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COMMONWEALTH OF VIRGINIA

STATE COMMISSION ON CONSERVATION AND DEVELOPMENT

VIRGINIA GEOLOGICAL SURVEY

ARTHUR BEVAN, *State Geologist*

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Bulletin 50

DIVISION OF MINERAL RESOURCES
P. O. Box 3667, University Station
Charlottesville, Virginia

Ground-water Resources of Northern Virginia

BY

R. C. CADY

PREPARED IN COOPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY

UNIVERSITY, VIRGINIA
1938

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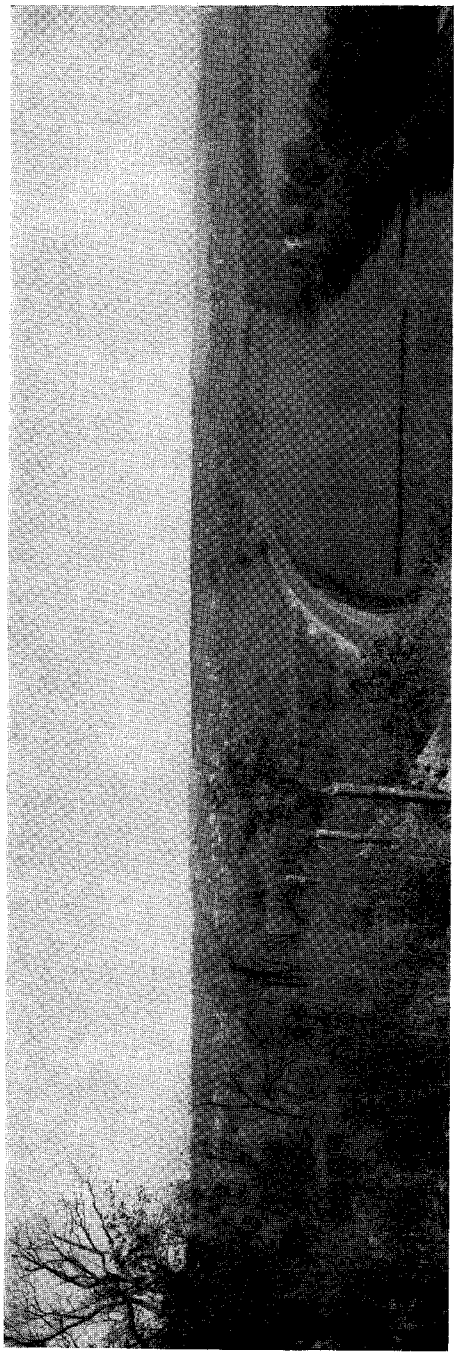
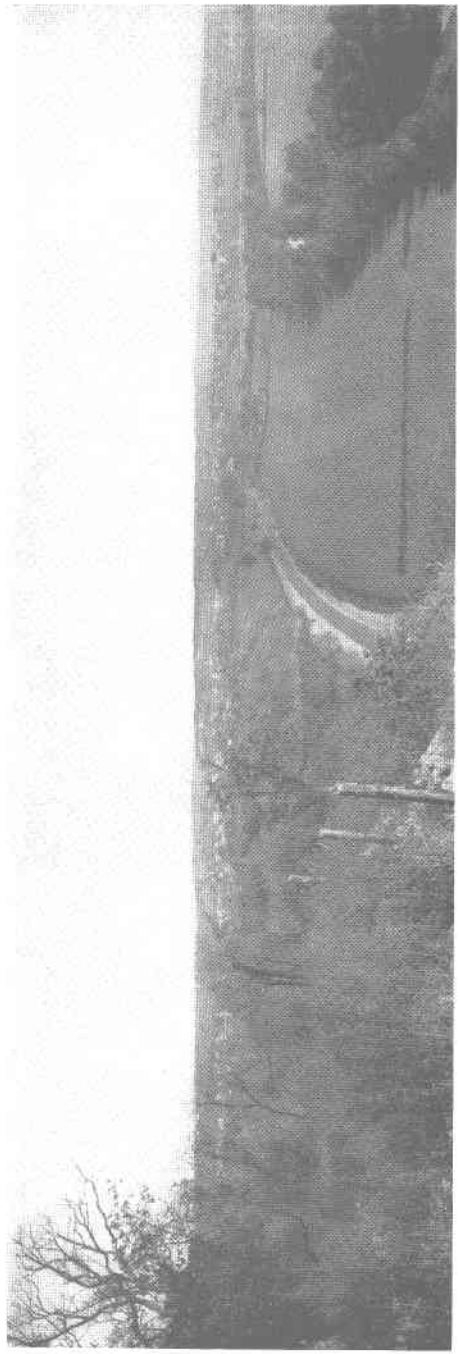


Erosion surfaces in the Shenandoah Valley near Strasburg, Shenandoah County, Virginia, looking north. Strasburg is situated on a terrace above the floodplain of the river. The dissected valley-floor peneplain is seen on the sky line.



Erosion surfaces in the Shenandoah Valley near Strasburg, Shenandoah County, Virginia, looking north. Strasburg is situated on a terrace above the floodplain of the river. The dissected valley-floor peneplain is seen on the sky line.

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LETTER OF TRANSMITTAL

COMMONWEALTH OF VIRGINIA
VIRGINIA GEOLOGICAL SURVEY
UNIVERSITY OF VIRGINIA

CHARLOTTESVILLE, VA., January 25, 1938.

To the State Commission on Conservation and Development:

GENTLEMEN:

I have the honor to transmit and recommend for publication as Bulletin 50 of the Virginia Geological Survey series of reports the manuscript and illustrations of the *Ground-water Resources of Northern Virginia,* by Mr. R. C. Cady of the United States Geological Survey.

This report is the second complete one of a series based on detailed field investigations of the ground-water resources of Virginia made in cooperation with the United States Geological Survey. The previous report is Virginia Geological Survey Bulletin 45, *Ground-water Resources of the Shenandoah Valley, Virginia,* published in 1936. Because of the lack of and urgent need for fundamental data about the occurrence of ground water in the diverse rocks in Virginia, a *Preliminary Report on Ground-water Resources of Northern Virginia* was published in 1933 as Bulletin 41 of the State Geological Survey.

The occurrence and quality of the ground water in Arlington, Clarke, Fairfax, Frederick, Loudoun, and Prince William counties are described in detail in this report, which gives also information concerning some wells in adjacent parts of Fauquier, Shenandoah, and Warren counties. In addition, the occurrence of ground water in relation to types of rocks and rock structure and the water-bearing properties of the rocks underlying northern Virginia are discussed. The report includes a brief summary of the geography, climate, drainage, geomorphology and geology of that part of the State.

As the amount and distribution of ground water depend upon local conditions and as there is a great demand for reliable, up-to-date information about these conditions by industries, municipalities and property owners, this report should be of value to everyone interested in northern Virginia.

Respectfully submitted,

ARTHUR BEVAN,
State Geologist.

Approved for publication:
State Commission on Conservation and Development,
Richmond, Virginia, January 31, 1938.
R. A. GILLIAM, *Executive Secretary and Treasurer.*

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Ground-Water Resources of Northern Virginia

By R. C. Cady

ABSTRACT

The area in northern Virginia discussed in this report includes Arlington, Fairfax, Prince William, Loudoun, Clarke, and Frederick counties and the independent cities of Alexandria and Winchester. This area consists of four physical divisions or provinces, which are unlike in geologic history, topography, and in the kind and structure of their underlying rocks. The Valley and Ridge province extends westward into West Virginia from the Shenandoah River in Clarke County. It is characterized by ridges, composed of resistant quartzite, separated by lowlands underlain by folded beds of limestone and shale. The Blue Ridge is a province of itself, being a long narrow ridge of granite, greenstone and some masses of shale and quartzite on which are preserved the remnants of three or more ancient erosion surfaces. The Piedmont province lies between the Blue Ridge and the easternmost parts of Prince William County and the southeastern part of Arlington and Fairfax counties. It is a dissected plateau sloping toward the southeast. Its eastern and western margins are underlain by ancient deformed sedimentary rocks, and igneous rocks, much metamorphosed, but near the center there is a wedge-shaped block of conglomerate, sandstone, shale, and trap, or diabase of Triassic age which has sunk into the older rocks along a fault on its western border. Near the eastern limit of the area covered by this report the surface of the ancient crystalline rocks dips seaward more steeply than the surface of the Piedmont plateau and the sand, silt and clay which characterize the Coastal Plains province have been deposited upon this surface. The eastward slope of the surface of the Coastal Plain is very gentle, and the rivers are sluggish and tidal.

Frederick County is separated into two different parts by Little North Mountain. West of the mountain are mostly shale, mudstone, and sandstone of Silurian and Devonian age. The wells are mostly weak, shallow, the water highly mineralized. There are some flowing wells, and in the valleys the water does not lie very deep below the ground. Springs are numerous and used extensively by the inhabitants. East of the mountain, the rocks are limestone and shale of Cambrian and Ordovician age. The rocks yield larger quantities of water than those to the west of the mountain, but a few wells are very weak, especially

in the limestone outcrops. The wells in the limestone are deeper and deliver more water on the average than the wells in the Ordovician (Martinsburg) shale. There are many very large springs in the limestone country, especially near the western boundary of the shale.

Clarke County is underlain mostly by limestone, dolomite and calcareous shale, in which the ground water occurs in solution cavities. If a well encounters a large water-bearing cavity, the amount of water obtained may be very great. On the contrary some wells pass through massive rock, and are very nearly failures, or actually dry. Springs were widely used on the lowland of Clarke County but a great number of them failed in the summers of 1930 and 1931. Hard pre-Cambrian crystalline rocks and the metamorphosed Cambrian formations of the Blue Ridge crop out east of the Shenandoah River. These rocks are massive and hard and it is difficult to obtain more than a very few gallons of water a minute from a well of moderate depth. There are springs along the mountain that are small in flow, but dependable and otherwise desirable. The water contains but little dissolved mineral matter.

Loudoun County is underlain mainly by granite and greenstone on Catoctin Mountain and westward. These rocks are the same as those in the Blue Ridge, and they are equally poor as water-bearers. East of the mountain is the area of Triassic conglomerate, sandstone, shale, and trap or diabase. These rocks are not metamorphosed to any considerable degree, and, except for the trap or diabase, are fair water-bearers. Most wells are not over 100 to 150 feet deep. In the trap or diabase shallow wells may obtain moderate supplies in some places, but those that strike no water immediately below the zone of soil are unlikely to get any farther down. The water in the Triassic rocks is hard and contains much iron.

Prince William County includes some areas of Triassic rocks. East of them are schist and granite which are somewhat less prolific as sources of water than the Triassic rocks. The schist is a better source of water than the granite. Farther east, near the Potomac River, the sands, silts, and clays of the Coastal Plain thicken from their frayed western border toward the southeast. Near the western border, these sediments are not very good sources of water, but eastward near Potomac River they become the best water-bearing formations in the area. The water is mostly of excellent quality, although in some cases organic matter or iron may be present in objectionable quantities. Wells near the level of the river are likely to flow under natural artesian pressure.

In Fairfax County the rocks are of the same types as in Prince William County: the belt of Triassic rocks in the west, the schist and

granite in the medial portion, and on the southeast, the sediments of the Coastal Plain.

Arlington County is underlain mostly by granite, but there are some sediments of the Coastal Plain near Alexandria.

INTRODUCTION

The area covered by this report consists of a tier of six counties which extends across the northern part of Virginia from the West Virginia boundary to the District of Columbia and comprises an aggregate of 1,919 square miles. (See Pl. 2.) Named from west to east the counties are Frederick, Clarke, Loudoun, Prince William, Fairfax, and Arlington.

This is the first unit area to be covered in a systematic investigation of the underground-water, or ground-water resources of the State, which has been undertaken as a result of a cooperative agreement between the State and Federal Geological Surveys. The investigation was begun by the writer in July, 1931, under the direction of O. E. Meinzer, geologist in charge of the division of ground water, United States Geological Survey. A preliminary report describing the general ground-water conditions was published in 1933 as Bulletin 41 of the Virginia Geological Survey.

The geologic map accompanying this report (Pl. 2) is based in general on the State geologic map published in 1928 by the Virginia Geological Survey. However, the part covering the Shenandoah Valley is based largely on the map published by the Virginia Geological Survey as Bulletin 42 resulting from the recent detailed studies of Charles Butts. The part covering the Triassic area is based largely on the published map by Joseph K. Roberts,[1] and the part covering the area of more ancient crystalline rocks is based largely on the published and unpublished work of Miss A. I. Jonas.

The hydrologic information was obtained in the field by the writer during the summer and early autumn of 1931. Personal observations, interviews with the owners of wells and springs, and discussions with municipal and corporation officials yielded the records of about 1,300 wells given in this report and the other data concerning the ground-water conditions of the area upon which the report is based. Much of the information obtained from well owners and drillers was given from memory, and some of it, therefore, is doubtless inaccurate. Most of the wells in regard to which information was obtained are household wells, for which only a small water supply is needed. When enough water is obtained the drilling is generally stopped, no effort being made to develop the maximum possible supply. Moreover, wells of large yield are generally not tested to their maximum capacity.

[1] Roberts, J. K., The geology of the Virginia Triassic: Virginia Geol. Survey Bull. 29, 1928.

On the other hand, the yield of the wells is not always accurately measured by the drillers and is probably often overestimated. With the above facts in mind, the writer has summarized the information obtained and has interpreted it to the best of his ability on the basis of his studies of the structure, texture, and water-bearing properties of the rock formations.

The report contains chemical analyses of about 60 samples of water collected by the writer in the course of the field work. The analyses were made by S. K. Love in the Water Resources laboratory of the United States Geological Survey.

The writer is especially indebted to the following well drillers for information: Messrs. W. E. Croson and George Cullen, of Arlington County; F. N. Hagmann, Jr., William Puckett, James Franklin, and Beatty and Aicholtz, of Fairfax County; Henry Seeley, Lee Johnson, Charles Daniels, and D. H. Sherman, of Prince William County and nearby parts of Fauquier County; L. W. Wortman, E. S. Adrian, Chester Fields, Robert Miller, Reed, Charles Wine and Ridgeway, of Loudoun County and northern Fauquier County; Fred Stickley, James Feltner, Turner Catlett, William J. Gochenour, Totten, Fred Braithwaite, Russell de Haven, Albert Thompson, Showalter, John Rinker, and Wade Muse, of the northern Shenandoah Valley region; and Charles F. Cole, president of the Virginia Machinery and Well Co., of Richmond, Virginia.

GEOGRAPHY

POPULATION

The area and population, according to the Fifteenth Census of the United States, for Frederick, Clarke, Loudoun, Prince William, and Arlington counties are given below.

TABLE 1.—*Area and population of counties and independent cities in northern Virginia, in 1930*

County or Independent City	Area	Population	
		Total	Per Square Mile
Frederick	431	13,167	30.5
[a]Winchester (city)	4	10,855	2,713.8
Clarke	171	7,167	41.9
Loudoun	519	19,852	38.3
Prince William	345	13,951	40.4
Fairfax	416	25,264	60.7
Arlington	25	26,615	1,064.6
[a]Alexandria (city)	8	24,149	3,018.6

[a] In northern Virginia there are two independent cities, Alexandria and Winchester, each of which has the same status as a county. For convenience in presentation, each of these cities is listed in the census tables immediately following the county in which it is geographically located. The statistics as given for the county do not include the independent city.

The relative density of the population of Arlington County is due to the fact that this county is part of the suburban area adjacent to Washington, D. C., and to Alexandria, Virginia, whereas the other counties are chiefly devoted to agriculture.

The incorporated places, with their population, are listed by counties below.

TABLE 2.—*Population of the larger communities of northern Virginia, by counties, in 1930*

COUNTY	TOWN	POPULATION
Frederick	Middletown	416
	Stephens City	606
	Winchester	10,855
Clarke	Berryville	1,094
	Boyce	325
Loudoun	Hamilton	295
	Hillsboro	119
	Leesburg	1,640
	Lovettsville	239
	Middleburg	298
	Purcellville	747
	Round Hill	359
	Waterford	256
Prince William	Dumfries	157
	Haymarket	167
	Manassas	1,215
	Occoquan	221
	Quantico	538
Fairfax	Accotink	194
	Alexandria	24,149
	Centerville	100±
	Clifton	181
	Dranesville	100±
	Fairfax	640
	Floris	100±
	Herndon	887
	Langley	114
	McLean	200
	Vienna	903
Arlington and Fairfax	Falls Church	2,019
Arlington	Fort Myer Heights	700

The industrial development of each of the counties described in this report is shown in the following table.

TABLE 3.—*Number of industrial establishments and value of products, by counties, in 1929*

COUNTY	NUMBER OF INDUSTRIAL ESTABLISHMENTS	VALUE OF PRODUCTS
Frederick county and Winchester city..	52	$ 7,301,663
Clarke.....	9	722,700
Loudoun.....	18	658,910
Prince William.....	15	495,438
Fairfax.....	14	375,811
Arlington county and Alexandria city..	51	8,868,761

The principal industrial development is in Arlington County, adjacent to Washington, D. C., and in Frederick County, in the Shenandoah Valley, in which the city of Winchester is situated. A moderate industrial expansion may be expected in the future. The existing industrial establishments consist chiefly of ice plants, creameries, feed and flour mills, quarries, and in Frederick County establishments engaged in packing and canning of fruits.

AGRICULTURE

The chief crops of northern Virginia are corn, hay, wheat and oats, fruit, potatoes, and other vegetables. Dairying is an active industry. The percentage of the total area devoted to farming is as follows:

TABLE 4.—*Percentage of area in northern Virginia in farms, by counties, in 1930*

COUNTY	PERCENTAGE OF AREA IN FARMS
Frederick.....	81.2
Clarke.....	91.5
Loudoun.....	85.4
Prince William.....	56.8
Fairfax.....	46.4
Arlington.....	9.4

Clarke County has the highest proportion of farm lands. It has no mountainous areas, as have Frederick and Loudoun counties, and has suffered less from soil depletion and other adverse circumstances operating toward the desertion of farm lands and their conversion into timber lands than Fairfax and Prince William counties. Arlington County and, to a much smaller degree, Fairfax County include urban and suburban property holdings. There has been a considerable increase in grazing and dairying east of the Blue Ridge and in the growing of apples and other fruit on a large scale farther west.

CLIMATE

Temperature.—The average annual temperature, the average of the mean annual temperatures of all stations in the northern Virginia area, is 53.8° F., with a minimum mean monthly temperature of 32.3° F. in January and a maximum mean monthly temperature of 75.2° F. in July. The mean yearly temperature and mean monthly temperature of the individual meteorologic stations in the area, together with the altitude of the stations above sea level, are given in Table 5. At all stations except Mount Weather the lowest mean monthly temperature occurs in January, whereas at Mount Weather the lowest is in February. The delayed minimum probably is a result of local topographic conditions. The mean yearly temperature and the mean monthly temperature at the various stations are progressively lower the greater the altitude of the station above sea level.

A general characteristic of the climate of the region is its variability, and this generalization applies well to the temperature. Some years are characterized by unusually warm summers and abnormally cold winters, but this relation is by no means inevitable: a period of unusual warmth or cold may persist almost uninterruptedly through all seasons for several years. In addition to the seasonal variations in temperature, there are many sudden changes brought about by cyclonic disturbances of the atmosphere. Warm southerly winds often produce mild temperature in the middle of winter, followed in a day or so by cold northerly winds.

The growing season—that is, the period between the last killing frost in spring and the first killing frost in autumn—is about 209 days, averaged for the whole area, and ranges from 159 days at Mount Weather to 231 days at Washington. In general the stations having the higher temperature have the longer growing season, as would be expected.

Precipitation.—The average of the mean annual rainfall at all stations in the area is 39.37 inches. The heaviest mean monthly rainfall is 4.41 inches, in June, and the lightest is 2.21 inches in November. The following tables give the mean monthly and mean annual rainfall at the several stations in the area:

The rainfall of the region is subject to wide variations from year to year—for instance, the total precipitation in 1930 was only about one-third of the precipitation recorded in 1889. Figure 1 shows graphically the total precipitation recorded at Washington, D. C., for the years 1870 to 1937. During the period from 1870 to 1890 the rainfall equalled or exceeded 50 inches five times,

TABLE 5.—*Mean monthly and annual air temperature at U. S. Weather Bureau stations in northern Virginia and the District of Columbia*

STATION	Altitude above Sea Level (Feet)	Number of Years of Record	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean for Year
Washington	112	62	33.4	35.3	42.6	53.3	63.7	72.2	76.7	75.0	68.1	57.4	45.2	36.6	55.0
Quantico	26	32	34.7	35.0	45.6	54.5	64.0	72.6	77.3	74.3	68.4	57.2	45.0	36.0	55.4
Lincoln	500	31	32.2	32.7	43.1	53.6	63.8	71.4	76.0	73.6	68.1	56.8	44.6	33.8	54.1
Mount Weather	1,725	28	30.1	29.5	39.3	49.4	59.0	67.0	70.2	69.2	67.8	51.7	41.8	32.0	50.3
Winchester	717	28	31.2	34.1	42.9	53.2	63.2	72.5	67.0	70.4	67.4	56.1	44.9	36.0	54.0
Monthly mean, all stations	.....	.....	32.3	33.3	42.7	52.8	62.9	71.1	75.2	72.5	68.0	55.8	44.3	34.9	53.8

TABLE 6.—*Mean monthly and annual precipitation, in inches, at U. S. Weather Bureau stations in northern Virginia and the District of Columbia*

STATION	Altitude above Sea Level (Feet)	Number of Years of Record	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean for Year
Washington	112	62	3.55	3.27	3.75	3.27	3.70	4.13	4.71	4.01	3.24	2.84	2.37	3.32	42.16
Quantico	26	32	3.15	2.56	3.45	2.92	3.11	4.13	4.01	4.41	2.85	2.89	1.89	2.89	38.46
Lincoln	500	31	3.11	2.39	3.05	3.27	3.53	5.03	3.48	4.29	2.74	2.98	2.14	2.90	38.77
Mount Weather	1,725	28	3.12	2.07	2.64	3.27	3.83	4.98	4.27	4.96	3.11	3.33	2.17	2.47	40.52
Winchester	717	28	2.72	1.89	2.68	3.37	4.19	3.80	3.53	3.68	3.21	2.56	2.49	2.83	36.95
Monthly mean, all stations	.....	.....	3.15	2.44	3.11	3.22	3.67	4.41	4.00	4.27	3.03	2.92	2.21	2.94	39.37

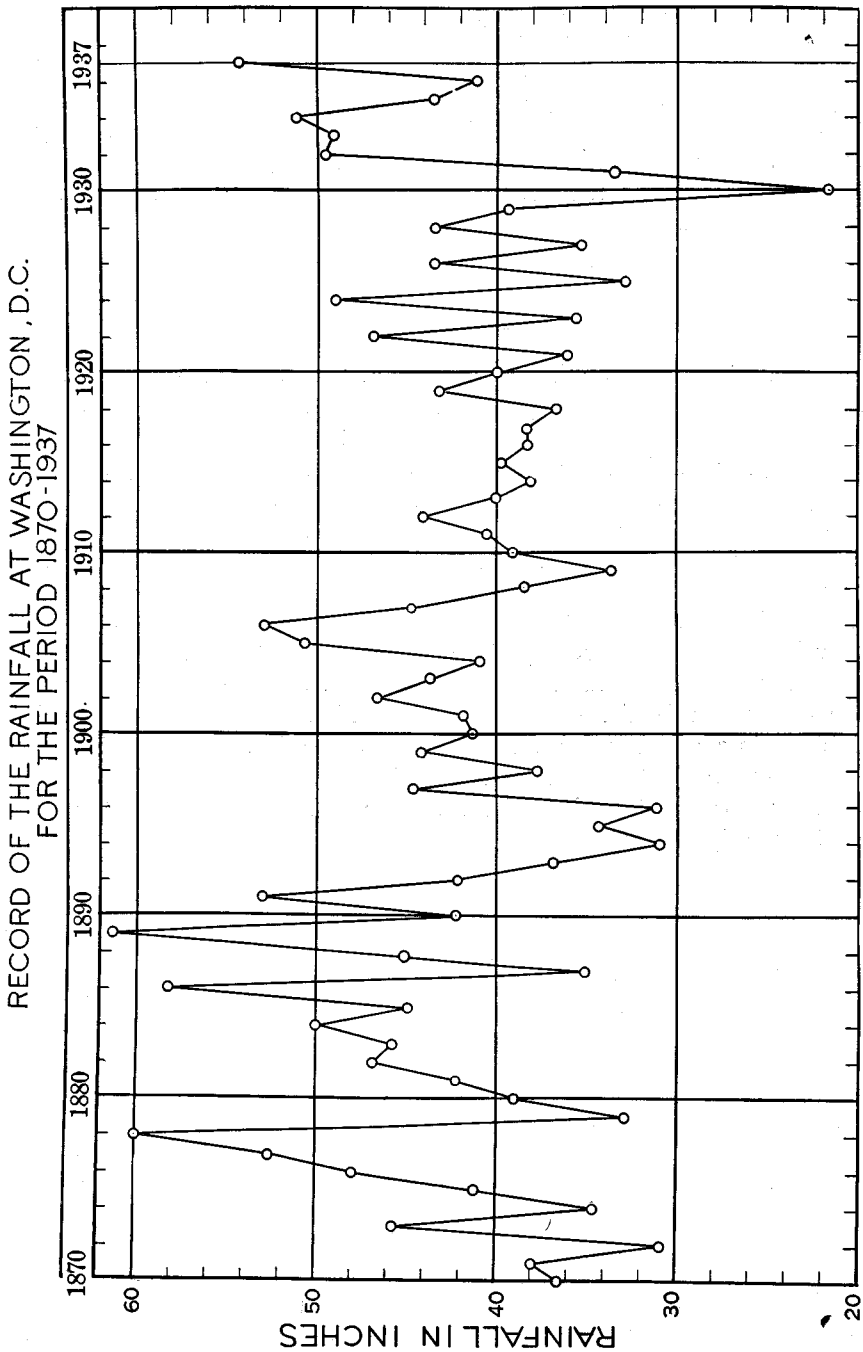


FIGURE 1.—Record of the rainfall at Washington, D. C., for the period 1870-1937.

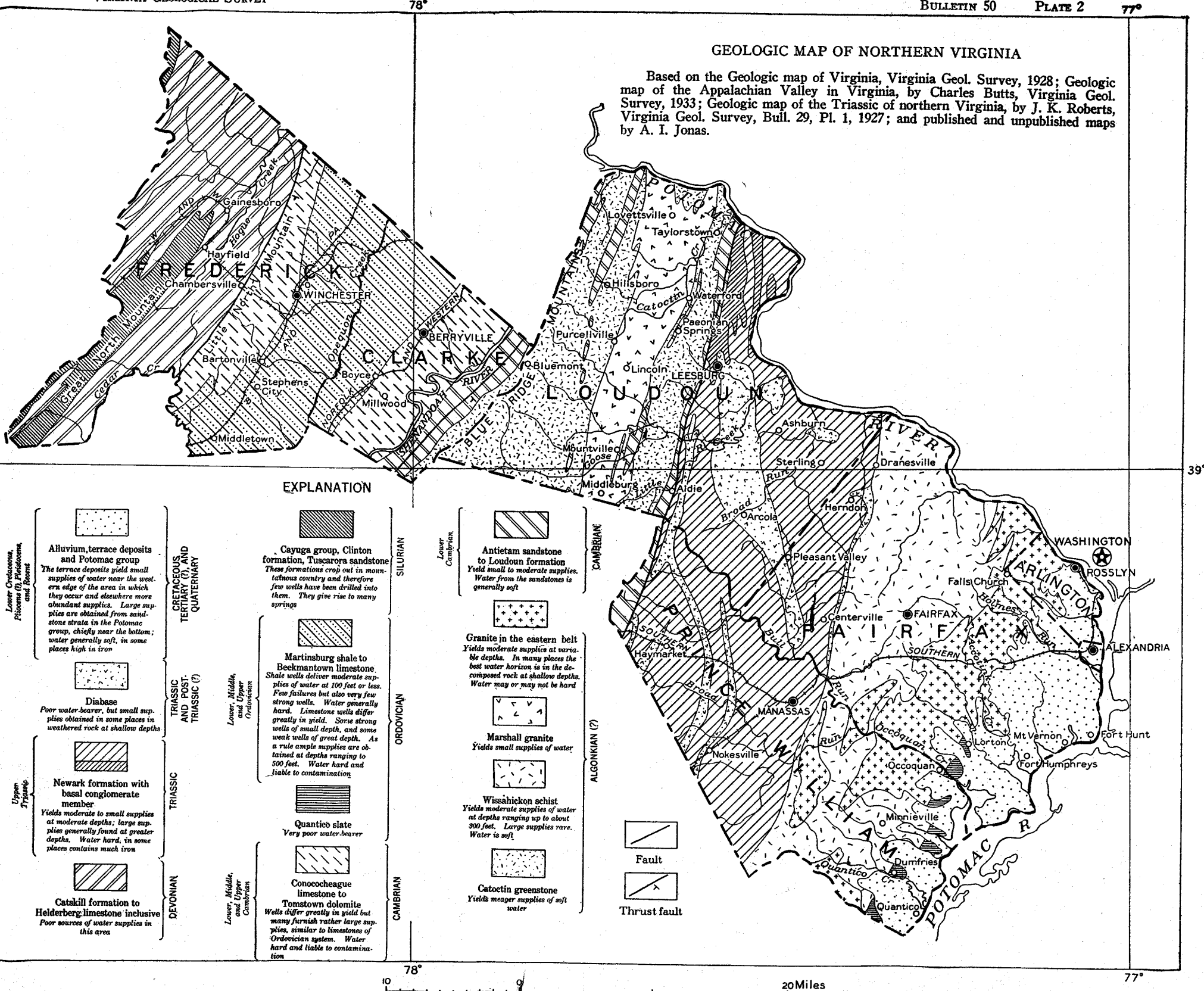
whereas in the subsequent 47 years of record the rainfall reached or exceeded 50 inches only four times. On the other hand, before 1890 the rainfall fell at or below 35 inches four times, and during the following 47 years it fell at or below 35 inches seven times. Thus the period from 1870 to 1890 was characterized by greater, but more variable, rainfall and by the wettest years in the record, whereas the period following 1890 is characterized by less rainfall, less variability from year to year, and the driest year on record. Apparently the trend since 1931 is upward.

DRAINAGE

Northern Virginia is drained by the tributaries of Potomac River, most of which, except Shenandoah River, are small streams. Many of these tributaries flow northeast by north into the Potomac, parallel to the structural trend of the underlying rocks; many others cut through the mountains by way of water gaps in courses unrelated to the structural trend. In the Shenandoah Valley Shenandoah River, Opequon Creek, and Hogue Creek follow the trend of the rocks, whereas Cedar Creek does not. In the Piedmont area, east of the Blue Ridge, most of the streams flow into Potomac River by the shortest route, and their drainage pattern is rather normal, except for a few, chief among which is the Goose Creek-Little River system, which appears to have had at one time a course due east and later to have been deflected northward to Potomac River. In the southeastern part of the area the streams flow into the Potomac estuary in an easterly or southeasterly direction.

GEOLOGIC MAP OF NORTHERN VIRGINIA

Based on the Geologic map of Virginia, Virginia Geol. Survey, 1928; Geologic map of the Appalachian Valley in Virginia, by Charles Butts, Virginia Geol. Survey, 1933; Geologic map of the Triassic of northern Virginia, by J. K. Roberts, Virginia Geol. Survey, Bull. 29, Pl. 1, 1927; and published and unpublished maps by A. I. Jonas.



GEOMORPHOLOGY

Valley and Ridge province.—Frederick County and most of Clarke County lie in the Valley and Ridge province, which includes all of that part of northern Virginia west of the Blue Ridge. The sandstones, shales, and limestones of Paleozoic age that underlie the province were folded into synclines and anticlines (Figs. 2 and 3), which subsequently were beveled by long-continued erosion to form a nearly level lowland. This lowland was then elevated in successive steps and was further eroded. The less resistant rocks, such as the shales and limestones, were the most extensively weathered and eroded and hence form the present valley areas. The more resistant rocks, such as the sandstones, were less weathered and eroded and hence form the present ridges.

During the erosion of the rocks of this province, most of the streams courses became so modified by the distribution of hard and soft rocks that they acquired linear patterns. Some streams in the area were not so modified, Cedar Creek being the most noteworthy example, for it cuts through Little North Mountain in a water gap. Gap Run has breached the same ridge near Chambersville, Frederick County. At Cedar Grove and Green Spring there are smaller water gaps. The three examples last mentioned appear to be streams that were once tributary to Opequon Creek but have been captured by headwaters of Back Creek.

Little North Mountain extends northeastward through Frederick County and is the first ridge on the west to rise above the lowland that lies immediately west of the Blue Ridge—the Shenandoah Valley, which is developed upon easily eroded and weathered shales and limestones. West of Little North Mountain the terrane is underlain by some younger, more resistant rocks, such as shale and sandstone, than those east of it, and consequently that area is more mountainous than Shenandoah Valley.

To the most casual observer it is clear that the topography of this province has undergone a complex history. At several times the earth's crust has remained stable long enough for the processes of weathering and erosion to reduce the region to a more or less flat surface or peneplain. The streams, rejuvenated by an uplift of the land, then cut valleys into the old plain, and a new erosion cycle began. The periods of crustal stability and therefore of prolonged erosion have become shorter from the past to the present and each erosion cycle and peneplain has been less complete than the first one, whose remnants are called the summit peneplain.[2] During the oldest erosion cycle, a peneplain

[2] Stose, G. W., Manganese deposits of the west foot of the Blue Ridge, Virginia: Virginia Geol. Survey Bull. 17, pp. 34-40, 1919.

was developed by the streams in the whole Appalachian region, including the Piedmont province. The interstream divides were cut down largely to the common level, and hard as well as soft rocks were beveled. After a long time the whole region was uplifted with respect to sea level, and the streams became swifter and began to cut valleys into the old plain. When the uplift ceased, the streams cut down nearly to the base-level of erosion and then began, by lateral planation, to remove the interstream divides. The second interval was not long enough for the streams to destroy those portions of the old plain that were underlain by the more resistant rocks, and therefore the ridges of harder rock stood out above the newer plain. Great North Mountain, in Frederick County, presumably retains a remnant of the first or summit peneplain. Still another uplift caused the dissection of the second or upland peneplain, and it was almost completely destroyed except where it was preserved on more resistant rocks in the same manner as the summit peneplain but at a lower altitude. Thus the part of the Blue Ridge which stands 2,500 feet above sea level near Front Royal and portions of Little North Mountain at the same altitude are taken to be remnants of this upland peneplain. A still lower surface known as the intermediate peneplain, was developed and later partly destroyed after crustal uplift, and it is believed to be represented by certain knobs and spurs along the western face of the Blue Ridge and also by the summit of the Blue Ridge near Potomac River. During the next period of crustal quiescence the softer and more soluble rocks of the Shenandoah Valley were weathered and eroded into a broad, flat valley floor, and the valley-floor peneplain may still be seen on the accordant summits of the low hills in the valley at an altitude of about 600 feet. Below these summits is a terrace, developed along the main streams during the last erosion cycle before the present one. (See Pls. 1 and 4, A.) The streams have cut below this terrace and are now engaged in widening and deepening their channels, a task which they will continue until there is another disturbance of the base level of stream erosion.

Blue Ridge province.—In northern Virginia the Blue Ridge province is restricted to a single ridge of ancient, hard rock, the Blue Ridge proper. The altitude of the Blue Ridge decreases from south to north. The higher portion at the south represents an ancient erosion surface, the upland peneplain, and knobs, spurs, and coves along the flanks of the Blue Ridge, as well as the lower portion of the crest near Potomac River, are the remnants of the younger intermediate peneplain. Since the time of the summit or perhaps the upland peneplain the Blue Ridge has been a divide for all the streams in the area except Potomac River.

Piedmont province.—The Piedmont province is underlain by rocks differing widely in character, age, and origin. It is a moderately dis-

sected surface extending from the Blue Ridge, on the west, to the Coastal Plain, on the east, and sloping from an altitude of about 500 feet on its western edge to about 300 feet on its eastern edge. Its drainage is rather complex and in some places shows a remarkable independence of the character and structure of the underlying rocks.

Coastal Plain province.—The Coastal Plain province is underlain by comparatively recent, more or less unconsolidated and undeformed sediments. The landward limit of the province is marked by a belt of country that is commonly called the Fall Line, or Fall Zone, where the ancient rocks that form the land surface of the Piedmont province pass beneath the newer sediments of the Coastal Plain. In the Fall Zone the streams of the Piedmont province descend over rapids into gorges that lead out to the wide and sluggish courses characteristic of the Coastal Plain province. Many of the larger streams, including Potomac River, are estuarine to the Fall Zone. The Coastal Plain province has had a complex erosional and depositional history, during which the coast line has shifted widely in position. At each successive position a sea bench with a wave-cut scarp was formed, and when the sea receded this bench remained as dry land. Thus the surface of the province consists largely of a series of dissected ancient sea benches at successively higher levels in the landward direction. Late in the development of this province the sea level rose and drowned the lower parts of the stream systems, thus converting them into estuaries of very intricate outline.

OUTLINE OF ROCK FORMATIONS

The rocks of northern Virginia may be classified into four broad types, based upon the age and lithology of the formations—(1) the pre-Cambrian and early Paleozoic metamorphosed and deformed sediments and igneous rocks; (2) the less altered, folded Paleozoic sandstones, shales, and limestones of the Shenandoah Valley and the area west of Little North Mountain; (3) the comparatively undeformed Triassic conglomerates, sandstones, and shales with their associated bodies of intrusive and extrusive diabase; and (4) the unconsolidated or slightly consolidated undisturbed Cretaceous and younger sediments of the Coastal Plain. The stratigraphic succession is shown in Table 7.

TABLE 7.—*Geologic formations in northern Virginia*

AGE	GROUP AND FORMATIONS		THICKNESS (FEET)	LITHOLOGY	WATER-BEARING PROPERTIES
Recent Pleistocene Pliocene (?)	Alluvium and terrace deposits		35±	Clay, loam, sand, gravel, and peat, cross-bedded and heterogeneous, characteristically yellowish. Gravel in a sandy matrix is common.	Recent alluvium, especially in the Potomac estuary, is a good water-bearer, but water may be of doubtful sanitary quality. The terrace deposits are a poor source of water.
Lower Cretaceous	Potomac group	Patapsco formation	0–100	Highly colored, variegated clay, interbedded with and grading into sand, sandy clay, and gravel. Arenaceous material in places indurated; sands usually cross-bedded; some of the clays dark with lignite.	Large supplies may be expected from deep, properly developed wells out from the western boundary of the Coastal Plain; nearer the border they are apt to be weak. Shallow wells usually weak. The water is generally but not everywhere soft. Soft water contains sodium carbonate as chief mineral constituent, and locally iron is present in sufficient quantities to limit the usefulness of the water.
		Patuxent formation	0–200	Prevailingly arenaceous with buff and light-colored sands characteristic, some coarse and some fine, arkosic in many places. Cross-bedding is the rule. Much of the sand is cemented with iron oxide. Red, drab, and lignitic clay intercalated.	

TABLE 7.—*Geologic formations in northern Virginia—Continued*

AGE	GROUP AND FORMATIONS	THICKNESS (FEET)	LITHOLOGY	WATER-BEARING PROPERTIES
Post-Triassic (?) and Upper Triassic	Diabase		Dikes, sills, and stocks of hard gray to greenish-black diabase. Exhibits spheroidal weathering near surface. Composed of plagioclase, pyroxene, olivine, and magnetite, and is wholly crystalline.	Poor water bearer. Best results obtained in weathered zone near surface. Many deep wells are failures. Very hard drilling. Water generally hard.
Upper Triassic	Newark formation	0–1,500	Red shale predominates, but gray, blue, black, and decolorized shales are included. Some parts are fissile, others massive mudstone.	Fair water bearer. The deeper the well, the greater the yield on the average, but care must be taken not to enter the rock floor beneath. Water generally hard.
			Red, gray, and yellow muddy sandstones of varying hardness due to unequal cementation; in places arkosic.	
			Conglomerate borders the northwestern boundary of northern Virginia Triassic basin. Rounded pebbles of limestone having either a white calcareous or a red ferruginous cement.	Fair water bearer down to 200 feet, almost dry below that depth. Water generally hard.

TABLE 7.—*Geologic formations in northern Virginia—Continued*

AGE	GROUP AND FORMATIONS	THICKNESS (FEET)	LITHOLOGY	WATER-BEARING PROPERTIES
Upper Devonian	Catskill formation	2,000±	Red mudrock and red micaceous sandstone, with some gray, green, and yellow sandstone and shale.	Very poor water bearers. No data on deep wells, but those more than 100 feet deep yield no more, on the average, than those less than 100 feet deep.
	Jennings formation	4,250 (?)	Upper 2,500 feet consists of dark-bluish and green sandstone with some argillaceous and arenaceous shale. Weathers to rusty color. Lower 1,750 feet less sandy, and consists of olive-green, stiff siliceous shale with intercalated beds of green fine-and even-grained flagstone.	
Middle Devonian	Romney shale	1,350	Predominantly fissile black shale with bands of black argillaceous limestone; stiff, hackly olive-green mudrock, and beds of sandstone. Olive-green shale in some places fissile, in others compact, with lenses of black, knotty argillaceous limestone.	

TABLE 7.—*Geologic formations in northern Virginia—Continued*

AGE	GROUP AND FORMATIONS	THICKNESS (FEET)	LITHOLOGY	WATER-BEARING PROPERTIES
Lower Devonian	Oriskany sandstone	200±	Gray to white and blue siliceous and calcareous sandstone and conglomerate.	Surprisingly poor results. Generally hard water.
	Helderberg limestone	500	Gray to dark-gray, somewhat cherty medium-bedded limestone; fine-to coarse-grained limestone, with beds of knotty, dark siliceous limestone and thin-bedded laminated blue limestone.	Surprisingly poor for a limestone. Hard water.
Silurian	Cayuga group	1,050	Thin-bedded black limestone with soft gray calcareous shale which weathers yellow. White and red sandstone, alternating with laminated gray limestone. Red sandstone and much soft fissile yellow shale.	
	Clinton formation	50±	Ferruginous thin-bedded sandstone, buff fine-grained fissile shale, and gray and green shale. Lower half consists of pure-white quartzitic and conglomeratic sandstone grading downward into a dull-red thick-bedded ferruginous sandstone.	
	Tuscarora sandstone	400	Thick-bedded buff, firmly cemented quartzite.	

TABLE 7.—*Geologic formations in northern Virginia—Continued*

AGE	GROUP AND FORMATIONS	THICKNESS (FEET)	LITHOLOGY	WATER-BEARING PROPERTIES
Upper Ordovician	Juniata formation	150	Red and some gray and green mudrock and red sandstone.	
	Oswego sandstone	200-300	Thick-bedded brownish speckled sandstone.	Martinsburg shale is a reliable, consistent source for shallow drilled wells. Unwise to drill deeper than 200 feet, and chances are poor of obtaining a large supply from a single well. Water likely to be poor and hard.
	Martinsburg	2,000-3,000	Yellow, greenish, dark-gray, and black carbonaceous and calcareous shale, with some arkosic sandstone and thin limestone beds. Mostly fissile but in part massive.	
Middle Ordovician	Chambersburg limestone	200-250	Dark compact nodular argillaceous limestone.	Good wells in these formations and in the Frederick limestone.[a] Depth of 400 feet a good place at which to stop drilling an unpromising well. Water generally hard. The Quantico slate[b] is a poor water bearer.
Lower Ordovician	Athens (?) limestone	100±	Shaly limestone with some dark even-bedded limestone.	
	Stones River group: Lenoir limestone	50	Black crystalline limestone containing black chert.	
	Stones River group: Mosheim limestone	50	Light dove-gray compact limestone.	
	Beekmantown limestone	2,500	Bluish fine-grained thick-bedded limestone, sparingly fossiliferous. In part somewhat cherty.	

[a] The Frederick limestone (probably of Chazy age) consists of blue, slaty crystalline limestone, which is brought to the surface by faulting north of Leesburg, Loudoun County.

[b] The Quantico slate (Ordovician) of Prince William County and the southeastern part of Fairfax County consists of blue slate with a conglomerate at the base and some interbedded rhyolite flows.

TABLE 7.—*Geologic formations in northern Virginia—Continued*

AGE	GROUP AND FORMATIONS	THICKNESS (FEET)	LITHOLOGY	WATER-BEARING PROPERTIES
Upper Cambrian	Conococheague limestone	2,000±	Blue magnesium limestone with thin, contorted argillaceous laminae that weather slowly and stand out on the outcrops in a characteristic fashion. Contains intercalated beds of sandstone and dolomite, with oolitic and conglomeratic limestone.	Very good source of water, but gives erratic results for different localities. Water hard.
Middle Cambrian	Elbrook limestone	1,500±	Blue and gray argillaceous thin-bedded limestone and calcareous shale.	
.....?.....	Waynesboro formation	1,500-1,800	Characterized by red mudrock, mostly green shale, some calcareous flaggy sandstone, and dolomite.	Only one well in this formation; it shows a good yield and is only of moderate depth.
Lower Cambrian	Tomstown dolomite	1,200	Blue-gray to dark-gray coarse-grained thick-bedded dolomite with some beds of limestone.	Fair water bearer; wells less than 100 feet deep give largest yields. Water hard.
	Antietam sandstone	500	White to dull light-brown fossiliferous sandstone composed of well-worn grains of quartz.	Poor source of water; wells 100 to 200 feet deep seem to give best results.
	Harpers shale	800-2,000	Grades vertically into Antietam sandstone. Uniform textured dull bluish-gray sandy shale with a few beds of sandstone. Weathers to light greenish-gray.	

TABLE 7.—*Geologic formations in northern Virginia—Continued*

AGE	GROUP AND FORMATIONS	THICKNESS (FEET)	LITHOLOGY	WATER-BEARING PROPERTIES
Lower Cambrain	Weverton sandstone	800	White to gray massive-bedded sandstone, composed of fine grains of water-worn quartz. Some fine conglomerate included.	Poor source of water; wells 100 to 200 feet deep seem to give best results.
	Loudoun formation	10–800	Dominantly a dark-gray fine textured slate, with shale, sandstone, and conglomerate.	

TABLE 7.—*Geologic formations in northern Virginia—Continued*

AGE	GROUP AND FORMATIONS	THICKNESS (FEET)	LITHOLOGY	WATER-BEARING PROPERTIES
Algonkian (?)	Granite of the eastern belt		Dark bluish-gray when fresh; rather fine and uniform texture; composed of quartz, plagioclase, muscovite, biotite, and subsidiary minerals. Exhibits locally well-marked planes of schistosity. A later, more massive facies shows some mineral parallelism, but not schistosity.	Poor water bearer. Best results seem to be found between 200 and 300 feet, but it is thought that at such depths the water is often of shallower origin. Lower limit of drilling should be 500 feet and preferably 300 feet. Water hard in many places.
	Marshall granite		Light-gray, pink, and green granite and quartz monzonite injected by pegmatite with blue quartz. In places spotted with garnets. May be massive, gneissoid, or schistose, with considerable mineral alteration. Relations to granite of the eastern belt unknown.	Poor water bearer; an added yield of 5 gallons a minute for each 100 feet of depth seems to be the rule.
	Peters Creek quartzite		Quartzite and chlorite schist.	
	Wissahickon schist	1,000±	Finely crystalline, sparkling bluish-green schist, composed of chlorite, muscovite, and quartz in variable quantities and albite at certain horizons. Closely crumpled. Contains intercalated lava flows.	Fair water bearer. Scant data seem to indicate a sudden increase in yield below 300 feet, but there is a uniform yield from 100 to 300 feet. Generally good water.

TABLE 7.—*Geologic formations in northern Virginia—Continued*

AGE	GROUP AND FORMATIONS	THICKNESS (FEET)	LITHOLOGY	WATER-BEARING PROPERTIES
Algonkian (?)	Catoctin greenstone	1,000±	Basalt flows altered to a crystalloblastic green amphibolite, containing remnants of feldspar, hornblende with some original pyroxene, secondary quartz, epidote, and chlorite. Occurs as a massive amygdaloidal as well as hornblende schist.	Poor water bearer; shallow wells seem to be as satisfactory as deep ones. Drilling very difficult. Water generally of excellent quality.
	White marble		White and crystalline.	Not many data. Seems to be only fair water bearer for a calcareous sediment.

GEOLOGIC HISTORY AND STRUCTURE

The geologic history of this area, in so far as it is recorded in the rocks, began in Algonkian (?) time, with the deposition of calcareous materials on the floor of a sea which invaded the western part of the present Piedmont province and perhaps the entire northern Virginia area. Later the sea apparently withdrew and a thick covering of basaltic lava was poured out over the calcareous deposits. Farther to the east, during the same or a subsequent invasion of the sea, a thick deposit of mud was laid down to form what is now the Wissahickon schist, and then it was covered by sand. After an unknown interval granitic magma invaded these sediments in both the eastern and western parts of the Piedmont region, perhaps contemporaneously, to form the Marshall granite and the granite of the eastern belt. A crustal disturbance began to exert tremendous compressive stresses in late pre-Cambrian time and the rocks of the Piedmont area were folded and metamorphosed. As a result of the intrusions and deformations the calcareous deposits were converted into the white marble, the lava flows into the Catoctin greenstone, the mud into the Wissahickon schist, and the sand into the Peters Creek quartzite. The deformation of the Piedmont region was followed by a long period of erosion, as a result of which the deep-seated granites were exposed.

The advent of the Cambrian period ushered in the long Paleozoic era, with almost unbroken marine sedimentation in at least parts of the area. The Lower Cambrian sediments were perhaps the most widespread, as they still occur in outcrops as far east as Bull Run Mountain, in Prince William County.

Most of the other Paleozoic formations were, however, apparently laid down only in the western part of the area. In general, the early Paleozoic deposits above the basal arenaceous deposits are limestones, dolomites, and calcareous shales, whereas the Martinsburg shale and higher formations are with a few exceptions dominantly clastic.

The variations in the sedimentation during the Paleozoic era were produced by only minor geographic changes. It was not until the end of that era that a radical change occurred—the Appalachian revolution. From the southeast came great compressive forces which crumpled the earth's crust, shortening its southeast-northwest dimension in the area affected by many miles, and built up great mountains out of the former sea bottom. The rocks of the Piedmont region were folded into a syncline in the eastern part, and into an arch known as the Catoctin-Blue Ridge anticlinorium farther to the west and further altered. Early in the deformation they were pushed bodily northwestward, along low-angle fault planes, over the younger sediments. One of the main over-

thrust faults lies at the western foot of the Blue Ridge. (See Pl. 2.) The dominant structural feature of the Shenandoah Valley east of Little North Mountain is a large syncline, along the axis of which lies an outcrop of Martinsburg shale. The eastern limb of the syncline was partly overridden by the Blue Ridge overthrust mass, and the western limb is terminated by the trace of another overthrust fault along which the syncline itself moved northwestward. (See Pl. 2 and Fig. 4.) West of Little North Mountain is a large anticline with smaller folds near by. The axis of this anticline forms Great North Mountain.

The Appalachian revolution was followed by a long period of erosion during which the mountains were worn down, probably nearly to a plain. Then in the Triassic period an elongated basin began to form in the Piedmont area, and gravel, sand, and mud were deposited by the streams in this basin. During and after this sedimentation igneous material was intruded in the form of sills, dikes, and stocks of diabase and extruded as lava flows. In late Triassic or post-Triassic time the basin was broken into blocks by normal faults, and the western border was down-faulted about 500 feet or less,[3] forming the Catoctin border fault. Thus the Triassic sediments were depressed into the older rocks and were partly preserved from later erosion.

After the Triassic period there was still more erosion, with the development of extensive lowland plains. In early Cretaceous time the nonmarine Patuxent and Patapsco formations were laid down in the eastern part of the area. After their deposition there was probably no more sedimentation in this area until late in the Tertiary period or early in the Pleistocene epoch, when the high-level terrace deposits were laid down. Later in the Pleistocene epoch and in the Recent epoch other gravel deposits were spread over the older formations at lower levels in the eastern part of the area.

[3] Roberts, J. K., The geology of the Virginia Triassic: Virginia Geol. Survey Bull. 29, p. 77, 1928.

OCCURRENCE OF GROUND WATER IN RELATION TO ROCK STRUCTURE

Unconformities mark buried ancient land surfaces and imply the cessation of one period of sedimentation and the beginning of another, generally with an intervening period of erosion. There may or may not be a radical difference in the nature of the deposits in the two series of unconformable sedimentary rocks. Where there is not, the unconformity is of no particular interest in the discussion of ground water, but where there is, especially where there is also a discordance in the dip of the two series of beds, the unconformity must exert some influnce upon the movement and disposition of the ground water. For instance, at many places in the Atlantic Coastal Plain the unconformity between the Cretaceous beds and the underlying ancient rocks repre-

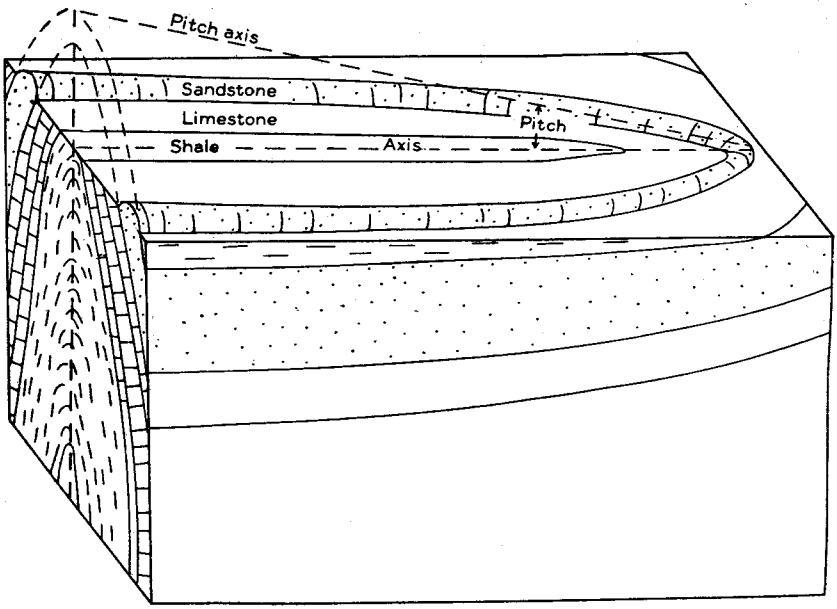


FIGURE 2.—Block diagram of an eroded pitching anticline. The beds of shale, limestone, and sandstone have been closely folded and beveled by streams and other agents. The weak rocks occupy a lowland surrounded by a ridge of resistant sandstone. The anticline pitches to the right, causing the outcrops of formations to disappear successively in that direction.

sents an excellent water horizon, and at the same time it generally marks the lower limit of large water supplies. An unconformity may be marked by a weathered zone, and in such a zone fractures, solution channels, and decomposed rock serve as good water-bearers. Valleys

with alluvial fill in the buried ancient land surface may also serve as excellent water conduits, whereas the ancient divides may be barren of water.

Anticlines, or up-folds, in the beds of rock, affect the ground water in two important respects: First, if the anticlinal axis plunges, artesian head may be developed along the axis. (See Fig. 2.) Second, a good water-bearing formation may be brought to or near the surface along the axis of an anticline, whereas on the sides of the anticline this formation may be too deeply buried to be reached in drilling. The Cayuga group of limestones, the Helderberg limestone, and the Oriskany sandstone of the western part of Frederick County are near the surface on the limbs of anticlines, and they are more promising sources of water supplies than the overlying Devonian sediments or the underlying Silurian formations. A well may also tap the water-bearing bed at some point down the dip from the axis, and the water that has percolated from the outcrop down to the well may be less highly mineralized than the water farther away from any outcrop of that bed.

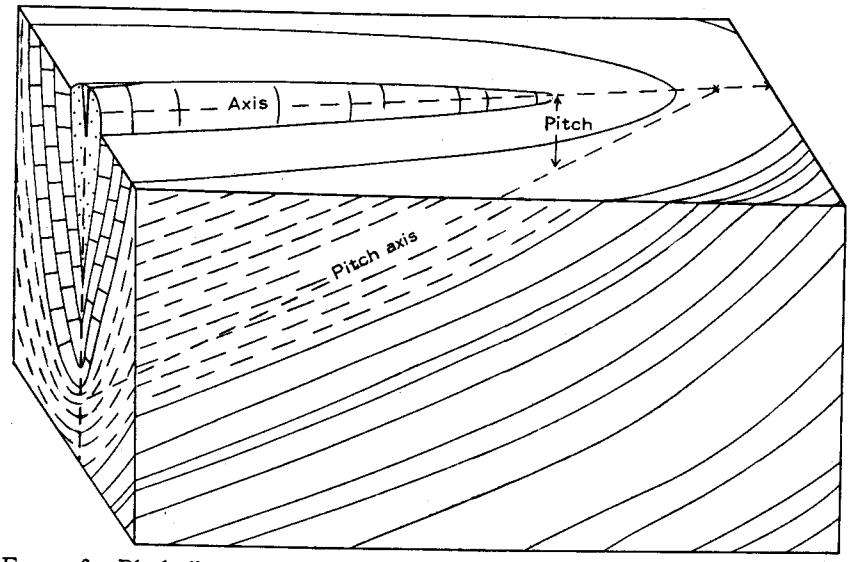


FIGURE 3.—Block diagram of an eroded pitching syncline. (Compare with Fig. 2.) The resistant sandstone forms a ridge in the lowland eroded on the surrounding weaker limestone and shale.

Synclines, or down-folds, are in general favorable to the development of artesian pressure, and if the water-bearing beds crop out in the limbs of the syncline at higher altitudes than the land surface nearer the axis, the conditions are favorable for obtaining flowing wells. (See Fig. 3.) On the other hand, a syncline may carry a water-bearing bed to such great depths as to make it unavailable for wells near the axis

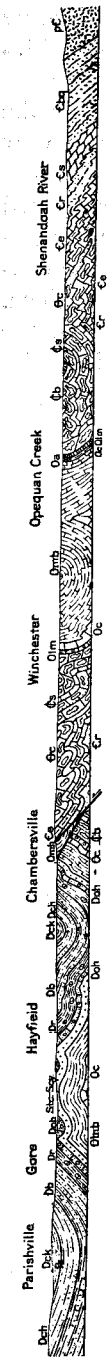


FIGURE 4.—Structure section across Frederick and Clarke counties, Virginia. From the Geologic map of the Appalachian Valley in Virginia, by Charles Butts, 1933. Dck, Catskill formation; Db and Dch, Brallier shale and Chemung formation (together called Jennings formation in this report); Dr, Romney shale; Doh, Helderberg limestone and Oriskany sandstone; Scy, Cayuga group; Stc, Tuscarora sandstone and Clinton formation; Omb, Martinsburg shale; Oc, Chambersburg limestone; Oa, Athens shale (called Athens (?) limestone in this report); Olm, Stones River group; Ꞓb and Ꞓs, Beekmantown limestone; Ꞓc, Conococheague limestone; Ꞓe, Elbrook limestone; Ꞓr, Rome formation (called Waynesboro formation in this report); Ꞓs, Shady dolomite (called Tomstown dolomite in this report); Ꞓbq, Basal Cambrian quartzites; pꞒ, pre-Cambrian.

of the fold. If water percolates into the outcrop of a water-bearing bed at a high level on one side of a syncline, it may be carried down the dip of the bed to a great depth, heated as a result of the high temperature prevailing at that depth, and thence carried up by artesian pressure to the opposite side, where it may be discharged as a warm spring at a level lower than the outcrop. The warm springs of central-western Virginia are, according to Reeves,[4] due to this condition.

Faults, or displacements of the rocks along fissures, may act in any of three ways to modify the disposition of ground water. A fault fissure may act as a conduit, especially if the rock which it cuts is brittle. Thus warm water or even hot water may be brought to the surface along faults from great depths. If the fault fissure is filled with gouge it may act as an impenetrable dam to store water on the upstream side, or the water may be dammed if the broken edge of the water-bearing bed is brought next to an impermeable bed by the faulting. A fault may displace a water-bearing bed so that it may be encountered in drilling at either a higher or a lower level than where it is expected, or it may cut out the bed entirely at the well site, or it may cause the bed to be encountered twice in the same well. In the northern Virginia area faults are comparatively rare, and so far as known there are no local examples of the effect of faults upon ground water. (See Fig. 4.)

Joints, fissures, and bedding planes may be efficient conduits for water, especially if they are near enough to the surface to be enlarged by weathering and solution. Joints and fissures are likely to decrease in size and number with depth, but bedding planes may remain channelways even at considerable depths. In beds of soluble rock, such as limestone, the structural features men-

[4] Reeves, Frank, Thermal springs of Virginia: Virginia Geol. Survey Bull. 36, pp. 28-35, 1932.

tioned may be enlarged greatly by the solution of the walls, and a great maze of interconnected tunnels and galleries may carry large quantities of water, forming true underground streams and lakes.

In northern Virginia artesian conditions are best developed in the Coastal Plain, where flowing wells are obtained on the lowlands near sea level. The deposits underlying the Coastal Plain consist of alternating beds of sand, gravel, silt, and clay, which dip at low angles toward the east from their outcrop areas. The water-bearing sand and gravel generally contain water under some artesian pressure, owing to the confining effects of the less permeable clay beds above and below them. Water under artesian head is also encountered in some places in the Triassic rocks, especially in the western part of the Triassic basin, where the westward dip of the rocks is greatest.

OCCURRENCE OF GROUND WATER IN RELATION TO THE PRINCIPAL TYPES OF ROCKS

Igneous rocks.—Intrusive igneous rocks do not contain interconnected pore spaces through which water may pass, but after earth stresses have acted upon them, they develop joints in two or more intersecting sets and in some places shear zones and faults. The joints are attacked by weathering and solution and consequently are most open near the surface. (See Pls. 3, A and 7, A.) In addition, the joints become less numerous with depth. In such intrusive rocks ground water in economic quantities is generally found in the joints, and therefore the likelihood of obtaining a water supply from these rocks to depths of more than a few hundred feet is small. Shear zones and faults may yield water freely and go deeper than the joints, but they are found only in certain localities. A zone of weathered rock, most commonly very porous, at the base of the soil is generally promising as a source of water, and it is suspected that in many deep wells drilled in granitic rocks the chief supply of water comes from the weathered material.

Rocks formed of extrusive lava are extensively jointed and contain flow breccia, lava tunnels, and other large openings which are excellent water conduits and make this rock a superior water bearer. In the course of time these openings are generally obliterated by pressure, recrystallization, and other agencies, and hence lava rocks, such as the Catoctin greenstone, that were originally doubtless excellent water-bearing formations have become very unproductive.

Metamorphic rocks.—Contact metamorphism, whereby new material has been introduced into a rock, is usually detrimental to that rock's water capacity, because not only are its pore spaces filled with the new material, but replacement may destroy all the openings that might serve as channelways for water.

Regional metamorphism may increase the capacity of a rock for water, especially where a shale or an igneous rock is compressed into a schist. The incipient fracture planes so developed may become enlarged by weathering, so that large quantities of water may move through or be stored in them. A schist is usually rather soft and easy to drill. A slate behaves very similarly to a schist, in that the slaty cleavage provides excellent space for water when the cleavage planes are once opened up. A gneiss is not usually different from a granite in its water-bearing properties. When a limestone is changed into a marble the joints and solution channels are likely to be closed, but new openings of the same kind may later be developed in the marble. A quartzite is a very poor water-bearer unless it is fractured, and even then

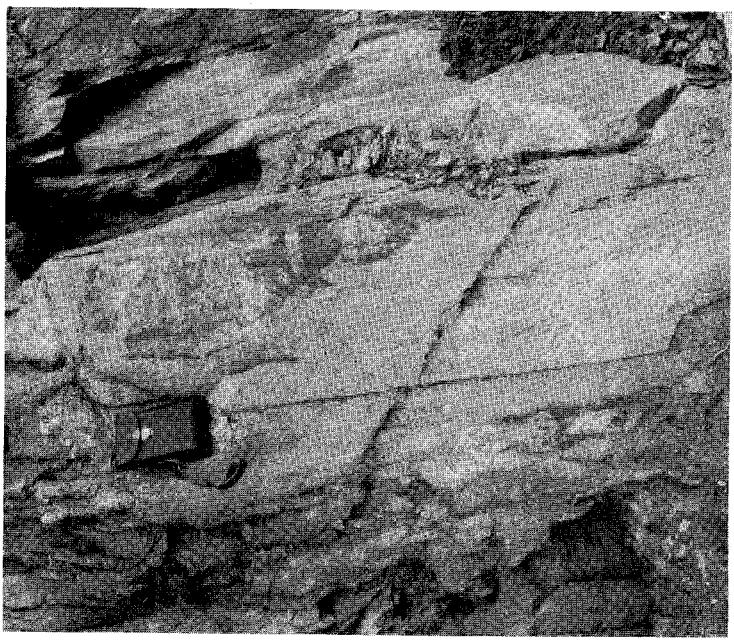
it may remain a poor source of water, because its relative insolubility prevents much enlargement of its fractures by solution. (See Pl. 3, B.) It is also hard to drill.

Sedimentary rocks.—The clastic rocks, such as gravel, conglomerate, sand, sandstone, silt, clay, and shale, and their derivatives of mixed types, differ from one another in their water-bearing properties. Clean gravel, such as some of that encountered locally in the sediments of the Coastal Plain, is one of the best of water-bearing beds. Much gravel, however, has a matrix of silt or sand that diminishes its permeability to a greater or lesser extent. Conglomerate is generally a poorer source of water than gravel, owing to the cementation of the matrix. In cemented conglomerate the water must percolate through fractures, which may be rare, as in the limestone conglomerate of Triassic age in northern Virginia.

A well-sorted sand usually yields large quantities of water. In the Potomac group the chief water supplies are generally found in beds of sand. Sandstone, if the sand was clean and well sorted and has not been cemented too much, is also an excellent water-bearer. Much sandstone is jointed and bedded, and in such rock the joints and bedding planes add considerably to the space available for water. However, the Cambrian, Silurian, Devonian, and Triassic sandstones of northern Virginia are disappointingly poor water-bearers, because of the high degree of cementation and poor sorting. The Triassic sandstones contain much silt, which not only reduces the number of large pore spaces but also makes the rocks less brittle and hence less likely to fracture and produce joints under stress.

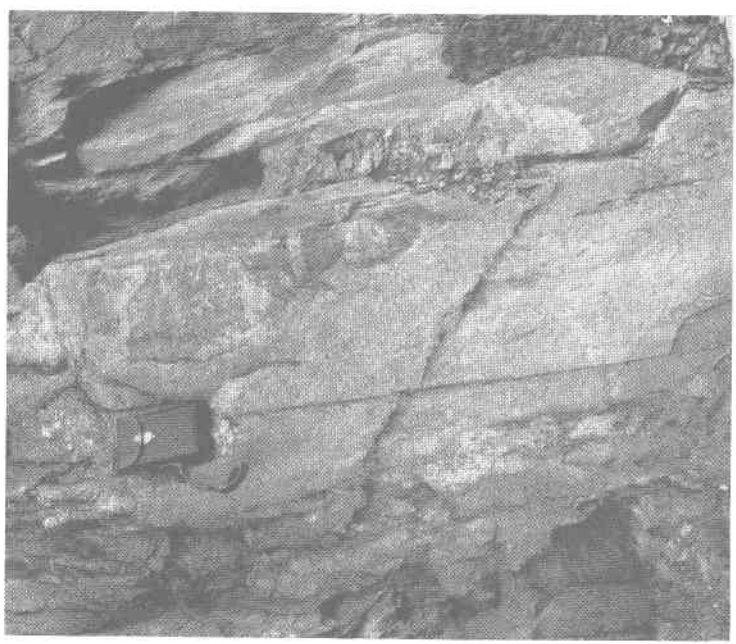
Clay is a poor source of water, because it consists of particles that are so small that the pore spaces between them hold the water by molecular attraction. The clays of the Potomac group yield practically no water. If the clay has become hardened into a shale, bedding planes, shaly partings, and joints may be numerous and more or less uniformly distributed, so that most shales are to be considered reliable sources of small water supplies. The Martinsburg shale is an example. Shallow wells in shale tend to survive drought better than similar wells in most other types of rock. The water in the shales of northern Virginia is usually rather highly mineralized. Mudstones like those in the Catskill formation, somewhat similar to shale lithologically but lacking the shaly partings, are usually very poor water-bearers.

Limestone is an erratic source of water. Its joints and bedding planes are enlarged by solution by water charged with carbon dioxide, probably above or immediately below the water table. When the solution channels become sufficiently widened, the water behaves like that in a surface stream. Where a large channel or underground stream is



A. Schistose granite in road cut south of Manassas, near Occoquan Creek, Prince William County, Virginia. Planes of schistosity provide channelways through which ground water can move.

B. Tuscarora quartzite at north end of Massanutten Mountain, Shenandoah County, Virginia. Small supplies of water can be obtained by means of wells and springs from such a hard, dense rock as this quartzite, if it had been shattered and jointed as at this locality.



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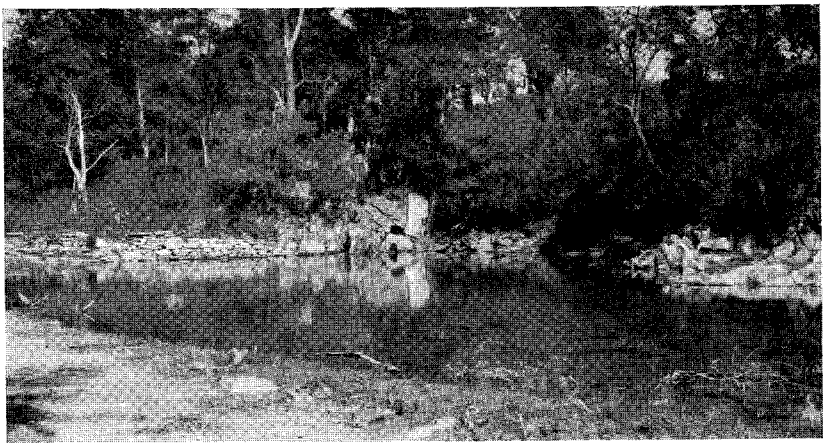
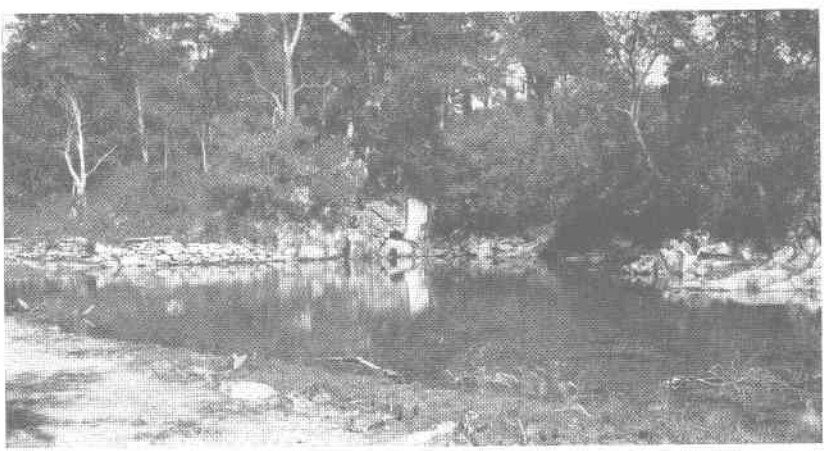
A. Valley-floor peneplain, dissected deeply by modern streams, and Sleepy Creek Mountain, remnant of an earlier peneplain, in background. Between Gainesboro and Cross Junction, Frederick County, Virginia, looking north.



B. Large spring issuing from Beekmantown dolomite near Vaucluse, Frederick County, Virginia.

A. Valley-floor peneplain, dissected deeply by modern streams, and Sleepy Creek Mountain, remnant of an earlier peneplain, in background. Between Gainesboro and Cross Junction, Frederick County, Virginia, looking north.



B. Large spring issuing from Beekmantown dolomite near Vaucluse, Frederick County, Virginia.

encountered by a well, an almost inexhaustible supply of water may be obtained. If a well misses the channels a dry hole may result. Many of the channelways become filled with mud, and a well drilled into one of these mud-filled channelways may be a failure unless the mud can be cased off. The behavior of limestone wells during a drought often causes considerable difficulty, because they may go dry with no warning whatever in the nature of a gradual diminution of yield and because the water in most limestone fluctuates widely over periods of excessive and deficient rainfall. The water from limestone wells is usually hard, and it is also liable to pollution owing to the ease and rapidity with which the water moves through it and the lack of natural filtration.

OBSERVATION WELLS

In Arlington and Fairfax counties five dug wells have been subject to close observation by the United States Geological Survey for some time past. On four of them automatic water-stage recorders have been maintained and one has been measured weekly. The wells are named for convenience according to name of the owner of the property. Two of the wells are in Arlington County, namely the Ross well, near Rosslyn, Arlington County, and the Halls Hill School well, in Halls Hill, about midway between Rosslyn and Falls Church. The remaining three wells are in Fairfax County situated 0.9 mile northwest of Tysons Corner, 2.4 miles west-northwest of Fairfax, on the western bank of Difficult Run, and 2.6 miles west-northwest of Fairfax, on the property of Nathaniel Bacon. These wells are referred to as the "Bell well," the "Swart well," and "Bacon well," respectively. The two wells in Arlington County and the Bacon well are abandoned wells and the other two in Fairfax County were dug in connection with the present investigation, with the permission of the owners of the property.

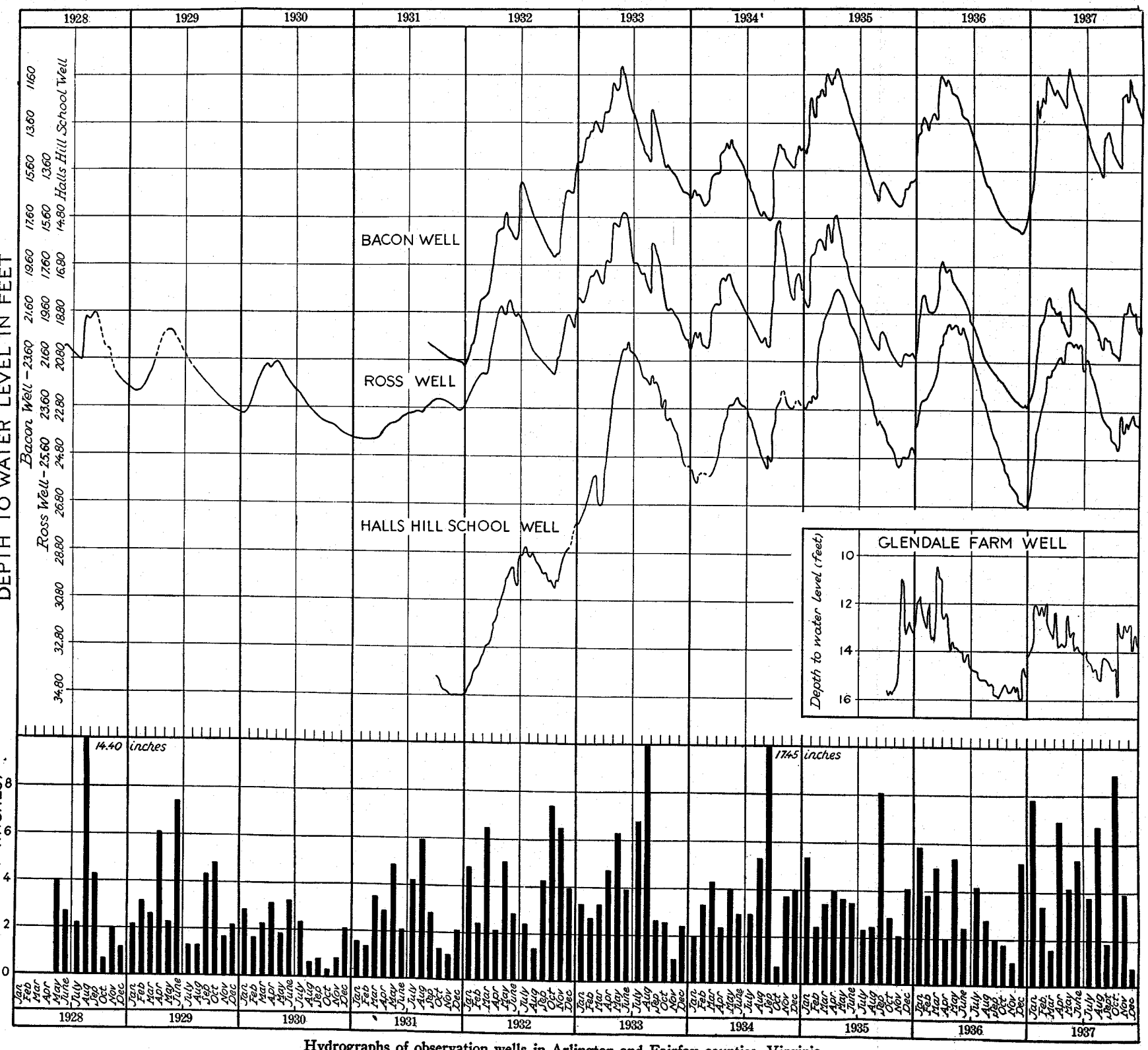
A well, known as the Glendale Farm well, owned by O. E. Meinzer, has been under observation since October, 1935. This well is in Fauquier County, 1½ miles northeast of Catlett on highway 233. It is a 6-inch drilled well, 94 feet deep. The detailed description of these observation wells and the complete record of the measurements may be found in Water-Supply Papers 777 and 817 of the United States Geological Survey and may be purchased from the Superintendent of Documents, Washington, D. C., for 30 cents and 75 cents respectively. Hydrographs of the Bacon, Ross, Halls Hills School, and Glendale Farm wells are presented in Plate 5. The monthly precipitation, measured by the United States Weather Bureau at Washington, D. C., for the same period is also shown.

The records of the wells are not all of the same length. The record of the Ross well is the longest, having been started in the late

spring of 1928; the Bacon well record dates back to August, 1931; the Halls Hills School record to October, 1932; and the Bell and the Swart records to April, 1932. The hydrograph of the Ross well covers the period of diminishing ground-water supplies which culminated in the severe drought of 1930, whereas the history of the other wells is known only during the period of recovery since the drought.

The rainfall in northern Virginia is distributed rather uniformly throughout the year, though reaching a maximum in the summer months, but the water level in the wells usually declines during the late spring, summer and autumn months at a rate that is remarkably constant in any single locality. This decline is a visible and potentially measurable function of the drainage of ground water out of the zone of saturation, by way of perennial streams, springs and marshy places where the water can evaporate from the soil and transpire through the leaves of marsh-plants and trees. During the growing season of the vegetation much of the moisture which exists in the soil above the saturated zone is exhausted through direct evaporation and through absorption by the roots of plants. Therefore the summer rains of only light or moderate intensity do little more than replenish the soil moisture, and consequently the ground water in the saturated zone continues to decline. Occasionally, however, the rain is so intense and long continued that the soil in the root zone receives more water than will remain suspended long enough to be used by the plants, and the excess percolates downward into the saturated zone. Then the supply of ground water is replenished and the water levels in the wells rise. Such was the case in August, 1928, when a severe storm brought the monthly rainfall to a total of 14.41 inches. The hydrograph of the Ross well indicates a rise in water level of about 2 feet for the early part of that month.

Normally the decline of the water level continues until the vegetation becomes dormant and enough rain has fallen to replenish the soil with moisture. The date of the beginning of ground-water recharge varies from season to season with the quantity of the moisture left by the vegetation, the amount and intensity of the rainfall, and, to a slight degree, the factors affecting the rate of evaporation, also in some seasons snow and frozen ground. The time of recharge varies somewhat from place to place according to the nature of the soil, thickness of the zone of unsaturated soil, the topography, and the amount and character of the vegetation, and probably other factors. In 1928-29 recharge at the Ross well began early in February; in 1929-30 in January; in 1930-31, near the end of March; in 1931-32, in January; in 1932-33, in the middle of October; in 1933-34 in January; in 1934-35 in September, which was an unusually rainy month; in 1935-36 in January; and in 1937 in October. In October, 1932, and in subsequent



Hydrographs of observation wells in Arlington and Fairfax counties, Virginia.

years when all five wells were being observed, it was found that ground-water recharge began at each well at very nearly the same time.

Between 1928 and the winter of 1930-31 there was a decline in the low stages of the Ross well and also in the high stages. Then in 1931 the uptrend began, recharge lasting through the summer of 1931, and continuing, after a brief lapse in the autumn of 1931, until the spring of 1932, at which time the water level stood higher than at any previous time covered by the record. The succeeding low stage was not so much depressed as any of the former low stages, and the high stage of 1933 is almost 4 feet higher than that of 1932, over 7 feet higher than that of 1931 and almost 10 feet higher than the extreme low stage of 1930-31. The high stages in 1934 and 1935 were about equal to the high stage in 1933, and the low stages in 1934 and 1935 were about equal to the low stage in 1933. In 1936 both the high stage and low stage were depressed about 2 feet below the corresponding 1935 levels, and in 1937 the high stage failed to attain the level of 1936 by about 1 foot. Early recharge in October, 1937, may have ended this downward trend. Thus the record of this well indicates that the ground-water storage has fully recovered from the depletion of the preceding dry period and has entered another period of decline. The records of the other observation wells are very similar to that of the Ross well for identical periods of time.

The Swart well is rather unusual because the water is so near the surface that when the other wells reach their high stages, the water in the former well is cut off at the surface of the ground. The well is situated in a swampy area abounding in plants which derive their water from the water table instead of the soil moisture, so that the well clearly records the pumpage from the zone of saturation by the plants with a daily decline in the water level of about 0.1 foot, and recovery after darkness when the plants cease to be active.

The Bell well behaves in a different, but equally unusual manner. During periods of abundant rainfall the water level is very near the surface, but in a dry period, it declines very much more rapidly than the other wells, and conversely, it recovers very much more rapidly. Thus the record of this well records all the changes in level affecting the others, but to an exaggerated extent. It is believed that at least one reason for this is that the soil in which the well is dug is very nearly impervious, as shown by tests made on samples in the hydrological laboratory of the United States Geological Survey. (See Table 8.)

The records of nearly all of the wells show, to variable degrees, the effects of changes in barometric pressure upon the ground waters. The effect is not well defined, or not discernible at all, when the soil in the zone of aeration is dry; but during rainy periods the moisture in the

TABLE 8.—*Physical properties of water-bearing materials from the Bell and Swart wells, Fairfax County, Virginia*

Laboratory Number	Depth	Larger Than 1.0	1.0 To 0.50	0.50 To 0.25	0.25 To 0.125	0.125 To 0.062	Silt	Clay	Porosity	Moisture Equivalent		Coefficient of Permeability
										Per Cent by Weight	Per Cent by Volume	
Bell well located at Leesburg Pike, 0.9 mile west of Tyson's Corner												
1535	18 inches	.....	2.4	6.8	9.8	6.4	39.6	36.8	39.4	35.4	58.4	Less than 1
1536	6 feet	3.1	9.1	17.1	13.6	10.6	37.0	9.1	48.8	26.6	40.1	7
1537	9 feet	1.8	7.6	15.6	13.3	11.3	43.1	7.6	50.7	30.0	43.2	6
1538	12 feet	3.7	9.1	14.3	13.6	11.1	40.3	7.2	52.4	28.9	39.0	7
1539	18 feet	3.9	8.0	15.9	17.2	10.7	37.1	6.4	45.1	28.8	44.6	3
Swart well located at Difficult Run on U. S. Highway 50												
1540	15 inches	2.3	2.2	5.7	8.4	11.4	45.2	23.8	42.9	23.9	37.8	1
1541	40 inches	1.4	1.5	3.2	7.2	12.1	44.1	28.1	48.9	31.8	46.4	8
1542	5.4 feet	7.3	7.6	15.2	21.6	17.8	19.9	9.4	52.5	17.8	24.4	18

soil clogs the pore-space so that changes in the pressure of the free air above the ground are not transmitted easily to the air in the interstices of the soil immediately above the water table. Thus when the atmospheric pressure drops, the imprisoned air below exerts a relatively greater pressure upon the water table than the free air exerts upon the water surface in the well, and this pressure is released by the rise of the water

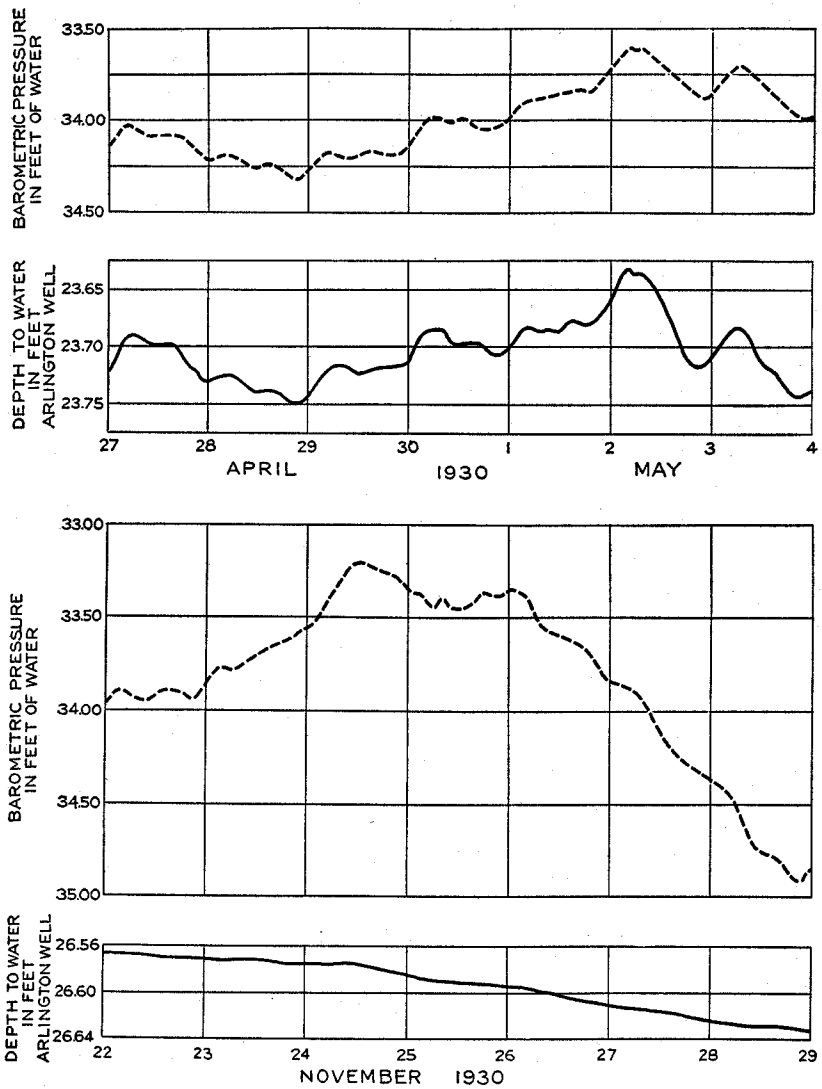


FIGURE 5.—Fluctuations of the water level in the Ross well, caused by changes in the atmospheric pressure.

level in the well. Conversely, when the atmospheric pressure increases, the free air pushes the water downward into the well. In very dry soil these barometric changes are transmitted from pore-space to pore-space, so that the pressure in the innumerable air-columns which connect the air above the surface with the water table is equal to the pressure of the air above the water in the well and there is no difference in head set up. Figure 5, prepared by W. N. White and L. K. Wenzel, hydraulic engineers in the U. S. Geological Survey, shows a portion of the hydrograph of the Ross well when the soil is dry, and another portion of the record when the soil is wet. For each period the barograph is drawn in, converted from terms of inches of mercury to feet of water, and inverted, for purposes of comparison.

WATER-BEARING PROPERTIES OF THE ROCK FORMATIONS

Pre-Cambrian white marble.—The white marble crops out in small linear areas in which it is exposed by the erosion of the overlying Catoctin greenstone at the crests of small, sharp anticlines, on the eastern limb of the Catoctin-Blue Ridge anticlinorium, in Loudoun County. The outcrops conform to a single axial line trending northeast by north about 1 mile east of the eastern boundary of the Marshall granite outcrop. The outcrops of the marble are too small to be shown on the map that accompanies this report.

Information was obtained from the drillers in regard to six domestic wells drilled into the white marble. These wells range in depth between 25 and 120 feet and average 68 feet. The reported yields range between a quarter of a gallon and 15 gallons a minute and average 8 gallons. The yields appear to be only slightly below normal for ordinary limestone wells. The open spaces in the ancient limestone may have been closed by recrystallization and rock flowage during its metamorphism into marble, and as the formation is buried beneath the Catoctin greenstone, the water may have had little opportunity to circulate and to dissolve large channelways. The analysis of a single sample of water from this formation shows a hardness of 116 parts per million.

Catoctin greenstone.—The Catoctin greenstone lies at the surface in two belts in Loudoun County. (See Pl. 2.) These belts form the western and eastern limbs of the Catoctin-Blue Ridge anticlinorium, bounded on the east by the Catoctin border fault and on the west by the overthrust fault at the western foot of the Blue Ridge. The rock is schistose in the eastern belt and more massive and dense in the western belt. It consists of successive lava flows which have been folded and extensively metamorphosed. The original openings have to a great extent been closed by metamorphism, but some small openings have been produced by the development of cleavage. Altogether the formation is massive and hard and is a poor water-bearer.

TABLE 9—*Average yield of wells ending in Catoctin greenstone in relation to depth of wells*

Depth (Feet)	Number of Wells	Yield (Gallons a Minute)	
		Range	Average
0–100	73	¼–30	4
101–200	14	2–30	6
201–300	3	¼– 7¼	4
301–704	3	1–12	6
	93	¼–30	4½

Information was obtained in regard to 93 wells with an average depth of 85 feet, that draw water from the Catoctin greenstone. The yields of these wells, as reported, range from about a quarter of a gallon to about 30 gallons a minute and average about 4½ gallons.

The available information indicates that if a well is unsuccessful in the first 200 to 300 feet, not much is generally gained by drilling deeper. Two of the 93 wells were reported to yield 30 gallons a minute. One of these is 31 feet and the other 188 feet deep. Eight wells were reported to yield between 10 and 20 gallons a minute, of which five are less than 100 feet deep, and the other three are 142, 170, and 350 feet deep. All the other wells in regard to which information was obtained were reported to yield 10 gallons a minute or less.

There are a few wells in the Catoctin greenstone that yield slight flows, but the artesian head does not carry the water far above the ground surface. Wells with a noticeable artesian pressure are rare in this formation, as the fractures are generally more or less vertical, preventing confinement of the water, and also the channelways are comparatively small, thus increasing the effect of friction.

Drilling into the formation is difficult. Bouldery weathering at the base of the soil zone tends to deflect the drill bit, and the formation itself is hard and tough rather than brittle. Where it is tilted a very hard layer tends to throw the bit off the vertical.

Analyses of four samples indicate that the water is generally of excellent quality, being soft and comparatively low in dissolved solids.

Wissahickon schist.—The Wissahickon schist crops out over a large area in Fairfax and Prince William counties. The western boundary of the outcrop passes through Dranesville, near Herndon, and about 3 miles east of Manassas. The eastern boundary is irregular. (See Pl. 2.) The tight folding of this formation is almost obscured by the later schistosity that transects the bedding. Near the surface weathering causes a leaching of the soluble material from the schist, and a skeleton of siliceous and clayey material and mica remains, preserving the structure where undisturbed. (See Pl. 7, B.) The soil under such conditions is rather porous. In the decomposed rock some distance below the surface the same condition of weathering prevails to a less complete degree. The rock itself is somewhat tight, and it is believed that as a rule the ground water is most abundant and is freest to move in this weathered zone. Farther down in the sound rock there are cavities, and they probably are more numerous, though generally smaller, than the joints in granite. At still greater depths the schistosity probably becomes incipient rather than actual. There are many quartz veins in the schist which were injected along the planes of foliation.

TABLE 10.—*Average yield of wells in the Wissahickon schist for each 100 feet of depth*

DEPTH (FEET)	NUMBER OF WELLS	YIELD (GALLONS A MINUTE)	
		Range	Average
0–100	100	¼–35	9
101–200	42	2–70	12
201–300	2	3–60	37 {14, 60}
301–400	1		
	145	¼–70	10

The range in depth of the wells in the Wissahickon schist of which records were obtained is rather small, and only scant data are available concerning conditions below 300 feet. But considering the rather generous average yield of wells shallower than 100 feet and the rather slight increase in the average yield with additional depth—about 2 gallons a minute for each 100 feet down to 300 feet—it is probable that for ordinary household wells 100 feet or thereabouts is generally the most favorable depth to drill. Only about four wells in 130 obtain more than 30 gallons a minute, and three of them are between 120 and 160 feet in depth; therefore the chances of obtaining large yields are poor, and a series of shallow wells perhaps 100 to 200 feet deep should be considered the most feasible source of a large supply of water. This generalization should be emphasized, especially in view of the fact that the wells have rather consistently uniform yield.

Drilling in this formation is easy, for the rock is soft. It tends to be tough rather than brittle and does not fracture as easily as some types of rock, but this is a minor objection. The quartz veins are apt to deflect the bit when encountered at an angle.

Analyses of three samples from the Wissahickon schist indicate that the water is soft and low in dissolved mineral matter. It is therefore highly desirable for most uses.

Marshall granite.—The outcrop of the Marshall granite occupies the axis of the Catoctin-Blue Ridge anticlinorium, in a belt 6 miles wide at the north end of the district and 4 miles wide at the south end. Middleburg, Mountville, Lincoln, and Lovettsville are about on the median line of the outcrop. (See Pl. 2.) This granite intrudes the Catoctin greenstone and the white marble; outside of the area shown on the map it invades sediments held to be equivalent in age to the Wissahickon schist, thereby showing its age to be younger than the pre-Cambrian[5] sediments of the eastern part of the Piedmont province.

[5] Jonas, A. I., oral communication.

The granite where massive is practically impermeable except for joints and other secondary fractures, but in places, chiefly toward the east side of the outcrop area, it is somewhat schistose, and in such rock, water is abundant, especially near the surface, where the planes of foliation are widened by weathering. The granite, taken as a whole, is a hard rock and a poor water-bearer, and the openings in which the water occurs decrease in number within the first few hundred feet of depth.

The available data are summarized below.

TABLE 11.—*Average yield of wells ending in the Marshall granite for each 100 feet of depth*

Depth (Feet)	Number of Wells	Yield (Gallons a Minute)	
		Range	Average
0–100	64	½–20	4
101–200	23	0–30	9
201–300	4	4–41	16
301–400	4	8–35	21
401–500	1	12–40	26 (12, 40)
501–600	1		
	97	0–41	7

The deeper wells, those from 300 to 400 feet deep, deliver the largest yields. Below 400 feet the results are not uniform and hence probably too uncertain to warrant exceeding that depth. Down to 400 feet the wells show an increase of about 5 gallons a minute for each additional 100 feet of depth, and therefore the depth of drilling is to be determined by the importance of the extra 5 gallons a minute yield as weighed against the cost of drilling another 100 feet. The range in yield increases with the depth of wells down to 200 to 300 feet and then it begins to decrease. The maximum yield occurs between 200 and 300 feet. Anyone desiring more than 20 gallons a minute should plan on drilling more than one well, keeping in mind the fact that there is a definite possibility of a totally dry hole.

Drilling in the hard granite is difficult, and therefore expensive. The wear on the bits is rapid, and dressing the tool is a frequent interlude in the course of drilling. A likely source of water is probably to be found in the zone of decomposed rock below the soil, and the well casing should be driven into the rock in such a manner as to take full advantage of this possibility.

The water in the granite is of good quality for drinking and household use. The hardness in two samples analyzed averaged 121 parts

per million, which is higher than the hardness of most waters from granite.

Granite of the eastern belt.—The granite of the eastern belt crops out along the eastern border of the Piedmont province in Arlington, Fairfax, and Prince William counties. On the west its contact with the Wissahickon schist is very irregular, with salients, outliers, and inliers, and on the east it is overlapped by the sediments of the Coastal Plain. (See Pl. 2.) The age relation of this granite to the Marshall granite is unknown; it may be older, contemporaneous with, or younger than the Marshall.

The granite is sheared and in some localities gneissoid and even schistose. (See Pl. 3, A.) Where it is more massive, it contains systems of joints, which intersect at rather uniform intervals. (See Pl. 7, A.) As the granite is in general massive, the formation as a whole is a poor water-bearer, although there are some wells of moderately high yield. Data on these wells are summarized below.

TABLE 12.—*Average yield of wells ending in the granite of the eastern belt for each 100 feet of depth*

Depth (Feet)	Number of Wells	Yield (Gallons a Minute)	
		Range	Average
0–100	43	½–18	6
101–200	19	1–27	8
201–300	4	0–40	16
301–400	2	5–50	26
401–500	2		28
501–600	..		22 ..
601–700	..		..
701–800	2		7
	72	0–50	9

According to the above table there is a sudden increase in the average yield of wells between 200 and 300 feet and another between 300 and 500 feet. Below 500 feet the yields seem to decrease. Thus the most favorable depth, so far as the yield is concerned, seems to be in the zone 200 to 500 feet below the surface. However, as the number of wells listed in the table having a depth of more than 200 feet is small, it is probable that for ordinary uses wells not more than 300 feet deep are the safest; the maximum yield to be expected increases with depth, but the minima remain nearly constant at all depths. Where the need for water warrants the expenditure of more money, the limit of

drilling might be set at 500 feet. There is an unknown factor in the above generalizations, and that is the possibility that much of the water yielded by the deeper wells was encountered in shallower zones. Such was the case, according to reliable reports, in one of the municipal wells at Falls Church, Fairfax County (see p. 154). The water was encountered in the zone of weathered rock below the soil, and although drilling was continued to a depth of about 300 feet, the yield was not increased to any appreciable degree. Until further and more detailed knowledge is available concerning the exact depth at which most wells in granite encounter their supplies, it may be wise to place the lower limit of drilling at the somewhat arbitrary depth of 300 feet.

Only one in three of the wells in the granite for which data are available delivers more than 10 gallons a minute, and only one in eleven delivers more than 20 gallons a minute, so that if a supply of 20 or even 10 gallons a minute is required, plans probably should be made for drilling more than one well. It should be kept in mind also that there is a chance of about one in thirty-five that a well will be a failure.

The granite is fairly difficult to drill, because of its hardness. Casing should be carried below the soil, of course, but an effort should be made to utilize the water that is so likely to occur in the zone of decomposed rock just below the soil.

The water in the granite may be very soft but is not soft everywhere. One deep well, owned by a laundry, delivered such hard water (hardness about 184 parts per million) that it was never used.

Loudoun formation, Weverton sandstone, Harpers shale, and Antietam sandstone.—The Loudoun, Weverton, Harpers, and Antietam formations—all of early Cambrian age—are considered together for convenience. They crop out in Clarke, Loudoun, and Prince William counties. In Clarke County they are exposed along the western flank of the Blue Ridge and at its foot east of Shenandoah River. The overthrust fault along which the Blue Ridge-Piedmont region was pushed westward over the younger Paleozoic formations of the Valley and Ridge province (see p. 25) cuts the outcrop of these formations. (See Pl. 2.) Hence the rocks west of the fault are in place, whereas the rocks east of the fault were carried westward on the overthrust mass into juxtaposition with them. (See Fig. 4.) In Loudoun County, the formations as a complete or incomplete group occur as narrow, infolded masses, aligned in a northeast by north direction. One of the larger masses lies about a mile west of Hillsboro and extends north to Potomac River, and three smaller areas are strung along the same axis, southwest by south, for a distance of 6 miles, passing about 2 miles east of Round Hill. Still another synclinal outcrop is on the same axis near the boundary of Fauquier and Loudoun counties, and it is almost con-

tinuous with the tip of another outcrop that lies almost wholly in Fauquier County. Three miles east of Middleburg a small spur of a large body in Fauquier County crosses northward into Loudoun County. Another outcrop extends from a point about 2 miles north of Mountville, southward for 5 miles toward Middleburg. Two miles east of this mass is another one, about twice as large, that covers the contact between the Catoctin greenstone and the Marshall granite. On the strike with this mass, near Paeonian Springs, is another one, 7 or 8 miles long and less than a mile wide. The largest outcrop is contiguous on the west with the Catoctin border fault between Leesburg and Potomac River, widening northward. There is a small break near Leesburg, and the mass continues southward to the Fauquier County line.

In Prince William County the Lower Cambrian formations crop out on the west side of the Catoctin border fault, at the boundary of Prince William and Fauquier counties.

These formations have been metamorphosed, probably to a great extent during the Appalachian revolution. The shale has in part been compressed into slate, and the sandstone changed into quartzite. The shale and slate, as in other similar formations, are not sources of copious ground water, but probably the quartzites are especially poor, except where they are brecciated. The formations as a whole show the greatest alteration toward the east; slate and schist have been derived from the fresher shales as seen near the Blue Ridge, and the sandstones have developed a cleavage near the eastern limits of the outcrop area.

The data for 21 wells, given in the table below, show an average depth of 164 feet, with a range from 30 to 530 feet.

TABLE 13.—*Average yield of wells ending in the Lower Cambrian rocks for each 100 feet of depth*

Depth (Feet)	Number of Wells	Yield (Gallons a Minute)	
		Range	Average
0–100	11	1–15	6
101–200	5	¼–15	6
201–300	1	3–16	5
301–400	3		10
401–500	..		..
501–600	1		5½
	21	¼–16	6½

The average yield of wells 100 feet or more deep shows no increase over that of the wells less than 100 feet deep. Apparently the

average yield scarcely increases below 200 feet. The chances that only 1 gallon a minute or even less will be obtained seem to be greater in the wells 100 feet or less in depth, and therefore it seems advisable to drill to 200 feet before considering an unpromising well a failure; but if an average quantity of water is obtained in the first 200 feet, the chances are uncertain that the yield will be augmented materially at greater depth. Considered as a whole, these Lower Cambrian rocks are poor sources of water. They contain shale and slate, which are generally poor sources, and beds of hard sandstone and quartzite which, unless highly shattered, probably would yield very little water. Quantities of more than 15 gallons a minute should not be expected in a single well.

The shale and slate are easy to drill, being soft but not brittle. The folded beds might tend to deflect the drill, but this has not been reported as a serious obstacle.

As slaty cleavage, fracture cleavage, and joints that cut through the bedding more or less vertically are prevalent in this group of rocks, artesian pressure is uncommon, in spite of the synclinal structure shown by the outcropping masses. Water levels 10 to 60 feet below the surface are reported (most of them the water levels at the time of drilling).

A single water sample from these sediments shows a hardness of 46 parts per million, and it is otherwise low in dissolved solids. It is possible that samples collected from some of the deeper wells in the slate or shale members would be mineralized more highly than the sample already tested.

Tomstown dolomite.—The Tomstown dolomite is exposed only in Clarke County in a belt about 1 mile wide along the foot of the Blue Ridge, and the outcrop is so disposed that Shenandoah River flows along its axis through much of the area under discussion.

The formation occupies the far edge of the syncline centered in eastern Frederick County, but of more immediate concern are the abundant small, sharply plunging folds superimposed upon the major structure. Joints are rather prominent on weathered outcrops, where solution has widened them.

There are seven wells that tap this formation concerning which data have been obtained. The average depth is 111 feet, with a range of 30 to 220 feet, and the reported yield averages 10 gallons a minute, ranging between 2 and 15 gallons a minute. The yield of wells less than 100 feet deep averages 13 gallons a minute and ranges between 8 and 15 gallons, whereas the yield of wells more than 100 feet deep averages 8 gallons a minute and ranges between 5 and 15 gallons.

These scanty data indicate a definite weakening of supply at depths greater than 100 feet, and it is therefore regarded as unwise to drill below 200 feet. The reason is, perhaps, that dolomite is not very solu-

ble except at depths where water charged with carbon dioxide circulates rather vigorously. This generalization is by no means dogmatic, however, because wells of much greater depths conceivably might tend to exhibit, on the average, a reverse in the trend of the shallower wells and the yields at lower levels might become greater. The largest yield to be expected is problematic, but probably 15 gallons a minute would be an optimistic estimate.

The analysis of a single sample of water from the Tomstown dolomite shows a hardness of 268 parts per million and total dissolved solids of 292 parts per million. It is a typical calcium-magnesium bicarbonate water from dolomite, with somewhat less hardness than many waters from pure limestone.

Waynesboro formation.—The Waynesboro formation, like the Tomstown dolomite, is exposed only in Clarke County, and its outcrop is immediately west of the dolomite. The outcrop is about 2 miles wide at the south end, gradually narrows to 1½ miles midway to the West Virginia boundary, and widens to 2½ miles near Castleman's Ferry, as a result of secondary folding.

The formation is soft and shaly near the surface, but where less weathered it is a rather compact mudrock, apparently with few openings other than bedding planes, shaly partings, and a few joints.

The only well drilled into this formation concerning which data were obtained is 190 feet deep and is reported to yield 15 gallons a minute.

Elbrook and Conococheague limestones.—The Elbrook limestone crops out in Clarke County in a strip 1 mile or less wide, contiguous with the western boundary of the Waynesboro formation. In Frederick County it occupies a narrow belt along the eastern foot of Little North Mountain. Its eastern boundary is a normal sedimentary contact with the Conococheague limestone; on the west it is separated from late Ordovician or Silurian sediments by an overthrust fault.

The exposure of the Conococheague limestone lies midway between Opequon Creek and Shenandoah River in Clarke County, striking northeast by north, and is approximately 2½ miles wide. Berryville and Millwood are on the outcrop, and Boyce is near the contact with the Beekmantown limestone. In Frederick County the outcrop lies immediately east of the Elbrook limestone. In the southern part of Frederick County it is about 1½ miles wide, but near Bartonsville it increases to 4 miles, owing to strong secondary folding, and it narrows gradually northeastward to 1½ miles at the West Virginia State line.

These limestone formations are synclinal in structure, but there are secondary folds which make the local recognition of the dominating struc-

ture difficult and, in fact, of rather less importance to the prospective seeker of a water supply. Near the surface joints have been greatly enlarged by solution, and to considerable distances below the surface large caverns and solution passages are likely to be found. According to Hall,[6] wells drilled into the Lower Ordovician limestone formations do not encounter large cavities in considerable numbers much below the level of Shenandoah River, except to the extent that the water table may have dropped below that level in periods of drought. The solution cavities are the outstanding features that affect the water-bearing properties of limestone, for the quantity of water delivered by channelways of other origins must, because of their small size, be far less. The presence or absence of large solution channels is often reflected in the incongruous results of near-by wells of similar depth drilled into the limestone. The position of the larger solution channels, although originally determined by joint systems, appears to be erratic.

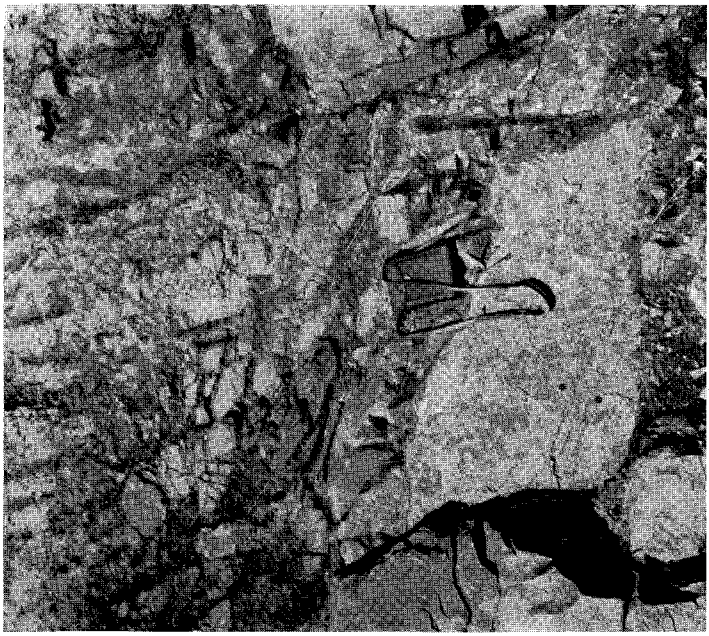
The combined data of 95 wells in these formations are summarized below.

TABLE 14.—*Average yield of wells ending in the Elbrook and Conococheague limestones for each 100 feet of depth*

Depth (Feet)	Number of Wells	Yield (Gallons a Minute)	
		Range	Average
0–100	26	1–50	17
101–200	45	½–30	11
201–300	17	½–90	19
301–400	7	1–30	11
	95	½–90	13

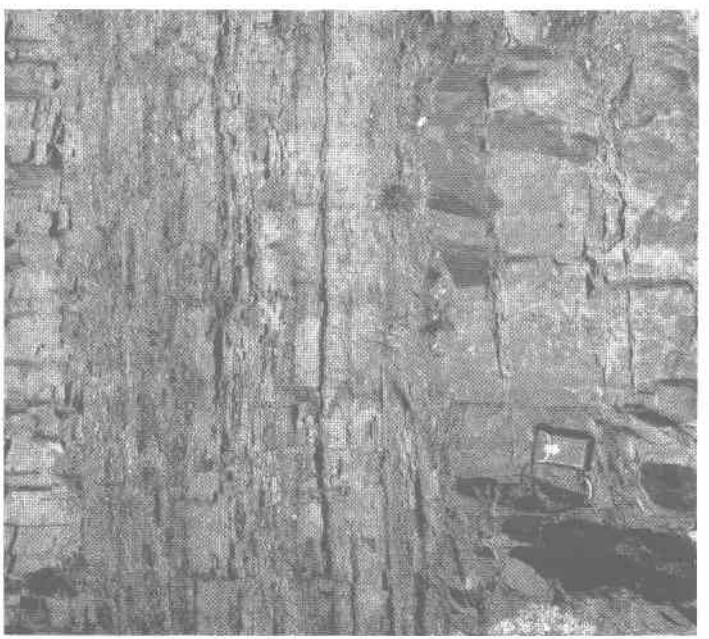
One well between 700 and 800 feet deep yielded 1½ gallons a minute. The above summary is rather disappointingly uniform in that it shows no depth at which wells obtain outstandingly copious yields. The average yield of the wells does not vary by more than 8 gallons a minute. The reason for this may be a mechanical one. It is generally considered that the formation of solution channels in limestone goes on most actively above and immediately below the water table, where the water in the rocks is most highly charged with carbon dioxide and circulates most vigorously. The water table fluctuates vertically in response to rainfall, and the magnitude of the fluctuations increases away from the main streams, being greatest in the divides between streams and least at the

[6] Hall, G. M., Ground water in the Ordovician rocks near Woodstock, Virginia: U. S. Geol. Survey Water-Supply Paper 596, pp. 58-59, 1927.



B. Trap, or diabase, in road cut at intersection of Manassas-Warrenton road with Lee Highway, Fauquier County, Virginia. In the weathered and fractured zone of the trap rock ground water may be found at shallow depths.

A. Newark formation in railroad cut along Manassas-Warrenton road, Prince William County, Virginia. The rock is red sandstone and red and green clay.



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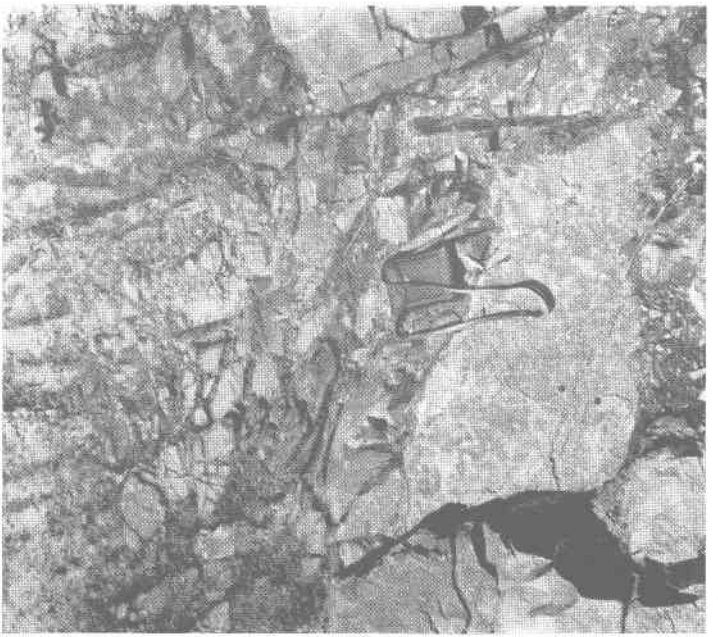
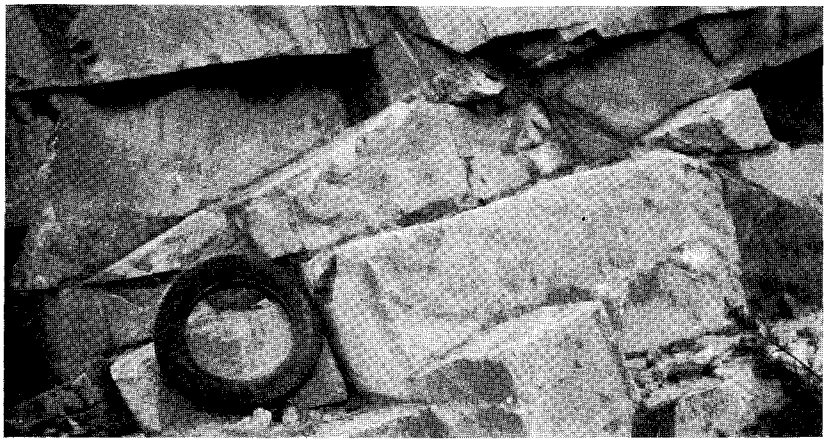
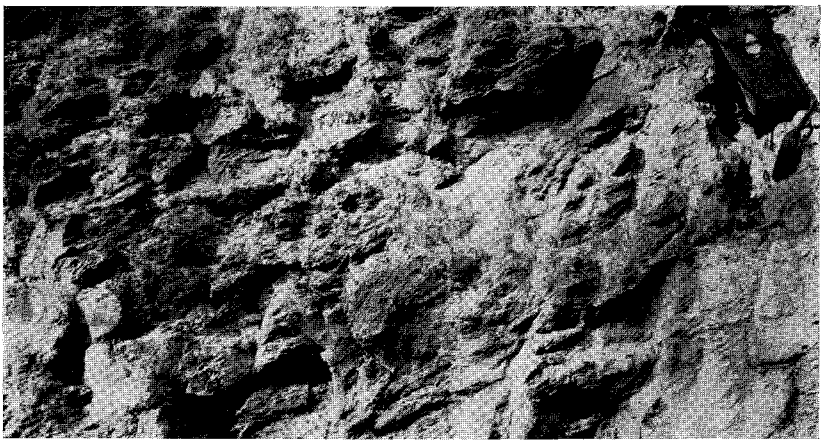


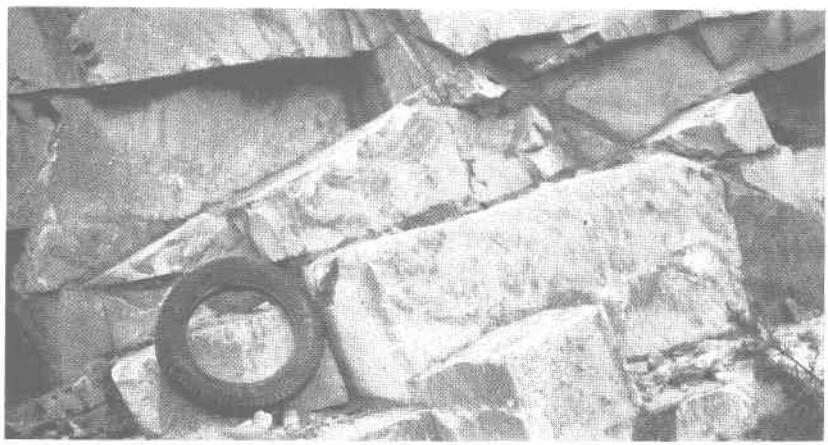
B. Trap, or diabase, in road cut at intersection of Manassas-Warrenton road with Lee Highway, Fauquier County, Virginia. In the weathered and fractured zone of the trap rock ground water may be found at shallow depths.



A. Granite in quarry 1 mile west of Falls Church, on Lee Highway, Fairfax County, Virginia. Regularly spaced clean-cut joint planes, from which water seeps, are clearly evident.



B. Residual soil developed on Wissahickon schist, on road near Great Falls, Fairfax County, Virginia. The preservation in the soil of the schistose structure of the rock enables water to move through a soil that contains much clay.



A. Granite in quarry 1 mile west of Falls Church, on Lee Highway, Fairfax County, Virginia. Regularly spaced clean-cut joint planes, from which water seeps, are clearly evident.

B. Residual soil developed on Wissahickon schist, on road near Great Falls, Fairfax County, Virginia. The preservation in the soil of the schistose structure of the rock enables water to move through a soil that contains much clay.

stream channels. Therefore, the vertical dimension of the zone in which wells may encounter large solution channels and possibly obtain large yields, when the position of the water table is adjusted to "normal" rainfall conditions, increases out from the stream channels toward the divides. The application of this discussion to the wells in the Elbrook and Conococheague limestones is apparent when it is recalled that these formations crop out near the Shenandoah River, on the eastern limit of the major syncline, whereas the western limit of the syncline brings the formations to the surface 18 miles west of the river. In addition to the position with respect to the drainage, the western outcrop is in an area of higher altitude (500 feet above Shenandoah River) and of greater surface relief, which makes for still less uniformity in the depth at which the wells may encounter solution channels below the "normal" water table. The average yield of wells in these limestones in the western outcrop area is uniform to a depth of 400 feet (and there are no data of wells deeper than 400 feet in that area), but in the eastern outcrop area, the average yields decrease below 300 feet. Therefore, a well in the eastern area should stand the best chance of success at a depth less than 300 feet, whereas in the western area it is not known to what depth the favorable zone extends.

Only 1 out of 8 wells recorded here obtains more than 20 gallons a minute, and only 1 out of 24 obtains more than 30 gallons a minute. It is therefore proper to consider these probabilities in drilling for a definite quantity of water. A well on the eastern outcrop area, if it derives its water at a depth of 200 feet or more, probably will survive any drought that does not completely dry up Shenandoah River. In the western outcrop area the absolutely safe depth is probably somewhat greater.

Drilling in limestone is not difficult, although the high content of argillaceous material characterizing the Elbrook and Conococheague limestones makes for less brittleness under impact. The dip of the formations causes some difficulty, which, however, is not as serious as it would be in a less uniform and harder rock.

The water from these limestones is very hard, eight samples averaging about 380 parts per million. The taste characteristic of hard water is noticeable, and boilers, cooking utensils, and pipes tend to accumulate lime very rapidly. The water should be softened for industrial and public supplies.

Beekmantown limestone, Stones River group, Athens (?) limestone, and Chambersburg limestone.—The Beekmantown, Stones River, Athens (?) and Chambersburg formations crop out on both limbs of the major syncline in Frederick and Clarke counties and lie immediately against the Martinsburg shale, both on the east and on the west. (See

Pl. 2.) In addition to these limestones the Frederick limestone[7] is brought to the surface by faulting in the northwest corner of the Triassic basin, north of Leesburg, Loudoun County.

In the Shenandoah Valley these formations are folded into small, narrow, plunging anticlines and synclines in addition to the major structure. They are jointed and contain bedding planes, but the largest openings through which water may percolate in the zone of saturation are the solution channels.

The data of 93 wells in these limestones are tabulated below.

TABLE 15.—*Average yield of wells ending in the Beekmantown, Stones River, Frederick, Athens (?), and Chambersburg limestones for each 100 feet of depth*

Depth (Feet)	Number of Wells	Yield (Gallons a Minute)	
		Range	Average
0–100	43	¼–33	10
101–200	35	1–75	14
201–300	10	1–16	6
301–400	2	12–32	24
401–500	..	.....	..
501–600	2	2–16	9
1,401–1,500	1	.....	150
	93	0–150	13

The permanent weakening with depth of the wells in these limestone formations does not seem to take place until a depth of 400 feet is reached, although there appears to be a slight decrease between 200 and 300 feet. One well between 300 and 400 feet in the Beekmantown limestone near Winchester encountered an opening 1½ feet in diameter at the bottom. Just how common these openings are below 300 feet is unknown, but it is likely that household wells should make use of the favorable zone less than 200 feet in depth. If a suitable supply is not encountered in that zone, drilling another 200 feet should bring in water, but if not, the hole probably should be abandoned. It is still more difficult to lay down any rules about obtaining a given large quantity (say 100 gallons a minute or more), because the well at the Winchester Woolen Mills, which was put down to a depth of 1,432 feet, encountered large water-bearing channels between 1,100 and 1,200 feet, according to W. J. Gochenour, the driller, but none below that. It is possible that the openings in the rock were originally faults. The data above given seem to indicate a weakening of wells below 400 feet, and it is probable

[7] The Frederick limestone, probably of Chazy age, is blue, slaty, crystalline limestone.

that unless there is unusual necessity for water, drilling should not be carried below that depth. At the same time, the decreased yields between 200 and 300 feet should be kept in mind.

Only 1 well in 2 of those tabulated above obtains a yield exceeding 20 gallons a minute, and many of them deliver less than 10 gallons a minute. Therefore the cheapest source of a large quantity of water probably would be a series of 200-foot wells.

The water in these formations, as in the Upper Cambrian limestones, is very hard, averaging 370 parts per million for five samples.

Quantico slate, Martinsburg shale, and Oswego sandstone.—The western boundary of the Martinsburg shale south of Winchester, Frederick County, coincides roughly with the Baltimore and Ohio Railroad, and north of Winchester it follows the Pennsylvania Railroad to the West Virginia line. The eastern boundary of the outcrop is marked approximately by Opequon Creek.

The Martinsburg shale is rather tightly folded, especially at the north end of the outcrop area, near the West Virginia boundary, into a major syncline upon which a large number of small folds are superimposed. In addition to the folds, cleavage cuts across the bedding and in places almost obscures it. The cleavage is very well marked on weathered outcrops, but where the shale is harder and more massive, the bedding is the more noticeable.

The Quantico slate, of Ordovician age, occupies the axis of a syncline, crossing the southern boundary of Prince William County just east of the Fall Zone, and extending along it in a strip about 2 miles wide as far as Lorton, Fairfax County, where it goes under the sediments of the Coastal Plain. This slate is a "soft, caving rock," and fissile, having a well-defined cleavage which crosscuts the bedding.

The Oswego sandstone is not important as a source of water because of its small outcrop area, and no information as to wells in it was obtained.

The data of wells in the shale and slate are summarized below.

TABLE 16.—*Average yield of wells ending in the Martinsburg shale for each 100 feet of depth*

DEPTH (FEET)	NUMBER OF WELLS	YIELD (GALLONS A MINUTE)	
		Range	Average
0–100	31	½–30	10
101–200	8	1–50	11
201–300	2	8–30	19
	41	½–50	11

TABLE 17.—*Average yield of wells ending in the Quantico slate for each 100 feet of depth*

Depth (Feet)	Number of Wells	Yield (Gallons a Minute)	
		Range	Average
0–100	4	1½–5	3
101–200	2	¼–7	4
301–400	1	....	1
	7	¼–7	2½

The Martinsburg shale is capable of delivering fairly small but rather reliable supplies of water from wells of small to moderate depth. Wells less than 100 feet deep are as satisfactory on the average as those 100 to 200 feet deep. The yield of two wells deeper than 200 feet is greater than that of the wells less than 200 feet, and this, perhaps, should be expected, as the slaty cleavage of this formation is not confined to the zone near the surface and therefore water should be encountered for considerable depths. It is doubtless true, however, that the yields are greater on the whole in the shallower zone of weathering than at extremely great depths, and that supplies of more than 20 gallons a minute should be sought by drilling more than one shallow well rather than a single deep one. In the Martinsburg shale an average yield of wells is a rather significant figure compared to that in a limestone, for instance, because in the long run the results of drilling in the shale are very consistent.

The wells in the Quantico slate for which data are available are very weak. Slightly better results seem to be obtained in wells less than 200 feet deep than in those more than 200 feet.

Both formations are soft and easy to drill, although they tend to compact rather than fracture like more brittle rocks. As they are fairly uniform in hardness and texture, there is less trouble in the drilling of tilted beds through deflection of the bit than in many other types of rock.

Three samples from the Quantico slate show an average hardness of 130 parts per million, and two samples from the Martinsburg shale had a hardness of 438 and 669 parts per million, with comparatively large quantities of sulphate and chloride.

Juniata formation, Tuscarora sandstone, Clinton formation, and Cayuga group.—The Juniata, Tuscarora, Clinton, and Cayuga formations crop out in the mountainous area of western Frederick County. Because of its superior resistance the Tuscarora sandstone crops out in

anticlines that stand out as ridges. Thus the Tuscarora sandstone and the overlying Clinton formation and Cayuga group of limestones are exposed where there are but few if any wells, and nothing is known of their water-bearing properties. The Juniata formation has so small an outcrop area that no data of wells in it are available. Because these formations are similar to others whose water-bearing properties are known, however, a few guesses may be made as to their possibilities as sources of water. As they occur on mountains, the water table in them would probably be subject to rather great fluctuations in response to rainfall. Probably the water in the Juniata formation would be rather scanty, owing to the silty but massive nature of the rock; the Tuscarora sandstone, really a quartzite in this area, would probably be dry except where highly shattered; the Clinton formation would probably be a lean water bearer in the shaly portion near the top, and the lower quartzite members would be very hard and very poor as sources of water. The Cayuga limestones probably do not differ materially from the other limestones of the region and should yield good quantities of water.

Helderberg limestone.—The Helderberg limestone crops out in three localities, all in Frederick County. Along the faulted area at Little North Mountain it occupies a narrow, irregular and interrupted belt. A better-developed exposure occupies the eastern slope of Great North Mountain, swings around the north end, and continues along the western flank. A small area cuts northeastward across the extreme northwest corner of the county.

As data for only five wells are at hand, the usual summary will be omitted, and the data merely set forth.

TABLE 18.—*Yield of wells ending in the Helderberg limestone*

WELL NUMBER	DEPTH (FEET)	YIELD (GALLONS A MINUTE)
31	100	10
43	195	3½
53	160	3
60	80	1
92	104	10
Average	128	5

These wells do not show such good results as those in many other limestones farther east. It may be that the isolated limestone outcrop is not acted upon by such vigorously circulating water as the broad limestone terranes. It is also possible that the wells have merely failed to encounter large cavities that nevertheless may exist in this limestone.

No water samples from this formation were analyzed chemically, but it is probable that the water is hard.

Oriskany sandstone.—The Oriskany formation crops out immediately west of the Helderberg limestone at Little North Mountain, down the slope from it at Great North Mountain, and east of it in the northwest corner of Frederick County. It is only about 200 feet or less thick and therefore where tilted steeply its outcrop is very narrow. The three wells in the Oriskany sandstone concerning which data are available are tabulated below.

TABLE 19.—*Yield of wells ending in the Oriskany sandstone*

WELL NUMBER	DEPTH (FEET)	YIELD (GALLONS A MINUTE)
36	118	1
38	130	6
47	142	8

Here again it is difficult to understand why a formation which in many places is an excellent water bearer should yield such small supplies. More abundant data perhaps would show better results.

A water sample taken from a well which ended in the Oriskany sandstone but which had passed through the overlying Romney shale was analyzed. It showed a hardness of 253 parts per million—a result, partly at least, of the calcareous cementing material in the sandstone.

Romney shale, Jennings formation, and Catskill formation.—The Romney, Jennings, and Catskill formations constitute the bedrock under the lowlands west of Little North Mountain and east, north, and northwest of Great North Mountain.

The formations are made up chiefly of arenaceous shale and mudstone, with limy material in the Romney shale and predominatingly mudrock and sandstone at the top in the Catskill. They are folded into synclines and anticlines, and are jointed but not otherwise altered to any great extent by the Appalachian deformation. The Jennings formation, composed mainly of siliceous shale and sandstone, with minor amounts of sandy mudrock in the upper 2,000 feet is jointed finely, so that the beds appear to be made up of brick-shaped fragments.

The data of 100 wells in these formations are summarized as follows:

TABLE 20.—*Average yield of wells ending in the Romney shale, Jennings formation, and Catskill formation for each 100 feet of depth*

Depth (Feet)	Number of Wells	Yield (Gallons a Minute)	
		Range	Average
0–100	82	0–16	5
101–200	18	½–16	5
	100	0–16	5

The wells in these formations are very weak, and the depth to which they are drilled seems to make very little difference in the yield, although the wells delivering from 10 to 16 gallons a minute average slightly deeper than those delivering less than 10 gallons a minute. It is probable, in the light of this fact, that the water circulates mainly through bedding planes and joints, which are small. The reason why most of the wells are shallow is not definitely known, but probably it is because of the expense of drilling deeper for larger supplies that are not absolutely necessary. It is unfortunate that no records of deep wells in the outcrop area of these formations are available, for in other regions the Catskill formation, especially, is a fairly good source of water. Some flowing wells are reported in the outcrop areas of these formations, but the artesian head does not extend much above the surface of the ground.

Five water samples from these formations show an average hardness of 189 parts per million, the Romney shale having the hardest water. In the Romney shale and Jennings formation much of the water has the odor of hydrogen sulphide.

Newark formation and associated diabase.—The eastern boundary of the Upper Triassic (Newark) sediments is a sedimentary contact which extends almost north and south from the northwest corner of Fairfax County through Dranesville, a mile east of Herndon and Centerville, crosses into Prince William County at a point northeast of Manassas, passes 2 miles east of Manassas, and swings southwest by south to the boundary of Stafford County. The western boundary is the Catoctin border fault, which trends northeast by north through Loudoun County, 2 miles west of Leesburg, and the western extremity of Prince William County.

Three separate and parallel belts of the border conglomerate of the Newark formation lie in the territory between Leesburg and Potomac River, in Loudoun County. The outcrops are faulted and dip steeply

westward toward the border fault. Widely spaced joints cut the formation. (See Pl. 6, A.)

TABLE 21.—*Average yield of wells ending in the border conglomerate of the Newark formation for each 100 feet depth*

Depth (Feet)	Number of Wells	Yield (Gallons a Minute)	
		Range	Average
0–100	20	½–20	9
101–200	10	0–60	9
201–300	1	.....	½
301–400	1	.....	(?)
	32	0–50	9

Although the yields of wells between 100 and 200 feet in depth average the same as those of wells less than 100 feet, the yields of 10 to 20 gallons a minute are obtained from wells that are shallower on the average than those which yield less than 10 gallons a minute. It seems likely that below some depth (indefinite through lack of data) the joints and solution channels diminish in size and number.

Potomac River is the permanent control of the water table, and it is doubtful if the ground water should sink below the river bed even in long periods of diminished rainfall, for it is known that the course of the river is a very ancient one. If it is agreed that solution of limestone does not proceed noticeably below the water table under ordinary conditions, then it would be expected that the solution of joints in the limestone conglomerate would be practically negligible below the Potomac River level, and therefore wells in the conglomerate below a depth of say 200 feet would suffer a diminishing chance of obtaining good supplies.

A single sample from the border conglomerate was a typical calcium carbonate water with a hardness of 186 parts per million. The water is, however, softer than most limestone waters in the Shenandoah Valley.

The Newark sediments dip westward with a monoclinal structure toward the downfaulted edge of the Triassic basin, and as their surface outcrop has been beveled by erosion their thickness increases westward. Faulting within the basin has cut the sediments into tilted blocks, whose boundaries, owing to the lack of horizon-marking beds, are very obscure. Joints break the rocks chiefly in one direction, parallel to the strike of the beds, and two other systems are less well developed.

The summarized data of 318 wells in the sandstone and shale follow:

TABLE 22.—*Average yield of wells ending in the Newark sediments above the border conglomerate for each 100 feet of depth*

Depth (Feet)	Number of Wells	Yield (Gallons a Minute)	
		Range	Average
0–100	198	0–55	4
101–200	108	½–50	7
201–300	9	½–55	27 {15
301–400	..	.....	..
401–500	1	.....	50
501–600	2	27–120	73
	318	0–120	17

There is a marked increase in yield with greater depth, probably because the bedding planes and porous beds of only moderately consolidated sandstone are original and do not decrease in number and efficiency as water bearers, like the joints in granite, which are secondary features, or the solution channels in limestone, which are probably controlled by the position of the water table. Therefore the yield of a deep well in the Triassic basin represents usually the combined contribution of beds and bedding planes and joints from the top of the well to the bottom. Drilling should not pass into the rock basement below the sediments, for it is probably dry. The chances of obtaining more than 10 gallons a minute from a single well less than 200 feet deep in the sandstone and shale are poor and those of getting more than 20 gallons a minute are negligible.

There is some indication that the water is likely to lie above trap sheets, with an unsaturated zone immediately below—or if the zone is saturated, the water is under diminished head. Where such water is encountered care should be taken not to puncture the trap sheet, lest the water pass down and be lost.

There is some artesian head locally in the sandstone and shale, especially in the western part of the basin, where the dips are steepest. The wells that flow must be pumped, however, if the water is to be lifted above the surface of the ground, or if the quantity of water desired is at all large, for the weak head causes only a mere trickle to issue from the well.

Drilling through the sandstone and shale is usually easy. The shales are soft, and the sandstone, in many places poorly consolidated, crumbles easily under impact.

The hardness of the water of six samples from sandstone and shale ranges from 125 to 250 parts per million, some of the water being harder than many limestone waters. Silica and iron are noticeable in some samples, especially the iron, which makes the water unfit for boiler or laundry work and even gives trouble when the water is used for cooking and in household water systems. The water is decidedly poor for most industrial uses other than cooling.

Trap or diabase.—The diabase or trap associated with the Newark sediments crops out in several bodies of varying size and form. (See Pl. 2.) The trap bodies have been injected as sills between the bedding planes of the sandstone and shale, as dikes into fractures that crosscut the bedding, and in the form of irregular masses known as stocks. In addition some were extruded as lava flows. Below the zone of surface weathering this massive, dense rock has but few open spaces through which water may percolate except faults and joints, which are not numerous. Near the surface, however, the rock weathers into rectangular fragments grading toward the surface into spheroidal masses and then into soil containing isolated masses. In this zone most of the ground water is to be found. (See Pl. 6, B.)

TABLE 23.—*Average yield of wells ending in the Newark trap for each 100 feet of depth*

Depth (Feet)	Number of Wells	Yield (Gallons a Minute)	
		Range	Average
0–100	91	0–60	7
101–200	12	0–20	4
301–400	1	.....	2½
801–900	1	.....	3
	105	0–60	6

The table shows the weakening in yield of wells with depth. Some of the very shallow wells yield large quantities of water. For instance, two wells that deliver 60 gallons a minute average only 48 feet in depth. Many of the deeper wells that obtain considerable quantities of water encounter most of it in shallower zones. It is true, however, that the deeper zones in the trap are not absolutely devoid of usable quantities of water, but the supplies are usually very small. Wells drilled into the trap should not be located in stream valleys where the weathered rock has been eroded away, as was the 803-foot well, which delivered only 3 gallons a minute. Drilling deeply in trap, therefore, is likely to be wasteful, for if a good supply is not found in the first 100 feet it is

almost certain that the well will be poor. Only one well in nine obtains more than 10 gallons a minute, and one well in sixteen obtains more than 20 gallons a minute. Where larger quantities are desired, several shallow wells, 100 feet or less in depth, should be put down rather than a single deep one.

Drilling in the trap is very difficult, because the hardness and toughness of the sound rock necessitate frequent dressing of the drilling bit and because the round masses produced by spheroidal weathering are very difficult to drill through, the tool being deflected and often jammed by loose "boulders."

The water in the trap is very hard, one sample showing a hardness as high as 350 parts per million. Such a hardness is high even for limestone wells. Other samples show between 100 and 200 parts per million of hardness. Water in the weathered zone may be very soft—40 parts per million in one sample—showing that most of the soluble mineral matter has been leached.

Potomac group.—The Potomac group of formations crops out on the Coastal Plain; the western boundary begins at the north, across the Potomac from Washington, and trends parallel to that river in a southwest by south direction; at the east it passes under Potomac River.

These deposits are of an entirely different type from those discussed above, being practically or wholly unconsolidated lenses of sand, overlain by and grading into silt and clay. The water follows the sandy portions, in places segregated from the water in other beds. Down the dip from the western edge of the outcrop artesian pressure is commonly exhibited, but owing to the slight difference in altitude of intake and outlet the head is small. There are very few evidences of any structural disturbance in the Potomac group. The seaward dip of the formations is only slightly greater than the dip of the original rock floor upon which they were deposited, and no important folds, faults, or joint systems have been developed. There seems to be an east-west ridge in the rock floor beneath the Potomac sediments in the vicinity of Fort Humphreys, Fairfax County, which apparently has decreased the gradient of the rock floor at that point. Near the base of the Potomac group, just above the rock floor, is a zone of coarse sediment, more noteworthy as a zone of water-bearing beds than the higher portions of the group. Near Washington this zone dips seaward from the western boundary of the Coastal Plain at about 100 feet to the mile, but farther south the slope appears to be nearer 70 feet to the mile, and at Fort Humphreys it is 45 feet to the mile. In projecting the rock floor it must always be remembered that the old surface is somewhat irregular, owing to an ancient drainage system that existed before the deposition of the Potomac sediments and also, possibly, to some post-Cretaceous folding.

Deeper wells intersecting more and better water-bearing beds in these formations have larger yields than the shallow ones. Another factor, however, which enters strongly into the contrasting yields of deep and shallow holes is the development of the wells after they are drilled. A "hard rock" driller, knowing but little of the highly specialized technique involved in developing wells in unconsolidated materials, is more than likely to obtain yields characteristic of "hard rock" formations, whereas a more skilled operator could develop a very successful well at the same point. Of course this explanation does not account for the comparatively poor results of all the shallow drilled wells, but it is certainly a factor in many of them. Near the western boundary of the Potomac group, where it is not very thick, the results seem to be especially poor.

On the basis of the data available there is about one chance in four of obtaining 50 gallons a minute or more from wells in these formations, but actually the chances are better if the site for drilling is not too near the western boundary of the Coastal Plain. A well 8, 10, or 12 inches in diameter, properly developed, should yield at least 50 gallons a minute more often than not.

The water is in some places hard but more usually soft, and in northern Virginia the quality does not seem to be related to either depth or to the nearness to the border of the outcrop. In the soft water sodium carbonate is the chief constituent. Iron is locally present in such quantities as to stain utensils and clothing, clog pipes, and render the water undrinkable.

Pliocene (?), Pleistocene, and Recent deposits.—The deposits of terrace gravel, which are of Pliocene (?) and Pleistocene age, are thin beds laid down on wave-cut platforms or on old land surfaces. They overlie the Potomac group and the older rocks of the Piedmont province in Virginia. The older (higher) terrace gravel has been almost entirely removed by erosion, and only more or less isolated outliers are left. The Recent sediments are represented by valley-floor alluvium, chiefly in the Potomac estuary.

Near the Fall Zone the terrace gravel deposits, because of their shallow depth and small intake area, are not a good source of water supplies, but farther east they are reported to yield copious amounts. A well 30 feet deep and one 60 feet deep drilled into the formation derive from it only 3 gallons a minute each.

The Recent valley fill is near the stream levels and is in many places saturated almost to the ground surface. Two wells near the west end of the Highway Bridge, in Arlington County, 27 and 5 feet deep, deliver 320 and 350 gallons a minute.

No analyses were made of samples from these formations.

Summary.—The relative number, depth, and yield of wells in the different formations are summarized below.

TABLE 24.—*Summary of data on wells in northern Virginia*

Rock Formation	Number of Wells	Depth (Feet)		Yield (Gallons a Minute)	
		Range	Average	Range	Average
Recent, Pleistocene, and Pliocene (?) formations	4	5– 60	31	3–350	169
Potomac group	75	24–530	145	0–320	32
Diabase or trap	105	14–803	71	0– 60	6
Newark formation	318	22–531	105	0–120	7
Conglomerate of Newark formation	32	28–360	101	0– 50	9
Romney shale, Jennings formation and Catskill formation	100	22–171	71	0– 16	5
Oriskany sandstone	3	118–142	127	1– 8	5
Helderberg limestone	5	80–195	128	1– 10	5
Silurian formations	0	.....	.....	.....	.....
Martinsburg shale	41	40–289	102	½– 50	11
Quantico slate	7	40–310	126	¼– 7	2½
Lower and Middle Ordovician limestones	93	23–1,432	145	0–150	13
Elbrook and Conococheague limestones	95	32–725	162	½– 90	13
Waynesboro formation	1	.....	190	.....	15
Tomstown dolomite	7	30–220	111	2– 15	10
Lower Cambrian sediments	21	30–530	164	¼– 16	6½
Granite of eastern belt	72	38–740	136	0– 50	9
Marshall granite	97	25–550	109	0– 41	7
Wissahickon schist	145	39–305	95	¼– 70	10
Catoctin greenstone	93	23–704	85	¼– 30	4½
Pre-Cambrian white marble	6	25–120	68	¼– 15	8

GROUND-WATER CONDITIONS, BY COUNTIES

FREDERICK COUNTY

GEOGRAPHY

Frederick County lies in the northwest corner of Virginia and adjoins West Virginia on the northwest and northeast; on the southeast, Opequon Creek separates it from Clarke County, and on the south it is bounded by Warren and Shenandoah counties. It is roughly diamond-shaped and about half of it lies in the Shenandoah Valley. Including the independent city of Winchester, which is a part of it geographically, it has an area of 435 square miles and in 1930 had a population of 24,022.

This county is largely agricultural, 81 per cent of its total area being under cultivation. Most of the lands not devoted to farming are mountainous. Winchester, with 10,855 inhabitants, is the largest city in the Shenandoah Valley north of Staunton, and, except for Alexandria and the suburban area of Washington, it is the largest community in the area covered by this report. Industry in Frederick County consists chiefly in the preparation for the market of agricultural products in creameries, feed and flour mills, fruit-packing houses, and canneries. There are also ice plants, quarries for lime and glass sand, woolen mills, foundries, and other industrial establishments. In 1929 the total number of industrial establishments was 52 and the value of their products was $7,301,663.

The main highway, known as the Valley Pike, runs through about the middle of the county in a northeast-southwest direction, passing through Winchester, Stephens City, and Middletown. Another arterial highway connects Winchester with Washington, D. C., and extends westward through West Virginia. An improved highway leads toward Washington by way of Berryville and Leesburg, and a network of other roads, many of which are paved, has been constructed through the county. Branch lines of the Baltimore & Ohio and Pennsylvania railroads traverse the county, and the Winchester & Western Railroad runs westward from Winchester into West Virginia.

DRAINAGE

Frederick County is drained by Sleepy Creek, Back Creek, and Opequon Creek, which flow northward through West Virginia and discharge into Potomac River, and by Cedar Creek, which discharges into the North Fork of the Shenandoah. The

drainage tends to be parallel to the geologic and topographic trends of the area, with a few exceptions: Cedar Creek cuts across the structure of the underlying rocks and passes through a gap in Little North Mountain; Gap Run breaches the same mountain near Chambersville; and other gaps have been cut through it at Cedar Grove and Green Spring by two smaller streams, which were once tributary to Opequon Creek but have been captured by the headwaters of Back Creek.

TOPOGRAPHY

The part of Frederick County that lies east of Little North Mountain—that is, roughly the eastern half—lies in the Shenandoah Valley and is comparatively flat and low, sloping eastward from an altitude of about 1,000 feet above sea level near the foot of Little North Mountain to an altitude of about 500 feet along Opequon Creek. The relief is not generally over 100 feet for any small area. The lowland is underlain by easily eroded shale and soluble limestone. The area west of Little North Mountain is characterized by linear ridges that trend northeastward and are separated by moderately dissected lowlands. Little North Mountain is rather discontinuous in Frederick County and is less than 1,500 feet in altitude. Great North Mountain reaches an altitude of about 2,500 feet, and Cacapon Mountain, to the northwest, is nearly as high. On the low lands between the ridges the relief is considerably greater than that east of Little North Mountain. The relief of the western half of the county taken as a whole is over 1,800 feet.

GEOLOGY

The formations present in Frederick County range from the Elbrook limestone (Middle and Upper Cambrian) to the Catskill formation (Upper Devonian). (See Pl. 2 and Table 7.)

The Elbrook limestone is exposed along an overthrust fault zone at the eastern foot of Little North Mountain. The belt of exposed Elbrook limestone is discontinuous, owing to the faulting, and only locally does the entire formation appear at the surface. The Conococheague, Beekmantown, Stones River, and Chambersburg limestones occupy the belt of territory between Little North Mountain and the Valley Pike. The Martinsburg shale lies between the pike and Opequon Creek, which forms the eastern boundary of the county.

Along the west side of the overthrust fault are small masses of the Martinsburg shale and the Clinton formation, with pos-

sibly smaller and less regular masses of the Oswego sandstone, Juniata formation, Tuscarora sandstone, and Cayuga limestone. Beyond the overthrust fault zone the Tuscarora sandstone caps the anticlinal ridges of Great North Mountain and Cacapon Mountain, and associated with it on the summits of the mountains the Clinton formation and the Cayuga group of limestones are exposed locally. The Helderberg limestone and Oriskany sandstone crop out along the flanks of the ridges, and the rest of the Devonian sediments underlie the synclinal lowlands between the ridges. (See Fig. 4.)

In the Shenandoah Valley the rocks are limestone and shale of Upper Cambrian and Ordovician age. They are folded into a complex asymmetric syncline that trends northeast by north, with the Martinsburg shale at the axis; the dip of the rocks is steep on the east limb of the fold—indeed, farther east in Clarke County the beds are overturned—but on the west limb the dip is slight. Many smaller folds are superimposed upon the larger fold. The whole syncline is part of an overthrust sheet that moved from the southeast along a fault plane and overrode the younger sediments to the northwest, so that along the overthrust zone at Little North Mountain the Elbrook limestone, of Middle and Upper Cambrian age, has come to lie adjacent to Silurian and Devonian sediments.

The structure of the rocks west of Little North Mountain trends northeast by north and is characterized by a succession of plunging anticlines and synclines. The first syncline beyond the overthrust fault has the form of an elongate bowl. The town of Mount Williams is situated near the axis. Great North Mountain is an anticlinal ridge lying immediately west of and parallel to the syncline. The Tuscarora sandstone occupies the axial line of the anticline along the top of the ridge, and the Helderberg limestone, Oriskany sandstone, and Romney shale crop out on the flanks. The anticline is comparatively simple in structure at the north end, where it plunges abruptly near Gainesboro, but farther south, in the vicinity of Star Tannery, it passes into an overthrust fault of minor displacement. North of Great North Mountain almost in line with its axis, there is a large syncline, which has on its median line an outcrop of the hard Pocono sandstone, of lower Mississippian age. It is because this sandstone has continued to resist weathering that this syncline forms a ridge—Sleepy Creek Mountain of West Virginia—in contrast to the general rule in the area that the anticlines form the ridges and the synclines the lowlands. A slight anticlinal fold immediately west of Sleepy Creek Mountain brings the Jennings formation to the surface, and still farther

west, the Catskill formation occupies the axis of a syncline that extends southwest along the west foot of Great North Mountain. In the northwest corner of the county a complex anticlinal fold brings the Tuscarora sandstone to the surface on the crest of Cacapon Mountain of West Virginia.

GROUND-WATER CONDITIONS

Martinsburg shale belt.—In the belt underlain by the Martinsburg shale, which lies east of the Valley Pike, wells ranging from about 50 to 100 feet in depth generally yield small to moderate supplies of water adequate for domestic use. Most of the wells that deliver less than 5 gallons a minute are shallow, but many other shallow wells yield 10 to 15 gallons a minute or even more. The strongest well reported in this area (No. 223) was one drilled on the property of Luther Wise, 1½ miles east of Stephens City, to a depth of 247 feet. It is reported that very little if any water was encountered by the driller in the upper part of the well but that near the bottom a 12-inch opening in the rock was found from which water rose to a level of 20 feet below the surface. Pumping tests of 30 gallons a minute failed to draw the water down noticeably. Most of the other exceptionally strong supplies of water are obtained near the western edge of this belt, near the contact with the limestone. East and northeast of Winchester and east of Middletown conditions seem to be less favorable, for most of the wells are reported to deliver smaller supplies than those drilled elsewhere in the belt. Where relatively large quantities of ground water are required it will be advisable to drill several wells of moderate depth rather than to attempt to obtain the entire supply from a single hole. The water level lies from about 10 to 50 feet below the surface in most places, commonly at about 20 feet. In the areas of rolling topography near Opequon Creek the water table is likely to lie comparatively deep. Artesian pressure is poorly developed because of the slight relief and because the shale is cut by joints through which the water may pass from one bedding plane to the next. The high content of dissolved mineral matter in the water in the Martinsburg shale may necessitate treatment of the water for use in boilers or other industrial purposes. In fact, some of the water in the Martinsburg shale belt is considerably harder than most of the water analyzed from limestone. It is believed that the water is extremely hard along the western side of the shale belt, near the limestone belt, but it probably becomes less hard farther east.

Dug wells are not a satisfactory source of water in the Mar-

tinsburg shale belt, aside from the general objections to them for reasons of sanitation. The water table lies below the surface of the shale on much of the area, so that there are mechanical difficulties in digging down to it. Also, in time of drought the dug wells are likely to dry up, whereas drilled wells in this area withstand droughts very well.

A few springs in this belt discharge generous supplies of water, but because the topography in most parts is not rugged enough for springs to be strong and numerous and because reliable supplies can generally be obtained from drilled wells at moderate cost, springs are not important quantitatively as sources of ground water in this area. Moreover, springs are more liable to surface contamination than properly constructed drilled wells.

Belt of Cambrian and Ordovician limestone.—In the belt of Cambrian and Ordovician limestone—the part of the Shenandoah Valley west of the Valley Pike—most of the ordinary wells are between 50 and 200 feet deep and yield 5 gallons or less to 20 gallons a minute. The shallowest wells are generally weak, although there are exceptions, such as a well of the Southern Dairy Co. (No. 206) in Stephens City, which is 75 feet deep and yields 33 gallons a minute. In this well the water stood at the surface at the time of drilling. Most of the strongest wells in this area are more than 150 feet in depth. The deepest well reported in the area is one owned by the Winchester Woolen Mill (No. 161) in the southeastern part of the city. It was drilled to a depth of 1,432 feet through dolomite and limestone. Water-bearing openings in the rock were passed through at about 100 feet, 300 feet, 700 feet, and between 1,100 and 1,200 feet. No more were encountered below 1,200 feet. The water stood at 16 feet below the surface and is drawn down 104 feet when it is pumped at 150 gallons a minute. The driller reported that the water was flowing through the deepest channels with sufficient force to wash out the drill cuttings. A well of such great depth is very expensive, and it is not certain that water-bearing cavities will be encountered at great depths in all places, in spite of the fact that some of the drillers in the area are confident that water can be obtained at low levels.

It is believed that the structure of the rocks in the eastern part of Frederick County exerts a definite influence upon the movement of the ground water in the areas of limestone and Martinsburg shale. The rocks constitute a syncline, with the shale in the axial region and limestone on the western limb passing under the shale and emerging at the surface at the east in Clarke County. The land surface slopes eastward from Little North Mountain to

Opequon Creek, so that the surface of the limestone just west of the shale belt is 200 to 300 feet higher than it is just east of the shale. The shale belt is 5 to 6 miles wide near Winchester. The ground water is thought to flow eastward through the limestone on the western limb of the fold, passing rather rapidly through the cavernous zone which extends 400 feet or more below the surface, then coming near the shale, which, in spite of its rather high content of lime, is less permeable than the soluble limestone. The water from the limestone, carrying its dissolved lime, enters the shale, but as it moves slowly through the small channelways in the shale its hardness increases, as shown by analyses. But analyses of water taken in counties farther south in the valley indicate that the hardness of the shale water decreases eastward suggesting less of the original water from the limestone and more of surface water percolating downward. That the shale obstructs the eastward movement of the ground water from the limestone and may act as a dam is further suggested by the occurrence of some of the largest springs of the county in the limestone near the contact with the shale. Such springs are the two at Winchester that furnish the present public supply and the large spring at Vaucluse. (See Pl. 4, B.) Whatever water that does not emerge at the surface or penetrate the shale may pass below the shale through the upper beds of limestone under the head resulting from the difference in altitude between the western and the eastern limbs of the syncline. The assumption of such an artesian circulation of the water in the limestone would make it easier to understand the strong flows of water encountered in cavities at depths of 1,100 and 1,200 feet in the well of the Winchester Woolen Mills. Moreover, on the basis of several analyses of ground-water in the limestone the water in the eastern limb of the syncline, in Clarke County, is harder than the limestone waters in the western limb of the fold. It is also interesting to note in this connection that most of the strongest wells in the shale belt were said to occur near the western boundary, where water might be entering the shale from the limestone under some artesian head, if the hypothesis of artesian circulation is correct.

There seem to be some differences among the wells in different parts of this belt—for instance, the number of wells yielding less than 10 gallons a minute is greater in a locality about 2 miles northwest of Winchester and near Kernstown than in the area as a whole. A considerable number of the wells in the limestone area failed during the droughts of 1930 and 1931. In most of the belt the water level lies between 15 and 100 feet below

the surface. One well was reported to flow, but this was very exceptional.

The water in the limestone belt is hard and should be softened for industrial and municipal uses.

The shallow depth at which the limestone lies beneath the surface in this belt discourages efforts to dig to the water table. The rock is hard; the solution channels near the surface are choked with fine mud; and a dug well probably would go dry during a drought because the relief of the land and the cavernous condition of the limestone both make for wide fluctuations of the water table with changes in the amount of rainfall.

The undulating surface in this belt and the shallow depth at which the limestone lies result in a large number of springs, many of which discharge large quantities of water. Two such springs are the municipal springs at Winchester; another is situated on the Rice farm at Vaucluse. All three of these springs discharge into large basins at a rate of several cubic feet a second. Many smaller springs are used locally for domestic supplies. However, the spring water especially during wet weather is likely to be contaminated by water that passes from the surface into sink holes and along the large solution channels, and it may be objectionably laden with mud. Moreover, many of the springs weaken seriously or go dry during dry seasons.

A spring known as Tidal Spring, on the farm of J. F. Orndorff, near Marlboro, is reported to ebb and flow. At the time it was visited by the writer it was discharging at an approximately uniform rate, but Mr. Orndoff confirmed the report that at some times it has a periodic action.

Area west of Little North Mountain.—Drilled wells in the area west of Little North Mountain are generally less than 100 feet deep, and most of them yield only small supplies of water. The deepest well recorded in the area is 170 feet deep and yields only 2 gallons a minute, but a well owned by Dr. C. H. Harbaugh (No. 48), near Hayfield, is only 56 feet deep and was pumped at 16 gallons a minute with very little draw-down. In general, the wells in this area are the weakest in the county, but it is believed that deeper drilling might produce greater supplies in some localities. This would not be true, perhaps, in one well in which the drilling was discontinued at a depth of 175 feet and no water was encountered. The water level is less than 35 feet below the surface in most places, and a few wells flow at the surface. The artesian pressure, however, is not great.

Dug wells are few in this area, owing to the thinness of the soil layer.

There are numerous small springs in this area and a few large ones. The use of springs for household and stock supplies is more common proportionately than elsewhere in the county. The uplands from which the waters flow to the point of issuance are practically uninhabited, and consequently the danger of pollution is comparatively small. The springs seem to withstand drought well. Some of the springs are thermal. The water enters a bed of permeable rock on one limb of a syncline and follows the bed down through the inverted arch of the syncline, rises on the other limb because of the hydrostatic pressure developed by gravity, and is discharged at a lower altitude than the intake. During the migration through the axial region of the fold the temperature of the water rises because of the higher temperature of the rocks at that depth, and on emerging at the spring the water is warmer than the local shallow ground water, the temperature ranging from slightly above the mean annual air temperature to 105° F. According to Reeves,[8] the Oriskany sandstone (Lower Devonian), the Lowville limestone (Middle Ordovician), and the Elbrook limestone (Middle and Upper Cambrian) are the three chief geologic formations in which thermal springs are found. The Oriskany sandstone and the Elbrook limestone crop out west of Little North Mountain; the Lowville limestone is absent in northern Virginia.

MUNICIPAL SUPPLIES

The city of Winchester obtains its water supply from two large springs in the limestone. The Rouss Spring, just outside the city limits on the road to Boyce, is the chief source, and the pumping and filter plant is situated beside it. An auxiliary supply is derived from the Shawnee Spring, within the city limits. The water from the Shawnee Spring is filtered and then piped by gravity to the Rouss Spring, where the whole supply is filtered and chlorinated. It is then either pumped directly through the distributing system or to two concrete reservoirs of 3,000,000 and 250,000 gallons capacity on the hill near Handley School, whence it is distributed. The springs were weakened in the summer of 1931, and consideration has been given to the development of an additional supply.

[8] Reeves, Frank, Thermal springs of Virginia: Virginia Geol. Survey Bull. 36, p. 36, 1932.

WELL

TABLE 25.—*Wells in*

Well number	Location	Owner	Driller	Type of well
1	3 miles northwest of Collinsville, which is 6 miles northwest by north of Gainesboro.	Mr. Gano	Fred Braithwaite	Drilled
2	¼ mile northwest by north of Collinsville.	Ernest Batt	Russell DeHaven	Drilled
3	1 mile northwest of Collinsville	Mr. Brannon	Fred Braithwaite	Drilled
4	1 mile northwest of Collinsville	Henry Batt	Albert Thompson	Drilled
5	1¼ miles northwest by north of Collinsville.	Fairview	Russell DeHaven	Drilled
6	1¾ miles northeast by north of Collinsville.	Mark Holliday	Albert Thompson	Drilled
7	1½ miles northeast by north of Collinsville.	Page Holliday	Albert Thompson	Drilled
8	2¾ miles northeast of Collinsville	Rich Omps	Albert Thompson	Drilled.
9	2¾ miles northeast of Collinsville	Rich Omps	Albert Thompson	Drilled
10	¾ mile northwest by west of Collinsville.	Mr. Shanholtz	Fred Braithwaite	Drilled
11	½ mile northeast of Collinsville	Henry Tuttrell	Albert Thompson	Drilled
12	Collinsville	Mr. Kerns	Fred Braithwaite	Drilled
13	Collinsville	Albert Thompson	Russell DeHaven	Drilled
14	1 mile southwest of Collinsville	(?)	Russell DeHaven	Drilled
15	2½ miles southeast of Collinsville	Mr. Manzy	Albert Thompson	Drilled
16	3½ miles north of Green Springs, which is 7½ miles north of Winchester.	Mr. DeHaven	Russell DeHaven	Drilled
17	4¾ miles north of Gainesboro	Elsie DeHaven	Russell DeHaven	Drilled
18	4¾ miles north of Gainesboro	Charles Davis	Russell DeHaven	Drilled
19	7 miles east of Whitaker, which is 6 miles northwest of Gainesboro.	Willie Lamb	Albert Thompson	Drilled
20	4 miles north of Gainesboro	Harry Kern	Russell DeHaven	Drilled
21	½ mile west of Whitaker, which is 6 miles northwest of Gainesboro.	Mr. Whitaker	Fred Braithwaite	Drilled
22	Whitaker	Clark Whitaker	Albert Thompson	Drilled
23	Whitaker	Mr. Dolan	Fred Braithwaite	Drilled
24	1 mile southwest of Whitaker	Mr. Whitaker	Fred Braithwaite	Drilled
25	½ mile south of Whitaker	Mr. Whitaker	Fred Braithwaite	Drilled
26	½ mile southeast of Whitaker	Mr. Johnson	Fred Braithwaite	Drilled
27	¾ mile west of Cross Junction, which is 4 miles northwest of Gainesboro.	Mr. Grove	Fred Braithwaite	Drilled
28	¼ mile west of Cross Junction	Lee Braithwaite	Fred Braithwaite	Drilled
29	½ mile south of Cross Junction	Mr. Braithwaite	Fred Braithwaite	Drilled
30	1¼ miles southeast by south of Cross Junction.	Mr. Font	Fred Braithwaite	Drilled
31	Gainesboro	Mack DeHaven	Russell DeHaven	Drilled
32	Gainesboro	Charles Adams	Russell DeHaven	Drilled
33	Gainesboro	Mrs. Willie Shade	Russell DeHaven	Drilled
34	Gainesboro	Forest Bogent	Russell DeHaven	Drilled
35	Gainesboro	Will Lewis	Russell DeHaven	Drilled
36	Gainesboro	Charles Adams	Russell DeHaven	Drilled
37	Gainesboro	Winchester & Western Railroad Co.	Albert Thompson	Drilled
38	Gainesboro	Canning factory	Albert Thompson	Drilled
39	1¼ miles southeast of Gainesboro	Sam Cline	Russell DeHaven	Drilled
40	Gore, which is 4 miles southwest by west of Gainesboro.	Sorball	Fred Braithwaite	Drilled
41	Gore	Winchester & Western Railroad Co.	Albert Thompson	Drilled
42	1 mile southwest of Gainesboro	Julian Larick	Russell DeHaven	Drilled
43	1¾ miles southwest of Gainesboro	H. W. Butler	Russell DeHaven	Drilled
44	¾ mile northeast of Hayfield	Lester Ramey	Russell DeHaven	Drilled
45	½ mile north of Hayfield	Oscar Cline	Russell DeHaven	Drilled
46	Hayfield	Matt Rosenburger	Albert Thompson	Drilled
47	1½ miles southwest by south of Gore.	Virginia Glass Sand Corp	William J. Gochenour	Drilled
48	1 mile southwest by south of Hayfield.	Dr. C. H. Harbaugh	William J. Gochenour	Drilled
48a	1¼ miles southwest by south of Hayfield.	J. G. Carper	William J. Gochenour	Drilled

RECORDS

Frederick County, Virginia

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
50	Shale	Romney		4		1
140	Red shale	Catskill		1		2
90	Grayish sandstone	Catskill		3		3
60	20 feet shale; last 40 feet red sandstone.	Catskill		½		4
100	Red sandstone and shale.	Catskill		4/10		5
70	Yellow shale	Catskill		½		6
60	Yellow shale	Catskill		1		7
100	Shale	Jennings		3½		8
80	Shale	Jennings		1		9
58	Shale	Jennings		9		10
70	Shale	Jennings		1		11
70	Shale, then gray sandstone.	Jennings		4		12
110	Shale	Jennings		5		13
108	Shale	Jennings		1½		14
110	30 feet red shale, red sandstone.	Catskill		½		15
69	Shale	Jennings		1		16
60	Shale	Jennings		1		17
45	Shale	Jennings	45	3½		18
70	Shale	Jennings		½		19
171	Shale	Jennings		2		20
48	Shale	Catskill		2		21
100	Red and gray sandstone, shale.	Catskill		4	Analysis on p. 80.	22
122	Sandstone	Catskill		2		23
50	Gray sandstone	Catskill		1+		24
115	Gray sandstone	Catskill		9		25
130	Shale	Jennings		3		26
132	Shale	Jennings		1½		27
102	Shale	Jennings		9½		28
115	Shale	Jennings		3		29
55	Shale	Jennings		3		30
100	Limestone	Helderberg		10		31
26	Black shale	Romney		10+		32
50	Black shale	Romney		1		33
41	Mucky, soft black shale.	Romney		10		34
37	Black shale	Romney		1		35
118	Black shale, sandstone	Romney, Oriskany		1	Analysis on p. 80.	36
60	Shale	Romney		3½		37
130	Black shale, sandstone	Romney, Oriskany		6		38
68	Black hard shale	Jennings		9		39
28	Shale	Romney		9½		40
50	Shale	Romney		3½		41
40	Black shale	Romney		1½		42
195	Limestone	Helderberg		3½		43
70	Black shale	Romney		2		44
80	Shale	Romney		9/10		45
80	Shale	Romney		3½		46
142	Shale sandstone	Romney, Oriskany	30	8		47
56	Shale	Romney	15	16+	Analysis on p. 80.	48
35	Shale	Romney	10	½		48a

WELL RECORDS

TABLE 25.—*Wells in Frederick*

Well number	Location	Owner	Driller	Type of well
49	2 miles northwest of Chambersville	Holmes Nagle	Russell DeHaven	Drilled
50	2 miles northwest of Chambersville	Cliff Nagle	Russell DeHaven	Drilled
51	2 miles northwest of Chambersville	Mr. Fletcher	Russell DeHaven	Drilled
52	4½ miles northwest by west of Winchester.	K. D. Marpole	William J. Gochenour	Drilled
53	4 miles southwest of Hayfield	Charles McIlwee	Albert Thompson	Drilled
54	4 miles southwest of Hayfield	Charles McIlwee	Albert Thompson	Drilled
55	1 mile southeast of Mount Williams, which is 7 miles northwest by west of Bartonville.	Edgar Smoke	Russell DeHaven	Drilled
56	2 miles northwest of Mount Williams.	(?)	Russell DeHaven	Drilled
57	Mount Williams	George Carver	Russell DeHaven	Drilled
58	Mount Williams	Will Orndorff	Russell DeHaven	Drilled.
59	2 miles northwest of Mount Williams.	(?)	Russell DeHaven	Drilled
60	1¾ miles north of Mountain Falls, which is 8¾ miles northwest of Middletown.	Jake Crabble	Albert Thompson	Drilled
61	2 miles northeast of Mountain Falls	Mr. Wright	Albert Thompson	Drilled
62	Mountain Falls	H. W. Butler	William J. Gochenour	Drilled
63	¾ mile east of Mountain Falls	J. W. Lineberg	William J. Gochenour	Drilled
64	Star Tannery, which is 4 miles west of Stephens City.	Mr. Cooper	Turner Catlett	Drilled
65	Star Tannery	Hessler Himmelright	Turner Catlett and Fred Stickley.	Drilled
66	Star Tannery	Sumner Orndorff	William J. Gochenour	Drilled
67	½ mile southwest by south of Star Tannery.	W. T. Green	William J. Gochenour	Drilled
68	¾ mile south of Star Tannery	W. F. Brill	William J. Gochenour	Drilled
69	Gravel Spring, which is 12½ miles west of Stephens City.	Gravel Spring Church	William J. Gochenour	Drilled
70	Gravel Spring	Thomas Himmelwright	William J. Gochenour	Drilled
71	2¾ miles southwest of Star Tannery.	Clarence Brill	William J. Gochenour	Drilled
72	2½ miles southwest of Star Tannery.	Charles E. Fishell	William J. Gochenour	Drilled
73	2½ miles southwest of Star Tannery.	Isiah McElure	William J. Gochenour	Drilled
74	2½ miles southwest of Star Tannery.	S. J. Fishell	William J. Gochenour	Drilled
75	3½ miles southwest of Star Tannery.	Charles Copeland	William J. Gochenour	Drilled
76	3½ miles southwest of Star Tannery.	Josephine Orndorff	William J. Gochenour	Drilled
77	3½ miles southwest of Star Tannery.	J. S. Peer	William J. Gochenour	Drilled
78	4 miles southwest of Star Tannery	J. W. Rudolph	William J. Gochenour	Drilled
79	4½ miles southwest of Star Tannery.	W. R. Linaweaver	William J. Gochenour	Drilled
80	4½ miles southwest of Star Tannery.	R. B. Orndorff	William J. Gochenour	Drilled
81	3½ miles southwest of Star Tannery.	I. R. McIlwee	William J. Gochenour	Drilled
82	3¾ miles southwest of Star Tannery.	Jeff McIlwee	William J. Gochenour	Drilled
83	3¾ miles southwest of Star Tannery.	Jeff McIlwee	William J. Gochenour	Drilled
84	5 miles southwest by south of Star Tannery.	De Kalb Orndorff	William J. Gochenour	Drilled
85	5 miles southwest of Star Tannery	P. J. Brill	William J. Gochenour	Drilled
86	4½ miles southwest of Star Tannery.	Charles Whittington	William J. Gochenour	Drilled
87	4¾ miles southwest by south of Star Tannery.	A. S. Wyman	William J. Gochenour	Drilled
88	5 miles southwest of Star Tannery	Snowden Bauserman	William J. Gochenour	Drilled
89	5½ miles southwest of Star Tannery.	J. W. Williams	William J. Gochenour	Drilled
90	4 miles southwest of Star Tannery	Geo. D. Jarnett	William J. Gochenour	Drilled
91	4¼ miles southwest by south of Star Tannery.	J. B. Racey	William J. Gochenour	Drilled
92	Green Spring, which is 8½ miles north of Winchester.	Stone Church	Russell DeHaven	Drilled
93	White Hall, which is 7½ miles north of Winchester.	J. A. Hancher	William J. Gochenour	Drilled
94	White Hall	Frederick County School	William J. Gochenour	Drilled
95	1 mile southwest by south of White Hall.	J. W. Reese	William J. Gochenour	Drilled
96	1½ miles northeast of White Hall	Hon. Harry Byrd	Mr. Showalter	Drilled
97	1 mile northeast of White Hall	E. R. Himmelright	William J. Gochenour	Drilled
98	3 miles northwest of Brucetown, which is 7½ miles northeast of Winchester.	George T. Pitzer	William J. Gochenour	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
22	Shale	Jennings		9/10		49
30	Shale	Jennings		1		50
60	Shale	Catskill		1½		51
31	Shale	Jennings		16+		52
160	80 feet of shale, 80 feet of limestone.	Romney, Helderberg		3		53
54	Shale	Romney		1		54
50	Shale	Jennings		1½		55
50	Shale	Jennings		1½		56
77	Shale	Jennings		1		57
75	Shale	Catskill		⅕		58
50	Shale	Jennings		1½		59
80	Limestone	Helderberg		1		60
60	Shale	Jennings		1		61
116	Shale	Jennings		2		62
46	Shale	Jennings		2	Analysis on p. 80.	63
72	Shale	Jennings	Flows	¼		64
125	Shale	Jennings		14		65
87	Shale	Jennings		3	Analysis on p. 80.	66
33	Shale (?)	Jennings		16		67
57	Shale	Jennings		6		68
91	Shale	Romney		5		69
79	Shale	Romney	20	7		70
90	Shale	Romney	35	10		71
116	Shale	Romney	66	8		72
81	Shale	Romney	25	2		73
38	Shale	Romney	2	13		74
52	Shale	Romney		2		75
104	Shale	Romney	35	8		76
81	Shale	Romney				77
51	Shale	Romney	15	8		78
63	Shale	Romney	16	16		79
43	Shale	Romney	16	8		80
62	Shale	Romney		13		81
100	Shale	Romney		9		82
114	Shale	Romney		16		83
54	Shale	Romney		4		84
73	Shale	Romney		13		85
51	Shale	Romney		5		86
103	Shale	Romney	60	2½		87
70	Shale	Romney		2		88
58	Shale	Romney	12	13		89
64½	Shale	Romney	29½	10		90
62	Shale	Romney		13		91
104	Limestone	Helderberg		10+		92
40	Limestone	Conococheague	28	13+		93
62	Limestone	Conococheague	30	1	Analysis on p. 80.	94
66	Limestone	Conococheague	34	8		95
146½	Limestone	Conococheague	30	16+		96
96	Limestone	Conococheague	36	13		97
187	Limestone	Beekmantown	45	12		98

WELL RECORDS

TABLE 25.—*Wells in Frederick*

Well number	Location	Owner	Driller	Type of well
99	1 mile north of Clearbrook, which is 6½ miles northeast of Winchester.	H. P. Boyce	William J. Gochenour	Drilled
100	1 mile northeast of Clearbrook	M. Anderson	William J. Gochenour	Drilled
101	2 miles southeast of White Hall	H. B. McCormick	William J. Gochenour	Drilled
102	1 mile northwest of Clearbrook	J. G. Hubbard	William J. Gochenour	Drilled
103	2 miles northwest of Stephenson, which is 5 miles northeast of Winchester.	H. W. Carter	William J. Gochenour	Drilled
104	1½ miles northwest by north of Stephenson.	F. W. Snyder	William J. Gochenour	Drilled
105	Clearbrook	Brucetown Woolen Mills	James Feltner	Drilled
106	1 mile southwest by west of Brucetown.	M. Anderson	William J. Gochenour	Drilled
107	1 mile south of Cedar Grove, which is 6 miles north of Winchester.	Russell DeHaven	Russell DeHaven	Drilled
108	1¼ miles south of Cedar Grove	Levi Boyd	Russell DeHaven	Drilled
109	½ mile north of Nain, which is 4½ miles northwest by north of Winchester.	Charles Brown	Russell DeHaven	Drilled
110	3½ miles northwest by north of Winchester.	George M. Carson	William J. Gochenour	Drilled
111	1¼ miles east of Nain	Mr. Barton	Mr. Showalter	Drilled
112	Nain	Charles Lloyd	Russell DeHaven	Drilled
113	4 miles northwest by north of Winchester.	Philip Gold	William J. Gochenour	Drilled
114	4 miles north of Winchester	Archie Orndorff	William J. Gochenour	Drilled
115	3½ miles north of Winchester	Roy Boyce	William J. Gochenour	Drilled
116	¼ mile south of Nain	Mr. Marple	Russell DeHaven	Drilled
117	1 mile south of Nain	Mr. Marple	Russell DeHaven	Drilled
118	3¾ miles northwest of Winchester	H. R. Butler	William J. Gochenour	Drilled
119	3½ miles north of Winchester	Bond Bros	William J. Gochenour	Drilled
120	1¾ miles southwest by west of Stephenson.	D. Metz, Jr	William J. Gochenour	Drilled
121	½ mile southeast of Stephenson	N. E. Tipton	William J. Gochenour	Drilled
122	1 mile southwest of Stephenson	J. W. Joliffe	William J. Gochenour	Drilled
123	3½ miles northeast by north of Winchester.	C. L. Nicodemus	William J. Gochenour	Drilled
124	3½ miles northeast of Winchester	F. S. Boyd	William J. Gochenour	Drilled
125	1½ miles southwest by south of Stephenson.	Bender Orchards	James Feltner	Drilled
126	3¾ miles northeast by north of Winchester.	J. W. Omps	William J. Gochenour	Drilled
127	2 miles northeast of Winchester on Baltimore & Ohio R. R.	(?)	Mr. Totten	Drilled
128	2¾ miles northeast of Winchester	L. F. Dorsey	William J. Gochenour	Drilled
129	3 miles northeast by north of Winchester.	C. W. Pingley	William J. Gochenour	Drilled
130	2¾ miles northwest by north of Winchester.	C. J. Robinson	William J. Gochenour	Drilled
131	3 miles northwest by north of Winchester.	E. W. Carber	William J. Gochenour	Drilled
132	2 miles north of Winchester	J. M. Williams	William J. Gochenour	Drilled
133	2 miles north of Winchester	Miller Streit	William J. Gochenour	Drilled
134	3¼ miles northwest by west of Winchester.	Sherman Bros	William J. Gochenour	Drilled
135	2½ miles northwest by west of Winchester.	Stonewall Orchard Co	William J. Gochenour	Drilled
136	2¼ miles northwest by west of Winchester.	H. C. DeGrange	William J. Gochenour	Drilled
137	2 miles northwest of Winchester	C. E. Pingley	William J. Gochenour	Drilled
138	2 miles northwest of Winchester	R. W. Renner	William J. Gochenour	Drilled
139	1¾ miles northwest of Winchester	John Gough	William J. Gochenour	Drilled
140	1½ miles northwest of Winchester	W. W. Glass	William J. Gochenour	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
63	Limestone	Beekmantown	17	16+		99
59½	Limestone	Chambersburg	35	1½		100
228	Limestone	Beekmantown	100	10		101
151	Limestone	Conococheague	84	8		102
66	Limestone	Beekmantown	30	16+		103
116	Limestone	Beekmantown	101	8		104
198	Limestone	Chambersburg		40		105
40	Limestone	Chambersburg		13		106
54	Yellow shale, black shale.	Romney		1½		107
51	Yellow shale, black shale.	Romney		2		108
68	Yellow shale, black shale.	Romney		1		
75	Black shale	Romney		9/10		109
75	Sandstone, limestone.	Conococheague	21	2		110
118½	Limestone	Conococheague	18	16+		111
68	Limestone with a sandstone bed.	Conococheague		1	Analysis on p. 81.	112
114	Limestone	Conococheague	34	15		113
81	Limestone	Beekmantown	56	16+		114
114	Limestone	Beekmantown		8		
110	Limestone with a 3-foot bed of sandstone at 90 feet.	Conococheague	98	13+		115
30	Black shale	Romney		2		116
71	Black shale	Romney		1½		117
82½	Limestone	Elbrook		16		118
137	Limestone	Conococheague	30	2	Analysis on p. 81.	119
101	Limestone	Beekmantown	8	4		120
64	Shale	Martinsburg		10		121
70	Limestone	Beekmantown		1		122
140	Limestone	Beekmantown	6	15		123
132	Limestone	Beekmantown (?)	70	16+	Drilled in bottom of 70-foot well.	124
522	Limestone	Beekmantown		2		125
196	Limestone	Beekmantown	51	16+		126
84	40 feet shale, then limestone.	Martinsburg and Chambersburg.		20	Cased 3 feet down.	127
211	Limestone	Beekmantown		5		128
75	Limestone	Beekmantown	45	¾		129
240	Limestone	Conococheague	80	15		130
90	Limestone	Conococheague	128	13		131
363	Limestone	Conococheague	125	4	Analysis on p. 81.	132
146	Limestone	Beekmantown	6	16		133
133	Limestone	Elbrook		8		134
116	Limestone	Conococheague		5		135
232	Limestone	Conococheague	30	16+		136
200	Limestone	Conococheague	55	½		137
128	Limestone	Conococheague	35	13		138
111	Limestone	Conococheague	22	13		139
117	Limestone	Conococheague	30	16		140

WELL RECORDS

TABLE 25.—*Wells in Frederick*

Well number	Location	Owner	Driller	Type of well
141	2 miles northwest of Winchester	Dr. Julian F. Ward	William J. Gochenour	Drilled
142	1¼ miles northwest by north of Winchester.	Ray Robinson	William J. Gochenour	Drilled
143	Winshester	Shenandoah Valley Vinegar & Cider Co.	William J. Gochenour	Drilled
144	Winchester	Fred S. Boyd	William J. Gochenour	Drilled
145	Winchester	W. L. Lattrell	William J. Gochenour	Drilled
146	Winchester	Mrs. Ellen C. Anderson	William J. Gochenour	Drilled
147	1 mile east of Winchester	N. S. Haines	William J. Gochenour	Drilled
148	1 mile east of Winchester	J. W. Patton	William J. Gochenour	Drilled
149	1½ miles west of Winchester	N. I. Cather	William J. Gochenour	Drilled
150	1 mile west of Winchester	E. M. Hicks	William J. Gochenour	Drilled
151	1¾ miles west of Winchester	J. S. Miller	William J. Gochenour	Drilled
152	Winchester	Handley School	William J. Gochenour	Drilled
153	Southwest side of Winchester	Harlow Tar Co	William J. Gochenour	Drilled
154	1 mile southeast of Winchester	J. K. Luttrell	William J. Gochenour	Drilled
155	1 mile southwest by south of Winchester.	J. W. Keller	William J. Gochenour	Drilled
156	3 miles southwest by west of Winchester.	J. C. Cather	William J. Gochenour	Drilled
157	1½ miles southwest of Winchester	A. S. Rundall	William J. Gochenour	Drilled
158	1½ miles north of Kernstown, which is 3 miles southwest by south of Winchester.	Barr & Miller	William J. Gochenour	Drilled
159	1½ miles northwest by north of Kernstown.	R. S. Bell	William J. Gochenour	Drilled
160	2¼ miles southwest by south of Winchester.	Charles H. Cook	William J. Gochenour	Drilled
161	1½ miles southeast by south of Winchester.	Winchester Woolen Mill Corporation.	William J. Gochenour	Drilled
162	1 mile north of Kernstown	Cooke's garage	Mr. Showalter	Drilled
163	1¼ miles northwest of Kernstown	Robert S. Smith	William J. Gochenour	Drilled
164	3½ miles southwest of Winchester	A. B. Richards	William J. Gochenour	Drilled
165	1¼ miles northwest of Kernstown	Josiah Lantz	William J. Gochenour	Drilled
166	½ mile northwest of Kernstown	W. M. Lockhart	Mr. Showalter	Drilled
167	½ mile north of Kernstown	L. J. Miller, Appleway Camp	William J. Gochenour	Drilled
168	1 mile northeast of Kernstown	C. E. Babb	William J. Gochenour	Drilled
169	Kernstown	W. N. Mason	William J. Gochenour	Drilled
170	Kernstown	H. R. Butler	William J. Gochenour	Drilled
171	½ mile west of Kernstown	J. A. Blackburn	William J. Gochenour	Drilled
172	1 mile west of Kernstown	C. E. Omps	William J. Gochenour	Drilled
173	1½ miles northwest by west of Kernstown.	Musselman McGleef	John Rinker	Drilled
174	2 miles west of Kernstown	J. W. Richard	William J. Gochenour	Drilled
175	2½ miles west of Kernstown	C. M. Ebert	William J. Gochenour	Drilled
176	4 miles west of Kernstown	John D. Marker	William J. Gochenour	Drilled
177	3 miles southwest by west of Kernstown.	Dr. P. W. Boyd	William J. Gochenour	Drilled
178	2 miles northwest of Bartonsville	E. H. Grove	William J. Gochenour	Drilled
179	2½ miles southwest of Kernstown	E. H. Grove	William J. Gochenour	Drilled
180	2 miles west of Kernstown	F. W. Bailey	William J. Gochenour	Drilled
181	1¾ miles southwest by west of Kernstown.	R. L. Miller	William J. Gochenour	Drilled
182	2 miles southwest by west of Kernstown.	Salem Cooper	William J. Gochenour	Drilled
183	1¼ miles southwest of Kernstown	Josiah Lantz	William J. Gochenour	Drilled
184	1¼ miles southwest of Kernstown	Shryhock & Lantz	William J. Gochenour	Drilled
185	½ mile southwest of Kernstown	Ray Robinson	William J. Gochenour	Drilled
186	½ mile south of Kernstown	Bond Bros	William J. Gochenour	Drilled
187	1 mile south of Kernstown	I. N. Good	William J. Gochenour	Drilled

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County Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
236	Limestone	Conococheague	32	1		141
104	Limestone	Conococheague	81	15		142
383	Limestone and sandstone.	Conococheague		30+		143
132	Limestone	Beekmantown	35(1929) 70(1931)	16+		144
23	Limestone	Chambersburg	6	13		145
79	Limestone	Beekmantown	12	10		146
51	Shale	Martinsburg		13		147
56	Shale	Martinsburg		3		148
101	Limestone	Conococheague	68	16+		149
200	Limestone	Conococheague	23	2		150
184	Limestone	Conococheague	75	13+		151
302	Limestone	Beekmantown	60	16		152
344	Limestone	Beekmantown	32	32		153
87	Limestone	Stones River	30	8		154
41	Limestone	Beekmantown	28	8		155
125	Limestone	Conococheague		13		156
205	Limestone	Conococheague	60	13		157
142	Limestone	Conococheague		13		158
320	Limestone	Conococheague	65	8		159
188	Limestone	Conococheague	35	1		160
1,432	Limestone	Stones River, Beekmantown.	16	150	Solution cavities at approximate depths of 100, 300, 700, and 1,100 to 1,200 feet. None below 1,200 feet. Analysis on p. 81.	161
(?)	Limestone	Conococheague	40	16+		162
64	Limestone	Conococheague	41	13		163
32	Limestone	Conococheague		8		164
119	Limestone	Conococheague		16		165
140	Limestone	Conococheague		8		166
115	Limestone	Beekmantown		4		167
58	Shale	Martinsburg		5		168
42	Limestone	Beekmantown		3	Analysis on p. 81.	169
190	Limestone	Beekmantown	40	16	Drilled in bottom of 160 foot well.	170
54	Limestone	Conococheague	27	13		171
154	Limestone	Conococheague		8		172
190	Limestone	Conococheague		3	Drilled in bottom of 90-foot well that had yielded 3 gallons a minute but had gone dry.	173
171	Limestone	Conococheague	55	10+		174
117	Limestone	Conococheague	33	½		175
172	Limestone	Conococheague		½		
201	Limestone	Conococheague		5		176
148	Limestone	Conococheague		8		177
47	Limestone	Conococheague	31	15		178
158	Limestone	Conococheague	85	15		179
187	Limestone	Conococheague	108	11		180
59	Limestone	Conococheague	46	4		181
104	Limestone	Conococheague	87	4		182
94	Limestone	Beekmantown	69	16+		183
145	Limestone	Conococheague	40	3		184
290	Limestone	Beekmantown		4		185
40	Limestone	Beekmantown		16+		186
105	Shale	Martinsburg (?)		13+	Drilled in 52-foot well that had gone dry.	187

WELL RECORDS

TABLE 25.—*Wells in Frederick*

Well number	Location	Owner	Driller	Type of well
188	¾ mile northwest of Bartonsville	J. H. Beaver	William J. Gochenour	Drilled
189	½ mile north of Bartonsville	O. F. Andrews	William J. Gochenour	Drilled
190	Bartonsville	F. W. Shenk & Son	William J. Gochenour	Drilled
191	Bartonsville	F. W. Shenk & Son	William J. Gochenour	Drilled
192	Bartonsville	M. J. Rogers	William J. Gochenour	Drilled
193	Bartonsville	M. B. Hook	William J. Gochenour	Drilled
194	3 miles northwest of Stephens City	Mr. Krause	Turner Catlett	Drilled
195	3½ miles northwest by west of Stephens City.	Virginia Valley Orchard Co.	William J. Gochenour	Drilled
196	2 miles northwest of Stephens City	William Beverly	William J. Gochenour	Drilled
197	2 miles northwest of Stephens City	Claude Rickard	John Rinker	Drilled
198	1½ miles northwest of Stephens City	Fred Rideing	John Rinker	Drilled
199	1¼ miles northwest of Stephens City	Fred Rideing	John Rinker	Drilled
200	1 mile northwest by north of Stephens City.	John Derflinger	John Rinker	Drilled
201	1½ miles northeast of Marlboro, which is 4½ miles northwest by north of Middletown.	E. Tevalt	William J. Gochenour	Drilled
202	3¼ miles west of Stephens City	Virginia Valley Orchard Co.	William J. Gochenour	Drilled
203	3 miles northwest of Vaucluse, which is Midway between Stephens City and Middletown.	Mr. Funkhouser	Wade Muse	Drilled
204	2¼ miles west of Stephens City	Charles Snapp	John Rinker	Drilled
205	2 miles west of Stephens City	Dudley Snapp	Turner Catlett	Drilled
206	Stephens City	Southern Dairy Co	Mr. Beatty	Drilled
207	½ mile south of Marlboro	Joe Hoffman	Mr. Totten	Drilled
208	3 miles northwest by north of Middletown.	R. J. Lantz	William J. Gochenour	Drilled
209	½ mile south of Vaucluse	(?)	Wade Muse	Drilled
210	1 mile north of Middletown	Press Boyer	Turner Catlett	Drilled
211	1 mile north of Middletown	H. S. Larrick	Wade Muse	Drilled
212	2 miles northwest of Middletown	Miller Bros	Mr. Totten	Drilled
213	¾ mile north of Middletown	Larrick & Larrick	Wade Muse	Drilled
214	Meadow Mills, which is 1½ miles west of Middletown.	Pitcher & Teake	Mr. Totten	Drilled
215	Meadow Mills	Wilbur Cooley	Mr. Totten	Drilled
216	1 mile southwest of Middletown	J. H. Brumback	William J. Gochenour	Drilled
217	½ mile west of Brucetown, which is 7½ miles northeast of Winchester.	A. G. Mellinger	William J. Gochenour	Drilled
218	2 miles south of Stephenson	C. W. Hardesty	William J. Gochenour	Drilled
219	5 miles northeast by east of Winchester.	Ella R. Benner	William J. Gochenour	Drilled
220	2½ miles east of Winchester	H. M. Busey	William J. Gochenour	Drilled
221	2½ miles east of Winchester	L. F. Anderson	William J. Gochenour	Drilled
222	2 miles east of Winchester	Dora Clemm	Turner Catlett	Drilled
223	1½ miles east of Winchester	D. M. Reardon	William J. Gochenour	Drilled
224	1¾ miles east of Winchester	Mrs. May L. McCarty	William J. Gochenour	Drilled
225	3 miles east of Winchester	J. O. Ritter	Mr. Showalter	Drilled
226	2½ (?) miles southeast by east of Winchester.	E. W. Pope	William J. Gochenour	Drilled
227	2 miles southeast by south of Winchester.	G. A. Newcome	William J. Gochenour	Drilled
228	2 miles northeast by east of Kernstown.	J. J. Harmer	William J. Gochenour	Drilled.
229	Stephens City	Morgan Tevalt	Mr. Showalter	Drilled
230	Stephens City	Morgan Tevalt	Mr. Showalter	Drilled
231	Stephens City	C. I. Brumback	Mr. Showalter	Drilled
232	Stephens City	Joseph Strode	William J. Gochenour	Drilled
233	1½ miles east of Stephens City	Luther Wise	Mr. Totten	Drilled
234	2¾ miles east of Stephens City	J. O. Newcome	William J. Gochenour	Drilled
235	3 miles east of Stephens City	M. S. Miller	William J. Gochenour	Drilled
236	2½ miles southeast of Stephens City.	State Highway Department.	William J. Gochenour	Drilled
237	Middletown	J. I. Watson	Wade Muse	Drilled
238	Middletown	George Wright	Wade Muse	Drilled
239	Middletown	Frank Whittington	Wade Muse	Drilled
240	Middletown	Jake Rinker	Wade Muse	Drilled
241	1 mile southeast of Middletown	Arva Willie	John Rinker	Drilled
242	1¼ miles southeast of Middletown	Modern Woodman Association.	John Rinker	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
109	Limestone	Beekmantown		3		188
51	Shale	Martinsburg		16		189
86	Limestone	Chambersburg	25	¼		190
82	Shale	Martinsburg		16		191
30	Limestone	Stones River	12	1		192
24½	Shale, limestone	Martinsburg, Chambersburg.	12	8	Analysis on p. 81.	193
172	Limestone	Conococheague		8		194
140	Limestone	Conococheague	101	16+		195
315	Limestone	Conococheague	65	2		196
154	Limestone	Conococheague		10+		197
217	Limestone	Beekmantown		3	Cased to 20 feet.	198
172	Limestone	Beekmantown		4		199
216	Limestone	Beekmantown		2+		200
158	Limestone	Conococheague	86	14		201
125	Limestone	Beekmantown	86	16+		202
256	Limestone	Conococheague		1		203
310	Limestone	Conococheague	210	10+	18-inch opening in limestone at 310 feet.	204
58	Limestone	Conococheague		16		205
75	Limestone	Chambersburg	0	33		206
81	Limestone	Conococheague		20	Analysis on p. 81.	207
175	Limestone	Beekmantown		10		208
75	Limestone	Stones River		1		209
110	Limestone	Beekmantown		16		210
93	Limestone	Beekmantown		8		211
51	Black and gray limestone.	Beekmantown		20		212
266	Limestone with some shale.	Beekmantown and Conococheague.		4		213
72	Shale	Martinsburg	30	30		214
64	Shale	Martinsburg	35	30		215
263	Limestone	Chambersburg		5		216
73	Shale	Martinsburg		2		217
99	Shale to 45 feet, limestone.	Martinsburg, Chambersburg.		1		218
78	Shale	Martinsburg		1		219
69	Shale	Martinsburg		2½		220
71	Shale	Martinsburg	10	9		221
68	Shale	Martinsburg		16		222
140	Shale	Martinsburg	60	7		223
70	Shale	Martinsburg	18	16+		224
133	Shale	Martinsburg		8		225
88	Shale	Martinsburg		13		226
72	Shale	Martinsburg	25	9		227
93	Shale	Martinsburg		15		228
91	Shale	Martinsburg		16		229
79	Shale	Martinsburg		16		230
95½	Shale	Martinsburg		16+	Analysis on p. 81.	231
44	Shale	Martinsburg		1½		232
247	Shale	Martinsburg	20	30	10 feet of casing.	233
46	Shale	Martinsburg	10	3		234
93	Shale	Martinsburg	20	13+		235
564	Shale, limestone	Martinsburg, Chambersburg.		16+		236
80	Shale	Martinsburg		10		237
48	Shale	Martinsburg		10		238
66	Limestone	Chambersburg		6		239
289	Shale	Martinsburg		8	Analysis on p. 81.	240
154	Shale	Martinsburg		3		241
52	Shale	Martinsburg		5		242

ANALYSES

TABLE 26.—*Analyses of ground waters*

[Analyst, S. K. Love. Parts per million. Numbers at heads

	22	36	48	63	66	94
Silica (SiO_2)	.....	.....	.....	.....	.....	11
Iron (Fe)	.....	.....	.....	.....	.....	2.6
Calcium (Ca)	42	70	78	[a]24	43	117
Magnesium (Mg)	26	19	12	.....	13	43
Sodium (Na)	[b]12	[b]11	[b] 1.1	.....	[b]17	4.1
Potassium (K)						1.5
Bicarbonate (HCO_3)	199	255	247	103	147	518
Sulphate (SO_4)	[a]16	[a]27	[a]38	[a]25	56	21
Chloride (Cl)	28	20	3.0	5.0	14	8.0
Nitrate (NO_3)	23	15	.30	.74	.25	12
Total dissolved solids	[b]265	[b]303	[b]264	.....	[b]224	472
Total hardness as $CaCO_3$ (calculated)	212	253	[d]244	[d]110	161	469
Date of collection (1931)	Oct. 28	Oct. 28	Oct. 28	Oct. 28	Oct. 28	Oct. 28

[a]By turbidity.
[b]Calculated.
[c]Less than 10 parts
[d]Determined.

OF WATER

from Frederick County, Virginia

of columns refer to corresponding well numbers in table 25.]

112	119	132	161	169	193	207	231	240
.....	.....	.....	9.6	.....	7.2	.....	19	12
.....	.....	.....	.26	.....	6.6	.....	.04	.14
[a]5	62	124	98	70	125	88	144	174
.....	29	20	30	34	75	35	19	57
.....	([c])	[b]9.8	14 4.8	([c])	146 10	[b]2.2	16 1.4	52 2.6
34	288	302	394	332	277	367	409	379
[a]3	[a]30	[a]26	44	[a]32	349	[a]16	105	46
2.0	4.0	57	9.0	6.0	255	12	16	298
.0	3.6	72	13	.20	.1	42	3.8	3.6
.....	[b]293	[b]480	409	[b]331	1,152	[b]406	539	869
[d]50 Oct. 27	274 Oct. 28	392 Oct. 29	368 Oct. 28	314 Oct. 28	620 Oct. 28	364 Oct. 28	438 Oct. 28	669 Oct. 28

ADJACENT AREAS IN SHENAN

TABLE 27.—*Wells in*

Well number	Location	Owner	Driller	Type of well
400	1½ miles east of Star Tannery, which is 10 miles west of Stephen City.	Frank Racey	Turner Catlett	Drilled
401	4 miles southwest by south of Star Tannery.	H. Orndorff	William J. Gochenour	Drilled
402	4¼ miles southwest by south of Star Tannery.	A. P. Stein	William J. Gochenour	Drilled
403	2 miles northwest of Strasburg	F. O. Miller	William J. Gochenour	Drilled
404	1½ miles northwest of Strasburg	G. L. Stickley	William J. Gochenour	Drilled
405	1¼ miles northwest of Strasburg	E. H. Hammond	William J. Gochenour	Drilled
406	4 miles southwest of Marlboro	N. Miller	William J. Gochenour	Drilled
407	1½ miles northeast of Strasburg	Mrs. Stickley	Mr. Totten	Drilled
408	½ mile north of Strasburg	G. F. Bowman	William J. Gochenour	Drilled
409	Strasburg	Bob Sonner	Turner Catlett	Drilled
410	Strasburg	Shenandoah Valley Cooperative Milk Producers Association.	William J. Gochenour	Drilled
411	At Fishers Hill, 1 mile southwest of Strasburg.	S. M. Childs	William J. Gochenour	Drilled
412	Midway between Strasburg and Toms Brook.	Mr. Riley	Mr. Totten	Drilled
413	Maurertown	Shenandoah Hatchery	First 90 feet drilled by William J. Gochenour, rest by Mr. Totten.	Drilled
414	Maurertown	W. E. Shaver	Fred Stickley	Drilled
415	3 miles northeast of Fort Cross Roads	F. Rittenour	William J. Gochenour	Drilled
416	1½ miles northeast of Fort Cross Roads.	Daniel G. Funk	William J. Gochenour	Drilled
417	1½ miles northeast of Fort Cross Roads.	Samuel Cullers	William J. Gochenour	Drilled
418	Fort Cross Roads	J. W. Munch	William J. Gochenour	Drilled
419	Fort Cross Roads	William Planger	William J. Gochenour	Drilled
420	Fort Cross Roads	A. G. Lichliter	William J. Gochenour	Drilled
421	4½ miles southwest of Fort Cross Roads.	M. J. Habron	William J. Gochenour	Drilled
422	7 miles northwest of New Market	Rose Showns	William J. Gochenour	Drilled
423	7 miles northwest of New Market	Elmer Showns	William J. Gochenour	Drilled
424	3 miles northeast of New Market on the Valley Pike.	Mrs. S. V. McCormick	Wililam J. Gochenour	Drilled

TABLE 27.—*Wells in*

Well number	Location	Owner	Driller	Type of well
425	3 miles northwest by west of Cedarville.	J. C. Beatty	John Rinker	Drilled
426	3 miles west of Cedarville	John Rinker	John Rinker	Drilled
427	½ mile northeast of Nineveh	F. K. Weaver	John Rinker	Drilled
428	4 miles south of Front Royal	Mr. Weaver	John Rinker	Drilled
429	2 miles northeast of Cedarville	George Lee	John Rinker	Drilled
430	2½ miles northeast of Cedarville	Thompson Sowers	John Rinker	Drilled
431	4 miles south of Front Royal	Lee Burke	Mr. Totten	Drilled

DOAH AND WARREN COUNTIES

Shenandoah County, Virginia

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
142	Blue and red shale	Jennings		1		400
63	Shale	Jennings		1+		401
62½	Shale	Jennings	14	½		402
84	Limestone	Conococheague		3	Drilled in bottom of 54-foot well.	403
115	Limestone	Conococheague	77	8		404
135	Limestone	Conococheague	115	4		405
49	Limestone	Conococheague		15		406
106½	Limestone	Chambersburg	50	20	11 feet of casing	407
154	Shale	Martinsburg		1		408
297	Limestone	Chambersburg	225	16		409
155	Shale	Martinsburg	3	50		410
150	Blue shale to 70 feet, gray limestone.	Martinsburg, Chambersburg.	12	5½		411
84	Limestone	Chambersburg		20	47 feet of casing. Limestone contained seams of mud to depth of 47 feet.	412
300	Blue limestone	Beekmantown		9		413
66	Limestone	Chambersburg		3½		414
57	Shale	Romney		1		415
40	Shale	Romney		6½		416
28	Shale	Romney		13	Water is sulphurous	417
38	Shale	Romney		5		418
64	Shale	Romney		6		419
38	Shale	Romney		6		420
123	Shale	Romney		5		421
76	Shale	Martinsburg	47	13		422
94	Shale	Martinsburg		5		423
120	Blue limestone	Chambersburg	49	7		424

Warren County, Virginia

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
104	Shale	Martinsburg		3		425
72	Shale	Martinsburg		1½		426
92	Limestone	Beekmantown		4		427
101	Limestone	Beekmantown		10+		428
182	Limestone	Conococheague		1½		429
220	Limestone, 30 feet shale, dolomite.	Elbrook, Waynesboro, Tomstown.		13		430
74	Greenstone	Catoctin		2		431

CLARKE COUNTY

GEOGRAPHY

Clarke County, once a part of Frederick County, covers 171 square miles and in 1930 had a population of 7,167. It is bounded on the north by West Virginia, on the west by Frederick County, and on the south by Warren County. On the east the crest of the Blue Ridge separates it from Loudoun and Fauquier counties. It has a higher percentage of its area devoted to agriculture than any other county in the area—91.5 percent. Even in the mountainous eastern part, the Blue Ridge, there is a large amount of orchard land. The largest community is Berryville, with a population of 1,094. According to the census, the county in 1929 had 9 industrial establishments, most of which are creameries, ice plants, and establishments engaged in packing and storing apples. The value of their output in 1929 was $722,700.

The county is crossed from north to south by the Norfolk & Western Railway and from east to west by two main highways that lead from Winchester to Washington, D. C. Another main road leads northward from Berryville to Charles Town and Harpers Ferry, W. Va.

DRAINAGE

Clarke County is drained by Shenandoah River and Opequon Creek and their tributaries. The configuration of the Opequon Creek drainage is interesting. The creek flows along the boundary between the Martinsburg shale, in Frederick County, and the older Ordovician limestones, in Clarke County. In the shale area the creek has numerous tributaries, but in the limestone area most of the drainage is underground and there are scarcely any surface tributaries. The same condition, though to a slighter extent, is observable in the drainage basin of Shenandoah River, which has fewer tributaries on the west side, in the limestone area, than on the east side, where the rocks are mainly crystalline.

TOPOGRAPHY

Clarke County lies in two geomorphic provinces—the Blue Ridge province and the Valley and Ridge province. Most of it is part of a gently undulating plain of the Valley and Ridge province and has a

relief that is generally less than 100 feet. Shenandoah River flows along the east margin of this plain and has cut 100 to 200 feet below it. Opequon Creek flows through a narrow valley less than 100 feet below the general level of the plain. East of Shenandoah River is the Blue Ridge, which rises to an altitude of 1,600 feet at the southeast corner of the county but is lower farther north. Gaps in the Blue Ridge provide easy passage for the two principal highways.

GEOLOGY

The rocks in Clarke County consist of the pre-Cambrian Catoctin greenstone, which forms most of the Blue Ridge, and the Cambrian and Ordovician sandstones, shales, and limestones, which chiefly underlie the plain. (See Pl. 2 and Table 7.)

Structurally the county includes the incomplete parts of the Catoctin-Blue Ridge anticlinorium of Loudoun County and of the eastern limb of the syncline whose axis is in eastern Frederick County. The anticlinorium, consisting of Catoctin greenstone with infolded synclines of Lower Cambrian shales and sandstones, was thrust from the southeast over the Cambrian and Ordovician rocks of the syncline. The trace of the overthrust fault is along the foot of the Blue Ridge east of Shenandoah River. The east limb of the syncline is overturned along its eastern edge, near the river, and farther west there is an abrupt upfolding of the strata. (See Fig. 4.)

GROUND-WATER CONDITIONS

Blue Ridge area.—Some of the wells drilled near the crest of the Blue Ridge near Snickers Gap are reported to be shallow—less than 100 feet deep—but their yields were found by the drillers to be moderately high. The rocks underlying the crest and west flank of the Blue Ridge are the Catoctin greenstone, Loudoun formation, and Weverton sandstone. These rocks are rather poor sources of ground water in some other localities, being dense and nonporous, but it is likely that on the Blue Ridge they are extensively shattered, thus permitting large quantities of water to be stored. A few of the wells were reported to be rather weak. Dug wells are impracticable in most parts of the area, owing to the thinness or absence of soil.

Springs of large yield are not common in the Blue Ridge area, but springs of small to moderate discharge are numerous, even near the

crest of the mountain. The water is clear and excellent for drinking, and in most parts of the area there is little danger of contamination.

Valley and Ridge area.—Dug wells are rare and are reported to be unsatisfactory in the Valley and Ridge area. Most of the drilled wells on the lowland west of the Blue Ridge derive their supplies from limestone, although a few have been drilled into the Lower Cambrian sandstones and shales and the Martinsburg shale. The limestone wells are exceptionally successful and are reported to yield moderate to large supplies. Three wells (No.'s 344, 345, 346) drilled on the estate of William DuPont, Jr., northeast of Boyce are 145, 148, and 180 feet deep and are reported to yield 20, 75, and 30 gallons a minute, respectively. Three wells (No.'s 319, 320, 321) on the property of the Berryville Ice Co., in Berryville, 100, 239, and 300 feet deep, deliver a total of 230 gallons a minute. On the other hand, at the Audley Farm, just east of Berryville, a well (No. 323) was put down through 725 feet of limestone, and only 1½ gallons of water was obtained.

Springs are numerous, especially in the parts of the area that are underlain by limestone. Many of these springs deliver large quantities of water. The water table lies rather close to the surface, and in some places the springs discharge on almost flat land. However, in a settled area underlain by limestone, such as this, the spring water may be contaminated. Moreover, the water is likely to be muddy in wet times. East of Berryville a large number of springs that had been used for household and stock supplies became weak or went dry in 1930, and still more failed in 1931.

MUNICIPAL SUPPLIES

The only community in Clarke County that has developed a public water supply is Berryville. The chief source of the supply is a small stream on the west flank of the Blue Ridge, 7 miles southeast of the town. The stream empties into a reservoir having a capacity of 2,600,000 gallons. In addition there is a well in the town, about 300 feet in depth, which delivers 40 gallons a minute. The well has not been used for several years. During the dry summers of 1930 and 1931 a large spring three fourths of a mile northeast of the town along the pipe line leading from the mountain reservoir was utilized, and also a privately owned well in the town. The spring delivered about 1,000 gallons a minute in 1930, but in 1931 the yield diminished to about half that amount.

About 60,000 gallons a day, on the average, is used by the town. The water is chlorinated and pumped into two steel tanks with a capacity of 3,000,000 gallons each for distribution.

WELL

TABLE 28.—*Wells in*

Well number	Location	Owner	Driller	Type of well
300	5 miles north of Berryville	Mr. Morehead	James Feltner	Drilled
301	4 miles north of Berryville	Mrs. Mary Feltner	James Feltner	Drilled
302	4 miles north of Berryville	Negro settlement	James Feltner	Drilled
303	7 miles east of Winchester and 1 mile east of Burnt Factory, which is on county line east of Winchester.	Mr. Lee	Turner Catlett	Drilled
304	3½ miles northeast by north of Berryville.	Negro settlement	James Feltner	Drilled
305	3¼ miles northeast by north of Berryville.	Dr. Humpston	James Feltner	Drilled
306	3½ miles northeast of Berryville	Mr. Cornwell	James Feltner	Drilled
307	3¼ miles northeast by north of Berryville.	Dr. Humpston	James Feltner	Drilled
308	Gaylord, which is 4 miles northeast of Berryville.	Matt Jones	James Feltner	Drilled
309	7 miles northwest by north of Boyce	Mr. Millerson	James Feltner	Drilled
310	4 miles southeast by east of Burnt Factory.	Myers Lumber Co	William J. Gochenour	Drilled
311	7 miles northwest by north of Boyce	(?)	James Feltner	Drilled
312	5½ miles northeast by north of Boyce.	Mr. Brotherton	James Feltner	Drilled
313	2 miles northwest of Berryville	R. H. McAtee	James Feltner	Drilled
314	2 miles northwest of Berryville	R. H. McAtee	James Feltner	Drilled
315	2 miles northwest of Berryville	R. H. McAtee	James Feltner	Drilled
316	1 mile west of Berryville on Winchester Road.	Barnes Bros	Mr. Totten	Drilled
317	1½ miles north of Berryville	Abe Hardesty	James Feltner	Drilled
318	4 miles northeast by north of Boyce	Mr. McAtee	James Feltner	Drilled
319	Berryville	Berryville Ice Plant	James Feltner	Drilled
320	Berryville	Berryville Ice Plant	James Feltner	Drilled
321	Berryville	Berryville Ice Plant	James Feltner	Drilled
322	Berryville	Town of Berryville	James Feltner	Drilled
323	1 mile east of Berryville	Jones Bros., Audley Farm	William J. Gochenour	Drilled
324	2 miles east of Berryville	Mr. Proctor	James Feltner	Drilled
325	2¾ miles east of Berryville	(?)	James Feltner	Drilled
326	3½ miles north of Castleman's Ferry which is 5 miles southeast by east of Berryville.	A. C. Cummins	James Feltner	Drilled
327	3 miles north of Castleman's Ferry	A. C. Cummins	James Feltner	Drilled
328	4 miles east of Berryville	Mr. Ashley	James Feltner	Drilled
329	Castleman's Ferry	State of Virginia	James Feltner	Drilled
330	Castleman's Ferry	Mr. McKenney	James Feltner	Drilled
331	Top of Blue Ridge near Bluemont	Mr. Droop	James Feltner	Drilled
332	Top of Blue Ridge near Bluemont	Mr. Meade	James Feltner	Drilled
333	Top of Blue Ridge near Bluemont	(?)	James Feltner	Drilled
334	Top of Blue Ridge near Bluemont	Commodore Peters	James Feltner	Drilled
335	1½ miles south of Castleman's Ferry.	Mrs. Shelder	Mr. Reed	Drilled
336	2 miles southeast of Castleman's Ferry.	William Fox	James Feltner	Drilled
337	3 miles south of Castleman's Ferry	William Fox	James Feltner	Drilled
338	3½ miles southwest of Castleman's Ferry.	William Lupton Lands	James Feltner	Drilled
339	2 miles northeast of Millwood	Fox Spring Woods	James Feltner	Drilled
340	2 miles northeast of Millwood	Maria Whiting	James Feltner	Drilled
341	1¼ miles northeast by north of Boyce.	Dr. B. M. Knight	William J. Gochenour	Drilled
342	1 mile northeast by north of Boyce	T. L. Clark	William J. Gochenour	Drilled
343	Boyce	Hotel	James Feltner	Drilled
344	2 miles northeast by north of Boyce	William DuPont, Jr	William J. Gochenour	Drilled
345	2 miles northeast by north of Boyce	William DuPont, Jr	James Feltner	Drilled
346	2 miles north of Boyce	William DuPont, Jr	James Feltner	Drilled
347	2 miles northwest of Boyce	R. T. Barton	William J. Gochenour	Drilled
348	2½ miles northwest by north of Boyce.	W. S. Carper	William J. Gochenour	Drilled
349	2¾ miles northwest of Boyce	Miss Ellen Wheele	William J. Gochenour	Drilled
350	2½ miles northwest of Boyce	W. J. Cook	William J. Gochenour	Drilled
351	1½ miles northwest of Boyce	J. W. Thompson	William J. Gochenour	Drilled
352	Boyce	J. W. Payton, Jr	William J. Gochenour	Drilled
353	Boyce	Mrs. Anderson	James Feltner	Drilled
354	Boyce	S. H. Edison	James Feltner	Drilled

RECORDS

Clarke County, Virginia

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
190	Limestone	Beekmantown		15+		300
110	Limestone	Beekmantown		15		301
114	Limestone	Beekmantown		15		302
65	Shale	Martinsburg		10		303
110	Limestone	Beekmantown		15		304
88	Limestone	Conococheague	51	15+		305
45	Limestone	Conococheague		15	Dry in summer of 1931	306
45	Limestone	Conococheague		"Strong"	Dry in summer of 1931	307
45	Limestone	Conococheague		15	Analysis on page 92	308
54	Limestone	Beekmantown		15		309
53	Limestone	Beekmantown	18	16+		310
62	Limestone	Beekmantown		15+		311
217	Limestone	Beekmantown		2		312
280	Limestone	Beekmantown		1+		313
180	Limestone	Beekmantown		1+		314
125	Limestone	Beekmantown	0	25+		315
307	Limestone to 305 feet, sandstone.	Beekmantown, Conococheague.		20		316
210+	Limestone	Conococheague		7		317
145	Limestone	Beekmantown		3		318
300	Limestone	Conococheague		90	8-inch well. Analysis on page 92.	319
100	Limestone	Conococheague		50	6-inch well.	320
239	Limestone	Conococheague		90	6-inch well.	321
300	Limestone	Conococheague		40		322
725+	Limestone	Elbrook		1½	Analysis on page 92.	323
110	Limestone	Elbrook		15		324
180	Limestone	Elbrook		1		325
70	Dolomite	Tomstown		8		326
127	Dolomite	Tomstown		15		
150	Dolomite	Tomstown		10	Analysis on page 92.	327
45	Dolomite	Tomstown		15		328
30	Dolomite	Tomstown		15	Dry in 1930.	329
(?)	Sandstone, shale	Lower Cambrian		7	Analysis on p. 92.	330
65	Greenstone	Catoctin		15+	Analysis on p. 92.	331
45	Sandstone, shale	Lower Cambrian		15+		332
80	Sandstone, shale	Lower Cambrian		15+		333
60	Greenstone	Catoctin		2		334
135	Dolomite	Tomstown		5		335
110	Greenstone	Catoctin		1		336
140	Sandstone, shale	Lower Cambrian		5		337
190	Sandstone	Waynesboro		15+		338
250	Limestone	Conococheague		1		339
325	Limestone	Conococheague		1		340
59	Limestone	Beekmantown		13		341
75	Limestone	Beekmantown	40	13		342
50	Limestone	Beekmantown		15+		343
180	Limestone	Beekmantown	47	30		344
145	Limestone	Beekmantown		20		345
148	Limestone	Beekmantown		75		346
170	Limestone	Beekmantown	40	14		347
121	Limestone	Beekmantown	66	2		348
113	Shale	Martinsburg	36	6		349
80	Shale	Martinsburg		1½		350
61	Limestone	Beekmantown		4		351
84	Limestone	Beekmantown	66	2	Analysis on p. 92.	352
60	Limestone	Conococheague		15+		353
45	Limestone	Beekmantown		15+		354

WELL RECORDS

TABLE 28.—*Wells in Clarke*

Well number	Location	Owner	Driller	Type of well
355	½ mile southeast of Boyce	Mr. Gilton	James Feltner	Drilled
356	¾ mile southeast of Boyce	Mr. Gilton	James Feltner	Drilled
357	½ mile southeast of Boyce	Mr. Gilton	James Feltner	Drilled
358	½ mile east of Boyce	H. B. Gilton	James Feltner	Drilled
359	1 mile southeast of Boyce	G. F. Blandy	William J. Gochenour	Drilled
360	1 mile southwest of Boyce	Sam Thompson	James Feltner	Drilled
361	1¼ miles northeast by north of White Post, which is 4 miles southwest by west of Millwood.	E. A. Stuart	William J. Gochenour	Drilled
362	1 mile northeast by north of Millwood.	Courtney Jones	James Feltner	Drilled
363	Millwood	Mr. Gilton	James Feltner	Drilled
364	Millwood	Rectory	James Feltner	Drilled
365	Millwood	Mr. Gilton	James Feltner	Drilled
366	Millwood	Susie Randolph	James Feltner	Drilled
367	White Post	David Meade	James Feltner	Drilled
368	White Post	Emmet Stuart	William J. Gochenour	Drilled
369	White Post	Geo. Hilliard	William J. Gochenour	Drilled
370	4 miles south of Boyce	P. R. Drury	William J. Gochenour	Drilled
371	1½ miles south of White Post	Thomas Shumatt	James Feltner	Drilled

—CONTINUED

County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
190	Limestone	Conococheague		30		355
90	Limestone	Conococheague		30		356
125	Limestone	Conococheague		30		357
300	Limestone	Conococheague		30		358
208	Limestone	Conococheague	35	½		359
65	Limestone	Beekmantown		2		360
97	Limestone	Beekmantown		5		361
139	Limestone	Conococheague		15		362
130	Limestone	Conococheague		30		363
240	Limestone, very hard below 180 feet.	Conococheague		2		364
244	Limestone, very hard below 180 feet.	Conococheague		4		364
250	Limestone, very hard below 180 feet.	Conococheague		6		364
79	Limestone	Conococheague		30		365
135	Cavernous limestone.	Conococheague		15	Analysis on p. 92.	366
65	Limestone	Beekmantown		15		367
66	Limestone	Beekmantown	31	13		368
122	Limestone	Beekmantown	25	2	Analysis on p. 92.	369
85	Limestone	Elbrook	66	5		370
65	Limestone	Conococheague		15		371

ANALYSES OF WATER

TABLE 29.—*Analyses of ground waters from Clarke County, Virginia*

[Analyst, S. K. Love. Parts per million. Numbers at heads of columns refer to corresponding well numbers in table 28.]

	308	319	323	327	330	331	352	366	369
Silica (SiO_2)	.....	15	.....	.....	.....	2.1	.....	.....	.....
Iron (Fe)	.....	.21	.....	.....	.....	19	.....	.....	.....
Calcium (Ca)	148	108	90	58	[a]7	5.0	106	128	102
Magnesium (Mg)	12	16	39	30	.....	1.2	17	42	18
Sodium (Na)	[b]13	28	[b]5.8	[b]2.0	.....	3.7	(c)	(c)	[b]4.6
Potassium (K)		4.4				2.0			
Bicarbonate (HCO_3)	374	306	388	294	82	33	334	478	328
Sulphate (SO_4)	[a]36	25	68	[a]11	[a]4	1.9	[a]5	[a]13	[a]15
Chloride (Cl)	21	55	6.0	4.0	1.0	2.0	14	21	19
Nitrate (NO_3)	90	47	.40	18	.0	.0	42	50	34
Total dissolved solids	[b]522	440	[b]429	292	.....	37	[b]367	[b]520	[b]372
Total hardness as $CaCO_3$ (calculated)	419	336	385	[d]268	[d]46	17	335	492	329
Date of collection (1931)	Oct. 29	Oct. 29	Oct. 29	Oct. 29	Oct. 29	Oct. 30	Oct. 29	Oct. 29	Oct. 29

[a]By turbidity.
[b]Calculated.
[c]Less than 10 parts.
[d]Determined.

LOUDOUN COUNTY

GEOGRAPHY

Loudoun County is 519 square miles in area and had a population in 1930 of 19,852. Potomac River separates it from Maryland on the north and northeast, and the Blue Ridge separates it from West Virginia on the northwest and from Clarke County on the southwest. Fauquier and Prince William counties lie to the south, and Fairfax County to the east. More than 85 per cent of the area is under cultivation, and the farms and estates are comparatively large. Leesburg is the largest community in the county, with a population in 1930 of 1,640, and Purcellville is next, with 747.

The Washington & Old Dominion Railway (electric) runs from Washington, D. C., through Sterling, Ashburn, Leesburg, Purcellville, and Round Hill, and ends at Bluemont. Two arterial highways cross the county in an east-west direction—one in the southern part of the county, passing through Middleburg and Aldie; the other farther north, passing through the gap at Bluemont and thence through Purcellville and Leesburg. A north-south highway runs from Aldie to Leesburg and thence north to Point of Rocks, on Potomac River. According to the census there were 18 industrial establishments in the county in 1929, and the value of their products was $658,910. Most of these establishments deal with products of farming, dairying, or fruit growing, or with the quarrying of rock products.

DRAINAGE

Loudoun County is drained by a large number of small streams tributary to Potomac River. Piney Run and Catoctin Creek and their tributaries occupy the northern part of the county, Goose Creek drains the southwestern and south-central part, and Bull Run and Broad Run the southeastern part. The streams are relatively independent of the structure of the underlying rock. Many of them pass through the mountain ridges in water gaps—for example, Goose Creek cuts Catoctin Mountain near Oatlands, and the North Fork of Catoctin Creek cuts through Short Hill at Hillsboro. Piney Run, on the other hand, flows northward between the Blue Ridge and Short Hill, and at some time in the future it probably will behead the North Fork of Catoctin Creek.

TOPOGRAPHY

There are in the county three parallel mountain ridges separated by lowlands—the Blue Ridge, Short Hill, and Catoctin Mountain. The Blue Ridge, on the western boundary, has an altitude of over 1,500 feet at the southwest corner of the county, but north of Bluemont it becomes lower, and above the Potomac River gap it is only about 1,000 feet above sea level. Its crest is serrated by several wind gaps, the most prominent of which is the one at Bluemont. Short Hill is 3 miles east of the Blue Ridge and parallel to it, but it extends south of the Potomac only a mile beyond Hillsboro. It maintains an altitude of 1,000 feet or slightly more for most of its length. Catoctin Mountain extends south from Potomac River, passing just west of Leesburg, down to the western boundary of Prince William County, where it is called Bull Run Mountain. It has an altitude of 500 to 1,000 feet at the north, but toward the south it becomes lower and less distinct. The southern part of the Blue Ridge in Loudoun County may be a remnant of the "Upland peneplain;" the similarity in altitude of its north end and that of Short Hill may indicate that both are remnants of the "Intermediate peneplain." (See p. 14.)

The lowland consists of a rolling, dissected plain at a general altitude of slightly under 500 feet, with an average relief of 100 feet or less. This lowland is not a simple plain, however, for a fairly flat terrace slopes gently away from the foot of the Blue Ridge at an altitude of 500 to 600 feet and midway between the Blue Ridge and Catoctin Mountain forms a depression 300 to 400 feet above sea level. Catoctin Mountain along most of its extent has about the same altitude as the terrace along the foot of the Blue Ridge. The lowland east of Catoctin Mountain is at about the same altitude as the intermontane valley. Thus there appear to be remnants of two old erosion levels in the lowland. The present streams have trenched below the lower level, in some places to depths of more than 100 feet.

GEOLOGY

The rocks in Loudoun County consist of two groups, the members of each group differing in age and geographic distribution from those of the other. The older rocks occupy the area west of the eastern foot of Catoctin Mountain and range in age from the pre-Cambrian white marble to the Lower Ordovician Frederick limestone. The younger rocks are the conglomerates, sandstones, shales, and associated diabase or trap bodies of Triassic age underlying the area east of the border fault along Catoctin Mountain. (See Pl. 2 and Table 7.)

The older rocks are involved in a complex known as the Catoctin-Blue Ridge anticlinorium, in which the Catoctin greenstone, overlying the white marble, occupies the east and west limbs, and the Marshall granite crops out along the axis in a belt 3 to 5 miles wide. Lovettsville and Middleburg are about in the center of the granite area. Sandstones and shales of Lower Cambrian age have been folded into the arch and are exposed on both limbs, notably on Short Hill, north of Hillsboro, and along the Catoctin border fault and in other smaller areas. The white marble is brought to the surface in the cores of small, sharp anticlines which lie end to end just east of the Marshall granite outcrop.

The Triassic rocks occur in a basin which has been faulted down on its west side to a depth of 500 feet or less, according to Roberts. In transverse section, therefore, the rocks of the basin are wedge-shaped, with the apex at the east. The dip of the rocks is toward the west, the angle of dip being slight in the eastern part but increasing toward the west edge to as much as 45° from the horizontal. The Triassic rocks have been very gently folded and also have been broken into blocks by intersecting normal faults. These faults are very difficult to detect because of the close similarity of the rocks on both sides of the fracture. Associated with the Triassic sediments are many bodies of trap, both intrusive and extrusive, the largest of which is a mass as much as 3 miles wide that extends from Leesburg southeastward into Fairfax County. The single small body of Frederick limestone exposed in the county has been faulted to the surface along the Catoctin border fault near the Potomac River.

GROUND-WATER CONDITIONS

Catoctin-Blue Ridge area.—The results of drilling wells in the Catoctin-Blue Ridge area are remarkably uniform and it has been found that the two rock formations that underlie the greatest part of the area, the Catoctin greenstone and the Marshall granite, do not differ very much in their water-bearing properties. Both are hard to drill, and the wells are mostly weak. Most of the ordinary small household wells are shallow or of moderate depth, generally less than 100 feet, and yield less than 10 gallons a minute—in fact, many of them deliver less than 1 gallon a minute and can be exhausted by a hand pump. But even with such small flows the owners find that by pumping carefully the wells can be made to serve. At the other extreme are some wells of great depth that are failures, considering the needs and the expense of construction. A well (No. 642) 10 inches in diameter was put down on the estate of D. C. Sands, near Middleburg, 704 feet through Catoctin

greenstone, and at 205 feet the capacity tested at 5 gallons a minute; no more water was encountered in the next 500 feet. Similarly, on the estate of Mrs. Dodge Sloane, near Upperville, a well 8 inches in diameter (No. 649) was drilled to a depth of 592 feet through very hard rock; at 324 feet a pumping test showed 2½ gallons a minute, and at 450 feet 3½ gallons a minute, but the water never cleared up after long pumping, and at present it delivers only 1¼ gallons a minute with a draw-down of 147 feet. Both of these deep wells are in the Catoctin greenstone. The shallow wells in the Marshall granite area are very similar to those in the greenstone. In the northern part of Fauquier County deep wells drilled into granite seem to derive somewhat larger supplies than those in greenstone but not much larger. The infolded areas of Lower Cambrian formations and the narrow belts of white marble are more favorable for wells, but the area of outcrop of these formations is comparatively very small.

The water level ranges from the surface of the ground to 60 feet below, in most places being about 20 to 30 feet. In the southern part of the county the water level is nearer the surface than elsewhere, and a few wells even flow a little at the surface. The jointing and schistosity of the rocks tend to prevent the confining of water in the folded beds, therefore artesian head is not built up to any considerable degree.

The water of the Catoctin-Blue Ridge area, considered as a whole, is of excellent chemical quality.

Dug wells are not numerous in this area as the rock in many places lies so close to the surface that digging to water is almost impossible. Even on outcrops of Catoctin greenstone, where it is difficult and expensive to drill for water, digging is not often resorted to. The moderately dissected topography of the district causes a rather wide vertical fluctuation of the water table, and therefore dug wells in or near the valley bottoms are most likely to prove satisfactory.

A rather large number of both drilled and dug wells dried up during the droughty summers of 1930 and 1931, the dug wells seeming to be the more susceptible.

There are many small springs in the area, but they are not used extensively except along the slopes of the Blue Ridge, Short Hill, and Catoctin Mountain, and a large number of them go dry in droughty seasons. In the white-marble belts a few of the springs deliver large quantities of water, some of which is reported to be rather highly mineralized.

Area of Triassic rocks.—Dug wells are few in the area of Triassic rocks, but drilled wells are very numerous. Most of the area is underlain by sandstone and shale. In these rocks the wells are generally less than 100 feet deep and deliver small quantities of water, most of them less than 10 gallons a minute. This area is not to be considered unfavorable for ground-water supplies, however, because ordinarily only small amounts of water are required, and such supplies as are needed can be obtained comparatively cheaply. If a large supply were needed, it is by no means certain that it could not be obtained by drilling several hundred feet down, for the water is not confined to the near-surface rock, as it seems to be in granite or in limestone but probably migrates between the beds, or, in the sandstone, perhaps through them.

In the limestone conglomerate, which crops out in and north of Leesburg, the results of drilling are varied. Most of the wells deliver small to moderate quantities, but some, such as the 360-foot town well (No. 725) in Leesburg, furnish large supplies. On the other hand, a few dry holes having been drilled, it is believed that the limestone conglomerate is rather tight below the level of Potomac River, and that wells drilled below that level are not likely to encounter strong supplies of water.

In the larger bodies of trap, such as the stocklike mass extending southeast of Leesburg, some general conditions have been observed: (1) Nearly all the wells that obtain large supplies of water encounter them at shallow depths, where the diabase is weathered, although in many such places the supply may be only moderate, or even weak; (2) wells that have been drilled into the trap where there is no weathered zone, as in the bottom of a valley, are not likely to obtain much water, if any; (3) wells that have not obtained a satisfactory amount of water within 100 feet are not likely to encounter any considerable flow at greater depths unless there is a chance of passing through the body of diabase. The last two generalizations are illustrated by a well that was drilled near the intersection of the Leesburg turnpike and Goose Creek to a depth of about 802 feet (No. 729). Although it flowed at the surface occasionally its capacity, as tested, was only 3 gallons a minute. At the other extreme is a well (No. 848) drilled by L. W. Wortman at his home near Ashburn, which is only 18 feet deep and delivered 10 gallons a minute.

The water levels vary widely. Around Leesburg the water table is deeper than elsewhere, in some places as much as 90 feet below the surface; east and south of Leesburg it is at 10 to 50 feet. The water in wells in the trap lies nearer the surface than in the sandstone, shale,

and conglomerate. Flowing wells in the sandstone and shale are rare but not unknown. The normal faults that break the Triassic rocks up into blocks and the joint systems seem to prevent the accumulation of artesian pressure on the water in the dipping water-bearing beds, and the low relief of the area would also tend toward the same result.

The ground water in the Triassic basin is often very hard and is likely to contain an objectionable quantity of iron.

Dug wells have not proved very satisfactory in the Triassic basin owing to the comparatively shallow soil layer. The soil derived from the shale is rather tight. It is very difficult to dig a well in the trap because of the presence of "niggerhead" cobbles and boulders.

Springs are not so numerous in the Triassic basin as in the Catoctin-Blue Ridge area, but some of the springs in the conglomerate north of Leesburg have a flow comparable to that of the springs in the limestone belt of the Shenandoah Valley because the conglomerate pebbles as well as the cement are high in lime. Such a spring is found on the Alexander estate, on the Point of Rocks road just north of Leesburg. It issues from joints in the westward-dipping conglomerate on the eastern foot of a small hill and forms a pool that overflows. The discharge is several cubic feet a second. There are many small springs on the eastern foot of Catoctin Mountain.

MUNICIPAL SUPPLIES

Leesburg, the county seat, operates a public waterworks depending upon ground water. Part of the supply is obtained from a large spring in the conglomerate and the rest comes from two drilled wells in the town. One well is 152 feet deep, 6 inches in diameter, and yields 35 gallons a minute. The other is 360 feet deep, 10 inches in diameter, and delivers 60 gallons a minute. A flow of about 35 to 40 gallons a minute is taken from the spring. The spring water is conducted by gravity to a concrete storage reservoir of 120,000-gallon capacity at the site of the distributing works, where the wells are also located. The water in the reservoir and the well water are then pumped into a tank on a steel tower, which stores 65,000 gallons for distribution. Chlorination is effected in the feed line. The average daily consumption is about 75,000 gallons, and the maximum is about 130,000 gallons.

Aldie obtains its municipal supply from three small springs on Bull Run Mountain, half a mile south of town. Each spring is protected with a concrete basin. The overflow of the springs is collected in a

concrete reservoir having a capacity reported to be about 2,000 gallons. The water then flows to a distributing reservoir situated on a hill in the town. About 15 households are served by this system.

WELL

TABLE 30.—*Wells in*

Well number	Location	Owner	Driller	Type of well
500	2 miles north of Lovettsville	D. C. Green	Chester Fields	Drilled
501	3 miles northeast of Lovettsville	Wash Foley	Robert Miller	Drilled
502	2 miles north of Lovettsville	Harvey Lynn	Robert Miller	Drilled
503	2 miles northeast of Lovettsville	Lina Greene	Robert Miller	Drilled
504	1 mile northwest by north of Lovettsville.	J. R. Beck	Chester Fields	Drilled
505	1 mile north of Lovettsville	Harry T. Potterfield	Chester Fields	Drilled
506	3 miles northwest by west of Lovettsville.	J. W. Fry	Chester Fields	Drilled
507	3 miles northwest by west of Lovettsville.	W. M. Everhart	Chester Fields	Drilled
508	2 miles northwest by west of Lovettsville	John Exline	Chester Fields	Drilled
509	¾ mile northwest of Lovettsville	A. E. Householder	Chester Fields	Drilled
510	Lovettsville	Paul Myers	Robert Miller	Drilled
511	Lovettsville	Ed Myers	Robert Miller	Drilled
512	¼ mile north of Lovettsville	Eamine Morgan	Chester Fields	Drilled
513	Lovettsville	Mrs. B. Myers	Chester Fields	Drilled
514	Lovettsville	Mollie Morgan	Robert Miller	Drilled
515	Lovettsville	Ray Fry	Robert Miller	Drilled
516	Lovettsville	Ed Potterfield	Chester Fields	Drilled
517	Lovettsville	Lovettsville School	Chester Fields	Drilled
518	Lovettsville	Maybel Dinjes	Chester Fields	Drilled
519	Lovettsville	Lovettsville School	Robert Miller	Drilled
520	Lovettsville	George Grubb	Robert Miller	Drilled
521	Lovettsville	T. C. Orrison	Chester Fields	Drilled
522	Lovettsville	Mr. Lanham	Robert Miller	Drilled
523	Lovettsville	Joe Shuemaker	Chester Fields	Drilled
524	Lovettsville	B. M. Fry	Chester Fields	Drilled
525	Lovettsville	Clayton J. Cooper	Chester Fields	Drilled
526	Lovettsville	Dr. Foley	Chester Fields	Drilled
527	Lovettsville	J. J. Wire	Chester Fields	Drilled
528	Lovettsville	H. W. Beatty	Chester Fields	Drilled
529	Lovettsville	Tom Winner	Chester Fields	Drilled
530	Lovettsville	Chas. Spring	Chester Fields	Drilled
531	Lovettsville	Mr. Virch	Robert Miller	Drilled
532	Lovettsville	H. M. Cooper	Chester Fields	Drilled
533	1 mile east of Lovettsville	D. C. Blessing	Chester Fields	Drilled
534	1½ miles east of Lovettsville	C. E. Sambower	Chester Fields	Drilled
535	1 mile south of Point of Rocks, which is 2½ miles northeast of Taylorstown.	Owen Heeter	Robert Miller	Drilled
536	Taylorstown	J. C. Slater	Chester Fields	Drilled
537	2½ miles southeast by east of Lovettsville.	J. S. Hickman	Chester Fields	Drilled
538	1½ miles northwest of Taylorstown	William F. Spring	Chester Fields	Drilled
539	1½ miles southeast by east of Lovettsville.	C. W. Orrison	Chester Fields	Drilled
540	2½ miles southeast of Lovettsville	Doy Baker	Robert Miller	Drilled
541	1 mile southeast by south of Lovettsville.	Brayton Carr	Robert Miller	Drilled
542	1 mile south of Lovettsville	H. O. Vincel	Chester Fields	Drilled
543	1 mile southwest by south of Lovettsville.	Ide Carns	Robert Miller	Drilled
544	1 mile southwest by south of Lovettsville.	Hugh Vincel	Robert Miller	Drilled
545	1½ miles south of Lovettsville	Daniel Fry	Chester Fields	Drilled
546	1½ miles southwest of Lovettsville	Hugh Baker	Robert Miller	Drilled
547	Bolington, which is 1¾ miles southwest of Lovettsville.	James R. Reed	Chester Fields	Drilled
548	1¾ miles west of Lovettsville	H. M. Rodeffer	Chester Fields	Drilled
549	2¼ miles west of Lovettsville	J. L. Bush	Chester Fields	Drilled
550	2¼ miles northwest of Bolington	Irving Hesket	Robert Miller	Drilled
551	2½ miles northwest of Bolington	B. O. Compher	Chester Fields	Drilled
522	2 miles west of Bolington	Frank N. Jacobs	Chester Fields	Drilled
553	¾ mile southwest of Neersville, which is 5 miles west of Lovettsville.	Michael Sagle	Chester Fields	Drilled
554	1¼ miles south of Neersville	G. W. Blocker	Chester Fields	Drilled
555	2¼ miles southwest by west of Bolington.	Mrs. Cecil Wilklow	Chester Fields	Drilled

RECORDS

Loudoun County, Virginia

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
25	Greenstone	Catoctin		5		500
60	Granite	Marshall		2½		501
35	Greenstone	Catoctin		2½		502
24	Greenstone	Catoctin		3	2 feet of casing.	503
53	Greenstone	Catoctin		2		504
63	Greenstone	Catoctin		1½		505
40	Greenstone	Catoctin		1		506
50	Greenstone	Catoctin		¾		507
33	Granite soil	Marshall		½		508
30	Greenstone	Catoctin		¾		509
40	Greenstone	Catoctin		3		510
40	Greenstone	Catoctin		2		511
25	Schistose granite	Marshall		4½		512
30	Granite	Marshall		1		513
25	Granite	Marshall		10+		514
50	Schistose granite	Marshall		10+		515
28	Granite	Marshall		1½		516
48	Schistose granite	Marshall		3		517
45	Schistose granite	Marshall		1½		518
150	Granite	Marshall		2½		519
40	Granite	Marshall		3	Analysis on p. 116.	520
43	Gchistose granite	Marshall		1½		521
63	Granite	Marshall		4½		522
47	Granite	Marshall		4		523
23	Greenstone	Catoctin		1		524
30	Schistose granite	Marshall		1		525
45	Granite	Marshall		¾		526
33	Schistose granite	Marshall		1¼		527
49	Granite	Marshall		¼		528
48	Granite	Marshall		3		529
47	Granite	Marshall		1½		530
50	Granite	Marshall		10+		531
18½	Schistose granite	Marshall		¾		532
67	Greenstone	Catoctin		¾		533
40	Greenstone	Catoctin		3		534
30	Shale soil	Loudoun		10+		535
51½	White marble	Pre-Catoctin		4		536
38	Greenstone	Catoctin		⅜		537
50	Greenstone	Catoctin		2½		538
39	Greenstone boulders	Catoctin		¼		539
58	Granite	Marshall		3½		540
60	Granite	Marshall		4		541
47	Schistose granite	Marshall		½		542
40	Greenstone	Catoctin		3		543
60	Greenstone	Catoctin		3		544
30	Schistose granite	Marshall		½		545
48	Greenstone	Catoctin		3		546
37½	Schistose granite	Marshall		1		547
43	Greenstone	Catoctin		¾		548
38	Schistose granite	Marshall		2½		549
63	Greenstone	Catoctin		2½		550
48	Greenstone	Catoctin		6		551
32	Greenstone	Catoctin		½		552
44	Greenstone	Catoctin		1½		553
43	Greenstone	Catoctin		2½	Analysis on p. 116.	554
46	Greenstone	Catoctin		2		555

WELL RECORDS

TABLE 30.—*Wells in Loudoun*

Well number	Location	Owner	Driller	Type of well
556	2¼ miles north of Hillsboro	Albert Wenner	Chester Fields	Drilled
557	2¼ miles north of Hillsboro	Mahale Tallon	Chester Fields	Drilled
558	2¼ miles north of Hillsboro	James H. Cole	Chester Fields	Drilled
559	2 miles northeast by north of Hillsboro.	Orra Jacobs	Chester Fields	Drilled
560	1¼ miles west of Morrisonville, which is 3½ miles northeast of Hillsboro.	Angeline Cooper	Chester Fields	Drilled
561	¾ mile west of Morrisonville	Norman Wercken	Chester Fields	Drilled
562	¾ mile west of Morrisonville	Arlington School	Chester Fields	Drilled
563	¾ mile west of Morrisonville	William Baker	Chester Fields	Drilled
564	¾ mile west of Morrisonville	Arlington School	Robert Miller	Drilled
565	1½ miles southeast by east of Morrisonville.	Ollie Virch	Robert Miller	Drilled
566	Milton, which is 2¾ miles south of Lovettsville.	John D. Wine	Chester Fields	Drilled
567	Milton	Wilmer Morrison	Robert Miller	Drilled
568	2½ miles south of Lovettsville and ½ mile northeast of Milton.	C. E. Franklin	Chester Fields	Drilled
569	3½ miles south of Lovettsville	S. R. Ridgeway	Chester Fields	Drilled
570	2 miles northwest of Waterford	Henry Clappen	Chester Fields	Drilled
571	2 miles northwest of Waterford	G. F. Everbart	Chester Fields	Drilled
572	2 miles northwest of Waterford	W. W. Wine	Chester Fields	Drilled
573	1 mile northeast of Wheatland, which is 2¾ miles east of Hillsboro.	Tom Fields	Chester Fields	Drilled
574	Wheatland	W. S. Coleman	Mr. Reed	Drilled
575	2 miles southeast of Hillsboro	Mr. Slentz	Mr. Reed	Drilled
576	1½ miles east of Hillsboro	William Beamer	Chester Fields	Drilled
577	1½ miles east of Hillsboro	Joe Beamer	Chester Fields	Drilled
578	½ mile north of Hillsboro	S. O. Clendening	Chester Fields	Drilled
579	Hillsboro	William Lewis	Chester Fields	Drilled
580	2½ miles west of Hillsboro	Near Bros	Mr. Reed	Drilled
581	1¼ miles south of Hillsboro	Short Hill Church	Mr. Reed	Drilled
582	1¼ miles south of Hillsboro	Hattie Moore	Mr. Reed	Drilled
583	3 miles north of Purcellville	Henry Norman	Mr. Reed	Drilled
584	2 miles north of Hamilton, which is 2½ miles east of Purcellville.	Mr. Coleman	Robert Miller	Drilled
585	3 miles northeast of Hamilton	Ambrose Warner	Mr. Reed	Drilled
586	Waterford	A. L. McGavack	E. S. Adrian	Drilled
587	Waterford	C. Elton James	E. S. Adrian	Drilled
588	Waterford	Robert Walker	E. S. Adrian	Drilled
589	Waterford	J. W. Virts	E. S. Adrian	Drilled
590	½ mile east of Waterford	Alfred Doolen	Mr. Reed	Drilled
591	3 miles northeast by east of Hamilton.	Charles Tavener	E. S. Adrian	Drilled
592	Paeonian Springs	Lar Baker	Robert Miller	Drilled
593	2½ miles northeast of Purcellville	Tom Alder (deceased)	Mr. Reed	Drilled
594	Round Hill, which is 3 miles west of Purcellville.	Sam Brooks	Mr. Reed	Drilled
595	Purcellville	H. C. Pancoast	Mr. Reed	Drilled
596	Purcellville	Loudoun Light & Power Co.	Mr. Reed	Drilled
597	Purcellville	Amos Holmes	Mr. Reed	Drilled
598	Purcellville	Dorothy Case	Mr. Reed	Drilled
599	Purcellville	John Case	Mr. Reed	Drilled
600	Purcellville	John Case	Mr. Reed	Drilled
601	Purcellville	Will Paxon	Mr. Reed	Drilled
602	Purcellville	Ruth Avery	Mr. Reed	Drilled
603	Purcellville	Sam Brooks	Mr. Reed	Drilled
604	Purcellville	Dr. Simpson	Mr. Reed	Drilled
605	Purcellville	Bush Meeting Ground	Mr. Reed	Drilled
606	Purcellville	Purcellville School	Mr. Reed	Drilled
607	Purcellville	Frank Hampton	Mr. Reed	Drilled
608	Purcellville	Lloyd Powell	Mr. Reed	Drilled
609	Purcellville	Joe Norman	Mr. Reed	Drilled
610	Hamilton	Mr. Evans	Mr. Reed	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
42½	Black shale	Loudoun		2		556
45	Greenstone	Catoctin		1½		557
31	Greenstone	Catoctin		30+		558
33	Greenstone	Catoctin		¾		559
47	Greenstone	Catoctin		1		560
37½	Schistose granite	Marshall		¾		561
37½	Schistose granite	Marshall		½		562
37	Schistose granite	Marshall		2		563
60	Schistose granite	Marshall		2½		564
35	Greenstone	Catoctin		10		565
23	Boulders of greenstone.	Catoctin		¼		566
50	Granite	Marshall		3		567
25	White marble	Pre-Catoctin		¼		568
46	White marble	Pre-Catoctin		½		569
84	Greenstone	Catoctin		4		570
47½	Greenstone	Catoctin		4		571
48	Greenstone	Catoctin		¾		
34	Schistose granite	Marshall		1		572
42	Greenstone	Catoctin		4½		573
66	Greenstone	Catoctin		5		574
114	Shale	Loudoun		5		575
68	Greenstone	Catoctin		5		
44	Marble	Pre-Catoctin		1	Water not good.	
73	Granite	Marshall		1½		576
70	Granite	Marshall		2½		577
153	Dark shale	Loudoun		5½		578
38	Black mud and shale.	Loudoun		1		579
50	Granite	Marshall	3	15+		580
50	Greenstone	Catoctin		15+		581
60	Greenstone	Catoctin		2		582
115	Greenstone	Catoctin		5		583
100	Greenstone	Catoctin		2½		584
108	Greenstone	Catoctin		3		585
41	Greenstone	Catoctin		4		586
40	Greenstone	Catoctin		3		587
50	Greenstone	Catoctin		5		588
73	Greenstone	Catoctin		6		589
82	Shale	Loudoun		2½		590
58	Greenstone	Catoctin		4		591
38	Greenstone	Catoctin		3		592
50	Greenstone, granite	Catoctin, Marshall		3	Analysis on p. 116.	593
60	Granite	Marshall		7		594
300	Greenstone, granite	Catoctin		5	No water in the granite.	595
200	Granite	Marshall		20		596
50	Greenstone	Catoctin		1½		597
75	Greenstone	Catoctin		3		598
75	Granite	Marshall		1½		599
75	Granite	Marshall		1½		600
65	Granite	Marshall		5		601
75	Granite	Marshall		15+		602
125	Greenstone, granite	Catoctin, Marshall		3		603
112	Greenstone	Catoctin		5		604
80	Greenstone	Catoctin		15+		605
100	Greenstone	Catoctin		5		606
70	Granite	Marshall		2		607
50	Granite	Marshall		1		608
75	Granite	Marshall		3		609
75	Granite	Marshall		15+		610

WELL RECORDS

TABLE 30.—*Wells in Loudoun*

Well number	Location	Owner	Driller	Type of well
611	Hamilton	Mr. Wilard	Mr. Reed	Drilled
612	2 miles northwest of Leesburg	Mr. Filler	(?)	Drilled
613	1 mile north of Leesburg	Dr. Shirley Carter	E. S. Adrian	Drilled
614	1 mile west of Leesburg	Mr. Hibbs	George Cullen	Drilled
615	Leesburg	Mr. Handback	(?)	Drilled
616	Leesburg	Mr. Murray	(?)	Drilled
617	2¼ miles southeast of Lincoln	John Ward	Mr. Reed	Drilled
618	2 miles southeast by east of Lincoln	Henry Taylor	Mr. Reed	Drilled
619	Lincoln	Walter Brown	Mr. Reed	Drilled
620	Lincoln	Lincoln Church	Mr. Reed	Drilled
621	Lincoln	(?)	Mr. Reed	Drilled
622	Lincoln	Will Nichols	Mr. Reed	Drilled
623	1½ miles north of Philomont, which is 3 miles northwest of Mountville.	Harry Pancoast	Mr. Reed	Drilled
624	2½ miles northwest of Philomont	Irving Smith	Mr. Reed	Drilled
625	Bluemont	Mr. Chapen	Mr. Reed	Drilled
626	Top of Blue Ridge west of Bluemont.	Mr. Droop	Mr. Reed	Drilled
627	Top of Blue Ridge west of Bluemont.	Dr. Garner	Mr. Reed	Drilled
628	Top of Blue Ridge west of Bluemont.	Dr. Moore	Mr. Reed	Drilled
629	5 miles southeast of Bluemont	Loudoun County Poor Farm.	George Cullen	Drilled
630	5½ miles southeast of Bluemont	Bloomfield-Unison School	Mr. Reed	Drilled
631	Philomont	Richard Lake	Mr. Reed	Drilled
632	Philomont	Mr. Pierce	Mr. Reed	Drilled
633	1½ miles west of Oatlands, which is 5 miles east of Mountville.	R. J. Skinner	E. S. Adrian	Drilled
634	2 miles east of Mountville	Old Francis Carter farm	James Franklin	Drilled
635	Mountville	W. H. Carter	E. S. Adrian	Drilled
636	4 miles northeast of Middleburg	Roger Fread	Fred Stickley	Drilled
637	3 miles north of Middleburg	Foxcroft School	Charles Wine	Drilled
638	2 miles north of Middleburg	Foxcroft School	(?)	Drilled
639	2 miles north of Middleburg	Foxcroft School	F. N. Hagmann, Jr.	Drilled
640	4 miles northwest of Middleburg	Mr. Murphy	George Cullen	Drilled
641	3½ miles west of Mountville	Mr. Baker	Mr. Reed	Drilled
642	3¼ miles northwest of Middleburg	D. C. Sands	Virginia Machinery & Well Co.	Drilled
643	4¼ miles west of Mountville	Mrs. Lemon	Mr. Reed	Drilled
644	5 miles west of Mountville	Mr. Metcalf	Mr. Reed	Drilled
645	2¾ miles north of Upperville, which is 8½ miles west of Middleburg.	George Gather	Mr. Reed	Drilled
646	1½ miles north of Upperville	Gen. Buchanan	George Cullen	Drilled
647	1½ miles north of Upperville	Mr. De Butts	Fred Stickley	Drilled
648	1 mile northwest by west of Upperville.	Mrs. Dodge Sloane	Virginia Machinery & Well Co.	Drilled
649	1 mile northwest by west of Upperville.	Mrs. Dodge Sloane	Virginia Machinery & Well Co.	Drilled
650	1 mile north of Middleburg	Mr. Belmont	(?)	Drilled
651	½ mile north of Middleburg	Capt. Islin	Charles Wine	Drilled
652	1 mile west of Middleburg	Mrs. Lee	Fred Stickley	Drilled
653	Middleburg	A. & P. store	Fred Stickley	Drilled
654	Middleburg	Dr. Spitter	Fred Stickley	Drilled
655	Middleburg	Mr. Ilsley	F. N. Hagmann, Jr.	Drilled
656	Middleburg	Gartrell Bros.	Charles Wine	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
50	Granite	Marshall		2		611
66	Greenstone	Catoctin		8		612
60	Greenstone	Catoctin		3		613
108	Granite	Marshall		0		614
33	White marble	Pre-Catoctin		1½		615
66	White marble	Pre-Catoctin		3		616
75	Greenstone	Catoctin		3	Analysis on p. 116.	617
75	Granite	Marshall		2		618
58	Granite	Marshall		1½		619
81	Granite	Marshall		1½		620
66	Granite	Marshall		2		621
65	Granite	Marshall		2½		622
118	Granite	Marshall		2		623
65	Greenstone	Catoctin		5		624
112	Greenstone	Catoctin		10	Analysis on p. 116.	625
178	Sandstone	Weverton		15+		626
80	Greenstone	Catoctin		10		627
70	Greenstone	Catoctin		2½	Analysis on p. 116.	628
222	Greenstone	Catoctin		¼	Less than 25 feet of 6-inch casing.	629
80	Greenstone	Catoctin		5		630
104	Greenstone	Catoctin		5		631
60	Granite	Marshall		3		632
85	Greenstone	Catoctin		8		633
83	White marble	Pre-Catoctin	35	18		634
83	White marble	Pre-Catoctin		11	Analysis on p. 116.	635
36	Granite	Marshall		3		636
40	Granite	Marshall		3		
550	Granite	Marshall	50	40		637
68	Granite	Marshall		2		638
300	Granite	Marshall		4	8-inch casing.	639
87½	Granite	Marshall	0	3½	6-inch casing. Well flowed	640
183	Greenstone	Catoctin		5		641
704	Greenstone	Catoctin	45	5	10-inch well. No water below 205 feet. Analysis on p. 116.	642
100+	Granite	Marshall		10		643
198	Greenstone	Catoctin		2	Called "glass rock" by driller.	644
154	Granite	Marshall	10	2		645
240	Greenstone	Catoctin	25	7½	10-inch casing part way, rest 8-inch. Gravel-packed between 8-inch and 6-inch casing.	646
117	Granite	Marshall		4		647
350	Greenstone	Catoctin	4	11¾	10-inch well. 10 gallons a minute at 301 feet.	648
592	Greenstone (loose boulders to 68 feet).	Catoctin	43	1¼	8-inch well. 2½ gallons a minute at 324 feet, 3½ at 450 feet. Water never cleared up. Analysis on p. 116.	649
135	Granite	Marshall		15		650
65	Granite	Marshall		5		
200	Gray sandstone	Loudoun (?)	60	17		651
270	Gray sandstone to 200 feet, granite.	Loudoun (?), Marshall.	60	16		
182	Granite	Marshall		3		652
46	Granite	Marshall		3½		653
142	Greenstone	Catoctin		13	Called "black glass rock" by driller.	654
300	Granite	Marshall		4	12-inch casing to 46 feet, and 8-inch to 60 feet. Concrete placed between 12-inch and 8-inch casing for sanitation.	655
130	Gray sandstone, granite.	Loudoun (?), Marshall.	50	30		656

WELL RECORDS

TABLE 30.—*Wells in Loudoun*

Well number	Location	Owner	Driller	Type of well
657	Middleburg	Central Garage	Charles Wine	Drilled
658	Middleburg	Dr. Bradfield	Charles Wine	Drilled
659	Middleburg	Mr. Tuck	Charles Wine	Drilled
660	Middleburg	Mrs. Lee	Charles Wine	Drilled
661	Middleburg	Mr. Dishman	Charles Wine	Drilled
662	Middleburg	Mr. Bell	Charles Wine	Drilled
663	Middleburg	Gen. Mitchell	Charles Wine	Drilled
664	Middleburg	Mrs. Whiting	Charles Wine	Drilled
665	Middleburg	Ernest Dawson	Charles Wine	Drilled
666	Middleburg	Mr. Belmont	Mr. Reed	Drilled
667	Middleburg	Red Fox Tavern	(?)	Drilled
668	Middleburg	Bank	(?)	Drilled
669	Middleburg	Mr. Hall	(?)	Drilled
670	Middleburg	Mr. Skinner	(?)	Drilled
671	Middleburg	Mr. Ferguson	(?)	Drilled
672	1¾ miles northeast of Middleburg	Mr. Hall	(?)	Drilled
673	1½ miles east of Middleburg	(?)	(?)	Drilled
674	1½ miles north of Lucketts, which is 4½ miles northeast by east of Waterford.	Mrs. Minnie Stalks	Mr. Reed	Drilled
675	2 miles northeast of Lucketts	Frank McKimmie	E. S. Adrian	Drilled
676	3 miles northeast of Lucketts	Burr Titus	E. S. Adrian	Drilled
677	3 miles east of Lucketts	J. T. McGaha	E. S. Adrian	Drilled
678	2½ miles northeast of Lucketts	A. G. McKimmie	E. S. Adrian	Drilled
679	3 miles east of Lucketts	Mr. Peacock	L. W. Wortman	Drilled
680	Lucketts	Mr. Lucketts	George Cullen	Drilled
681	Lucketts	Lucketts Church	Mr. Reed	Drilled
682	½ mile south of Goresville, which is 4 miles northeast by east of Waterford.	J. H. Whitmore	E. S. Adrian	Drilled
683	¾ mile south of Goresville	J. H. Whitmore	L. W. Wortman	Drilled
684	1 mile south of Goresville	Harvey Arthur	L. W. Wortman	Drilled
685	4 miles northeast by north of Leesburg.	Mrs. A. T. M. Rust	E. S. Adrian	Drilled
686	4 miles northeast by north of Leesburg.	Mrs. A. T. M. Rust	(?)	Drilled
687	2½ miles north of Leesburg	David Steveson	E. S. Adrian	Drilled
688	3 miles northeast by east of Leesburg	Mr. Curtis	L. W. Wortman	Drilled
689	3 miles northeast by east of Leesburg	Mr. Curtis	L. W. Wortman	Drilled
690	1 miles northwest of Leesburg	J. W. Scott	E. S. Adrian	Drilled
691	1 mile northeast by north of Leesburg.	Mr. Harrison	(?)	Drilled
692	1 mile south of Goresville	H. H. Trundle	E. S. Adrian	Drilled
693	Leesburg	William Orson	(?)	Drilled
694	½ mile west of Leesburg	Mr. Forsythe	(?)	Drilled
695	½ mile west of Leesburg	Mr. Nelson	(?)	Drilled
696	½ mile west of Leesburg	Mr. Umbole	(?)	Drilled
697	Leesburg	Ed Nichols	E. S. Adrian	Drilled
698	1 mile east of Leesburg	Camp Ordway, U. S. Army.	E. S. Adrian	Drilled
699	½ mile east of Leesburg	Mr. Ridgeway	(?)	Drilled
700	2 miles east of Leesburg	Saunders & Myers	Mr. Reed	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
117	Granite	Marshall	0	15	Flows.	657
132	Granite	Marshall	15	3		658
196	Granite	Marshall	50	10		659
180	Granite	Marshall	60	3		660
200	Granite	Marshall	40	10		661
196	Very hard greenstone to 100 feet, granite.	Catoctin, Marshall	6	10		662
144	Granite	Marshall	20	10		663
140	Granite	Marshall		15		664
35	Granite	Marshall	25	4		665
34	Granite	Marshall		15+		666
75	Granite	Marshall		3		667
56	Granite	Marshall		20+		668
46	Granite	Marshall		5		669
104	Granite	Marshall		½		670
44	Granite	Marshall		20		671
44	Shale, granite	Loudoun, Marshall		5		672
55	Granite	Marshall		3		673
75	Limestone conglomerate.	Newark		15+		674
71	Red shale	Newark		11		675
74	Red shale	Newark		6		676
52	Red sandstone	Newark		3		677
71	Red sandstone	Newark		1		
66	Red shale	Newark		4		678
67	Red sandstone	Newark		6		679
28	Limestone conglomerate.	Newark		4	6-inch casing.	680
60	Red sandstone and shale.	Newark		2½		681
29	Limestone conglomerate.	Newark		8		682
29	Limestone conglomerate.	Newark		12		683
53	Limestone conglomerate.	Newark		3½	Analysis on p. 116.	684
126	Limestone conglomerate.	Newark		0		685
75	Limestone conglomerate.	Newark		1½		686
265	Limestone conglomerate.	Newark		½		
176	Limestone conglomerate.	Newark	76	10+		687
55	Limestone conglomerate.	Newark		12		688
50	Limestone conglomerate.	Newark		8		689
80	Limestone conglomerate.	Newark		10+		690
44	Limestone conglomerate.	Newark		16		691
40	Limestone conglomerate.	Newark	34	11+	8-inch casing with 6-inch casing inside	692
120	White marble	Pre-Catoctin		15+		693
72	Shale	Newark		20+		694
52	Limestone conglomerate and shale.	Newark		20+		695
52	Limestone conglomerate and shale.	Newark		20+		696
80	Limestone conglomerate.	Newark		8		697
36	Blue limestone	Frederick		8		698
63	Blue limestone	Frederick		8		
71	Blue limestone	Frederick		10		
172	Limestone conglomerate.	Newark		½		699
58	Limestone conglomerate.	Newark		7		700

WELL RECORDS

TABLE 30.—*Wells in Loudoun*

Well number	Location	Owner	Driller	Type of well
701	Leesburg	Mr. Stedman	(?)	Drilled
702	1 mile south of Leesburg	Mr. Miller	Mr. Reed	Drilled
703	2 miles south of Leesburg	Mr. Berry	(?)	Drilled
704	1¾ miles south of Leesburg	Mr. Phillips	(?)	Drilled
705	Leesburg	E. B. White	L. W. Wortman	Drilled
706	Leesburg	Arthur Fulton	L. W. Wortman	Drilled
707	1 mile southwest of Leesburg	Mr. Lynn	George Cullen	Drilled
708	Leesburg	Children's Home	Charles Wine	80 feet dug, rest drilled.
709	1 mile south of Leesburg	Mr. Jenkins	Charles Wine	Drilled.
710	Leesburg	Bruce MacIntosh	Charles Wine	Drilled
711	Leesburg	W. S. Jenkins	L. W. Wortman	Drilled
712	Leesburg	T. D. Daly	L. W. Wortman	Drilled
713	Leesburg	Mr. Garret	L. W. Wortman	Drilled
714	Leesburg	Mr. Fling	Mr. Reed	Drilled.
715	Leesburg	Mrs. Hempstone	Mr. Reed	Drilled
716	1 mile east of Leesburg	Mrs. Kinkaid	Mr. Reed	Drilled
717	Leesburg	W. S. Jenkins	E. S. Adrian	Drilled
718	Leesburg	Mrs. McIntosh	L. W. Wortman	Drilled
719	Leesburg	Harrison Williams	Mr. Reed	Drilled
720	Leesburg	W. S. Jenkins Co	E. S. Adrian	Drilled
721	Leesburg	Wallace George	(?)	Drilled
722	Leesburg	H. Williams	Mr. Reed	Drilled
723	Leesburg	Billy Hibbs	Mr. Reed	Drilled
724	Leesburg	W. S. Jenkins	L. W. Wortman	Drilled
725	Leesburg	Town of Leesburg	F. M. Hagmann, Jr.	Drilled
726	Leesburg	Town of Leesburg	George Cullen	Drilled
727	3 miles southeast of Leesburg	Robert Harper	E. S. Adrian	Drilled
728	4½ miles north of Ashburn	Roger Shroy	(?)	Drilled
729	4 miles southeast of Leesburg on Goose Creek.	Mr. Hopkins	George Cullen	Drilled
730	3½ miles southeast by east of Leesburg on Goose Creek.	Miss Harrison	Charles Wine	Drilled
731	3 miles southeast of Leesburg	Mr. Utterback	E. S. Adrian	Drilled
732	3½ miles south of Leesburg	George Dubin	L. W. Wortman	Drilled
733	4 miles south of Leesburg	Mr. Atwell (tenant)	Mr. Ridgeway	Drilled
734	4 miles south of Leesburg	(?)	Mr. Ridgeway	Drilled
735	1 mile north of Oatlands	Mrs. Eustace	Charles Wine	Drilled
736	5 miles south of Leesburg	L. Shomate	E. S. Adrian	Drilled
737	2¼ miles northwest of Waxpool, which is 7¼ miles southeast by south of Leesburg.	(?)	(?)	Drilled
738	5½ miles southeast of Leesburg	James Mattox	E. S. Adrian	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
68	Limestone conglomerate.	Newark		20+		701
64	Red shale	Newark		15+		702
70	Limestone conglomerate and shale.	Newark		15+		703
44	Trap (diabase)	Late and/or post-Newark.		2½		704
44	Limestone conglomerate.	Newark		6		705
65	Limestone conglomerate.	Newark		½		706
123	Limestone conglomerate.	Newark		½		707
180	Limestone conglomerate.	Newark	85	25		708
112	Limestone conglomerate.	Newark	50	5		709
202	100 feet trap, 100 feet blue limestone.	Late and/or post-Newark; Frederick.		0		710
167	Limestone conglomerate.	Newark			Failure.	711
60	Limestone conglomerate.	Newark		1½		712
33	Limestone conglomerate.	Newark		12		713
164	Limestone conglomerate.	Newark		1		714
150	Limestone conglomerate.	Newark	20	1		715
40	Limestone conglomerate.	Newark		15+		716
184	Limestone	Frederick		¼		717
29	Trap soil and boulders.	Late and/or post-Newark.		6		718
80	Trap (diabase)	Late and/or post-Newark.	1	5		719
32	Trap (diabase)	Late and/or post-Newark.		5		720
66	Trap (diabase)	Late and/or post-Newark.		1½		721
50	Shale and sandstone.	Newark		2		722
78	Shale and sandstone.	Newark		5		723
31	Sandstone	Newark		3		724
360	Limestone conglomerate.	Newark	35	60	8 inches in diameter. Draw down about 225 feet. Analysis on page 116.	725
160	Limestone conglomerate.	Newark	35	35		726
36	Sandstone	Newark		3		727
225	Red shale	Newark		¾		728
70	Red shale	Newark		½		
802½	Trap (diabase)	Late and/or post-Newark.	Flowed	3	20 feet of 6-inch casing.	729
107	Trap (diabase)	Late and/or post-Newark.	25	10		730
55	Trap (diabase)	Late and/or post-Newark.		3		731
49	Red shale	Newark		5		732
65	Red shale	Newark		3½		733
52	Red shale and sandstone.	Newark		15+		734
60	Shale 40 feet, sandstone 20 feet.	Newark	20	60		735
96	Shale 40 feet, sandstone 20 feet, trap (diabase)	Newark; late and/or post-Newark.		25		
87	Sandstone	Newark		8		736
126	Trap (diabase)	Late and/or post-Newark.		½		737
64	Trap (diabase)	Late and/or post-Newark.		9/10		738

WELL RECORDS

TABLE 30.—*Wells in Loudoun*

Well number	Location	Owner	Driller	Type of well
739	2¼ miles north of Waxpool	Waxpool School	(?)	Drilled
740	1¼ miles north of Waxpool	John Ankers	E. S. Adrian	Drilled
741	1 mile north of Waxpool	George Shryock	E. S. Adrian	Drilled
742	Waxpool	William Ankers	E. S. Adrian	Drilled
743	Waxpool	William Crimm	E. S. Adrian	Drilled
744	Waxpool	Mr. Shryock	E. S. Adrian	Drilled
745	Waxpool	Mr. Shryock	E. S. Adrian	Drilled
746	Waxpool	Charles Shryock	James Franklin	Drilled
747	Waxpool	Mr. Ankers	L. W. Wortman	Drilled
748	1½ miles northeast of Aldie	Mr. Littleton	Mr. Ridgeway	Drilled
749	1½ miles northeast of Aldie	Mr. Littleton	Mr. Ridgeway	Drilled
750	1 mile north of Aldie	(?)	Charles Wine	Drilled
751	Watson, which is 2 miles east of Aldie	Mr. Fletcher	Mr. Puckett	Drilled
752	Watson	Mr. Fletcher	L. W. Wortman	Drilled
753	Watson	John Thompson	L. W. Wortman	Drilled
754	Watson	J. O. Daniel	L. W. Wortman	Drilled
755	Near Watson	Mr. Ridicor	L. W. Wortman	Drilled
756	Near Watson	Mrs. Tyler	L. W. Wortman	Drilled
757	1 mile south of Watson	Ed Morton	L. W. Wortman	Drilled
758	1 mile south of Watson	Mr. Mitchell	L. W. Wortman	Drilled
759	Lenah, which is 3½ miles southeast of Aldie.	Carol Hutchison	Fred Stickley	Drilled
760	Lenah	William Frame	L. W. Wortman	Drilled
761	Lenah	Mrs. Burton	Henry Seeley	Drilled
762	Lenah	G. H. Hutchison	L. W. Wortman	Drilled
763	1½ miles southwest by west of Arcola.	Mr. Lee	L. W. Wortman	Drilled
764	1 mile west of Arcola	Bull Run View filling station.	F. N. Hagmann, Jr	Drilled
765	1¼ miles northwest of Arcola	Mr. Middleton	E. S. Adrian	Drilled
766	1 miles northwest by north of Arcola	D. C. Sands	F. N. Hagmann, Jr	Drilled
767	Arcola	J. F. Ryan	L. W. Wortman	Drilled
768	1 mile northeast of Arcola	Brook Middleton	E. S. Adrian	Drilled
769	1½ miles east of Arcola	T. E. Little	E. S. Adrian	Drilled
770	5½ miles northwest by north of Pleasant Valley.	J. C. Roller	E. S. Adrian	Drilled
771	Arcola	Dr. C. P. Hutchison	E. S. Adrian	Drilled
772	Arcola	Sarah Little	E. S. Adrian	Drilled
773	Arcola	C. J. C. Moffett	E. S. Adrian	Drilled
774	Arcola	Sarah Little	L. W. Wortman	Drilled
775	Arcola	Sarah Little	L. W. Wortman	Drilled
776	1 mile southwest by west of Arcola	Henry Smith	L. W. Wortman	Drilled
777	1 mile south of Arcola	Mr. Poland	L. W. Wortman	Drilled
778	1 mile south of Arcola	R. Summers	L. W. Wortman	Drilled
779	1 mile south of Arcola	Dick Ratliff	L. W. Wortman	Drilled
780	1½ miles south of Arcola	E. F. Smith	E. S. Adrian	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
27	Trap soil and rock	Late and/or post-Newark.		1½		739
50	Trap (diabase)	Late and/or post-Newark.		2		740
30	Trap (diabase)	Late and/or post-Newark.		6		741
39	Blue shale overlying trap (diabase).	Newark; late and/or post-Newark.		1		742
43	Red shale	Newark		1½		743
113	Trap (diabase)	Late and/or post-Newark.		6		744
30	Trap (diabase)	Late and/or post-Newark.		5		745
113	Trap (diabase)	Late and/or post-Newark.	16	20		746
50	Trap (diabase)	Late and/or post-Newark.		1½		747
270	Trap; bottom part shale and sandstone.	Late and/or post-Newark; Newark.		½		748
80	Decomposed trap (diabase).	Late and/or post-Newark.		10		749
86	Decomposed trap (diabase).	Late and/or post-Newark.		10+		
120	Trap (diabase)	Late and/or post-Newark.	50	10		750
130	Red shale and sandstone.	Newark		7		751
57	Red shale	Newark		1		752
42	Trap (diabase)	Late and/or post-Newark.		2		753
57	Red shale	Newark		3		754
72	Trap (diabase)	Late and/or post-Newark.		¼+		755
65	Red shale	Newark		2		756
42	Red shale	Newark		4		757
55	Red shale	Newark		1		758
150	Red shale	Newark		10		759
90	Red shale	Newark		1½		760
70	Sandstone	Newark		5		761
90	Red shale	Newark		1½		762
80	Red shale	Newark		1		763
100	Red sandstone and shale.	Newark		7		764
60	Red shale	Newark		2		765
200	Red sandstone and shale.	Newark		15		766
57	Red shale	Newark		2		767
67	Red shale	Newark		6		768
77	Red shale	Newark		2		769
77	Red shale	Newark		6		770
35	Trap (diabase)	Late and/or post-Newark.		3		771
40	Blue shale	Newark		3		772
42	Trap (diabase)	Late and/or post-Newark.	22	6	Analysis on p. 116.	773
40	Trap (diabase)	Late and/or post-Newark.		1½		774
76	Trap (diabase)	Late and/or post-Newark.		5		775
103	Red shale	Newark		½		776
55	Trap (diabase)	Late and/or post-Newark.		½		777
27	Sandstone	Newark		1		778
54	Trap (diabase)	Late and/or post-Newark.		5		779
57	Trap (diabase)	Late and/or post-Newark.		3		780

WELL RECORDS

TABLE 30.—*Wells in Loudoun*

Well number	Location	Owner	Driller	Type of well
781	2 miles south of Arcola	Frank Harley	L. W. Wortman	Drilled
782	1¼ miles south of Arcola	E. L. Poland	E. S. Adrian	Drilled
783	3 miles south of Lenah	Mr. Heller	Henry Seeley	Drilled
784	4 miles south of Lenah	Norman & Harding	Henry Seeley	Drilled
785	3 miles north of Catharpin, which is 4½ miles northeast of Haymarket.	Carter Byrne	Henry Seeley	Drilled
786	4 miles northeast by east of Catharpin.	Mr. Iffnis	Henry Seeley	Drilled
787	4 miles northeast by east of Catharpin.	Fairview Church	Henry Seeley	Drilled
788	4 miles northeast by east of Catharpin.	Ham Lee	Henry Seeley	Drilled
789	1½ miles east of Catharpin	(?)	Henry Seeley	Drilled
790	4 miles southeast by south of Arcola.	Fred Couim	Charles Daniels	Drilled
791	1½ miles northwest by west of Pleasant Valley.	Wort Wilson	E. S. Adrian	Drilled
792	1 miles northwest of Pleasant Valley on Winchester Pike.	H. S. Polend	F. N. Hagmann, Jr	Drilled
793	1½ miles north of Pleasant Valley	H. Blebbins	Mr. Puckett	Drilled
794	1 mile west of Willard, which is 4 miles southwest of Herndon.	P. D. Sowers	E. S. Adrian	Drilled
795	½ mile west of Willard	Howard Middleton	E. S. Adrian	Drilled
796	2½ miles north of Pleasant Valley	Mathew Middleton	L. W. Wortman	Drilled
797	1½ miles northeast of Willard	John Middleton	James Franklin	Drilled
798	3 miles south of Sterling	Frank Cockrelle	E. S. Adrian	Drilled
799	3 miles southwest of Sterling	J. W. Six	W. S. Adrian	Drilled
800	4½ miles northwest of Pleasant Valley.	R. J. Carter	E. S. Adrian	Drilled
801	2 miles southwest of Sterling	Charles B. Hairford	E. S. Adrian	Drilled
802	2¼ miles southwest of Sterling	Frank Cockerel	L. W. Wortman	Drilled
803	1½ miles southwest of Sterling	R. W. Bell	L. W. Wortman	Drilled
804	1½ miles southwest of Sterling	Mrs. Coleman	L. W. Wortman	Drilled
805	1½ miles south of Sterling	Mr. Cornett	James Franklin	Drilled
806	1½ miles southwest by south of Sterling.	Tom Blinker	James Franklin	Drilled
807	¾ mile southwest of Sterling	Rollins Dairy	James Franklin	Drilled
808	Sterling	Col. Wall	L. W. Wortman	Drilled
809	Sterling	E. S. Adrian	E. S. Adrian	Drilled
810	Sterling	Mrs. H. E. Snedberg	E. S. Adrian	Drilled
811	Sterling	E. E. Jenkins	E. S. Adrian	Drilled
812	Sterling	Town of Sterling	E. S. Adrian	Drilled
813	Sterling	M. A. Hummer	E. S. Adrian	Drilled
814	Sterling	E. T. Harding	E. S. Adrian	Drilled
815	Sterling	J. W. Whaley	E. S. Adrian	Drilled
816	Sterling	W. F. Sexton	E. S. Adrian	Drilled
817	½ mile northeast by north of Sterling.	Ben Keene	James Franklin	Drilled
818	1 mile northeast of Sterling	W. O. Hummer	L. W. Wortman	Drilled
819	1 mile northeast of Sterling	Wm. Wilson	L. W. Wortman	Drilled
820	¾ mile north of Sterling	Dr. Albert Shaw	E. S. Adrian	Drilled
821	½ mile northwest of Sterling	Dr. Albert Shaw	James Franklin	Drilled
822	1¼ miles northwest of Sterling	F. J. Hill	E. S. Adrian	Drilled
823	1 mile southwest of Sterling	Aubrey Hummer	James Franklin	Drilled
824	1¾ miles west of Sterling	Mrs. Manning	E. S. Adrian	Drilled
825	2¾ miles south of Ashburn	Mr. Works	L. W. Wortman	Drilled
826	1¼ miles south of Ashburn	C. P. Jenney	L. W. Wortman	Drilled
827	1½ miles south of Ashburn	Henry Craver	L. W. Wortman	Drilled
828	1½ miles southeast by south of Ashburn.	John Ely	L. W. Wortman	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
53	Trap (diabase)	Late and/or post-Newark.		3		781
46	Trap (diabase)	Late and/or post-Newark.		3		782
80	Brown sandstone	Newark		2		783
60	Hard sandstone, trap (diabase).	Newark; late and/or post-Newark.		1		784
100	Sandstone	Newark		3		785
20	Trap (diabase)	Late and/or post-Newark.		1+		786
40	Trap soil	Late and/or post-Newark.		1½		787
105	Blue shale and brown sandstone.	Newark		2		788
75	Trap (diabase)	Late and/or post-Newark.		1		789
40	Trap (diabase)	Late and/or post-Newark.		1½	16 feet of casing.	790
26	Trap (diabase)	Late and/or post-Newark.		3		791
50	Trap (diabase)	Late and/or post-Newark.	8	4½	12 feet of 6-inch casing.	792
113	Shale and sandstone.	Newark	32	3		793
36	Blue shale	Newark		5		794
33	Red shale	Newark		2		795
67	Red shale	Newark		1		796
119	Red sandstone and shale.	Newark		15		797
75	Red shale	Newark		3½		798
50	Red shale	Newark		3		799
60	Red shale	Newark		1¾		800
54	Red shale	Newark		5		801
75	Red shale	Newark		6		802
85	Red shale	Newark		1½		803
82	Red shale	Newark		1½		804
79	Trap (diabase)	Late and/or post-Newark.	7	12		805
65	Trap (diabase)	Late and/or post-Newark.		4		806
160	Red sandstone and shale.	Newark		"Big"	20 feet of casing.	807
31	Trap (diabase)	Late and/or post-Newark.		1		808
54	Red shale	Newark		4		809
80	Red shale	Newark		2½		810
40	Red shale	Newark		6		811
48	Red shale	Newark		3		812
65	Red shale	Newark		2		813
76	Red shale	Newark		3		814
75	Red shale	Newark		2½		815
70	Red shale and sandstone.	Newark		2		816
135	Red shale and sandstone.	Newark	43	10	8 to 10 feet of casing.	817
94	Red shale	Newark		5		818
22	Sandstone and shale.	Newark		8		819
160	Red sandstone and shale.	Newark		10		820
178	Shale and sandstone.	Newark	37	12	10 feet of 5⅝-inch casing.	821
104	Red shale	Newark		7		822
139	Red sandstone and shale.	Newark		"10-20"		823
107	Red shale	Newark		2½		824
53	Red shale	Newark		5		825
125	Red shale	Newark		1½		826
72	Red shale	Newark		1		827
102	Red shale	Newark		2½		828

WELL RECORDS

TABLE 30.—*Wells in Loudoun*

Well number	Location	Owner	Driller	Type of well
829	2¼ miles southeast of Ashburn	Atherton & McDougall	E. S. Adrian	Drilled
830	2 miles southwest by west of Ashburn	Dr. B. F. Noland	E. S. Adrian	Drilled
831	1¾ miles southeast of Ashburn	H. S. Smith	E. S. Adrian	Drilled
832	1¾ miles southeast of Ashburn	W. W. Finley	E. S. Adrian	Drilled
833	1¾ miles southeast of Ashburn	Mrs. A. V. Fling	E. S. Adrian	Drilled
834	2 miles southeast by east of Ashburn	Joseph Shry	E. S. Adrian	Drilled
835	1¼ miles east of Ashburn	H. C. Harding	E. S. Adrian	Drilled
836	Ashburn	John Bryant	E. S. Adrian	Drilled
837	Ashburn	W. J. Hay	(?)	Drilled
838	Ashburn	Mr. Bryant	L. W. Wortman	Drilled
839	Ashburn	Mr. Fadley	L. W. Wortman	Drilled
840	Ashburn	Dr. J. T. Jones	E. S. Adrian	Drilled
841	Ashburn	Mr. Higgins	E. S. Adrian	Drilled
842	Ashburn	Thomas Banckman	E. S. Adrian	Drilled
843	Ashburn	M. M. Fadley	E. S. Adrian	Drilled
844	1 mile south of Ashburn	Senator Stuart	L. W. Wortman	Drilled
845	¾ mile southwest of Ashburn	Senator Stuart	E. S. Adrian	Drilled
846	Ashburn	(?)	(?)	Drilled
847	½ mile northwest of Ashburn	H. C. Harding	E. S. Adrian	Drilled
848	1 mile north of Ashburn	L. W. Wortman	E. S. Adrian	Drilled
849	1¼ miles north of Ashburn	L. W. Wortman	L. W. Wortman	Drilled
850	2 miles northwest by north of Ashburn	Patrick Hurley, Belmont Farms.	L. W. Wortman	Drilled
851	2 miles north of Ashburn	Downes filling station	L. W. Wortman	Drilled
852	2 miles north of Ashburn	L. W. Wortman	L. W. Wortman	Drilled
853	2½ miles northeast of Ashburn	Mr. Owen	E. S. Adrian	Drilled
854	2½ miles northwest by north of Sterling.	C. P. Janney	E. S. Adrian	Drilled
855	3½ miles north of Sterling	E. V. Jenkins	E. S. Adrian	Drilled
856	3½ miles north of Sterling	Mrs. Vandeventer	E. S. Adrian	Drilled
857	3½ miles north of Sterling	Potomac View Farm	Mr. Puckett	Drilled
858	2¼ miles north of Sterling on Leesburg Pike.	William Ellmore	L. W. Wortman	Drilled
859	2 miles north of Sterling	Clayton Banister	E. S. Adrian	Drilled
860	2½ miles north of Sterling, north of Leesburg Pike.	J. E. Anderson	E. S. Adrian	Drilled
861	2½ miles north of Sterling, north of Leesburg Pike.	Will Eeds	Mr. Puckett	Drilled
862	2 miles north of Sterling	S. J. Holsinger	E. S. Adrian	Drilled
863	2½ miles northeast by north of Sterling.	David O'Rourke	E. S. Adrian	Drilled
864	2¼ miles northeast by north of Sterling.	L. M. Furgeson	Mr. Puckett	Drilled
865	3¾ miles northwest by west of Dranesville.	T. W. Grimes	E. S. Adrian	Drilled
866	1½ miles north of Sterling	J. W. Nicholo	E. S. Adrian	Drilled
867	2 miles northeast by north of Sterling	J. E. Milster	L. W. Wortman	Drilled
868	2 miles northeast by north of Sterling	Carl Nokes	E. S. Adrian	Drilled
869	2 miles northeast of Sterling	Dr. Avey	James Franklin	Drilled
870	3¼ miles northeast of Sterling	T. W. Caper	E. S. Adrian	Drilled
871	3 miles northwest by north of Dranesville.	G. L. Thraves	F. N. Hagmann, Jr.	Drilled
872	2 miles northwest of Dranesville	James Edwards	E. S. Adrian	Drilled
873	2¼ miles northwest of Dranesville	W. F. Crosen	E. S. Adrian	Drilled
874	2½ miles northeast by east of Sterling.	J. M. Hughes	(?)	Drilled
875	2 miles east of Sterling	W. V. Hummer	E. S. Adrian	Drilled
876	2 miles east of Sterling	William Wilson	E. S. Adrian	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Death to water level in feet	Yield (gallons a minute)	Remarks	Well number
225	Red shale	Newark		10+		829
92	Red shale	Newark		5		830
84	Red shale	Newark		6		831
190	Red shale	Newark		8		832
123	Red shale	Newark		6		
100	Red shale	Newark		5		833
90	Red shale	Newark		6		834
140	Red shale	Newark		2½		835
105	Red shale	Newark		3		836
123½	Red shale	Newark		10		837
105	Red shale	Newark		5		838
57	Red shale	Newark		2½		839
115	Red shale	Newark		5		840
70	Red shale	Newark		1½		841
81	Red shale	Newark		1½		842
57	Red shale	Newark		4		843
196	Red rock	Newark		8		844
196	Red shale	Newark		12		845
63	Trap (diabase)	Late and/or post-Newark.		2		846
139	Red shale	Newark		2½		847
55	Red shale	Newark		2		848
50	Red shale	Newark		5		849
80	Trap (diabase))	Late and/or post-Newark.		40		850
75	Trap (diabase)	Late and/or post-Newark.		45		
65	Trap (diabase)	Late and/or post-Newark.		1		851
18	Trap (diabase)	Late and/or post-Newark.		10		852
31	Trap (diabase)	Late and/or post-Newark.		2		853
61	Red shale	Newark		¾		854
50	Red shale	Newark		10		855
80	Red shale	Newark		1½		856
176	Red shale and sandstone.	Newark		5		857
85	Red shale	Newark		½		858
31	Trap soil	Late and/or post-Newark.		4		859
67	Red shale	Newark		3½		860
148	Red shale	Newark	50	8		861
111	Red shale	Newark		1		862
50	Red shale	Newark		4		863
182	Red shale	Newark	19	9		864
125	Red shale and sandstone.	Newark		1		865
167	Red shale and sandstone.	Newark		3		
147	Red shale	Newark		8		866
100	Red shale	Newark		1		867
140	Red shale	Newark		1		868
200	Shale and sandstone.	Newark	90	8	40 feet of casing.	869
118	Red shale	Newark		2		870
66½	Shale and sandstone.	Newark	30	5		871
66	Hard shale	Newark		¾		872
66	Red shale	Newark		4		873
300	Red shale	Newark	15	3½		874
94	Red shale	Newark		5		875
22	Trap (diabase)	Late and/or post-Newark.		11		876

ANALYSES OF WATER

TABLE 31.—*Analyses of ground waters from Loudoun County, Virginia*

[Analyst, S. K. Love. Parts per million. Numbers at heads of columns refer to corrresponding well numbers in table 30.]

	520	534	593	617	625	628	635	642	649	684	725	773
Silica (SiO_2)	.....	.....	.....	.....	49	.....	.....	27	18	.....	17	.....
Iron (Fe)	.....	.....	.....	.....	.39	.....	.....	.22	.25	.....	.18	.....
Calcium (Ca)	[a]18	[a]2	37	[a]16	16	[a]9	[a]22	26	26	50	68	100
Magnesium (Mg)	.....	.....	7.4	.....	9.1	.....	.....	5.4	6.9	15	19	23
Sodium (Na)	.....	.....	[b]6.9	.....	9.4	.....	.....	8.5	8.7	[b]3.5	19	[b]14
Potassium (K)	.....	.....		.....	1.4	.....	.....	5.6	1.8		4.7	
Bicarbonate (HCO_3)	108	15	122	71	94	39	32	94	131	206	239	338
Sulphate (SO_4)	[a]12	[a]1	[a]8	[a]8	7.7	[a]5	[a]5	21	4.0	[a]5	19	[a]11
Chloride (Cl)	11	2.0	19	4.0	4.0	4.0	28	3.0	4.0	5.0	29	40
Nitrate (NO_3)	12	6.0	3.3	.10	3.6	3.8	51	4.0	3.0	16	50	36
Total dissolved solids	.....	.....	[b]148	.....	142	.....	.....	143	131	[b]209	331	[b]411
Total hardness as $CaCO_3$ (calculated)	[c]120	[c]14	123	[c]50	77	[c]30	[c]116	87	93	186	248	344
Date of collection (1931)	Oct. 30	Oct. 30	Oct. 30	Dec. 2	Oct. 30	Oct. 30	Dec. 2	Oct. 30	Oct. 30	Oct. 30	Oct. 30	Oct. 30

[a]By turbidity.
[b]Calculated.
[c]Determined.

ADJACENT AREA

TABLE 32.—*Wells in*

Well number	Location	Owner	Driller	Type of well
900	Upperville	Mrs. Ball	Mr. Reed	Drilled
901	2½ miles southeast of Upperville	Samuel Ross, Blue Ridge Farm.	F. N. Hagmann, Jr.	Drilled
902	1 mile northwest of Delaplane	R. A. Goode	Fred Stickley	Drilled
903	4 miles southwest by west of Middleburg.	Mr. Phipps	Charles Wine	Drilled
904	3 miles southwest by west of Middleburg.	Mr. Phipps	Begun by Fish Eustace, finished by Charles Wine.	Drilled
905	3¾ miles southwest of Middleburg	Mr. Phipps	Charles Wine	Drilled
906	2¼ miles west of Middleburg	Mr. Stevenson	Charles Wine	Drilled
907	¼ mile south of Middleburg	Mrs. Judah Whiting	Fred Stickley	Drilled
908	2½ miles southwest of Middleburg	Mr. Ziegler	Charles Wine	Drilled
909	2¾ miles southwest of Middleburg	Mrs. Phillips	Charles Wine	Drilled
910	4 miles southwest by south of Middleburg.	Mr. Redmond	Charles Wine	Drilled
911	5 miles south of Middleburg	Mr. Atkins	Fred Stickley	Drilled
912	2 miles north of The Plains	Mr. Filly	Fred Stickley	Drilled
913	The Plains	Creamery	(?)	Drilled
914	4½ miles southwest by west of Buckland.	Henry Smith	Henry Seeley	Drilled
915	1¼ miles north of New Baltimore (4 miles southwest by west of Buckland).	Mr. Sprow	Henry Seeley	Drilled
916	3½ miles northwest of Warrenton	Capt. Sterling Larrabee	Virginia Machinery & Well Co.	Drilled
917	5 miles northwest by west of Warrenton.	C. T. Baldwin	Virginia Machinery & Well Co.	Drilled
918	5 miles northwest by west of Warrenton.	C. T. Baldwin	Virginia Machinery & Well Co.	Drilled
919	2½ miles southeast of Orlean	William Doeller	Virginia Machinery & Well Co.	Drilled
920	2½ miles southwest of Warrenton	A. S. Carbart	Virginia Machinery & Well Co.	Drilled
921	1¾ miles south of Warrenton	R. C. Wimmill	Virginia Machinery & Well Co.	Drilled
922	2 miles south of Warrenton	Mr. Wallace	D. H. Sherman	Drilled
923	2½ miles south of Warrenton	Mr. Coleman	D. H. Sherman	Drilled
924	3½ miles south of Warrenton	L. Schumate	D. H. Sherman	Drilled
925	4 miles northwest of Bealeton	John May	D. H. Sherman	Drilled
926	3½ miles northwest by west of Bealeton.	Will Martin	D. H. Sherman	Drilled
927	3 miles west of Bealeton	(?)	D. H. Sherman	Drilled
928	2 miles north of Remington	(?)	D. H. Sherman	Drilled
929	Remington	(?)	D. H. Sherman	Drilled
930	Remington	Standard Oil Co	D. H. Sherman	Drilled
931	1 mile east of Remington	Lewis Miller	D. H. Sherman	Drilled
932	1¾ miles southwest by south of Bealeton.	(?)	D. H. Sherman	Drilled
933	¾ mile southwest of Bealeton	Mr. Willingham	D. H. Sherman	Drilled
934	Midland	Mr. Stafford	D. H. Sherman	Drilled
935	Midland	(?)	D. H. Sherman	Drilled
936	1 mile south of Midland	(?)	D. H. Sherman	Drilled
937	1½ miles southeast of Midland	Mr. Messenger	D. H. Sherman	Drilled
938	2 miles northwest by north of Midland.	Mr. Hensburger	D. H. Sherman	Drilled
939	1 mile north of Midland	W. O. Bower	D. H. Sherman	Drilled
940	Calverton	Undrel Payne	D. H. Sherman	Drilled
941	Calverton	(?)	D. H. Sherman	Drilled
942	Calverton	(?)	D. H. Sherman	Drilled
943	Calverton	Mr. Gray	D. H. Sherman	Drilled

IN FAUQUIER COUNTY

Fauquier County, Virginia

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
64	Greenstone	Catoctin		2		900
325	Granite	Marshall		8	8-inch well.	901
50+	Granite	Marshall		4	Electric deep-well pump.	902
443	200± feet sandstone, 200± feet granite.	Weverton, Marshall	50	12		903
400+	Gray sandstone, granite.	Weverton, Marshall	75	35		904
200	Granite	Marshall	50	12		905
400	Granite	Marshall	60	17		906
116	Granite	Marshall		12		907
312	Gray sandstone	Weverton	20	12		908
400	Granite	Marshall	100	20		909
165	Shale, granite	Loudoun, Marshall	30	7		910
60	Granite	Marshall		12		911
58	Granite	Marshall		5		912
47	Granite	Marshall		5		
48	Granite	Marshall		3		
170	Greenstone	Catoctin		13		913
65	Sandstone	Weverton		4		914
110	Shale	Loudoun		⅓		915
188	Greenstone	Catoctin	61½	30	10-inch well to 84 feet, rest 8-inch. Boulders near surface caused two well sites to be abandoned.	916
530	Shale	Loudoun	6	5½	10-inch well. At 438 feet yield was 6½ gallons a minute.	917
284	Shale	Loudoun	12	5	10-inch well.	918
218¼	Sandstone (at 7 to 20 feet), shale, granite.	Weverton, Loudoun, Marshall.	15	41		919
325	Shale	Loudoun	40	3	8-inch hole; not completed.	920
323	Shale	Loudoun	17	16		921
60	Sandstone	Weverton	20	2		922
72	Sandstone	Weverton	30±	2	30 feet of casing.	923
60	Sandstone	Weverton	15	3	20 feet of casing.	924
94	Greenstone	Catoctin	35	3	15 feet of casing.	925
140	Red shale	Newark	30	4	20 feet of casing.	926
123	Red shale	Newark	20	3	12 feet of casing.	927
40	Red shale	Newark	10	1½	10 feet of casing.	928
90	Trap (diabase)	Late and/or post-Newark.	20	2	12 feet of casing.	929
80	Trap (diabase)	Late and/or post-Newark.	15	4	15 feet of casing.	930
101	Trap (diabase)	Late and/or post-Newark.	30	4	20 feet of casing.	931
60	Trap (diabase)	Late and/or post-Newark.	20	3		932
85	Trap (diabase)	Late and/or post-Newark.	20	1½	10 feet of casing.	933
90	Red shale	Newark	20±?	2		934
92	Red shale	Newark	15	2½	35 feet of casing.	935
80	Red shale	Newark	25	4		936
80	Red shale	Newark	25	4		937
70	Red shale	Newark	10	4	12 feet of casing.	938
72	Red shale	Newark	20	3	20 feet of casing.	939
75	Red shale	Newark	20	1½		940
100	Red shale	Newark	15	5		941
70	Red shale	Newark	15	1½	10 feet of casing.	942
40	Red shale	Newark	10	1	10 feet of casing.	943

ADJACENT AREA IN FAU

TABLE 32.—*Wells in Fauquier*

Well number	Location	Owner	Driller	Type of well
944	Calverton	Mr. Trumbow	D. H. Sherman	Drilled
945	Calverton	Sam Simpson	D. H. Sherman	Drilled
946	1 mile north of Catlett	Judge Smith	D. H. Sherman	Drilled
947	2 miles north of Catlett	Mrs. Chauncey Day	Charles Daniels	50 feet dug, rest drilled.
948	3½ miles north of Catlett	Lewis Beydler	Charles Daniels	Drilled
949	3½ miles north of Catlett	M. F. Burgess	Charles Daniels	Drilled
950	4½ miles north of Catlett	Landon Green	Charles Daniels	Drilled
951	4½ miles north of Catlett	Mary Keyes	Charles Daniels	Drilled
952	Greensville (3½ miles west of Nokesville).	Mr. Clark	Charles Daniels	Drilled
953	1½ miles northeast of Catlett	O. E. Meinzer	D. H. Sherman	Drilled
954	3 miles southwest of Nokesville	Ben May	Charles Daniels	Drilled
955	Weaversville (1 mile south of Catlett).	Charles Daniels	Charles Daniels	Drilled
956	1½ miles southeast by east of Weaversville.	Joe Peters	D. H. Sherman	Drilled
957	1 mile southeast of Weaversville	Guy Heflin	D. H. Sherman	Drilled
958	3 miles southeast of Weaversville	D. H. Sherman	D. H. Sherman	Drilled
959	2½ miles north of Bristersburg	Lewis Guy	D. H. Sherman	Drilled
960	2 miles north of Bristersburg	M. C. Heflin	D. H. Sherman	Drilled
961	Sowego	Clarence Herndon	Charles Daniels	Drilled
962	½ mile east of Bristersburg	Joe George	D. H. Sherman	Drilled
963	Bristersburg	W. L. Griffith	D. H. Sherman	Drilled
964	1½ miles northeast by north of Elk Run.	Elmer Peters	D. H. Sherman	Drilled
965	¾ mile northwest of Elk Run	Clyde Lomax	D. H. Sherman	Drilled
966	Elk Run	George Embry	D. H. Sherman	Drilled
967	2½ miles south of Bristersburg	Mr. Bumbry	D. H. Sherman	Drilled
968	2½ miles south of Bristersburg	Seth Morton	D. H. Sherman	Drilled
969	3 miles south of Bristersburg	Mr. Washington	D. H. Sherman	Drilled
970	1½ miles northeast of Elk Run	Mr. Peters	D. H. Sherman	Drilled

QUIER COUNTY—CONTINUED

County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
70	Trap (diabase)	Late and/or post-Newark.	15	1½	15 feet of casing.	944
90	Red shale	Newark	20	3		945
304	Trap soil	Late and/or post-Newark.		½		946
30	Trap soil	Late and/or post-Newark.		10	Analysis on p. 122.	
140	Red shale	Newark		2½		947
100	Shale	Newark		2	42 feet of casing.	948
72	Shale	Newark		2	19 feet of casing.	949
86	Red beds	Newark		1½	8 feet of casing.	950
70	Shale	Newark		2	57 feet of casing.	951
80	Shale	Newark		2?	25 feet of casing.	952
60	Trap (diabase)	Late and/or post-Newark.	20	3	Analysis on p. 122.	953
35	Trap soil	Late and/or post-Newark.		3	24 feet of casing.	954
87	Blue shale and red shale.	Newark		2½	10 feet of casing.	955
90	Red shale	Newark	20	5	20 feet of casing.	956
60	Red shale	Newark		1½		
75	Red shale	Newark	20	2½	20 feet of casing.	957
100	Red shale	Newark	15	3	10 feet of casing	958
35	Red shale	Newark		2		
112	Trap (diabase)	Late and/or post-Newark.	40	½		959
140	Trap (diabase)	Late and/or post-Newark.	60	½+		960
92	Shale	Newark		2±	20 feet of casing.	961
80	Red shale	Newark	14	15		962
52	Red shale	Newark	8	2	6 feet of casing.	963
90	Red shale	Newark	20	2	20 feet of casing.	964
80	Red shale	Newark	20	3		965
125	Red shale	Newark	20	4	20 feet of casing.	966
100	Red shale	Newark	30	1		967
79	Red shale	Newark	20	1	20 feet of casing.	968
60	Red shale	Newark	8	2	10 feet of casing.	969
78	Red shale	Newark	30	2	15 feet of casing.	970

TABLE 33.—*Analyses of ground waters from Fauquier County, Virginia*

[Analyst, S. K. Love. Parts per million. Numbers at heads of columns refer to corresponding well numbers in table 32.]

	946	953
Silica (SiO_2)	.....	22
Iron (Fe)	.....	2.8
Calcium (Ca)	[a]12	92
Magnesium (Mg)	.....	39
Sodium (Na)	.....	24
Potassium (K)	.....	1.8
Bicarbonate (HCO_3)	50	322
Sulphate (SO_4)	[a]7	40
Chloride (Cl)	3.0	83
Nitrate (NO_3)	3.6	38
Total dissolved solids	.....	465
Total hardness as $CaCO_3$ (calculated)	[b]42	390
Date of collection (1931)	Dec. 2	Dec. 2

[a]By turbidity.
[b]Determined.

PRINCE WILLIAM COUNTY

GEOGRAPHY

Prince William County lies south of Loudoun and Fairfax counties and is bounded by Fauquier County on the west and southwest and by Stafford County on the south. It extends from Bull Run Mountain on the west to Potomac River on the east. It has an area of 345 square miles, and in 1930 its population was 13,951. Manassas, the largest community and county seat, had a population in 1930 of 1,215; Quantico, 538; Occoquan, 221; Haymarket, 167; and Dumfries, 157.

Two trunk railroads cross Prince William County, the Richmond, Fredericksburg & Potomac and the Southern, and a branch line of the Southern Railway runs west from Manassas through Thorofare Gap into Fauquier County. The Shenandoah Valley highway from Washington, D. C., to Richmond passes through the eastern part of the county, and the highway from Washington to Warrenton and the Shenandoah Valley passes through the western part. Other surfaced roads provide the rest of the county with transportation facilities.

DRAINAGE

Prince William County is drained by small streams, all of which are tributaries of Potomac River. Chopawamsic Creek, at the south, is the boundary between Prince William and Stafford counties; Little, Quantico, Powells, and Neabsco creeks flow southeastward into estuarine embayments of the Potomac. Occoquan Creek, the boundary between Fairfax and Prince William counties, is formed by the confluence 5 miles east of Manassas of Bull Run and Broad Run. Broad Run is joined by Cedar Run 3 miles south of Manassas. These three streams drain most of the western part of the county. The drainage systems of Prince William County appear to be of a normal dendritic type, little affected by the structure of the underlying rocks. There may be at least one case of piracy—the decapitation of Little Creek by tributaries of Quantico Creek—but such piracy does not seem to be common.

TOPOGRAPHY

Extending north and south along the west boundary of Prince William County are the Bull Run Mountains, which are cut at the south by Thorofare Gap. These mountains have altitude of as much as 1,250 feet but average about 1,000 feet. At the foot of the mountains the

Piedmont Plateau lies at an altitude of about 500 feet and has a relief of 200 feet. Toward the southeast the plateau declines gradually and its relief becomes less. Along the Fall Zone, which marks the boundary between the Piedmont Plateau and the Coastal Plain, the altitude of the upland is about 200 to 250 feet and the relief slightly over 200 feet. In the Coastal Plain, east of the Fall Line, the upland is 200 feet above sea level and the relief is almost 200 feet. The streams have well-graded beds except at the Fall Line, where they flow over rapids and through gorges into the tidal estuaries. In the Piedmont Plateau the surface is characterized by flat-topped uplands with intervening gently sloping valleys. The uplands are remnants of an ancient erosion surface. The outcrops of the sills and dikes of resistant trap rock are conspicuous in that they form long, well-defined ridges, which in some places rise 50 to 75 feet above the rest of the upland.

GEOLOGY

The rock formations in this county may be divided into three groups. The sandstone and shale of Triassic age, with their associated intrusive and extrusive diabase, or trap occupy the central and western parts of the county; the pre-Cambrian and lower Paleozoic folded and metamorphosed rocks and associated intrusives occupy a belt about 10 miles wide in the eastern part of the county and the gravel, sand, silt, and clay of the Coastal Plain occupy a belt about 5 miles wide east of the area of pre-Cambrian and Paleozoic rocks. (See Pl. 2 and Table 7.)

The Triassic rocks dip rather gently in the eastern part of their area, but the dip increases westward to the Catoctin border fault, at the eastern foot of the Bull Run Mountains. Normal faults break the continuity of the sedimentary beds, but they are obscure, owing to the lack of horizon-marking strata. The trap forms ridges where it crops out.

The belt of pre-Cambrian and Paleozoic folded and metamorphosed rocks is underlain chiefly by Wissahickon schist on the west side; on the east side, near the Fall Line, it is intruded by the granite. The Peters Creek quartzite and Quantico slate are exposed at the edge of the Coastal Plain. There are exposures of Lower Cambrian rocks west of the area of Triassic rocks along the Bull Run Mountains.

The sediments of the Coastal Plain are almost undisturbed except for a slight steepening of their seaward dip due to the repeated uplifts of the continent since their deposition. At present, in most of the area the rock floor and overlying sediments dip seaward about 70 to 100 feet to the mile, but each younger formation dips less steeply. No folds or faults have been detected in this area.

GROUND-WATER CONDITIONS

Area of Triassic rocks.—Dug wells have been largely replaced by drilled wells in the area of Triassic rocks, a large number having been drilled during the past 30 years. Most of them, as in the rest of northern Virginia, were put down for household and stock supplies; for this reason wells ranging from 2½ to 6 inches in diameter abound, and most of them are of shallow or moderate depth, obtaining at such depths small but adequate supplies of water. This is especially true in the western part of the Triassic area. The yield of some wells is very small —only a fraction of a gallon a minute reported at the time of drilling. The fact that the rather hard sandstone is more extensively present in the western part may be of some significance in this connection, for even though the sandstone may not be a poorer source of water than the shale, it is harder and more expensive to drill, and where wells seemed unpromising drilling may have been stopped at an earlier stage than where the rock is softer and easier to drill. In the eastern part of the Triassic basin some wells of large diameter have been drilled to greater depths for the purpose of developing large supplies, and uncommonly large yields of water have been obtained. Such are the four municipal wells at Manassas (Nos. 1115, 1116, 1117, and 1119), which are 297, 406, 505, and 531 feet deep, and are reported to have a total yield of 250 gallons a minute.

Most of the shallow household wells in the area of Triassic rocks, that deliver 10 gallons a minute or more, were put down into the trap in localities where the zone of decomposed rock is rather thick. In this area, as in areas of Triassic rocks in other counties, wells drilled in the trap rock on the hilltops are more successful than those in the stream valley, where the water-bearing decomposed rock has been eroded away.

The water level in the wells in the western part of the Triassic area lies from 15 to 40 feet below the surface, and in the eastern part it is usually from 50 to 70 or even as much as 100 feet below the surface. The higher level to the west is probably the result of a slight artesian head where the dip of the rocks is steeper. A few of the wells have gone dry during droughty seasons, the percentage being comparable to that of wells in the Triassic area of Loudoun County. As in other parts of the Triassic basin, the ground water is likely to contain objectionable quantities of iron in solution and to be rather hard. For municipal and industrial supplies treatment is likely to be necessary.

Springs are rather abundant along the eastern foot of the Bull Run Mountains. Many of them rise in the greenstone west of the Catoctin border fault and are piped to homes east of the fault; but many of

them rise in the Triassic beds, for the relief is rather great near the western edge of the Triassic basin. The yield is almost invariably small, being less than 10 gallons a minute in all springs investigated. Many of the springs are perennial, and their discharge does not vary noticeably from season to season or from year to year. Elsewhere in the Triassic area springs are not numerous, and few of them are used except for watering stock.

Area of crystalline rocks.—There are only a few drilled wells in the area of crystalline rocks, and most of them are east of Manassas and north of Broad Run. They are shallow, mostly less than 100 feet deep, they deliver only small quantities of water, 10 gallons a minute or less, and many are reported to be rather unsatisfactory. The water lies about 20 to 50 feet below the surface of the ground, somewhat lower than the surface of the sound rock, and the length of casing used is usually less than the distance down to water.

In parts of the area there are almost no drilled wells, the ground water being recovered by dug wells and wells bored by hand. The bored wells are usually cased with 8-inch terra cotta pipe. Neither the dug wells nor the bored wells go into the solid rock, as the water level is in the decomposed material above the rock. The wells range in depth from 20 to 50 feet. The water level in most localities averages from 25 to 30 feet below the surface. Very few pumping tests are made of dug or hand-bored wells, and it is believed that the yields are comparatively small, partly because the possible draw-down is limited, although the decomposed rock may be rather permeable. Although in seasons of average rainfall dug and hand-bored wells are reasonably satisfactory in this area a high percentage of these wells were dry at the time they were examined in the summer of 1931, and many were seriously threatened with pollution. These wells should either be improved or abandoned for drilled wells with tight casings.

Springs are fairly numerous, especially in the vicinity of Occoquan Creek. They are mostly seeps, emerging on the sides of hills from the soil that covers the granite, schist, and other rocks of the area. Where there is no soil, as along the walls of the gorges near the Fall Zone, the springs issue from joints, planes of schistosity, and other openings in the rocks. The volume of all the springs investigated is very small, less than 10 gallons a minute and in some only a fraction of a gallon a minute. The springs are somewhat more widely used proportionately than in most other areas where they are similar in number and magnitude. In general they are reported to be reliable during droughty seasons.

Coastal Plain area.—Drilled wells are not numerous on the Coastal Plain in Prince William County, in spite of the fact that, in general, the sediments underlying the Coastal Plain are the best water-bearers in northern Virginia. Not all the wells drilled into these beds are strong, because near the western edge the sediments are thin and also because many of the wells were not constructed in such as manner as to recover the greatest possible supply. Farther east the thickness and the number of the water-bearing beds increase. At Quantico there are six deep wells, which deliver very large supplies of water. Because they represent the magnitude of the supplies that can be obtained from properly constructed wells in the western part of the Coastal Plain the logs of these wells are given on pages 142-147.

The record of the wells at Quantico indicates the irregular surface of the rock floor below the Coastal Plain sediments, for there is a drop of at least 200 feet within a linear distance of less than 500 yards, indicating that there is a steep-sided rock-cut channel beneath the present course of Potomac River in some places. A similar depression in the rock floor was noted by Hall[9] after an examination of records of a well near the Washington airport.

Dug and hand-bored wells are more numerous than drilled wells in the Coastal Plain area. Their average depth is between 25 and 35 feet, and at those depths the quantity of water delivered seems to be sufficient for household needs—in fact, in some wells the yield is moderately large. These wells are reported to be reliable in droughts.

The incised condition of parts of the Coastal Plain in Prince William County makes springs rather numerous, and they are used extensively as sources of household and stock supplies, especially along the western edge. The springs are small in yield but reliable.

MUNICIPAL SUPPLIES

Manassas.—The county seat of Prince William County, Manassas, has derived its public supply from ground water since 1905, when a well was put down by the town. This well, according to information furnished to Clapp,[10] went down to a depth of about 531 feet in Triassic sandstone and ended in what is considered to be the underlying crystalline rocks of pre-Cambrian age. The well is 8 inches in diameter to a depth of 200 feet, and 6 inches below 200 feet. The water stood 58 feet below the surface at the time of its completion. The well is

[9] Hall, G. M., Well at Hoover flying field, Alexander Island: U. S. Geol. Survey, unpublished report, 1926.

[10] Clapp, F. G., Underground waters near Manassas, Va.: U. S. Geol. Survey Water-Supply Paper 258, pp. 94-97, 1911.

said to have been pumped at a rate of 120 gallons a minute by the driller, R. L. Thomas, of Charlottesville, for a period of 6 to 10 hours. In 1921 D. G. Thompson, of the U. S. Geological Survey, made an investigation for the purpose of determining the most feasible method of increasing the town's water supply. At that time this well constituted the only source of water. Near the pump house the discharge from the well passed by gravity into a concrete reservoir with a capacity of about 75,000 gallons, from which the water was pumped into the distribution system. Any excess was pumped into a standpipe for storage, but at the time of the investigation the ordinary demands of the users were taxing the supply to the utmost. It was found at this time also that the well was delivering a quantity of water estimated at about 20 to 30 gallons a minute, much less than was reported in 1905.

In 1921 wells 2 and 3 were drilled near the power house, some distance from well 1, by Henry Seeley, of Manassas, and in 1929 well 4 was put down. The yield of well 2 was reported to be 50 gallons a minute at the time of drilling, but in 1921 it was pumped at a rate of 24 gallons a minute, and a year later an air-lift test showed a yield of 35 gallons a minute. This yield was sustained after its diameter was increased from 6 inches to 8 inches in 1927. Well 3 is nearby. It was reported to yield 27 gallons a minute when drilling was completed, but in 1924 an air-lift test showed a yield of 50 gallons a minute. Wells 2 and 3 are so near together that their cones of depression interfere when both are pumped. Well 4 was put down in 1929, so that well 2 could be made to serve as an auxiliary supply. Its yield was reported by the driller to be 55 gallons a minute. Wells 1 and 2 are not ordinarily pumped. The water from wells 3 and 4 is pumped to the reservoir, the same mode of distribution being used as was in operation originally. The water is chlorinated "periodically." There were 315 meters in the town in 1931, and the consumption for the quarter ending June 30, 1931, was 3,435,000 gallons.

Quantico.—At Quantico the public supply was formerly derived entirely from the surface flow of Chopawamsic Creek. However, during 1930 and 1931 wells were put down for the purpose of adding to the inadequate surface supply. Four wells were finished after a number of test holes had indicated favorable water-bearing zones. These four wells produced a total of 790 gallons a minute when tested just after their completion. (See logs, pp. 142-147.) The completed wells were cased to the bottom and equipped with silicon-bronze shutter screens at the level of the chief water-bearing sands. There is a prominent zone of water-bearing sand near the rock floor in the wells that reached the

granite. The intake of the old surface system is 5 miles southwest of the town, with a filter plant nearby, which has a capacity of 2,000,000 gallons. The well supply uses the same distributing system as the surface supply.

WELL

TABLE 34.—*Wells in Prince*

Well number	Location	Owner	Driller	Type of well
1000	4 miles south of Aldie	Mr. Vermillion	R. L. Thomas	Drilled
1001	5 miles southeast by south of Aldie	Robert George	F. N. Hagmann, Jr.	Drilled
1002	½ mile west of Hickory Grove, which is 6¼ miles north of Haymarket.	Mr. Latham	Henry Seeley	Drilled
1003	Hickory Grove	Hickory Grove Cheese Factory.	Henry Seeley	Drilled
1004	3 miles northwest of Woolsey, which is 4¼ miles north of Haymarket.	Teneer Burkley	Henry Seeley	Drilled
1005	2 miles northwest of Woolsey	Col. Bertley	Henry Seeley	Drilled
1006	1 mile northwest of Woolsey	(?)	Henry Seeley	Drilled
1007	2½ miles northeast of Woolsey	Mr. Hunt	Henry Seeley	Drilled
1008	3 miles north of Woolsey	Mr. Beaumont	Henry Seeley	Drilled
1009	2½ miles northeast by east of Woolsey.	William Beaumont	Henry Seeley	Drilled
1010	3 miles east of Woolsey	Morris Poland	Henry Seeley	Drilled
1011	3 miles southeast by east of Woolsey	William Thomas	Henry Seeley	Drilled
1012	½ mile northwest of Catharpin, which is 4½ miles northeast of Haymarket.	Jet Pattie	Henry Seeley	Drilled
1013	½ mile west of Catharpin	Mr. McDonald	Henry Seeley	Drilled
1014	Catharpin	F. H. Sanders	Henry Seeley	Drilled
1015	Catharpin	E. N. Pattie	Henry Seeley	Drilled
1016	Catharpin	Mr. Pattie	Henry Seeley	Drilled
1017	1½ miles southeast of Woolsey	Holmes Robertson	Henry Seeley	Drilled
1018	½ mile southeast of Woolsey	Faxey Lynn	Henry Seeley	Drilled
1019	Woolsey	Church	Henry Seeley	Drilled
1020	Antioch, which is 4 miles northwest of Haymarket.	Antioch School	Henry Seeley	Drilled
1021	Woolsey	Howard Downes	Henry Seeley	Drilled
1022	4 miles north of Haymarket	W. C. Kelley	Henry Seeley	Drilled
1023	3 miles north of Thorofare, which is 2¼ miles northwest by west of Haymarket.	R. B. Gossom	Henry Seeley	Drilled
1024	1¼ miles east of Antioch	Rand Smith	Henry Seeley	Drilled
1025	Woolsey	Mr. Forsythe	Henry Seeley	Drilled
1026	1¼ miles west of Thorofare	Mr. Nawls	Henry Seeley	Drilled
1027	1 mile southeast by east of Thorofare	Mrs. McDonough	Henry Seeley	Drilled
1028	1 mile southeast by east of Thorofare	Al Rust	Henry Seeley	Drilled
1029	½ mile west of Haymarket	H. S. Herrell	Henry Seeley	Drilled
1030	Haymarket	Will Garrett	Henry Seeley	Drilled
1031	Haymarket	Mr. Hulfish	Henry Seeley	Drilled
1032	Haymarket	Melton's Store	Henry Seeley	Drilled
1033	½ mile east of Haymarket	Mr. McGill	Henry Seeley	Drilled
1034	¾ mile northwest of Gainesville, which is 1½ miles southeast of Haymarket.	Ed Carter	Henry Seeley	Drilled
1035	Gainesville	Mrs. Marstellar	Henry Seeley	Drilled
1036	Gainesville	Bob Florence	Henry Seeley	Drilled
1037	Gainesville	Tom Meredeth	Henry Seeley	Drilled

RECORDS

William County, Virginia

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
93	Sandstone and shale.	Newark		6+		1000
91½	Sandstone and shale.	Newark				1001
30	Trap (diabase)	Late and/or post-Newark.		1		1002
40	Soft sandstone	Newark		5		
95	Hard brown sandstone, trap (diabase).	Newark; late and/or post-Newark.		⅛		
115	Sandstone	Newark		3		1003
60	Yellowish shale	Newark		1±		1004
60	Sandstone	Newark		1½		1005
70	Shale	Newark		5		1006
119	Trap (diabase)	Late and/or post-Newark.		⅙		1007
65	Light sandstone or grit.	Newark		⅙		1008
45	Light sandstone or grit.	Newark		⅙		1009
135	Sandstone	Newark				1010
50	Soft red shale	Newark		5		1011
135	Hard brown shale	Newark		3		1012
125	Brown shale	Newark		3		1013
130	Hard brown sandstone and shale.	Newark		1¼		1014
60	Brown shale	Newark		2		1015
65	Brown shale, sandstone at bottom.	Newark		1		1016
85	Gray sandstone	Newark		1½		1017
90	Hard brown sandstone.	Newark		2		1018
50	Yellowish shale	Newark		2		1019
60	Shale	Loudoun		1		1020
65	Yellowish shale	Newark	15	1	Analysis on p. 148.	1021
190	Red shale	Newark	30	6		1022
66	"Conglomerate"	Newark		1	Dry in 1931.	1023
55	Trap soil and boulders.	Late and/or post-Newark.		4		1024
70	Brown sandstone	Newark		½		1025
100±	Trap (diabase)?	Late and/or post-Newark.		1		1026
70	Trap (diabase)	Late and/or post-Newark.		3		1027
135	Red shale with stringers of trap.	Newark		5		1028
80	Trap (diabase) soil	Late and/or post-Newark.		5	Analysis on p. 148.	1029
123	Red shale	Newark		2		1030
125	Red shale	Newark		1½		1031
150	Red sandstone and shale.	Newark	25±?	10		1032
160	Red shale and sandstone.	Newark		10		1033
120	Red shale	Newark		3		1034
25	Trap (diabase), soil	Late and/or post-Newark.		3½		1035
125	Red sandstone and shale.	Newark	23±	10		1036
160	Red shale	Newark	25±	10		1037

WELL RECORDS

TABLE 34.—*Wells in Prince William*

Well number	Location	Owner	Driller	Type of well
1038	3 miles southwest of Sudley Springs, which is 5 miles northeast by east of Haymarket.	Mr. Brown (formerly)	Henry Seeley	Drilled
1039	2½ miles southwest of Sudley Springs.	Mr. Swartz	Henry Seeley	Drilled
1040	2 miles south of Sudley Springs	Mr. Redman	Henry Seeley	Drilled
1041	2 miles south of Sudley Springs	Mr. Dogan	Henry Seeley	Drilled
1042	2½ miles south of Sudley Springs	(?)	Henry Seeley	Drilled
1043	2 miles south of Sudley Springs	G. Peterson	Henry Seeley	Drilled
1044	1 mile southwest of Sudley Springs	Mrs. Harover	Henry Seeley	Drilled
1045	Sudley Springs	Mrs. Wilkins	Henry Seeley	Drilled
1046	Sudley Springs	Laws Spencer	Henry Seeley	Drilled
1047	Sudley Springs	Ray Cross	Henry Seeley	Drilled
1048	1 mile southwest of Sudley Springs	Hoot Cross	Henry Seeley	Drilled
1049	1½ miles south by southwest of Sudley Springs.	Mr. Caldwell	Henry Seeley	Drilled
1050	2 miles southeast by south of Sudley Springs.	Mr. Burns	Henry Seeley	Drilled
1051	2 miles southeast by south of Sudley Springs.	Mr. Ayres	Henry Seeley	Drilled
1052	5 miles northeast by north of Manassas on Lee-Jackson Highway.	G. H. Ayres	Henry Seeley	Drilled
1053	3½ miles south of Sudley Springs	U. S. Army	Henry Seeley	Drilled
1054	3½ miles south of Sudley Springs	U. S. Army	Henry Seeley	Drilled
1055	4¼ miles south of Sudley Springs	U. S. Army	Henry Seeley	Drilled
1056	5 miles southeast by south of Sudley Springs.	Charles Laynn	Henry Seeley	Drilled
1057	5 miles southeast by south of Sudley Springs.	Charles Lewis	Henry Seeley	Drilled
1058	2½ miles northwest of Manassas	Colored Horse Show grounds	Mr. Puckett	Drilled
1059	2½ miles west of Manassas	Joe Lewis	Lee Johnson	Drilled
1060	1¾ miles southeast of Gainesville	George Brean	Henry Seeley	Drilled
1061	1½ miles southeast of Gainesville	Buck Ellis	Henry Seeley	Drilled
1062	1 mile southeast of Gainesville	Mr. Davis	Henry Seeley	Drilled
1063	½ mile southeast of Gainesville	Buck Ellis	Henry Seeley	Drilled
1064	Gainesville	J. Clark	Henry Seeley	Drilled
1065	Buckland, which is 3 miles southwest of Haymarket.	Harry Lee	Henry Seeley	Drilled
1066	Buckland	Joe Calvert	Henry Seeley	Drilled
1067	Buckland	Doug Mayhugh	Henry Seeley	Drilled
1068	Buckland	John Sweeney	Henry Seeley	Drilled
1069	Greenwich, which is 5 miles northwest of Nokesville.	Mr. Cooke	Charles Daniels	Drilled
1070	Greenwich	R. L. Johnson	Charles Daniels	Drilled
1071	3 miles east of Greenwich	Mr. Cook	Henry Seeley	Drilled
1072	4 miles east of Greenwich	Linton Hall	Henry Seeley	Drilled
1073	3½ miles east by southeast of Greenwich.	(?)	Henry Seeley	Drilled
1074	2 miles northwest of Bristoe, which is 3 miles northeast of Nokesville.	Mr. Rollins	Henry Seeley	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
98	Brown and red shale.	Newark		6		1038
35	Brown shale	Newark		1		1039
130	Brown shale	Newark		3		1040
90	Brown shale	Newark		1+		1041
95	Black and blue shale.	Newark		5		1042
50	Blue shale	Newark		1		1043
45	Trap (diabase)	Late and/or post-Newark.		¼		1044
40	Brown rock	Newark		2		1045
70	Brown rock	Newark		1½	Analysis on p. 148.	1046
70	Brown shale	Newark		¼		1047
40	Red shale	Newark		1½		1048
90	Brown sandstone	Newark		1½		1049
100±	Red shale	Newark		3		1050
100±	Red shale	Newark		3		1051
155	Sandstone	Newark		7	Gasoline deep-well pump. 14 feet of 6-inch casing.	1052
185	Grayish and brown shale and brown sandstone.	Newark		7½		1053
165	Brown shale	Newark		10		1054
150	Red shale	Newark		10		1055
58	Trap (diabase) soil	Late and/or post-Newark.		20		1056
30	Trap (diabase) soil	Late and/or post-Newark.		33		1057
178	Red sandstone and shale.	Newark	40±	7½		1058
210	Red sandstone and shale.	Newark		15		1059
40	Trap (diabase)	Late and/or post-Newark.		¼		1060
90	Trap (diabase)	Late and/or post-Newark.		6		1061
120	Hard brown sandstone.	Newark		¾		1062
96	Red shale	Newark		5		1063
70	Red shale and sandstone.	Newark		1+		1064
100	Brown shale and sandstone.	Newark		¼		1065
60	Trap (diabase)	Late and/or post-Newark.		½		1066
25	Trap soil	Late and/or post-Newark.		1		1067
60	Trap and soft brown sandstone.	Late and/or post-Newark; Newark.		1½		1068
14	Trap (diabase)	Late and/or post-Newark.		0	10 feet of casing.	1069
47	Trap (diabase)	Late and/or post-Newark.		1½		
45	Trap (diabase)	Late and/or post-Newark.		(?)		
54	Trap (diabase)	Late and/or post-Newark.		(?)		1070
90	Trap (diabase)	Late and/or post-Newark.		1½		1071
115	Red shale and sandstone.	Newark		3		1072
70	Trap soil	Late and/or post-Newark.		1		1073
90	Red shale, trap (diabase).	Newark; late and/or post-Newark.		1½		1074

WELL RECORDS

TABLE 34.—*Wells in Prince William*

Well number	Location	Owner	Driller	Type of well
1075	1½ miles northwest of Bristoe	(?)	Henry Seeley	50 feet dug, rest drilled.
1076	½ mile northwest of Bristoe	A. Wright	Charles Daniels	Drilled
1077	Bristoe	Sam Fogle	Charles Daniels	Drilled
1078	Bristoe	Mr. Sherrett	Henry Seeley	Drilled
1079	Nokesville	T. B. Flickenger	Charles Daniels	Drilled
1080	1 mile west of Nokesville	John King	Charles Daniels	Drilled
1081	3 miles northwest of Nokesville	L. A. Mooney	Charles Daniels	Drilled
1082	2 miles west of Nokesville	E. K. Bodine & Son	Charles Daniels	Drilled
1083	¾ mile west of Nokesville	Tom Green	Charles Daniels	Drilled
1084	Nokesville	J. A. Hooker	Charles Daniels	Drilled
1085	Nokesville	W. F. Hale	Charles Daniels	Drilled
1086	Nokesville	Nowell Free	Charles Daniels	Drilled
1087	Nokesville	Nokesville School	Charles Daniels	Drilled
1088	Nokesville	M. A. Seese	Charles Daniels	Drilled
1089	Nokesville	Charles Rhodes	Charles Daniels	Drilled
1090	Nokesville	R. S. Bretton	Charles Daniels	Drilled
1091	1½ miles south of Nokesville	H. W. Herring	Charles Daniels	Drilled
1092	2 miles south of Nokesville	Mr. Hagen	Charles Daniels	Drilled
1093	3 miles south of Nokesville	C. S. Smith	Charles Daniels	Drilled
1094	5½ miles southeast by south of Nokesville.	C. L. Reading	Charles Daniels	Drilled
1095	5½ miles south of Brentsville, which is 4 miles east of Nokesville.	Dewitt Herndon	Charles Daniels	Drilled
1096	4 miles south of Brentsville	T. M. Berryman	Charles Daniels	Drilled
1097	Aden, 3 miles southwest of Brentsville.	Mr. Fielding	Charles Daniels	Drilled
1098	Aden	Mrs. Barbara Smith	Charles Daniels	Drilled
1099	Aden	S. G. Whetsel	Charles Daniels	Drilled
1100	Aden	J. L. Brown	Charles Daniels	Drilled
1101	Aden	A. Eichelberger	Charles Daniels	Drilled
1102	Brentsville	Robert Molair	Charles Daniels	Drilled
1103	Brentsville	Dr. Wine	Charles Daniels	Drilled
1104	1⅛ miles west of Manassas	Mr. McMillan	Mr. Puckett	Drilled
1105	1½ miles northwest of Manassas	James Payne	Charles Daniels	Drilled
1106	1 mile west of Manassas	Lee Johnson	Charles Daniels	Drilled
1107	Manassas	Milt Hottel	Henry Seeley	Drilled
1108	Manassas	Cemetery	Henry Seeley	Drilled
1109	Manassas	H. R. Bryant	Mr. Puckett	Drilled
1110	Manassas	Prof. Taylor	Lee Johnson	Drilled
1111	Manassas	Bud Johnson, laundry	Mr. Puckett	Drilled
1112	Manassas	R. Carter	Mr. Puckett	Drilled
1113	½ mile west of Manassas	John Roy	Charles Daniels	Drilled
1114	Manassas	Easton College	Lee Johnson	Drilled
1115	Manassas	Town of Manassas	Henry Seeley	Drilled
1116	Manassas	Town of Manassas	Henry Seeley	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
129	Trap (diabase)	Late and/or post-Newark.		0		1075
24	Trap (diabase)	Late and/or post-Newark.		1	9 feet of casing.	1076
33	Hard shale	Newark		2	14 feet of casing.	1077
125	Soft red sandstone	Newark	15	10		1078
72	Hard brown shale	Newark		2±	6 feet of casing.	1079
80	Shale	Newark		2±?	15 feet of casing.	1080
135	Sandstone and shale	Newark		2	33 feet of casing.	1081
70	Shale	Newark		1½	6 feet of casing.	1082
48	Decomposed trap	Late and/or post-Newark.		2	19 feet of casing.	1083
156	Hard shale	Newark		5	6½ feet of casing.	1084
120	Red shale	Newark	100	10		1085
81	Shale	Newark		3±?	11 feet of casing.	1086
80	Shale	Newark		5	6? feet of casing. Hard sandstone and shale 60 to 80 feet.	1087
75	Shale	Newark		5?	9 feet of casing.	1088
100	Shale	Newark		3	8 feet of casing.	1089
92	Red and blue shale	Newark		7	10 feet of casing.	1090
132	Red shale	Newark	40	2		1091
60	Red shale	Newark	20	9		
55	Hard shale	Newark		4±	9 feet of casing.	1092
98	Shale	Newark		3	6 feet of casing.	1093
70	Shale	Newark			5 feet of casing.	1094
85	Shale	Newark		2½?	16 feet of casing.	1095
102	Shale	Newark		4	25 feet of casing.	1096
53	Shale	Newark		(?)	8 feet of casing.	1097
84	Shale	Newark		4	6 feet of casing.	1098
102	Shale	Newark		2	10 feet of casing.	1099
60	Shale	Newark		5	6? feet of casing.	1100
67	Shale	Newark		3	6? feet of casing.	1101
121	Sandstone and some shale.	Newark		2±	15 feet of casing.	1102
200	Shale	Newark		10	10 feet of casing.	1103
129	Red sandstone and shale.	Newark	60	4		1104
126	Red shale	Newark	45	4½	13 feet of casing.	1105
100	Red shale	Newark	50	5		1106
115	Brown sandstone	Newark		3		1107
110	Hard brown sandstone.	Newark		3		1108
147	Shale and sandstone.	Newark	60	5½		1109
195	Red sandstone and white quartz gravel.	Newark	40	25		1110
96	Shale and sandstone.	Newark		7½	6 feet of casing.	1111
67	Red sandstone and shale.	Newark	40	1		1112
73	Red shale	Newark	62	1½	7 feet of casing.	1113
135	Red sandstone	Newark		7		1114
297	Red shale and sandstone.	Newark	69	55	Well 4. 57 feet of 6-inch casing. Analysis on p. 148.	1115
505	Brown sandstone	Newark		27	Well 3. Yield when drilled in 1921 reported to be 27 gallons per minute. In 1924 air-lift test showed yield of 50 gallons a minute. Analysis on p. 148.	1116

WELL RECORDS

TABLE 34.—*Wells in Prince William*

Well number	Location	Owner	Driller	Type of well
1117	Manassas	Town of Manssas	R. L. Thomas	Drilled
1118	Manassas	Bull Run Power Co	James Franklin	Drilled
1119	Manassas	Town of Manassas	Henry Seeley	Drilled
1120	Manassas	Manassas Ice & Fuel Co	Lee Johnson	Drilled
1121	Manassas	Manassas Milling Co	Lee Johnson	Drilled
1122	Manassas	Henry Sphear	Mr. Puckett	Drilled
1123	Manassas	Rex Rode	Lee Johnson	Drilled
1124	Manassas	Bob Kaufman	Lee Johnson	Drilled
1125	Manassas	Grover Evans	Lee Johnson	Drilled
1126	Manassas	Cornwell Ice Plant (now defunct).	Lee Johnson	Drilled
1127	1¾ miles northeast of Manassas	Jack Howard	Mr. Puckett	Drilled
1128	Manassas	Gene Williams	Henry Seeley	Drilled
1129	1½ miles southeast of Manassas	W. J. Young	Charles Daniels	Drilled
1130	Buckhall School (2 miles southeast of Manassas).	Buckhall School	Lee Johnson	Drilled
1131	1½ miles south of Manassas	Josh Johnson	Lee Johnson	Drilled
1132	Bradley School (2½ miles south of Manassas.)	Mr. Gevina	Henry Seeley	Drilled
1133	2½ miles south of Manassas	Mr. Hixon	Lee Johnson	Drilled
1134	2½ miles south of Manassas	Mrs. Daily	Lee Johnson	Drilled
1135	3½ miles south of Manassas	P. D. Gallahan	Charles Daniels	Drilled
1136	4½ miles south of Manassas	Mr. Jones		Hand drilled.
1137	6½ miles south of Manassas	W. B. Bowers	Charles Daniels	Drilled
1138	7 miles south of Manassas	Granville Keys	Charles Daniels	Drilled
1139	6½ miles south of Manassas	S. C. Cooper	Charles Daniels	Drilled
1140	6¼ miles south of Manassas	Charles B. Ellicott	Charles Daniels	Drilled
1141	6 miles south of Manassas near Woodbine School.	Miss Herell	Henry Seeley	Drilled
1142	1½ miles northeast by north of Independent Hill, which is 4¾ miles west of Minnieville.	Dence Cole		Dug
1143	2½ miles west of Hoadly, which is 2¾ miles northwest by north of Minnieville.	John S. Beavers		Dug
1144	2 miles west of Hoadly	J. Garner		Dug
1145	2¾ miles southwest by west of Hoadly.	Andy Swak		Dug
1146	1 mile northwest of Minnieville	C. A. Barbee		Dug
1147	1½ miles east of Independent Hill	T. A. Cooper		Dug
1148	Independent Hill	Sam Lowe	Charles Daniels	Drilled
1149	Independent Hill	H. F. Keip		Dug
1150	4½ miles northwest by west of Dumfries.	L. G. Tolson		Hand drilled.

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
531	Sandstone and shale; ends in crystalline rock floor.	Newark	58	120	Well 1. Drilled in 1905. Not usually pumped now. 8 inches in diameter to 200 feet, rest 6 inches. 180 feet of casing. Yield reported by driller in 1905 was 120 gallons a minute. Yield in 1921 estimated at 20 to 30 gallons a minute. Test in 1922 gave 42 gallons a minute.	1117
200	Shale and sandstone.	Newark	50	20	40 feet of 6-inch casing.	1118
406	Sandstone; trap (diabase) from 234 to 246 feet.	Newark	85?	50	Well 2. Yield when drilled in 1921 reported to be 50 gallons a minute; later pumped at rate of 24 gallons a minute. In 1922 air-lift test showed yield of 35 gallons a minute, which continued after diameter was increased from 6 to 8 inches in 1927.	1119
140	Red shale	Newark		10		1120
210	Red shale	Newark		25		1121
63	Red sandstone and shale.	Newark		2		1122
156	Red sandstone and shale.	Newark	58±	12±		1123
115	Red shale	Newark		4½		1124
70	Shale	Newark		2		1125
135	Red sandstone	Newark	15	12		1126
93	Red sandstone and shale.	Newark	37	2		1127
40	Schist	Wissahickon	30	1		1128
100	Granite	Algonkian (?)		3	17 feet of casing.	1129
70	Schist and granite	Wissahickon		1½		1130
70	Red sandstone	Newark		3½		1131
82	Sandstone	Newark	20	5	82 feet of 6-inch casing.	1132
40	Schist	Wissahickon	18	10		1133
86	Schist	Wissahickon		5		1134
79	Granite soil	Algonkian (?)	25		60 feet of casing.	1135
32	Granite soil	Algonkian (?)	20±		8-inch tile casing.	1136
117	Shale	Newark			15 feet of casing.	1137
104	Shale	Newark		3	15 feet of casing.	1138
117	Hard shale	Newark			8 feet of casing.	1139
101	Shale	Newark		2	17 feet of casing.	1140
65	Schist	Wissahickon	15	10		1141
40	Granite soil	Algonkian (?)	30±			1142
49	Schist soil	Wissahickon		Dry		1143
29	Schist soil	Wissahickon	27			1144
40	Schist soil	Wissahickon	30			1145
35	Chocolate-colored clay.	Potomac	30			1146
34	Granite	Algonkian (?)	31½			1147
98	Granite soil	Algonkian (?)	30	2		1148
30	Schist soil	Wissahickon	24			1149
35	Schist soil	Wissahickon	29.3		8-inch terra cotta casing.	1150

WELL RECORDS

TABLE 34.—*Wells in Prince William*

Well number	Location	Owner	Driller	Type of well
1151	1½ miles south of Independent Hill	L. F. Merrill		Dug
1152	2 miles northwest by west of Kopp, which is 6½ miles northwest by west of Dumfries.	Dick Keys		Hand drilled.
1153	2¾ miles southeast of Independent Hill.	L. S. Carter		Dug
1154	3 miles southeast of Independent Hill.	Willie Jones		Dug
1155	3 miles southeast of Independent Hill.	George A. Jones		Dug
1156	3½ miles south of Independent Hill	E. C. Dewitt		Dug
1157	Kopp	G. C. Wright		Dug
1158	1¼ miles southeast by east of Kopp.	J. A. Poland		Dug
1159	1 mile west of Joplin, which is 3 miles west of Dumfries.	Fred Tuell		Hand drilled.
1160	Joplin	W. M. Crow		Dug
1161	1 mile southeast by south of Joplin	G. Abel		Hand drilled.
1162	Triangle, which is 3 miles northwest of Quantico.	Milly's Restaurant		Hand drilled.
1163	Dumfries	Ratcliffe Store	Charles Daniels	Drilled
1164	Dumfries	Robert Watrons	Charles Daniels	Drilled
1165	Dumfries	Dumfries School	Henry Seeley	Drilled
1166	1 mile northwest by west of Dumfries.	Pyrite Mine	Charles Daniels	Drilled
1167	2¼ miles west of Dumfries	J. H. Davis		Hand drilled.
1168	2½ miles south of Posey Store	Joe Florence		Dug
1169	1½ miles north of Dumfries	J. Cooper		Hand drilled.
1170	1¾ miles southeast by south of Posey Store.	Bob Thomas		Hand drilled.
1171	2½ miles southwest of Minnieville	D. H. Carter		Dug
1172	2½ miles southeast of Minnieville	(?)		Hand drilled.
1173	1¼ miles south of Minnieville	Raymond Curtis		Hand drilled.
1174	1 mile southwest of Minnieville	Luther Windsor		Hand drilled.
1175	1 mile west of Minnieville	W. W. Baltzell		Dug
1176	Minnieville	F. M. Pearson		Dug
1177	5½ miles southwest by south of Occoquan.	A. P. Cheshire		Dug
1178	1¾ miles east by southeast of Hoadly.	E. S. Reid		Dug
1179	1 mile east of Hoadly	W. A. Davis		Dug
1180	Hoadly	Annie O. Garner		Dug
1181	1 mile north of Hoadly	Henry Purcell		Dug
1182	2½ miles north of Hoadly	J. F. Simpson		Dug
1183	2 miles east of Hoadly	Mrs. Ruth Hedges		Dug
1184	Occoquan	Mr. Ruffner	F. N. Hagmann, Jr.	53 feet dug, rest drilled.
1185	1 mile southwest of Occoquan	Marion Washington		Dug
1186	2 miles southwest of Occoquan	Mr. Davis	Charles Daniels	Drilled
1187	Woodbridge, which is 2 miles southeast of Occoquan.	Rust Engineering Co.	F. N. Hagmann, Jr.	Drilled
1188	Woodbridge	Mrs. M. I. Thompson	Charles Daniels	Drilled
1189	2½ miles south of Occoquon	E. H. Sheppard		Dug
1190	4 miles southwest of Occoquan	G. C. Russel		Dug
1191	5 miles south of Occoquan	Mrs. Mary Jane Lynn		Dug
1192	2 miles south of Woodbridge	Mr. Calvert (?)	F. N. Hagmann, Jr.	Drilled
1193	2½ miles south of Woodbridge	Mr. Hoover	F. N. Hagmann, Jr.	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
20	Schist soil	Wissahickon	16±			1151
40	Schist soil	Wissahickon		Dry		1152
21½	Schist soil	Wissahickon	19			1153
45	Schist soil	Wissahickon	39			1154
42½	Schist soil	Wissahickon	41½			1155
48	Schist soil	Wissahickon	39			1156
50	Granite soil	Algonkian (?)	40±?			1157
38½	Granite soil	Algonkian (?)	37½			1158
37	Granite soil	Algonkian (?)	31			1159
25	Schist soil	Wissahickon	20.5			1160
21	Schist soil	Wissahickon	14±			1161
21½	Sand	Potomac	4.13		8-inch terra cotta casing.	1162
40	Slate	Quantico		2½		1163
40±	Slate	Quantico	20±	2½±		1164
127	Slate	Quantico	10	¼	30 feet of 5⅝-inch casing. Deep-well hand pump. Analysis on p. 148.	1165
240	Schist	Wissahickon				1166
39	Schist soil	Wissahickon	25			1167
32	Schist soil	Wissahickon	24			1168
42	Terrace gravel	Recent, Pleistocene, and Pliocene (?).	34.5			1169
40	Schist soil	Wissahikon	36.4			1170
33	Schist soil	Wissahickon	30.1			1171
37½	Blue sand	Potomac	28			1172
55	Schist soil	Wissahickon	41			1173
41	Schist soil	Wissahickon	34		38 feet of 8-inch terra cotta casing.	1174
43	Schist soil	Wissahickon	37			1175
35	Schist	Wissahickon	30±			1176
36	Schist	Wissahickon		Dry		1177
22½	"Sand overlying white gravel" (Granite soil).	Algonkian (?)	22.2			1178
40	Granite soil	Algonkian (?)	37±		Analysis on p. 148.	1179
22	Granite soil	Algonkian	19		Analysis on p. 148.	
25½	Granite	Algonkian (?)	17		8-inch tile casing.	1180
35	Granite soil	Algonkian (?)	31			1181
36	Granite soil, bottom in rock.	Algonkian (?)	32			1182
23	Granite soil	Algonkian (?)	18			1183
85	Slate	Quantico		5	45 feet of casing. Analysis on p. 148.	1184
58	Granite soil	Algonkian (?)	54			1185
60	Granite soil	Algonkian (?)	30±	2		1186
98	Unconsolidated sediments to 56 feet; slate.	Potomac; Quantico		1½		1187
140	Slate	Quantico		7	50 feet of 8-inch casing. Deep-well electric pump, with capacity of 7 gallons a minute. Analysis on p. 148.	1188
46½	Decomposed granite	Algonkian (?)	42			1189
26	Schist soil	Wissahickon		Dry		1190
36	Schist soil	Wissahickton		Dry		1191
185	Sand	Potomac	0		53 feet of casing.	1192
200	Sand	Potomac	Flows	45±		1193
200+	Sand	Potomac	Flows	45±		

WELL RECORDS

TABLE 34.—*Wells in Prince William*

Well number	Location	Owner	Driller	Type of well
1194	1 mile east of Minnieville	Charles Hopkins		Dug
1195	2½ miles north of Dumfries	Mr. Kincheloe		Hand drilled
1196	Quantico	U. S. Marine Corps	Layne Atlantic Co.	Drilled
1197	Quantico	U. S. Marine Corps	Layne Atlantic Co.	Drilled
1198	Quantico	U. S. Marine Corps	Layne Atlantic Co.	Drilled
1199	Quantico	U. S. Marine Corps	Layne Atlantic Co.	Drilled
1200	Quantico	U. S. Marine Corps	Layne Atlantic Co.	Drilled
1201	Quantico	U. S. Marine Corps	Layne Atlantic Co.	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
37	Sand	Potomac	29			1194
50	Sand	Potomac	33½			1195
358	Sand	Potomac	7	125	Well 1. 297 feet of casing; 38-inch pit to 100 feet; 18-inch casing to 208 feet; 8-inch casing to bottom. Log on p. 142. Analysis on p. 149.	1196
360	Sand	Potomac	27	125	Well 2. 355 feet of casing. 38-inch pit to 100 feet; 18-inch casing to 204 feet; 10-inch to 250 feet; and 8-inch to bottom. Log on p. 143. Analysis on p. 149.	1197
355	Sand	Potomac	10	220	Well 3. 355 feet of casing. 38-inch pit to 100 feet; 13-inch casing to 208½ feet; 10-inch to 230 feet; 8-inch to 355 feet. Log on p. 144. Analysis on p. 149.	1198
551	Sand	Potomac		320	Well 4. 38-inch pit with 3 inches of cement grouting on outside to 95 feet; 13-inch casing to 150 feet; 9-inch casing to 477 feet. Log on p. 145. Analysis on p. 149.	1199
391	Sand	Potomac	45	(?)	Test well 1. Log on p. 146.	1200
350	Sand	Potomac	24	125	Test well 2. Log on p. 147.	1201

TABLE 35.—*Logs of wells in Prince William County, Virginia*

Well 1196 (U. S. Marine Corps), Quantico.

[Altitude, 8 feet above sea level]

	Thickness (feet)	Depth (feet)
Potomac group:		
Top soil	3	3
Sand, bluish	17	20
Bluish sandy clay	20	40
Bluish sandy clay, lighter blue, more sand	20	60
Bluish sandy clay, 50 per cent more sand	2	62
Bluish sandy clay, streaked with red clay, very hard	5	67
Bluish sandy clay, very hard	8	75
Bluish-gray sand	5	80
Brownish sandy clay, hard	10	90
Reddish-brown clay, very hard	15	105
Brownish sandy clay, hard	40	145
Brownish sandy clay, mixed with blue clay	20	165
Brownish clay mixed with small quantity blue clay	37	202
Gray sand, water-bearing	33	235
Brownish sandy clay	5	240
Gray sand, water-bearing (sample of water for chemical analysis taken at 200-foot level)	55	295
Brownish sandy clay, hard	40	335
Brownish clay mixed with blue clay	21	356
Brownish sandy clay with gravel	2	358
Granite.		

Well 1197 (U. S. Marine Corps 2), Quantico.

[Altitude, 28 feet above sea level]

	Thickness (feet)	Depth (feet)
Potomac group:		
Red sandy clay	29	29
Coarse red sand	12	41
Gray coarse sand	22	63
Dark coarse sand	10	73
Brown clay	6	79
Gray coarse sand, water-bearing	9	88
Light-gray sandy clay	8	96
Gravel	17	113
"Soapstone"	23	136
"Soapstone," hard	46	182
Sandstone, hard	15	197
Brown sandy clay	26	223
Gray sand, water-bearing	27	250
Tough clay	7	257
Hard sandy clay	8	265
Hard sandstone	2	267
Tough clay	40	307
Gray sand, water-bearing	48	355
Tough clay	5	360

Well 1198 (U. S. Marine Corps 3), Quantico.

[Altitude, 8 feet above sea level]

	Thickness (feet)	Depth (feet)
Potomac group:		
Red sand	10	10
Gray sand	20	30
Red sand	10	40
Gray sand	28	68
Sandy clay, hard	4	72
Fine sand, hard	18	90
Tough bluish clay, hard	14	104
Soft brown clay, some sand	51	155
Sandstone, hard	38	193
Tough clay	22	215
Sandrock	1	216
Sandy clay	12	228
Sandstone, soft	10	238
Blue clay, soft	23	261
Soft sandy clay	26	287
Tough clay	27	314
Sand with a little clay, water-bearing	22	336
Tough clay	6	342
Hard shale	3	345
Gray sand, water-bearing	10	355

Well 1199 (U. S. Marine Corps 4), Quantico.

[Altitude, 8 feet above sea level]

	Thickness (feet)	Depth (feet)
Potomac group:		
Loam	5	5
Gray sand, water-bearing	35	40
Bluish clay with sand, hard	38	78
Hard sandy clay	17	95
Sand and boulders	7	102
Bluish clay, tough	6	108
Bluish sandy clay	16	124
Hard shale, some sand	26	150
Hard red clay with bluish streaks	20	170
Red and blue clay with sand and hard streaks	50	220
Hard blue clay	10	230
Extra hard blue clay	50	280
Hard sandstone	5	285
Hard clay	55	340
Red and blue clay	5	345
Blue sandy clay	28	373
Soft sandstone	9	382
Hard clay	32	414
Blue sandy clay	26	440
Bluish sandy clay, hard	16	456
Bluish sandy clay	21	477
Hard clay	23	500
Hard clay streaked with sandstone	25	525
Hard clay streaked with mica	26	551

Well 1200 (U. S. Marine Corps test well 1), Quantico.

[Altitude, 45 feet above sea level]

	Thickness (feet)	Depth (feet)
Potomac group:		
Soil and clay	5	5
Sand and gravel	8	13
Fine hard sand	7	20
Hard sandy clay and gravel	25	45
Sand and gravel	20	65
Gray sand	8	73
Hard blue clay	2	75
Hard brown sandstone and clay	35	110
Brown clay	20	130
Brown clay, very hard	12	142
Brown clay, soft	23	165
Gray sandy clay	13	178
Blue sandy clay, hard streaks	17	195
Brown sandy clay	7	202
Brown sandstone	5	207
Soft brown clay	11	218
Gray sand	5	223
Brown sandy clay	21	244
Brown sandy clay, hard	36	280
Brown clay, hard	44	324
Gray sandy clay, soft	5	329
Gray sand	19	348
Blue sandy clay and marl	6	354
Gray sand rock	8	362
Gray rock	13	375
Bluish gray rock	10	385
Granite	6	391

Well 1201 (U. S. Marine Corps test well 2), Quantico.

[Altitude, 27 feet above sea level]

	Thickness (feet)	Depth (feet)
Potomac group:		
Soil and clay, soft	8	8
Sandy clay, soft	15	23
Bluish sandy clay, very hard	47	70
Reddish brown clay, very hard	55	125
Gray sand, soft; some water	5	130
Bluish-gray sandy clay	40	170
Gray soft sand, water-bearing	40	210
Brownish sandy clay, hard	20	230
Gray sand, water-bearing	10	240
Brownish sandy clay	45	285
Gray sand, water-bearing	15	300
Brownish sandy clay	25	325
Gray sandstone, soft and hard	15	340
Granite	10	350

ANALYSES OF WATER

TABLE 36.—*Analyses of ground waters from Prince William County, Virginia*

[Analyst, S. K. Love. Parts per million. Numbers at heads of columns refer to corresponding well numbers in Table 34.]

	1021	1029	1046	1115	1116	1165	1179	[d]1179(a)	1184	1188
Silica (SiO_2)	.....	67	.....	50	38	.....	.....	.....	.....	.....
Iron (Fe)	.....	2.3	.....	.25	1.1	.....	.....	.....	.....	.....
Calcium (Ca)	[a]35	36	72	39	31	[a]35	[a]6	[a]2	[a]40	[a]14
Magnesium (Mg)	.....	21	17	11	23	.....	.....	.....	.....	.....
Sodium (Na)	.....	12	[b]15	12	12	.....	.....	.....	.....	.....
Potassium (K)	.....	1.0		1.6	1.4	.....	.....	.....	.....	.....
Bicarbonate (HCO_3)	212	204	204	181	219	147	21	29	112	51
Sulphate (SO_4)	[a]3	11	67	5.4	5.8	[a]38	[a]1	[a]2	[a]20	[a]4
Chloride (Cl)	6.0	15	14	10	5.0	5.0	26	6.0	48	27
Nitrate (NO_3)	1.8	2.0	31	4.6	1.8	.0	17	.0	30	18
Total dissolved solids	.....	254	[b]330	212	202	.....	.....	.....	.....	.....
Total hardness as $CaCO_3$ (calculated)	[c]176	176	250	143	172	[c]132	[c]33	[c]9	[c]182	[c]78
Date of collection (1931)	Dec. 2	Dec. 2	Dec. 2	Dec. 1	Sec. 1	Dec. 1	Dec. 1	Dec. 1	Dec. 1	Dec. 1

[a]By turbidity.
[b]Calculated.
[c]Determined.
[d]This well is the second one listed under No. 1179 in Table 34.

TABLE 36.—*Analyses of ground water from Prince William County, Virginia—Continued*

[Analyst, R. B. Rudy, Bureau of Standards. Parts per million. Numbers at heads of columns refer to corresponding well numbers in Table 34.]

	1196	1197	1198	1199
Silica (SiO_2)	18	35	28	34
Iron (Fe)	Trace	Trace	Very small amount	Very small amount
Calcium (Ca)	.9	2.4	4.3	3.5
Magnesium (Mg)	.3	1.3	3.1	2.7
Sodium (Na)	[b]35	[b]27	[b]21	[b]57
Potassium (K)	.....	.....	.....	.....
Bicarbonate (HCO_3)	76	63	61	70
Sulphate (SO_4)	12	12	11	6.2
Chloride (Cl)	3.4	3.9	4.7	57
Nitrate (NO_3)	.....	.....	.....	.....
Total dissolved solids	118	108	100	198
Total hardness as $CaCO_3$ (calculated)	[b]3.5	[b]11	[b]23	[b]20
Date of collection (1931)	Mar. 18	Mar. 5	June 12	July 28

[b]Calculated.

FAIRFAX COUNTY

GEOGRAPHY

Fairfax County occupies the northeast corner of Virginia, where Potomac River swings from an easterly to a southerly course. Thus the river separates the county from Maryland on the north and east; on the west is Loudoun County, and on the south, Prince William County. Fairfax County is 416 square miles in area and in 1930 had a population of 25,264. The towns, with their population in 1930, are Fairfax, the county seat, 640; Falls Church (partly in Arlington County), 2,019; Vienna, 903; Herndon, 887; Clifton, 181; Wiehle, 72. Falls Church and some other villages in the northeastern part of the county are in the suburban area of Washington, D. C. Dairying is a main industry, and corn, hay, alfalfa, and vegetables are widely grown, as elsewhere in northern Virginia. Fairfax County and Prince William County together have 14 industrial establishments, the value of whose output for 1929 was $375,811.

Fairfax County is crossed by several railroads—the Southern Railway, whose right of way is used also by the Chesapeake and Ohio Railway; the Richmond, Fredericksburg and Potomac Railroad; the Arlington and Fairfax Railway (electric); and the Washington and Old Dominion Railway (electric). U. S. highway 1 and the Mount Vernon Memorial highway run from Washington, D. C., through Alexandria and the eastern part of the county, leading to Richmond and the south. Another main highway runs from Washington through Falls Church to Fairfax and thence to the Shenandoah Valley. Improved highways also run from Alexandria through Fairfax to Winchester and from Falls Church through Leesburg to Winchester.

DRAINAGE AND TOPOGRAPHY

Fairfax County is drained by small tributaries of Potomac River. Nicholson Branch and three smaller creeks flow northward into the Potomac above Great Falls. Difficult Run, Bull Neck Run, Scott Run, and Pimmit Run flow in a northerly or northeasterly direction into the river below Great Falls and occupy precipitous gorges in their lower courses. Cameron Run, Accotink Creek, Pohick Creek, and Occoquan Creek flow eastward or southeastward across the Fall Line into the Potomac; their upper reaches are fairly well graded, with gentle slopes and in most parts small flood plains. But in their middle courses they pass through gorges with narrow floors and canyonlike walls, and near their mouths they are estuarine. The pattern of the streams has been influenced very little by the structure of the underlying rocks. Taken

broadly, the surface of the land is a level upland, cut into by streams to a depth of 75 feet or less in the interior of the county but 200 feet at the Fall Zone. It slopes gently toward the east. Near the river south of Arlington County the descent from the peneplaned upland to the river level is effected by a series of steplike escarpments, probably four in number, separated by gently sloping terraces several hundred yards in width where entirely preserved. Upstream from Washington this descent is more abrupt. Each higher terrace is successively older and represents a current and wave-built terrace heading into a wave-cut scarp formed when the sea level stood higher than it does at present. The terraces extend up the main streams at levels at which the rivers formerly flowed and are capped with gravel, but are now much dissected, the oldest and highest being almost obliterated, except for outlying remnants, such as the flat-topped hills near Tysons Crossroads and those a mile west of Falls Church.

GEOLOGY

The rock formations present in Fairfax County range in age from the pre-Cambrian to Pleistocene and are widely diverse in their composition and origin. The oldest formation is the Wissahickon schist, which underlies most of the western part of the county. It is intruded by pre-Cambrian granite, which forms an irregular belt extending in a south-southwesterly direction through the middle part of the county. The Quantico slate, of Ordovician age, is exposed near Woodbridge, in the southwest corner of the county, where the overlying sediments of the Coastal Plain have been eroded away. The Triassic sandstones and shales crop out in the extreme western part of the county, thickening toward the west. Trap (diabase) occurs as sills and dikes and larger bodies. A large body of trap crops out south and southeast of Pleasant Valley, extending almost to the Prince William County line in a belt 2 to 4 miles wide. Another belt of trap extends southward from Herndon almost to the Prince William County line. The eastern margin of the county, south of Arlington County, is covered with sediments of the Coastal Plain—the Potomac group, and Pliocene (?), Pleistocene, and Recent terrace gravel. (See Pl. 2 and Table 7.)

The Triassic rocks are very little deformed except that they have a westerly dip. However, there are gentle flexures, joint systems, and normal faults of indeterminate but small throw.

In the central area the pre-Cambrian crystalline and Paleozoic sedimentary rocks are extensively deformed. The Wissahickon schist, which occupies the western part of this area, bordering the area of Triassic rocks, is an ancient mud deposit that has been compressed and recrys-

tallized almost beyond recognition. The bedding, now very obscure, dips toward the southeast. The planes of schistosity dip very steeply toward the west and in some places are vertical. The granite of the eastern belt lies between the Wissahickon schist and the Coastal Plain. It has intruded the schist, and the contact between the two is very irregular and complicated. The granite is also schistose locally but is more commonly gneissoid. Joints are very prominent; the planes are rather closely spaced and intersect in three directions. In fresh exposures the granite almost invariably shows a clean break along the joint planes. The Peters Creek quartzite and Quantico slate are exposed locally in the southeastern part of the belt of crystalline rocks along the Fall Zone.

The rocks of the Coastal Plain, mostly unconsolidated gravel, sand, silt, and clay, dip seaward on a southeastward-sloping floor of crystalline rock. They have been disturbed very little by earth forces since their deposition. The rock floor is somewhat irregular; its slope is about 100 feet to the mile near the western edge of the Coastal Plain, farther east it appears to flatten out to about 70 feet to the mile, and at Fort Humphreys it seems to be only about 45 feet to the mile, owing, perhaps to a buried ridge on the rock floor. In some localities well logs show that there is a gorgelike depression in the rock floor beneath the present course of Potomac River.

GROUND-WATER CONDITIONS

Area of Triassic rocks.—The results of drilling in the Triassic area in Fairfax County seem to be at least as favorable, on the whole, as in the Triassic area of Prince William and Loudoun counties. The average household well is of shallow to moderate depth and delivers small quantities of water. Although there are a number of dry holes, most of this area is characteristically favorable for the development of small or moderate supplies, and a few wells deliver rather large quantities of water. Two wells (Nos. 1406 and 1407) about a mile southwest of Floris, which were drilled about 100 feet into red shale and sandstone, deliver 50 and 55 gallons a minute. A few other wells in and near Herndon and Floris are nearly as strong, and from these evidences it appears that this area is especially favorable for drilled wells. A well (No. 1455) on the property of Henry Sutphin, 1½ miles south of Chantilly, is 60 feet deep, entirely in trap, and was reported to have yielded 60 gallons a minute at the time of its completion. This well is similar to many others in the area of Triassic rocks, which obtain exceptionally strong supplies at shallow depth in the trap.

The water level lies for the most part at depths between 20 to 80 feet, averaging perhaps 35 feet. In the trap rock the water seems to

stand higher than elsewhere, perhaps because the trap bodies cause the water to be perched. A well drilled into Triassic rocks near Chantilly is reported to have flowed at first, but the water does not now rise to the surface.

Dug wells are fairly numerous in this area, and some of them are as much as 45 feet in depth. However, in the summer of 1931, following the dry year of 1930, most of the wells were either dry or dangerously depleted, and many of them were deepened by further digging or by drilling. The observations indicate that dug wells are not generally satisfactory in the area of Triassic rocks, because of their low yield and the likelihood of failure; there are other general objections to them for sanitary reasons.

The rather numerous springs occur more or less uniformly on the hillsides. All the springs that were examined are small, yielding less than 5 gallons a minute and usually from 1 to 3 gallons a minute. However, they seem to be reliable during droughty periods. Several springs have been so developed as to meet all household needs, some of the water being pumped automatically from the spring basin to a storage tank and the overflow being used to cool milk and to water cattle.

Area of crystalline rocks.—The western part of the area of crystalline rocks is underlain by schist and is favorable for the development of very satisfactory small supplies from drilled wells. Most of the wells are household wells of moderate or shallow depth that yield less than 10 gallons a minute, with only a few that deliver less than 1 gallon a minute. A considerable number of these wells encounter large quantities of water near the surface, giving a total of 20 gallons a minute or more. A well (No. 1475) drilled at the Ivacoda Farm, near Clifton, which is only 20½ feet deep, is reported to deliver 35 gallons a minute. There are also wells of large diameter which were drilled for the purpose of obtaining a large supply and were carried to a depth sufficient to yield a suitable quantity. Thus the two municipal wells at Fairfax are 160 and 305 feet deep and deliver 70 and 60 gallons a minute, respectively. (See also p. 156.) The area underlain by the Wissahickon schist is one of the most satisfactory in the Piedmont region of northern Virginia for the recovery of ground water by drilled wells. Some of the holes are reported to be dry or nearly so, but many of them were found to be shallow, and it is likely that if drilling had been continued to 200 or 300 feet water would have been encountered. Near Vienna there are many wells whose yields are exceptionally small, though apparently adequate for household needs; these wells are smaller in diameter than most wells elsewhere in this area, and their comparative weakness, therefore, is probably due to their construction and not to any local peculiarity of the rock.

Ground-water conditions are somewhat different in the eastern part of the belt of crystalline rocks. The granite exposed there in a strip about 5 miles wide is a less favorable water-bearer because the openings in the rock are less numerous. However, the ordinary household wells are similar to those in other crystalline rocks of the Piedmont region, being generally 100 feet or less deep and delivering small supplies. A few wells—more than in the area of schist—were unsuccessful in getting water but the chief difference is that there are very few wells that obtain moderately large quantities. The well whose reported yield is the greatest is one at the Episcopal High School, Alexandria, which is reported to deliver 50 gallons a minute (No. 1154.) This well ends in the granite, but the main supply of water was encountered in the overlying sediments of the Coastal Plain. An occasional well is reported to yield 25 gallons a minute or more, such as the municipal wells at Falls Church. (See p. 156.) The first of these wells was drilled to about 300 feet, and periodic pumping tests during the course of drilling showed that little water was encountered below about 100 feet. On the other hand, some wells have been put down to considerable depth and have failed to obtain a satisfactory supply. Thus, at a nursery near the Arlington County line between Falls Church and Alexandria there is a well (No. 1644) 431 feet deep, which encountered a small flow of water in sand above the granite at 240 feet and very little, if any, in the granite. Small quantities of water may be expected at most localities in the belt of granite but not large supplies. The southeastern part of the belt of crystalline rocks, underlain by Quantico slate, is very unsatisfactory for drilled wells. The water is highly mineralized and is usually obtained only in small amounts.

Dug wells were formerly used very extensively in this area, and where properly constructed they were satisfactory prior to the dry years of 1930 and 1931. During that time they failed in great numbers. Deepening by digging into solid rock proved an expensive and in many places a futile attempt at relief. Since then the local drillers have put down many drilled wells. It is curious to note that in several places one of two nearby dug wells may have failed in the summer or autumn of 1930 while the other continued to yield and then in 1931 the second failed and the first recovered. The few wells of known yield dug into the soil of the crystalline rocks show wide variation, some delivering as much as 20 gallons a minute and others less than 1 gallon a minute. It is believed, however, that in most places this soil is very impermeable. Many inhabitants of this area have carefully constructed dug wells that have given excellent satisfaction for many years; but in general the dug wells are not as reliable or as sanitary as the drilled wells.

There are numerous small springs in this area, many of which can be detected only as seeps near which the vegetation thrives unusually well. If a basin is dug out, such a spring may furnish sufficient water for ordinary uses, but many springs so used went dry during 1930 and 1931.

Coastal Plain area.—The sediments in the Coastal Plain area—mainly unconsolidated gravel, sand, silt, and clay—are the best water-bearers in northern Virginia. It must not be thought, however, that all parts of the area are equally suitable for drilled wells, for near the Fall Line the sediments are thin, and most of the wells drilled there strike the underlying rock floor within a short distance below the surface. In such localities only small to moderate supplies may be expected. Generally speaking, ground water is more abundant eastward from the Fall Line, and near Potomac River there are wells that deliver as much as 100 gallons a minute. One of the wells drilled on the Mount Vernon estate is 530 feet deep and is reported to have a capacity of about 100 gallons a minute, although at present it is pumped only at the rate of about 50 gallons a minute. (See log, p. 184.) Most of the other wells in the county are less than 200 feet deep and yield smaller quantities. This may be due partly to the fact that they were not developed thoroughly after drilling, as well as to their shallower depth. The rock floor beneath the sediments does not seem to be water-bearing, and wells should not be drilled any great distance into it. A few wells in the western part of the Coastal Plain, such as one drilled at the Episcopal High School, Alexandria, are reported to have passed into the crystalline rocks without obtaining any water.

The ground water in this part of the Coastal Plain area is usually soft and low in dissolved solids. Some is calcium bicarbonate water, and some is sodium sulphate water. Iron is present locally in troublesome quantities, and most of the samples analyzed showed rather large amounts of silica. Some wells have encountered water that is unfit for drinking because of an unpleasant "marshy" taste and odor. Water of this kind was encountered in the two deep wells at Mount Vernon and had to be cased off.

Dug wells are numerous and widely used. Most of them are satisfactory if properly constructed. However, it is probable that a drilled well would in the end be the more economical source of ground water, for it can be sunk deeper and therefore has a better chance of passing into a bed of water-bearing sand; the dug well, if it does not encounter a sufficient quantity of water within about 75 feet of the surface, is likely to be a waste of money. It is reported that a large number of dug wells that were failing during 1930 and 1931 were deepened by drilling; others were dug deeper and proved satisfactory. Many of the dug wells

deliver as much as 5 gallons a minute, and one (No. 1531) was examined from which 28 gallons a minute can be pumped continuously. The most reliable and productive dug wells are in the lowlands near Potomac River, and the least reliable and productive are in the thin terrace gravel overlying the hard rocks on the Piedmont Plateau.

Springs are numerous, especially along the west edge of the Coastal Plain area. The springs of the Coastal Plain are the largest in northern Virginia except the springs of the limestone areas of Frederick and Clarke counties and of the limestone conglomerate of Loudoun County. Many of the springs are used, and most of them are reported to be reliable and otherwise satisfactory. Some of them are rather highly mineralized, a few with minerals that improve their usefulness but mostly with such materials as carbonates, sulphates, and iron.

MUNICIPAL SUPPLIES

Fairfax.—Fairfax obtains its public supply from two drilled wells (Nos. 1430 and 1431)—one on the north side of the town and the other on the south. They are 160 and 305 feet deep and deliver 70 and 60 gallons a minute, respectively. The deeper well is 10 inches in diameter, the other 8 inches. The water from both wells is pumped to a steel tank tower at the site of the deeper well on the south side of the town, where it is distributed by gravity. The minimum daily consumption is about 550 gallons. The water is chlorinated both at the wells and in the tank.

Herndon.—Herndon is supplied by a privately operated water system using a single drilled well that is 196 feet deep and delivers 13 gallons a minute. The water is pumped into a tank tower of 31,000-gallon capacity at the site of the well, whence it is distributed by gravity to 120 households. The average consumption is 20,000 gallons a day, and the maximum 25,000 gallons. The water is chlorinated occasionally.

Fort Hunt.—Fort Hunt is supplied by one well 284 feet deep, which yields 34 gallons a minute. Three other wells on the property are not used. An overhead reservoir of 30,000-gallon capacity distributes the water by gravity. The maximum consumption is 12,000 gallons a day. The water is not treated for sanitation.

Fort Humphreys.—Fort Humphreys obtains its main supply from Accotink Creek, but a well drilled near the filter plant is used as an auxiliary supply.

Water supply of Falls Church[11].—The town of Falls Church is a good example of a small town which has recently developed a municipal water supply from underground sources. Prior to 1931, the inhabitants obtained their water mainly from shallow private wells. The dry year of 1930 caused the failure of many of the shallow wells, and a shortage of water became so pressing that water had to be brought into the town by

[11] By Fred H. Klaer, Jr., United States Geological Survey, 1938.

tank trucks. The town was faced with the choice of purchasing water from the Washington water works, which supply the neighboring communities in Arlington County, or of developing a water supply from underground sources. At the request of the town authorities, the Geological Survey made a short investigation to determine the ground-water conditions and the most suitable locations for wells. Several days were spent in the field by R. M. Leggette and L. K. Wenzel, of the Geological Survey. In the report on this investigation, it was recommended that one or more wells should be drilled in the partly decomposed granite, preferably in the southeast section of the town. Three wells were drilled in 1931 and 1932, and a fourth well was drilled in the summer of 1936.

At present the town of Falls Church is adequately supplied with water, but as the population increases, more water will be required. In dry years such as 1930, the water levels may fall so low that additional wells will be required to supply the needs of the town. In order to be prepared for such an emergency it is highly desirable to keep accurate records of the amount of pumpage, the water levels in the pumped wells and the water levels in wells in the surrounding area. Such records will involve but little extra work and will prove of great value in future water-supply problems of Falls Church.

Preliminary to the preparation of the present brief report, a few days have been spent in the field by the writer (Mr. Klaer), during January, 1938, in ascertaining recent developments in the water supply. Calculations on pumpage have been made from data supplied by Mayor L. P. Daniel, and Mr. Charles Gage, of Falls Church.

The first well for the public water supply (No. 1) was drilled on the site of the present elevated water tank, near the center of the town. This well entered granite at a depth of 85 feet and was drilled to a total depth of 318 feet. The well was cased to the depth of 85 feet with an eight-inch casing, and it was originally pumped at a rate of 30 gallons a minute. The rate was soon reduced to 22 gallons a minute, which rate has been continued to the present. It is reported that during the winter of 1931-32, the well was almost emptied by pumping for 10 hours at this rate. Well No. 2 was drilled about three-quarters of a mile east of well No. 1. Granite was struck at 73 feet and the well was drilled to a total depth of 217 feet. In May, 1932, pumping was started at a rate of 55 gallons a minute, but the rate has been increased to 60 gallons a minute, which is the present rate. This well, although not as deep as the other town wells, is probably the best well in the area. It is reported, however, that in the spring of 1932, this well could be emptied in 10 hours of pumping at the rate of 60 gallons a minute.

Well No. 3 was drilled about a quarter of a mile northwest of Well No. 2, to a depth of 407 feet. The well developed only 9 gallons a min-

ute in the first hundred feet. At 305 feet, 20 to 24 gallons a minute were obtained, and from 340 to 367 feet, there were indications of additional water. Pumping was started in August, 1932, at a rate of 32 gallons a minute, and the rate has since been increased to 38 gallons a minute.

In the summer of 1936, a fourth well, No. 4, was drilled in Lee Boulevard Heights, about 1¾ miles southeast of Well No. 1, to a depth of 429 feet. Granite was struck at 93 feet. Pumping was originally at 60 gallons a minute during a pumping test and has since been reduced to 40 gallons a minute. It is interesting to note that 20 gallons a minute was obtained in the first 160 feet, an additional 10 gallons a minute in the next 80 feet, and 10 gallons a minute in the remaining 189 feet.

A hole was drilled west of the town to a depth of about 100 feet, but as there were no indications of water, it was abandoned.

The water from the four wells is pumped directly into the distribution system, which is connected with a 100-foot elevated tank that has a storage capacity of 200,000 gallons. Most of the pumping is done at night, when sufficient water is stored to supply the needs of the town during the day. In times of exceptionally heavy use of water, pumping is done both day and night.

Pumpage records compiled for 1932-33 and 1936-37 show a great increase in the amount of water pumped. The following table has been compiled by multiplying the rated capacity of each pump by the number of hours that the pump was used each month. As the actual rate of pumping has doubtless not always been equal to the rated capacity, the figures are only approximately accurate.

TABLE 37.—*Pumpage from the municipal wells, Falls Church (in gallons)*

MONTH	1932	1933	1934	1936	1937
January	.....	1,371,600	1,163,904	.....	2,711,040
February	.....	1,288,980	.....	.....	2,631,120
March	.....	1,109,653	.....	.....	2,976,000
April	.....	1,270,260	.....	.....	2,919,600
May	.....	987,000	.....	.....	2,998,800
June	.....	1,188,600	.....	.....	2,926,800
July	.....	1,196,300	.....	.....	2,953,200
August	.....	1,263,192	.....	.....	(2,953,200)[a]
September	1,162,740	951,000	.....	2,942,400	2,962,080
October	1,058,040	1,114,422	.....	3,346,800	3,575,900
November	1,059,960	.....	.....	880,520	2,537,640
December	1,233,480	1,333,980	.....	2,511,360	.....

[a]Estimated. Records for August 1937, not complete.

The records show that in September, 1932, an average of only about 34,000 gallons a day was pumped from the three wells which were in

existence at that time, but that in September, 1937, an average of about 98,000 gallons a day was pumped from the four wells that were then in use.

As many of the inhabitants are now using water from the municipal system, many of the shallow wells have been abandoned. Some have been filled in and others securely cemented over to prevent contamination of the underground supply. Measurements of water levels are therefore somewhat difficult to obtain. However, Mr. Charles Gage has furnished records of measurements of the water level which he made in his dug well, on Great Falls Street, near the center of the town, in 1931, 1932, and 1933. The water level was measured by the writer (Mr. Klaer) in the same well on January 4, 1938, when it stood 18.88 feet below the top of the tile casing, which is about 2½ feet above the ground surface. The measurements show that the water level has risen about 10 feet since 1931 and stands at present at approximately the same level as it did in 1933. The rapid recovery of the water level after the dry year of 1930 to its position in 1933 is doubtless due to the return to more normal precipitation. The withdrawal of water from the municipal wells has apparently not greatly affected the water level in this area as Well No. 1 is only about a quarter of a mile from the well of Mr. Charles Gage.

A measurement made by the writer (Mr. Klaer) in Well No. 2, while the pump was being repaired, showed the water level on January 4, 1937, to be 21.88 feet below the top of the casing, which is about 2½ feet above the ground surface. A measurement made by the writer (Mr. Klaer) in the well of the Jefferson High School, on Cherry Street, showed the water level on January 10, 1936, to be 22.08 feet below the ground surface.

WELL

TABLE 38.—*Wells in*

Well number	Location	Owner	Driller	Type of well
1300	2 miles north of Forestville (Great Falls post office), which is 3 miles east of Dranesville.	Byron Thomas	F. N. Hagmann, Jr.	45 feet dug, rest drilled.
1301	1½ miles north of Forestville	Mr. Houchens	F. N. Hagmann, Jr.	Drilled
1302	1 mile northeast of Forestville	Mr. Walker	F. N. Hagmann, Jr.	Drilled
1303	1 mile north of Dranesville	S. M. Stover	E. S. Adrian	Drilled
1304	½ mile north of Dranesville	J. R. McGuire	E. S. Adrian	Drilled
1305	¾ mile north of Dranesville	C. B. L. Costello	F. N. Hagmann, Jr.	Drilled
1306	¾ mile northwest by west of Dranesville.	Frank Hammond	James Franklin	Drilled
1307	Dranesville	J. A. Houghlin	E. S. Adrian	Drilled
1308	3½ miles northeast by east of Herndon.	Mr. Jenkins	F. N. Hagmann, Jr.	Drilled
1309	¾ mile west of Forestville	Mr. Cox	Dr. Hutchison	Drilled
1310	Forestville	H. L. Oliver	Milton Frame	Drilled
1311	1 mile southeast of Forestville	F. B. Groves	F. N. Hagmann, Jr.	Drilled
1312	1¾ miles southeast of Forestville	G. C. Shank	F. N. Hagmann, Jr.	Drilled
1313	Elkins, which is 7 miles east of Herndon.	E. W. Fugitt	F. N. Hagmann, Jr.	Drilled
1314	Elkins	Wm. Winston	F. N. Hagmann, Jr.	Drilled
1315	¼ mile south of Elkins	C. A. Pirkey	F. N. Hagmann, Jr.	Drilled
1316	Peacock, which is ½ mile southeast of Elkins.	Capt. R. L. Miller	E. S. Adrian	Drilled
1317	Peacock	John Peacock	E. S. Adrian	Drilled
1318	Peacock	N. R. Grimm	E. S. Adrian	Drilled
1319	1 mile south of Peacock	B. D. Iden	E. S. Adrian	Drilled
1320	2¼ miles southwest by south of Elkins, on Leesburg Pike.	G. H. Lowe	W. E. Croson	Drilled
1321	4 miles north of Vienna, which is 5 miles west of Falls Church.	John Oliver	F. N. Hagmann, Jr.	Drilled
1322	2½ miles south of Forestville	Mrs. Leigh	James Franklin	Drilled
1323	2 miles northeast by east of Wiehle, which is 2 miles southeast of Herndon.	J. A. Wheeler	James Franklin	Drilled
1324	1½ miles southwest of Forestville	Harry Money	James Franklin	32 feet dug, rest drilled.
1325	2½ miles northeast of Wiehle	Wheeler Milling Co.	Dr. Hutchison	Drilled
1326	2¾ miles northeast of Wiehle	Mr. Slack	James Franklin	Drilled
1327	¾ mile north of Herndon	Madison Kenfield	E. S. Adrian	Drilled
1328	¾ mile north of Herndon	(?)	(?)	Drilled
1329	Herndon	Herndon Ice & Supply Co.	Milton Frame	Drilled
1330	Herndon	Good-Lou Mill	Ryan & Fouche	Drilled
1331	Herndon	(?)	Milton Frame	Drilled
1332	Herndon	J. R. Brady	Mr. Carter	Drilled
1333	Herndon	C. M. Lawrence	Dr. Hutchison	Drilled
1334	Herndon	David Bixler	E. S. Adrian	Drilled
1335	Herndon	Sergeant Cockerel	Mr. Puckett	Drilled
1336	Herndon	O. A. Chamberlin	E. S. Adrian	Drilled
1337	½ mile east of Herndon	Herbert Bixler	E. S. Adrian	Drilled
1338	Herndon	Dr. Hutchison	Dr. Hutchison	Drilled
1339	½ mile west of Herndon	E. H. Brady	James Franklin	Drilled

RECORDS

Fairfax County, Virginia

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
75	Schist	Wissahickon	43	8		1300
95½	Schist	Wissahickon		25	72 feet of casing.	1301
70	Schist	Wissahickon	46	6		1302
67	Red shale	Newark		1		1303
25	Trap (diabase)	Late and/or post-Newark.		6		1304
45	Schist	Wissahickon		3		1305
160	Shale and sandstone.	Newark	37	3	10 to 12 feet of casing.	1306
78	Schist	Wissahickon		5		1307
50	Schist	Wissahickon	17	12		1308
91½	Schist	Wissahickon	34	10½		1309
88	Schist	Wissahickon		(?)		1310
72	Schist	Wissahickon	32	8	49½ feet of 6-inch casing.	1311
81	Schist	Wissahickon	30	20	6-inch well.	1312
116	Schist	Wissahickon	46	5	114½ feet of 6-inch casing.	1313
87	Schist	Wissahickon	30	2	58 feet of 6-inch casing.	1314
75	Schist	Wissahickon	40	15	63 feet of 6-inch casing.	1315
85	Schist	Wissahickon		8		1316
80	Schist	Wissahickon		4		1317
47	Schist	Wissahickon		10		1318
48	Schist	Wissahickon		3		1319
62	Schist	Wissahickon	20	20		1320
111	Schist	Wissahickon	48	12	108 feet of 6-inch casing.	1321
101	Schist	Wissahickon	90±	20		1322
69	Schist	Wissahickon	30	15		1323
75	Schist	Wissahickon	40	11±		1324
105	Schist	Wissahickon	35	15		1325
123	Schist	Wissahickon	35?	2		1326
37	Sandstone	Newark		2		1327
77	Trap (diabase)	Late and/or post-Newark.	5	3±		1328
219	Red shale	Newark		25		1329
176	Red shale and sandstone.	Newark		25		1330
99	Shale and sandstone.	Newark		6		1331
172	Shale and sandstone.	Newark		10	80 feet of 6-inch casing. Some stringers of trap (diabase) encountered.	1332
196	Red shale	Newark	96±	13	6-inch casing. Analysis on p. 186. Trap (diabase) overlies the water-bearing shale.	1333
75	Sandstone	Newark		2		1334
96	Sandstone and shale.	Newark	40	2	Trap (diabase) encountered near bottom of well.	1335
95	Sandstone	Newark		3		1336
31	Sandstone	Newark		5		1337
300	Red shale	Newark		½	Trap (diabase) encountered in bottom of well, but there was no water in it.	1338
161	Sandstone and shale.	Newark	15	15	45 feet of 5⅝-inch casing. Contained stringers of trap (diabase).	1339

WELL RECORDS

TABLE 38.—*Wells in Fairfax*

Well number	Location	Owner	Driller	Type of well
1340	½ mile west of Herndon	Harry Brady	James Franklin	Drilled
1341	Herndon	Mrs. A. F. Eccles	E. S. Adrian	Drilled
1342	Herndon	Dr. Poole	Beatty & Aicholtz	21 feet dug, rest drilled.
1343	1½ miles west of Herndon	Mr. Mathers	E. S. Adrian	Drilled
1344	1½ miles northwest of Floris, which is 2¾ miles southwest of Herndon.	E. E. Beard	James Franklin	Drilled
1345	½ mile south of Herndon	C. W. Grear	E. S. Adrian	Drilled
1346	¼ mile south of Herndon	C. W. Grear	E. S. Adrian	Drilled
1347	1¼ miles south of Herndon	V. C. Cockerel	Mr. Puckett	Drilled
1348	Wiehle	Mr. Bowman	Dr. Hutchison (?)	Drilled
1349	3½ miles northwest of Vienna	Ray Cockerel	F. N. Hagmann, Jr.	Drilled
1350	3 miles northwest of Vienna	Mr. Yowell	F. N. Hagmann, Jr.	50 feet dug, rest drilled.
1351	2 miles north of Vienna	J. G. Crowell	F. N. Hagmann, Jr.	Drilled
1352	1½ miles north of Vienna	Mrs. Gibson	F. N. Hagmann, Jr.	Drilled
1353	1½ miles north of Vienna	Mr. Leichman	F. N. Hagmann, Jr.	Drilled
1354	1 mile northeast of Vienna toward Tysons Crossroads.	T. J. Beavers	F. N. Hagmann, Jr.	Drilled
1355	1 mile east of Vienna	Walter Thompson	F. N. Hagmann, Jr.	Drilled
1356	Vienna	Arthur Thompson	F. N. Hagmann, Jr.	Drilled
1357	1 mile southeast of Vienna	Charles Moore	F. N. Hagmann, Jr.	Drilled
1358	Vienna	Vienna Ice & Fuel Co.	F. N. Hagmann, Jr.	Drilled
1359	Vienna	Mr. Reid	F. N. Hagmann, Jr.	Drilled
1360	Vienna	Mrs. Matthews	F. N. Hagmann, Jr.	Drilled
1361	Vienna	Lovell Jeffries	F. N. Hagmann, Jr.	Drilled
1362	Vienna	J. M. Willey	F. N. Hagmann, Jr.	Drilled
1363	Vienna	Methodist Church	F. N. Hagmann, Jr.	Drilled
1364	Vienna	George Darnes	F. N. Hagmann, Jr.	Drilled
1365	Vienna	Mrs. M. B. Douglass	F. N. Hagmann, Jr.	Drilled
1366	Vienna	E. H. Russell	F. N. Hagmann, Jr.	Drilled
1367	Vienna	E. W. Ericson	F. N. Hagmann, Jr.	Drilled
1368	Vienna	Mr. Griffith	F. N. Hagmann, Jr.	Drilled
1369	Vienna	Lorraine Jenkins	F. N. Hagmann, Jr.	Drilled
1370	Vienna	C. J. Jones	F. N. Hagmann, Jr.	Drilled
1371	Vienna	W. M. Roles	F. N. Hagmann, Jr.	Drilled
1372	Vienna	Vienna School	F. N. Hagmann, Jr.	Drilled
1373	1 mile east of Oakton, which is 2 miles southwest of Vienna.	Mr. Dennison	F. N. Hagmann, Jr.	Drilled
1374	Five Oaks, which is 1½ miles northwest by west of Oakton.	William Morian	F. N. Hagmann, Jr.	Drilled
1375	2 miles northwest of Fairfax, on Lee Highway.	Mrs. E. W. Dalton	F. N. Hagmann, Jr.	Drilled
1376	2½ miles northeast of Fairfax, on Lee Highway.	Gibson Garage	F. N. Hagmann, Jr.	Drilled
1377	½ mile east of Oakton	Harvey Johnson	F. N. Hagmann, Jr.	Drilled
1378	Oakton	Mrs. E. F. Meyerhoff	F. N. Hagmann, Jr.	Drilled
1379	Oakton	J. A. Ashby	F. N. Hagmann, Jr.	Drilled
1380	¾ mile east of Oakton	George Miles	F. N. Hagmann, Jr.	Drilled
1381	½ mile south of Oakton	F. N. Larkin	F. N. Hagmann, Jr.	Drilled
1382	1½ miles northwest of Vienna	Ben Trammel	F. N. Hagmann, Jr.	Drilled
1383	2½ miles northwest of Vienna	B. Beckwith	F. N. Hagmann, Jr.	Drilled
1384	2¼ miles north of Oakton	Mr. Ways		Dug
1385	2 miles northwest of Oakton	Mr. Dalziel	(?)	Drilled
1386	1 mile west of Oakton	J. C. Johnson	(?)	Drilled
1387	1 mile west of Oakton	J. A. Hunt	F. N. Hagmann, Jr.	Drilled

—CONTINUED

County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
160	Red sandstone	Newark		17	40 feet of 6-inch casing.	1340
52	Hard sandstone	Newark		6		1341
118	Shale	Newark	43	12		1342
57	Red shale	Newark		3		1343
106	Red shale and sandstone.	Newark	18	45		1344
109	Trap (diabase)	Late and/or post-Newark.		1+		1345
109	Sandstone	Newark		1		1346
90	Trap (diabase)	Late and/or post-Newark.		30		1347
65	Trap (diabase)	Late and/or post-Newark.		12		1348
60	Trap (diabase)	Late and/or post-Newark.		1½		
90	Schist	Wissahickon		20	52½ feet of 6-inch casing.	1349
77	Schist	Wissahickon		20	55 feet of casing.	1350
75½	Yellow clayey soil and schist.	Wissahickon			58½ feet of 6-inch casing.	1351
39	Schist	Wissahickon				1352
60	Schist	Wissahickon	30	4	51½ feet of 4½-inch casing.	1353
102	Schist	Wissahickon	25	20	97 feet of 4½-inch casing.	1354
52	Schist	Wissahickon	26	5	43½ feet of 6-inch casing.	1355
68	Schist	Wissahickon	33	3	62 feet of 6-inch casing.	1356
113	Schist	Wissahickon		4	102½ feet of 4½-inch casing.	1357
52	Schist	Wissahickon		25±	44 feet of casing. Analysis on p. 186.	1358
77½	Schist	Wissahickon		6	4½-inch casing.	1359
72	Schist	Wissahickon	55	3	4½-inch well.	1360
75	Schist	Wissahicken		8	64½ feet of 5⅝-inch casing.	1361
163	Schist	Wissahickon	55	8	137 feet of 6-inch casing.	1362
60	Schist	Wissahickon	20	15	56 feet of 4½-inch casing.	1363
86	Schist	Wissahickon	50	2	73½ feet of 4½-inch casing.	1364
65	Schist	Wissahickon	40	3	59 feet of 4½-inch casing.	1365
58	Schist	Wissahickon	30	5	53 feet of casing.	1366
74	Schist	Wissahickon			6-inch casing.	1367
98	Schist	Wissahickon	35	6	78½ feet of 4-inch casing.	1368
50	Schist	Wissahickon		12	45½ feet of 6-inch casing.	1369
165	Schist	Wissahickon	30	2½	4½-inch casing.	1370
72½	Schist	Wissahickon	40	5	47 feet of 4½-inch casing.	1371
103	Schist	Wissahickon	30	14	86 feet of 6-inch casing.	1372
45	Schist	Wissahickon		6	4-inch casing.	1373
70	Schist	Wissahickon		5	60 feet of 4½-inch casing.	1374
78	Schist	Wissahickon	35	15	61 feet of 4½-inch casing.	1375
59	Schist	Wissahickon		7	41 feet of 4½-inch casing.	1376
56	Schist	Wissahickon	26	3	4-inch casing.	1377
72	Schist	Wissahickon	35	3	61½ feet of 4½-inch casing.	1378
111	Schist	Wissahickon	28	10	96 feet of 6-inch casing.	1379
80	Schist	Wissahickon	28		4½-inch well.	1380
122	Schist	Wissahickon	25	10	95 feet of 6-inch casing.	1381
98	Schist	Wissahickon	33	3	78 feet of 6-inch casing.	1382
91	Schist	Wissahickon		4	81 feet of 4-inch casing.	1383
70	Schist	Wissahickon		0		1384
65	Schist	Wissahickon	45	7	20 (?) feet of 6-inch casing.	1385
67	Schist soil	Wissahickon	59			1386
64	Schist soil	Wissahickon	25	10	45 feet of 6-inch casing. Hand pump.	1387

WELL RECORDS

TABLE 38.—*Wells in Fairfax*

Well number	Location	Owner	Driller	Type of well
1388	1 mile west of Oakton	Mr. Porter	Mr. Harding	30 feet dug, rest drilled.
1389	2 miles northeast of Pender, which is 3½ miles northwest by west of Fairfax.	Morris Fox	F. N. Hagmann, Jr.	Drilled
1390	2 miles northeast by north of Pender.	Morris Pearson	Mr. Harding	Drilled
1391	4 miles northwest of Oakton	B. M. Kidwell	Mr. Harding	22 feet dug, rest drilled.
1392	4 miles northwest of Oakton	J. A. Miller	James Franklin	Drilled
1393	3¾ miles northwest of Pender	Mr. Pettit	(?)	Drilled
1394	2¼ miles southeast of Floris	W. O. Beatty	Beatty & Aicholtz	Drilled
1395	2½ miles northwest of Pender	M. C. Fleming		Dug
1396	1½ miles northwest of Pender	Jasper Thompson		Dug
1397	2½ miles northwest of Pender	(?)	Mr. Harding	Drilled
1398	3½ miles northwest of Pender	J. C. Starr		Dug
1399	1¼ miles southeast of Floris	E. H. Sasscer	James Franklin	Drilled
1400	1 mile southeast of Floris	Mr. Rutter	Mr. Harding	Drilled
1401	Floris	Floris School	F. N. Hagmann, Jr.	Drilled
1402	Floris	E. W. Hessick	F. N. Hagmann, Jr.	45 feet dug, rest drilled.
1403	Floris	M. K. Stroud	(?)	Part dug, rest drilled.
1404	2½ miles southwest by south of Herndon.	Mr. Dunlop	L. W. Wortman	Drilled
1405	¾ mile northwest of Floris	J. W. Murphy	F. N. Hagmann, Jr.	Drilled
1406	½ mile west of Floris	Ben Middleton	James Franklin	Drilled
1047	½ mile west of Floris	Ben Middleton	Mr. Wilkins	Drilled
			James Franklin	Drilled
1408	2 miles north of Pleasant Valley, which is 10 miles northwest by west of Fairfax.	Wamsley Bros	(?)	Drilled
1409	¾ mile northeast by north of Pleasant Valley.	W. W. Wilson	E. S. Adrian	Drilled
1410	½ mile north of Pleasant Valley	M. S. Stuart	(?)	Drilled
1411	Pleasant Valley	Mr. Hutchison	F. N. Hagmann, Jr.	Drilled
1412	Pleasant Valley	Mr. Rector	Mr. Orrison	Drilled
1413	1 mile southwest by south of Pleasant Valley.	Mayhugh Bros	F. N. Hagmann, Jr.	Drilled
1414	2½ miles northwest of Chantilly, which is 7 miles northwest by west of Fairfax, and 1 mile southwest of Pleasant Valley.	Cameron Head	F. N. Hagmann, Jr.	Drilled
1415	1½ miles northwest by west of Chantilly.	Negro Church	Mr. Puckett	Drilled
1416	1 mile northwest of Chantilly on Herndon road.	Mr. Henderson	F. N. Hagmann, Jr.	36 feet dug, rest drilled.
1417	½ mile northwest of Chantilly	Dunn's Garage	James Franklin	Drilled
1418	2 miles north of Chantilly	William E. Miller	E. S. Adrian	Drilled
1419	3½ miles north of Chantilly	Mrs. Bradley	E. S. Adrian	Drilled
1420	2 miles northeast of Chantilly	G. F. Harrison	Mr. Puckett	Drilled
1421	1½ miles north of Chantilly	R. T. Harrison	Milton Frame	Drilled
1422	1 mile north of Chantilly	A. Harrison	Mr. Puckett	Drilled
1423	Chantilly	Hugh R. Sutphin	Mr. Puckett	Drilled
1424	1½ miles northwest of Pender on Winchester Pike.	E. L. Burch	(?)	Drilled
1425	Pender	V. Kidwell		Dug
1426	3 miles northwest by west of Fairfax, ½ mile west of Difficult Run on Winchester Pike.	Nathaniel Bacon	F. N. Hagmann, Jr.	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
60	Schist	Wissahickon	20±			1388
87	Schist	Wissahickon		12	6-inch casing.	1389
51½	Schist	Wissahickon			12 feet of 6-inch casing.	1390
48	Schist	Wissahickon				1391
104	Schist soil	Wissahickon	35	10	84 feet of 5-inch casing. Gasoline deep-well pump.	1392
92	Shale and sandstone.	Newark	30±		90 feet of 6-inch casing.	1393
79	Shale	Newark	40±	15	51 feet of 6-inch casing.	1394
35	Shale and sandstone.	Newark	32			1395
27½	Sandstone	Newark	26½			1396
40	Shale and sandstone.	Newark			5 to 6 feet of 6-inch casing.	1397
40±	Shale and sandstone.	Newark	38±			1398
82	Red shale	Newark	32	1		1399
60	Shale and sandstone.	Newark				1400
72	Trap (diabase)	Late and/or post-Newark.		5		1401
80	Red shale and sandstone.	Newark	35	3		1402
90	Trap (diabase)	Late and/or post-Newark.		3		1403
80	Red shale	Newark		3		1404
102	Red shale	Newark	27	3		1405
96	Red shale	Newark		55±		1406
100	Red shale	Newark	55±	50+		1407
110	Red shale	Newark				
92	Red shale	Newark		6		1408
57	Trap (diabase)	Late and/or post-Newark.		1		1409
80	Red shale	Newark		10±		1410
62	Red shale and sandstone.	Newark	15	2		1411
28	Red sandstone	Newark		6	No casing.	1412
100	Trap (diabase)	Late and/or post-Newark.			36 feet of casing.	1413
88	Red shale and sandstone.	Newark	20±	8	8 feet of 6-inch casing.	1414
150	Red shale and sandstone.	Newark		4		1415
112	Red shale and sandstone.	Newark		12		1416
64	Red shale and sandstone.	Newark	0	10	Flowed at first.	1417
98	Sandstone	Newark		6		1418
57	Red shale	Newark		1		1419
96	Red shale and sandstone.	Newark	30	10	6-inch casing.	1420
64	Red shale, trap (diabase).	Newark, late and/or post-Newark.	24	8	7 to 8 feet of 6-inch casing.	1421
180	Red shale	Newark		9		1422
107½	Shale and sandstone.	Newark	57	15	8 feet of 6-inch casing.	1423
49½	Sandstone	Newark	15	1	12 feet of 8-inch casing. Hand pump.	1424
32	Schist soil	Wissahickon		0	Not completed.	1425
72	Schist	Wissahickon	30	20	40 feet of 6-inch casing. Analysis on p. 186.	1426

WELL RECORDS

TABLE 38.—*Wells in Fairfax*

Well number	Location	Owner	Driller	Type of well
1427	1 mile north of Fairfax	Ronald Blake	F. N. Hagmann, Jr.	Drilled
1428	¾ mile north of Fairfax	Miss Edith Thompson	F. N. Hagmann, Jr.	Drilled
1429	Fairfax	Mr. Carne	F. N. Hagmann, Jr.	Drilled
1430	Fairfax	Town of Fairfax	F. N. Hagmann, Jr.	Drilled
1431	Fairfax	Town of Fairfax	F. N. Hagmann, Jr.	Drilled
1432	1 mile east of Fairfax on Little River Pike.	Fairfax County Department of Highways.	F. N. Hagmann, Jr.	Drilled
1433	2 miles east of Fairfax on Little River Pike.	Mrs. J. Mathey	F. N. Hagmann, Jr.	Drilled
1434	1 mile southeast of Fairfax	W. P. Earle	F. N. Hagmann, Jr.	Drilled
1436	Fairfax	Miss Hillyear	F. N. Hagmann, Jr.	Drilled
1437	Jermantown, at intersection of Winchester and Warrenton roads, 1 mile northwest by west of Fairfax.	Black Lantern Inn	Mr. Puckett	Drilled
1438	Jermantown	Gilbert Sherwood, Kamp Washington.	F. N. Hagmann, Jr.	Drilled
1439	1 mile northwest of Jermantown	R. H. Downes	F. N. Hagmann, Jr.	24 feet dug, rest drilled.
1440	Jermantown	Ella Botts	Mr. Puckett	Drilled
1441	1 mile west of Jermantown	C. L. Rosemund	F. N. Hagmann, Jr., finished by Mr. Puckett.	Drilled
1442	1 mile west of Jermantown	Mr. Green	Mr. Puckett	Drilled
1443	1¼ miles west of Jermantown	Marshall Alder	Mr. Puckett	Drilled
1444	1 mile east of Legato and 2 miles west of Jermantown.	Manual Tourist Camp	Mr. Puckett	Drilled
1445	Legato, which is 3¼ miles west of Fairfax.	W. W. Swart	Mr. Puckett	Drilled
1446	1 mile north of Legato	L. W. Millan	Mr. Puckett	Drilled
1447	Legato	J. A. Buckley	Mr. Puckett	30 feet dug, rest drilled.
1448	Legato	Major Robey	Mr. Puckett	Drilled
1449	2½ miles east of Centerville	C. E. Utterback	F. N. Hagmann, Jr.	24 feet dug, rest drilled.
1450	2¼ miles east of Centerville	Norman Crouch	Mr. Puckett	Drilled
1451	1 mile southeast by east of Centerville on Braddock Road.	C. D. Roberson	Mr. Puckett	30 feet dug, rest drilled.
1452	Centerville	M. M. Carter	Frank Whitmer	Drilled
1453	Centerville	Sprugins & Holmes garage	Mr. Puckett	Drilled
1454	¾ mile north of Centerville	W. B. Owen	(?)	Drilled
1455	1¼ miles south of Chantilly	Henry Sutphin	F. N. Hagmann, Jr.	Drilled
1456	2½ miles south of Chantilly	P. L. McWhorter	F. N. Hagmann, Jr.	Drilled
1457	2½ miles south of Chantilly	G. R. L. Turberville	F. N. Hagmann, Jr.	Drilled
1458	2 miles southwest of Chantilly	O. H. Hutchison	Begun by James Franklin, finished by F. N. Hagmann, Jr.	Drilled
1459	1¼ miles west of Chantilly	D. P. Hutchison	F. N. Hagmann, Jr.	Drilled
1460	5 miles northwest of Centerville	P. H. Keys	F. N. Hagmann, Jr.	Drilled

[a]Since drought of 1930-31.

[b]In 1931.

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
121	Schist	Wissahickon	70	15	6-inch well.	1427
125	Schist	Wissahickon		14	6-inch casing.	1428
90	Granite	Algonkian(?)	37	10	5⅝-inch casing.	1429
305	Schist	Wissahickon	50–75?	60	165 feet of 10-inch casing. Public supply. Analysis on p. 186.	1430
160	Schist	Wissahickon	50–75?	70	85 feet of 8-inch casing. Public supply.	1431
133	Schist	Wissahickon	100±?	15	115 feet of casing.	1432
200	Schist	Wissahickon	160	15	200 feet of 6-inch casing.	1433
126	Schist	Wissahickon		20	117½ feet of 6-inch casing.	1434
136	Schist	Wissahickon	28	10	6-inch well.	1436
85	Schist	Wissahickon		10		1437
100	Schist	Wissahickon		15½		1438
74½	Schist	Wissahickon		5		1439
72	Schist	Wissahickon	25±	6	67 feet of 6-inch casing.	1440
65	Schist	Wissahickon	28, [a]40	½	Deep-well hand pump.	1441
83	Schist	Wissahickon		10		1442
209	Schist	Wissahickon	60	3	209 feet of casing.	1443
112	Schist	Wissahickon		6½	107 feet of casing.	1444
102½	Schist	Wissahickon	30	10	6-inch casing.	1445
106	Schist	Wissahickon	36	8	106 feet of galvanized casing. Gasoline Myers deep-well pump used.	1446
74	Schist	Wissahickon	30	2	65± feet of 5⅝-inch casing.	1447
82	Schist	Wissahickon	25	6		1448
83	Schist	Wissahickon	27	7½	81 feet of 6-inch casing. Electric pump with capacity of 4 gallons a minute.	1449
47½	Schist	Wissahickon		2	25 feet of casing. Failed during drought of 1930-31.	1450
47	Sandstone	Newark	15±	1½	6-inch casing.	1451
101	Shale and sandstone	Newark	30, [b]50	4	7 feet of 6-inch casing.	1452
36½	Sandstone	Newark	15	2		1453
70	Sandstone	Newark	40+		50± feet of 6-inch casing. Hand pump.	1454
36	Trap (diabase)	Late and/or post-Newark.		60	6-inch casing.	1455
51	Trap (diabase)	Late and/or post-Newark.	15	7	22 feet of 6-inch casing.	1456
165	Red sandstone and shale.	Newark	40	3	6-inch casing.	1457
165	Red sandstone	Newark		17?		1458
137	Red sandstone and shale.	Newark	28+	2		1459
35	Trap soil	Late and/or post-Newark.	25±	3	10 to 12 feet of 6-inch casing. Buckets used on well.	1460

WELL RECORDS

TABLE 38.—*Wells in Fairfax*

Well number	Location	Owner	Driller	Type of well
1461	4 miles northwest of Centerville on Braddock Road.	F. Korzendorfer	F. N. Hagmann, Jr.	Drilled
1462	3 miles northwest of Centerville on Braddock Road.	C. C. Reynolds	Daniel Senger	Drilled
1463	2¼ miles northwest of Centerville on Braddock Road.	C. W. Candle	Daniel Senger	Drilled
1464	2 miles north of Bull Run post office which is 3¼ miles southwest by west of Centerville.	O. N. Taylor	Charles Beeler	Drilled
1465	1¼ miles northwest by north of Bull Run post office.	E. Ebens	Mr. Puckett	Drilled
1466	1 mile northwest of Bull Run post office.	F. K. Eddison	Henry Seeley	Drilled
1467	2½ miles west of Centerville	J. R. Wells		Dug
1468	4 miles northwest by north of Manassas.	E. Cornwell	Mr. Puckett	Drilled
1469	2 miles west of Centerville	Prof. Ormond Stone	Mr. Puckett	Drilled
1470	1 mile northwest of Centerville	C. K. Belcher	James Franklin	Drilled
1471	½ mile west of Centerville	J. Debell	Mr. Puckett	Drilled
1472	2¾ miles southwest by south of Centerville.	Mr. Parrish	Mr. Puckett	Drilled
1473	2 miles northwest of Clifton, which is 6 miles southwest of Fairfax.	Ralph Crouch	James Franklin	Drilled
1474	2 miles southeast of Centerville	Mr. Myers (tenant farm)	Charles Beeler	Drilled
1475	1½ miles northwest of Clifton	Ivacoda Farm	James Franklin	Drilled
1476	1½ miles northwest by north of Clifton.	Mr. Myers	Charles Beeler	Drilled
1477	Clifton	Mort Moore	Mathers & McCain	Drilled
1478	½ mile north of Clifton	F. L. Ford		Dug
1479	1½ miles northeast by north of Clifton.	Mr. Buckley	James Franklin	Drilled
1480	2 miles north of Clifton	C. DeBusk	Mathers & McCain	Drilled
1481	2¼ miles north of Clifton	John Harris	Mr. Puckett	Drilled
1482	1¼ miles south of Legato	J. O. Cobb		Dug
1483	1 mile southwest by south of Legato.	D. M. Woodward	(?)	Drilled
1484	1 mile southwest by south of Legato.	Mr. Anderson	Charles Beeler	Drilled
1485	2 miles northwest of Fairfax station, which is 3½ miles southwest by south of Fairfax.	Mrs. Mary Scott		Dug
1486	1 mile northwest by north of Fairfax station.	Mr. Kerns		Dug
1487	1½ miles north of Fairfax station	H. C. Haight	James Franklin	Drilled
1488	Fairfax station	C. O. Green		Dug
1489	Fairfax station	G. Ford	Mr. Puckett	22 feet dug, rest drilled.
1490	Fairfax station	Fairfax Development Corp.	Mr. Puckett	Drilled
1491	1¼ miles northeast of Fairfax station.	J. G. Dumaine		Dug
1492	1½ miles east of Fairfax station	Dennis Folks	James Franklin	Drilled
1493	2 miles east of Fairfax station	J. W. Hopkins		Dug
1494	1¾ miles north of Burke, which is 4 miles southeast by south of Fairfax.	Cam Sheads		Dug
1495	1½ miles north of Burke	C. A. Boyce		Dug
1496	1 mile northeast by north of Burke	J. T. Dove		Dug
1497	Burke	Mr. Fitzhugh		Dug
1498	Burke	Paul Curtis		Dug
1499	2 miles northeast of Burke	J. E. Ross	James Franklin	Drilled
1500	1½ miles northeast by north of Burke and 4 miles southeast of Fairfax.	Mr. Fitzhugh	F. N. Hagmann, Jr.	Drilled
1501	½ mile southwest of Burke	Mr. Blinco	James Franklin	Drilled
1502	1⅛ miles south of Burke	W. K. Jerman		Dug

[a]Since drought of 1930-31. [c]Before drought of 1930-31. [d]In 1912.

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
106	Trap (diabase)	Late and/or post-Newark.			6-inch casing. Gasoline deep-well force pump.	1461
45	Trap soil	Late and/or post-Newark.	15		11½ feet of 6-inch casing. Buckets used.	1462
107	Shale and sandstone at contact with trap body.	Newark	30	3	10 feet of 5⅝-inch casing.	1463
47	Trap (diabase)	Late and/or post-Newark.	38	1	20 feet of 6-inch casing.	1464
49½	Trap (diabase)	Late and/or post-Newark.	20	2		1465
150?	Trap (diabase)	Late and/or post-Newark.		½		1466
30	Trap soil	Late and/or post-Newark.	[c]26	[a]Dry		1467
149	Red sandstone and shale.	Newark	60	5½		1468
120	Shale and sandstone.	Newark				1469
65	Shale and sandstone.	Newark	20	3	10 feet of 6-inch casing.	1470
137	Shale and sandstone.	Newark		4½		1471
57	Red sandstone and shale.	Newark			20 feet of galvanized casing.	1472
56	Trap (diabase), sandstone and shale.	Late and/or post-Newark; Newark.	20	3		1473
33	Trap (diabase), sandstone and shale.	Late and/or post-Newark; Newark.	15	11		1473
90	Schist	Wissahickon	45?	2½	Terra cotta pipe used as casing.	1474
20½	Schist	Wissahickon		35		1475
90	Schist	Wissahickon		5		1475
58	Schist	Wissahickon	38±?			1476
102	Schist	Wissahickon				1477
21	Schist	Wissahickon	8			1478
83	Schist	Wissahickon		5	6-inch casing.	1479
125	Schist	Wissahickon	75	3	22 feet of 6-inch casing. Hand pump.	1480
73	Schist	Wissahickon	49±			1481
30	Schist soil	Wissahickon	14			1482
95	Schist	Wissahickon	60+		95 feet of 5-inch casing.	1483
80	Schist soil	Wissahickon	16	20	6-inch casing.	1484
32	Schist soil	Wissahickon	[c]12			1485
12	Schist soil	Wissahickon				1486
103	Schist	Wissahickon	35	11		1487
44	Schist	Wissahickon	26			1488
117	Schist	Wissahickon	22	10		1489
236	Schist	Wissahickon	30±	25+	107 feet of 8-inch casing.	1490
65	Schist	Wissahickon	60½	20	Gasoline pump.	1491
49	Schist	Wissahickon		10	34 feet of 6-inch casing.	1492
47	Schist	Wissahickon	44½			1493
40	Schist soil	Wissahickon	30±			1494
56	Schist	Wissahickon	55	"Small"		1495
31	Schist soil	Wissahickon	25			1496
31	Schist soil	Wissahickon	29			1497
21½	Schist soil	Wissahickon	13½			1498
120	Granite	Algonkian (?)	100	25–30	6-inch casing to bottom of well. Myers gasoline pump used.	1499
95	Schist	Wissahickon	[d]42	[d]20	95 feet of casing. Deep-well hand pump.	1500
80	Schist	Wissahickon	37	"Large"	Electric pump.	1501
37	Clayey schist soil	Wissahickon	36			1502

WELL RECORDS

TABLE 38.—*Wells in Fairfax*

Well number	Location	Owner	Driller	Type of well
1503	2¼ miles south of Burke	Mr. Goodhart		Dug
1504	3 miles south of Burke	J. W. Chrisman		Dug
1505	Bellear School, 2 miles southwest of Burke.	H. G. Rice	James Franklin	Drilled
1506	3 miles southwest of Burke	J. E. Donovan		Dug
1507	3 miles southwest by west of Burke	S. R. Riggles		Dug
1508	1 mile south of Fairfax station	Mike Carrol		Dug
1509	Fairfax station	Fairview school	James Franklin	Drilled
1510	1½ miles south of Fairfax station	C. E. Riggles	James Franklin	Drilled
1511	3 miles east of Clifton	N. S. Violett		Dug
1512	3¼ miles southeast of Clifton	Norman Maley		Dug
1513	3 miles southeast of Clifton	James Franklin	James Franklin	Drilled
1514	3 miles southeast of Clifton	James Franklin	James Franklin	Drilled
1515	2 miles east of Clifton	A. E. Davis		Dug
1516	2 miles southeast of Clifton	R. M. Curran	James Franklin	Drilled
1517	2 miles southeast of Clifton	J. H. Wolford	Mr. Puckett	Drilled
1518	1 mile southeast of Clifton	H. J. West		Dug
1519	1½ miles southwest of Clifton	T. T. Crouch		Dug
1520	2 miles south of Clifton	James Kincheloe	James Franklin	Drilled
1521	1½ miles north of Occoquan	Frank Davis	James Franklin	Drilled
1522	District of Columbia workhouse (1 mile north of Occoquan).	District of Columbia workhouse.	F. N. Hagmann, Jr	Drilled
1523	Lorton	Lorton telephone office	James Franklin	Drilled
1524	Lorton	Lorton school	James Franklin	Drilled
1525	1 mile southeast of Lorton	Mr. Holmes	James Franklin	Drilled
1526	2 miles south of Lorton	N. A. Dawson		Dug
1527	1½ miles south of Lorton	John Tanner		Dug
1528	Lebanon School (2½ miles southeast of Lorton).	William Howard		Dug
1529	4 miles southwest of Fort Humphreys.	J. K. M. Norton		Dug
1530	2½ miles southeast of Woodbridge, which is 3 miles southwest by south of Lorton.	Belmont Club		Dug
1531	2½ miles southeast of Woodbridge	High Point Club		Dug
1532	Gunston Manor, which is 3 miles south of Fort Humphreys.	Mr. Henritze	F. N. Hagmann, Jr	Drilled
1533	Gunston Manor	Mr. Maul	F. N. Hagmann, Jr	Drilled
1534	Gunston Manor	Lewis Turner	F. N. Hagmann, Jr	Drilled
1535	3 miles southwest of Fort Humphreys.	J. C. Frye		Dug
1536	Fort Humphreys	U. S. Army	Layne Atlantic Co	Drilled
1537	Accotink, which is 3½ miles east of Lorton.	J. P. Mason	F. N. Hagmann, Jr	53 feet dug, rest drilled.
1538	Pohick Church, 1½ miles east of Lorton.	Rectory of Pohick Church		Dug
1539	Pohick, which is 1½ miles northeast of Lorton.	W. H. Cranford		Dug
1540	2½ miles northwest by north of Accotink.	J. Denty		Dug
1541	3¼ miles north of Accotink	Francis Galliot		Dug
1542	Telegraph Road 4 miles northeast of Accotink station and 5 miles southwest of Alexandria.	J. R. Sutton	Mathers & McCain	Drilled

[a]In 1931.

[c]Before drought of 1930-31.

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
37½	Schist	Wissahickon		Dry[a]		1503
46	Schist soil	Wissahickon	35			1504
83	Schist	Wissahickon	60	20	79 feet of 5⅝-inch casing. Deep-well hand pump.	1505
58	Schist soil	Wissahickon	53			1506
27	Schist soil	Wissahickon	21			1507
36	Schist soil	Wissahickon		Dry[a]		1508
103	Schist	Wissahickon	60		89 feet of casing. Used as community well during drought.	1509
99½	Schist	Wissahickon	50±	3	85 feet of casing.	1510
29	Schist soil	Wissahickon	28½			1511
30	Decomposed schist	Wissahickon	28			1512
104	Schist	Wissahickon	40	7	70 feet of 5⅝-inch casing.	1513
73	Schist	Wissahickon	35	20	53 feet of casing.	1514
40	Schist soil	Wissahickon	32			1515
82	Schist	Wissahickon	40	3½	62½ feet of 5⅝-inch casing. Deep-well pump.	1516
100	Schist	Wissahickon	30	4	86 feet of 5⅝-inch casing.	1517
47	Schist soil	Wissahickon	42			1518
35	Schist soil	Wissahickon	[c]25			1519
(?)	Schist	Wissahickon	60	½		1520
	Schistose granite	Algonkian				1521
65	12-foot bed of sand	Potomac		12	55 feet of 6-inch casing. Log on p. 182.	1522
310	Slate	Quantico	100	1	100 feet of casing.	1523
65	Sand	Potomac		1+	5⅝-inch casing.	1524
114	Dark clay	Potomac		12	112 feet of casing.	1525
80	Red clay	Potomac	75±			1526
36	Gravel bed	Potomac	30			1527
13	Gravel bed	Potomac	9			1528
55	Gravel bed	Potomac	52			1529
32	White sand	Recent, Pleistocene and Pliocene (?).	26	5–6		1530
31	White sand	Recent, Pleistocene and Pliocene (?).	29	28	Deep-well electric pump of 25-30 gallons a minute capacity.	1531
97	Terrace gravel	Recent, Pleistocene and Pliocene (?).	46	8	90 feet of 4½-inch casing.	1532
109	Terrace gravel	Recent, Pleistocene and Pliocene (?).	4	10	102 feet of 4½-inch casing.	1533
94	Sand	Potomac		10		1534
25	Sand	Potomac	22½			1535
279	Sand	Potomac			8-inch casing. Log on p. 182. Well went 26 feet into granite.	1536
128½	Sand	Potomac	100	4	4-inch casing.	1537
83	Sand	Potomac	81½			1538
60	Sand	Potomac	55			1539
12	Sand	Potomac	9			1540
30	Sand	Potomac	27±			1541
204	Granite	Algonkian (?)	59	12	130 feet of 6-inch casing. Water encountered in white sand at 80-90 feet but was malodorous and was cased off. Entered granite very near bottom of the well. Hand pump. Analysis on p. 186.	1542

WELL RECORDS

TABLE 38.—*Wells in Fairfax*

Well number	Location	Owner	Driller	Type of well
1543	2 miles south of Franconia, which is 6 miles southwest by west of Alexandria.	C. Nalls		Dug
1544	3 miles south of Springfield, which is 7½ miles west of Alexandria.	C. S. Arrick		Dug
1545	1 mile west of Barkers Crossroads, which is 3 miles southwest of Springfield.	N. Deavers		Dug
1546	1¼ miles north by northwest of Barkers Crossroads.	Archer Hall		Dug
1547	Barkers Crossroads	E. E. Crown		Dug
1548	2½ miles south of Springfield	Frank Dodson		Dug
1549	¾ mile south of Franconia	J. E. Schurtz		Dug
1550	½ mile southeast of Franconia	Mrs. B. C. Simms		Dug
1551	1 mile west of Franconia (on Richmond, Fredericksburg & Potomac Railroad.)	C. P. Talbot	Mathers & McCain	Drilled
1552	1 mile west of Franconia	M. M. Schurtz	Mathers & McCain	Drilled
1553	2 miles south of Springfield	Fair Deal Nursery		Dug
1554	1 mile south of Springfield	Mrs. Martha Lyles		Dug
1555	Springfield	R. T. Ponton		Dug
1556	1¼ miles north of Springfield	W. E. Dean		Dug
1557	On Braddock Road 3 miles southwest of Annandale, which is 8 miles west of Alexandria.	J. T. Bristow	F. N. Hagmann, Jr	Drilled
1558	1 mile southeast by south of Annandale.	John Bennett		Dug
1559	Annandale	Annandale School	F. N. Hagmann, Jr	Drilled
1560	½ mile west of Annandale	Towell Wakefield	F. N. Hagmann, Jr	Drilled
1561	2 miles southeast by south of Ilda, which is 3 miles east of Fairfax.	Thomas Ayers		Dug
1562	1 mile southeast of Ilda	Mr. Lowry	F. N. Hagmann, Jr	Drilled
1563	½ mile east of Ilda	H. C. Boughman		Dug
1564	Ilda	Edward Lee		Dug
1565	2 miles northwest of Annandale on Gallows Road.	Mrs. Groves	Mr. Puckett	Drilled
1566	3¼ miles southwest of Falls Church on Annandale road.	Mr. Waggaman	F. N. Hagmann, Jr	Drilled
1567	2 miles southwest of Falls Church toward Annandale.	R. A. Casilear	F. N. Hagmann, Jr	Drilled
1568	¼ mile south of Merrifield, which is 3 miles west of Falls Church.	A. G. Anderson		Dug
1569	Merrifield	Merrifield Nursery		Dug
1570	1 mile west of Merrifield on Lee Highway.	B. F. Salisbury	James Franklin	Drilled
1571	¼ mile north of Merrifield	Charles Kaiser		Dug
1573	2 miles west of Falls Church on Lee Lee Highway.	Strathmeade	(?)	Drilled
1574	Wedderburn, which is 4 miles northwest by west of Falls Church.	C. Sobrito		Dug
1575	Dunn Loring, which is 3 miles northwest by west of Falls Church.	Mr. Elgin	F. N. Hagmann, Jr	42 feet dug, rest drilled.
1576	Idylwood, which is 2 miles northwest by west of Falls Church.	Mr. Bean	F. N. Hagmann, Jr	Drilled
1577	Idylwood	G. B. Davis	F. N. Hagmann, Jr	Drilled

[b]In 1931. [c]Before drought of 1930-31. [e]In 1930.

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
43	Terrace gravel	Recent, Pleistocene and Pliocene (?).	39			1543
30	Terrace gravel	Recent, Pleistocene and Pliocene (?).	30			1544
32	Decomposed granite.	Algonkian (?)	28			1545
30	Granite soil	Algonkian (?)	28			1546
37	Sand, terrace gravel.	Recent, Pleistocene and Pliocene (?).	[c]34			1547
23	Terrace gravel	Recent, Pleistocene and Pliocene (?).	22			1548
34	Gravel and sand	Recent, Pleistocene and Pliocene (?).	30			1549
31	Gravel and sand	Recent, Pleistocene and Pliocene (?).	28			1550
67	White sand	Potomac	46	8	50 feet of 6-inch casing. Hand pump.	1551
133½	Blue granite at 100 feet.	Algonkian (?)	45	½	107 feet of 6-inch casing.	1552
25	Terrace gravel	Recent, Pleistocene an Pliocene (?).	[c]16			1553
27	Granite	Algonkian (?)	[c]23		4½-inch casing.	1554
33	8 feet of granite at bottom of well.	Algonkian (?)	25±			1555
28	Clay	Potomac	25			1556
56	Granite	Algonkian (?)		5	53 feet of casing. Hand pump.	1557
70	Granite	Algonkian (?)		4	44 feet of casing. Hand pump.	1557
25	Terrace gravel	Recent, Pleistocene and Pliocene (?).	21			1558
78½	Granite	Algonkian (?)		10	Cased to 73 feet.	1559
195	Granite	Algonkian (?)			Deep-well electric pump.	1560
43	Schist	Wissahickon		[b]Dry	Hand pump.	1561
80	Schist soil	Wissahickon	60±	¼	6 inch well. Unfinished.	1562
44	Schist	Wissahickon	42			1563
38	Schist	Wissahickon	34±		Bucket.	1564
77½	Schist soil	Wissahickon	35½	3+	5⅞-inch casing. Hand pump.	1565
83	Blue sand at 43 feet overlying granite.	Potomac; Algonkian (?).	43	6	45 feet of 6-inch casing. Electric deep-well pump with capacity of 1½ gallons a minute.	1566
86½	Sand overlying granite.	Pliocene (?), Pleistocene and Recent; Algonkian (?)	29½	10	72½ feet of 6-inch casing. Electric deep-well pump.	1567
36	Schist soil	Wissahickon	32			1568
36	Schist soil	Wissahickon	[c]16	Dry		1569
89	Schist	Wissahickon	50	14	40 to 50 feet of 6-inch casing.	1570
29	Schist	Wissahickon	27½			1571
76	Schist	Wissahickon	28	3½	Used during Spanish-American War for soldiers' camp.	1573
59	Schist	Wissahickon		4	Used during Spanish-American War for soldiers' camp.	1573
35	Schist soil	Wissahickon	34			1574
60	Clay	Potomac		0	Unfinished.	1575
182½	Schist	Wissahickon		7	6-inch well.	1576
93	Soft decomposed schist.	Wissahickon		3	86½ feet of 6-inch casing.	1577

WELL RECORDS

TABLE 38.—*Wells in Fairfax*

Well number	Location	Owner	Driller	Type of well
1578	Idylwood	Mr. Coe	F. N. Hagmann, Jr.	Drilled
1579	Leesburg pike 2½ miles northwest of Falls Church.	D. B. Patterson	F. N. Hagmann, Jr.	Drilled
1580	2 miles southeast of Tysons Crossroads, which is 4 miles northwest of Falls Church.	D. B. Patterson	F. N. Hagmann, Jr.	Drilled
1581	1¼ miles southeast of Tysons Crossroads on Leesburg pike.	John West	F. N. Hagmann, Jr.	Drilled
1582	1½ miles southeast of Tysons Crossroads on Leesburg pike.	E. M. Tyler	F. N. Hagmann, Jr.	Drilled
1583	1 mile southeast of Tysons Crossroads on Leesburg pike.	W. F. Fisher	F. N. Hagmann, Jr.	Drilled
1584	1 mile northeast of Tysons Crossroads on Lewinsville road.	J. W. Scrivener	F. N. Hagmann, Jr.	Drilled
1585	1 mile southwest of Lewinsville, which is 3½ miles northwest by north of Falls Church.	Dr. Ulfelder	F. N. Hagmann, Jr.	Drilled
1586	1 mile northwest of Tysons Crossroads.	C. C. Pierpont	James Franklin	Drilled
1587	1½ miles northwest of Lewinsville	P. E. Montgomery	F. N. Hagmann, Jr.	Drilled
1588	Spring Hill, which is 5½ miles northwest by north of Falls Church.	Mr. Meyers	F. N. Hagmann, Jr.	Drilled
1589	¼ mile south of Spring Hill	Mrs. Rector	F. N. Hagmann, Jr.	Drilled
1590	Georgetown pike 2 miles southeast of Difficult Run, 6¼ miles northwest by north of Falls Church.	Wallace Carper	F. N. Hagmann, Jr.	Drilled
1591	On Georgetown-Leesburg road near Difficult Run, 6¾ miles northwest by north of Falls Church.	Madeira School	F. N. Hagmann, Jr.	Drilled
1592	1¼ miles northwest of McLean, which is 3½ miles north of Falls Church.	F. J. Dahler	F. N. Hagmann, Jr.	Drilled
1593	Langley, which is 4¼ miles north of Falls Church.	Frank Lyon	F. N. Hagmann, Jr.	Drilled
1594	Langley	Frazier Guitrie	F. N. Hagmann, Jr.	Drilled
1595	Langley	Harry Darnes	F. N. Hagmann, Jr.	Drilled
1596	½ mile southwest of Langley	Mr. Briggs	F. N. Hagmann, Jr.	Drilled
1597	½ mile north of McLean	J. S. Smith	F. N. Hagmann, Jr.	Drilled
1598	Balls Hill, which is 1 mile northwest by west of McLean.	Edwards & Ball	F. N. Hagmann, Jr.	Drilled
1599	McLean	Captain Abel	F. N. Hagmann, Jr.	Drilled
1600	McLean	Mr. Schmidt	F. N. Hagmann, Jr.	Drilled
1601	McLean	Mr. Ross	F. N. Hagmann, Jr.	Drilled
1602	McLean	Cliff Loughlin	F. N. Hagmann, Jr.	Drilled
1603	¼ mile northwest of McLean	Mr. Davis	F. N. Hagmann, Jr.	Drilled
1604	McLean	Mr. Eaton	F. N. Hagmann, Jr.	Drilled
1605	¼ mile southeast of McLean	Chas. Hutchison	F. N. Hagmann, Jr.	Drilled
1606	McLean	Fire department	James Franklin	Drilled
1607	Lewinsville	Colin Hamilton	F. N. Hagmann, Jr.	Drilled
1608	Lewinsville	Clements Storm	James Franklin	Drilled
1609	¼ mile east of Langley	Burton Waters	James Franklin	Drilled
1610	1 mile east of Langley	John Robinson	Mr. Puckett	Drilled
1611	1¾ miles southeast by east of McLean	F. M. & C. H. Tompkins	F. N. Hagmann, Jr.	Drilled
1612	McLean	L. H. Young	F. N. Hagmann, Jr.	Drilled
1613	1 mile southeast of McLean	H. A. Conover	F. N. Hagmann, Jr.	Drilled
1614	1 mile southeast of McLean	Mr. Robinson	George Cullen	Drilled
1615	2¾ miles north of Falls Church	J. F. Casilow	F. N. Hagmann, Jr.	Partly dug.
1616	2¾ miles north of Falls Church	Mrs. Ruby Coleman	F. N. Hagmann, Jr.	Drilled
1617	2¾ miles north of Falls Church	A. Whetman	F. N. Hagmann, Jr.	Drilled
1618	1 mile north of Falls Church on Lewinsville road.	George C. Taylor	F. N. Hagmann, Jr.	Drilled
1619	1 mile north of Falls Church on Lewinsville road.	Ada Walker	F. N. Hagmann, Jr.	Drilled
1620	½ mile northwest of Falls Church	J. F. Taylor	F. N. Hagmann, Jr.	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
216	Schist	Wissahickon			200 feet of 6-inch casing.	1578
154	Schist	Wissahickon	70	8	134 feet of 6-inch casing.	1579
154	Schist	Wissahickon	70	8	134 feet of 6-inch casing.	1580
44	Schist	Wissahickon	36	20		1581
157	Schist	Wissahickon		6	141 feet of 6-inch casing.	1582
105	Schist	Wissahickon	50	6	83 feet of 6-inch casing.	1583
79	Schist	Wissahickon	20	4	4½-inch casing.	1584
147	Schist	Wissahickon		45	87 feet of 8-inch casing.	1585
98½	Decomposed schist	Wissahickon	22½	6½		1586
123	Schist	Wissahickon	70	7	6-inch casing.	1587
75	Schist	Wissahickon		15	6-inch galvanized casing.	1588
69	Schist	Wissahickon		10	71 feet of 4½-inch casing.	1589
71	Schist	Wissahickon		25	31½ feet of 6-inch casing.	1590
187	Schist	Wissahickon	37	7	88 feet of 6-inch casing.	1591
70	Schist	Wissahickon	40	3	6-inch casing.	1592
97	Granite	Algonkian (?)		10	45 feet of 6-inch casing.	1593
91½	Granite	Algonkian (?)			72½ feet of 6-inch casing.	1594
146	Granite	Algonkian (?)	30	2½	6-inch casing.	1595
90	Granite	Algonkian (?)		6	4½-inch well.	1596
82	Schist	Wissahickon		5	4½-inch well.	1597
135	Schist	Wissahickon	50±	8	92 feet of 6-inch casing.	1598
90	Schist	Wissahickon			4½-inch well.	1599
85	Schist	Wissahickon	14	6	6-inch well.	1600
90	Granite	Algonkian (?)	21	8	51½ feet of 4½-inch casing.	1601
91	Granite	Algonkian (?)	20	6	6-inch well.	1602
102	Schist	Wissahickon	35	7	93 feet of 4½-inch casing.	1603
55½	Schist	Wissahickon	18	12	43 feet of 4½-inch casing.	1604
66	Schist	Wissahickon		10	56 feet of casing.	1605
126	Granite	Algonkian (?)		12	80 feet of 5⅝-inch casing.	1606
75	Schist	Wissahickon	16	6	4-inch well.	1607
143	Schist	Wissahickon	40	14	88½ feet of 5⅝-inch casing.	1608
{ 104	Granite	Algonkian (?)	24	4	92 feet of casing.	
{ 110	Granite	Algonkian (?)	30	12	97 feet of casing.	1609
93½	Granite	Algonkian (?)	33	4½		1610
116½	Granite	Algonkian (?)	17	25	6-inch casing.	1611
82	Schist	Wissahickon		5	4-inch casing.	1612
88½	Schist	Wissahickon	40	14	74½ feet of 6-inch casing.	1613
90	Schist	Wissahickon		¼		1614
60	Schist	Wissahickon	20	5	4-inch casing.	1615
52	Schist	Wissahickon	25	14	34 feet of 6-inch casing.	1616
64	Granite	Algonkian (?)		5	30 feet of 4½-inch casing.	1617
115	Schist at 106 feet	Wissahickon	55	6	106½ feet of 6-inch casing.	1618
{ 74	Schist	Wissahickon	50	6	4½-inch well.	
{ 145	Schist	Wissahickon		8	4½-inch well.	1619
115	Schist	Wissahickon	15	10	108 feet of 6-inch casing.	1620

WELL RECORDS

TABLE 38.—*Wells in Fairfax*

Well number	Location	Owner	Driller	Type of well
1621	Falls Church	Mrs. Brenizer	F. N. Hagmann, Jr.	Drilled
1622	Falls Church	Mrs. Lovelace	F. N. Hagmann, Jr.	Drilled
1623	Falls Church	St. James School	F. N. Hagmann, Jr.	Drilled
1624	Falls Church	A. S. Worthington	F. N. Hagmann, Jr.	Drilled
1625	Falls Church	F. W. Lawrence	F. N. Hagmann, Jr.	Drilled
1626	Falls Church	Mrs. Grumdry	F. N. Hagmann, Jr.	Drilled
1627	Falls Church	Mrs. Rosa B. Ogden	F. N. Hagmann, Jr.	Drilled
1628	Falls Church	Town of Falls Church	F. N. Hagmann, Jr.	Drilled
1629	Falls Church	Col. R. B. Robinson	F. N. Hagmann, Jr.	Drilled
1630	Falls Church	E. P. Harrison	F. N. Hagmann, Jr.	Drilled
1631	Falls Church	Falls Church High School	F. N. Hagmann, Jr.	Drilled
1632	Falls Church	A. L. Anderson	F. N. Hagmann, Jr.	Drilled
1633	Falls Church	Mr. Boland	F. N. Hagmann, Jr.	Drilled
1634	Falls Church	Susie Boland	F. N. Hagmann, Jr.	Drilled
1635	1 mile west of Falls Church	Mr. Roberts	F. N. Hagmann, Jr.	Drilled
1636	Falls Church	J. T. Cowgill	F. N. Hagmann, Jr.	Drilled
1637	1 mile west of Falls Church	H. F. Cornwell		Dug
1638	1 mile southeast of Falls Church	J. R. Thorne	F. N. Hagmann, Jr.	Drilled
1639	1 mile south of Falls Church	J. W. Kerns	F. N. Hagmann, Jr.	40 feet dug, rest drilled.
1640	Annandale Church, 1 mile northeast of Annandale on Little River pike.	Morton T. Webb	F. N. Hagmann, Jr.	Drilled
1641	1¼ miles northeast by east of Annandale.	G. H. Williams	F. N. Hagmann, Jr.	Drilled
1642	2 miles east of Annandale, near Alexandria Reservoir.	W. L. Clark		Dug
1643	1½ miles southeast of Baileys Crossroads, which is 3 miles southeast of Falls Church.	W. S. Lacey		Dug
1644	½ mile southeast of Baileys Crossroads on Alexandria-Leesburg road.	O. A. Delvigne	F. N. Hagmann, Jr.	Drilled
1645	¾ mile southeast of Baileys Crossroads.	Mr. Cornelius	F. N. Hagmann, Jr.	84 feet dug, rest drilled.
1646	1 mile south of Baileys Crossroads	R. E. Dugan	F. N. Hagmann, Jr.	Drilled
1647	¾ mile northwest of Lincolnia, which is 4¾ miles west of Alexandria.	J. L. Melton	Beatty & Aicholtz	Drilled
1648	1½ miles northwest by west of Lincolnia on Little River road.	G. W. Biller		Dug
1649	½ mile west of Lincolnia on Little River road.	Mrs. J. D. Graham	F. N. Hagmann, Jr.	Drilled
1650	½ mile west of Lincolnia	R. D. Lewis	F. N. Hagmann, Jr.	Drilled
1651	¼ mile south of Lincolnia	B. L. Carter	F. N. Hagmann, Jr.	Drilled
1652	1 mile northwest of Theological Seminary, which is 2½ miles northwest of Alexandria.	Mrs. R. Klipstein	F. N. Hagmann, Jr.	Drilled
1653	¼ mile northwest of Episcopal High School, which is 2½ miles northwest of Alexandria.	Mrs. W. Brookings	F. N. Hagmann, Jr.	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
62	Granite	Algonkian (?)	25	10		1621
85	Schist at 72 feet	Wissahickon	24	15	72 feet of 4½-inch casing.	1622
63	Granite at 53 feet	Algonkian (?)		10	53 feet of 6-inch casing.	1623
65	Granite	Algonkian (?)	20	4	4½-inch casing.	1624
90	Schist	Wissahickon	50	4	6-inch casing.	1625
70	Granite	Algonkian (?)		14	6-inch galvanized casing.	1626
62	Granite	Algonkian (?)	25	5	4½-inch casing.	1627
300	Granite	Algonkian (?)	31	25	Public supply.	1628
265	Granite	Algonkian (?)	60		Public supply.	
400 (?)	Granite	Algonkian (?)	35-38		Public supply.	
90	Granite	Algonkian (?)			32 feet of 4½-inch casing.	1629
95	Granite	Algonkian (?)		8	68 feet of 4½-inch casing.	1630
76	Granite	Algonkian (?)	27	12	6-inch casing.	1631
92	Granite	Algonkian (?)	23	8	61½ feet of 4½-inch casing.	1632
50	Granite	Algonkian (?)	35	10	4½-inch well.	1633
90	Granite	Algonkian (?)	24	8	4½ inch well.	1634
87	Schist at 76 feet	Wissahickon	34	12	76 feet of casing.	1635
188	Schist at 154 feet	Wissahickon	23	12	154 feet of 6-inch casing.	1636
32	Schist soil	Wissahickon	23			1637
136	Beds of sand	Recent, Pleistocene Pliocene (?), Potomac.	45	15	131 feet of 6-inch casing. Granite at bottom of the well.	1638
61	Granite	Algonkian (?)	19	18	61 feet of 6-inch casing. Electric pump.	1639
90	Granite at 68 feet	Algonkian (?)		8-10	Analysis on p. 186.	1640
127	Sand	Potomac	52	7	120± feet of 6-inch casing. Granite encountered below water bearing sand.	1641
36	Soft sandstone	Potomac	35	5	Electric pump. Capacity 5 gallons a minute.	1642
33	Sand below bed of clay.	Potomac	29		Buckets.	1643
431	Terrace gravel	Recent, Pleistocene and Pliocene (?).	80	5	8-inch well cased to 240 feet, with strainer at bottom. Deep-well electric pump, granite at bottom of the well. Analysis on p. 186.	1644
140	Granite	Algonkian (?)	90	2½	124 feet of casing.	1645
135	2-3-foot bed of sand above granite.	Potomac	117	2½	128 feet of casing 4½-inch in diameter.	1646
114	Granite	Algonkian (?)	37	8	72 feet of 6-inch casing. Hand pump.	1647
21	Terrace gravel	Recent, Pleistocene and Pliocene (?).	18			1648
130	Granite	Algonkian (?)	80	2¼	98 feet of 6-inch casing. Electric pump.	1649
125	Blue clay from 60 feet.	Potomac	50	5	Deep-well electric pump with capacity of 3 gallons a minute.	1650
250	Sand at 117 feet	Potomac	110-115	1	117 feet of 6-inch casing. Well filled with sand to the 117-foot level.	1651
205	13-foot bed of sand	Potomac	90	10	192 feet of 4½-inch casing. Yielded 6 gallons a minute at 150 feet, but water would not clear up.	1652
170	5 feet of granite	Algonkian (?)	40	14	165½ feet of 6-inch casing.	1653

WELL RECORDS

TABLE 38.—*Wells in Fairfax*

Well number	Location	Owner	Driller	Type of well
1654	Episcopal High School	Episcopal High School	Charles Dowling	Drilled
1655	Seminary Hill, Alexandria, near Theological Seminary.	Mr. Hulfish	F. N. Hagmann, Jr.	45 feet dug, rest drilled.
1656	Seminary Hill, Alexandria, ¼ mile north of Little River road.	Conrad Strong	F. N. Hagmann, Jr.	Drilled
1657	Seminary hill, ⅛ mile north of Little River road.	Sydney H. Smith	F. N. Hagmann, Jr.	Drilled
1658	2½ miles west of Alexandria on Little River road.	Mrs. S. O. Jones		Dug
1659	2½ miles west of Alexandria on Little River road.	Lee-Jackson School	F. N. Hagmann, Jr.	Drilled
1660	2½ miles west of Alexandria on Little River road.	D. J. Culleton	F. N. Hagmann, Jr.	Drilled
1661	1½ miles west of Alexandria on Little River road.	Mr. Beatty	Beatty & Aicholtz	Drilled
1662	1 mile west of Alexandria on Little River road.	Mr. Starnell	Beatty & Aicholtz	Drilled
1663	1½ miles southwest by west of Alexandria.	N. M. Ridgeway	F. N. Hagmann, Jr.	Drilled
1664	2 miles southwest by west of Alexandria.	W. F. Downey	Mr. Snyder	Drilled
1665	1¾ miles southwest of Alexandria	J. A. Edginton	R. L. Thomas	Drilled
1666	1¾ miles southwest of Alexandria	J. A. Tomlin		Dug
1667	On hill south of Hunting Creek, 1½ miles southwest of Alexandria.	F. H. Duehey	F. N. Hagmann, Jr.	Drilled
1668	Belle Haven, which is 1 mile southwest of Alexandria near Hunting Creek.	Belle Haven	F. N. Hagmann, Jr.	42 feet dug, rest drilled
1669	2 miles southwest of Alexandria	Mr. Bayliss	James Franklin	36 feet dug, rest drilled.
1670	2½ miles southwest of Alexandria on U. S. highway 1.	Penn-Daw Hotel	F. N. Hagmann, Jr.	Drilled
1671	2½ miles southwest of Alexandria on U. S. highway 1.	Mrs. Peck	F. N. Hagmann, Jr.	Drilled
1672	2¾ miles southwest of Alexandria on U. S. highway 1.	Reid Dairy Farm	Beatty & Aicholtz	61 feet dug, rest drilled.
1673	Hybla Valley, which is 4 miles southwest by south of Alexandria.	Henry Painter	F. N. Hagmann, Jr.	Drilled
1674	1 mile west of Warwick between U. S. highway 1 and Fort Hunt road.	H. P. Wilson	F. N. Hagmann, Jr.	Drilled
1675	Warwick, which is on Mount Vernon Memorial Highway, 3½ miles south of Alexandria.	Girl's Friendly Society Holiday House.	F. N. Hagmann, Jr.	Drilled
1676	3 miles northwest by north of Fort Hunt.	F. H. Wilkinson	Anderson & Osgood	18 feet dug, rest drilled.
1677	Wellington, which is 2 miles north of Fort Hunt.	Harry White	Beatty & Aicholtz	Drilled

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
300 320 448	White sand overlain by blue "marl".	Potomac		0 40 50	2 deep-well pumps with capacities of 50 and 40 gallons a minute. These wells weakened after use, but not owing to drought. Deepest well went 40 feet into granite.	1654
150	Beds of sand	Recent, Pleistocene and Pliocene (?), Potomac.		8	150 feet of casing.	1655
255	Granite	Algonkian (?)		40	243 feet of 6-inch casing.	1656
125	Sand	Potomac	85	10–15	125 feet of casing.	1657
40±	Sand and gravel	Potomac	32			1658
65	Sand	Potomac	20–30?	6	62 feet of casing.	1659
83	White sand near bottom of well	Potomac		6	Hand force pump.	1660
36	White sand	Potomac	16	12	Log on p. 182.	1661
160	Gray sand	Potomac	75	15	Log on p. 183.	1662
72	Sand and gravel associated with dark clay.	Potomac	60–62			1663
217	Gravel	Potomac	80±			1664
241	White sand near bottom of the well.	Potomac	80		5-inch casing to bottom of well. Electric deep-well pump.	1665
53	Sand in terrace gravel.	Recent, Pleistocene and Pliocene (?).	44½		Hand pump.	1666
249	Sand in terrace gravel.	Recent, Pleistocene and Pliocene (?), Potomac.	177	10	249 feet of 5-inch casing with 12-foot strainer at bottom. Electric deep-well pump.	1667
207	Sand	Potomac	65	20	6-inch casing. Deep-well pump of capacity of 25 gallons a minute once supplied 10 homes.	1668
60	Gravel	Potomac		4	51 feet of casing.	1669
315	Sand	Recent, Pleistocene and Pliocene (?), Potomac.		12	10 feet of 14-slot strainer.	1670
237	Sand	Recent, Pleistocene and Pliocene (?) Potomac.		6		1671
297	Medium gray sand from 266 feet to 281 feet.	Potomac	245	18	Log on p. 183.	1672
137	White sand	Potomac	23	20	Analysis on p. 186.	1673
240	Sand	Potomac	175–200	55+	Brass strainer near bottom.	1674
282	Sand	Potomac		15–20	Cased to bottom. 16-slot strainer. Deep-well electric pump.	1675
220	Sand	Potomac	0	5½	6-inch casing. Deep-well gasoline pump, capacity 5 to 6 gallons a minute.	1676
143	White sand at 143 feet.	Potomac	70	15	135 feet of 6-inch casing. Log on p. 183.	1677

WELL RECORDS

TABLE 38.—*Wells in Fairfax*

Well number	Location	Owner	Driller	Type of well
1678	Warwick	J. M. Reed	F. N. Hagmann, Jr.	Drilled
1679	Arcturus, which is 1½ miles north of Fort Hunt.	C. L. Roberts		Dug
1680	2 miles north of Mount Vernon, which is 2 miles west of Fort Hunt.	WJSV Radio Station	Charles Dowling	Drilled
1681	2½ miles north of Mount Vernon	George Taylor	Beatty & Aicholtz	21 feet dug, rest drilled.
1682	2½ miles north of Mount Vernon	George Taylor	Beatty & Aicholtz	22 feet dug, rest drilled.
1683	2 miles northwest by west of Mount Vernon.	Mr. Badger	Beatty & Aicholtz	12 feet dug, rest drilled.
1684	2 miles northwest by west of Mount Vernon.			Drilled
1685	1 mile northwest by north of Mount Vernon.	Gilbert Fletcher	F. N. Hagmann, Jr.	Drilled
1686	1 mile north of Mount Vernon	Mrs. Klipstein	F. N. Hagmann, Jr.	Drilled
1687	1¼ miles northwest of Fort Hunt	Mrs. E. H. Scarlett	Mr. Burch	Drilled
1688	1 mile north of Fort Hunt	Mr. Wilkins	F. N. Hagmann, Jr.	Drilled
1689	1¼ miles northwest by west of Mount Vernon.	Mr. Costello	F. N. Hagmann, Jr.	Drilled
1690	Mount Vernon	Mount Vernon Association	F. N. Hagmann, Jr.	Drilled
1691	Mount Vernon	Mount Vernon Association	F. N. Hagmann, Jr.	Drilled
1692	Mount Vernon	Mount Vernon Association	Shannahan Bros.	Drilled
1693	Fort Hunt	U. S. Army	Mr. Anderson	Drilled

[1] At time of drilling total yield was tested at 250+ gallons a minute.

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
88	Water sand overlain by clay.	Potomac		6–12	Deep-well pump.	1678
20	Sand	Potomac	19			1679
200	Sand	Potomac	85	9		1680
56	White coarse sand	Potomac	17	16	6-inch casing.	1681
59	White coarse sand	Potomac	21	5	6-inch. casing. Electric shallow-well pump.	1682
52	Dark sand	Potomac	12	15	52 feet of 6-inch casing.	1683
24	Sand	Potomac	13	1±	24 feet of 5⅝-inch casing.	1684
123	Sand	Potomac	95	5	119 feet of 4½-inch casing.	1685
160	Sand	Potomac	80	10	147 feet of 4½-inch casing.	1686
125	Sand	Potomac		3	5-inch casing.	1687
164	Sand	Potomac		20		1688
100	Sand	Potomac		10	93 feet of casing.	1689
530	Blue and gray sand	Potomac	81	/100	514 feet of 6-inch casing. Electric pump. Log on p. 184, analysis on p. 186.	1690
179	Sand	Potomac	87½	60	Electric pump. Log on p. 185.	1691
525	Green sand	Potomac	21⅜	15	525 feet of 8-inch casing. Gould triplex electric pump. Log on p. 185, analysis on p. 186.	1692
284	Sand	Potomac	30	34	6-inch casing with 5-inch pipe inside. Air compressor pump.	1693

TABLE 39.—*Logs of wells in Fairfax County, Virginia*

Well 1522, 1 mile north of Occoquan.

	Thickness (feet)	Depth (feet)
Recent		
Pleistocene		
Pliocene (?)		
Yellow sandy clay	18	18
Potomac group:		
White sandy clay	35	53
Coarse sand	12	65

Well 1536 (test well), Fort Humphreys.

	Thickness (feet)	Depth (feet)
Potomac group:		
Fill, heavy gravel	5	5
Boulders	1	6
Fill, gravel	19	25
Sand and gravel	6	31
Blue sandy clay	13	44
Fine gray sand	10	54
Brown sandy clay	3	57
Fine brown sand	10	67
Sand and gravel	12	79
Gray sand, some clay	11	90
Blue sand, boulders	10	100
Dark sandy clay	8	108
Brown sandy clay	108	216
Blue sand	21	237
Hard sand, boulders	16	253
Algonkian (?):		
Rock, hard (granite)	19	272
Granite	7	279

Well 1661, 1½ miles west of Alexandria on Little River road.

	Thickness (feet)	Depth (feet)
Potomac group:		
Clay	26	26
Hardpan	8	34
White sand; water	2	36

Well 1662, 1 mile west of Alexandria, on Little River road.

	Thickness (feet)	Depth (feet)
Potomac group:		
Yellow clay	65	65
Yellow clay with gravel	35	100
Blue clay	55	155
Gray sand; water	5	160

Well 1672, ½ mile south of Penn-Daw Hotel on U. S. Highway 1.

	Thickness (feet)	Depth (feet)
Potomac group:		
Old dug well	61	61
Blue clay	10	71
Yellow sand	15	86
Blue and gray stiff clay	180	266
Gray sand, medium-grained; water	15	281
Gray and yellow stiff clay	16	297

Well 1677, Wellington, 2 miles north of Fort Hunt.

	Thickness (feet)	Depth (feet)
Potomac group:		
Yellow clay	60	60
Gray sand and gravel; 20 gallons of water a minute, muddy, cased off	30	90
Fine silty dark sand; no water	12	102
Hard slate-colored clay	25	127
Slate-colored clay that becomes shaly	16	143
White sand; water.		

Well 1690, at Engine House, Mount Vernon.

[Altitude, about 100 feet above sea level]

	Thickness (feet)	Depth (feet)
Potomac group:		
Gravel and cobbles	15	15
Blue clay	14	29
Sand; no water	24	53
Blue clay	3	56
Sand; very little water	9	65
Blue clay and "marsh mud"	17	82
Blue clay, very hard	11	93
Sand; very little water	7	100
Blue clay	15	115
"Marsh mud" and sand	13	128
Blue clay	11	139
Blue and gray water-bearing sand; 100 gallons of water a minute	28	167
Gray sand	24	191
Green sandy clay	9	200
Blue and green clay	25	225
Blue clay	26	251
Blue sandy clay	13	264
Blue and brown clay	6	270
Brown clay	15	285
Blue and brown clay	23	308
Gray sand; 30 gallons of water a minute	8	316
Blue clay	3	319
Blue and brown clay	19	338
Brown clay	11	349
Blue and brown clay	11	360
Blue clay	14	374
Blue and gray sand; 65 gallons of water a minute	23	397
Blue sandy clay	10	407
Yellow clay	11	418
Brown clay, "very hard to mix"	7	425
Blue and brown clay	25	450
Blue clay	15	465
Blue and brown clay	7	472
Brown clay	16	488
Blue and brown clay, very hard	17	505
Blue clay	6	511
Blue and sandy clay	11	522
Fine sand; 55 gallons of water a minute	8	530

Well 1691, near Engine House, Mount Vernon.

[Altitude, 91 feet above sea level]

	Thickness (feet)	Depth (feet)
Potomac group;		
Sand and gravel	30	30
Sandy clay	10	40
Light-blue clay	10	50
Dark-blue clay	20	70
Fine dark-colored sand	15	85
Coarse sand	14	99
Fine white sand	2	101
Gray sand; water-bearing	1	102
Fine white sand	16	118
Blue clay	16	134
Gravel and sand	9	143
Gravel, sand, and clay	16	159
Sand; 60 gallons of water a minute	20	179

Well 1692, near wharf, Mount Vernon.

[At sea level]

	Thickness (feet)	Depth (feet)
Potomac group:		
Blue and red clay	10	10
Gray and red clay	15	25
Hard green and blue clay	25	50
Hard green, brown, and blue clay	25	75
Sandy brown clay	25	100
Coarse green water-bearing sand, smelling of marsh water	25	125
Brown and green clay and gray sandy clay	25	150
Marsh clay	50	200
Green and blue clay	100	300
Light-green sandy clay	25	325
Light-green sand; water-bearing below 340 feet, source of present supply	25	350
Clay	165	515
Algonkian (?):		
Bedrock	10	525

ANALYSES OF WATER

TABLE 40.—*Analyses of ground waters from Fairfax County, Virginia*

[Analyst, S. K. Love. Parts per million. Numbers at heads of columns refer to corresponding well numbers in Table 37.]

	1333	1358	1426	1430	1542	1640	1644	1673	1690	1692
Silica (SiO_2)	.....	20	.....	44	.....	.....	.....	53	42	24
Iron (Fe)	.....	.14	.....	.91	.....	.....	.....	.31	13	.04
Calcium (Ca)	[a]24	8.1	[a]4	9.1	[a]6	[a]6	[a]2	6.0	3.9	.5
Magnesium (Mg)	.....	4.0	.....	9.6	.....	.....	.....	1.7	2.4	.3
Sodium (Na)	.....	6.9	.....	8.8	.....	.....	.....	40	5.3	69
Potassium (K)	.....	1.8	.....	2.0	.....	.....	.....	3.9	2.4	1.4
Bicarbonate (HCO_3)	162	30	25	83	37	55	52	136	43	164
Sulphate (SO_4)	[a]4	2.2	[a]1	3.1	[a]7	[a]1	[a]2	2.2	3.1	6.7
Chloride (Cl)	10	7.0	5.0	6.0	2.0	3.0	9.0	1.0	4.0	10
Nitrate (NO_3)	.57	12	2.5	.15	.0	.10	2.1	.0	.0	.05
Total dissolved solids	.....	72	.....	105	.....	.....	.....	178	81	192
Total hardness as $CaCO_3$ (calculated)	[b]122	37	[b]21	62	[b]27	[b]33	[b]33	22	20	2.5
Date of collection (1931)	Oct. 21	Oct. 21	Oct. 21	Oct. 23	Oct. 21	Oct. 21	Oct. 21	Oct. 23	Oct. 23	Apr. 8 (1932)

[a]By turbidity.
[b]Determined.

ARLINGTON COUNTY

GEOGRAPHY

Arlington County, once part of the District of Columbia, is 25 square miles in area. The independent city of Alexandria now controls 6 square miles of territory that formerly belonged to the county. The population in 1930, not including Alexandria, was 26,615, or 1,064.6 persons to the square mile, by far the densest population in northern Virginia. Alexandria had a population of 24,149 in 1930, and Falls Church, which lies partly in Arlington and partly in Fairfax County, had a population of 2,019. A large part of the population is made up of persons employed in Washington, D. C. In 1929 there were 51 industrial establishments in Arlington County and Alexandria, many of which are situated along the river; the products were valued at $8,868,761. Agriculture is not practiced extensively, only 9.4 per cent of the area being under cultivation, most of it in the western part of the county.

Arlington County is served by the same transportation agencies as Fairfax County—the Southern Railway with the Chesapeake & Ohio using its right of way, the Richmond, Fredericksburg & Potomac Railroad, and the Arlington & Fairfax and Washington & Old Dominion electric lines. The main highways are the Winchester turnpike and the Lee Highway, leading west, and the Mount Vernon Memorial Highway and U. S. Highway 1, which connect Alexandria with Washington and other points north and south.

DRAINAGE AND TOPOGRAPHY

The largest stream in Arlington County is Fourmile Run, which drains the southern part of the county southeastward to Potomac River. The rest of the streams are small, rising near the top of the escarpment that borders the Piedmont Plateau and flowing through gorges into the Potomac.

The topography of Arlington County is characterized by the rolling dissected upland of the Piedmont Plateau, which is deeply incised near Potomac River by the streams that have cut back through the escarpment into the plateau. Back from the river the altitude of the upland is about 350 to 400 feet and the valley floors are from 50 to 100 feet below this level. North of Rosslyn there is a descent of 250 feet from the plateau to the river in a single escarpment. Farther south the descent is more gradual over flat but dissected river terraces.

GEOLOGY

The formations present in Arlington County are the granite of the eastern belt, of Algonkian (?) age, the Lower Cretaceous Potomac group, the terrace gravels of Pliocene (?), Pleistocene, and Recent age, and Recent alluvium. The granite of the eastern belt is extensively jointed and locally schistose, as elsewhere in the Piedmont Plateau. The sediments of the Coastal Plain lie in the southeastern part of the county. They lie unconformably upon the granite, dipping southeastward at low angles. The higher, older terrace gravel is present in most of the eastern part of the county, but in much of the western part it has been eroded so generally that it remains only in isolated outliers.

GROUND-WATER CONDITIONS

Area of crystalline rocks.—Most of the wells drilled into the granite are of shallow or moderate depth and deliver from 2 to 10 gallons a minute. As most of these supplies are for household uses, the wells may be considered satisfactory and economical. Even though a well may deliver only a very small amount of water, this water can be stored in a tank with an automatic pumping system so that shortages are not likely to be experienced. The granite area is very unsatisfactory for those who need an abundant supply of water, such as some of the industrial establishments in the east-central part of the county. The Bergmann Laundry, on the Lee Highway, Rosslyn drilled five wells (No. 1722) to depths of 740, 705, 140, 40, and 40 feet and obtained a total supply of only about 20 gallons a minute. It must be said, however, that these unusually poor results are probably due in part to the fact that the site of the drilling is in a newly cut gorge where there is no zone of decomposed and highly jointed rock. There are not many places in which wells have been drilled without obtaining at least a small supply of water, and few drilled wells that were once satisfactory failed in the drought of 1930 and 1931. An objection to the ground water in the granite area is that in many places it contains small flakes of mica, which settle out very slowly. In a drilled well, cased tightly to the zone of weathered rock below the soil, there will probably be little mica; however, where it is present pumping the well to full capacity for some time generally clears the water. The water in the granite is likely to be harder than in most areas of crystalline rock, but it is otherwise low in dissolved solids and very suitable both for drinking and for most industrial uses.

The dug wells range in depth between 20 and 50 feet. In most places it would be necessary to blast into hard rock to dig a well more than 50 feet below the surface. The water level lies from 20 to 50 feet below the ground. Dug wells in this area, as in the synclinal area of

Fairfax County, failed in great numbers during 1930 and 1931. Some were dug deeper, but many others were drilled or neglected temporarily. It would not be advisable to dig new wells, as drilling usually has been found to be the more satisfactory procedure.

Springs are not very numerous or large in this area of Arlington County. They occur as seeps near the foot of the walls of valleys.

Coastal Plain area.—The drilled wells in the Coastal Plain area are very satisfactory on the whole. Many household wells of small diameter and moderate depth deliver more than enough water for ordinary uses. Some of the wells drilled near the western edge of the Coastal Plain in the thin terrace gravel are not very successful because the terraces or sheets of gravel have been cut up into small patches by stream erosion; thus the intake area for such wells is very small. On the other hand, near Alexandria some wells (No. 1758) put down for the Alexandria Ice Co. to a depth of 300 feet, gravel-packed and equipped with screens, deliver from 100 to 160 gallons a minute each. The strongest wells in this area are shallow drilled wells, 6 inches in diameter, in the Recent alluvial material on the west bank of the Potomac near the Washington airport. One well (No. 1737) 5 feet deep yields 350 gallons a minute and one 27 feet deep yields 320 gallons a minute. Not all the wells drilled near the river are so strong, however.

Dug wells are mostly shallow, from 15 to 40 feet deep. The yield of these wells, where known, is small. Arlington County is thickly settled, but much of it has no system of sewage disposal other than private septic tanks; therefore it is probable that owners of dug wells would be wise to abandon them in favor of city water or drilled wells.

There are a few springs in this part of Arlington County. The yields are small, but those used for domestic supplies appear to be adequate and reliable. However springs are open to the same objection as dug wells—the danger of pollution.

MUNICIPAL SUPPLIES

There are no communities in Arlington County that derive their water supplies from ground water.

WELL

TABLE 41.—*Wells in*

Well number	Location	Owner	Driller	Type of well
1700	West of Chain Bridge, which is at northernmost point in the county.	Henry Lentz	W. E. Croson	Drilled
1701	2 miles northwest of Halls Hill	Saegmuller School		Dug
1702	2 miles northwest of Halls Hill, which is 2½ miles west of Rosslyn.	I. W. Langton		Dug
1703	Midway between Cherrydale, which 1¾ miles west of Rosslyn and Chain Bridge.	(?)		Dug
1704	Vanderwerken, which is 2 miles northeast of Falls Church.	L. H. Buckman		Dug
1705	Vanderwerken	M. J. Saegmuller	(?)	Drilled
1706	½ mile northwest of Halls Hill	M. R. Beck	(?)	Drilled
1707	Livingston Heights, which is 2½ miles west of Rosslyn.	John Marshall School	W. E. Croson	Drilled
1708	1½ miles northeast of Falls Church	Mr. Wolfe	F. N. Hagmann, Jr.	Drilled
1709	1½ miles northeast of Falls Church on Lee Highway.	Robert E. Lee School	W. E Croson	Drilled
1710	½ mile northeast of Falls Church on Lee Highway.	J. S. Wine	F. N. Hagmann, Jr.	Drilled
1711	½ mile east of Falls Church	J. A. Hicks	F. N. Hagmann, Jr.	Drilled
1712	1 mile northeast of Falls Church	S. W. Fox	F. N. Hagmann, Jr.	Drilled
1713	1 mile northeast of Falls Church on Lee Highway.	I. C. Burneston	F. N. Hagmann, Jr.	Drilled
1714	1 mile northeast of Falls Church on Lee Highway.	L. E. Shoemaker	F. N. Hagmann, Jr.	Drilled
1715	Halls Hill	John M. Langston School		Dug
1716	Cherrydale	E. M. Shreve	George Cullen	Drilled
1717	Cherrydale	E. M. Shreve	George Cullen	Drilled
1718	Cherrydale	Cherrydale School	Mr. Hunter	Drilled
1719	Between Cherrydale and Rosslyn	George Cullen	George Cullen	Drilled
1720	Between Cherrydale and Rosslyn	Lyon & Fitch	Charles R. Dowling	Drilled
1721	Rosslyn	Woodrow Wilson School	W. E. Croson	Drilled
1722	Rosslyn	Bergmann's Laundry	J. T. Helbert	Drilled
1723	Rosslyn	Hires Turner Glass Co	George Cullen	Drilled
1724	Rosslyn	Crupper Lumber Co	George Cullen	Drilled
1725	Clarendon, which is 1 mile southwest by west of Rosslyn.	G. B. B. Ricker		Dug
1726	Clarendon	Marcey's dairy	W. E. Croson	Drilled
1726a	Clarendon	Marcey's dairy	W. E. Croson	Drilled
1726b	Clarendon	Marcey's dairy	George Cullen	Drilled
1727	Clarendon	Arlington Bottling Works	Geo. Cullen	Drilled
1728	Between Cherrydale and Clarendon on Washington & Old Dominion Railway.	Virginia Ice & Fuel Corporation.	George Cullen	Drilled
1729	Between Clarendon and Cherrydale	Washington and Lee High School.	W. E. Croson	Drilled
1730	1 mile east of Falls Church	B. E. Barnes	F. N. Hagmann, Jr.	Drilled

RECORDS

Arlington County, Virginia

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
57	Sand, decomposed granite, and a little sound granite.	Algonkian (?)		½		1700
42	Terrace gravel	Recent, Pleistocene and Pliocene (?).	38½			1701
54½	Decayed granite	Algonkian (?)	51½		Buckets used.	1702
35	Granite	Algonkian (?)	28			1703
31	Granite soil	Algonkian (?)	23		Hand pump.	1704
560	Granite	Algonkian (?)				1705
135	Granite	Algonkian (?)	47		Hand pump.	1706
90	Granite soil and decomposed granite.	Algonkian (?)	60±	4	60 feet of 6-inch casing. Deep-well pump, with capacity of 2½ gallons a minute.	1707
122	Granite	Algonkian (?)	35	4	84 feet of 4½-inch casing.	1708
80	Granite soil and decomposed granite.	Algonkian (?)	50±	8	60± feet of 6-inch casing. Deep-well pump with capacity of 2½ gallons a minute.	1709
80	Granite soil and granite.	Algonkian (?)	30	4		1710
100	Granite	Algonkian (?)	50	2	77 feet of 6-inch casing.	1711
67	Granite	Algonkian (?)		7	58 feet of 6-inch casing.	1712
65	Granite	Algonkian (?)	25	5	4½-inch casing.	1713
114	Granite	Algonkian (?)		1	6-inch casing.	1714
40	Granite soil	Algonkian (?)	34½	Very small		1715
46	Decomposed granite.	Algonkian (?)	12			1716
60	Granite soil	Algonkian (?)			Deep-well pump. Water becomes muddy after rain.	1717
83	Granite soil and 7 feet of granite.	Algonkian (?)	50		Electric deep-well pump.	1718
84	Granite	Algonkian (?)	20	1½	18 feet of 6-inch casing. Deep-well pump.	1719
302	Granite	Algonkian (?)				1720
180	Granite	Algonkian (?)	50±	10	Deep-well pump. 50 to 60 feet of 6-inch casing.	1721
740	Granite	Algonkian (?)		3–5	The wells are cased only about 16 feet or less. Electric double-action deep-well pump. Analysis on p. 196.	1722
705	Granite	Algonkian (?)	0	11		
40	Granite	Algonkian (?)		1		
40	Granite	Algonkian (?)		1		
140	Granite	Algonkian (?)		2–3		
175	Granite	Algonkian (?)	10	2¼		1723
75	Granite	Algonkian (?)		3		1724
20	Terrace gravel	Recent, Pleistocene and Pliocene (?).	17±		Windmill.	1725
60	Gravel	Recent, Pleistocene and Pliocene (?).	30±		Electric deep-well pump. Perforated casing from 20 to 59 feet.	1726
100	Decomposed granite.	Algonkian (?)				1726a
150	Decomposed granite.	Algonkian (?)				1726b
180	Clay	Potomac		0		1727
30 60 160 30-60	Terrace gravel	Recent, Pleistocene and Pliocene (?).	24	22	Myers electric deep-well pumps. Temperature 61°F.	1728
139	Terrace gravel (well went 4 feet into granite).	Recent, Pleistocene and Pliocene (?).	30	8	Electric deep-well pump.	1729
96	Granite	Algonkian (?)		12	90 feet of 6-inch casing.	1730

WELL RECORDS

TABLE 41.—*Wells in Arlington*

Well number	Location	Owner	Driller	Type of well
1731	¼ mile west of Ballston, which adjoins Clarendon on west.	Bon Air School	W. E. Croson	Drilled
1732	1 mile west of Ballston	M. Griffin	F. N. Hagmann, Jr.	Drilled
1733	Ballston	Mrs. E. C. Owen		Dug
1734	Ballston	Dr. R. S. Noland	F. N. Hagmann, Jr.	Drilled
1735	Ballston	H. J. Isted	F. N. Hagmann, Jr.	Drilled
1736	Near Fort Myer, which is ½ mile southwest of Rosslyn.	E. T. Mullin	F. N. Hagmann, Jr.	Drilled
1737	Arlington Junction, which is 2½ miles southeast by south of Rosslyn.	Airport swimming pool	Mr. Puckett	Drilled
1738	Arlington Junction	James Colliflower Co	F. N. Hagmann, Jr.	Drilled
1739	Arlington Junction	Gulf Refining Co	F. N. Hagmann, Jr.	Drilled
1740	Johnson Hill, which is 2¼ miles south of Rosslyn.	Jefferson School	Mathers & McCain	Drilled
1741	2 miles southwest by south of Rosslyn.	Patrick Henry School	W. E. Croson	Drilled
1742	1½ miles southeast of Falls Church	T. T. Reeves	F. N. Hagmann, Jr.	Drilled
1743	2 miles southeast of Falls Church	J. L. Shaw		Dug
1744	2 miles southeast of Falls Church	Glencarlyn School	W. E. Croson	Drilled
1745	Barcroft, which is 2¾ miles southwest of Rosslyn.	Walter O'Hara		Dug
1746	Barcroft	Barcroft School	W. E. Croson	Drilled
1747	Barcroft	Mrs. W. House	F. N. Hagmann, Jr.	Drilled
1748	3 miles northeast of Alexandria	Kemper School	W. E. Croson	Drilled
1749	2¾ miles south of Rosslyn	Gibson Gardner	F. N Hagmann, Jr.	Drilled
1750	2¾ miles south of Rosslyn	Miss Simpson	F. N. Hagmann, Jr.	Drilled
1751	2¾ miles south of Rosslyn	Mrs. Clark	F. N. Hagmann, Jr.	Drilled
1752	2¾ miles south of Rosslyn	J. L. Price	F. N. Hagmann, Jr.	90 feet dug, rest drilled.
1753	3 miles southeast by east of Rosslyn.	Capital Paint Co	F. N. Hagmann, Jr.	Drilled

[h]Depth below basement floor.

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County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
85	Sand	Recent, Pleistocene and Pliocene (?).	65–70	6	50 feet of 6-inch casing. Deep-well pump with capacity of 3 gallons a minute.	1731
93	Granite	Algonkian (?)	20	1½	4½-inch casing.	1732
23–25	Granite soil	Algonkian (?)	20±	.....	Hand pump.	1733
114	Granite soil	Algonkian (?)	38	1½	114 feet of 6-inch casing. Electric deep-well pump.	1734
38	Granite	Algonkian (?)	20	6	37 feet of 4½-inch casing.	1735
68	Granite	Algonkian (?)	21	5	27 feet of 4½-inch casing.	1736
[a]27	Terrace gravel	Recent, Pleistocene and Pliocene (?).	10	320	6-inch casing to the bottom of well.	1737
[a]89			10	30+	Deep-well electric pump on 89-foot well.	
[a]5			10	350	Deepest well penetrates the Potomac group.	
75	Terrace gravel	Recent, Pleistocene and Pliocene (?).	12	30	67½ feet of 8-inch casing.	1738
49	White sand in terrace gravel.	Recent, Pleistocene and Pliocene (?).	11	5	6-inch well.	1739
130	Sand and gravel	Recent, Pleistocene and Pliocene (?).	.....	15	40 feet of 6-inch casing. Deep-well pump, capacity 3 gallons a minute.	1740
127	Terrace gravel	Recent, Pleistocene and Pliocene (?).	70±	12	65 feet of 6-inch casing. Deep-well pump with 6-gallon a minute capacity.	1741
137	Granite	Algonkian (?)	73	11	127 feet of 6-inch casing.	1742
25	Terrace gravel	Recent, Pleistocene and Pliocene (?).	21	4	.....	1743
75	Terrace gravel	Recent, Pleistocene and Pliocene (?).	55±	6	60± feet of 6-inch casing. Deep-well pump, capacity 3 gallons a minute.	1744
33	Terrace gravel	Recent, Pleistocene and Pliocene (?).	26	10	Electric deep-well pump; exhausts 7 feet of water in 1½ hours.	1745
95	Terrace gravel	Recent, Pleistocene and Pliocene (?).	60±	8	70 feet of 6-inch casing. Deep-well pump, capacity 3 gallons a minute.	1746
150	Granite	Algonkian (?)	.....	.....	60 feet of 6-inch terra cotta casing. Hand pump.	1747
129	Gravel	Recent, Pleistocene and Pliocene (?).	80±	8	90 feet of 6-inch casing. Deep-well pump, capacity 3 gallons a minute.	1748
?	Terrace gravel	Recent, Pleistocene and Pliocene (?).	40±	6	.....	1749
65	Terrace gravel	Recent, Pleistocene and Pliocene (?).	40±	6	.....	1750
163	Sand	Recent, Pleistocene and Pliocene (?), Potomac.	100±?	10	.....	1751
143	Dug portion in blue clay; drilled portion in sand and gravel.	Recent, Pleistocene and Pliocene (?), Potomac.	40	10–12	143 feet of 8-inch casing. Myers deep-well pump, capacity 15 gallons a minute. Supplies 120 houses.	1752
84	Sand	Recent, Pleistocene and Pliocene (?), Potomac.	.....	25–35	73 feet of casing.	1753

WELL RECORDS

TABLE 41.—*Wells in Arlington*

Well number	Location	Owner	Driller	Type of well
1754	On Fourmile Run, 2½ miles northeast by north of Alexandria.	G. Patterson		Dug
1756	On Fourmile Run, 2½ miles northeast by north of Alexandria.	M. Magner		Dug
1757	Braddock Heights, which is 1½ miles west of Alexandria.	(?)	F. N. Hagmann, Jr.	Drilled
1758	Alexandria	Mutual Ice Co	F. N. Hagmann, Jr.	Drilled
1759	Alexandria	Gil Brotzer	F. N. Hagmann, Jr.	Drilled

—CONTINUED

County, Virginia—Continued

Depth of well (feet)	Water-bearing material	Geologic horizon	Depth to water level in feet	Yield (gallons a minute)	Remarks	Well number
15	Alluvium	Recent	9		Hand pump.	1754
35	Alluvium and sand and gravel	Recent	28–29	Small	Hand pump. Can be pumped dry.	1756
160	White sand 12 feet thick from 90 feet to 102 feet.	Potomac	125	25		1757
302	Gravel	Potomac	90	100	302-foot well has electric centrifugal pump; others, air-blown pumps. Water used for ammonia coils; temperature 55° F.; analysis on p. 196.	1758
300	Gravel	Potomac	90	160		
300	Gravel	Potomac	90	160		
268	Sand	Potomac		75	6-inch casing.	1759

ANALYSES OF WATER

TABLE 42—*Analyses of ground water from Arlington County, Virginia*

[Analyst, S. K. Love. Parts per million. Well 1722 is at Rosslyn, well 1758 at Alexandria; see also Table 41.]

	1722	1758
Silica (SiO_2)	.....	48
Iron (Fe)	.....	.04
Calcium (Ca)	54	1.4
Magnesium (Mg)	12	.4
Sodium (Na)	[a]67	22
Potassium (K)		3.4
Bicarbonate (HCO_3)	191	50
Sulphate (SO_4)	[b]7	11
Chloride (Cl)	118	3.0
Nitrate (NO_3)	.10	.36
Total dissolved solids	[a]358	116
Total hardness as $CaCO_3$ (calculated)	184	5.1
Date of collection (1931)	Oct. 21	Oct. 21

[a]Calculated.
[b]By turbidity.

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