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JOSEPH T. SINGEWALD, JR., *Director*

BULLETIN 13

GEOLOGY AND WATER RESOURCES OF GARRETT COUNTY

GEOLOGY OF GARRETT COUNTY

By Thomas W. Amsden

GROUND WATER RESOURCES

By Robert M. Overbeck

SURFACE WATER RESOURCES

By Robert O. R. Martin

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PREFACE

In 1902 the Maryland Geological Survey published a topographic map, geologic map, and a report on the physical features of Garrett County. The topographic map had long been out of date and the accuracy of the topography was far below present standards. The geologic map had long been out of print. The accounts of the mineral and water resources in the county report were brief. Much more information had been collected and much more was needed on the geology, mineral resources and water resources.

The first requirement for a restudy of the geology, mineral resources, and water resources of Garrett County was a satisfactory topographic map. A resurvey of the County in cooperation with the United States Geological Survey was started in 1946, and a new topographic map published in 1949. Through presentation of the need for exploration of the lower coal seams in the Maryland coal-bearing formations, the United States Bureau of Mines carried on core-drilling explorations in the Georges Creek and Upper Potomac coal basins in 1945 and 1946 and in the Castleman Basin in 1947 to 1949. The Bureau of Mines reports on these explorations are cited in the list of references at the end of this report. While these explorations were being carried on the Department of Geology, Mines and Water Resources in cooperation with the United States Geologic Survey investigated the refractory clays of the coal basins and cooperated with the Bureau of Mines in the interpretation and utilization of the drill cores, especial attention being directed to the fire clays of the Castleman Basin. The results of the fire clay investigation were published in 1950 as Bulletin 9. Remapping of the geology of Garrett County was started upon the completion of the new topographic base map in 1949, and a new geologic map of Garrett County was published in 1953. In 1950, the Department in cooperation with the United States Geological Survey began an investigation of the ground-water resources of Garrett County. In the same year the geologic remapping of Garrett County was started, the discovery well of the Mt. Lake Park gas field was brought in, so that the restudy of the geology of Garrett County was opportunely tied in with the investigation of the structure and stratigraphy of the gas field. In the preparation of the geologic section of this report full use was made of the information derived from the exploratory borings of the United States Bureau of Mines, the logs of the gas wells, and the cooperative investigations with the United States Geological Survey of the fire clays of the coal basins and of the groundwater resources and the surface water resources of the County. The results of the water resources investigations are published in this report with the consent of the United States Geological Survey. The report is the concluding presentation and interpretation of explorations and investigations of the geology, mineral resources, and water resources carried on in Garrett County during the period 1946 to 1953 by the Department of Geology, Mines and Water Resources, the United States Geological Survey and the United States Bureau of Mines.

The section on the geology, geologic structure, and gas development was prepared by Dr. Thomas W. Amsden of the Department of Geology, Mines and Water Resources; the section on the ground waters by Dr. Robert M. Overbeck of the Department of Geology, Mines and Water Resources on the cooperative ground-water staff in Maryland; and the section of surface water resources by Mr. Robert O. R. Martin of the United States Geological Survey on the cooperative surface water staff in Maryland.

JOSEPH T. SINGEWALD, JR., DIRECTOR

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BY

THOMAS W. AMSDEN

INTRODUCTION

Basis for report. This report is based upon four summers' field work during the years 1949 to 1952. The primary purpose was to prepare a geologic map of the county on a scale of 1:62,500. This map, published by the Maryland Department of Geology, Mines and Water Resources in 1953, represents the combined work of the writer, Robert M. Overbeck, and Karl M. Waagé. Waagé's mapping was confined to Castleman basin and was published on a scale of 1:24,000 in Bulletin 9 of the Maryland Department of Geology, Mines and Water Resources. Dr. Overbeck and the writer worked together on the geologic map of the Youghiogheny basins and the Georges Creek-Upper Potomac basins; the Deer Park and Accident anticlines were mapped by the writer.

Stratigraphic studies made along with the mapping are included in the section on SURFACE STRATIGRAPHY. Little new paleontological information is available, but the age of all formations is given as closely as possible along with a summary of the problems of correlation. No new stratigraphic names are introduced but existing nomenclature is used although it is not always appropriate.

In the past five years a number of deep wells have been drilled in search of gas. Most of these wells penetrate a part of the Devonian section (and Silurian) which is not exposed in Garrett County. The Department of Geology, Mines and Water Resources has assembled the information pertaining to these wells, including well samples from many of them. The stratigraphic and structural data obtained from this material are given in the sections on SUBSURFACE STRATIGRAPHY and STRUCTURE. All the Garrett County deep wells known to the writer are listed on pages 108 to 115, including a summary of the pertinent facts and a reference to the location on the structure maps, Plates I and II. A relatively large proportion of these wells have yielded at least some gas. Their yield is presented in Table 6.

Previous investigations. The first comprehensive publication on the geology of Garrett County was the report written by G. C. Martin in 1902 to accompany his geologic map of Garrett County (1902). This was followed in 1908 by the Accident-Grantsville folio by Martin. In 1913 the Maryland Geological Survey published a 3-volume work on the Devonian of Maryland, which included a discussion of the faunas and stratigraphy of those Devonian formations (Hampshire and upper Jennings) exposed in Garrett County (Schuchert and authors, 1913; Prosser and Swartz, 1913). The Pennsylvanian strata of Maryland were first comprehensively described by C. K. Swartz in the Second Report on the Coals of Maryland (1920). Knowledge of the Pennsylvanian of Garrett County has been greatly increased by K. M. Waagé, A. L. Toenges and others (Waagé 1950; Toenges and authors 1952; Toenges and authors 1949). These publications are based largely upon information derived from diamond drill holes put down by the U. S. Bureau of Mines in Castleman basin and in the Georges Creek-Upper Potomac basin. This drilling program is discussed in the section on the PENNSYLVANIAN SYSTEM. The locations of the drill holes are given in the structure map, Plate I, and they are listed in Tables 7 and 9.

Acknowledgments. The writer is indebted to Robert M. Overbeck for his help on various problems encountered in the field as well as for many valuable

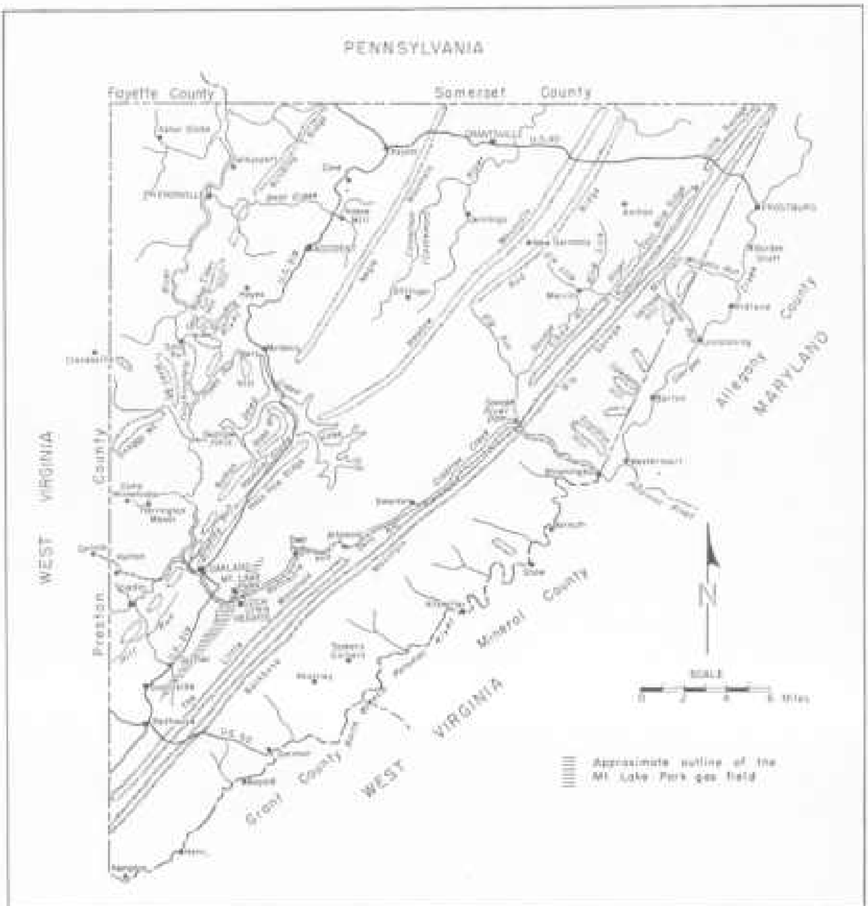

FIGURE 1. Map of Garrett County showing the principal geographic features

suggestions made on this report. He acknowledges also the assistance given by John C. Reed, Jr., Kenneth Weaver and John Schlee on the subsurface investigation. John Reed examined the cuttings from a number of the wells and helped in preparing the structure map of the Mountain Lake Park area; Kenneth Weaver also helped in preparing this map and studied the well samples from the lower part of the Shaw #2 well (Plate III). John Schlee logged the upper part of the McCullough well (fig. 3).

Surface Stratigraphy

Garrett County is the westernmost county in Maryland and lies entirely within the Allegheny Plateaus (fig. 10). The physiography and ground-water resources of the county are discussed by R. M. Overbeck in the section on the ground-water resources. Geographic localities referred to in the text are shown in figure 1.

Garrett County is divisible on both structural and stratigraphic grounds into the seven units shown in figure 11. Two of these are anticlines, the Accident and Deer Park anticlines, on which Devonian and Mississippian strata are brought to the surface. The other 5 units are synclines, or coal basins, in which Pennsylvanian strata are exposed. These synclines are the Georges Creek basin, its southern continuation the Upper Potomac basin,* the Castleman basin, the Upper Youghiogheny basin, and the Lower Youghiogheny basin.

The strata exposed at the surface in Garrett County range in age from Upper Devonian through the Pennsylvanian and may include a thin veneer of Permian at the top (see under PERMIAN SYSTEM). This Paleozoic section is divided in the literature on Garrett County into the following formations:

? Dunkard group	Permian system
Monongahela formation Conemaugh formation Allegheny formation Pottsville formation	Pennsylvanian system
Mauch Chunk formation Greenbrier formation Pocono formation	Mississippian system
Hampshire formation Jennings formation	Devonian system

* Almost all authors have separated the Georges Creek and Upper Potomac basins along the line of the Savage River. In Garrett County there is no reason for making a structural division at this line, but the established practice is followed in this report.

Exposures of bed rock in Garrett County are poor. The formations which are thicker and contain a fairly high proportion of sandstone (e.g. Hampshire and Pocono formations) may be moderately well exposed in some areas, but on the whole outcrops of bed rock are not common, which greatly increases the difficulty of mapping and of making stratigraphic studies. This difficulty is partly offset by subsurface data obtained from drilling on both the synclines and the anticlines. The core drilling in the coal basins by the U. S. Bureau of Mines involves strata which are present at the surface and the discussion on them is included in the section on SURFACE STRATIGRAPHY (PENNSYLVANIAN SYSTEM). Most of the strata penetrated by the deep drilling on the anticlines never reached the surface in this county, and they are treated in the section on SUBSURFACE STRATIGRAPHY.

DEVONIAN SYSTEM

The stratigraphy and stratigraphic terminology of the Maryland Devonian presents difficult problems. In Maryland, as well as throughout the middle and northern Appalachians, the Devonian system is complicated by facies changes. The problem is further complicated by the use of stratigraphic names in areas far removed from the type area; thus the questions concerning local stratigraphy are tied in with questions of broad correlation.

In 1913 the Maryland Geological Survey published a monograph on the Devonian of Maryland. This work covers both the stratigraphy and paleontology of the system, but unfortunately the authors used a mixture of local and New York terms. In Washington and Allegany counties a rather complete Devonian section is exposed which they described under the following subdivisions:

Upper Devonian	Catskill formation	
	Jennings formation	Chemung member Parkhead member Woodmont member Genesee member
Middle Devonian	Romney shale	Hamilton member Marcellus member Onondaga member
Lower Devonian	Oriskany sandstone	Ridgeley sandstone Shriver chert
	Helderberg limestone (includes the Keyser limestone)	

In Garrett County only the upper part of this section, the Hampshire (Catskill) and the upper Jennings formations, is exposed; drilling for gas however, has made available a fair amount of data on the unexposed part of the Devonian.

Due to the difficulties of correlating the subsurface with the surface the information derived from surface studies is kept separate from that derived from the deep wells. For convenience in reference, the complete Devonian section, with subdivisions herein recognized, is given below, but the subsurface portion is discussed in a separate section.

Devonian
(Surface)

Hampshire (Catskill) formation	
Jennings formation (base not exposed)	"Chemung" member

Devonian
(Subsurface)

Jennings formation	"Chemung" member Woodmont member Burket member
"Tully" limestone	
Romney formation	"Hamilton" member "Marcellus" member "Onondaga" member
Huntersville chert	Upper chert member Lower shale member
Oriskany sandstone	Ridgeley sandstone
"Helderberg" limestone (includes the Keyser limestone)	

Since no new names are used, it has been necessary to employ some names even though there is serious doubt as to their suitability. The New York names utilized by the earlier Maryland geologists are retained but are placed in quotation marks because of the correlation problems involved (see chart, p. 1788, Cooper et al 1942). The use of such names as Jennings without quotation marks does not mean, however, that they are accepted as entirely satisfactory but only that the correlation of these units with the type areas is on somewhat safer grounds. The problems concerned with each of the units are discussed under the appropriate heading.

JENNINGS FORMATION

The Jennings formation was first proposed by Darton in 1892 for exposures at Jennings Gap and on Jennings branch, Augusta County, Virginia (about 70 miles southeast of Garrett County). It included the beds above the Romney shale and below the Hampshire formation and was thought to include strata of Chemung, Portage and possibly Hamilton age. The name has been rather extensively employed by workers in the middle Appalachian region, but has usually been defined to include only beds believed to represent Chemung, Portage and Genesee equivalents,—the Hamilton portion being restricted to the Romney.

The name Jennings was introduced into Maryland terminology in the county maps and reports of O'Harra (1900) and Martin (1902). Prosser and Swartz (1913, pp. 347–399) in their monograph on the Upper Devonian of Maryland continued the usage of this name and gave a detailed description of the stratigraphic sequence and the included fossils. They subdivided the formation into the following members:

Chemung sandstone member
Parkhead sandstone member
Woodmont shale member
Genesee black shale member

Two of these names, Chemung and Genesee, are taken from New York terminology and the other two are local.

The name Jennings has been little used by geologists on the West Virginia Geological Survey. Reger and Tucker (1924) in their report on Mineral and Grant Counties divided the Upper Devonian into the following:

Catskill
Chemung
Portage
Genesee

The Genesee, Portage, and Chemung are presumably equivalent to the Jennings formation of Maryland, with the Portage equal to the Woodmont member.

Woodward (1943) in his discussion of the Devonian of West Virginia uses a somewhat different terminology.

Hampshire (Catskill)
Chemung
Brallier
Harrell

The Brallier shale was proposed by Butts in 1918 for exposures in Bedford County, southern Pennsylvania. Woodard believes the Brallier of West Virginia and Pennsylvania is equivalent to the "Portage" of earlier West Virginia publications and at least in part to the Woodmont of the Maryland Geological Survey. The name Harrell was applied by Woodward (1943, pp. 390–412) to a series of black shales which are supposedly the same as the "Genesee" of other West Virginia authors, but he expressed doubts concerning the northern equivalents. Butts proposed the name Harrell in 1918 for a sequence of shales exposed in central Pennsylvania. The basal member of this formation is a black shale which Butts called the Burket black shale member. As originally defined the Harrell formed the basal formation of the Portage group and was underlain by the Hamilton formation. Later Willard (1935, pp. 1209–1213) removed the Burket black shale from the Harrell formation and made it the uppermost member of his Rush formation:

Rush formation
  Burket member
  Tully member

In his volume on the Middle and Upper Devonian of Pennsylvania, Willard (1939, p. 239) discussed these stratigraphic units and suggested the following tentative correlation:

Maryland	*Pennsylvania*	*New York*
Chemung	Chemung	Chemung
("*Spirifer disjunctus*")	("*Spirifer disjunctus*")	("*Spirifer disjunctus*")
Parkhead sandstone	Parkhead sandstone	Enfield shale
Woodmont member	Braillier-Trimmers	Ithaca shale
Beds with Ithaca fauna	Rock shale and sandstone	Cashaqua shale
Reticularia laevis zone	Losh Run shale	Sherburne sandstone
Beds with Naples fauna	Harrell grey shale	Genesee group
Genesee black shale member	Burket black shale*	Genesee black shale
	Tully limestone	Tully limestone

If the above correlation is correct, and if the Harrell black shale of West Virginia is equivalent to the same named shale in Pennsylvania, then the "Genesee" black shale of Maryland must be absent in West Virginia. This question of correlation is important in the Garrett County subsurface stratigraphy because the drilling has revealed a black shale which is underlain by a thin limestone, a sequence that suggests the Burket-Tully of Pennsylvania. On the other hand, a limestone has never been found at the surface beneath the "Genesee" black shale in Maryland. This black shale may not, therefore, be equivalent to the one encountered in drilling.

Since the writer's studies in Garrett County do not furnish conclusive evidence on this problem the existing Maryland terminology is used insofar as possible. Future studies will undoubtedly reveal the need for changes and modifications. Accordingly the "Chemung" and Woodmont are recognized as stratigraphic units within the Jennings formation. The Parkhead sandstone has not been identified from well cuttings and is here included within the lower

* Willard in his discussion of the Burket member on page 219 states that the "Genesee of Maryland equals our Harrell to the exclusion of the Burket which, it is altogether probable, is absent in Maryland."

"Chemung." The black shale immediately overlying the "Tully" limestone is called the Burket black shale and is tentatively correlated with the "Genesee" black shale of Maryland authors. The name Burket is preferred to Genesee since the correlation of this black shale with the Pennsylvania shale would seem to be on safer grounds than with the New York Genesee. A comparison of this terminology with that used in the Devonian volume of the Maryland Geological Survey (1913) is:

M.G.S. 1913 (based entirely upon surface studies)	*This report* (surface and subsurface studies)
Catskill formation	Hampshire formation
Jennings formation	Jennings formation
Chemung member	"Chemung" member
Parkhead member	
Woodmont member	Woodmont member
Genesee member	Burket black shale
Absent	"Tully" limestone

The Burket black shale is included within the Jennings formation, whereas Willard placed it with the Tully in the Rush formation. Willard's reasons for making such a grouping seem valid, but in the subsurface investigations in Garrett County it does not appear to serve any useful purpose; the present arrangement keeps the subdivisions more nearly in accord with the earlier Maryland publications.

As the base of the Jennings formation is nowhere exposed in Garrett County, its thickness can be obtained only from subsurface information. The thickness of this formation (base of Hampshire to top of "Tully" limestone) is estimated to be about 5,500 feet. On the Deer Park anticline no wells which start in the Hampshire continue as deep as the "Tully"; all the wells that reach this limestone begin in the "Chemung" (see under "CHEMUNG" MEMBER). To get the thickness of the Jennings on this structure, surface and subsurface data are combined. The best place to do this is at the north end, in the region around the Robeson well (F-66). The thickness of the Jennings formation in this area is estimated to be between 5,500 and 6,000 feet, the former being probably nearer correct.

On the Accident anticline the Shartzer (F-12) and the McCullough (F-113) wells start in or above the Hampshire formation and continue through the "Tully" into the Oriskany. Martens (1945, pp. 752–758) gives a detailed log of the Shartzer well which shows an interval of 5,573 feet from the base of the Hampshire (Catskill) to the top of the "Tully".* The Maryland Department

* Martens did not identify the "Tully" in his log but it is probably the limestone recorded at 7,204–7,212 feet. It is overlain by a black calcareous shale, here identified as the Burket.

of Geology, Mines and Water Resources has a complete set of cuttings from the McCullough well, and a study of these reveals that this interval is 5,210 feet.

Prosser and Swartz (1913, p. 353) state that the thickness of the Jennings formation at the surface ranges from 3,400 feet to 4,750 feet.

"Chemung" Member

Name. The name Chemung was first proposed by James Hall over 100 years ago for exposures in Chemung County, New York. This stratigraphic unit has been discussed and redefined so many times that a rather formidable literature exists on this topic. A good idea of the various ways in which this name is now employed can be obtained from the Devonian Correlation Chart (Cooper, et al, 1942).

Martin (1902, p. 87; 1908, p. 3) in his report on Garrett County indicated that the upper part of the Jennings formation was of the same age as the Chemung of New York but did not otherwise use the name. Prosser and Swartz (1913) were the first to use Chemung in Maryland, applying it to the upper sandstone member of the Jennings formation which carried the "*Spirifer disjunctus*" fauna. As defined by them this member consisted of a sequence of sandstones and interbedded shales, which rested upon the Parkhead sandstone member, "with which it is so intimately connected by transitional beds as to render their discrimination difficult." West of Wills Mountain (Cumberland area) the Parkhead was said to lose its sandy and conglomeratic character, so that it could "scarcely be separated from the Woodmont member in that region."

It is a moot point whether the Chemung of Maryland usage is equivalent to the Chemung of the type area, a question that depends in part upon how the New York formation or group is defined. The authors of the Maryland Devonian volume would have simplified matters if they had employed a local name and thus divorced the Maryland terminology from problems of correlation and revisions of New York stratigraphy. The name "Chemung" is retained in this report, however, because it does not seem desirable to revise the Maryland Devonian from studies restricted to Garrett County where only a poorly exposed part of the Jennings formation reaches the surface.

Distribution. Outcrops of the "Chemung" member are confined to an elongate belt along the crest of the Deer Park anticline. This belt extends from West Virginia to Pennsylvania and averages two to two and a half miles in width, except in the area just north of Deep Creek Lake where it narrows abruptly to a few hundred feet. The base of this member probably does not reach the surface. The highest point on the Deer Park anticline, in a structural sense, lies about a mile or so south of Mountain Lake Park (see Plate I). There the Welch #1 well (F-16) encountered the "Tully" limestone at a depth of 2,262 feet which is the least depth at which any well reached this horizon. As the estimated thickness of the "Tully"-"Chemung" interval (Woodmont plus Burket) is about 1,800 feet,* the Woodmont is probably not exposed in the county. Since, however, exposures in the area south of Mountain Lake Park are not good and outcrops are small and disconnected, it is possible for the Woodmont to be exposed. Prosser and Swartz (1913, pp. 396–397) record the "*Spirifer disjunctus*" fauna from exposures on Trout Run, about 3 miles south of Mountain Lake Park, but they do not mention any from the region around the Welch well (F-16) nor has the writer found any.

The "Chemung" member is exposed in many places along the Deer Park anticline but mostly in small isolated outcrops. The best and most complete exposures are in the area between Avilton and Dry Run, where the topography is deeply dissected by a number of streams. Many of these streams furnish numerous fairly continuous exposures, one of the best being on Big Run. Probably the best place to see a complete section of the upper 1,000 feet of the "Chemung" member is along the road leading southeast from Merrill, about 3 miles southeast of New Germany (see described section under *Lithology and thickness*). Both north and south of this area the relief is much less and only scattered outcrops are found.

Martin in his 1902 geologic map of Garrett County shows a small outcrop of Jennings ("Chemung") on the Accident anticline, but probably all of the strata in this area should be included within the Hampshire formation (see under HAMPSHIRE FORMATION, *Lithology and Thickness*).

Lithology and thickness. The "Chemung" member consists of a series of alternating sandstones, siltstones and shales with the shale-siltstone part making up about 60 percent of the total (Pl. IV). There are thin beds of conglomerate scattered through the section, especially in the upper part, but they are only a small fraction of the whole. The conglomerates are usually well cemented and thus resistant to weathering, so that small loose blocks of conglomerate are found in many areas where the Chemung outcrops. Prosser and Swartz (1913, pp. 418–419) found two persistent conglomerates in the area east of Wills Mountain (Cumberland area) which they used for subdividing the Chemung member into smaller units. They noted, however, "that other conglomerates are present and may be readily confused with them." The writer has not mapped any of the conglomerate beds in Garrett County.

The prevailing color of the weathered rock is yellowish-to greenish-brown although there are numerous zones of dark reddish-brown and a few beds of bright red. On the fresh surface the rock is commonly a light grey or pale greenish-grey. Soils produced by weathering of this member are brown or buff and contrast sharply with the red soils of the Hampshire formation.

* This is based upon a single measurement in the Robeson #1, F-66; see Plate III and discussion under Woodmont member.

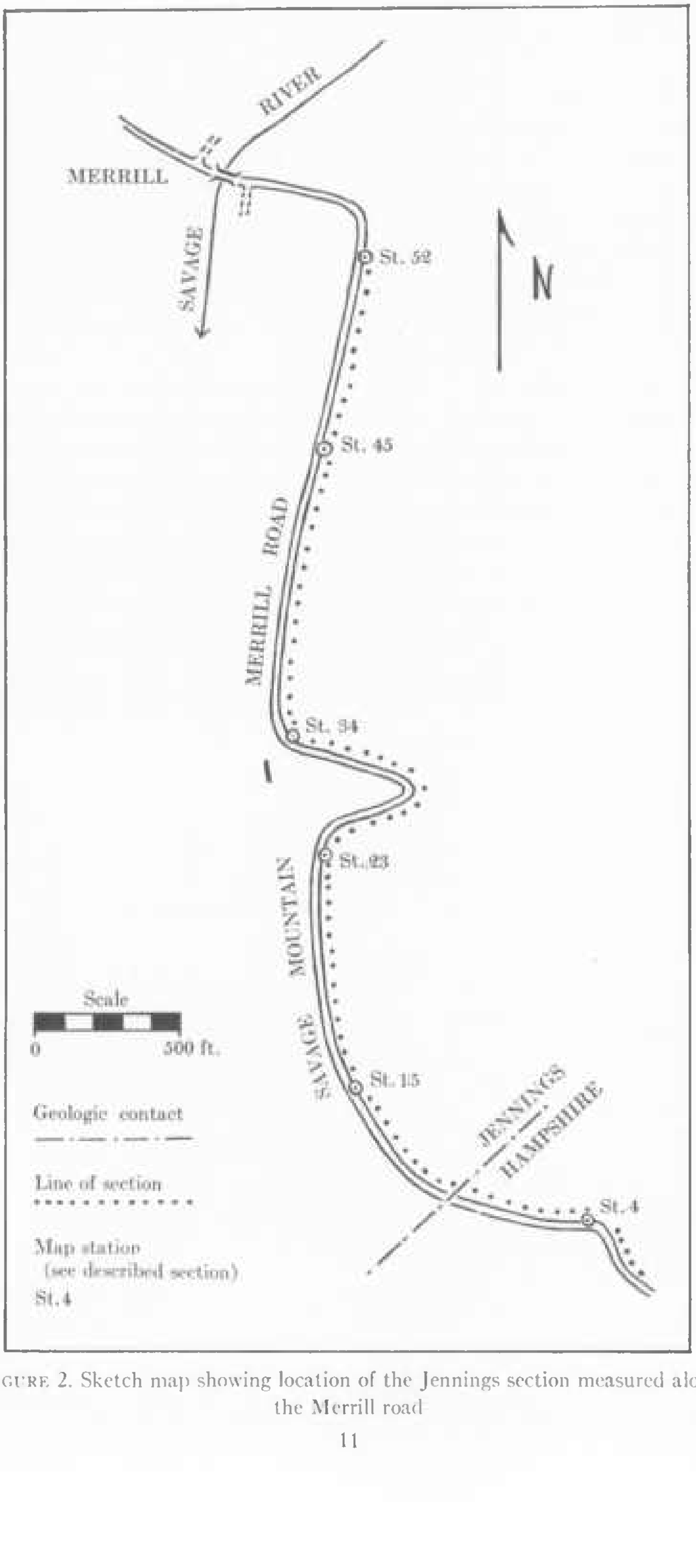

FIGURE 2. Sketch map showing location of the Jennings section measured along the Merrill road

Most of the sandstones in the "Chemung" are medium- to fine-grained and well cemented. Individual sandstone beds reach a thickness of 2 feet or more but are generally a foot or less in thickness. In places there are zones of fairly clean sandstone up to 20 feet or more in thickness, but as a rule the sandstones are interbedded with siltstones and shales. Most of the sandstones are evenly-bedded with moderately smooth bedding surfaces. Upon weathering they tend to break down into rectangular, "blocky" fragments (Pl. IV). Individual beds do not appear to be persistent and where well exposed may be seen to pinch out along the strike. Some sandstone beds show moderate cross-bedding, but this is never developed on the scale of the Hampshire or Pocono formations.

The siltstone and shale beds are commonly olive or greenish-brown and the latter are generally fissile. As a rule these beds are interbedded with sandstones, but there are zones up to 20 feet in thickness of non-sandy siltstones and shales.

The "Chemung" member shows a very low calcium carbonate content, even on unweathered surfaces (e.g. well sample cuttings). Some of the coarser-grained sandstones show a moderate amount of lime cement, but the siltstones and shales are generally not calcareous. Even the fossiliferous beds have a low lime content because the fossils almost always occur as casts and molds.

One of the best exposures of the upper part of the "Chemung" member is about 3 miles southeast of New Germany. The traverse of the following section measured along the road leading southeast from Merrill over Elbow Mountain is shown in figure 2.

Hampshire formation

Partly covered; few ledges of red sandstone	17 ft.
Partly covered; few beds of fissile, green shale	8 ft.
Greenish-brown, medium-grained sandstone; 8 in. conglomerate near the top, pebbles to ½ in.	10 ft.
Interbedded green shale and reddish-brown sandstone	3 ft.
Cross-bedded, dark reddish-brown to greenish-brown sandstone; beds of flat pebble (shale) conglomerate	7 ft.
Green, fissile shale	11 ft.
Reddish- to greenish-brown, strongly cross-bedded sandstone with scattered quartz pebbles	13 ft.
Covered	40 ft.

Map station 4

Red shale and interbedded red sandstone; about 60 percent shale, 40 percent sandstone	38 ft.
Red, fine-grained, cross-bedded sandstone	23 ft.
Largely covered; few outcrops of red shale	32 ft.
Partly covered; outcrops of red sandstone and shale	40 ft.
Partly covered; outcrops of greenish-brown, medium-grained sandstone; ?fragmentary plant fossils	20 ft.
Partly covered; outcrops of red sandstone	12 ft.
Partly covered; few outcrops of greenish-brown sandstone and red shale	8 ft.

Jennings formation
(+ 1,231 feet)

Partly covered; outcrops of greenish-brown to buff, micaceous sandstone and buff shale; fragmentary pelecypods	44 ft.
Partly covered; outcrops of greenish-brown weathering sandstone	23 ft.
Olive-brown fissile shale	20 ft.
Olive-brown fissile shale with beds of greenish-brown weathering sandstone in beds to 6 in.; few beds of flat, shale conglomerate	44 ft.
Dark reddish-brown sandstone; bedding irregular; few shale beds present	31 ft.
Covered	25 ft.
Reddish-brown, sandstone and red shale; bedding irregular	20 ft.

Map station 15

Dark, reddish-brown sandstone with minor siltstone beds; bedding irregular; fossils; *Camarotoechia contracta, Cyrtospirifer disjunctus?, Tylothyris mesacostalis?;* also pelecypods	36 ft.
Covered	20 ft.
Dark reddish-brown, micaceous siltstone; few poorly preserved brachiopods and pelecypods	10 ft.
Dark reddish-brown, fine-grained sandstone with some cross-bedding; few brachiopods	20 ft.
Fine-grained, rusty brown sandstone; micaceous; fresh surface pale greenish-brown	8 ft.
Interbedded buff to green shale and siltstone	39 ft.
Dark reddish-brown siltstone and fissile shale; few beds of a fine-grained, "blocky" sandstone with crinoid stems	39 ft.
Olive-brown fissile shale with a few beds of blocky sandstone carrying crinoid fragments	37 ft.
Buff to olive-brown shale and siltstone; few red beds; crinoid stems, *?Cypricardella marylandica* and other pelecypods, *Cyrtospirifer disjunctus* and other brachiopods	28 ft.
Olive-green fissile shale; fossiliferous, brachiopods and pelecypods. *Productella* sp.	18 ft.
Dark reddish-brown, micaceous siltstone and shale	22 ft.
Buff shale with beds of thin "blocky" sandstone; brachiopods and pelecypods; *?Cypricardella tenuistriata, Schizophoria striatula* var. *marylandica*	32 ft.

Map station 23

Interbedded brown- to greenish-brown shale and sandstone; sandstone beds "blocky", evenly bedded and lenticular; fossils, mostly brachiopods	8 ft.
Covered	13 ft.
Reddish-brown shale with minor thin sandstones	24 ft.
Buff to olive-brown shale and sandstone; fossils	14 ft.
Light-brown sandstone with irregular beds to 1 ft. Upper 6 inches with rounded quartz pebbles to ¾ in.	24 ft.
Covered	20 ft.
Interbedded sandstone, siltstone and shale. Color buff to olive-brown; sandstones mostly fine- to medium-grained, "blocky", with beds less than 1 ft. thick. About 70 percent of this unit is shale. Several fossiliferous beds with brachiopods, pelecypods and crinoid stems	79 ft.

Greenish-brown fine-grained sandstone in beds to 18 inches	7 ft.
Interbedded sandstone, siltstone and shale; buff to greenish brown. 60 to 70 percent of rock is sandstone	22 ft.

Map station 34

Brown sandstone in beds to 6 inches	6 ft.
Interbedded sandstone, siltstone and shale; bedding nodular, thin; brown to olive-brown; few brachiopods and crinoid stems; ?*Cyrtospirifer disjunctus*; 70 percent or more is sandstone	10 ft.
Interbedded sandstone, siltstone and shale; brown to greenish-brown; sandstones evenly-bedded, "blocky"; *Cyrtospirifer disjunctus* and other fossils; about 60 percent shale	20 ft.
Dark reddish-brown, minor greenish-brown, sandstone, siltstone and shale. Sandstone "blocky", evenly bedded but lenticular; unit is about 60 percent shale; several beds with poorly preserved fossils, mostly crinoid stems	80 ft.
Greenish-brown interbedded, sandstone, siltstone and shale; sandstone in beds usually less than 1 foot, "blocky" and evenly bedded; about 60 percent shale; many of the beds, especially the sandstone, are fossiliferous, with numerous *Tentaculites* sp.	145 ft.
Covered	18 ft.
Olive-brown sandstone and shale	6 ft.

Map station 45

Reddish-brown to greenish-brown shale, siltstone and sandstone. Most of the sandstone beds are fine-grained, less than a foot in thickness. Many of the beds are fossiliferous, especially the sandstones: *Douvillina cayuta*?, *Ambocoelia* cf. *A. umbonata*, *Schuchertella chemungensis*? and other brachiopods; also pelecypods. 60 to 70 percent of this unit is shale	115 ft.
Covered	5 ft.
Reddish-brown sandstone, siltstone and shale like 115 ft. unit above	25 ft.
Green to olive-brown sandstone, siltstone and shale; sandstone beds up to 8 inches, "blocky" and evenly bedded; mostly fine-grained. Sandstone and siltstone commonly fossiliferous, the most common fossils crinoid stems, but some brachiopods and pelecypods	72 ft.

Map station 52

Covered to Savage River.

The section shows that the "Chemung"-Hampshire contact is not a sharp one. Above this contact is about 160 feet of incompletely exposed strata which are almost all red in color, followed by 70 feet of beds which have the characteristic brown or greenish-brown color of the "Chemung"; overlying this the strata are almost entirely red. This contact zone of alternating red and brown may be seen in many places along the Deer Park anticline and can even be detected by the soil cover in some areas where the strata are concealed. On the geologic map the contact is placed at the base of the lowest red bed sequence having any appreciable thickness. This leaves a few red beds in the Jennings formation, but they are all thin and interbedded with the olive shales and sandstones. In a region of such poor exposures it is probable that the contact has not always been placed at the same stratigraphic position, but the magnitude of the discrepancy is probably less than 250 feet (stratigraphic thickness).

Excluding this contact zone, the "Chemung" member is lithologically quite distinct from the Hampshire formation, a distinction involving more than color. Most of the sandstones of the Hampshire are strongly cross-bedded, highly lenticular, and with marked channeling; whereas the sandstones of the "Chemung" are evenly-bedded (Pl. IV, fig. 1) and although they show some cross-bedding and channeling this is on a much more subdued scale. The "Chemung" sandstones are commonly lenticular but they pinch out gradually. These differences are well shown in the illustrations in Woodward's Devonian System of West Virginia (1943; compare Pls. LI and LIV).

Another factor that distinguishes the two formations is the presence of marine fossils in the "Chemung." Fossiliferous beds are common throughout this member and almost every outcrop will yield some. In contrast the Hampshire is generally unfossiliferous; and, where fossils do occur, they consist of macerated plant remains or fish remains. Most authors have interpreted the Hampshire (Catskill) as a terrestrial deposit and the evidence from Garrett County supports this conclusion.

Only the upper 1,200 feet of the Chemung are exposed in the preceding section. The strata beneath this are exposed in a number of places on the anticline, but the outcrops are mostly discontinuous and do not expose a reasonably thick and continuous sequence. As the base of this member probably does not reach the surface in Garrett County, its thickness and its relation to the Woodmont member are discussed in the section on SUBSURFACE STRATIGRAPHY.

Fauna and age. The "Chemung" member is abundantly fossiliferous. Most of the fossils occur as casts and internal cores but the preservation on these is sharp and with rubber molding compounds excellent replicas of both the exteriors and interiors can be obtained. The fauna is dominated by brachiopods and pelecypods with a fair number of gastropods represented. Prosser and Swartz (1913) describe 47 species of brachiopods, 46 species of pelecypods, 23 species of gastropods, 5 species of corals, and 4 species of cephalopods. One of the most common species is the brachiopod, "*Spirifer disjunctus*" (*Cyrtospirifer disjunctus*), and the fauna is often called by this name. The fauna has been discussed and described at length in the Devonian volume of the Maryland Geological Survey. On the Devonian Correlation Chart (Cooper, et al, 1942) the "Chemung" of Maryland is shown as approximately equal to the Chemung stage of the Upper Devonian.

HAMPSHIRE FORMATION

Name. The name Hampshire formation was proposed by N. H. Darton in 1892 for exposures in Hampshire County, West Virginia. He included within this formation all the strata between the top of the Jennings formation and the base of the Pocono formation. The name was introduced into Maryland by O'Harra (1900) and Martin (1902). Both used the name in much the same way as did Darton, including within the Hampshire formation the sequence of red sandstones and shales between the Jennings and Pocono formations.

Subsequently Martin (1908, p. 4), in his report on the Accident-Grantsville quadrangles, dropped the name Hampshire, substituting the New York name of Catskill formation, and this procedure was followed also in the Devonian volume of the Maryland Geological Survey (Prosser and Swartz 1913, pp. 399–409, 438; see also Cloos 1951, p. 92). According to these authors the Catskill (Hampshire) formation of Maryland was at least in part equivalent to the New York strata and therefore on the basis of priority Catskill was preferable to Hampshire.

The name Catskill was proposed by Mather in 1840 for the thick sequence of terrestrial sediments, predominantly red in color, exposed in the Catskill Mountains of southeastern New York. Since the first introduction of this term there has been, and continues to be, much discussion concerning the definition of the Catskill formation in the type area. There is rather general agreement that the Devonian red beds represent a great wedge of terrestrial sediments which reach their maximum thickness in southeastern New York and northeastern Pennsylvania, where they occupy all the Upper Devonian and a considerable part of the Middle Devonian. It has never been satisfactorily determined just what part of this red bed facies should be included within the Catskill formation. So much has been written on this subject that even a cursory review of the problem is beyond the scope of this report. The literature is summarized in the Lexicon of Geologic Names (Wilmarth 1938, pp. 373–375).

To the east and southeast of the type area this sequence of red beds thins rather rapidly, largely through the lower portion grading into a marine facies. In Maryland only the post-Chemung part of the Devonian remains in the red bed facies. There is little doubt that these Devonian red beds in Maryland represent at least a part of this facies in the type region, although there is uncertainty as to the precise time relationship. As there is no unanimity of opinion as to how the name Catskill should be applied in the New York area, it seems preferable to use the name Hampshire in Garrett County which is only a few miles away from the type area of that formation.

Woodward (1943, pp. 527–529) in his report on the Devonian of West Virginia discussed this problem and also concluded that it was desirable to retain the name Hampshire, but he did suggest that the entire sequence of Devonian red beds be called the Catskill facies. This seems to be a useful terminology but it might be better to speak of the Catskill magnafacies.

Distribution. The Hampshire formation is widely distributed in parts of Washington County, Allegany County, and Garrett County. In Garrett County it forms three prominent belts of outcrop. Two of these are on the flanks of the Deer Park anticline and the third at the crest of the Accident anticline. On the Deer Park anticline the two belts of Hampshire are separated by a considerable belt of Jennings formation except in the area just north of Deep Creek Lake where they almost come together on the crest of the structure. This formation is the oldest exposed on the Accident anticline where it makes a rather irregular outcrop pattern, due in part to minor structural variations and in part to topography.

The Hampshire formation is well exposed in a number of places in the county. One of the best places to see the formation is on the road leading north from Savage River Dam to Big Run where a rather complete section is exposed in the road cuts. There are also a number of exposures on the Accident structure along the road cuts of U.S. Highway 219 and on the Bear Creek road west of Kaese Mill.

Lithology and thickness. The Hampshire formation consists of a sequence of interbedded sandstones, siltstones and shales, dominantly red in color. The relative proportion of sandstone to siltstone and shale varies from place to place, but in most areas sandstone probably constitutes 60 percent or more. Beds of conglomerate and conglomeratic sandstone are locally present but are not an important part of the formation. The shales and siltstones are usually evenly-bedded, but the sandstones are commonly cross-bedded and in some beds this structure may be strongly developed, although on the whole the Hampshire formation is not so conspicuously cross-bedded as is the Pocono formation. Ripple marks and mud cracks are also present in many of the beds.

Throughout the length of the exposures on the Deer Park anticline the predominant color is red, but at some places it is green to greenish-brown. Soils derived from this formation are typically red and generally make a sharp color contrast with the brown to buff soils of the Jennings and Pocono formations. In the western area of outcrop, on the Accident anticline, the Hampshire strata have a considerably larger percentage of beds which lack the typical red color. These beds are generally a light greenish-brown to brown micaceous siltstone or fine-grained sandstone and their abundance within the formation makes mapping difficult. Such strata lithologically resemble the Jennings formation, and Martin in his 1902 geologic map shows a small outcrop of Jennings about a mile and a half west of the town of Accident. The writer, however, prefers to map all such strata within the Hampshire because there are a number of places where such greenish-brown, evenly-bedded strata can be seen to be interbedded with, and to grade laterally into, typical Hampshire red beds. An excellent exposure of such lateral gradation is on the road which parallels Cove Run, about a thousand feet northwest of the settlement of Cove. This "Jennings" type of lithology is also well exposed in two quarries near the Bear Creek road, about 2 miles west of Kaese Mill (see Garrett County geologic map.) Although

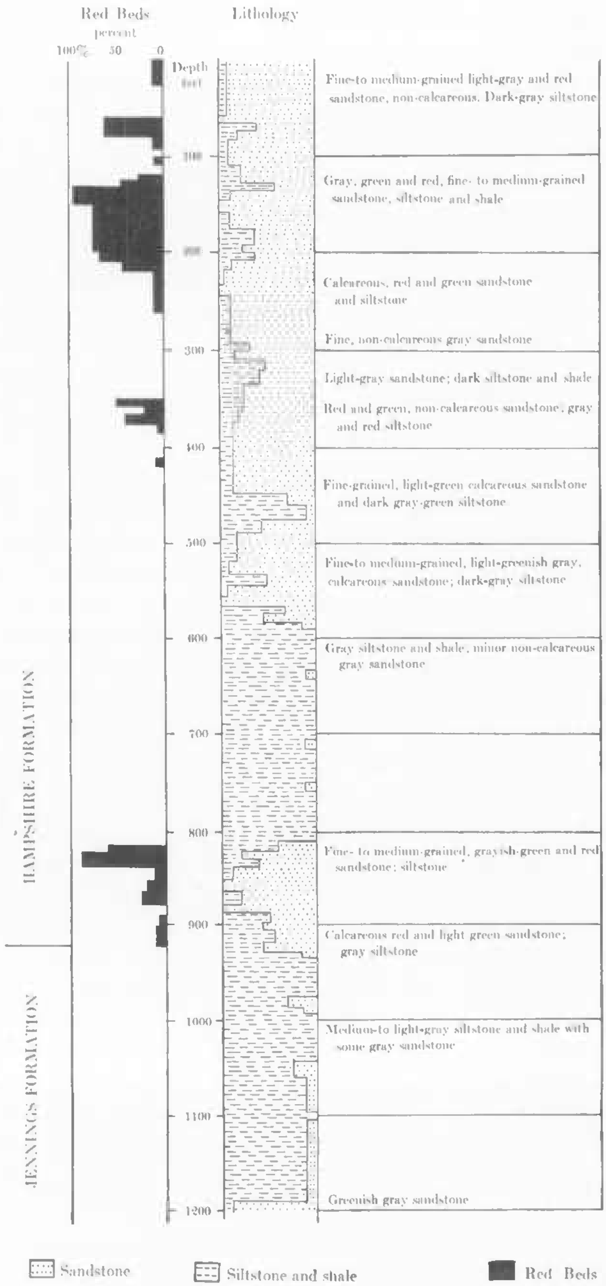

FIGURE 3. Graphic log of the upper part of the McCullough #1 well (F-113), Accident anticline, Garrett County (location on Plate I)—Right hand column gives lithologic percentages, left hand column percentage of red beds. Logged by J. S. Schlee.

these strata have at least a superficial lithologic resemblance to the Jennings formation, they almost never carry any marine fossils. The writer has never found any of this rock in place which had fossils, but a loose block of brown sandstone with brachiopods was found near the mouth of Fikes Run and another similar block was found along the Bear Creek road between Cove Run and Fikes Run. Evidently the Hampshire red beds in this western area of outcrop are beginning to lose the red color, grading laterally into greenish brown and brown sandstones, and very locally to tongue into typical marine strata. Such lenses are, however, too local in their development to be mapped separately and do not in any way appear to make a distinct stratigraphic unit as does the Jennings. This interpretation is further supported by the well cuttings from the upper part of the McCullough well (F-113). As is shown in figure 3 the red bed type of lithology is interstratified with greenish-grey and grey sandstones and siltstones. The contact in this well, as in most places, is not easy to locate, but all the thick red bed section is included in the Hampshire, thus placing the contact at a depth of 925 feet. The cuttings below this depth show no more significant zones of red beds. There are intervals with reddish brown or even red strata, but they are all thin. This section is also important because it shows that in the Bear Creek area the red beds continue for some distance below the surface, making it unlikely that any of the brown or greenish-brown rock exposed at the surface is true Jennings. The log in figure 3 is unusual in that it shows a higher percentage of sandstone than is generally found in the Hampshire formation.

The Hampshire formation is fairly resistant to erosion, this being especially true of the sandstones. Where the sandstone beds are especially well developed the formation makes prominent hills which locally exceed those formed by the Pocono, although in most places this is not the case.

A complete section of the Hampshire formation measured along Monroe Run, about 6 miles southwest of New Germany and ¾ mile north of Blackhawk school is given below. The traverse of the section is shown in figure 4.

Pocono formation

Dark brown to buff, medium- to fine-grained sandstone; beds 3 to 4 inches thick	20 ft.
Covered	72 ft.
Red siltstone and shale, beds to 3 inches	31 ft.
Covered	42 ft.
Brown to buff, iron-stained, fine- to medium-grained sandstone; beds to 3 in., strongly cross-bedded	33 ft.
Covered (first bridge in this interval)	40 ft.
Buff to brown, iron-stained, fine- to medium-grained sandstone; beds 1 in. to 1 ft., cross-bedded	75 ft.

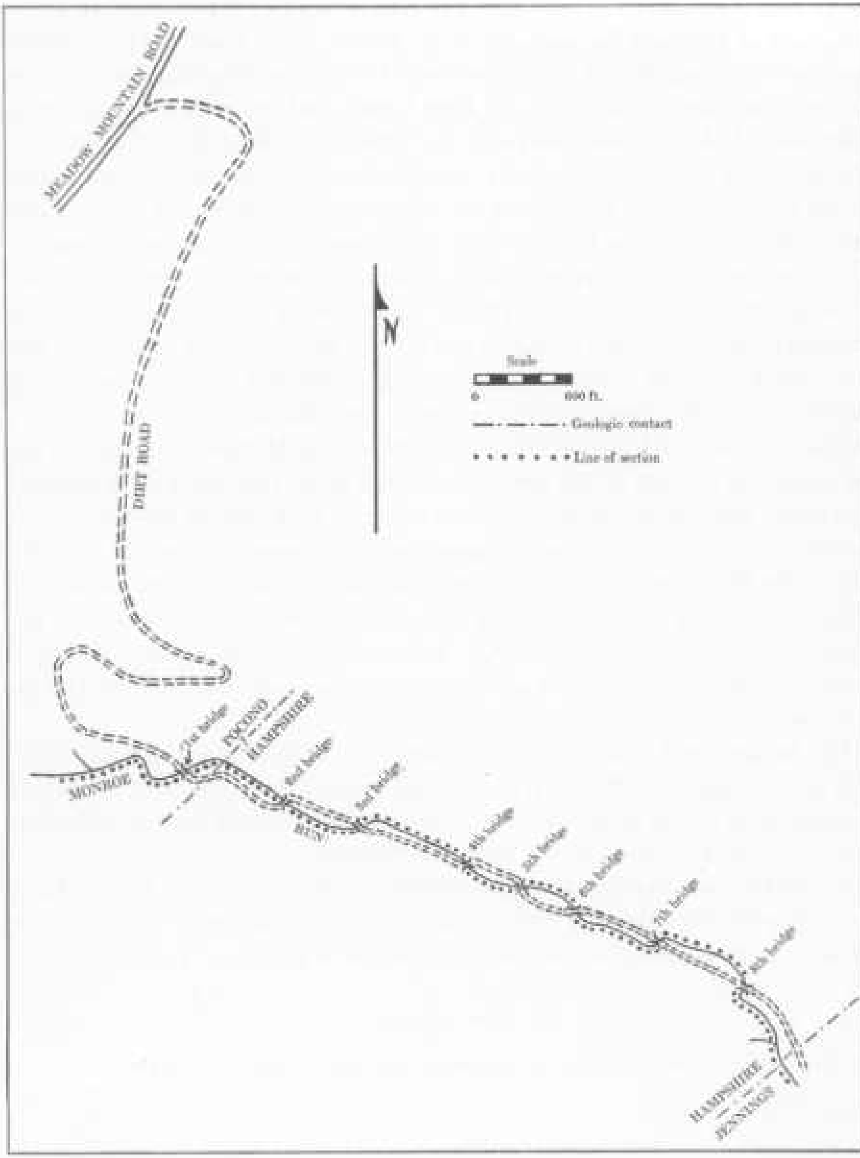

FIGURE 4. Sketch map showing location of the section of the Hampshire formation measured along Monroe Run

Hampshire formation

(1,595 ft. included in this formation)

Covered (Hampshire-Pocono contact probably falls in this interval)	24 ft.
Reddish-brown, thin-bedded, fine-grained sandstone	4 ft.
Covered (2nd bridge in this interval)	165 ft.
Reddish-brown, fine-grained sandstone; beds to 6 in.	10 ft.
Covered	60 ft.
Red siltstone; beds to 1 ft.	25 ft.
Covered (3rd bridge in this interval)	54 ft.
Red, fine-grained sandstone; beds to 1 in.	20 ft.
Covered	13 ft.
Buff thin-bedded sandstone; fine-grained	6 ft.
Covered	15 ft.
Red fine-grained sandstone and siltstone	8 ft.
Covered	19 ft.
Red micaceous siltstone, beds to 8 in.	30 ft.
Covered	5 ft.
Red siltstone and shale; minor brown siltstone	15 ft.
Covered	25 ft.
Buff thin-bedded sandstone	3 ft.
Covered	20 ft.
Red fine- to medium-grained micaceous sandstone; minor cross-bedding	12 ft.
Covered	15 ft.
Red fine- to medium-grained micaceous sandstone; strongly cross-bedded	4 ft.
Covered (4th bridge in this interval)	40 ft.
Greenish-brown, fine grained sandstone; beds to 8 in.	5 ft.
Covered	7 ft.
Greenish-brown, fine-grained sandstone	3 ft.
Covered	36 ft.
Red to reddish-brown, fine-grained sandstone; beds to 3 in.	9 ft.
Covered	5 ft.
Red fine-grained sandstone	5 ft.
Covered (5th bridge in this interval)	12 ft.
Buff thin-bedded, fine-grained sandstone	2 ft.
Covered	15 ft.
Red siltstone and sandstone; beds to 2 in.	8 ft.
Covered	84 ft.
Red thin-bedded siltstone	3 ft.
Covered	33 ft.
Red siltstone	7 ft.
Covered (6th bridge in this interval; about 70 ft. horizontal distance from 7 ft. unit above)	177 ft.
Reddish-brown fine-grained sandstone; strongly cross-bedded	10 ft.
Covered	37 ft.
Greenish-brown fine-grained evenly-bedded sandstone; beds to 5 in.	8 ft.
Reddish-brown fine-grained cross-bedded sandstone	7 ft.
Covered (7th bridge in this interval)	31 ft.
Red fine-grained cross-bedded sandstone	20 ft.
Covered	164 ft.

Red to brown fine-grained cross-bedded, and ripple marked sandstone; beds to 8 in.	35 ft.
Covered (8th bridge at the end of this interval)	62 ft.
Red to reddish-brown fine-grained sandstone	23 ft.
Covered	23 ft.
Red thin-bedded fine-grained sandstone	7 ft.
Covered	20 ft.
Red thin-bedded cross-bedded sandstone	16 ft.
Covered	38 ft.
Red fine-grained sandstone	6 ft.
Covered (in this interval there is a small stream entering Monroe Run from the west. The Hampshire-Jennings contact may fall in this interval)	61 ft.

Jennings formation

Rusty brown weathering, fine-grained sandstone with a few thin beds of conglomeratic sandstone with pebbles to 1/4 in. Fresh surface is greenish-brown. Marine fossils, brachiopods	16 ft.

The foregoing section shows only minor amounts of shale and is misleading in this respect. Much of the formation is covered and a considerable part of the unexposed strata is probably shale since such beds are less resistant to erosion. A better place to study the lithologic composition of the Hampshire is in the cuts along the road leading north from the Savage River Dam to Big Run. This section was not measured because the general trend of the road cuts the strike of the strata at a low angle. An almost complete section can be seen on this road, however, with the shales and sandstones equally well exposed.

In the Monroe Run section, 1,595 feet of strata have been included within the Hampshire, but since neither the upper nor the lower portion is well exposed this thickness may not be exact. It is difficult also to get a very precise stratigraphic thickness of a formation in which cross-bedding is so well developed. Structure sections in this area, based upon the geologic map, indicate a thickness of 1,600 to 1,800 feet. In the northern part of the Deer Park anticline the formation appears to increase slightly in thickness, reaching 1,800 to 2,000 feet. South of Monroe Run the Hampshire thins and in the southwestern part of the Deer Park structure, between Deep Creek Lake and the West Virginia line, the formation is probably less than 1,400 feet thick.

On the Accident anticline the thickness of this formation cannot be determined from surface data because the base of the Hampshire is not exposed, but the Shartzer well (F-12) is believed to have penetrated the entire formation. Martens (1945, pp. 752–758) gives a very complete description of the cuttings from this well. He included the upper 1,631 feet within the Hampshire (Catskill) formation, but the upper 30 feet or so is probably Pocono (see under POCONO FORMATION). This would give the Hampshire a thickness of 1,600 feet, or somewhat less since the well interval is probably not true stratigraphic thickness.

East of Garrett County the Hampshire formation apparently thickens to around 2,000 feet in Allegany County and 3,800 feet in Washington County (Prosser and Swartz 1913, pp. 400–401). In eastern Hampshire County, West Virginia, about 30 miles southeast of Garrett County, Woodward (1943, p. 501) reports a thickness of 3,500 feet; and in Randolph County, about 40 miles southwest of Garrett County, he records a thickness of 600 to 1,000 feet. Woodward presents also an isopachous map of the Catskill (Hampshire) red bed facies for Pennsylvania, Maryland, and West Virginia (1943, p. 526).

The contact between the Hampshire and the Pocono is clearly a gradational one (see under POCONO FORMATION) and this is true also of the contact with the Jennings formation (see under JENNINGS FORMATION).

Fauna and age. No fossils were found in the Hampshire formation. Martin (1902, p. 90) recorded a few poorly preserved fish plates, and Prosser and Swartz (1913, p. 400) state that some imperfectly preserved pelecypods were found on the Baltimore and Ohio Railroad near Frankville* and in the railroad cut just east of Altamont. Woodward (1943, p. 527) notes that the Hampshire formation appears to be entirely devoid of marine fossils, but many of the beds carry macerated plant fragments and one zone, the "Saxton" shale member near Marlinton in Pocahontas County, has yielded some very well preserved plant fossils as well as a few linguloid brachiopods. He also mentions a locality in Pendleton County which has furnished a number of fish plates.

The reference of the Hampshire formation to the late Devonian is based largely upon its stratigraphic relations; it is underlain by the Jennings formation which is Chemung in age and overlain by the Pocono formation which is usually referred to the lower Mississippian. Though it is convenient to draw the Devonian-Mississippian contact at the Hampshire-Pocono contact, there is little evidence to support this (see under AGE of the POCONO FORMATION).

MISSISSIPPIAN SYSTEM

The Mississippian strata in Garrett County are subdivided into three stratigraphic units, the lowest being the Pocono formation followed by the Greenbrier and the Mauch Chunk formations. These formations are widely distributed in Garrett County, but the Mauch Chunk and Greenbrier formations have relatively little resistance to erosion and therefore are not well exposed. The Pocono, on the other hand, is a fairly resistant sandstone which commonly forms low ridges with scattered rock ledges exposed.

POCONO FORMATION

Name. The name Pocono was proposed by Lesley in 1876 to replace such names as Vespertine or Grey Catskill which had been used by the earlier

* Frankville, now called Floyd, is a small settlement about a mile east of the Savage River Dam. There the Baltimore and Ohio Railroad is on the Pocono formation and not on the Hampshire. See 1953 Garrett County geologic map.

workers in Pennsylvania. No type locality was designated, but later workers have assumed the type area to be in the Pocono Mountains of northeastern Pennsylvania. In recent years there has been considerable discussion as to the distribution of this formation in the type area and on the validity of the name (see under *Fauna and Age*), but most geologists have continued to use Pocono for those sandstones and shaly sandstones believed to be of lower Mississippian age (Weller and authors, 1948, Pl. 2, p. 171).

The Pocono formation has been recognized over a wide area in Pennsylvania, Maryland, West Virginia and northwestern Virginia. In many places it has been treated as a group and subdivided into several formations. Stose and Swartz (1912) in their study of the region around Hancock, Maryland, divided the Pocono group into the following formations:

Pinkerton sandstone
Meyers shale
Hedges shale
Purslane sandstone
Rockwell formation

The Pocono group in the Hancock area is between 1,800 and 2,000 feet thick, but west of there it is thinner and has not been broken down into smaller stratigraphic units. In Allegany County O'Harra mapped the Pocono as a single formational unit and this was done by Martin in the 1902 geologic map of Garrett County. Both presented a brief discussion of the formation in the County Reports which accompanied their maps (O'Harra 1900, pp. 109–110, p. 162; Martin 1902, pp. 90–92, pp. 169–170).

Distribution. In Garrett County the Pocono formation crops out on the flanks of the Deer Park and the Accident anticlines. On the former structure it forms two, narrow, elongate, outcrop belts, extending the length of the county in a northeast-southwest direction. Since the Pocono formation is composed largely of sandstone which is relatively resistant to erosion, it forms a series of elongate hills which are parallel to the higher hills of the Pottsville formation. It has the same general outcrop pattern on the Accident anticline, but since this structure pitches to the northeast and to the southwest the Pocono outcrop closes around both ends. As the Accident anticline is a flatter structure than the Deer Park anticline, the Pocono formation has a much gentler dip and a wider outcrop belt.

The Pocono outcrop pattern on the new Garrett County geologic map is in general similar to that shown on the 1902 geologic map of Martin. The most significant change is in the southeastern portion of the Accident anticline where the new map shows a much wider outcrop belt which extends eastward to cap the higher hills in the region west and southwest of Accident. In this area bedrock is well exposed only along Rocklick Creek and the South Branch of Bear Creek, where the strata are composed of buff and brown sandstone of the Pocono type. Exposures on the higher hills are meager, but in general the soil has a brown color and the float is made up largely of brown to buff sandstone fragments, indicating the presence of at least a thin veneer of Pocono. This interpretation is further supported by the Shartzer #1 well (F-12, Plate I) which was drilled on the hill northwest of Accident. Martens' log (1946, pp. 725–758) of this well shows the upper 30 feet composed largely of brown sandstone, followed by a sequence of sandstones and shales which are dominantly red. This upper 30 feet is probably basal Pocono underlain by the Hampshire red beds. It could be only a zone of brown sandstone within the Hampshire, but almost all the surface float and soil in this vicinity has a buff or brown color which seems more reasonably placed within the Pocono. Furthermore, by excluding this, the Hampshire formation has a thickness of approximately 1,600 feet, which checks moderately well with the thickness at the north end of the Deer Park anticline (1,600 to 2,000 feet). It should be emphasized, however, that the Hampshire-Pocono contact is gradational and especially difficult to map in an area where the dip is gentle and the outcrops poor.

Lithology and thickness. The Pocono formation consists largely of sandstone interbedded with some siltstone and shale. The sandstone beds are composed mostly of quartz grains, of medium-to coarse-grain size, but locally they may be very conglomeratic. In most places the sandstones have an irregular, lenticular bedding and are conspicuously cross-bedded (Pl. V). A considerable amount of siltstone and shale are present, but it is estimated that from 60 percent to 80 percent of the formation is composed of coarser material. The weathered color is typically some shade of greenish- to yellowish-brown or grey, commonly with a rusty, iron-stained appearance. Red to reddish-brown beds are present, however, and these resemble the underlying Hampshire formation.

The Pocono-Hampshire contact is a gradational one and the two formations are similar in being composed almost entirely of clastic material, although there is probably a larger proportion of shale in the Hampshire; the sandstones of both are usually strongly cross-bedded. For field identification and mapping these formations are distinguished primarily by color—the Hampshire being predominantly a red bed sequence and the Pocono formation being composed largely of strata of shades of grey and brown. This gradational contact is not an easy one to map, and the difficulty is further complicated by the fact that there are some red beds scattered throughout the Pocono. The transitional nature of this contact has been noted in many other places, as in the Hancock area (Stose and Swartz 1912, p. 13) and in West Virginia (Woodward 1943, p. 503, pp. 510–511). On the geologic map of Garrett County the writer has tried to place the contact at the stratigraphic position where the dominant red of the Hampshire gives way to the dominant browns and greys of the Pocono, but where the dips are low and the strata poorly exposed it is very difficult to locate the contact accurately (as on the western side of the Accident anticline).

The Pocono formation disintegrates to form a sandy soil with a brown color, whereas the Hampshire formation usually weathers into a soil of varying shades of red. This contrast between the soils of the two formations is best seen in plowed fields or along unimproved dirt roads.

The Pocono-Greenbrier contact is placed where the non-calcareous sand-

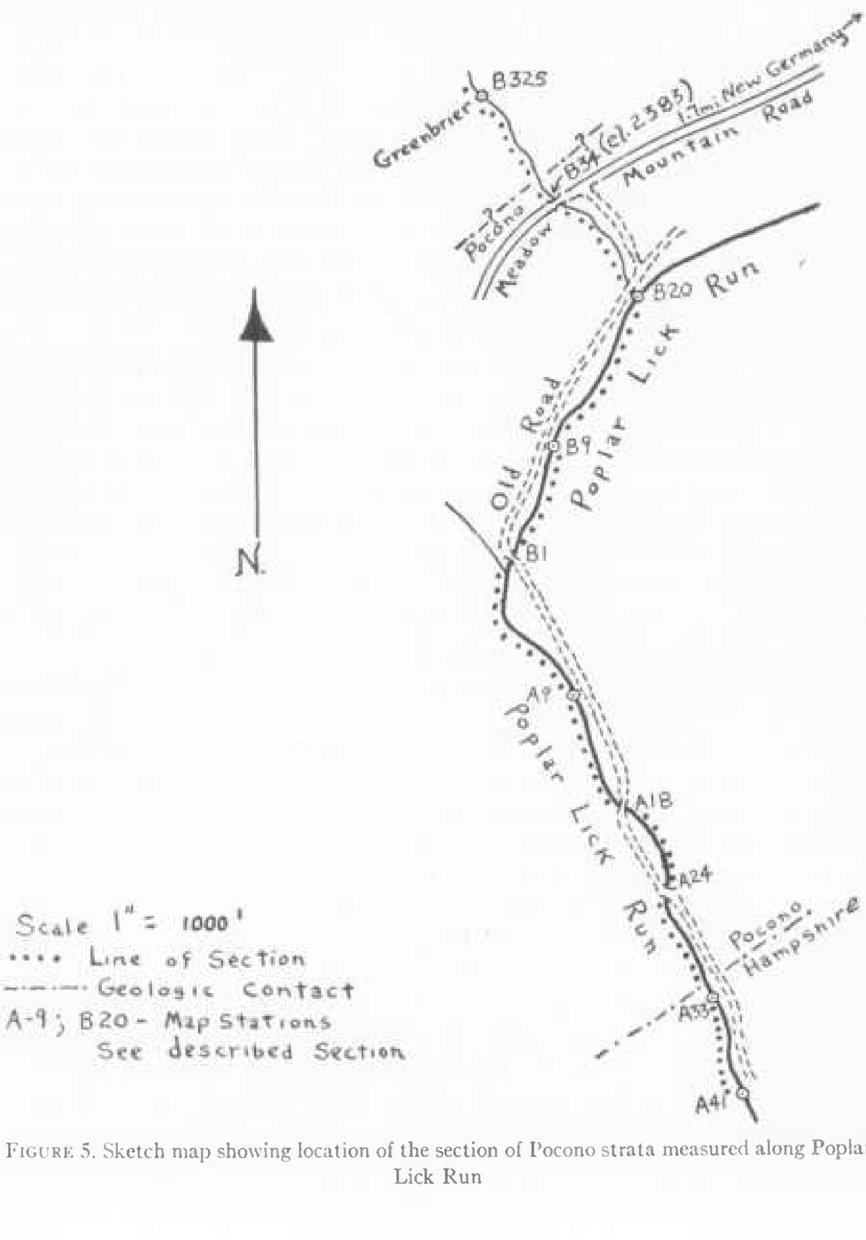

FIGURE 5. Sketch map showing location of the section of Pocono strata measured along Poplar Lick Run

stones of the Pocono are overlain by the calcareous shales or sandy limestones of the Greenbrier formation. Martin (1902, p. 96) has described this contact as a gradational one, but where observed by the writer it appears to be rather sharp, so if it is gradational the transitional zone is only a few feet thick. The upper contact of the Pocono formation is only rarely seen in Garrett County. As the Greenbrier and Mauch Chunk formations disintegrate rather readily to form soil covered slopes, the contact is concealed over large areas and its position has to be inferred. The contact was at one time rather well exposed on the north side of the Savage River dam but the completion of that structure has flooded the outcrops (see Greenbrier section, page 39). It is also rather well exposed on the west flank of the Accident anticline, along the Friendsville-Kaese Mill road about 2 miles east of Friendsville. The contact may also be seen in a quarry at the southwestern end of this structure, about a mile and three-quarters northeast of Sang Run and a mile and three-quarters west and south of Hoyes (see Garrett County geologic map). The Greenbrier limestone is being quarried, and in places this formation has been entirely stripped away, exposing the top of the Pocono formation.

The most complete Pocono section measured is about 1.7 miles southwest of New Germany on the west flank of the Deer Park anticline. It was measured along Poplar Lick Run, beginning about ¾ mile southeast of the Meadow Mountain road, extending along the run to a point where it is near the road (near elevation 2,583 on the Garrett County map), and then continuing northwest up the small creek draining off the east side of Meadow Mountain. The traverse of the section is shown in figure 5. The section is:

Greenbrier formation

Red calcareous clay (Station B-235)	18 ft.
Covered	7 ft.
Red and green calcareous clay; beds less than 1 in.	12 ft.
Covered (*Greenbrier-Pocono* contact in this interval)	187 ft.

Pocono formation (1,080+ feet)

Buff non-calcareous sandstone	4 ft.
Covered (bridge over Meadow Mt. road in this interval; station B-34)	30 ft.
Dark reddish-brown medium- to coarse-grained non-calcareous sandstone; beds to 3 in.; strongly cross-bedded	14 ft.
Covered	97 ft.
Greenish-brown fine-grained sandstone and siltstone; beds 1 in. to 3 in.; cross-bedded; much iron-stained, in places weathering a dark brown	30 ft.
Covered	43 ft.
Brown iron-stained medium-grained sandstone; beds 1 in. to 4 in.; cross-bedded (station B-20)	2 ft.
Covered	6 ft.
Brown to greenish-brown iron-stained medium- to fine-grained sandstone; micaceous in places; beds 1 in. to 5 in.; cross-bedded	27 ft.

Covered	46 ft.
Brown-weathering iron-stained fine-grained sandstone; beds to 5 in., irregular	26 ft.
Covered	10 ft.
Brown irregularly bedded sandstone	3 ft.
Covered	4 ft.
Brown to greenish-brown medium-grained sandstone; beds 3 in. to 8 in.	7 ft.
Covered	10 ft.
Greenish-brown sandstone (station B-9)	2 ft.
Covered	44 ft.
Reddish-brown sandstone	2 ft.
Covered	4 ft.
Brown to grey sandstone; beds less than 3 in.	2 ft.
Covered	14 ft.
Dark-brown to greenish-brown fine- to medium-grained sandstone; beds 1 in. to 4 in., cross-bedded	15 ft.
Covered	2 ft.
Dark-brown sandstone; beds to 1 ft.	2 ft.
Covered (to bridge; station B 1)	10 ft.
Covered	49 ft.
Dark reddish-brown fine-grained micaceous sandstone	4 ft.
Covered	34 ft.
Dark reddish-brown fine-grained micaceous sandstone; beds usually less than 1 in.; cross-bedded	4 ft.
Covered	62 ft.
Dark-brown to greenish-brown medium-grained sandstone; beds to 5 in., cross-bedded. (station A 9)	8 ft.
Covered	68 ft.
Bright red clay	3 ft.
Covered	51 ft.
Dark red micaceous siltstone; beds usually less than 1 in.	14 ft.
Dark reddish-brown and greenish-brown sandstone; beds 1 in. to 1 ft., cross-bedded	21 ft.
(bridge; station A 18)	
Covered	169 ft.
Dark reddish-brown fine- to medium-grained sandstone; beds 1 in. to 3 in.; some cross-bedding (bridge, station A 24)	27 ft.
Covered	17 ft.
Greenish-brown fine-grained sandstone; beds to 8 in.	5 ft.
Covered	23 ft.
Greenish-brown to brown medium grained cross-bedded, sandstone	18 ft.
Covered	15 ft.
Greenish-brown medium-grained sandstone, beds to 1 ft.	6 ft.
Covered	6 ft.
Brown to reddish-brown fine grained cross-bedded sandstone	15 ft.
Covered	5 ft.

Hampshire formation

Red siltstone	3 ft.
Covered	5 ft.

Station A 33	
Covered	23 ft.
Dark red fine-grained sandstone	4 ft.
Covered	30 ft.
Red to dark-red fine- to medium-grained cross-bedded sandstone; beds to 3 in.	16 ft.
Covered	8 ft.
Dark-red fine-grained cross-bedded sandstone	18 ft.
Covered	15 ft.
Light red sandstone	2 ft.
Covered	19 ft.
Red to dark-red fine-grained micaceous sandstone and red shale; beds to 8 in.	25 ft.
Station A 41	
Red thin-bedded (to 2 in.) ripple marked sandstone	8 ft.

In the foregoing section almost no shale is recorded, and the section is therefore somewhat misleading. Over half of this section is covered and a part of the unexposed strata is probably shale, since such beds erode easily whereas the sandstone beds form ledges.

A better idea of the amount of shale present is obtained from two incomplete sections measured in the vicinity of the Savage River dam. The sections show also that locally the Pocono may have a rather high percentage of red beds. The first of these sections, showing the upper part of the Pocono formation, is about 4 miles northwest of Westernport. It extends north-south across Crabtree Creek, a short distance west of its junction with Savage River, just above (north) the dam. It was measured before the dam was completed. Most of the area is now flooded.

Greenbrier formation

Sandy limestone	
Covered (Greenbrier-Pocono contact in this interval)	40 ft.

Pocono formation

Dark brown non-calcareous sandstone; beds 6 in. to 2 ft., irregular	20 ft.
Red and brown interbedded siltstone and shale; beds usually 1 in. or less	22 ft.
Brown interbedded sandstone, siltstone and shale; beds to 5 in.	5 ft.
Light brown medium-grained non-calcareous sandstone; beds to 2 ft.; cross-bedded	10 ft.
Light brown shale	4 ft.
Brown medium-grained sandstone	2 ft.
Interbedded red siltstone and shale; beds usually less than 1 in.	10 ft.
Greenish-brown, non-calcareous siltstone	8 ft.
Covered	13 ft.
Dark brown fine- to medium-grained sandstone, beds 6 in. to 2 ft., cross-bedded; non-calcareous	25 ft.
Covered	

The lower part of the Pocono formation is shown in the following section located a short distance north and west of the preceding section, along Middle Fork Run, just north of the junction with Crabtree Creek. Most of this section is also flooded by the new Savage River lake.

Pocono formation

Covered	
Interbedded dark-red siltstone and shale; beds usually less than 8 in.	30 ft.
Covered	15 ft.
Dark brown non-calcareous medium-grained sandstone; beds to 3 ft.; strongly cross-bedded	80 ft.
Covered	46 ft.
Red shale	3 ft.
Reddish-brown to light-brown fine- to medium-grained sandstone; some beds of flat shale pebble conglomerate; beds to 3 ft.	30 ft.
Greenish-brown shale	6 ft.
Reddish-brown cross-bedded sandstone	2 ft.
Red shale	3 ft.
Brown sandstone	2 ft.
Brown to light-brown fine- to medium-grained sandstone; cross-bedded; beds to 5 in.	20 ft.
Red shale	2 ft.
Light brown non-calcareous sandstone; bedding irregular	10 ft.
Reddish-brown shale	5 ft.
Brown cross-bedded sandstone	5 ft.
Covered	117 ft.
Red siltstone and shale	6 ft.
Reddish-brown sandstone; beds to 6 in.	3 ft.
Dark reddish-brown fine- to medium-grained sandstone; non-calcareous; strongly cross-bedded; beds to 2 ft.	43 ft.

Hampshire formation

Red interbedded siltstone, shale and sandstone	

Another incomplete section of lower Pocono strata was measured near Altamont station on the Baltimore and Ohio Railroad, about 6 miles northeast of Mountain Lake Park. It begins just west of the point where Maryland highway 38 crosses the railroad and extends west along the railroad.

Pocono formation

Light brown fine-grained sandstone; beds 6 in. to 2 ft., evenly bedded	24 ft.
Partly covered; exposures of light brown to grey shale and brown blocky siltstone	37 ft.
Light brown to grey fine-grained sandstone; spheroidal weathering	15 ft.
Light brown fine-grained sandstone; beds usually less than 3 inches	10 ft.
Partly covered; some exposures of light brown shale	16 ft.
Light yellowish-brown fine-grained sandstone; evenly bedded, beds average 6 in.	47 ft.

Partly covered; few exposures of light brown sandstone	12 ft.
Covered 14 ft.	14 ft.
Reddish-brown shale	3 ft.
Covered (Hampshire red beds exposed a short distance to the north)	

The foregoing Pocono section is unusual in lacking the cross-bedded sandstones so common in the formation. No fossils were found here, but Martin (1902, p. 91) records marine fossils from the Pocono formation at Altamont. The presence of marine fossils in this formation is discussed under *Fauna and Age*.

In the above sections the Pocono shows very little clastic material above the sand size, but locally it may be conglomeratic. The conglomerate facies is well displayed at the quarries of the Silver Knob Sand Company on the west flank of the Deer Park anticline, about 5 miles southwest of Oakland. There are two quarries, one on each side of the road leading northwest from Sunnyside Grange Hall to the Youghiogheny River (see new Garrett County geologic map). In this area the Pocono consists of a very clean quartz conglomeratic-sandstone with rounded pebbles up to an inch in diameter. The bedding is irregular and individual beds range up to a foot or more in thickness. The individual grains are not so well cemented as in most places and the rock is somewhat friable.

No sections of the Pocono formation were measured on the Accident anticline, but numerous exposures are on the flanks of this structure. There are a number of Pocono road-cuts along U.S. Route 40 where it crosses the north end of the anticline. There are also some fairly good exposures along the Bear Creek road, about 2 miles east of Friendsville.

The Poplar Lick Run section gives a thickness of 1,080 to 1,267 feet, depending upon where the position of the upper contact is placed in the covered interval at the top. Near the Savage River dam the Pocono is about 900 feet thick. At the north end of the Deer Park anticline, in the area between Avilton and U.S. Highway 40, structure sections based upon the geologic map indicate a thickness between 900 and 1,200 feet. Towards the south end of this anticline, in the area between Mt. Lake Park and the State line, the formation appears to have thinned to about 700 feet. Around the Accident anticline it is between 700 and 900 feet thick.

East of Garrett County the formation is thicker. In the Hancock region Stose and Swartz (1912) record a thickness of 1,800 to 2,000 feet. In Allegany County, Maryland, and Mineral County, West Virginia, Reger and Tucker give the Pocono thickness as 1,150 feet (1924, p. 146).

Fauna, flora and age. The name Pocono, as used by most authors, applies to a sequence of clastic sediments which are generally thought to be of lower Mississippian age. This stratigraphic unit has been recognized over a large area in Pennsylvania, Maryland, and West Virginia, and in many places it carries a Mississippian flora. In the area around Hancock, Maryland, David

White (in Stose and Swartz 1912) listed a number of plants from the Pocono group (Rockwell formation, Hedges shale and Pinkerton sandstone), and on the basis of these fossils he correlated the strata with the Pocono of Pennsylvania which he considered to be Mississippian. However, Chadwick has raised a question as to the age of the Pocono formation in its type area. In 1933 (1933A, p. 177) he stated "The eastern or type Pocono has nothing whatever to do with the Mississippian strata and faunas called by that name, but is midway in the upper Devonian, as may also be the typical Mauch Chunk." This idea was discussed at greater length in a second paper (1933B, pp. 106–107) in which he again concluded that the "Pocono is Devonic in age." In 1934 David White (pp. 265–272) reviewed the palaeobotanical evidence and repeated his earlier views that the Pocono "consisting mainly of grey sandstones" between the "red Mauch Chunk and the red Catskill" was Mississippian in age. This question was reviewed at some length by Caster (1934, pp. 134–148) who concluded: "By way of summary of the controversy the nomenclatorial nature of the problem rather than its stratigraphic aspect must be emphasized. There is no argument about the existence of both a Devonian "Pocono"-like magnafacies in the Catskill delta deposits to the east of the typical red magnafacies; nor will any deny, who are familiar with the strata, that there are present over a large area of Pennsylvania beds of "Pocono"-like lithology which overlie Devonian beds and do not grade laterally into the magnafacies which characterize the Devonian delta beds of the same general territory. These latter are the ones which carry Mississippian faunas and floras and the ones to which the name "Pocono" is linked in common and long accepted usage. The problem now arises whether this usage despite its ubiquity in print is tenable on the grounds of strict priority of usage and particularly of specific geographic designation."

Since the publication of the above papers most geologists have continued to use Pocono for those clastic strata of early Mississippian age (see bibliography in Wilmarth 1938, pp. 1688–1689; especially papers by Ashley and Willard 1935 and Willard 1936). This procedure was followed by the authors of the Mississippian Correlation Chart (Weller and authors 1948, Pl. 2), although in the text they did note that there was a question in regard to the type locality (p. 171) and also a question concerning the Devonian-Mississippian boundary in southcentral Pennsylvania. They go on to state that in West Virginia the strata called Pocono do not correspond to the same named units in Pennsylvania although on the chart (Pl. 2) the Pocono of West Virginia and Maryland are shown to be in part equivalent to the Pocono of Pennsylvania.

Most of the fossils that have been collected from the Pocono are plants and this fact, together with the general lithologic and stratigraphic characters of the formation, has led most investigators to interpret it as predominantly a terrestrial deposit (White 1934, p. 267; Willard and authors 1948, p. 171), an interpretation with which the writer is in accord. There is, however, at least one marine zone present in southern Pennsylvania, Maryland, and West Virginia. W. A. Price (1920, pp. 146–147) has recorded marine fossils from the following localities:

1. Broad Top Coal Field, southern Pennsylvania.
2. Beaverhole (ford and quarries), Cheat River, Preston County, West Virginia.
3. Laurel Mountain, Tucker County, West Virginia.
4. Altamont, Garrett County, Maryland (Martin 1902, p. 91)
5. Limestone Mountain, Tucker County, West Virginia.
6. Price sandstone (Pocono?), southwestern Virginia.

The stratigraphy of the Pocono in the Broad Top Basin of Pennsylvania was described by Reger and marine fossils were recorded from four areas (1927, pp. 398–402). In each of the described sections the marine fossils were confined to a 75 to 90 foot zone of dark shale (Riddlesburg shale) which was believed to represent a common horizon, some 500 to 670 feet below the top of the Pocono. This fauna was later described and illustrated by Girty (1928, pp. 111–123) who reported the following species:

Scarphiocrinus kirkianus
Spirorbis sp.
Stenopora ? sp.
Lingulidiscina newberryi ?
Rhipidomella huntingdonensis
Schuchertella chemungensis
Chonetes acutiliratus
Camarotoechia aff. C. contracta
Cranaena sp.
Spirifer compositus
Nucula aff. N. houghtoni
Palaeoneilo concentrica
Leda aff. L. spatulata
Cypricardinia consimilis
Glossites ? sp.
Pleurotomaria aff. P. hickmanensis
Loxonema sp.
Orthoceras sp.
Cytherellina ? sp.
Kirkbya ? sp.

Girty was uncertain as to the age of this fauna. He states that "the Carboniferous age of this fauna, though it is very probable on broader grounds, is but slenderly supported by the evidence of the fauna itself. Except for a few types that have more distinctly Carboniferous affinities, it might almost as well be Devonian." On the Mississippian Correlation Chart the Pocono in this area of southern Pennsylvania is placed in the lower Mississippian, but the text makes a note of Girty's uncertainty concerning this fauna and also states "On the basis of unpublished faunal studies Laird places the Mississippian-Devonian boundary at the base of the Riddlesburg."

This brief summary shows that although there are questions as to the age of the Pocono, most authors have treated it as a stratigraphic unit, referred to the lower Mississippian system, and probably varying somewhat in age in different places. This investigation adds little to the general information on this problem. The only fossils seen were fragmentary plant remains, although Martin and Price recorded marine fossils in the strata at Altamont. Thus outside of the Hancock area little is known as to the floras or faunas of the Pocono (or of the underlying Hampshire formation) in Maryland. In Garrett County the Pocono-Hampshire contact is clearly a gradational one and, although for descriptive purposes the Devonian-Mississippian contact is placed at this point, there is actually no supporting paleontologic evidence. The first significant fossils which can be obtained beneath this contact are from the Jennings formation (Devonian) and the first significant fossils above this contact are from the Greenbrier (Mississippian). On the basis of regional stratigraphic relations it seems reasonable to assume that the Pocono in Garrett County is, at least in part, lower Mississippian in age.

GREENBRIER FORMATION

Name. The Greenbrier limestone was named by Rodgers in 1879. According to Wilmarth (1938, p. 867) the name was taken from the Greenbrier River, Pocahontas County, West Virginia, but Reger and Price (1926, p. 445) state that "the name is derived from the Greenbrier River or perhaps from Greenbrier County in southern West Virginia." Although it was not very clearly defined by Rodgers, the name came to be rather widely applied to those strata, dominantly calcareous, which were overlain by the Mauch Chunk formation and underlain by the Pocono or Maccrady formations. The Greenbrier formation was discussed in many of the early publications of the West Virginia Geological Survey, but it was first fully described in the report by Reger and Price (1926, pp. 443–451) on Mercer, Monroe, and Summers Counties. They treated the Greenbrier as a series and subdivided it into the following formations:

Alderson limestone
Greenville shale
Union limestone
Pickaway limestone
Upper Taggard shale
Taggard limestone
Lower Taggard shale
Patton limestone
Patton shale
Sinks Grove limestone
Hillsdale limestone

In 1950 Wells presented much additional stratigraphic and paleontological information on the Greenbrier series of southeastern West Virginia. He recognized the stratigraphic divisions of Reger and Price, but he did combine the Patton limestone and shale and the Sinks Grove limestone into a single formation, the Denmar.

The Greenbrier has been recognized over a large area in West Virginia, Maryland, and southwestern Pennsylvania, and has also been correlated with the Big Lime and Maxville limestone of southeastern Ohio (Weller and authors 1948; Rittenhouse 1949, p. 1707; Morse 1910, pp. 109–111). It is well represented in Maryland, being present in the western part of Allegany County and in Garrett County. Martin treated the Greenbrier as a formation on his map of Garrett County and this has been done on the new map. However, in his report on the county, Martin (1902, p. 96) subdivided the formation into three members, the Upper Greenbrier, Middle Greenbrier, and Lower Greenbrier. The Upper member was described as consisting largely of limestone, the Middle member as probably shale and sandstone, and the Lower as dominantly calcareous. Martin (1908, p. 4) further discusses the Greenbrier formation in the Accident-Grantsville folio and there correlated the Lower Greenbrier member with the Loyalhanna limestone of southwestern Pennsylvania.* The writer recognizes the Loyalhanna member but questions the other two subdivisions proposed by Martin; the problem of lithologic subdivisions is discussed more fully under *Lithology and Thickness*.

The Greenbrier reaches its maximum thickness in southeastern West Virginia where it may be as much as 1,800 feet thick. There it has been divided into a number of formations and accordingly has been elevated to a series.† To the north the Greenbrier thins progressively (Wells 1950, p. 919) so that in western Maryland, where it is treated as a formation, it probably does not exceed 300 feet in thickness. It is present in southwestern Pennsylvania only in the counties of Greene, Fayette, Washington, Westmoreland, Indiana, Cambria and Allegheny (Rittenhouse 1949, p. 1707). North and east of here it is not recognized and the Mauch Chunk rests directly upon the Pocono. Thus the Greenbrier formation of Maryland and southwestern Pennsylvania represents only a small tongue of the Greenbrier series of southeastern West Virginia. Furthermore in the northern areas it covers only a part of the time interval represented in southwestern West Virginia. The inferred stratigraphic and time relationships are shown in figure 6 and discussed under *Fauna and Age*.

The Greenbrier formation and fauna was the subject of a Johns Hopkins

* The Loyalhanna limestone is sometimes treated as an independent formation and sometimes as a member of the Greenbrier formation; see Wilmarth 1938, p. 1932; Butts 1924, p. 254; Weller and authors 1948.

† It would probably be better to treat the Greenbrier in southeastern West Virginia as a rock unit, Greenbrier group, rather than as a time-rock unit, Greenbrier series.

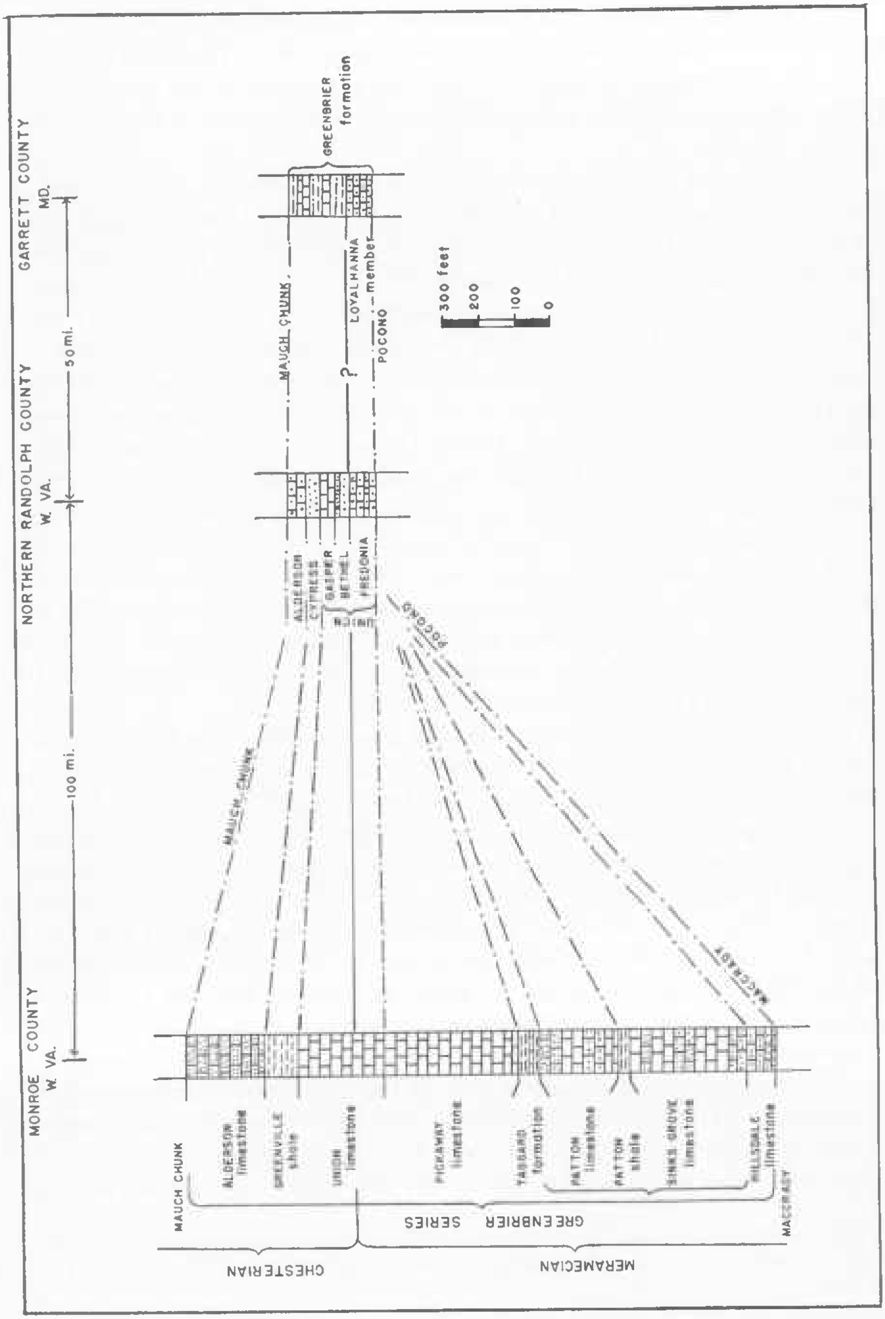

FIGURE 6. Generalized sections of the Greenbrier in West Virginia and Maryland to show the inferred stratigraphic and time relationships. Data from Wells 1950; Reger 1931; Weller and authors 1948.

University Ph.D. dissertation by C. W. Cooke in 1912. This contains much excellent information that has never been published.

In 1949 Rittenhouse made a study of the petrology and paleogeography of the Greenbrier formation based on both surface and subsurface data from West Virginia, Ohio, and southwestern Pennsylvania. He concluded (pp. 1721–1724) that the clastic limestones of this formation were the result of near shore accumulation, probably in part bar, beach, channel, and dune deposits.

Distribution. The Greenbrier formation crops out along both flanks of the Deer Park anticline, but being a relatively thin formation with a fairly steep dip it forms a narrow outcrop belt. This same condition prevails on the Accident anticline except at the southern end where the dips are gentle and the formation comes to the surface in two long belts along the Youghiogheny River and Hoyes Run.

The Greenbrier formation is poorly exposed in Garrett County. It is composed largely of limestone and calcareous shale, having so little resistance to weathering and erosion that natural exposures are uncommon. The Greenbrier is underlain by a resistant formation, the Pocono, and is overlain by the non-resistant Mauch Chunk formation which is in turn overlain by the resistant Pottsville formation. Erosion acting on this lithologic sequence usually produces two ridges, a lower Pocono ridge and a much higher Pottsville ridge, separated from one another by a valley. The valley, though in places cut in the Greenbrier formation, is usually formed on the back or dip slope of the Pocono formation. The Pottsville formation, making a much higher ridge than does the Pocono, to some extent protects the Mauch Chunk and Greenbrier formations.

The best exposures are found in quarries which have been opened in the limestones of the Greenbrier formation (see Garrett County geologic map). These exposures, however, present a somewhat misleading picture of Greenbrier lithology since the quarry workings seldom extend into the more shaly parts of the formation.

Natural exposures of Greenbrier ledges are exposed along the Youghiogheny River, about a half mile west of Sang Run. Good exposures of the lower part of the formation may also be seen on the east flank of the Deer Park anticline, just east of Pine Swamp Run near the Eric Lookout Tower, and about 2½ miles north of the Savage River dam.

One of the best exposures of the Greenbrier formation is on the hill slope just east of the Savage River dam where excavations for the spillway have exposed about 250 feet of strata (Pl. VI) (*See section under Lithology and thickness.*)

The geologic mapping of a poorly exposed formation such as the Greenbrier is difficult and the difficulties are increased because the formation is overlain by the equally poorly exposed Mauch Chunk formation. The Greenbrier is doubtless everywhere present in Garrett County (except on the anticlines where it is removed by erosion) because partial exposures may be found at widely separated localities. On the Deer Park anticline, Greenbrier rocks crop out on both flanks, extending from Pennsylvania south to West Virginia, and also on the Accident anticline. There are, however, large gaps between these exposures without any bed rock exposed so that both the upper and lower contacts have to be inferred over considerable areas. However, the distribution of the Greenbrier formation is probably shown with reasonable accuracy on the new geologic map, even though the exact position of the contacts is uncertain in many places. The distribution of the Greenbrier formation shown on the new map conforms in general to that on the older map of Martin. Some changes have been made, however, in the position of the Greenbrier-Pocono contact. At many places, especially on the flanks of the Deer Park anticline, outcrops of Pocono were found in areas which Martin mapped as Greenbrier.

Lithology and thickness. The Greenbrier formation in Garrett County is composed predominantly of calcareous shales and sandstones and argillaceous and arenaceous limestones (Pl. VI). The shales are commonly some shade of red or red mottled with green, but some are brown or green. The limestones are commonly grey, but they may be red or reddish-brown. Most of the limestone beds are very impure. Mathews and Grasty (1908, p. 467) gave 6 chemical analyses of the Greenbrier limestone from different parts of the county which show a CaO content of 20.9 percent to 53.2 percent and a SiO_2 content ranging from 4.4 percent to 20.9 percent, and averaging about 13 percent. In most samples the MgO was low, less than 1 percent, but in one sample it was 7.5 percent.

In many areas of Maryland, and perhaps in all places, the lower part of the Greenbrier formation is a distinctive stratigraphic unit which can be easily separated from the overlying strata (Pls. VI, VII). This lower member consists of medium- to fine-crystalline limestone with varying amounts of quartz sand dispersed through it and commonly with conspicuous cross-bedding (Pl. VII, fig. 2). The quartz sand is so concentrated in some beds that they grade over into a calcareous sandstone, whereas in other beds the sand grains are in scattered, isolated grains. The quartz grains are commonly rounded and may be as much as 2 mm. or more in diameter although the average size is somewhat less. There is little doubt that this unit is the same as the Lower Greenbrier member described by Martin in 1902 (p. 96) and which he later correlated with the Loyalhanna limestone of Pennsylvania (Martin 1908, p. 4), a correlation with which Butts (1924, p. 249) agreed. This correlation is reasonable since these strata in Maryland are lithologically similar to and occupy the same stratigraphic position as the Loyalhanna limestone of Pennsylvania, but there is no supporting faunal evidence since fossils have not been described from these strata in either State. In Pennsylvania Butts (1924, p. 249) treated the Loyalhanna limestone as a formation but stated that in Maryland "it has been properly included in the Greenbrier limestone [formation] as a basal member." In view of the poor exposures in Garrett County that procedure is followed in this report.

The Loyalhanna member is overlain by strata which are predominantly calcareous shales, but with some calcareous sandstones, and which are mostly red or red mottled with green. Interbedded with these shales are beds of argillaceous limestone (less commonly arenaceous), generally grey or greenish-grey, in which marine fossils are common. The Loyalhanna member and the overlying strata are well exposed in the cliff just east of the Savage River dam (Pl. VI). The lowest exposure of Greenbrier is 42 feet below the spillway; the section continues up the hill to the highest exposed bed. The section was measured before the dam was completed; the lower 40 feet of strata are now flooded.

Greenbrier or *Mauch Chunk formation*

A few feet of strata exposed high on the cliff and not examined; above here the rocks are covered	

Greenbrier formation

Maroon calcareous siltstone and shale. Few thin argillaceous limestone beds	20 ft.
Grey argillaceous limestone. Lower and upper portions with some red shale. Numerous marine fossils, mostly brachiopods and bryozoa	3 ½ ft.
Red calcareous siltstone and shale; beds to 2 ft.	5 ft.
Reddish-brown medium-grained calcareous sandstone	20 ft.
Red fissile micaceous shale	12 ft.
Greenish-grey fine- to medium-grained sandstone mottled with red; beds to 4 in.	4 ft.
Maroon calcareous shale and siltstone; lower 2 ft. fossiliferous	15 ft.
Light greenish-grey argillaceous limestone; lenses of shale; poorly preserved brachiopods and corals(?)	2 ft.
Thin-bedded (to 2 in.) calcareous shale and siltstone; lower 15 ft. is greenish red, upper part maroon	23 ft.
Strongly calcareous reddish- to brownish-grey fine sandstone; upper 4 or 5 feet with many brachiopods	10 ft.
Maroon calcareous siltstone and shale; beds 1 in. to 1 ft.	12 ft.
Reddish-grey medium- to coarse-grained calcareous sandstone	3 ½ ft.
Interbedded red calcareous shale and siltstone with argillaceous limestone; beds average 2 to 3 in. in thickness; bedding somewhat lenticular	19 ft.
Grey to greenish-grey sandy limestone with irregular beds of red shale	3 ft.
Maroon calcareous siltstone and shale; bedding irregular	7 ft.
Mottled, maroon and pale green, sandy limestone; sand is fine-grained, shows some cross-bedding	3 ft.
Maroon calcareous shale and siltstone; a few lenticular beds of calcareous sandstone showing cross-bedding and channeling	10 ft.
Maroon calcareous shale and sandstone; pale green streaks	13 ft.

(Loyalhanna member)

Grey fine- to medium-grained sandy limestone; sand scattered through the beds and also concentrated in seams. Beds 6 in. to 2 ft.	38 ft.
Reddish-brown-weathering very sandy limestone; sand grains to 2 mm.; some channeling and cross-bedding	11 ft.
Red calcareous siltstone and shale	2 ½ ft.
Light grey-weathering fine- to medium-grained very sandy limestone; sand grains largely quartz, well rounded and up to 2 mm. in diameter; the more sandy layers weather into relief and show cross-bedding. The fresh surface of this rock is a darker grey or greenish-grey	16 ft.
Covered (Pocono or Greenbrier formation)	8 ft.

Pocono formation

Brown to reddish-brown fine- to medium-grained sandstone; largely not calcareous; conspicuous cross-bedding.

In the above section the Loyalhanna member is 67 feet thick, excluding the 8 foot covered interval at the base. The total exposed Greenbrier (including the Loyalhanna) is 252 feet, excluding the 8 foot covered interval at the base and the undescribed strata at the top. The latter may be the lower Mauch Chunk or the upper Greenbrier; even if it is not the Mauch Chunk formation, this is probably a nearly complete section of Greenbrier.

The Loyalhanna member is also well exposed about 2½ miles northeast of the Savage River dam, on the hillslope just east of Pine Swamp Run near the Eric Lookout Tower. Another good exposure of the Loyalhanna member is in a road cut on the east side of the highway along Bear Creek, about 2½ miles east of Friendsville. The Loyalhanna member in this area is a red-to reddish-brown cross-bedded sandy limestone which rests upon the yellowish-brown to reddish-brown sands and shales of the Pocono.

This member has been quarried in a few places. One such quarry is located about 1½ miles northeast of Sang Run and a short distance south of Gap Run (see geologic map); here the Loyalhanna has been removed down to the Pocono, giving an excellent view of the contact.

Locally the quartz grains in the Loyalhanna become so abundant that the rock grades over into a calcareous quartz-sandstone. This type of lithology is exposed along Ginseng Run, a short distance west of Sang Run.

The Loyalhanna member is also present in Allegany County. O'Harra (1900, pp. 111, 112) described a section along Stony Run in which the lower part of the Greenbrier is an arenaceous limestone which Martin (1902, p. 95) correlated with his Lower Greenbrier member (Loyalhanna).

Martin thought that the Pocono-Greenbrier (Loyalhanna) contact was a gradational one; he stated (1902, p. 96), "There is a gradual lithologic transition from the upper beds of the Pocono into the calcareous sandstone and siliceous limestone of the basal Greenbrier, and it is very difficult to draw an exact line between the formations." However, the lithologic break between these two formations is fairly sharp; the quartz sandstones and the shales of the Pocono appear to have little or no calcareous material, whereas the Loyalhanna member is dominantly a sandy (quartz) limestone and is strongly calcareous even where it grades into a quartz sandstone. If there is a transition zone, it is confined to a few feet of strata. Rittenhouse (1949, p. 1707) states that in the northwestern part of West Virginia and in all of Pennsylvania and Ohio the Greenbrier (including the Loyalhanna member) rests unconformably on the Lower Mississippian sandstones and shales. The Mississippian Correlation Chart (Weller and authors, 1948) also suggests a time break at this stratiraphic position in Maryland, Pennsylvania, and Ohio.

Martin divided the Greenbrier strata above the Lower or Loyalhanna member into two additional members, an Upper Greenbrier and a Middle Greenbrier member. The Upper member was said to be composed largely of fossiliferous limestone with some interbedded shale and it was thought to furnish most of the quarry rock in the county. The Middle Greenbrier member, composed largely of shale with some sandstone, was stated to be much like the Mauch Chunk formation except that it contained some calcareous beds. The stratigraphic evidence which Martin (1902, pp. 94–98) presented to support such a division is not conclusive. No complete section of the Greenbrier formation in Garrett County was given, and several of the sections have neither a top nor a bottom. Furthermore, it was stated that the Middle member was 'nowhere well exposed."

It is questionable whether the two upper members described by Martin constitute well-defined lithologic units. The Savage River dam section shows no concentration of limestone in the upper part although over 250 feet of strata are exposed. This is in marked contrast to the Crabtree section described by Martin (1902, p. 94) in which a considerable amount of limestone is recorded in the upper part of the Greenbrier formation. These two sections are rather close together and must stratigraphically overlap one another to a large extent.

Cooke (1912, pp. 5–9) was able to recognize the two upper members in Allegany County, but he had difficulty in distinguishing them in Garrett County and noted that at Crabtree the two members were not separable and that the limestones were much more shaly than in Allegany County.

Apparently the Greenbrier above the Loyalhanna member consists of a sequence of calcareous shales, calcareous sandstones and impure limestones which are interbedded with one another and which grade laterally into one another. These limestone bodies are thought to be lenticular in the sense that they grade laterally into calcareous shales or sandstones. Such limestone bodies may be concentrated in the upper part of the formation, but they may also be developed at lower horizons.

The evidence for this interpretation is based in part upon the position and distribution of the limestone quarries which to some extent indicate the distribution of relatively pure limestone in the Greenbrier formation. Although these quarries do appear to be somewhat more numerous in the upper part of the formation, they are also present in the middle portion. Furthermore, the reason many of them were abandoned is probably that the limestone "lens" being quarried played out. An example of this type may be seen in the following section measured in an abandoned quarry on the west flank of the Deer Park anticline, about 1 mile southwest of New Germany and about 400 feet west of the Meadow Mountain road (quarry location shown on the geologic map).

Mauch Chunk formation ?

Reddish-brown medium-grained non-calcareous sandstone; strongly cross-bedded	6 ft.

Greenbrier formation

Red to brown calcareous shale	15 ft.
Grey, mottled with red, argillaceous limestone; in places this grades into a calcareous shale; numerous fossils, mostly brachiopods and corals; this is the bed which was quarried	17 ft.
Partly covered; exposures of reddish-brown to greenish-brown, calcareous shale	12 ft.
Red calcareous shale with pale green streaks	15 ft.

Below this section is a covered interval which is estimated to be about 100 feet in stratigraphic thickness; beneath this covered interval are good exposures of Pocono sandstone. The beds quarried consist of only 17 feet of argillaceous limestone, overlain and underlain by calcareous shales. It is only a local body of limestone as the equivalent strata at the north and south end of the quarry are much more shaly and of little value as a source of lime. The Greenbrier appears to be much thinner here than at Savage River dam. Although it is difficult to get an exact thickness here because of poor exposures, the Greenbrier cannot be much over 160 feet thick.

Complete, or even partially complete, sections of Greenbrier are rare. The more calcareous portions have been opened in numerous quarries, but it is commonly difficult to determine the exact stratigraphic position of such strata within the formation. Much additional stratigraphic work is needed to determine the exact vertical and horizontal distribution of lithologic types, especially in the part above the Loyalhanna member. The writer's own investigation in Garrett County shows that the Greenbrier can be divided into two distinct lithologic units: a lower cross-bedded sandy (quartz) limestone, the Loyalhanna, and an upper sequence of interbedded fossiliferous calcareous shales, sandstones, and impure limestones. These two units could be treated as formations, as was done on the Mississippian Correlation Chart, since they are distinct enough to be mapped separately where there are sufficient exposures. As these strata are so poorly exposed, however, it was necessary to map the

Loyalhanna with the Greenbrier and retain it as a member of that formation. Subdivisions of the strata above the Loyalhanna have not been recognized by the writer.

The strata in Garrett County do not furnish much information concerning the Greenbrier-Mauch Chunk contact. This contact was seen only at one or two places, where it was poorly exposed. To the north, in Pennsylvania, the Greenbrier is believed to grade into the lower part of the Mauch Chunk and some extent this may take place in Maryland, thus giving a possible explanation for variations in thickness. (For a further discussion on the relationship of these two formations see Stevenson 1902; Butts 1924, pp. 254–257; Weller and authors 1948, p. 171; Rittenhouse 1949, p. 1706–1709.)

Fauna and age. The part of the Greenbrier formation above the Loyalhanna member is abundantly fossiliferous, the best represented group being the brachiopods, but others such as pelecypods, gastropods and corals are also present. Several collections made from this part of the formation have not yet been studied. The most comprehensive study of the Greenbrier fauna in Maryland was made by C. W. Cooke in 1912. Most of the fauna described by Cooke came from the strata above the Loyalhanna member, but he did record three species of brachiopods and a species of *Bellerophon* from this lower member (1912, pp. 16–17).

The age of the Greenbrier has been in question. Reger and Price (1926, pp. 460–462), in their study of the Greenbrier in southeastern West Virginia, concluded that the Alderson, Greenville, and the upper part of the Union limestone were Chester in age. They were somewhat uncertain concerning the older Greenbrier formations but suggested that the Hillsdale formation was equivalent to the St. Louis limestone. Later Reger (1931, pp. 323–324), in his study of the Greenbrier strata in Randolph County, definitely correlated the Hillsdale limestone with the St. Louis limestone and also stated that the basal part of the Union limestone (Fredonia member) was equivalent to the Loyalhanna limestone of Pennsylvania.

Martin (1902, p. 98), in his report on Garrett County, correlated the Greenbrier fauna with that of the Ste. Genevieve limestone (Meramecian series) of the Mississippi valley. This correlation had been proposed earlier by Stevenson (1902, pp. 248–249) who based his conclusions upon a study of the fauna from the Greenbrier formation* in southwestern Pennsylvania. However, Stevenson (1902, p. 247) noted that Meek had assigned a Chester age to this fauna.

Martin also correlated the Greenbrier formation of Maryland with the Maxville limestone of Ohio (see also Morse 1910, pp. 109–111), but the Mississippian Correlation chart shows the Maxville slightly older than the Loyalhanna limestone.

Most later investigators have assigned only the Loyalhanna member to the

* The fossils studied by Stevenson and Martin came from the part of the Greenbrier above the Loyalhanna member.

Meramecian series, the upper part of the Greenbrier being placed in the Chester series. This was the conclusion reached by Butts (1924, p. 257) and is the one given in the Mississippian Correlation Chart. The generalized sections in figure 6 summarize the current ideas on correlation and age assignments for the Greenbrier of West Virginia and Maryland.

MAUCH CHUNK FORMATION

Name. The name Mauch Chunk shale was proposed by J. P. Lesley in 1876 to replace the stratigraphic designation of XI which had been used by the Pennsylvanian Geological Survey. No type locality was designated, but the type area is generally assumed to be at Mauch Chunk, Carbon County, Pennsylvania. The name has been rather widely used for late Mississippian strata in Pennsylvania, Maryland, and West Virginia. As usually defined they consist of a sequence of shales, typically red, and sandstones which overlie the Greenbrier formation and underlie the Pottsville formation. Lesley (1895, p. 1815) gave a measured section at Mauch Chunk which totaled 2,168 feet, and at Pottsville, Pennsylvania, a thickness of 3,000 feet has been reported. In Maryland, however, the Mauch Chunk is much thinner and probably does not exceed 700 feet. Toward the south it again increases, attaining a thickness of 2,800 feet in Greenbrier County in southeastern West Virginia (Price and Heck 1939, p. 254). There the Mauch Chunk is treated as a series* and divided into a number of formations. As the Greenbrier is also thick in this southern area, reaching 1,800 feet, the combined Greenbrier-Mauch Chunk thickness may be as much as 4,600 feet, whereas these same strata in Maryland are only 1,000 feet or less in thickness.

Distribution. The Mauch Chunk formation crops out on both flanks of the Deer Park anticline where it forms a narrow outcrop belt due to the prevailing steep dips. The Mauch Chunk also forms a narrow outcrop belt on the flanks of the Accident anticline except at the south end where the dips are gentle and the outcrop belt correspondingly wide.

The Mauch Chunk formation is one of the most poorly exposed in Garrett County. It has a rather high percentage of shale which disintegrates readily and this, combined with its narrow outcrop belt, explains why natural outcrops are rare. The sandstones of the Mauch Chunk do form ledges although even these are not very common. These sandstones are useful, however, in mapping since they have a distinctive appearance, being thin-bedded, micaceous and strongly cross-bedded.

Exposures of this formation may be seen in a number of road cuts. One of the best places to see the Mauch Chunk is in the cuts along the road leading from the Meadow Mountain road over Meadow Mountain to Pleasant Valley

* It would probably be better to treat the Mauch Chunk in this southern area as a rock unit, Mauch Chunk group, rather than as a time-rock unit, Mauch Chunk series.

Recreation Center. This road has recently been widened and the new excavations furnish good exposures of a considerable portion of the formation although neither the top nor the bottom is exposed. Some fairly good exposures of the Mauch Chunk sandstones lie also along the road paralleling Hoyes Run, just north of the settlement of Hoyes Run.

Lithology and Thickness. The Mauch Chunk formation consists of interbedded fine-grained sandstones, siltstones and shales. The shales are typically non-calcareous and red or green. Most of the sandstones are brown to green, micaceous, and thin-bedded, the beds usually less than 3 inches in thickness. The sandstones and siltstones are at most places strongly cross-bedded. The Mauch Chunk sandstones are easily distinguished from the overlying Pottsville sandstones which are coarser-grained and more massive.

The red Mauch Chunk shales are similar to the shales of the Greenbrier, and in an area of poor exposures there is difficulty in separating the two. The shales of the Greenbrier formation are, however, strongly calcareous, whereas those of the Mauch Chunk formation are either non-calcareous or only weakly so. The fauna may also be of aid in separating the two, the Greenbrier commonly carrying marine fossils whereas no fossils were found in the Mauch Chunk.

Martin gave no thickness for the Mauch Chunk formation in Garrett County, but O'Harra (1900, p. 113) estimated the thickness of the formation in Allegany County to be about 800 feet. No sections have been measured in Garrett County so the exact thickness is not known. Sections based upon the geologic map indicate a thickness ranging from 500 to 700 feet.

Fauna, flora and age. No fossils have been recorded from the Mauch Chunk formation in Garrett County, but some plant fossils and vertebrate remains have been described in Pennsylvania. This formation in Maryland and Pennsylvania has been interpreted as a non-marine deposit, based in part upon the fossil evidence and in part upon the character of the sediments. However, in the southern part of West Virginia the Mauch Chunk carries numerous marine fossils (Price and Heck 1939, p. 258, 695–701), showing that the terrestrial conditions of sedimentation of the northern areas had given way to a predominantly marine environment in the south.

The Mauch Chunk formation is assigned to the Chester series, but it is not believed to be everywhere the same age. In northeastern Pennsylvania the Mauch Chunk is thought to be lower Chester in age, and thus at least in part equivalent to the Greenbrier formation of Maryland, whereas the Mauch Chunk of southern West Virginia is believed to be somewhat younger, being placed in the middle and upper Chester (Weller and authors, 1948).

PENNSYLVANIAN SYSTEM

Previous investigations. During the past 60 or 70 years considerable geologic work has been done on the coal-bearing strata of Maryland so that the stratigraphy is fairly well-known. The results of much of this work have been published by the Maryland Geological Survey (now Maryland Department of Geology, Mines and Water Resources), United States Geological Survey, and the United States Bureau of Mines. One of the first publications to present a comprehensive survey of the Pennsylvanian strata was the Allegany County report of the Maryland Geological Survey (O'Harra 1900). This was followed in 1902 by a report on the geology of Garrett County (Martin 1902). Both of these include extensive bibliographies on publications prior to 1900.

In 1905 the Maryland Geological Survey published a *Report on the Coals of Maryland* (Clark 1905) in which the economic resources as well as the geology of the coal measures were treated at some length. The geology of the Lower Youghiogheny basin was covered in the U. S. Geological Survey Atlas on the Accident-Grantsville quadrangles (Martin 1908).

Dr. C. K. Swartz spent many years studying the geology of the Pennsylvanian rocks of Maryland and adjacent states. The results of his early work are incorporated in the *Second Report on the Coals of Maryland* (Swartz and Baker 1920; see also Swartz, Price and Bassler 1919). It corrected many errors of earlier reports and established a standard geologic section for each of the Maryland coal basins. Following the publication of this *Second Report*, Swartz, assisted by R. W. Brown, H. G. Hershey and others, continued his work on this problem although he did not publish his findings. Fortunately the results of this later work were available in the form of unpublished notes and maps. This material is especially valuable where it furnishes information on old drill holes, prospect pits, and mines which is no longer accessible.

Much additional information has been provided by two core-drilling projects of the U. S. Bureau of Mines. The first of these projects, in Georges Creek basin and the northern part of the Upper Potomac basin, included 26 holes of which 15 are located in, or near, Garrett County (Pl. I). The second project comprised 40 holes drilled in the part of Castleman basin which lies in Garrett County (Pl. I). A log describing the lithology of each hole, as well as a short discussion on the geology, is given in U. S. Bureau of Mines Technical Paper 725 (Toenges and authors, 1949) and U. S. Bureau of Mines Bulletin 507 (Toenges and authors, 1952). The geologic work connected with these projects was done largely by K. M. Waagé. Bulletin 9, 1950, of the Maryland Department of Geology, Mines and Water Resources by Waagé, on the *Refractory Clays of the Maryland Coal Measures* presents an excellent discussion on the Pennsylvanian stratigraphy of Castleman, Georges Creek, and northern Upper Potomac basins, based upon Waagé's field studies and on the data from the two core-drilling projects. Bulletin 9 also includes a geologic map of Castleman basin which was incorporated into the new Garrett County geologic map.

Several publications of the West Virginia Geological Survey deal, at least in part, with the geology of Garrett County. Two of these which were utilized in this work are the reports on Preston County (Hennen, Reger and Price 1914) and on Grant and Mineral Counties (Reger and Tucker 1924). The latter was especially useful since it furnished information on several drill holes in the Upper Potomac basin which were used in preparing the structure map (see discussion of the Upper Potomac basin).

Distribution. Pennsylvanian strata constitute a large proportion of the bed rock in Garrett County. These rocks occupy five structural troughs or basins: Georges Creek basin, its southern continuation the Upper Potomac basin, Castleman basin, Upper Youghiogheny basin, and Lower Youghiogheny basin (fig. 11).

The deepest basin, which has the thickest and most complete section, is the Georges Creek basin (and Upper Potomac basin). In this basin the Pennsylvanian beds are 1,600 to 1,800 feet thick and are overlain by 350 feet or more of Permian beds. These Permian strata are largely confined to the central and deeper part of the Georges Creek basin which lies in Allegany County but may extend into the eastern edge of Garrett County. The youngest Pennsylvanian formation, the Monongahela, is well represented in this basin and extends westward from the central part in Allegany County into eastern Garrett County. This is the only area in Maryland with Monongahela and Permian rocks.

The other basins are less deeply folded and do not have as thick nor as complete a section of Pennsylvanian rocks. The youngest strata in these basins belong to the Conemaugh formation. The lower member of this formation (below the Barton coal) is well represented in all. The upper member (above the Barton coal) is present in the central part of Castleman and the Lower Youghiogheny basins, but it is doubtful whether any part of this member is present in the Upper Youghiogheny basin.

Natural outcrops of Pennsylvanian rocks in Garrett County are not common. Most of the outcrops consist of sandstone, although there are some exposures, especially along the deeper stream valleys, of shale, red beds and even coal beds. Since the most important units in mapping are the coal beds it is necessary to rely rather heavily on artificial exposures, as prospect pits, mine openings, and strip mines. These openings are shown on the geologic map, but because of the transitory nature of most mine operations in Garrett County, no distinction is made on the map between operating and abandoned mines.

Sandstone, shale and red beds may be exposed in road cuts and in many places the coal outcrop may also be located, usually in the form of a carbonaceous streak or "smut." Such coal exposures are indicated on the geologic map.

Core-drill holes furnish valuable information on the distribution of the various members of the Pennsylvanian system. They are useful in obtaining the approximate position of those coal beds which do not crop out in the vicinity of the hole and are also of help in identifying those coals which do crop out nearby. All drill holes for which data are available are shown on the structure map, Plate I, and are listed on pages 101 to 107.

Stratigraphic divisions. The early history pertaining to the classification of

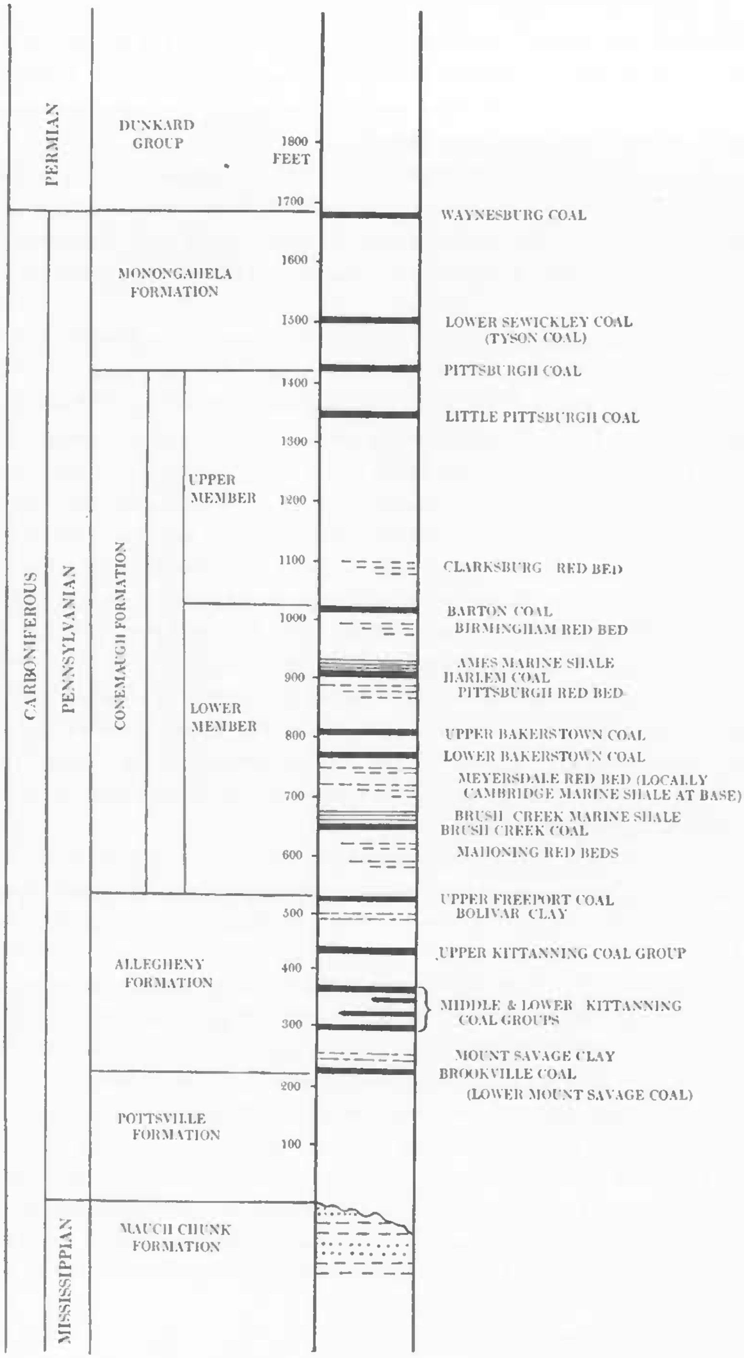

FIGURE 7. Generalized geologic section of the Pennsylvanian strata of Maryland

the Pennsylvanian strata was discussed at some length by Waagé (1950, pp. 6–9). Most geologists recognize four stratigraphic divisions in the northern bituminous coal fields: Pottsville, Allegheny, Conemaugh, and Monongahela. The type locality for each of these units is in Pennsylvania, but all have been recognized over a wide area in the neighboring states of Ohio, Maryland, and West Virginia. Many state geological organizations and individual geologists treat these as series within the Pennsylvanian system (Moore and authors 1944, chart opp. p. 706), but the U. S. Geological Survey regards them as formations within the Pennsylvanian system.* In this report they are also treated as formations in conformity with the practice in most of the publications dealing with the coal measures of Maryland.

These formations are usually defined in terms of persistent coal beds (fig. 7). Thus the Conemaugh formation extends from the top of the Upper Freeport coal to the base of the Pittsburgh coal and the Monongahela formation from the base of the Pittsburgh coal to the top of the Waynesburg coal. Some difficulty is encountered in drawing the Pottsville-Allegheny contact since this part of the section has no persistent coal bed in Garrett County. Waagé (1950, pp. 7–8) discussed this problem and concluded that the Brookville coal is the best horizon to use. He did not, however, map this coal and on his geologic map of Castleman basin the Allegheny and Pottsville are mapped together as a single stratigraphic unit, a procedure followed on the new geologic map of Garrett County.

Each of these formations has certain gross lithologic characters which are peculiar to it and which serve to distinguish it from the other formations. For example, both the Pottsville and Conemaugh formations are composed of a sequence of sandstones, siltstones, shales, and coal beds, but the former is predominantly sandstone and siltstone whereas the latter has more shale and carries several prominent red beds and fossiliferous marine shales. In general the percentage of sandstone decreases upwards, the Pottsville formation having the greatest sand content, the Allegheny formation less and the Conemaugh the least.† This change is well shown in Tables 1, 2, and 3 which were compiled by R. M. Overbeck from the drill core logs of the U. S. Bureau of Mines reports (Toenges and authors 1949; Toenges and authors 1952).

Lithologic differences such as those shown in the tables may be recognized in a complete, or reasonably complete, stratigraphic section, but they are difficult to apply in mapping an area in which exposures are poor and the sandstone and shale beds of one formation look like those of any other. Therefore the

* In the past the U. S. Geological Survey has ranked the Pennsylvanian and Mississippian as series within the Carboniferous, but in the spring of 1953 they were given the rank of systems.

† All of the U. S. Bureau of Mines diamond drill holes started below the Monongahela and comparative data are not available from this information, but presumably its sandstone content is somewhat similar to that of the Conemaugh.

TABLE 1

Percentages of sand and clay compiled from diamond drill logs of U. S. Bureau of Mines

Castleman Basin

Drill hole no.	Lower Conemaugh formation		Allegheny formation		Pottsville formation	
	Clay	Sand	Clay	Sand	Clay	Sand
2	78%	22%	58%	42%	40%	60%
3	71	29	35	65		
4	80	20	57	43		
5					48	52
10	71	21				
17			68	32		
19	81	19				
21	82	18	61	39		
25			59	40		
28			34	66		
29	75	25				
39	80	20				
14			67	33		
	Average		Average		Average	
	Clay	78%	Clay	55%	Clay	44%
	Sand	22%	Sand	45%	Sand	56%
	Sand–clay ratio	0.3	Sand–clay ratio	0.8	Sand–clay ratio	1.3

practice usually followed is to map the key coal beds and use them to define the upper and lower limits of the formations. The coal beds thus assume considerable stratigraphic importance. There are several difficulties in using this method. Natural outcrops of coal beds are not very common; coal outcrops can often be located in road cuts but to a large extent it is necessary to rely upon prospect pits and mines. Therefore the accuracy of the map for a particular coal bed in a particular area depends largely upon the degree to which this coal has been prospected and exploited. Of the coal basins in Garrett County, the Upper Youghiogheny basin* was the most difficult and gave the least satisfactory map because there are fewer mine openings than in the other basins. This is also brought out by the 1952 coal production figures for Maryland (Powers 1952, p. 8):

Georges Creek basin (includes Allegheny and Garrett County)	316,700 tons
Upper Potomac basin	169,455
Castleman basin	80,578
Lower Youghiogheny basin	2,519
Upper Youghiogheny basin	612
Total	569,864

* The southern quarter of the Upper Potomac Basin was also difficult to map.

TABLE 2

Percentages of sand and clay compiled from diamond drill logs of U. S. Bureau of Mines

Upper Potomac Basin

Drill hole no.	Lower Conemaugh formation		Allegheny formation		Pottsville formation	
	Clay	Sand	Clay	Sand	Clay	Sand
13			24	76		
18	64	36	52	48		
22			68	32	44	56
23			32	68		
	Average		Average		Average	
	Clay 64%		Clay 44%		Clay 44%	
	Sand 36%		Sand 56%		Sand 56%	
	Sand–clay ratio 0.5		Sand–clay ratio 1.3		Sand–clay ratio 1.3	

TABLE 3

Percentages of sand and clay compiled from diamond drill logs of U. S. Bureau of Mines

Georges Creek Basin

Drill hole no.	Lower Conemaugh formation		Allegheny formation		Pottsville formation	
	Clay	Sand	Clay	Sand	Clay	Sand
3			53%	47%		
4			69	31		
5	71%	29%	54	46	31%	69%
9	66	34				
10	70	30	53	47		
12			27	73		
20					33	67
21					32	68
25	79	21				
	Average		Average		Average	
	Clay 71%		Clay 51%		Clay 32%	
	Sand 29%		Sand 49%		Sand 68%	
	Sand–clay ratio 0.4		Sand–clay ratio 0.9		Sand–clay ratio 2.1	

The production figures are only a crude index to the accuracy of the map. Mines and prospect pits in the lenticular coal beds below the Upper Freeport coal are of little value in mapping compared with those in the more persistent seams above. Furthermore there are other important factors, such as topographic relief (which controls to some extent natural outcrops) and drill hole information which help greatly in geologic mapping.

Another problem involved in mapping these coal beds is the correct identification of the coal in an outcrop. This is almost always difficult but there are several methods which help in solving the problem. Certain of the coal beds have distinctive characters which can be recognized in the field. The Pittsburg coal can usually be recognized because it is considerably thicker than any of the other coals. On the other hand, the Harlem coal and Brush Creek coal are usually thin but are almost everywhere overlain by a distinctive black shale containing marine fossils.

A second aid in recognition is the fact that the more persistent coals between the Upper Freeport and Pittsburgh coals maintain a fairly constant stratigraphic position and thus a coal may be identified by its position above or below a known coal. Within the lower Conemaugh formation, too, the sequence of coal beds, marine shales and red beds is rather distinctive and can be recognized in many areas. The recognition of such a sequence, or of an isolated coal outcrop, is greatly facilitated by core-drill holes located nearby. The locations of such holes in Garrett County are shown on the structure map (Pl. I).

POTTSVILLE-ALLEGHENY FORMATIONS

The Pottsville formation is usually defined as extending from the Mauch Chunk formation to the base of the Brookville coal (Lower Mount Savage coal of C. K. Swartz). The Allegheny formation includes those strata between the base of the Brookville coal and the top of the Upper Freeport coal.

The Pottsville formation consists of a number of sandstones, separated from one another by siltstones and shales. The basal portion of this formation is composed of a fairly thick sequence of sandstones and conglomerates which are resistant to erosion and form conspicuous ridges or mountains.

These basal Pottsville clastics form the crest of Backbone and Big Savage Mountains, these being the mountains defining the western edge of the Georges Creek-Upper Potomac basis. These strata also crop out on the crests of Negro and Meadow Mountains which mark the western and eastern edges of Castleman basin; towards the south end of this basin, in the region just north of Deep Creek lake, these two ridges merge into one another where this syncline dies out (fig. 1).

In Garrett County the northeastern rim of the Lower Youghiogheny basin is defined by Winding ridge, but the southeastern edge is not set off by any well-defined mountain. Where the two Youghiogheny basins abut, the lower Pottsville strata form a low, flat arch so that the Pottsville formation has a broad outcrop area. There the basal sandstones and conglomerates make a series of hills such as Gap Hill, Marsh Hill, and Piney Mountain, which lack the linear character of the other mountains (fig. 1). The lower Pottsville also produces a series of hills along the eastern edge of the Upper Youghiogheny basin.

The Allegheny formation is similar to the Pottsville formation although it commonly has less sandstone (Tables 1, 2, 3) and more coal beds. The top of this formation is drawn at the top of the Upper Freeport coal, a very persistent coal which has been mapped in all the coal basins. The formation includes other coal beds, such as the Kittanning coals and the Mount Savage coals, but as the U. S. Bureau of Mines core-drilling has shown that most of these coals are lenticular, no attempt was made to map them. Martin (1908) mapped the Lower Kittanning coal in the Lower Youghiogheny basin but he probably included different coals at different places. On the eastern side of this basin his coal outcrop map needs to be modified.

The thickness of the Pottsville-Allegheny formations is variable, ranging from 300 to 600 feet in thickness. Waagé has shown that in the Georges Creek-Upper Potomac basin it thickens to the south, with the greatest increase taking place in the Pottsville formation (1950, p. 14).

CONEMAUGH FORMATION

The Conemaugh formation is defined as including the strata between the top of the Upper Freeport coal and the base of the Pittsburgh coal (fig. 7). The only complete section of this formation in Maryland is in the Georges Creek-Upper Potomac basin where it varies between 825 and 925 feet in thickness. It includes claystone, shale, sandstone, fresh-water limestone,* red shale, marine shale and coal beds (Waagé 1950, p. 32). Most of the coal beds are thin but some are remarkably persistent and therefore useful in stratigraphic work.

There is a rather pronounced change in the character of the sediments in the lower part of the Conemaugh formation and those in the upper part. In the lower 450 to 500 feet are several marine shales and the coal beds are relatively persistent. In the upper 400 to 450 feet the strata are much more irregular, there are no marine shales and the coals are lenticular. Swartz, Price, and Bassler (1919, p. 579) noted this difference and also pointed out the significance of these lower marine shales and persistent coal beds in regional correlation. Waagé (1950) in his study of the surface and subsurface distribution of these strata in the Castleman basin presented much evidence of such a twofold division and proposed to call them the upper and lower Conemaugh members. The lower member was defined as extending from the top of the Upper Freeport coal to the top of the Barton coal, and the upper member as comprising those strata between the Barton coal and the base of the Pittsburgh coal.

Lower member—Conemaugh formation

The lower member is present in all the Garrett County coal basins. It includes a number of coal beds which are separated from one another by shale, claystone and sandstone. There are also several marine shales and red beds present. the more persistent being shown in figure 7.

* Probably most of the strata called limestone are calcareous clays or calcareous shales.

For correlation and mapping the most important stratigraphic units are the coal beds and the marine shales, and to a lesser extent the red beds.

Coal beds of the lower Conemaugh member. The coal beds which have the widest geographic distribution in western Maryland are the Barton, Harlem, Upper and Lower Bakerstown, and Brush Creek. Three of these coal beds, the Barton, the Harlem, and the Brush Creek, were mapped in one or more of the coal basins for the new Garrett County geologic map; Waagé mapped also the Lower Bakerstown coal in the Castleman basin (1950, Pl. 8).

The distribution, thickness and character of the coals in the Castleman and Georges Creek-Upper Potomac basins have been discussed at some length in earlier publications (Toenges and authors, 1949; Toenges and authors 1952; Waagé 1950). A summary of the subsurface distribution of the lower Conemaugh coals in these basins is shown in Tables 4 and 5.

These two tables show that the Brush Creek and Upper and Lower Bakerstown coals are well developed in the Castleman basin but are somewhat irregularly developed in the Georges Creek and northern part of the Upper

TABLE 4

Distribution of some of the stratigraphic units in the lower member of the Conemaugh formation in the U. S. Bureau of Mines test holes in the Georges Creek and northern Upper Potomac basins

The numbers of the holes are the numbers used on the Structure Map and are the same as those used by the U. S. Bureau of Mines. These have been arranged roughly from north to south. — indicates the hole began below this horizon, × that the member was identified in the hole, and 0 that it was not recognized in the hole.

Drill hole no.	Barton coal	Birmingham red bed	Ames marine shale	Harlem coal	Pittsburgh red bed	Upper Bakerstown coal	Lower Bakerstown coal	Meyersdale red bed	Cambridge marine shale	Brush Creek marine shale	Brush Creek coal	Mahoning red bed	Upper Freeport coal
GC 21	×	0	×	×	×	×	×	0	×	×	×	0	×
GC 10	0	0	×	×	×	×	×	0	0	0	×	0	×
GC 5	×	0	×	×	0	×	×	×	0	×	×	0	×
GC 3	—	—	—	—	—	×	×	0	0	×	×	0	×
GC 4	—	—	—	—	—	×	×	×	0	0	×	0	×
GC 1	—	—	—	—	—	0	×	0	0	0	×	0	×
GC 14	×	0	×	×	×	×	×	0	0	×	×	0	×
GC 9	×	0	0	×	×	0	×	0	0	×	×	0	×
GC 12	—	—	—	—	—	—	×	0	0	0	0	0	×
GC 13	—	0	×	×	×	×	0	×	0	×	0	0	×
GC 17	—	—	0	×	×	×	0	0	0	0	×	×	×
GC 18	×	×	×	×	×	×	×	×	0	0	0	0	×
GC 23	—	×	×	×	0	×	×	0	0	0	0	0	×
GC 22	—	—	—	—	—	—	×	×	0	0	0	0	×
GC 24	—	—	—	—	—	—	—	×	0	0	×	0	×

TABLE 5

Distribution of some of the stratigraphic units in the lower member of the Conemaugh formation in the U. S. Bureau of Mines test holes drilled in Castleman basin

The numbers of the holes are the numbers used on the Structure Map and are the same as those used by the U. S. Bureau of Mines. These have been arranged roughly from north to south. — indicates the hole began below this horizon, × that the member was identified in the hole, and 0 that it was not recognized in the hole.

Drill hole no.	Barton coal	Birmingham red bed	Ames marine shale	Harlem coal	Pittsburgh red bed	Upper Bakerstown coal	Lower Bakerstown coal	Meyersdale red bed	Cambridge marine shale	Brush Creek marine shale	Brush Creek coal	Mahoning red bed	Upper Freeport coal
CB 13	—	—	—	—	—	—	—	—	—	×	×	0	×
CB 39	×	0	×	×	0	0	×	×	×	×	×	0	×
CB 17	×	0	×	×	0	×	×	×	×	×	×	×	×
CB 40	—	—	—	—	—	—	×	×	×	×	×	×	×
CB 32	—	—	—	—	—	×	×	×	0	×	×	0	×
CB 26	—	—	—	—	—	×	×	×	×	×	×	×	×
CB 24	—	—	—	—	—	×	×	×	×	×	×	×	×
CB 34	—	—	—	—	×	×	×	×	×	×	×	0	×
CB 37	—	—	—	—	—	×	×	×	×	×	×	×	×
CB 14	—	—	—	—	—	×	×	×	0	×	×	0	×
CB 22	0	0	×	×	×	×	×	×	×	×	×	0	×
CB 19	×	0	×	×	0	×	×	×	×	×	×	0	×
CB 31	×	0	×	×	×	×	×	×	×	×	×	0	×
CB 38	—	0	×	×	0	×	×	×	×	×	×	×	×
CB 33	—	—	—	—	—	—	—	—	—	×	×	0	×
CB 15	—	—	—	—	—	—	×	×	0	×	×	×	×
CB 27	—	0	×	×	0	×	×	×	×	×	×	0	×
CB 2	×	0	×	×	×	×	×	×	0	×	×	0	×
CB 10	×	0	×	×	×	×	×	×	0	×	×	0	×
CB 12	—	—	×	×	×	×	×	×	0	×	×	×	×
CB 16	—	×	×	×	×	×	×	×	0	×	×	0	×
CB 36	—	0	×	×	×	×	×	×	×	×	×	0	×
CB 8	×	0	×	×	×	×	×	×	0	×	×	×	×
CB 29	×	0	×	×	×	×	×	×	0	×	×	0	×
CB 4	×	0	×	×	×	×	×	×	0	×	×	×	×
CB 9	—	—	×	×	0	×	×	×	0	×	×	×	×
CB 6	—	—	×	×	0	0	×	0	0	×	×	0	×
CB 35	—	—	—	—	—	×	×	×	×	×	×	0	×
CB 25	—	—	—	—	—	—	×	×	×	×	×	0	×
CB 21	×	0	×	×	×	×	×	×	×	×	×	0	×
CB 23	—	—	—	—	—	—	—	—	—	—	—	—	0
CB 30	—	—	—	—	—	—	—	—	—	—	—	—	0
CB 1	×	0	0	×	×	×	×	×	0	×	×	×	0
CB 5	—	—	×	×	×	0	×	×	0	×	×	×	×
CB 20	—	—	—	—	—	—	—	—	—	—	—	—	0
CB 28	—	—	—	—	—	0	×	0	0	×	×	×	0
CB 3	×	×	×	×	0	0	×	×	0	0	0	0	0
CB 18	—	×	×	×	×	×	×	×	0	×	×	×	0
CB 7	—	—	—	—	—	—	—	—	—	×	×	×	0
CB 11	—	—	—	—	—	—	×	×	0	0	0	0	0

Potomac basins and that the Harlem is the most persistent of the coals, being present in every hole which penetrated this horizon.

The Brush Creek, Lower Bakerstown, and Harlem coals are also present in the Lower Youghiogheny basin as is shown in the following section measured by Swartz and Price (Swartz and Baker, 1920, pp. 95–96) in the area just north of Friendsville.

Ames limestone and shale containing numerous *Ambocoelia planoconvexa*, *Chonetes granulifer*, *Derbya* (sic) *crassa*	10 ft.
Harlem coal	1 ft. 3 in.
Pittsburgh red beds, variegated red shale	10 ft.
Saltsburg sandstone, fine-grained and cross-bedded; replaced by clays and shales on the strike	32 ft.
Yellowish clay and sandy shale with ferruginous and calcareous nodules	22 ft.
Cambridge [*Friendsville*] *shale and fauna*. Yellow sandy shale containing marine fauna	4 ft.
Yellow sandy shale above, black shale below	20 ft. 6 in.
Lower Bakerstown coal (Thomas coal)	1 ft. 6 in.
Clay	2 ft.
Sandstone, variable, argillaceous	12 ft.
Dark shales	14 ft.
Meyersdale red shale containing a band of gray limestone with marine fossils [*Cambridge* shale]. Some marine fossils are also found in the red shale	28 ft.
Meyersdale limestone [*Cambridge*] containing *Spirifer cameratus?* and other marine fossils	1 ft.
Buffalo sandstone. Interbedded shale and sandstone	9 ft.
Brush Creek shale and limestone. Dark shale bearing calcareous nodules with a band of limestone near base; containing *Chonetes verneuilanus* and many other fossils	26 ft.
Brush Creek coal	2 ft.
Concealed	12 ft.
Corinth sandstone	15 ft.
Calcareous clay above, concealed below	15 ft.
Gallitzin (?) coal blossom	
Concealed	38 ft.
Piedmont coal [*Mahoning*] with shale parting 6 ft. thick	7 ft.
Black shale	10 ft.
Lower Mahoning sandstone Sandstone and shale, partially concealed	33 ft.
Upper Freeport coal	
Brush Creek coal-Ames shale interval	184 ft.
Upper Freeport coal-Ames shale interval	316 ft.

Stratigraphic work since the above section was published showed a need for several revisions in the terminology which are indicated in brackets. Waagé (1950, p. 35) showed that the Piedmont coal of Swartz, Price and Baker is properly correlated with the Mahoning coal and has questioned the use of the name Gallitzin (p. 39). Revisions in the terminology applied to the marine horizons between the Brush Creek shale and the Harlem coal are discussed in the section on marine shales.

All the more persistent coal beds between the Upper Freeport and the Harlem coals are present in this section except the Upper Bakerstown coal. This coal was not mapped by the writer and R. M. Overbeck, but a coal lying about a hundred feet below the Harlem and believed to be the Lower Bakerstown has been prospected in several places in the Friendsville area. One such coal opening may be seen approximately a half mile northeast of Asher Glade and about 400 feet east of Maryland Route 42. Three abandoned prospects are also located about a mile southwest of Friendsville, on the south side of a small stream which drains into the Youghiogheny River. Numerous exposures of the Brush Creek and Harlem coals were found in this area and both of these coals were mapped in the Lower Youghiogheny coal basin (1953 Garrett County geologic map).

Swartz and Baker (1922, Pl. 6) show the Barton coal absent in the Lower Youghiogheny basin, and the writer and R. M. Overbeck were unable to find it. However, the horizon or stratigraphic position of this coal is present. The hill north of Friendsville, between the Youghiogheny River and Buffalo Run, is high enough to include the lower part of the upper Conemaugh member. Martin (1908, p. 6, and Economic Geology map) mapped a coal bed on this hill and identified it as Little Pittsburgh, but Swartz and Baker (1920, Pl. 6) referred this to the Little Clarksburg coal. One coal outcrop found in this area by the writer and R. M. Overbeck is shown on the new Garrett County geologic map. There seems little doubt that this is the same coal mapped by Martin. Since it is only 200 feet or so above the Harlem coal it must be considerably below the Little Pittsburgh coal. This coal is less than 100 feet below the summit of the hill and therefore approximately 300 feet of strata are present between the Harlem coal and the hill top. Since the horizon of the Barton coal lies between 100 and 150 feet above the Harlem coal there must be about 150 feet or so of beds present which are referable to the upper member of the Conemaugh. Since the Barton coal has not been recognized in the Lower Youghiogheny basin, it is not possible to separate the two members in this basin.

Rock exposures, both natural and man-made, are not very good in the Upper Youghiogheny basin, and few subsurface data are available. Nevertheless, there is stratigraphic evidence to show that most of the lower Conemaugh coals are present. This is seen in the following section near Herrington Manor, about 4 miles northwest of Oakland. It is a composite section, based in part upon subsurface data obtained from drill hole Md. 1 (see Structure Map, Plate I) and in part on surface data. The subsurface part of this section is taken from page 117 of the Garrett County Report (Martin 1902) and begins with the stratigraphic unit which Martin listed as No. 4 (15 feet of sandstone). The surface part is taken from the unpublished notes of C. K. Swartz.

Surface	
Sandstone	20 ft.
Ames shale. Brown shale with marine fossils	1 ft.
Concealed to top of drill hole	3 ft.
Subsurface (Drill hole Md 1)	
Not described (upper part of hole)	22 ft.
Sandstone (this is unit 4 of the Garrett County Report)	15 ft.
Shale and shaly sandstone	5 ft.
Coarse sandstone	26 ft.
Gray sandstone	3 ft. 9 in.
Gray shale	2 ft.
Oolitic shale	2 ft.
Shale	3 ft. 7 in.
Oolite	6 in.
Shale	4 ft. 8 in.
Upper Bakerstown coal and shale (Middle and Lower Kittanning coal of Garrett County Report)	3 ft. 9 in.
Gray shale	13 ft. 4 in.
Calcareous rock	1 ft. 2 in.
Black shale	3 ft. 11 in.
Lower Bakerstown coal and shale ("Split Six" of Garrett County Report)	1 ft. 7 in.
Gray shale	1 ft. 2 in.
Black shale	10 ft.
Gray shale	19 ft. 6 in.
Hard gray sandstone	4 ft. 9 in.
Green shale	1 ft. 6 in.
Meyersdale red shale	12 ft. 7 in.
Meyersdale red and green shale	2 ft.
Green sandy shale	16 ft.
Dark green and brown shale	6 ft.
Alternating shales and sandstones	18 ft. 3 in.
?*Brush Creek shale.* Fossiliferous limestone, ferriferous	1 ft. 2 in.
Alternating shales and sandstones	17 ft.
Brush Creek coal (Clarion coal in Garrett County Report)	5 in.
Plastic fire clay	1 ft. 8 in.
Flint fire clay	1 ft.
Plastic fire clay	1 ft. 8 in.
Shale	3 ft.
Brush Creek coal-Ames shale interval	216 ft.

In the above section the Brush Creek and Upper and Lower Bakerstown coals are present; the Harlem coal is not reported but is thought to be present in the concealed interval beneath the Ames shale. The Brush Creek coal-Ames shale interval is approximately 216 feet, which is almost the same interval as given by Swartz and Baker (1920, Pl. 6) in their generalized section for this basin, but somewhat greater than the interval (184 feet) in the Lower Youghiogheny basin (see section p. 56). In the Georges Creek-Upper Potomac and Castleman coal basins the stratigraphic interval between the Brush Creek coal and the Ames shale varies from 210 to 260 feet (Waagé 1950, p. 40).

The section given above shows that the stratigraphic interpretation given by the writer, R. M. Overbeck and C. K. Swartz is very different from that of Martin. The latter thought that the coal identified as Upper Bakerstown was one of the Kittanning coals and therefore much lower in the section. This influenced his mapping of this basin and he includes all the surface strata in the vicinity of Herrington Manor in the Allegheny formation (Garrett County geologic map, 1902). He shows the Conemaugh formation in the Upper Youghiogheny Basin only in small patches capping the higher hills, whereas on the new map the entire central part of this basin is shown as underlain by the Conemaugh. There seems to be little doubt that the stratigraphic interpretation given to the above section by Martin, as well as his general map interpretation, is incorrect although it must be admitted that stratigraphic investigations in this basin are difficult due to the poor exposures. The presence of the two marine shales is good evidence that this section is in the Conemaugh formation, a conclusion which is further supported by the presence of red beds and the stratigraphic intervals between the coal beds.

Additional support for the revised mapping is afforded by the following section which was measured by C. K. Swartz (unpublished notes) in the vicinity of Hutton, Maryland. This section extends westward along the Baltimore and Ohio Railroad, from the western edge of Hutton to the stream 1,810 feet west of the railroad station at Corinth, West Virginia.

Center of road beneath culvert (near BM. 2471 Oakland 7½ min. quadrangle).		
Massive cross-bedded sandstone (exposed on county road at culvert)	19 ft.	
Ames shale yellow and brown clay; few marine fossils	1 ft.	6 in.
Ames shale. Brown fossiliferous shale; marine fossils	1 ft.	2 in.
Harlem coal		10 in.
Yellow and white shale; some fire clay	5 ft.	
Pittsburgh red bed. Shale weathering yellowish green; streaks and bands of red	22 ft.	
Maryland-West Virginia state line		
Pittsburgh red beds. Arenaceous shale; some red beds	7 ft.	
Concealed	28 ft.	
West end of cut; second class road crossing		
Concealed	60 ft.	
? Lower Bakerstown coal		6 in.
Concealed	45 ft.	
Culvert		
Concealed	45 ft.	

Center of station at Corinth, W. Va.	
Concealed	7 ft.
Greenish argillaceous cross-bedded sandstone	8 ft.
Buff shale	4 ft.
? *Mahoning red bed.* Light-colored arenaceous shale with some interbedded light-colored clay; red shale near the bottom	24 ft.
Interbedded argillaceous sandstone and arenaceous shale	40 ft.
Gray clay; thin coal smut at top	6 ft.
Center of bridge over railway	
Arenaceous shale with thin bands of argillaceous sandstone	11 ft.
Dark arenaceous shale	10 ft.
Upper Freeport coal; coal and shale	4 ft. 4 in.
Clay	1 ft.
Argillaceous sandstone	12 ft.
Concealed	
Upper Freeport-Ames shale interval	322 ft.

In the foregoing section neither the Upper Bakerstown nor the Brush Creek coals are recorded, but they may be present in the concealed interval above and below the Lower Bakerstown coal. The Upper Freeport coal-Ames shale interval is 322 feet which compares favorably with the generalized section given by Swartz and Baker for this interval in the Lower Youghiogheny basin (Swartz and Baker 1920, Pl. 6). Waagé (Toenges and authors 1952, p. 26) records a thickness ranging from 320 to 380 feet for this interval in the Castleman basin.

On the 1902 Garrett County geologic map the area where this section was measured is shown as underlain by the Allegheny formation, but there is little doubt that Swartz was correct in referring these beds to the Conemaugh formation.

One deep well, the Harned Heirs #1 (F-5) was drilled in the Upper Youghiogheny basin to a depth of 3,200 feet (Plate I). The log is given in the Preston County report of the West Virginia Geological Survey (Hennen, Reger and Price 1914, pp. 212–214) and in its report on the Deep Wells (Tucker 1936, pp. 372–373). This log, which is very sketchy, appears to be taken from a "driller's log" and the lithologic descriptions are difficult to interpret, but at least the coal beds and red beds can be recognized. The upper part of this log is reproduced below in order to show how the writer's interpretation (in italics) differs from that of the earlier authors (in parentheses).

Harned Heirs #1—surface elevation approximately 2500 feet

Conductor	0– 10 ft.
Black shale	10– 30 ft.
Coal *Harlem* (Brush Creek)	30– 33 ft.
White lime	33– 65 ft.
Slate	65– 80 ft.

Sand, medium hard	80–100 ft.
Slate, black	100–115 ft.
Red rock—?*Meyersdale red beds*	115–160 ft.
Slate, black	160–180 ft.
Lime (Upper Freeport)	180–185 ft.
Slate, white	185–193 ft.
Gritty limestone	193–222 ft.
Black shale (5 feet coal) *Brush Creek* (Lower Freeport)	222–227 ft.
Gray slate	227–248 ft.
Lime	248–285 ft.
Sand and lime	285–293 ft.
Slate, gray	293–315 ft.
Black slate	315–340 ft.
Lime, dark	340–380 ft.
Sand, white, hard	380–410 ft.
Shale, dark, 6 ft. coal. ?*Lower Freeport* (Clarion)	410–420 ft.

Though the identification of coal beds and red beds based upon this log is bound to be questionable, the revised interpretation fits in better with the Herrington Manor and Corinth sections. The *Harlem-Brush Creek* interval of 192 feet agrees fairly well with other sections in the western basins (190 to 216 feet), but does not agree with the Upper Freeport-Brush Creek interval which rarely exceeds 100 feet.

In addition to the sections given above, there are four test holes (Md. 2–Md. 5) listed in the Upper Youghiogheny basin. The logs are given on pages 153 to 159 and their locations on Plate I.

Red beds of the lower Conemaugh member. There are several red beds in the lower member of the Conemaugh formation (fig. 7). The distribution of these red beds in the Castleman and the Georges Creek-Upper Potomac basins, already discussed in earlier publications (Toenges and authors 1949, p. 24; Toenges and authors 1952, pp. 25–26; Waagé 1950, pp. 35–45, 47), is summarized in Tables 4 and 5. These tables show that the red beds are better developed and more persistent in the Castleman basin than in the eastern basins.

The distribution of the different red beds is not nearly so well known in the western basins where no intensive core drilling project was carried on. That the Pittsburgh and Meyersdale red beds are present in the Lower Youghiogheny basin is shown in the section on page 56. The Meyersdale, Pittsburgh and Mahoning red beds have also been recorded in the Upper Youghiogheny basin (sections on pages 58 and 59).

Marine shales of the lower Conemaugh member. Four marine shales have been recorded in the lower member of the Conemaugh formation (fig. 7). In the past there have been some inconsistencies in the names applied to them as is shown in the following table:

Swartz and Baker 1920, Pl. 6.	Swartz, Price and Bassler 1919	Waagé 1950
Ames limestone Harlem coal	*Ames limestone* Harlem coal	*Ames shale* Harlem coal
Woods Run shale Lower Bakerstown (Thomas) coal	*Friendsville shale* *Cambridge fauna* Thomas—Lower Bakerstown coal	*Friendsville shale* Lower Bakerstown coal
Pine Creek limestone	*Upper Brush Creek limestone*	*Cambridge shale*
Brush Creek limestone Brush Creek coal	*Lower Brush Creek limestone* Brush Creek coal	*Brush Creek shale* Brush Creek coal

The names Ames and Brush Creek* have been used rather consistently for the marine zones overlying the Harlem and Brush Creek coals. Confusion has arisen, however, in the names applied to the other two. In the stratigraphic chart which accompanied the Second Report on the Coals of Maryland (Swartz and Baker 1920, Pl. 6) the name Woods Run shale was used for the shale above the Lower Bakerstown coal, but on page 61 of the report this was called the Friendsville shale (for exposures near Friendsville, Md.) and was correlated with the Cambridge limestone of Ohio and the Pine Creek limestone of western Pennsylvania and West Virginia. This shale was reported also in the measured section on page 95 (see page 56 of this report) and was referred to as Cambridge (Friendsville) with no mention of the Pine Creek limestone. Thus the names Cambridge and Friendsville were applied in the text to the shale which was called Woods Run in the stratigraphic chart. Furthermore in the text the Cambridge-Friendsville (and by inference the Woods Run) were correlated with the Pine Creek limestone, whereas in the chart that name was used for marine strata associated with the Meyersdale red beds which are below the Lower Bakerstown coal, and which in the text (pp. 59, 95) were referred to the Meyersdale limestone.

Swartz, Price and Bassler used the names Cambridge and Friendsville for the strata just above the Lower Bakerstown coal (1919, p. 574). No mention was made of the Pine Creek limestone although they did divide the Brush Creek shale into a lower and an upper zone (pp. 576–578), of which the upper is presumably equivalent to the Pine Creek (on the stratigraphic chart) and the Meyersdale limestone (in the text) of the Second Coal Report.

Waagé (1950; see also Wanless, 1939) removed much of the confusion in the use of names for these marine zones. The name Friendsville, as proposed by

* Earlier workers usually referred to these marine zones as limestones, but they are more accurately described as shales or calcareous shales.

Swartz, Price and Bassler, was accepted for the shale overlying the Lower Bakerstown coal and was correlated with the Woods Run shale of Pennsylvania and the Portersville limestone of Ohio (1950, p. 42). The name Cambridge shale was used for the marine beds associated with the Meyersdale red beds because they appear to be correlative with strata of that name in Pennsylvania; it was also noted that the name Pine Creek (Wanless 1939, p. 98) had been used for these same beds in Pennsylvania.

Of the four marine shales, the Ames and Brush Creek seem to be the most persistent. Their distribution is well known in Castleman Basin, Georges Creek basin, and the northern part of the Upper Potomac basin due to the core-drilling program of the U. S. Bureau of Mines (Toenges and authors 1949; Waagé 1950; Toenges and authors 1952). As is shown in Tables 4 and 5 the Ames marine shale* was encountered in every hole that penetrated that horizon and the Brush Creek marine shale in all but two in Castleman basin and all but five in the Georges Creek-Upper Potomac basin. These zones were also recorded from the Upper and Lower Youghiogheny basins in the earlier publications of Swartz and Baker, and Swartz, Price and Bassler; their presence is indicated in the sections on pages 56, 58 and 59 of this report. Both the Harlem and Brush Creek shales are usually thin and, since the rock disintegrates readily, surface exposures are not common, but a number of fossiliferous outcrops for both shales are indicated on the new Garrett County map. An especially good collecting locality for Harlem fossils is a strip mine near Bethlehem School (Upper Potomac basin), about 5 miles southeast of Mt. Lake Park. Several fossil localities for the Brush Creek shale are in the area to the north of Friendsville, Lower Youghiogheny basin (1953 Garrett County geologic map).

The core-drilling projects in the Castleman and the Georges Creek-Upper Potomac basins showed that the Cambridge marine shale, associated with the Meyersdale red beds, is much more erratic in its distribution. This shale is fairly well represented in the northern part of the Castleman basin, disappearing towards the south, but in the eastern basins it has been identified only in the northwestern part of the Georges Creek basin (Waagé 1950, p. 41; Table 4 of this report). Swartz and Baker (1920, Pl. 6) recorded marine fossils from this shale in the Lower Youghiogheny basin (as Pine Creek limestone; see section on page 56 of this report) but not in the Upper Youghiogheny basin. The writer and R. M. Overbeck did not observe marine fossils in this part of the section in either basin.

Swartz and Baker (1920) and Swartz, Price and Bassler (1919) state that the Friendsville shale carries marine fossils in Castleman basin and in the Upper and Lower Youghiogheny basins. This is questionable at least for the Castleman basin because the core drilling in this basin did not reveal any marine

* Waagé (1950, p. 44) states that there is a local area in the Georges Creek basin where the Ames shale is barren of marine fossils and carries plant fossils.

fossils in this shale (Waagé, 1950, p. 42); nor have any marine fossils been found in the Friendsville shale in the eastern basins. Swartz's measured section for the Lower Youghiogheny basin, (page 56), shows a marine fauna in the Friendsville shale but none is noted in his section from the Upper Youghiogheny basin (p. 58). The writer and R. M. Overbeck did not observe any fossils in the shale but it was not intensively investigated as the underlying Lower Bakerstown coal was not mapped.

The marine faunas from these Conemaugh shales were studied by W. A. Price in a Ph.D. dissertation presented to The Johns Hopkins University. He described and illustrated the Conemaugh faunas in the Preston County Report of the West Virginia Geological Survey (Hennen, Reger and Price, 1914, pp. 473–547, Pls. XLII–XLIII) and later presented extended faunal lists for these marine zones (Swartz, Price and Bassler 1919, pp. 576–578).

Joseph Lintz has undertaken a study of the marine fossils obtained from the cores of the U. S. Bureau of Mines drilling projects in Castleman and in Georges Creek-Upper Potomac basins. This study, based upon the relatively large collection of fossils obtained from well-identified stratigraphic sections, should be a valuable addition to our knowledge of Pennsylvanian faunas.

Upper member—Conemaugh formation

The upper member of the Conemaugh formation includes the strata between the top of the Barton coal and the base of the Pittsburgh coal. This member differs from the lower member chiefly in the lack of marine shales and in the lenticularity and irregularity of the coal beds. The lithologic characters of the two members are much alike, and in mapping they can be separated with certainty only where the Barton coal can be mapped.

Complete sections of the upper member in Maryland are found only in the eastern coal basins where the thickness ranges between 450 and 500 feet. The outcrop of the Barton coal is shown on the new Garrett County geologic map in the Georges Creek basin and in the northern part of the Upper Potomac basin. Swartz and Martin (in Swartz and Baker, 1920, Pl. 5) mapped this coal throughout the length of the Upper Potomac basin in Maryland but they do not show any coal openings for the southern portion. The writer and R. M. Overbeck did not recognize the Barton coal in the southern portion, although it may be present as a thin seam which was not extensively prospected. The most southerly U. S. Bureau of Mines core drill hole which penetrated this coal was GC 18, about 2 miles west of Barnum, in which the Barton coal consisted of 2 feet, 7 inches of coal and shale (Toenges and authors, 1949, p. 70; Plate I).

The Barton coal was also mapped by Waagé in the Castleman basin (1950, Pl. 8; new Garrett County geologic map). In this basin erosion has removed the Monongahela formation and part of the Conemaugh, so it has only an incomplete section of the upper member.

Swartz and Baker did not record the Barton coal in their stratigraphic section for the Lower Youghiogheny basin, nor were the writer and R. M. Overbeck able to find it in this basin, although at least the lower part of the upper member is present in the area north of Friendsville.

Swartz and Baker recorded the Barton coal from the Upper Youghiogheny basin, but it is doubtful if any part of the upper member, or this coal, is present in the part of this basin that lies in Garrett County. There is not sufficient difference in elevation between the Harlem and the top of the highest hill for the Barton coal to be present. In West Virginia this coal and the lower part of the upper Conemaugh member may be present.

MONONGAHELA FORMATION

The Monongahela formation consists of 240 to 270 feet of interbedded shales, sandstones, and limestones with several coal beds (Swartz and Baker 1920, pp. 70–77; Clark and authors 1905, pp. 255–257; 308–312; 379–404). The thickest and most important coal in this formation is the Pittsburgh coal which has been extensively mined in Maryland and other eastern states. This coal is the basal unit of the Monongahela formation and is easily recognized as it is one of the thickest coals in the Maryland coal measures. Martin (1902, p. 142) records a section in the area south of Frostburg with 13 feet of Pittsburgh coal of which 9½ feet are presumably clean coal. Clark (Clark and authors 1905, pp. 379–386) presents a number of sections of this coal, many being over 10 feet thick although all have some shale partings. The top of the Monongahela formation is drawn at the top of the Waynesburg coal, but this seam is not known to be open in Garrett County and strata this high in the section may not be present (see PERMIAN SYSTEM).

In Maryland the Monongahela formation is present only in the Georges Creek and Upper Potomac basins. It is most extensively represented in Allegany County, occupying the central part of the Georges Creek basin and extending westward into Garrett County where it caps several of the higher hills between Wrights Run (northwest of Midland, Allegany County) and Franklin Hill (west of Westernport, Allegany County). Along this eastern margin of Garrett County the Pittsburgh coal has been opened at several places by strip mines, some of which extend along the outcrop for considerable distances (see 1953 Garrett County geologic map). The exposures above the Pittsburgh coal are poor in this area and most of the information on the Monongahela formation has been obtained from observations in Allegany County. For a complete section of this formation see page 255 of the *Report on the Coals of Maryland* (Clark and authors 1905).

In the Upper Potomac basin of Garrett County the Monongahela formation is present in only a small patch capping Manor Hill, about 1 mile west of Shaw. The Pittsburgh coal is exposed by strip mining.

PERMIAN SYSTEM

The only rocks of Permian age which outcrop in Maryland are referred to the Dunkard group. Strata of this age were called the Upper Barren Coal Measures by the early geologists of the Pennsylvania Geological Survey but were renamed the Dunkard Creek series by White (1891, p. 22) for exposures on Dunkard Creek, Greene County, Pennsylvania. This name has subsequently been shortened to Dunkard, and is treated as a group by the United States Geological Survey.

The Dunkard group includes all the Permian strata above the Waynesburg coal bed. Lithologically it consists of a sequence of shales, sandstones, limestones, and coal beds which are similar to the underlying Monongahela formation although none of the coal beds are thick or persistent. The Dunkard group has been divided into two formations, the Washington formation, named for exposures in Washington County, Pennsylvania, and the overlying Greene formation, named for exposures in Greene County, Pennsylvania. The Washington formation includes the strata between the top of the Waynesburg coal and the top of the Upper Washington limestone; the Greene formation encompasses all of the Permian strata above this limestone member.

In Maryland the Dunkard group is present only in the central portion of the Georges Creek basin where it is largely, if not entirely, confined to Allegany County. The distribution of these strata in this basin is shown on the Allegany County geological map (Maryland Geological Survey, 1900) and on the geologic map of the Georges Creek and Upper Potomac basins in the Second Report on the Coals of Maryland (Swartz and Baker, 1920). The Dunkard group was discussed briefly in the Allegany County Report (O'Harra, 1900, pp. 128–130). A more detailed description was given in the Report on the Coals of Maryland (Clark and authors, 1905, pp. 289, 312–315, 406) and in Second Report on the Coals of Maryland (Swartz and Baker, 1920, pp. 77–79). In these reports the Washington formation was described as consisting of about 300 feet of shale, sandstone, limestone, and thin coal beds which were best exposed near the Borden shaft, a short distance east of the town of Midlothian in Allegany County. The only exposure of the Greene formation was said to be in the vicinity of the Borden shaft, where it consisted of about 70 feet of strata similar to those of the underlying formation. This is the youngest Paleozoic formation in Maryland.

Whether the Dunkard strata extend as far west as Garrett County is questionable. On the geologic map of Garrett County (1902) Martin shows Permian strata occupying three hills on the eastern edge of the county: the most northerly exposure caps the hill just north of Koontz Run; the next is on the summit of Detmold hill, extending south along the Allegany-Garrett County line for about a mile and a half; the most southerly outcrop is on Caledonia hill ("Swanton hill") to the west of Barton (fig. 1). In the report on Garrett County, Martin (1902, pp. 144–145) pointed out that there were no good exposures on these hills and that the "only reason for showing the Dunkard on the map is that these hills are high enough above the base of the Monongahela to include more than the normal thickness of that formation." The outcrop pattern shown on the geologic map of the Georges Creek and Upper Potomac basins which accompanied the Second Report on the Coals of Maryland (Swartz and Baker 1920) is essentially the same as that of the old Garrett County geologic map, although the Permian outcrops are not extended as far west on the hill north of Koontz Run.

In the western part of Georges Creek basin the outcrop pattern of the Monongahela formation is shown on the new Garrett County map essentially as shown by Swartz and Martin. The Pittsburgh coal is now exposed in several places in this area by strip mines; but, with the exception of the Tyson coal (Upper Sewickley) the overlying strata are poorly exposed. No Permian outcrops are shown on the new Garrett County map, although as noted in the explanation the Monongahela may include some Permian. The new topographic map which was used as a base indicates that with one possible exception the hills in Garrett County are probably not high enough to be capped by Permian. On Caledonia Hill there is not room for over 150 to 180 feet of strata above the Pittsburgh coal, and since the Monongahela formation in Maryland is about 250 feet thick (Swartz and Baker, 1920, p. 71) it seems reasonably certain that the Dunkard is absent. The evidence on Detmold Hill is less conclusive, because the Pittsburgh coal is not so well exposed as on Caledonia Hill. The relationship of geology to topography indicates the presence of 250 to 280 feet of strata above the Pittsburgh. Thus there may be a thin cap of Dunkard on this hill. North of Koontz Run probably less than 200 feet of strata are present between the Pittsburgh coal and the top of this hill.

Subsurface Stratigraphy

Deep well records. One hundred and four deep wells have been drilled in Garrett County in search of gas, of which about 75 extended at least as deep as the Huntersville chert. Only three were located in the coal basins: Bayard Coal Co. #1 (F-2) and Nydegger #1 (F-3) in the Upper Potomac basin near Gorman, and the Harned Heirs #1 (F-6) in the Upper Youghiogheny basin (Pl. 1). These three wells were completed 20 to 30 years ago. The Maryland Department of Geology, Mines and Water Resources has no data pertaining to them, but their logs were published in Volume VII of the West Virginia Geological Survey (Tucker 1936, pp. 125–128; 372–374). These logs appear to be in the form of a "driller's log" so that it is difficult to make formation identifications, but an attempt was made to identify the principal coal beds from the upper part of the Harned Heirs #1 (see LOWER MEMBER, CONEMAUGH FORMATION).

All of the other deep-wells are on the anticlines, five on the Accident anticline and the rest on the Deer Park anticline. Most of the latter are at the south end of the Deer Park anticline, between Deep Creek Lake and the West Virginia line, with the greatest concentration in and around the town of Mountain Lake Park. Only four wells have been drilled on this structure north of Deep Creek Lake, one (F-77) about a mile east of North Glade and the other three in the Avilton area.

The Garrett County deep-wells are listed on pages 108 to 115 along with a summary of the pertinent data, and their locations are shown on Plates I and II.

Stratigraphic section. The Maryland Department of Geology, Mines and Water Resources has samples from most of the wells drilled since 1945. The writer, John Reed, Kenneth Weaver, and John Schlee studied a number of these, but a complete examination of all of the cuttings from every well was not made, the work having been concentrated on the part of the Devonian system extending from the "Tully" limestone to the Oriskany sandstone. Plate III presents in graphic form percentage logs of several wells covering the stratigraphic interval from the lower "Chemung" member into the Helderberg limestone and of one well (F-78) which extends down into the Silurian.

The following formations are recognized in the subsurface work.

Devonian	Jennings formation	"Chemung" member Woodmont member Burket member
	"Tully" limestone	
	Romney formation	"Hamilton" member "Marcellus" member "Onondaga" member
	Huntersville chert	Upper chert member Lower shale member
	Oriskany sandstone	Ridgeley sandstone
	"Helderberg" limestone (includes the Keyser limestone)	
Silurian	Tonoloway formation	
	Wills Creek formation	
	Williamsport sandstone	
	McKenzie formation	
	Rose Hill formation	
	Tuscarora sandstone	

These formation identifications are only tentative and much additional information is needed before final conclusions can be reached concerning the Garrett County subsurface section (see under DEVONIAN SYSTEM). Further study is especially desirable on the part of the section above the "Tully" limestone. The Silurian section is based on a single well.

JENNINGS FORMATION

"Chemung" member

Most of the wells drilled on the Deer Park anticline start in the "Chemung" member, but in only the Robeson #1 (F-66, Pl. III) have the cuttings been described in sufficient detail to show the lithologic character of the sediments in this part of the section. In this well there is a fairly sharp decrease in the amount of sandstone at a depth of 2100 feet; here the sandstone drops from an average of about 40 percent to an average of 10 percent or less, and this is taken as the "Chemung"-Woodmont contact. Above this contact the cuttings show a series of sandstones and siltstones and shales which is much like the upper part of the "Chemung" as exposed at the surface. The lower part of this member shows a slight increase in the sand content and this may correlate with the Parkhead member as described by Prosser and Swartz (1913, pp. 415–417). It is also interesting to note that this lower portion shows several zones of dark grey to black siltstone and shale because Prosser and Swartz (1913, p. 417) note that the lower "sandstones of the Parkhead can be distinguished by being bluish black when freshly exposed." The "Chemung"-Woodmont contact is placed at the base of the lowest thick sandstone series, which would seem to be lithologically comparable to the Chemung (including the Parkhead)-Woodmont contact of the Devonian volume. This boundary, however, is based strictly upon lithologic characters, no diagnostic fossils having been recovered from the well cuttings.

In the Robeson well the base of the "Chemung" is placed at 2,100 feet below the surface, but this 2,100 feet does not necessarily represent true stratigraphic thickness since this well is situated somewhat off the crest of the anticline (see Structure Map, Pl. I). Furthermore, surface studies indicate that there may be considerable small scale folding (see under STRUCTURE) in the crestal zone and therefore the stratigraphic thickness may be considerably less than 2,100 feet. Structure sections indicate about 2,000 feet of "Chemung" strata between the top of the Robeson well and the base of the Hampshire which would give the Chemung a thickness of 3,500 to 4,000 feet. Prosser and Swartz (1913, p. 415; 417) estimated the combined Chemung-Parkhead thickness in Allegany County to be 2,800 to 3,100 feet. Woodward (1943, p. 450; isopachous map, p. 458) gave the thickness of the Chemung (including the Parkhead) as around 3,000 feet in Hampshire, Hardy, and Pendleton Counties, West Virginia. Reger and Tucker (1924, p. 194) give a maximum thickness of 4,047 feet for the Chemung strata in Mineral and Grant counties.

Woodmont member

Name. Woodmont member was named by Prosser and Swartz (1913, pp. 412–415) for exposures at Woodmont Station in Washington County, Maryland. It was treated as a member in the Jennings formation overlying the Genesee member and underlying the Chemung member and was described as consisting of alternating beds of olive-green shale and thin fine-grained sandstones. Willard (1939, p. 239; Cooper, et al, 1942, Chart 4) correlated this member with the Braillier-Trimmers Rock, Losh Run, and Harrell formations of Pennsylvania. The Woodmont is apparently equivalent to the formation which most West Virginia investigators have called the Portage and which Woodward (1943, p. 444) designated as the Brallier shale (see pp. 6 and 7).

Lithology and thickness. The deep drilling in Garrett County reveals a stratigraphic unit beneath the "Chemung" member and above the Burket black shale member which is composed predominantly of shale and siltstone. This is believed to be at least in part, and perhaps entirely, equivalent to the Woodmont member of Allegany and Washington Counties and accordingly that name is used. This member consists of a sequence of dark- to medium-grey shales and siltstones with some fine-grained sandstones (Pl. III). In subsurface studies the distinction between the Woodmont and the "Chemung" is based entirely upon the relative proportion of sandstone to shale (and siltstone), the "Chemung" having about 40 percent sandstone, the Woodmont 10 percent or less. This sandstone-shale ratio is similar to that recorded for surface exposures of this member (Prosser and Swartz 1913), but is different from that of the Brallier (Portage) of West Virginia, in which Woodward (1943, p. 412) estimates the sandstone and shale are about equal in volume.

The Woodmont member, like the "Chemung" member, contains very little calcium carbonate, although a few of the sandstone beds have a calcareous matrix. The base of this member is placed at the contact between the dark-grey shales and the black calcareous shale and siltstone of the Burket member.

The Woodmont member has been carefully studied only in the Robeson (F-66) well. It occupies an interval of slightly over 1,800 feet, but this is believed to be somewhat in excess of the true thickness since the hole probably does not cut the strata at right angles to the bedding. Prosser and Swartz (1913, p. 413) give the thickness of this member as 1,600 feet in the eastern sections, decreasing to 1,200 or 1,300 feet in the sections west of Green Ridge in Allegany County. Woodward (1943, p. 416) states that the thickness ranges from 1,500 to 1,700 feet in the region along the Potomac River.

Fauna and age. No fossils were recovered from the cuttings of the Woodmont member. Prosser and Swartz (1913) described the fauna from the Woodmont member in considerable detail and recognized two faunal zones, a lower one with a fauna similar to that of the Naples of New York and an upper one which was correlated with the Ithaca. The Devonian Correlation Chart refers the Woodmont to the Finger Lake stage of the Upper Devonian.

Burket member

Name. Butts named the Burket for exposures in central Pennsylvania, treating it as the basal black shale member of the Harrell shale. In 1939 Willard (pp. 218–219) removed the Burket from the Harrell and placed it as the uppermost member in the Rush formation, the Tully being the lower member. In his correlation chart (p. 239) he correlated the Burket member with the Genesee of Maryland, but in the text (pp. 218–219) he stated that the Genesee of Maryland equaled the Harrell of Pennsylvania and that the Burket was probably absent in Maryland. The Devonian Correlation Chart (Cooper, et al, 1942) correlates the Burket of Pennsylvania with the Genesee of Maryland.

In this report the black shale unit beneath the Woodmont member is provisionally called the Burket member because in almost all the wells where this black shale appears it is underlain by a thin limestone, the "Tully", a stratigraphic sequence much like that which Willard describes in Pennsylvania. This member may be tentatively correlated with the Genesee member of Prosser and Swartz, but there is no faunal evidence to support this correlation and the "Tully" limestone has not been found at the surface (see p. 7).

Lithology and thickness. The Burket member is composed almost entirely of black shale and siltstone. It is generally slightly to strongly calcareous, particularly in the lower part. Fragments placed in dilute hydrochloric acid usually effervesce vigorously, but only for a short time. The color is characteristically jet black, but pieces examined under a microscope commonly show numerous very small white flecks which probably are disseminated calcium carbonate.

In a few wells this member is as much as 150 feet thick, but it is generally less. Plate III shows its stratigraphic position and thickness in three wells (F-66, F-18 and F-22). Willard in his volume on the Middle and Upper Devonian of Pennsylvania (figure 65) says the Burket reaches a thickness of about 250 feet although this appears to be unusually great. Prosser and Swartz (1913, p. 412) state that in the area west of Wills Mountain (Allegany County) the Genesee member is 90 to 100 feet.

Fauna and age. No fossils were obtained from the well cuttings of the Burket member. The fauna of the Genesee of Maryland with which it is supposedly equivalent is described in the Devonian volume of the Maryland Geological Survey. On the Devonian Correlation Chart the Genesee of Maryland is assigned to the Taghanic stage of the Middle Devonian.

"Tully" limestone

Name. The name Tully was applied by Vanuxem in 1839 to a thin fossiliferous limestone formation which was exposed at Tully, Onondaga County, New York.

In 1935 Cooper and Williams redescribed this formation, divided it into three members, and discussed the fauna in detail. They (1935, p. 824) noted that, although the Tully fauna had long been considered to be Upper Devonian in age, it included many species with Hamilton affinities. A few years later Cooper (1942 Cooper et al, pp. 1786–1788) gave additional information on this fauna and placed it in the late Middle Devonian.

The southward extension of the Tully into Pennsylvania was discussed by Willard (1939, pp. 218–235), who included the Tully as the basal member of his Rush formation (see under JENNINGS FORMATION). He gives much information on the lithology and fauna of the Tully as well as a sketch map showing its distribution in Pennsylvania.

According to Woodward (1943, pp. 387–389) the Tully limestone has never been definitely recognized in surface exposures of West Virginia, but it has been reported from the subsurface in the western and northwestern parts of West Virginia.

The Tully limestone has not been found in surface exposures in Maryland. It should lie between the Genesee member of the Jennings formation and the Hamilton member of the Romney formation. Prosser and Swartz (1913, p. 412), in discussing this Genesee-Romney boundary, state that "A massive sandstone occurs either at or a short distance below the top of the Romney, while the shale of the upper part of that formation breaks into fragments of very irregular shape which weather to a yellowish or greenish color, contrasting sharply with the smooth fissile brown, or black platy fragments of the Genesee." They did not find any typical Tully species such as *Hypothyridina venustula* and *Chonetes aurora*, but they did note that "A characteristic Hamilton fauna is known to extend within at least 30 feet of the black shale [Genesee]."

Deep drilling for gas in Garrett County reveals a thin, but persistent, limestone underlying a calcareous black shale, the Burket. This limestone is present in most of the wells drilled at the south end of the Deer Park anticline, in all three drilled at the north end and in the two wells on the Accident structure which were completed to the Oriskany sandstone (Pl. III). This formation is here called the "Tully," although the identification can only be regarded as provisional in the absence of diagnostic fossils. It is, as pointed out by Woodward (1943, p. 389), difficult from well data to distinguish between a limestone representing the true Tully and a lower limestone in the Hamilton or a higher one in the Jennings. This limestone does, however, occupy a stratigraphic position somewhat like that of the Tully of Pennsylvania, the Woodmont-Burket-"Tully" sequence of Garrett County being similar to the section given by Willard for Pennsylvania. Furthermore, Willard (1939, pp. 219–221) has definitely identified the Tully with its typical fauna in the central and northern parts of Bedford County, which is only about 40 miles northeast of Garrett County, though the Tully limestone is apparently absent in the southern part of Bedford County and in Allegany County, Maryland.

The Jennings-Romney contact (Middle-Upper Devonian) in the subsurface investigations in Garrett County is based upon the "Tully" limestone, strata above this limestone being referred to the Jennings formation and those below to the Romney formation. Therefore if this limestone is incorrectly referred to the Tully, the Middle-Upper Devonian boundary is not correctly located.

Lithology and thickness. The "Tully" limestone is a rather finely-crystalline medium- to light-grey limestone which may have a slightly brownish cast. In most places it is impure and silty, and locally it grades into a calcareous siltstone. Much pyrite is commonly present.

The Tully limestone of New York and Pennsylvania (Cooper and Williams 1935, p. 787; Willard 1939, p. 211) rests disconformably on older strata and there is evidence that the "Tully" of Maryland is also underlain by a disconformity. In Garrett County the lithology of the strata immediately underlying this unit is not everywhere the same. At the south end of the Deer Park anticline it is generally underlain by a black shale followed by a sequence of grey to dark-grey shales and siltstones, whereas at the north end it is underlain by light-grey sandstones and grey siltstones and shales (compare the logs of F-66, F-18 and F-22 of Plate III). In the McCullough well (F-113) on the Accident anticline the "Tully" is underlain by about 30 feet of black calcareous siltstone followed by a series of medium- to dark-grey shales and siltstones.

The interval between the "Tully" limestone and the Oriskany sandstone varies considerably from place to place which could be caused by a disconformity. Some of this variation, which takes place within short distances may be due to minor structures, such as small folds and faults, and some may be due to variations in the angle between the bedding and the hole. There does, however, seem to be an increase in this interval towards the north end of the county which appears to be independent of any of these factors. Figure 8 shows this interval ranges from 607 feet to 650 feet in the most southerly wells, increases to around 700 feet in the area north of Deer Park, and reaches its maximum of around 1100 feet in the Avilton area at the north end of the Deer Park anticline (see also Martens 1939, fig. 2). On the Accident anticline it ranges from 878 feet to 1,055 feet. This change in the stratigraphic interval, along with the lithologic variations, might well be produced by a disconformity below the "Tully" limestone.

The "Tully" limestone in Garrett County is always thin, usually 10 feet or less in thickness. In a few wells (e.g., F-22, Pl. III) it may be represented by a small percentage of the cuttings extending through a thickness of 30 feet, suggesting several thin limestones interbedded with black shale.*

The Tully limestone in its type area in New York is 30 feet thick (Cooper and Williams 1935, p. 782). Willard (1939, p. 225) found a maximum thickness

* Willard (1939, p. 221) notes that the Tully limestone in Pennsylvania is commonly interbedded with shale.

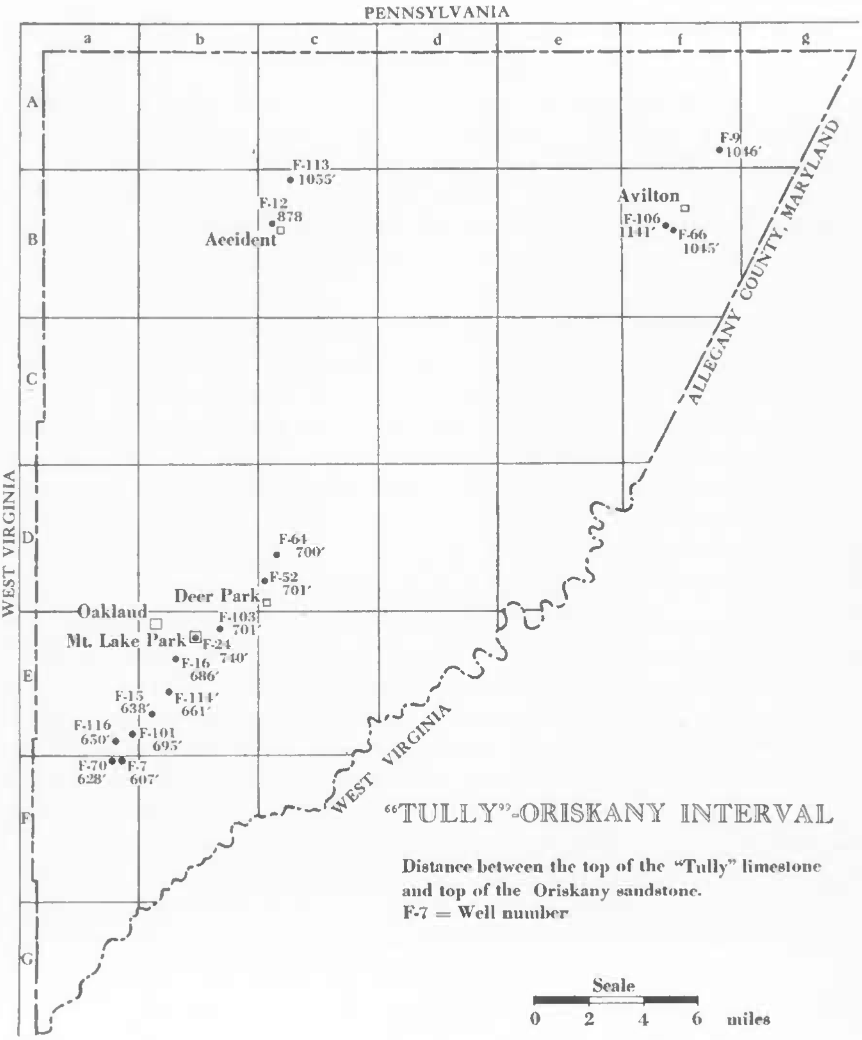

FIGURE 8

of 240 feet in north central Pennsylvania; but the limestone thins rapidly towards the south, and in northern Bedford County it is only a few feet thick. Woodward (1943, p. 238) presents an isopachous map of the Tully (?) limestone of southwestern Pennsylvania, western Maryland, and West Virginia.

Fauna and age. Well cuttings of the "Tully" limestone commonly show fossil fragments such as crinoid stems, but no identifiable specimens were obtained. The Tully in New York and Pennsylvania is abundantly fossiliferous, one of the most distinctive species being the brachiopod *Hypothyridina venustula.*

The Devonian Correlation Chart (Cooper, et al, 1942) refers this formation to the Taghanic stage of the late Middle Devonian.

ROMNEY FORMATION

The Romney formation was named by Darton for exposures at Romney, Hampshire County, West Virginia. He applied this name to the sequence of dark shales and sandstones underlying the Jennings formation, and stated that they contained Hamilton fossils. Most later authors have included Hamilton, Marcellus and Onondaga strata within the Romney (Wilmarth 1938, p. 1841).

Martin (1902) in his report on Garrett County does not mention this formation since these strata are not exposed at the surface, but O'Harra (1900, p. 103–106) used the name in Allegany County as equivalent to the Marcellus and Hamilton. Prosser and Swartz (1913, pp. 47–50), continued to use Romney, dividing it into three members, Onondaga, Marcellus and Hamilton. According to them the Onondaga member consisted of drab shales with thin limestones having a fauna similar to that of the type Onondaga in New York; the Marcellus member was composed largely of black shales having a fauna like the type Marcellus in New York; the Hamilton member consisted of bluish gray shales and sandstones with a large fauna like that of the type Hamilton (New York).

The name Romney is retained in this report for the strata between the base of the "Tully" limestone and the top of the Huntersville chert. Such a usage probably approximates that of Prosser and Swartz, although the absence of faunal information as well as the presence of the Huntersville chert raise serious problems. At the surface the shales and thin limestones of the Onondaga rest directly upon the Oriskany sandstone, whereas in Garrett County the "Onondaga" is underlain by the Huntersville which rests upon the Oriskany. Therefore in this report the following units are recognized:

- Romney formation
  - "Hamilton" member
  - "Marcellus" member
  - "Onondaga" member
- Huntersville chert
  - Upper chert member
  - Lower shale member
- Oriskany sandstone

This usage of Romney formation may not correspond very closely to the Romney in its type area. Furthermore the application of the names "Hamilton," "Marcellus" and "Onondaga" to subsurface lithologic units far removed from the type area is questionable. It does not, however, seem desirable to make revisions in terminology solely on the basis of subsurface studies in a limited area.

"Hamilton" member

Name. The name Hamilton was proposed by Vanuxem for exposures at West Hamilton, New York. The stratigraphy and fauna of this formation has been described in a series of papers by G. A. Cooper (1930; 1933; 1934). This name has been extensively used as a formation or group name in Pennsylvania, Maryland, and West Virginia. In this report "Hamilton" is used as a member name within the Romney formation although there is no faunal evidence to support a correlation with the Hamilton of New York nor does it appear to have many lithologic similarities with that formation. Even its equivalence to the Hamilton member of Prosser and Swartz is not above question; however, its stratigraphic position suggests that it is middle Devonian in age and very likely correlates, at least in part, with the so-called Hamilton of Allegany County and Washington County. It would be desirable to use local names for this and some of the other stratigraphic units of this report, but there are hardly sufficient data to justify such. For further discussion on this see under *"Tully" Limestone* and under ROMNEY FORMATION.

Lithology and thickness. The "Hamilton" member is not well-defined lithologically but is used as a convenient receptacle for the sequence of fine-grained sandstones and grey to black shales and siltstones between the solid black shale of the "Marcellus" member and the "Tully" limestone. At the north end of the Deer Park anticline (wells F-9, F-66, F-106) it consists of about 350 feet of light-gray, fine-grained sandstone and dark-grey shale (see F-66, Pl. III), but at the south end, in and around the Mountain Lake Park gas field, the "Tully" is usually underlain by a black shale followed by a series of dark-grey shales and siltstones. The thickness of the "Hamilton" in this southern area is variable; in the two wells on Plate III (F-18, F-22) it ranges from 150 feet to 300 feet, but in some of the wells in this area almost the entire interval between the "Tully" and the Huntersville chert is occupied by "Marcellus" black shale and the "Hamilton" is not recognizable.

Prosser and Swartz (1913, p. 48, 50) state that the Hamilton member of the Romney formation is approximately 1,000 feet thick, but in discussing the thickness of the entire Romney they state that this formation ranges from 600 to 1,650 feet. In Mineral County, West Virginia, which is just east of Garrett County, the thickness ranges from 200 to 300 feet (Woodward 1943, p. 334).

Fauna and age. No identifiable fossils were observed from this part of the section. Prosser and Swartz (1913) describe the fauna collected from the surface exposures of the Hamilton member.

"Marcellus" member

Name. The Marcellus was named by James Hall for exposures at Marcellus, Onondaga County, New York. The name has been rather widely applied to Middle Devonian black shales in New York, Pennsylvania, Maryland, and

West Virginia. Hall and many of the earlier workers excluded the Marcellus from the Hamilton, but later workers have commonly included it within the Hamilton (Cooper 1930; Cooper, et al, 1942). In the Devonian volume of the Maryland Geological Survey (Prosser and Swartz 1913, pp. 49–50) the Marcellus black shale is treated as a member of the Romney formation, equal in rank to the Hamilton, and this procedure is followed here largely because in subsurface work the so-called "Marcellus" black shales are a distinctive unit which make up a large part of the Romney formation. In Garrett County this member occupies a stratigraphic position which is at least roughly comparable to the generally accepted usage of Marcellus, although uncertainties concerning the stratigraphic and time relationships exist.

Lithology and thickness. The "Marcellus" member consists of black, carbonaceous shale and minor siltstone, parts of which carry considerable pyrite. The middle and upper part is generally not calcareous, but in the lower 200 feet zones of limey shale and impure limestone appear. At the base it grades into the dark calcareous shale and limestone of the "Onondaga" member, so that the "Marcellus"-"Onondaga" boundary is not sharply defined. Surface studies in Maryland (Prosser and Swartz 1913, p. 49), West Virginia (Woodward 1943, p. 314), and Pennsylvania (Willard 1939, p. 169–176) show a similar calcareous zone in the lower part of the Marcellus. It is a question whether the "Marcellus"-"Onondaga" contact as defined in the subsurface work in Garrett County corresponds to the surface boundary as drawn by Prosser and Swartz. The entire "Onondaga" of this report may correlate with the lower calcareous zone of the Marcellus member as defined by surface investigations in Maryland and West Virginia. This is discussed more fully under the *Onondaga Member.*

The black shales of the "Marcellus" member are present in all the Garrett County wells which have been studied. The thickness varies greatly, but largely because the upper contact with the "Hamilton" member is difficult to locate. All the solid black shales above the "Onondaga" are referred to the "Marcellus" and the overlying dark-grey shales and siltstones to the "Hamilton." It is often difficult, however, to separate the two lithologies by well cuttings, and in some wells at the south end of the Deer Park anticline the entire interval between the "Onondaga" and the "Tully" is occupied by very dark grey to black shales. In this southern area it might be better to include all the strata in this interval ("Hamilton"-"Marcellus") in a single stratigraphic unit, but this would ignore the fact that there is commonly a zone of grey to dark-grey shale and siltstone above the black shales.

At the south end of the Deer Park structure the thickness of the "Marcellus" ranges from around 200 feet to over 500 feet. This variation as noted above may be due largely to the fact that the upper boundary is indefinite so that the contact is not everywhere drawn at the same place. Commonly where the

"Marcellus" is thick the "Hamilton" is thin and vice versa. This fact is brought out by the "Tully"-Oriskany interval (or "Tully"-Huntersville chert interval) which in the area around the Mountain Lake Park gas field shows a maximum range of about 150 feet (fig. 8), whereas the "Marcellus" member may vary over 300 feet in thickness.

Prosser and Swartz (1913, p. 49) give a thickness of 500 feet for the Marcellus member in Allegany County. In West Virginia, Woodward (1943, p. 316) gives a thickness range of 250 to 500 feet.

Fauna and age. No identifiable fossils have been observed in the "Marcellus" black shale. Prosser and Swartz (1913) describe and illustrate the fauna from the Marcellus member in Allegany and Washington Counties.

"Onondaga" member

Name. The name Onondaga was proposed by James Hall for exposures in Onondaga County, New York. This name has since been employed over a large area extending from New York to Tennessee (Cooper, et al, 1942, Chart 4) where it has been variously treated as a member, as a formation, or as a group and has been applied to strata of differing lithology.

Willard (1939, p. 144) used the Onondaga as a group name and divided it into two formations (central Pennsylvania):

Marcellus formation
Onondaga group
  Selinsgrove limestone
  Needmore shale
Oriskany group

In contrast Prosser and Swartz (1913, pp. 48–49) used the Onondaga as a member of the Romney formation. According to them it consisted of brown to grey or black shales and thin dark argillaceous limestones, underlain by the Ridgeley sandstone member of the Oriskany formation and overlain by the Marcellus member of the Romney formation. The fauna was stated to contain numerous species "found in the Marcellus and Hamilton of New York. Associated with them, however, are some which are restricted to the Onondaga of New York. . . ."

Woodward (1943, pp. 255–308) recognized the Onondaga as a group which included the Needmore shale and the Huntersville chert. He noted that "The interrelation of these named units [Needmore shale and Huntersville chert] has not been worked out in all details. As they seem laterally to intergrade, it is believed they are partly of the same age. Nonetheless, a few sections reveal both Huntersville chert and Needmore shale."

Subsurface studies in Garrett County show the following stratigraphic sequence (Pl. III):

Black shales, calcareous in lower part	"Marcellus"	
Impure limestones and dark calcareous shales	"Onondaga"	
Light to dark grey chert	Upper member	Huntersville
Dark grey shale and siltstone	Lower member	
Light grey sandstone	Oriskany	

It is difficult to correlate this section with the different units which have been recognized in the surface exposures of Pennsylvania, Maryland, and West Virginia. The writer uses the name "Onondaga" for the impure limestones above the chert formation (Huntersville) and considers it correlative with the Onondaga member of Prosser and Swartz and probably with the Needmore shale* of Willard. Such an interpretation agrees reasonably well with the Devonian correlation chart in which the Huntersville chert of the type area (central West Virginia) is correlated with the Schoharie and Esopus of New York and the Needmore and Selinsgrove are correlated with the Onondaga of New York. However, the Garrett County subsurface studies have not yielded any faunal evidence to support this correlation. The "Onondaga" may actually correlate in part or entirely with the lower calcareous portion of the Marcellus as seen in the surface exposures of Maryland, Pennsylvania, and West Virginia. If this were the case then the chert might correlate with the Onondaga member of the Romney. (The age of the Huntersville chert in its type area is discussed under HUNTERSVILLE CHERT; also see Martens 1939, fig. 6.)

Lithology and thickness. The "Onondaga" consists of an impure, argillaceous to slightly silty limestone and calcareous shale. The color is almost always very dark, ranging from dark grey to black. A few of the limestone beds may be fairly pure, but most of them contain much silt and clay, and grade into calcareous shale. The upper contact of this member is poorly defined, passing into the "Marcellus" member through a thick sequence of transitional beds (see under *"Marcellus" Member*). In contrast the lower contact is rather sharp as the impure limestones of the "Onondaga" change rather abruptly to the underlying chert. If a transitional zone is present, it must be 10 feet or less in thickness (Pl. III).

A distinctive and unusual rock type is almost invariably found in the well cuttings from the "Onondaga." This rock has a dark-brown to deep reddish-brown color and is commonly referred to as the "brown break." It is a rock of medium-grain size, is only faintly calcareous, and contains considerable mica. Its composition has not been determined and its genesis is unknown, although

* Willard applied the name Needmore to a calcareous shale overlying the Oriskany sandstone, the type locality being in Fulton County, southern Pennsylvania. This would seem to be correlative with the Onondaga member of Prosser and Swartz and further work in Allegany and Washington Counties will probably show that the latter name should be replaced by Needmore. The "Onondaga" of this report might also be replaced by Needmore, but in view of the uncertainties mentioned above it seems preferable to defer this until more information on the stratigraphic relationships in this area is available.

it has been called bentonite. It is an easily recognized rock type which makes an excellent marker bed. It appears to be confined to the "Onondaga" and in some wells is present as a small percentage of the cuttings through a large part of this member.

The "Onondaga" is a persistent stratigraphic unit, being present in all the Garrett County wells which have been studied. It is always thin, ranging from 10 feet up to about 50 feet, although this apparent variation in thickness may be due to uncertainties in fixing the upper contact.

Prosser and Swartz (1913, p. 49) give their Onondaga member a thickness of 100 to 150 feet; according to Willard (1939, p. 149) the Needmore shale in southern Pennsylvania has a similar thickness; Woodward (1943, p. 280) states that the Needmore shale in West Virginia varies from 35 to 200 feet in thickness.

Fauna and age. No identifiable fossils have been obtained from the well cuttings of this member in Garrett County. The fauna of the Onondaga member of Maryland is discussed by Prosser and Swartz (1913). Willard (1939, pp. 156–160) gives a faunal list for the Needmore shale of Pennsylvania, and Woodward discusses the Needmore fauna of West Virginia.

HUNTERSVILLE CHERT

Name. The name Huntersville chert was proposed by Price (1929, pp. 236–237) for exposures near Huntersville in the southeastern part of Pocahontas County, West Virginia (about 80 miles southwest of Garrett County). In the type area this stratigraphic unit consists of about 60 feet of yellow to grey chert with minor amounts of sandstone. The following section was measured by Price at Burr Post Office in Pocahontas County:

Shales, *Marcellus*		
Chert, yellow, sandy	4 ft.	Huntersville chert
Chert, grey to black	8 ft.	
Sandstone, bluish-green, shaly, phosphatic	1 ft.	
Chert, yellow, gray, cobbly	15 ft.	
Concealed	30 ft.	
Sandstone, *Ridgeley*		

Price placed the Huntersville chert as the upper member of the Oriskany series, the lower member being the Ridgeley sandstone.

This formation was discussed at some length by Woodward (1943, pp. 256–278) who included it with the Needmore shale in the Onondaga group (see under *"Onondaga" Member*). According to him the name chert was not entirely appropriate because it was mostly a highly silicified black shale with less true chert than commonly supposed. The maximum thickness was stated to be about 100 feet where the Huntersville has its best development, in Pocahontas and Greenbrier Counties, West Virginia, and Bland County, Virginia. The most northerly exposures of this unit were reported from the North Fork Valley of

Pendleton and Grant Counties where it consisted of a few feet of silicified shaly sandstone containing phosphatic nodules. Woodward states that north of this area the Huntersville is absent and the Needmore shale occupies its general level in the stratigraphic column.

No Huntersville chert is present in the surface exposures of Maryland, and the Onondaga member (probably equals the Needmore shale) of Prosser and Swartz rests directly upon the Ridgeley sandstone member of the Oriskany. They state (1913, p. 49) that "Unconformable relations between the shale of the Onondaga member and the Oriskany sandstone are strongly suggested by the extremely abrupt and complete change in the character of the sediments at the top of the Oriskany sandstone" (see Schuchert, et al, 1913, p. 95).

All the wells drilled in Garrett County which penetrate this part of the section show a chert sequence beneath the "Onondaga" member of the Romney formation (see under *"Onondaga" Member*). Under this is a thin zone of dark-grey siltstone and shale, in places containing minor amounts of chert, which rests upon the Oriskany sandstone. This siltstone which intervenes between the solid chert and the Oriskany sandstone is persistent and may be easily recognized from well samples (Pl. III). In this report it is included with the overlying chert in the Huntersville, so that the latter is defined as follows:

Huntersville chert
  Upper chert member
  Lower shale member
Oriskany sandstone

The siltstone and shale member is included within the Huntersville because in some wells it carries minor amounts of chert and the well samples indicate that it grades into the overlying chert member (Pl. III). The Huntersville chert in West Virginia seems to show a somewhat comparable sequence because Woodward (1943, p. 257) notes that the "lower portion is commonly arenaceous, and the basal beds contain residual sand from the underlying Ridgeley sandstone that is intimately mixed with the silt of the black-soil or black-shale type, both being cemented with amorphous, possibly colloidal, silica, . . .". Also it seems possible that the 30 feet of concealed strata at the base of Price's Burr Post Office section may be composed of shaly and silty material.

This formation in Garrett County occupies the same stratigraphic position as the Huntersville chert in its type area and it seems reasonably certain that the two are largely correlative. The problems involved in the correlation of the Huntersville chert with the surface exposures in Washington and Allegany Counties, Maryland, are discussed under the *"Onondaga" Member*.

Lithology and thickness. The upper member of the Huntersville chert consists of light- to dark-grey chert. At the south end of the Deer Park anticline, where this member is well-developed and has been penetrated by numerous wells, the uppermost portion generally consists of a light-grey to white chert, whereas the lower part is a medium- to dark-grey or black chert. A considerable portion of this upper member must be a solid chert because chert makes up 95 to 100 percent of the well samples. The upper contact ("Marcellus"-Huntersville) is well defined, the impure limestones of the "Marcellus" giving way rather abruptly to the chert of the Huntersville. The lower contact is not so well defined and there is commonly a zone of 30 feet or more in which the chert is mixed in with the dark grey siltstone and shale of the lower member (Pl. III).

The chert in several wells shows evidence of having been fractured and recemented with silica (most samples show little or no calcium carbonate), a feature also noted by Woodward (1943, p. 257). The significance of the brecciation is not clear, but very commonly this member is a gas producing zone in the Mountain Lake Park gas field. Some of the operators say that the upper few feet of the Huntersville does not yield any gas, and that it is necessary to drill into the formation a short distance to get production. Presumably the major gas reservoir is the Oriskany sandstone, but some gas passes upwards into the chert. It is generally stated that the gas in the Huntersville must be in fractures since a dense chert would not have primary porosity. Under such conditions one would expect the gas bearing fractures to extend all the way through the chert, including the uppermost portion.

At the south end of the Deer Park anticline the upper member may reach a thickness of 100 feet, athough it is commonly less than this. It is much thinner at the north end of this structure ranging from 15 to 20 feet; in this northern area the entire member is composed of a dark grey chert similar to that in the basal part at the south end.

The writer has not examined any of the well samples from the upper chert member in the Accident anticline, but the log given by Martens (1945, pp. 757–758) for the Shartzer well (F-12) shows a section much like that found in the Mountain Lake Park field. The chert member is about 100 feet thick and is composed of light brownish-grey chert in the upper part, becoming dark-grey in the lower part.

The lower member of the Huntersville chert is composed of dark grey to almost black siltstone and shale. In many of the wells this lower member (below the transition zone) is free of chert, but in a few wells chert fragments are found throughout. This may be the result of caving, but probably there is chert in this member.

The contact of this member with the underlying Oriskany is difficult to evaluate on the basis of well cuttings alone. The dark siltstones and shales are commonly intermixed with the Oriskany sandstone through a thickness of 30 feet or more (Pl. III).

The total thickness of the Huntersville chert (including the lower member) at the south end of the Deer Park anticline is about 120 to 130 feet, whereas at the north end the thickness is 50 to 60 feet with most of the difference due to the reduced thickness of the upper member. On the Accident anticline the Shartzer (F-12) well shows a thickness of 135 feet and the McCullough well (F-113) a thickness of 145 feet.

Fauna and age. No fossils were obtained from the Huntersville chert. Price (1929, p. 236) noted that this formation in the type area carried a sparse fauna of Oriskany age and tentatively correlated it with the Esopus and Schoharie of New York. In the Devonian Correlation Chart (Cooper, et al, 1942) the Huntersville formation is also correlated with the Esopus and Schoharie. Woodward (1943, p. 274) gives a list of the Huntersville fauna of West Virginia.

ORISKANY SANDSTONE

Ridgeley sandstone

Name. The name Oriskany was first used for a sandstone exposed at Oriskany, Oneida County, New York. The name has been applied over a large area in the Appalachians, sometimes being given the rank of formation, sometimes group, more rarely series (Price 1929, p. 232). O'Harra (1900, pp. 98–103) used Oriskany formation in Allegany County, noting that in this county it was divisible into two members, an upper sandstone and a lower unit composed of dark-grey arenaceous shale and blue-black chert. Later the authors of the Lower Devonian volume of the Maryland Geological Survey (Schuchert, et al, 1913, pp. 90–96) recognized the same division and proposed member names for each: the lower was called the Shriver chert member, named for exposures at Shriver Ridge, Cumberland, Maryland; the upper was called the Ridgeley sandstone member, this name being taken from Ridgeley,* West Virginia. The Shriver chert member was said to consist of dark grey siliceous shale containing large quantities of black impure chert. In the Cumberland area the Shriver chert-Helderberg contact was placed at the boundary between the black cherts of the Shriver and the white cherts of the New Scotland. To the east, in the Hancock area, the Shriver member was reported to be absent and the Ridgeley sandstone member rested directly upon the Helderberg. The Ridgeley sandstone member was described as consisting of calcareous sandstone, at places grading into an arenaceous limestone.

Cleaves (1939, p. 97) recognized these same divisions in the central and southern parts of Pennsylvania, but he treated the Oriskany as a group with the Ridgeley and Shriver as formations. Woodward (1943, pp. 127–158) also recognized the Oriskany as a group, but included only the Ridgeley sandstone within it. He questioned the validity of Shriver chert as a stratigraphic unit (1943, pp. 15, 109, 134).

* In the Devonian volume the name is spelled Ridgely, but according to Wilmarth (1938, p. 1813) the correct spelling is Ridgeley.

In Pennsylvania, Maryland, and West Virginia the Ridgeley sandstone is commonly a quartz sand with considerable amounts of calcareous cement that in many areas grades into an arenaceous limestone. This lithologic variation has also been noted in New York where Chadwick used the name Glenerie for the arenaceous limestone facies of the Oriskany.

In this report the name Ridgeley sandstone* is applied to the sequence of calcareous sandstones which underlie the lower member of the Huntersville chert and grade downward into the underlying Helderberg limestone, with no Shriver chert recognized. There is no fossil evidence bearing on the age of this sandstone, but its stratigraphic position seems to show that it is at least in part equivalent to the Ridgeley sandstone of Schuchert and authors. In Garrett County no well defined lithologic break separates this sandstone from the Helderberg limestone and in most well logs it has been necessary to select a contact arbitrarily (Pl. III). It is not known how the Shriver chert fits into this stratigraphic sequence, but if correlative strata do exist they are probably included within the Helderberg.

Lithology and thickness. The Ridgeley is a grey to white sandstone (fresh surface) which is composed largely of quartz, although minor amounts of other minerals are present.† The grain size is mostly in the fine to medium range with only small quantities of coarse sand. The shape of most grains ranges from angular to sub-angular. Calcium carbonate is the dominant cementing material but the percentage varies considerably as is shown in the logs of wells F-17, F-18, F-22 on Plate III. The percentage increases steadily, but irregularly, downwards so that the lithology gradually passes over to an arenaceous limestone. This is apparently a rather typical feature, as it has been noted in all of the southern wells which were drilled into the Helderberg. None of the wells at the north end of the Deer Park anticline are deep enough to show this, but Martens (1945, p. 758) log of the Shartzer well (F-113) on the Accident anticline indicates that the Ridgeley (Oriskany) becomes increasingly calcareous downwards. Since the underlying Helderberg is an impure limestone this gradual transition from a calcareous sandstone to a sandy limestone makes the Ridgeley-Helderberg contact difficult to locate. The contact has been placed where the calcium carbonate exceeds 50 percent, but it is not always possible to get a precise location on this point and even then there will be beds below in which the strata revert to a calcareous sandstone.

The Ridgeley sandstone (Oriskany sandstone of the drillers) is the principal

* There seems to be little point in using Oriskany as a group name in Garrett County since only a single unit, the Ridgeley, is recognized. However, the general heading of Oriskany sandstone is retained since in subsurface investigations this sandstone is commonly so designated.

† Martens (1939, pp. 30–36) discusses the mineralogical composition of the Ridgeley (Oriskany) sandstone in his paper on the Petrography of Deep-Well Sections in West Virginia and Adjacent States

producing horizon in Garrett County although gas is also found in the Huntersville chert. No data on the porosity of this sand in Maryland are available, but tests made in West Virginia and Pennsylvania indicate it ranges from 6.8 to 11 percent with the average around 8.8 percent (Martens 1939, p. 31). Acid is commonly used in the wells of the Mountain Lake Park gas field to increase the flow of gas.

An accurate thickness of the Ridgeley sandstone is difficult to get because of the gradational lower contact, but it is generally about 100 feet in the area around the gas field. No information on thickness is available for wells at the north end of the Deer Park anticline or for those on the Accident anticline because all were stopped before reaching the Helderberg. The thickness of the Ridgeley sandstone at the surface in Allegany County is about 250 feet (Schuchert et al, 1913, p. 92). Woodward (1943, p. 135; isopachous map on p. 129) notes that in northeastern West Virginia and northern Virginia the thickness of the Ridgeley has been variously reported from 200 feet to 375 feet, but he thinks this may be too great due to the inclusion of some Helderberg strata. Martens (1939, p. 35; subsurface data) records an average thickness of 40 ft. for the Ridgeley (Oriskany) sandstone in Kanawha County, southwestern West Virginia, but in northern and central West Virginia the thickness is greater, ranging from 60 to 150 feet.

Fauna and age. No fossils have been found in the Ridgeley sandstone of Garrett County. The Ridgeley fauna is described in the Lower Devonian volume of the Maryland Geological Survey (Schuchert, et al, 1913). In the Devonian Correlation Chart the Ridgeley sandstone of Pennsylvania, Maryland, and West Virginia is correlated with the Oriskany sandstone of New York.

"HELDERBERG" LIMESTONE

The Lower Devonian volume of the Maryland Geological Survey (Schuchert and authors 1913) included the Keyser limestone as a member in the Helderberg formation, but most later authors have removed the Keyser from the Helderberg and placed it in the late Silurian (Cooper and authors 1942; Swartz and authors 1942). In the subsurface studies, based exclusively upon lithology, it has not been possible to make this separation and the Keyser is included in the "Helderberg" limestone.

Several of the Garrett County wells have been drilled into the "Helderberg," but only one, the Shaw #2 (F-78, Pl. III) was continued through this formation.

The name "Helderberg" is applied to the sequence of silty and sandy limestone which underlies the Ridgeley sandstone. In the upper part this limestone becomes very arenaceous and grades up into the calcareous sandstones of the Ridgeley. Some chert zones are present in the "Helderberg," but they are largely confined to the middle and lower part. The lower contact is drawn at

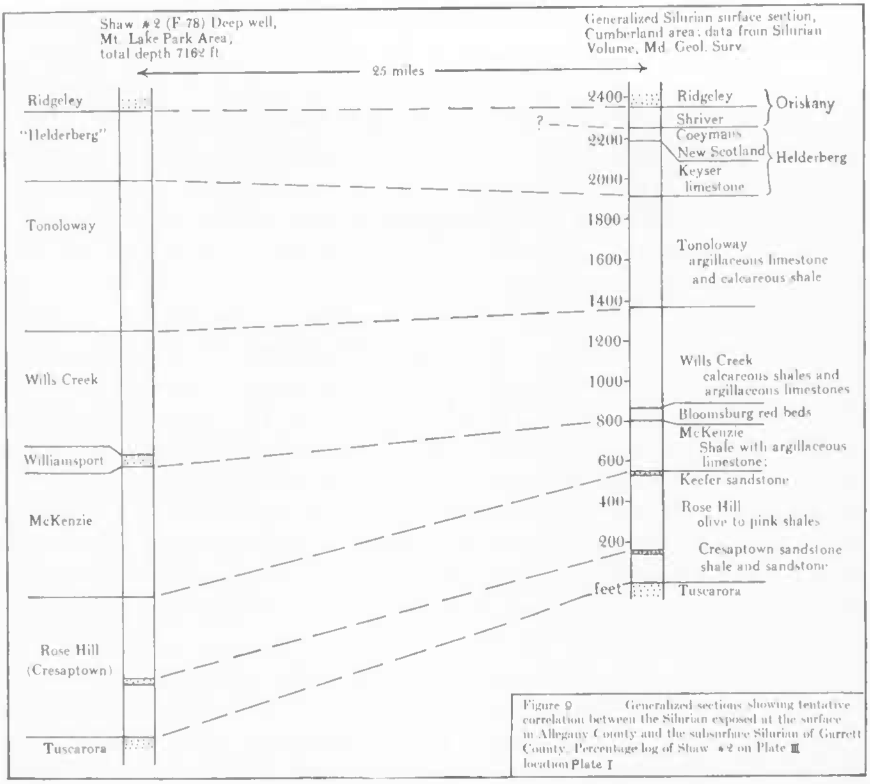

FIGURE 9. Generalized sections showing tentative correlation between the Silurian exposed at the surface in Allegany County and the subsurface Silurian of Garrett County. Percentage log of Shaw #2 on Plate III; location on Plate I.

the place where the shale-siltstone content increases from around 10 percent to over 40 percent. This contact is tentatively correlated with the surface boundary between the Keyser limestone and the argillaceous limestone and calcareous shale of the Tonoloway.

The thickness of the "Helderberg" limestone in Garrett County seems to indicate that it includes strata equivalent to the Keyser limestone.* The Shaw #2 well penetrated 340 feet of "Helderberg" limestone and although this is probably not true stratigraphic thickness it is still far in excess of the 50 feet or so which represents the surface thickness of the Helderberg (Coeymans-New Scotland-Becraft; Schuchert and authors 1913, pp. 84–90) with the Keyser removed. On the other hand it compares favorably with the combined Helderberg-Keyser surface thickness of 340 to 350 feet. The inferred stratigraphic relations are shown in figure 9.

* The type locality of this formation is at Keyser, West Virginia, about 25 miles east of Mountain Lake Park.

SILURIAN SYSTEM

The Silurian strata of Garrett County are known only from the Shaw #2 well (F-78) on the eastern edge of Mountain Lake Park (Pl. II). This well, which has a total depth of 7162 feet, started in the upper part of the Devonian (Jennings formation) and is believed to extend into the upper part of the Tuscarora (Lower Silurian). A percentage log of the part of this well below the "Onondaga" is given on Plate III, and a tentative correlation with the surface exposures of the Silurian in Allegany County is shown in figure 9. The stratigraphic divisions, formation names, and correlations shown in these illustrations are provisional in view of the meager data available. Since the information is so limited the discussion is restricted to comments on the similarities and differences between the surface and subsurface sections.

The part of the Silurian section above the sandstone identified as Williamsport and below the "Helderberg" consists of about 1400 feet of argillaceous limestone and calcareous shale and siltstone. The upper 700 feet averages perhaps 60 percent calcium carbonate and is correlated with the Tonoloway. Beneath this, but not sharply marked off from it, is about 700 feet of similar rock which averages somewhat less than 50 percent calcium carbonate which is correlated with the Wills Creek. Insofar as can be determined from well cuttings there is a similarity between this section and that of the Tonoloway and Wills Creek at the surface, where these formations consist of interbedded calcareous shale and argillaceous limestone of comparable thickness, with the Tonoloway having the greater percentage of limestone (Swartz 1923, pp. 49–50).

Below the Wills Creek is about 50 feet of fine-grained sandstone here called the Williamsport (Reger and Tucker 1924, pp. 396–397). This sandstone seems to correlate with the Bloomsburg red beds of Allegany County, as noted by Woodward (1941, pp. 149–156). The Bloomsburg of Maryland and West Virginia is now believed to be the basal member of the Upper Silurian or Cayugan series* (Swartz and authors 1942).

Beneath the Williamsport sandstone is about 650 feet of calcareous shale and limestone which is correlated with the surface McKenzie† (Swartz 1923, pp. 35–39). The well cuttings from this formation are similar to those of the Wills Creek, but have only about 20 percent of calcium carbonate. The decrease in calcium carbonate at the top of this formation is rather abrupt, taking place just at the Williamsport sandstone as is shown in the log on Plate III. In the Shaw #2 well this makes a good lithologic break, although it is not certain that

* The Bloomsburg of Maryland is also correlated with the lower part of the Salina group of New York, but it may not everywhere be equivalent to the lower part of the salina formation as this name is commonly used in sub- surface work.

† As here used the McKenzie includes the Rochester shale of the Silurian volume of the Maryland Geological Survey (Amsden 1951, p. 113), in which the Upper-Middle Silurian contact was placed between the McKenzie and the Rochester shale, but almost all later workers include the McKenzie in the Middle Silurian (Swartz and authors 1942).

it corresponds to the McKenzie-Bloomsburg contact of surface exposures. The lithology of this unit is not, however, unlike that of the surface McKenzie which is composed of interbedded shale and argillaceous limestone.

At the base of the subsurface McKenzie a marked change in lithology takes place. From the base of the Ridgeley sandstone to the base of the McKenzie the strata are all calcareous, beginning with the "Helderberg," which is very high in calcium carbonate, and progressively decreasing in carbonate content downwards to the lower McKenzie. Below the McKenzie the calcium carbonate drops sharply to almost nothing, and the strata are composed of greenish-gray to red shales and sandstones. This lithologic change is thought to correlate with the surface contact of the Rose Hill with the McKenzie. The Rose Hill, named by Swartz (1923, pp. 27–35) for exposures near Cumberland, was described as consisting of shale and sandstone with only a few thin bands of limestone which are largely confined to the upper part of the formation. Thus the Rose Hill at the surface stands in sharp contrast to the overlying McKenzie and higher strata in that it contains very little limestone. Furthermore, the lithologic sequence found in the surface exposures of the Rose Hill is much like that in the subsurface. Swartz divided the Rose Hill into three lithologic members as follows:

Upper shale, prevailing drab or olive but with pink and red beds.
Cresaptown sandstone; 10 to 30 feet of sandstone cemented by hematite (about 24 percent iron).
Lower shale and sandstone.

This sequence corresponds rather well with the Rose Hill section in the Shaw #2 well in which there is a lower zone of shale and sandstone (about 300 feet) overlain by a series of greenish-grey to red shales. Between these two is a bright red sandstone which may well correlate with the Cresaptown sandstone.

A noticeable difference between the surface and the subsurface sections is the absence of the Keefer sandstone in the latter. In Allegany and Washington County this is a thin (10 to 30 feet) and persistent sandstone which is present at the top of the Rose Hill formation, but no trace of it appears in the Shaw #2 well.

Below the Rose Hill, near the bottom of the well, is 30 feet of light-grey fine- to medium-grained sandstone which may represent the Tuscarora or may be only another sand low in the Rose Hill.

The lithologic divisions and correlations in the Silurian of Garrett County are very similar to those recognized by Woodward (1939, p. 248, fig. 12) in the Hartman #1 well, Randolph County, West Virginia, about 40 miles southwest of Garrett County. The thickness of the Silurian in the Hartman well, however, is somewhat less than the thickness of the same strata at the surface in Allegany County, whereas the thickness in the Shaw well is greater. The stratigraphic intervals between the top of the Tonoloway and the top of the Tuscarora are:

Surface Allegany County	*Hartman #1 Randolph County*	*Shaw #2 Garrett County*
2400 feet	1800 feet	3100 feet

In Marten's (1939, pp. 36–38; 114–120) description of the Hartman #1, and of other wells penetrating this part of the section, the Silurian was divided into three formations: Salina, Clinton and Albion (the latter also called the White Medina or "Clinton" sands*). As defined by this author the Salina isdominantly a shale-carbonate sequence, commonly with much dolomite and anhydrite; the Clinton is composed of red to green or grey shale and sandstone; and the Albion is composed of white sandstone with grey shale. The writer is of the opinion that the name Salina, at least as it is applied in many of the wells, does not correspond to the Salina in its type area, New York. Martens (1939, p. 38) himself suggests that the subsurface Salina formation may include strata of Middle Silurian age (Lockport), thus making the lower part older than New York Salina. He points out that in the Hartman well the lower part of the so-called Salina may correspond to the Lockport dolomite of western New York. Woodward (1941, pp. 247–248, fig. 12) in his interpretation of this well adopted a completely different set of names, applying the formation names used in the surface exposures of Maryland and West Virginia, and in so doing he treated the Salina-Clinton contact of Martens as the Rose Hill-McKenzie contact. This is a more reasonable interpretation since it fits in very well with the lithologic sequence found in nearby surface sections where faunal evidence is available.

Structure

Previous investigations. The first comprehensive discussion of the geologic structure of Garrett County was by Martin in his report on the county in 1902 (pp. 147–163), which included a structure map (Pl. XIII) on a scale of approximately 6 miles to the inch with the structure contour lines drawn on the Pottsville formation. He used a contour interval of 100 feet on the synclines and 500 feet on the anticlines. A few years before the publication of Martin's report Darton and Taff (1896) had prepared the U. S. Geological Survey Piedmont Folio which took in the southern part of Garrett County (parts of the Upper Youghiogheny basin, Deer Park anticline, Georges Creek basin, and Upper Potomac basin). This folio includes a structure map of parts of the Upper Youghiogheny and Georges Creek-Upper Potomac basins, the stratum contoured being the "six-foot" coal (Swartz and Baker 1920, p. 55, call this the Piedmont coal). In 1920 Swartz and Martin (Plate V in Swartz and Baker, 1920) presented a geologic map of the part of the Georges Creek-Upper Potomac basin in Allegany County and Garrett County with structure contours on the Pittsburgh coal for the Georges Creek basin and on the Upper Freeport coal for the Upper Potomac basin.

* The Albion, White Medina and "Clinton" sands correlate with the Tuscarora sandstone.

The U. S. Geological Survey Accident-Grantsville Folio (Martin, 1908), contained a structure map of the Lower Youghiogheny and Castleman basins and a small part of the Georges Creek and Upper Youghiogheny basins. As in his earlier county report, Martin drew his structure contour lines on the top of the Pottsville formation. The top of the Pottsville formation is not very suitable for this purpose because of the difficulty in locating the Pottsville-Allegany contact. For the general structural pattern of the synclines Martin's contours conform to those of this report although the recent core drilling of the U. S. Bureau of Mines in the Georges Creek basin, Castleman basin, and northern part of the Upper Potomac basin has furnished much additional information on the structure of these synclinal areas. However, several changes in the structural interpretation of the Deer Park and Accident anticlines have been made based largely upon the information obtained from deep drilling on them.

General structural features. Garrett County lies entirely within the Allegheny plateaus. The geologic structure consists of a series of broad open anticlines and synclines, their width ranging from 5 to 8 miles. The trend of these structures is commonly between N 30 E and N 40 E, although locally there may be considerable variation. The dips on the flanks of the anticlines generally range between 15 and 25 degrees. On the flanks of the synclines the beds are flatter, being commonly less than 10 degrees although in the eastern basins the beds near the margin are sometimes moderately steep and may reach 15 degrees.

Seven structural units (fig. 11) lie partly within the County, two being anticlines, the Deer Park and the Accident, and the other five synclines. The synclines, commonly referred to as basins, are the Upper and Lower Youghiogheny basins, the Castleman basin, and the Georges Creek and Upper Potomac basins. The surface geology of these anticlines and synclines is shown on the Garrett County geologic map and the structure on Plate I.

Coal basins. The easternmost structural unit is a syncline with only a part of the western limb within Garrett County. Almost all of the Maryland geologists (O'Harra 1900, Martin 1902, Swartz and Baker 1920, Waagé 1949) have divided it into two basins, a northern one, the Georges Creek basin, and a southern one, the Upper Potomac basin separated along the Savage River. There is no structural basis for making a division at this line. According to Reger and Tucker (1924, Maps II and IV; see also Darton and Taff 1896; Martin 1902, p. 150) the Georges Creek basin of Garrett County and Allegany County, Maryland, continues as a single structural unit southwards into West Virginia for 3 or 4 miles. It then splits into two synclines, a western one called the North Potomac (Upper Potomac of Maryland investigators) and an eastern one called the Stony River, the two being separated by the Blackwater anticline. The names Georges Creek basin and Upper Potomac basin are retained in this report in order to keep the terminology in accord with that of the previous Maryland investigations.

The structure of the part of the Georges Creek-Upper Potomac basins within Garrett County is shown on Pl. I, the structure contours being drawn on the top of the Upper Freeport coal. In the Georges Creek basin and the northern part of the Upper Potomac basin there are fifteen U. S. Bureau of Mines diamond drill holes located in or near to Garrett County (Pl. I). In addition, a number of coal seams have been mined in this area and these are also helpful in working out the stratigraphy and structure. Therefore, the structure and geologic maps from the region of West Vindex on north to the Pennsylvanian line are fairly accurate. South of here there is much less information and the structure and geologic maps are in more question. In this southern portion are some old test holes recorded by the West Virginia Geological Survey (Reger and Tucker 1924, pp. 477–479; Table 8 and Plate I of this report) but there are no detailed logs available so that the identification of the Upper Freeport coal is not always certain. Furthermore the geographic location and the surface elevation of these test holes is not very accurate.

The Georges Creek basin and the northern portion of the Upper Potomac basin are the deepest basins in Garrett County and have the steepest dips on the flanks. Within the County the Upper Freeport coal reaches an elevation of 1,000 feet above sea level, going still deeper in Allegany County, whereas in all the other basins this coal bed is 1,500 feet or higher above sea level. This deep folding also affects the stratigraphic distribution so that a complete Pennsylvanian section and some basal Permian strata are present in the Georges Creek basin whereas the Permian and upper Pennsylvanian (Monongahela formation) are absent in the western basins. The Georges Creek is the easternmost coal basin in Maryland, its eastern edge forming the Allegheny front.

The U. S. Bureau of Mines put down forty diamond drill holes in Castleman basin (Pl. I). The stratigraphic section derived from these cores, as well as the structure of this basin, has been described in Bulletin 507 of the U. S. Bureau of Mines (Toenges et al, 1952) and in Bulletin 9 of the Maryland Department of Geology, Mines and Water Resources (Waagé 1950). The Upper Freeport coal in this basin shows a rather symmetrical structure and reaches an elevation of 1,700 feet above sea level in the deepest part (in Garrett County).

There is no record of any test holes from the part of the Lower Youghiogheny basin that lies within Garrett County. A number of coal seams have been mined or prospected, however, so that the surface geology is fairly well known and both the geologic map and the structure map of this basin have a fair degree of precision. The Upper Freeport coal in this basin shows an asymmetrical syncline with the steepest dip on the east flank, a feature noted by Martin (1902, Pl. XIII; Martin 1908).

There are five records of test holes drilled in the Upper Youghiogheny basin. These holes are numbered Md. 1 to Md. 5 on Plate I, and the logs are given on pages 104 to 107. These records are from the unpublished notes of Professor C. K. Swartz, but unfortunately he had only the old topographic maps to use in location so that the geographic positions and the surface elevations are not certain. Also they are only abbreviated descriptive logs so that the stratigraphic sections are not above question. Since the coal seams have not been extensively explored the surface geology and the structure shown on Plate I is in some doubt. The structure contour map based upon the Upper Freeport coal does not agree with that of Martin (1902, Pl. XIII) based upon the Pottsville formation. Martin shows several isolated "highs" in the central part of this basin, but no evidence was found for this. The basin is structurally deeper than shown by Martin. The central part of the Upper Youghiogheny basin is underlain by Conemaugh strata, whereas Martin's map shows Alleghany strata outcropping in the central part with only some isolated outcrops of Conemaugh.

Deer Park anticline. This is an elongate anticline which extends in a northeast direction from West Virginia across Garrett County into Pennsylvania. It is a fairly symmetrical structure with a width ranging from 5 to 7 miles. The Jennings formation is exposed at the surface along the crestal zone, flanked on each side by the Hampshire formation and Mississippian strata. The dips along the flanks vary but generally range from 15 to 30 degrees. In the central and northern parts, from Deep Creek Lake north to the Pennsylvanian state line, the flanks have an average dip of 15 to 20 degrees, but at the southern end, from Mountain Lake Park south to the West Virginia state line, the dips are steeper, averaging between 25 and 30 degrees. The more steeply dipping strata at the southern end reflect the structural high shown in Plates I and II.

The crest of this fold has certain aspects whose significance is not entirely clear. In general throughout the central and northern part of this anticline (from Deep Creek Lake north) the crest is a broad zone ranging up to a mile and a half in width and consisting of alternating, small anticlines and synclines (Garrett County geologic map).

This zone of second and third order folds is confined mainly to the Jennings formation, but on the western flank, in the area between Big Run and Elk Lick, the Hampshire formation becomes involved. The strata in this western portion show a rather persistent reversal of dip, tilting them towards the east which has the effect of deflecting the Hampshire formation towards the east. Thus the Deer Park anticline in this central zone appears to be an anticlinorium with two major crests. On Plate I, this structure is shown extending down and involving the Huntersville chert, though it may die out before reacing that depth.

In the part of the Deer Park anticline south of Mountain Lake Park, in the area of the gas field, the crest is much narrower, only a few hundred feet wide, and is defined on each side by steeply tilted strata. The dips range as high as 60 degrees and present a rather odd structural pattern. The fault outlined by the deep drilling (Pls. I and II) may be reflected at the surface in these steeply dipping strata.

There is little evidence of faulting in the surface exposures of this anticline.

The Garrett County geologic map shows only one fault (west of Blue Lick Run), but the exposures in this area are not very good and this apparent displacement of the Hampshire-Jennings contact could be the result of a change in strike instead of a displacement along a fault. It could also be due to a stratigraphic anomaly, because this contact is a gradational one and the contact could be displaced upwards in the section by a small facies change.

Ninety six wells have been drilled on the Deer Park anticline.* All but four are situated south of Deep Creek Lake with the greatest concentration in, and south of, the town of Mountain Lake Park. Of the four wells north of the lake, the Beckman well (F-77) is about 3 miles north of Swanton and the other three (F-9, F-66, F-106) are at the north end in the area around Avilton. The locations of these wells are shown on Plates I and II. The structure contours are drawn on the top of the Huntersville chert, the interval being 250 feet. It would have been desirable to use the Oriskany sandstone as a datum plane since this is the horizon customarily used, but the Huntersville was selected because some of the wells did not reach the sandstone.

The drilling has revealed two major structural highs on the Deer Park anticline, one just south of Mountain Lake Park and the other south of Avilton. The southern one has by far the greatest closure, bringing the Huntersville chert up to an elevation of 420 feet below sea level, whereas in the northern one it attains only an elevation of minus 2,260 feet. The anticline pitches northwards from the Mountain Lake Park structural high, and southwards from the Avilton structural high, reaching its lowest point in the region just north of Swanton where the Huntersville chert is approximately 3,500 feet below sea level. This structure is clearly revealed in the surface outcrops, the Hampshire formation almost closing over the crest in the Swanton area, leaving the Jennings formation with an outcrop width of only a few hundred feet (Garrett County geologic map). The Beckman #1 well (F-77, location Cd), on the crestal zone a short distance to the north, encountered the Huntersville chert at a depth of minus 3197 feet.

South of the Mountain Lake Park structural high the anticline pitches rather steeply to the south so that at the Durr #1 well (F-14) the Huntersville chert is at minus 2,100 feet. From the Riley #1 (F-100, minus 463 feet) to the Durr #1 the Huntersville chert drops 1,637 feet in a distance of about 7 miles; this is 234 feet per mile or an average pitch of approximately 2½ degrees. From the Welch #1 (F-16, minus 420 feet) to the Smith #1 (F-64, minus 2,364 feet) there is a drop of 1,944 feet in a distance of about 6 miles; this is 324 feet per mile or an average pitch of approximately 3½ degrees. It is more difficult to estimate the pitch north and south of the Avilton structural high because of the scarcity of subsurface information, but it is probably less than at the south

* The Preston Lumber Co. #1 well (F-10, location Fa, Pl. I) was drilled in 1930 but did not reach the Huntersville chert. The first well on this anticline to reach the chert was the Durr #1 (F-14, location Fa) which was completed in 1947.

end. The pitch between the Jacobs #1 well (F-106, minus 2,260) and Bear Pen Run, a distance of approximately 6 miles, is about 1½ degrees.

The drilling has revealed several faults at the south end of the Deer Park anticline. The largest of these lies on the west side of this structure, extending in a northeasterly direction beneath the town of Mountain Lake Park (Pls. I and II). The position of this fault can be located very closely where it passes between the Artis #1 and the Kitzmiller #1 wells (F-28 and F-40). The difference in the elevation of the Huntersville chert between these two wells is 575 feet, a figure which must closely approximate the displacement on the fault since the wells are only a hundred feet apart. North of here the fault must pass west of the Mountain Lake Park Association #1, the Harvey #1, and the Rumer #1 wells (F-21, F-47, F-63) and east of the Richards #1, the Bolyard #1, and the Naylor wells (F-38, F-49 and F-75). Its position north of the Naylor (F-75) cannot be determined. This fault appears to continue to the south, passing west of the Welch #1 (F-16), the Gnegy (F-112), and the Riley (F-100) wells. It gradually bends around more to the west, passing between the Lohr (F-110) and the Rice (F-99). According to this interpretation it has a smaller displacement in this region, gradually dying out south of here.

Two smaller faults are thought to be present at the south end of the Mountain Lake Park structural high. They are shown on Plate I as having roughly a north-south strike, but neither has been well defined by drilling and their position and trend is uncertain.

Three smaller faults, believed to have a displacement of 100 feet or less, are shown on the west side of the structure in the enlarged map of the Mountain Lake Park area (Pl. II). There seems to be little doubt that minor faulting is present in this area, but its exact position and trend is difficult to determine.

Very little is known about the dip of these faults. Some information might be obtained by contouring higher horizons, such as the "Tully" limestone, but this has not been done due to the lack of stratigraphic data. These faults, especially the smaller ones, may lose their identity upwards, passing into folds in the shales and siltstones of the Romney and Jennings formations. The larger faults may continue upwards to the surface where they may be reflected in dips which are somewhat steeper than the average, an idea which has been advanced by some of the petroleum geologists. In the absence of more concrete evidence on the dip and strike of such faults it is not possible to say much about their surface expression than that surface mapping of Jennings-Hampshire and other contacts shows very little evidence of faulting. Faulting on the Deer Park anticline may be more or less confined to the more competent stratigraphic units (Huntersville chert-Oriskany sandstone) near the crest of the structure, whereas the less competent formations such as the Jennings produced a number of small folds.

North of Deep Creek Lake the deep wells are too few and too widely spaced to furnish definite evidence of faulting, so that none are shown on the structure map, but it is to be expected that faults are present in this area, probably being of the same order of magnitude as in the southern part.

Accident anticline. The part of the Accident anticline which lies in Garrett County is a flatter structure than the Deer Park anticline, with the dips on the flanks ranging from 5 to 15 degrees. The crest is very broad and poorly defined, so that throughout the entire central portion the strata are gently undulating as is shown on the new Garrett County geologic map. This map of the writer differs considerably from that of Martin (1902) which shows a small area of Jennings strata west of the town of Accident. He thought this was structurally the highest part of this anticline as is shown on his structure map (1902, Pl. XIII). The writer, however, does not believe that there is any Jennings formation exposed on this anticline, and part of the area which Martin shows as Jennings is referred to the Pocono formation. The highest area, structurally, lies either under the town of Accident or a little east of it, extending for some distance to the north and to the south. Only two of the deep wells drilled on this anticline have been completed to the Huntersville chert (F-12 and F-113, location Bc) and they support the conclusion that the structural high is considerably east of the position shown by Martin. The structure map, with contours on the top of the Huntersville chert, is believed to give a reasonably accurate picture of the general structure in this area, but since the data upon which it is based are meager it probably needs revision as to details. The Huntersville chert on this anticline is about 5,000 feet or more below sea level which is much deeper than at any place on the Deer Park anticline.

Gas Fields

BY

JOSEPH T. SINGEWALD, JR.

Gas has been discovered in two areas in Garrett County, the Mt. Lake Park field and the Accident field.

In the Accident area only the Shartzer (F-12) and the McCullough (F-113) wells have been drilled deep enough to reach the Huntersville and Oriskany formations. Though Martens (1945, p. 758) reported the Shartzer well yielded 30,000 cu. ft. of gas along with salt water, it was abandoned. The McCullough well was brought in as a productive well early in 1953, and began to produce in the fourth quarter of 1953.

MT. LAKE PARK FIELD

LOCATION AND AREA

The Mt. Lake Park gas field is near the southern end of the Deer Park anticline (fig. 1 and Pls. I, II). The name is taken from the town of Mt. Lake Park which is near the northern end of the field. It extends in a northeast-southwest direction for a distance of about 7½ miles and is from ½ to ¾ mile wide. The producing wells are within an area of about 2,400 acres. The most southerly producing well is the Dodge #1 (F-70) and the most northerly the Offutt #1 (F-51). Production is from the Huntersville chert and the Oriskany sandstone. The closure in the gas-producing portion of the structure is about 1,500 feet.

DISCOVERY AND DEVELOPMENT

The Durr #1 (F-14) well drilled in 1947 was abandoned as a dry hole. The discovery well, Beachy #1 (F-7), was completed in October, 1949. Nearly a year later in September, 1950, the second producing well, Welch #1 (F-16), was completed with an open flow of 8,500,000 cubic feet, followed in January 1951, by the Mt. Lake Park (F-21) well with an open flow of 11,500,000 cubic feet.

The Beachy well set off a drilling rush so that by the end of the second quarter of 1951, there were 13 producing wells. The quarterly record of producing wells from June 30, 1951, to December 31, 1953, is:

Year	*Quarter*	*New producers*	*Producers abandoned*	*In production*
1951	Second	13	—	13
	Third	6	—	19
	Fourth	4	—	23
1952	First	8	—	31
	Second	3	—	34
	Third	3	2	35
	Fourth	4	8	31
1953	First	0	1	30
	Second	0	3	27
	Third	1	1	27
	Fourth	0	0	27
Total		42	15	27

That the rush of uncontrolled drilling practically completed the development of the field by the end of 1952 is shown also by the following record of permits to drill gas wells issued quarterly:

Year	*Quarter*	*Permits Issued*	*Year*	*Quarter*	*Permits Issued*	*Year*	*Quarter*	*Permits Issued*
1947	Second	1	1951	First	26	1952	Second	8
1949	Second	1	1951	Second	14	1952	Third	2
1949	Third	2	1951	Third	24	1952	Fourth	2
1950	Third	1	1951	Fourth	9	1953	First	1
1950	Fourth	8	1952	First	7	1953	Second	0

The discovery of the Mt. Lake Park field found Maryland without effective control over the drilling and abandonment of gas wells and no control whatever over well location and spacing to prevent waste and the drilling of unnecessary wells, or to protect the correlative rights of the gas owners.

A law enacted in 1945 primarily to control the drilling of water wells did require a driller to be licensed and to secure a permit to drill a well and also required him to furnish a completion report and log of the well and to furnish cuttings samples when requested by the Department of Geology, Mines and Water Resources. It also required the sealing and filling of abandoned wells. In the development of the Mt. Lake Park field, both operators and drillers were almost all from outside of Maryland. The requirement of a driller's license and a well permit was enforceable. The only well drilled by non-licensed drillers and without a well permit, the Kite #1 (F-8), was drilled in 1949 for Garrett County interests. The less responsible drillers and operators, especially those who drilled dry holes, flaunted the requirements of the 1945 law requiring the submission of a log and cuttings samples, and the filling and plugging of abandoned wells. Only a few of the fifteen abandoned producers have been plugged and almost none of the fifty dry holes. The wells for which the drillers and operators failed to file a log and to furnish cuttings samples are designated in the REMARKS column in Table 10.

To meet the situation presented by Maryland's first gas field, two measures were introduced in the 1951 Legislature, one a tax bill and the other an oil and gas conservation bill.

The gas-tax bill, sponsored by Garrett County interests, was enacted. It levied a 7 percent tax upon the gas production, beginning with the production after January 1, 1951, due as of June 30, 1951, and thereafter quarterly, payable to the County Commissioners of Garrett County. The bill provides that 15 percent of the tax on gas produced from wells within the limits of an incorporated town be paid to the municipal government, the first additional $50,000 each year be applied to the Garrett County school indebtedness, the next $25,000 each year be applied to the maintenance and operation of the Garrett County Memorial Hospital, and any remainder accrue to a new school building repair and addition fund for Garrett County. The tax collected under this law has been:

1951	$46,548.51
1952	32,954.66
1953	19,762.93
Total	$99,266.10

The oil and gas conservation bill, sponsored by the Department of Geology, Mines and Water Resources, was passed by the House of Delegates but died in committee in the Senate through the opposition of the sponsors of the tax bill. One objective of this bill was to implement the 1945 well control law by requiring well owners to post a bond to guarantee compliance with that law and thereby to protect the gas field against damage by unsealed abandoned wells and to protect the potable water resources of the area against contamination by salt water and polluted surface water encroachment through unsealed abandoned wells.

The main objective of the bill was to save the field from the disastrous results of development under the long-before discredited and outmoded "law of capture." The history of the Mt. Lake Park gas field is the inevitable result that the proposed oil and gas conservation measure was intended to prevent. A conservative estimate of the cost of the development of the field is $3,000,000. The market value of the gas produced to the end of 1953 is $1,416,866. The royalties paid to the land owners is 12.5 percent and the tax paid to Garrett County 7 percent, a total of 19.5 percent, or $276,289. The net return to the well owners to the end of 1953 is $1,140,577. The ultimate net return is not likely to exceed $1,500,000.

The discovery well of the Accident field made the enactment of the conservation oil and gas bill desirable in 1953 to prevent a repetition of the history of the Mt. Lake Park field. The bill was enacted by the Legislature of 1953, but an amendment permitting its application to Garrett County only to the extent consented to by the Garrett County Commissioners has limited the usefulness of the bill to the implementation of the enforcement of the 1945 law by requiring the well owners to post a preformance bond, but it completely nullified well spacing control in Garrett County, leaving the Accident field and deeper potential gas horizons in the Mt. Lake Park field open to financially ruinous unnecessary drilling and without protection to the correlative rights of the gas owners. The opponents of well spacing control secured the repeal of the entire law by the 1954 Legislature when the amendment was declared unconstitutional.

GAS PRODUCTION

The production prior to 1951 is reported by the United States Bureau of Mines to have been 373,000,000 cubic feet. The production for the years 1951 to 1953 inclusive, as reported in compliance with the gas tax law to the Garrett County Commissioners, is given in Table 6. The locations of the producing wells are shown on Plates I and II.

The wasteful drilling that resulted from the lack of well-spacing control is evident from the distribution of the producing wells. Twenty of the producing wells are in Mountain Lake Park and eight in Loch Lynn, whereas only fourteen are outside the corporate limits of these two towns. Even more striking evidence is the fact that eight of the Mt. Lake Park producers and seven of the Loch Lynn producers are already abandoned, whereas not one producer outside of these towns, where the lease units are farm-size acreage, has been abandoned.

Twenty one of the twenty eight producing wells in Mt. Lake Park and Loch Lynn are within an area of 189 acres, and four other of the twenty eight wells are in an area of 3 acres. Thus, twenty five of the procuding wells are concen-

TABLE 6

Gas Production-Mountain Lake Park Gas Field

M.C.F. produced

Well No.	Permit No.	Name	Operator	1951 Quarters			1952 Quarters				1953 Quarters				Total
				1st & 2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1951–1953
F-7	4,128	Beachy #1	Cumberland and Allegheny Gas Co.	51,226	750	36,462	28,511	25,011	22,941	20,853	18,429	19,442	18,732	12,032	254,389
F-15	7,062	Miller #1	Columbian Carbon Co.	56,387	55,010	44,432	35,663	28,368	37,696	50,321	25,617	23,318	19,390	10,160	386,362
F-16	6,272	Welch #1	Columbian Carbon Co.	512,072	210,952	217,214	218,210	123,393	114,711	91,380	69,830	68,428	61,239	51,547	1,738,976
F-17	6,917	Graser #1	Columbian Carbon Co.	18,857	14,905	10,307	7,281	5,847	5,038	4,609	3,845	3,112	2,639	2,299	78,739
F-18	6,951	Baker #1	Snee and Eberly	17,683	27,907	17,103	10,163	6,803	4,364	4,977	3,957	3,741	3,714	2,952	103,364
F-19	6,864	O'Donnell #1	Snee and Eberly	50,113	38,350	62,653	38,146	26,614	24,212	22,724	14,626	6,865	—	3,318	287,621
F-20	6,972	Grimes #1	Shearer	21,836	21,379	12,652	6,458	3,280	3,222	2,260	1,806	1,908	1,935	1,578	78,314
F-21	6,889	Mt. Lake Park	Nollem	359,240	166,031	92,199	50,981	26,896	19,014	13,602	9,263	7,807	7,659	7,112	759,804
F-22	7,090	Gordon #1	Snee and Eberly	19,593	22,379	15,132	16,385	11,462	9,122	8,800	7,470	6,944	6,245	5,707	129,239
F-24	7,246	Naylor #1	Nollem	20,910	41,396	21,622	11,112	7,109	6,001	4,566	2,567	1,870	775	33	117,961
F-27	7,252	Dawson #1	O. M. Fox	146,053	70,514	24,440	20,310	9,300	5,396	3,491	8,226	10,230	9,922	8,620	316,502
F-28	7,294	Artis #1	Snee and Eberly	—	48,910	29,571	18,866	13,144	10,639	9,280	5,713	5,578	4,944	4,647	151,292
F-29	7,482	Mt. Lake Park Ass'n.	Blaho (Kight)	—	16,495	4,020	2,505	788	1,020	2,235	3,566	263	—		30,892
F-43	7,404	Holloway #1	Delaware Gas Co.	9,917	51,918	32,257	14,643	16,360	12,822	11,079	7,347	5,880	4,581	4,843	171,647
F-44	7,564	White #1	Johnston Bros.	—	54,192	68,841	31,535	17,412	9,945	405	121	—	—		182,451
F-47	7,412	Harvey #1	Shaw and Smith	5,333	148,628	66,702	37,347	25,783	24,665	20,587	16,426	16,072	14,820	11,238	387,601
F-51	7,399	Offutt #1	Columbian Carbon	—	—	5,064	6,023	4,836	3,291	2,596	2,302	2,250	2,024	1,644	30,030
F-55	7,802	Shahan #1	Nollem	—	17,435	28,946	18,375	12,995	10,236	8,780	6,260	5,659	5,593	4,422	118,701
F-56	7,723	Fee #4	Snee and Eberly	—	38,651	51,985	32,135	23,677	16,621	11,258	10,854	8,921	8,009	7,152	209,263
F-57	7,770	McKee #1	O. M. Fox	—	146,340	80,412	212	254	—	—	—	—	—		227,218
F-62	7,997	Calhoun #1	G. Jackson	—	—	1,203	2,092	1,497	434	—	—	—	—		5,226
F-63	8,139	Rumer #1	Blaho	—	—	—	15,012	14,415	10,420	8,211	6,233	5,442	4,543	4,095	68,371
F-70	8,218	Dodge #1	Columbian Carbon	—	—	—	860	2,059	1,867	1,633	1,403	1,423	1,359	1,134	11,738
F-72	8,524	Weeks #1	Cumberland and Allegheny Gas Co.	—	—	4,780	24,927	17,283	15,759	6,237	—	—	—		68,986
F-80	10,296	Nellie Lee	Lexa Oil Co.	—	—	—	—	—	719	—	—	—	—		719
F-81	8,389	Simmons #1	Snee and Eberly	—	—	49,972	95,716	24,221	4,690	—	—	—	—		174,599
F-84	8,768	Mason #1	Cumberland and Allegheny Gas Co.	—	—	—	1,300	459	—	—	—	—	—		1,759
F-85	9,325	Friend #1	Kight	—	—	—	—	—	1,967	4,868	716	—	—		7,551
F-87	8,709	Mt. Lake Park Motor	Lafferty and Whetzel	—	—	—	37,831	13,010	13,616	8,804	6,231	3,816	1,954	659	85,921
F-88	9,157	I.O.O.F.	Mid Atlantic Oil and Gas Co.	—	—	—	12,685	12,904	3,295	—	—	—	—		28,884
F-90	9,010	United Brethren Church	W. H. and J. A. Roeder	—	—	—	—	5,044	9,916	—	—	—	—		14,960
F-92	8,404	Perrine #1	Delaware Gas Co.	—	—	—	63,849	56,541	31,042	—	—	—	—		151,432
F-93	9,186	Kight #1	Kight (Boyle)	—	—	—	—	—	7,533	8,077	3,323	—	—		18,933
F-96	8,787	Killius Sisler	Antietam Nat. Gas	—	—	—	311	2,701	67	—	—	—	—		3,079
F-97	9,456	Callis	Mid Atlantic Oil and Gas Co.	—	—	—	3,547	1,972	3	—	—	—	—		5,522
F-101	8,666	Beachy #3	Snee and Eberly	—	—	—	—	—	—	9,520	24,463	17,400	13,805	18,508	83,696
F-107	10,058	W. N. Beckman	Cumberland and Allegheny Gas Co.	—	—	—	—	—	—	3,287	13,269	11,184	9,335	8,361	45,436
F-108	10,034	Rice #2	Cumberland and Allegheny Gas Co.	—	—	—	—	25,678	26,063	23,781	39,256	35,595	32,438	31,229	214,040
F-110	9,921	Lohr	Eagle Gas Co.	—	—	—	—	—	—	2,421	4,568	3,694	3,424	3,106	17,213
F-111	9,999	Jas. Riley #2	Cumberland and Allegheny Gas Co.	—	—	—	—	8,161	91,913	61,406	25,238	36,185	32,833	31,829	287,565
F-114	10,767	Milton Riley	Columbian Carbon	—	—	—	—	—	—	12,673	63,084	40,095	24,635	16,814	157,301
F-119	12,057	H. D. Swartzentruber	Snee and Eberly	—	—	—	—	—	—	—	—	—	43,067	53,900	96,967
Total				1,289,214	1,192,142	977,969	862,991	575,277	560,260	444,721	406,009	353,122	339,614	308,939	7,310,258

trated in 192 acres and seventeen of the procuding wells are spread over the remaining more than 2,200 acres of the gas-containing acreage of the field. In these 192 acres the average spacing is 9 acres per well. In the remainder of the field, where farm acreages were the controlling factor in well spacing, the spacing averages 130 acres per well. Of the twenty one producers in the 189 acres within Mt. Lake Park and Loch Lynn, only eight or nine will have produced an amount of gas equal in value to the mere cost of drilling, and eleven have already been abandoned. The total production of the twenty one wells to the end of 1953 was $444,006, or an average of $21,143 per producing well. The four producers in the 3 acres have been abandoned. Only one produced an amount of gas equal in value to the cost of drilling. The total production of the four wells was $51,397 or an average of $12,849 per well.

In contrast to the financially disastrous record of the twenty five producers subject to uncontrolled competitive drilling under the "law of capture" is the record of the seventeen producers protected by the spacing control enforced by farm acreage leases. All of the seventeen are still in production. Eight have already produced an amount of gas in value in excess of the drilling cost and three or four more will do so. Five will produce gas equal in value to the drilling cost. The seventeen wells produced $921,763 to the end of 1953, or an average of $54,221 per well, which is about twice the cost of drilling.

The Mt. Lake Park gas field is thus another example of the financial ruin and waste resulting from uncontrolled drilling under the "law of capture" in contrast to the profitable development attainable under proper control of well spacing.

The adverse effects of the exploitation of the Mt. Lake Park gas field under the "law of capture" were not restricted to well owners but were suffered also by owners of the gas lands. In the beginning all of the gas belonged to all of the land owners, and the share of each land owner was proportional to the area of his land to the area of the pool. Gas is of such nature that if an owner takes gas from under his land, gas from his neighbors' lands flows in to take its place. Obviously as the former continues to take gas from under his land, he continues to take not only his own gas but also the gas belonging to his neighbors. The well owners pay an established royalty of 12½ per cent for the gas produced, but the payment is made to the owners of the lands on which the wells are located. Those owners who have no well on their lands receive no payment for their share of the gas. Thus, under the "law of capture" the owners as a whole receive full payment for their gas, but the payment is not divided fairly and equitably among the owners.

During the three years 1951 to 1953, the gas owners of the Mt. Lake Park field were paid $177,108, or an average $7.30 per acre of land underlain by gas. Those who received more than $7.30 per acre received all they were entitled to plus what belonged to others. Those who received nothing, had their gas taken from them and the payments pocketed by others. If the Mt. Lake Park field had been developed under well-spacing unit control, each land owner would have been protected to receive payment for his share of the gas.

Analogous to the development of the Mt. Lake Park gas field under the "law of capture" would be if there were no fences in the area and each owner were free to harvest as much of the crops and round up as many of the cattle as he could beat his neighbors to and sell them as his own. If the Mt. Lake Park gas field had been developed under spacing unit control, it would have been analagous to customary property rights, wherein each owner has his land fenced and is protected in his ownership of what is within the enclosure of his fences. Well spacing units function in the same way in a gas field that fences function on the surface. The opponents of well spacing control, unabashed by the record of the Mt. Lake Park field, have insisted that it be repeated in the Accident field and in other gas pools that may underlie Garrett County.

APPENDIX

Lists of Garrett County Coal Test Holes and Deep Wells

Following is a summary of all the Garrett County coal test holes and deep wells for which information is available. It includes both new as well as previously published data. The locations are given on Plate I or Plate II and as an aid in finding a set of reference letters is used, e.g., Plate I Aa. The capital letters refer to an east-west grid and the lower case letters to a north-south grid. The subsurface data are separated under two major headings, TEST HOLES FOR COAL and DEEP-WELLS. The former are subdivided geographically into the different basins: Georges Creek, Upper Potomac, Castleman, Upper Youghiogheny, and Lower Youghiogheny basins. The DEEP-WELLS have not been geographically subdivided. Almost all of these are confined to the two anticlines, Deer Park and Accident, but a few of the earlier wells were drilled in the basins.

TEST HOLES FOR COAL

GEORGES CREEK AND UPPER POTOMAC BASINS

In addition to the test holes in Tables 7 and 8, two deep wells, F-2 and F-3, were drilled in the Upper Potomac Basin. They are listed in the section on DEEP WELLS.

CASTLEMAN BASIN

The best holes in the Castleman basin are listed in Table 9.

LOWER YOUGHIOGHENY BASIN

No records of drill holes in this basin are available.

UPPER YOUGHIOGHENY BASIN

Records of 6 wells drilled in this basin are available. One of these, F-6, has a depth of 3,200 feet and is discussed in the section on DEEP-WELLS.

TABLE 7

U. S. Bureau of Mines Diamond Drill Holes

The data are taken from the U. S. Bureau of Mines Technical Paper 725. U.S.B.M. hole numbers are used; page references are to this publication; locations on Plate I are taken from Technical Paper 725, in most cases field checked by T. W. Amsden and R. M. Overbeck. Surface elevations used to compute the Upper Freeport elevations (Pl. I) are from the Garrett County topographic map.

Hole No.	Location	Reference
	Georges Creek Basin	
GC 1	Plate I; Cf	1949, pp. 29–31
GC 3	Plate I; Cf	1949, pp. 35–36
GC 4	Plate I; Cf	1949, pp. 36–37
GC 5	Plate I; Bg	1949, pp. 39–40
GC 9	Plate I; Cf	1949, pp. 47–50
GC 10	Plate I; Bg	1949, pp. 51–52
GC 12	Plate I; Ce	1949, pp. 56–57
GC 14	Plate I; Cf	1949, pp. 60–61
GC 21	Plate I; Ag	1949, pp. 80–84
	Upper Potomac Basin	
GC 13	Plate I; De	1949, pp. 57–58
GC 17	Plate I; De	1949, pp. 69–70
GC 18	Plate I; De	1949, pp. 70–72
GC 22	Plate I; Ed	1949, pp. 85–87
GC 23	Plate I; Dd	1949, pp. 89–90
GC 24	Plate I; Ec	1949, pp. 91–92

TABLE 8

UPPER POTOMAC BASIN

West Virginia Geological Survey

The data are taken from the Mineral and Grant County report. The numbers used are the same as those of the West Virginia Geological Survey; the page references are to the above report. Locations on Plate I are from the Grant County geologic map; surface elevations used to compute Upper Freeport elevations are from Garrett County topographic map. Locations and elevations are approximate.

Hole No.	Location	Reference
W. Va. 38A	Plate I; Fc	1924, p. 477
W. Va. 57	Plate I; Fb	1924, p. 478
W. Va. 58	Plate I; Fb	1924, p. 478
W. Va. 63	Plate I; Fa	1924, p. 478
W. Va. 65	Plate I; Ga	1924, p. 478
W Va. 68	Plate I; Ga	1924, p. 478
W. Va. 69	Plate I; Ga	1924, p. 478
W. Va. 70	Plate I; Ga	1924, p. 478
W Va. 71	Plate I; Ga	1924, p 478
W. Va. 72	Plate I; Ga	1924, p. 478
W. Va. 73	Plate I; Ga	1924, p. 478
W. Va. 90	Plate I; Ga	1924, p. 479
W. Va. 94	Plate I; Ga	1924, p. 479
W. Va. 95	Plate I; Ga	1924, p. 479

TABLE 9

U. S. Bureau of Mines Diamond Drill Holes

The data are taken from the U. S. Bureau of Mines Bulletin 507. U.S.B.M. hole numbers are used; page references are to this bulletin; locations on Plate I are from Bulletin 507 and from Bulletin 9 of the Maryland Department of Geology, Mines and Water Resources. Surface elevations used to compute Upper Freeport elevations (Pl. I) are from the Garrett County topographic map.

Hole No.	Location	Reference
CB 1	Plate I; Bd	1952, pp. 27–29
CB 2	Plate I; Ae	1952, pp. 30–32
CB 3	Plate I; Bd	1952, pp. 33–34
CB 4	Plate I; Be	1952, pp. 35–38
CB 5	Plate I; Bd	1952, pp. 38–41
CB 6	Plate I; Be	1952, pp. 41–43
CB 7	Plate I; Bd	1952, pp. 43–45
CB 8	Plate I; Bd	1952, pp. 45–48
CB 9	Plate I; Be	1952, pp. 48–50
CB 10	Plate I; Ae	1952, pp. 50–52
CB 11	Plate I; Bd	1952, pp. 52–53
CB 12	Plate I; Ae	1952, pp. 54–55
CB 13	Plate I; Ad	1952, pp. 56–57
CB 14	Plate I; Ad	1952, pp. 57–59
CB 15	Plate I; Ad	1952, pp. 59–60
CB 16	Plate I; Bd	1952, pp. 61–62
CB 17	Plate I; Ae	1952, pp. 63–65
CB 18	Plate I; Bd	1952, pp. 65–66
CB 19	Plate I; Ae	1952, pp. 66–68
CB 20	Plate I; Be	1952, pp. 68–69
CB 21	Plate I; Be	1952, pp. 70–72
CB 22	Plate I; Ae	1952, pp. 72–74
CB 23	Plate I; Be	1952, pp. 74–75
CB 24	Plate I; Ae	1952, pp. 75–76
CB 25	Plate I; Bd	1952, pp. 77–78
CB 26	Plate I; Ad	1952, pp. 79–80
CB 27	Plate I; Ae	1952, pp. 81–82
CB 28	Plate I; Bd	1952, pp. 82–83
CB 29	Plate I; Be	1952, pp. 84–85
CB 30	Plate I; Bd	1952, pp. 85–86
CB 31	Plate I; Ae	1952, pp. 86–87
CB 32	Plate I; Ae	1952, pp. 88–89
CB 33	Plate I; Ad	1952, pp. 89
CB 34	Plate I; Ae	1952, pp. 90
CB 35	Plate I; Be	1952, pp. 91
CB 36	Plate I; Bd	1952, pp. 92–93
CB 37	Plate I; Ae	1952, pp. 93–94
CB 38	Plate I; Ae	1952, pp. 94–96
CB 39	Plate I; Ae	1952, pp. 96–97
CB 40	Plate I; Ae	1952, pp. 98–99

The others, Md. 1 to Md. 5, are less than 500 feet deep and are coal test holes. The locations of these wells are shown on Plate I. Surface elevations are from the Garrett County topographic map. Both locations and elevations are approximate.

Hole Md. 1

Herrington Manor, location Da, Plate I. Surface elevation 2,440 feet; to depth, 326 ft. Information and location taken in part from the Garrett County Report (Martin 1902, p. 117) and in part from the unpublished notes of C. K. Swartz. The log of this hole is given on page 58.

Hole Md. 2

Location Ea, Plate I. Surface elevation approximately 2,600 ft.; depth 448 ft. Data and location from unpublished notes of C. K. Swartz (hole No. 2 Sisler tract).

	Thickness		*Depth (top)*
Clay and sand	4 ft.		
Grey sandstone, Upper Grafton sandstone	24	4 in.	4 ft.
Blue slate	23	8	
Black slate	1		
Coal, Federal Hill Coal		9	53 ft.
Fire clay	3		
Blue shale	26	3	
White sandstone, Lower Grafton sandstone	16	1	83 ft.
Black slate	7	3	
Coal with bone and sulphur, fairly hard; Harlem coal		8	106 ft. 4 in.
Fire clay	17	7	
Blue shale		5	
White sandstone	1	2	
Blue shale	3		
Variegated shale		3	
Blue shale	3	5	
Variegated shale		7	
Blue shale	3	2	
White sandstone		9	
Blue shale	1	6	
Variegated shale, ? Pittsburgh red bed	24	11	138 ft. 10 in.
Blue shale	9		
Variegated shale	8	6	
Blue shale	6	6	
Variegated shale	8	9	
Blue shale	11	6	
White sandstone	3	10	
Blue shale	5	7	

Black slate		2	7	
Coal, clean and bright	Lower Bakerstown coal		5	220 ft.
Slate			2	
Coal, some sulphur		1	4	
Black slate, very solid		9	2	
Coal with sulphur and ½ inch slate binder			6	
Fire clay		14	2	
Variegated shale		3		
Blue shale		8	3	
Variegated shale, ? Meyersdale red bed		15	6	257 ft.
Blue shale		28		
Grey sandstone		9	3	
Dark shale and slate		17	4	
Coal, Brush Creek coal			2	327 ft. 1 in.
Fire clay		10	3	
Blue shale		11		
White sandstone		2	4	
Dark shale		2	9	
Blue shale		4		
Variegated shale, ? Mahoning red bed		8	9	357 ft. 7 in.
Blue shale		17	6	
Grey sandstone, Mahoning sandstone		53	7	
Coal in two benches with thick parting, Upper Freeport coal		11	¼	448 ft. 5 in.
Total Depth				448 ft. 5 in.

Hole Md. 3

Location Ea, Plate I. Surface elevation approximately 2,450 ft., depth 253 ft. Data and location from unpublished notes of C. K. Swartz (hole No. 8).

	Thickness		*Depth (top)*
Surface	16 ft.	0 in.	
Sandstone	14	5	
Black slate	6	6	
Coal, Brush Creek coal	1		36 ft. 11 in.
Fire clay	21	4	
Blue shale	6	5	
Grey sandstone	3	3	
Blue shale	6	11	
Variegated shale, ? Mahoning red beds	21	2	75 ft. 10 in.
Blue shale	6		
Variegated shale	1	11	
Blue shale	10	1	
Dark shale	3	3	
Blue shale	31		
Dark shale	13	9	
Grey sandstone	4	7	
Coal, fair, very little pyrite; Upper Freeport coal	3	1	167 ft. 7 in
Black slate	6	0	

Fire clay	7	8	
Blue shale	17	9	
Grey sandstone	12		
Dark shale	21	6	
Grey sandstone	7		
Dark shale	10	5	
Total depth			253 ft.

Hole Md. 4

Location Ea, Plate I. Surface elevation approximately 2,430 ft., to depth 420 ft. Data from unpublished notes of C. K. Swartz (hole No. 1 Hardesty tract).

	Thickness		*Depth (top)*
Sand and clay boulder	16 ft.		
Blue shale	7		
Grey shale	10		
Blue shale	26		
Black slate, ? Lower Bakerstown coal horizon	16		59 ft.
Variegated shale (red (blue — ? Meyersdale red beds	5		
Blue shale — ? Meyersdale red beds	12	8	
Red shale — ? Meyersdale red beds	8	4	
Variegated shale — ? Meyersdale red beds	8		
Blue shale	55		
Black slate	3		
Blue shale	20		
Black slate, ? Brush Creek shale	9		188 ft.
Blue shale	56		
Grey sandstone	22	6	
Dark shale	1	6	
Grey sandstone	4		
Dark shale	12		
Blue shale	17		
Coal, ? Upper Freeport coal	0	4	310 ft.
Blue shale	25	8	
Black shale	6	0	
Blue shale	3		
Grey sandstone	2		
Blue shale	28	6	
White sandstone	9	6	
Coal, ? Lower Freeport coal	0	7	385 ft.
White sandstone	10	5	
Dark shale	24		
Total depth			420 ft.

Hole Md. 5

Location Ea, Plate I. Surface elevation approximately 2,600 ft., to depth 433 ft. Data and location from unpublished notes of C. K. Swartz (hole No. 3 on Heevner Tract).

	Thickness		Depth (top)	
Sand and clay	17 ft.	0 in.		
White sandstone } Lower Grafton	20		17 ft.	
Grey sandstone } sandstone	33			
Blue shale	30	7		
Red shale, Pittsburgh red bed		6	100 ft.	7 in.
Blue shale	13			
Variegated shale, ? Pittsburgh red bed	4			
Blue shale	19			
Grey sandstone	3	6		
Blue shale	47	11		
Grey sand	9	6		
Blue shale	2	7		
Black slate		11		
Coal, Lower Bakerstown coal	1	6	201 ft.	6 in.
Black slate	6	10		
Fire clay and shale	10			
Grey shale	8	6		
Blue shale	13			
Red shale, Meyersdale red bed	3		241 ft.	4 in.
Variegated shale	8	8		
Blue shale	5			
Grey shale	15			
Dark shale	14			
Blue shale	20	7		
Coal, Brush Creek coal		5	307 ft.	7 in.
Blue shale	37	6		
Grey sandstone	47			
Dark shale	9			
Black shale with streaks of coal, Mahoning coal (Piedmont coal)	1	9	401 ft.	6 in.
Dark shale	8	10		
Coal, Upper Freeport coal	7	8	412 ft.	1 in.
Fire clay	2	10		
Blue slate	10	8		
Total depth			433 ft.	3 in.

DEEP-WELLS

Table 10 summarizes the available information on the deep-wells drilled in search of gas. All are located in Garrett County with the exception of F-4 which is in Allegany County and are shown on Plate I or Plate II. The loca-

TABLE 10

Deep-Well Records

Well No.	Permit No.	Samples (feet)	Name (property)	Operator	Location	Surface Elevation (feet)	Total depth (feet)	Top "Tully" Limestone (feet)	Top Huntersville chert (feet)	Top Oriskany sandstone (feet)	Remarks
F-2	None	None	Bayard Coal Co. #1	Potomac Oil and Gas Co.	Plate I—Fc	2,390±	2,240	—	Not reached	—	Completed 1920. See W. Va. Geological Surv., *Deep-Well Records*, 1936, pp. 125–126. *Dry.*
F-3	None	None	Nydegger #1	Potomac Oil and Gas Co.	Plate I—Fb	2,350±	3,500	—	Not reached	—	Completed 1921. See W. Va. Geological Surv., *Deep-Well Records*, 1936, pp. 127–128. *Dry.*
F-4	None	None	Narrows Well		"Narrows," Wills Creek, west of Cumberland, Allegany Co.	625±	2,240	—	Not reached	—	Completed before 1924. See W. Va. Geological Survey, *Deep-Well Records*, 1936, pp. 311–312. *Dry.*
F-5	None	None	Speicher #1	Norwood Johnson et al.	Plate I—Bc	2,380±	5,160	—	Not reached	—	Completed Oct. 1922. See W. Va. Geological Survey, *Deep-Well Records*, 1936, pp. 312–313. *Dry.*
F-6	None	None	Harned Heirs #1	Oakland Oil and Gas Co.	Plate I—Da	2,500±	3,200	—	Not reached	—	See p. 67 of this report; also W. Va. Geol. Surv., *Deep-Well Records*, 1936, pp. 372–373. *Dry.*
F-7	4,128	491–4,910	Beachy #1	Cumberland and Allegheny Gas Co.	Plate I—Fa	2,473	4,910	—1,438	—1,925	—2,045	Completed Oct. 1949. *Producer.* Logged by J. Reed.
F-8	None	None	Kite #1	Fox and Trimble	Plate I—Ea	2,480	5,019		—2,220	—2,348	Samples borrowed from W. Va. Geological Survey; logged by J. Reed, 3,900–5,019 feet. *Dry.*
F-9	4,927	139–5,136	Blocher #1	Snee and Eberly	Plate I—Af	2,630	5,136	—1,460	—2,436	—2,506	Completed May 1950. Logged by J. Reed and T. Amsden—139–5136 feet. *Dry.*
F-10	None	None	Preston Lumber Co. #1		Plate—Fa	2,425	1,540		Not reached		Completed 1930. *Dry.*
F-11	None	None	Georg #1	New Penn. Dev. Co. Snee et al.	Plate I—Bc	2,550	6,735		Not reached		Completed July 1942. *Dry.*
F-12	None	None	Shartzer #1	New Penn. Dev. Co. Snee et al.	Plate I—Bc	2,620	8,163	—4,584	—5,287	—5,462	Completed 1944. See W. Va. Geological Survey vol. XVII, 1945, pp. 752–758. *Dry.*

F-13	None	None	Rush #1	Snee et al.	Plate I—Bc	2,480	6,539		Not reached		Completed 1944. See W. Va. Geological Surv. vol. XVI, 1944, p. 743. *Dry.*
F-14	1,585	10–3,331	Durr #1	Columbian Carbon Co.	Plate I—Fa	2,460	5,259		—2,100	—2,237	Completed Dec. 1947. Logged by J. Reed. *Dry.*
F-15	7,062	8–4,398	Miller #1	Columbian Carbon Co.	Plate I—Eb	2,460	4,398	—845	—1,353	—1,483	Completed March 1951. Logged by J. Reed and T. Amsden. *Producer.*
F-16	6,272	0–2,869	Welch #1	Columbian Carbon Co.	Plate I—Eb Plate II—Ec	2,415	3,388	+153	—420	—533	Completed Sept. 1950. Logged by J. Reed and T. Amsden, 0–2860 feet. *Producer.*
F-17	6,917	0–3,601	Graser #1	Columbian Carbon Co.	Plate II—Ec	2,385	3,601		—583	—711	Completed Dec. 1950. Logged by J. Reed 0–3601 feet (Pl. 3). *Producer.*
F-18	6,951	0–3,803	Baker #1	Snee and Eberly	Plate II—Dc	2,410	3,803	—50 ?	—685	—810	Completed April 1951. Logged by J. Reed, 0–3,694 feet. (Pl. 3). *Producer.*
F-19	6,864	0–3,522	O'Donnell #1	Snee and Eberly	Plate II—Dd	2,390	3,522		—890	—1,020	Completed Feb. 1951. Logged by J. Reed, 0–3,522 feet. *Producer.*
F-20	6,972	3,174–3,651	Grimes #1	Shearer	Plate I—Eb Plate II—Dd	2,420	3,651		—965	—1,100	Completed Mar. 1951. Logged by J. Reed, 3,200–3,651 feet. *Producer.*
F-21	6,889	8–3,665	Mt. Lake Park	Nollem Oil and Gas Co.	Plate II—Dd	2,460	3,672		—1,182		Completed Jan. 1951. Logged by J. Reed, 8–3,665 feet. *Producer.*
F-22	7,090	50–4,145	Gordon #1	Snee and Eberly	Plate I—Eb Plate II—Bf	2,450	4,145	—682	—1,270	—1,390	Completed Mar. 1951. Logged by J. Reed and T. Amsden, 50–4,145 feet (Pl. 3). *Producer.*
F-23	7,094	35–4,854	Gilbert #1	Nollem Oil and Gas Co.	Plate I—Eb	2,470	4,854		Not reached		Completed July 1951. *Dry.*
F-24	7,246	7–3,543	Naylor #1	Nollem Oil and Gas Co.	Plate II—Dd	2,395	3,543	—290	—905	—1,030	Completed May 1951. Logged by J. Reed and T. Amsden, 2,550–3,330 feet. *Producer.*
F-27	7,252	150–3,492	Dawson #1	O. M. Fox et al	Plate II—Dd	2,445	3,500 (Completion Report)	—250 ?	—917		Completed 1951. Logged by J. Reed, 150–3,492 feet. *Producer.*
F-28	7,294	75–3,869	Artis #1	Snee and Eberly	Plate I—Eb Plate II—Dc	2,415	3,869		—952	—1,105	Completed June 1951. Data from Completion Report. *Producer.*
F-29	7,482	1,142–3,695	(Kight) Mt. Lake Park Association	Blaho	Plate I—Eb Plate II—De	2,415	3,675		—1,191		Completed 1951. Huntersville chert checked by J. Reed. *Producer.*

TABLE 10—*Continued*

Well No.	Permit No.	Samples (feet)	Name (property)	Operator	Location	Surface Elevation (feet)	Total depth (feet)	Top "Tully" limestone (feet)	Top Huntersville chert (feet)	Top Oriskany sandstone (feet)	Remarks
F-30	7,316	235–5,531	Cogley #1	Petroleum Drilling Co.	Plate I—Eb	2,410	5,531		Not reached		Completed 1951. Samples checked by T. Amsden. *Dry.*
F-32	7,273	0–4,323	Hirshman #1	Petroleum Drilling Co.	Plate II—Db	2,445±	4,323		Not reached		Completed 1951. Data from Completion Report. *Dry.*
F-33	7,638	0–4,362	Beachy #1	Snee and Eberly	Plate I—Ea	2,445	4,365		—1,562	—1,681	Completed 1951. Data from Completion Report. Huntersville and Oriskany checked by J. Reed. *Dry.*
F-38	7,645	75–4,462	Richards #1	Blaho	Plate I—Eb Plate II—Cd	2,490	4,552		Not reached		Completed 1951. Data from Completion Report. *Dry.*
F-39	7,400	0–4,618	Germaine #1	Eagle Gas Co.	Plate I—Eb Plate II—Dc	2,430	4,621	—1,080	—2,117		Completed 1952. Data from Completion Report; chert checked by K. Weaver. *Dry.*
F-40	7,401	20–4,395	Kitzmiller #1	New York State Nat. Gas. Co.	Plate I—Eb Plate II—Dc	2,411	4,532		—1,527	—1,689	Completed 1951. Data from Completion Report. Huntersville chert checked by J. Reed. *Dry.*
F-43	7,404	94–3,268	Holloway #1	Delaware Gas Co.	Plate II—Dd	2,400	3,268		—798		Completed 1951. Huntersville chert checked by J. Reed. *Producer.*
F-44	7,564	0–3,863	White #1	Johnston Bros.	Plate II—Dd	2,410	3,863		—1,217	—1,343	Completed July 1951. Data from Completion Report. Chert checked by J. Reed. *Producer* (abandoned in 1953).
F-46	7,537	20–4,088	Martin #1	New York State Nat. Gas Co.	Plate II—Cd	2,425	4,089		—1,107	—1,240	Completed 1952. Huntersville and Oriskany checked by K. Weaver. *Dry.*
F-47	7,412	2,352–3,907	Harvey #1	Shaw and Smith	Plate II—Cd	2,490	3,907		—1,366		Completed May 1951. Huntersville chert checked by K. Weaver. *Producer.*
F-49	7,637	0–5,015	Bolyard #1	New York State Nat. Gas Co.	Plate II—Cd	2,453	5,015		Not reached		Completed 1952. Data from Completion Report, checked by T. Amsden. *Dry.*
F-50	7,500	0–3,932	Fee #3	Snee and Eberly	Plate II—Cd	2,440	3,932		—1,249	—1,377	Completed Oct. 1951. Data from Completion Report; chert checked by J. Reed. *Dry.*

F-51	7,399	0–4,512	Offutt #1	Columbian Carbon Co.	Plate I—Eb Plate II—Bg	2,530	4,512		—1,360	—1,505	Completed June 1951. Logged by J. Reed, 0–4,078 feet. *Producer*.
F-52	7,882	0–5,195	Lashorn #1	Mid Atlantic Oil and Gas Co.	Plate I—Dc	2,540	5,195	—1,953	—2,531	—2,654	Completed 1952. Logged by T. Amsden, 4,400–5,195 feet. *Dry*.
F-53	7,872	99–4,186	Simmons #1 (Symonds)	Mid Atlantic Oil and Gas Co.	Plate II—De	2,460	4,186		—1,496	—1,619	Completed 1952. Data from Completion Report; chert checked by K. Weaver. *Dry*.
F-54	8,296	130–3,800	Roy B. Lichty #1	Union Drilling Co.	Plate I—Eb	2,510	3,800		Not reached		Completed 1952. Data from Completion Report. *Dry*.
F-55	7,802	8–3,664	Shahan #1	Nollem Oil and Gas Co.	Plate II—Dd	2,435	3,667	—353	—975	—1,096	Completed July 1951. Data from Completion Report; chert and Oriskany checked by K. Weaver. *Producer*.
F-56	7,723	45–3,599	Fee #4	Snee and Eberly	Plate II—Dd	2,440	3,600		—918	—1,047	Completed 1951. Huntersville and Oriskany checked by K. Weaver. *Producer*.
F-57	7,770	410–3,831	McKee #1	O. M. Fox	Plate II—De	2,430	3,834	—740	—1,362		Completed 1951. Logged by J. Reed and T. Amsden. *Producer* (abandoned in 1952).
F-58	7,977	72–3,590	Grimes #2	Mid Atlantic Oil and Gas Co.	Plate II—Dd	2,435	3,602	—371	—951?	—1,080	Completed 1952. Data from Completion Report; Oriskany checked by K. Weaver. *Dry*.
F-59	7,602	460–4,004	Hammel #1	Mid Atlantic Oil and Gas Co.	Plate I—Eb	2,500	4,004		Not reached		Completed 1951. Data from Completion Report. *Dry*.
F-60	7,777	None	H. Mussard #1	Eagle Gas Co.	Plate II—Cb	2,475	118		Not reached		Completed Sept. 1951. Data from Completion Report. *Dry*.
F-61	7,788	2,634–4,266	Calhoun #1	Guesman, Matthews and Harper	Plate II—Dc	2,425	4,390		Not reached		Completed 1951; Data from Completion Report. *Dry*
F-62	7,997	30–3,564	A. M. Calhoun #1	George Jackson	Plate II—Dc	2,395	3,571		—863	—1,041	Completed Nov. 1951. Chert and Oriskany checked by K. Weaver. *Producer*. (abandoned in 1952).
F-63	8,139	300–4,050	Rumer #1	Blaho Oil and Gas Co.	Plate I—Eb Plate II—Cd	2,460	4,051		—1,347	—1,480	Completed 1951. Chert and Oriskany checked by K. Weaver. *Producer*.
F-64	7,776	225–5,200	F. P. Smith #1	C. E. Young, Columbian Carbon Co.	Plate I—Dc	2,570	5,200	—1,780 ?	—2,364	—2,480	Completed Nov. 1951. Logged by T. Amsden, 4,000–5,090 feet. *Dry*.
F-65	7,783	none	Ashby #1	Eagle Oil and Gas Co.	Plate I—Dc	2,540	1,427		Not reached		Reported abandoned in July 1952. *Dry*.
F-66	7,613	0–5,004	Robeson #1	Superior Oil Co.	Plate I—Bf	2,530	5,004	—1,380	—2,375	—2,425	Completed Sept. 1951. Logged by T. Amsden, 0–5,004 feet (Pl. 3). *Dry*.

TABLE 10—*Continued*

Well No.	Permit No.	Samples (feet)	Name (property)	Operator	Location	Surface Elevation (feet)	Total depth (feet)	Top "Tully" limestone (feet)	Top Huntersville chert (feet)	Top Oriskany sandstone (feet)	Remarks
F-67	8,209	none	Holtschneider #1	H. Goodman	Plate I—Db	2,640	2,600		Not reached		Completed 1952. Data from Completion Report. *Dry.*
F-68	8,427	none	Murphy #1	Penn Maryland Gas Co.	Plate I—Eb	2,480			Not reached		Started in 1951. No cuttings or Completion Report; probably abandoned at a shallow depth. *Dry.*
F-69	8,219	0–4,623	Noah Lichty #1	Columbian Carbon Co.	Plate I—Ea	2,425	4,623	−1,770	−2,166		Completed 1951. Logged by T. Amsden, 4,000–4,623 feet. *Dry.*
F-70	8,218	20–4,395	Dodge #1	Columbian Carbon Co.	Plate I—Fa	2,475	4,395	−1,125	−1,635	−1,753	Completed Dec. 1951. Logged by T. Amsden, 3,500–4,240 feet. *Producer.*
F-71	8,584	none	Pleasant Valley Church. ?	Roeder	Plate I—Eb	2,460				−1,560?	Started 1951. No completion Report or cuttings. Penn. Geol. Survey reported Oriskany at 4,020 feet. No record of production.
F-72	8,524	20–3,686	Weeks #1	Cumberland and Allegheny Gas Co.	Plate II—De	2,390	3,719	−538	−1,100	−1,224	Completed Nov. 1951. Data from Completion Rept.; chert and Oriskany checked by K. Weaver. *Producer.* (abandoned in 1953).
F-73	8,360	none	McClain #1	Brinkley-Moran Co.	Plate II—Cd	2,505	3,986		?		Completed in 1951. Completion Report is not clear, may have reached the Huntersville. *Dry.*
F-74	8,623	none		Roeder and Roeder	Plate II—Ce	2,420					Started to set up rig in Feb. 1952. No Completion Report or other information.
F-75	8,303	0–4,671	Naylor	Union Drilling Co.	Plate I—Eb Plate II—Bd	2,460	4,671		Not reached		Completed 1952. Data from Completion Report. *Dry.*
F-76	8,220	0–4,261	Moon #1	Columbian Carbon Co.	Plate I—Eb Plate II—Be	2,450	4,267		−1,576	−1,704	Completed Oct. 1951. Data from Completion Report; chert checked by J. Reed. *Dry.*
F-77	8,310	none	Beckman #1	Oil Ventures	Plate I—Cd	2,640	6,010		−3,197	−3,232	Completed 1952. Data from Completion Report. *Dry.*

F-78	8,438	0–7,162	Shaw #2	New York State Nat. Gas Co.	Plate II—De	2,450	7,162		—1,343	—1,463	Completed 1952. Logged by K. Weaver, 3,792–7,162 feet (Pl. 3). *Dry.*
F-80	10,296	none	Nellie Lee	Lexa Oil Co.	Plate II—Dd	2,410	3,445?		—994?		Completed 1952. Data from Completion Report. *Producer*, (abandoned 1953).
F-81	8,389	55–3,770	Simmons #1	Snee and Eberly	Plate II—De	2,410	3,786	—700	—1,334		Completed Nov. 1951. Data from Completion Report. *Producer*, (abandoned in 1952).
F-83	8,924	none	McKee #2	Fox and Trimble	Plate II—De	2,400	4,038		—1,432	—1,564	Completed 1952. Data from Completion Report. *Dry.*
F-84	8,768	208–3,980	Mason #1	Cumberland and Allegheny Gas Co.	Plate II—De	2,420	3,980		—1,309	—1,428	Completed Dec. 1951. Chert and Oriskany checked by K. Weaver. *Producer*, (abandoned 1952).
F-85	9,523	none	Friend #1	Ray Kight	Plate II—De	2,440	3,924		—1,295	—1,408	Completed 1952. Data from Completion Report. *Producer*, (abandoned 1953).
F-86	9,158	20–3,712	Baltimore and Ohio R.R.	Union Drilling Co.	Plate II—De	2,400	3,709		—1,251		No Completion Report. Huntersville checked by T. Amsden. *Dry.*
F-87	8,709	174–3,717	Mt. Lake Park Motors (Ashby)	Lafferty and Whetzel	Plate II—Dd	2,390	3,719		—1,140	—1,251	Completed Dec. 1951. Chert and Oriskany checked by K. Weaver. Location, Pl. II, uncertain. *Producer.*
F-88	9,137	625–3,975	I.O.O.F. Lodge #8	Mid Atlantic Oil and Gas Co.	Plate II—De	2,425	3,975		—1,304	—1,421	Completed 1951. Chert and Oriskany checked by K. Weaver. *Producer*, (abandoned 1952).
F-89	9,224	none	H. Z. Gibson	S. and M. Oil and Gas Co.	Plate II—De	2,410	4,044		—1,175	—1,230	Completed 1952. Data from Completion Report. *Dry.*
F-90	9,010	none	United Brethren Church	W. H. Roeder and J. A. Roeder	Plate II—De	2,420	3,721		—1,252		Completed 1951. Data from Completion Report. *Producer*, (abandoned 1952).
F-91	8,866	none	White #2	Loch Lynn Gas Co.	Plate II—Dd	2,390	3,500?		—1,023?		Letter May 1953 gives depth of chert—no other information. Presumably *dry*.
F-92	8,404	500–3,843	Perrine #1	Delaware Gas Co.	Plate I—Eb Plate II—Ee	2,420	3,833	—612	—1,291	—1,408	Completed 1951. Data from Completion Report; chert and Oriskany checked by K. Weaver. *Producer*, (abandoned 1952).

TABLE 10—*Continued*

Well No.	Permit No.	Samples (feet)	Name (property)	Operator	Location	Surface Elevation (feet)	Total depth (feet)	Top "Tully" limestone (feet)	Top Huntersville chert (feet)	Top Oriskany sandstone (feet)	Remarks
F-93	9,186	400–3,542	Kigbt #1	G. A. Kigbt (Boyle)	Plate II—Ed	2,400	3,548		—1,020	—1,142	Completed 1952. Data from Completion Report—chert checked by K. Weaver. *Producer.* (abandoned 1953).
F-94	9,517	200–3,511	Graser #2	Mid Atlantic Oil and Gas Co.	Plate II—Ed	2,390	3,511	—278	—880	—1,003	Completed 1952. Data from Completion Report; Chert and Oriskany checked by K. Weaver. *Dry.*
F-95	9,489	none	Gower #1 (Garrett #1?)	Blaho Oil and Gas Co.	Plate II—Ed	2,400			—1,140?		March 1952 well reported at 1,000 feet. No Completion Report. Oil and Gas Journal May 12, 1952, reports chert in Garrett #1 (Blaho) at 3,540 feet. Presumably *Dry?*
F-96	8,787	1,230–4,077	Killius-Sisler	Antietam Nat. Gas Co.	Plate II—De	2,440	4,077		—1,410	—1,539	Completed 1951. Chert and Oriskany checked by J. Reed; *Producer.* (abandoned in 1952). No Compl. Rept.
F-97	9,156	none	Callis	Mid Atlantic Oil and Gas Co.	Plate I—Eb Plate II—De	2,480	4,040		—1,432	—1,542	Completed 1951. Data from Completion Report. *Producer.* (abandoned 1952).
F-98	9,172	none	Smith #1	Penn-Maryland Gas Co.	Plate II—De	2,490			—1,612	—1,741	No Completion Report. Oil and Gas Journal, April 28, 1952, reports chert at 4,102 feet, Oriskany at 4,231 feet. *Dry?*
F-99	9,009	75–3,182	Rice #1	Cumberland and Allegheny Gas Co.	Plate I—Eb	2,440	3,182		—508		Completed 1952; no Completion Report. Cbert checked by T. Amsden. *Dry?*
F-100	9,388	none	Riley #1	Cumberland and Allegheny Gas Co.	Plate I—Eb	2,400	3,109		—463	—590	Completed 1952. Data from Completion Report. *Dry.*
F-101	8,666	none	Beachy #3	Snee and Eberly	Plate I—Ea	2,430	4,362	—1,065	—1,646	—1,760	Completed 1952. Data from Completion Report. *Producer.*
F-102	8,390	11–4,395	Beachy #2	Snee and Eberly	Plate I—Eb	2,460	4,395		—1,592	—1,714	Completed 1951. Chert and Oriskany checked by K. Weaver. *Dry.*
F-103	9,339	0–4,091	Gordon #3	Snee and Eberly	Plate II—Cf	2,510	4,091	—711	—1,290	—1,412	Completed 1952. Data from Completion Report; chert checked by K. Weaver. *Dry.*

F-104	8,570	0–4,034	Gordon #2	Snee and Eberly	Plate II—Bf	2,480	4,042	—724 ?	—1,331?	—1,451?	Completed 1951. Data from Completion Report. Samples do not check with Report. *Dry.*
F-105	8,200	0–3,963	Shaw #3	New York State Nat. Gas Co.	Plate II—Ce	2,440	3,963		—1,262	—1,390	Completed 1952. Chert and Oriskany checked by K. Weaver. *Dry.*
F-106	9,547	0–4,884	Wilt Jacobs	Seaboard Oil and Gas Co.	Plate I—Bf	2,559	4,884	—1,177	—2,260	—2,318	Completed 1952. Data from Completion Report; chert and Oriskany checked by T. Amsden. *Dry.*
F-107	10,058	0–3,351	W. N. Beckman	Cumberland and Allegheny Gas Co.	Plate I—Eb	2,440	3,351		—688	—750	Completed 1952. Data from Completion Report; chert and Oriskany checked by K. Weaver. *Producer.*
F-108	10,034	533–3,698	Rice #2	Cumberland and Allegheny Gas Co.	Plate I—Eb	2,420	3,698		—1,206		Completed 1952. Chert checked by K. Weaver. Samples end in the Huntersville. *Producer.*
F-110	9,921	0–3,558	Lohr	Eagle Gas Co.	Plate I—Eb	2,420	3,558		—746	—847	Completed 1952. No Completion Report. Chert and Oriskany checked by K. Weaver. *Producer.*
F-111	9,999	32–3,319	Jas. Riley #2	Cumberland and Allegheny Gas Co.	Plate I—Eb	2,400	3,322	—235	—893		Completed 1952. Data from Completion Report. Chert checked by K. Weaver. *Producer.*
F-112	10,102	none	Welch #2	Columbian Carbon Co.	Plate I—Eb	2,395	3,047		?	—484	Completed Aug. 1952. Data from Completion Report—no record of chert. *Dry?*
F-113	9,766	0–7,191	McCullough #1	Snee and Eberly	Plate I—Bc	2,010	7,191	—4,121	—5,030	—5,176	Completed 1953. Data from Completion Report; "Tully" checked by J. Schlee. Gas production begun 4th quarter, 1953.
F-114	10,767	none	Milton Riley	Columbian Carbon Co.	Plate I—Eb	2,410	3,924	—664	—1,209	—1,325	Completed 1952. Data from Completion Report. *Producer.*
F-115	10,033	2,400–4,688	N. D. Shrock	Cumberland and Allegheny Gas Co.	Plate I—Ea	2,500	4,714	—1,455	—1,931	—2,038	Completed 1952. Data from Completion Report; chert and Oriskany checked by K. Weaver. *Dry.*
F-116	10,463	0–4,177	Lichty #1	Snee and Eberly	Plate I—Ea	2,430	4,177	—970	—1,500	—1,620	Completed 1953. Data from Completion Report; chert and Oriskany checked K. Weaver. *Dry.*
F-117	12,058	0–4,021	Joni Miller	Snee and Eberly	Plate I—Eb	2,440	4,021		—1,293	—1,417	Completed 1953. Data from Completion Report. *Dry.*
F-118	11,085	none	S. D. Swartzentruber #1	Cumberland and Allegheny Gas Co.	Plate I—Ea	2,435	4,153	—847	—1,483	—1,602	Completed 1953. Data from Completion Report.
F-119	12,057	100–3,397	H. D. Swartzentruber	Nollem Oil and Gas Co. Eberly.	Plate I—Eh	2,460	3,399		—768	—870	Completed 1953. Data from Completion Report. Reported to have an open flow of 1,161,000 cf. per day.

tions have been field checked for almost all of the wells drilled since 1946; locations for those drilled prior to 1945 are taken from earlier reports or from information supplied by organizations engaged in drilling in the county.

Table 10 gives the elevation of the top of the "Tully" limestone, the Huntersville chert, and the Oriskany sandstone in all wells penetrating these horizons and for which the information is available. The elevations are given in plus or minus sea level and are based upon surface elevations taken from the U. S. Geological Survey topographic quadrangle maps (7½ min.). The Maryland Department of Geology, Mines and Water Resources has on file samples for most of the wells drilled since 1945 as is shown under the column, *Samples*. The depths of the three formations, "Tully", Huntersville and Oriskany, are based on the cuttings where available; otherwise the depths are taken from the driller's Completion Report or from earlier publications. The column *Permits* records the number of the drilling permit issued by the Maryland Department of Geology, Mines and Water Resources. The source of the information is given under the column *Remarks*, which also includes a notation on whether it is a dry or a producing well.

GROUND-WATER RESOURCES

BY

ROBERT M. OVERBECK

Introduction

Location of the area. Garrett County is the westernmost county in Maryland (fig. 10). It lies between parallels 38°11′ and 39°43′ north latitude and meridians 78°55′ and 79°29′ west longitude. The county is bounded on the north by Somerset and Fayette Counties, Pennsylvania; on the west by Preston County, West Virginia; on the south and southeast by Grant and Mineral Counties, West Virginia; and on the east by Allegany County, Maryland. Its northern, western, and eastern boundaries are man-made, but its boundary on the south and southeast is the south bank of the North Branch of the Potomac River. Both the western and eastern boundaries of the county have been shifted within the last seventy-five years (Mathews, 1906, pp. 499–501), which should be kept in mind when use is made of old maps of the county, such as the old geologic map (Martin, 1902). The eastern boundary on the maps in this report is the Bauer line, recognized as the official boundary by the State of Maryland. The area of the county is 664.25 square miles.

Purpose and scope of investigation.—This investigation of the ground-water resources of Garrett County is a part of the Statewide cooperative ground-water studies by the Maryland Department of Geology, Mines and Water Resources and the United States Geological Survey.

Ground water is an important natural resource of Garrett County. It provides an economical supply of water for municipalities and rural homes and farms. Surface water is available generally throughout the county but the relatively high cost of dam construction and treatment plants and their maintenance and operation restrict its general use as a source of water for present needs.

The purpose of the investigation was to study and appraise the ground-water resources of the county. This was accomplished by inventorying 489 wells and springs, by studying the geology of the county as it relates to the occurrence of ground water, by measuring four observation wells periodically to determine the seasonal water-level fluctuations, and by collecting four samples of well water for laboratory analysis to determine the chemical quality of the ground water. Also analyses by the Maryland State Department of Health of water samples from public water supplies in the county were obtained. Most of the well data were obtained from well-completion reports submitted by drillers to the Maryland Department of Geology, Mines and Water Resources.

FIGURE 10. Map of Maryland showing physiographic provinces and location of Garrett County

Of the 489 records in the well and spring inventory, 363 are from drilled wells, 10 from dug wells, and 116 from springs. These are not all the wells and springs in the county, but they are a representative sampling of them. Practically all the wells for which important hydrologic data are obtainable were inventoried. Records of the wells, including their owners, depths, diameters, yields, water levels, specific capacities, and other information about them, are given in Table 20. Records of the springs, including their owners, rates of discharge, improvements, and other information, are given in Table 21.

The locations of the wells and springs are shown on Plate VIII. The map in Plate VIII is divided into 5-minute quadrangles which are lettered alphabetically by capital letters from north to south, and by small letters from west to east. Wells and springs within each quadrangle are numbered in the order in which they were inventoried. Each well or spring is designated by (1) an abbreviation of the county name, (2) a combination of the margin letters for the quadrangle in which it lies, and (3) the number given the well or spring within the quadrangle. Thus, the well numbered 2 in quadrangle Cc in Garrett County is designated Gar-Cc 2. As all the wells referred to in the report are in Garrett County, the county abbreviation has been omitted.

Recently published reports on exploration of the coal beds and refractory clays by diamond drilling in the Georges Creek basin, in part of the Upper Potomac basin, and in the Castleman basin by the U. S. Bureau of Mines provide valuable information on the geology of these basins, and the position and thickness of water-bearing beds. The logs of gas wells on the Deer Park anticline also have been helpful in outlining the water-bearing beds.

Previous investigations.—The ground-water resources received little attention in previous studies of the geology and mineral resources of Garrett County. The Accident-Grantsville geologic folio (Martin, 1908) discusses briefly the presence of the many springs in the county and the potential supplies available to drilled wells. Clark and others (1918), in a report on the water resources of Maryland, include a brief description of the occurrence of ground water and records of 43 wells in Garrett County.

Acknowledgments.—The well drillers of the county were most cooperative in supplying information about wells which they drilled and in collecting sample well-cuttings. Drillers A. C. Brenneman, D. C. Dilley, and J. B. Tressler were especially helpful. The cooperation of Thomas W. Amsden is greatly appreciated.

The investigation was made in large part under the supervision of R. R. Bennett, District Geologist of the U. S. Geological Survey in charge of cooperative ground-water investigations in Maryland, until the summer of 1953, when he was succeeded by E. G. Otton.

Geography

Culture.—The population of Garrett County in 1950 was 21,259 (U.S. Department of Commerce, 1950 census). About one-fourth of the people live in towns. The principal towns and their populations are: Oakland, 1,640; Mountain Lake Park, 891; Kitzmiller, 652; Friendsville, 607; Grantsville, 461; Loch Lynn Heights, 415; Deer Park, 320. There are a number of smaller villages. About 170,000 summer visitors vacation in the county each year; they reside chiefly near Deep Creek Lake and in the State-owned forests and parks.

Garrett County is primarily a stock-raising and agricultural area. The 1949–50 agricultural census (U. S. Department of Commerce, 1950) shows 215,070 acres of land in farms, which is 50.8 percent of the total land area. The annual livestock production was valued at $2,125,259, hay at $727,285, and potatoes at $120,881. The county contains 98,563 acres of woodland. Forests and forest products were valued at $78,219. Lumbering was once a large industry in Garrett County but now only a few sawmills are in operation. The Maryland Bureau of Mines reported 343,599 tons of coal were mined in 1952, almost entirely from strip mines in the Georges Creek and Upper Potomac coal basins, and 20,336 tons of fire clay (Annual Report, Maryland Bureau of Mines, 1953). The mining industry employed 385 men.

Deep Creek, a tributary of the Youghiogheny River, is dammed near its confluence with the Youghiogheny to form Deep Creek Lake, which is used in the generation of power. A flood-control dam has recently been completed across the Savage River, a short distance upstream from its confluence with the Potomac River. A flood-control dam across the Youghiogheny River, in Pennsylvania has formed a lake in the river valley that at times extends southward almost to Friendsville.

The Baltimore and Ohio Railroad serves the southern part of Garrett County. The Castleman River Railroad, which runs from Jennings northward along the Casselman River valley into Pennsylvania, and the Preston Railroad from Hutton to the West Virginia line below Crellin, are small spur lines of the Baltimore and Ohio. U. S. Highway 40 crosses the northern part of the county and U. S. 50, the southern part. U. S. Highway 219 and Maryland Route 495 connect these two main east-west routes.

Climate.—Garrett County has a greater mean annual precipitation (44.59 inches) and a lower mean annual temperature (47.9°F.) than any other Maryland county. The mean precipitation and temperature vary somewhat from station to station within the county. Fassig (1902) described in detail the climate of the county. More current climatological data are given in a report on the climate of Maryland by Weeks (1939) and in monthly and annual publications of the U. S. Weather Bureau. In 1952 the Weather Bureau had seven cooperative stations in Garrett County at which temperature and precipitation

TABLE 11

Average Monthly and Annual Precipitation in Inches

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual average
Deer Park	4.01	3.56	3.95	3.92	4.60	4.93	4.37	4.24	3.00	3.15	2.58	3.90	46.21
Friendsville	3.58	2.85	4.11	3.49	3.75	4.71	4.34	3.98	2.79	2.96	2.51	3.65	42.72
Grantsville	3.59	3.12	3.98	3.77	4.05	4.45	4.03	4.27	2.81	2.94	2.70	3.53	43.24
Oakland	3.79	3.28	4.00	3.92	4.37	4.78	4.66	4.28	3.07	3.30	2.82	3.92	46.19

were measured daily, but there are gaps in the records for some of these stations.

The normal monthly and annual average precipitation at four stations (Weeks, p. 50) in Table 11 show the variations in precipitation geographically and seasonally within the county. These averages are based on a period of record of 35 years.

Deer Park and Oakland are in the upland plateau area of the southwestern part of the county. Friendsville is in the narrow valley of the Youghiogheny River in the northwestern part of the county, and Grantsville is on a rolling upland plateau west of the Casselman River valley in the northeastern part of the county. The average number of days with 0.01 inch or more of precipitation in the eastern and northwestern parts of the county is about 140, and in the south-central part about 160. Heavy thunderstorms are frequent during the summer months. Snowfall ranges from 45 inches per year in the east to 70 inches in the north-central part of the county.

The normal monthly and the annual average temperature at four stations (Weeks, pp. 52–53) in Table 12, show the seasonal and geographic variations in temperature within the county. Temperatures seldom rise above freezing in the months of January, February, and December.

Topography and drainage.—Garrett County lies within the Appalachian Plateaus physiographic province (fig. 10). Garrett County is a broadly rolling upland deeply incised by stream valleys. Ridges, between which the major

TABLE 12

Average Monthly and Annual Temperature in Degrees Fahrenheit

Station	Period of record Years	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual average
Friendsville	20	30.7	31.3	38.3	47.4	56.9	65.2	69.2	67.4	52.9	51.5	40.8	32.1	49.5
Grantsville	45	27.7	27.0	36.4	45.8	56.4	63.7	68.0	66.4	61.1	50.0	39.0	29.5	47.6
Oakland	40	28.8	28.3	36.8	46.0	55.8	63.7	67.3	65.9	61.0	49.5	38.5	29.8	47.6
Sines (Deep Creek)	11	29.4	28.1	35.4	44.8	55.5	63.7	67.9	65.7	60.0	48.1	38.2	29.8	47.2

streams flow, trend northeastward. The most prominent ridges are Backbone-Big Savage Mountain, Meadow Mountain, Negro Mountain, and Winding Ridge. Backbone Mountain and Meadow Mountain are part of a major north-trending divide in the eastern United States that separates areas that drain into the Atlantic Ocean from those that drain into the Gulf of Mexico. In Garrett County the Youghiogheny and Casselman Rivers flow northward as a part of the Ohio River drainage basin, and the Savage River flows southward as a part of the Potomac River drainage basin. The North Branch of the Potomac River flows northeastward, paralleling the ridges. Bear Creek and Deep Creek, large tributaries of the Youghiogheny River, flow westward through deep water gaps in the northeast-trending ridges.

Poorly drained meadows, locally called "glades," occur at the headwaters of many streams.

The average altitude of the county is about 2,200 feet above mean sea level. The lowest point, at an altitude of about 1,000 feet, is at the mouth of the Big Savage River. The highest point is on Backbone Mountain north of Kempton, at an altitude of 3,360 feet. This is believed to be the highest point in Maryland. The principal geographic features of the country are shown in figure 1.

General Geology*

Consolidated sedimentary rocks of Devonian, Mississippian, and Pennsylvanian ages underlie Garrett County to known depths of several thousand feet. They were deposited in horizontal and parallel beds, or in series of lenses, and were later buried, indurated, and folded to form anticlinal and synclinal and related structures. The major structures (fig. 11) are the Deer Park anticline, the Accident dome, the Georges Creek syncline, the Upper Potomac syncline, the Castleman Syncline, the Lower Youghiogheny syncline, and the Upper Youghiogheny syncline. The axes of these structures parallel each other and trend northeastward. The Georges Creek and Upper Potomac synclines are parts of one structural downwarp which is divided geographically near Westernport by the Savage River. The Lower and Upper Youghiogheny synclines are separated by a minor cross-fold, called in this report a "cross structure." The Deer Park anticline is a pronounced structural feature which extends from beyond the southwest corner to beyond the northeast corner of the county. The Accident dome is an upwarp in the north-central part of the county.

The general regional strike of the strata is northeast. The dip of the beds is low in and near the axes of the synclines, and about 15 degrees on the flanks of

* The geologic names used are those of the Maryland Department of Geology, Mine and Water Reserves and differ somewhat from those used by the U. S. Geological Survey.

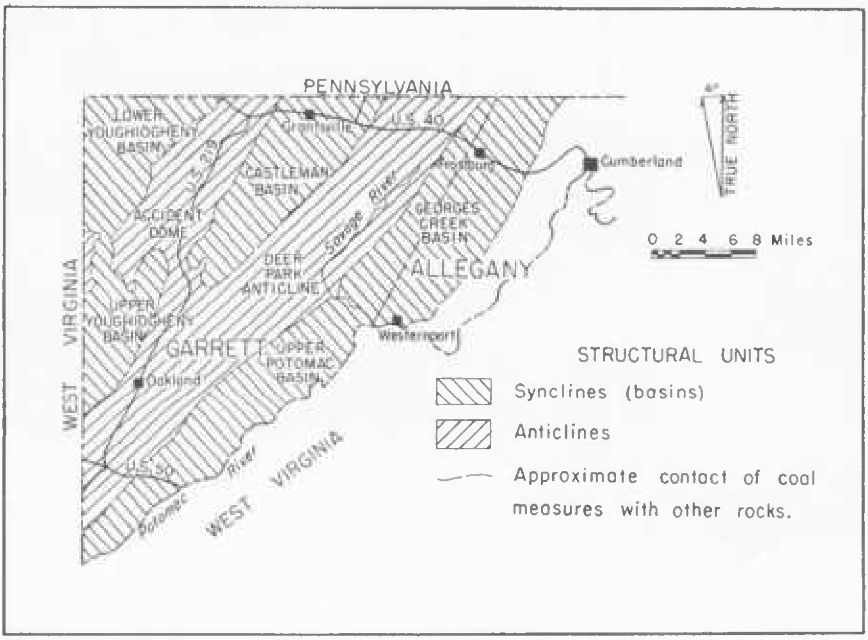

FIGURE 11. Geologic structural units in Garrett County

the folds. Dips are variable near the axes of the anticlines; they are steep on the Deer Park anticline and highly variable on the Accident dome.

The rocks include sandstone, shale, limestone, conglomerate, coal, fire clay, and related intermediate types such as calcareous shale, sandy limestone, sandy shale, and shaly coal.

Unconsolidated Pleistocene and Recent deposits of minor importance are present in the county as slide rock, alluvium and terrace deposits of silt, sand and gravel, and peaty material in the "glades."

The physiography of Garrett County is chiefly the surface expression of the differential weathering and erosion of the strata comprising the geologic structures. The hard and massive sandstones of the Pottsville formation form the high ridges bounding the synclinal basins. Soft calcareous shale, such as the shale of the Greenbrier formation, weathers and erodes easily and forms narrow valleys having the trend of the underlying structures. The sandy Pocono formation forms minor ridges. The shales of the Jennings and Hampshire formations of Devonian age and the shales of the Pennsylvanian coal measures characteristically erode in the form of low, rolling hills.

The geologic formations and their water-bearing properties are described briefly in Table 13.

TABLE 13

Geologic Formations and their Water-Bearing Properties

System	Formation	Member	Thickness (feet)	Lithology	Water-bearing properties
Quaternary	Deposits of Recent and Pleistocene age	—	0–70±	Slide rock, alluvium, sand, gravel, and peaty material.	Owing to limited distribution and thickness, not important as a water-bearing formation. Locally, under favorable conditions, may be potentially important.
	Monongahela	—	240–270	Shale, siltstone, sandy shale, thin sandstone beds, coal seams.	No known water supplies derived from this formation. Not an important source of water because areal extent relatively small and formation partly drained by mine shafts and drifts.
	Conemaugh	Upper	400–450	Sandstone, shale, shaly sandstone, siltstone, red beds, clay, coal seams.	Of minor importance as a water-bearing formation of limited extent in the Castleman basin. Adequate spring and well supplies obtained for domestic use. Average yield of wells about 8 gallons a minute.
Pennsylvanian		Lower	450–500	Shale, sandy shale, siltstone, calcareous shale, lenticular sandstone, red beds, coal seams.	Important water-bearing formation in the Castleman basin and in the Upper Potomac basin. Adequate well and spring supplies for commercial and domestic use. Yields as much as 75 gallons a minute to wells. Average yield 15 gallons a minute.

	Allegheny	—	275–325	Sandy shale, siltstone, shale, sandstone lenses, small amount of calcareous shale near top.	Important water-bearing formation in the synclinal basins. Adequate well or spring supplies for small commercial and domestic use. Yields as much as 40 gallons a minute to wells; average yield 14 gallons a minute.
	Pottsville	—	180–250	Sandy shale, siltstone, fire clay, lenticular coal beds; sandstone and conglomerate in lower part.	Important water-bearing formation in synclinal basins and on their flanks. Only a few wells derive water from this formation; yields as much as 200 gallons a minute; average yield of five wells about 38 gallons a minute. Springs that issue from rocks of this formation are an important source of water; some discharge at a rate of 10 gallons or more a minute.
Mississippian	Mauch Chunk	—	500–700	Reddish and greenish sandy shale, platy crossbedded sandstone.	Of moderate importance as a water-bearing formation along the flanks of the Deer Park anticline and the edges of the Accident dome. Utilized as a source of water for domestic wells primarily in the vicinity of Deep Creek Lake. Yields as much as 24 gallons a minute to wells; average yield 15 gallons a minute. Several springs are used for water supplies.
	Greenbrier	—	200–300	Red and green shale, lenticular limestone, calcareous sandstone.	Of moderate importance as a water-bearing formation along the edges of the major anticlinal structures. Yields as much as 20 gallons a minute to wells; average yield 14 gallons a minute. Several springs are used for water supplies.

TABLE 13 *Concluded*

System	Formation	Member	Thickness (feet)	Lithology	Water-bearing properties
Mississippian	Pocono	—	700–1,300	Brown and green sandstone, locally conglomeratic, crossbedded, and platy; shale, sandy shale.	Important water-bearing formation in the areas of the Deer Park anticline and Accident dome. Many well and spring water supplies, including town of Oakland public supply, obtained from rocks of this formation. Yields as much as 130 gallons a minute to wells; average yield 13 gallons a minute. Many springs used for municipal and domestic water supplies, some discharging at a high rate.
	Hampshire	—	1,400–2,000	Brown and yellowish green sandy shale, shale, lenticular, platy sandstone; red beds.	Important water-bearing formation in the Deer Park anticline and Accident dome areas. Most existing wells are along Deep Creek Lake and in and near Accident. Yields as much as 57 gallons a minute to wells; average yield 14 gallons a minute. Springs adequate for domestic use issue from rocks of this formation.
Devonian	Jennings	—	4,000–5,000± 3,000 exposed	Yellowish gray and brown marine shale and sandy shale, sandy siltstone, and subordinate thin-bedded sandstone.	Important water-bearing formation in the area of the Deer Park anticline for domestic and farm water supplies. Yields as much as 40 gallons a minute to wells; average yield 10 gallons a minute. Springs for domestic water supplies used commonly; most numerous in the central part of the Deer Park anticline area.

General Hydrology

Ground water utilized in Garrett County is derived from the weathered zone (subsoil) and from the upper part of the hard consolidated rocks. Where saturated the soil and subsoil supply water to many of the springs and shallow dug wells; the hard rocks supply water to the drilled wells and some of the springs.

Ground water moves downward through the soil zone and percolates through the fractures and intergranular openings in the weathered material. Upon entering the zone of hard, unweathered rock its movement is confined chiefly to openings along fractures and bedding planes in the rock, but in porous sandstones movement is also through intergranular openings. The degree of permeability in the hard rocks varies with the type of rock. Porous sandstone is more capable of transmitting water than are relatively impervious shale and clay. Sandstone beds of Pennsylvanian and Mississippian age are the best aquifers in the county. Siltstone, shale, and clay are relatively poor aquifers; but because shale and siltstone underlie a large part of the county, most rural and domestic supplies are derived from them.

In general, in Garrett County the soil and subsoil form a mantle overlying the bedrock in which the strata are tilted at various angles from horizontal to nearly vertical, depending on their position within the anticlines and synclines.

The upper surface of the zone of saturation is the water table. This surface is within the hard consolidated rocks in some places and in the subsoil or soil zone in other places. The water table roughly parallels the land surface, although generally it is at greater depth below the surface near the crest of hills than in valleys. Where the water table intersects the land surface, ground-water discharges into lakes, springs, or streams. The water table rises and falls largely in response to recharge from precipitation and to discharge by drainage to natural outlets or to wells. In Garrett County the water table is usually highest during spring and early summer and lowest during the late fall and early winter.

Artesian conditions exist where a water-bearing bed is overlain by a less permeable or a relatively impermeable bed and the contained water is confined under hydrostatic pressure. The head in an artesian aquifer at a given locality is that of the unconfined or water-table head in the recharge area of the aquifer less the amount of head lost by friction as the water moves from the recharge area to the locality. Artesian conditions occur in some localities in Garrett County as a result of water moving downgradient, in response to hydraulic head, along steeply-dipping fractures or bedding planes in the shale or sandstone. Where a well penetrates a water-saturated opening at a point where the pressure head is sufficient to raise the water above the land surface, a flowing well is obtained.

Water in many of the pervious beds of fractured sandstone and shale exists under artesian head in the topographically low points within the synclinal basins of the coal measures in Garrett County. The presence, locally, of a seal of clayey subsoil or soil may create artesian conditions in the fractured bedrock. Such local areas of artesian head may or may not be related to the general geologic structure of the area.

Recharge to the ground-water reservoirs occurs as a result of precipitation on the surface of the earth. A part of the water runs off directly over the surface and a part percolates into the soil. Of the water that enters the soil, the amount available for recharge is that which percolates downward to the zone of saturation after the water demands of the soil and the plants have been met (evapotranspiration). The rate of recharge to the ground-water reservoirs in Garrett County has not been determined, although in areas of similar hydrologic and geologic conditions it ranges from a few percent up to 20 or 30 percent of the precipitation.

Ground water leaves the zone of saturation, or is discharged, by both natural and artificial means. It is discharged naturally by means of evaporation at the land surface, transpiration, and ground-water runoff through seeps and springs. Soil evaporation and transpiration are effective means of ground-water discharge, and much of the ground-water discharge occurs in this way. Discharge of ground water by transpiration is greatest during the growing season, from April through October.

Water is artificially withdrawn from the ground-water reservoirs chiefly through wells, although in Garrett County the amount of the withdrawal is only an extremely small amount of the total annual precipitation, probably less than 1 percent, because springs are in common use for water supplies.

Geologic Formations and their Water-Bearing Properties

DEVONIAN SYSTEM

Although deep-lying rocks of Early Devonian age that do not crop out at the land surface in Garrett County have been penetrated by deep gas wells, little is known of the occurrence of ground water in these rocks except that they are likely to contain saline water. Geologic information from Allegany County and from neighboring States indicates that even older sedimentary rocks underlie those of the Devonian system in Garrett County. Inasmuch as it is generally impractical and unnecessary to drill water wells deeper than several hundred feet, and owing also to the lack of data on the water-bearing character of the deep-lying rocks, only those formations that crop out at the land surface are discussed.

JENNINGS FORMATION

The Jennings formation, of Late Devonian age, is the oldest geologic formation exposed in the county.

Distribution and character.—The Jennings formation crops out in a belt about 44 miles long extending from the southwest corner of the county to the northeast corner, along the crest and axis of the Deer Park anticline. The width of the belt ranges from about 1.5 to 3 miles, averaging about 2.5 miles.

The terrain in areas underlain by this formation is rolling in the southwest and northeast parts of the county and rugged along the Big Savage River valley in the central part. The formation is described on pages 5 to 115.

Water-bearing properties.—As the Jennings formation consists chiefly of shale, intergranular openings are extremely small and storage and movement of ground water is primarily in fracture and bedding-plane openings. The formation yields adequate supplies of water for domestic needs, but only rarely are yields adequate for large commercial or industrial use. Although the drillers report shale as the water-bearing material in 36 wells ending in the formation, they do not distinguish in their logs the brittle sandy shales, which probably are relatively good water-bearing materials, from the softer, more plastic, shales which probably are poor water-bearing materials. Sandstone is reported as the water-bearing bed in only 10 wells ending in the Jennings formation. Well-defined sandstone beds are subordinate and thin in the formation, and are less important as water-bearing materials than are the extensive shales. Ground water occurs under both artesian and water-table conditions in the Jennings formation. The artesian pressure, however, apparently is not great enough to permit flowing artesian wells, for no flowing wells were observed in this formation.

Records of 57 wells drilled in the formation show an average depth of 84 feet, an average yield of 10 gallons a minute, and an average specific capacity of 0.4 gallon a minute per foot of drawdown.

Well Bf 3, near Avilton, is 218 feet deep and is the deepest water well in the Jennings formation. The log of this well shows two water-bearing zones, one at 35 to 41 feet, the other at 185 to 218 feet. As the casing in this well extends only to a depth of 23.5 feet, both zones contribute to the well discharge. It is reported to yield 4 gallons a minute.

The highest yield reported from a well in the Jennings formation is 40 gallons a minute, from well Db 8, 3 miles east of Oakland, and the lowest yield reported is 1 gallon a minute from wells Af 9, 2.5 miles northeast of Avilton, and Bf 9, at Avilton. Well Db 8 has a specific capacity of 1.3 gallons a minute per foot of drawdown as compared with a specific capacity of only 0.1 for well Af 9. It was reported that wells Dc 8 and Dc 9, along the shore of Deep Creek Lake, yielded 6 and 15 gallons a minute, respectively, with no drawdown of the water level in the wells. As some drawdown is required for water to flow into a well, it seems likely that the drawdown in these wells was not measured accurately; however, the drawdown may be small and the specific capacity correspondingly high.

Logs of gas wells drilled in the Mountain Lake Park and Avilton areas

TABLE 14

Water-bearing zones reported in gas-well logs

(Locations are shown on Plates I and II)

Well number	Depth to water-bearing zone	Quality of water
F-9	70	Fresh
	175	Do.
	495	Do.
F-20	55	Do.
	400	Do.
F-22	50	Do.
	500	Do.
F-24	53	Do.
	1,264	Salty
F-25	50	Fresh
	465	Do.
F-28	20	Do.
	610	—
	690	—
F-35	45	Fresh
	440	Do.
F-38	405–415	Do.
F-39	360	Do.
F-40	45	Do.
	442	Salty
F-44	30	Fresh
	300	Do.
F-51	51–55	Do.
	385	Do.
F-63	20–80	Do.
	1,030	Salty
F-66	40–75	Fresh
	425–430	Do.
	440–462	Do.
	635–660	Do.
F-100	12	Do.
	84	Do.
	450	—
F-103	51	Fresh
	120	Do.
	416–420	—
F-111	19–40	Fresh
	111	Do.
	1,050	—

report some of the water-bearing zones encountered in the Jennings formation and describe the chemical character (salty or fresh) of the water in these zones. The high-chloride water is connate sea water which has not yet been flushed from the Jennings formation by circulation of the ground water. Table 14 gives the depth at which water-bearing zones were encountered in some gas wells, and remarks recorded by the driller on whether the water is salty or fresh (usually determined only by taste).

The logs of the gas wells do not describe the water-bearing rocks in detail or give the thickness of each water-bearing zone. Probably only the more important water-bearing zones were reported by the drillers and others may exist in the vicinities of these wells. Salt water was reported in well F 24 at a depth of 1,264 feet, in well F 40 at 442 feet, and in well F 63 at 1,030 feet. Hence in some areas salt water might be encountered in water wells drilled into the Jennings formation at depths as shallow as 500 feet or less.

Springs in the Jennings formation.—In the Jennings formation springs, which represent points where the water table comes to the land surface, or where the piezometric surface is above the land surface and natural openings exist in the rocks to carry the water upward from the aquifer, are most common in the deeply dissected central part of the Deer Park anticline, in the central part of the county, where they are the chief sources of domestic water supply. Most of the springs discharge at a rate of less than 2 gallons a minute and may be classed as seepage springs. Spring Bf 1 had a yield of about 6 gallons a minute, but this spring is beside a stream and the discharge might in part be underflow from the stream.

HAMPSHIRE FORMATION

Distribution and character.—The Hampshire formation of Late Devonian age crops out as two parallel bands, each about 1 to 1.5 miles in width, which flank the crest of the Deer Park anticline, extending from the southwestern part of the county to the northeastern part, and as an irregular but roughly elliptical area in the crest of the Accident dome in the northwestern part of the country.

The rocks of the Hampshire formation are described on pages 15 to 23. No distinctive beds which might serve as key beds have been found, so that correlation between wells is difficult.

Soil overlying the Hampshire rocks generally is brick red. The shale of the formation weathers thoroughly at and near the land surface and erodes smoothly, resulting in a gently rolling topography. Where thick sandstone beds are at or near the surface, and where the formation is deeply dissected by the Savage River, the topography is more rugged.

Water-bearing properties.—In general, the Hampshire formation is a better water-bearing formation than the Jennings. Most of the wells drilled in the Hampshire formation are along the shores of Deep Creek Lake on the Deer

Park anticline, and in or near the town of Accident on the Accident dome. Wells in the two localities have the same average depth, about 100 feet. The ground water probably is mainly stored in, and transmitted through, fracture openings in the rock which are not uniformly distributed, so that the yields of wells drilled in the formation are not uniform but range from poor to good. Well logs of 39 wells show that 31 of these wells obtain water from shale or sandy shale, and 8 wells obtain water from sandstone. Ground water occurs under both artesian and water-table conditions in the Hampshire formation, but, as in the Jennings, the artesian pressure apparently is not great enough to produce flowing wells.

Records of 58 wells drilled in the Hampshire formation show an average depth of 94 feet, an average yield of 14 gallons a minute, and an average specific capacity of 0.7 gallon a minute per foot of drawdown. In general, the highest yields are obtained in the southwestern part of the Deer Park anticline, and the lowest in the northeastern part of the anticline. Intermediate yields are obtained from wells drilled in the Hampshire formation on the Accident dome. As a rule, the deepest wells have the largest yields.

Well Bc 29, on the Accident dome 3 miles northeast of Accident, is 600 feet deep and is the deepest well in the Hampshire formation in Garrett County. This well penetrated shale almost entirely and produced 22 gallons a minute. The well is near the deeply incised valley of Bear Creek, in the vicinity of which the rocks are well drained by seeps and springs. Thus the great depth required on this well is partly explained by the low water table in its vicinity. The driller reported a static water level of 163 feet below the land surface in November 1952.

The highest yield reported from a well drilled in the Hampshire formation is 57 gallons a minute, from an unused municipal supply well, Eb 2, at Oakland in the southwestern part of the county; the lowest yields reported are 1 gallon a minute from well Ag 23 and 1.5 gallons a minute from several wells, all in the northeastern part of the county. According to the driller's log, well Eb 2 encountered water-bearing sandstone beds at three horizons; the log reports a larger percentage of sandstone beds in the Hampshire formation than do most other logs. The specific capacity of well Eb 2 is 1.4 as compared with a specific capacity of only 0.1 for well Ag 23. Insufficient or inaccurate pumping-test data reported by drillers for some wells in the county made it impossible to evaluate the capacity of these wells and the aquifer from which they produce. They reported no drawdown occurred in some wells when they were pumped at rates of as much as 36 gallons a minute, which is hydraulically impossible. Other wells were reportedly pumped dry when pumped at a certain rate, but it was not established during the tests at what rate they would yield water without being pumped dry.

The wells that were inventoried in the Hampshire formation in the Deer

Park anticline are located along its west limb. The outcrop of the east limb is relatively narrow and is sparsely settled, and there springs are the main source of supply. The beds along the west limb dip from 5 degrees to 64 degrees to the west, and their general strike is N 32° E. Wells drilled a short distance from each other may be greatly different in depth, but often this is not because of a lateral change in geology between the wells but is due to variations in topography. Some areas have more relief and are better drained than others, and hence the water table is lower, requiring deeper wells; or wells near each other are at different elevations and reach the same water-bearing zone at different depths. Most of the wells drilled in the Hampshire formation in the Deer Park anticline are at vacation cabins along Deep Creek Lake. The water levels in these wells are approximately at the same altitude as the surface of the lake, so it is likely that the water in the near surface rocks of the Hampshire formation in the vicinity of the lake occurs under water-table conditions.

In the town of Accident, on the Accident dome, the yields of wells range from 5 to 40 gallons a minute and average 18 gallons a minute. However, in the Cove area, about 3 miles to the north on the Accident dome, considerable difficulty was experienced in obtaining a water supply for a public school. The first well (Bc 5) drilled for the school ended at a depth of 401 feet and yielded 7 or 8 gallons a minute. The driller reported that no water-bearing rocks were encountered below 225 feet. A second well was reported to be inadequate but no other information is available for this well. The third well (Bc 29) was successful, yielding 22 gallons a minute. Its depth is 600 feet.

Geologically the Accident and Cove areas are similar except for their differences in topography. Accident lies in a basinlike depression near the head of South Branch of Bear Creek and is bounded by hills on the east and west, whereas Cove is on a high, flat terrace that is deeply dissected on the east, west, and south by steep-sided stream valleys. Hence, the Cove area is much more thoroughly drained, and apparently deeper wells are required to obtain yields comparable to those obtained by shallower wells in the Accident area.

Springs in the Hampshire formation.—Six of the springs that were inventoried issue from rocks of the Hampshire formation on the Deer Park anticline. Spring Eb 17, about 3 miles south of Mountain Lake Park near the foot of the steep western slope of Little Mountain, in July 1951 had an estimated discharge of 4 gallons a minute. Springs Ag 12 and 13, near the northeastern corner of the county, are adjacent to surface streams and yield an adequate quantity of water for domestic use. The other springs also are used for domestic water supplies.

Six of the springs inventoried issue from rocks of the Hampshire formation on the Accident dome. The two best springs are Bc 2, with a flow of more than 4 gallons a minute, and Bc 24, which also has a moderately large flow. Both these springs are at the base of steep slopes in the Bear Creek valley, about 20 feet above stream level. Spring Bc 2 issues from joints and bedding-plane openings in blocky sandy shale along the east side of highway U. S. 219, about three-quarters of a mile south of Cove. The other springs are seepage or depression-type springs of small discharge.

MISSISSIPPIAN SYSTEM

POCONO FORMATION

Distribution and character.—The Pocono formation of Mississippian age crops out along the flanks of the Deer Park anticline as two parallel belts which vary between 0.25 and 0.75 mile in width, and as a band 1 to 3 miles wide encircling the Accident dome.

In outcrops, rocks of the Pocono formation are predominantly cross-bedded sandstones that are locally conglomeratic. Sandstones and sandy shales compose 80 percent and shales 20 percent of the formation. The olive-brown and yellowish-green color of the formation contrasts sharply with the reddish-brown color of the underlying Hampshire and overlying Greenbrier formations. The sandstones are extensively jointed and crossbedded and in places show a prominent porosity. The sandstone beds crop out along minor ridge tops under a thin soil covering. The formation is described on pages 23 to 34.

Water-bearing properties.—The Pocono formation is a source of water for both rural and municipal use. The water supply of Oakland, largest town in the county, is obtained from three wells and a spring in this formation. Ground water occurs in the Pocono formation under both artesian and water-table conditions. The steeply dipping permeable sandstone beds are ideal for artesian conditions, and several flowing wells and an artesian spring were observed. Of 21 logs of wells in the Pocono formation, 13 logs show that the wells obtain most of their water from sandstone and 9 logs show shale to be the main water-bearing material.

Records of 41 wells in the Pocono formation are available. They average 85 feet in depth, 13 gallons a minute in yield, and 0.8 gallon a minute per foot of drawndown in specific capacity.

Wells Db 12, 13, and 21, in the Oakland municipal well field, are the deepest producing wells in the Pocono formation in the county. Their depths are respectively 257, 254, and 250 feet. Wells Db 25 and 26 on Hoop Pole Ridge, about 5 miles northeast of Oakland, were drilled for domestic use to depths of 200 feet. Although only about 50 feet shallower, these are much poorer wells than those at Oakland, perhaps because of differences in topography and lithology. Drillers' logs of wells in the Oakland well field show sandstone beds form a large percentage of the Pocono formation, whereas the logs of wells Db 25 and 26 report only shale was encountered.

Yields of the wells range from 130 gallons a minute (Oakland public-supply well Db 12) to 1 gallon a minute or less in several wells drilled in the outcrop of the formation, mostly in the Accident area in the northwestern part of the county and in the northeastern part of the Deer Park anticline. Well Db 12 flows at a rate of about 45 gallons a minute. Specific capacities range from less than 0.1 in several wells to 4.0 in domestic well Cb 23, 4 miles southwest of Accident. Well Cb 23 is 150 feet deep and reportedly yielded 20 gallons a minute. According to the log, the well ends in 20 feet of dark sand, but most of the water was obtained from gray "slate" at depths of 60 to 90 feet.

Springs in the Pocono formation.—Thirteen springs that issue from rocks of the Pocono formation on the Deer Park anticline were inventoried. Most of the springs occur near the base of steep slopes or at a break in slope. Spring Ag 10, near the northeast corner of the county, is the spring number for a general area of seepage reportedly consisting of 30 or 40 separate springs near the western base of Big Savage Mountain. These springs furnish an important part of the water supply of the town of Frostburg (Allegany County). Springs Eb 33, 34, and 35, in the southwestern part of the county at the base of the steep westward slope of Backbone Mountain, are the source of supply for the public water systems of Loch Lynn Heights and Mountain Lake Park. A large number of small seepage-type springs are found near the main springs. Spring Db 16, known as Bradley Spring, furnishes part of the Oakland municipal water supply. It issues from the bottom of a narrow valley west of Oakland and probably is at or near the contact of the Pocono formation with the overlying Greenbrier formation. The water discharging from this spring is under artesian pressure. The discharge of the spring varies seasonally and at times is extremely small. It was reported that the spring did not flow in October 1951. Boiling Spring (Ec 1), about 2 miles southeast of Deer Park, is at the foot of the steep westward slope of Backbone Mountain. Its point of issue from the bedrock cannot be seen, for the slope is covered by talus. The water may be coming from the Pocono formation or from the contact between the Greenbrier and Pocono formations. The yield of this spring is large but could not be measured readily. The water is piped to Mountain Lake Park and bottled for use in the dining cars of the Baltimore and Ohio Railroad.

Eight of the springs inventoried issue from rocks of the Pocono formation on the Accident dome, in the northwestern part of the county. Most of them are depression-type springs of low flow. Spring Bc 19, 2.5 miles northeast of Accident, has perhaps the largest yield. It is impossible to estimate accurately the total discharge of the spring, but a part of it flows through a pipe and was measured at 2 gallons a minute.

Oakland public water supply.—The Oakland water supply is derived from shale and sandstone of the Pocono formation. The well field is in and near a broad valley flat along Bradley Run, to the west of Oakland. The rocks dip steeply to the west, and their outcropping edges form the high hills of Hoop

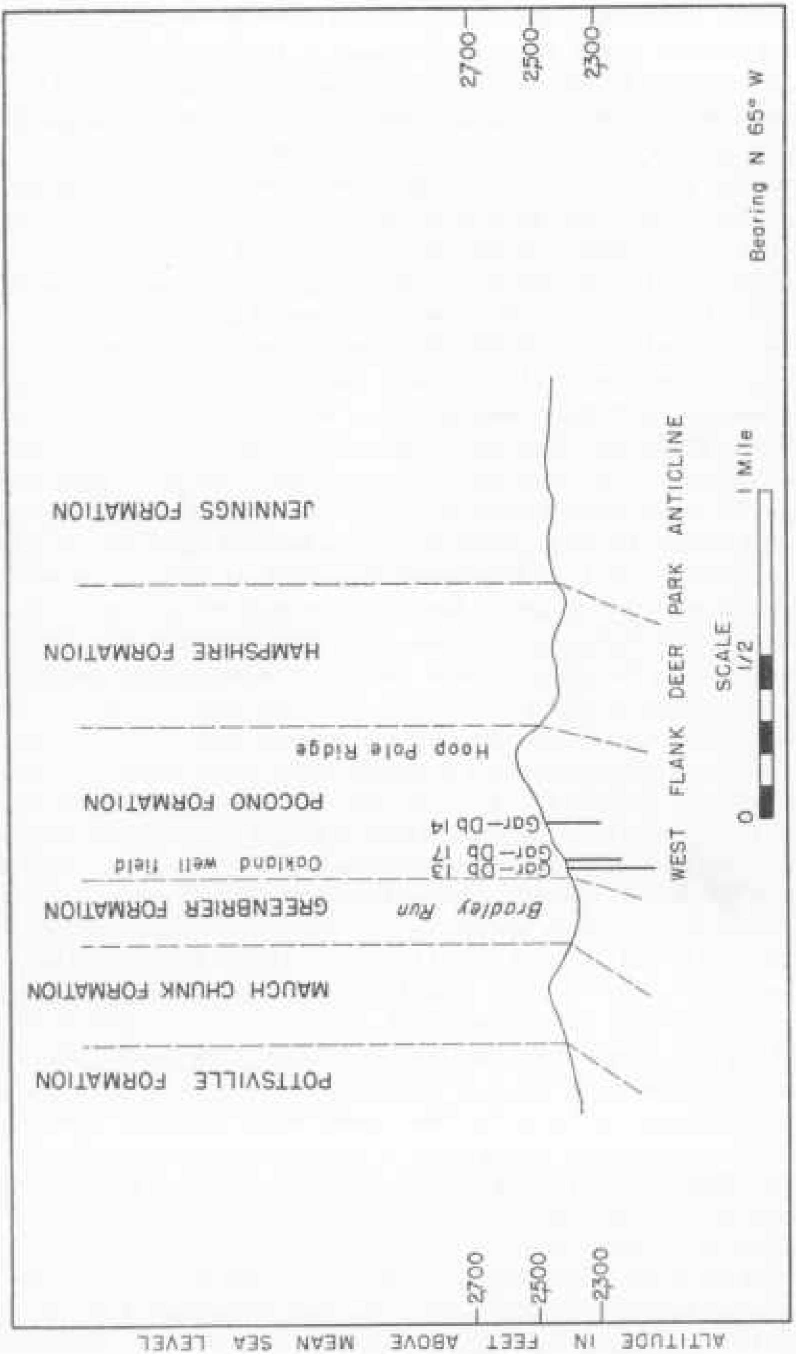

FIGURE 12. Profile section through Oakland municipal well field

Pole Ridge just east of the Bradley Run valley (fig. 12). Thus, the water-bearing zones penetrated by the wells probably crop out a short distance to the east of the valley, and the recharge to the aquifers probably is derived principally from precipitation on these outcrops. About 14 wells have been drilled for the public supply, but only 3 wells (Db 12, 13, and 14) are now used. As some of the wells are flowing wells, the water in the water-bearing zones is under artesian pressure. The yield of the wells and of Bradley spring fluctuates widely during the year owing to large fluctuation in the water table. The static water level in well Db 7, for example, was 62.45 feet below the land surface in December 1946 but was only 21.61 feet below the land surface in April 1947, a difference of 40.84 feet. The static water level in well Db 13 was reported to be 8 to 9 feet below the land surface in July or August of 1947, but the well was flowing in December 1947 with an estimated static level of 30 to 40 feet above the land surface. In this well, then, there was a rise in water level of 40 to 50 feet between July or August and December of 1947.

The large fluctuation of the water levels is probably due chiefly to a low storage capacity of the rocks beneath the outcrops and a large range in the rate of recharge. It is likely that the rate of recharge is considerably less during dry periods, causing a large decline in the water table, and the decrease in elevation of the water table on the outcrop causes a reduction in artesian head down the dip in the public-supply well field. Withdrawal of water from the public-supply wells causes additional decline in the artesian head. About 200,000 gallons of water is withdrawn daily from the wells and spring.

A brief test was run on well Db 13 in January 1948 to determine its specific capacity. This well is 254 feet deep and 6 inches in diameter, and is cased to a depth of 43.5 feet. The log shows alternating beds of sandstone and shale. The well had a flow of 29 gallons a minute on December 4, 1947. A centrifugal suction pump was installed on the well for the test to increase the discharge. The well was pumped at a rate of 50 gallons a minute and after 50 minutes the pumping level was 9.9 feet below the pump base. The discharge was increased to 60 gallons a minute and after 20 minutes the pumping level was 18.6 feet below the pump base. The discharge was then increased to 70–75 gallons a minute, the maximum rate that could be obtained with the 21 feet of suction pipe in the well. These rates of discharge and pumping levels indicate that the specific capacity of well Db 13 is about 1 to 1.5 gallons a minute per foot of drawdown for short periods of pumping. The specific capacity would likely be less during long periods of pumping. With a specific capacity of 1, a change in water level in the well of 40 feet due to a seasonal change in artesian head, such as measured in well Db 7 between December 1946 and April 1947, would represent a difference in the capacity of the well of about 40 gallons a minute.

GREENBRIER FORMATION

Distribution and character.—The Greenbrier formation of Mississippian age crops out in Garrett County as a series of narrow bands rimming the major anticlinal structures. On the east flank of the Deer Park anticline it is exposed along Big Savage Mountain from the Pennsylvania border on the north to the West Virginia border on the south. This Greenbrier outcrop belt is commonly from 0.1 to 0.3 mile wide, attaining a maximum of 0.5 mile near the Savage River dam site. On the west flank of the Deer Park anticline it is exposed along Meadow Mountain and on Hoop Pole Ridge where its outcrop belt ranges from 0.1 to 0.4 mile wide. A third outcrop belt rims the Accident dome in a band ranging from 0.1 to as much as 1.2 miles in width. The fourth and smallest area of outcrop is a few square miles west of Piney Mountain along the West Virginia State line.

The Greenbrier formation, because of its calcareous and shaly nature, breaks down easily under weathering. Exposures of undecomposed rock are rare. Outcrops are commonly seen only along deep gullies and in fresh road cuts. Lithologically, the formation consists of red and green shales, limestones, sandy limestones, and rather thin platy sandstones or siltstones. The formation is described on pages 34 to 44.

Although composed predominantly of shaly or sandy limestones, locally the formation contains thicker, purer limestone beds; one of these, the Loyalhanna member, is well developed at Thayerville and at the Savage River dam site. At John Friends Cave near Sang Run and at a sinkhole near Ginseng Run extensive solution cavities have been developed in limestone layers (Davies, 1950).

Water-bearing properties.—Because of its limited area of outcrop the Greenbrier formation is not an important aquifer in Garrett County. It is tapped by a number of domestic and farm wells, of which 16 were inventoried. The depths of these wells range from less than 50 feet to about 200 feet and average 91 feet. The yields of the wells range from 1 to 20 gallons per minute and average 14 gallons. The four best wells, Cc 3, Cb 4, Cb 15, and Cb 19, all of which yield 20 gallons a minute, are on the shores of Deep Creek Lake. The depths of these wells range from 72 to 100 feet. One of them, well Cb 15 near McHenry, yields water from an 8-foot limestone bed near the bottom of the well. However, the water-bearing zone in well Cc 3, located a few miles south of Cb 15, is a 55-foot bed of "red rock" or red shale. The driller of well Cb 19, also near McHenry, reported that the water-bearing zone is gray slate at a depth of 50 feet. Therefore, beds of varying lithology in the Greenbrier formation are capable of yielding water to wells. The comparatively high yield of many of the domestic wells near Deep Creek Lake may be due largely to the infiltration of water from the lake into the pervious strata penetrated by the wells. The reported specific capacities of nine wells tapping the Greenbrier formation range from 0.1 to

2.0 gallons per minute per foot of drawdown. The average specific capacity of these nine wells is 0.9, which is of limited significance because of their small number.

Springs in the Greenbrier formation.—Only two springs issuing from the Greenbrier formation in Garrett County were inventoried. One of these, spring Ad 8, is along the roadside a few miles west of Grantsville on the steep east slope of Meadow Mountain. In August 1951 part of the flow of this spring was at a rate of 4 gallons per minute.

The other spring, Cb 27, a little more than a mile west of McHenry, is used for domestic water supply, although it is hardly more than a trickle. The water issues from an exposure of limestone. In August 1951 it had a flow of only 0.25 gallon a minute.

MAUCH CHUNK FORMATION

Distribution and Character.—The Mauch Chunk formation of Mississippian age crops out as a narrow band along both the east and west flanks of the Deer Park anticline and around the rim of the Accident dome. The belt of outcrop essentially parallels that of the underlying Greenbrier formation, but is a little wider. Along the limbs of the Deer Park anticline, the width ranges from 0.1 to 0.9 mile. The outcrop belt is more than a mile wide in places at the south end of the Accident dome east of Piney Mountain and along the shores of Deep Creek Lake. The formation is exposed also in an irregular belt west of Piney Mountain along the valley of Salt Block Run and Muddy Creek near the West Virginia border.

Lithologically the formation is somewhat variable, consisting of brown to greenish-brown fine-grained micaceous sandstone and reddish and greenish shale. The sandstone is typically thin bedded and is rarely coarse grained. The shales weather to a reddish-brown color, similar to that of soils derived from the rocks of the Hampshire formation. The formation is described on pages 44 to 45.

Water-bearing properties.—Seventeen wells in the Mauch Chunk formation were inventoried. They range in depth from 40 to 250 feet and average 88 feet. The reported yields range from 5 to 24 gallons a minute and average 15 gallons. One of the best wells, Cb 7, about a mile south of McHenry on the shores of Deep Creek Lake, is a 6-inch well 75 feet deep, in which the water-bearing zone is red shale penetrated about 5 feet below the top of the hole. Two other wells of comparatively high yields, Cb 4 and Cb 5, are located in the same vicinity along the shore of Deep Creek Lake. The wells are 85 and 70 feet deep, respectively, and both reported to yield 20 gallons a minute. No log is available for well Cb 4, but the driller's log of well Cb 5 indicates the water is obtained from a 25-foot zone of "red rock" encountered at a depth of 45 feet. In general, the best wells tapping the Mauch Chunk formation are located adjacent to Deep

Creek Lake, and it is likely that their comparatively high yields are due in part to the infiltration of lake water into the formation through joints and along bedding planes. It is probable that the formation, where it is tapped by wells in localities distant from bodies of surface water, is a poor aquifer chiefly because of its shaly character.

Springs in the Mauch Chunk formation.—Eight springs were inventoried which issue from the Mauch Chunk formation in Garrett County. The measured or estimated discharge of four of them ranged from less than 0.5 to 5 gallons a minute.

The best spring, Bb 3, is a few miles east of Friendsville in the Youghiogheny River valley. In August 1950 this spring had an estimated flow of 5 gallons a minute from crevices and bedding planes in the Mauch Chunk formation. However, a measurement of its flow in September 1952 showed that its discharge had declined to less than 2 gallons a minute. The flow of many of the small springs of the county fluctuates widely, and a few of the springs issuing from the Mauch Chunk were reported to have stopped flowing completely during the drought of 1930.

Pennsylvanian System

POTTSVILLE FORMATION

Distribution and character.—The Pottsville formation of Pennsylvanian age is widely distributed at the surface throughout Garrett County. It is the basal formation of the coal measures and crops out as a more or less regular band around the edges of the coal basins, and along a broad irregular area in the so-called "cross structure" between the Upper and Lower Youghiogheny basins.

The sediments composing the lower part of the formation are chiefly massive sandstones and conglomerates. These beds grade upward into shales, thin sandstones, sandy shales, fire clays, and coal beds.

The diamond-drill cores of the U. S. Bureau of Mines show that in the Castleman basin the Pottsville formation consists of 44 percent shale and 56 percent sandstone and sandy shale. In the Georges Creek basin the Pottsville consists of 32 percent shale and 68 percent sandstone. The formation is described on pages 52 to 53.

The basal sandstone of the formation commonly forms a pronounced ridge along its area of outcrop. There it is much fractured and jointed. Commonly, large blocks of the sandstone break away from the main exposures and are found as slump material as far as half a mile from their point of origin. Locally, the sandstone is soft, friable, and porous.

Water-Bearing properties.—As only a few wells have been drilled into the Pottsville formation in Garrett County, data concerning its water-bearing properties are scarce. However, as the Pottsville formation consists largely of thick, fractured, and permeable sandstones, it is believed to be a fairly good aquifer. The structural position of the beds, outcropping as they do in the highest ridges and dipping down into the coal basins, provides favorable conditions for the storage and transmission of ground water to wells downslope from the ridgetops. Five wells ending in the Pottsville formation in Garrett County range in yield from 20 to 200 gallons a minute and average about 38 gallons a minute. One of these, well Ad 1 near Grantsville, is a flowing well 300 feet deep which has a reported yield of 45 gallons a minute. The overflow ditch from this well is heavily coated with iron oxide, indicating the high iron content of water from the formation at this locality.

Well Da 9 at the Swallow Falls State Park, drilled to a depth of 200 feet, was abandoned because of the poor quality of the water. Well Da 10, about 200 feet from Da 9, was completed at the same depth and reportedly yielded 200 gallons a minute. This water also is high in iron and is treated before use.

Well Dd 6, east of Swanton, yields 20 gallons a minute and is about 55 feet deep. The water from this well also is high in iron content.

Well Dd 3, near East Vindex, is 315 feet deep and reportedly yields 40 gallons a minute. Apparently most of the water is derived from about 25 feet of sandstone at the base of the well.

Springs in the Pottsville formation.—In the outcrop area of the Allegheny and Pottsville formations in the Castleman basin 12 springs were inventoried. The largest of these, spring Cc 13 located near Rock House on Cherry Glade Road, flowed about 10 gallons a minute at the time of inspection. The point of issue of Cc 13 from bedrock is covered, but is believed to be close to, if not at, the contact of the Pottsville with the underlying Mauch Chunk formation. As both the rock strata and the slope of the hill incline eastward, it is likely that the recharge area of the spring lies some distance upgradient to the west. In general, the geologie and hydrologic situation is similar to that of the Friendsville springs described on this page.

Many of the springs in the Castleman basin lie along the eastern slope of Negro Mountain. The rock strata here dip eastward at a greater angle than the slope of the hillside. One of these springs, Ad 13, furnishes most of the water for the Grantsville municipal supply. Another of these springs is Ad 3.

Spring Ad 2, about half a mile east of spring Ad 3, had a flow of about 2 gallons a minute at the time of inspection. Although it flows perennially it was not possible to measure the flow of spring Ad 14. Springs Bd 5 and Bd 7, at about the horizon of the Upper Freeport coal, presumably discharge a small amount of ground water from fractures in the coal.

Along the west slope of Winding Ridge in the Lower Youghiogheny basin, three springs issue from the Pottsville formation. These springs reportedly flow 30,000 to 50,000 gallons a day and are the chief source of water for the town of Friendsville. The recharge area for the Friendsville supply is believed to be fractured and permeable sandstone and conglomerate of the Pottsville which crop out along the ridge top.

Springs Cc 14 and Cc 17 are in the vicinity of the "glades" or upland swamps. Spring Cc 14 flowed about 3 gallons a minute in August 1951. The discharge from spring Cc 17 is even less. The glades constitute large poorly drained spring zones which exist where the water table lies at or coincides with the land surface. During extensive drought periods the glades may temporarily dry up owing to a lowering of the water table below the land surface.

In the Upper Potomac basin four springs were inventoried which issue from the Pottsville and Allegheny formations. Three of them (springs Fa 8, Fa 9, and Fb 2) are on the upper part of Backbone Mountain a few miles west of Redhouse. Although these springs have a moderately large sustained flow, their collecting area is not extensive. The fourth spring, Db 1, is a small seepage spring in the Potomac State Forest south of the Savage River dam site.

ALLEGHENY FORMATION

Distribution and character.—In Garrett County the Allegheny formation is not readily separable from the underlying Pottsville. It crops out in a rather narrow band along the west edge of the Georges Creek and Upper Potomac synclinal basins and around the rim of the Castleman basin. In the Youghiogheny basin it crops out as a broad irregularly shaped band trending southwest from the Pennsylvania line along Piney Mountain and southward along Roman Nose and Snaggy Mountains.

Lithologically, the formation resembles the upper part of the Pottsville formation but is less sandy. Diamond-drill logs (Waagé, 1950, and Toenges and others, 1949) show that in the Castleman basin the formation is 45 percent sandstone and sandy shale and 55 percent shale, in the Upper Potomac basin 49 percent sandstone and sandy shale and 51 percent clay and shale, and in the Georges Creek basin 56 percent sandstone and sandy shale and 44 percent clay. The sand is commonly fine grained. Lateral variation in the lithology of the beds and the absence of persistent coals are characteristic. The formation is described on pages 52 to 53. Figure 13 is a generalized section of the Allegheny formation in Garrett County.

Water-bearing properties.—Castleman basin.—Five wells are known to yield water from the Allegheny formation in the Castleman basin. Their depths range from 46 feet in well Cc 19 to 90 feet in well Ad 7. Average of their depths is 72 feet. Their yields range from 6 to 20 gallons and average 13 gallons a minute. Their specific capacities range from 0.4 to 3.0 gallons per foot. The best well, Bd 10, is 86 feet deep and yields water from dark-colored shale in the lower part of the well. The drillers logs indicate that in three wells the water-bearing zones are shale, slate, and coal. One well obtains water from a sandstone. Wells Ad 7 and Ad 8, west of Grantsville, yield water from slate and coal layers, re-

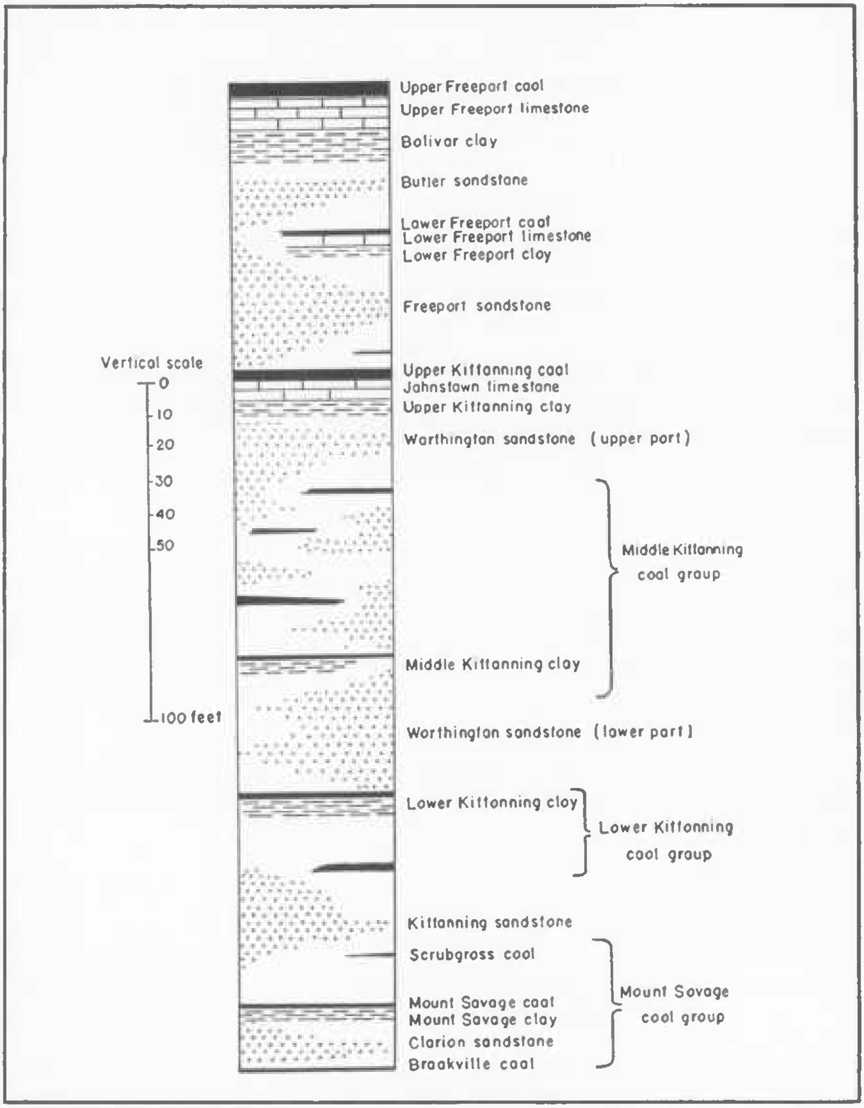

FIGURE 13. Generalized section of the Allegheny formation in Garrett County (after Waagé, 1950)

spectively. Well Cd 13, a few miles south of Bittinger, yields about 10 gallons a minute from a 2-foot coal seam, presumably the Upper Freeport coal. Some water is reported also from 12 feet of gray shale underlying the coal.

Artesian flows of water are reported from the Allegheny formation in the diamond-drill logs of five holes in the Castleman basin (Toenges and others, 1952). In one of these holes, 7-CB, 2 miles south of Jennings, the water-bearing zone is a fine- to medium-grained sandstone which lies, stratigraphically, about 106 feet below the Middle Kittanning coal. Part of the log of this hole is:

	Thickness		Depth	
	Ft.	In.	Ft.	In.
			393	6
Light gray siltstone	2	3	395	9
Interbedded siltstone and fine sandstone	10	1	405	10
Light gray siltstone and fine sandstone	9	10	415	8
Fine to medium stylolitic sandstone (artesian water flow)	14	8	430	4
Interbedded siltstone and fine sandstone	1	4	431	8

In hole 11-CB, on the east flank of the Castleman basin near Bittinger, a 23-foot water-bearing sandstone was reported in the Allegheny formation at a depth of 438 feet. Part of the log of this hole is:

	Thickness		Depth	
	Ft.	In.	Ft.	In.
			431	5
Coal		5	431	10
Bone		2	432	0
Tan, silty, shaly claystone, plant fossils	3	5	435	5
Interbedded siltstone and fine sandstone	3	1	438	6
Fine to medium sandstone, stylolitic (artesian water flow)	23	0	461	6
Gray siltstone, plant fossils	20	4	481	10
Gray, silty claystone, grading to shaly siltstone	11	8	493	6

An artesian flow of water was obtained in hole 20-CB, about 1.5 miles southeast of Jennings, from a 54-foot sandstone at a depth of 209 feet. Part of the log of this hole is:

	Thickness		Depth	
	Ft.	In.	Ft.	In.
Bottom of a Middle Kittanning coal			183	1
Bone		2	183	3
Tan claystone and silty semi-plastic clay	6	9	190	0
Light and tan fragmental plastic clay siderite pebbles in lower 6 in.	1	4	191	4
Tan claystone and silty, semi-plastic clay	3	0	194	4
Fragmental tan plastic and semi-flint clay		5	194	9
Interbedded siltstone and fine sandstone, tan silty claystone, and silty, semi-plastic clay	14	3	209	0
Medium stylolitic sandstone (artesian water flow)	54	1	263	1
Brown, silty claystone	8	11	272	0
Interbedded siltstone and fine sandstone	19	0	291	0
Carbonaceous shale		8	291	8
Mount Savage coal	1	6	293	2

Water flowed from a 16-foot coarse conglomeratic sandstone encountered at a depth of 395 feet in hole 37-CB, 1 mile south of Grantsville on the axis of the Castleman syncline. The water-bearing zone is 13 feet below the base of the

Lower Freeport coal, or about 50 to 60 feet below the top of the formation. Part of the log of this hole is:

	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
Bottom of Lower Freeport coal			382	0
Gray claystone and siltstone	7	0	389	0
Interbedded siltstone and fine sandstone	6	4	395	4
Coarse to conglomeratic sandstone (artesian water flow)	16	4	411	8
Upper Kittanning coal	1	9	413	5

A flow of water was obtained from the same water-bearing sandstone in hole 40-CB, 1 mile east of Grantsville. There the 16-foot sand immediately overlies the Upper Kittanning coal at a depth of 363 feet. Part of the log of this hole is:

	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
			338	5
Carbonaceous shale and bone		6	338	11
Interbedded siltstone and fine sandstone	24	5	363	4
Coarse stylolitic sandstone, conglomeratic (artesian water flow)	16	8	380	0
Upper Kittanning coal		2	380	2

Upper Potomac basin.—Three wells were inventoried in the Upper Potomac basin which yield water from the Allegheny formation. They are wells Dd 1, De 8, and Eb 25 which yield 6 to 10 gallons a minute and range in depth from 45 to 120 feet. They are on the steeply dissected east slope of Backbone Mountain on the west flank of the syncline.

An artesian flow of water was reported from a 15-foot sandstone in the Allegheny formation at a depth of 503 feet in diamond-drill hole 3-GC in the Georges Creek-Upper Potomac syncline (Toenges and others, 1949); hole 3-GC is 2.5 miles north of the town of Barton. Part of the log of this hole is:

	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
			432	7
Hard, silty, calcareous clay		10	433	5
Clayey siltstone	2	7	436	0
Clayey sandstone	4	4	440	4
Shaly claystone	4	10	445	2
Interbedded sandstone and siltstone	50	2	495	4
Sandstone	6	10	502	2
Carbonaceous shale, shale conglomerate	1	4	503	6
Medium, hackled sandstone (water at 505 ft., 150 gallons a minute)	15	9	519	3
Carbonaceous clayey shale	6	2	525	5
Lower Kittanning coal		5	525	10

Upper and Lower Youghiogheny basins.—Water-bearing strata in the Allegheny formation yield water to only six wells inventoried in the Upper and Lower Youghiogheny basins. These wells, Ab 1, Bb 2, Bb 4, Da 15, Ea 11, and

Ea 15, range in depth from 41 to 115 feet and average about 66 feet. Their yields range from 5 gallons to 40 gallons a minute; the average yield of the six wells is 16 gallons a minute, which is slightly more than the average yield of 13 gallons a minute reported from the wells ending in the formation in the Castleman basin. Specific capacities of the five wells range from 0.3 to 2.5 and average 1.0 gallon per minute per foot of drawdown.

The best well, Bb 2 at Friendsville, is only 50 feet deep and has a reported yield of 40 gallons a minute with a reported specific capacity of 2.5 gallons per foot of drawdown. The water-bearing zone in well Bb 2 is reported to be 23 feet of black slate and gray sandstone between the depths of 22 to 45 feet.

Well Bb 4, also at Friendsville, is only 41 feet deep and reportedly yields 21 gallons a minute from black slate encountered at a depth of 30 feet. This well is in the valley of the Youghiogheny River and may derive a large part of its water through infiltration from the nearby surface stream.

Summary.—The water-bearing properties of the Allegheny formation in the various synclines are briefly summarized, on the basis of the existing well data, in Table 15.

TABLE 15

Summary of Yields and Specific Capacities of Wells Tapping the Allegheny Formation in the Synclinal Basins in Garrett County

Basin	Number of wells	Average yield (gallons a minute)	Average specific capacity
Castleman	5	13	—
Upper Potomac	3	8	0.3
Upper and Lower Youghiogheny	6	16	1.0

CONEMAUGH FORMATION

Distribution and Character.—Rocks of the Conemaugh formation of Pennsylvanian age occupy the central areas of the coal basins in Garrett County and cover a wider area of outcrop than the other formations of that age. The formation consists of a variety of lithologic types including siltstone, sandstone, coal, shale, and underclay. The stratigraphic and structural relations of the Conemaugh formation to the underlying Allegheny and Pottsville formations in the Castleman basin are shown in Figures 14 and 15.

Lower member of the Conemaugh formation

Lithology and thickness.—The lower member of the Conemaugh formation consists of about 450 to 500 feet of beds of shale, sandy shale, siltstone, calcareous shale, clay, red beds, sandstone, and coal. Bureau of Mines diamond-drill cores show that in the Castleman basin it consists of 22 percent sandstone and sandy shale and 78 percent clay and shale, in the Georges Creek basin of 29

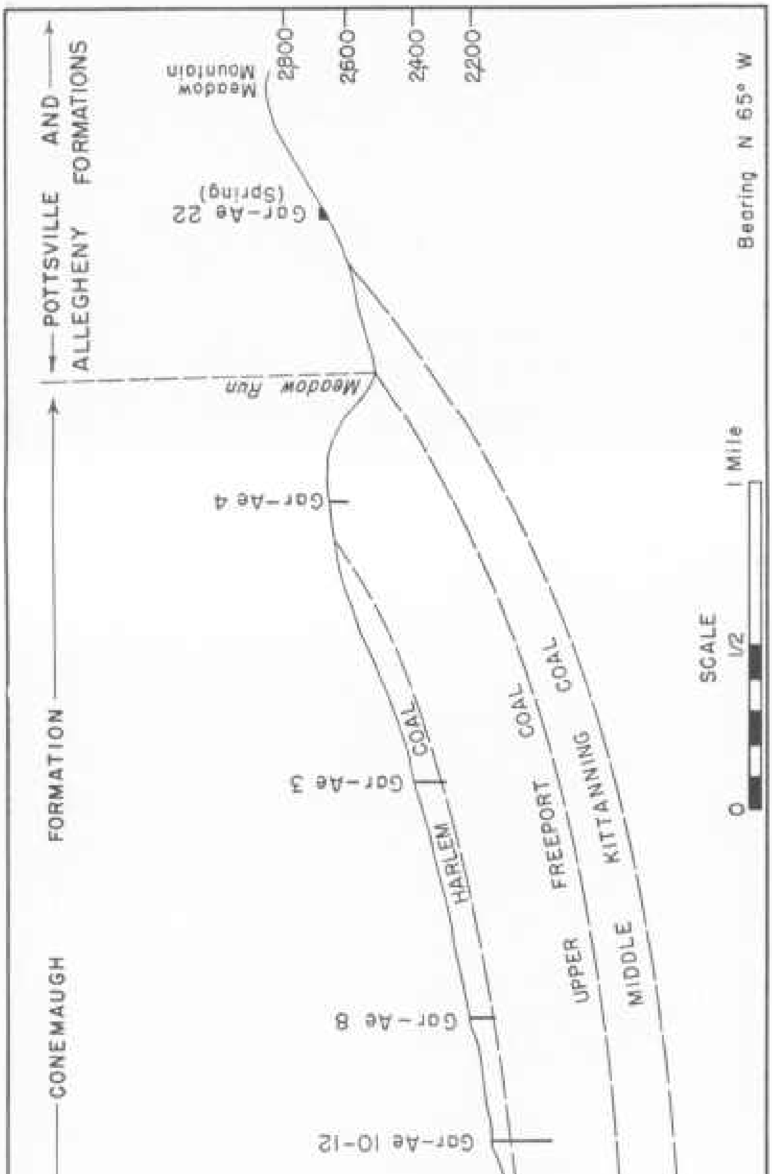

FIGURE 14. Profile section across the Casselman basin from the Casselman River to Meadow Mountain

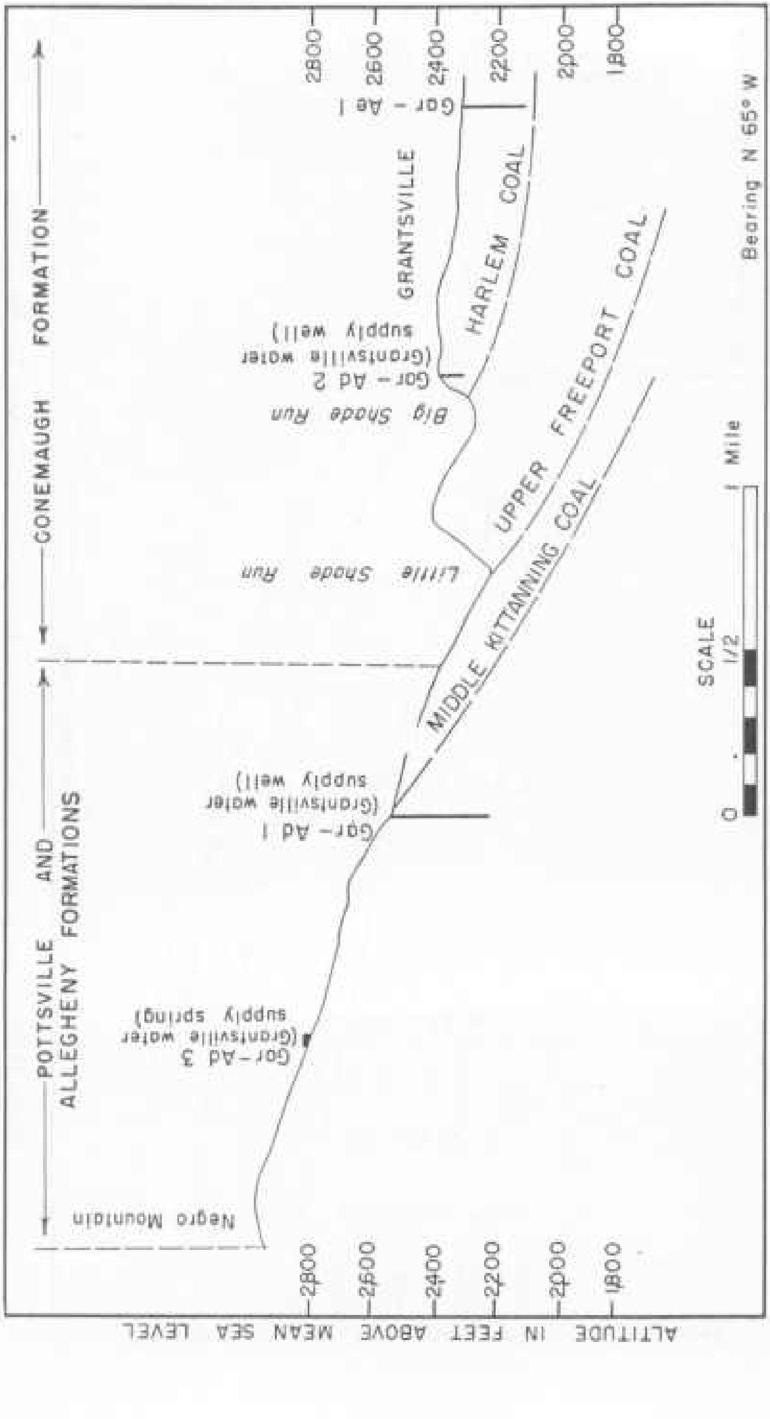

FIGURE 15. Profile section across the Castleman basin from Negro Mountain to Grantsville

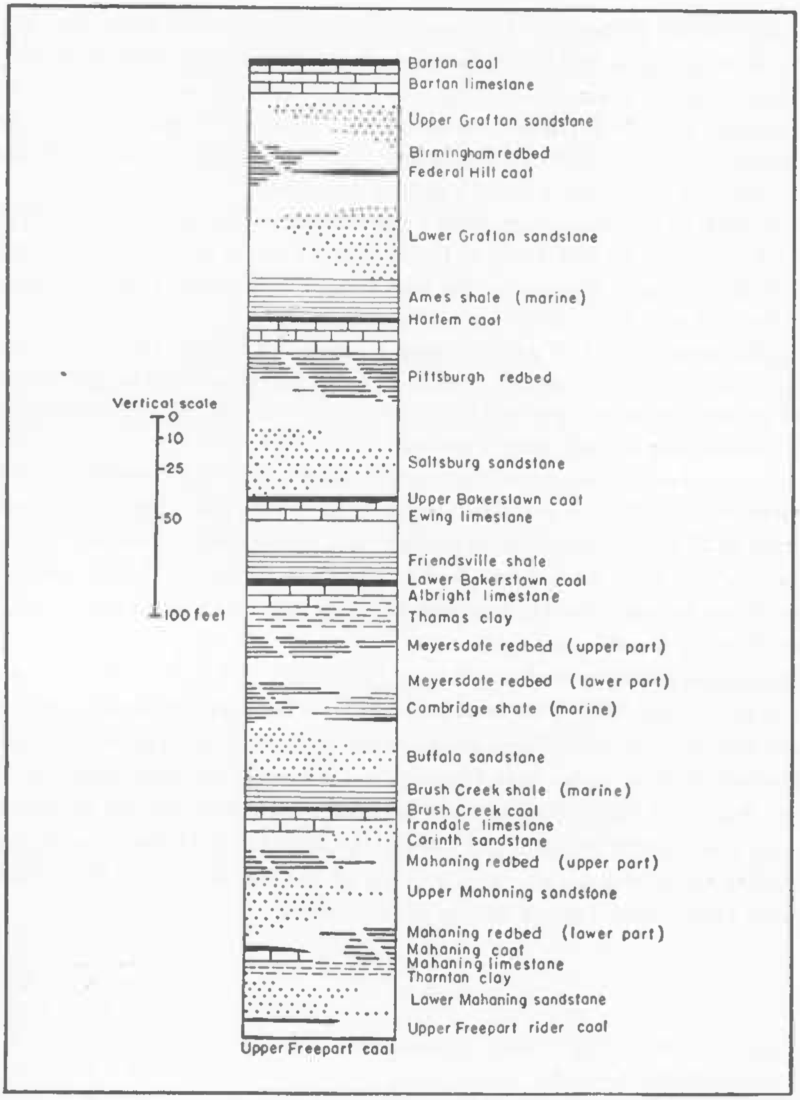

FIGURE 16. Generalized section of the lower member of the Conemaugh formation in Garrett County (after Waagé, 1950)

percent sandstone and sandy shale and 71 percent clay and shale, and in the Upper Potomac basin of 36 percent sandstone and sandy shale and 64 percent shale.

The major lithologic units in the member are shown in figure 16. It is described on pages 53 to 64.

Water-bearing properties.—Castleman basin.—Twenty-six wells are known to yield water from the lower member of the Conemaugh formation in the Castleman basin. Their depths range from 43 to 250 feet and average 97 feet. The deepest well, Ae 12, drilled for the Garrett County Cooperative, Inc., near Grantsville, ends in a 28-foot "soapstone" bed 43 feet below the Lower Bakerstown coal and reportedly yields 75 gallons a minute.

The yields of the wells range from 4 gallons (Ae 8 near Grantsville) to 75 gallons a minute (Ae 10 and Ae 12 at Grantsville). Four of the best wells average 16 gallons a minute. In general, the best yields are obtained from the deepest wells located near the axis of the synclinal basin.

Specific capacities of 19 wells average 1.7 gallons a minute per foot of drawdown. The drillers of six wells in which reported pumping rates ranged from 20 to 60 gallons a minute reported that there was no drawdown, which means that the pumping was of very short duration.

The water-bearing zones are distributed rather uniformly through the lower member from the Barton coal down to the Brush Creek coal. The water-bearing stratum in 25 wells is reported to be shale and in one well, to be coal.

Eight wells, Ac 1, Ae 3, Ae 5, Ae 14, Ae 17, Ae 19, Ae 23, Ae 24, ending in strata lying between the Harlem and Barton coals, have an average yield of approximately 9 gallons a minute.

The largest yields were obtained from eight wells, Ad 5, Ae 4, Ae 10, Ae 12, Ae 13, Bc 18, and Bd 8, which end in strata lying between the Brush Creek and Lower Bakerstown coals. These wells yielded an average of 30 gallons a minute.

Artesian flows of water were reported in the Castleman basin from the logs of two Bureau of Mines diamond-drill holes (Toenges, 1952, pp. 42, 43, and 90). Ground water under artesian head was encountered in a 14-foot zone of interbedded siltstone and sandstone at a depth of 224 feet in hole 6-CB, 2.5 miles south of Grantsville. Part of the log of this hole is:

	Thickness		*Depth*	
	Ft.	*In.*	*Ft.*	*In.*
			218	9
Dark gray siltstone grading to shaly claystone, plant fossils	5	10	224	7
Gray claystone, limy inclusions	5	1	229	8
Interbedded siltstone and fine sandstone (artesian water flow)	14	0	243	8
Gray, silty claystone grading to shaly claystone	17	6	261	2
Dark gray, shaly claystone grading to black, carbonaceous clay, marine fossils	22	1	283	3
Brush Creek coal		7	283	10

An artesian flow of water was encountered in a sandstone bed, 32 feet thick, at a depth of 340 feet in hole 34-CB, one mile south of Grantsville. The top of the sandstone lies about 60 feet above the Upper Freeport coal. Part of the log of this hole is:

	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
			321	6
Green, silty claystone, sandy streaks	13	10	335	4
Fragmental tan claystone, silty claystone and tan, semiflint clay, quartz streaks in lower foot	4	9	340	1
Medium sandstone (artesian water flow)	32	7	372	8
Silty, shaly, claystone, plant fossils	12	11	385	7
Interbedded siltstone and fine sandstone, plant fossils	7	11	393	6
Gray to black, shaly clay	6	10	400	4
Upper Freeport coal		11	401	3

Upper Potomac basin.—The depths of 13 wells ending in the lower member of the Conemaugh formation in the Upper Potomac basin range from 33 to 205 feet and average 85 feet, a little less than for the wells ending in this unit in the Castleman basin. The deepest well, Fb 11, near Gorman, yields 2 gallons a minute from a sandstone encountered at a depth of 180 feet.

The yields of the wells range from 2 to 8 gallons a minute and average 5 gallons a minute. The low average yield of the wells in the Upper Potomac basin may be due, in part, to many of the wells inventoried being domestic wells, which were not tested for their maximum yield. The specific capacities of the wells average 0.5 gallon a minute per foot of drawdown. Two wells have specific capacities of less than 0.1.

The drillers' logs show that shale yields water in seven wells, sandstone in four wells, and coal in one. All the wells are on the west limb of the Upper Potomac syncline. Six obtain water from strata between the Barton and Harlem coals; four produce from strata between the Harlem and Lower Bakerstown coals.

An artesian flow of water (25 gallons a minute) is reported from an 8-foot sandstone at a depth of 220 feet in the log of diamond-drill hole 5-GC (Toenges, 1949). This hole is on Koontz Run 2.0 miles northwest of the town of Lonaconing along the west flank of the syncline. Part of the log of this hole is:

	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
			198	0
Siltstone	8		206	0
Interbedded sandstone and siltstone	10	2	216	2
Medium sandstone (water at 200 ft.; flowed 25 gals. a minute)	7	10	224	0
Silty, shaly clay	12	9	236	9
Fossiliferous, dark shale	11	2	247	11
Carbonaceous shale, coal streaks		5	248	4
Silty clay shale	12	7	260	11
Carbonaceous shale, coal partings	4	8	265	7
Harlem coal		10	266	5

A flow of water under artesian head is reported in the log of hole 21-GC, on the west flank of the Upper Potomac syncline, 1.3 miles northwest of Frostburg (in Allegany County). The water issues from a 22-foot conglomeratic sandstone encountered at a depth of 490 feet. This sandstone is probably the Buffalo sandstone of Waagé (1950, p. 34). At one time the water discharging from this hole was piped to the Frostburg municipal water system.

Upper and Lower Youghiogheny basins.—The depths of 18 wells ending in the lower member of the Conemaugh formation in the Upper and Lower Youghiogheny basins range from 42 to 86 feet and average 58 feet. The deepest well, Eb 26, 3 miles southeast of Loch Lynn Heights, reportedly yields 5 gallons a minute from sandstone near the bottom of the well.

The yields of the wells range from 5 to 22 gallons a minute and average 13 gallons a minute. Specific capacities of the wells range from 0.2 to 6.6 and average 2.3. The best well, Ba 1, only 70 feet deep, is a few miles west of Friendsville in the northwestern part of the County. The water is obtained from a 25-foot layer of "soapstone" penetrated at a depth of 26.5 feet.

Eight of the wells inventoried are near the axis of the syncline; six are on the west limb; and two are on the east limb. The stratigraphic intervals in which the water-bearing zones were encountered are between the Harlem and Lower Bakerstown coals in 11 wells, and between the Barton and the Harlem coals in 4 wells.

Summary.—The water-bearing properties of the lower member of the Conemaugh formation in the synclinal basins are shown in Table 16 based on the yields and specific capacities reported by the drillers.

TABLE 16

Summary of Yields and Specific Capacities of Wells Ending in the Lower Member of the Conemaugh Formation in the Synclinal Basins

Basin	Number of wells	Average yield (gallons a minute)	Average specific capacity
Castleman	23	20	1.7
Upper Potomac	13	5	.5
Upper and Lower Youghiogheny	18	13	2.3

Springs in the lower member.—Of the more than twenty springs inventoried which issue from the lower member of the Conemaugh formation, none had measured flows of more than 5 gallons a minute, at the time of measurement. Of thirteen springs in the Upper Potomac basin, spring Eb 20 was the best. This spring, about 2.5 miles south of Loch Lynn Heights, had a discharge of about 5 gallons a minute in July 1951. It lies along the east slope of Backbone Mountain and the water apparently issues from the Lower Bakerstown coal.

An excellent spring, Da 11, is used at the Herrington Manor State Park in the Upper Youghiogheny basin. The water is piped to the bathhouses and the lower picnic grounds. The source of the water is probably parting planes in the Harlem coal.

Spring Bc 17, near Bittinger, one of the better springs in the Castleman basin, had a measured flow of 4 gallons a minute in June 1951. The source of the water is probably the Lower Bakerstown coal.

Upper member of the Conemaugh formation

Lithology and thickness.—The upper member of the Conemaugh formation consists of about 400 to 450 feet of sandstone, shale, shaly sandstone, underclay, siltstone, red beds, and coal. The member is described on pages 64 to 65.

Water-bearing properties.—Only five wells were inventoried in Garrett County which end in the upper member of the Conemaugh formation; all are in the Castleman basin. The wells range in depth from 54 to 80 feet and average 66 feet. The yields range from 6 to 11 gallons a minute and average 8 gallons. Specific capacities, as reported by the drillers, are between 0.1 and 1.6. The drillers' logs show that the water-bearing zones are shale.

Water under artesian head is reported to flow from the upper member in diamond-drill hole 21-GC, in the Upper Potomac basin 1.3 miles northwest of Frostburg. The water is from a 1.5-foot laminated sandstone about 49 feet above the Barton coal. This hole also yielded an artesian flow in the lower member. Part of the log showing the upper member is:

	Thickness		Depth	
	Ft.	In.	Ft.	In.
			468	0
Gray, silty claystone and silty clay	5	0	473	0
Black to carbonaceous shale, plant remains	2	8	475	8
Gray siltstone, minor silty claystone	4	8	480	4
Fine gray sandstone, some siltstone	9	8	490	0
Coarse white conglomeratic sandstone (water flow)	22	6	512	6
Carbonaceous shale, pyritized fossils	1	0	513	6
Brush Creek coal		2.5	513	8.5

Springs in the upper member.—Two springs were inventoried which issue from the upper member of the Conemaugh formation. One of these, Ae 6, is north of Grantsville at the base of a long slope. Its flow was estimated at 2 to 3 gallons a minute in August 1950.

Spring Ae 20, a few miles south of Ae 6, has been used as a source of domestic supply since 1905. It is reported to cease flowing during dry summers.

MONONGAHELA FORMATION

Distribution, character, and water-bearing properties.—The Monongahela formation of Pennsylvanian age is present in only a few square miles in the hilltops in the Georges Creek-Upper Potomac basin in eastern Garrett County. The unit consists of about 240 to 270 feet of sandstone, shale, siltstone, limestone, and coal. It crops out in the Phoenix and Franklin Hills east of the crest of Big Savage Mountain. As a result of extensive mining of the Pittsburgh coal seam at its base, the hills composed of it are well drained, and it is an unimportant aquifer. In Garrett County no use has been made of the formation as a source of water for either drilled or dug wells.

QUATERNARY SYSTEM

DEPOSITS OF PLEISTOCENE AND RECENT AGE

Distribution and character.—As the Pleistocene deposits are not readily separable from the deposits of Recent age, they are considered as one in this report. The Pleistocene and Recent deposits consist of slide rock, alluvium, stream-terrace sand and gravel, and organic peaty material in the swamps or "glades." Generally, the Recent alluvium is found along the major stream valleys, but the deposits are of only minor importance in Garrett County.

Martin (1902, p. 146) describes a terrace deposit in the valley of the Castleman River a few miles south of Grantsville. This terrace is at an elevation of about 2,200 feet above sea level and is underlain by about 20 feet of well-stratified sand and sticky blue clay. The sand and clay contain rounded quartz pebbles and rolled crusts of limonite. A similar terrace deposit is in the valley of the Youghiogheny River north of Friendsville.

Although few data are available concerning the nature of these deposits in Garrett County, they are described by Piper (1933, p. 112) for adjacent counties in southwestern Pennsylvania where they are utilized as a source of ground water by several towns. His description of the deposits follows:

> "The alluvium of the Monongahela valley is made up entirely of local debris from the Carboniferous sandstones and shales; the denser and more resistant sandstones form the larger particles, which are in part rather well-rounded, and the more abundant shales yield silt and clay. In the vicinity of McKeesport and Clairton the alluvium is made up of alternating beds of sand and clay or of massive gritty clay to a depth of 40 feet below the flood plain."

Thickness and stratigraphic relations.—The thickness of the deposits varies from place to place, but is generally in the range of 5 to 50 feet. The deposits are commonly irregular in thickness, grading from a featheredge along the valley walls to maximum thickness in the center of the valleys.

In the Castleman basin the logs of wells indicate that these deposits range from 10 to 68 feet thick. The Pleistocene and Recent sediments lie unconformably on the older consolidated rocks.

Water-bearing properties.—Although some dug wells in the County end in the Pleistocene alluvium and many springs issue from unconsolidated slope and alluvial debris, few data are available concerning the water-bearing properties of the Quaternary deposits. It is reported that wells at Kitzmiller, along the valley of the Potomac, end in alluvial sediments but no additional information is at hand. It is likely that, in some localities, the Pleistocene and Recent deposits comprise a potential source of ground-water supplies, but owing to their limited distribution and thickness they are not regarded as a major source of ground water in Garrett County.

It is reported that wells ending in Quaternary deposits in Pennsylvania yield as much as 150 to 170 gallons a minute. Piper (1933, p. 113) states that at McKeesport in the Youghiogheny River Valley, a 61-foot well into the alluvium yielded about 170 gallons a minute with a reported specific capacity of 12.0. He states also that four 12-inch wells drilled into the alluvium in the flood plain of the Monongahela near Floreffe (in Allegheny County) yielded 60 to 80 gallons a minute each. The wells were equipped with perforated casing and ranged in depth from 69 to 73 feet, being bottomed on solid rock. However, not all wells completed in the river alluvium in southwestern Pennsylvania were successful, and a number of wells were abandoned or drilled into the underlying hard rock because of the low yields obtained from the alluvium.

Occurrence of Ground Water

GENERAL PRINCIPLES

The general principles governing the occurrence of ground water have been described in detail by various authors, as Meinzer and others (1942, pp. 385–439) and Tolman (1937). Therefore, only a brief statement of those principles applicable to conditions in Garrett County will be given.

Rain and snow are the chief sources of ground water in Garrett County, although some of the saline waters in the deep gas-test wells may be, in part, water of connate origin (water originally trapped with the sediments at the time of burial). Much of the water falling upon the land surface is removed directly by runoff along streams and drainage-ways. Some evaporates from the land surface or enters the soil zone where it is taken up by plants and evaporated through their life processes; this process is known as transpiration. The portion of the precipitation that, after entering the soil zone, filters down into the rocks to the water table is known as ground water; this water is in what can be called "transient storage," and it is later discharged by flowing into surface-water bodies or by evapotranspiration.

Water is stored in the pores or intergranular voids in the unconsolidated rocks and chiefly along planes of fracture, or parting, in the harder, more dense consolidated rocks. Rocks such as sandstone, however, contain some water in the interstices between the grains as well as in the joints and parting planes of the rock. Most of the recoverable water stored in shales and siltstone probably is in the openings along the parting and fracture planes.

Zones of saturation and aeration

The permeable rocks that lie below a certain level are commonly saturated with water under hydrostatic pressure. This is the water that supplies springs and is encountered in dug and drilled wells. The upper surface of the zone of

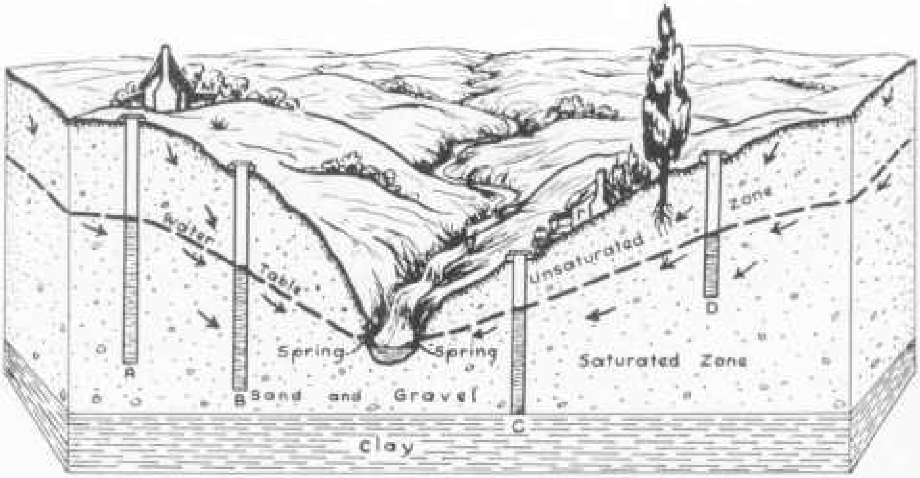

FIGURE 17. Sketch showing relation between the water table and surface topography. Springs form where the land surface intersects the water table. The arrows indicate the direction of movement of the water.

saturation is known as the water table, except where that surface is formed by an impermeable stratum (fig. 17).

Above the zone of saturation is the zone of aeration. Water here either is moving downward on its way to the water table or is held in place by molecular attraction. This is the zone of soil and rock not permanently saturated with water.

Water-table and artesian conditions

The water table is almost everywhere a gently undulating surface which fluctuates slowly in responses to changes in the rate of additions to or subtractions from the ground-water reservoir. In Garrett County, where there is relatively little change in the rate of precipitation, the water table moves chiefly in response to seasonal changes in recharge.

In some places a body of ground water is "perched" on an impermeable stratum below which there may be unsaturated permeable rock. If a well is drilled through the impermeable layer at the base of the overlying ground-water body, the water may move downward until it reaches the main body of ground water below. Perched ground-water bodies are apparently common in the stratified formations of Pennsylvanian age in areas of rugged topography characteristic of parts of Garrett County.

Artesian conditions occur where water moving through a permeable bed moves beneath a less pervious stratum and there becomes confined under pressure. An artesian well is a well in which the water encountered exists under

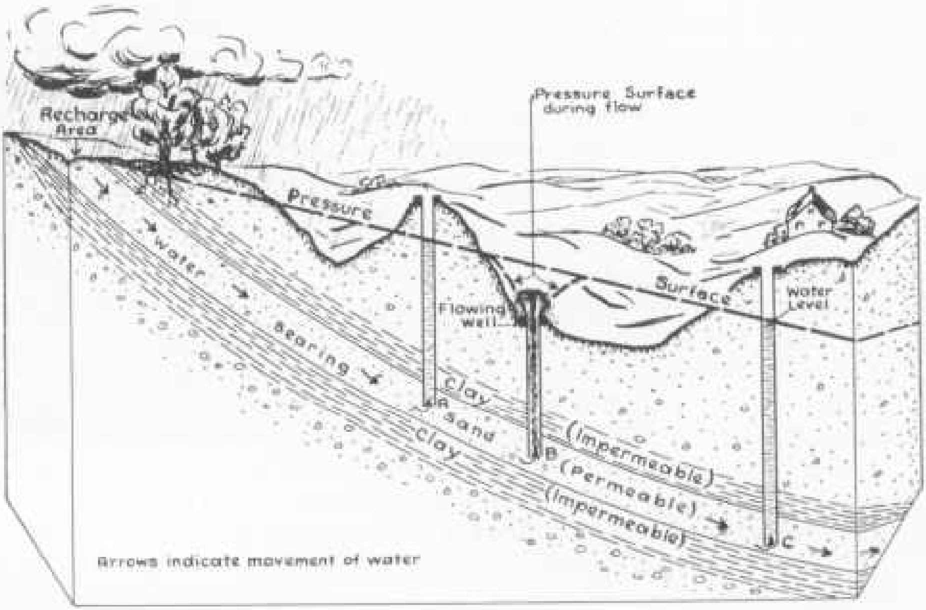

FIGURE 18. Sketch showing principle of artesian flow. Water moves down from the surface (recharge area) along a permeable sand bed which is sealed above and below by impermeable clay beds. When wells A and C, which are on hills, were drilled, water rose into them to the pressure surface, but the wells did not flow. Well B was drilled in a valley at an elevation below the pressure surface and it became, therefore, a flowing well.

head—that is, where the water level in the well rises above the water-bearing stratum (fig. 18). An artesian well is not necessarily a flowing well; flowing wells result when wells are drilled into an artesian stratum where the land surface lies below the piezometric surface (or surface of artesian pressure). Flowing wells are not common in Garrett County, although a few have been drilled. The most likely places for the occurrence of flowing wells in Garrett County are in the topographically low areas along river valleys in or near the center of the synclinal basins. Here the permeable sandstones of Pennsylvanian age lie at great depth, and their contained water is confined under relatively great artesian head. However, in the few instances that wells have penetrated these deep sands, the water has not always been of a satisfactory quality.

Porosity and permeability

The porosity of a rock is its property of containing interstices. It is expressed quantitatively as the percentage of total volume of the rock that is occupied by interstices. A rock is said to be saturated when all the interstices are filled with water. A rock may be porous but not permeable. The property of permeability is defined as the ability of a rock to transmit water or other fluids. To transmit water freely the pore spaces, or interstices, must be freely connected. Rocks that contain small pore spaces (shale, limestone, or clay) generally transmit water very slowly, unless the voids are enlarged by secondary processes, such as solution or fracturing. The permeability of a rock may be decreased by cementation, incrustation, or other forms of clogging.

Recharge and discharge of ground water

Recharge to the ground-water bodies in Garrett County occurs chiefly from local precipitation. The water available for replenishment of the ground-water reservoirs is that which percolates down into the zone of saturation after the moisture demands of the zone of aeration have been met. The parts of the aquifers in which water-table conditions exist are recharged by direct penetration of precipitation. Where the aquifers occur under artesian conditions the recharge enters the reservoir rock at its outcrop area, or percolates into it from another aquifer. Because of the rugged terrain in Garrett County, rapid surface runoff is facilitated, and the percentage of the precipitation that becomes ground water is relatively low. The rate of recharge to the ground-water reservoirs in Garrett County was not determined, but in similar areas in the eastern half of the United States it ranges from a few percent to 20 or 30 percent of the total precipitation.

Ground water is discharged from the rock reservoirs by both natural and artificial means. It is discharged naturally by evaporation from the soil zone, by transpiration, and by ground-water runoff (including seeps and springs). Ground water is discharged artificially through wells, and locally in Garrett County, through mine drifts or tunnels, which are essentially horizontal wells. Assuming a per-capita consumption of ground water of 50 to 75 gallons daily, between 1,000,000 and 1,500,000 gallons of water is withdrawn each day from wells and springs in Garrett County. No data are available concerning the amount of discharge from mines or tunnels.

Ground water in relation to character of rock

Sandstone.—Sandstone consists of hardened or indurated sand, and its water-bearing properties are to some extent analogous to those of sand deposits in that the coarser, better sorted sands normally are the most permeable. However, the water-bearing properties of a sandstone depend also on the degree of cementation of the sand grains. If the proportion of cement binding together the sand grains is great, even a coarse-grained or gravelly sandstone is relatively impermeable. The water entering such beds will commonly circulate chiefly along bedding and fracture planes. Many of the sandstones in Garrett County are sufficiently cemented that the primary porosity of the rocks is small. However, owing to the variable nature of the sandstones, particularly in the Pennsylvanian strata, a sandstone may grade in character from one locality to another and in places may consist of loose, poorly cemented sand grains forming an aquifer of fairly high permeability. Wells penetrating material of this character below the zone of saturation would be fairly productive.

Shale.—Although silt and clay, from which shale is formed by induration and compaction, may be composed of well-sorted particles and have a high porosity, the pore spaces are so minute that the rocks are essentially impervious. Circulation of ground water in shales, therefore, must occur chiefly along parting and joint planes. Many of the shales in Garrett County are brittle and well jointed. As most of the wells in the county yield water from shale, it is an aquifer of surprising importance. However, in some localities the water reportedly obtained from shale may be issuing from a sandstone lentil in the shale. Joints and fractures in brittle shales may extend to greater depths than heretofore believed—hence, the presence of water-bearing zones in the shales at depths of more than 150 or 200 feet as reported in some wells.

Limestone.—In Garrett County limestones do not generally constitute an important source of ground water. Where the limestones are thin bedded and shaly they weather and transmit water in a manner similar to indurated sandstone—that is, chiefly along joint and bedding planes. Where the limestones are relatively thick and consist chiefly of calcium or magnesium carbonate, solution is an effective means of weathering, and ground water is transmitted chiefly along solutional openings. The solvent action of ground water in a limestone region is reflected in the development of sinkholes and other distinctive land features of a karst topography. The scarcity of these features in Garrett County suggests that the solution of limestone by circulating ground water has not occurred to any great extent.

Coal.—Ground water is reported to issue from the coal beds in several of the wells in Garrett County. Because of its brittleness, coal fractures readily and therefore transmits water with relative ease. It is likely that the coal seams constitute an important source of ground water in the synclinal basins of the county. Spring zones along the hillsides where the coal beds crop out provide evidence of the water-yielding capacity of the coals. Some of the water issuing from the coal seams, however, is high in sulfate or iron and is not satisfactory for many uses.

SPRINGS

Classification and description

In Garrett County many of the domestic and most of the municipal supplies of ground water are obtained from springs. In the more rugged, isolated parts of the area springs are used almost exclusively as a source of water supply. About 119 springs were inventoried in Garrett County (Table 21). At one locality on Big Savage Mountain about 28 springs are reported to issue from the rocks. The towns of Grantsville, Friendsville, Mountain Lake Park, and Loch Lynn Heights use spring water for the municipal supply. However, some towns have standby wells for use during dry periods in the late summer or fall. Part of the water used by the town of Oakland is obtained from a spring which supplements the well field. Frostburg, in adjacent Allegany County, is supplied in part by springs in the Savage River valley in Garrett County. Boiling Spring, near Deer Park, furnishes the bottled drinking water used on the Baltimore and Ohio Railroad dining cars.

Springs may be classified in different ways; they may be large or small, thermal or cold, gravity or artesian; they may also be classified according to the structure of the rocks from which they issue, or according to the kind of opening in the rocks.

The springs of Garrett County are mostly gravity springs (Meinzer and others, 1942, p. 418). In parts of the county spring water is locally referred to as gravity water. Gravity springs are those in which the water issues chiefly under the force of gravity. They have been divided into the following groups (Meinzer, 1942, p. 419):

1) Depression springs, due to the land surface cutting the water table in permeable rocks.
2) Contact springs, due to permeable water-bearing rock overlying relatively impermeable rock.
3) Artesian springs, due to a permeable water-bearing bed between relatively impermeable confining beds.
4) Springs in impermeable rocks (tubular and fracture springs).

Most of the springs in Garrett County issue from the soil zone or from rock debris on the hillsides although they have their source in the buried crevices and fractures in the underlying strata. Most of the springs are depression springs, resulting from the intersection of the water table with the land surface in valleys, draws, or other depressions. Many are contact springs resulting from the presence of an impervious rock layer under a water-bearing stratum.

Contact springs are fairly common in the synclinal basins where the jointed and fractured coals are underlain by tight underclays. Lines of springs or seeps issue where the coals crop out and are underlain by clay. They serve as an aid to recognition of the position of the coal layers.

Tubular springs issuing from calcareous strata are believed to be present in areas underlain by the Greenbrier formation. Caverns and sinkholes occur along Ginseng Run near Sang Run, and on Crabtree Creek (Davies, 1950). The water in these caves reaches the surface through solution channels or orifices developed by circulating ground water. Davies (1950, p. 34) reports such a spring at the Sang Run School.

Size of springs

Springs may be grouped according to the magnitude of their discharge. Meinzer (1923, pp. 52–53) proposed the following classification based on the volumetric units commonly used in the United States.

Magnitude	*Discharge*
First to third	449 to 44,900+ gallons a minute
Fourth	100 to 449 gallons a minute
Fifth	10 to 100 gallons a minute
Sixth	1 to 10 gallons a minute
Seventh	0.125 to 1 gallon a minute
Eighth	Less than 0.125 gallon a minute (or less than 5 barrels a day)

Most of the springs observed in Garrett County are of the sixth magnitude, although a few are of the fifth magnitude. Most of the springs have seasonal fluctuations in flow, and in the late summer and early fall, or during other dry parts of the year, the flow of many ceases entirely. The flow is related to and governed by the position of the water table in the rocks. Large springs discharging from extensive systems of fractures are less likely to show major changes in their rate of discharge than small springs draining a limited area.

In general, springs having a flow adequate for domestic and farm needs can be found throughout the county. Flows of 2 to 10 gallons a minute during most of the year are common.

Relation to stratigraphy

Springs issue from all the formations in the county. Certain physiographic and geologic factors give rise to abundant spring zones in some localities, whereas in other localities springs are largely absent or of small size and importance.

The larger springs, Boiling Spring (Ec 1), Bradley Spring near Oakland (Db 16), the Loch Lynn Springs (Eb 33, Eb 34, Eb 35, and Eb 36) and the Frostburg springs (Ag 10), occur in a similar stratigraphic position—the water issues from openings at, or close to, the contact between the Pocono formation and the overlying Greenbrier formation at the base of steep hill slopes on limbs of the Deer Park anticline.

WATER-LEVEL FLUCTUATIONS

Fluctuations in the water levels in the shallow wells and in the yield of springs of the county are governed largely by the distribution of precipitation and the effects of evaporation and transpiration. The effect of fluctuation of the water table can be inconvenient to the users of small springs or shallow wells. Near the end of a long dry spell the springs may fail or the water level may drop below the bottom of the well (fig. 19). Where the water in a water-bearing stratum

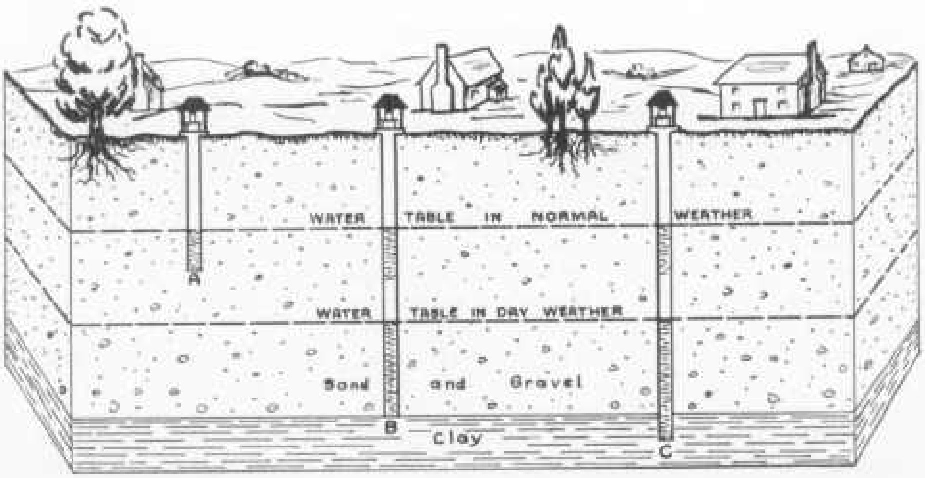

FIGURE 19. Sketch showing effect of decline in water table at wells A, B, and C. Well A would go dry in time of drought; wells B and C would have a decline in water level, but would not go dry. Well C, because of the additional storage space in the underlying clay, would be the most reliable in extreme droughts.

occurs under artesian conditions, wells ending in the stratum show less seasonal fluctuation than wells ending in strata in which water-table conditions exist. Fluctuations of water level in artesian wells may be caused chiefly by pumping of the well or of neighboring wells. Such a large variety of physiographic and geologic conditions exist in Garrett County that water-level fluctuations in observation wells may show only local rather than general conditions. Water levels were measured at approximately monthly intervals in four observation wells in Garrett County. The graphic record of one well (Ag 1) is shown in figure 20 and the tabulated record of measurements in the four wells is given in Table 17.

Water-level fluctuations have been measured in well Ag 1, near the northeastern corner of the county and near the base of the western slope of Little Savage Mountain, since October, 1946. The well is 30 feet deep and 8 inches in diameter and is drilled in the Pocono formation. Figure 19 shows the relation between precipitation at Frostburg and water-level fluctuations in the well. An exact correspondence between the graphs of precipitation and water level is not to be expected. Evaporation and transpiration greatly reduce the amount of precipitation that reaches the water table in the summer and fall. Also though heavy summer thundershowers contribute to the monthly precipitation, they add little to the ground-water supply, as most of the water is lost through surface runoff or is held by the soil and later evaporated or transpired. In the winter much of the precipitation consists of snow which becomes part of the ground-water recharge only in the spring when the thawing of the ground permits the melted snow to percolate downward into the soil and rock layers. The

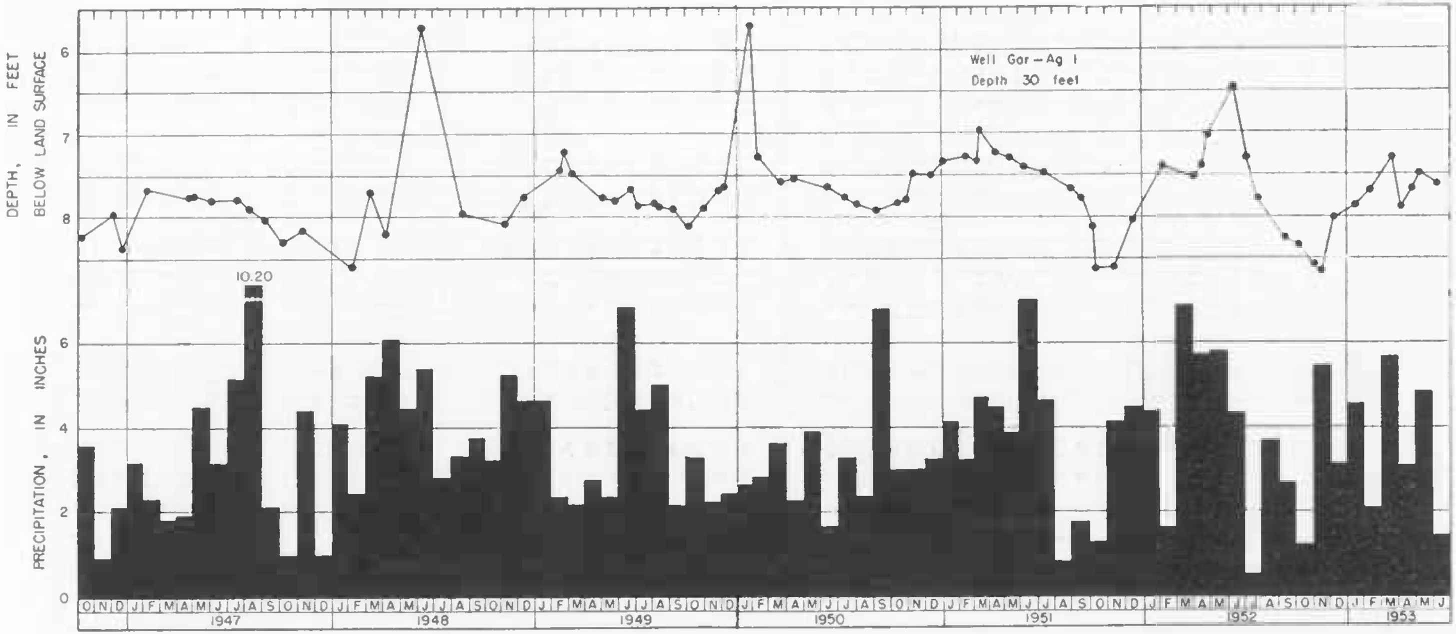

FIGURE 20. Diagram showing precipitation at Frostburg (Allegany County) and the water level in well Ag 1

TABLE 17

Water Levels in Observation Wells in Garrett County

Gar-Ag 1. Town of Frostburg. 2.5 miles northwest of Frostburg. Depth, 30 ft. Diameter, 8 in.
Water level, in feet, below land-surface datum

Date	Depth to water	Date	Depth to water	Date	Depth to water	Date	Depth to water
10- 3-46	8.20	3- 5-49	7.47	10-18-50	7.82	4-28-52	7.04
12- 6-46	7.93	5- 4-49	7.76	10-25-50	7.80	6-10-52	6.47
12-19-46	8.34	5-23-49	7.80	11- 9-50	7.47	7- 2-52	7.31
2- 6-47	7.65	6-17-49	7.66	12-13-50	7.47	7-22-52	7.76
4-22-47	7.73	7- 8-49	7.85	1- 5-51	7.32	9-10-52	8.23
4-28-47	7.71	8- 4-49	7.82	2-13-51	7.28	10- 7-52	8.32
6- 3-47	7.76	8-12-49	7.85	3- 5-51	7.32	11- 7-52	8.57
7-10-47	7.79	9- 8-49	7.91	3- 9-51	6.98	11-13-52	8.63
8- 6-47	7.87	10- 4-49	8.10	4-12-51	7.23	12- 5-52	8.03
9- 3-47	7.99	11- 2-49	7.88	5- 9-51	7.28	1-14-53	7.86
10- 2-47	8.27	11-30-49	7.67	6- 5-51	7.40	2-10-53	7.67
11- 5-47	8.13	12- 7-49	7.61	7-12-51	7.47	3-16-53	7.29
2- 3-48	8.54	1-19-50	5.71	8-24-51	7.62	4- 2-53	7.36
3- 8-48	7.70	2- 2-50	7.29	9-14-51	7.77	4-20-53	7.62
4- 6-48	8.18	3-15-50	7.57	10- 5-51	8.14	5- 7-53	7.48
6- 4-48	5.72	4-11-50	7.53	10- 9-51	8.64	6- 8-53	7.60
8-17-48	7.95	6- 5-50	7.59	11- 9-51	8.60	7- 6-53	7.75
11- 7-48	8.04	6- 6-50	7.64	12-13-51	8.04	7-23-53	7.85
12- 8-48	7.76	7-10-50	7.72	2- 6-52	7.40	8-12-53	8.14
2-15-49	7.42	8- 2-50	7.82	4- 4-52	7.52	9- 8-53	8.40
2-22-49	7.21	9- 6-50	7.90	4-17-52	7.40	10-14-53	8.30

Gar-Bb 1. R. O. McCullough. In Friendsville. Depth, 37 ft. Diameter, 16 in.

Date	Depth to water	Date	Depth to water	Date	Depth to water	Date	Depth to water
10- 3-46	28.14	10- 2-47	26.08	5- 5-49	24.12	11- 9-50	13.32
12- 5-46	24.75	11- 4-47	27.15	6-15-49	25.16	12-13-50	10.52
12-19-46	23.98	2- 3-47	29.70	7- 8-49	24.88	1- 5-51	3.53
1- 8-47	8.08	3- 7-48	6.10	9-10-49	24.90	2- 7-51	3.95
2- 6-47	13.75	4- 6-48	19.49	10- 5-49	26.90	3- 9-51	9.74
2-20-47	21.65	5- 6-48	10.90	11- 3-49	26.41	4-12-51	12.94
3- 5-47	24.50	6- 4-48	23.85	12- 8-49	17.89	5- 9-51	11.50
3-29-47	23.98	8-18-48	25.00	4-11-50	14.58	6- 5-51	24.83
4-23-47	24.27	11- 6-48	25.07	6- 6-50	13.60	7-12-51	24.35
6- 4-47	23.98	12- 6-48	4.50	7-11-50	25.41	8-23-51	25.36
7- 9-47	14.88	2-15-49	11.97	8- 2-50	20.38	9-14-51	26.57
8- 7-47	26.97	2-22-49	6.72	9- 6-50	25.51		
9- 3-47	30.90	3- 5-49	9.62	10-18-50	23.34		

Gar-Bc 1. E. H. Ault. In Accident. Depth, 19.5 ft. Diameter, 3 ft.

Date	Depth to water	Date	Depth to water	Date	Depth to water	Date	Depth to water
8-12-49	15.82	4-17-52	9.97	12- 4-52	15.90	5- 6-53	15.30
11-30-49	13.83	7-22-52	16.69	1-16-53	9.11	6- 8-53	16.30
6- 6-50	11.69	9- 9-52	17.75	2- 9-53	11.56	7- 6-53	17.54
10-25-50	15.85	10-14-52	18.00	3- 5-53	10.29	8-14-53	17.77
3- 5-51	13.05	11- 6-52	18.34	4- 2-53	8.88	9- 9-53	18.12
10- 5-51	17.36	11-13-52	18.48	4-20-53	11.27	10- 6-53	18.60

Gar-Eb 23. Ray Porter. 0.1 mile north of Oakland. Depth, 37± ft. Dug well.

Date	Depth to water	Date	Depth to water	Date	Depth to water	Date	Depth to water
11-30-49	24.38	4- 4-52	23.40	10- 6-52	36.67	4-20-53	22.17
6- 6-50	24.23	4-17-52	20.86	11-14-52	(a)	5- 6-53	25.91
10-25-50	28.57	4-29-52	18.62	12- 4-52	32.55	6- 9-53	27.92
3- 6-51	22.55	6-10-52	25.64	1-15-53	23.47	7- 7-53	23.27
10- 9-51	36.63	7- 2-52	30.99	2- 9-53	22.25	7-23-53	34.91
11- 9-51	36.62	7-22-52	33.85	3-10-53	21.67	8-12-53	33.38
12-11-51	22.66	9- 7-52	35.03	4- 2-53	20.52	10- 6-53	(a)
2- 6-52	20.06						

(a) Well dry.

decline of the water level during the dry spell of August, September, and October, 1951, is plainly shown on figure 20. Likewise, the effect of the rainy spell, together with the melting of the winter snow, of March, April, and May, 1952, is indicated by the rise in water level during this period. The water level declined during the late summer dry weather of 1952, and rose again after the heavy November rains. For the period of record, the trend of the water level in this well is essentially horizontal, that is, the water table in its vicinity essentially has neither risen nor declined. Therefore, the quantity of ground water stored in the rocks in the vicinity of the well in 1953 is about equal to the amount that was in the rocks in 1947.

The water level in well Bb 1, at Friendsville, was measured from October 1946 through September 1951, a period of five years. It is a dug well 16 inches in diameter and 37 feet deep in the valley of the Youghiogheny River and probably ends in the Allegheny formation. Measurements in this well were discontinued when it was suspected that water was leaking into it from a layer of water that at times accumulated on the floor of the well pit. The well record shows a normal cycle of fluctuations, the highest water levels in the winter and early spring months and the lowest water levels in the summer and early fall. The annual range of fluctuation in this well of 15 to 20 feet indicates that the storage capacity of the rocks is low. A part of this range of fluctuation may be due to the suspected leakage.

Water-level fluctuations were measured at approximately 6-month intervals in well Bc 1, at Accident, from August 1949 to July 1952, and thereafter monthly. It is a rock-lined dug well 19.5 feet deep and 36 inches in diameter that ends in the Hampshire formation. Measurements made prior to 1952 are inadequate to show the seasonal characteristics of the water-level fluctuations, but those made subsequently show that this well fluctuates in a normal cycle with the high water level in the winter and early spring and low water level in the summer and fall. The record water level (18.60 feet below the land surface) in October 1953, resulted from an extended period of practically no precipitation in Garrett County coinciding with a period of high evaporation and transpiration. The annual range in fluctuation in this well is about 8 to 9 feet.

Dug well Eb 23, at Oakland, was measured at approximately 6-month intervals from November 1949 to October 1951, and thereafter at monthly intervals. The well is 37 feet deep and is in the Hampshire formation. Measurements prior to October 1951 are too few to show the characteristic seasonal fluctuations, but the record of subsequent measurements shows that the water level fluctuates in the normal pattern of high water level in the winter and early spring and low water level in the summer and fall. Twice during the period of record, in November 1952 and in October 1953, the water table declined below the elevation of the bottom of the well. The annual range in fluctuation in this well is about 15 to 18 feet.

WELLS AND PUMPS

Water wells in Garrett County are drilled by the cable-tool percussion method. A 5⅝-inch casing is used in most of the wells, although a few wells have 8- and 10-inch casings. The casing is driven through the unconsolidated surface material and is set on the hard rocks underneath. Below the casing the hole stands open. No screen is used. Water, therefore, may enter the well anywhere below the bottom of the casing.

Most of the domestic wells are equipped with electric jet or plunger pumps, although a few of the large diameter wells are equipped with turbine pumps.

Many springs also are equipped with pumps, which furnish running tap water for domestic needs.

CHEMICAL CHARACTER OF THE GROUND WATER

Chemical and physical properties

A knowledge of the chemical character of water is important in connection with the use of water. The use of water in this region is mostly for domestic and industrial purposes. The domestic use of water is for drinking and cleansing; the industrial use for cooling and processing. Drinking water should be palatable and contain no harmful ingredients; for cleansing purposes, the water should be soft and should not stain clothes or other articles. Water for industrial or cooling purposes should have a low summertime temperature and should not contain substances that precipitate and clog pipes, nor should it be corrosive. For industrial processing, the type of water needed varies with the process for which it is used.

Rocks are made up of chemical elements combined to form minerals. The common chemical elements found in rocks are silicon, aluminum, iron, calcium, magnesium, sodium, potassium, carbon, oxygen, and hydrogen. Silicon combined with oxygen alone forms silica or quartz. Silica together with aluminum, magnesium, iron, and other elements form, silicates, the common minerals of igneous rocks and shales; calcium, magnesium, carbon, and oxygen form the carbonate minerals calcite and dolomite, the chief minerals of limestone. Iron combines with oxygen and water to form iron oxides and hydroxides. Iron is the chief coloring agent of nature and, in solution in water, is the bane of the housewife who wants her wash to look white. Manganese in solution has a similar staining effect.

The mineral constituents of the rocks are soluble in water but most of them are soluble only to a slight degree. Water moving through the rocks breaks down the minerals and takes into solution some of the elements of the rock minerals. The use to which the water is to be put determines whether the elements are present in an amount sufficient to be deleterious. For other than cooling purposes, industries generally require water that is relatively free of dissolved substances and other impurities.

TABLE 18

Chemical Analyses of Ground Water in Garrett County

(In parts per million, except pH and specific conductance)

Well or spring number	Principal water-bearing formation	Date of collection	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Aluminum (Al)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	pH	Specific conductance ($K \times 10^6$ at 25°C)	Analyst
Wells																				
Ad 1	Allegheny and Pottsville	3/6/51	5.4	0.80	0.34	0.1	6.0	2.3	0.8	0.8	27	4.5	0.6	0.1	0.3	35	24	6.8	53.5	A
Ae 2	Conemaugh-lower member	—	5.2	.3	—	—	31	—	—	—	—	—	8	—	—	152	94	7.0	—	B
Ae 8	Do	3/7/51	6.6	.27	.04	1.0	30	8.2	3.4	1.1	87	10	27	.1	4.6	170	109	6.7	258	A
Bb 2	Allegheny	—	7.1	.10	—	—	42	—	—	—	—	92	8	—	—	167	134	6.1	—	B
Bc 29	Hampshire	—	5.2	.6	—	3.8	45	14	—	—	—	—	—	—	—	298	170	8.1	—	B
Cc 2	Greenbrier	3/6/51	5.9	.31	.06	.1	9.6	.7	1.6	.7	19	9.9	1.4	.1	4.4	53	27	6.9	69	A
Db 12	Pocono	12/—/46	17	2.5	—	—	13	4.8	9.9	1.0	69	16	.8	.1	.1	94	52	7.4	147	A
Dd 3	Allegheny	—	6.7	4.0	—	—	—	—	—	—	—	—	6.4	—	—	70	20	6.1	—	B
Ea 11	Do	—	—	3.0	—	—	—	—	—	—	—	—	16	—	—	172	122	6.7	—	B
Springs																				
Ab 8	Allegheny and Pottsville	—	—	0	—	—	—	—	—	—	—	—	4.6	—	—	—	24	5.7	—	B
(a) Ad 3	Allegheny	—	1.7	0	—	—	6.4	—	—	—	—	—	4.4	—	—	38	30	6.2	—	B
(b) Ad 3	Do	—	.4	0	—	—	2.2	—	—	—	—	—	3.2	—	—	32	28	4.9	—	B
(c) Ea 12	Do	—	4.2	0	—	—	3.0	—	—	—	—	—	3.0	—	—	20	15	6.9	—	B
(b) Ea 12	Do	—	3.2	.3	—	—	—	—	—	—	—	—	2.4	—	—	23	10	6.1	—	B
Ec 1	Greenbrier	—	3.0	0	—	—	52(?)	—	—	—	—	—	4.3	—	—	100	74(?)	7.1	—	B
Ga 1	Conemaugh-lower member	—	.6	0	—	—	7.8	—	—	—	—	—	3.2	—	—	44	20	6.8	—	—

(a) Upper spring; (b) Lower spring; (c) New spring

Analyst: A—U. S. Geological Survey. B—Maryland State Department of Health.

The chief use of ground water in Garrett County is for domestic and farm purposes. Table 18 gives 16 chemical analyses of Garrett County ground water, of which 4 are complete analyses made by the U. S. Geological Survey and 11 were made by the Maryland Department of Health. The analyses give the constituents in part per million by weight. The specific conductance of the water, a rough measure of the content of dissolved mineral matter, is given also.

Iron.—Table 18 shows that iron is present in troublesome amounts in nearly all the well samples. An iron content of more than 0.3 part per million is commonly regarded as undesirable, as this amount is sufficient to cause staining of laundry and of porcelain fixtures. When water containing a large amount of dissolved iron is exposed to the atmosphere, the iron precipitates from the water as a reddish-brown precipitate, one common cause of clogging of water systems or plumbing. Iron may be partially removed from water by aeration, a method generally too complicated and expensive for domestic supplies. Water high in dissolved iron may be rendered usable by passing the water through a filter that removes this iron chemically, or by adding chemicals that convert the iron in the water to a more stable, soluble form. These types of iron-treatment systems are commonly used in Garrett County.

The presence of iron was reported by the owners of many wells. Field and laboratory analyses of well water showed iron in amounts ranging from 0.5 to 10 parts per million. In two areas the well water was especially high in iron. The water from well Aa 6, northeast of Sand Spring along Maryland Route 135, is not used because of the high iron content. A field analysis from well Aa 7, in the same area, showed 1.5 parts per million of iron which rendered the water useless for culinary purposes. The water from a third well, Aa 8, in the same area is of a similar type. No logs are available for these wells, but they are believed to start in the basal part of the lower member of the Conemaugh formation and to extend into the Upper Freeport coal in the underlying Allegheny formation. In the Bloomington Road area wells Dd 6, De 2, De 3, and De 5 yield water high in iron. Field tests of the water from wells Dd 6 and De 2 showed about 6 parts per million of iron. Well Dd 6 is 55 feet deep and probably ends in the lower part of the Pottsville formation; well De 2 probably ends in the Pottsville formation; well De 3 ends in the Lower Bakerstown coal in the Conemaugh formation; well De 5 begins above the Barton coal (Conemaugh formation) and may end in the coal. The number of analyses of ground water in Garrett County is inadequate to draw any firm conclusions concerning the distribution of waters high in iron. Iron content (Fe) averages more than 1 part per million in six analyses of well water from Pennsylvanian strata. In general, the distribution of iron in ground water is erratic and is not understood very well.

Hardness.—Hardness is the capacity of water for consuming soap. Hard water is not desirable for laundry purposes, as the soap consumption is increased, and excessively hard water creates curds which interfere with the laundering process. Hardness is caused chiefly by the salts of calcium and magnesium, although iron, aluminum, and other constituents also may cause hardness in water. The hardness of water is commonly measured according to the following hardness scale (Collins and others, 1934, pp. 15–16):

Hardness range (parts per million)	*Type of Water*
0–60	Soft water; hardness scarcely noticed for general use.
61–120	Moderately soft to moderately hard water; suitable for many purposes without treatment, but soap consumption increases. Softening of a supply in this class may be profitable for laundry purposes.
121–180	Hard water. Hardness noticeable. Many cities having water of a total hardness of 150 parts per million or over soften the water chemically.
180+	Very hard water. Necessary to soften for use in laundry or steam boilers. Some supplies would be unsatisfactory even after softening.

The total hardness as $CaCO_3$ in the well and spring waters of Garrett County ranges from 10 to 170 parts per million. The average total hardness of 16 samples of well and spring water is 55 parts per million. The softest water (10 parts per million) is obtained from spring Ea 12, owned by the Kray Coal Co. near rellin. This spring issues from the Allegheny formation where it is exposed along a steep hillside. The hardest water (170 parts per million) was from well Bc 29 which ends in the Hampshire formation at a depth of 600 feet.

Although the number of analyses is inadequate for reliable conclusions, it would appear that the water from the drilled wells is harder than that from the springs. The ground water from nine wells in the county averages 83 parts per million in total hardness, whereas the water from seven springs averages only 28 parts per million in total hardness.

Dissolved solids.—The dissolved-solids content in the ground waters of Garrett County is generally low and ranges, in 15 analyses of well and spring water, from 35 to 298 parts per million. The average dissolved-solids content is 97 parts per million. The sample containing the greatest amount of dissolved solids, from well Bc 29 near Accident, had also the greatest hardness. It is likely that the somewhat larger amount of dissolved solids in this water is the result of slow movement of the water at the depth penetrated.

Hydrogen-ion concentration.—The hydrogen-ion concentration of water, expressed as the pH, is a measure of the intensity of its alkalinity or acidity. Water having a pH greater than 7.0 is alkaline; water having a pH less than 7.0 is acidic. Six of the waters sampled had a pH of 6.9 or less (acid water), and three of them had a pH of 7.0 or more (neutral or alkaline water). Water containing large quantities of dissolved carbon dioxide gas is commonly acidic, and if the pH is below about 6.0 such water may have a corrosive effect on the well casings and water pipes.

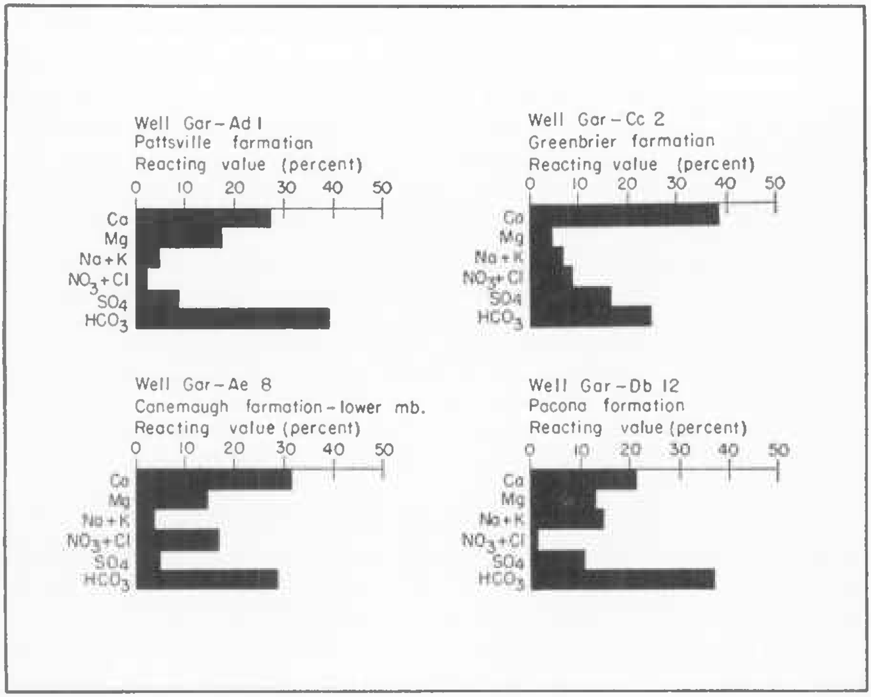

FIGURE 21. Diagram showing the percent reacting value of the chemical constituents in ground water from four wells in Garrett County

General chemical character

The results of four complete analyses of ground water in Garrett County show that the waters are mainly of the calcium bicarbonate type. Figure 21, in which the percent reacting value of the mineral constituents is plotted graphically, shows that the amount of calcium (Ca) dissolved in most of the waters is greater than the amount of magnesium (Mg). Sodium (Na) and potassium (K) ions are generally low, as are nitrate (NO_3) and chloride (Cl) ions.

The relatively high nitrate and chloride content of water from well Ae 8 may be due in part to surface contamination. Well Ae 8 is a drilled 6-inch well completed at a depth of 85 feet in the lower member of the Conemaugh formation.

No complete chemical analyses are available of the spring waters but Table 18 gives seven partial analyses. These analyses show that the spring waters are generally lower in dissolved solids than are the well waters. The spring water is commonly softer also.

TEMPERATURE OF GROUND WATER

The temperature of ground water seldom fluctuates more than a few degrees during the year, and for this reason ground water is in great demand in many areas for air conditioning or industrial cooling. There are, however, no large industrial or commercial users of ground water for cooling in Garrett County.

Well water.—The temperature of the ground water in 16 wells ranged from 48.5° F. to 57° F. and averaged approximately 53° F. However most of the measurements were made during the summer months. The depths of the wells range from 20 to 300 feet. The highest temperature was measured in three wells ranging in depth from 55 to 160 feet. The 160-foot well, Cd 6 was drilled into the Conemaugh formation just south of Bittinger. The coolest water (48.5° F.) was from well Ae 2 which was drilled to a depth of 98 feet into the lower member of the Conemaugh formation as a supply well for the town of Grantsville. The measurements are too few to reveal a relation between well depth and water temperature. In general, below a depth of a few tens of feet, ground-water temperatures rise at the rate of the temperature gradient of the earth which is 1° F. increase for each additional 50 to 100 feet in depth.

Spring water.—The temperature of the water was measured at 73 springs. It ranged from 48° F. to 62° F. In general, springs having the largest flow were slightly cooler than those of smaller flow. Twenty springs having a measured (or estimated) flow of more than 2 gallons a minute had an average temperature of 51° F. Fifty-two springs flowing less than 2 gallons a minute had an average temperature of 54.9° F. The water temperatures were measured during July and August when the mean air temperature range from 65° F. to 69° F. However, the mean annual air temperature, varying slightly with geographic location, ranges from 47° F. to 49° F. The average temperature of the larger springs during July and August is considerably lower than the mean air temperature for these months indicating that the temperature of much of the water discharged from these springs is inherited, in part, from temperature regimens of previous months or years.

Summary and Conclusions

The yields, specific capacities, and depths of the wells ending in the different water-bearing formations in Garrett County show no significant differences. One reason may be that many domestic wells are not tested at their maximum capacity because the additional water is not needed. Conversely, where a large supply is needed and several wells are drilled into a particular formation and tested to their maximum capacity to obtain the required supply, the apparent average yield for wells tapping that formation may be above that for other formations tapped by only domestic wells. Nevertheless, the yields, specific capacities, and depths summarized in Table 19 provide a fair guide to the water-yielding potential of the formations, except the Monongahela formation and the Quaternary deposits.

The most favorable places for the development of large ground-water supplies are in the synclinal coal basins where the Allegheny and Pottsville formations may be penetrated by drilling to moderate depths. The presence of coarse-

TABLE 19

Summary of Yields, Specific Capacities, and Depths of Wells in Garrett County

Formation	Number of wells	Average depth (feet)	Average yield (gals./min.)	Specific capacity (gals. a minute per foot of drawdown)
Jennings	57	84	10	0.4
Hampshire	58	94	14	.7
Pocono	41	85	13	.8
Greenbrier	16	91	14	.9
Mauch Chunk	16	87	15	.4
Pottsville and Allegheny	18	77	26	.9
Conemaugh–lower member	57	83	15	1.5
upper member	8	66	8	—

grained, massive or fractured permeable sandstones within these formations probably explains the relatively high yields obtained from some wells ending in them. The yields of 18 wells average more than 26 gallons a minute, and yields in excess of 200 gallons per minute have been reported from a few wells. However, where these strata lie at considerable depth the water may be of poor quality and unsuitable for use without dilution or treatment.

The records of 57 wells ending in the Jennings formation show this formation is one of the poorest aquifers in Garrett County. The average yield of the wells tapping it is only 10 gallons a minute, and the yield per foot of drawdown is only 0.4 gallon a minute. The average yield per foot of well drilled is 0.08 gallon a minute, whereas in the Allegheny and Pottsville formations it is 0.3 gallons a minute.

Springs are important sources of domestic and municipal ground-water supplies in Garrett County. The springs are mostly gravity springs which issue from the lower part of permeable strata where they are underlain by less permeable strata along the sides of valleys and draws. The flow of the springs is variable, but most of those inventoried flowed less than 10 gallons a minute at the time of measurement. The largest springs provide the public water supply of the towns of Grantsville, Friendsville, Mountain Lake Park, and Loch Lynn Heights. A part of the municipal supply of Oakland is obtained from a spring.

In general, the quality of the ground water in Garrett County is satisfactory for most uses. In some wells, however, the iron content of the water is sufficiently high to make treatment for iron removal desirable. Field and laboratory analyses show that the iron content of well water ranges from 0.5 to 10 parts per million. The iron content of spring water is commonly lower, although the number of analyses of iron in spring water is limited. The hardness of ground water from wells and springs in Garrett County ranges from 10 to 170 parts per million. The average hardness of 16 samples, from both wells and springs, is 55 parts per million as $CaCO_3$. Water of this degree of hardness is generally regarded as soft.

The measured temperature of well and spring water ranged from 48° F. to 62° F. and averaged approximately 53° F. No direct relationship between the temperature of well water and the depth of the well was established by the temperature measurements.

Records of Wells and Springs

The locations of the wells and springs inventoried in Garrett County are shown on Plate VIII. The records of the wells are given in Table 20 and of the springs in Table 21. Their altitudes are taken from Department of Geology, Mines and Water Resources and United States Geological Survey topographic maps on which the contour interval is 20 feet.

Pumping equipment: Method of lift: B, bucket; C, cylinder; I, impeller; J, jet; W, windmill
Type of power: E, electricity; H, hand
Use of water: C, commercial; D, domestic; F, farm; N, none; P, public supply; S, school

TAB

RECORDS OF WELLS

Well number (Gar-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing below land surface (feet)	Water-bearing formation and *structural unit*
Aa 1	Frisby Humbleson	—	About 1875	1,980	Dug	28	—	—	Conemaugh—lower memb. *Lower Youghiogheny basin*
Aa 4	Wm. Buner	Brenneman	1941	1,720	Drilled	85	5⅝	—	do
Aa 6	Emerson Thomas	do	About 1950	1,920	do	—	5⅝	—	do
Aa 7	Geo. W. Thomas	do	1946	2,030	do	55	5⅝	—	do
Aa 8	Russell Lawson	—	About 1937	2,030	do	55	5⅝	—	do
Ab 1	Ross Friend	Brenneman	1949	1,730	do	50	5	19	Allegheny *Lower Youghiogheny basin*
Ab 2	Harvey Frank	—	About 1905	1,740	Dug	19	—	—	do
Ab 4	S. Kelley	—	—	1,530	do	8	—	—	*Recent alluvium*
Ab 5	John Ceiler	—	1949	1,510	Drilled	39	—	15	Allegheny (?) *Lower Youghiogheny basin*
Ac 1	Robert G. Meinel	Brenneman	1949	2,990	do	120	6	25	Pocono *Accident dome*
Ac 2	Clyde Glover	Tressler	About 1935	2,480	do	160	5⅝	—	Hampshire *Accident dome*
Ac 3	do	—	—	2,450	do	125	—	—	do
Ac 5	Thomas H. Taylor	—	About 1912	2,890	do	109	—	—	Pocono *Accident dome*
Ac 6	Anna Morgroff	Brenneman	About 1935	2,880	do	68	—	—	do
Ac 7	John Opel	Tressler	1937	2,920	do	72	—	—	do
Ac 10	Carl Glass	do	About 1947	2,780	do	95	—	—	Pocono and Hampshire *Accident dome*
Ac 11	Harry T. Collier	Brenneman	1942	2,930	do	206	—	—	Pocono *Accident dome*
Ac 12	Stephen Baruch	do	1938	2,775	do	120	—	—	do
Ac 13	Ed. Bougher	—	—	2,510	Dug	28	—	—	do
Ac 18	Vernon Reichenbecker	Tressler	1952	2,450	Drilled	56	5⅝	22	Greenbrier *Accident dome*
Ac 19	Lester Durst	do	1952	2,780	do	106	5⅝	20	Pocono *Accident dome*
Ad 1	Town of Grantsville	Brenneman	1949	2,540	do	300	8	68	Allegheny and Pottsville *Castleman basin*
Ad 4	Sherman Beachy	Tressler	1950	2,160	do	43	5⅝	23	Conemaugh-lower memb. *Castleman basin*
Ad 5	Bruce Folk	do	1949	2,160	do	49	5⅝	31	do

LE 20

IN GARRETT COUNTY

Water level (feet below land surface)			Pumping equipment	Depth of pump below land surface (feet)	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Pumping	Date			Gallons a minute	Date				
—	—	—	C; E, H	—	—	—	—	D	—	Reported never dry. Bottom about 70 feet above Brush Creek coal.
—	—	—	C; E	—	—	—	—	D	—	Reported never dry. Starts under Brush Creek coal; may reach Upper Freeport coal.
—	—	—	—	—	—	—	—	N	—	Water reported bad. Bottom probably in Upper Freeport coal.
—	—	—	C; H	—	—	—	—	D	—	Water reported poor quality; yellow-brown; Fe 1.5 ppm (field test). Probably reaches upper Freeport coal.
—	—	—	C; E	—	—	—	—	D	—	Water reported poor quality; stains clothes. Probably reaches Upper Freeport coal.
20	40	10/49	C; H	—	5	10/49	0.3	D	—	Water reported soft, but irony. Starts just below Upper Freeport coal. See well log.
—	—	—	C; H	—	—	—	—	D	—	Never dry. Water reported good.
—	—	—	C; H	—	—	—	—	D	—	Well beside stream. Well water pH 5.8; stream water pH 4.7. Mine water in stream at times.
—	—	—	—	—	3±	8/51	—	D	52	Flowing well.
32	47	4/49	—	—	24	4/49	1.6	D	—	See well log.
—	—	—	—	—	—	—	—	N	—	Owner prefers spring water.
—	—	—	—	—	—	—	—	N	—	Drilled "many years ago."
—	—	—	C; E	—	—	—	—	D	—	Pumps down quickly. Quality reported good.
—	—	—	C; E	—	—	—	—	D	—	Never dry. Quality reported good.
—	—	—	C; E	—	—	—	—	D	—	Do.
—	—	—	C; E	—	—	—	—	F	—	Yield reported 3 barrels per hour.
—	—	—	C; E	—	—	—	—	D, F	—	Water reported good and adequate in amount.
—	—	—	C; E	—	—	—	—	D	—	Do.
—	—	—	C; H	—	—	—	—	D	—	Pumps dry in Sept. and Oct.
25	30	2/52	C; H	—	10	2/52	2.0	D	—	See well log.
65	90	9/52	—	—	3	9/52	0.1	D	—	Do.
—	—	—	—	—	8±	7/50	—	P	51	Flowing (7/50). See well log and chemical analysis. Starts just under Middle Kittanning coal. Stand-by well.
6	20	3/50	—	—	10	3/50	0.7	D	—	Starts just under Harlem coal; does not reach Lower Bakerstown coal. See well log.
5	12	6/49	—	—	16	6/49	2.3	D	—	Ends in Meyersdale red bed. See well log.

TABLE 20

Well number (Gar-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing below land surface (feet)	Water-bearing formation and *structural unit*
Ad 6	Dorsey Hileman	Brenneman	1949	2,630	Drilled	84	5	40	Greenbrier and Pocono *Accident dome*
Ad 7	Raymond Durst	do	1949	2,450	do	90	6	22	Allegheny *Castleman basin*
Ad 8	Thomas Hutzeld	do	1949	2,430	do	80	6	22	do
Ad 9	William J. Miller	do	1950	2,660	do	95	5⅝	31	Pocono *Accident dome*
Ad 10	Everett Duckworth	Irwin	1949	2,860	do	66	6	—	do
Ad 12	Raymond Failinger	Tressler	1951	2,233	do	70	5⅝	—	Conemaugh-lower memb. *Castleman basin*
Ae 1	Grantsville Dairy, Inc.	Brenneman	1946	2,310	do	198	5	42	do
Ae 2	Town of Grantsville	—	About 1945	2,395	do	98	6	—	do
Ae 3	Gilbert Green	Tressler	1949	2,400	do	98	5⅝	18	do
Ae 4	Marshall McKinzie	Buser	1948	2,680	do	73	5⅝	33	do
Ae 5	Sam Yoder	Tressler	1949	2,380	do	108	5⅝	20	do
Ae 7	Irvin Yoder	do	1950	2,320	do	65	5⅝	25	Conemaugh-upper memb. *Castleman basin*
Ae 8	Harry Younkin	do	1950	2,250	do	85	5⅝	21	Conemaugh-lower memb. *Castleman basin*
Ae 9	Marshall Durst	do	—	2,265	do	87	—	—	do
Ae 10	Garrett County Cooperative, Inc.	Brenneman	1947	2,160	do	250	8	38	do
Ae 11	Eli Yoder	do	1947	2,380	do	170	8	28	do
Ae 12	Garrett County Cooperative, Inc.	do	1947	2,160	do	250	8	60	do
Ae 13	Elmer Schrock	do	1946	2,480	do	192	6	—	do
Ae 14	Edison Miller	Tressler	1950	2,170	do	110	5⅝	29	do
Ae 15	E. R. Durst	do	1951	2,260	do	91	5⅝	29	do
Ae 16	Irvin Sivits	Brenneman	1950	2,520	do	65	5⅝	18	do
Ae 17	Robert Cobough	do	1950	2,530	do	65	5⅝	21	do
Ae 18	Clarence Rodamer	Tressler	1950	2,670	do	74	5⅝	16	do
Ae 19	Melvin Beiler	do	1950	2,520	do	53	5⅝	15	do
Ae 23	Freeman Beitzel	do	1951	2,180	do	57	5⅝	—	do
Ae 24	Eli Tice	do	1951	2,360	do	58	5⅝	24	do
Ae 25	Wm. Layman	do	1951	2,640	do	80	5⅝	52	do
Ae 26	Floyd C. Hetz	do	1951	2,170	do	80	5⅝	40	do

—Continued

Water level (feet below land surface)			Pumping equipment	Depth of pump below land surface (feet)	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Pumping	Date			Gallons a minute	Date				
40	80	2/49	C; H	—	10	2/49	0.3	D	—	See well log.
30	30	4/49	J; E	80	10	4/49	—	D	—	Coal in log probably Middle Kittanning coal. See well log.
30	30	4/49	C; H	—	10	4/49	—	D	—	Do.
—	—	—	—	—	—	—	—	D	—	See well log.
31	42	7/49	C; E	—	2	7/49	0.2	D	—	Do.
—	—	—	—	—	—	—	—	D	—	Ends in Meyersdale red bed. See well log.
75	—	4/46	I; E	—	60	1946	—	C	—	Ends about 100 feet below Barton coal. See well log. 7/50—Pumped dry at 7 gpm in a few minutes.
—	—	—	I; E	—	38	—	—	P	48.5	Ends above Harlem coal. See chemical analysis. Stand-by well.
35	50	8/49	C; H	—	5	8/49	0.3	D	—	Ends about 25 feet above Barton coal. See well log.
16	34	12/48	—	—	8	12/48	0.4	D	—	Ends between Lower Bakerstown and Brush Creek coals. See well log. A little iron reported.
28	50	6/49	W	—	8	6/49	0.4	F	—	Ends above Harlem coal. See well log. Water reported hard. Used for stock.
25	30	6/50	—	—	8	6/50	1.6	D, F	—	Ends above Barton coal. See well log.
33	55	9/50	C; H	—	4	9/50	0.2	D	—	Ends about 15 feet below Harlem coal. See well log and chemical analysis. Waterlevel, 32.26 feet 8/17/51.
—	—	—	—	—	—	—	—	D	—	Ends about at Harlem coal.
42	51	6/47	I; E	150	75	—	8.3	N	—	Ends between Lower Bakerstown and Brush Creek coals. See well log. Cannery closed.
53	75	7/47	—	—	50	7/47	2.3	C	—	Probably below Barton coal. See well log.
47	55	6/47	I; E	—	75	—	9.3	N	—	Ends under Meyersdale shale. See well log.
40	40	7/46	—	—	30	7/46	—	D	—	Ends below Lower Bakerstown coal. See well log.
51	55	3/51	—; E	—	8	3/51	2.0	D	—	Probably above Harlem coal. Water reported unfit for washing clothes. Fe 0.5 ppm (field test); pH 7.5. See well log.
40	50	4/51	—	—	7	4/51	0.7	D	—	Ends about 5 feet below Harlem coal. See well log.
—	—	—	J; E	60	—	—	1.2	D	—	Ends close to Harlem coal.
30	30	1/50	J; E	—	20	1/50	—	D	—	Ends above Harlem coal. See well log.
14	50	10/50	—	—	4	10/50	0.1	D	—	Ends between Harlem and Lower Bakerstown coals. See well log.
20	35	11/50	—	—	6	11/50	0.4	D	—	Ends between Harlem and Brush Creek coals. See well log.
35	—	9/51	—	—	10	9/51	—	D	—	Ends above Harlem coal. See well log.
30	33	9/51	—	—	6	9/51	2.0	D	—	Do.
40	46	10/51	—	—	6	10/51	1.0	D	—	Ends about 30 feet below Harlem coal. See well log.
49	49	6/51	—	—	10	6/51	—	D	—	Ends about 35 feet below top of Pittsburgh red bed. See well log.

TABLE 20

Well number (Gar-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing below land surface (feet)	Water-bearing formation and *structural unit*
Ae 28	Henry Eli Yoder	Tressler	1952	2,510	Drilled	130	5⅝	23	Conemaugh-lower memb. *Castleman basin*
Ae 29	Dewey Yommer	Brenneman	1951	2,150	do	145	5⅝	23	do
Af 1	Lloyd Martin	—	—	2,690	do	—	—	—	Hampshire and Jennings *Deer Park anticline*
Af 2	E. E. Hartman	—	—	2,629	do	—	—	—	Jennings *Deer Park anticline*
Af 3	Dave Gunter	Tressler	1949	2,670	do	135	5⅝	31	Hampshire and Jennings *Deer Park anticline*
Af 4	Olin L. Garlitz	do	1949	2,480	do	78	5⅝	20	Jennings *Deer Park anticline*
Af 7	Randall Holliday	Brenneman	1950	2,660	do	200	5⅝	23	Greenbrier *Deer Park anticline*
Af 8	Wilber Railey	Irwin	1950	2,557	do	60	5⅝	—	Hampshire *Deer Park anticline*
Af 9	Gerald M. McKinzie	do	1948	2,590	do	60	5⅝	18	Jennings *Deer Park anticline*
Af 10	William Turner	do	1949	2,420	do	67	5⅝	17	Hampshire *Deer Park anticline*
Af 11	John F. Ash	do	1949	2,550	do	219	5⅝	6	do
Af 13	Earl E. Garlitz	Tressler	1952	2,680	do	96	5⅝	29	Hampshire and Jennings *Deer Park anticline*
Af 14	Harry Robeson	do	1952	2,740	do	79	5⅝	23	Pocono *Deer Park anticline*
Ag 1	Town of Frostburg	Irwin	1932	2,560	do	30	8	—	do
Ag 2	do	do	do	2,560	do	—	—	—	do
Ag 3	W. F. Warner	—	—	2,610	Dug	39	30	—	Hampshire *Deer Park anticline*
Ag 4	do	—	—	2,610	Drilled	80	5	—	do
Ag 5	M. H. Warner	—	About 1907	2,530	do	43	4	—	do
Ag 6	Odell P. Layman	Irwin	1946	2,620	do	95	5⅝	32	Pocono *Deer Park anticline*
Ag 7	Leonard Shockey	—	About 1945	2,650	do	—	—	—	do
Ag 8	Clarence McKinzie	Irwin	1945	2,790	do	86	6	29	do
Ag 9	Earl Caton	do	1932	2,817	do	68	4	—	do
Ag 16	Johnston School	do	1947	2,620	do	80	5	26	Hampshire *Deer Park anticline*
Ag 18	Albert Drees	do	1948	2,770	do	70	6	12	Pocono *Deer Park anticline*
Ag 19	Cecil Warner	do	1948	2,605	do	60	6	20	do
Ag 20	C. L. Brant	do	1947	2,750	do	75	6	—	do
Ag 21	Anthony McKinzie	do	1950	2,750	do	40	5⅝	11	do
Ag 22	Fred Kilip	do	1946	2,710	do	100	5	—	Greenbrier *Deer Park anticline*
Ag 23	Murrell McKinzie	do	1948	2,560	do	78	6	22	Hampshire *Deer Park anticline*

—Continued

Water level (feet below land surface)			Pumping equipment	Depth of pump below land surface (feet)	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Pumping	Date			Gallons a minute	Date				
50	80	5/52	—	—	6	5/52	0.2	D	—	Ends between Harlem and Lower Bakerstown coals. See well log.
40	80	10/51	—	—	18	10/51	0.4	D	—	Ends about 40 feet below Pittsburgh red bed. See well log.
—	—	—	—	—	—	—	—	C	—	
—	—	—	—	—	—	—	—	C	—	Some iron reported. Adequate supply.
65	—	10/49	—	—	—	—	—	C	—	See well log.
15	35	8/49	C; H	—	4	8/49	0.2	D	—	Do.
50	200	8/50	C; E	189	18	8/50	0.1	D	—	See well log. Pumps down in 1 hour.
22	40	10/50	C; H	—	1.5	10/50	0.1	D	—	See well log.
21	50	9/48	C; H	—	1	9/48	0.1	D	—	Do.
10	28	11/49	J; E	60	6	11/49	0.3	D; F	—	Do.
49	180	10/49	C	200	3	10/49	less than 0.1	D	—	Do.
48	75	8/52	—	—	3	8/52	0.1	D	—	Do.
50	57	8/52	—	—	15	8/52	2.1	D	—	Do.
8.2[a]	—	10/46	—	—	—	—	—	N	—	Observation well.
1.0[a]	—	10/46	—	—	—	—	—	N	—	
30.54[a]	—	7/50	J; E	—	—	—	—	D	—	Goes dry some summers.
—	—	—	J; E	—	—	—	—	F	—	Reported never dry. Quality good.
—	—	—	C; E	—	4	—	—	C	—	Reported never dry.
40	—	1946	J; E	—	—	—	—	D	—	
—	—	—	J; E	—	—	—	—	D	—	Water reported hard.
—	—	—	C; H	—	—	—	—	D	—	Supplies 4 families.
—	—	—	C; H	—	—	—	—	D	—	Reported adequate.
12	30	2/47	—	—	5	2/47	0.3	S	—	See well log.
31	50	9/48	—	—	1	9/48	0.1	D	—	Do.
33	40	10/48	C; H	—	3	10/48	0.3	D	—	Do.
15	25	1/47	—	—	—	—	—	D	—	Water a little hard.
17	28	10/50	C; H	—	1	10/50	0.1	D	—	See well log.
61	61	12/46	—	—	1	12/46	—	D	—	Do.
21	40	11/48	—	—	1	11/48	0.1	D	—	Do.

TABLE 20

Well number (Gar-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing below land surface (feet)	Water-bearing formation and *structural unit*
Ag 24	Arvel Minick	Irwin	1950	2,540	Drilled	65	$5\frac{5}{8}$	—	Hampshire *Deer Park anticline*
Ag 26	Nannie Caton	do	1952	2,800	do	61	$5\frac{5}{8}$	12	Pocono *Deer Park anticline*
Ba 1	Blaine Frantz	Brenneman	1950	2,010	do	70	$5\frac{5}{8}$	41	Conemaugh-lower memb. *Lower Youghiogheny basin*
Ba 3	Ellis Friend	Irwin	About 1906	2,080	do	60	—	—	do
Ba 6	C. F. Williams	Brenneman	About 1947	2,400	do	150	—	—	do
Bb 1	R. O. McCullough	—	—	1,550	Dug	37	16	—	Allegheny (?) *Lower Youghiogheny basin*
Bb 2	Town of Friendsville	Brenneman	1946	1,490	Drilled	50	6	22	Allegheny *Lower Youghiogheny basin*
Bb 4	William M. Frazee	do	1950	1,500	do	41	5	30	do
Bb 5	George Wahl	do	1950	1,910	do	55	$5\frac{5}{8}$	21	Hampshire *Deer Park anticline*
Bb 6	Gerald Glass	do	1951	1,910	do	55	do	25	Hampshire *Accident dome*
Bb 7	Clark Schlossnagle	do	1950	2,470	do	75	do	30	Pocono *Accident dome*
Bb 9	James Resh	do	1948	2,210	do	185	8	65	Greenbrier and Pocono *Accident dome*
Bb 10	Orval Ross	do	1950	1,620	do	60	$5\frac{5}{8}$	31	Conemaugh-lower memb. *Lower Youghiogheny basin*
Bb 11	J. L. Fazenbaker	do	1948	2,360	do	100	$5\frac{5}{8}$	28	Hampshire *Accident dome*
Bb 12	Paul Frazee	do	1928	2,520	do	86	—	—	Pottsville *Lower Youghiogeny basin*
Bc 1	E. H. Ault	—	—	2,415	Dug	20	36	—	Hampshire *Accident dome*
Bc 3	Zion Church	Brenneman	1950	2,400	Drilled	157	$5\frac{5}{8}$	40	do
Bc 4	F. E. Spoerlein	do	1950	2,380	do	85	$5\frac{5}{8}$	31	do
Bc 5	Cove School	do	1951	2,430	do	401	—	—	do
Bc 6	State of Maryland: Bear Creek Fish Hatchery	do	1947	2,150	do	65	$5\frac{5}{8}$	26	do
Bc 7	T. R. van Marter	do	1949	2,110	do	30	$5\frac{5}{8}$	20	do
Bc 8	Carl Mosser	do	1951	2,360	do	110	$5\frac{5}{8}$	26	do
Bc 9	Harry Humberson	do	1950	2,390	do	100	$5\frac{5}{8}$	30	do
Bc 10	Roy Broadwater	do	1949	2,390	do	100	$5\frac{5}{8}$	59	do
Bc 11	Earl Haentfling	do	1950	2,375	do	55	$5\frac{5}{8}$	—	do
Bc 12	Harrison Kamp	do	1950	2,375	do	55	$5\frac{5}{8}$	26	do
Bc 13	Rosie Smith	do	1950	2,420	do	100	$5\frac{5}{8}$	31	do
Bc 14	County Roads Commission	do	1947	2,390	do	101	$5\frac{5}{8}$	22	do
Bc 15	Thomas Custer	do	1948	2,400	do	100	$5\frac{5}{8}$	20	do
Bc 16	Charles Wilt	do	1951	2,320	do	130	$5\frac{5}{8}$	22	do

—*Continued*

Water level (feet below land surface)			Pumping equipment	Depth of pump below land surface (feet)	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Pumping	Date			Gallons a minute	Date				
21	30	11/50	—	—	1.5	11/50	0.2	D	—	See well log.
12	20	1/52	—	—	0.75	1/52	—	D	—	Do.
15	20	4/50	J; E	—	22	4/50	4.4	C	—	Do.
21.75[a]	—	8/51	C; H	—	—	—	—	N	—	Much iron reported.
—	—	—	C; E	—	—	—	—	D	—	Reported never dry. Quality good.
28.14[a]	—	10/46	C; H	—	—	—	—	N	—	Observation well.
3.9[a]	19.9[a]	3/46	I; E	—	40	3/46	2.5	S	—	See well log and chemical analysis.
20	20	1/50	J; E	—	21	1/50	—	C	—	See well log.
18	22	12/50	—	—	8	12/50	2.0	D	—	Do.
15	15	2/51	—	—	18	2/51	—	D	—	Do.
20	20	11/50	—	—	36	11/50	—	F	—	See well log. Water supplies chickens.
5	185	1/49	C; E	—	10	11/49	0.1	D	—	See well log. Pumped down in 2 hrs.
18	60	10/50	—	—	18	10/50	0.4	D	—	Do.
14	24	2/48	—	—	12	2/48	1.2	D	—	See well log.
—	—	—	—; E	—	—	—	—	D	—	Reported never dry.
15.82[a]	—	8/49	B	—	—	—	—	D	—	Do.
14	145	4/50	J; E	—	5	4/50	—	D	—	See well log. Pumped down in 2 hrs.
20	30	4/50	—	—	22	4/50	2.2	D	—	See well log.
384	398	8/51	—	—	2	8/51	—	N	—	Well abandoned because of low yield. See well log.
10	10	4/47	—	—	40	4/47	—	D	—	See well log.
18	18	4/49	J; E	—	24	4/49	—	D	—	Do.
30	65	11/51	—	—	10	11/51	0.2	D	—	Do.
22	100	10/50	—	—	18	10/50	—	D	—	See well log. Pumped dry in 2 hrs. at 18 gpm.
30	30	7/49	—	—	24	7/49	—	D	—	See well log.
6	20	5/50	—	—	20	5/50	1.5	D	—	Do.
20	20	10/50	—	—	36	10/50	—	D	—	Do.
22	22	10/50	—	—	18	10/50	—	D	—	Do.
8	12	4/47	—	—	15	4/47	3.8	D	—	Do.
20	20	3/48	—	—	25	3/48	—	D	—	Do.
60	60	11/51	—	—	36	11/51	—	D	—	Do.

TABLE 20

Well number (Gar-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing below land surface (feet)	Water-bearing formation and *structural unit*
Bc 18	Casselman School	Dilley	1951	2,710	Drilled	114	$5\frac{5}{8}$	15	Conemaugh-lower memb. *Castleman basin*
Bc 20	Cecil Resh	Tressler	1951	2,670	do	100	$5\frac{5}{8}$	—	Pocono *Accident dome*
Bc 22	Jacob Beitzel	do	1930	2,700	do	32	—	19	Allegheny and Pottsville *Castleman basin*
Bc 25	Charles De Witt	Brenneman	1952	2,430	do	100	$5\frac{5}{8}$	40	Hampshire *Accident dome*
Bc 26	Vernon Richter	Tressler	1952	2,460	do	143	$5\frac{5}{8}$	24	do
Bc 27	Raymond Beitzel	do	1952	2,560	do	123	6	40	Conemaugh-lower memb. *Castleman basin*
Bc 28	Cove School	Dilley	1951	2,450	do	—	—	—	Hampshire *Accident dome*
Bc 29	do	Brenneman	1952	2,430	do	600	8	68	do
Bd 1	Clark Hetrick	Tressler	1950	2,690	do	54	$5\frac{5}{8}$	19	Conemaugh-upper memb. *Castleman basin*
Bd 2	Lawrence Beitzel	do	1950	2,610	do	80	$5\frac{5}{8}$	30	do
Bd 3	Jason Wilburn	—	1945	2,300	do	70	—	—	Conemaugh-lower memb. *Castleman basin*
Bd 8	Walter Bittinger	Tressler	1951	2,490	do	43	$5\frac{5}{8}$	20	do
Bd 10	Mahlon Hutzel	do	1952	2,650	do	86	$5\frac{5}{8}$	24	Allegheny *Castleman basin*
Be 1	Md. Dept. of State Forests and Parks	Washington Pump & Well Co.	1938	2,560	do	196	6	4	Pocono *Deer Park anticline*
Be 4	New Germany School	Dilley	1951	2,530	do	83	$5\frac{5}{8}$	15	do
Bf 2	St. Annes Church School	Irwin	1949	2,629	do	63	—	11	Hampshire *Deer Park anticline*
Bf 3	James B. Turner	Tressler	1950	2,590	do	218	$5\frac{5}{8}$	24	Jennings *Deer Park anticline*
Bf 4	Otis Camp	Irwin	1949	2,640	do	115	6	13	Hampshire *Deer Park anticline*
Bf 5	Parker Warnick	—	About 1905	2,420	do	102	—	18	do
Bf 8	Wm. J. Weir	—	About 1895	2,550	Dug	20	—	—	Conemaugh-lower memb. *Georges Creek basin*
Bf 9	Samuel Tipton	Tressler	1951	2,690	Drilled	103	$5\frac{5}{8}$	17	Jennings *Deer Park anticline*
Ca 1	Sam Thomas	Brenneman	1951	2,000	do	45	$5\frac{5}{8}$	21	Greenbrier *Cross structure*
Ca 2	John E. Hinebaugh	—	About 1861	2,030	do	86	—	—	do
Cb 1	Jacob Dolence	Brenneman	1950	2,480	do	40	$5\frac{5}{8}$	23	Mauch Chunk *Cross structure*
Cb 2	Dwarl Ringer	do	1949	2,490	do	110	6	36	do
Cb 3	W. J. Gorniak	do	1950	2,490	do	100	$5\frac{5}{8}$	34	do
Cb 4	C. M. Railey	do	1948	2,480	do	85	6	21	do
Cb 5	Carr Coal Co.	do	1948	2,480	do	70	$5\frac{5}{8}$	42	do
Cb 6	Arthur R. Morris	do	1948	2,540	do	250	6	—	do

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Water level (feet below land surface)			Pumping equipment	Depth of pump below land surface (feet)	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Pumping	Date			Gallons a minute	Date				
20	70	5/51	C; H	85	8	5/51	0.1	S	—	See well log.
—	—	—	—	—	1	—	—	N	—	Do.
6	—	—	—; E	—	—	—	—	D	—	Water reported to rust pipe. Supply adequate.
6	35	4/52	—	—	10	4/52	0.4	D	—	See well log.
85	130	6/52	—	—	5	6/52	0.1	D	—	Do.
30	50	9/52	—	—	20	9/52	1.0	D	—	
—	—	—	—	—	—	—	—	N	—	Insufficient supply.
163	337	11/52	I; E	—	22	11/52	0.1	S	—	See well log and chemical analysis.
30	30	5/50	—	—	8	5/50	—	D	—	See well log.
49	49	9/50	—	—	10	9/50	—	D	—	Do.
—	—	—	C; H	—	—	—	—	D	—	Water reported adequate and good.
24	27	9/51	—	—	5	9/51	1.7	D	—	See well log.
8	10	4/52	—	—	6	4/52	3.0	D	—	Do.
—	—	—	C; E	—	45	7/50	—	C	—	Pumping rating reported 45 gpm.
0	15	5/51	C; H	42	15	5/51	1.0	S	—	See well log.
38	42	4/49	C; H	—	3	4/49	0.8	S	—	See well log. Water reported hard.
195	195	6/50	—	—	4	6/50	—	D	—	Do.
35	60	5/49	—	—	2	5/49	0.1	D, F	—	See well log.
60	—	8/51	C; H	—	—	—	—	D	—	Reported never dry.
12	—	—	B	—	—	—	—	D	52	Ends close to Lower Bakerstown coal. Water gets very low.
—	—	—	B	—	1	9/51	—	D	—	See well log.
20	25	2/51	—	—	18	2/51	3.6	D	—	Do.
—	—	—	J; E	—	—	—	—	D	—	Reported never dry.
20	20	9/50	—	—	18	9/50	—	D	—	See well log.
40	100	9/49	J; E	100	6	9/49	0.1	D	—	See well log. Pumped down in 2 hrs.
40	40	9/50	J; E	—	18	9/50	—	D	—	See well log.
18	85	10/48	—	—	20	10/48	—	D	—	Pumped dry in 2 hrs. at 20 gpm.
30	30	10/48	—	—	20	10/48	—	D	—	See well log.
109	195	5/48	C; E	200	12	5/48	0.1	D	—	Do.

TABLE 20

Well number (Gar-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing below land surface (feet)	Water-bearing formation and *structural unit*
Cb 7	Chas. Gurley	Brenneman	1949	2,540	Drilled	75	6	49	Mauch Chunk *Cross Structure*
Cb 8	John D. Young	do	1948	2,480	do	80	$5\frac{5}{8}$	37	Pocono *Accident dome*
Cb 9	John E. Ferguson	do	1945	2,600	do	80	$5\frac{5}{8}$	11	do
Cb 10	Parley Savage	do	1945	2,490	do	65	$5\frac{5}{8}$	17	do
Cb 11	Hubert H. Bowman	do	1950	2,475	do	85	$5\frac{5}{8}$	29	do
Cb 12	Marshall B. Pressman	do	1950	2,490	do	72	$5\frac{5}{8}$	66	Greenbrier *Accident dome*
Cb 13	Vesta McSpadden	do	1950	2,520	do	100	$5\frac{5}{8}$	72	do
Cb 14	Fred Boetner	do	1948	2,490	do	85	$5\frac{5}{8}$	31	Mauch Chunk, Greenbrier *Accident dome*
Cb 15	H. E. Cochran	do	1950	2,480	do	72	$5\frac{5}{8}$	64	do
Cb 16	G. V. Tidball	do	1948	2,480	do	80	$5\frac{5}{8}$	20	Greenbrier *Accident dome*
Cb 17	Bert Frazee	do	1948	2,480	do	60	$5\frac{5}{8}$	32	do
Cb 18	John E. Beck	do	—	2,480	do	65	—	—	do
Cb 19	C. O. Travers	do	1948	2,480	do	80	$5\frac{5}{8}$	20	do
Cb 20	— Snodgrass	—	—	2,480	do	—	—	—	do
Cb 21	— Grossland	—	—	2,480	do	—	—	—	do
Cb 22	P. R. Hagner	Brenneman	1948	2,500	do	65	$5\frac{5}{8}$	38	do
Cb 23	Charles F. White	do	1950	2,870	do	150	$5\frac{5}{8}$	22	Pocono *Accident dome*
Cb 24	O. Halsey	do	1945	2,480	do	100	$5\frac{5}{8}$	65	Mauch Chunk *Cross structure*
Cb 25	S. A. Rodeheaver	do	About 1950	2,400	do	—	$5\frac{5}{8}$	—	Pocono *Accident dome*
Cb 26	Bretbren Church	Taylor	1937	2,580	do	40	—	—	do
Cb 31	Edith Friend	Skipper	1947	2,610	do	80	—	—	Conemaugh-lower memb. *Upper Youghiogheny basin*
Cb 32	Irving Feld	Brenneman	1948	2,490	do	60	$5\frac{5}{8}$	43	Mauch Chunk *Cross structure*
Cb 33	Richard Coddington	do	1952	2,580	do	65	$5\frac{5}{8}$	44	Greenbrier *Accident dome*
Cb 34	C. Dribles	Dilley	1952	2,475	do	89	$5\frac{5}{8}$	30	Mauch Chunk *Cross structure*
Cb 35	Frank O. Rendalic	Miller	1952	2,490	do	95	$5\frac{5}{8}$	—	do
Cb 36	Ralph Duwell	do	1952	2,510	do	102	$5\frac{5}{8}$	—	do
Cb 37	Roy Glotfelty	Brenneman	1950	2,480	do	65	$5\frac{5}{8}$	—	Hampshire *Accident dome*
Cb 38	M. G. Shipley	Miller	1952	2,480	do	74	$5\frac{5}{8}$	—	Greenbrier *Accident dome*
Cb 39	W. E. Pardoe	Brenneman	1952	2,490	do	80	$5\frac{5}{8}$	51	Mauch Chunk *Cross structure*
Cc 1	Lester Hardman	Miller	1949	2,520	do	164	$5\frac{5}{8}$	—	Mauch Chunk, Greenbrier *Deer Park anticline*
Cc 2	George Essey	Brenneman	1948	2,520	do	85	$5\frac{5}{8}$	47	Greenbrier *Deer Park anticline*
Cc 3	Edna M. Whitworth	do	1948	2,490	do	100	$5\frac{5}{8}$	46	Mauch Chunk, Greenbrier *Deer Park anticline*
Cc 4	E. R. Cooper	do	1948	2,510	do	100	$5\frac{5}{8}$	36	Hampshire *Deer Park anticline*

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Water level (feet below land surface)			Pumping equipment	Depth of pump below land surface (feet)	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Pumping	Date			Gallons a minute	Date				
30	30	9/49	—	—	24	9/49	—	D	—	See well log.
12	20	3/48	—	—	10	3/48	1.3	D	—	Do.
0	80	12/45	—	—	5	12/45	0.1	D	—	Do.
10	10	12/45	—	—	20	12/45	—	D	—	Do.
26	26	10/50	—	—	36	10/50	—	D	—	Do.
32	32	5/50	—	—	20	5/50	—	D	—	
50	50	8/50	—	—	18	8/50	—	D	—	Do.
22	22	4/48	J; E	—	20	4/48	—	D	—	Do.
22	22	5/50	J; E	63	20	5/50	—	D	—	Do.
10	10	5/48	J; E	60	10	5/48	—	D	—	Do.
14	14	4/48	—	—	10	4/48	—	D	—	Do.
—	—	—	—	—	—	—	—	D	—	
15	30	4/48	—	—	20	4/48	1.3	D	—	Do.
—	—	—	—	—	—	—	—	D	—	
—	—	—	—	—	—	—	—	D	—	
12	12	5/48	—	—	10	5/48	—	D	—	Do.
35	40	3/50	J; E	140	20	5/48	4.0	D, F	—	Do.
18	18	11/45	—	—	20	11/45	—	D	—	Do.
—	—	—	—; E	—	—	—	—	D	—	—
—	—	—	C; H	—	—	—	—	D	53	Well goes dry after heavy pumping.
—	—	—	J; E	—	—	—	—	D	—	Ends near Brush Creek coal. Water rept. irony.
18	18	3/48	—	—	20	3/48	—	D	—	See well log.
20	20	2/52	J; E	—	18	2/52	—	D	—	Do.
30	50	4/52	—	—	—	—	0.4	D	—	Do.
31	64	8/52	J; E	80	20	8/52	0.6	D	—	Do.
31	55	8/52	J; E	85	5	8/52	0.2	D	—	Do.
—	—	—	—	—	—	—	—	D	—	Do.
18	—	8/52	—	—	—	—	—	D	—	Do.
30	45	3/52	—	—	10	3/52	0.6	D	—	Do.
40	90	8/49	C; E	154	10	8/49	0.2	D	—	Do.
60	85	9/48	C; H	—	10	9/48	—	D	—	See well log and chemical analysis. Can be pumped dry.
30	30	9/48	J; E	—	20	9/48	—	D	—	See well log.
40	40	8/48	—	—	20	8/48	—	D	—	Do.

TABLE 20

Well number (Gar-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing below land surface (feet)	Water-bearing formation and *structural unit*
Cc 5	Wm. Parrish	Skipper	1950	2,480	Drilled	73	$5\frac{5}{8}$	20	Pocono *Deer Park anticline*
Cc 6	A. D. Naylor	Brenneman	1945	2,480	do	50–55	$5\frac{5}{8}$	23	do
Cc 7	Mrs. George Hinds	Skipper	1946	2,530	do	152	$5\frac{5}{8}$	25	do
Cc 8	Frank J. Bryan	Brenneman	1948	2,480	do	60	$5\frac{5}{8}$	49	do
Cc 9	Jessie Bloch	do	1950	2,500	do	115	$5\frac{5}{8}$	41	Mauch Chunk *Cross structure*
Cc 10	J. G. Bennett	do	1947	2,480	do	80	$5\frac{5}{8}$	21	Pocono *Deer Park anticline*
Cc 11	R. J. Hosteller	do	1948	2,480	do	85	$5\frac{5}{8}$	43	do
Cc 12	John Vicho	do	1950	2,480	do	92	$5\frac{5}{8}$	58	Greenbrier *Cross structure*
Cc 15	Nelson Orendorf	Tressler	1949	2,710	do	110	$5\frac{5}{8}$	—	Conemaugh-lower memb. *Castleman basin*
Cc 16	E. E. Albig	Brenneman	1950	2,500	do	115	$5\frac{5}{8}$	38	Hampshire *Deer Park anticline*
Cc 18	Dr. T. D. Chataway	do	1952	2,530	do	115	$5\frac{5}{8}$	40	Mauch Chunk *Cross structure*
Cc 19	James Glottelty	do	1951	2,700	do	46	$5\frac{5}{8}$	33	Allegheny *Castleman basin*
Cc 20	Paul E. Friend	Miller	1952	2,635	do	105	6	—	Pocono *Deer Park anticline*
Cc 21	F. Crouch	Brenneman	1952	2,510	do	80	$5\frac{5}{8}$	—	do
Cc 22	Edwin C. Betz	do	1947	2,480	do	80	$5\frac{5}{8}$	57	Mauch Chunk *Cross structure*
Cc 23	Howard Naylor	Dilley	1952	2,480	do	75	$5\frac{5}{8}$	30	Pocono *Deer Park anticline*
Cd 3	F. M. Bittinger	Brenneman	About 1939	2,640	do	63	$5\frac{5}{8}$	—	Conemaugh-lower memb. *Castleman basin*
Cd 4	U. S. Government	do	1937	2,720	do	240	—	—	Conemaugh-lower memb. and Allegheny *Castleman basin*
Cd 5	do	do	1937	2,680	do	180	—	—	Conemaugh-lower memb. *Castleman basin*
Cd 6	do	do	1937	2,660	do	160	—	—	do
Cd 9	North Glade School	do	1946	2,500	do	90	$5\frac{5}{8}$	37	Hampshire *Deer Park anticline*
Cc 10	Curtis C. Miller	do	About 1949	2,500	do	33	$5\frac{5}{8}$	18	Hampshire and Jennings *Deer Park anticline*
Cd 11	Joe Faulkner	Tressler	About 1946	2,360	do	95	—	—	Jennings *Deer Park anticline*
Cd 12	Ralph Buckle	do	1951	2,670	do	53	$5\frac{5}{8}$	—	Conemaugh-lower memb. *Castleman basin*
Cd 13	Olen Yoder	do	1952	2,640	do	57	$5\frac{5}{8}$	21	Allegheny *Castleman basin*
Da 1	Jerry Friend	Kelley	1946	2,470	do	68	$5\frac{5}{8}$	8	Conemaugh-lower memb. *Upper Youghiogheny basin*
Da 2	Harold Gank	Dilley	1950	2,520	do	75	$5\frac{5}{8}$	26	do
Da 3	Elwood Carscaden	Kelley	1946	2,490	do	50	$5\frac{5}{8}$	14	do
Da 4	Preston B. Coulter	do	1946	2,500	do	58	$5\frac{5}{8}$	20	do

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Water level (feet below land surface)			Pumping equipment	Depth of pump below land surface (feet)	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Pumping	Date			Gallons a minute	Date				
20	55	9/50	—	—	2	9/50	0.1	D	—	See sample log.
22	22	10/45	C; H	—	40	10/45	—	D	—	
60	60	11/46	—	—	10	11/46	—	D	—	See well log.
8	8	3/48	—	—	10	3/48	—	D	—	Do.
30	70	10/50	—	—	15	10/50	0.4	D	—	Do.
3	20	10/47	—	—	24	10/47	1.4	D	51.5	See well log. Well flowing. More than 3 ppm Fe (field test).
8	8	3/48	—	—	10	3/48	—	D	—	See well log.
5	55	6/50	—	—	20	6/50	0.4	D	—	Do.
—	—	—	—	—	—	—	—	D	—	See well log. Water reported somewhat hard.
65	65	3/50	J; E	105	10	3/50	—	D	—	
50	50	2/52	—	—	18	2/52	—	D	—	See well log.
20	40	10/51	—	—	18	10/51	0.9	D	—	Do.
40	70	6/52	—	—	3	6/52	0.1	D	—	Do.
0	25	5/52	—	—	20	5/52	1.0	D	—	See well log. Flowed about 4 gpm.
22	22	9/47	—	—	12	9/47	—	D	—	See well log.
16	23	5/52	—	—	8	5/52	1.1	D	—	Do.
17	—	3/51	J; E	—	—	—	—	D	—	Ends above Brush Creek coal. Supply reported ample.
—	—	—	J; E	—	—	—	—	P	—	Probably ends between Upper Freeport and Middle Kittanning coals. Water reported hard.
—	—	—	—	—	—	—	—	P	—	Probably ends at Upper Freeport coal. Water reported hard.
—	—	—	C; H	—	—	—	—	P	57	Do.
22	40	8/46	—	—	10	8/46	0.6	S	—	Water reported poor (8/51). See well log.
19	—	—	—; E	—	—	—	—	C, D	—	Adequate supply reported.
28	—	3/51	J; E	—	—	—	—	D	—	Do.
—	—	—	—	—	—	—	—	D	—	Starts about at Barton coal. See well log.
8	40	6/52	—	—	20	6/52	0.6	D	—	Starts above and ends below Upper Freeport coal. See well log.
28	68	6/46	—	—	3	6/46	0.1	D	—	Ends between Harlem and Lower Bakerstown coals.
14	60	10/50	—	—	8	10/50	0.2	D	—	Ends between Harlem and Lower Bakerstown coals. See well log.
6	7	6/46	—	—	6	6/46	6.0	D	—	Do.
30	58	6/46	—	—	6	6/46	0.2	D	—	Ends in Pittsburgh red shale. See well log.

TABLE 20

Well number (Gar-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing below land surface (feet)	Water-bearing formation and *structural unit*
Da 5	Md. Dept. of State Forests and Parks	Kelley	1946	2,480	Drilled	63	5⅝	15	Conemaugh-lower memb. *Upper Youghiogheny basin*
Da 6	T. J. Johnson	do	1946	2,590	do	60	5⅝	24	do
Da 7	John O'Haver	do	1946	2,460	do	43	5⅝	8	do
Da 9	Md. Dept. of State Forests and Parks	—	About 1933	2,420	do	200	5⅝	—	Allegheny & Pottsville *Upper Youghiogheny basin*
Da 10	Do	Brenneman	About 1938	2,435	do	200	5⅝	—	do
Da 12	T. J. Johnson	Kelley	1951	2,520	do	42	5⅝	34	Conemaugh-lower memb. *Upper Youghiogheny basin*
Da 13	Do	do	1951	2,430	do	45	5⅝	9	do
Da 14	John O'Haver	Hardesty	1951	2,480	do	55	5⅝	5	do
Da 15	Frank Hansen	do	1952	2,460	do	115	5⅝	21	Allegheny *Upper Youghiogheny basin*
Da 16	Do	do	1952	—	—	—	—	—	do
Db 1	H. W. Quick	Miller	1945	2,585	do	85	5⅝	—	Jennings *Deer Park anticline*
Db 2	W. W. Groves	do	1946	2,560	do	60	5⅝	—	do
Db 3	Patrick Rhodehaver	Hardesty	1951	2,470	do	79	5⅝	20	Pocono *Deer Park anticline*
Db 4	Arden May	Brenneman	1950	2,680	do	85	5⅝	22	do
Db 5	Ariel House	Skipper	1947	2,690	do	73	5⅝	26	Pocono & Hampshire *Deer Park anticline*
Db 6	E. A. Roth	Brenneman	1934	2,670	do	78	5⅝	36	Jennings *Deer Park anticline*
Db 7	Town of Oakland	do	1934	2,400	do	165	5⅝	—	Pocono *Deer Park anticline*
Db 8	Ralph Romesburg	Skipper	1948	2,560	do	67	5⅝	43	Jennings *Deer Park anticline*
Db 12	Town of Oakland	Kelley	1950	2,390	do	257	10	46	Pocono *Deer Park anticline*
Db 13	Do	do	1947	2,390	do	254	5⅝	44	do
Db 14	Do	Brenneman	1943	2,480	do	250	5⅝	20	do
Db 15	Do	—	1934	2,460	do	165	5⅝	—	do
Db 17	J. A. Deberry	—	About 1920	2,510	do	60	5⅝	30	Jennings *Deer Park anticline*
Db 18	Town of Oakland	do	1939	2,410	do	180	5⅝	—	Pocono *Deer Park anticline*
Db 19	Do	—	—	2,400	do	300+	—	—	Mauch Chunk & Greenbrier *Deer Park anticline*
Db 20	Ralph Pritt	—	1951	2,450	do	76	5⅝	25	Hampshire *Deer Park anticline*
Db 21	Town of Oakland	Kelley	1951	2,390	do	250	10	42	Pocono *Deer Park anticline*
Db 22	Lucille Mitchel	Dilley	1951	2,430	do	80	5⅝	14	Hampshire *Deer Park anticline*
Db 23	Lawrence Skipper	do	1952	2,580	do	80	5⅝	16	Jennings *Deer Park anticline*

—Continued

Water level (feet below land surface)			Pumping equipment	Depth of pump below land surface (feet)	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Pumping	Date			Gallons a minute	Date				
30	63	5/46	—	—	5	5/46	0.2	N	—	Ends below Harlem coal. Static level 29.5 feet (6/6/50). See well log.
30	30	6/46	—	—	18	6/46	—	D	—	Ends above Harlem coal. See well log.
7	10	6/46	—	—	20	6/46	6.6	D	—	Ends between Harlem and Lower Bakerstown coals. See well log.
—	—	—	—	—	—	—	—	N	—	Well abandoned about 1938 because of poor quality of water; reported high in iron.
—	—	—	I; E	—	220	7/52	—	D	—	State Park water treated. Drilled for C.C.C. Camp.
9	14	10/51	—	—	15	10/51	3.0	D	—	Ends about 60 feet above Harlem coal. See well log.
4.5	27	10/51	—	—	15	10/51	0.7	D, F	—	Ends between Harlem and Brush Creek coals. See well log.
—	—	—	—	—	5	—	—	D	—	Ends close to Lower Bakerstown coal. See well log.
30	50	9/52	—	—	7	9/52	0.4	S	—	Starts below upper Freeport coal. See well log.
—	—	—	—	—	—	—	—	—	—	Starts below Upper Freeport coal. Drilled close to Da 15.
17	30	9/45	C; H	—	8	9/45	0.6	D	—	See well log.
20	30	8/46	C; H	51	10	8/46	1.0	D	—	Do.
16	52	7/51	—	—	8	7/51	0.2	D	—	
0	0	5/50	—	—	20	5/50	—	D	—	Do.
20	20	10/47	—	—	7	10/47	—	D	—	See well log. Static level 31.3—7/24/51.
25	—	—	J; E	—	—	—	—	D, F	—	Reported never dry.
—	—	—	—	—	—	—	—	P	—	Siphon well. Rarely used.
18	50	10/48	—	—	40	10/48	1.3	D	—	See well log.
—	90	7/50	I; E	—	130	7/50	—	P	—	See chemical analysis. Flowing well.
—	—	—	—	—	30	8/51	—	P	—	See well log. Flow reported to be 30 gpm.
—	35	8/51	C; E	—	50	8/51	1.4	P	—	Flows part of time. Stand-by well.
—	—	—	—	—	—	—	—	N	—	
—	—	—	C; E	—	—	—	—	D	—	Has been pumped dry.
—	—	—	—	—	—	—	—	P	—	Do.
—	—	—	—	—	—	—	—	N	—	Reported no water is obtainable.
10	20	8/51	—	—	8	8/51	0.8	D	—	
8	55	12/51	I; E	—	60	12/51	1.3	P	—	See well log.
20	40	9/51	—	—	8	9/51	0.4	D	—	Do.
30	55	6/52	—	—	5	6/52	0.2	D	—	Do.

TABLE 20

Well number (Gar-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing below land surface (feet)	Water bearing formation and *structural unit*
Db 24	Roy White	Miller	1952	2,560	Drilled	106	$5\frac{5}{8}$	—	Jennings *Deer Park anticline*
Db 25	Arch Peck	Brenneman	1952	2,460	do	200	$5\frac{5}{8}$		Pocono *Deer Park anticline*
Db 26	Harold Gnegy	do	1952	2,460	do	200	$5\frac{5}{8}$	—	do
Dc 1	F. M. Twigg	do	1950	2,500	do	150	$5\frac{5}{8}$	41	Hampshire *Deer Park anticline*
Dc 2	Wm. H. Pentz	do	1948	2,510	do	125	$5\frac{5}{8}$	32	do
Dc 3	Walter Shaffer	do	1948	2,510	do	151	$5\frac{5}{8}$	42	do
Dc 4	Chas. C. Reckard	do	1950	2,510	do	175	$5\frac{5}{8}$	39	do
Dc 5	Eric Hyvarinen	do	About 1948	2,515	do	125	$5\frac{5}{8}$	—	do
Dc 6	Clarence Morley	Skipper	1946	2,520	do	61	$5\frac{5}{8}$	15	Jennings *Deer Park anticline*
Dc 7	Edward Madigan	do	1946	2,520	do	97	$5\frac{5}{8}$	16	do
Dc 8	Wm. Ducan	do	1947	2,480	do	96	$5\frac{5}{8}$	—	do
Dc 9	Dr. Robert Bess	Kelley	1946	2,470	do	68	$5\frac{5}{8}$	14	do
Dc 10	Clarence Bateman	Miller	1946	2,540	do	65	$5\frac{5}{8}$	—	Hampshire *Deer Park anticline*
Dc 11	Holy Cross House	Brenneman	1946	2,480	do	150	$5\frac{5}{8}$	36	Jennings *Deer Park anticline*
Dc 12	G. Gibson	Skipper	1946	2,480	do	77	$5\frac{5}{8}$	23	do
Dc 13	R. B. Marshall	Dilley	1951	2,470	do	95	$5\frac{5}{8}$	18	Hampshire *Deer Park anticline*
Dc 14	Winkle Voss	do	1951	2,470	do	90	$5\frac{5}{8}$	20	do
Dc 15	N. M. Dell	do	1951	2,470	do	80	$5\frac{5}{8}$	21	do
Dc 16	Samuel E. Griffiths	do	1951	2,470	do	80	$5\frac{5}{8}$	30	do
Dc 17	J. K. Kaminick	do	1951	2,470	do	80	$5\frac{5}{8}$	10	do
Dc 18	Perry Smith	Buser	1950	2,520	do	171	$5\frac{5}{8}$	28	Jennings *Deer Park anticline*
Dc 19	Do	do	1950	2,520	do	156	$5\frac{5}{8}$	22	do
Dc 20	Robert S. Hamilton	Miller	1946	2,480	do	70	$5\frac{5}{8}$	—	do
Dc 21	Dr. J. H. Wolverton	Brenneman	1947	2,480	do	100	$5\frac{5}{8}$	30	do
Dc 22	Claude Friend	—	About 1900	2,500	do	75	$5\frac{5}{8}$	—	do
Dc 24	G. G. Harris	Brenneman	1947	2,490	do	80	$5\frac{5}{8}$	22	Hampshire *Deer Park anticline*
Dc 25	R. R. Keener	do	1940	2,490	do	75	$5\frac{5}{8}$	32	do
Dc 26	John Clabaugh	Dilley	1952	2,500	do	91	$5\frac{5}{8}$	21	Jennings *Deer Park anticline*
Dc 27	A. P. Clarke	Brenneman	1947	2,520	do	75	$5\frac{5}{8}$	30	Hampshire *Deer Park anticline*
Dc 28	Bertha Dunlap	do	1947	2,500	do	100	$5\frac{5}{8}$	33	do
Dc 30	T. Lafferty	Dilley	1951	2,470	do	84	$5\frac{5}{8}$	22	do
Dc 31	Wm. R. Goebels	Tressler	1952	2,480	do	92	$5\frac{5}{8}$	29	Jennings *Deer Park anticline*
Dc 32	Geo. Lemmert	do	1952	2,480	do	—	—	—	do
Dc 33	Clarence M. Walker	do	1952	2,480	do	55	$5\frac{5}{8}$	29	do
Dc 34	Joseph R. Wheelan	do	1952	2,490	do	64	$5\frac{5}{8}$	21	do
Dc 35	Carl Clark	Miller	1952	2,470	do	101	$5\frac{5}{8}$	—	Hampshire *Deer Park anticline*
Dc 36	Wm. H. Martin	do	1952	2,480	do	102	$5\frac{5}{8}$	—	do
Dc 37	Thos. H. Kingsley	do	1952	2,480	do	107	$5\frac{5}{8}$	—	do
Dc 38	Chas. B. Bowser	do	1952	2,470	do	102	$5\frac{5}{8}$	—	Jennings *Deer Park anticline*

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Water level (feet below land surface)			Pumping equipment	Depth of pump below land surface (feet)	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Pumping	Date			Gallons a minute	Date				
32	—	6/52	—	—	—	—	—	D	—	See well log.
45	200	5/52	—	—	10	5/52	—	D	—	See well log. Can be pumped dry.
45	180	5/52	—	—	10	5/52	—	D, F	—	Do.
27	40	8/50	—	—	18	8/50	1.4	D	—	See well log.
48	125	9/48	C; H	—	20	9/48	—	D	—	See well log. Pumped dry.
55	151	8/48	C; E	—	20	8/48	—	D	—	Do.
50	175	8/50	J; E	—	18	8/50	0.1	D	—	See sample log.
—	—	—	C; H	—	—	—	—	—	—	
18	18	8/46	C; H	—	20	8/46	—	D	—	See well log.
38	38	8/46	C; H	—	20	8/46	—	D	—	Do.
20	20	10/47	—	—	6	10/47	—	D	—	Do.
26	26	9/46	—	—	15	9/46	—	D	—	Do.
18	30	7/46	J; E	55	5	7/46	0.4	D, F	—	Do.
20	30	8/46	—	—	12	8/46	1.2	S	—	Do.
25	25	9/46	C; H	75	15	9/46	—	D	—	Do.
25	40	1/51	—	—	10	1/51	0.7	D	—	Do.
22	44	1/51	—	—	8	1/51	0.3	D	—	Do.
30	42	1/51	—	—	12	1/51	1.0	D	—	Do.
10	22	5/51	—	—	12	5/51	1.0	D	—	Do.
15	29	7/51	—	—	10	7/51	0.7	D	—	Do.
31	140	11/50	C; H	—	2.5	11/50	—	D, F	—	Do.
42	—	6/50	C; E	151	3	6/50	—	D	—	Do.
15	30	12/46	C; H	60	10	12/46	0.6	D	—	Do.
20	100	9/47	—	—	4	9/47	0.1	D	—	Do.
25	—	—	C; E	—	—	—	—	D	—	Never dry.
24	24	10/47	—	—	24	10/47	—	D	—	See well log.
30	—	—	J; E	—	—	—	—	D	—	
30	60	1/52	—	—	10	1/52	0.3	D	—	Do.
20	20	8/47	—	—	20	8/47	—	D	—	Do.
45	45	8/47	—	—	12	8/47	—	D	—	Do.
16	40	7/51	—	—	10	7/51	0.4	D	—	Do.
20	60	6/52	—	—	15	6/52	0.4	D	—	Do.
—	—	—	—	—	—	—	—	D	—	
—	40	7/52	—	—	15	7/52	—	D	—	Do.
20	24	7/52	—	—	23	7/52	5.7	D	—	Do.
14	—	5/52	—	—	—	—	—	D	—	Do.
12	22	5/52	J; E	—	8	5/52	0.8	D	—	Do.
14	—	5/52	—	—	—	—	—	D	—	Do.
24	—	5/52	—	—	—	—	—	D	—	Do.

TABLE 20

Well number (Gar-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing below land surface (feet)	Water-bearing formation and *structural unit*
Dc 39	Alonzo Warwick	Dilley	1951	2,510	Drilled	55	5⅝	14	Jennings *Deer Park anticline*
Dc 40	Burt Kimmel	do	1952	2,500	do	48	5⅝	10	Hampshire *Deer Park anticline*
Dc 41	James Baitman	do	1952	2,530	do	75	5⅝	18	do
Dc 42	D. Nolan Obenshain	do	1951	2,480	do	75	5⅝	21	Jennings *Deer Park anticline*
Dc 43	Harry V. Reeves	Tressler	1952	2,480	do	72	5⅝	23	do
Dc 44	Ignatius P. Hokoj	Brenneman	1950	2,550	do	130	5⅝	28	Hampshire *Deer Park anticline*
Dc 45	J. E. Sullivan	do	1950	2,510	do	80	5⅝	49	do
Dc 46	Dr. F. A. Arnold, Jr.	do	1947	2,520	do	100	5⅝	43	do
Dc 47	Claude D. Jewell	do	1950	2,510	do	85	5⅝	41	do
Dc 48	Albert Kahl	Dilley	1952	2,550	do	125	5⅝	18	Pocono *Deer Park anticline*
Dc 49	Sam Frazee	Brenneman	1952	2,500	do	250	5⅝	41	Hampshire *Deer Park anticline*
Dd 1	Leo Rowan	Brenneman	1946	2,910	do	120	5⅝	21	Allegheny *Upper Potomac basin*
Dd 2	Lee McRobie	Dilley	1949	2,910	do	45	5⅝	—	do
Dd 3	Johnstown Coal & Coke Co.	Brenneman	1945	1,930	do	315	5⅝	37	Pottsville *Upper Potomac basin*
Dd 4	do	—	1935	2,330	do	310	5⅝	—	— *Upper Potomac basin*
Dd 6	O. W. Tasker	Brenneman	1946	2,900	do	55	5⅝	21	Pottsville *Upper Potomac basin*
Dd 7	Hale Wright	Skipper	1950	2,290	do	55	5⅝	20	Pocono *Deer Park anticline*
Dd 8	Elwood George	—	About 1932	2,530	do	75	5⅝	—	Hampshire *Deer Park anticline*
Dd 9	Fred Tasker	Dilley	1952	2,750	do	50	5⅝	20	Conemaugh-lower memb. *Upper Potomac basin*
De 2	Stanley Virts	Brenneman	About 1946	2,560	do	72–75	5⅝	—	Allegheny and Pottsville *Upper Potomac basin*
De 3	Lawson Tichnell	Dilley	1948	2,270	do	50	5⅝	—	Conemaugh-lower memb. *Upper Potomac basin*
De 4	Earl Virts	Skipper	1947	2,190	do	60–65	5⅝	—	do
De 5	G. Wilson	Dilley	1949	2,060	do	60	5⅝	13	Conemaugh-lower memb. (?) *Upper Potomac basin*
De 6	Albert Goodwin	do	1952	2,460	do	92	5⅝	33	Conemaugh-lower memb. *Upper Potomac basin*
De 7	Bernard Guy	Buser	1949	1,820	do	160	5⅝	21	do
De 8	Paul Barnard	Dilley	1951	2,700	do	45	5⅝	19	Allegheny *Upper Potomac basin*
Ea 1	Clyde B. Love	Skipper	1948	2,580	do	85	5⅝	41	Pottsville *Upper Youghiogheny basin*

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Water level (feet below land surface)			Pumping equipment	Depth of pump below land surface (feet)	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Pumping	Date	Pumping equipment	Depth of pump below land surface (feet)	Gallons a minute	Date	Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
20	48	10/51	—	—	3	10/51	0.1	D	—	See well log.
16	38	7/52	—	—	8	7/52	0.4	D	—	Do.
12	23	6/52	—	—	10	6/52	1.0	D	—	Do.
25	35	10/51	—	—	8	10/51	0.8	D	—	Do.
22	50	8/52	—	—	15	8/52	0.5	D	—	Do.
20	80	6/50	—	—	20	6/50	0.3	D	—	Do.
30	30	5/50	—	—	20	5/50	—	D	—	Do.
44	44	8/47	C; H	—	20	8/47	—	D	—	Do.
30	30	6/50	—	—	20	6/50	—	D	—	Do.
55	95	3/52	—	—	6	3/52	0.1	D	—	Do.
45	60	8/52	—	—	20	8/52	1.3	D	—	Do.
20	120	2/46	C; H	—	10	2/46	0.1	D	—	Ends about 18 feet under Upper Freeport coal. See well log.
—	—	—	C; H	—	—	—	—	C	—	Supply reported adequate and of good quality.
138	—	9/45	—	—	40	9/45	—	P	—	Ends well down in Pottsville. See well log and chemical analysis
158	—	1935	—	—	6-8	1951	—	P	—	
10	55	2/46	J; E	—	20	2/46	0.4	D	56	Basal part of Pottsville. See well log. Fe—6 ppm (field test).
0	—	8/51	B	—	—	—	—	D	53	Well sometimes flows.
—	—	—	—; E	—	—	—	—	—	—	Supply reported adequate and of good quality.
20	40	3/52	—	—	6	3/52	0.3	D	—	Starts above Brush Creek coal. See well log.
	—	—	C; H, E	—	—	—	—	C	54	Water level gets low, but well never goes dry. Fe 6 ppm (field test).
20±	—	—	C; H	—	—	—	—	C	52	Water possibly from Lower Bakerstown coal. See well log. Reported yield 20 gph. Fe 1.2 ppm (field test); pH 5.7.
—	—	—	C; H	—	—	—	—	D	53	Water possibly from Lower Bakerstown coal. Much iron reported. Pumps dry.
48	—	5/49	C; H	—	Less than 1	—	—	D	52	May end in Barton coal. Fe 0.6 ppm; pH 7.2.
32	64	1/52	—	—	3	—	0.1	D	—	Coal at 82 feet possibly Lower Bakerstown coal. See well log.
125	—	10/49	—	—	3	—	—	D	—	Probably cuts Barton coal at 120 feet. See well log.
8	20	10/51	—	—	8	—	0.7	D	—	See well log.
30	40	10/48	—	—	—	—	—	D	—	Do.

TABLE 20

Well number (Gar-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing below land surface (feet)	Water-bearing formation and *structural unit*
Ea 2	Leonard Carr	Kelley	1948	2,495	Drilled	60	$5\frac{5}{8}$	15	Conemaugh-lower memb. *Upper Youghiogheny basin*
Ea 3	Edward Glotfelty	do	1946	2,410	do	48	$5\frac{5}{8}$	29	do
Ea 4	E. C. Jenkins	Skipper	1949	2,480	do	100	$5\frac{5}{8}$	40	Mauch Chunk, Greenbrier *Deer Park anticline*
Ea 5	Dorsey Ashby	do	1943	2,395	do	50	$5\frac{5}{8}$	42	Allegheny *Upper Youghiogheny basin*
Ea 6	Sport Adams	do	1946	2,410	do	55	$5\frac{5}{8}$	25	Conemaugh-lower memb. *Upper Youghiogheny basin*
Ea 7	A. W. Swiger	Kelley	1946	2,560	do	110	$5\frac{5}{8}$	17	Jennings *Deer Park anticline*
Ea 8	W. A. Swartzentruber	do	1946	2,460	do	46	$5\frac{5}{8}$	31	do
Ea 9	Lee Ludwig	do	1946	2,490	do	75	$5\frac{5}{8}$	37	do
Ea 10	W. E. Spoerlein	Brenneman	1949	2,480	do	200	$5\frac{5}{8}$	32	do
Ea 11	Stanley Ashby	Kelley	1946	2,390	do	91	$5\frac{5}{8}$	25	Allegheny *Upper Youghiogheny basin*
Ea 14	Kenneth Shaffer	Hardesty	1952	2,520	do	61	$5\frac{5}{8}$	5	Conemaugh-lower memb. *Upper Youghiogheny basin*
Ea 15	J. C. Frantz	do	1951	2,420	do	55	$5\frac{5}{8}$	20	Lower Conemaugh *Deer Park anticline*
Ea 16	Frank Piper	do	1951	2,430	do	72	$5\frac{5}{8}$	9	Pocono *Deer Park anticline*
Ea 17	Edward Hardesty	Dilley	1952	2,460	do	75	$5\frac{5}{8}$	21	Greenbrier and Pocono *Deer Park anticline*
Ea 18	Nola Reinhart	do	1951	2,430	do	45	$5\frac{5}{8}$	21	Pocono *Deer Park anticline*
Ea 19	J. L. Stoltzfus	Hardesty	1951	2,420	do	87	$5\frac{5}{8}$	26	do
Ea 20	Arlie Dodge	Dilley	1952	2,490	do	50	$5\frac{5}{8}$	20	Jennings *Deer Park anticline*
Ea 21	Silver Knob Sand Co.	Brenneman	1952	2,500	do	80	$5\frac{5}{8}$	23	Pocono *Deer Park anticline*
Ea 22	Ross Gank	Hardesty	1951	2,430	do	50	$5\frac{5}{8}$	16	Conemaugh-lower memb. *Upper Youghiogheny basin*
Ea 23	Dick Dewitt	Dilley	1952	2,440	do	58	$5\frac{5}{8}$	32	Pocono *Deer Park anticline*
Eb 1	R. L. Weber	Kelley	1947	2,400	do	65	$5\frac{5}{8}$	32	Jennings *Deer Park anticline*
Eb 2	Town of Oakland	do	1948	2,420	do	380	$5\frac{5}{8}$	32	Hampshire *Deer Park anticline*
Eb 3	Lynndale School	Dilley	1951	2,540	do	65	$5\frac{5}{8}$	16	Jennings *Deer Park anticline*
Eb 4	Edward Helbig	do	1951	2,570	do	87	$5\frac{5}{8}$	27	do
Eb 5	Mrs. R. E. Weber	Kelley	1947	2,420	do	197	$5\frac{5}{8}$	38	do
Eb 6	A. M. Queer	do	1947	2,420	do	69	$5\frac{5}{8}$	27	do
Eb 7	Imperial Ice Cream Co.	do	1946	2,470	do	326	10	28	Hampshire *Deer Park anticline*
Eb 8	Owen Martin	do	1947	2,440	do	70	$5\frac{5}{8}$	32	Jennings *Deer Park anticline*
Eb 9	C. M. Calhoun	do	1947	2,450	do	43	$5\frac{5}{8}$	26	do

—Continued

Water level (feet below land surface)			Pumping equipment	Depth of pump below land surface (feet)	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Pumping	Date			Gallons a minute	Date				
16	60	5/48	—	—	15	5/48	0.3	D	—	Ends between Harlem and Brush Creek coals. See well log.
12	15	8/46	—	—	15	8/46	5.0	D	—	Ends between Harlem and Lower Bakerstown coals. See well log.
60	80	10/49	—	—	10	10/49	—	D	—	Starts in Mauch Chunk; may not reach Greenbrier. See well log. Pump test—5 minutes.
30	45	10/48	—	—	10	10/48	0.9	D	—	Ends below Lower Freeport(?) coal. See well log.
20	20	10/46	—	—	20	10/46	—	D	—	Ends in Mahoning red shale. See well log.
29	110	8/46	—	—	6	8/46	—	D	—	Near Hampshire contact. See well log.
20	32	7/46	—	—	20	7/46	1.7	D, F	—	See well log.
9	12	7/46	—	—	20	7/46	7.0	C	—	Do.
30	70	6/49	—	—	24	6/49	0.6	D	—	Do.
15	30	9/46	—	—	15	9/46	1.0	P	—	Starts just below Upper Freeport coal. See well log and chemical analysis. Water discolored.
14	14	8/52	—	—	6	8/52	—	D	—	Ends between Harlem and Lower Bakerstown coals.
6	10	9/51	J; E	—	16	9/51	4.0	D	—	Ends between Harlem and Lower Bakerstown coal. See well log.
12	28	9/51	—	62	6	9/51	0.4	D	—	See well log.
36	70	10/52	—	—	3	10/52	0.9	D	—	
14	25	9/51	C; H	—	6	9/51	0.6	D	—	Do.
8	20	11/51	—	—	4	11/51	0.4	D	—	Do.
8	25	2/52	—	—	12	2/52	0.7	D	—	Do.
8	20	9/52	—	—	20	9/52	1.7	C	—	Do.
10	15	11/51	—	—	5	11/51	1.0	D	—	Ends about 50 feet above Lower Bakerstown coal. See well log.
22	40	7/52	—	—	5	7/52	0.3	D	—	Starts near Greenbrier contact. See well log.
9	46	9/47	—	—	16	9/47	0.4	D	—	See well log.
15	55	8/48	—	—	57	8/48	1.4	P	—	See well log. Well never used.
20	42	7/51	—	—	8	7/51	0.4	S	—	See well log.
35	50	11/51	—	—	6	11/51	0.4	D	—	Do.
18	197	4/47	—	—	8	4/47	0.4	D, F	—	Do.
16	69	4/47	—	—	12	4/47	0.2	D, F	—	Do.
108	142	9/46	—	—	25	9/46	0.7	C	—	Do.
30	38	9/47	—	—	18	9/47	2.2	D	—	Do.
5	43	9/47	—	—	—	—	—	D	—	Do.

TABLE 20

Well number (Gar-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing below land surface (feet)	Water bearing formation and *structural unit*
Eb 10	D. E. Callis	Kelley	1948	2,465	Drilled	90	$5\frac{5}{8}$	18	Jennings *Deer Park anticline*
Eb 11	Joe Callis	Brenneman	1945	2,515	do	120	$5\frac{5}{8}$	25	do
Eb 12	Mark H. Moon	do	1945	2,490	do	100	$5\frac{5}{8}$	—	do
Eb 13	Lynn T. Browning	Miller	1946	2,570	do	58	$5\frac{5}{8}$	—	do
Eb 14	William H. Deniker	do	1946	2,560	do	80	$5\frac{5}{8}$	—	do
Eb 15	Ray Philips	Skipper	1948	2,450	do	105	$5\frac{5}{8}$	22	do
Eb 16	Gordon Miller	Brenneman	1945	2,470	do	80	$5\frac{5}{8}$	24	do
Eb 18	Robert Paugh	do	1948	2,440	do	75	$5\frac{5}{8}$	50	do
Eb 21	Imperial Ice Cream Co.	do	About 1925	2,370	do	201	$5\frac{5}{8}$	60	Hampshire *Deer Park anticline*
Eb 22	E. O. Biser	Hardesty	1951	2,460	do	12	$5\frac{5}{8}$	27	Jennings *Deer Park anticline*
Eb 23	Ray Porter	—	—	2,560	Dug	37	—	—	Hampshire *Deer Park anticline*
Eb 24	A. D. Naylor	Dilley	1952	2,390	Drilled	50	$5\frac{5}{8}$	21	Jennings *Deer Park anticline*
Eb 25	Keith Steyer	do	1952	2,920	do	88	$5\frac{5}{8}$	20	Allegheny *Upper Potomac basin*
Eb 26	Earl Frazee	do	1951	2,850	do	86	$5\frac{5}{8}$	20	Conemaugh lower memb. *Upper Potomac basin*
Eb 27	Noah Licty	do	1952	2,520	do	90	$5\frac{5}{8}$	22	Jennings *Deer Park anticline*
Eb 28	Emanuel Miller	do	1952	2,520	do	100	$5\frac{5}{8}$	—	do
Eb 29	Walter Beckamin	do	1952	2,490	do	50	$5\frac{5}{8}$	25	do
Eb 30	Cumberland & Allegheny Gas Co.	Brenneman	1952	2,490	do	118	$5\frac{5}{8}$	43	do
Eb 31	Mrs. Edward Offutt	Dilley	1952	2,660	do	103	$5\frac{5}{8}$	—	Hampshire *Deer Park anticline*
Eb 32	E. C. Litler	do	1952	2,418	do	57	$5\frac{5}{8}$	22	Jennings *Deer Park anticline*
Ec 2	Harold Steyer	do	1950	2,580	do	120	$5\frac{5}{8}$	28	Conemaugh-lower memb. *Upper Potomac basin*
Ec 8	C. V. Harvey	Miller	1946	2,670	do	65	$5\frac{5}{8}$	—	do
Ec 10	Md. Dept. of State Forests and Parks	—	About 1933	2,530	do	600?	—	—	do
Ec 13	Wm. Hebb	Hardesty	1951	2,850	do	33	$5\frac{5}{8}$	17	do
Ed 1	Roscoe Rohrbaugh	—	1939	2,500	Dug	24	—	—	do
Ed 2	Wolf Den Coal Co.	Brenneman	1948	2,460	Drilled	390	$6\frac{5}{8}$	404	— *Upper Potomac basin*
Fa 1	Roy J. Bowman	Kelley	1947	2,480	do	43	$5\frac{5}{8}$	22	Jennings *Deer Park anticline*
Fa 2	James Hamilton	do	1946	2,470	do	85	$5\frac{5}{8}$	24	do
Fa 3	Cyrus Wolfe	do	1946	2,440	do	45	$5\frac{5}{8}$	20	do
Fa 4	Roy Martin	do	1946	2,460	do	109	$5\frac{5}{8}$	31	do
Fa 7	Martha Shoult	—	1944	2,570	do	120	$5\frac{5}{8}$	—	do
Fa 12	Elmer Beachy	Taylor	About 1929	2,460	do	40	$5\frac{5}{8}$	—	do

—Continued

Water level (feet below land surface)			Pumping equipment	Depth of pump below land surface (feet)	Yield		Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
Static	Pumping	Date			Gallons a minute	Date				
5	22	11/48	—	—	7	11/48	0.4	D	—	See well log.
35	120	10/45	—	—	5	10/45	0.1	D	—	
30	30	10/45	—	—	20	10/45	—	D	—	
17	25	8/46	—	—	—	—	—	D	—	Do.
30	45	8/46	C; H	70	2	8/46	0.1	D	—	
30	35	10/48	—	—	4	10/48	0.9	D	—	Do.
22	24	12/45	—	—	10	12/45	5.0	D	—	Do
20	20	3/48	—	—	10	3/48	—	D	—	Do.
—	—	—	—	—	60	7/46	—	C	51	Flows in wet weather.
12	25	8/51	—	—	8	8/51	0.6	D	—	See well log.
22.55[a]	—	3/51	—	—	—	—	—	N	—	Observation well.
20	34	9/52	—	—	8	9/52	0.7	D	—	See well log.
30	60	6/52	—	—	6	6/52	0.2	D	—	Starts just under Upper Freeport coal. See well log.
13	75	10/51	—	—	5	10/51	0.1	D	—	Ends above Upper Freeport coal. See well log.
26	40	9/52	—	—	10	9/52	0.5	D	—	See well log.
35	85	7/52	—	—	8	7/52	0.1	D	—	Do.
2	35	3/52	—	—	12	3/52	0.4	D	—	Do.
44	75	1/52	—	—	18	1/52	0.6	C	—	Do.
28	96	7/52	J; E	41	3	10/52	—	D	—	See well log. Well can be pumped dry.
16	30	10/52	—	—	—	—	0.6	D	—	—
18	100	8/50	—	—	4	8/50	—	F	—	Ends in Pittsburgh red beds. See well log. Water reported hard.
17	24	10/46	C; H	—	8	8/50	1.1	D	—	Ends between Harlem and Upper Bakerstown coals. See well log.
—	—	—	—	—	—	—	—	D	—	Water reported hard. Well used only when spring goes dry.
5	8	8/51	—	—	2	8/51	0.7	D	—	Ends between Lower Bakerstown and Upper Freeport coals. See well log.
—	—	—	—; E	—	—	—	—	C, D	—	Ends just under Harlem coal. Sometimes goes dry.
—	—	—	—	—	—	—	—	N	—	Hole drilled to take power lines to mine.
4	14	9/47	—	—	18	9/47	1.8	D	—	See well log.
12	75	7/46	—	—	15	7/46	0.2	D	—	Do.
8	45	8/46	—	—	4	8/46	0.1	D, F	—	Do.
25	50	11/46	—	—	5	11/46	0.2	D, F	—	Do.
—	—	—	—	—	—	—	—	D	—	Water reported a little hard.
—	—	—	—	—	—	—	—	D	—	Pumps down. Stock watered from spring

TABLE 20

Well number (Gar-)	Owner or name	Driller	Date completed	Altitude (feet)	Type of well	Depth of well (feet)	Diameter of well (inches)	Depth of casing below land surface (feet)	Water-bearing formation and *structural unit*
Fa 13	Wayne Fike	Hardesty	1951	2,530	Drilled	70	5⅝	20	Jennings *Deer Park anticline*
Fa 14	Howard Osborne	Kelley	1952	2,690	do	104	5⅝	46	Greenbrier *Deer Park anticline*
Fa 15	Carl Ritter	Dilley	1952	2,500±	do	75	5⅝	16	Jennings *Deer Park anticline*
Fb 4	George Hoffman	—	About 1941	2,580	Dug	40	—	—	Conemaugh-lower memb. *Upper Potomac basin*
Fb 5	Warren Harvey	Kelley	1947	2,680	Drilled	60	5⅝	10	Conemaugh-upper (?) memb. *Upper Potomac basin*
Fb 6	Zella Shreve	do	1947	2,690	do	66	5⅝	12	do
Fb 7	John W. Grubb	do	1947	2,750	do	60	5⅝	22	do
Fb 9	Harvey Arbighast	Dilley	1951	2,580	do	66	5⅝	21	Conemaugh-lower memb. *Upper Potomac basin*
Fb 10	Gorman Fire Dept.	do	1951	2,330	do	50	5⅝	20	do
Fb 11	Elsie Reel	do	1952	2,500	do	205	5⅝	11	do
Fb 12	Paul Henline	do	1952	2,570	do	80	5⅝	21	do
Fb 13	Harvey Arbighast	Hardesty	1951	2,570	do	66	5⅝	21	do
Fb 14	Isadore Skewiers	Dilley	1952	2,650	do	66	5⅝	12	do
Fb 15	C. L. Blamble	Hardesty	1951	2,620	do	70	5⅝	20	do

[a] Water level measured by State or Federal personnel; all others reported by driller or owner.

—*Concluded*

Water level (feet below land surface) Static	Pumping	Date	Pumping equipment	Depth of pump below land surface (feet)	Yield Gallons a minute	Date	Specific capacity (g.p.m./ft.)	Use of water	Temperature (°F.)	Remarks
16	30	8/51	—	—	6	8/51	0.4	D	—	See well log.
75	90	8-52	C; H	100	7	8/52	0.5	D	—	Do.
12	60	2/52	—	—	8	2/52	0.2	D	—	Do.
—	—	—	—	—	—	—	—	D	—	Starts above Harlem coal. Supply inadequate.
4	60	4/47	—	—	6	4/47	0.1	D, F	—	See well log.
6	51	4/47	—	—	11	4/47	0.3	D	—	Do.
10	25	5/47	—	—	20	5/47	1.3	D	—	Do.
20	60	9/51	—	—	4	9/51	0.1	D	—	Starts above Harlem coal. See well log.
10	—	10/51	—	—	5	10/51	—	D	—	Starts below Lower Bakerstown coal. See well log.
10	135	7/52	—	—	2	7/52	—	D	—	Starts between Harlem and Lower Bakerstown coals. See well log.
30	70	6/52	—	—	5.5	6/52	1.3	D	—	Starts above Harlem coal. See well log.
20	60	9/51	—	—	4	9/51	0.1	D	—	Do.
16	50	6/52	—	—	5	6/52	0.1	D	—	Do.
12	50	10/51	—	—	7	10/51	0.2	F	—	Do.

TABLE 21

Record of Springs in Garrett County

Use of water: C, commercial; D, domestic; F, farm; N, none; P, public-supply.

Spring number	Owner or name	Topography	Date observed	Altitude (feet)	Water-bearing formation and *structural unit*	Improvements	Yield: Gallons a minute (Est.)	Yield: Date	Use of water	Temperature (°F.)	Remarks
Aa 2	Frisby Humbleson	Swale in hill slope	8/31	2,000	Conemaugh—lower memb. *Lower Youghiogheny basin*	Piped to barn	—	—	F	—	Below Harlem coal.
Aa 3	A. M. Chisholm Estate	do	8/31	2,100	do	Walled	—	—	D	57	Above Harlem coal. Reported never dry. Two openings; one reported hard water, other soft.
Aa 5	Emerson Thomas	Steep draw	8/31	1,900	do	Cement basin	—	—	D	—	Between Brush Creek and Upper Freeport coals. Low in dry spell.
Ab 3	James Vites	Narrow valley	8/31	1,650	Allegheny *Lower Youghiogheny basin*	Stone basin	2.5	8/21/31	D	52	Never dry. Fe 3.5 ppm (field test); pH 6.3. Unfit for washing clothes. 80 feet below Upper Freeport.
Ab 6	Ivan Humberson	Fairly steep slope	8/31	1,310	Conemaugh—lower memb. *Lower Youghiogheny basin*	Piped to house	—	—	D	60	Probably from Brush Creek coal. Reported never dry.
Ab 7	Ralph Humberson	do	8/31	1,740	Allegheny *Lower Youghiogheny basin*	do	—	—	D	—	Probably from Harlem coal.
Ab 8	Town of Friendsville	Steep slope near top of Winding Ridge	9/32	2,300-2,600	Pottsville and Allegheny *Lower Youghiogheny basin*	Distribution system in town	—	—	P	—	3 springs. Reported to produce 30,000-50,000 gpd. See chemical analysis.
Ac 4	Clyde Glover	Steep slope	8/31	2,550±	Hampshire *Accident dome*	1600-ft. pipe line	—	—	D	—	Reported never dry.
Ac 8	Ross R. Ryland	Draw; steep slope	8/31	2,700	Pocono *Accident dome*	—	2	8/15/31	D, F	51.5	Do.
Ac 9	W. H. Watt	—	5/31	2,770	do	Piped to house	—	—	D	—	Gets low but reported never dry.
Ac 14	Ed. Bougher	Gentle slope	8/31	2,340	do	do	3	8/16/31	F		Close to contact with Greenbrier. Reported never dry.
Ac 15	Albert Richter	do	8/31	2,530	do	Piped to house; tile basin	—	—	D	56	Reported never dry.

Ac 16	Lucinda Kalbfleisch	In draw	8/51	2,550	Pocono *Accident dome*	Piped to house	—	—	D, F	—	Reported never dry
Ac 17	Bert Griffith	do	8/51	2,300	Hampshire *Accident dome*	Piped to house; rock basin	—	—	D	61	Do.
Ad 2	C. E. Ashby	Gentle slope	7/50	2,715	Pottsville *Castleman basin*	Piped to house	2	7/21/50	C, D	52	Reported never dry (18 years). From crevice in white sandstone.
Ad 3	Town of Grantsville	do	8/50	2,800	Allegheny *Castleman basin*	Gathering basin; 2.5 mi. pipeline	—	8/10/50	P	—	To standpipe, Grantsville. See chemical analyses.
Ad 11	Jefferson T. Durst	Draw in gentle slope	8/51	2,560	do	—	2	8/9/51	D	54	Below Middle Kittanning coal. Reported never dry.
Ad 13	Town of Grantsville	do	9/52	2,820	Pottsville *Castleman basin*	Piped to Ad 3	—	—	P	—	
Ad 14	Alvin E. Beady	do	9/52	2,860	do	—	2	9/29/52	D, F	54	Reported never dry.
Ae 6	Mary Yoder	Bottom of draw	8/50	2,340	Conemaugh—upper memb. *Castleman basin*	Small excavation	3	—	D	53	Reported never dry.
Ae 20	Floyd H. Durst	Gentle slope	8/51	2,540	do	Piped to house	—	—	D	—	Used by present owner since 1905. Sometimes dry in summer.
Ae 21	Russel Bittinger	Steep slope	8/51	2,360	Conemaugh *Castleman basin*	do	1	—	D	—	Probably from Barton coal. Gets low—water cloudy.
Ae 22	Jonas Tice	Moderate slope	8/51	2,650	Allegheny *Castleman basin*	do	—	—	D, F	—	2700-ft. pipeline across valley.
Ae 27	Frank Bittinger	Small draw	9/51	2,610	Conemaugh—lower memb. *Castleman basin*	Small excavation	Low	9/21/51	D	—	Between Barton and Harlem coals. Goes dry.
Af 5	Ed Wampler	Hill slope	8/50	2,600	Jennings *Deer Park anticline*	Sump	—	—	D	—	Report plenty of water.
Af 6	Julius Wilhelm	Stream draw	9/51	2,620	do	Spring house	0.25	9/13/51	D	55	Lowest it has been (9/13/51).
Af 12	Edgar Marchel	Moderate slope	9/51	2,570	Pocono and Greenbrier *Deer Park anticline*	Reservoir	Low	9/13/51	D	53	Reported never dry.
Ag 10	Town of Frostberg	Steep hill slope	8/50	2,650	Pocono and Greenbrier *Deer Park anticline*	Piped to reservoir	—	—	P	—	Report 28 to 43 openings.
Ag 11	Homer McKinzie	Slope near valley floor	8/50	2,480	Hampshire *Deer Park anticline*	Piped to house	—	—	D	52	Report never short of water.
Ag 12	Wm. Finzel	Valley floor	8/50	2,430	do	—	—	—	D	52	Do.
Ag 13	Wm. Garlitz	do	8/50	2,400	do	Spring house	—	—	D	—	Do.
Ag 14	D. Barr	Steep hillside	7/50	2,650	Pocono *Deer Park anticline*	1100-ft. pipeline	—	—	D	—	

TABLE 21—*Continued*

Spring number	Owner or name	Topography	Date observed	Altitude (feet)	Water-bearing formation and *structural unit*	Improvements	Yield: Gallons a minute (Est.)	Yield: Date	Use of water	Temperature (°F.)	Remarks
Ag 15	Roy Metz	Bottom of draw	7/50	2,540	Hampshire *Deer Park anticline*	2-ft. pipe in ground	—	—	D	53	Reported never dry. Water cloudy.
Ag 17	C. Caton	Steep hillside	7/50	2,775	Pocono *Deer Park anticline*	2-ft. pipe	—	—	D	54	Do.
Ag 25	Geo. Durr	Draw	9/51	2,580	Jennings *Deer Park anticline*	Wooden box	0.25	9/13/51	D	52	Reported never dry. Slightly cloudy.
Ba 2	Hiram Fraze	Draw	8/51	2,030	Conemaugh—lower memb. *Lower Youghiogheny basin*	Cement basin	—	—	D	62	Between Harlem and Brush Creek coals.
Ba 4	Ellis Friend	Moderate slope	8/51	2,080	do	Rockwall	0.25	8/22/51	D	59	Just above Brush Creek coal. Nearly dry, 8/51.
Ba 5	Leslie Savage	Gentle slope	8/51	2,320	do	Piped to house	—	—	D	—	Probably from Brush Creek coal. Very low. Recently cleaned (8/22/51).
Ba 7	Roy Fisher	Small draw	8/51	2,250	Allegheny *Lower Youghiogheny basin*	Concrete basin	—	—	D	52	Probably from Upper Freeport coal. Reported never dry.
Ba 8	G. C. Sisler	do	8/51	2,410	Conemaugh—lower memb. *Lower Youghiogheny basin*	Piped to house	—	—	D	—	Between Brush Creek and Upper Freeport coals. Reported never dry.
Ba 9	Casper Sisler	Ridge top	8/51	2,430	Allegheny *Lower Youghiogheny basin*	—	—	—	D	58	Probably from Upper Freeport coal. Goes dry.
Bb 3	Roadside	Cut in hillside	8/51	1,650	Greenbrier, Mauch Chunk *Accident dome*	—	1-2	9/30/51	D	51	Est. 5 gpm 8/22/50.
Bb 8	Joseph McCroble	Head of draw	8/51	2,310	Pocono *Accident dome*	Rock basin	0.5	8/21/51	D	52	Reported never dry, but gets low.
Bb 13	Wm. Enlow	Draw	8/51	2,300	Pocono and Greenbrier *Accident dome*	Piped to house	—	—	D	56	Do.
Bc 2	Roadside	Steep hillside	8/50	2,180	Hampshire *Accident dome*	—	8	8/10/50	—	50	4 gpm, 8/16/51. Measurement of part of flow.
Bc 17	Edwin Beitzel	Gentle slope	6/51	2,600	Conemaugh—lower memb. *Castleman basin*	Piped to house	4	6/27/51	D, F	50	Probably from Lower Bakerstown coal. Reported never dry.

Bc 19	Roadside	Draw in steep hillside	8/51	2,560	Pocono *Accident dome*	Concrete basin	2	8/9/51	—	52	Near Greenbrier contact.
Bc 21	Woodrow Friend	Bottom steep slope	8/51	1,920	Hampshire *Accident dome*	Piped to house	—	—	D	—	Very low (8/16/51); goes dry.
Bc 23	Albert Beckett	Head of draw	8/51	2,420	do	do	—	—	D	57	Reported never dry.
Bc 24	W. L. Devine	Bear Creek Valley bottom	8/51	2,060	do	do	—	—	C, D		Yield reported large; never dry (23 years).
Bd 4	Kermit Bittinger	Draw	8/51	2,500	Conemaugh—lower memb. *Castleman basin*	do	—	—	D	53	Between Harlem and Lower Bakerstown coals. Gets low in fall. Another spring for stock.
Bd 5	Clarence Oeser	Gentle slope	8/51	2,510	Allegheny *Castelman basin*	do	—	—	D	—	Probably from Upper Freeport coal. Reported never dry. Three families.
Bd 6	Flossie Bittinger	Draw in gentle slope	8/51	2,620	do	do	—	—	D	51	From below Middle Kittanning coal. Goes dry. Two families.
Bd 7	Jessie Burkholder	do	8/51	2,670	do	do	0.5	8/9/51	D	56	Probably from Upper Freeport coal. Reported never dry.
Bd 9	John Klotz	do	8/51	2,660	Conemaugh—lower memb. *Castleman basin*	do	—	—	D, F	—	Probably from Brush Creek Coal. Has gone dry.
Be 2	Stanley Swanger	Stream bank	9/50	2,520	Pocono *Deer Park anticline*	Small sump	Less than 0.5	—	D	53	
Be 3	Md. Dep't. State Forests and Parks	Foot of steep slope	9/50	2,415	do	Box	1.25	7/20/50	D	55	Park use.
Be 5	Ira R. Broadwater	do	8/51	2,610	Greenbrier, Mauch Chunk *Deer Park anticline*	Rock basin	—	—	D	52	At contact. Sometimes dry.
Be 6	Raymond C. Durst	Moderately steep slope	8/51	2,520	Hampshire and Pocono *Deer Park anticline*	Piped to house	1.5	8/13/51	D	54	Contact zone. Reported never dry.
Be 7	Sam Otto	Foot of steep slope	8/51	2,510	Pocono and Greenbrier *Deer Park anticline*	—	—	—	D	—	Contact zone. Reported never dry. Spring under house.
Be 8	Wm. Warnick	Steep slope	8/51	2,550	Hampshire and Pocono *Deer Park anticline*	—	0.25	8/13/51	D	56	Contact zone. Spring at house. Stock has surface supply.
Bf 1	Sally Garlitz	Stream bottom	8/50	2,390	Jennings and Hampshire *Deer Park anticline*	Spring house	6	8/3/50	D	50.5	Contact zone. Reported never dry.
Bf 6	Wm. Robertson	Moderately steep slope	8/51	2,520	Jennings *Deer Park anticline*	Piped to house	—	—	D	53	Reported "plenty" (48 years). Two families.
Bf 7	Edward L. Crowe	Draw in steep slope	8/51	2,600	Pocono *Deer Park anticline*	Rock basin	—	—	D	48	Very slight flow (8/23/51).

TABLE 21—*Continued*

Spring number	Owner or name	Topography	Date observed	Altitude (feet)	Water-bearing formation and *structural unit*	Improvements	Yield: Gallons a minute (Est.)	Yield: Date	Use of water	Temperature (°F.)	Remarks
Cb 27	Richard Glottelty	Steep hill slope	8/51	2,480	Greenbrier *Accident dome*	Piped to house	0.25	8/22/51	D	57	Reported never dry.
Cb 28	Saul Teets	do	8/51	2,110	Mauch Chunk *Accident dome*	Board basin	2	8/22/51	D	51	Reported never dry. Two families.
Cb 29	Peter Baasland	do	8/51	2,150	do	Piped to house	—	—	D	—	
Cb 30	Mrs. Gott	Flat draw	8/51	2,480	Pottsville *Upper Youghiogheny basin*	—	—	—	D	—	Just under a coal seam. Reported never dry.
Cc 13	Roadside	Steep slope above stream	7/51	2,620	Pottsville *Castleman basin*	Concrete trough	10	7/12/51	—	—	Near Mauch Chunk contact.
Cc 14	Elwood Glotfelty	Draw in gentle slope	8/51	2,680	Allegheny *Castleman basin*	Piped to house Spring house	3	8/9/51	D	53	Between Middle Kittanning and Upper Freeport coals. Reported never dry.
Cc 17	Sam Teets	Gentle slope	8/51	2,650	do	do	Small	—	D, F	55	At Middle Kittanning coal.
Cd 1	Harvey Bittinger	Steep slope	8/51	2,460	Greenbrier and Pocono *Deer Park anticline*	—	3	8/8/51	D	51	Contact zone. Reported never dry.
Cd 2	Frank W. Bittinger	Foot of steep slope	8/51	2,640	Mauch Chunk, Greenbrier *Deer Park anticline*	Piped to house Spring house	2	8/8/51	D	58	Contact zone. Gets low in fall.
Cd 7	Roadside	Draw in steep slope	8/51	2,490	Greenbrier and Pocono *Deer Park anticline*	Concrete basin	25	8/10/51	—	50	Contact zone. Reported never dry.
Cd 8	Do	do	8/51	2,500	Greenbrier *Deer Park anticline*	Concrete dam	4	8/10/51	—	50	—
Ce 1	Bertha Sines	Very steep slope	8/51	1,650	Jennings *Deer Park anticline*	Piped to house	—	—	D, F	—	Reported never dry, but low at times.
Cf 4	Jessie Green	Moderate slope	8/51	2,590	Conemaugh—lower memb. *Deer Park anticline*	Spring house	—	—	D	61	Between Harlem and Upper Freeport coals. Reported never dry, but gets low.

Da 8	Henry Campbell	Steep slope	7/51	2,500	Allegheny *Upper Youghiogheny basin*	Piped to house	—	—	D	—	Probably from Upper Freeport coal. Reported never dry.
Da 11	Md. Dept. State Forests and Parks	Draw in moderate Slope	7/51	2,430	Conemaugh—lower memb. *Upper Youghiogheny basin*	Piped to Park	Large	—	—	48	Close to Harlem coal.
Db 9	H. C. Lewis	Stream bed	7/51	2,440	do	—	—	—	D	60	Probably from Brush Creek coal. Not dependable; large fluctuations.
Db 10	Edgar Sines	Draw	7/51	2,560	do	Piped to house	—	—	D	56	Probably from Brush Creek coal. Reported never dry (6 years).
Db 11	Raymond G. Sines	Gentle Slope	7/51	2,640	Allegheny *Upper Youghiogheny basin*	(none)	2	7/26/51	D	56	Probably from Upper Freeport coal. Gets low at times. Two families.
Db 16	Town of Oakland	Near broad valley bottom	8/51	2,390	Pocono *Deer Park anticline*	—	37	8/1/51	P	51	Bradley Spring. Near Greenbrier contact. Probably more than 37 gpm.
Dc 23	Herman Schmidt	Draw	8/51	2,580	Hampshire *Deer Park anticline*	Piped to house	—	—	D	—	Reported never dry.
Dc 29	E. D. Fike	Gentle Slope	8/51	2,740	Mauch Chunk *Deer Park anticline*	Rock basin	Small	—	D	53	Reported never dry except in 1933.
Dd 5	Roadside	Steep slope	8/51	2,900	do	Trough	3	8/2/51	—	58	—
De 1	Robert Berhard	Ridge top	8/51	2,710	Allegheny *Upper Potomac basin*	Piped to house	0.3	8/3/51	D	53	Possibly from Upper Freeport coal. Reported never dry.
Ea 12	Kray Coal Co.	Steep slope	7/51	2,560	Allegheny *Upper Youghiogheny basin*	Piped to Crellin	—	—	P	—	Not visited. Supplement to town supply. See chemical analyses.
Ea 13	Luther Canan	Stream valley	7/51	2,400	do	Rock basin	2	7/31/51	D	56	Probably from Upper Freeport coal. Reported never dry.
Eb 17	A. L. Riley	Gentle Slope	7/51	2,480	Hampshire and Jennings *Deer Park anticline*	Walled basin	4	7/26/51	D	51	Contact zone. Reported never dry.
Eb 19	Gerald Broadwater	Draw on hilltop	7/51	2,740	Pocono *Deer Park anticline*	do	2	7/27/51	D	57	Reported never dry. Gets low.
Eb 20	N. Harvey	Draw in gentle slope	7/51	2,700	Conemaugh—lower memb. *Upper Potomac basin*	Piped to house	5	7/27/51	D, F	51	From below Lower Bakerstown coal. Reported never dry.

TABLE 21—(*Continued*)

Spring number	Owner or name	Topography	Date observed	Altitude (feet)	Water-bearing formation and *structural unit*	Improvements	Yield: Gallons a minute (Est.)	Yield: Date	Use of water	Temperature (°F.)	Remarks
Eb 33	Loch Lynn Water Co.	Steep slope	10/52	2,600	Greenbrier and Pocono *Deer Park anticline*	—	—	—	P		Probably contact. Loch Lynn and Mountain Lake Park water supply.
Eb 34	Do	do	10/52	2,600	Pocono *Deer Park anticline*	—	—	—	P		Loch Lynn and Mountain Lake Park water supply.
Eb 35	Do	do	10/52	2,650	Greenbrier and Pocono *Deer Park anticline*	—	—	—	P		Probably contact. Loch Lynn and Mountain Lake Park water supply.
Ec 1	B. & O. RR. Boiling Spring	Foot of steep slope	7/51	2,500	Greenbrier *Deer Park anticline*		—	—	C	50	Used in dining cars on B. & O. RR. See chemical analysis.
Ec 3	Elmer Harvey	Draw in moderate slope	7/51	2,740	Conemaugh—lower memb. *Upper Potomac basin*	—	Small	—	D	55	From above Harlem coal. Reported never dry.
Ec 4	Delman Ray	Hilltop	7/51	2,800	do	Piped to house	—	—	D	—	Probably from Harlem coal. Reported never dry (2 years).
Ec 5	Wm. Welch	do	7/51	2,800	do	—	—	—	—	—	Probably from Harlem coal.
Ec 6	Harry Shaffer	Gentle slope	7/51	2,620	do	—	1	7/27/51	D	58	From below Lower Bakerstown coal. Reported never dry.
Ec 7	James C. Harvey	Ridge top	7/51	2,900	Pottsville and Mauch Chunk contact	Barrel	0.5	7/27/51	D	55	Contact zone. Went dry in 1930.
Ec 9	C. V. Harvey	Gentle slope	8/51	2,650	Conemaugh—lower memb. *Upper Potomac basin*	Piped to house	1	8/1/51	D	58	Between Harlem and Upper Bakerstown coals. Reported never dry.
Ec 11	Geo. Uphole	—	8/51	2,560	do	—	—	—	D	—	Under Lower Bakerstown coal. Two families.
Ec 12	Bert Paugh	Moderately steep slope	8/51	2,670	do	—	—	—	D	57	Lower Bakerstown coal. Reported never dry. Two families.
Fa 5	Paul Dixon	Hilltop	7/51	2,520	Jennings *Deer Park anticline*	Concrete basin	—	—	D	51.5	Reported never low.

Fa 6	Mark Bechtel	Stream side	7/51	2,530	Jennings *Deer Park anticline*	Piped to bouse	—	—	D, F	—	Reported little fluctuation.
Fa 8	Bill Biel	Ridge top	7/51	3,030	Pottsville, Mauch Chunk *Deer Park anticline*	—	—	—	—	—	Contact zone.
Fa 9	Do	do	7/51	3,030	Pottsville *Upper Potomac basin*	Shed and basin	2	7/25/51	D	51	Near Mauch Chunk contact. Reported never dry.
Fa 10	Bertha Hall	Stream side	7/51	2,640	Conemaugh—lower memb. *Upper Potomac basin*	—	—	—	D	—	Lower Bakerstown coal.
Fa 11	Daniel Beachy	Draw	7/51	2,490	Jennings *Deer Park anticline*	—	2	7/25/51	D, F	56	Reported great fluctuation.
Fb 1	Paul Cullers	Saddle on ridge top	7/51	2,700	Conemaugh—lower memb. *Upper Potomac basin*	—	1	7/25/51	D	53	Above Harlem coal.
Fb 2	R. Wotrung	Small draw	7/51	2,870	Allegheny *Upper Potomac basin*	Walled	—	—	D	51	Below Upper Freeport coal.
Fb 3	Marshall Lewis	Near top of spur	7/51	2,640	Conemaugh—lower memb. *Upper Potomac basin*	Piped to house	1	7/25/51	D	51	Above Harlem coal. Reported low in dry weather.
Fb 8	Ed. Uphole	Draw, gentle slope	7/51	2,650	Pocono *Deer Park anticline*	Piped to house	—	—	D	56	Near Hampshire contact. Fairly reliable.
Ga 1	Town of Kempton	Shoulder, steep slope	7/51	2,860	Conemaugh—lower memb. *Upper Potomac basin*	Town supply	—	—	P	—	Above Harlem coal. See chemical analysis. Reported goes dry at times in late summer.
Ga 2	Berlinda Lipsco	—	—	2,690	do	Tile and rock basins	—	—	—	—	Above Harlem coal. Three openings. Gets low in very dry summer.

TABLE 22

Drillers' Logs of Wells

	Thickness (feet)	Depth (feet)
Well Gar-Ab 1 (Altitude: 1730 feet)		
Allegheny formation:		
Surface rocks	16	16
"Rocks", yellow	34	50
Driller's note: The rock was not very water bearing.		
Well Gar-Ac 1 (Altitude: 2990 feet)		
Pocono formation:		
Surface rocks	10	10
Slate, red	20	30
Slate, gray	20	50
Shale, red	10	60
Shale, gray (water)	50	110
Sand, gray	10	120
Well Gar-Ac 18 (Altitude: 2450 feet)		
Greenbrier formation:		
Surface rocks	4	4
Shale, red	10	14
"Rock"	2	16
Shale, red	2	18
"Rock", hard	6	24
Clay, red	4	28
Shale, red (water)	2	30
Shale, brown	5	35
"Soapstone", gray	10	45
"Rock", hard, blue	7	52
"Rock", blue (water)	4	56
Well Gar-Ac 19 (Altitude: 2780 feet)		
Pocono formation:		
Surface rocks	2	2
"Rock", hard	32	34
"Rock" and brown shale	14	48
Shale, gray (water)	6	54
Shale, red	25	79
Shale, pale red (water)	20	99
Shale, green	7	106
Well Gar-Ad 1 (Altitude: 2540 feet)		
Pottsville and Allegheny formations:		
Surface rock	10	10
Sandstone, gray	36	46
Slate, black	1	47
Sandstone, gray	9	56
"Soapstone"	44	100
Sandstone, gray	34	134

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
"Soapstone", gray	22	156
Coal (Upper Freeport?)	2	158
Clay, black	2	160
Slate, black	15	175
Sand, dark gray	20	195
"Soapstone", gray	27	222
Sandstone, gray	23	245
Slate, black, and coal	5	250
Sandstone, gray	5	255
"Soapstone", dark	18	273
Sandstone, gray	27	300

Driller's note: At 245 feet I drilled to a fair stream of water, but I also got small streams between the different strata.

Well Gar-Ad 4 (Altitude: 2160 feet)
Conemaugh formation:
Lower member (bottom just above Lower Bakerstown coal):

	Thickness (feet)	Depth (feet)
Clay, yellow	10	10
Shale, yellow	6	16
"Quicksand" (water)	2	18
Clay, blue	6	24
Shale, blue (water)	19	43

Well Gar-Ad 5 (Altitude: 2160 feet)
Conemaugh formation:
Lower member (bottom in Meyersdale red bed):

	Thickness (feet)	Depth (feet)
River wash	18	18
Slate, black (Lower Bakerstown coal?)	6	24
Clay, blue	6	30
Shale, light gray	10	40
Shale, sandy (water)	6	46
Shale, red	3	49

Well Gar-Ad 6 (Altitude: 2630 feet)
Greenbrier and Pocono formations:

	Thickness (feet)	Depth (feet)
Surface rocks	10	10
"Rock", red	27	37
"Rock", yellow	23	60
"Soapstone"	10	70
Sand, gray	13½	83½

Well Gar-Ad 7 (Altitude: 2450 feet)
Allegheny formation:

	Thickness (feet)	Depth (feet)
Surface rocks	5	5
Clay, yellow	5	10
"Soapstone", cream	8	18
"Rock", yellow	12	30
Sandrock, yellow	25	55

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Coal (Middle Kittaning)	2	57
Soapstone	25	82
Sandstone, gray	2	84
Slate, black (water)	6	90
Well Gar-Ad 8 (Altitude: 2430 feet)		
Allegheny formation:		
Surface rocks	5	5
Clay, yellow	13	18
Sand, yellow	39	57
Coal and slate (Middle Kittaning) (water)	3	60
Well Gar-Ad 9 (Altitude: 2660 feet)		
Pocono formation:		
Surface rocks	5	5
Shalerock, yellow	25	30
Shale, gray	40	70
Sandstone, gray	25	95
Well Gar-Ad 10 (Altitude: 2860 feet)		
Pocono formation:		
"Limestone", "solid", sandy	60	60
Note: No limestone in Pocono.		
Well Gar-Ad 12 (Altitude: 2233 feet)		
Conemaugh formation:		
Lower member:		
Clay, yellow	7	7
Shale, soft, brown	10	17
Shale, gray	8	25
Shale, brown	2	27
Shale, gray	8	35
Shale, dark gray; 6 in. coal (Lower Bakerstown)	4	39
Shale, light gray	2	41
Shale, calcareous, light gray	6	47
Shale, slightly calcareous, light gray	3	50
Shale, light gray	11	61
Shale, slightly calcareous	5	66
Shale, pale brown (Meyersdale red bed)	3½	69½
Well Gar-Ae 1 (Altitude: 2310 feet)		
Conemaugh formation:		
Upper member:		
Surface rocks	2	2
Sandrock, yellow	23	25
"Soapstone"	28	53
Sandstone, gray	35	88

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Lower member:		
Coal (Barton)	2	90
"Soapstone"	25	115
Sandstone	10	125
Slate, black	40	165
Soapstone	33	198
Driller's note: Water-bearing from 86 to 198 feet.		
Well Gar-Ac 3 (Altitude: 2400 feet)		
Conemaugh formation:		
Lower member (between Harlem and Barton coals):		
Shale, soft, yellow	12	12
Slate, black	4	16
Sandrock	2	18
Shale, dark	7	25
"Rock", gray	6	31
Shale, lime	12	43
Sandrock, white	12	55
Shale, dark	3	58
Rock, hard, gray	12	70
Shale, dark (Ames shale?) (water)	20	90
"Rock", dark gray	8	98
Well Gar-Ac 4 (Altitude: 2680 feet)		
Conemaugh formation:		
Lower member (between Lower Bakerstown and Brush Creek coals):		
Clay, yellow, boulders	8	8
Sandstone, hard, red	14	22
Clay, soft, yellow	10	32
"Soapstone", white (water)	41	73
Well Gar-Ae 5 (Altitude: 2380 feet)		
Conemaugh formation:		
Lower member (between Barton and Harlem coals):		
Surface rocks	4	4
Sandrock, yellow	29	33
Clay, yellow	3	36
Shale, gray	10	46
Shale, red	6	52
Shale, gray	29	81
"Rock", hard, gray	6	87
Shale, dark gray (water)	6	93
Shale, light gray	15	108
Well Gar-Ae 7 (Altitude: 2320 feet)		
Conemaugh formation:		
Upper member:		
Clay, yellow	10	10
Shale, yellow	11	21

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Sandrock (water)	18	39
Shale, "lime", gray (water)	20	59
Shale, sandy, gray	6	65
Well Gar-Ae 8 (Altitude: 2250 feet)		
Conemaugh formation:		
Lower member:		
Clay, yellow	15	15
Shale, yellow	5	20
Sandrock	25	45
Shale, dark blue (4 in. coal, Harlem)	27	72
Shale, limey, gray	13	85
Well Gar-Ae 10 (Altitude: 2160 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	2	2
Sandrock	18	20
Fire clay	5	25
Shale, black	30	55
Slate, gray	10	65
Sand, gray	5	70
"Soapstone"	58	128
Slate, black	2	130
Coal (Upper Bakerstown)	2	132
"Soapstone"	30	162
Sand, gray	8	170
Slate, black	6	176
Coal (Lower Bakerstown)	3	179
Clay, black	16	195
Fire clay	10	205
Slate, gray	5	210
Shale, red (Meyersdale shale)	5	215
"Soapstone"	10	225
Well Gar-Ae 11 (Altitude: 2380 feet)		
Conemaugh formation:		
Lower member:		
Surface	3	3
Sandrock	6	9
Clay, brown	9	18
"Soapstone"	42	60
Sandstone	24	84
"Soapstone"	38	122
Sandrock	18	140
Slate, black	22	162
"Soapstone"	8	170

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Ae 12 (Altitude: 2160 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	8	8
Sand	17	25
Fire clay	10	35
Slate, black	25	60
Coal (Harlem)	2	62
"Soapstone"	73	135
Slate, black	2	137
Coal (Upper Bakerstown)	2	139
"Soapstone"	26	165
Slate, black	10	175
Coal (Lower Bakerstown)	4	179
Clay, black	6	185
"Soapstone"	21	206
Shale, red (Meyersdale shale)	6	212
Sand, gray	10	222
"Soapstone"	28	250
Well Gar-Ae 13 (Altitude: 2480 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	30	30
"Soapstone"	100	130
Coal (Lower Bakerstown)	5	135
"Soapstone"	35	170
Slate, black	22	192
Well Gar-Ae 14 (Altitude: 2470 feet)		
Conemaugh formation:		
Lower member:		
Clay, yellow, and boulders	24	24
Clay, brown, and boulders	6	30
Clay, dark blue	10	40
Shale, light gray	20	60
Shale, dark	10	70
Shale, light gray (water)	40	110
Well Gar-Ae 15 (Altitude: 2260 feet)		
Conemaugh formation:		
Lower member:		
Clay, yellow	3	3
Shale, yellow	8	11
Shale and dark slate	8	19
Shale, gray	16	35

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Sandrock (water)	20	55
Shale, gray	5	60
Shale, dark	25	85
Coal (Harlem) (water)	1	86
Shale, gray	5	91
Well Gar-Ae 17 (Altitude: 2530 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	6	6
Sand, yellow	48	54
Slate, black (Ames shale?)	11	65
Well Gar-Ae 18 (Altitude: 2670 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	5	5
Sandrock, broken	15	20
Clay, yellow	5	25
"Rock", hard	3	28
"Soapstone", greenish	4	32
Shale, yellow	4	36
Shale, gray	5	41
Shale, blue	8	49
Shale, gray	25	74
Well Gar-Ae 19 (Altitude: 2520 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	1	1
"Rock", hard (water)	34	35
Shale, gray	5	40
Slate, black	2	42
Shale, gray (water)	8	50
Slate, black (Ames shale?)	3	53
Well Gar-Ae 23 (Altitude: 2180 feet)		
Conemaugh formation:		
Lower member:		
Clay and boulders	20	20
Shale, soft, brown	5	25
Shale, gray	13	38
Shale, sandy, gray	3½	41½
Shale, olive-gray	2	43½
Sand and olive clay (water)	3½	47
Sandstone, white (water)	6	53
Shale, gray	3½	56½

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Ae 24 (Altitude: 2360 feet)		
Conemaugh formation:		
Lower member:		
Clay, yellow	19	19
Shale, yellow	5	24
Shale, mixed	6	30
Shale, hard, brown (water)	6	36
Shale, soft, brown	4	40
Shale, gray	18	58
Well Gar-Ae 25 (Altitude: 2640 feet)		
Conemaugh formation:		
Lower member:		
Dirt fill	4	4
Sand and boulders	14	18
Clay, brown	12	30
Shale, dark, and slate	19	49
Coal (Harlem)	1	50
Shale, gray	27	77
Shale, red and gray (Pittsburgh red bed)	3	80
Well Gar-Ae 26 (Altitude: 2170 feet)		
Conemaugh formation:		
Lower member:		
Not reported	11	11
Clay, yellow; sand, soft	15	26
Clay, yellow; sandstone	13	39
Clay and sand, yellow	17	56
Shale, calcareous, pale brown (Pittsburgh red bed)	3	59
Shale, calcareous, weak yellow (water, little)	4	63
Shale, gray (water, little)	3	66
Shale, gray	12	78
"Bastard limestone"	2	80
Well Gar-Ae 28 (Altitude: 2510 feet)		
Conemaugh formation:		
Lower member:		
Clay, yellow	6	6
Clay, white	6	12
Clay, blue	32	44
Shale, dark (water)	30	74
Shale, light gray (water)	46	120
Shale, dark (Ames shale)	10	130
Well Gar-Ae 29 (Altitude: 2150 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	4	4
"Rock", yellow	16	20

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Shale, gray	25	45
Slate, dark, gray	15	60
Shale, black	25	85
Shale, gray	20	105
Shale, red (Pittsburgh red bed)	5	110
Shale, gray	35	145
Driller's note: The formation did not contain water.		
Well Gar-Af 3 (Altitude: 2670 feet)		
Jennings formation:		
Surface rocks	2	2
Clay, yellow	13	15
Shale, yellow	16	31
Shale, dark gray	8	39
Shale, light gray (water)	20	59
Shale, yellow	13	72
Shale, red	4	76
"Rock", hard, blue (water)	59	135
Well Gar-Af 4 (Altitude: 2480 feet)		
Hampshire formation:		
Clay, yellow	19	19
Shale, blue	10	29
Shale, hard, gray	8	37
"Rock", hard, blue	12	49
Shale, red	10	59
Shale, gray	6	65
Shale, red	4	69
"Rock", hard, blue	6	75
Shale, gray (water)	3	78
Well Gar-Af 7 (Altitude: 2660 feet)		
Greenbrier formation:		
Surface rocks	5	5
Shale, red	15	20
"Rock", soft, yellow	40	60
Clay, sandy, yellow	40	100
"Rock", soft, yellow	40	140
Clay, sandy, yellow	60	200
Driller's note: Formation carried very little water.		
Well Gar-Af 8 (Altitude: 2557 feet)		
Hampshire formation:		
Shale, red	60	60
Well Gar-Af 9 (Altitude: 2590 feet)		
Jennings formation:		
"Limestone shales"	60	60

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Af 10 (Altitude: 2420 feet)		
Hampshire formation:		
"Rock", red	67	67
Well Gar-Af 11 (Altitude: 2550 feet)		
Hampshire formation:		
"Limestone, shale partings"	219	219
Well Gar-Af 13 (Altitude: 2680 feet)		
Jennings formation:		
Shale, yellow	14	14
Shale, blue	8	22
Shale, yellow (water)	11	33
"Rock", hard, blue	10	43
Shale, gray	24	67
"Rock", hard, blue	20	87
Shale, red	9	96
Well Gar-Af 14 (Altitude: 2740 feet)		
Pocono formation:		
Shale, soft, yellow	12	12
Sandstone, white	28	40
Shale, blue	18	58
Shale, green	8	66
Shale, gray (water)	13	79
Well Gar-Ag 16 (Altitude: 2620 feet)		
Hampshire formation		
Clay, red, and boulders	25	25
Shale, red	15	40
Shale, green	10	50
Sandrock, red (water)	30	80
Well Gar-Ag 18 (Altitude: 2770 feet)		
Pocono formation:		
"Limestone"	70	70
Note: No limestone in Pocono.		
Well Gar-Ag 19 (Altitude: 2605 feet)		
Pocono formation		
Red shale, limestone	60	60
Well Gar-Ag 21 (Altitude: 2750 feet)		
Pocono formation:		
Clay, yellow	3	3
"Limestone"	34	37
Note: No limestone in Pocono.		

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Ag 22 (Altitude: 2710 feet)		
Greenbrier formation:		
Shale, red	87	87
"Rock"	13	100
Well Gar-Ag 23 (Altitude: 2560 feet)		
Hampshire formation:		
Soil and clay	12	12
"Limestone", sandy	66	78
Well Gar-Ag 24 (Altitude: 2540 feet)		
Hampshire formation:		
"Rock", red	65	65
Well Gar-Ag 26 (Altitude: 2800 feet)		
Pocono formation:		
"Limestone"	61	61
Note: No limestone in Pocono.		
Well Gar-Ba 1 (Altitude: 2010 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	10	10
Clay, yellow	5	15
Clay, black	5	20
Slate, black	5	25
Coal (Brush Creek)	1½	26½
"Soapstone" (water)	25½	52
Sandstone (Mahoning)	18	70
Well Gar-Bb 2 (Altitude: 1490 feet)		
Allegheny formation:		
Slate	5	5
Sand, yellow	17	22
Slate, black	8	30
Sandstone, gray	10	40
"Soapstone"	10	50
Driller's note: Water-bearing from 22 to 45 feet.		
Well Gar-Bb 4 (Altitude: 1500 feet)		
Allegheny formation:		
Surface rocks	5	5
River rock	25	30
Slate, black	11	41
Well Gar-Bb 5 (Altitude: 1910 feet)		
Hampshire formation:		
Surface rocks	5	5
Sand, yellow	15	20
Sandstone, gray	35	55

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Bb 6 (Altitude: 1910 feet)		
Hampshire formation:		
"Surface rocks"	5	5
"River rocks"	15	20
Shale, red (water)	35	55
Well Gar-Bb 7 (Altitude: 2470 feet)		
Pocono formation:		
Surface rocks	8	8
Sand, soft, yellow	20	28
Shale, gray	17	45
Shale, hard, sandy, gray (water)	30	75
Well Gar-Bb 9 (Altitude: 2210 feet)		
Pocono formation:		
Surface rocks	10	10
Shale, soft, red	60	70
Sand, red	50	120
Sand, gray	65	185
Well Gar-Bb 10 (Altitude: 1620 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	6	6
Sandrock, yellow	26	32
Shale, gray	8	40
Slate, black (water)	20	60
Well Gar-Bb 11 (Altitude: 2360 feet)		
Hampshire formation:		
Surface rocks	10	10
Shale, red	40	50
Sand, gray	10	60
"Rock", red	40	100
Well Gar-Bc 3 (Altitude: 2400 feet)		
Hampshire formation:		
Surface rocks	5	5
Shale, red	70	75
"Rock", red	82	157
Driller's note: The formations were not very porous for a good flow of water.		
Well Gar-Bc 4 (Altitude: 2380 feet)		
Hampshire formation:		
Surface rocks	10	10
Shale, red	58	68
"Soapstone"	2	70
Shale, red	15	85

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Bc 5 (Altitude: 2430 feet)		
Hampshire formation:		
"Rock", red and shale (water)	340	340
"Rock", very hard, red	61	401
Driller's note: Lost water at 225 feet.		
Well Gar-Bc 6 (Altitude: 2150 feet)		
Hampshire formation:		
Surface rocks	4	4
Sand, yellow	21	25
Shale, red	40	65
Well Gar-Bc 7 (Altitude: 2110 feet)		
Hampshire formation:		
Shale, red	8	8
"Rock", red	12	20
Shale, red	10	30
Well Gar-Bc 8 (Altitude: 2360 feet)		
Hampshire formation:		
Surface rocks	5	5
"Rock", red	30	35
"Rock", grayish yellow	20	55
Shale, sandy, red	5	60
Shale, red	20	80
Shale, gray	30	110
Well Gar-Bc 9 (Altitude: 2390 feet)		
Hampshire formation:		
Surface rocks	8	8
"Mud", red	18	26
Shale, red	30	56
Shale, gray	19	75
Shale, red	25	100
Well Gar-Bc 10 (Altitude: 2390 feet)		
Hampshire formation:		
Shale, red	100	100
Driller's note: Water was reached about 75 feet.		
Well Gar-Bc 11 (Altitude: 2375 feet)		
Hampshire formation:		
"Flag rock", red	55	55
Driller's note: Good water-bearing strata.		
Well Gar-Bc 12 (Altitude: 2375 feet)		
Hampshire formation:		
Surface rocks	8	8
Shale, sandy, brown	14	22
Shale, red (water)	3	25

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Bc 13 (Altitude: 2420 feet)		
Hampshire formation:		
Surface rocks	5	5
"Rock", red	17	22
Shale, red	38	60
"Rock", sandy, red and shale	40	100
Well Gar-Bc 14 (Altitude: 2390 feet)		
Hampshire formation:		
Shale, red	101	101
Driller's note: Water at 80 feet.		
Well Gar-Bc 15 (Altitude: 2400 feet)		
Hampshire formation:		
Surface rocks	17	17
"Rock", red	13	30
Shale, red	64	94
"Rock", red	6	100
Well Gar-Bc 16 (Altitude: 2320 feet)		
Hampshire formation:		
Surface rocks	5	5
"Rock", red	25	30
Shale, red	20	50
Sandstone, gray	20	70
Shale, gray	10	80
Sandstone, gray	30	110
Shale, red (water)	20	130
Well Gar-Bc 18 (Altitude: 2710 feet)		
Conemaugh formation:		
Lower member:		
Gravel, sandy	12	12
Sandstone	21	33
Shale	47	80
Slate	10	90
Shale, gray (water)	24	114
Well Gar-Bc 20 (Altitude: 2670 feet)		
Pocono formation:		
Clay	6	6
"Rock", red	16	22
Shale, red and gray	7	29
"Rock", red (a little water)	26	55
"Rock", red	43	98
Sandrock, white (no water; stopped)	2	100

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Bc 25 (Altitude: 2430 feet)		
Hampshire formation:		
Surface rocks	5	5
"Mud", red	15	20
Shale, red (water)	80	100
Well Gar-Bc 26 (Altitude: 2460 feet)		
Hampshire formation:		
Surface rocks	2	2
Slate, soft, red	18	20
Shale, red	6	26
"Rock", hard, red	4	30
Shale, red	5	35
"Rock", red	55	90
"Rock", red; shale	53	143
Well Gar-Bc 29 (Altitude: 2430 feet)		
Hampshire formation:		
Surface rocks	5	5
Shale, red	5	10
Shale, red, soft	5	15
Clay, yellow	5	20
Mud, red	5	25
Shale, red	25	50
Shale, red and yellow	10	60
Shale, red and gray	30	90
Sand, red to light	10	100
Shale, red, hard	18	118
Shale, red	7	125
Shale, red and gray	15	140
Shale, red	35	175
Sand, red	2	177
Shale, red	28	205
"Rock", red and gray	5	210
Shale, red	38	248
Shale, gray	10	258
Sand, gray	5	263
"Rock", red	27	290
Shale, red	25	315
Shale, gray	5	320
Shale, red	10	330
Shale, red and gray	10	340
Shale, gray	11	351
Shale, red	4	355
Shale, gray	25	380
Shale, red	8	388
Shale, gray	12	400
Shale, red	5	405

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Shale, gray	30	435
Shale, red and gray	70	505
Shale, red	15	520
Shale, gray	15	535
Shale, red	5	540
Shale, gray	20	560
Shale, red	30	590
Well Gar-Bd 1 (Altitude: 2,690 feet)		
Conemaugh formation:		
Upper member:		
Clay, yellow	10	10
"Rock", broken	4	14
Sandrock, yellow	36	50
Shale, gray	4	54
Well Gar-Bd 2 (Altitude: 2,610 feet)		
Conemaugh formation:		
Upper member:		
Surface rocks	2	2
Shale, yellow	2	4
Clay and sand	3	7
Clay, blue	6	13
"Limestone"	5	18
Lime shale, hard	10	28
Lime shale, soft	30	58
Clay, dark blue	2	60
Shale, gray	20	80
Well Gar-Bd 8 (Altitude: 2,490 feet)		
Conemaugh formation:		
Lower member:		
Clay, yellow	3	3
Shale, soft, yellow	14	17
Sandrock, soft, yellow (water)	4	21
Sandrock, yellow	7	28
Shale, dark (Brush Creek shale)	15	43
Well Gar-Bd 10 (Altitude: 2,650 feet)		
Allegheny formation:		
Clay, yellow	14	14
Sandrock	4	18
Shale, brown	3	21
"Rock", hard	10	31
Shale, brown	10	41
Shale, gray	5	46
"Rock", black (water)	34	80
Shale, dark	6	86

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Be 4 (Altitude: 2,530 feet)		
Pocono formation:		
Sand and gravel	12	12
Sandstone	18	30
Shale, gray (water)	53	83
Well Gar-Bf 2 (Altitude: 2,629 feet)		
Hampshire formation:		
Sand soil	4	4
Shale, red	36	40
Sandrock, red	23	63
Well Gar-Bf 3 (Altitude: 2,590 feet)		
Jennings formation:		
Surface rocks	10	10
Shale, yellow	20	30
Clay, gray	5	35
"Limestone" (water)	6	41
Shale, gray	38	79
"Rock", hard, gray	5	84
Shale, gray	16	100
"Rock", blue	25	125
Shale, gray	50	175
Shale, dark	10	185
Shale, gray (water)	33	218
Well Gar-Bf 4 (Altitude: 2,640 feet)		
Hampshire formation:		
Shale, red	61	61
"Rock", hard	18	79
Shale, sandy (water)	36	115
Well Gar-Bf 9 (Altitude: 2,690 feet)		
Jennings formation:		
Clay, yellow	2	2
Shale, yellow	10	12
"Ironstone"	3	15
Shale, red	5	20
Shale, soft, yellow	16	36
Shale, gray	15	51
Shale, light gray (a little water)	30	81
Shale, light gray (some water)	22	103
Well Gar-Ca 1 (Altitude: 2,000 feet)		
Greenbrier formation:		
Surface rocks	5	5
River rock	13	18
Shale, red	2	20
Limestone	25	45

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Cb 1 (Altitude: 2,480 feet)		
Mauch Chunk formation:		
"Mud", red	24	24
Shale, red (water)	14	38
"Rock", sandy gray	2	40
Well-Gar-Cb 2 (Altitude: 2,490 feet)		
Mauch Chunk formation:		
Surface rocks	10	10
"Rock", yellow	26	36
"Soapstone"	9	45
Sandstone, gray	19	64
"Soapstone"	8	72
Sandstone, gray	38	110
Driller's note: The above formation was not very water-bearing.		
Well Gar-Cb 3 (Altitude: 2,490 feet)		
Mauch Chunk formation:		
Surface rocks	10	10
Shale, red and gray	10	20
Shale, yellowish gray	10	30
Shale, gray	10	40
Shale, sandy, gray	10	50
Shale, gray and red	10	60
Shale, sandy, red	30	90
Shale, reddish gray (water)	10	100
Well Gar-Cb 5 (Altitude: 2,480 feet)		
Mauch Chunk formation:		
Surface rocks	25	25
Shale, red	20	45
"Rock", red (much water)	25	70
Well Gar-Cb 6 (Altitude: 2,540 feet)		
Mauch Chunk formation:		
Surface rocks	42	42
Shale, red	28	70
"Limestone", gray	15	85
Shale, red	105	190
"Rock", red	60	250
Well Gar-Cb 7 (Altitude: 2,540 feet)		
Mauch Chunk formation:		
Surface rocks	5	5
Shale, red (much water)	70	75
Well Gar-Cb 8 (Altitude: 2,480 feet)		
Pocono formation:		
Surface rocks	16	16
Shale	19	35

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
"Rock", yellow	25	60
"Soapstone"	20	80
Well Gar-Cb 9 (Altitude: 2,600 feet)		
Pocono formation:		
Surface rocks	6	6
Sandrock	66	72
Well Gar-Cb 10 (Altitude: 2,490 feet)		
Pocono formation:		
Surface rocks	14	14
Shale, gray	37	51
Well Gar-Cb 11 (Altitude: 2,475 feet)		
Pocono formation:		
Surface rocks	4	4
"Rock", sandy, brown	6	10
Shale, red	32	42
Shale, sandy, gray (much water)	43	85
Well Gar-Cb 13 (Altitude: 2,520 feet)		
Greenbrier formation:		
Surface rocks	5	5
Shale, red	25	30
"Mud", red	40	70
"Rock", sandy, very soft, brown (water)	30	100
Well Gar-Cb 14 (Altitude: 2,490 feet)		
Greenbrier and Mauch Chunk formations:		
Surface rocks	29	29
Shale, red	49	78
"Rock"	7	85
Well Gar-Cb 15 (Altitude: 2,480 feet)		
Greenbrier formation:		
"Mud", red	64	64
Limestone	8	72
Driller's note: Water in cavity in limestone.		
Well Gar-Cb 16 (Altitude: 2,480 feet)		
Greenbrier formation:		
Surface rock	18	18
"Rock", red	27	45
"Rock", red (water)	35	80
Well Gar-Cb 17 (Altitude: 2,480 feet)		
Greenbrier formation:		
Surface	30	30
"Rock", red	30	60

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Cb 19 (Altitude: 2,480 feet)		
Greenbrier formation:		
Surface rocks	18	18
Shale, red	32	50
Slate, gray	30	80
Well Gar-Cb 22 (Altitude: 2,500 feet)		
Greenbrier formation:		
Surface rock	34	34
"Rock", red (water)	31	65
Well Gar-Cb 23 (Altitude: 2,870 feet)		
Pocono formation:		
Surface rocks	8	8
"Rock", yellow	52	60
Slate, gray (much water)	30	90
Sand, gray	30	120
"Soapstone"	10	130
Sand, dark	20	150
Well Gar-Cb 24 (Altitude: 2,480 feet)		
Mauch Chunk formation:		
"Mud"	63	63
"Soapstone"	37	100
Well Gar-Cb 32 (Altitude: 2,490 feet)		
Mauch Chunk formation:		
Surface rocks	40	40
"Soapstone"	20	60
Well Gar-Cb 33 (Altitude: 2,580 feet)		
Greenbrier formation:		
Surface rocks	5	5
"Mud", red	36	41
"Rock", red	19	60
"Rock", lime	5	65
Driller's note: Good supply water between red rock and lime.		
Well Gar-Cb 34 (Altitude: 2,475 feet)		
Mauch Chunk formation:		
Sand and boulders	12	12
Shale	14	26
"Rock", red	36	62
Sandstone (water)	27	89
Well Gar-Cb 35 (Altitude: 2,490 feet)		
Mauch Chunk formation:		
Clay	14	14
Sandstone	81	95

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Cb 36 (Altitude: 2,510 feet)		
Mauch Chunk formation:		
Clay	14	14
Sandstone	88	102
Well Gar-Cb 37 (Altitude: 2,480 feet)		
Hampshire formation:		
Surface	5	5
Shale, red	17	22
"Rock", red	28	50
"Rock", gray	15	65
Well Gar-Cb 38 (Altitude: 2,480 feet)		
Greenbrier formation:		
Clay	9	9
Sandstone	65	74
Well Gar-Cb 39 (Altitude: 2,490 feet)		
Mauch Chunk formation:		
Surface rocks	5	5
"Mud", red	10	15
Shale, red	35	50
"Limestone", gray (water)	30	80
Well Gar-Cc 1 (Altitude: 2,520 feet)		
Mauch Chunk and Greenbrier formations:		
Clay	15	15
Limestone	69	84
"Rock", red	20	104
Sandstone	54	158
Clay, blue	6	164
Well Gar-Cc 2 (Altitude: 2,520 feet)		
Greenbrier formation:		
Shale, red	46	46
Limestone	19	65
"Rock", red	20	85
Driller's note: Not much water in the formation.		
Well Gar-Cc 3 (Altitude: 2,490 feet)		
Greenbrier formation:		
Surface	20	20
Shale, red	18	38
Limestone	7	45
"Rock", red	55	100

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Cc 4 (Altitude: 2,510 feet)		
Hampshire formation:		
Surface rocks	30	30
"Rock", red	70	100
Well Gar-Cc 5 (Altitude: 2,480 feet)		
Pocono formation:		
Top dirt	3	3
Sandstone	64	67
Shale, black	6	73
Well Gar-Cc 7 (Altitude: 2,530 feet)		
Hampshire formation:		
Clay, yellow	30	30
Shale, red	30	60
Shale, gray	30	90
"Limestone"	10	100
Shale, red	51	151
Well Gar-Cc 8 (Altitude: 2,480 feet)		
Greenbrier formation:		
Surface rocks	40	40
Shale, red (water)	20	60
Well Gar-Cc 9 (Altitude: 2,500 feet)		
Mauch Chunk formation:		
Surface rocks	5	5
"Rock", yellow	25	30
Shale, gray	10	40
Shale, red	75	115
Well Gar-Cc 10 (Altitude: 2,480 feet)		
Pocono formation:		
Surface rocks	3	3
Sandstone	65	68
"Soapstone"	12	80
Well Gar-Cc 11 (Altitude: 2,480 feet)		
Greenbrier formation:		
Surface rocks	48	48
Shale, red (water)	37	85
Well Gar-Cc 12 (Altitude: 2,480 feet)		
Greenbrier formation:		
Surface rocks	6	6
"Mud", sandy, brown	49	55
Sandstone, gray	37	92

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Cc 15 (Altitude: 2,710 feet)		
Conemaugh formation:		
Lower member:		
Sand wash	12	12
"Rock"	17	29
Clay, soft, gray	4	33
Coal (Brush Creek coal?)	2	35
Clay, dark gray	2	37
Shale, light gray	15	52
Shale, red and gray (Mahoning red bed?)	18	70
Shale, gray	10	80
Shale, hard, gray	30	110
Well-Gar-Cc 18 (Altitude: 2,530 feet)		
Mauch Chunk formation:		
Surface rocks	5	5
"Mud", yellow	25	30
Shale, red	85	115
Well Gar-Cc 19 (Altitude: 2,700 feet)		
Allegheny formation:		
Surface rocks	6	6
Sand, yellow	24	30
Sand, dark gray	16	46
Well Gar-Cc 20 (Altitude: 2,635 feet)		
Pocono formation:		
Clay	24	24
Sandrock	81	105
Well Gar-Cc 21 (Altitude: 2,510 feet)		
Pocono formation:		
Sandrock, yellow	35	35
Sand, gray	17	52
Slate, gray	13	65
Sand, yellow (water)	15	80
Well Gar-Cc 22 (Altitude: 2,480 feet)		
Mauch Chunk formation:		
Surface rocks	10	10
Sand, yellow	50	60
Shale, red	20	80
Well Gar-Cc 23 (Altitude: 2,480 feet)		
Pocono formation:		
Clay	10	10
Shale, red	15	25
Shale, gray	35	60
"Rock", blue (water)	15	75

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Cd 9 (Altitude: 2,500 feet)		
Hampshire formation:		
Surface	10	10
Shale, red	80	90
Well Gar-Cd 12 (Altitude: 2,670 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	3	3
Coal (Harlem)	1	4
Shale, yellow	15	19
Shale, blue	34	53
Well Gar-Cd 13 (Altitude: 2,640 feet)		
Allegheny formation:		
Surface rocks	5	5
Sandrock, hard, white (water)	18	23
Shale, yellow	7	30
Clay, dark	13	43
Coal	2	45
Shale, gray (water)	12	57
Well Gar-Da 2 (Altitude: 2,520 feet)		
Conemaugh formation:		
Lower member:		
Shale, brown	10	10
Shale, gray	13	23
"Soapstone"	13	36
Shale, gray (water)	39	75
Well Gar-Da 3 (Altitude: 2,490 feet)		
Conemaugh formation:		
Lower member:		
Surface	6	6
Sandstone, soft (water)	15	21
Shale	3	24
Sandstone, very hard	5	29
Slate, black	18	47
Shale, gray (water)	3	50
Well Gar-Da 4 (Altitude: 2,500 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	12	12
Sandstone, soft	15	27
Sandstone, hard (water)	5	32
Slate, black	18	50
Shale, gray (water underneath)	4	54
Shale, red	4	58

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Da 5 (Altitude: 2,480 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	5	5
Sand, soft	25	30
Shale, dark gray	15	45
Slate, black (water)	5	50
Coal	1½	51½
Fire clay (water)	11½	63
Well Gar-Da 6 (Altitude: 2,590 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	8	8
Shale, sandy	20	28
Sand, hard	12	40
Shale, sandy	9	49
Sand, hard (water)	7	56
Fireclay	4	60
Well Gar-Da 7 (Altitude: 2,460 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	5	5
Sandstone	10	15
Shale	18	33
"Limestone"	3	36
Sandstone (water)	7	43
Well Gar-Da 12 (Altitude: 2,520 feet)		
Conemaugh formation:		
Lower member:		
Clay	5	5
Sand and gravel (water)	18	23
Shale, soft, gray	9	32
Sandstone (water)	8	40
Shale, hard, gray	2	42
Well Gar-Da 13 (Altitude: 2,430 feet)		
Conemaugh formation:		
Lower member:		
Top soil	4	4
Sandstone, medium hard, dark gray	14	18
Shale, dark gray (water)	6	24
Shale, light	9	33
Sandstone, hard	4	37
Shale, light	5	42
Sandstone, medium hard, gray (water)	3	45

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Da 14 (Altitude: 2,480 feet)		
Conemaugh formation:		
Lower member:		
Top soil	3	3
Sandstone	42	45
Fire clay	2	47
Slate, gray (water)	7½	54½
Well Gar-Da 15 (Altitude: 2,460 feet)		
Allegheny formation:		
Top soil and boulders	17	17
Sandstone	68	85
Slate, gray	25	110
Sandstone	5	115
Well Gar-Db 1 (Altitude: 2,585 feet)		
Jennings formation:		
Shale	60	60
Sandstone	20	80
Clay	5	85
Well Gar-Db 2 (Altitude: 2,560 feet)		
Jennings formation:		
Flagstone	20	20
Shale, gray	40	60
Well Gar-Db 4 (Altitude: 2,680 feet)		
Pocono formation:		
Surface rocks	10	10
Clay, sandy, yellow	10	20
Slate, gray	45	65
Sand, gray	20	85
Well Gar-Db 5 (Altitude: 2,690 feet)		
Hampshire formation:		
Clay, yellow	25	25
"Limestone" (water)	25	50
Shale, red (no water)	23	73
Well Gar-Db 8 (Altitude: 2,560 feet)		
Jennings formation:		
Clay, yellow	40	40
"Limestone"	27	67
Well Gar-Db 13 (Altitude: 2,390 feet)		
Pocono formation:		
Surface rocks	10	10
Sand and boulder bed (water)	10	20

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Sandstone, very hard, gray	108	128
Sandstone, medium hard	18	146
Shale, hard, gray	6	152
Sandstone, hard, gray	28	180
Shale, dark gray	3	183
Sandstone, hard, white	11	194
Shale, hard, dark gray	23	217
Shale, light gray	6	223
Sandstone, very hard, light gray	31	254
Well Gar-Db 21 (Altitude: 2,390 feet)		
Pocono formation:		
Sand and gravel	39	39
Sandstone, very hard, dark gray	18	57
Shale, soft, red (water)	3	60
Sandstone, very hard, dark gray	6	66
Sandstone, hard, light gray	13	79
Shale, hard, sandy	65	144
Shale, medium hard, dark	24	168
Sandstone, hard, dark gray	6	174
Shale, hard, dark gray	24	198
Sandstone, very hard, fine-grained, light	27	225
Shale, dark gray (water)	14	239
Sandstone, hard, light gray	10	249
Well Gar-Db 22 (Altitude: 2,430 feet)		
Hampshire formation:		
Soil	12	12
Sandstone	28	40
Shale	20	60
Sandstone (water)	20	80
Well Gar-Db 23 (Altitude: 2,580 feet)		
Jennings formation:		
Clay	12	12
Shale	18	30
Sandstone (water)	32	62
Shale (water)	18	80
Well Gar-Db 24 (Altitude: 2,560 feet)		
Jennings formation:		
Shale	18	18
"Lime rock"	88	106
Well Gar-Db 25 (Altitude: 2,460 feet)		
Pocono formation:		
Surface rocks	5	5
Clay, yellow	2	7

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Shale, yellow	16	23
Shale, red	12	35
Shale, gray	5	40
Shale, red	35	75
Shale, gray	20	95
Shale, red	10	105
Shale, hard, gray	15	120
Shale, red	60	180
Shale, gray	10	190
Shale, red (water)	10	200
Well Gar-Db 26 (Altitude: 2,460 feet)		
Pocono formation:		
Surface rocks	5	5
Shale, gray	25	30
Sand, gray	45	75
Shale, gray	55	130
Shale, red	55	185
Shale, gray	15	200
Well Gar-Dc 1 (Altitude: 2,500 feet)		
Hampshire formation:		
Surface rocks	8	8
Shale, red	32	40
Shale, sandy, red	75	115
Shale, sandy, red and gray	35	150
Well Gar-Dc 2 (Altitude: 2,510 feet)		
Hampshire formation:		
Surface rocks	30	30
"Rock", red	95	125
Well Gar-Dc 3 (Altitude: 2,510 feet)		
Hampshire formation:		
Surface rocks	30	30
Shale, red	10	40
"Rock", red	110	151
Well Gar-Dc 4 (Altitude: 2,510 feet)		
Hampshire formation:		
Surface rocks	5	5
"Rock", red	10	15
Shale, red	30	45
"Rock", red	22	67
Clay, reddish yellow	1	68
Shale, sandy, gray	7	75
"Rock", red	3	78
"Rock", gray	2	80

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
"Rock", red	16	96
Shale, sandy, gray	9	105
"Rock", red	9	114
"Rock", gray	19	133
"Rock", red	4	137
Shale, sandy, gray	18	155
"Rock", red	10	165
Rock, sandy, gray	10	175
Driller's note: The above strata contained very little water.		
Well Gar-Dc 6 (Altitude: 2,520 feet)		
Jennings formation:		
Clay, yellow	12	12
Sandrock	8	20
Shale, red	30	50
Sandrock, gray (water)	11	61
Well Gar-Dc 7 (Altitude: 2,520 feet)		
Jennings formation:		
Clay, yellow	16	16
Sandrock (water)	40	56
Sandrock, fine	10	66
Shale, red	20	86
Shale, gray	11	97
Well Gar-Dc 8 (Altitude: 2,480 feet)		
Jennings formation:		
Clay, yellow	33	33
"Limerock"	17	50
Shale, gray	46	96
Well Gar-Dc 9 (Altitude: 2,470 feet)		
Jennings formation:		
Surface rocks	12	12
Sandstone, medium-hard, gray	8	20
Shale, red (water)	28	48
Sandstone, hard (water underneath)	20	68
Well Gar-Dc 10 (Altitude: 2,540 feet)		
Jennings formation:		
Loamy soil	20	20
Shale, red	45	65
Well Gar-Dc 11 (Altitude: 2,480 feet)		
Jennings formation:		
Surface rocks	30	30
"Soapstone"	120	150

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Dc 12 (Altitude: 2,480 feet)		
Jennings formation:		
Clay, yellow	23	23
Sandrock (water)	10	33
Shale, gray (water)	40	73
"Limerock" (water)	4	77
Well Gar-Dc 13 (Altitude: 2,470 feet)		
Hampshire formation:		
Top soil	14	14
"Rock", red	36	50
Shale, gray	25	75
"Rock", red	20	95
Well Gar-Dc 14 (Altitude: 2,470 feet)		
Hampshire formation:		
Top soil	14	14
"Rock", red	46	60
Shale, gray (water)	30	90
Well Gar-Dc 15 (Altitude: 2,470 feet)		
Hampshire formation:		
Top soil	15	15
"Rock", red	50	65
Shale, gray (water)	15	80
Well Gar-Dc 16 (Altitude: 2,470 feet)		
Hampshire formation:		
Shale, red	20	20
"Rock", red (water)	60	80
Well Gar-Dc 17 (Altitude: 2,470 feet)		
Hampshire formation:		
"Dirt" and shale	8	8
"Rock", red	22	30
Sandstone and "rock", red (water)	50	80
Well Gar-Dc 18 (Altitude: 2,520 feet)		
Jennings formation:		
Clay, yellow	12	12
Slate, yellow	58	70
"Limestone", white (water)	74	144
"Limestone", blue	27	171
Well Gar-Dc 19 (Altitude: 2,520 feet)		
Jennings formation:		
Clay, yellow	14	14
"Stone", red	8	22

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Slate, yellow	31	53
"Soapstone", white (water)	103	156
Well Gar-Dc 21 (Altitude: 2,480 feet)		
Jennings formation:		
Surface, rocks	28	28
"Rock", red	62	90
Shale, red (water)	10	100
Well Gar-Dc 24 (Altitude: 2,490 feet)		
Hampshire formation:		
Surface rocks	20	20
Shale, red	60	80
Well Gar-Dc 26 (Altitude: 2,500 feet)		
Jennings formation:		
Clay and gravel	15	15
Shale and blue "rock"	76	91
Well Gar-Dc 27 (Altitude: 2,520 feet)		
Hampshire formation:		
Surface rocks	30	30
Shale, red (water)	45	75
Well Gar-Dc 28 (Altitude: 2,500 feet)		
Hampshire formation:		
Surface rocks	30	30
Shale, red	70	100
Driller's note: Water-bearing from 60 to 100 feet.		
Well Gar-Dc 30 (Altitude: 2,470 feet)		
Hampshire formation:		
"Dirt"	10	10
Sandstone	15	25
Sandstone, red	13	38
Shale	23	61
Sandstone (water)	3	64
Well Gar-Dc 31 (Altitude: 2,480 feet)		
Jennings formation:		
Surface rocks	3	3
Shale, yellow and red	7	10
Shale, soft, gray	10	20
Shale, hard, gray (water)	4	24
Shale, green	4	28
Shale, gray	10	38
Shale, red	4	42

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
"Rock", hard (water)	5	47
Shale, gray (water)	43	90
Shale, red	2	92
Well Gar-Dc 33 (Altitude: 2,480 feet)		
Jennings formation:		
Shale, yellow	10	10
Shale, gray	13	23
"Rock", yellow	12	35
Shale, gray	20	55
Well Gar-Dc 34 (Altitude: 2,490 feet)		
Jennings formation:		
Shale, yellow	30	30
Shale, light gray	18	48
"Rock", hard, gray	4	52
Shale, light gray	11½	63½
Well Gar-Dc 35 (Altitude: 2,470 feet)		
Hampshire formation:		
Clay	17½	17½
Sandstone	83½	101
Well Gar-Dc 36 (Altitude: 2,480 feet)		
Hampshire formation:		
Clay	14	14
Sandstone	88	102
Well Gar-Dc 37 (Altitude: 2,480 feet)		
Hampshire formation:		
Clay	18	18
"Rock", red	83	101
Clay, gray	6	107
Well Gar-Dc 38 (Altitude: 2,470 feet)		
Jennings formation:		
Shale, red	60	60
Sand, gray	42	102
Well Gar-Dc 39 (Altitude: 2,510 feet)		
Jennings formation:		
Clay and shale	10	10
Sandstone (water)	45	55
Well Gar-Dc 40 (Altitude: 2,500 feet)		
Hampshire formation:		
Clay	6	6
"Rock", red (water)	42	48

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Dc 41 (Altitude: 2,530 feet)		
Hampshire formation:		
Clay	12	12
Shale, red	24	36
Shale, gray (water)	39	75
Well Gar-Dc 42 (Altitude: 2,480 feet)		
Jennings formation:		
Clay	12	12
Shale, gray (water)	63	75
Well Gar-Dc 43 (Altitude: 2,480 feet)		
Jennings formation:		
Shale, yellow	10	10
Shale, gray	13	23
"Rock", gray (water)	12	35
Shale, gray (water)	29	64
Shale, hard, gray	7½	71½
Well Gar-Dc 44 (Altitude: 2,550 feet)		
Hampshire formation:		
Surface rocks	10	10
Shale, red	15	25
"Rock", red	35	60
Shale, gray	5	65
Shale, red	40	105
"Rock", red	25	130
Well Gar-Dc 46 (Altitude: 2,520 feet)		
Hampshire formation:		
Surface rocks	40	40
——— (water)	60	100
Well Gar-Dc 47 (Altitude: 2,510 feet)		
Hampshire formation:		
Surface rock	10	10
"Mud", red	30	40
"Rock", red	45	85
Well Gar-Dc 48 (Altitude: 2,550 feet)		
Pocono formation:		
Shale, red	24	24
"Rock", red	66	90
Shale (water)	35	125
Well Gar-Dc 49 (Altitude: 2,500 feet)		
Hampshire formation:		
Surface rocks	3	3
"Rock", red	35	38

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Shale, gray	13	51
"Rock", gray	9	60
"Rock", red	16	76
Shale, gray	16	92
Shale, red	48	140
Shale, gray	52	192
Shale, red	28	220
Shale, gray	15	235
Shale, red	5	240
Shale, gray (water)	10	250
Well Gar-Dd 1 (Altitude: 2,910 feet)		
Allegheny formation:		
Surface rocks	15	15
"Soapstone"	85	100
Coal (Upper Freeport)	2	102
"Soapstone"	18	120
Well Gar-Dd 3 (Altitude: 1,930 feet)		
Allegheny and Pottsville formations:		
Surface rocks	24	24
Sandrock, red	23	47
Sandrock, gray	23	70
Slate, gray	27	97
Sand, yellow	33	130
Slate, gray	5	135
Slate, black	15	150
Sand, gray	20	170
Sandstone	5	175
Slate, gray	5	180
Sandstone, gray	15	195
Slate, gray	20	215
Sandstone, gray	45	260
Slate, gray	28	288
Sand, gray	2	290
Sandstone	25	315
Well Gar-Dd 6 (Altitude: 2,900 feet)		
Pottsville formation:		
Surface	3	3
Sand, yellow	22	25
Soapstone	30	55
Well Gar-Dd 9 (Altitude: 2,750 feet)		
Conemaugh formation:		
Lower member:		
Sand	10	10
Sandstone	30	40
Shale (water)	10	50

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-De 3 (Altitude: 2,270 feet)		
Conemaugh formation:		
Lower member:		
Clay	26	26
Sandstone	16	42
Clay	4	46
Sandstone	3½	49½
Well Gar-De 6 (Altitude: 2,460 feet)		
Allegheny formation:		
Clay	14	14
Sandstone (crevices)	16	30
Sandstone	40	70
Slate	12	82
Coal	2	84
Shale (water)	8	92
Well Gar-De 7 (Altitude: 2,520 feet)		
Conemaugh formation:		
Lower member:		
Clay	8	8
"Soapstone", white	41	49
Sandstone, hard, yellow	22	71
"Soapstone"	33	104
Slate, black	16	120
Coal (Barton)	5	125
"Soapstone", white	35	160
Well Gar-De 8 (Altitude: 2,700 feet)		
Allegheny and Pottsville formations (?):		
Sand and boulders	14	14
Shale and fire clay layers (water)	31	45
Well Gar-Ea 1 (Altitude: 2,580 feet)		
Pottsville formation:		
Clay, yellow	38	38
"Limestone"	40	78
Shale, gray	7	85
Well Gar-Ea 2 (Altitude: 2,495 feet)		
Conemaugh formation:		
Lower member:		
Surface rocks	7	7
Shale, green	6	13
Sandstone, soft	14	27
Sandstone, hard (water)	8	35
Shale, hard, gray (water)	25	60

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Ea 3 (Altitude: 2,410 feet)		
Conemaugh formation:		
Lower member:		
Surface	10	10
Shale	4	14
Sand and "gravel" bed (water)	6	20
Shale, hard	15	35
Sandstone, soft	6	41
Sandstone, hard (water)	7	48
Well Gar-Ea 4 (Altitude: 2,480 feet)		
Greenbrier and Mauch Chunk formations:		
Topsoil, clay	40	40
Shale, gray, layers of "rock" (water)	60	100
Well Gar-Ea 5 (Altitude: 2,395 feet)		
Allegheny formation:		
Top soil	20	20
Slate and coal	8	28
Shale, gray (water)	22	50
Well Gar-Ea 6 (Altitude: 2,410 feet)		
Conemaugh formation:		
Lower member:		
Clay	20	20
Sandrock (water)	30	50
Shale, red (Mahoning red shale)	5	55
Well Gar-Ea 7 (Altitude: 2,560 feet)		
Jennings formation:		
Surface rocks	17	17
Sandstone, soft	30	47
Shale, sandy	17	64
Sandstone, hard	19	83
Slate, gray	16	99
Sandstone, soft (water)	7	106
Sandstone, hard	4	110
Well Gar-Ea 8 (Altitude: 2,460 feet)		
Jennings formation:		
Surface rocks	8	8
Shale, soft (water)	20	28
Sandstone, soft	11	39
Sandstone, hard (water)	7	46
Well Gar-Ea 9 (Altitude: 2,490 feet)		
Jennings formation:		
"Soapstone", soft (water)	33	33
Sandstone, soft	22	55

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Shale, hard	14	69
Sandstone, hard (water on top)	6	75
Well Gar-Ea 10 (Altitude: 2,480 feet)		
Jennings formation:		
Surface rocks	12	12
Shale, soft, sandy	16	28
"Soapstone", gray	172	200
Driller's note: The gray sandstone carried ample water after 150 feet.		
Well Gar-Ea 11 (Altitude: 2,390 feet)		
Allegheny formation:		
Surface rocks	24	24
Sandstone, medium hard	18	42
Shale, gray (water)	23	65
Slate, dark gray	9	74
Shale, gray (water)	17	91
Well Gar-Ea 15 (Altitude: 2,420 feet)		
Conemaugh formation:		
Lower member:		
Clay, sand, boulders	15	15
Slate (water)	25	40
Shale, black	5	45
Slate, gray (water)	10	55
Well Gar-Ea 16 (Altitude: 2,430 feet)		
Pocono formation:		
Clay	8	8
Sandstone	30	38
Slate	7	45
Sandstone (water)	27	72
Well Gar-Ea 18 (Altitude: 2,430 feet)		
Pocono formation:		
Boulders, sand	16	16
Slate	9	25
"Limestone"	20	45
Well Gar-Ea 19 (Altitude: 2,420 feet)		
Pocono formation:		
Clay	23	23
Sandstone	49	72
Slate, gray (water)	15	87
Well Gar-Ea 20 (Altitude: 2,490 feet)		
Jennings formation:		
Clay	10	10
Shale, gray (water)	40	50

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Ea 21 (Altitude: 2,500 feet)		
Pocono formation:		
Surface rocks	8	8
Sand, gray (water)	72	80
Well Gar-Ea 22 (Altitude: 2,430 feet)		
Conemaugh formation:		
Lower member:		
Top soil	6	6
Sandstone	6	12
Shale, gray	18	30
Slate, black	5	35
Shale, gray (water)	15	50
Well Gar-Ea 23 (Altitude: 2,440 feet)		
Pocono formation:		
Clay	16	16
Shale	12	28
Sandstone (water)	30	58
Well Gar-Eb 1 (Altitude: 2,400 feet)		
Jennings formation:		
Surface rocks	19	19
Shale, gray (water)	12	31
"Soapstone"	15	46
Sandstone, medium hard	3	49
Shale, gray (water)	16	65
Well Gar-Eb 2 (Altitude: 2,420 feet)		
Hampshire formation:		
Surface rocks	8	8
Sand, soft, "shelly"	11	19
Shale, red	7	26
Sandstone, dark	11	37
Shale, sandy, gray	3	40
Sandstone, hard, dark gray	9	49
Shale, hard, dark	3	52
Sandstone, dark gray (water)	7	59
Sandstone, light	6	65
Shale, sandy	4	69
Sandstone, hard, gray	1	70
Shale, red	8	78
Shale, gray (water)	7	85
Sandstone, very hard, gray	8	93
Sandstone, medium hard	4	97
Sandstone, hard gray	6	103
Sandstone, soft, dark (water)	10	113
Sandstone, medium hard	6	119
Sandstone, fine, hard, light	12	131
Sandstone, hard, "shelly", gray	2	133

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Eb 3 (Altitude: 2,540 feet)		
Jennings formation:		
Clay	10	10
Sandstone	20	30
Shale (water)	35	65
Well Gar-Eb 4 (Altitude: 2,570 feet)		
Jennings formation:		
Clay	10	10
Shale	14	24
Sandstone	63	87
Well Gar-Eb 5 (Altitude: 2,420 feet)		
Jennings formation:		
Surface rocks	15	15
Shale, hard, gray	17	32
Sandstone, soft	22	54
Shale, hard, gray	13	67
Slate, hard, dark gray	44	111
Sandstone, soft (water underneath)	12	123
Shale, hard, gray	27	150
Shale, sandy, dark gray (water)	21	171
Shale, light gray	26	197
Well Gar-Eb 6 (Altitude: 2,420 feet)		
Jennings formation:		
Surface rocks	12	12
Shale, soft, gray	11	23
Shale, hard, gray	14	37
Sandstone (water below)	4	41
Shale, hard, gray	17	58
Slate, dark (water)	7	65
Shale, hard, gray	4	69
Well Gar-Eb 7 (Altitude: 2,470 feet)		
Hampshire formation:		
Surface rocks	8	8
Shale	10	18
Sandstone	6	24
Shale	3	27
Sandstone, soft	12	39
Sandstone, hard	4	43
Shale, soft	8	51
Sandstone, brown	8	59
Fire clay	5	64
Sandstone, medium hard, brown	10	74
Slate, gray (water underneath)	23	97
Sandstone, hard, gray	95	192

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Shale, dark gray	12	204
Sandstone, fine, very hard, brown	9	213
Sand, hard, blue	52	265
Sandstone, medium hard, gray	11	276
Sandstone, hard	9	285
Shale, hard, red	10	295
Shale, hard, gray	7	302
Sand, fine, very hard, white	24	326
Well Gar-Eb 8 (Altitude: 2,440 feet)		
Jennings formation:		
Surface clay	20	20
Shale, hard, gray (water)	15	35
Sandstone	7	42
Slate, gray	18	60
Shale, gray (water)	10	70
Well Gar-Eb 9 (Altitude: 2,450 feet)		
Jennings formation:		
Surface rocks	18	18
Shale, hard, gray	19	37
Sandstone, hard, brown	6	43
Well Gar-Eb 10 (Altitude: 2,465 feet)		
Jennings formation:		
Surface rocks	15	15
Sandstone	12	27
Shale, gray	15	42
Sandstone, hard	7	49
Shale, gray	12	61
Sandstone, medium hard (water)	12	73
Sandstone, hard	4	77
Shale, gray (water)	13	90
Well Gar-Eb 13 (Altitude: 2,570 feet)		
Jennings formation:		
Loamy soil	20	20
Shale, gray	38	58
Well Gar-Eb 15 (Altitude: 2,450 feet)		
Jennings formation:		
Clay	18	18
Sandrock and gray shale (water)	87	105
Well Gar-Eb 16 (Altitude: 2,470 feet)		
Jennings formation:		
Surface rocks	22	22
Slate or gray shale	58	80

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Eb 18 (Altitude: 2,440 feet)		
Jennings formation:		
Surface rocks	20	20
Shale, red	10	30
"Soapstone"	45	75
Well Gar-Eb 22 (Altitude: 2,460 feet)		
Jennings formation:		
Slate	20	20
Sandstone	8	28
Slate	12	40
"Limestone" (water)	33	73
Well Gar-Eb 24 (Altitude: 2,390 feet)		
Jennings formation:		
Clay	16	16
Shale	24	40
"Limestone"	10	50
Well Gar-Eb 25 (Altitude: 2,920 feet)		
Allegheny formation:		
Clay	8	8
Shale	24	32
Sandstone	28	60
Shale (water)	28	88
Well Gar-Eb 26 (Altitude: 2,850 feet)		
Conemaugh formation:		
Lower member:		
Clay	19	19
Slate, black	16	35
Shale, gray	15	50
Sandstone	25	75
Shale, gray	11	86
Well Gar-Eb 27 (Altitude: 2,520 feet)		
Jennings formation:		
Clay	15	15
Shale	15	30
"Limestone"	20	50
Shale (water)	40	90
Well Gar-Eb 28 (Altitude: 2,520 feet)		
Jennings formation:		
Clay	3	3
Shale	15	18
"Limestone"	32	50
Shale (water)	50	100

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Eb 29 (Altitude: 2,490 feet)		
Jennings formation:		
Clay	10	10
Shale	11	21
Sandstone	9	30
Shale (water)	20	50
Well Gar-Eb 30 (Altitude: 2,490 feet)		
Jennings formation:		
Surface material	5	5
Shale, yellow	25	30
Shale, gray	88	118
Well Gar-Eb 31 (Altitude: 2,660 feet)		
Hampshire formation:		
Clay	7	7
Shale	23	30
Shale, gray	45	75
Shale, red (water)	28	103
Well Gar-Ec 2 (Altitude: 2,580 feet)		
Conemaugh formation:		
Lower member:		
Dirt	12	12
Slate, brown	8	20
Slate, gray; fire clay layers	60	80
"Rock", red (Pittsburgh red bed) (water)	40	120
Well Gar-Ec 8 (Altitude: 2,670 feet)		
Conemaugh formation:		
Lower member:		
Soil, red	20	20
Shale	40	60
Coal (Upper Bakerstown)	5	65
Well Gar-Ec 13 (Altitude: 2,850 feet)		
Conemaugh formation:		
Lower member:		
Clay and sand	0	15
Sandstone (water)	18	33
Well Gar-Fa 1 (Altitude: 2,480 feet)		
Jennings formation:		
Surface rocks	19	19
Slate, gray	11	30
"Soapstone"	8	38
Shale, gray	5	43

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Fa 2 (Altitude: 2,470 feet)		
Jennings formation:		
Surface rocks	24	24
Sandstone, soft (water)	10	34
Shale	40	74
Shale, sandy, red	8	82
Sandstone, hard (water)	3	85
Well Gar-Fa 3 (Altitude: 2,440 feet)		
Jennings formation:		
Surface rocks	20	20
Sandstone, hard (water)	15	35
Shale, sandy	5	40
Sandstone, hard (water)	5	45
Well Gar-Fa 4 (Altitude: 2,460 feet)		
Jennings formation:		
Surface rocks	20	20
Shale, soft, gray	15	35
Sandstone, medium hard, gray	29	64
Shale, gray	4	68
Sandstone, gray	15	83
Shale, gray	26	109
Well Gar-Fa 13 (Altitude: 2,530 feet)		
Jennings formation:		
"Shale rock"	10	10
"Shale lime"	35	45
"Limestone"	25	70
Well Gar-Fa 14 (Altitude: 2,690 feet)		
Greenbrier formation:		
Surface rocks	10	10
Sand and gravel	30	40
Sandstone, hard	18	58
Shale, gray	8	66
Shale, red	24	90
Sandstone, gray	14	104
Well Gar-Fa 15 (Altitude: 2,500± feet)		
Jennings formation:		
Clay	12	12
"Rock", red	28	40
"Rock", blue (water)	35	75
Well Gar-Fb 5 (Altitude: 2,680 feet)		
Conemaugh formation:		
Upper member:		
Surface rocks	5	5
Sandstone, gray	28	33

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Sandstone, brown (water)	4	37
Shale, dark gray	7	44
Shale, light gray	15	59
Slate, dark	1	60
Well Gar-Fb 6 (Altitude: 2,690 feet)		
Conemaugh formation:		
Upper member:		
Surface rocks	10	10
Sandstone, hard, gray	27	37
Slate, black	4	41
Fire clay	2	43
Shale, gray (water)	23	66
Well Gar-Fb 7 (Altitude: 2,750 feet)		
Conemaugh formation:		
Upper member:		
Surface rocks	9	9
Shale, gray	11	20
Sandstone, soft	14	34
Sandstone, hard, gray	9	43
Fire clay	5	48
Shale, gray (water)	12	60
Well Gar-Fb 9 (Altitude: 2,580 feet)		
Conemaugh formation:		
Lower member:		
Clay	16	16
Shale	14	30
Sandstone (water)	8	38
Shale (water)	28	66
Well Gar-Fb 10 (Altitude: 2,330 feet)		
Conemaugh formation:		
Lower member:		
Clay	17	17
Sandstone	33	50
Well Gar-Fb 11 (Altitude: 2,500 feet)		
Conemaugh formation:		
Lower member:		
Clay	6	6
Shale	54	60
Sandstone	14	74
Shale	106	180
Sandstone (water)	25	205

TABLE 22—*Continued*

	Thickness (feet)	Depth (feet)
Well Gar-Fb 12 (Altitude: 2,570 feet)		
Conemaugh formation:		
Lower member:		
Clay	12	12
Shale, brown	20	32
Sandstone	34	66
Shale (water)	14	80
Well Gar-Fb 13 (Altitude: 2,570 feet)		
Conemaugh formation:		
Lower member:		
Clay	16	16
Shale	14	30
Sandstone	8	38
Shale (water)	28	66
Well Gar-Fb 14 (Altitude: 2,560 feet)		
Conemaugh formation:		
Lower member:		
Clay	6	6
Sandstone	39	45
Shale, gray (water)	21	66
Well Gar-Fb 15 (Altitude: 2,620 feet)		
Conemaugh formation:		
Lower member:		
Clay	20	20
Sandstone	30	50
Shale, gray	20	70

TABLE 23

Logs of Wells from Which Cuttings Were Obtained

	Thickness (feet)	Depth (feet)
Well Gar-Ae 8 (Altitude: 2,250 feet)		
Conemaugh formation:		
Lower member:		
Clay, yellow	20	20
Shale	5	25
Sandstone, light yellowish-brown; residue, medium-sized quartz	20	45
Shale, medium gray; a few quartz and calcite grains; very fine-grained pyrite rather common	8	53
Siltstone, somewhat calcareous; medium gray; pyrite, rather common; marine fossils fairly common, *Nucula* sp.	9	62
Shale, calcareous, medium gray; fossils, few	2	64
Shale, highly calcareous, medium gray; pyrite fairly common, coarsely crystalline and in aggregates; fossiliferous, *Euphemites* sp.	2	66

TABLE 23—*Continued*

	Thickness (feet)	Depth (feet)
Shale, somewhat calcareous, medium gray; coal; calcite stringers; pyrite fairly common	4	70
Shale, calcareous, medium light-gray; fragments of fibrous calcite	4	74
Shale, calcareous, medium light-gray	11	85
Well Gar-Cc 5 (Altitude: 2,480 feet)		
Pocono formation:		
Sandstone, pale yellowish-orange; cuttings chiefly quartz fragments of fine, very fine, and medium-grained; quartz, chiefly whitish or cloudy, slight iron-staining	9	9
No sample	8	17
Sandstone, weak orange; same as above	2	19
Sandstone, weak orange; chiefly quartz fragments; iron cemented quartz fragments, common	5	24
Sandstone, weak yellowish-orange; chiefly fragments of quartz, coarse	6	30
Sandstone, mixed moderate yellow-brown and yellowish-gray; chiefly fragments of fine-grained sandstone	6	36
Sandstone, light yellowish-brown; chiefly fragments of coarse-grained sandstone; some coarse quartz well-rounded	6	42
Sandstone, moderate yellow-brown; same as 36–42 feet	6	48
Sandstone, light yellowish-brown; chiefly fine- and medium-grained quartz, somewhat iron-stained; quartz grains, chiefly cloudy, some well-rounded; a little mica	7	55
Sandstone, moderate yellow-brown; chiefly medium-grained quartz, both clear and cloudy; some coarse quartz	9	64
Shale, dark gray; chiefly flaky and rounded pieces of shale; whitish quartz, fairly common, medium- to fine-grained; fine-grained pyrite, free and agglomerated, rather common; fragments of calcareous shale common	6	70
Well Gar-Dc 4 (Altitude: 2,510 feet)		
Hampshire formation (upper part):		
No sample	65	65
Sandstone, chiefly, and some siltstone, reddish brown; chiefly fragments of pale brown sandstone; a little very fine-grained quartz	2	67
Clay, sticky, light brown, and a little greenish-yellow sandy clay; very little sand	3	70
Clay, sticky, light brown, and a little dark gray sandy shale; cuttings show some pieces of gray silty, fine-grained sandstone; rare muscovite flakes	3	73
Shale, fine-grained sandy, weak red; cuttings residue chiefly fine- and very fine-grained quartz, free or agglomerated	2	75
Shale, sandy, grayish-red	3	78
Shale, sandy, brownish-gray	2	80

TABLE 23—*Continued*

	Thickness (feet)	Depth (feet)
Shale, pale reddish-brown; chiefly flakes of weak reddish-brown sandy shale and medium- to very fine-grained quartz	5	85
Shale, sandy, pale reddish-brown	4	89
Shale, weak reddish-orange; drilling mud, very thick	3	92
Shale, weak reddish-orange and a few fragments of coarse, gray sandstone	3	95
Shale, light brown	3	98
Shale, sandy, medium light-gray	4	102
Shale, sandy, weak red	3	105
Shale, weak reddish-orange	4	109
Shale, sandy, brown and gray	6	115
Sandstone and a little shale; sand, fine and very fine; residue, pale red	5	120
Shale, sandy, hard, light brownish-gray; fragments of impure sandstone	3	123
Shale, sandy, mixed brown and gray and pale red	7	130
Shale, pale reddish-brown; little sand	5	135
Shale, pale reddish-brown; cuttings mixed brown and dark gray shale; little sand	2	137
Sandstone, fine-grained, and a little shale, very pale brown; a few fragments of red shale	5	142
Shale, sandy, light brownish-gray	8	150
Shale, mixed gray and brownish-gray	5	155
Sand and sandy shale, medium-gray; pyrite present, but rare	10	165
Sand and sandy shale, medium gray; cuttings show pieces of fine- and very fine-grained sandstone; fragments of a flesh-colored sandstone; pyrite fairly common	10	175

SURFACE-WATER RESOURCES

BY

ROBERT O. R. MARTIN

Introduction

Human life and progress are closely dependent upon water, and man can exist but a few days without it. The conservation and control of water have become one of his vital problems. The demands of an advancing civilization have placed limitations on the use of water, especially after man abandoned his nomadic way of life and established a permanent home rather than moving continually from water hole to water hole. In densely populated areas, the demand for water very often approaches the limit of supply. Areas lacking in water are most often sparsely settled because the expense of transporting water is a burden to the homemaker. An adequate water supply is a prerequisite to the growth of our cities.

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

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

The never-ending circulation of water in various forms from ocean and land surfaces to the atmosphere by evaporation and transpiration, from the atmosphere to the land by precipitation, and then back to the ocean is called the hydrologic cycle. As water travels from the land to the ocean, a part runs off directly into the streams and a part enters ground-water storage before later appearing as streamflow.

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

Streamflow Measurement Stations

To study systematically the range of streamflow in order to derive maximum benefits from it, the U. S. Geological Survey has installed numerous stream-gaging stations throughout the country. In cooperation with the Maryland Department of Geology, Mines and Water Resources, and other State, Federal, and municipal agencies, many stations are in operation in Maryland. Most of these are equipped with automatic water-stage recorders, which collect a continuous record of the stage of the stream (fig. 22). In conjunction with the stage record, flow determinations must be made periodically by means of a precise instrument known as a current meter in order to correlate stage with discharge (Pl. X, fig. 1). The discharge corresponding to a given stage can be determined by interpolation, provided the channel conditions of the stream remain unchanged.

The selection of a site for a gaging station requires a careful appraisal of the stream channel to be assured that hydraulic conditions are stable and that a fixed relation between stage and discharge will be maintained. The gage must be accessible under adverse conditions of storm and high water and the measurement of discharge of the stream must be possible at all stages. To avoid building expensive structures it is economical to benefit by the proximity of a bridge suitable for discharge measurements. In some cases there is no alternative except to erect a cableway across a stream. This cableway is generally suspended from high A-frames on each bank and is used to support a cable car. The elevation of the cableway must be sufficient to support an engineer and his measuring equipment with clearance above the stages of anticipated floods.

Present-day construction practice favors a permanent-type recording-gage structure. The usual gage well and house in Maryland is constructed of concrete block or reinforced concrete and has inside dimensions of about 4 feet square. The structure is provided with steel doors for house and well and is connected to the stream by one or more horizontal pipes or intakes to permit the water in the well to fluctuate simultaneously with the stream. The height of the structure is governed by the height of the maximum anticipated flood (Pl. IX, fig. 1).

A continuous graphic record of stage with respect to time is obtained by means of a water-stage recorder installed in the gage house to record the fluctuations of the water level in the gage well (fig. 22). The modern water-stage recorder requires very little attention. Inspections to change the continuous

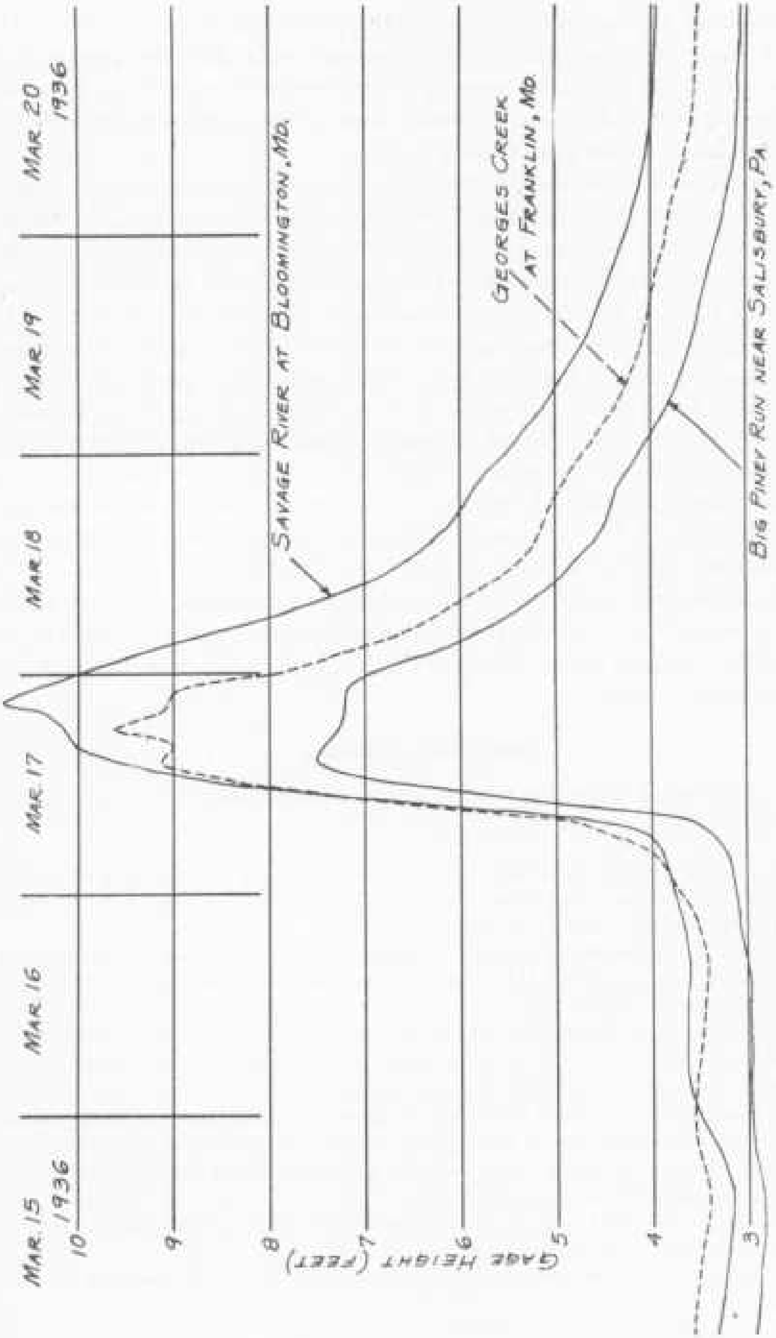

FIGURE 22. Graph of river stage from automatic water-stage recorder

recorder charts can be made once a month or even less frequently. Plate IX figure 2, shows an automatic recorder in operation. In silt-laden streams it is necessary to clean the intake pipes by forcing water through them by means of a flushing device. In Garrett County most of the streams contain enough silt to require an intake-pipe flushing system.

The rate of flow of a stream, or the discharge, is the quantity of water passing a point in a given time. This quantity is expressed in terms of cubic feet per second (cfs), commonly called second-feet. Discharge varies with precipitation and with basin characteristics such as depth and texture of the soils and steepness of the terrain. The discharge at any point on a stream is determined by multiplying the cross-sectional area of the water by its velocity. Streamflow measurements are made periodically by means of a Price current meter which determines the velocity of the water. Plate X, figure 1, shows a Price standard current meter mounted on a rod for use in making a discharge measurement by wading a stream and the smaller Pygmy meter designed for shallow streams. Plate X, figure 2, shows the heavier crane and reel equipment used to measure deep swift streams. The purpose of a discharge measurement is to define the stage-discharge relation existing at that time (fig. 23).

Daily discharge records for the gaging-stations are published in annual water-supply papers of the United States Geological Survey, in Parts 1 and 3 of the series called "Surface-Water Supply of the United States", or in Parts 1B and 3A subsequent to 1950.

Definition of Terms

Several technical terms are used in stream-flow records. Brief explanations of them are:

Cfs.—An abbreviation for "cubic feet per second." A cubic foot per second is the rate of discharge of a stream whose channel is 1 square foot in cross-sectional area and whose average velocity is 1 foot per second.

Discharge.—A rate of flow of water, usually expressed in cfs. One cfs flowing for one day equals 86,400 cubic feet, equals 646,317 gallons, equals about 2.0 acre-feet (an area of one acre covered with two feet of water).

Cubic feet per second per square mile.—An average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the runoff is distributed uniformly as regards both time and area.

Million gallons per day per square mile.—An average number of gallons of water flowing per day from each square mile of area drained, on the assumption that the runoff is distributed uniformly as regards both time and area. One million gallons per day equals 1.5472 cfs, equals 3.07 acre-feet per day.

Runoff in inches.—The depth to which an area would be covered if all the water draining from it in a given period were uniformly distributed on its surface.

Drainage basin.—The area drained by a stream or stream system, usually expressed in square miles.

Water year.—A special annual period selected to facilitate water studies, commencing October 1 and ending September 30.

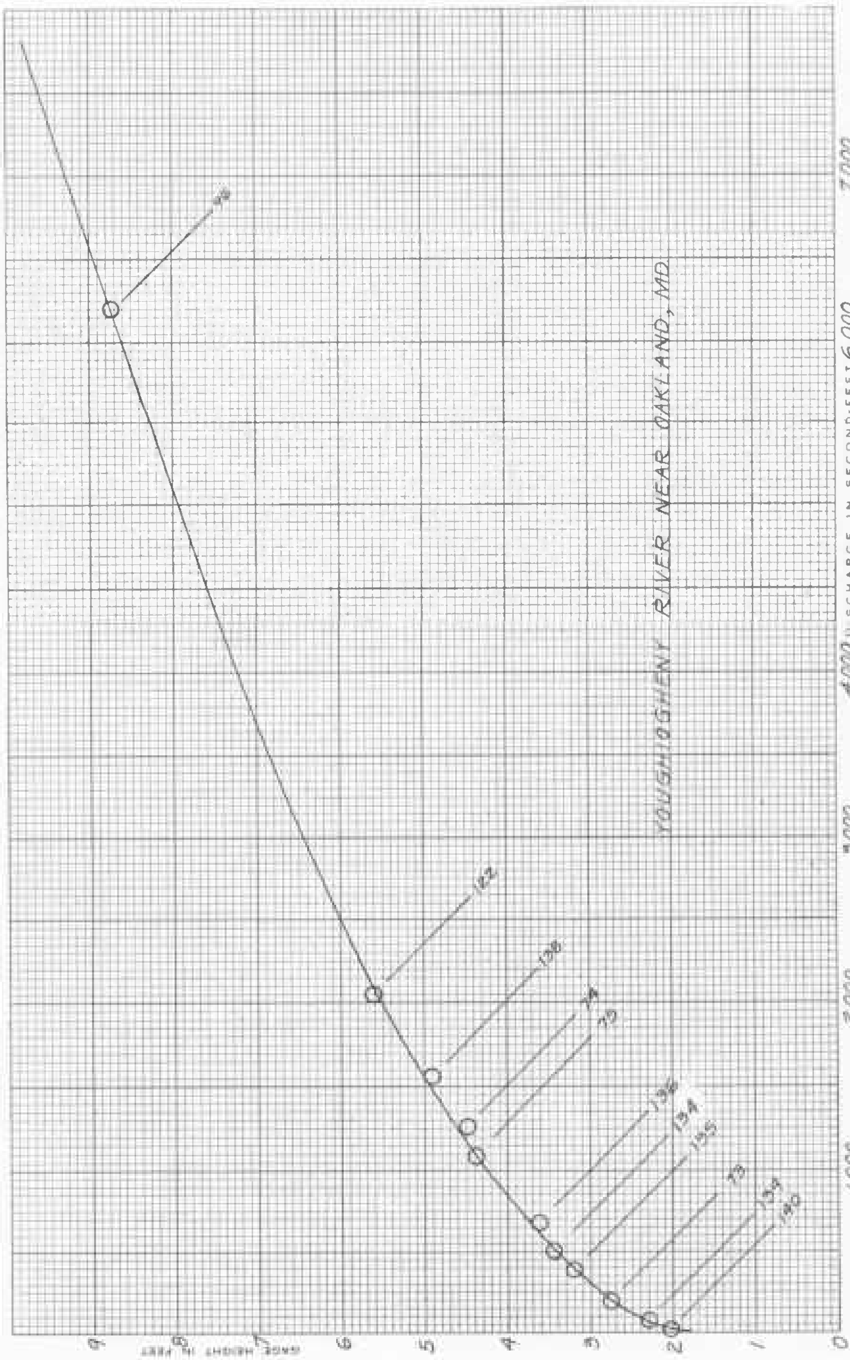

FIGURE 23. Typical rating curve showing relation between stage and discharge at a streamgaging station

Surface-Water Resources of Garrett County

Garrett County at the extreme western edge of the State is unique for Maryland in having both eastward and westward flowing streams. Owing to drainage area distribution, most of the surface water drains towards the western drainage joining progressively the Youghiogheny River, Monongahela River, Ohio River, Mississippi River, and finally the Gulf of Mexico. Streams on drainages adjacent to this divide along the southern and eastern borders of Garrett County drain eastward via the North Branch Potomac River, Potomac River, Chesapeake Bay, and finally the Atlantic Ocean. Hence, raindrops separated by this drainage basin divide reach the Atlantic Ocean at points more than 1,100 land miles apart.

All of the major streams, regardless of their final destination, start by flowing northeastward along the major valleys which are the topographic pattern of Garrett County. The Backbone Mountain ridge, which forms the headwaters of the east-west divide, also extends northeastward across the County. The topography is generally mountainous so that the flow characteristics of streams reflect this pattern of relief. Comparatively fast velocities in the streams due to steep channel gradients cause pronounced erosion, but most of the stream beds are quite rocky and relatively free from silt. There is an absence of small lakes, swamps, and other factors that would tend to delay runoff, except for a minor portion of the plateau on the headwaters for the western drainage.

The North Branch Potomac River provides a natural southern boundary along the State of West Virginia, and the western boundary also bordering West Virginia is an established north-south line. The historical Mason and Dixon line established during 1763–67 by two English astronomers, Charles Mason and Jeremiah Dixon, forms the northern boundary with the State of Pennsylvania. The eastern boundary along Allegany County is a straight line extending approximately north-north-east from Luke, a Maryland town on the North Branch Potomac River. See map of Garrett County (fig. 24).

Compared with the other twenty-two counties of Maryland, Garrett County is the highest in average elevation, the youngest in age (1872), the second largest in size (658.7 square miles), but ranks only seventeenth in population (1950 census). Although possessing bountiful mineral resources, Garrett County population decreased more than five percent during the last census decade, dropping from thirteenth to seventeenth position in rank. There has been a gradual exodus of workmen and their families from the coal-mining areas towards the large busy industrial centers. There has been an awareness of water resources in Garrett County as evidenced by the stream-gaging programs, which began as early as 1898. Since that time 17 stream-gaging stations have systematically collected data on runoff from Garrett County. The location as well as the period of operation for each of these gaging stations is presented in Table 24.

FIGURE 24. Map of Garrett County showing locations of principal streams and gaging stations

TABLE 24

Stream Gaging Stations in and near Garrett County

No. on map	Stream-gaging stations	Drainage area (square miles)	Records available*
1	Youghiogheny River at Crellin	89.3	Aug. 1946–July 1947.
2	Youghiogheny River near Oakland	134	Aug. 1941–
3	Youghiogheny River at Sang Run	260	May 1935–Sept. 1935.
4	Youghiogheny River at Friendsville	295	Dec. 1940–
5	Youghiogheny River at Friendsville	298	Aug. 1898–Dec. 1904. Sept. 1922–Sept. 1931. Jan. 1940–Dec. 1940.
6	Casselman River at Grantsville	62.5	July 1947–
7	Big Piney Run near Salisbury, (Pa.)	24.5	May 1932–
8	N. Br. Potomac River at Kitzmiller	225	Oct. 1949
9	N. Br. Potomac River at Bloomington	287	Oct. 1924–Sept. 1927. July 1929–Sept. 1950.
10	Savage River near Barton	49.1	Sept. 1948–
11	Crabtree Creek near Swanton	16.7	Sept. 1948–
12	Savage River near Bloomington (below dam)	106	Oct. 1948–
13	Savage River at Bloomington	115	May 1905–July 1906. Oct. 1924–Sept. 1927. Aug. 1929–Sept. 1950.
14	N. Br. Potomac River at Luke	404	Oct. 1949–
15	N. Br. Potomac River at Piedmont, (W. Va.)	406	June 1899–July 1906.
16	Georges Creek at Franklin	72.4	Oct. 1929–
17	Georges Creek at Westernport	72.7	June 1905–July 1906.

* Stations for which no closing dates are shown are still in operation.

Sedimentation is not a serious problem for most of the streams in this rocky region. Continuous records of sediment discharge are not available for estimating the load of sediment carried by the streams. The sediment content and the chemical quality of surface waters vary depending upon rainfall, use of water resources and land, geologic characteristics of the basin, and the season of the year. The drainage from many coal mines, mostly inactive, of acid mine wastes into some of the streams creates a pollution problem, especially for the industries using the North Branch Potomac River. These industries are all situated downstream from Garrett County. Farther downstream the Potomac River becomes the principal source of water supply for the metropolitan areas of Hagerstown, Maryland, and Washington, D. C.

The largest towns of Garrett County, Oakland and Friendsville, have less than 2,000 population. These and most of the smaller towns are dependent on wells and springs for water supply. There are a few surface-water supplies from very small streams but none from the larger streams. At present no known sewage treatment plants are in operation in Garrett County.

Water for irrigation is not a primary requirement, as rainfall throughout Garrett County has been generally ample for its timberland, small farms, and orchards. Long-term weather records collected at Oakland by the U. S. Weather Bureau during the past half century indicate a 47-inch annual rainfall towards the west of the County and 36–42 inches toward the east along the Allegany County boundary. During the winter season there is some water storage in the form of ice and snow resulting from temperatures as low as −40° Fahr. Both Deep Creek Reservoir (Youghiogheny River) and Savage River Reservoir (North Branch Potomac River) are regulated by alternately storing and releasing water from the reservoirs.

These large bodies of water have developed into major recreational areas, due to their high altitude and attractive natural surroundings. The existence of three State Forests, namely, Swallow Falls, Savage River, and Potomac, and many smaller areas for recreation, game propagation, game refuge, and fish hatching have enhanced the recreational facilities.

The more important streams of Garrett County and their drainage areas at selected points are listed in Table 25, based chiefly on data in the "Report to the General Assembly of Maryland by the Water Resources Commission of Maryland, January 1933." The principal streams are shown on figure 24.

Gaging Stations in and near Garrett County

Streamflow records for the 1951–52 water year were collected at seven gaging stations within Garrett County and at three nearby gaging stations having partial drainage from Garrett County. There are records also for former years for seven discontinued gaging stations. Records from the ten active gaging stations represent about 100 station-years of streamflow in Garrett County, with 24 years of continuous record at the oldest station. Half of these active stations were only established during the past 5 or 6 years, but records from four discontinued stations—two 6-year and two 24-year continuous records—are also available. These gaging-station records are fairly well distributed geographically.

Bulletin 1, Maryland Department of Geology, Mines and Water Resources, "Summary of Records of Surface Waters of Maryland and Potomac River Basin, 1892–1943," published in 1944, gives discharge records by calendar months of the maximum, mean, and minimum daily flows, and the discharge in cubic feet per second per square mile, runoff in inches, and discharge in millions of gallons per day per square mile for all gaging stations in Maryland from their dates of establishment to September 30, 1943. This Bulletin is referred to for monthly data prior to October 1, 1943, for the indicated dates of the following gaging stations:

Youghiogheny River near Oakland	1942–43
N. Br. Potomac River at Bloomington	1925–27, 1929–43
Savage River at Bloomington	1905–06, 1925–27, 1929–43

TABLE 25

Drainage Areas of Streams in Garrett County

Name of stream arranged in downstream order	Tributary to:	Drainage area (square miles)	
		At point	U.S.G.S. gage
Monongahela River	Ohio		
Youghiogheny River at West Virginia State Line	Monongahela	32.8	
Cherry Creek at mouth	Youghiogheny	17.2	
Snowy Creek at mouth	Youghiogheny	33.6	
Laurel Run at mouth	Snowy Creek	10.8	
Youghiogheny River at Crellin (old mill)	Monongahela		89.3
Little Youghiogheny River at mouth	Youghiogheny	40.5	
Youghiogheny River near Oakland	Monongahela		133.9
Deep Creek at dam outlet	Youghiogheny	64.7	
Deep Creek at mouth	Youghiogheny	66.6	
Youghiogheny River at Sang Run	Monongahela		260
Youghiogheny River at Friendsville (recording gage)	Monongahela		295.2
Youghiogheny River at Friendsville (hwy. bridge)	Monongahela		297.6
Bear Creek at mouth	Youghiogheny	50.5	
Buffalo Run at mouth	Youghiogheny	22.6	
Mill Run at mouth	Youghiogheny	18.5	
Youghiogheny River at Pennsylvania State Line	Monongahela	396.9	
N. Br. Casselman River at mouth	Youghiogheny	25.2	
S. Br. Casselman River at mouth	N. Br. Casselman	20.3	
Casselman River at Grantsville	Youghiogheny		62.5
Casselman River at Pennsylvania State Line	Youghiogheny	68.7	
Big Piney Run at Pennsylvania State Line	Casselman	23.6	
Big Piney Run near Salisbury, Pennsylvania	Casselman		24.5
Ohio River drainage basin within Maryland	Ohio	418.9	
Upper Potomac River	Potomac		
N. Br. Potomac River above Stony River	Potomac	94.8	
Stony River at mouth	N. Br. Potomac	59.2	
N. Br. Potomac River at Kitzmiller (hwy. br.)	Potomac	225.1	
N. Br. Potomac River at Kitzmiller	Potomac		225.2
N. Br. Potomac River at Bloomington (hwy. br.)	Potomac		287.0
Savage River near Barton	N. Br. Potomac		49.1
Crabtree Creek near Swanton	Savage		16.7
Crabtree Creek at mouth	Savage	29.1	
Savage River Dam at outlet	N. Br. Potomac	105	
Savage River near Bloomington (below dam)	N. Br. Potomac		106.5
Savage River at Bloomington	N. Br. Potomac		115.3
Savage River at mouth	N. Br. Potomac	116.4	
N. Br. Potomac River at Luke	Potomac		403.5
N. Br. Potomac River at Piedmont, West Virginia	Potomac		406.3
Georges Creek at Franklin	N. Br. Potomac		72.4
Georges Creek at Westernport	N. Br. Potomac		72.7
Georges Creek at mouth	N. Br. Potomac	73.9	

Several other Garrett County gaging stations having records in Bulletin 1 are republished in this publication because of drainage area revision and to present additional data. Such records have been included in their entirety in this report, as well as records for all gages through September 30, 1952. The drainage areas and the years of records that are available for the gaging stations in and near Garrett County are presented in Table 24 and their locations are shown on figure 24. The average discharge at these stations, in cubic feet per second per square mile, is summarized in Table 25 for various periods of records.

Storage Reservoirs in Garrett County

Deep Creek Lake, a tributary to the Youghiogheny River, is Maryland's largest and highest lake. The Pennsylvania Electric Company constructed and operates the dam for the hydroelectric power obtained from this 68.5 square-mile drainage area. The dam is 90 feet high, at 2,462 feet altitude, and has a spillway 812 feet long. The reservoir, with a usable capacity of 93,000 acre-feet at the spillway crest, was first filled on January 6, 1925. The lake has a surface area of 4,500 acres at spillway level. Though the hydroelectric development at Deep Creek Dam is in Maryland, all of its electrical power is transmitted to Pennsylvania.

Savage River Reservoir, located about 4.5 miles upstream from the confluence of Savage River with North Branch Potomac River at Bloomington, is a comparatively new flood-control development, completed on January 11, 1952, by the Corps of Engineers, United States Army. The 105 square-mile drainage area of the reservoir comprises a mountainous wooded terrain with bordering ridges as high as 3,000 feet and a valley floor elevation of 1,313 feet at the dam. The reservoir began filling July 15, 1951, and completely filled January 3, 1952, to a usable capacity of 20,000 acre-feet at the spillway crest (Pl. XI, fig. 2). This dam has a 155 feet high side-channel spillway 320 feet long at 1,468.5 feet elevation. The lake has a surface area of 360 acres at spillway level.

The jurisdiction of this development is given in Public Law 526—79th Congress—Chapter 596—2nd Session (HR 6597), approved July 24, 1946, to complete the dam substantially in accordance with plans contained in House Document No. 622. The construction of this rolled earth and rock-filled dam and the operation of it after completion was sponsored by the Upper Potomac River Commission, created by the Maryland Legislature in April 1935. The W.P.A. started initial construction in September 1939, but owing to war emergency the construction was discontinued in 1942 when only two-thirds complete. Construction was resumed in March 1949 by the Corps of Engineers.

Regulation of releases from the Savage River Reservoir must, insofar as possible, maintain flows at downstream points within the following limits:

1. Savage River downstream from dam shall not be less than 10 cfs nor more than 5,000 cfs.

2. North Branch Potomac River at Luke shall not be less than 93 cfs nor more than 13,000 cfs at the gaging station.

For most efficient river regulation the latest hydrological equipment has been installed. Long-distance telephonic transmitters are now operating at three gaging stations, on the North Branch Potomac River at Kitzmiller and at Luke, and on Savage River below the dam. By dialing a number an instantaneous river-stage reading can be obtained, which can be converted to discharge by rating table. A network of instruments throughout the Savage River basin makes it possible to collect systematic and continuous records of temperature, precipitation, evaporation, and wind velocity for use in forecasting and controlling river stages.

Local interests contributed $200,000 towards the cost of construction of Savage River dam, which they now maintain and operate through an Operating Supervisor in accordance with a mutually accepted Reservoir Regulation Manual. The minimum-flow limitation is a great benefit to industries dependent on prescribed amounts of river water, and a great economy results from more water available by the storage of flows formerly wasted during floods.

The Savage River Reservoir, as well as functioning for flood control and river regulation, eventually may become a source of water supply for most of the small local towns. Westernport, in Allegany County, now operates an intake in this reservoir for water-supply withdrawal.

Runoff in Garrett County

MAXIMUM FLOOD RUNOFF

Most of the information concerning major floods in Maryland is contained in United States Geological Survey Water-Supply Paper 771, "Floods in the United States—magnitude and frequency." Potomac River basin floods are known at some sites since 1882 when systematic records began; since 1852 from high-water marks resurrected by the Corps of Engineers, United States Army; and since 1748 from various historical sources. These floods are discussed in Water-Supply Paper 800, "The Floods of March 1936 on Potomac, James and Upper Ohio Rivers."

From flood studies it appears that the flood of March 29, 1924, was extraordinarily severe on the North Branch Potomac River upstream from Cumberland. There is little known about the earlier flood of June 1, 1889, except that at Cumberland the river stage was 0.8 foot higher than the 1924 high-water mark. The discharge of 101 cfs per square mile for the peak discharge of 29,000 cfs on March 29, 1924, on the North Branch Potomac River at Bloomington was the highest of record for Garrett County. Although the discharge of the same flood upstream at Kitzmiller cannot be as accurately determined, it may have been even greater than at Bloomington.

High-water marks for major floods on the Youghiogheny River have been recorded since 1888 at Confluence, Pennsylvania. As on the Upper Potomac River, the flood of March 1924 on the Upper Youghiogheny River was also the highest of record. The flood of March 17, 1936, resulting from a general storm over a large area, was the second largest flood of record in Garrett County, as there was no 1889 flood reported on the Youghiogheny River.

MINIMUM DROUGHT RUNOFF

Extreme drought conditions prevailed throughout Maryland during 1930 to 1934. The drought commenced in 1930 when the State annual precipitation averaged only 24 inches as compared with a 54-year average of 42 inches. For details on drought studies see United States Geological Survey Water-Supply Paper 680, "Droughts of 1930–34." Three gaging stations pertaining to Garrett County were operating during this period. The North Branch Potomac River at Bloomington had an all-time instantaneous minimum of 0.019 cfs per square mile on September 22, 1932. Such low unit flows vary according to tributaries, as Savage River at Bloomington and Georges Creek at Franklin discharged 0.006 and 0.030 cfs per square mile respectively on September 21, 1932, the day of the Savage River all-time minimum. The minimum flow for a great many of these gaging stations may be affected by upstream river regulation or diversion.

AVERAGE RUNOFF

Streamflow records in Garrett County comprise a 53-year period from 1899 to 1952 from two major drainage basins receiving substantially different amounts of rainfall. The runoff from the drainage basins above the gaging-station, the areas of the drainage basins, and period of records are presented in Table 26.

The selection of a representative figure of average discharge per square mile is not possible from Table 26, but the table shows that the runoff for the Youghiogheny River basin is greater than the runoff in the North Branch Potomac River basin. The runoff is consistent with rainfall records for the respective basins. However, the runoff for both of the basins in Garrett County far exceeds the runoff in other Maryland counties. In Washington County it is 1 cfs per square mile, in Prince Georges County 1 cfs per square mile, and in St. Marys County slightly more than 1 cfs per square mile.

STREAM FLOW REGULATION

Stream-gaging history in Garrett County illustrates the gradual development in the use of water resources. Most streams that had natural unaffected flow at the beginning of their gaging-station record have become seriously

TABLE 26

Average Discharge from Garrett County Drainage Basins, in cfs per sq. mi.

Station no. on map			7	6	2	4	5	11	10	16	12	13	8	9	14	15
Gaging station			Big Piney Run	Casselman River	At Oakland	Above Friendsville	In Friendsville	Crabtree Creek	Savage River near Barton	Georges Creek	Savage River below dam	Savage River at Bloomington	At Kitzmiller	At Bloomington	At Luke	At Piedmont
Period of record			Youghiogheny River					North Branch Potomac River								
From	To	Years	Drainage area (sq. mi.)					Drainage area (sq. mi.)								
			24.5	62.5	134	295	298	16.7	49.1	72.4	106	115	225	287	404	406
1899	1904	6					2.68									
1900	1904	5					2.59									1.74
1900	1905	6														1.67
1926	1927	2										1.82		2.16		
1930	1950	21										1.41		1.70		
1931	1952	22								1.08						
1933	1952	20	1.58							1.11						
1942	1952	11	1.62		2.18	2.10				1.12						
1948	1952	5	1.65	1.97	2.40	2.31				1.26						
1949	1952	4	1.69	1.97	2.38	2.28		1.98	1.63	1.28	1.86					
1950	1952	3	1.78	2.02	2.37	2.29	—	1.94	1.69	1.28	1.80	—	2.09	—	1.86	—

affected by artificial regulation from upstream storage reservoirs or by the diversions of flow into or out of the stream at points upstream from the station. Basically, in this way the greatest benefits are often derived from a stream, and such use provides a means for achieving the greatest economy of this natural resource. Unfortunately, these diversions often impair the quality of the water, as in the case of Georges Creek, which at its headwaters receives a more or less constant flow of municipal sewage.

The interchange of flow between basins is illustrated clearly by the complex use of water by the City of Frostburg. The source of water supply is principally from the headwaters of Savage River, with supplementary pumpage from Big Piney Run. Thus two different major basins, the Youghiogheny River basin and the North Branch Potomac River basin, contribute to a single water supply with approximately 80 percent eventually emptying into the North Branch River as sewage. The greater part—about 7/8—of this sewage empties into Georges Creek and the remainder into the headwaters of Wills Creek, a tributary farther east in Allegany County. This distribution of flow from Savage River and Big Piney Run into both Georges and Wills Creeks cannot be determined accurately. The amount of discharge involved, however, can be neglected for practical purposes when compared with the flow passing the gaging station.

In comparing runoff in cubic feet per second per square mile at the various gaging stations, the flow must be reduced to natural flow, when appropriate. The "natural flow," is the flow of a stream as it occurs under natural as opposed to regulated conditions. To adjust for artificial diversion and regulation requires a separate adjustment for each effect. It is common practice to determine the change in contents of a storage reservoir for specified periods of time. The change in volume of water stored per period of time, reduced to equivalent rate in cubic feet per second, gives the adjustment to be applied to the discharge as measured at the gaging station downstream. A similar adjustment may be made for artificial diversions. When artificial diversion and regulation have been adjusted for, natural flow is assumed to result.

For gaging stations affected by diversion or regulation the computations in the yearly table have been adjusted wherever possible. For some stations, such as on the Savage River, the amount of diversion is only approximately known so that no reliable adjustments can be made. The diversions for Georges Creek are mostly estimated, amounting to a negative adjustment of about half a cubic foot per second, but only a few yearly figures have been adjusted where studies have warrented such accuracy.

All gaging stations on the North Branch Potomac River are affected by the regulation of Stony River Reservoir near Dobbin, West Virginia. Construction of the original dam began June 13, 1912, and following its failure on January 15, 1913, the storage of water at the new dam began again on May 15, 1913. The storage adjustments for the change in contents of this reservoir (drainage area 12 square miles) are available for the end of each water year since September 30, 1929. The yearly adjustments, however, for gaging stations at Kitzmiller, at Bloomington, and at Luke are relatively small. Although practically negligible, they are nevertheless known, and have been applied to all yearly tables. In each case, the differential between the adjusted mean in the yearly table and the actual mean in the monthly table represents the magnitude of the adjustment.

Considerable river regulation results from the operation of Deep Creek Reservoir and Savage River Reservoir. Their storage details are presented in the gaging-station Remarks paragraph which follows "Discharge Records."

DISCHARGE RECORDS

Discharge records by calendar months prior to October 1943 for the following gaging stations are published in Bulletin 1, Maryland Department of Geology, Mines and Water Resources. Similar (continued) records follow for the water years 1944–52 and for some earlier periods not included in Bulletin 1.

MONONGAHELA RIVER BASIN

1. Youghiogheny River at Crellin, Md.

Location.—Water-stage recorder, lat. 39°23′21″, long. 79°27′54″, on left bank in old abandoned mill in Crellin, Garrett County, 0.15 mile downstream from Snowy Creek, 3.5 miles southwest of Oakland.

Drainage area.—89.3 square miles (determined by Corps of Engineers, U. S. Army).

Records available.—From about August 1946 to July 1947 water-stage recorder charts collected by and in files of Pittsburgh (Penna.) U. S. Engineers Department. Not known to be published.

Discharge.—During period of record 13 current-meter discharge measurements made by U. S. Geological Survey and 3 by the U. S. Engineers Department. Original field notes for 13 measurements (and results of 3 U.S.E.D. measurements) in U.S.G.S. files at College Park, Md.

Remarks.—Station established by U.S.E.D. for flood forecasting purpose. Last discharge measurement made July 9, 1947. Station discontinued about that time. Results of 13 discharge measurements are published in Water-Supply Papers 1053 and 1083 under Miscellaneous Discharge Measurements.

2. Youghiogheny River near Oakland, Md.

Location.—Water-stage recorder and concrete control, lat. 39°25′19″, long. 79°25′32″, on left bank 200 feet downstream from Baltimore & Ohio Railroad bridge, 250 feet downstream from Little Youghiogheny River, 1¼ miles northwest of Oakland, Garrett County, and 1½ miles upstream from Dunkard Lick Run. Datum of gage is 2,353.11 feet above mean sea level, unadjusted. Prior to Aug. 1, 1946, wire-weight gage at same datum on upstream side of Baltimore & Ohio Railroad bridge.

Drainage area.—134 square miles.

Records available.—August 1941 to September 1952.

Extremes.—Maximum discharge, 7,800 second-feet Dec. 16, 1948 (gage height, 9.77 feet); minimum, 5.7 second-feet Sept. 12, 14, 15, 1952 (gage height, 1.83 feet).

Flood of March 1936 reached a stage of 15.3 feet, from floodmarks.

Remarks.—Records excellent except those for periods of ice effect, which are fair. Wire-weight gage read twice daily prior to Aug. 1, 1946.

Monthly discharge of Youghiogheny River near Oakland, Md.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1943–44						
October	57	8.8	23.1	0.172	0.20	0.111
November	420	37	139	1.04	1.16	.672
December	143	20	62.2	.464	.53	.300
January	2,370	60	255	1.90	2.20	1.23
February	2,570	140	543	4.05	4.37	2.62
March	2,430	267	755	5.63	6.50	3.64
April	1,600	267	625	4.66	5.21	3.01
May	1,290	116	324	2.42	2.79	1.56
June	465	37	112	.836	.93	.540
July	86	11	28.7	.214	.25	.138
August	20	9.0	10.5	.078	.09	.050
September	109	10	19.4	.145	.16	.094
The year	2,570	8.8	240	1.79	24.39	1.16

Monthly discharge of Youghiogheny River near Oakland, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1944–45						
October	1,500	50	190	1.42	1.64	0.918
November	900	42	178	1.33	1.48	.860
December	3,570	76	497	3.71	4.28	2.40
January	2,270	150	373	2.78	3.21	1.80
February	3,970	111	865	6.46	6.72	4.18
March	3,170	158	720	5.37	6.19	3.47
April	622	104	253	1.89	2.11	1.22
May	1,800	86	384	2.87	3.30	1.85
June	195	29	94.3	.704	.78	.455
July	855	13	141	1.05	1.22	.679
August	1,380	29	211	1.57	1.81	1.01
September	1,840	76	533	3.98	4.44	2.57
The year	3,970	13	367	2.74	37.18	1.77
1945–46						
October	610	48	164	1.22	1.41	0.789
November	1,550	48	424	3.16	3.53	2.04
December	510	90	216	1.61	1.86	1.04
January	1,750	54	417	3.11	3.59	2.01
February	1,360	100	373	2.78	2.90	1.80
March	840	146	330	2.46	2.84	1.59
April	252	63	121	.903	1.01	.584
May	930	135	319	2.38	2.75	1.54
June	1,590	70	331	2.47	2.76	1.60
July	149	16	48.6	.363	.42	.235
August	73	10	19.1	.143	.16	.092
September	52	7.8	12.7	.095	.11	.061
The year	1,750	7.8	230	1.72	23.34	1.11
1946–47						
October	318	8.3	35.2	0.263	0.30	0.170
November	115	20	45.5	.340	.38	.220
December	1,020	28	203	1.51	1.74	.976
January	1,260	152	527	3.93	4.54	2.54
February	440	84	158	1.18	1.23	.763
March	2,170	73	473	3.53	4.07	2.28
April	1,100	75	271	2.02	2.25	1.31
May	520	125	277	2.07	2.38	1.34
June	560	37	129	.963	1.07	.622
July	158	24	76.0	.567	.65	.366
August	213	16	61.2	.457	.53	.295
September	265	11	46.2	.345	.38	.223
The year	2,170	8.3	193	1.44	19.52	.931

Monthly discharge of Youghiogheny River near Oakland, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1947–48						
October	66	8.7	14.6	0.109	0.13	0.07
November	578	20	227	1.69	1.89	1.09
December	485	62	171	1.28	1.47	.827
January	3,810	74	473	3.53	4.07	2.28
February	3,000	54	552	4.12	4.44	2.66
March	1,970	176	445	3.32	3.83	2.15
April	3,850	115	577	4.31	4.80	2.79
May	1,280	97	486	3.63	4.18	2.35
June	650	97	345	2.57	2.87	1.66
July	1,650	79	508	3.79	4.37	2.45
August	473	60	154	1.15	1.33	.743
September	259	26	67.0	.500	.56	.323
The year	3,850	8.7	334	2.49	33.94	1.61
1948–49						
October	344	35	95.5	0.713	0.82	0.461
November	802	64	276	2.06	2.30	1.33
December	6,900	172	803	5.99	6.91	3.87
January	2,640	230	756	5.64	6.50	3.65
February	1,140	297	563	4.20	4.38	2.71
March	806	194	371	2.77	3.19	1.79
April	532	115	259	1.93	2.16	1.25
May	340	41	120	.896	1.03	.579
June	462	23	109	.813	.91	.525
July	2,380	45	387	2.89	3.33	1.87
August	226	25	70.4	.525	.61	.339
September	51	19	28.2	.210	.23	.136
The year	6,900	19	320	2.39	32.37	1.54
1949–50						
October	394	16	73.2	0.546	0.63	0.353
November	2,070	97	281	2.10	2.34	1.36
December	1,140	214	432	3.22	3.71	2.08
January	2,520	183	564	4.21	4.86	2.72
February	2,800	240	713	5.32	5.54	3.44
March	1,970	234	693	5.17	5.96	3.34
April	1,220	128	320	2.39	2.67	1.54
May	1,620	164	435	3.25	3.75	2.10
June	750	87	252	1.88	2.10	1.22
July	588	41	121	.903	1.04	.584
August	111	18	35.4	.264	.30	.171
September	774	18	106	.791	.88	.511
The year	2,800	16	334	2.49	33.78	1.61

Monthly discharge of Youghiogheny River near Oakland, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1950–51						
October	378	27	103	0.769	0.89	0.497
November	939	87	210	1.57	1.75	1.01
December	2,400	110	465	3.47	4.00	2.24
January	2,330	140	692	5.16	5.95	3.33
February	3,590	190	642	4.79	4.99	3.10
March	1,200	141	450	3.36	3.87	2.17
April	1,070	188	496	3.70	4.13	2.39
May	780	64	284	2.12	2.44	1.37
June	2,570	56	449	3.35	3.74	2.17
July	522	43	138	1.03	1.19	.666
August	71	10	26.5	.198	.23	.128
September	149	9.8	27.1	.202	.23	.131
The year	3,590	9.8	330	2.46	33.41	1.59
1951–52						
October	91	9.4	15.6	0.116	0.13	0.075
November	1,140	24	205	1.53	1.71	0.989
December	2,010	128	555	4.14	4.77	2.68
January	2,880	238	861	6.43	7.40	4.16
February	615	88	239	1.78	1.92	1.15
March	1,540	80	501	3.74	4.31	2.42
April	1,260	181	522	3.90	4.35	2.52
May	1,280	192	434	3.24	3.73	2.09
June	192	26	73.9	.551	.62	.356
July	50	10	20.5	.153	.18	.099
August	203	9.4	35.7	.266	.31	.172
September	52	6.3	14.4	.107	.12	.069
The year	2,880	6.3	291	2.17	29.55	1.40

Yearly discharge of Youghiogheny River near Oakland

Year	Year ending Sept. 30				Calendar year			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1942......	232	1.73	23.48	1.12	307	2.29	31.06	1.48
1943......	336	2.51	34.01	1.62	244	1.82	24.71	1.18
1944......	240	1.79	24.39	1.16	294	2.19	29.90	1.42
1945......	367	2.74	37.18	1.77	361	2.69	36.58	1.74
1946......	230	1.72	23.34	1.11	187	1.40	18.96	.905
1947......	193	1.44	19.52	.931	203	1.51	20.59	.976
1948......	334	2.49	33.94	1.61	400	2.99	40.48	1.93
1949......	320	2.39	32.37	1.54	286	2.13	29.02	1.38
1950......	334	2.49	33.78	1.61	333	2.49	33.74	1.61
1951......	330	2.46	33.41	1.59	329	2.46	33.38	1.59
1952......	291	2.17	29.55	1.40	—	—	—	—
Highest..........	367				400			
Average..........	292	2.18	29.59	1.41	294	2.19	29.73	1.42
Lowest..........	193				187			

3. YOUGHIOGHENY RIVER AT SANG RUN, MD.

Location.—Vertical staff gage, lat. 39°33′57″, long. 79°25′47″, on right downstream side of county highway steel bridge at village of Sang Run, Garrett County, 0.2 miles downstream from Sang Run, 3.5 miles downstream from hydro-electric plant, 5 miles below mouth of Deep Creek. Datum of gage is 1,976.279 feet above mean sea level (Youghiogheny Hydro-Electric Corporation datum).

Drainage area.—260 square miles.

Records available.—Staff-gage readings May 13, 1935 to Sept. 30, 1935 collected by U. S. Geological Survey but not published. The Youghiogheny Hydro-Electric Power Co. had zero of their former gage at about same site at 1,976.03 feet above mean sea level in 1923. Records were maintained by them for approximately a 7-year period for which the dates are unknown. A staff gage belonging to Power Co. was found painted on bridge pier May 13, 1938.

Remarks.—Unpublished records based on twice-daily readings of staff gage by observer. During 1935 period of operation 4 current-meter measurements were made by U. S. Geological Survey. Results of 1935 discharge measurements are published in Water-Supply Paper 783 under Miscellaneous Discharge Measurements. Private engineers made 5 additional discharge measurements during January and February 1923 and results are available at known datum in office files at College Park, Md. Regulation from power plant upstream.

History.—Steel bridge built in 1867 is one of the oldest in Maryland and replaced former covered wooden bridge.

4. YOUGHIOGHENY RIVER AT FRIENDSVILLE, MD.

Location.—Water-stage recorder, lat. 39°39′17″, long. 79°24′27″, on left bank 0.6 mile upstream from highway bridge at Friendsville, Garrett County, and 1¼ miles upstream from Bear Creek. Datum of gage is 1,487.33 feet above mean sea level, datum of 1929. Aug. 17, 1898 to Dec. 31, 1904, and Sept. 1, 1922 to Sept. 30, 1931, chain gages at highway bridge 0.6 mile downstream at data 16.24 and 16.29 feet lower respectively.

Drainage area.—295 square miles at recording gage; 298 square miles (revised) at highway bridge prior to Dec. 4, 1940; published as 295 square miles.

Records available.—August 1898 to December 1904 and December 1940 to September 1952 in reports of Geological Survey. August 1898 to December 1904 and September 1922 to September 1931 (gage heights only September 1922 to September 1926) in reports of Pennsylvania Department of Forests and Waters (see former station downstream at Friendsville).

Extremes.—*1940–52:* Maximum discharge at present site and datum, 13,900 second-feet Dec. 16, 1948 (gage height, 7.97 feet); minimum discharge, 19 second-feet Sept. 15, 1952 (gage height, 1.84 feet); minimum daily discharge, 30 second-feet Sept. 1, 1952.

1898–1904, 1922–32: Maximum gage height, at former site and datum then in use, 14.2 feet Mar. 29, 1924, from floodmarks, (about 10 feet, present site and datum, determined from relation curve, discharge not determined); minimum daily discharge, 19 second-feet (regulated) Nov. 18, 1930 at former site.

Remarks.—Records good except those for period of no gage-height record, which are fair. Low and medium flow regulated by Deep Creek Reservoir (total capacity, 4,620,000,000 cubic feet) since Jan. 6, 1925. Records in last three columns of monthly table adjusted for change in contents in Deep Creek Reservoir.

Cooperation.—Records of change in contents of Deep Creek Reservoir furnished by Pennsylvania Electric Co.

Monthly discharge of Youghiogheny River at Friendsville, Md.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1941						
December 4–31	1,070	382	678			
January	2,090	379	797	2.41	2.78	1.56
February	783	384	523	1.33	1.38	.860
March	1,890	327	849	3.13	3.61	2.02
April	2,720	126	622	2.44	2.72	1.58
May	1,240	88	264	1.07	1.23	.692
June	6,540	128	922	3.79	4.23	2.45
July	4,500	145	782	2.73	3.15	1.76
August	1,510	103	429	1.00	1.15	.646
September	708	104	339	.356	.40	.230
1941–42						
October	493	144	349	0.339	0.39	0.219
November	1,030	217	473	1.09	1.22	.704
December	1,310	140	425	1.56	1.80	1.01
January	1,120	160	406	1.59	1.83	1.03
February	1,930	210	706	2.89	3.01	1.87
March	3,110	234	791	3.40	3.92	2.20
April	3,810	213	725	2.97	3.31	1.92
May	2,260	196	813	3.56	4.10	2.30
June	367	124	210	.732	.82	.473
July	212	45	96.9	.279	.32	.180
August	2,910	50	505	1.59	1.83	1.03
September	864	106	314	.973	1.09	.629
The year	3,810	45	483	1.74	23.64	1.12

Monthly discharge of Youghiogheny River at Friendsville, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1942–43						
October	2,070	193	534	2.05	2.36	1.32
November	1,460	288	657	2.24	2.50	1.45
December	6,120	350	1,343	4.67	5.38	3.02
January	3,000	550	1,220	3.94	4.54	2.55
February	3,030	572	1,233	3.95	4.11	2.55
March	3,000	520	1,058	3.34	3.85	2.16
April	3,220	347	1,055	3.76	4.20	2.43
May	796	186	397	1.53	1.76	.989
June	546	57	186	.559	.62	.361
July	1,320	64	308	.651	.75	.421
August	1,480	184	415	.881	1.02	.569
September	460	72	232	.169	.19	.109
The year	6,120	57	718	2.31	31.28	1.49
1943–44						
October	397	48	207	0.142	0.16	0.092
November	768	156	324	.803	.90	.519
December	300	62	145	.356	.41	.230
January	2,840	60	379	1.55	1.79	1.00
February	4,160	200	824	3.57	3.85	2.31
March	4,520	574	1,388	5.80	6.69	3.75
April	2,160	546	1,063	4.41	4.92	2.85
May	1,850	244	588	2.34	2.70	1.51
June	1,020	100	277	.929	1.04	.600
July	478	68	242	.342	.39	.221
August	280	47	196	.047	.05	.030
September	290	58	207	.149	.17	.096
The year	4,520	47	485	1.69	23.07	1.09
1944–45						
October	2,250	232	495	1.28	1.48	0.827
November	1,740	131	472	1.18	1.32	.762
December	6,330	350	986	3.81	4.39	2.46
January	3,120	305	790	2.61	3.01	1.69
February	8,630	200	1,522	6.05	6.30	3.91
March	6,080	446	1,490	5.80	6.69	3.75
April	1,240	284	606	2.03	2.26	1.31
May	3,400	336	836	3.05	3.52	1.97
June	614	126	327	.776	.87	.502
July	1,120	62	254	.773	.89	.500
August	2,200	67	424	1.39	1.60	.898
September	2,640	177	920	3.36	3.75	2.17
The year	8,630	62	756	2.66	36.08	1.72

Monthly discharge of Youghiogheny River at Friendsville, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1945–46						
October	857	172	493	1.22	1.41	0.789
November	2,720	220	943	3.14	3.50	2.03
December	1,070	280	588	1.62	1.87	1.05
January	3,220	350	915	3.25	3.75	2.10
February	2,250	292	732	2.52	2.62	1.63
March	1,200	370	698	2.75	3.17	1.78
April	626	184	342	1.02	1.14	.659
May	1,510	293	585	2.31	2.66	1.49
June	2,010	265	615	2.29	2.56	1.48
July	364	67	219	.349	.40	.226
August	306	46	155	.129	.15	.083
September	209	55	121	.074	.08	.048
The year	3,220	46	532	1.72	23.31	1.11
1946–47						
October	367	57	171	0.283	0.33	0.183
November	335	80	210	.342	.38	.221
December	1,650	74	385	1.35	1.56	.873
January	1,950	343	889	3.64	4.20	2.35
February	822	194	390	1.30	1.35	.840
March	3,540	190	870	3.34	3.85	2.16
April	2,000	192	515	2.00	2.23	1.29
May	920	330	566	2.22	2.56	1.43
June	1,420	114	384	1.46	1.63	.944
July	535	96	288	.868	1.00	.561
August	411	60	206	.414	.48	.268
September	343	67	216	.295	.33	.191
The year	3,540	57	425	1.46	19.90	.944
1947–48						
October	404	90	210	0.163	0.19	0.105
November	966	133	521	1.56	1.74	1.01
December	983	160	440	1.29	1.49	.834
January	6,520	150	796	3.08	3.55	1.99
February	5,770	117	1,169	4.61	4.97	2.98
March	2,270	344	847	3.25	3.75	2.10
April	7,460	322	1,198	4.71	5.26	3.04
May	2,230	211	870	3.38	3.90	2.18
June	1,320	274	786	2.52	2.81	1.63
July	2,310	286	936	2.99	3.45	1.93
August	738	116	383	.885	1.02	.572
September	586	75	237	.420	.47	.271
The year	7,460	75	697	2.39	32.60	1.54

Monthly discharge of Youghiogheny River at Friendsville, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1948–49						
October	644	96	320	0.573	0.66	0.370
November	1,250	160	547	1.66	1.85	1.07
December	12,000	410	1,502	5.50	6.34	3.55
January	4,540	418	1,432	5.19	5.98	3.35
February	2,230	533	1,155	3.97	4.13	2.57
March	1,380	358	713	2.71	3.12	1.75
April	1,080	259	562	2.09	2.33	1.35
May	631	124	294	1.02	1.18	.659
June	826	67	278	.953	1.06	.616
July	4,000	102	657	2.78	3.20	1.80
August	634	156	339	.729	.84	.471
September	290	97	215	.153	.17	.099
The year	12,000	67	667	2.27	30.86	1.47
1949–50						
October	644	112	293	0.407	0.47	0.263
November	2,400	268	584	1.64	1.83	1.06
December	1,780	422	790	3.01	3.47	1.95
January	4,520	414	1,032	3.84	4.43	2.48
February	4,890	731	1,479	5.14	5.35	3.32
March	3,270	629	1,358	5.11	5.89	3.30
April	2,020	339	733	2.35	2.62	1.52
May	2,250	338	808	3.23	3.72	2.09
June	1,290	250	585	1.82	2.03	1.18
July	756	140	292	.786	.91	.508
August	236	55	156	.220	.25	.142
September	2,630	114	429	1.45	1.62	.937
The year	4,890	55	711	2.40	32.59	1.55
1950–51						
October	759	172	398	0.790	0.91	0.511
November	1,550	290	588	1.52	1.70	.982
December	3,930	412	1,029	3.38	3.90	2.18
January	3,760	370	1,288	5.05	5.82	3.26
February	5,200	410	1,137	4.46	4.64	2.88
March	1,990	395	895	3.11	3.58	2.01
April	1,830	378	880	3.54	3.95	2.29
May	1,420	148	642	2.15	2.48	1.39
June	4,200	114	843	2.88	3.21	1.86
July	764	119	316	.786	.91	.508
August	272	33	167	.085	.10	.055
September	378	60	163	.098	.11	.063
The year	5,200	33	693	2.31	31.31	1.49

Monthly discharge of Youghiogheny River at Friendsville, Md.—*Concluded*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1951–52						
October	333	50	191	0.095	0.11	0.061
November	2,000	94	436	1.43	1.60	.924
December	3,300	320	1,075	3.91	4.51	2.53
January	4,990	480	1,664	6.40	7.38	4.14
February	1,310	269	628	1.84	1.98	1.19
March	2,940	203	1,002	4.01	4.62	2.59
April	2,140	401	932	3.79	4.23	2.45
May	2,600	400	944	3.29	3.79	2.13
June	528	79	236	.661	.74	.427
July	188	52	128	.098	.11	.063
August	353	46	162	.211	.24	.136
September	239	30	175	.014	.02	.009
The year	4,990	30	633	2.16	29.33	1.40

Yearly discharge of Youghiogheny River at Friendsville

Year	Year ending Sept. 30				Calendar year			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1941	—	—	—	—	523	1.77	24.06	1.14
1942	513	1.74	23.64	1.12	662	2.24	30.47	1.45
1943	680	2.31	31.28	1.49	490	1.66	22.51	1.07
1944	500	1.69	23.07	1.09	624	2.12	28.79	1.37
1945	784	2.66	36.08	1.72	776	2.63	35.67	1.70
1946	506	1.72	23.31	1.11	409	1.39	18.80	.898
1947	432	1.46	19.90	.944	457	1.55	21.05	1.00
1948	706	2.39	32.60	1.54	823	2.79	38.03	1.80
1949	671	2.27	30.86	1.47	604	2.05	27.78	1.32
1950	708	2.40	32.59	1.55	725	2.46	33.33	1.59
1951	681	2.31	31.31	1.49	674	2.28	31.02	1.47
1952	636	2.16	29.33	1.40	—	—	—	—
Highest	784				823			
Average	620	2.10	28.51	1.36	615	2.08	28.24	1.34
Lowest	432				409			

Note: All figures in Yearly table have been adjusted for change in contents of Deep Creek Reservoir.

5. YOUGHIOGHENY RIVER AT FRIENDSVILLE, MD.

Location.—Chain gage, lat. 39°39′50″, long. 79°24′27″, on upstream side of former steel highway bridge right span at Friendsville, Garrett County, 0.8 mile upstream from Bear Creek. Datum of gage 1,471.30 feet above mean sea level prior to 1905 and 1,471.30 feet

1471.69

1,471.04

from Sept. 1, 1922 to April 1932. A wire-weight gage on new concrete highway bridge at datum 1,473.00 feet above mean sea level was used Jan. 31, 1940 to Dec. 3, 1940 prior to discontinuing station and establishing recording gage 0.6 mile upstream (see new station upstream from Friendsville).

Drainage area.—298 square miles revised; published as 295 square miles.

Records available.—August 1898 to December 1904 (republished and revised in Report of Flood Commission of Pittsburgh, Pa., 1912) in reports of Geological Survey. August 1898 to December 1904 and September 1922 to September 1931 (gage heights only September 1922 to September 1926) in reports of Pennsylvania Department of Forests and Waters. Unpublished records for October 1931 to April 1932, and Jan. 31, 1940 to Dec. 3, 1940.

Extremes.—Maximum discharge observed, 10,800 second-feet Mar. 1, 1902 (gage height, 11.5 feet, site and datum then in use); minimum daily, 19 second-feet (regulated) Nov. 18, 1930 (see later records for station upstream).

Maximum stage known, 14.2 feet, from floodmarks, Mar. 29, 1924, former site and datum; probably highest since 1860 based on high-water marks at Confluence, Pennsylvania.

Remarks.—Low and medium flow regulated by Deep Creek Reservoir (drainage area, 68.5 square miles) since Jan. 6, 1925. Records of change in contents of reservoir furnished by Pennsylvania Electric Co. Chain gage read twice daily and wire-weight gage read 3 times daily but neither gage gave accurate mean daily gage height after Jan. 6, 1925 due to daily stage regulation. Discharges from Jan. 6, 1925 to Dec. 3, 1940 are therefore considered subject to indeterminate error due to regulation.

History.—The Youghiogheny River was measured by surface floats on Oct. 13, 1892 at Ohiopyle, Pennsylvania by Mr. Kenneth Allen, a private investigator for water supply. This predated any local stream-gaging by governmental agencies and the 106 second-feet determined for this 1,775 square mile drainage area gave 0.060 cfs per square mile for a period reported to be an extreme drought.

Monthly discharge of Youghiogheny River at Friendsville, Md.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1898						
August 17–31	1,510	158	447	1.50	0.84	0.969
September	290	95	140	.470	.52	.304
1898–99						
October	4,250	95	609	2.04	2.35	1.32
November	2,000	405	794	2.66	2.97	1.72
December	3,950	405	1,146	3.85	4.44	2.49
January	4,400	710	1,471	4.94	5.70	3.19
February	4,250	545	1,489	5.00	5.21	3.23
March	4,720	1,180	2,028	6.81	7.85	4.40
April	2,780	345	939	3.15	3.51	2.04
May	6,900	345	1,516	5.09.	5.87	3.29
June	2,250	241	802	2.69	3.00	1.74
July	795	158	275	.923	1.06	.597
August	470	95	156	.523	.60	.338
September	241	71	129	.433	.48	.280
The year	6,900	71	945	3.17	43.04	2.05

Monthly discharge of Youghiogheny River at Friendsville, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1899–1900						
October	124	71	85	0.285	0.33	0.184
November	625	124	254	.852	.95	.551
December	1,400	197	666	2.23	2.57	1.44
January	2,000	625	1,104	3.70	4.27	2.39
February	2,640	470	1,183	3.97	4.13	2.57
March	2,920	885	1,477	4.96	5.72	3.21
April	1,400	345	720	2.42	2.70	1.56
May	545	241	354	1.19	1.37	.769
June	545	241	658	2.21	2.47	1.43
July	1,080	95	282	.946	1.09	.611
August	405	95	172	.577	.67	.373
September	95	51	69	.232	.26	.150
The year	2,920	51	582	1.95	26.53	1.26
1900–1						
October	197	71	110	.369	.43	.238
November	6,900	124	640	2.15	2.40	1.39
December	3,650	197	1,033	3.47	4.00	2.24
January	2,000	545	805	2.70	3.11	1.75
February	1,630	625	660	2.21	2.30	1.43
March	5,200	625	1,932	6.48	7.47	4.19
April	5,040	885	2,198	7.38	8.23	4.77
May	3,350	345	1,197	4.02	4.64	2.60
June	2,000	241	672	2.26	2.52	1.46
July	795	95	187	.628	.72	.406
August	345	95	147	.493	.57	.319
September	241	71	114	.383	.43	.248
The year	6,900	71	808	2.71	36.82	1.75
1901–2						
October	95	22	76	0.255	0.29	0.165
November	290	71	135	.453	.51	.293
December	6,540	241	1,756	5.89	6.79	3.81
January	3,350	405	1,030	3.46	3.99	2.24
February	3,500	625	925	3.10	3.23	2.00
March	8,160	625	2,181	7.32	8.44	4.73
April	4,720	405	1,846	6.19	6.91	4.00
May	1,400	241	564	1.89	2.18	1.22
June	1,280	197	392	1.32	1.47	.853
July	2,640	158	660	2.21	2.55	1.43
August	545	71	189	.634	.73	.410
September	95	51	69	.232	.26	.150
The year	8,160	22	820	2.75	37.35	1.78

Monthly discharge of Youghiogheny River at Friendsville, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1902–3						
October	885	124	291	0.977	1.13	0.631
November	1,880	124	413	1.39	1.55	.898
December	5,360	710	2,238	7.51	8.66	4.85
January	4,880	405	1,417	4.76	5.49	3.08
February	6,030	710	2,296	7.70	8.02	4.98
March	4,720	710	1,817	6.10	7.03	3.94
April	2,640	405	1,058	3.55	3.96	2.29
May	1,080	158	492	1.65	1.90	1.07
June	5,200	470	1,823	6.12	6.83	3.96
July	1,880	158	804	2.70	3.11	1.75
August	290	95	175	.587	.68	.379
September	158	35	83	.279	.31	.180
The year	6,030	35	1,068	3.58	48.67	2.31
1903–4						
October	470	35	155	0.520	0.60	0.336
November	1,180	71	281	.943	1.05	.609
December	197	197	197	.661	.76	.427
January	5,360	197	1,113	3.73	4.30	2.41
February	3,990	290	1,571	5.27	5.68	3.41
March	3,770	470	1,458	4.89	5.64	3.16
April	1,260	405	664	2.23	2.49	1.44
May	2,400	241	838	2.81	3.24	1.82
June	545	197	361	1.21	1.35	.782
July	345	95	192	.644	.74	.416
August	124	35	62	.208	.24	.134
September	51	51	51	.171	.19	.111
The year	5,360	35	576	1.93	26.28	1.25
1904						
October	71	51	67	0.225	0.26	0.145
November	71	51	56	.188	.21	.122
December	4,450	71	775	2.60	3.00	1.68

Yearly discharge of Youghiogheny River at Friendsville

Year	Year ending Sept. 30				Calendar year			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1899	945	3.17	43.04	2.05	818	2.74	37.13	1.77
1900	582	1.95	26.53	1.26	650	2.18	29.51	1.41
1901	808	2.71	36.82	1.75	823	2.76	37.58	1.78
1902	820	2.75	37.35	1.78	900	3.02	41.10	1.95
1903	1,068	3.58	48.67	2.31	872	2.93	39.74	1.89
1904	576	1.93	26.28	1.25	601	2.02	27.34	1.31
Highest	1,068				900			
Average	800	2.68	36.38	1.73	777	2.61	35.43	1.69
Lowest	576				601			

6. CASSELMAN RIVER AT GRANTSVILLE, MD.

Location.—Water-stage recorder and concrete control, lat. 39°42′05″, long. 79°08′05″, on left bank at steel bridge on county highway, 0.3 mile upstream from Slaubough Run, 0.8 mile downstream from U. S. Route 40 and 1.0 mile northeast of Grantsville, Garrett County.

Drainage area.—62.5 square miles.

Records available.—July 1947 to September 1952.

Extremes.—Maximum discharge, 5,110 second-feet July 4, 1948 (gage height, 8.13 feet), from rating curve extended above 1,600 second-feet on basis of contracted-opening determination of peak flow; minimum discharge, 1.7 second-feet probably Sept. 14, 1952 (gage height, 0.97 foot).

Remarks.—Records good except those for periods of ice effect or no gage-height record, which are fair.

Monthly discharge of Casselman River at Grantsville, Md.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1947						
July 25–31	176	23	51.6	0.826	0.21	0.534
August	281	17	72.5	1.16	1.34	.750
September	128	12	27.6	.442	.49	.286
1947–48						
October	32	5.5	9.05	0.145	0.17	0.094
November	192	11	75.1	1.20	1.34	.776
December	160	29	71.7	1.15	1.32	.743
January	1,150	29	172	2.75	3.18	1.78
February	568	25	197	3.15	3.39	2.04
March	550	84	167	2.67	3.08	1.73
April	1,580	75	286	4.58	5.10	2.96
May	427	50	175	2.80	3.22	1.81
June	433	48	124	1.98	2.22	1.28
July	2,200	25	155	2.48	2.86	1.60
August	87	9.5	24.9	.398	.46	.257
September	154	7.3	22.6	.362	.40	.234
The year	2,200	5.5	123	1.97	26.74	1.27
1948–49						
October	211	12	43.2	0.691	0.80	0.447
November	347	28	110	1.76	1.96	1.14
December	1,450	64	242	3.87	4.47	2.50
January	919	99	253	4.05	4.66	2.62
February	543	125	210	3.36	3.50	2.17
March	414	80	169	2.70	3.13	1.74
April	353	38	142	2.27	2.54	1.47
May	126	27	52.5	.840	.97	.543
June	238	10	36.3	.581	.65	.376
July	382	12	60.9	.974	1.12	.630
August	344	12	36.4	.582	.67	.376
September	20	8.9	12.9	.206	.23	.133
The year	1,450	8.9	114	1.82	24.70	1.18

Monthly discharge of Casselman River at Grantsville, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1949–50						
October	72	6.8	17.5	0.280	0.32	0.181
November	358	30	62.3	.997	1.11	.644
December	399	70	139	2.22	2.57	1.43
January	612	70	147	2.35	2.72	1.52
February	706	80	249	3.98	4.16	2.57
March	1,250	70	260	4.16	4.80	2.69
April	540	62	151	2.42	2.70	1.56
May	445	83	165	2.64	3.04	1.71
June	174	27	74.8	1.20	1.34	.776
July	107	14	34.6	.554	.64	.358
August	156	8.9	27.0	.432	.50	.279
September	1,490	8.9	137	2.19	2.44	1.42
The year	1,490	6.8	121	1.94	26.34	1.25
1950–51						
October	159	28	65.8	1.05	1.21	0.679
November	334	23	83.7	1.34	1.49	.866
December	790	54	192	3.07	3.55	1.98
January	628	62	261	4.18	4.81	2.70
February	672	86	231	3.70	3.85	2.39
March	488	67	173	2.77	3.19	1.79
April	666	85	205	3.28	3.65	2.12
May	450	34	123	1.97	2.28	1.27
June	1,050	22	200	3.20	3.57	2.07
July	238	20	66.7	1.07	1.23	.692
August	35	4.8	11.7	.187	.22	.121
September	50	3.0	7.29	.117	.13	.076
The year	1,050	3.0	134	2.14	29.18	1.38
1951–52						
October	23	3.2	4.78	0.076	0.09	0.049
November	247	6.0	40.8	.653	.73	.422
December	900	24	185	2.96	3.41	1.91
January	1,330	90	333	5.33	6.13	3.44
February	318	35	106	1.70	1.82	1.10
March	1,520	32	259	4.14	4.77	2.68
April	516	91	244	3.90	4.36	2.52
May	550	105	218	3.49	4.02	2.26
June	300	16	65.9	1.05	1.18	.679
July	30	4.3	12.4	.198	.23	.128
August	35	2.5	8.30	.133	.15	.086
September	7.0	1.8	3.11	.050	.06	.032
The year	1,520	1.8	124	1.98	26.95	1.28

Yearly discharge of Casselman River at Grantsville

Year	Year ending Sept. 30				Calendar year			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1948	123	1.97	26.74	1.27	143	2.29	31.14	1.48
1949	114	1.82	24.70	1.18	98.8	1.58	21.47	1.02
1950	121	1.94	26.34	1.25	132	2.11	28.59	1.36
1951	134	2.14	29.18	1.38	125	2.00	27.16	1.29
1952	124	1.98	26.95	1.28	—	—	—	—
Highest	134				143			
Average	123	1.97	26.74	1.27	125	2.00	27.15	1.29
Lowest	114				98.8			

MONONGAHELA RIVER BASIN

7. BIG PINEY RUN NEAR SALISBURY PA.

Location.—Water-stage recorder and concrete control, lat. 39°43′32″, long. 79°02′57″, on left bank an eighth of a mile upstream from Little Piney Run, a quarter of a mile north of Maryland-Pennsylvania State line, and 2½ miles southeast of Salisbury, Somerset County.

Drainage area.—24.5 square miles.

Records available.—May 1932 to September 1952.

Extremes.—Maximum discharge, 4,300 second-feet Apr. 26, 1937, from rating curve extended above 320 second-feet on basis of slope-area determination at gage height 7.5 feet; maximum gage height, 8.87 feet Feb. 22, 1944 (ice jam); minimum discharge, 0.10 second-foot on many days during September 1943.

Remarks.—Records good except those for periods of ice effect or no gage-height record, which are fair. Records do not include a small amount of water diverted 3 miles above station through pumps to city of Frostburg, Md., and from spring 700 feet above station by gravity to city of Salisbury, Pa. Findley Spring, located 700 feet upstream from gaging station (on Big Piney Run near Salisbury, Pa.) has 25 discharge measurements published under Miscellaneous Discharge Measurements in Water-Supply Papers for the period September 1937 to June 1947.

Monthly discharge of Big Piney Run near Salisbury, Pa.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1932						
May 31	—	—	8.0			
June	25	2.6	7.47			
July	23	1.0	3.86			
August	8.3	.41	1.74			
September	1.4	.25	.444			
1932–33						
October	126	.35	17.5			
November	244	13	51.1			
December	89	5	24.5			
January	100	21	37.4			
February	88	33	50.5			
March	736	22	123			
April	376	28	103			
May	330	23	94.2			
June	20	2.3	9.72			
July	33	1.1	5.22			
August	55	.5	5.12			
September	39	2.4	10.2			
The year	736	.35	44.3	1.81	24.57	1.17

Monthly discharge of Big Piney Run near Salisbury, Pa.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1933–34						
October	11	.9	2.45			
November	19	1.1	8.29			
December	196	4.7	39.6			
January	645	16	81.1			
February	32	5.0	11.8			
March	134	6.0	49.1			
April	227	15	62.1			
May	15	4.3	9.58			
June	137	1.7	12.1			
July	20	.9	2.91			
August	62	.6	7.16			
September	109	.8	10.5			
The year	645	.6	24.8	1.01	13.71	.653
1934–35						
October	45	3.1	9.23			
November	82	6.3	20.4			
December	102	8.0	35.0			
January	319	22	73.5			
February	219	13	62.2			
March	143	27	74.4			
April	224	14	55.1			
May	243	10	72.6			
June	56	5.5	18.8			
July	19	1.6	7.97			
August	164	1.5	31.3			
September	145	4.0	23.6			
The year	319	1.5	40.3	1.64	22.26	1.06
1935–36						
October	12	1.8	4.09			
November	46	3.1	12.8			
December	120	6.6	31.9			
January	132	12	47.1			
February	550	9	73.2			
March	2,060	85	316			
April	254	14	61.5			
May	28	2.3	9.84			
June	9.0	.9	2.36			
July	39	.4	2.82			
August	34	.9	4.08			
September	3.8	.5	1.36			
The year	2,060	.4	47.4	1.93	26.20	1.25

Monthly discharge of Big Piney Run near Salisbury, Pa.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1936–37						
October	244	0.6	20.2			
November	164	5.3	25.2			
December	148	3.4	53.2			
January	629	52	168			
February	117	22	48.9			
March	268	22	61.0			
April	2,000	24	150			
May	88	14	33.5			
June	23	2.6	9.06			
July	13	.7	2.88			
August	142	.6	14.0			
September	35	1.2	9.11			
The year	2,000	.6	49.6	2.02	27.42	1.31
1937–38						
October	1,300	1.2	92.4			
November	77	13	28.8			
December	211	9.5	42.0			
January	86	10	28.6			
February	126	20	45.8			
March	231	21	57.4			
April	64	14	35.8			
May	126	6.3	40.3			
June	19	2.5	8.72			
July	188	1.0	26.3			
August	16	.3	3.79			
September	5.1	.5	1.64			
The year	1,300	.3	34.4	1.40	19.00	.905
1938–39						
October	1.3	.22	.444			
November	5.2	.20	1.05			
December	32	2.9	10.5			
January	150	2.9	29.4			
February	322	38	116			
March	192	18	73.0			
April	298	29	74.9			
May	62	3.8	19.8			
June	65	1.9	12.9			
July	55	3.4	12.4			
August	13	.69	3.20			
September	12	.18	1.38			
The year	322	.18	28.9	1.18	16.02	.763

Monthly discharge of Big Piney Run near Salisbury, Pa.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1939–40						
October	36	.40	3.78			
November	24	2.0	7.51			
December	24	2.8	11.0			
January	27	4.0	6.94			
February	48	3.5	19.1			
March	373	16	95.6			
April	363	27	116			
May	269	8.7	33.7			
June	156	15	44.8			
July	103	2.0	16.7			
August	709	1.4	60.5			
September	150	5.5	35.6			
The year	709	.40	37.5	1.53	20.77	.989
1940–41						
October	31	3.1	7.39			
November	145	18.5	23.2			
December	110	25	55.0			
January	60	13.0	26.3			
February	53	9.7	17.6			
March	138	10.0	48.3			
April	510	8.5	65.9			
May	25	5.1	9.74			
June	536	7.3	62.5			
July	28	2.5	9.13			
August	35	.75	5.89			
September	5.4	.38	1.45			
The year	536	.38	28.7	1.17	15.88	.756
1941–42						
October	3.4	0.43	0.988			
November	18.5	1.5	4.92			
December	167	2.0	18.8			
January	53	6.1	18.3			
February	127	15.5	43.9			
March	399	12.5	83.8			
April	312	10.5	64.1			
May	585	8.2	81.7			
June	262	16.0	50.9			
July	264	3.8	23.2			
August	117	3.3	25.2			
September	91	5.4	24.2			
The year	585	.43	36.6	1.49	20.23	.963

Monthly discharge of Big Piney Run near Salisbury, Pa.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1942–43						
October	2,740	7.0	164			
November	63	17.0	30.8			
December	738	17.0	85.4			
January	324	22	75.4			
February	174	28	71.3			
March	224	16.0	59.2			
April	429	12.5	73.2			
May	623	13.5	65.6			
June	58	2.4	12.7			
July	9.4	1.0	2.93			
August	2.5	.22	.912			
September	.30	.10	.146			
The year	2,740	.10	53.6	2.19	29.73	1.42
1943–44						
October	2.7	0.15	0.581			
November	13.5	.75	3.01			
December	3.5	.15	.871			
January	400	.90	28.4			
February	400	10.0	54.8			
March	300	50	127			
April	229	35	92.8			
May	442	9.1	62.1			
June	82	3.4	13.8			
July	16.0	.89	3.93			
August	.89	.26	.574			
September	1.9	.30	.942			
The year	442	.15	32.3	1.32	17.92	.853
1944–45						
October	230	2.2	21.2			
November	94	3.8	16.5			
December	150	16.0	33.6			
January	110	12.0	30.0			
February	657	11.0	115			
March	679	34	142			
April	91	16.5	39.6			
May	158	14.5	56.2			
June	34	4.2	12.3			
July	58	3.2	14.1			
August	77	2.9	15.1			
September	530	4.0	83.2			
The year	679	2.2	47.8	1.95	26.47	1.26

Monthly discharge of Big Piney Run near Salisbury, Pa.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1945–46						
October	26	4.0	9.63			
November	218	4.0	54.1			
December	78	14.5	35.2			
January	150	8.0	48.2			
February	185	8.8	29.4			
March	154	33	74.0			
April	67	7.9	21.8			
May	253	7.3	60.4			
June	306	14.5	67.8			
July	21	3.0	6.69			
August	26	.83	4.16			
September	37	.36	2.40			
The year	306	.36	34.5	1.41	19.14	0.911
1946–47						
October	94	1.4	10.7			
November	13.5	3.8	6.55			
December	130	3.1	17.7			
January	106	16.0	59.5			
February	63	7.0	17.7			
March	242	6.2	59.0			
April	127	10.5	39.0			
May	120	17.0	43.8			
June	61	3.6	15.0			
July	103	2.4	20.7			
August	65	3.6	22.6			
September	41	3.4	9.88			
The year	242	1.4	27.0	1.10	14.97	0.711
1947–48						
October	9.3	1.5	2.66			
November	54	2.6	22.2			
December	20	2.9	10.5			
January	468	10	61.8			
February	467	10	77.8			
March	269	26	68.3			
April	588	21	103			
May	105	11	47.1			
June	128	12	29.7			
July	54	2.7	11.8			
August	16	.7	3.03			
September	15	.5	1.79			
The year	588	.5	36.4	1.49	20.21	0.963

Monthly discharge of Big Piney Run near Salisbury, Pa.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1948–49						
October	63	0.8	9.10			
November	70	3.2	28.4			
December	335	20	74.6			
January	317	29	90.3			
February	148	46	72.7			
March	98	21	42.5			
April	84	17	42.4			
May	19	4.7	9.27			
June	218	1.1	25.7			
July	59	5.8	14.8			
August	45	1.9	7.09			
September	7.2	1.8	3.72			
The year	335	.8	34.9	1.42	19.31	0.918
1949–50						
October	23	1.4	5.11			
November	55	7.6	14.8			
December	123	18	42.0			
January	128	14	40.6			
February	226	26	89.5			
March	556	16	88.3			
April	209	12	45.4			
May	84	18	38.0			
June	45	6.3	17.7			
July	27	2.2	6.19			
August	18	1.5	4.88			
September	500	1.7	46.5			
The year	556	1.4	36.2	1.48	20.06	0.956
1950–51						
October	43	7.6	21.3			
November	130	5.0	30.1			
December	378	15	83.1			
January	235	28	100			
February	254	39	98.4			
March	229	18	70.1			
April	238	26	76.1			
May	145	9.8	43.7			
June	460	6.6	60.8			
July	44	5.4	15.3			
August	7.9	.60	2.67			
September	9.1	.30	1.02			
The year	460	.30	49.9	2.04	27.66	1.32

Monthly discharge of Big Piney Run near Salisbury, Pa.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1951–52						
October	3.0	0.30	0.635			
November	55	1.2	9.20			
December	450	6.8	62.6			
January	703	25	123			
February	182	8.5	41.4			
March	1,090	6.6	119			
April	198	29	84.4			
May	158	35	70.0			
June	97	5.7	23.1			
July	12	.66	3.51			
August	7.8	.38	1.48			
September	10	.30	1.04			
The year	1,090	0.30	45.1	1.84	25.06	1.19

Yearly discharge of Big Piney Run near Salisbury, Pa.

Year	Year ending Sept. 30				Calendar year			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1932	—				—			
1933	44.4	1.81	24.57	1.17	40.9	1.67	22.66	1.08
1934	25.0	1.02	13.89	.659	26.2	1.07	14.52	.692
1935	40.4	1.65	22.37	1.07	39.1	1.60	21.64	1.03
1936	47.6	1.94	26.47	1.25	51.8	2.11	28.79	1.36
1937	49.8	2.03	27.57	1.31	55.3	2.26	30.64	1.46
1938	34.9	1.42	19.29	.918	22.2	.906	12.28	.586
1939	29.3	1.20	16.24	.776	30.1	1.23	16.69	.795
1940	37.9	1.55	21.08	1.00	44.2	1.80	24.53	1.16
1941	29.0	1.18	16.03	.762	23.0	.939	12.71	.607
1942	37.0	1.51	20.46	.976	58.4	2.38	32.36	1.54
1943	53.8	2.20	29.76	1.42	30.4	1.24	16.88	.801
1944	32.6	1.33	18.13	.860	38.1	1.56	21.22	1.01
1945	47.9	1.96	26.53	1.27	50.2	2.05	27.83	1.32
1946	34.6	1.41	19.12	.911	29.2	1.19	16.18	.769
1947	27.0	1.10	14.97	.711	27.0	1.10	14.96	.711
1948	36.4	1.49	20.21	.963	42.9	1.75	23.82	1.13
1949	34.9	1.42	19.31	.918	30.6	1.25	16.97	.808
1950	36.2	1.48	20.06	.956	42.3	1.73	23.45	1.12
1951	49.9	2.04	27.66	1.32	44.7	1.82	24.78	1.18
1952	45.1	1.84	25.06	1.19	—	—	—	—
Highest	53.8				58.4			
Average	38.7	1.58	21.45	1.02	38.2	1.56	21.18	1.01
Lowest	25.0				22.2			

Note: Figures in Yearly table have been adjusted for slight diversion upstream from station except after Sept. 30, 1946 when records for adjustments are not available; yearly adjustment is practically negligible.

POTOMAC RIVER BASIN

8. NORTH BRANCH POTOMAC RIVER AT KITZMILLER, MD.

Location.—Water-stage recorder and concrete control, lat. 39°23′25″, long. 79°10′40″, on left bank in Kitzmiller, Garrett County, a quarter of a mile downstream from bridge on State Highway 38 and 1.2 miles downstream from Wolfden Run. Datum of gage is 1,579.84 feet above mean sea level, datum of 1929, Parkersburg—Uniontown supplementary adjustment of 1944.

Drainage area.—225 square miles.

Records available.—October 1949 to September 1952.

Extremes.—Maximum discharge, 8,510 second-feet Dec. 7, 1950 (gage height, 8.71 feet); minimum, 11 second-feet Aug. 3, 1952 (gage height, 1.60 feet).

Prior to October 1949, high-water marks established at highway bridge a quarter of a mile upstream and flood profiles identified by the Corps of Engineers, U. S. Army (and verified by local residents) are as follows:

Maximum stage known, Mar. 29, 1924, elevation about 1,610.2 feet msl, discharge not known (bridge floor about 1,610.7 feet msl).

Most reliable information is for flood of Mar. 17, 1936, elevation about 1,605.4 feet msl; discharge, approximately 20,000 second-feet on basis of slope-area studies using Corps of Engineers high-water marks.

From published profile for flood of Oct. 15, 1942, elevation about 1,603.4 feet msl.

Current-meter measurement No. 14 on Dec. 4, 1950 made at about elevation 1,598.8 feet msl at bridge compared with simultaneous elevation of 1,585.66 feet msl at gaging station (5.82 feet gage datum).

Remarks.—Records good except those for periods of ice effect or doubtful or no gage-height record, which are fair. Some regulation at low flow by Stony River Reservoir, about 29 miles upstream from station (capacity, 1,533 million gallons at crest of spillway, and 1,800 million gallons with 2 feet of flashboards).

Cooperation.—Record of change in reservoir contents furnished by West Virginia Pulp & Paper Co.

Monthly discharge of North Branch of Potomac River at Kitzmiller, Md.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1949–50						
October 1–31*	524	50	105			
November	2,780	105	336			
December	1,200	301	522			
January	3,680	266	643			
February	3,830	388	1,093			
March	4,000	373	1,069			
April	2,010	240	498			
May	1,660	339	667			
June	1,580	129	405			
July	635	63	151			
August	100	46	58.1			
September	1,910	26	264			
The year	4,000	26	480	2.13	28.98	1.38

Monthly discharge of North Branch of Potomac River at Kitzmiller, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1950–51						
October	514	68	174			
November	1,190	82	278			
December	3,160	204	788			
January	3,000	248	971			
February	5,180	360	958			
March	2,430	316	756			
April	1,630	320	824			
May	901	128	411			
June	4,990	88	610			
July	438	55	147			
August	112	36	52.8			
September	192	34	55.7			
The year	5,180	34	499	2.22	30.11	1.43
1951–52						
October	94	28	35.7			
November	786	44	159			
December	4,140	97	601			
January	3,970	407	1,297			
February	1,660	168	471			
March	4,090	137	855			
April	3,170	341	919			
May	1,590	337	678			
June	370	41	117			
July	69	12	28.5			
August	191	12	46.6			
September	58	21	28.5			
The year	4,140	12	438	1.95	26.47	1.26

* Record began Oct. 25, 1949; Oct. 1–24 discharge computed on basis of weather records and record for station at Bloomington.

Yearly discharge of North Branch Potomac River at Kitzmiller, Md.

Year	Year ending Sept. 30				Calendar year			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1950	481	2.14	29.05	1.38	503	2.24	30.41	1.45
1951	494	2.20	29.86	1.42	463	2.06	27.96	1.33
1952	439	1.95	26.54	1.26	—	—	—	—

Note: All figures in Yearly table have been adjusted for slight yearly change in contents in Stony River Reservoir.

9. NORTH BRANCH POTOMAC RIVER AT BLOOMINGTON, MD.

Location.—Water-stage recorder, lat. 39°28′48″, long. 79°04′08″, on right bank at highway bridge at Bloomington, Garrett County, 600 feet upstream from Savage River and 2 miles upstream from Piedmont, W. Va. Datum of gage is 951.98 feet above mean sea level, adjustment of 1912. Prior to Sept. 1, 1929 chain gage at same site and datum.

Drainage area.—287 square miles.

Records available.—October 1924 to September 1927, July 1929 to September 1950 (discontinued).

Extremes.—Maximum discharge, 22,500 second-feet Mar. 17, 1936, Oct. 28, 1937 (gage height, 14.85 feet), by slope-area determination at peak flow of 1936; minimum, 5.4 second-feet Sept. 22, 1932 (gage height, 1.81 feet).

Maximum stage known, 20.3 feet on left bank from floodmarks (equivalent to stage of about 17 feet in gage well on right bank) Mar. 29, 1924 (discharge, 29,000 second-feet, from rating curve extended above 10,000 second-feet on basis of slope-area determination at gage height 14.85 feet).

Remarks.—Records good except those for periods of doubtful, fragmentary, or no gage-height record, which are fair. Low flow affected by Stony River Reservoir in West Virginia, about 45 miles upstream from station. (see Remarks for station at Kitzmiller).

Cooperation.—Record of change in Stony River Reservoir contents furnished by West Virginia Pulp & Paper Co.

Monthly discharge of North Branch Potomac River at Bloomington, Md.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1943–44						
October	153	21	44.9			
November	232	44	108			
December	250	20	64.9			
January	3,800	84	381			
February	4,270	220	864			
March	3,840	652	1,498			
April	3,010	570	1,105			
May	3,840	315	834			
June	1,420	149	343			
July	165	30	73.7			
August	51	27	33.6			
September	195	28	67.3			
The year	4,270	20	450	1.57	21.33	1.01

Monthly discharge of North Branch Potomac River at Bloomington, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1944–45						
October	3,530	82	403			
November	1,290	92	217			
December	3,830	180	639			
January	2,860	200	578			
February	5,080	180	1,193			
March	5,080	386	1,297			
April	876	246	457			
May	2,220	235	711			
June	333	74	188			
July	1,560	31	205			
August	1,780	43	269			
September	4,540	97	751			
The year	5,080	31	572	1.99	27.08	1.29
1945–46						
October	432	124	231			
November	1,950	141	632			
December	906	190	422			
January	2,920	180	766			
February	1,750	156	558			
March	1,350	405	697			
April	507	160	262			
May	1,860	256	734			
June	1,860	196	615			
July	325	39	104			
August	468	25	69.6			
September	78	19	34.8			
The year	2,920	19	426	1.48	20.17	0.957
1946–47						
October	529	31	73.3			
November	124	31	49.3			
December	1,160	25	177			
January	1,820	255	723			
February	664	100	229			
March	2,870	110	752			
April	2,040	204	598			
May	1,160	198	482			
June	592	50	143			
July	691	34	129			
August	277	38	76.7			
September	145	23	57.6			
The year	2,870	23	292	1.02	13.82	.659

Monthly discharge of North Branch Potomac River at Bloomington, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1947–48						
October	74	25	31.5			
November	1,100	43	315			
December	610	80	216			
January	3,740	110	597			
February	4,400	100	976			
March	3,300	441	1,005			
April	5,200	291	1,054			
May	1,990	188	753			
June	1,080	159	474			
July	1,500	105	365			
August	415	62	178			
September	405	63	130			
The year	5,200	25	505	1.76	23.97	1.14
1948–49						
October	888	74	223			
November	783	105	281			
December	6,000	360	1,115			
January	3,540	485	1,182			
February	1,820	691	1,075			
March	1,420	304	626			
April	1,010	231	544			
May	1,620	101	307			
June	5,160	58	639			
July	3,000	127	544			
August	695	62	194			
September	171	52	89.7			
The year	6,000	52	566	1.97	26.78	1.27
1949–50						
October	486	58	115			
November	2,030	142	341			
December	1,190	331	567			
January	2,790	288	649			
February	3,370	423	1,180			
March	3,380	418	1,129			
April	1,740	287	569			
May	1,710	445	797			
June	1,200	195	456			
July	642	80	169			
August	128	46	64.4			
September 1–30	2,010	30	288			
The year	3,380	30	523	1.82	24.73	1.18

Yearly discharge of North Branch Potomac River at Bloomington

Year	Year ending Sept. 30				Calendar year			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1925....	—	—	—	—	431	1.50	20.66	0.969
1926....	579	2.02	27.36	1.31	621	2.16	29.36	1.40
1927....	661	2.30	31.24	1.49	—	—	—	—
1930....	*360	1.25	16.97	.808	231	.805	10.91	.520
1931....	*382	1.33	18.05	.860	433	1.51	20.47	.976
1932....	*487	1.70	23.14	1.10	490	1.71	23.26	1.11
1933....	*597	2.08	28.27	1.34	607	2.11	28.71	1.36
1934....	*370	1.29	17.49	.834	369	1.29	17.50	.834
1935....	*551	1.92	26.11	1.24	541	1.89	25.58	1.22
1936....	*570	1.99	27.09	1.29	586	2.04	27.81	1.32
1937....	*593	2.07	28.10	1.34	708	2.47	33.50	1.60
1938....	*559	1.95	26.50	1.26	395	1.38	18.65	.892
1939....	*498	1.74	23.53	1.12	504	1.76	23.85	1.14
1940....	*470	1.64	22.26	1.06	*512	1.78	24.25	1.15
1941....	*429	1.49	20.23	.963	*388	1.35	18.36	.873
1942....	*426	1.48	20.03	.957	*594	2.07	28.07	1.34
1943....	*599	2.09	28.40	1.35	*404	1.41	19.17	.911
1944....	*448	1.56	21.23	1.01	*535	1.86	25.32	1.20
1945....	*576	2.01	27.28	1.30	*575	2.00	27.13	1.29
1946....	*423	1.47	19.95	.950	*345	1.20	16.29	.776
1947....	*292	1.02	13.82	.659	*314	1.09	14.84	.704
1948....	*506	1.76	23.97	1.14	*597	2.08	28.31	1.34
1949....	*568	1.98	26.88	1.28	*514	1.79	24.38	1.16
1950....	*524	1.83	24.84	1.18	—	—	—	—
Highest......	661				621			
Average......	499	1.74	23.62	1.12	486	1.69	22.94	1.09
Lowest......	292				231			

* Adjusted for change in contents of Stony River Reservoir; practically negligible for year.

10. SAVAGE RIVER NEAR BARTON, MD.

Location.—Water-stage recorder and concrete control, lat. 39°34′05″, long. 79°06′10″, on right bank 0.9 mile upstream from Bear Pen Run, 1.5 miles downstream from Poplar Lick Run, and 5.4 miles northwest of Barton, Allegany County.

Drainage area.—49.1 square miles.

Records available.—September 1948 to September 1952.

Extremes.—Maximum discharge, 2,630 second-feet Sept. 21, 1950 (gage height, 5.00 feet), from rating curve extended above 530 second-feet by logarithmic plotting; minimum, 1.2 second-feet Sept. 14, 15, 1952 (gage height, 1.29 feet).

Remarks.—Records good except those for periods of ice effect or doubtful or no gage-height record, which are fair. City of Frostburg diverts about half a cubic foot per second from headwaters of stream for municipal supply.

Monthly discharge of Savage River near Barton, Md.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1948						
September 18–30	41	3.2	11.1	0.226	0.11	0.146
1948–49						
October	122	3.0	23.2	0.473	0.54	0.306
November	144	9.2	59.6	1.21	1.35	.782
December	729	37	146	2.97	3.44	1.92
January	546	49	176	3.58	4.12	2.31
February	360	78	146	2.97	3.10	1.92
March	211	44	90.8	1.85	2.13	1.20
April	186	33	85.8	1.75	1.95	1.13
May	51	17	27.1	.552	.64	.357
June	515	6.6	58.5	1.19	1.33	.769
July	203	9.7	33.3	.678	.78	.438
August	87	5.0	13.5	.275	.32	.178
September	13	4.6	6.62	.135	.15	.087
The year	729	3.0	71.8	1.46	19.85	.944
1949–50						
October	33	4.1	9.84	0.200	0.23	0.129
November	190	12	30.5	.621	.69	.401
December	360	36	85.0	1.73	2.00	1.12
January	242	30	80.9	1.65	1.90	1.07
February	467	38	168	3.42	3.55	2.21
March	726	30	163	3.32	3.84	2.15
April	360	31	81.9	1.67	1.86	1.08
May	200	41	100	2.04	2.35	1.32
June	83	6.3	23.9	.487	.54	.315
July	30	4.1	9.97	.203	.23	.131
August	64	3.7	10.8	.220	.25	.142
September	974	7.3	98.1	2.00	2.23	1.29
The year	974	3.7	71.2	1.45	19.67	.937
1950–51						
October	103	11	44.9	0.914	1.05	0.591
November	288	9.0	54.6	1.11	1.24	.717
December	578	23	131	2.67	3.06	1.73
January	407	43	189	3.85	4.43	2.49
February	616	66	194	3.95	4.11	2.55
March	489	33	135	2.75	3.16	1.78
April	423	47	146	2.97	3.32	1.92
May	297	16	87.0	1.77	2.04	1.14
June	1,060	13	129	2.63	2.92	1.70
July	105	11	29.5	.601	.69	.388
August	19	2.9	6.66	.136	.16	.088
September	17	1.7	3.71	.076	.08	.049
The year	1,060	1.7	95.0	1.93	26.26	1.25

Monthly discharge of Savage River near Barton, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1951–52						
October	13	1.9	3.22	0.066	0.08	0.043
November	71	3.5	15.1	.308	.34	.199
December	544	12	58.1	1.18	1.36	.763
January	1,400	50	251	5.11	5.89	3.30
February	290	20	70.9	1.44	1.56	.931
March	1,550	16	218	4.44	5.11	2.87
April	450	43	159	3.24	3.61	2.09
May	485	64	161	3.28	3.77	2.12
June	169	8.6	37.7	.768	.86	.496
July	21	2.1	7.47	.152	.18	.098
August	9.6	1.6	4.26	.087	.10	.056
September	11	1.3	3.14	.064	.07	.041
The year	1,550	1.3	82.7	1.68	22.93	1.09

11. CRABTREE CREEK NEAR SWANTON, MD.

Location.—Water-stage recorder and concrete control, lat. 39°30′00″, long. 79°09′35″, on left bank 0.9 mile upstream from Middle Fork, 1.0 mile downstream from Springlick Run, and 5.0 miles northeast of Swanton, Garrett County. Datum of gage is 1,529.06 feet above mean sea level (Corps of Engineers bench mark).

Drainage area.—16.7 square miles.

Records available.—September 1948 to September 1952.

Extremes.—Maximum discharge, 3,260 second-feet July 12, 1949 (gage height, 5.01 feet), from rating curve extended above 210 second-feet on basis of slope-area and contracted-opening determinations of peak flow; minimum, 0.3 second-foot Nov. 22, 1951 (gage height, 0.66 foot).

Remarks.—Records good except those for periods of ice effect or doubtful gage-height record, which are fair. Small diversion above station by Baltimore & Ohio Railroad.

Monthly discharge of Crabtree Creek near Swanton, Md.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1948						
September 17–30	15	4.8	8.03	0.481	0.25	0.311
1948–49						
October	72	4.6	14.9	0.892	1.03	0.577
November	45	5.9	21.8	1.31	1.46	.847
December	411	22	68.5	4.10	4.73	2.65
January	217	26	69.2	4.14	4.78	2.68
February	87	29	53.4	3.20	3.33	2.07
March	85	21	35.6	2.13	2.46	1.38
April	61	15	33.8	2.02	2.26	1.31
May	38	8.7	16.9	1.01	1.16	.653
June	166	4.4	30.8	1.84	2.05	1.19
July	717	8.0	61.8	3.70	4.27	2.39
August	55	3.0	8.75	.524	.60	.339
September	8.0	2.9	4.06	.243	.27	.157
The year	717	2.9	34.9	2.09	28.40	1.35

Monthly discharge of Crabtree Creek near Swanton, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1949–50						
October	17	2.4	4.79	0.287	0.33	0.185
November	93	8.0	17.2	1.03	1.15	.666
December	74	18	35.1	2.10	2.42	1.36
January	198	14	37.5	2.25	2.59	1.45
February	280	18	69.1	4.14	4.31	2.68
March	263	14	65.2	3.90	4.50	2.52
April	49	15	27.7	1.66	1.85	1.07
May	135	24	52.2	3.13	3.61	2.02
June	35	8.0	16.5	.988	1.10	.639
July	11	3.0	5.51	.330	.38	.213
August	4.0	1.7	2.39	.143	.17	.092
September	160	1.7	18.3	1.10	1.22	.711
The year	280	1.7	29.0	1.74	23.63	1.12
1950–51						
October	23	5.1	10.2	0.611	0.71	0.395
November	81	4.4	17.3	1.04	1.15	.672
December	292	7.0	53.2	3.19	3.68	2.06
January	220	17	66.8	4.00	4.61	2.59
February	217	22	68.8	4.12	4.29	2.66
March	183	15	52.4	3.14	3.62	2.03
April	150	15	50.2	3.01	3.35	1.95
May	130	9.2	36.8	2.20	2.54	1.42
June	383	7.8	48.9	2.93	3.26	1.89
July	11	3.0	6.09	.365	.42	.236
August	4.8	1.3	2.16	.129	.15	.083
September	7.5	1.2	1.90	.114	.13	.074
The year	383	1.2	34.3	2.05	27.91	1.32
1951–52						
October	4.9	1.2	1.52	0.091	0.10	0.059
November	32	1.2	5.68	.340	.38	.220
December	260	4.6	31.4	1.88	2.17	1.21
January	420	30	116	6.95	8.01	4.49
February	90	9.9	27.4	1.64	1.77	1.06
March	337	8.4	70.5	4.22	4.87	2.73
April	257	18	73.7	4.41	4.92	2.85
May	161	27	61.5	3.68	4.25	2.38
June	23	4.6	10.6	.635	.71	.410
July	6.0	1.7	3.43	.205	.24	.132
August	7.6	1.5	2.65	.159	.18	.103
September	5.8	1.0	1.87	.112	.13	.072
The year	420	1.0	34.0	2.04	27.73	1.32

12. Savage River below Savage River Dam, near Bloomington, Md.

Location.—Water-stage recorder and concrete control, lat. 39°30′05″, long. 79°07′25″, on left bank 0.7 mile downstream from Savage River Dam, 1.1 miles downstream from Crabtree Creek, and 3.2 miles northwest of Bloomington, Garrett County. Datum of gage is 1,276.40 feet above mean sea level (Corps of Engineers bench mark).

Drainage area.—106 square miles.

Records available.—October 1948 to September 1952.

Extremes.—Maximum discharge, 4,910 second-feet Jan. 8, 1952 (gage height, 6.78 feet); minimum, 0.5 second-foot July 31, Aug. 1, 1951; minimum daily, 0.6 second-foot July 27–31, Aug. 5, 6, 9, 10, 1951.

Remarks.—Records good except those for periods of ice effect, backwater from debris or stones, shifting control, or no gage-height record, which are fair. Diversions upstream from station by Baltimore & Ohio Railroad and by Frostburg and Westernport for municipal supply. Information regarding quantities of water diverted can be obtained from the office of Chief Engineer, Maryland State Department of Health, Baltimore. Peak flows flattened and occasional regulation of low flow beginning with construction of Savage River Dam. Reservoir began filling July 15, 1951 and was completely filled Jan. 3, 1952. Dam construction was completed Jan. 11, 1952 by the Corps of Engineers, U. S. Army.

Monthly discharge of Savage River below Savage River Dam near Bloomington, Md.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1948–49						
October 1–31*	285	13	56.5			
November	260	22	125			
December	2,310	98	384			
January	1,440	129	397			
February	769	140	303			
March	454	100	193			
April	464	76	192			
May	109	41	69.1			
June	899	16	118			
July	2,400	32	190			
August	213	13	35.3			
September	27	10	15.2			
The year	2,400	10	173	1.63	22.12	1.05
1949–50						
October	69	9.2	20.0			
November	403	30	73.9			
December	617	80	198			
January	680	66	182			
February	1,270	94	385			
March	2,070	72	388			
April	585	77	182			
May	541	114	262			
June	194	20	66.5			
July	60	12	22.3			
August	107	6.8	16.2			
September	2,200	12	168			
The year	2,200	6.8	162	1.53	20.78	0.989

Monthly discharge of Savage River below Savage River Dam near Bloomington, Md.
Continued

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1950–51						
October	179	23	84.5			
November	245	17	128			
December	384	54	317			
January	412	280	354			
February	458	424	447			
March	441	319	382			
April	429	322	394			
May	408	44	271			
June	2,280	31	298			
July	91	.6	23.4			
August	17	.6	6.37			
September	45	7.9	11.7			
The year	2,280	0.6	255	2.12	28.79	1.37
1951–52						
October	12	5.7	8.14			
November	17	6.0	8.88			
December	598	8.5	28.9			
January	2,890	8.7	713			
February	701	8.1	142			
March	1,420	8.8	278			
April	1,480	12	295			
May	1,110	97	351			
June	244	19	70.4			
July	87	27	64.4			
August	68	11	30.4			
September	105	21	78.8			
The year	2,890	5.7	173	1.63	22.24	1.05

* Record began Oct. 26, 1948; Oct. 1–25 discharge computed on basis of record for station at Bloomington.

Yearly discharge of Savage River below Savage River Dam near Bloomington, Md.

Year	Year ending Sept. 30				Calendar year			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1949	173	1.63	22.12	1.05	150	1.42	19.16	0.918
1950	162	1.53	20.78	.989	*185	1.75	23.76	1.13
1951	*228	2.15	29.19	1.39	*199	1.88	25.52	1.22
1952	*185	1.75	23.76	1.13	—	—	—	—

* Figures in Yearly table have been adjusted for change in contents in Savage River Reservoir; figures prior to December 1950 are subject to very slight regulation of low flows and flattening of peaks due to partially completed Savage River Dam but yearly change believed to be negligible.

13. SAVAGE RIVER AT BLOOMINGTON, MD.

Location.—Water-stage recorder, lat. 39°29′00″, long. 79°04′24″, on left bank at Bloomington, Garrett County, 2,200 feet upstream from mouth and 2 miles upstream from Piedmont, W. Va. Datum of gage is 978.76 feet above mean sea level (Corps of Engineers bench mark). Prior to Sept. 7, 1929, chain or staff gages at various sites and datum as follows: from May 3, 1905 to July 15, 1906 chain gage on left downstream side of steel highway bridge 800 feet upstream from mouth, independent datum; from Oct. 31, 1924 to Sept. 30, 1927 vertical staff gage on right bank at "Deep Hole" 1,400 feet upstream from mouth, independent datum; from Aug. 19, 1929 to Sept. 7, 1929 staff gage on right bank at present site and datum. A weir was installed 400 feet downstream from Deep Hole gage Oct. 31, 1924; destroyed by ice Jan. 27, 1925.

Drainage area.—115 square miles.

Records available.—May 1905 to July 1906, October 1924 to September 1927, August 1929 to September 1950 (discontinued).

Extremes.—Maximum discharge, 14,800 second-feet Mar. 17, 1936 (gage height, 10.8 feet), by slope-area method; minimum, 0.7 second-foot Sept. 21, 1932, Dec. 16, 1943; minimum daily, 0.7 second-foot Sept. 21, 1932.

Maximum stage known, about 13 feet by debris marks Mar. 29, 1924, present datum.

Remarks.—Records good except those for periods of shifting control or no gage-height record, which are fair. Low flow affected by diversion above station by Baltimore & Ohio Railroad (quantity negligible) and by Frostburg, Piedmont, and Westernport for municipal supply. Information regarding the quantity of water diverted can be obtained from the office of chief engineer, Maryland State Department of Health, Baltimore. Some flattening of peak flows by partially completed Savage River Dam. (see Remarks for station below dam.) Chain and staff gages read twice daily by observer.

Monthly discharge of Savage River at Bloomington, Md.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1943–44						
October	24	1.1	4.91			
November	44	4.0	13.2			
December	40	1.4	5.26			
January	1,410	6.0	99.4			
February	1,460	40	280			
March	1,360	211	535			
April	1,010	217	395			
May	2,170	56	298			
June	804	22	92.0			
July	44	4.4	16.4			
August	10	2.0	3.45			
September	20	2.2	8.37			
The year	2,170	1.1	145			

Monthly discharge of Savage River at Bloomington, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1944–45						
October	856	11	81.1			
November	352	12	51.1			
December	1,210	59	194			
January	628	60	163			
February	2,600	56	498			
March	2,200	123	493			
April	495	75	181			
May	896	101	281			
June	92	26	51.9			
July	278	11	39.5			
August	480	13	91.7			
September	2,100	29	321			
The year	2,600	11	202			
1945–46						
October	130	24	51.0			
November	819	24	226			
December	367	50	143			
January	1,040	40	274			
February	819	62	182			
March	598	165	305			
April	288	46	113			
May	784	43	244			
June	1,050	52	238			
July	165	7.5	32.4			
August	75	4.7	14.1			
September	203	3.1	13.1			
The year	1,050	3.1	153			
1946–47						
October	328	8.5	41.1			
November	35	12	17.4			
December	510	7.3	62.8			
January	604	79	247			
February	239	40	91.7			
March	1,090	42	273			
April	425	54	158			
May	1,110	77	238			
June	402	23	98.6			
July	300	16	90.1			
August	124	15	39.7			
September	88	7.6	20.0			
The year	1,110	7.3	115			

Monthly discharge of Savage River at Bloomington, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1947–48						
October	19	5.2	7.49			
November	227	7.9	95.0			
December	94	16	49.7			
January	2,170	35	250			
February	777	30	296			
March	1,600	150	357			
April	2,100	130	456			
May	996	54	267			
June	490	67	190			
July	1,200	35	162			
August	87	13	31.4			
September	131	12	27.0			
The year	2,170	5.2	182			
1948–49						
October	315	13	59.9			
November	282	20	135			
December	2,170	105	402			
January	1,380	151	422			
February	770	165	333			
March	480	110	214			
April	485	82	210			
May	138	42	77.7			
June	904	16	125			
July	2,300	33	197			
August	235	13	37.7			
September	30	10	16.0			
The year	2,300	10	185			
1949–50						
October	70	9.6	20.9			
November	429	29	77.9			
December	658	83	215			
January	688	71	195			
February	1,520	119	455			
March	2,100	80	423			
April	618	80	187			
May	625	123	288			
June	215	21	68.1			
July	64	13	22.9			
August	100	7.2	15.7			
September 1–30	2,310	12	177			
The year	2,310	7.2	177	1.54	20.89	0.995

Yearly discharge of Savage River at Bloomington

Year	Year ending Sept. 30				Calendar year			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1926	172				181			
1927	246				—			
1930	116				65.2			
1931	112				121			
1932	133				148			
1933	196				185			
1934	106				114			
1935	178				175			
1936	213				224			
1937	207				236			
1938	156				103			
1939	148				150			
1940	166				190			
1941	162				138			
1942	146				216			
1943	205				128			
1944	145				171			
1945	202				209			
1946	153				128			
1947	115				118			
1948	182				219			
1949	185				161			
1950	177				—	—	—	—
Highest	246				236			
Average	166	1.44	19.55	0.931	161	1.40	19.00	0.905
Lowest	106				65.2			

14. NORTH BRANCH POTOMAC RIVER AT LUKE, MD.

Location.—Water-stage recorder and concrete control, lat. 39°28′45″, long. 79°03′55″, on right bank 0.2 mile downstream from Savage River and 0.5 mile northwest of Luke, Garrett County. Datum of gage is 946.25 feet above mean sea level, adjustment of 1912.

Drainage area.—404 square miles.

Records available.—October 1949 to September 1952.

Extremes.—Maximum discharge, 11,200 second-feet June 13, 1951 (gage height, 10.28 feet); minimum, 32 second-feet Oct. 20, 1951, (gage height, 1.70 feet).

Prior to October 1949 highwater marks for several major floods were noted at the dam of the West Virginia Pulp and Paper Co. located 0.55 mile downstream from gaging station as follows: Mar. 17, 1936 was about 951.0 feet above mean sea level (7.0 feet above crest of dam), Mar. 29, 1924 was about 952.6 feet above mean sea level (8.6 feet above crest of dam). Discharges not known.

Remarks.—Records good except those for periods of ice effect or doubtful or no gage-height record, which are fair. Low flow affected by Stony River Reservoir, about 45 miles above station (see Remarks for station at Kitzmiller). Slight flattening of peak flows and regulation since December 1950 by Savage River Dam about 5 miles upstream from gage. Savage River Reservoir began filling July 15, 1951 and was completely filled Jan. 3, 1952. Dam construction was completed Jan. 11, 1952 by the Corps of Engineers, U. S. Army. (See Remarks for Savage River below dam near Bloomington).

Monthly discharge of North Branch Potomac River at Luke, Md.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1949–50						
October 1–31*	679	72	143			
November	2,960	173	455			
December	1,830	415	807			
January	3,970	360	866			
February	5,180	512	1,636			
March	5,680	505	1,552			
April	2,030	372	758			
May	2,280	594	1,091			
June	1,240	216	543			
July	608	94	183			
August	167	61	83.3			
September	4,430	42	472			
The year	5,680	42	710	1.76	23.85	1.14

Monthly discharge of North Branch Potomac River at Luke, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1950–51						
October	748	107	279			
November	1,820	140	446			
December	4,350	270	1,261			
January	3,690	556	1,511			
February	5,530	875	1,605			
March	3,120	732	1,345			
April	2,680	717	1,463			
May	1,840	212	868			
June	7,020	144	1,125			
July	647	65	188			
August	132	48	61.4			
September	252	42	66.9			
The year	7,020	42	846	2.09	28.43	1.35
1951–52						
October	86	36	45.5			
November	735	58	174			
December	4,400	126	630			
January	5,260	616	2,276			
February	2,190	214	727			
March	4,810	185	1,300			
April	4,690	440	1,377			
May	2,630	560	1,175			
June	688	95	214			
July	119	81	99.9			
August	161	63	86.4			
September	172	67	115			
The year	5,260	36	687	1.70	23.15	1.10

* Record began Oct. 21, 1949; Oct. 1–20 discharge computed on basis of records for station at Bloomington and Savage River at Bloomington.

Yearly discharge of North Branch Potomac River at Luke, Md.

Year	Year ending Sept. 30				Calendar year			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1950	711	1.76	23.89	1.14	761	1.88	25.52	1.22
1951	844	2.09	28.37	1.35	766	1.90	~~25.86~~ 25.77	1.23
1952	700	1.73	23.55	1.12	—	—	—	—

Note: All figures in Yearly table have been adjusted for change in contents in Savage River Dam and Stony River Reservoir.

15. North Branch Potomac River at Piedmont, W. Va.

Location.—Wire-weight and chain gage, lat. 39°28′41″, long. 79°03′16″, on right downstream side of iron highway bridge connecting Luke, Md., with Piedmont, Mineral County, 1.6 miles downstream from Savage River.

Drainage area.—406 square miles (revised); published as 410 square miles.

Records available.—June 1899 to July 1906.

Extremes.—Maximum daily discharge, 13,400 second-feet, Feb. 28, 1902; minimum daily, 6 second-feet (regulated), Sept. 4, 1904.

Remarks.—Some regulation at low stages by West Virginia Pulp & Paper Co. Gage read twice daily by observer.

Monthly discharge of North Branch Potomac River at Piedmont, W. Va.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1899						
June 27–30	595	292	387	0.953	0.14	0.616
July	418	95	209	.515	.59	.333
August	350	50	116	.293	.34	.189
September	540	67	157	.387	.43	.250
1899–1900						
October	105	67	88.4	0.218	0.25	0.141
November	840	105	275	.677	.76	.438
December	2,130	140	421	1.04	1.20	.672
January	2,970	240	838	2.06	2.38	1.33
February	3,130	350	1,032	2.54	2.74	1.64
March	3,210	622	1,306	3.22	3.71	2.08
April	1,660	465	821	2.02	2.25	1.31
May	875	240	392	.966	1.11	.624
June	6,220	240	802	1.98	2.21	1.28
July	1,250	116	308	.759	.87	.491
August	330	67	136	.335	.39	.217
September	240	34	53.6	.132	.15	.085
The year	6,220	34	536	1.32	18.02	.853
1900–1						
October	440	67	143	0.352	0.41	0.228
November	7,090	81	579	1.43	1.60	.924
December	2,970	310	692	1.70	1.96	1.10
January	2,900	310	705	1.74	2.01	1.12
February	650	292	407	1.00	1.04	.646
March	4,910	292	1,387	3.42	3.94	2.21
April	6,330	680	2,334	5.50	6.14	3.55
May	6,220	490	1,681	4.14	4.77	2.68
June	1,830	395	925	2.28	2.54	1.47
July	2,260	153	490	1.21	1.40	.782
August	1,830	128	409	1.01	1.16	.653
September	359	57	149	.367	.41	.237
The year	7,090	57	818	2.01	27.38	1.30

Monthly discharge of North Branch Potomac River at Piedmont, W. Va.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1901–2						
October	138	40	63.5	0.156	0.18	0.101
November	277	28	73.6	.181	.20	.117
December	7,540	125	1,472	3.63	4.18	2.35
January	2,900	242	644	1.59	1.83	1.03
February	13,400	210	1,082	2.66	2.77	1.72
March	7,430	990	2,578	6.35	7.32	4.10
April	5,200	542	1,980	4.88	5.44	3.15
May	945	242	483	1.19	1.37	.769
June	406	100	215	.530	.59	.343
July	1,600	77	265	.635	.75	.422
August	226	20	85.8	.211	.24	.136
September	166	20	40.9	.101	.11	.065
The year	13,400	20	748	1.84	24.98	1.19
1902–3						
October	635	100	213	0.525	0.61	0.339
November	2,460	100	288	.709	.79	.458
December	6,330	484	1,764	4.34	5.00	2.81
January	5,700	359	1,292	3.18	3.67	2.06
February	9,070	635	2,223	5.48	5.71	3.54
March	4,530	571	1,662	4.09	4.72	2.64
April	3,380	635	1,506	3.71	4.14	2.40
May	1,550	210	580	1.43	1.65	.924
June	4,440	359	1,292	3.18	3.55	2.06
July	2,130	166	570	1.40	1.61	.905
August	277	77	163	.401	.46	.259
September	210	28	90.5	.223	.25	.144
The year	9,070	28	962	2.37	32.16	1.53
1903–4						
October	180	34	103	0.254	0.29	0.164
November	603	57	134	.330	.37	.213
December	1,280	48	193	.475	.55	.307
January	4,720	110	643	1.58	1.82	1.02
February	3,630	224	795	1.96	2.11	1.27
March	4,340	484	1,433	3.53	4.07	2.28
April	2,200	372	937	2.31	2.58	1.49
May	3,210	302	792	1.95	2.25	1.26
June	786	134	392	.966	1.08	.624
July	425	60	160	.394	.45	.255
August	99	9	37.0	.091	.10	.059
September	30	6	17.1	.042	.05	.027
The year	4,720	6	469	1.16	15.72	.750

Monthly discharge of North Branch Potomac River at Piedmont, W. Va.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1904–5						
October	68	12	27.6	0.068	0.08	0.044
November	51	15	33.5	.083	.09	.054
December	1,660	15	243	.599	.69	.387
January	3,210	99	360	.887	1.02	.573
February	484	99	232	.571	.59	.369
March	7,420	282	2,484	6.12	7.06	3.96
April	830	161	585	1.44	1.61	.931
May	1,910	191	496	1.22	1.41	.789
June	1,600	242	588	1.45	1.62	.937
July	2,460	161	653	1.61	1.86	1.04
August	1,780	88	376	.926	1.07	.598
September	1,020	51	195	.480	.54	.310
The year	7,420	12	527	1.30	17.64	.840
1905–6						
October	1,720	36	348	0.857	0.99	0.554
November	1,380	148	267	.658	.73	.425
December	2,900	208	815	2.01	2.32	1.30
January	7,500	327	1,255	3.09	3.56	2.00
February	488	88	220	.542	.56	.350
March	5,710	121	1,161	2.86	3.30	1.85
April	4,520	700	2,013	4.96	5.53	3.21
May	740	109	323	.796	.92	.514
June	2,080	160	413	1.02	1.14	.659
July 1–15	224	70	120	.296	.16	.191

Yearly discharge of North Branch Potomac River at Piedmont, W. Va.

Year	Year ending Sept. 30				Calendar year			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1900	536	1.32	18.02	0.853	592	1.46	19.78	0.944
1901	818	2.01	27.38	1.30	831	2.05	27.97	1.32
1902	748	1.84	24.98	1.19	804	1.98	26.82	1.28
1903	962	2.37	32.16	1.53	806	1.99	26.97	1.29
1904	469	1.16	15.72	.750	459	1.13	15.37	.730
1905	527	1.30	17.64	.840	622	1.53	20.82	.989
Highest	962				831			
Average	677	1.67	22.65	1.08	686	1.69	22.96	1.09
Lowest	469				459			

16. GEORGES CREEK AT FRANKLIN, MD.

Location.—Water-stage recorder and concrete and ledge rock control, lat. 39°29′38″, long. 79°02′42″, on right bank at Franklin, Allegany County, 1¼ miles upstream from Westernport and mouth. Datum of gage is 958.96 feet above mean sea level (West Virginia Pulp & Paper Co. bench mark).

Drainage area.—72.4 square miles.

Records available.—October 1929 to September 1952. June 1905 to July 1906 at site downstream at Westernport.

Extremes.—Maximum discharge, 8,500 second-feet Mar. 17, 1936 (gage height, 9.6 feet, site 95 feet downstream from present gage), from rating curve extended above 2,000 second-feet on basis of slope-area determination of peak flow; minimum, 1.6 second-feet Oct. 2, 4–8, 1930.

Maximum stage known, from floodmarks near gage, occurred Mar. 29, 1924 with stage about a half foot higher than 1936 flood; discharge not determined. See paragraph on History.

Remarks.—Records good except those for periods of ice effect or doubtful or no gage-height record, which are fair. Records include about half a cubic foot per second of sewage from city of Frostburg, which obtains its water supply from Big Piney Run (Monongahela River Basin) and Savage River. A negligible discharge diverted above station by Frostburg Water Co. for municipal supplies of cities of Eckhart and Welsh Hill. Records include drainage from numerous active and abandoned coal mines. Records of pumpage from Big Piney Run and the amount of mine drainage can be obtained from the office of Chief Engineer, Maryland State Department of Health, Baltimore. Actual discharge used for all figures in first three columns of monthly table. Diversion adjustments applied from October 1936 to September 1940 for all figures in last three columns.

History.—Information on local floods for Lonaconing, Maryland, about 7 miles upstream from gaging station was noted in 1923 publication by Thomas and Williams "History of Allegany County" as follows: "During the past 100 years Georges Creek has been at flood stages numerous times, notably in 1810, 1823, 1861, but in July 1884, the greatest high water ever known rushed through the valley. Three feet of water covered the Cumberland and Pennsylvania Railroad tracks at the depot following rain for three days and nights." This was believed to have been about 9 feet higher than the flood of March 17, 1936.

Monthly discharge of Georges Creek at Franklin, Md.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1929–30						
October 17–31			51.7	0.714	0.40	0.461
November	413	—	87.4	1.21	1.35	.782
December	294	—	90.2	1.25	1.44	.808
January	113	—	53.2	.735	.85	.475
February	110	—	50.5	.698	.73	.451
March	113	37	72.2	.997	1.15	.644
April	120	34	68.3	.943	1.05	.609
May	60	16	31.0	.428	.49	.277
June	108	6.4	16.2	.224	.25	.145
July	14	1.9	5.19	.072	.08	.047
August	10	1.8	3.97	.055	.06	.036
September	11	1.6	2.80	.039	.04	.025
The year	—	1.6				
1930–31						
October	2.3	1.6	1.78	0.025	0.03	0.016
November	4.7	2.3	3.40	.047	.05	.030
December	73	—	9.35	.129	.15	.083
January	47	—	15.8	.218	.25	.141
February	70	9.3	28.6	.395	.41	.255
March	465	26	85.7	1.18	1.36	.763
April	494	43	161	2.22	2.48	1.43
May	1,220	49	244	3.37	3.88	2.18
June	86	11	29.7	.410	.46	.265
July	32	4.6	10.9	.151	.17	.098
August	33	3.2	9.86	.136	.16	.088
September	37	3.9	7.25	.100	.11	.065
The year	1,220	1.6	50.8	.702	9.51	.454
1931–2						
October	8	3.7	4.70	0.065	0.07	0.042
November	7	4.1	4.91	.068	.08	.044
December	80	4.5	20.6	.285	.33	.184
January	185	16	50.9	.703	.81	.454
February	569	24	96.8	1.34	1.44	.866
March	640	21	126	1.74	2.01	1.12
April	572	32	136	1.88	2.10	1.22
May	1,430	29	207	2.86	3.30	1.85
June	48	14	25.7	.355	.40	.229
July	26	5.5	11.1	.153	.18	.099
August	11	2.8	4.53	.063	.07	.041
September	4.5	2.1	2.65	.037	.04	.024
The year	1,430	2.1	57.6	.796	10.83	.514

Monthly discharge of Georges Creek at Franklin, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1932–33						
October	124	2.7	18.3	0.253	0.29	0.164
November	328	14	77.6	1.07	1.19	.692
December	114	15	39.2	.541	.62	.350
January	364	30	74.8	1.03	1.19	.666
February	155	47	85.5	1.18	1.23	.763
March	867	50	268	3.70	4.26	2.39
April	1,170	116	298	4.12	4.60	2.66
May	494	52	204	2.82	3.24	1.82
June	44	13	23.5	.324	.36	.209
July	25	6	10.4	.144	.17	.093
August	44	4.1	8.56	.118	.14	.076
September	44	5.7	13.0	.180	.20	.116
The year	1,170	2.7	93.3	1.29	17.49	.834
1933–34						
October	11	4.6	5.92	0.082	0.09	0.053
November	16	5.5	8.26	.114	.13	.074
December	224	5.7	39.1	.540	.62	.349
January	833	25	124	1.71	1.97	1.11
February	45	12	20.2	.279	.29	.180
March	212	12	75.6	1.04	1.20	.672
April	331	37	118	1.63	1.82	1.05
May	49	17	27.7	.383	.44	.248
June	286	8.2	30.4	.420	.47	.271
July	28	4.8	10.9	.151	.17	.098
August	111	4.8	16.0	.221	.25	.143
September	263	4.6	31.5	.435	.49	.281
The year	833	4.6	42.4	.586	7.94	.379
1934–35						
October	59	9.1	18.8	0.260	0.30	0.168
November	218	11	39.7	.548	.61	.354
December	250	25	70.3	.971	1.12	.628
January	423	42	141	1.95	2.25	1.26
February	485	48	164	2.27	2.36	1.47
March	176	68	122	1.69	1.95	1.09
April	413	49	141	1.95	2.18	1.26
May	429	33	137	1.89	2.18	1.22
June	78	18	33.3	.460	.51	.297
July	260	10	41.7	.576	.66	.372
August	224	10	51.5	.711	.82	.460
September	484	10	65.5	.905	1.01	.585
The year	485	9.1	85.0	1.17	15.95	.756

Monthly discharge of Georges Creek at Franklin, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1935–36						
October	33	8.4	12.8	0.174	0.20	0.112
November	118	10	30.8	.424	.47	.274
December	181	15	50.6	.698	.80	.451
January	304	30	122	1.69	1.95	1.09
February	740	20	136	1.88	2.03	1.22
March	4,130	195	682	9.42	10.86	6.09
April	599	54	167	2.31	2.58	1.49
May	55	21	36.4	.499	.58	.323
June	150	14	38.1	.521	.58	.337
July	69	4.5	14.7	.198	.23	.128
August	21	6.5	11.6	.153	.18	.099
September	8.7	4.0	5.69	.072	.08	.047
The year	4,130	4.0	109	1.51	20.54	.976
1936–37						
October	33.3	5.5	25.4	0.345	0.40	0.223
November	120	7.3	22.6	.311	.35	.201
December	295	2.7	87.9	1.21	1.40	.782
January	933	130	371	5.12	5.90	3.31
February	336	83	150	2.07	2.16	1.34
March	384	55	111	1.53	1.76	.989
April	3,610	56	304	4.20	4.69	2.71
May	290	49	113	1.56	1.80	1.01
June	120	25	50.9	.702	.78	.454
July	59	6.0	17.3	.232	.27	.150
August	418	2.7	38.9	.530	.61	.342
September	92	6.3	24.1	.325	.36	.210
The year	3,610	2.7	109	1.51	20.48	.976
1937–38						
October	2,830	8.3	204	2.82	3.25	1.82
November	215	34	72.8	1.00	1.12	.646
December	323	20	68.8	.946	1.09	.611
January	226	27	60.3	.829	.96	.536
February	196	47	85.6	1.18	1.23	.763
March	281	46	108	1.49	1.72	.963
April	125	47	82.7	1.14	1.27	.737
May	336	30	109	1.51	1.74	.976
June	144	26	50.3	.688	.77	.445
July	56	9.8	16.6	.221	.25	.143
August	35	4.7	9.49	.121	.14	.078
September	15	4.3	6.98	.089	.10	.058
The year	2,830	4.3	73.0	1.00	13.64	.646

Monthly discharge of Georges Creek at Franklin, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1938–39						
October	6.2	4.3	4.67	0.056	0.06	0.036
November	18	4.5	7.97	.103	.11	.067
December	24	5.0	10.2	.135	.16	.087
January	174	7.2	27.6	.376	.43	.243
February	628	64	201	2.78	2.90	1.80
March	466	54	150	2.07	2.39	1.34
April	874	91	205	2.83	3.16	1.83
May	159	23	61.4	.847	.98	.547
June	125	12	38.2	.525	.59	.339
July	82	8.6	32.9	.453	.52	.293
August	49	5.1	13.9	.188	.22	.122
September	30	3.9	7.22	.092	.10	.059
The year	874	3.9	62.2	.855	11.62	.553
1939–40						
October	26	4.7	9.28	0.122	0.14	0.079
November	27	6.9	11.8	.160	.18	.103
December	26	9.8	13.7	.185	.21	.120
January	33	7.0	10.9	.142	.16	.092
February	209	7.2	71.4	.979	1.06	.633
March	476	40	183	2.53	2.92	1.64
April	1,030	112	291	4.02	4.48	2.60
May	563	39	86.4	1.19	1.37	.769
June	354	32	107	1.48	1.65	.957
July	232	10.0	28.7	.392	.45	.215
August	165	8.3	29.9	.409	.47	.264
September	135	8.6	29.4	.405	.45	.262
The year	1,030	4.7	72.3	.994	13.54	.642
1940–41						
October	21	9.5	12.2	0.169	0.19	0.109
November	202	28	47.9	.662	.74	.428
December	168	47	93.5	1.29	1.49	.834
January	184	38	71.2	.983	1.13	.635
February	89	30	42.8	.591	.61	.382
March	258	28	109	1.51	1.73	.976
April	854	35	141	1.95	2.17	1.26
May	78	16	31.7	.438	.50	.283
June	1,480	20	158	2.18	2.44	1.41
July	379	23	83.6	1.15	1.33	.743
August	39	10	18.0	.249	.29	.161
September	15	6.8	8.59	.119	.13	.077
The year	1,480	6.8	68.1	.941	12.75	.608

Monthly discharge of Georges Creek at Franklin, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1941–42						
October	10	6.5	7.48	0.103	0.12	0.067
November	40	7.4	11.0	.152	.17	.098
December	135	7.1	19.3	.267	.31	.173
January	68	11	24.0	.331	.38	.214
February	182	18	55.4	.765	.80	.494
March	460	24	139	1.92	2.22	1.24
April	625	39	155	2.14	2.38	1.38
May	894	34	224	3.09	3.57	2.00
June	92	20	43.9	.606	.68	.392
July	32	8.0	15.0	.207	.24	.134
August	45	7.1	19.4	.268	.31	.173
September	79	8.9	17.7	.244	.27	.158
The year	894	6.5	61.0	.843	11.45	.545
1942–43						
October	3,510	11	270	3.73	4.29	2.41
November	111	32	50.0	.691	.77	.447
December	1,240	30	173	2.39	2.75	1.54
January	368	68	159	2.20	2.54	1.42
February	382	91	167	2.31	2.40	1.49
March	415	49	137	1.89	2.18	1.22
April	560	41	128	1.77	1.97	1.14
May	190	39	71.6	.989	1.14	.639
June	39	8.8	17.7	.244	.27	.158
July	18	5.0	9.06	.125	.14	.081
August	8.4	4.0	5.21	.072	.08	.047
September	5.3	3.1	3.62	.050	.06	.032
The year	3,510	3.1	99.2	1.37	18.59	.885
1943–44						
October	15	3.3	5.30	0.073	0.08	0.047
November	28	4.7	8.91	.123	.14	.079
December	5.3	2.0	3.42	.047	.05	.030
January	355	1.9	28.4	.392	.45	.253
February	500	11	99.9	1.38	1.49	.892
March	500	118	257	3.55	4.09	2.29
April	364	84	160	2.21	2.46	1.43
May	1,040	34	183	2.53	2.91	1.64
June	97	15	33.8	.467	.52	.302
July	23	5.7	10.5	.145	.17	.094
August	8.4	3.5	4.90	.068	.08	.044
September	14	3.3	6.43	.089	.10	.058
The year	1,040	1.9	66.7	.921	12.54	.595

Monthly discharge of Georges Creek at Franklin, Md. —*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1944–45						
October	267	7.2	29.0	0.401	0.46	0.259
November	51	10	15.6	.215	.24	.139
December	351	21	59.8	.826	.95	.534
January	182	23	54.2	.749	.86	.484
February	1,020	20	199	2.75	2.86	1.78
March	796	65	246	3.40	3.92	2.20
April	197	50	94.0	1.30	1.45	.840
May	262	49	123	1.70	1.95	1.10
June	52	15	31.0	.428	.48	.277
July	36	8.3	14.2	.196	.23	.127
August	173	4.8	23.0	.318	.37	.206
September	860	8.7	141	1.95	2.18	1.26
The year	1,020	4.8	85.1	1.18	15.95	.763
1945–46						
October	64	13	26.7	0.369	0.42	0.238
November	326	13	81.6	1.13	1.26	.730
December	155	35	77.5	1.07	1.23	.692
January	380	34	135	1.86	2.15	1.20
February	322	37	80.4	1.11	1.16	.717
March	218	99	146	2.02	2.33	1.31
April	149	36	67.2	.928	1.04	.600
May	451	32	136	1.88	2.16	1.22
June	566	46	136	1.88	2.10	1.22
July	68	12	29.3	.405	.47	.262
August	116	8.7	23.6	.326	.38	.211
September	34	5.7	8.64	.119	.13	.077
The year	566	5.7	79.1	1.09	14.83	.704
1946–47						
October	123	7.4	15.4	0.213	0.25	0.138
November	15	5.7	8.54	.118	.13	.076
December	260	4.8	29.5	.407	.47	.263
January	220	33	89.1	1.23	1.42	.795
February	81	13	35.4	.489	.51	.316
March	368	19	109	1.51	1.73	.976
April	121	35	64.5	.891	.99	.576
May	286	38	93.9	1.30	1.49	.840
June	80	13	31.1	.430	.48	.278
July	69	8.7	23.8	.329	.38	.213
August	262	5.3	52.2	.721	.83	.466
September	52	8.3	20.8	.287	.32	.185
The year	368	4.8	48.0	.663	9.00	.429

Monthly discharge of Georges Creek at Franklin, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1947–48						
October	16	6.6	7.82	0.108	0.12	0.070
November	112	7.0	47.1	.651	.73	.421
December	36	12	24.3	.336	.39	.217
January	529	20	94.9	1.31	1.51	.847
February	277	18	102	1.41	1.51	.911
March	1,000	84	182	2.51	2.89	1.62
April	1,680	90	325	4.49	5.00	2.90
May	321	45	127	1.75	2.02	1.13
June	143	29	59.5	.822	.92	.531
July	145	15	32.8	.453	.52	.293
August	50	9.5	17.9	.247	.28	.160
September	50	7.9	15.6	.215	.24	.139
The year	1,680	6.6	85.8	1.19	16.13	.769
1948–49						
October	171	11	30.2	0.417	0.48	0.270
November	93	14	51.1	.706	.79	.456
December	570	64	164	2.27	2.61	1.47
January	574	76	194	2.68	3.09	1.73
February	260	132	171	2.36	2.46	1.53
March	135	60	90.1	1.24	1.44	.801
April	185	49	105	1.45	1.61	.937
May	99	29	48.1	.664	.77	.429
June	706	14	111	1.53	1.71	.989
July	810	25	112	1.55	1.79	1.00
August	168	13	31.5	.435	.50	.281
September	31	9.0	15.3	.211	.24	.136
The year	810	9.0	93.2	1.29	17.49	.834
1949–50						
October	51	8.6	13.9	0.192	0.22	0.124
November	121	13	27.4	.378	.42	.244
December	160	36	62.1	.858	.99	.555
January	298	38	70.0	.967	1.11	.625
February	528	66	216	2.98	3.10	1.93
March	654	45	180	2.49	2.86	1.61
April	211	46	97.0	1.34	1.49	.866
May	382	60	140	1.93	2.22	1.25
June	88	12	31.8	.439	.49	.284
July	32	8.0	13.1	.181	.21	.117
August	10	5.4	6.65	.092	.11	.059
September	442	5.8	42.5	.587	.65	.379
The year	654	5.4	74.1	1.02	13.87	.659

Monthly discharge of Georges Creek at Franklin, Md.—*Continued*

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1950–51						
October	69	9.3	27.4	0.378	0.44	0.244
November	176	12	42.2	.583	.65	.377
December	582	20	142	1.96	2.27	1.27
January	440	46	176	2.43	2.81	1.57
February	668	96	227	3.14	3.26	2.03
March	546	84	170	2.35	2.71	1.52
April	385	71	185	2.56	2.86	1.65
May	310	40	140	1.93	2.22	1.25
June	1,440	29	161	2.22	2.49	1.43
July	45	14	22.3	.308	.35	.199
August	17	6.3	9.28	.128	.15	.083
September	21	5.2	7.24	.100	.11	.065
The year	1,440	5.2	108	1.49	20.32	.963
1951–52						
October	10	4.7	5.62	0.078	0.09	0.050
November	36	5.8	10.7	.148	.16	.096
December	274	6.6	31.3	.432	.50	.279
January	797	61	214	2.96	3.41	1.91
February	450	36	107	1.48	1.60	.957
March	1,830	32	270	3.73	4.30	2.41
April	676	74	199	2.75	3.07	1.78
May	468	96	208	2.87	3.32	1.85
June	339	18	66.7	.921	1.03	.595
July	38	6.4	14.4	.199	.23	.129
August	19	5.4	9.00	.124	.14	.080
September	21	4.6	7.66	.106	.12	.069
The year	1,830	4.6	95.6	1.32	17.97	.853

Yearly discharge of Georges Creek at Franklin

Year	Year ending Sept. 30				Calendar year			
	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile	Discharge in second-feet		Runoff in inches	Discharge in million gallons per day per square mile
	Mean	Per square mile			Mean	Per square mile		
1930	—	—	—	—	26.3	0.363	4.93	0.235
1931	50.8	0.702	10.52	0.454	52.1	.720	9.87	.465
1932	57.6	.796	10.83	.514	66.2	.914	12.45	.591
1933	93.3	1.29	17.49	.834	86.5	1.19	16.23	.769
1934	42.4	.586	7.94	.379	48.7	.673	9.13	.435
1935	85.0	1.17	15.95	.756	82.0	*1.13	*15.39	.730
1936	109	*1.51	*20.54	.976	110	*1.52	*21.22	.982
1937	109	*1.51	*20.48	.976	127	*1.75	*23.79	1.13
1938	73.0	*1.00	*13.64	.646	45.8	*.627	*8.51	.405
1939	62.2	*.855	*11.62	.553	63.2	*.870	*11.82	.562
1940	72.3	*.994	*13.54	.642	82.3	1.14	15.47	.737
1941	68.1	.941	12.75	.608	58.3	.805	10.93	.520
1942	61.0	.843	11.45	.545	99.5	1.37	18.66	.885
1943	99.2	1.37	18.59	.885	59.0	.815	11.05	.527
1944	66.7	.921	12.54	.595	74.0	1.02	13.92	.659
1945	85.1	1.18	15.95	.763	91.8	1.27	17.21	.821
1946	79.1	1.09	14.83	.704	68.1	.941	12.77	.608
1947	48.0	.663	9.00	.429	50.1	.692	9.39	.447
1948	85.8	1.19	16.13	.769	99.9	1.38	18.77	.892
1949	93.2	1.29	17.49	.834	81.3	1.12	15.24	.724
1950	74.1	1.02	13.87	.659	83.2	1.15	15.60	.743
1951	108	1.49	20.32	.963	94.5	1.13	17.71	.847
1952	95.6	1.32	17.97	.853	—	—	—	—
Highest	109				127			
Average	78.1	1.08	14.66	.698	75.0	1.04	14.12	.672
Lowest	42.4				26.3			

* Adjusted for small diversions upstream from gaging station.

Note: Diversion into Georges Creek upstream from station estimated on basis of partial records, 0.2 cfs from 1930–35, 0.3 cfs from 1936–40, 0.4 cfs from 1941–44, 0.5 cfs from 1945–52.

17. GEORGES CREEK AT WESTERNPORT, MD.

Location.—Chain gage, lat. 39°29′24″, long. 79°02′33″, at upstream side of middle of iron highway bridge in Westernport, Allegany County, and 0.5 mile upstream from mouth.

Drainage area.—72.7 square miles (revised).

Records available.—May 1905 to July 1906.

Extremes.—Maximum daily discharge, 1,300 second-feet Mar. 31, 1906; minimum daily, 6 second-feet Aug. 24, 1905.

Remarks.—Mine drainage from many active and abandoned mines. Gage read twice daily by observer. Natural control considered unstable and subject to frequent changes.

Monthly discharge of Georges Creek at Westernport, Md.

Month	Discharge in second-feet				Runoff in inches	Discharge in million gallons per day per square mile
	Maximum	Minimum	Mean	Per square mile		
1905						
May 4–31	92	26	44.8	0.616	0.64	0.398
June	154	15	45.7	.629	.70	.407
July	1,090	13	127	1.75	2.02	1.13
August	68	6	15.1	.208	.24	.134
September	528	8	46.4	.638	.71	.412
1905–6						
October	370	12	65.8	0.905	1.04	0.585
November	102	12	33.8	.465	.52	.301
December	1,250	39	267	3.67	4.23	2.37
January	1,130	80	320	4.40	5.07	2.84
February	145	39	71.2	.979	1.02	.633
March	1,300	42	260	3.58	4.13	2.31
April	1,040	115	378	5.20	5.80	3.36
May	315	21	83.0	1.14	1.31	.737
June	342	29	91.4	1.26	1.41	.814
July 1–15	27	16	20.8	.286	.16	.185

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PLATES

FIGURE 1. Jennings formation, road leading from Merrill to the top of Elbow Mountain, about a half mile east of Merrill. Interbedded, fine-grained "blocky" sandstone and shale. Photograph by R. M. Overbeck.

FIGURE 2. Jennings formation along the Merrill road not far from the exposures shown above. This shows the "blocky" weathering pattern of the sandstones. Both pictures show the typical, evenly-bedded character of the sandstones and shales. Photograph by R. M. Overbeck.

Pocono formation showing the typical uneven character of the sandstone beds. About a mile and a half southeast of Merrill, at the top of Elbow Mountain; just west of the junction of the Merrill-Elbow Mountain road with the Mt. Zion Church road. Photograph by R. M. Overbeck.

FIGURE 1. Greenbrier formation at the Savage River dam, about 4 miles northwest of Bloomington. The Loyalhanna limestone is the light-colored limestone at the lower left. The light-colored beds in the section above the Loyalhanna member are impure limestones; the darker strata are mostly red, calcareous shales. Photograph by R. M. Overbeck.

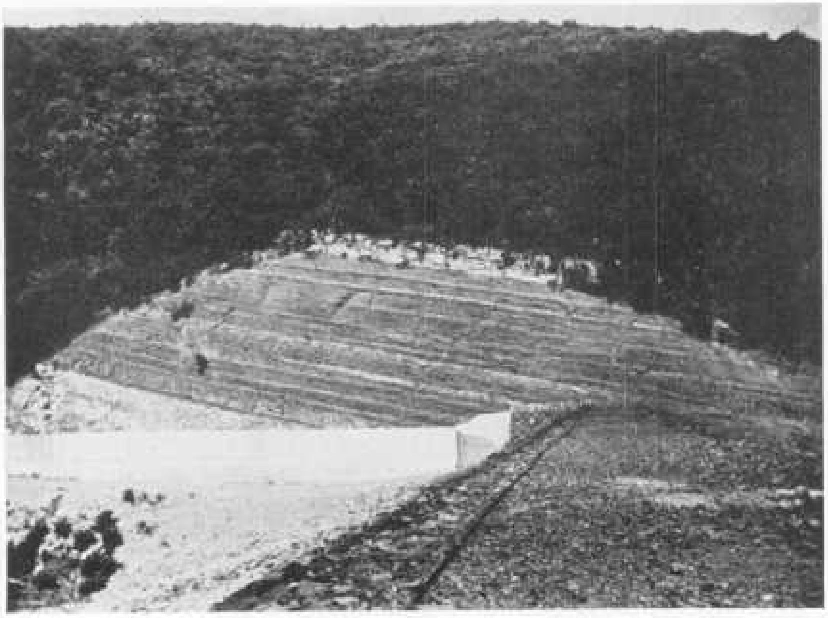

FIGURE 2. View of the same exposure from the west side of dam. Photograph by R. M. Overbeck.

FIGURE 1. Greenbrier formation in a quarry about a mile and a half northeast of Sang Run. The light-colored rock in the center is the Loyalhanna limestone member. Overlying are the interbedded argillaceous limestones and calcareous shales of the Upper Greenbrier. The quarry floor is on the top of the Pocono formation. Photograph by R. M. Overbeck.

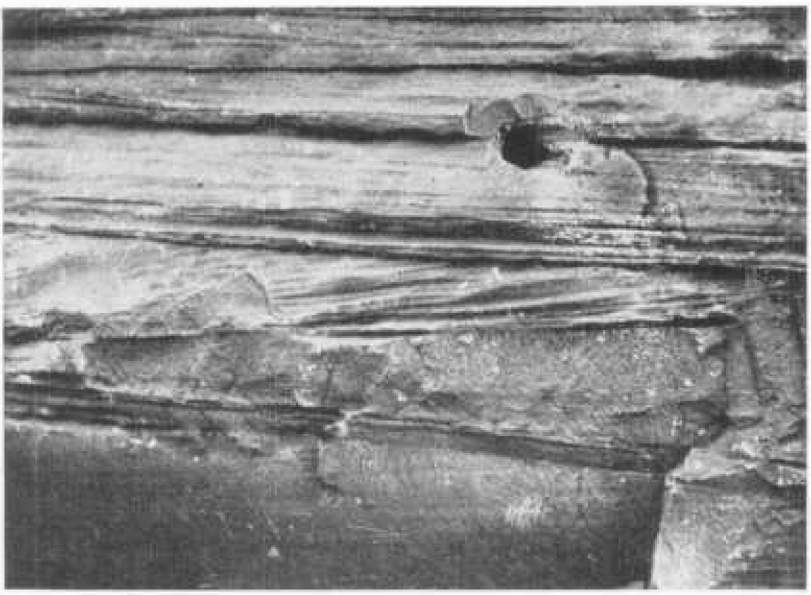

FIGURE 2. Loyalhanna member of the Greenbrier formation, exposed along the Bear Creek road, about 2 miles east of Friendsville. The cross-bedding is common in the Loyalhanna sandy limestones. Photograph by R. M. Overbeck.

FIGURE 1. Gage house on Savage River below Savage River Dam after releasing about 5,000 cfs at dam.

FIGURE 2. Engineer inspecting automatic water-stage recorder.

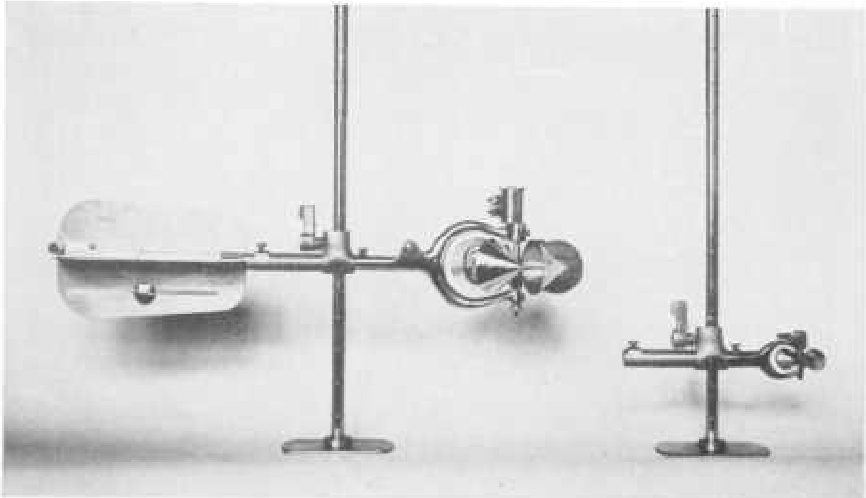

FIGURE 1. Price standard current meter and pygmy meter suspended on wading rods, used to measure discharge.

FIGURE 2. Equipment used in making discharge measurements from bridge.

FIGURE 1. Swallow Falls State Forest showing eroded streambed.

FIGURE 2. Savage River Dam showing spillway on left side.

(Photo by Corps of Engrs.)

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* Page numbers in **boldface** type indicate detailed descriptions.

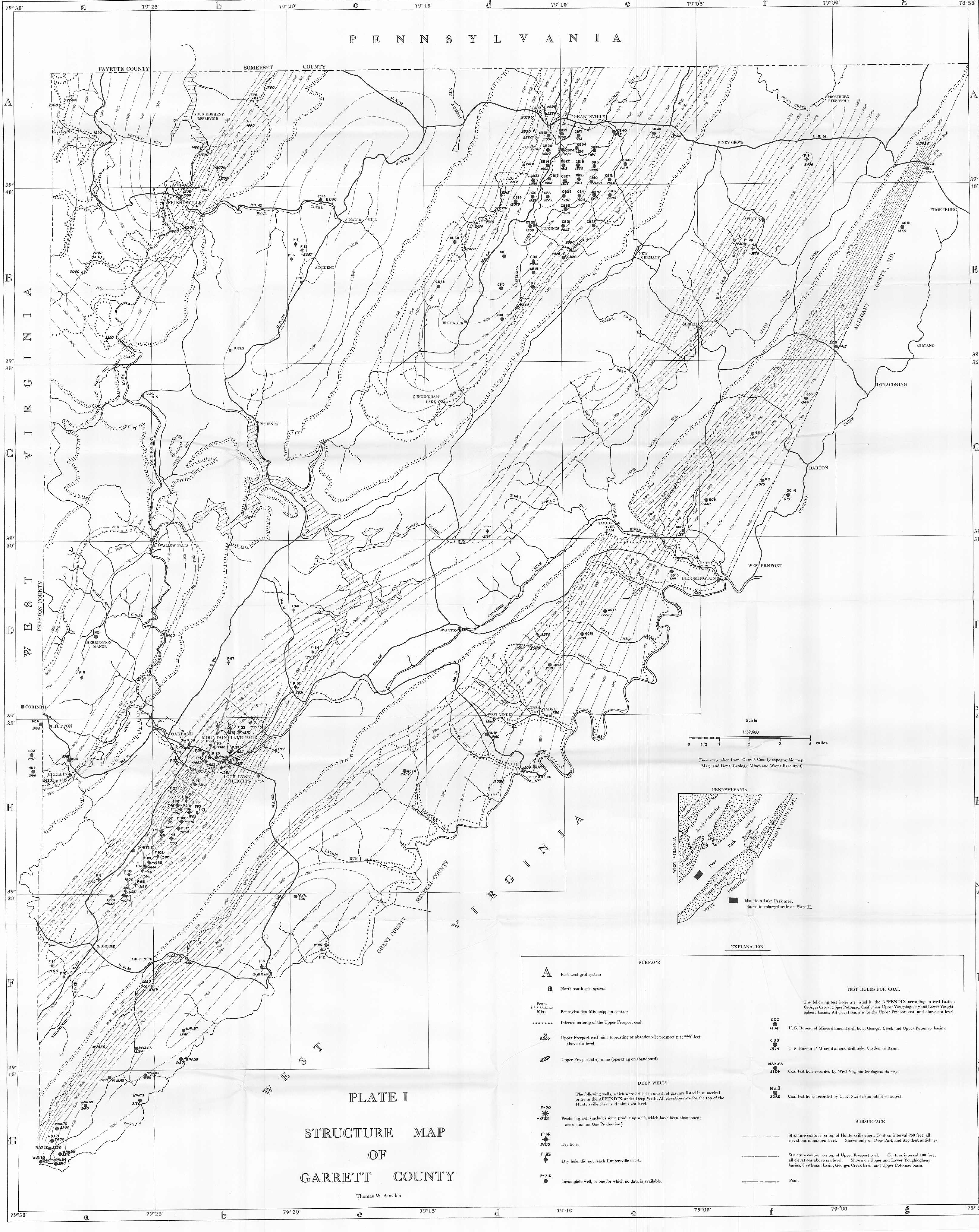


PLATE I

STRUCTURE MAP OF GARRETT COUNTY

Thomas W. Amsden

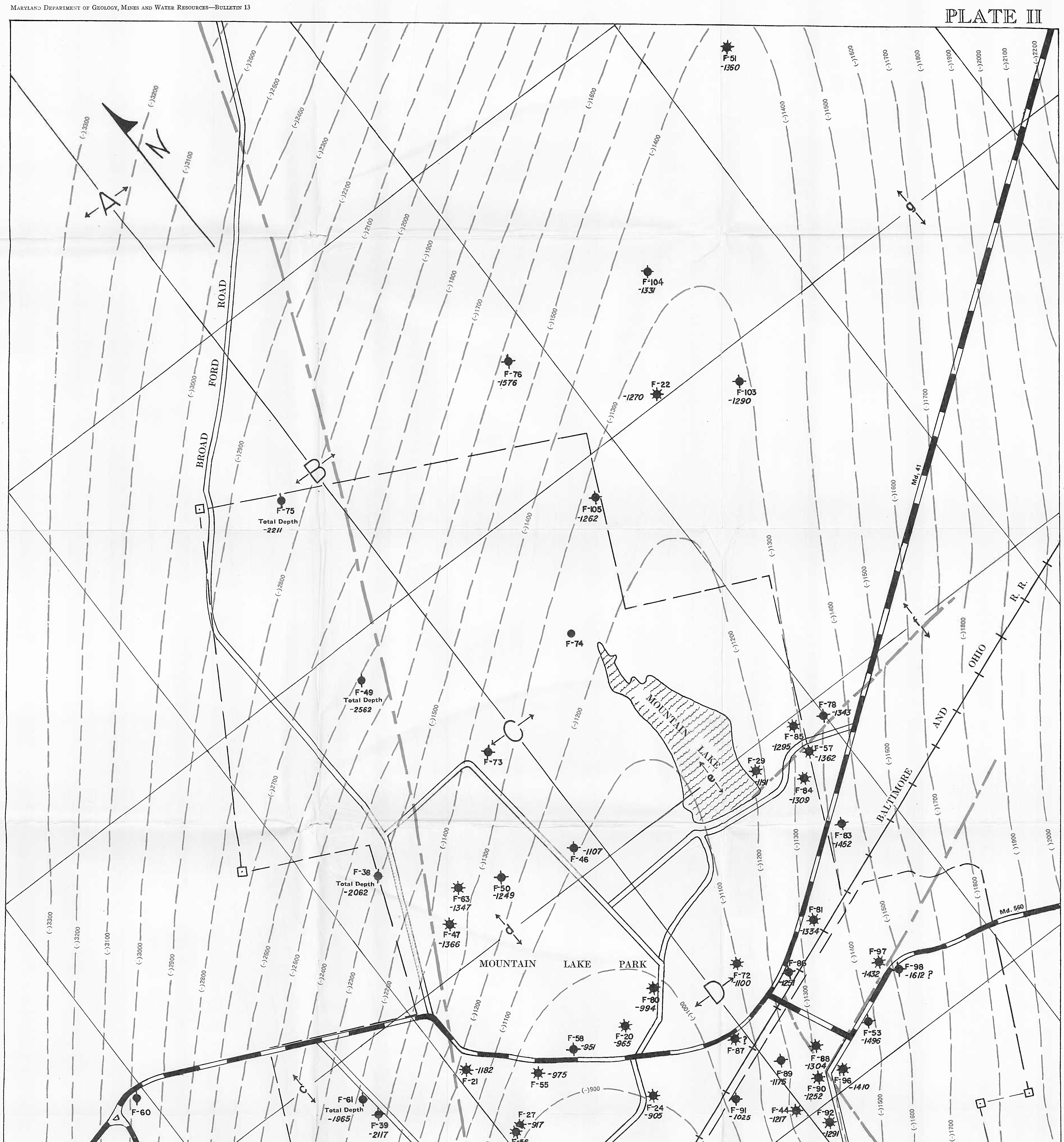


PLATE II

STRUCTURE MAP OF THE MOUNTAIN LAKE PARK AREA

GARRETT COUNTY, MARYLAND

Thomas W. Amsden and John C. Reed, Jr.

Scale: 0 — 500 — 1000 — 1500 — 2000 Feet

(Base map enlarged from U. S. Geological Survey topographic maps, 7½ minute series)

Location of this map given on Plate I

EXPLANATION

Town boundary	Producing well (includes some producing wells which have been abandoned).
East-west grid system	Dry hole
North-south grid system	Dry hole, did not reach Huntersville chert
Structure contour on top of Huntersville chert; 100 foot contour interval; all elevations minus sea level.	Incomplete well or one for which no data is available.
Fault.	F-24 Well number. A summary of the pertinent data for each well is given in the APPENDIX. All well depths are to the top of the Huntersville chert.

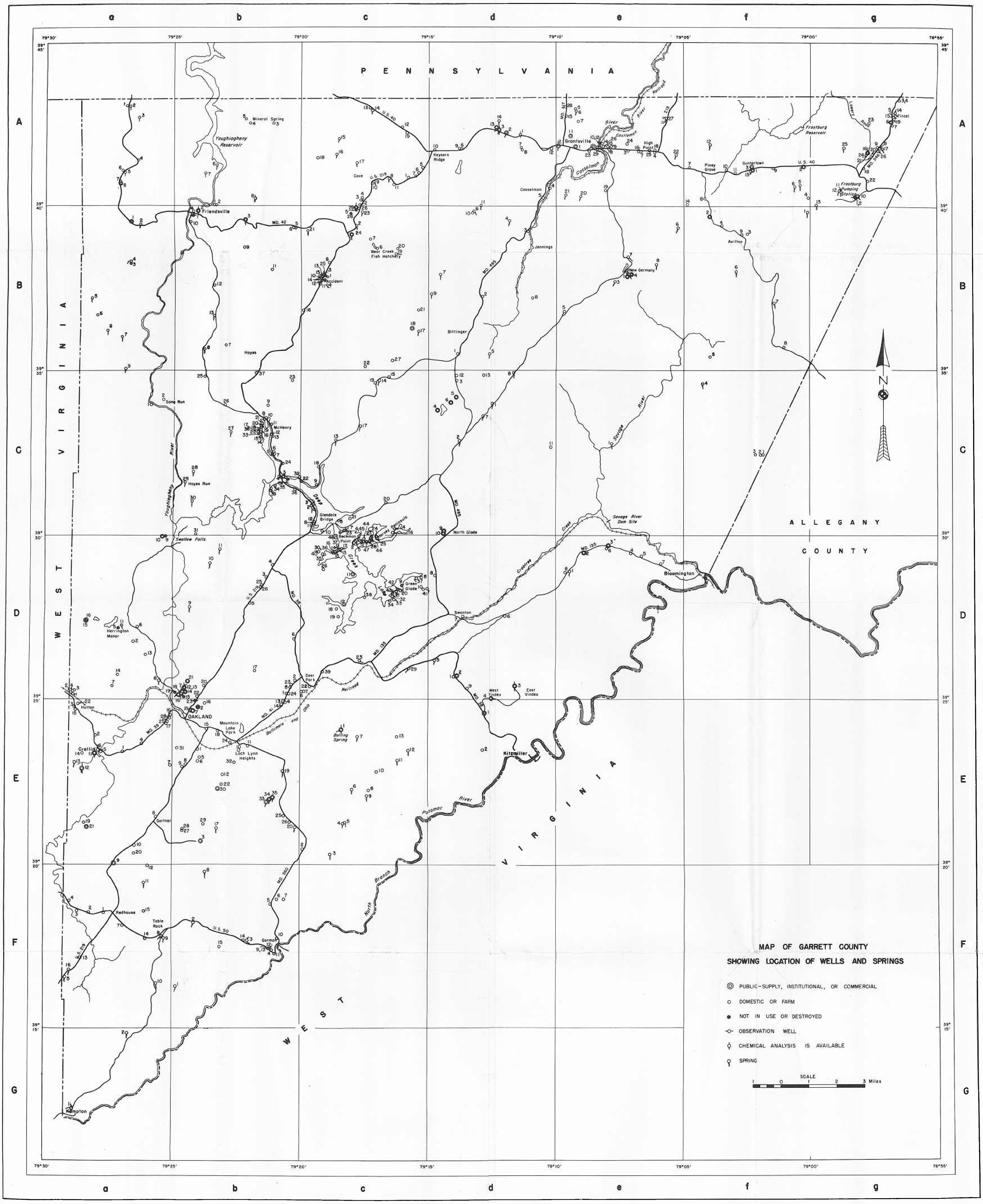
PLATE III

REPRESENTATIVE GRAPHIC LOGS OF SOME GARRETT COUNTY DEEP WELLS on DEER PARK ANTICLINE

	PERMIT #	NAME OF WELL	OPERATOR	APPROXIMATE SURFACE ELEVATION (FT.)	LOGGED BY:	LOCATION
F-66	7613	ROBESON	SUPERIOR OIL CO.	2530	T. W. AMSDEN	FOR LOCATION SEE STRUCTURE MAP
F-78	8438	SHAW #2 (LOWER PART)	N. Y. STATE NATURAL GAS	2450	K. N. WEAVER	
F-17	6917	GRASER #1 (LOWER PART)	COLUMBIAN CARBON CO.	2385	J. REED	
F-18	6951	BAKER #1 (LOWER PART ONLY)	SNEE AND EBERLY	2410	J. REED	
F-22	7090	GORDON #1 (LOWER PART ONLY)	SNEE AND EBERLY	2450	J. REED	

LEGEND:

- LIGHT-TO DARK-GRAY SHALE AND SILTSTONE
- BLACK SHALE
- GREEN SHALE AND SILTY SHALE
- RED SHALE
- SANDSTONE
- LIMESTONE, AND PERCENT $CaCO_3$ IN MAJOR LITHOLOGIC TYPE
- CHERT
- ESTIMATED PERCENT INSOLUBLE RESIDUE IN MAJOR LITHOLOGIC TYPE (*LOGS: F-17, F-18, F-22*)


MAP OF GARRETT COUNTY
SHOWING LOCATION OF WELLS AND SPRINGS
PUBLIC-SUPPLY, INSTITUTIONAL, OR COMMERCIAL
DOMESTIC OR FARM
NOT IN USE OR DESTROYED
OBSERVATION WELL
CHEMICAL ANALYSIS IS AVAILABLE
SPRING
SCALE
3 Miles
PENNSYLVANIA
WEST VIRGINIA
ALLEGANY COUNTY
Youghiogheny Reservoir
Friendsville
Grantsville
Keysers Ridge
Mineral Spring
Cove
Accident
Bear Creek Fish Hatchery
Jennings
New Germany
Bittinger
Hoyes
McHenry
Sang Run
Hoyes Run
Swallow Falls
Glendale Bridge
Bachman Point
North Glade
Green Glade
Swanton
Savage River Dam Site
Bloomington
Herrington Manor
Hutton
OAKLAND
Mountain Lake Park
Loch Lynn Heights
Deer Park
Boiling Spring
West Vindex
East Vindex
Kitzmiller
Crellin
Gortner
Redhouse
Table Rock
Gorman
Kempton
Casselman
Piney Grove
Guntertown
Avilton
High Point
Frostburg Reservoir
Frostburg Pumping Station
Finzel
Deep Creek
Savage River
Crabtree Creek
Potomac River
North Branch
Baltimore and Ohio Railroad
U.S. 40
U.S. 219
U.S. 50
MD. 42
MD. 495
MD. 135
MD. 39
MD. 38
MD. 560
N