MARYLAND GEOLOGICAL SURVEY
REPORT OF INVESTIGATIONS NO. 3

Kenneth N. Weaver, *Director*

WATER RESOURCES OF THE SALISBURY AREA, MARYLAND

by
Durward H. Boggess and Sumner G. Heidel

Prepared in cooperation with the Geological Survey
United States Department of the Interior
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WATER RESOURCES OF THE SALISBURY AREA, MARYLAND

by

Durward H. Boggess and Sumner G. Heidel

ABSTRACT

Large quantities of good-quality water are available for development in the Salisbury area. The Salisbury Formation of Hansen (1966) of Pleistocene age is the principal aquifer, presently supplying most of the 8 mgd (million gallons of water per day) used in the area. This formation will support additional large-scale development to an estimated 45 mgd. Conjunctive development of both surface- and ground-water sources may eventually achieve a water-production rate of about a million gallons per day per square mile, or about 90 mgd from the area.

Large untapped reserves of ground water are available from the channel-fill deposits in the Naylor Mill paleochannel where the Salisbury Formation attains a maximum thickness of about 230 feet. Individual well yields of 3,000–4,000 gpm (gallons per minute) may be obtained from properly constructed and developed wells in the thicker parts of this formation.

In addition smaller quantities of ground water are available from artesian aquifers underlying the Salisbury area. The Manokin and Nanticoke aquifers of Miocene age are the major alternate water-supply sources. These aquifers are presently used only in areas where the overlying Pleistocene sediments are thin, or contain water of undesirable quality. However, in most places, water from these deeper sediments is of poorer chemical quality than that generally obtained from the overlying sediments.

INTRODUCTION

A detailed appraisal of the hydrologic and environmental relationships that control the quantity, quality, and movement of water is necessary to the planned development of the water resources of any area. In the past, water resources have generally been developed on a casual basis, development proceeding according to the immediate needs with little recognition of possible future effects of such development. As greater demands were later placed on these resources, problems of local overdevelopment, deterioration in quality of water supplies, conflict between water users, and many other related problems became more apparent.

Fortunately, the Salisbury area has escaped the serious problems generally associated with "immediate need" water-resources development, and has encountered no water problems for which solutions cannot be found. This may be attributed both to circumstances surrounding the growth of the area and the general abundance of water, although planning, as early as 1925 when the Salisbury well field was relocated, helped avoid some of the problems frequently associated with an area's development.

This report is intended as an aid in future long-range planning of the water resources of the upper Wicomico River basin. An earlier report (Hansen, 1966) describing the Pleistocene geology of the area, should also assist in long-range planning. Both reports are based on an investigation conducted over the period July 1963 to December 1965 by the U.S. Geological Survey in cooperation with the Maryland Geological Survey and the City of Salisbury.

Purpose and scope

The basic purpose of this investigation was to determine the quantity and quality of water locally available to meet the present needs and future requirements of the city of Salisbury and the surrounding area to the year 2000. The investigation was primarily concerned with the availability of water from the aquifers of Pleistocene age, as previous investigations had indicated the excellent potential of these water-bearing sediments, and data indicate that further development of water supplies will be from this source. The investigation included an evaluation of significant geologic and hydrologic factors related to the distribution, movement, and availability of water in the Pleistocene aquifers. The scope and direction of the study were guided by Planning Report No. 2 on the Salisbury-Wicomico Region, prepared for the Salisbury Planning Commission and the Wicomico County Planning and Zoning Commission (George, Miles & Buhr, 1960).

Following the discovery of the deep channel deposits of Pleistocene age near the Naylor Mill Road, the project was broadened in scope to allow a more detailed evaluation of the thickness and extent of this part of the Salisbury Formation (Hansen, 1966).

Previous investigations

A brief investigation of the ground-water conditions at Salisbury was made by D. G. Thompson in 1925. This investigation and subsequent test drilling resulted in the location and early development of the present well field along the banks of Beaverdam Creek.

In 1947, R. R. Meyer and R. R. Bennett conducted the first detailed investigation of the ground-water resources of the Salisbury area with emphasis on the existing well field and areas of potential development near Schumaker Pond. The results of this investigation were included as a special section entitled "Ground-Water Resources of the Salisbury Area" in a report by Rasmussen and Slaughter (1955). Following the 1947 study, eight new production wells were constructed in the present well field.

A detailed investigation of the elements of the hydrologic cycle was made in the Beaverdam Creek basin in 1950–1952. The results of this study (Rasmussen and Andreasen, 1959) led to the preparation of a hydrologic budget, a detailed accounting of total water gains and losses in the basin.

An investigation of water-quality problems and declining well yields in the Salisbury municipal well field made by Heidel and Otton in 1962, led to a program of well reconditioning. The results of this study were presented in an open-file report in 1963.

Acknowledgments

The authors are indebted to the many individual well owners and well drillers who provided many of the well data used in this report. The authors also wish to express their appreciation to Mr. P. C. Cooper, Director, Department of Public Works of Salisbury, and to the mem-

bers of his staff whose excellent cooperation added measurably to the successful completion of the investigation.

Richard A. Gardner contributed substantially to this investigation. He prepared most of the discussion and tables included in the analysis of streamflow characteristics and availability of surface water. He participated in aquifer tests and in several other elements of the ground-water phase of the study.

The valuable advice and assistance rendered by H. J. Hansen III, Geologist, Maryland Geological Survey, is gratefully acknowledged. The authors have also drawn freely on previous publications on the area. The efforts of these earlier authors provided much of the ground work for the present study.

The publication of this report was authorized by the Director of the U.S. Geological Survey.

DESCRIPTION OF THE AREA

Location and extent

As used in this report, the Salisbury area refers to the entire northern part of the Wicomico River drainage basin as shown in figure 1. This part of the basin, covering an area of about 90 square miles, is roughly one-fifth of the area of Wicomico County, Maryland. Although nearly all of the drainage basin lies within Wicomico County, a small area of about 2 square miles in the northern part of the basin is in Sussex County, Delaware. The city of Salisbury is in the west-central part of the basin. The town of Delmar spans the basin divide in the northern part of the area and the town of Parsonsburg is on the basin divide in the eastern part of the area. The town of Fruitland is located entirely within the basin, near the southern limits of the report area.

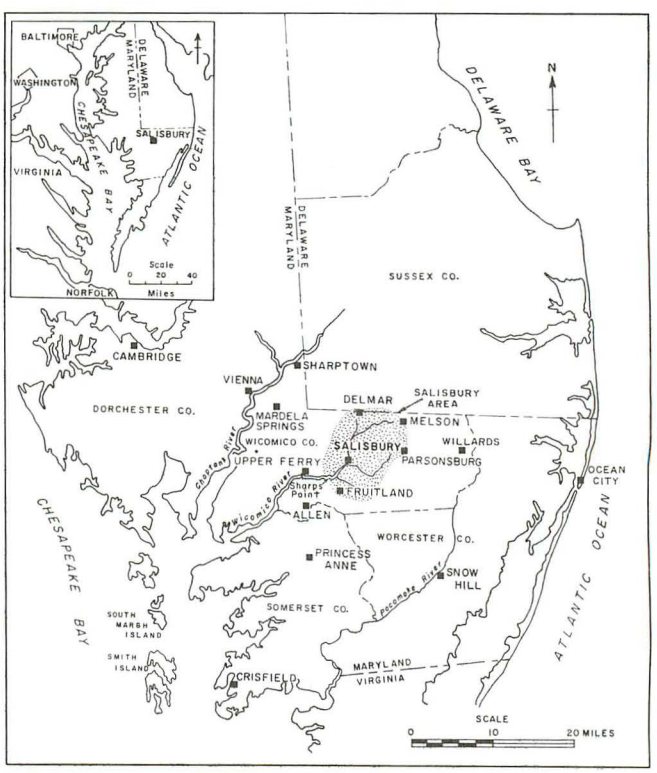

Figure 1—Map of the lower counties on the Eastern Shore of Maryland and Delaware showing location of the Salisbury area and principal cities and towns.

Culture

Estimates based on the 1960 Census of Population (U.S. Dept. of Commerce) indicate that about 36,000 persons lived in the Salisbury area in 1960. A large segment of this population, about 16,300 persons, lived within the city limits of Salisbury. An additional 13,000 persons resided in the urban fringe immediately surrounding the city, and the remaining 6,700 persons live in the rural parts of the area. Assuming that the county population growth rate of 24 percent in the 1950–1960 period provides a reasonable basis for projection, the 1965 population of the Salisbury area (upper Wicomico River basin) was about 40,000.

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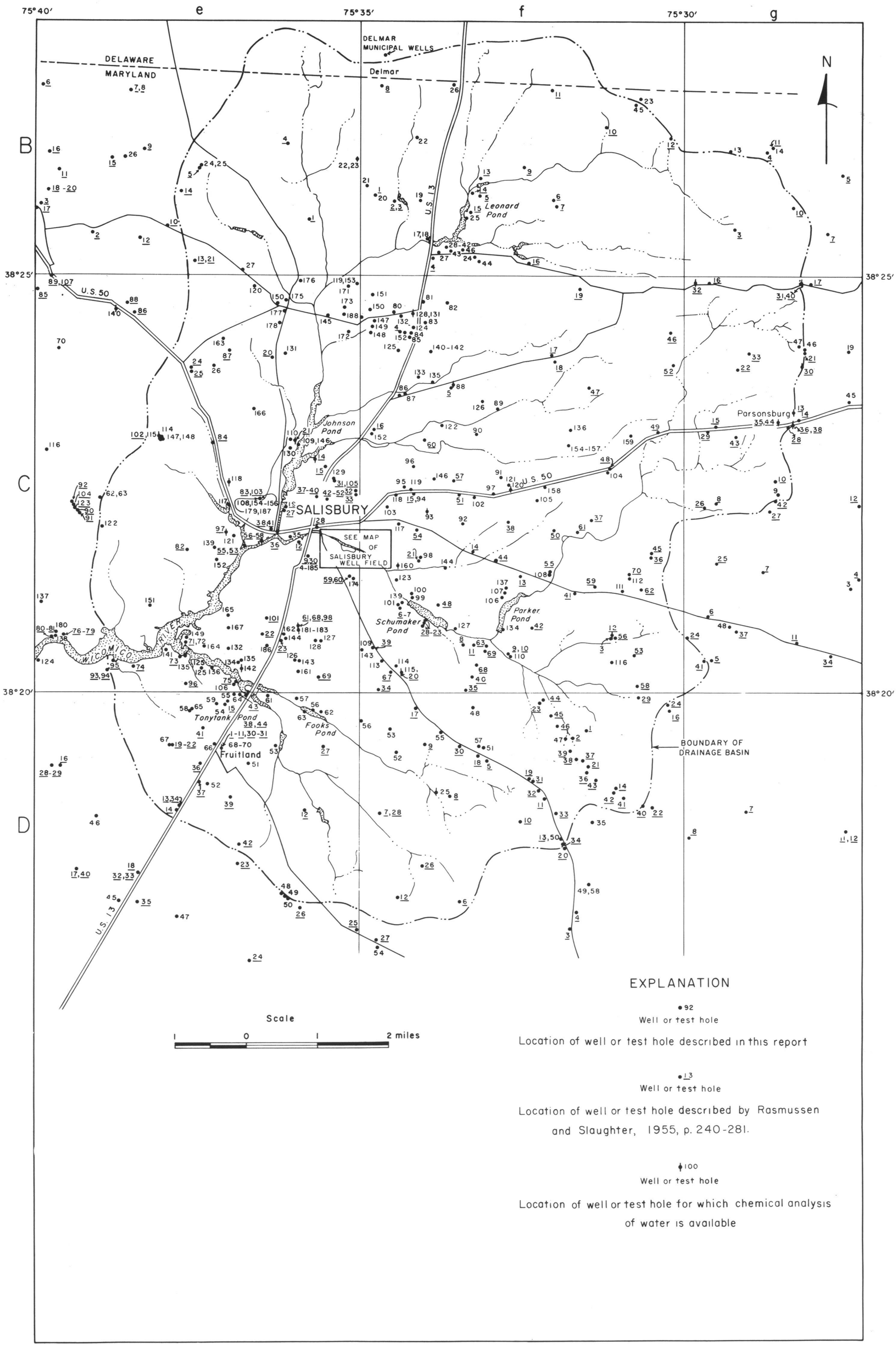

Figure 2—Well location map of the Salisbury area.

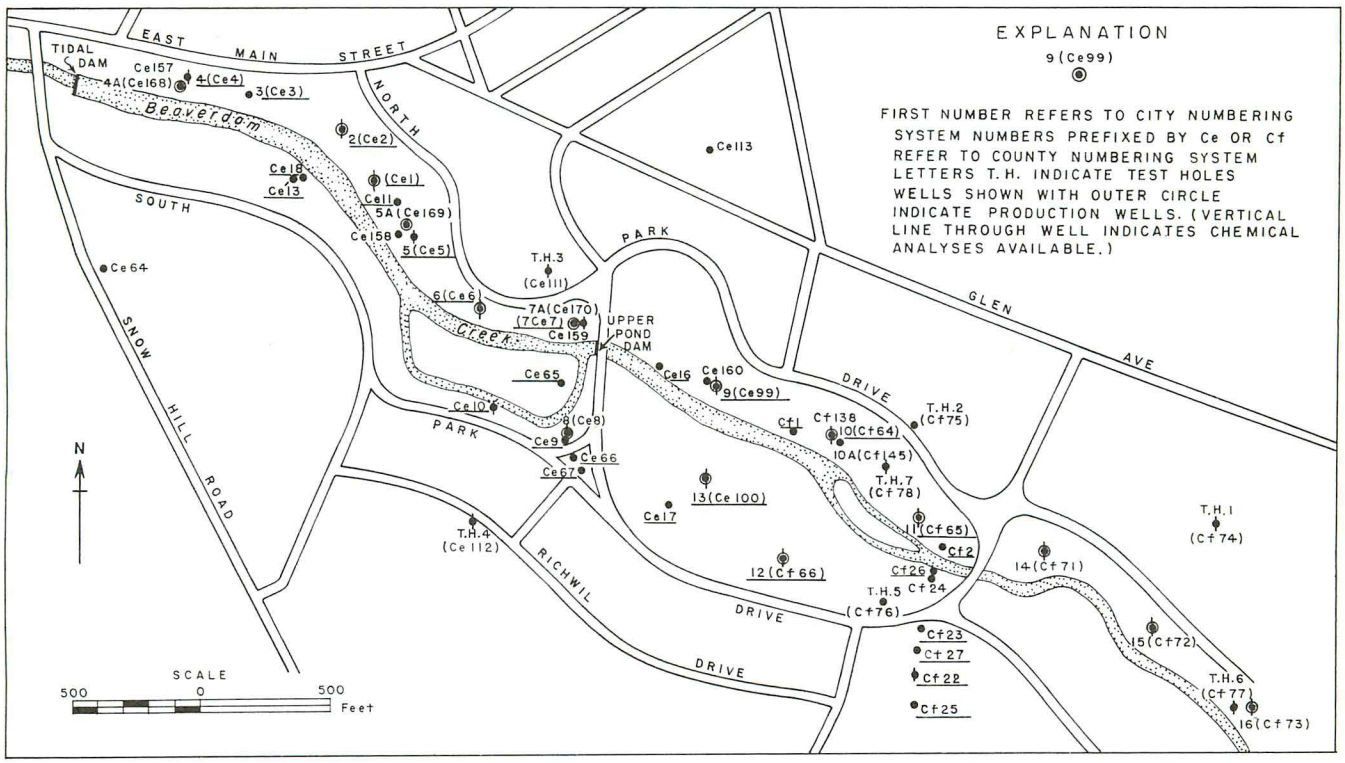

Figure 3—Well location map of the Salisbury well field.

Chicken broiler production, related feed and processing industries, and the production and processing of other farm products are an important part of the economy. Several industries which specialize in manufactured products are located at Salisbury. Many small business firms provide employment to a large number of people in the area.

Salisbury is at the intersection of two major highways, U.S. 50 which connects the Baltimore-Washington area with the ocean beaches, and U.S. 13 which connects Norfolk and points south with the large northeastern cities. The area is also served by commercial airline and rail facilities. The tidal portion of the Wicomico River at Salisbury is of sufficient width and depth to support some water-borne commerce, and is used principally by oil tankers and barges.

Physical features of the area

The Salisbury area is part of the Atlantic Coastal Plain province of Maryland. The gently rolling topography rises from near sea level at Salisbury to about 85 feet in the eastern part of the area near Parsonsburg. Most of the area lies at altitudes ranging between 30 and 60 feet. Numerous small streams dissect the area, draining toward the central part of the basin. Small dams placed across the stream valleys have created numerous small fresh-water ponds. These ponds, originally constructed to operate grain mills, are now used principally for recreational purposes. Dams constructed on the lower reaches of the streams form tidal barriers that separate the tidal and fresh-water parts of the Wicomico River.

The predominantly sandy soils of the basin allow such high infiltration rates for precipitation that flooding is seldom a problem. Although a large part of the basin is still in agricultural production, it is estimated that about 12,000 acres or about 8 percent of the farm acreage for the county reported in 1954 (U.S. Census of Agriculture, 1959), has since been diverted to nonagricultural uses. Most of this diversion is attributed to urban expansion in the vicinity of Salisbury.

WELL-NUMBERING SYSTEM

The Maryland well-numbering system used in this report classifies wells by counties, in which an abbreviation of the county name forms part of the well number. Thus, in Wicomico County, all wells have the prefix Wi- as the first part of the well number; those in Somerset County have Som-; and those in Worcester County have Wor-. Because most of the wells discussed herein are in Wicomico County, the prefix Wi- is used only where necessary to avoid confusion.

Each county is divided into 5-minute quadrangles of latitude and longitude. Each quadrangle from north to south is designated by uppercase letters and west to east by lowercase letters, as shown in margins on figure 2. The wells are numbered in each 5-minute quadrangle in the order in which they were inventoried. For example: Wi-Ce 147 indicates the 147th well inventoried in the west-central (Ce) 5-minute quadrangle in the Salisbury area. In the text of this report the well is listed only as Ce 147.

A dual well numbering system is used in the Salisbury municipal well field as shown in the inset map, figure 3. The city well numbers, or test hole numbers, are given in addition to the assigned county well numbers. For example: city well 10 is Wi-Cf 64 in the statewide numbering system and city well 10A is Wi-Cf 145. Where no city well number has been assigned, only the statewide number is given.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

The Salisbury area is underlain by more than 5,000 feet of unconsolidated Coastal Plain sediments consisting of gravel, sand, silt, and clay. These sediments in turn are underlain by crystalline rocks similar to those exposed along the Fall Zone in the Baltimore area. A detailed description of the unconsolidated sediments as they occur in Somerset, Wicomico, and Worcester Counties was presented by Rasmussen and Slaughter (1955, p. 41–120). As part of the current investigation a publication by Hansen (1966) gives a detailed description of the sediments comprising the Pleistocene Series. The part of the investigation described herein is primarily concerned with the water-bearing properties of the Pleistocene sediments.

Selected logs for wells inventoried as part of the present study were published by Hansen (1966). The well records for these, and other wells in the Salisbury area are given in table 1 in the Appendix of this report.

The Coastal Plain sediments underlying the Salisbury area are divided into geologic units or formations, in which the strata are grouped together as a geologic unit. Thus, a geologic formation may consist largely of sand or clay, or may contain both sand and clay members. In describing the water-bearing properties of these formations, the term aquifer is used to denote sand formations or permeable members that yield water to wells, whereas the term aquiclude denotes clay formations or impermeable members that yield little or no water to wells. Although the aquifers are of great importance as water-supply sources, the aquicludes serve the important function of separating water contained in one aquifer from that contained in another aquifer. Aquifers may be further classified as artesian or water table. In artesian aquifers the water is confined between less permeable layers and the water level in a penetrating well rises above the top of the water-bearing sand. In some cases the water level may rise above the land surface, as in a flowing well. In water-table aquifers the water is unconfined and the water level essentially represents the upper surface of the zone of saturation.

An important property of earth materials governing the rates of movement of liquids and fluids through them is their permeability. *Hydraulic permeability* is the ability of a material to transmit water. The *coefficient of permeability* (P_f) is defined as the rate of flow of water, in gallons per day, through a cross-sectional area of 1 square foot under a hydraulic gradient of 1 foot per foot at the prevailing temperature.

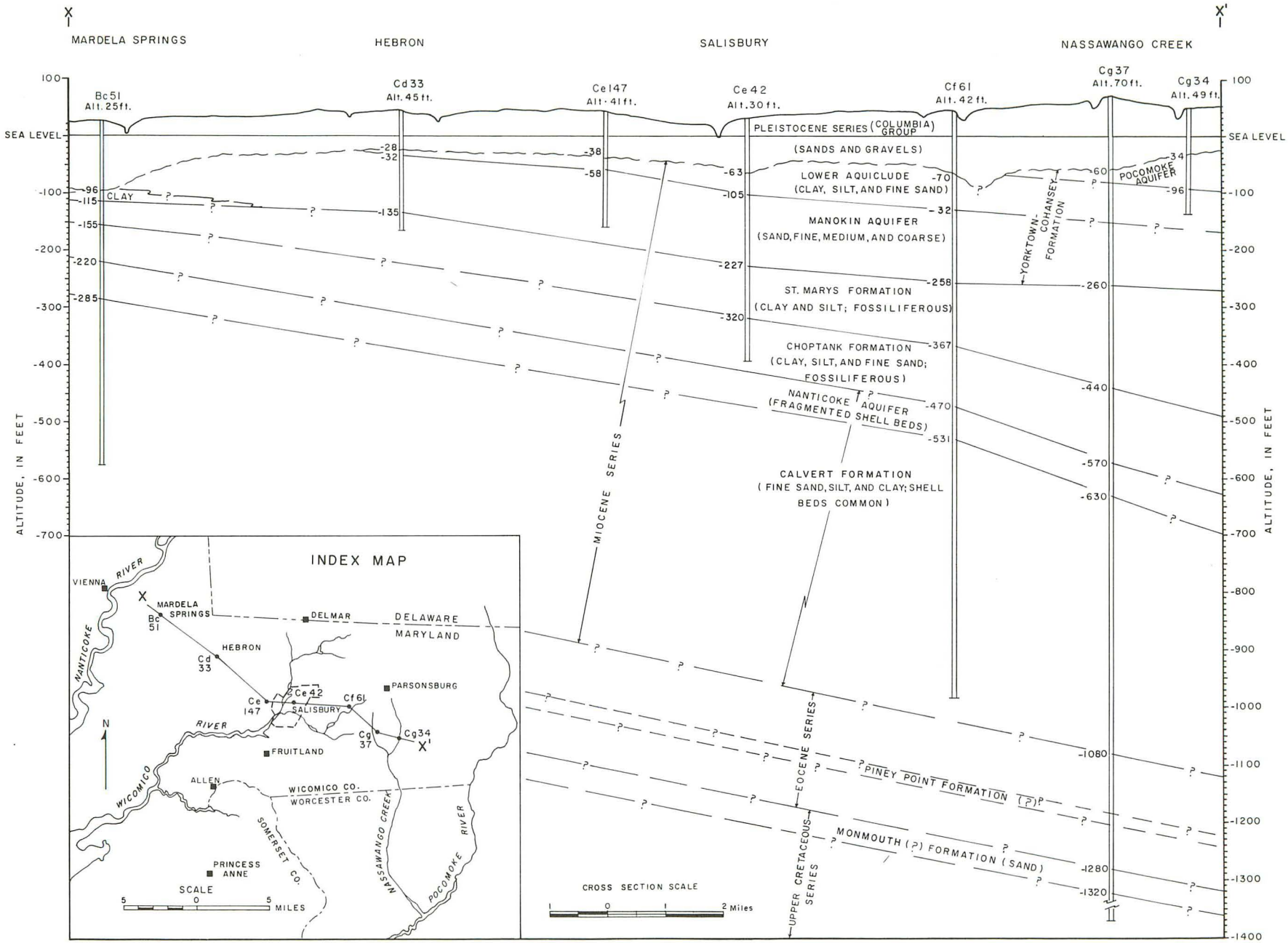

Figure 4—Generalized geologic section from Mardela Springs to Nassawango Creek.

The *coefficient of transmissibility* (T) is the rate of flow of water, in gallons per day, through a vertical section of the aquifer 1 foot wide, extending through its full saturated thickness under a hydraulic gradient of 1 foot per foot. The thickness of the aquifer in feet is designated by the symbol (m). Thus, the coefficient of transmissibility may be written: $T = P_f m$.

In addition to transmitting water, aquifers store enormous quantities of it. The *coefficient of storage* (S) is defined as the volume of water released from or taken into storage per unit vertical prism of the aquifer per unit change in the hydraulic head. It is dimensionless.

By use of appropriate formulae the coefficients of transmissibility and storage may be used to predict the hydrologic effects of pumping, drainage, and recharge.

Ground water is obtained in the Salisbury area chiefly from drilled, driven, or dug wells whose diameters commonly range from about 1¼ inches for household wells up to 36 inches for large-capacity industrial or irrigation wells. A common measurement of the efficiency of wells is their *specific capacity,* defined as the yield in gallons per minute per foot of drawdown. Thus a well having a drawdown of 100 feet and yielding 50 gpm has a specific capacity of 0.5 gpm/foot.

The geologic and hydrologic units in the Salisbury area, are summarized in table 2. The approximate depth, thickness, and relative position of these units are shown in the geologic section, figure 4. Correlation of some of these sediments between Mardela Springs and Allen is based on descriptive and electrical resistivity logs of wells as shown in figure 5. Although the wells at Mardela Springs and Allen are outside of the report area, the well at Allen is considered to be representative of the lithologic sequence, and possibly is representative of the depth and thickness of the formations in the Salisbury area.

Table 2. Geologic units and their water-bearing properties in the Salisbury area.

(Sediment beneath 1,350 feet not included)

System	Series	Geologic Unit	Hydrologic Unit	Geologic Characteristics	Water bearing properties, (Small, indicates yields of 5–25 gpm; moderate 25–300 gpm; large, over 300 gpm.)
Quaternary	Pleistocene	Columbia Group (Salisbury Formation)	Aquifer	Sand, medium to coarse and lensoidal gravel, fine to medium; white, tan, orange-brown, and red, 50–230 feet thick.	Yields small to very large quantities of water depending on location and type of well construction.
Tertiary	Miocene	Yorktown-Cohansey Formations	Upper Aquiclude	Not present in Salisbury area	
			Pocomoke Aquifer	Sand, fine to medium, occasionally coarse; gray and tarnish gray; 0–30 feet thick.	Present only in eastern part of basin. Where present, hydraulically connected to overlying Pleistocene aquifer.
			Lower Aquiclude	Clay, silt, and sand, very fine to fine; dark gray; rarely fossiliferous; 0–80 feet thick.	Yields very small quantities of water to a few wells in southern part of basin. Generally acts as an upper confining layer for the Manokin aquifer.
			Manokin Aquifer	Sand, fine to coarse; gray; 100–130 feet thick, except beneath the Naylor Mill Paleochannel where 20–90 feet thick.	Yields small to moderate quantities of water. Flowing wells frequently encountered at altitudes less than 25 feet above mean sea level.
		St. Marys Formation	Aquiclude	Clay, "sticky", silt and sand, very fine to fine; dark gray; very fossiliferous; 70–140 feet thick.	No water produced in area from these sediments. Acts as lower confining member for Manokin aquifer.
		Choptank Formation	Aquiclude	Clay, silt, and sand, fine; gray to greenish gray; commonly fossiliferous; 50–100 feet thick.	No water produced in area from these sediments.
		Calvert Formation	Nanticoke Aquifer	Shell bed, fragmental, silt, and fine sand, gray; about 60 feet thick.	Yields small to moderate quantities of water to few wells in southern part of basin.
			Aquiclude	Silt, clay, and sand, very fine to fine, gray; fossiliferous; 500–550 feet thick.	No water produced in area from these sediments.
	Eocene (Paleocene undifferentiated)		Aquiclude	Clay and silt, dark gray; green, brown; 100 feet thick.	Non-productive.
		Piney Point(?) Formation	Aquifer	Sand, fine to medium; brown and green; 15 to 30 feet thick.	Water-bearing properties of these sediments in this area are unknown.
			Aquiclude	Clay and silt; brownish-white and sand, fine; greenish; 80 feet thick.	Non-productive.
Cretaceous	Upper Cretaceous	Monmouth(?) Formation	Aquifer	Sand, medium; dark green; fossiliferous; 40 feet thick.	Water-bearing properties of these sediments in this area are unknown.

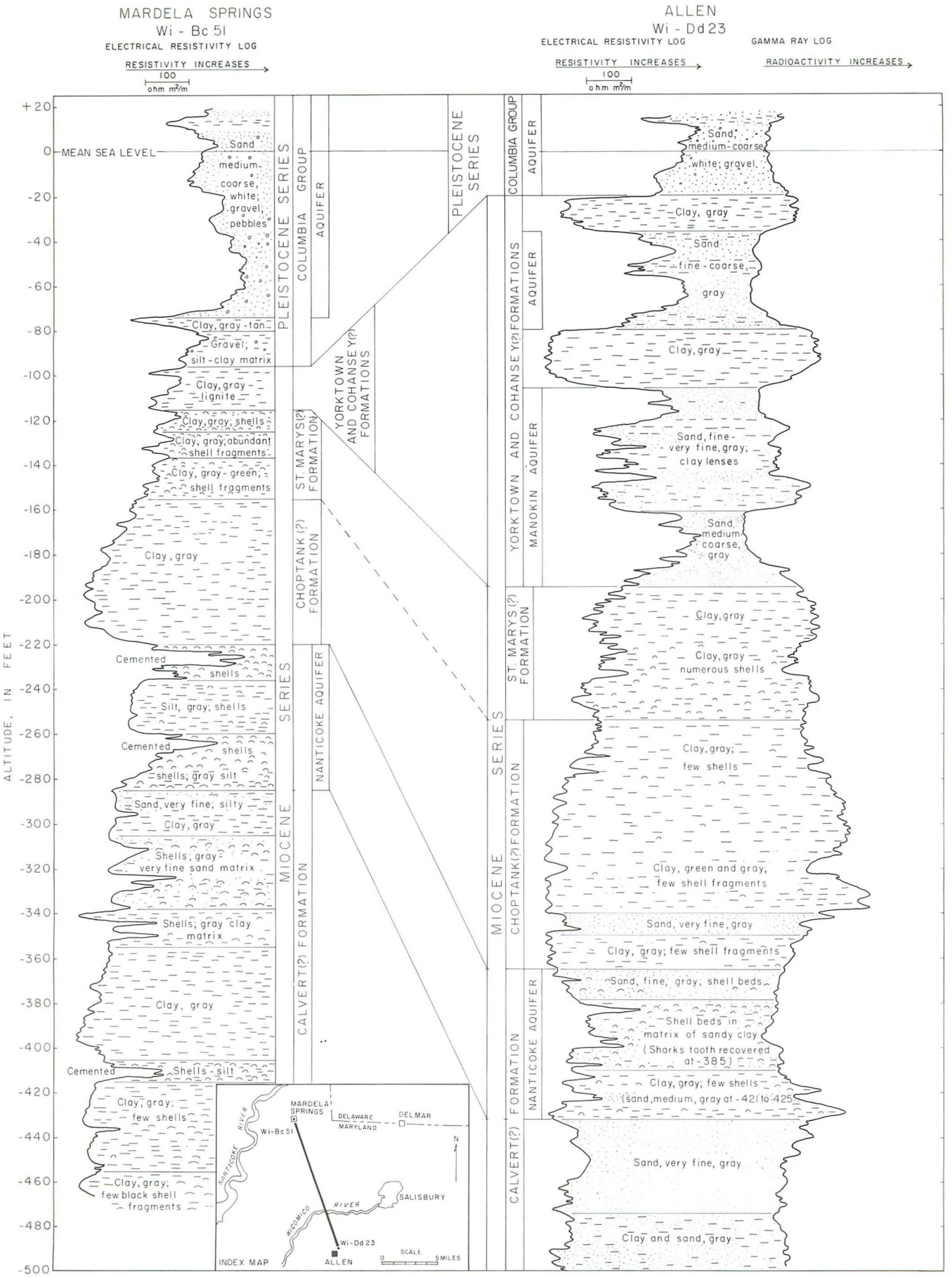

Figure 5–Correlation of sediments between Mardela Springs and Allen with descriptive logs, electrical resistivity logs, and comparison with a gamma ray log.

Holocene and Pleistocene Series

The sediments comprising the Holocene Series in the Salisbury area include wind transported fine sands which mantle the interstream divide areas; water transported sands and gravels associated with the Wicomico River; and tidal marsh deposits found in low lying areas near the river. In this area these sediments are of limited thickness and distribution, and are not differentiated from the underlying Pleistocene sediments in this report.

The sediments of Pleistocene age form the most important aquifer system in the Salisbury area. These sediments have been subdivided into three formations by Hansen (1966) and include the Parsonsburg Sand, the Walston Formation, and the Salisbury Formation.

The Walston Formation, consisting of predominantly clayey sediments, separates the overlying Parsonsburg Sand and other dune sands from the underlying Salisbury Formation. The Walston ranges in thickness from 2 to 20 feet and occurs throughout most of the area. Its upper surface ranges in altitude from 10 to more than 40 feet above mean sea level. Even though these clayey sediments have no importance as a water-supply source, they significantly affect the hydrology of the basin. Their significance is discussed in detail in subsequent sections of this report.

Parsonsburg Sand: The Parsonsburg Sand, as described by Hansen (1966), is a fine to medium, well sorted, tan to gray, surficial sand. This sand extends for several miles along a north-south topographic ridge which passes through the town of Parsonsburg. It reaches a maximum thickness of 25 to 30 feet in the eastern part of the Salisbury area, between Parsonsburg and Melson. As the Parsonsburg Sand is highly permeable, it readily accepts infiltration from rainfall. However, the storage capacity of this sand is small because of its limited thickness. Nonetheless, a number of small-diameter domestic wells in the area obtain water from it.

Where the water table occurs in the Parsonsburg Sand it ranges from 70 to 80 feet above mean sea level, a higher altitude than elsewhere in the Salisbury area. The underlying clays of the Walston Formation retard the downward movement of water from the Parsonsburg Sand, so that most of the natural drainage occurs laterally. During a 2-year period, the range in fluctuation of the water table in this sand was only about 4 to 5 feet, whereas in similar sands at lower altitudes, fluctuations in the water table were nearly twice as great during the same period.

Salisbury Formation: The Salisbury Formation is the most important source of ground water in the Salisbury area. It extends throughout most of Wicomico County, and varies in thickness from less than 50 feet to about 230 feet. The variation in thickness is the result of both the differences in the altitude of the erosional surface of the underlying Miocene sediments and the differences in altitude of the present land surface. The Salisbury Formation is generally thickest in locations where the Miocene sediments are most deeply incised, as in the Naylor Mill paleochannel, and where the present land surface is highest.

As described by Hansen (1966) the Salisbury Formation consists of two distinctive lithofacies, an orange-brown sand (red gravelly facies) and a gray-white sand (Beaverdam facies). Both facies form a single hydrologic unit or aquifer extending throughout the Salisbury area, except to the south where the red gravelly facies wedges out. To determine the physical character and hydrologic properties of the aquifer, grain-size analyses of 233 core samples were obtained from 24 test holes drilled in the Salisbury Formation. These analyses indicate that, according to the predominant grain size, 52 percent of the core samples were medium sand, 34 percent were coarse sand, 12 percent were fine sand, and 2 percent were coarse sand or gravel. The grain size characteristics of the core samples obtained from the saturated part of the formation are summarized as follows:

Facies	Total thickness of cores from saturated zone (feet)	Average median diameter (mm)	Average effective size (mm)	Range of Trask sorting coefficient
Beaverdam Sand	157.5	0.41	.15	1.09–4.41
Red gravelly Sand	301.5	.58	.20	1.13–4.33

In the above table the median diameter is defined as the grain size, in millimeters, in which 50 percent of the sample by weight is coarser, and 50 percent is finer than the given size. The effective size refers to the grain size, in millimeters, in which 90 percent of the sample is coarser, and 10 percent is finer than the given

size. The Trask sorting coefficient is a dimensionless number that describes the degree of sorting, or spread of grain sizes, whereby 1.00 indicates perfect sorting and 4.00 indicates poor sorting.

The red gravelly sand is generally coarser than the Beaverdam Sand, although the range in particle sizes indicated by the sorting coefficients are nearly identical. Permeability estimates, based on permeability-effective grain-size relationships, indicate that the average permeability of the red gravelly sand is about 2,600 gpd (gallons per day) per square foot, whereas that of the Beaverdam Sand is about 1,700 gpd per square foot. The weighted average permeability for all core samples from the zone of saturation is estimated to be about 2,200 gpd per square foot. This value compares favorably with average permeability values of 2,000 obtained from pumping tests.

Laboratory permeability tests were run on a large number of the cores. Wide variations were noted, however, in both laboratory permeabilities and estimated permeabilities based on effective grain size. For example, laboratory permeabilities ranged from 9 to 5,200 gpd per square foot in two core samples from test hole Be 27, even though one sample consisted of medium to coarse sand and the other consisted of coarse to very coarse sand. In test hole Cf 126, estimated permeabilities based on effective grain size, were invariably higher than those determined in the laboratory. These estimated permeabilities ranged from 300 gpd per square foot for a fine sand to 9,400 gpd per square foot for a very coarse sand. These wide variations in permeabilities emphasize the effect of stratification on the vertical and horizontal permeability. Although many of the samples from the lower part of the Salisbury Formation were found to be more permeable than samples from the upper part, no consistent pattern was apparent.

Aquifer tests in the Salisbury area by previous investigators (Rasmussen and Slaughter, 1955, p. 142–144), have shown transmissibility values for the Salisbury Formation that range from 38,000 gpd per foot to 585,000 gpd per foot. Although it was concluded that the average value for the formation was about 100,000 gpd per foot, it should be noted that considerable variations in transmissibility were encountered within relatively short distances. Some variation in transmissibility is doubtlessly due to differences in aquifer thickness, but wide variations in transmissibility where the aquifer is of equal thickness suggests variations in the permeability of the aquifer materials as indicated by the analysis of core samples.

An estimate of the transmissibility at two test hole locations was made by assigning permeability values to each depth interval from which core samples were obtained. The reliability of this method is influenced by the selection of permeability values and the total thickness of the cored intervals compared to the total saturated thickness of the aquifer. The procedure used to estimate transmissibility is illustrated in figure 6. Permeabilities of the core samples were estimated from effective grain size-permeability relationships. The transmissibility values thus obtained were near median values computed for aquifer tests at these locations.

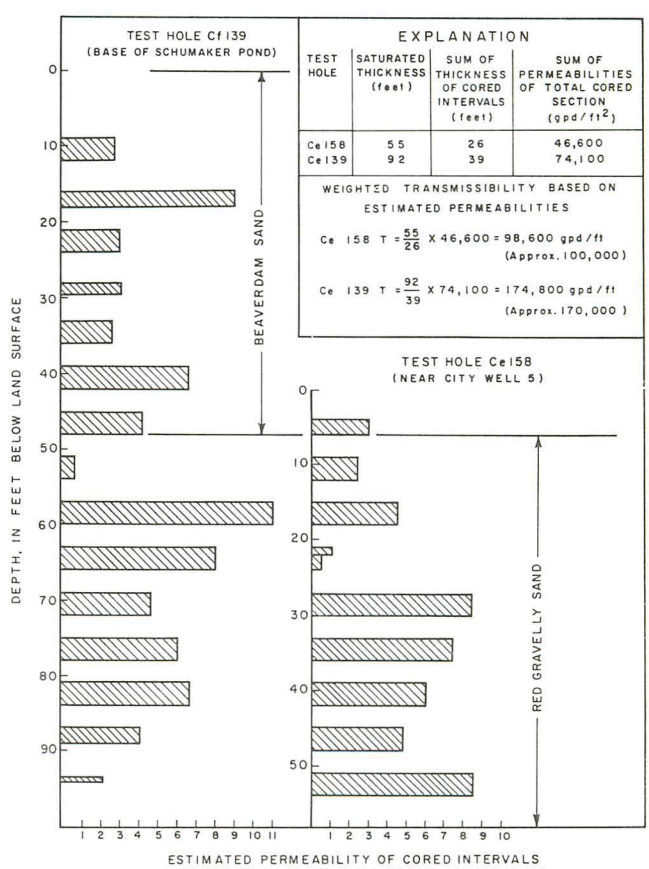

Figure 6—Graph comparing estimated permeabilities and transmissibilities of sediments from test holes Ce 158 and Cf 139, based on core samples.

Miocene Series

The Miocene Series underlying the Salisbury area includes the Yorktown, St. Marys, Choptank, and Calvert Formations. Three major aquifers are present in the series; these are, in descending order, the Pocomoke, Manokin, and Nanticoke aquifers. The Miocene strata consist of nearly 1,000 feet of unconsolidated sand, silt, and clay. These sediments, of marine origin, dip to the southeast at rates of about 10 to 20 feet per mile. After deposition the Miocene sediments were tilted to the southeast and eroded prior to, or during the period of deposition of the Pleistocene sediments, so that often only erosional remnants of some of the formations remain. As a result, progressively younger deposits of Miocene age underlie the Pleistocene mantle to the southeast. This is illustrated in figure 4, where the Pocomoke aquifer and the lower aquiclude are shown wedging out beneath the Pleistocene sediments.

Aquifers in the Miocene Series consist predominantly of fine- to medium-grained gray sands. In the Salisbury area, however, parts of these aquifers contain some coarse sand, gravel, or shell material. The Pocomoke aquifer is present only in the eastern part of the basin and consequently is of limited importance. A thin sand within the lower aquiclude is present over a large part of the basin, but is of limited importance as a source of water. On the other hand, the Manokin aquifer in the Yorktown Formation and the Nanticoke aquifer in the Calvert Formation are important sources of water throughout the Salisbury area.

Manokin Aquifer: The Manokin aquifer in the Yorktown Formation is the principal artesian aquifer in use in the Salisbury area. However, owing to the general availability of larger quantities of water of better quality from the overlying Pleistocene aquifers, this aquifer has not been extensively developed in the area. Thus, most of the data on the Manokin aquifer have been collected from wells and test holes drilled outside of the Salisbury area.

This aquifer is recharged to the west of the Salisbury area where it is hydraulically connected to the overlying Pleistocene aquifers. The location of the intake area, the altitude of the water table in this area, and the related artesian head distribution in the Manokin aquifer are shown in figure 7. From the intake area, the top of the aquifer slopes to the southeast at a rate of about 10 feet per mile. East of the intake area the aquifer is confined above by the clays of the Lower aquiclude and below by the clays in the underlying St. Marys Formation. The aquifer is only a few feet thick near the inner edge of the intake area but is estimated by Rasmussen and Slaughter (1955, p. 99) to be 270 feet thick at Ocean City, some 30 miles eastward.

Regionally, the Manokin aquifer is predominantly a fine- to medium-grained sand, with some coarse sand in its lower part. Locally, sands in the Manokin aquifer deviate considerably from the general description. The variability of the sands of the Manokin aquifer at three different locations is shown in figure 8. Locations of the wells used area shown on figure 7.

At Princess Anne, the aquifer consists entirely of fine sand, which accounts for the transmissibility of only 7,000 gpd per foot reported by Rasmussen and Slaughter (1955, p. 152). At Snow Hill, the aquifer consists predominantly of medium to coarse sand and its transmissibility was reported as 40,000 gpd per foot (Rasmussen and Slaughter, 1955, p. 154). At Allen, about 3 miles southwest of the Salisbury area, medium to coarse sands were logged in the lower part of the aquifer.

At Salisbury, test holes Cf 77 and Cf 78, which were drilled in the municipal well field, penetrated the top of the Manokin aquifer at about 80 feet below mean sea level. At this location, the uppermost 100 feet of the aquifer consists predominantly of fine gray sand. However, a zone of medium to coarse sand was logged between 122 and 127 feet below mean sea level. Because these wells did not penetrate the full thickness of the aquifer, it is not known whether additional coarse sands are present in the lowermost part of the aquifer. At Fruitland, coarse sand was found in the lower part of this aquifer at a depth of 161–175 feet below mean sea level. Moreover, wells Ce 147 and Ce 148, at the Mardel Byproducts plant west of Salisbury, penetrated coarse sand near the base of the aquifer between 138–158 feet below mean sea level.

A coefficient of transmissibility of 40,000 gpd per foot and a coefficient of storage of 0.0003 was determined from aquifer tests conducted at the Mardel Byproducts plant. These values indicate the Manokin to be a good aquifer at that location. However, the aquifer coefficients may not be truly representative of the aquifer throughout the Salisbury area. At Princess

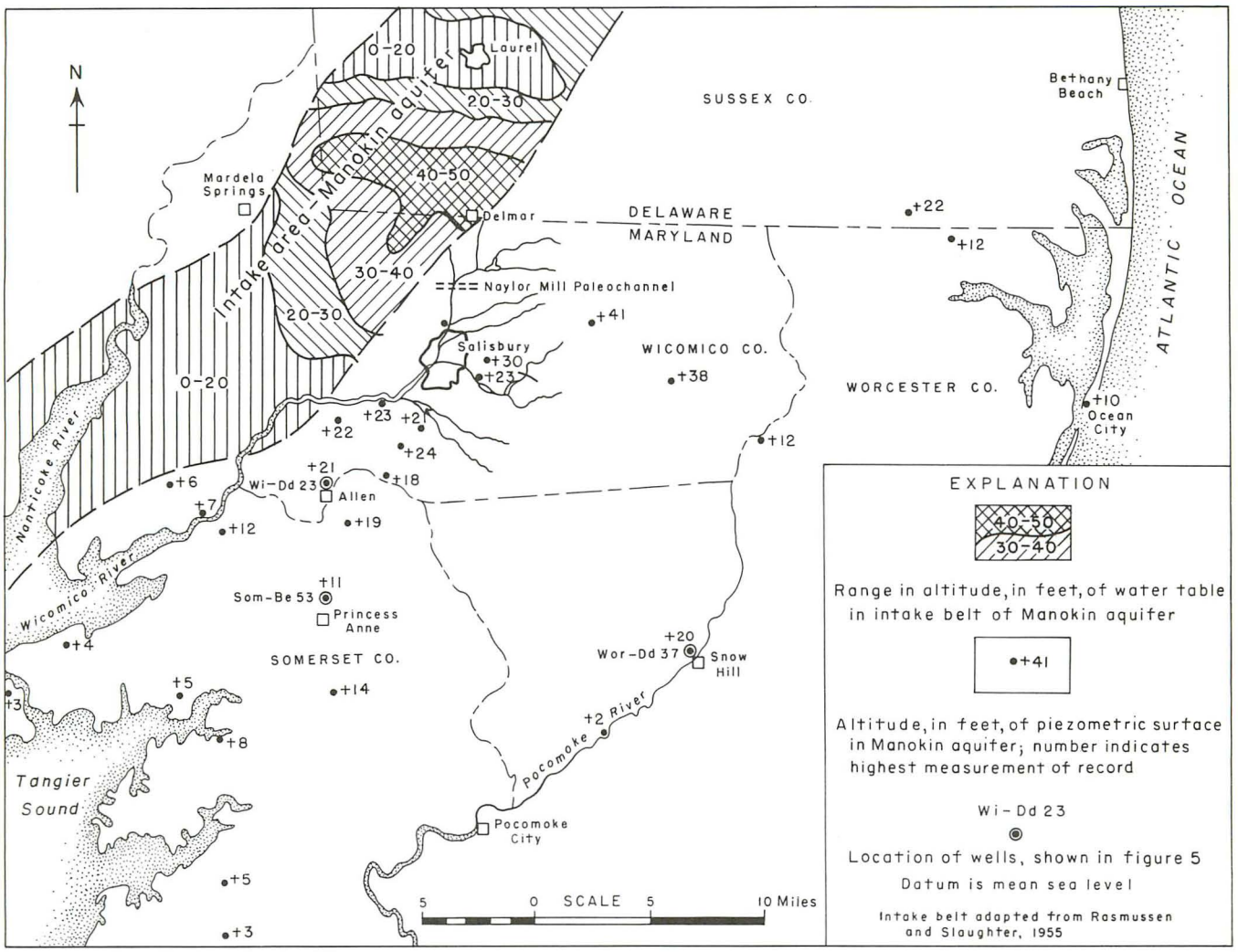

Figure 7—Map showing artesian head distribution in the Manokin aquifer as related to altitude of water levels in the intake area.

Anne, 12 miles southwest of Salisbury, the transmissibility of the Manokin is reported to be only 7,000 gpd per foot (Rasmussen and Slaughter, 1955).

It is concluded that the Manokin aquifer is present throughout most of the Salisbury area. Available data indicate that its top ranges from about 50–60 feet below mean sea level near the western boundary of the Wicomico River basin, to about 150–200 feet below mean sea level near the eastern boundary. Although the thickness of the aquifer generally exceeds 100 feet, only in some localities are the more permeable zones sufficiently thick to furnish wells of large capacity. Electric logs used in conjunction with test drilling would be a valuable aid in determining the depth interval to be screened in the production wells.

Nanticoke Aquifer: The Nanticoke aquifer is a relatively thin aquifer in the upper part of the Calvert Formation. The Nanticoke aquifer probably extends over most of Wicomico County and is the principal artesian aquifer in use at Vienna, Mardela Springs, and Sharptown. Cor-

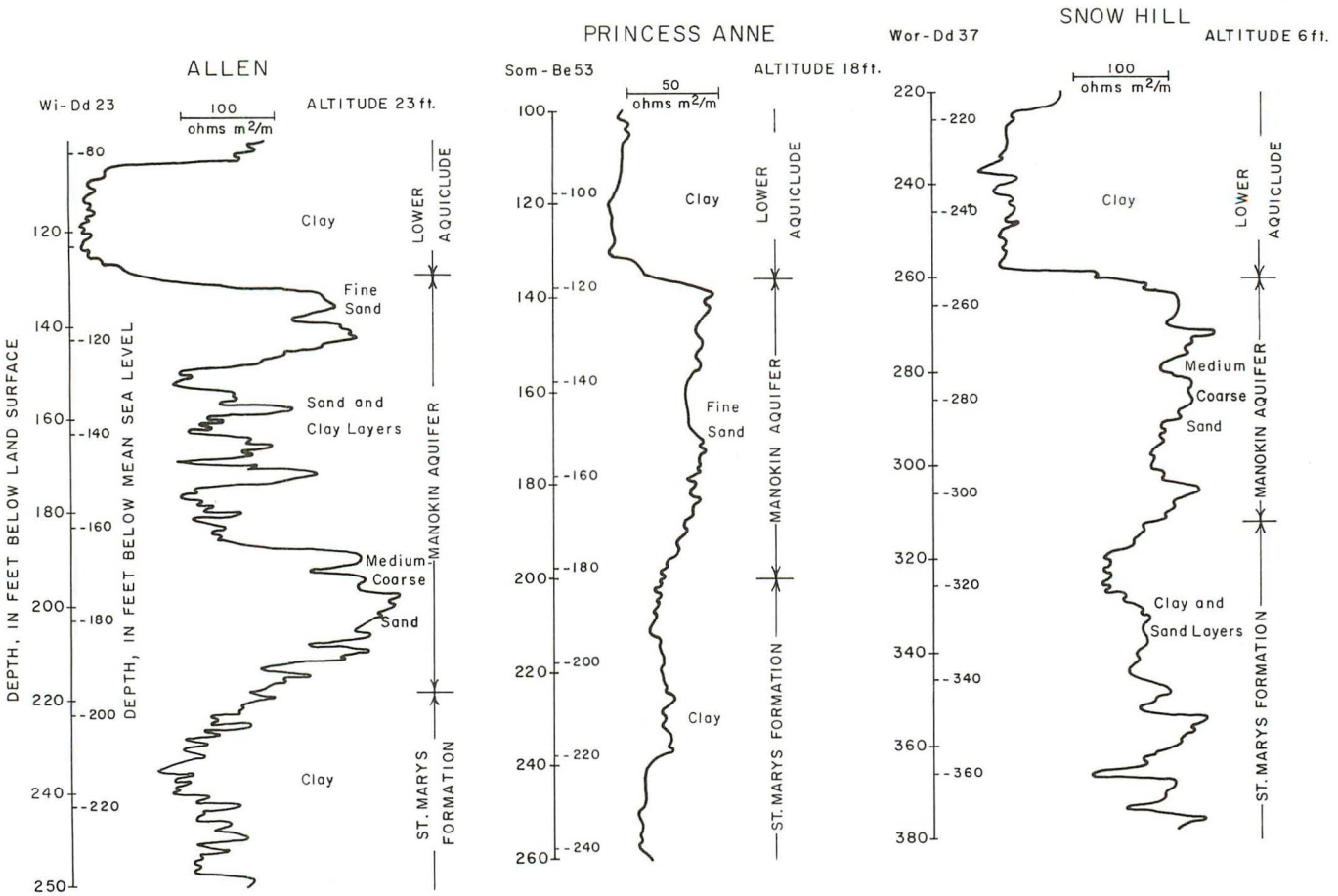

Figure 8—Electric log resistivity curves showing variations in thickness, depth, and lithology of the Manokin aquifer at Allen, Princess Anne, and Snow Hill.

relation of this aquifer from Mardela Springs to Salisbury by means of well logs is shown in the geologic cross section, figure 4. Electric log correlation of the Nanticoke aquifer from Mardela Springs to Allen is shown in figure 5. It is estimated that its top ranges from about 350–400 feet below mean sea level in the western parts of the Salisbury area, to 500–550 feet near the eastern part. The top of the Nanticoke aquifer was found at 412 feet below mean sea level in wells De 69 and De 70 at Fruitland.

Samples collected from wells Bc 51 at Mardela Springs and Dd 23 at Allen, indicate that the more permeable parts of the Nanticoke consist largely of fragmented shell beds, which are usually described by well drillers as "crusty and hard". The thickness of the aquifer is estimated to average about 60 feet in the Salisbury area, although a thickness of more than 100 feet was logged in wells at Fruitland. A driller's test on these wells gave specific capacity values of 3.0 and 4.0 (gallons per minute per foot of drawdown) gpm per foot. The analysis of an aquifer test on this aquifer at Fruitland indicated a coefficient of transmissibility of about 5,500 gpd per foot (Rasmussen and Slaughter, 1955). This relatively low transmissibility value indicates an aquifer with lower-than-average permeability.

Older sediments

The older sediments including strata of the Eocene Series, Paleocene Series, Upper Cretaceous Series, and Lower Cretaceous Series are relatively unexplored in the Salisbury area. Regional geologic correlation indicates the probable occurrence of several water-bearing formations in these older sediments beneath the Salisbury area. Included are the Piney Point Formation of Eocene age, which serves as a major source of ground water at Cambridge; the Monmouth Formation of Cretaceous age from which some water might be derived; and the Magothy Formation, also of Cretaceous age, which is used at Crisfield, Smith, and South Marsh Islands. Other Cretaceous formations at greater depths from which some water might be obtained include the Raritan, Patapsco, and Patuxent Formations.

The water in these older sediments is believed to be of poor quality. Based on interpretations from electric logs and chemical analyses of water from some of these sediments, it is concluded that the water is highly mineralized and may be brackish or saline. Considering the general availability of good quality water in the shallow aquifers in Salisbury area, it seems unlikely that any of these older and deeper sediments will be of importance as water-supply sources for many years. Most of the available information on these older sediments is summarized by Rasmussen and Slaughter (1955, p. 44–57).

AVAILABILITY AND QUALITY OF GROUND WATER

Pleistocene Series

The Pleistocene sediments in the Salisbury area include the Parsonsburg Sand, the Walston Formation, and the Salisbury Formation. The latter is subdivided into the Beaverdam Sand and the red gravelly sand. From a regional standpoint, the Salisbury Formation (Hansen, 1966) is the most important as a source of water supply.

The availability of water from the Salisbury Formation is primarily controlled by its permeability and saturated thickness. The sediments of the formation vary widely in their permeability and saturated thickness. As a result, transmissibility values are also quite variable. Transmissibility values obtained from aquifer tests are generally considered more reliable than those obtained by other methods; however, facilities for conducting aquifer tests are not always available so the results of laboratory determinations are sometimes used to estimate transmissibilities.

One such determination involves an evaluation of the saturated sediments according to their physical properties and obtaining an estimation therefrom of the hydraulic properties of the sediments. Transmissibility values obtained by this method are considered relative or estimated values in this report to distinguish them from values obtained from aquifer tests.

In some areas, where cores or samples are not available, the saturated thickness of the sediments provides the best means of indicating the relative availability of water. Assuming a relatively constant average permeability, generally larger quantities of water may be obtained from areas where the sediments are of greater saturated thickness. Figure 9 is a map of the Salisbury area showing the saturated thickness of the Pleistocene sediments and the estimated transmissibility at selected points within the Wicomico River basin.

Based on an estimated porosity of 35 percent, it is estimated that nearly 600 billion gallons of water are stored in the Pleistocene sediments in the approximately 90 square miles comprising the Salisbury area. Probably less than one-half of the water in storage could be removed by pumping. Nevertheless, these sediments constitute an extensive usable reservoir for the storage of water. Although some water is removed from storage during pumping operations, the total average annual use of water, from both ground and surface sources, is only 0.5 percent of the total water estimated to be stored in the Pleistocene deposits.

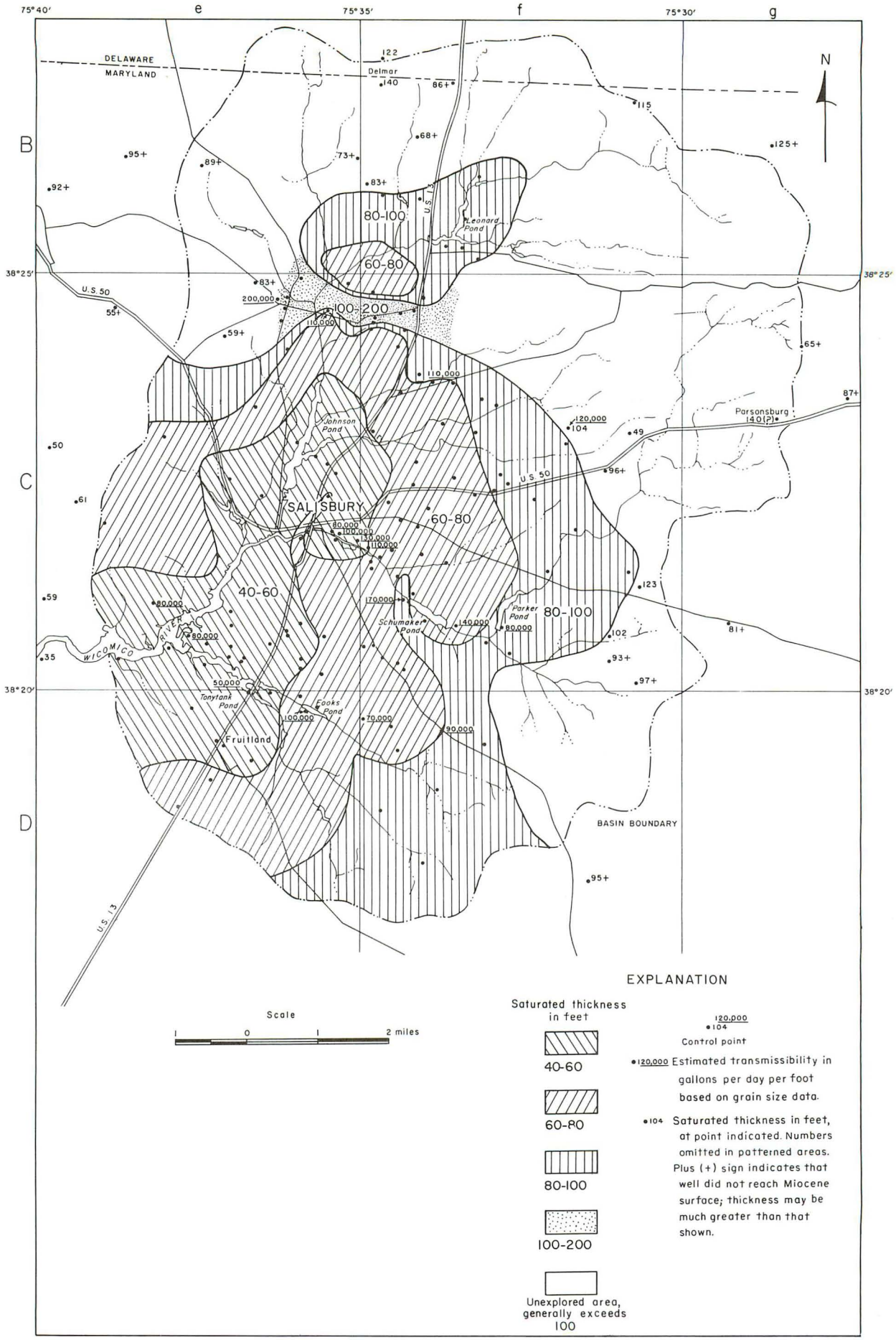

Figure 9—Map of the Salisbury area showing the saturated thicknesss of the Pleistocene sediments and estimated transmissibility at selected points.

Under normal conditions the amount of water in storage varies, depending on the relative quantities of water being discharged from, and recharged to the aquifer at any given time. A decline of the water table averaging 1 foot throughout the area would decrease the amount of water in storage by about 6 billion gallons. Water-table fluctuations of a few feet occur seasonally, but over a long period of time the quantity of water in storage does not tend to change significantly. Rasmussen and Andreasen (1959) report that the amount of ground-water recharge in the Salisbury area is about equal to the losses from the system, and, further, that the losses are about equally divided between the ground-water evapotranspiration and the ground-water discharge to the streams in the basin. Some ground water is lost through leakage to the underlying artesian aquifers, although this may be largely offset by water gains from artesian aquifers in other parts of the basin.

The quantity of water that may be obtained from these sediments by pumping without permanently depleting the amount of water in storage is of basic interest in this report. This quantity, the perennial or safe yield of the formation, is limited by the quantity of water that is available for recharge of the aquifer. Based on the average ground-water recharge of about 50 percent of the precipitation as determined by Rasmussen and Andreasen (1959, p. 98) for the Beaverdam Creek basin, and the average annual precipitation of 46 inches measured at Salisbury, recharge to the Pleistocene sediments averages nearly 38 billion gallons of water per year. This represents a recharge rate of about 1.1 mgd per square mile. However, as indicated in figure 10, recharge to the aquifer from precipitation is not evenly distributed throughout the year. Most recharge occurs during the fall and winter months when evapotranspiration losses are low.

Coordinated development of water supplies from the Salisbury Formation might significantly increase the perennial yield from it. For maximum benefit an aquifer must be of sufficient thickness to provide sufficient storage of water to withstand relatively long periods of little or no recharge. In places where the water table is near the land surface, as near ponds, streams, or other low lying areas, water may be recovered by pumping that otherwise would have discharged to the atmosphere by evaporation or transpiration, or to the stream. Where the bed

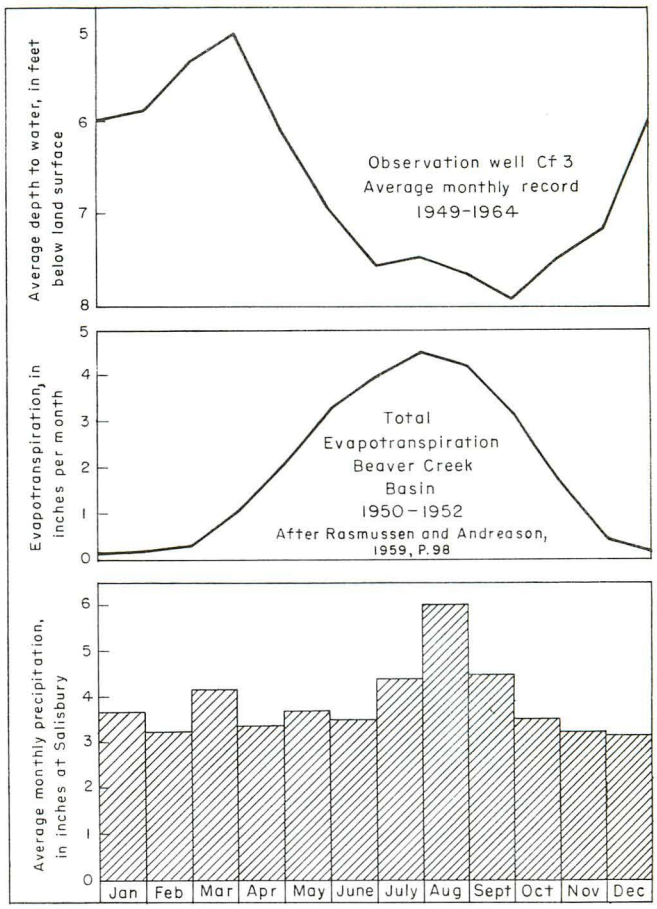

Figure 10—Graph showing the relationship between average precipitation, evapotranspiration, and ground-water levels.

of the pond or stream is sufficiently permeable, additional water that would have been discharged as surface runoff may be salvaged by reversing the normal hydraulic gradient. In these cases water can move from the surface source to the well instead of in the other direction. Lowering of water levels in the formation also creates storage space for additional recharge from precipitation which is normally rejected when the aquifer is full or overflowing.

The perennial yield by pumping from the Pleistocene sediments is related to the quantity of water that may be diverted from natural discharge. If all of the naturally discharging water could be captured by pumping, the perennial yield would equal the recharge rate or about 1.1 mgd per square mile. This obviously is not feasible because it would require a system of closely spaced and continuously pumped wells throughout the basin. In the 19-square mile Beaverdam Creek basin, it was estimated that about 300,000 gallons per day per square mile was available

Table 3. Description of major chemical constituents in natural water of average composition compared to water from the Pleistocene sediments in the Salisbury area.
(Concentrations in parts per million)

Constituent	Concentration in natural water of average composition	Effect upon usability of water	Water from Pleistocene sediments in Salisbury area				Recommended limit Drinking Water Standards, 1962
			No. sampled	Max.	Min.	Avg.	
Silica (SiO_2)	Ranges generally from 1.0 to 30 ppm, although as much as 100 ppm is not uncommon.	Forms hard scale in pipes and boilers. Silicates have been used as coagulants and corrosion inhibitors in water treatment.	29	30	6.4	21	None
Iron (Fe)	Generally less than 0.50 ppm in fully aerated water. Ground water having a pH less than 8.0 may contain 10 ppm; rarely as much as 50 ppm may occur. Most troublesome constituent of ground water in Salisbury area.	More than 0.1 ppm precipitates after exposure to air; causes turbidity, stains plumbing fixtures, laundry, and utensils and gives objectionable tastes and colors to foods and drinks. More than 0.2 ppm is objectionable for most industrial uses.	40	5.5	.00	.42	0.3
Manganese (Mn)	Generally 0.20 ppm or less. Ground water and acid mine water may contain more than 10 ppm. Normal concentration in alkaline waters only a fraction of iron concentration.	More than 0.2 ppm precipitates upon oxidation; causes undesirable tastes; deposits on foods during cooking; stains plumbing fixtures. Most industrial users object to water containing more than 0.2 ppm.	22	.09	.00	.02	0.05
Calcium (Ca)	Wide variations in concentration depending on area and rock type drained. Water from limestone may contain more than 160 ppm; water in contact with gypsum frequently contains 600 ppm.	Calcium and magnesium combine with bicarbonate, carbonate, sulfate, and silica to form scale in boilers and other heat-exchange equipment. Calcium and magnesium cause most of the hardness and scale-forming properties of water. At high concentrations magnesium salts have a laxative effect.	28	7.8	1.2	4.5	None
Magnesium (Mg)	Wide range of concentration in natural waters. As much as 50 ppm common in waters from magnesian limestones. Ratio of Mg/Ca is 3.1 in ocean water; Increase of Mg/Ca ratio may indicate sea-water intrusion.		28	2.5	.5	1.1	None
Sodium (Na)	Concentrations of 1 ppm possible in dilute waters of humid areas. Ocean water contains about 10,000 ppm.	Sodium and potassium salts may cause foaming in boilers, and a high sodium content may limit the use of water for irrigation. Potassium in low concentrations is essential in plant nutrition.	28	15	4.5	7.7	None
Potassium (K)	Proportion of potassium to sodium may be nearly 1 to 1 in waters low in dissolved solids. Concentration of potassium usually 10 ppm or less in ground water.		28	4.2	1.1	1.8	None
Bicarbonate (HCO_3) and Carbonate (CO_3)	Concentrations of bicarbonate usually less than 500 ppm, but may exceed 1,000 ppm in water highly charged with carbon dioxide. Carbonate not found in water with less than 8.2 pH and not reported in Salisbury area samples.	Bicarbonate and carbonate cause alkalinity. Bicarbonates of calcium and magnesium decompose in hot water facilities to form scale and release carbon dioxide. In combination with calcium and magnesium cause carbonate hardness.	30	25	3	13	None
Sulfate (SO_4)	Usually less than 1,000 ppm, except in streams and wells affected by mine drainage. Sulfate dissolved from rocks containing gypsum.	Water containing about 500 ppm tastes bitter. Sulfate combines with calcium to form a hard scale in boilers.	30	39	.2	4.6	250
Chloride (Cl)	Present in all natural waters. Usually less than 10 ppm in humid regions. Chloride content of sea water about 19,000 ppm.	Concentrations exceeding 100 ppm usually give a salty taste. Large quantities increase corrosiveness of water.	32	23	0	7.0	250
Fluoride (F)	Concentrations usually less than 10 ppm in ground water and 1.0 ppm in surface water.	Concentrations between 0.6 and 1.7 ppm are beneficial in reduction of dental decay in children. Excessive fluoride in drinking water causes "mottled enamel" in children's teeth.	27	.2	.0	.03	Recommended control limits depend upon annual averages of max. daily air temp. and range from 0.6 to 0.8 ppm at 79.3° to 90.5°F and 0.9 to 1.7 ppm at 50.0° to 53.7°F.
Nitrate (NO_3)	Seldom as much as 5 ppm in unpolluted surface waters, but concentrations in ground water of nearly 1,000 ppm have been reported.	For irrigation, nitrates in general are desirable for fertilizing value. Concentration much higher than local average may suggest pollution. High nitrate concentration reportedly causes infant methemoglobinemia.	30	29	.0	9.2	45 In areas in which nitrate content is known to be above 45 ppm the public should be warned of potential danger of using water for infant feeding.
Dissolved Solids	Natural waters in areas of high precipitation may contain 30 ppm or less. Brines, however, may have 300,000 ppm or more. Ocean water contains about 35,000 ppm.	Dissolved solids can cause foaming in boilers. Limiting concentrations for industrial use vary from 50 ppm to 1,000 ppm depending upon special requirements.	31	114	33	72	500

from the Pleistocene sediments (Rasmussen and others, 1955, p. 198). If this is assumed to be representative throughout the Salisbury area, the perennial yield would be about 27 mgd from the 90 square miles comprising the basin.

However, from consideration of the many factors affecting the availability of water from these sediments, it is concluded that with intensive development, the perennial safe yield from this formation may average nearly 500,000 gpd per square mile, or about 45 mgd for the entire basin. There are some areas within the basin in which these withdrawal rates may not be achieved; however, in other areas these rates may be exceeded. For example, long-term pumpage of 2 to 3 mgd from an area of roughly 1 square mile in the Salisbury municipal well field has shown no adverse effects on water levels in the aquifer. Moreover, even larger quantities of water are expected to be withdrawn from the thick channel deposits in the Naylor Mill paleochannel without any adverse effects.

Quality of water: Chemical analyses of water from the Pleistocene Series in the Salisbury area show that, with the exception of iron, the concentrations of the major constituents are sufficiently low for the water to be of acceptable quality for most uses without extensive treatment. The chemical constituents usually found in water are silica, iron, manganese, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, fluoride, and nitrate. For all practical purposes, the sum of these constituents constitutes the total dissolved solids in the water. The reported quantity of dissolved solids is determined by evaporating a sample of water and weighing the residue after heating for 1 hour at 180°C.

The concentrations of the constituents usually found in natural water of average composition, the significance of their occurrence, and the range and average values in ground water from the Pleistocene sediments in the Salisbury area are given in table 3. The chemical analysis of water from wells in the Salisbury area is given in table 4.

The nitrate content of the water in the Salisbury Formation is of interest because it is above average for most ground water. The average concentration in samples from this area of about 9 parts per million (ppm) is, however, far less than the recommended maximum limit of 45 ppm. The occurrence of more than the average amount of nitrate is probably the result of percolation of waters through soil that has been repeatedly fertilized. The occurrence of this constituent is too widespread to indicate any other source of contamination.

In the Salisbury area, concentrations of silica as shown in table 4 are in the same range as those found in most natural waters. Silica is usually removed from feed water for high pressure boilers because it contributes to formation of boiler scale.

Another constituent of special interest is the fluoride ion. No significant quantities of fluoride are in the ground water of the Salisbury area. Therefore, additional fluoride is necessary to raise the content to the recommended optimum level of 0.9 ppm, based on an annual average maximum daily air temperature of 68°F.

Water quality in the Salisbury Formation in the area north of the paleochannel is represented by the analysis for well Be 22 in table 4, which shows a very low iron content of 0.03 ppm. The quality of water in the Naylor Mill paleochannel is represented by the analyses for wells Cf 129 and Cf 130. A concentration of 0.37 ppm iron was measured by Penniman and Browne, a commercial laboratory, and an analysis by the Geological Survey on another sample showed 0.02 ppm of iron.

Concentrations of iron in ground water in the Salisbury area vary widely as shown in figure 11. Concentrations of iron ranged from 0.00 to 5.5 ppm in water samples from 40 Pleistocene wells in the area. A water sample from one well, De 18 just outside the project area, was collected and analyzed in 1947 and found to contain 15 ppm of iron.

The iron content of samples from the Salisbury Formation is generally less than that from the underlying Manokin aquifer in the Salisbury area. Generally, objectionable concentrations of iron can be readily removed from the water by proper treatment. The chemistry of iron in natural water is very complex, and the conditions under which iron occurs in the Salisbury municipal well field is discussed in the section entitled the "Salisbury municipal well field".

Other properties of water that determine its acceptability for withdrawal uses are hardness, total dissolved solids, acidity, and color. Hardness is caused principally by calcium and magnesium ions and hard water requires excessive amounts of soap or other detergents in home or industrial use. Hardness of water is no problem in the

Table 4. Chemical analyses of water from wells in Salisbury area.

(Chemical constituents in parts per million. Aquifer or formation: S, Salisbury Formation of Hansen (1966); M, Manokin Aquifer; Y-C, Yorktown-Cohansey Formation; S-N, Salisbury Formation-Naylor Mill Paleochannel.)

Date of collection	Well Number (Wi-)	Aquifer or formation	Water Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color
4/28/64	Be 22	S	56	22	0.03	0.00	2.2	0.4	7.0	1.1	10	0.2	5.2	0.0	8.7	61	7	0	57	6.3	--
11/29/62	Ce 2	S	61	22	.19	.01	7.8	1.1	8.4	2.1	16	7.8	8.0	.0	15	80	24	11	109	6.4	5
2/7/63	Ce 6	S	58	21	.26	.04	5.0	1.0	6.7	1.6	10	4.0	6.8	.0	13	69	16	9	81	6.7	0
3/24/64	Ce 97	S	58	23	.04	.00	5.9	1.3	9.5	1.9	10	.0	9.5	.0	27	103	20	12	112	6.3	--
2/7/63	Ce 100	S	58	15	.05	.04	7.8	1.8	8.3	1.7	24	6.2	6.6	.0	13	80	27	8	109	6.4	2
3/23/64	Ce 102	S	--	21	1.1	.01	1.2	.7	4.5	1.6	3	11	2.8	.0	.0	52	6	4	49	5.7	--
2/6/63	Ce 111	S	58	30	.13	.00	3.5	1.3	6.3	1.8	17	7.0	3.7	.1	2.7	68	14	0	68	6.2	0
2/6/63	Ce 112	S	58	25	.21	.02	4.0	.7	7.8	1.2	15	2.0	5.6	.0	10	68	13	1	73	6.4	0
3/23/64	Ce 115	M	58	21	.97	.01	1.2	.7	4.3	1.6	3	11	2.8	.0	.0	48	6	4	47	6.3	--
3/24/64	Ce 118	S	57	16	.05	.00	5.4	1.1	7.9	2.0	9	.2	8.5	.0	23	88	18	11	98	6.3	--
3/24/64	Ce 140	S	53	15	.18	.00	2.8	1.2	7.4	3.0	13	.2	7.6	.0	20	77	12	2	95	6.4	--
3/24/64	Ce 142	Y-C	57	31	2.6	.01	1.5	1.6	5.9	2.0	9	16	3.4	.0	.0	69	10	3	72	6.7	--
11/28/62	Cf 64	S	58	21	.16	.09	5.2	.7	7.4	1.9	[a]/6	6.8	6.1	.0	12	70	16	11	85	[a]/6.0	0
11/29/62	Cf 65	S	58	19	.22	.00	4.5	.5	6.8	1.7	[a]/6	3.6	5.6	.1	11	62	13	8	74	[a]/6.3	5
2/7/63	Cf 66	S	58	22	.03	.00	7.5	1.7	8.4	1.7	16	4.6	6.6	.0	21	86	26	12	109	7.1	0
2/7/63	Cf 71	S	58	20	.00	.02	5.2	1.6	8.5	2.5	10	7.8	7.1	.0	18	80	20	11	100	5.9	0
11/29/62	Cf 73	S	--	23	.02	.02	5.0	.6	6.8	1.7	[a]/7	4.4	6.1	.0	12	70	15	9	80	[a]/6.1	10
3/27/63	Cf 74	S	--	29	.94	.05	3.0	.9	5.9	1.7	14	8.2	4.7	.0	.3	62	11	0	60	6.0	0
2/7/63	Cf 75	S	58	26	.04	.00	3.0	.4	6.2	1.5	12	2.4	4.3	.0	5.9	60	9	0	58	6.2	0
11/14/62	Cf 77	M	58	38	7.3	.23	9.0	1.8	10	1.5	60	.4	4.4	.1	.2	112	30	0	112	6.6	60
11/28/62	Cf 78	M	58	38	4.9	.00	9.5	1.2	9.9	1.5	[a]/87	0.0	3.4	.1	.0	92	28	0	111	[a]/6.8	5
3/24/64	Cf 88	S	57	22	2.2	.00	4.6	1.3	9.9	1.4	20	1.0	6.5	.0	16	86	17	1	99	6.4	--
3/24/64	Cf 93	S	57	22	.03	.00	2.5	.7	6.9	1.8	12	.2	5.1	.0	14	64	9	0	72	6.6	--
3/24/64	Cf 115	S	54	26	.24	.01	5.4	1.1	9.7	1.5	12	.4	8.1	.0	26	98	18	8	108	6.4	--
3/23/64	Cf 129-130	S-N	60	30	.02	.04	3.7	1.2	8.2	1.1	25	.4	5.5	.0	4.2	68	14	0	78	6.4	--
3/27/63	Cf 160	S	--	24	.07	.02	4.0	1.0	8.6	1.7	24	.6	7.4	.0	13	76	14	0	96	6.4	0

a/ Field determination.

Salisbury area. All of the water samples analyzed from the area have contained less than 30 ppm hardness. Hence, the water is within the range described as soft, (0 to 60 ppm). In fact, the lack of hardness might contribute to the potential corrosion of metallic surfaces by the water.

The total dissolved solids in water are indicated by the specific electrical conductance of the water sample. Specific conductance can be easily and accurately determined. The dissolved solids (in ppm) in most natural waters is commonly about 65 percent of the conductance (in micromhos at 25°C), but in the Salisbury area the percentage is usually higher. Higher than normal ratios of dissolved solids to conductance are common in water that contains undissociated substances reported as part of the dissolved solids. Highly colored waters are diagnostic of this type, but the color is negligible in most ground water of the Salisbury area.

The acidity of water is expressed as pH units within the limits of 0 (extremely acid) to 14 (extremely alkaline or basic). The pH of most natural waters is between 5.0 and 8.0 and the pH of samples obtained in this study from the Salisbury Formation ranged from 5.4 to 7.1, fully within the range of average values. However, the water from most wells is slightly acid.

The calcium carbonate saturation index can be used to define scale-forming tendencies or corrosive properties of water more directly than the pH determinations alone. This index developed by Langelier (1936) is an indication of instability with respect to calcium carbonate deposition and solution, and can be defined as the difference between the actual pH of a sample and its computed pH_S. The term pH_S or pH saturation is the pH at which water of a given calcium content, alkalinity, and temperature is in equilibrium with solid calcium carbonate. A negative index indicates a water may be corrosive as contrasted to a positive index which can indicate a water is scale forming. Red water problems are often the result of corrosion of iron in the distribution pipes, and such corrosion can be prevented by adjusting the chemical balance of the water. Computations by Heidel and Otton (1963) indicated a negative index ranging from 3.1 to 3.9 for four municipal wells in Salisbury, and a negative index of more than 2 for finished water. These results indicate that care is needed when using ground water from the Pleistocene Series in the Salisbury area to neutralize the corrosiveness of the water supply.

Salisbury municipal well field: The municipal water supply for Salisbury in 1965 was obtained from a series of 15 large-diameter wells constructed in the Salisbury Formation. The location of production wells, and other wells in the area are shown on figure 3. The production wells, spaced along a 0.9-mile reach of the lower part of Beaverdam Creek in the Municipal Park, have a total rated capacity of about 7,600 gpm if pumped individually. However, because of limited pump capacities, transmission-line pressures, and interference between wells, the estimated combined yield of these wells was about 6,200 gpm (8.9 mgd) in 1965.

Maximum pumpage from this well field in 1964 was about 4.0 mgd, with a daily average of 2.4 mgd for the year. Based on the trend in maximum water use for the period 1961–1964, following the installation of universal metering, the daily water demands will not fully utilize the existing facilities for many years. However, several unpredictable factors are involved; the trend in water use may change rapidly over a relatively short period of time; or deterioration of wells as experienced in the past (table 5) might lower the production capacity of the present well system. This latter problem could be largely offset by a carefully planned maintenance program designed to keep the wells in peak operating condition.

In Salisbury's municipal well field decreasing yields of some wells have been related to precipitated iron compounds that clogged well screens and the aquifer adjacent to the well screens. During a study of 15 production wells in this field, the concentrations of iron were found to range from 0.00 to 1.1 ppm in 50 determinations. As indicated in table 6, random variations with time occurred in wells that were sampled repeatedly. Some wells, particularly the older ones in the well field, consistently yielded water with higher iron concentrations than newer wells at the east end of the field.

Each production well was sampled from two to five times during 1962–63, and in only 1 well (Cf 71), was iron absent from every sample. The average iron content, based on the last observation at each of the wells was 0.22 ppm. The iron concentration in most of the wells was

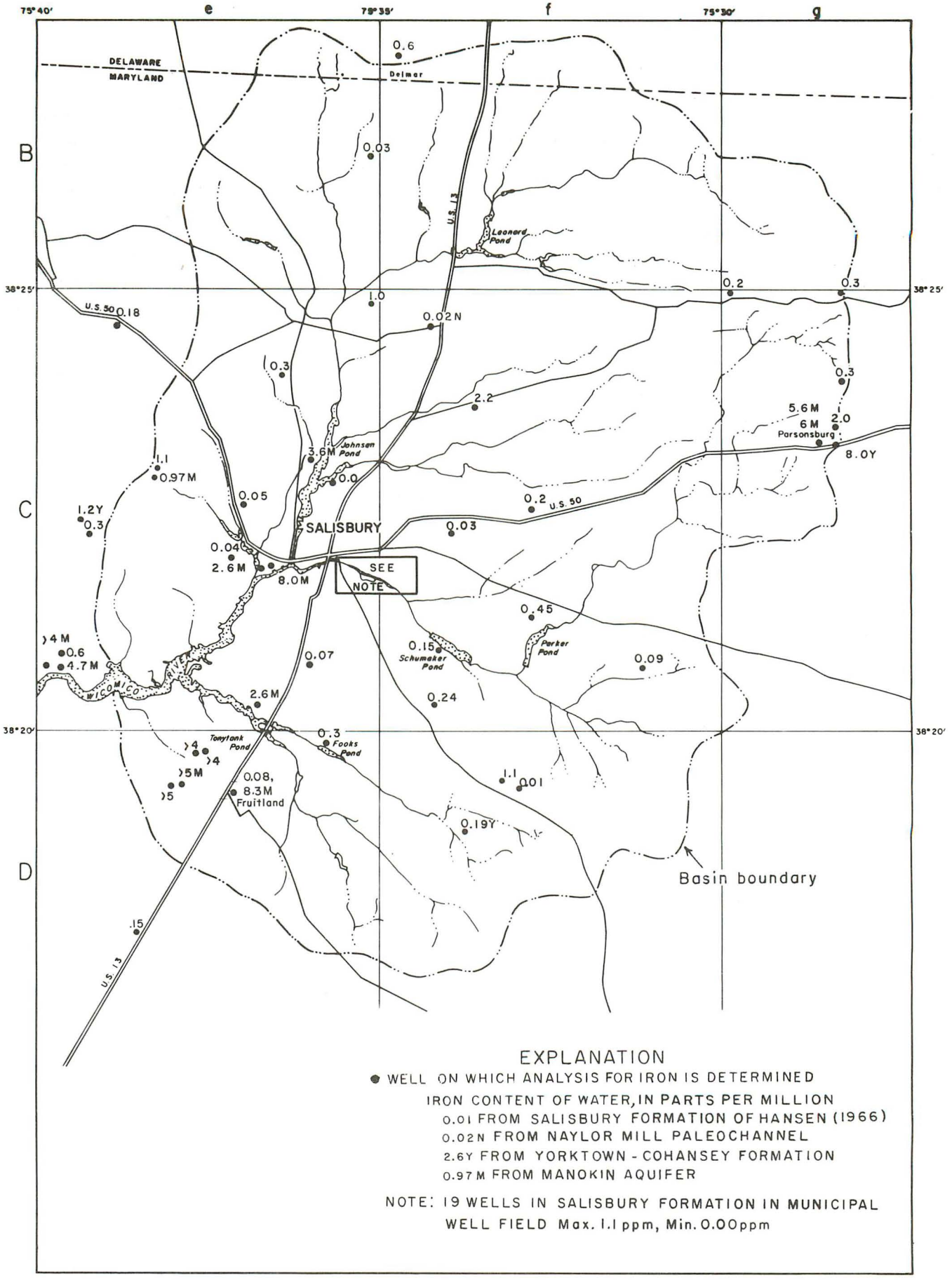

Figure 11—Map of the Salisbury area showing iron concentration in ground water.

Table 5. Summary of specific capacity test data, Salisbury well field.

Well No. City	Well No. State	Date	Length of test (min.)	Static water level (msl)	Pumping water level (msl)	Draw-down (ft.)	Average pumping rate (gpm)	Specific capacity (gpm/ft.)	Reported previous specific capacity and date (gpm/ft.)	Well efficiency/1 1963 (percent of original)
1	Ce 1	10/9/63	240	+3.62	-34.80	38.42	140	3.6	43?(1925),10(1955)	8(?)
2	Ce 2	10/7/63	245	3.33	29.81	33.14	405	12.2	56?(1925),30.3(1951)	22(?)
4	Ce 4	10/4/63	91	2.87	36.64	39.51	90	2.3	35?(1925),18.5(1951)	7(?)
4A	Ce 168	12/17/64	540	3.07	26.71	29.78	576	19.3		
5	Ce 5	10/8/63	120	3.51	24.05	27.56	162	5.9	36(1925),32.3(1951)	16
5A	Ce 169	12/10/64	1380	4.42	24.11	28.53	880	30.8		
6	Ce 6	10/11/63	481	3.19	34.36	37.55	335	8.9	22(1936),12.7(1951)	40
7	Ce 7	10/14/63	448	4.08	34.26	38.34	717	18.7	32(1937),21(1951)	58
7A	Ce 170	12/28/64	1415	4.33	27.51	31.84	1254	39.4		
8	Ce 8	10/15/63	459	3.97	28.94	32.91	726	22.1	31(1945)	71
9	Ce 99	10/16/63	398	4.75	32.01	36.76	112	3.0	24.4(1950)	13
10	Cf 64	10/17/63	472	5.44	32.18	37.62	355	9.4	25.0(1950),13.1(1958)	38
10A	Cf 145	12/19/64	1425	5.13	22.13	27.26	580	21.3		
11	Cf 65	10/18/63	450	6.40	31.85	38.25	344	9.0	18.2(1951),18(1955)	50
12	Cf 66	10/21/63	450	4.65	35.84	40.69	376	9.2	25.8(1951),20.0(1955)	36
13	Ce 100	10/22/63	487	4.54	29.50	34.04	306	9.0	18(1949),13.9(1951)	50
14	Cf 71	10/24/63	260	6.5	26	32.5	738	23	32(1957),25.3(1959)	72
15	Cf 72	10/24/63	434	5.77	30.72	36.49	473	13.0	14(1957),13.6(1959)	92
16	Cf 73	10/23/63	454	6.38	20.99	27.37	425	15.5	18(1957),18(1958)	86

/1 Derived by comparison of 1963 specific capacity with highest previously reported specific capacity, which was assumed to represent 100 percent efficiency. Reduction in specific capacity is largely related to incrustation and clogging of well screens.

such that some treatment is required prior to use for most purposes.

The erratic occurrence of iron in the ground water in the Salisbury area may be explained by unstable conditions in the aquifer. Iron usually occurs in one of two ionic states, the ferrous state, designated by the symbol Fe^{+2}, and the ferric or oxidized state shown by the symbol Fe^{+3}.

Ground water is not in contact with the atmosphere and may attain a low Eh (oxidation-reduction potential), very low dissolved oxygen, and high ferrous iron content. Water in contact with air attains a higher Eh and dissolved-oxygen content, and loses its capacity to retain ferrous iron in solution. In the Salisbury wells listed in table 6 appreciable concentrations of dissolved oxygen and ferrous iron occur and reflect the unstable condition existing in the aquifer. Most concentrations of ferrous iron were determined immediately after collection. These results are more reliable and representative of

Table 6. Dissolved oxygen and iron concentrations in Salisbury well field.

Well No.		Date	Dissolved oxygen (ppm)	Iron			Hours pumped before sampling
City	U.S.G.S.			Field (F) or Laboratory (L)	Fe^{+2} (ppm)	Fe (total) (ppm)	
1	Ce 1	12/ 4/62	7.2	F	0.46	0.51	----------
		6/19/63	8.5	L	.30	.50	----------
		10/ 9/63	----------	L	----------	.71	4
2	Ce 2	11/29/62	6.6	L	.14	.19	----------
		12/ 4/62	6.7	F	.17	.19	----------
		6/19/63	7.2	L	----------	.31	----------
		9/27/63	5.9	L	----------	.16	----------
		10/15/63	----------	L	----------	.22	>8
4	Ce 4	12/ 4/62	5.4	F	.11	.14	----------
		6/19/63	6.2	L	.03	.08	----------
		9/27/63	5.9	L	----------	.55	----------
		10/ 4/63	----------	L	----------	.56	4
5	Ce 5	12/ 4/62	7.9	F	.42	.45	----------
		6/19/63	8.5	L	----------	.66	----------
		10/ 8/63	----------	L	----------	.49	1½
6	Ce 6	12/ 4/62	7.5	F	1.0	1.1	----------
		2/ 7/63	6.9	L	.26	.26	----------
		10/11/63	----------	L	----------	.35	7
7	Ce 7	12/ 5/62	8.5	F	.00	.02	----------
		10/14/63	----------	L	----------	.08	7½
8	Ce 8	12/ 4/63	8.0	F	.06	.09	----------
		6/19/63	7.0	L	----------	.10	----------
		9/27/63	6.3	L	----------	.86	----------
		10/15/63	----------	L	----------	.19	5½
9	Ce 99	12/ 5/62	7.9	F	.00	.00	----------
		10/16/63	----------	L	----------	.08	----------
10	Cf 64	11/28/62	5.4	L	.12	.16	----------
		12/ 5/62	6.5	F	.08	.11	----------
		10/17/63	----------	L	----------	.17	7½
11	Cf 65	11/29/62	7.8	L	.06	.16	0
		11/29/62	7.9	L	.10	.13	½
		11/29/62	7.9	L	.18	.22	1
		12/ 5/62	7.9	F	.17	.20	----------
		10/18/63	----------	L	----------	.06	7
12	Cf 66	12/ 5/62	7.6	F	.00	.03	----------
		2/ 7/63	6.5	L	.02	.03	----------
		10/21/63	----------	L	----------	.04	7½
13	Ce 100	12/ 5/62	4.1	F	.03	.10	----------
		2/ 7/63	3.7	L	.05	.05	----------
		10/22/63	----------	L	----------	.11	7
14	Cf 71	12/ 5/62	5.2	F	.00	.00	----------
		2/ 7/63	6.9	L	.00	.00	----------
		6/19/63	7.0	L	.00	.00	----------
15	Cf 72	12/ 5/62	8.6	F	.04	.07	----------
		6/19/63	8.3	L	.00	.05	----------
		10/24/63	----------	L	----------	.24	7
16	Cf 73	11/29/62	7.7	L	.00	.02	----------
		12/ 5/62	7.7	F	.00	.00	----------
		6/19/63	7.2	L	.00	.02	----------
		10/23/63	----------	L	----------	.03	7
TH-1	Cf 74	2/ 6/63	1.8	L	.80	.82	----------
TH-2	Cf 75	2/ 7/63	7.5	L	.04	.04	----------
TH-3	Ce 111	2/ 6/63	2.4	L	.13	.13	----------
TH-4	Ce 112	2/ 6/63	7.5	L	.17	.21	----------
TH-6	Cf 77*	11/14/62	----------	L	----------	7.3	----------
TH-7	Cf 78*	11/28/62	0	L	4.7	4.9	----------
Reservoir at City water plant.		12/ 5/62	10.6	F	.00	.04	----------
Beaverdam Creek opposite well No. 10.		11/28/62	10.7	L	.19	.28	----------
		12/ 4/62	9.2	F	.02	.13	----------
		12/ 5/62	10.9	F	.01	.12	----------

*In Manokin aquifer.

actual conditions than analyses of samples that had to await transportation to the laboratory. However, the samples for laboratory determination of ferrous iron were treated specifically to stabilize them and minimize chemical change.

Determination of dissolved oxygen at specific depths in the large production wells is not practical because water enters along a 20- to 30-foot length of screen. However, in test wells having short lengths of screen, an inverse relation to dissolved oxygen is indicated.

Test hole No.	Depth of screen below water table (feet)	Dissolved oxygen (ppm)	Ferrous (Fe^{+2}) iron (ppm)
2	42	7.5	0.04
4	54	7.5	.17
3	58	2.4	.13
1	63	1.8	.80

All four of these test wells were drilled into the Salisbury Formation. The permeable sandy soil of the area allows a fairly rapid recharge of water containing large amounts of dissolved oxygen. At greater depths below the water table the amount of available oxygen was less, and more ferrous iron was measured.

Water similar to that from the Salisbury well field frequently has been treated by using polyphosphates that promote a chemically balanced supply and prevent scale formation at undesirable points. To be effective, the chemicals must be added before the iron in solution is oxidized because the polyphosphates combine only with iron in the ferrous state. This treatment is complicated by the fact that polyphosphates are a good source of phosphorus for bacteria; thus polyphosphate use is supplemented with chlorination. Iron-precipitating bacteria can also contribute to the clogging of well screens and discharge lines. Evidence of bacteria in the Salisbury municipal wells was found by Dr. C. E. Renn of the Department of Sanitary Engineering, Johns Hopkins University. By means of microscopic examination of iron oxide material deposited in the discharge line of well Ce 7, Dr. Renn identified numerous slime sheaths from various species of iron bacteria. The Maryland State Department of Health made confirmatory analyses of bacteria in wells Cf 64 and Cf 65.

Recharge to the aquifer in the vicinity of the Salisbury well field is from two sources. Infiltration from precipitation recharges the sediments throughout the year. This has been established from observation wells in the area, which show rising water levels following moderate to heavy precipitation. A second source of recharge is derived from Beaverdam Creek by lowering adjacent ground-water levels by pumping, which results in the water moving from the stream to the aquifer. This induced recharge is additive to that available from natural recharge, and therefore is of great importance to the determination of the perennial yield of the aquifer in this area.

The Salisbury Formation in the vicinity of the municipal well field is composed of stratified deposits of coarse, medium, and fine sands. The stratification, or layering of these sediments is illustrated in figure 12. The grain-size characteristics of samples from these, and other test holes in the area are discussed by Hansen (1966).

The principal hydrologic effect of stratification of these deposits is reflected in the wide difference in horizontal and vertical permeability. This allows water to move more readily in the horizontal direction than in the vertical direction. A second feature, having a similar effect on water movement is the occurrence, at shallow depth, of a layer of organic silt that underlies part of the stream bed of Beaverdam Creek throughout much of the length of the present well field, being absent only in those areas where stream scour or dredging has removed it, as seen near the base of the dam on the Upper Pond. It should be noted that this is the same area where the highest well yield in the field was obtained from well Ce 170 (7A).

The differences in vertical and horizontal permeability within the formation are believed to account for many of the observed departures of aquifer characteristics from the basic concept of a water-table aquifer, and consequently has a bearing on the stream-aquifer relationship.

The Salisbury Formation in the vicinity of the municipal well field might be assumed to function primarily as a water-table aquifer for the following reasons: It has an average coefficient of transmissibility of about 100,000 gpd per foot and an average coefficient of storage of about 0.15; water levels in the aquifer rise in direct response to precipitation; and dewatering of the sediments by pumping has been ob-

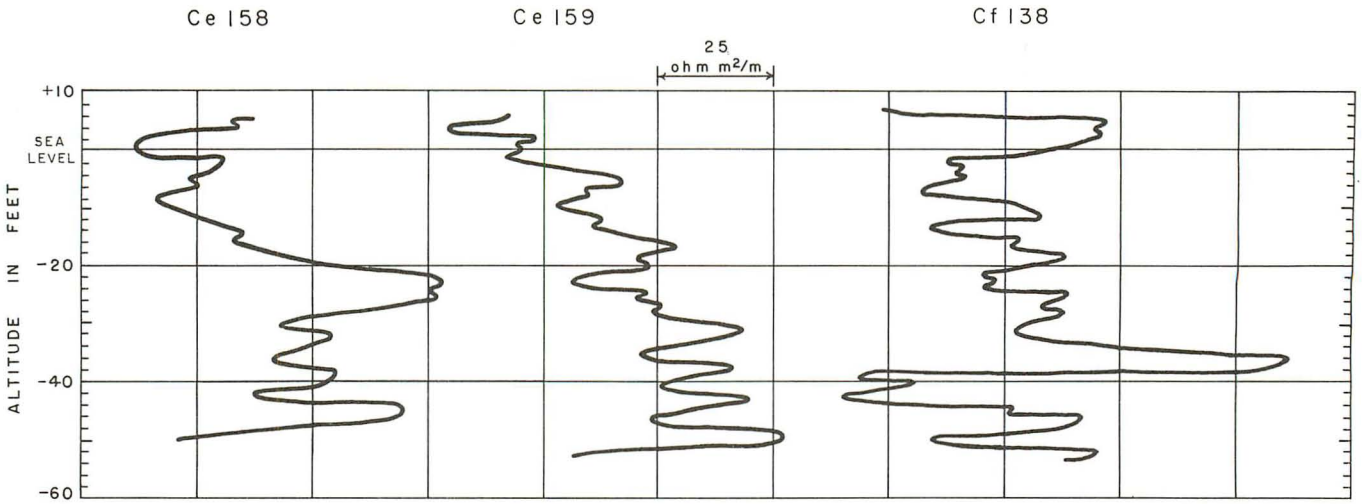

Figure 12—Electric log resistivity curves for test holes Ce 158, Ce 159, and Cf 138 in the Salisbury well field showing stratification of sediments as indicated by variations in resistivity.

served. This assumption of water-table conditions implies that water levels in the aquifer should not respond to pressure fluctuations in the same manner and degree as an artesian aquifer would.

However, aquifer water levels in the municipal well field respond to tidal loading and unloading as indicated in figure 13, which shows the effects of tides in the Wicomico River on water levels in City well 2 (Ce 2). This tidal effect was also observed in City well 3 (Ce 3), which is more than 600 feet from the tidal portion of the Wicomico River. These fluctuations cannot be related to a rise in pond level with high tides, because the variations in pond level were less than 0.1 foot over the period. Additionally in all parts of the well field, water levels in observation wells show an immediate response to starting or stopping of production wells, although the wells may be on opposite sides of the stream and more than 500 feet apart. Such responses are characteristic of artesian aquifers and seemingly indicate the existence of confining or semiconfining layers in the upper part of the Salisbury aquifer. If these effects are attributed to the organic-silt layer in the stream, or other shallow semipermeable layers beneath the stream bed, it appears unlikely that a direct hydraulic connection could exist between the stream and the aquifer. But if these effects can be attributed to the differences in vertical and horizontal permeability in the underlying aquifer, it would suggest that a good hydraulic connection does exist between the stream and the upper portion of the aquifer.

A test designed to show the effect of the stream on ground-water levels in the vicinity of a pumping well was conducted on City well 2 (Ce 2). If the stream had been contributing a large proportion of the pumped water as induced recharge to the well, ground-water levels along the edge of the stream nearest the pumping well would have remained at or slightly below stream level throughout the pumping period. Moreover, ground-water levels on the opposite side of the stream would not have been affected by pumping. As shown in figure 14, ground-water levels near the stream did not remain at or near stream level. The drawdown in each of four observation wells spaced 95 feet from the producing well was 1.91 feet (2A); 2.01 feet (2B); 1.93 feet (2C); and 1.81 feet (2D) after 48 hours of pumping. From these measurements and other data shown on figure 14, it is apparent that the cone of influence around the pumping well was roughly circular in shape; if the stream had been contributing significant quantities of recharge water to the aquifer, some distortion would have been noted. As shown in the N–S cross section on figure 14, the cone of influence of the pumping well extended across the stream, beyond observation well Ce 13. The water level in this well declined 0.93 foot over the pumping period and had not stabilized after 48 hours,

indicating that the cone of influence continued to expand beneath the stream throughout the test. Although the test indicated that recharge from the stream had not been effective in supplying water to the pumping well during this test, it is concluded that the well field pumpage probably diverts some ground water which would otherwise become part of the streamflow.

Discharge measurements made on the stream between Schumaker Pond and City wells 7 and 8 indicate that pumping from the city wells reduced the rate of ground-water discharge to the stream from 2.8 cfs per mile of channel length between Schumaker Pond and City well 16 (non-pumping reach), and to 1.8 cfs per mile of channel between City well 16 and City wells 7 and 8 (pumping reach). This clearly indicates that the city wells do intercept some of the water moving toward the stream, but the stream continues to receive substantial ground-water discharge throughout the pumped reach.

The minimum observed rate of ground-water discharge to the stream in the pumped area was 1.1 cfs per mile of channel. The apparent diversion of ground-water discharge appeared to be about 35 percent of the rate of pumpage.

Naylor Mill paleochannel: The name Naylor Mill paleochannel has been assigned to the unusually thick section of sand and gravel deposits which filled the channel of an ancestral Pleistocene river in the vicinity of the Naylor Mill Road. This paleochannel has been mapped by test drilling over a distance of about 2 miles, between U.S. Route 13 on the east to the Jersey Road on the west. Hansen (1966, p. 18–20) has described the historical sequence of events leading to the development and refilling of this ancestral river channel, and has presented a detailed structure-contour map showing its position and alignment. Hansen's illustration is repeated herein as figure 15, for ease of reference. Assuming that the contours of 75 feet below mean sea level essentially represent the northern and southern limits of the channel, its width would range from about 1,800 feet near U.S. Route 13, to about 4,800 feet near the Jersey Road. Its length is not known, but because of its size, it is assumed to be several miles long.

The maximum thickness of channel-fill sediments encountered during the test drilling program was 230 feet. These materials consist predominantly of medium- to coarse-grained sand

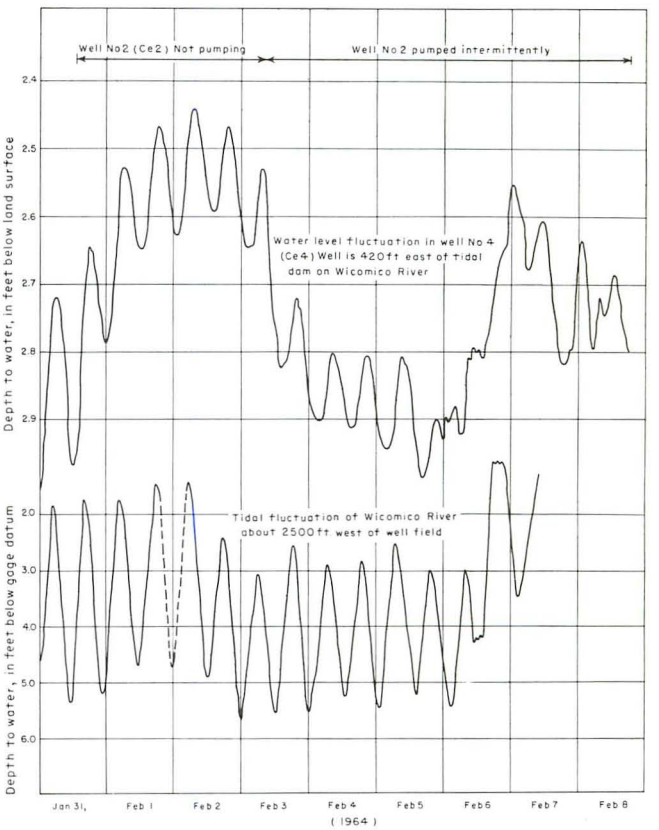

Figure 13—Graph showing effects of tidal fluctuation in the Wicomico River on water levels in City well 4 (Ce 4) and combined effects of tide and pumpage from City well 2 (Ce 2).

and sandy gravel. The sediments near the base of the channel appear to be fine sand reworked from the underlying Manokin aquifer of Miocene age.

Two characteristics of the Pleistocene channel-fill deposits in the Naylor Mill paleochannel are of great significance in terms of potential water yield. One is the total saturated thickness of the deposits and the other is the coarse texture of the materials. The saturated thickness of the sediments near the center of the channel probably exceeds 200 feet throughout most of the length of the mapped channel and the average saturated thickness across the width of the channel generally exceeds the maximum saturated thickness of the Pleistocene sediments in

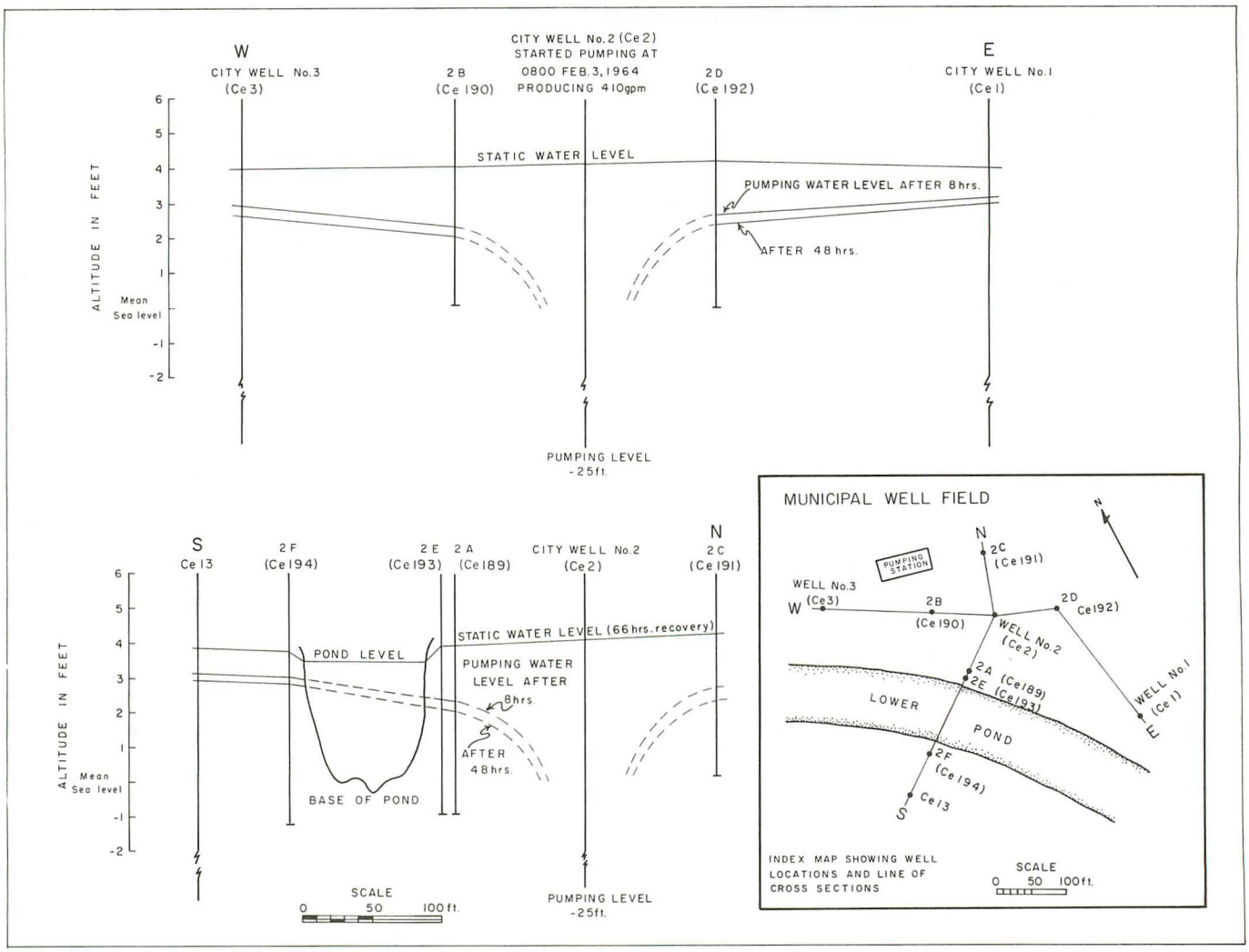

Figure 14—Cross sections of the Salisbury well field showing the effects of pumping City well 2 on water levels in observation wells parallel to the stream (E-W) and across the stream (N-S).

most other parts of the Salisbury area. Moreover, comparison of the drill cuttings from the channel-fill deposits with drill cuttings from other Pleistocene sediments in the area indicates that the channel deposits are generally coarser, but more poorly sorted, than other sediments. However, the zones of coarse sand and gravel in the channel-fill deposits are usually thicker than those elsewhere in the Pleistocene sediments. The combination of the high average saturated thickness, plus the generally thick zones of coarse sediments give indications of potentially high well yields.

Although the installation of high-capacity wells will be required to prove the validity of the above assumption, some indication of the potential well yields is derived by an evaluation of existing wells that produce water from the channel-fill deposits. Pumping tests on wells Cf 129, 130, and 131, drilled for the Eastern Shore Public Service Company in 1957, showed that the wells have specific capacities of 43.6, 54.0, and 49.3 gpm per foot of drawdown, respectively. Theoretically, by using most of the available drawdown in these wells and assuming that the specific capacity does not decrease rapidly as the water level is lowered, the wells could produce 3,000–4,000 gpm. Their actual yield, however, is probably somewhat less than the theoretical yield since the specific capacity generally decreases gradually with time. However, since these wells were constructed at a maximum depth of about 143 feet, thereby limiting the availability drawdown to about 70 to 80 feet, similar wells constructed in deeper parts of the paleochannel would have greater available draw-

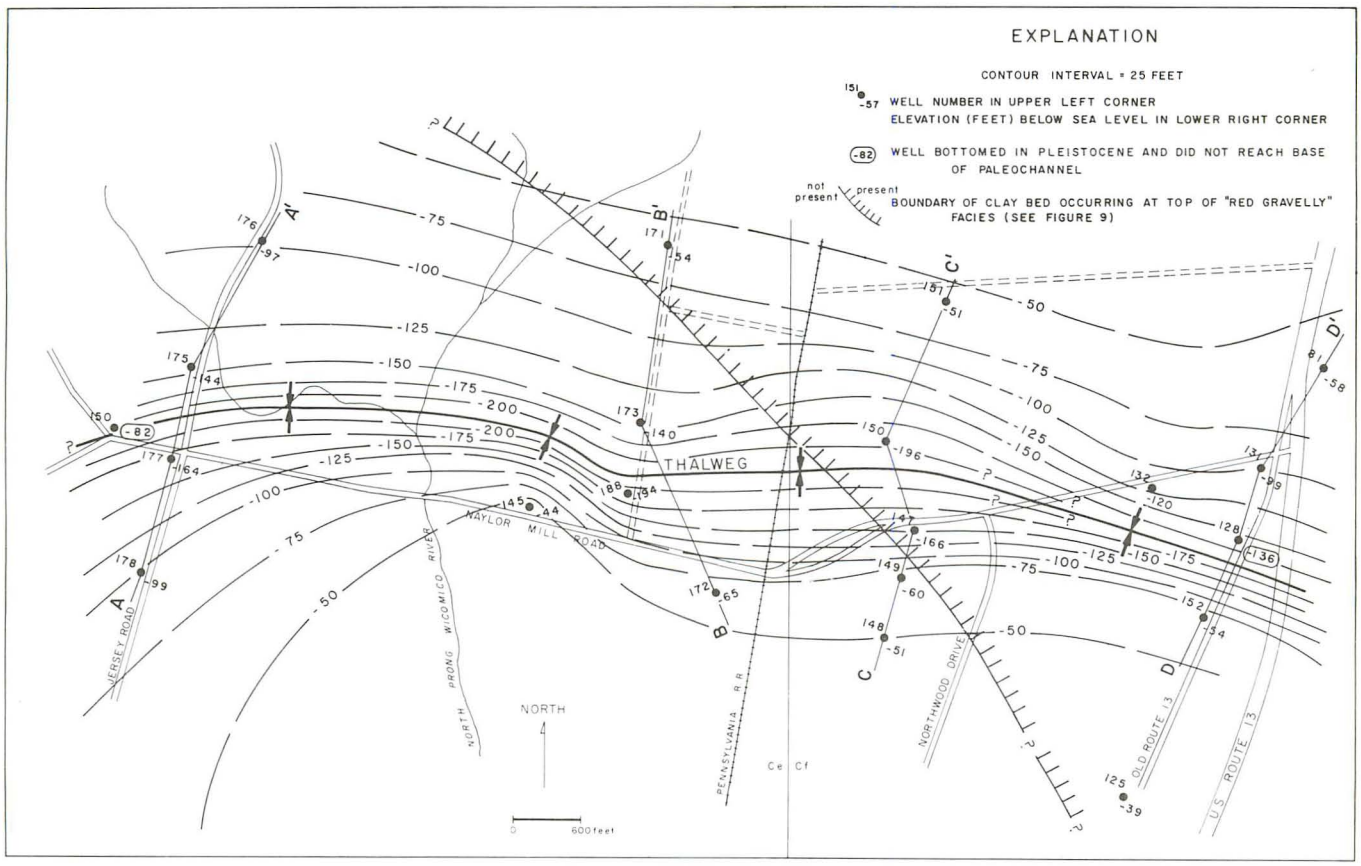

Figure 15—Detailed structure contour map on the base of the Naylor Mill paleochannel.

down. For example, a well constructed near test hole Cf 150, screened in the interval from 175 to 225 feet below land surface, would have a total available drawdown of about 163 feet. Assuming an average specific capacity of 40 gpm per foot of drawdown and using only 100 feet of the available drawdown, the well would yield 4,000 gpm.[1]

As water is developed from the Naylor Mill paleochannel deposits, the possibility exists that changes in water quality will impose some limitation on the quantity available. This limitation could result from the direct hydraulic connection that exists between the Salisbury Formation and the Manokin aquifer along the base and flanks of the paleochannel, as shown in figure 16. The most objectionable characteristic of the water from the Manokin aquifer throughout most of the Salisbury area is the high concentration of iron. Although the water from this aquifer might contain less iron in the subcrop area as indicated by the analysis of water from well Ce 115 (0.97 ppm of iron), well Ce 21 in the Manokin 1.7 miles south of the paleochannel yielded water with an iron content of 3.6 ppm. The Manokin aquifer contains water of similar iron content in the vicinity of the Naylor Mill paleochannel. The possible changes in water quality which could result from heavy pumping are best evaluated by considering the differences in quality of the water in the two aquifers (see the discussions on water quality in this report). The ultimate effects of the hydraulic connection must await more detailed tests and additional hydrologic data.

[1] In 1967 a large-diameter well completed near the center of the Naylor Mill paleochannel yielded as much as 4,200 gpm.

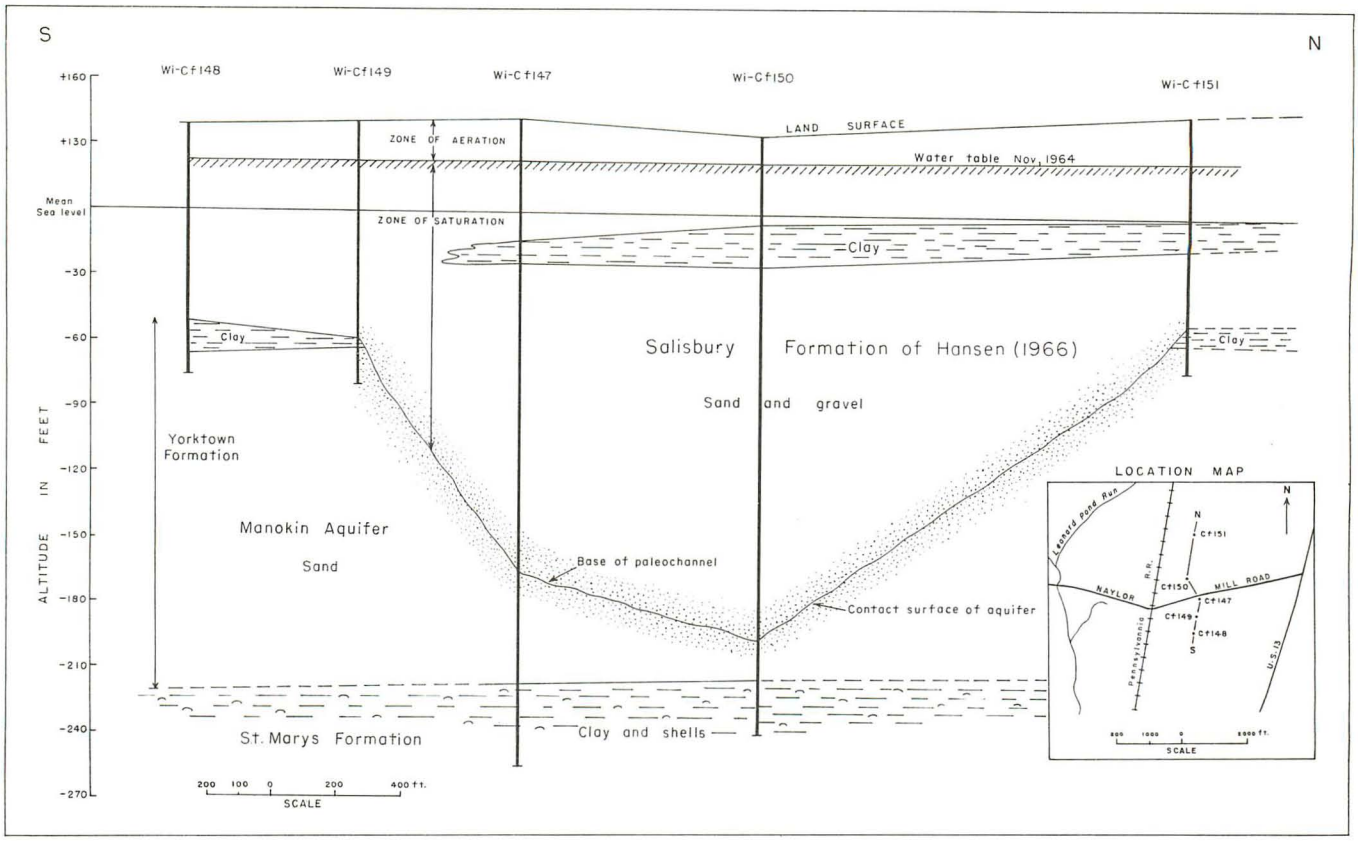

Figure 16—Generalized geologic section of the Naylor Mill paleochannel showing contact zone between the Salisbury Formation and the Manokin aquifer.

Pond and stream areas: The quantity of water available from the Salisbury Formation in areas near ponds or streams is largely dependent on the permeability of the sediments, the saturated thickness of the aquifer, and the degree of interconnection between the pond or stream and the aquifer. From test holes drilled near several of the larger ponds, and near streams in parts of the basin, the saturated thicknesses of the Pleistocene sediments near each were determined. The analysis of core samples from these test holes provided some information on the relative permeability of the sediments in these areas; the combination of these data make it possible to estimate transmissibility values at each location as shown on figure 9.

The water table is at or near land surface in those areas where ground water is discharging to the streams. Evapotranspiration losses from the water table are also high in these areas. Lowering of the ground-water level near ponds or streams by pumping would serve the dual purpose of reducing evapotranspiration losses, and intercepting water that would naturally be discharged to the streams. Moreover, where the bed of the stream or pond is sufficiently permeable, additional water would be obtained by reversing the normal hydraulic gradient, whereby water would be induced to move from the surface source towards the well.

Although it has been demonstrated, as in the Salisbury well field, that large quantities of

water may be obtained by locating wells near streams, two undesirable features of this arrangement should be considered before additional large-scale development takes place. Because modern stream valleys represent the deepest erosion surface of the present topography, the thickness of the underlying Pleistocene sediments is generally less than in the surrounding areas. This limits the amount of available drawdown for wells constructed in the stream valleys. Several notable exceptions, shown on figure 9, are at the base of Schumaker Dam and in the Naylor Mill Road area where the North Prong, Wicomico River crosses the Naylor Mill paleochannel.

A second undesirable feature concerns the quantities of water that may be derived from the pond or stream as induced recharge. The hydraulic connection between the surface-water body and the aquifer is greatly affected by the materials deposited on the bottom of the pond or stream. Although the streams in the Salisbury area normally carry only a small amount of sediment, some clay, silt, sand, and organic matter is transported following heavy rains. The velocity of water through most of the ponds is low, so that much of this sediment is deposited on the pond bed forming a layer of low permeability. Furthermore, the ponds support a large amount of aquatic vegetation which seasonally adds to the accumulation of organic sediment. This layer of low permeability may restrict the movement of water from the pond to the aquifer as the hydraulic gradient is reversed by pumping. Because most of the ponds have similar depositional characteristics, this factor may be relatively constant throughout the Salisbury area.

The streams in the upper part of the basin flow over remnants of the relatively impermeable Walston Formation. Hence, these streams have virtually no hydraulic connection with the underlying Salisbury Formation. In the lower reaches of these streams near the tidal portion of the Wicomico River where the Walston Formation has been eroded away, organic-silt deposits of low permeability have accumulated in the stream beds. Therefore, the presence of a stream or pond does not automatically indicate a potential area for induced recharge by pumping. The degree of permeability of each stream bed at a particular site will have to be evaluated separately; this could be done by augering or boring several shallow holes along the appropriate stream reach.

Based on the transmissibility data for the Pleistocene sediments shown in figure 9, it would appear that one of the most favorable areas for development of large ground-water supplies is along Beaverdam Creek from the existing City well field eastward to the upper end of Schumaker Pond. In this area transmissibility values range from 100,000 to 170,000 gpd per foot.

Another favorable area of smaller size is the vicinity of Fooks Pond where the transmissibility is about 100,000 gpd per foot.

Based on the estimated transmissibility values, which range from 100,000 to 200,000 gpd per foot, the area along Naylor Mill Road west of U.S. 13 to Jersey Road is highly favorable for the development of large ground-water supplies. Recent (1967) data, not shown on figure 9, indicate that the transmissibility of the Pleistocene deposits in this area may be as high as 400,000 gpd per foot. This area is near a small pond on the North Prong of the Wicomico River.

In the Johnson Pond area and southward along the Wicomico River the Pleistocene sediments are thin and somewhat less permeable; estimated transmissibility values range from 40,000 to 80,000 gpd per foot. Therefore, this area is less favorable for the development of large ground-water supplies than other areas discussed previously. Furthermore, the lower reaches of the river are tidal and heavy pumpage in this area might cause brackish water to be drawn into the aquifer.

In the Leonard Pond area north of Salisbury estimated transmissibility values range from 80,000 to 100,000 gpd per foot, but the presence of a 15- to 20-foot thick clay layer about at sea level reduces the likelihood of direct ground-water recharge from the pond.

Upland areas: An alternative to the development of ground-water supplies from the Pleistocene sediments in low-lying areas near ponds or streams is the development of supplies from the sediments in the upland areas of the basin. The principal advantage of water-supply development in the upland areas as compared with the lowland areas is the generally greater saturated thickness of the sediments, and hence, a greater amount of available drawdown for producing wells. The additional drawdown would result in increased well yields if all other factors re-

mained equal. In the upland areas, water would be removed from storage during that part of the year when recharge rates from precipitation are low, but would be replaced during periods when recharge rates are high. The total range in fluctuation of water levels, however, would be increased because of the removal of water from storage during part of the year.

The quantity of water that may be obtained in the upland areas is partly dependent on the thickness of the red gravelly sand, which generally has a higher average permeability than the Beaverdam Sand. As indicated by Hansen (1966), the red gravelly sand thins, or is completely absent in the eastern parts of the basin, and thins appreciably to the south. In these areas, the Salisbury Formation consists largely, or entirely of the Beaverdam Sand. As a consequence, lower individual well yields for similar types of well construction, are expected in the eastern and southeastern parts of the basin than in the western and northwestern parts of the basin. However, the transmissibility of the Beaverdam Sand in the eastern and southeastern parts of the basin probably ranges from 50,000 to 150,000 gpd per foot indicating a good aquifer, superior to any of the older and deeper aquifers underlying the area.

The Pleistocene sediments underlying the Parsonsburg ridge and extending westward about 2 miles to well Cf 159, show a marked difference from the sediments encountered in test hole Cf 136, which is 0.8 mile west of Cf 159. The predominantly gray sands and blue clays in the log of Cf 159, which are tentatively correlated with the Beaverdam Sand and the Walston Formation, may in reality be remnants of the upper aquiclude and the Pocomoke aquifer of Miocene age. Therefore, the saturated thickness shown for the Pleistocene sediments at Parsonsburg may be in error. Regardless of the geologic name applied to these sediments, the water contained in these gray sands in the Parsonsburg area is of poor quality because it contains high concentrations of iron, and frequently has a marshy odor.

Although only a limited amount of geologic data are available in the northern parts of the basin, the high ground-water levels are assumed to indicate a large saturated thickness of the Salisbury Formation. As this assumption is based partly on estimates of the position of the underlying Miocene surface, local variations within this area are expected. The relatively large saturated thickness of the red gravelly sand, the high ground-water levels, and the generally good quality of water, are all factors that indicate good possibilities for water-supply development in the northern part of the basin.

Miocene Series

The Miocene Series of sediments contains four water-bearing sands in the Salisbury area. From youngest to oldest, these include the Pocomoke aquifer, a sand member in the lower aquiclude, the Manokin aquifer, and the Nanticoke aquifer. Only one of these, the Manokin aquifer, is of importance throughout the Salisbury area.

Pocomoke aquifer: The Pocomoke aquifer, present only along the eastern margins of the basin, is reported to contain water with high concentrations of iron and a marshy odor. No wells are known to produce water from this aquifer in the Salisbury area, nor is it likely to be extensively developed as long as adequate supplies of good quality are obtainable from aquifers in the overlying Pleistocene sediments or from the underlying Manokin aquifer.

Lower aquiclude: The second youngest aquifer in the Miocene Series is part of the unit designated the lower aquiclude by Rasmussen and Slaughter (1955, p. 94). This aquifer, consisting predominantly of fine gray sand, is present over a large part of the eastern half of the basin and ranges in thickness from about 10 to 30 feet. The top of this aquifer is found at depths ranging from about 40 feet below mean sea level along the Wicomico River, to more than 100 feet below mean sea level along the eastern margin of the basin. The sand probably is hydraulically connected to the overlying Pleistocene deposits and the quality of the water is probably similar. An analysis (table 4) for well Ce 142, located 0.2 mile north of Tonytank Pond shows the quality of water in this aquifer to be satisfactory except for its high iron concentration. Although small quantities of water may be obtained from this sand, its limited distribution, thickness, and fineness of grain, plus its proximity to the more productive overlying aquifers, make it unlikely that it will be used to any great extent.

Manokin aquifer: Development of water supplies from the Manokin aquifer has been confined largely to the southwestern part of the Salisbury area where the overlying deposits of Pleistocene age are thin, or contain water of poor

quality. In this area, well yields of 300–400 gpm have been obtained from large-diameter industrial wells that are screened in the Manokin. Small-diameter domestic wells in the area yield 15–25 gpm.

Based on available geologic data, it is concluded that the Manokin aquifer is present throughout most of the Salisbury area. The top of the unit ranges from about 50 to 150 feet below sea level and its thickness ranges from about 20 to more than 100 feet. Although the more permeable zones appear to be confined to the lower part of the aquifer, their erratic distribution warrants careful sampling of the strata during drilling, in conjunction with geophysical logging, in order to place the well screen opposite the most permeable zone.

The quality of water in the Manokin aquifer is indicated by analyses for wells Ce 10, 21, 53, 56–68, Cg 35, and De 30 (Rasmussen and Slaughter, 1955, p. 204–205), and wells Ce 115, Cf 77 and Cf 78 presented in table 4. The water generally may be classified as a soft (0–60 ppm) calcium-magnesium bicarbonate type water. It has a relatively low dissolved-solids content. The principal problem in using water from this aquifer is the high iron concentration which averages 5 ppm in the area. The concentrations of iron in 10 water samples ranged from 0.97 to 8.3 ppm.

The Manokin aquifer represents a large relatively untapped source of ground water in the Salisbury area. Although no quantitative estimates of the total aquifer potential can be made from the small amount of information available, it is considered likely that yields of 300–500 gpm could be obtained from properly constructed and developed wells in most parts of the basin. However, the high iron content of the water may tend to limit development of water supplies from this source, particularly in areas where large supplies of water of good quality are available from the overlying Pleistocene sediments.

Nanticoke aquifer: The Nanticoke aquifer in the Calvert Formation (Rasmussen and Slaughter, 1955, p. 80–85) yields water to a few wells along the Nanticoke River, some 10 to 15 miles northwest of Salisbury. It consists of about 40 feet of gray sand with some shells. It occurs at a depth of about 200 feet below sea level near Vienna and dips eastward toward Parsonsburg where it is about 500 feet below sea level.

Only three wells (Cg 35, De 69, and De 70) are known to produce water from this aquifer in the Salisbury area. Wells De 69–70 at the Dulany Foods plant in Fruitland reportedly yield about 400 gpm each from the Nanticoke and the hydraulically connected underlying sands. The water is saline or slightly saline; an analysis of it in 1961 showed 572 ppm of chlorides. Water analyses for wells Ad 1 and Bd 11 (Rasmussen and Slaughter, 1955) at Mardela Springs, indicate that the water contains 188 and 135 ppm of chlorides, respectively; 245 ppm of sodium (Bd 11); 830 and 44 ppm of bicarbonate; and low iron concentrations of 0.27 and 0.16 ppm. At Vienna, in Dorchester County, the chloride content of the water was 98 ppm. Chloride concentrations in the Nanticoke aquifer apparently increase downdip. The brackish or salty taste of the water and the high concentrations of sodium bicarbonate will restrict the development of potable water supplies from this source.

GROUND-WATER DISCHARGE TO STREAMS FROM THE PLEISTOCENE SEDIMENTS

The upper Wicomico River drainage basin is underlain by unconsolidated sands and clays of Pleistocene age. These sediments, hydrologically, consist of two aquifers, the overlying Parsonsburg Sand and the underlying Salisbury Formation separated by a partial aquiclude, the Walston Formation.

The Salisbury Formation is, in some places, hydraulically connected to the underlying Miocene sands. This connection may provide a means whereby the ground water in the Miocene sands may discharge upward through the Salisbury Formation to streams in the basin.

On October 15, 1963, more than 50 observations of base flow were made in the basin and adjacent areas in order to better define ground-water conditions in the basin and to relate these conditions to factors influencing ground-water discharge (fig. 17). These measurements, made when streamflow in the basin was at about 94 percent of duration, reflect the contribution of ground-water discharge to the dry-weather

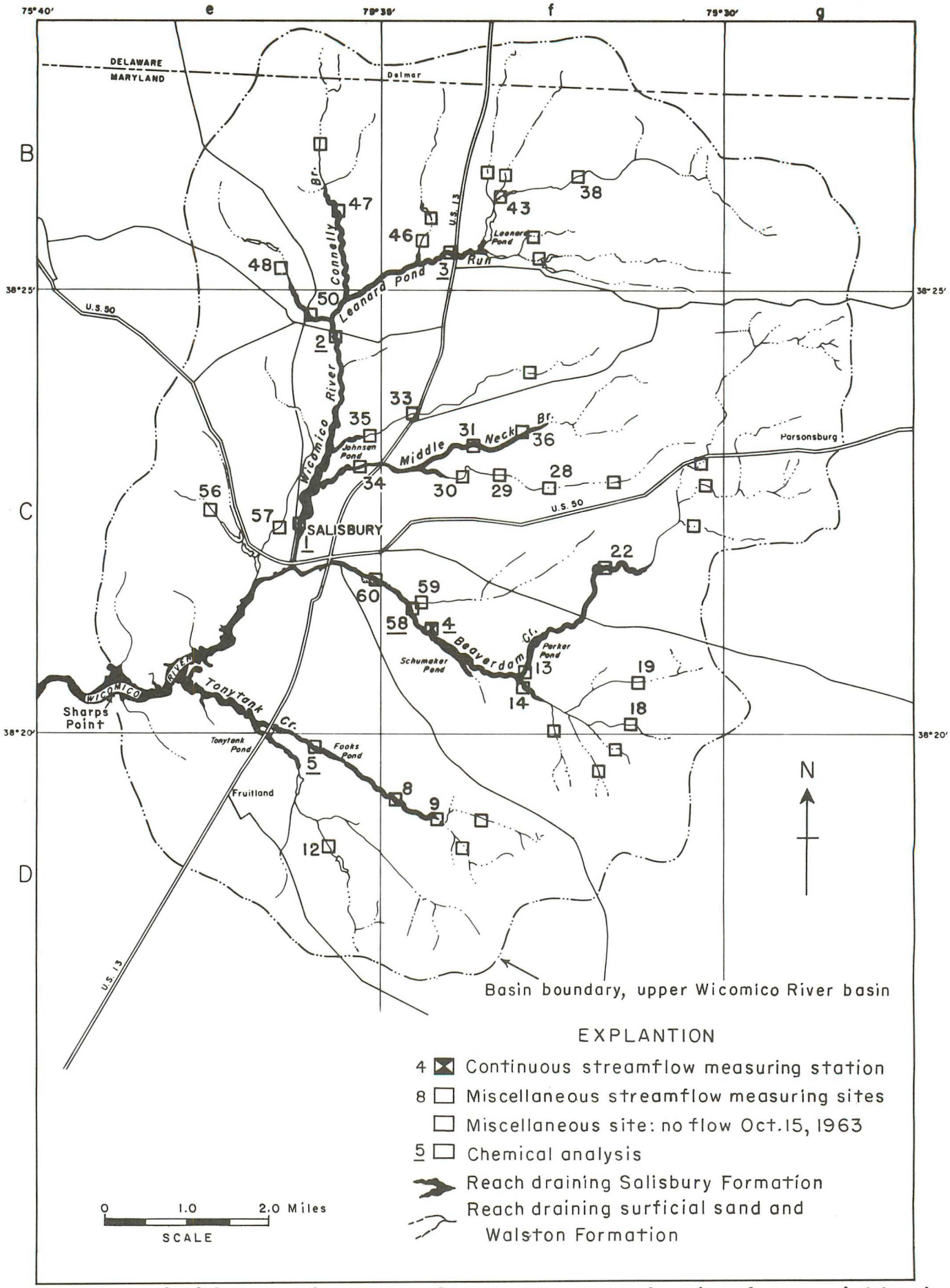

Figure 17—Map of Salisbury area showing streamflow measuring sites and reaches of streams draining the Salisbury Formation.

flow of streams. Discharge values ranged from less than 0.1 cfsm (cubic feet per second per square mile) to about 1.0 cfsm.

Figure 18 shows the results of the base-flow measurements plotted against drainage area. The lack of any clear relationship between base-flow discharge and basin size is evident.

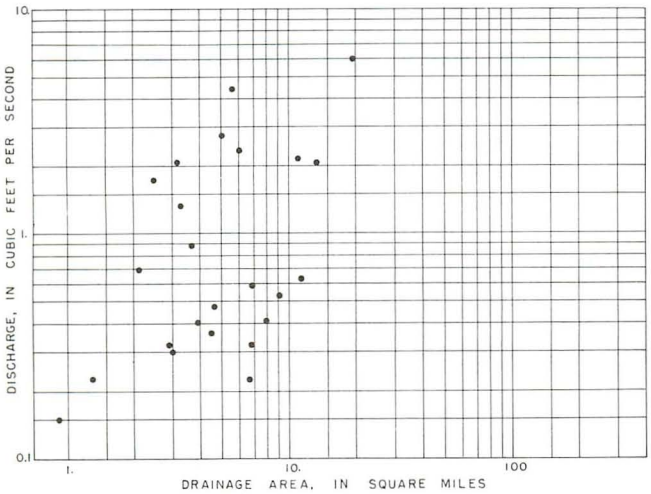

Figure 18—Graph showing relation between base flow of small drainage areas in the upper basin Wicomico River and size of drainage area.

Analysis of low-flow data from the upper Wicomico River basin indicates that the seasonal variability of low flow is less in areas that have high discharge per square mile during low-flow periods, than in areas that have low discharge per square mile. Further analysis indicates that in the areas with high dry-weather flow, the total annual discharge is appreciably larger than in areas with small dry-weather flow.

This can be illustrated by comparing the long term streamflow characteristics of two streams in the area with dissimilar ground-water discharge characteristics. Figure 19 shows the duration curves for the Pocomoke River near Willards, Md. (drainage area 60.5 square miles) and Beaverdam Creek near Salisbury (drainage area 19.5 square miles) (Darling, 1962, p. 30, 33).

The upper left end of the curve is representative of basin discharge during the infrequent events with maximum runoff and for these basins the curve trends are identical. The lower right portion of the curves is representative of the stream discharge during the infrequent time when the contributions to streamflow from ground-water discharge is the total flow of the stream. The slopes of the low-flow discharge curves are indicative of the variability of streamflow in these two basins. The area beneath the curves represents the total discharge from the basin for the period represented by the data.

Examination of these curves indicates that during times when ground water is the major contributor to streamflow: (1) the rate of ground-water discharge to streams in the Beaverdam Creek basin is large, as compared to the Pocomoke River basin, (2) the rate of ground-water discharge in the Beaverdam Creek basin is less variable than the ground water discharge of the Pocomoke River basin, and (3) the combination of these factors results in a greater total discharge per square mile of drainage area from the Beaverdam Creek basin. The quantity of additional water discharged in the Beaverdam Creek basin is indicated by the area between the two curves.

The rate at which ground water is discharged to streams, or the average rate at which water

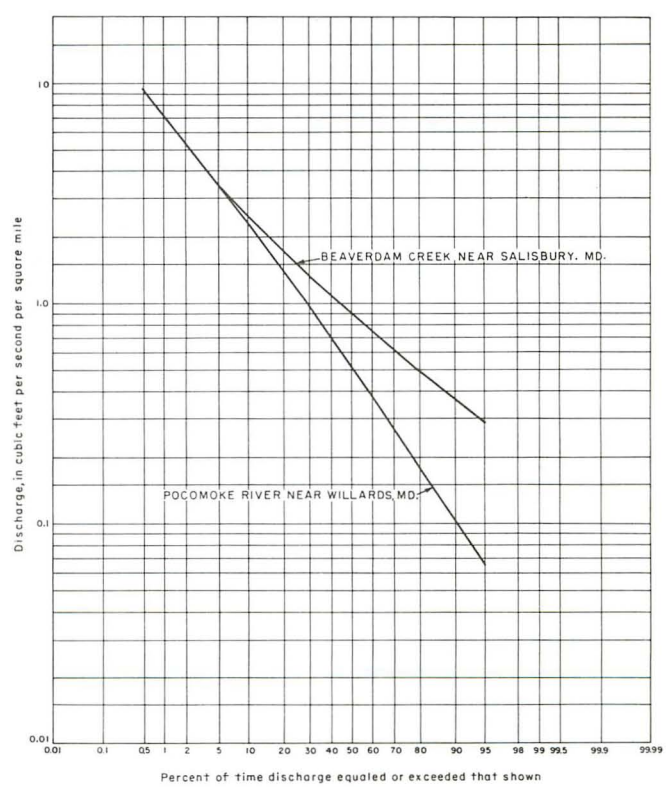

Figure 19—Graph showing duration curves for Beaverdam Creek near Salisbury and the Pocomoke River near Willards, Md.

moves through permeable material, is the product of aquifer permeability and the hydraulic gradient. The relationship is expressed by Darcy's Law: $R = P(H/L)$, in which R is the rate of movement, P is the permeability, H is the difference in elevation of two points on the water table, and L is the distance between these points. These factors are influenced by basin geology and topography.

Permeability is an inherent characteristic of granular materials. It is dependent primarily upon the size, shape, and arrangement of the grains, and is a measure of the ability of the material to transmit water.

The variability of rate of ground-water discharge from any given formation is determined by the variability of the hydraulic gradient. In turn the variability of the hydraulic gradient is limited physically by the topographic relief of the basin, the areal extent, and thickness of the aquifers in contact with the stream, and the density of drainage in the basin. Other related factors are the infiltration rate, precipitation, evaporation, transpiration, inflow to the basin from other areas and outflow from the basin other than by natural discharge to streams in the basin, and cultural activities.

Surficial sands

In the basin surficial sands of Holocene age occur primarily as relict offshore bar and dune deposits. The most prominent of these features is the Parsonsburg ridge, a remnant of an ancient dune-capped bar (Hansen, 1966).

Although the surficial sands are very permeable, they have limited areal extent and thickness, and therefore, are of limited value as aquifers. With few exceptions, streams draining the surficial sands have their channels cut through the sands into the Walston Formation.

Precipitation falling on the surficial sands infiltrates quickly with little if any overland runoff. Water levels in the sand respond quickly to precipitation.

The relative rate at which discharge to streams from these sands occurs is determined by the height of the water table and the density of drainage. In those locations in the basin where the surficial sands are the most extensive they provide sufficient ground-water storage to contribute significantly to the dry-weather flow of the small streams draining them.

In the areas where drainage is well developed, ground-water discharge to the streams occurs more rapidly and the streams are frequently dry for a large part of each year. In areas where the surficial sands are less dissected by streams, some of the streams are perennial. The hydraulic gradient in these areas is flatter and ground-water depletion is less rapid. In areas where the surficial sands consist primarily of minor bar and dune-like deposits, the sands are usually highly permeable but not extensive or thick, and therefore provide only minimal storage for ground water. Streams do not normally dissect these sands and some ground-water discharge occurs as seeps at the base of the sand at their contact with the underlying Walston Formation.

Walston Formation

The Walston Formation is a silty to sandy clay that acts as an aquiclude throughout the basin. It covers a major part of the interstream divides in the Salisbury area, where it ranges in thickness from 2 to 20 feet; its average thickness is 7 to 8 feet. Hansen (1966, fig. 10) shows that the altitude of the base of the Walston ranges from 2 feet above sea level southwest of Salisbury to 52 feet above sea level a few miles north of Parsonsburg. Along the lower reaches of some of the major streams in the basin where it has been removed by channel erosion this formation is missing.

Precipitation falling on the Walston Formation is discharged rather quickly overland and does not provide ground water to sustain streamflow. Thus, the relatively short reaches of streams draining the outcrop area of the Walston Formation become dry before those draining the outcrop area of the surficial sands. Some stream channels, however, convey drainage from the surficial sands across the outcrop area of the Walston Formation, and hence do not become dry.

Salisbury Formation

The Salisbury Formation is the most important aquifer in the basin. Most wells in this area produce from this aquifer and most low flows in streams are sustained by ground-water discharge from it.

The Salisbury Formation is underlain throughout most of the basin by the lower aquiclude. Along the northwest edge of the basin the lower aquiclude feathers out and the Salisbury Formation is in contact with the underlying Manokin aquifer. Along the south and east edges of

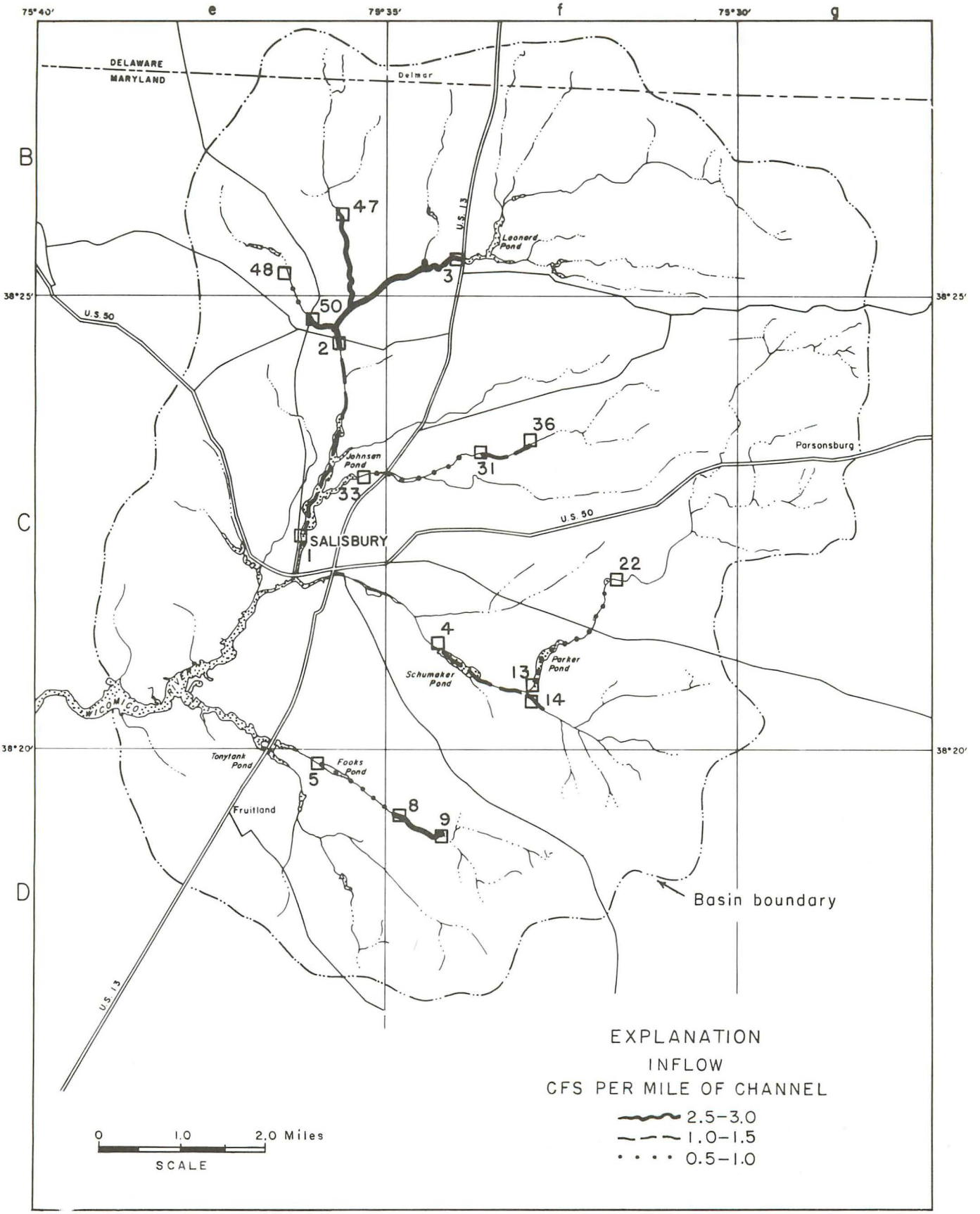

Figure 20—Map showing rate of discharge in cubic feet per second per mile of channel length from the Salisbury aquifer on October 15, 1963.

the basin the Salisbury Formation is in contact with underlying sands of the Pocomoke aquifer (Yorktown Formation) which in turn overlie the lower aquiclude. In the intermediate area, which comprises most of the basin, the Salisbury Formation is in contact with the underlying Manokin aquifer only in those areas where the lower aquiclude has been incised by the channel erosion of an ancient (Pleistocene) river and its tributaries (Hansen, 1966). Where the Salisbury Formation is in contact with the Miocene sands it is believed that a good hydraulic connection is provided and an opportunity for the movement of water between the sands is possible. In such areas the direction and rate of movement of water between aquifers is determined by the difference in hydraulic heads in the two aquifers.

Throughout the basin the Salisbury Formation is overlain by the Walston Formation. The Walston Formation prevents rapid downward percolation of precipitation to the underlying Salisbury Formation and serves as a confining unit or aquiclude. Ground-water discharge from the Salisbury Formation to streams in the basin is limited to those reaches of streams where the present stream channel has cut through the Walston Formation. In these reaches of the streams ground-water discharge is at a relatively high rate during periods when most streams draining the Walston Formation and Parsonsburg Sand are dry.

The Salisbury Formation in a few isolated locations, as in the Naylor Mill paleochannel, may possibly provide a connection between the deeper Miocene artesian aquifers and the surface streams. The total quantity of water that moves through the Salisbury Formation, and water levels in it are, possibly in part, dependent somewhat upon conditions in the Miocene artesian aquifers.

Because of geologic variation, hydrologic conditions differ from place to place in the basin. Discharge to streams in the basin from the Salisbury Formation appears to be erratic as illustrated by figure 20.

The rate of discharge to streams from the Salisbury Formation appears to be greater in areas where the differences between artesian heads and stream channel elevations are greater. For example: The North Prong, Wicomico River crosses the thalweg of an ancient filled river channel (Naylor Mill paleochannel) just upstream from measuring site 2. Here the ancient filled channel cuts through the lower aquiclude and is incised deeply into the underlying Manokin (Miocene) aquifer. The channel of the North Prong, Wicomico River and its tributaries in this area are developed in the Salisbury Formation. It is believed that water moves from the Manokin through the Salisbury and discharges into the stream. This condition is believed to generally prevail in areas where the Salisbury Formation is in contact with the Manokin aquifer.

In the vicinity of the old Naylor Mill Pond above measuring site 2, the influence of the combined aquifer systems appears to be more pronounced than at any other place in the basin. The rate of ground-water discharge to North Prong, Wicomico River in this area was about 3 cfs per mile of channel on October 15, 1963. In the basin this rate of ground-water discharge was equaled only by the reach on Tonytank Creek between sites 8 and 9. The total discharge to North Prong, Wicomico River, however, was much greater than the discharge to Tonytank Creek because of the greater total length of stream channel cut into the Salisbury Formation.

The quantity of ground water discharged to the various streams in the basin from the Salisbury Formation varies appreciably and its effect is most apparent when discharge from the surficial sands and from overland runoff is minimal. A comparative analysis of precipitation and streamflow records for Beaverdam Creek near Salisbury and four nearby streams for nine years (1952–1960) of concurrent record is indicative of the degree to which basin hydrology is influenced by the Salisbury aquifer and its relationship with the Manokin aquifer.

Data in table 7 indicate that precipitation for the control stations was about 46 inches and runoff for the four control streams (Pocomoke River, Nassawango Creek, Chicamacomico River, and Trap Pond outlet) averaged about 15 inches. Both values are thought to represent long-term averages for the control area. These values may be substituted in a modified form of the hydrologic equation to determine the evapotranspiration:

Evapotranspiration (ET) = Precipitation (P) — Runoff (R) + Change in ground-water storage (S)

or ET = 46 — 15 + 0 = 31 (inches)

Thus, the evapotranspiration for the 9-year period for the control area should be about 31 inches, if the change in ground-water storage is negligible.

Table 7—Average streamflow and precipitation for Beaverdam Creek and four control stations, 1952-1960.

Streamflow station	Runoff (inches)[1]	Precipitation (inches)[2]
Beaverdam Creek near Salisbury, Md.	20.8	45.11 (a)
Pocomoke River near Willards, Md.[3]	15.4	45.11 (a)
Nassawango Creek near Snow Hill, Md.[3]	16.7	49.62 (b)
Chicamacomico River near Salem, Md.[3]	15.8	43.73 (c)
Trap Pond Outlet near Laurel, Del.[3]	13.9	44.24 (d)

(a) Precipitation record at Salisbury, Md.
(b) Precipitation record at Snow Hill, Md.
(c) Precipitation record at Salem, Md.
(d) Precipitation record at Georgetown, Del.
[1] U.S. Geological Survey Water-Supply Paper 1722
[2] Climatological Data, Maryland and Delaware—U.S. Dept. of Commerce.
[3] Control Station—see discussion in text

Precipitation in the Beaverdam Creek basin averaged about 45 inches and runoff averaged about 21 inches for the 9-year priod. Balancing the hydrologic budget for Beaverdam Creek for this period gives 24 inches for ET. If it is assumed that 31 inches is more representative of the long term annual rate for ET in the Salisbury area there is a difference of 7 inches (31–24) to be explained. This difference of 7 inches is believed to be representative of the magnitude of additional water provided by the Manokin aquifer to the ground-water discharge from the Salisbury Formation.

The additional water flowing to streams from the Salisbury Formation is discharged at a relatively steady rate in short reaches of certain streams. The quantity of water flowing through the Manokin aquifer into the Salisbury Formation to be discharged in these reaches of the streams thus helps to maintain streamflow in the affected streams at a relatively high rate when adjacent streams depending on local precipitation for water are dry or almost dry.

Other factors that influence the rate of ground-water discharge from the Salisbury Formation include the existence of surface ponds and the development of well fields adjacent to streams.

Of the many ponds which have been constructed along streams in the basin, most are along reaches where the stream channels are cut into the Salisbury Formation. These impoundments raise the ground-water levels adjacent to the ponds which decreases the hydraulic gradient, thereby reducing the rate of ground-water discharge to the stream and locally increasing the volume of water in storage in the aquifer.

The influence of ponds on water levels in the aquifer and ground-water discharge to the stream can be illustrated by figure 21. The water levels in well Wi-Cf 43 were measured weekly and the height of the water level in Schumaker Pond was obtained from a continuous water-level recorder. On October 25, 1963, prior to opening the gates, the water level in the well was 19.6 feet above mean sea level and the water level in Schumaker Pond was 19.05 feet above mean sea level. The hydraulic gradient was about 4 feet per mile. On November 8, 1963 the gates to Schumaker Pond were opened to drain the pond for maintenance. On November 22, 1963 the water level in the well was 18.4 feet and the water level in Schumaker Pond was 13.96 feet. The resultant hydraulic gradient was about 32 feet per mile and ground-water discharge in the reach had increased from less than 1 cfs on October 25 to about 6 cfs on November 22.

AVAILABILITY AND QUALITY OF SURFACE WATER

The upper basin of the Wicomico River, unlike most Eastern Shore drainage basins, has large quantities of surface water of generally excellent quality available for development. Precipitation in the Salisbury area averages about 46 inches annually, and about 18 inches becomes runoff, including ground-water discharge and overland runoff. The surface-water runoff is at present largely undeveloped though it was utilized extensively in the past as a source of power for many small water-operated mills.

In the development of a stream as a source of

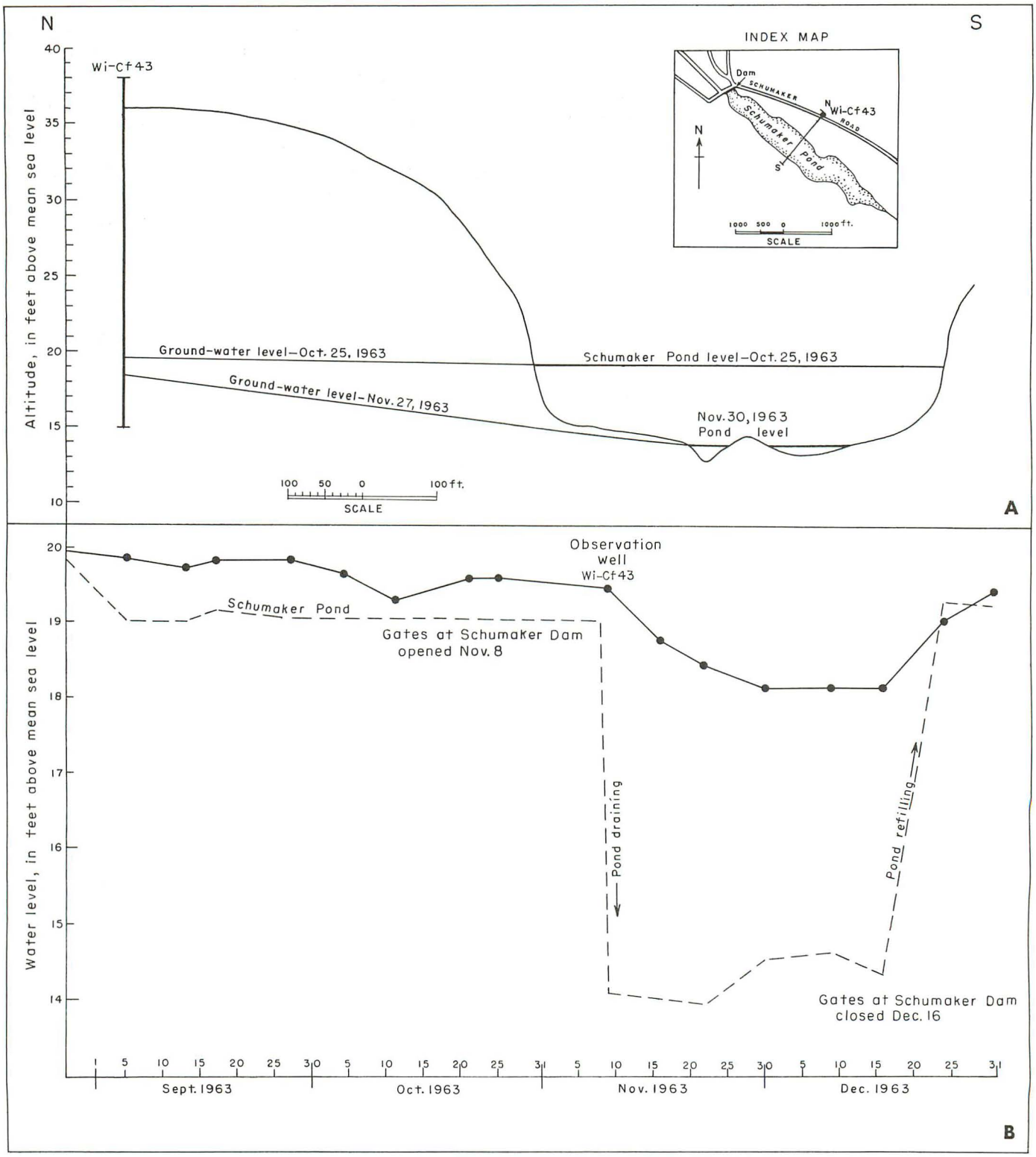

Figure 21—A. Cross section at Schumaker Pond showing the decline in ground-water levels resulting from draining the pond. B. Hydrograph of well Wi-Cf 43 during late 1963.

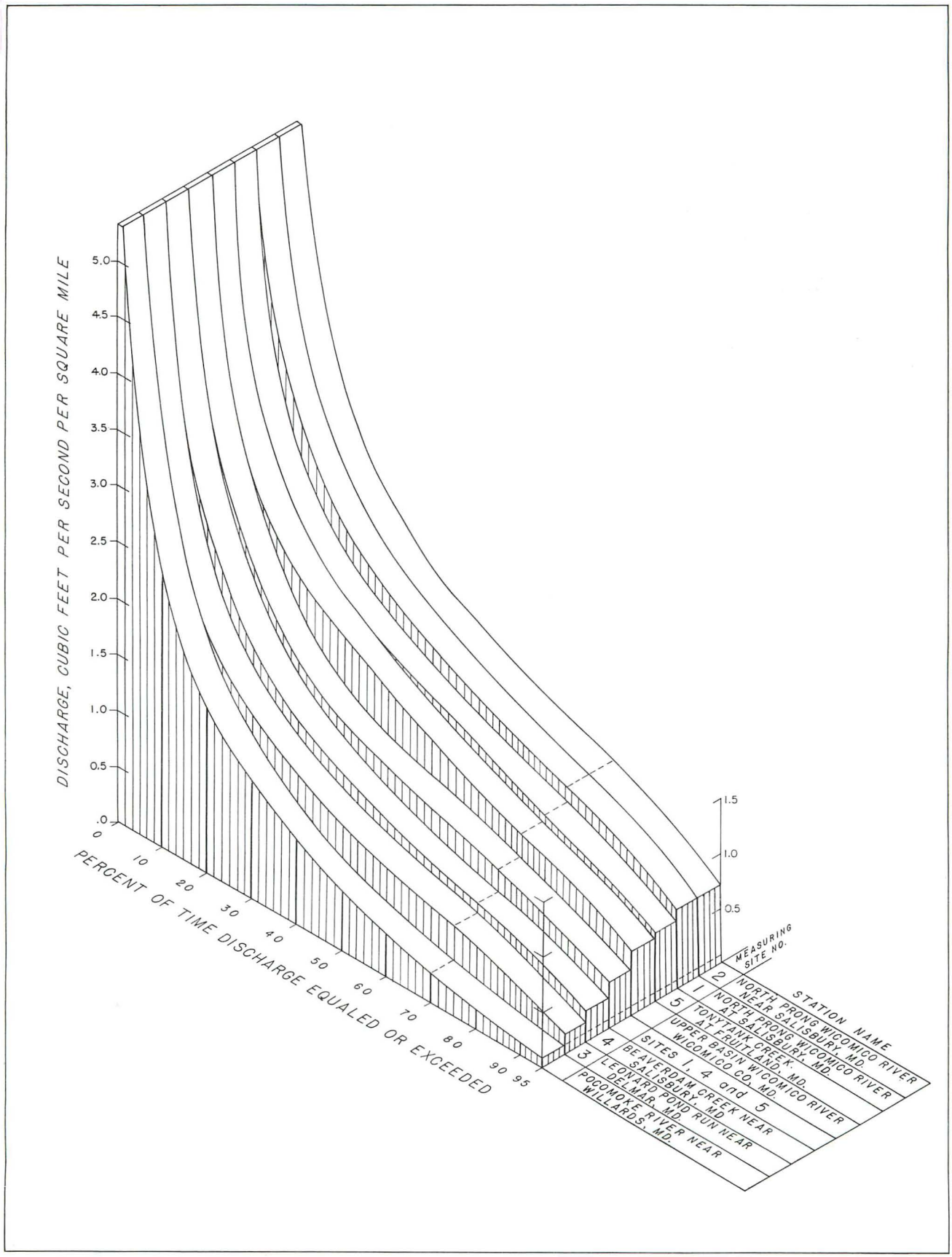

Figure 22—Three-dimensional duration curves for the Pocomoke River, and streams in the upper basin Wicomico River.

water supply, the streamflow characteristics should be carefully examined. Of particular importance is the examination of the low-flow characteristics of the stream and of the feasibility of supplementing these low flows if necessary. The principal tools used in an evaluation of the potential of a stream as a source of water are the duration analysis and the low-flow analysis. A supplementary method used in this report is the draft-storage analysis.

Duration analysis

A tool widely used for evaluating overall streamflow characteristics is the duration analysis. In this analysis, data are presented in the form of duration curves (fig. 19). These curves can be used to determine the percent of time for which streamflow of a given magnitude can be expected to be equaled or exceeded. Several duration curves shown in figure 22 illustrate the streamflow characteristics of streams in the basin. The manner in which these characteristics are influenced by basin geology is illustrated by the varying shapes of the curves.

The duration curve for the Pocomoke River near Willards, Md., is shown for comparison. This stream is nearby but outside of the Salisbury area. Because the mean annual runoff for this stream is typical of Eastern Shore streams and because the duration curve is very nearly a straight line when plotted in the usual manner on log-probability paper (fig. 19), the curve is useful for comparative purposes.

The upper ends of the curves, shown in figure 22 are identical, but, as lower values of discharge are approached the curves deviate appreciably. The overall result indicates an increase in unit discharge for streams in the upper basin of the Wicomico River. The effect is similar to that which would be produced if streamflow in the Pocomoke River were supplemented during periods of low flow by water diverted into the basin. Streamflow in the upper basin of the Wicomico River is believed to be supplemented by water from the Miocene sands which are hydraulically connected to the Salisbury Formation by sand-filled ancient river channels. Ground water from the Salisbury Formation discharges directly into some reaches of the streams in this area. The effect of this discharge is more noticeable during periods of low flow.

The lower end of the curve, which is indicative of the low-flow characteristics of the stream is of prime importance to those responsible for water-resources development. The duration curves indicate that during low-flow periods ground-water discharge to some streams in the basin is relatively large. At 95 percent of duration the combined discharge of North Prong, Wicomico River at Salisbury, Beaverdam Creek near Salisbury, and Tonytank Creek at Fruitland (combined drainage area 61.6 sq. mi.) is about five times as great as that for the Pocomoke River near Willards (60.5 sq. mi.).

Low-flow analysis

Low-flow analysis indicates the frequency with which low flows of a particular magnitude can be expected to occur and is useful as a planning tool when a stream is considered as a potential source of water supply. The low-flow frequency curves in figure 23 can be used to determine, for example, that for this stream, the expected recurrence interval of an average discharge, for 7 consecutive days, of 3.0 mgd is 4 years. The same average discharge for 60 consecutive days would not be expected to recur more often than once in 50 years. The expected recurrence intervals are for long term averages and the analysis does not guarantee that the 60-day minimum with a 50-year recurrence interval will not occur, for example, in 2 consecutive years.

Draft-storage analysis

A draft-storage analysis is a study of the volume of storage required to maintain given draft-rates, or discharges, of a stream during periods of low flow. In the section of this report titled "Low-Flow Characteristics," analyses are given for selected sites for periods of low flow having recurrence intervals of 10, 20, and 50 years. They indicate the degree to which low flows can be augmented by supplemental storage.

A draft-storage curve for a drought with a 10-year recurrence interval for Beaverdam Creek near Salisbury, Md. is shown in figure 24. This curve gives the draft-storage relationship for a drought that would occur on the average once in every 10 years. The example shown is for Schumaker Pond which has a known storage of 44 million gallons. The curve shows that with this storage and the natural flow of the stream, a draft of slightly less than 5 million gallons per day can be maintained during a drought with a 10-year recurrence interval.

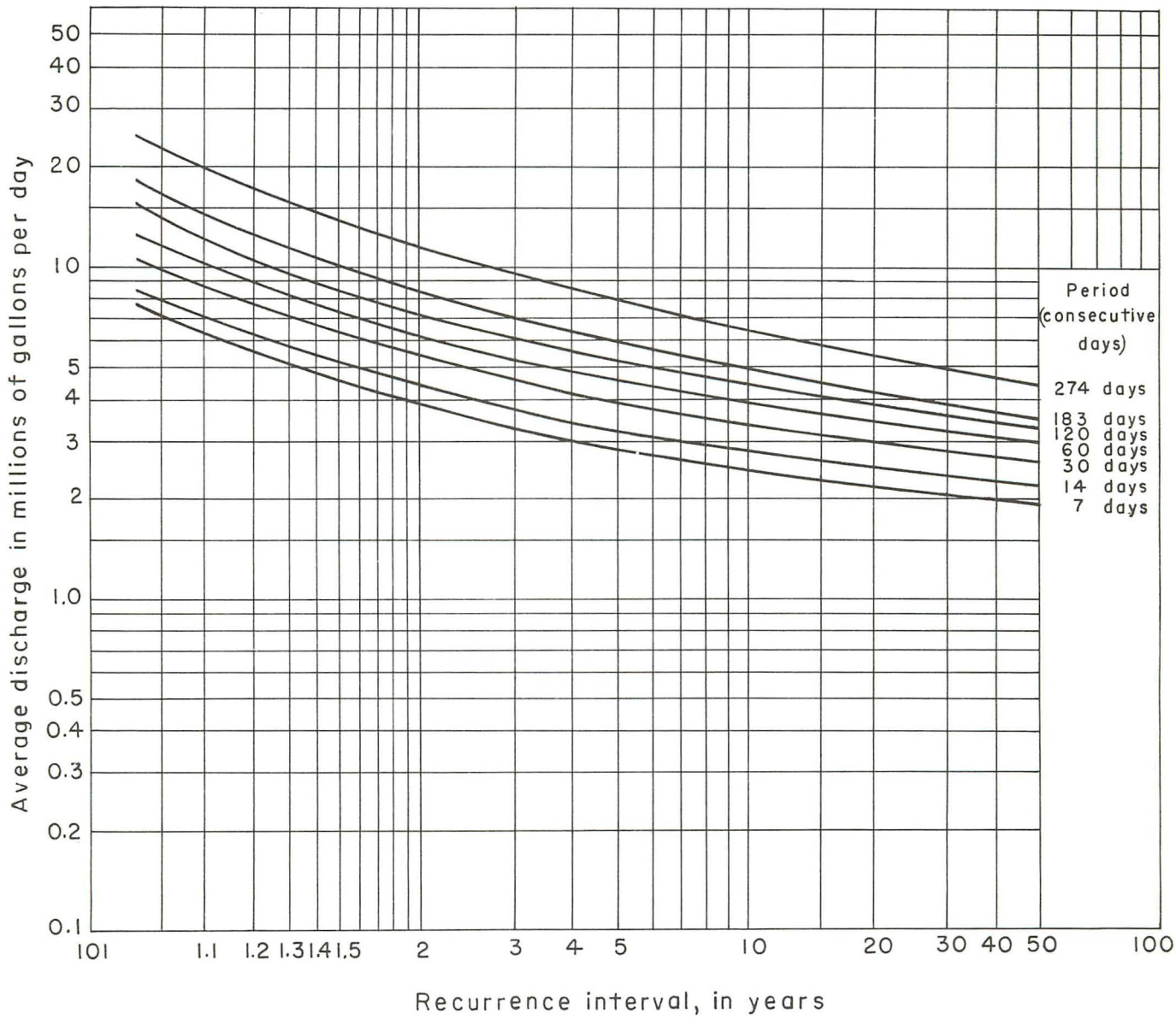

Figure 23—Low-flow frequency curves for Beaverdam Creek near Salisbury, Md.

The draft-storage analysis illustrated in figure 24 does not include allowance for evapotranspiration or seepage losses from surface impoundments nor does it include the additional water stored in the adjacent permeable surficial deposits. The latter appears to be sufficiently significant in the Salisbury area to justify further comment.

Areas with little topographic relief, such as the Salisbury area, afford little opportunity to develop large surface reservoirs. However, substantial quantities of water can be retained in small surface impoundments and in the surficial deposits back of these structures.

Lowering the water level in the impoundment will gradually release water held in storage in the surficial deposits, thereby adding to the normal ground-water discharge to the pond or stream. The effect is a rearrangement in time of the streamflow regimen resulting in greater

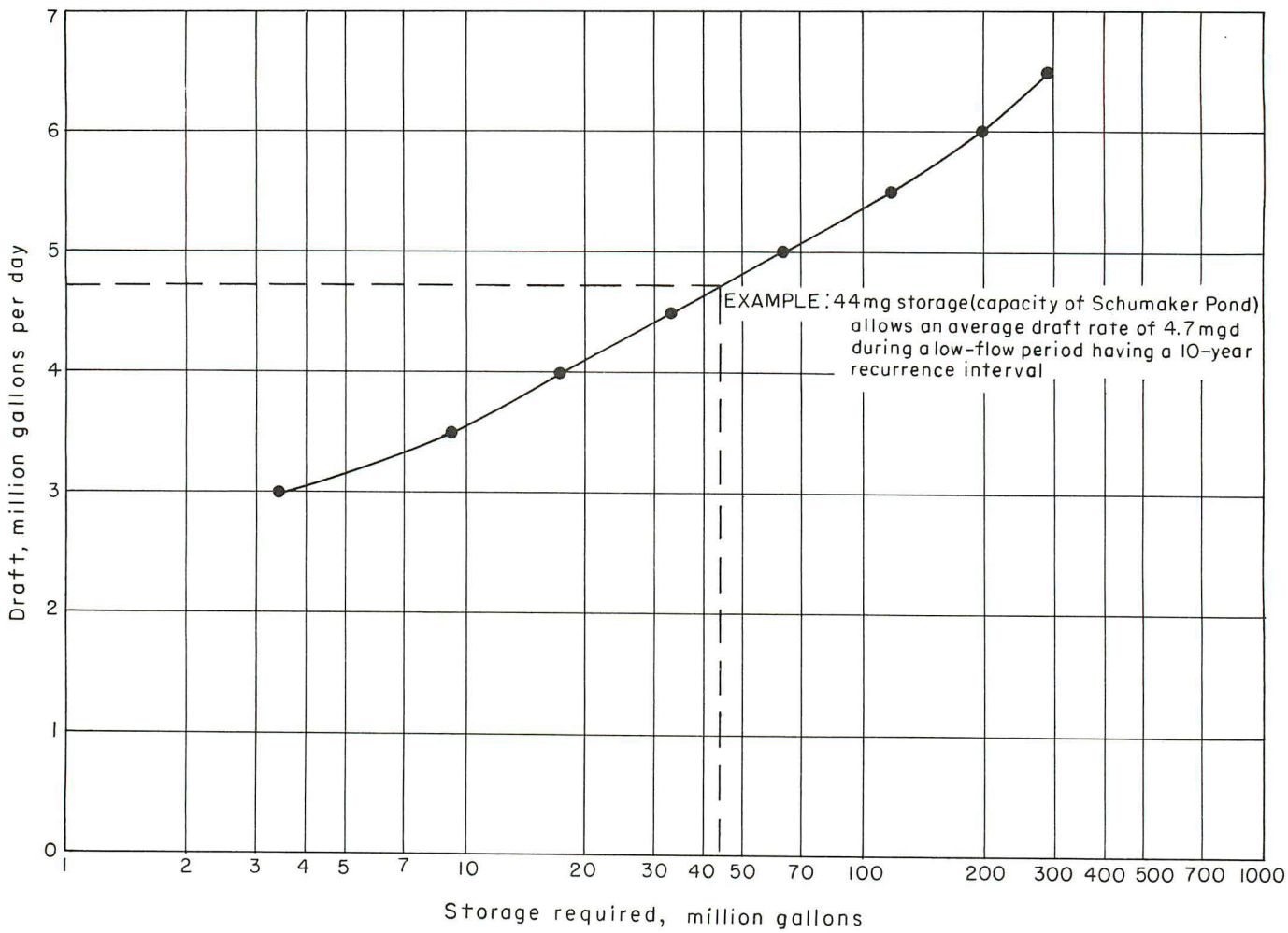

Figure 24—Draft-storage curve, 10-year recurrence interval, for Beaverdam Creek near Salisbury, Md.

streamflows than would be indicated by draft-storage analysis alone. One analysis of the situation at Schumaker Pond suggests the probable magnitude of the increase in flow which can be expected for the period indicated. The analysis is illustrated in figure 25.

During the period November 8 to 22, flow measured at the gaging station on Schumaker Pond dam (Beaverdam Creek near Salisbury), totaled 155 million gallons. This flow was considered to be composed of unregulated streamflow into Schumaker Pond, water released from surface storage in Schumaker Pond, and water released from subsurface storage in permeable surficial deposits as the pond level fell.

Unregulated surface inflow to the pond was estimated, on the basis of streamflow trends and weather records as 60 million gallons (area A, fig. 25). The volume equivalent to surface storage in the pond (area B, fig. 25) was known to be approximately 44 million gallons. Therefore, the release from subsurface storage (area C, fig. 25) was estimated to be 51 million gallons, the remainder of the total flow past the gage. This

indicates that during the 15-day period, November 8 to 22, under base-flow conditions, there was 33 percent more streamflow past the gaging station than would have been expected to result from augmentation of the natural streamflow with releases from the surface storage.

Low-flow characteristics

The low-flow characteristics discussed in succeeding sections of this report are based upon discharge measurements made in the basin and in adjacent areas during 1962, 1963, and 1964. These data have been extended by developing a relationship between base flow at the sites and nearby stations which have continuous streamflow records. Beaverdam Creek near Salisbury, Md. was used as the station to which most base flow sites in the basin were related. The data are published annually in *Surface Water Records of Maryland and Delaware.* Prior to 1961 streamflow records of Maryland were published in the U.S. Geological Survey Water-Supply Papers series *Surface-Water Supply of the United States,* Part 1–B. Duration analysis and low-flow analysis for streamflow stations in Maryland are published in Maryland Geological Survey Bulletin 25, *Maryland Streamflow Characteristics* (J. Darling, 1962).

The upper Wicomico River basin, which is that part of the Wicomico River basin upstream from Sharps Point, Wicomico County, contains approximately 90 square miles (see figure 17). The mean annual discharge from the upper basin of the Wicomico River is 135 cfs (87 mgd). The 7-day minimum flow with a 2-year recurrence interval is 37 cfs (24 mgd). Low flow (7-day minimum 2-year recurrence) varies from about 0.07 cfsm for those areas draining the surficial sands to about 0.7 cfsm for some of the streams receiving discharge from the Salisbury aquifer, and mean annual runoff in these respective areas varies from about 1.0 to 2.0 cfsm.

Most of the ground-water discharge to streams in the basin during low-flow periods is restricted

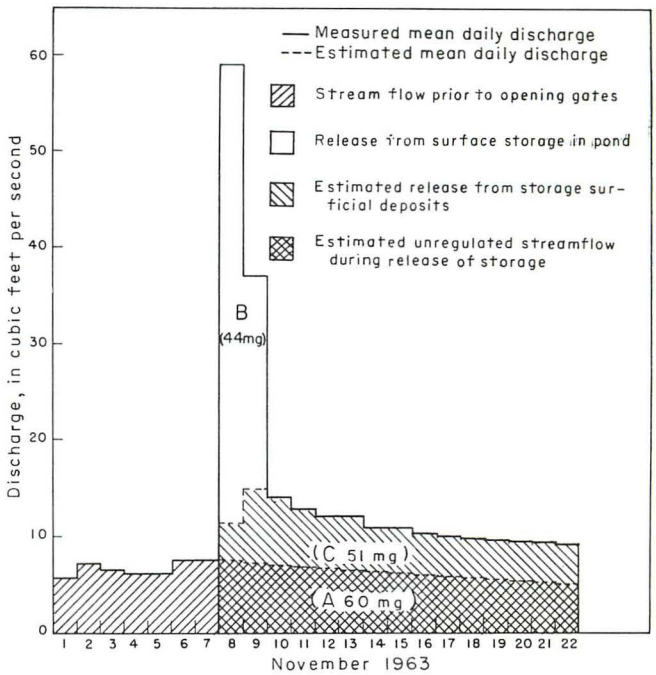

Figure 25—Graph showing estimated components of streamflow in Beaverdam Creek near Salisbury, Md., Nov. 8-22, 1963

to relatively short reaches of the streams draining the Salisbury Formation (fig. 17). These areas and the reaches immediately downstream, therefore, offer the best potential for the development of surface-water supplies.

Data for selected measuring sites in the basin are presented in the following sections.

North Prong, Wicomico River at Salisbury, Md.: This measuring site (1) is at Isabella Street in Salisbury, Md. 0.15 mi. downstream from the dam at Johnson Pond. Discharge measurements are made in the flume at the downstream side of the Isabella Street bridge. The drainage area above this point is 37.1 sq. mi. Average discharge is about 72 cfs (46 mgd) and the 7-day minimum with a 2-year recurrence interval is 28 cfs (18 mgd). Duration, low-flow, and draft-storage data are given below.

Magnitude and frequency of annual low flow

Period (consecutive days)	Discharge, in cubic feet per second, for indicated recurrence interval, in years						
	1.03	1.2	2	5	10	20	50
7	41	34	28	24	23	22	21
14	44	37	30	26	24	23	22
30	51	41	33	28	26	25	24
60	58	46	36	31	28	27	25
120	69	51	39	33	29	28	26
183	77	58	44	35	32	29	27
274	96	73	55	44	37	34	30

Duration table of daily flow

Discharge, in cubic feet per second, equaled or exceeded for indicated percent of time											
0.5	1	2	5	10	20	30	50	70	80	90	95
340	260	200	145	112	86	71	53	41	35	31	27

Draft—storage table

Drought (recurrence interval in years)	Required storage, in millions of gallons, for indicated draft (mgd)									
	13	14	15	16	17	18	19	20	21	22
10	—	—	1.0	8.0	21	36	66	156	276	396
20	—	—	5.6	15	29	54	108	238	421	604
50	—	2.8	11	25	48	144	293	476	659	842

North Prong, Wicomico River near Salisbury, Md.: This streamflow measuring site (2) is at the bridge on Naylor Mill Road and is just downstream from the thalweg of the Naylor Mill paleochannel, which crosses North Prong, Wicomico River near Salisbury at right angles to the river. The drainage area above this site is 24.8 sq. mi. Mean annual discharge is about 53 cfs (34 mgd) and the 7-day minimum with a 2-year recurrence interval is about 18 cfs (12 mgd). The duration date, low flow data, and draft-storage data are given below.

Magnitude and frequency of annual low flow

Period (consecutive days)	Discharge, in cubic feet per second, for indicated recurrence interval, in years						
	1.03	1.2	2	5	10	20	50
7	28	22	18	15	14	13	12
14	30	25	19	16	15	14	13
30	36	28	21	18	16	16	15
60	42	32	24	20	18	17	16
120	52	36	26	21	18	18	16
183	59	42	30	23	21	18	17
274	76	56	40	30	25	22	19

Duration table of daily flow

Discharge, in cubic feet per second, equaled or exceeded for indicated percent of time											
0.5	1	2	5	10	20	30	50	70	80	90	95
230	175	150	110	85	65	54	38	28	23	20	17

Draft—storage table

Drought (recurrence interval in years)	Required storage, in millions of gallons, for indicated draft (mgd)									
	8	8.5	9	9.5	10	11	12	13	14	15
10	—	—	—	3.5	7.0	21	51	168	288	408
20	—	0.7	4.2	7.7	14	28	73	256	439	622
50	1.4	4.9	8.4	15	22	84	204	366	549	740

Beaverdam Creek near Salisbury, Md.: The streamflow record for this site (4) is obtained from a continuous water-level recorder. The dam at Schumaker Pond is the control structure. Records are available for 30 years, (1929–32, 1938–65). Duration and low-flow analysis published in *Maryland Streamflow Characteristics,* are reproduced here.

Magnitude and frequency of annual low flow

Period (consecutive days)	Discharge, in cubic feet per second, for indicated recurrence interval, in years						
	1.03	1.2	2	5	10	20	50
7	12	8.7	6.0	4.4	3.9	3.5	3.0
14	13	9.9	6.8	5.0	4.4	3.9	3.4
30	16	12	8.3	6.0	5.3	4.7	4.0
60	19	14	9.4	7.0	6.1	5.4	4.6
120	24	16	11	8.2	7.0	6.1	5.1
183	28	19	13	9.0	7.6	6.5	5.4
274	38	26	18	13	10	8.6	6.8

Duration table of daily flow

Discharge, in cubic feet per second, equaled or exceeded for indicated percent of time											
0.5	1	2	5	10	20	30	50	70	80	90	95
180	138	104	68	48	33	25	17	12	9.8	7.3	5.6

Draft—storage table

Drought (recurrence interval in years)	Required storage, in millions of gallons, for indicated draft (mgd)									
	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5
10	—	—	3.4	9.2	17	34	64	118	199	290
20	—	1.7	6.7	14	31	67	146	239	329	420
50	0.4	4.2	13	32	93	185	276	369	459	578

Tonytank Creek at Fruitland, Md.: The drainage area above this measuring site (5) is 4.98 square miles. The measuring site is at the downstream side of the dam at Fooks Pond. Mean annual discharge is about 8.5 cfs (5.5 mgd) and the 7-day minimum discharge with a 2-year recurrence interval is about 3 cfs (2 mgd). Duration data, low flow, and storage data are given in the tables below.

Magnitude and frequency of annual low flow

Period (consecutive days)	Discharge, in cubic feet per second, for indicated recurrence interval, in years						
	1.03	1.2	2	5	10	20	50
7	5.0	4.0	3.2	2.6	2.4	2.2	2.0
14	5.2	4.3	3.4	2.8	2.6	2.4	2.2
30	6.1	5.0	3.9	3.2	2.9	2.7	2.4
60	6.8	5.5	4.2	3.5	3.2	3.0	2.6
120	8.1	6.1	4.7	3.8	3.5	3.2	2.8
183	9.0	6.8	5.2	4.1	3.7	3.4	3.0
274	11	8.5	6.6	5.2	4.4	4.0	3.4

Duration table of daily flow

Discharge, in cubic feet per second, equaled or exceeded for indicated percent of time											
0.5	1	2	5	10	20	30	50	70	80	90	95
50	38	29	19	13	10	8.3	6.3	5.0	4.3	3.6	3.0

Draft—storage table

Drought (recurrence interval in years)	Required storage, in millions of gallons, for indicated draft (mgd)									
	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0
10	—	—	0.4	1.8	4.5	9.9	20	41	75	112
20	—	—	1.3	3.5	7.8	16	40	73	110	146
50	—	0.8	2.5	7.5	23	48	84	121	164	219

Leonard Pond Run near Delmar, Md.: This measuring site (3) is at the downstream side of the old mill dam at the outlet of Leonard Pond. The drainage area above this site is 13.4 square miles and streamflow is only slightly larger than average for streams in the general area. This is the largest drainage area in the basin not receiving significant discharge from the Salisbury Formation. Mean annual discharge is about 16 cfs (10 mgd) and discharge for the 7-day minimum with a 2-year recurrence interval is about 3 cfs (2 mgd). Duration, low flow, and draft-storage data are given below.

Magnitude and frequency of annual low flow

Period (consecutive days)	Discharge, in cubic feet per second, for indicated recurrence interval, in years						
	1.03	1.2	2	5	10	20	50
7	6.9	4.4	2.7	1.8	1.6	1.5	1.3
14	8.1	5.4	3.2	2.2	1.8	1.6	1.5
30	10	6.9	4.1	2.7	2.2	2.0	1.8
60	12	8.7	5.1	3.5	2.7	2.5	2.0
120	16	10	6.1	4.1	3.0	2.7	2.2
183	19	12	8.1	4.7	3.8	3.0	2.5
274	27	18	11	8.1	5.4	4.4	3.2

Duration table of daily flow

Discharge, in cubic feet per second, equaled or exceeded for indicated percent of time											
0.5	1	2	5	10	20	30	50	70	80	90	95
120	95	70	50	33	23	16	11	7	5	3.5	2.5

Draft—storage table

Drought (recurrence interval in years)	Required storage, in millions of gallons, for indicated draft (mgd)									
	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6
10	—	—	1.2	3.4	6.2	11	17	31	55	79
20	—	0.2	2.4	5.2	9.3	15	31	55	84	121
50	—	1.1	3.2	7.2	22	46	70	106	143	179

Temperature and chemical quality

Other characteristics of the streams in the Salisbury area which are favorable for water supply are their temperature and chemical quality. Temperatures in those reaches which have high rates of ground-water discharge during periods of low flow are less variable and have lower temperatures during warm weather than adjacent streams. Note the larger variations in temperatures in Leonard Pond Run and North Prong, Wicomico River at Salisbury compared to those of North Prong, Wicomico River near Salisbury as shown in the table below.

The surface waters in the Salisbury area are generally of excellent chemical quality, and except for tidal reaches where their quality is altered by salt-water encroachment, the streams contain very low concentrations of dissolved mineral constituents. Chemical analyses reported in table 8 show that several tributaries to the

Wicomico River in the area contained from 54 to 68 ppm dissolved solids and no undesirably high concentrations of any constituent except iron. Concentrations of iron ranging from 0.29 to 0.49 ppm were measured in Beaverdam Creek and the North Prong, Wicomico River. These concentrations are not unusual since concentrations of iron of this magnitude or higher may be expected in ponded areas where aquatic vegetation is abundant and decomposition of organic matter favors production of soluble organic complexes containing iron.

Water temperatures (°F) at measuring sites 1, 2, and 3

Location	8/6/63	8/28/63	10/15/63	8/28/64
Leonard Pond Run near Delmar, Md. (3)	84°	74°	59°	80°
North Prong Wicomico River near Salisbury, Md. (2)	67°	62°	58°	65°
North Prong Wicomico River at Salisbury, Md. (1)	82°	75°	62°	78°

Concentrations of dissolved constituents in the surface waters of this area are low principally because of precipitation averaging over 40 inches per year and the relatively insoluble sandy soil on which the streams flow. Few, if any, significant differences in chemical composition occur between one part of the area and another.

The maximum concentration of mineral constituents usually occurs in most streams during lowest flow conditions. The following recorded observations show this trend in the Salisbury area:

Location	Date 1963	Discharge (cfs)	Specific Conductance (micromhos/cm)
North Prong, Wicomico River near Salisbury (Site 2)	9/25 10/15	17.8 15.7	74 79
Leonard Pond Run near Delmar (Site 3)	9/25 10/15	2.98 2.03	59 65
Tonytank Creek at Fruitland (Site 5)	9/25 10/15	3.14 2.72	74 80

Because of seasonal variations and several environmental factors, however, no consistent relation exists between conductance and discharge. There is no precise correlation of increasing mineralization with decreasing flow. Storage of water in ponds or impoundments tends to prevent abrupt changes in chemical quality. Rainfall contributes significant amounts of dissolved constituents to streams on the Eastern Shore and variations in composition of precipitation can be sufficient to affect the quality of the surface waters in this area.

The effect of ground-water discharge on the chemical quality of the surface water is largest during periods of low flow. Therefore, water samples were collected for partial chemical analyses when base-flow discharge measurements were made. Results of measurements made on October 15, 1963, are as follows:

Table 8. Chemical analyses of water from streams in the Salisbury area.

(Chemical constituents in parts per million)

Date of collection	Discharge (cfs)	Water Temperature (°F)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$		Specific conductance (micromhos at 25°C	pH	Color
																	Calcium, magnesium	Noncarbonate			
Leonard Pond Run near Delmar																					
9/25/63	2.98	64	16		a/0.03	a/0.00	3.5	0.1	7.8		16	4.0	6.2	0.0	0.4	54	9	0	59	6.3	20
North Prong Wicomico River near Salisbury																					
9/25/63	17.8	53	22		a/0.01	a/0.00	4.0	0.5	8.1	1.5	16	2.6	7.2	0.0	6.5	66	12	0	74	6.2	
North Prong Wicomico River at Salisbury																					
9/25/63	30.6	64	15		0.49	0.03	5.0	0.6	8.7		18	6.4	7.5	0.0	2.3	63	15	0	76	6.4	15
1-4865 Beaverdam Creek near Salisbury																					
6/19/63 9/25/63	b/18 6.6	79 62	12	a/0.2	a/0.29	0.00	4.0	0.2	6.9	0.6	14	3.6	7.1	0.1	2.2	60	11	0	79 69	6.3 6.4	40
Beaverdam Creek opposite well Wi-Cf 64 in Salisbury																					
11/28/62	b/12	48	19		0.28	0.00	5.5	0.9	6.8	1.6	11	8.8	6.5	0.0	4.7	68	17	8	81	6.3	20
Tonytank Creek at Fruitland																					
9/25/63	3.14	65	17		a/0.04	a/0.00	5.0	0.9	7.4	1.5	19	3.2	7.6	0.0	3.3	62	16	1	74	6.5	
Passerdyke Creek at Allen																					
9/25/63	0.59	55									20								89	6.4	
Quantico Creek at Quantico																					
9/25/63	1.26	55									14								85	7.0	

a/ In solution when analyzed.
b/ Daily mean discharge at gaging station.

Location No. (Site on fig. 17)	Discharge (cfs)	Specific Conductance (micromhos/cm)	pH
1	25.9	76	6.3
13	2.16	78	6.8
14	2.38	65	6.8
18	.148	65	6.7
29	1.09*	88	6.8
33	.324	81	7.3
34	4.40	86	6.6
35	.40	149	6.6
36	.693	86	6.6
38	.363	65	6.8
43	.316	61	6.5
46	.590*	122	7.4
47	.886	60	6.6
50	1.32	78	6.6

* Not base flow

The highest conductivities were for site 35 (Brewington Branch) and site 46 (Wood Creek), 149 and 122 micromhos respectively, and probably were the result of some local pollution rather than natural conditions. Otherwise the uniformly good quality of the ground water throughout the Salisbury area is indicated by the range of conductance from 60 to 88 micromhos and an average conductance of 74 micromhos for the 15 other sites measured at this time.

Data collected in 1952 suggested that intrusion of saline water from Chesapeake Bay during tidal cycles increased the chloride concentration in the Wicomico River at Upper Ferry (Murphy, 1957). At that time, however, no significant changes in chemical character of the river upstream at Salisbury occurred. Usually the maximum salt-water intrusion occurs during the part of the year with less than average precipitation and runoff—October to December. Specific conductivity is a convenient measure of salinity and the following table shows an increased conductivity of river water at three locations on the Wicomico River during a tidal cycle.

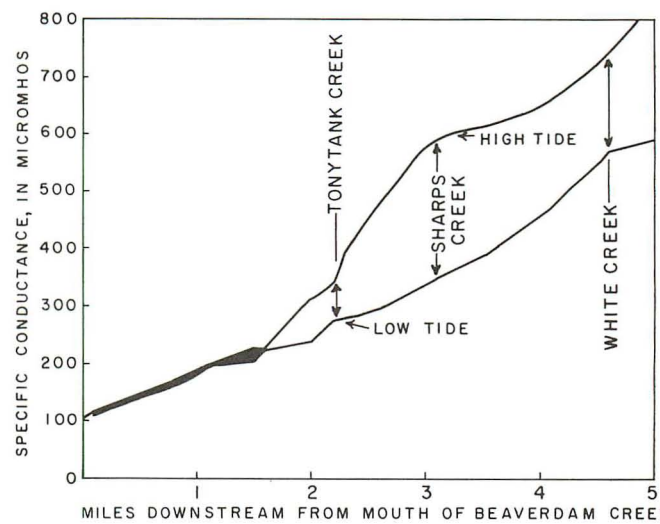

Figure 26—Graph showing conductivity profile of the Wicomico River on September 26, 1963.

Conductivity of the Wicomico River
(micromhos per cm at 25°C)

	Location					
	Whitehaven		Upper Ferry		Salisbury	
	Low Tide	High Tide	Low Tide	High Tide	Low Tide	High Tide
August 11-12, 1952	6,000	10,800	98	213	75	85
September 26, 1963	—	17,000	690	1,200	102	110

As is shown in figure 26 the salt-water intrusion at Salisbury and for a distance of 1½ miles downstream was negligible.

Downstream from Shad Point (just below the confluence with Tonytank Creek) the salinity of the Wicomico River increased rapidly; the highest salinity occurred at high tide or high water slack. On October 1–2, 1963 conductivity was recorded continuously through several tidal cycles at Shad Point, and ranged from 220 to 520 micromhos. These conductivities indicate a range of about 30 to 120 ppm of chloride or a concentration near the taste threshold. Figure 27 shows numerous erratic fluctuations of conductivity during each tidal cycle, but the maximum salinity is reached during the maximum high tides (at 0200 hours in this example) and the minimum salinity occurs during the minimum low tides. Further periodic measurements were made at Shad Point, and the conductivities ranged from 75 micromhos on April 14, 1964 to a high of 886 micromhos on October 23, 1964. The maximum chloride concentration observed was 227 ppm on October 23, 1964, which is still below the maximum recommended drinking water standards limit of 250 ppm. At low tide on October 23, 1964 a chloride concentration of 110 ppm (conductivity of 485 micromhos) was measured. It is concluded, therefore, that the salt-water intrusion of the Wicomico River in the Salisbury area is noticeable during low-flow periods. However, the salt content is not too high for irrigation or most industrial or other uses.

In conclusion it may be stated that streams in the basin are excellent sources of water. A combination of geologic and hydrologic factors result in a stream system capable of providing a population of 100,000 people 200 gallons of water per day per person. The areas from which relatively large, dependable sources of water can be developed are, however, limited to those reaches where stream channels are incised into the Salisbury Formation. Surface water in the basin is of comparable chemical quality to water in the Salisbury aquifer and water temperatures in those reaches of stream channels which have high rates of ground water discharge are less variable than in other streams in the general area.

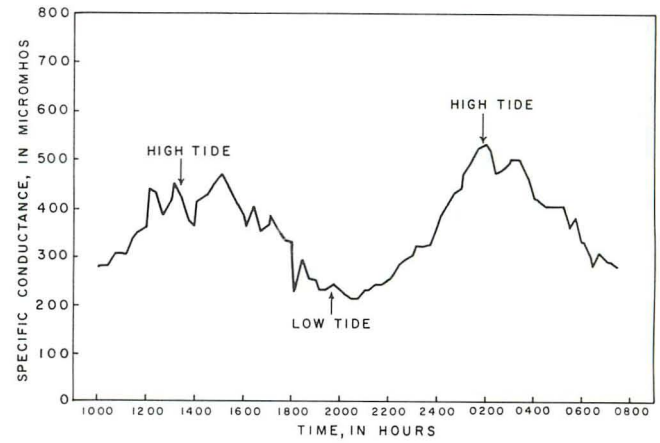

Figure 27—Graph showing variation in specific conductance of the Wicomico River at Shad Point, October 1-2, 1963.

Small ponds in the area provide a limited surface storage of water but are much more significant in terms of the ground-water storage created. This storage can, in both cases, be utilized to supplement dry-weather streamflow.

It should be emphasized that the streamflow data presented herein give good areal coverage but are relatively general in nature. Therefore, additional geologic and hydrologic data are essential to the development of surface-water supplies at specific sites in the basin.

WATER USE

Water use may be classified in several different ways. One classification is concerned with the use of water in terms of navigation, recreation, conservation, or waste disposal; such uses would be termed "nonwithdrawal" use. A second classification is based on "withdrawal" uses in which the water is removed from wells, ponds, and streams. This section of the report is primarily concerned with the latter classification. Withdrawal use of water may be further classified as consumptive (lost to further use in the immediate area) or nonconsumptive. Most of the water use in the Salisbury area is considered nonconsumptive. However, large amounts of water, particularly that used for the Salisbury municipal system and most of the indus-

trial water used, are discharged to the tidal portion of the Wicomico River through the municipal sewage system or storm drains. Water used by the Delmar municipal system, although pumped from ground-water sources outside of the basin, is eventually discharged from the sewage treatment plant into Wood Creek, which drains into the North Prong of the Wicomico River. The water from these sources, although increasing the flow of the Wicomico River, is generally not available for further use.

Table 9 summarizes water use in the Salisbury area in 1964. All of this water, except about one-half of the water used for irrigation, was from ground-water sources. It is estimated that between 80–90 percent of the water used was withdrawn from the Pleistocene sediments, including a small amount from the Parsonsburg Sand, with the remainder obtained from the Salisbury Formation (Beaverdam Sand and red gravelly sand). Other aquifers in use in the area include the Manokin aquifer, from which some domestic and industrial water is obtained, and the Nanticoke aquifer, which is used mainly as a source of industrial water.

Table 9. Summary of water use in the Salisbury area in 1964.
(million gallons per day)

	Daily average (based on yearly total)	Peak consumption (maximum daily)
Municipal-Salisbury	2.405	3.793
Delmar	.347	.698
Industrial (self supplied)	3.600	5.000
Commercial (self supplied)	.400	.600
Domestic (urban and rural)	1.200	2.000
Farm (stock)	.100	.150
Irrigation (ground- and surface-water sources)	.300	3.000
Totals	8.352	15.241

Water used for domestic and commercial purposes is generally discharged to individual septic tanks. Part of the effluent infiltrates downward to recharge the water-table aquifer, and eventually discharges to streams draining the area. A small part of the water used for irrigation may also recharge the aquifer. However, the primary purpose of irrigation is the replenishment of water lost from the plant root zone; therefore, the application of water in excess of these requirements would be of little value to plant growth. Furthermore, the application of excess water would tend to increase the loss of available plant nutrients by leaching.

No reliable estimate can be made concerning the volume of recharge to the ground-water aquifers in the basin from these sources. However, assuming recharge of about one-half the commercial-domestic use, plus a small amount of irrigation water, the quantities of ground water available for re-use in the basin may be as much as 1 mgd. This represents only a small fraction of the recharge available from precipitation.

The per capita rate of water use, based on the estimated basin population of 40,000 and totals from table 9, averaged about 210 gpd (gallons per day) with peak demands of 380 gpd during the maximum water-use periods in 1964.

Municipal

The city of Salisbury and the town of Delmar are the only incorporated communities in the basin presently served by municipal water systems. Although a large part of the town of Delmar is located within the basin, the municipal water supply is derived from wells located outside of, but very near the northern limits of the drainage basin. Because these wells may have some effect on the availability of water in the basin, and because the effluent water is discharged into the basin, pumpage from the Delmar municipal system is included in the summary of water use. In 1964, water for the Delmar water system was pumped from two wells of nearly identical capacity, constructed in the Salisbury Formation. A third well at Delmar in the same formation will be placed in operation in 1965. Pumpage from the Delmar munipal well field for the 1-year period ending in July 1965 is shown in table 10.

Table 10. Pumpage from the Delmar municipal well field, 1964-1965.

(Millions of gallons)

	Metered well
Aug. 1964	7.821
Sept. 1964	5.772
Oct. 1964	4.656
Nov. 1964	4.578
Dec. 1964	4.381
Jan. 1965	4.716
Feb. 1965	4.151
Mar. 1965	4.176
Apr. 1965	4.954
May 1965	5.731
June 1965	5.873
July 1965	6.505
Metered well total[1]	63.314

TOTAL PUMPAGE (est.) for year. . 127 million gallons.
Daily avg. (year) .347
Daily avg. (max. mo.) .505
Pumpage (max. day) .698

[1] Metered well total represents about one-half of total water pumped.

The municipal water supply for the city of Salisbury is pumped from a series of 15 wells deriving water from the Salisbury Formation and located along Beaverdam Creek. Well locations are shown in figure 3. Pumpage from the municipal well field for the period 1954–1964 is shown in table 11. Earlier pumpage records (1948–1953) for this well field have been published by Rasmussen and Slaughter (1955, p. 136). Figure 28 illustrates the variations in water use over the period 1954–1964.

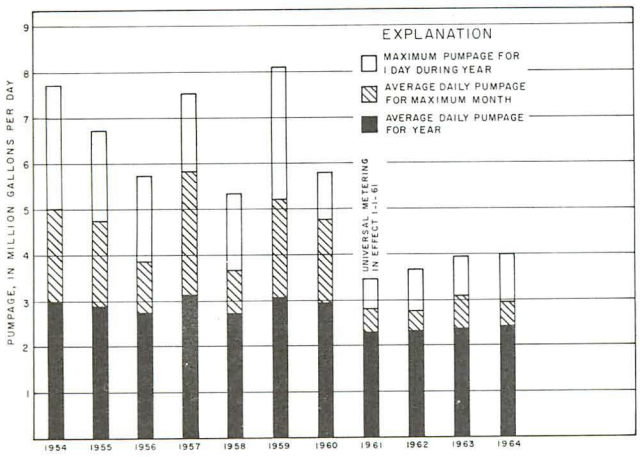

Figure 28. Graph showing variations in water use from the Salisbury well field, 1954-1964.

Water use at Salisbury increased steadily over the period 1948–1954, from an average of about 2.2 mgd in 1948 to nearly 3.0 mgd in 1954. Although this trend was reversed in 1955–1956, seasonal demands in 1957 and 1959 increased the average daily use to more than 3 mgd. The peak demands in 1957 and 1959, when water use restrictions were in effect, led to the installation of universal metering. The installation of meters had a pronounced effect on water use, as indicated in figure 28. Total use of water decreased by about 21 percent between 1960 and 1961, and although the trend of water use has been upward since then, the total pumpage in 1964 was less than that used in 1952. Prior to the installation of meters, the peak demand had been 2.0 to 2.6 times the average daily requirements, whereas subsequent to metering, the peak demand was only 1.5 to 1.6 times the average.

Industrial

Nearly all of the self-supplied industrial water pumped in the area is used by the food processing or chicken broiler industries. Each company, within this classification, has two or more wells located at the plant site which supply all, or nearly all of the water used for processing. Several companies also have water connections to the municipal water system from which emergency water supplies may be obtained. Most of the water withdrawn for industrial use is pumped from wells in the Pleistocene Series. Industries which have wells producing all of their water from the Pleistocene sediments include A. W. Perdue and Son, Inc., Shoreland Freezers, Inc., Campbell Soup Co., and the Messick Ice Co. Other industries including Dulany Foods, Inc., and the Mardel Byproducts Corp., obtain water from other aquifers in addition to the Pleistocene sediments. It is estimated that the average daily industrial water use in 1964 included pumpage of about 2.4 mgd from the Pleistocene Series, about 0.8 mgd from the Manokin aquifer, and about 0.4 mgd from the Calvert (?) Formation. Peak water consumption by industry probably places proportionate increased demands on each formation.

Domestic

Water used for domestic purposes includes that used for drinking, cooking, washing, sanitation, lawn and garden watering, and other miscellaneous small household uses. Individually, the amount of water used per household, or per person is relatively small, but collectively the

Table 11. Pumpage from the Salisbury municipal well field, 1954-1964.

(thousands of gallons)

Month	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
Jan.	62,927	68,506	71,290	71,086	71,185	77,970	67,845	68,947	65,086	66,639	60,374
Feb.	56,815	65,372	65,720	61,460	67,350	69,698	68,259	61,363	58,562	58,565	55,118
Mar.	63,077	71,305	69,605	68,440	69,360	73,647	77,849	67,511	62,692	73,159	64,619
Apr.	73,385	76,415	72,095	76,650	71,517	78,916	86,880	65,006	62,640	68,865	70,919
May	82,840	109,731	87,250	134,380	83,325	126,996	90,901	70,495	81,646	78,311	83,756
June	130,244	106,913	111,850	133,495	92,743	156,130	114,002	77,756	79,901	80,103	89,113
July	156,370	147,068	105,621	181,177	114,373	125,803	126,452	87,222	84,747	96,116	89,024
Aug.	149,099	112,103	119,815	111,271	109,562	99,005	115,125	79,469	86,045	87,938	87,123
Sept.	95,986	83,117	90,911	87,172	90,009	91,522	91,324	75,685	72,222	73,538	77,680
Oct.	83,247	75,849	77,487	76,750	78,709	85,553	79,526	67,327	68,635	69,885	71,797
Nov.	65,653	66,595	66,175	69,725	71,518	70,242	71,927	62,069	63,542	58,965	67,602
Dec.	69,558	70,680	65,209	70,425	78,127	69,736	74,320	59,248	64,274	61,366	63,258
Total	1,089,201	1,053,654	1,003,028	1,142,031	997,778	1,125,218	1,064,410	842,098	849,992	873,450	880,383
Daily avg. (year)	2,984	2,887	2,748	3,128	2,734	3,083	2,916	2,307	2,329	2,393	2,405
Daily avg. (max. month)	5,044	4,744	3,865	5,844	3,689	5,204	4,079	2,814	2,776	3,100	2,970
Pumpage (max. day)	7,775	6,750	5,745	7,540	5,381	8,129	5,795	3,468	3,685	3,914	3,973

amount is significant. Most of the water used for domestic purposes (excluding that provided from municipal systems) is pumped from small diameter, drilled or driven wells, many of which are constructed in the Pleistocene sediments, principally the Salisbury Formation.

Of the estimated population of 40,000 persons in the Salisbury area in 1965, it is estimated that about one-half were supplied with water from privately owned wells. Assuming an average per capita consumption of 60 gallons per day, which is similar to that used for the same purposes from municipal systems, water use in this category would average about 1.2 mgd. Peak water consumption, which occurs during the warm summer months as indicated by increased municipal pumpage, is estimated to increase domestic water use to a maximum of about 2.0 mgd.

Irrigation

Water used for irrigation supplements water received from precipitation during periods when precipitation is inadequate or unevenly distributed. Although the total land acreage in agricultural production decreased between 1954 and 1959 (U.S. Census of Agriculture, 1959), the total water use for irrigation increased. Part of this water (about one-half) is obtained from surface-water sources. The remainder of the water is from ground-water sources such as wells and ponds dug into aquifers where the water table lies at shallow depths. Irrigated crops in the Salisbury area include field and sweet corn, watermelons, cucumbers, cantaloupes, snap beans, strawberries, nursery stock, pasture, and other miscellaneous crops. Data supplied by William H. Miller, Wicomico County Farm Agent, indicate that more than 40 irrigation systems were in operation in the Salisbury area in 1963. It is assumed that a similar or larger number were in operation in 1964.

The quantity of water required for irrigation is extremely variable, largely because of variations in precipitation. During an unusually wet growing season, little or no water is used for irrigation, whereas during a relatively dry growing season, large amounts of water may be used. The predominantly sandy soils of the Salisbury area probably require more frequent periods of irrigation because of low moisture retention characteristics. For strawberry growing The W. F. Allen Co. at Salisbury has established the procedure of applying an acre-inch of irrigation water per week for periods when the weekly precipitation is less than 1 inch.

Water used for irrigation is primarily consumptive, although some of the water, if applied in excessive amounts, probably infiltrates through the highly permeable soils to recharge the water table.

Other uses

Individual wells supply water to several hundred commercial firms in the area. Included in this group are motels, service stations, restaurants, swimming pools, hatcheries, and miscellaneous other small business firms. Most of the water used by these firms is obtained from sediments of the Pleistocene Series. The water required for this type of use is usually greatest during the summer months, but is relatively stable during the remainder of the year.

Self-supplied water, obtained chiefly from wells, for schools, care homes, private clubs, and other institutions is estimated to average about only 0.1 mgd. Water use in this category, most of which is derived from the Pleistocene Series, is included under domestic use in table 9. Water used for watering farm stock is used primarily for chicken broiler production, although the estimate also includes water used for other farm animals including cattle, horses, hogs, sheep, and chickens (other than broilers). Although a small amount of water used for farm stock was from surface-water sources, most of the water was from wells drilled or driven to the Pleistocene sediments.

FUTURE DEVELOPMENT

The maximum utilization of both ground- and surface-water resources in the Salisbury area can be achieved by a planned development and management program. This program should be guided by a comprehensive plan formulated after consideration of not only the hydrologic and geologic factors, but also economic considerations and other related factors. Because the Pleistocene aquifers are especially vulnerable to contamination from the surface, consideration

should be given to the protection of those areas of greatest potential water-supply development. This does not imply that these areas must be entirely reserved for this purpose, but that discriminate care should be exercised to avoid possible contaminating sources, particularly from chemical wastes. The plan should provide for the continued collection of geologic and hydrologic data that may be of importance in the solution of problems arising from development.

Future large-scale development of water supplies should be directed toward those parts of the basin where large, untapped reserves are available. The drainage basin of the North Prong of the Wicomico River which contains Johnson and Leonard Ponds, and the Naylor Mill paleochannel, represents a large, relatively undeveloped source of water supply. Although this is the largest subbasin in the Salisbury area, the average rate of water use from this subbasin was only about 2.4 mgd in 1964. Assuming that the perennial yield from ground- and surface-water sources may be as much as 1 mgd per square mile, the present rate of water use from this subbasin is only a small fraction of the 42 mgd available. However, it should be emphasized that this is only a very rough approximation, requiring the coordinated development of both surface- and ground-water sources.

As development proceeds, the problems associated with such development will increase. As previously discussed in this report, water-supply development from the Naylor Mill paleochannel should be preceded by additional test holes to explore the deepest parts of the channel. Pumping tests should be conducted to determine the transmissibility and storage coefficients of the channel-fill deposits, and to establish the degree of hydraulic connections with the underlying Manokin aquifer. From these tests, the optimum spacing of production wells, the potential yield from these deposits, and other related factors can be determined.

Increased pumpage from the Salisbury Formation in the paleochannel will increase the proportion of water derived from the Manokin aquifer. Because the Manokin aquifer contains water relatively high in iron and the Salisbury Formation contains relatively iron-free water, an increase in iron concentrations in the upper aquifer may result. Several factors complicate this problem. As the Manokin aquifer has a much lower permeability than the Salisbury Formation, proportionately smaller quantities of water will normally be derived from the Manokin. Another factor concerns the possible change in quality of water from the Manokin aquifer as it moves upward into the channel deposits. Assuming that this water generally contains a relatively high concentration of iron (see the analysis for well Cf 78 in table 4), mixing of the water in the Salisbury Formation with the deeper iron-laden water will probably cause some change in chemical character. Exactly what effect water moving from the Manokin aquifer into the channel-fill deposits, either by pumping or by natural discharge to the streams, will have on the chemical quality of the water is unknown, but it is unlikely that the change will seriously interfere with the development and use of water supplies from these deposits.

Monitoring of ground-water levels and water quality should be continued. An important part of this monitoring program is the establishment and operation of a gaging station on the North Prong in its lower part. Preferably, this station should be in operation for several years prior to large-scale water development to provide adequate background data on the natural operation of the hydrologic system in this part of the Salisbury area.

When large quantities of ground water are pumped from the Naylor Mill paleochannel, it will become increasingly important to map its unexplored parts. Thus, a comprehensive plan for development and control of the water resources of this area should provide for a continued mapping program of these channel-fill deposits.

Additional water-level measurements should be initiated on wells in both the Salisbury and Manokin aquifers so as to identify the direction and rate of movement of water through these saturated deposits and to monitor future changes in ground-water storage.

In the Beaverdam Creek basin, the possibilities for further development are limited by the existing water production facilities. Although the average water use from this basin was only 3.1 mgd in 1964, the present pumping facilities, including those in the Salisbury municipal well field, are probably greater than 10 mgd. The maximum demands from the basin, estimated at 5.6 mgd in 1964, coincided with periods of low ground-water levels and minimum streamflow. The limited saturated thickness of the aquifer in the lower part of the basin, indicates that further development should be restricted to its

upstream parts. Assuming that the perennial yield from surface- and ground-water sources averages about 1 mgd per square mile, about 27 mgd are available for development. Probably less than one-half of this quantity may be derived from ground-water sources. Comparison of the estimated perennial yield of 10–15 mgd from the Pleistocene sediments in the basin and the present pumping facilities of 10 mgd or more, are a further indication that future large scale development should be directed to other parts of the Salisbury area.

Based on individual well capacities in the Salisbury municipal well field, it appears unlikely that the full water production potential of 9 or 10 mgd can be sustained over long periods of time, particularly during periods of low ground-water levels. This is primarily related to the lack of storage space in the aquifer, which averages only about 55 feet in thickness. The location and length of well screens further reduces the usable saturated thickness of the formation to about 30 feet. In addition, during periods of little or no recharge, the lower ground-water and stream levels, the 1 or 2 feet of interference between pumping wells and the continued lowering of water levels by pumping will reduce the maximum sustained pumping capacity of the well field.

A considerable increase in the maximum capacity of the well field could be expected by improving the hydraulic connection between stream and aquifer. The removal of the organic-silt layer in the city pond area would be of some value, although maximum improvement would require excavation to a much greater depth. Various recharge methods using the stream as a source of recharge water could increase the quantity of water available in the well field. Full use of the recharge potential from the stream would require regulation of upstream ponds from which water could be released to augment streamflow during periods of low flow.

Future development of water supplies from deeper aquifers underlying the Salisbury area should be based on more detailed information than is presently available. The Manokin aquifer, which has been developed to a limited extent in the southern and western parts of the basin, may provide an alternate water-supply source for emergency use. Because this is an artesian aquifer in most of the Salisbury area, it is less subject to direct surface contamination than the overlying Pleistocene sediments. The characteristically high iron content of water from this aquifer would, however, require special treatment facilities. Locating the best water-producing zone, selecting the proper well screen, and developing wells to their maximum capacity must be done if this aquifer is to be an important water-supply source. It is imperative that the relationship between this aquifer and the channel-fill deposits in the Naylor Mill paleochannel be clearly understood, prior to large-scale development of water supplies in that area.

In those parts of the basin where water from the Pleistocene sediments contain relatively high amounts of iron, small quantities of water may be obtained at greater depth from the Nanticoke aquifer. Water from this aquifer, although relatively iron-free, may contain objectionable concentrations of chlorides. However, the water may be usable for some purposes.

CONCLUSIONS

The upper surface of the Miocene sediments underlying the upper Wicomico River basin has, in the past, been subjected to erosion by a major ancestral river or its tributaries. The resulting deeply eroded surface was subsequently blanketed with a medium to coarse sand. Overlying the Salisbury Formation is the Walston Formation, a sandy to silty clay. Superimposed on the Walston Formation are many small sandy dune and bar-like features, the most prominent of which is the Parsonsburg ridge. The result is an area which is geologically and hydrologically interesting. The most notable manifestation of this system is the influence that a major, filled, ancestral river channel, the Naylor Mill paleochannel, has upon the hydrology of the upper basin of the present day Wicomico River. The Pleistocene sediments, which fill the paleochannel and blanket the area, make available large quantities of water of generally excellent quality.

Streams in the area are the natural discharge points for ground water from the shallow aqui-

fers. In those reaches of the stream channels that are cut into the Salisbury Formation, the streamflow characteristics are indicative of the productivity of the aquifer. Aquifer tests conducted in the Salisbury aquifer indicate high permeabilities, averaging about 2,000 gpd/ft.[2] Wells constructed in this aquifer are capable of producing water at rates ranging from several hundred gallons per minute to an estimated three to four thousand gallons per minute. The largest capacity wells will be developed in areas where the ancient filled river channel(s) provide an unusually thick saturated section of permeable Pleistocene sands.

The influence of the paleochannel upon basin hydrology is most noticeable in the reach of North Prong, Wicomico River just north of Naylor Mill Road. Exploration of the buried channel system has, at present (1964), been restricted to this immediate area. In this area the channel appears to provide a hydraulic connection between the underlying Manokin aquifer and the Salisbury Formation. Wells along this reach of the North Prong, or along similar reaches of streams, compete with the stream for ground water which would otherwise be discharged to the stream. Extensive development of such wells could substantially modify the streamflow.

The stream channels in many of these areas have accumulations of organic silt ranging in thickness from a few inches to a few feet. Impermeable deposits of silt, if not periodically scoured by channel erosion, tend to retard the movement of water between the stream and the aquifer.

Though both ground water and surface water in the basin are generally of excellent quality some problems exist that are associated with chemical constituents and pollutants in the water. Iron encrustation on well screens, for example, has reduced the specific capacity of some wells in the city well field at Salisbury by more than 80 percent. The problem of iron encrustation of well screens, however, can probably be largely alleviated with an adequate well maintenance program.

Industrial and municipal pollution have adversely affected the quality of some of the surface waters. To some degree surface-water quality is affected by the decay of natural occurring organic materials. Surface water of good quality and useful for many purposes is available, however, in streams in the basin and in the upper reach of the tidal portion of the Wicomico River.

Effective utilization of the ground-water and surface-water resources of the Salisbury area will depend upon a continuing program of data collection and evaluation. With adequate geologic and hydrologic data upon which to base development, the upper Wicomico River basin can support an average daily combined surface and ground-water use of 90 mgd.

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[1] The name of this agency was changed to the Maryland Geological Survey in June 1964.

APPENDIX

Table 1. Records of wells in Salisbury area.

The Manokin aquifer forms a lower member of the Yorktown-Cohansey formation; units designated Yorktown-Cohansey formation are upper sands or clays not correlative with the Manokin aquifer. Water-bearing units designated Salisbury formation include the Beaverdam facies and "red gravelly" facies of the Pleistocene sediments.
Where reference "see log" is shown in remarks, well log is presented in report by Hansen (1966)

Static water level: Measured depths are designated by "m".
Pumping equipment: A, air; J, jet; N, none, S, suction (includes hand pumps, piston pumps, piston pumps, and centrifugal pumps); Sb, submersible; T, turbine.
Use of water: C, commercial; D, domestic; F, farm; Ind, industrial; Ins, Institutional; Irr, Irrigation; N, not used; O, observation well; PS, public supply, T, test hole.

Well number	State permit number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Total screen length (feet)
Be 22	-	P. A. Avery	P. A. Avery	1959	48	Driven	45	2	40 - 45	5
Be 23	30215	do.	E. P. Schultz	1958	48	Jetted	83	2	73 - 83	10
Be 24	41984	Jack Braughler	do.	1961	46	do.	95	2	85 - 95	10
Be 25	-	do.	——	1955	46	Driven	20	2	-	-
Be 26	37517	H. M. Hearne	R. F. Maher	1960	49	Drilled	105	22	0 - 105	53
Be 27	-	Wicomico County Roads Board	U. S. Geol. Survey	1963	42	Augered-cored	58	-	-	-
Bf 17	28486	Maryland State Roads Commission	N. M. Shannahan	1957	42	Drilled	80	2	75 - 80	5
Bf 18	42914	G. J. Cobb	E. P. Schultz	1961	42	Jetted	80	2	70 - 80	10
Bf 19	39599	J. W. Steward	do.	1960	45	do.	90	2	80 - 90	10
Bf 20	31112	Edgewood Pipe & Block Co.	C. Cannon	1958	47	Drilled	80	22	40 - 80	40
Bf 21	43937	Interstate Amiesite	E. R. Kauffman	1961	47	do.	88	6	58 - 88	30
Bf 22	38921	William Bratten	E. P. Schultz	1960	50	Jetted	80	2	70 - 80	10
Bf 23	40845	H. J. Murphy, Jr.	do.	1960	54	do.	100	2	90 - 100	10
Bf 24	40475	Walter Shockley, Jr.	do.	1960	48	do.	83	2	73 - 83	10
Bf 25	44979	E. S. Mortimer	P. W. Hubbert	1961	42	do.	88	2	78 - 88	10
Bf 26	36455	State Line Motel	do.	1959	50	do.	100	4	92 - 100	8
Bf 27	-	Wicomico County Roads Board	U. S. Geol. Survey	1963	48	Augered-cored	62	-	-	-
Bf 28	30485	Richard Bowen	E. P. Schultz	1958	51	Jetted	99	2	89 - 99	10
Bf 29	39598	R. J. Morris	do.	1960	42	do.	94	2	84 - 94	10
Bf 30	44969	Dean Wells	P. W. Hubbert	1961	51	do.	98	2	93 - 98	5
Bf 31	40947	Frank Farlow	do.	1960	50	do.	97	2	91 - 97	6
Bf 32	44661	Hubert Burbich	E. A. Marshall	1961	45	do.	88	2	80 - 88	8
Bf 33	44000	Arthur Nelson	P. W. Hubbert	1961	45	do.	93	2	87 - 93	5
Bf 34	40769	Ronald Hawkins	do.	1960	45	do.	94	2	88 - 94	6
Bf 35	32721	W. Q. French	E. P. Schultz	1958	42	do.	92	2	82 - 92	10
Bf 36	40147	Robert Morris	do.	1960	45	do.	96	2	86 - 96	10
Bf 37	33389	Morris Ward	do.	1959	50	do.	110	2	100 - 110	10
Bf 38	35968	Waldon Wooten	do.	1959	46	do.	100	2	90 - 100	10

Water-bearing formation or unit	Water level (feet below land surface)			Pumping equipment	Yield		Specific capacity (gpm/ft)	Use of water	Temperature (°F.)	Remarks	Well number
	Static	Pumping	Date		Gallons a minute (gpm)	Date					
Salisbury Fm.	8.16^{m}	-	8/14/58	S	-	-		D,F	-	See chemical analysis.	Be 22
do.	7	26	4/5/58	S	38	4/5/58	2.0	D,F	-	See log.	Be 23
do.	6	20	3/15/61	S	60	3/15/61	4.3	D,F	-	Reported no iron in water.	Be 24
do.	7.19^{m}	-	8/14/63	S	-	-	-	D	-		Be 25
do.	-	36	4/21/60	-	1020	4/21/60	36	Irr	-	Alternately cased and screened. Concrete construction. Gravel packed.	Be 26
	8.77^{m}	-	8/14/63								
do.	14	-	11/12/63	N	-	-	-	T	-	See log. Core samples obtained.	Be 27
do.	16.7	34	9/9/57	J	20	9/9/57	1.2	D	-		Bf 17
do.	14	28	5/28/61	S	50	5/28/61	3.6	C	-		Bf 18
do.	12	20	7/6/60	S	60	7/6/60	7.5	D	-	See log.	Bf 19
do.	16.91^{m}	30	8/15/63	S	700	8/1/58	50.0	C	-	Concrete casing and screen.	Bf 20
do.	14	22	8/11/61	S	80	8/11/61	10.0	C	-	See log. Well gravel packed 15 to 88 feet.	Bf 21
	16.39^{m}	-	8/15/63								
do.	12	20	5/19/60	S	60	5/19/60	7.5	D	-		Bf 22
do.	12	23	10/15/60	S	60	10/15/60	5.5	D,F	-	See log. Screen slot size No. 20.	Bf 23
do.	14	28	9/15/60	J	50	9/15/60	3.6	F	-	Screen slot size No. 20.	Bf 24
do.	13	18	11/3/61	J	70	11/3/61	14.0	D	-		Bf 25
do.	14	-	11/20/59	-	80	11/20/59	-	C	-		Bf 26
do.	16	-	11/8/63	N	-	-	-	T	-	See log. Core samples obtained.	Bf 27
do.	10	30	6/28/58	S	60	6/28/58	3.0	D	-	Screen slot size No. 20.	Bf 28
do.	10	18	7/8/60	S	60	7/8/60	7.5	D	-	do.	Bf 29
do.	21	25	10/27/61	-	25	10/27/61	6.2	D	-		Bf 30
do.	22	-	10/28/60	-	35	10/28/60	-	D	-		Bf 31
do.	17	20	10/18/61	S	22	10/18/61	7.3	D	-		Bf 32
do.	15	20	8/12/61	-	30	8/12/61	6.0	D	-		Bf 33
do.	17	-	10/12/60	-	30	10/12/60	-	D	-		Bf 34
do.	15	26	11/11/58	-	60	11/11/58	5.5	D	-	Screen slot size No. 20.	Bf 35
do.	18	30	8/16/60	-	50	8/16/60	4.1	D	-	do.	Bf 36
do.	18	30	7/21/59	-	60	7/21/59	5.0	D	-	See log. Screen slot size No. 20.	Bf 37
do.	13	28	8/29/59	-	60	8/29/59	4.0	D	-	Screen slot size No. 20.	Bf 38

Well number	State permit number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Total screen length (feet)
Bf 39	31695	L. E. Birkigt	E. P. Schultz	1958	42	Jetted	93	2	83 - 93	10
Bf 40	44970	Gene Phillips	P. W. Hubbert	1961	44	do.	100	2	95 - 100	5
Bf 41	34258	R. D. Smith	E. P. Schultz	1959	43	do.	94	2	84 - 94	10
Bf 42	33103	E. W. Hastings	do.	1958	42	do.	92	2	82 - 92	10
Bf 43	41742	Louis White	P. W. Hubbert	1961	46	do.	98	2	92 - 98	6
Bf 44	65W67	Walter Shockley, Jr.	M. P. Brittingham	1965	48	do.	99	2	86 - 99	13
Bf 45	65W71	W. P. Chew	do.	1965	55	do.	104	2	96 - 104	8
Bf 46	65W68	W. S. Murray, Jr.	do.	1965	50	do.	100	2	90 - 100	10
Bg 13	48583	Elisha Tingle	C. I. Daisey	1962	60	do.	68	2	60 - 68	8
Bg 14	56940	Melson Methodist Church	E. P. Schultz	1961	63	do.	76	-	66 - 76	10
Ce 108	-	Campbell Soup Co.	M. A. Pentz	1946	20	-	68	8	-	-
Ce 109	-	City of Salisbury	J. B. Rulon	1957	23	Drilled	150	-	-	-
Ce 110	-	do.	—	1959	22	Driven	44	-	-	-
Ce 111	49741	do.	U. S. Geol. Survey	1962	26.8	Drilled	80	4	76 - 80	4
Ce 112	49742	do.	do.	1962	34.4	do.	85	4	81 - 85	4
Ce 113	47777	W. E. Fries	E. R. Kauffman	1962	32	do.	77	3	57 - 77	20
Ce 114	14456	Mardel Byproducts Corp.	M. A. Pentz	1946	42	Jetted	75	8-6	66 - 75	9
Ce 115	14342	do.	P. E. White	1954	42	Drilled	190	8	175 - 190	15
Ce 116	41486	I. H. Guy	E. R. Kauffman	1961	36	do.	84	22	4 - 84	40
Ce 117	31800	Atlantic Refining Co.	E. P. Schultz	1958	23	Jetted	66	2	50 - 66	16
Ce 118	28095	Maryland National Guard Armory	N. M. Shannahan	1957	25	Drilled	68	6	57 - 69	11
Ce 119	30279	F. P. Schumann	E. P. Schultz	1958	45	Jetted	89	2	79 - 89	10
Ce 120	47677	L. L. Wilkins	do.	1962	42	do.	95	2	85 - 95	10
Ce 121	43312	James Hitchens	P. W. Hubbert	1961	25	do.	80	2	70 - 80	10
Ce 122	30769	Willard Oakley	E. R. Kauffman	1958	38	Drilled	88	22	4 - 88	44

Water-bearing formation or unit	Water level (feet below land surface)			Pumping equipment	Yield		Specific capacity (gpm/ft)	Use of water	Temperature (°F.)	Remarks	Well number
	Static	Pumping	Date		Gallons a minute (gpm)	Date					
Salisbury Fm.	12	28	8/2/58	-	60	8/2/58	3.8	D	-	Screen slot size No. 20.	Bf 39
do.	12	20	11/7/61	-	35	11/7/61	4.4	D	-		Bf 40
do.	10	26	5/27/59	-	60	5/27/59	3.8	D	-	Screen slot size No. 20.	Bf 41
do.	10	27	12/31/58	-	60	12/31/58	3.5	D	-		Bf 42
do.	15	-	1/25/61	-	30	1/25/61	-	D	-		Bf 43
do.	16.90[m]	29	1/26/65	J	20	1/15/65	1.7	F	-		Bf 44
do.	14	28	1/28/65	S	28	1/28/65	2.0	D,F	-	See log.	Bf 45
	9.24[m]	-	1/29/65								
do.	16.88[m]	28	1/12/65	-	35	1/12/65	2.9	D	-		Bf 46
do.	14	21	8/31/62	S	40	8/31/62	5.7	D,F	-	Screen slot size No. 18.	Bg 13
do.	14	30	4/6/64	-	60	4/6/64	3.8	D	-	See log.	Bg 14
do.	24	-	11/28/53	N	168	11/28/63	-	N	-	Well abandoned and sealed.	Ce 108
do.	-	-	-	-	-	-	-	T	-		Ce 109
do.	17.60[m]	-	5/7/57	-	-	-	-	-	-		Ce 110
do.	22.78[m]	-	9/17/63	N	-	-	-	O	58	See chemical analysis. Test hole 3.	Ce 111
do.	29.60[m]	-	11/8/62	N	-	-	-	O	-	do. Test hole 4.	Ce 112
do.	21	28	7/17/62	J	25	7/17/62	3.6	Irr	-	Used for lawn watering.	Ce 113
	23.28[m]	-	5/3/63								
do.	8	56	7/6/46	T	225	7/6/46	4.6	Ind	-	Stand-by well.	Ce 114
Manokin aquifer	10	25	5/4/54	T	300	5/4/54	20	Ind	-	See chemical analysis.	Ce 115
Salisbury Fm.	5	28	1/12/61	S	943	1/12/61	41	Irr	-	See log. Well alternately cased and screened. Concrete construction.	Ce 116
	6.49[m]	-	8/23/63								
do.	18	30	8/8/58	S	25	8/8/58	2.1	C	-		Ce 117
do.	16.7	29	8/8/57	Sb	60	8/8/57	5.0	Ins	57	See log and chemical analysis.	Ce 118
	17.49[m]	-	9/11/63								
do.	22	32	4/14/58	S	30	4/4/58	3.0	N	-	Well abandoned, replaced by Ce 153.	Ce 119
do.	12	25	6/29/62	S	30	6/29/62	2.3	D	-		Ce 120
do.	28	-	7/20/61	S	15	7/20/61	-	D	-		Ce 121
do.	6	40	5/20/58	A	433-1460	5/20/58	-	Irr	-	See log. Well alternately cased and screened. Concrete construction.	Ce 122
	8.44[m]	-	9/11/63								

Well number	State permit number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Total screen length (feet)
Ce 123	28976	University of Maryland Vegetable Research Farm	S. V. Shannahan	1957	36	Jetted	67	10	47 - 67	20
Ce 124	14159	Fish Products Corp. of Maryland	N. M. Shannahan	1954	5	Drilled	145	6	135 - 145	10
Ce 125	50036	L. W. Johnson	S. V. Shannahan	1963	10	Jetted	73	4	62 - 73	11
Ce 126	49768	Glasgow and Davis Co.	E. P. Schultz	1962	27	do.	63	2	53 - 63	10
Ce 127	43002	Harry Derickson	P. W. Hubbert	1961	38	do.	58	2	53 - 58	5
Ce 128	18651	J. A. Parks	R. B. White	1955	36	do.	63	2	55 - 63	8
Ce 129	40650	Peninsula Goslee, Inc.	P. W. Hubbert	1959	30	do.	75	2	65 - 75	10
Ce 130	43538	Adele Downing	E. P. Schultz	1961	22	do.	72	2	62 - 72	10
Ce 131	32901	Charles Goslee	P. W. Hubbert	1958	43	do.	83	2	73 - 83	10
Ce 132	41485	F. W. Bently	E. R. Kauffman	1961	23	Drilled	60	2	50 - 60	10
Ce 133	36025	C. A. Hannah	E. P. Schultz	1959	60	Jetted	55	2	45 - 55	10
Ce 134	44287	M. H. Levinson	P. W. Hubbert	1962	20	do.	42	4	37 - 42	5
Ce 135	37889	M. F. Mader	E. P. Schultz	1960	18	do.	58	2	53 - 58	5
Ce 136	38922	W. C. Morgan	do.	1960	20	do.	70	2	58 - 70	12
Ce 137	34330	Robert Williams	E. R. Kauffman	1959	25	Drilled	85	-	-	-
Ce 138	52197	J. B. Rawson	M. O. Ford	1963	20	Jetted	101	2	89 - 101	12
Ce 139	47678	Fred Poole	E. P. Schultz	1962	30	do.	83	2	75 - 83	8
Ce 140	46172	P. P. Schisler	do.	1962	42	do.	65	2	55 - 65	10
Ce 141	13439	J. K. Gunby	R. B. White	1953	10	do.	115	2	103 - 115	12
Ce 142	42666	J. J. Tamasi	M. O. Ford	1961	19	do.	75	2	67 - 75	8
Ce 143	38219	L. B. Francis	P. W. Hubbert	1960	27	do.	75	2	70 - 75	5
Ce 144	50011	L. T. Hoppe	E. P. Schultz	1962	27	do.	70	2	60 - 70	10
Ce 145	-	Wicomico County Roads Board	U. S. Geol. Survey	1963	36	Augered-cored	92	-	-	-
Ce 146	-	Wicomico County Recreation Commission	do.	1963	25	do.	72	-	-	-

Water-bearing formation or unit	Water level (feet below land surface)			Pumping equipment	Yield		Specific capacity (gpm/ft)	Use of water	Temperature (°F.)	Remarks	Well number
	Static	Pumping	Date		Gallons a minute (gpm)	Date					
Salisbury Fm.	11	35	11/16/57	T	400	11/16/57	16.7	Irr	57	Screen slot size No. 60. Fe 0.3 ppm, pH 6.3, sp. cond. 88.	Ce 123
Manokin aquifer	+10.6[m]	12	1/22/54	T	64	1/22/54	2.8	Ind	56	Flow reported 30 gpm in 1954, 10 gpm in 1963. Water irony.	Ce 124
	+11.88[m]	-	9/11/63								
Salisbury Fm.	8	19	5/11/63	Sb	30	5/11/63	2.7	D	-	Screen slot size No. 40.	Ce 125
	9.53[m]	-									
do.	12	28	11/12/62	S	50	11/12/62	3.1	C	-	Screen slot size No. 20.	Ce 126
do.	14	-	5/26/61	S	25	5/26/61	-	D	-		Ce 127
do.	19	-	9/-/55	S	6	9/-/55	-	D	-		Ce 128
do.	12	17	6/-/59	J	22	6/-/59	4.4	C	-		Ce 129
do.	13	28	7/18/61	S	50	7/18/61	3.3	D	-	Screen slot size No. 20.	Ce 130
	11.39[m]	-	9/12/63								
do.	17	-	11/21/58	S	30	11/21/58	-	D	-		Ce 131
do.	16	21	1/6/61	J	15	1/6/61	3.0	D	-	Plastic casing and screen. Fe 4.0 ppm, pH 6.5, Cl. 9.5 ppm.	Ce 132
do.	12	28	9/5/59	S	50	9/5/59	3.1	D	-	See log. Screen slot size No. 12.	Ce 133
do.	11.08	28	9/12/63	J	60	2/14/62	3.3	D	-	See log.	Ce 134
do.	14	28	2/11/60	S	18	2/11/60	1.3	D	-	Fe 4.0 ppm, pH 5.7	Ce 135
Yorktown-Cohansey Fm.	12	30	6/16/60	S	30	6/16/60	1.7	D	-	Screen slot size No. 12. Iron 5.0 ppm, pH 6.0	Ce 136
do.	15	-	6/27/59	N	-	-	-	T	-		Ce 137
Manokin aquifer	1	-	6/15/63	S	16	6/15/63	-	D	56	Fe 4.7 ppm, pH 6.1, sp. cond. 90	Ce 138
Salisbury Fm.	14	25	6/30/62	J	40	6/30/62	3.6	D	-	See log. Screen slot size No. 18.	Ce 139
do.	10	24	3/15/62	S	60	3/15/62	4.3	D	53	See chemical analysis.	Ce 140
Manokin aquifer	-	-	-	-	-	-	-	D	-	Well flowing when drilled.	Ce 141
Yorktown-Cohansey Fm.	8	-	5/24/61	J	10	5/24/61	-	D	-	See chemical analysis.	Ce 142
Salisbury Fm.	13	28	4/-/60	-	25	4/-/60	1.7	D	-		Ce 143
do.	14	28	12/-/62	-	40	12/-/62	2.9	D	-	Screen slot size No. 20.	Ce 144
Yorktown-Cohansey Fm.	18	-	11/7/63	N	-	-	-	T	-	See log. Core samples obtained.	Ce 145
do.	16	-	11/15/63	N	-	-	-	T	-	do.	Ce 146

Well number	State permit number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Total screen length (feet)
Ce 147	-	Mardel By-products Corp.	P. E. White	1963	42	Jetted	200	-	-	-
Ce 148	54843	do.	do.	1964	42	Drilled	197	8	182 - 197	15
Ce 149	-	Pine Bluff State Hospital	Penniman & Browne	1964	12	Augered-cored	70	-	-	-
Ce 150	-	Wicomico County Roads Board	do.	1964	43	do.	125	-	-	-
Ce 151	-	Mrs. Fred Bell	do.	1964	27	do.	66	-	-	-
Ce 152	-	City of Salisbury	do.	1964	23	do.	84	-	-	-
Ce 153	-	F. P. Schumann	W. K. Wood	1963	45	Drilled	60	-	-	-
Ce 154	27774	Campbell Soup Co.	P. E. White	1957	20	-	67	8	52 - 67	15
Ce 155	33835	do.	do.	1959	20	-	66	8	51 - 66	15
Ce 156	49815	do.	S. V. Shannahan	1962	20	-	69	8	53 - 69	16
Ce 157	-	City of Salisbury	N. M. Shannahan	1964	4.3	Drilled	53	-	-	-
Ce 158	-	do.	do.	1964	6.2	do.	60	-	-	-
Ce 159	-	do.	do.	1964	7.0	do.	66	-	-	-
Ce 160	-	do.	do.	1964	6.8	do.	51	-	-	-
Ce 161	-	Arnold Palmer Driving Range	W. K. Wood	1964	29	do.	63	4	53 - 63	10
Ce 162	30876	Atlantic Refining Co.	E. P. Schultz	1958	30	Jetted	71	2	56 - 71	15
Ce 163	30727	John Langeler	do.	1958	44	do.	63	2	53 - 63	10
Ce 164	51411	R. C. Besche	do.	1963	15	do.	50	2	40 - 50	10
Ce 165	39241	Milton Robinowitz	P. W. Hubbert	1960	18	do.	53	2	46 - 53	7
Ce 166	65W16	Wicomico County Elementary School	W. K. Wood	1964	38	Drilled	118	-	-	-
Ce 167	-	Paul Feig	do.	1964	25	do.	60	2	46 - 60	14
Ce 168	165W43	City of Salisbury	Sydnor Pump & Well Co.	1964	5.1	do.	47	12	32 - 47	15

Well number	Water-bearing formation or unit	Water level (feet below land surface)			Pumping equipment	Yield		Specific capacity (gpm/ft)	Use of water	Temperature (°F.)	Remarks
		Static	Pumping	Date		Gallons a minute (gpm)	Date				
Ce 147	Manokin aquifer	18.40[m]	-	1/2/64	N	-	-	-	T	-	See log.
Ce 148	do.	18.12[m]	24.22[m]	1/3/64	T	300	6/4/64	13.1	Ind	-	Screen slot size No. 15.
Ce 149	Yorktown-Cohansey Fm	14	-	3/17/64	N	-	-	-	T	-	See log. Core samples obtained.
Ce 150	Salisbury Fm.	21	-	3/20/64	N	-	-	-	T	-	do.
Ce 151	Yorktown-Cohansey Fm	13	-	3/24/64	N	-	-	-	T	-	do.
Ce 152	do.	21	-	3/25/64	N	-	-	-	T	-	do.
Ce 153	Salisbury Fm.	-	-	-	S	-	-	-	D,F	62	Fe 1.0 ppm, pH 6.0, sp. cond. 123.
Ce 154	do.	15.5	22	8/15/57	N	80	8/-/57	12.3	N	-	Screen slot size No. 20. Well abandoned and sealed.
Ce 155	do.	13	26	5/2/59	T	195	5/-/59	15.0	Ind	-	Screen slot size No. 20. Well replacement for Ce 154.
Ce 156	do.	14.5	22.5	12/7/62	T	129	12/-/62	16.1	Ind	-	Screen slot size No. 40.
Ce 157	Salisbury Fm.	3	-	5/11/64	N	-	-	-	T	-	See log. Test hole near city well 4. Core samples obtained.
Ce 158	do.	2	-	5/12/64	N	-	-	-	T	-	See log. Test hole near city well 5. Core samples obtained.
Ce 159	do.	3	-	5/13/64	N	-	-	-	T	-	See log. Test hole near city well 7. Core samples obtained.
Ce 160	do.	2	-	5/18/64	N	-	-	-	T	-	See log. Test hole near city well 9. Core samples obtained.
Ce 161	do.	10	19	5/15/64	-	100	5/15/64	9.1	Irr	-	Used for lawn watering. Plastic casing and screen.
Ce 162	do.	13	30	6/11/58	-	60	6/11/58	3.5	C	-	
Ce 163	do.	4	28	5/20/58	-	30	5/30/58	1.2	D,F	-	Screen slot size No. 20.
Ce 164	do.	8	25	4/30/63	-	50	4/30/63	2.9	D	-	do.
Ce 165	do.	12	28	6/10/60	-	33	6/10/60	2.1	D	-	See log.
Ce 166	do.	12.69[m]	-	7/31/64	-	-	-	-	T	-	do.
Ce 167	do.	17.25[m]	27	8/3/64	-	40	8/3/64	4.0	D	57	Plastic casing and screen.
Ce 168	do.	1.99[m]	31.77[m]	12/17/64	T	576	12/17/64	19.3	PS	59	City well 4A. Screen slot size No. 25. Outer casing 24 inches. Graded gravel pack.

Well number	State permit number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Total screen length (feet)
Ce 169	165W44	City of Salisbury	Sydnor Pump & Well Co.	1964	6.5	Drilled	52	12	32 - 52	20
Ce 170	165W45	do.	do.	1964	6.7	do.	57	16-12	37 - 57	20
Ce 171	-	Alex Pollitt	Middletown Well Drilling Co.	1964	38	do.	115	-	-	-
Ce 172	-	Lambert Oeder	do.	1964	38.0	do.	122	-	-	-
Ce 173	-	Alex Pollitt	do.	1964	35	do.	200	-	-	-
Ce 174	65W64	Charles Brown	W. K. Wood	1964	32	do.	54	2	44 - 54	10
Ce 175	-	Larmar Corp.	Middletown Well Drilling Co.	1964	34	do.	205	-	-	-
Ce 176	-	Andrew Turner	do.	1964	42	do.	160	-	-	-
Ce 177	-	James Mitchell	do.	1964	41	do.	215	-	-	-
Ce 178	-	do.	do.	1964	42	do.	165	-	-	-
Ce 179	20254	Campbell Soup Co.	P. E. White	1955	20	-	61	8	55 - 61	6
Ce 180	-	L. Carter	——	-	22	Driven	50	-	-	-
Ce 181	18178	Shoreland Freezers	P. E. White	1955	35	-	80	6	64 - 80	16
Ce 182	50669	do.	do.	1963	35	Drilled	76	8	61 - 76	15
Ce 183	65W28	do.	W. K. Wood	1964	45	do.	76	8	61 - 76	15
Ce 184	16565	Messick Ice Co.	M. A. Pentz	1964	30	-	86	6	72 - 86	14
Ce 185	23894	do.	do.	1964	30	-	83	8	72 - 83	11
Ce 186	65W78	W. F. Allen Co.	E. R. Kauffman	1965	30	Drilled	96	6	25 - 50 80 - 96	41
Ce 187	65W12	Campbell Soup Co.	S. V. Shannahan	1964	20	-	70	8	54 - 70	16
Ce 188	66W20	Richard Maddix	W. K. Wood	1965	40	Drilled	250	-	-	-
Ce 189	-	City of Salisbury	U. S. Geol. Survey	1964	5.2	Driven	5.6	1¼	-	1.5
Ce 190	-	do.	do.	1964	6.4	do.	6.5	1¼	-	1.5
Ce 191	-	do.	do.	1964	10.1	do.	10.1	1¼	-	1.5
Ce 192	-	do.	do.	1964	7.8	do.	7.9	1¼	-	1.5
Ce 193	-	do.	do.	1964	5.0	do.	5.6	1¼	-	1.5
Ce 194	-	do.	do.	1964	5.0	do.	5.1	1¼	-	1.5

Well number	Water-bearing formation or unit	Water level (feet below land surface)			Pumping equipment	Yield		Specific capacity (gpm/ft)	Use of water	Temperature (°F.)	Remarks
		Static	Pumping	Date		Gallons a minute (gpm)	Date				
Ce 169	Salisbury Fm.	2.05[m]	30.58[m]	12/10/64	T	880	12/10/64	30.9	PS	-	City well 5A. Screen slot size No. 40. Outer casing 24 inches. Graded gravel pack.
Ce 170	do.	2.33[m]	32.80[m]	12/21/64	T	1276	12/21/64	41.8	PS	59	City well 7A. Screen slot size No. 40. Outer casing 28 inches. Graded gravel pack.
Ce 171	Yorktown-Cohansey Fm	20.3	-	11/16/64	N	-	-	-	T	-	See log.
Ce 172	do.	17.2	-	11/13/64	N	-	-	-	T	-	do.
Ce 173	do.	19.8	-	11/13/64	N	-	-	-	T	-	do.
Ce 174	Salisbury Fm.	21.50[m]	31	10/29/64	N	30	10/29/64	2.0	D	-	Plastic casing and screen.
Ce 175	Yorktown-Cohansey Fm	8.6	-	11/16/64	N	-	-	-	T	-	See log.
Ce 176	do.	18.7	-	11/16/64	N	-	-	-	T	-	do.
Ce 177	do.	-	-	-	N	-	-	-	T	-	do.
Ce 178	do.	-	-	-	N	-	-	-	T	-	do.
Ce 179	Salisbury Fm.	12	42	8/16/55	N	225	8/16/55	6.8	N	-	Well abandoned and sealed.
Ce 180	do.	-	-	-	S	-	-	-	D	56	Fe 0.6 ppm, pH 6.1, sp. cond. 123.
Ce 181	do.	21	26	4/18/55	T	50	4/18/55	10.0	Ind	-	Screen slot size No. 30.
Ce 182	do.	16.5	25.5	4/2/63	T	60	4/2/63	6.7	Ind	-	Screen slot size No. 20.
Ce 183	do.	21.87[m]	37.81[m]	8/28/64	T	220	8/28/64	13.8	Ind	-	Plastic casing and screen.
Ce 184	do.	24	32	9/19/54	T	100	9/19/54	12.5	C	-	
Ce 185	do.	22	68	6/17/57	T	500	6/17/57	10.9	C	-	
Ce 186	do.	16	18	3/23/65	S	50	3/23/65	25.0	Irr	-	Plastic casing and screen.
Ce 187	do.	11	40	8/29/64	T	300	8/29/64	10.3	Ind	-	Screen slot size No. 40. Well replacement for Ce 179.
Ce 188	Yorktown-Cohansey Fm	-	-	-	N	-	-	-	T	-	See log.
Ce 189	Salisbury Fm.	1.18[m]	3.09[m]	2/3/64	N	-	-	-	O	-	
Ce 190	do.	2.36[m]	4.37[m]	2/3/64	N	-	-	-	O	-	
Ce 191	do.	5.81[m]	7.74[m]	2/3/64	N	-	-	-	O	-	
Ce 192	do.	3.59[m]	5.40[m]	2/3/64	N	-	-	-	O	-	
Ce 193	do.	1.01[m]	2.83[m]	2/3/64	N	-	-	-	O	-	
Ce 194	do.	1.23[m]	2.13[m]	2/3/64	N	-	-	-	O	-	

Well number	State permit number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Total screen length (feet)
Cf 71	25933	City of Salisbury	Rulon & Cook, Inc.	1957	11.2	Drilled	68	12	48 - 68	20
Cf 72	25934	do.	do.	1957	10.7	do.	69	12	49 - 69	20
Cf 73	25935	do.	do.	1957	15.8	do.	64	12	44 - 64	20
Cf 74	49739	do.	Middletown Drilling Co.	1962	27.0	do.	86	4	82 - 86	4
Cf 75	49740	do.	do.	1962	22.5	do.	60	4	56 - 60	4
Cf 76	49743	do.	do.	1962	25.9	do.	69	4	65 - 69	4
Cf 77	49744	do.	do.	1962	9.8	do.	135	4	131 - 135	4
Cf 78	49745	do.	do.	1962	8.0	do.	135	4	131 - 135	4
Cf 79	32359	Henny Penny Farm	E. P. Schultz	1958	42	Jetted	84	2	74 - 84	10
Cf 80	41985	Gaither Aydelotte	do.	1961	42	do.	84	2	74 - 84	10
Cf 81	46375	Holiday Inn	N. M. Shannahan	1962	40	Drilled	96	6	86 - 96	10
Cf 82	44829	Lord Salisbury Motel	E. P. Schultz	1961	40	Jetted	90	2	80 - 90	10
Cf 83	27688	English Grill	R. B. White	1957	42	do.	77	2	64 - 77	13
Cf 84	33890	Howard Johnson Motor Lodge	P. W. Hubbert	1959	42	do.	61	4	53 - 61	8
Cf 85	48800	do.	do.	1962	42	do.	81	4	71 - 81	10
Cf 86	48317	C. O. Harrington	E. R. Kauffman	1962	35	Drilled	90	2	80 - 90	10
Cf 87	48316	Floyd Catlin	do.	1962	38	do.	90	2	76 - 90	14
Cf 88	33506	F. E. Ennis	E. P. Schultz	1959	42	Jetted	90	2	80 - 90	10
Cf 89	43331	J. S. Parker	E. R. Kauffman	1961	40	Drilled	74	4	49 - 74	25
Cf 90	45348	Horace Snowden	do.	1961	40	do.	74	2	62 - 74	12
Cf 91	38731	K. R. McGinnis	E. P. Schultz	1960	42	Jetted	83	2	73 - 83	10
Cf 92	47776	I. L. Larsen	E. R. Kauffman	1962	42	Drilled	58	3	38 - 58	20
Cf 93	37134	J. E. Smith	P. W. Hubbert	1960	38	Jetted	75	2	70 - 75	5
Cf 94	38644	W. L. Powell	——	1960	42	do.	75	2	70 - 75	5
Cf 95	28138	American Stores Co.	S. M. Shannahan	1957	38	do.	58	6	48 - 58	10
Cf 96	46205	Byard Collins	P. W. Hubbert	1962	40	do.	75	2	70 - 75	5

Water-bearing formation or unit	Water level (feet below land surface)			Pumping equipment	Yield		Specific capacity (gpm/ft)	Use of water	Temperature (°F.)	Remarks	Well number
	Static	Pumping	Date		Gallons a minute (gpm)	Date					
Salisbury Fm.	5.4	38	3/20/57	T	1030	3/20/57	31.8	PS	-	See chemical analysis. City well 14. Screen slot size No. 60. Outer casing 24 inches. Gravel pack.	Cf 71
do.	5.3	51	4/25/57	T	665	4/25/57	-	PS	-	City well 15. Screen slot size No. 60. Outer casing 24 inches. Gravel pack.	Cf 72
do.	10	44	5/1/57	T	600	5/1/57	-	PS	-	See chemical analysis. City well 16 Screen slot size No. 60. Outer casing 24 inches. Gravel pack.	Cf 73
do.	22.20[m]	-	11/8/62	N	-	-	-	O	58	See log and chemical analysis. Test hole 1.	Cf 74
do.	16.46[m]	-	11/8/62	N	25	11/8/62	-	O	58	See chemical analysis. Test hole 2.	Cf 75
do.	20.26[m]	-	11/13/62	N	-	-	-	O	-	Test hole 5.	Cf 76
Manokin aquifer	+12.00[m]	-	11/13/62	N	40	11/13/62	-	O	59	See chemical analysis. Test hole 6.	Cf 77
do.	+13.95[m]	-	11/29/62	N	1.4	11/29/62	-	O	58	do. Test hole 7.	Cf 78
Salisbury Fm.	20	30	10/8/58	S	50	10/8/58	5.0	C	-	Screen slot size No. 20.	Cf 79
do.	10	24	3/13/61	S	50	3/13/61	3.5	F	-	do.	Cf 80
do.	12	-	4/11/62	Sb	36	4/11/62	-	C	-	See log.	Cf 81
	15.07[m]	-	9/12/63								
do.	12	26	10/18/61	S	60	10/18/61	4.3	C	-	Screen slot size No. 20.	Cf 82
do.	18	-	8/-/57	J	-	-	-	C	-		Cf 83
do.	15	23	3/26/59	-	60	3/26/59	7.5	N	-	Screen clogged. Well abandoned.	Cf 84
do.	15	30	10/6/62	J	80	10/6/62	5.3	C	-		Cf 85
do.	15	26	8/11/62	S	20	8/11/62	1.8	D	-	Plastic casing and screen.	Cf 86
do.	15	25	8/7/62	J	30	8/7/62	3.0	T	-	See log. Plastic casing and screen.	Cf 87
do.	13	26	2/13/59	J	60	2/13/59	4.6	D	-	See chemical analysis.	Cf 88
do.	7	20	7/7/61	J	55	7/7/61	4.2	C	-		Cf 89
do.	12	20	11/22/61	S	50	11/22/61	6.2	D	-	See log. Plastic casing and screen.	Cf 90
do.	12	22	5/4/60	J	60	5/4/60	6.0	D	-		Cf 91
do.	13	25	7/19/62	J	40	7/19/62	3.3	D	-		Cf 92
do.	14	16	2/10/60	S	50	2/10/60	25	D	-	See chemical analysis.	Cf 93
do.	14	28	4/23/60	S	40	4/23/60	2.9	D	-		Cf 94
do.	11	32	9/18/57	J	100	9/18/57	4.8	C	-		Cf 95
	10.82[m]	-	9/12/63								
do.	16	28	2/24/62	S	55	2/24/62	4.6	D	-		Cf 96

Well number	State permit number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Total screen length (feet)
Cf 97	49157	J. M. Parker	E. R. Kauffman	1962	45	Jetted	83	4	63 - 83	20
Cf 98	27258	J. W. Parks	R. B. White	1957	35	do.	70	2	58 - 70	12
Cf 99	35036	C. R. Berry	E. P. Schultz	1959	38	do.	95	2	85 - 95	10
Cf 100	19582	E. C. Malcom	P. W. Hubbert	1955	38	do.	81	2	70 - 81	11
Cf 101	42735	P. L. Wingate	E. P. Schultz	1961	34	do.	82	2	72 - 82	10
Cf 102	49156	N. L. Morris	E. R. Kauffman	1962	44	Drilled	74	4	44 - 74	30
Cf 103	47959	B. C. Grinnalds	E. P. Schultz	1962	35	Jetted	72	2	62 - 72	10
Cf 104	29948	Wicomico County Board of Education	N. M. Shannahan	1958	50	Drilled	83	6	72 - 83	11
Cf 105	48318	J. W. Brittingham	E. R. Kauffman	1962	45	do.	84	6	10 - 84	74
Cf 106	46640	E. R. Bailey	M. O. Ford	1962	42	Jetted	62	2	54 - 62	8
Cf 107	-	T. S. Falone	——	1963	42	Driven	38	1.5	-	-
Cf 108	47452	Hotton Brothers	E. P. Schultz	1962	42	Jetted	93	2	83 - 93	10
Cf 109	50979	James Williams	M. P. Brittingham	1963	38	do.	80	2	75 - 80	5
Cf 110	45813	M. H. Ward	E. R. Kauffman	1962	40	Drilled	76	2	66 - 76	10
Cf 111	13418	Rayner Brothers	R. C. Scott	1953	55	Jetted	77	2	65 - 77	12
Cf 112	30768	do.	C. Cannon	1958	55	Drilled	100	22	60 - 100	40
Cf 113	37022	W. C. Luffman	E. R. Kauffman	1960	38	do.	108	22	4 - 108	54
Cf 114	35424	Richard Toadvine	do.	1959	38	do.	108	17	48 - 108	60
Cf 115	48804	W. C. Luffman	do.	1962	42	Drilled	84	4	64 - 84	20
Cf 116	47008	Symington-Wayne Corp.	P. W. Hubbert	1962	50	Jetted	97	4	92 - 97	5
Cf 117	38218	M. W. Twilley	do.	1960	33	do.	77	2	70 - 77	7
Cf 118	20006	Houlihan Brothers	P. E. White	1955	36	Drilled	63	4	58 - 63	5
Cf 119	45667	F. E. Poole	P. W. Hubert	1961	40	Jetted	81	2	73 - 81	8
Cf 120	40844	L. A. Vollmer	E. P. Schultz	1960	45	do.	90	2	80 - 90	10
Cf 121	32106	G. R. Ward	do.	1958	45	do.	73	2	-	-
Cf 122	38186	J. W. Aydelotte	do.	1960	35	do.	74	2	64 - 74	10

Water-bearing formation or unit	Water level (feet below land surface)			Pumping equipment	Yield		Specific capacity (gpm/ft)	Use of water	Temperature (°F.)	Remarks	Well number
	Static	Pumping	Date		Gallons a minute (gpm)	Date					
Salisbury Fm.	14	26	10/9/62	-	50	10/9/62	4.2	D	-		Cf 97
do.	16	-	7/-/57	-	-		-	D	-	See log.	Cf 98
do.	30	-	6/18/59	S	20	6/18/59	-	D	-	Screen slot size No. 20.	Cf 99
do.	28	31	12/1/55	-	12	12/1/55	4.0	D	-		Cf 100
do.	18	30	5/6/61	J	50	5/6/61	4.2	D	-	See log. Screen slot size No. 20.	Cf 101
do.	13	25	10/9/62	J	40	10/9/62	3.3	Irr	-	Used for garden watering. Plastic casing and screen.	Cf 102
	14.99[m]	-	9/16/63								
do.	12	28	7/24/62	J	40	7/24/62	2.5	D	-	Screen slot size No. 18.	Cf 103
do.	8.25	15	6/6/58	Sb	72	6/6/58	10.3	Ind	-		Cf 104
	9.52[m]	-	9/18/63								
do.	12	28	8/10/62	-	300	8/10/62	18.8	Irr	-		Cf 105
	9.04[m]	-	9/18/63								
do.	9	-	4/11/62	S	12	4/11/62	-	D	-		Cf 106
do.	13.86[m]	-	9/18/63	-	-	-	-	D	-		Cf 107
do.	14	26	6/18/62	-	30	6/18/62	2.5	C	-	See log. Screen slot size No. 18.	Cf 108
do.	12	23	4/4/63	-	25	4/4/63	2.3	D	-		Cf 109
do.	22	28	1/30/62	S	30	1/30/62	5.0	D	-		Cf 110
do.	10	18	9/30/53	S	25	9/30/53	3.1	C	-		Cf 111
do. &	3	39	6/3/58	T	600-	6/3/58	-	Irr	-	Concrete casing and screen.	Cf 112
Yorktown-Cohansey Fm.	6.51[m]	-	9/18/63		1000						
do.	16	35	5/2/60	S	1200	5/2/60	63.2	Irr	-	Well alternately cased and screened Concrete construction.	Cf 113
	18.15[m]	-	9/18/63								
do.	15	42	7/29/59	N	1000	7/29/59	37.0	Irr	-	See log. Concrete construction.	Cf 114
	17.18[m]	-	9/18/63								
Salisbury Fm.	9	22	9/14/62	J	50	9/14/62	3.8	D,C	-	See chemical analysis. Plastic casing and screen.	Cf 115
	12.72[m]	-	9/18/63								
do.	12	-	7/3/62	Sb	55	7/3/62	-	C	-		Cf 116
do.	14	23	4/13/60	J	75	4/13/60	9.3	Irr	-	Used for garden watering.	Cf 117
	18.91[m]	-	9/19/63								
do.	20	28	8/1/55	J	40	8/1/55	5.0	C	-	Screen slot size No. 20.	Cf 118
do.	16	22	12/-/61	-	60	12/-/61	10.0	D	-		Cf 119
do.	14	28	10/15/60	S	40	10/15/60	2.9	D	58	Fe 0.2 ppm, pH 6.0, sp. cond. 65.	Cf 120
do.	11.5	24.5	9/-/58	-	60	9/-/58	4.6	D	-		Cf 121
do.	15	27	3/12/60	-	60	3/12/60	5.0	D	-	Screen slot size No. 20.	Cf 122

Well number	State permit number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Total screen length (feet)	Water-bearing formation or unit	Water level (feet below land surface) Static	Pumping	Date	Pumping equipment	Yield Gallons a minute (gpm)	Date	Specific capacity (gpm/ft)	Use of water	Temperature (°F.)	Remarks	Well number
Cf 123	46226	R. C. Johnson	P. W. Hubbert	1962	40	Jetted	82	2	76 - 82	6	Salisbury Fm.	21	28	3/5/62	-	20	3/5/62	2.6	D	-		Cf 123
Cf 124	38485	G. C. Insley	E. F. Schultz	1960	42	do.	83	2	73 - 83	10	do.	18	26	4/10/60	S	60	4/10/60	7.5	D	-	Screen slot size No. 20.	Cf 124
Cf 125	-	Wicomico County Roads Board	U. S. Geol. Survey	1963	38	Augered-cored	102	-	-	-	Yorktown-Cohansey Fm.	19	-	11/13/63	N	-	-	-	T	-	See log. Core samples obtained.	Cf 125
Cf 126	-	do.	do.	1963	45	do.	102	-	-	-	do.	13	-	11/14/63	N	-	-	-	T	-	do.	Cf 126
Cf 127	-	A. E. Parker	do.	1963	28	do.	97	-	-	-	do.	8	-	11/20/63	N	-	-	-	T	-	do.	Cf 127
Cf 128	20849	Eastern Shore Public Service Co.	N. M. Shannahan	1955	42	Drilled	109	6	99 - 109	10	Salisbury Fm.	16	20	10/7/55	T	40	10/7/55	10.0	C	-	See log. Fe 0.45 ppm, pH 7.2, Cl 12 ppm, CO_4 ppm.	Cf 128
Cf 129	25877	do.	do.	1957	43	do.	132	10	100 - 132	32	do.	23	37	8/15/57	T	610	8/15/57	43.6	Ind.	58	See chemical analysis. Used for heating and air conditioning.	Cf 129
Cf 130	25888	do.	do.	1957	43	do.	132	10	100 - 132	32	do.	16	22	7/15/57	T	297	7/15/57	54.0	Ind.	-	do.	Cf 130
Cf 131	25889	do.	do.	1957	44	do.	143	16-10	90 - 143	53	do.	20	34	9/5/57	N	690	9/5/57	49.3	Ind.	-	See log. Used as recharge well.	Cf 131
Cf 132	-	W. F. Allen Co.	Boggs Concrete Co.	1964	42	do.	225	-	-	-	Yorktown-Cohansey Fm.	14	-	2/11/64	N	-	-	-	T	-	See log.	Cf 132
Cf 133	65W5	do.	E. R. Kauffman	1964	40	do.	99	6	19 - 99	80	Salisbury Fm.	15	18	7/10/64	S	60	7/10/64	20.0	D, Irr	-	Plastic casing and screen.	Cf 133
Cf 134	-	A. E. Parker	Penniman & Browne	1964	24	Augered-cored	90	-	-	-	Yorktown-Cohansey Fm.	4	-	3/17/64	N	-	-	-	T	-	See log. Core samples obtained.	Cf 134
Cf 135	-	W. F. Allen Co.	do.	1964	25	do.	97	-	-	-	do.	3	-	3/20/64	N	-	-	-	T	-	do.	Cf 135
Cf 136	-	A. W. Perdue & Son, Inc.	do.	1964	47	do.	125	-	-	-	do.	12	-	3/30/64	N	-	-	-	T	-	do.	Cf 136
Cf 137	-	Wilmer Brown	—	1963	42	-	50	-	-	-	Salisbury Fm.	-	-	-	S	-	-	-	D	57	Fe 0.45 ppm, pH 5.7, sp. cond. 70.	Cf 137
Cf 138	-	City of Salisbury	N. M. Shannahan	1964	7.3	Drilled	63	-	-	-	Yorktown-Cohansey Fm.	1	-	5/14/64	N	-	-	-	T	-	See log. Test hole near city well 10. Core samples obtained.	Cf 138
Cf 139	-	do.	do.	1964	19.5	do.	99	-	-	-	do.	7	-	5/19/64	N	-	-	-	T	-	See log. Test hole near Schumaker Dam. Core samples obtained.	Cf 139
Cf 140	42944	Baysinger Trailer Park	E. F. Schultz	1961	35	Jetted	83	2	73 - 83	10	Salisbury Fm.	15	22	10/9/61	-	60	10/9/61	8.6	PS	-	Screen slot size No. 20.	Cf 140
Cf 141	38066	do.	do.	1960	35	do.	80	2	70 - 80	10	do.	12	28	2/26/60	-	60	2/26/60	4.3	PS	-	do.	Cf 141
Cf 142	34439	do.	do.	1959	35	do.	78	2	68 - 78	10	do.	10	28	5/6/59	-	60	5/6/59	3.3	PS	-	do.	Cf 142
Cf 143	-	James Williams	W. K. Wood	1964	38	Drilled	70	3	-	-	do.	10	-	8/4/64	-	50	8/4/64	-	D, Irr	-	Plastic casing and screen. Used for lawn watering.	Cf 143
Cf 144	65W15	Wicomico County Board of Education	do.	1964	35	do.	115	-	-	-	Yorktown-Cohansey Fm.	16.68[m]	-	8/3/64	-	-	-	-	T	-	See log.	Cf 144
Cf 145	65W46	City of Salisbury	Sydnor Pump & Well Co.	1964	7.4	do.	59	12	30 - 45 51 - 59	23	Salisbury Fm.	2.24[m]	29.78[m]	12/19/64	T	580	12/19/64	21.1	PS	58	City well 10A. Screen slot size No. 25. Outer casing 24 inches. Graded gravel pack.	Cf 145
Cf 146	-	S. L. Smith	W. K. Wood	1964	42	do.	50	2	-	-	do.	-	-	-	-	-	-	-	D	-	Plastic casing and screen.	Cf 146

Well number	State permit number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Total screen length (feet)	Water-bearing formation or unit	Water level (feet below land surface) Static	Pumping	Date	Pumping equipment	Yield Gallons a minute (gpm)	Date	Specific capacity (gpm/ft)	Use of water	Temperature (°F.)	Remarks	Well number
Cf 147	-	W. F. Allen Co.	Middletown Well Drilling Co.	1964	40.8	Drilled	80	2	60 - 80	20	Salisbury Fm.	18.5	-	-	N	-	-	-	T,O	-	See log. Well drilled to 280 feet. Plastic casing and screen.	Cf 147
Cf 148	-	do.	do.	1964	38.6	do.	105	-	-	-	Yorktown-Cohansey Fm.	16.8	-	11/12/64	N	-	-	-	T	-	See log.	Cf 148
Cf 149	-	W. F. Allen Co.	do.	1964	39.7	do.	120	-	-	-	do.	17.7	-	11/12/64	N	-	-	-	T	-	See log.	Cf 149
Cf 150	-	Henny Penny Farm	do.	1964	34.6	do.	265	-	-	-	St. Marys Fm.	12.4	-	11/16/64	N	-	-	-	T	-	do.	Cf 150
Cf 151	-	Gaither Aydelotte	do.	1964	46.4	do.	115	-	-	-	Yorktown-Cohansey Fm.	20.1	-	11/16/64	N	-	-	-	T	-	do.	Cf 151
Cf 152	-	W. F. Allen Co.	do.	1964	42	do.	125	-	-	-	do.	14.7	-	11/17/64	N	-	-	-	T	-	do.	Cf 152
Cf 153	65W72	WBOC, Inc.	M. P. Brittingham	1965	30	Jetted	62	4	55 - 62	7	Salisbury Fm.	13	29	2/26/65	Sb	40	2/26/65	2.5	C, Irr	-	Screen slot size No. 20. Used for lawn watering.	Cf 153
Cf 154	43072	A. W. Perdue & Son, Inc.	T. O. Shannahan	1961	47	Drilled	86	10	64 - 86	22	do.	8	19.5	7/17/61	T	455	7/17/61	39.6	Ind	-	Use mainly for cooling.	Cf 154
Cf 155	52300	do.	do.	1963	47	do.	93	10	67 - 93	26	do.	12	43	7/20/63	T	610	7/20/63	19.7	Ind	-	do.	Cf 155
Cf 156	31120	do.	N. M. Shannahan	1958	47	do.	75	4	54 - 75	21	do.	4.7	13	6/12/58	T	60	6/12/58	7.3	N	-		Cf 156
Cf 157	33936	do.	do.	1959	47	do.	85	4	64 - 85	21	do.	5.3	6.5	2/18/59	-	50	2/18/59	-	N	-		Cf 157
Cf 158	18459	do.	do.	1955	45	do.	77	4	57 - 77	20	do.	6.3	14	4/18/55	-	42	4/18/55	5.4	Ind	-	Hatchery No. 1.	Cf 158
Cf 159	66W23	Edward Tull	W. K. Wood	1965	48	do.	54	2	46 - 54	8	do.	-	-	-	-	60	9/29/65	-	D	-	Test hole drilled to 100 feet.	Cf 159
Cf 160	-	E. L. Outten	—	1963	27	Driven	50	1.25	-	-	do.	-	-	-	-	-	-	-	D	-		Cf 160
Cg 45	47321	W. E. Lewis	L. E. Cowger	1962	69	Jetted	108	2	100 - 108	8	do.	-	-	-	S	25	6/2/62	-	D	-	See log. Water reported irony.	Cg 45
Cg 46	-	T. C. Jones & Sons	W. K. Wood	1964	80	Drilled	94	4	81 - 94	13	do.	35	-	5/15/64	-	-	-	-	F	-		Cg 46
Cg 47	49270	do.	E. R. Kauffman	1962	80	do.	90	2	70 - 90	20	do.	33	45	10/11/62	S	10	10/11/62	.8	F	-		Cg 47
Cg 48	35525	F. R. Hoffman	R. C. Scott	1959	65	Jetted	89	2	77 - 89	12	do.	8	17	7/9/59	J	15	7/9/59	1.7	D	-		Cg 48
De 45	35376	M. R. Stevenson	E. C. Cusick	1959	32	Jetted	230	1.5	210 - 230	20	Manokin aquifer	14	16	7/9/59	S	25	7/9/59	12.5	D	-		De 45
De 46	43999	O. E. Martin	P. W. Hubbert	1961	37	do.	228	1.5	210 - 228	18	do.	12	15	8/18/61	-	35	8/18/61	11.7	D	-		De 46
De 47	32589	Edward Palmer	do.	1958	45	do.	68	1.5	58 - 68	10	Yorktown-Cohansey Fm.	9	-	11/8/58	S	18	11/8/58	-	F	-		De 47
De 48	39797	Clyde Pryor	E. R. Kauffman	1960	48	Drilled	110	4	75 - 110	35	Salisbury Fm. & Yorktown-Cohansey Fm.	5 6.88[m]	15 -	7/25/60 8/20/63	S	100	7/25/60	10.0	Irr	-	Plastic casing and screen.	De 48
De 49	39798	do.	do.	1960	48	do.	70	6	40 - 70	30	Salisbury Fm.	5 6.45[m]	20 -	7/26/60 8/20/63	S	100	7/26/60	6.7	Irr	-	do.	De 49

Well number	State permit number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Total screen length (feet)	Water-bearing formation or unit	Water level (feet below land surface) Static	Pumping	Date	Pumping equipment	Yield Gallons a minute (gpm)	Date	Specific capacity (gpm/ft)	Use of water	Temperature (°F.)	Remarks	Well number
De 50	39799	Clyde Pryor	E. R. Kauffman	1960	48	Drilled	115	6	80 - 115	35	Salisbury Fm. & Yorktown-Cohansey Fm.	5 7.59[m]	15 -	7/27/60 8/20/63	S	100	7/27/60	10.0	Irr	-	See log. Plastic casing and screen.	De 50
De 51	15549	Wicomico County Board of Education	N. M. Shannahan	1954	40	Drilled	64	6	-	-	Salisbury Fm.	13 11.86[m]	27 -	7/7/54 8/21/63	Sb	45	7/7/54	3.2	Ins	-	See log.	De 51
De 52	44288	Samuel Ruark	P. W. Hubbert	1961	38	Jetted	66	2	61 - 66	5	do.	12	28	10/2/61	J	25	10/2/61	1.6	D	-		De 52
De 53	49874	Alfred Davis	C. I. Disey	1962	30	do.	76	2	66 - 76	10	do.	18	28	11/20/62	S	50	11/20/62	5.0	F	-	Screen slot size No. 18.	De 53
De 54	24421	W. H. Jackson	N. M. Shannahan	1956	28	Drilled	52	6	41 - 52	11	do.	11	36	9/11/56	T	110	9/11/56	4.4	Irr	-		De 54
De 55	26865	Mrs. S. F. Woodcock	do.	1957	25	do.	54	6	43 - 54	11	do.	16.7 16.54[m]	25 -	6/5/57 8/21/63	Sb	40	6/5/57	5.0	N	-		De 55
De 56	30280	J. C. Stinebaugh	E. P. Schultz	1958	35	Jetted	82	2	72 - 82	10	do.	17	30	4/22/58	-	32	4/22/58	2.5	D	58	See log. Fe 0.3 ppm, pH 5.7, sp. cond. 74.	De 56
De 57	35617	Mrs. C. W. Coulbourn	do.	1959	35	do.	80	2	70 - 80	10	do.	18	28	7/31/59	S	20	7/31/59	2.0	D	-	Screen slot size No. 20.	De 57
De 58	44616	R. R. Harr	do.	1961	28	do.	73	2	63 - 73	10	do.	18	30	10/6/61	S	25	10/6/61	2.1	D	57	See log. Screen slot size No. 20. Fe 5.5 ppm, pH 6.0, sp. cond. 82.	De 58
De 59	19574	C. W. Parker	P. W. Hubbert	1955	25	do.	67	2	-	-	do.	13	25	12/7/55	J	22	12/7/55	11.0	D	-	See log.	De 59
De 60	34736	W. B. Long	R. B. White	1959	22	do.	155	2	139 - 155	16	Manokin aquifer	3	-	11/-/59	J	22	11/-/59	-	D	-		De 60
De 61	38720	Canal Park Swim Club Inc.	P. W. Hubbert	1960	25	do.	55	2	45 - 55	10	Salisbury Fm.	14	28	6/15/60	J	40	6/15/60	2.9	C	-	See log.	De 61
De 62	42096	Merrill Culver	do.	1961	35	do.	65	2	60 - 65	5	do.	14	22	3/15/61	-	38	3/15/61	4.8	D	-		De 62
De 63	-	Wicomico County Roads Board	Penniman & Browne, Inc.	1964	28	Augered-cored	82	-	-	-	Yorktown-Cohansey Fm.	8	-	3/18/64	N	-	-	-	T	-	See log. Core samples obtained.	De 63
De 64	-	C. O. Long	do.	1964	20	do.	70	-	-	-	do.	11	-	3/28/64	N	-	-	-	T	-	do.	De 64
De 65	-	Mrs. R. Harr	W. K. Wood	1963	28	Drilled	60	-	-	-	Salisbury Fm.	-	-	-	-	-	-	-	D	62	See log. Fe> 4 ppm, sp. cond. 63.	De 65
De 66	-	Atlantic Refining Co.	E. P. Schultz	1958	38	Jetted	63	2	53 - 63	10	do.	12	30	6/6/58	-	35	6/6/58	1.9	C	-	See log.	De 66
De 67	-	B. Quillin	P. W. Hubbert	1962	35	do.	190	-	-	-	Manokin aquifer	-	-	-	-	-	-	-	D,F	-	Fe> 5 ppm, pH 6.5, sp. cond. 150.	De 67
De 68	15621	Dulany Foods, Inc.	S. V. Shannahan	1954	38	-	58	10	43 - 58	15	Salisbury Fm.	12	33	2/2/54	T	250	2/2/54	11.9	Ind	-	Screen slot size No. 100.	De 68
De 69	11841	do.	do.	1954	38	-	531	6-3	-	-	Nanticoke aquifer	16	28	1/30/54	T	60	1/30/54	3.0	Ind	-		De 69
De 70	15620	do.	do.	1955	38	-	550	10-6	510 - 550	40	do.	16	116	1/28/55	T	400	1/28/55	4.0	Ind	-	Screen slot size No. 100.	De 70
Df 49	34705	W. A. Spearin	E. P. Schultz	1959	55	Jetted	96	4	86 - 96	10	Salisbury Fm.	7	12	5/9/59	N	30	5/9/59	6.0	N	-	Water reported very irony.	Df 49
Df 50	41889	Frederick Pusey	P. W. Hubbert	1961	57	do.	113	2	108 - 113	5	do.	4	8	3/10/61	S	40	3/10/61	10.0	D,C	-		Df 50
Df 51	51798	B. T. Payne	M. O. Ford	1963	50	do.	74	2	66 - 74	8	do.	7.31[m]	-	8/15/63	J	14	5/25/63	-	D	58	Fe <.01 ppm, sp. cond. 99.	Df 51

Well number	State permit number	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of screen below land surface (feet)	Total screen length (feet)	Water-bearing formation or unit	Water level (feet below land surface) Static	Pumping	Date	Pumping equipment	Yield Gallons a minute (gpm)	Date	Specific capacity (gpm/ft)	Use of water	Temperature (°F.)	Remarks	Well number
Df 52	50607	Wallace Luffman	E. R. Kauffman	1963	44	Drilled	90	2	80 - 90	10	Salisbury Fm.	12	25	3/22/63	S	60	3/22/63	4.6	D,F	-	See log. Plastic casing and screen.	Df 52
Df 53	48805	Roland Dixon	do.	1962	45	do.	65	4	50 - 65	15	do.	15	25	9/25/62	J	30	9/25/62	3.0	D,F	-		Df 53
Df 54	42696	John Griffith	E. P. Schultz	1961	48	Jetted	70	2	60 - 70	10	do.	14	28	5/4/61	S	60	5/4/61	4.3	D	-		Df 54
Df 55	-	Maryland State Roads Commission	Penniman & Browne, Inc.	1964	43	Augered-cored	101	-	-	-	Yorktown-Cohansey Fm.	18	-	3/24/64	N	-	-	-	T	-	See log. Core samples obtained.	Df 55
Df 56	-	W. C. Luffman	do.	1964	38	do.	92	-	-	-	do.	16	-	3/27/64	N	-	-	-	T	-	do.	Df 56
Df 57	-	J. E. Thompson	——	-	50	-	50	-	-	-	Salisbury Fm.	-	-	-	S	-	-	-	D	-		Df 57
Df 58	12663	W. A. Spearin	W. J. Porter	1953	55	Jetted	112	3-2	104 - 112	8	do.	12	-	8/20/53	S	30	8/20/53	-	N	57	Fe 1.1 ppm, pH 6.0, sp. cond. 80.	Df 58