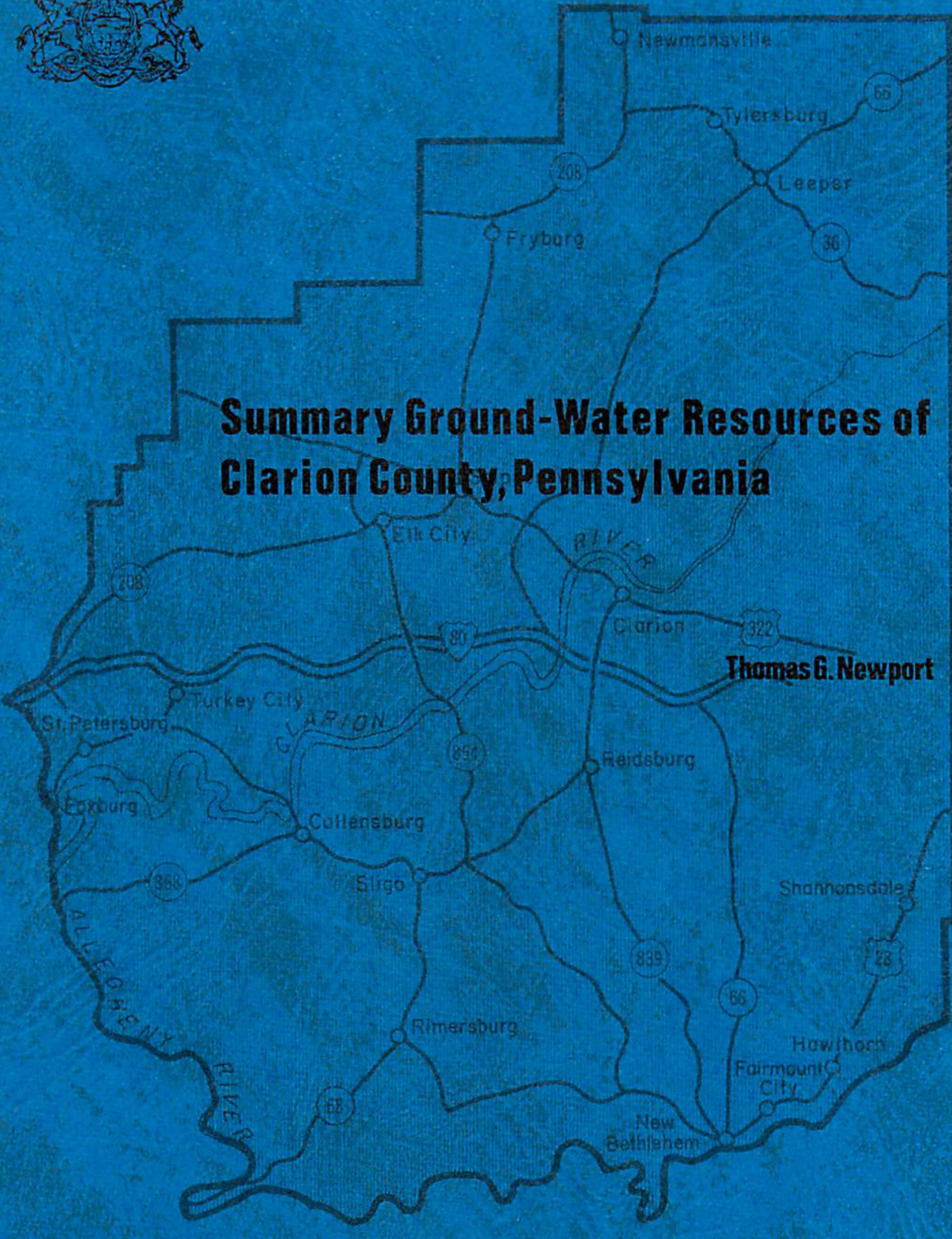
Water Resource Report 32

1973

Summary Ground-Water Resources of Clarion County, Pennsylvania

Thomas G. Newport



COMMONWEALTH OF PENNSYLVANIA

DEPARTMENT OF ENVIRONMENTAL RESOURCES

BUREAU OF

TOPOGRAPHIC AND GEOLOGIC SURVEY

Arthur A. Socolow, State Geologist

Bulletin W 32

Summary Ground-Water Resources of Clarion County, Pennsylvania

by Thomas G. Newport
U.S. Geological Survey

Prepared by the United States
Geological Survey, Water Resources Division,
in cooperation with the
Pennsylvania Geological Survey

PENNSYLVANIA GEOLOGICAL SURVEY
FOURTH SERIES
HARRISBURG
1973

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PREFACE

This report is presented as a comprehensive description and inventory of the ground-water resources available in Clarion County. With the continuing growth of our population and the expansion of our industries, there is an ever increasing rise in demand for quality water resources. Ground water, or subsurface water, constitutes one of the largest reserves of quality water remaining to be developed.

This report can be of assistance to anyone who is planning for future water needs. It will help to evaluate the quantity and quality of ground water available in any part of the county, and it will aid in choosing the locations, depths, and conditions most favorable for desired ground-water yield.

While this publication has attempted to include all available ground-water data for the county, the Pennsylvania Topographic and Geologic Survey will continue to collect ground-water and water well data for the area; such data will be kept on open file at the Survey offices in Harrisburg, available to anyone who desires the very latest information.

We hope that this report will aid all users of water in Clarion County to develop and manage their water resources so as to accommodate their water needs.

Arthur A. Socolow

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Summary Ground-Water Resources of Clarion County, Pennsylvania

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ABSTRACT

The geologic formations in Clarion County range from the Mississippian Pocono Group to Quaternary alluvium along some of the major streams. Data from more than 70 wells drilled in the county indicate that the highest ground-water yields are obtained from aquifers in the Pocono Group and in the alluvium deposits. If saturated, the alluvium deposits yield large quantities of ground water through pore openings. Yields ranged from 50 to 200 gpm in four wells drilled. Ground water in the sandstone and limestone aquifers of the consolidated rocks in the county occurs in pore spaces and in secondary openings such as fractures and solution channels. Yields from sandstone in the Pocono Group vary widely, depending on the amount of shale interbedded. Yields of less than 50 gpm to over 500 gpm have been reported. In the Pottsville Group, the average yield is 28 gpm, but if the wells penetrate both the upper and lower sandstone members, the yield may be much higher. The sandstone and limestone members of the Allegheny Group are reliable sources of small to moderate amounts of ground water and will yield adequate amounts for domestic use at almost any location drilled.

Chemical analyses of ground water from 47 wells, most of them in the sandstone aquifers, showed that many of the samples were high in iron. Excessive iron is the main water quality problem in ground water of Clarion County. Ground water in the deeper aquifers is generally highly mineralized. In some areas, acid water from coal mines has reportedly drained into aquifers, ruining the quality of the water.

INTRODUCTION

PURPOSE AND SCOPE

This report is part of a program to summarize the ground-water resources of Pennsylvania in a series of county reports that will be easy to read and suitable for widespread distribution. It contains a general description of the aquifers in the county, a geologic map, a well location map, and data on the depth and yield of wells and the chemical quality of ground water.

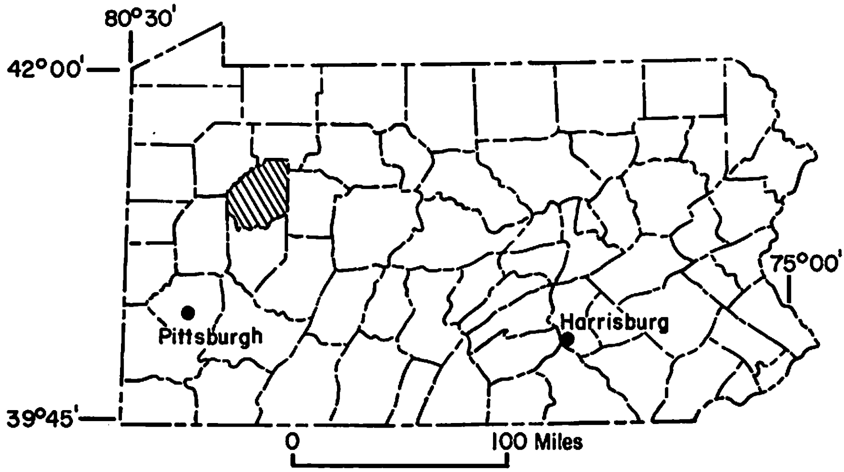

Figure 1. Location of Clarion County (shaded).

LOCATION AND GENERAL GEOGRAPHIC FEATURES

Clarion County is in west-central Pennsylvania (Figure 1). It is bordered on the north by Forest County, on the east by Jefferson County, on the south by Armstrong County, and on the west by Venango County. It has an area of about 600 square miles. Redbank Creek forms the southern boundary, and the Allegheny River forms part of the western boundary. Clarion, the county seat, is 60 miles northeast of Pittsburgh and 150 miles northwest of Harrisburg.

LANDFORMS

Clarion County is in a dissected part of the Allegheny Plateau. Several cycles of erosion have acted on the rock strata. The earlier cycles of erosion reduced most of the area to a gently sloping plain, except for a few gently rolling hills. Later erosion of the gently rolling hills has produced a few rounded ridgetops rising above deep, steep-sided stream valleys. The highest point in the county is 1,912 feet above sea level. The lowest part of the county is along the Allegheny River at an altitude of about 840 feet.

The Clarion River drains most of the county. It meanders southwestward in a narrow valley, the walls of which rise 400 feet or more above the stream. The Clarion River joins the Allegheny River near Foxburg.

POPULATION TRENDS

The total population of Clarion County has changed very little in the last 70 years. Table 1 gives the census figures for the population of Clarion County from 1900 to 1970.

The 1970 population density in Clarion County is 63 persons per square mile. The population density per square mile ranges from about 8 to over 4,130.

Table 1. *Population of Clarion County, 1900-1967.*

Year	Population
1900	34,283
1910	36,638
1920	36,170
1930	34,531
1940	38,410
1950	38,334
1960	37,408
1970	37,882

LAND USE IN THE 1960's

In Clarion County about 47 percent of the total land area is forested. Farm lands occupy 46 percent of the area. Strip mines cover 6 percent and urban development covers the remaining 1 percent of the land area.

Most of the farms in Clarion County produce dairy, beef or poultry products. The largest industry in the county is coal mining, but lumbering is important also.

WHERE THE WATER COMES FROM

HYDROLOGIC CYCLE

Water is one of our most important resources and it constitutes the major part of most living things. Man's existence depends upon it, yet water supplies are taken for granted by most individuals. As shown in Figure 2, water evaporates from the oceans and is carried as vapor until it condenses and falls as precipitation. Most of the precipitation that falls on the land either is used by vegetation, evaporates back to the atmosphere, or runs overland as streamflow. Part enters the soil and bedrock to recharge water-bearing formations, called aquifers. The water moves at a varying pace, depending on its environment, but eventually it returns to the oceans.

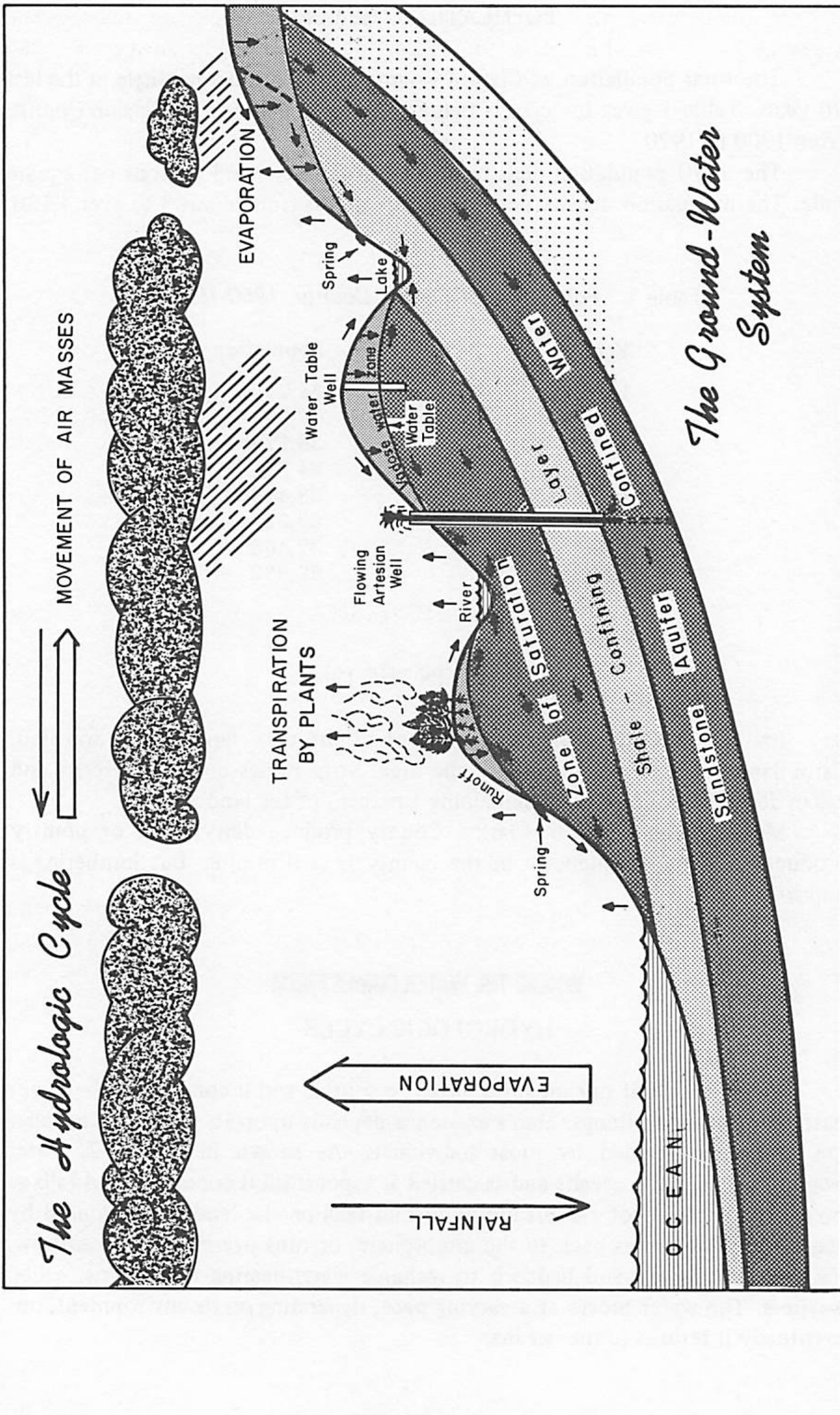

Figure 2. Hydrologic cycle showing movement of water from ocean to land and back to the ocean.

If man interrupts or changes the hydrologic cycle he may cause undesirable effects which last for many years. Man-made changes in the hydrologic cycle in Clarion County are discussed in the following pages.

PRECIPITATION

Precipitation is the source of all fresh water in the county. Not all of the available water is that which has fallen on the county, as some streams carry in runoff from areas outside the political boundaries. The average yearly precipitation is 43 inches at Clarion and 40 inches at East Brady (U.S. Department of Commerce Environmental Data Service).

Precipitation is generally well distributed throughout the year. The summer has a little more rainfall than the other seasons of the year. Much of the summer rain comes as intense thundershowers of short duration. About one-tenth of the total precipitation is snow.

WHERE THE WATER GOES

EVAPOTRANSPIRATION

Evapotranspiration is a collective term describing the return, through the sun's energy, of water to the atmosphere as vapor. In the process of transpiration, soil moisture returns to the atmosphere as a by-product of plant growth. In the evaporation process, water changes directly from a liquid to a vapor.

The estimated mean annual rate of evaporation from surface-water bodies in Clarion County is 28 inches. The surface area of water bodies in Clarion County is small, and the water evaporated from them is only a minor part of the hydrologic system. However, the total water loss from both evaporation and transpiration is about 24 inches.

STREAMFLOW

Most of the water not lost through evapotranspiration leaves the county as discharge from streams. This discharge accounts for 20 to 25 inches of the original precipitation on the area. The larger streams and the locations of gaging stations that measure streamflow in Clarion County are shown in Figure 3. Identification numbers are those assigned by the U.S. Geological Survey. A summary of discharge data for three gaging stations is given in Table 2. More detailed information on streamflow can be obtained from Surface Water Records for Pennsylvania, U.S. Department of the Interior, 1969 (see reference list).

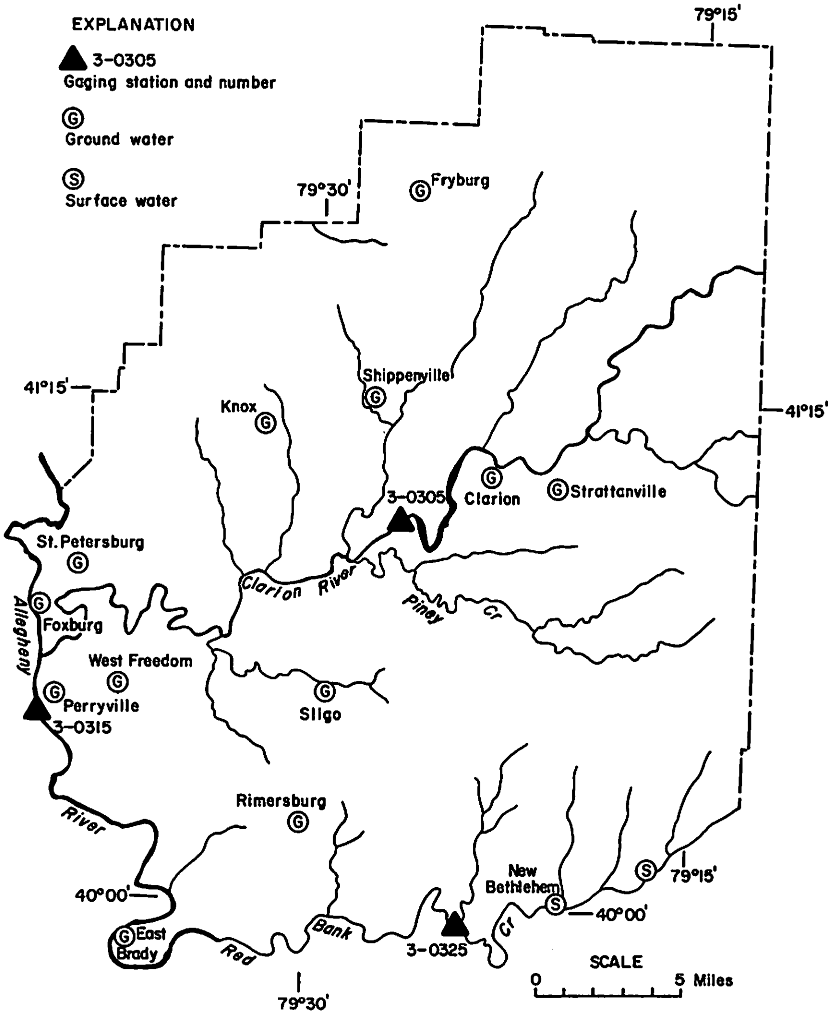

Figure 3. Locations of towns, sources of their water, and stream gaging stations and numbers.

GROUND WATER

Much of the water falling on the land surface returns to the atmosphere or reaches streams as overland runoff. Part infiltrates through the soil and through fractures and other void spaces in the underlying rock. Its downward movement

Table 2. *Discharge Data of the Gaged Streams in Clarion County*

Clarion River near Piney, Pa. 3-0305
- Average discharge, 23 years of record: 1,672 cfs
- Maximum discharge, March 10, 1964: 46,100 cfs
- Minimum discharge, not determined

Allegheny River at Parker, Pa. 3-0315
- Average discharge, 35 years of record: 12,790 cfs
- Maximum discharge, January 22, 1959: about 175,000 cfs
- Minimum discharge, July 30, 1934: 409 cfs

Redbank Creek at St. Charles, Pa. 3-0325
- Average discharge, 49 years of record: 836 cfs
- Maximum discharge, March 18, 1936: 35,200 cfs
- Minimum discharge, October 1, 1918: 19 cfs

continues until it reaches the zone of saturation, a zone in which all of the interconnected voids are filled with water. This is illustrated in Figure 4. After reaching the zone of saturation the water moves downward and laterally toward lower elevations and eventually returns to the surface, either naturally from springs and seeps or from wells.

Ground water occurs under both water table and artesian conditions. Water table conditions are those in which ground water is unconfined and the

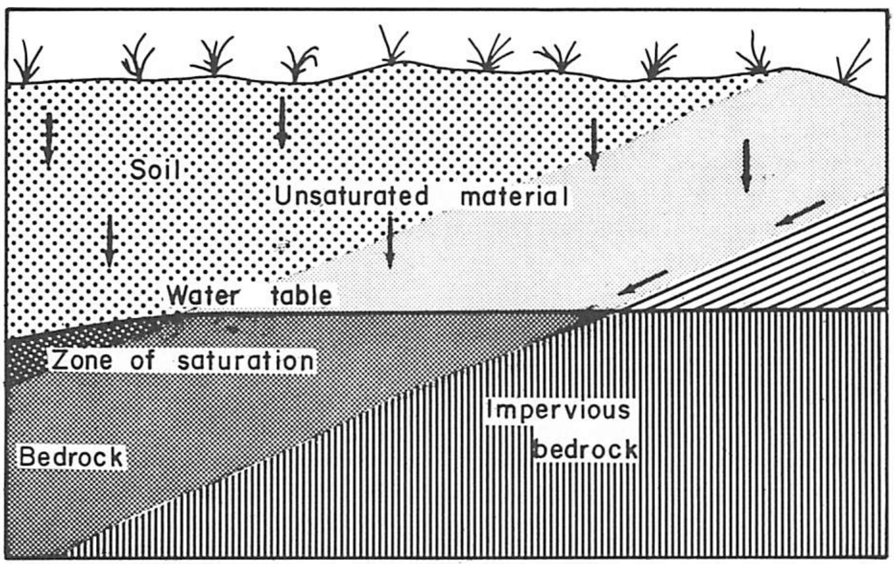

Figure 4. Diagrammatic section showing downward movement of water through soil and rock to water table.

upper surface of the water is free to rise or fall. Artesian conditions exist where the ground water is confined in a permeable (having interconnected openings) formation that is overlain by a relatively impermeable formation. The upper surface is not free to rise or fall, but the water is under enough pressure to rise above the containing aquifer in wells penetrating it. The imaginary surface to which water will rise in wells tapping an artesian aquifer is called the piezometric surface.

The water table fluctuates up and down according to the relative amounts of recharge (additions to the aquifer) and discharge (losses to seeps, springs and wells). Because of the heavy evapotranspiration losses during the growing season (April to October), very little recharge reaches the zone of saturation and water levels decline; water levels generally rise throughout the rest of the year. A hydrograph of a well located at Cook Forest State Park camp grounds is shown in Figure 5. This hydrograph illustrates the changes in ground-water levels from 1961 through 1969.

Water levels in the county are at or near the land surface in the valleys and rise under the hilltops and ridges. The rate of water level rise, however, is less than that of the land surface; so, depths to water at the higher elevations are greater than those in the valleys.

Ground water occurs in and moves through interconnected openings (Figure 6), either primary or secondary in nature. Primary openings are void spaces between the individual grains, such as in unconsolidated material, sandstone or shale. The openings in unconsolidated material or coarse-grained sandstone are large compared with those in shale. The larger interconnecting openings allow much more ground-water movement than the smaller ones.

Secondary openings are those formed after the deposition and consolidation of the formations. In Clarion County they result from the fracture or solution of the rock. The fractures are the result of external forces that caused rupture of the rock. Solution cavities are formed by the solution and removal, by water, of parts of rocks such as limestone. Large quantities of water move through connected fractures and solution cavities.

GROUND-WATER QUALITY

As precipitation enters the ground it dissolves parts of the soil and rock and thus picks up various mineral constituents. Because ground water is in contact with soil and rocks longer than surface water, it has more dissolved material in it. Some spring and well water may contain so much dissolved matter that it is not fit to drink. Water containing more than 500 mg/1 (milligrams per liter) of dissolved solids is not considered desirable for domestic supplies, though more highly mineralized water is used where better water is not available. Ground water, on the whole, is of better quality than surface water. This does

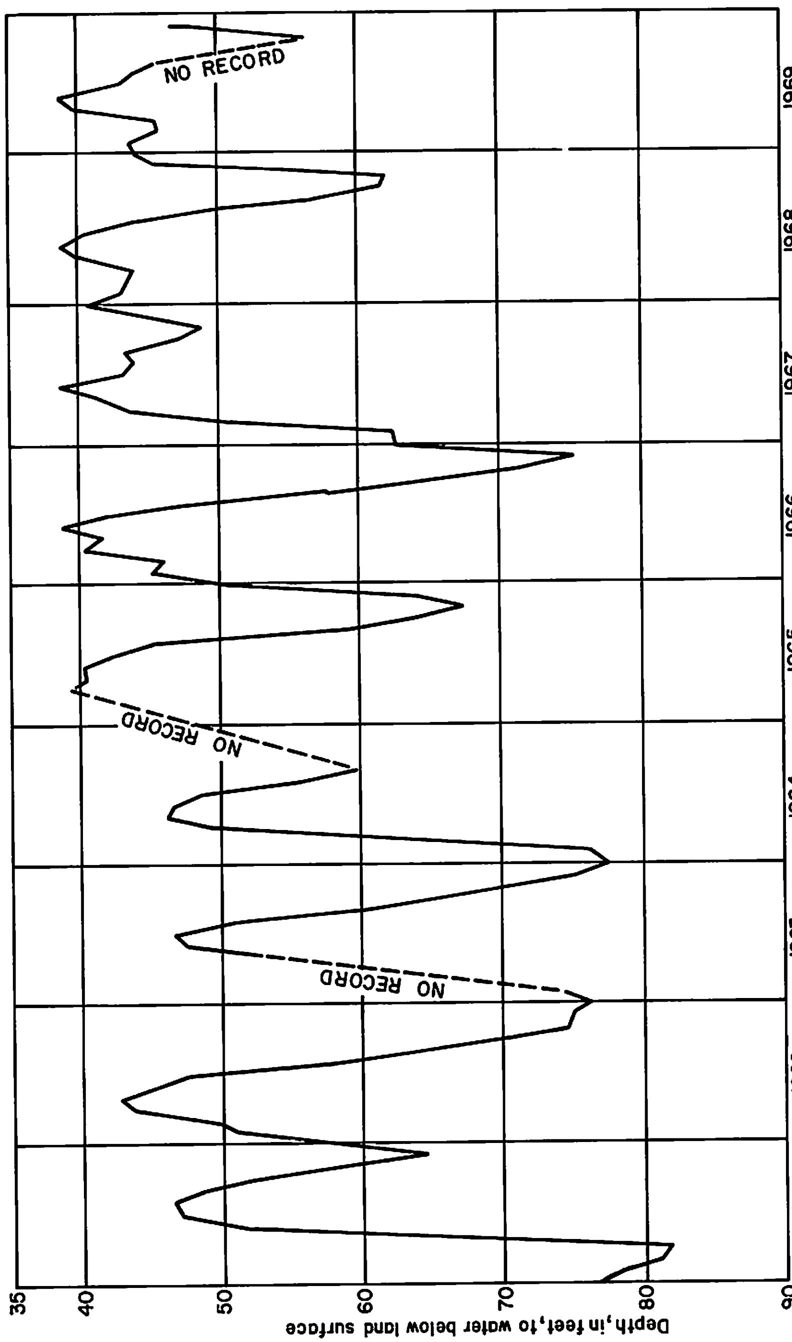

Figure 5. Hydrograph of well Cr-3, located in Cook Forest State Park.

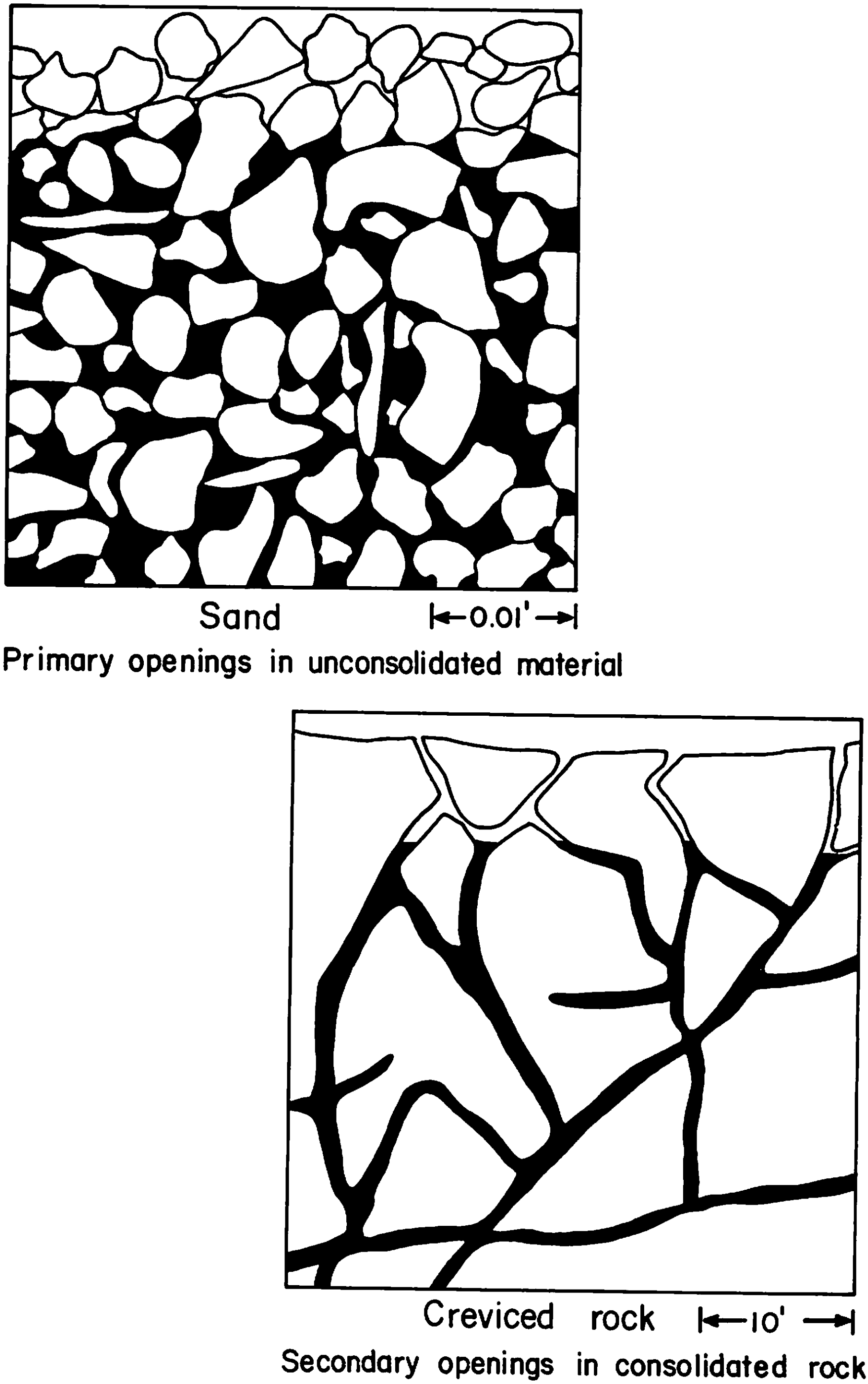

Figure 6. How water occurs in the rocks.

not mean that all ground water is completely pure, but the soil and rocks through which it percolates tend to screen out solid suspended materials and bacteria.

Analyses of ground water from Clarion County are listed in Table 3. Most of these waters are from the sandstone aquifers, and many of them are high in iron. Excessive iron is the main water quality problem encountered by most users of ground water in Clarion County. It has been reported that acid water from coal mines has been allowed to drain into the sandstone aquifers, thus spoiling the quality of the ground water in the area. Acid water is formed when air and water come in contact with the mineral pyrite. The pyrite occurs in the rocks associated with the coal seams, and when the coal is mined the pyrite is exposed to air and moisture and forms weak sulfuric acid.

HOW AND WHERE GROUND WATER IS FOUND

Ground water in Clarion County occurs under both artesian and water table conditions. Well yields range from less than 1 gpm (gallon per minute) to over 500 gpm. Data on more than 70 wells drilled in the various geologic formations that underlie the county are listed in Table 5. Plate 1 shows the locations of selected wells in Clarion County.

A summary of the water-bearing characteristics of the geologic units in Clarion County follows. The areal extent of these geologic units in the county is shown in Plate 1 and a composite stratigraphic section is presented in Table 4. Sample logs of several wells are shown in Table 6. These sample logs are representative of the complexity of the rocks encountered in drilling in this county.

A study of aerial photographs of the area might show where fractures in the bedrock intersect. The intersection of two or more fractures is usually a good location for a well.

ALLUVIUM

Lithology and Structure

The alluvium is an unconsolidated heterogeneous mixture of silt, sand, and gravel. The glaciers did not reach Clarion County, but water produced by the melting ice sheet carried outwash material down some of the streams of this county and partly filled the valleys with silt, sand, and gravel. Along the Clarion River there are deposits similar in every respect to the glacial outwash except that they contain only rocks of local derivation. Near Foxburg, glacial outwash and alluvium are intermingled. In this report both types of deposits will be discussed as alluvium.

These alluvial deposits have been greatly eroded since deposition and are now discontinuous narrow bands along the sides of the major streams. The

Table 3. *Chemical Analyses of Ground Water from Wells in Clarion County*

(In milligrams per liter, except as noted)

Well number	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Sodium and Potassium[1]	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)	pH	Color
Cr- 2	1928	56	—	0.20	—	18	—	—	21	—	10	54	24	—	25	157	73	65	—	—	—
12	1929	50	9.9	.04	8.9	60	—	4.2		3.0	113	102	3.0	—	.1	267	186	94	—	—	—
13	1928	50	—	3.40	—	48	—		30		168	28	4.0	—	.8	187	187	50	—	—	—
14	1928	53	12	6.05	—	37	9.8	151		8.4	240	156	84	—	0.0	574	133	0	—	—	—
17	1925	—	—	3.0	—	—	—	—		—	221	—	68	—	.1	—	—	160	—	6.9	—
17	1961	—	—	8.0	.9	—	—	—		—	170	—	75	—	—	830	305	166	—	—	5
18	1928	50	9.5	.93	—	22	4.9	130		3.0	223	1.5	128	—	—	447	75	—	—	—	—
18	1961	—	—	8.0	2.0	—	—	—		—	155	—	77	—	—	930	370	243	—	—	—
19	1928	52	—	6.82	—	20	—	—	52	—	118	30	37	—	1.1	201	67	—	—	—	—
20	—	—	—	12.0	.7	—	—	—		—	—	—	—	—	—	—	—	—	—	6.6	—
21	1928	50	7.5	11.02	—	27	6.4	3.5		2.2	92	13	8.0	—	0.0	114	94	—	—	—	—
22	—	—	—	14.0	.7	—	—	—		—	—	—	—	—	—	—	—	—	—	6.6	—
23	1928	49	7.2	19.04	—	11	6.5	13.0		3.4	44	33	11	—	.1	108	54	—	—	—	—
25	1928	51	—	7.55	—	10	—	—	18	—	57	30	10	—	.1	106	53	—	—	—	—
26	1928	49	—	1.33	—	10	—	—	101	—	231	35	26	—	0.0	283	42	—	—	—	—
27	1928	52	—	7.31	—	16	—	—	78	—	170	28	40	—	0.2	245	56	—	—	—	—
28	1928	50	8.5	2.73	—	24	7.5	2.6		1.7	103	12	1.0	—	.1	106	91	—	—	—	—
29	1928	50	—	2.08	—	40	—	—	20	—	102	34	14	—	0.0	155	96	—	—	—	—
31	1928	50	5.8	.3	—	3.8	1.8	3.8		1.2	6	6.9	2.5	—	12	38	17	—	—	—	—
36	1928	51	8.4	3.53	—	28	5.7	46		3.2	140	23	44	—	.1	227	93	—	—	—	—
42	1928	50	—	3.02	—	20	—	—	196	—	232	104	153	—	.1	584	89	—	—	—	—
52	1929	52	—	.4	—	38	—	123		—	238	325	90	—	—	675	145	—	—	—	—
55	1958	—	—	.1	0.0	—	—	—		—	324	—	75	—	—	—	120	—	—	8.2	—
56	1964	53	8.8	.22	0.0	30	8.5	363		3.5	417	189	94	0.3	0.0	794	110	0	1,300	7.5	6
59	1953	—	—	—	.3	—	—	—		—	100	—	44	.3	0.0	260	90	—	—	7.1	10
59	1965	—	—	4.8	—	—	—	—		—	—	—	425	—	0.0	—	270	—	—	6.6	0
61	1965	—	—	.18	.9	—	—	—		—	244	—	32	—	—	—	164	—	—	7.8	—
62	1965	52	—	0.0	0.0	—	—	—		—	58	70	22	—	—	—	112	—	—	6.5	—
64	1925	—	—	4.0	—	—	—	—		—	265	—	38	—	—	355	—	—	—	7.2	—

65	1925	—	—	1.4	—	—	—	—	—	235	—	53	—	—	346	—	—	—	7.4	—
66	1925	—	—	1.0	—	—	—	—	—	210	—	80	—	0.0	381	120	—	—	7.4	—
67	1925	—	—	.8	—	—	—	—	—	205	—	52	—	—	391	120	—	—	7.6	—
68	1925	—	—	.5	—	—	—	—	—	145	—	170	—	—	486	110	—	—	7.6	—
69	1925	—	—	.6	—	—	—	—	—	135	—	95	—	—	356	84	—	—	7.2	—
70	1925	—	—	1.2	—	—	—	—	—	125	—	76	—	—	306	100	—	—	7.1	—
71	1925	—	—	7	—	—	—	—	—	245	—	65	—	—	413	170	—	—	6.7	—
72	1925	—	—	4	—	—	—	—	—	160	—	80	—	—	334	110	—	—	7.5	—
73	1925	—	—	4	—	—	—	—	—	205	—	34	—	—	311	160	—	—	7.0	—
76	1958	—	—	10	—	—	—	—	—	190	—	43	.2	.2	310	115	—	—	7.1	—
78	1958	—	—	8	—	—	—	—	—	100	—	38	.4	2.2	235	90	—	—	6.9	—
79	1961	—	—	2	.4	—	—	—	—	200	—	75	—	0.0	650	210	—	—	7.2	5
80	1961	—	—	10	4.5	—	—	—	—	140	—	74	—	0.0	1,205	580	—	—	6.8	15
81	1960	—	—	6	—	—	—	—	—	71	—	7	—	0.0	110	36	—	—	6.6	—
82	1968	45	—	8	.8	—	—	—	—	52	—	23	—	.5	132	64	—	—	6.0	10
83	1960	—	—	5	—	—	—	—	—	36	—	12	—	0.0	120	94	—	—	6.3	5
84	1965	—	—	24.0	2	—	—	—	—	—	170	12	—	.2	—	200	—	—	6.2	5
86	1965	—	—	.8	0.0	—	—	—	—	—	—	7	—	.3	—	110	—	—	6.5	0

[1] Combined sodium and potassium weights were determined by subtracting the combined equivalence of all other constituents from the total equivalence of the sample.

Table 4. *Composite Stratigraphic Section for Clarion County*

System	Group or Formation	Thickness (feet)	Character of Strata	Water-Bearing Characteristics
Quaternary	Alluvium	0-50+	Unconsolidated, heterogeneous mixture of silt, sand, and gravel deposited along stream valleys.	Yields of as much as 200 gpm reported for wells in this material. The water is moderately hard.
Pennsylvanian	Conemaugh	thin	Present as erosional remnants on hilltops; consists of shale.	Unimportant as an aquifer.
	Allegheny	300	Consists of shale, sandstone, limestone, clay and as many as seven coal beds or horizons.	Yields as much as 160 gpm have been reported. If yields of more than 35 gpm are desired, the well should be at least 250 feet deep. The water is moderately hard and is high in iron.
	Pottsville	130	Two massive sandstones separated by sandy shale and coal.	The average reported yield is 28 gpm; the maximum is 150 gpm. The water is moderately hard and high in iron.
Mississippian	Pocono	300	Medium- to coarse-grained sandstone. Crops out in county only in valleys of major streams.	Yields as much as 500 gpm have been reported. Water is moderately hard and high in iron. Deeper wells may produce salt water.

Table 5. *Record of Wells in Clarion County*

Method of construction: Dr, drilled; Du, dug.
Aquifer name: Al, alluvium; IPa, Allegheny Group; IPp, Pottsville Group; Mp, Pocono Group.
Use: D, domestic; I, industrial; O, observation; PS, public supply; U, unused; D, destroyed.
Remarks: Ca, chemical analysis, Sl, sample log; H, hydrograph available.

Well Number	Location Number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
Cr- 1	4112-7923	John Mesinger	—	1931	1,480	Du	36	28	IPa	4-5-32	12.80	—	U	
2	4106-7929	G. W. Texter	—	1880	1,180	Du	48	14.8	IPa	12-10-29	9.00	—	D	Ca
3	4120-7913	Comm. of Pa.	—	1950	1,530	Dr	6	130	IPp	8-9-50	23.17	0.2	O	H
7	4107-7912	Klamath Coal Co.	Morris Smith	—	1,290	Dr	6	130	IPp	—	—	—	—	Sl
8	4058-7937	Fordyce Woolen Mills	—	1913	860	Dr	6	71	Mp	—	—	20	I	
9	4058-7937	Rex Hide Rubber Co.	—	1917	840	Dr	6	51	Mp	—	—	28	I	
10	4058-7937	East Brady Borough	—	1916	900	Dr	7	76	Mp	—	— 16	PS		
11	4058-7936	do.	—	1923	1,040	Dr	5	115	Mp	—	—	—	PS	
12	4059-7934	R. M. Kiefer	Eddinger	1928	1,340	Dr	8	213	IPa	—	—	15	D	Ca
13	4102-7930	Rimersburg Borough	W. E. Pipher	1928	1,360	Dr	8-1/4	158	IPa	1928	55	17	PS	Ca, Sl
14	4102-7930	do.	William Piper	1925	1,320	Dr	6-1/4	262	IPa	1925	100	36	M	Ca, Sl
15	4058-7937	Rex Hide Rubber Co.	—	1924	840	Dr	5-5/8	53	Mp	—	—	25	I	
16	4058-7937	do.	—	1917	840	Dr	8	60	Mp	1947	53	50	I	
17	4106-7929	Sligo Borough	—	1910	1,280	Dr	—	313	Mp	—	130	25	PS	Ca
18	4106-7929	do.	Mertin	1926	1,280	Dr	—	310	Mp	—	140	50	PS	Ca, Sl
19	4112-7922	Berney Brand Glass Co.	O. H. Culbertson	1913	1,460	Dr	6-1/4	300	Mp	—	96	69	I	Ca
20	4113-7922	Shippenville Borough	—	1923	1,100	Dr	6-1/4	90	—	—	—	70	PS	
21	4121-7926	Fryburg Water Co.	William Judy	1925	1,700	Dr	5-5/8	208	IPa	—	—	—	PS	Ca, Sl
22	4120-7924	United Natural Gas Co.	—	—	1,500	Dr	—	157	Mp	—	—	—	—	
23	4115-7927	Shippenville Borough	—	1913	1,400	Dr	6-1/4	255	IPa	1913	65	35	PS	Ca
25	4114-7932	Knox Glass Co.	J. B. Rassman	1917	1,360	Dr	4	156	Mp	—	20	26	I	Ca
26	4114-7932	Knox Beverage	do.	1928	1,360	Dr	6-1/4	160	Mp	—	50	8	I	Ca
27	4114-7932	Knox Borough	—	—	1,540	Dr	5-5/8	375	Mp	—	225	24	PS	Ca
28	4110-7939	St. Petersburg Borough	—	—	1,500	Dr	6-1/4	150	IPa	—	—	6	PS	Ca
29	4109-7939	do.	—	1918	1,460	Dr	6-1/4	160	IPa	—	—	20	PS	Ca

Table 5. *(Continued)*

Well Number	Location Number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
30	4110-7939	St. Petersburg Borough	—	1909	—	Dr	6-1/4	150	IPa	—	—	4	PS	
31	4108-7940	Foxburg Water Co.	—	1907	1,160	Dr	8	150	Mp	—	—	10	PS	Ca
32	4108-7940	do.	—	1907	1,160	Dr	8	150	Mp	—	—	9.4	PS	
33	4108-7940	do.	—	1907	1,160	Dr	8	150	Mp	—	—	12.7	PS	
34	4108-7940	do.	—	1907	1,160	Dr	8	150	Mp	—	—	6.4	PS	
35	4108-7940	do.	—	1928	1,160	Dr	8	170	Mp	—	—	—	U	
36	4114-7932	Edenburg Borough	—	1917	—	Dr	5-5/8	417	Mp	—	225	30	PS	Ca
37	4121-7917	United Natural Gas Co.	—	—	1,460	Dr	—	157	Mp	—	Flowing	20	—	
38	4110-7521	do.	—	—	1,325	Dr	—	—	Mp	—	Flowing	20	—	Salt water
39	4109-7923	do.	—	—	1,353	Dr	—	500	Mp	—	Flowing	—	—	
40	4110-7926	—	—	—	1,240	Dr	—	265	Mp	—	—	—	—	
41	4107-7929	—	—	—	1,145	Dr	—	385	Mp	—	—	—	—	Salt water
42	4106-7929	J. B. Miller	—	—	—	—	—	809	Mp	—	Flowing	250	D	Ca
46	4100-7926	—	—	—	1,331	Dr	—	2,677	Mp	—	—	—	—	
50	4103-7930	Rimersburg Borough	G. Schiner	1965	1,320	Dr	—	481	—	—	—	—	T	Sl
51	4103-7930	do.	do.	1965	1,265	Dr	6-1/4	243	IPa	1965	44.5	20	T	Sl
52	4103-7930	do.	do.	1965	1,255	Dr	—	228	IPa	1965	33.7	160	PS	Ca, Sl
53	4103-7930	do.	do.	1965	1,260	Dr	6-1/4	257	IPa	1965	34	150	PS	Sl
54	4103-7929	do.	Lurch	1962	—	Dr	10	250	IPa	1965	195	80	PS	Sl
55	4103-7929	do.	do.	1962	—	Dr	10	250	IPa	—	—	100	PS	Ca
56	4103-7929	do.	do.	1962	—	Dr	10	210	IPa	—	—	135	PS	Ca
57	4058-7936	East Brady Borough	G. R. Schiner	—	—	Dr	—	300	IPa	—	180	80	U	Sl
58	4158-7936	do.	R. L. Ostrander	1932	—	Dr	6-1/4	207	IPa	—	70	30	U	
59		do.	—	—	988	Dr	4-1/2	275	IPa	—	180	48	U	Ca, Sl
60		do.	Pennsylvania Drilling	1965	—	Dr	—	49	A1	—	—	—	U	Sl
61		do.	do.	1965	—	Dr	—	49	A1	—	—	—	U	Ca, Sl
62	4058-7937	do.	do.	1965	843	Dr	12	51	A1	12-22-65	22.75	200	PS	Ca, Sl
63	4058-7937	Rex Hide Inc.	do.	1962	—	Dr	6	49	A1	—	20	—	U	Sl
64	4113-7922	Clarion Water Co.	Sarny	1923	1,100	Dr	6-1/4	135	Mp	—	—	—	PS	Ca
65	4113-7922	do.	—	1924	1,100	Dr	6-1/4	—	Mp	—	—	—	PS	Ca
66	4113-7922	do.	—	1924	1,100	Dr	6	132	Mp	—	—	—	PS	Ca

67	4113-7922	do.	—	1924	1,100	Dr	6	132	Mp	—	—	54	PS	Ca
68	4113-7922	do.	—	—	1,100	Dr	6	134	Mp	—		54	PS	Ca
69	4113-7922	do.	—	—	1,100	Dr	6	—	Mp	—	—	54	PS	Ca
70	4113-7922	do.	—	—	1,100	Dr	6	—	Mp	—	—	54	PS	Ca
71	4113-7922	do.	—	—	1,100	Dr	6	—	Mp	—	—	54	PS	Ca
72	4113-7922	do.	—	—	1,100	Dr	6	—	Mp	—	—	54	PS	Ca
73	4113-7922	do.	—	—	1,100	Dr	6	—	Mp	—	—	54	PS	Ca
74	4113-7922	do.	—	1928	—	Dr	6-1/4	149	Mp	—	—	54	PS	Sl
75	4133-7922	do.	—	1926	—	Dr	6	—	Mp	—	—	—	U	
76	4113-7922	do.	—	1958	—	Dr	12	200	Mp	—	24.0	400	PS	Ca, Sl
77	4113-7922	do.	—	—	—	Dr	12	220	Mp	—	—	—	U	
78	4113-7922	do.	—	1958	—	Dr	12	225	Mp	—	46.0	500	PS	Ca, Sl
79		Sligo Borough	—	—	—	Dr	6	315	—	—	110	28	PS	Ca, Sl
80		do.	Moody Drilling Co.	1960	1,165	Dr	8	210	—	11-28-60	6	192	PS	Ca, Sl
81		Corner Water Supply	—	—	—	Dr	6-1/4	166	—	—	—	20	PS	Ca
82		do.	—	—	—	Dr	6	180	—	—	—	—	PS	Ca
83		do.	—	—	—	Dr	—	165	—	—	—	10	PS	Ca
84		Fryburg Water Co.	—	1939	—	Dr	6	215	IPp	—	—	20	PS	Ca
85		do.	—	1945	—	Dr	6	323	—	—	—	15	U	
86		do.	—	1958	—	Dr	6-1/4	230	—	—	175	10	PS	Ca, Sl
87		do.	—	1960	—	Dr	6-1/4	97	—	—	45	15	PS	

Table 6. *Sample Logs of Wells in Clarion County*

Well Cr-7

Owner: Klamath Coal Mine

Description	Thickness (feet)	Depth (feet)
Surface material	8	8
Shale, dark	13	21
Sandstone, gray	7	28
Shale, sandy, dark	8.7	36.7
Sandstone, hard, white	30.3	67.00
Shale, sandy, dark	3.5	70.5
Sandstone, hard, white	40.5	111.0
Shale, sandy, light, some sandstone	18.9	129.9

Well Cr-13

Owner: Rimersburg Borough

Description	Thickness (feet)	Depth (feet)
Surface material	10	10
Slate, gray	20	30
Sandstone	6	36
Slate, black	7	43
Coal	2	45
Fireclay	7	52
Sandstone	40	92
Slate, black	33	125
Coal	4	129
Fireclay	5	134
Shale, calcareous	14	148
Limestone	11	159
Well was bridged at 158 feet.		

Well Cr-14

Owner: Rimersburg Borough

Description	Thickness (feet)	Depth (feet)
Surface material	10	10
Slate, gray	20	30
Sandstone	6	36
Slate, black	7	43

Table 6. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Coal	2	45
Fireclay	7	52
Sandstone	40	92
Slate, black	33	125
Coal	4	129
Fireclay	5	134
Shale, calcareous	14	148
Limestone	11	159
Sandstone, white	2	161
Sandstone	10	171
Shale, sandy	29	200
Shale, gray	21	221
Slate, black	17	238
Sandstone	66	304
Hole plugged at 262 feet.		

Well Cr-18

Owner: Sligo Borough

Description	Thickness (feet)	Depth (feet)
Soil	2	2
Sandstone, gray	20	22
Slate, black	15	37
Sandstone, gray	27	64
Coal	3	67
Fireclay	6	73
Sandstone	4	77
Coal	1	78
Fireclay	3	81
Slate, black	14	95
Sandstone	55	150
Slate, black	8	158
Sandstone, gray	10	168
Fireclay	3	171
Slate, shaly	30	201
Sandstone, white	20	221
Slate and sandstone	5	226
Sandstone	72	298
Slate, gray	10	308
Sandstone, white	2	310

Table 6. *(Continued)*

Well Cr-21

Owner: Fryburg Water Co.

Description	Thickness (feet)	Depth (feet)
Unconsolidated material	100	100
Sandstone, white	90	190
Slate	8	198
Sandstone	10	208

Well Cr-50

Owner: Rimersburg Borough

Description	Thickness (feet)	Depth (feet)
Shale, silty, clayey, weathered, yellow brown	8	8
Shale, silty, some fine sand, fractured, brown	8	16
Sandstone, brown	7	23
Sandstone, light gray	13	36
Shale, soft, gray	6	42
Shale, soft, black	20	62
Shale, soft, dark gray	19	81
Shale, soft, gray	7	88
Sandstone, gray	3	91
Coal	1	92
Shale, soft, gray	19	111
Shale, sandy, dark gray	6	117
Sandstone, dark gray	1	118
Shale, sandy, dark gray	1	119
Sandstone, dark gray	1	120
Shale, dark gray to black	17	137
Coal	1	138
Sandstone, gray to brownish gray	7	145
Shale, gray	36	181
Shale; coal, black	1	182
Shale, gray to dark gray	34	214
Sandstone, trace of coal at 24 feet	28	242
Sandstone, gray	78	310
Shale, black	19	329
Shale, black and shells	23	352
Sandstone, white, some gray layers	129	481

Table 6. *(Continued)*

Well Cr-51

Owner: Rimersburg Borough

Description	Thickness (feet)	Depth (feet)
Surface material	26	26
Coal	3	29
Shale	1	30
Sandstone, white	6	36
Sandstone, gray	3	39
Shale	21	60
Limestone	9	69
Shale, sandy, some limestone beds	26	95
Sandstone, fractured	5	100
Shale, sandy	8	108
Shale, black	2	110
Sandstone, fractured	6	116
Shale, sandy	13	129
Shale, black	2	131
Shale, sandy	10	141
Sandstone, fractured	2	143
Shale, sandy	4	147
Sandstone, fractured	10	157
Shale, sandy	8	165
Sandstone, gray	47	212
Sandstone, white	5	217
Shale, black, sandy	2	219
Sandstone, fractured	3	221
Sandstone, dark gray	22	243

Well Cr-52

Owner: Rimersburg Borough

Description	Thickness (feet)	Depth (feet)
Surface material	26	26
Sandstone, gray	1	27
Sandstone, hard, gray	13	40
Shale	16	56
Limestone	11	67
Shale	10	77
Shale, black	3	80
Shale, gray	8	88

Table 6. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Shale, black	2	90
Sandstone	7	97
Shale	6	103
Shale, black	2	105
Sandstone, light gray	8	113
Shale, sandy, gray	13	126
Shale, sandy, black	1	127
Shale, sandy, gray	24	151
Sandstone, medium-grained, gray	6	157
Shale, sandy	17	174
Sandstone, medium-grained, gray	13	187
Sandstone, medium-grained, brown	4	191
Sandstone, medium-grained, gray	21	212
Shale, sandy	9	221
Sandstone, soft, gray	7	228

Well Cr-53

Owner: Rimersburg Borough

Description	Thickness (feet)	Depth (feet)
Shale, weathered	27	27
Coal	3	30
Shale	16	46
Limestone	1	47
Shale	5	52
Limestone	12	64
Shale, sandy	23	87
Coal, shaly	3	90
Sandstone, white	6	96
Shale, sandy	8	104
Shale, black	3	107
Sandstone, gray	12	119
Shale, sandy	9	128
Shale, black; some coal	3	131
Shale, sandy	34	165
Sandstone	16	181
Sandstone, fractured	17	198
Sandstone	9	207
Shale, sandy	9	216
Sandstone, fractured	15	231
Sandstone, gray	12	243
Sandstone, fractured	2	245
Shale, sandy, gray	3	248
Shale, sandy, black	9	257

Table 6. *(Continued)*

Well Cr-54

Owner: Rimersburg Borough

Description	Thickness (feet)	Depth (feet)
Clay, brown	10	10
Clay, gray	8	18
Clay, sandy	12	30
Coal	3	33
Shale, black	2	35
Sandstone, gray	5	40
Shale, gray	12	52
Limestone	16	68
Shale, gray	8	76
Shale, dark gray	14	90
Coal	2	92
Shale	7	99
Coal	4	103
Shale, gray	12	115
Sandstone	3	118
Shale, gray	12	130
Coal	1	131
Shale, gray	24	155
Sandstone	50	205
Sandstone	53	258
Shale, black, coal shines	6	264
Limestone and shale	11	275
Shale, black	15	290

Well Cr-57

Owner: East Brady Water Co.

Description	Thickness (feet)	Depth (feet)
Clay	11	11
Coal	1	12
Shale	14	26
Sandstone, soft	12	38
Shale	7	45
Slate, black	2	47
Coal	2	49
Clay	6	55
Shale	2	57
Sandstone	9	66
Shale	3	69
Sandstone	2	71

Table 6. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Slate	15	86
Coal	6	88
Clay	2	90
Sandstone, gray	200	290
Sandstone, white	10	300

Well Cr-59

Owner: East Brady Water Co.

Description	Thickness (feet)	Depth (feet)
Sand and clay	20	20
Shale, gray	15	35
Coal	2	37
Clay, white	5	42
Sandstone, soft	14	56
Slate, gray	9	65
Coal	1	66
Clay, white	6	72
Sandstone, brown	15	87
Slate, soft, gray	3	90
Coal	3	93
Clay, white	4	97
Sandstone, hard, white	97	194
Clay, brown	1	195
Sandstone, hard, white	70	265
Slate, black	1	266
Sandstone, hard, white	9	275

Well Cr-60

Owner: East Brady Water Co.

Description	Thickness (feet)	Depth (feet)
Clay, sandy	8	8
Clay, gravel, sand	40	48
Sandstone	1	49

Table 6. *(Continued)*

Well Cr-61

Owner: East Brady Water Co.

Description	Thickness (feet)	Depth (feet)
Topsoil	1	1
Sand	14	15
Gravel, very coarse, some clay	14	29
Gravel, coarse, some sand	19	48
Sandstone	1	49

Well Cr-62

Owner: East Brady Water Co.

Description	Thickness (feet)	Depth (feet)
Topsoil, sandy	12	12
Gravel and clay	9	21
Gravel, very coarse, some sand	29	50
Sandstone	1	51

Well Cr-63

Owner: Rex Hide Inc.

Description	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sand and clay	13	15
Gravel, coarse; sand, clay	5	20
Gravel and sand	15	35
Gravel	5	40
Gravel, sand, clay	5	45
Sand, clay	4	49

Table 6. *(Continued)*

Well Cr-74

Owner: Clarion Water Co.

Description	Thickness (feet)	Depth (feet)
Surface material	14	14
Sandstone, gray	16	30
Slate, gray	8	38
Shale	12	50
Sandstone, red	20	70
Sandstone, gray	13	83
Shale, gray	9	92
Sandstone, red	12	104
Slate, dark gray	35	139
Sandstone, gray	10	149

Well Cr-76

Owner: Clarion Water Co.

Description	Thickness (feet)	Depth (feet)
Surface material	29	2
Gravel and sand	8	37
Gravel and clay	18	55
Slate, gray	9	64
Sandstone, gray	9	73
Sandstone, red	6	79
Slate, gray	25	104
Sandstone, white	21	125
Sandstone, gray	47	172
Shale, gray	3	175
Sandstone, gray	25	200

Well Cr-78

Owner: Clarion Water Co.

Description	Thickness (feet)	Depth (feet)
Gravel and sand	61	61
Slate	23	84
Sandstone, white	11	95
Sandstone, red	15	110
Slate	30	140

Table 6. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Sandstone, white	15	155
Sandstone, gray	25	180
Slate	6	186
Sandstone, gray	34	220
Slate	2	225

Well Cr-79

Owner: Sligo Borough

Description	Thickness (feet)	Depth (feet)
Surface material	30	30
Coal	4	34
Clay	12	46
Limestone	6	52
Shale and slate	18	70
Coal	4	74
Shale and clay	26	100
Sandstone	50	150
Slate	8	158
Coal	2	160
Sandstone	10	170
Slate	26	196
Sandstone	3	199
Slate and shale	37	236
Sandstone	6	242
Slate and shale	18	260
Sandstone	15	275
Slate	5	280
Sandstone	24	304
Slate and shale	11	315

Well Cr-80

Owner: Sligo Borough

Description	Thickness (feet)	Depth (feet)
Topsoil	1	1
Sandstone, brown	10	11
Shale, dark gray	34	45
Slate and sandstone	33	78

Table 6. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Sandstone, white	12	90
Shale, black	31	121
Sandstone, gray; some slate, black	39	160
Sandstone, white	50	210

Well Cr-86

Owner: Fryburg Water Co.

Description	Thickness (feet)	Depth (feet)
Sandstone, brown; some shale	35	35
Shale	10	45
Limestone	7	52
Shale, gray; some sandstone lenses	38	90
Coal	2	92
Slate, black	3	95
Shale, white, calcareous layers	4	99
Shale, light gray	2	101
Sandstone; some shale	12	113
Sandstone, hard, white	34	147
Sandstone, gray	2	149
Sandstone, white	44	193
Sandstone, gray; some shale	23	216
Shale, gray	7	223
Sandstone, gray	4	227
Sandstone, brown	3	230

alluvium now covers only a small area along the river at East Brady, Foxburg, and several isolated places along Redbank Creek.

Water-Bearing Characteristics

Alluvium is porous and where saturated will yield large supplies of water to wells. Where alluvium partly fills the valley, that part of the material lower than the stream bed may be recharged by water from the stream.

Well Depths and Yields

Two of the wells drilled in the alluvium in Clarion County were completed at a depth of 50 feet and did not penetrate the full thickness of the unconsolidated material. Two other wells encountered bedrock at 48 and 50 feet. The yields of these four wells ranged from 50 to 200 gpm.

Well Location and Spacing

Wells drilled in alluvium should be located parallel to any associated stream to minimize interference between wells. This parallel alignment to the stream also will increase the amount of recharge to the alluvium from the stream when the wells are pumped. Exact distances between wells and between the stream and wells should be determined after the areal extent, saturated thickness, and permeability of the alluvium are known.

Water Quality

Three partial chemical analyses (Table 3) are available and they show the water in the alluvium to be moderately hard, very low in chlorides, and low in iron and bicarbonate.

CONEMAUGH GROUP

Lithology and Structure

The Conemaugh Group in Clarion County consists of consolidated gray shale with interbeds of sandstone that are, in places, conglomeratic. Thin coal and limestone beds occur, but are not continuously persistent. Only the lower part of the Conemaugh is present in Clarion County and it caps only the higher hills in the southern part of the county. The group dips 40 feet per mile to the southwest.

Water-Bearing Characteristics

Because of its small areal extent and topographic position on hilltops, this formation is of little value as a source of water.

There are no known wells in Clarion County that obtain water from the Conemaugh Formation.

ALLEGHENY GROUP

The Allegheny Group includes all the rock between the top of the Upper Freeport coal and the base of the Brookville coal. The individual units of the Allegheny Group differ in thickness from place to place. Thinning of one seems to be accompanied by thickening of another, with the result that the group as a whole has a rather uniform thickness.

Lithology and Structure

The Allegheny Group contains seven coal beds or horizons separated by shales, sandstones, limestones and clay. Coarse sandstone beds are prominent in some places, although in others there appears to be no massive sandstone. Throughout most of the group the shales are gray, but in the middle and upper portions greenish-gray shales are not uncommon.

The beds dip 40 to 50 feet per mile to the southwest.

Water-Bearing Characteristics

The pore spaces in the shale and coal beds are very small and these units generally yield small amounts of ground water. Most of the higher yields of ground water in the Allegheny Group are from the more permeable sandstone and limestone members. Ground water occurs in and moves through pore spaces and fractures in the sandstone and in the secondary openings (fractures and solution cavities) in the limestone. The size and number of the openings differ from bed to bed within the geologic group; thus, some beds yield more water to wells than others. These openings in the geologic units allow downward percolation of precipitation to recharge the aquifers. The downward percolation of water through the rocks is sometimes retarded by clay or other less permeable beds. When the water reaches one of these less permeable zones it will move laterally to a point of discharge or until it can again move downward to the zone of saturation.

Well Depths and Yields

The Allegheny Group is a reliable source of small to moderate supplies of ground water. Some wells yield more than 100 gpm, but if yields of 35 gpm or more are desired, wells should be drilled to depths of at least 250 feet. The deepest water well reported in the Allegheny Group was drilled 300 feet and produced 80 gpm. The highest reported yield (160 gpm) was from a well 228 feet deep.

Sufficient water for domestic purposes can be obtained at almost any location from wells that are drilled 80 to 100 feet below the water table, but yields large enough for industrial and municipal purposes are more difficult to obtain. If large supplies are sought, test wells should be drilled to find the best site for a production well.

Well Location and Spacing

Wells in valleys, where the water table is close to the land surface, have more available drawdown than wells of the same depth on hills. Well spacing is generally not critical when water is being pumped for domestic purposes, but wells used for industrial and municipal purposes should be spaced sufficiently far apart to prevent mutual interference. Where several pumping wells are closely spaced, the cones of depression coalesce and the yield of each well is reduced. Wells less than 500 feet apart in the Allegheny Group have generally shown some interference.

Water Quality

Chemical analyses of ground water in the Allegheny Group show it to be of the calcium bicarbonate type when the concentrations of dissolved solids are less than 500 mg/l (milligrams per liter) and of the calcium sulfate type when the dissolved solids are greater than 500 mg/l. The median dissolved-solids content is about 260 mg/l. The median hardness as $CaCO_3$ is about 94 mg/l. Total iron in the water runs high. The median for iron is about 2.1 mg/l. Except for the high iron content the water from the Allegheny Group almost always meets U. S. Public Health Service standards for mineral content (U. S. Dept. of Health, Education and Welfare, 1964).

POTTSVILLE GROUP

Lithology and Structure

The Pottsville Group in Clarion County consists of consolidated sandy shale, coal and sandstone. The sandstone members are light gray, coarse grained and massive. In some parts of the county they are loosely cemented.

The classical interpretation of this unit taken from the Foxburg-Clarion Folio (Shaw and Munn, 1911) is that the Homewood Sandstone, where present, is the top unit of the Pottsville Group. It is a coarse-grained, cross-bedded, massive rock. In some places sandy shale zones are present. The Homewood Sandstone's average thickness is about 40 feet. The Mercer coals and Shale lie between the Homewood Sandstone and the Connoquenessing Sandstone. The Connoquenessing is a coarse, massive rock ranging in thickness from 30 to 50 feet. The beds dip 40 to 50 feet per mile to the southwest.

Recent work has shown that this description drawn from the Foxburg-Clarion Folio (Shaw and Munn, 1911) is not entirely correct. The probable correct interpretation (William E. Edmunds, 1973, personal commun.) of the geologic column given in the Folio is as follows:

F-C Folio	Probable correct interpretation
Craigsville coal	Brookville coal
Brookville coal	Upper Mercer coal
Homewood Sandstone	Unnamed sandstone
Mercer coal and Shale	Lower Mercer coal and shale
Connoquenessing Sandstone	Upper Connoquenessing sandstone

The Homewood Sandstone, where present in western Pennsylvania, lies between the Upper Mercer coal and the base of the Brookville coal. In the Folio, no Homewood Sandstone is shown between the Brookville and Upper Mercer coals, although it is unlikely that the Homewood is missing entirely.

Water-Bearing Characteristics

Ground water in the Pottsville Group occurs in pore spaces between the grains and in secondary openings (such as fractures) in the rock. The size of the openings between the grains differs with the degree of sorting of the original material and with the amount of cementation that binds the grains together. The sandstones, coals and shales in the group differ in their water-bearing characteristics because of the difference in grain size and the degree of sorting. The Lower Mercer coal and shale interval is a poor water-producing unit because the fineness of the sediments allows little water storage or movement. The unnamed sandstone between the Upper and Lower Mercer coals and the Upper Connoquenessing sandstone are coarse grained, well sorted, and yield moderate amounts of water to wells.

Well Depths and Yields

The highest yields and specific capacities (yield per unit of drawdown) reported are for wells tapping both the unnamed sandstone and the Upper Connoquenessing sandstone. The average reported yield for wells in this group is 28 gpm. This average yield probably would be higher if all the wells fully penetrated both the unnamed sandstone and the Upper Connoquenessing sandstone. The yields of two wells known to fully penetrate these sandstones are 80 and 150 gpm.

Well depths in the Pottsville Group range from 76 to 262 feet. Some of the deeper wells may obtain some water from the overlying geologic formations.

Well Location and Spacing

Wells drilled in the Pottsville Group should be located where they will penetrate the greatest saturated thickness of the most permeable beds. The Pottsville Group is exposed in the deeper valleys so that wells located to tap only these rocks will have to start near the valley floor. Data concerning proper well spacing are lacking, but wells should be placed as far apart as possible.

Water Quality

Analyses of the water from the Pottsville Group are presented in Table 3. Most of the waters are from the sandstones and three samples are very high in iron. The median concentration of dissolved iron is about 6.82 mg/l. Excessive concentration of iron should be removed by treatment to make the water acceptable for most uses. The median hardness as $CaCO_3$ is about 94 mg/l.

POCONO GROUP

Two formations of the Pocono Group crop out or occur very near the surface in Clarion County. The two formations are the Burgoon Sandstone and the underlying Cuyahoga Formation. These two formations are exposed only in the valley bottoms of the major streams. The Cuyahoga Formation (the lower unit of the two) is exposed a few miles northwest of Clarion County but is not considered a good aquifer because it is a hard sandy shale.

Lithology and Structure

The Burgoon is generally a medium- to coarse-grained sandstone, and in places contains lenses of shale. It is gray to white in color, though commonly stained by iron. The Burgoon Sandstone has a thickness of 300 to 320 feet. The beds dip to the south at about 40-50 feet per mile. As in other rock units, folding in the Pocono is gentle and follows the northeast-southwest trend of regional structure.

Water-Bearing Characteristics

Ground water moves through the pore spaces and fractures in the sandstone. The ground-water movement is retarded in areas where lenses of shale are interbedded in the sandstone. The size of the openings between the grains differs with the amount of cementation that binds the grains together and the amount of shale material. The drawdown will be rather large in wells that encounter shale lenses or sandstone beds that are well cemented.

Good supplies of water can generally be obtained from the Burgoon Sandstone, although only small supplies will be obtained where the sandstone is shaly.

Well Depths and Yields

The Burgoon Sandstone of the Pocono Group is a reliable source of ground water. Some wells yield more than 200 gpm and a yield of 500 gpm was obtained in one well. The yield of a well in the Burgoon Sandstone is not dependent upon the depth. Some wells drilled less than 100 feet deep yield up to 50 gpm, while other wells drilled over 300 feet deep yield less than 50 gpm. The yield of a well depends mostly upon the amount of shale interbedded in the sandstone or the number of fractures the well intersects. The more shale zones encountered, the lower the well yield. Several deep oil and gas test wells have been plugged back to the middle of the Burgoon Sandstone because salt water was encountered in the lower part of this formation. No information is available concerning the depths of the Cuyahoga Formation, but probably water encountered in it would be highly mineralized.

Well Location and Spacing

Wells located in the bottom of the major stream valleys would encounter the Burgoon Sandstone at or near the surface. In the upland areas it would be easier to develop a well in an overlying aquifer than in the Burgoon. Data concerning proper well spacing are lacking, so wells should be spaced as far apart as possible to minimize interference.

Water Quality

Ground water from the Pocono Group in Clarion County is generally highly mineralized in the lower part and high in iron. The median value for total iron is 4.0 mg/l. The highest total iron is 14 mg/l and the lowest total iron is 0.3 mg/l. The median dissolved-solids content is about 350 mg/l. The total hardness of the ground water from the Pocono Group ranges from 42 mg/l to 370 mg/l, and the median hardness is 110 mg/l. Most ground water from the Burgoon Sandstone requires softening and iron removal.

It is reported that water from several flowing wells in the Burgoon near Sligo is highly mineralized, but chemical analyses of water from these wells are not available. There are many old oil and gas wells drilled in other parts of Clarion County that encountered artesian water in the Burgoon Sandstone, but the water from most of them was reported to be salty or highly mineralized.

STRUCTURE

There are several major folds in the consolidated rocks in Clarion County. These folds trend northeastward, essentially parallel to the Appalachian structure that is prominent in the region to the southeast of the area here described. The axes of the major folds are shown in Plate 1. Ground water in folded rocks tends to move down the dip of the beds and when confined by less permeable material will build up artesian pressure. Part of the ground water in dipping beds discharges in springs and seeps along the flanks of the synclines.

Fractures

Fractures occur in all of the consolidated rocks in Clarion County. As ground water can move freely through the fractures, wells penetrating fractures generally yield the most water. A study of aerial photographs of Clarion County could help locate the larger fractures. Locating a well on a fracture or at the intersection of fractures should give the best production of ground water.

HOW MAN HAS CHANGED THE HYDROLOGIC SYSTEM

PRESENT STATUS OF DEVELOPMENT

The hydrologic system in Clarion County began to change early in the development of the area. Initially, homes were located near readily available water supplies, such as streams and springs. Shallow wells soon supplemented these sources, because increased population along streams caused pollution, many streams dried up in the summer, and people wished to build homes farther from flood-prone streams. Eventually, almost every house had a shallow dug well from which water was withdrawn from the upper few feet of the aquifer. As the population density increased, many individually owned wells were abandoned and public-supply wells were installed. These public-supply wells were, in most cases, drilled wells that pumped water from deeper aquifers; also, several springs were developed for use in the municipal systems. A few wells were drilled for industrial use.

Additional supplies of ground water could be developed in many parts of Clarion County. The major stream valleys could be important for ground-water development, because the water table is near the land surface and in places the valley has been filled with unconsolidated material. Much of the area in the northern part of the county could be further developed, because the ground-water supply there is not being utilized.

Ground-Water Pumpage

Several Clarion County municipalities and urban communities use ground water for public supplies. The locations of these communities are shown in Figure 3, and ground-water pumpage is summarized in Table 7.

Surface-Water Pumpage

Two communities in Clarion County get their water supplies from streams. The Boroughs of Hawthorn and New Bethlehem take 600,000 and 200,000 gallons per day, respectively, from Redbank Creek.

WATER PROBLEMS RESULTING FROM THE ACTIVITIES OF MAN

CONTAMINATION OF GROUND WATER

Coal Mining Operations

The corrosive effect of acid mine water on plumbing, concrete, and steel structures is well known. As the coal was mined in Clarion County, precipitation

Table 7. *Summary of Ground-Water Pumpage for Municipal and Urban Communities in Clarion County*

Supplier	Number of wells	Number of springs	Average daily yield for 1968 in thousands of gallons
Clarion County Water Co.	3	—	400
East Brady Water Works Co.	2	2	50
Foxburg Area Water and Sewer Authority	5	—	23
Fryburg Water Co.	2	—	14
Knox Borough	7	—	140
Corner Water Supply Co.			
Village of Marianne	3	—	12
Perryville Cooperative System	—	3	—
Rimersburg Borough	2	—	100
Shippensburg Borough	2	—	24
Sligo Borough	3	—	42
St. Petersburg Borough	1	1	30
West Freedom Cooperative System	1	1	—

accumulated in the strip mines, leaked into the underground mines, or percolated through the spoil piles, and came into contact with pyrite, forming sulfuric acid. This acid water recharged the underlying aquifers. It is reported that this acid-mine water has contaminated the sandstone aquifers in several parts of Clarion County.

Oil and Gas Well Operations

Several hundred wells were drilled in Clarion County in the search for oil and gas. Many of these wells were nonproductive and the casings were removed or the well site was covered over. In wells where the casing was removed, highly mineralized water under artesian pressure could move up the borehole and contaminate any fresh-water zones encountered. In some wells where the casing was left in place, salt water has corroded holes in the casing and is now leaking into the overlying fresh-water aquifers. To locate and plug all these old wells would be an expensive and difficult job.

CONTAMINATION OF SURFACE WATER

Coal Mining Operations

As explained in the preceding section, acid water formed in and around coal mines drains into the streams and contaminates parts or all of them. Many of the smaller streams in Clarion County are discharging acid water into either the Clarion River or Redbank Creek.

Oil and Gas Well Operations

Many of the oil wells in the county have old corroded casings and pumps that leak some petroleum onto the land surface. When storms occur, crude oil that has leaked out of the wells can be washed into the streams. Many of the oil and gas wells contain highly mineralized water under artesian pressure and some of these wells are leaking at the surface. This salt water also may be carried into the streams. These sources of contamination are not a major problem, but with time more well casings may corrode and leak larger volumes of highly mineralized water.

DEVELOPMENT OF WELLS

DRILLING METHODS

Dug wells in Clarion County are being replaced gradually by drilled wells. Two methods are used to drill most of the wells in Clarion County, the cable-tool percussion method and the rotary-drilling method.

In the cable-tool percussion method, wells are drilled by alternately lifting and dropping a heavy drill bit in the borehole. The drill bit breaks or crushes the rock into small fragments, which are then removed from the hole. In the rotary-drilling method, wells are drilled by a rotating bit, and the rock chips are removed by circulating water, drilling mud, or compressed air in the borehole. Well diameters for drilled wells are smaller than those of dug wells, but depths and yields of drilled wells usually are much greater.

WELL-DEVELOPMENT METHODS

In Clarion County, well development usually consists of pumping the borehole for a period of time to clean out drill cuttings. In consolidated rocks, higher well yields might be obtained through development techniques such as mechanical surging, use of explosives, treating the well with chemicals, or by hydrofracturing.

Mechanical surging is similar to operating a piston in a cylinder, with the well bore or casing acting as the cylinder and the surge block acting as the piston. Raising and lowering of the surge block in the well forces the water in and out of openings in the rock. Any loose rock chips, clay or sand grains are drawn into the well bore and can be cleaned out after the surging has stopped. This method is most successful in sand and gravel or poorly cemented sandstones and conglomerates. Alluvium and sandstone formations in the Pottsville Group and in some of the sandstone beds in the Allegheny Group might yield more water to wells if they were developed by surging. The Burgoon Sandstone is poorly cemented, and surging could aid in the development of wells.

An explosion in a well will fracture the rock and permit easier passage of water into the borehole. Explosives are not always successful in developing higher well yields, but they may be tried in the dense and brittle sedimentary rocks. In the more resistant rocks in Clarion County, such as the Vanport Limestone of the Allegheny Group and some of the highly cemented rocks, explosives could be used to develop higher well yields.

Developing wells by using chemicals can increase well yields in certain types of rock. In carbonate rocks, for example, acid is pumped down the borehole and forced into openings. The acid reacts with the rock, enlarging the openings. Acid is then pumped out of the well, and the enlarged openings may allow more water to enter the borehole. Detergents can be used in wells where very fine-grained material is plugging fractures in the aquifer. The detergents loosen small particles so that they can be pumped out of the well, thereby opening the fractures.

Hydrofracturing is a well-development method that introduces water and sand into the well under high pressure. The water and sand are forced into fractures and when the pressure is released the sand grains keep the fractures from closing. This then allows more water to pass through the fractures.

MANAGEMENT OF WATER SUPPLIES

PROTECTION FROM OVERDRAFT

There is no known overdraft of ground water anywhere in Clarion County. Overdraft should be guarded against in any future expansion of well fields or where additional large ground-water supplies are needed. Test wells should be drilled first and, if possible, the interference between wells determined before any final production well is completed. After wells are completed, periodic water-level measurements should be made to determine the long-term trend of water-table fluctuations and the effect of pumping.

PROTECTION FROM POLLUTION

A primary consideration in protecting a ground-water supply is to keep it free of pollutants. Pollutants may be carried downward from the land surface by infiltrating water or moved laterally from adjacent areas. Because ground-water movement is relatively slow, such pollutants are slow to accumulate, but they are just as slow or slower to disperse after the polluting source is removed. The part of the aquifer updip from wells and nearby recharge areas should be kept free of possible sources of pollution such as sanitary landfills and septic tanks.

Government agencies are becoming increasingly active in the field of pollution prevention. For example, the Pennsylvania Department of Health has set standards for length and cementing of casing in wells. The Pennsylvania Bureau of Mines and Mineral Industries, Department of Environmental Resources, has regulations on the backfilling of strip mines to reduce the formation of acid water in the stripped areas.

As discussed in an earlier part of this report, the leakage of highly mineralized water from oil and gas wells is polluting some of the fresh-water aquifers. The pumping of large volumes of water would cause increased amounts of mineralized water to be drawn into the fresh-water aquifers, thereby causing additional pollution. A program to control pumping rates and the amount of drawdown in areas that are affected by such pollution would reduce the movement of highly mineralized water into fresh-water aquifers. Periodic analysis of water from wells would allow early detection of any increase in salt-water concentrations.

It is everyone's responsibility to protect water supplies from pollution. Too often the public blames industry for pollution, and sometimes rightly so; however, many people deposit trash, garbage, sewage, and other waste products haphazardly without thinking about how it will affect their own water supply or that of others.

WHERE TO GET INFORMATION ABOUT WATER

The Pennsylvania Topographic and Geologic Survey has information on the geology of Clarion County and has published a report describing in detail some of the aquifers that underlie Clarion County and the chemical quality of the ground water (Leggette, 1936). Well drillers' logs and reports on new wells that have been drilled in the county are also available.

The Private Water Supply section, Division of Sanitation, Bureau of Health, Pennsylvania Department of Environmental Resources, can supply information on proper well construction requirements, biological reports on well water, and the chemical quality of ground water in Clarion County. The Pennsylvania Department of Environmental Resources, Bureau of Health, through various regional offices, can test water samples for bacterial pollution. The nearest regional Health Department testing laboratory is in Meadville. They also can advise corrective measures when pollution is reported.

The Water Resources section of the Pennsylvania Department of Environmental Resources, Office of Engineering and Construction, has information on stream discharges, flood data, reservoir requirements, and power plant discharges.

The Public Utility Commission, Bureau of Rates and Research, has information on some municipal water supplies, including source, average daily use, total annual use, and estimated future needs.

The Water Resources Division of the U. S. Geological Survey has data on wells, springs, and streams, and on the chemical quality of water.

When requesting information on water supplies, give an accurate location of the site about which you wish information. This will help the above-listed agencies to assist you with your problem.

Local well drillers and pump installers can provide prices and suggest the type of equipment needed to develop a water supply. Also, local drillers will have experience on the drilling depth necessary to obtain adequate yields, and how much casing is required. They can also suggest the proper well diameter for the necessary pumping equipment. Pump installers can supply information concerning the size of the pump, depth of the pump setting, and pressure-tank capacity.

If chemical analysis of the well water indicates that treatment is necessary, commercial water-treatment companies can provide necessary information and equipment. Equipment for water treatment can be purchased or rented, and can be serviced by the supplier.

GLOSSARY

Aquifer: A formation, group of formations or part of a formation that is water bearing.

Artesian conditions: The occurrence of ground water under sufficient hydrostatic head to rise above the upper surface of the aquifer.

Base flow: Discharge entering stream channels as effluent from the ground water reservoir; the fair-weather flow of streams.

Cubic feet per second: The discharge of a stream of rectangular cross section, 1 foot wide and 1 foot deep, whose velocity is 1 foot per second; equivalent to 448.8 gallons per minute.

Cone of depression: A conical depression, on a water table or piezometric surface, produced by pumping a well.

Direct runoff: The water that moves over the land surface directly to streams promptly after rainfall or snowmelt.

Dip of beds: The angle at which a formation or bed is inclined from the horizontal, measured at a right angle to the strike.

Discharge, ground-water: The process by which water is removed from the zone of saturation; also the quantity of water removed.

Drawdown: The lowering of the water table or piezometric surface caused by pumping (or artesian flow).

Evapotranspiration: Water withdrawn from a land area by direct evaporation from water surfaces and moist soil and by plant transpiration.

Fault: A fracture or fracture zone along which there has been displacement of the two sides relative to one another parallel to the fracture. The displacement may be a few inches or many miles.

Fracture: A break in rocks.

Ground-water reservoir: An aquifer or a group of related aquifers.

Head (hydrostatic head): The height of a vertical column of water, the weight of which, in a unit cross section, is equal to the hydrostatic pressure at a point.

Homocline: A structural condition in which the beds dip uniformly in one direction.

Hydraulic gradient: The rate of change of hydrostatic head per unit of distance of flow at a given point and in a given direction.

Perched ground water: Ground water separated from an underlying body of ground water by unsaturated deposits.

Permeability: The capacity of a material to transmit a fluid.

Piezometric surface: The surface to which the water from a given aquifer will rise under its full head.

Porosity: The ratio of the aggregate volume of interstices in a rock or deposit to its total volume, expressed as a percent.

Recharge, ground-water: The process by which water is added to the zone of saturation; also, the quantity of water added.

Runoff: That part of the precipitation that appears in surface streams.

Saturation, zone of: The zone in which interconnected interstices are saturated with water under pressure equal to or greater than atmospheric.

Specific capacity: The yield of a well, in gallons per minute, divided by the drawdown of water level in the well, in feet, during pumping.

Stream-gaging station: A gaging station where a record of discharge of a stream is obtained. Within the Geological Survey this term is used only for those gaging stations where a continuous record of discharge is obtained.

Surface water: Water on the surface of the earth.

Transpiration: The quantity of water absorbed and transpired and used directly in the building of plant tissue, in a specified time; also the process by which water vapor escapes from the living plant, principally the leaves, and enters the atmosphere.

Unconformity: A surface of erosion that separates younger strata from older rocks.

Underflow: The movement of water in the ground-water reservoir; also the quantity of water moving in the ground-water reservoir through any vertical plane.

Vadose water: Water in the zone of aeration.

Water table: The upper surface of the zone of saturation, except where the surface is formed by an impermeable body.

Water-table conditions: The conditions under which water occurs in an aquifer that is not overlain by an impermeable body and that has a water table.

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