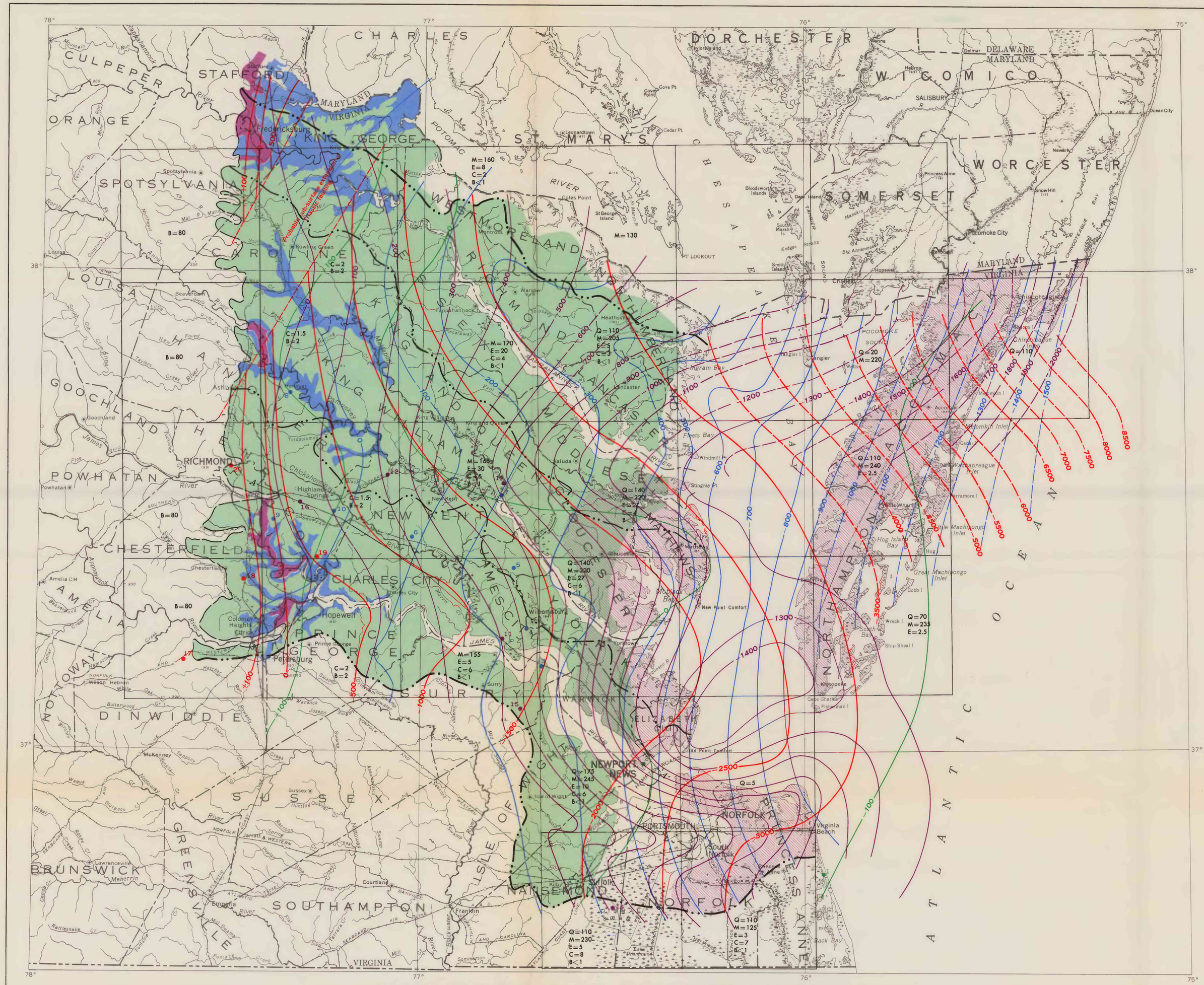
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

HYDROLOGIC INVESTIGATIONS
ATLAS HA-284 (SHEET 1 OF 2)



MAP SHOWING GEOLOGY AND GROUND-WATER AVAILABILITY

Base from U.S. Geological Survey 1:500,000, state bases:
Virginia 1961, Maryland and Delaware, 1959

EXPLANATION

AREA OF OUTCROP

Miocene formations — Eocene formations — Cretaceous formations

CONTOURS

Show altitude of top of the various formations and the basement rocks. Datum is mean sea level

Miocene formations — 100 — Contour interval, 100 feet

Eocene formations — 300 — Dashed where approximately located; contour interval, 100 feet

Cretaceous formations — 200 — Dashed where approximately located; contour interval, 100 feet

Basement rocks — 1000 — Dashed where approximately located; contour intervals, 100 and 500 feet

Quaternary . . . . . Q=140
Miocene . . . . . M=220
Eocene . . . . . E=27
Cretaceous . . . . . C=4
Basement rocks . B=1

Availability of ground water from aquifers within the 20-mile squares, shown on map, in million gallons per day

Area within Cretaceous aquifers where chloride concentration exceeds 250 parts per million

1 Miocene formations — 3 Eocene formations — 12 Cretaceous formations — 18 Basement rocks

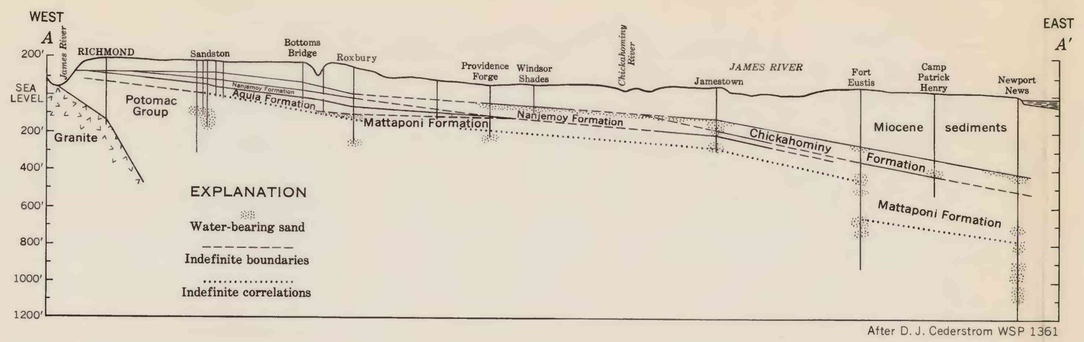
Well used for chemical analysis
Number refers to test. For analysis see sheet 2

Boundary of the lower Chesapeake Bay drainage basin in Virginia — Physiographic province boundary — River basin boundary

TABLE 1.—*Geologic units in the Coastal Plain province of Virginia and their water-bearing characteristics*

System	Series	Formation		Approximate thickness (feet) outcrop	Approximate thickness (feet) subsurface	Physical character	Hydrologic comments
Quaternary	Recent and Pleistocene			0 to 100	0	Unconsolidated gravels, sand, loam, partly of fluvial and partly of marine origin.	Good aquifers for domestic and small industrial supplies when sources are located some distance from surface saline waters.
Tertiary	Miocene	Chesapeake Group	Yorktown St. Marys Choptank Calvert	125 180 50 200	0 to 600+	Blue and gray sandy diatomaceous shales, shell marls, and minor amounts of sand.	In eastern peninsular area sands yield moderate supplies subject to salt-water encroachment when pumping is heavy near marine estuaries.
	Eocene	Chickahominy (subsurface)		–		Blue, gray, and brown pyritic and glauconitic clay.	Aquiclude
		Pamunkey Group	Nanjemoy	125	0 to 1,000	Gray marls and fine quartz and glauconitic sands.	Quartz and glauconitic sands furnish water to some screened wells.
			Aquia	100			
	Paleocene						
Cretaceous	Upper Cretaceous	Mattaponi (subsurface)		–	0 to 100+	Mottled clay, glauconitic sands and marls with thick quartz basal sand.	A very good water-bearing formation in central part of Coastal Plain. East of Williamsburg the formation yields brackish water.
	Lower Cretaceous	Potomac Group[1]	Patapsco	150	Up to 4,000	Lenticular sands and clays underlying the entire Coastal Plain of Virginia.	Some of the sands are excellent aquifers and furnish large supplies to wells. Down dip to the east these same deposits contain water too brackish for use.
			Patuxent	250–300			
Pre-Cretaceous		Basement complex				Large thick crystalline masses of granites, gneiss, schist and other metamorphic type rocks.	Good aquifers where overlain by permeable soils adjacent to the Fall Line, down dip water quality becomes poor.

[1]Not recognized in outcrop



After D. J. Cederstrom WSP 1361

INTRODUCTION

The information used in this report was compiled from a variety of sources. No new field studies were initiated, instead broad interpretations were made of existing information.

Officials of the Virginia Division of Mineral Resources, Virginia Division of Water Resources, and other State and local governmental offices kindly furnished unpublished information from their files for use in this study. Without the help and cooperation of these offices such a study would not be possible.

LOCATION AND EXTENT OF THE AREA

The area covered by this study is approximately 6,600 square miles or about 1/6 of the total area of the State. About 700 square miles of this is the so-called "Eastern Shore" of Virginia that is separated from the rest of the State by the lower reaches of the Chesapeake Bay. The remaining 5,900 square miles is the part of the James, York, and Rappahannock River basins east of the Fall Line.

PHYSIOGRAPHY

The terrane east of the Fall Line in Virginia has a total relief of about 200 feet from the exposed basement rocks along the Fall Line, to the water edge of the Atlantic Ocean. The flooding of estuaries to form Chesapeake Bay has resulted in a highly irregular coast line. Topographically the area is a series of relatively flat terraces that rise in steps toward the west.

GENERAL STRATIGRAPHY AND STRUCTURE

The Coastal Plain physiographic province is underlain by unconsolidated sediments of Cretaceous and younger age, (table 1). The generalized stratigraphic section shows the hydrologic characteristic of the included aquifers. These deposits, shown on the geologic section, generally dip to the southeast at a rate of 20 to 80 feet per mile in a gradually thickening wedge. The uppermost unit of the oldest Coastal Plain formation (Potomac Group) occurs as a thin veneer overlying the crystalline rocks of the Piedmont province. This unit, however, is buried hundreds of feet below the surface by younger deposits when followed down dip to the coast.

HYDROLOGY OF THE AREA

The total quantity of water available on the surface of the earth is virtually constant. The processes of the hydrologic cycle repeatedly purify, relocate, and in general make this same given quantity of water available for man's reuse. Excessive withdrawal, or other unwise uses of an aquifer, can result in encroachment of saline water. This causes a permanent irreversible damage that can render otherwise good water in the aquifer economically unsuited for a particular use.

An indication of the total water resources of any area is the average annual precipitation of the area. The supply of the perennially available water in the humid East is rapidly becoming a major limiting factor to the economic development of this region.

Yields of wells in the Coastal Plain area range from a few gallons a minute from small-diameter shallow domestic wells developed in thin sandy deposits to several hundred gallons a minute developed from large-diameter industrial and municipal wells drilled into aquifers tens and even hundreds of feet thick. Most ground water developed in the Coastal Plain has been from artesian aquifers. The effect of geology on the occurrence, movement, and quality of ground water is so complex that in most areas detailed hydrologic and geologic studies are necessary to assure the optimum development of the maximum amount of water.

Studies in the Coastal Plain area of New Jersey (Barksdale and others, 1958), where similar climatic, geologic, and hydrologic conditions exist, indicate that about 20 to 21 inches of the annual precipitation (approximately 43 inches) percolates into the ground to become ground water. At this rate of infiltration the Coastal Plain aquifers are recharged at an estimated rate of 1 mgd (million gallons per day) per square mile. The remaining part of the annual precipitation is lost from the area by overland runoff and evapotranspiration.

The storage capacity of an unconsolidated aquifer is controlled by the size and sorting of the mineral grains that compose the aquifer. In the Coastal Plain deposits the storage capacity ranges from 10 to 30 percent of the volume of the aquifer.

In the Coastal Plain aquifers another source of water that is sometimes available for limited development is the aquicludes (confining layers) above and below the artesian aquifers. When the hydrostatic pressure in an artesian aquifer is lowered by pumping, some water in the aquicludes is released into the aquifer.

If aquifers of the Coastal Plain are tapped and pumped in their down dip extension at a total rate that does not exceed the approximately 1 mgd per square mile that is believed available then the aquifers should show no evidence of depletion. Where adequate storage is available the daily continued yield of the aquifer may be more than 1 mgd per square mile of recharge area. However, if such an aquifer is pumped at a rate that exceeds the amount of water that is available by natural recharge plus the amount of water, if any, that is available through or from the confining aquicludes then the water must come from storage in the aquifer itself. When water is removed from storage within the aquifer it is in effect being mined. When aquifers are overpumped or if wells are not located wisely with reference to potential sources of saline contamination, a gradual deterioration of the aquifer can be expected. Water quality will deteriorate with the decline in water levels and eventually result in the destruction of the aquifer for future use.

AVAILABILITY OF GROUND WATER

The Coastal Plain aquifers of Virginia are estimated to be capable of receiving recharge at the above stated rate of about 1,000,000 gallons per day per square mile of intake area. This estimated rate of recharge assumes that water falling on the less permeable members of the different formations migrates latterly beyond the limits of the less permeable members and is absorbed by adjacent permeable units. Therefore, in an area of 6,600 square miles, if all the available recharge is absorbed by the permeable members of the Coastal Plain formations, then a yield based on 6,600 mgd of recharge is theoretically available. However, because some of the theoretically available recharge is rejected at the intake of the aquifer and since it would not be feasible to establish a network of wells that would capture all the recharge theoretically available, a more likely yield of the aquifers based on recharge is estimated to be about 4,000 mgd for the area.

The illustration indicating the total ground-water yield available for the area is based upon the following assumptions. (1) The indicated total yield in millions of gallons per day is based primarily on the amount of available recharge. (2) The quantity of water in storage in the ground is not considered because withdrawing this quantity of water would amount to a mining operation which could result in an encroachment of undesirable water or otherwise injure the aquifer. (3) The location of pumping wells will recognize the potential of contamination from adjacent sources and will recognize the need to maintain a minimum of interference between adjacent wells and well fields, and (4) the water withdrawn will generally be of good chemical quality except in those areas and from those deposits that are indicated as being highly mineralized.

The bedrock supplies a limited amount of water mostly along the Fall Line.

The Cretaceous aquifers in this area thicken from a few feet in the outcrop area to several hundreds of feet in the subsurface and should have a yield based upon available recharge in the intake area of about 55 mgd. In the easternmost part of the area, water from the Cretaceous sands about 1,000 feet below sea level is mineralized. As the water moves down dip the total dissolved solids in the water increases sharply.

Eocene formations have outcrops that cover about 225 square miles. However, several aquifers of Eocene age, even though thick and extensive in the subsurface sections, have no known surface exposures. These aquifers are believed to be recharged from younger overlapping formations and perhaps in some cases from older permeable formations that lie beneath them.

Based upon the available recharge from precipitation, it is estimated that the yield of these Eocene aquifers will amount to about 145 mgd.

Waters from the Eocene and Cretaceous aquifers are generally of good chemical quality for municipal and industrial uses. They are basically sodium bicarbonate type waters. A few of the analyses of water from the Eocene aquifers indicate that one might expect to find locally areas of fluoride concentration that are above the maximum concentration recommended for public water supplies.

Miocene formations crop out in a wide area or belt that covers about 4,200 square miles. Yields of these aquifers, based on available recharge in the outcrop areas are estimated to total about 2,700 mgd.

Water from Miocene formations generally has a higher iron content than does the water from the older formations. Of eleven samples of untreated water analyzed, nine contained too much iron for use in public water supplies. Other chemical constituents of these waters are generally below the maximum acceptable concentration.

The eastern quarter of the area, about 1,500 square miles, is covered by a veneer of Quaternary deposits. These deposits, consisting of sands, gravels, and clays, vary from a few inches to over 100 feet thick in their easternmost occurrence in Northampton and Accomack Counties.

Water from aquifers within the Quaternary section is generally good but is likely to have an above-normal iron content and is subject to contamination from nearby salt-water estuaries if overdeveloped.

Based upon the available recharge from precipitation and by observing a proper location of wells in relation to potential sources of salt-water contamination, the yield of the Quaternary aquifers is estimated to be about 1,100 mgd. Shallow dug and driven wells will yield small to modest supplies of water where the aquifers are thin and near the surface. Where the aquifers are thicker and at greater depth, properly located and developed wells are capable of yielding several hundred gallons per minute.

GROUND-WATER RESOURCES OF THE EASTERN SHORE OF VIRGINIA AND THE JAMES, YORK, AND RAPPAHANNOCK RIVER BASINS OF VIRGINIA EAST OF THE FALL LINE

By
George D. DeBuchananne

SCALE 1:500 000

10 0 10 20 30 40 50 MILES

10 0 10 20 30 40 50 KILOMETERS

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