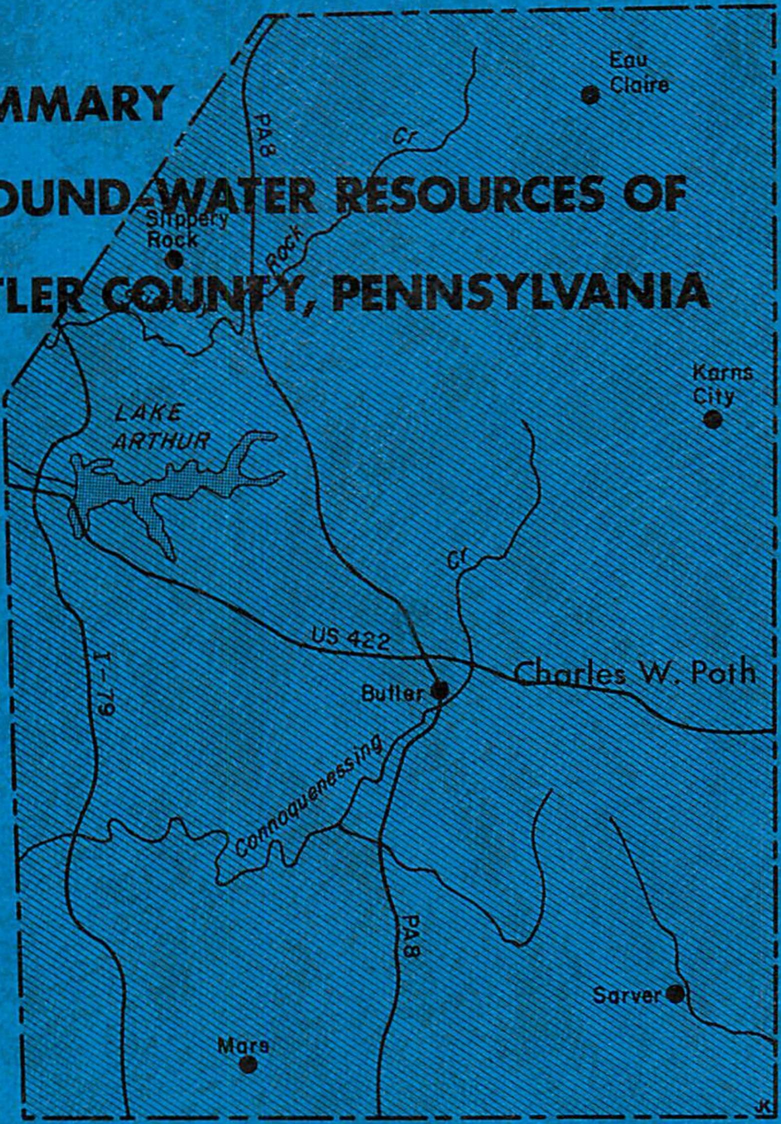
Water Resource Report 36

1973

SUMMARY GROUND-WATER RESOURCES OF BUTLER COUNTY, PENNSYLVANIA



Charles W. Poth

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF
TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

Water Resource Report 36

SUMMARY

GROUND-WATER RESOURCES OF BUTLER COUNTY, PENNSYLVANIA

by Charles W. Poth
U. S. Geological Survey

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

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PREFACE

This report is presented as a comprehensive description and inventory of the ground-water resources available in Butler 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 the 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 users of water in Butler 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 BUTLER COUNTY, PENNSYLVANIA

by
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ABSTRACT

The geologic units in Butler County include the Mississippian Pocono Group, the Pennsylvanian Conemaugh, Allegheny and Pottsville Groups, and unconsolidated Quaternary deposits. The Quaternary outwash deposits and some of the Quaternary lacustrine deposits are highly permeable and are capable of yielding 100 gpm or more to wells. Rocks of the Conemaugh Group underlie about two-thirds of the county. Reported yields of wells in the Conemaugh range from less than 5 gpm to more than 100 gpm; about half of the wells yield 20 gpm or more. The Allegheny Group crops out in the northern half of the county and along the major stream valleys throughout the county. This group is capable of supplying moderate amounts of water to wells. Yields range from less than 5 gpm to more than 100 gpm, and about half the wells yield 50 gpm or more. The Pottsville Group crops out along the major stream valleys in the northern part of the county. Yields of wells in the Pottsville range from less than 5 gpm to more than 300 gpm, and average 36 gpm. The Burgoon Sandstone of the Pocono Group occurs in the northeastern part of the county along the Allegheny River and the lower reaches of Bear Creek. It is an excellent aquifer; reported yields range from 9 to 260 gpm and average 82 gpm.

High iron content is the main water quality problem in the county. In 23 of 48 samples analyzed, iron concentrations exceed the maximum recommended by the U.S. Public Health Service.

There is no known overdraft of ground water anywhere in the county, except in the vicinity of active mines, where the water table is being lowered to facilitate mining.

The locations of sources of pollution, such as sanitary landfills and septic tanks, are a major factor in the selection of well sites. The discharge from abandoned strip and deep mines is a major source of pollution. The hundreds of oil and gas wells that were abandoned and not properly plugged are another source of pollution. In many of these wells, salt water has moved up the boreholes and contaminated shallow freshwater aquifers.

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.

LOCATION AND GENERAL GEOGRAPHIC FEATURES

Butler County encompasses an area of about 795 square miles in west-central Pennsylvania (Figure 1). The county is bordered on the north by Venango County, on the east by Armstrong County, on the south by Allegheny County, and on the west by Mercer, Lawrence, and Beaver Counties. The city of Butler, the county seat, is 34 miles north of Pittsburgh and 218 miles northwest of Harrisburg.

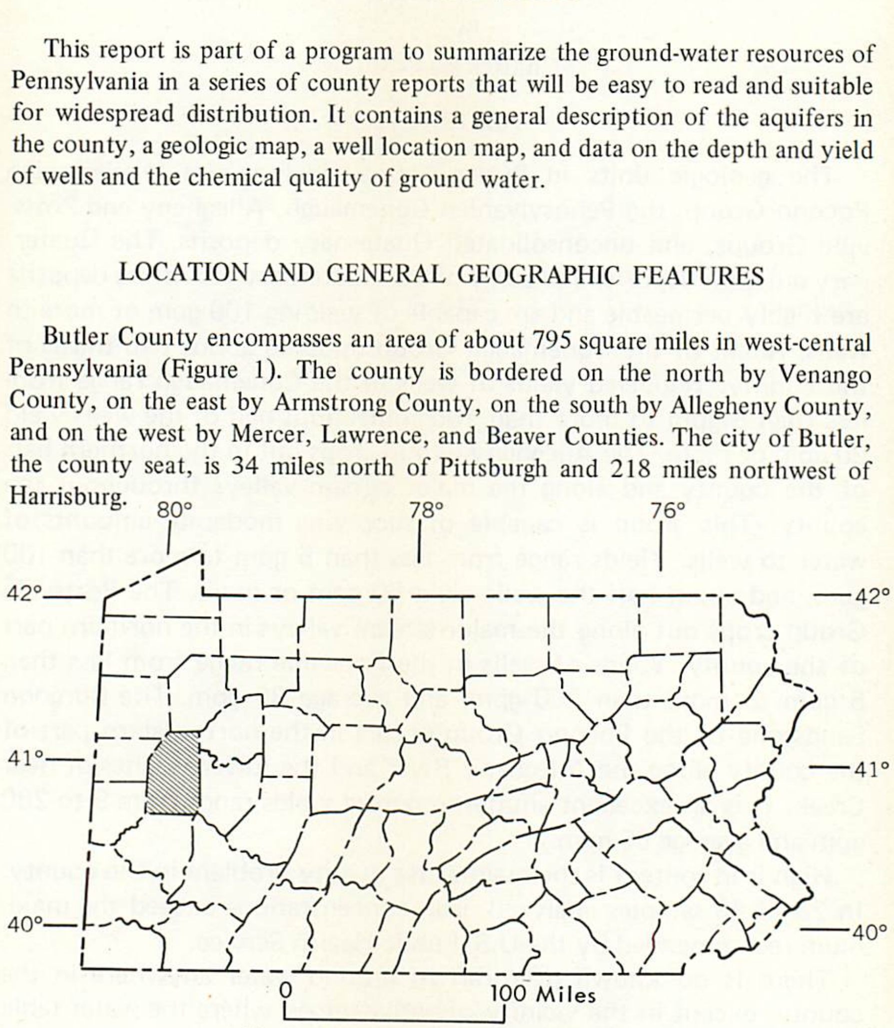


Figure 1. Location of Butler County.

POPULATION TRENDS

The population of Butler County during most of the last 50 years has grown at a slowly increasing rate. In the last decade, however, the rate has been about the same as that of the 1950 to 1960 decade. Table 1 shows the results of the decennial census from 1920 to 1970. The 1970 population density in the county was about 160 persons per square mile.

Table 1. *Population of Butler County, 1920-1970*

Year	Population
1920	77,270
1930	80,480
1940	87,590
1950	97,320
1960	114,639
1970	127,941

LANDFORMS

Butler County is in the west-central part of the Appalachian Plateaus province. Its surface is characterized by rounded hills and steep-sided valleys. Flat upland surfaces are rare and, where present, are small. Flood plains are present along some of the streams, especially Connoquenessing Creek and its tributaries.

The western three-fourths of the county is drained by Slippery Rock, Muddy, and Connoquenessing Creeks, which flow into the Beaver River. The eastern fourth of the county drains to the Allegheny River, which touches only the northeast and southeast corners of Butler County.

The highest land is in the eastern part of the county, where some of the hilltops in the vicinity of Eau Claire and Annisville are more than 1580 feet above mean sea level. The lowest part of the county is the southeast corner, where it touches the Allegheny River. The pool level of the river at this point is 745 feet above mean sea level. The lowest point in the western part of the county lies at about 900 feet on the Connoquenessing Creek west of Zelienople. Local relief is 200 to 300 feet.

LAND USE IN THE 1960'S

Data from the Butler County Planning Commission show that about 45 percent of the county, or 228,000 acres, was farmland in 1970. This amounts to a decrease of 17 percent, or 87,000 acres, since 1940. The number of farms decreased, as did the total acreage; however, the average size of the farms increased about 30 percent, from 70 to 100 acres. The principal farm products are corn, wheat, and dairy products.

Residential use of the land continued to expand during the 1960's. Plans to develop land for residential use were filed on more than 2300 acres, though building did not take place on all the properties. The average size lot was about a half acre.

Industrial acreage increased by about 700 acres, of which 480 acres were acquired by Armco Steel Company at Butler.

Recreational use of the land expanded in the 1960's. Moraine State Park and its corridors to Jennings Blazing Star Nature Reserve and Old Stone House were constructed on 16,000 acres. The park includes the 3225-acre Lake Arthur on the site of Glacial Lake Watts. (See section on unconsolidated deposits.) Second largest is Alameda Park, which occupies about 400 acres on the northwest corner of the city of Butler. Several other communities have parks, though all are not new. Zelienople and Harmony share a 27-acre community park; and Chicora, East Butler, Karns City, Portersville, Slippery Rock and Cranberry Township each have a park ranging in size from 5 to 20 acres.

Fifteen hundred acres of land were acquired for highway right-of-way. The major part of this land was along Interstate Route 79; smaller amounts lay along the Allegheny Valley Expressway and Interstate Route 80.

The county contains about 655 strip mines covering 17,500 acres; most of them now abandoned. Six of eight active sanitary landfills and three recently abandoned ones are in strip pits. Increasingly strict regulations have curtailed strip mining in recent years and brought about an increase in deep mining.

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.

If man interrupts or changes the hydrologic cycle he may cause effects which last for many years. Man-made changes in the hydrologic cycle in Butler County are discussed later in the report.

PRECIPITATION

Precipitation is the source of all fresh water in the county. The average yearly precipitation from 1961 to 1970 was 36.64 inches at Butler and 35.81 inches at Slippery Rock (U.S. Department of Commerce, 1969). Not all the water in the streams, however, is from precipitation on the county, as some streams carry runoff from areas outside the county.

Precipitation is usually distributed evenly throughout the year. The summer has a little more rainfall than the other seasons. Much of the summer rain comes

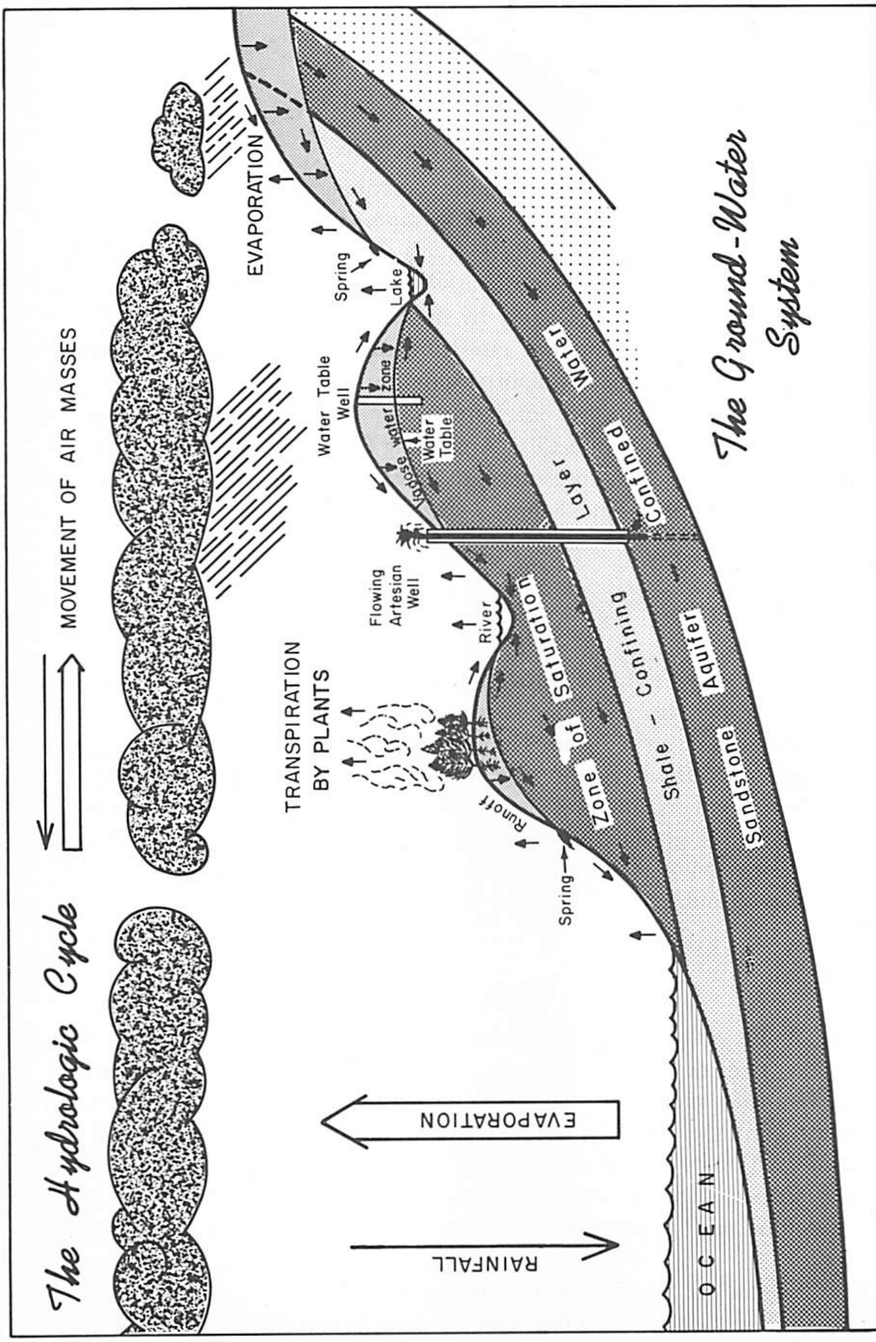


Figure 2. Hydrologic cycle showing movement of water from ocean to land and back to ocean.

as intense storms 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 transpiration process, 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 total annual water loss from Butler County by both evaporation and transpiration is about 19 inches. The evaporation rate from free water surfaces, however, is greater than the combined evapotranspiration rate from other surfaces. Measurements of evaporation from a free water surface by the U.S. Weather Bureau at their station at Ford City, Armstrong County, the nearest station to Butler County where such measurements have been made, show an average annual evaporation of about 28 inches. Direct measurements of transpiration have not been made.

STREAMFLOW

Most of the water not lost through evapotranspiration leaves the county as discharge from streams. This discharge accounts for about 17 inches of the original precipitation on the area. The larger streams and the locations of gaging stations that measure streamflow in Butler County are shown in Plate 1. Identification numbers are those assigned by the U.S. Geological Survey. A summary of discharge data for the gaging stations is given in Table 2. More detailed information on streamflow can be obtained from *Surface Water Records for Pennsylvania,* published annually by the U.S. Geological Survey (1970).

GROUND WATER

Much of the water falling on the land surface returns to the atmosphere or reaches the streams as overland runoff. Part infiltrates the soil and moves through fractures and other void spaces in the underlying rock. Its downward movement continues until it reaches the water table, below which all the interconnected voids are filled with water. This is illustrated in Figure 3. After reaching the zone of saturation, the water moves downward and laterally toward lower elevations and eventually returns to land surface, either from springs or from wells.

Ground water occurs under both water-table and artesian conditions. Water-table conditions are those in which ground water in unconfined, and the upper surface of the water, or water table, is free to rise or fall. Artesian conditions

Table 2. *Discharge Data for the Gaged Streams in Butler County*

Station number	Location	Length of record (years)	Average discharge (cfs)	Maximum discharge (cfs)	Date of maximum discharge	Minimum discharge (cfs)	Date of minimum discharge
1060	Connoquenessing Creek[1]	1919 to present	485	23,000	June 29, 1924	6	July 21-23, 1936
1063	Muddy Creek	1963 to present	61.2	1,640	March 10, 1964	0.4	September 17, 1966

[1] Station is 8.8 miles downstream from the Butler County line. Approximately 93 percent of the basin area upstream from this station lies in Butler County.

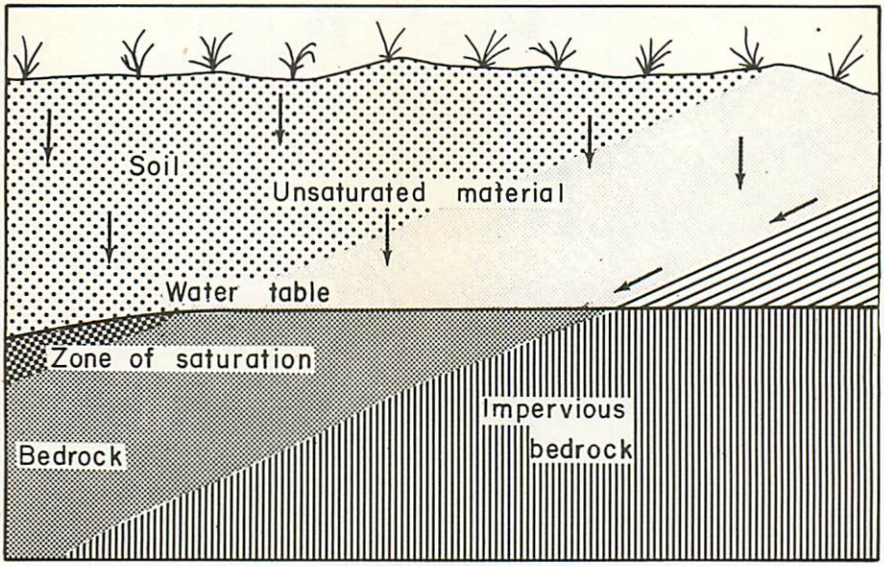


Figure 3. Movement of water through soil and rock to the water table.

exist where ground water is confined in a permeable rock (having interconnected openings) that is overlain by a relatively impermeable rock. 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 that penetrate the aquifer.

The water table fluctuates according to the relative amounts of recharge (additions to the aquifer) and discharge (losses through springs and wells). Because large evapotranspiration losses occur during the growing season (April to October), little recharge reaches the zone of saturation during that period, and water levels decline. Water levels generally rise throughout the rest of the year.

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. The water table, therefore, is a subdued replica of the land surface. Because wells drilled in valleys generally encounter water at shallower depths than wells drilled on hills, they have more available drawdown than a hill well of the same depth and are less likely to go dry during droughts.

Ground water occurs in and moves through interconnected openings in rocks (Figure 4), either of primary or secondary origin. Primary openings are the spaces between individual grains and occur chiefly in unconsolidated material. Secondary openings are those formed after the consolidation and cementation of the sediments into rock and usually 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.

Ground-Water Quality

As precipitation enters the ground, it dissolves parts of the soil and rock and, thus, picks up various mineral constituents. The changes that occur in the chemical quality of the water in the bedrock are discussed more thoroughly in a later section. Ground water usually contains more dissolved mineral matter than surface water, and occasionally may contain so much dissolved matter that it is not fit to drink. Water containing more than 500 mg/l (milligrams per liter) dissolved solids is not considered desirable for domestic supplies, though more highly mineralized water is used where better water is not available. The soil and rocks through which the ground water percolates tend to screen out solid suspended materials and bacteria so that the ground water is generally clear, and has fewer bacteria than surface water. The temperature of ground water is fairly uniform throughout the year.

Analyses of 48 samples of well water are listed in Table 3. One sample is from a well in glacial outwash; five samples are from wells in the Conemaugh Group; 18 from wells in the Allegheny Group; 15 from wells in the Pottsville Group; one from freshwater sand and two from brine-filled sand of Devonian age; and five from partly plugged flowing wells whose aquifer is unidentified.

High iron content is the main water-quality problem encountered by most users of ground water in the county. Iron concentrations exceed the maximum (0.3 mg/l) recommended by the U.S. Public Health Service (1962) in 23 of the samples. The samples exceed the maximum dissolved-solids content (500 mg/l) recommended by the U.S. Public Health Service.

An analysis of water from Connoquenessing Creek at Butler (Station 1056) is also given.

HOW AND WHERE GROUND WATER IS FOUND

Ground water in Butler County occurs under both artesian and water-table conditions. Reported well yields range from less than 1 to 500 gpm (gallons per minute). Data on about 380 wells drilled in the several geologic formations that underlie the county are listed in Table 4. Plate 1 shows the locations of the wells and the areas of the geologic units exposed at the surface or beneath the unconsolidated deposits.

A summary of the water-bearing characteristics of the geologic units in Butler County follows. Sample logs of several wells are shown in Table 5. These sample logs are representative of the variety of rocks encountered in drilling in this county. A composite stratigraphic section of the rocks exposed in Butler County is given in Table 6.

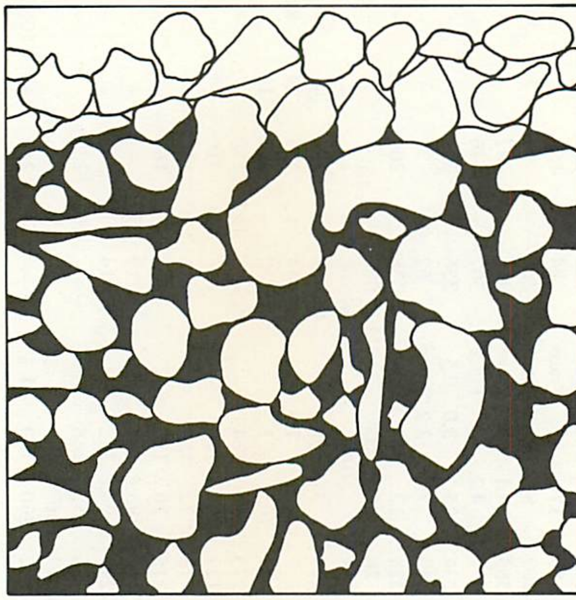
Table 3. *Chemical Analyses of Ground Water in Butler County*

Aquifer: Qio, Illinoian outwash; ₽c, Conemaugh Group; ₽cs, Glenshaw Formation, Saltsburg Sandstone Member; ₽cbc, Glenshaw Formation, Brush Creek Limestone Member; ₽cm, Glenshaw Formation, Mahoning Sandstone Member; ₽ak, Kittanning Formation; ₽av, Vanport Limestone; ₽ac, Clarion Formation; ₽ph, Homewood Formation; ₽pm, Mercer Formation; ₽pc, Connoquenessing Formation; Mb, Burgoon Sandstone; Mm, Murrysville Sandstone; Ms, Squaw sand; Dh, Hundred-foot sand.

Station and well number	Aquifer	Date of sampling	Silica (SiO_3)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Calcium and magnesium[c]	Magnesium (Mn)	Sodium (Na)	Sodium and potassium[d]	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Dissolved solids: Residue at 180°C	Dissolved solids: Sum	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25°C)
Bt- 13	₽pc	8-23-59	10	0.00	0.17	47	–	8.3	7.5	---	1.8	200	7.5	1.4	0.2	180	182	152	–	311
18	–	11-25-53	9.1	.1	–	35.2	–	8.5	--	113	–	108	1.0	198	–	518	–	123	–	–
20	₽ak	5-3-48	7.7	4.0	.6	48	–	13	--	10.8	–	155	60	11	.1	288	–	169	–	–
25	₽pc	9-15-59	13	1.2	.77	77	–	13	4.2	---	1.0	222	65	1.2	–	300	285	246	64	474
27	–	11-25-53	10.2	–	–	36.3	–	8.5	--	2.3	–	116	15	14	–	248	–	125	–	–
28[a]	₽pc	---	–	.2	–	--	15.6	--	--	78.3	–	218	4.8	16	–	290	–	38	–	–
28[b]	₽pc	---	5.3	–	–	12.6	–	2.3	--	75.4	–	202	3.9	22	–	280	–	42	–	–
29[b]	₽pc	---	–	.1	–	--	20	--	--	69.6	–	191	4.8	26	–	260	–	50	–	–
29[a]	₽pc	---	5.0	–	–	15	–	2.4	--	71.4	–	198	4.2	23	–	278	–	45	–	–
29	₽pc	6-25-54	8.7	.02	–	11	–	1.6	--	77.1	–	216	10	10	.3	252	225	34	34	453
29	₽pc	10-16-59	7.1	.14	.03	17	–	3.8	78	---	3.3	252	4.3	9.2	–	260	247	58	–	453
35	₽ph	10-27-57	9.2	.04	.05	60	–	7.8	3.6	---	1.8	178	35	4.0	6.0	214	215	182	36	362
43	₽pm	9-25-59	8.6	.80	.17	64	–	15	4.2	---	1.5	268	18	1.0	0.5	255	245	221	2	427
44	–	10-27-57	8.4	.10	.02	15	–	3.5	256	---	4.8	330	–	238	.2	672	689	52	–	1250
52	₽ac	4-17-57	18	.14	.17	61	–	8.0	3.5	---	1.6	188	38	6.2	1.0	237	230	185	31	382
65	–	12-4-53	8.8	4.2	–	9.0	–	2.6	--	69.0	–	146	1.5	49	–	210	223	20	–	–
65	–	10-27-57	9.1	.06	–	9.5	–	2.6	78	---	2.6	154	–	53	.4	226	231	34	–	407
67	₽pc	4-17-57	12	4.9	.14	11	–	7.2	2.5	---	2.1	23	33	8.4	.3	89	88	57	38	151
68	Qio	8-18-26	3.4	.24	–	42	–	7.5	80	---	4.0	23	53	145	27	397	–	136	–	–
83	₽av	9-24-59	7.9	2.3	.15	114	–	30	5.5	---	4.3	262	207	3.2	1.3	520	503	408	194	760
84	₽pm	9-22-50	–	1.6	–	–	60.8	--	--	---	–	189	–	2	–	205	–	152	–	–
85	₽pm	9-22-50	–	1.3	–	–	67.2	--	--	---	–	159	–	3	–	230	–	168	–	–

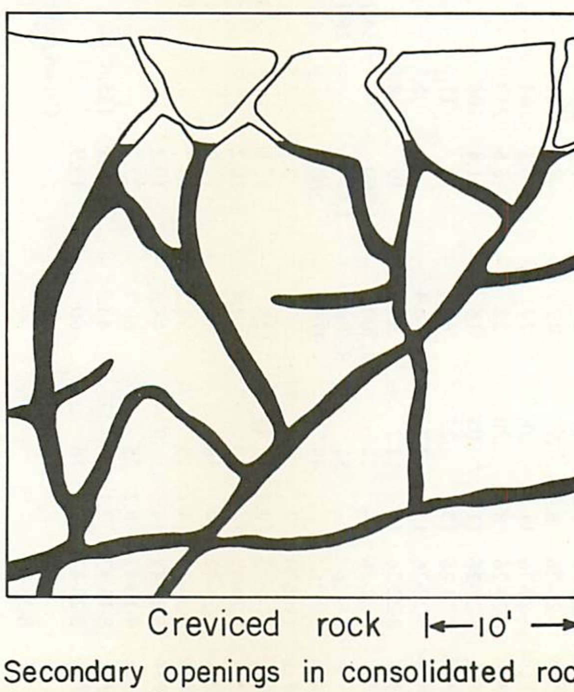
86	ℙac	7-28-53	–	2.9	–	63.2	10.7	--	--	---	–	193	18	–	–	275	–	202	–	–
98	ℙak	10-28-59	6.4	11	1.1	40	14	--	5.0	---	.8	88	52	29	.4	228	192	158	86	340
163	ℙav	8-18-26	9.0	0.37	–	87	–	9.1	3.5	---	2.2	264	40	2.2	Trace	279	–	255	–	–
166	ℙak	8-18-26	12	.13	–	6.5	–	8.4	4.4	---	2.6	46	18	2.0	Trace	67	–	51	–	–
168	ℙpc	8-19-26	7.1	.20	–	19	–	4.0	66	---	2.7	178	2.3	50	Trace	237	–	64	–	–
172	Mb	8-20-26	6.6	7.1	–	59	–	14	45	---	6.7	112	178	28	Trace	390	–	205	–	–
218	ℙc	8-23-26	8.8	.12	–	23	–	15	216	---	2.7	279	7.4	246	Trace	663	–	119	–	–
226	ℙak	8-23-26	8.4	.97	–	49	–	8.6	44	---	4.5	189	17	61	Trace	284	–	158	–	–
232	ℙcm	8-22-26	11	.28	–	24	–	8.1	44	---	2.0	209	8.1	1.3	Trace	201	–	93	–	–
236	ℙac	8-29-26	8.6	.20	–	22	–	6.6	319	---	9.9	355	4.1	368	Trace	916	–	82	–	–
237	ℙak	8-22-26	11	.08	–	16	–	1.4	106	---	2.9	227	4.2	56	Trace	307	–	46	–	–
252	ℙcbc	8-24-26	13	.20	–	60	–	13	11	---	3.4	234	25	3.0	0.5	236	–	203	–	–
265	ℙcbc	8-22-26	13	2.2	–	6.4	–	3.0	5.5	---	1.8	43	7.6	2.2	Trace	62	–	28	–	–
266	ℙcs	8-22-26	14	1.2	–	65	–	10	8.0	---	2.3	238	13	8	Trace	238	–	204	–	–
302	ℙh	8-22-26	–	52	–	11,300	–	1,860	–	34,740	–	20	42	78,900	–	132,000	–	–	–	–
309	Ms	9-8-26	–	51	–	8,708	–	1,470	–	26,170	–	58	3	60,000	–	96,500	–	–	–	–
209	Mm	9-9-26	–	49	–	975	–	200	–	5,077	–	434	3	9,880	–	16,600	–	–	–	–
311	ℙak	11-2-70	7	1.4	.33	5	–	3.1	3.5	---	.8	1	28	1.9	.2	44	43	25	24	81
349	ℙph	11-10-37	13.4	12.44	–	128	–	13.8	–	296	–	61	705	131	–	1,370	–	417	316	–
362	ℙak	5-23-47	14	30	–	42.4	–	10.2	–	96	–	173	116	104	–	---	497	148	–	–
363	ℙak	5-23-47	14	18	–	91.2	–	19.9	–	119	–	127	260	160	–	---	745	310	–	–
364	ℙak	5-23-47	14	13	–	51.2	–	28	–	116	–	173	72	152	–	---	510	156	–	–
365	ℙak	5-23-47	14	.9	–	48.8	–	10.2	–	99	–	215	20	130	–	---	428	164	–	–
366	ℙak	4-10-47	8.2	25	–	60.7	–	27.1	–	84	–	112	195.4	199.1	2.0	712	657	–	–	–
367	ℙak	8-15-47	2.1	–	–	43.3	–	97.3	155.6	---	–	290	94.6	362	Trace	914	896	–	–	–
368	ℙak	5-23-47	12	18	–	60	–	19.9	–	62	–	156	52	168	–	---	468	232	–	–
Connoquenessing Creek at Butler																				
1056	–	8-23-67	–	–	–	--	–	---	–	130	–	92	230	150	1.3	---	–	244	169	1050

[a]CO_3 – 2 mg/l
[b]CO_3 – 3 mg/l
[c]Calculated from hardness determinations.
[d]Combined sodium and potassium weights were determined by subtracting the combined equivalence of all other constituents from the total equivalence of the sample.



Sand |←0.01'→|

Primary openings in unconsolidated material



Creviced rock |←10'→|

Secondary openings in consolidated rock

Figure 4. How water occurs in the rocks.

Table 4. *Record of Wells in Butler County*

Well number: Identification number that relates record in this table to wells location on map.
Location: The number is the coordinates in degrees and minutes of the southeast corner of a 1-minute quadrangle within which the well is located.
Use: A, air conditioning; C, commercial; H, domestic; N, industrial; P, public supply; R, recreation; S, stock; T, institution; U, unused.
Topographic setting: H, hilltop; S, slope; T, terrace; V, valley; W, hillside drainageway.
Aquifer: Qem, Wisconsin end moraine; Qgl, glacial lacustrine deposits; Qio, Illinoian outwash; IPc, Conemaugh Group; IPcs, Glenshaw Formation, Saltsburg Sandstone Member; IPcb, Glenshaw Formation, Buffalo Sandstone Member; IPcbc, Glenshaw Formation, Brush Creek Limestone Member; IPcm, Glenshaw Formation, Mahoning Sandstone Member; IPa, Allegheny Group; IPaf, Freeport Formation; IPak, Kittanning Formation; IPav, Vanport Limestone; IPac, Clarion Formation; IPp, Pottsville Group; IPph, Homewood Formation; IPpm, Mercer Formation; IPpc, Connoquenessing Formation; Mb, Burgoon Sandstone; Mm, Murrysville Sandstone; Ms, Squaw sand; Dh, Hundred-foot sand.
Lithology: gv, gravel; sd, sand; sdgv, sand and gravel; ls, limestone; ss, sandstone; ssh, sandy shale; sh, shale; shss, shaly sandstone.
Static water level: F, flowing; +, above land surface.
Pumping data: gpm, gallons per minute; dd, drawdown; ft, feet; hr, hours.
Hardness: gpg, grains per gallon.

Well number	Location	Owner	Driller	Date completed	Use	Altitude of Land Surface (feet)	Topographic setting	Aquifer/ Lithology	Total Depth Below Land Surface (feet)	Casing: Depth (feet)	Casing: Diameter (inches)	Depth(s) to Water-Bearing Zone(s) (feet)	Static Water Level: Depth Below Land Surface (feet)	Static Water Level: Date measured	Pumping Data: Yield (gpm)	Pumping Data: dd (feet)	Pumping Data: Time (hour)	Hardness	Specific conductance (micromhos at 25°C)	pH
Bt- 1	4100-7953	Wick, Ralph			U	1400	H	IPc	18		48		9							
2	4100-7943	Daugherty Refining Co.			U	1175	V	IPak/ss	124		10				50					
3	4106-8001	Isacco, Guy	H. I. Mong	1954	H	1420	S	IPak/ss	132	45	4		45	July 1954						
4	4107-8001	McConnell, Harry	H. I. Mong	1953	H	1340	S	IPph/ss	125	78	5		80	Aug. 1954						
5	4106-8000	Neely, W. H.	N.L. & R.L. Chase		H	1330	S	IPac	100	100	4		76	July 1954	13					
6	4102-8002	McKnight, James	James Dobson	1907	H	1290	S	IPpc	276	210	6									
7	4101-8002	Cooper, Edward			H	1205	S	IPph	85											
8	4107-8002	Youshock, J.	McWilliams	1955	H	1390	H	IPak/ss	87	60	5		28							
9	4108-8001	Montgomery, Paul	H. I. Mong	1952	H	1365	H	IPav/ls	95		5		50							
10	4108-8000	Walter, Richard	H. I. Mong	1951	H	1297	H	IPph/ss	97	97	5		18							
11	4109-8000	Lott, Mrs.	John E. Williams	1951	H	1340	S	IPak/ss	26	26	5		11							
12	4109-7954	Dunlap, Clinton		1925	U	1383	S		546		6		82	July 1955						
13	4100-8004	Rogers, C. S.		1925	U	1240	V	IPpc/ss	454	110	7		73	July 1955				11	325	7.0
14	4105-8001	Pink, A. J.	Robert Ralston	1955	H	1378	S	IPak/sh	80	28	6		38	July 1955						
15	4100-8003	Ripley, Harry	U. S. Dean	1955	H	1220	V	IPak/ss	60	25	5		25							
16	4059-8001	Snyder, Neel	Braden C. Griffin	1955	H	1380	H	IPak	95		5		45	June 1955	15					
17	4103-8003	Slippery Rock Borough	Roy Keaton		U	1220	H	IPak	496	92	10	50, 150, 475	90	Feb. 1954						
18	4101-8004	Crestview Farm			H	1120	V		373	20	10		F		200					
19	4100-8003	McDevitt, David	Summerlea, Inc.	1955	U	1200	S		310	20	10		33							

Table 4. *(Continued)*

Well number	Location	Owner	Driller	Date completed	Use	Altitude of Land Surface (feet)	Topographic setting	Aquifer/ Lithology	Total Depth Below Land Surface (feet)	Casing: Depth (feet)	Casing: Diameter (inches)	Depth(s) to Water-bearing Zone(s) (feet)	Static Water Level: Depth Below Land Surface (feet)	Static Water Level: Date measured	Pumping Data: Yield (gpm)	Pumping Data: dd (feet)	Pumping Data: Time (hour)	Hardness	Specific conductance (micromhos at 25°C)	pH
20	4104-8003	Slippery Rock Borough	Pioneer Drilling & Pump Co.	1948	P	1330	S	P ak/sh	105	43	12		40	Apr. 1948	50	12	20			
21	4104-8003	Slippery Rock Borough	Pioneer Drilling & Pump Co.	1948	P	1335	S	P pc/ss	406	185	8				85	167	9			
22	4055-7950	Northvue Water Co.	George L. Davis & Sons	1956	P	1300	S	P cm/ss	195	64	6		70	Apr. 1956						
23	4049-8000	Connoquenessing Jt. Area School Auth.	L. Purvis & Son	1956	U	1280	H	P c	215	190										
24	4102-8006	Land, L. P.	Leise Brothers	1956	H	1110	V	P pm	76	68	6			May 1956						
25	4104-8003	Slippery Rock Borough	Roy Keaton	1953	U	1280	V	P pc/ss	436	80	7		13	July 1956				17	470	7.1
26	4105-8003	Ucker, C. I.		1935	H	1240	T	Qem			36		23	July 1956						
27	4105-8003	Ucker, C. I.			U	1160	V				5		+3	July 1956						
28	4105-8003	Slippery Rock Borough	Roy Keaton	1953	P	1160	V	P pc/ss	115		8		F							
29	4105-8003	Slippery Rock Borough	Roy Keaton	1953	P	1160	V	P pc/ss	128	112	8	30, 107, 115	F		55			4	450	7.6
30	4101-8004	Greenway, Don	Leise Brothers	1955	H	1200	T	P pm/sh	90	70	7		61		5					
31	4101-8005	Ralston, A. C.	Robert Ralston	1946	H	1230	W	P ac/ss	90	85	4		20							
32	4101-8005	Connell, A. R.	Braden C. Griffin	1953	H	1302	H	P ak/sh	92	60	5		38							
33	4101-8005	Barron, J.	U. S. Dean	1956	H	1310	H	P ak/ss	89	70	5		50							
34	4102-8005	English, J. P.	C. Dietrich Brothers		H	1230	T	P ph/ss	137	45	6							7	190	7.1
35	4100-8006	Moore, Clyde	Dewey H. Bupp	1931	H	1235	S	P ph/ss	100		5	80	58					8	200	
36	4100-8007	McCleary, J. M.	Dewey H. Bupp	1925	H	1290	S	P ak	105				87					16	390	6.7
37	4100-8007	Davis, A. G.	Dewey H. Bupp	1930	S	1210	V	P pc/ss	150	39	6		54							
38	4101-8007	Brandon, Russell	Glenn Cunningham	1944	H	1150	T	P pc/ss	165	155			75					8	390	7.2
39	4100-8008	Studebaker, J. C.		1928	S	1170	V	P ph	92	50	10		5	Aug. 1956				13	350	6.7
40	4100-8008	Studebaker, O. N.		1927	U	1270	S	P ph	189	40	10		51	Aug. 1956						
41	4100-8008	Studebaker, J. C.			U	1155	V		302	36	8		17	Aug. 1956						
42	4100-8008	Studebaker, O. N.			S	1310	S	P ak	42	22			25					18	435	5.9
43	4102-8006	Boyd, J. L.	U. S. Dean	1956	H	1150	S	P pm/sh	105	81	6		52		10			15	430	
44	4102-8005	Cooper, H. W.			U	1100	V				8		F					3	800	7.0
45	4100-8007	Vosler, V. C.		1880	S	1140	V		745	42	8		+1					9	230	6.3
46	4100-8008	Ohanlon, D. R.			H	1230	S	P pc/ss	180									12	290	6.9
47	4102-8006	Grossman, W. S.			H	1220	H	Qem	5											
48	4102-8006	Johnson, W. C.	U. S. Dean	1952	H	1170	S	P av/ls	62	30	5		30					7	190	6.6
49	4101-8007	Murphy, H. T.			H		V	P pc	106	90	6							10	285	6.7
50	4101-8003	Hines, C. J.	Robert Ralston		H	1176	T	P pc	155									6	450	7.0
51	4102-8004	Friedman, Jake			H	1180	V	P ph/ss	68	40	4		28					10	320	
52	4102-8003	Redmond, G. E.	Braden C. Griffin	1950	H	1245	S	P ac/ss	110	76	5		78	Aug. 1956				10	325	
53	4102-8002	McConnell, Earl		1915		1245	S	P ac	70	20	3		35							

54	4101-8002	Croll, D. W.	Allen L. Dufford		H	1130	V	ᵽ ph/ss	42				6							
55	4101-8003	Carlin, D. N.	Uber	1954	H	1165	T	Qgl/gv	105	105	7		49							
56	4101-8002	Guthrie, Aaron	Dittmer & Sons		H	1180	T	ᵽ pm/sh	173	150			64					3	820	6.5
57	4100-8002	Winter, Paul W.				1200	S				6		15							
58	4101-8001	Lawry, J. D.	Robert Ralston		H	1240	S	ᵽ ph/ss	111	40	4		35							
59	4101-8001	Veit, L. F.		1920	H	1190	T	ᵽ ph	85									6	200	6.6
60	4103-8004	Hines, R. W.	George L. Davis & Sons	1955	H	1225	S	ᵽ ph/ss	100	60	6		40							
61	4103-8004	Hines, J. R.	Chambers	1930	H	1200	W	ᵽ ph/ss	112	80	6							13		7.7
62	4103-8004	Boyd, W. E.	Thornbury	1943	H	1320	S	ᵽ ak	100	60	5		70					19	470	6.7
63	4103-8004	Hoffman	Chambers		H	1260	S	ᵽ ph/ss	141	100	5		100							
64	4104-8004	Hadley, L. L.	U. S. Dean	1954	H	1210	S	ᵽ ac/ss	36	8			15					6	140	6.1
65	4103-8000	Camp Bucoco			U	1150	V		1135				F	Aug. 1956				3	300	
66	4103-8002	Long, Clarence	George L. Davis & Sons	1955	H	1260	S	ᵽ ph/ss	70	31	6		55	Jan. 1955	30			9	230	6.5
67	4104-8001	Hartzell, Duane	Robert Ralston	1946	H	1320	S	ᵽ pc/ss	154	16	5	147	49	Aug. 1956				3	110	6.0
68	4108-8000	Cathcart Hotel			C	1314	H	Qio/v	14											
69	4106-8007	Neely, W. H.			H	1325	S	Qem	14		24		10							
70	4102-8001	Stroughton, S. R.	Walter J. Baldauf Sons		H	1270	S	ᵽ pc/ss	160	81	6	150	38	June 1957	40					
71	4108-8001	McClintock, Alden	H. I. Mong	1957	H	1360	H	ᵽ ak/ss	78	4	6		58		8		1			
72	4108-8001	Baker, Vernon	Virgil C. Palmer	1957	H	1360	H	ᵽ ac/sh	141	95	6									
73	4058-8008	Highway Sand & Gravel, Inc.	Andrew Beikert			1170	V	ᵽ p	85	68	6		50							
74	4048-8000	Kidd, George	L. Purvis & Son	1957	H	1285	H	ᵽ c	227	152	6	30, 50, 115	138		3	227		1	1085	8.0
75	4055-8008	Dewdrop Inn			C	1380	H	ᵽ c	30		48		25							
76	4102-8007	Stewart, T. D.	Ray E. McQuiston	1957	H	1120	V	ᵽ ac/sh	51	40	6		9							
77	4101-8006	Homer, J. H.	Manufacturers Light & Heat	1929	U	1188	S		1157	56	8									
78	4102-8004	Wadsworth, William		1918	P	1219	V		794	26	8									
79	4102-8004	Cline, Mrs.	Daugherty		U		S		853	45	8									
80	4104-8000	Hartzell, D.	D. & V. Eakin	1904	U	1297	T		777	414	6									
81	4103-8000	Sankey, L.	R. L. Gruff & Co.	1912	U	1242	S		1077	472	6									
82	4102-7959	Houk, Dale	Elmer L. Book	1957	H	1180	V	ᵽ ph	68	22	5							5	425	7.3
83	4103-8004	Allison, Lee	George L. Davis & Sons	1958	H	1257	S	ᵽ av/ls	110	95	6	104	73	July 1958	18					
84	4103-8002	Slippery Rock State College		1935	P	1317	S	ᵽ pm/sh	263		6		130		50					
85	4103-8002	Slippery Rock State College	Roy Stofford	1938	P	1355	S	ᵽ pm/sh	297	175	7		130		125					
86	4103-8002	Slippery Rock State College	Pennsylvania Drilling Co.	1953	U	1275	S	ᵽ ac/sh	102	50	20	5, 43, 58	68		10					
87	4103-8002	Slippery Rock State College	Pennsylvania Drilling Co.	1953	P	1280	S	ᵽ ac/ss	99	65	16	88	68		149	11	48			
88	4103-8002	Slippery Rock State College	Pennsylvania Drilling Co.	1953	P	1320	S	ᵽ ph/ss	250	151	8	170	132		25	69	24			
89	4104-8000	Dechant, John	Thornbury	1940	H	1352	S	ᵽ pc/ss	178	135		130, 178	138		5					
90	4104-8000	Campbell, William	H. I. Mong	1949	H	1345	S	ᵽ pc/ss	211			98, 200								
91	4105-8000	McCandless, Howard	Braden C. Griffin	1956	H	1337	S	ᵽ ph/ss	67	20	6	64	30							
92	4104-8000	McCandless, W. P.	H. I. Mong		H	1340	S	ᵽ ph/ss	80	30	5	36, 72	30							
93	4103-8001	Doerr, N. F.	George L. Davis & Sons	1955	H	1285	S	ᵽ pc	170	60	6									
94	4102-8001	Osborne, Floyd	George L. Davis & Sons	1957	H	1223	H	ᵽ ph/ss	76	39	6	55	35		16					
95	4102-8001	Gallagher, W. P.	George L. Davis & Sons	1957	H	1248	H	ᵽ ph/ss	108	49	6		60		30					
96	4103-8000	Renick, C. D.			H		S	ᵽ ph/ss	101											
97	4057-8009	Miller, H. P.		1925	H	1320	H	ᵽ ak	95		6		60							
98	4100-8009	Book, Frank	George L. Davis & Sons	1957	U	1295	S	ᵽ ak/ss	92	61	6	70	35		30			8	400	6.4
99	4102-8006	Slippery Rock U. P. Church	George L. Davis & Sons	1958		1168	S	ᵽ ac	65	36	6	50	28							
100	4102-8001	Kennedy, Paul E.	George L. Davis & Sons		H	1177	S	ᵽ ph/ss	108	61	6	72, 90	42		32					

Table 4. *(Continued)*

Well number	Location	Owner	Driller	Date completed	Use	Altitude of Land Surface (feet)	Topographic setting	Aquifer/ Lithology	Total Depth Below Land Surface (feet)	Casing: Depth (feet)	Casing: Diameter (inches)	Depth(s) to Water-bearing Zone(s) (feet)	Static Water Level: Depth Below Land Surface (feet)	Static Water Level: Date measured	Pumping Data: Yield (gpm)	Pumping Data: dd (feet)	Pumping Data: Time (hour)	Hardness	Specific conductance (micromhos at 25°C)	pH
101	4102-8002	Fenick, William	George L. Davis & Sons		H	1310	H	ℙ ac/sh	138	43	6	125			16					
102	4101-8001	Wolford, Richard	George L. Davis & Sons		H	1181	V	ℙ ph/ss	98	41	6	46, 80	30		36					
103	4105-7959	McConnell, K. R.	Braden C. Griffin		H	1280	S	ℙ pm	47	23	8		14					11	425	7.0
104	4100-8009	Book, Floyd	Leise Brothers	1958	H	1339	S	ℙ pc/ss	258	250	7	85, 145, 185	100					10	450	7.0
105	4101-8001	Spencer, Crosby	H. I. Mong	1945	H	1180	S	ℙ pm	100			50, 100								
106	4101-8001	Hall, William	George Suess	1950	H	1245	S	ℙ ac	51	35		47								
107	4101-8000	Labor, A. P.	George L. Davis & Sons	1956	H	1250	S	ℙ ac/sh	85											
108	4101-8000	Holland, Elmer	George L. Davis & Sons	1956	H	1267	S	ℙ ph/ss	127	56	6	68, 115	60		30					
109	4100-8004	Arblaster, Henry			H	1220	S		50				37							
110	4100-8003	Methodist Church	George Suess		H	1226	S	ℙ ac	65											
111	4100-8003	Alexander, Albert	U. S. Dean	1957	H	1238	S	ℙ ak/ss	70	16	5		35							
112	4102-8001	Birckbichler, J. A.	Walter J. Baldauf Sons	1957	H	1172	V	ℙ p	152	60	6	70, 96, 128								
113	4100-7943	Daugherty Refining Co.			U	1175	V	ℙ ak/ss	124		6				130					
114	4100-7943	Daugherty Refining Co.			N	1175	V	ℙ ak/ss	352	90	6				115					
115	4100-7943	Daugherty Refining Co.			N	1175	V	ℙ ak/ss	332		6		24		145	71	12			
116	4100-7943	Daugherty Refining Co.			N	1175	V	ℙ ak/ss	412		6				95					
117	4100-7943	Daugherty Refining Co.			U	1175	V	ℙ ak/ss	357		6		14	Oct. 1951	100					
118	4100-7943	Daugherty Refining Co.			U	1175	V	ℙ ak/ss	290		6				125					
119	4100-7943	Daugherty Refining Co.			U	1180	V	ℙ ak/ss	397		10				300					
120	4100-7943	Daugherty Refining Co.		1932	U	1190	V	ℙ ak/ss	551	154	10		60	July 1944	10					
121	4100-7943	Daugherty Refining Co.	F. A. Vogt	1932	N	1180	V	ℙ ak/ss	225	146	10		60	Aug. 1958	360					
122	4100-7943	Daugherty Refining Co.	F. A. Vogt	1932	N	1180	V	ℙ ak/ss	260	250	10				350	50				
123	4100-7943	Daugherty Refining Co.	Smith & Hefler	1933	N	1200	V	ℙ ak/ss	125	63	8		30	Aug. 1933	95	20	48			
124	4100-7943	Daugherty Refining Co.	Smith & Hefler	1933	N	1210	V	ℙ ak/ss	145	91	8		30	Sept. 1933	105	25	48			
125	4100-7943	Daugherty Refining Co.	Smith & Hefler	1933	N	1210	V	ℙ ak/ss	209	165	8		54	July 1944	220	60	9			
126	4100-7943	Daugherty Refining Co.	Wick & Roxbury	1937	U	1180	V	ℙ ak/ss	475	170	8				60					
127	4100-7943	Daugherty Refining Co.	Wick & Roxbury	1937	N	1175	V	ℙ ak	313	200	6		20	Oct. 1951	129	120	9			
128	4100-7943	Daugherty Refining Co.	Pennsylvania Drilling Co.	1940	U	1175	V	ℙ ak/ss	180		12		17	Oct. 1951	30					
129	4100-7941	Daugherty Refining Co.	Pennsylvania Drilling Co.	1940	N	1320	V	ℙ af/ss	198	35	16		37	Mar. 1940	450	19	45			
130	4100-7941	Daugherty Refining Co.	Pennsylvania Drilling Co.	1949	N	1320	V	ℙ af/ss	130	28	16		69	Sept. 1949						
131	4103-8003	Kaufman, Robert	U. S. Dean	1959	H	1323	S	ℙ av	102	80	5	55, 70, 90	87	July 1959				9		7.1
132	4102-8006	Myers, U. J.	U. S. Dean	1959	H	1170	S	ℙ ac	71	29	5		30	1959						
133	4058-8008	Zion Church Parsonage	U. S. Dean	1959	H	1274	S	ℙ ac	95	90	5	90	80	July 1959				12	310	7.1
134	4103-8000	Horrell, Robert F.	Andrew Beikert	1957	H	1273	H	ℙ ph	74	18	6	60	45	Dec. 1957						
135	4103-8002	Mershimey, Don L.	George L. Davis & Sons	1957	H	1266	S	ℙ ph		21	6		40	Nov. 1957	30			9	350	7.4
136	4103-8002	Jefferies, William	George L. Davis & Sons	1957	H	1242	S	ℙ ph	85	42	6	65	35	Nov. 1957	30					

137	4103-8002	Causer, Albert	George L. Davis & Sons	1957	H	1238	S	▸ ph	74		6	60			30					
138	4101-8001	Morse, Carl	George L. Davis & Sons	1959	H	1180	T	▸ ph	82	31	6	65	38	Sept. 1959	30					
139	4101-8000	Ledonne, Bennie	George L. Davis & Sons	1959	H	1150	V	▸ ph	34	21	6	25	15	Aug. 1959	18					
140	4101-8000	McGuire, Thomas	George L. Davis & Sons	1959	H	1180	V	▸ ph	73	41	6	55	30	Apr. 1959	30					
141	4102-8001	Greaves, John	George L. Davis & Sons	1959	H	1250	S	▸ ac	104	53	6	85	57	Sept. 1959	30			5	200	7.0
142	4101-8004	Steiner, Robert	George L. Davis & Sons	1958	H	1132	V	▸ pm	126	108	6	110	27		30			14	400	7.1
143	4106-8000	Cooper, E.	Walter J. Baldauf Sons	1959	H	1338	S	▸ ph/sh	160	86	6	135	88							
144	4106-8000	Ciochette, Louie	Walter J. Baldauf Sons	1959	H	1340	S	▸ ac	150	92	6	139	72		20	72		13	400	7.0
145	4105-8000	Hogg, Calvin	George L. Davis & Sons	1959	H	1303	V	▸ ac	85	52	6	70	31		30			7	370	7.1
146	4104-7958	Klein, E. A.	Walter J. Baldauf Sons		H	1180	V	▸ pc	82	77	6	78	10		50	10				6.8
147	4104-7958	Koler, Jim	Walter J. Baldauf Sons	1958	H	1196	V	▸ pc	67	65	6	65			30	10				
148	4104-7958	Gress, Donald	Walter J. Baldauf Sons	1958	H	1182	V	▸ pc	110	100	6	105	2		50	2				
149	4102-8007	Mayerott, Lou	George L. Davis & Sons	1959	H	1123	S	▸ ph	72	29	6	55	25		8					
150	4100-7959	Devore, Mike	George L. Davis & Sons	1957	H	1240	V	▸ av/ls	55	41	6	50	15		30					
151	4102-7959	Stamm, Howard	Andrew Beikert	1949	H	1310	S	▸ ph	112	21	8	95, 102						8	350	6.4
152	4100-8004	Swope, M. C.	Andrew Beikert	1948	H	1216	V	▸ ac	71	47	6	56	30		15					
153	4104-8002	Reep, Dean	Hugh Collins	1959	H	1338	S	▸ ak/ss	64	42	6	56	28		25	6	2			
154	4105-8001	Pink, Wilson	George F. Ralston		H	1365	S	▸ ak	60	40	5		45		30	45	0.5			
155	4100-8005	Miller, B. S.	Manufacturers Light & Heat	1926	U	1200	V		776	176	8									
156	4100-8005	Miller, B. S.	Manufacturers Light & Heat	1926	U	1200	V		795	155	8									
157	4100-8005	Miller, B. S.	Manufacturers Light & Heat		U	1170	V		1,110	143	8									
158	4106-8002	Hockenberry, J. C.	Manufacturers Light & Heat	1944	U	1270	V		10,096											
159	4108-8000				U	1400	S		233											
160	4106-8002	McGarvey, J. J.			U	1269	V		169											
161	4106-8003	Brenneman, D.			U	1328	S		164											
162	4106-7942	Byers, J.	Farrington		U	1480	H		1,392											
163	4106-8000	Bessemer & Lake Erie R.R.	Findley Surrena	1925	H	1320	W	▸ av/ls	75	55	4	62, 83								
164	4106-8000	Dufford	Findley Surrena	1925	U	1320	S	▸ ak/sh	40		6									
165	4106-8001	Bessemer & Lake Erie R.R.	James Dobson		H	1310	S	▸ ak	70		6									
166	4110-7959	Greene, Harry	Findley Surrena	1926	H	1440	H	▸ ak/sh	30		6	23	10		25					
167	4107-8057	Silver Fox Farm	Findley Surrena	1925	H	1300	S	▸ pc/ss	116		6		96							
168	4106-7953	Pittsburgh Limestone Co.	Mel Stalker	1924	H	1200	V	▸ pc/ss	100		6		+5							
169	4106-7953	Sack	Mel Stalker	1923	H	1210	V	▸ pc/sd	119	100	5		18	1923						
170	4106-7953	Pittsburgh Limestone Co.		1920	H	1235	S	▸ pc	150		6		30		20					
171	4106-7953	Pittsburgh Limestone Co.		1924	N	1235	S	Mb/ss	208	65	10				65					
172	4106-7953	Middendorf, Henry		1910	U	1200	V	Mb/ss	250		8		F		200					
173	4100-7953		A. J. Campbell		H	1390	H	▸ c/ss	120											
174	4107-7952	Golf-Kirby Coal Co.	Mel Stalker	1920	H	1250	S	▸ ph	116	60	6									
175	4110-7948	Dokey, Mike	Mel Stalker	1915	H	1490	H	▸ ac/sh	188	150										
176	4108-7947	Kerr, Bessie	Mel Stalker	1920	H	1510	H	▸ ak/ss	160	80										
177	4108-7947	McCall, Earl	Mel Stalker	1920	H	1460	H	▸ ak/ss	44											
178	4108-7947	Beyers, S. H.	Mel Stalker	1919	H	1500	H	▸ cm/sh	51		6									
179	4108-7947	Stalker, Mel	Mel Stalker	1923	H	1460	S	▸ ak/sd	60	34										
180	4106-7951	Keystone Coal Co.	Mel Stalker	1919	U	1275	V	▸ pc/ss	200		6									
181	4053-7958				H	1335	H	▸ c/ssh	20											
182	4103-8002	Slippery Rock Borough		1912	P	1435	H	▸ pc/ss	365		6		175		4					
183	4103-8002	Slippery Rock Borough		1912	P	1435	H	▸ pc/sd	398		6									

Table 4. *(Continued)*

Well number	Location	Owner	Driller	Date completed	Use	Altitude of Land Surface (feet)	Topographic setting	Aquifer/ Lithology	Total Depth Below Land Surface (feet)	Casing: Depth (feet)	Casing: Diameter (inches)	Depth(s) to Water-bearing Zone(s) (feet)	Static Water Level: Depth Below Land Surface (feet)	Static Water Level: Date measured	Pumping Data: Yield (gpm)	Pumping Data: dd (feet)	Pumping Data: Time (hour)	Hardness	Specific conductance (micromhos at 25°C)	pH
184	4103-8002	Slippery Rock Borough		1925	P	1325	S	P pc	375	105	10		80		8					
185	4103-8002	Slippery Rock Borough	Harry Schaffner	1926	P	1300	V	P pc/ss	475				80		36					
186	4103-8002	Slippery Rock State College			P	1250	S	Mb	300		6				9					
187	4103-8002	Slippery Rock State College		1889	H	1310	S	P pc/ss	200		6				6					
188	4103-8002	Slippery Rock State College		1889	P	1320	S	P pc/ss	275		6				17					
189	4102-8001	Oak Grove Dance Hall	A. J. Campbell		H	1280	S	P ac/ss	102	35	-									
190	4102-8001	Always Inn	A. J. Campbell		P	1200	V	P ph/sd	60											
191	4103-7959	Bessemer & Lake Erie R.R.	Edward Barnes	1917	N	1190	V	Mb/ss	332	52	12	80, 120, 240	20	Nov. 1917	260	4				
192	4104-7959			1895	U	1170	V	Mb/ss			6		F		100					
193	4105-7956				U	1180	V	Mb	300				F							
194	4105-7948	Standard Coal Mining Co.	Mel Stalker	1919	U	1260	V	P pc/ss	236	192	6									
195	4105-7947	Sims, Ross	Mel Stalker	1922	H	1470	S	P ak/ss	103		6									
196	4103-7948		A. J. Campbell	1925	H	1500	H	P ak/ss	180											
197	4103-7943		A. J. Campbell		H	1100	V	P pk/ss	18		6				0.5					
198	4103-7943	Bruin Coal Co.	A. J. Campbell	1924	N	1105	V	P pc/ss	150		6				15					
199	4100-8003		Ross Chambers		H	1250	V	P a/ss	50	22	6		45							
200	4101-7959	Bessemer & Lake Erie R.R.	C. A. Porter	1914	H	1190	V	P ph/ss	53	32	6									
201	4059-7955				H	1318	S	P c/ss	75		6									
202	4059-7955	Bessemer & Lake Erie R.R.	A. J. Campbell	1923	N	1320	V	P ak/ss	108	60	5	93, 108	25							
203	4058-7955	Bessemer & Lake Erie R.R.		1924	N	1225	V	P ak/ssh	80	62	5		60							
204	4058-7955	Bessemer & Lake Erie R.R.	C. A. Porter	1910	C	1225	V	P a/ss	242		12	35, 140, 222	35	1910	10					
205	4059-7949	Hooker School			H	1395	H	P c/ss	130											
206	4059-7949	Kuhns, Will			H	1410	H	P c/ss	35		6									
207	4059-7949	Campbell	A. J. Campbell		H	1370	H	P c	70		5									
208	4059-7949	Ryder, Frank			H	1420	H	P c/ss	208											
209	4058-7949			1880	P	1150	V	Mb			12		+3		50					
210	4059-7943			1926	H	1215	V	P ak/ss	70				50							
211	4059-7943	Pennsylvania Refining Co.	A. J. Campbell		N	1215	V	Mb/ss	550		8		5		125					
212	4057-8008	Burnside School	Dewey H. Bupp	1926	P	1225	S	P ac/sh	81	65		72	35							
213	4054-8004	Roberts	Dewey H. Bupp	1926	H	1375	H	P cm/sh	80		6		45		0.5					
214	4055-8005	Bupp, Dewey H.	Dewey H. Bupp	1925	H	1400	H	P cm/sh	75											
215	4048-8002	Watson, E. A.		1900	H	1190	V	P ak/shss	50											
216	4056-7957	Graham Service Station	A. J. Campbell		C	1310	V	P cm/ss	100	60	6									
217	4053-7954	Hendricks			H	1325	S	P ak	300											
218	4053-7952	Kosko Coal and Gas Co.			H	1080	S	P c			6									
219	4053-7952	Montgomery, H.	F. W. Smith	1924	H	1050	V	P ak/sh	92	20	6		42							

220	4054-7949	Spicker, Joe	F. W. Smith	1924	H	1320	H	P cm/sh	72	28	5							
221	4054-7949	Weyland, John	F. W. Smith	1924	H	1330	H	P cm/ss	91		6							
222	4053-7949	Dunn, Charles	F. W. Smith	1924	H	1330	H	P c	171			65, 160	50		3			
223	4056-7946	Silver Side Inn			C	1190	V	Mb					+1		20			
224	4057-7944	Millerstown Water Works	E. E. Leopold	1912	P	1260	S	P ak/ss	190	100	7				30			
225	4057-7944	Millerstown Water Works		1874	U	1380	H	P ak/sd	200									
226	4056-7944	Millerstown Water Works	E. E. Leopold	1914	P	1180	V	P ak/ss	60	28	7				53	10		
227	4050-8002	McCandless, Greer	Fred Rahiser & Son	1925	H	1220	S	P af/ls	123		6							
228	4049-7959	Loyal Order of Moose	Fred Rahiser & Son	1925	R	1230	H	P c	128	36	6	50, 97, 110						
229	4053-7955	Butler Street Railway Co.	Fred Rahiser & Son	1923	R	1060	V	P ak	225	73	6	128			85		24	
230	4052-7953	Gilbreath	Harry Schaffner	1926	H	1290	H	P cm/ssh	550			210	250		1			
231	4053-7954	Rieger, Paul		1924	C	1275	H	P c/sh	120			80, 110, 115	80	1924				
232	4052-7957	Bortmas, W. H.	Ed Spohn	1925	N	1300	H	P cm/sh	209	13	6		139		13			5
233	4052-7956	Butler and McGinness	F. W. Smith	1924	H	1320	H	P cbc/sh	127		6							
234	4051-7955	Sobkuz, Stanley	F. W. Smith	1924	H	1260	H	P cbc/sh	90	50								
235	4052-7954	Citizens Mutual Water Co.	Harry B. Dietrich	1922	P	1140	S	P a	397	144	6	205, 300	40		9			
236	4051-7954	Citizens Mutual Water Co.		1924	P	1000	V	P ac/ss	225	122	4		60		20	25	12	
237	4051-7954	Butler Steam Laundry	F. W. Smith	1905	N	1020	V	P ak/sh	101		8				15			
238	4050-7953	Spang and Co.	F. W. Smith	1924	N	1025	V	P ak/sh	120	20	8							
239	4052-7952	Bessemer & Lake Erie R.R.	C. A. Porter	1904	C	1010	V	P ak	95	32	6		50		30			
240		Gallagher			H	1050	V	P ak/ss	134				F					
241		Bessemer & Lake Erie R.R.	W. W. Smith	1920		1015	V	P ak	62	37	6							
242	4050-7953	Spang and Co.	F. W. Smith	1924	N	1025	V	P ak/ss	195	14	8				25			
243	4051-7953	Hosford, Charles	Fred Rahiser & Son	1923	H	1040	V	P ak/sd	191	125	6	177						
244	4051-7954	Standard Steel Car Co.		1912	N	1000	V	P ak/sd	161	152	4				400			
245	4051-7954	Standard Steel Car Co.			N	1000	V	P ph	249	154	6				500			
246	4050-7954	Brown	F. W. Smith	1924	H	1190	S	P af/sh	70	50	5							
247	4050-7954	Hilliard, Basil	F. W. Smith	1924	H	1080	S	P af	83		6							
248	4053-7951	Valvoline Oil Co.	Harry Schaffner	1926	N	1030	V	P p/ss	210		8				300			
249	4051-7951	Pistorius, Herman	F. W. Smith	1924	H	1270	H	P af/ssh	151				81	1924				
250	4051-7948	Birchbegler, Frank	Clarence Smith	1924	H	1280	S	P af/ss	125			120						
251	4051-7947	Graham, Lawrence	Clarence Smith	1925	C	1290	H	P cm/ss	87		6		45	1925				
252	4050-7949	Steighner, Edward	Clarence Smith	1925	H	1340	H	P cbc/sh	75		5		35	1925				
253	4049-7948	Monastery	E. C. Rudert		H	1335	H	P af/sh	317	165	6		100					
254	4050-7947	Smith, Clarence	Clarence Smith		H	1320	H	P cm	107				94		3			
255	4048-8007	Talbo, Bert	Fred Rahiser & Son	1925	H	920	V	P ak/ssh	51	49	6							
256	4047-8008	Clark, Mrs.	Fred Rahiser & Son	1912	H	960	V	P ak/sh	147	100	6							
257	4046-8005	Evansburg Borough	Fred Rahiser & Son	1923	P	975	V	P ak/sh	122	47	6							
258	4046-8005	Evansburg Borough	Fred Rahiser & Son	1923	P	950	V	P ph/ss	269	160	6		40	1923	50			
259	4048-8000	Love, J. N.	Fred Rahiser & Son	1924	H	1190	W	P cm/ss	71	43	6							
260	4047-7959	Girl Scout Camp	Harry Schaffner	1924	R	980	V	P ph/ss	300						25			
261	4047-8002	Boggs, Addison	Fred Rahiser & Son	1924	H	1020	V	P ak/sh	61	34	6		10	1924				
262	4047-8001	Community Camp	Fred Rahiser & Son	1924	H	940	V	P ak/ss	106	39	6							
263	4045-8002	Irwin, Robert	Fred Rahiser & Son	1926	H	1000	V	P af/sh	45	15	6							
264	4044-8002	Kaufman, Lew	Fred Rahiser & Son	1924	H	1070	S	P af/ss	211		6							
265	4047-7956	Fletcher, W.	F. W. Smith	1924	H	1210	H	P cbc/sh	176	150	5	160						
266	4046-7956	Miller, Philip	F. W. Smith	1924	H	1220	H	P cs/ss	105	82	6							

Table 4. *(Continued)*

Well number	Location	Owner	Driller	Date completed	Use	Altitude of Land Surface (feet)	Topographic setting	Aquifer/ Lithology	Total Depth Below Land Surface (feet)	Casing: Depth (feet)	Casing: Diameter (inches)	Depth(s) to Water-bearing Zone(s) (feet)	Static Water Level: Depth Below Land Surface (feet)	Static Water Level: Date measured	Pumping Data: Yield (gpm)	Pumping Data: dd (feet)	Pumping Data: Time (hour)	Hardness	Specific conductance (micromhos at 25°C)	pH
267	4048-7951	Trimber, C. C.	F. W. Smith	1924	H	1340	H	P cb/ss	102				80							
268	4048-7948	Bachman, Willis	Clarence Smith	1925	H	1310	S	P cb/sh	140				98	1925						
269	4048-7952	Bertner, Forest	F. W. Smith	1924	H	1290	S	P cm/sh	193	34	6									
270	4046-7950	Weitzel	F. W. Smith	1924	H	1145	V	P cbc/sh	52	19	6									
271	4046-7950				U	1120	V	P cm/ss					+20		200					
272	4045-7949		E. C. Rudert		H	1300	H	P cm/ss	130	95			63							
273	4046-7946	Standard Plate Glass Co.	Clarence Smith	1924	N	1220	V	P cbc/sh	103		6		12		25	2				
274	4046-7946	Fronck	Clarence Smith	1925	H	1310	H	P cb/ss	100				57	1925						
275	4046-7945	Kennedy, Harry	Clarence Smith	1925	H	1350	S	P cm/ss	93	61	6		57							
276	4045-7946	Steignheizer, J.	Clarence Smith	1925	H	1330	H	P c/sh	46											
277	4046-7946	Shearer, H. P.	Clarence Smith	1925	H	1235	V	P c/ss	35	25			F		3					
278	4047-7941	Pennsylvania Clay Products Co.	E. C. Rudert		H	1000	V	P ac/ss	100											
279	4046-7941	Denny, Flavius	E. C. Rudert	1924	H	1200	S	P cm/ss	151	101	5		126							
280	4044-8007	Klein, Michael	Fred Rahiser & Son	1923	H	1190	H	P cm/ss	194		6		150							
281	4043-8008	Link, Harvey	Fred Rahiser & Son	1923	H	1150	H	P cbc/sh	136	18	6									
282	4041-8004	Baird, W. F.	Fred Rahiser & Son	1925	H	1200	S	P cs/sh	96	24	7									
283	4044-8003	Bunbar, W. E.	Fred Rahiser & Son	1926	H	1100	H	P cbc/sh	111	19	7		18		1					
284	4044-8000	Callery School	Fred Rahiser & Son	1926	T	990	V	P sf/ssh	83	21	7				1					
285	4043-8003	Maier, E. J.	Fred Rahiser & Son	1924	H	1125	H	P cbc/sh	151	23	6		90							
286	4041-8000	Mars Borough			P	1040	V	P cm	194		8									
287	4041-8000	Mars Borough			P	1040	V	P cm	90		6									
288	4040-7959	Cox, Grant	George F. Harbison		H	1100	S	P cb/ss	145	80	6		105							
289	4040-7959	Kramers Packing Plant	George F. Harbison	1917	N	960	V	P cm/ss	70		6		1		5					
290	4043-7955	McCarty	George F. Harbison		H	1150	S	P cb/ss	63	20	6		28							
291	4040-7956	McNanny, James	George F. Harbison		H	1150	V	P cs/ss	28	18	6				3					
292	4043-7950	Bessemer & Lake Erie R.R.	C. A. Porter	1909	C	1200	V	P cm/ss	165		12		150		110					
293	4042-7952	Williams, A. T.	C. A. Porter		H	1225	H	P cbc/sh	98		6									
294	4042-7951	Bessemer & Lake Erie R.R.	E. C. Rudert	1920	H	1170	V	P cm/ss	75	50	6		35							
295	4041-7949	Bessemer & Lake Erie R.R.	C. A. Porter	1916	U	1060	S	P ak/ss	215	10	8		75							
296	4043-7945	Wetzel	Clarence Smith	1925	H	1060	S	P cm/ss	80		6		55	1925						
297	4044-7944	American Natural Gas Co.	T. W. Phillips Gas & Oil Co.		N	1100	V	P cm/ss	49		8		6							
298	4047-8002	Drushell, Phillip	Fred Rahiser & Son	1924	H	1010	T	P ak/ss	64	40	6		40							
299	4103-7946	Kelly, F. L.	T. W. Phillips Gas & Oil Co.		U	1300	S	Mm												
300	4104-7945	Butler, A. E.	T. W. Phillips Gas & Oil Co.			1390	H	ss							0.1					
301	4058-7952	Fleming, G. W. – No. 3	T. W. Phillips Gas & Oil Co.		U	1280	W	ss							1					
302	4048-7950	Boyers			U	1275	S	Dm/ss							0.2					
303	4056-7948	Conway, C. H.	T. W. Phillips Gas & Oil Co.			1225	S					1260, 1425								

304	4054-7945	Donaldson, A. E.	T. W. Phillips Gas & Oil Co.			1230	V								0.1		
305	4050-7947	Michal, Christian	T. W. Phillips Gas & Oil Co.		U	1290	S	ss							0.5		
306	4049-7949	Eichenlaub, Joseph	T. W. Phillips Gas & Oil Co.		U	1340	H	ss									
307	4048-7949	Nagley, D. F.	T. W. Phillips Gas & Oil Co.		U	1290	H	ss									
308	4042-7951	Morrison, Walter	Clarence Smith	1926	U	1150	V	Mm/ss	2000				300				
309	4041-7950	Miller, Sara, Mrs.	Joseph Bachman	1926	U	1025	S	Mm	1163	447	6		250				
310	4043-7944	Faulkner, Samuel	T. W. Phillips Gas & Oil Co.	1911	U	1060	S		1350						0.5		
311	4105-7952	U.S. Geological Survey		1970	U	1465	H	▸ ak	89	12	7	10, 46, 68	21	June 1970	12		
312	4108-7949	Sloan, Foster	Mel Stalker	1895	H	1500	S	▸ ak/sh	25								
313	4101-7943	Koppers Co., Inc.			N	1175	V	▸ ph/ss	250		6		50	1946	100		
314	4101-7943	Koppers Co., Inc.			N	1175	V	▸ ak/ss	80		6				125		
315	4101-7943	Koppers Co., Inc.		1943	U	1175	V	▸ ak/ss	125		6		32	Oct. 1951			
316	4101-7942	Koppers Co., Inc.			N	1175	V	▸ ph/ss	300		6				100		
317	4101-7942	Koppers Co., Inc.	Robert Wick	1943	N	1250	V	▸ ak/ss	250		6				10		
318	4101-7942	Koppers Co., Inc.			N	1170	V	▸ ph	400		6				100		
319	4059-7944	Pennsylvania Refining Co.	Pennsylvania Refining Co.		N	1220	V	▸ a	200		8				100		
320	4047-7942	Penn Dixie Cement Co.	Smith & Hefler	1927	P	960	V	▸ ac	68		6				40		
321	4047-7942	Penn Dixie Cement Co.	Layne-New York Co., Inc.	1950	N	960	V	▸ ph	250	15	10				260		
322	4047-7942	Penn Dixie Cement Co.		1943	N	960	V	▸ ph	200		6				100		
323	4047-7942	Penn Dixie Cement Co.	Layne-New York Co., Inc.	1950	N	960	V	▸ ph	225	15	10				320		
324	4047-7942	Penn Dixie Cement Co.		1943	N	960	V	▸ ph	125		6				100		
325	4052-7951	Butler Coop. Egg Auction			N	1020	V	▸ a	80		4				5		
326	4052-7951	Freedom Valvoline Oil Co.			N		V	▸ ph	160		6				100		
327	4052-7951	Fretz-Moon Tube Co.	Jacob Schaffner	1930	N	1030	V	▸ ph	325		6		100		100		
328	4044-8002	Mine Safety Appliance Co.		1941	N	960	V	▸ af	95		8		55		100		
329	4044-8002	Mine Safety Appliance Co.	J. C. McNeill	1942	N	960	V	▸ af	169		8		45		60		
330	4044-8002	Mine Safety Appliance Co.	Roy Stofford	1949	N	980	V	▸ af/ss	150	84	10		50		70	22	23
331	4051-7954	U.S. Bottling Co.		1920	N	1000	V	▸ a	150		6		31	Oct. 1949	7		
332	4051-7954	U.S. Bottling Co.	Joseph Nebel Sons	1947	N	1000	V	▸ a	140	40	6		20				
333	4051-7954	Butler Packing Co.		1937	N	990	V	▸ a	180		6		12		9		
334	4051-7953	R. D. Dunn Candy Co.		1900	N	990	V	▸ a	130		6		10	July 1949			
335	4051-7954	Butler Water Co.		1909	P	1000	V	▸ a	200		4		45	Aug. 1949	15		
336	4051-7954	Butler Water Co.		1938	P	1000	V	▸ ph	225	146	6		28	Mar. 1949	80		
337	4051-7953	Butler Water Co.		1944	P	1000	V	▸ ph	225	149	6		55	Aug. 1949	80		
338	4051-7954	Butler Water Co.		1909	P	1000	V	▸ ph	230		4		45	Aug. 1949	15		
339	4041-8000	Mars Borough	Joseph D. Anderson	1943	U	1000	S	▸ cb/ss	180		8		80		25	5	
340	4041-8001	Mars Borough	Joseph D. Anderson	1945	P	1065	S	▸ cb	65		10		28		100		
341	4041-8001	Mars Borough	Joseph D. Anderson	1948	P	1060	S	▸ cb	60		10		22		30	20	
342	4041-8000	Mars Borough		1905	U	940	V	▸ cm/ss	110		5		25		30		
343	4041-8000	Mars Borough	L. Purvis & Son	1947	U	940	V	▸ cm	42		10		25		50	20	
344	4047-8009	Johns-Manville Corp.			A	900	V	▸ ak/ss	50		4				20		
345	4051-7953	Pittsburgh Crushed Steel Co.	Andrew Beikert	1949	N	1000	V	▸ a	87	87	8		19	July 1949			
346	4051-7953	Penn Theater	Jacob Schaffner	1938	A	1040	V	▸ ph/ss	375		8				300		
347	4043-7945	Peoples Natural Gas Co.			U	1080	S	▸ cb/ss	43	20	8		23	Nov. 1951			
348	4051-7953	Franklin Glass Corp.			U	1020	V	▸ a	100		6				50		
349	4051-7953	Franklin Glass Corp.			U	1030	V	▸ ph			6				50		
350	4041-7943	B. W. Cramer Dairy	Clarence Hepler	1917	N	1040	V	▸ cm/ss	100		6				6		
351	4041-7943	R. W. Cramer Dairy	Clarence Hepler	1917	N	1040	V	▸ cm/ss	135		6				6		
352	4041-7943	R. W. Cramer Dairy	Clarence Hepler	1917	N	1040	V	▸ cm/ss	100		6				6		

Table 4. *(Continued)*

Well number	Location	Owner	Driller	Date completed	Use	Altitude of Land Surface (feet)	Topographic setting	Aquifer/ Lithology	Total Depth Below Land Surface (feet)	Casing: Depth (feet)	Casing: Diameter (inches)	Depth(s) to Water-Bearing Zone(s) (feet)	Static Water Level: Depth Below Land Surface (feet)	Static Water Level: Date measured	Pumping Data: Yield (gpm)	Pumping Data: dd (feet)	Pumping Data: Time (hour)	Hardness	Specific conductance (micromhos at 25°C)	pH
353	4041-7943	R. W. Cramer Dairy	Clarence Hepler	1940	N	1040	V	P cm	173		8				20					
354	4045-7948	Saxonburg Borough	Fry	1937	P	1260	H	P cb/ss	100		8		16	1937	20					
355	4046-7949	Saxonburg Borough	Joseph Nebel Sons	1950	U	1200	H	P cb	300		10		60	1950	20					
356	4045-7949	Saxonburg Borough		1958	P	1260	H	P a	300						90					
357	4044-7948	Saxonburg Borough	Clarence Hepler	1942	U	1290	H	P cb	150		6		50		20					
358	4044-7948	Saxonburg Borough	Joseph Nebel Sons	1947	U	1320	H	P c	400		10		60	1947	20					
359	4102-7943	Ultra-Penn Refining Co.			N	1120	V	P ph/ss	300		6		15		100					
360	4102-7943	Ultra-Penn Refining Co.			N	1120	V	P ph/ss	300		6		30		50					
361	4102-7943	Ultra-Penn Refining Co.			N	1120	V	P ph/ss	300		6		30		50					
362	4050-7955	American Rolling Mill Co.	Layne-New York Co., Inc.	1945	N	995	V	P ak	152	38	12		23	Feb. 1946	119	34	8	9		6.7
363	4050-7955	American Rolling Mill Co.	Layne-New York Co., Inc.	1938	N	995	V	P ak	478	75	10		18	May 1938	214	21	8	18		6.3
364	4050-7955	American Rolling Mill Co.	Layne-New York Co., Inc.	1945	N	995	V	P ak	115	38	12		19	Sept. 1945	142	28	8	9		6.5
365	4050-7955	American Rolling Mill Co.	Layne-New York Co., Inc.	1931	U	993	V	P ak	81		8		21	Aug. 1949				10		7.1
366	4050-7955	American Rolling Mill Co.	Layne-New York Co., Inc.	1947	N	990	V	P ak	150	24	12		20	Sept. 1947	406	22	32			7.0
367	4050-7955	American Rolling Mill Co.	Layne-New York Co., Inc.	1947	N	990	V	P ak	150	33	12		18	Sept. 1947	418	16				7.3
368	4050-7955	American Rolling Mill Co.	Layne-New York Co., Inc.	1931	U	993	V	P ak	165		8		23	Aug. 1949				14		7.3
369	4048-8007	Harmony Borough			U	920	V	Qgl/sdgv	24		8			Apr. 1951	25					
370	4048-8007	Harmony Borough			U	920	V	Qgl/sdgv	24		6		2	Apr. 1951	25					
371	4048-8007	Harmony Borough			U	920	V	Qgl/sdgv	24		6		2	Apr. 1951	25					
372	4048-8007	Harmony Borough			U	920	V	Qgl/sdgv	19		8		1	Apr. 1951	25					
373	4048-8007	Harmony Borough			U	920	V	Qgl/sdgv	21		8		2	Apr. 1951	25					
374	4048-8007	Harmony Borough		1945	U	920	V	Qgl/sdgv	19		10		1	Apr. 1951	25					
375	4048-8007	Harmony Borough		1945	U	920	V	Qgl/sdgv	20		10		1	Apr. 1951						
376	4048-8007	Harmony Borough			U	920	V	Qgl/sdgv	22		8		4	Apr. 1951						
377	4056-7944	Chicora Water Co.		1960	P	1160	S	P a	100						107	17	14			
378	4041-8001	Mars Borough			P	1080	V	P c	100						150					
379	4101-7943	Petrolia Water Co.		1965	P	1280	S	P av/ls	268						30		65			
380	4041-8007	Cranberry Twp. Water Auth.	Pennsylvania Drilling Co.	1970	P	990	V		185				15							
381	4105-8003	Slippery Rock Borough		1970	P	1228	S	P pc/ss	195	106	10		77		225	59	24			

Table 5. *Logs of Wells in Butler County, Pennsylvania* [1]

Well Bt-17

Description	Thickness (feet)	Depth (feet)
Quaternary System		
Illinoian till		
Sand and gravel, coarse, pebbles consist mostly of sandstone	5	5
Pennsylvanian System		
Kittanning Formation, middle member		
Sandstone, brownish-gray, very fine- to fine-grained; considerable interbedded grayish-black carbonaceous shale containing some muscovite	11	16
Claystone, gray, minute fragments of carbonized plant remains; interbedded very fine-grained gray sandstone at 24 to 26 feet	14	30
Shale, grayish-black, containing a little muscovite and abundant pyrite	2	32
Claystone, gray, containing abundant muscovite and a few minute fragments of carbonized plant remains	12	44
Sample missing	2	46
Kittanning Formation, lower member		
Coal, containing a little pyrite	4	50
Claystone, light-gray, sandy, containing a little muscovite and abundant siderate nodules at 59-61 feet; considerable interbedded light-gray shale	11	61
Sandstone, light-gray, very fine-grained, silty, containing abundant siderite nodules	6	67
Claystone, greenish-gray, containing abundant siderite nodules; considerable interbedded light-gray shale	3	70
Vanport Limestone		
Limestone, grayish-brown, very fine, dense	20	90
Clarion Formation		
Coal, Scrubgrass	1	91
Sandstone, gray, very fine- to fine-grained, silty, containing muscovite and pyrite	6	97
Shale, gray, containing considerable minute fragments of carbonized plant remains, abundant muscovite and a little interbedded gray, sandy siltstone	–	–
Sandstone, very light-gray, very fine-grained, containing muscovite and minute fragments of carbonized plant remains	16	118
Siltstone, gray, sandy, containing considerable muscovite and a few minute fragments of carbonized plant remains	10	128
Shale, gray, containing considerable muscovite	6	134
Coal, Brookville	1	135
Claystone, light-gray, containing a few minute fragments of carbonized plant remains and a little muscovite	3	138

[1] The stratigraphic nomenclature used in this report conforms to the usage of the Pennsylvania Topographic and Geologic Survey and not necessarily to that of the U.S. Geological Survey.

Table 5. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Homewood Formation		
Sandstone, gray, very fine-grained, silty, containing muscovite, minute carbonized plant remains, and a few siderite nodules	34	172
Sandstone, very light-gray, very fine- to very coarse-grained	37	209
Mercer Formation		
Shale, gray, silty, containing muscovite	6	215
Sandstone, light-gray, very fine- to coarse-grained, containing muscovite	4	219
Claystone, brownish-gray; interbedded silty shale, containing muscovite, pyrite and siderite nodules	3	222
Sandstone, very light-gray, very fine; interbedded gray silty shale	8	230
Claystone, very light-gray, containing abundant pyrite and a few minute fragments of carbonized plant remains	2	232
Sandstone, gray, fine-grained, silty, containing muscovite, minute fragments of carbonized plant remains, and siderite nodules	7	239
Shale, dark-gray, silty, containing considerable muscovite	8	247
Coal	1	248
Sandstone, gray, very fine- to fine-grained, silty, containing many minute fragments of carbonized plant remains and a little muscovite	8	256
Siltstone, gray, sandy, containing many carbonized plant remains and a little muscovite	5	261
Shale, gray and brown, containing considerable muscovite and pyrite	28	289
Connoquenessing Formation, upper member		
Sandstone, light-gray, very fine- to fine-grained, silty, containing muscovite and a few very coarse, very light-gray quartz grains	6	295
Sandstone, light-gray, very fine- to medium-grained, containing muscovite and a few coarse quartz grains	7	302
Sandstone, light-gray, very fine- to coarse-grained	7	309
Connoquenessing Formation, middle member		
Coal, Quakertown	1	310
Connoquenessing Formation, lower member		
Sandstone, clear, very fine- to fine-grained, containing muscovite, siderite nodules, and carbonized plant remains	13	323
Sandstone, clear, very fine- to medium-grained, argillaceous, containing muscovite and a few coarse quartz grains; 4 feet of light-gray silty shale at base	20	343
Sandstone, very light-gray, very fine- to medium-grained, argillaceous	8	351
Sandstone, clear, very fine- to coarse-grained, argillaceous	9	360

Table 5. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Mississippian System		
Burgoon Sandstone		
Siltstone, gray, sandy, containing siderite nodules and a little muscovite	4	364
Sandstone, clear, very fine- to medium-grained, argillaceous, containing a little muscovite and a few siderite nodules	27	391
Sandstone, very light greenish-gray, very fine- to fine-grained, silty, containing considerable muscovite	1	392
Sandstone, clear, very fine- to medium-grained, argillaceous, containing a little muscovite and a few siderite nodules	32	424
Siltstone, gray to brownish-gray, containing muscovite; interbedded light-gray shale	2	426
Sandstone, clear, very fine- to medium-grained, argillaceous, containing many siderite nodules and a little muscovite and pyrite	11	437
Sandstone, light greenish-gray to gray, very fine- to very coarse-grained, argillaceous, containing minute fragments of carbonized plant remains, pyrite, and a little muscovite	4	441
Hempfield Shale		
Shale, gray to grayish-brown, containing a little muscovite and pyrite; interbedded gray to grayish-brown siltstone; a small amount of very fine- to medium-grained, light-gray sandstone	6	447
Siltstone, gray, containing a little pyrite and minute fragments of carbonized plant remains; interbedded grayish-brown to dark-gray shale; a little very light-gray to gray, very fine- to coarse-grained sandstone	5	452
Shale, gray to brownish-gray, silty, containing pyrite and minute fragments of carbonized plant remains	6	458
Sandstone, light-gray to gray, very fine- to fine-grained, containing a little pyrite	3	461
Shale, dark-brown and gray, silty, containing a little muscovite and a little pyrite	11	472
Sandstone, light-gray to gray, very fine- to fine-grained, containing a little muscovite and a little pyrite	4	476
Shale, gray and brown, silty, containing muscovite, pyrite, and minute fragments of carbonized plant remains	11	487
Shenango Formation		
Sandstone, very light-gray, very fine- to coarse-grained, argillaceous and calcareous	2	489
Sandstone, greenish-gray, very fine- to fine-grained, argillaceous, containing considerable muscovite and a little biotite	8	497
Shale, gray, silty, containing considerable muscovite and minute fragments of carbonized plant remains	3	500

Table 5. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Sandstone, very light-gray, very fine- to fine-grained, containing muscovite, a little pyrite, and minute fragments of carbonized plant remains	3	503
Siltstone, gray, sandy, containing muscovite and minute fragments of carbonized plant remains	10	513
Sandstone, light-gray to greenish-gray, very fine, silty, containing muscovite and minute fragments of carbonized plant remains	7	520

Well Bt-19

Description	Thickness (feet)	Depth (feet)
Pennsylvanian System		
Homewood Formation		
Sample missing	85	85
Sandstone, medium- to coarse-grained; loosely cemented; coal	10	95
Sandstone, fine- to medium-grained, some grains show crystal faces	5	100
Sandstone, medium- to coarse-grained	7	107
Sandstone, fine-grained	4	111
Mercer Formation		
Sandstone, medium-grained, clayey; interbedded siltstone and coal	9	120
Sandstone, coarse-grained, clayey; interbedded siltstone	8	128
Siltstone, dark gray to dark red; limonite and clay cement on grains	6	134
Sandstone, very fine- to fine-grained	10	144
Siltstone, dark gray; coal	5	149
Siltstone, dark gray	13	162
Connoquenessing Formation, upper member		
Sandstone, fine-grained	21	183
Sandstone, medium- to coarse-grained, loosely cemented	7	190
Connoquenessing Formation, middle member		
Siltstone, gray	10	200
Connoquenessing Formation, lower member		
Sandstone, fine-grained, loosely cemented	30	230
Mississippian System		
Burgoon Sandstone		
Sandstone, fine-grained; abundant dark-red and white siltstone	32	262

Table 5. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Sandstone, fine-grained, loosely cemented; a little black shale or poor coal	9	271
Sandstone, fine-grained, loosely cemented	8	279
Sandstone, medium-grained	6	285
Sandstone, medium-grained, loosely cemented	6	291
Sandstone, very fine- to coarse-grained, loosely cemented	7	298
Sandstone, medium-grained	7	305
Sandstone, very fine- to medium-grained; interbedded siltstone	20	325
Sandstone, very fine-grained; much gray siltstone	15	340
Hempfield Shale		
Siltstone, dark-gray; small amount of coal	7	347
Siltstone, dark-gray	6	353
Sandstone, fine-grained	9	362
Siltstone, gray; interbedded very fine- to fine-grained sandstone	39	401
Shenango Formation		
Sandstone, very fine- to medium-grained; interbedded siltstone near bottom	41	442
Siltstone, gray	10	452
Sandstone, very fine- to fine-grained	13	465
Siltstone, gray	15	480
Sandstone, fine-grained; abundant gray siltstone	24	504

Well Bt-151

Description	Thickness (feet)	Depth (feet)
Quaternary System		
Illinoian till	10	10
Pennsylvanian System		
Kittanning Formation, lower member		
Slate and fireclay	38	48
Crevice	3	51
Vanport Limestone	11	62
Clarion Formation		
Shale and slate	23	85
Sandstone, gray	18	103
Homewood Formation		
Sandstone with a little shale	9	112

Table 5. *(Continued)*

Well Bt-158

Description	Thickness (feet)	Depth (feet)
Quaternary System		
Kent ground moraine		
Sand and gravel, pebbles consist mostly of sandstone	28	28
Pennsylvanian System		
Vanport Limestone		
Limestone, brownish-gray, very fine, dense	28	56
Clarion Formation		
Shale, dark-gray, silty; a little interbedded coal	1	57
Sandstone, light-gray, in part stained yellowish brown by weathering, fine-grained, containing muscovite	23	80
Coal, bony	1	81
Homewood Formation		
Shale, gray, sandy, containing some muscovite	19	100
Shale, very dark-gray, silty, containing muscovite and minute fragments of carbonized plant remains	10	110
Mercer Formation		
Shale, black	5	115
Shale, dark-gray	7	122
Shale, gray, sandy, containing muscovite and minute fragments of carbonized plant remains	3	125
Shale, very dark-gray; interbedded coal and gray claystone	6	131
Shale, gray to dark-gray, sandy, containing muscovite and minute fragments of carbonized plant remains	8	139
Shale, dark-gray	9	148
Shale, dark-gray to grayish-black	3	151
Shale, dark-gray, silty	14	165
Sandstone, light-gray, fine-grained; a little interbedded black shale and coal	4	169
Shale, dark-gray, silty, containing minute fragments of carbonized plant remains; interbedded fine grained, light gray sandstone	15	184
Shale, very dark-gray, silty, containing muscovite and minute fragments of carbonized plant remains	12	196
Sandstone, light-gray, fine-grained, containing a little muscovite	11	207
Shale, dark-gray, silty, containing muscovite and minute fragments of carbonized plant remains	10	217
Shale, dark-gray, silty; a little interbedded coal	6	223
Claystone, dark grayish-brown	5	228
Connoquenessing Formation, upper member		
Sandstone, brownish-gray, medium-grained; interbedded dark-gray, silty shale	5	233
Sandstone, light-gray, medium-grained, poorly sorted, containing well-rounded quartz grains	6	239

Table 5. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Connoquenessing Formation, middle member		
Shale, dark-gray, silty, containing muscovite	13	252
Connoquenessing Formation, lower member		
Sandstone, light-gray, fine-grained, containing muscovite	18	270
Sandstone, light-gray, fine- to medium-grained, containing a little muscovite	37	307
Sandstone, light-gray, very fine to fine-grained, containing a little muscovite	23	330
Mississippian System		
Burgoon Sandstone		
Sandstone, light-gray, fine- to medium-grained, friable; interbedded dark-gray, silty shale	6	336
Sandstone, light-gray, fine- to medium-grained, containing some muscovite	7	343
Sandstone, light-gray, fine- to medium-grained, containing some muscovite and minute fragments of carbonized plant remains; interbedded dark-gray, silty shale	7	350
Sandstone, light-gray, fine-grained, containing a little muscovite	18	368
Sandstone, light greenish-gray, fine-grained, containing muscovite	25	393
Hempfield Shale		
Shale, dark greenish-gray, silty; interbedded greenish-gray siltstone, containing muscovite and minute fragments of carbonized plant remains	51	444
Shenango Formation		
Sandstone, light greenish-gray, very fine- to fine-grained, moderately friable, containing biotite and muscovite, and minute fragments of carbonized plant remains	17	461
Shale, greenish-gray, silty; interbedded, very fine-grained, light greenish-gray sandstone, containing muscovite and minute fragments of carbonized plant remains	13	474
Sandstone, light greenish-gray, very fine- to fine-grained, containing muscovite and minute fragments of carbonized plant remains	19	493
Sandstone, light greenish-gray, fine-grained, containing a little muscovite	23	516
Sandstone, light-gray, fine-grained	17	533
Shale, dark-gray; interbedded very fine-grained, greenish-gray sandstone	8	541
Sandstone, light greenish-gray, fine-grained, poorly sorted, containing muscovite	9	550
Sandstone, light greenish-gray, very fine-grained; interbedded dark-gray shale	7	557
Shale, dark greenish-gray, silty	39	596

Table 5. *(Continued)*

Well Bt-292

Description	Thickness (feet)	Depth (feet)
Quaternary System		
Soil	2	2
Pennsylvanian System		
Glenshaw Formation		
Buffalo Sandstone Member	48	50
Shale, dark	23	73
Brush Creek coal(?)	1	74
Fireclay	48	122
Limestone	2	124
Mahoning Sandstone Member	14	138
Shale, light	6	144
Freeport Formation		
Upper Freeport coal	1	145
Shale, dark	7	152
Limestone	9	161

Well Bt-363

Description	Thickness (feet)	Depth (feet)
Pennsylvanian System		
Kittanning Formation, upper member		
Fill	4	4
Clay, yellow	13	17
Clay, blue	1	18
Shale, blue, hard, and clay	45	63
Shale, and clay, blue, hard, interbedded	33.5	96.5
Kittanning Formation, middle member		
Coal	5	101.5
Clay, blue and brown, some shale	30.5	132
Clay, black, and shale	24	156
Kittanning Formation, lower member		
Coal	3	159
Clay, blue	9	168
Sandstone, gray	7	175
Clay, tough	17	192
Clay and shale	10	202
Vanport Limestone	14	216
Clarion Formation		
Coal	2.5	218.5
Clay, hard, and shale	10.5	229
Coal	1	230
Clay and shale	25	255

Table 5. *(Continued)*

Description	Thickness (feet)	Depth (feet)
Homewood Formation		
Sandstone, gray	15	270
Clay and shale	4	274
Sandstone, white	2	276
Sandstone, gray	5	281
Clay and shale	5	286
Sandstone, white	14	300
Clay and shale	5	305
Sandstone, white	11	316
Mercer Formation		
Clay and shale	12	328
Clay, tough	30	358
Shale and sandstone	7	365
Clay, tough	3	368
Shale, hard	2	370
Connoquenessing Formation, upper member		
Sandstone, white	2	372
Shale and sandstone	3	375
Sandstone, white	3	378
Shale and sandstone	10	388
Sandstone	2	390
Sandstone, coarse, white	8	398
Connoquenessing Formation, middle member		
Clay, white	2	400
Clay, blue and white	6	406
Shale and sandstone	5	411
Clay and shale	2	413
Shale, black	13	426
Clay and shale	20	446
Coal	1	447
Clay and shale	8	455
Connoquenessing Formation, lower member		
Sandstone, fine, white	23	478

UNCONSOLIDATED DEPOSITS

Origin and Lithology

The unconsolidated materials were deposited in a variety of geologic environments. Glaciers moved into northwestern Butler County at least twice during Pleistocene time and deposited a heterogeneous mixture of clay, silt, sand, and boulders, called till (Plate 1).

The earliest glaciation of which we have record in Pennsylvania is called the Illinoian, after the state where it was first studied. The later glaciation is called

Table 6. *Composite Stratigraphic Section for Butler County*

System	Group	Thickness (feet)	Character of strata	Water-bearing properties
Quaternary		0-100+	Unconsolidated material, ranging in size from clay to boulders; deposited by glacial ice, by streams flowing off the ice, in glacial lakes, and along modern streams.	Yields of wells range widely depending on sorting and thickness of deposits. Few data available; yields may exceed 100 gpm.
	Conemaugh	275	Sandstone, shale, limestone, thin coal beds, and red beds.	Yields of wells range from less than 5 gpm to more than 100 gpm. About half the wells yield 20 gpm or more. Dissolved solids of water are chiefly calcium bicarbonate; the average iron content is 0.28 mg/l; the water is moderately hard.
Pennsylvanian	Allegheny	320	Sandstone (sometimes in thick channels, shale, limestone (Vanport), and several commercial grade coal beds.	Yields of wells range from less than 5 gpm to more than 300 gpm. About half the wells yield 50 gpm or more. Dissolved solids may locally be mainly calcium or sodium and bicarbonate, sulfate, or chloride. Water is generally hard, and three-fourths of samples contain more than 0.3 mg/l of iron.
	Pottsville	220	Sandstone, shale, several thin coal beds.	Yields of wells range from less than 5 gpm to more than 300 gpm and average 36 gpm. Dissolved solids are mainly calcium magnesium bicarbonate in the upper part of group and sodium bicarbonate in lower part of group. Water is hard in upper part and soft in lower part of group. Half of samples contain more than 0.3 mg/l iron.
Mississippian	Pocono	300	Sandstone and shale.	Yields of wells range from 9 to 260 gpm and average about 82 gpm. Dissolved solids from single sample contain prominent proportions of calcium, sodium, bicarbonate, sulfate, and chloride, and 7.1 mg/l iron. Where deeply buried, the formation may contain saline water.

the Kent Stade (or subdivision) of the Wisconsinan glaciation (named in the same fashion as the Illinoian).

As meltwater streams flowed off the ice, they carried abundant debris with them and deposited it as outwash both within and beyond the glacial border. Outwash deposits that were deposited in valleys beyond the ice were later eroded and are present now as terrace remnants along the sides of some valleys. The debris generally contains chiefly sand and gravel, most of the silt and clay having been carried far downstream.

As the ice advanced across northwestern Pennsylvania, the preglacial drainage was disrupted and the northward-flowing streams were forced back on themselves, so that lakes formed in their valleys. Two such valleys that have been studied (Present, 1950) are those of Slippery Rock and Muddy Creeks. Streams of meltwater flowing into these valleys deposited their coarse material near the ice and their fine material in the quiet waters of the lake far from where the stream entered the valley. Most of the deposits filling glacial Lake Edmund, which occupied the valley of Slippery Rock Creek, are coarse. The sediment in glacial Lake Watts, which lay in the valley of Muddy Creek, is fine except in the extreme west end because most of the water in Lake Watts was derived from overflow from Lake Edmund (Plate 1).

Most of the till is less than 25 feet thick. Some outwash, however, may exceed 100 feet in thickness. Also, the sand and gravel in the west end of Lake Edmund may be thicker than 100 feet in places.

Water-Bearing Characteristics

The till is generally poorly permeable and capable of yielding only small supplies of water to wells. The outwash deposits, including the material at the west end of Lake Edmund, are highly permeable and, where water-saturated, should be capable of yielding 100 or more gallons of water per minute to wells. Unfortunately, yield data are available for only a half dozen wells (19 to 24 feet deep), which are reported to yield 25 gpm each.

Well Construction, Location, and Spacing

Yields of wells in the alluvium are greatest if they are drilled completely through it to the underlying bedrock and if screens are installed opposite any coarse saturated zones. Wells aligned parallel to any associated stream minimize interference between wells. A parallel alignment to the streams also increases the amount of recharge to the alluvium from the stream when the wells are pumped. Distances between wells and between the stream and wells can be determined after the areal extent, saturated thickness, and permeability of the alluvium are known.

Water Quality

Chemical analysis of water is available for only one well. The sample taken from a well penetrating Illinoian outwash shows the water is hard and generally high in chloride and sulfate, but low in iron.

BEDROCK

General Features

Origin and Lithology

The exposed bedrock, or that immediately beneath the unconsolidated material in Butler County, consists of sandstone, shale, limestone, and coal. These sedimentary rocks were deposited on, or a short distance seaward of, a large delta that grew generally westward during the time of Pennsylvania's great coal swamps.

The oldest of these rocks is the Pocono Group of Mississippian age. Only the uppermost unit of the Pocono, the Burgoon Sandstone, is exposed in Butler County.

Overlying the Mississippian rocks are three groups of rocks of Pennsylvanian age: Pottsville (oldest), Allegheny, and Conemaugh (youngest). Each of the three groups is composed of sandstone, shale, limestone, and coal, but certain rock types predominate over others in the different groups. In the Pottsville and Conemaugh Groups, sandstone is prominent, and coal is poorly developed; however, in the Allegheny, the coal and shale are best developed and sandstone beds are generally thinner and shaly.

Each of the groups contain channel sandstones, which are long narrow bodies of sandstone that appear to have been deposited in a stream channel. The channels are cut into the underlying beds, and some of the major channels may cut entirely through the beds of one group into the underlying group of rocks. The major channel sandstones commonly overlie one another, so that the entire stratigraphic sequence at a given point may be sandstone. A few miles on either side of the channel the beds may be dominantly shale.

Structure

The stresses that formed the Appalachian Mountains to the east of Butler County were much weaker in Butler County but still made their presence known. To determine the effect of these stresses in Butler County, it is necessary to measure the altitude of a single rock layer at many different places throughout the county. For convenience, the layer should be one that is widely distributed and easily recognized. (Such a layer is called a marker bed.) Only the Vanport Limestone and some of the coal beds qualify as marker beds here.

The Vanport is the most easily recognized by the available marker beds and is used in this report. Plate 1 shows how the rocks have been warped into many folds or structural ridges (anticlines) and structural troughs (synclines). These folds have been superposed on a broader regional structure that causes the rocks to dip generally southwestward. The total relief, or range of altitude, on the top of the Vanport in the county is more than 800 feet.

A structure map is important in the study of ground water because it makes possible the determination of the altitude of the rocks. Thus, a rock may be an important water-bearer in one area but lie too deep to be worth drilling to in another area.

Water-Bearing Characteristics

Water occurs in consolidated rocks, chiefly in fractures. Where the rock is shale, the fractures are small and close readily because shale is a weak rock and crumbles easily. Sandstone is generally well cemented, but when fractured it tends to develop clean breaks that remain open and serve as excellent conduits for water. The fractures are irregularly distributed in the rock, however, and make up a relatively small amount of the total volume of the rock, so that they are unable to store the large quantities of water that the spaces between grains of the unconsolidated material are capable of storing.

Well Location and Spacing

Wells of good yield in consolidated rocks must intercept fractures in which water occurs, though the locations of such fractures are difficult to determine. In recent years it has been discovered that fractures or concentrations of fractures are sometimes detectable on aerial photographs as linear features, called fracture traces, which result from topographic (including straight stream segments), vegetational, or soil-tonal alignments. Care must be taken to ensure that the fracture traces are natural features and are not man-made.

If aerial photographs are not available, or if fracture traces cannot be identified on the photographs, good results may often be obtained by drilling in stream valleys – especially straight reaches. The drilling of wells in valleys is justified theoretically because fractures are zones of weakness in the rocks and, therefore, are more erodible and apt to become valleys than adjacent areas. Also, because water occurs at shallower depths beneath the surface in valleys than in hills, there is more available drawdown in the valley wells.

The location and spacing of wells in a well field is a major factor controlling their interference with one another during pumping. When a well that obtains its water from a fracture is pumped, the water level draws down in the shape of a cone whose horizontal dimension is distorted into an elongate shape that extends along the fracture in both directions from the well. If two or more fractures supply the well, a part of the cone will extend along each of the fractures.

Fractures are not randomly oriented, but are usually arranged in any particular area chiefly in two or three major directions. In a small area, two fractures may be parallel and only poorly interconnected, so that a well on each of the fractures interferes with the other only slightly or not at all. In contrast, if the fractures are well connected or if the wells tap the same fracture, pumping one of the wells produces nearly as much drawdown in the umpumped well as in the pumped well.

In summary, wells located on fracture traces tend to yield more water; and when several wells of high-yield design are drilled in a small area, wells located on different fractures, or as far apart as practicable, interfere with one another to a minimum extent.

Water Quality

The chemical character of the water in the rocks of the Appalachian Plateau is diverse. Geologic conditions here give rise to three distinct types of water and, of course, mixtures of these types.

First, as precipitation percolates through the soil and underlying rock it dissolves small amounts of mineral matter, chiefly calcium and magnesium carbonate, which become bicarbonate in solution, and minor amounts of silica, iron, manganese, sodium, potassium, sulfate, chloride, nitrate, and fluoride. The resultant solution is called a calcium magnesium bicarbonate water. It generally contains about 200 mg/l dissolved solids and is the type of water that is usually referred to as ground water of good quality.

Second, ancient environments that favored the accumulation of plant material that later was transformed into coal also favored the deposition of iron sulfides, chief of which is pyrite. Many coal beds, therefore, have pyrite associated with them, either in masses interbedded with the coal or finely disseminated in the overlying strata. The pyrite dissolves in the ground water and contributes iron and sulfuric acid to form a second type of water, called a sulfate water. More commonly it is known as acid-mine water, though it may not be connected with any mining operations, and the acid may have been neutralized by reaction with limestone. However, mining will accelerate the solution of pyrite by breaking up the rock and exposing more surface area of pyrite to water and the air.

The presence of sulfuric acid enables the water to attack the rocks more strongly, which may increase the dissolved-solids content of the water to more than 2000 mg/l.

Third, when the sediments that form the consolidated rocks were laid down, sea water, which contains chiefly sodium and chloride, was trapped in the pore spaces. Subsequent changes have concentrated the dissolved-solids content of this trapped water so that today the dissolved material may exceed 200,000 mg/l. Such water occurs below the zone of fresh water and is encountered commonly during the drilling of deep oil and gas wells. Sometimes the salt water invades the freshwater aquifers through damaged or poorly plugged deep wells.

Precipitation has flushed the salt water from the upper several hundred feet of rock. However, all the constituents are not flushed with equal ease. Some sodium is held by the clay in the rocks and is removed very slowly, but the chloride is readily flushed. The flushing may be summarized as taking place in the following steps: (1) the dissolved-solids content is decreased, yielding a dilute sodium chloride water; (2) almost all the chloride is removed, leaving a sodium bicarbonate water; (3) the sodium concentration is still further reduced, and the water in the rocks becomes the type 1, or calcium magnesium bicarbonate type.

In absence of poorly permeable, difficult-to-flush rocks or contamination from leaky wells, the upper 100 to 300 feet of rocks in the county contain fresh ground water. Near the base of this zone the partly flushed water discussed above is present.

Conemaugh Group

Distribution and Lithology

About two-thirds of Butler County is underlain by rocks of the Conemaugh Group. The group is about 450 feet thick in Butler County (175 feet or more have been removed by erosion from the upper part) and is divided into two formations: the Casselman and the Glenshaw.

The following is a generalized geologic section of the Conemaugh Group in Butler County:

	Thickness range (feet)
Casselman Formation	
Morgantown Sandstone Member	40- 45
Birmingham Shale Member – red and gray shale, clayey to sandy, one or more thin coal beds, limestone	120-150
Glenshaw Formation	
Ames Limestone Member	0- 3
Pittsburgh red beds – red and gray shale, clayey to sandy	90-140
Saltsburg Sandstone Member – sandstone, shale, one to three coal beds	20- 40
Cambridge (or Pine Creek) Limestone Member	0- 2
Buffalo Sandstone Member – sandstone, shale	20- 40
Brush Creek Limestone Member – shale, coal, limestone	20- 30
Mahoning Sandstone Member – sandstone, red to gray shale, coal	70-100

The lithology of the formations is extremely variable so that sandstone is superseded by shale both laterally and vertically within short distances, and the coal and limestone beds are thin and not persistant. The Ames is more widely distributed than the other limestones in the Conemaugh and is sometimes used as a marker bed.

Well Depths and Yields

Data are available for 73 wells in the Conemaugh Group in Butler County. Ten are less than 50 feet deep and only two are more than 300 feet deep; the average depth is 100 feet.

Yields were reported for 27 of the wells. Eight yield less than 5 gpm and three yield more than 100 gpm. About half the wells yield 20 gpm or more.

Water Quality

Analyses of five samples of water from the Conemaugh show the water is of the calcium bicarbonate type and is low in chloride and sulfate. The single water sample (from well Bt-218) high in sodium and chloride is reported to be contaminated by water from nearby oil wells. Iron ranges from 0.12 to 2.2 mg/l; the average is 0.28 mg/l. Hardness of the water ranges from 28 to 204 mg/l and averages about 120 mg/l.

Allegheny Group

Distribution and Lithology

The Allegheny Group crops out in the northern half of the county and along the major stream valleys throughout the county. It includes all the rock between the top of the Upper Freeport coal and the base of the Brookville coal or its underclay. The Allegheny has been divided into the Freeport Formation (youngest), Kittanning Formation, Vanport Limestone, and Clarion Formation (oldest).

The following is a generalized section of the Allegheny Group:

	Thickness range (feet)
Freeport Formation	
Upper Freeport coal	0- 5½
Clay, limestone, sandstone, shale	33- 59
Lower Freeport coal	0- 4
Clay, coarse sandstone to fine conglomerate, shale	30- 66
Kittanning Formation	
Upper Kittanning coal	0- 8
Clay, sandstone, sandy shale, shale	35- 55
Middle Kittanning coal	0- 2
Clay, shale, thin-bedded sandstone, thin coal	55-108
Lower Kittanning coal	2- 4
Shale and thin sandstone	25- 45
Vanport Limestone	0- 18
Clarion Formation	
Shale	20- 40

	Thickness range (feet)
Clarion coal	1- 5
Clay, coarse sandstone, shale	38- 80
Brookville coal	0- 2
Clay	3- 12

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 of about 320 feet.

The Allegheny Group contains eight coal beds or horizons separated by shale, sandstone, limestone, and clay. Beds of coarse sandstone are prominent in some places, although there seems to be no sandstone in others.

The Vanport Limestone is a blue-gray fossiliferous rock usually containing about 90 percent calcium carbonate. In some places a low grade iron ore is present at the top of the limestone. The Vanport's distinctive appearance and widespread occurrence make it an ideal marker bed. (See section on structure.)

Well Depths and Yields

The Allegheny Group is capable of supplying moderate amounts of water to wells. About half the wells on which data are available (35 out of 69 wells) yield more than 50 gpm. Only one well yields less than 5 gpm, but seven wells (10 percent) yield 300 gpm or more. Measurements of depth of 144 wells are available. About half the wells are more than 103 feet deep. Ten percent are less than 55 feet deep, and 90 percent are 300 feet or less.

Water Quality

Water from the Allegheny Group is typically hard and high in iron. Eight of the 18 samples of water from these rocks have a hardness of 185 mg/l or more, and 76 percent contain more than 0.3 mg/l of iron, the maximum recommended by the U.S. Public Health Service for drinking water.

Six samples exceed the U.S. Public Health Service standards for dissolved solids (500 mg/l). Four of the wells from which these samples were collected are in a well field on industrial property. The numbers of the wells in the well field are Bt-362 to Bt-368. All are high in sodium and chloride, although the depths of most of the wells are not such that naturally occurring salt water would be expected. The depths are 152, 478, 115, 81, 150, 150, and 156 feet, respectively.

Local pollution may be the source of the high solids in the other two wells that contain more than 500 mg/l dissolved solids, but a specific source cannot be pinpointed. Well Bt-236, a municipal well at the time of inventory but no longer used, is high in sodium chloride. The other well, Bt-83, a domestic well, is high in calcium and sulfate. The wells are 225 feet and 110 feet deep, respectively.

Pottsville Group

Distribution and Lithology

The Pottsville Group crops out along the major stream valleys in the northern part of the county. It generally consists of two massive sandstones (the Connoquenessing Formation at the base of the group and the Homewood Formation at the top of the group) and an intervening shale (Mercer Formation).[1] However, the sandstones grade laterally into sandy shale or shale and are then difficult to distinguish from the Mercer or the shale in the overlying Clarion Formation.

The sandstones of the Pottsville are sometimes misidentified because of their similar appearance and the common practice of identifying them by their relation to a nearby economically important coal bed. Thus, the Homewood is considered to lie immediately beneath the Brookville coal or its underclay (Allegheny Group). However, the Brookville was misidentified in some of the older reports, and its name was applied to a coal bed in the Mercer. This usage is sometimes applied today, so that the Homewood then becomes a bed in the Clarion, the Connoquenessing is called the Homewood, and a sandstone in the Pocono becomes the Connoquenessing.

The base of the Pottsville is also difficult to define in places. The underlying Mississippian surface has been truncated by erosion so that the upper shale units may be missing, and the Pottsville then rests directly on sandstone of the Pocono. Both the Pottsville and Pocono sandstones are typically gray to white, well-cemented quartzites. The Pottsville is about 220 feet thick.

A conventional, generalized section through the Pottsville Group is as follows:

	Thickness range (feet)
Homewood Formation	
Shale to massive sandstone, thin coals	0- 90
Mercer Formation	
Sandy shale, shale, coal (one to three beds), clay, limestone	0-120

[1] These formation names do not conform to the nomenclature used by the Pennsylvania Geological Survey, For a discussion of the stratigraphy of the Pottsville Group in western Pennsylvania, see Edmunds, W. E. (1969), *Revised lithostratigraphic nomenclature of the Pottsville and Allegheny Groups (Pennsylvanian), Clearfield County, Pennsylvania,* Pa. Geol. Survey, 4th ser., Inf. Circ. 61, 36 p.; Ashley, G. H. (1945), *The Pittsburgh-Pottsville boundary,* Jour. Geology, v. 53. p. 374-389; and Renick, B. C. (1924), *The correlation of the Allegheny-Pottsville section in western Pennsylvania,* Jour. Geology, v. 32, p. 64-80.

	Thickness range (feet)
Connoquenessing Formation	
Sandstone, massive to shaly	15- 50
Shale, sandy shale, coal	0- 40
Sandstone, massive to shaly	30- 75

Well Depths and Yields

Data for the Pottsville are available from 102 wells. Ten percent of the wells are less than 70 feet deep, and 90 percent are less than 315 feet deep. The average depth is 145 feet. Yields of 55 of the wells are reported. Ten wells yield less than 5 gpm, and four wells yield 300 gpm or more. The average yield is 36 gpm. Data are more abundant from the Homewood than from the Mercer and Connoquenessing, of course, as the Homewood is stratigraphically higher. Yields are also greater from wells drilled to the Homewood; they average 50 gpm.

Water Quality

Analyses of water from each of the formations constituting the Pottsville Group show that the water in the upper part of the group is dominantly a calcium magnesium bicarbonate type, whereas that in the lower part is a sodium bicarbonate type. Hardness differs accordingly; the water is hard in the upper part of the group and generally soft in the lower part.

Most samples contain between 200 and 300 mg/l dissolved solids, and half exceed U.S. Public Health Service drinking water standards for iron (0.3 mg/l).

Of the analyses, only the one from Bt-349 showed evidence of contamination. This is an unused well at the former Franklin Glass Company plant. The dissolved solids are 1370 mg/l, and the water is dominantly of sodium sulfate type.

Pocono Group

Distribution and Lithology

The Pocono Group consists of a sequence of thick sandstone and shale. The uppermost of these is the Burgoon Sandstone, which crops out only in the northeastern part of the county – along the Allegheny River and along the lower reaches of Bear Creek. It is generally a gray, to white, coarse-grained sandstone, but in places it contains lenses of shale.

Because the sandstones of the Pottsville Group commonly rest directly on the Burgoon, and the two rocks resemble each other, it is usually difficult to determine where one ends and the other begins. The Burgoon is about 300 feet thick.

Water-Bearing Characteristics

The Burgoon is an excellent aquifer where it is not buried too deeply. Table 4 contains records of nine wells in this formation, although not all records are complete. The average depth is about 300 feet (six wells), and the average yield is 82 gpm (eight wells). The depths range from 208 to 550 feet and the yields from 9 to 260 gpm.

Water Quality

The single sample of water from this formation (well Bt-172) contains 390 mg/l dissolved solids and contains prominent proportions of calcium, sodium, bicarbonate, sulfate, and chloride. The iron content is 7.1 mg/l, and the water is hard.

Where the Burgoon is deeply buried, it may contain saline water. This is also true of other deep-lying beds. Table 3 gives analyses of water from three of the deeper formations. (See analyses of water from wells Bt-302 and Bt-309 – two zones.) Also included are analyses of water from two wells (Bt-44 and Bt-65) that may or may not get water from the Burgoon.

DEVELOPMENT OF GROUND-WATER SUPPLIES

During the early settlement of the area, water needs of the people were easily satisfied by shallow dug wells. The shallower of these wells failed during late summer and fall and especially during drought years, so that the wells had to be deepened. Even so, the yield of a dug well was severely limited because it could be dug only a short distance below the water table. Dug wells were also easily polluted because their sides were loosely lined with stone, permitting ready access of water without the benefit of slow filtration; also, burrowing animals might tumble into the dug well and drown.

As advancing technology made possible the drilling of wells, this type of construction supplanted the digging of wells. Drilled wells overcame both the disadvantages of dug wells cited above. They could be drilled to any depth, thus ensuring a perennial supply of water. Surface pollutants, discrete zones of undesirable water, and burrowing animals could be kept out by the installation of steel casing.

As more people settled close to each other and as mining activities were carried on in the area, the drilled well next to the owner's home could no longer be counted on to supply adequate amounts of pure water. In some instances, the close proximity of many families discharging their wastes into cesspools exceeded the ground's capacity to filter the water, and some or all of the wells were polluted.

Mining activities can adversely affect the quality of the water by accelerating the oxidation of iron sulfide minerals and also can permanently lower the water table, so that where water is finally found, it is brackish.

The latest step in the development of ground-water supplies is the construction of community-supply wells. These wells are drilled in favorable locations where large supplies may be obtained and where the sites can be protected from pollution.

PUBLIC WATER SUPPLIES

Approximately 55 percent (70,000) of the population of Butler County uses water from a public supply. Four communities use surface water supplies and 11 communities use water obtained from wells or springs. Evans City uses both surface-water and ground-water supplies. Data on these supplies are given in Table 7.

Table 7. *Communities Having Public Water Supplies*[1]

System	Number of customers served	Average daily 1969 pumpage (gallons)	Source of water
Boyers	46	7,000	Two wells.
Butler Water Company	3,290	6,000,000	Impoundment of Connoquenessing Creek and Thorn Run; Allegheny River.
Center	473	81,500	Butler Water Company.
Chicora	356	60,000	Two wells.
Cranberry	700	250,000	Two wells.
Evans City	860	288,000	Five wells. Impoundment of Liken Run.
Harmony	450	130,000	Little Connoquenessing Creek.
Mars	555	215,000	Three wells.
Moraine State Park	--	---	Nine wells.
Northvue	98	25,000	Two wells.
Petrolia	175	30,000	Two wells.
Saxonburg	375	68,000	Two wells.
Scenic View	51	10,000	Six wells and springs.
Slippery Rock	715	300,000	Three wells.
Winfield-Penn Dixie	11	7,000	One well.
Zelienople	1,375	675,000	Impoundment of Scholars Run; Connoquenessing Creek.

[1] From Butler County Planning Commission, 1970.

WATER PROBLEMS RESULTING FROM THE ACTIVITIES OF MAN

The activities of man in Butler County have caused an acceleration of some natural processes and have resulted in a marked worsening of the chemical quality of the water.

Chief among these activities is coal mining. As noted earlier, the mining operations break up the rock and expose more surface area of the iron sulfide minerals to air and water. The consequent oxidation and solution of the iron sulfide minerals yield water that is high in sulfate, iron, and acid. The acid in the water attacks calcium carbonate minerals and increases the water's hardness. The water continues to move through the rocks, so that it is found not only in association with the iron sulfide minerals but also in underlying rocks or in rocks down the hydraulic gradient; this is, in the direction the water moves naturally. This water eventually is discharged to streams, where, in sufficient quantities, it kills fish and plant life and leaves an orange scum of oxidized iron on the stream bottom.

Mining activities will affect the water table during the operation of the mine and may result in a permanent lowering of water levels afterward. This effect, plus land subsidence, may greatly reduce the value of land above the mine.

Oil and gas operations constitute another source of contamination of water supplies. Hundreds of wells have been drilled in Butler County in the search for oil and gas. When a well proved nonproductive, it was abandoned. Not always in the past, however, were wells properly plugged before abandonment. Some were left open or merely capped, so that salt water and small amounts of oil were able to rise in the borehole. When the casing became corroded – or worse, when the casing was removed – the saline water and oil moved into freshwater aquifers and to streams.

WELL CONSTRUCTION

DRILLING METHODS

Dug wells are being replaced gradually by drilled wells. Two methods are used to drill most of the wells: 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 air under pressure 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.

Steel casing is emplaced in the drilled wells to the bottom of the weathered rock, and a slurry of rock cuttings (in most domestic wells) or concrete (in public supply and industrial wells) is then poured in the annular space between the casing and the wall of the well to seat the casing tightly.

WELL DEVELOPMENT

The method commonly used to increase well yields consists of heavy pumping of the well for a short period of time to remove drill cuttings and fine material. Other less common techniques used to increase yields are mechanical surging and the addition of detergents.

Mechanical surging is similar to operating a piston in a cylinder, with the casing or well bore acting as the cylinder and the surge block as the piston. Alternately raising and lowering the block in the well forces water in and out of openings in the aquifer. Loose rock chips or fine sand grains are loosened and drawn into the well bore, from which they may be pumped after surging. This method is most successful in sandstone, conglomerate, and unconsolidated aquifers.

Detergents can be used in wells where clay and silty materials are plugging small fractures and other openings in the aquifer. The detergent helps break up these plugs into small particles, so that they may be pumped out, leaving the aquifer openings clear to transmit more water to the borehole.

MANAGEMENT OF WATER SUPPLIES

PROTECTION FROM OVERDRAFT

Except in the vicinity of active mines, where the water table is deliberately being lowered to facilitate mining, there is no known overdraft of ground water anywhere in the county. Overdraft is possible wherever well fields are established or expanded to supply large amounts of ground water. Determining interference between wells before drilling final production wells is a safeguard against possible overdraft, as are periodic water-level measurements to determine the long-term trend of water-table fluctuations and the effect of pumping.

PROTECTION FROM POLLUTION

Pollutants are carried downward from the land surface by infiltrating water or move laterally from adjacent areas. Because ground-water movement is relatively slow, such pollutants are slow to accumulate and just as slow to disperse after the polluting source is removed. The locations of sources of pollution, such as sanitary landfills and septic tanks, is a major factor in the selection of well sites.

Government agencies are becoming increasingly active in the field of pollution prevention. For example, the Pennsylvania Department of Environmental Resources has set standards for length and cementing of casing in wells. The Bureau of Land Protection and Reclamation, Division of Oil and Gas, has regulations concerning the abandonment of oil and gas wells and on the backfilling of strip mines to reduce the formation of acid water in the stripped areas.

WHERE TO GET INFORMATION ABOUT WATER

A variety of information on water supplies is available from the several government agencies listed below. When requesting information, it is important to give an accurate location of the site for which you wish information.

The Pennsylvania Topographic and Geologic Survey has information on the geology of Butler County and has published reports that describe in detail the rocks that underlie the county. Well drillers' logs and reports on new wells that have been drilled in the county are also available at their office.

The Division of Water Quality, Bureau of Water Quality Management, 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. The department, through various regional offices, tests water samples for bacterial pollution. They also can advise effective corrective measures when pollution is reported.

The Division of Natural Resources and Technical Services, Bureau of Engineering, Pennsylvania Department of Environmental Resources, 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 U.S. Geological Survey has data on wells, springs, and streams and on the chemical quality of water.

Local well drillers and pump installers can provide prices and suggest the type of equipment needed to develop a water supply. 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 the pressure-tank capacity.

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

GLOSSARY

Aquifer: A formation, group of formations, or part of a formation from which water is collectable in usable quantities.

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 (cfs): 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 other potentiometric surface, produced by a pumping 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 the 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 other potentiometric 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.

Formation: A fundamental unit in rock stratigraphic classification. It is a body of rock characterized by lithologic homogeneity; it is prevailingly but not necessarily tabular and is mappable at the earth's surface or traceable in the subsurface.

Fracture: A break in rocks.

Generalized geologic section: The description of the prominent features in a sequence of rocks. Minor features are neglected.

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 in hydrostatic head per unit of distance in a given direction.

Overdraft: The withdrawal from the ground of more water than is replaced by recharge. This results in excessive lowering of the water level in the ground and the eventual failure of a well in the overdraft area.

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.

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

Potentiometric surface: The surface that represents the static ground-water head. It is defined by the levels to which water will rise in tightly cased wells.

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 streams. It is the same as streamflow unaffected by artificial diversions, storage, or other works of man in or on the stream channels.

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

Soil-tonal alignments: The arrangement of similar tones or shades of color in a particular direction on an aerial photograph due to a similarity in the properties of the soil.

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

Stream-gaging station: A gaging station where a record of discharge of a stream is obtained. Within the U.S. 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 process by which 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.

Vadose water: Water in the zone of aeration.

Water table: The potentiometric surface of an unconfined water body where the pressure is equal to that of one atmosphere.

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

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