silt, and clay; glauconitic; green to black; calcite cementation is common. Constitutes the Aquia aquifer
Cretaceous	Upper Cretaceous	Brightseat and Severn Formations undifferentiated	Clay, silt, and sand; gray to grayish-black. Some sand beds may be water bearing locally
		Magothy Formation	Sand, light gray to white; interbedded layers of organic clay; coarse sand and gravel near base. Constitutes the Magothy aquifer
	Lower Cretaceous	Potomac Group undifferentiated (Patapsco, Arundel, and Patuxent Formations)	Sand layers interbedded with thick clay layers; red, yellow, gray, and variegated. Includes the Patapsco aquifer (upper part) and the Patuxent aquifer (lower part)

others, 1972, pl. 5). Consolidated sedimentary and igneous rift-basin rocks of Late Triassic(?) and Jurassic(?) age may also underlie the unconsolidated units in some places. Geologic units overlying the basement are described in table 1.

The Coastal Plain in the area is a broad, upland plain. These uplands are capped by deposits of gravel, sand, silt, and clay, generally less than 60 ft thick. Zekiah Swamp Run has cut through the upland deposits and into the underlying Calvert and Nanjemoy Formations forming a fairly straight, U-shaped valley with a broad flood plain. Thin alluvial deposits of sand, gravel, and silt, generally less than 20 ft thick, underlie the stream channel and flood plain throughout the length of the valley.

Water-Bearing Geologic Units

The general water-bearing character of the geologic units overlying consolidated basement rock is indicated in table 1. The relation of the geologic units to each other and to the valley of Zekiah Swamp Run is shown in cross section on plate 1.

Several confined aquifers are present at depth. Water-bearing sands of the Potomac Group are known as the Patuxent aquifer (lower part) and Patapsco aquifer (upper part). Water-bearing sands of the Magothy and Aquia Formations are known as the Magothy and Aquia aquifers, respectively. Shallow water-table aquifers are the upland deposits and the alluvium of Zekiah Swamp Run. The other geologic units are predominantly silt and clay and are generally poor sources of water, although some water-bearing sands are present locally in some of these units.

The Magothy aquifer, which is one of the principal aquifers underlying the northern part of the Zekiah Swamp Run basin, is not present in the southern part (Mack and Mandle, 1977, p. 10). The approximate southern limit of this unit is shown on plate 1. Section B-B' (pl. 1) shows the relative positions of the geologic units where the Magothy Formation is missing.

Effects of Sea-Level Changes on Valley Fill

For relatively brief periods during the past million years, sea level rose a few tens of feet above the present level; however, for most of that period, sea level was below the present level. Meisler and others (1984, p. 7; based on work by Zellmer, 1979) conclude that the average sea level for the past 900,000 years was about 150 ft below the present level.

Changes in sea level changed the base level for the local stream system and caused alternate cutting and filling of stream valleys. During sea-level declines, streams cut deep channels in their lower reaches as they graded toward the lower base level. Then, during sea-level rises, the lower reaches of the stream valleys were drowned and sediment gradually filled the deep channels. Hack (1957, p. 823) determined from borings for the U.S. Route 301 bridge across the Potomac River that the river cut channels to a maximum of 165 ft below sea level during low sea-level stands, and, during higher levels, deposited as much as 150 ft of fill in the channels.

"It might appear at first glance that the valley of Zekiah Swamp Run is a drowned valley, swampy because it was filled by river silt during a rising sea level. Actually, however,...it is probably flowing on only a shallow fill or directly on Tertiary bedrock." (Hack, 1957, p. 828). Data from highway borings and from test wells drilled during this study substantiate Hack's conclusions. (See pl. 1 and fig. 3.) The profile of figure 3 shows that the fill is thin; the base of the alluvial fill is less than 15 ft below the streambed. Sections across the valley at Routes 5 and 6 (pl. 1) show the maximum thickness of fill to be about 25 ft.

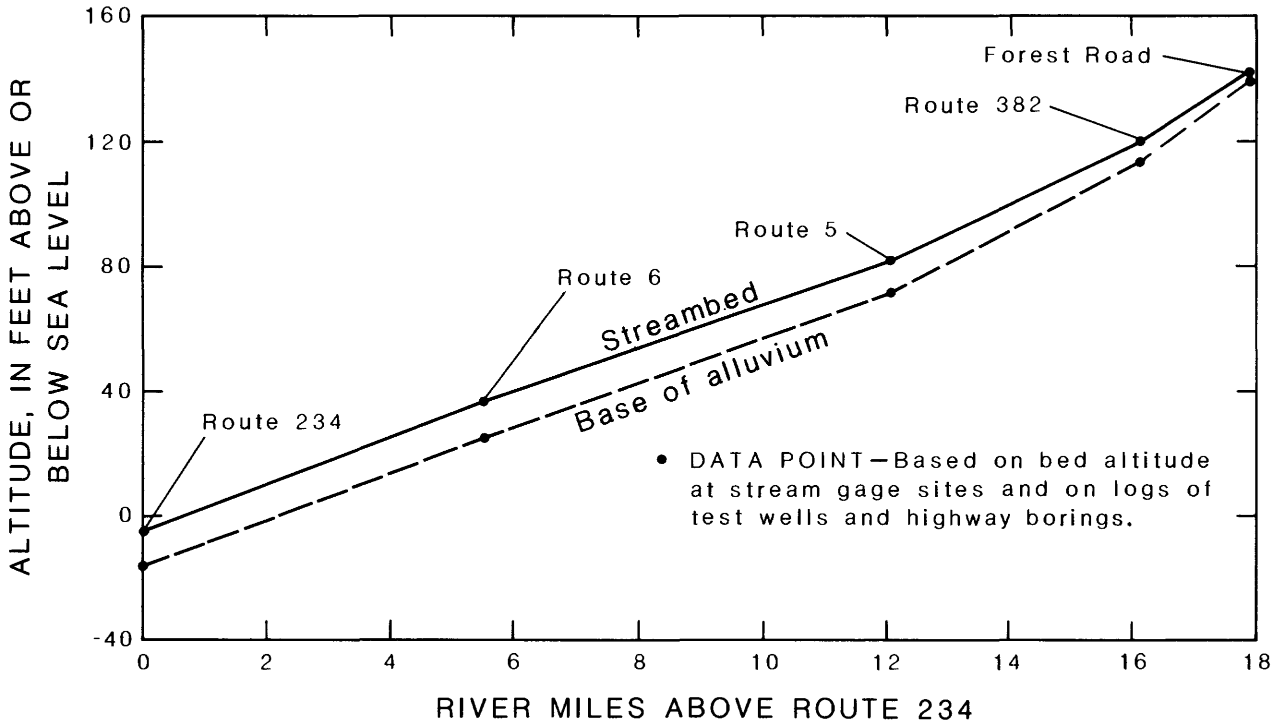


Figure 3.-- Profile of streambed and base of alluvium, Zekiah Swamp Run.

The valley below Route 234, however, which is occupied by Allens Fresh Run and the Wicomico River, is drowned. The base of the channel (base of the alluvium) continues to deepen downstream, while the streambed flattens and is less than 10 ft below sea level 6 mi downstream of Route 234 (U.S. Geological Survey 7 1/2-minute quadrangle, Rock Point, Md., 1982). The fill at this point is probably more than 40 ft thick (based on projection of the profile), and, farther downstream at the confluence with the Potomac River, the thickness of fill probably exceeds 100 ft.

GROUND-WATER, SURFACE-WATER SYSTEM

Sources of Water and Description of System

Water in the Zekiah Swamp Run basin is derived from precipitation, from ground-water underflow, and from diversions such as seepage of imported water from septic systems, sewers, or waste-treatment systems. Water leaves the basin by stream discharge to Allens Fresh Run, by evapotranspiration, by ground-water underflow, by pumping from wells, and by diversions such as pick up of ground water by sewers discharging out of the basin.

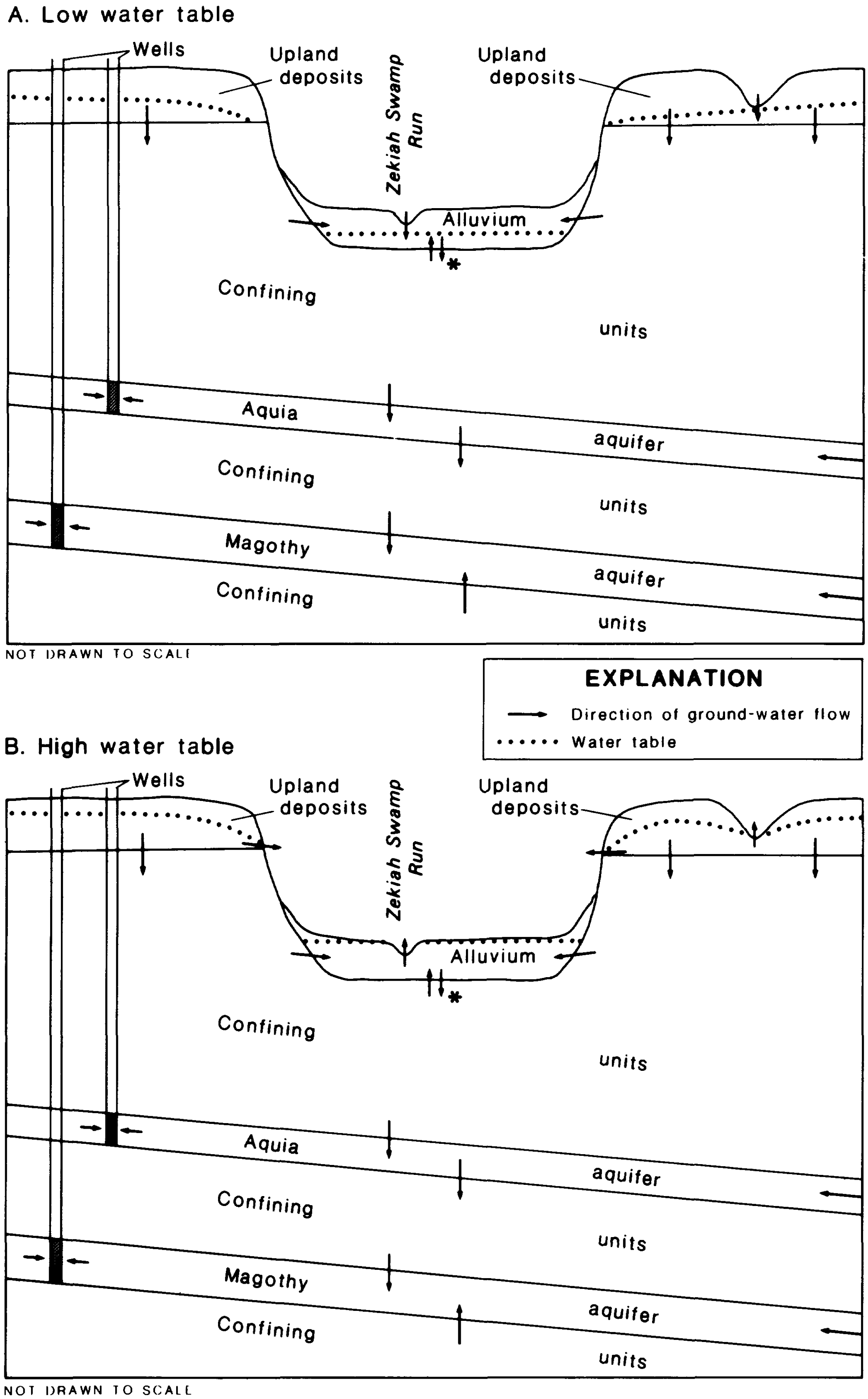
Part of the precipitation in the basin goes directly to streams as overland runoff, part is stored in the soil and is discharged to the atmosphere by evapotranspiration, and part percolates to the water table. In the uplands, ground water is stored in the upland deposits forming a water-table aquifer. This aquifer still supplies water to shallow wells, although modern wells tap deeper aquifers. Water from the upland deposits seeps into streams, maintaining flow during most dry periods. Water goes directly to the stream or discharges to contact springs or seeps along the base of the upland deposits where the stream has cut below them. Some water from the upland deposits seeps downward into the underlying Calvert Formation. Although the Calvert in this area acts as a confining unit, it has some permeability and some water moves through it. Water from the Calvert discharges to entrenched streams and to the alluvium of Zekiah Swamp Run.

Except for the headwaters area, the Zekiah Swamp Run valley is cut below the upland deposits, and the alluvium in the valley is a water-table aquifer. The alluvium receives water directly from percolation of precipitation and from underflow from the Calvert Formation. During most of the year, the water table in the alluvium is above the stream level and the aquifer contributes water to the stream. However, high evapotranspiration rates during the summer sometimes lower the water table below the stream level. Water then moves from the stream to the alluvium and, at times, some reaches of the stream become dry. Figure 4 shows directions of ground-water flow and contrast high water-table and low water-table conditions.

Surface water discharges from the Zekiah Swamp Run basin to Allens Fresh Run and then to the Wicomico River. Underflow of ground water in the alluvium follows the same general path and ultimately discharges to the Wicomico River.

Most water in the deeper confined aquifers is derived from outside the basin and moves through the area as ground-water underflow. Discharge from these aquifers is mostly to wells in pumping centers that are outside or on the western margin of the Zekiah Swamp Run basin. There is a vertical component of flow between the confined aquifers and the water-table aquifers (fig. 4), although the rate of vertical movement of water is very slow because of the low vertical permeability of the intervening units. Before pumping of the confined aquifers began, the vertical flow gradient between the confined aquifers and the water table was generally downward in high topographic areas (such as the uplands) and upward in low topographic areas near sea level (such as the lower reaches of Zekiah Swamp Run). As a result of pumping, heads in the shallowest confined aquifers (the Aquia and Magothy) are now (1984) below sea level (pl. 1 and figs. 15 and 16) and the overall vertical flow gradient between these aquifers and the water table is downward throughout the area. The sections of plate 1 show the relation of heads in the water-table aquifers (alluvium and upland deposits) to heads in the Aquia and Magothy aquifers in September 1984.

The reduced head in the confined aquifers results in an adjusted pressure gradient across the confining units (Calvert and Nanjemoy Formations) between the confined aquifers and the water table. While the downward vertical component of flow has been increased, most flow in the upper part of the system is essentially the same. That is, some water seeps from the upland deposits into the confining units and most of this water then flows laterally to entrenched streams and to the alluvium of Zekiah Swamp Run. The head in the



* Flow direction at base of alluvium depends on vertical head distribution through confining units separating alluvium and Aquia aquifer. The overall gradient between the water table in the alluvium and the potentiometric surface of the Aquia aquifer is downward. (See potentiometric surface on plate 1.)

Figure 4.-- Diagrammatic sections showing direction of ground-water flow.

confining unit in contact with the alluvium of Zekiah Swamp Run, however, probably has been reduced, to some small degree, by the pressure adjustment. This would result in reduced flow from the confining unit to the alluvium. It is even possible that, in places, the direction of flow at the base of the alluvium has reversed and water flows from the alluvium into the underlying confining unit. Without data on the head distribution in the confining units and on vertical permeability of the units, quantities involved and their significance with respect to the hydrology of the swamp cannot be determined.

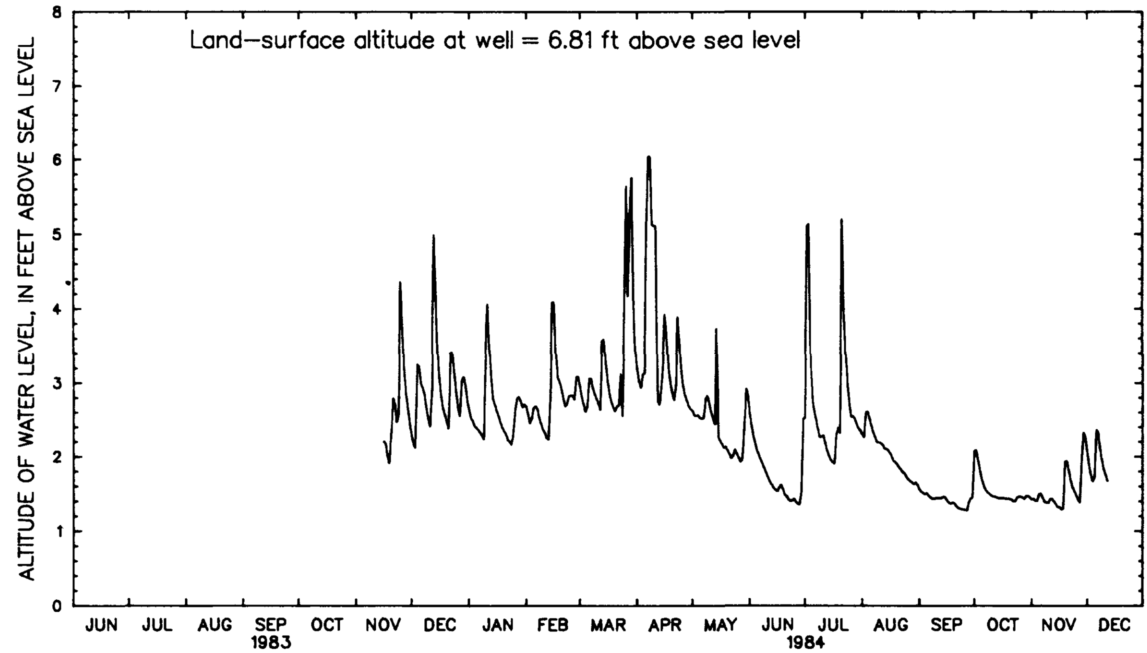


Figure 5.-- Altitude of water level in well CH EE 90, Route 234, November 1983 to December 1984.

Ground-Water Levels

Water-Table Aquifers

Water levels in the water-table aquifer in the alluvium of Zekiah Swamp Run fluctuate in response to precipitation, evapotranspiration, and stream stage. Hydrographs of water levels in five test wells tapping the alluvial aquifer are shown in figures 5 to 9. Stream stage at gaging sites near four of the wells is also shown on the hydrographs to compare the altitude of the water table with the altitude of the stream surface. Stream stage near the fifth well, CH EE 90 (fig. 5), is tidal.

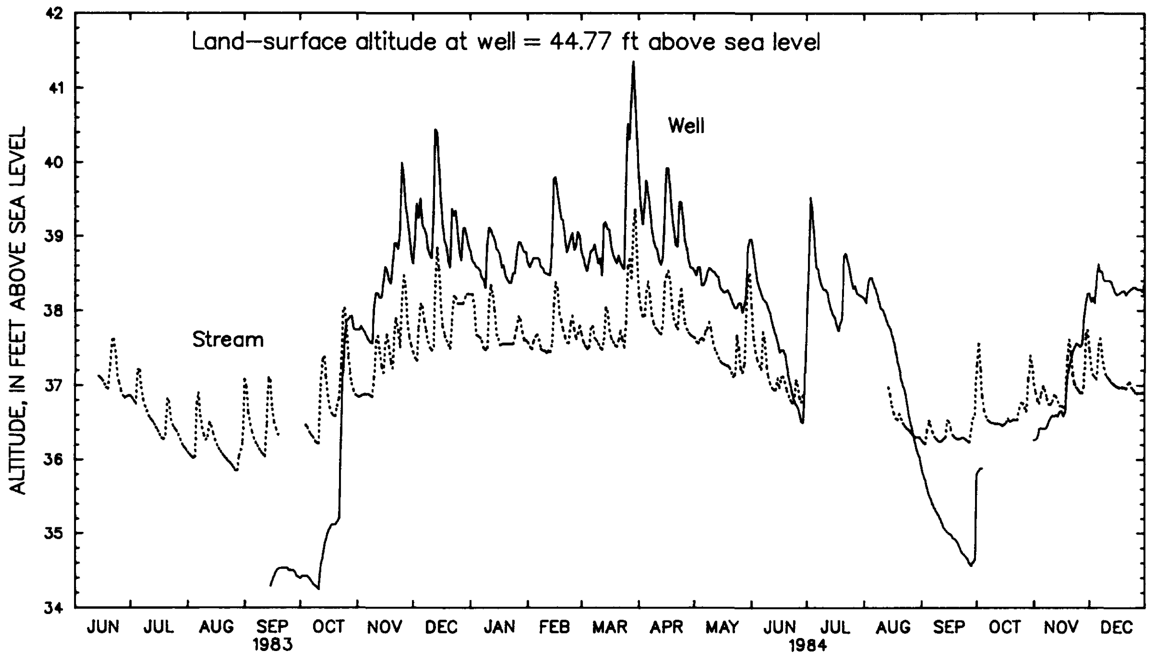


Figure 6.-- Altitude of water level in well CH DE 45, September 1983 to December 1984, and level of Zekiah Swamp Run at gage, Route 6 (site 10).

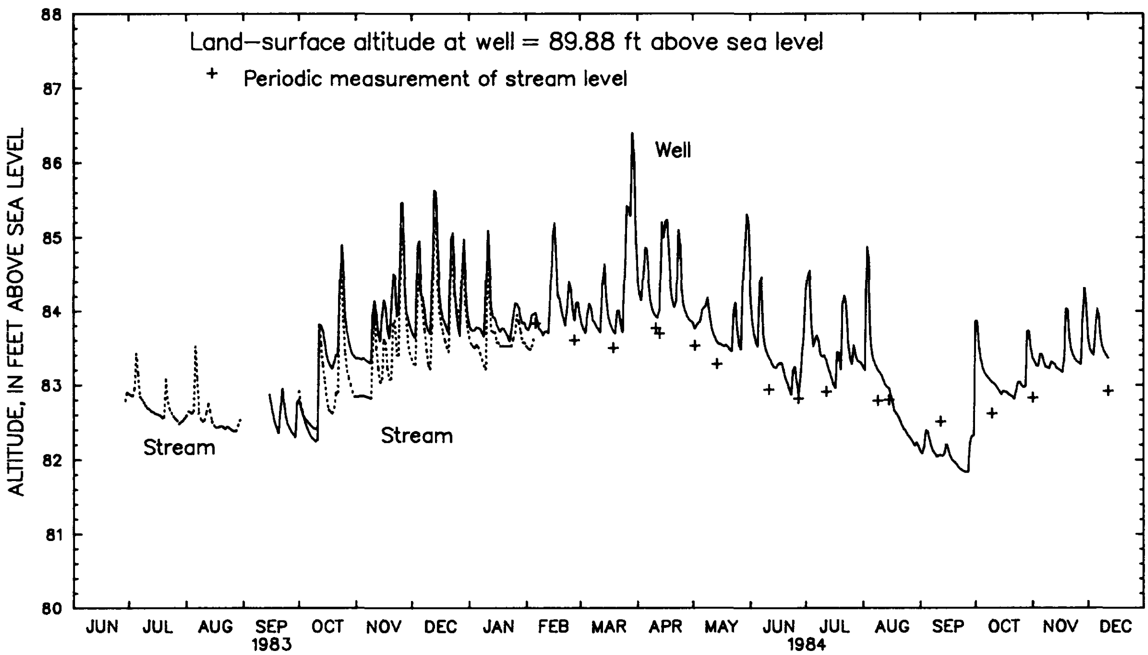


Figure 7.-- Altitude of water level in well CH CF 33, September 1983 to December 1984, and level of Zekiah Swamp Run at gage, Route 5 (site 5).

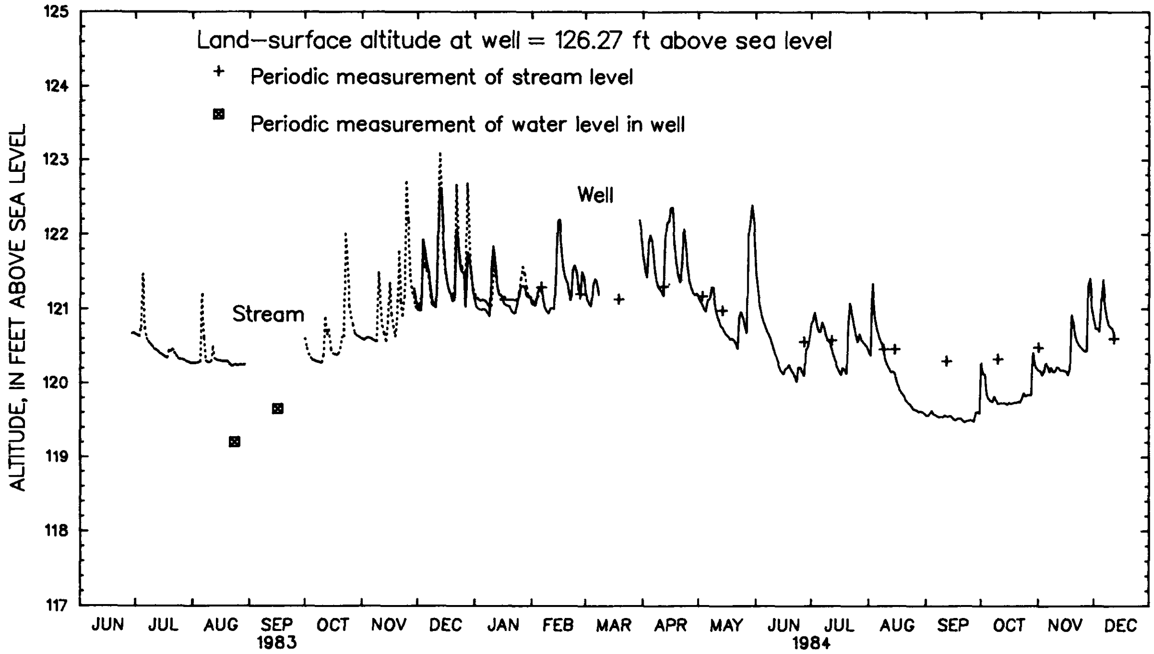


Figure 8.-- Altitude of water level in well CH BG 13, September 1983 to December 1984, and level of Zekiah Swamp Run at gage, Route 382 (site 1).

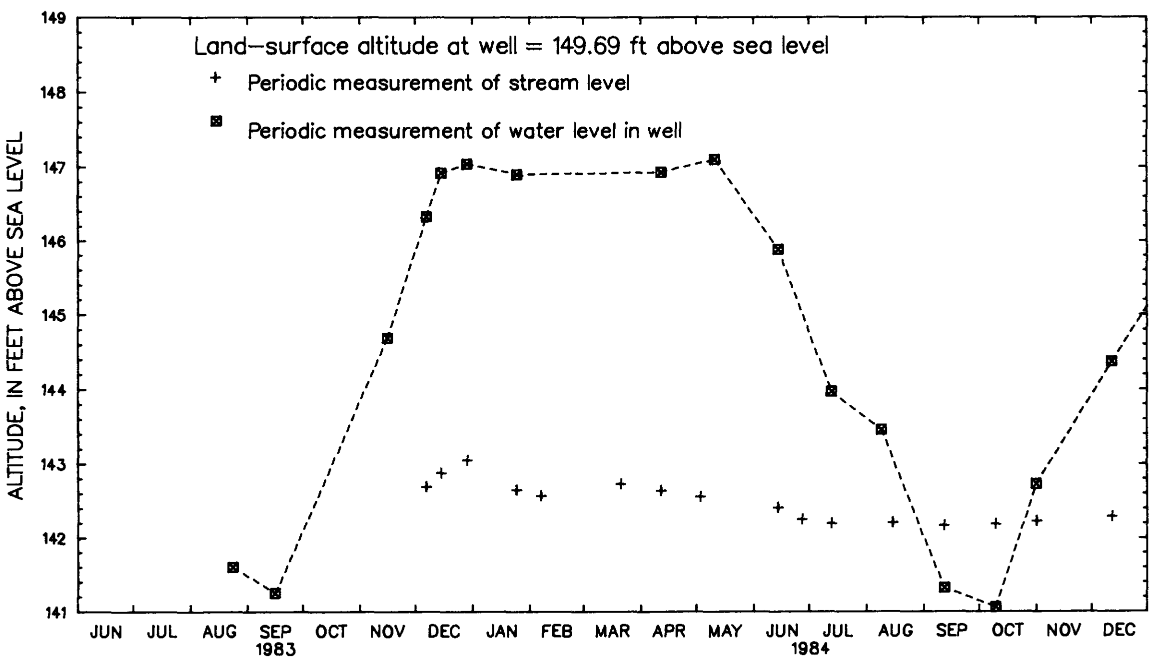


Figure 9.-- Altitude of water level in well CH BG 12, August 1983 to December 1984, and level of Zekiah Swamp Run at gage, Forest Road (site 13).

For all five test wells, the maximum range of water-level fluctuation measured during the study was about 7 ft and the maximum depth to water was about 11 ft. Both of these extremes were measured in well CH DE 45 at Route 6 (fig. 6). Water-level fluctuations were very similar in all test wells. Water levels in wells are generally above stream stage except during the high evapotranspiration period in late summer and early fall. The water level in well CH BG 13, however, is at or slightly below stream stage at the gage at Route 382 during the winter period of low evapotranspiration (fig. 8). This is probably a local effect of pooling of the stream at the gage. Well CH BG 13 is near the stream and about 30 feet downstream from the gage.

Water levels in the water-table aquifer in the upland deposits fluctuate naturally in response to precipitation and evapotranspiration. Septic systems, small scale land-use changes, and pumping from this aquifer may have local effects on levels. Large scale land-use changes, such as the residential developments in the Waldorf-St. Charles area, may either lower or raise levels in a relatively large area by altering recharge and drainage quantities and patterns. Changes in water level in the upland deposits may affect Zekiah Swamp by changing flow in the tributaries to Zekiah Swamp Run that drain the upland deposits. (Water levels in the upland deposits were not measured during this study.)

Confined Aquifers

Water levels in the confined aquifers fluctuate primarily in response to pumping and are on a general downward trend. Fluctuations caused by climatic variations are generally obscured. Ground water, most from confined aquifers, is the sole source of public water supply in the Zekiah Swamp Run basin, and marked increases in ground-water use have paralleled increases in population growth. Two centers of population growth in the area are Waldorf-St. Charles and La Plata. Figure 10 shows population growth and water use by public-supply systems that serve Waldorf-St. Charles and La Plata. The Waldorf-St. Charles supply is primarily from the Magothy aquifer with a lesser amount from the Patapsco aquifer. The La Plata supply is primarily from the Patapsco aquifer with a small amount from the Aquia aquifer. The steady increase in water use is reflected in steady decline in water level in the confined aquifers. Water-level declines in observation wells tapping the Aquia, Magothy, and Patapsco aquifers are shown in figure 11. Maps of the potentiometric surfaces of the Aquia and Magothy aquifers in September 1984 by Mack and others (1985a, 1985b) are reproduced in the appendix as figures 15 and 16. Comparison of data from Slaughter and others (1968 p. 36) and Slaughter and Laughlin (1966 p. 58, 59) with the potentiometric map of the Aquia aquifer (fig. 15) indicates about 40 ft of decline in water level on the east side of Zekiah Swamp between 1960 and 1984. Comparison of data from Mack (1983, p. 13) and the potentiometric map of the Magothy aquifer (fig. 16) indicates more than 60 ft of decline on the east side of the swamp between about 1950 and 1984. Declines near the pumping centers west of the swamp are even greater.

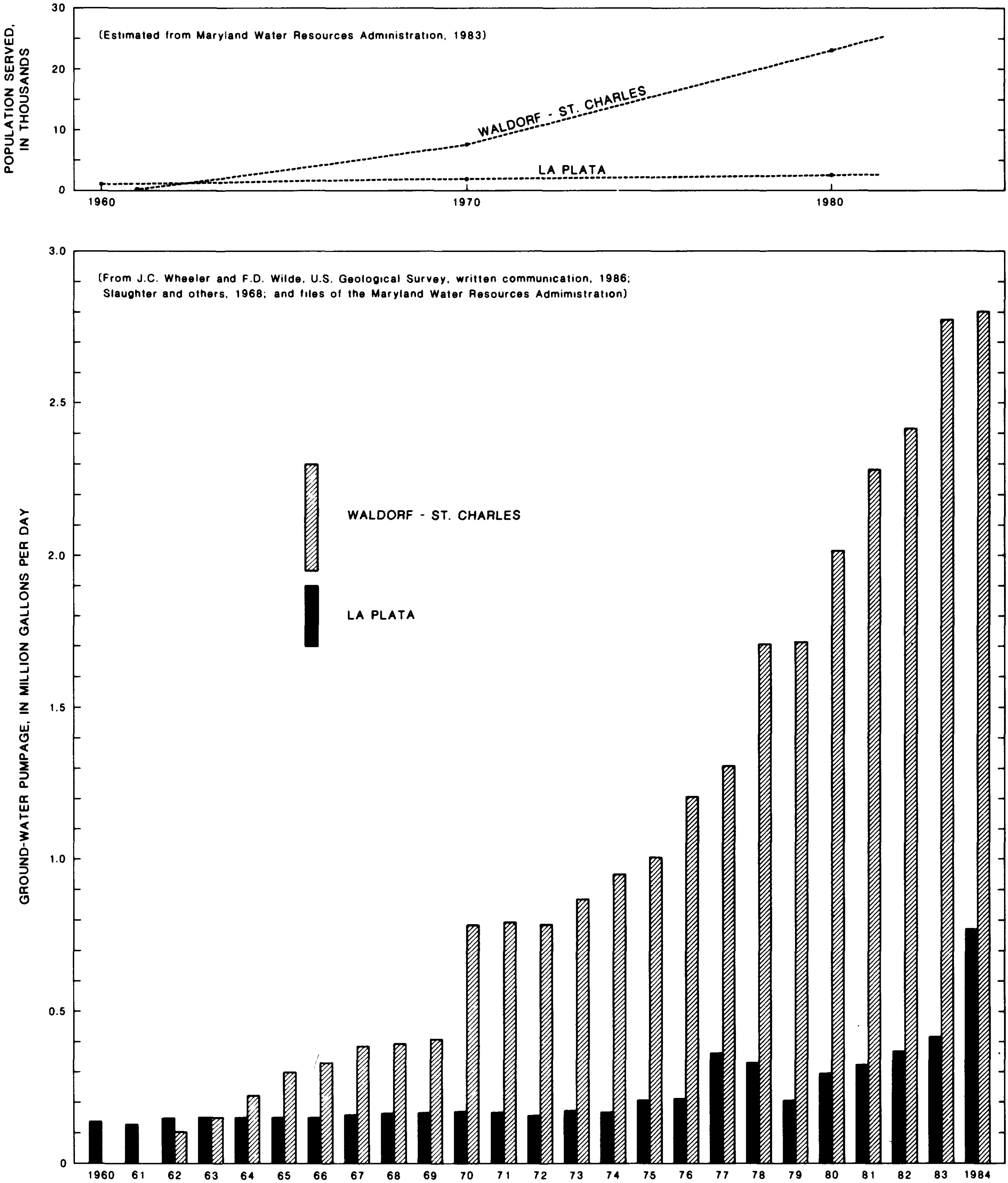


Figure 10.-- Water use by public-supply systems that serve La Plata and Waldorf-St. Charles, 1960-84, and population served.

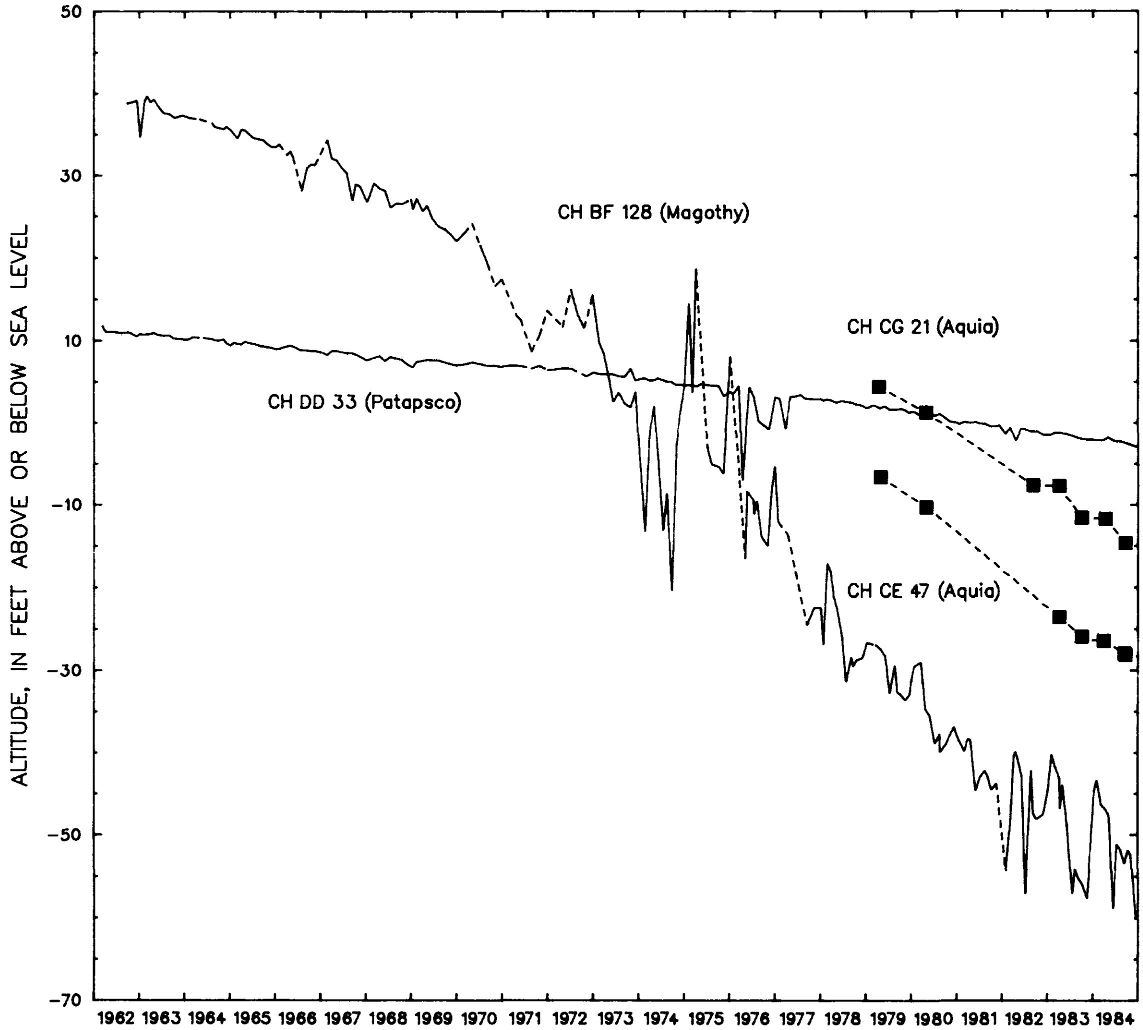


Figure 11.-- Altitudes of water levels in observation wells screened in the Aquia, Magothy, and Patapsco aquifers, 1962 to 1984.

The relation of the September 1984 potentiometric surfaces of the Aquia and Magothy aquifers to Zekiah Swamp is indicated in the cross sections of plate 1. As far as the hydrology of Zekiah Swamp is concerned, the potential significance of the decline in water level of the confined aquifers is the increased downward gradient between the water-table aquifer in the swamp and the underlying confined aquifers. This increased gradient might cause a reduction in water supply to the swamp. (See section, "Sources of Water and Description of System.")

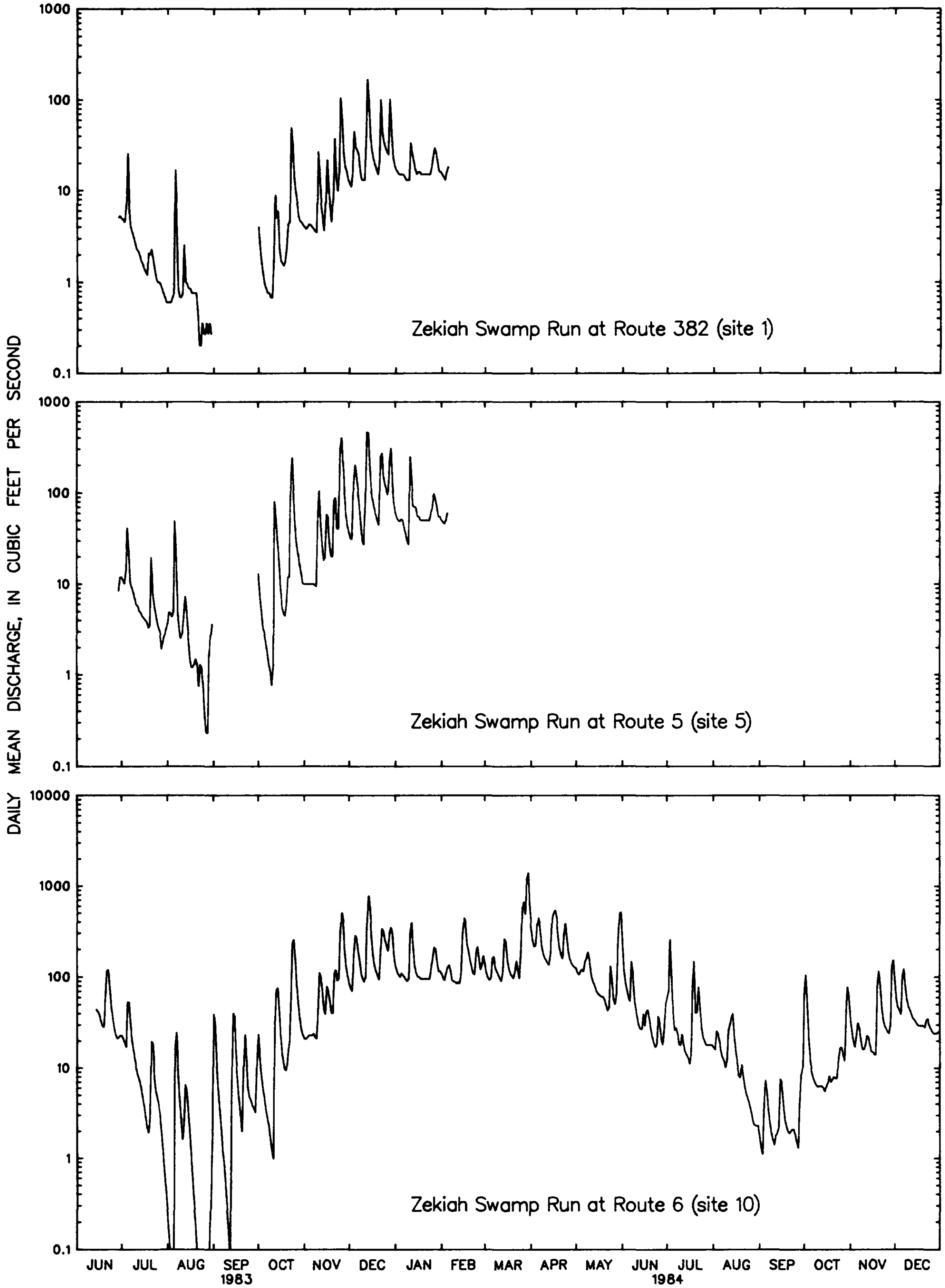


Figure 12.-- Discharge of Zekiah Swamp Run at Routes 382 (site 1), 5 (site 5), and 6 (site 10).

Streamflow

Discharge at Gaged Sites

Discharge of Zekiah Swamp Run at the continuous-record station at Route 6 (site 10, station 01660920) is shown in figure 12 for June 1983 to December 1984. Discharge of Zekiah Swamp Run at Routes 5 (site 5, station 01660910) and 382 (site 1, station 01660905), based on staff-gage readings from June 1983 to February 1984, is also shown in figure 12 (site locations are shown on plate 1.) Miscellaneous staff-gage readings and corresponding discharges for Zekiah Swamp Run at Routes 5 and 382 and at Forest Road, Cedarville State Forest, are given in the appendix (table 7). Altitudes of stream stage are compared with water-level altitudes of nearby test wells in figures 5 to 9.

Streamflow measurements by the U.S. Geological Survey in the Zekiah Swamp Run basin before 1983 are rare. Daily discharge of Piney Branch at the approximate location of site 6 is available 1960-62. (See Slaughter and others, 1968, p. 40.) Crest-stage (high-flow) data are available for Clark Run at site 11 (station 01660930) for 1947-58 and 1966-76, and a few low-flow measurements are available for 1966-79. Crest-stage data for Wolf Den Branch at the culvert on Forest Road, Cedarville State Forest, (station 01660900) are available for 1966-77. A few low-flow measurements are available for Zekiah Swamp Run at Route 382 (site 1, station 01660905) for 1975-82. Records are published by the U.S. Geological Survey in a series of annual water-data reports. Most records collected for this study are published in the 1984 volume of this series, "Water Resources Data, Maryland and Delaware, Water Year 1984."

Low-Flow and Flood-Flow Characteristics

Low-flow characteristics provide an indication of the severity and probability of drought conditions that can be expected for a stream. Independent determination of low-flow characteristics requires a long-term streamflow record, usually a minimum of 10 years. Carpenter (1983) determined equations that can be used to estimate low-flow characteristics for most ungaged streams in Maryland, but was not able to determine suitable equations for southern Maryland. However, one of the streams measured and evaluated during his study was Zekiah Swamp Run near Malcolm (station 01660905), which is site 1 at Route 382. Results of his analysis indicate that a flow of less than 0.5 ft^3/s can be expected over a period of 7 consecutive days on the average once every 2 years, and that no flow for 7 consecutive days can be expected once every 10 years (Carpenter, 1983, p. 235).

Carpenter (1983) presents equations that can be used to estimate flood-peak flows for recurrence intervals ranging from 2 to 100 years. For the southern region of Maryland, which includes Zekiah Swamp, flood flows are estimated from drainage area alone. Standard errors of estimate for the estimating equations range from -39 and +65 percent for the 2-year flood flow to -54 and +117 for the 100-year flood flow. Table 2 presents estimates of peak discharge for the three stream-gage sites on Zekiah Swamp Run at Routes

382, 5, and 6. The highest peak recorded during this study, 1,740 ft^3/s, occurred on March 29, 1984, at site 10 at Route 6 (Zekiah Swamp Run near Newtown, station 01660920). Comparison with table 2 shows that this peak had a recurrence interval between 2 and 5 years.

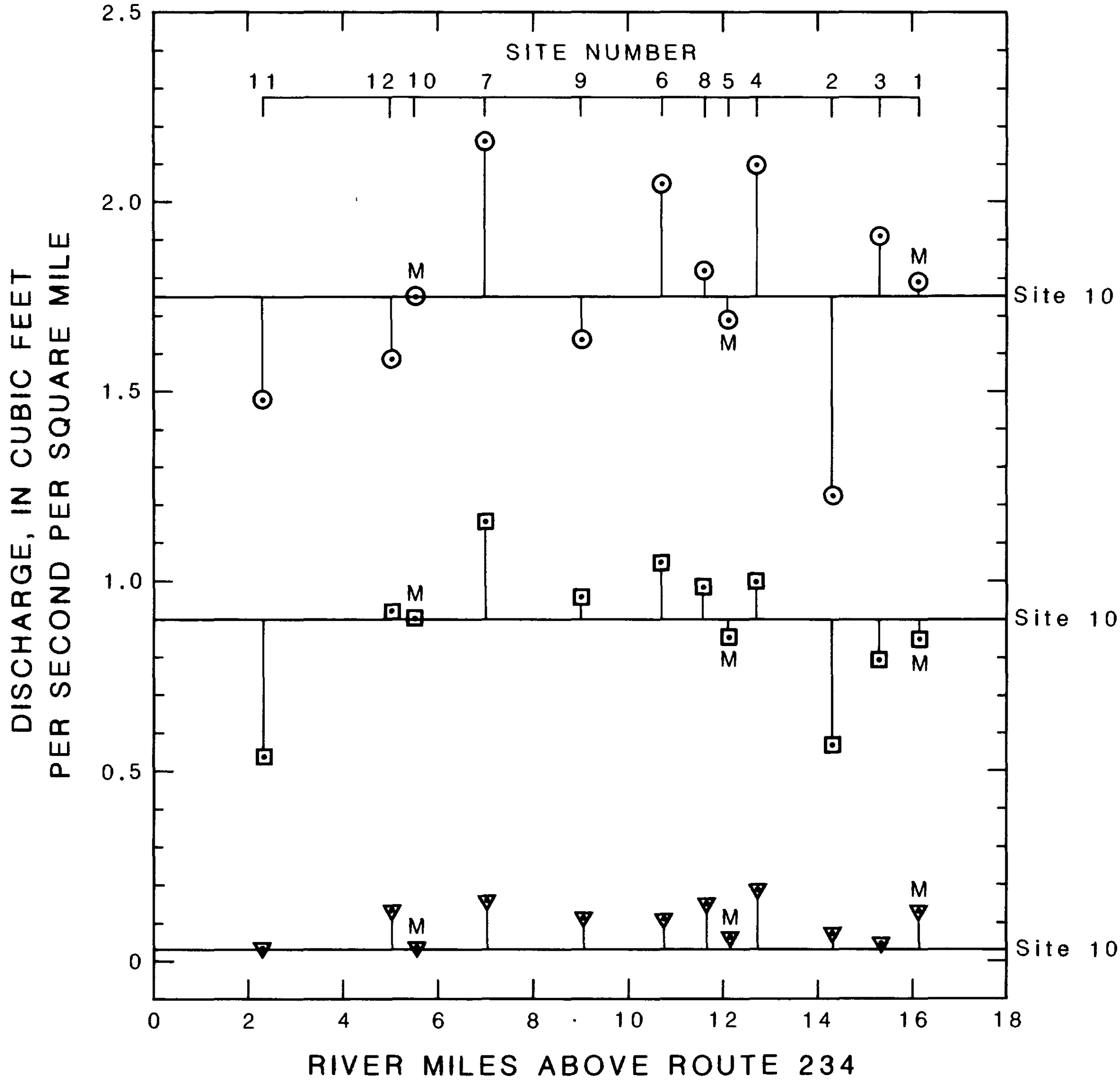
Table 2.--Estimates of peak discharge of Zekiah Swamp Run at Routes 382, 5, and 6

Recurrence interval (years)	Peak discharge, in cubic feet per second 1/		
	Site 1 Route 382	Site 5 Route 5	Site 10 Route 6
2	294	639	1,050
5	595	1,290	2,110
10	907	1,960	3,200
25	1,470	3,180	5,180
50	2,070	4,460	7,260
100	2,850	6,130	9,960

1/ Estimated using equations from Carpenter (1983).

Synoptic Base-Flow Surveys

Three synoptic surveys were made of base flow at 12 stream sites in the Zekiah Swamp Run basin. Stream discharge, pH, specific conductance, dissolved oxygen, and water temperature were measured at three sites on Zekiah Swamp Run (sites 1, 5, and 10) and at sites on nine tributaries where they enter the Zekiah Swamp Run valley. (See locations on pl. 1.) Measurements for each survey were made during a 1- or 2-day period to define conditions at approximately the same time. Results of the surveys are given in table 3. No precipitation occurred at the La Plata, Md., weather station for 3 days before May 12, 1983, 13 days before July 20, 1983, and 6 days before April 12, 1984. The measurements are presumed to be base flow unaffected by overland runoff, although the non-rain period before the May 1983 survey is short and minor effects are possible.



EXPLANATION

⊙ April 12 and 13, 1984

▼ July 20, 1983

⊡ May 12 and 13, 1983

M Main-stem site

Figure 13.-- Discharge per square mile at synoptic survey sites and relation to that at gaging station on Zekiah Swamp Run at Route 6 (site 10).

Table 3.--Results of synoptic base-flow surveys, Zekiah Swamp Run and tributaries

River mile above Route 234	Site No.	Stream	Drainage area (mi^2)	May 12 and 13, 1983 Discharge (ft^3/s)	Discharge per square mile [$(ft^3/s)/mi^2$]	Water temperature (°C)	Conductivity (microsiemens)
16.1	1	Zekiah Swamp Run	12.2	10.2	0.84	-	60
15.3	3	Devils Nest Run	3.95	3.12	.79	-	60
14.3	2	Jordan Swamp Run	10.4	5.90	.57	13.0	98
12.5	4	Mill Dam Run	4.90	4.85	.99	-	82
12.1	5	Zekiah Swamp Run	38.4	32.7	.85	-	78
11.6	8	Unnamed	3.21	3.13	.98	15.0	60
10.7	6	Piney Branch	7.12	7.41	1.04	-	80
9.0	9	Unnamed	2.68	2.56	.96	14.0	60
7.0	7	Kerrick Swamp Run	12.8	14.7	1.15	13.0	60
5.5	10	Zekiah Swamp Run	79.9	72.8	.91	-	65
5.0	12	James Run	.76	.70	.92	14.0	70
2.3	11	Clark Run	11.2	6.00	.53	14.0	70

1/ Estimated; too shallow to measure with a current meter.

Each synoptic survey gives a picture of conditions at a particular time (approximately) and shows how conditions vary areally. Comparison of one survey with another shows how conditions change from one time to another. Variations in discharge per square mile of drainage area at the survey sites are shown in figure 13. Figure 14 shows variations in specific conductance of the water. The figures also relate conditions at the various sites to conditions at the continuous-record gaging station on Zekiah Swamp Run at Route 6 (site 10).

Most obvious in figure 13 is the difference in base flow (shown as discharge per square mile) from one survey to another. Antecedent evapotranspiration and precipitation are the primary causes of these differences. High

July 20, 1983						April 12 and 13, 1984					
Discharge (ft^3/s)	Discharge per square mile [$(ft^3/s)/mi^2$]	Water temperature (°C)	pH	Conductivity (microsiemens)	Dissolved oxygen (mg/L)	Discharge (ft^3/s)	Discharge per square mile [$(ft^3/s)/mi^2$]	Water temperature (°C)	pH	Conductivity (microsiemens)	Dissolved oxygen (mg/L)
1.62	0.13	24.5	5.7	65	8.2	21.7	1.78	11.0	6.2	47	10.2
.17	.04	24.0	6.4	78	8.0	7.54	1.91	13.0	5.5	74	8.5
.74	.07	25.0	-	150	7.0	12.7	1.22	10.5	6.2	93	11.0
.87	.18	23.0	8.7	100	6.6	10.2	2.08	13.0	6.6	87	10.0
2.23	.06	25.0	6.5	95	6.6	64.6	1.68	10.5	6.4	88	7.8
.45	.14	25.0	6.8	115	8.4	5.83	1.82	14.5	7.1	90	12.2
.78	.11	23.0	6.8	95	8.3	14.5	2.04	13.0	6.5	86	11.5
1/ .30	-	-	-	-	-	4.37	1.63	12.0	6.6	87	-
1.97	.15	23.5	6.2	73	7.5	27.6	2.16	13.5	6.2	63	10.0
2.35	.03	24.0	6.3	95	6.5	141	1.76	16.0	6.9	71	-
1/ .01	-	-	-	-	-	1.21	1.59	14.0	7.3	67	9.4
.30	.03	23.5	6.4	70	7.4	16.6	1.48	14.0	6.9	74	14.2

precipitation in late March 1984 resulted in high base flow during the April 1984 survey. The low base flow during the July 1983 survey is a cumulative result of several months of high evapotranspiration coupled with a fairly long period (13 days) of no precipitation before the survey. High consumption of water by evapotranspiration had lowered ground-water levels below the stream level (figs. 6 and 7) and the stream was losing water to the ground-water system. Downstream increases in discharge between main stem sites (sites 1, 5, and 10) were only a fraction of the measured tributary inflows (table 3). These measurements indicate significant loss of streamflow between sites 1 and 10 during the July 1983 survey. Presumably a similar loss continues between site 10 and Route 234.

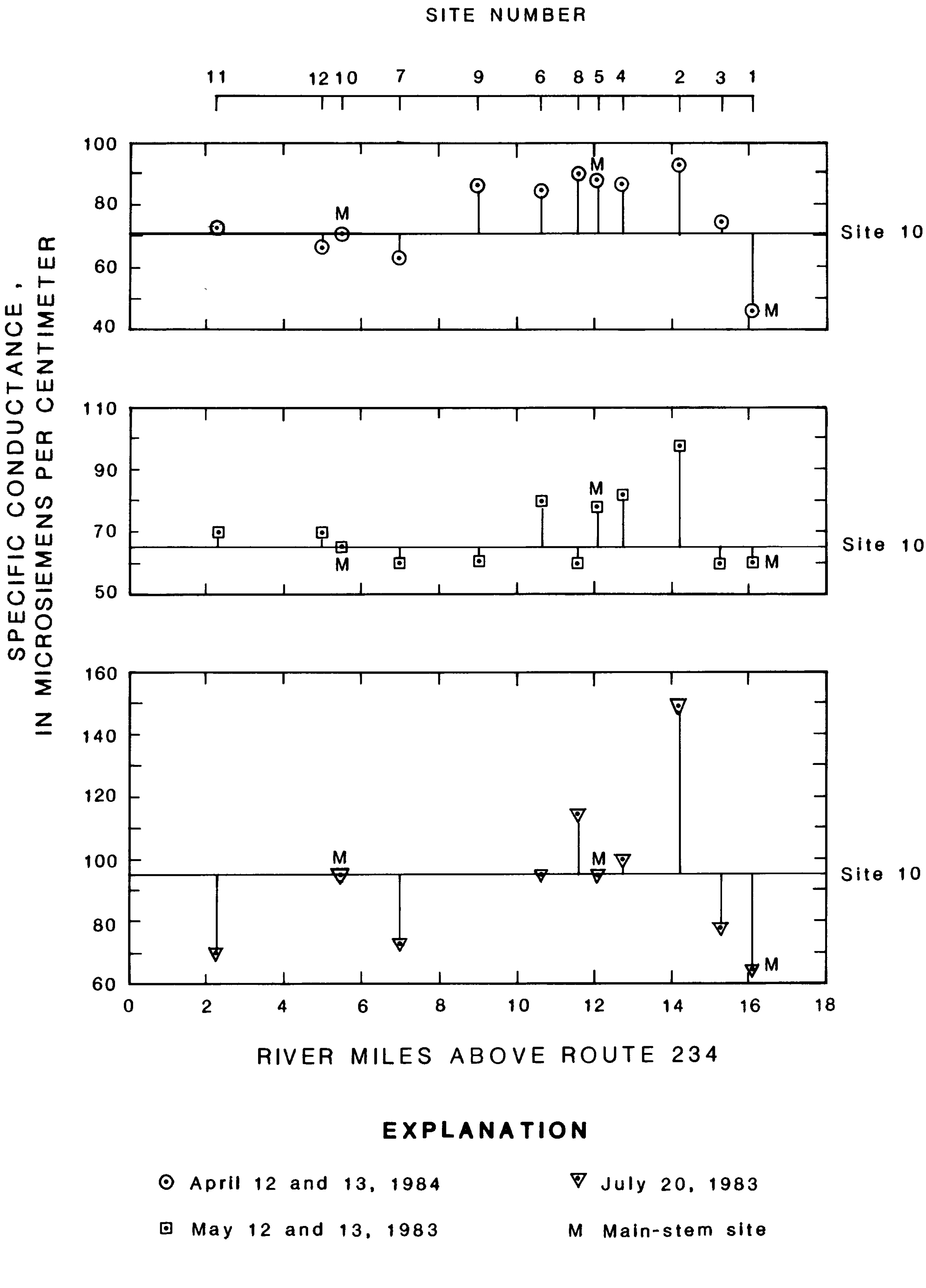


Figure 14.-- Specific conductance of streamflow at synoptic survey sites and relation to that at gaging station on Zekiah Swamp Run at Route 6 (site 10).

Clark Run (site 11) and Jordan Swamp Run (site 2), which drain most of the La Plata and Waldorf-St. Charles areas, respectively, had the lowest discharge per square mile of all sites during the May 1983 and April 1984 surveys (fig. 13). These lower base flows may be related to the relatively concentrated residential and commercial land uses in these basins. Reduction in recharge area as a result of development, or drainage of ground water by sewers could result in reduced base flow. Causes were not investigated, however, and many other possibilities exist, including local diversion of streamflow for irrigation, storage in ponds, or some natural variation.

Specific conductance of water in Jordan Swamp Run (site 2) was the highest measured during all three surveys (fig. 14). However, the highest measurement, 150 μS/cm (microseimens per centimeter, formerly micromhos per centimeter), is not very high and indicates a total dissolved solids of only about 100 mg/L (milligrams per liter). The higher conductivity at site 2 may be related to some local aspect of development in the Waldorf-St. Charles area, but water from Clark Run (site 11), which drains the La Plata area, an area of similar land use, had lower conductivity than most sites.

INFLOW AND OUTFLOW QUANTITIES

One of the purposes of the study was to obtain rough estimates of quantities of water inflow and outflow in the Zekiah Swamp Run basin. Inflow and outflow for the basin above the gaging station at Route 6 are given in table 4. Precipitation for the 1984 water year (table 4) is about 8 in. greater than the 1951-80 normal (42.62 in.) and free-water-surface evaporation (assumed to equal evapotranspiration) is about 6 in. less than the 1956-70 average (39 in.) mapped by Farnsworth and others (1982, map 3). Streamflow at Route 6 during the 1984 water year was probably about 4 in. greater than long-term average based on comparison to the 16-year record of a nearby stream, St. Clements Creek near Clements, Md. (station 01661050, 15.5 mi southeast of the Route 6 gage).

The synoptic base-flow surveys provide measurements of streamflow in and out of that part of the valley of Zekiah Swamp Run between Routes 5 and 6. This area is mostly swamp and conditions here are typical of conditions in Zekiah Swamp. A streamflow budget of this area, table 5, shows a gain of about 6 ft^3/s for the April 1984 survey and a loss of almost 5 ft^3/s for the July 1983 survey. These figures illustrate the large seasonal difference in streamflow conditions that occur in Zekiah Swamp.

A water-budget analysis for the same area for each of the synoptic surveys is given in table 6. Evapotranspiration is the major discharge during the July survey, as expected. Evapotranspiration is also significant, however, even in the April survey where it still represents about 10 percent of the flow. Reduction in storage (soil moisture and ground water) and underflow through the Calvert Formation along the valley walls are not estimated independently, but the sum of these elements is calculated by balancing the budget. This sum is significant for all surveys and is the major source of water during the July survey. Reduction in storage is probably a substantial part of this sum particularly during the July survey.

Table 4.-- Inflow and outflow quantities, Zekiah Swamp Run basin above Route 6 (site 10), 1984 water year

[Quantities in inches per year.
Does not include deep, confined ground water. 1/]

Inflow	
Streams	0
Precipitation 2/	50.21
Ground-water underflow (water table) 3/	Negligible
Diversions 4/	Unknown
Outflow	
Streams (Zekiah Swamp Run at Route 6)	20.10
Evapotranspiration 5/	33
Ground-water underflow (water table) 6/	.1
Pumpage of ground water (water table) 7/	Negligible
Diversions 4/	Unknown
Change in storage	
Surface water	Negligible
Ground water (water table) and soil moisture 8/	Probably small reduction

1/ Underflow into the deep confined aquifers approximately equals underflow out plus pumpage and change in aquifer and confining-unit storage. For this analysis, interflow between the deep, confined aquifers and the shallow water-table aquifers is assumed to be negligible.

2/ Precipitation for 1984 water year at La Plata, Md.

3/ The surface-water divide, basin boundary, approximately coincides with the water-table divide and flow across the basin boundary is assumed to be negligible except for outflow through the alluvium of Zekiah Swamp Run at Route 6.

4/ Quantities of water diverted from outside the basin or from deep aquifers to the shallow system are unknown, as are diversions exporting water from the basin. Public-supply distribution systems and waste-water disposal systems possibly divert significant quantities of water into or out of the basin.

5/ Based on pan evaporation measured at Upper Marlboro, Md., and on maps 2, 3, and 4 of Farnsworth and others (1982). May-October pan evaporation for the 1984 water year times a factor (map 4) to convert pan evaporation to free-water-surface evaporation times the ratio of annual (map 3) to May-October (map 2) free-water-surface evaporation equals annual free-water-surface evaporation for the 1984 water year [30.34 in. X 0.77 (factor) X 1.4 (ratio) = 33 in/yr]. For the purposes of this analysis, this method is assumed to relate measured pan evaporation to evapotranspiration; however, this determination has many potential sources of error and is given only as a best available estimate. (The National Weather Service station at Upper Marlboro is located in Prince Georges County about 23 mi northeast of La Plata and 10 mi north of the Zekiah Swamp Run basin boundary.)

6/ Underflow through the alluvium of Zekiah Swamp Run at Route 6 was estimated using Darcy's Law--discharge equals permeability times the hydraulic gradient times the cross-sectional area. At Route 6, the width of the alluvial fill is about 0.8 mi, the average saturated thickness is about 12 ft, and the gradient is about 14 ft/mi (assumed parallel to gradient of streambed and base of alluvium shown in figure 4). Using these estimates, the under-flow in the alluvium at Route 6 is (1) 0.06 ft^3/s, 0.01 in/yr, if the average permeability of the alluvium is 40 ft/d (permeability of a moderately permeable sand), or (2) 0.6 ft^3/s, 0.1 in/yr, if the permeability is 400 ft/d (permeability of a moderately permeable gravel). The larger figure is probably more nearly correct, but the actual average permeability is not known.

7/ Assumes that most pumpage from the water-table aquifer is returned through septic systems and that the net loss of water is negligible.

8/ Water levels in the test wells averaged about the same at the end of the 1984 water year as at the beginning. September 1984, however, was very dry (1.90 in. less precipitation than normal) compared to September 1983 (0.16 in. less than normal), and soil-moisture storage at the end of the year was probably less than at the beginning. A small net reduction in soil-moisture and ground-water (water table) storage is likely.

Table 5.--Streamflow budget of Zekiah Swamp Run valley between Routes 5 (site 5) and 6 (site 10) during synoptic surveys

	Site No.	Drainage area (mi^2)	Discharge, in cubic feet per second		
			May 12, 13, 1983	July 20, 1983	April 12, 13, 1984
Streamflow in					
	5	38.4	32.7	2.23	64.6
	8	3.21	3.13	.45	5.83
	6	7.12	7.41	.78	14.5
	9	2.68	2.56	.30	4.37
	7	12.8	14.7	1.97	27.6
	ungaged 1/	10.6	10.3	1.35	18.4
Total		74.8	70.8	7.08	135
Streamflow out					
	10	79.9	72.8	2.35	141
Difference					
Increase		5.1	2.0		6
Decrease				4.73	

1/ Ungaged areas tributary to 5.1 mi^2 valley floor between Routes 5 and 6. Discharge per square mile is assumed to equal the average for areas above sites 8 and 9, which are similar to the ungaged areas.

Table 6.--Water-budget analysis of Zekiah Swamp Run valley between Routes 5 (site 5) and 6 (site 10) during synoptic surveys

	Inches of water per day 1/		
	May 12, 13, 1983	July 20, 1983	April 12, 13, 1984
Source			
Streamflow in (table 5)	0.52	0.05	0.99
Precipitation	0	0	0
Ground-water underflow in alluvium at Route 5 2/	.004	.004	.004
Reduction in soil-moisture and ground-water storage plus underflow through Calvert Formation (calculated to balance budget) 3/	.19	.21	.16
Total	0.71	0.26	1.15
Sink			
Streamflow out (table 5)	0.53	0.02	1.03
Evapotranspiration 3/	.18	.24	.12
Ground-water underflow in alluvium at Route 6 2/	.004	.004	.004
Total	0.71	.26	1.15

1/ 1 in/d = 26.89 $(ft^3/s)/mi^2$ = 137.1 ft^3/s for 5.1 mi^2 budget area.

2/ Underflow at Route 5 is probably slightly less than at Route 6, and, at both stations, is moderately less in July than in April or May because the saturated thickness is less. These differences, however, are less than other potential errors in the estimate, and the figure equivalent to that used in table 4 is used in all cases. See table 4, footnote 6 for rationale of the estimate.

3/ Based on 3-day average pan evaporation at Upper Marlboro, Md., for May 11-13, 1983 (0.237 in/d), July 18-20, 1983 (0.31 in/d), and April 11-13, 1984 (0.157 in/d), times a factor of 0.77. See table 4, footnote 5 for explanation of the factor.

CONSIDERATIONS FOR SWAMP PRESERVATION

The ecosystem of Zekiah Swamp and the swamp itself are partly dependent on maintenance of adequate supply (level) and quality of water. Sensitivity to changes in supply and quality, and the range of tolerance are not part of this study, but some limits exist. The supply and quality of water are largely controlled by activities outside the swamp, in the tributary drainages. Because of this physical separation, the relation of such activities to the swamp may not always be apparent. Listed below are a few such activities and the type of potential effect:

Diversions (for example, sewers, septic systems, waste-disposal systems, public-supply distribution systems).--May increase or decrease water supply depending on the situation. May change water quality.

Surface-water storage.--Depending on management of the storage, may increase or decrease flows during dry periods. May also modify water quality.

Waste-disposal or storage.--Depending on situation, could affect water quality.

Land disturbance.--Depending on management, may affect water quality and sediment transport.

Change in land use.--Depending on type of change, may increase or decrease water supply, and may modify water quality.

Pumping from confined aquifers.--The downward head gradient between the water-table aquifer in Zekiah Swamp and the confined aquifers has increased, as discussed previously. This provides a potential for loss of water from the swamp, but the significance cannot be determined without head data for the confining unit separating the aquifers.

Continued monitoring of water levels and streamflow at Route 6 would provide minimum data on changes in the system and for identification of trends, if any exist. Periodic synoptic base-flow surveys similar to those done during this study would be useful in providing an areal appraisal of conditions. Collection of chemical quality of water data at Route 6 and during synoptic surveys would provide a minimum base for evaluating stream quality.

SUMMARY

Part of the precipitation in the Zekiah Swamp Run basin goes directly to streams, part is stored in the soil and is discharged to the atmosphere by evapotranspiration, and part percolates to the water table. Water from the water-table aquifer in the upland deposits seeps into streams, maintaining their flow through most dry periods. Except in the headwaters, the Zekiah Swamp Run valley is cut below the upland deposits and the alluvium in the valley forms a thin water-table aquifer, generally less than 20 ft thick.

During most of the year, the water table is above stream level and the aquifer contributes water to the stream. During the summer, however, high evapotranspiration sometimes lowers the water table below the stream level. Water then moves from the stream to the alluvium and, at times, some reaches of the stream become dry.

Most water in the deeper confined aquifers (Patuxent, Patapsco, Magothy, and Aquia) is derived from outside the basin and moves through the area as underflow. Discharge from these aquifers is mostly to wells outside or on the western margin of the Zekiah Swamp Run basin. Pumping from the confined aquifers has caused water levels in these units to decline. On the east side of the Zekiah Swamp Run valley, about 40 ft of decline in the Aquia aquifer and more than 60 ft of decline in the Magothy aquifer has been measured since about 1950. These declines have increased the downward gradient between the water-table aquifer in the swamp and the underlying confined aquifers.

Synoptic surveys of base flow at three sites on Zekiah Swamp Run and at sites on nine tributaries were made during May 1983, July 1983, and April 1984. The surveys show areal variations in discharge, pH, specific conductance, dissolved oxygen, and temperature. Comparison of one survey with another shows how conditions change from one time to another. High precipitation in late March 1984 resulted in high base flow during the April 1984 survey. High consumption of water by evapotranspiration for several months before the July 1983 survey had lowered ground-water levels below the stream level, and measurements indicate significant loss of streamflow.

Estimates of quantities of inflow and outflow of the Zekiah Swamp Run basin above Route 6 for the 1984 water year include: Precipitation, 50.21 in.; stream outflow, 20.10 in.; shallow ground-water underflow, 0.1 in.; and evapotranspiration, 33 in. A streamflow budget of a 5.1 mi^2 area of the valley of Zekiah Swamp Run between Routes 5 and 6, during the synoptic surveys, shows a gain of 6 ft^3/s during the April 1984 survey and a loss of almost 5 ft^3/s during the July 1983 survey.

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APPENDIX

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Table 7.--Miscellaneous staff-gage readings and corresponding discharges for Zekiah Swamp Run at Forest Road and Routes 382 and 5.

[Discharge from rating except those noted with an m, which are measured.]

Forest Road (site 13)			Route 382 (site 1)			Route 5 (site 5)		
Gage reading at zero flow = 3.50ft, altitude = 141.99ft			Gage reading at zero flow = 1.30ft, altitude = 120.12ft			Gage reading at zero flow = 1.75ft, altitude = 82.27ft		
Date	Staff gage reading(ft)	Discharge (ft^3/s)	Date	Staff gage reading(ft)	Discharge (ft^3/s)	Date	Staff gage reading(ft)	Discharge (ft^3/s)
12/ 7/83	4.20	9.9	5/12/83	2.12	10.2m	5/12/83	2.77	32.7m
12/15/83	4.39	16.3	6/13/83	2.00	7.99m	6/15/83	2.64	24.8m
12/29/83	4.56	23.3	7/12/83	1.65	2.52m	7/12/83	2.16	5.32m
1/25/84	4.16	8.7	7/20/83	1.57	1.62m	7/20/83	2.20	2.23m
2/ 7/84	4.08	7.02m	8/22/83	1.42	.30m	8/22/83	1.84	.14m
3/21/84	4.24	10.9m	9/16/83	1.51	1.12	9/16/83	2.14	5.21
4/12/84	4.15	8.4	10/ 4/83	1.52	1.33m	10/ 4/83	2.05	3.53m
5/ 3/84	4.07	6.75m	11/14/83	1.89	4.05m	11/14/83	2.52	19.4m
6/14/84	3.92	3/43	11/16/83	2.48	20.3	12/ 8/83	3.08	57.9
6/27/84	3.76	1.26m	12/ 8/83	2.37	16.8	12/12/83	3.06	51.2m
7/13/84	3.71	.82	12/12/83	2.77	29.8m	12/13/83	4.97	589m
8/15/84	3.72	.89m	12/13/83	4.39	203m	12/29/83	4.27	289
9/12/84	3.68	.59	12/29/83	3.08	44.2	1/25/84	3.15	65.2
10/10/84	3.70	.74	1/25/84	2.49	20.6	2/ 6/84	3.31	86.3m
11/ 1/84	3.74	1.03	2/ 6/84	2.47	20.6m	2/27/84	3.08	57.9
12/12/84	3.80	1.72	2/27/84	2.38	17.1	3//84	2.98	57.2m
			3//84	2.31	16.7m	4/11/84	3.25	76.5
			4/12/84	2.48	21.7m	4/13/84	3.17	64.6m
			5/ 3/84	2.35	18.3m	5/ 2/84	3.01	57.7m
			5/14/84	2.16	11.3	5/14/84	2.76	31.7
			6/27/84	1.74	3.79m	6/11/84	2.42	13.7
			7/12/84	1.76	3.75	6/27/84	2.30	11.8m
			8/ 9/84	1.64	2.29	7/12/84	2.40	12.9
			8/15/84	1.64	2.36m	8/ 9/84	2.27	8.53
			9/12/84	1.48	.85	8/15/84	2.28	11.1
			10/10/84	1.51	1.12	9/12/84	1.99	2.49
			11/ 1/84	1.66	2.51	10/10/84	2.10	4.39
			12/12/84	1.78	4.03	11/ 1/84	2.31	9.76
						12/12/84	2.40	12.9

Table 8.--Records of wells referred to in this report

Well No.	Permit No.	Owner or name	Driller	Year drilled	Depth of hole (feet)	Depth of well (feet)	Casing Diameter (inches)	Casing Depth (feet)	Screen Diameter (inches)	Screen Interval(s) (feet)
CH BF 128	CH-03-1306	So. Md. Novelty Co.	Patuxent Pump and Well	1958	430	430	4	420	2.5	420-430
144	CH-73-2423	Charles County	Layne Atlantic	1980	1976	700	12	479	12	479-700
146	CH-81-0593	Charles County	Sydnor	1983	1604	1427	6	1427	6	1059-1417
CH BG 12	CH-81-0600	USGS	Water Resources Administration	1983	41	24.5	4 2	13.5 24.5	2	13.5-18.5
13	CH-81 0601	USGS	Water Resources Administration	1983	30	22.6	4 2	12.6 22.6	2	12.6-17.6
CH CE 35	CH-65-W13	La Plata	Sydnor	1965	1250	1114	10 6	625 1058	6	1058-1114
37	CH-73-0219	USGS	Sydnor	1973	2014	1345	6 4	300 1345	4 4 4	1174-1184 1250-1260 1330-1340
47	CH-73-0727	Del Rosario, David	Estes, R. O.	1975	440	378	4 2.5	358 361	2.5	361-378
CH CF 33	CH-81-0602	USGS	Water Resources Administration	1983	30	22.2	4 2	14.7 22.2	2	14.7-19.7
28	CH-67-0066	T. C. Martin School	East Coast Well and Pump	1967	661	613	6	593	6	593-613
CH CG 18	CH-73-0560	USGS	Kauffman, E. R.	1974	1030	709	4	699	2	699-709
21	CH-73-0886	Savoy, Walter	Wooster, L. D.	1975	540	540	4 2	272 525	2	525-540
CH DE 33	CH-02-6769	Loyola Retreat	Washington Pump and Well	1957	694	694	6 4	564 688	4	687-694
CH DE 45	CH-81-0604	USGS	Water Resources Administration	1983	116	25.5	4 2	15.5 25.5	2	15.5-20.5
CH DF 13	CH-18660	Rybikowsky, J. A.	Shannahan Artesian Well Co.	1955	403	403	4 2	300 388	2	388-403
CH EE 90	CH-81-0606	USGS	Water Resources Administration	1983	31	21	4 2	11 21	2	11-16

Table 8.--Records of wells referred to in this report--Continued

Aquifer	Land-surface altitude (feet above sea level)	Water level (feet below land surface) Static	Date	Pumping	Date	Yield test Rate (gal/min)	Date	Hours pumped	Specific capacity [(gal/min)/ft]	Use of water or well	Well No.
Magothy	210	170	7/7/58	205	7/7/58	25	7/7/58	6	0.7	Observation	CH BF 128
Magothy and Patapsco	202.29	203	2/1/80	241	2/1/80	520	2/1/80	12	13.7	Public supply	144
Patapsco	192.74	200.5	12/21/83	247.2	12/22/83	164	12/21/83	24	3.5	Observation	146
Alluvium and Calvert	149.69	8.09	8/24/83	-	-	-	-	-	-	Observation	CH BG 12
Alluvium and Calvert	126.27	7.07	8/24/83	-	-	-	-	-	-	Observation	13
Patapsco	165	165	2/65	440	2/65	240	2/65	37	.9	Public supply	CH CE 35
Patapsco	184.95	189.35	11/12/73	216.99	11/12/73	120	11/12/73	24	4.3	Observation	37
Aquia	156	148	5/10/75	193	5/10/75	20	5/10/75	12	4.4	Domestic	47
Alluvium	89.88	7.96	8/25/83	-	-	-	-	-	-	Observation	CH CF 33
Magothy	190	150	4/20/67	300	4/20/67	30	4/20/67	8	.2	Institution	28
Magothy	153.71	152	11/5/74	200	11/5/74	30	11/5/74	14	.6	Destroyed	CH CG 18
Aquia	180	170	10/31/75	210	10/31/75	20	10/31/75	3	.5	Domestic	21
Patapsco	100	104	6/27/57	300	6/27/57	10	6/27/57	12	5.1	Observation	CH DD 33
Alluvium	44.77	10.51	8/23/83	-	-	-	-	-	-	Observation	CH DE 45
Aquia	145	131	5/26/55	165	5/26/55	10	5/26/55	10	.3	Domestic	CH DF 13
Alluvium	6.81	6.09	8/23/83	-	-	-	-	-	-	Observation	CH EE 90

Table 9.--Logs of test wells, Zekiah Swamp Run valley

[Geologists field logs of test wells by H. T. Hopkins. (Approximate tops of geologic units by L. J. McGreevy.)]

Description	Depth interval (feet)
CH BG 12, Completed August 24, 1983	
(Alluvium)	
Soil	0-1
Sand and gravel, silty, tan, dry	1-2.5
Gravel, silt, and trace of fine to medium sand, tan	2.5-3.5
Sand, medium to coarse, silty, tan, moist (not saturated)	3.5-5
Clay, silty and sandy, brown, moist	5-6.5
Sand, fine to very fine, silty; color change back to tan from brown; more moist than above	at 8
(Calvert Formation at 9 ft)	
Core number 1, 7 blows:	
Sand, fine to very fine, silty, gray-green, moist (no free water)	9-10
Core number 2, 12 blows:	
Clay, gray, plastic, with sand dikes, moist	15-15.5
Sand, fine to very fine, gray-green moist	15.5-16
Core number 3, 11 blows:	
Silt with some fine to very fine sand and shells, gray-green, moist	20-21
Core number 4, 14 blows:	
As above but tighter, more silty and clayey, same color	25-26
Core number 5, same as above	40-41
CH BG 13, Completed August 24, 1983	
(Alluvium)	
Soil and fill, reddish-brown sand, silt, and gravel	0-1
Silt, sandy, fine to very fine, reddish brown	2-3.5
Silt with fine to medium sand, gray, green, slightly moist	3.5-5.5
Core number 1, 23 blows: No recovery	4-5
Clay, sandy, gray-brown, plastic, moist, saturated at about 7 feet	5.5-8.5
Sand, coarse, with gravel, gray	8.5-12
Core number 2:	
Sand, coarse, with gravel, gray	9-10

Table 9.--Logs of test wells--Continued

Description	Depth interval (feet)
CH BG 13--Continued	
(Calvert Formation at 12 ft)	
Silt, tight, with mica, green (change)	at 12
Core number 3:	
Silt, tight, with mica, green moist (no free water)	14-15
Core number 4, 20 blows:	
Sand, fine to very fine, and silt, with mica, green, no shells	29-30
CH CF 33, Completed August 25, 1983	
(Alluvium)	
Soil, sand	0-2
Gravel and brown silty sand (may be fill)	2-3.5
Clay, sandy, silty, orange and reddish brown; clay is mottled white, tan, and orange and is moist	3.5-5
Sand, fine to very fine, silty, with some clay, orange and reddish brown; more moist than above	5-7
Sand, coarse, some medium and fine sand, and trace of silt; layer of gravel at 8 feet; saturated	7-8.5
Core number 1, 14 blows:	
Gravel and coarse to medium sand; some silt and gray clay	9-10
Core number 2, 32 blows:	
Gravel and coarse sand, very light gray; extended below core to about 18.5 feet	14-15
(Calvert Formation at 18.5 ft)	
Core number 3, 29 blows:	
Sand, fine to very fine, green	18.5-19.5
Core number 4, 121 blows:	
Silt, gray-green	29-30
CH DE 45, Completed August 17, 1983	
(Alluvium)	
Sand, silty, trace of clay and gravel, brown, moist	0-3.5
Sand, silty, trace of clay, brown, moist	3.5-5
Core number 1, 4 blows/ft:	
No recovery; lower part of core barrel moist	5-6.5

Table 9.--Logs of test wells--Continued

Description	Depth interval (feet)
CH DE 45--Continued	
Clay, silty, trace of medium to coarse sand, brown; becoming more moist, not saturated	5-9.5
Core number 2, 36 blows/ft	
No recovery; core barrel wet; water table between 9-11 ft.	9.5-11
Clay, silty, trace of medium to coarse sand and gravel; saturated	11-14
Sand, medium, and gravel, white, trace of coarse sand, silt, and clay; clean quartz sand and gravel; saturated	14-15
Core number 3, 25 blows/ft:	
Sand, medium, and gravel, white, trace of coarse sand, silt, and clay; clean quartz sand; saturated	15.5-17
Sand, medium, and gravel, white, trace of coarse sand, silt, and clay; clean quartz sand; saturated	17-19
(Nanjemoy Formation at 19 ft)	
Sand, fine, silty, glauconitic, trace of shell fragments, green, tight, moist (no free water)	19-21
Core number 4, 19 blows/ft:	
Sand, silty, glauconitic, shell fragments, green, trace of mica, tight, moist (no free water)	20-21
Sand, silty, glauconitic, shell fragments, green, trace of mica, tight, moist (no free water)	21-25
Core number 5, 25 blows/ft:	
Sand, silty, some clay and shell fragments, glauconitic, trace of mica, dark-green, tight, moist (no free water)	25-26
Core number 6, 22 blows/ft:	
Sand, silty, some clay and shell fragments, glauconitic, trace of mica, dark-green, tight, moist (no free water)	30-31
Core number 7, 27 blows/ft:	
Sand, silty, some clay and shell fragments, glauconitic, trace of mica, dark-green, tight, moist (no free water)	35-36
Core number 8, 27 blows/ft:	
Sand, fine, silty, with glauconite, mica, trace of shells, layered (bedded), dark green, tight, moist (no free water)	40-41
Core number 9, 29 blows/ft:	
Sand, fine, silty, glauconitic, trace of medium sand, mica, and clay, layered (bedded), dark green; firmer than above, moist (no free water)	45-46

Table 9.--Logs of test wells--Continued

Description	Depth interval (feet)
CH DE 45--Continued	
Core number 10, 42 blows/ft:	
Sand, fine, silty, with clay and shells, glauconitic, layered (bedded), dark green, firm, moist (no free water)	50-51
Core number 11, 39 blows/ft:	
Sand, fine, silty, with clay and shells, glauconitic, layered (bedded) dark green, firm, moist (no free water)	55-56
Core number 12, 39 blows/ft:	
Sand, fine, silty, with clay and shells, glauconitic, layered (bedded) dark green, firm, moist (no free water)	60-61
Core number 13, 38 blows/ft:	
Sand, fine to very fine, silty, clayey, glauconitic, some mica, bedded, dark green; firmer than numbers 11 and 12 above, moist (no free water)	65-66
Core number 14, 40 blows/ft:	
Silt and fine to very fine sand, glauconitic, with mica and shells, bedded, dark green; slightly more moist than number 13 above	70-71
Core number 15:	
Sand, fine to very fine, silt and clay, glauconitic with mica, layered (bedded), dark green; fewer shells than in number 14 above, moist (no free water)	75-76
Core number 16:	
Sand, fine to very fine, silty, clayey, with glauconite and mica, green; no shells, tight, moist (no free water)	85-86
(Water level 10:15 a.m., August 17, 1983, measured inside hollow stem auger, 10.37 ft below land surface. Auger stem at 85 ft.)	
Core number 17, 39 blows/ft:	
Sand, fine to very fine, silty and clayey, glauconitic, thin streaks of black sand and shells, dark green; tight, moist (no free water)	95-96
Core number 18, 38 blows/ft:	
Same as number 17 above with color change from dark to light green	105-106
Core number 19, 36 blows/ft:	
Same as number 18 above (light green)	115-116

Table 9.--Logs of test wells--Continued

Description	Depth interval (feet)
CH EE 90, Completed August 23, 1983	
(Alluvium)	
Soil, dark gray to black	0-2
Clay, silty and coarse gravel	2-2.5
Sand, silty, brown, and gravel, moist at 4 ft; water table below 5.5 ft.	2.5-5.5
Sand, silty and clayey, tan (cream color), saturated; water table at about 6 ft.	5.5-11.5
Core number 1, 15 blows:	
Top half of core--sandy clay, green, with some medium sand, silty, brown. Lower half of core--silt with fine sand and mica, dark green, moist (no free water)	15-16
(Nanjemoy Formation at 15.5 ft)	
Core number 2:	
Silt, sandy, with shells and mica, dark green, moist (no free water)	20-21
Core number 3:	
Silt, sandy, with shells and mica, dark green, moist (no free water)	30-31

Table 10.--Logs of highway borings, Zekiah Swamp Run valley

[Logs of highway borings by State Road Commission. (Approximate tops of geologic units by L. J. McGreevy.)]

Description	Depth interval (feet)
Route 5 steel beam bridge (number 8002), Zekiah Swamp Run	
West end, station 305+01, streambed altitude 81.2 ft	
Water	0-4
(Alluvium)	
Silt, gray; 1 blow/ft	4-6
Sand, medium to coarse, and gravel, gray; 23 blows/ft	6-13
(Calvert Formation)	
Silt, green; 22 to 35 blows/ft	13-25
Silt, green; 13 to 27 blows/ft	25-39.4
Silt, sandy, fine, green; 24 to 27 blows/ft except 45 blows/ft at bottom (May be into top of Nanjemoy Formation)	39.4-55
East end, station 305+97, streambed altitude 80.2 ft	
Water	0-5
(Alluvium)	
Sand, fine, and gravel, silty, gray; 23 to 32 blows/ft	5-11
(Calvert Formation)	
Silt, green; 29 to 37 blows/ft	11-37
Silt, sandy, fine, green; 22 to 32 blows/ft except 52 blows/ft at bottom (May be into top of Nanjemoy Formation)	37-55

Table 10.--Logs of highway borings--Continued

Description	Depth interval (feet)
Route 5 steel beam bridge (number 8003), Zekiah Swamp Run	
East end, station 310+61, streambed altitude 82.2 ft	
Water	0-3
(Alluvium)	
Silt, green; 3 blows/ft	3-6.5
Sand, coarse, and gravel, green; 28 blows/ft	6.5-8.5
(Calvert Formation)	
Silt, green; 24 to 38 blows/ft	8.5-43
Sand, medium, and gravel, green; 30 blows/ft	43-45.5
Silt, green; 21 blows/ft	45.5-52
Sand, coarse, and gravel, green; 30 blows/ft	52-54
(Nanjemoy Formation?)	
Silt, sandy, fine, with traces of shells, green; 48 to 52 blows/ft	54-60
Route 6 steel beam bridge (number 8007), Zekiah Swamp Run	
West end, station 200+02, surface altitude 37.5 ft	
(Alluvium)	
Silt, sandy, with organic material, brown; 3 blows/ft	0-3.5
Sand, medium, with medium gravel, light brown; 10 to 24 blows/ft	3.5-12.5
(Nanjemoy Formation)	
Silt, gray, organic; 31 to 33 blows/ft	12.5-20
Silt, sandy, black, organic; 37 blows/ft	20-25
Silt, black, organic; 41 blows/ft	25-30
Station 200+64, streambed altitude 33.9 ft	
Water	0-4
(Alluvium)	
Sand, coarse, with medium gravel, light brown; 18 to 27 blows/ft	4-12
(Nanjemoy Formation)	
Silt with shells, gray, slightly organic; 31 to 38 blows/ft	12-30

Table 10.--Logs of highway borings--Continued

Description	Depth interval (feet)
Station 201+28, surface altitude 36.7 ft	
(Alluvium)	
Silt, brown, organic; 2 blows/ft	0-3
Sand, medium, with medium gravel, brown; 12 to 20 blows/ft	3-11.5
(Nanjemoy Formation)	
Silt, gray, slightly organic; 37 to 38 blows/ft	11.5-20
Silt with shells, gray, slightly organic; 41 to 43 blows/ft	20-30
East end, station 201+89, surface altitude 36.8 ft	
(Alluvium)	
Sand, silty, with organic material, brown; 2 blows/ft	0-4
Organic material, black; 100 blows per 10 inches	4-5
Sand, silty, and medium gravel, brown; 12 blows/ft	5-12
(Nanjemoy Formation)	
Silt with shells, gray, slightly organic; 31 to 42 blows/ft	12-30
Route 6 arch bridge (number 8006), Zekiah Swamp Run	
West end, station 205+26, surface altitude 37.8 ft	
(Alluvium)	
Silt with organic material, brown; 3 blows/ft	0-3
Sand, medium, with medium gravel, brown; 17 to 23 blows/ft	3-13
(Nanjemoy Formation)	
Silt with shells, gray, slightly organic; 36 to 42 blows/ft	13-30
East end, station 205+86, surface altitude 37.9 ft	
(Alluvium)	
Silt with organic material, brown; 2 blows/ft	0-3.5
Sand, silty, with medium gravel, brown; 9 blows/ft	3.5-5
Sand, coarse, with medium gravel, light brown; 18 blows/ft	5-13
(Nanjemoy Formation)	
Silt with shells, gray, slightly organic; 38 to 52 blows/ft	13-30

Table 10.--Logs of highway borings--Continued

Description	Depth interval (feet)
Route 6 concrete slab bridge (number 8005), Zekiah Swamp Run	
West end, station 207+34, streambed altitude 36.4 ft	
Water	0-2
(Alluvium)	
Sand, medium, and silt, light brown; 23 to 29 blows/ft	2-12
(Nanjemoy Formation)	
Silt with shells, gray, slightly organic; 33 to 58 blows/ft	12-30
East end, station 207+56, surface altitude 38.3 ft	
(Alluvium)	
Sand, coarse and medium gravel, light brown; 2 blows/ft	0-2
Sand, medium, and silt, with medium gravel, light brown; 11 blows/ft	2-5
Sand, coarse, with medium gravel, light brown; 14 blows/ft	5-13
(Nanjemoy Formation)	
Silt, gray, organic; 22 blows/ft	13-15
Silt with shells, gray, slightly organic; 33 to 43 blows/ft	15-30
Route 234 concrete girder bridge (number 8036), Allens Fresh Run (East Bridge)	
East end, station 67+25, surface altitude 5.8 ft	
(Alluvium)	
Top soil and fill; 1 to 5 blows/ft	0-4.8
Sand and gravel; water; 3 to 8 blows/ft	4.8-6.3
Sand, clayey, gray; 4 to 8 blows/ft	6.3-9.3
Sand, silty; 3 to 39 blows/ft	9.3-17.8
Sand and gravel; 48 to 79 blows/ft	17.8-22.8
(Nanjemoy Formation)	
Sand, clayey, blue, tight; 43 to 216 blows/ft	22.8-27.8
Marl, blue	at 27.8

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WATER RESOURCES INVESTIGATION
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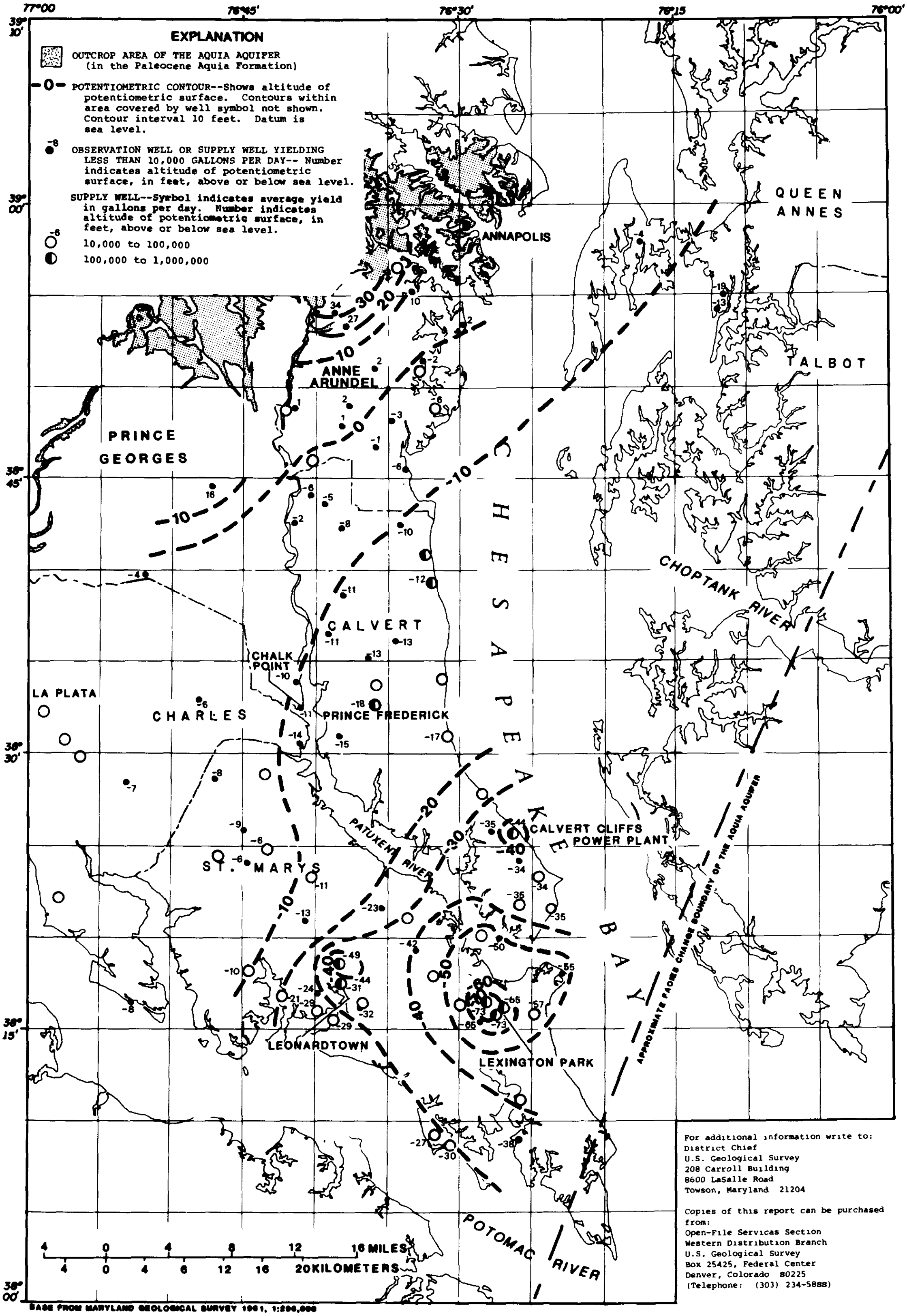

Figure 15. Preliminary map showing the potentiometric surface of the Aquia aquifer in southern Maryland, September 1984. (From Mack and others, 1985 a.)

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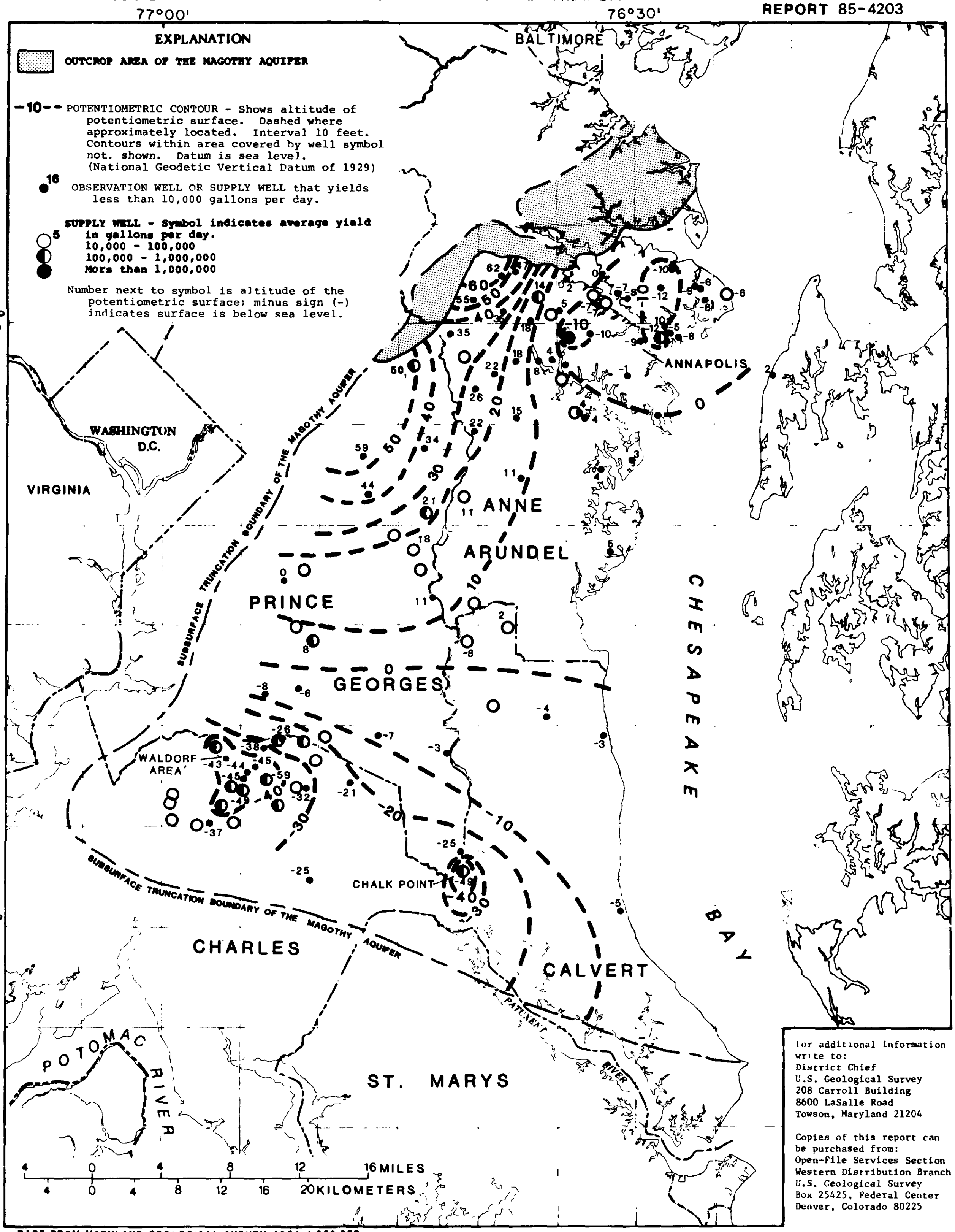

BASE FROM MARYLAND GEOLOGICAL SURVEY 1961, 1:250,000

Figure 16. The potentiometric surface of the Magothy aquifer in southern Maryland September 1984. (From Mack and others, 1985 b.)