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THE WATER RESOURCES OF CARROLL AND FREDERICK COUNTIES

THE GROUND-WATER RESOURCES

By Gerald Meyer

THE SURFACE-WATER RESOURCES

By Robert M. Beall

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THE WATER RESOURCES OF CARROLL AND FREDERICK COUNTIES

The Ground-Water Resources

BY
GERALD MEYER

ABSTRACT

Carroll and Frederick Counties are in central Maryland and include parts of the Piedmont and Blue Ridge physiographic provinces. The Piedmont, which includes most of the area of these counties, is underlain by metamorphic rocks of Precambrian or Cambrian age, chiefly schist and phyllite and associated marble and limestone. At its west edge, along the east foot of Catoctin Mountain, the Piedmont is underlain by Cambrian and Ordovician limestone and Triassic shale and sandstone. The Blue Ridge includes the mountainous western part of Frederick County and is formed chiefly by metabasalt and quartzite and smaller bodies of shale, conglomerate, slate, and phyllite.

The average daily use of ground water in Carroll and Frederick Counties in 1956 and 1957 was about 6.6 million gallons, of which about 16 percent was for institutional and public supplies, 15 percent for industrial and commercial supplies, and 69 percent for rural domestic and farm supplies. Ground water in small to moderate amounts is available nearly everywhere. Under especially favorable conditions of geology and hydrology, moderately large supplies are obtainable, but prospecting is required to outline the favorable areas. Application of available knowledge of the occurrence of ground water in the rocks of these counties may aid substantially in the location and development of ground-water supplies in untried areas. Optimum development requires that well construction, well-field patterns, and pumping regimens be adapted to the local geohydrologic conditions.

In most of the rocks ground water occurs chiefly in pores and fractures in the mantle of semidecomposed rock that underlies the surface and in fractures in the fresh bedrock below. Solution by moving water has enlarged the openings in the carbonate rocks to a much greater degree (some of the openings being of cavernous dimensions) than in the siliceous rocks, and the wells of largest yield generally penetrate the carbonate rocks. Statistical analysis of well records shows a general relation among the yield of a well, ground-water levels in the vicinity, the geology, and the topography. Most wells yield 5 to 20 gpm, but those favorably situated geohydrologically may yield as much as

several hundred gallons per minute. Owing to small storage capacity of the rocks resulting from their low porosity and to low permeability, continuous pumping may result in a substantial decrease in well yield. Pumping tests long enough to enable predicting the effect of long-term pumping should be made before it is concluded that a satisfactory yield is obtainable from a well. Test drilling, detailed geologic mapping, and aquifer and well-performance tests, should precede development of major ground-water supplies.

Geophysical methods used in the ground-water study of Carroll and Frederick Counties include electric and temperature logging and current-meter surveys. Drilling-time logs also were made. Aquifer tests and well-performance tests, particularly specific-capacity step tests, were made to determine the performance characteristics of wells and the water-bearing ability of aquifers.

Periodic measurements of water levels in wells show that ground-water levels fluctuate in a more or less uniform pattern from year to year, the levels being highest in the late winter and early spring and lowest in the late summer and early fall. The yields of wells vary with the amount of ground water in storage. When droughts occur during periods when ground-water replenishment normally begins, well yields may be seriously reduced. The water-level observations show no overall long-term upward or downward trend. In a few localities heavy pumping has lowered ground-water levels appreciably, reducing well yields.

Chemical analyses of well and spring water show that few problems of chemical quality of ground water exist in Carroll and Frederick Counties. The siliceous rocks yield water generally low in mineral content, with the exception of the Triassic sediments which yield hard water. The carbonate rocks yield hard water. Locally, high iron concentration may be an objectionable feature. Ground-water temperatures fluctuate seasonally, but generally not more than a degree or two. The average ground-water temperature is 53°F.

INTRODUCTION

Location of the Area

Carroll and Frederick Counties are in central Maryland (fig. 1). Carroll County is bordered on the east by Baltimore County and the North Branch of the Patapsco River and on the south by the South Branch of the Patapsco River. Frederick County is bordered on the west by Washington County and on the south by Montgomery County and the Potomac River. The Pennsylvania State line is the northern boundary of both counties.

Purpose, Scope, and Methods of Investigation

The purpose of the investigation was to obtain basic information on the occurrence, availability, and quality of ground water in Carroll and Frederick

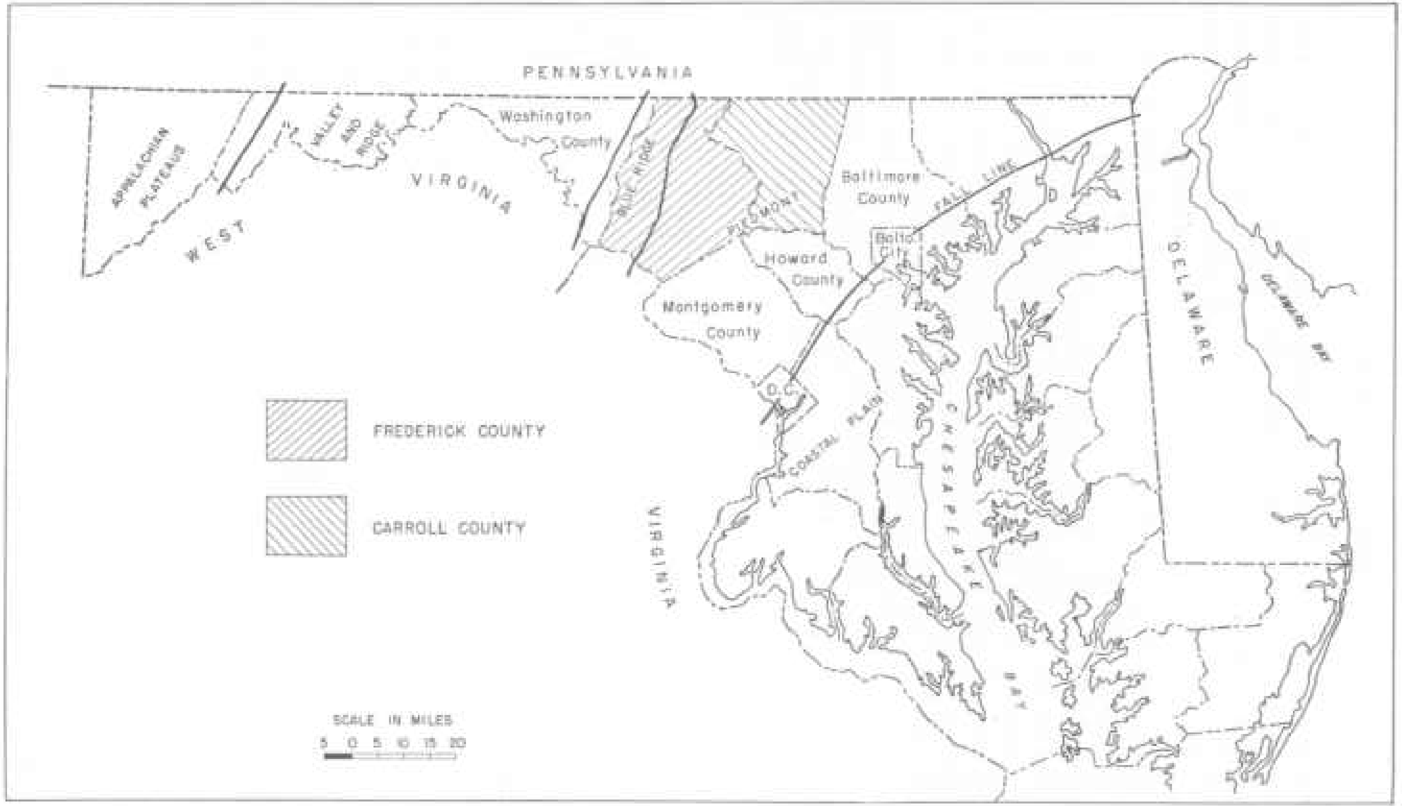


FIGURE 1. Map of Maryland Showing the Physiographic Provinces and the Location of Carroll and Frederick Counties

Counties. A general study of the lithologic and hydrologic characteristics of the rocks and an inventory of their present use as sources of water was made, and samples of the ground water were collected for determination of its mineral content and chemical properties. This study is one of a series of investigations of the ground-water resources of the counties of Maryland being made by the United States Geological Survey and the Maryland Department of Geology, Mines and Water Resources.

An inventory of 1,270 wells and springs was made, and the data are listed in Tables 25 and 26. Drillers' logs of wells were available in the records of the Department of Geology, Mines and Water Resources, and selected ones are given in Table 27. Geophysical surveys (electric logs, temperature logs, and fluid-velocity surveys) were made of several wells. Aquifer tests and specific-capacity tests were made.

Fluctuations of ground-water levels were determined in 11 wells by periodic tape measurements and by continuous water-level recorders. Measurements in most of the wells began in 1946.

Chemical analyses of water samples from 61 wells and springs were made by the Quality of Water laboratory of the Geological Survey. The data are given in Tables 11 and 12.

Previous Investigations

Records of 47 wells in Carroll County and 37 wells in Frederick County are given in a report on the water resources of Maryland, Delaware, and the District of Columbia by Clark, Mathews, and Berry (1918, p. 428–430, 440–442). The occurrence of ground water and its relation to the geology are summarized briefly by Bennett (1946, p. 165–187) in a report on the physical features of Carroll and Frederick Counties. He gives the rate of use of ground water from public-supply systems and lists a large number of well records in the files of the Maryland Department of Geology, Mines and Water Resources. In the same report Stose and Stose (p. 1–131) describe the geology of the two counties. A companion publication of that report is a geologic map (Jonas and Stose, 1938) of Frederick County and parts of Washington and Carroll Counties. Geologic investigations of South Mountain by Cloos (1950), of Catoctin Mountain by Whitaker (1955), and of Sugarloaf Mountain by Scotford (1951) and Thomas (1952) have led to a different interpretation of the structural geology of these mountains from that of Jonas and Stose, which necessitated revision of their stratigraphic description of those parts of Frederick County. The existence of conflicting conclusions may have some bearing on detailed evaluation of data on the occurrence of ground water in the mountainous parts of the area, but for convenience the map by Jonas and Stose is used in this report for identifying water-bearing formations.

Well-Numbering System

The locations of inventoried wells and springs are shown on Plates 1 and 2. Each well or spring has an identifying number. Uppercase letters on the left and right sides of the well-location maps designate 5-minute intervals of latitude, and lowercase letters on the top and bottom of the maps designate 5-minute intervals of longitude. The 5-minute quadrangles formed by the intersections of the lines are identified by a combination of the letters. The wells and springs in each 5-minute quadrangle are assigned consecutive numbers, approximately in the order in which they were inventoried. Where confusion might occur when referring to specific wells, the abbreviation for Carroll County (Car) or Frederick County (Fr) is placed before the coordinate letters. For example, well Fr-Bc 2 is in Frederick County, within the quadrangle identified by "B" and "c", and is the second well inventoried in that quadrangle.

Acknowledgments

The full cooperation of well drillers, municipal and industrial-plant officials, and residents of the area greatly facilitated the collection of data. Water-supply facilities were made available for aquifer and well-performance tests by the towns of Mount Airy, Taneytown, and Hampstead, and the Black and Decker Manufacturing Co. (Hampstead) and Thomas and Co. (Adamstown).

The investigation was under the general supervision of A. N. Sayre, chief of the Ground Water Branch of the U. S. Geological Survey, and under the immediate supervision of E. G. Otton, district geologist in charge of cooperative ground-water investigations in Maryland. Charles P. Laughlin, engineering aid of the Geological Survey, made the well inventory in a large part of Frederick County and effectively assisted in other fieldwork and in office work.

Population and Economy

Carroll and Frederick Counties are among the most prosperous and productive agricultural counties of the State. Dairying is the most important farm activity; poultry, grain, and vegetables also are important sources of agricultural income. Industries in the two counties include vegetable canning, clothing manufacture, and rock quarrying. The chief mineral products are lime, cement, and crushed stone.

Carroll County has an area of 456 square miles, of which about 86 percent is used for agricultural purposes. The value of all farm products in 1950 was about $11.5 million. The chief industrial enterprises are vegetable canning and manufacture of portable tools, rubber goods, cement, apparel, and accessory products for the linoleum industry. The value of manufactured products was about $17.6 million in 1947. The population of Carroll County was 44,970 in 1950. Westminster (pop. 6,140) is the county seat and largest municipality in the county.

Frederick County has an area of 670 square miles, of which 80 percent is used for agricultural purposes. The value of all farm products in 1950 was about $16.1 million. Industrial enterprises include manufacture of apparel, brushes, bricks and the canning of vegetables. The value of manufactured products was about $12.1 million in 1947. Most of the manufacturing plants are in the city of Frederick. The population of Frederick County was 62,287 in 1950. Frederick (pop. 18,142) is the county seat and largest municipality.

Climate

The climate of Carroll and Frederick Counties is temperate and moderately humid. The annual precipitation usually is between 40 and 46 inches and the mean annual temperature between 52° and 55°F. Precipitation and temperature records are available for stations at Westminster, in Carroll County, and at Emmitsburg, Frederick, and Unionville in Frederick County.

Precipitation is distributed fairly evenly through the year, ranging from an average of about 3 inches in February to an average of a little more than 4 inches in July and August. The mean monthly precipitation at Emmitsburg and Westminster, which have the longest periods of record, 89 and 46 years respectively, is given in Table 1 and shown graphically in figure 2. Annual snowfall averages about 25 inches.

The temperature in Carroll and Frederick Counties ranges from about an average of 31° or 32°F in January to 75°F in July. The mean monthly temperatures at Emmitsburg and Westminster are given in Table 2, and for Westminster are shown graphically in figure 2. The first killing frost occurs near the end of October and the last about the end of April.

There are no evaporation stations in Carroll or Frederick County. An evaporation pan is in operation at Beltsville (Prince Georges County), about

TABLE 1

Mean Monthly Precipitation at Emmitsburg and Westminster

(in inches)

Month	Emmitsburg	Westminster	Month	Emmitsburg	Westminster
January	3.27	3.21	July	4.22	4.02
February	3.01	2.93	August	4.17	4.60
March	3.98	3.72	September	3.69	3.75
April	3.62	3.45	October	3.55	3.30
May	4.20	3.76	November	3.33	3.02
June	4.20	4.10	December	3.16	3.22
			Year	44.40	43.08

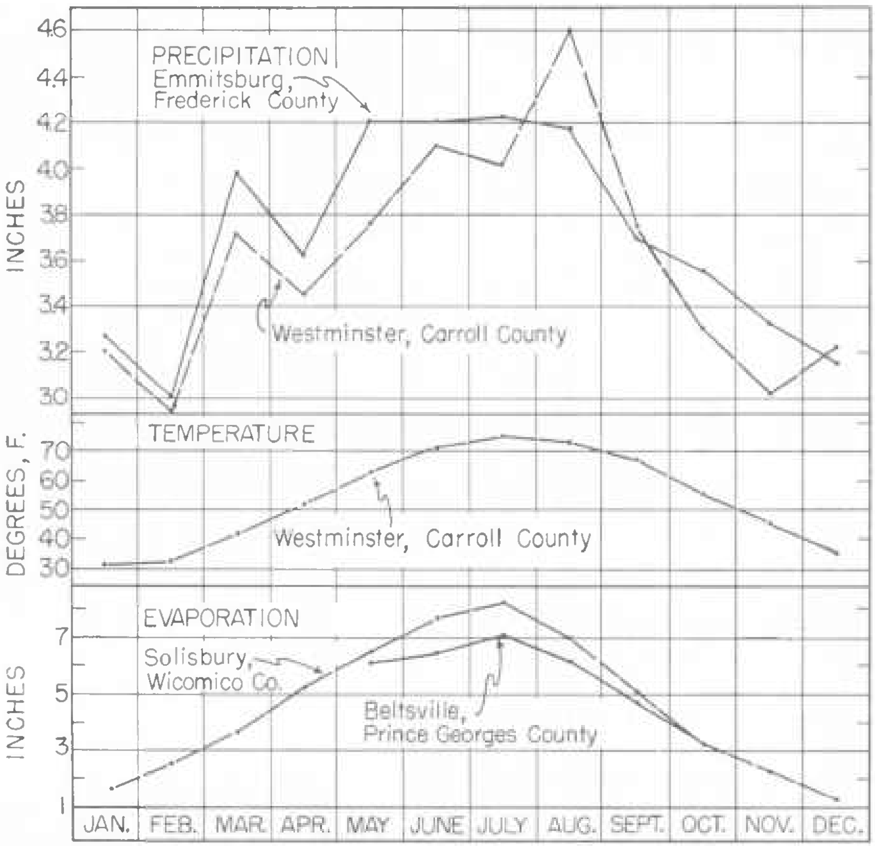


FIGURE 2. Average Monthly Precipitation and Temperature at Stations in Carroll and Frederick Counties and Evaporation at Stations in Wicomico and Prince Georges Counties

20 miles south of Carroll County, from May through October each year. Average monthly measurements at the Beltsville station, based on a 15-year record, are:

	Inches
May	6.6
June	6.5
July	7.1
August	6.1
September	4.7
October	3.3

A 4-year record is available for a station formerly operated at Salisbury (Wicomico County) throughout the year. The records of both stations are presented graphically, as monthly averages, in figure 2. The graphs show the

TABLE 2

Mean Monthly Temperature at Emmitsburg and Westminster

(in degrees F)

Month	Emmitsburg	Westminster	Month	Emmitsburg	Westminster
January	31.2	31.9	July	75.2	75.0
February	32.4	32.6	August	72.8	73.1
March	40.9	41.9	September	66.3	67.4
April	51.9	51.9	October	55.3	55.7
May	62.3	62.8	November	43.7	45.0
June	70.2	70.8	December	33.7	35.0

rate of evaporation varies with the temperature, although wind velocity, humidity, sunshine, and other meteorological factors also play an important part.

Precipitation, temperature, and evaporation have a direct bearing on the occurrence of ground water in Carroll and Frederick Counties.

Physiography and General Geology

Carroll and Frederick Counties lie within two physiographic provinces (fig. 1)—the Piedmont province, which includes the area east of Catoctin Mountain, and the Blue Ridge province, which includes the area west of the east foot of Catoctin Mountain. The Piedmont is gently rolling and of moderate relief; the Blue Ridge is predominantly rugged and mountainous.

The Piedmont is subdivided into eastern and western divisions, separated by Parrs and Dug Hill Ridges in central Carroll County (fig. 3). The eastern division and the eastern part of the western division are characterized by moderate relief, gentle slopes, and rounded hills. The rocks are predominantly schist and phyllite, of Precambrian or possibly Cambrian[1] age, and some carbonate rocks and metavolcanics. The western part of the western division is a slightly to moderately rolling area that includes the low-lying Frederick Valley, underlain by Cambrian and Ordovician limestone, and the slightly higher Triassic upland, underlain by Triassic shale and sandstone. A prominent ridge of quartzite separates the Frederick Valley from the Piedmont upland area to the east.

The Blue Ridge province includes Catoctin Mountain, Middletown Valley, and South Mountain. Catoctin and South Mountains are northeastward-trending ridges whose crests are formed by quartzite of Cambrian age. Metabasalt and aporhyolite of Precambrian age are the most widely distributed rocks of the mountains. Other rocks include shale, slate, phyllite, and con-

[1] The stratigraphic nomenclature and age designations used in this report do not necessarily follow the usage of the U. S. Geological Survey.

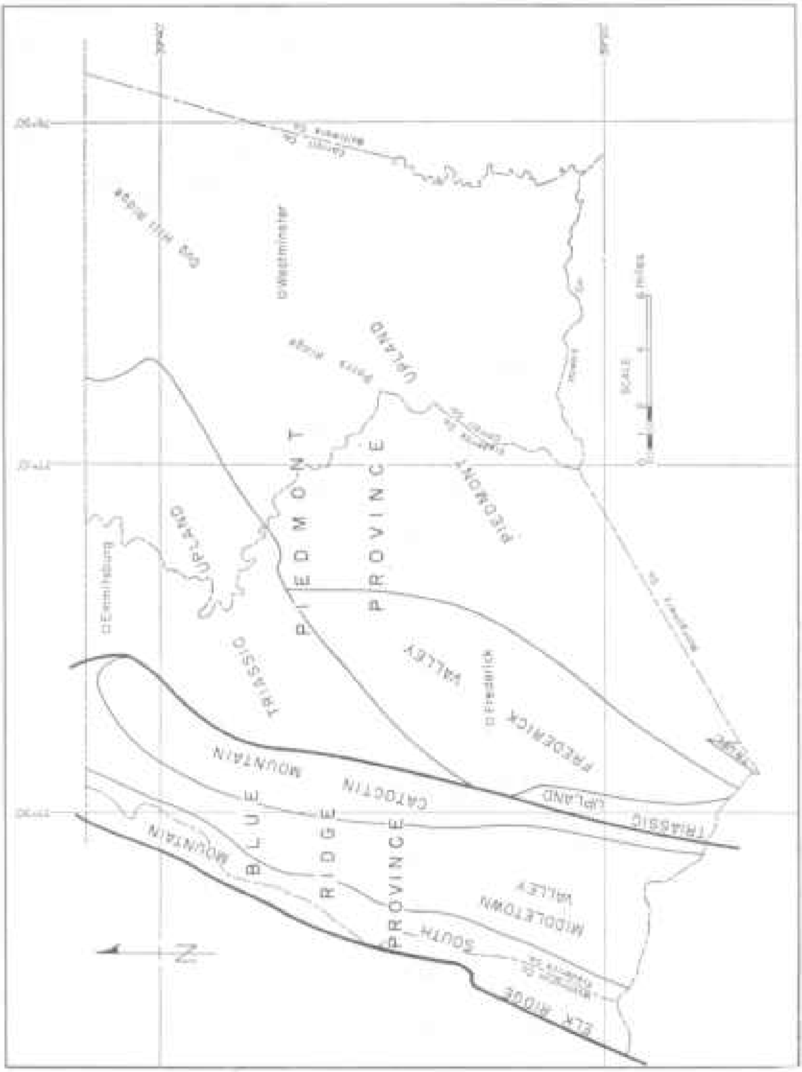


FIGURE 3. Map of Carroll and Frederick Counties Showing Physiographic Divisions

glomerate. The Middletown Valley, a rolling upland between the mountain ridges in the southwestern part of Frederick County, is underlain by granodiorite and granite gneiss of Precambrian age.

The stratigraphy and structure of Carroll and Frederick Counties are complicated by faults, unconformities, and bodies of intrusive rocks. Four areal stratigraphic columns are shown in the explanation accompanying the geologic map of the counties (Plate 3). The oldest rocks, the "injection complex," are exposed in the Middletown Valley as the core of the Middletown anticline. These early Precambrian rocks are overlain by volcanic rocks, chiefly metamorphosed rhyolite and basalt flows of late Precambrian age. Lower Cambrian quartzite, phyllite, and dolomite overlie the volcanic series. Overlying this largely arenaceous series are the Upper Cambrian and Lower Ordovician limestones of the Frederick Valley.

East of the Frederick Valley rocks of the Martic overthrust block are exposed. The oldest, the Baltimore gneiss of early Precambrian age, occurs at the southeastern tip of Carroll County as a part of the Woodstock anticline. Metamorphosed sedimentary rocks of the Glenarm series overlie the Baltimore gneiss unconformably and are cut by granitic and gabbroic intrusives. Intricately folded volcanic rocks and marble of the Glenarm series occur between the other Glenarm rocks and the east edge of the Frederick Valley. Quartzites of Cambrian age overlie the volcanic rocks and form Sugarloaf Mountain in southern Frederick County and small ridges in northern Carroll County.

The rocks of the Martic overthrust block and the limestones of the Frederick Valley are unconformably overlain by sedimentary rocks of Triassic age. Upper Triassic diabase dikes and sills are intruded into the Triassic sedimentary rocks and the adjacent older rocks.

Quaternary unconsolidated deposits of sand, clay, gravel, and cobbles are associated with major streams in their present positions and erosional remnants of similar deposits mark former positions of the streams at higher levels. Remnants of extensive Quaternary mountain-wash deposits occur along the east flank of Catoctin Mountain.

Drainage

The Potomac River flows southeastward across the strike of the rocks along part of the southern boundary of Frederick County. Its major tributary in this area is the Monocacy River, which flows southward from Pennsylvania across the Triassic upland and the eastern edge of the Frederick Valley to join the Potomac River at the southern tip of Frederick County. Eastward-flowing tributaries of the Monocacy head on the east slope of Catoctin Mountain and in the mountainous area to the west. Tributaries flowing westward to the Monocacy head on the slopes of Dug Hill Ridge and Parrs Ridge.

In the Middletown Valley, Catoctin Creek flows southward to the Potomac in deeply incised meanders along the center of the valley. This creek and its tributaries, which head on the east slope of South Mountain and the west slope of Catoctin Mountain, drain practically the entire Middletown Valley and part of the mountainous area to the north between South and Catoctin Mountains.

East of Dug Hill and Parrs Ridges the Piedmont upland is drained by the South Branch and the North Branch of the Patapsco River and their tributaries. Most of the tributaries head near Dug Hill and Parrs Ridges and flow southward or southeastward. The South Branch and the North Branch join at the southeastern tip of Carroll County to become the Patapsco River. The North Branch is dammed about 2 miles north of the junction to form the Liberty Reservoir, a part of the Baltimore City water-supply system. A small part of the northeast tip of Carroll County is drained by small tributaries of the Gunpowder Falls of Baltimore County.

HYDROLOGY

The Hydrologic Cycle

Hydrology is the science concerned with the occurrence of water in and on the earth and the physical and chemical relations of water to the earth. The basic concept of hydrology is a dynamic cycle of circulation of water upward by evaporation from oceans and other bodies of surface water, movement through the atmosphere, deposition on the land by precipitation, and then return to the atmosphere by evaporation, or to surface-water bodies by overland flow and flow through subsurface passages. This circulation is known as the hydrologic cycle.

Some components of the hydrologic cycle are measured more easily than others. The amount of precipitation can be estimated from measurements at a network of stations. The U. S. Weather Bureau maintains about 120 such stations in Maryland. Within the two counties weather stations are maintained at Emmitsburg, Frederick, Unionville, and Westminster. Streamflow can be measured directly. In Carroll and Frederick Counties three continuous-record stream-gaging stations operate within the Patapsco River Basin and eleven in the Potomac River Basin. Changes in ground-water storage are observed by means of continuous or periodic measurements of water levels in a network of 116 observation wells and 2 springs. Water-level measurements do not indicate directly the volumes of the changes in storage, but they are essential to determinations of those volumes. Soil-moisture measurements are made intermittently, as a part of special projects of the cooperative ground-water program, by the U. S. Soil Conservation Service and by State agencies concerned with agricultural development.

Ground-Water Hydrology

General Principles

Ground-water hydrology is concerned with that portion of the hydrologic cycle which pertains to water below the surface of the earth, particularly water in the zone that is completely saturated. But in the study of ground water all parts of the hydrologic cycle must be considered, for all are intimately related to the replenishment, storage, and discharge of ground water.

Water seeping into soil during and after a period of rainfall or snow-melt may evaporate immediately from the soil, either directly or through plant transpiration, or it may be retained to satisfy a soil-moisture deficiency and later discharged by evapotranspiration. The water escaping capture and discharge by these means continues downward under the pull of gravity and satisfies moisture deficiencies in the remainder of the vadose zone (the zone of soil and rock above the fully saturated rocks). What remains merges with the water in the zone of saturation and becomes, by definition, ground water. It then moves slowly and, perhaps for the first time since entering the soil, laterally toward nearby surface drainage channels, where it is discharged as springs or seeps; or, as it nears the land surface, it may be evaporated to the atmosphere or transpired by plants.

Although under certain geologic conditions ground water may flow many miles underground, so that its exit from the ground may be a long distance from its entrance, in Carroll and Frederick Counties the precipitation that replenishes the ground-water bodies ordinarily is discharged not far—hundreds or thousands of feet or perhaps a few miles—from where it entered the ground. This is because the major zones of circulation are at shallow depth, and the land surface is incised by a dense network of streams. Also, the shallow rocks are broken by joints and other openings which allow the ground water to move readily to local surficial drainageways. The popular concept that the mountains of Maryland are the catchment and recharge areas for the aquifers of the Piedmont and Coastal Plain is erroneous.

The ground water moves smoothly by laminar (viscous, streamline) flow, except in some of the near-surface cavernous openings in the limestones of the Frederick Valley and in the immediate vicinity of wells being pumped at high rates, where the flow is turbulent as in streams and pipes. Local variations in rock permeability and topography complicate the pattern of movement, but it is always in the direction of the hydraulic gradient, from points of high pressure head to points of lower head. The natural rate of movement of ground water is ordinarily only a few inches or feet a day; in the relatively impermeable residual materials formed by weathering of bedrock and in massive crystalline rocks themselves, the ground water moves so slowly that it is almost stagnant.

Definition of an aquifer

A geologic formation, part of a formation, or group of formations from which it is economically feasible to obtain ground water in usable quantity is called an "aquifer". The rock formations of Carroll and Frederick Counties are all waterbearing, in that nearly everywhere they are capable of yielding water in usable quantities to wells or springs; in most places, however, only the shallow parts of the formations where joints are open and solution is active can be considered aquifers, the deeper parts being essentially non-waterbearing. Joints of the principal systems may transect several formations and interconnect them hydrologically. Local zones of fracture or shear may create nearly isolated small aquifers, but ordinarily these zones are not entirely isolated hydraulically from neighboring rocks. In the Triassic rocks, for example, the beds of competent sandstone are fractured cleanly and somewhat commonly and may be better waterbearers than the interbedded shale in which fractures are more poorly developed. Many of the joints in the sandstone do not continue into the bordering shale, but some do persist through both rock types and tend to integrate the rocks hydraulically.

Unlike the stratified deposits of the Maryland Coastal Plain to the east, where the aquifers are generally parallel to the formational contacts, the aquifers in the consolidated rocks of Carroll and Frederick Counties tend to parallel the land surface and thus are roughly horizontal and cut across the rock structures. Erosion has removed most of the weathered material along the major streams. The weathered material that remains between the streams has been divided by them into physically and hydrologically separate units. Minor streams which have not eroded the rocks deeply have not created such distinct and separate physical and hydraulic units.

Hydrologic properties of the water-bearing materials

General characteristics

The general water-bearing characteristics, or hydrologic properties, of the rocks of Carroll and Frederick Counties are summarized in Table 3. Because a given rock type may occur in innumerable topographic and structural situations, its hydrologic character may vary over a wide range, so that the descriptions in the table are necessarily highly generalized.

Porosity and specific yield

The porosity of a rock, the percentage of its total volume occupied by voids, determines the volume of water that can be stored in the rock. Openings existing at the time the rocks were originally deposited or emplaced form "primary porosity"; fractures, openings developed by weathering and solution,

TABLE 3
Water-bearing Properties of Rocks in Carroll and Frederick Counties

Rock type	Geologic formations in which it occurs	General water-bearing characteristics
Schist	Antietam quartzite, Setters formation, Wissahickon formation, Peters Creek quartzite, Sams Creek metabasalt, Marburg schist	Water occurs in fractures, along planes of schistosity and shear zones, and in weathered mantle. Principal source of ground water in both counties. Adequate domestic supplies everywhere and larger supplies locally. Water generally is soft and low in mineral content.
Gneiss	Baltimore gneiss, "injection complex"	Water occurs in fractures, along planes of schistosity and shear zones, and in weathered mantle. Important as a source of water in western Frederick County; of minor importance in Carroll County. Adequate domestic supplies generally available and larger supplies locally. Water is soft and generally low in mineral content, except for iron locally.
Quartzite	Loudoun formation, Weverton quartzite, Antietam quartzite, Setters formation, Peters Creek quartzite, Urbana phyllite, Sugarloaf Mountain quartzite, Marburg schist	Water occurs chiefly in fractures. Mantle generally thin. An important source of ground water in botb counties. Interbedded quartzite makes moderately good aquifers of some of the schist and phyllite that otherwise are mediocre water-bearers. Adequate supplies for domestic and limited commercial or industrial use available. Water is generally soft and low in mineral content.
Phyllite and slate	Loudoun formation, Harpers phyllite, Ijamsville phyllite, Urbana phyllite, Marburg schist	Water occurs in fractures and along cleavage planes of slaty rocks. Weathered mantle thin to absent. Adequate domestic supplies generally obtainable, but locally only one of several wells may be successful. Little likelihood of obtaining large supplies except under most favorable conditions. Water is soft and low in mineral content.
Metabasalt	Catoctin metabasalt, Sams Creek metabasalt	Water occurs in fractures and shear zones and in weathered mantle. Important source of water in western Frederick County but of less importance in Carroll County. Adequate domestic supplies obtainable but larger supplies rare. Water is soft and low in objectionable mineral content.
Aporhyolite, metarhyolite, and rhyolite	Libertytown metarhyolite, other unnamed bodies of rock	Water occurs chiefly in fractures. Weathered mantle generally tbin. Moderately important source of water for domestic supplies in western Frederick County; of minor importance in Carroll County. The chemical quality of the water is good.
Granodiorite and diorite	"Injection complex"	Water occurs in fractures, along planes of schistosity and shear zones, and in weathered mantle. Important source of ground water in Frederick County; no rocks of this type in Carroll County. Adequate domestic supplies available nearly everywhere; larger supplies available locally. The chemical quality of the water is good.
Monzonite and pegmatite	Sykesville formation, small unnamed bodies of rock	Water occurs in fractures, along planes of schistosity and zones of shear, and in weathered mantle. Moderately important source of water in southeastern Carroll County. Adequate domestic supplies available; large supplies obtainable locally. Water is soft and low in mineral content.
Serpentine, metagabbro, and diabase	Unnamed bodies of rock	Water occurs in fractures and shear zones. Of minor importance as sources of ground water. Adequate domestic supplies obtainable, but not larger supplies.

TABLE 3—*Continued*

Rock type	Geologic formations in which it occurs	General water-bearing characteristics
Limestone, dolomite and marble	Tomstown dolomite, Frederick limestone, Grove limestone, Wakefield marble, Silver Run limestone, unnamed bodies of rock	Water occurs in fractures and openings in shear zones, some of which are solutionally enlarged. Rocks are major sources of ground water, particularly in Frederick County. Adequate domestic supplies obtained nearly everywhere. Chances of obtaining moderately large to large supplies are good. Water is hard but otherwise of good chemical quality.
Sandstone and shale	New Oxford formation, Gettysburg shale	Water occurs in fractures and, to a small extent, in the pores of sandstone. Adequate domestic supplies available to wells everywhere; larger supplies can be obtained locally. Water is of good quality generally but locally is hard.
Clay, silt, sand, gravel, and cobbles	Mountain wash, terrace deposits, stream alluvium	Water occurs in pore spaces. Owing to poor sorting and thinness of the deposits, they are generally of minor importance as sources of ground water. Where saturated, these deposits may supply water to underlying bedrocks when water is pumped from these rocks by wells. Water quality generally is good, but water from some terrace and stream deposits has marshy odor.

and other openings developed later form "secondary porosity." Original porosity may be increased by such processes as fracturing, or decreased by such processes as the filling of pore spaces in sand with cement to form a sandstone.

The rocks in Carroll and Frederick Counties that have the highest primary porosity are the unconsolidated Quaternary alluvium and mountain wash, which have a porosity estimated to be 20 to 30 percent in most places. Locally, the porosity of these deposits may be higher or lower, according to the size, shape, and sorting of the component particles. The primary porosity of the consolidated sedimentary rocks—the Cambrian and Ordovician limestones and Triassic shales and sandstones—is smaller, about 1 to 10 percent, and that of the igneous and metamorphic rocks is smallest, generally 1 percent or less. Laboratory porosity measurements for some of the rock types of the area are given in Table 4.

Secondary porosity is far more important to the occurrence of ground water in Carroll and Frederick Counties than is primary porosity, because consolidated rocks in which the principal porosity is secondary occupy a much larger area than other rocks. Although crystalline rock that is unfractured and unweathered is of low porosity, the crystalline rocks generally are fractured and are overlain by a mantle of mechanically and chemically weathered silty or clayey rock of relatively high porosity. Dense nonporous metabasalt or granite is rendered moderately porous by secondary processes such as jointing or shearing. The porosity of limestone and marble commonly is increased appreciably by solutional enlargement of existing voids as water moves through them, or by selective solution of granules or crystals of the rock.

TABLE 4

Porosity of Rocks[1]

Rock type	Number of specimens	Measured range in porosity (percent)	Average porosity (percent)
Igneous			
Diabase	2	0.17–1.00	0.58
Gabbro	3	.00–.62	.29
Granite	17	.44–3.98	1.11
Granodiorite	1	—	.50
Sedimentary			
Limestone	7	.27–4.36	1.70
Limestone (dolomitic)	2	—	2.08
Sandstone	6	1.62–26.40	9.25
Sandstone (clayey)	1	—	6.10
Metamorphic			
Gneiss	5	.30–2.23	.78
Marble	7	.31–2.02	.62
Marble (dolomitic)	2	—	.60
Quartzite	3	—	.46
Slate	3	.00–1.06	—

[1] Adapted from a table compiled by J. H. Griffith (1937).

Not all the water stored in the openings in rocks is recoverable. Some is retained by molecular attraction. The ratio (generally expressed as a percentage) of the volume of water that drains by gravity from a rock to the total volume of the rock is known as the "specific yield." The complementary term, "specific retention," refers to the water that is retained against the pull of gravity. Together the specific yield and specific retention equal the porosity of the rock. A saturated rock having a specific yield of 25 percent, for example, will yield by gravity drainage a volume of water equal to 25 percent of the rock's volume. If 1 inch of rainwater were to percolate down to the water table in an aquifer having this specific yield, it would increase the thickness of the saturated zone by 4 inches. In reciprocal terms, a 1-foot decline of the water table would represent discharge of 3 inches of water.

Permeability and transmissibility

Permeability, frequently confused with porosity, refers to the ability of a rock to transmit water under head. As defined by the Geological Survey, the *coefficient of permeability* is the rate of flow of water in gallons per day under a hydraulic gradient of 1 foot per foot at a temperature of 60°F across a section of the rock 1 foot square. The field coefficient of permeability is the same measured at the prevailing temperature of the water instead of at 60°F. Permeability is governed chiefly by the number, size, shape, and degree of interconnection of the openings in a rock. Although permeability and porosity are related, the relationship may be either direct or inverse. The porosity of clay, which is extremely fine grained, is high; but, owing to the minuteness of the interstices between particles of the clay, water clings to the particles by molecular attraction and does not move through the clay freely. Hence, the permeability of clay—its ability to transmit water—is low, despite its high porosity. The much larger interstices in well-sorted sand and gravel transmit water more readily—the permeability is high—although their porosity frequently is less than that of clay.

The metamorphic rocks consist principally of silicate minerals and are comparatively insoluble. The principal water-bearing openings in these rocks are fractures, chiefly tension joints and shear fractures. Microscopic openings along cleavage planes play a relatively unimportant role in the circulation of ground water. Weathering is important to the occurrence of ground water in foliated metamorphic rocks because, with their innumerable though small openings along planes of schistosity, they are especially susceptible to weathering. They yield a residuum which invariably is more permeable than the original fresh rock. Weathering also enlarges joints and other fractures through solution.

The important openings in the Triassic shale and sandstone are those formed by jointing, although some original interstitial porosity has survived. Lack of solutional enlargement of the joints is shown by the smooth, intact condition of the joint surfaces where exposed at the land surface. The Cambrian and Ordovician limestones contain joints and openings along bedding planes, many enlarged solutionally.

The term *coefficient of transmissibility*, introduced by Theis (1935, p. 520), is used to express the gross permeability of a rock body. It is the average field coefficient of permeability times the thickness in feet of saturated rock. More specifically, this coefficient is defined as the rate of flow of water, in gallons per day at the prevailing temperature of the water, under unit hydraulic gradient, across a section of rock 1 foot wide that extends the full saturated thickness of the rock body. The coefficient is useful for calculating the rate of discharge of ground water to streams and for predicting the effects on ground-water levels of withdrawing water from wells. It is determined in the field by means of controlled pumping tests (aquifer tests). Values for the coefficient of transmissibility determined in the aquifer tests made during this investigation (Table 6) are relatively low in comparison with those in many other areas, ranging from 430 to 7,300 gpd per foot, except for one test which yielded a value of 52,000. Recently another constant, the coefficient of leakage, or "leakance," was introduced (Hantush and Jacob, 1955) which expresses the

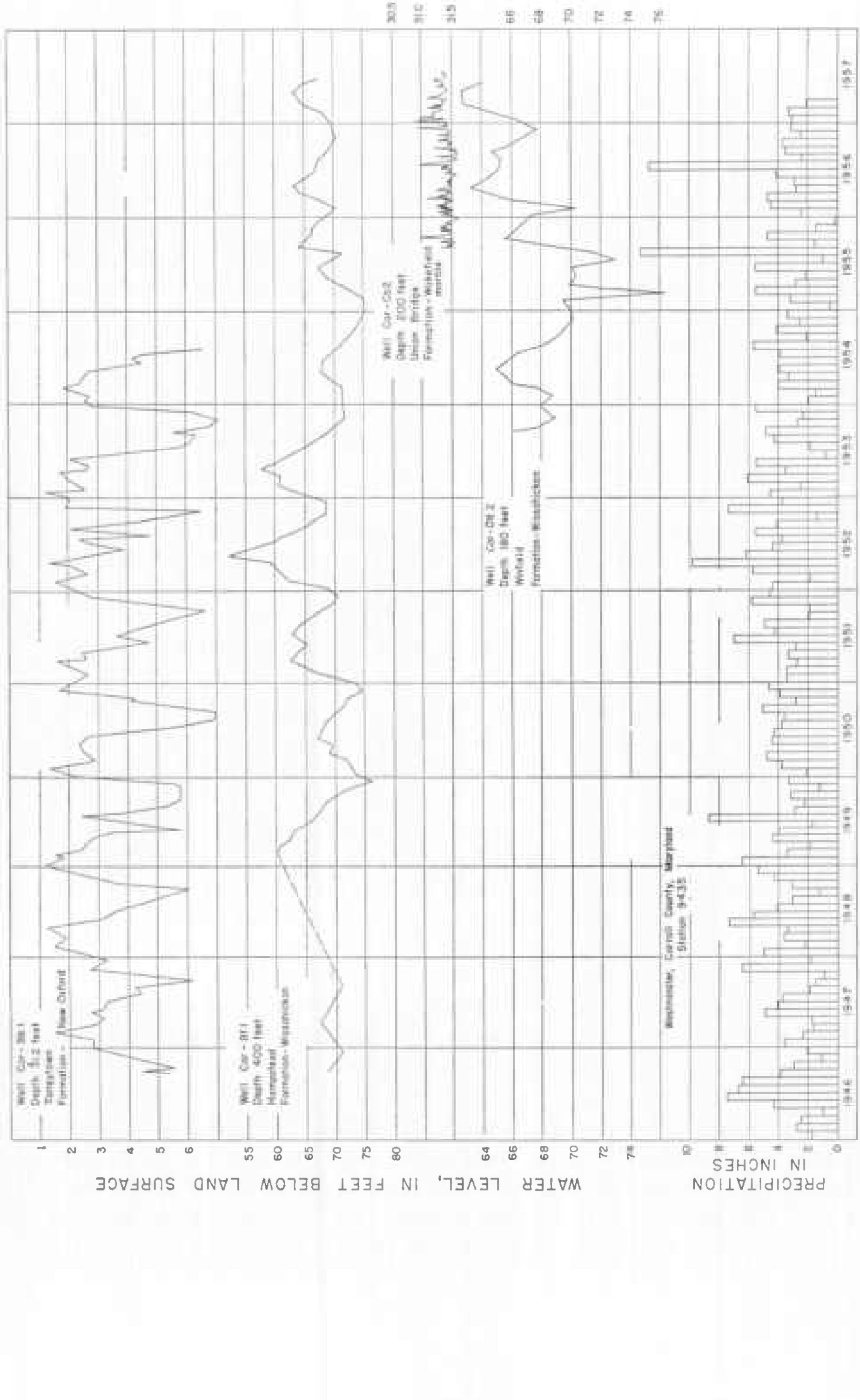


FIGURE 4. Hydrographs Showing Fluctuations of Water Levels in Four Wells in Carroll County and Precipitation at Westminster

ability of poorly permeable rock bodies to transmit water to neighboring permeable ones by upward or downward leakage. One determination of this coefficient is included in the described aquifer tests.

Coefficient of storage

The term "specific yield," is applicable only to water-table conditions. The analogous term that covers artesian conditions also is the *coefficient of storage*, which is defined as the volume of water released from, or taken into, storage per unit surface area of the aquifer per unit change in the component of head normal to that surface. For water-table aquifers the coefficient of storage is approximately equal to the specific yield. Ordinarily the coefficient of storage of an artesian aquifer is only a hundredth to a thousandth as large as that of a water-table aquifer. Approximate values for the coefficient of storage determined by the aquifer tests of rocks in Carroll and Frederick Counties, with one exception, range from 0.03 to 0.004, indicating a range from water-table conditions to semiartesian conditions. The exception was a determination of 0.000017 for an artesian water-bearing zone in limestone (Table 6).

Recharge, storage, and discharge of ground water

A knowledge of the characteristics of water-level fluctuations in aquifers is important to an understanding of the relations between recharge, storage, and discharge of ground water. Hydrographs of water level fluctuations in ten wells in Carroll and Frederick Counties are shown in figures 4 and 5.

The major fluctuations are caused as follows:

(1) Rises and reductions in rates of decline caused by recharge from precipitation.

(2) Declines caused by natural discharge of water from the ground-water reservoirs—mainly drainage to streams.

(3) Declines caused by pumping of wells and rises caused by cessation of pumping, these fluctuations being substantial but local.

A number of other factors cause minor fluctuations of water levels, among them variations in the rate of evaporation and transpiration from the ground-water reservoirs, variations in load at the land surface caused by changes in barometric pressure, moving railroad trains, etc. The latter fluctuations are characteristic of artesian aquifers.

The relation between precipitation and natural water-level fluctuations is not simple and direct. Evaporation in the air, at the land surface, and just below the land surface and transpiration by plants consume most (about 70 percent, according to data on precipitation and streamflow) of the precipitation during the summer and early fall. During this period little rainwater reaches the water table, and water levels decline in spite of the fact that precipitation in Maryland ordinarily is then high. Recharge to the ground-water

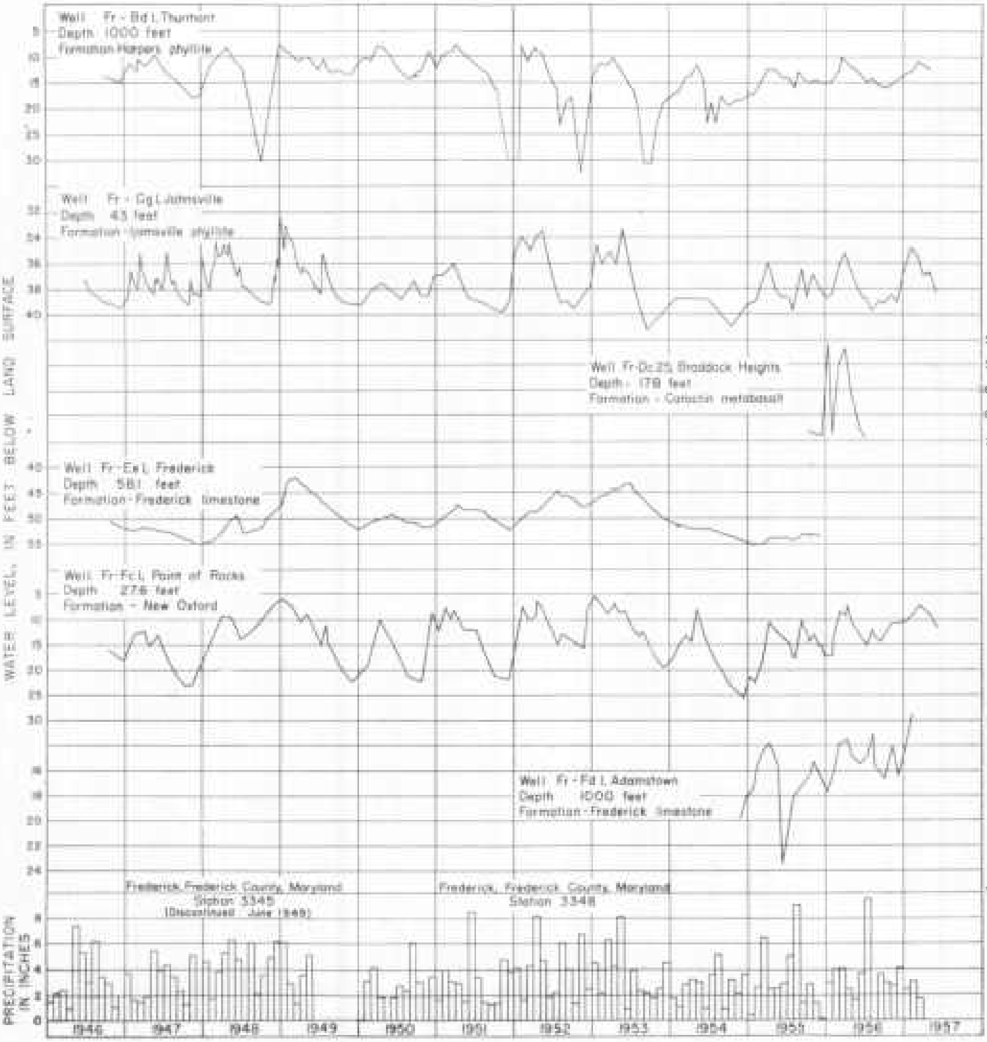


FIGURE 5. Hydrographs Showing Fluctuations of Water Levels in Six Wells in Frederick County and Precipitation at Frederick

reservoirs is greatest in the winter and early spring. During this period relatively little precipitation is diverted by evapotranspiration and water levels rise. Water levels, therefore, fluctuate in most wells in a systematic annual cycle, being highest in winter and early spring and lowest in summer and early fall. This cyclic pattern is well exemplified by the record of well Car-Bb 1, but is shown also by the hydrographs of most of the other observation wells in figures 4 and 5.

The yield of wells varies with the amount of ground water in storage. When droughts reduce recharge in periods of normally low ground-water levels, such as late summer and fall, well yields may be reduced substantially.

Under certain geohydrologic conditions, particularly in areas underlain by calcareous rocks, deviations from the general pattern of fluctuations may occur. For example, the water level in well Car-Cb 2 (fig. 4), which is at the edge of a wide outcrop of the Wakefield marble near its contact with metabasalt, fluctuates within a range of only a few tenths of a foot. The nature of the fluctuations indicates complex geohydrologic conditions, including at times what is seemingly a siphoning action. Well Fr-Ee 1 (fig. 5) also is in calcareous rocks, but in the broad belt of the Frederick limestone in the Frederick Valley. Its fluctuations correspond more closely to those in noncalcareous rocks. The hydrograph is smoother than typical hydrographs of wells in the Piedmont and mountainous areas owing to the greater storage capacity of the Frederick limestone and the more moderate topographic relief.

The magnitude and character of water-level fluctuations are related also to the topography. Water levels beneath hills fluctuate through a greater range than do those beneath valleys. A short record in well Fr-Dc 25 (fig. 5), at Braddock Heights on the crest of Catoctin Mountain, shows a range of fluctuations in part of 1956 of nearly 20 feet. In contrast, well Car-Bb 1 (fig. 4), in the Triassic upland characterized by low relief, shows a range of fluctuations of not quite 6 feet in eight years.

Under natural conditions ground-water storage reflects the balance between recharge and discharge. Although ground-water levels fluctuate from season to season and year to year, the long-term picture is one of equilibrium between recharge and discharge. Thus, in areas where little or no water is withdrawn, water levels in wells are essentially the same today as they were decades ago. The popular concept that ground-water levels in Maryland have declined persistently through the years applies only to certain local heavily pumped areas.

The natural balance between recharge and discharge permits a reasonable approximation of the magnitude of this component of the hydrologic cycle by means of streamflow records. The records are analyzed to determine the "base flow" of the streams—the portion of the total streamflow discharged from the ground-water reservoirs. The procedures are described by Houk (1921, p. 165) and Meinzer and Stearns (1929, p. 111), among many others. The values obtained by such an analysis of streamflow are less by a small amount than the total discharged from, or recharged to, the ground-water reservoirs, for a small amount of ground water is intercepted in transit, before reaching the streams, by evapotranspiration and by pumping. However, the ground-water component of streamflow may be said to be equal to the *effective* recharge, because only a negligible amount of the water discharged from the ground-water reservoirs by evapotranspiration could be salvaged by pumping from wells.

No determinations of base flow were made for streams in Carroll and Frederick Counties, but results of analyses of stream records for neighboring Montgomery, Baltimore, and Harford Counties (Dingman and Meyer, 1954, p. 38–43; Dingman and Ferguson, 1956, p. 46–52) are applicable to the Piedmont portion of Carroll and Frederick Counties, inasmuch as the geology and physiography are similar. The results cannot be applied to the Frederick Valley or the mountainous area of western Frederick County, which are quite different physiographically and geologically from the Piedmont. Discharge values, expressed in inches of depth over the drainage basin and percent of precipitation on the basis of 43 inches per year, determined for the Rock Creek basin in Montgomery County and the Little Gunpowder Falls basin in Baltimore and Harford Counties are:

	Inches	Percent of precipitation
Evaporation and transpiration	28.2	65.5
Ground-water runoff (base flow)	10.1	23.5
Direct runoff	4.7	11.0
	43.0	100.0

For these two drainage basins the average total runoff per square mile per day is about 700,000 gallons. Inasmuch as 10.1 inches of the 14.8 inches of total runoff represents ground-water runoff, about 68 percent, or 475,000 gallons, is the ground-water component of the runoff. This discharge from the ground-water reservoirs of 475,000 gpd (330 gpm) per square mile is the theoretical maximum quantity of ground water that could be pumped indefinitely from each square mile of the Piedmont. To recover such an amount over a large area would be impractical, however, for a large number of closely spaced wells would be required and the development and operating costs would be prohibitive. Also, it would be necessary to consider the effects on surface-water users of depleting the base flow of streams.

The ground water in storage in the rocks permits pumping at rates greater than the recharge, or intake, rate for limited periods. Eventually, however, discharge must be kept in line with recharge if the supply is to be perennial. In areas of heavy pumping in Carroll and Frederick Counties where an appreciable part of the water in storage in the vicinity of pumping wells has been extracted, the water levels will become stabilized if the discharge is kept in line, but the long-term yields of the wells will be less than the original because some of the openings that originally yielded water to the upper part of the well have been drained.

Water-table and artesian aquifers

Aquifers are commonly classed as either water-table or artesian. This classification is of practical importance in that the production of water from wells, the quantity of water derived from storage by pumping, and the area affected by pumping for a given period are somewhat different for the two conditions. Few aquifers, however, fulfill rigidly all the requirements of either classification. Customarily aquifers are classed as water-table or artesian according to which condition is approached more nearly, or the terms "semi-confined" or "semiartesian" are used to denote intermediate conditions.

Water-table aquifers contain unconfined ground water; that is, the surface of these ground-water bodies—the water table—is in direct contact with the atmosphere in the soil and unsaturated rocks overlying the ground-water body. Wells drilled into water-table aquifers fill with water to the level of the water table.

In an artesian aquifer ground water in a permeable rock is confined under pressure between less permeable rocks. The water level in a well that penetrates the aquifer will rise above the level of the top of the aquifer. Where the artesian head is sufficiently high and the land surface is sufficiently low, wells flow, but the term "artesian" is applied whether or not wells flow.

Inasmuch as the aquifers in Carroll and Frederick Counties are chiefly hydraulically integrated networks of water-filled fracture and solutional openings, the upper parts of which are in contact with the atmosphere, ground water occurs in these counties largely under water-table conditions. However, local variations in lithologic character and permeability of the rocks give to them some of the conditions of artesian aquifers, especially on a small scale. These conditions are revealed in several ways. In many places in both crystalline and sedimentary rocks water from a rainstorm may quickly recharge shallow water-bearing zones, as shown by a rise in water level in shallow wells shortly after the storm; but, because of their more devious connection with the surface, the deeper water-bearing zones show delayed and subdued effects of the precipitation, in the form of smaller and tardier rises of water level in deep wells. If no further addition of water occurs, the water levels in wells in both the shallow and deep horizons gradually tend to assume equilibrium positions. This does not necessarily mean that equilibrium is represented by equal water levels in shallow and deep wells; there may be perennial differences that reflect upward or downward movement of water. Such vertical differences in head are substantial in places. The water levels in dug wells, which penetrate only the uppermost part of the aquifers, indicate reasonably well the head at the water table. But in drilled wells, which ordinarily are uncased for most of their depth and thus tap large sections of the aquifers, the water level represents a composite head of a magnitude somewhere between the highest and lowest heads that exist in the aquifer in the vicinity of the well. Few drilled wells in Carroll and

Frederick Counties are constructed with casings extending a considerable distance into the aquifer and with only a small section of open hole, to permit the measurement of head at a small interval of depth undisturbed by pressures extant at shallower levels.

In general, under water-table conditions in upland locations it would be expected that the head would decrease with depth, reflecting the downward movement of water from the source at the water table to the deeper parts of the aquifer. Near streams, however, the reverse generally should be true: water is rising from the deeper parts of the aquifer to discharge into the streams, and the head should tend to increase with depth.

Obvious evidence of artesian conditions is flowing wells, of which there are a few in Carroll and Frederick Counties. The flow from most of them is intermittent, being related to wet weather and local geohydrologic conditions. Instances are common in which the driller notes a small rise in the water level in a well during drilling, indicating at least local artesian conditions.

Pronounced fluctuations of ground-water levels due to changes in atmospheric pressure and moving railroad trains were measured in a number of wells situated near railroad tracks in several geologically different areas. In the crystalline-rock areas the contrast in permeability between a silty or clayey water-saturated overburden and an underlying, more permeable zone of rock may be sufficient to produce local artesian conditions. An inclined water-bearing fracture, zone of fracture, or permeable stratum bordered by less permeable rock (such as occur in Triassic shale and sandstone and in crystalline rocks) also may contain water under artesian pressure. Deep water-bearing zones that are poorly connected, hydraulically, to shallower zones may be artesian. Examples of the latter are not uncommon in the limestone areas of the Frederick Valley.

The brief records obtained at various wells indicate, tentatively, barometric efficiencies of at least 30 percent. The barometric efficiency of a well is the ratio of its change in water level to the barometric change, expressed in feet of water, that caused the water-level change. Low efficiencies may indicate local or partial confinement of the water, and higher efficiencies more extensive confinement. The diurnal variation in atmospheric pressure appears in the water-level graphs as a gentle wavering of a few hundredths of a foot. Superimposed on this fluctuation may be a fluctuation of the water level related to the passage of major air masses or to remote pumping.

The fluctuations caused by passing railroad trains were similar in all the wells tested. The water level rose abruptly several hundredths to a tenth of a foot as the engine passed the well. It declined slowly while the lighter passenger or freight cars passed, the aquifer partly adjusting itself to the new load, and then dropped sharply to a few hundredths of a foot below the original level immediately after the last car passed in response to the removal of the load.

Then it very slowly recovered to the static level. The effect was smallest in wells penetrating limestone, presumably because of rigidity of the rock and the freedom with which water can move through its relatively large openings.

Measurements of the effects of trains and atmospheric-pressure changes on water levels serve to demonstrate the existence, even though possibly only local, of artesian conditions. Where such conditions exist, adjustments for barometric effects must be made in studying water-level fluctuations as a part of comprehensive hydrologic studies.

The concept of ground-water storage in artesian aquifers is different from that of storage in water-table aquifers. In a water-table aquifer, water drains by gravity out of openings in the rocks as the water table declines. In an artesian aquifer the voids remain filled with water even when the head is lowered by pumping. The water pumped from storage is derived by slight compaction of the aquifer and expansion of the water itself as the head is lowered. If the pumping is heavy or long-continued enough to lower the water level below the top of the aquifer and thereby dewater some of it, then water-table conditions exist in the area of partial dewatering. An artesian aquifer may change to a water-table aquifer naturally if, as a result of natural ground-water drainage during a period of deficient precipitation, the water level of the aquifer drops below the top of the aquifer. In reverse manner, a water-table aquifer may change to an artesian one if the water table rises to the bottom of a layer of material of low permeability, such as clayey residuum resting on fractured bedrock. Undoubtedly changes of this kind occur in aquifers of Carroll and Frederick Counties as a result both of natural fluctuations of the water table and of fluctuations caused by pumping and cessation of pumping from wells.

Source of water discharged from wells

Cone of depression

When a well is pumped, ground-water levels in its vicinity are drawn down in the general shape of an inverted cone, termed the "cone of depression," whose apex is at the well. The slope of the sides of this cone and its rate of enlargement depend on the coefficients of transmissibility and storage of the aquifer and on the pumping rate. Immediately after pumping starts and for a while thereafter, the water discharged is drawn from storage in the vicinity of the well. As pumping continues the cone of depression expands until it intercepts some source of replenishment, such as a nearby stream, which prevents further lateral growth of the cone by satisfying the withdrawal requirements of the pumping well, or until sufficient natural discharge is intercepted and diverted to the well. The natural discharge that is diverted may be either liquid outflow or evapotranspiration—just so the lowering of water level caused by pumping results in a reduction of the natural discharge. If the pumping is too heavy, it will not be possible to intercept enough natural discharge to balance the pumping by the time the water level at the well declines excessively, and the pumping must be reduced accordingly.

Most of the water supplied to wells in Carroll and Frederick Counties is derived from the immediate vicinity of the wells, particularly in the case of domestic wells which are pumped at small rates and infrequently. Large ground-water developments may induce recharge from nearby streams or ponds. The well field of the town of Taneytown, Carroll County, borders on Piney Creek, and the available data suggest that some of the pumped water is derived by induced infiltration from the stream (p. 122).

Hydraulic interference between wells

When the cone of depression developed around one pumped well overlaps that of another, the wells are said to interfere with each other, for they must share the part of the ground-water reservoir that lies between them. The amount of interference depends on the pumping rates of the wells, the distance between them, and the hydrologic and geologic character of the aquifer. A rule-of-thumb spacing of 500 feet is often considered adequate for the rocks of the Maryland Piedmont, but the most efficient spacing, from purely hydrologic considerations, is governed by the nature of the aquifer so that the optimum spacing varies from place to place. A spacing of 500 feet between wells at one place might be unnecessarily generous, whereas at another it might be too close. Aquifer and well-performance tests help determine the proper well-field pattern. Economic considerations, such as pipeline costs, locations of structures, landscaping, etc., are considerations that may affect the pattern of the well field.

As new wells are drilled or as the discharge rates of existing ones are increased the interference increases, for water levels in the aquifer must decline to provide the increased hydraulic gradient required to bring the additional water into the area of pumping. This decline in water level ordinarily results in a decrease in yield of wells within the area of influence of the pumping. In areas of major ground-water development it is desirable to measure routinely the changes in water levels and yields, as a guide to procedures required to maintain an adequate water supply. Periodic measurements of discharge and pumping levels should be made in all wells being pumped, and measurements of water levels should be made in nonpumping wells also. Many turbine-type well pumps, such as are commonly used in major ground-water developments, are designed to discharge at a nearly constant rate until the pumping level declines to just below the pump bowls. Thus, measurements of the discharge of wells equipped with such pumps may reveal little as to the rate of depletion of an aquifer until it has progressed rather far.

Well hydraulics

The ability of a well to furnish water is governed not only by the nature of the aquifer penetrated but also by the construction of the well.

When pumping from a well is started, the water level in the well declines. This decline, termed "drawdown," is requisite to the yield of the well, for it establishes the hydraulic gradient necessary to move water from the aquifer into the well. Thus, a report that a well yields water with no drawdown is erroneous; it may represent an instance in which the drawdown is so small as to be unmeasurable with the available facilities. Ordinarily the water level draws down rapidly at first and then more slowly. After a few days the rate of decline may be so slow that it is thought that the water level has stabilized, but this is true only where there is a source of recharge close by. Generally, the water level continues to lower indefinitely, though at a progressively slower rate, until there is a rise in water level resulting from cessation of pumping from this or another well or from recharge. When pumping of the well is stopped the water level recovers, but not necessarily to the original level.

The yields of wells in the consolidated rocks of Carroll and Frederick Counties are determined almost entirely by the water-bearing characteristics of the aquifer. This contrasts with sand aquifers, such as those in the Coastal Plain of Maryland, in which the efficiency of construction and development of a well affect its yield to an important degree. Nevertheless, not all wells in consolidated rocks are constructed and developed efficiently. Where the major aquifer is the basal part of the weathered zone, as is frequently the case, seating the well casing firmly on the underlying fresh rock may seal off the important part of the aquifer and result in a well of poor yield. On the other hand, too short a casing may allow weathered rock to slump into the well. A well that does not penetrate the permeable zone of the rocks fully will have a smaller yield than one that does and is more susceptible to declining yield during droughts.

Other constructional features that may reduce yield include drilling a crooked hole which limits the size of pump or depth to which the pump can be lowered; drilling too small a hole to accommodate the size of pump needed; and casing and grouting to unnecessarily great depths for sanitary protection, thereby shutting off the important water-bearing zones. In one instance a well 302 feet deep yielded 45 gpm when equipped with a short length of casing. Later the casing was extended to a depth of 104 feet, and the yield of the well was reduced by half.

Drilling of wells by the cable-tool method sometimes introduces "rock flour" (powdered rock) into water-bearing crevices as the drill bit pounds through them. The compressed air commonly used in rotary drilling may force rock cuttings into water-bearing crevices, or drilling mud may seal them off.

Ordinarily sufficient water is pumped during the acceptance test made after completion of the well to remove this material, but if it is suspected that some of the crevices are still clogged, steps can be taken to open them, such as by swabbing the well.

Perforated casing has been used in wells drilled in crystalline rocks in the Maryland Piedmont. This casing is equivalent to the well screen used in granular aquifers, except that the openings are considerably larger. Under favorable conditions, perforated casing may be installed opposite weathered material that is water bearing but is somewhat unstable. Wells that would have been unsuccessful if conventional casing had been used were successfully completed by use of such casing. It cannot be used promiscuously, however, for if the weathered material is too soft or the holes are too large, it may flow through the holes or clog them.

The term "yield" is used in reference to the ability of a well to respond to pumping. Although a useful general term, it is somewhat vague. To comprehend the nature of its vagueness is to understand to some degree the hydraulics of wells and hydrology of aquifers in Carroll and Frederick Counties. In an effort to give the term a more definite meaning, qualifying adjectives such as "maximum" and "potential" are used to denote the greatest possible rate of pumping, but ordinarily no effort is made to specify the time factor, which, for other than small domestic pumpage, is important. A typical well in the crystalline rocks of Carroll or Frederick Counties would be capable of yielding, at its lowest practicable pumping level, a certain volume of water on the first day of pumping, but considerably less the second day and even less the third day (Table 21). Further, during seasons of high water table it would be capable of greater yield than during periods of lower water table.

In this report the term "yield" is used interchangeably with "pumping rate" or "discharge rate." The well yields reported by drillers are simply the rates at which they bailed or pumped the wells. The wells may, or may not, be capable of supplying water at a rate greater than that reported and for a period of time longer than that reported. A better unit for expressing the ability of a well to furnish water is the "specific capacity," which relates the pumping rate to the drawdown of the water level.

Source of water discharged from springs

Springs represent points of intersection between the land surface and the zone of saturated rocks, but this general description belies their complex nature. They are an important means of ground-water discharge. Springs that discharge weakly through a number of indefinite openings are termed "seeps" or "seepage springs." Although inconspicuous and not generally utilized for water supplies, seeps in lowland areas and along the sides of valleys and draws play an important part in the hydrologic cycle, for a substantial amount of ground water is discharged through them. An even larger amount is discharged by diffused seepage directly into the beds of streams. Springs important as sources of water supply generally discharge through a smaller number of more definite openings.

Springs are of various types, but their type is not always ascertainable owing to the presence of soil or talus, vegetal cover, or structures built to collect the flow. The rock structures responsible for many springs lie hidden below surficial deposits which merely conduct the water to the surface but play no important part in causing it to flow. The springs of Carroll and Frederick Counties are "gravity" springs, as opposed to those that result from deep-seated flow. Some of the springs discharge along permeable zones of sheared rock, particularly in the schists; some are along local zones of closely spaced joints which favor discharge of ground water; some emerge at the contact between permeable overburden and the underlying less permeable fresh rock; and others discharge from local permeable zones within the overburden. Systems of solutional openings that intersect the land surface may discharge large quantities of ground water. This type of spring is associated with the most soluble rocks, the limestones and marbles. Small seeps emerge in small depressions on flood plains. Such seeps are commonly developed for use simply by means of a dug pit and are, in effect, shallow dug wells. Some of the marshy wet spots on flood plains result from capillary rise of water from the shallow water table. These areas of capillary discharge are not properly classed as seeps or springs as water does not flow from them.

Gravity springs may be classified in the following manner (adapted in part from Bryan):

a. Depression springs, due to the intersection of the land surface and the zone of saturation. In its general sense this class may include nearly all springs, but in a restricted sense it refers to those that result when a stream cuts down to the water table. Depression springs are common near the heads and along the sides of draws and on stream flood plains.
b. Contact springs, which discharge where permeable water-bearing rock overlies relatively impermeable rock. In Carroll and Frederick Counties springs of this type occur most commonly along the contact of the permeable mantle with the underlying fresh rock; some occur at the contact of marble with interbedded volcanics; and some occur along the contact between mountain-wash or flood-plain deposits and the underlying bedrock.
c. Artesian springs, which rise along crevices from a permeable water-bearing zone confined between relatively impermeable rocks. Zones of fracture or shear bordered by more massive and less permeable rocks which serve as confining beds may produce artesian springs in Carroll and Frederick Counties. In like manner, permeable beds in the tilted

Triassic rocks may produce artesian springs. Water in isolated joints fed from higher ground may be under artesian pressure and may form artesian springs.

Obviously these categories overlap. A spring may be both a depression spring and a contact spring, or an artesian spring and a contact spring, or even a combination of all three types.

The discharge of springs in Carroll and Frederick Counties ranges from several hundred gallons per minute for some of the limestone springs to a fraction of a gallon per minute. Most of the springs utilized for water supply discharge between 1 and 10 gpm. The public water-supply systems of many of the towns are entirely or partly dependent upon springs. Most of the springs fluctuate greatly in discharge rate, in accordance with fluctuations of the water table in their vicinity. Some are intermittent wet-weather springs—usually those near hilltops where the water-table fluctuations are greatest and those that discharge from small perched ground-water bodies that soon drain. Others, at lower elevations, have access to greater ground-water reserves and are perennial.

Utilization of ground water

Amounts used

The daily use of ground water in Carroll and Frederick Counties amounted to about 6.6 million gallons in 1956 and 1957. About 16 percent was used for institutional and public supplies, 15 percent for industrial and commercial purposes, and 69 percent for rural domestic and farm supplies. Table 5 shows the uses by counties.

The principal public-supply systems that use ground water for a major part or all of their supply are those of Hampstead, Manchester, New Windsor, Taneytown, and Union Bridge, in Carroll County, and Braddock Heights, Brunswick, Emmitsburg, Middletown, Mount Airy (partly in Carroll County),

TABLE 5

Use of Ground Water in Carroll and Frederick Counties, 1956–57

(million gallons per day)

	Institutional and public supplies[a]	Industrial and commercial supplies	Domestic and farm supplies	Totals
Carroll Co.	0.36	0.70	2.39	3.45
Frederick Co.	.74	.32	2.11	3.17
Both counties	1.10	1.02	4.50	6.62

[a] Includes some ground water supplied to industrial users through public-supply systems.

Myersville, Walkersville, and Woodsboro, in Frederick County. Frederick, the largest municipality in the area, uses surface water.

Pumping of ground water for cannery operations is heavy during the canning season (June to September), but the canneries are shut down during the rest of the year. The water is used chiefly for cooling canned foods.

Although about 5 million gallons of water was used daily for irrigation in the two counties during the irrigating season of 1957, practically all came from streams and ponds. About 300,000 gallons was pumped daily from wells for irrigation in Carroll County, but wells were a negligibly small source of irrigation water in Frederick County. Some ponds are partly or entirely fed by ground water either because they are dug below the water table or because they are spring fed. The water from such ponds should be considered ground water. The practice of supplemental irrigation, which has increased substantially in the last decade, is expected to continue to increase, and the use of ground water for this purpose also will continue to increase.

Not included in Table 5 is the water pumped from several operating quarries. Several million gallons of water is pumped daily from these quarries, most of this being ground water discharged from crevices in the quarry walls and floors. The water is removed to keep the quarries from flooding and is used for washing rock. It is pumped to nearby streams. Also not included is the discharge from ditches dug to reclaim swampy land for cultivation.

Methods

There are numerous methods of obtaining ground water—wells, radial collectors, infiltration galleries, springs, spring-fed ponds, and others. In Carroll and Frederick Counties drilled wells and springs are the principal means of obtaining ground water. Dug wells, although popular in the past, are rapidly being replaced by the more sanitary, more efficient, and more dependable drilled wells. The greater efficiency of drilled wells lies in the fact that, being deeper than dug wells, usually they penetrate a greater portion of the aquifer. In addition, most of the well hole is open, or uncased, whereas dug wells may be brick walled or lined with concrete rings which inhibit the entrance of ground water. The hard rocks of these counties do not lend themselves readily to the construction of bored, driven, or jetted wells. Locally where the rocks are soft (for example, unconsolidated alluvial deposits that are free of boulders) wells may be constructed by these methods.

Drilled wells are constructed by both the cable-tool percussion method and the rotary method. Only a few drillers use rotary equipment, which although it drills a hole faster, is considerably more expensive than cable-tool equipment and requires greater skill in operation. Compressed air rather than the conventional drilling mud is commonly used to bring cuttings to the surface.

Commonly, domestic drilled wells are 6 inches in diameter, and $5\frac{5}{8}$-inch steel casing is installed, extending from the land surface to bedrock. Most public-supply and industrial wells are 8 inches in diameter. Although the greater diameter increases the yield very little, it permits the use of a larger pump. Also, the heavier 8-inch tools facilitate drilling.

Both developed and undeveloped springs are used in Carroll and Frederick Counties. The developmental structure usually is a brick or concrete-lined collecting pit at the spring site from which the water flows by gravity, or is pumped, to the place of use. Like dug wells, springs are less sanitary and dependable than drilled wells and are gradually being abandoned in favor of drilled wells.

Little can be done to improve the flow of a spring other than to keep the openings free of silt or vegetation and to construct the collecting basin to capture as much as possible of the discharge. Artificial springs may be constructed at favorable sites by drilling horizontally into a hillside.

Infiltration galleries are trenches dug in permeable unconsolidated rocks where the water table is shallow. Drain pipes are laid in the trenches and are inclined toward a central collecting sump from which the water is pumped. In Carroll and Frederick Counties no such galleries are in use, and they would be limited to areas bordering streams where the water table is shallow and the rock soft. Where the water table fluctuates greatly the discharge of infiltration galleries may be intermittent. There is also the problem of susceptibility to contamination, as with other structures that take ground water from shallow depth.

Dual-purpose fish and irrigation ponds dot the countryside of these counties. Most of the ponds are formed by impounding water with earth dams across small draws. The ponds may depend upon surface runoff or spring discharge but most commonly depend on both. Some ponds have been excavated several feet into the zone of saturation in soft rock alongside streams. They are essentially large-diameter wells. Water is discharged from the ponds by pumping, by flow over the spillway, by leakage, and by evaporation. Some ponds in Maryland are replenished with water from wells, but no such ponds are known in Carroll and Frederick Counties.

As electricity became accessible to rural areas, dependence upon windmills, bucket-and-windlass assemblies, and hand pumps declined, and now about 80 percent of the wells in Carroll and Frederick Counties are equipped with electrically powered pumps. Most of them are jet pumps or deep-well cylinder (plunger) pumps having motors of about 1 horsepower and capacities between 3 and 6 gpm. Municipalities and industrial firms commonly use higher capacity pumps, usually deep-well cylinder or turbine pumps. Where the water table is shallow and the specific capacity of the well high, so that the drawdown is not excessive, centrifugal suction pumps are used.

Aquifer and well evaluation by pumping-test methods

Various field methods are used to determine the performance characteristics and yield of wells and the water-bearing characteristics of aquifers. They include (1) drillers' acceptance tests, (2) specific-capacity tests, and (3) aquifer tests. The first two may be grouped together as "well-performance" tests.

Drillers' acceptance tests

Upon completing a well the driller bails or pumps it for a short time to bring clear water into it, to clean out crevices in the rock bordering the hole, and to ascertain the availability of the required supply of water. Most wells are drilled with a cable-tool machine, and the dart-valve bailer used to extract cuttings from the well hole during drilling is used generally to withdraw water from the well during the acceptance test. The rate of withdrawal by this method is governed by the capacity of the bailer and the rapidity with which the driller can perform repeatedly the cycle of lowering the bailer, filling it, raising it, and emptying it. Although the water level in the well is fluctuating during the pumping, lowering abruptly when a bailerfull is withdrawn and then rising while the bailer is being emptied and rising further as the bailer is submerged again, ordinarily the driller can determine a reasonable value for an average pumping level. Markings on the bailer cable indicate the depth to which the bailer is lowered.

Most wells are bailer tested for only a short time, a few minutes to 2 hours, but some drillers bail for several hours. Short tests are of questionable value as indicators of well yields. During short periods of pumping most of the water is derived from the well hole and from storage in the rock in the immediate vicinity of the well. During these brief tests the cone of depression of the well is not given a chance to expand so as to show whether storage in the surrounding area is adequate to maintain the yield of the well for longer periods of pumping or during periods of low water table. Industrial, commercial, and public-supply wells generally are test pumped for longer periods, commonly 6 hours to 3 days, and more elaborate equipment is used, such as turbine pumps or cylinder pumps. The discharge rate is estimated on the basis of pump capacity, or where more accurate measurements are desired a meter or a gage of some type is used, or the discharge is estimated from the time it takes to fill a large container of known volume.

Considerable hydraulic information of this nature on wells, as well as geologic information, has been acquired by the Maryland Department of Geology, Mines and Water Resources through implementation of the State Water Resources Law of 1933 and the complementary Well Law of 1945. These laws require that a permit be obtained from the Department before a well is drilled and that a well completion report be filed with the Department after the well

STATE OF MARYLAND

Form 5

DEPARTMENT OF GEOLOGY, MINES AND WATER RESOURCES

The Johns Hopkins University
BALTIMORE 18, MARYLAND

WELL COMPLETION REPORT

This report must be submitted within 30 days after completion of the well

WELL DESCRIPTION				
WELL LOG State the kind of formations penetrated, their depth, their thickness, and if water-bearing	FEET from...... to...	CASING AND SCREEN RECORD State the kind and size of casing, liner, shoe, screen, and other accessories (if no casing used, give diameter of well)	DIAM. (inches)	FEET from ..... to ...

Permit Number

Name of Owner

PUMPING TEST

Hours Pumped

Type of Pump Used

Pumping Rate
Gallons per Minute

WATER LEVEL

Distance from land surface to water:

Before Pumping ....Ft.

When Pumping ....Ft.

APPEARANCE OF WATER

Clear ....

Cloudy ....

Taste ....

Odor ....

Height of Casing Above Land Surface ....Ft.

PUMP INSTALLED

Type ....

Capacity

Gallons per Minute ....

Gallons per Hour ....

Pump Column Length ....Ft.

REMARKS

....

....

....

....

....

....

....

Well Was Completed

Date ....

Well Driller ....

....
Signature

FIGURE 6. Well-Completion Report Form

is completed. Figure 6 is a copy of the Well Completion Report form. Owners of commercial, industrial, and public-supply wells, and even domestic wells would find it advantageous to maintain a similar record of their wells in order to facilitate repairs to pumping equipment or wells, and for comparison of acceptance-test data with subsequent well performance to detect changes in yield and specific capacity.

Specific-capacity tests

Although a simple bailing or pumping test is informative, a more refined evaluation of the hydraulic characteristics of a well is obtained by a specific-capacity test. The specific capacity is the rate of discharge per unit drawndown of the water level, and is commonly expressed in gallons per minute per foot of drawdown. Abbreviating the units to "gallons per foot of drawdown," as is sometimes done, is misleading in that it implies a relation between the volume of water pumped and the resultant drawdown, whereas the intended relation is between the rate of pumping and the drawdown. A simple specific-capacity test consists of pumping a well at a constant rate for a certain period of time and measuring accurately the drawdown caused by the pumping.

As an example, if a well whose initial nonpumping water level was 10 feet below the land surface were pumped at a rate of 20 gpm for 6 hours, and by the end of the 6 hours the water level had declined to 50 feet below the land surface, the specific capacity for a 6-hour period would be

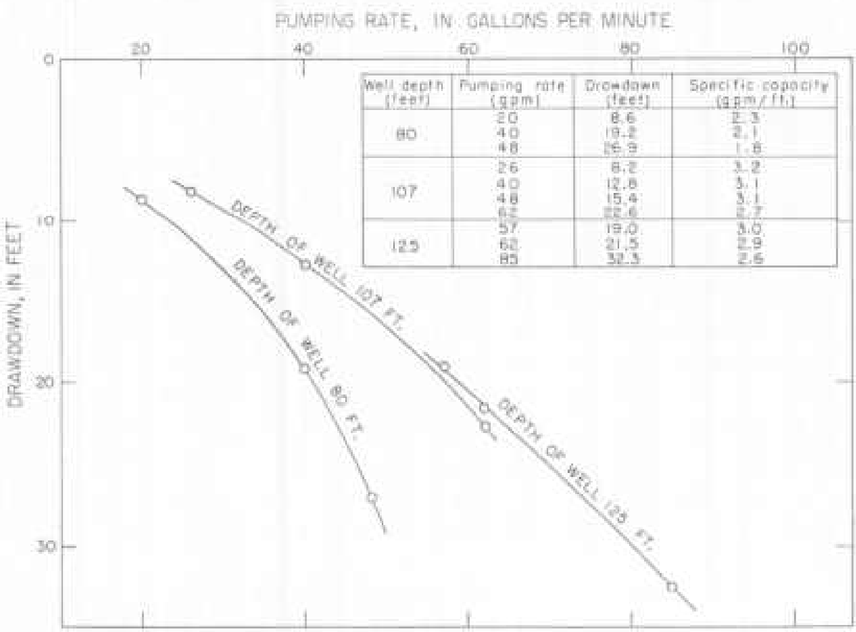
$$\frac{\text{Pumping rate}}{\text{Pumping level} - \text{Static level}} = \frac{20 \text{ gpm}}{50 \text{ ft.} - 10 \text{ ft.}}$$

$$= 0.5 \text{ gpm per foot of drawdown}$$

Specifying the length of pumping time is important because, in most wells, the water level is still declining, even though slowly, at the end of a pumping period, and it is misleading to compare specific capacities determined in tests of greatly different lengths. It is helpful also to give the water-level data as well as the final result, particularly where the water occurs under water-table conditions and the aquifers yield water chiefly from crevices as they do in Carroll and Frederick Counties. The specific capacity decreases with continued pumping, chiefly because of the decreased thickness of saturation in the vicinity of the pumped well and of the withdrawal of water from storage in the uppermost crevices. A number of wells of small yield in Carroll and Frederick Counties are equipped with pumps of high capacity selected on the basis of short tests.

In a well penetrating an extensive aquifer the pumping level will decline approximately in proportion to the logarithm of time, and a seeming tendency of the pumping level to level off after a time should not be interpreted as stabilization of the water level. This apparent leveling off reflects the logarithmic relation with time, and although the additional water-level decline for each consecutive hour of pumping may be small, the cumulative drawdown after a long period of pumping will be large and significant in comparison to that for a short period. This hydraulic characteristic is not especially important for most domestic wells, but it is of great importance to commercial, industrial, and municipal wells which may be pumped continuously for hours or days.

A refinement of the specific-capacity test is the "step test," which consists of pumping a well for short periods at each of several successively greater pumping rates and determining the drawdown for each pumping rate. Wells in Carroll and Frederick Counties customarily show a decrease in specific capacity with each incremental increase in pumping rate, reflecting, among other things, a decrease in the permeability of the rocks with depth due to the emptying of the uppermost crevices and a diminution in size of crevices with depth. Specific-capacity tests, and especially step tests, are useful in establishing the magnitude of increases in well capacity as a well is deepened. Figure 7 shows specific-capacity curves for step tests made at three stages of the drilling of a well in schist (Car-Bf 29 at Hampstead). A substantial increase in well yield was obtained when the well was deepened from 80 to 107 feet, as indicated by the more moderate slope of the 107-foot curve and its position to the right of the



Well depth (feet)	Pumping rate (gpm)	Drawdown (feet)	Specific capacity (gpm/ft.)
80	20	8.6	2.3
	40	19.2	2.1
	48	26.9	1.8
107	26	8.2	3.2
	40	12.8	3.1
	48	15.4	3.1
	62	22.6	2.7
125	57	19.0	3.0
	62	21.5	2.9
	85	32.3	2.6

FIGURE 7. Specific-Capacity Curves Based on Drawdown and Pumping Rate for Short Periods of Pumping at Three Depths of Drilling of a Well in Schist

80-foot curve. The specific-capacity curve for a step test made when the well was 125 feet deep plots only slightly to the right of the 107-foot curve and is practically an extension of it. On the basis of the third step test it was concluded that the important water-bearing zone had been fully penetrated and drilling was terminated. Such tests may also reveal the bottom of an aquifer, inasmuch as the specific capacity will decrease sharply when the pumping level falls below the bottom of the principal water-bearing zone. Step tests have been helpful in the ground-water investigations in Carroll and Frederick Counties, and the results of step tests are included in the descriptions of the water-bearing formations. Specific-capacity tests of the wells involved should precede aquifer tests, because they outline the hydraulic characteristics of the wells and reveal aquifer characteristics that are helpful in planning and deciphering the aquifer tests.

Aquifer tests

An aquifer test is a test in which measurements of the response of the head of the aquifer to imposition of external forces can be interpreted in terms of transmissibility and storage coefficients. Most such tests involve withdrawing water from or adding water to wells and measuring the resulting changes in head in those and other wells. Theis (1935) developed a formula that relates the change of the water level in an aquifer as a function of time since withdrawal or addition began to the rate of withdrawal of water from or addition of water to a well or wells. The basic formula is widely used in hydrologic investigations to determine coefficients of transmissibility and storage and to evaluate the water-bearing capacity of aquifers and the efficiency of wells. It is superior to earlier formulas in that the time factor is taken into consideration. The formula is:

$$s = \frac{114.6Q}{T} \int_{1.87r^2S/Tt}^{\infty} \frac{e^{-u}}{u} du$$

where s = the drawdown or recovery of water level in feet at any point within the cone of depression

Q = the discharge rate of the pumped (recharged) well in gallons per minute

T = the coefficient of transmissibility in gallons per day per foot

S = the coefficient of storage

r = the distance in feet of the point of observation from the pumped (recharged) well

t = the time in days since pumping (recharge) started or stopped

u = $1.87r^2S/Tt$

Knowing the transmissibility and storage coefficients, it is possible to substitute them in the above formula and estimate future water-level drawdown at any time for any pumping rate and at any distance from the well being pumped, on the assumption that the aquifer satisfies the assumptions in the formula.

The formula assumes ideal geologic and hydrologic conditions that do not exist in nature, so that it must be used with caution. The major assumptions are that the aquifer is infinite in areal extent, is homogeneous and isotropic (transmits water equally readily in all directions), has uniform thickness, releases water from storage instantaneously with a decline in head, and is overlain and underlain by impermeable material. It is further assumed that the pumped well is of infinitesimal diameter and completely penetrates the aquifer so that flow toward the well is radial (two-dimensional).

The field procedure is similar to that for specific-capacity tests. The rate or rates of discharge should be held constant and precisely measured, and water levels in observation wells and the pumped well should be measured to 0.01 foot or better to define accurately the shape of the cone of depression and its rate of change in shape. After pumping is stopped, recovery of the water levels also is measured, for the hydrologic coefficients and other information often can be determined from the nature of recovery of the cone of depression. Brown (1953) has summarized the principal procedures for analyzing aquifer-test data.

Various methods have been developed to simplify solution of the Theis equation (Wenzel, 1942; Cooper and Jacob, 1946). Other modifications (Muskat, 1937; Jacob, 1946; Ferris, 1948) are designed to adjust for field conditions that deviate from those required by the basic Theis formula, such as aquifer boundary conditions and leakage from one aquifer to another. These adaptations and the theory on which they are based are relevant to a study of ground water in Carroll and Frederick Counties, where the aquifer characteristics are appreciably different from those required by the basic formula.

In Carroll and Frederick Counties the aquifers are, in the main, neither homogeneous nor isotropic, the water being transmitted through irregularly distributed fractures and solutional openings and through a weathered mantle of variable thickness and permeability. Ordinarily the mantle of weathered rock will satisfy the requirements of the Theis formula more closely than the fresh rocks. Generally in the fresh rocks the permeability decreases with depth as fractures tighten and solutional openings become smaller and less numerous. The "aquifer thickness"—the thickness of the zone in which openings are effective in transmitting water—varies from place to place. The upper surface of the aquifers (the water table) conforms more or less to the land surface, though it is more subdued. The lower aquifer "surfaces" are indefinite zones within which joints and solutional openings disappear. Rock schistosity or foliation or principal directions of jointing may lead to preferred directions of transmission of ground water.

TABLE 6

Summary of Hydrologic Coefficients Determined by Aquifer Tests

Location	Water-bearing formation	Hydrologic coefficients	
		Transmissibility (gpd/ft)	Storage
Carroll County			
Westminster	Wakefield marble	52,000	0.004
Hampstead	Wissahickon (albite facies)	5,000	.03
Taneytown	New Oxford formation	5,000	.001
Frederick County			
Burkittsville	Catoctin metabasalt	6,800	.021
Foxville	Aporhyolite	2,200	—
Adamstown	Frederick limestone (400-ft. zone)[a]	430–680	.000017
Mount Airy	Marburg schist	7,300	.02

[a] Coefficient of leakage of 0.00016 gpd/ft²/ft determined for overlying semiconfining rock.

Streams, which may act as positive hydraulic boundaries or line sources of recharge (Theis, 1953), intersect the aquifers here and there. In interstream areas, owing to the relatively high elevation of the water table beneath uplands, the aquifers are mound-shaped, the water moving in the directions of slope of the mound surfaces.

Although the aquifers in Carroll and Frederick Counties do not lend themselves readily to analysis by aquifer-test methods, the tests are of value in that they yield approximate values of the hydrologic coefficients, reveal certain hydrologic and geologic characteristics of the aquifers and associated rocks, permit rough estimates of "safe yield," and furnish actual measurements of interference between wells. From this information it is possible to make reasonable estimates of the long-term effects of various pumping regimens. Results of aquifer tests made in Carroll and Frederick Counties are summarized in Table 6. The tests are described in the section on the geologic formations and their water-bearing properties.

Analysis of well data

Introductory statement

The subsections that follow evaluate the importance of the factors that determine aquifer characteristics and well yields, primarily by means of a statistical analysis of well records. The analysis shows, among other things, the relation between well yields and their depth, their topographic position or geologic setting, and the thickness of the weathered mantle.

Certain characteristics of the well data moderate the significance of the results.

Well data reported by drillers generally are reasonably accurate, but the yields reported may be based on tests ranging in duration from a few minutes to several days. In addition, the wells may or may not be pumped at their maximum rates of output. Conversion of the reported pumping-test data into terms such as specific capacity and yield per foot of depth smooths out the irregularities to some extent. The data on topographic position of the wells are subject to personal interpretation, as there is no precise dividing line between topographic forms.

Although the well data violate some of the requirements of formal statistical analysis—data for some geologic units are voluminous and for others skimpy, for example—the results of the analysis appear to be reasonably reliable. Moreover the well records are the best information available for evaluating the water-bearing properties of the rocks. In some instances statistical reliability has been improved by omitting items for which only a few data were available.

Relation of yield of wells to rock type

Variations in lithology and structure and in topography and exposure of the rocks in Carroll and Frederick Counties result in differences in their water-bearing properties. Even within one rock body the water-bearing properties vary from place to place. A body of crystalline rock may be massive in one place and schistose in another, closely jointed in one place and widely jointed in another. A sedimentary rock may contain sizable intergranular openings in one place which are filled with a cementing material in another; a carbonate rock may be more soluble in one place than another so that the magnitude of solutional openings varies. The water-bearing properties of most of the rocks are similar to the extent that the bulk of the wells yield between 5 and 20 gpm. A few of the rocks, particularly the carbonate rocks, are capable of furnishing much larger yields to wells. A summary of the average well yield for each geologic unit is given in Table 7 and is shown graphically in figure 8. The units are listed in order of decreasing average yield.

Relation of yield of wells to depth

The yields of wells in Carroll and Frederick Counties are not directly proportional to their depth, or even their depth below water level, because the permeability of the rocks is not uniform, ordinarily being greatest at shallow depth and less at successively greater depths. Thus each increment of depth does not cause a corresponding increase in yield.

The frequency with which various yields are obtained is shown in the upper part of figure 9. Most of the wells yield less than 30 gpm. The chance of obtaining a yield larger than this is small, but judicious selection of drilling sites will increase the chance (Table 8). The lower part of figure 9 shows the

TABLE 7

Average Depth and Yield of Wells in Carroll and Frederick Counties by Geologic Units (For a Few Units the Average Value Shown is Based on Less Than the Total Number of Wells Inventoried)

Geologic Unit	Number of wells	Average depth (feet)	Average yield (gpm)	Average specific capacity (gpm/ft.)	Average yield per foot of depth (gpm/ft)	Rank in water-yielding capacity
Wakefield marble	35	139	106	5.8	0.76	1
Weverton quartzite	5	391	35	.4	.09	2
Grove limestone	32	135	32	2.5	.24	3
Frederick limestone	119	119	25	3.8	.21	4
Sykesville formation	16	125	23	2.7	.18	5
Silver Run limestone	6	141	21	.7	.15	6
Tomstown dolomite	2	79	20	1.0	.25	7
Marburg schist	86	88	17	2.7	.19	8
Wissahickon formation, albite-chlorite facies	168	100	16	1.5	.16	9
Peters Creek quartzite	28	99	16	1.5	.16	9
Catoctin metabasalt	83	91	14	1.1	.15	11
Aporhyolite	22	52	12	.8	.23	12
Urbana phyllite	39	79	11	.4	.14	13
New Oxford formation	161	106	11	.7	.10	13
Gettysburg shale	57	93	10	.5	.11	15
Harpers phyllite	39	169	10	.5	.06	15
Antietam quartzite	23	92	9	.8	.09	17
Sams Creek metabasalt	35	98	8	.5	.08	18
Ijamsville phyllite	58	77	8	.9	.10	18
Libertytown metarhyolite	9	82	8	.7	.10	18
Baltimore gneiss	2	137	8	$<.1$	.06	18
Granodiorite and granite gneiss	47	74	7	.6	.09	22
Loudoun formation	20	81	6	.3	.07	23
Mountain wash (alluvial cones)	5	25	4	.4	.16	24
Metagabbro	1	45	3	—	.07	25

frequency of occurrence of well depths. Most of the wells are less than 150 feet deep, and probably most of the wells that were drilled deeper than 150 to 200 feet obtained little water in their lower parts. Two 150-foot wells may be expected to yield more water than one 300-foot well.

The relation between well yield and well depth is shown in figure 10. Inasmuch as ground water occurs in the carbonate rocks under conditions somewhat different from those in the siliceous rocks, the data for wells drilled in these rock types are shown separately. The upper graph shows that practically no increase in yield is obtained by drilling below 200 to 300 feet in the silicate rocks. In yield per foot of depth, the greatest contributions of water come from depths of less than 100 feet. The lower graph suggests that deeper drilling in

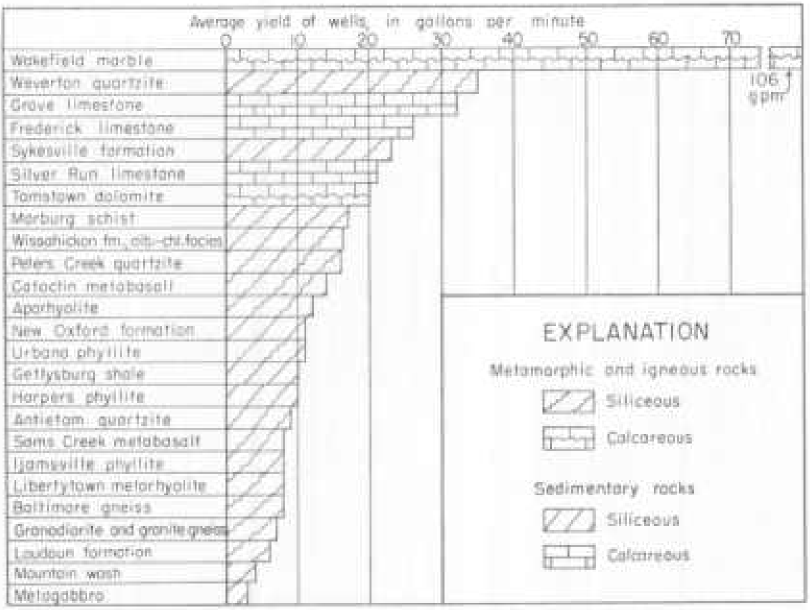


FIGURE 8. Comparison of the Average Yield of Wells in the Principal Water-Bearing Formations

the carbonate rocks is more rewarding. However, the 400- to 1,200-foot interval is based on records of only a few wells, and at least one of these apparently obtains most of its water from the shallower part of the interval. Nevertheless, the chances of encountering water-bearing zones in the lower part of this interval in the carbonate rocks are much better than in silicate rocks.

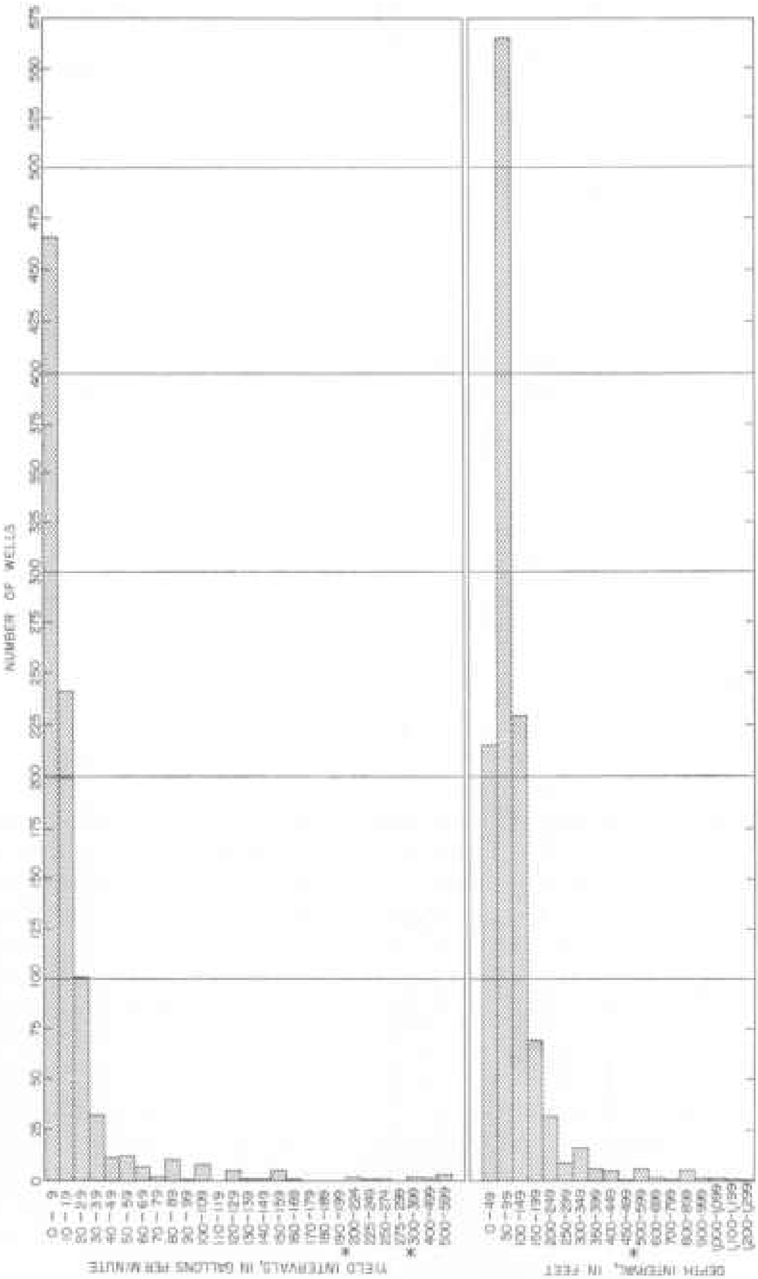
Relation of yield of wells to topographic position

The topographic position of a well drilled in the silicate crystalline rocks in Carroll and Frederick Counties is an important factor in regard to its yield. The relation is less apparent, and presumably less significant, in the areas of sedimentary rock and marble, which are characterized by low to moderate relief.

In the areas of silicate crystalline rock, wells drilled in valleys have the highest average yields and those drilled on hilltops have the lowest. On the average, wells drilled on broad upland flat areas or hillsides have intermediate yields. The relations are summarized in Table 8.

Essentially the same relations have been determined for other Maryland counties in the Piedmont province (Dingman and Meyer, 1954; Dingman and Ferguson, 1956).

Draws and valleys are the most productive areas chiefly for the following reasons:



* Note change in magnitude of intervals.

FIGURE 9. The Frequency Distribution of Wells by Yield and by Depth

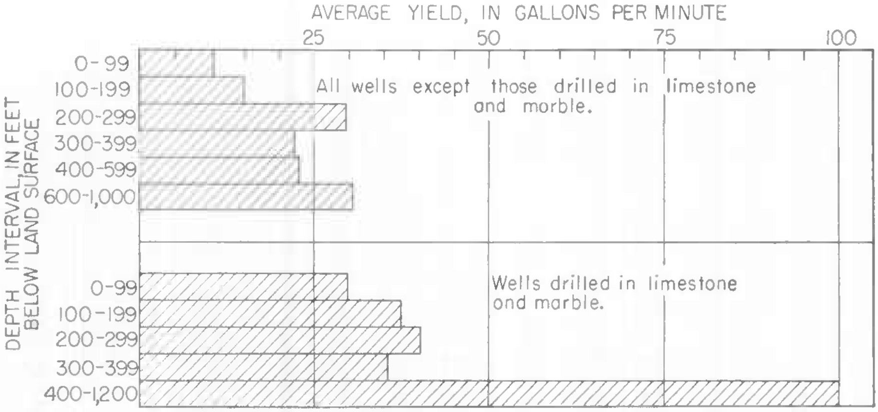


FIGURE 10. The Relation Between Yield and Depth of Wells

TABLE 8

Average Yield of Crystalline-Rock Wells in Carroll and Frederick Counties According to Topographic Position

	Average yield (gpm)
Valley, valley flat, and draw	27
Hillside	12
Upland flat	11
Hilltop	10

(1) In draws and valleys the water table is near the surface, so that a larger part of the well penetrates the saturated zone. Ordinarily, the mantle of weathered rock plays an important part in determining the productivity of crystalline-rock wells, and it is more fully saturated in valleys than on hilltops, though probably not thicker on the average. The relationship is depicted schematically in figure 11. Well A penetrated unsaturated mantle rock above the water table and derived a small supply from the bedrock. Well B penetrated the saturated mantle and obtained a better supply.

(2) The draws and valleys are areas toward which the ground water moves. A well is favorably situated hydrologically when the water table slopes toward it from every direction except the downstream one. A cone of depression developed around a pumped well steepens the gradient toward the well from these directions and may even reverse the downstream gradient. Hilltops, on the other hand, generally overlie ground-water divides, and hence ground water is moving away from wells on hilltops.

(3) Draws and valleys may mark zones of weakness in the rocks—that is, zones of closer fracturing or greater susceptibility to weathering, solution, or

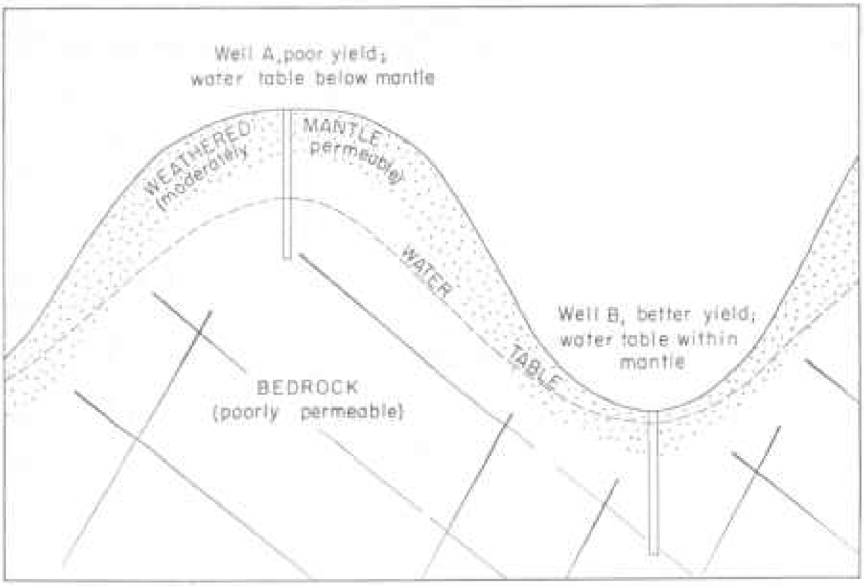


FIGURE 11. Diagram Showing Relation Between Well Yields and Position of Water Table in Crystalline Rocks

erosion. Fracturing, weathering, and solution facilitate development of porous and permeable rock under most circumstances.

Depth of weathering and well yield

The yield of many wells in Carroll and Frederick Counties appears to be governed by the depth and character of the weathered zone. When wells are drilled in the Maryland Piedmont, the casing is commonly seated on the ledge of hard rock beneath the mantle rock or weathered zone. Thus, the lengths of casing used in wells indicate approximately the depth of the weathered zone.

The lengths used in 699 wells in the area range from a few feet to 235 feet in a well in limestone in the Frederick valley. The average depth of weathering ranges from 16 feet in the Libertytown metarhyolite to 68 feet in the Wakefield marble. It is significant that the Wakefield marble is the best aquifer (average yield 106 gpm) and the metarhyolite among the poorest (average yield 8 gpm).

Table 9 indicates the depth of weathering according to major provinces and rock groups. The table shows little differences among the major rock groups, except that the depth of weathering in the carbonate rocks of the Piedmont upland province is the greatest, averaging 59 feet in 24 wells. The average depth

TABLE 9

Depths of Weathering in Carroll and Frederick Counties According to Provinces and Rock Types

Province and rock group	Water-bearing unit	Depth of weathering[a]		
		No. of wells	Maximum (feet)	Average (feet)
Precambrian rocks of the South Mountain-Catoctin Mountain Area	Granodiorite and granite gneiss	30	107	30
	Catoctin metabasalt	60	102	30
	Aporhyolite	18	45	26
	All units	108	107	29
Paleozoic metamorphosed rocks of sedimentary origin	Loudoun formation	15	125	38
	Harpers phyllite	31	165	35
	Antietam quartzite	16	40	19
	All units	62	165	31
Cambrian and Ordovician limestones of the Frederick valley	Tomstown dolomite	2	77	55
	Frederick limestone	81	235[b]	30
	Grove limestone	19	195[b]	49
	All units	102	235[b]	34
Silicate crystalline rocks of the Piedmont Upland	Baltimore gneiss	1	56	—
	Peters Creek quartzite	19	56	28
	Sams Creek metabasalt	15	60	23
	Libertytown metarhyolite	3	23	16
	Ijamsville phyllite	32	57	20
	Urbana phyllite	22	42	17
	Marburg schist	45	82	25
	Wissahickon formation (albite-chlorite facies)	113	225	37
	All units	250	225	29
Carbonate rocks of the Piedmont Upland	Wakefield marble	19	170	68
	Silver Run limestone	5	92	47
	All units	24	170	59
Rocks of the Triassic system	New Oxford formation	109	75	19
	Gettysburg shale	44	52	18
	All units	153	75	19

[a] Based chiefly on depths of well casings driven to refusal.

[b] Casings in some limestone wells are placed far below the weathered zone to seal off muddy water from cavernous zones.

of weathering is the least in the rocks of the Triassic system, only 19 feet in 153 wells. The average depth of weathering in all the rock units is about 29 feet.

Quality of Ground Water

Sources of mineral constituents

The dissolved gases and mineral salts in the ground waters of Carroll and Frederick Counties include (1) those obtained from the atmosphere as the water vapor precipitates and falls through the atmosphere, (2) those dissolved from the soil and deeper portions of the zone of aeration as the water moves downward to the water table, and (3) those dissolved from the rocks below the water table as water circulates through them. Loss or alteration of previously absorbed mineral or gaseous matter may occur during this cycle. Of those constituents obtained from the atmosphere, carbon dioxide and oxygen are the most significant, for their presence increases appreciably the chemical activity of the water. Rainwater and snow-melt may contain also small quantities of chlorine, sulfur dioxide, hydrogen sulfide, oxides of nitrogen, ammonia, and other constituents. Carter and Sokoloff (1951, p. 14) determined a pH of 5.5, a chloride (Cl) content of 20 to 40 ppm, and traces of sodium, magnesium, zinc, and nitrate in two samples of rainwater collected in northern Baltimore City in the summer of 1951; and a pH of 5.0 to 5.5, chloride of approximately 10 ppm, and traces of sodium, magnesium, and other cations in a sample of rainwater collected near Frederick, Frederick County, during the same summer. Whether the chlorine was free or combined is not known; if combined, it is surprising that only traces of sodium and other cations were reported. Analyses of rainwater collected between July 1955 and July 1956 at Washington, D. C., supplied by Dr. Christian E. Junge, of the Air Force Cambridge Research Center, Bedford, Massachusetts, are summarized in Table 10.

Passing downward through the soil zone, the water may absorb carbon

TABLE 10

Monthly Average Concentrations of Chemical Constituents in Rainwater at Washington, D. C., July 1955–July 1956.

Constituent	Range of concentration (ppm)	Average concentration (ppm)
Cl^-	0.14–1.00	0.32
SO_4^{--}	1.9–7.8	3.6
NO_3^-	.12–1.80	.71
Na^+	.13–1.12	.29
Ca^{++}	.12–.80	.40
K^+	.05–.42	.17
Mg^{++}	.02–.17	.06
NH_4^+	.02–.70	.11

dioxide and organic acids from humus and dissolve mineral matter from soil particles. Additional mineralization of the water occurs by solution of minerals as the water continues to move downward to the water table and then laterally to areas of discharge. The ground water may also deposit mineral matter. In Carroll and Frederick Counties this is shown by local "caulking" of joints and other openings with mineral matter, usually carbonate salts. The mineralogy of the rocks through which the ground water passes ordinarily determines the predominant chemical characteristics of the water. Owing to the great variety of rock types and structural conditions, the geochemistry of ground water in Carroll and Frederick Counties is complex.

Ground water flowing through the limestone and marble of Carroll and Frederick Counties dissolves appreciable quantities of mineral matter, chiefly calcium and magnesium carbonates which are the major constituents of these rocks. Most igneous and metamorphic rocks of the area are composed chiefly of silicate minerals, which are less soluble than carbonates, and ground water in these rocks is not highly mineralized. The principal constituents, however, are generally the same as are found in greater quantity in ground waters in the carbonate rocks. The Triassic rocks yield water somewhat similar to that of the limestone and marble, indicating the presence of abundant calcareous minerals in these rocks. A relatively high sulfate content in the water from the Triassic rocks, however, suggests the presence of gypsum or anhydrite as well as carbonate minerals. Ground water in some of the Triassic shales and sandstones is more highly mineralized than that from the limestones and marbles, presumably because the water in some of the Triassic formations moves more slowly, through minute openings, than it does in the carbonate rocks.

Chemical analyses were made by the Quality of Water Laboratory of the Geological Survey, Washington, D. C., of 21 samples of ground water from Carroll County and 41 samples from Frederick County. The results are given in Tables 11 and 12. The analyses aid in the study of the ground-water hydrology as well as indicating the suitability of the waters for specific purposes. Locally, for example, analyses of dissimilar ground waters may be used to distinguish concealed contacts between geologic formations.

The concentration of dissolved constituents is reported in water analyses as the number of parts by weight in a million parts by weight of water. The mineral constituents determined are divided into the positively charged cations and the negatively charged anions. The cations generally determined are iron, calcium, magnesium, sodium, and potassium; others include aluminum, manganese, copper, zinc, and lithium. The anions determined are bicarbonate, sulfate, chloride, fluoride, nitrate, and, less commonly, phosphate. In addition, silica and carbon dioxide were determined for many of the samples. The specific conductance and pH also were determined and the hardness was calculated. The temperature of the water was measured at the time the samples were

TABLE 11

Chemical Analyses of Ground Water in Carroll County
(chemical constituents in parts per million)

Well or spring (Car-)	Date of collection	Water-bearing formation	Silica (SiO_2)	Aluminum (Al)	Iron (Fe), total	Manganese (Mn), total	Copper (Cu)	Zinc (Zn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids	Hardness as $CaCO_3$: Total	Hardness as $CaCO_3$: Noncarbonate	Carbon dioxide (CO_2)	Specific conductance (micromhos at 25°C)	pH
Ab 2	Dec. 21, 1955	New Oxford	—	—	—[a]	—	—	—	19	1.6	18		—	38	21	16	—	22	—	—	54	23	—	207	6.4
Af 8	May 12, 1954	Wissahickon (albite)	5.4	0.0	0.00	0.01	0.02	0.03	5.0	2.5	2.3	.6	0.1	10	3.0	4.9	0.0	14	0.0	51	23	15	13	64.3	6.1
Bb 2–7	Nov. 18, 1947	New Oxford	17	—	.03	—[b]	—	—	46	8.6	8.4	1.0	—	164	16	8.6	.0	3.8	—	190	150	—	—	325	7.9
Bb 4	Dec. 18, 1946	do	19	—	.06	—	—	—	40	7.9	13	1.0	—	151	16	8.0	.1	4.4	—	182	132	—	—	303	8.0
Bb 9	Feb. 5, 1952	do	22	.00	.39	.00	.01	.3	45	6.1	19	.7	—	150	24	11	.1	16	.1	221	137	—	—	351	7.7
Bd 13	Mar. 15, 1955	Marburg schist	4.2	.3	.12	.01	.02	.00	4.8	1.7	1.8	.8	.0	5.0	7.5	5.0	.0	8.1	.0	42	21	17	—	64.0	5.5
Bd 21–22	May 14, 1956	Silver Run limestone	—	—	.03	.01	—	—	—	—	6.6		—	95	22	19	—	30	—	—	137	60	4.8	316	7.5
Bf 2	Mar. 20, 1951	Wissahickon (albite)	7.8	.2	.00	.55	—	—	19	15	44	6.0	—	9	16	79	0	96	—	286	109	0	—	491	5.6
Bf 3	Feb. 5, 1952	do	7.8	.00	.06	.01	.03	.1	15	9.5	20	4.0	—	19	6.5	31	.0	71	.0	185	76	—	—	291	5.8
Bf 17[c]	Jan. 19, 1954	do	—	—	0	—	—	—	—	—	—	—	—	—	—	11	—	5.0	—	128	33	—	—	—	6.3
Bf 34	June 21, 1955	do	—	—	.06	—	—	—	—	—	4.3		—	15	.2	7.8	—	15	—	—	26	14	24	91.6	6.0
Cb 3	June 22, 1955	Wakefield marble	—	—	.04	—	—	—	—	—	14		—	146	9.9	4.0	—	14	—	—	116	0	9.2	290	7.4
Cd 16	May 12, 1954	do	11	.0	.09	.02	.01	.20	41	3.5	5.1	.8	.2	111	6.6	12	.0	16	.1	170	117	26	7.0	266	7.4
Cd 18	May 12, 1954	do	9.5	.4	.14	.02	.00	.00	49	4.5	3.5	.6	.2	144	11	6.3	.0	18	.1	194	143	25	4.6	296	7.7
Cd 21	June 22, 1955	do	—	—	.04	—	—	—	—	—	8.2		—	134	6.2	6.6	—	9.0	—	—	115	6	8.5	256	7.4
Cd 23	Mar. 9, 1955	do	9.9	.0	.39	.01	.00	.64	65	15	5.6	1.2	.2	240	13	8.2	.2	20	.0	270	225	28	1.2	443	7.5
Cf 11	Aug. 1945	Peters Creek quartzite	21	—	.70	—	—	—	5.4	2.7	6.1	.8	—	21	3.0	6.0	.0	14	—	80	25	—	—	79.4	6.7
Dd 1	Mar. 21, 1951	Marburg schist	7.4	1.2	.1	.05	—	—	6.6	2.4	4.3	.9	—	17	.2	6.4	0	25	—	74	27	13	—	102	6.2
De 1	June 22, 1955	Peters Creek quartzite	—	—	.08	—	—	—	—	—	9.4		—	40	.1	.8	—	.5	—	—	14	0	13	59.9	6.7
De 4	Mar. 9, 1955	Wissahickon (albite)	11	.0	.08	.01	.00	.00	7.4	1.6	3.0	.3	.1	18	3.2	4.1	.2	12	.0	52	25	10	9.0	73.2	6.5
De 12	June 20, 1955	do	—	—	.08	—	—	—	—	—	12		—	43	.1	5.8	—	12	—	—	27	0	14	116	6.7

[a] Iron in solution 0.12.
[b] Manganese in solution 0.00.
[c] Analysis by Maryland Department of Health.

TABLE 12

Chemical Analyses of Ground Water in Frederick County
(chemical constituents in parts per million)

Well or spring (Fr-)	Date of collection	Water-bearing formation	Silica (SiO_2)	Aluminum (Al)	Iron (Fe), total	Manganese (Mn), total	Copper (Cu)	Zinc (Zn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids	Hardness as $CaCO_3$: Total	Hardness as $CaCO_3$: Noncarbonate	Carbon dioxide (CO_2)	Specific conductance (micromhos at 25°C)	pH
Ad 2	Apr. 4, 1955	Catoctin metabasalt	23	0.0	1.4	0.04	0.00	1.4	24	12	7.7	0.7	0.1	62	51	12	0.0	12	0.0	182	112	61	31	271	6.5
Af 4	Apr. 4, 1955	Gettysburg shale	25	.0	.11	.03	.00	1.3	70	25	8.8	1.0	.4	195	131	5.2	.4	1.6	.0	373	280	120	3.1	567	8.0
Bc 2	Apr. 4, 1955	Aporhyolite	15	1.1	.46	.02	.04	2.2	7.2	.5	3.1	1.4	.0	29	4.2	1.8	.0	8.5	.0	65	30	6	9.2	85.7	6.7
Bd 3–4	July 30, 1952	do	17	.0	.02	.00	—	—	4.6	1.8	3.7	.7	—	24	2.0	2.9	.0	2.1	.0	47	19	0	19	57.6	6.2
Bd 6	June 6, 1955	Catoctin metabasalt	13	.0	.50	.35	.02	.00	8.0	2.7	1.7	1.7	.0	40	.1	.6	.0	3.0	.0	55	32	0	—	75.0	6.7
Bd 9	May 11, 1956	Weverton quartzite	—	—	.02	.00	—	—	—	—	1.4		—	3	14	2.5	—	2.0	—	—	19	16	6.2	63.2	5.9
Be 3	June 14, 1955	Frederick limestone	—	—	.08	—	—	—	—	—	1.2		—	90	5.4	.4	—	6.0	—	—	82	8	14	168	7.0
Be 11	May 4, 1956	Gettysburg shale	14	.0	.02	.05	.05	1.2	56	10	12	.8	.4	188	45	6.0	.0	11	.0	269	183	29	—	414	7.2
Bf 4	Dec. 20, 1955	New Oxford	44	.0	.03	.02	.00	4.8	46	23	8.9	.6	.2	209	22	14	.0	26	.1	306	217	46	17	440	7.3
Cb 7	May 11, 1956	Aporhyolite	—	—	.11	.00	—	—	—	—	2.6		—	10	1.0	1.5	—	.5	—	—	6	0	32	32.2	5.7
Ce 6	Dec. 20, 1955	Grove limestone	6.1	.2	.09	.01	.00	.85	41	27	1.8	.1	.3	209	21	1.8	.0	34	.0	245	216	45	6.6	417	7.7
Ce 7	May 9, 1956	Frederick limestone	—	—	.55	.03	—	—	—	—	7.2		—	208	17	10	—	34	—	—	214	44	6.6	440	7.7
Ce 8	May 9, 1956	do	—	—	.04	.58	—	—	—	—	32		—	466	17	67	—	35	—	—	454	72	15	982	7.7
Cf 1	Mar. 15, 1955	Grove limestone	8.3	.0	.05	.02	.00	.18	70	7.6	1.2	1.9	.3	208	10	7.7	.0	29	.0	249	206	36	—	413	7.4
Cf 17	Dec. 20, 1955	Ijamsville phyllite	6.6	.1	.18	.02	.04	1.4	7.7	2.3	.6	.1	.1	39	.2	1.4	.1	.7	.0	42	31	0	7.8	68.3	6.9
Cf 20	May 9, 1956	Frederick limestone	—	—	.17	—	—	—	—	—	3.2		—	256	34	5.0	—	24	—	—	265	55	4.1	493	8.0
Cg 1	Mar. 20, 1951	Ijamsville phyllite	6.8	1.9	.10	.00	—	—	6.0	3.6	8.7	2.0	—	22	3.0	7.4	0	40	—	100	30	12	—	163	6.3
Ch 1	June 22, 1955	do	—	—	.04	—	—	—	—	—	5.8		—	32	8.4	19	—	21	—	—	66	40	40	200	6.1
Db 2	Apr. 1, 1955	Catoctin metabasalt	19	.0	.04	.03	.00	.10	18	6.0	7.0	.6	.0	31	13	11	.1	39	.1	138	70	44	9.8	191	6.7
Dc 6	Dec. 20, 1955	do	17	1.2	.11	.02	.02	2.8	19	7.8	5.7	.3	.0	83	19	4.1	.0	11	.0	128	91	23	4.2	192	7.5
Dc 16	May 9, 1956	do	—	—	2.1	.02	—	—	—	—	2.4		—	12	4.0	17	—	3.0	—	—	35	25	9.6	94.9	6.3
Dc 21	Dec. 20, 1955	Granodiorite and granite gneiss	26	.0	.10	.00	.00	.11	14	4.7	5.1	.8	.2	33	28	5.0	.1	6.6	.1	114	54	27	3.3	147	7.2
Dd 1	Apr. 14, 1953	Contact—Frederick limestone and New Oxford (limestone conglomerate)	10	—	.29	—	—	—	61	19	19		—	243	29	12	.0	32	—	322	230	31	—	527	8.0

Dd 3	Apr. 14, 1953	New Oxford	11	—	1.3	—	—	—	31	13	9.3		—	151	8.2	10	.0	5.8	—	162	131	7	—	283	7.8
Dd 11	May 11, 1956	Catoctin metabasalt	—	—	.03	.00	—	—	—	—	5.8		—	37	10	9.0	—	16	—	—	54	24	19	138	6.5
Dd 65	May 4, 1956	New Oxford	9.8	.0	.04	.02	.03	.00	51	9.0	2.5	.4	.2	172	10	3.5	.0	16	.0	203	164	23	—	319	7.7
Dd 77[a]	Dec. 13, 1956	Harpers phyllite	—	.0	.06	.02	3.3	.00	—	—	—	—	—	23	—	7.2	—	36	—	—	36	0	37	161	6.0
De 2	Apr. 14, 1953	Frederick limestone	11	—	.04	—	—	—	58	21	9.4		—	253	20	6.0	.2	18	—	268	231	24	—	469	7.8
De 15	May 9, 1956	do	—	—	.02	.09	—	—	—	—	4.9		—	188	5.2	4.5	—	26	—	—	176	22	3.8	359	7.9
De 16	May 4, 1956	do	7.2	.0	.04	.06	.11	.77	55	3.1	5.0	.8	.4	152	14	7.2	.0	18	.1	208	151	27	—	319	7.5
Df 2	Dec. 21, 1955	Libertytown metarhyolite	—	—	—[b]	—	—	—	19	8.9	17		—	60	9.6	11	—	58	—	—	84	35	—	229	6.5
Df 15	May 2, 1956	do	—	—	.09	.01	—	—	—	—	3.4		—	24	.4	2.0	—	28	—	—	37	17	9.6	106	6.6
Ed 14	May 9, 1956	Frederick limestone	—	—	.01	.03	—	—	—	—	95		—	282	66	114	—	178	—	—	396	165	4.5	1,106	8.0
Ee 2	Mar. 21, 1951	Grove limestone	7.8	.1	.40	.00	—	—	66	24	2.8	5.6	—	275	12	7.5	0	36	—	290	263	38	—	504	7.7
Ef 2	Apr. 1, 1955	Sams Creek metabasalt	18	.1	.05	.02	.00	.48	49	50	19	.3	.2	279	64	30	.1	.0	.0	412	329	101	35	680	7.4
Eh 1	Mar. 10, 1955	Marburg schist	6.1	.0	.10	.01	.00	.00	12	14	52	10	.5	258	1.9	1.9	.4	.6	.0	283	88	0	3.3	383	8.1
Fb 1	Apr. 1, 1955	Granodiorite and granite gneiss	30	.0	.16	.03	.02	1.4	8.9	2.0	6.2	.8	.0	28	8.1	3.2	.1	16	.0	92	33	10	18	107	6.4
Fc 1	Dec. 20, 1955	New Oxford (limestone conglomerate)	12	.0	.53	.02	.04	2.8	1.6	2.4	5.5	3.4	.4	11	.2	7.5	.0	20	.0	58	18	9	17	75.8	6.0
Fd 4	Dec. 26, 1946	Frederick limestone	11	—	.66	—	—	—	99	10	7.5	1.8	—	274	48	8.4	.1	17	—	345	288	—	—	566	7.6
Fd 16	May 9, 1956	do	—	—	.02	.00	—	—	—	—	4.9		—	187	21	3.5	—	13	—	—	180	27	9.4	363	7.5
Fe 18	Apr. 30, 1948	Urbana phyllite	—	—	.07	—	—	—	—	—	—	—	—	88	2	3	.1	11	—	—	78	—	—	179	6.8

[a] Nickel 0.09.
[b] Iron in solution 0.06

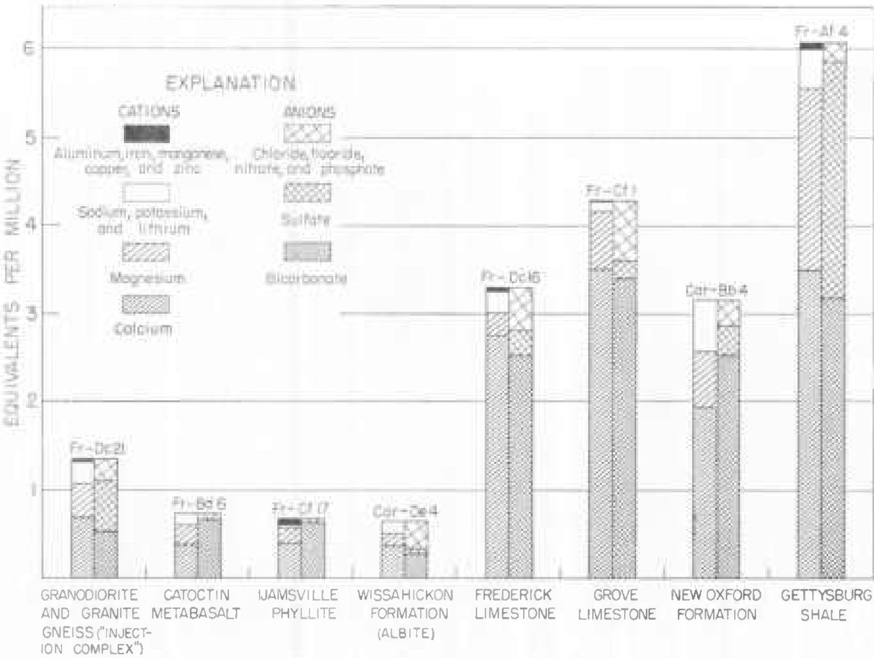


FIGURE 12. Comparison of Typical Chemical Analyses of Ground Water in Equivalents per Million

collected, and is given in the remarks column of the well tables (Tables 25 and 26).

Analyses of water from the principal water-bearing formations are shown graphically in figure 12. Owing to variations within each formation in chemical character of the rocks, geologic structure, and topography, as well as other factors, the chemical character of the ground water in a formation varies somewhat from place to place, both vertically and areally, so that the analyses in figure 12 are representative in a general way only. To facilitate comparison of the analyses, the concentrations of the ions are expressed in equivalents per million. When expressed as equivalents per million the sum of the cations equals the sum of the anions. There is some evidence that the mineral content of water in the Triassic formations decreases to the south and east, possibly reflecting a southward and eastward decrease in soluble components in the rocks or the increase in coarseness and permeability.

The Frederick and Grove limestones show little lateral variation in chemical character of the contained ground water, which is a hard calcium magnesium bicarbonate type. A substantial increase in mineralization with depth in at least one place, however, is indicated by a comparison of the analyses of samples from wells Fr-Ce 7 and -Ce 8, which are only about 30 feet apart, and 29 and 275 feet deep, respectively. Dissolved solids were not determined in the two samples, but the specific conductance, a general indication of dissolved-solids content, was 440 and 982 micromhos, respectively. Relatively high concentrations of chloride, sodium, and nitrate are common in ground waters in limestone and probably are largely products of the decomposition of nitrogenous wastes, indicating some present or former organic contamination. Agricultural fertilizers may be the source of some of these constituents.

Relation of chemical character to use

The chemical quality and temperature of ground water govern its suitability for most uses. The most important chemical characteristics to be considered for domestic and public-supply uses are the contents of iron, dissolved solids and carbon dioxide, the hydrogen-ion concentration expressed as pH, and the hardness. Industrial users of ground water may be concerned with silica, other cations in addition to iron, trace elements not ordinarily determined in water analysis, such as copper, and the ground-water temperature and its range of fluctuation. Conventional methods for evaluating the suitability of waters for supplemental irrigation indicate that the ground waters of Carroll and Frederick Counties may be classed as good to excellent for this purpose.

Silica (SiO_2)

Silica generally is of minor concern in ground waters except for some industrial uses. It contributes to the formation of boiler scale. Silica is the most abundant constituent in the crust of the earth, but it constitutes only a small percentage of the total mineral matter in many ground waters. Silica probably is largely dispersed in water in a colloidal rather than an ionic state. In the analyses the silica content ranges from 4.2 to 44 ppm.

Iron (Fe) and manganese (Mn)

Locally in Carroll and Frederick Counties iron may be present in the ground water in sufficient quantity to give the water a disagreeable taste and to stain fixtures, utensils, and laundry. When in excess of about 0.3 ppm in ground water, iron will form a reddish-brown precipitate (hydrous ferric oxide) upon exposure to air. The analyses show a range of 0.00 to 2.1 ppm.

Manganese, like iron, is objectionable for its staining propensities when present in amounts of more than 0.3 ppm. Manganese is generally low in the ground waters of Carroll and Frederick Counties, exceeding 0.05 ppm in few samples.

Iron and manganese may be present in ground waters in either ionic or colloidal form.

Calcium (Ca) and magnesium (Mg)

Calcium and magnesium are the principal constituents that cause hardness in water. In Carroll and Frederick Counties these ions, particularly calcium, constitute most of the cation content in the waters of the limestone and marble and the Newark group. Some calcareous schists and phyllites have appreciable quantities of calcium and magnesium. The analyses show a range in calcium content from 1.6 to 99 ppm and in magnesium content from 0.5 to 50 ppm.

Sodium (Na) and potassium (K)

Sodium and potassium occur in many of the rocks of Carroll and Frederick Counties, and appear in the ground water in small to moderate amounts, sodium being more plentiful than potassium. Moderate quantities of sodium and potassium are unimportant to the usefulness of water for most purposes, but large quantities may render the water unfit for irrigation or some industrial uses. The analyses show a range from 1.2 to 52 ppm for sodium and 0.1 to 6.0 ppm for potassium. In partial analyses the sum of sodium and potassium is reported. Some of the waters may contain sodium derived from organic contamination and potassium from agricultural fertilizers.

Aluminum (Al), copper (Cu), zinc (Zn), and lithium (Li)

The metallic ions Al, Cu, Zn, and Li are found in very small or trace amounts in most of the ground waters of Carroll and Frederick Counties. It is probable that part of the aluminum, copper, and zinc determined in samples from wells was dissolved from well casings, pump pipes, and pumps. When sampled at the source, spring waters show none or extremely small amounts. To minify the metallic contamination in samples from wells, the wells were pumped for a time before collecting the samples, wells having plastic pump pipes were selected where possible, and the samples were collected as near the well source as the plumbing permitted.

In the usual very small concentrations these metals are unimportant, but where they occur in larger quantities in drinking water they may be physiologically harmful. Copper is the most troublesome. When present in substantial quantity it causes a bluish-green stain on fixtures, and in concentrations above 3.0 ppm it may be toxic (U. S. Public Health Service Drinking Water Standards, 1946). Only in well Fred-Dd 77 at Braddock Heights was the copper content found to be in excess of 3.0 ppm; an analysis of this water in December, 1956, showed a copper content of 3.3 ppm.

Bicarbonate (HCO_3) and carbonate (CO_3)

Bicarbonate (HCO_3) is the principal anion in most ground waters of Carroll and Frederick Counties. Although the samples collected were analyzed for carbonate, invariably it was absent. Maryland ground waters rarely contain carbonate. Because carbonate is not present, the bicarbonate represents essentially the alkalinity. High alkalinity is objectionable in boiler-feed waters that are high also in sodium. The concentration of bicarbonate in ground water in Carroll and Frederick Counties ranges from 3 to 466 ppm, being highest in water from calcareous rocks and least in water from siliceous rocks.

Sulfate (SO_4)

A few of the analyses show a high sulfate content, chiefly of waters from the Gettysburg shale and Frederick limestone, although not all analyses for these formations are high in sulfate. The determined values range from 0.1 to 131 ppm. High sulfate is objectionable in boiler-feed water and domestic hot-water systems because it contributes to the formation of a hard calcium sulfate scale.

Chloride (Cl) and nitrate (NO_3)

Only small amounts of chloride and nitrate, several parts per million or less, are present in most ground waters of Carroll and Frederick Counties. However, a number of the analyses in Tables 11 and 12 show relatively high values for these constituents, probably indicating organic contamination. Even small amounts of chloride and nitrate may indicate contamination when they represent an appreciable percentage of the total mineralization. Shallow dug wells, which are difficult to protect from contamination, and wells drilled in cavernous limestones, which permit relatively free movement of contaminating substances, show the highest chloride and nitrate contents.

The small quantities of chloride found in the ground waters of Carroll and Frederick Counties have no bearing on its usefulness, except perhaps for specialized industrial purposes. Nitrate concentrations in excess of about 44 ppm in drinking water may cause infant cyanosis ("blue baby"), and investigators recommend that waters containing such quantities not be used in infants' formulas (Davis and Carlson, 1952).

Fluoride (F)

Fluoride is present in the ground waters of Carroll and Frederick Counties in only small amounts, the highest concentration determined being 0.4 ppm. Thus, these waters contain substantially less than the 1.5-ppm limit specified by the Public Health Service for waters subject to its jurisdiction.

Phosphate (PO_4)

Phosphate is physiologically important to both plants and animals. It occurs in very small quantities in some of the ground waters of Carroll and Frederick Counties. None of the concentrations exceed 0.1 ppm. Its presence in these concentrations has little bearing on the usefulness of the water.

Dissolved solids

The dissolved solids of water consist almost entirely of the constituents reported in Tables 11 and 12. They may include small quantities of organic material and water of crystallization. Ordinarily waters containing more than 500 ppm of dissolved solids are not recommended for public-water supplies, but a dissolved-solids content up to 1,000 ppm is acceptable if better water is not available. Ground-water samples from Carroll and Frederick Counties show a range from 42 to 412 ppm, well below the recommended limit. In general, water from siliceous rocks contains the least dissolved solids and that from calcareous rocks the most (fig. 12).

Hardness

The term hardness refers to the capacity of water to consume or precipitate soap. If mineral constituents causing hardness are present in water in relatively large quantities, the addition of soap to the water forms a sticky insoluble curd. Excessive hardness is objectionable because of the increased quantity of soap required to produce a lather and the difficulty of removing the curd from containers and fabrics. Hardness also causes deposition of scale in steam boilers, water pipes, and cooking utensils.

The principal constituents that cause hardness in water are calcium and magnesium. Other polyvalent cations, such as iron, manganese, aluminum, copper, and zinc cause hardness, and so does the hydrogen ion, but these generally are not present in natural water in large enough quantity to have an appreciable effect. The total hardness and noncarbonate hardness of the water samples analyzed are listed in Tables 11 and 12. The total hardness includes the effect of all hardness-forming constituents that are present in significant quantities; the noncarbonate hardness is that which is in excess of the equivalent bicarbonate. The classification of water according to hardness used in this report is:

Class of water	Total hardness (ppm)
Soft	0– 60
Moderately hard	61–120
Hard	121–200
Very hard	More than 200

The calcareous rocks and the Newark group yield water that is hard to very hard. The other formations generally yield soft to moderately hard water.

Hydrogen-ion concentration and carbon dioxide (CO_2)

Hydrogen-ion concentration in waters is generally indicated by the pH, which is the negative logarithm of the hydrogen-ion concentration in moles per liter of water. A pH of 7 indicates a neutral condition; a pH less than 7, an excess of hydrogen ions over hydroxyl ions; and a pH greater than 7, an excess of hydroxyl ions over hydrogen ions. Water having a low pH is acidic and corrodes well casings, pumping equipment, and distribution systems. Water having a high pH is alkaline and may deposit mineral matter in water supply systems, though it may be corrosive under certain conditions.

The pH of samples of water from Carroll and Frederick Counties ranged from 5.5 to 8.1. The crystalline silicate rocks characteristically yield water having a pH below 7; the calcareous rocks and Newark group, water having a pH above 7.

The carbon dioxide content of ground water increases its solvent action (corrosiveness). Ground water having a low dissolved-solids content and a pH of about 5 or 6, such as is characteristic of ground waters of the crystalline silicate rocks in Carroll and Frederick Counties, generally contains appreciable amounts of carbon dioxide. Although no simple relation exists between corrosion potential and the quantity of carbon dioxide in ground water, water having a carbon dioxide content in excess of about 10 ppm is likely to be corrosive. It exceeds 10 ppm in sixteen of the analyses in Tables 11 and 12.

Radioelements

As a part of the nationwide program of the Geological Survey to determine the natural and normal distribution of radioelements in surface and ground waters, as background from which to determine changes caused by atomic-energy activities, radiochemical analyses were made of water samples from two wells, well Car-Bd 13 near Union Mills in Carroll County and well Fr-Cf 1 at Woodsboro in Frederick County. The only naturally occurring radioactive substances in water that are now being determined routinely by the Geological Survey are radium and uranium. Beta-gamma radioactivity also is measured for detection of contamination by artificial radioactive substances. The radiochemical data for Carroll and Frederick Counties and reported maximum permissible tolerances are given in Table 13.

The tolerances are for internal exposure—that is, exposure through drinking the water. The concentrations in the well samples are well within the permissible tolerances. The tolerances for radioelements are largely theoretical and the

TABLE 13

Radiochemical Analyses for Two Wells in Carroll and Frederick Counties and Maximum Permissible Tolerances

	Radium (Ra) (micromicrocuries per liter)	Uranium (U) (micrograms per liter)	Beta-gamma activity (micromicrocuries per liter)
Well Car-Bd 13 (drilled in schist)	0.1	0.7	5
Well Fr-Cf 1 (drilled in limestone)	.1	1.0	20
Maximum permissible tolerances[a]	40	31	100[b]

[a] National Bureau of Standards Handbook 52.

[b] Provisional level of activity believed safe for exposure for a few months.

specifications may change as additional information on the biological effects of radioelements is acquired.

Temperature of the Ground Water

The temperature of ground water is a valuable property, as it is relatively constant throughout the year and is lower than that of surface water in the summer. These characteristics make it an excellent and dependable medium for storage and extraction of heat. In Carroll and Frederick Counties ground water is utilized for cooling canned foods after cooking and for air conditioning.

The temperature of ground water fluctuates a few degrees between seasons but generally averages about the same as the mean annual air temperature, which in Carroll and Frederick Counties is between 53° and 54°F. Temperatures measured at the discharge points of 55 wells and springs in Carroll and Frederick Counties range between 49° and 62° and average about 53°F. The range of temperature fluctuation of water from any one well or spring generally is considerably less than the 13 degrees indicated by all the measurements, these having been obtained from wells and springs in a variety of geologic and topographic settings and at various times of the year. The annual temperature range of spring and shallow well waters is greater than for deep well waters, owing to the greater susceptibility of the shallow ground-water zones to variations in atmospheric temperature and to the effects of recharging rainwater and snowmelt. The following temperature measurements of spring Car-Af 8, at Lineboro, Carroll County, show a seasonal fluctuation of about 10 degrees in a shallow ground-water zone:

	Temperature (°F)
April 28, 1954	51.5
May 11, 1954	51.0
May 12, 1954	51.0
July 20, 1954	59.0
August 10, 1954	59.0
October 19, 1954	55.0
January 4, 1955	49.0
January 4, 1956	52.0

Measurements at various times of the temperature of water from several drilled wells indicate a much smaller seasonal fluctuation. The temperature of water obtained from a well several hundred feet deep would probably not vary more than a degree or so, provided all the water pumped is derived from deep zones.

Monthly averages of all available spring- and well-water temperatures for the portions of Maryland within the Piedmont and Blue Ridge provinces and mean monthly air temperatures at Westminster are plotted in figure 13. Although 122 measurements from six counties (Harford, Baltimore, Howard,

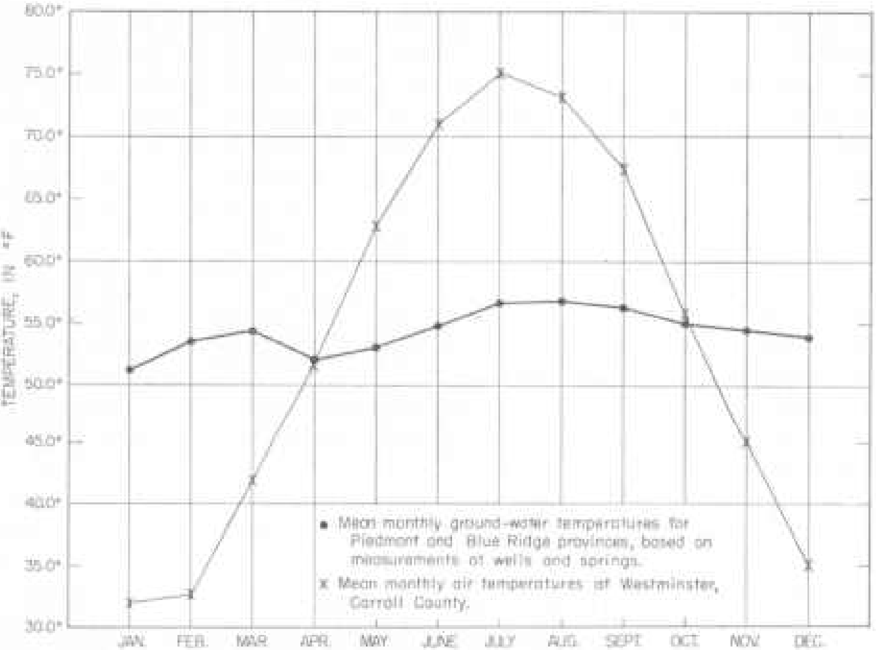


FIGURE 13. Comparison of Mean Monthly Temperature of Shallow Ground Water in the Maryland Piedmont and Mean Monthly Air Temperature at Westminster

Montgomery, Carroll, and Frederick) were used to give the monthly averages more validity, averages based on the 55 measurements obtained in Carroll and Frederick Counties alone define essentially the same graph. In general the data form an arc, concave downward, the ground-water temperatures being highest in July and August and lowest in January. Low average ground-water temperatures for April, May, and June define a dip in the curve which cannot be explained on the basis of the available data. Ground-water temperature changes ordinarily lag behind atmospheric temperature changes. Lag in transmission of temperature changes through the soil zone to depths of 20 feet was shown by Singer and Brown (1956).

Stream temperatures fluctuate over a wide range, from the freezing point in winter to as high as 85°F in the summer. Thus, stream water is a poor refrigerant in the summer, when the need for coolants of low temperature ordinarily is the greatest. In some parts of the United States conservation of the refrigerant property of the cold winter stream water has been accomplished by introducing the water into the ground in the winter months, through either recharge wells or recharge basins, and then retrieving it by pumping in the warmer season. The local geology, hydrology, and water chemistry determine the feasibility of such a temperature-conservation plan at a given site.

Temperature logs yield information on depth to water-bearing zones, magnitude of seasonal water-temperature fluctuations, circulation of ground water, and magnitude of the geothermal gradient. The measuring equipment utilized consists of a thermal element including a thermistor which is lowered into the well by an insulated cable. The cable conducts the effects of electrical-resistance variations in the element caused by temperature variations to a potentiometer circuit at the land surface. Temperature values are read from a microammeter calibrated to read directly in degrees Fahrenheit.

The temperature of rocks is controlled primarily by heat generated in the interior of the earth and transferred outward to the surface of the earth. The rate of increase in temperature as the interior is approached is known as the geothermal gradient. It can be measured in deep wells. The gradient measured to depths of 1,000 feet in wells in Maryland is on the order of 1°F for each 70 to 120 feet in depth. A temperature log of well Fr-Fd 1 at Adamstown shows a temperature of 56.2°F at 100 feet and 63.2°F at 954 feet. Thus, a gradient of 122 feet per degree Fahrenheit is indicated. The log shows evidence of disturbance of the geothermal gradient by ground-water circulation to depths of 400 to 500 feet.

At shallow depths the gradient is continually being altered by atmospheric-temperature changes and circulation of ground water. In the winter earth temperatures at shallow depths are below the temperature that would be obtained by extrapolation of the geothermal gradient to shallow depths. In the summer temperatures at shallow depths are raised above the extrapolated gradient. Thus, in a series of graphs depicting the geothermal gradient at various times of the year, the lower part of the graphs would be essentially static throughout the year, but the upper part would waver back and forth in response to seasonal temperature changes.

Temperature logs of two wells at the Catoctin Mountain National Park, in the western part of Frederick County, are shown in figure 14. The wells are along a small tributary of Hunting Creek, about 0.8 mile north of the National Park Service's area office. Well Fr-Bd 7 is about 280 feet downstream from well Fr-Bd 8, and about 30 feet lower in elevation.

Well Bd 7 had flowed slightly at times, but at the time the log was made its water level was about 0.1 foot below the land surface. The well yielded only a few gallons per minute when pumped and was not put into use. Its temperature log shows little influence of ground-water circulation below a depth of 46 feet, and since the well was cased to 45 feet it is understandable that the yield was negligibly small. Below 46 feet the temperature of the water in the well increased rather steadily with depth to the bottom, at a rate of about 280 feet per degree. This is considerably less than a normal geothermal gradient, and it seems likely that this zone must be affected by climatic factors. If it were possible to log to greater depths, an increase in gradient might be expected.

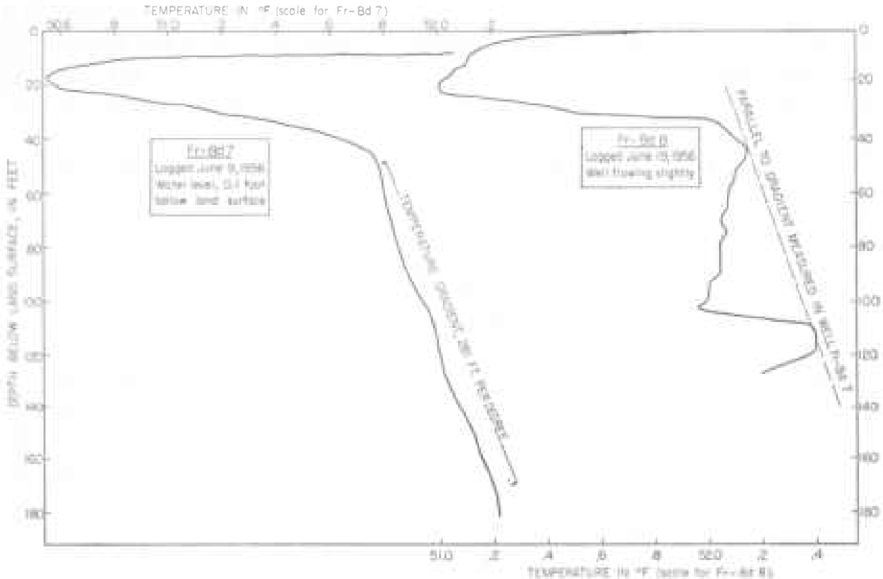


Figure 14. Temperature Logs of Two Wells in the Catoctin Metabasalt at the Catoctin Mountain National Park

The large deflection of the shallow part of the log to the left is interpreted to represent a residual zone of cold water dating from the winter of 1955–56, and the deflection far to the right in the uppermost part of the log, a zone of warm water from the late spring and summer of 1956.

Well Fr-Bd 8 was drilled several days before its temperature log was run, and it flowed continuously and slightly. It yielded a good supply of water, and later a pump was installed. During the 24-hour acceptance test, the temperature of the water discharged was measured periodically with a mercury thermometer. The temperature remained constantly at 51.0°F, which is the temperature of the shallow cold water indicated by the temperature log. The temperature of the naturally flowing water was about 51.75°F, showing that the water was warmed by the rocks as it rose slowly; otherwise it should have been at the pumping temperature of 51.0°F. In contrast to that for Bd 7, the temperature log for Bd 8 shows a pronounced effect of ground-water circulation to a depth of about 100 feet. The zone of influx into the well appears to be between depths of 50 and 100 feet, but most of the water may enter in the lower part of this interval. The cold water entering at this depth may be derived from the zone of cold ground water in the 10- to 30-foot interval presumably through a fracture system tapping that shallow cold zone some distance up the valley. Below 102 feet the rocks apparently are impermeable, and the water in the hole at this depth, being essentially stagnant, assumed the temperature of the rocks. A dashed line drawn from this section of the log to the protrusion at a depth of about 45 feet, which represents the point of maximum warming of the column of water rising up to flow from the well, parallels the gradient indicated by the log of well Bd 7. It serves as a convenient reference line to show the amount of temperature disturbance caused by the circulating ground water. The deflection to the left in the bottom 8 feet of the log is not explainable with present information. It may represent a contribution of cold water from a narrow fracture near the bottom of the well.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

Precambrian Rocks of the South Mountain-Catoctin Mountain Area

Table 14 summarizes the data concerning yields for wells in the South Mountain-Catoctin Mountain province. It shows little difference in the average yield of 113 wells in the depth intervals above 150 feet, where the average yield of wells is about 10 gpm. Eight wells deeper than 150 feet yield an average

TABLE 14

Average Yield, Specific Capacity, and Yield per Foot of Hole for Wells in the Precambrian Rocks in the South Mountain-Catoctin Mountain Area

Depth interval (feet)	Average yield		Average specific capacity		Average yield per ft. of hole		Aquifer or water-bearing unit
	(gpm)	No. of wells	(gpm/ft. of dd.)	No. of wells	(gpm/ft.)	No. of wells	
0–50	2.5	(1)	—	—	0.06	(1)	Granodiorite or granite gneiss
	9.6	(16)	0.8	(13)	.26	(16)	Catoctin metabasalt
	15	(8)	.7	(5)	.33	(8)	Aporhyolite
	11	(25)	.7	(18)	.27	(25)	All units
50–100	7	(29)	.4	(21)	.10	(30)	Granodiorite or granite gneiss
	10	(28)	1.1	(21)	.14	(27)	Catoctin metabasalt
	14	(10)	.9	(6)	.24	(10)	Aporhyolite
	9.3	(67)	.7	(48)	.14	(67)	All units
100–150	8	(11)	.6	(9)	.07	(11)	Granodiorite or granite gneiss
	12	(10)	.8	(9)	.10	(10)	Catoctin metabasalt
	9.9	(21)	.7	(18)	.08	(21)	All units
150+	20[a]	(8)	.3[a]	(4)	.09	(8)	Catoctin metabasalt

[a] Well Fr-Ae 31, yielding 160 gpm and having a specific capacity of 21.3 gpm/ft. of drawdown omitted from computations.

of 20 gpm, or nearly twice as much. However, much of the water coming from the deeper wells is known to be derived from the upper part of the holes. This is suggested also by the progressive decrease in the yield per foot of hole for the three depth intervals from 0 to 150 feet. The comparatively high average yield of these eight wells results also from heavy weighting of the data by three wells at the Victor Cullen State Hospital at Sabillasville reported to yield 30 gpm each. The wells were drilled many years ago and the reliability of the information is questionable. The average yield of the 121 wells is 10.5 gpm and the average specific capacity of 88 of the wells is 0.7 gpm/ft. The average yield per foot of hole is 0.15 gpm, which is among the lowest in the two counties.

Generally, the specific capacities and the yields per foot of hole decrease with increasing depth of hole. Nevertheless, the data in Table 14 indicate that drilling to a depth of at least 150 feet is warranted if maximum yields are desired.

Early Precambrian Rocks

Granodiorite and Granite Gneiss

Geology.—In Frederick County granodiorite and biotite granite gneiss underlie most of the Middletown Valley between Middletown and the Potomac River. These intrusive rocks have been referred to as the "injection complex" by Jonas and Stose (1939). The most common rock is light-gray to green gneissic granodiorite, interlayered in places with dark hornblende diorite. Biotite granite gneiss and augen gneiss containing layers of mica schist occur in places in the southeastern part of the Middletown Valley. Numerous dikes of green metadiabase transect the older rocks.

Typical drillers' logs of wells are given in Table 27. Common drillers' terms for the rocks of this unit are "mountain rock," "green rock," and "slate." The decomposed rock of the overburden is usually described as "shale" or "clay."

Water-bearing properties.—Nearly all wells in the granodiorite or granite gneiss yield sufficient water for domestic supplies, but only a few wells yield large supplies. The yields of 31 wells average 7 gpm. Only one well yielded as much as 30 gpm.

The average depth of the wells is 74 feet, and the average yield per foot of hole is 0.16 gpm.

Well Fr-Eb 4 at Arnoldtown was reported to yield 30 gpm in a 2-hour test, with a drawdown of 28 feet. The well was 108 feet deep and water-bearing zones were reported at a depth of 40–60 feet in "white sandy rock" and at 107–108 feet in "green rock."

No data are available concerning the water-bearing character of the granodiorite and granite gneiss below a depth of about 131 feet; presumably the fractures and crevices disappear or become very small below 200 or 250 feet, and little additional ground water may be expected.

Chemical quality.—One spring (Fr-Dc 21) and one well (Fr-Fb 1) were sampled for chemical analysis. Inasmuch as the complex includes a variety of rocks, a large number of ground-water analyses would be required to determine areal variations in chemical character of the water. The spring water is a calcium sulfate bicarbonate water; the well water is a calcium bicarbonate water. Both waters have a relatively high silica content. The high concentration of nitrate in the well water may indicate some pollution. Both waters are soft and of moderate mineralization. The well water is slightly acidic (pH 6.4). The high zinc content (1.4 ppm) probably was due to corrosion of the plumbing system. The spring water is weakly alkaline and contains a small amount of zinc.

Late Precambrian Volcanic Series

The Catoctin metabasalt underlies most of the area between South and Catoctin Mountains north of Middletown and fringes the injection complex south of Middletown. Associated with the metabasalt are aporhyolite, rhyolite tuff, and a basal tuffaceous unit, the Swift Run formation, which underlies small parts of the area between the two mountain ridges.

Swift Run formation

Geology.—The contact between the Catoctin metabasalt and the rocks of the injection complex is marked in places by sericitic quartzite, schist, or tuffaceous slate of the Swift Run formation. Limited outcrops of this formation occur in the vicinities of Burkittsville, Bolivar, Middletown, and Jefferson.

Water-bearing properties.—Because of its small areal extent the Swift Run formation is relatively unimportant as a source of ground-water supplies. It seems likely that moderate yields, on the order of 5 to 15 gpm, may be expected from wells drilled in it.

Catoctin metabasalt

Geology.—The Catoctin metabasalt is a dense green schistose rock which is believed to be a series of metamorphosed lava flows. The metabasalt usually has a cryptocrystalline texture, shows flow banding and amygdules in places, and, where fresh, is very hard. Hornblende schist and rhyolite tuff are interbedded with the metabasalt. Relatively small linear outcrops of the rhyolite tuff, striking northeast, occur throughout the central part of the Catoctin metabasalt area. The tuff consists of slate, in part sericitic, and sericitic quartz schist. Blue fine-grained amygdaloidal meta-andesite outcrops in a long, narrow belt northwest of Wolfsville and as a thin dike just east of Church Hill.

Drillers' logs of 11 wells in the Catoctin metabasalt are given in Table 27.

Water-bearing properties.—The metabasalt is dense and its primary porosity and permeability are small. Ground water moves principally through joint openings. Although the rock is amygdaloidal in places, this characteristic apparently does not contribute to its permeability because the amygdules are generally filled with mineral matter, are squeezed flat, and are hydraulically disconnected. A porosity of only 0.5 percent (Blair, 1955, p. 8) was measured for a sample of metabasalt (greenstone) from Franklin County, Pennsylvania, near the Frederick County line.

Because of its areal extent, the Catoctin metabasalt is an important water-bearing formation in the western part of Frederick County. Adequate water supplies for domestic use and limited commercial and public supplies are generally obtainable.

Well yields range from 1 to 160 gpm and average about 14 gpm. About 18 percent of the wells yield less than 5 gpm. Dry holes are uncommon.

The average depth of wells is about 91 feet and the average yield per foot of hole is 0.15 gpm.

The best well, Fr-Ae 31, west of Emmitsburg, reportedly yielded 160 gpm. The well is 161 feet deep and is a few feet west of a small reservoir on Turkey Creek belonging to the town of Emmitsburg. The well is reported to have been pumped for several days at its maximum capacity with a drawdown of the water level of only 7.5 feet. The high yield very likely is the result of its nearness to the surface reservoir, which may serve as a source of replenishment.

Another excellent well is Fr-Dd 13 on the flood plain of Rock Creek about 2 miles north of Braddock Heights. It is 85 feet deep and was pumped at 50 gpm for 70 minutes with a drawdown of only 6 feet. The driller's log shows "mountain boulders" to a depth of 35 feet overlying "copper rock" (metabasalt) from 35 to 85 feet. The high yield of this well may be attributed to the permeable character of the saturated bouldery colluvium and the nearness of Rock Creek.

Aquifer and well-performance tests.—Burkittsville. A test made on January 27, 1956, on two wells about a mile south of Burkittsville, Frederick County, demonstrated that interference may take place between shallow dug wells and deeper drilled wells, even though the drilled wells are cased to bedrock. The maximum depth of dug wells is usually limited by the depth to bedrock. The test demonstrated that ground water in the voids in the weathered rock and that in the crevices in the upper part of the crystalline rock are hydraulically connected. The data also permitted a rough computation of the coefficients of transmissibility and storage.

The wells are in the western part of the Middletown Valley near the eastern slope of South Mountain in an area underlain by the Catoctin metabasalt. Two farm wells were used: dug well Fr-Eb 7, which is 23.9 feet deep, rock lined, and 9 feet in diameter; and drilled well Fr-Eb 8, which is 12½ feet east of the center of the dug well, 201.6 feet deep, steel cased, and 6 inches in diameter.

The dug well was pumped for 205 minutes at an average rate of about 67.5 gpm. The yield declined from 74 gpm near the start of pumping to 58 gpm near the end, probably reflecting a decrease in pump efficiency as the water level lowered in the well, but also to some extent dewatering of the rock in the vicinity of the well. The water level in the well lowered 12.6 feet during the test. About 13,800 gallons was pumped, but only 7,800 gallons came from the aquifer, the rest coming from storage in the well. An average discharge, for purposes of hydraulic analysis, would be 7,800 gal./205 min. or 38 gpm. Using this discharge rate, the specific capacity of the dug well is 3.0 gpm per foot of drawdown for the 205 minute test.

The water level in the drilled well was lowered about 2.7 feet during the period that the dug well was pumped, demonstrating hydraulic connection between the two wells. Plotted against the logarithm of time the drawdown measurements made in the drilled well conform reasonably well to a straight line (fig. 15). Using the slope of this line and the modified Theis formula, the

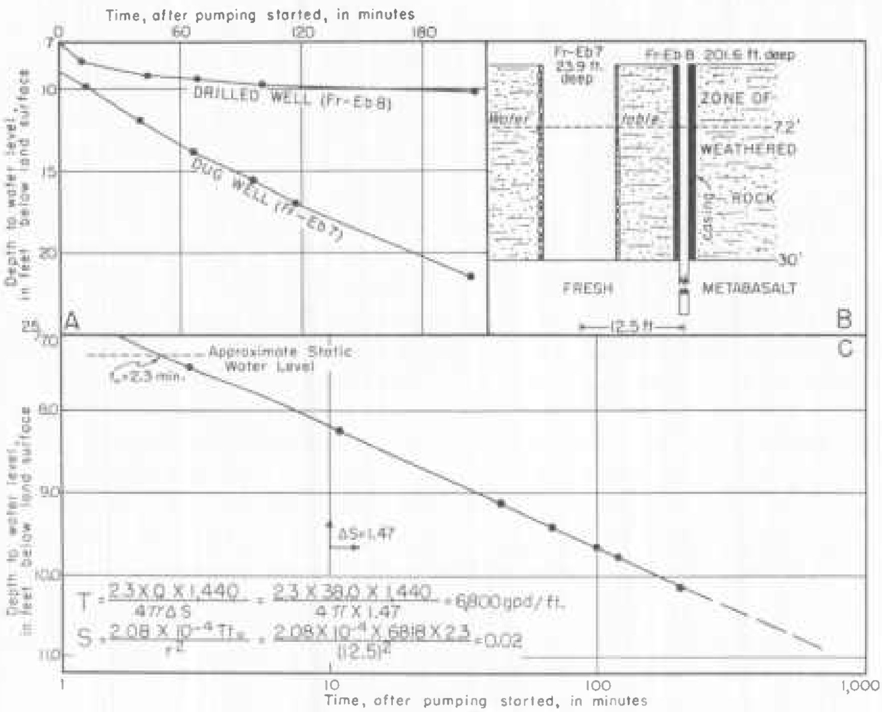


FIGURE 15. Graphs of Data for Aquifer Test near Burkittsville, Frederick County

A. Decline in water levels versus time pumping well Eb 7 at 38 gpm.

B. Cross-sections through wells Eb 7 and Eb 8.

C. Semi-log plot of water levels in well Eb 8 versus time and computations of coefficients of transmissibility and storage.

transmissibility is about 6,800 gpd per foot and the storage coefficient is 0.02. These coefficients are only approximate because the field conditions do not satisfy all the requirements of the Theis formula.

Chemical quality.—The chemical character of ground water in the Catoctin metabasalt is shown by analyses from 1 spring and 5 wells. The water is characterized by a considerable range in mineral content and hardness. Locally, it may contain objectionable quantities of iron. The range in important constituents is:

Constituent	No. of samples	Range (ppm, except for pH)
Dissolved solids	4	55–182
Hardness as $CaCO_3$	6	32–112
Total iron (Fe)	6	.03–2.1
Nitrate (NO_3)	6	3–39
Chloride (Cl)	6	.6–17
pH	6	6.7–7.5

Aporhyolite

Geology.—Two northeast-trending belts of metamorphosed rhyolitic lava almost entirely surrounded by the Catoctin metabasalt crop out in the northern part of the area between Catoctin and South Mountains. The aporhyolite is chiefly blue or gray in color, cryptocrystalline in texture except for quartz and feldspar phenocrysts, and hard and brittle. Red porphyritic aporhyolite occurs within the western belt near Wolfsville Crossing and Pleasant Walk School and near Sensenbaugh School. Associated with the aporhyolite are relatively small areas of metamorphosed sediments of pyroclastic origin—tuffaceous breccias and slates. In the vicinity of Wolfsville Crossing bands of rhyolite tuff occur with the red aporhyolite.

Well logs show that the weathered zone is at least 45 feet thick in places but averages about 26 feet. Drillers commonly describe the material of the zone of pronounced weathering as "clay and boulders," the boulders being masses of the rock not yet decomposed. Well casings commonly extend through this zone to the surface of the underlying fresher rock, frequently termed "mountain rock" or "copper rock" by drillers. The logs of several wells drilled in the aporhyolite are in Table 27.

Water-bearing properties.—The aporhyolite is a moderately good aquifer, but of relatively small areal extent. As the aporhyolite underlies rural areas, wells are drilled principally for farm and domestic use. The yield of 18 wells averages about 12 gpm. About 11 percent of the wells yield less than 5 gpm.

The average depth of wells is approximately 52 feet and the average yield per foot of hole is 0.23 gpm.

The best well is Fr-Bd 6 at Catoctin Mountain Park (Camp David). It yielded 30 to 36 gpm for the first 2 hours of its acceptance test. The well is 230 feet deep and is on a topographic bench at an altitude of about 1,750 feet.

The well may have penetrated metabasalt below the aporhyolite. The principal zone of contribution appeared to be within the weathered aporhyolite at a depth of 26 to 70 feet. That the weathered zone in the vicinity of this well may constitute a "pocket" of limited areal extent is suggested by the aquifer test data and by the substantial decline in yield that occurred during a drought in 1956.

Other good wells are Fr-Bc 10 and Bc 11 near the head of a branch of Hunting Creek, 1 mile southwest of Foxville. Each of these wells was pumped at 30 gpm for 1 hour. Their logs show that weathered rock extends to depths of 45 and 75 feet, respectively. The high yields of these wells may be attributed to their situation in a valley and to the existence of a thick saturated weathered zone.

It is fortunate that adequate domestic supplies of ground water can be obtained from most wells in the aporhyolite at depths of less than 100 feet, for the rock is extremely hard and difficult to drill below the zone of weathering.

Aquifer and well-performance tests.—Foxville. On June 7–8, 1955, a 24-hour acceptance test was run by the driller on well Fr-Bd 6, 1½ miles northeast of Foxville in the Catoctin Mountain Park. It is one of the few wells in the mountainous part of Frederick County for which a 24-hour acceptance test was run, most such tests being of an hour's duration or less. The well is an exceptionally good one, for yields of 30–40 gpm are uncommon in the mountainous sections of Frederick County.

The well casing extends to a depth of 57 feet. A turbine pump was used to test the well for 24 hours at rates varying from 36 to 24 gpm; the well was pumped at the higher rate for the first 2 hours and reduced to the lower rate thereafter. The water level in the well had lowered 12 feet by the end of the test. The specific capacity for 24 hours was 2.1 gpm per foot. The water-level measurements reflect the variations in pumping rate. The increased rate of decline of the water level after about 720 minutes of pumping, shown in figures 16A and 16C, probably is due in part to a slight increase in pumping rate, but more likely it indicates that the cone of depression had spread laterally to the limits of the pocket of weathered rock contributing water to the well.

Water levels for the period 170 to 720 minutes after pumping started conform reasonably well to a straight line when plotted against the logarithm of time, as shown in figure 16C. The computed coefficient of transmissibility is 2,200 gpd per foot for this period of the test. Owing to the complex geology and hydrology at the well site, the computed transmissibility may be only approximate. About 43 feet of the weathered rock was water-saturated at the start of the test. Dividing this figure into the transmissibility, a coefficient of permeability of about 51 gpd per square foot is obtained, which seems of the right order of magnitude. A computation of the transmissibility, based on the latter part of the hydrograph, where the rate of water-level decline is greater, gives a value of about 650 gpd per foot.

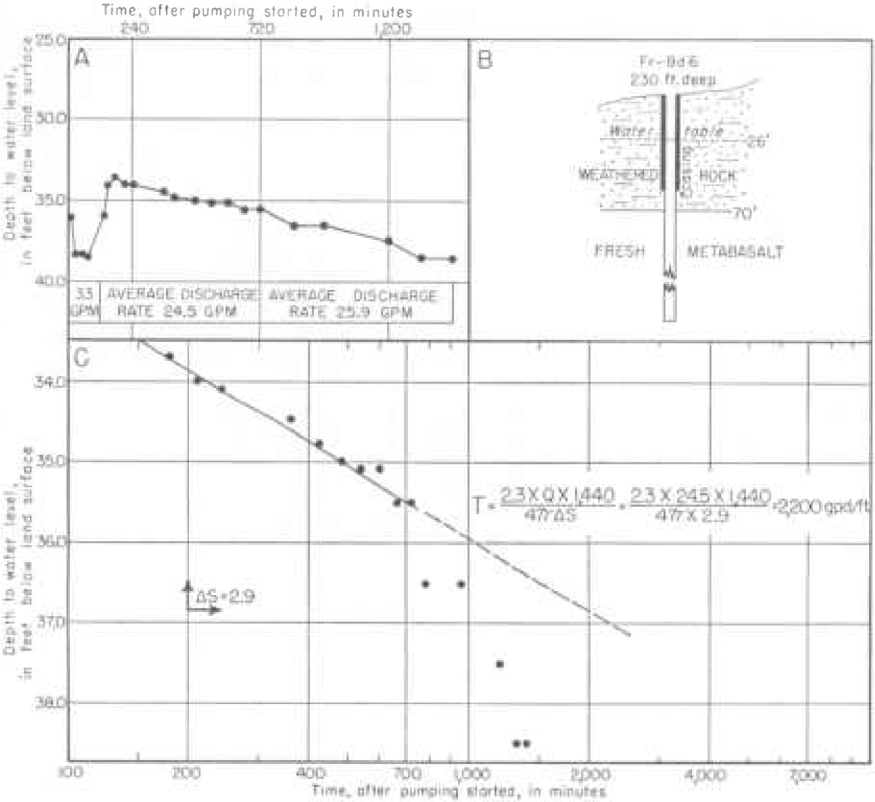


FIGURE 16. Graphs of Data for Aquifer Test on Well Fr-Bd 6 near Foxville, Frederick County. A. Plot of water levels versus pumping time. B. Cross section through well. C. Semilog plot of water levels versus time and computation of coefficient of transmissibility.

Chemical quality.—Two spring-water analyses (Fr-Cb 7, and a composite sample of Fr-Bd 3 and 4) and one well-water analysis (Fr-Bc 2) were obtained for the aporhyolite. The water is soft and of low mineral content. The pH of about 6.0 indicates that the water may be slightly corrosive.

Metamorphosed Paleozoic Rocks of Sedimentary Origin

The metamorphosed Paleozoic sedimentary rocks include the Loudoun formation, the Weverton quartzite, the Harpers phyllite, and the Antietam quartzite. Although composed of somewhat different rock types, these units have the same physiographic expression, tending to form hills and ridges.

Table 15 shows the average yield, specific capacity, and yield per foot of hole for 65 wells for 50-foot depth intervals to a depth of 150 feet. Data for depths below 150 feet are grouped together. Table 15 shows that the average yield of 11 wells more than 150 feet deep is 26 gpm, compared with an average yield of 7.1 gpm for 54 wells 150 feet deep or less. This is the result of the inclu-

TABLE 15

Average Yield, Specific Capacity, and Yield per Foot of Hole for Wells in the Metamorphosed Paleozoic Sedimentary Rocks

Depth interval (feet)	Average yield		Average specific capacity		Average yield per foot of hole		Water-bearing unit
	(gpm)	No. of wells	(gpm/ft. of dd.)	No. of wells	(gpm/ft.)	No. of wells	
0–50	2	(1)	0.1	(1)	0.05	(1)	Loudoun formation
	4	(3)	.2	(3)	.10	(3)	Harpers phyllite
	10	(1)	—	—	.25	(1)	Antietam quartzite
	4.4	(5)	.2	(4)	.12	(5)	All units
50–100	8.2	(11)	.4	(8)	.11	(10)	Loudoun formation
	6.7	(11)	.4	(10)	.08	(11)	Harpers phyllite
	11	(10)	1.3	(4)	.15	(10)	Antietam quartzite
	8.5	(32)	.6	(22)	.11	(31)	All units
100–150	6.0	(4)	.2	(4)	.05	(5)	Loudoun formation
	5.2	(8)	.3	(6)	.04	(8)	Harpers phyllite
	5.3	(5)	.1	(3)	.05	(5)	Antietam quartzite
	5.4	(17)	.2	(13)	.04	(18)	All units
150+	5	(1)	.2	(1)	.03	(1)	Loudoun formation
	35	(3)	.4	(1)	.11	(3)	Weverton quartzite
	29	(6)	.7	(4)	.07	(5)	Harpers phyllite
	5	(1)	—	—	.03	(1)	Antietam quartzite
	26	(11)	.6	(6)	.07	(10)	All units

sion of some public-supply and commercial wells which were drilled to great depths after obtaining fairly high yields at shallow depths. The high average yield of the 11 wells is reflected in high average specific capacities. The progressive decrease in yield per foot of hole drilled for the three depth intervals of 0–50, 50–100, and 100–150 feet would be expected as the rocks become denser, less fractured, and less permeable with increasing depth below the weathered zone.

Cambrian System

Loudoun formation

Geology.—The Loudoun formation is the oldest of the Cambrian formations in the area. As mapped by Stose and Stose (1946), the formation crops out on the slopes of Catoctin and South Mountains and in places forms their crests.

Cloos (1951, p. 29) believes that in the South Mountain area it is present on the east slope of the mountain only. Owing to stratigraphic revisions necessitated by his different structural interpretation of Catoctin Mountain, Whitaker (1955) does not consider the Loudoun to be present along the east slope of Catoctin Mountain. The formation is highly variable in character and thickness. It is composed chiefly of soft coarse arkosic quartzite, purer quartzite, quartzose conglomerate, and phyllite or slate. The maximum thickness may be about 300 feet, and the thickness generally is greater in Catoctin Mountain than in South Mountain. Four drillers' logs of wells in this formation are given in Table 27. Few detailed logs are available. Drillers generally refer to the quartzite and conglomerate as "sandstone," "sand," or "sand rock" and to the phyllite or slate as "shale," "shale rock," or "blue slate." The surficial zone of weathered rock is commonly called "clay and boulders" by drillers.

Water-bearing properties.—The Loudoun formation is only a fair water-bearing unit and underlies chiefly uninhabited mountainous parts of Frederick County. Records of 20 wells and 2 springs show that adequate ground-water supplies for domestic use and small commercial or public-supply use are available. Yields of 17 wells range from 1 to 20 gpm and average about $6\frac{1}{2}$ gpm. About 40 percent of the wells yield 3 gpm or less.

The depths of 20 wells range from 27 to $153\frac{1}{2}$ feet and average about 81 feet. Based on 15 casing-length records, the average thickness of the weathered zone is about 38 feet. Although the zone of weathering in the Loudoun formation is comparatively thick throughout much of its area, it is unsaturated and contributes little or no water when penetrated by wells.

One of the best wells in the Loudoun formation is Fr-Be 19, $2\frac{3}{4}$ miles north of Thurmont. It is 71 feet deep and is near the contact of the Loudoun formation with the Harpers phyllite. The well yielded 20 gpm during a 2-hour test with a drawdown of only 10 feet. Its specific capacity thus was 2.0 gpm/ft.

Well Fr-Ae 4, $2\frac{1}{2}$ miles south of Emmitsburg, also yielded 20 gpm, but its test lasted only half an hour. It is 125 feet deep and the principal water-bearing zone was reported to be at a depth of 115–120 feet. The specific capacity of this well was only 0.3 gpm per foot, which is about the average for the formation.

Weverton quartzite

Geology.—Hard vitreous quartzite beds of the Weverton quartzite, which stratigraphically overlies the Loudoun, are the principal ridge formers of both South and Catoctin Mountains. The Weverton forms much of the crests and slopes of the mountains. As mapped by Stose and Stose (1946), the Weverton is absent on Catoctin Mountain south of Braddock Heights, except for the Pine Mountain area, and it is absent on the east prong of South Mountain.

The formation is composed principally of layers of dark- and light-colored quartzite but has a coarse conglomeratic quartzite at its base. Massive vitreous beds form rocky ledges and cliffs along the mountain slopes. The thickness of the Weverton quartzite is on the order of 500 feet. Whitaker (1955, p. 442–445) distinguished eight clastic facies of the Weverton in Catoctin Mountain. The distribution of the Weverton on his geologic map of Catoctin Mountain is not everywhere in agreement with the distribution on the geologic map by Stose and Stose.

Water-bearing properties.—The Weverton quartzite is of minor importance as a water-bearing formation owing to its relatively small areal extent and the fact that it underlies rugged uninhabited mountainous parts of western Frederick County. As the unit forms the crests of the mountains, much of it lies above the water table and cannot supply water to wells. Springs are common but few wells are drilled in the formation. A number of wells were drilled for purposes other than domestic, such as for park, municipal, or school use, and were drilled to uncommon depths in search of large supplies. Domestic wells are commonly shallow; probably few exceed 50 feet. The reported yields of three wells in the quartzite were 4, 20, and 80 gpm, respectively. Because so few well yields are known, their average yield of 35 gpm is meaningless.

Well Fr-Bd 28 was drilled about 1930 to a depth of 1,000 feet, in the valley of High Run, to supplement the water supply of the town of Thurmont. A yield of less than 20 gpm was obtained, and the well is not used. Two other wells of the town supply were drilled about half a mile east of this one in the Harpers phyllite.

Well Fr-Ae 28 was drilled near the east foot of Catoctin Mountain to a depth of 850 feet for Mount St. Marys College. A yield of 80 gpm was obtained. The well is equipped with a turbine pump and is maintained as a standby source. The static water level is about 10 feet below the land surface, so that the system of fractures which supplies the water to the well is almost completely filled with water.

Well Wa-Dj 1 is a 400-foot well on the crest of South Mountain at the Washington Monument State Park in Washington County, just west of the Frederick County line. Its log, the source of which is unknown, is:

0–300 feet Weverton quartzite
300–400 feet Catoctin metabasalt (greenstone)

A yield of $1\frac{1}{2}$ gpm was obtained at the formational contact, and this only after the well was dynamited. The static water level was about 138 feet below the land surface in April 1956, suggesting that a substantial part of the Weverton is above the zone of saturation in the well. The poor yield of this well may be typical of wells on the rocky mountain crests.

Aquifer and well-performance tests.—*Yellow Springs.* A brief test was run on well Fr-Dd 74, a mile northwest of Yellow Springs in the valley of a tributary of Tuscarora Creek. The well is 21.1 feet deep, is 6 inches in diameter, and is cased for part of its depth. The flatness of the land surface along the stream here suggests that the valley may be partly filled with rock debris. No log for the well is available to establish the depth and character of the rock debris. The well was pumped for 27 minutes at an average rate of 4.4 gpm. The water level declined 0.25 foot, and after pumping was stopped it recovered in 17 minutes to within 0.01 foot of the static level. Thus, the specific capacity was 17.6 gpm per foot, which is among the highest in the two counties.

Although the test was of short duration and small pumping rate, the high specific capacity and rapid recovery of the water level after pumping show that the shallow quartzite here, or perhaps the rock debris overlying it, is moderately permeable. It is likely that at some localities conditions are favorable for induced recharge of the aquifers from the small streams draining the mountain slopes.

Chemical quality.—One partial analysis of water from the Weverton quartzite (dug well Fr-Bd 9) showed the sample to be soft and of low mineral content.

Harpers phyllite

Geology.—The Harpers phyllite underlies a belt of foothills on the east side of Catoctin Mountain in Frederick County. According to Stose and Stose (1946, p. 40) it is bounded by the Triassic border fault on the east and a nearly parallel fault on the west. Nowhere does it occur in normal stratigraphic position overlying the Weverton quartzite. The Harpers also underlies a small area in northern Carroll County east of the Triassic upland. Whitaker's conclusions (1955, p. 445–446) regarding the geology and distribution of the Harpers in the Catoctin Mountain area differ from those of the Stoses. The Harpers, or stratigraphically equivalent rocks, may underlie parts of southeastern Frederick County (Scotford, 1950; Thomas, 1952).

The principal rocks of the Harpers are a bluish-gray phyllite and finely micaceous slate. The total thickness is about 2,000 feet. Drillers commonly refer to the fresh rock as slate or "mountain rock." The term "soapstone" is used for weathered or partly weathered rock, which is easily drilled. The lengths of casing in wells indicate that rock weathering extends to an average depth of about 35 feet, although in some places the weathered zone is much thicker. Parts of the outcrop of the Harpers between Frederick and Emmitsburg are covered by mountain wash, as is shown by the drillers' logs of several wells which refer to sand, gravel, or boulders overlying the Harpers. Logs of 7 wells are given in Table 27, including 4 which are interpreted as having penetrated mountain wash (colluvium) above the bedrock.

Water-bearing properties.—The eastern foothills of Catoctin Mountain are an area of increasing residential development, so that the Harpers phyllite is important as a water-bearing unit. Records of about 40 wells and several springs that yield water from this formation show that adequate supplies for domestic use are generally obtainable, although many of the wells yield only enough water for minimum requirements. The records of a few wells indicate that locally the formation may be capable of supplying sufficient water for small industrial or public supplies.

The yields of wells range from less than 1 to 70 gpm and average about 10 gpm. About 50 percent of the wells yield less than 5 gpm.

The depths of 39 wells range from 9 to 1,140 feet and average about 169 feet. The average value is weighted by two exceptionally deep wells drilled several years ago in searching for a public ground-water supply for the town of Frederick. These wells, Fr-Dd 5 and Dd 6, are 996 feet and 1,140 feet deep, respectively. Exclusive of the 2 deep wells, the average yield per foot of hole drilled is about 0.06 gpm. Well Fr-Dd 5 is the best well in the formation, having a reported yield of 70 gpm.

A 214-foot well, Fr-Dd 44, 0.5 mile north of Yellow Springs, is reported to yield 50 gpm. It had a specific capacity of 2.0 gpm per foot in a 25-hour acceptance test. The high yield may be due to the existence of saturated colluvium at the well site. However, not all wells penetrating the phyllite where it is overlain by saturated colluvium (or alluvium) are successful. Well Fr-Be 2, about 1 mile north of Thurmont, penetrated 19 feet of such material (which was cased off) and 93 feet of the Harpers phyllite. The well was abandoned as unsuccessful because its yield was inadequate.

Chemical quality.—Two partial analyses of water from the Harpers are available; both are of samples from well Fr-Dd 77 at Braddock. The water is soft and of moderate mineral content. The water is probably corrosive, owing to the low pH (6.0) and high carbon dioxide content. A water sample collected at the well contained 3.3 ppm of copper, most of which probably was dissolved from the copper pipe submerged in the well. Another sample taken at the kitchen faucet showed a copper content of 3.4 ppm. The high concentrations of nitrate and chloride may indicate pollution of the water.

Antietam quartzite

Geology.—The Antietam quartzite is exposed on both sides of the Frederick Valley. On the west side it underlies the foothills of Catoctin Mountain in a series of narrow northeast-trending ridges extending from Point of Rocks at the Potomac River to just south of Yellow Springs. On the east side of the valley it forms a line of one or two conspicuous low ridges, extending from the southeast corner of Frederick County at the Potomac River northeastward to New Midway. In Carroll County the Antietam quartzite underlies a small area northeast of Taneytown near the Pennsylvania State line.

The Antietam quartzite in the eastern foothills of Catoctin Mountain is described by Stose and Stose (1946, p. 41) as a well-bedded light gray, rusty-weathering, granular quartzite and underlying crumbly sericitic quartz schist. Its thickness here is estimated to be about 300 feet. On the east side of the Frederick Valley the formation is largely quartz schist containing beds of hard gray quartzite. The base of the formation is not exposed here and its thickness is not known.

Drillers commonly refer to the fresh rock of the Antietam as "blue" or "gray slate" or "mountain rock" and to the softer weathered rock as "shale" or, where more intensely weathered, as "clay." Drillers' logs of 5 wells are given in Table 27. The thickness of the weathered zone, based on casing lengths of 16 wells, is as much as 40 feet, but it averages about 19 feet.

Water-bearing properties.—The Antietam quartzite is a water-bearing formation of moderate importance along the east flank of Catoctin Mountain, but it is less important on the east side of the Frederick Valley, an area of sparser habitation owing partly to the more hilly topography. The formation appears to be a poorer water bearer there than to the west of the valley.

Yields of 16 wells range from less than 1 to 20 gpm and average about 9 gpm. Four of the wells yielded less than 5 gpm.

The average depth of 23 wells is 92 feet and the range in depth is from 40 to 209 feet.

Well Fr-Ed 58, 0.5 mile south of Braddock, yielded 20 gpm and is the best well in the aquifer. It is 87 feet deep and had a specific capacity of 4.0 gpm per foot after 1 hour of pumping. The points of entrance of water into the well are not known, but they must be below a depth of 55 feet, the static level at the time of the pump test.

One of the poorest wells in the aquifer, Fr-Cf 24, yielded only ½ gpm. It is 123 feet deep and is on the crest of a prominent ridge just east of LeGore. The driller's log (Table 27) indicated extremely hard rock beneath about 30 feet of unsaturated weathered rock.

Limestones of the Frederick Valley

The Paleozoic limestones and dolomites of the Frederick Valley are the Tomstown dolomite and the Frederick and Grove limestones. Because of the soluble character of their contained minerals, these rocks have physical and hydrologic characteristics which set them apart from the other crystalline rocks.

The average yield of 105 wells in these aquifers is 25 gpm, or more than 2½ times that of the Precambrian volcanic rocks or the metamorphosed Paleozoic noncarbonate sedimentary rocks.

Table 16 shows the grouping by depth intervals of average yield, specific capacity, and yield per foot of hole for wells in the limestone aquifers. The average yield of 21 wells more than 150 feet deep is 50 gpm, whereas the average yield is only 19 gpm for 54 wells less than 150 feet deep. Thus, the well

TABLE 16

Average Yield, Specific Capacity, and Yield per Foot of Hole for Wells in the Limestones of the Frederick Valley

Depth interval (feet)	Average yield		Average specific capacity		Average yield per foot of hole		Water-bearing unit
	(gpm)	No. of wells	(gpm/ft. of dd.)	No. of wells	(gpm/ft.)	No. of wells	
0–50	13	(18)	4.6	(11)	0.33	(18)	Frederick limestone
50–100	20	(2)	1.0	(1)	0.24	(2)	Tomstown dolomite
	22	(39)	4.5	(24)	.35	(39)	Frederick limestone
	24	(8)	1.0	(4)	.32	(8)	Grove limestone
	22	(49)	3.9	(29)	.34	(49)	All units
100–150	16	(13)	3.0	(9)	0.14	(13)	Frederick limestone
	29	(4)	.5	(2)	.27	(4)	Grove limestone
	19	(17)	2.5	(11)	.17	(17)	All units
150+	53	(13)	0.3	(3)	0.20	(13)	Frederick limestone
	45	(8)	4.1	(6)	.17	(8)	Grove limestone
	50	(21)	2.9	(9)	.19	(21)	All units

data suggest that it is advantageous to drill wells in the limestones to a minimum depth of 150 feet if large yields are desired. However, the maximum average specific capacities and the maximum average yields per foot of well hole are from wells less than 100 feet deep.

Cambrian System

Tomstown dolomite

Geology.—The Tomstown dolomite occurs along a narrow northeast-trending belt at the east foot of Catoctin Mountain between Point of Rocks and Shookstown. It is bordered on the west in normal sequence by the Antietam quartzite and on the east is cut off by the Triassic border fault. Exposures of the dolomite are rare. In most places it is represented by its weathered product, red clay, or is covered by mountain wash. Its thickness is about 200 feet. In an exploratory core-drilling project near Feagaville, Hoy and Schumacher (1956) determined that the Tomstown there is 180 feet thick. They describe (p. 1525) the lower 40 feet as "white to light-gray, medium- to fine-grained, massive to thin-bedded dolomite with minor sericite partings" and the remainder as "gray thin-banded dolomitic limestone with numerous sericite and carbonaceous partings."

Water-bearing properties.—Owing to its limited extent, the Tomstown dolomite is of minor importance as a water-bearing formation. Only two wells tap the dolomite; these are well Fr-Fc 6 near Point of Rocks and Fr-Dd 46 at Shookstown. They are 93 and 65 feet deep and yield 30 and 10 gpm, respectively.

Frederick limestone

Geology.—The rocks of the Frederick Valley form a syncline, the Frederick limestone underlying most of the valley and the Grove limestone occupying the axis of the syncline. The outcrop of the Frederick limestone is about 0.5 mile wide near Licksville at the Potomac River, widens northward to about 5 miles in the vicinity of Frederick and then narrows north of Frederick to disappear beneath Triassic sediments in the vicinity of New Midway. Smaller areas of the Frederick limestone occur in the Thurmont-Catoctin Mountain area and between ridges of the Antietam quartzite on the east side of the Frederick Valley.

The Frederick limestone is chiefly thin-bedded dark-blue limestone with dark argillaceous partings. Dark shale occurs near the base of the formation, cropping out along the east side of the Frederick Valley. The stratigraphic thickness of the Frederick limestone is approximately 500 feet. In their logs, drillers generally refer to the limestone rock and the weathered clayey mantle by the correct lithologic terms. Records of eight wells are given in Table 27.

Weathering separates the limestone along bedding planes, and fractures transverse to the bedding split it into tabular blocks which are commonly used for stone fences throughout the valley. In most places a blanket of 10 to 35 feet of reddish smooth-textured or gritty brown residual clay overlies the limestone. The thickness of the clay mantle varies markedly over short distances owing to differential susceptibility of beds of the limestone to weathering and to erosion of the clay. Well Fr-De 16, near Hansonville, penetrated 14 feet of clay over the rock, but relatively fresh limestone crops out about 20 feet from the well. In places wells encounter residual boulders of limestone embedded in the clay.

Because limestone is relatively easily dissolved by water, fractures and partings at shallow depth become enlarged as water circulates through them. Cavernous openings have developed in some areas underlain by the Frederick limestone, but large underground openings are not so numerous as in areas underlain by the Grove limestone. Davies (1950, p. 29) described a large cavern in the Frederick limestone near Adamstown. Large solutional openings and residual boulders give rise to drilling problems and call for special drilling techniques. Boulders tend to deflect the drill bit. Large solutional openings cause deviations of the drill hole from the vertical and loss of drilling fluid in rotary-drilled wells.

Water-bearing properties.—The Frederick limestone is one of the most important water-bearing units in the area. A large number of farm and suburban homes and several commercial and industrial firms are supplied with water from wells in the formation. Well yields range from practically nothing to as much as 275 gpm and average about 25 gpm. The pumping rates of acceptance tests for domestic wells usually are less 30 gpm. That some of the wells for which small yields were reported are capable of considerably greater yield is supported by the small drawdowns during their acceptance tests. Industrial and public-supply wells, on the other hand, ordinarily are tested at their maximum capacity, and their average yield (about 120 gpm) is considerably greater than the overall average. Data for nine high-capacity wells in the Frederick limestone are:

Location	Well No.	Depth (feet)	Yield (gpm)	Length of test (hours)	Specific capacity (gpm/ft.)
Thurmont	Fr-Be 1	192	150	—	—
Do	Be 3	151	155	24	3.4
Woodsboro	Ce 8	275	80	2	—
Frederick	De 27	200	80	—	—
Do	Ee 4	61	275	—	34.7
Do	Ee 6	120	67	—	—
Adamstown	Fd 1	954	95	108	.9
Do	Fd 4	60	120	—	—
Do	Fd 7	1,209	120	—	—
Do	Fd 7	—	65	48.7	.6
Average		358	120		

The best well, Fr-Ee 4, is an industrial well only 61 feet deep in the center of Frederick. It was pumped for several hours at 275 gpm with a drawdown of only 8 feet. The log of the well shows that two cavernous zones were encountered below the water table at depths of 31 and 55 feet. The high sustained yield of this well indicates connection via solution cavities with nearby Carroll Creek.

Depths of wells in the Frederick limestone vary considerably from place to place, even for nearby wells, owing to the differential solubility of the limestone layers and to variations in number and size of water-bearing openings. The wells range in depth from 20 to as much as 1,209 feet and average 119 feet. The few records of deep wells suggest that little water is likely to be encountered below a depth of about 400 or 450 feet. However, where large supplies are needed it may be prudent to prospect for water-bearing zones at even greater depths.

Aquifer and well-performance tests.—Adamstown. Adamstown is in the southern part of the Frederick Valley and is underlain by eastward-dipping beds of the Frederick limestone. The residual red and brown clay overlying the bed-

TABLE 17

Data for Wells at the Adamstown Cannery

Well No.	Depth (ft.)	Length of casing (ft.)	Reported yield (gpm)	Remarks
Fr-Fd 1	954	235 (or 400?)	190	Originally 430 ft. deep, with similar yield. Drilled through dug well 36 ft. deep.
Fd 2	150	22	—	Water reported encountered in 3-ft. cavity at 135 ft.
Fd 3	76.8	17	—	
Fd 4	60	20	120	
Fd 5	35	20	—	Water reported contaminated.
Fd 6	65	20	—	
Fd 7	1,209	220 (or 400?)	120	Originally 364 ft. deep, with yield of 80 gpm. Equipped with turbine pump.

rock is several feet to about 20 feet thick. Beneath the clay, to a depth of 100 or 150 feet, are residual boulders of limestone embedded in a matrix of residual clay and partly decomposed rock. This zone, particularly the shallower part, is characterized by cavernous solutional openings. It grades downward into solid bedrock, where the ground-water circulation is through joint openings and solutional openings of moderate size. Water-bearing zones of any size probably are absent below a depth of about 400 or 450 feet.

The well field of the former Thomas and Co. cannery was made available for an aquifer test during December 1954. The field consists of seven wells, data for which are given in Table 17.

Well Fr-Fd 7 was the only well in use at the time of the test; the others either had no pumps or were equipped with inoperative pumps. All the wells, especially the shallow ones, yielded muddy water, as is common for wells obtaining water from cavernous openings in the limestone.

Except for well Fd 2, the well records indicate that the principal water-bearing zones occur within two depth intervals, approximately 35 to 80 feet and 350 to 450 feet. Hence, approximately 270 feet of poorly permeable rock lies between these water-bearing zones, although within this interval there are small bodies of permeable rock, as is indicated by the cavity reported in well Fd 2 at a depth of 135 feet. Measurements at various times during the period 1954-57 in deep well Fd 1 and in the shallow dug well in which it is drilled show that the water level in the deep wells is consistently lower than the water level in the shallow wells, the range in head difference being 0.5 to 4 feet. That the two zones are hydraulically connected is indicated by the reported decrease in yield of the shallow wells when the deeper ones were pumped. Also, when a sinkhole collapse occurred beneath the Baltimore and Ohio Railroad tracks along the side of the cannery, dewatering of the sinkhole to facilitate repairs

TABLE 18

Drawdown in Observation Wells in Adamstown Aquifer Tests

Well no.	Distance from pumped well Fd 7 (feet)	Drawdown (feet)	Remarks
(Shallow drilled wells)			
Fr-Fd 3	203	1.72	Equipped with continuous recorder.
Fd 5	229	1.69	Manual measurements.
Fd 6	217	1.74	Continuous recorder.
(Deep drilled wells)			
Fd 1	168	53.5	Continuous recorder.
Fd 7	0	116.0	Manual measurements.
(Shallow dug wells)			
Fd 41	500	.8+	Depth 19.6 ft. Data erratic and difficult to interpret.
Fd 49	600	.45	Depth 13.9 ft. Data erratic on first day of test, but consistent on second day.

to the track bed was accomplished by pumping deep well Fd 7. It appears that water moves downward from the shallow zone of higher head to the deeper zone of lower head. The direction of subsurface drainage in the Adamstown area apparently is to the west and south toward Tuscarora Creek.

Well Fr-Fd 7 was pumped for 48 hours and 40 minutes. Drawdowns of the water levels in all wells were observed by means of tape measurements or automatic water-level recorders. The wells used for observation were shallow wells Fd 3, 5, and 6 and deep wells Fd 1 and Fd 7. In addition, water levels in two dug wells, Fd 41 and Fa 49, south of the cannery were observed. Pumping rates during the test ranged from 60 to 78 gpm and were measured by the rate of rise of the water level in the cannery's water-storage tank. The weighted average pumping rate was 65 gpm. The drawdown in each well, just before cessation of pumping, is summarized in Table 18.

The pumping level in Fd 7 lowered 183 feet after about 20 hours of pumping, and slowly rose several feet during the remainder of the pumping period. The water level in the observation well Fd 1 declined 55 feet after about 20 hours of pumping, and remained at practically this level for the rest of the pumping period. The drawdown in this well plotted against time since pumping began, on a logarithmic base is shown in figure 17. The three shallow drilled wells responded slowly to the pumping but at a consistently increasing rate with respect to the logarithm of time. The water levels in these wells declined at almost identical rates (Table 18), even though the wells were not at equal

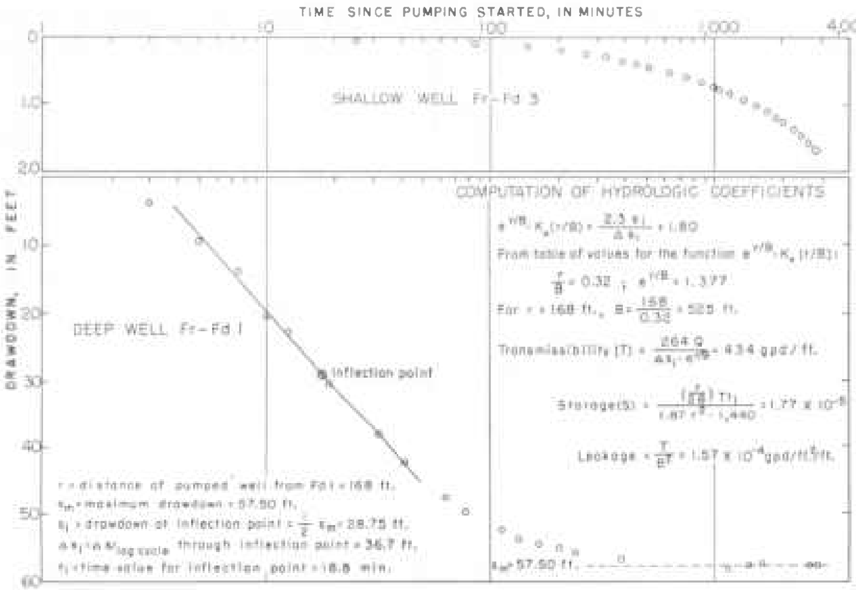


FIGURE 17. Graphs of Drawdown in Observation Wells Fr-Fd 1 and Fd 3 and Computation of Hydrologic Coefficients for Adamstown Aquifer Tests

distances from the pumped well. Water-level data for well Fd 3 are plotted in figure 17, and its graph is representative of the drawdown in all three shallow drilled wells.

The aquifer test data suggest that the deep water-bearing zone responds to pumping as though it were a leaky artesian aquifer (Jacob, 1946; Hantush and Jacob, 1955), in which downward leakage through the overlying poorly permeable limestone replenishes the water-bearing zone as water is withdrawn from it by pumping. Factors suggesting this are the cessation of drawdown in the two deep wells after 20 hours of pumping, and the slow but progressively increasing response of the shallow wells to the pumping. Hantush and Jacob obtained a solution for nonsteady distribution of drawdown in an aquifer in which leakage takes place. Later Hantush (1956) outlined graphical methods for determining the hydrologic coefficients of leaky artesian aquifers, including the coefficient of leakage (leakance) of the semiconfining bed. Recently he applied the leaky-aquifer analysis extensively in a quantitative ground-water study of the Roswell basin (1957). Analysis of the drawdown curve for Fd 1 by the method of Hantush is shown on figure 17. The table of values for the function referred to in the computations may be found in his Roswell basin paper. For the Adamstown test coefficients of transmissibility and storage of 430 gpd/ft. and 1.8×10^{-5}, respectively, were computed. A coefficient of leakage of 1.6×10^{-4} gpd/ft.^{2} was obtained. All three coefficients are important to quantitative evaluation of ground-water circulation, availability of ground-water supplies and interference between wells. Owing to the heterogeneous water-bearing character of the limestones of the Frederick Valley, the coefficients may be strictly applicable only to the rocks in the Adamstown area and only to the extent that the limiting geologic and hydrologic factors are understood.

Analysis by the Theis nonequilibrium recovery formula of the water-level recovery curves for the two deep wells after pumping was stopped gave a transmissibility of 680 gpm per foot, somewhat larger than that computed from the drawdown curves but still a very low figure.

Chemical quality.—Nine well samples and one spring sample were collected for analysis (Table 12). The water is of the calcium bicarbonate type and is moderately hard to very hard. Water-softening units are a fairly common part of water-supply systems using ground water from the Frederick limestone. Most of the analyses show high concentrations of nitrate and variable quantities of chloride which may indicate local organic pollution. In some places iron may be present in objectionable quantities. The range of important constituents in the samples is:

Constituent	No. of samples	Range (in ppm, except for pH)
Dissolved solids	3	208–345
Hardness as $CaCO_3$	10	82–459
Total iron (Fe)	10	.02–.6
Nitrate (NO_3)	10	6–178
Chloride (Cl)	10	.4–114
pH	10	7.0–8.0

Radiochemical data for water from well Fr-Cf 1 are given on p. 57.

Ordovician System

Grove limestone

Geology.—The Grove limestone, of early Ordovician age, underlies a linear strip along the center of the Frederick Valley. Small parallel outcrops along the west side of the valley represent subordinate folds of the west limb of the syncline. The main belt is about a mile wide and extends from near Buckeystown northward through Frederick to where it disappears beneath Triassic sediments. The formation is described by Stose and Stose (1946, p. 47) as "a thick-bedded high calcium limestone, with beds of massive dolomite in the lower part and highly quartzose limestone at the base." The basal beds are characterized by an abundance of glassy quartz grains, and in places the siliceous limestone weathers to sand. Owing to their greater resistance to weathering than that of the purer limestone above, these basal beds form low topographic ridges or crop out in narrow linear belts which outline the rock structure. The total thickness of the formation is about 600 feet.

In their logs drillers commonly refer to the rock as limestone, but where it is siliceous they may use the term "sandstone." The siliceous beds are difficult to drill. Logs of six wells are given in Table 27. The weathered mantle of the Grove limestone is variable in thickness and character. Generally it is 20 to 40 feet thick and consists of clay or sand. Solutional cavities are more prevalent in the Grove than in the Frederick limestone, presumably owing to the generally purer character of the Grove. Davies (1950, p. 30) describes several cavernous openings in the formation. Large openings were reportedly encountered during the drilling of several wells, among which are wells Fr-Ee 2 and Ee 3. However, it is not always possible to distinguish creviced openings from soft fissure-filling clay, both of which are penetrated rapidly by the drill. A 7-foot limestone layer penetrated in the midst of 52 feet of red clay at a depth of 38 to 45 feet in well Fr-De 9 near Walkersville may be a residual boulder. Such boulders embedded in the clay mantle frequently deflect the drill bit and make it difficult to drill straight well holes. Inclined bedding or jointing also may deflect well holes.

Water-bearing properties.—The Grove limestone is among the most important water-bearing formations in Frederick County. A number of farms, rural homes, and commercial and industrial firms are supplied with water from wells in this formation. Its outcrop passes through the eastern part of the city of Frederick, where industries utilize it as a source of water. Yields of 20 wells range from a few gpm to about 150 gpm and average about 32 gpm. Data for seven of the best wells producing from the Grove limestone are given below; the average yield of these wells is about 72 gpm and their average depth is 190 feet:

Location	Well No.	Depth (feet)	Yield (gpm)	Length of test (hours)	Specific capacity (gpm/ft.)
Woodsboro	Fr-Cf 1	200	130	64	3.8±
Walkersville	De 34	330	100	2	20
Do	De 35	100±	60	—	—
Do	De 7	123	45	6	—
Do	De 13	70	100	12	—
Frederick	Ee 2	155	30	8	.33
Do	Ee 3	350	40	8	.6

The depths of all inventoried wells in the Grove limestone range from 15 to 400 feet and average 135 feet. It is likely that little increase in well yield may be expected below 300 to 400 feet; in most localities the major water-bearing openings appear to be above 100 feet. The average yield per foot of hole drilled is 0.24 gpm.

The best well in the formation is Fr-Cf 1, owned by the town of Woodsboro.

It yielded an average of 130 gpm for 64 hours with a specific capacity of about 3.8 gpm per foot. The well is only a few hundred feet from a diabase dike intruded into the Grove limestone. The high yield may be related to rock fracturing associated with the diabase intrusion and subsequent solutional activity.

Chemical quality.—Three samples of water from the Grove limestone were analyzed. The analyses show the water to be similar to that from the Frederick limestone. Calcium and magnesium are the principal cations and bicarbonate the principal anion. The water is moderately high in dissolved solids and is very hard. The water is slightly alkaline and the iron content is low.

The range of important constituents in analyses is:

Constituent	No. of samples	Range (ppm, except for pH)
Dissolved solids	3	245–290
Hardness as $CaCO_3$	3	206–263
Total iron (Fe)	3	.09–.4
Nitrate (NO_3)	3	29–36
Chloride (Cl)	3	2–7
pH	3	7.4–7.7

Silicate Crystalline Rocks of the Piedmont Upland

The silicate crystalline rocks of the Piedmont upland are of Precambrian and early Paleozoic age. They lie east of the Frederick Valley in an area characterized by rolling, well-drained hills, locally steeply sloping. Formations in this category are the Baltimore gneiss, Peters Creek quartzite, Sams Creek metabasalt, Libertytown metarhyolite, Ijamsville phyllite, Urbana phyllite, Marburg schist, and Wissahickon formation. The average yield of 266 wells in these rocks is about 13 gpm.

Table 19 shows by depth intervals of 50 feet the average yield, specific capacity, and yield per foot of hole for the wells in these formations. The average yield of wells is highest in the depth interval from 100 to 150 feet and in the interval more than 150 feet. If large-capacity wells are desired, drilling should proceed to a depth of at least 100 or 150 feet. Table 19 also shows the usual progressive decline in average specific capacity and average yield per foot of hole for wells in the successive depth intervals.

Baltimore gneiss

Geology.—The Baltimore gneiss, of Precambrian age, occurs in a small area at the southeastern tip of Carroll County, as a part of the Woodstock anticline, the major part of which lies to the southeast in Howard and Baltimore Counties. In Carroll County it consists of alternating dark biotitic layers and light-colored granitic layers.

TABLE 19

Average Yield, Specific Capacity, and Yield per Foot of Hole for Wells in the Silicate Crystalline Rocks of the Piedmont Upland

Depth interval (feet)	Average yield		Average specific capacity		Average yield per ft. of hole		Water-bearing unit
	(gpm)	Number of wells	(gpm/ft. of dd.)	Number of wells	(gpm/ft.)	Number of wells	
0–50	8	(1)	—	—	0.25	(1)	Peters Creek quartzite
	10	(4)	1.3	(2)	.26	(4)	Sams Creek metabasalt
	10	(3)	6.2	(2)	.24	(3)	Ijamsville phyllite
	10	(8)	2.9	(3)	.25	(8)	Marburg schist
	14	(7)	2.4	(2)	.35	(7)	Wissahickon formation (albite-chlorite)
	11	(23)	3.2	(9)	.28	(23)	All units
50–100	12	(1)	—	—	—	—	Baltimore gneiss
	10	(7)	2.2	(7)	0.16	(7)	Peters Creek quartzite
	9	(4)	.2	(4)	.08	(4)	Sams Creek metabasalt
	12	(2)	1.0	(2)	.19	(2)	Libertytown metarhyolite
	8.7	(22)	.3	(12)	.12	(22)	Ijamsville phyllite
	12	(17)	.4	(8)	.16	(17)	Urbana phyllite
	16	(34)	2.7	(18)	.23	(31)	Marburg schist
	11	(72)	1.8	(30)	.16	(72)	Wissahickon formation (albite-chlorite)
	11	(159)	1.5	(81)	.16	(155)	All units
100–150	25	(3)	0.6	(1)	0.25	(3)	Peters Creek quartzite
	7	(1)	.1	(1)	.04	(1)	Sams Creek metabasalt
	1	(1)	—	—	.01	(1)	Libertytown metarhyolite
	5.7	(7)	.2	(4)	.06	(7)	Ijamsville phyllite
	7.1	(6)	.1	(4)	.06	(6)	Urbana phyllite
	7.5	(11)	.6	(5)	.06	(11)	Marburg schist
	25	(24)	1.3	(9)	.20	(24)	Wissahickon formation (albite-chlorite)
	16	(53)	.7	(24)	.14	(53)	All units
150+	4	(1)	0.1	(1)	0.02	(1)	Baltimore gneiss
	25	(6)	.3	(4)	.13	(6)	Peters Creek quartzite
	2	(1)	—	—	.01	(2)	Sams Creek metabasalt
	10	(2)	.1	(1)	.04	(2)	Ijamsville phyllite
	7	(4)	.1	(1)	.03	(3)	Marburg schist
	23	(17)	.4	(8)	.10	(17)	Wissahickon formation (albite-chlorite)
	19	(31)	.3	(15)	.09	(31)	All units

Water-bearing properties.—Because of its small areal extent the Baltimore gneiss is of little importance as a water-bearing formation. Records of two wells in the Patapsco State Park were obtained. Well Car-Ef 13 is 178 feet deep and reportedly yielded 4 gpm in an 8-hour test with a drawdown of 97 feet and well Car-Ef 14 is 95 feet deep and reportedly yielded 12 gpm. The yield and depth of the latter well are fairly typical for wells drilled in this formation in Baltimore and Howard Counties. Owing to the hilly topography the depth to the water table is relatively great in the localities underlain by the Baltimore gneiss in Carroll County; thus, in that county the yield of wells may be somewhat less than in Baltimore and Howard Counties, where the topographic relief in the gneissic areas is more subdued.

Eastern Sequence of Crystalline Schists

Setters formation

Geology.—The Setters formation overlies the Baltimore gneiss unconformably and its outcrop encircles the dome structures of Baltimore and Howard Counties. The Setters crops out in a northeast-trending ridge in the southeastern corner of Carroll County along the periphery of the Woodstock anticline. Inasmuch as the formation is only about 250 feet thick and is inclined rather steeply, 25° to 45° to the northwest, its outcrop is narrow. The unit consists of fine- to medium-grained mica schist, coarse-grained vitreous quartzite, and fine-grained micaceous gneiss.

Water-bearing properties.—Its limited outcrop area in Carroll County makes the Setters formation a minor water-bearing unit. In Baltimore and Howard Counties, where its area of outcrop is more extensive, well yields average 10 and 5 gpm and depths 172 and 130 feet, respectively (Dingman and Ferguson, 1956, p. 20; Dingman and Meyer, 1954, p. 23). The formation may be a poorer water-bearing unit in Carroll County owing to the rugged topography along the North and South Branches of the Patapsco River where it is exposed. The hydrologic conditions may be similar to those in the Baltimore gneiss.

Wissahickon formation (oligoclase-mica schist facies)

Geology.—The Wissahickon formation is divided into two facies, the albite-chlorite schist facies that crops out west of the Peters Creek quartzite and the oligoclase-mica schist facies east of the quartzite. The oligoclase-mica schist facies underlies an area of less than 2 square miles in the southeastern corner of Carroll County but is extensive in the counties east and southeast of Carroll County. It consists of interbedded layers of coarse- to medium-grained mica schist and mica gneiss and thin layers of quartzite. Biotite, muscovite, and quartz are the dominant minerals, there being subsidiary amounts of orthoclase feldspar. Owing to strong contortion of the beds, no reasonable estimate of the thickness of this facies can be made.

Water-bearing properties.—Few data are available on the water-bearing character of the oligoclase-mica facies of the Wissahickon formation in Carroll County. In the other Piedmont counties it is a fair aquifer in which wells average about 135 feet in depth and yield 11 to 12 gpm. In Carroll County the average yield of wells may be slightly less, because its outcrop area near the North and South Branches of the Patapsco River is characterized by rugged well-drained terrain.

Peters Creek quartzite

Geology.—The Peters Creek quartzite crops out as a northeast-trending belt several miles wide in southeastern Carroll County. It consists of grayish green medium- to fine-grained micaceous quartz schist containing biotite, chlorite and muscovite interbedded with micaceous quartzite. Because the unit is strongly contorted it is not possible to estimate its thickness.

Well logs and casing records show that weathering of the Peters Creek quartzite extends to depths ranging from a few to more than 50 feet and averaging about 28 feet. The weathered rock has been largely stripped away in the deep gorgelike valleys of the North and South Branches of the Patapsco River. In most places these streams flow on fresh rock. Drillers commonly describe the material of the weathered zone as "shale," "sand rock," or "dirt." Generally well casings extend through this zone to the underlying fresh rock, but at some wells the lower part of the weathered zone is firm enough to require no casing and is left uncased. The fresh rock commonly is called by the drillers "granite," "mica rock," or simply "rock." Drillers' logs of four wells drilled in the Peters Creek are given in Table 27.

Water-bearing properties.—The water-bearing character of the Peters Creek quartzite is similar to that of the Wissahickon formation. The Peters Creek is only moderately important as a water-bearing unit. Wells are drilled in this formation principally for domestic supplies, but a carpeting manufacturer at Cedarhurst utilizes water from it for air conditioning and drinking.

Well yields range from 2 to 100 gpm and average 16 gpm. Only about 9 percent of the wells yielded less than 5 gpm. The depths of 28 wells range from 20 to 325 feet and average about 98 feet. The average yield per foot of hole is 0.16 gpm. Specific capacities of 15 wells range from less than 0.1 to 4.4 gpm per foot of drawdown.

The best well is Car-Cf 11, on the bank of the North Branch of the Patapsco River at the plant of Congoleum-Nairn, Inc. It is 200 feet deep and was reportedly pumped at a rate of 100 gpm for 12 hours with little drawdown. The position of the water-yielding zone or zones is not known. The high yield may be due to recharge of the aquifer from the North Branch of the Patapsco. Several other wells drilled at the plant have comparatively small yields and are not used.

Chemical quality.—Two partial analyses of water from the Peters Creek quartzite (Car-Cf 11 and Car-Dc 1) indicate that the water is of the bicarbonate type and is very soft.

Metamorphosed volcanic rocks of the Western Piedmont

Sams Creek metabasalt

Geology.—The Sams Creek metabasalt of Stose and Stose (1946) overlies the Wakefield marble and crops out in a belt of parallel bands extending from the northeast corner of Carroll County southwestward to the vicinity of New Windsor (Pl. 3). West and southwest of New Windsor the pattern of outcrop is curvilinear. In the vicinity of New Market the outcrop is extensive, but it narrows to a series of linear bands east and southeast of Urbana. The metabasalt is characterized by dissected hills of moderate relief lying between narrow valleys underlain by the much more soluble Wakefield marble. In the northeastern part of its outcrop belt the metabasalt is overlain by the albite-chlorite facies of the Wissahickon formation; in the central part it is overlain by the Ijamsville phyllite and is interbedded with the Libertytown metarhyolite of Stose and Stose (1946); in the southwestern part it is overlain by the Urbana phyllite. The metabasalt is a grayish-green amygdaloidal rock which is massive in some places and schistose in others. Interbedded with it in places are blue and green schist. Well Car-Ce 2 at Westminster was drilled to a depth of 850 feet in the belt of Wakefield marble and Sams Creek metabasalt (Table 27). After penetrating about 170 feet of marble the well penetrated chiefly green schist with thin layers of marble.

The weathered zone, according to 15 well records, may be as much as 60 feet thick but averages only about 23 feet. Drillers customarily describe the weathered material as "shale," or they may refer to the uppermost weathered part as "clay." "Slate" and "rock" are the most commonly used terms for the fresh rock. Logs of five wells are given in Table 27.

Water-bearing properties.—The Sams Creek metabasalt itself is of minor importance as a water-bearing formation, but it is intimately associated with the important water-bearing Wakefield marble. Some of the wells listed in Tables 25 and 26 as producing from the Sams Creek may also penetrate one or more zones of marble and yield water chiefly from them. The log of well Car-Cc 5 at Marston shows that at a depth of 93 to 94 feet an opening was encountered which may be a solutional opening in a thin layer of marble in the metabasalt.

The yields of 18 wells in the Sams Creek metabasalt range from 2 to 20 gpm and average about 8 gpm. About 30 percent of the wells yielded less than 5 gpm. Well depths range from 10 to 1,033 feet and average 95 feet. The average yield per foot of hole drilled is about 0.14 gpm.

The best well is Car-Cc 5 at Marston in Carroll County. It yielded 20 gpm in a half-hour test in 1953 with a drawdown of about 30 feet. The well is 94 feet deep and is situated along a small tributary of Sams Creek. Its location near a creek may explain its comparatively high yield.

Several springs of moderate to small discharge issue from the Sams Creek metabasalt. One of the largest, Fr-Ef 22, issues from the side of a steep draw at a farm just south of New London. Its flow was estimated to be approximately 30 gpm in March 1956.

In general, the Sams Creek metabasalt should not be expected to yield large ground-water supplies. Because of its low storage capacity, wells on hills may fail as the water table declines during long droughts.

Chemical quality.—An analysis of water from well Fr-Ef 2 at New Market shows the water to be hard, moderately high in dissolved solids, and slightly alkaline. The principal cations are calcium and magnesium and the principal anion is bicarbonate, but substantial sulfate also is present.

Libertytown metarhyolite

Geology.—A belt of scattered outcrops of acidic volcanics called the Libertytown metarhyolite by Stose and Stose (1946), consisting of interbedded schistose metarhyolite and metaandesite occurs between Union Bridge and New Market, chiefly in Frederick County. The Libertytown metarhyolite overlies the Wakefield marble and interfingers with the Sams Creek metabasalt and Ijamsville phyllite. The metarhyolite is a dense, purple, bluish-black, or red rock; the metaandesite is blue or purple. Some quartzite beds are infolded with these rocks.

Well logs and casing-length records indicate that the weathered zone is about 15 feet thick. Drillers commonly refer to the weathered rock as "clay" or "shale" and to the underlying fresher rock as "slate."

Water-bearing properties.—The Libertytown metarhyolite underlies only a small area and is relatively unimportant as a water-bearing formation. Yields of 5 wells range from 1 to 15 and average 8 gpm. The 15-gpm well, Fr-Df 2 at Libertytown, is 86 feet deep and during its acceptance test had a drawdown of 25 feet (specific capacity 0.6 gpm/ft.). It is unlikely that the Libertytown metarhyolite will yield much more than domestic supplies of ground water.

Chemical quality.—Chemical analyses were made of water from wells Fr-Df 2 and Df 15 in the Libertytown metarhyolite. Both analyses show evidence of contamination of the wells by organic debris or other sources of nitrate and chloride. Although the natural water appears to be of the calcium magnesium carbonate type, the nitrate content exceeds the bicarbonate in the analysis for well Fr-Df 15 and is about equal to the bicarbonate in the analysis for Fr-Df 2.

Ijamsville phyllite

Geology.—The Ijamsville phyllite underlies a large area that encompasses the outcrops of other metavolcanic rocks, extending from near Westminster southwestward through the vicinities of Libertytown and New London and continuing southwestward into Montgomery County. Its broadest belt of outcrop is about 12 miles wide in the area between Mount Pleasant and Taylorsville. The Ijamsville phyllite is chiefly a blue, green, or purple rock, in places showing flattened blobs. It is slaty in places and has been quarried at Ijamsville.

The weathered mantle of the Ijamsville phyllite is commonly thin and locally absent. The maximum thickness reported in well logs is 57 feet and the average is about 20 feet. Drillers generally refer to the fresh rock as "slate" and to its weathered mantle as "shale" or, less often, "clay." Drillers' logs of five wells are given in Table 27.

Water-bearing properties.—Although wells of only small to moderate capacity are obtained in the Ijamsville phyllite, it is an important water-bearing formation because of its wide areal extent. Practically all the wells supply domestic or farm users. Numerous springs occur along hillslopes and near the heads of draws, but, owing to the small storage capacity of the rock, their flow declines markedly during droughts. A large spring, Fr-Dg 11, near the head of a draw on a farm just east of Libertytown, discharged at an estimated rate of 50 gpm in August 1955, but it is reported to cease flowing during dry spells. Another spring several hundred feet downstream in the same draw is reported to be less subject to fluctuations in flow.

The yields of 35 wells range from 1 to 20 and average about 8 gpm. About 20 percent of the wells yield less than 5 gpm. The Ijamsville is drilled with difficulty below the weathered zone, and few wells are more than 100 feet deep. The depths of wells range from 19 to 253 and average about 77 feet. The average yield per foot of hole drilled is about 0.10 gpm.

One of the best wells is Car-Ad 4 at Silver Run in Carroll County, which reportedly yields 20 gpm. It is 93 feet deep. Little other information is available on it and there is no apparent reason for its high yield. A nearby well, Car-Ad 5, is 76 feet deep and yields 15 to 20 gpm. Its high yield is attributed to the thick section of saturated weathered material at the site.

Many dug wells are in use in the outcrop area of the Ijamsville phyllite, but they are gradually being replaced with deeper drilled wells for sanitary and other reasons. Some of the dug wells fail during droughts when the water table falls below their bottoms.

Chemical quality.—Three samples of ground water from the Ijamsville phyllite were collected for analysis (Fr-Cf 17, Cg 1, and Ch 1). The analysis for Cf 17 is considered to represent the character of the natural water best; it shows the water to be of the calcium bicarbonate type but of low mineralization and soft. The other two analyses indicate, by their high values for nitrate, the probability of organic contamination. Iron content is low. The water may be somewhat corrosive to plumbing, as the values for pH are in the acidic range.

Urbana phyllite

Geology.—In eastern Frederick County the Urbana phyllite overlies the Sams Creek metabasalt. The phyllite occupies irregular areas in the vicinity of New Market, from where it extends southwestward in three somewhat parallel bands to the Montgomery County line (Pl. 3). The westernmost and central bands merge in the vicinity of Sugarloaf Mountain and encircle it. The Urbana is chiefly green muscovitic, quartzose phyllite; interbedded with the phyllite are slate, schist, calcareous layers, and quartzite. The quartzite is most prevalent in the upper part of the formation.

A weathered mantle, seldom exceeding 20 feet, overlies the fresh phyllitic rock. The quartzite is generally more resistant to weathering and underlies many ridge crests, cropping out in some places as ledges but otherwise occurring as a weathered mantle of loose sand. Well Fr-Be 10 at Flint Hill, on the crest of a narrow ridge upheld by quartzite, penetrated 100 feet of quartzite, the upper 14 feet of which is weathered sandy material. Some wells penetrate both quartzite and phyllite, as shown by the log of well Fr-Ef 14 (Table 27). Drillers commonly refer to the weathered zone of the phyllite as "clay" or "shale" and to the underlying fresh rock as "slate." Quartzite beds are described as "flint," "sandstone," or "sand rock," and their mantle rock as "sand" or "sandy."

Water-bearing properties.—The water-bearing character of the Urbana phyllite is similar to that of the Ijamsville phyllite. Springs appear to be somewhat less common in areas underlain by the Urbana, presumably because its terrain is less rugged and its drainage pattern less dense, reducing the opportunity for springs to emerge. A spring near Park Mills, Fr-Fe 13, had an estimated flow of 10 to 20 gpm early in 1952. Quartzite beds, common to both formations, appear to influence the water-bearing character of the Urbana to a somewhat greater extent than that of the Ijamsville.

The yields of 23 wells range from 2 to 35 and average 11 gpm. Four of the wells yield less than 5 gpm. The average specific capacity was 0.4 gpm per foot of drawdown. The depths of 39 wells range from 29 to 128 feet and average 78 feet. The formation is difficult to penetrate below the zone of rock weathering because of its toughness; hence, few wells are more than 100 feet deep. The yield per foot of hole drilled is about 0.14 gpm.

The best well, Fr-Ef 8, at a cannery at Monrovia, is approximately 95 feet deep and is reported to yield 35 gpm. No log is available. Its comparatively high yield may be due to its nearness to Bush Creek. The well data suggest that wells penetrating the quartzite where it occurs below the water table may be relatively productive. One of the best wells of this type is Fr-Fe 11, near Sugarloaf Mountain. This well is about 87 feet deep and yielded 20 gpm in a 1-hour test with a specific capacity of 0.8 gpm per foot.

Chemical quality.—One partial analysis of water from well Fr-Fe 18 at Urbana shows that the water is of the bicarbonate type and is moderately hard but low in iron content.

Western Sequence of Crystalline Schists

Sugarloaf Mountain quartzite

Geology.—Stratigraphically overlying the Urbana phyllite is the Sugarloaf Mountain quartzite, which is composed of two thick, hard, ledge-making quartzite beds between which are softer sericitic quartzite and slaty beds. These rocks underlie Sugarloaf Mountain, a hill that stands prominently above the rolling Piedmont hills in southern Frederick County. Some of the quartzite beds assigned to the Urbana phyllite may be a part of the hard lower bed of the Sugarloaf Mountain quartzite (Stose and Stose, 1946, p. 71). These beds may be equivalent in age to the Weverton formation of the Blue Ridge province (Scotford, D. M., 1951; Thomas, B. K., 1952).

Water-bearing properties.—The Sugarloaf Mountain quartzite is relatively unimportant as a water-bearing formation because it underlies only a small, uninhabited area of steep slopes. Throughout much of the outcrop area the water table probably occurs at relatively great depth within comparatively fresh rock containing few and small fractures. Inasmuch as no well data are available for this rock unit, discussion of its water-bearing character would be conjectural.

Marburg schist

Geology.—The Marburg schist underlies a large area between Ridgeville and Taylorsville along the southern part of the boundary between Frederick and Carroll Counties. It is bordered by the Ijamsville phyllite on the west and by the albite-chlorite facies of the Wissahickon formation on the east. It also underlies a large area in northcentral Carroll County, encompassing the towns of Frizzelburg, Union Mills, and Wentz, lying between Triassic sedimentary rocks on the west and the Wissahickon formation on the east. The principal rock type in the Marburg is bluish-gray to green fine-grained schist containing muscovite, chlorite, quartz, and either albite or ottrelite (Stose and Stose, 1946, p. 74). The schist is injected with quartz along the layering planes and is closely folded. The upper part of the formation is quartzite and conglomerate, these rocks occurring chiefly in the Union Mills-Wentz area and near Watersville.

In most places clay and weathered rock about 25 to 40 feet thick overlie the fresh schist, but, as shown by well logs, the thickness of the weathered zone may range from 5 to 90 feet. Drillers' logs generally report "topsoil and clay" immediately underlying the land surface, beneath which is "shale" (weathered rock) followed by "slate" (bedrock). Drillers refer to the material of quartz veins or quartzites as "flint," but this term is also used to some extent for hard schist or phyllite. Logs of four wells are given in Table 27.

Water-bearing properties.—The Marburg schist is an important water-bearing formation furnishing numerous commercial, domestic, and farm water supplies. Two wells of the Mount Airy public water supply that penetrate the Marburg schist furnish about 75,000 gallons of water daily.

Springs are fairly common but are not utilized to a great extent except to supply ponds and for watering cattle. They occur near the head of draws, along hillslopes, and at the break in slope between hillsides and stream flats. Most of the springs discharge less than 15 gpm and undoubtedly yield much less during extended droughts. The discharge of the largest spring, Fr-Eg 13 at the head of a deep draw near Woodville, was estimated to be about 100 gpm in August 1955.

Except for limited areas along high ridge crests, particularly Parrs Ridge in the Ridgeville area, adequate supplies of ground water can be obtained from wells nearly anywhere within the outcrop of this unit. The yields of 56 wells range from less than 1 to 223 gpm and average about 17 gpm. About a fifth of the wells yield less than 5 gpm. The depths of 85 wells range from 20 to 300 feet and average 87 feet. The average yield per foot of hole drilled is 0.19 gpm.

The two best wells, so far as reported yields are concerned, are Fr-Eh 1 and Eh 2, which supply Mount Airy. Well Fr-Eh 1 was pumped at an average rate of 223 gpm during a 48-hour aquifer test. Well Eh 2 is reported to yield 127 gpm. Both wells are in a small valley west of Mount Airy in a locality underlain by deeply weathered calcareous schist. In some less favorable localities not even domestic supplies are available from the Marburg schist. Wells Car-Dc 7 and Dd 3 in the Taylorsville-Winfield area are among the poorest wells. They are on high ridges far above the water table in localities where fresh rock crops out near the well sites. These wells yielded less than 1 gpm and were abandoned.

Aquifer and well-performance tests.—Mount Airy. The Mount Airy municipal well field consists of wells Fr-Eh 1 and Eh 2 in a small valley flat about 0.5 mile west of the town and about 400 feet from Woodville Branch (fig. 18). The well field is at an elevation of about 640 feet above sea level.

In 1955 four 6-inch test holes were drilled to obtain data on the geology of the well-field area and for use as water-level observation wells during an aquifer test. Short pumping tests were run on each test hole at various stages of drilling to detect increases in capacity as the holes were deepened. During the aquifer test well Fr-Eh 1 was pumped continuously for 48 hours and measurement of the water-level fluctuations were made in all wells. Step drawdown and mutual-interference tests were then run on the two public-supply wells. The details of the test are recorded in an open-file memorandum (Meyer, 1955).

Schist is exposed in road cuts and on hillsides bordering the valley where the well field is located, but the valley floor is underlain by a thick mantle of weathered rock. Quartz veins an inch or two thick cut the schist, many of

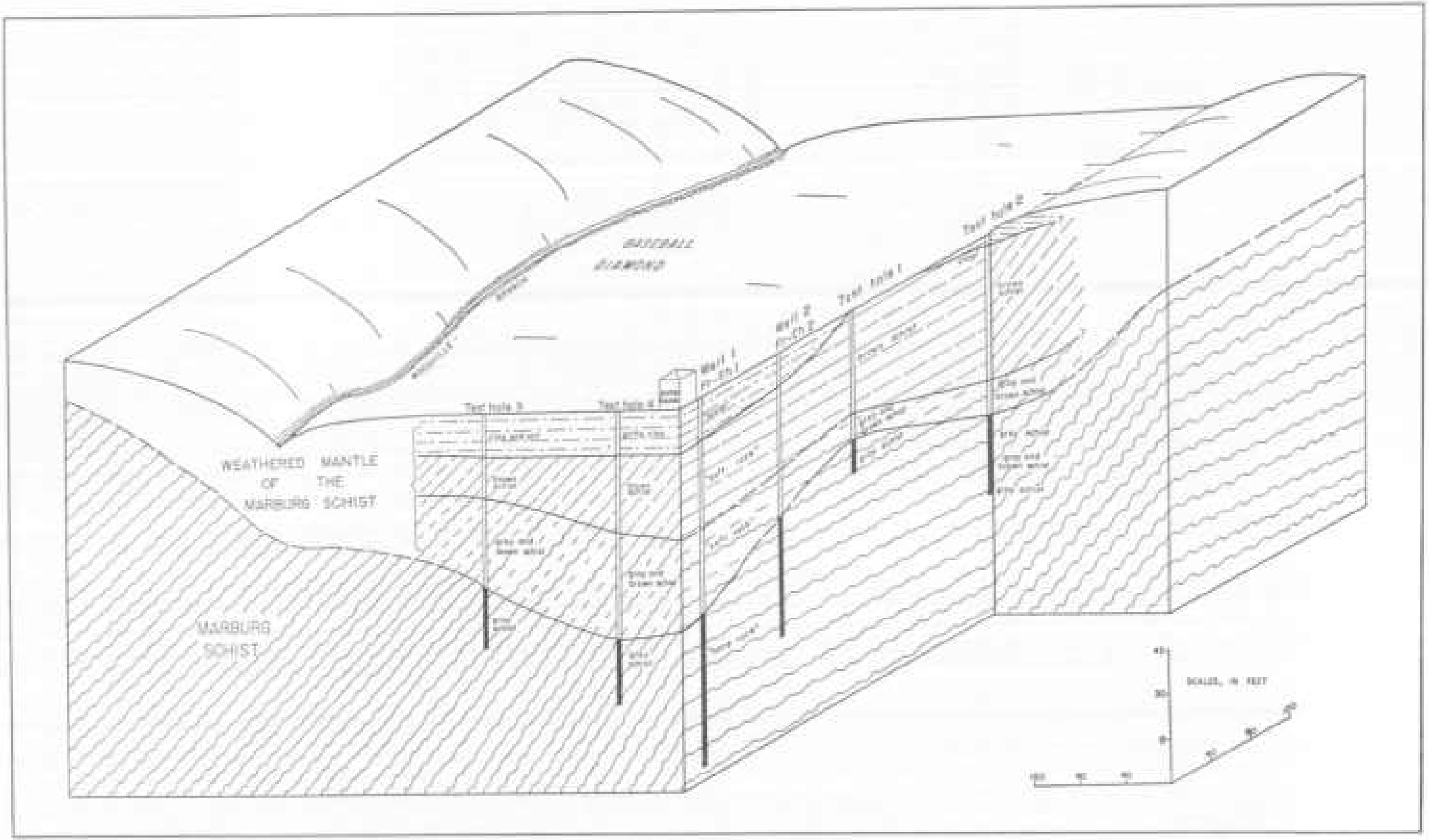


FIGURE 18. Block Diagram of Mount Airy Well-Field Area Showing Locations of Production Wells and Test Holes

of them striking north-northeast in the general direction of the schistosity but their dip not everywhere concordant with the schistosity. Cuttings from the deeper parts of the test holes show marble interlaminated in the schist. The rock is similar to the calcareous phyllite described by Thomas (1952, p. 57–58) in the Sugarloaf Mountain area.

Two of the test holes were north of the public-supply wells and along the trend of the valley and strike of the schist and two west of the public-supply wells and normal to the valley trend. Cuttings descriptions, geophysical logs, and pump-test data for test hole 3 are summarized in figure 19. The well logs show 45 to 80 feet of weathered mantle over fresh gray schist. The mantle rock is zoned from top to bottom as follows:

1 foot of soil
15 feet of residual silty clay
15 to 45 feet of soft yellow-brown rotted schist
10 to 50 feet of alternating gray and brown schist of moderate hardness
fresh gray schist (bedrock)

The zones of yellow-brown schist and alternating gray and brown schist are the chief water-bearing materials. According to the tests not much water comes from the bedrock. The yellow-brown rotted schist is physically unstable and much of it was cased off. The zone of alternating gray and brown schist is the most important zone contributing ground water. Presumably in this zone enlargement of fractures has occurred through solution and removal of calcareous material. In one of the test holes, after a yield of 21 gpm was obtained at a depth of 42 feet, driving the casing 1 inch deeper to firmer rock reduced the yield to nothing. In another test hole, raising the casing 0.7 foot increased the well yield by 40 percent.

To determine the relative hardness of the rock at successive depths and to estimate the degree and depth of weathering, drilling-time logs were kept for each test hole. Inasmuch as many variable factors govern the drilling rate of a cable-tool machine these logs are useful for general comparisons only. Drilling-time data for test hole 3 are given in figure 19. The logs show a continuous slight increase in drilling time with depth until the fresh gray rock is encountered, when the drilling time increases abruptly. The important water-bearing zone terminates at approximately the depth of sharp increase in drilling time. As a rule, in the crystalline rocks the important water-bearing zones are the soft, easily drilled zones.

Several of the test holes were electrically logged, but, as casings in the holes sealed off much of the weathered zone, it was possible to log only the basal uncased part of the holes. The spontaneous-potential and resistivity logs for test hole 3 are given in figure 19. The logs begin several feet below the bottom of the casing but their upper segments show the effect of the casing.

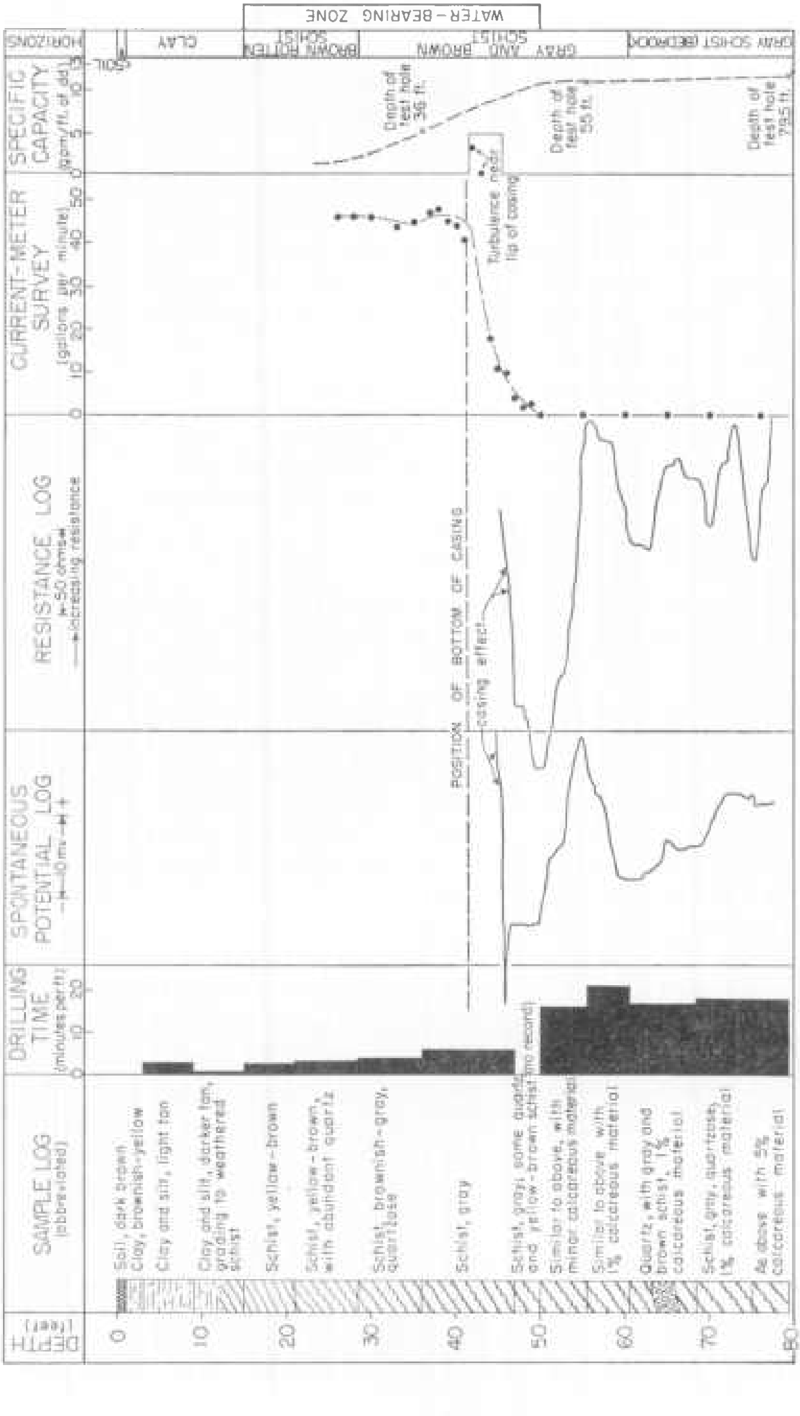


FIGURE 19. Geological and Geophysical Data for Mount Airy Test Hole 3

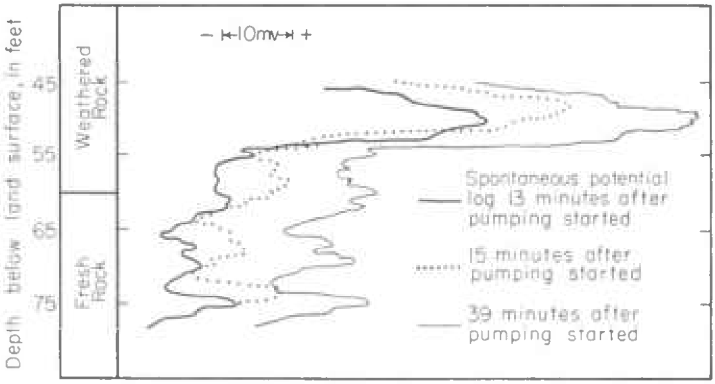


FIGURE 20. Progressive Positive Effect on the Spontaneous-Potential Log for Mount Airy Test Hole 3 Caused by Pumping the Well

The spontaneous potential measured in logging crystalline-rock wells is attributed principally to the electrochemical phenomenon that an electrical potential develops when waters of different concentrations of dissolved mineral matter are in contact. Characteristically, spontaneous-potential logs of crystalline-rock wells show lower values in the weathered zone, ordinarily the water-bearing zone, than in the underlying hard rock. In the log of test hole 3 (fig. 19) the lowest readings were obtained in the neighborhood of 50 feet, the basal part of the weathered zone. A very hard zone at about 55 feet is indicated by a pronounced positive deviation.

Generally flow of water from the well into the rock formation produces a negative potential and flow from the formation into the well produces a positive potential. With this relation in mind resistivity and potential logs were run while the test hole 3 was being pumped (fig. 20). The potential logs show a pronounced migration in a positive direction for the basal part of the weathered zone, the water-bearing zone, but considerably less shift for the underlying hard rock. Resistivity logs were nearly identical to those obtained prior to pumping. Potential logs made after pumping ceased and while the water level in the well was recovering are complex and irregular but show a progressive trend towards the values of potential observed prior to pumping.

The differences in electrical resistance measured in well logging are chiefly those determined by the amount and mineral character of the water contained in the rocks. In the Piedmont of Maryland vertical variations in chemical character of the water at any one place generally are small, so that the important factor is the amount of water contained in the rock. Crystalline-rock wells characteristically show low resistivity in the weathered zone (water content relatively high) and high resistivity in the fresh rock (water content relatively low). The resistance log for test hole 3 (fig. 19) shows that the resistance of the more weathered rock is low in comparison to that of the fresher rock. Undulations of the log in the bedrock represent variations in the "freshness" of the rock. Logging the test hole during and after pumping showed no effect on the resistivity curve, presumably because water moving toward the well from neighboring areas was of the same chemical character as that which was in and around the well before pumping.

Current-meter surveys of pumped wells are useful to show the zones contributing water. Figure 19 shows the results of such a survey of test hole 3, while it was being pumped at a rate of about 45 gpm. No flow was measured in the bottom part of the hole; the first measurable flow was at a depth of 49 feet, building up to a maximum at the bottom of the casing at 41.5 feet, above which the full rate of pumping was measured within the casing. The extremely high readings obtained as the current meter passed the lip of the casing are attributed to turbulence around the meter at that point. The survey indicates that water enters the well in the depth interval between 41.5 and approximately 50 feet. This agrees with the position of the contributing zone indicated by the electric logs, particularly that shown in figure 20.

The specific-capacity tests run at successively greater depths as each test hole was drilled show that little or no increase in yield is obtained below the zone of weathered rock.

The relation between pumping rate and drawdown is not a linear one for crystalline-rock wells, owing chiefly to dewatering of the aquifer during pumping and possibly also to a decrease in permeability with depth. For these reasons, specific capacities determined for successively increasing pumping rates become progressively smaller. The following summary of the step-drawdown test for well Fr-Eh 2 shows that the Mount Airy wells exhibit the characteristic decrease in specific capacity with increasing pumping rates:

Discharge rate (gpm)	Drawdown (feet)	Specific capacity (gpm/ft.)
60	7.5 (approx.)	8 (approx.)
87	19	4.6
93	23	4.1

A maximum of about 50 feet of drawdown is available in this well, based on the estimated thickness of the water-bearing zone. Extrapolation of the decline in specific capacity indicated by the test suggests that the maximum capacity of the well for short periods of pumping is about 125 gpm. This tallies closely with the reported yield of 127 gpm when the well was drilled.

Pumping from well Eh 2 was continued after the step test and well Fr-Eh 1, 85 feet distant, was pumped at an average rate of 213 gpm to determine the interference effect. The water level in well Eh 2 lowered an additional 8 feet and its yield decreased from 93 to 75 gpm. A reduction in its capacity of 20 to 25 percent as a result of the combined pumping is indicated.

The static water level of Eh 1 declined 4 feet during the step-drawdown test on well Eh 2, and by the end of the period of combined pumping its water level had declined an additional 26 feet. Its discharge averaged 213 gpm, whereas later when it was pumped alone its yield was about 250–255 gpm for the equivalent period of pumping. Thus, a loss of about 40 gpm due to interference from well Eh 2 is indicated. The drawdown for an equivalent period of pumping was only 23 feet during the later test, as compared with 30 feet during the interference test. A reduction in the well's capacity of about 20 percent due to the interference from well Eh 2 is indicated.

The specific-capacity values used in the above discussion are based on short periods of pumping—1 or 2 hours—and would not be applicable for longer periods of pumping, inasmuch as progressive and pronounced reduction in yield, and hence in specific capacity, occurs during long periods of pumping. During the 48-hour aquifer test, the discharge of well Eh 1 declined from about 255 gpm to about 190 gpm, a decrease of 65 gpm. The water level in the well lowered from 22 feet below the land surface shortly after pumping started to 33 feet at the end of the test. The specific capacity decreased from 11.6 to 6.8 gpm per foot of drawdown, a decrease of about 40 percent after 2 days of pumping. In computing specific capacities the average discharge from the beginning of the test to the particular time being considered was used rather than the discharge that was occurring at that particular time. Extrapolation of the trend indicated by the data suggests that, if pumping were continued for 30 days, the yield would decrease to 52 gpm, or about one-fifth the initial rate, the water level would decline to 51 feet, and the specific capacity would be about 3 gpm per foot of drawdown.

The geologic and hydrologic conditions in the vicinity of the Mount Airy well field are complex and in many ways deviate from the basic assumptions on which are predicated the formulas commonly used to compute aquifer coefficients. Some of the complicating factors for the Mount Airy test are: the proximity of Woodville Branch, which probably serves as a source of recharge; variations in the thickness of the water-bearing zone; differences between lateral and vertical permeability and variations in both; a higher water table in the bordering hills; and a thinning of the aquifer in the bordering hills.

The aquifer test involved 48 hours of continuous pumping from well Eh 1, and measurements of its pumping rate and of the decline in water levels in all the wells and test holes. The water-level data are given in figure 21. Three-dimensional profiles of the water table prior to pumping, after 1 day of pumping, and after 2 days of pumping are shown in figure 22. Minor adjustment of measurements was made to compensate for the fact that water levels were rising slowly prior to the test. Figure 22 shows the portion of the water-bearing material that was dewatered and the shape of the cone of depression. The slope of the water table from the stream to the well field during the latter part of the test indicates the possibility of ground-water recharge from the stream.

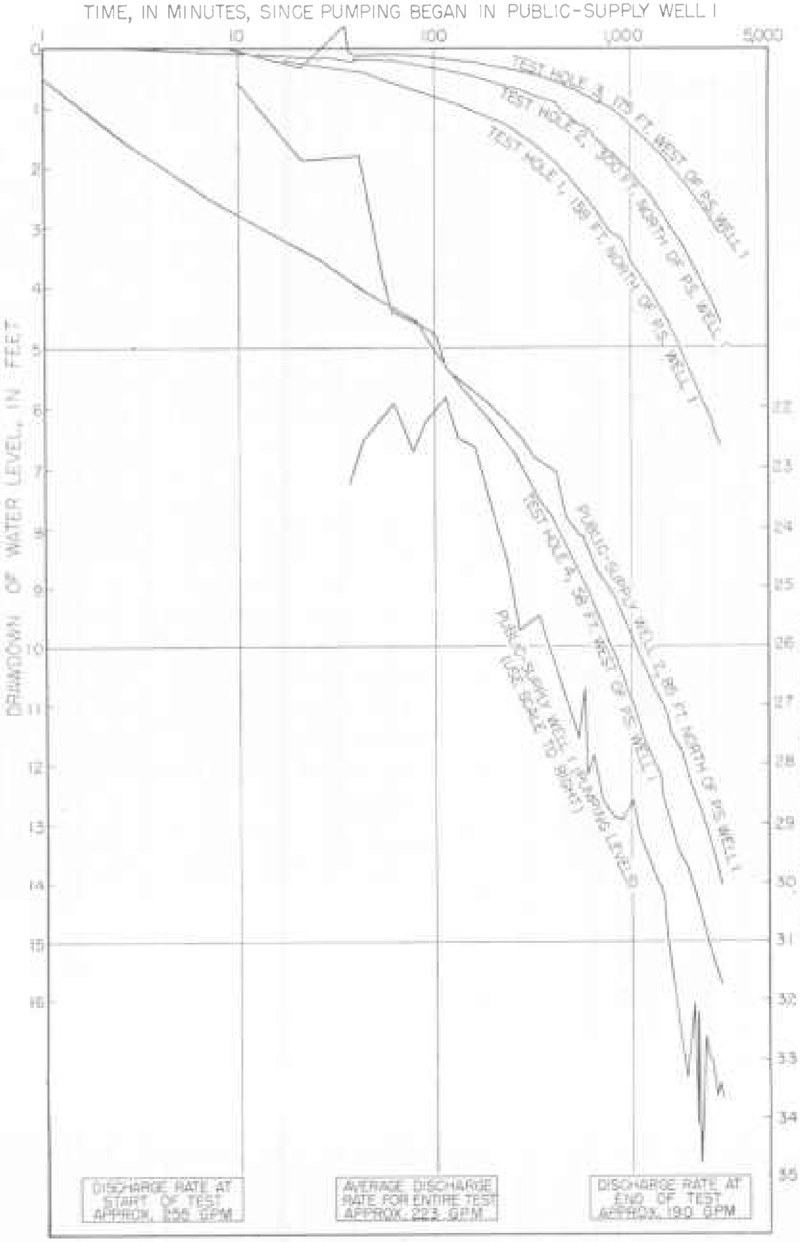


FIGURE 21. Decline of Water Levels in Wells Caused by Two Days of Pumping from Mount Airy Public-Supply Well 1

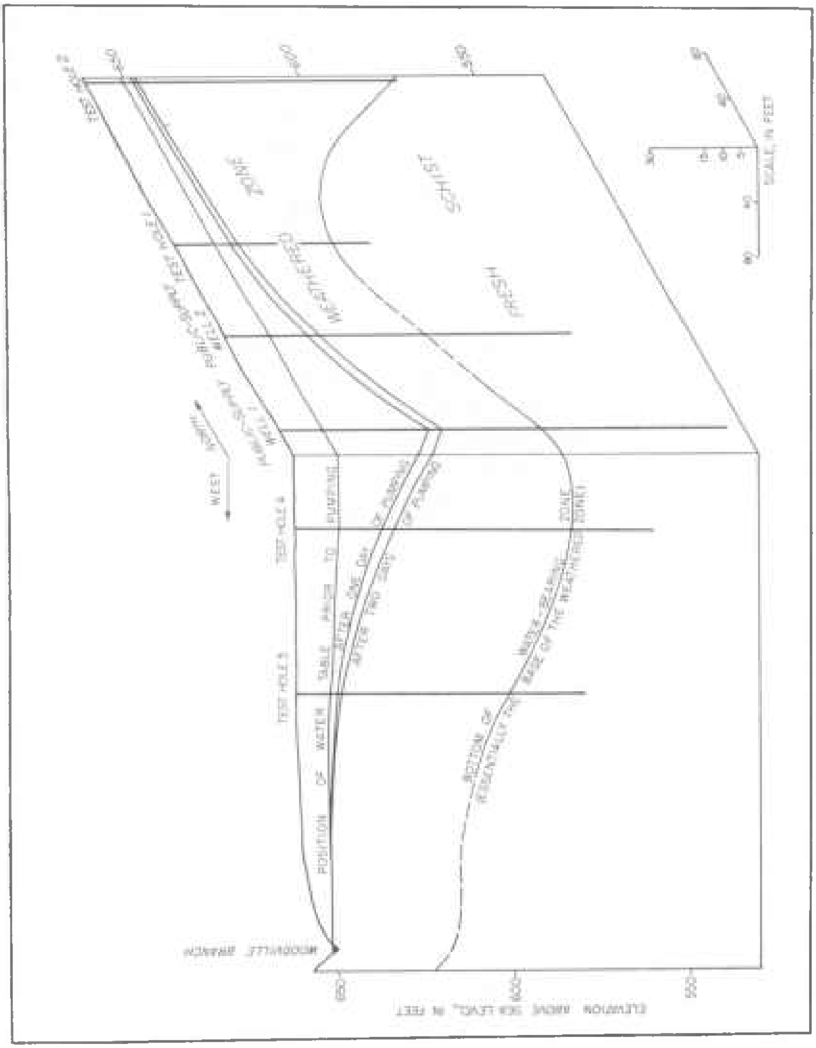


FIGURE 22. Isometric Drawing of Mount Airy Well Field Showing Positions of the Water Table During the Aquifer Test

The initial parts of the drawdown curves yield unrealistically high transmissibility and storage coefficients, owing to the fact that most of the water pumped during this period was taken from storage in the vicinity of the pumped well, only limited drawdown occurring outside the immediate vicinity of the pumped well. Later, the water levels began to decline at considerably greater rates, with respect to the log of time (fig. 21). At the end of the test the water levels in the wells nearest the pumped well, Eh 2 and test hole 4, were declining at approximately the rate of the pumped well and those at greater distances were declining at somewhat smaller but increasing rates. If pumping had continued for 2 or 3 more days the rates of water-level decline probably would have been nearly the same in all wells.

The drawdown was least in test hole 3, although it is not the farthest from the pumped well. Test hole 2 is nearly twice as far away but its water level lowered 1.5 feet more than that of test hole 3. Presumably the decline in water level in test hole 3 was slowed by its proximity to the stream, from which recharge may occur. Regardless of the stream effect, if the hills bordering the valley constitute impermeable boundaries, then test hole 3 is the most favorably situated hydrologically of all the wells and test holes.

It is possible that the hills bordering the valley are partially effective as impermeable or barrier-type boundaries. Although the water table is at a higher elevation beneath the hills than in the valley, it is farther below the land surface, so that much of the permeable potentially water-bearing material may lie above the water table. If Woodville Branch, which runs along the west side of the valley, is a perfect line source of recharge to the well field, then the hills beyond the stream on the west side of the valley, would be effective as a barrier boundary only after the stream were pumped dry or ceased to flow during dry spells. Only then would the cone of depression be able to expand beyond it.

The water-level data that appear to be the most useful for computations of the hydrologic coefficients are the data for test holes 2 and 4, public-supply well 2, and the pumped well. Computations based on the latter part of the test, using the nonequilibrium method of Theis (1935) and the modified method of Cooper and Jacob (1946), give transmissibilities of 5,400 to 9,400 gpd per foot and storage coefficients of 0.012 and 0.032. Average values are about 7,300 gpd per foot and 0.02, respectively.

The data for test hole 3, the observation well closest to the stream, yield somewhat higher values, 13,000 gpd per foot and 0.051, which support the interpretation that recharge is derived from the stream and that hole 3 is favorably situated with respect to the possibly impervious hills bordering the valley. A previous brief recovery test run on test hole 3 gave a transmissibility of 7,600 gpd per foot, which is in close agreement with the average of 7,300. Probably this earlier test was too brief to be affected by recharge from the stream.

Chemical quality.—Two samples of ground water from the Marburg schist were collected in Carroll County (Car-Bd 13 and Car-Dd 1) and one in Frederick County (Fr-Eh 1). The Carroll County analyses are similar to those of ground water from the other schists of the Maryland Piedmont; the water is low in dissolved solids and is slightly acidic. The water is likely to be somewhat corrosive to plumbing equipment. The water from the Frederick County well is unusual for waters from schist in that it is a sodium bicarbonate water.

Radiochemical data for water from well Car-Bd 13 are given on page 57.

Wissahickon formation (albite-chlorite schist facies)

Geology.—The albite-chlorite schist facies of the Wissahickon formation underlies most of eastern and southern Carroll County. It consists chiefly of closely folded biotitic and chloritic albite schist. Quartz is injected along the layering. The rock is finer grained than the eastern oligoclase-mica schist facies. In the northwestern part of its outcrop belt it is a chlorite-quartz schist. In the northeastern part quartzite beds occur at the base. Some quartzite beds occur stratigraphically higher in the formation southwest of Westminster.

Drillers' logs commonly refer to the fresh rock as "slate" or simply "rock." Colors invariably are described as blue or gray. The term "flint" is used to describe vein quartz and quartzite but is also used occasionally for the schist where it is hard and brittle. Sometimes the word "sandstone" is used to describe the quartzite. Locally, beds of conglomeratic sandstone do occur. The Wissahickon weathers to a silty micaceous overburden, and the term "shale" commonly is used by drillers to describe this material, the word "clay" being used only infrequently. Invariably this zone is described as brown in color. The average thickness of the weathered zone is about 37 feet, but the well logs show that it is 100 feet or more in places. Logs of five wells are given in Table 27.

Water-bearing properties.—By virtue of its large areal extent and moderately good water-bearing properties, the albite-chlorite facies of the Wissahickon formation is an important aquifer in Carroll County. A large percentage of the domestic and farm water supplies are obtained from wells and springs in this unit, and several municipalities, a number of canneries, and a few industrial plants utilize springs or wells in it.

Nearly all the springs in the albite-chlorite facies of the Wissahickon formation discharge along the sides of valleys and draws. Many occur at the contact of the permeable weathered zone with underlying less permeable fresh rock. The springs discharge at small rates, most of them ranging from seeps to a few gallons per minute. The largest springs are those of the Manchester municipal supply, some of which yield 10 to 15 gpm. Here the overburden is thin and the springs likely issue from joints in the rock.

The yields of about 120 wells range from essentially nothing to a reported 300 gpm and average about 16 gpm. About 12 percent of the wells yield less than 5 gpm. The depths of wells range from 21 to 645 feet and average about

100. The two deepest wells, Car-Bf 7 and Bf 8, were drilled to depths of 410 and 645 feet, respectively. The yields of both wells were disappointingly small, averaging only 8 gpm. The average yield per foot of hole drilled is 0.16 gpm.

By intelligent prospecting and the application of knowledge concerning the occurrence of ground water in the crystalline rocks, some fair-sized industrial and public-supply wells have been constructed in this aquifer. Pertinent data concerning six of the best wells are:

Well number and location	Depth (feet)	Yield (gpm)	Specific capacity (gpm/ft.)	Length of test (hours)
Car-Bf 2, Hampstead	165	60+	—	—
Bf 17, do	202	55	0.7	13
Bf 29, do	125	100±	3±	36
Bf 35, do	200	68	.7	24
Ce 5, Reese	400	40	.4	4
Ce 45, Westminster	140	300±	6±	7

The best well, Car-Ce 45, was drilled for a nursery near Westminster. It reportedly yielded 500 gpm when completed in 1946. It is cased with 90 feet of 8-inch perforated casing. The driller's log indicates that the hole penetrated "shale and blue slate." The high yield is not readily explained except that the well is near the contact with the Wakefield marble. A hydraulic connection may exist between the schist and the marble. The use of perforated casing opposite the saturated zone also may contribute to the high capacity of this well.

Aquifer and well-performance tests.—Hampstead. The water-supply facilities of the Hampstead plant of the Black and Decker Manufacturing Co., were made available for extensive aquifer and well-performance tests during 1954. The plant is on the southern edge of Hampstead, on the Wissahickon formation (albite-chlorite facies). An average of about 45 gpm of ground water is used for drinking, sanitary purposes, air conditioning, and processing. A small surface-water reservoir at the south edge of the plant grounds captures runoff from the roof of the building and from the grounds to augment the well supply. In 1957 the well field consisted of 5 drilled wells, 4 of which were in use, located a few hundred feet north of the building and bordering a small tributary of Deep Run. Although yields of as much as 100 gpm were obtained from some of the wells during their acceptance tests, they have declined in yield when pumped for long periods. The wells also interfere with one another hydraulically. During periods of deficient precipitation, when regional ground-water levels are low, the combined yield of the well field is less than that required for plant operation.

The details of the test and the hydrology of the well field will serve as a guide in planning the development of ground-water supplies in other areas of similar geology.

Two 6-inch test holes were drilled and seven 1½-inch shallow holes were put down with a jeep-mounted power auger near one of the production wells (Car-Bf 17—owner's well 3) to obtain geologic data and for use as observation wells during the aquifer tests. Their locations are shown in figure 23.

In the Hampstead area the fresh bedrock is nearly everywhere blanketed with 50 to 75 feet of weathered rock, consisting of very soft silty weathered schist in the upper part and firmer less decomposed schist at greater depth. Drillers commonly refer to the surficial material as "soil" or "dirt," and to the deeper material as "shale" or "rotten rock." Well cuttings from test holes T-3 and T-4 show the "rotten rock" to consist of soft light-brown and gray schist, intersected by numerous quartz veins. Sample logs and drilling-time logs for these holes are given in figure 24.

Measurements of the strike of the schistosity were made in a shallow railroad cut on the plant grounds. The strike ranges from N. 36° E. to N. 46° E. The rocks exposed here are strongly weathered, and joints are poorly preserved or obliterated. The principal direction of drainage, to the southwest in the direction of flow of Deep Run, is approximately in alinement with the schistosity of the rocks. A small intermittent stream near the well field trends about N. 35° E.

Step drawdown tests at consecutively increasing pumping rates were made in three production wells to determine the decline in specific capacity with increased drawdown. This decline, characteristic of crystalline-rock wells, is attributed to progressive dewatering of the rocks, a reduction in rock permeability with depth, and, in places, lateral thinning of the aquifer. As the pumping rate is increased, the water level in the well declines, but at a disproportionately faster rate for each increment of pumping. In many wells when the water level declines below the bottom of the water-bearing zone (weathered zone) it falls abruptly, because no water is contributed from the underlying fresh rock. The results of two step drawdown tests are shown in figure 25. The graph of well Bf 17 shows the abrupt fall in water level.

The graph for well Bf 16 (fig. 25) shows the pumping levels decreasing more nearly in proportion to increased pumping rates, although specific capacities for larger pumping rates clearly are less than those for smaller rates. The more uniform step pattern is related to the construction of this well. Its casing extends to fresh rock at a depth of 104 feet, probably sealing off the weathered rock so that the chief contributing zone is the fractured bedrock. Dewatering of the bedrock did not begin until the water level was lowered to the bottom of the casing, and, therefore, no pronounced change in specific capacity occurred as the pumping level declined. The water-level response to the pumping was somewhat similar to that of an artesian well. If it had been possible to include

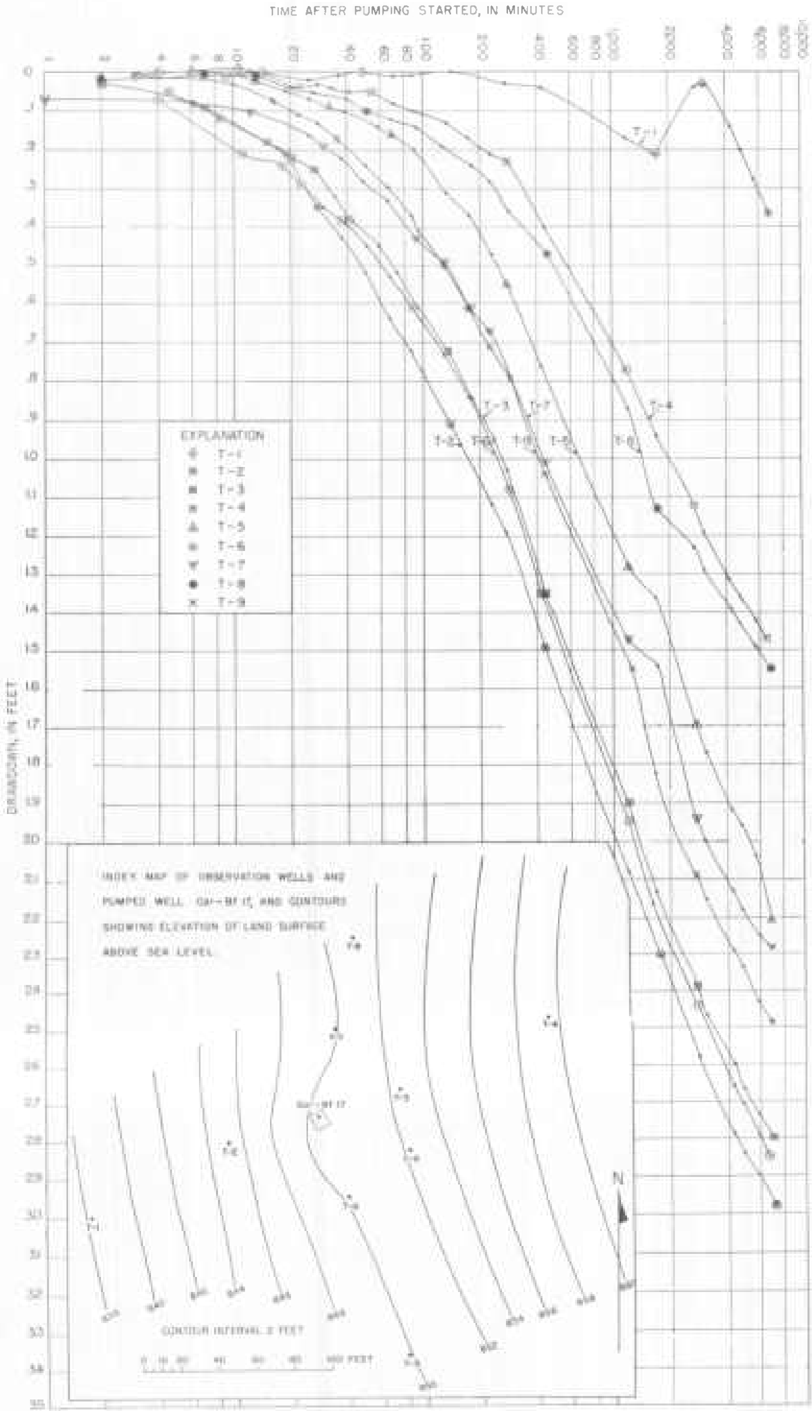


FIGURE 23. Graphs of the Decline in Water Levels During Aquifer Test at Hampstead and Index Map Showing Location of Wells and Configuration of Land Surface

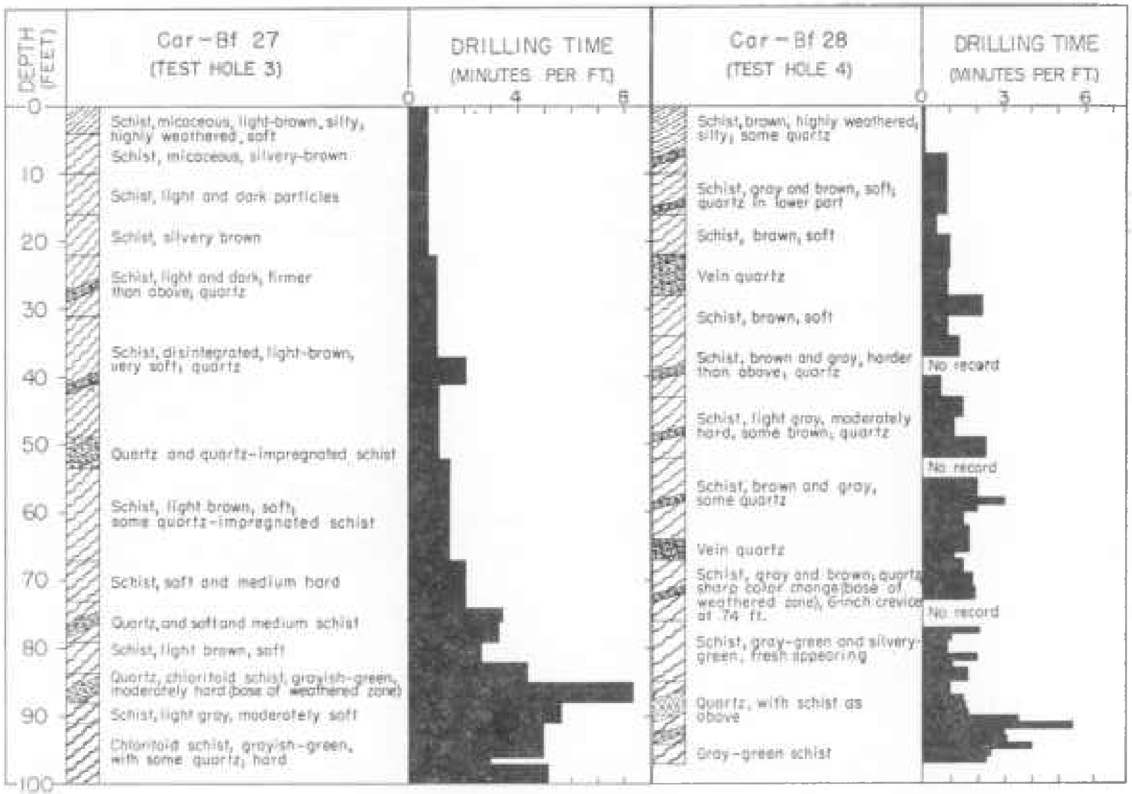


FIGURE 24. Sample Logs and Drilling-Time Logs for Wells Car-Bf 27 and Bf 28 at Hampstead

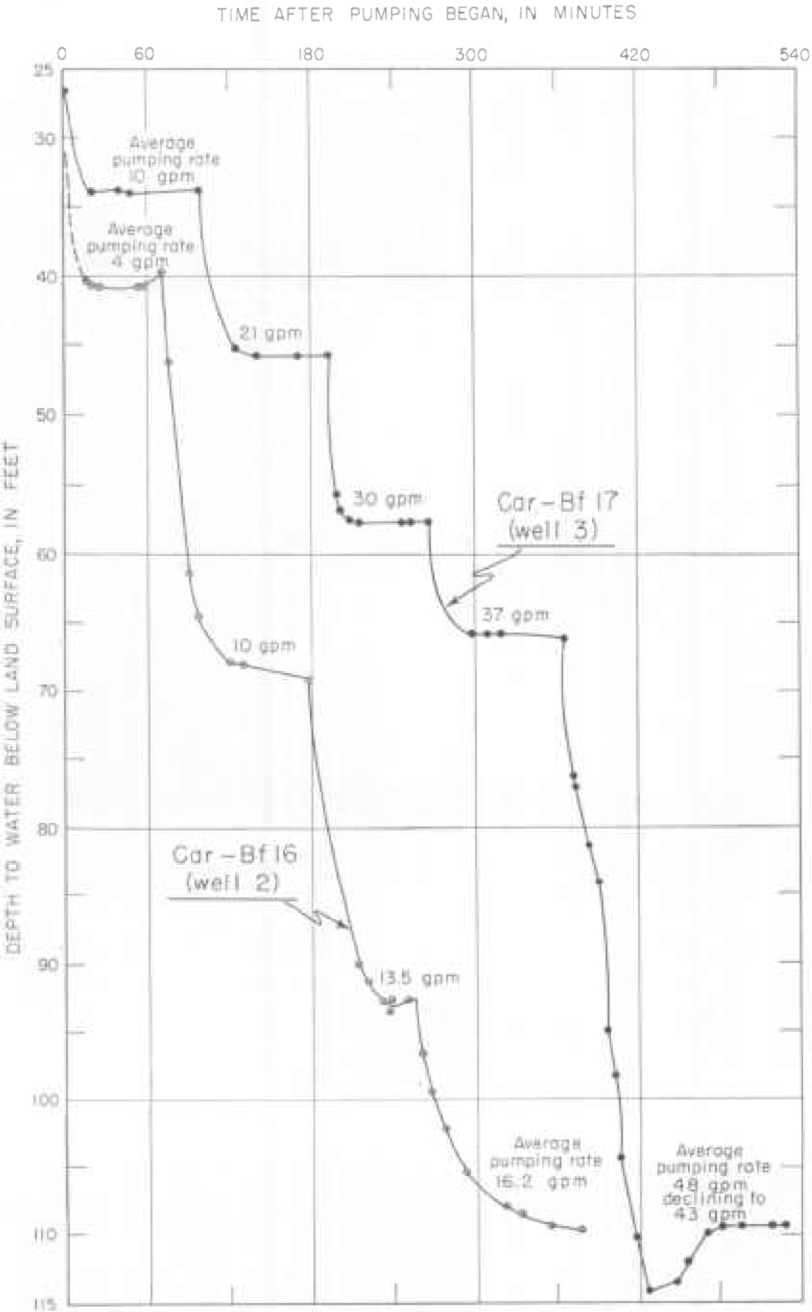


FIGURE 25. Graphs of Step-Drawdown Tests on Wells Car-Bf 16 and Bf 17 at Hampstead

another step at a higher pumping rate, it is likely that a sharp decrease in specific capacity would have been measured. Because of an obstruction in the well it was not possible to measure the water level below 110 feet. In earlier tests by the driller the pumping levels were 175 and 206 feet below the land surface at discharge rates of 21 and 22 gpm, respectively. These data show that drawing down the water level in a well below the bottom of the most productive part of the aquifer is hydraulically inefficient, for the flow of water from the aquifer into the well is turbulent and the pumping lift is substantially increased. That the same pumping rate could be obtained with a shallower pumping level within the water-bearing zone, was demonstrated in a later test of well Bf 17 when the discharge was reduced to 44 gpm and the pumping level was held at 85 feet.

It would be profitable in areas whose geology and hydrology are similar to those of the Hampstead area to check pumping levels to determine if they are being maintained below the productive water-bearing zone, so that pumping costs are being unnecessarily increased. The solution may be to increase the discharge gradually to the most efficient rate and automatically fix the pumping level accordingly by means of control equipment.

During August 1954 well Bf 17 was pumped for a period of 107 hours. Water-level measurements were made by tape in all the wells except observation wells T-3 and T-4 which were equipped with water-level recorders. The discharge of well Bf 17 was throttled to about 24 gpm to insure a constant pumping rate during the test. This necessitated opening the discharge valve from time to time to compensate for a constantly decreasing specific capacity as the pumping level declined. The discharge rate was determined periodically by measuring the time required to fill a container of known volume.

Figure 23 shows the drawdowns in the observation wells during the test plotted on an arithmetic scale versus time since pumping started on a logarithmic scale. The drawdown in the pumped well Bf 17 was 26.5 feet at the end of the test. The slope of the drawdown curves is gentle during the first few hours of the test, gradually steepening as water from storage in the immediate vicinity of the well field was depleted and as the cone of depression expanded. After about 5 hours of pumping the water levels in three of the observation wells (T-2, T-3, and T-6) were declining at the same rate. The drawdowns are significant in that they indicate the continued withdrawal of ground water from storage in the aquifer and form a basis for predicting future yields of wells in the field.

Profiles of the water table prior to the start of the test and just before the end of the test are shown in figure 26. Prior to pumping the water table was nearly horizontal in the plane of wells T-2 to T-4 but sloped downward from well T-2 to T-1. Pumping well 3 lowered the water level in T-2 and T-3, equal distances uphill and downhill from it, by nearly the same amount, but the

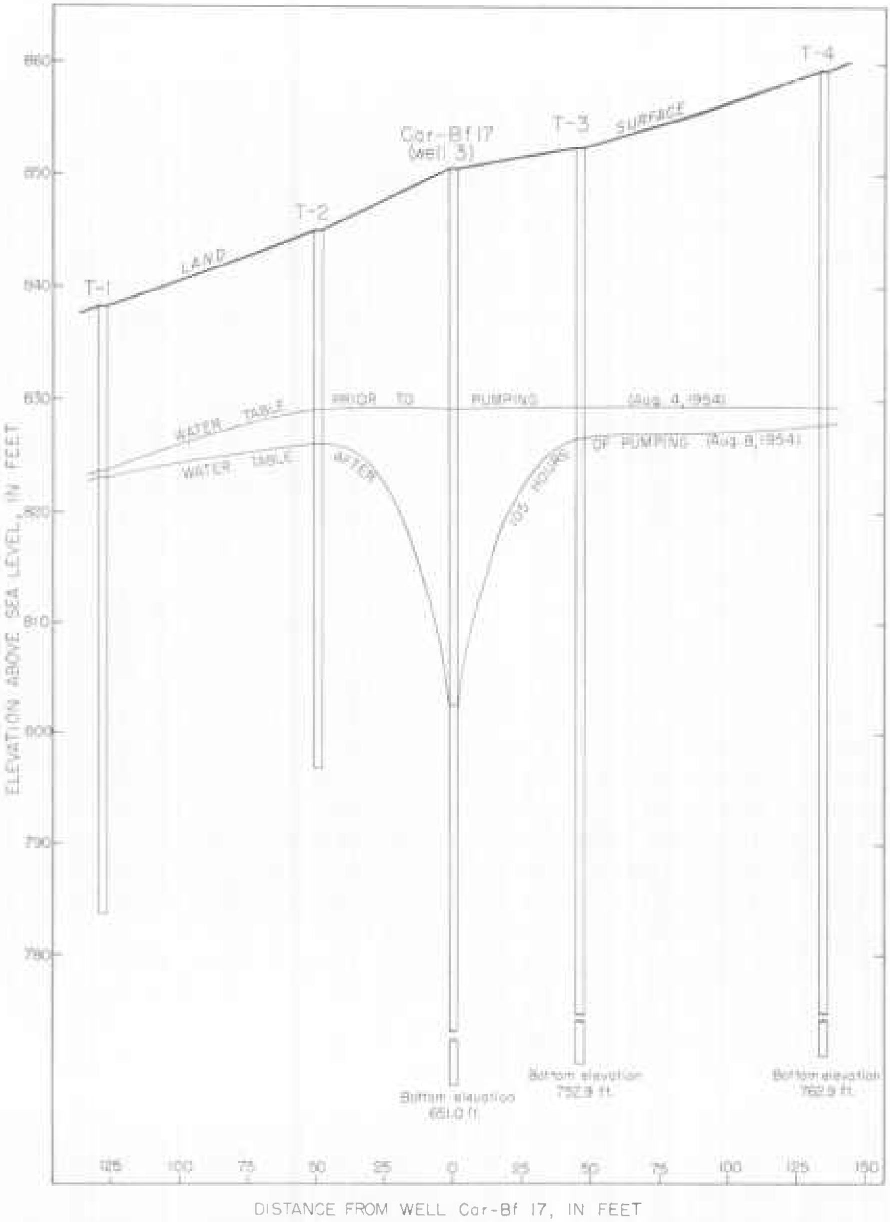


FIGURE 26. Profiles of the Water Table in the Vicinity of Well Car-Bf 17 Prior To and After Pumping

lowering in well T-4 was considerably greater than that in T-1, although these wells also are at equal distances from the pumped well. By the end of the test a divide had formed in the water table between well T-1 and the pumped well, apparently because the initial slope of the water table downslope from well T-2 was so large that the pumping was not able to reverse it. The water level in well T-1 rose nearly 0.2 foot after intermittent light rains began on August 5. The ground-water divide would have been more pronounced if this had not occurred, for the water level in well T-1 would have been an estimated 0.6 foot lower. Between August 5 and the end of the test 0.9 inch of rain fell. This well responded rapidly to the precipitation because the water table is relatively shallow in its immediate vicinity and because the water table was declining only slowly. The effect of the rain on the water levels in the other wells is small to undiscernible, owing to the greater depth to the water table in their vicinity and to the fact that the water levels were declining more rapidly. The tail ends of some of the graphs in figure 23 show slight curvature to the right, probably as the result of recharge from the rain.

The hydrologic coefficients were determined by analysis of the drawdown curves in figure 23 and of the slope of a profile of the cone of depression. Coefficients of transmissibility computed from the rates of water-level decline during the last 3 days of the test range from about 4,900 gpd per foot for the observation wells nearest the pumped well to 5,500 gpd per foot for those at greater distances from the pumped well. Storage coefficients computed for wells nearest the pumped well are about 0.017, and for those at greatest distances are about 0.007. The effective thickness of the aquifer is not accurately known. Observation wells T-3 and T-4 penetrate the aquifer completely, but the other observation wells terminate in the upper part of it. Computations based on the profile of the cone of depression between wells 3 and 4 give coefficients of transmissibility and storage of 4,300 gpd per foot and 0.03, respectively; for the profile between wells 5 and 6, 5,300 gpd per foot and 0.0003; and for the profile between 7 and 8, 5,100 gpd per foot and 0.03 (for method *see* Wenzel, 1942, p. 88–89). A coefficient of transmissibility of 5,000 gpd per foot and a storage coefficient of 0.03 seem in the right order of magnitude to use in computing well spacing, future drawdowns in wells and other hydraulic properties. With an expansion of the well field, rocks of different hydrologic properties might be encountered, and this possibility should be considered in evaluating the hydraulics of an expanded well field. For instance well Car-Bf 45, several hundred yards west of well Bf 17, yields only 20 gpm and apparently is in an area of lower transmissibility.

Chemical quality.—Chemical analyses of water samples from seven wells in the albite-chlorite facies of the Wissahickon formation are given in Table 11. They show that the water is usually soft and low in dissolved solids. Owing to its moderately low pH and low mineral content, the water may be corrosive.

Several of the samples have high concentrations of nitrate, which may indicate contamination. The range of the important constituents in these samples is:

Constituent	No. of samples	Range (ppm, except for pH)
Dissolved solids	5	51–286
Hardness as $CaCO_3$	7	23–109
Total iron (Fe)	7	.00–.08
Nitrate (NO_3)	7	5–96
Chloride	7	4.1–71
pH	7	5.6–6.7

Carbonate Rocks of the Piedmont Upland

The carbonate rocks, consisting of the Cockeysville and Wakefield marbles and the Silver Run limestone, characteristically weather to form narrow, somewhat troughlike valleys. The average yield of 32 wells in the Wakefield and Silver Run formations is about 92 gpm. The average yield per foot of hole drilled is 0.72 gpm. Table 20, which shows well-yield data by depth intervals of 50 feet, indicates an erratic increase in yield with increasing well depths.

TABLE 20

Average Yield, Specific Capacity, and Yield per Foot of Hole for Wells in the Carbonate Rocks of the Piedmont Upland

Depth interval (feet)	Average yield		Average specific capacity		Average yield per ft. of hole		Aquifer or water-bearing unit
	(gpm)	No. of wells	(gpm/ft. of dd).	No. of wells	(gpm/ft.)	No. of wells	
0–50	50	(2)	—	—	1.0	2	Wakefield marble
50–100	98	(8)	3.0	(5)	1.06	(8)	Wakefield marble
	11	(1)	1.1	(1)	.15	(1)	Silver Run limestone
	88	(9)	2.7	(6)	.95	(9)	Both units
100–150	68	(7)	10.9	(4)	.66	(6)	Wakefield marble
	1.5	(1)	—	—	.01	(1)	Silver Run limestone
	57	(8)	10.9	(4)	.57	(7)	Both units
150+	150	(10)	8.8	(4)	.76	(10)	Wakefield marble
	31	(3)	.5	(3)	.15	(3)	Silver Run limestone
	122	(13)	5.2	(7)	.62	(13)	Both units

Wells in the 150+ interval yield the most water. The highest average yield per foot of hole, 1.06 gpm, is in the depth interval from 50 to 100 feet in the Wakefield marble. These values show an irregular decrease as depth increases. The statistics are weighted by a few exceptional wells near Westminster which yield more than 300 gpm. The statistics indicate, however, if large supplies of ground water are needed, prospecting to depths of at least 150 feet is warranted.

Cockeysville marble

Geology.—On the geologic map of Carroll County (Jonas, 1928) all the marble and limestone in the county are mapped as the Cockeysville marble. A reinterpretation of the geology, shown on a later map (Jonas and Stose, 1938) and discussed in a companion report (Stose and Stose, 1946, p. 55), restricted the Cockeysville to a narrow band of crystalline white marble overlying the Setters formation in the southeast corner of the county near Marriottsville, where it underlies a narrow northeast-trending valley paralleling the ridgelike outcrop of the Setters on its east side. The Cockeysville's thickness is estimated to be about 400 feet. Its outcrop area is less than one-half square mile.

Water-bearing properties.—Owing to its small area in Carroll County, the Cockeysville is of negligible importance as a water-bearing formation. Little or no information is available regarding its water-bearing character. In neighboring Baltimore and Howard Counties the Cockeysville generally is a good water-bearing unit, although some wells in it yield little or no water. The average yield of 54 wells in these counties is about 19 gpm, and the average depth about 180 feet, exclusive of one exceptionally deep well in Baltimore County (Dingman and Ferguson, 1956, p. 20).

Dingman and Ferguson (1956, p. 23) have observed that the poorest wells in the Cockeysville are on small rises, which may be underlain locally by a more resistant type of marble, perhaps dolomitic. In Baltimore County, some wells located along contacts of the Cockeysville marble with adjacent formations have penetrated a zone of decomposed rock in the form of clay or mud. In one well it extended to a depth of at least 500 feet (Dingman and Ferguson, 1956, p. 16–17). The existence of this zone is attributed to solution of the marble by mildly acidic ground water moving from the bordering silicate rocks toward the contact and into the marble. Wells penetrating these clayey zones are very poor producers as a rule.

Wakefield marble

Geology.—The Wakefield marble is intimately associated with the belt of volcanic rocks that extends southwestward from the northeast corner of Carroll County. In Frederick County it crops out east of the Frederick Valley in the vicinity of Sams Creek and Englars Mill. Mostly the Wakefield crops out in narrow linear bands which trend to the northeast, but in places in Frederick

County and southwestern Carroll County the outcrop is a repetitious series of parallel curved bands which suggest folding and subsequent erosion of interbedded volcanic rocks and marble.

Two minor areas of the Wakefield marble in the eastern part of Carroll County, in the vicinities of Millers and Hoffmans Mill, differ from the main belt of marble in their stratigraphic relations in that no volcanics lie between the marble and the Wissahickon formation.

In general, the Wakefield marble is a closely folded white finely crystalline marble consisting of calcite or dolomite, with few impurities. Near its contact with the overlying volcanic rocks it is white or blue mottled with pink and green. Its thickness in the vicinity of Union Bridge is estimated to be 150 feet.

In their logs drillers commonly refer to the unweathered rock in the Wakefield as "limestone," but sometimes as "marble" or simply "rock." Six logs are given in Table 27. Fresh rock is exposed at the surface in only a few places. The weathered mantle is red or brown clay and generally is 10 to 35 feet thick, although in some places weathering extends to depths as great as 100 feet. In places gravel has been reported in wells, either in the lower part of the clay mantle or in the upper part of the bedrock. The term gravel presumably refers to quartz veins, beds of siliceous limestone, or gravel-filled caverns. Wells that apparently penetrated gravel-filled openings are Car-Ce 2 and Ce 3 at Westminster (Table 27). In places the openings may contain sand or clay instead of gravel. Davies (1950, p. 29–30) describes several caverns in the Wakefield marble in Carroll and Frederick Counties.

Water-bearing properties.—In spite of its relatively small areal extent, the Wakefield marble is of considerable importance as a water-bearing formation, particularly in Carroll County, where it is the source of domestic, commercial, and small industrial water supplies. The geologic and structural relations between the volcanic rocks and the Wakefield marble are complex and give rise to a complex hydrology. Several wells apparently start in the volcanic rocks but penetrate layers of marble at depth. Marble zones encountered at shallow depths have been subjected to solutional weathering and in some places are good aquifers, but those encountered at depths of several hundred feet sandwiched between volcanic rocks have undergone little solution and are not aquifers.

Fair-sized springs are numerous, generally occurring at the contact of the marble with silicate rocks or along the edges of the flood plains of streams. A spring at Union Bridge, Car-Cb 3, discharges about 50 gpm from fissured marble and supplies water for about 12 homes, a high school, and a farm.

Owing to the relative ease with which marble is dissolved by ground water, fractures and bedding-plane partings have been enlarged to a greater degree than in the silicate rocks, and wells of considerably higher capacity are obtained. The yield of 27 wells ranges from nearly nothing to several hundred gallons a minute and averages 106 gpm. The depths of wells in the Wakefield range from 10 to 575 feet and the average depth of 35 wells is 139 feet. The average yield per foot of hole drilled is 0.76 gpm.

The best wells are Car-Ce 2 and Ce 3, owned by a creamery in Westminster. They are in a small valley in the northeastern part of town. The wells were 160 and 116 feet deep, respectively, and during March 1948 they were pumped simultaneously at individual rates of 575 and 540 gpm. Subsequently well Ce 2 was deepened to 850 feet, penetrating layers of schist and thin marble. Because of flowing mud, the shallower openings in the marble were cased off; the well then yielded only 7 gpm and it was later destroyed. The high yields of these wells suggest that an extensive system of solutional openings is present in that part of the Westminster area. The possibility of pollution of the water obtained from such a source should be considered. It has been reported that during late summer and early fall, after periods of heavy ground-water withdrawals, the water levels have lowered considerably in wells in the Westminster valley. The marble aquifer is apparently of limited areal extent. Another excellent well in the Wakefield marble is Car-Cb 8 at Union Bridge. It is 170 feet deep and is reported to yield 400 to 500 gpm for several hours before the pump breaks suction. This well furnishes the water supply for the town of Union Bridge. However, not all wells in the aquifer are successful. Well Car-Cb 1 at the Union Bridge High School was 575 feet deep and was abandoned after reportedly yielding no water. There is no obvious explanation for the wide difference in hydrologic character of the rocks at the various well sites, although such experiences are not uncommon in limestone rocks. A possible explanation for well Cb 1 is that it may have penetrated the Sams Creek metabasalt instead of the Wakefield marble.

Aquifer and well-performance tests.—Westminster. The heterogeneous distribution of voids in the Wakefield marble and its restricted lateral extent limit the successful application of aquifer tests. Although the coefficients determined from the tests are of questionable value, the tests do demonstrate qualitatively the effects of pumping on the water level in the aquifer, interference between wells, specific capacities, and other hydrologic and hydraulic characteristics.

On May 10, 1948, an aquifer test was made at the Koontz Creamery in Westminster. The creamery is in the valley of Cranberry Branch, which is underlain by the Wakefield marble and is bordered on both sides by schist. Well Car-Ce 3 was pumped at a rate of approximately 300 gpm for 61 minutes, during which time the lowering of the water level was measured in well Car-Ce 2, 75 feet away. The immediate vicinity of the wells is underlain by clay and residual boulders, beneath which is cavernous marble from which the water is obtained (fig. 27B). The water-level graph of well Ce 2 during the pumping of Ce 3 is shown in figure 27A. After 20 minutes of pumping, the pump was unavoidably stopped momentarily, the result being an abrupt rise in the water level in Ce 2. However, 10 minutes after pumping was resumed the water level resumed its downward trend. Figure 27C shows the best match of the drawdown data to the Theis curve. A transmissibility of 52,000 gpd per ft. and a storage coefficient of 0.004 were computed. Deviation of the slope of the water-level curve from that of the type curve in the direction of an increasing rate of drawdown in the latter part of the test (left side of graph) is attributed to partial dewatering of the aquifer in the vicinity of the wells and to boundary effects of the less permeable bordering schists.

The effect of these factors on the productivity of wells in the marble is revealed by a driller's test of these two wells on March 3, 1948, in which they were pumped simultaneously for 3 days. The yield of Ce 2 declined from 600 gpm at the start to 470 gpm at the end; that of well Ce 3 declined from 600 gpm to 550 gpm. Specific capacities declined from 11.3 to 7.0 gpm per foot and 11.3 to 8.2 gpm per foot, respectively. The reported water levels in both wells were nearly the same, lowering from an initial static level of 42 feet to a final pumping level of 109 feet. The drawdown data, the proximity of the wells, and the cavernous character of the aquifer suggest that the wells react essentially

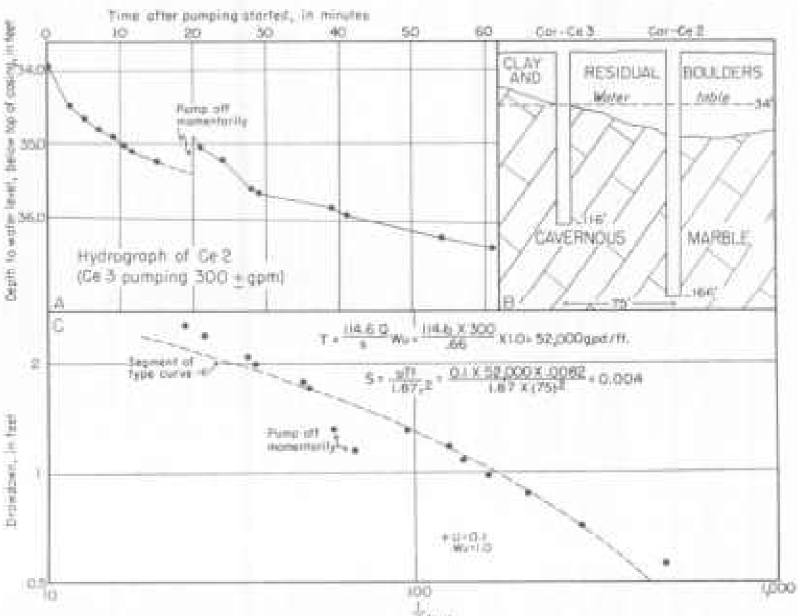


FIGURE 27. Graphs of Data for Aquifer Test at Westminster

A. Decline of water level in well Car-Ce 2 caused by pumping Ce 3.

B. Cross section through wells Ce 2 and Ce 3.

C. Drawdown in Ce 2 versus reciprocal of time; match with Theis type curve; computations of transmissibility and storage.

TABLE 21

Yield and Specific Capacity of Wells Car-Ce 2 and Ce 3 at Westminster

Time after pumping started (hours)	Well Ce 2		Well Ce 3	
	Yield (gpm)	Specific capacity (gpm/ft.)	Yield (gpm)	Specific capacity (gpm/ft.)
6	600	11.3	600	11.3
28	600	10.2	600	10.2
34	500	8.2	600	9.8
49	490	7.5	570	8.8
71.5	470	7.0	550	8.2

as one when pumped simultaneously. The yields and computed specific capacities at various times during the test are given in Table 21.

Chemical quality.—Water from two springs (Car-Cb 3 and Cd 2) and three wells (Car-Cd 16, 18, and 23) in the Wakefield marble was sampled for chemical analysis. The analyses show the water to be a moderately to very hard calcium bicarbonate water. Analyses of both the ground water and the rock indicate they are high in calcium but low in magnesium. The range of the important constituents in the ground water from this aquifer is:

Constituent	No. of samples	Range (ppm except for pH)
Dissolved solids	3	170–270
Hardness as $CaCO_3$	5	116–225
Total iron (Fe)	5	.04–.39
Nitrate (NO_3)	5	9–20
Chloride (Cl)	5	4–12
pH	5	7.4–7.7

Silver Run limestone

Geology.—The Silver Run limestone crops out sporadically in northwestern Carroll County within an ill-defined belt that extends from the vicinity of Union Mills southwestward to McKinstrys Mill, where its outcrop belt merges with that of the Wakefield marble (Stose and Stose, 1946, p. 58). Outcrops in most places are narrow northeast-trending bands in valleys, but in the area between Uniontown and Linwood the outcrop is irregular in shape and larger in area. In most places the Marburg schist overlies the Silver Run limestone. The Silver Run is principally a thin-bedded finely crystalline blue limestone, but the uppermost beds are calcareous slate. The formation is highly contorted and the original bedding planes are disturbed; near Uniontown and Walls Mill dips of the fold axes range from 20° to 30°.

Water-bearing properties.—The Silver Run limestone is of minor importance as an aquifer, owing to its small areal extent. Large solutional openings apparently are less plentiful in the Silver Run than in the Wakefield marble. In a few places, where solutional openings are developed, fairly large groundwater supplies may be obtained. The formation is one of the best aquifers in north-central Carroll County.

Six wells in the Silver Run have an average yield of about 21 gpm and an average specific capacity of 0.7 gpm per foot. The averages, however, are weighted by the data from well Car-Bd 21 at Frizzelburg, whose yield of 80 gpm was far above average. The yields of the other 5 wells ranged from 1.5 to 11 gpm. Well Bd 21 is in a belt of the Silver Run limestone which is only a few hundred feet wide. Its log is:

Material	Thickness (feet)	Depth (feet)
Shale, brown, soft	92	92
Rock, gray	20	112
Rock, gray, and fool's gold	3	115
Rock, gray (openings at 170 and 190 feet)	75	190
Rock, gray, and a little fool's gold	10	200

The well reportedly was pumped at a rate of 80 gpm for 5 hours with a drawdown of 55 feet. Its specific capacity is thus 1.4 gpm per foot. The well of next highest reported yield is Car-Cc 4, near Linwood. It is 71 feet deep and yielded 11 gpm for half an hour with a drawdown of only 5 feet (specific capacity, 2.2 gpm per foot). The few records suggest that the water-bearing properties of the Silver Run limestone are variable from place to place and that there may be no consistent relationship between depths of the wells and their yields. The depths of seven wells range from 29 to 225 feet and average 141 feet. The average yield per foot of hole drilled is about 0.15 gpm.

Chemical quality.—The analysis of a composite sample of ground water from the Silver Run limestone collected from wells Car-Bd 21 and 22 at a dairy near Frizzleburg shows the water to be similar to that from the Wakefield marble.

Mesozoic Sedimentary Rocks

Triassic System (Newark group)

Northwest-dipping beds of red and gray arkosic sandstone and red shale and siltstone of the Newark group of Triassic age occur in northwestern Carroll County and in northeastern Frederick County. These sedimentary rocks, which were deposited under continental conditions, crop out as a wedge-shaped body that tapers in width from about 13 miles at the Pennsylvania State line to a few miles just northwest of Frederick, where it terminates. The outcrop resumes again just southwest of Frederick and continues southward in a belt about 2 to 3 miles wide to and beyond the Potomac River (Plate 3). The rocks of the Newark group terminate on the west at the Triassic border fault along the base of Catoctin Mountain and on the east at the western edge of the Piedmont upland. Southwest of Frederick the Triassic rocks are bordered on the east by Paleozoic limestones of the Frederick Valley. The lower beds of Triassic age are predominantly arkosic sandstone or arkose and have been assigned to the New Oxford formation. They crop out in the eastern part of the belt of Newark rocks. The upper beds are predominantly shale and have been assigned to the Gettysburg shale. They crop out in the western part of the belt of Newark rocks. The change from one to the other is gradational and the contact between them is placed somewhat arbitrarily on the geologic map. Thin dikes of diabase, generally striking north, cut both formations. Two large diabase sills occur north of Emmitsburg, and two major dikes of diabase extend southward from the eastern sill.

Well logs show the change in lithology from east to west. Logs of wells in the eastern part of the Newark group commonly refer to sandstone or "sand rock" between beds of shale, whereas those of wells in the western part commonly list only shale. The sandstones are dense and appear to have little interstitial permeability, fractures being the important openings that transmit ground water. Apparently the sandstones are more competent than the shales and have developed a denser pattern of fracturing. Shale outcrops generally show widely spaced cracks that are tight, "healed," or indefinite and hackly, whereas sandstone outcrops generally show closely spaced more distinct joints.

The rocks of the Triassic system are characterized by little or no metamorphism and as aquifers are more typical of sedimentary rocks. The average yield of 169 wells is only 11 gpm. The average specific capacity, based on records of 80 wells, is 0.9 gpm per foot and the average yield per foot of hole drilled, based on 154 wells, is 0.11 gpm.

Table 22 shows that the average yield of wells increases with depth. The yields of 21 wells deeper than 150 feet average 18 gpm, whereas the yields of 72 wells 50 to 100 feet deep average only 8.4 gpm. However, the average in the deeper interval (150+) is weighted by a higher proportion of commercial and public-supply wells. The yield per foot of hole decreases from 0.17 gpm in the 0–50 foot interval to 0.08 gpm in the deepest interval (150+ feet). Thus the overall permeability of the Triassic rocks decreases with depth. Much of the ground water in these rocks, as in the crystalline rocks, is transmitted through openings resulting from weathering. Nevertheless, if large supplies of ground water are needed, prospecting to a depth of at least 150 feet seems warranted.

TABLE 22

Average Yield, Specific Capacity, and Yield per Foot of Hole for Wells in the Rocks of the Triassic System

Depth interval (feet)	Average yield		Average specific capacity		Average yield per ft. of hole		Aquifer or water bearing unit
	(gpm)	Number of wells	(gpm/ft. of dd.)	Number of wells	(gpm/ft.)	Number of wells	
0–50	6.7	(24)	1.7	(4)	0.15	(9)	New Oxford formation
	9.0	(3)	.9	(3)	.20	(3)	Gettysburg shale
	6.9	(27)	1.4	(7)	.17	(12)	Both units
50–100	6.9	(55)	0.5	(26)	.09	(55)	New Oxford formation
	13	(17)	.7	(10)	.20	(17)	Gettysburg shale
	8.4	(72)	.6	(36)	.11	(72)	Both units
100–150	18	(33)	2.7	(14)	.14	(33)	New Oxford formation
	7.2	(16)	.3	(11)	.06	(16)	Gettysburg shale
	15	(49)	1.6	(25)	.11	(49)	Both units
150+	19	(18)	.4	(9)	.09	(18)	New Oxford formation
	10	(3)	.3	(3)	.06	(3)	Gettysburg shale
	18	(21)	.4	(12)	.08	(21)	Both units

New Oxford formation

Geology.—The New Oxford formation dips westward beneath the overlying Gettysburg shale. The major outcrop belt of the New Oxford extends from just northwest of Frederick northeastward across Carroll County. The formation crops out also southwest of Frederick as a narrow belt that extends southward to the Potomac River. Here it is terminated on the west by the Triassic border fault. Small areas of the New Oxford occur also in the vicinity of Tyrone, in Carroll County, and near the mouth of the Monocacy River, in Frederick County. The rocks are chiefly red, gray, and brownish sandstone and red shale and siltstone. A conglomerate composed of pebbles of limestone and quartz in a fine-grained limy matrix is present in most places at the base of the formation, cropping out generally at its eastern edge. The variety of colored pebbles gives the rock a spotted appearance that is responsible for the local name of "calico." It is known also as "Potomac marble." To the north it changes to a quartz conglomerate.

Drillers generally describe the New Oxford formation as "red shale" or "red

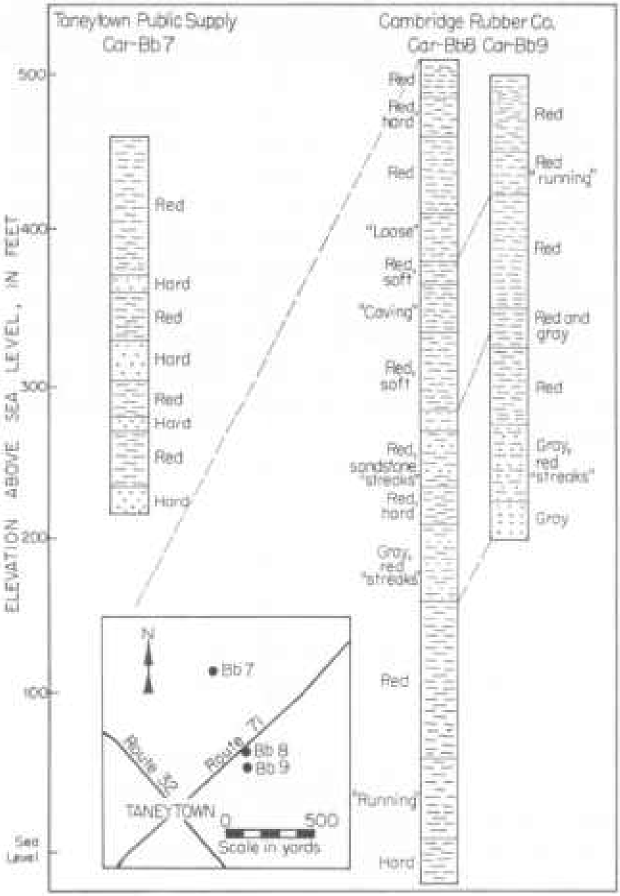


FIGURE 28. Logs of Wells in the Triassic Rocks at Taneytown
(Sandstone stippled, shale lined, probable correlations indicated)

rock," noting only the more conspicuous sandstone layers. The sandstone beds are lenticular and do not persist for great distances. The lithologic character of the formation is shown by logs of three wells in figure 28 and logs in Table 27. The depth of weathering ranges from nothing to 70 or 75 feet and averages about 19 feet.

Water-bearing properties.—The New Oxford formation is an important water-bearing unit in both Carroll and Frederick Counties, supplying water to domestic, farm, and industrial users and to the well field of Taneytown.

Small springs, largely seeps, are common along draws and near the heads of valleys. The discharge of individual springs rarely exceeds 5 to 10 gpm.

The yields of 124 wells range from 1 to 65 gpm and average about 11 gpm.

Specific capacities of 54 wells average 0.7 gpm per foot. The depths of 158 wells range from 21 to 530 feet and average about 106 feet. The average yield per foot of hole drilled is 0.10 gpm.

The best wells are those of the Taneytown municipal well field, which consists of 6 wells 140 to 163 feet deep. The well field is less than half a mile north of town on the edge of Piney Creek. Four of the wells are adjacent to one another in a large pumphouse. They have a combined yield of 300 gpm. Their high sustained yield is probably the result of recharge of the aquifer from Piney Creek. Another comparatively good well is Fr-De 3 at Fort Detrick. It is 140 feet deep and yielded 65 gpm in a 3-hour test. It penetrated the basal conglomerate or "calico rock" of the New Oxford formation. Although normally the basal conglomerate does not yield more water than other parts of the formation, solution of the limy matrix may result in higher permeability of the rock locally.

Aquifer and well-performance tests.—Taneytown. During November 1947 an aquifer test was made on the Taneytown public-supply well field. In addition to wells Car-Bb 2 to Bb 5 in the pumphouse about 30 feet south of Piney Creek, a well Bb 7 is 132 feet south of the pumphouse and well Bb 6 is 170 feet southwest of Bb 7 and 332 feet from Piney Creek. Well Bb 33 was drilled in 1956 after the aquifer test was run.

Owing to the town's water demand, it was not possible to control the pumping schedule as rigidly as would be desired. Physical conditions made it impractical to measure well discharge, so that reported pumping capacities had to be used in the computations. Prior to the start of the test the four pumphouse wells had been pumping for about 6¾ hours at a combined rate of 300 gpm. Thus, the water level in well Bb 7, the observation well, was declining slightly just before the test. An adjustment in the data was made for this decline.

The test may be divided into three stages. (1) Pumping of the four wells was stopped, and the recovery of the water level in Bb 7 was measured for about 2 hours. The water level rose at a diminishing rate to 9 feet above its previous level. (2) Then well Bb 6 (the well farthest from Piney Creek) was pumped at a rate of 50 gpm, which caused a decline of 2 feet in the water level in Bb 7 at the end of 1 hour. (3) Finally pumping from the four wells was started and that from Bb 6 continued. An additional drawdown of 8.5 feet was measured in Bb 7 after 44 minutes.

All the water-level graphs constructed from these data show some departure from the standard well-function type curve, likely attributable to the influence of recharge from Piney Creek. Computations for the first stage of the test (the recovery curve of the water level in well Bb 7), give a transmissibility coefficient of 14,000 gpd per foot and a storage coefficient of 0.00025. Using the second stage of the test (the drawdown effect of pumping well Bb 6) a match

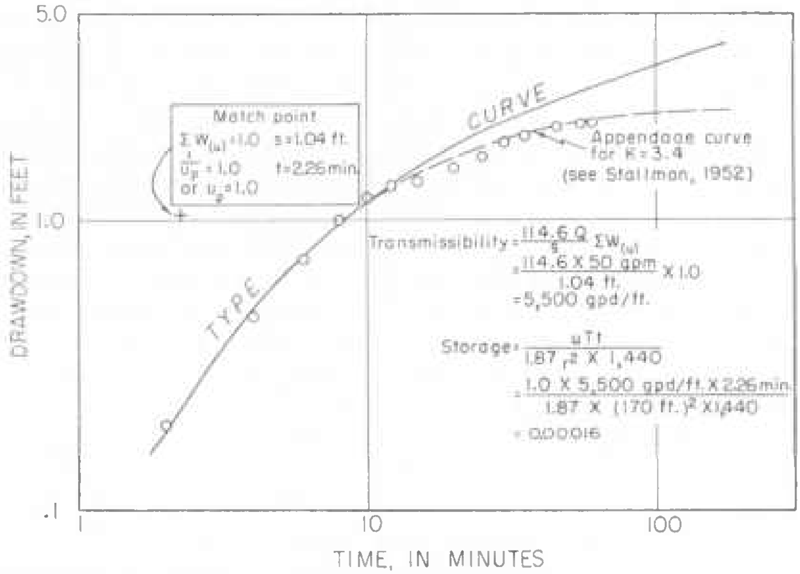


FIGURE 29. Match of Taneytown Aquifer-Test Data to the Type Curve and Deviation from Type Curve Attributed to Recharge from Piney Creek

of the first part of the curve to the type curve gives coefficients of 5,500 gpd per foot and 0.00016, respectively. A match of the last part of the curve yields coefficients of 9,700 gpd per foot and 0.0009, respectively. The second stage seems to be the most reliable part of the test for determination of the transmissibility, and in its latter part it is also more clearly suggestive of stream recharge than the others. For the second stage the drawdown versus time since pumping started is shown in figure 29. During the first 12 minutes the drawdown follows the type curve, but then it deviates in the direction of a reduced rate of drawdown. The smaller hydrologic coefficients (5,500 and 0.00016) were computed from the match, this being the period during which the cone of depression was expanding but had not yet been sensibly affected by recharge from Piney Creek. The larger coefficients (9,700 gpd per foot and 0.0009) were obtained by matching the part of the curve that deviates from the type curve. For convenience in computation the abscissa of the type curve is plotted as the reciprocal of *u* rather than as *u*. This permits utilization of a time scale expressed in real time units rather than the reciprocal of time.

Stallman (1952) constructed a family of modified type curves based on the image-well theory for two-well systems, the shape of each curve depending on the relative position of the observation well with respect to the pumping and image wells. These curves and the theory on which they rest apply to the Taneytown test to the extent that Piney Creek appears to be a line source of recharge and may be represented hydraulically as a recharge well located a distance north of Piney Creek equal to the distance the real well is south of it. This hypothetical well recharges at the same rate the pumped well discharges. Thus, it is assumed that the stream represents a line beyond which no drawdown would occur, but it is doubtful that it is 100-percent effective and does not permit spread of the cone of depression beyond it. A match to Stallman's family of curves yields a K value of about 3.4 (fig. 29), this value being the ratio of the distance of the image well from the observation well to the distance of the pumped well from the observation well. The distance from the pumped well to the observation well being 170 feet, the distance from the image well to the observation well is 3.4 $\times$ 170 feet, or 580 feet. The distance between the image well and the pumped well is then 750 feet. In a simple two-well image system the line source of recharge is halfway between the pumped well and its image, or a computed distance of 375 feet. The actual distance of the pumped well from Piney Creek is 332 feet, a fairly close agreement considering the physical deviations here from requirements of the formulas.

Probably the true transmissibility of the aquifer is on the order of 5,000 gpd per foot. All of the computed storage values are probably smaller than the value that would be measured with continued pumping, owing to gradual drainage of water from the rocks and to contributions of water from Piney Creek.

Chemical quality.—Samples of ground water from eight wells in the New Oxford formation were analyzed (Tables 11 and 12). The analyses show that the water is of the calcium magnesium bicarbonate type, similar to the limestone waters of the Frederick Valley area. The water is mostly hard to very hard. Except locally, the iron content is low.

The range in important constituents in the water is:

Constituent	No. of samples	Range (ppm, except for pH)
Dissolved solids	7	58–306
Hardness as $CaCO_3$	8	18–217
Total iron (Fe)	8	0.03–1.3
Nitrate (NO_3)	8	3.8–26
Chloride (Cl)	8	3.5–16
pH	8	6.0–8.0

The analysis of well Fr-Fc 1 is atypical of waters from the New Oxford formation. The water is high in nitrate (20 ppm), acidic (pH 6.0), and soft (hardness 58 ppm). As the well is only 27 feet deep, the water may be contaminated.

Gettysburg shale

Geology.—The Gettysburg shale lies west of the New Oxford formation in a belt that extends northeastward from the vicinity of Creagerstown, where it is about 3 miles wide, to the Pennsylvania State line, where it is about 8 miles wide. It consists chiefly of westward-dipping beds of red shale and siltstone and some sandstone. Adjacent to the large diabase sills and dikes, the shale and siltstone are baked to hard, brittle purple and blue rock. A limestone conglomerate crops out in a small area at the west edge of the Gettysburg shale along the Triassic border fault.

Drillers describe the Gettysburg shale as "red shale" or "red rock." The thin overburden is described as "dirt" or "shale," the term "shale" being used to connote softness. The four drillers' logs in Table 27 are not typical, a typical log being simply "red rock" or "red shale" for the entire depth of the well. Wells Fr-Ae 9 and Ag 1 penetrated diabase. Well Ae 9, near the outcrop of the westernmost diabase sill, apparently penetrated 52 feet of baked sediments above the diabase. Well Ag 1 apparently penetrated 41 feet of typical red rock, then 18 feet of baked rock, and then diabase.

Water-bearing properties.—Although the water-bearing capacity of the Gettysburg shale is similar to that of the New Oxford formation, it is a less important formation, inasmuch as its area of outcrop is smaller. Few industrial wells and no public-supply wells tap it, and small-capacity wells—1 or 2 gpm—are the most common. The principal well supplies are for domestic and farm use. Except for seeps, springs are rare. The towns of Thurmont and Emmitsburg, in the outcrop area, are supplied with water from sources in Cambrian rocks west of the Triassic belt.

Well yields range from 1 to 80 gpm and average about 10 gpm. About 40 percent of the wells yield less than 5 gpm. The depths of the wells range from 20 to 191 feet and average about 93 feet. The average specific capacity is 0.5 gpm per foot of drawdown and the average yield per foot of hole drilled is 0.13 gpm.

The best well is Fr-Af 11, 2.5 miles southeast of Emmitsburg. It is only 55 feet deep and yielded 80 gpm in a half-hour test with a drawdown of 32 feet. The reason for the high yield is not known for certain, but as the well is only a few hundred feet west of a diabase dike, the Gettysburg shale adjacent to the dike may be fractured more closely than average and, thus, more permeable. As the water level was only 8 feet below the land surface, much of the hole penetrated saturated rock, a situation conducive to greater well yield. Another good well is Fr-Af 4, about half a mile northeast of Emmitsburg on U. S. Route 15. It is 66 feet deep and was pumped at 40 gpm for 1 hour with a drawdown of only 4 feet. This well also is situated a few hundred feet from a large diabase intrusion. Not all wells in the Gettysburg shale furnish adequate supplies for even domestic use. Nine wells, whose depths range from 50 to 164 feet, yield an average of only about 1½ gpm. Five of these wells are in the so-called "baked" zone, suggesting that the hydrologic conditions in this zone are unfavorable for adequate well supplies.

Chemical quality.—Two analyses of water from the Gettysburg shale (Table 12) show the water to be similar to that of the New Oxford, but somewhat harder. The hardness of the two samples was 183 and 280 ppm. The few analyses of ground water from the New Oxford formation and the Gettysburg shale suggest there may be an increase in mineralization and hardness of the ground water from east to west.

Intrusive Rocks of Various Ages

Serpentine and metagabbro

Geology.—A band of serpentine about half a mile wide crosses the southeast corner of Carroll County. The serpentine is an altered mass of pyroxenite that was intruded between the Peters Creek quartzite and the oligoclase-mica facies of the Wissahickon formation, which crop out on the west and east, respectively. Talc, steatite, and chlorite schists occur at the borders of the serpentine.

Metagabbro, a dark greenish-black rock, occurs as dikes in eastern Carroll County, the thickest ones being in the vicinity of the Liberty Reservoir. An extensive dike of metagabbro enters Carroll County from Baltimore County just east of Finksburg and passes southward through Louisville, Eldersburg, and just west of Sykesville to the South Branch of the Patapsco River. None of the metagabbro dikes are more than 0.1 mile wide.

Water-bearing properties.—These intrusive rocks underlie relatively small sparsely settled portions of Carroll County and are unimportant as water-bearing formations. Only small to moderate yields are obtainable from wells in these rocks. Presumably the softness of the serpentine is detrimental to the preservation of clean, open fractures. Several wells in and near Eldersburg are drilled in metagabbro, but their yields are small. Well Car-Ee 16, for example, about 0.2 mile south of Eldersburg, was drilled to a depth of 45 feet in "hard gray rock." It yielded 3 gpm in a test during which the pumping level dropped to the bottom of the well. The meager available data suggest that the metagabbro is a poor aquifer.

Sykesville formation

Geology.—Monzonite of the Sykesville formation is intruded as dikes and as *lit-par-lit* injections into the Peters Creek quartzite in southeastern Carroll County. An irregularly shaped outcrop is in the Sykesville and Eldersburg areas and another occurs along a belt 0.5 to 0.8 mile wide west of and parallel to the Liberty Reservoir. According to Stose and Stose (1946, p. 93) the Sykesville formation is younger than the Peters Creek, which is of early Paleozoic age, and older than the regional folding, which occurred in late Paleozoic time. The typical rock of this formation is a gray to greenish-gray biotite-quartz monzonite having schistose or gneissic structure.

About 30 to 50 feet of soil and weathered rock overlie the fresh monzonite. The lowermost part of the weathered zone consists of residual boulders embedded in partly disintegrated and decomposed rock. Drillers generally refer to the near-surface material as "sand and gravel" or "clay," according to its texture, to the intermediate zone as "boulders," and to the fresh monzonite as "hard rock."

Water-bearing properties.—The Sykesville formation is a moderately important water-bearing unit in southeastern Carroll County, where springs or wells yielding water from it supply farms, rural homes, and commercial establishments in Sykesville and Eldersburg. The Springfield State Hospital, just north of Sykesville, formerly obtained its water supply from deep wells in the Sykesville formation but now uses a surface-water supply from Piney Run.

Wells in the Sykesville generally yield adequate water for domestic uses. The reported yields of 8 wells range from a few gallons per minute to as much as 60 gpm and average 23 gpm. The best wells are unused wells at the Springfield State Hospital. Wells Car-Ee 13 and Ee 15, about 500 feet deep, reportedly yielded 22 and 60 gpm, and Ee 14, 140 feet deep, yielded 40 gpm. Not all wells in the formation furnish adequate supplies for even domestic use. However, some of the poorest wells are in well-drained hilly localities near the tributaries of the Patapsco River.

Pegmatite

Geology.—Muscovitic pegmatite dikes, 50 to 150 feet wide and a mile or more long, have intruded the oligoclase-mica facies of the Wissahickon formation, the Cockeysville marble, the Peters Creek quartzite, and the Sykesville formation in southeastern Carroll County. In places the pegmatites are highly quartzose.

Water-bearing properties.—The area underlain by pegmatite is small, and this rock is unimportant as a water-bearing formation. No wells in it were inventoried in Carroll County. In adjacent Howard County the average yield of three wells is 10 gpm and the average depth 124 feet (Dingman and Meyer, 1954, p. 23).

Diabase

Geology.—Dikes of gray and black diabase intruded in late Triassic time intersect many of the geologic formations in Carroll and Frederick Counties. Two large sills of diabase, the major portions of which are in Pennsylvania, crop out in northern Frederick County (Plate 3). Generally the dikes form low ridges, particularly where they have intruded limestones in the Frederick Valley and Triassic sandstones and shales. The village of Rocky Ridge is underlain by one. The dike is well exposed in the Western Maryland Railroad cut through the ridge.

Water-bearing properties.—The diabase underlies a relatively small percentage of the area and is not important as a water-bearing rock. The yields of the few wells that have been drilled in it are small. The wells are commonly less than 40 feet deep, as the diabase is relatively unweathered and the fresh rock is extremely hard and difficult to drill. Although the rock is fractured in places, the fractures are tight. It is unlikely that yields in excess of domestic requirements are obtainable from wells in it.

Cenozoic Sedimentary Rocks

Quaternary System

Mountain wash (Alluvial cones)

Geology.—Heterogeneous deposits of mountain wash consisting of boulders, pebbles, sand, and silt occur at the mouths of ravines along the east foot of Catoctin Mountain. These deposits were laid down as alluvial cones on the floor of the Frederick Valley in early Pleistocene or late Tertiary time. The largest of these cones is that at the mouths of Hunting and Little Hunting Creeks in the vicinity of Thurmont; other deposits are at the mouths of Fishing Creek, Little Tuscarora Creek, and the North Branch of Owens Creek. Associated with the alluvium is colluvium resulting from the creep of soil down the slopes.

Drillers commonly describe the material of the wash as "sand and gravel" in their well logs but frequently refer also to "boulders." Some wells penetrate only the mountain wash; others continue through it and into the underlying rocks. Well Fr-Bd 15 at Catoctin Furnace penetrated 135 feet of "ironstone boulders, sand and gravel," all of which may be wash, and then penetrated "soapstone," probably the Harpers phyllite. Well Fr-Be 15, just north of Thurmont, penetrated 67 feet of "small stones, soft clay, and gravel" and then "gray mountain rock," apparently also the Harpers phyllite. These thicknesses of wash are unusual; in most places it is not more than 30 feet thick.

Water-bearing properties.—In spite of the detrital origin of the mountain wash and its generally coarse and unconsolidated character, it is only a fair aquifer because it commonly is well drained, lies above the water table, and contains enough clay and silt to make its permeability low.

Three springs and five wells yielding water from the wash were inventoried. Most springs discharge at small to moderate rates. The yields of the recorded wells range from 3 to 5 gpm, and the relatively great drawdown at these small discharge rates suggests that the reported yields approach the maximum obtainable. Wells that produce from the wash deposits range from 20 to 30 feet in depth. Although many wells penetrate the wash, it is frequently cased off and water is obtained from the underlying bedrock. Well Fr-Be 15 near Thurmont was originally developed in the wash, but it was inadequate and was later deepened to 100 feet, where a supply was obtained from the underlying phyllite. In 1946, when the well was 67 feet deep and ended in the mountain wash, the water level in it was 48 feet below the surface. Thus 19 feet of the wash was saturated. In 1955, after a drought, the water level was 19 feet lower at the contact of the wash with the underlying rock. The wash at that time was essentially dry and the well had to be deepened.

Terrace deposits and stream alluvium

Geology.—Terrace deposits, probably of Pleistocene age, occur sporadically along the borders of the Potomac and Monocacy Rivers, but at considerably higher elevations than their present channels. The deposits cap low rounded hills and are thin, seldom exceeding 25 feet. They consist of an admixture of gravel and boulders, sand, and silt. They are remnants of flood-plain deposits of the streams formed when their channels were at these elevations.

Most of the major streams are bordered irregularly by Recent flood-plain deposits, but extensive areas underlain by these deposits are associated only with the largest streams, the Potomac and Monocacy Rivers. These deposits are chiefly silt and clay containing some layers of sand and gravel. They were explored with a power auger at a number of places along both major and minor streams to determine their character and suitability for development of ground-water supplies. The results are summarized in Table 23, and four auger-hole logs are given in Table 24. The holes were drilled to refusal, which in most

TABLE 23
Summary of Auger-hole Sampling of Flood-plain Deposits

Stream	Location of flood plain	Number of auger holes	Range in depth (feet)	General character of material
	Carroll County			
South Fork, Linganore Creek	1 mile southeast of Linganore	3	3 to 4	Chiefly thin alternations of blue, gray, and brown clay.
East Branch	1½ miles west of Hampstead	2	12 to 16	Brown pebbly clay. Log 5, Table 24.
Deep Run	1 mile east of Union Mills	1	21¾	Clay and silt; some gravel and coarser material.
Big Pipe Creek	2 miles north of Mayberry	6	2 to 10±	Clay (redeposited Triassic shale); beds of phyllite pebbles.
	Frederick County			
Catoctin Creek	1 mile south of Middletown	3	3 to 6	Chiefly brown silty and pebbly clay. Log 1, Table 24.
Do	1½ miles south of Middletown	6	3 to 19	Chiefly brown clay. Log 2, Table 24.
Potomac River	Lander Station	4	4 to 18	Chiefly brown and gray clay. Log 3, Table 24.
Do	¾ mile northwest of Point of Rocks	1	15	Chiefly brown silty clay and clay; gravelly in lower part. Log 4, Table 24.
Do	1 mi. south of Licksville	1	4	Probably undisturbed Triassic rock below thin soil cover.

TABLE 24

Logs of Auger Holes in the Flood-plain Deposits

	Material	Thick-ness (feet)	Depth (feet)
Frederick County			
1. "Thayer No. 2". 1 mi. south of Middletown, along Catoctin Creek.	Clay, silty, brown; a few small pebbles of quartz and schist	3	3
	Clay, silty, brown; no pebbles	1	4
	Pebbles of quartz and schist	2	6
2. "Taylor No. 1". 1½ miles south of Middletown, along Catoctin Creek.	Clay, brown	3	3
	Clay, brown; gravel bed about 1 foot thick near base	5	8
	Clay, brown	5	13
	Clay, gritty, brown	4	17
	No samples; bedrock at 19 ft.	2	19
3. "Lander No. 1". Lander Station, along Potomac River.	Silt and clay, yellowish-brown; silt grains chiefly subangular quartz	1.5	1.5
	Silt and fine sand; grains chiefly subangular to subrounded quartz; abundant dark minerals and carbonaceous material. Approximate grain-size analysis, percent by volume:	1.5	3.0
	Coarse sand or larger 1		
	Fine to medium sand 15		
	Very fine sand, silt, and clay 84		
	Silt and clay, yellowish-brown, and carbonaceous material	2.5	5.5
	Clay and silt, grayish orange. Approximate grain-size analysis, percent by volume:	2.5	8.0
	Coarse sand or larger 8		
	Fine to medium sand 15		
	Very fine sand, silt, and clay 77		
	No sample	5.0	13.0
	Clay and silt, grayish-orange; fine sand and few silt-size rounded plates of silvery schist; carbonaceous material. Approximate grain-size analysis, percent by volume:	2.0	15.0
	Coarse sand or larger 2		
	Fine to medium sand 4		
	Very fine sand, silt, and clay 94		
	Silt and clay, grayish-orange; embedded angular to subangular sand-size quartz grains and rounded schist grains. Approximate grain-size analysis, percent by volume:	2	17
	Coarse sand or larger 35		
	Fine to medium sand 12		
	Very fine sand, silt, and clay 53		
	Silt and sand, quartz, subrounded. Approximate grain-size analysis, percent by volume:	1	18
	Coarse sand or larger 35		
	Fine to medium sand 12		
	Very fine sand, silt, and clay 53		
4. "Point of Rocks No. 1". ¾ mile northwest of Point of Rocks, along Potomac River.	Silt, clayey, brown	1.5	1.5
	Loam, loose, brown	1.5	3.0
	Clay, silty, brown	5.0	8.0
	Clay, lighter brown	5.0	13.0
	Clay, as above; small gravel	1.0	14.0
	Clay, as above; more gravel	1.0	15.0
Carroll County			
5. "East Branch No. 1". 1½ mi. west of Hampstead, bank of East Branch.	Clay, brown; pebble gravel	5	5
	Clay, darker brown; pebble gravel	7	12

holes was the surface of the bedrock but in a few holes may have been boulders or coarse gravel which the auger bit could not penetrate. The depth of the holes ranged from 3 to 20 feet.

Water-bearing properties.—As the terrace deposits are composed of poorly permeable materials, and are commonly of small areal extent and well drained, they apparently are not water yielding. Several wells penetrate them but continue into and obtain water from the underlying consolidated rocks.

Although the exploratory augering was discouraging, additional prospecting may reveal isolated permeable lenses of sand and gravel in these deposits. Unless localities are found where deposits are thicker and more permeable than any seen so far, it is unlikely they will ever constitute an important aquifer.

Future Development of Ground Water

The rocks that underlie Carroll and Frederick Counties, with few exceptions, are water-bearing formations of small storage capacity and low transmissibility from which large ground-water supplies are not available. On the basis of the discharge of an average of about 475,000 gpd of ground water from each square mile of the Piedmont, determined by streamflow analysis, and an area of 1126 square miles, the quantity of ground water theoretically available for use perennially in the two counties is 535 million gallons per day. This is about 80 times the present rate of use. However, even though ground water could be withdrawn for a time at rates greater than the rate of recharge, the total quantity practically available perennially is far less than 535 mgd, because an impractical number of closely spaced wells would be required to approach the theoretical maximum rate of withdrawal.

Existing important ground-water supplies in Carroll and Frederick Counties are chiefly those of municipalities and small industries. Therefore competition for water is restricted to only a few localities at present. The number of small industrial plants having moderate water requirements is increasing, but heavy industry has generally avoided the Piedmont in favor of the Coastal Plain with its abundance of ground water. A major ground-water supply in the Piedmont and mountainous parts of the State can be considered one of 50,000 to 100,000 gpd. Relatively few present users need more than this quantity, and ordinarily several wells are required to obtain it.

Under favorable geohydrologic conditions, particularly where conditions are suitable for ground-water recharge from a perennial stream, considerably larger supplies are available. Major ground-water developments should be preceded in chronological order by:

(1) Surface geologic mapping and/or exploratory drilling of the potential site to outline areas of productive and poorly productive rocks.

(2) Drilling of test wells to determine by means of well-performance tests

proper well construction and local aquifer characteristics; geophysical well surveys are valuable aids.

(3) An aquifer test to determine the hydrologic coefficients, the optimum well spacing, and the relation of well and aquifer productivity to areal geology and topography and to nearby streams.

After a well field is completed and in use, valuable information on the sustained availability of ground water may be obtained by periodic measurement of:

(1) The pumping levels and discharge rates of the pumped wells.
(2) The static levels in nonpumping wells.
(3) Precipitation and the flow of nearby streams.

Ground water eventually will be used for supplemental irrigation in the most favorable areas of Carroll and Frederick Counties. This is especially true in the valleys underlain by marble where supplies in excess of domestic requirements can usually be obtained. It is likely that ground water stored in the limestone aquifers in favorable localities can be withdrawn at rates of a few hundred gallons per minute for the limited periods for which it would be required for supplemental irrigation.

Except for particular uses that require water of a specified chemical quality, the ground water in Carroll and Frederick Counties is usable with little or no treatment. Generally it contains only small to moderate amounts of mineral matter, consisting chiefly of unobjectionable constituents or those easily removed or reduced by treatment.

RECORDS OF WELLS AND SPRINGS

Descriptions of the wells and springs in Carroll County are given in Table 25 and in Frederick County in Table 26. The location of the wells is shown on Plates 1 and 2.

The altitude of the land surface at the wells was estimated from topographic maps having a 20-foot contour interval.

"Type of well" refers to the method of construction. The wells that were drilled by the cable-tool percussion or rotary method are described as "drilled," and those that were dug manually or by some form of mechanical digger are described as "dug." A few wells drilled through the bottom of dug wells are described as "dug and drilled."

The well depths are reasonably accurate, except where approximate depths are indicated. Most of the depths were reported by well drillers; some were reported by the well owners; some were measured.

Wherever practical, depths to water level were measured. The depth to water level in many wells was reported by drillers and well owners. Because many wells are not tested for their maximum capacity, many reported yields are less than the maximum rate at which the wells could be pumped. Some yields were measured in connection with the aquifer and well-performance tests.

TABLE

Records of Wells and

Water level: Reported water levels designated by "a".
Pumping equipment: Method of lift: B, bucket; C, cylinder; J, jet; N, none; NI, to be installed; S, suction; T, turbine.
Type of power: E, electric motor; H, hand; W, windmill.
Use of Water: C, commercial or industrial; D, domestic; F, farming; I, school, institution, or camp; N, none; P, public supply.

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ab 1	A. H. Alexander	Le Gore	1947	450	Drilled	79	6	7.5	Upland flat
Ab 2	Richard Leister	Showers	1951	510	do	46	6	10.5	do
Ab 3	W. L. Reifsnider	H. E. Wantz	1952	518	do	100	6	19	Hilltop
Ab 4	N. L. Ridinger	do	1948	510	do	125	6	8	do
Ab 5	Earl Welty, Jr	do	1950	495	do	92	6	12	Upland flat
Ab 6	Piney Creek Presbyterian Church	C. L. Wantz	1948	485	do	78	6	4	Hilltop
Ab 7	G. F. Knox	do	1948	495	do	201	6	10	do
Ac 1	W. G. Bollinger	Utermahlen	1950	455	do	45	6	—	Hillside
Ac 2	Mrs. Catherine Martin	H. E. Wantz	1952	560	do	108	6	11.7	Upland flat
Ac 3	Do	—	Old	560	Dug	?	48±	—	do
Ac 4	C. E. Shank	Sterner	1951	570	Drilled	73	6	17	do
Ac 5	Edward Warner	LeGore	1949	515	do	88	6	22	do
Ac 6	Kenneth Frock	do	1949	515	do	103	6	16.2	do
Ac 7	C. E. Mayers	do	1948	515	do	80	6	21	Hilltop
Ac 8	A. O. Erb	Reichart	1951	545	do	60–70	6	—	Hillside
Ac 9	Mr. Parks	—	Old	550	do	110	6	—	Upland flat
Ac 10	Do	—	Old	550	Dug	12	48	—	do
Ac 11	Mrs. Mason	H. E. Wantz	1951	550	Drilled	107	6	—	do
Ac 12	Guy Dayhoff	LeGore	1949	545	do	60	6	10.5	do
Ac 13	H. A. Hainsborough	Wantz	1938	455	do	67	6	15	Valley flat
Ac 14	Jason Hapson	—	—	560	do	90	6	—	Draw
Ad 1	R. L. Bankert	Utermahlen	1953	840	do	44	6	4	Hilltop
Ad 2	H. L. Harman	Reichart	1951	800	do	95	6	—	do
Ad 3	S. L. Flickinger	do	1951	770	do	94	6	—	do
Ad 4	C. C. Stonesifer	do	1951	760	do	93	6	—	do
Ad 5	Vernon Zimmerman	H. E. Wantz	1950	720	do	76	6	14.7	Hillside
Ad 6	Do	—	—	530	Dug	44	48	—	do

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Springs in Carroll County

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pump-ing	Date		Gallons per minute	Date				
New Oxford	24[a]	65[a]	10/6/47	J,E	12	10/6/47	4	0.29	D	Drilled about 1915 to 68 ft., with reported yield of 5 gpm.
do	11[a]	—	9/25/51	J,E	4	9/25/51	—	—	D	See chemical analysis.
do	20[a]	—	6/27/52	?,E	4(?)	6/27/53	—	—	D	Reported bailed dry in 30 minutes.
do	20[a]	—	2/7/48	—	3.5(?)	2/7/48	—	—	D	Do
do	25[a]	—	5/5/50	J(?), E	2.5(?)	4/5/50	—	—	D	Do
do	40[a]	50[a]	3/6/48	?,E	25	3/6/48	.5	2.5	D	Main supply reported at 75 feet.
do	49[a]	—	6/18/48	—	3(?)	6/18/48	—	—	D	Reported bailed dry in 45 minutes.
do	40[a]	45(?)[a]	8/14/50	J,E	3	8/14/50	1	—	D	Adequate supply reported.
do	11.5[a]	—	12/24/52	J,E	4(?)	12/24/52	—	—	D	See well log.
do	—	—	—	C,H	—	—	—	—	N	Water reported "hard". Apparently was inadequate.
do	27[a]	—	12/7/51	J,E	7	12/7/51	—	—	D	
do	15.5[a]	—	6/9/49	—	3	6/9/49	2	—	D	
do	30[a]	—	9/27/47	J(?),E	3	9/27/47	4	—	C	Drilled to 73 ft. in 1947; 15 ft. of casing; inadequate and "marshy" odor. No improvement in yield or quality in 1949.
	21.78	—	2/15/55		3	6/18/49				
do	20[a]	—	5/20/48	?,E	1.5	5/20/48	3	—	D	
do	19[a]	—	5/9/51	J,E	7.5	5/9/51	—	—	D	
do	—	—	—	J,E	—	—	—	—	D	Adequate supply reported.
do	5.8	—	2/15/55	S,E	—	—	—	—	F	Roof runoff piped to well; water level in well may be higher than water table.
do	20[a]	—	5/25/51	?,E	3(?)	5/25/51	—	—	N	Reported bailed dry in 25 minutes.
do	10±	—	4/30/56	J,E	4	7/13/49	2	—	D	
New Oxford (quartz conglomerate)	—	—	—	C,E	—	—	—	—	D	
do	—	—	—	C,E	—	—	—	—	F	Cistern supplies home.
Marburg schist	25[a]	44[a]	4/30/53	J,E	4	4/30/53	.5	—	D	
	18.54	—	1/1/55							
Ijamsville phyllite	—	—	—	?,E	—	—	—	—	D	See well log.
do	—	—	—	?,E	4.5	7/10/51	—	—	D	
do	—	—	—	?,E	20	7/7/51	—	—	D	
do	36[a]	—	1/4/50	C,E	15-20	1/4/50	—	—	D	Water reported slightly hard and rusty.
do	43.2	—	1/10/55	N	—	—	—	—	N	Reported to go dry in summers

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ad 7	John Irvin	Utermahlen	—	620	Drilled	37	6	—	Hillside
Ad 8	Roy Hill	Reichart	1950	560	do	131	6	20	Valley
Ad 9	R. Scholl	Kyker	—	565	do	29	6	—	do
Ad 10	J. C. Cassell, Jr.	Sterner	—	580	do	32	6	25±	do
Ad 11	M. C. Utz	Reichart	1952	760	do	113	6	15	Hilltop
Ad 12	Mose Keffer	Showers	1952	745	do	90	6	21	Hillside
Ad 13	L. H. Haines	Reichart	1948	705	do	49	6	—	do
Ad 14	(Unknown)	—	—	630	do	60	6	—	do
Ad 15	L. H. Haines	Reichart	1950	690	do	83	6	—	Hilltop
Ad 16	F. N. Farnham	Utermahlen	1949	805	do	66	6	—	do
Ad 17	Lester Zeigle	—	1940	690	do	100±	6	—	do
Ad 18	Robert W. Myers	Reichart	1954	665	do	85	6	50	Upland flat
Ae 1	Mountain View Bible School	Sterner	1952	1,005	do	100	6	17.5	Draw
Ae 2	Do	—	—	1,010	Dug	46	36	—	do
Ae 3	Do	—	—	1,000	Drilled	118	6	—	do
Ae 4	Paul C. Wentz	—	—	1,010	do	65±	6	—	Hilltop
Ae 5	Stuart Horvick	Sterner	1953	995	do	137	6	22.5	do
Ae 6	Roland Markle	do	1951	990	do	78	6	21	do
Ae 7	N. C. Krumrine	Reichart	1953	835	do	80	6	—	do
Ae 8	V. C. Wolfe	—	—	675	Dug	24	48	—	Hillside
Ae 9	Do	—	1947	705	Drilled	100	6	—	do
Ae 10	Do	—	—	660	Spring	—	—	—	Valley
Ae 11	B. E. Sterner	—	—	830	do	—	—	—	Hillside
Af 1	Raymond Wentz	Sterner	1950	965	Drilled	73	6	14	Hilltop
Af 2	W. E. Hersh	do	1950	840	do	61	6	26	Hillside
Af 3	Vernon Krebs	do	1949	845	do	80	6	79	do
Af 4	Carroll Shaeffer	R. H. Leppo	1948	920	do	75	6	10	do
Af 5	Farmers Cooperative, Inc.	do	1937	855	do	180	6	—	Valley

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Marburg schist	14.25	—	1/6/55	NI	—	—	—	—	D	Bottom of well mucky; may have been drilled deeper than 37 ft. Jet pump and electric motor to be installed.
Silver Run limestone	—	—	—	J,E	1.5	7/6/50	—	—	D	Field test of hardness: 362 ppm. Owner reports well was drilled in "flint rock."
do	—	—	—	J,E	—	—	—	—	D	Formerly 12 ft. deep and inadequate. Now adequate.
Silver Run limestone or Ijamsville phyllite	—	—	—	S,E	—	—	—	—	D	Adequate supply reported; water soft.
Marburg schist	—	—	—	—	—	—	—	—	D	See well log.
do	27[a]	32[a]	4/25/52	?,E	40	4/25/52	3	8.0	D	
do	18[a]	—	1/12/48	?,E	10	1/12/48	—	—	D,F	See well log.
Harpers phyllite	—	—	—	J,E	—	—	—	—	D,F	
do	—	—	—	J,E	15	3/15/50	—	—	D	
Marburg schist	50[a]	—	8/4/49	J,E	8	8/4/49	1	—	D	
Harpers phyllite	33–38[a]	—	11/30/56	C,E	—	—	—	—	D,F	Good quality reported.
do	—	—	—	—	—	—	—	—	D	
Marburg schist	18[a]	—	8/25/52	T,E	15±	8/25/52	—	—		
	36.55	—	11/16/53							
do	36.32	—	11/16/53	J,E	—	—	—	—	N(?)	
do	39.40	—	11/16/53	N	—	—	—	—	N	Jet pump pipes in well; no pump.
do	—	—	—	J(?), E	—	—	—	—	D	Adequate yield reported.
do	72.31	—	11/16/53	NI	2(?)	10/8/53	—	—	D	
do	32[a]	—	3/7/51	—	11	3/7/51	—	—	D	
do	20[a]	—	4/13/53	J,E	—	—	—	—	D	
do	18.85	—	1/4/54	J,E; C,H	—	—	—	—	D	Standby well.
do	—	—	—	J,E	7±	—	15	—	D,F	Pump capacity 7 gpm.; operated 15 hrs. once with no noticeable decrease in yield.
do	—	—	—	N	6–8	1/4/54	—	—	N	Concrete collecting chamber.
do	—	—	—	N	15–20	1/7/55	—	—	D,F	Water flows by gravity to home and barn. Continuous flow reported.
do	29[a]	—	12/7/50	J,E	6	12/7/50	—	—	D	Adequate supply reported. Depth of pump jet 65 ft. ±.
do	29[a]	—	5/22/50	—	12	5/22/50	—	—	D	
Wakefield marble(?)	31[a]	—	4/18/49	—	7	4/18/49	—	—	D	See well log.
Wissahickon (albite)	35[a]	—	5/20/48	J,E	10	5/20/48	1	—	D	Adequate supply reported.
Marburg schist	—	—	—	C,E	—	—	—	—	C	Inadequate yield reported. Cannery inoperative part of the winter. Well drilled through "slate soapstone." Well casing connects below land surface with a duct from a concrete tank fed by a nearby spring. Water pumped from well is largely spring water.

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Af 6	Farmers Cooperative, Inc.	—	1948±	990	Drilled	300±	8	—	Hilltop
Af 7	Do	—	—	910	Spring	—	—	—	Valley
Af 8	Mrs. Wareheim	—	—	800	do	—	—	—	Hillside
Af 9	Town of Manchester	—	—	900–950	do	—	—	—	Valley and hillside
Af 10	Sinclair Hook	Sterner	1953	710	Drilled	79	6	11	Valley side
Af 11	M. E. Warner	do	1952	800	do	46	6	11	Hillside
Af 12	George Warner	do	1954	720	do	59	6	—	do
Af 13	E. W. Dell	—	Old	715	Dug	8.7	48	—	Draw
Af 14	Walter Detter	Sterner	1952	840	Drilled	70	6	57	Hilltop
Af 15	L. Fowble	—	—	830	Dug	20	—	—	Valley side
Af 16	Do	—	—	895	Spring	—	—	—	Draw
Af 17	Melrose Canning Co.	—	1944	810	Drilled	125	6	—	Valley
Af 18	Do	—	1937	810	do	125	8	—	do
Af 19	Do	—	1930	810	do	125	8	—	do
Af 20	Russell Royer	Sterner	1953	875	do	88	6	52.5	Hillside
Af 21	W. H. Wey	Leppo	1953–54	1,000	do	65	6	—	do
Af 22	Do	—	—	980	Spring	—	—	—	do
Af 23	Do	—	—	980	do	—	—	—	do
Af 24	H. J. Stemmer	—	—	880	Dug	15	—	—	do
Af 25	Do	—	—	860	Spring	—	—	—	do
Af 26	E. W. Dell	—	—	715	do	—	—	—	Valley
Af 27	George Simpers	Sterner	1955	910	Drilled	82	6	22	Hilltop
Af 28	Paul Warner	—	1935	790	do	120	6	—	Hillside
Af 29	Do	—	—	800	Spring	—	—	—	do
Ag 1	Raymond M. Walker	H. R. Leppo	1947	730	Drilled	55	6	23	do
Ag 2	Guy O. Sanders	—	—	800	do	66+	6	—	Hilltop

—Continued

Water-bearing formation	Water level (feet below land surface) Static	Pumping	Date	Pumping equipment	Yield Gallons per minute	Date	Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
Marburg schist	76.21	—	11/17/53	C,E	—	—	—	—	C	
do	—	—	—	N	.5	11/17/53	—	—	C	Continuous flow reported. Part of discharge is directed into well Af 5. Situated at base of steep ridge slope.
Wissahickon (albite)	—	—	—	N	7	5/11/54	—	—	D,F	Two sets of openings in hillside, each with a collecting chamber. Water flows by gravity to home and a pond. See chemical analysis. Temperature measurements, p. 58.
do	—	—	—	N	—	—	—	—	P	Series of springs from which water flows through drain tiles to a cistern.
do	—	—	—	C,E	6.5(?)	9/21/53	—	—	D	See well log.
Sams Creek metabasalt	10[a]	—	4/17/52	J,E	15(?)	4/17/52	—	—	D	Water reported corrosive.
do	35.09	—	4/28/54	NI	8	3/23/54	—	—	D	See well log.
Wakefield marble	7.80	—	7/20/54	C,H	—	—	—	—	N	Intermittent discharge. Use spring Af 26 for water supply.
Wissahickon (albite)	17[a]	—	11/15/52	J,E	9(?)	11/15/52	—	—	D	
Marburg schist	19.3	—	1/4/55	S,E	—	—	—	—	N	Inadequate; use spring Af 16 for water supply.
do	—	—	—	—	7-8	1/4/55	—	—	D	Good flow in all seasons reported. Water flows by gravity to home. Temperature Jan. 4, 1955, 50°F.
Wakefield marble(?)	—	—	—	T,E	—	—	—	—	C	Pump capacity 100 gpm. Soft water reported.
do	11.70	—	1/7/55	T,E	120	—	—	—	C	Soft water reported.
do	—	—	—	T,E	—	—	—	—	C	Hard water reported.
Marburg schist	16[a]	—	6/15/53	—,E	11	6/15/53	—	—	D	
do	—	—	—	J,E	—	—	—	—	D	Good yield reported.
do	—	—	—	N	3	1/7/55	—	—	N	Concrete collecting chamber. Reported contaminated.
do	—	—	—	N	—	—	—	—	N	Rock-lined collecting chamber. Reported contaminated.
do	—	—	—	J,E; C,H	—	—	—	—	D	Poor yield at times.
do	—	—	—	N	—	—	—	—	D,F	Nest of 3 springs. Concrete collecting chambers. The one at lowest elevation reported to flow continuously.
Wakefield marble (?)	—	—	—	S,E	—	—	—	—	D	Concrete collecting chamber. Small discharge, but reported perennial.
Wissahickon (albite)	18[a]	—	9/27/55	—	10	9/27/55	—	—	D	
Wakefield marble (?)	40[a]	—	11/30/56	J,E	—	—	—	—	D	
do	—	—	—	—	3.6	11/30/56	—	—	F	Gravity flow to barn. Temperature Nov. 30, 1956, 56°F.
Wissahickon (albite)	32[a]	—	2/14/47	J,E	6	2/14/47	—	—	D	Adequate.
do	50.0	—	7/20/54	J,E	—	—	—	—	D	Good yield reported. Depth of pump jet 66 ft.

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ag 3	Henry A. Walker	—	—	680	Spring	—	—	—	Valley side
Ag 4	Mr. Baller	—	—	780	do	—	—	—	Draw
Ba 1	Carmen Delaplane	Owings	1951	375	Drilled	124	6	17	Hillside
Ba 2	C. F. Dougherty	H. E. Wantz	1953	345	do	67	6	22	Valley side
Ba 3	Do	—	Old	345	Dug	19	—	—	do
Ba 4	Ralph P. Waybright	H. E. Wantz	1946	485	Drilled	260	6	18	Upland flat
Ba 5	Do	—	—	485	do	160	6	—	do
Ba 6	Cmdr. Luther L. Dilley	H. E. Wantz	1953	445	do	142	6	4¾	Hilltop
Ba 7	Do	—	1953(?)	445	do	140	6	—	do
Ba 8	Lloyd Wilhide	C. L. Wantz	1952	500	do	70	6	11.2	do
Bb 1	Mrs. Joseph Elliott	—	Before 1900	525	Dug	31.2	—	—	Upland flat
Bb 2	Municipality of Taneytown	—	About 1925	440	Drilled	140	8	—	Valley
Bb 3	Do	—	About 1925	440	do	130	8	—	do
Bb 4	Do	—	—	440	do	150	8	—	do
Bb 5	Do	—	1898	440	do	150	8	—	do
Bb 6	Do	—	1940	460	do	363	8	10±	Valley side
Bb 7	Do	H. E. and C. L. Wantz	1946	460	do	244	8	5	do
Bb 8	Cambridge Rubber Co.	Columbia Pump and Well Co.	1948	510	do	530	8	23	Upland flat
Bb 9	Do	do	1948	510	do	300	10–8	78	do
Bb 10	Do	—	—	500	do	200±	8	—	do
Bb 11	Delmar Riffle	H. E. Wantz	1950	505	do	101	5⅝	21.3	Hilltop
Bb 12	Luther J. Claybaugh	C. L. Wantz	1945	520	do	107	5⅝	8	Upland flat

—*Continued*

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Wissahickon (albite)	—	—	—	N	2	7/20/54	—	—	D,F	
do	—	—	—	N	5±	7/20/54	—	—	D,F	
New Oxford	21[a]	75[a]	12/8/51	C,E	12	12/8/51	.5	.2	D	Depth of pump pipe 110 ft.
do	8[a]	—	6/3/53	J,E	—	—	—	—	D	Driller reported bailed dry in 30 minutes. Adequate supply reported by well owner.
do	—	—	—	N	—	—	—	—	N	Abandoned because of inadequate yield in summer of 1953; replaced by well Ba 2.
do	25[a]	—	9/17/46	C,E	—	—	—	—	D,F	Driller reported bailed dry in 30 minutes.
do	—	—	—	C,E	—	—	—	—	N	Poor yield reported. Water contaminated by a nearby buried gasoline tank.
do	65[a]	—	8/10/53	?,E	—	—	—	—	D	Driller reported bailed dry in 20 minutes.
do	—	—	—	N	—	—	—	—	N	Inadequate yield; destroyed(?).
do	23[a]	—	10/8/52	J,E	4 (?)	10/8/52	—	—	D	Driller reported bailed dry in 20 minutes.
do	5.61	—	7/16/53	N	—	—	—	—	N	Water-level observation well.
do	20[a]	—	1946	T,E	—	—	—	—	P	Well no. 1. See chemical analysis. In northeast corner of pumping station. Combined yield of wells 1-4 reported to be 300 to 350 gpm; individual yields range from 60 to 110 gpm.
do	20[a]	—	1946	T,E	—	—	—	—	P	Well no. 2. In southeast corner of pumping station.
do	20[a]	—	1946	T,E	—	—	—	—	P	Well no. 3. See chemical analysis. In southwest corner of pumping station.
do	20[a]	—	1946	T,E	—	—	—	—	P	Well no. 4. In northwest corner of pumping station.
do	—	—	—	C,E	—	—	—	—	P	Well no. 5. About 200 ft. southwest of pumping station.
do	40[a]	—	11/21/47	T,E	50	11/21/47	8	—	P	Well no. 6. About 130 ft. southwest of pumping station. See well log in Fig. 28.
do	8[a]	300[a]	4/3/48	T,E	30	4/3/48	6	0.1	C	Well no. 2. See well log in Fig. 28.
	67.30	—	2/5/52		17	Fall 51				
do	8[a]	125	4/3/48	C,E	25	4/3/48	3	.2	C	Well no. 3. See well log in Fig. 28 and chemical analysis.
					15	2/—/52				
do	—	—	—	—	17	2/—/52	—	—	C	Well no. 1. In boiler room.
do	26[a]	—	12/27/50	?,E	4(?)	12/27/50	0.5	—	D	Bailed dry in 30 minutes.
do	26[a]	—	10/29/45	J,E	4(?)	10/29/45	.5	—	D	Bailed dry in 30 minutes. Originally 85 ft. deep; deepened to improve yield.

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Bb 13	C. Edgar Hockensmith	C. L. Wantz	1948	550	Drilled	156	5⅝	25	Hilltop
Bb 14	William F. Airing	do	1947	495	do	68	6	17	Hillside
Bb 15	Do	—	Old	495	Dug	15±	36	—	do
Bb 16	Taneytown Mill	—	Old	500	Drilled	150–160	6(?)	—	do
Bb 17	William Abra	Sterner	1949	425	do	87	6	23	do
Bb 18	Frederick Mehring Fertilizer Works	H. E. Wantz	1947	425	do	105	6	11	do
Bb 19	Russell Blackston	do	1952	460	do	95	5⅝	—	Upland flat
Bb 20	Middleburg Methodist Church	Corum	1951	465	do	69	6	10	do
Bb 21	Cleon S. Wolfe	H. E. Wantz	1950	485	do	94	5⅝	21	do
Bb 22	Joseph A. Cashun	C. L. Wantz	1952	520	do	148	6	10	do
Bb 23	Monroe R. Pfoutz	Owings	1948	525	do	128	6	13	do
Bb 24	Jean W. Lowman	C. L. Wantz	1947	475	do	150	6	11.5	do
Bb 25	A. W. Feeser and Co.	Witherow	1921	450	do	194	6.5	—	Hillside
Bb 26	Do	H. E. and C. L. Wantz	1925	450	do	125	6	—	do
Bb 27	Do	—	Old	450	do	300	—	—	do
Bb 28	Do	—	—	450	do	300	6(?)	—	do
Bb 29	Do	—	1935	490	do	325	8	—	Hilltop
Bb 30	Do	—	1918	490	do	200	8	—	Draw
Bb 31	Do	—	Old	490	do	100	6	—	Hilltop
Bb 32	Do	—	Old	490	do	100	6	—	Hillside
Bb 33	Municipality of Taneytown	Kohl Bros.	1954	470	do	225	10–8	32	do
Bb 34	Brooke B. Helterbridle	H. E. Wantz	1947	515	do	125	6	10	Valley flat
Bb 35	William Sharote	do	1929	510	do	80	6	12	Hilltop
Bb 36	Earl K. Stonesifer	do	1949	490	Dug and Drilled	126	6	—	do
Bb 37	Joseph Ashcroft	Sterner	1952	510	Drilled	73	6	14	Upland flat
Bc 1	Philip L. Rosselle	C. L. Wantz	1952	580	do	100	6	10	Hillside
Bc 2	William F. Corbin, Jr.	Sterner	1950	640	do	80	6	16	Hilltop
Bc 3	Daniel Boone	Owings	1951	645	do	93	6	16	do
Bc 4	Mrs. Paul Will	Utermahlen	1948	620	do	75	6	—	Hillside

—Continued

Water-bearing formation	Water level (feet below land surface) Static	Pumping	Date	Pumping equipment	Yield Gallons per minute	Date	Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
New Oxford	45[a]	—	9/2/48	C,E	6(?)	9/2/48	.7	—	D,F	Bailed dry in 40 minutes. Adequate supply reported.
do	12[a]	—	9/10/47	J,E	5(?)	9/10/47	.3	—	D	Bailed dry in 20 minutes. Adequate supply reported.
do	10.95	—	8/6/54	C,H	—	—	—	—	F	Poor yield reported.
do	—	—	—	C,E	—	—	—	—	N	Good yield reported.
do	36[a]	—	3/24/49	J,E	3(?)	3/24/49	—	—	D	
do	45[a]	—	7/22/47	C,E	2(?)	7/22/47	.3	—	D	Bailed dry in 20 minutes. Adequate supply reported.
do	51[a]	—	10/18/52	?,E	4(?)	10/18/52	.3	—	D	Bailed dry in 20 minutes. Originally 67 ft. deep; drilled to 95 ft. to increase supply.
do	30[a]	30[a]	5/15/51	?,E	10	5/15/51	.25	—	D	Test pumped 10 gpm but driller states well will furnish 5 gpm.
do	12[a]	—	3/18/50	J,E	3(?)	3/18/50	.3	—	D	Bailed dry in 20 minutes. Driller reported that "rock was very hard and lay on an angle." Tried three other sites before this one.
do	22[a]	—	6/16/52	?,E	—	—	—	—	D	Adequate supply reported.
do	15[a]	50[a]	3/20/48	C,E	7	3/20/48	.25	.2	D	
do	76[a]	91[a]	10/18/47	?,E	15	10/18/47	.5	1.0	D	
do	—	—	—	C,E	40	—	—	—	C	Cannery; wells pumped June through September. Water zone reported at depth of 188 ft.
do	—	—	—	J,E	4.5	—	—	—	D	At residence on cannery property. Was 100 ft. deep; deepened to improve yield.
do	—	—	—	C,E	—	—	—	—	C	Good yield reported.
do	—	—	—	N	—	—	—	—	N	
do	35.5	—	5/1/56	C,E	40	—	—	—	C	Well pumped 24 hrs. per day at times during June–Sept.
do	—	—	—	C,E	.30	—	—	—	C	Do
do	—	—	—	C,E	10	—	—	—	C	Seldom used.
do	—	—	—	N	—	—	—	—	N	Covered by concrete floor. Reported yield decreased markedly when well Bb 29 was put into operation.
do	36[a]	100[a]	12/20/54	T,E	25	12/20/54	1.5	.4	P	
do	10[a]	125[a]	3/12/47	C,E	3	3/12/47	.3	<.1	D	
do	16.17	—	11/28/56	C,H	4.5	—	—	—	D	
do	14.5[a]	—	6/13/49	J,E	—	—	—	—	D,F	Depth of dug well 17 ft. No casing in drilled well. Adequate yield.
do	6[a] 6.12	— —	4/23/53 11/28/56	J,E	—	—	—	—	D	
New Oxford (quartz conglomerate)	20[a]	—	3/26/52	J,E	—	—	—	—	C,D	Reported bailed dry in 20 minutes. Supply adequate.
Marburg schist	36[a]	—	4/28/50	J,E	6±	4/28/50	—	—	D	
do	58[a]	75[a]	11/10/51	C,E	12	11/10/51	.5	.7	D	Adequate supply. Depth of pump pipe 75 ft.
do	40[a]	40[a]	11/15/48	?,E	8	11/15/48	1	—	D	Water corrosive to copper pipes in home.

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Bc 5	Robert Lawrence	Showers	1952	470	do	98	6	3	Valley side
Bc 6	G. E. Gonder	Sterner	1950	460	do	97	6	—	Hillside
Bc 7	Frank Reinman	LeGore	1948	480	do	78	6	8	Hilltop
Bc 8	J. E. Baker	Showers	1954	535	do	133	6	12	Upland flat
Bc 9	P. Trent and H. Moffett	C. L. Wantz	1947	560	do	110	6	10	do
Bc 10	J. E. Baker	—	—	535	do	43	6	—	do
Bc 11	W. H. Myers	H. E. Wantz	1947	495	do	142	6	6	Hillside
Bc 12	J. C. Corbin	C. L. Wantz	1951	545	do	81	6	17½	Hilltop
Bc 13	Mildred Hymiller	Kyker	1954	530	do	50	6	14	Hillside
Bc 14	C. S. Haines	C. L. Wantz	1954	605	do	84	6	23	Hilltop
Bc 15	Dorsey Rake	—	1930	645	Dug and Drilled	85	48 and 6(?)	—	do
Bd 1	Mr. Myers	Owings	1947	645	Drilled	73	6	56	Hillside
Bd 2	Walter Myers	do	1947	620	do	90	6	82	do
Bd 3	E. S. Baugher	do	1947	710	do	115	6	40	do
Bd 4	Harvey Stoner	H. E. Wantz	1952	665	do	63	6	63	Hilltop
Bd 5	Richard Little	do	1949	750	do	227	6	13	do
Bd 6	Kriders Reformed Church	Utermahlen	1952	770	do	48	6	4	do
Bd 7	S. L. Hyde	—	—	770	Dug	32	42	—	do
Bd 8	William R. Rickell	W. Hoffman	1948	790	Drilled	85	6	10	
Bd 9	Mr. Hammett	—	About 1937	810	do	103	6	—	do
Bd 10	William C. Bridges	W. Hoffman	1952	785	do	100	6	17	do
Bd 11	Ralph T. Humbert	do	1952	865	do	80	6	8	do
Bd 12	John Roser	Utermahlen	1947	660	do	60	6	—	do
Bd 13	Do	do	1950	585	do	47	6	4	do
Bd 14	Do	—	Old	560	Dug	25.3	—	—	Hillside
Bd 15	Do	—	Old	565	do	32.1	—	—	do
Bd 16	Do	—	—	550	Spring	—	—	—	do
Bd 17	Charles Gist	W. Hoffman	1952	725	Drilled	135	6	7	Hilltop
Bd 18	D. Ray Myers	Utermahlen	1950	600	do	32	6	2	Valley
Bd 19	C. B. Foutz	do	1952	560	do	47	6	4	Hilltop
Bd 20	George Smith	do	1953	785	do	80	6	4	do

—Continued

Water-bearing formation	Water level (feet below land surface) Static	Pumping	Date	Pumping equipment	Yield Gallons per minute	Date	Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
New Oxford	12[a]	90[a]	5/31/52	J,E	8	5/31/52	.5	.1	D	
do	6[a]	—	4/24/50	J,E	3	4/24/50	—	—	D	
	36.98	—	7/20/54							
do	31[a]	78[a]	11/19/48	C,H	.75	11/19/48	2	—	D	Adequate supply reported.
do	12[a]	133[a]	4/8/54	J,E	6	4/8/54	1	—	D	
do	23.5[a]	110[a]	5/7/47	J,E	—	—	.5	—	C,D	Driller reported bailed dry in 30 minutes. Adequate supply reported.
do	—	—	—	N	—	—	—	—	N	Well covered. Poor yield reported.
do	16[a]	—	8/20/47	C,E	8	8/20/47	—	—	D	Driller reported bailed dry in 30 minutes. See well log.
do	25[a]	—	2/5/51	?,E	4	2/5/51	—	—	D	Bailed dry in 20 minutes.
New Oxford (quartz conglomerate)	4[a]	15[a]	5/14/54	?,E	25	5/14/54	3	2.3	D	
do	32[a]	—	5/18/54	J,E	5	5/18/54	—	—	D	Bailed dry in 20 minutes.
Wakefield marble	58.61	—	3/29/55	J,E	—	—	—	—	D	Dug well, 65 feet deep, went dry in 1930. Deepened to 85 ft. Adequate supply.
Marburg schist	25[a]	30[a]	10/30/47	J,E	20	10/30/47	—	4	D	Supply reported adequate.
do	30[a]	35[a]	11/6/47	J,E	20	11/6/47	.5	4	D	Supply reported adequate and quality satisfactory.
Wakefield marble	45[a](?)	50[a](?)	6/16/47	T(?), E	18	6/16/47	.5	3.6	C	Restaurant and dairy plant. Depth of pump 100 ft.
Marburg schist	32[a]	36[a]	4/11/52	J,E	25	4/11/52	.5	6.2	D	
do	45[a]	—	12/24/49	?,E	—	—	—	—	D	Driller reported bailed dry in 20 minutes.
Sams Creek metabasalt	30[a]	48(?)	11/8/52	J,E	6	11/8/52	.5	—	D	
	29.90	—	11/1/54							
do	28.25	—	11/1/54	C,H	—	—	—	—	D	Adequate supply, hard water reported.
Marburg schist	35[a]	—	4/24/48	C,E	6.5	4/24/48	2	—	D	
	54.41	—	1/19/55							
do	—	—	—	C,E	7.5	About 1937	—	—	D	
do	50[a]	55[a]	9/9/52	J,E	11	9/9/52	3	2.2	D	
do	35[a]	40[a]	3/1/52	—	7	3/1/52	2	1.4	D	
do	40[a](?)	45[a](?)	1/18/47	J,E	6	1/18/47	1	1.2	D	Adequate supply reported.
do	17[a]	—	8/24/50	J,E	15	8/24/50	1	—	F	Do
	32.55	—	1/20/55							
do	23.66	—	1/20/55	C,E	—	—	—	—	N	Small yield reported.
do	29.51	—	1/20/55	J,E; C,H	—	—	—	—	D	Adequate supply reported.
do	—	—	—	N	5	—	—	—	N	Stone collecting chamber; gravity flow to milk house.
do	40[a]	130[a]	9/25/52	—	2	9/25/52	2	.2	D	
do	4[a]	12[a]	10/13/50	J,E	12	10/13/50	1	1.5	D	
do	32[a]	—	7/26/52	J,E	16	7/26/52	1	—	F	Adequate supply reported.
Ijamsville phyllite	20[a]	30[a]	6/15/53	—	10	6/15/53	1	—	D	

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Bd 21	Willow Farms Dairy	Owings	1949	650	do	200	8	92	Draw
Bd 22	Do	—	1930	650	do	136	6	—	Draw
Bd 23	W. O. Warner	Owings	1945	670	do	202	6	45	Hillside
Bd 24	Pleasant Valley Canning Co.	Millender	1929	580	do	80	6	30	Valley flat
Be 1	Mr. Snably	H. A. Leppo	1947	890	do	80	6	11	Hilltop
Be 2	Francis L. Hunter	—	Before 1932	915	Dug and Drilled	72(?)	48± and 6(?)	—	do
Be 3	Donald Dell	R. H. Leppo	1950	875	Drilled	80	6	10	do
Be 4	St. Johns Church	Owings	1950	925	do	258	8—6	10	do
Be 5	Mr. Wampler	R. H. Leppo	1953	890	do	95	5⅝	20	Hillside
Be 6	Cleveland Bell	Utermahlen	1952	680	do	22	6	4	Valley
Be 7	Sam L. Bare	Owings	1945	740	do	58	6	49	Draw
Be 8	J. Sterling Garner	—	Before 1904	720	do	48	6	—	Hillside
Be 9	Do	—	—	710	Spring	—	—	—	Valleyside
Be 10	J. H. Englar	Utermahlen	1949	760	Drilled	55	6	—	Upland flat
Be 11	Francis F. Hening	do	1954	790	do	54	6	6	Hilltop
Be 12	John H. Hull	—	—	810	Dug	30	42±	—	Upland flat
Be 13	Do		1950	790	Drilled	53	6	22	Draw
Be 14	Shaffer Bros.	Owings	1953	790	do	69	6	52	do
Be 15	Albert W. Gosnell	Hines	1949	815	do	70	6	—	Hilltop
Be 16	C. V. Sullivan	Reichart	1952	765	do	71.5	6	—	Hillside
Be 17	V. Sullivan	—	—	725	Dug	31.4	36	—	Draw
Be 18	Do	—	—	725	do	60	—	—	do
Be 19	Mr. Roten	—	Old	1,020	Drilled	—	6	—	Hilltop
Be 20	Ralph L. Schuchert	—	—	680	Spring	—	—	—	—
Be 21	B. F. Shriver Co.	—	—	690	do	—	—	—	Draw
Be 22	Walter R. Wareheime	—	—	700	do	—	—	—	Valley side
Be 23	(Unknown)	—	—	680	do	—	—	—	Draw
Be 24	Richman's Flying Service	Utermahlen	1946	765	Drilled	46+	5⅝	—	do

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Silver Run limestone	25[a]	80[a]	5/2/49	T,E	80	5/2/49	5	1.4	C	Pump capacity 100 gpm; operates 8 hrs. per day. Openings in rock at 170 and 190 ft. See well log, p. 118, and chemical analysis. Depth of pump 180 ft.
do	—	—	—	T,E	—	—	—	—	C	Pumped 8 hours or more per day. May be filled in to a depth of 130 ft. by near-surface slumping of well wall. See chemical analysis.
Marburg schist	40[a]	202[a]	7/26/45	C,E	15	7/26/45	.5	—	D	Supplies 2 to 3 families. Depth of pump pipe 185 ft. Present yield reported 2 gpm.
do	6[a]	—	—	—	22	—	—	—	N	Plant idle.
Wissahickon (albite)	40[a]	—	1947	?,E	—	1947	1	—	D	
do	57[a]	—	10/—/53	J,E	—	—	—	—	D	Dug well is 60 ft. deep. Depth of pump jet 60+ ft.
do	40[a]	—	4/16/50	—	20		2	—	D	
do	108[a]	223[a]	6/12/50	C,E	11	6/12/50	1	.1	D	8 inch diameter to 120 ft. Depth of pump pipe 140 ft.
	87.99	—	10/29/54							
do	50[a]	—	7/2/53	J,E	8	7/2/53	1	—	D	
Sams Creek metabasalt	17[a]	—	5/1/52	?,E	16	5/1/52	1	—	D	
Wissahickon (albite)	4[a]	15[a]	8/21/45	C,E	20	8/21/45	.5	1.8	C	Heating oil storage plant.
do	—	—	—	N	—	—	—	—	N	
do	—	—	—	J,E	5	11/10/54	—	—	D,F	Water reported rusty at times.
Marburg schist	40[a]	—	4/23/49	?,E	24	4/23/49	1	—	D	
Wissahickon (albite)	30[a]	—	3/27/54	—	15	3/27/54	1	—	D	
do	—	—	—	J,E; C,H	—	—	—	—	D,F	Adequate supply reported.
do	33[a] (?)	34[a] (?)	9/1/50	J,E	12	9/1/50	—	12(?)	D	
do	20[a]	25[a]	7/22/53	?,E	20	7/22/53	.5	4	F	
do	35[a]	—	10/14/49	J,E	4	10/14/49	1	—	D	Water reported rusty at times.
	38.20	—	11/10/54							
do	36.70	—	1/4/55	J,E	—	—	—	—	D	Adequate supply. Depth of pump jet 72 ft.
Sams Creek metabasalt	30.60	—	1/4/55	C,H	—	—	—	—	N	Reported inadequate.
do	27.23	—	1/4/55	C,H	—	—	—	—	D	Adequate supply reported.
Wissahickon (albite)	29.86	—	3/16/55	—	—	—	—	—	D	
Marburg schist	—	—	—	S,E	—	—	—	—	D	Adequate supply reported.
Sams Creek metabasalt	—	—	—	S,E	—	—	—	—	D,F	
Wakefield marble	—	—	—	C,E	3-5	11/12/54	—	—	D	Two springs in same drainage line.
Sams Creek metabasalt	—	—	—	S,E	1	11/12/54	—	—	D,F	Concrete collecting chamber.
do	9[a]	20[a]	8/26/46	J,E	8	8/26/46	1	.7	C	Deepened after original drilling; present depth not known.

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Be 25	Mr. Finley	—	—	800	Dug	25	24	—	Hilltop
Be 26	Do	—	—	800	do	25±	36	—	do
Bf 1	Town of Hampstead	—	1936	933	Drilled	400±	8	65±	do
Bf 2	Do	—	1936	890	do	165	8	—	Upland flat
Bf 3	Do	H. R. Leppo	1941	870	do	204	—	—	Hilltop
Bf 4	William Hennie	R. H. Leppo	1950	870	do	132	6	20	do
Bf 5	L. C. Sarhammer	Sterner	1950	1,100	do	128	6	37	do
Bf 6	Town of Manchester	H. R. Leppo	1930's	930	do	150	8	—	Valley
Bf 7	Do	A. C. Reider	1930's	1,020	do	410	8	—	Hilltop
Bf 8	Do	do	1930's	960	do	645	8	—	Valley
Bf 9	Do	do	1930's	1,000	do	310	8	—	Hilltop
Bf 10	Do	—	—	940	Spring	—	—	—	Valley side
Bf 11	Do	—	—	940	do	—	—	—	do
Bf 12	Do	—	—	1,000	do	—	—	—	Hillside
Bf 13	Mr. Weldie	R. H. Leppo	1951	860	Drilled	100	6	14	Hilltop
Bf 14	Mr. Simms	do	—	965	do	70±	6	—	do
Bf 15	Black and Decker Mfg. Co.	Hagmann	1951	841.9	do	301	12–8	98	Hillside
Bf 16	Do	do	1951	854	do	302	12 and 8	104	do
Bf 17	Do	do	1951	853	do	202	12 and 8	63	Valley side
Bf 18	Carl W. Cook	R. H. Leppo	1951	835	do	85	6	47	Hilltop
Bf 19	Burnell Hare	do	1953	865	do	75	5⅝	8	Draw
Bf 20	Paul Newdecker	do	1951	905	do	80	6	10	Hilltop

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pump-ing	Date		Gallons per minute	Date				
Wissahickon (albite)	19.55	—	3/16/55	S,E	—	—	—	—	D	Dry during winter of 1955.
do	—	—	—	C,H	—	—	—	—	F	Adequate supply reported.
do	58.64	—	5/1/53	N	—	—	—	—	N	Water-level observation well. Reported yielded 20 gpm. for 1 hour, then nothing. Owner's well no. 1. See well log.
do	—	—	—	T,E	60(?)	1944	—	—	P	See chemical analysis. Temperature Mar. 20, 1954, 54.5°F. Depth of pump 150 ft.
do	—	—	—	T,E	40	1941	—	—	P	See chemical analysis. Depth of pump 150 ft.
do	80[a]	—	4/6/50	C,E	1	4/6/50	1	—	D	
do	41[a]	—	8/24/50	J,E	5	8/24/50	—	—	D	Adequate supply. Depth of pump jet 124 ft.
do	—	—	—	J,E	3-5	—	— —	—	P	Diameter may reduce to 6 inches at some depth. Wells Bf 6, 8, and 9 used as auxiliary supply for springs. Water reportedly encountered only at shallow depth in all wells.
do	—	—	—	N	10	—	—	—	N	Covered. Not used because of poor yield.
do	—	—	—	J,E	6±	2/10/54	—	—	P	Diameter may reduce to 6 inches at some depth. Water level affected by level of water in nearby open-bottom cistern.
do	—	—	—	T,E	25-30	—	—	—	P	Depth of pump 70 ft.
do	—	—	—	—	—	—	—	—	P	Combined discharge Bf 10 and Bf 11, estimated 10-15 gpm on Feb. 10, 1954. Small discharge in summer and fall. Gravity flow to reservoir.
do	—	—	—	—	—	—	—	—	P	Small discharge in summer and fall. Gravity flow to reservoir.
do	—	—	—	—	15	2/10/54	—	—	P	Do
do	60[a]	—	3/19/51	?,E	1.5	3/19/51	1	—	D	
do	56.94	—	5/14/54	NI	—	—	—	—	D	
do	27[a]	294[a]	9/27/51	N	13	9/27/51	—	<.1	N	Owner's well no. 1. 12 in. casing 0-73 ft.; 8 in. casing 0-98 ft.
do	35[a]	205[a]	8/21/51	T,E	23	8/21/51	—	.1	C	Owner's well no. 2. 12 in. casing 0-94 ft.; 8 in. casing 0-104 ft.; grouted between casings. See chemical analysis. Depth of pump 197 ft.
do	12[a]	93[a]	10/22/51	T,E	55	10/22/51	13	.7	C	Owner's well no. 3. Hole diameter 12 in. to bottom; 12 in. casing to 60 ft.; 8 in. casing to 63 ft.; grouted between casings. See chemical analysis. Depth of pump 156 ft.
do	35[a]	—	10/14/51	J,E	4	9/14/51	1	—	D	Adequate.
do	40[a]	—	6/4/53	?,E	15	6/4/53	1	—	D	
do	40[a]	—	4/16/51	J,E	15	4/16/51	1	—	D	

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Bf 21	Helen Murray	H. R. Leppo	1951	815	do	85	5⅝	17	Upland flat
Bf 22	John Rote	R. H. Leppo	1950	830	do	80	5⅝	43	Hilltop
Bf 23	Allen Armacost	Sterner	1952	870	do	82	6	38	do
Bf 24	Do	R. H. Leppo	1948	870	do	110	6	105	do
Bf 25	Vernon E. Mahanna	Sterner	1952	885	do	80	6	70½	do
Bf 26	Norman Thomas	H. R. Leppo	1947	825	do	50	6	11	Hillside
Bf 27	Coop. Investigations Ground Water	Harr	1954	852	do	100	6 and 4	60	do
Bf 28	Do	do	1954	859	do	97	6 and 4	20	do
Bf 29	Black and Decker Mfg. Co.	do	1954	835	do	125	12 and 8	59.2	Valley
Bf 30	Charles Bankert	R. H. Leppo	1951	845	do	100	6	23	Hilltop
Bf 31	Burnell Boernen	do	1952	860	do	101	5⅝	20	do
Bf 32	C. L. Haifley	do	1952	870	do	78½	5⅝	28	do
Bf 33	Claude V. Rebert	Owings	1949	780	do	65	6	28	do
Bf 34	Hampstead Esso Station	—	1952±	850	do	80–84	6	—	do
Bf 35	Town of Hampstead	R. H. Leppo	1954	890	do	200	8 and 6	48	Upland flat
Bf 36	Do	H. R. Leppo	1904±	890	do	86	8 and 6	47	do
Bf 37	Park Hill Camp	—	—	675	do	28	6	15	Valley flat
Bf 38	Do	—	—	675	do	24	6	—	do
Bf 39	C. A. Congdon	—	Old	670	Dug	25.2	42	—	Valley side
Bf 40	William Frederick	R. H. Leppo	1955	860	Drilled	122	5⅝	32	Hilltop
Bf 41	E. C. Wentz	—	—	830	Spring	—	—	—	Hillside
Bf 42	John Singer	H. R. Leppo	1946	960	Drilled	65	6	22	Hilltop
Bf 43	Ross Blocker	Millender	1933	990	do	80	6	45	Upland flat
Bf 44	Board of Education	—	—	990	Dug and Drilled	120	—	—	do
Bf 45	Black and Decker Mfg. Co.	Harr	1955		Drilled	151	12–8–6	72	Valley
Bg 1	Faraway Kennels	—	—	745	Spring	—	—	—	do
Cb 1	Elmer Wolfe High School	Owings	1953	440	Drilled	575	—	0	Hilltop
Cb 2	Do	do	1953	440	do	200	12 and 11	35	do

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Wissahickon (albite)	40[a] (?)	43[a] (?)	10/2/51	?, E	4	10/2/51	—	1.3	D	
do	40[a]	—	3/4/50	—	8	3/4/50	2	—	D	
do	24[a]	—	4/27/52	NI	—	—	—	—	D	
	55.40	—	4/28/54							
do	60[a]	—	5/1/54	J, E	10	5/1/48	2	—	D	
do	18[a]	—	5/23/52	J, E	10	5/23/52	—	—	D	
do	5[a]	—	3/—/47	J, E	10	3/—/47	1	—	D	
	25.25	—	5/11/54							
do	22.97	—	8/4/54	N	—	—	—	—	N	Test hole. Hole diameter 6 in.; 4 in. casing to 60 ft.
	29.29	—	1/30/55							
do	30.09	—	8/4/54	N	—	—	—	—	N	Test hole. Hole diameter 6 in.; 4 in. casing to 20 ft.
	36.20	—	1/30/55							
do	8.6	45	8/20/54	T, E	100	8/20–21, 1954	36	2.7	C	Owner's well no. 4. 12 in. casing to 50 ft., 8 in. casing to 59.2 ft.; grouted between casings.
do	50[a]	—	3/21/51	C, E	10	3/21/51	1	—	D	
	58.57	—	5/14/54							
do	60[a]	—	4/16/52	?, E	1	4/16/52	1	—	D	
do	30[a]	—	4/5/52	—	4	4/5/52	4	—	D	
do	25[a]	—	11/17/49	J, E	20	11/17/49	.5	—	D	
do	27.36	—	2/19/54	C, E	—	—	—	—	C	Adequate. See chemical analysis.
do	18±	79	4/1/54	T, E	60	4/1/54	24	1.0	P	
do	15.55	—	3/30/54	N	—	—	—	—	N	
Wakefield marble(?)	2.39	—	8/26/54	S, E	—	—	—	—	I	Poor yield reported. Used for swimming pool.
do	—	—	—	S, E	—	—	—	—	I	Do
do	23.20	—	11/9/54	C, E	—	—	—	—	D	Good yield reported.
Wissahickon (albite)	65[a]	—	3/3/55	NI	4	3/3/55	2	—	D	
do	—	—	—	—	1	1/4/55	—	—	D	Gravity flow to home.
do	40[a]	65[a]	9/—/46	J, E	6	9/—/46	—	.2	D	
do	47[a]	—	—	—	7.5	—	—	—	N	Water reported encountered at 68 ft. Use Manchester public water supply.
do	—	—	—	N(?)	—	—	—	—	N	Manchester school. Use Manchester public water supply.
do	11[a]	50[a]	7/9/55	T, E	20	7/9/55	24	.5	I	12-in. casing to 54.1 ft.; 8-in. casing to 59.9 ft.; 6-in. casing to 123.5 ft. Grouted between 12 and 8-in. casings. 6-in. casing slotted from 72 to 102 ft.
do	—	—	—	S, E	1–3	2/11/54	—	—	D, C	Iron-oxide deposits in collecting chamber. Adequate supply reported.
Wakefield marble	—	—	—	N	0	2/10/53	—	—	N	No water reported; destroyed.
do	31.54	—	9/10/56	N	5	4/7/53	—	—	N	12 in. casing to 35 feet; 11 in. casing to bottom. Water-level observation well.

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Cb 3	J. Paul Bowman	—	—	420	Spring	—	—	—	Valley flat
Cb 4	Union Bridge Water Co.	Downin	1903–04	400	Drilled	214	6	—	Upland flat
Cb 5	Do	do	1903–04	400	do	50	6	—	do
Cb 6	Do	do	1903–04	400	do	50	6	—	do
Cb 7	Do	do	1903–04	400	do	464	6	—	do
Cb 8	Do	Shoemaker	1913	400	do	170	8 and 6	170	do
Cb 9	Do	Downin	1903–04	400	do	246	6	—	do
Cb 10	Lehigh Portland Cement Co.	H. E. and C. L. Wantz	1926	400	do	85	6	—	Valley side
Cb 11	Chesapeake and Potomac Telephone Co.	Owings	1949	440	do	70	6	27	Hillside
Cb 12	Henry Carr	do	1949	445	do	164	6	79.5	Hilltop
Cb 13	Charles Angell	do	1950	425	do	137	6	48	Hillside
Cb 14	Albert Flickinger	McCrory	1932	440	do	117	6	—	Valley flat
Cc 1	Lester Dunson	Owings	1947	525	do	70	6	22	Hillside
Cc 2	Roger T. Lawrence	do	1947	450	do	195	6	39	Hilltop
Cc 3	Grayson Shank	do	1945	465	do	225	6	40	do
Cc 4	Mr. Haifley	do	1952	450	do	71	6	42.5	do
Cc 5	Reuben H. Morningstar	do	1953	645	do	94	6	23	Hillside
Cc 6	Do	—	Old	650	Dug	14–16	—	—	do
Cc 7	Malcolm Dodd	Kyker	1954	790	Drilled	77	6	24	Hilltop
Cc 8	Max Price	Sterner	1953	615	do	70	6	42	do
Cc 9	Harold Fritz	do	1953	620	do	58	6	28	do
Cc 10	Bodie Smith	—	—	475	Spring	—	—	—	Valley
Cc 11	R. G. Spoerline	Owings	1949	540	Drilled	150	6	36	Hilltop
Cc 12	R. W. Malinowski	—	—	500	Dug	26	36	—	Valley side
Cc 13	Ralph Yingling	Owings	1946	430	Dug and Drilled	115	6	4	Valley flat
Cc 14	Edward Derr	—	1939	585	Drilled	1,033	6	—	Hilltop
Cc 15	Do	—	—	560	Spring	—	—	—	Drawside
Cd 1	L. Simpson	Owings	1951	705	Drilled	108	6	—	Hilltop
Cd 2	Stewart Bell	do	1953	675	do	65	6	35	do

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Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pump-ing	Date		Gallons per minute	Date				
Wakefield marble	—	—	—	C,E	25–50	6/22/55	—	—	I,F, P	Supplies farm, Elmer Wolfe High School, and about 12 homes. See chemical analysis.
do	12[a]	—	—	N	50	—	—	—	N	Covered.
do	12[a]	—	—	N	50	—	—	—	N	Reported water encountered in gravel bed. Covered.
do	12[a]	—	—	N	50	—	—	—	N	Do
do	12[a]	—	—	N	300+	—	—	—	N	Reported water encountered in solution channel. Covered.
do	30	—	1956	S,E	400	—	—	—	P	Equipped with 500 gpm suction centrifugal pump.
do	12[a]	—	—	N	50	—	—	—	N	Covered.
do	—	—	—	N	25	—	—	—	N	Probably destroyed.
do	15[a]	50[a]	1/8/49	J,E	80	1/8/49	15	2.3	C	See well log.
do	60[a]	160[a]	1/9/49	C,E	15	1/9/49	.3	.2	D	
do	50[a]	115[a]	8/12/50	J,E	12	8/12/50	.5	.2	D	
Ijamsville phyllite	60[a]	—	9/27/56	C,E	—	—	—	—	D	
Libertytown metarhyolite	25[a]	65[a]	4/27/47	J,E	5	4/27/47	.5	.1	D	Depth of pump jet 65 ft.
Silver Run limestone	55[a]	180[a]	4/21/52	C,E	11	4/21/52	.5	.1	D	Water reported encountered at 150 ft.
do	40[a]	190[a]	12/15/45	C,E	2	12/15/45	.7	<.1	D	Depth of pump pipe 190 ft.
do	45[a]	55[a]	4/3/52	?,E	11	4/3/52	.5	1.1	D	
Sams Creek metabasalt	10[a]	40[a]	11/20/53	NI	20	11/20/53	.5	.7	N	To be put into service later. Opening reported at 93–94 ft.
	3.84	—	3/29/55							
do	—	—	—	C,E	—	—	—	—	D	Goes dry at times.
Ijamsville phyllite	32[a]	57[a]	10/12/54	J,E	15	10/12/54	2.5	.6	D	
Sams Creek metabasalt	32[a]	—	2/26/53	J,E	12	2/26/53	—	—	D	See well log.
do	29[a]	—	3/2/53	J,E	10	3/2/53	—	—	D	
Wakefield marble	—	—	—	S,E	20	2/16/55	—	—	D	
do	20[a]	148[a]	11/5/49	C,E	5	11/5/49	7	<.1	D,F	Yielded 100 gpm for 15 min, then decreased to 5 gpm. Depth of pump pipe below 90 ft.
Sams Creek metabasalt	18.8	—	2/16/55	C,H; S,E	—	—	—	—	D	Adequate supply reported.
Wakefield marble	20[a]	—	8/10/46	C,E	20	8/10/46	.5	—	D	25-ft. dug well. Depth of pump pipe 25 ft.
Sams Creek metabasalt	—	—	—	N	2	1939	—	—	N	Drilled in "blue rock" for town of New Windsor. Destroyed because of poor yield.
do	—	—	—	S,E	—	—	—	—	D,F	Numerous small springs.
do	40[a]	90[a]	3/7/51	J,E	7	3/7/51	.5	.1	D	Depth of pump jet 75 ft.
Sams Creek metabasalt and Wakefield marble(?)	20[a]	20[a]	4/20/53	J,E	22	4/20/53	.5	—	D	Water reported hard. Depth of pump jet 50 ft.

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Cd 3	L. J. Bicker	Owings	1948	690	Drilled	80	6	79	Valley
Cc 4	R. E. Yingling	do	1953	675	do	125	6	115	Hillside
Cd 5	Mr. Hahn	do	1949	650	do	55	6	37	do
Cd 6	Mr. Nusbaum	do	1950	650	do	80	6	62	do
Cd 7	J. W. Owings	do	1946	740	do	70	6	31	Hilltop
Cd 8	Otts Levin	do	1947	700	do	54	6	40	Hillside
Cd 9	Mr. Myers	do	1950	735	do	76	6	22	Hilltop
Cd 10	G. C. Babcock	W. Hoffman	1953	805	do	76	6	19	do
Cd 11	H. L. Bair	Owings	1946	710	do	85	6	20	Hillside
Cd 12	Oscar Myers	do	1946	735	do	76	6	36	do
Cd 13	Paul Johnson	do	1947	765	do	57	6	23	Hilltop
Cd 14	Crown Central Petroleum Corp.	W. Hoffman	1953	600	do	55	6	53	Valley
Cd 15	Do	do	—	600	do	21.7	6	0	do
Cd 16	Thomas, Bennett, and Hunter, Inc.	Owings	1952	650	do	169	8	26	do
Cd 17	Stone Chapel Church	Utermahlen	1949	640	do	45	6	—	do
Cd 18	Babylon Vault Co.	Owings	1950	495	do	65	6	11	Valley flat
Cd 19	W. B. Royer	Hiner	1950	675	do	88	6	30	Hillside
Cd 20	Mr. Beacham	—	Old	610	Dug	65	48	—	do
Cd 21	Do	—	—	605	Spring	—	—	—	Draw
Cd 22	S. T. Statler	Hiner	1949	825	Drilled	70	6	—	Hillside
Cd 23	John Teeter Quarry	Kohl Bros.	1954	480	do	167	6	30	do
Cd 24	Uniformed Ranks, Knights of Pythias	W. Hoffman	1954	620	do	50	6	12	Valley
Cd 25	Denton Aldridge	Utermahlen	1949	610	do	40	6	—	Valley side
Cd 26	Crown Central Petroleum Corp.	Reichart	1954	600	do	94	6	74	Valley
Ce 1	Koontz Creamery	—	1943±	695	do	72	8	—	do
Ce 2	Do	Reider and Son	1947	695	do	160–166	12	—	do
							10	59	
			1955			850	10	25	
							6	182	

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Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Wakefield marble	8[a]	75[a]	6/16/48	J,E	100	6/16/48	5	1.5	D	Depth of pump jet 40 ft.
do	20[a]	120[a]	8/21/46	J,E	5	8/21/46	.5	<.1	D	Depth of pump jet 120 ft.
do	35[a]	40[a]	11/14/49	C,E	25	11/14/49	.5	5.0	D	
do	35[a]	75[a]	6/27/50	C,E	50	6/27/50	8	1.2	D	Depth of pump pipe 60 ft.
Wissahickon (albite)	25[a]	30[a]	8/26/46	J,E	20	8/26/46	.5	4.0	D	
do	20[a]	20[a]	6/21/47	J,E	20	6/21/47	5	—	D	Depth of pump jet 40 ft.
do	35[a]	56[a]	8/30/50	C,H (?)	20	8/3/50	5	.9	D	Depth of pump pipe 60 ft.
do	35[a] 52.38	35[a] —	6/17/53 9/29/53	NI	10	6/17/53	2	—	D	
do	18[a]	—	5/15/46	J,E	20	5/15/46	.25	—	D	Depth of pump jet 50 ft.±
do	35[a]	35[a]	12/24/46	J,E	20	12/24/46	.5	—	D	Depth of pump jet 65 ft.
do	30[a]	35[a]	5/12/47	J,E	30	5/12/47	.5	6.0	D	Depth of pump jet 50 ft.
Contact-Wakefield marble and Sams Creek metabasalt	15[a]	25[a]	6/28/53	N	20	6/28/53	3	2.0	N	Abandoned and destroyed because of muddy water.
do	12.10	—	9/29/53	N	0	9/—/53	—	—	N	May have been drilled deeper later. Abandoned and destroyed.
Wakefield marble	30[a]	40[a]	2/20/53	T,E	100	2/20/53	12	10.0	C	See chemical analysis. Depth of pump 100 ft.
Wissahickon (albite)	30[a]	30[a]	5/17/49	?,E	16	5/17/49	1	—	D	
Wakefield marble	20[a]	40[a]	4/24/50	C,E	100(?)	4/24/50	8	5(?)	C	See chemical analysis. Temperature May 12, 1954, 55°F.
Wissahickon (albite)	62[a]	—	11/25/50	?,E	3	11/25/50	—	—	D	
Ijamsville phyllite	15[a]	—	—	N	—	—	—	—	N	Poor yield reported, especially during summers. Reported water level is for winter months. Another dug well here also inadequate. Use spring Cd 21 for water supply.
Wakefield marble	—	—	—	—	20+	2/11/54	—	—	D,F	Continuous discharge reported. Ram pump. See chemical analysis.
Wissahickon (albite)	36[a]	43[a]	1/8/49	?,E	5	1/8/49	.5	.7	D	
Wakefield marble	28[a]	30[a]	3/23/54	C,H	40	3/23/54	2	20	C	Temperature Mar. 10, 1955, 54°F. See chemical analysis. Depth of pump pipe 75 ft.
Wissahickon (albite)	8[a]	25[a]	5/6/54	?,E	9	5/6/54	2	.5	I	
do	25[a]	25[a]	9/5/49	J,E	8	9/5/49	1	—	D	
Contact-Wakefield marble and Sams Creek metabasalt	—	—	—	J,E	—	—	—	—	C	
Wakefield marble	—	—	—	N	350–450	—	—	—	N	Crooked hole. Dry Sept. 2, 1955. Another well, 10 feet west, 8 inches in diameter, is plugged at 29 ft.
do	32[a] 42[a](?)	40[a] 109[a](?)	12/—/47 6/12/48	C,E T,E	200 575	1947 1948	10 72	25 8.9(?)	N	Former water-level observation well. In 1955 casing extended to 182 feet, and well deepened to 850 ft. Yielded only 7 gpm and was destroyed. See well log.
Wakefield marble and Sams Creek metabasalt	85[a]	250[a]	9/20/55	N	7	9/20/55	—	<.1		

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ce 3	Koontz Creamery	Reider and Son	1947	695	Drilled	116	10	61	Valley
Ce 4	Shriver Packing Co.	do	1938	695	do	885±	10–6	—	Hilltop
Ce 5	Shilling Bros., Inc.	Owings	1946	800	do	400	10	57	do
Ce 6	Do	—	—	800	do	—	6	—	do
Ce 7	Do	—	Before 1946	790	do	250	—	—	do
Ce 8	Do	—	—	785	do	100	8 or 6	—	do
Ce 9	Reese Volunteer Fire Dept.	W. Hoffman	1952	810	do	95	6	65	do
Ce 10	J. P. Gassman	R. H. Leppo	1950	790	do	95	6	75	do
Ce 11	Sandy Mount Church	Utermahlen	1950	750	do	88	6	—	do
Ce 12	F. L. Vogt, Jr.	R. H. Leppo	1951	700	do	62	6	50	do
Ce 13	Walter Hoffman	W. Hoffman	1953	860	do	64	6	20	Hillside
Ce 14	Margaret Murray	Utermahlen	1953	830	do	66	6	6	Hilltop
Ce 15	W. H. Davis Co.	Owings	1953	830	do	79	6	34	do
Ce 16	G. Merryman	—	—	715	do	29	6	—	Hillside
Ce 17	Mr. Williams	Owings	1942	825	do	132	6	18	Hilltop
Ce 18	M. L. Long	—	—	565	do	40	6	—	Valley
Ce 19	Mr. Naill	W. Hoffman	1954	755	do	97	6	84	Upland flat
Ce 20	Harvey Beard	Edwin Smith	1954	720	do	70	6	60	Hillside
Ce 21	Paul Cover	Sterner	1954	805	do	112	6	29	Hilltop
Ce 22	Ralph Cover	Owings	1953	805	do	265	6	19	do
Ce 23	Mr. Magsamen	—	—	650	do	58	6	—	Hillside
Ce 24	R. L. Long	—	Before 1918	620	Dug	21	60	—	Valley side
Ce 25	Mr. Rose	Reichart	1952	680	Drilled	81	6	12.5	Hillside
Ce 26	R. L. Long	—	Old	680	Dug	49	48 or 60	—	do
Ce 27	Roger Hollenbaugh	Utermahlen	1946	840	Drilled	90	6	—	Hilltop
Ce 28	R. V. Peterson	R. H. Leppo	1952	845	do	130	6	24	Hillside
Ce 29	Ridge Drive-In Theatre	Kyker	1954	860	do	94	6	46	Draw
Ce 30	H. F. Green	W. Hoffman	1949	880	do	60	6	57	Upland flat

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Wakefield marble	24[a] 42[a](?)	29[a] 109[a](?)	8/—/47	C,E	200 540	1947 1948	10 72	40 8.9(?)	C	40 H.P., 500 gpm. pump. See well log.
Sams Creek metabasalt, Wakefield marble and/or Wissahickon (albite	—	—	—	T,E	500	—	—	—	C	Operated during summer and early fall only. Pumps intermittently after operating a few hours. Ten-inch hole to about 150 ft. Depth of pump 150 ft.
Wissahickon (albite)	40[a]	150[a]	5/6/46	T,E	40	5/6/46	4	.4	C	40 gpm yield measured when 300 ft. deep; additional water reported encountered in 300–400 ft. interval. Yields only 6 gpm at present, but may be pump trouble.
do	63.91	—	10/27/54	C,E	—	—	—	—	C,D	Supplies office and a residence.
do	—	—	—	C,E	—	—	—	—	C	Reported to supply most of the water for cannery. Depth of pump pipe 100 ft.±.
do	—	—	—	C,E	—	—	—	—	C	Supplies cooling water for cannery. Water is returned to the well.
do	50[a] 65.45	55[a] —	6/11/52 10/25/54	C,E C,E	8+	6/11/52	2	1.6+	D	
do	50[a]	—	10/28/50	C,E	5	10/28/50	2	—	D	
do	17[a]	17[a]	7/20/50	—,E	15	7/20/50	1	—	D	
do	50[a]	—	10/11/51	J,E	15	10/11/51	1	—	D	
do	14[a]	35[a]	4/1/53	J,E	10	4/1/53	2	1.0	D	
do	20[a]	20[a]	8/24/53	?,E	12	8/24/53	1	—	D	
do	40[a]	45[a]	1953	C,E	22	1953	.5	4.4	C	Depth of pump pipe 65 ft.
do	6.21	—	10/26/54	C,H	—	—	—	—	D	
do	75[a]	110[a]	9/20/47	C,E	5	9/20/47	.5	.1	D	
do	2–6[a]	—	—	J,E	—	—	—	—	C,D	Encountered rock at 36 ft. Water level reported to fluctuate between 2 and 6 ft. below land surface.
do	45[a]	95[a]	4/13/54	?,E	3	4/13/54	2	<.1	D	
Sams Creek metabasalt	40[a]	50[a]	8/21/54	J,E	—	—	—	—	D	Depth of pump jet 57 ft.
Wissahickon (albite)	41[a]	—	5/6/54	J(?), E	2	5/6/54	—	—	D	
do	40[a]	260[a]	6/2/53	J,E	11	6/2/53	.75	<.1	D	Driller estimates constant yield of 5 gpm.
do	—	—	—	C(?), E	—	—	—	—	D	
do	18–27	—	10/29/54	N	—	—	—	—	N	Reported adequate, but not used because water is hard.
do	—	—	—	C,H	—	—	—	—	D	
do	46.30	—	10/29/54	N	—	—	—	—	N	Formerly used by a tannery.
do	60[a]	60[a]	7/5/46	J(?),E	12	7/5/46	1	—	D	
do	100[a] 61.16	— —	12/9/52 11/5/54	C,E	1	12/9/52	1	—	D	
do	35[a]	35[a]	4/25/54	—	30	4/25/54	4	—	C	
do	20[a]	40[a]	11/2/49	C,E	5	11/2/49	4	.2	D	

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ce 31	C. H. Gist	Owings	1947	880	Drilled	48	6	12	Upland flat
Ce 32	W. H. Herbert	do	1951	885	do	125	6	26	Hilltop
Ce 33	G. W. Bullock	do	1954	875	do	106	6	55½	Hillside
Ce 34	C. W. Saylor	do	1946	825	do	125	6	25	Hilltop
Ce 35	Carroll Owings	do	1946	860	do	90	6	20	do
Ce 36	Mr. Frick	—	Old	870	Dug	67	48	—	do
Ce 37	G. B. Price	W. Hoffman	1953	725	Drilled	72	6	70	Upland flat
Ce 38	Carl Hoff	—	—	725	do	67.5	6	—	Valley
Ce 39	J. T. Forney	—	Before 1939	810	Dug and Drilled	60	48 and 6	—	Hillside
Ce 40	Koontz Creamery	—	—	695	Drilled	325±	12, 10, and 8	300	Valley
Ce 41	Do	—	—	695	do	320	8	8-9	do
Ce 42	Do	—	—	695	do	822	8	8	do
Ce 43	Do	—	—	695	do	75-120	—	—	do
Ce 44	Albaugh and Babylon Grocery Co.	Owings	1951	720	do	255	6	255	Hillside
Ce 45	Dutterer's Nursery	do	1946	725	do	140	8	90	do
Ce 46	George Bollinger	—	—	730	Spring	—	—	—	Valley
Ce 47	Robert L. Long	—	—	630	do	—	—	—	do
Ce 48	Mr. Long	—	—	620	do	—	—	—	do
Ce 49	William F. Myers & Sons	Owings	1946	750	Drilled	200	8	92	Hillside
Cf 1	Congoleum-Nairn, Inc.	R. H. Leppo	1948	605	do	68	6	35	do
Cf 2	Norman Barrick	—	Old	490	Dug	20	48	—	Valley

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Wissahickon (albite)	15[a]	15[a]	7/10/47	J,E	20	7/10/47	.5	—	D	Depth of pump jet 40 ft.
do	75[a]	75[a]	6/11/51	J(?),E	10	6/11/51	.5	—	D	
do	45[a]	50[a]	7/6/54	?,E	5	7/6/54	.5	1.0	D	
do	45[a]	100[a]	1/7/46	?,E	15	1/7/46	.5	.5	D	
do	45[a]	65[a]	9/5/46	J,E	20	9/5/46	.25	1.0	C,D	Depth of pump jet 80 ft.
do	65.25	—	11/9/54	J,E; C,H	—	—	—	—	D	Yield reported decreases greatly during dry spells.
do	35[a]	60[a]	9/24/53	J(?),E	5	9/24/53	2	.2	D	
do	9.29	—	11/9/54	J,E	—	—	—	—	D,F	
do	24[a]	—	—	J,E	—	—	—	—	D	Adequate; reported will discharge about 100 gallons before yield begins to decrease. Dug well to rock at 30 ft. Drilled through bottom to 60 ft.
Sams Creek metabasalt and Wakefield marble	—	—	—	N	0	—	—	—	N	Blue muck reported for entire depth.
do	—	—	—	N	45	—	—	—	N	Covered by cement walk but not filled in.
do	—	—	—	N	8	—	—	—	N	Covered by creamery concrete floor but may not be filled. Mostly white material (marble) encountered; some blue (volcanic schist).
do	—	—	—	N	—	—	—	—	N	This record for 5 or 6 wells drilled north of creamery. No good aquifer encountered; mostly muck or stiff, brown clay. Destroyed.
Wissahickon (albite)	60[a] 62.34	230[a] —	6/6/51 1/4/56	C,E	6	6/6/51	8	<.1	D,F	Reported backfilled with cement to 237–240 feet. Sounding weight stopped at 215 ft. Casing perforated from 80–100 ft. See well log.
do	—	—	—	T,E	300±	—	—	—	C,F	Reported "3-inch stream" of water was pumped for 7 hours with a decline of water level to 50 ft. "Shale and blue slate" encountered.
do	—	—	—	N	.5	11/9/54	—	—	D	Supplies home and fish and duck pond. Continuous flow reported. Concrete collecting chamber.
do	—	—	—	S,E	10	10/29/54	—	—	D	Iron deposit in collecting chamber; reported clogs plumbing.
do	—	—	—	S,E	5±	10/25/54	—	—	D	Adequate.
Wakefield marble and Sams Creek metabasalt	55[a]	100[a]	1/21/46	T,E	150	1/21/46	6	3.3	C	Meat packing plant. Depth of pump 140 ft. See well log.
Wissahickon (albite)	30[a]	—	7/9/48	J,E	35	7/9/48	6	—	D	Club house.
do	—	—	—	J,E	—	—	—	—	D	Adequate supply reported.

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Cf 3	Redmen's Hall	Kyker	1954	480	Drilled	42	6	18.5	Valley side
Cf 4	Kenneth Long	W. Hoffman	1954	630	do	40	6	14	do
Cf 5	Henry Miller	Kyker	1954	665	do	78	6	34	Hilltop
Cf 6	Paul Welsh	R. H. Leppo	1950	745	do	68	6	65	Upland flat
Cf 7	Raymond Buckman	—	Before 1900	730	do	—	6	—	Draw
Cf 8	Do	H. R. Leppo	1946	730	do	30	6	23	do
Cf 9	Claude Armacost	R. H. Leppo	1951	590	do	80	6	10	Hilltop
Cf 10	Dr. M. E. Shamer	do	1952	700	do	90	6	25	Hillside
Cf 11	Congoleum-Nairn, Inc.	H. R. Leppo	1945	430	do	200–215	6	12(?)	Valley
Cf 12	Do	do	1945	450	do	244	6	78	do
Cf 13	Do	do	1946	515	do	145	6	20	Hillside
Cf 14	Do	do	1946	430	do	325	6	17	Valley
Cf 15	Dr. M. E. Shamer	—	—	790	Spring	—	—	—	Draw
Cf 16	Wesley Chapel	Millender	1933	710	Drilled	72	6	33	Hillside
Dc 1	B. F. Shriver Co.	Reichart	1953	710	do	99.5	6	—	do
Dc 2	W. E. Wright	D. Brown	1951	825	Drilled	80	6	—	do
Dc 3	Mr. Norwood	—	—		Dug	24	48	—	do
Dc 4	Preston Wright	W. Hoffman	1948	805	Drilled	62	6	46	Upland flat
Dc 5	Mr. Lovell	—	—	835	—	110	6	—	Hilltop
Dc 6	Moore's Service Station	—	1947	805	Dug and Drilled	48	48 and 6	—	Upland flat
Dc 7	Albert A. Franklin	Thompson	1955	840	Drilled	149	5⅝	23	Hilltop
Dc 8	Do	Easterday	1956	840	do	80	6	22	do
Dd 1	Winfield Elementary School	—	1938±	855	do	189 or 300	6	—	Hillside
Dd 2	Do	—	1935±	865	do	143 or 180±	6	—	Hilltop
Dd 3	E. A. Barnes	Owings	1949	850	do	335	6	—	Hillside
Dd 4	Do	E. Brown	1953	850	do	103	6	—	do
Dd 5	Do	—	—	850	do	75	6	—	do
Dd 6	Harry Guy	Owings	1946	725	do	42	6	36	Valley
Dd 7	R. C. Heinz	R. H. Leppo	1948	745	do	100	6	80	Hilltop
Dd 8	R. Kontz	Utermahlen	1951	730	do	56	6	—	Hillside
Dd 9	Zion Methodist Church	Hiner	1950	790	do	205	6	20	Hilltop

—*Continued*

Water-bearing formation	Water level (feet below land surface) Static	Pumping	Date	Pumping equipment	Yield Gallons per minute	Date	Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
Wissahickon (albite)	8[a]	8[a]	9/7/54	J(?),E	15–20	9/7/54	3	—	D	
do	11[a]	22[a]	5/27/54	C,H	9	5/27/54	1	.8	D	
do	25[a]	70[a]	5/26/54	?,E	8	5/26/54	3.5	.1	D	
do	40[a]	120[a]	1/27/50	?,E	8	1/27/50	1	—	D	
do	—	—	—	C,E	—	—	—	—	D,F	Good supply reported.
do	10±[a]	30[a]	8/—/46	C,E	10	8/—/46	—	.5±	D	
do	30[a]	—	7/9/51	C,E	8	7/9/51	2	—	D	
do	60[a]	—	2/16/52	J,E	8	2/16/52	2	—	D	
	35.25	—	11/8/54							
Peters Creek quartzite	9.5[a]	—	7/—/45	J,E	85–100	7/—/45	3–12	—	C	Rock at 10 ft.(?). Temperature measured Aug. 1945, 54°F. Used for drinking and air conditioning. See well log. Depth of pump jet 100 ft.
Wissahickon (albite)	3.5[a]	244[a]	11/—/45	N	12	11/—/45	12	—	N	Heaving sand reported above 78 ft.
	6.87	—	3/17/55							
do	44.5[a]	145	3/—/46	N	35	3/—/46	12	—	N	
	48.28	—	3/17/55							
Peters Creek quartzite	10[a]	325[a]	8/—/46	N	15	8/—/46	—	—	N	
	4.25	—	3/17/55							
Wissahickon (albite)	—	—	—	N	2	11/8/54	—	—	F	Spring at head of draw. Gravity flow to rock-lined collecting basin.
do	50[a]	52[a]	Old	C,E	9.5	Old	—	4.7	D	
	30.95	—	11/9/54							
do	20[a]	—	1/2/53	J,E	—	—	—	—	D	See well log.
Marburg schist	50(?)[a]	—	11/12/51		5	11/12/51	25	—	D	
do	3.30	—	8/30/55	C,E	—	—	—	—	D	Adequate supply reported.
do	22[a]	22[a]	7/13/48	?,E	18	7/13/48	2	—	D	
do	80±[a]	—	2/—/55	—	—	—	—	—	D	Water level usually about 50 ft. reported.
do	—	—	—	C,E	—	—	—	—	C	Dug well 28 ft.
do	90[a]	151[a]	8/19/55	N	.5	8/19/55	.5	—	N	Inadequate.
	88.16	—	8/24/56							
do	35[a]	50[a]	8/31/56	NI	10	8/31/56	—	.7	D	
do	—	—	—	C,E	3.5	7/19/54	1	—	I	See chemical analysis.
do	58.16	—	9/16/53	C,N	—	—	—	—	N	Not used because of poor yield. Water-level observation well.
do	60[a]	335[a]	1/12/49	N	—	—	—	—	N	Practically a dry hole. Destroyed.
do	40[a]	—	9/1/53	C,E	12±	9/1/53	—	—	D	
do	—	—	—	?,E	—	—	—	—	D	Adequate supply reported.
do	12[a]	15[a]	11/19/46	J,E	20	11/19/46	.5	7.0	D	
Wissahickon (albite)	60[a]	—	7/19/48	J(?),E	15	7/19/48	8	—	D	
do	40[a]	—	6/17/51	C,H	6	6/17/51	1	—	D	
do	62[a]	—	12/23/50	J,E	1	12/23/50	—	—	D	Two dry holes were drilled here before this well. Pumps air with water; inadequate.

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Dd 10	William Muller	—	Old	780	Dug	51	60	—	Hilltop
Dd 11	Joseph Abell	—	Before 1930	745	do	65–75	36	—	Hillside
Dd 12	D. W. Caples	—	do	700	do	22–23	42	—	Valley side
Dd 13	Mr. Yohn	—	Old	775	Drilled	85	6	—	Hillside
Dd 14	Raymond Gist	D. Brown	1956	770	do	103.	6	36	Draw
Dd 15	George V. Kelly	Owings	1955	820	do	78	6	60	Hilltop
Dd 16	William Boone	do	1955	830	do	102	6	24	do
Dd 17	Charles R. Beck	—	—	660	Dug	47	—	—	Hillside
Dd 18	F. L. Goldeisen	Frounfelter	1956	825	Drilled	65	6	24	Hilltop
Dd 19	Paul Flickinger	Hoffman	1951	600	do	70	5⅝	12	Hillside
Dd 20	Albert K. Belt	S. Smith	1931	740	do	52	6	—	do
De 1	Eldersburg School	Owings	1954	620	do	180	6 or 8	—	do
De 2	Robert Rill	H. R. Leppo	1947	640	do	132	6	107	Upland flat
De 3	Calvary Methodist Church	J. B. Edmondson	1948	625	do	40	5⅝	—	Hilltop
De 4	Gamber School	Owings	1947 and 1948	630	do	161	6	102	Hillside
De 5	James N. Stansfield	R. H. Leppo	1952	705	do	95	5⅝	92	Hilltop
De 6	Frank Colbeck	J. B. Edmondson	1950	590	do	50	5⅝	—	do
De 7	Mr. Christ	—	—	560	do	90	6	—	do
De 8	Raymond S. Gorsuch	Owings	1946	630	do	68	6	43	do
De 9	Do	—	Old	630	Dug	50	48	—	do
De 10	Do	—	—	635	Spring	—	—	—	Draw
De 11	James D. Clise	Hiner	1950	790	Drilled	100	6	32	Hilltop
De 12	Do	Stern and Frounfelter	1955	790	do	76	8	12	do
De 13	Do	Frounfelter	1955	790	do	144	8 and 6	4.7	do

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Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Wissahickon (albite)	59.2	—	2/9/55	C,E	—	—	—	—	D	Yields practically no water.
do	50.60	—	2/9/55	C,H	—	—	—	—	D	Adequate supply. Water reported somewhat irony.
do	18.71	—	2/9/55	C,H	—	—	—	—	D	Soft material encountered for entire depth. Adequate supply. Depth of pump pipe 21 ± ft.
do	67±	—	7/16/54	J,E	—	—	—	—	D	Filled with sediment to 75 ft.
do	60[a]	80[a]	4/20/56	J,E	6	4/20/56	.5	.3	D	
	47.67	—	8/24/56							
do	35[a]	70[a]	7/9/55	J,E	6	7/9/55	.5	.1	D	A well drilled 75 ft. away to a depth of 240 ft. yielded no water. Depth of pump jet 70 ft.
do	40[a]	80[a]	4/28/55	J,E	17	4/28/55	5	.4	D	2 gpm obtained at 50 ft. 15 gpm at 80–102 ft.
do	41.11	—	11/5/56	C,E	—	—	—	—	F	Water-level observation well.
do	40[a]	—	12/1/56	N1	15	12/1/56	2	—	D	
do	30[a]	60[a]	6/18/51	J,E	6	6/18/51	2	.2	D	
do	22[a]	—	—	C,E	5	—	—	—	D,F	
Peters Creek quartzite	35[a]	110[a]	2/26/54	T,E	19	2/26/54	0.5	0.3	I	See well log and chemical analysis. Depth of pump 160 ft.
Wissahickon (albite)	25[a]	—	4/12/47	J,E	15	4/12/47	1	—	D	
do	5[a] (?)	10[a] (?)	10/27/48	—	20	10/27/48	2	4	D	
do	30[a]	40[a]	9/6/47	C,E	25	9/6/47	.5	2.5	I	Temperature Mar. 9, 1955: 55°F. Originally drilled to 125 ft.; lower 60 ft. of casing perforated; sandy water. Deepened in 1948 to 161 ft., unperforated casing installed; water clear but yield less. See well log and chemical analysis.
	25[a]	150[a]	9/23/48		13	9/23/48	8	.1		
do	50[a]	—	6/2/52	J,E	12	6/2/52	2	—	D	
	57.65	—	10/8/54							
Peters Creek quartzite	—	—	—	J,E	10	5/11/50	1	1(?)	D	
Wissahickon (albite)	—	—	—	J,E	—	—	—	—	D	Adequate
do	35[a]	54[a]	1/1/46	C,H	20	1/1/46	.5	1	D	
do	—	—	—	N	—	—	—	—	N	Inadequate; destroyed.
do	—	—	—	N	—	—	—	—	N	Collecting chamber lined with fieldstone. Small discharge.
do	27[a]	—	8/26/50	N	2	8/26/50	—	—	N	Originally drilled to 335 ft.; no water below 100 ft.; backfilled to 100 ft.
do	—	—	—	J,E	.3	3/16/55	—	—	D	Originally 6 in. diameter. Redrilled to 8 in. diameter but no increase in yield (20 gal. per hour). See chemical analysis.
do	32.09	—	2/8/55	N	See Remarks	2/—/55	—	—	N	Yield of 30 gal. per day reported. Diameter 6 in. below 16 ft.
	23.80	—	3/16/55							

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Dc 14	Robert C. Shipley	Kyker	1955	715	Drilled	84	6	19(?)	Draw
Dc 15	Charles Mitten	R. H. Leppo	1947	645	do	78	6	—	Upland flat
Dc 16	Mr. Babel	—	Old	660	Dug and drilled	72	48 and 6	—	Hilltop
Dc 17	Do	—	—	660	Drilled	52	6	—	do
Df 1	Raymond Green	E. Smith	1954	580	do	60	6	18	do
Df 2	Robert Wiley	W. Hoffman	1954	510	do	50	$5\frac{5}{8}$	9	do
Df 3	Donald Roten	R. H. Leppo	1951	555	do	60	$5\frac{5}{8}$	48	do
Df 4	Robert Roten	do	1949	570	do	68	6	12	do
Df 5	Howard E. Bonner	Utermahlen	1952	600	do	79	6	20	do
Df 6	Baltimore Bureau of Water Supply	—	—	390	do	89	6	40±	Valley side
Df 7	Do	—	—	420	Spring	—	—	—	do
Df 8	Do	John W. Edmondson	1941	340	Drilled	156	8	—	Valley side
Ec 1	William Rigler	Easterday	1951	790	do	105	6	—	Hilltop
Ec 2	John Lettieri	do	1951	780	do	68	6	—	Hillside
Ec 3	Harry E. Reaver	D. Brown	1951	740	do	55	6	10	do
Ec 4	E. T. Loque	Easterday	1951	760	do	93	6	—	Hilltop
Ec 5	Charles Jones	E. Brown	1952	815	do	95	6	24	do
Ec 6	Henry C. Krantz	—	Old	645	do	59	6	—	Hillside
Ec 7	Do	Frounfelter	1955	650	do	70	6	31	do
Ec 8	Gordon H. Davis	Easterday	1955	570	do	129	6	10	do
Ec 9	Watersville Methodist Church	E. Brown	1955	580	do	41	6	30	Valley side
Ec 10	E. F. Hartmann	—	—	570	Spring	—	—	—	do
Ec 11	A. J. Marock	—	1940	735	Drilled	71	6	25	Hilltop
Ec 12	Leroy Welsh	—	1940	725	do	110	6	20	Hillside
Ed 1	Killian-Colbert Canning Co.	—	—	440	do	100±	6	20	Valley side
Ed 2	Do	—	—	460	do	100±	6	30	do
Ed 3	Do	—	1922	430	do	75	6	—	do
Ed 4	Do	Ault	1949	430	do	176–179	6	8	do
Ed 5	Russell Gosnell	E. Brown	1953	805	do	76	6	24	Hilltop
Ed 6	Clarence Conaways	D. Brown	1956	750	do	80	6	22	Upland flat
Ed 7	Edward H. Blanker	Trumpower	1956	650	do	80	6	40	Hillside

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Wissahickon (albite)	—	—	—	J,E	3	6/24/54	3	.15	D	
do	—	—	—	C,E	6	8/5/47	1	—	D	
do	—	—	—	J,E; C,H	—	—	—	—	D	Dug well to 42 feet; drilled through bottom to 72 ft. Dug well was inadequate and yielded muddy water.
do	31±	—	3/9/55	C,E	—	—	—	—	D	Depth reported 92 ft., measured 52 ft. Well may be destroyed.
do	20[a] 47.00	30[a] —	8/—/54 11/14/54	NI	10	8/—/54	—	1	D	
Peters Creek quartzite	20[a] 25.30	— —	6/21/54 10/14/54	J,E	7	6/21/54	1.5	—	D	
do	40[a]	—	7/6/54	J,E	15	7/6/51	2	—	D	
do	38[a]	—	3/24/49	J,E	15	3/24/49	1	—	C	Filling station.
Wissahickon (albite)	40[a]	—	6/14/52	—	10	6/14/52	1	—	D	
Peters Creek quartzite	21.37	—	10/18/54	N	—	—	—	—	N	Abandoned home; now flooded by Patapsco Reservoir.
Sykesville	—	—	—	N	.2	10/18/54	—	—	N	Now flooded by Patapsco Reservoir. Temperature Oct. 19, 1954, 53°F.
Peters Creek quartzite	—	—	—	N	12	—	—	—	N	Site of a woolen mill inundated by Patapsco Reservoir.
Marburg schist	30[a]	65[a]	3/1/51	—	6	3/1/51	.5	.17	D	See well log.
do	32[a]	—	1/30/51	J,E	2	1/30/51	—	—	D	
do	35[a]	—	5/28/51	—	3	5/28/51	.5	—	D	
Sams Creek metabasalt	25[a]	93[a]	7/25/51	J,E	2	7/25/51	—	<.1	D	
Marburg schist	55[a]	88[a]	4/21/55	?,E	5	4/21/55	1	.1	D	
do	35.09	—	8/24/56	C,E	—	—	—	—	D	
do	39[a]	50[a]	8/20/55	J,E	22	8/20/55	—	2.0	F	
Wissahickon (albite)	48[a]	129[a]	10/21/55	J,E	5	10/21/55	—	—	D	
Marburg schist	—	—	—	J,E	3.3	3/—/55	—	—	D	
do	—	—	—	S,E	3	4/5/55	—	—	D	Continuous flow reported.
Wissahickon (albite)	35[a]	—	11/29/56	C,E	—	—	—	—	D	Adequate supply.
do	40.71	—	11/29/56	C,E	—	—	—	—	D,F	
Peters Creek quartzite	—	—	—	C,E	35	—	—	—	D	Reported to pump water for 4 hrs., then pumps air. Cannery idle. Well supplies a few homes nearby.
do	—	—	—	T,E	20	—	—	—	N	Reported to pump air after operating a while.
do	—	—	—	N	—	—	—	—	N	Formerly equipped with 30 gpm pump. Failed during 1930 drought. Plugged with debris.
do	8[a]	85[a]	7/—/49	C,E	5.3	7/—/49	10	<.1	N	Reported water-bearing zones: 76 ft., 105 ft., 151 ft.
Wissahickon (albite)	45[a] 37.17	63[a] —	5/7/53 9/16/53	J,E	5	5/7/53	.5	.3	D	
do	50[a]	60[a]	8/15/56	NI	6	8/15/56	.5	.6	D	
do	45[a]	48[a]	4/17/56	J,E	20	4/17/56	—	6.7	D	

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ed 8	Robert H. Mercer, Jr.	E. Brown	1956	625	Drilled	72	6	28	Valley flat
Ed 9	W. A. Cosley	—	Old	750	do	82	—	—	Hillside
Ed 10	Herbert Kessler	All Md. Pump and Well Co.	1956	590	do	64	5⅝	11.5	do
Ed 11	George Learmouth	Easterday	1953	835	do	107	6	0	Upland flat
Ed 12	John W. Duvall	do	1952	770	do	65	6	10.5	Hilltop
Ed 13	Ralph L. Pickett	D. Brown	1955	745	do	73	6	18	Upland flat
Ed 14	Noah Hatfield	S. Smith	1928	600	do	70	6	—	Hillside
Ed 15	Do	—	—	600	Dug	45	36	—	do
Ed 16	Do	—	—	570	Spring	—	—	—	Valley flat
Ee 1	Howard County Farmers Coop., Inc.	E. Brown	1947	450	Drilled	90	6	38	Hillside
Ee 2	State Roads Commission	—	—	390	do	97.8	6	—	Valley
Ee 3	Mrs. Mullinix	Owings	1947	635	do	65	6	31	Hilltop
Ee 4	Do	do	1950	635	do	100+	6	—	do
Ee 5	Gilbert Gardner	Williams	1950	645	do	67	5⅝	51	do
Ee 6	Harry Devries	Owings	1950	645	do	100	6	23½	do
Ee 7	William S. Widerman	Williams	1951	500	do	32	6	14	Valley side
Ee 8	Floyd A. Conaway	E. Brown	1951	525	do	56	6	24	Hillside
Ee 9	Do	—	—	525	do	60±	6	—	do
Ee 10	J. F. Gassaway	Edmondson(?)	—	590	do	45	6	—	Draw
Ee 11	C. W. Adams	—	—	590	Spring	—	—	—	Valley side
Ee 12	William H. Frankton	Williams	1949	620	Drilled	60	5⅝	41	Upland flat
Ee 13	Springfield State Hospital	Schultz	1911–15	490	do	500–505	8–6	—	Hillside
Ee 14	Do	O'Donovan	1897	490	do	140	—	—	—
Ee 15	Do	Schultz	1911–15	490	do	507–550	8–6	—	Hillside
Ee 16	William T. Fleming	Easterday	1952	575	do	45	6	11	Valley side
Ee 17	I. R. Zeltman	—	—	510	Dug	24±	—	—	Hillside
Ee 18	Do	—	—	560	Drilled	93±	6	—	Hilltop
Ee 19	W. W. Schwartz	—	—	630	do	?	—	—	Hillside
Ee 20	Flohrville Methodist Church	—	—	600	do	32	6	—	Hilltop
Ee 21	A. R. Rhuebottom	D. Brown	1956	620	do	71	6	15	do

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Wissahickon (albite)	60[a]	80[a]	3/10/56	J,E	10	3/10/56	1	.5	D	
do	37.53	—	8/24/56	C,H	—	—	—	—	N	Reported inadequate.
do	30[a]	—	5/5/56	J,E	25	5/5/56	2	—	D	
do	30[a]	107[a]	11/14/53	J,E	5	11/14/53	—	<.1	D	
do	26[a]	48[a]	6/19/52	J,E	7	6/19/52	—	.3	D	
do	40[a]	60[a]	10/31/55	J,E	4	10/31/55	.5	.2	D	
do	35[a]	—	—	C,E	8	—	—	—	F	Water reported at 40 ft.
do	43.00	—	11/29/56	N	—	—	—	—	N	Inadequate supply.
do	—	—	—	S,E	—	—	—	—	D	Adequate. Concrete-ring collecting basin.
Sykesville	10[a]	32[a]	3/14/47	J,E	25	3/14/47	10	1.1	C	Used chiefly for refrigerator compressors. Pump capacity 25 gpm.
do	14.82	—	4/29/55	J,E	—	—	—	—	D	Garage.
Peters Creek quartzite	30[a]	35[a]	8/7/47	J,E	22	8/7/47	.5	4.4	D	Became inadequate in 1950; well Ee 4 drilled as supplementary supply. Depth of pump jet 55 ft.
do	—	below 63	10/19/54	J,E	—	—	—	—	D	Pump operating when water level measured.
do	30[a]	45[a]	7/27/50	?,E	2	7/27/50	5	.14	D	
do	45[a]	50[a]	3/24/50	J,E	20	3/24/50	.5	4	D	See log.
do	20[a]	24[a]	5/2/51	J,E	8	5/2/51		2	D	
Sykesville	22[a]	—	5/8/51	J,E	6	5/8/51	1	—	D	Iron-treatment unit.
do	13.08	—	10/20/54	J,E	—	—	—	—	D,F	Supplies tenant home and barns. Iron-treatment unit.
Wissahickon (albite)	—	—	—	C,H	—	—	—	—	D	Reported adequate, good quality.
Peters Creek quartzite	—	—	—	S,E	—	—	—	—	D,F	Supplies two homes and cattle.
Sykesville or serpentine	25[a]	40[a]	9/20/49	J,E	4	9/20/49	5	.3	D	
Sykesville	16±	—	3/23/55	—	22.5–50	—	—	—	N	Airlift pump. Combined capacity of Ee 13 and Ee 15 estimated 100,000 gallons per day by power-plant superintendent.
do	40[a]	—	—	N	40	—	—	—	N	Exact location unknown.
do	17[a]	—	—	—	22.5–60	—	—	—	N	Airlift pump.
metagabbro	10[a]	45[a]	3/25/52	J,E	3	3/25/52	—	—	D	Adequate.
	13.31	—	10/19/54	J,E						
Peters Creek quartzite	21.37	—	11/5/56	—	—	—	—	—	D	
do	56.50	—	11/5/56	N	—	—	—	—	N	
Wissahickon (albite)	—	—	—	C,E	—	—	—	—	D	
Sykesville	23.26	—	11/29/56	C,H	—	—	—	—	D	Water-level observation well.
Peters Creek quartzite	40[a]	50[a]	9/20/56	J,E	6	9/20/56	2	.6	D	

TABLE 25

Well number (Car-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ee 22	A. R. Rhuebottom	—	—	580	Drilled	66	6	—	Hillside
Ee 23	Prentis W. VanSant	Driver	1956	625	do	71	6	46	do
Ee 24	Carlton Poff	Thompson	1956	625	do	80	6	22	Hilltop
Ee 25	Herman Manahan	Easterday	1954	555	do	75	6	40	do
Ef 1	Wilbur Trott	—	Before 1940	520	Dug	25	48	—	do
Ef 2	Mr. Shervette	—	1940	515	Dug and drilled	56	48–6	—	do
Ef 3	Mr. O'Donnell	—	Before 1940	516	Drilled	75±	6	—	do
Ef 4	Mr. Erb(?)	—	1950–51	515	do	30–40	6	—	do
Ef 5	Mr. Trott	—	—	515	Dug	—	48	—	do
Ef 6	Mr. Merman	—	—	515	Drilled	80	6	—	do
Ef 7	Edward F. Wilson	Williams	1949	505	do	65	6	48	do
Ef 8	Mose Kaphrin	do	1951	535	do	84	6	56	do
Ef 9	J. P. Clark	J. B. Edmondson	1948	560	do	75	$5\frac{5}{8}$	—	do
Ef 10	John M. Schmidt	J. R. Edmondson	1951	565	do	82	6	50	do
Ef 11	John W. Williams	Williams	1950	595	do	164	6	46	do
Ef 12	Do	do	1954	540	do	46	6	—	Draw
Ef 13	Patapsco State Park	Tawney	1956	450	do	178	6	57	Hillside
Ef 14	Do	Shultz	—	460	do	95	6	—	do

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Peters Creek quartzite	43.29	—	11/29/56	C,H	—	—	—	—	D	Water-level observation well 1956–57.
do	41[a]	66[a]	5/28/56	J,E	5	5/28/56	.5	.2	D	
do	52[a]	60[a]	5/5/56	J,E	12	5/5/56	2	1.5	D	
Sykesville	42[a]	50[a]	7/3/54	J,E	8	7/3/54	—	1.0	D	
do	24.65	—	11/9/53	S,E	—	—	—	—	D	Inadequate at times. Depth of pump pipe 24.8 ft.
do	21.65	—	11/9/53	J,E	—	—	—	—	D,C	Dug well 21.5 ft. deep with water level at 21.0 ft.; drilled through bottom to depth of 56 ft. Water level in drilled well measured while recovering after pumping. Dug well yield inadequate. Depth of pump jet 23.5 ft.
do	30.54	—	11/9/53	J,E	—	—	—	—	D	Adequate supply reported.
do	—	—	—	J,E	—	—	—	—	D	Do
do	—	—	—	?,E	—	—	—	—	D	Do
do	—	—	—	J,E	—	—	—	—	D	Do
Peters Creek quartzite	38[a]	43[a]	9/5/49	C,E	10+	9/5/49	4	2+	D	Greenish color of water reported; corrected by treatment unit.
do	59[a]	73[a]	4/17/51	?,E	4	4/17/51	3	.3	D	
Sykesville	35[a]	40[a]	4/26/48	—	30	4/26/48	1	6	D	
do	35[a]	—	6/1/51	J,E	10	6/1/51	1	—	D	
Peters Creek quartzite	78[a]	85[a]	1/14/50	J,E	5	1/14/50	4	.7	D	See well log.
do	—	—	—	NI	—	—	—	—	D	Incomplete; poor yield; to be drilled deeper.
Baltimore gneiss	58[a]	145[a]	2/24/56	J,E	4	2/24/56	8	<.1	D	
do	—	—	—	J,E	12	—	—	—	D	To be destroyed.

TABLE

Records of Wells and

Water level: Reported water levels designated by "a".
Pumping equipment: Method of lift: B, bucket; C, cylinder; J, jet; N, none; NI, to be installed; S, suction; T, turbine.
Type of power: E, electric motor; H, hand; W, windmill; G, gasoline engine.
Use of water: C, commercial or industrial; D, domestic; F, farming; I, school, institution, or camp; N, none; P, public supply.

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ad 1	Frederick County Roads Comm.	—	—	1,140±	Spring	—	—	—	Hillside
Ad 2	Richard M. Fox	Funt	1954	1,240	Drilled	36	5⅝	35	Draw
Ad 3	Vaughan W. Waynant	Rock	1950	1,050	do	130	5⅝	33	Hillside
Ad 4	James Weamirt	Keyser	1951	1,130	do	86	6	45	Valley side
Ad 5	Alvin Anderson	Funt	1954	1,050	do	50	5⅝	16	do
Ad 6	Theodore F. Forest	do	1954	1,050	do	47	6	13	do
Ad 7	Donald Manahan	do	1952	1,240	do	62	6	32	do
Ad 8	Walter Benchoff	do	1952	1,240	do	45	6	35.5	do
Ad 9	Robert E. Overcash	do	1952	1,140	do	45	6	20	Valley
Ad 10	Edwin Delauter	do	1952	880	do	60	5⅝	45	do
Ad 11	Victor Cullen State Hospital	—	—	1,350	Spring	—	—	—	Hillside
Ad 12	Do	—	1914	1,110	Drilled	200+	6	—	do
Ad 13	Do	—	1914	1,110	do	185±	6	—	do
Ad 14	Do	—	1923	1,110	do	185±	6	—	do
Ad 15	Glenn Fox	Funt	1954	990	do	35	5⅝	11	do
Ad 16	Raymond H. Kipe	do	1955	1,080	do	55	5⅝	37	do
Ad 17	Melvin Rowe	do	1955	1,190	do	56	5⅝	46	do
Ad 18	Samuel F. Royer, Sr	do	1955	795	do	38	6	22	do
Ad 19	Henson Harbaugh	do	1956	880	do	60	6	34	do
Ad 20	Floyd E. Brown	do	1956	1,560	do	70	5⅝	21	do
Ad 21	Glenn R. Bumbaugh	do	1956	1,585	do	45	5⅝	40.5	do
Ae 1	Edward L. Myers	H. E. Wantz	1946	570	do	179	5⅝	75	do
Ae 2	C. H. Grable	—	—	515	Spring	—	—	—	Valley
Ae 3	Austin J. Knott	H. E. Wantz	1950	610	Drilled	53	5⅝	32.8	Hilltop
Ae 4	Mrs. Toye	Owings	1949	710	do	125	6	125(?)	do
Ae 5	Henery T. Zurgable	C. L. Wantz	1946	445	do	100	6	6	Hilltop
Ae 6	Mr. Richards	—	Before 1915	680	Drilled	60–65	6(?)	—	Hillside
Ae 7	L. A. Herring	—	Old	545	Dug	27	48	—	Hilltop
Ae 8	Mr. Tellis	—	1945–47	540	Drilled	40	6	—	Hillside
Ae 9	George D. Florence	H. E. Wantz	1949	540	do	75	8	10	Hilltop
Ae 10	Edward Meadows	Cromwell	1955	500	do	150	5⅝	31	Hillside
Ae 11	Do	—	—	500	do	100	6	—	do

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Springs in Frederick County

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
aporhyolite	—	—	—	N	1.0	8/12/54	—	—	D	Temperature May 31, 1956, 49°F.
					13	5/31/56				
Catoctin metabasalt	15[a]	25[a]	3/12/49	C,E	10	3/12/49		1.0	D	See chemical analysis. Adequate supply.
do	70[a]	110[a]	7/31/50	J,E	2.5	7/31/50	0.3	<.1	D	
do	35[a]	50[a]	1/5/51	J,E	5	1/5/51	.5	.3	D	
do	15[a]	40[a]	6/7/54	—	10	6/6/54	2	.4	D	
do	12[a]	30[a]	3/8/54	—	5	3/8/54	1	.2	D	See well log.
do	5[a]	25[a]	3/7/52	J,E	10	3/7/52	2	.4	D	
do	10[a]	15[a]	7/3/52	—	10	7/3/52	1	2.0	D	
do	10[a]	30[a]	7/10/52	—	6	7/10/52	1	.3	D	See well log.
do	30[a]	50[a]	10/1/52	J,E	7	10/1/52	1	.35	D	
Contact-aporhyolite and Catoctin metabasalt	—	—	—	N	40–80	6/12/56	—	—	I	"Bowman Spring."
Catoctin metabasalt	5[a]	175[a]	6/13/56	T,G	30	6/13/56	—	.1	I	
do	5[a]	—	6/13/56	T,E	30	6/13/56	—	—	I	
do	5[a]	—	6/13/56	T,G	30	6/13/56	—	—	I	
do	15[a]	28[a]	3/25/54	J,E	8	3/25/54	1	.4	D	
do	16[a]	40[a]	3/7/55	J,E	8	3/7/55	2	.3	D	
aporhyolite	20[a]	35[a]	11/11/55	J,E	12	11/11/55	1	.8	D	
Catoctin metabasalt	20[a]	31[a]	2/18/55	J,E	8	2/18/55	2	.7	D	See well log.
do	20[a]	50[a]	6/16/56	—	10	6/16/56	2	.3	D	
do	18[a]	45[a]	8/8/56	J,E	15	8/8/56	2	6.0	D	
do	18[a]	36[a]	11/23/56	J,E	10	11/23/56	1	.55	D	
Frederick limestone	16[a]	—	9/27/46	?,E	5(?)	9/27/46	.3	—	D	Reported bailed dry in 20 minutes.
Alluvial cones	—	—	—	N	—	—	—	—	D	Perennial flow reported. Rock-lined collecting chamber.
Frederick limestone(?)	25[a]	—	8/4/50	?,E	10(?)	8/4/50	.1	—	D	
Loudoun	40[a]	100[a]	4/2/49	J,E	20	—	.5	0.3	D	Water reported "rusty." See well log.
	40.7	—	10/3/55							
Gettysburg shale	21[a]	—	10/7/46	J,E	7(?)	10/7/46	.3	—	C,D	Reported bailed dry in 20 minutes. Depth of pump jet 70 ft.
	22.25	—	8/26/55							
Catoctin metabasalt	—	—	—	—	—	—	—	—	—	Irony water reported.
diabase	23.75	—	9/13/55	J,E	—	—	—	—	D	Barely adequate.
do	19.23	—	9/13/55	C,H; J,E	—	—	—	—	D	Adequate supply.
Gettysburg shale (baked zone)	20[a]	—	7/12/49	J(?), E	1.5(?)	7/12/49	.3	—	D	Reported bailed dry in 20 minutes. See well log.
Gettysburg shale	37[a]	94[a]	7/11/55	NI	10	7/11/55	2	.1	F	
	19.50	—	9/13/55							
do	22.62	—	9/13/55	J,E	—	—	—	—	D,F	Small yield reported.

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ae 12	Edward Meadows	—	—	500	Drilled	77	6	—	Hillside
Ae 13	Do	—	Old	500	Dug	34	—	—	do
Ae 14	Dr. R. T. Marshall	Easterday	1952	550	Drilled	164	6	77	do
Ae 15	R. B. Derlinger	—	—	780	Spring	—	—	—	do
Ae 16	Harry Masser	Funt	1954	1,010	Drilled	50	5⅝	46	do
Ae 17	Howard Late	do	1950	950	do	87	6	85	do
Ae 18	Do	—	—	970	Spring	—	—	—	do
Ae 19	Mr. Mesner	—	—	670	do	—	—	—	Valley
Ae 20	Gurmon Working	Funt	1955	1,100	Drilled	35	6	19	Hillside
Ae 21	Franklin Brauner	Kohl Bros.	1954	500	do	42	5⅝	32	Valley
Ae 22	William Brauner	do	1954	515	do	65	5⅝	42	Hillside
Ae 23	Charles Long	Harris	1954	515	do	74	5⅝	23	do
Ae 24	Joseph Ash	H. E. and C. L. Wantz	1945	450	do	83	6	10	Hilltop
Ae 25	Mr. Rial	—	—	505	Spring	—	—	—	Hillside
Ae 26	Clarence Wivell	C. L. Wantz	1954	450	Drilled	99	5⅝	15½	do
Ae 27	James M. Condon	Funt	1953	520	do	40	5⅝	38	do
Ae 28	Mt. St. Marys College	—	Old	650	do	850	6	—	do
Ae 29	Do	—	Old	630	do	240	—	—	do
Ae 30	Do	—	—	760	Spring	—	—	—	do
Ae 31	Emmitsburg Water Co.	—	Old	670	Drilled	161	8	20±	Valley
Ae 32	Do	—	—	800	do	47	6	20±	Hillside
Ae 33	Do	—	Old	710	do	58	6	20±	Valley side
Ae 34	Do	—	1936	780	do	98	6	20±	Hillside
Ae 35	Lawrence J. Ott	Keyser	1951	620	do	23	6	23	do
Ae 36	Joseph Young	—	—	710	Spring	—	—	—	Valley side
Af 1	Toms Creek Methodist Church	H. E. Wantz	1950(?)	430	Drilled	46	5⅝	41.5	Hillside
Af 2	Frank Valentine	do	1950	445	do	50	5⅝	41.8	Hilltop
Af 3	Dennis C. Simmons	C. L. Wantz	1950	420	do	103	5⅝	32	Hillside
Af 4	G. Arthur Starner	Fair	1949	460	do	66	6	6	Hilltop
Af 5	Norman Sheeley	do	1955	445	do	135	6	11	do
Af 6	John W. Hickman	do	1951	490	do	81	6	23	do
Af 7	Carl Frock, Jr.	do	1953	490	do	145	6	11	do
Af 8	William F. Routzahan	Showers	1952	420	do	100	6	7	Hillside

—*Continued*

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Gettysburg shale	23.3	—	9/13/55	N	—	—	—	—	N	Small yield reported.
do	23.20	—	9/13/55	C,W	—	—	—	—	N	
do	14[a]	164[a]	5/8/52	J,E	1	5/8/52	—	<.1	D	Barely adequate.
Catoctin metabasalt	—	—	—	—	15	5/31/56	—	—	N	Improved with collecting chamber. Temperature May 31, 1956, 54°F.
Loudoun	10[a]	40[a]	3/27/54	J,E	6	3/27/54	1	.2	D	
Catoctin metabasalt	52[a]	57[a]	8/8/50	J,E	20	8/8/50	1	4(?)	D	
	25.51	—	6/13/56							
do	—	—	—	N	2-4	6/13/56	—	—	N	Rock-lined spring pit.
Loudoun	—	—	—	C,?	10	6/13/56	—	—	—	Rock-lined spring pit. Temperature June 13, 1956, 58°F.
Catoctin metabasalt	12[a]	32[a]	2/15/55	J,E	10	—	1	.5	D	
Gettysburg shale (baked zone)	10[a]	12.5[a]	2/18/54	J,E	4	2/18/54	1	1.8	D	Water reported hard.
do	11[a]	14[a]	2/28/54	J,E	3	2/28/54	1	1.0	D	Do
do	20[a]	60[a]	12/11/54	J,E	—	—	—	—	D	
Gettysburg shale	30[a]	—	11/11/45	C,E	15	10/19/45	—	—	D	
Harpers phyllite	—	—	—	N	5	6/15/51	—	—	N	Temperature June 15, 1956, 62°F.
Gettysburg shale	21.5[a]	—	6/9/54	J,E	—	—	.5	—	D	Bailed dry in 30 minutes.
Gettysburg shale (baked zone)	10[a]	34[a]	8/3/53	J,E	8	8/3/53	2	.3	D	
Weverton quartzite	10[a]	—	—	T,E	80	—	—	—	I	Standby well. Crooked hole.
Weverton quartzite or Frederick limestone	20[a]	—	—	C,E	—	—	—	—	I	Standby well.
Weverton quartzite	—	—	—	—	27	9/21/56	—	—	I	Main supply. Temperature Sept. 21, 1956, 57°F. Gravity flow to reservoir.
Catoctin metabasalt	4.5[a]	12[a]	1956	C,E	160	1956	24+	7.5	N	Standby well. Main supply is spring- and stream-fed surface reservoir.
	.70	—	11/9/56							
do	6.02	—	11/13/56	N	—	—	—	—	N	
do	—	—	—	C,E	10	—	—	—	N	Standby well. Reported yield 15,000 gpd during dry periods.
do	7.16	—	11/13/56	C,E	—	—	—	—	N	Standby well.
Loudoun or Harpers phyllite	15[a]	23[a]	11/29/51	J,E	3	11/29/51	.5	.3	D	
	16.52	—	11/29/51							
Loudoun	—	—	—	N	4	11/14/56	—	—	D	Supplies two homes; gravity flow. Temperature Nov. 14, 1956, 56°F.
Gettysburg shale	12[a]	—	7/3/50	J,E	15	7/3/50	.6	—	I	Reported bailed dry in 40 minutes.
do	25[a]	—	8/26/50	J,E	.5	8/26/50	—	—	D	
do	15[a]	—	9/4/50	J,E	20(?)	9/4/50	.5	—	D,F	See well log.
do	6.8	—	4/4/55	J,E	40	8/21/55	1	—	D	Adequate supply. Water reported hard. See chemical analysis.
do	27[a]	130[a]	2/9/55	?,E	3	2/9/55	1	<.1	D	
Gettysburg shale (baked zone?)	40[a]	81[a]	9/10/51	—	1	9/10/51	.25	<.1	D	
do	23[a]	140[a]	9/12/53	C,H	9	9/12/53	2	<.1	D	
Gettysburg shale	15[a]	75[a]	6/6/52	?,E	30	6/6/52	1	.5	D	

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Af 9	Milton G. Springer	C. L. Wantz	1945	415	Drilled	67	6	?	Upland flat
Af 10	William H. Wivell	do	1951	445	do	91	5⅝	29.5	Hilltop
Af 11	Charles Copenhaver	Showers	1952	450	do	55	6	6.5	Hillside
Af 12	Roland L. Frock	Fair	1954	445	do	98	6	9	do
Af 13	Paul C. Glass	Miller	1956	400	do	109	5⅝	16	Hilltop
Af 14	Scott McNair, Jr.	H. E. Wantz	1950	430	do	72	5⅝	8	Hillside
Af 15	H. S. McNair	do	1953	450	do	114	5⅝	8	do
Af 16	Regis R. Sanders	Fair	1955	425	do	70	6	10	do
Af 17	Do	—	Old	425	Dug	63	36	—	do
Af 18	Robert E. Hampson	C. L. Wantz	1950	425	Drilled	120	5⅝	6.5	do
Af 19	Ralph Baumgardner	H. E. Wantz	1954	390	do	123	6	6	do
Af 20	Do	—	—	390	do	110	6	—	do
Ag 1	J. M. Brooks	Sterner	1950	395	do	62	6	12	Hilltop
Ag 2	Peter L. Shockley	Fair	1949	445	do	135	6	13.5	Upland flat
Ag 3	Do	—	—	445	do	100±	6	—	do
Bc 1	Floyd Spade	Harley	1951	1,130	do	44	6	9	Hillside
Bc 2	Richard Spangler	do	1951	1,110	do	59.5	6	33	do
Bc 3	Paul Kline, Jr.	do	1951	1,260	do	33	6	12	do
Bc 4	Charles Leatherman	Holtzman	1947	1,105	do	47	5⅝	12	do
Bc 5	Richard Spangler	Rock	1950	1,110	do	22	6(?)	0	do
Bc 6	Floyd Spade	Cowan	1954	1,120	do	95	5⅝	33	do
Bc 7	James A. Bear	do	1955	1,160	do	90	6	26	do
Bc 8	Abe Grossnickle	E. R. Smith	1955	1,320	do	68	5⅝	23	Hilltop
Bc 9	Kenneth Frushour	do	1956	1,320	do	42	5⅝	20	do
Bc 10	Evans Brown	Harley	1951	1,600	do	54	6	45	Valley side
Bc 11	O'Day Toms	do	1951	1,580	do	40	6	25	do
Bc 12	Hunter McAfee	Martin	1954	1,620	do	56	6	46	Hillside
Bc 13	Roseann McAfee	E. R. Smith	1955	1,670	do	48	5⅝	36	do
Bc 14	Cyrus Early	Fogel	Old	1,455	do	80	5⅝	13	Hilltop
Bc 15	Paul Delauter	Funt	1956	1,680	do	32	6	20	Hillside
Bc 16	Albert L. Pryor	—	1940	1,310	do	69	6	—	do
Bd 1	Town of Thurmont	—	1929–30	630	do	200–400	6	—	Valley
Bd 2	Do	—	1929–30	640	do	500	6	22(?)	do

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Gettysburg shale	7[a]	—	10/21/45	?,E	3	10/24/45	.5	—	D	Bailed dry in 25 minutes.
do	20[a]	—	5/9/51	—	5(?)	5/9/51	.5	—	D	Bailed dry in 30 mieutes.
do	8[a]	40[a]	5/28/52	J,E	80	5/28/52	.5	3.5	D,F	
do	11[a]	75[a]	6/9/54	J,E	8	6/9/54	.5	1 1	D	Poor yield in summer
do	21[a]	25[a]	1/12/56	J,E	7	1/12/56	2	1.4	F	
Gettysburg shale (baked zone?)	17.5[a]	—	4/20/50	J,E	15	4/20/50	.5	—	D,F	
Gettysburg shale	38.5[a]	—	12/8/53	C,?	—	—	.3	—	D,F	Bailed dry in 20 minutes.
Gettysburg shale (baked zone?)	40[a]	65[a]	4/28/55	J,E	7	4/28/55	1	.3	F	
do	35[a]	—	6/21/56	C,E	±5	6/21/56	—	—	D	Poor supply some summers.
Gettysburg sbale	16[a]	—	8/10/50	C,E	—	—	.3	—	D	Bailed dry in 20 minutes.
do	60[a]	—	11/17/54	J,E	.5(?)	11/17/54	—	—	F	Reported bailed dry in 20 minutes. See well log.
	57.73	—	10/24/56							
do	60[a]	—	—	C,E	—	—	—	—	D	
do	18[a]	—	6/6/50	C,H	—	—	—	—	D	See well log.
	25.30	—	3/20/51							
do	40[a]	85[a]	7/29/49	C,E	12	7/29/49	1.5	27	D	Adequatc supply.
do	22.70	—	9/12/55	C,W	—	—	—	—	F	Water discharged into cistern. Well pumped just before water-level measurement.
aporhyolite	17[a]	31[a]	4/30/51	J,E	3	4/30/51	—	.2	N	Inadequate. Three essentially dry holes drilled prior to this one.
do	21[a]	21[a]	4/20/51	J,E	20	4/20/51	—	—	D	See chemical analysis.
do	23[a]	28[a]	10/4/51	J,E	2.5	10/4/51	—	.5	D	
do	28[a]	39[a]	2/25/47	C,E	5	2/25/47	1	.4	D	
do	—	—	—	N	—	—	—	—	N	Filled in; driller could not penetrate below 22 ft.
do	71[a]	95[a]	9/15/54	J,E	8–10	9/15/54	—	.45	D	
do	72[a]	90[a]	5/30/55	—	4.5	5/30/55	2	.27	D	Reamed and grouted to 18 ft.
do	22[a]	40[a]	12/26/55	NI	2	12/26/55	1	.11	D	Reamed and grouted to 18 ft. See well log.
	21.16	—	4/26/56							
do	22[a]	30[a]	12/12/55	J,E	10	12/12/55	1	1.22	D	
	25.06	—	4/26/56							
do	30.5[a]	30.5[a]	9/26/51	J,E	30	9/26/51	1	—	D	
do	24[a]	24[a]	9/28/51	J,E	30	9/28/51	1	—	D	See well log.
do	32[a]	—	11/10/54	J,E	20	11/10/54	6	—	D	
do	34[a]	40[a]	7/23/55	J,E	6	7/23/55	1	1.0	D	See well log.
do	31[a]	—	Old	C,E	8–10	—	—	—	D,F	
	35.49	—	9/14/56							
Catoctin metabasalt	8[a]	20[a]	11/2/56	NI	15	11/2/56	2	1.2	D	
	1.67	—	11/6/56							
metaandesite	27.61	—	10/25/56	C,E	—	—	—	—	D,F	
Harpers phyllite	13.61	—	10/1/46	N	—	—	—	—	N	Water-level observation well. Obstruction at 34 ft.
do	20.35	—	10/1/46	C,E	—	—	—	—	P	Augments spring supply.

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Bd 3	Catoctin Mountain Park	—	—	1,386	Spring	—	—	—	Hillside
Bd 4	Do	—	—	1,400	do	—	—	—	do
Bd 5	Do	—	1936(?)	1,648	Drilled	40.5	—	—	do
Bd 6	Do	Columbia Pump & Well Co.	1955	1,750	do	230	8	57	Hilltop
Bd 7	Do	E. R. Smith and Kohl Bros.	1956	1,140	do	180	6	45±	Valley side
Bd 8	Do	Kohl Bros.	1956	1,160	do	126	6	30	do
Bd 9	Clyde Kendall	C. Kendall	1953–54	820	Dug	30	36	—	Hillside
Bd 10	Wade Reed	—	—	690	Spring	—	—	—	do
Bd 11	Melvin Huyett	Harley	1950	600	Drilled	43	6	16	do
Bd 12	George P. Skates, Jr.	Rock	1950	1,460	do	65	5⅝	43	Valley side
Bd 13	Alice Wetzel	—	Old	860	Dug	39	36	—	do
Bd 14	Ernest Delphey	Keyser	1952	500	Drilled	44	5⅝	39	Hillside
Bd 15	Catoctin Furnace School	Cromwell	1949	535	do	163	6	150	Upland flat
Bd 16	Lorraine G. Harne	Green	1946	500	do	40	6	10	Hillside
Bd 17	A. Lampsi	Cromwell	1955	525	do	47	5⅝	20	do
Bd 18	George Miller	do	1955	500	do	50	5⅝	43	do
Bd 19	Robert Devilbiss	Harley	1952	450	do	38	6	22	do
Bd 20	Paul Sweeney	Corum	1949	480	do	48	5⅝	33	do
Bd 21	W. R. Kelly	Holtzman	1946	540	do	77	5⅝	36	do
Bd 22	George M. Eichelberger, Jr.	Keyser	1949	580	do	52	5⅝	36	do
Bd 23	Do	do	1949	580	do	52	5⅝	36	do
Bd 24	Do	do	1950	565	do	114	6	8	do
Bd 25	Arnold Hurley	Harley	1951	1,510	do	27	6	22	do
Bd 26	State of Maryland	—	—	950	Spring	—	—	—	do
Bd 27	Catoctin Mountain Park	Kohl Bros.	1956	1,860	Drilled	144	6	11	Hilltop
Bd 28	Town of Thurmont	—	1929–30	—	do	1,000	—	—	Valley
Bd 29	Do	—	—	540	do	400	8 or 10	—	do
Be 1	Do	—	about 1936	510	do	192	8–6	73	Upland flat
Be 2	U. S. Army	U. S. Army	1955	455	do	112	7	19.4	Valley side

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Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
aporhyolite	—	—	—	C,E	46 10.5 14	7/—/53 11/1/53 8/—/54	—	—	I	Concrete spring pit. System includes 3 small springs in addition to Bd 3 and Bd 4. Yield is for all 5 springs. Perennial flow. See chemical analysis.
do	—	—	—	—	3±	11/3/53	—	—	I	Concrete spring pit. See chemical analysis. Yield for Bd 4 only.
do	20.0[a]	--	8/—/54	C,E	7.5–10 4.5	7/—/54 11/—/53	—	—	I	Supplies storage area and garages. Depth of pump pipe 39 ft.
aporhyolite and/or Catoctin metabasalt	12[a]	36–40[a]	6/7/55	T,E	25	6/7/55	24	1±	I	Depth of pump 200 ft.
Catoctin metabasalt	.87	165	4/17/56	N	4.5	4/17/56	24	<.1	N	
do	Flowing	107	6/21/56	T,E	12–15	6/21/56	—	.1+	I	Temperature June 22, 1956, 51°F.
Weverton quartzite	13.91	—	5/11/56	C,H	—	—	—	—	D	Large residual boulders embedded in decomposed rocks all the way. See chemical analysis.
Alluvial cones	—	—	—	?,E	4.5	7/17/56		—	D	Temperature July 17, 1956, 57°F.
Loudoun	5[a]	34[a]	3/11/50	J,E	2	3/11/50	1	<.1	D	
aporhyolite	25[a]	30[a]	8/8/50	J,E	15	8/8/50	1.5	3.0	D	
Catoctin metabasalt	11.97	—	6/13/56	C,H	---	—	—	—	D	Perennial supply.
Frederick limestone	15[a]	30[a]	7/22/52	—	10	7/22/52	1	0.7	D	
Harpers phyllite	6[a]	163[a]	1/6/49	?,E	4	1/6/49	1	<.1	I	See well log.
Frederick limestone	18[a]	—	9/30/46	—	6	9/30/46	1.5	—	D	
do	15[a]	—	2/16/55	J,E	15	2/16/55	1.5	—	D	Drilled through bottom of old dug well 22 ft. deep. Cased from 19–39 ft.
do	15[a]	18[a]	2/18/55	J,E	10	2/18/55	1	3.3	D	
Frederick limestone or Harpers phyllite	23[a]	28[a]	7/3/52	J,E	10	7/3/52	—	2.0	D	
Frederick limestone(?)	16[a]	—	10/18/49	J,E	10	10/18/49	.5	—	D	
Gettysburg shale	22[a]	—	12/19/46	C,E	10+	12/19/46	—	—	D	
Frederick limestone or Harpers phyllite	20[a]	30[a]	8/12/49	J,E	15	8/12/49	1	—	C	Restaurant.
do	25[a]	30[a]	8/—/49	J,E	5	8/—/49	.5	1.0	D	
Frederick limestone(?)	50[a]	100[a]	11/13/50	J,E	2	11/13/50	.5	<.1	D	
Catoctin metabasalt	10[a]	—	9/1/51	C,E	8	9/1/51	1	—	D	See well log.
do	—	—	—	N	1	11/9/56	—	—	P	Public roadside spring. Temperature Nov. 9, 1956, 54°F.
do	10[a]	126	11/20/56	—	7	11/20/56	24	<.1	I	
Weverton quartzite	—	—	—	N	20	1929–30	—	—	N	
Harpers phyllite	—	—	—	T,E	—	—	—	—	P	Hardness 50 ppm reported.
Frederick limestone	10[a]	—	8/—/54	T,E	150	8/—/54	—	—	P	At ice plant. Pumps 10–15 hours daily during canning season. Hardness 150 ppm reported.
Harpers phyllite	6±	—	6/16/55	N	<1(?)	6/16/55	—	—	N	See well log.

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Be 3	U. S. Army	U. S. Army	1955	450	Drilled	151	8–7	51.2	Valley side
Be 4	Mr. Trepening	—	—	420	Spring	—	—	—	Valley flat
Be 5	Do	—	—	420	do	—	—	—	do
Be 6	Merhle Grable	Funt	1952	518	Drilled	60	5⅝	58	Hilltop
Be 7	Robert Ogle	Keyser	1951	402	do	136	—	—	do
Be 8	Hillside Turkey Farm	C. L. Wantz	1946	415	do	191	5⅝	52	Hillside
Be 9	David Sayler	Keyser	1950	352	do	126	6	6	do
Be 10	Mary E. Famous	H. E. Wantz	1946	340	do	87	6	8	Hilltop
Be 11	Mr. Portner	Corum	1952	405	do	113	6	6	Draw
Be 12	Mrs. Florence Dietz	Kyker	1954	500	do	45	6	41	Hill-side
Be 13	Andrew Derwart	Shaff	1955	580	do	109	5⅝	30	do
Be 14	Cbarles F. Myers	H. E. Wantz	1954	620	do	117	5⅝	90	do
Be 15	Mrs. Charles F. Sharer	C. L. Wantz	1946	540	do	100.5	5⅝	64	Upland flat
Be 16	Charles F. Forest	Keyser	1951	570	do	45	5⅝	24	Valley side
Be 17	Lee D. Portner	Harris	1953	545	do	33	5⅝	27	Hill-side
Be 18	Clifford Stull	Harley	1953	620	do	99.5	5⅝	12	Hilltop
Be 19	Charles Smith	Keyser	1952	650	do	71	5⅝	69	do
Be 20	Do	Funt	1955	750	do	50	5⅝	50	Hillside
Be 21	Victor Christ	Miller	1956	450	do	75	5⅝	11	Upland flat
Be 22	Raymond Keepers	LeGore	1910±	475	do	65	5⅝	21	Hilltop
Be 23	Do	—	Old	475	Dug	22	36	—	do
Be 24	Harold M. Wildasin	C. L. Wantz	1951	490	Drilled	130	6	26	Upland flat
Be 25	Richard E. Waynant	do	1946	490	do	62	6	24	do
Be 26	Leslie Sovocool	H. E. Wantz	1946	440	do	94	6	9	do
Be 27	Clifford Blair	Harley	1953	480	do	107	5⅝	12	do
Be 28	Eugene Wood	do	1952	480	do	100	6	12	do
Be 29	Harry L. Sharer	C. L. Wantz	1946	490	do	82	6	74	Hillside
Be 30	Farmers Supply and Service Center	do	1946	450	do	88	6	2	Upland flat
Be 31	Graceham Post Office	—	Old	440	do	160	6	—	Hillside
Be 32	Mr. Homerick	—	Old	455	Dug	24	30	—	Valley
Be 33	Ralph E. Kass	—	1938	445	Drilled	81	6	—	Upland flat
Be 34	J. E. Cornet	—	Old	390	do	100	6	—	Hillside
Bf 1	Robert G. Fitez	C. L. Wantz	1951	430	do	103	6	7.6	do

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Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Frederick limestone	0±	44.4	6/14/55	N	155	6/13/55	24	3.4	N	See well log and chemical analysis. Temperature June 13, 1955, 54°F.
Gettysburg shale	—	—	—	N	—	—	—	—	F(?)	Temperature June 23, 1955, 52.5°F.
do	—	—	—	—	—	—	—	—	—	
Frederick limestone(?)	12[a]	50[a]	9/26/52	C,H	5	9/26/52	1	.1	D	Water reported "a little rusty". See well log.
Gettysburg shale	50[a]	100[a]	2/2/51	J,E	5	2/2/51	1	.1	D	Originally 85 feet deep and inadequate.
do	21[a]	42[a]	11/7/46	—	20	11/7/46	2.5	.9	D,F	Adequate.
do	50[a]	90[a]	9/24/50	—	6	9/24/50	1	.15	D	
New Oxford	20[a]	—	2/11/46	?,E	6(?)	2/11/46	1.5	—	F	
Gettysburg shale	28[a]	—	11/6/52	C,H	8	11/6/52	.5	—	D	See chemical analysis.
Frederick limestone	10[a]	32[a]	9/13/54	J,E	10	9/13/54	2	.4	D	
Harpers phyllite	10[a]	20[a]	6/20/55	J,E	10	6/20/55	1	1.0	D	
do	18[a]	—	2/25/54	J,E	5	2/25/54	.33	—	D	Reported bailed dry in 20 minutes. Principal supply at depth of 95 or 96 feet. See well log.
do	48[a] 67[a]	69[a] —	10/14/46 1/1/55	C,E	25	1/1/55	.5	1.2	D,F	Originally 67 feet deep. See well log.
do	10[a]	34[a]	10/10/51	J,E	4	10/10/51	1	.16	D	
Frederick limestone or alluvial cones	15[a]	25[a]	8/27/53	J,E	4	8/27/53	1	.4	D	
Harpers phyllite	33[a]	39[a]	2/28/53	J,E	15	2/28/53	1.5	2.5	D	
Loudoun	20[a]	30[a]	8/20/52	J,E	20	8/20/52	2	2.0	D	
do	15[a]	42[a]	4/6/55	C,E	6	4/6/55	1	.2	C	Sawmill supply.
Gettysburg shale	12[a] 12.96	16[a] —	5/12/56 6/15/56	C,H	—	—	—	—	D	Grouted to 21 ft.
do	18[a]	40[a]	11/14/55	C,E	20	11/14/55	.5	.8	D	
do	18.13	—	6/15/56	N	—	—	—	—	N	
do	36.5[a]	—	10/1/51	J,E	2	10/1/51	.5	—	D	
do	18[a]	—	12/7/46	J,E	—	—	—	—	D	
do	21[a]	—	11/18/46	—	2.25(?)	11/18/46	.3	—	D	
do	15[a]	100[a]	7/15/53	J,E	4	7/15/53	—	<.1	D	
do	31[a]	90[a]	7/16/52	J,E	3	7/16/52	—	<.1	D	
New Oxford (limestone conglomerate)	18[a]	—	12/23/46	J,E	6	12/23/46	.5	—	D	
Gettysburg shale	16.5[a] 12.50	88[a] —	11/26/46 5/16/56	J,E	4(?)	11/26/46	—	—	N	Reported bailed dry in 20 minutes.
do	—	—	—	C,E	—	—	—	—	D	Adequate.
do	6.4	—	5/4/56	C,H	—	—	—	—	N	
do	47.85	—	10/24/56	C,E	—	—	—	—	D,F	
do	70[a]	—	—	J,E	—	—	—	—	D	
do	—	—	—	J,E	3.5	4/10/51	.33	—	D	Driller reported bailed dry in 20 minutes. Adequate supply.

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Bf 2	Roland E. Shaver	H. E. Wantz	1951	460	Drilled	110	6	6	Hillside
Bf 3	Maurice H. Moser	do	1947	420	do	132	6	4	Hilltop
Bf 4	Howard Welty	do	1946	430	do	82	—	0	Hillside
Bf 5	Church of tbe Brethren	Corum	1952	415	do	68	6	12	Hilltop
Bf 6	Ralph Baker	Showers	1955	400	do	—	6	—	Hillside
Bf 7	Raymond Anders	H. E. Wantz	1955	420	do	87	5⅝	17.3	Draw
Bf 8	Baxter C. Dougherty	C. L. Wantz	1949	440	do	217	5⅝	9.5	Hillside
Bf 9	John Kass	Corum	1952	445	do	92	6	12	Upland flat
Bf 10	Adolph F. Brooks	Utermahlen	1951	385	do	72	6	10	Hillside
Bf 11	Mt. Tabor Park	—	—	425	do	46	6	—	Upland flat
Bf 12	Catherine Valentine	—	—	380	Dug	31±	48	—	Valley flat
Bf 13	Do	—	—	380	do	21	48	—	do
Bf 14	Western Maryland R. R.	—	Old	405	Drilled	80	4 or 6	—	do
Bf 15	Mr. Pasternak	—	Old	410	Dug	22	60	—	do
Bf 16	Castle Farms	H. E. Wantz	1949	330	Drilled	165	6	8	Valley side
Bf 17	Do	—	Old	340	do	48	6	—	do
Bf 18	Do	—	Old	330	do	53	6	—	do
Bf 19	Claude W. De Barry	C. L. Wantz	1952	405	do	201	6	8	Hilltop
Bf 20	Do	do	Old	405	do	39	6	—	do
Bg 1	Mr. Garber	Harris	1954	460	do	70	5⅝	26	Hillside
Cb 1	C. R. Bowman	French	1954	1,270	do	116	5⅝	33	do
Cb 2	Echo Lake Camp	Keyser	1954	1,000	do	154.8	6	0	do
Cb 3	Do	do	1955	950	do	70	5⅝	28	do
Cb 4	Do	—	—	915	Spring	—	—	—	do
Cb 5	Willard Snook	J. Hoffman	1950	1,000	Drilled	50	5⅝	20	do
Cb 6	A. W. Goodwin	Holtzman	1947	980	do	88	5⅝	21	do
Cb 7	Town of Myersville	—	—	1,160±	Springs	—	—	—	do
Cc 1	Lauren Wolf	E. R. Smith	1955	1,030	Drilled	89	5⅝	23.2	do
Cc 2	Russell Harshman	Harley	1951	800	do	42	6	24	do
Cc 3	Asa P. Stottlemyer	Cowan	1955	1,030	do	92	5⅝	7	Valley side
Cc 4	H. L. Leatherman	—	Old	1,070	do	53	6	—	Hilltop
Cc 5	C. F. Grossnickle	—	Old	780	Dug	23	48	—	do
Cc 6	Do	—	—	790	Spring	—	—	—	Hillside
Cc 7	Grayson Cline	Keyser	1952	1,205	Drilled	23	5⅝	23	do
Cc 8	Mr. Flook	—	Old	685	Dug	136	36	—	Hilltop
Cc 9	Lawrence Lewis	—	—	890	Spring	—	—	—	Hillside

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Gettysburg shale	39[a]	—	8/28/51	J,E	1+	8/28/51	.25	—	D	Bailed dry in 15 minutes. Adequate.
do	41[a]	do	9/3/47	J,E	2	9/3/47	.33	—	D	Bailed dry in 20 minutes. Adequate. Stains fixtures slightly.
New Oxford	30[a]	—	7/13/46	J,E	5.5	7/13/46	.5	—	D	Adequate. See chemical analysis.
New Oxford (baked zone)	21[a]	40[a]	5/5/52	C,E	10	5/15/52	1	.5	D	
	45.22	—	10/11/55							
New Oxford	18.87	—	10/12/55	N	—	—	—	—	D	
do	16[a]	—	7/27/55	C,H	6	7/27/55	.5	—	D	Bailed dry in 30 minutes.
do	37[a]	172[a]	5/27/49	—	12	5/27/49	1.5	—	—	
do	23[a]	—	6/4/52	J,E	8	6/4/52	.5	—	D	
do	12[a]	70[a]	6/28/51	J,E	3	6/28/51	.5	<.1	D	
do	15.55	—	5/17/56	C,H; J,E	—	—	—	—	D	Picnic grounds.
do	.6±	—	5/18/56	N	—	—	—	—	N	
do	1.38	—	5/24/56	N	—	—	—	—	N	
do	5.5	—	5/17/56	C,H	—	—	—	—	D	
do	7.20	—	5/17/56	J,E; C,H	—	—	—	—	D	
do	19[a]	115[a]	12/6/49	J,E	15	12/6/49	1	.15	C	Dairy plant.
do	27.73	—	—	C,W	—	—	—	—	C	Adequate for dairy barn.
do	30[a]	—	—	C,E	—	—	—	—	D	
do	3[a]	—	1/31/52	J,E	3.5(?)	1/31/52	—	—	F	Bailed dry in 30 minutes. See well log.
do	15[a]	—	—	C,E	—	—	—	—	D	Adequate.
New Oxford (quartz conglomerate)	28[a]	58[a]	5/21/54	—	—	—	—	—	D	
Contact-aporhyolite and Loudoun	60[a]	90[a]	9/11/54	J,E	5	9/11/54	6	.16	C	Gift shop and service station.
Catoctin metabasalt	50[a]	155[a]	9/5/54	N	2	9/5/54	.5	<.1	I	Inadequate supply.
do	35[a]	—	4/25/56	J,E	20	4/25/56	—	—	I	
aporhyolite	—	—	—	N	15±	4/25/56	—	—	I	Continuous flow reported.
Catoctin metabasalt	35[a]	50[a]	5/—/50	N	1	5/—/50	.5	<.1	N	Reported contaminated.
do	30[a]	—	8/7/47	J,E	4	8/7/56	1	—	D	See well log.
aporhyolite	—	—	—	—	22+	—	—	—	P	Seven developed springs. Gravity flow to reservoir. See chemical analysis.
Catoctin metabasalt	20[a]	70[a]	4/16/55	?,E	2	4/16/55	2	<.1	D	Reamed and grouted to 18 ft. See well log.
rhyolite tuff	15[a]	15[a]	11/21/51	—	10	11/21/51	—	—	D	
Catoctin metabasalt	10[a]	89[a]	4/26/56	C,H	6	5/30/56	2	<.1	N	
do	3[a]	—	4/26/56	C,E	12	4/26/56	—	—	D	Perennial supply.
do	18[a]	—	4/26/56	C,H	—	—	—	—	N	Rock-lined.
do	—	—	—	S,E	6	4/26/56	—	—	D,F	Discharges to pond.
aporhyolite	10[a]	10[a]	8/29/52	J,E	20	8/29/52	.5	—	D	
Catoctin metabasalt	25[a]	—	—	N	—	—	—	—	N	
aporhyolite	—	—	—	?,E	3	1956	—		D	

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Cc 10	Albert G. Harshman	Cowan	1955	650	Drilled	40	5⅝	35	Hillside
Cc 11	W. E. Moser	do	1955	1,105	do	125	5⅝	36	do
Cc 12	Claude Stottlemyer	Harley	1955	1,125	do	74	5⅝	30	do
Cc 13	Charles Fawley	Shaff	1956	810	do	25	5⅝	—	do
Cc 14	Roger Moser	Bittle	Old	695	do	41	6	—	do
Cc 15	George R. Marker	—	Old	870	Dug and drilled	56	36–6	—	do
Cc 16	Merle P. Kline	—	Old	1,285	Dug	23	48	—	do
Cc 17	Roy L. Easterday	—	—	920	do	29	36	—	Valley side
Cc 18	Do	Easterday	1948	920	Drilled	57	6	—	do
Cc 19	Enogene Baker	—	Old	1,140	Dug	29	48	—	Hillside
Cd 1	Resley Stull, Jr.	Keyser	1950	440	Drilled	85	6	22	Hilltop
Cd 2	Chester Weltry	do	1951	530	do	38	5⅝	25	Hillside
Cd 3	Catoctin Church	Cromwell	1955	470	do	61.5	5⅝	60	do
Cd 4	Vernon T. Bear	Shaff	1948	440	do	78.5	6	22	Upland flat
Cd 5	Marion Stull	Keyser	1954	440	do	82	5⅝	14	do
Cd 6	Do	—	—	440	Dug	24	—	—	do
Cd 7	Frank Harper	Harris	1953	405	Drilled	62	5⅝	42	Hillside
Cd 8	Charles E. Heffner	Keyser	1952	470	do	48	5⅝	46	Upland flat
Cd 9	Howard Fisher	do	1951	465	do	64	6	60	do
Cd 10	Ellis C. Rice	Harley	1950	530	do	41	5⅝	29	do
Cd 11	Richard Gladhill	Harris	1955	530	do	34	5⅝	33	do
Cd 12	Marion W. Rice	Harley	1951	550	do	23	6	24	Hillside
Cd 13	Lewis S. Rice	Keyser	1950	580	do	21	6	21	Upland flat
Cd 14	Robert L. Keyser	do	1953	550	do	21	6	21	do
Cd 15	Alvie Rice	do	1951	550	do	15	5⅝	15	do
Cd 16	Catoctin Church	—	—	470	Spring	—	—	—	Hillside
Cd 17	Harry Martin	Harley	1953	475	Drilled	63	5⅝	23	do
Cd 18	Stanley S. Barnes	D. Brown	1954	415	do	44	6(?)	23	Upland flat
Cd 19	William Reuner	Keyser	1956	460	do	105	5⅝	11	do
Ce 1	Mr. Wise	—	Old	350	Dug	20±	—	—	Hillside
Ce 2	Do	—	—	340	Spring	—	—	—	Valley
Ce 3	Mr. McDevitt	—	1949–50	320	Drilled	60	6	—	Hillside
Ce 4	Do	—	Old	340	do	100	6	—	do
Ce 5	Mr. Baker	Keyser	1953	375	do	150	6	15	Hilltop
Ce 6	Edward Oden	do	1953	330	do	264	6	25	Upland flat
Ce 7	Nelson Summers	—	Old	310	Dug	29	42	—	do

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Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Catoctin metabasalt	19[a]	31[a]	9/28/55	C,E	10	9/28/55	2	.8	D	
do	95[a]	125[a]	6/14/55	J,E	16	6/14/55	.5	.5	D,F	
aporhyolite	6[a]	20[a]	6/30/55	?,E	15	6/30/55	—	1.1	D	
Catoctin metabasalt	20[a]	25[a]	3/27/56	J,E	5	3/27/56	2	1.0	D	
do	25[a]	—	—	J,E	—	—	—	—	D	Adequate.
do	23[a]	—	—	C,E	—	—	—	—	D	Drilled through bottom of dug well 24 ft. deep. Adequate.
do	18.87	—	9/27/56	C,H	—	—	—	—	D	Adequate.
aporhyolite	20[a]	—	—	C,E	—	—	—	—	D	
do	32.34	—	9/27/56	J,E	—	—	—	—	F	Adequate.
do	23.80	—	10/25/56	C,H	—	—	—	—	D	
New Oxford	17[a]	42[a]	12/23/50	J,E	3	12/23/50	1	.1	D	
	18.55	—	5/4/56							
Harpers phyllite	20[a]	37[a]	6/25/51	J,E	3	6/25/51	1	.2	D	
New Oxford or Gettysburg shale	15[a]	30[a]	7/21/55	NI	—	—	—	—	D	Parish house.
New Oxford	4[a]	15[a]	11/28/48	—	8	11/28/48	6	1.4	D	
do	40[a]	60[a]	8/27/54	J,E	6	8/27/54	1	.3	D	
do	11.23	—	6/12/56	N	—	—	—	—	N	
do	25[a]	50[a]	12/23/53	J,E	6	12/23/53	—	.2	D	
do	13[a]	15[a]	5/1/52	—	10	5/1/52	1.5	5.2	D	
do	35[a]	50[a]	1/16/51	J,E	4	1/16/51	1	.3	D	
do	25[a]	—	3/31/50	J,E	12	3/31/50	—	—	D	
do	8[a]	22[a]	10/1/55	J,E	8	10/1/55	—	.6	D	
Contact-Harpers phyllite and Loudoun	15[a]	—	12/11/51	J,E	5	12/11/51	—	—	D,C	General store and residence.
Alluvial cones(?)	10[a]	21[a]	11/5/50	C,E	3	11/5/50	.5	.27	D	
do	10[a]	—	4/20/53	J,E	4	4/20/53	.5	—	D	
do	7[a]	12[a]	10/25/51	—	4	10/25/51	.8	1	D	
Alluvial cones	—	—	—	N	—	—	—	—	N	Temperature May 18, 1956, 55F°
Harpers phyllite	2[a]	55[a]	5/22/53	J,E	5	5/22/53	—	.1	D	See well log.
New Oxford	25[a]	—	4/23/54	J,E	5	4/23/54	.5	—	D	
Frederick limestone	20[a]	90[a]	8/30/56	J,E	5	8/30/56	1	<.1	D	
	11.62	—	12/13/56							
New Oxford	9.05	—	9/7/51	C,H	—	—	—	—	F	Seldom used.
do	—	—	—	J,E	3	—	—	—	D,F	Continuous discharge reported.
do	—	—	—	S,E	—	—	—	—	D	
do	—	—	—	J,E	—	—	—	—	F	Good yield reported.
do	30[a]	50[a]	7/15/53	J,E	10	7/15/53	1	.5	D	
Grove limestone	20[a]	100[a]	3/3/53	C,E	2	3/3/53	1	<.1	D	Inadequate at times. Temperature Dec. 20, 1955, 46°F. Depth of pump pipe 60 ft. ±.
Frederick limestone	23.12	—	1/18/56	J,E; C,H	—	—	—	—	N	Yield adequate. Temperature May 9, 1956, 52°F. See chemical analysis.

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ce 8	Nelson Summers	Keyser	1956	310	Drilled	275	5⅝	20	Upland flat
Ce 9	Raymond Reeder	Cromwell	1955	405	do	115	6	—	do
Ce 10	William Anders	Keyser	1954	440	do	113	6	23.5	do
Ce 11	Dalton E. Leary	Harris	1954	320	do	105	5⅝	24	Hilltop
Ce 12	Henry L. Davis	Green	1952	430	do	138	6	15	Upland flat
Ce 13	C. O. West	Shirley	1954	375	do	126	6	12	Hillside
Ce 14	Eugene Whitmore	Keyser	1953	350	do	152	6	27	Upland flat
Ce 15	Do	—	1940	350	do	147	6	—	do
Ce 16	Sam Whitmore	Kline	1930±	355	do	44	6	—	do
Ce 17	Charles Cutsail	Corum	1952	430	do	89	6	35	do
Cf 1	Town of Woodsboro	Columbia Pump and Well Co.	1952	380	do	200	10–8	35	do
Cf 2	John Rice	Corum	1951	610	do	52+	6	10	Hillside
Cf 3	Raymond O. Butt	Keyser	1952	395	do	102	5⅝	13	do
Cf 4	James Horner	Corum	1952	500	do	53	6	10	Hilltop
Cf 5	Mr. Stevens	—	—	420	Spring	—	—	—	Hillside
Cf 6	Paul H. Main	—	—	400	do	—	—	—	Valley
Cf 7	Edward H. Pierce	Keyser	1953	380	Drilled	95	6	10.5	Hillside
Cf 8	Mrs. Louise Kline	Cromwell	1954	360	do	50	6	20	do
Cf 9	Florence Flanigan	do	1955	440	do	97	—	—	do
Cf 10	Do	Cromwell and Keyser	1955	440	do	115	8	80	do
Cf 11	Do	—	Old	450	Dug	35	36	—	do
Cf 12	Stuart Widner	Utermahlen	1953	500	Drilled	59	6	8	Hilltop
Cf 13	Mr. Dorcus	—	Old	380	Dug	20	—	—	Hillside
Cf 14	Do	—	—	380	Drilled	178	6	—	do
Cf 15	Do	—	—	380	do	95	6	—	do
Cf 16	Millard Crum	Cromwell	1955	370	do	60	5⅝	24	Hilltop
Cf 17	Russell M. Mathews, Jr.	Owings	1955	550	do	66	6	48	Hillside
Cf 18	Ernest C. Colbert	Cromwell	1949	600	do	96	8	10	Hilltop
Cf 19	Do	—	—	600	Dug	40±	36	—	do
Cf 20	James Misner	Harris	1953	385	Drilled	29	5⅝	26	Hillside
Cf 21	Gregg Strine	—	—	390	do	65	6	—	Upland flat

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Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Frederick limestone	16[a]	—	2/6/56	—	80	2/6/56	2	—	D,F	Test in Feb. made with air compressor; test in Mar. made with submersible. See chemical analysis. Depth of pump 218 ft.
	14[a]	16.5[a]	3/15/56	T,E	10	3/15/56	8	4.0		
New Oxford	5[a]	6[a]	12/13/55	—	9	12/13/55	2	9.0	D	Orginally 85 ft. deep.
do	6[a]	28[a]	12/7/54	C,E	10	12/7/54	5	.4	D	
do	45[a]	83[a]	9/24/54	J,E	—	—	—	—	D	
do	50[a]	90[a]	6/16/52	J,E	10	6/16/52	1	.25	D,F	
do	30[a]	40[a]	10/29/54	J,E	30	10/29/54	4	3.0	D	
do	30[a]	75[a]	8/4/53	J,E	4	8/4/53	.5	.1	D,F	
do	27.45	—	7/18/56	J,E	6	—	—	—	D	
do	15[a]	—	—	C,E	—	—	—	—	F	Cistern supplies home.
do	40[a]	—	—	J,E	—	—	—	—	D	
Grove limestone	3[a]	45[a]	6/20/52	T,E	110–150	6/—/52	64	3.8±	P	See well log and chemical analysis.
Ijamsville phyllite	25[a]	—	7/7/51	J,E	10	7/7/51	1	—	D	Deepened by Green; present depth not known.
do	30[a]	102[a]	5/14/52	J,E	2	5/14/52	1	—	D,F	
do	28[a]	40[a]	8/12/52	C,H	15	8/12/52	.5	1.2	D	
	23.50	—	10/4/55							
Antietam quartzite	—	—	—	S,E	—	—	—	—	D	Adequate and reliable.
Contact-Antietam quartzite and Frederick limestone	—	—	—	S,E	—	—	—	—	D	Adequate.
Frederick limestone	20[a]	25[a]	6/14/53	J,E	20	6/14/53	1	4	D,C	Adequate for 3 families and service station. Water softener used.
	11.90	—	10/4/55	J,E						
do	20[a]	—	1/6/54	N	30	1/6/54	2	—	N	Destroyed. Gasoline contaminated.
Grove limestone	—	—	—	N	—	—	—	—	N	Destroyed. Crooked hole; could not install casing.
do	12[a]	46[a]	7/1/55	J,E	9	7/1/55	1	.27	F	Orginally 91 ft. deep with 55 ft. of casing. Reamed to 8 in. and deepened to 115 ft. by Keyser to correct sanding condition. See well log.
do	22.53	—	10/7/55	J,E; C,H	—	—	—	—	D,F	
New Oxford	40[a]	—	9/25/53	J,E	1	9/25/53	.2	—	D	
Frederick limestone	8.5	—	10/12/55	N	—	—	—	—	N	
do	—	—	—	J,E	—	—	—	—	D,F	Good yield reported.
do	—	—	—	C,N	—	—	—	—	N	
do	18[a]	26[a]	4/20/55	—	7	4/20/55	2	.9	D	
Ijamsville phyllite	5[a]	52[a]	3/24/55	J,E	8	3/24/55	.5	.17	D	Depth of pump jet 55 ft.
do	34[a]	76[a]	7/16/49	C,H	6	7/16/49		.1	D	Irony taste reported.
do	34.45	—	10/12/55	B,H	—	—	—	—	N	Low yield at times.
Frederick limestone	18[a]	22[a]	9/8/53	J(?), E	6	9/8/53	—	1.5	D	See chemical analysis.
	24.2	—	10/12/55							
do	—	—	—	C,H	—	—	—	—	D	Adequate.

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Cf 22	Charles Stup	Corum	1949	430	Drilled	82	5⅝	12	Draw
Cf 23	Mrs. Effie Strine	do	1950	350	do	58	6	8	Hilltop
Cf 24	Carmen L. Fiogle	H. E. Wantz	1953	510	do	123	6	17.5	do
Cf 25	Mr. Lookingbill	—	—	460	do	—	6	—	do
Cf 26	N. L. Stitly	Harris	1954	480	do	103	5⅝	28	do
Cf 27	C. J. Martin	do	1954	480	do	64	5⅝	8	Hillside
Cf 28	Russell W. Martin	Corum	1951	530	do	80	6	15	do
Cf 29	Harry Gruber	All Md. Pump and Well Co.	1956	380	do	47	5⅝	14	Upland flat
Cf 30	Woodsboro Savings Bank	Keyser	1953	325	do	88	6	11.5	do
Cf 31	Mr. Fillers	—	—	355	Spring	—	—	—	Hillside
Cf 32	Do	—	Old	360	Drilled	—	6	—	Upland flat
Cf 33	David L. Nash	LeGore	1955	590	do	110	6	31	Hillside
Cf 34	Albert Gonner	—	—	550	Spring	—	—	—	do
Cf 35	Glenn Holt	—	1954	520	Drilled	98	6	13	Upland flat
Cg 1	A. B. Potts		Old	586	Dug	43	36	—	do
Cg 2	Jesse N. Nicodemus	Greene	1949	605	Drilled	71	6	11	do
Cg 3	Russell Frowfelter	E. Brown	1955	595	do	100	6	36	do
Cg 4	Carville T. Grabill	Hiner	1948	605	do	100	6	—	do
Cg 5	Bernard Keefer	Corum	1952	410	do	81	5⅝	21	Hillside
Cg 6	Thomas Keeney	do	1953	600	do	58	5⅝	21	Upland flat
Cg 7	Earl F. Keefer	C. L. Wantz	1948	430	do	98	6	8	Hillside
Cg 8	John W. Baker	H. E. Wantz	1951	610	do	70	5⅝	17.6	do
Cg 9	Earl F. Keefer	Cromwell	1953	440	do	95+	6	—	do
Cg 10	Do	Showers	1955	470	do	120	6	17	do
Cg 11	Elmer Sager	Wantz	1931	500	do	349	6	—	do
Cg 12	Paul Fogle	do	1931	470	do	64	6	—	Valley side
Cg 13	James Hoy	—	Old	550	do	149	6	—	Hillside
Cg 14	Stephen V. Knott	E. Brown	1949	550	do	64	6	—	Hilltop
Cg 15	Do	—	—	550	Dug	19	36	—	do
Ch 1	Charles J. Fogle	—	Before 1935	725	Drilled	46	6	—	Hillside
Db 1	R. H. Hinds	Harley	1951	620	do	49	6	14.5	Hilltop
Db 2	Do	—	—	600	Dug	30	36	—	Hillside
Db 3	Do	—	—	600	Spring	—	—	—	do

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Frederick limestone	19[a]	—	5/7/49	C,H	7	5/7/49	1	—	D	
New Oxford (quartz conglomerate)	—	—	—	C,H	10	12/7/50	.5	—	D	
Antietam quartzite	27[a]	—	5/2/53	?,E	.5	5/2/53	.2	—	D	Bailed dry in 10 minutes. See well log.
New Oxford	—	—	—	J,E	—	—	—	—	D	
do	30[a]	70[a]	8/2/54	E	—	—	—	—	D	
New Oxford (quartz conglomerate)	12[a]	52[a]	8/17/54	J,E	—	—	—	—	D	Adequate.
do	30[a]	60[a]	3/12/51	J,E	15	3/12/51	.5	.5	D	
Frederick limestone	20[a]	—	1956	NI	25	1956	2	—	D	
do	20[a]	25[a]	6/5/53	—	20	6/5/53	1	4.0	N	
Grove limestone	—	—	—	N	100–200	10/5/55	—	—	N	Discharges from cavern-like opening in hillside.
do	—	—	—	J,E	—	—	—	—	D	Adequate.
Ijamsville phyllite	53[a]	90[a]	1/13/55	J,E	10	1/13/55	2	.27	D	See well log.
do	—	—	—	N	10	10/26/56	—	—	N	Temperature Oct. 26, 1956, 58°F.
Antietam quartzite	—	—	—	J,E	—	—	—	—	D	
Ijamsville phyllite	37.46 38.94	— —	6/28/46 9/10/56	J,E; C,H	7	1946	—	—	D	Water-level observation well. See chemical analysis.
do	27[a]	—	8/1/49	J,E	—	—	—	—	D	
do	40[a]	—	4/21/55	J,E	6	4/21/55	—	—	D	
do	36[a]	—	12/18/48	J,E	7	12/18/48	.5	—	D	
New Oxford	22[a]	60[a]	2/5/52	J,E	10	2/5/52	1	.2	D	
Ijamsville phyllite	24[a]	39[a]	5/4/53	—	12	5/4/53	—	.4	D	
New Oxford	10[a]	—	2/21/48	J,E	1.75	2/21/48	.3	—	F	Reported bailed dry in 20 minutes.
New Oxford (quartz conglomerate)(?)	28[a]	—	11/19/51	J,E	—	—	—	—	D	
New Oxford	31[a]	86[a]	12/24/53	J,E	7	12/24/53	—	1.0	D	
do	50[a]	90[a]	6/16/52	J,E	10	6/16/52	—	.25	D	
Wakefield marble	—	—	—	C,E	8	—	—	—	D,F	Water reported hard.
do	—	—	—	C,E	25	—	—	—	D,F	Well drilled at site of dry spring.
Sams Creek metabasalt	70±	—	9/27/56	C,E	—	—	—	—	D,F	Adequate.
Ijamsville phyllite	20[a]	—	—	C,E	—	—	—	—	F	
do	16.76	—	11/14/56	C,E	—	—	—	—	D	
do	—	—	—	J,E	—	—	—	—	D	Adequate. See chemical analysis.
Catoctin metabasalt	6[a]	—	4/14/51	J,E	35	4/14/51	—	—	F	Inadequate at times. Turkey farm. Owner reports well may be 105 ft. deep.
do	2[a]	—	4/1/55	J,E	—	—	—	—	F	Good yield reported. Supplements supply from Db 1. See chemical analysis.
do	—	—	—	—	15	4/1/55	—	—	N	Continuous discharge reported.

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Db 4	Elmer Smith	Holtzman	1949	1,280	Drilled	70	$5\frac{5}{8}$	21	Hillside
Db 5	Harlen Haupt	do	1948	1,330	do	69.5	$5\frac{5}{8}$	51	do
Dc 1	H. J. Mock	Corum	1950	850	do	50	$5\frac{5}{8}$	7	do
Dc 2	Gladhill Furniture Co.	E. Brown	—	570	do	104	6	—	do
Dc 3	Oscar Myers	Smith	1955	600	do	58	$5\frac{5}{8}$	35.5	do
Dc 4	Fred A. Leonard	Keyser	1953	1,080	do	112	6	14	Hilltop
Dc 5	E. C. Tullis	do	1953	1,060	do	113	6	15	do
Dc 6	G. F. Crouse	do	1953	1,000	do	130	6	13	Hillside
Dc 7	Wilbur Gladhill	do	1952	700	do	66	$5\frac{5}{8}$	45	do
Dc 8	Guy Gladhill	do	1950	620	do	20	$5\frac{5}{8}$	21	do
Dc 9	Paul A. Routzahn	Smith	1955	625	do	93	$5\frac{5}{8}$	8	Upland flat
Dc 10	Howard Marker	Shaff	1950	560	do	129	$5\frac{5}{8}$	56	Hillside
Dc 11	Austin Marker	do	1953	580	do	50	$5\frac{5}{8}$	50	Hilltop
Dc 12	Park A. Beachley	Keyser	1955	500	do	60	6	—	Valley
Dc 13	Rudy's Motel	Harley	1952	500	do	69	6	12	Hillside
Dc 14	Frank Sheffer	do	1950	480	do	45	$5\frac{5}{8}$	21	do
Dc 15	Ruthland Boyer	Keyser	1951	465	do	103	$5\frac{5}{8}$	38	do
Dc 16	Town of Middletown	Shaff	1955	645	do	130	8	—	Upland flat
Dc 17	J. B. Sampsell	do	1951	615	do	67	$5\frac{5}{8}$	—	Hillside
Dc 18	Do	Sampsell	1947	615	do	55	6	55	do
Dc 19	W. P. Bireley	Keyser	1951	600	do	117	6	17	Hilltop
Dc 20	Mr. Thayer	—	Old	415	do	40	36	—	Valley flat
Dc 21	Do	—	—	480	Spring	—	—	—	Hillside
Dc 22	Franklin Rydzek	—	—	620	do	—	—	—	do
Dc 23	Mrs. Thelma Black	—	Old	460	Dug	19	36	—	do
Dc 24	E. F. Holter	—	—	570	Spring	—	—	—	do
Dc 25	Dr. William Sweet	—	—	1,050	Drilled	178	$5\frac{5}{8}$	—	Hilltop
Dc 26	Do	Keyser	1950	980	do	95	$5\frac{5}{8}$	10	Hillside
Dc 27	Braddock Heights Water Co.	E. Brown	Before 1942	830±	do	100	—	—	do
Dc 28	Damon Blinkenstaff	—	1940	680	do	76	6	—	do
Dc 29	William Willis	—	—	685	Spring	—	—	—	do
Dc 30	J. Wilbur House	Keyser	1956	785	Drilled	230	6	—	Hilltop
Dc 31	South Mountain Creamery	Kohl Bros.	1925	470	do	375	6	—	Hillside
Dd 1	Fort Detrick	—	About 1943	325	do	?	?	—	Upland flat
Dd 2	Do	—	About 1943	350	do	?	8	—	do

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Catoctin metabasalt	39[a]	58[a]	10/25/49	C,H	6	10/25/49	1	0.3	D	See well log.
do	39[a]	59[a]	10/18/48	C,H	5	10/18/48	1	.25	D	
do	14[a]	—	10/17/55	J,E	8	6/16/50	.75	—	D	
do	50[a]	—	—	C,E	15	—	—	—	N	
granodiorite and granite gneiss	44[a]	49[a]	8/29/55	—	10	8/29/55	1	2.0	D	Grouted to 17 ft.
Catoctin metabasalt	20[a]	110[a]	5/12/52	J,E	3	5/12/52	1	<.1	D	
do	15[a]	35[a]	4/16/53	J,E	8	4/16/53	2.5	.4	D	
do	30[a]	125[a]	4/4/53	C,E	2	4/4/53	1	<.1	D	See chemical analysis.
Catoctin metabasalt or rhyolite tuff	15[a]	25[a]	2/8/52	J,E	10	2/8/52	1	1.0	D	
Catoctin metabasalt	5[a]	12[a]	8/14/50	C,H	3	8/14/50	.5	.4	D	
do	33[a]	—	7/15/55	J,E	10	7/15/55	1	—	D	See well log.
granodiorite and granite gneiss	35[a]	—	7/1/50	J,E	10	7/1/50	4	—	D	
do	10[a]	—	3/31/53	J,E	5	3/31/53	1	—	D	
do	30[a]	35[a]	2/14/55	J,E	8	2/14/55	2	1.6	D	
Catoctin metabasalt	14[a]	60[a]	9/3/52	J,E	10	9/3/52	—	.2	C	See well log.
Catoctin metabasalt or Loudoun	6[a]	—	4/22/50	J,E	10	4/22/50	—	—	D	
Catoctin metabasalt	30[a]	50[a]	11/21/51	—	10	11/21/51	2	.5	D	
do	30[a]	60[a]	4/30/55	T,E	30	4/30/55	1	1.0	P	See chemical analysis. Temperature May 9, 1956, 52°F.
	35.29	—	10/18/55							
do	38[a]	45[a]	11/3/51	C,H	5	11/3/51	1.5	.7	N	
	16.69	—	10/18/55							
do	15.60	—	10/18/55	J,E	—	—	—	—	D	See well log.
Loudoun	30[a]	50[a]	5/30/51	J,E	6	5/30/51	1	.3	D	
granodiorite and granite gneiss	7.65	—	10/20/55	J,E; CH	—	—	—	—	D	
do	—	—	—	N	4	10/20/55	—	—	D	Temperature Oct. 20, 1955, 56°F; Dec. 20, 1955, 46°F.
Catoctin metabasalt	—	—	—	N	3	10/21/55	—	—	D	Supplies 4 homes.
granodiorite and granite gneiss	9.88	—	10/21/55	N	—	—	—	—	N	
Catoctin metabasalt	—	—	—	J,E	2	10/21/55	—	—	D,F	
do	68.18	—	10/17/55	C,H	—	—	—	—	N	Water-level observation well.
do	45[a]	90[a]	7/12/50	J,E	1	7/12/50	.5	<.1	D	
Loudoun or Catoctin metabasalt	50[a]	—	—	N(?)	25	—	—	—	N	Exact location unknown. May be destroyed.
Catoctin metabasalt	20[a]	—	1940	J,E	—	—	—	—	D	Depth of pump jet 68 ft.
do	—	—	—	N	5	8/15/56	—	—	D	Temperature Aug. 15, 1956, 58°F.
do	—	—	—	NI	—	—	—	—	D	
do	60[a]	—	—	C,E	30	—	—	—	N	
Contact-Frederick limestone and New Oxford (limestone conglomerate)	—	—	—	T,E	75	—	—	—	I	
Frederick limestone	—	—	—	N	—	—	—	—	N	Poor yield reported.

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Dd 3	Fort Detrick	Keyser	1952	375	Drilled	140	6	45	Hillside
Dd 4	Do	—	About 1943	320	do	800±	—	—	Upland flat
Dd 5	City of Frederick	—	1844	540	do	996	—	—	Hillside
Dd 6	Do	—	1844	560	do	1,140	—	—	do
Dd 7	William Lantz	Shaff	1950	690	do	153.5	5⅝	—	do
Dd 8	Do	do	1952	730	do	100	8	—	do
Dd 9	Mr. McCavett	Easterday	1956	500	do	209	6	23	do
Dd 10	Braddock Heights Water Co.	Cullen	—	690	do	510	8	8	Valley
Dd 11	Do	—	—	690	Spring	—	—	—	do
Dd 12	Do	—	—	960	do	—	—	—	Valley side
Dd 13	Do	Cromwell	1954	910	Drilled	85	6	42	Valley
Dd 14	Claude H. Dutrow	Keyser	1954	480	do	85	6	27	Hillside
Dd 15	L. B. Pennington	Harley	1949	480	do	124	6	0	do
Dd 16	Walter L. Andrews	Keyser	1951	510	do	88	6	35	Hilltop
Dd 17	William D. Mathews	do	1951	530	do	122	6	9	do
Dd 18	Harvey Whipp	Harley	1951	680	do	88	6	12	Hillside
Dd 19	Do	—	—	680	Dug	53	30	—	do
Dd 20	Robert F. Penn	Harley	1950	790	Drilled	85	—	6	do
Dd 21	Leonard M. Thompson	Keyser	1952	680	do	105	6	18	do
Dd 22	Charles Korrell	Harley	1953	570	do	130	5⅝	28	Hilltop
Dd 23	Graeon Korrell	do	1953	580	do	90	5⅝	22	do
Dd 24	Harvey Blank	Harris	1954	550	do	80	5⅝	13	do
Dd 25	Lester Shaffer	Harley	1953	450	do	93	5⅝	23	Hillside
Dd 26	M. E. Rhoderick	Shaff	1953	400	do	70	6	60	Upland flat
Dd 27	Austin Kemp	—	Before 1930	400	do	74	6	—	Hillside
Dd 28	Milton Blank	Harris	1955	570	do	80	5	17	do
Dd 29	Hermann B. Brust, Jr.	Keyser	1950	750	do	62	6	21	do
Dd 30	M. Lloyd Blank	Harley	1949	550	do	70	6	30	do
Dd 31	John M. Etzler	Keyser	1952	690	do	104	6	12	Hilltop
Dd 32	Norman Dutrow	Harris	1953	580	do	108	5⅝	12	do
Dd 33	Paul O. Jones	Keyser	1955	450	do	75	5⅝	25	do
Dd 34	Spencer Brittain	do	1956	430	do	86	6	—	do
Dd 35	Walter A. Martz	do	1949	380	do	100	6	14	do
Dd 36	Do	—	Old	360	do	67(?)	6	—	Hillside
Dd 37	Do	Keyser	1952	390	do	90	6	15	Hilltop
Dd 38	John Wiley	—	—	350	Spring	—	—	—	Valley
Dd 39	Do	—	—	340	do	—	—	—	do
Dd 40	Zion Reformed Chruch	do	1951	325	Drilled	34	6	0	Valley side

—*Continued*

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
New Oxford	30[a]	—	9/12/52	T,E	65	9/12/52	3	—	I	See well log.
	34.62	—	9/25/53	T,E						
Frederick limestone	—	—	—	N	—	—	—	—	N	Destroyed.
Harpers phyllite	3.61	—	11/9/56	N	70	—	—	—	N	Airlift pump pipes in well.
do	—	—	—	N	—	—	—	—	N	Do
Loudoun	53[a]	73[a]	10/9/50	—	5	10/9/50	2	0.25	D	
do	40[a]	94[a]	3/10/52	J,E	2	3/10/52	3	<.1	N	Formerly a restaurant.
Harpers phyllite and/or Antietam quartzite	39[a]	209[a]	5/2/56	NI	3	5/1/56	—	—	D	Small amount of water at 70 and 170 ft. Blasting at these depths improved supply. Two dry holes, 232 and 100 ft. deep, drilled previously.
Catoctin metabasalt	15[a]	—	—	C,E	10	—	—	—	P	Principal supply obtained at 200 ft. Supplements springs.
do	—	—	—	N	—	—	—	—	P	Two springs piped to nearby reservoir. Springs Dd 11 and 12 are main sources.
do	—	—	—	N	—	—	—	—	P	Gravity flow to reservoir.
do	5[a]	11[a]	7/24/54	C,E	50	7/24/54	1.2	8.3	P	Supplements spring supply.
Harpers phyllite	30[a]	60[a]	6/3/54	J,E	10	6/3/54	2	.3	D	
Antietam quartzite	6[a]	110[a]	2/4/49	?,E	3	2/4/49	—	<.1	D	
Harpers phyllite	35[a]	70[a]	3/10/51	J,E	3	3/10/51	1	.1	D	
do	20[a]	40[a]	8/22/51	J,E	2.5	8/22/51	1	.12	D	
Loudoun	48[a]	77[a]	7/24/51	J,E	2.5	7/24/51	—	<.1	D	
	49.10	—	6/15/56							
do	45.49	—	6/15/56	N	—	—	—	—	N	
do	36[a]	81[a]	2/18/50	—	3.5	2/18/50	—	<1.1	D	
do	20[a]	100[a]	10/15/52	J,E	1	10/15/52	0.5	<.1	D	Adequate.
Harpers phyllite	30[a]	50[a]	6/3/53	J,E	15	6/3/53	—	.8	D	
do	25[a]	80[a]	1/14/53	J,E	3	1/14/53	—	<.1	D	
do	35[a]	70[a]	4/26/54	?,E	5	4/26/54	—	.14	D	
New Oxford	23[a]	76[a]	10/16/53	J,E	12	10/16/53	—	.2	D	
do	—	—	—	J,E	3	12/2/53	4	—	D	
do	54[a]	—	1930	J,E	—	—	—	—	D	
Harpers phyllite	—	—	—	?,E	—	—	—	—	D	
Loudoun	30[a]	45[a]	10/20/50	J,E	6	10/20/50	1	.4	D	See well log.
Harpers phyllite	35[a]	55[a]	3/18/49	?,E	6	3/18/49	—	.3	D	
Loudoun	30[a]	104[a]	5/2/52	J,E	2	5/2/52	1	—	D	
Harpers phyllite	30[a]	80[a]	5/2/53	?,E	—	—	—	—	D	
New Oxford	32[a]	48[a]	4/28/55	J,E	9	4/28/55	1	.56	D	
do	—	—	—	J,E	—	—	—	—	D	Adequate.
do	25[a]	80[a]	12/6/49	J,E	6	12/6/49	1	.11	D,F	
do	24.96	—	6/6/56	J,E	—	—	—	—	D	Adequate.
do	10[a]	86[a]	4/12/52	?,E	5	4/12/52	1	<.1	D	
do	—	—	—	N	5–10	6/11/56	—	—	D,F	Discharge ceased during 1930 drought. West spring.
do	—	—	—	N	5–10	6/11/56	—	—	F	Continuous discharge. East spring.
do	2[a]	30[a]	9/6/51	J,E	3	9/6/51	1	.1	D	Drilled at site of dried up spring.

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Dd 41	Herbert G. Tyeryar	Keyser	1951	400	Drilled	69	5⅝	33	Hillside
Dd 42	Mr. Stup	—	Before 1900	380	do	18-20	36	—	Valley side
Dd 43	Howard Zimmerman	Keyser	1954	450	do	25	5⅝	25	Upland flat
Dd 44	Brosius Homes Corp.	do	1955	490	do	214	6	100	Hillside
Dd 45	Benjamin J. Wilson	Harley	1952	340	do	81	6	75	Hilltop
Dd 46	Ruben Stockman	do	1951	430	do	65	6	24	Hillside
Dd 47	Robert H. Layman	do	1952	640	do	160	6	22	Hilltop
Dd 48	Silas D. Kuhn	Keyser	1952	600	do	135	5⅝	16	do
Dd 49	Joseph L. Lebherz	do	1950	650	do	128	5⅝	20	do
Dd 50	Thomas Shepley	Harley	1953	480	do	75	5⅝	15	do
Dd 51	Harp Gilbert	do	1953	480	do	77	5⅝	23	Hillside
Dd 52	George E. Hamilton	Keyser	1953	560	do	100	6	11	do
Dd 53	Harry Ramsburg	Harley	1955	640	do	36	5⅝	20	do
Dd 54	C. B. Schmitt	do	1951	1,000	do	60	6	36	do
Dd 55	Do	—	—	1,000	do	27	48	—	do
Dd 56	Do	Keyser	1952	1,020	do	80	5⅝	33	do
Dd 57	J. R. Yingling	Harley	1953	990	do	84	6	50	do
Dd 58	Dr. M. L. Lerner	Harris	1954	1,130	do	74	5⅝	67	do
Dd 59	Rose's Restaurant	Keyser	1954	380	do	125	5⅝	15.5	do
Dd 60	Gale W. Cook	do	1953	380	do	30	6	22	do
Dd 61	Lucky's Trailer Court	Corum	1949	370	do	41	6	32	do
Dd 62	Do	Keyser	1953	380	do	92	6	—	do
Dd 63	Masser's Motel	do	1955	410	do	214	8	28	Upland flat
Dd 64	Do	do	1951	410	do	163	—	—	do
Dd 65	Resley Stull, Jr.	Harley	1956	420	do	56	5⅝	22	do
Dd 66	Mrs. Anna J. Harnwell	Keyser	1953	325	do	92	6	9	Hillside
Dd 67	Dan-Dee Restaurant	Cromwell	1948	930	do	30	5	30	do
Dd 68	Dan-Dee Motel	Harley	1952	945	do	76	5⅝	23	do
Dd 69	Monocacy Broadcasting Co.	Cromwell	—	1,710	do	95-100	6(?)	—	Hilltop
Dd 70	Charles Mc. Smith, Jr.	Keyser	1952	500	do	96	5⅝	39	Hillside
Dd 71	Do	Cromwell	Before 1952	500	do	90±	6	—	do
Dd 72	Do	—	Old	500	Dug	40.7	48	—	do
Dd 73	Alton J. Toms	Keyser	1952	600	Drilled	140	6	14	do
Dd 74	C. Arnold Duvall	—	—	660	do	21.1	6	—	Valley
Dd 75	State of Maryland	—	—	780	Spring	—	—	—	Hillside

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping rest (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
New Oxford	20[a]	50[a]	9/1/51	J,E	4	9/1/51	.5	.13	D	
do	—	—	—	C,H	—	—	—	—	D	Adequate.
Alluvial cones	10[a]	23[a]	9/2/54	?,E	4	9/2/54	1	.3	D	
Harpers phyllite	25[a]	50[a]	5/4/55	T,E	50	5/4/55	23	2.0	P	Supplies about 10 homes in subdivision. Depth of pump 150 ft.
New Oxford	60[a]	—	5/17/52	?,E	15	5/17/52	—	—	D	
Tomstown dolomite(?)	30[a]	40[a]	11/26/51	S,E	10	11/26/51	—	1.0	D	
	9.47	—	6/15/56							
Harpers phyllite	43[a]	150[a]	6/21/52	C,E	2	6/21/52	—	<.1	D	Barely adequate. See well log.
do	25[a]	130[a]	1/17/52	J,E	.5	1/17/52	.5	<.1	D	
do	50[a]	120[a]	9/28/50	C,E	2.5	9/28/50	1	<.1	D	Just adequate.
Antietam quartzite	33[a]	65[a]	5/30/53	—	8	5/30/53	—	.25	D	
do	30[a]	65[a]	7/27/53	J,E	4	7/27/53	—	.1	D	See well log.
Harpers phyllite	10[a]	50[a]	9/16/53	J,E	5	9/16/53	1	.1	D	
do	9[a]	30[a]	1/22/55	J,E	5	1/22/55	—	.24	D	
Loudoun	20[a]	—	9/12/51	J,E	15	9/12/51	—	—	D	
do	13.51	—	9/5/56	C,H	—	—	—	—	N	Inadequate yield at times.
do	25[a]	30[a]	2/27/52	J,E	3	2/27/52	1	.1	N	Drilled to 55 ft. by Keyser; Deepened by Harley because of muddy water. May have increased casing length. Water still muddy.
do	22[a]	25[a]	3/11/53	J,E	3	3/11/53	—	<.1	D	
do	48[a]	56[a]	12/29/54	—	—	—	—	—	D	See well log.
New Oxford (limestone conglomerate)	35[a]	70[a]	5/14/54	J,E	10	5/14/54	1	—	C	
do	15[a]	20[a]	7/24/53	J,E	20	7/24/53	1	4.0	C	
do	17[a]	19[a]	11/3/49	T,E	15	11/3/49	1	7.5	D	
do	—	—	—	T,E	—	—	—	—	D	
Frederick limestone	10[a]	180[a]	9/30/55	J,E	10	9/30/55	1	<.1	C	
do	—	—	—	J,E	—	—	—	—	C	Reported not as good as Dd 63.
New Oxford	8[a]	22[a]	3/9/56	J,E	10	3/9/56	—	.7	D	See chemical analysis. Temperature May 4, 1956, 55°F.
New Oxford (limestone conglomerate)	10[a]	—	9/9/53	J,E	25	9/9/53	2	—	D	
Catoctin metabasalt	—	—	—	J,E	—	—	—	—	C	Reported flowing Mar. 1948; water level below land surface Sept. 1956.
do	17[a]	—	11/5/52	J,E	12	11/5/52	—	—	C	
Loudoun	45–50[a]	—	—	?,E	6–7	—	—	—	D	See well log.
Harpers phyllite	10[a]	80[a]	8/12/52	J,E	2	8/12/52	.5	<.1	D	
	20.98	—	11/8/56							
do	—	—	—	N	—	—	—	—	N	Crooked hole; caved while drilling.
do	5.45	—	11/8/56	N	—	—	—	—	N	Was inadequate at times.
do	20[a]	120[a]	8/26/52	C,E	1.5	8/26/52	1	<.1	D	
Weverton quartzite	8.51	8.76	11/8/56	C,H	4.4	11/8/56	.4	17.6	N	
do	—	—	—	N	20	11/8/56	—	—	P	"Spout Spring." Roadside public spring. Temperature Nov. 8, 1956, 53°F.

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Dd 76	J. Ruskin Loy	Keyser	1952	620	Drilled	105	6	9	Hilltop
Dd 77	E. A. Heywood	do	1952	515	do	73	$5\frac{5}{8}$	18	do
Dd 78	Gambrill State Park	—	—	1,400	Spring	—	—	—	Hillside
De 1	Fort Detrick	Keyser	1953	340	Drilled	87	6	18	Upland flat
De 2	Do	—	—	340	Spring	—	—	—	Valley
De 3	Charles W. Brunner	Shaff	1952	485	Drilled	41(?)	$5\frac{5}{8}$	—	Hilltop
De 4	Edward Hoffman	Corum	1952	390	do	97	6	14	Hillside
De 5	Harry Finneyfrock	Harris	1953	445	do	40	6	34	Hilltop
De 6	Guy E. Buckey	Harley	1954	310	do	40	$5\frac{5}{8}$	28	Upland flat
De 7	Frank N. Stauffer	Shirley	1954	310	do	123	$5\frac{5}{8}$	51	do
De 8	Do	—	Old	310	Dug	15	36 or 48	—	do
De 9	Charles Routzan	Shirley	1954	320	Drilled	65	6	59	Hillside
De 10	Harry S. Rippeon	Harley	1952	320	do	111	$5\frac{5}{8}$	17.9	do
De 11	Ralph L. Zimmerman	Corum	1949	290	do	83	6	6	Upland flat
De 12	Nevin W. Staley	Keyser	1954	310	do	84	6	23	do
De 13	Sanitary Products Corp.	Owings	1951	300	do	70	12	21	do
De 14	J. R. McLaren	E. Brown	Before 1942	320	do	400	6	70	do
De 15	Guy E. Buckey	Shirley	1954	310	do	71	6	45	do
De 16	Edward W. Wachter	Cromwell	1955	325	do	55	$5\frac{5}{8}$	18	Hillside
De 17	Nicholas J. Ritter	Keyser	1951	280	do	43	$5\frac{5}{8}$	21	do
De 18	James Dunn	Harris	1954	385	do	79	$5\frac{5}{8}$	23	Hilltop
De 19	Perry Beckley	—	Old	290	do	18	—	—	Draw
De 20	Beckley's Motel	Cromwell	1955	300	do	37	$5\frac{5}{8}$	30	Hillside
De 21	Robert C. Schultz, III	Keyser	1949	300	do	22	$5\frac{5}{8}$	4.5	Hilltop
De 22	Do	do	1955	300	do	100±	—	—	do
De 23	Claude C. Clemson	—	Before 1926	275	do	104	6	—	do
De 24	Do	—	Old	275	Dug	35	48	—	do
De 25	Do	Keyser	1952	280	Drilled	100	$5\frac{5}{8}$	14.5	do
De 26	James W. Carmack	Harley	1956	320	do	70	6	19	Hillside
De 27	Ebert Ice Cream Co.	E. Brown	1930	290	do	200	8	0	Upland flat
De 28	Do	Grove	1930	305	do	735	8	—	Hillside

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Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Harpers phyllite	30[a]	40[a]	9/27/52	J,E	20	9/27/52	1	2.0	D	
do	20[a]	30[a]	2/8/52	J,E	6	2/8/52	1	.6	D	See chemical analysis. Temperature Nov. 28, 1956, 54°F.
Weverton quartzite and Loudoun	—	—	—	C,E	—	—	—	—	P	"Bootjack Spring."
Frederick limestone	20[a]	25[a]	4/24/53	J,E	25	4/24/53	3	5.0	D	See chemical analysis.
	6.01	—	9/24/53							
do	—	—	—	S,E	40	—	—	—	F	Water ponded downstream for irrigation use. See chemical analysis.
Ijamsville phyllite	20[a] (?)	23[a] (?)	10/1/52	J,E	5	10/1/52	1	2.5	D	
	39.77	—	10/24/55							
Antietam quartzite	—	—	—	—	10	6/9/52	1	2.0(?)	D	
do	15[a]	—	6/26/53	—	10	6/26/53	—	—	D	
Frederick limestone	25[a]	—	1/15/54	N	10	1/15/54	—	—	N	Destroyed because of muddy water, low yield.
Grove limestone	30[a]	—	9/7/54	J,E	45	9/7/54	6	—	D,F	
do	—	—	—	C,H	—	—	—	—	N	Inadequate.
do	32[a]	40[a]	8/11/54	J,E	22	8/11/54	1.5	2.75	D	See well log.
do	30[a]	100[a]	4/23/52	J,E	2.5	4/23/52	—	<.1	D	
do	16[a]	—	6/25/49	C,E	10	6/25/49	.5	—	D	
Frederick limestone	30[a]	30[a]	2/2/54	?,E	15	2/2/54	1	—	D	
Grove limestone	15[a]	—	11/29/51	—	100	11/29/51	12	—	N	Plant closed. See well log.
do	—	—	—	N	50	—	—	—	N	Main supply at 70 ft. Reported supply diminished with depth so well was plugged at 70 ft. Reported water temperature 62°F.
Frederick limestone	48[a]	—	8/25/54	J,E	30	8/25/54	3	—	D	Orginally 25 ft. of casing; well filled with mud; corrected by increasing casing to 45 ft. See chemical analysis.
do	5[a]	5.3[a]	1/12/55	S,E; C,H	13	1/12/55	1	43	D	Temperature May 4, 1956, 53°F. See chemical analysis.
do	15[a]	20[a]	7/5/51	?,E	10	7/5/51	1.5	2.0	D	
New Oxford	30[a]	65[a]	10/9/54	J,E	—	—	—	—	D	Adequate.
Frederick limestone	13.55	—	6/11/56	S,E	—	—	—	—	D	
do	25[a] (?)	25.5[a] (?)	1/19/55	S,E	10	1/19/55	2	20	C	
do	10[a]	—	8/5/49	N	10	8/5/49	.5	—	N	Reported went dry and was destroyed.
do	—	—	—	J,E	—	—	—	—	D	Adequate.
do	—	—	—	C,H	—	—	—	—	D	Do
do	17.32	—	6/7/56	C,H	—	—	—	—	N	
do	30[a]	—	1/29/52	?,E	20	1/29/52	1	—	C	Kitty's Produce.
do	20[a]	60[a]	5/1/56	J,E	6	5/1/56	—	.1	D	See well log.
do	28[a]	—	—	N	80	—	—	—	N	Principal supply at 60 ft. Covered by floor of main building.
do	41.50	—	8/29/56	J,E	30	—	—	—	C	Restaurant and dairy plant. Located behind plant. Hardness 222 ppm reported. Reported 5 gpm at 60 ft. and main yield at 300 ft.

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
De 29	Ebert Ice Cream Co.	Ebert	1930	290	Drilled	30	8	—	Valley
De 30	Do	do	1930	300	do	235	8	—	Hillside
De 31	Do	do	1930	300	do	350	—	—	do
De 32	Do	do	1924	310	do	310	8	—	Upland flat
De 33	Harold E. Roderick	Fagel	1931	325	do	72	6	—	Valley flat
De 34	Do	Keyser	1956	325	do	330	6	26	do
De 35	Glade Valley Milling Co.	P. Brown	1906	300	do	100±	6	20	do
De 36	John L. Eaves	Fogel	1932	300	Dug and drilled	169	36–6(?)	—	do
De 37	Charles D. Burrier	Shirley	1954	320	Drilled	96	6	26	Hillside
De 38	W. J. Hahn	—	Before 1944	305	do	63	6	—	Hilltop
De 39	Do	—	—	305	do	155	6	—	Hillside
De 40	Do	Keyser	1954	305	do	105	6	52.5	do
De 41	J. C. Hall	Grove	1929	290	do	90	6	—	Upland flat
Df 1	Samuel Summers	—	—	395	Dug	24±	36	—	Valley
Df 2	George Stevenson, Jr.	Harley	1954	560	Drilled	86	5⅝	23	Hilltop
Df 3	Arthur Rippeon	Harris	1953	520	do	70	6	10	do
Df 4	Do	—	1929	520	do	89	6	8	Hillside
Df 5	Mr. Crum	—	—	535	Dug	18	42	—	Draw
Df 6	Paul Beard	—	—	450	Spring	—	—	—	Hillside
Df 7	Mr. Smith	Cromwell	1956	540	Dug and drilled	100±	48–6	—	Hilltop
Df 8	Granison L. Eader	Easterday	1954	520	Drilled	73	6(?)	—	do
Df 9	E. L. Shoemaker	Harris	1954	535	do	81	5⅝	20	Hillside
Df 10	William T. Delauter	Corum	1950	465	do	100	6	8	Hilltop
Df 11	E. P. Summers	—	—	460	Spring	—	—	—	Draw
Df 12	C. W. Boyer	Harley	1952	490	Drilled	56.5	6	13	Hilltop
Df 13	Ethan P. Summers	Harris	1953	525	do	74	6	19	do
Df 14	Richard K. Stitley	Keyser	1950	500	do	123	5⅝	21	Hillside
Df 15	Libertytown Elementary School	—	1941	580	do	95–109	6	—	Hilltop
Df 16	Do	—	1927	580	do	180	6	—	do
Df 17	Mr. Edwards	—	—	320	Dug	30±	—	—	Hillside
Df 18	L. Grosswein(?)	—	—	470	do	11	48	—	Hilltop

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Frederick limestone	1 to 2[a]	—	Old	S,E	30	—	—	—	C	In pasture behind plant.
	—	6.93	8/29/56							
do	20[a]	—	—	N	30	—	—	—	N	Behind plant; covered. Reported some water at 30 ft.; main yield at 200 ft.
do	—	—	—	N	30	—	—	—	N	Behind plant; covered.
do	—	—	—	N	50	—	—	—	N	Site occupied by Haller's Grocery.
Grove limestone	27.14	—	—	C,E	10	—	—	—	F	Reported main yield at 68 ft.
do	25[a]	30[a]	2/5/56	T,E	100	2/5/56	2	20.0	D,F	
do	10±[a]	—	—	T,E	60	—	—	—	N	Reported very hard.
Frederick limestone	36.70	—	8/31/56	J,E	15	—	—	—	D,F	Dug well 59 ft. deep. Temperature Aug. 31, 1956, 52°F.
Grove limestone	27[a]	70[a]	7/22/54	J,E	22	7/22/54	1	.5	D	
do	40.91	—	9/17/56	J,E	—	—	—	—	D	Adequate.
do	100[a]	—	—	N	—	—	—	—	N	Inadequate; filled in.
do	50[a]	60[a]	9/6/54	J,E	10	9/6/54	—	1.0	F	
do	35[a]	—	—	C,E	7	—	—	—	D,F	
Ijamsville phyllite	19[a]	—	1954	S,E	—	—	—	—	D,F	Adequate.
Libertytown metarhyolite	20[a]	45[a]	4/23/54	J,E	15	4/23/54	—	.6	D	See chemical analysis.
Ijamsville phyllite	32[a]	60[a]	6/16/53	J,E	—	—	—	—	D,F	
do	47±	—	12/23/55	N	—	—	—	—	N	Poor yield reported.
do	—	—	—	C,H	—	—	—	—	D	Good yield reported.
do	—	—	—	N	—	—	—	—	F	Continuous flow reported. Temperature Dec. 23, 1955, 53°F.
do	32.18	—	1/13/56	J,E; C,H	—	—	—	—	D	Drilled through bottom of dug well, which is 5 ft. deep and inadequate.
do	26[a]	73[a]	4/17/54	J,E	5	4/17/54	—	.1	D	
do	40[a]	75[a]	4/13/54	—	5	4/13/54	—	.1	D	
Contact-Ijamsville phyllite and Antietam quartzite	40[a]	—	11/16/50	J,E	10	11/16/50	.25	—	C	Restaurant and service station.
Ijamsville phyllite	—	—	—	S,E	15	12/24/54	—	—	D,F	Discharge small at times, but never ceases. Temperature Dec. 14, 1955, 57°F.
do	10[a]	49[a]	6/2/52	C,H	6	6/2/52	—	.2	D	Temperature Oct. 24, 1955, 57°F.
Libertytown metarhyolite	30[a]	50[a]	6/26/53	J,E	—	—	—	—	D	Adequate.
Ijamsville phyllite	40[a]	119[a]	7/22/50	J,E	2	7/22/50	1	<.1	D	
Libertytown metarhyolite	—	—	—	J,E	—	—	—	—	I	Good yield reported. See chemical analysis.
do	—	—	—	N	—	—	—	—	N	Probably destroyed, location not known.
Frederick limestone	—	—	—	J,E	—	—	—	—	D	Adequate. Depth of pump jet 25 ft.
Libertytown metarhyolite	10±	—	5/20/56	S,H	—	—	—	—	N	

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Df 19	William T. Delauter	Greene	1945	465	Drilled	120+	$5\frac{5}{8}$	—	Hilltop
Dg 1	Roy Schneider	—	—	590	Spring	—	—	—	Draw
Dg 2	Orville E. Smith	—	—	500	Dug and drilled	90±	48–6	—	do
Dg 3	Harvey Rippeon	—	Old	415	Dug	9	—	—	Valley
Dg 4	Mr. Etzler	—	1942(?)	620	Drilled	94	6	—	Hilltop
Dg 5	Norman C. Smith	—	—	430	Dug	36	36	10	Draw
Dg 6	Paul O. Fritz	—	1938	485	Drilled	65	6	—	Hilltop
Dg 7	Mr. Hitchcock	Utermahlen	1953	500	do	42	6	20	Hillside
Dg 8	Otto Gerts	Harley	1950	510	do	62	6	23	do
Dg 9	F. Loraine Simpson	Corum	1949	505	do	57	6	12	Hilltop
Dg 10	Arthur Gray, tenant	—	—	485	do	47	—	—	Valley side
Dg 11	Clyde M. Bohn	—	—	515	Springs	—	—	—	Draw
Dg 12	Weldon Hill	—	Old	580	Dug	19.4	36	—	Hilltop
Dg 13	Unionville Methodist Church	E. Brown	1949	460	Drilled	90	6	50	do
Dg 14	Clifton P. Dudderar	D. Brown	1952	550	do	71	6	42	Draw
Dg 15	Francis Staley	Keyser	1953	490	do	90	6	22	Valley side
Dg 16	Miss Cora Sappington	—	Old	455	Dug	27	—	—	Hillside
Dg 17	Mr. Nicodemus	—	—	445	Drilled	75–80	6	—	Hilltop
Dg 18	C. Pryor	—	—	450	do	45	6	—	do
Dg 19	Earl Disney	Fogel	Old	430	do	186	$5\frac{5}{8}$	24	do
Dh 1	Mr. Rippin	—	—	685	do	60	6	—	Hillside
Dh 2	Oscar Clifford	—	—	550	Spring	—	—	—	Draw
Dh 3	Mr. Beachley	—	1953±	550	Drilled	110	—	—	Hilltop
Dh 4	H. W. Cantwell	Hoffman	1955	645	do	70	6	16	Hillside
Dh 5	Do	—	—	645	Dug	33.6	36	—	do
Ea 1	James G. Webber	Keyser	1951	520	Drilled	69	$5\frac{5}{8}$	20	Hillside
Ea 2	William Cooper	Myers	1947	505	do	43(?)	6	33	do
Eb 1	George Wolfe	Shaff	1953	545	do	76	$5\frac{5}{8}$	—	do
Eb 2	Charles D. Beachley	Keyser	1951	500	do	62	$5\frac{5}{8}$	62	do
Eb 3	D. M. Guyton	F. Corum	1953	520	do	72	6	24	Hilltop

—Continued

Water-bearing formation	Water level (feet) below land surface: Static	Pumping	Date	Pumping equipment	Yield: Gallons per minute	Date	Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
Contact-Ijamsville phyllite and Antietam quartzite	30[a]	—	7/1/45	N	.5	7/1/45	—	—	N	Inadequate.
Marburg schist	—	—	—	—	—	—	—	—	D,F	Perennial supply.
Ijamsville phyllite	—	—	—	C,E	—	—	—	—	D,F	Drilled through bottom of 16 ft. dug well. Perennial supply.
Sams Creek metabasalt	1.0	—	9/8/55	J,E	—	—	—	—	D,C	Residence and general store. Adequate.
Ijamsville phyllite	83.20	—	8/30/55	C,E	—	—	—	—	D	Good yield reported.
Wakefield marble	18[a]	—	—	J,E	—	—	—	—	D,F	Adequate.
Libertytown metarhyolite	13.65	—	9/8/55	C,E	—	—	—	—	D	Do
Ijamsville phyllite	34[a]	—	1953	J,E	15	1953	—	—	D	"Bluish and greenish" material encountered; easy drilling. Adequate.
do	25[a]	52[a]	1/30/50	C(?), E	6	1/30/50	—	0.2	D	See well log.
do	20[a]	—	8/2/49	C,H	12	8/2/49	1	—	F	
Ijamsville phyllite or Wakefield marble	6.83	—	8/29/55	C,H	—	—	—	—	D	Adequate.
Ijamsville phyllite	—	—	—	C,E	50	8/29/55	—	—	D,F	Upper spring not perennial, lower spring perennial. Concrete collecting chambers.
do	11.40	—	8/29/55	B,H	—	—	—	—	D	Dry during 1930 drought.
do	40[a]	75[a]	5/6/49	?,E	10	5/6/49	1	.3	D	See well log.
Ijamsville phyllite or Wakefield marble	35[a]	—	4/23/52	?,E	5	4/23/52	.5	—	D	
Ijamsville phyllite	30[a]	46[a]	1/8/53	—	15	1/8/53	1	.9	D	
Sams Creek metabasalt	22.50	—	10/16/55	S,E	—	—	—	—	D	
do	—	—	—	—	—	—	—	—	D	Adequate.
do	—	—	—	C,H	—	—	—	—	D	Do
do	30[a]	—	—	N	—	—	—	—	N	Well covered. Hard water reported. Upper part drilled through limestone reported.
Marburg schist	—	—	—	J,E	—	—	—	—	—	Inadequate at times.
Ijamsville phyllite	—	—	—	—	15–20	8/30/55	—	—	D	Gravity flow to residence. Continuous flow.
do	—	—	—	C,E	—	—	—	—	D	
do	30[a]	—	8/28/55	J,E	—	—	—	—	D,C	Residence and grocery. Water cloudy due to brown clayey particles; may increase casing to correct this.
do	26.98	—	8/29/55	N	—	—	—	—	N	Inadequate at times.
granodiorite and granite gneiss	25[a]	50[a]	11/25/51	S,E	3	11/25/51	1	.12	D,F	
do	23[a] (?)	—	5/30/47	J,E	2.5	5/30/47	1	—	D	
do	12[a]	30[a]	2/11/53	J,E	8	2/11/53	2	.44	D	
do	35[a]	50[a]	1/25/51	J,E	3	1/25/51	1	.2	D	
do	40[a]	60[a]	6/12/53	J,E	6	6/12/53	1	.3	D	
	33.75	—	10/18/55							

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Eb 4	Robert Arnold	Ambrose	1954	530	Drilled	108	6	22	Hilltop
Eb 5	Thomas Arnold	Shaff	1949	525	do	100	$5\frac{5}{8}$	22	do
Eb 6	Robert Staley	do	1954	585	do	100	$5\frac{5}{8}$	20	Upland flat
Eb 7	Do	—	Old	560	Dug	23.9	96	—	Hillside
Eb 8	Do	Shaff	1949	560	Drilled	201.6	$5\frac{5}{8}$	24	do
Eb 9	T. West Claggett	Harley	1950	490	do	75	6	23	do
Eb 10	Do	Cromwell	1954	465	do	100	6	20	do
Eb 11	Samuel Crane	Shaff	1949	550	do	70	$5\frac{5}{8}$	26	Upland flat
Eb 12	Pleasant View Church	do	1949	525	do	80	6	30	Hilltop
Eb 13	T. E. Conner	Conner	1941	565	Dug	27.8	48	—	Upland flat
Eb 14	Charles Deck	Corum	1949	465	Drilled	85	$5\frac{5}{8}$	12	Hillside
Eb 15	Frank Kefauver	Shaff	1952	575	do	65	$5\frac{5}{8}$	12	do
Eb 16	Maurice Guyton	do	1952	540	do	64	$5\frac{5}{8}$	18	do
Eb 17	Robert Greenwood	Holtzman	1947	525	do	77	$5\frac{5}{8}$	15	Hilltop
Eb 18	Hawaiian Club	Shaff	1954	520	do	99	$5\frac{5}{8}$	22	do
Eb 19	Emory Hargett	Corum	1951	465	do	54	6	12	Hillside
Eb 20	Robert Coates	Shaff	1953	520	do	56	$5\frac{5}{8}$	—	do
Eb 21	Do	do	1952	520	do	50	$5\frac{5}{8}$	—	Hilltop
Eb 22	J. E. Morrison	—	1937	545	do	55	6	—	Upland flat
Eb 23	Do	—	—	720	Spring	—	—	—	Hillside
Eb 24	William E. Fauble	—	1935	505	Dug	39	36	—	do
Eb 25	Col. James M. McHugh	—	Old	555	Drilled	108	6	—	Upland flat
Eb 26	Do	—	—	520	Spring	—	—	—	Draw
Eb 27	Mr. Everett	—	Old	550	Dug	37	36	—	Upland flat
Eb 28	Gathland State Park	—	do	1,020	Drilled	53.5	6	—	Hilltop
Ec 1	Rev. J. W. Bowlus	Shaff	1949	465	do	100	$5\frac{5}{8}$	—	Hillside
Ec 2	C. E. Ahalt	—	—	385	Spring	—	—	—	do
Ec 3	Do	—	1951	370	Drilled	75	6	—	Hilltop
Ec 4	Charles Diehle	—	—	600	Spring	—	—	—	Hillside
Ec 5	Henry Killar	Shaff	1954	490	Drilled	110	$5\frac{5}{8}$	35	Upland flat
Ec 6	Lee's Diner	Smith	1955	595	do	165	$5\frac{5}{8}$	165	Hilltop
Ec 7	Emery Baker	Corum	1949	510	do	58	6	14	Upland flat

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Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
granodiorite and granite gneiss	50[a]	78[a]	12/13/54	N	30	12/13/54	2	2.4	N	See well log.
do	30[a]	60[a]	12/1/49	J,E	10	12/1/49	6	.33	D	
	25.70	—	10/18/55							
Catoctin metabasalt	8[a]	12[a]	6/14/54	J,E	20	6/14/54	10	5.0	D	
do	7.54	—	12/22/55	N	5	1955	8	2.0	N	
					38(?)	1/27/56	3.4	3.1(?)		
do	6.64	—	12/22/55	N	7(?)	1955	8	—	N	
granodiorite and granite gneiss	8[a]	60[a]	9/1/50	J,E	9	9/1/50	—	.17	F	See well log.
do	14.6[a]	85[a]	8/5/54	J,E	7	8/5/54	1	.1	D,F	Originally 76 ft. deep and inadequate.
do	30[a]	40[a]	11/25/49	J,E	4	11/25/49	5	.40	D	
do	15[a]	18[a]	10/11/49	J,E	5	10/11/49	1	1.7	D	
Catoctin metabasalt	4.83	—	12/22/52	B,H	—	—	—	—	D	Site of a dry spring.
granodiorite and granite gneiss	22[a]	—	6/17/49	J,E	10	6/17/49	1	—	D	
Catoctin metabasalt	35[a]	50[a]	12/18/52	J,E	8	12/18/52	4	.53	D	
granodiorite and granite gneiss	25[a]	—	9/12/52	J,E	10	9/12/52	6	—	D	
do	42[a]	68[a]	3/17/47	J,E	5	3/17/47	1	.19	D	Owner reports pumps dry in one-half hour.
do	30[a]	—	5/27/54	J,E	20	5/27/54	1	—	C	Tavern and motel.
do	25[a]	—	11/20/51	C,H	8	11/20/51	.5	—	D	
	37.87	—	12/14/55							
do	10[a]	40[a]	1/14/53	J,E	3	1/14/53	4	.1	C	Service station.
do	12[a]	18[a]	11/10/52	J,E	6	11/10/52	4	1.0	C	
do	16.76	—	8/27/56	C,E	4	—	—	—	D,F	
do	—	—	—	—	4.6	8/27/56	—	—	D	Temperature Aug. 27, 1956, 56°F.
do	31[a]	—	5/15/56	C,E	—	—	—	—	D	Adequate.
do	40[a]±	—	—	J,E	7	—	—	—	D	Blue-green stain on fixtures.
do	—	—	—	N	2	9/21/56	—	—	N	Intermittent. Temperature Sep. 21, 1956, 53°F.
do	8.61	—	9/21/56	C,H	—	—	—	—	N	
Weverton quartzite	38.70	—	7/19/56	C,H	—	—	—	—	I	
granodiorite and granite gneiss	10[a]	40[a]	10/2/49	J,E	2	10/2/49	6	<.1	D	
do	—	—	—	N	2	10/21/55	—	—	F	
do	40[a]	—	—	J,E	5	11/—/51	—	—	D	
Catoctin metabasalt	—	—	—	N	3	10/21/55	—	—	D	
granodiorite and granite gneiss	8[a]	12[a]	12/6/54	J,E	10	12/14/54	6	2.5	D	
	31.71	—	12/14/55							
Harpers phyllite	85[a]	—	7/5/55	J,E	10	7/5/55	5	—	C	See well log.
granodiorite and granite gneiss	25[a]	—	11/9/49	J,E	15	11/9/49	.5	—	D	

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ec 8	Harry R. Baker	Keyser	1952	350	Drilled	70	5⅝	29.5	Valley flat
Ec 9	I. Calvin Rice	do	1949	575	do	71	5⅝	22	Upland flat
Ec 10	John S. Bowlus	Harley	1953	460	do	131	5⅝	23	Hillside
Ec 11	Doris Corum	A. L. Smith	1955	575	do	62	5⅝	40	Upland flat
Ec 12	Edward Weedon	Corum	1951	420	do	58	6	9	Hillside
Ec 13	Howard Weedon	do	1951	450	do	60	6	10	do
Ec 14	Harry Summers	Shaff	1949	555	do	72	5⅝	12	Upland flat
Ec 15	Paul B. Stockman	Harley	1950	450	do	83	6	24	Hillside
Ec 16	H. D. Lakin	do	1955	440	do	76	5⅝	23	do
Ec 17	Hillside Motel	do	1951	595	do	86	6	72	Hilltop
Ed 1	Joseph Himes	—	About 1929	400	do	70	6	—	Hillside
Ed 2	Do	—	1930	420	do	604–615	8–6	—	do
Ed 3	Do	—	—	410	Spring	—	—	—	Draw
Ed 4	Do	—	—	405	do	—	—	—	do
Ed 5	Harry L. Whittington	Harris	1955	525	Drilled	93	5⅝	21	Hilltop
Ed 6	Lawrence Frye	Easterday	1955	280	do	81	6	43	Upland flat
Ed 7	Lacy Degrange	D. Brown	1948	290	do	67	6	33	do
Ed 8	Andrew Younkins	Cromwell	1955	310	do	48	5⅝	30	do
Ed 9	Roger Etzler	Smith	1955	300	do	115	6	2.5	do
Ed 10	Mary Dixon	D. Brown	1956	280	do	72	6	33	do
Ed 11	Miss Annie Rogers	—	—	295	do	40.8	5⅝	—	do
Ed 12	Harriet E. Bell	Keyser	1952	290	do	146	6	27	do
Ed 13	J. W. Gaver	—	Before 1908	415	do	92	6	—	do
Ed 14	Lester Zimmerman	—	Old	385	Dug	22.1	36	—	Hilltop
Ed 15	Howard D. Zimmerman	Keyser	1952	490	Drilled	76	5⅝	24	do
Ed 16	Bowyer B. Font, Jr.	do	1952	410	do	82	5⅝	15	do
Ed 17	Family Drive-In Theatre	Corum	1952	390	do	68	5⅝	12	Upland flat
Ed 18	Mr. Cookley	Keyser	1954	430	do	136	6	15–17	do
Ed 19	Fred Smith	—	Old	450	do	65	6	—	do
Ed 20	Monocacy Broadcasting Co.	Keyser	1950	440	do	76	5⅝	22	Hilltop
Ed 21	Rose Tourist Court	do	1953	405	do	93	5⅝	25	Hillside

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
granodiorite and granite gneiss	10[a]	15[a]	6/8/52	J,E	20	6/8/52	1	4.0	D	
	12.19	—	12/15/55							
do	30[a]	55[a]	7/13/49	J,E	3	7/13/49	.5	.1	D	
	38.16	—	12/14/55							
do	30[a]	110[a]	7/8/53	J,E	2	7/8/53	—	<.1	F	See well log.
Catoctin metabasalt	41[a]	—	6/3/55	J,E	10	6/3/55	.5	—	D	Do
Antietam quartzite	25[a]	40[a]	7/9/51	J,E	15	7/9/51	1	1.0	D,F	
do	45[a]	60[a]	7/6/51	J,E	15	7/6/51	1	—	D,F	Do
Catoctin metabasalt	25[a]	35[a]	3/14/49	S,G	5	3/14/49	4	.2	C	
granodiorite and granite gneiss	30[a]	—	9/21/50	J,E	6	9/21/50	—	.2	D	
Catoctin metabasalt	30[a]	67[a]	7/8/55	J,E	14	7/8/55	—	.38	D	
Harpers phyllite	33[a]	74[a]	8/24/51	J,E	4	8/24/51	—	.1	C	
New Oxford or limestone conglomerate	19.78	—	11/9/54	N	—	—	—	—	N	
Contact(?)-New Oxford and Frederick limestone	—	—	—	T,E	150	—	30	—	D,F	Supplies 2 homes and barns.
New Oxford	—	—	—	N	0	11/9/54	—	—	F	Intermittent.
do	—	—	—	N	0	11/9/54	—	—	F	Do
Harpers phyllite	—	—	—	J,E	—	—	—	—	D	
Frederick limestone	28[a]	39[a]	2/27/55	J,E	10	2/27/55	—	.9	D	See well log.
do	—	—	—	C,E	3	11/21/48	.5	—	D,F	Noticeable decrease in yield in summer.
do	20[a]	21[a]	2/21/55	J,E	15	2/21/55	1	15	D	See well log.
do	25[a]	50[a]	12/10/55	J,E	15	12/10/55	.25	.6	F	
do	50[a]	—	12/3/48	C,H	3	12/3/48	—	.5	D	
do	5.29	—	3/22/56	C,H	—	—	—	—	N	Drilled through bottom of dug well 8.4 ft. deep.
do	30[a]	140[a]	11/22/52	—	2	11/22/52	1	<.1	D	
	33.04	—	8/17/56							
New Oxford (limestone conglomerate)	42[a]	—	11/—/55	C,E	10	—	—	—	D	
Frederick limestone	12.70	—	5/9/56	C,H	—	—	—	—	D	Temperature May 9, 1956, 50°F. See chemical analysis.
Antietam quartzite	36[a]	—	5/23/52	J,E	8	5/23/52	1	—	D	
New Oxford	15[a]	20[a]	3/3/52	J,E; C,H	10	3/3/52	1	.2	D	
do	15[a]	50[a]	10/13/52	?,E	10	10/13/52	1	.3	C	
do	—	—	—	J,E	—	—	—	—	D	Field test: hardness 112 ppm, chloride 10 ppm.
New Oxford (limestone conglomerate)	7.09	—	7/2/56	J,E	7	—	—	—	D	Originally 40 ft. deep. Deepened by Harley to improve sanitary quality.
New Oxford	35[a]	50[a]	4/30/50	J,E	3	4/30/50	1	.2	C	Field test: hardness 98 ppm, chloride 11 ppm.
New Oxford (limestone conglomerate)	10[a]	25[a]	3/10/53	J,E	10	3/10/53	1	.7	C	Adequate. Originally 75 ft. deep and inadequate.
	23.41	—	3/10/53							

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ed 22	Preston Zimmerman	A. L. Smith	1955	530	Drilled	84	5⅝	39.5	Hilltop
Ed 23	Do	—	Old	530	do	90	36–6	—	do
Ed 24	Do	—	—	470	do	90	6	—	do
Ed 25	Tumblebrook Farms	Keyser	1954	320	do	150	6	37	Hillside
Ed 26	Mr. Hicks	Cromwell	1955	325	do	40	6	—	Hilltop
Ed 27	E. Staley	E. Brown	1949	320	do	45	6	20	do
Ed 28	R. A. Dudrow	—	Before 1938	280	do	21–24	36	—	Hillside
Ed 29	Niles E. Abrecht	D. Brown	1948	320	do	106	6	24	Upland flat
Ed 30	Charles F. Harley	Harley	1953	320	do	103	5⅝	15	do
Ed 31	Martin L. Summers	Cromwell	1949	320	do	116	6	10	do
Ed 32	Do	D. Brown	1925	320	do	106	6	—	do
Ed 33	Ideal Farms	Grove	1932	340	do	100	6	—	Hilltop
Ed 34	Do	—	—	340	do	170	6	—	do
Ed 35	Do	Hilton	1948	340	do	55	6	30	do
Ed 36	Do	do	1948	340	do	90	6	35	do
Ed 37	Do	do	1954	340	do	58	6	26	do
Ed 38	Do	do	1955	240	do	82	6	14	Draw
Ed 39	Orval Wolfe	Harley	1955	620	do	150	5⅝	12	Hillside
Ed 40	Charles T. King	Keyser	1951	425	do	102	5⅝	24	do
Ed 41	W. A. Prior	Selders	1947	285	do	370	12–8–6	—	do
Ed 42	Do	—	—	285	Spring	—	—	—	do
Ed 43	William Moran	Grove	Old	265	Drilled	90	6	—	Upland flat
Ed 44	Allen E. Wiles	Harley	1955	440	do	67	5⅝	57	Draw
Ed 45	Paul A. Rockwell	do	1953	450	do	90	—	—	Hilltop
Ed 46	F. A. Hardy	do	1954	450	do	108	—	25	do
Ed 47	John Bowers	Keyser	1952	440	do	60	5⅝	10	do
Ed 48	D. R. Stodsgill	Harley	1951	440	do	70	6	25–30	do
Ed 49	Edgar Larson	do	1952	455	do	90	6	21	do
Ed 50	Gardner G. Gremillion	do	1952	455	do	77	5⅝	12–20	do
Ed 51	Franklin Waters	Keyser	1952	450	do	70	6	10	do

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Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Antietam quartzite	48.47	—	8/27/56	J,E	10	9/13/55	.3	—	F	
do	48.83	—	8/27/56	C,E	—	—	—	—	D	Dug well to 60 ft. Reported when pumped, no noticeable effect on water level in dug well.
do	60[a]	—	1955	J,E	—	—	—	—	D	Adequate.
Frederick limestone	50[a]	100[a]	5/10/54	J,E	12	5/10/54	2	.24	D	
do	—	—	—	J,E	—	—	—	—	D	Water reported slightly hard. Adequate supply.
do	25[a]	32[a]	6/9/49	J,E	10	6/9/49	1	1.4	D	
do	17.23	—	8/29/56	C,E	—	—	—	—	D	Adequate.
do	70[a]	—	11/12/48	N	3(?)	11/12/48	.5	—	N	Destroyed.
do	23[a]	90[a]	5/27/53	?,E	3	5/27/53	—	<.1	D	
do	70[a]	72[a]	9/9/49	J,E	14	9/9/49	2	7	D	Depth of pump jet 90 ft.
	30.74	—	8/28/56							
do	—	—	—	N	—	—	—	—	N	4 ft. south of Ed 31. Poor yield.
do	15[a]	—	—	C,E	10	—	—	—	C	Milk bottlers and distributors.
do	—	—	—	C,E	4–5	—	—	—	N	
do	20[a]	—	1948	J,E	30	1948	1	—	C	See well log.
do	30[a]	40[a]	1948	J,E	20	1948	1	2	C	Temporarily not used.
do	31[a]	42[a]	8/22/54	N	20	8/22/54	2	1.8	N	
	26.60	—	8/29/56							
do	12[a]	58[a]	8/22/55	C,E	20	8/22/55	2	.43	C	
Harpers phyllite	57[a]	140[a]	2/4/55	C,E	2.5	2/4/55	—	<.1	D	
New Oxford (limestone conglomerate) (?)	30[a]	60[a]	11/15/51	J,E	20	11/15/51	3	.6	D	
	29.16	—	8/30/56							
Grove limestone	27[a]	240[a]	7/25/47	C,E	2.25	7/25/47	2.5	<.1	D	Water softener.
do	—	—	—	S,E	20–25	8/30/56	—	—	D,F	Temperature Aug. 30, 1956, 58°F.
Frederick limestone	19±[a]	—	—	J,E	5	—	—	—	D	
New Oxford	10[a]	20[a]	1955	J,E	10	1955	—	1	D	Field test: hardness 122 ppm, chloride 10 ppm.
	29.71	—	7/2/56							
do	10[a]	—	4/6/53	J,E	15	4/6/53	—	—	D	
	17.55	—	7/2/56							
do	15[a]	30[a]	9/15/54	J,E	16	9/15/54	—	1.1	D	Keyser reamed 8 in. hole to 25 ft., installed 5⅝ in. casing to 25 ft., grouted in attempt to improve sanitary quality. Field test: hardness 212 ppm, chloride 12 ppm.
do	10[a]	40[a]	7/28/52	J,E	10	7/28/52	1.25	.3	D	Field test: chloride 14 ppm.
do	8[a]	25[a]	8/22/51	J,E	15	8/22/51	—	.9	D	Field test: hardness 246 ppm, chloride 16 ppm.
	13.33	—	7/2/56							
do	8[a]	—	7/10/52	J,E	20	7/10/52	—	—	D	Field test: hardness 290 ppm, chloride 30 ppm.
	19.46	—	7/2/56							
do	3[a]	70[a]	8/22/52	J,E	4	8/22/52	—	<.1	D	Field test: hardness 350 ppm, chloride 40 ppm.
do	20[a]	35[a]	7/25/52	J,E	20	7/25/52	1	1.3	D	Field test: hardness 206 ppm, chloride 16 ppm.

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ed 52	Howard Minnick	Harris	1954±	450	Drilled	80	6	40	Hilltop
Ed 53	Howard Smith	—	Old	450	do	70	6	5±	Upland flat
Ed 54	Do	—	Old	450	Dug	30	48–6	—	do
Ed 55	Miss Annie Rogers	—	Old	280	do	24	42±	—	Hillside
Ed 56	Do	—	Old	290	do	11	36	—	Valley
Ed 57	Weldon Harper	Keyser	1952	370	Drilled	82	$5\frac{5}{8}$	30	Upland flat
Ed 58	John Hammond	do	1956	450	do	87	$5\frac{5}{8}$	13	Hillside
Ed 59	Board of Education	—	—	290	Spring	—	—	—	Hilltop
Ed 60	Alpha Portland Cement Co.	Keyser	1957	300	Drilled	156	6	54.5	Upland flat
Ee 1	Mrs. Roy Putman	—	—	330	Dug	58.1	43	—	do
Ee 2	Miss Constance Harding	Columbia Pump and Well Co.	1946	290	Drilled	155	6	110	do
Ee 3	Barbara Fritchie Candy Co.	do	1947	305	do	350	6	195	do
Ee 4	The Everedy Co.	E. Brown	1941	280	do	61	6	29.7	do
Ee 5	Chestnut Farms Dairy, Inc.	—	—	270	do	42.5	6	—	do
Ee 6	Do	—	1910±	275	do	120	—	—	do
Ee 7	Do	—	—	275	do	105.5	8	—	do
Ee 8	Paul Guysmith	Grove	1915–20	250	do	100	6	—	Hillside
Ee 9	Betsy Ross Motel	—	—	310	do	150	6	20	Upland flat
Ee 10	Baltimore and Ohio R. R.	Myers	1956	270	do	100	6	32.5	Hillside
Ee 11	Herman Rice	Harley	1952	290	do	109	6	15	do
Ee 12	Charles Hahn	A. L. Smith	1955	330	do	83	$5\frac{5}{8}$	37	do
Ee 13	Sportsmen's Club	Corum	1948	360	do	253	6	12	Valley flat
Ee 14	William Lindsay	Shaff	1955	440	do	50	$5\frac{5}{8}$	23	Hillside
Ee 15	Woodrow Bowers	Easterday	1953	360	do	105	6	19	do
Ee 16	Mrs. Annie Perkins	—	Before 1914	420	Dug	25	36 or 48	—	Hilltop
Ee 17	Rayner Montgomery	—	—	430	Drilled	60	6	—	Draw
Ee 18	John Montgomery	—	—	500	do	85–95	6	—	Hilltop
Ee 19	W. E. Bagent	Harley	1954	400	do	76	—	6	Hillside

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date (yield)				
New Oxford	—	—	—	J,E	—	—	—	—	D	Originally 32 ft. of casing. Keyser reamed 8 in. hole, installed 40 ft. casing, grouted in attempt to improve sanitary quality. Field test: hardness 175 ppm, chloride 13 ppm.
do	10.5±	—	6/29/56	J,E	—	—	—	—	N	Small yield. About 5 ft. of 4 in. casing.
do	10.65	—	6/29/56	C,H	1±	6/29/56	1	—	N	Dug well 26 ft. deep; drilled well 4 ft. deep in bottom. Temperature June 29, 1956, 51°F.
Grove limestone	21.9	—	8/16/56	C,H	—	—	—	—	D	
Frederick limestone	1.98	—	8/16/56	S,—	—	—	—	—	N	Pump operated by water wheel with flow of small creek.
do	30[a]	50[a]	2/23/52	J,E	8	2/23/52	1	.4	D	
Antietam quartzite	55[a]	60[a]	7/9/56	J,E	20	7/9/56	1	4.0	D	See well log.
Frederick limestone	—	—	—	S,E	—	—	—	—	N	Reported contaminated.
Grove limestone	40[a]	—	1/5/57	NI	—	—	—	—	I	
Frederick limestone	53.61	—	12/6/55	N	—	—	—	—	N	Former water-level observation well. Destroyed in 1955.
Grove limestone	30[a] 42.42	60[a] —	9/4/46 3/21/51	J,E	30	9/4/46	8	.6	D,F	8-in. to 110 ft.; 6-in. casing. See well log and chemical analysis. Temperature Mar. 21, 1951, 50°F. Depth of pump jet 80 ft.
do	30[a]	—	8/1/47	T(?), E	40	8/1/47	8	.33	D	Candy factory and restaurant. See well log.
Frederick limestone	13[a]	21[a]	1941	T,E	275	1941 and 1954	—	34.7	C	Fire protection. See well log and chemical analysis.
Grove limestone	12.91	—	11/9/54	N	—	—	—	—	N	
Frederick limestone	30[a]	—	1954	T,E	60–75	1954	—	—	C	Pumped continuously six days per week.
do	14.85	—	11/9/54	T,E	—	—	—	—	C	
Antietam quartzite	40±[a]	—	—	J,E	10	—	—	—	D,F	
Grove limestone	—	—	—	C,E	—	—	—	—	C	Contaminated with oil or gasoline.
Frederick limestone	45[a]	50[a]	2/21/56	J,E	30	2/21/56	2	6.0	C	Western Union office. Bedrock at 22 ft. Depth of pump jet 80 ft.
do	60[a]	95[a]	12/1/52	J,E	14	12/1/52	—	.4	D	
Antietam quartzite	40[a]	—	7/30/56	C,E	10	7/30/56	.5	—	D	
Ijamsville phyllite	8[a]	—	11/—/48	J,E	12	11/—/48	1.5	—	D	Water at shallow depth only.
Antietam quartzite	26[a]	—	8/20/55	J,E	10	8/20/55	3	—	D	
do	40[a]	105[a]	12/18/53	J,E	3	12/18/53	—	<.1	D	See well log.
diabase	12.80	—	2/13/56	C,H	—	—	—	—	D	Adequate.
Urbana phyllite	14±	—	4/6/56	J,E	—	—	—	—	F	
Ijamsville phyllite	—	—	—	J,E	—	—	—	—	D	Adequate.
do	12[a]	40[a]	10/6/54	C,H	5	10/6/54	—	.18	D	

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ee 20	Roland Kline	Harley	1953	510	Drilled	95	—	6	Upland flat
Ee 21	Mt. Carmel Church	do	1955	400	do	74	5⅝	12	Hilltop
Ee 22	Eston H. Hoffman	D. Brown	1949	360	do	68	6	11	Valley
Ee 23	Robert D. Weedon	Harley	1950	440	do	100	6	6	Hilltop
Ee 24	Richard L. Main	Keyser	1952	410	do	108	5⅝	57	Hillside
Ee 25	Roger L. Main	—	—	310	do	85±	6	—	do
Ee 26	Niles E. Abrecht	—	—	320	do	106	6	46	Upland flat
Ee 27	Shields Trailer Sales	Green	1955	310	do	282	5⅝	24	do
Ee 28	Irving E. Norwood	Keyser	1956	310	do	116	5⅝	22.5	do
Ee 29	Do	E. Brown	1949	310	do	68	6	—	do
Ee 30	Thomas Oden	Shirley	1955	310	do	87	6	78	do
Ee 31	W. A. Prior	Gladhill	1952	295	do	92	6	—	do
Ee 32	Miss Julia Young	Grove	—	400	do	162	6	—	Hilltop
Ee 33	Milton Mosberg	—	—	325	do	365	6	—	Upland flat
Ee 34	Do	—	1931	315	do	187	6	—	do
Ee 35	Craig Esworthy	Harley	1952	330	do	90	5⅝	15	do
Ee 36	Glenn Crouse	do	1956	325	do	87	5⅝	22	do
Ee 37	James Sier	do	1955	280	do	117	5⅝	8	Valley flat
Ef 1	Grange Hall	Easterday	1954	550	do	40	6	30	Hillside
Ef 2	New Market Elementary School	—	1932	540	do	96	6	—	Hilltop
Ef 3	Mr. Stall	Harley	1950	530	do	80	6	23.5	do
Ef 4	Stanley Mullineaux	Easterday	1953	400	do	100	6	—	do
Ef 5	Millard Grossnickel	do	1953	645	do	54	6	30	Hillside
Ef 6	Monrovia Canning Co.	—	1951–53	430	do	95–100	6	—	Valley side
Ef 7	Do	—	1951–53	430	do	103	8–6	8+	do
Ef 8	Do	E. Brown	Old	430	do	84–95	6	—	do
Ef 9	Do	do	do	430	do	54	—	—	—
Ef 10	E. W. Jackson	—	—	565	do	110	6	—	Draw
Ef 11	Marshall Brandenburg	Easterday	1951	500	do	32	—	—	Valley side
Ef 12	Margaret Dromenburg	do	1955	390	do	91	6	9.5	Hillside
Ef 13	J. E. Hatcher	Greene	1945	490	do	112	5⅝	0	do
Ef 14	A. J. Smith	Easterday	1955	535	do	119	6	23	Hilltop
Ef 15	H. C. Green	E. Brown	1955	560	do	80	6	30	do
Ef 16	Hilltop Liquors	do	1955	555	do	90	6	—	do
Ef 17	G. P. Burdette	D. Brown	1940	470	do	50	—	22±	Hillside
Ef 18	Austin W. Luhn	Harris	1954	545	do	75	5⅝	24	do
Ef 19	Do	—	—	545	do	67	6	—	do
Ef 20	Howard U. Quinn	Easterday	1952	600	do	101	6	16	do
Ef 21	Bernard F. Rippeon	Keyser	1952	450	do	50	6	6	do

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Urbana phyllite	16[a]	80[a]	5/18/53	?,E	4	5/18/53	—	—	D	
do	30[a]	64[a]	6/2/55	J(?), E	4	6/2/55	—	.1	D	
Ijamsville phyllite	40[a]	—	3/5/49	C,E	3	3/5/49	.5	—	D	
do	45[a]	70[a]	1/14/50	J,E	3	1/14/50	—	.12	D	
do	30[a](?)	50[a](?)	2/5/52	J,E	10(?)	2/5/52	1	.5(?)	D	
Antietam quartzite	—	—	—	J,E	—	—	—	—	D	Adequate.
Frederick limestone	—	—	—	J,E	—	—	—	—	D	12 ft. of casing originally; increased to 46 ft. in unsuccessful attempt to eliminate contamination.
Grove limestone	60[a]	—	3/2/55	T,E	4	3/2/55	5	—	C	
do	60[a]	—	11/28/56	NI	5	11/28/56	2	—	D	
	54.20	—	8/29/56							
do	—	—	—	J,E	—	—	—	—	D	Practically no yield.
do	57[a]	70[a]	1/5/55	J,E	10	1/5/55	4	.7	D	
do	—	—	—	T,E	—	—	—	—	D	Adequate.
Antietam quartzite	—	—	—	C,E	5	—	—	—	D	Reported slightly irony.
Frederick limestone	—	—	—	C,W	—	—	—	—	D,F	Poor yield reported.
do	30[a]	—	—	C,E	—	—	—	—	D	
do	63[a]	—	4/9/52	J,E	10	4/9/52	—	—	D	
do	41[a]	60[a]	1/4/56	J,E	10	1/4/56	—	.5	D	
Antietam quartzite	38[a]	100[a]	9/20/55	J,E	10	9/20/55	—	.16	D	
Sams Creek metabasalt	15[a]	20[a]	5/18/54	?,E	10	5/18/54	—	2.0	D	See well log.
do	—	—	—	J,E	—	—	—	—	I	Adequate supply. See chemical analysis.
do	9[a]	65[a]	11/11/50	J,E	4	11/11/50	—	<.1	D	
Libertytown metarhyolite	22[a]	100[a]	6/3/53	?,E	1	6/3/53	—	—	D	
Ijamsville phyllite	20[a]	—	12/5/53	J,E	5	12/5/53	—	.1	D	See well log.
Urbana phyllite	—	—	—	C,E	—	—	—	—	C	Good yield reported. Pumped in summer only.
do	16.13	—	4/19/56	N	—	—	—	—	N	
do	1[a]	—	Old	C,E	35	—	—	—	C	Pumped in summer only.
do	1[a]	—	Old	N	5	—	—	—	N	Probably destroyed.
do	70[a]	—	11/—/55	C,H	—	—	—	—	D	Water reported rusty.
Sams Creek metabasalt	2[a]	32[a]	8/31/51	?,E	5	8/31/51	—	—	D	See well log.
Ijamsville phyllite	30[a]	91[a]	5/20/55	J,E	1	5/20/55	—	—	D	
Urbana phyllite	40[a]	—	10/24/55	C,E	10	10/24/55	0.25	—	D,F	
do	45[a]	69[a]	5/24/55	?,E	10	5/24/55	—	.42	D	See well log.
do	32[a]	65[a]	4/29/55	J,E	20	4/29/55	1	.6	C	Filling station.
do	86[a](?)	—	1955	J,E	—	—	—	—	C	Yield less than 1 gpm.
do	—	—	—	J,E	—	—	—	—	D	Adequate.
do	30[a]	60[a]	4/7/54	J,E	7	4/7/54	—	.2	D	
do	—	—	—	N	—	—	—	—	N	Inadequate at times.
do	70[a]	80[a]	11/10/53	C,E	8	11/10/53		.8	D	
Libertytown metarhyolite	28[a]	35[a]	2/23/52	?,E	10	2/23/52	1	1.4	D	

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Ef 22	E. E. Zimmerman	—	—	460	Spring	—	—	—	Draw
Ef 23	L. H. Crickenberger	Easterday	1956	510	Drilled	167	6	8	Hillside
Eg 1	J. Wesley Hood	—	—	690	Dug and drilled	58	36 and 6	—	Hilltop
Eg 2	Charles Jones	—	1898	840	Drilled	60	6	—	do
Eg 3	Edgar Rhinecker	D. Brown	1950	710	do	70	6	10	Hillside
Eg 4	Mr. Derr	Easterday	1952	640	do	29	6	15	do
Eg 5	Do	—	—	630	Spring	—	—	—	do
Eg 6	Harry E. Hahn	Easterday	1955	470	Drilled	42	6	23.5	do
Eg 7	Mr. Goetz	Green	1954	625	do	90	6	7	do
Eg 8	Frederick M.E. Church	Easterday	1954	660	do	120	6	—	Hilltop
Eg 9	The Chesapeake and Potomac Telephone Co.	do	1954	835	do	90	6	32	Hillside
Eg 10	John Driver	E. Brown	1948	600	do	110	6	10	Hilltop
Eg 11	John M. Spencer, Sr.	—	—	720	do	87	6	—	do
Eg 12	Frank A. Gardner	—	—	645	do	29	6(?)	—	Draw
Eg 13	Do	—	—	625	Spring	—	—	—	do
Eg 14	C. P. Jacobs	—	—	560	Drilled	85±	6	—	Hilltop
Eg 15	Paul R. Kolb, Jr.	—	—	550	do	64	6	—	Hillside
Eg 16	Charles N. Tregoning	Shaff	1952	430	do	72	$5\frac{5}{8}$	—	Hilltop
Eg 17	George A. Myers	D. Brown	1945	600	do	107	6	17	Draw side
Eg 18	George Harne	Easterday	1953	630	do	90	6	—	Hillside
Eh 1	Town of Mount Airy	E. Brown	1925	660	do	125	8	34	Valley flat
Eh 2	Do	do	1930	660	do	96	8	30 (?)	do
Eh 3	Mr. Loving	Easterday	1951	675	do	106	6	—	Hilltop
Eh 4	Do	Easterday(?)	—	645	do	?	6	—	Hillside
Eh 5	Harold L. Blaylock	Easterday	1955	600	do	53	6	11	Valley
Eh 6	Coop. Ground Water Investigations	E. Brown	1955	660	do	55	6	37.5	Valley flat
Eh 7	Do	do	1955	660	do	89	6	38	do
Eh 8	Do	do	1955	660	do	79.5	6	41.5	do
Eh 9	Do	do	1955	660	do	99.5	6	49	do

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Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Sams Creek metabasalt	—	—	—	S,E	30	3/25/56	—	—	D,F	Continuous flow reported.
do	20[a]	167[a]	2/16/56	NI	2	2/16/56	—	—	D	
	24.69	—	8/27/56							
Marburg schist	38.20	—	6/13/55	C,E	—	—	—	—	D,F	Dug well 42 ft., drilled through bottom.
do	—	—	—	?,E	—	—	—	—	D	Adequate.
do	50[a]	—	11/16/50	J,E	3(?)	11/16/50	—	—	D	
do	4[a]	29[a]	4/10/52	S,E	4	4/10/52	—	.2	C	Reported cloudy after rains.
	3.5	—	9/22/55							
do	—	—	—	N	5+	—	—	—	D,C	Gravity flow to home and grocery store Temperature Sept. 22, 1955, 59°F.
Ijamsville phyllite	15[a]	16[a]	7/15/55	J,E	10	7/15/55	—	10	C	Filling station.
Marburg schist	30[a]	40[a]	2/15/54	?,E	10	2/15/54	1	1	D	
do	40[a]	120[a]	3/19/54	J,E	3	3/19/54	—	—	D	See log well.
do	30[a]	54[a]	9/21/54	J,E	12	9/21/54	—	.5	C	
do	30(?)[a]	98(?)[a]	12/28/48	C,E	10	12/28/48	1	.1(?)	D	
do	67[a]	—	7/—/55	J,E	—	—	—	—	D	Water corrosive.
do	—	—	—	S,E	—	—	—	—	D,F	Adequate.
do	—	—	—	N	100	8/30/55	—	—	F	Continuous flow reported.
Sams Creek metabasalt	—	—	—	C,E	—	—	—	—	D,F	
Urbana phyllite(?)	18.90	—	9/8/55	C,H	—	—	—	—	D	
Libertytown metarhyolite or Wakefield marble	42[a](?)	66[a](?)	11/4/52	J,E	2	11/4/52	2	<.1	D	
Marburg schist	29.16	—	11/14/56	J,E	—	—	—	—	D,F	Adequate.
do	—	—	—	C,E	—	—	—	—	D	
do	6[a]	8[a]	1925	T,E	60	1925	1.2	30	P	Town well no. 1. Main supply. Originally 106 ft. deep. See chemical analysis.
	—	—	—		265	1947	—	—		
	12.5	45.0	5/—/55		190-255	5/—/55	48	6±		
do	20[a]	60[a]	1930	T,E	106	1930	—	2.6	P	Auxiliary supply. Depth of pump 60 ft.
					120	1947	—			
					127	3/—/55	.5	4±		
do	30[a]	80[a]	8/14/51	C,E	8	8/14/51	—	.2	D	
do	—	—	—	J,E	—	—	—	—	D,F	Adequate.
do	10[a]	35[a]	3/26/55	?,E	8	3/26/55	—	.3	D	
do	11.23	—	5/23/55	N	24.7	5/—/55	.5	2.4	N	Test hole and aquifer-test observation well no. 1. 158 ft. north of Eh 1.
do	11.48	—	5/23/55	N	24.5	5/—/55	.3	5.4	N	Test hole and aquifer-test observation well no. 2. 300 ft. north of Eh 1.
do	9.83		5/23/55	N	26.7	5/—/55	.75	10.7	N	Test hole and aquifer-test observation well no. 3. 175 ft. west of Eh 1.
do	12.59	—	5/23/55	N	26.7	5/—/55	.78	3.6±	N	Test hole and aquifer-test observation well no. 4. 58 ft. west of Eh 1.

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Fb 1	Robert V. Mahoney	Corum	1950	480	Drilled	63	5⅝	12	Hilltop
Fb 2	C. M. Eagle	Myers	1947	425	do	115	6	41	do
Fb 3	Ralph Stauffer, Jr.	Keyser	1950	480	do	88	6	13	do
Fb 4	John T. Quinn	Shaff	1954	300	do	80	5⅝	—	Hillside
Fb 5	Dennis R. Cooper	Keyser	1951	285	do	109	5⅝	107	do
Fb 6	Levin Cooper	do	1950	270	do	50	5⅝	12	do
Fb 7	Do	do	1950	315	do	112	5⅝	42	do
Fb 8	H. L. Wood	Shaff	1951	525	do	70	5⅝	—	Hilltop
Fc 1	Charles F. Orrison	—	—	240	Dug	27.6	52	—	Valley
Fc 2	Miss Lake Wright	Hilton	1953	290	Drilled	102	5⅝	102	Hillside
Fc 3	Do	do	1953	290	do	86	5⅝	—	do
Fc 4	Bernard Kolb	D. Brown	1954	305	do	94	5⅝	23	do
Fc 5	John Nuss	Shaff	1952	540	do	53	6	—	do
Fc 6	T. B. King	Keyser	1952	375	do	93	5⅝	77	do
Fc 7	William Bell	—	Old	280	Dug	38.2	—	—	do
Fc 8	Do	—	—	260	Spring	—	—	—	Valley flat
Fc 9	Harry Hildebrand	Shaff	1952	410	Drilled	71	5⅝	—	Hillside
Fc 10	L. E. Rutherford	Keyser	1952	225	do	33	5⅝	33	do
Fc 11	C. E. Reed	—	Old	475	do	92	5⅝	36	do
Fc 12	Do	—	—	490	Spring	—	—	—	do
Fc 13	L. P. Hale	—	—	290	do	—	—	—	do
Fc 14	Assembly of God Church	Keyser	1952	245	Drilled	77	5⅝	77	do
Fc 15	C. E. Reed	—	—	550	Spring	—	—	—	do
Fd 1	Thomas and Company	E. Brown and Hagmann	1947	305	Drilled	954	12–8–6	235 or 430	Upland flat
Fd 2	Do	E. Brown	1916	305	do	150	6	22	do

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Water-bearing formation	Water level (feet below land surface) Static	Pumping	Date	Pumping equipment	Yield Gallons per minute	Date	Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
granodiorite and granite gneiss	12[a]	41[a]	2/4/50	J,E	15	2/4/50	1	.5	D	See chemical analysis.
do	24[a]	32[a]	5/19/47	C,H	2.5	5/19/47	—	.33	D,F	
do	35[a]	67[a]	12/19/50	J,E	4	12/19/50	1	.13	D	
do	20[a]	50[a]	7/5/54	S,E	5	7/5/54	6	.16	D	
do	30[a]	90[a]	7/30/51	C,E	3	7/30/51	1	<.1	D	
do	20[a]	35[a]	8/14/50	J,E	3	8/14/50	.5	1.0	D	
do	55[a]	82[a]	7/24/50	—	3	7/24/50	1.5	.11	D	
do	20[a]	30[a]	5/14/51	S,E	5	5/14/51	2	.5	D	
New Oxford (limestone conglomerate)	16.06	—	10/22/46	C,H	—	—	—	—	D	Went dry in 1943. Water-level observation well. See chemical analysis. Temperature Dec. 20, 1955, 51.5°F.
Catoctin metabasalt(?)	—	—	—	J,E	—	—	—	—	D	Muddy water reported by driller.
do	—	—	—	N	—	—	—	—	N	Cased through blue clay and black mud to rock at 86 ft.; no water; casing pulled, hole destroyed.
New Oxford (limestone conglomerate)	—	—	—	J,E	10	5/5/54	.5	—	D	
granodiorite and granite gneiss	—	—	—	J,E	—	—	—	—	D	
Tomstown dolomite	30[a]	—	9/17/52	J,E	30	9/17/52	1	—	D	
granodiorite and granite gneiss	26.54	—	12/15/55	C,H	—	—	—	—	D	
do	—	—	—	N	3	12/15/55	—	—	F	
do	40[a]	55[a]	6/30/52	S,E	3	6/30/52	2.5	.2	D	
Catoctin metabasalt	10[a]	—	10/9/52	C,H	5	10/9/52	1	—	D	
do	13.39	—	12/21/55	C,H	—	—	—	—	D,F	
do	—	—	—	N	3	12/21/55	—	—	F	Discharge in summer low or ceases.
granodiorite and granite gneiss	—	—	—	N	3	12/21/55	—	—	D	Supplies two homes.
Catoctin metabasalt	20[a]	40[a]	8/12/52	J,E	10	8/12/52	1	.5	D	
do	—	—	—	N	12	12/21/55	—	—	D,F	Gravity flow to home and barns.
Frederick limestone	21[a]	180[a]	3/—/47	N	95	3/—/47	108	.9	N	Drilled to 430 ft. in 1941 by E. Brown; water muddy. Reamed 12-in. diameter to 235 ft. by Hagmann; cased with 8-in. pipe. Drilled through bottom of 6-ft. diameter dug well 36 ft. deep. Formerly equipped with 120-200 gpm turbine pump. Water-level observation well.
	16.67	—	10/1/56		190	1947				
do	—	—	—	C,—	—	—	—	—	N	Steam power. Muddy if pumped for long periods. Water encountered in 3-ft. cavity at about 135 ft.

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Fd 3	Thomas and Company	Hilton	1911	305	Drilled	76.8	6	17	Upland flat
Fd 4	Do	E. Brown	1938	305	do	60	8	20	do
Fd 5	Do	—	1902	305	do	35	6	20	do
Fd 6	Do	—	1904	305	do	65	6	20	do
Fd 7	Do	Hagmann	1947	305	do	1,209	12–8–6	220(?)	do
Fd 8	Claggett Diocese Center	—	1904(?)	320	do	110	6	—	Hilltop
Fd 9	Unknown	—	1952	320	do	100+	6	0	Hillside
Fd 10	Jennings Bailey	Hilton	1952	300	do	99	6	48	Upland flat
Fd 11	Pleasant View School	Keyser	1950	320	do	179	6	8	Hillside
Fd 12	N. C. Fairall	Stottlemyer	1954	320	do	127	5⅝	17	do
Fd 13	Tuscarora Gun Club	Hilton	1955	300	do	115	5⅝	38	do
Fd 14	Francis Wells	—	Old	285	Dug	43.6	36	—	Upland flat
Fd 15	Do	Hilton	1955	285	Drilled	164(?)	6	43	do
Fd 16	Do	do	1955	270	do	49	6	18	Valley side
Fd 17	Clarence Ausherman	Harley	1952	330	do	96	6	23	Upland flat
Fd 18	Howard Delauder	Keyser	1952	340	do	95	6	12	Hilltop
Fd 19	Carl Davis	do	1952	325	do	79	5⅝	22	do
Fd 20	Veva V. Brown	do	1952	315	do	62	6	21.5	Hillside
Fd 21	John E. Baker	do	1952	350	do	86	6	6	Hilltop
Fd 22	Lawrence Walters	do	1953	345	do	35	5⅝	22	do
Fd 23	E. B. Earhart	Shaff	1950	350	do	100	6	0(?)	Hillside
Fd 24	Richard White	Keyser	1952	345	do	127	5⅝	30	do
Fd 25	W. H. Lauthon	do	1952	305	do	165	6	23	Upland flat
Fd 26	Robert Jenkins	Shaff	1955	290	do	52	5⅝	22	do
Fd 27	John Thomas	E. Brown	1950	330	do	184	6	26	do
Fd 28	W. Homer Renn	Harklund	1956	290	do	75.5	6	24.7	do
Fd 29	Do	do	1954	295	do	93	8–6¼	41.5	do
Fd 30	Gilbert Lowe	Smith	1955	305	do	96	5⅝	23	do
Fd 31	Earl Smith	Shaff	1948	315	do	54.5	6	—	do
Fd 32	Tony Gibson	Smith	1955	325	do	27.5	5⅝	23.5	Hillside
Fd 33	Harry Kanode	Harley	1955	310	do	68	5⅝	9	Upland flat

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Frederick limestone	17.38	—	12/26/46	N	—	—	—	—	N	Muddy. Reported depth 73 ft.
do	—	—	—	T,E	120	—	—	—	N	Muddy. See chemical analysis. No drawdown reported at 100 gpm.
do	—	—	—	C,H	—	—	—	—	N	Water reported contaminated.
do	—	—	—	N	—	—	—	—	N	Sounded 48 ft. deep (filled in?).
do	24[a]	—	5/—/47	T,E	120	1954	—	—	N	Originally 364 ft. deep; yield 80 gpm; 100 ft. of casing. Reamed 12-in. hole to 220 ft.; cased with 8-in.(?) pipe. 8-in. hole to 975 ft. Depth of pump 300 ft.±.
Antietam quartzite	—	—	—	C,E	—	—	—	—	I	Principal yield at 90 feet. Adequate for intermittent heavy demand.
Contact(?)-Antietam quartzite and Frederick limestone	—	—	—	N	—	—	—	—	N	"Clay and mud" penetrated to bottom. Well destroyed.
Frederick limestone	16[a]	68[a]	12/29/52	J,E	9	12/29/52	2	.17	F	See well log.
New Oxford	19[a]	79[a]	11/5/50	J,E	10	11/5/50	2	.6	I	
do	42[a]	120[a]	11/18/54	T,E	7	11/18/54	1	<.1	D	Owner reports yield 37 gpm.
do	56[a]	90[a]	8/1/55	C(?), E	8	8/1/55	1	.24	C	
Frederick limestone	38.52	—	3/21/56	C,E	—	—	—	—	D	
do	33[a]	120[a]	1/21/55	N	2	1/21/55	1	<.1	N	Poor yield; destroyed. May have been deepened to over 200 ft.
do	18[a]	29[a]	8/1/55	C,E	24	8/1/55	1	2.2	D	See chemical analysis.
do	34[a]	—	12/19/52	C,E	19	12/19/52	—	—	D	
New Oxford	25[a]	—	6/16/52	?,E	2	6/16/52	.5	—	D	
do	30[a]	50[a]	5/30/52	J,E	3	5/30/52	1	.15	D	
New Oxford and limestone conglomerate	35[a]	40[a]	4/12/52	J,E	10	4/12/52	1	2.0	D	
New Oxford	40[a]	60[a]	5/27/52	J,E	5	5/27/52	1	.25	D	
do	25[a]	100[a]	1/10/53	T,E	8	1/10/53	1	1.0	D,F	Low yield in summer.
do	30[a]	—	6/28/50	J,E	10	6/28/50	6	—	C,D	Service station and residence.
do	10[a]	90[a]	3/27/52	J,E	2	3/27/52	.5	<.1	D	
do	30[a]	70[a]	9/27/52	C,E	12	9/27/52	2	.35	D	
Frederick limestone	12[a]	—	6/10/55	—	7	6/10/55	3	—	D	
do	32[a]	—	2/16/56	?,E	4	2/16/56	1	—	D	
do	—	—	—	?,E	—	—	—	—	D	Reamed 8-in. diameter to 28 ft. Grouted outside casing.
do	26[a]	50[a]	12/8/54	J,E	12±	12/8/54	.5	.5+	D	
do	60[a]	70[a]	7/16/55	J,E	10	7/16/55	.25	1.0	D	
do	23[a]	—	11/31/48	C,E	4	11/31/48	4	—	D	Contaminated with gasoline. See well log.
do	8.5[a]	10[a]	9/6/55	J,E	10	9/6/55	.25	6.6	D	
do	6[a]	12[a]	8/19/55	?,E	15	8/19/55	—	2.5	D	

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Fd 34	Harry Kanode	E. Brown	1948	290	Drilled	70	6	18	Upland flat
Fd 35	George Hoffman, Jr.	Smith	1955	325	do	34	5⅝	16	do
Fd 36	Joseph Leaks	Harley	1953	305	do	49	5⅝	15	Hillside
Fd 37	W. B. Grimes	Keyser	1950	300	do	86	6	23	Upland flat
Fd 38	Charles F. Wilt	Shaff	1951	275	do	38	6	0	do
Fd 39	Conner M. Thomas	Keyser	1956	380	do	150	5⅝	42	Hilltop
Fd 40	Do	—	Old	360	do	64.4	48	—	Hillside
Fd 41	Baltimore and Ohio R. R.	—	Old	300	Dug	19.6	48	—	Upland flat
Fd 42	John Strailman	Cromwell	1955	300	Drilled	92	5⅝	7	do
Fd 43	St. Joseph's Catholic Church	—	1920–25	340	Dug	65	60	—	Hilltop
Fd 44	G. C. Proctor	—	Old	285	Drilled	37	6(?)	—	Upland flat
Fd 45	W. H. Harris	—	Old	285	Dug	58	—	—	do
Fd 46	Raymond Quillian	—	1939	305	Drilled	111	6	36	do
Fd 47	Do	—	1945	290	do	116	6	—	Valley side
Fd 48	Claggett Diocese Center	—	—	320	do	120	6	—	Hilltop
Fd 49	William Renn	—	Old	310	Dug	13.9	—	—	Upland flat
Fe 1	G. O. Hendrickson	Easterday	1953	480	Drilled	80	—	—	Hilltop
Fe 2	Cecil A. Webb	do	1954	450	do	76	6	8	do
Fe 3	Charles R. Harmon	Keyser	1950	500	do	86	5⅝	11	Hillside
Fe 4	Do	—	1941	500	do	85	6	10	do
Fe 5	George P. Denny	Grove	Old	470	do	60	6	—	Hilltop
Fe 6	Urbana Zion Church	—	—	445	do	29.3	6	—	Upland flat
Fe 7	Stronghold, Inc.	Hilton	1929	560	do	59	6	23	Hillside
Fe 8	A. D. Pollack	D. Brown	1951	430	do	59	6	25	Hilltop
Fe 9	Hope Hill M.E. Church	—	Old	380	do	95.9	6	—	Hillside
Fe 10	Flint Hill Church	Easterday	1954	460	do	100	6	14	Hilltop
Fe 11	Stronghold, Inc.	Hilton	1952	490	do	87.6	6	42	Hillside
Fe 12	R. F. Myers	—	—	380	do	65±	6	—	Hilltop
Fe 13	Do	—	—	380	Spring	—	—	—	Draw
Fe 14	John W. Davis	Hilton	1910±	440	Drilled	75	6	30±	Hilltop
Fe 15	Do	—	Before 1910	440	do	75	6	—	Hillside
Fe 16	Do	Hilton	1949	430	do	102	5⅝	12	Upland flat
Fe 17	Mr. Pohlmann	—	Old	450	do	54	6	—	Hilltop
Fe 18	William T. Babcock	—	1946	460	do	62	6	—	Upland flat
Fe 19	Carlyle Sale	Hilton	1955	450	do	146	5⅝	40	Hilltop
Fe 20	Frank Kendall	do	1955	390	do	128	6	22	do
Fe 21	Do	—	Old	390	Dug	46	36	—	do

—Continued

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Frederick limestone	30[a]	—	12/17/48	J,E	6	12/17/48	.5	—	D,F	
do	10[a]	28[a]	11/3/55	?,E	6	11/3/55	.33	.33	D	
do	20.00	—	8/16/56	C,H	—	—	—	—	D	
do	25[a]	35[a]	2/20/50	—	6	2/20/50	1	.6	D	
do	10[a]	—	1/16/51	J,E	10	1/16/51	2	—	D	
Ijamsville phyllite	35[a]	150[a]	1/23/56	T,E	8	1/23/56	1	<.1	D,F	Tenant reports depth of 275 ft.
do	59.72	—	3/30/56	C,E	2	1954	—	—	N	
Frederick limestone	12.53	—	3/30/56	C,H	—	—	—	—	N	
do	20[a]	82[a]	7/5/55	J,E	3	7/5/55	.5	<.1	D	
do	37.02	—	8/31/56	C,H	—	—	—	—	D	
Grove limestone	Below 22	—	8/16/56	C,H	—	—	—	—	D	Adequate.
Frederick limestone	30±[a]	—	—	C,H	—	—	—	—	D	Do
do	20[a]	—	—	C,E	—	—	—	—	D,F	Good yield reported.
do	23.66	—	11/6/56	C,E	—	—	—	—	D	Do
Antietam quartzite	—	—	—	C,E	—	—	—	—	I	Used alternately with Fd 8. Adequate for intermittent heavy demand.
Frederick limestone	12.05	—	12/6/54	B,H	—	—	—	—	D	
Urbana phyllite	32[a]	80[a]	9/26/53	J,E	6	9/26/53	—	—	D,C	General store. See well log.
do	30[a]	55[a]	12/1/54	J,E	8	12/1/54	—	.3	D	
do	35[a]	52[a]	9/18/50	J,E	4	9/18/50	1	.73	D	
do	—	—	—	J,E	10	1941	12	—	F	
do	38.33	—	8/30/56	C,E	10	—	—	—	D,F	
do	20.66	—	8/30/56	C,H	—	—	—	—	D	
do	26.06	—	9/17/56	C,E	24	—	—	—	D	Penetrated yellow loam and white sand.
do	40[a]	—	10/23/51	?,E	6	10/23/56	1	—	D	
Ijamsville phyllite	51.70	—	2/21/56	C,H	—	—	—	—	N	
Urbana phyllite	70[a]	92[a]	4/21/54	C,E	8	4/21/54	—	.36	D	See well log.
do	20[a]	45[a]	1/3/52	J,E	20	1/3/52	1	.8	D	
	25.51	—	3/30/56							
do	—	—	—	C,H	—	—	—	—	F	
do	—	—	—	S,E	10–20	1952	—	—	D	Continuous flow reported.
do	35[a]	—	1931	C,E	5+	—	—	—	D,F	Can pump more than 24 hrs. continuously.
do	—	—	—	C,H	—	—	—	—	N	Inadequate. Crooked hole.
do	16[a]	30[a]	8/16/49	C,E	5	8/16/49	1	.3	D,F	
do	28.35	—	4/11/56	N	—	—	—	—	N	Poor yield reported.
do	30[a]	—	1947	J,E	—	—	—	—	D	See chemical analysis.
Sams Creek metabasalt	76[a]	—	9/28/55	T,E	3.5	9/28/55	1	—	D	Depth of pump 116 ft.
Urbana phyllite	48[a]	—	7/3/55	J,E	2.5	7/3/55	1	—	D	
do	35.96	—	4/11/56	C,H	—	—	—	—	N	

TABLE 26

Well number (Fr-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Length of casing (feet)	Topographic position
Fe 22	Mr. Cosgrove	—	—	440	Drilled	127	6	—	Hilltop
Fe 23	Claude A. Webb	Keyser	1953	420	do	58	5⅝	12	Hillside
Ff 1	Arno G. Page	—	Old	440	do	41	6	4	Valley side
Ff 2	Do	—	—	440	Spring	—	—	—	do
Ff 3	Beary Bell	Green	1955	450	Drilled	86	6	18	Hilltop
Ff 4	Dr. Charles Fenwick	Hilton	1953	390	do	58	5⅝	19	Hillside
Ff 5	Blake Merson	—	—	390	do	41	6	—	do
Ff 6	Do	Green	1955	390	do	90	5⅝	20	do
Ff 7	W. C. Askins	—	Old	460	do	108–110	6	—	do
Ff 8	James M. Day	Green	1952±	640	do	100+	6	—	Hilltop
Gd 1	E. A. Henderson	Hilton	1951	290	do	71	6	30	Hillside
Gd 2	J. P. Harris	Stottlemyer	1949	340	do	80	6	9	do
Gd 3	Do	do	1949	340	do	80	6	9	do
Ge 1	Charles H. Johnson	do —	1949	460	do	70	5⅝	25	do

—*Continued*

Water-bearing formation	Water level (feet below land surface)			Pumping equipment	Yield		Duration of pumping test (hours)	Specific capacity (g.p.m./ft.)	Use of water	Remarks
	Static	Pumping	Date		Gallons per minute	Date				
Urbana phyllite	—	—	—	C,E		—	—	—	D,F	
do	20[a]	50[a]	2/13/53	—	4	2/13/53	.5	.13	D	
do	17.18	—	4/11/56	C,H	—	—	—	—	D	Adequate.
do	—	—	—	N	—	—	—	—	F	
Sams Creek metabasalt	66(?)[a]	76(?)-	3/20/55	J,E	5	3/20/55	1	.5(?)	D	
do	16[a]	32[a]	9/17/53	J,E	5	9/17/53	1	.3	D	
do	9.25	—	4/5/56	N	—	—	—	—	N	
do	16[a]	80[a]	9/20/55	?,E	6	9/20/55	2	.1	D	
Urbana phyllite	—	—	—	J,E	—	—	—	—	D	Good yield reported.
Ijamsville phyllite	—	—	—	J,E	—	—	—	—	D	Originally 62 ft.; only slight increase in yield after deepened.
Frederick limestone	39[a]	52[a]	6/12/51	C,E	16	6/12/51	1	1.2	D	
New Oxford	45[a] (?)	75[a] (?)	6/4/49	T,E	5	6/4/49	1	.10	F	
do	45[a] (?)	75[a] (?)	6/4/49	T,E	5	6/4/49	1	.10	F	
Urbana phyllite	10[a]	—	10/20/49	C,E; C,H	30	10/20/49	1	—	D	

TABLE 27

Drillers' Logs of Wells in Carroll and Frederick Counties

	Material	Thickness (feet)	Depth (feet)
Wells in granodiorite, granite gneiss, and associated rocks:			
Fr-Eb 4. 1½ miles northeast of Burkittsville	Shale	20	20
	Rock, green	20	40
	Rock, sandy, white (water)	26	66
	Rock, green (water)	42	108
Fr-Eb 9. 1 mile southwest of Petersville	Shale	20	20
	Sand rock, gray	30	50
	Flint and mountain rock	25	75
Fr-Ec 10. 2.3 miles northwest of Jefferson	Clay	10	10
	Soapstone	70	80
	Mountain rock	51	131
Wells in the Catoctin metabasalt:			
Fr-Ad 6. At Sabillasville	Clay and sandstone	12	12
	Copper stone	28	40
	Sandstone (water)	7	47
Fr-Ad 9. ½ mile northwest of Sabillasville	Loose formation	20	20
	Sand rock	18	38
	Copper rock (water)	7	45
Fr-Ad 18. 2 miles east of Sabillasville	Rock and clay	20	20
	Sandstone	14	34
	Copper rock (water)	4	38
Fr-Bd 25. 2½ miles southeast of Foxville	Clay	21	21
	Copper rock (water at 25 ft.)	6	27
Fr-Cb 6. 1½ miles northwest of Myersville	Shale, yellow	18	18
	Slate, green	70	88
Fr-Cc 1. At Wolfsville	Earth	8	8
	Rock with crevices (water)	18	26
	Rock (water)	63	89
Fr-Db 4. 3 miles west of Myersville	Clay, sandy, red	21	21
	Mountain rock, green	43	64
	Sandstone, brown, hard	6	70
Fr-Dc 9. ½ mile north of Middletown	Slate	20	20
	Mountain rock, blue	36	56
	Boulder, ironstone	2	58
	Mountain rock, gray	35	93
Fr-Dc 13. ½ mile west of Middletown	Clay	6	6
	Shale rock	63	69

TABLE 27—*Continued*

	Material	Thickness (feet)	Depth (feet)
Fr-Dc 18. 1½ miles north of Braddock Heights	Clay, red	15	15
	Shale	40	55
	Copper rock (water at 38 ft. and 72 ft.)	21	76
Fr-Ec 11. At Jefferson	Mountain slate	40	40
	Mountain rock, blue	22	62
Wells in aporhyolite:			
Fr-Bc 8. At community of Sensenbaugh School	Earth	10	10
	Rock	51	61
	Rock with crevices (water)	7	68
Fr-Bc 11. 1 mile southwest of Foxville	Clay and boulders	25	25
	Mountain rock	15	40
Fr-Bc 13. ¾ mile west of Foxville	Clay	14	14
	Rock	5	19
	Clay and boulders	16	35
	Rock	11	46
	Earth (water)	2	48
Wells in the Loudoun formation:			
Fr-Ae 4. 2½ miles southwest of Emmitsburg	Sandstone	70	70
	Shale, brown, soft	10	80
	Sandstone	35	115
	Shale, brown, soft (water)	5	120
	Sandstone	5	125
Fr-Dd 29. 1 mile northwest of Shookstown	Clay, yellow	21±	21±
	Sandstone boulders	41±	62
Fr-Dd 58. 2 miles northwest of Shookstown	Boulders and clay	60	60
	Rock	14	74
Fr-Dd 69. 2 miles east of Harmony	Overburden	25	25
	Sand rock, sharp, very hard	70–75	95–100
Wells in the Harpers phyllite:			
Fr-Bd 15. At Catoctin Furnace	Mountain wash and Harpers phyllite:		
	Ironstone boulders, sand, and gravel	135	135
	Harpers phyllite:		
	Soapstone	28	163
Fr-Be 2. 1.2 miles northeast of Thurmont	Mountain wash and/or alluvium:		
	Material not reported	19.4	19.4
	Harpers phyllite:		
	Shale	37.0	56.4
	Rock	55.6	112.0

TABLE 27—*Continued*

	Material	Thickness (feet)	Depth (feet)
Fr-Be 14. 2 miles north of Thurmont	Mountain wash:		
	Dirt, soft; clay, yellow; and muck	82	82
	Harpers phyllite:		
	Slate and flint, yellow	35	117
Fr-Be 15. ½ mile north of Thurmont	Mountain wash:		
	Stones, small; clay, soft; and gravel (water at 60–67 ft.)	67	67
	Harpers phyllite:		
	Mountain rock, gray; 6-inch opening at 97 ft.	33.5	100.5
Fr-Cd 17. ¾ mile south of Catoctin Furnace	Sand	15	15
	Copper rock	48	63
Fr-Dd 47. At Braddock	Soapstone	55	55
	Slate, blue	105	160
Fr-Ec 6. 1 mile east of Jefferson	Dirt	22	22
	Mountain rock, gray	63	85
	Flint rock	10	95
	Mountain rock, gray	70	165
Wells in the Antietam quartzite:			
Fr-Cf 24: ¾ mile northeast of LeGore	Dirt, soft	3	3
	Rock, yellow	27	30
	Rock, blue; partly very hard and rough (very little water)	93	123
Fr-Dd 51. At Braddock	Clay	10	10
	Shale	30	40
	Mountain rock	37	77
Fr-Ec 13. 2¼ miles southeast of Jefferson	Clay	6	6
	Rock, hard, gray	54	60
Fr-Ed 58. ½ mile south of Braddock	Slate	70	70
	Sandstone	17	87
Fr-Ee 15. 1½ miles east of Buckeystown	Topsoil	4	4
	Shale	20	24
	Rock, blue	81	105
Wells in the Frederick limestone:			
Fr-Be 3. 1.2 miles northeast of Thurmont	Alluvium:		
	Boulders	19.0	19.0
	Frederick limestone:		
	Clay, sandy, yellow	9.5	28.5
	Rock and shale, weathered	22.7	51.2
	Limestone, hard	100	151.2

TABLE 27—*Continued*

	Material	Thickness (feet)	Depth (feet)
Fr-Be 6. 1.3 miles north of Thurmont	Sand and clay	23	23
	Sandstone	17	40
	Clay	17	57
	Flint rock (water)	3	60
Fr-De 26. At Harmony Grove	Clay, red	10	10
	Limestone (water at 65 ft.)	60	70
Fr-Ed 6. At Buckeystown	Topsoil	3	3
	Clay	5	8
	Sandy material	32	40
	Limestone	41	81
Fr-Ed 8. 1 mile northwest of Limekiln	Clay, tough	20	20
	Limestone, flag	28	48
Fr-Ed 35. ½ mile south of Frederick	Clay, yellow	15	15
	Sand, brown	10	25
	Limestone	30	55
Fr-Ee 4. At Frederick	Clay	29.5	29.5
	Shale	2.0	31.5
	Cavity (water)	4.0	35.5
	Limestone	20.0	55.5
	Limestone; cavity (water)	5.5	61
Fr-Fd 10. At Limekiln	Earth	36	36
	Earth and shale	9	45
	Limestone	54	99
Wells in the Grove limestone:			
Fr-Cf 1. At Woodsboro	Clay	4	4
	Limestone, hard	14	18
	Limestone, black, hard	92	110
	Limestone, white, soft	90	200
Fr-Cf 10. 0.9 mile west of Woodsboro	New Oxford formation, quartzose conglomerate member:		
	Sand and gravel	55	55
	Grove limestone:		
	Limestone	36	91
Fr-De 9. ½ mile south of Walkersville	Clay, red	38	38
	Limestone	7	45
	Clay, red	7	52
	Limestone	13	65
Fr-De 13. At Walkersville	Clay, yellow, and boulders	21	21
	Limestone, blue	46	67
	Opening	3	70

TABLE 27—*Continued*

	Material	Thickness (feet)	Depth (feet)
Fr-Ee 2. 1.2 mile south of Frederick	Clay, red	40	40
	Limestone, blue	40	80
	Cavern, red mud	4	84
	Limestone, blue	19	103
	Cavern, red mud	3	106
	Limestone, blue (water)	49	155
Fr-Ee 3. 1 mile south of Frederick	Clay	30	30
	Limestone	30	60
	Openings, mud	25	85
	Limestone	30	115
	Openings, mud	15	130
	Limestone	45	175
	Openings, mud	10	185
	Limestone, blue	165	350
Wells in the Peters Creek quartzite:			
Car-Cf 11. At Cedarhurst	Weathered rock (?)	10	10
	Rock	190–205	200–215
(Geologist's description of well cuttings: chiefly fragments of mica schist; some white and clear quartz; a little fine-grained magnetite and crystallized pyrite.)			
Car-De 1. 1 mile north of Eldersburg	Shale, soft, green (water at base; sandy water)	73	73
	Rock, hard, gray and black	107	180
Car-Ee 6. 1 mile west of Eldersburg	Shale, soft, brown	20	20
	Rock, brown (little water)	30	50
	Rock, gray (much water)	50	100
Car-Ef 11. 2 miles northeast of Eldersburg	Topsoil	1.5	1.5
	Clay, red	8.5	10
	Sand, rock	35	45
	Granite, soft	30	75
	Granite, becoming harder with depth (water; first water at 88 ft.)	89	164
Wells in the Sams Creek metabasalt:			
Car-Af 12. At Lineboro	Earth	12	12
	Slate, green (water, 3 gpm)	26	38
	Slate and flint, hard (water, 1 gpm)	7	45
	Flint, hard (water, 4 gpm)	9	54
	Slate, green	5	59
Car-Cc 8. At New Windsor	Shale	37	37
	Slate, blue, and flint (water, 2 gpm)	16	53
	Flint and slate (water, 10 gpm)	12	65
	Slate, blue	5	70

TABLE 27—*Continued*

	Material	Thickness (feet)	Depth (feet)
Fr-Ef 1. At New Market	Topsoil	3	3
	Clay	7	10
	Sandy material	20	30
	Rock, gray	10	40
Fr-Ef 11. At Ijamsville	Topsoil	2	2
	Shale	2	4
	Rock, light green	22	26
	Rock, light green, hard	6	32
Wells in the Ijamsville phyllite:			
Car-Ad 2. At Silver Run	Clay and shale, yellow	28	28
	Shale, yellow, and flint, mixed (water)	34	62
	Rock, blue (water)	28	90
	Rock, blue	5	95
Fr-Cf 33. Near Ladiesburg	Soil and slate, yellow (water at 24 ft.)	24	24
	Slate (water at 70 ft. and 102 ft.)	86	110
Fr-Dg 8. At Libertytown	Shale, soft, and clay, mixed	20	20
	Soapstone	42	62
Fr-Dg 13. At Unionville	Slate, soft	50	50
	Slate, blue-yellow, hard	40	90
Fr-Ef 5. 2 miles southeast of New Market	Topsoil	4	4
	Clay	24	28
	Slate, blue	26	54
Wells in the Urbana phyllite:			
Fr-Ef 14. 2½ miles west of Monrovia	Topsoil	4	4
	Shale	6	10
	Sandy	10	20
	Slate rock	20	40
	Slate and flint rock	50	90
	Sand rock	29	119
Fr-Fe 1. At Urbana	Shale	20	20
	Slate, brown	40	60
	Slate, blue	20	80
Fr-Fe 10. At Flint Hill	Topsoil	3	3
	Sandy	11	14
	Sand rock and flint	86	100
Wells in the Marburg schist:			
Car-Ad 11. 1½ miles northwest of Silver Run	Clay and shale, yellow	12	12
	Shale and flint	43	55
	Rock, blue	53	108
	Water-bearing zone	.5	108.5
	Rock, blue	4.5	113

TABLE 27—*Continued*

	Material	Thickness (feet)	Depth (feet)
Car-Ad 13. 2 miles northwest of Silver Run	Ground	6	6
	Clay and flint stone	10	16
	Shale, yellow	14	30
	Flint and shale, mixed (a little water)	2	32
	Shale, yellow	9	41
	Flint stone and shale (water)	3	44
	Rock, blue	5	49
Car-Ec 1. 1½ miles north of Mount Airy	Topsoil	5	5
	Slate, brown	65	70
	Slate, blue	35	105
Fr-Eg 8. At Kemptown	Topsoil	3	3
	Shale	47	50
	Slate, blue	70	120
Wells in the Wissahickon formation:			
Car-Af 10. Near Lineboro	Shale	8	8
	Slate (water, ½ gpm)	23	31
	Slate and flint (water, 2 gpm)	15	46
	Slate, blue, and flint (water, 4 gpm)	25	71
	Slate	8	79
Car-Bf 1. At Hampstead	Earth and decayed rock	40	40
	Gray rock, laminated, containing flint and mica (water, 17 gpm at 150 ft.)	330	370
	Rock, gradually hardening	37	407
Car-Ce 44. Westminster	Wissahickon formation:		
	Shale, brown, soft; some fine sand (water)	250	250
	Wakefield marble(?):		
	Limestone, white	2	252
	Clay, brown, soft (water)	3	255
Car-Dc 1. Near Taylorsville	Soil and clay	5	5
	Shale, yellow, and gravel, mixed	48	53
	Shale, yellow, and flint, mixed (little water)	18	71
	Shale and flint (water, 6-inch vein)	24	95
	Shale and flint	4.5	99.5
Car-De 4. At Gamber	Shale, soft	45	45
	Flint	5	50
	Shale	52	102
	Rock, gray, soft (water, 3 gpm)	18	120
	Rock, blue, hard (water, 10 gpm at 150 ft.)	41	161
Wells in the Wakefield marble:			
Car-Af 3. Melrose	Clay, yellow	31	31
	Gravel	3	34
	Clay, yellow	30	64
	Shale	12	76
	Gravel (water)	4	80

TABLE 27—*Continued*

	Material	Thickness (feet)	Depth (feet)
Car-Cb 11. At Union Bridge	Shale, brown soft	24	24
	Mud, brown	3	27
	Limestone; opening at about 55 ft. with dark brown sand (water)	43	70
Car-Ce 2. At Westminster	Wakefield marble:		
	Clay and boulders	57	57
	Limestone, solid	103	160
	Gravel, coarse (water)	—	160
	Sams Creek metabasalt and Wakefield marble:		
	Schist, blue and green, with interbedded white marble	690	850
Car-Ce 3. At Westminster	Clay and boulders	37	37
	Limestone, solid	17	54
	Openings	4	58
	Limestone, solid	58	116
	Gravel, coarse (water)		at 116
Car-Ce 49. At Westminster	Sams Creek metabasalt(?):		
	Flint and shale	92	92
	Sams Creek metabasalt and Wakefield marble(?):		
	Rock, gray, with many openings	58	150
	Sams Creek metabasalt:		
	Rock, gray	50	200
Wells in the New Oxford formation:			
Car-Ac 2. 1 mile northeast of Taneytown	Dirt, soft	4	4
	Shale, soft, and rock, red	61	65
	Sand rock	25	90
	Rock, red	18	108
Car-Bc 11. At Mayberry	Dirt, soft, and stone	6	6
	Shale, red	12	18
	Sandstone, red, and sand rock, gray; soft and hard layers	82	100
	Sandstone, red, softer, and red rock	100	142
Fr-Bf 19. 4 miles southeast of Emmitsburg	Dirt, soft	3	3
	Shale rock, red	6	9
	Rock, red	186	195
	Rock, blue	6	201
Fr-Dd 3. 1 mile northwest of Frederick	Clay, and rock, red	45	45
	Rock, red	10	55
	Calico, and rock, red	85	140

TABLE 27—*Continued*

	Material	Thickness (feet)	Depth (feet)
Wells in the Gettysburg shale:			
Fr-Ae 9. 1 mile northwest of Emmitsburg	Gettysburg shale:		
	Sandstone, coarse; sand and clay (baked zone)	52	52
	Diabase dike:		
	"Ironstone or granite"	23	75
Fr-Af 3. 2 miles west of Bridgeport	Dirt, soft	2	2
	Rock, red	24	26
	Rock, red, soft; caving	6	32
	Rock, red	70	102
	Rock, blue	1	103
Fr-Af 19. ¾ mile southwest of Bridgeport	Dirt, soft	3	3
	Rock, red	17	20
	Sand, brown, soft	30	50
	Rock, red	15	65
	Rock, red, hard; some sand	30	95
	Rock, red, softer	22	117
	Rock, red, hard	5.5	122.5
	Rock, very hard	.5	123
Fr-Ag 1. At Bridgeport	Shale	8	8
	Rock, red	33	41
	Sand, rock, gray, hard	18	59
	Iron boulders (water at 59 ft.)	3	62

The Surface-water Resources

BY

ROBERT M. BEALL

ABSTRACT

The surface-water resources of Carroll and Frederick Counties have been studied through the operation of 20 complete-record gaging stations. The data collected at these stations consist of continuous records of stage and periodic measurements of discharge. Mean daily discharges can be computed when a stage-discharge relation has been established.

Half of Carroll County is in the Monocacy River basin and, except for small areas tributary to Gunpowder Falls, Conewego Creek, and Codorus Creek, the remainder is in the Patapsco River basin. All of Frederick County is tributary to the Potomac River and three-quarters of it is within the Monocacy River basin. Catoctin Creek basin occupies most of the remaining area.

Although the surface-water resources are relatively undeveloped, about 165 square miles of Carroll County is in watersheds of the Baltimore water-supply system. During the 1957 season the amount of water used for irrigation was about 5 mgd. Municipal, institutional, and industrial facilities used about 7 mgd.

Except for silt pollution of the Piedmont streams, the quality of the surface waters is generally good. Weekly analyses of the Monocacy River at Bridgeport were made for a 3-year period. Daily partial analyses of raw water from Linganore Creek are made at the Frederick water treatment plant, and a continuous record of water temperature at the Linganore Creek gaging station has been obtained since 1952.

Analyses of streamflow records for the Monocacy River at Jug Bridge near Frederick indicate a mean annual flood of 21,000 cfs, a flow equal to or exceeding 494 cfs for 50 percent of the time, and the probability that the lowest 7-day flow in a year would be less than 66 cfs at average intervals of 5 years.

Tables of monthly discharge through September 1956 are presented, supplementing or superseding those published in Bulletins 1, 14 and 17.

INTRODUCTION

Increased demands for water create many complex problems, such as pollution and contamination from known or unknown sources within the drainage basin. Water precipitated as rain is essentially pure, but man has a trying task to maintain the quality. Outbreaks of sickness and epidemics have been traced in impure drinking water. Clean, pure streams and lakes are important assets to a community for recreational purposes in addition to their value as sources of public water supplies.

With few exceptions, the low-flow characteristics of a stream govern its utilization and exert a major influence on the costs of development. The magnitude, duration, and frequency of low flows are used to determine whether a project can be operated without storage or to compute the amount of storage required. The frequency of low flows affects the economics of both construction and operation of a water-utilization project.

Navigation was one of the earliest uses of surface waters, but with increased farming and industry, the use of streams for irrigation and industrial purposes has become important. There are manifold industrial uses of surface waters in our cities for which temperature and chemical quality are important factors.

Although streams are indispensable to man, floods can cause tremendous damage and even loss of life. It has been the inclination of man to establish his home on or near a stream in order to have a readily accessible supply of water or means of transportation. As river settlements grow, the usual trend is to encroach upon the flood plains and even for the normal stream channel to be crowded and its carrying capacity reduced by structures of various kinds. Thus, the tendency toward flooding is aggravated and the actual or potential flood damages are vastly increased. The problem of flood control then arises. For the proper planning of flood-control works such as dams, levees, or channel improvements and the designing of bridges with adequate waterways records of streamflow are needed over a sufficient number of years to establish the flood-flow characteristics of the stream.

DEFINITION OF TERMS AND ABBREVIATIONS

The terms used in streamflow and other hydrologic data are defined as follows:

Cubic foot per second (cfs) is the rate of discharge of a stream whose channel is 1 square foot in cross-sectional area and whose average velocity is 1 foot per second.

Cubic feet per second per square mile (cfsm) is the average number of cubic feet of water flowing per second from each square mile of area drained, assuming that the runoff is distributed uniformly in time and area.

Million gallons per day per square mile (mgdsm) is the average number of millions of gallons of water flowing per day from each square mile of area drained, assuming a uniform runoff distribution. One mgd is equivalent to 1.5472 cfs. Conversely, 1 cfs flowing for 1 day is equal to 0.646317 million gallons.

Runoff in inches is the depth to which an area would be covered if all the water draining from it in a given period were uniformly distributed on its surface. The term is used for comparing runoff with rainfall, which is also usually expressed in inches.

Drainage area of a stream at a specified location is that area, measured in a horizontal plane and usually expressed in square miles, which is so enclosed by a topographic divide that direct surface runoff from precipitation normally would drain by gravity into the river above the specified point.

Stage or *gage height* of a stream is the height of the water surface above a chosen datum corresponding to the zero of the gage. The mean sea level elevation of the zero of the gage is determined either by levelling to an established bench mark or from a topographic map.

Stage-discharge relation is the relation between gage height and the amount of water flowing in a channel, expressed as volume per unit of time.

Control designates a feature downstream from the gage that determines the stage-discharge relation at the gage. This feature may be a natural constriction of the channel, a long reach of the channel, or an artificial structure.

Water-year is a special annual period selected to facilitate water studies, commencing October 1 and ending September 30. The minimum flow of most streams usually occurs near the end of the water year. Another annual period, April 1 to March 31, normally encompassing the low-flow season, is sometimes used in the study of low-flow characteristics.

STREAMFLOW MEASUREMENT STATIONS

To systematically study the variations in streamflow which provide for its maximum beneficial use, the U. S. Geological Survey operates stream gaging stations throughout the country. In cooperation with the Maryland Department of Geology, Mines and Water Resources, and other State, Federal and municipal agencies, 84 gaging stations are in operation in Maryland and the District of Columbia. Six others are maintained in Pennsylvania or Delaware on streams which subsequently flow through Maryland.

The base data collected at gaging stations consist of records of stage and measurements of discharge. In addition, observations of factors affecting the stage-discharge relation, weather records, and other information are used to supplement base data in determining the daily flow.

The records of stage are obtained from a continuous water-stage recorder. Segments of typical water-stage recorder charts for two streams are shown in figure 30. Inspections to service the recorder and to change the chart are usually made at intervals of four to six weeks.

Most water-stage recorders in Maryland are housed in concrete-block or reinforced-concrete structures whose inside dimensions are 4 feet square. These structures are connected to the stream by one or more horizontal intake pipes so that the water level in the gage well (and hence the recorder float)

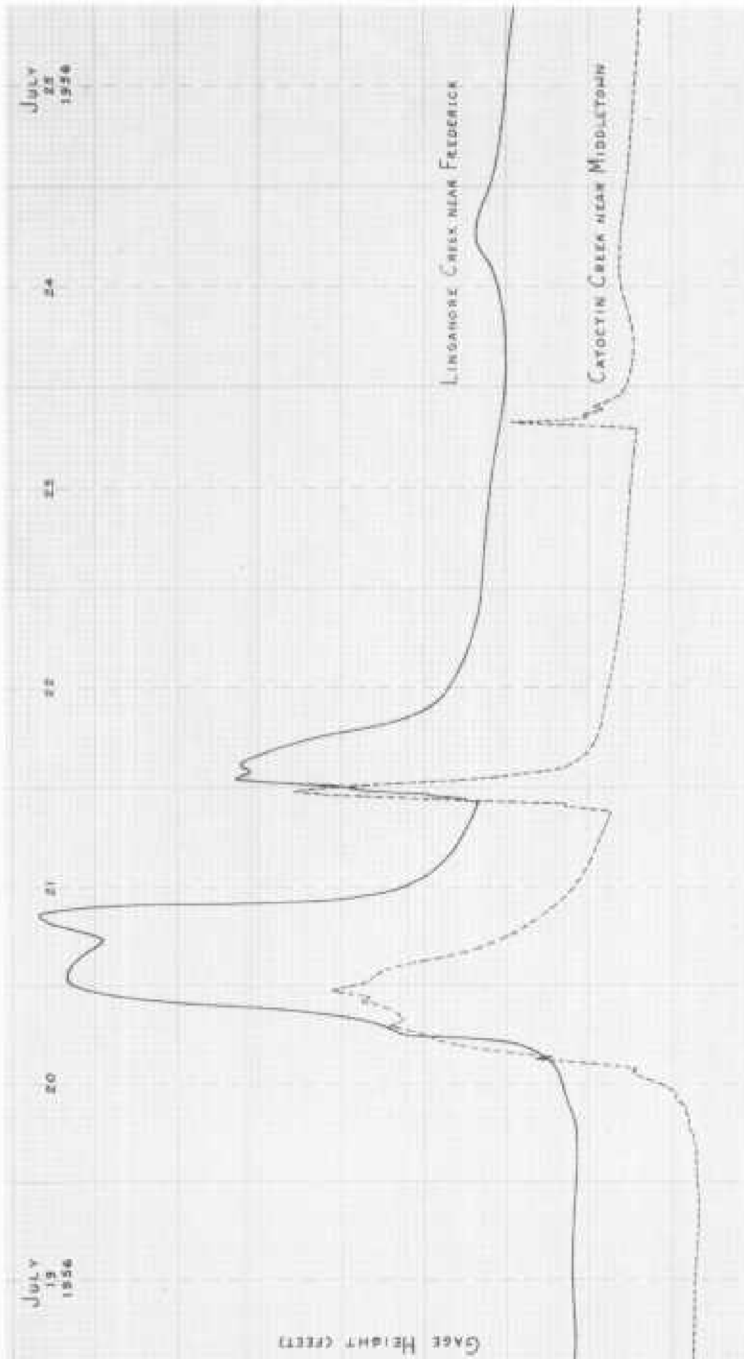

FIGURE 30. Graphs of River Stages from Automatic Water-Stage Recorders

can fluctuate simultaneously with the stream. The gage well is usually equipped with a flushing device for removing silt from the intake pipes. The height of the structure is determined on the basis of anticipated flood stages (Pl. 4, fig. 1). A temporary structure may be used where short-term records are desired. These are usually constructed of corrugated culvert pipe placed in a vertical position to act as the stilling well and topped with a small box-like shelter to house the recorder.

Measurements of discharge are made by means of a current meter and graduated rods or lines by which the mean velocity, depth and width at preselected points in the stream cross section can be determined. The product obtained by multiplying the area and the mean velocity of a part of the cross section constitutes a discharge measurement of that part. The summation of discharges for 20 to 30 or more representative parts of the total cross section defines, with acceptable accuracy, the discharge of the stream at that location. Plate 4, figure 2 shows a standard small Price-type and a pygmy current meter used for making discharge measurements, the latter designed for use in shallow depths. Figures 1 and 2 of Plate 5 illustrate the use of the current meter by wading and from a bridge.

Discharge measurements are made periodically and at various stages of the stream in order to establish a stage-discharge relation for the station. A typical relation, or rating, curve is shown in figure 31. A rating table giving the discharge for any stage is prepared from the relation curve. If extensions to the rating curves are necessary to define the extremes of discharge, they are made on the basis of indirect determinations of peak discharge (such as slope-area or contracted-opening determinations, computation of flow over dams or weirs, or by other methods), velocity-area studies, and logarithmic plotting. The application of the daily mean stage or gage height to the rating table gives the daily mean discharge, from which the monthly and yearly mean discharges are computed.

The selection of a gaging station site requires careful appraisal of various conditions: the stability of the stream channel; height of banks, their relative freedom from overflow, and suitability of conditions for installation and maintenance of gage structures; the range in stage within which current meter measurements can be obtained by wading; and the availability and accessibility of structures suitable for use in making measurements at higher stages. The site selected may not meet all requirements. A modified low weir may be necessary to stabilize the stage-discharge relation, especially for low flows. For a channel subject to frequent or continual change and where an artificial control is not feasible, more frequent measurements are required to define the stage-discharge relation. If a suitable bridge is not available near the gage site, a cableway from which high-stage measurements can be made may be required.

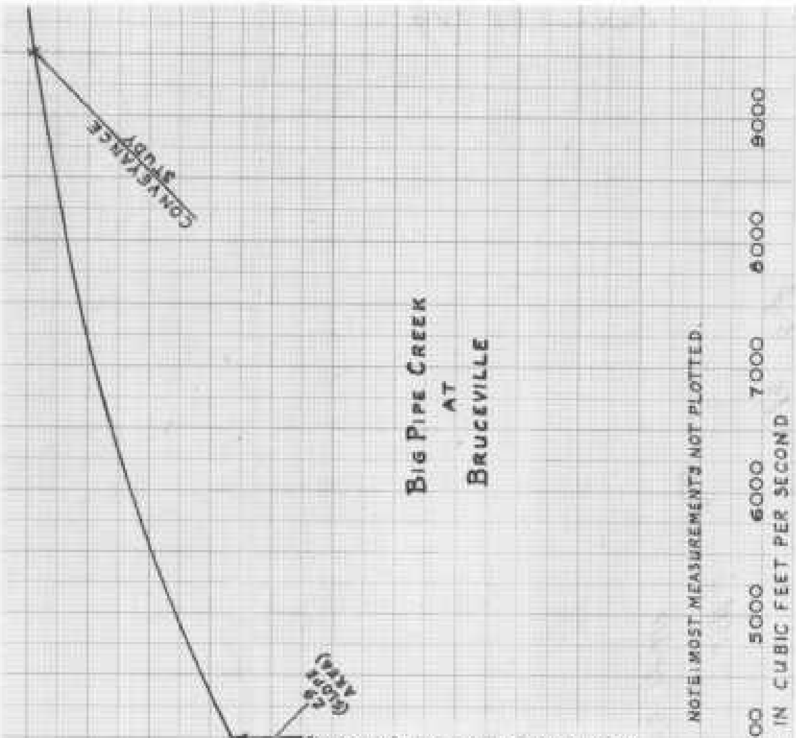

FIGURE 31. Typical Rating Curve Showing Stage-Discharge Relation

TOPOGRAPHY AND DRAINAGE

Carroll County

Carroll County lies entirely within the Piedmont Province of the Appalachian Highlands (fig. 3) and contains the headwaters of four streams which become major tributaries of the Susquehanna River, Chesapeake Bay and the Potomac River. The topography of most of the county is gently rolling and is of moderate relief. The drainage patterns are well established and not subject to extensive man-made modification. There are no natural lakes or ponds of significant size.

The highlands of the county bisect it in a southwest to northeast line from Mount Airy, along Parrs Ridge to Westminster, Manchester, and northward through Melrose. Elevations on this divide range from 700 to 1100 feet. From the divide, elevations decrease to 250 and 300 feet in the river valleys which form the southeast and northwest county boundaries.

The headwaters of South Branch Conewego Creek and West Branch Codorus Creek, Susquehanna River tributaries, are located in the extreme north-central part of the county. They account for 5 of the 456 square miles of Carroll County. Part of this area is tributary to Sheppard-Meyers Reservoir in the Hanover, Pennsylvania, municipal waterworks system.

The northeast part of the county beyond Wentz, Manchester, and Hampstead lies in the Gunpowder Falls basin. Most of the 33-square-mile-area is in the watershed of Prettyboy Reservoir, a unit of the Baltimore water-supply system.

Eastern, southeastern, and southern Carroll County contains 195 square miles of the Patapsco River basin. This is 43 percent of the county area. The eastern drainage, 135 square miles, contributes to the North Branch Patapsco River and most of it is in the watershed of Liberty Reservoir, another unit of the Baltimore water-supply system. The other 60 square miles to the south constitutes 13 percent of the county area and 70 percent of the South Branch Patapsco River basin at its confluence with the North Branch Patapsco River.

The remaining 49 percent of the county, the western 223 square miles, is directly or secondarily tributary to the Monocacy River. This is 23 percent of the total Monocacy River drainage area.

Frederick County

Frederick County lies within the Blue Ridge and Piedmont Provinces of the Appalachian Highlands (fig. 3). All of the streams and rivers of the county are eventually tributary to the Potomac River. The west-to-east topographic variation, through Myersville, Walkersville, and Libertytown, for example, is quite pronounced. There is a steep descent down the east slope of South Mountain to the rolling hills of Middletown Valley which terminate in the rugged relief of Catoctin Mountain. East of this mountain lie the relatively flat lands of Frederick Valley which give way to the undulating terrain of the Piedmont uplands east of Walkersville. The only ponds of significant size in the county are those, principally in Frederick valley, devoted to fish culture.

The drainage area of the Potomac River below the mouth of the Monocacy River at the southernmost tip of the county is 10,670 square miles. The Monocacy River basin accounts for 970 square miles of which 499 square miles is in Frederick County. Of the remainder of the Monocacy basin, 228 square miles is in Pennsylvania, 223 square miles in Carroll County, and 20 square miles in Montgomery County. The Monocacy River drains 73 percent of the 670 square mile county area. Catoctin Creek, meandering down Middletown Valley, has a total drainage area of 121 square miles, or 18 percent of the county area, and is entirely within the county. The remaining 50 square miles of Frederick County is composed of the Potomac River itself and minor small drainage basins directly tributary to the Potomac.

The more important streams of Carroll and Frederick Counties and their drainage areas at selected points are listed in Table 28, based chiefly on data in the "Report to the General Assembly of Maryland by the Water Resources Commission of Maryland, January 1933." The principal streams are shown in figure 32.

SURFACE-WATER UTILIZATION

The surface-water resources played a dominant role in the early history of Frederick and Carroll Counties. In *The External Relations of Frederick, Maryland*, Mackin (1956, p. 10) writes:

From the end of the Revolution until the beginning of quantity commercial production in the Ohio country, (the 1870's), wheat farming in the Monocacy Valley enjoyed a heyday.****Industry was at first limited to home handicrafts. Soon however, the excellent waterpower sites on both sides of the valley began to attract small enterprises. Flour mills were erected first, to be followed by sawmills, paper mills, textile mills, and others.***The sites were selected on the basis of the availability of water power (and)***being centers of business activity, frequently became the sites of villages***(some of which) prospered, grew and became towns.****After the opening up of practical trade routes between the Midwest and the Atlantic Coast, commercial grain farming***suffered a relative decline.****Cheap West Virginia coal shipped in by canal and railroad made local manufacturers independent of water power sites.

Although a small number of mills are still in operation little remains of this once prominent industry except for place names like Greenfield Mills on the lower Monocacy River and Union Mills on Big Pipe Creek.

At present, the largest user of the surface-water resources of the bicounty area is the water-supply system of the City of Baltimore. Approximately 165

TABLE 28

Drainage Areas of Streams in Carroll and Frederick Counties

Name of stream in downstream order	Tributary to	Drainage area (square miles)	
		At point	Outside of Md.
Patapsco River Basin			
East Branch Patapsco River at mouth	North Branch Patapsco River	21.1	—
West Branch Patapsco River at mouth	do.	20.8	—
Cranberry Branch near Westminster	West Branch Patapsco River	*3.29	—
North Branch Patapsco River at Cedarhurst	Patapsco River	*56.6	—
Beaver Run near Finksburg	North Branch Patapsco River	†12.7	—
Beaver Run at mouth	do.	16.2	—
North Branch Patapsco River near Reisterstown	Patapsco River	*91.0	—
Morgan Run near Gamber	North Branch Patapsco River	†25.9	—
Morgan Run at mouth	do.	44.6	—
North Branch Patapsco River at Liberty Dam	Patapsco River	164	—
North Branch Patapsco River near Marriottsville	do.	*165	—
North Branch Patapsco River at mouth	do.	171	—
South Branch Patapsco R. above Gillis Falls	do.	11.4	—
Gillis Falls at mouth	South Branch Patapsco River	19.3	—
South Branch Patapsco River at Henryton	Patapsco River	*64.4	—
Piney Run near Sykesville	South Branch Patapsco River	*11.4	—
Piney Run at mouth	do.	18.2	—
South Branch Patapsco River at mouth	Patapsco River	85.7	—
Potomac River Basin			
Little Catoctin Creek at Harmony	Catoctin Creek	*8.91	—
Little Catoctin Creek at mouth	do.	13.0	—
Catoctin Creek near Middletown	Potomac River	*66.9	—
Broad Run at mouth	Catoctin Creek	16.0	—
Catoctin Creek near Jefferson	Potomac River	*111	—
Catoctin Creek at mouth	do.	121	—
Potomac River at Point of Rocks	Chesapeake Bay	*9,651	8,374
Tuscarora Creek at mouth	Potomac River	20.5	—
Potomac River above Monocacy River	Chesapeake Bay	9,697	N.d.
Marsh Creek at mouth	Monocacy River	80.1	79.1
Rock Creek at mouth	do.	64.4	64.4
Alloway Creek at mouth	do.	23.8	17.7
Monocacy River at Bridgeport	Potomac River	*173	N.d.
Monocacy River at Bridgeport (staff gage)	do.	*174	N.d.
Piney Creek near Taneytown	Monocacy River	†22.1	7.47
Piney Creek at mouth	do.	35.5	7.47
Friends Creek at mouth	Piney Creek	13.5	2.85
Middle Creek at mouth	Toms Creek	26.9	24.5
Toms Creek at mouth	Monocacy River	88.8	59.3
Bear Branch at mouth	Big Pipe Creek	14.5	—
Monocacy River above Double Pipe Creek	Potomac River	319	228

TABLE 28—*Continued*

Name of stream in downstream order	Tributary to	Drainage area (square miles)	
		At point	Outside of Md.
Potomac River Basin—continued			
Big Pipe Creek at Bachman Mills	Double Pipe Creek	†9.39	—
Big Pipe Creek near Mayberry	do.	†49.9	—
Meadow Branch near Uniontown	Big Pipe Creek	†12.6	—
Big Pipe Creek at Bruceville	Double Pipe Creek	*102	—
Big Pipe Creek at mouth	do.	108	—
Little Pipe Creek at Avondale	do.	*8.10	—
Wolfpit Branch at Linwood	Little Pipe Creek	†2.00	—
Little Pipe Creek at Union Bridge	Double Pipe Creek	†40.4	—
Sams Creek at mouth	Little Pipe Creek	15.4	—
Little Pipe Creek at mouth	Double Pipe Creek	76.5	—
Double Pipe Creek at mouth	Monocacy River	192	—
Owens Creek at Lantz	do.	*5.93	—
Owens Creek at mouth	do.	39.8	—
Hunting Creek at Jimtown	do.	*18.4	—
Little Hunting Creek at mouth	Hunting Creek	11.8	—
Hunting Creek at mouth	Monocacy River	42.2	—
Fishing Creek near Lewistown	do.	*7.29	—
Fishing Creek at mouth	do.	18.2	—
Tuscarora Creek at mouth	do.	16.8	—
Monocacy River near Frederick (Ceresville Bridge)	Potomac River	*665	228
Israel Creek at mouth	Monocacy River	33.2	—
Carroll Creek at mouth	do.	18.6	—
North Fork Linganore Creek at mouth	Linganore Creek	20.3	—
South Fork Linganore Creek at mouth	do.	19.7	—
Linganore Creek near Frederick	Monocacy River	*82.3	—
Linganore Creek near Frederick (pump station)	do.	*84.6	—
Linganore Creek at mouth	do.	88.4	—
Monocacy River near Frederick (Jug Bridge)	Potomac River	*817	228
Bush Creek at mouth	Monocacy River	33.7	—
Ballenger Creek at mouth	do.	18.0	—
Little Bennett Creek at mouth	Bennett Creek	24.6	—
Bennett Creek at Park Mills	Monocacy River	*62.8	—
Bennett Creek at mouth	do.	66.1	—
Monocacy River at mouth	Potomac River	970	228
Potomac River below mouth of Monocacy River	Chesapeake Bay	10,667	N.d.

* At complete-record gaging station.
† At partial-record low-flow site.
N. d. Not determined.

square miles of Carroll County provides about 40 percent of the safe yield of this system through the development of the Gunpowder Falls basin (Prettyboy Reservoir) and the North Branch Patapsco River basin (Liberty Reservoir).

The principal water-supply systems or facilities, within Carroll and Frederick Counties, that use surface-water sources for a major part or all of their supply, are shown in Table 29.

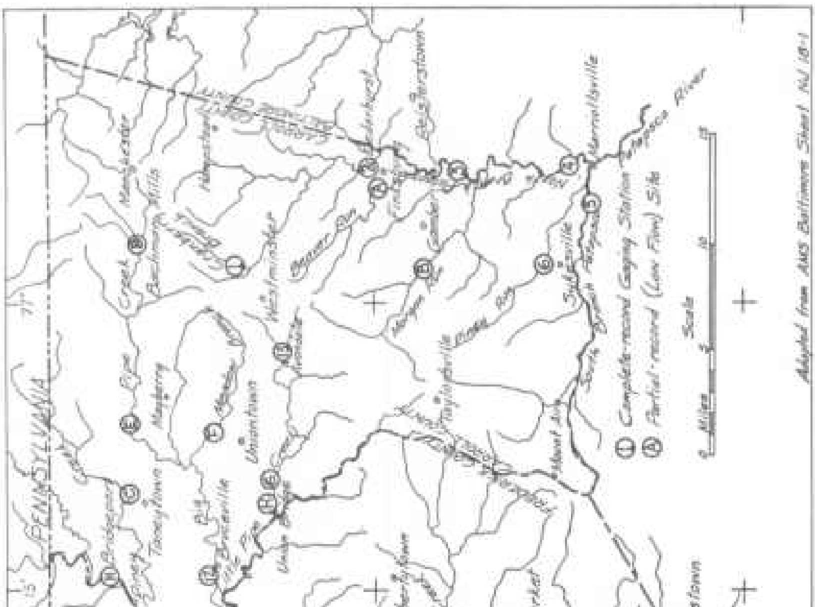

FIGURE 32. Location Map of Principal Streams and Gaging Stations

TABLE 29

Principal Water-supply Facilities in Carroll and Frederick Counties Using Surface-water

Data for 1957

Facility	Stream source	Capacity (mgd)	Output (mgd)
Municipal			
Emmittsburg	Turkey Run	—	0.13
Frederick	Linganore, Tuscarora, and Fishing Creeks	4.5	2.8
Thurmont	High Run	—	0.13*
Westminster	Cranberry Branch and West Branch Patapsco River (Luckabaugh and Hull Branches)	1.4	0.74
Institutional			
Camp Detrick	Monocacy River	2.0	2.0
Springfield State Hospital	Piney Run	1.0	1.0
Victor Cullen State Hospital	Owens Creek	0.13	(seldom used)
Industrial (power)			
Congoleum-Nairn Company	North Branch Patapsco River		0.18

* Partly derived from ground-water sources.

Practically all of the estimated five million gallons daily of water used for irrigation during the 1957 season was derived from streams and ponds. Some ponds are partly or entirely supplied from ground-water storage, either because they are dug below the water table or are spring fed. Other ponds, though established on small perennial streams, are replenished to some degree by surface runoff following precipitation. Bohanan (1955, p. 5) reported that during 1954, 6 farms in Carroll County irrigated 1,740 acres and 12 farms in Frederick County irrigated 740 acres. M. B. Fussell, Maryland State Soil Conservationist, stated (personal communication) that as of January 1, 1958, 180 farm ponds had been constructed in Carroll County and 393 in Frederick County under the Soil Conservation Districts Law passed in 1937 and that perhaps 50 to 75 had been privately built. One early farm pond use, ice production, has practically disappeared. Ponds continue to be a valuable asset, however, for livestock watering, supplemental irrigation, recreation, fish production, fire-fighting, and other purposes.

Mackin (idem. p. 18) has further stated:

A rather unusual rural industry located in Frederick County is the commercial raising of goldfish. Hundreds of acre-sized ponds are scattered in clusters throughout the Monocacy Valley, especially along the sides of the valley where cool water from upland streams is available. (According to Dr. J. Pearson, Ichthyologist, U. S. Fish and Wildlife Service) the valley happens to lie within a narrow latitudinal belt, extending across the country, in which the temperature range is suited to goldfish breeding.

QUALITY OF SURFACE WATER

The many chemical and physical quality characteristics of surface waters vary in time and with rainfall, geology, land and water use, and climatic season. Systematic study of these characteristics in Carroll and Frederick Counties has been confined to (1) the analysis of weekly samples collected from the Monocacy River at Bridgeport between 1948 and 1951, (2) the collection of a continuous record of the temperature of Linganore Creek near Frederick since 1951 and (3) the daily partial analyses of Linganore Creek water entering the Frederick water treatment plant.

Isolated samples from the Monocacy River near Frederick indicated a calcium bicarbonate water, slightly alkaline on the pH scale and moderately hard. Similar samples from Fishing and Linganore Creeks showed a water very low in hardness and mineral content, and slightly acid on the pH scale. The latter analyses are published in U. S. Geological Survey Water-Supply Paper 1299, *Industrial Utility of Public Water Supplies*, wherein also is given average and extreme values for 1950 of alkalinity, pH, hardness, and turbidity for the raw and finished water at the Linganore Creek treatment plant. The treatment plant data for 1950 are given in Table 30 which also contains the raw water data for the years 1955 to 1957.

TABLE 30

Extremes and Average of Determinations of Alkalinity, pH, Hardness and Turbidity of Raw and Finished Water, Linganore Creek Water Treatment Plant, City of Frederick

Year		Alkalinity as $CaCO_3$ (ppm)			pH		Hardness as $CaCO_3$ (ppm)			Turbidity		
		Av	Max	Min	Max	Min	Av	Max	Min	Av	Max	Min
1950	Raw water	46	61	17	8.6	6.9	52	66	39	15	1000	5
	Finished water	34	45	23	7.0	6.2	53	68	44	5	5	5
1955	Raw water	49	68	27	8.6	6.3	48	79	34	13	400	5
1956	do.	49	63	27	9.1	6.7	47	67	34	15	350	5
1957	do.	53	79	32	8.9	6.8	52	65	35	12	350	5

Computed from data on daily plant operation record sheets furnished by G. K. Smith, City Chemist. Data for 1955–57 include occasional analyses of raw water taken from a temporary storage pond (copper sulfate treated) which was used during periods of high river turbidity. Extremes, therefore, may not be representative of the river water although average figures may not be unduly biased.

TABLE 31

Monocacy River at Bridgeport Maximum, Minimum and Average Values of Chemical Constituents and Related Physical Measurements

(chemical constituents in parts per million)

Period of collection	Apr. 1948 to Sept. 1948		Oct. 1948 to Sept. 1949			Oct. 1949 to Sept. 1950			Oct. 1950 to June 1951	
Number of samples	23		48			43			30	
	Maximum	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Minimum
Silica (SiO_2)	11	0.8	12	—	0.8	12	—	2.6	15	5.5
Iron (Fe)	.11	.03	.43	—	.05	1.1	—	.04	.65	.02
Calcium (Ca)	27	14	22	—	15	23	—	9.4	22	9.0
Magnesium (Mg)	8.1	4.7	7.3	—	4.3	7.1	—	3.9	6.7	3.0
Sodium (Na) and Potassium (K)	5.4	3.3	15	—	2.0	19	—	1.3	9.4	1.8
Bicarbonate (HCO_3)	94	36	100	58	26	108	66	34	83	24
Sulfate (SO_4)	32	18	38	—	14	58	—	17	29	14
Chloride (Cl)	5.5	2.5	12	—	4.0	7.0	—	1.5	5.5	1.0
Fluoride (F)	0	0	.2	—	0	0	—	0	0	0
Nitrate (NO_3)	7.8	.5	11	2.6	.2	7.0	3.4	.2	9.0	1.0
Dissolved solids (Residue on evaporation at 180°C)	119	92	130	—	89	151	—	84	128	69
Suspended solids	185	18	161	21	1	403	26	1	690	1
Hardness as $CaCO_3$	183	48	196	79	44	102	70	40	86	35
Specific conductance (micromhos at 25°C)	215	128	218	161	122	245	173	94.8	217	87.4
pH	7.7	6.8	7.6	—	6.6	8.4	—	6.6	7.8	6.7
Color	90	1	70	15	1	180	25	5	140	5
Dissolved oxygen	9.5	5.3	13.0	8.7	4.6	14.4	9.2	4.5	14.5	5.7
Bio-chemical oxygen demand (5 days at 20°C)	3.0	.2	4.7	2.1	0	5.8	2.2	.6	7.2	.6
Temperature (°F)	80	45	81	58	36	81	59	33	77	34
Discharge (cfs)	1,260	5.2	1,950	193	7.6	2,160	187	4.8	3,080	13

During the period April 1948 to June 1951, the U. S. Geological Survey, in cooperation with the Pennsylvania Department of Forests and Waters, collected and analysed 144 water samples from the Monocacy River at Bridgeport. Samples were obtained at weekly intervals and analysed for ten quality properties. Nine additional properties were determined on a monthly basis. These analyses have been published in U. S. Geological Survey Water-Supply Papers 1132, 1162, 1186 and 1197 which are in the annual series entitled *Quality of Surface Waters of the United States, Parts 1–4*. The data obtained in these analyses are summarized in Table 31. An average and a range is shown for those properties analysed on a weekly basis during complete water years and a range is shown for those properties determined monthly or determined weekly during incomplete water years.

A water-temperature recorder has been operated since October 1951 in conjunction with the water-stage recorder on Linganore Creek near Frederick. The temperature record is collected by the U. S. Geological Survey in cooperation with the Maryland Department of Research and Education. Records of daily water temperature extremes are published in the quality-of-water series of water-supply papers referred to above. A summary of the monthly temperature variation of Linganore Creek is shown in Table 32.

Data are particularly lacking on the amount, areal distribution, and rates

TABLE 32

Monthly Temperature of Linganore Creek near Frederick

(degrees Farenheit)

		1952	1953	1954	1955	1956	1957
Jan.	max.	48	50	45	44	38	45
	min.	33	36	32	32	33	32
Feb.	max.	45	52	50	—	47	53
	min.	35	36	33	32	34	36
Mar.	max.	52	56	58	54	50	53
	min.	36	39	35	—	36	38
Apr.	max.	63	68	72	70	72	75
	min.	46	46	42	45	41	44
May	max.	65	72	75	79	76	75
	min.	52	57	51	56	53	52
June	max.	82	83	82	79	83	86
	min.	60	54	60	59	59	61
July	max.	85	82	88	86	86	85
	min.	65	66	67	69	64	65
Aug.	max.	80	86	85	87	80	83
	min.	62	63	65	67	63	65
Sept.	max.	78	82	80	74	81	81
	min.	57	53	56	58	55	54
Oct.	max.	68	67	74	70	65	64
	min.	40	47	45	—	49	45
Nov.	max.	57	56	54	—	64	58
	min.	38	35	37	35	35	37
Dec.	max.	49	47	43	45	50	53
	min.	35	32	34	33	35	34
Annual	max.	85	83	88	87	86	86
	min.	33	32	32	32	33	32

of sediment production in the region although certain problem areas have been investigated by the Soil Conservation Service. The Maryland State Planning Commission (1951, pp. 35, 39) states:

When farming began in Frederick County, there was an estimated average of 15 inches of top soil. After allowing two inches for shrinking, the loss on the average throughout the county is approximately 7 inches with an average of 6 inches remaining.*****The Maryland Water Pollution Control Commission has stated, "Our observations of the Monocacy River would indicate that industrial and sewage pollution contributed to this river is secondary in magnitude to the pollution caused by heavy silting from soil erosion."

The Interstate Commission on the Potomac River Basin has urged that a special sampling program be initiated " . . . to determine the amount of silt deposited annually in the Potomac watershed."[1]

GAGING STATIONS IN CARROLL AND FREDERICK COUNTIES

Complete-record stations

In 1888, The Federal Geological Survey began systematic work in collecting records of streamflow, mainly in the West, and in studying the problems related to the utilization of water for irrigation and other purposes. Specific appropriations for stream gaging were made by the Congress in an act of August 18, 1894, and a station was established on the Potomac River at Point of Rocks on February 15, 1895. The State of Maryland began cooperation with the Survey in 1896 by the payment of the services of gage readers. On August 4, 1896, a gaging station was established on the Monocacy River at Ceresville Bridge near Frederick under this cooperative plan. The Point of Rocks gage has been in practically continuous operation since 1895. The Ceresville Bridge gage was operated at that site (above the mouth of Linganore Creek) until September 1930, when it was replaced by the station at Jug Bridge below Linganore Creek established in November 1929.

Six additional gaging stations were established between 1927 and 1932, one in 1942, and ten between 1945 and 1949. The drainage areas and periods of record for all the stream-gaging stations in Carroll and Frederick Counties are presented in Table 33. Their locations are shown on figure 32. As of September 30, 1956, 351 station years of record have been accumulated, 104 years in the Patapsco River basin and 247 years in the Potomac River basin. No gaging stations have been operated on streams in the relatively small part of Carroll County in the Susquehanna and Gunpowder River basins. There are also a number of secondary basins of significant size whose streamflow characteristics have not been defined.

[1] From an account of the May 10, 1958 meeting of the commission in Bedford, Pa., as reported in The Evening Star, Washington, D. C.

TABLE 33

Stream-gaging Stations in Carroll and Frederick Counties

Map identification	Stream-gaging station or low-flow site (numbered) (lettered)	Drainage area (sq mi)	Records available*
	Patapsco River Basin		
1	Cranberry Branch near Westminster	3.29	Oct. 1949–
2	North Branch Patapsco River at Cedarhurst	56.6	Oct. 1945–
A	Beaver Run near Finksburg†	12.7	1957
3	North Branch Patapsco River near Reisterstown	91.0	June 1927 to Dec. 1953.
B	Morgan Run near Gamber†	25.9	1957
4	North Branch Patapsco River near Marriottsville	165	Oct. 1929–
5	South Branch Patapsco River near Henryton	64.4	Aug. 1948–
6	Piney Run near Sykesville	11.4	Oct. 1931–
	Potomac River Basin		
7	Little Catoctin Creek at Harmony	8.91	July 1947–
8	Catoctin Creek near Middletown	66.9	Aug. 1947–
9	Catoctin Creek near Jefferson	111	June 1928 to Sept. 1931.
10	Potomac River at Point of Rocks	9651	Feb. 1895–
11	Monocacy River at Bridgeport	173	May 1942–
C	Piney Creek near Taneytown†	22.1	1956
D	Big Pipe Creek at Bachman Mills†	9.39	1956
E	Big Pipe Creek near Mayberry†	49.9	1956
F	Meadow Branch near Uniontown†	12.6	1956
12	Big Pipe Creek at Bruceville	102	Oct. 1947–
13	Little Pipe Creek at Avondale	8.10	Aug. 1947 to Sept. 1956.
G	Wolfpit Branch at Linwood†	2.00	1956
H	Little Pipe Creek at Union Bridge†	40.4	1956
14	Owens Creek at Lantz	5.93	Oct. 1931–
15	Hunting Creek at Jimtown	18.4	Oct. 1949–
16	Fishing Creek near Lewistown	7.29	Oct. 1947–
17	Monocacy River near Frederick (Ceresville)	665	Aug. 1896 to Sept. 1930.
18	Linganore Creek near Frederick	82.3	Dec. 1931 to Mar. 1932. Sept. 1934–
19	Monocacy River at Jug Bridge near Frederick	817	Nov. 1929–
20	Bennett Creek at Park Mills	62.8	July 1948–

* Stations without closing date are still in operation.

† Initial base-flow measurements at partial-record sites made in indicated year.

Partial-record stations

In order that some knowledge might be gained of the low-flow characteristics of a greater number of streams, a modest low-flow program was initiated in 1956. Eight sites were selected in Carroll County (Table 33 and figure 32).

The program consists of measuring the base-flow discharge[2] at these sites two or three times a year for several years after which they will be correlated with nearby complete-record stations. A limited but useful amount of information can be obtained from this discharge relation in regard to duration and frequency of low and medium flows at the partial-record sites. Some of the sites are on gaged streams but at locations with significant differences in drainage area.

CHARACTERISTICS OF RUNOFF

Floods

Knowledge of the magnitude, frequency, and volume of flood runoff is a necessary prerequisite to the efficient and economic design of such structures as bridge and culvert openings, reservoirs, and flood control works.

The annual series of surface-water-supply papers contain the maximum gage heights and discharges for the report year and, since 1938, a listing of peak discharges above a base so selected that an average of about three peaks a year will be presented.

Detailed information on the stage and discharge of many streams during major floods has been included in special reports of the U. S. Geological Survey. Some of these reports also contain other pertinent hydrologic information and analyses and compilations of data relating to earlier notable floods. The following reports contain data on streams in Carroll and Frederick Counties:

Water-supply Paper 771: Floods in the United States, magnitude and frequency

Water-supply Paper 800: The floods of 1936, Part 3, Potomac, James, and upper Ohio Rivers

Water-supply Paper 1420: Floods of August–October 1955, New England to North Carolina.

Records for the Monocacy River at Ceresville Bridge and at Jug Bridge indicate that the greatest known general floods occurred in 1889, 1933, 1934 and 1937. Storm damage was probably most widespread following the flood of August 1933, although the floods of June 1889 must have been devastating to the many riverbank millsites. Peak discharges from these large general storms (frequently hurricanes or extra-tropical cyclones) have been exceeded on Monocacy and Patapsco River tributaries by peaks resulting from intense thunder-shower activity. An example of such a flood was that of July 20, 1956, on Piney Run near Sykesville when a peak discharge of 7,380 cfs was recorded, in comparison with a peak of 1,800 cfs on August 23, 1933.

[2] The base-flow discharge of a stream has been described as that sustained or fair-weather flow which is largely composed of ground-water effluent, as differentiated from direct runoff which principally results from overland flow during and following periods of rainfall or snowmelt.

As an example of the magnitude-frequency analysis of the floods at a single station site, the recurrence interval of annual floods on the Monocacy River at Jug Bridge near Frederick is shown in figure 33. The analysis was based on a historical flood peak plus the momentary maximum discharge occurring during each of the water years of record in Table 34. The flood experience at the Ceresville gage site was used in the determination of the recurrence interval of several of the higher order floods. The recurrence interval is the average interval in which a flood of a given size may be expected to recur as an annual flood. The data have been shown on an extreme value probability paper which was designed to enhance the straight-line plotting of such data. The mean annual flood is considered to be that having a recurrence interval of 2.33 years. The statistical theory of extreme values and some practical applications have been discussed by Gumbel (1954) in a series of lectures published by the National Bureau of Standards.

Since the individual station records are strongly influenced by the inclusion or exclusion of chance events of great magnitude in dissimilar periods of operation, a regional, rather than single-station, analysis is desirable. Such an analysis will be made in the near future and will provide information for presently ungaged areas.

Average Runoff

The streamflow records presented in this report are for various intervals during the period from 1895 to 1956. Because of the year-to-year variation in precipitation and consequent runoff, comparisons between different streams should be made for similar periods of time. To facilitate such comparisons, Table 35 presents the average discharge in cubic feet per second per square mile for different periods of time, corresponding to the full length of record at each of the gaging stations.

While it might appear that runoff varies inversely with drainage area, it should be remembered that the gaging stations are usually established on perennial streams and that relatively large parts of the larger drainage areas contain streams that are intermittent or ephemeral in character. Principally because of dissimilarities in climatic environment the average discharge of the Potomac River is not comparable with that of the other streams in the area. It will be noted that the average discharge per square mile from Hunting and Fishing Creeks, draining the east slope of Catoctin Mountain, and from Owens Creek on the east slope of South Mountain, is significantly higher than that of the other gaged streams.

Flow-Duration Studies

As described by Mitchell (1957, p. 3):

Charts that show the frequency of occurrence of the various rates of flow throughout the entire regimen of a stream at a given point are known as flow-

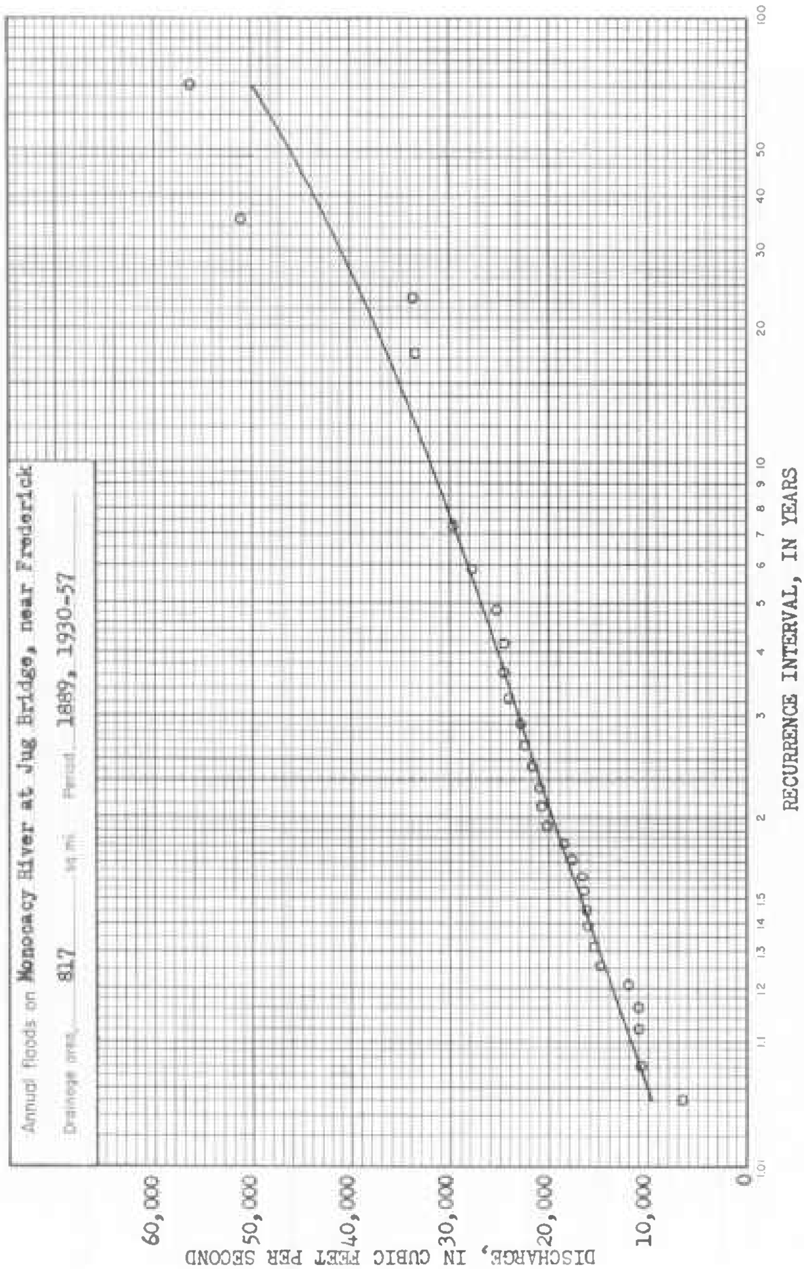

FIGURE 33. Frequency of Annual Floods on Monocacy River at Jug Bridge near Frederick

TABLE 34

Frequency Analysis of Annual Floods, Monocacy River at Jug Bridge near Frederick

Drainage area 817 square miles. Period of record: Nov. 21, 1929 to Sept. 30, 1957

Water year	Date	Gage Height (feet)	Discharge (cfs)	Order (M) in specified period		Recurrence Interval (years)‡
				69 yrs.	28 yrs.	
1889	June	30*	56,000	1		70.0
1930	Oct. 3, 1929	—	18,500†		16	1.81
1931	Apr. 2, 1931	11.37	10,800		27	1.07
1932	May 13, 1932	13.76	14,900		23	1.26
1933	Aug. 24, 1933	28.1	51,000	2	(1)	35.0
1934	Sept. 17, 1934	21.6	33,500	4	(3)	17.5
1935	Dec. 2, 1934	17.2	22,800		10	2.90
1936	Mar. 12, 1936	16.4	20,900		14	2.07
1937	Apr. 27, 1937	21.7	33,800	3	(2)	23.3
1938	Nov. 14, 1937	16.75	21,800		12	2.42
1939	Feb. 4, 1939	14.46	16,800		18	1.61
1940	Sept. 1, 1940	17.85	24,100		9	3.22
1941	Apr. 6, 1941	14.35	16,500		19	1.53
1942	Aug. 14, 1942	20.29	27,900		5	5.80
1943	May 21, 1943	18.74	24,600		7	4.14
1944	Jan. 4, 1944	19.01	25,300		6	4.83
1945	Sept. 19, 1945	15.50	16,300		20	1.45
1946	June 3, 1946	19.27	24,600		8	3.62
1947	May 22, 1947	12.57	11,000		25	1.16
1948	Jan. 2, 1948	15.43	16,100		21	1.38
1949	July 13, 1949	21.30	29,700		4	7.25
1950	Mar. 23, 1950	15.09	15,500		22	1.32
1951	Dec. 5, 1950	17.30	20,100		15	1.93
1952	Apr. 27, 1952	18.41	22,500		11	2.64
1953	Nov. 22, 1952	17.73	21,000		13	2.23
1954	Mar. 2, 1954	9.37	6,590		28	1.04
1955	Mar. 23, 1955	16.17	17,700		17	1.71
1956	July 21, 1956	13.08	12,000		24	1.21
1957	Apr. 6, 1957	12.37	11,000		26	1.12

* From floodmarks.

† Estimated on basis of graphed peak for station at Ceresville Bridge.

‡ Recurrence interval = $(N + 1)/M$. $N = 69$ for floods of order 1–4, based on flood experience at Ceresville Bridge gage; $N = 28$ for floods of order 4–28.

duration curves.*****They indicate the percent of time, within a given period, during which any given rate of flow was equaled or exceeded.

Flow-duration analyses have long been used in water power development investigations and, more recently, have been found useful in studies related to water supply and waste disposal.

Data for the gaging stations on Monocacy River near Frederick are combined

TABLE 35

Average Discharge of Streams in Carroll and Frederick Counties

Map Identification	Gaging station	Drainage area (square miles)	Period of record beginning October 1 ending September 30												
			1895 to 1956	1896 to 1930	1927 to 1953	1928 to 1931	1929 to 1956	1929 to 1952	1931 to 1956	1934 to 1956	1942 to 1956	1945 to 1956	1947 to 1956	1948 to 1956	1949 to 1956
			Number of water years												
			61	34	26	3	27	23	25	22	14	11	9	8	7
			Average discharge in cfs per square mile												
1	Cranberry Branch near Westminster	3.29	—	—	—	—	—	—	—	—	—	—	—	—	*1.24
2	N. Br. Patapsco River at Cedarhurst	56.6	—	—	—	—	—	—	—	—	—	*1.25	1.25	1.24	1.21
3	N. Br. Patapsco River near Reisterstown	91.0	—	—	*1.13	.899	—	1.09	—	—	—	—	—	—	—
4	N. Br. Patapsco River near Marriottsville	165	—	—	—	—	—	*1.08	—	—	—	—	—	—	—
5	S. Br. Patapsco River at Henryton	64.4	—	—	—	—	—	—	—	—	—	—	—	*1.21	1.16
6	Piney Run near Sykesville	11.4	—	—	—	—	—	—	*1.13	1.14	1.20	1.25	1.26	1.25	1.21
7	Little Catoctin Creek at Harmony	8.91	—	—	—	—	—	—	—	—	—	—	*1.16	1.17	1.12
8	Catoctin Creek near Middletown	66.9	—	—	—	—	—	—	—	—	—	—	*1.20	1.22	1.16
9	Catoctin Creek near Jefferson	111	—	—	—	*.659	—	—	—	—	—	—	—	—	—
10	Potomac River at Point of Rocks	9,651	*.965	.990	.964	.689	.938	.948	.966	.982	.969	.957	1.01	1.03	.984
11	Monocacy River at Bridgeport	173	—	—	—	—	—	—	—	—	*1.16	1.12	1.16	1.16	1.12
12	Big Pipe Creek at Bruceville	102	—	—	—	—	—	—	—	—	—	—	*1.13	1.12	1.08
13	Little Pipe Creek at Avondale	8.10	—	—	—	—	—	—	—	—	—	—	*1.14	1.16	1.14
14	Owens Creek at Lantz	5.93	—	—	—	—	—	—	*1.56	1.58	1.59	1.62	1.68	1.72	1.67
15	Hunting Creek at Jimtown	18.4	—	—	—	—	—	—	—	—	—	—	—	—	*1.50
16	Fishing Creek near Lewistown	7.29	—	—	—	—	—	—	—	—	—	—	*1.67	1.71	1.62
17	Monocacy River near Frederick	665	—	*1.42	—	—	—	—	—	—	—	—	—	—	—
18	Linganore Creek near Frederick	82.3	—	—	—	—	—	—	—	*1.05	1.08	1.10	1.12	1.12	1.08
19	Monocacy River at Jug Bridge	817	—	—	—	—	*1.12	1.15	1.16	1.16	1.15	1.14	1.18	1.19	1.13
20	Bennett Creek at Park Mills	62.8	—	—	—	—	—	—	—	—	—	—	—	*1.05	.990

* Longest period of record.

TABLE 36

Daily Flow-duration Data for Monocacy River near Frederick (for the years starting April 1 during 1897–1955)

(Drainage area, 817 square miles)

Discharge		Number of days or percent of time discharge equaled or exceeded that shown					
		Minimum year 1930		59-year period 1897–1955		Maximum year 1902	
cfsm	cfs	Days	Percent	Days	Percent	Days	Percent
0.028	23			21549	100.00		
.048	39	365	100.00	21526	99.89		
.059	48	347	95.07	21469	99.63		
.073	60	310	84.93	21273	98.72		
.092	75	233	63.84	21018	97.54	365	100.00
.115	94	194	53.15	20659	95.87	355	97.26
.143	117	169	46.30	19980	92.72	343	93.97
.177	145	150	41.10	19133	88.79	326	89.32
.219	179	130	35.62	18168	84.31	317	86.85
.270	221	109	29.86	16918	78.51	307	84.11
.335	274	92	25.21	15335	71.16	261	71.51
.417	341	72	19.73	13624	63.22	240	65.75
.521	426	58	15.89	12096	56.13	208	56.99
.652	533	41	11.23	10370	48.12	196	53.70
.815	666	28	7.67	8602	39.92	176	48.22
1.01	829	19	5.21	6865	31.86	165	45.21
1.26	1,030	13	3.56	5411	25.11	155	42.47
1.55	1,270	9	2.47	4299	19.95	144	39.45
1.92	1,570	7	1.92	3327	15.44	126	34.52
2.37	1,940	6	1.64	2577	11.96	120	32 88
2.95	2,410	—	—	1950	9.05	91	24.93
3.66	2,990	3	.822	1455	6.75	74	20.27
4.55	3,720	—	—	1050	4.87	47	12.88
5.69	4,650	2	.548	791	3.67	38	10.41
7.14	5,830	1	.274	561	2.60	27	7.40
8.95	7,310			390	1.81	18	4.93
11.2	9,150			275	1.28	16	4.38
14.0	11,400			165	.766	11	3.01
17.4	14,200			96	.445	6	1.64
21.5	17,600			34	.158	2	.548
26.7	21,800			10	.046		
33.3	27,200			3	.014		
51.5	42,100			1	.0046		

Note that data for the station at Ceresville Bridge (1897–1930) have been converted to equivalent Jug Bridge values through a discharge relation curve developed from the period of concurrent operation.

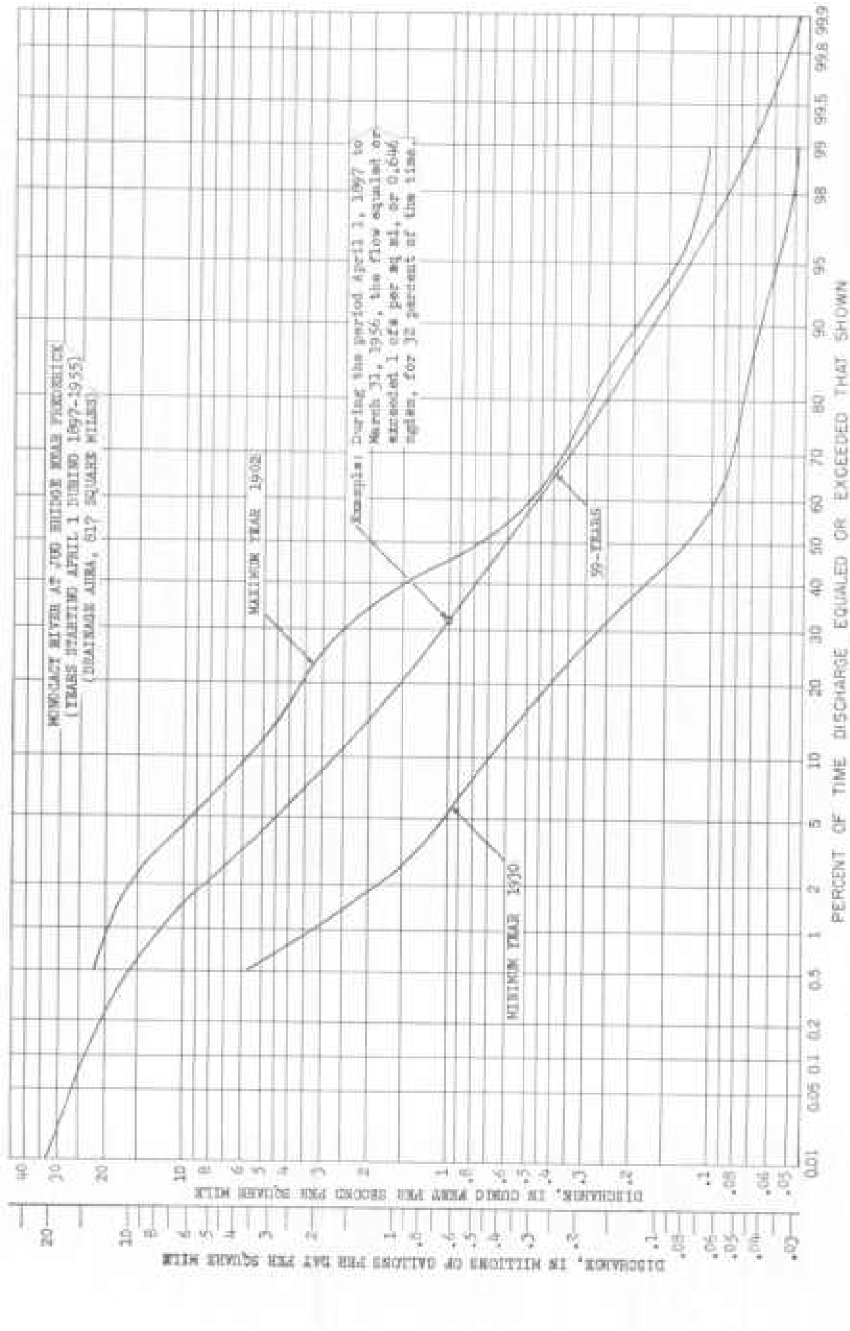

FIGURE 34. Duration Curves of Daily Flow on Monocacy River near Frederick

and used as an example of single site flow-duration study (Table 36 and figure 34). A yearly period beginning on April 1 was adopted rather than the customary water year (beginning October 1) in order that the usual low-flow season (during the fall months) would remain unbroken and be entirely contained within a single "year". In addition to a summary curve for the entire period of record, 1897–1956, the annual curves for the maximum and minimum years are shown.

As is the case with flood-frequency and low-flow frequency analyses, flow-duration analyses can be improved by regionalization to some long-term standard period. These procedures modify the individual gaging-station records so that the position of the curves from short-term records, and particularly the ends of those curves, will not be unduly influenced by a predominance of wet years or dry years within the short period.

Low-Flow Frequency

Extreme drought conditions prevailed throughout Maryland from 1930 to 1934. The annual precipitation in 1930 was only 24 inches compared with a 54-year average of 42 inches. A study of the hydrologic conditions during this period was published by the U. S. Geological Survey in Water-Supply Paper 680, *Droughts of 1930–34*. Sustained periods of subnormal streamflow were experienced also in 1910, 1941, and 1943.

Information on the frequency of consecutive days of low flows can be expressed best by curves which indicate how often, on the average, flow for

TABLE 37

Magnitude and Frequency of Annual Low Flow, Monocacy River near Frederick (for periods of 7 to 365 days based on records for 1897–1955)

Periods (consecutive days)	Average discharge in cubic feet per second for indicated recurrence intervals				
	2 years	5 years	10 years	25 years	50 years
7	109	66	49	38	33
15	121	72	55	42	37
30	146	86	66	50	42
60	206	120	88	63	51
120	308	177	129	88	68
183	445	261	189	127	95
274	695	440	330	232	180
365	1,040	735	590	450	370

Note that data have been taken from smoothed curves (figure 35) based on records for station at Jug Bridge (1930–55) and for station at Ceresville Bridge (1897–1930) which have been converted to equivalent Jug Bridge values through a discharge relation curve developed from the period of concurrent operation.

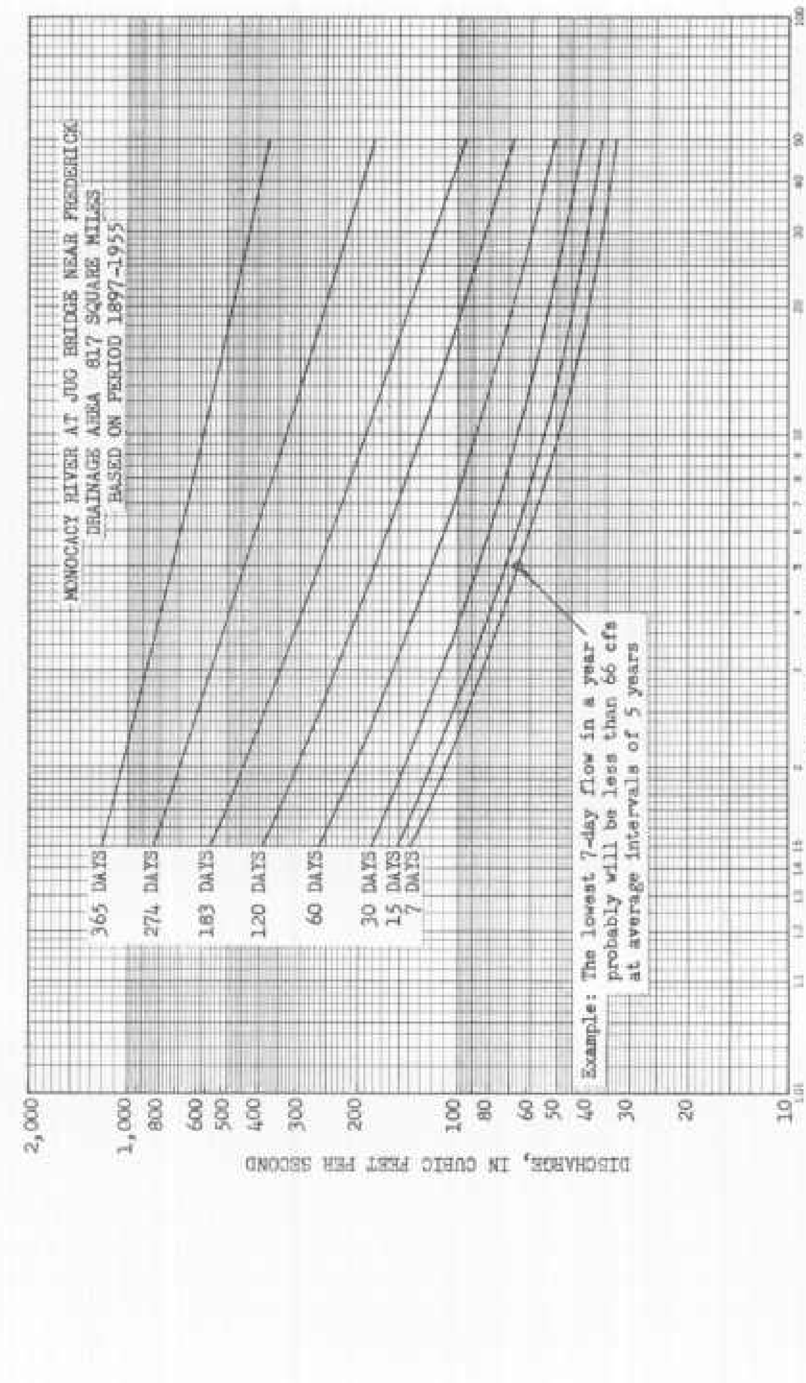

FIGURE 35. Magnitude and Frequency of Annual Low Flows on Monocacy River near Frederick

periods of various lengths might be expected to be as low as a specified discharge. Such analyses, treating consecutive days as a unit, indicate, for instance, whether the lowest 30 days of record occurred in one rare drought year or as a few days in each of many years. As an example of low-flow frequency, data for the two Monocacy River stations near Frederick have been combined and analysed to determine the recurrence interval of the average discharge during selected consecutive periods. This information is presented in figure 35 and summarized in Table 37.

Reliable low-flow frequency analyses for other gaging stations in Carroll and Frederick Counties, which have relatively short records, would require correlation with the long-term Monocacy River record. These and other useful analyses of low-flow characteristics such as curves that indicate the maximum number of consecutive days during which the flow was less than a specified discharge, and draft-storage curves which show the additional net storage required to maintain specific outflow rates, are beyond the scope of this report.

DISCHARGE RECORDS

Daily discharge records for the gaging stations in Frederick and Carroll Counties are published in Part 1 (Part 1B subsequent to 1950) of the annual series of water-supply papers of the U. S. Geological Survey entitled *Surface Water Supply of the United States.*

Monthly discharge records prior to October 1943 were published in Bulletin 1 of the Maryland Department of Geology, Mines and Water Resources. Similar records for the period since October 1943 are contained in the following pages. A summary table of annual data for the entire period of record is presented for each station. Some monthly discharge figures prior to October 1943 are republished herein, either because of a drainage area revision, which necessitated revision of the previously published unit runoff figures, or because a recent area-wide review and compilation disclosed errors in the data. Some of the monthly data subsequent to October 1943, for stations in the Patapsco River basin, have been published in Bulletins 14 and 17 and are not repeated here unless revisions have been made. Reference to the bulletins in which specific records may be found is contained in the *Records available* paragraph of the individual station records.

The gaging station records follow in downstream order. The locations of the stations are shown in figure 32.

PATAPSCO RIVER BASIN

1. Cranberry Branch near Westminster

Location.—Lat 39°35′35″, long 76°58′05″, on left bank 80 ft upstream from small wooden bridge, half a mile upstream from mouth, and 1.8 miles northeast of Westminster, Carroll County.

Drainage area.—3.29 sq mi.

Records available.—October 1949 to September 1956.

Gage.—Water-stage recorder and concrete control. Altitude of gage is 670 ft (from topographic map).

Average discharge.—7 years, 4.09 cfs.

Extremes.—Maximum discharge, 720 cfs July 4, 1951 (gage height, 5.14 ft, from high-water mark in well), from rating curve extended above 200 cfs by logarithmic plotting; minimum, 0.4 cfs Jan. 20, 1955, result of freezeup.

Monthly discharge of Cranberry Creek near Westminster

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1949–50						
October	6.8	1.5	2.16	0.657	0.76	0.425
November	3.9	1.7	2.06	.626	.70	.405
December	10	1.7	2.89	.878	1.01	.567
January	5.6	2.3	2.77	.842	.97	.544
February	9.1	2.3	4.48	1.36	1.42	.879
March	26	2.1	5.34	1.62	1.87	1.05
April	4.9	2.9	3.70	1.12	1.26	.724
May	9.7	2.9	4.22	1.28	1.48	.827
June	7.1	2.1	3.13	.951	1.06	.615
July	7.0	1.7	2.45	.745	.86	.482
August	12	1.3	2.14	.650	.75	.420
September	33	1.6	4.19	1.27	1.42	.821
The year	33	1.3	3.29	1.00	13.56	.646
1950–51						
October	11	2.0	2.69	0.818	0.94	0.529
November	32	2.1	3.82	1.16	1.30	.750
December	49	3.1	6.55	1.99	2.30	1.29
January	16	3.5	4.95	1.50	1.74	.969
February	32	4.3	8.15	2.48	2.58	1.60
March	10	4.1	5.52	1.68	1.93	1.09
April	8.0	3.3	4.54	1.38	1.54	.892
May	6.2	2.9	3.86	1.17	1.35	.756
June	33	2.7	6.24	1.90	2.12	1.23
July	55	2.4	5.27	1.60	1.85	1.03
August	7.6	2.0	3.20	.973	1.12	.629
September	4.8	1.7	2.18	.663	.74	.429
The year	55	1.7	4.73	1.44	19.51	.931

Monthly discharge of Cranberry Creek near Westminster—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1951–52						
October	3.1	1.6	1.93	0.587	0.68	0.379
November	16	2.1	3.98	1.21	1.35	.782
December	18	2.3	4.57	1.39	1.60	.898
January	15	4.3	6.37	1.94	2.23	1.25
February	15	3.9	5.54	1.68	1.82	1.09
March	38	3.9	8.09	2.46	2.84	1.59
April	47	5.2	11.9	3.62	4.05	2.34
May	36	4.9	11.3	3.43	3.97	2.22
June	30	4.9	7.55	2.29	2.56	1.48
July	18	3.1	5.54	1.68	1.94	1.09
August	7.3	2.1	3.39	1.03	1.19	.666
September	36	2.3	3.91	1.19	1.33	.769
The year	47	1.6	6.17	1.88	25.56	1.22
1952–53						
October	5.3	2.1	2.46	0.748	0.86	0.483
November	58	2.0	6.66	2.02	2.26	1.31
December	20	3.5	5.76	1.75	2.02	1.13
January	22	3.9	7.58	2.30	2.66	1.49
February	16	4.9	6.25	1.90	1.98	1.23
March	25	4.9	8.44	2.57	2.96	1.66
April	15	4.9	7.12	2.16	2.41	1.40
May	16	3.7	6.18	1.88	2.17	1.22
June	11	2.7	4.06	1.23	1.38	.795
July	3.9	2.1	2.51	.763	.88	.493
August	10	1.6	2.59	.787	.91	.509
September	6.5	1.4	2.11	.641	.71	.414
The year	58	1.4	5.14	1.56	21.20	1.01
1953–54						
October	7.3	1.3	1.73	0.526	0.61	0.340
November	5.9	1.4	2.15	.653	.73	.422
December	19	1.7	4.99	1.52	1.75	.982
January	6.6	2.1	2.77	.842	.97	.544
February	4.7	1.9	2.50	.760	.79	.491
March	24	2.4	3.79	1.15	1.33	.743
April	8.0	2.2	2.82	.857	.96	.554
May	7.2	1.9	3.07	.933	1.08	.603
June	2.3	1.1	1.57	.477	.53	.308
July	5.5	.7	1.38	.419	.48	.271
August	4.1	.7	1.46	.444	.51	.287
September	1.7	1.0	1.18	.359	.40	.232
The year	24	.7	2.46	.748	10.14	.483

PATAPSCO RIVER BASIN—*Continued*

Monthly discharge of Cranberry Creek near Westminster—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1954–55						
October	6.1	1.0	1.61	0.489	0.56	0.316
November	4.9	1.5	1.98	.602	.67	.389
December	6.6	1.4	2.43	.739	.85	.478
January	2.8	1.3	1.76	.535	.62	.346
February	23	1.3	4.00	1.22	1.26	.789
March	29	2.4	4.95	1.50	1.73	.969
April	4.6	2.5	3.08	.936	1.05	.605
May	3.7	1.5	2.02	.614	.71	.397
June	13	1.4	2.73	.830	.93	.536
July	2.0	.9	1.25	.380	.44	.246
August	70	.8	6.91	2.10	2.42	1.36
September	5.8	2.1	2.66	.809	.90	.523
The year	70	.8	2.94	.894	12.14	.578
1955–56						
October	32	2.0	3.55	1.08	1.24	0.698
November	5.1	1.9	2.51	.763	.85	.493
December	2.7	1.7	2.09	.635	.73	.410
January	25	1.6	2.92	.888	1.02	.574
February	21	3.0	6.43	1.95	2.11	1.26
March	24	3.0	5.69	1.73	2.00	1.12
April	11	3.8	5.39	1.64	1.83	1.06
May	8.5	2.5	3.62	1.10	1.27	.711
June	5.7	1.7	2.69	.818	.91	.529
July	40	1.6	6.63	1.98	2.29	1.28
August	5.8	1.9	2.74	.833	.96	.538
September	5.2	1.9	2.29	.696	.78	.450
The year	40	1.6	3.87	1.18	15.99	.763

PATAPSCO RIVER BASIN—*Continued*

Yearly discharge of Cranberry Creek near Westminster

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1950	3.29	1.00	13.56	0.646	3.79	1.15	15.63	0.743
1951	4.73	1.44	19.51	.931	4.51	1.37	18.60	.885
1952	6.17	1.88	25.56	1.22	6.54	1.99	27.07	1.29
1953	5.14	1.56	21.20	1.01	4.64	1.41	19.15	.911
1954	2.46	.748	10.14	.483	2.22	.675	9.13	.436
1955	2.94	.894	12.14	.578	3.12	.948	12.88	.613
1956	3.87	1.18	15.99	.763	—	—	—	—
Highest	6.17	1.88	25.56	1.22	6.54	1.99	27.07	1.29
Average	4.09	1.24	16.87	.801	4.14	1.26	17.08	.814
Lowest	2.46	.748	10.14	.483	2.22	.675	9.13	.436

2. North Branch Patapsco River at Cedarhurst

Location.—Lat 39°30′00″, long 76°53′00″, on left bank at downstream side of private footbridge at Cedarhurst, Carroll County, 0.8 mile downstream from Roaring Run and 8 miles southeast of Westminster.

Drainage area.—56.6 sq mi.

Records available.—October 1945 to September 1956. Monthly records October 1945 to September 1954 published in Bulletin 17.

Gage.—Water-stage recorder and concrete control. Altitude of gage is 425 ft (from topographic map).

Average discharge.—11 years, 70.9 cfs.

Extremes.—Maximum discharge, 4,130 cfs Aug. 13, 1955 (gage height, 10.38 ft), from rating curve extended above 1,700 cfs by logarithmic plotting; minimum, 3.0 cfs Oct. 16, 1949 (gage height, 1.18 ft), result of filling pond above station; minimum daily, 12 cfs Aug. 2, Sept. 14, 1954.

Remarks.—Slight diurnal fluctuation at low and medium flow caused by mill above station. Small diversion above station for municipal supply of Westminster; sewage effluent discharged into Little Pipe Creek.

Monthly discharge of North Branch Patapsco River at Cedarhurst

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1954–55						
October	88	13	23.3	0.412	0.47	0.266
November	70	20	28.8	.509	.57	.329
December	135	17	36.7	.648	.75	.419
January	46	16	26.7	.472	.54	.305
February	518	18	67.6	1.19	1.24	.769
March	338	41	84.4	1.49	1.72	.963
April	75	40	51.6	.912	1.02	.589
May	59	23	32.5	.574	.66	.371
June	161	21	47.2	.834	.93	.539
July	55	13	19.7	.348	.40	.225
August	2,240	14	165	2.92	3.36	1.89
September	98	30	43.4	.767	.86	.496
The year	2,240	13	52.2	.922	12.52	.596
1955–56						
October	663	29	67.3	1.19	1.37	0.769
November	116	29	44.4	.784	.87	.507
December	43	22	31.8	.562	.65	.363
January	270	22	44.2	.781	.90	.505
February	350	56	120	2.12	2.29	1.37
March	375	48	106	1.87	2.17	1.21
April	191	50	88.6	1.57	1.75	1.01
May	100	40	51.2	.905	1.04	.585
June	83	24	40.8	.721	.80	.466
July	1,150	18	115	2.03	2.34	1.31
August	93	27	39.5	.698	.80	.451
September	73	23	30.7	.542	.60	.350
The year	1,150	18	64.8	1.14	15.58	.737

PATAPSCO RIVER BASIN— *Continued*

Yearly discharge of North Branch Patapsco at Cedarhurst

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1946	79.9	1.41	19.16	0.911	73.7	1.30	17.68	0.840
1947	62.7	1.11	15.03	.717	63.4	1.12	15.20	.724
1948	77.3	1.37	18.58	.885	80.6	1.42	19.38	.918
1949	79.7	1.41	19.10	.911	72.2	1.28	17.31	.827
1950	51.7	.913	12.39	.590	61.3	1.08	14.68	.698
1951	78.4	1.39	18.81	.898	73.3	1.30	17.59	.840
1952	102	1.80	24.64	1.16	109	1.93	26.23	1.25
1953	88.3	1.56	21.18	1.01	80.3	1.42	19.27	.918
1954	42.6	.753	10.22	.487	37.9	.670	9.08	.433
1955	52.2	.922	12.52	.596	56.8	1.00	13.62	.646
1956	64.8	1.14	15.58	.737	—	—	—	—
Highest	102	1.80	24.64	1.16	109	1.93	26.23	1.25
Average	70.9	1.25	17.02	.808	70.8	1.25	17.00	.808
Lowest	42.6	.753	10.22	.487	37.9	.670	9.08	.433

PATAPSCO RIVER BASIN

3. North Branch Patapsco River near Reisterstown

Location.—Lat 39°26′31″, long 76°53′14″, on left bank at upstream side of highway bridge on Louisville-Delight road, 600 ft upstream from Cooks Branch and 3½ miles southwest of Reisterstown, Baltimore County.

Drainage area.—91.0 sq mi.

Records available.—July 1927 to December 1953 (discontinued). Monthly records July 1927 to September 1943 published in Bulletin 1 (1930 revised herein); October 1943 to December 1953, in Bulletin 17.

Gage.—Water-stage recorder. Concrete control since May 15, 1942. Datum of gage is 344.35 ft above mean sea level, adjustment of 1912.

Average discharge.—26 years, 103 cfs.

Extremes.—Maximum discharge, 11,000 cfs Aug. 24, 1933 (gage height, 14.6 ft from high-water mark in gage house), from rating curve extended above 2,400 cfs on basis of velocity-area determination of peak flow; minimum, 8.0 cfs Feb. 21, 1947 (gage height, 1.34 ft).

Remarks.—Slight diurnal fluctuation at low and medium flow caused by mill above station. Small diversion above station for municipal supply of Westminster; sewage effluent discharged into Little Pipe Creek.

Monthly discharge of North Branch Patapsco River near Reisterstown

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1929–30						
October*	2,080	58	169	1.86	2.14	1.20
November	346	60	105	1.15	1.28	.743
December	140	—	87.4	.960	1.11	.620
January	120	—	75.3	.827	.95	.535
February	559	—	149	1.64	1.71	1.06
March	519	84	137	1.51	1.74	.976
April	569	91	142	1.56	1.74	1.01
May	95	60	76.4	.840	.97	.543
June	303	43	84.4	.927	1.03	.599
July	91	24	37.4	.411	.47	.266
August	39	18	24.7	.271	.31	.175
September	126	19	30.0	.330	.37	.213
The year	2,080	18	92.8	1.02	13.82	.659

* Revised.

PATAPSCO RIVER BASIN—*Continued*

Yearly discharge of North Branch Patapsco River near Reisterstown

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1928	141	1.55	21.09	1.00	128	1.41	19.10	0.911
1929	108	1.19	16.13	.769	121	1.33	18.00	.860
1930	92.8	1.02	13.82	.659	70.9	.779	10.57	.503
1931	44.6	.490	6.66	.317	41.7	.458	6.24	.296
1932	47.3	.520	7.10	.336	70.0	.769	10.49	.497
1933	149	1.64	22.23	1.06	138	1.52	20.56	.982
1934	92.0	1.01	13.71	.653	98.7	1.08	14.71	.698
1935	102	1.12	15.19	.724	93.6	1.03	13.95	.666
1936	119	1.31	17.84	.847	118	1.30	17.70	.840
1937	110	1.21	16.40	.782	133	1.46	19.87	.944
1938	94.4	1.04	14.07	.672	70.9	.779	10.58	.503
1939	88.5	.973	13.19	.629	86.1	.946	12.85	.611
1940	87.0	.956	13.03	.618	97.5	1.07	14.59	.692
1941	83.4	.916	12.44	.592	68.3	.751	10.19	.485
1942	73.0	.802	10.90	.518	104	1.14	15.52	.737
1943	114	1.25	17.06	.808	96.5	1.06	14.37	.685
1944	90.2	.991	13.48	.641	83.8	.921	12.53	.595
1945	91.7	1.01	13.68	.653	106	1.16	15.86	.750
1946	130	1.43	19.35	.924	118	1.30	17.64	.840
1947	75.0	.824	11.18	.533	71.4	.785	10.65	.507
1948	103	1.13	15.49	.730	116	1.27	17.32	.821
1949	125	1.37	18.67	.885	114	1.25	16.96	.808
1950	80.8	.888	12.05	.574	93.6	1.03	13.95	.666
1951	119	1.31	17.77	.847	113	1.24	16.83	.801
1952	168	1.85	25.16	1.20	182	2.00	27.19	1.29
1953	145	1.59	21.68	1.03	130	1.43	19.41	.924
Highest	168	1.85	25.16	1.20	182	2.00	27.19	1.29
Average	103	1.13	15.36	.730	102	1.12	15.29	.724
Lowest	44.6	.490	6.66	.317	41.7	.458	6.24	.296

PATAPSCO RIVER BASIN

4. North Branch Patapsco River near Marriottsville

Location.—Lat 39°21′56″, long 76°53′06″, on left bank at downstream side of highway bridge 0.9 mile downstream side of highway bridge 0.9 mile downstream from Liberty Dam, 1.2 miles northeast of Marriottsville, Howard County, and 2.3 miles upstream from confluence with South Branch.

Drainage area.—165 sq mi.

Records available.—October 1929 to September 1956. Monthly records October 1929 to September 1943 published in Bulletin 1 (1930 and 1938 revised herein); October 1943 to September 1952, in Bulletin 14.

Gage.—Water-stage recorder. Datum of gage is 269.78 ft above mean sea level (city of Baltimore bench-mark).

Extremes.—Maximum discharge, 19,500 cfs Aug. 24, 1933 (gage height, 20.8 ft, from high-water mark in gage house), from rating curve extended above 2,700 cfs on basis of slope-area determination at gage height 13.93 ft and velocity-area study of peak flow; minimum, 0.2 cfs on many days in September, October 1954.

Remarks.—Flow regulated by Liberty Reservoir beginning July 22, 1954 (usable capacity, 42,072,000,000 gal). Diversion above station for municipal supply of Westminster (sewage effluent discharged into Little Pipe Creek) and from Liberty Reservoir beginning Feb. 1953 for municipal supply of Baltimore.

Cooperation.—Records of diversion for municipal supply of Westminster furnished by Maryland Waterworks Co., those for diversions from and change in contents in Liberty Reservoir furnished by Baltimore Department of Public Works.

Monthly discharge of North Branch Patapsco River near Marriottsville

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1929-30						
October*	3,000	100	279	1.69	1.95	1.09
November	725	92	191	1.16	1.29	.750
December	259	—	156	.945	1.09	.611
January	209	—	138	.836	.96	.540
February	654	—	249	1.51	1.57	.976
March	1,100	164	262	1.59	1.83	1.03
April	1,200	164	257	1.56	1.74	1.01
May	176	109	136	.824	.95	.533
June	454	80	144	.873	.97	.564
July	104	36	58.0	.352	.41	.228
August	49	29	35.5	.215	.25	.139
September	150	26	43.9	.266	.30	.172
The year	3,000	26	162	.982	13.31	.635

* Revised.

PATAPSCO RIVER BASIN—*Continued*

Monthly Discharge of North Branch near Marriottsville—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1937–38						
October	2,230	69	254	1.54	1.78	0.995
November*	4,200	141	369	2.24	2.49	1.45
December	229	154	177	1.07	1.23	.692
January	373	126	167	1.01	1.16	.653
February	430	143	185	1.12	1.17	.724
March	300	151	188	1.14	1.31	.737
April	334	136	168	1.02	1.14	.659
May	207	114	135	.818	.94	.529
June	491	67	116	.703	.78	.454
July	451	58	131	.794	.92	.513
August	426	41	88.5	.536	.62	.346
September	553	54	108	.655	.73	.423
The year	4,200	41	174	1.05	14.27	.679
1952–53						
October	188	98	116	0.703	0.81	0.454
November	2,940	96	353	2.14	2.39	1.38
December	965	185	296	1.79	2.07	1.16
January	1,270	207	398	2.41	2.78	1.56
						Diversions and change in contents, equivalent in cfs†
February	612	248	317			+1.3
March	1,340	234	478			+6.6
April	636	294	402			0
May	859	213	339			0
June	538	113	203			+8.4
July	276	34	91.0			+35.9
August	391	20	66.0			+41.9
September	628	7.7	79.6			+41.5
The year	2,940	7.7	261			+11.4

† Diversions only prior to July 1954.

Monthly Discharge of North Branch near Marriottsville—*Continued*

Month	Discharge in cfs				Runoff in inches	Diversions and change in contents, eqivalent in cfs
	Maximum	Minimum	Mean	Per square mile		
1953–54						
October	238	23	50.9			+36.0
November	249	17	62.6			+39.8
December	864	9.9	203			+19.5
January	290	28	98.1			+35.7
February	219	35	79.9			+42.2
March	686	150	210			+1.1
April	308	61	139			+15.4
May	1,090	70	187			+13.1
June	64	2.8	15.4			+59.8
July	208	.4	42.9			+41.3
August	1.8	.3	.53			+72.8
September	.5	.2	.25			+53.0
The year	1,090	.2	91.3			+35.7
1954–55						
October	1.0	0.2	0.29			+67.3
November	.6	.3	.40			+83.4
December	2.0	.3	.59			+121
January	.6	.4	.42			+87.2
February	3.1	.3	.61			+226
March	3.2	.5	.79			+280
April	1.1	.6	.76			+146
May	.9	.4	.55			+114
June	4.4	.4	.85			+170
July	.5	.3	.43			+52.8
August	27	.3	1.94			+535
September	.8	.4	.55			+135
The year	27	.2	.68			+168
1955–56						
October	11	0.6	1.08			+203
November	1.2	.5	.70			+120
December	.8	.6	.67			+93.3
January	3.6	.7	.88			+138
February	574	1.2	225			+112
March	747	122	296			+8.9
April	502	180	256			−.4
May	210	92	143			+5.4
June	400	15	92.3			+37.1
July	4,100	12	322			+54.6
August	130	17	55.2			+50.1
September	140	1.2	27.0			+59.9
The year	4,100	.5	118			+73.5

PATAPSCO RIVER BASIN—*Continued*

Yearly discharge of North Branch Patapsco River near Marriottsville

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1930	162	0.982	13.31	0.635	122	0.739	10.07	0.478
1931	75.8	.459	6.23	.297	73.4	.445	6.04	.288
1932	87.8	.532	7.24	.344	124	.752	10.22	.486
1933	262	1.59	21.56	1.03	245	1.48	20.19	.957
1934	164	.994	13.44	.642	175	1.06	14.40	.685
1935	188	1.14	15.49	.737	176	1.07	14.48	.692
1936	211	1.28	17.42	.827	208	1.26	17.16	.814
1937	195	1.18	16.09	.763	236	1.43	19.40	.924
1938	174	1.05	14.28	.679	133	.806	10.96	.521
1939	169	1.02	13.86	.659	167	1.01	13.73	.653
1940	154	.933	12.72	.603	167	1.01	13.82	.653
1941	139	.842	11.41	.544	113	.685	9.33	.443
1942	123	.745	10.13	.482	177	1.07	14.58	.692
1943	206	1.25	16.93	.808	174	1.05	14.29	.679
1944	159	.964	13.15	.623	150	.909	12.39	.588
1945	170	1.03	13.99	.666	198	1.20	16.26	.776
1946	229	1.39	18.82	.898	206	1.25	16.98	.808
1947	142	.861	11.66	.556	137	.830	11.25	.536
1948	197	1.19	16.23	.769	222	1.35	18.33	.873
1949	237	1.44	19.47	.931	211	1.28	17.38	.827
1950	151	.915	12.40	.591	175	1.06	14.38	.685
1951	215	1.30	17.68	.840	201	1.22	16.56	.789
1952	304	1.84	25.07	1.19	331	2.01	27.32	1.30
				Diversions and change in contents equivalent in cfs				Diversions and change in contents equivalent in cfs
1953	261	—	—	+11.4	224	—	—	+19.9
1954	91.3	—	—	+35.7	64.8	—	—	+50.5
1955	.68	—	—	+168	.78	—	—	+180
1956	118	—	—	+73.5	—	—	—	—
1930–52								
Highest	304	1.84	25.07	1.19	331	2.01	27.32	1.30
Average	179	1.08	14.72	.698	179	1.08	14.76	.698
Lowest	75.8	.459	6.23	.297	73.4	.445	6.04	.288

5. South Branch Patapsco River at Henryton

Location.—Lat 39°21′05″, long 76°54′50″, on right bank at downstream side of bridge on State Highway 101 at Henryton, Carroll County, 1.3 miles upstream from Piney Run, 2.3 miles upstream from confluence with North Branch, and 3.2 miles southeast of Sykesville.

Drainage area.—64.4 sq mi.

Records available.—August 1948 to September 1956. Monthly records September 1948 to September 1952 published in Bulletin 14; October 1952 to September 1954, in Bulletin 17.

Gage.—Water-stage recorder and concrete control. Datum of gage is 289.15 ft above mean sea level, datum of 1929.

Average discharge.—8 years 78.0 cfs.

Extremes.—Maximum discharge, 12,100 cfs July 21, 1956 (gage height, 19.40 ft), from rating curve extended above 1,900 cfs on basis of slope-area determination of peak flow; minimum, 5.3 cfs Jan. 28, 1955, result of freezeup.

Monthly discharge of South Branch Patapsco River at Henryton

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1948						
August‡	125	39	64.2	0.997	1.15	0.644
1954–55						
October	66	8.0	17.7	0.275	0.32	0.178
November	47	19	23.5	.365	.41	.236
December	145	15	39.7	.616	.71	.398
January	53	16	28.3	.439	.51	.284
February	696	15	78.5	1.22	1.27	.789
March	327	45	96.6	1.50	1.73	.969
April	84	43	52.7	.818	.91	.529
May	73	24	35.5	.551	.64	.356
June	346	20	59.9	.930	1.04	.601
July	60	12	21.8	.339	.39	.219
August	2,080	9.8	157	2.44	2.80	1.58
September	96	37	50.5	.784	.87	.507
The year	2,080	8.0	55.0	.854	11.60	.552
1955–56						
October	483	36	70.6	1.10	1.26	0.711
November	99	39	52.3	.812	.91	.525
December	45	27	36.9	.573	.66	.370
January	250	30	51.2	.795	.92	.514
February	317	66	128	1.99	2.14	1.29
March	428	60	115	1.79	2.06	1.16
April	166	66	90.8	1.41	1.57	.911
May	79	43	56.1	.871	1.00	.563
June	163	28	48.1	.747	.83	.483
July	3,010	27	162	2.52	2.90	1.63
August	76	28	40.6	.630	.73	.407
September	76	24	30.9	.480	.54	.310
The year	3,010	24	73.4	1.14	15.52	.737

‡ August 1–18 estimated.

PATAPSCO RIVER BASIN—*Continued*

Yearly discharge of South Branch Patapsco River at Henryton

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1949	101	1.57	21.32	1.01	87.7	1.36	18.49	0.879
1950	60.5	.939	12.75	.607	70.3	1.09	14.81	.704
1951	81.2	1.26	17.13	.814	72.9	1.13	15.38	.730
1952	114	1.77	24.04	1.14	125	1.94	26.45	1.25
1953	95.8	1.49	20.21	.963	83.5	1.30	17.61	.840
1954	42.8	.665	9.02	.430	38.8	.602	8.19	.389
1955	55.0	.854	11.60	.552	61.6	.957	12.99	.619
1956	73.4	1.14	15.52	.737	—	—	—	—
Highest	114	1.77	24.04	1.14	125	1.94	26.45	1.25
Average	78.0	1.21	16.45	.782	77.1	1.20	16.27	.776
Lowest	42.8	.665	9.02	.430	38.8	.602	8.19	.389

6. Piney Run near Sykesville

Location.—Lat 39°22′55″, long 76°58′00″, on left bank 75 ft downstream from bridge on State Highway 32, 1¼ miles north of Sykesville, Carroll County, and 5¼ miles upstream from mouth.

Drainage area.—11.4 sq mi.

Records available.—October 1931 to September 1956. Monthly records October 1931 to September 1943 published in Bulletin 1 (1933, 1938 revised herein); October 1943 to September 1952, in Bulletin 14 (1944 revised herein); October 1952 to September 1954, in Bulletin 17.

Gage.—Water-stage recorder and concrete control. Altitude of gage is 450 ft (from topographic map).

Average discharge.—25 years, 12.9 cfs.

Extremes.—Maximum discharge 7,380 cfs July 20, 1956 (gage height, about 12.0 ft), from rating curve extended above 1,200 cfs on basis of slope-area determination of peak flow; minimum, 0.4 cfs Jan. 25, 1939; minimum daily, 1.2 cfs Sept. 17–21, 25, 26, 1932.

Monthly discharge of Piney Run near Sykesville

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1932–33						
October	53	1.4	8.25	0.724	0.83	0.468
November	125	7.1	18.4	1.61	1.80	1.04
December	30	5.4	10.5	.921	1.06	.595
January	59	8.2	13.2	1.16	1.34	.750
February	49	10.5	16.1	1.41	1.47	.911
March	53	11.5	20.8	1.82	2.10	1.18
April	99	17	30.3	2.65	2.96	1.71
May	59	14.5	22.4	1.96	2.26	1.27
June	41	8.7	12.9	1.13	1.26	.730
July	102	5.8	13.7	1.20	1.38	.776
August*	561	5.0	32.5	2.85	3.29	1.84
September	45	8.5	11.8	1.04	1.16	.672
The year	561	1.4	17.6	1.54	20.91	.995
1937–38						
October	202	4.8	18.2	1.60	1.84	1.03
November*	356	8.8	25.6	2.25	2.51	1.45
December	18	8.5	11.0	.965	1.11	.624
January	28	8.5	11.9	1.04	1.20	.672
February	38	9.4	13.1	1.15	1.20	.743
March	19	10	13.1	1.15	1.33	.743
April	38	8.8	12.2	1.07	1.19	.692
May	17	7.2	9.67	.848	.98	.548
June	41	5.1	9.94	.872	.97	.564
July	134	3.9	16.0	1.40	1.61	.905
August	87	3.6	10.1	.886	1.02	.573
September	40	4.1	8.71	.764	.85	.494
The year	356	3.6	13.3	1.17	15.81	.756

* Revised

Monthly Discharge of Piney Run near Sykesville—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1943–44						
October	38	2.4	4.85	0.425	0.49	0.275
November*	199	4.5	16.8	1.47	1.64	.950
December	100	3.7	8.79	.771	.89	.498
January	514	5.0	26.6	2.33	2.69	1.51
February	12	5.4	7.55	.662	.71	.428
March	83	7.7	18.7	1.64	1.90	1.06
April	33	10	15.5	1.36	1.52	.879
May	59	7.4	12.8	1.12	1.29	.724
June	95	5.4	11.1	.974	1.08	.630
July	6.8	2.6	4.11	.361	.42	.233
August	11	2.0	3.10	.272	.31	.176
September	23	2.2	4.58	.402	.45	.260
The year	514	2.0	11.2	.982	13.39	.635
1954–55						
October	13	2.2	3.59	0.315	0.36	0.204
November	10	3.5	4.39	.385	.43	.249
December	27	3.0	7.00	.614	.71	.397
January	7.8	3.0	4.45	.390	.45	.252
February	109	3.0	15.3	1.34	1.40	.866
March	66	7.1	16.1	1.41	1.63	.911
April	15	6.5	8.78	.770	.86	.498
May	12	4.5	6.09	.534	.62	.345
June	85	3.9	10.7	.939	1.05	.607
July	13	2.6	4.31	.378	.44	.244
August	481	2.5	33.0	2.89	3.33	1.87
September	21	6.5	8.85	.776	.87	.502
The year	481	2.2	10.2	.895	12.15	.578
1955–56						
October	101	6.5	12.3	1.08	1.24	0.698
November	19	7.1	9.40	.825	.92	.533
December	9.0	5.6	7.05	.618	.71	.399
January	58	5.4	10.0	.877	1.01	.567
February	74	11	24.0	2.11	2.27	1.36
March	86	11	20	1.75	2.02	1.13
April	34	9.9	15.0	1.32	1.46	.853
May	66	6.8	10.8	.947	1.10	.612
June	23	5.4	8.95	.785	.88	.507
July	600	5.1	42.5	3.73	4.30	2.41
August	15	5.4	8.20	.719	.83	.465
September	18	5.1	6.77	.594	.66	.384
The year	600	5.1	14.6	1.28	17.40	.827

PATAPSCO RIVER BASIN—*Continued*

Yearly discharge of Piney Run near Sykesville

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1932	6.21	0.545	7.41	0.352	8.68	0.761	10.36	0.492
1933	17.6	1.54	20.91	.995	16.5	1.45	19.65	.937
1934	11.3	.991	13.50	.641	12.0	1.05	14.23	.679
1935	13.5	1.18	16.01	.763	13.0	1.14	15.53	.737
1936	15.4	1.35	18.42	.873	15.0	1.32	17.90	.853
1937	13.8	1.21	16.43	.782	16.6	1.46	19.73	.944
1938	13.3	1.17	15.81	.756	10.7	.939	12.81	.607
1939	12.4	1.09	14.76	.704	12.0	1.05	14.25	.679
1940	10.5	.921	12.49	.595	11.2	.982	13.42	.635
1941	8.80	.772	10.48	.499	7.20	.632	8.57	.408
1942	7.62	.668	9.08	.432	11.0	.965	13.17	.624
1943	12.3	1.08	14.70	.698	10.6	.930	12.66	.601
1944	11.2	.982	13.39	.635	10.5	.921	12.50	.595
1945	11.6	1.02	13.87	.659	13.7	1.20	16.35	.776
1946	16.1	1.41	19.14	.911	14.0	1.23	16.65	.795
1947	10.3	.904	12.22	.584	10.5	.921	12.51	.595
1948	15.0	1.32	17.87	.853	17.6	1.54	20.97	.995
1949	18.0	1.58	21.41	1.02	15.3	1.34	18.27	.866
1950	11.8	1.04	14.02	.672	13.6	1.19	16.24	.769
1951	15.1	1.32	18.00	.853	13.7	1.20	16.29	.776
1952	20.3	1.78	24.27	1.15	22.1	1.94	26.39	1.25
1953	17.4	1.53	20.70	.989	15.1	1.32	18.00	.853
1954	7.26	.637	8.64	.412	6.58	.577	7.84	.373
1955	10.2	.895	12.15	.578	11.3	.991	13.52	.641
1956	14.6	1.28	17.40	.827	—	—	—	—
Highest	20.3	1.78	24.27	1.15	22.1	1.94	26.39	1.25
Average	12.9	1.13	15.32	.730	12.9	1.13	15.33	.730
Lowest	6.21	.545	7.41	.352	6.58	.577	7.84	.373

POTOMAC RIVER BASIN

7. Little Catoctin Creek at Harmony

Location.—Lat 39°28′55″, long 77°32′20″, on right bank at upstream side of highway bridge, 0.9 mile southwest of Harmony, Frederick County, 2.6 miles north of Middletown, and 2.8 miles upstream from mouth.

Drainage area.—8.9 sq mi, approximately.

Records available.—July 1947 to September 1956.

Gage.—Water-stage recorder and concrete control. Altitude of gage is 540 ft (from topographic map).

Average discharge.—9 years, 10.3 cfs.

Extremes.—Maximum discharge, 5,400 cfs Aug. 20, 1952 (gage height, 8.49 ft in gage well, 9.82 ft from floodmark), from rating curve extended above 220 cfs on basis of slope-area determinations at gage heights 3.87, 5.58, and 6.82 ft, and contracted-opening determination of peak flow; minimum, 0.4 cfs part of each day July 28 to Aug. 2, Oct. 12–14, 1954.

Remarks.—Small diversion above station for municipal water supply of Middletown.

Monthly discharge of Little Catoctin Creek at Harmony

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1947						
July	64	2.8	8.70	0.978	1.13	0.632
August	60	2.1	5.91	.664	.77	.429
September	2.1	1.3	1.66	.187	.21	.121
1947–48						
October	2.8	1.3	1.55	0.174	0.20	0.112
November	37	1.6	6.83	.767	.86	.496
December	6.1	2.3	3.34	.375	.43	.242
January	40	5.0	9.09	1.02	1.18	.659
February	91	3.6	13.0	1.46	1.57	.944
March	34	12	16.6	1.87	2.15	1.21
April	56	14	22.2	2.49	2.78	1.61
May	77	9.7	22.1	2.48	2.86	1.60
June	25	2.6	6.30	.708	.79	.458
July	7.5	1.9	2.99	.336	.39	.217
August	7.0	1.6	2.63	.296	.34	.191
September	2.8	1.3	1.54	.173	.19	.112
The year	91	1.3	8.98	1.01	13.74	.653

Monthly Discharge of Little Catoctin Creek at Harmony—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1948–49						
October	11	1.3	2.80	0.315	0.36	0.204
November	65	1.8	10.9	1.22	1.37	.789
December	179	8.5	23.4	2.63	3.03	1.70
January	121	15	36.5	4.10	4.72	2.65
February	44	21	26.8	3.01	3.13	1.95
March	18	6.5	10.5	1.18	1.35	.763
April	25	5.8	11.0	1.24	1.37	.801
May	78	6.5	16.7	1.88	2.16	1.22
June	26	2.4	4.40	.494	.55	.319
July	182	2.0	17.7	1.99	2.29	1.29
August	12	2.2	4.09	.460	.53	.297
September	30	1.6	4.03	.453	.51	.293
The year	182	1.3	14.0	1.57	21.37	1.01
1949–50						
October	17	1.9	3.28	0.369	0.42	0.238
November	7.9	2.4	3.32	.373	.42	.241
December	28	2.2	7.66	.861	.99	.556
January	12	4.8	7.73	.869	1.00	.562
February	32	9.0	17.1	1.92	2.00	1.24
March	78	7.0	18.7	2.10	2.42	1.36
April	20	7.2	11.0	1.24	1.38	.801
May	28	8.5	14.3	1.61	1.85	1.04
June	22	5.1	10.2	1.15	1.27	.743
July	8.4	2.0	3.81	.428	.49	.277
August	3.0	1.4	1.79	.201	.23	.130
September	15	1.5	5.41	.608	.68	.393
The year	78	1.4	8.63	.970	13.15	.627
1950–51						
October	26	2.4	5.69	0.639	0.74	0.413
November	144	3.4	11.4	1.28	1.43	.827
December	172	9.0	31.1	3.49	4.02	2.26
January	24	7.8	13.9	1.56	1.80	1.01
February	98	12	26.5	2.98	3.10	1.93
March	27	12	16.7	1.88	2.17	1.22
April	25	12	17.9	2.01	2.25	1.30
May	17	5.1	10.6	1.19	1.38	.769
June	72	3.2	15.5	1.74	1.95	1.12
July	9.2	2.2	3.99	.448	.52	.290
August	9.6	1.0	1.76	.198	.23	.128
September	3.8	.6	1.12	.126	.14	.081
The year	172	.6	12.9	1.45	19.73	.937

Monthly Discharge of Little Catoctin Creek at Harmony—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1951–52						
October	1.4	0.7	0.98	0.110	0.13	0.071
November	23	1.8	3.76	.422	.47	.273
December	49	1.3	6.31	.709	.82	.458
January	43	9.7	20.1	2.26	2.60	1.46
February	71	7.9	20.1	2.26	2.44	1.46
March	89	6.7	24.3	2.73	3.15	1.76
April	178	14	39.8	4.47	4.99	2.89
May	101	11	30.2	3.39	3.91	2.19
June	18	3.6	8.53	.958	1.07	.619
July	4.2	1.6	2.47	.278	.32	.180
August	150	.9	7.56	.849	.98	.548
September	90	2.0	7.55	.848	.95	.548
The year	178	.7	14.3	1.61	21.83	1.04
1952–53						
October	4.5	1.8	2.22	0.249	0.29	0.161
November	286	1.7	19.9	2.24	2.49	1.45
December	53	7.6	14.3	1.61	1.85	1.04
January	59	7.0	23.5	2.64	3.04	1.71
February	27	9.1	14.0	1.57	1.64	1.01
March	56	9.1	23.2	2.61	3.01	1.69
April	32	11	20.4	2.29	2.55	1.48
May	47	8.6	17.4	1.96	2.25	1.27
June	65	3.1	12.0	1.35	1.51	.873
July	21	1.8	3.25	.365	.42	.236
August	5.2	1.0	1.86	.209	.24	.135
September	11	.8	1.76	.198	.22	.128
The year	286	.8	12.8	1.44	19.51	.931
1953–54						
October	2.1	0.8	1.01	0.113	0.13	0.073
November	3.0	1.0	1.23	.138	.15	.089
December	26	1.1	4.34	.488	.56	.315
January	11	1.2	2.72	.306	.35	.198
February	10	1.8	3.71	.417	.43	.270
March	34	4.8	8.68	.975	1.12	.630
April	39	4.2	9.08	1.02	1.14	.659
May	12	2.8	6.72	.755	.87	.488
June	5.1	1.2	2.16	.243	.27	.157
July	8.1	.4	1.35	.152	.18	.098
August	18	.4	1.80	.202	.23	.131
September	2.6	.7	.91	.102	.11	.066
The year	39	.4	3.65	.410	5.54	.265

POTOMAC RIVER BASIN—*Continued*

Monthly Discharge of Little Catoctin Creek at Harmony—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1954–55						
October	25	0.4	1.95	0.219	0.25	0.142
November	3.8	1.2	1.72	.193	.22	.125
December	40	1.1	5.63	.633	.73	.409
January	6.5	1.3	2.80	.315	.36	.204
February	53	1.3	8.28	.930	.97	.601
March	71	7.2	21.4	2.40	2.77	1.55
April	20	5.8	10.2	1.15	1.28	.743
May	14	2.6	5.63	.633	.73	.409
June	21	2.2	4.41	.496	.55	.321
July	13	1.4	2.73	.307	.35	.198
August	228	1.2	31.2	3.51	4.04	2.27
September	16	3.2	6.10	.685	.76	.443
The year	228	.4	8.54	.960	13.01	.620
1955–56						
October	69	2.8	7.49	0.842	0.97	0.544
November	12	2.5	4.19	.471	.52	.304
December	4.0	1.6	2.67	.300	.35	.194
January	26	1.5	3.93	.442	.51	.286
February	56	4.8	19.1	2.15	2.32	1.39
March	68	8.0	20.6	2.31	2.67	1.49
April	46	10	21.1	2.37	2.64	1.53
May	12	3.4	6.29	.707	.82	.457
June	7.0	2.0	3.10	.348	.39	.225
July	102	1.7	11.6	1.30	1.50	.840
August	9.0	1.6	3.49	.392	.45	.253
September	9.9	1.4	2.34	.263	.29	.170
The year	102	1.4	8.77	.985	13.43	.637

POTOMAC RIVER BASIN—*Continued*

Yearly discharge of Little Catoctin Creek at Harmony

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1948	8.98	1.01	13.74	0.653	11.1	1.25	17.01	0.808
1949	14.0	1.57	21.37	1.01	12.1	1.36	18.44	.879
1950	8.63	.970	13.15	.627	11.5	1.29	17.51	.834
1951	12.9	1.45	19.73	.937	9.80	1.10	14.96	.711
1952	14.3	1.61	21.83	1.04	16.4	1.84	25.04	1.19
1953	12.8	1.44	19.51	.931	10.3	1.16	15.72	.750
1954	3.65	.410	5.54	.265	3.88	.436	5.90	.282
1955	8.54	.960	13.01	.620	8.96	1.01	13.65	.653
1956	8.77	.985	13.43	.637	—	—	—	—
Highest	14.3	1.61	21.83	1.04	16.4	1.84	25.04	1.19
Average	10.3	1.16	15.70	.750	10.5	1.18	16.03	.763
Lowest	3.65	.410	5.54	.265	3.88	.436	5.90	.282

8. Catoctin Creek near Middletown

Location.—Lat 39°25′35″, long 77°33′25″, on right bank 300 ft downstream from bridge on State Highway 17, 1.3 miles south of Middletown, Frederick County, and 2¼ miles downstream from Little Catoctin Creek.

Drainage area.—66.9 sq mi.

Records available.—August 1947 to September 1956.

Gage.—Water-stage recorder and concrete control. Altitude of gage is 385 ft (from topographic map).

Average discharge.—9 years, 80.4 cfs.

Extremes.—Maximum discharge, 7,760 cfs July 18, 1949 (gage height, 11.18 ft), from rating curve extended above 1,500 cfs on basis of slope-area determination of peak flow; minimum daily 1.5 cfs July 31, Aug. 1, 1954.

Monthly discharge of Catoctin Creek near Middletown

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1947						
August‡	125	14	30.4	0.454	0.52	0.293
September	15	5.1	9.24	.138	.15	.089
1947–48						
October	31	5.1	7.96	0.119	0.14	0.077
November	222	12	48.2	.720	.80	.465
December	36	16	23.5	.351	.41	.227
January	604	21	107	1.60	1.85	1.03
February	520	18	118	1.76	1.91	1.14
March	245	71	125	1.87	2.15	1.21
April	526	86	179	2.68	2.99	1.73
May	590	59	157	2.35	2.70	1.52
June	89	22	43.0	.643	.72	.416
July	56	12	22.6	.338	.39	.218
August	136	9.5	24.1	.360	.42	.233
September	22	6.3	9.26	.138	.15	.089
The year	604	5.1	71.9	1.07	14.63	.692
1948–49						
October	136	6.0	31.6	0.472	0.54	0.305
November	345	17	103	1.54	1.72	.995
December	1,280	85	218	3.26	3.75	2.11
January	800	92	256	3.83	4.40	2.48
February	295	128	171	2.56	2.67	1.65
March	113	49	76.8	1.15	1.32	.743
April	205	47	79.7	1.19	1.33	.769
May	187	34	69.7	1.04	1.20	.672
June	118	18	33.4	.499	.56	.323
July	1,410	10	214	3.20	3.69	2.07
August	110	14	31.4	.469	.54	.303
September	149	9.5	27.1	.405	.45	.262
The year	1,410	6.0	109	1.63	22.17	1.05

‡ August 1–19 estimated.

Monthly Discharge of Catoctin Creek near Middletown—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1949–50						
October	151	11	24.5	0.366	0.42	0.237
November	75	18	31.0	.463	.52	.299
December	498	18	81.0	1.21	1.40	.782
January	126	35	64.4	.963	1.11	.622
February	372	62	174	2.60	2.71	1.68
March	692	44	154	2.30	2.65	1.49
April	156	49	82.7	1.24	1.38	.801
May	234	58	118	1.76	2.03	1.14
June	218	22	69.0	1.03	1.15	.666
July	33	8.4	18.8	.281	.32	.182
August	22	4.4	7.55	.113	.13	.073
September	198	6.2	40.4	.604	.67	.390
The year	692	4.4	71.5	1.07	14.49	.692
1950–51						
October	142	15	36.6	0.547	0.63	0.354
November	1,480	23	107	1.60	1.79	1.03
December	1,930	64	245	3.66	4.22	2.37
January	253	58	111	1.66	1.92	1.07
February	856	90	233	3.48	3.63	2.25
March	258	71	133	1.99	2.30	1.29
April	250	79	131	1.96	2.19	1.27
May	149	30	70.3	1.05	1.21	.679
June	568	24	130	1.94	2.16	1.25
July	57	13	26.1	.390	.45	.252
August	45	5.4	11.4	.170	.20	.110
September	14	2.9	5.45	.081	.09	.052
The year	1,930	2.9	102	1.52	20.79	.982
1951–52						
October	10	2.7	4.93	0.074	0.08	0.048
November	113	9.2	22.8	.341	.38	.220
December	338	12	62.2	.930	1.07	.601
January	620	74	199	2.97	3.43	1.92
February	548	46	124	1.85	1.99	1.20
March	621	46	185	2.77	3.18	1.79
April	1,250	79	289	4.32	4.82	2.79
May	1,240	56	220	3.29	3.79	2.13
June	142	22	54.4	.813	.91	.525
July	44	7.5	16.1	.241	.28	.156
August	208	5.0	19.6	.293	.34	.189
September	740	9.2	60.6	.906	1.01	.586
The year	1,250	2.7	105	1.57	21.28	1.01

Monthly Discharge of Catoctin Creek near Middletown—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1952–53						
October	30	8.1	11.9	0.178	0.21	0.115
November	1,620	7.5	161	2.41	2.69	1.56
December	639	65	145	2.17	2.49	1.40
January	630	60	212	3.17	3.65	2.05
February	179	68	102	1.52	1.58	.982
March	655	68	206	3.08	3.55	1.99
April	280	76	164	2.45	2.74	1.58
May	473	62	121	1.81	2.09	1.17
June	527	23	89.0	1.33	1.48	.860
July	493	8.4	36.8	.550	.63	.355
August	65	3.1	12.8	.191	.22	.123
September	52	2.6	10.3	.154	.17	.100
The year	1,620	2.6	106	1.58	21.50	1.02
1953–54						
October	22	2.8	5.50	0.082	0.09	0.053
November	24	5.1	8.71	.130	.15	.084
December	191	7.5	37.0	.553	.64	.357
January	90	9.0	23.9	.357	.41	.231
February	70	13	28.8	.430	.45	.278
March	299	54	89.2	1.33	1.54	.860
April	200	30	63.4	.948	1.06	.613
May	114	24	53.0	.792	.91	.512
June	24	4.7	13.5	.202	.23	.131
July	74	1.5	8.90	.133	.15	.086
August	183	1.5	16.6	.248	.29	.160
September	23	3.1	6.77	.101	.11	.065
The year	299	1.5	29.7	.444	6.03	.287
1954–55						
October	164	2.7	21.2	0.317	0.37	0.205
November	43	12	20.5	.306	.34	.198
December	219	10	53.8	.804	.93	.520
January	72	12	31.5	.471	.54	.304
February	270	12	72.0	1.08	1.12	.698
March	833	69	186	2.78	3.21	1.80
April	107	49	70.3	1.05	1.17	.679
May	69	15	35.9	.537	.62	.347
June	135	11	31.0	.463	.52	.299
July	181	4.0	20.7	.309	.36	2.00
August	1,490	2.6	208	3.11	3.58	2.01
September	74	18	33.8	.505	.56	.326
The year	1,490	2.6	65.6	.981	13.32	.634

POTOMAC RIVER BASIN—*Continued*

Monthly Discharge of Catoctin Creek near Middletown—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1955–56						
October	434	16	58.8	0.879	1.01	0.568
November	83	24	32.4	.484	.54	.313
December	29	10	18.6	.278	.32	.180
January	220	11	29.7	.444	.51	.287
February	556	83	190	2.84	3.06	1.84
March	576	64	151	2.26	2.61	1.46
April	264	54	104	1.55	1.74	1.00
May	74	23	40.8	.610	.70	.394
June	58	7.8	22.7	.339	.38	.219
July	621	7.8	76.9	1.15	1.32	.743
August	53	9.2	20.4	.305	.35	.197
September	47	6.4	12.8	.191	.21	.123
The year	621	6.4	62.7	.937	12.75	.606

Yearly discharge of Catoctin Creek near Middletown

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1948	71.9	1.07	14.63	0.692	94.8	1.42	19.29	0.918
1949	109	1.63	22.17	1.05	91.2	1.36	18.50	.879
1950	71.5	1.07	14.49	.692	92.6	1.38	18.79	.892
1951	102	1.52	20.79	.982	77.3	1.16	15.68	.750
1952	105	1.57	21.28	1.01	124	1.85	25.14	1.20
1953	106	1.58	21.50	1.02	83.8	1.25	16.99	.808
1954	29.7	.444	6.03	.287	33.4	.499	6.79	.323
1955	65.6	.981	13.32	.634	66.8	.999	13.55	.646
1956	62.7	.937	12.75	.606	—	—	—	—
Highest	109	1.63	22.17	1.05	124	1.85	25.14	1.20
Average	80.4	1.20	16.33	.776	83.0	1.24	16.84	.801
Lowest	29.7	.444	6.03	.287	33.4	.499	6.79	.323

POTOMAC RIVER BASIN

9. Catoctin Creek near Jefferson

Location.—Lat 39°21′25″, long 77°34′24″, on left bank 500 ft downstream from bridge on U.S. Highway 340, 600 ft downstream from small tributary, and 2 miles west of Jefferson, Frederick County.

Drainage area.—111 sq mi.

Records available.—June 1928 to September 1931 (discontinued). Monthly records published in Bulletin 1.

Gage.—Staff gage. Altitude of gage is 270 ft (from topographic map). Jan. 27 to Nov. 27, 1929, chain gage at bridge 500 ft upstream at datum 2 ft lower.

Extremes.—Maximum discharge observed, 6,980 cfs June 19, 1928 (gage height, 11.3 ft), from rating curve extended above 610 cfs; minimum observed, 0.7 cfs Aug. 10–14, Sept. 29, 30, 1930 (gage height, 0.90 ft).

Maximum stage known, about 18 ft in 1885, from information by local resident.

Stage of about 15 ft reached in 1926, from information by local residents.

Monthly discharge of Catoctin Creek near Jefferson

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1928						
June‡	2,820	45	373	3.36	3.75	2.17

‡ Not previously published; discharge partly estimated.

Yearly discharge of Catoctin Creek near Jefferson

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1929	94.0	0.847	11.49	0.547	111	1.00	13.63	0.646
1930	79.4	.715	9.70	.462	55.7	.502	6.80	.324
1931	46.3	.417	5.67	.270	—	—	—	—

POTOMAC RIVER BASIN

10. Potomac River at Point of Rocks

Location.—Lat 39°16′25″, long 77°32′35″, on left bank at downstream side of bridge on U. S. Highway 15 at Point of Rocks, Frederick County, a third of a mile downstream from Catoctin Creek (Virginia) and 6 miles upstream from Monocacy River.

Drainage area.—9,651 sq mi.

Records available.—February 1895 to September 1956. Monthly records March 1895 to September 1943 published in Bulletin 1 (1895, 1896, 1899, 1901, 1902, 1904, 1905, 1912, 1915, 1918, 1920, 1924 revised herein). Monthly records August 1931 to September 1936 for Chesapeake and Ohio Canal published in Bulletin 1.

Gage.—Water-stage recorder. Datum of gage is 200.54 ft above mean sea level, adjustment of 1912. Sept. 2, 1902, to Oct. 28, 1929, chain gage on downstream side of highway bridge at same datum. Prior to Sept. 2, 1902, wire-weight gage at same site, at datum 0.45 ft higher. Jan. 1 to June 17, 1896, 1897, and Apr. 16, 1901, to Sept. 1, 1902, datum questionable.

July 14, 1931, to Sept. 30, 1936, staff gage on Chesapeake and Ohio Canal at locks 0.6 mile upstream at different datum.

Average discharge.—61 years, 9,316 cfs.

Extremes.—Maximum discharge, 480,000 cfs Mar. 19, 1936 (gage height, 41.03 ft), from rating curve extended above 300,000 cfs on basis of adjustment of figure of peak flow at station near Washington for inflow and storage, and slope-area determination of peak flow; minimum, 540 cfs Sept. 10, 1914 (gage height, 0.38 ft).

Flood of June 2, 1889, reached a stage of 40.2 ft, from floodmarks (discharge, about 460,000 cfs, from rating curve extended as explained above).

Remarks.—Low flow affected slightly since 1913 by Stony River Reservoir.

Discharge of Chesapeake and Ohio Canal which parallels the Potomac River on the Maryland side is not included in records for this station. Canal diverts from left bank of Potomac River at Harpers Ferry and returns below gaging station. Canal closed after Nov. 20, 1935, and not reopened, as the flood of March 1936 destroyed canal banks above the gage.

Monthly discharge of Potomac River at Point of Rocks

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1895						
February‡	15,260	3,000	5,593	0.580	0.60	0.375
March	65,980	11,520	24,560	2.54	2.93	1.64
April	67,640	6,200	14,500	1.50	1.67	.969
May	29,340	7,120	12,540	1.30	1.50	.840
June	7,580	2,280	3,910	.405	.45	.262
July	10,500	2,600	4,462	.462	.53	.299
August	3,300	1,340	1,997	.207	.24	.134
September	2,600	1,180	1,565	.162	.18	.105
The year						

‡ Not previously published; estimated or partly estimated.

Monthly Discharge of Potomac River at Point of Rocks—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1895–96						
October	1,340	1,040	1,163	0.121	0.14	0.078
November	1,540	1,180	1,333	.138	.15	.089
December	5,320	1,180	2,259	.234	.27	.151
January*	26,020	1,760	6,393	.662	.76	.428
February*	39,320	3,680	11,950	1.24	1.34	.801
March‡	34,500	3,000	10,070	1.04	1.20	.672
April‡	34,500	3,000	10,410	1.08	1.20	.698
May‡	6,660	2,280	3,390	.351	.40	.227
June*	14,160	1,760	6,038	.626	.70	.405
July	50,300	2,940	9,283	.962	1.11	.622
August	9,500	1,540	3,449	.357	.41	.321
September	25,380	1,180	2,175	.225	.25	.145
The year	50,300	1,040	5,632	0.548	7.93	.377
1898–99						
October	86,730	1,760	13,670	1.42	1.64	0.918
November	15,260	5,320	8,557	.887	.99	.573
December	54,360	6,200	15,330	1.59	1.83	1.03
January	45,500	8,540	18,680	1.94	2.24	1.25
February*	100,800	7,000	23,710	2.46	2.56	1.59
March	115,400	14,160	35,240	3.65	4.21	2.36
April	25,380	5,760	11,750	1.22	1.36	.789
May	49,140	5,320	11,600	1.20	1.38	.776
June	16,380	2,940	5,314	.551	.61	.356
July	7,120	1,540	2,519	.261	.30	.169
August	3,680	1,540	2,335	.242	.28	.156
September	3,680	1,670	2,345	.243	.27	.157
The year	115,400	1,540	12,560	1.30	17.67	0.840
1900–01						
October	2,600	1,180	1,333	0.138	0.16	0.089
November	46,300	1,040	4,570	.474	.53	.306
December	29,340	2,280	6,218	.644	.74	.416
January	21,040	1,760	4,950	.513	.59	.332
February*	4,080	2,280	3,148	.326	.34	.211
March	80,920	2,280	13,800	1.43	1.65	.924
April	150,600	7,120	39,750	4.12	4.60	2.66
May	95,860	6,200	26,920	2.79	3.22	1.80
June	48,700	8,060	19,180	1.99	2.22	1.29
July	26,680	4,900	10,720	1.11	1.28	.717
August	20,440	4.080	8,337	.864	1.00	.558
September	28,000	3,680	7,636	.791	.88	.511
The year	150,600	1,040	12,230	1.27	17.21	.821

* Revised

Monthly Discharge of Potomac River at Point of Rocks—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1901–02						
October	12,040	2,600	4,303	0.446	0.51	0.288
November	19,840	2,280	4,648	.482	.54	.312
December	130,700	4,480	25,610	2.65	3.06	1.71
January	75,110	7,580	17,520	1.82	2.10	1.18
February*	203,800	8,000	25,230	2.61	2.72	1.69
March	218,700	14,700	54,260	5.62	6.47	3.63
April	108,700	7,700	28,760	2.98	3.32	1.93
May	9,530	4,670	5,973	.619	.71	.400
June	4,330	2,530	3,186	.330	.37	.213
July	4,330	2,000	3,086	.320	.37	.207
August	4,330	1,515	2,464	.255	.29	.165
September	2,000	1,295	1,490	.154	.17	.100
The year	218,700	1,295	14,680	1.52	20.63	.982
1903–04						
October	6,130	2,000	3,212	0.333	0.38	0.215
November	2,810	2,000	2,175	.225	.25	.145
December	4,010	2,000	2,926	.303	.35	.196
January	35,620	3,400	7,287	.755	.87	.488
February*	31,000	7,200	14,680	1.52	1.64	.982
March	22,300	5,380	11,170	1.16	1.34	.750
April	28,120	3,400	7,406	.767	.86	.496
May	27,460	5,380	9,362	.970	1.12	.627
June	38,500	3,100	10,160	1.05	1.17	.679
July	10,970	2,530	4,505	.467	.54	.302
August	3,400	1,750	2,394	.248	.29	.160
September	2,000	1,295	1,592	.165	.18	.107
The year	38,500	1,295	6,372	.660	8.99	.427
1904–05						
October	2,000	900	1,164	0.121	0.14	0.078
November	1,515	1,090	1,340	.139	.16	.090
December	5,020	1,515	2,201	.228	.26	.147
January	17,430	4,670	8,626	.894	1.03	.578
February*	5,000	4,000	4,368	.453	.47	.293
March	63,900	6,520	23,480	2.43	2.80	1.57
April	10,000	4,010	6,581	.682	.76	.441
May	9,070	2,810	4,493	.466	.54	.301
June	32,820	2,810	6,979	.723	.81	.467
July	22,300	3,400	10,190	1.06	1.22	.685
August	13,530	2,810	5,830	.604	.70	.390
September	5,750	2,000	3,205	.332	.37	.215
The year	63,900	900	6,578	.682	9.26	.441

Monthly Discharge of Potomac River at Point of Rocks—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1911–12						
October	33,500	4,010	8,510	0.882	1.02	0.570
November	13,000	2,940	5,970	.619	.69	.400
December	29,400	3,390	10,200	1.06	1.22	.685
January*	21,100	3,500	7,330	.760	.88	.491
February*	80,500	5,100	14,900	1.54	1.66	.995
March	80,500	8,180	28,700	2.97	3.42	1.92
April	37,100	7,330	14,900	1.54	1.72	.995
May	68,900	6,130	19,800	2.05	2.36	1.32
June	7,330	3,700	5,280	.547	.61	.354
July	46,000	3,860	8,550	.886	1.02	.573
August	7,750	2,120	3,460	.359	.41	.232
September	39,200	1,640	6,360	.659	.74	.426
The year	80,500	1,640	11,200	1.16	15.75	.750
1914–15						
October	2,800	706	1,400	0.145	0.17	0.094
November	2,940	643	1,540	.160	.18	.103
December*	15,700	1,100	5,540	.574	.66	.371
January	84,600	4,500	28,600	2.96	3.41	1.91
February	121,000	10,000	27,000	2.80	2.92	1.81
March	16,300	4,670	8,230	.853	.98	.551
April	5,750	3,090	4,370	.453	.51	.293
May	15,200	3,240	5,900	.611	.70	.395
June	127,000	3,540	20,400	2.11	2.35	1.36
July	3,390	1,910	2,670	.277	.32	.179
August	19,800	1,240	6,760	.700	.81	.452
September	11,000	2,800	5,350	.554	.62	.358
The year	127,000	643	9,690	1.00	13.63	.646
1917–18						
October	30,100	770	4,770	0.494	0.57	0.319
November	18,600	1,260	3,830	.397	.44	.257
December*	3,000	1,700	2,270	.235	.27	.152
January	—	—	2,500	.259	.30	.167
February	105,000	—	28,300	2.93	3.05	1.89
March	43,000	4,500	13,600	1.41	1.63	.911
April	111,000	4,010	39,800	4.12	4.60	2.66
May	16,300	2,660	5,990	.621	.72	.401
June	5,750	2,250	3,310	.343	.38	.222
July	4,840	2,120	3,360	.348	.40	.225
August	3,700	2,120	2,910	.302	.35	.195
September	6,920	1,990	3,940	.408	.46	.264
The year	111,000	770	9,370	.971	13.17	.628

Monthly Discharge of Potomac River at Point of Rocks—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1919–20						
October	4,840	1,010	2,420	0.251	0.29	0.162
November	14,100	2,250	4,620	.479	.53	.310
December	12,000	3,700	6,880	.713	.82	.461
January*	35,000	5,000	12,700	1.32	1.52	.853
February*	35,000	10,000	20,300	2.10	2.26	1.36
March	103,000	9,070	32,300	3.35	3.86	2.17
April	32,800	8,620	14,500	1.50	1.67	.969
May	13,500	4,840	8,700	.901	1.04	.582
June	18,600	4,010	8,550	.886	.99	.573
July	7,750	2,660	3,790	.393	.45	.254
August	32,100	1,990	7,150	.741	.85	.479
September	18,000	2,250	4,960	.514	.57	.332
The year	103,000	1,010	10,600	1.10	14.85	.711
1923–24						
October	1,930	676	1,040	0.108	0.12	0.070
November	2,920	780	2,030	.210	.23	.136
December	14,000	2,920	6,880	.713	.82	.461
January	68,300	8,550	18,700	1.94	2.24	1.25
February	14,500	5,000	8,170	.847	.91	.547
March	156,000	6,130	33,800	3.50	4.04	2.26
April*	76,500	8,130	22,100	2.29	2.56	1.48
May	237,000	8,130	42,000	4.35	5.02	2.81
June	24,400	7,300	14,400	1.49	1.66	.963
July	19,600	3,580	8,960	.928	1.07	.600
August	4,270	2,600	3,170	.328	.38	.212
September	15,500	1,420	2,680	.278	.31	.180
The year	237,000	676	13,700	1.42	19.36	.918
1943–44						
October	2,530	995	1,514	0.157	0.18	0.101
November	5,210	1,600	2,403	.249	.28	.161
December	2,600	1,000	1,439	.149	.17	.096
January	27,000	2,150	5,860	.607	.70	.392
February	27,600	2,500	7,281	.754	.81	.487
March	57,700	12,800	23,760	2.46	2.84	1.59
April	30,300	9,280	14,840	1.54	1.72	.996
May	57,900	6,420	15,100	1.56	1.80	1.01
June	7,520	2,620	4,159	.431	.48	.279
July	2,930	1,330	1,787	.185	.21	.120
August	1,780	1,110	1,296	.134	.15	.087
September	13,000	1,100	2,666	.276	.31	.178
The year	57,900	995	6,849	.710	9.65	.459

Monthly Discharge of Potomac River at Point of Rocks—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1944–45						
October	33,400	2,040	5,499	0.570	0.66	0.368
November	3,660	1,910	2,378	.246	.27	.159
December	23,800	3,040	7,185	.744	.86	.481
January	21,900	5,380	8,567	.888	1.02	.574
February	49,300	3,400	15,430	1.60	1.66	1.03
March	43,300	7,330	18,060	1.87	2.16	1.21
April	19,200	6,060	9,109	.944	1.05	.610
May	19,700	6,600	10,100	1.05	1.21	.679
June	6,800	2,800	4,487	.465	.52	.301
July	10,700	2,060	3,166	.328	.38	.212
August	21,200	2,000	6,071	.629	.73	.407
September	115,000	2,650	17,600	1.82	2.03	1.18
The year	115,000	1,910	8,925	.925	12.55	.598
1945–46						
October	11,100	2,550	4,472	0.463	0.53	0.299
November	32,500	2,530	6,888	.714	.80	.461
December	29,200	5,550	12,250	1.27	1.46	.821
January	31,000	6,420	14,220	1.47	1.70	.950
February	20,900	6,780	10,670	1.11	1.16	.717
March	25,900	10,700	15,480	1.60	1.85	1.03
April	19,700	4,540	8,198	.849	.95	.549
May	25,900	5,550	13,510	1.40	1.61	.905
June	43,600	4,340	11,870	1.23	1.37	.795
July	5,380	1,950	3,389	.351	.40	.227
August	8,880	1,740	3,149	.326	.38	.211
September	3,560	1,090	1,726	.179	.20	.116
The year	43,600	1,090	8,828	.915	12.41	.591
1946–47						
October	8,680	1,570	2,824	0.293	0.34	0.189
November	3,880	1,700	2,163	.224	.25	.145
December	6,960	1,450	2,144	.222	.26	.143
January	18,300	4,870	8,969	.929	1.07	.600
February	12,100	2,900	5,083	.527	.55	.341
March	37,500	2,680	10,490	1.09	1.25	.704
April	9,480	4,700	6,201	.643	.72	.416
May	13,300	5,210	8,353	.866	1.00	.560
June	9,880	3,040	5,697	.590	.66	.381
July	12,400	2,410	5,020	.520	.60	.336
August	8,610	1,780	3,555	.368	.42	.238
September	3,260	1,350	1,972	.204	.23	.132
The year	37,500	1,350	5,220	.541	7.35	.350

Monthly Discharge of Potomac River at Point of Rocks—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1947–48						
October	1,760	995	1,305	0.135	0.16	0.087
November	8,090	1,430	4,566	.473	.53	.306
December	4,110	1,850	2,680	.278	.32	.180
January	26,100	2,300	6,085	.631	.73	.408
February	54,600	2,300	11,380	1.18	1.27	.763
March	32,500	8,480	15,780	1.64	1.88	1.06
April	74,200	8,680	19,930	2.07	2.30	1.34
May	33,700	5,210	14,980	1.55	1.79	1.00
June	14,200	4,170	6,399	.663	.74	.429
July	8,090	2,820	3,988	.413	.48	.267
August	8,280	2,620	4,985	.517	.60	.334
September	4,200	2,000	2,624	.272	.30	.176
The year	74,200	995	7,867	.815	11.10	.527
1948–49						
October	23,300	2,400	8,249	0.855	0.99	0.553
November	22,900	3,290	9,269	.960	1.07	.620
December	62,200	9,880	23,600	2.45	2.82	1.58
January	53,100	11,100	24,930	2.58	2.98	1.67
February	28,100	15,000	19,590	2.03	2.11	1.31
March	14,600	7,900	10,300	1.07	1.23	.692
April	35,000	6,780	12,570	1.30	1.45	.840
May	18,300	6,600	9,489	.983	1.13	.635
June	110,000	2,720	13,050	1.35	1.51	.873
July	63,900	5,890	16,000	1.66	1.91	1.071
August	20,200	3,690	7,259	.752	.87	.486
September	14,200	2,220	4,365	.452	.50	.292
The year	110,000	2,220	13,210	1.37	18.57	.885
1949–50						
October	4,540	1,660	2,242	0.232	0.27	0.150
November	12,000	2,850	4,988	.517	.58	.334
December	21,200	3,600	7,565	.784	.90	.507
January	12,000	4,700	7,307	.757	.87	.489
February	63,300	7,710	21,380	2.22	2.31	1.43
March	44,500	5,890	15,090	1.56	1.80	1.01
April	16,800	5,210	8,337	.864	.96	.558
May	29,200	7,900	14,410	1.49	1.72	.963
June	24,400	3,530	8,550	.886	.99	.573
July	3,780	2,550	3,028	.314	.36	.203
August	3,480	1,290	1,941	.201	.23	.130
September	32,500	2,360	8,818	.914	1.02	.591
The year	63,300	1,290	8,543	.885	12.01	.572

Monthly Discharge of Potomac River at Point of Rocks—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1950–51						
October	13,700	3,070	5,511	0.571	0.66	0.369
November	52,300	3,880	10,170	1.05	1.18	.679
December	98,700	7,710	25,010	2.59	2.99	1.67
January	28,000	7,140	14,300	1.48	1.71	.957
February	54,000	15,000	26,200	2.71	2.83	1.75
March	36,600	11,600	18,330	1.90	2.19	1.23
April	60,900	10,700	22,710	2.35	2.63	1.52
May	19,200	5,380	11,550	1.20	1.38	.776
June	90,000	4,700	15,240	1.58	1.76	1.02
July	7,520	3,240	4,499	.466	.54	.301
August	3,210	1,760	2,388	.247	.29	.160
September	2,090	1,310	1,706	.177	.20	.114
The year	98,700	1,310	13,030	1.35	18.36	.873
1951–52						
October	1,490	1,130	1,304	0.135	0.16	0.087
November	3,070	1,510	2,210	.229	.26	.148
December	18,800	2,290	5,939	.615	.71	.397
January	50,500	11,100	20,330	2.11	2.43	1.36
February	43,300	6,780	14,860	1.54	1.66	.995
March	82,200	6,420	21,660	2.24	2.59	1.45
April	123,000	11,100	27,570	2.86	3.19	1.85
May	49,300	11,600	20,850	2.16	2.49	1.40
June	10,500	3,910	6,012	.623	.70	.403
July	9,480	2,110	4,001	.415	.48	.268
August	4,070	2,180	2,871	.297	.34	.192
September	17,800	2,200	4,601	.477	.53	.308
The year	123,000	1,130	11,010	1.14	15.54	.737
1952–53						
October	2,390	1,500	1,941	0.201	0.23	0.130
November	100,000	1,570	11,180	1.16	1.29	.750
December	38,500	5,460	10,550	1.09	1.26	.704
January	51,900	6,180	21,380	2.22	2.55	1.43
February	30,500	9,360	14,620	1.51	1.58	.976
March	75,900	9,920	26,220	2.72	3.13	1.76
April	30,700	10,200	16,180	1.68	1.87	1.09
May	27,400	7,250	14,200	1.47	1.70	.950
June	29,500	3,080	7,761	.804	.90	.520
July	5,390	1,760	2,695	.279	.32	.180
August	3,160	1,300	1,968	.204	.24	.132
September	2,320	1,200	1,535	.159	.18	.103
The year	100,000	1,200	10,840	1.12	15.25	.724

Monthly Discharge of Potomac River at Point of Rocks—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1953–54						
October	1,650	1,100	1,210	0.125	0.14	0.081
November	2,790	1,260	1,600	.166	.18	.107
December	7,330	1,460	2,866	.297	.34	.192
January	8,440	1,400	3,315	.343	.40	.222
February	9,240	1,950	3,842	.398	.41	.257
March	87,700	6,700	17,120	1.77	2.05	1.14
April	12,700	4,860	7,043	.730	.81	.472
May	15,500	4,470	7,071	.733	.84	.474
June	12,400	2,500	5,578	.578	.64	.374
July	4,360	1,250	2,055	.213	.25	.138
August	6,290	1,080	2,321	.240	.28	.155
September	3,820	1,240	1,799	.186	.21	.120
The year	87,700	1,080	4,665	.483	6.55	.312
1954–55						
October	119,000	1,040	10,610	1.10	1.27	0.711
November	30,200	2,860	8,036	.833	.93	.538
December	37,400	4,360	10,870	1.13	1.30	.730
January	55,700	2,450	10,170	1.05	1.21	.679
February	28,000	2,800	10,660	1.10	1.15	.711
March	73,100	11,600	27,200	2.82	3.25	1.82
April	27,200	6,150	10,950	1.13	1.27	.730
May	12,800	4,540	6,587	.683	.79	.441
June	44,400	2,640	10,570	1.10	1.22	.711
July	4,750	1,610	2,618	.271	.31	.175
August	190,000	1,460	23,580	2.44	2.82	1.58
September	7,600	2,580	3,943	.409	.46	.264
The year	190,000	1,040	11,350	1.81	15.98	.763
1955–56						
October	8,050	2,110	2,936	0.304	0.35	0.196
November	2,940	2,020	2,503	.259	.29	.167
December	2,580	1,550	1,981	.205	.24	.132
January	3,800	1,500	1,947	.202	.23	.131
February	41,000	10,100	18,980	1.97	2.12	1.27
March	49,600	7,180	16,680	1.73	1.99	1.12
April	55,400	6,580	15,260	1.58	1.76	1.02
May	14,900	4,300	6,445	.668	.77	.432
June	10,000	2,860	5,219	.541	.60	.350
July	17,400	2,160	5,528	.573	.66	.370
August	28,400	2,320	5,517	.572	.66	.370
September	4,680	1,860	2,355	.244	.27	.158
The year	55,400	1,500	7,056	.731	9.94	.472

Yearly discharge of Potomac River at Point of Rocks

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1896	5,632	0.584	7.93	0.377	7,259	0.752	10.22	0.486
1897	11,760	1.22	16.53	.789	10,630	1.10	14.94	.711
1898	9,566	.991	13.44	.641	11,830	1.23	16.64	.795
1899	12,560	1.30	17.67	.840	10,140	1.05	14.27	.679
1900	6,395	.663	9.00	.429	6,665	.691	9.37	.447
1901	12,230	1.27	17.21	.821	14,130	1.46	19.89	.944
1902	14,680	1.52	20.63	.982	13,810	1.43	19.40	.924
1903	13,740	1.42	19.32	.918	12,390	1.28	17.42	.827
1904	6,372	.660	8.99	.427	6,069	.629	8.57	.407
1905	6,578	.682	9.26	.441	7,518	.779	10.57	.503
1906	9,257	.959	13.02	.620	10,770	1.12	15.14	.724
1907	13,900	1.44	19.54	.931	13,500	1.40	18.98	.905
1908	14,000	1.45	19.73	.937	12,200	1.26	17.21	.814
1909	6,430	.666	9.03	.430	6,370	.660	8.94	.427
1910	7,750	.803	10.91	.519	7,570	.784	10.68	.507
1911	6,500	.674	9.13	.436	8,150	.844	11.45	.545
1912	11,200	1.16	15.75	.750	9,910	1.03	13.97	.666
1913	7,930	.822	11.16	.531	9,490	.983	13.36	.635
1914	10,200	1.06	14.43	.685	8,580	.889	12.09	.575
1915	9,690	1.00	13.63	.646	10,400	1.08	14.63	.698
1916	10,400	1.08	14.63	.698	9,520	.986	13.45	.637
1917	7,880	.816	11.09	.527	8,200	.850	11.54	.549
1918	9,370	.971	13.17	.628	10,200	1.06	14.30	.685
1919	8,390	.869	11.80	.562	7,850	.813	11.03	.525
1920	10,600	1.10	14.85	.711	10,800	1.12	15.22	.724
1921	7,040	.729	9.90	.471	7,080	.734	9.97	.474
1922	8,160	.846	11.46	.547	7,070	.733	9.93	.474
1923	5,030	.521	7.08	.337	5,480	.568	7.71	.367
1924	13,700	1.42	19.36	.918	14,200	1.47	20.04	.950
1925	6,920	.717	9.73	.463	6,860	.711	9.63	.460
1926	7,970	.826	11.22	.534	9,870	1.02	13.90	.659
1927	11,500	1.19	16.14	.769	11,100	1.15	15.57	.743
1928	12,000	1.24	16.94	.801	10,100	1.05	14.19	.679
1929	8,550	.886	12.03	.573	10,700	1.11	15.14	.717
1930	6,490	.672	9.14	.434	3,760	.390	5.28	.252
1931	4,920	.510	6.92	.330	5,050	.523	7.11	.338
1932	6,920	.717	9.78	.463	8,860	.918	12.51	.593
1933	12,700	1.32	17.83	.853	11,100	1.15	15.57	.743
1934	4,856	.503	6.84	.325	6,123	.634	8.61	.410
1935	10,670	1.11	15.00	.717	9,948	1.03	14.00	.666
1936	13,440	1.39	18.95	.898	13,650	1.41	19.25	.911
1937	12,760	1.31	17.83	.847	14,940	1.55	21.02	1.00

POTOMAC RIVER BASIN—*Continued*

Yearly discharge of Potomac River at Point of Rocks—*Continued*

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in millon gallons per day per square mile	Discharge		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1938	8,692	.901	12.24	.582	5,881	.609	8.28	.394
1939	9,002	.933	12.65	.603	8,944	.927	12.57	.599
1940	9,108	.944	12.86	.610	10,200	1.06	14.41	.685
1941	7,317	.758	10.31	.490	5,841	.605	8.23	.391
1942	6,744	.699	9.48	.452	11,350	1.18	15.94	.763
1943	13,480	1.40	18.96	.905	8,839	.916	12.43	.592
1944	6,849	.710	9.65	.459	7,671	.795	10.81	.514
1945	8,925	.925	12.55	.598	9,638	.999	13.55	.646
1946	8,828	.915	12.41	.591	7,442	.771	10.47	.498
1947	5,220	.541	7.35	.350	5,334	.553	7.51	.357
1948	7,867	.815	11.10	.527	10,610	1.10	14.97	.711
1949	13,210	1.37	18.57	.885	10,980	1.14	15.44	.737
1950	8,543	.885	12.01	.572	10,730	1.11	15.09	.717
1951	13,030	1.35	18.36	.873	10,400	1.08	14.66	.698
1952	11,010	1.14	15.54	.737	12,190	1.26	17.19	.814
1953	10,840	1.12	15.25	.724	9,338	.968	13.13	.626
1954	4,665	.483	6.55	.312	6,672	.691	9.39	.447
1955	11,350	1.18	15.98	.763	9,492	984	13.36	.636
1956	7,056	.731	9.94	.472	—	—	—	—
Highest	14,680	1.52	20.63	0.982	14,940	1.55	21.02	1.00
Average	9,316	.965	13.11	.624	9,357	.970	13.17	.627
Lowest	4,665	.483	6.55	.312	3,760	.390	5.28	.252

POTOMAC RIVER BASIN

11. Monocacy River at Bridgeport

Location.—Lat 39°40′43″, long 77°14′06″, on right bank 60 ft downstream from bridge on State Highway 32, at Bridgeport, Carroll County, 0.9 mile upstream from Cattail Branch, 3.4 miles northwest of Taneytown, and 4.8 miles downstream from confluence of Rock and Marsh Creeks at Pennsylvania-Maryland State line.

Drainage area.—173 sq mi. At site used prior to May 3, 1946, 174 sq mi.

Records available.—May 1942 to September 1956.

Supplemental records available.—Records of chemical analyses and water temperatures for the period April 1948 (suspended sediment loads from August 1948) to June 1951, are published in reports of U. S. Geological Survey.

Gage.—Water-stage recorder. Concrete control since Sept. 15, 1947. Datum of gage is 340.83 ft above mean sea level (Corps of Engineers benchmark). Prior to May 3, 1946, staff gage and crest-stage indicators at site 0.3 mile downstream at datum 0.98 ft lower.

Average discharge.—14 years, 201 cfs.

Extremes.—Maximum discharge, 15,000 cfs May 21, 1943 (gage height, 20.53 ft, former site and datum), from rating curve extended above 6,700 cfs on basis of logarithmic plotting and velocity-area studies; minimum, 0.1 cfs Aug. 27, 28, 1944.

Maximum stage known, about 25 ft, present site and datum, Aug. 24, 1933, from floodmarks. Stage exceeded that of June 1889 from information by local residents.

Remarks.—Occasional regulation at low flow from unknown source above station.

Monthly discharge of Monocacy River at Bridgeport

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1942						
May	5,900	28	378	2.17	2.50	1.40
June	1,300	36	207	1.19	1.33	.769
July	2,380	22	349	2.01	2.32	1.30
August	4,620	65	613	3.52	4.06	2.28
September	523	16	53.5	.307	.34	.198
1942–43						
October	5,160	16	520	2.99	3.44	1.93
November	720	62	188	1.08	1.21	.698
December	5,230	47	575	3.30	3.81	2.13
January	510	83	179	1.03	1.19	.666
February	2,340	117	447	2.57	2.68	1.66
March	2,030	94	401	2.30	2.66	1.49
April	2,400	57	272	1.56	1.75	1.01
May	7,640	57	554	3.18	3.67	2.06
June	156	16	56.0	.322	.36	.208
July	162	6.0	22.4	.129	.15	.083
August	27	2.7	6.56	.038	.04	.025
September	6.3	.3	2.34	.013	.01	.008
The year	7,640	.3	269	1.55	20.97	1.00

Monthly discharge of Monocacy River at Bridgeport—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1943–44						
October	1,270	0.3	93.8	0.539	0.62	0.348
November	5,840	22	361	2.07	2.32	1.34
December	739	6.0	63.5	.365	.42	.236
January	5,210	4.6	348	2.00	2.31	1.29
February	972	15	153	.879	.95	.568
March	4,090	117	709	4.07	4.70	2.63
April	1,440	107	333	1.91	2.14	1.23
May	540	52	142	.816	.94	.527
June	48	9.6	26.9	.155	.17	.100
July	12	2.3	5.48	.031	.04	.020
August	7.0	.2	2.40	.014	.02	.009
September	89	.4	10.5	.060	.07	.039
The year	5,840	.2	188	1.08	14.70	.698
1944–45						
October	427	2.5	35.7	0.205	0.24	0.132
November	675	10	57.8	.332	.37	.215
December	4,030	32	358	2.06	2.37	1.33
January	780	32	103	.592	.68	.383
February	2,240	35	769	4.42	4.60	2.86
March	1,320	64	285	1.64	1.89	1.06
April	1,680	71	308	1.77	1.97	1.14
May	450	60	166	.954	1.10	.617
June	64	11	35.2	.202	.23	.131
July	578	7.0	110	.632	.73	.408
August	1,740	13	178	1.02	1.18	.659
September	4,980	18	328	1.89	2.10	1.22
The year	4,980	2.5	224	1.29	17.46	.834
1945–46						
October	74	17	34.2	0.197	0.23	0.127
November	4,200	19	411	2.36	2.64	1.53
December	3,340	70	499	2.87	3.30	1.85
January	1,320	59	249	1.43	1.65	.924
February	1,800	50	179	1.03	1.07	.666
March	2,600	110	345	1.98	2.29	1.28
April	170	28	58.7	.337	.38	.218
May	1,830	27	230	1.33	1.53	.860
June	6,970	25	377	2.18	2.43	1.41
July	106	8.2	31.1	.180	.21	.116
August	402	8.6	50.1	.290	.33	.187
September	1,200	1.3	65.1	.376	.42	.243
The year	6,970	1.3	211	1.22	16.48	.789

Monthly discharge of Monocacy River at Bridgeport—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per suqare mile
	Maximum	Minimum	Mean	Per square mile		
1946–47						
October	409	8.9	73.6	0.425	0.49	0.275
November	66	22	33.4	.193	.22	.125
December	470	16	81.1	.469	.54	.303
January	1,650	87	307	1.77	2.04	1.14
February	341	29	78.1	.451	.47	.291
March	2,330	44	263	1.52	1.75	.982
April	186	44	68.8	.398	.44	.257
May	3,760	47	303	1.75	2.02	1.13
June	655	35	91.1	.527	.59	.341
July	944	31	167	.965	1.12	.624
August	488	9.6	44.6	.258	.30	.167
September	26	6.5	12.6	.073	.08	.047
The year	3,760	6.5	128	.740	10.06	.478
1947–48						
October	36	3.7	6.67	0.039	0.04	0.025
November	1,990	13	254	1.47	1.64	.950
December	138	32	62.5	.361	.42	.233
January	3,780	29	295	1.71	1.96	1.11
February	1,570	30	397	2.29	2.48	1.48
March	1,040	153	402	2.32	2.68	1.50
April	2,520	97	393	2.27	2.54	1.47
May	2,310	56	276	1.60	1.84	1.03
June	492	30	90.2	.521	.58	.337
July	68	12	30.2	.175	.20	.113
August	806	11	84.4	.488	.56	.315
September	19	5.2	7.62	.044	.05	.028
The year	3,780	3.7	190	1.10	14.99	.711
1948–49						
October	102	5.6	23.8	0.138	0.16	0.089
November	1,840	13	326	1.88	2.10	1.22
December	5,440	74	512	2.96	3.41	1.91
January	3,610	97	617	3.57	4.11	2.31
February	903	162	379	2.19	2.28	1.42
March	178	55	94.7	.547	.63	.354
April	3,000	71	277	1.60	1.78	1.03
May	472	27	81.2	.469	.54	.303
June	68	10	21.7	.125	.14	.081
July	5,000	8.8	598	3.46	3.98	2.24
August	77	7.2	25.7	.149	.17	.096
September	47	7.7	15.9	.092	.10	.059
The year	5,440	5.6	248	1.43	19.40	.924

Monthly discharge of Monocacy River at Bridgeport—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1949–50						
October	250	10	33.3	0.192	0.22	0.124
November	156	18	38.5	.223	.25	.144
December	2,710	21	218	1.26	1.46	.814
January	409	68	138	.798	.92	.516
February	2,380	66	557	3.22	3.35	2.08
March	5,480	56	468	2.71	3.12	1.75
April	229	58	112	.647	.72	.418
May	2,630	81	415	2.40	2.76	1.55
June	1,580	23	175	1.01	1.13	.653
July	331	13	53.5	.309	.36	.200
August	42	5.7	12.1	.070	.08	.045
September	666	7.5	56.2	.325	.36	.210
The year	5,480	5.7	188	1.09	14.73	.704
1950–51						
October	249	12	54.8	0.317	0.37	0.205
November	1,870	30	155	.896	1.00	.579
December	5,430	60	436	2.52	2.91	1.63
January	1,580	81	365	2.11	2.43	1.36
February	3,620	140	674	3.90	4.06	2.52
March	2,060	103	281	1.62	1.88	1.05
April	673	97	213	1.23	1.37	.795
May	250	27	70.9	.410	.47	.265
June	2,860	20	426	2.46	2.74	1.59
July	1,150	15	85.3	.493	.57	.319
August	327	7.7	24.6	.142	.16	.092
September	21	3.7	9.14	.053	.06	.034
The year	5,430	3.7	230	1.33	18.02	.860
1951–52						
October	15	4.3	7.09	0.041	0.05	0.026
November	662	27	99.7	.576	.64	.372
December	1,950	41	282	1.63	1.88	1.05
January	3,400	143	773	4.47	5.15	2.89
February	3,600	81	327	1.89	2.04	1.22
March	6,730	82	656	3.79	4.37	2.45
April	3,000	114	637	3.68	4.11	2.38
May	1,770	74	287	1.66	1.91	1.07
June	244	18	62.9	.364	.41	.235
July	2,900	15	200	1.16	1.33	.750
August	603	10	60.2	.348	.40	.225
September	1,830	11	157	.908	1.01	.587
The year	6,730	4.3	296	1.71	23.30	1.11

Monthly discharge of Monocacy River at Bridgeport—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1952–53						
October	42	8.0	15.8	0.091	0.11	0.059
November	6,000	11	394	2.28	2.54	1.47
December	2,920	65	337	1.95	2.25	1.26
January	4,260	92	662	3.83	4.41	2.48
February	1,440	109	316	1.83	1.90	1.18
March	1,450	103	468	2.71	3.12	1.75
April	1,360	84	243	1.40	1.57	.905
May	1,350	58	275	1.59	1.83	1.03
June	1,340	22	128	.740	.82	.478
July	255	8.5	25.4	.147	.17	.095
August	59	2.8	11.9	.069	.08	.045
September	59	.9	8.21	.047	.05	.030
The year	6,000	.9	240	1.39	18.85	.898
1953–54						
October	21	1.7	5.59	0.032	0.04	0.021
November	28	3.9	10.4	.060	.07	.039
December	1,000	7.6	157	.908	1.05	.587
January	130	22	51.4	.297	.34	.192
February	507	19	101	.584	.61	.377
March	1,230	84	250	1.45	1.66	.937
April	1,210	34	123	.711	.79	.460
May	1,900	32	186	1.08	1.24	.698
June	62	5.0	15.8	.091	.10	.059
July	8.0	.6	4.45	.026	.03	.017
August	76	.3	9.99	.056	.07	.036
September	20	.9	4.96	.029	.03	.019
The year	1,900	.3	76.8	.444	6.03	.287
1954–55						
October	73	1.3	14.3	0.083	0.10	0.054
November	124	15	40.9	.236	.26	.153
December	1,640	24	191	1.10	1.27	.711
January	245	14	68.4	.395	.46	.255
February	1,700	12	235	1.36	1.42	.879
March	5,380	118	616	3.56	4.10	2.30
April	404	54	139	.803	.89	.519
May	157	19	50.7	.293	.34	.189
June	1,220	11	162	.936	1.04	.605
July	326	4.5	39.2	.227	.26	.147
August	2,960	2.3	303	1.75	2.02	1.13
September	129	13	33.8	.195	.22	.126
The year	5,380	1.3	158	.913	12.38	.590

POTOMAC RIVER BASIN—*Continued*

Monthly discharge of Monocacy River at Bridgeport—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1955–56						
October	2,070	17	192	1.11	1.28	0.717
November	426	42	86.5	.500	.56	.323
December	55	15	28.9	.167	.19	.108
January	652	14	52.0	.301	.35	.195
February	1,930	120	564	3.26	3.52	2.11
March	3,150	90	490	2.83	3.26	1.83
April	1,970	74	290	1.68	1.87	1.09
May	432	26	86.3	.499	.58	.323
June	158	12	39.2	.227	.25	.147
July	2,540	9.7	199	1.15	1.33	.743
August	120	10	33.0	.191	.22	.123
September	86	8.0	19.2	.111	.12	.072
The year	3,150	8.0	172	.994	13.53	.642

Yearly discharge of Monocacy River at Bridgeport

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1943	269	1.55	20.97	1.00	203	1.17	15.87	0.756
1944	188	1.08	14.70	.698	183	1.05	14.32	.679
1945	224	1.29	17.46	.834	265	1.52	20.65	.982
1946	211	1.22	16.48	.789	148	.855	11.56	.553
1947	128	.740	10.06	.478	139	.803	10.91	.519
1948	190	1.10	14.99	.711	236	1.36	18.56	.879
1949	248	1.43	19.40	.924	200	1.16	15.66	.750
1950	188	1.09	14.73	.704	218	1.26	17.08	.814
1951	230	1.33	18.02	.860	208	1.20	16.31	.776
1952	296	1.71	23.30	1.11	326	1.88	25.63	1.22
1953	240	1.39	18.85	.898	193	1.12	15.11	.724
1954	76.8	.444	6.03	.287	82.8	.479	6.50	.310
1955	158	.913	12.38	.590	163	.942	12.78	.609
1956	172	.994	13.53	.642	—	—	—	—
Highest	296	1.71	23.30	1.11	326	1.88	25.63	1.22
Average	201	1.16	15.78	.750	197	1.14	15.46	.737
Lowest	76.8	.444	6.03	.287	82.8	.479	6.50	.310

12. Big Pipe Creek at Bruceville

Location.—Lat 39°36′45″, long 77°14′10″, on left bank 300 ft downstream from bridge on State Highway 71, 800 ft downstream from Bruceville, Carroll County, and 3½ miles upstream from Detour and confluence with Little Pipe Creek.

Drainage area.—102 sq mi.

Records available.—October 1947 to September 1956.

Gage.—Water-stage recorder and concrete control. Altitude of gage is 340 ft (from topographic map).

Average discharge.—9 years, 115 cfs.

Extremes.—Maximum discharge, 9,500 cfs July 12, 1949 (gage height, 11.92 ft), from rating curve extended above 2,300 cfs on basis of slope-area determination at gage height 8.38 ft and slope-conveyance study; minimum, 2.4 cfs July 28, 1954; minimum daily, 7.4 cfs Aug. 1, 1954.

Remarks.—Diurnal fluctuation caused by mills above station.

Monthly discharge of Big Pipe Creek at Bruceville

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1947–48						
October‡	—	—	22	0.216	0.25	0.140
November‡	—	—	185	1.81	2.02	1.17
December‡	64	32	37.0	.363	.42	.235
January	1,240	40	155	1.52	1.75	.982
February	1,400	37	232	2.27	2.46	1.47
March	367	103	169	1.66	1.91	1.07
April	687	88	163	1.60	1.78	1.03
May	764	98	208	2.04	2.35	1.32
June	462	76	141	1.38	1.54	.892
July	477	59	120	1.18	1.36	.763
August	197	40	79.4	.778	.90	.503
September	56	28	35.7	.350	.39	.226
The year	—	—	128	1.25	17.13	.808
1948–49						
October	147	30	51.8	0.508	0.59	0.328
November	542	38	100	.980	1.10	.633
December	2,070	64	225	2.21	2.55	1.43
January	1,170	117	307	3.01	3.48	1.95
February	367	163	227	2.23	2.32	1.44
March	172	96	127	1.25	1.43	.808
April	371	94	159	1.56	1.74	1.01
May	197	62	99.8	.978	1.13	.632
June	70	38	49.4	.484	.54	.313
July	2,700	28	295	2.89	3.33	1.87
August	94	38	57.9	.568	.65	.367
September	51	28	35.0	.343	.38	.222
The year	2,700	28	144	1.41	19.24	.911

‡ October 1 to December 22 estimated.

Monthly discharge of Big Pipe Creek at Bruceville—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1949–50						
October	141	29	42.8	0.420	0.48	0.271
November	66	30	38.1	.374	.42	.242
December	485	30	74.2	.727	.84	.470
January	134	43	59.0	.578	.67	.374
February	511	70	190	1.86	1.94	1.20
March	1,800	54	201	1.97	2.27	1.27
April	131	66	92.7	.909	1.01	.588
May	305	78	127	1.25	1.43	.808
June	340	39	76.9	.754	.84	.487
July	103	28	44.6	.437	.50	.282
August	349	18	34.6	.339	.39	.219
September	342	27	75.7	.742	.83	.480
The year	1,800	18	87.4	.857	11.62	.554
1950–51						
October	157	32	45.7	0.448	0.52	0.290
November	1,000	37	96.6	.947	1.06	.612
December	1,820	60	192	1.88	2.17	1.22
January	466	70	130	1.27	1.47	.821
February	1,250	120	291	2.85	2.97	1.84
March	360	103	143	1.40	1.61	.905
April	175	80	108	1.06	1.18	.685
May	121	50	70.6	.692	.80	.447
June	682	43	156	1.53	1.71	.989
July	866	42	99.2	.973	1.12	.629
August	666	36	79.5	.779	.90	.503
September	87	21	35.8	.351	.39	.227
The year	1,820	21	119	1.17	15.90	.756
1951–52						
October	57	20	25.8	0.253	0.29	0.163
November	364	40	86.2	.845	.94	.546
December	536	37	132	1.29	1.49	.834
January	895	121	276	2.71	3.12	1.75
February	746	103	175	1.72	1.85	1.11
March	1,020	103	228	2.24	2.58	1.45
April	2,420	123	393	3.85	4.30	2.49
May	887	133	263	2.58	2.97	1.67
June	769	73	140	1.37	1.53	.885
July	432	54	107	1.05	1.21	.679
August	209	38	67.4	.661	.76	.427
September	1,220	43	109	1.07	1.19	.692
The year	2,420	20	167	1.64	22.23	1.06

Monthly discharge of Big Pipe Creek at Bruceville—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1952–53						
October	68	30	37.9	0.372	0.43	0.240
November	1,800	30	186	1.82	2.03	1.18
December	1,000	75	171	1.68	1.93	1.09
January	767	80	243	2.38	2.75	1.54
February	558	116	171	1.68	1.75	1.09
March	935	111	245	2.40	2.77	1.55
April	385	114	178	1.75	1.95	1.13
May	734	99	217	2.13	2.45	1.38
June	288	53	92.8	.910	1.02	.588
July	75	29	42.8	.420	.48	.271
August	523	23	56.4	.553	.64	.357
September	169	20	38.5	.377	.42	.244
The year	1,800	20	140	1.37	18.62	.885
1953–54						
October	93	21	29.0	0.284	0.33	0.184
November	126	26	39.9	.391	.44	.253
December	1,150	31	154	1.51	1.74	.976
January	222	36	70.0	.686	.79	.443
February	107	32	58.1	.570	.59	.368
March	484	71	118	1.16	1.33	.750
April	293	46	75.7	.742	.83	.480
May	260	38	77.8	.763	.88	.493
June	38	14	27.5	.270	.30	.175
July	39	8.2	17.4	.171	.20	.111
August	229	7.4	40.9	.401	.46	.259
September	49	14	21.4	.201	.23	.130
The year	1,150	7.4	61.0	.598	8.12	.386
1954–55						
October	130	15	27.9	0.274	0.32	0.177
November	104	25	36.3	.356	.40	.230
December	389	21	73.2	.718	.83	.464
January	108	21	47.4	.465	.54	.301
February	1,120	28	127	1.25	1.30	.808
March	1,670	72	229	2.25	2.59	1.45
April	154	63	84.5	.828	.92	.535
May	126	27	46.2	.453	.52	.293
June	690	27	78.0	.765	.85	.494
July	43	14	24.2	.237	.27	.153
August	2,180	11	212	2.08	2.40	1.34
September	205	39	66.0	.647	.72	.418
The year	2,180	11	87.5	.858	11.66	.555

POTOMAC RIVER BASIN—*Continued*

Monthly discharge of Big Pipe Creek at Bruceville—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1955–56						
October	1,170	40	119	1.17	1.34	0.756
November	246	42	73.0	.716	.80	.463
December	58	30	41.3	.405	.47	.262
January	289	26	54.0	.529	.61	.342
February	808	89	252	2.47	2.67	1.60
March	1,000	72	211	2.07	2.38	1.34
April	487	82	150	1.47	1.64	.950
May	156	51	71.6	.702	.81	.454
June	128	52	55.2	.541	.60	.350
July	1,240	30	151	1.48	1.70	.957
August	145	35	53.7	.526	.61	.340
September	140	28	39.6	.388	.43	.251
The year	1,240	26	105	1.03	14.06	.666

POTOMAC RIVER BASIN—*Continued*

Yearly discharge of Big Pipe Creek at Bruceville

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1948	128	1.25	17.13	0.808	140	1.37	18.68	0.885
1949	144	1.41	19.24	.911	126	1.24	16.74	.801
1950	87.4	.857	11.62	.554	102	1.00	13.63	.646
1951	119	1.17	15.90	.756	112	1.10	14.87	.711
1952	167	1.64	22.23	1.06	179	1.75	23.90	1.13
1953	140	1.37	18.62	.885	126	1.24	16.74	.801
1954	61.0	.598	8.12	.386	53.8	.527	7.16	.341
1955	87.5	.858	11.66	.555	95.6	.937	12.72	.606
1956	105	1.03	14.06	.666	—	—	—	—
Highest	167	1.64	22.23	1.06	179	1.75	23.90	1.13
Average	115	1.13	15.40	.730	117	1.15	15.56	.743
Lowest	61.0	.598	8.12	.386	53.8	.527	7.16	.341

POTOMAC RIVER BASIN

13. Little Pipe Creek at Avondale

Location.—Lat 39°33′40″, long 77°02′40″, on left bank at downstream side of private bridge, 0.1 mile downstream from Copps Branch, 0.5 mile northwest of Avondale, Carroll County, and 3.0 miles southwest of Westminster.

Drainage area.—8.10 sq mi.

Records available.—September 1947 to September 1956.

Gage.—Water-stage recorder and concrete control. Altitude of gage is 525 ft (from topographic map).

Average discharge.—9 years, 9.21 cfs (adjusted for inflow).

Extremes.—Maximum discharge, 1,880 cfs July 4, 1956 (gage height, 8.47 ft), from rating curve extended above 130 cfs on basis of slope-area determinations at gage heights 3.85 and 5.50 ft, and contracted-opening determination at 7.60 ft; minimum, 1.4 cfs July 1, 1954 (gage height, 1.36 ft), result of storage behind temporary earth dam upstream; minimum daily, 3.0 cfs Sept. 13, 1947.

Remarks.—Records include pumpage from Patapsco River basin for municipal supply of Westminster which is discharged as sewage into Little Pipe Creek above station.

Monthly discharge of Little Pipe Creek at Avondale

Month	Discharge in cfs					Adjusted	
	Observed			Adjusted			
	Maximum	Minimum	Mean	Mean	Per square mile	Runoff in inches	Discharge in million gallons per day per square mile
1947							
September	4.3	3.0	3.51	2.80	0.346	0.39	0.224
1947–48							
October	6.0	3.1	3.74	3.11	0.384	0.44	0.248
November	24	3.8	6.48	5.80	.716	.80	.463
December	6.3	3.8	4.34	3.73	.460	.53	.297
January	84	4.3	9.41	8.80	1.09	1.26	.704
February	87	3.8	12.6	11.9	1.47	1.58	.950
March	20	7.5	9.97	9.30	1.15	1.33	.743
April	22	7.5	9.72	9.09	1.12	1.25	.724
May	53	7.5	14.0	13.2	1.63	1.88	1.05
June	55	8.8	12.8	12.0	1.48	1.65	.957
July	17	6.7	8.35	7.61	.940	1.08	.608
August	13	5.2	7.05	6.39	.789	.91	.510
September	7.1	4.6	5.12	4.48	.553	.62	.357
The year	87	3.1	8.61	7.93	.979	13.33	.633

Monthly discharge of Little Pipe Creek at Avondale—*Continued*

Month	Discharge in cfs					Adjusted	
	Observed			Adjusted		Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Mean	Per square mile		
1948–49							
October	11	4.6	5.45	4.83	0.596	0.69	0.385
November	21	4.9	6.56	5.91	.730	.81	.472
December	93	6.6	13.4	12.8	1.58	1.82	1.02
January	87	11	20.6	20.0	2.47	2.85	1.60
February	28	16	19.0	18.3	2.26	2.35	1.46
March	16	11	13.2	12.6	1.56	1.80	1.01
April	22	10	12.6	12.0	1.48	1.65	.957
May	18	8.6	10.1	9.28	1.15	1.33	.743
June	9.5	6.6	7.66	6.87	.848	.95	.548
July	95	5.2	10.7	10.1	1.25	1.44	.808
August	10	4.8	5.89	5.11	.631	.73	.408
September	7.2	4.4	5.14	4.47	.552	.62	.357
The year	95	4.4	10.8	10.1	1.25	17.04	.808
1949–50							
October	10	4.1	4.86	4.15	0.512	0.59	0.331
November	7.4	4.4	4.92	4.19	.517	.58	.334
December	19	4.4	6.25	5.59	.690	.80	.446
January	10	4.9	5.45	4.76	.588	.68	.380
February	20	6.8	10.2	9.40	1.16	1.21	.750
March	57	6.2	12.1	11.3	1.40	1.61	.905
April	11	7.0	8.31	7.63	.942	1.05	.609
May	27	6.2	8.27	7.49	.925	1.07	.598
June	21	5.2	8.10	7.37	.910	1.02	.588
July	19	4.9	6.85	6.17	.762	.88	.492
August	15	4.3	5.23	4.58	.565	.65	.365
September	19	4.1	7.04	6.40	.790	.88	.511
The year	57	4.1	7.27	6.56	.810	11.02	.524
1950–51							
October	19	4.6	5.99	5.29	0.653	0.75	0.422
November	74	4.6	8.89	8.11	1.00	1.12	.646
December	95	7.4	14.8	14.1	1.74	2.01	1.12
January	29	7.8	10.5	9.85	1.22	1.41	.789
February	70	12	19.6	19.0	2.35	2.45	1.52
March	20	9.0	11.5	10.9	1.35	1.56	.873
April	13	7.8	9.59	8.98	1.11	1.24	.717
May	10	5.9	7.34	6.61	.816	.94	.527
June	62	5.9	13.6	12.9	1.59	1.77	1.03
July	21	6.2	7.80	7.09	.875	1.01	.566
August	23	4.9	6.56	5.83	.720	.83	.465
September	8.6	4.1	4.79	4.12	.509	.57	.329
The year	95	4.1	10.0	9.31	1.15	15.66	.743

Monthly discharge of Little Pipe Creek at Avondale—*Continued*

Month	Discharge in cfs					Adjusted	
	Observed			Adjusted		Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Mean	Per square mile		
1951–52							
October	7.4	4.0	4.55	3.91	0.483	0.56	0.312
November	32	4.9	8.21	7.60	.938	1.05	.606
December	22	4.3	8.86	8.24	1.02	1.18	.659
January	26	8.8	14.3	13.7	1.69	1.95	1.09
February	31	7.9	13.0	12.4	1.53	1.65	.989
March	72	7.9	18.1	17.4	2.15	2.48	1.39
April	181	14	32.9	32.3	3.99	4.45	2.58
May	75	11	25.8	25.1	3.10	3.57	2.00
June	31	11	15.2	14.5	1.79	2.00	1.16
July	35	8.0	12.7	12.0	1.48	1.71	.957
August	49	6.3	10.3	9.58	1.18	1.36	.763
September	181	7.5	15.6	14.9	1.84	2.05	1.19
The year	181	4.0	14.9	14.2	1.75	24.01	1.13
1952–53							
October	15	6.3	7.41	6.72	0.830	0.96	0.536
November	130	5.9	16.3	15.6	1.93	2.15	1.25
December	47	11	15.5	14.8	1.83	2.11	1.18
January	48	11	19.0	18.4	2.27	2.62	1.47
February	39	13	16.0	15.3	1.89	1.97	1.22
March	55	13	20.0	19.3	2.38	2.74	1.54
April	30	13	17.0	16.3	2.01	2.24	1.30
May	28	11	14.8	14.0	1.73	1.99	1.12
June	18	7.1	9.52	8.70	1.07	1.19	.692
July	9.2	4.3	5.99	5.21	.643	.74	.416
August	36	4.3	7.37	6.60	.815	.94	.527
September	25	4.4	6.81	6.04	.746	.83	.482
The year	130	4.3	13.0	12.3	1.52	20.48	.982
1953–54							
October	14	4.4	5.23	4.51	0.557	0.64	0.360
November	13	4.6	5.66	4.97	.614	.68	.397
December	49	4.9	12.8	12.1	1.49	1.72	.963
January	14	5.6	7.25	6.39	.789	.91	.510
February	10	5.9	6.81	5.94	.733	.76	.474
March	40	8.2	10.7	9.82	1.21	1.40	.782
April	15	7.0	8.12	7.25	.895	1.00	.578
May	32	6.0	9.55	8.53	1.05	1.21	.679
June	6.0	4.2	5.16	4.01	.495	.55	.320
July	36	3.6	6.58	5.48	.677	.78	.438
August	30	3.4	6.78	5.68	.701	.81	.453
September	7.1	3.3	4.27	3.15	.389	.43	.251
The year	49	3.3	7.44	6.52	.805	10.89	.520

POTOMAC RIVER BASIN—*Continued*

Monthly discharge of Little Pipe Creek at Avondale—*Continued*

Month	Discharge in cfs					Adjusted	
	Observed			Adjusted		Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Mean	Per square mile		
1954–55							
October	20	3.5	4.89	3.95	0.488	0.56	0.315
November	11	4.6	5.54	4.63	.572	.64	.370
December	16	4.6	7.03	6.03	.744	.86	.481
January	8.4	4.6	5.98	4.83	.596	.69	.385
February	65	4.6	11.1	9.87	1.22	1.27	.789
March	66	6.7	13.4	12.3	1.52	1.75	.982
April	12	7.4	8.95	7.91	.977	1.09	.631
May	8.6	4.4	6.10	4.92	.607	.70	.392
June	19	4.5	6.03	4.89	.604	.67	.390
July	5.6	3.4	4.35	3.00	.370	.43	.239
August	204	3.6	19.6	18.3	2.26	2.61	1.46
September	12	5.8	7.16	6.01	.742	.83	.480
The year	204	3.4	8.33	7.21	.890	12.10	.575
1955–56							
October	44	5.6	8.34	7.24	0.894	1.03	0.578
November	11	5.2	6.92	5.85	.722	.81	.467
December	6.6	4.9	5.45	4.44	.548	.63	.354
January	34	4.9	6.34	5.33	.658	.76	.425
February	40	7.3	13.9	12.9	1.59	1.72	1.03
March	45	7.9	13.3	12.3	1.52	1.75	.982
April	22	9.7	12.1	11.1	1.37	1.53	.885
May	12	7.6	8.74	7.58	.936	1.08	.605
June	10	5.2	6.41	5.15	.636	.71	.411
July	184	5.0	23.9	22.7	2.80	3.23	1.81
August	11	5.9	7.13	5.71	.705	.81	.456
September	12	5.5	6.42	5.13	.633	.71	.409
The year	184	4.9	9.92	8.78	1.08	14.77	.698

POTOMAC RIVER BASIN—*Continued*
Yearly discharge of Little Pipe Creek at Avondale
(Adjusted for inflow)

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1948	7.93	0.979	13.33	0.633	8.85	1.09	14.88	0.704
1949	10.1	1.25	17.04	.808	9.31	1.15	15.69	.743
1950	6.56	.810	11.02	.524	7.70	.951	12.93	.615
1951	9.31	1.15	15.66	.743	8.66	1.07	14.57	.692
1952	14.2	1.75	24.01	1.13	15.7	1.94	26.44	1.25
1953	12.3	1.52	20.48	.982	11.0	1.36	18.30	.879
1954	6.52	.805	10.89	.520	5.92	.731	9.91	.472
1955	7.21	.890	12.10	.575	7.45	.920	12.51	.595
1956	8.78	1.08	14.77	.698	—	—	—	—
Highest	14.2	1.75	24.01	1.13	15.7	1.94	26.44	1.25
Average	9.21	1.14	15.48	.737	9.32	1.15	15.65	.743
Lowest	6.52	.805	10.89	.520	5.92	.731	9.91	.472

POTOMAC RIVER BASIN

14. Owens Creek at Lantz

Location.—Lat 39°40′36″, long 77°27′52″, on right bank half a mile west of Lantz Post Office (Deerfield station on Western Maryland Railway), Frederick County, 1½ miles south fo Sabillasville, and 4½ miles northwest of Thurmont.

Drainage area.—5.93 sq mi.

Records available.—October 1931 to September 1956. Monthly records October 1931 to September 1943 published in Bulletin 1.

Gage.—Water-stage recorder and concrete control. Altitude of gage is 965 ft (from topographic map).

Average discharge.—25 years, 9.26 cfs (adjusted for diversion).

Extremes.—Maximum discharge, 3,270 cfs Dec. 1, 1934 (gage height, 8.4 ft), from rating curve extended above 750 cfs on basis of slope-area determinations at gage heights 5.11 and 6.30 ft; minimum, 0.06 cfs Oct. 8, 1941, Sept. 7, 1944, not including water diverted above gage; minimum daily, including water diverted above gage, 0.18 cfs Sept. 20, 1932, Sept. 30, Oct. 7, 8, 1941.

Remarks.—Occasional diversions half a mile above station to Victor Cullen State Hospital at Cullen (formerly Maryland Tuberculosis Sanatorium at Sabillasville).

Monthly discharge of Owens Creek at Lantz

Month	Discharge in cfs					Adjusted	
	Observed			Adjusted		Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Mean	Per square mile		
1943–44							
October	12.0	0.21	1.21	1.29	0.218	0.25	0.141
November	45	.76	4.53	4.56	.769	.86	.497
December	7.5	.37	1.40	1.43	.241	.28	.156
January	58	1.1	8.10	8.10	1.37	1.58	.885
February	13	2.7	4.89	4.89	.825	.89	.533
March	47	6.0	19.4	19.4	3.27	3.77	2.11
April	28	11.5	16.7	16.7	2.82	3.15	1.82
May	54	3.6	12.1	12.1	2.04	2.35	1.32
June	20	1.6	3.64	3.64	.614	.68	.397
July	4.0	.80	1.28	1.30	.219	.25	.142
August	2.2	.14	.507	.557	.094	.11	.061
September	7.3	.07	.726	.814	.137	.15	.089
The year	58	.07	6.21	6.23	1.05	14.32	.679

Monthly discharge of Owens Creek at Lantz—*Continued*

Month	Discharge in cfs					Adjusted	
	Observed			Adjusted		Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Mean	Per square mile		
1944–45							
October	20	0.41	2.73	2.78	0.469	0.54	0.303
November	10.5	1.1	2.06	2.10	.354	.40	.229
December	105	2.1	11.9	12.0	2.02	2.33	1.31
January	29	4.3	8.05	8.05	1.36	1.57	.879
February	52	3.7	15.3	15.3	2.58	2.69	1.67
March	40	7.3	18.1	18.1	3.05	3.52	1.97
April	42	6.8	16.3	16.3	2.75	3.07	1.78
May	30	6.8	15.0	15.0	2.53	2.92	1.64
June	8.6	1.9	4.84	4.84	.816	.91	.527
July	6.3	1.1	2.26	2.29	.386	.44	.249
August	16.0	.56	2.04	2.08	.351	.40	.227
September	115	.76	9.14	9.16	1.54	1.72	.995
The year	115	.41	8.94	8.96	1.51	20.51	.976
1945–46							
October	6.7	2.4	3.23	3.23	0.545	0.63	0.352
November	71	2.3	9.63	9.63	1.62	1.81	1.05
December	39	8.5	15.9	15.9	2.68	3.09	1.73
January	30	6.7	13.6	13.6	2.29	2.64	1.48
February	28	5.6	9.29	9.29	1.57	1.64	1.01
March	25	9.5	15.1	15.1	2.55	2.94	1.65
April	9.5	4.0	6.04	6.04	1.02	1.14	.659
May	86	3.7	13.2	13.2	2.23	2.57	1.44
June	121	6.2	18.7	18.7	3.15	3.51	2.04
July	8.5	4.0	5.11	5.11	.862	.99	.557
August	9.9	1.3	2.98	2.98	.503	.58	.325
September	14.5	.65	2.31	2.33	.393	.44	.254
The year	121	.65	9.59	9.59	1.62	21.98	1.05
1946–47							
October	11.5	1.5	3.92	3.92	0.661	0.76	0.427
November	3.7	2.3	2.81	2.81	.474	.53	.306
December	10.5	1.7	3.42	3.43	.578	.67	.374
January	20	5.2	8.92	8.92	1.50	1.73	.969
February	12.5	3.0	5.91	5.91	.997	1.04	.644
March	46	3.9	10.5	10.5	1.77	2.04	1.14
April	10.5	5.0	6.59	6.59	1.11	1.24	.717
May	39	6.2	12.9	12.9	2.18	2.51	1.41
June	34	4.8	11.2	11.2	1.89	2.11	1.22
July	13.5	3.1	6.08	6.08	1.03	1.19	.666
August	11.5	2.0	3.51	3.51	.592	.68	.383
September	3.1	1.5	2.18	2.18	.368	.41	.238
The year	46	1.5	6.51	6.51	1.10	14.91	.711

Monthly discharge of Owens Creek at Lantz—*Continued*

Month	Discharge in cfs					Adjusted	
	Observed			Adjusted		Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Mean	Per square mile		
1947–48							
October	4.1	0.98	1.23	1.23	0.207	0.24	0.134
November	17	1.3	4.97	4.97	.838	.94	.542
December	4.7	2.2	3.03	3.03	.511	.59	.330
January	44	3.6	8.32	8.32	1.40	1.61	.905
February	21	3.1	9.85	9.85	1.66	1.79	1.07
March	22	10	14.9	14.9	2.51	2.89	1.62
April	50	12	19.6	19.6	3.31	3.69	2.14
May	46	8.0	16.6	16.6	2.80	3.23	1.81
June	24	4.0	8.39	8.39	1.41	1.57	.911
July	9.0	2.5	4.35	4.35	.734	.85	.474
August	14.5	1.8	3.49	3.49	.589	.68	.381
September	3.5	1.2	1.61	1.61	.272	.30	.176
The year	50	.98	8.01	8.01	1.35	18.38	.873
1948–49							
October	20	1.2	4.25	4.25	0.717	0.83	0.463
November	28	3.2	11.5	11.5	1.94	2.16	1.25
December	94	6.9	16.8	16.8	2.83	3.26	1.83
January	57	9.5	22.1	22.1	3.73	4.30	2.41
February	28	14	18.8	18.8	3.17	3.30	2.05
March	14	5.6	8.30	8.30	1.40	1.61	.905
April	30	6.7	12.6	12.6	2.12	2.36	1.37
May	22	3.9	8.02	8.02	1.35	1.56	.873
June	14	2.2	3.71	3.71	.626	.70	.405
July	200	1.5	27.1	27.1	4.57	5.27	2.95
August	72	2.4	7.83	7.83	1.32	1.52	.853
September	15	3.0	6.25	6.25	1.05	1.17	.679
The year	200	1.2	12.3	12.3	2.07	28.04	1.34
1949–50							
October	20	3.6	5.95	5.95	1.00	1.15	0.646
November	14	4.3	6.77	6.77	1.14	1.27	.737
December	48	4.3	10.6	10.6	1.79	2.06	1.16
January	15	6.0	9.59	9.59	1.62	1.87	1.05
February	35	8.4	18.8	18.8	3.17	3.30	2.05
March	45	6.2	15.9	15.9	2.68	3.09	1.73
April	21	6.9	11.4	11.4	1.92	2.14	1.24
May	36	7.4	15.6	15.6	2.63	3.03	1.70
June	20	3.0	7.18	7.18	1.21	1.35	.782
July	10	1.5	2.93	2.93	.494	.57	.319
August	4.9	.58	1.25	1.30	.219	.25	.142
September	7.9	.84	2.21	2.27	.383	.43	.248
The year	48	.58	8.96	8.97	1.51	20.51	.976

Monthly discharge of Owens Creek at Lantz—*Continued*

Month	Discharge in cfs					Adjusted	
	Observed			Adjusted			
	Maximum	Minimum	Mean	Mean	Per square mile	Runoff in inches	Discharge in million gallons per day per square mile
1950–51							
October	71	0.89	7.57	7.58	1.28	1.48	0.827
November	171	3.5	13.3	13.3	2.24	2.50	1.45
December	283	8.6	34.4	34.4	5.80	6.69	3.75
January	25	7.9	14.4	14.4	2.43	2.80	1.57
February	57	12	22.4	22.4	3.78	3.94	2.44
March	28	10	16.1	16.1	2.72	3.14	1.76
April	52	14	20.7	20.7	3.49	3.89	2.26
May	15	4.3	9.25	9.25	1.56	1.80	1.01
June	74	3.6	15.3	15.3	2.58	2.88	1.67
July	12	2.4	4.67	4.67	.788	.91	.509
August	29	1.6	3.85	3.85	.649	.75	.419
September	2.8	.65	1.36	1.41	.238	.27	.154
The year	283	.65	13.5	13.5	2.28	31.05	1.47
1951–52							
October	1.8	0.47	0.955	1.04	0.175	0.20	0.113
November	32	1.8	4.06	4.12	.695	.78	.449
December	41	2.0	8.21	8.24	1.39	1.60	.898
January	74	9.1	19.8	19.8	3.34	3.85	2.16
February	82	6.8	16.3	16.3	2.75	2.97	1.78
March	139	6.4	23.2	23.2	3.91	4.51	2.53
April	92	11	26.3	26.3	4.44	4.95	2.87
May	48	9.4	20.7	20.7	3.49	4.02	2.26
June	37	4.3	11.0	11.0	1.85	2.06	1.20
July	24	1.7	4.41	4.51	.761	.88	.492
August	6.9	1.1	2.26	2.26	.381	.44	.246
September	355	3.0	24.0	24.0	4.05	4.52	2.62
The year	355	.47	13.4	13.4	2.26	30.78	1.46
1952–53							
October	7.5	1.9	2.87	2.90	0.489	0.56	0.316
November	260	1.9	21.3	21.3	3.59	4.00	2.32
December	55	9.0	15.8	15.8	2.66	3.07	1.72
January	95	6.6	22.5	22.5	3.79	4.37	2.45
February	19	10	12.8	12.8	2.16	2.25	1.40
March	60	9.1	22.5	22.5	3.79	4.37	2.45
April	39	11	20.0	20.0	3.37	3.76	2.18
May	31	7.8	16.2	16.2	2.73	3.15	1.76
June	24	2.8	7.06	7.06	1.19	1.33	.769
July	46	1.2	3.35	3.35	.565	.65	.365
August	5.0	.57	1.43	1.43	.241	.28	.156
September	2.7	.45	.892	.909	.153	.153	.099
The year	260	.45	12.2	12.2	2.06	27.96	1.33

Monthly discharge of Owens Creek at Lantz—*Continued*

Month	Discharge in cfs					Adjusted	
	Observed			Adjusted		Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Mean	Per square mile		
1953–54							
October	1.4	0.26	0.526	0.611	0.103	0.12	0.067
November	2.6	.47	.846	.868	.146	.16	.094
December	20	.54	3.41	3.41	.575	.66	.372
January	17	.80	2.46	2.46	.415	.48	.268
February	14	1.2	3.48	3.48	.587	.61	.379
March	70	7.0	13.1	13.1	2.21	2.55	1.43
April	27	4.2	8.81	8.81	1.49	1.66	.963
May	22	3.7	9.59	9.59	1.62	1.87	1.05
June	4.5	1.0	2.33	2.33	.393	.44	.254
July	3.2	.34	.841	.841	.142	.16	.092
August	11	.31	1.12	1.14	.192	.22	.124
September	.90	.28	.478	.543	.092	.10	.059
The year	70	.26	3.93	3.95	.666	9.03	.430
1954–55							
October	33	0.29	2.16	2.18	0.368	0.42	0.238
November	8.5	.97	2.20	2.21	.373	.42	.241
December	44	1.5	7.26	7.26	1.22	1.41	.789
January	8.0	1.3	3.29	3.29	.555	.64	.359
February	28	1.4	8.99	8.99	1.52	1.58	.982
March	114	11	26.9	26.9	4.54	5.22	2.93
April	16	6.8	11.1	11.1	1.87	2.09	1.21
May	11	2.9	5.44	5.44	.917	1.06	.593
June	40	2.0	7.63	7.63	1.29	1.44	.834
July	2.7	.80	1.57	1.57	.265	.31	.171
August	252	.60	25.1	25.1	4.23	4.87	2.73
September	14	2.5	4.66	4.66	.786	.88	.508
The year	252	.29	8.88	8.88	1.50	20.34	.969
1955–56							
October	75	2.2	7.86	7.86	1.33	1.53	0.860
November	10	3.0	4.20	4.20	.708	.79	.458
December	3.9	1.6	2.55	2.55	.430	.50	.278
January	28	1.7	3.79	3.79	.639	.74	.413
February	31	9.0	18.0	18.0	3.04	3.27	1.96
March	51	8.4	17.8	17.8	3.00	3.46	1.94
April	59	9.8	20.2	20.2	3.41	3.80	2.20
May	25	5.8	12.1	12.1	2.04	2.34	1.32
June	11	2.0	4.69	4.69	.791	.88	.511
July	45	1.5	5.09	5.09	.858	.99	.555
August	5.8	.93	1.82	1.82	.307	.35	.198
September	5.8	.74	1.46	1.46	.246	.28	.159
The year	75	.74	8.24	8.24	1.39	18.93	.898

POTOMAC RIVER BASIN—*Continued*

Yearly discharge of Owens Creek at Lantz

(Adjusted for diversion)

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1932	5.34	0.901	12.25	0.582	8.99	1.52	20.63	0.982
1933	14.0	2.36	32.02	1.53	11.0	1.85	25.23	1.20
1934	6.39	1.08	14.61	.698	9.38	1.58	21.45	1.02
1935	10.6	1.79	24.33	1.16	8.60	1.45	19.69	.937
1936	10.8	1.82	24.78	1.18	10.1	1.70	23.31	1.10
1937	12.3	2.07	28.21	1.34	14.2	2.39	32.55	1.54
1938	7.66	1.29	17.51	.834	6.29	1.06	14.40	.685
1939	8.55	1.44	19.58	.931	7.45	1.26	17.06	.814
1940	8.69	1.47	19.97	.950	11.0	1.85	25.19	1.20
1941	7.27	1.23	16.63	.795	4.72	.796	10.80	.514
1942	7.79	1.31	17.78	.847	11.2	1.89	25.58	1.22
1943	11.4	1.92	25.99	1.24	8.19	1.38	18.71	.892
1944	6.23	1.05	14.32	.679	7.06	1.19	16.20	.769
1945	8.96	1.51	20.51	.976	9.95	1.68	22.77	1.09
1946	9.59	1.62	21.98	1.05	8.03	1.35	18.41	.873
1947	6.51	1.10	14.91	.711	6.43	1.08	14.72	.698
1948	8.01	1.35	18.38	.873	9.96	1.68	22.86	1.09
1949	12.3	2.07	28.04	1.34	11.5	1.94	26.27	1.25
1950	8.97	1.51	20.51	.976	11.7	1.97	26.70	1.27
1951	13.5	2.28	31.05	1.47	10.0	1.69	22.96	1.09
1952	13.4	2.26	30.78	1.46	15.6	2.63	35.83	1.70
1953	12.2	2.06	27.96	1.33	9.30	1.57	21.27	1.01
1954	3.95	.666	9.03	.430	4.51	.761	10.34	.492
1955	8.88	1.50	20.34	.969	9.13	1.54	20.91	.995
1956	8.24	1.39	18.93	.898	—	—	—	—
Highest	14.0	2.36	32.02	1.53	15.6	2.63	35.83	1.70
Average	9.26	1.56	21.22	1.01	9.35	1.58	21.41	1.02
Lowest	3.95	.666	9.03	.430	4.51	.761	10.34	.492

15. Hunting Creek at Jimtown

Location.—Lat 39°35′40″, long 77°23′50″, on right bank just downstream from highway bridge, 0.4 mile southwest of Jimtown, Frederick County, about 2¼ miles southeast of Thurmont, and 2¼ miles upstream from Little Hunting Creek.

Drainage area.—18.4 sq mi.

Records available.—October 1949 to September 1956.

Gage.—Water-stage recorder and concrete control. Altitude of gage is 355 ft (from topographic map).

Average discharge.—7 years, 27.6 cfs.

Extremes.—Maximum discharge, 1,170 cfs Sept. 1, 1952 (gage height, 4.94 ft), from rating curve extended above 500 cfs by logarithmic plotting; minimum, 1.0 cfs Aug. 1, 2, 1954.

Remarks.—Slight regulation at irregular intervals caused by pumpage at recreation camp near Foxville, Md.

Monthly discharge of Hunting Creek at Jimtown

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1949–50						
October	72	6.2	12.7	0.690	0.80	0.446
November	33	11	16.3	.886	.99	.573
December	136	9.7	26.5	1.44	1.66	.931
January	36	14	22.5	1.22	1.41	.789
February	128	24	58.1	3.16	3.29	2.04
March	237	18	59.8	3.25	3.75	2.10
April	62	21	34.8	1.89	2.11	1.22
May	155	28	60.0	3.26	3.76	2.11
June	68	7.8	23.0	1.25	1.39	.808
July	28	3.9	7.85	.427	.49	.276
August	21	2.3	3.95	.215	.25	.139
September	57	3.5	10.7	.582	.65	.376
The year	237	2.3	27.8	1.51	20.55	.976
1950–51						
October	226	3.9	23.4	1.27	1.46	0.821
November	270	9.7	28.9	1.57	1.75	1.01
December	342	20	68.1	3.70	4.27	2.39
January	81	19	37.1	2.02	2.32	1.31
February	210	34	71.0	3.86	4.02	2.49
March	116	30	51.7	2.81	3.24	1.82
April	116	35	57.4	3.12	3.48	2.02
May	46	11	24.2	1.32	1.51	.853
June	285	9.0	46.0	2.50	2.79	1.62
July	24	5.6	11.2	.609	.70	.394
August	68	4.3	9.47	.515	.59	.333
September	6.2	2.3	3.54	.192	.21	.124
The year	342	2.3	35.7	1.94	26.34	1.25

Monthly discharge of Hunting Creek at Jimtown—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1951–52						
October	5.2	2.6	3.16	0.172	0.20	0.111
November	88	4.3	12.2	.663	.74	.429
December	192	5.6	28.5	1.55	1.79	1.00
January	233	32	65.8	3.58	4.13	2.31
February	300	22	51.3	2.79	3.01	1.80
March	598	22	80.7	4.39	5.06	2.84
April	510	32	90.3	4.91	5.48	3.17
May	190	22	55.9	3.04	3.50	1.96
June	67	8.5	24.3	1.32	1.47	.853
July	36	1.9	7.28	.396	.46	.256
August	73	2.0	7.89	.429	.49	.277
September	437	5.7	35.2	1.91	2.14	1.23
The year	598	1.9	38.5	2.09	28.47	1.35
1952–53						
October	17	5.3	7.88	0.428	0.49	0.277
November	513	5.3	55.0	2.99	3.33	1.93
December	176	21	39.8	2.16	2.50	1.40
January	339	19	67.2	3.65	4.21	2.36
February	83	28	38.6	2.10	2.18	1.36
March	279	26	78.3	4.26	4.91	2.75
April	137	28	53.5	2.91	3.24	1.88
May	105	21	42.1	2.29	2.64	1.48
June	80	8.6	20.8	1.13	1.26	.730
July	281	3.3	17.6	.957	1.10	.619
August	43	2.5	7.34	.399	.46	.258
September	9.0	2.2	3.40	.185	.21	.120
The year	513	2.2	36.0	1.96	26.53	1.27
1953–54						
October	5.7	2.0	2.99	0.162	0.19	0.105
November	7.8	2.2	3.60	.196	.22	.127
December	61	2.5	12.4	.674	.77	.436
January	53	3.4	9.25	.503	.58	.325
February	47	4.4	11.6	.603	.66	.390
March	112	19	31.8	1.73	1.99	1.12
April	129	13	29.2	1.59	1.77	1.03
May	44	11	22.0	1.20	1.38	.776
June	19	3.1	7.19	.391	.44	.253
July	5.2	1.2	2.59	.141	.16	.091
August	23	1.2	3.76	.204	.24	.132
September	4.8	1.4	2.23	.121	.14	.078
The year	129	1.2	11.6	.630	8.54	.407

POTOMAC RIVER BASIN—*Continued*

Monthly discharge of Hunting Creek at Jimtown—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1954–55						
October	30	1.6	4.73	0.257	0.30	0.166
November	20	3.4	6.43	.349	.39	.226
December	52	3.7	13.9	.755	.87	.488
January	17	4.0	7.93	.431	.50	.279
February	74	4.5	19.9	1.08	1.12	.698
March	298	24	58.8	3.20	3.68	2.07
April	56	19	32.3	1.76	1.96	1.14
May	30	7.0	13.6	.739	.85	.478
June	110	5.5	21.7	1.18	1.32	.763
July	50	2.5	7.34	.399	.46	.258
August	584	1.6	56.2	3.05	3.52	1.97
September	38	7.3	12.5	.679	.76	.439
The year	584	1.6	21.3	1.16	15.73	.750
1955–56						
October	170	6.2	19.5	1.06	1.22	0.685
November	29	9.6	12.6	.685	.76	.443
December	11	5.0	7.27	.395	.46	.255
January	50	5.0	8.90	.484	.56	.313
February	101	20	53.1	2.89	3.11	1.87
March	191	22	53.8	2.92	3.37	1.89
April	179	22	48.2	2.62	2.92	1.69
May	34	10	18.8	1.02	1.18	.659
June	22	4.4	9.48	.515	.57	.333
July	226	4.0	22.4	1.22	1.40	.789
August	21	3.4	6.58	.358	.41	.231
September	15	2.8	4.46	.242	.27	.156
The year	226	2.8	22.0	1.20	16.23	.776

POTOMAC RIVER BASIN—*Continued*

Yearly discharge of Hunting Creek at Jimtown

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1950	27.8	1.51	20.55	0.976	33.3	1.81	24.58	1.17
1951	35.7	1.94	26.34	1.25	29.3	1.59	21.59	1.03
1952	38.5	2.09	28.47	1.35	43.3	2.35	32.06	1.52
1953	36.0	1.96	26.53	1.27	29.0	1.58	21.39	1.02
1954	11.6	.630	8.54	.407	12.1	.658	8.92	.425
1955	21.3	1.16	15.73	.750	22.5	1.22	16.61	.789
1956	22.0	1.20	16.23	.776	—	—	—	—
Highest	38.5	2.09	28.47	1.35	43.3	2.35	32.06	1.52
Average	27.6	1.50	20.34	.969	28.2	1.53	20.86	.989
Lowest	11.6	.630	8.54	.407	12.1	.658	8.92	.425

POTOMAC RIVER BASIN

16. Fishing Creek near Lewistown

Location.—Lat 39°31′35″, long 77°28′00″, on left bank immediately upstream from Fishing Creek Reservoir, 50 ft downstream from Little Fishing Creek, and 4.5 miles west of Lewistown, Frederick County.

Drainage area.—7.29 sq mi.

Records available.—October 1947 to September 1956.

Gage.—Water-stage recorder and concrete control. Altitude of gage is 735 ft (from topographic map).

Average discharge.—9 years, 12.2 cfs.

Extremes.—Maximum discharge, 500 cfs July 12, 1949 (gage height, 3.73 ft), from rating curve extended above 100 cfs on basis of slope-area determination of peak flow; minimum 0.8 cfs Oct. 12–14, 1954.

Monthly discharge of Fishing Creek near Lewistown

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1947–48						
October	2.9	1.9	2.10	0.288	0.33	0.186
November	10	1.9	5.29	.726	.81	.469
December	6.4	4.4	5.12	.702	.81	.454
January	14	5.0	7.17	.984	1.13	.636
February	30	4.8	11.7	1.60	1.73	1.03
March	22	15	18.1	2.48	2.86	1.60
April	30	15	20.4	2.80	3.12	1.81
May	40	14	20.1	2.76	3.17	1.78
June	16	6.4	10.2	1.40	1.56	.905
July	7.1	3.4	4.45	.610	.70	.394
August	6.0	2.2	3.36	.461	.53	.298
September	3.2	1.7	2.15	.295	.33	.191
The year	40	1.7	9.15	1.26	17.08	.814
1948–49						
October	6.7	1.8	2.42	0.332	0.38	0.215
November	19	2.1	9.05	1.24	1.39	.801
December	128	14	26.1	3.58	4.13	2.31
January	91	17	36.9	5.06	5.84	3.27
February	38	21	25.2	3.46	3.60	2.24
March	20	9.0	13.0	1.78	2.06	1.15
April	42	9.0	20.1	2.76	3.07	1.78
May	35	9.3	18.4	2.52	2.91	1.63
June	14	5.2	7.68	1.05	1.17	.679
July	143	4.4	38.6	5.29	6.10	3.42
August	17	4.6	7.98	1.09	1.26	.704
September	13	3.5	4.56	.626	.70	.405
The year	143	1.8	17.5	2.40	32.61	1.55

Monthly discharge of Fishing Creek near Lewistown—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1949–50						
October	11	3.3	4.53	0.621	0.72	0.401
November	10	5.9	7.36	1.01	1.13	.653
December	31	5.1	10.6	1.45	1.68	.937
January	18	7.9	11.5	1.58	1.81	1.02
February	37	12	22.4	3.07	3.20	1.98
March	50	9.6	20.9	2.87	3.30	1.85
April	30	10	15.9	2.18	2.43	1.41
May	47	13	25.1	3.44	3.97	2.22
June	25	5.9	12.6	1.73	1.93	1.12
July	11	3.0	4.48	.615	.71	.397
August	3.9	2.0	2.46	.337	.39	.218
September	21	2.0	5.03	.690	.77	.446
The year	50	2.0	11.8	1.62	22.04	1.05
1950–51						
October	37	3.0	10.9	1.50	1.73	0.969
November	56	8.3	14.4	1.98	2.20	1.28
December	91	11	30.7	4.21	4.86	2.72
January	20	9.6	13.6	1.87	2.15	1.21
February	44	17	27.6	3.79	3.94	2.45
March	31	12	18.8	2.58	2.97	1.67
April	32	18	24.0	3.29	3.67	2.13
May	23	8.7	16.1	2.21	2.54	1.43
June	72	6.8	20.3	2.78	3.10	1.80
July	13	3.9	6.27	.860	.99	.556
August	4.4	2.2	2.94	.403	.46	.260
September	3.3	1.5	1.95	.267	.30	.173
The year	91	1.5	15.5	2.13	28.91	1.38
1951–52						
October	2.0	1.4	1.52	0.209	0.24	0.135
November	11	1.5	2.44	.335	.37	.217
December	27	1.7	5.55	.761	.88	.492
January	44	15	23.2	3.18	3.66	2.06
February	56	11	22.1	3.03	3.27	1.96
March	89	9.6	28.3	3.88	4.48	2.51
April	150	20	40.6	5.57	6.21	3.60
May	110	16	35.4	4.86	5.60	3.14
June	31	5.4	12.6	1.73	1.93	1.12
July	6.5	2.5	3.70	.508	.59	.328
August	4.3	1.7	2.47	.339	.39	.219
September	41	1.7	3.67	.503	.56	.325
The year	150	1.4	15.1	2.07	28.18	1.34

Monthly discharge of Fishing Creek near Lewistown—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1952–53						
October	3.9	1.9	2.21	0.303	0.35	0.196
November	90	1.7	13.4	1.84	2.05	1.19
December	40	10	17.2	2.36	2.71	1.53
January	59	10	25.9	3.55	4.10	2.29
February	22	12	16.0	2.19	2.28	1.42
March	64	12	28.5	3.91	4.50	2.53
April	31	12	22.0	3.02	3.37	1.95
May	46	12	19.4	2.66	3.06	1.72
June	66	5.4	16.8	2.30	2.58	1.49
July	35	3.2	5.57	.764	.88	.494
August	7.8	2.0	3.29	.451	.52	.291
September	5.5	1.5	2.17	.298	.33	.193
The year	90	1.5	14.4	1.98	26.73	1.28
1953–54						
October	3.0	1.5	1.61	0.221	0.26	0.143
November	3.6	1.2	1.58	.217	.24	.140
December	10	1.2	3.20	.439	.51	.284
January	6.8	1.8	2.70	.370	.43	.239
February	6.3	2.5	3.65	.501	.52	.324
March	18	8.3	11.2	1.54	1.77	.995
April	42	7.9	15.3	2.10	2.34	1.36
May	23	7.6	14.6	2.00	2.31	1.29
June	7.6	3.0	5.03	.690	.77	.446
July	6.7	1.6	2.66	.365	.42	.236
August	9.0	1.4	2.09	.287	.33	.185
September	2.2	1.0	1.25	.171	.19	.111
The year	42	1.0	5.42	.743	10.09	.480
1954–55						
October	4.6	0.8	1.28	0.176	0.20	0.114
November	2.8	1.1	1.47	.202	.23	.131
December	7.9	1.2	3.37	.462	.53	.299
January	5.9	3.0	4.35	.597	.69	.386
February	11	3.0	6.79	.931	.97	.602
March	60	11	23.7	3.25	3.75	2.10
April	19	10	15.6	2.14	2.38	1.38
May	16	5.9	9.79	1.34	1.55	.866
June	16	4.8	7.33	1.01	1.12	.653
July	10	2.8	4.15	.569	.66	.368
August	207	2.3	34.3	4.71	5.42	3.04
September	15	5.4	8.66	1.19	1.33	.769
The year	207	.8	10.1	1.39	18.83	.898

POTOMAC RIVER BASIN—*Continued*

Monthly discharge of Fishing Creek near Lewistown—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1955–56						
October	26	4.3	8.22	1.13	1.30	0.730
November	13	5.6	7.11	.975	1.09	.630
December	7.0	4.1	5.46	.749	.86	.484
January	8.2	3.3	4.32	.593	.68	.383
February	28	5.7	20.4	2.80	3.02	1.81
March	37	14	22.1	3.03	3.50	1.96
April	38	12	21.0	2.88	3.21	1.86
May	15	7.4	9.95	1.36	1.57	.879
June	10	4.8	6.99	.959	1.07	.620
July	51	3.9	11.7	1.60	1.85	1.03
August	10	3.3	6.10	.837	.96	.541
September	5.9	2.7	3.49	.479	.53	.310
The year	51	2.7	10.5	1.44	19.64	.931

Yearly discharge of Fishing Creek near Lewistown

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1948	9.15	1.26	17.08	0.814	11.3	1.55	21.03	1.00
1949	17.5	2.40	32.61	1.55	16.2	2.22	30.24	1.43
1950	11.8	1.62	22.04	1.05	14.7	2.02	27.30	1.31
1951	15.5	2.13	28.91	1.38	11.6	1.59	21.61	1.03
1952	15.1	2.07	28.18	1.34	17.0	2.33	31.80	1.51
1953	14.4	1.98	26.73	1.28	12.2	1.67	22.63	1.08
1954	5.42	.743	10.09	.480	5.39	.739	10.04	.478
1955	10.1	1.39	18.83	.898	11.3	1.55	21.12	1.00
1956	10.5	1.44	19.64	.931	—	—	—	—
Highest	17.5	2.40	32.61	1.55	17.0	2.33	31.80	1.51
Average	12.2	1.67	22.68	1.08	12.5	1.71	23.22	1.11
Lowest	5.42	.743	10.09	.480	5.39	.739	10.04	.478

Potomac River Basin

17. Monocacy River near Frederick

Location.—Lat 39°27′09″, long 77°22′16″, near right bank on downstream side of bridge on State Highway 26 at Ceresville, 1200 ft upstream from Israel Creek and 3.3 miles northeast of Frederick, Frederick County.

Drainage area.—665 sq mi.

Records available.—August 1896 to September 1930 (discontinued). Monthly records published in Bulletin 1 (1897–99, 1902, 1904, 1905, 1917 revised herein).

Gage.—Chain gage. Datum of gage is 242.45 ft above mean sea level (levels by Corps of Engineers). Prior to Sept. 3, 1902, wire-weight gage at same site and datum.

Average discharge.—34 years, 943 cfs.

Extremes.—Maximum discharge, 26,600 cfs Sept. 1, 1911 (gage height, 27.5 ft, from graph based on gage readings); from rating curve extended above 4,700 cfs on basis of curve of relation with station at Jug Bridge; minimum 15 cfs several days in October 1910 (gage height 3.54 ft).

Maximum stage known, about 35 ft in June 1889, from floodmark (discharge, about 46,000 cfs, from rating curve extended as explained above).

Monthly discharge of Monocacy River near Frederick

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1896						
August‡	345	69	140	0.211	0.24	0.136
September‡	480	69	115	.173	.19	.112
1896–97						
October	396	103	144	0.217	0.25	0.140
November	2,195	124	306	.460	.51	.297
December	396	124	187	.281	.32	.182
January*	730	147	266	.400	.46	.259
February	9,750	256	2,062	3.10	3.23	2.00
March	4,400	575	1,384	2.08	2.40	1.34
April	3,900	322	907	1.36	1.52	.879
May	10,380	322	1,650	2.48	2.86	1.60
June	2,195	198	492	.740	.83	.478
July	4,500	198	710	1.07	1.23	.692
August	11,100	172	968	1.46	1.68	.944
September	812	114	191	.287	.32	.185
The year	11,100	103	765	1.15	15.61	.743

‡ Not previously published.

* Revised

Monthly discharge of Monocacy River near Frederick—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1897–98						
October	241	94	137	0.206	0.24	0.133
November	9,592	185	1,008	1.52	1.70	.982
December	9,330	550	1,980	2.98	3.44	1.93
January	7,020	416	2,099	3.16	3.64	2.04
February*	9,540	450	1,335	2.01	2.09	1.30
March	5,350	437	1,319	1.98	2.28	1.28
April	1,845	396	692	1.04	1.16	.672
May	8,070	322	1,575	2.37	2.73	1.53
June	730	256	408	.614	.68	.397
July	675	124	223	.335	.39	.217
August	7,020	147	926	1.39	1.60	.898
September	198	103	128	.192	.21	.124
The year	9,592	94	988	1.49	20.16	.963
1898–99						
October	6,150	103	693	1.04	1.20	0.672
November	6,968	256	1,132	1.70	1.90	1.10
December	12,850	480	1,943	2.92	3.37	1.89
January	9,592	480	1,971	2.96	3.41	1.91
February*	12,690	500	2,637	3.97	4.13	2.57
March	12,060	1,370	3,428	5.16	5.95	3.33
April	7,230	396	1,179	1.77	1.98	1.14
May	2,375	322	680	1.02	1.18	.659
June	5,700	198	759	1.14	1.27	.737
July	288	124	196	.295	.34	.191
August	525	103	208	.313	.36	.202
September	1,025	85	309	.465	.52	.301
The year	12,850	85	1,254	1.89	25.61	1.22
1901–02						
October	575	172	268	0.403	0.46	0.260
November	4,000	198	480	.722	.81	.467
December	14,740	358	2,313	3.48	4.01	2.25
January	12,950	437	1,924	2.89	3.33	1.87
February*	19,200	650	3,288	4.94	5.14	3.19
March	20,460	785	4,677	7.03	8.10	4.54
April	12,800	480	2,261	3.40	3.79	2.20
May	575	226	339	.510	.59	.330
June	1,845	147	323	.486	.54	.314
July	1,680	124	335	.504	.58	.326
August	575	69	143	.215	.25	.139
September	3,700	55	232	.349	.39	.226
The year	20,460	55	1,372	2.06	27.99	1.33

Monthly discharge of Monocacy River near Frederick—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1903–04						
October	1,930	226	477	0.717	0.83	0.463
November	437	198	239	.359	.40	.232
December	6,652	172	540	.812	.94	.525
January*	14,800	190	975	1.47	1.70	.950
February	8,758	294	1,502	2.26	2.44	1.46
March	11,960	538	1,812	2.72	3.14	1.76
April	2,400	294	729	1.10	1.23	.711
May	789	198	375	.561	.65	.363
June	4,300	144	817	1.23	1.37	.795
July	2,765	120	586	.881	1.02	.569
August	7,130	80	436	.656	.76	.424
September	734	80	251	.377	.42	.244
The year	14,800	80	727	1.09	14.90	.704
1904–05						
October	969	80	176	0.265	0.31	0.171
November	228	120	139	.209	.23	.135
December	3,905	120	549	.826	.95	.534
January	12,170	538	1,503	2.26	2.61	1.46
February*	734	250	320	.481	.50	.311
March	9,440	538	3,056	4.60	5.30	2.97
April	2,220	368	790	1.19	1.33	.769
May	450	170	279	.420	.48	.271
June	2,860	144	748	1.12	1.25	.724
July	6,605	260	1,296	1.95	2.25	1.26
August	13,640	228	1,427	2.15	2.48	1.39
September	2,130	170	546	.821	.92	.531
The year	13,640	80	911	1.37	18.61	.885
1916–17						
October	7,010	122	440	0.662	0.76	0.428
November	525	122	158	.238	.26	.154
December	2,610	158	576	.866	1.00	.560
January	3,290	405	1,250	1.88	2.17	1.22
February*	1,420	190	554	.833	.87	.538
March	9,750	705	2,380	3.58	4.13	2.31
April	7,550	434	1,130	1.70	1.90	1.10
May	2,050	232	430	.646	.74	.418
June	4,230	218	783	1.18	1.32	.763
July	2,840	204	701	1.05	1.21	.679
August	4,900	165	643	.967	1.11	.625
September	2,410	204	460	.692	.77	.447
The year	9,750	122	796	1.20	16.24	.776

POTOMAC RIVER BASIN—*Continued*

Yearly discharge of Monocacy River near Frederick

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1897	765	1.15	15.61	0.743	974	1.46	19.92	0.944
1898	988	1.49	20.16	.963	1,042	1.57	21.25	1.01
1899	1,254	1.89	25.61	1.22	1,020	1.53	20.82	.989
1900	699	1.05	14.28	.679	707	1.06	14.44	.685
1901	849	1.28	17.34	.827	1,018	1.53	20.78	.989
1902	1,372	2.06	27.99	1.33	1,595	2.40	32.56	1.55
1903	2,162	3.25	44.13	2.10	1,786	2.69	36.45	1.74
1904	727	1.09	14.90	.704	694	1.04	14.20	.672
1905	911	1.37	18.61	.885	1,100	1.65	22.46	1.07
1906	1,215	1.83	24.81	1.18	1,236	1.86	25.23	1.20
1907	1,325	1.99	27.05	1.29	1,436	2.16	29.33	1.40
1908	1,573	2.37	32.20	1.53	1,231	1.85	25.20	1.20
1909	720	1.08	14.69	.698	739	1.11	15.09	.717
1910	725	1.09	14.83	.704	676	1.02	13.83	.659
1911	552	.830	11.26	.536	769	1.16	15.67	.750
1912	1,165	1.75	23.82	1.13	1,050	1.58	21.55	1.02
1913	796	1.20	16.25	.776	913	1.37	18.62	.885
1914	905	1.36	18.47	.879	725	1.09	14.81	.704
1915	1,070	1.61	21.80	1.04	1,070	1.61	21.80	1.04
1916	987	1.48	20.22	.957	901	1.35	18.45	.873
1917	796	1.20	16.24	.776	891	1.34	18.21	.866
1918	935	1.41	19.10	.911	858	1.29	17.53	.834
1919	786	1.18	16.04	.763	830	1.25	16.92	.808
1920	885	1.33	18.09	.860	897	1.35	18.33	.873
1921	703	1.06	14.37	.685	631	.949	12.89	.613
1922	663	.997	13.53	.644	592	.890	12.09	.575
1923	461	.693	9.44	.448	516	.776	10.55	.502
1924	1,250	1.88	25.70	1.22	1,290	1.94	26.38	1.25
1925	513	.771	10.48	.498	533	.802	10.87	.518
1926	754	1.13	15.36	.730	945	1.42	19.24	.918
1927	929	1.40	18.96	.905	926	1.39	18.87	.898
1928	1,280	1.92	26.11	1.24	1,020	1.53	20.87	.989
1929	749	1.13	15.31	.730	904	1.36	18.48	.879
1930	595	.895	12.15	.578	—	—	—	—
Highest	2,162	3.25	44.13	2.10	1,786	2.69	36.45	1.74
Average	943	1.42	19.26	.918	955	1.44	19.51	.931
Lowest	461	.693	9.44	.448	516	.776	10.55	.502

POTOMAC RIVER BASIN

18. Linganore Creek near Frederick

Location.—Lat 39°24′55″, long 77°20′00″, on left bank 2¼ miles upstream from mouth and 4 miles east of Frederick, Frederick County.

Drainage area.—82.3 sq mi. At site used Nov. 27, 1931, to Mar. 28, 1932, 84.6 sq mi.

Records available.—December 1931 to March 1932, September 1934 to September 1956. Monthly records December 1931 to February 1932, October 1934 to September 1943 published in Bulletin 1 (March 1932, September 1934 completed herein).

Supplemental records available.—Records of water temperatures for October 1951 to September 1956 are published in reports of U. S. Geological Survey.

Gage.—Water-stage recorder. Concrete control since Sept. 23, 1946. Altitude of gage is 270 ft (from topographic map). Nov. 27, 1931, to Mar. 26, 1932, staff gage at Frederick pumping station, 1½ miles downstream at datum about 20 ft lower. Sept. 12, 1934, to Sept. 25, 1946, staff gage at present site and datum.

Average discharge.—22 years (1934–56), 86.5 cfs.

Extremes.—Maximum discharge, 4,100 cfs Apr. 27, 1952 (gage height, 11.34 ft), from rating curve extended above 1,500 cfs on basis of slope-area determination at gage height 10.01 ft; maximum gage height, 12.22 ft June 2, 1946; minimum discharge observed, 6.0 cfs Oct. 9, 1941.

Flood of Aug. 23 or 24, 1933 reached a stage of 10.5 ft, from floodmarks (discharge, 2,920 cfs).

Monthly discharge of Linganore Creek near Frederick

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1932						
March‡	500	24	85.9	1.02	1.17	0.659
1934						
September‡	780	10	87.0	1.06	1.18	0.685
1943–44						
October	288	11	37.6	0.457	0.53	0.295
November	768	26	94.8	1.15	1.28	.743
December	126	21	35.1	.426	.49	.275
January	1,350	25	128	1.56	1.79	1.01
February	91	33	46.9	.570	.61	.368
March	697	47	182	2.21	2.55	1.43
April	320	90	137	1.66	1.86	1.07
May	126	41	70.4	.855	.99	.553
June	780	29	64.6	.785	.88	.507
July	248	15	31.1	.378	.44	.244
August	43	9.7	15.4	.187	.22	.121
September	70	9.4	19.6	.238	.27	.154
The year	1,350	9.4	72.0	.875	11.91	.566

‡ Not previously published; partly estimated.

Monthly discharge of Linganore Creek near Frederick—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1944–45						
October	134	16	26.8	0.326	0.38	0.211
November	151	17	28.0	.340	.38	.220
December	355	24	63.8	.775	.89	.501
January	355	26	55.3	.672	.77	.434
February	519	25	133	1.62	1.68	1.05
March	258	53	108	1.31	1.51	.847
April	227	49	80.5	.978	1.09	.632
May	126	38	61.2	.744	.86	.481
June	261	24	51.7	.628	.70	.406
July	411	23	112	1.36	1.57	.879
August	964	42	117	1.42	1.64	.918
September	654	34	95.7	1.16	1.30	.750
The year	964	16	77.4	.940	12.77	.608
1945–46						
October	75	36	45.5	0.553	0.64	0.357
November	863	33	95.2	1.16	1.29	.750
December	733	84	179	2.17	2.51	1.40
January	296	81	135	1.64	1.89	1.06
February	205	68	92.6	1.13	1.17	.730
March	192	74	108	1.31	1.51	.847
April	86	46	59.5	.723	.81	.467
May	517	41	106	1.29	1.48	.834
June	2,830	59	243	2.95	3.29	1.91
July	502	38	84.5	1.03	1.18	.666
August	144	33	51.1	.621	.72	.401
September	108	24	38.4	.467	.52	.302
The year	2,830	24	103	1.25	17.01	.808
1946–47						
October	213	26	41.8	0.508	0.59	0.328
November	47	30	34.1	.414	.46	.268
December	154	25	41.2	.501	.58	.324
January	344	44	87.6	1.06	1.23	.685
February	93	33	59.5	.723	.75	.467
March	365	51	94.7	1.15	1.33	.743
April	68	38	49.9	.606	.68	.392
May	722	42	102	1.24	1.44	.801
June	193	34	53.6	.651	.73	.421
July	396	29	73.4	.892	1.03	.577
August	286	19	57.9	.704	.81	.455
September	32	19	23.6	.287	.32	.185
The year	722	19	60.2	.731	9.95	.472

Monthly discharge of Linganore Creek near Frederick—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1947–48						
October	46	15	18.7	0.227	0.26	0.147
November	297	19	68.3	.830	.93	.536
December	69	26	34.6	.420	.48	.271
January	968	36	115	1.40	1.60	.905
February	682	40	145	1.76	1.90	1.14
March	323	82	130	1.58	1.82	1.02
April	345	77	119	1.45	1.62	.937
May	617	81	162	1.97	2.28	1.27
June	532	58	118	1.43	1.60	.924
July	208	50	81.0	.984	1.13	.636
August	212	41	81.1	.985	1.14	.637
September	52	29	35.6	.433	.48	.280
The year	968	15	92.2	1.12	15.24	.724
1948–49						
October	158	28	52.5	0.638	0.73	0.412
November	471	37	82.4	1.00	1.12	.646
December	1,640	80	223	2.71	3.13	1.75
January	996	126	290	3.52	4.06	2.28
February	395	161	227	2.76	2.87	1.78
March	208	95	123	1.49	1.72	.963
April	268	86	132	1.60	1.78	1.03
May	397	71	117	1.42	1.64	.918
June	71	39	52.2	.634	.71	.410
July	525	31	88.0	1.07	1.23	.692
August	78	25	34.3	.417	.48	.270
September	59	20	28.0	3.40	.38	.220
The year	1,640	20	120	1.46	19.85	.944
1949–50						
October	100	20	30.0	0.365	0.42	0.236
November	72	22	28.3	.344	.38	.222
December	271	22	55.1	.670	.77	.433
January	122	32	44.0	.535	.62	.346
February	351	56	145	1.76	1.83	1.14
March	1,300	50	161	1.96	2.25	1.27
April	115	62	78.6	.955	1.07	.617
May	198	55	84.1	1.02	1.18	.659
June	171	31	57.3	.696	.78	.450
July	75	21	33.1	.402	.46	.260
August	84	14	21.7	.264	.30	.171
September	240	20	67.6	.821	.92	.531
The year	1,300	14	66.6	.809	10.98	.523

Monthly discharge of Linganore Creek near Frederick—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1950–51						
October	196	27	42.3	0.514	0.59	0.332
November	1,400	30	94.2	1.14	1.28	.737
December	1,250	60	159	1.93	2.23	1.25
January	224	61	88.5	1.08	1.24	.698
February	1,000	90	230	2.79	2.91	1.80
March	272	93	120	1.46	1.67	.944
April	143	64	87.6	1.06	1.19	.685
May	104	44	61.3	.745	.86	.482
June	701	38	149	1.81	2.02	1.17
July	198	37	64.1	.779	.90	.503
August	385	25	54.7	.665	.77	.430
September	70	17	25.0	.304	.34	.196
The year	1,400	17	97.0	1.18	16.00	.763
1951–52						
October	37	17	20.8	0.253	0.29	0.164
November	192	21	46.2	.561	.63	.363
December	365	24	69.7	.847	.98	.547
January	386	95	181	2.20	2.54	1.42
February	521	79	136	1.65	1.78	1.07
March	831	82	178	2.16	2.50	1.40
April	2,950	107	421	5.12	5.71	3.31
May	1,720	107	286	3.48	4.01	2.25
June	301	68	115	1.40	1.56	.905
July	340	45	92.9	1.13	1.30	.730
August	64	30	43.0	.522	.60	.337
September	958	30	70.9	.861	.96	.556
The year	2,950	17	138	1.68	22.86	1.09
1952–53						
October	61	26	31.4	0.382	0.44	0.247
November	931	24	112	1.36	1.52	.879
December	553	60	118	1.43	1.66	.924
January	540	71	175	2.13	2.45	1.38
February	280	88	116	1.41	1.46	.911
March	450	83	183	2.22	2.56	1.43
April	300	99	153	1.86	2.08	1.20
May	651	83	165	2.00	2.31	1.29
June	567	47	97.2	1.18	1.32	.763
July	92	29	40.5	.492	.57	.318
August	101	16	28.9	.351	.40	.227
September	144	15	28.5	.346	.39	.224
The year	931	15	104	1.26	17.16	.814

Monthly discharge of Linganore Creek near Frederick—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1953–54						
October	40	16	19.2	0.233	0.27	0.151
November	103	18	25.9	.315	.35	.204
December	463	20	82.2	.999	1.15	.646
January	135	23	41.5	.504	.58	.326
February	62	24	37.4	.454	.47	.293
March	368	49	77.1	.937	1.08	.606
April	208	37	64.8	.787	.88	.509
May	650	39	107	1.30	1.49	.840
June	147	17	32.5	.395	.44	.255
July	148	11	25.4	.309	.36	.200
August	90	9.5	26.4	.321	.37	.207
September	31	11	14.8	.180	.20	.116
The year	650	9.5	46.3	.563	7.64	.364
1954–55						
October	93	9.5	21.5	0.261	0.30	0.169
November	61	20	26.0	.316	.35	.204
December	218	17	51.8	.629	.73	.407
January	70	18	33.5	.407	.47	.263
February	800	19	92.9	1.13	1.18	.730
March	1,100	49	170	2.07	2.38	1.34
April	99	57	68.8	.836	.93	.540
May	166	28	46.2	.561	.65	.363
June	431	27	71.7	.871	.97	.563
July	333	20	46.6	.566	.65	.366
August	2,830	17	231	2.81	3.24	1.82
September	133	46	70.2	.853	.95	.551
The year	2,830	9.5	77.6	.943	12.80	.609
1955–56						
October	771	41	83.4	1.01	1.17	0.653
November	142	39	57.3	.696	.78	.450
December	48	28	38.0	.462	.53	.299
January	240	26	50.4	.612	.71	.396
February	590	84	191	2.32	2.51	1.50
March	815	72	176	2.14	2.47	1.38
April	291	70	119	1.45	1.61	.937
May	79	43	56.9	.691	.80	.447
June	226	31	53.5	.650	.72	.420
July	1,220	29	172	2.09	2.40	1.35
August	79	32	46.3	.563	.65	.364
September	101	28	36.1	.439	.49	.284
The year	1,220	26	89.7	1.09	14.84	.704

POTOMAC RIVER BASIN—*Continued*

Yearly discharge of Linganore Creek near Frederick

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per sqaure mile
	Mean	Per square mile			Mean	Per square mile		
1935	78.9	0.959	13.01	0.620	74.6	0.906	12.30	0.586
1936	96.3	1.17	15.92	.756	98.8	1.20	16.33	.776
1937	103	1.25	17.00	.808	122	1.48	20.14	.957
1938	76.8	.933	12.68	.603	57.0	.693	9.42	.448
1939	82.8	1.01	13.66	.653	77.6	.943	12.78	.609
1940	76.8	.933	12.68	.603	91.7	1.11	15.16	.717
1941	70.6	.858	11.66	.555	53.1	.645	8.77	.417
1942	74.5	.905	12.29	.585	107	1.30	17.58	.840
1943	98.8	1.20	16.30	.776	75.9	.922	12.52	.596
1944	72.0	.875	11.91	.566	68.0	.826	11.26	.534
1945	77.4	.940	12.77	.608	94.3	1.15	15.56	.743
1946	103	1.25	17.01	.808	86.1	1.05	14.20	.679
1947	60.2	.731	9.95	.472	60.4	.735	9.99	.475
1948	92.2	1.12	15.24	.724	112	1.36	18.55	.879
1949	120	1.46	19.85	.944	99.7	1.21	16.44	.782
1950	66.6	.809	10.98	.523	81.8	.994	13.51	.642
1951	97.0	1.18	16.00	.763	83.6	1.02	13.80	.659
1952	138	1.68	22.86	1.09	149	1.81	24.58	1.17
1953	104	1.26	17.16	.814	92.8	1.13	15.31	.730
1954	46.3	.563	7.64	.364	44.0	.535	7.25	.346
1955	77.6	.943	12.80	.609	84.2	1.02	13.90	.659
1956	89.7	1.09	14.84	.704	—	—	—	—
Highest	138	1.68	22.86	1.09	149	1.81	24.58	1.17
Average	86.5	1.05	14.28	.679	86.4	1.05	14.25	.679
Lowest	46.3	.563	7.64	.364	44.0	.535	7.25	.346

19. Monocacy River at Jug Bridge, near Frederick

Location.—Lat 39°24′13″, long 77°21′58″, on right bank a quarter of a mile upstream from Jug Bridge on U. S. Highway 40, 0.35 mile downstream from Linganore Creek, and 2½ miles east of Frederick, Frederick County.

Drainage area.—817 sq mi.

Records available.—October 1929 to September 1956. Monthly records December 1929 to September 1943 published in Bulletin 1 (October, November 1929 completed herein).

Gage.—Water-stage recorder. Datum of gage is 231.92 ft above mean sea level (Corps of Engineers benchmark).

Average discharge.—27 years, 916 cfs.

Extremes.—Maximum discharge, 51,000 cfs Aug. 24, 1933 (gage height, 28.1 ft); minimum, 35 cfs Oct. 1, 1930.

Maximum stage known, 30 ft in June 1889, from floodmarks (discharge, 56,000 cfs).

Monthly discharge of Monocacy River at Jug Bridge near Frederick

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1929–30						
October‡	11,000	147	1,240	1.52	1.75	0.982
November‡	7,160	350	1,270	1.55	1.73	1.00
December	1,620	—	655	.802	.92	.518
January	2,170	—	761	.931	1.07	.602
February	4,430	—	1,430	1.75	1.82	1.13
March	8,050	572	1,380	1.69	1.95	1.09
April	5,090	440	878	1.07	1.19	.692
May	530	177	297	.364	.42	.235
June	1,230	139	270	.330	.37	.213
July	604	68	127	.155	.18	.100
August	79	57	66.3	.081	.09	.052
September	142	39	70.2	.086	.10	.056
The year	11,000	39	699	.856	11.59	.553
1943–44						
October	4,340	69	341	0.417	0.48	0.270
November	17,100	233	1,176	1.44	1.61	.931
December	2,430	135	333	.408	.47	.264
January	22,000	236	1,785	2.18	2.52	1.41
February	1,000	240	464	.568	.61	.367
March	10,800	546	2,438	2.98	3.44	1.93
April	4,330	850	1,442	1.76	1.97	1.14
May	2,180	366	820	1.00	1.16	.646
June	2,500	185	360	.441	.49	.285
July	782	101	158	.193	.22	.125
August	159	46	82.7	.101	.12	.065
September	308	62	113	.138	.15	.089
The year	22,000	46	795	.973	13.24	.629

‡ Not previously published; October 1 to November 20 estimated.

Monthly Discharge of Monocacy River at Jug Bridge near Frederick—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1944–45						
October	1,160	99	229	0.280	0.32	0.181
November	950	116	206	.252	.28	.163
December	5,900	203	1,009	1.24	1.42	.801
January	2,650	270	508	.622	.72	.402
February	6,960	238	2,010	2.46	2.56	1.59
March	4,160	478	1,223	1.50	1.73	.969
April	6,010	464	1,100	1.35	1.50	.873
May	3,140	437	941	1.15	1.33	.743
June	900	255	459	.562	.63	.363
July	3,640	145	931	1.14	1.31	.737
August	7,280	329	1,064	1.30	1.50	.840
September	10,900	273	1,358	1.66	1.85	1.07
The year	10,900	99	912	1.12	15.15	.724
1945–46						
October	561	262	374	0.458	0.53	0.296
November	16,600	251	1,331	1.63	1.82	1.05
December	5,340	620	1,824	2.23	2.57	1.44
January	4,880	547	1,300	1.59	1.83	1.03
February	5,200	451	808	.989	1.03	.639
March	2,840	720	1,341	1.64	1.89	1.06
April	746	341	466	.570	.64	.368
May	6,230	310	1,012	1.24	1.43	.801
June	17,200	385	1,905	2.33	2.60	1.51
July	1,910	190	426	.521	.60	.337
August	3,240	227	539	.660	.76	.427
September	2,520	138	407	.498	.56	.322
The year	17,200	138	979	1.20	16.26	.776
1946–47						
October	1,520	183	400	0.490	0.57	0.317
November	386	239	277	.339	.38	.219
December	1,430	183	386	.472	.54	.305
January	4,520	496	1,171	1.43	1.65	.924
February	2,210	237	616	.754	.78	.487
March	4,280	360	1,078	1.32	1.52	.853
April	618	368	453	.554	.62	.358
May	6,970	386	1,098	1.34	1.55	.866
June	2,170	299	625	.765	.85	.494
July	3,690	246	787	.963	1.11	.622
August	1,320	166	331	.405	.47	.262
September	236	111	147	.180	.20	.116
The year	6,970	111	617	.755	10.24	.488

Monthly discharge of Monocacy River at Jug Bridge near Frederick—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1947–48						
October	225	96	116	0.142	0.16	0.092
November	4,170	138	830	1.02	1.13	.659
December	553	183	299	.366	.42	.237
January	12,800	270	1,199	1.47	1.69	.950
February	4,590	280	1,409	1.72	1.86	1.11
March	3,390	880	1,628	1.99	2.30	1.29
April	6,010	760	1,727	2.11	2.36	1.36
May	5,580	602	1,556	1.90	2.20	1.23
June	2,450	399	811	.993	1.11	.642
July	1,510	303	554	.678	.78	.438
August	1,880	232	548	.671	.77	.434
September	239	143	180	.220	.25	.142
The year	12,800	96	902	1.10	15.03	.711
1948–49						
October	701	153	299	0.366	0.42	0.237
November	3,890	211	1,126	1.38	1.54	.892
December	13,300	660	2,243	2.75	3.16	1.78
January	14,100	1,250	3,166	3.88	4.47	2.51
February	3,600	1,440	2,181	2.67	2.78	1.73
March	1,440	607	890	1.09	1.26	.704
April	4,700	672	1,376	1.68	1.88	1.09
May	1,800	421	819	1.00	1.16	.646
June	546	246	331	.405	.45	.262
July	24,100	179	2,571	3.15	3.63	2.04
August	778	179	350	.428	.49	.277
September	370	146	210	.257	.29	.166
The year	24,100	146	1,295	1.59	21.53	1.03
1949–50						
October	581	156	247	0.302	0.35	0.195
November	1,150	192	296	.362	.40	.234
December	5,000	204	745	.912	1.05	.589
January	1,150	346	547	.670	.77	.433
February	6,930	560	2,054	2.51	2.62	1.62
March	11,000	396	1,862	2.28	2.63	1.47
April	1,340	482	735	.900	1.00	.582
May	5,550	569	1,395	1.71	1.97	1.11
June	2,450	249	650	.796	.89	.514
July	698	152	280	.343	.39	.222
August	924	104	165	.202	.23	.131
September	3,610	138	657	.804	.90	.520
The year	11,000	104	795	.973	13.20	.629

Monthly discharge of Monocacy River at Jug Bridge near Frederick—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1950–51						
October	2,160	179	489	0.599	0.69	0.387
November	6,710	272	871	1.07	1.19	.692
December	12,800	450	1,933	2.37	2.73	1.53
January	3,370	607	1,281	1.57	1.81	1.01
February	8,060	985	2,743	3.36	3.50	2.17
March	4,720	790	1,389	1.70	1.96	1.10
April	2,360	731	1,188	1.45	1.62	.937
May	1,140	330	580	.710	.82	.459
June	7,800	283	1,579	1.93	2.16	1.25
July	2,750	239	550	.673	.78	.435
August	2,350	156	372	.455	.52	.294
September	408	116	179	.219	.24	.142
The year	12,800	116	1,084	1.33	18.02	.860
1951–52						
October	204	111	135	0.165	0.19	0.107
November	2,060	207	504	.617	.69	.399
December	3,790	250	1,129	1.38	1.59	.892
January	7,890	1,060	2,741	3.35	3.87	2.17
February	7,190	662	1,591	1.95	2.10	1.26
March	11,200	677	2,468	3.02	3.48	1.95
April	18,400	1,060	3,410	4.17	4.66	2.70
May	10,000	790	1,986	2.43	2.80	1.57
June	2,000	408	810	.991	1.11	.641
July	6,000	245	758	.928	1.07	.600
August	1,100	175	383	.469	.54	.303
September	6,000	195	877	1.07	1.20	.692
The year	18,400	111	1,398	1.71	23.30	1.11
1952–53						
October	324	176	214	0.262	0.30	0.169
November	17,400	176	1,463	1.79	2.00	1.16
December	6,430	514	1,392	1.70	1.96	1.10
January	7,710	632	2,403	2.94	3.39	1.90
February	4,400	812	1,382	1.69	1.76	1.09
March	5,370	746	2,143	2.62	3.02	1.69
April	2,940	758	1,426	1.75	1.95	1.13
May	3,650	632	1,534	1.88	2.16	1.22
June	3,980	299	764	.935	1.04	.604
July	2,000	179	326	.399	.46	.258
August	1,990	146	275	.337	.39	.218
September	854	126	200	.245	.27	.158
The year	17,400	126	1,126	1.38	18.70	.892

Monthly discharge of Monocacy River at Jug Bridge near Frederick—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1953–54						
October	272	101	123	0.151	0.17	0.098
November	346	118	168	.206	.23	.133
December	3,980	132	807	.988	1.14	.639
January	1,260	185	414	.507	.58	.328
February	1,890	175	440	.539	.56	.348
March	4,880	541	1,031	1.26	1.45	.814
April	2,840	324	718	.879	.98	.568
May	4,510	292	825	1.01	1.16	.653
June	365	138	205	.251	.28	.162
July	306	67	126	.154	.18	.100
August	872	51	178	.218	.25	.141
September	365	88	129	.158	.18	.102
The year	4,880	51	432	.529	7.16	.342
1954–55						
October	694	80	156	0.191	0.22	0.123
November	527	149	251	.307	.34	.198
December	3,110	130	686	.840	.97	.543
January	1,170	160	375	.459	.53	.297
February	4,790	160	990	1.21	1.26	.782
March	11,100	710	2,317	2.84	3.27	1.84
April	1,300	505	823	1.01	1.12	.653
May	978	243	407	.498	.57	.322
June	3,900	190	678	.830	.93	.536
July	1,230	108	296	.362	.42	.234
August	14,400	96	2,045	2.50	2.89	1.62
September	1,560	243	484	.592	.66	.383
The year	14,400	80	793	.971	13.18	.628
1955–56						
October	8,120	254	907	1.11	1.28	0.717
November	1,180	300	499	.611	.68	.395
December	360	170	245	.300	.35	.194
January	1,760	160	282	.345	.40	.223
February	7,660	985	2,304	2.82	3.04	1.82
March	7,550	632	2,051	2.51	2.89	1.62
April	5,520	587	1,434	1.76	1.96	1.14
May	999	314	536	.656	.76	.424
June	957	156	342	.419	.47	.271
July	9,900	146	1,052	1.29	1.48	.834
August	632	162	280	.343	.40	.222
September	708	138	220	.269	.30	.174
The year	9,900	138	841	1.03	14.01	.666

POTOMAC RIVER BASIN—*Continued*

Yearly discharge of Monocacy River at Jug Bridge near Frederick

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1930	699	0.856	11.59	0.553	462	0.565	7.67	0.365
1931	329	.403	5.46	.260	322	.394	5.35	.255
1932	523	.640	8.72	.414	876	1.07	14.60	.692
1933	1,590	1.95	26.37	1.26	1,310	1.60	21.74	1.03
1934	761	.931	12.66	.602	918	1.12	15.27	.724
1935	842	1.03	14.04	.666	723	.885	12.04	.572
1936	1,079	1.32	17.97	.853	1,127	1.38	18.77	.892
1937	1,249	1.53	20.73	.989	1,471	1.80	24.42	1.16
1938	872	1.07	14.48	.692	624	.764	10.36	.494
1939	907	1.11	15.07	.717	829	1.01	13.79	.653
1940	1,041	1.27	17.34	.821	1,316	1.61	21.92	1.04
1941	855	1.05	14.20	.679	539	.660	8.95	.427
1942	874	1.07	14.54	.692	1,256	1.54	20.87	.995
1943	1,139	1.39	18.92	.898	873	1.07	14.50	.692
1944	795	.973	13.24	.629	763	.934	12.70	.604
1945	912	1.12	15.15	.724	1,086	1.33	18.05	.860
1946	979	1.20	16.26	.776	772	.945	12.83	.611
1947	617	.755	10.24	.488	631	.772	10.46	.499
1948	902	1.10	15.03	.711	1,106	1.35	18.44	.873
1949	1,295	1.59	21.53	1.03	1,096	1.34	18.21	.866
1950	795	.973	13.20	.629	964	1.18	16.01	.763
1951	1,084	1.33	18.02	.860	956	1.17	15.88	.756
1952	1,398	1.71	23.30	1.11	1,506	1.84	25.09	1.19
1953	1,126	1.38	18.70	.892	963	1.18	15.98	.763
1954	432	.529	7.16	.342	431	.528	7.15	.341
1955	793	.971	13.18	.628	840	1.03	13.96	.666
1956	841	1.03	14.01	.666	—	—	—	—
Highest	1,590	1.95	26.37	1.26	1,506	1.84	25.09	1.19
Average	916	1.12	15.23	.724	914	1.12	15.19	.724
Lowest	329	.403	5.46	.260	322	.394	5.35	.255

20. Bennett Creek at Park Mills

Location.—Lat 39°17′40″, long 77°24′30″, on left bank 75 ft downstream from highway bridge, 0.2 mile south of Park Mills, Frederick County, 1.8 miles upstream from mouth, and 3.7 miles southwest of Urbana.

Drainage area.—62.8 sq mi.

Records available.—August 1948 to September 1956.

Gage.—Water-stage recorder and concrete control. Altitude of gage is 240 ft (from topographic map).

Average discharge.—8 years, 65.7 cfs.

Extremes.—Maximum discharge, 3,230 cfs Nov. 21, 1952 (gage height, 10.34 ft), from rating curve extended above 1,500 cfs on basis of slope-area determination at gage height 8.12 ft; minimum, 4.8 cfs Aug. 1, 2, 1954.

Monthly discharge of Bennett Creek at Park Mills

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1948						
August	179	22	50.6	0.806	0.93	0.521
September	58	16	21.9	.349	.39	.226
1948–49						
October	200	16	42.3	0.674	0.78	0.436
November	521	27	75.9	1.21	1.35	.782
December	1,070	61	180	2.87	3.31	1.85
January	700	96	211	3.36	3.88	2.17
February	300	120	169	2.69	2.81	1.74
March	321	68	102	1.62	1.87	1.05
April	199	58	84.7	1.35	1.50	.873
May	245	44	75.5	1.20	1.39	.776
June	48	25	34.2	.545	.61	.352
July	330	19	62.5	.995	1.15	.643
August	154	19	30.1	.479	.55	.310
September	53	15	23.0	.366	.41	.237
The year	1,070	15	90.7	1.44	19.61	.931
1949–50						
October	107	16	25.2	0.401	0.46	0.259
November	59	20	25.2	.401	.45	.259
December	233	20	54.6	.869	1.00	.562
January	145	27	39.7	.632	.73	.408
February	408	50	129	2.05	2.14	1.32
March	900	40	120	1.91	2.21	1.23
April	84	44	56.7	.903	1.01	.584
May	150	44	65.4	1.04	1.20	.672
June	100	19	38.1	.607	.68	.392
July	107	15	25.7	.409	.47	.264
August	36	10	14.1	.225	.26	.145
September	64	11	22.4	.357	.40	.231
The year	900	10	50.9	.811	11.01	.524

Monthly discharge of Bennett Creek at Park Mills—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1950–51						
October	134	13	24.5	0.390	0.45	0.252
November	592	19	49.6	.790	.88	.511
December	830	38	101	1.61	1.85	1.04
January	100	40	54.1	.861	.99	.556
February	671	60	153	2.44	2.54	1.58
March	215	65	88.3	1.41	1.62	.911
April	139	48	70.8	1.13	1.26	.730
May	149	35	55.9	.890	1.03	.575
June	672	30	140	2.23	2.49	1.44
July	152	27	47.6	.758	.87	.490
August	31	14	21.0	.334	.39	.216
September	20	9.5	12.9	.205	.23	.132
The year	830	9.5	67.5	1.07	14.60	.692
1951–52						
October	24	9.0	13.6	0.217	0.25	0.140
November	105	17	28.5	.454	.51	.293
December	216	15	49.1	.782	.90	.505
January	277	53	107	1.70	1.96	1.10
February	383	50	90.2	1.44	1.55	.931
March	297	52	102	1.62	1.87	1.05
April	1,570	70	263	4.19	4.67	2.71
May	560	78	166	2.64	3.05	1.71
June	213	39	69.2	1.10	1.23	.711
July	248	24	47.9	.763	.88	.493
August	648	25	61.3	.976	1.13	.631
September	886	28	67.1	1.07	1.19	.692
The year	1,570	9.0	88.5	1.41	19.19	.911
1952–53						
October	40	20	24.6	0.392	0.45	0.253
November	1,050	19	114	1.82	2.03	1.18
December	440	58	107	1.70	1.97	1.10
January	542	68	149	2.37	2.73	1.53
February	258	66	90.0	1.43	1.49	.924
March	613	63	173	2.75	3.18	1.78
April	216	74	116	1.85	2.05	1.20
May	371	58	122	1.94	2.23	1.25
June	194	32	58.9	.938	1.05	.606
July	112	19	28.9	.460	.53	.297
August	474	15	46.9	.747	.86	.483
September	134	13	22.7	.361	.40	.233
The year	1,050	13	87.8	1.40	18.97	.905

Monthly discharge of Bennett Creek at Park Mills—*Continued*

Month	Discharge in cfs				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1953–54						
October	49	12	15.5	0.247	0.28	0.160
November	59	15	21.3	.339	.38	.219
December	390	18	65.7	1.05	1.21	.679
January	120	21	39.6	.631	.73	.408
February	78	25	38.9	.619	.65	.400
March	250	38	59.8	.952	1.10	.615
April	226	30	59.4	.946	1.06	.611
May	225	24	54.8	.873	1.01	.564
June	156	11	23.0	.366	.41	.237
July	85	5.8	15.5	.247	.28	.160
August	243	5.2	19.2	.306	.35	.198
September	16	6.6	9.26	.147	.16	.095
The year	390	5.2	35.2	.561	7.62	.363
1954–55						
October	45	5.8	13.3	0.212	0.24	0.137
November	39	13	16.6	.264	.29	.171
December	158	10	35.4	.564	.65	.365
January	48	11	21.6	.344	.40	.222
February	563	13	74.4	1.18	1.23	.763
March	723	41	122	1.94	2.23	1.25
April	94	36	48.0	.764	.85	.494
May	100	17	30.5	.486	.56	.314
June	230	13	33.8	.538	.60	.348
July	106	6.6	14.9	.237	.27	.153
August	1,580	5.5	148	2.36	2.72	1.53
September	58	22	31.6	.503	.56	.325
The year	1,580	5.5	49.1	.782	10.60	.505
1955–56						
October	257	21	38.9	0.619	0.71	0.400
November	72	26	32.6	.519	.58	.335
December	30	17	22.4	.357	.41	.231
January	150	16	35.7	.568	.66	.367
February	382	60	131	2.09	2.24	1.35
March	636	50	128	2.04	2.35	1.32
April	168	45	73.0	1.16	1.30	.750
May	52	27	36.9	.588	.68	.380
June	69	17	27.5	.438	.49	.283
July	680	16	106	1.69	1.94	1.09
August	41	16	23.9	.381	.44	.246
September	73	13	21.8	.347	.39	.224
The year	680	13	56.2	.895	12.19	.578

POTOMAC RIVER BASIN—*Continued*

Yearly discharge of Bennett Creek at Park Mills

Year	Year ending Sept. 30				Calendar year			
	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in cfs		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1949	90.7	1.44	19.61	0.931	74.4	1.18	16.08	0.763
1950	50.9	.811	11.01	.524	56.8	.904	12.28	.584
1951	67.5	1.07	14.60	.692	60.5	.963	13.08	.622
1952	88.5	1.41	19.19	.911	101	1.61	21.98	1.04
1953	87.8	1.40	18.97	.905	75.9	1.21	16.39	.782
1954	35.2	.561	7.62	.363	32.1	.511	6.93	.330
1955	49.1	.782	10.60	.505	51.5	.820	11.12	.530
1956	56.2	.895	12.19	.578	—	—	—	—
Highest	90.7	1.44	19.61	0.931	101	1.61	21.98	1.04
Average	65.7	1.05	14.22	.679	64.6	1.03	13.98	.666
Lowest	35.2	.561	7.62	.363	32.1	.511	6.93	.330

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FIGURE 1. Gaging Station on Linganore Creek near Frederick

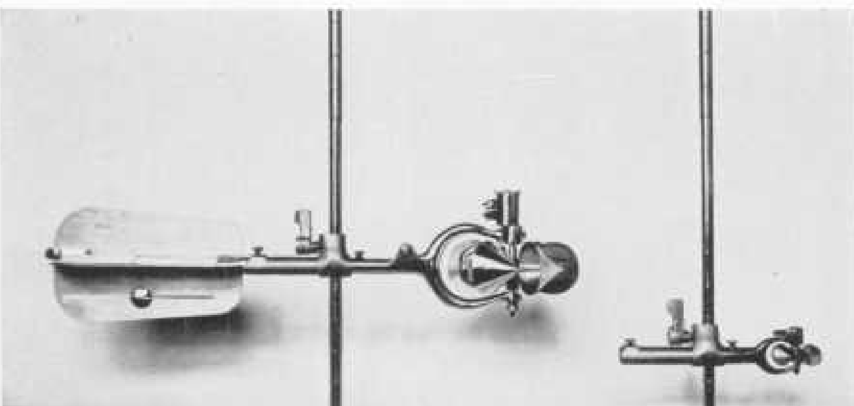
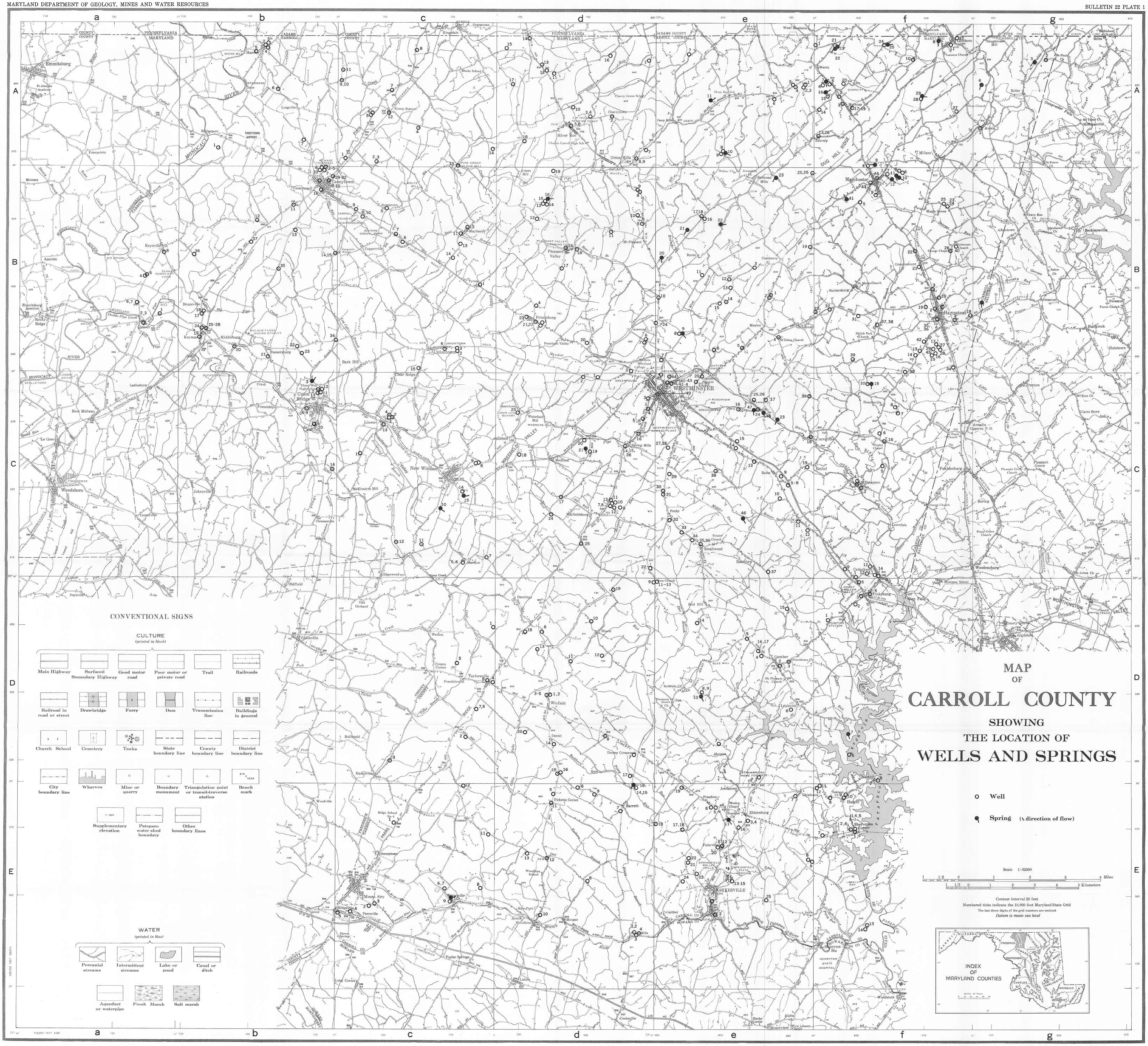
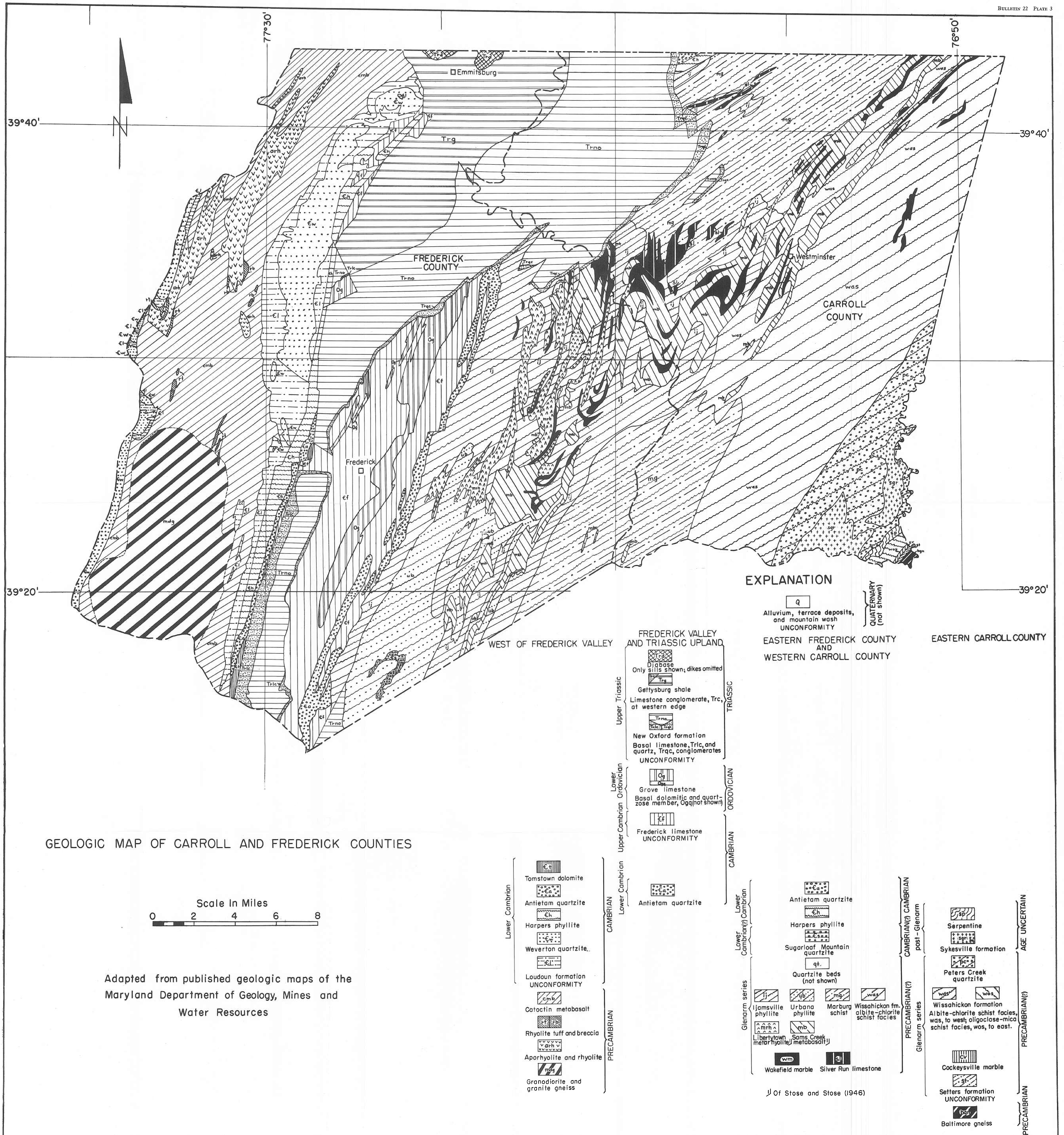


FIGURE 2. Price Standard Current Meter and Pygmy Meter suspended on Wading Rods, used to measure discharge

FIGURE 1. Engineer making measurement by wading

FIGURE 2. Highway Bridge Equipment Used to Measure Discharge at Stages Higher than Wading


MAP
OF
CARROLL COUNTY
SHOWING
THE LOCATION OF
WELLS AND SPRINGS
Well
Spring (↖ direction of flow)
Scale 1:62500
Miles
Kilometers
Contour interval 20 feet
Numbered ticks indicate the 10,000 foot Maryland State Grid
The last three digits of the grid numbers are omitted
Datum is mean sea level
INDEX
OF
MARYLAND COUNTIES
CONVENTIONAL SIGNS
CULTURE
(printed in black)
Main Highway
Surfaced Secondary Highway
Good motor road
Poor motor or private road
Trail
Railroads
Railroad in road or street
Drawbridge
Ferry
Dam
Transmission line
Buildings in general
Church
School
Cemetery
Tanks
State boundary line
County boundary line
District boundary line
City boundary line
Wharves
Mine or quarry
Boundary monument
Triangulation point or transit-traverse station
Bench mark
Supplementary elevation
Patapsco water shed boundary
Other boundary lines
WATER
(printed in blue)
Perennial streams
Intermittent streams
Lake or pond
Canal or ditch
Aqueduct or waterpipe
Fresh Marsh
Salt marsh
WESTMINSTER
Taneytown
Emmitsburg
Union Bridge
New Windsor
Manchester
Hampstead
Mount Airy
SYKESVILLE
Eldersburg
Woodsboro
Uniontown
Finksburg



GEOLOGIC MAP OF CARROLL AND FREDERICK COUNTIES

Adapted from published geologic maps of the Maryland Department of Geology, Mines and Water Resources