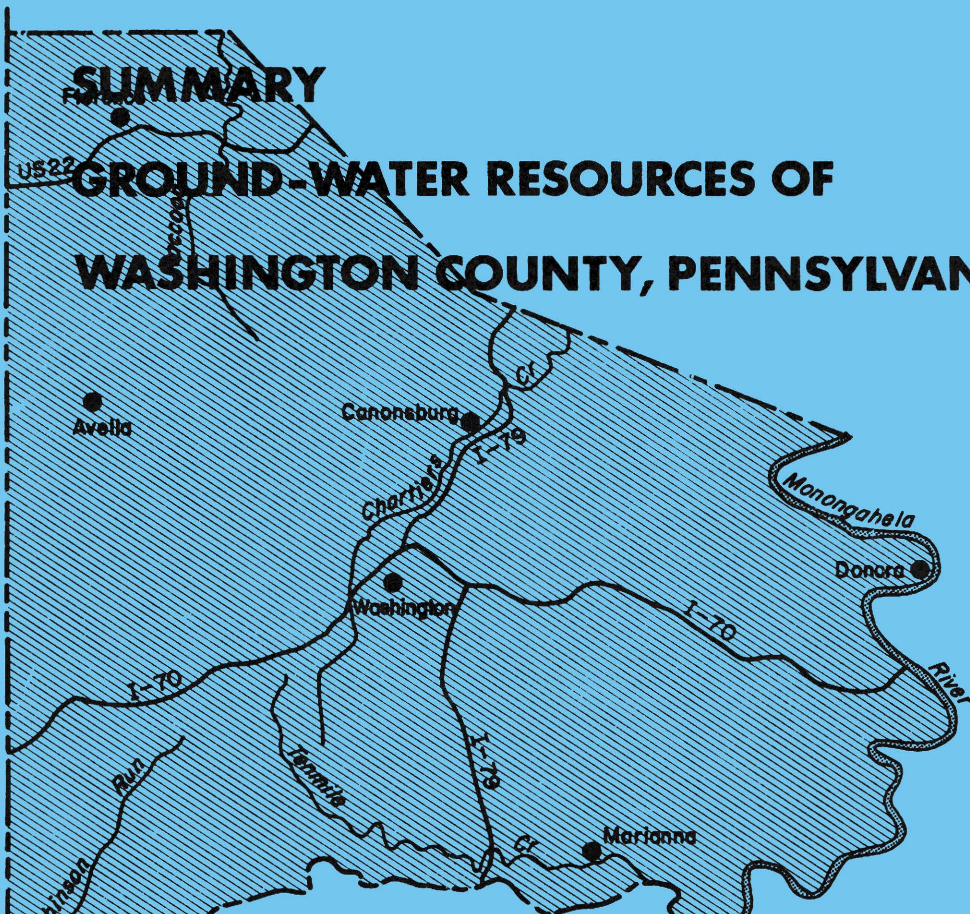
Water Resource Report 38

1973

SUMMARY GROUND-WATER RESOURCES OF WASHINGTON COUNTY, PENNSYLVANIA



by Thomas G. Newport

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

Water Resource Report 38

SUMMARY GROUND-WATER RESOURCES OF WASHINGTON COUNTY, PENNSYLVANIA

by Thomas G. Newport
U. S. Geological Survey

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

PENNSYLVANIA GEOLOGICAL SURVEY
FOURTH SERIES
HARRISBURG
1973

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PREFACE

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

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ABSTRACT

The geologic units in Washington County include the Pennsylvanian Monongahela and Conemaugh Groups, the Permian-Pennsylvanian Washington Formation, the Permian Greene Formation, and unconsolidated Quaternary deposits. The Quaternary deposits consist of alluvium which overlies bedrock in a few places along the major stream valleys in the county. The alluvium is generally permeable and, when saturated, will yield moderate to large supplies of water, depending upon the degree of sorting by grain size.

Ground water in a bedrock occurs largely in secondary openings, such as joint planes or solution openings. The Greene Formation and the Monongahela Group are poor water bearers because of the smallness and scarcity of fractures. The Washington Formation crops out extensively in the county, but is also a poor water bearer. The Conemaugh Group crops out in the extreme northern part of the county and along some stream valleys in other parts of the county. This group is a source of small to moderate supplies of water; the median yield is 5 gpm.

Chemical analyses of water from Washington County show many extremes in quality due to both man-made and natural causes. The most common undesirable constituent of the ground water is iron, which often exceeds the limit recommended by the U.S. Public Health Service and which sometimes requires the water to be treated for iron removal. Water drilled in aquifers too far below the level of the major drainage systems shows excessive mineralization.

There is no known overdraft of water in Washington County. The greatest water problem in the county is pollution of the water resources by drainage from coal-mining operations. Collapse of unsupported roof material has caused fracturing and dewatering of the overlying aquifers in some parts of the county. The hundreds of oil and gas wells that were abandoned but not properly plugged are another source of ground-water pollution; salt water in these wells has in some cases 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 are easy to read and suitable for widespread distribution. It contains a general description of the aquifers in the county, a geologic map showing locations of wells, and data on the depth and yields of wells and the chemical quality of ground water.

LOCATION AND GENERAL GEOGRAPHIC FEATURES

Washington County encompasses an area of 857 square miles in western Pennsylvania (Figure 1). The county is bordered on the north by Beaver and Allegheny Counties, on the east by Westmoreland and Fayette Counties, on the south by Greene County, and on the west by the State of West Virginia. Washington, the county seat, is about 28 miles south of Pittsburgh and 220 miles west of Harrisburg.

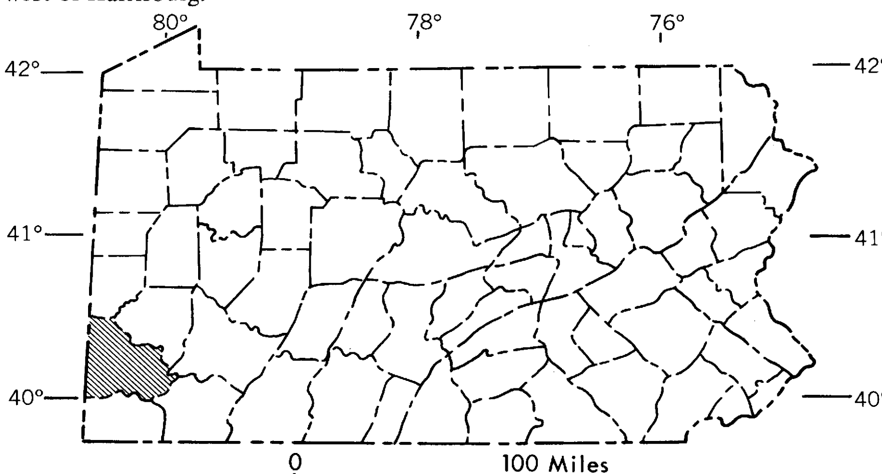


Figure 1. Map of Pennsylvania showing location of Washington County.

LANDFORMS

Washington County is in a rugged section of the Allegheny Plateau. The present land surface was formed through the erosion by streams of a former plainlike area. Remnants of this ancient plain slope from altitudes of about 1,500 feet above mean sea level in the southern part of the county to about 1,200 feet in the northern part.

Stream erosion has created a complexly dissected area, having as much as 750 feet of relief between hilltops and valley bottoms. The major streams erode their channels downward to about 650 feet above sea level; later filling by sediments has created the present-day flat valley floors, which range in altitude from about 750 to 790 feet. The tributary streams generally lie in V-shaped valleys, and their gradients are much steeper than those of the major streams.

POPULATION TRENDS

The population of Washington County has changed very little in the last 50 years, as may be seen in Table 1. During this period, the population increased from 188,992 in 1920 to 210,852 in 1940, decreased slightly in 1950, increased in 1960, and decreased back to the 1940 population level in 1970. The 1970 population density in the county was 246 persons per square mile.

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

Year	Population
1920	188,992
1930	204,802
1940	210,852
1950	209,628
1960	217,271
1970	210,876

LAND USE IN THE 1960'S

Land use has changed to accommodate the movement of people and industry from congested areas. Farm acreage has been reduced from 76 percent of the land area in 1940 to 44 percent in 1970. The farmland is used primarily for dairy cattle, poultry, fruit, and nursery products. A total of 10 percent of the land area is strip mined.

A large percentage of the land is not readily adaptable to most uses because of the steepness of the terrain. Valley bottoms and the relatively flat tops of many of the hills offer the greatest potential as sites for industrial and residential development.

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

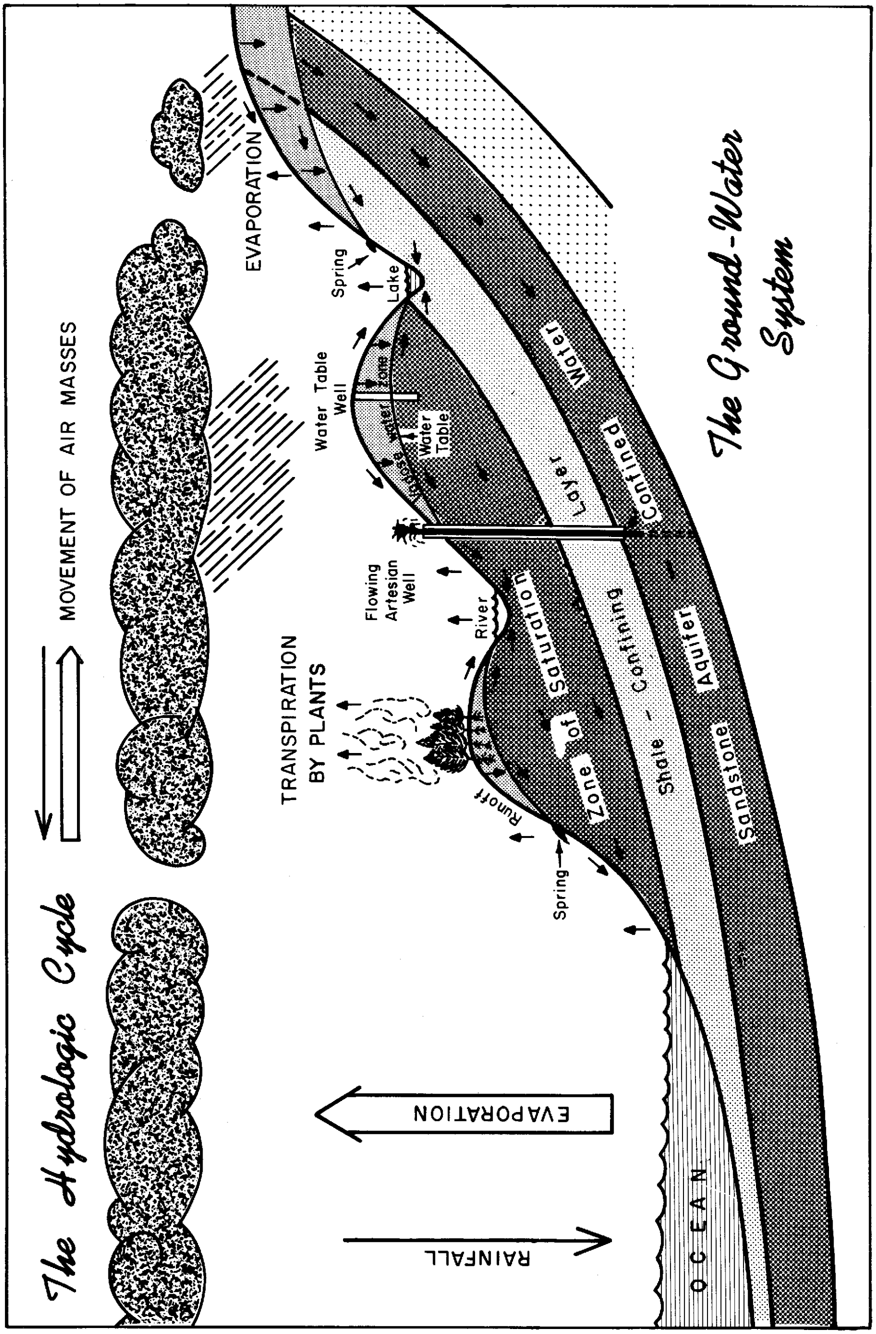


Figure 2. The hydrologic cycle.

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. Most of the precipitation on the land 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 rate of water movement varies, depending on its environment, but eventually it returns to the oceans, completing the cycle.

If man interrupts or changes the hydrologic cycle the results may have serious effects for many years. Man-made changes in the hydrologic cycle in Washington County are discussed in the following pages.

PRECIPITATION

Precipitation is the source of all fresh water in the county, but not all the available water falls directly on the county. Streams entering Washington County carry water that fell as precipitation in other parts of Pennsylvania and in West Virginia.

Annual precipitation at the National Weather Service (formerly U.S. Weather Bureau) station at Burgettstown averages nearly 35 inches, and at the station at Charleroi Lock Number 4 it averages 39 inches (U.S. Department of Commerce, 1971). The precipitation records for these stations show no monthly averages less than 2 inches. The months of greatest rainfall correspond with the growing season and with the periods of peak water needs.

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. Transpiration returns soil moisture to the atmosphere as a product of plant growth; evaporation changes water directly from a liquid to a vapor.

The estimated mean annual rate of evaporation from surface-water bodies in Washington County, as reported by the National Weather Service, is 28 inches, of which three-fourths is evaporated from May to October. However, the surface-water bodies constitute a very small percentage of the county area, so this water loss represents a minor part of the total loss. The total annual loss by evapotranspiration is on the order of 14 inches, or about 40 percent of the mean annual precipitation.

STREAMFLOW

Most of the precipitation not lost through evaporation and transpiration leaves the county as part of the flow of the Ohio River. This is equivalent to 23 inches of precipitation annually. The water contributing to streamflow follows two general routes. Part of it moves directly over the ground to the surface-water bodies. The rest follows a slower route, moving through the earth as ground water to points of discharge in the stream valleys.

The major streams and locations of stream-gaging stations are shown in Plate 1. Identification numbers are those assigned by the U.S. Geological Survey. Discharge data at two gaging stations are given in Table 2; detailed streamflow information can be obtained from *Surface Water Records of Pennsylvania* by the U.S. Geological Survey (see references).

Table 2. *Discharge Data for Gaged Streams*

Bush Run near Buffalo, Pa. 111150
- Average discharge, 10 years of record: 7.87 cfs*
- Maximum discharge, February 13, 1966: 1180 cfs
- Minimum discharge, many days: no flow

Monongahela River at Charleroi, Pa. 075000
- Average discharge, 37 years of record: 8758 cfs
- Maximum discharge, March 7, 1967: 158,000 cfs
- Minimum discharge: not determined

*Cubic feet per second

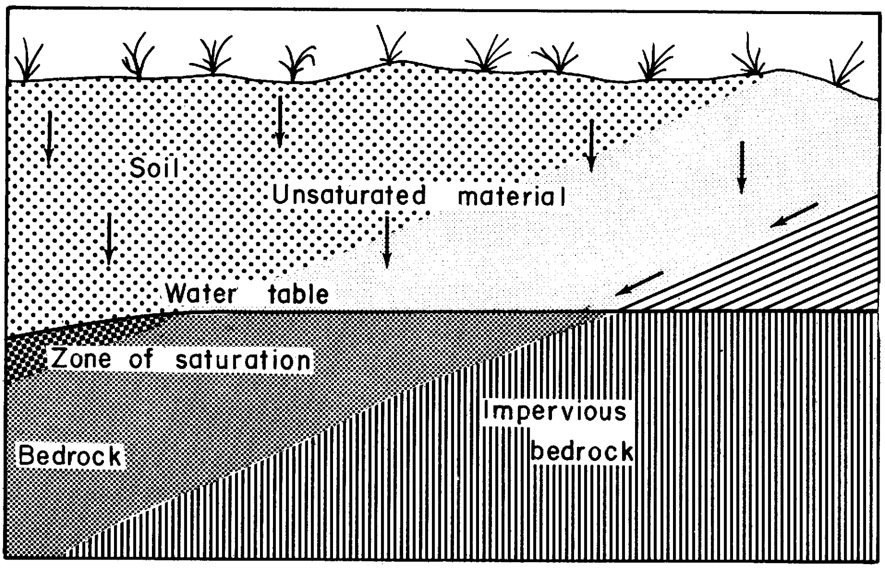
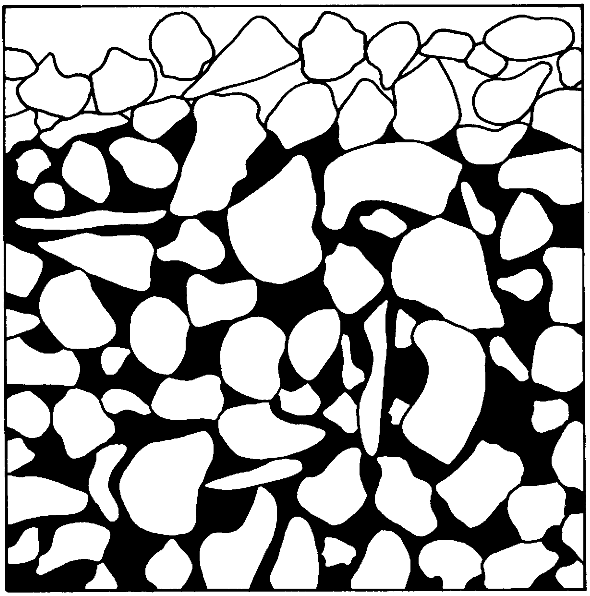
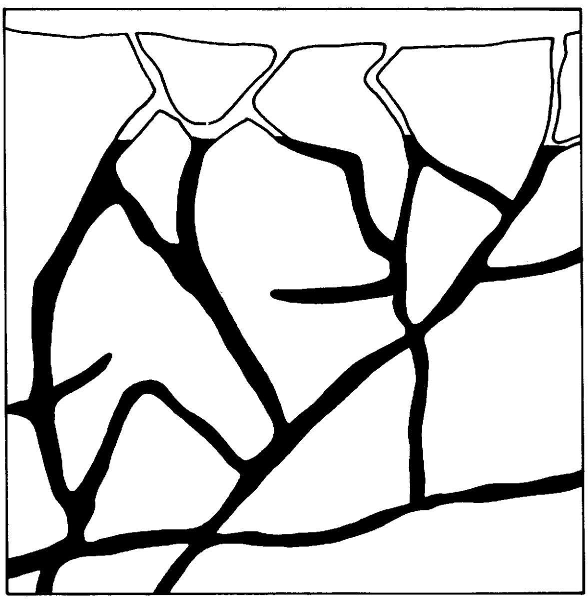


Figure 3. Downward movement of water through soil and rock to the water table.



Primary openings in unconsolidated material



Secondary openings in consolidated rock

Figure 4. How water occurs in rocks.

GROUND WATER

Much of the water falling on the land surface returns to the atmosphere by evapotranspiration or reaches streams as overland runoff. Part infiltrates through the soil and through fractures and pores (void spaces) in the underlying rock. Its downward movement continues until it reaches the saturated zone, a zone in which all the interconnected voids are filled with water. This is illustrated in Figure 3. After reaching the saturated zone, the water moves downward and laterally toward lower altitudes and eventually returns to the surface, either naturally from springs or as discharge from wells. During prolonged dry periods, the seepage into stream channels provides nearly all the surface-water flow.

Ground water occurs in and moves through interconnected openings (Figure 4), which are either primary or secondary in nature. Primary porosity consists of the spaces between individual grains of material. Permeability, or efficiency in transmitting water, depends on the size and degree of interconnection of intergranular spaces. Size and interconnection of pores are largely dependent upon the particle size, the degree of sorting by particle size, and the amount of cementation. Well-sorted lenses of sand or gravel and loosely cemented coarse-grained sandstone have relatively large interconnected openings and transmit water readily. Shale, dense limestone, firmly cemented sandstone, and rock material of heterogeneous particle size have little interconnected pore space and allow less water movement.

Secondary openings are those formed after deposition and consolidation of the formations. They result from fractures or solution of the rock. Fractures are the result of applied stresses, such as those associated with mountain building. Solution openings are formed by the solution and removal by water of rock material, such as limestone, especially along fractures. These channels generally become smaller with depth, and their ability to transmit water is correspondingly reduced.

Ground water occurs under both water-table (free, unconfined) and artesian (confined under pressure) conditions. Water-table conditions are those in which ground water is unconfined, and the upper surface of the water is free to rise or fall. Artesian conditions exist where the water is confined in a permeable formation that is overlain by a relatively impermeable formation. The upper surface of the water is not free to rise or fall, but the water is under enough pressure to rise above the containing aquifer in wells penetrating the aquifer. The surface to which water will rise in wells tapping an artesian aquifer is called the potentiometric surface.

The water table rises and declines according to the relative amounts of recharge (additions to the aquifer) and discharge (losses to springs, streams, and wells). Very little recharge reaches the saturated zone during the growing season (April to October) because of the heavy evapotranspiration losses; however, recharge causes a general rise of water levels throughout the rest of the year.

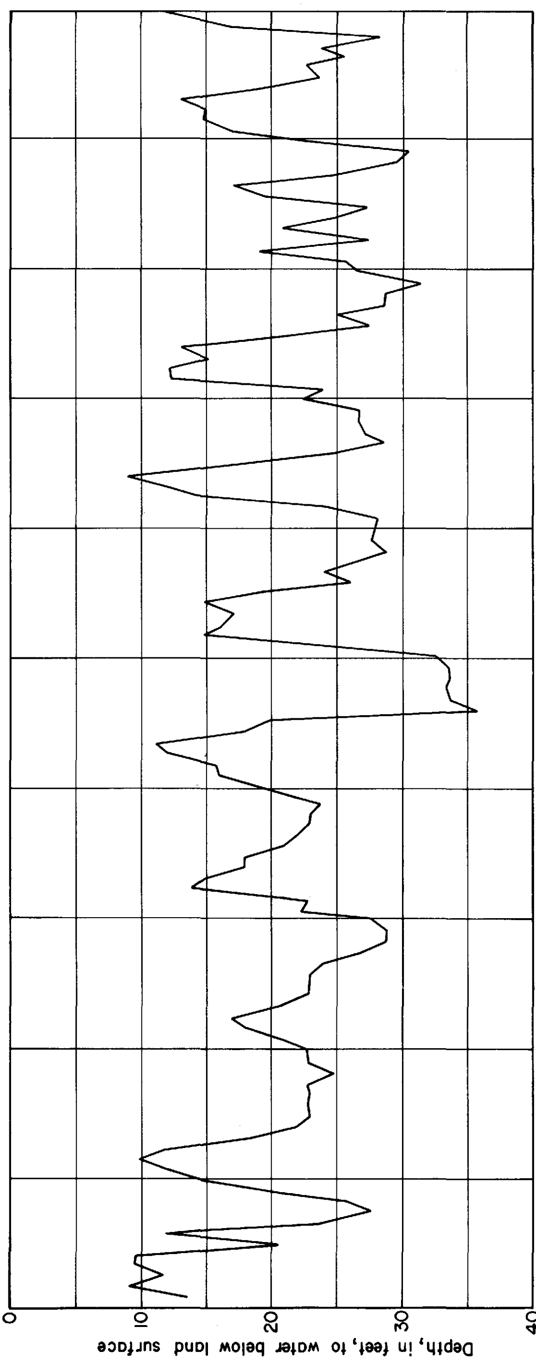


Figure 5. Hydrograph for well Ws-1.

Table 3. *Source and Significance of Dissolved Mineral Constituents and Physical Properties of Natural Waters*

(In milligrams per liter)

Constituent or physical property	Source or cause	Significance
Silica (SiO_2)	Dissolved from almost all rocks and soils, generally in small amounts from 1-30 mg/l. High concentrations – as much as 100 mg/l – generally occur in highly alkaline waters.	Forms hard scale in pipes and boilers. Carried over in steam of high-pressure boilers to form deposits on blades of steam turbines. Inhibits deterioration of zeolite-type water softeners.
Iron (Fe)	Dissolved from almost all rocks and soils. May also be derived from iron pipes, pumps, and other equipment. More than 1 or 2 mg/l of soluble iron in surface water generally indicates acid wastes from mine drainage or other sources.	On exposure to air, iron in ground water oxidizes to reddish-brown sediment. Content of more than about 0.3 mg/l stains laundry and utensils reddish brown. Objectionable for food processing, beverages, dyeing, bleaching, ice manufacture, brewing, and other processes. The U.S. Department of Health, Education and Welfare (1962) recommends, in its water-quality standards, that iron and manganese together should not exceed 0.3 mg/l; larger quantities cause unpleasant taste and favor growth of iron bacteria.
Manganese (Mn)	Dissolved from some rocks and soils. Not as common as iron. Large quantities often associated with high iron content and with acid waters.	Same objectionable features as iron. Causes dark-brown or black stain. Federal standards recommend that iron and manganese together should not exceed 0.3 mg/l.
Calcium (Ca) and magnesium (Mg)	Dissolved from almost all soils and rocks, especially limestone, dolomite, and gypsum. Calcium and magnesium are found in large quantities in some brines. Large quantities of magnesium are present in sea water.	Cause most of the hardness and scale-forming properties of water; soap consuming (see hardness). Water with low calcium and magnesium contents desired for electroplating, tanning, dyeing, and textile manufacturing.

Sodium (Na) and potassium (K)	Dissolved from almost all rocks and soils. Found in ancient brines, sea water, some industrial brines, and sewage.	Large amounts, in combination with chloride, give a salty taste. Moderate quantities have little effect on the usefulness of water for most purposes. Sodium salts may cause foaming in steam boilers, and a high sodium ratio may limit the use of water for irrigation.
Bicarbonate (HCO_3) and carbonate (CO_3)	Action of carbon dioxide in water on carbonate rocks such as limestone and dolomite.	Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot-water facilities to form scale and release corrosive carbon dioxide. In combination with calcium and magnesium cause carbonate hardness.
Sulfate (SO_4)	Dissolved from rocks and soils containing gypsum, iron sulfide, and other sulfur compounds. Generally present in mine waters and in some industrial wastes.	Sulfate in water containing calcium forms hard scale in steam boilers. In large amounts, sulfate in combination with other ions gives bitter taste to water. Some calcium sulfate is considered beneficial in the brewing process. Federal standards recommend that the sulfate content should not exceed 250 mg/l.
Chloride (Cl)	Dissolved from rocks and soils. Present in sewage. Found in large amounts in ancient brines, sea water, and industrial brines.	In large amounts in combination with sodium gives salty taste to drinking water. In large quantities increases the corrosiveness of water. Federal standards recommend that chloride content should not exceed 250 mg/l.
Fluoride (F)	Dissolved in small to minute quantities from most rocks and soils.	Fluoride in drinking water reduces the incidence of tooth decay when the water is consumed during the period of calcification. However, it may cause mottling of the teeth depending on the concentration of fluoride, age of the child, amount of drinking water consumed, and susceptibility of the individual.
Nitrate (NO_3)	Decaying organic matter, sewage, and soil nitrate.	Concentrations much greater than the local average may suggest pollution. There is evidence that more than about 45 mg/l nitrate may cause a type of methemoglobinemia in infants that is sometimes fatal. Water with high nitrate content should not be used in baby feeding. Nitrate has shown to be helpful in reducing intercrystalline cracking of boiler steel. It encourages growth of algae and other organisms, which produce undesirable tastes and odors.

Table 3. *Continued*

Dissolved solids	Chiefly mineral constituents dissolved from rocks and soils; may include organic matter.	Federal standards recommend that dissolved solids should not exceed 500 mg/l. Water becomes unsuitable for many purposes when it contains more than 1000 mg/l dissolved solids.
Hardness as calcium carbonate ($CaCO_3$)	Nearly all the hardness in most waters is due to calcium and magnesium. All metallic cations other than the alkali metals also cause hardness.	Consumes soap before a lather will form. Deposits soap curd on bathtubs. Hard water forms scale in boilers, water heaters, and pipes. Hardness equivalent to the bicarbonate and carbonate is called carbonate hardness. Any hardness in excess of this is called noncarbonate hardness. Waters of hardness up to 60 mg/l are considered soft; 61-120 mg/l, moderately hard; 121-180 mg/l, hard; more than 180 mg/l, very hard.
Specific conductance (micromhos at 25°C)	Mineral content of the water.	Specific conductance is a measure of the capacity of water to conduct an electric current; varies with concentration and degree of ionization of the constituents. Varies with temperature; reported at 25°C.
Hydrogen-ion concentration (pH)	Acids, acid-generating salts, and free carbon dioxide lower the pH. Carbonate, bicarbonate, hydroxide and phosphate, silicate, and borate raise the pH.	pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. The pH is a measure of hydrogen-ion activity. The corrosive properties of water generally increase with decreasing pH; however, excessively alkaline water may also attack metals.
Temperature	-----	Affects the usefulness of water for many purposes. For most uses, a water of uniformly low temperature is desired. Shallow wells show some seasonal fluctuations in water temperature. Ground water from moderate depths generally is nearly constant in temperature, which is near the mean annual air temperature of the area. In very deep wells the water temperature generally increases on the average about 1°F with each 60-foot increment of depth. Seasonal fluctuations in temperatures of surface water are comparatively large – depending on the depth of water – but do not reach the extremes of air temperature.

These changes in water levels are illustrated in Figure 5. Water levels in the county are at or near the land surface in the valleys and rise toward the drainage divides. The rate of water level rise, however, is less than that of the land surface; so wells at the higher altitudes must be drilled deeper than those in the valleys.

WATER QUALITY

Precipitation is slightly mineralized and acts as a mild solvent. As it enters the ground and moves slowly through the soil and rocks, it dissolves various minerals and carries them in solution. Water containing more than 500 mg/l (milligrams per liter) dissolved minerals is considered undesirable for domestic use, but more highly mineralized water is used where better supplies are not available. The significance of water-quality factors is given in Table 3.

Surface water resulting from direct runoff after rain or snowmelt is usually far less mineralized than ground water because it moves more rapidly and, therefore, has less contact with mineral matter. After extended periods without precipitation, streamflow is maintained entirely by ground-water seepage and has a higher than normal mineral content.

Ground water has the advantage of being much more constant in quality than surface water over long periods of time. Ground water also is generally more free of bacteria than surface water because the soil and rocks through which it percolates effectively filter out most biological organisms. One of the disadvantages of ground water is that, because of the slow movement, ground-water reservoirs require much more time than stream channels to flush out pollutants.

Ground water is subject to less temperature variation than surface water. Unless subjected to thermal pollution (man-induced temperature changes), it maintains a temperature of about 53°F, the average air temperature of the county. Stream temperatures in Washington County, however, vary with the seasons and range from the low 30's to the low 80's.

Analyses of ground water from Washington County are listed in Table 4. The analyses of water from bedrock aquifers show many extremes in quality; the high concentrations of the various constituents are due to both man-induced and natural causes. Generally, the most common undesirable constituent of ground water in the county is iron, which often exceeds the 0.3 mg/l limit recommended by the U.S. Public Health Service (1962). If the iron content is excessive, the water generally requires treatment for its removal. Some of the analyses show excessive mineralization because the wells were drilled to an aquifer lying too far below the level of the major drainage systems; water at such depths moves slowly, so that some of the water trapped in the sediments when they were deposited may not yet be flushed. Also, the water has had a long time to dissolve minerals from the rocks.

Most of the analyses in Table 4 represent chemical quality to be expected for water from wells drilled in the county. Some of the water analyzed showed excesses of one or more constituents; generally, these waters were sampled because they represented extreme conditions.

Table 4. *Chemical Analyses of Ground Water*

Well number	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos 25°C)	pH
Ws- 19	--	52	7.3	0.22	–	2.8	2.1	440	9.6	867	3.8	200	–	2.9	1120	16	–	–	–
23	–	52	17	.93	–	98	30	12	3.5	356	86	64	–	1.5	436	368	–	–	–
31	--	52	16	.07	–	5.3	3.9	140	3.2	388	5.0	12	–	1.1	382	29	–	–	–
41	--	52	26	1.3	–	83	18	12	2.2	333	23	2.6	–	.10	320	281	–	–	–
61	--	50	17	1.7	–	36	9.0	34	2.4	224	5.3	9.0	–	.00	222	127	–	–	–
74	--	53	16	.70	–	62	17	34	4.8	259	6.2	18	–	.80	330	225	–	–	–
92	--	50	10	.52	–	64	30	12	1.8	305	46	3.7	–	.20	321	283	–	–	–
93	--	50	17	.17	–	82	30	97	5.9	383	200	18	–	2.0	637	328	–	–	–
100	--	52	24	2.3	–	506	141	27	12	241	1600	16	–	6.7	2600	1840	–	–	–
113	--	54	12	.70	–	73	27	32	5.0	45	210	38	–	75	495	293	–	–	–
130	--	52	12	.81	–	120	7.3	8.2	3.2	272	61	20	–	40	411	330	–	–	–
137	--	56	10	.80	–	108	22	8.2	3.7	286	130	1.4	–	.10	439	360	–	–	–
142	--	54	17	.07	–	63	18	240	6.1	477	77	220	–	.20	898	231	–	–	–
155	1971	–	9.8	.50	.04	15	4.3	120	1.7	327	3.7	1.5	.6	.10	318	55	0	520	8.2

HOW AND WHERE GROUND WATER IS FOUND

Ground water in Washington County occurs in both artesian and water-table aquifers; well yields range from a fraction of a gallon per minute to over 350 gpm (gallons per minute). Data for 176 wells are listed in Table 5.

A summary of the geologic and water-bearing characteristics of the different rock units in Washington County follows. Table 6 and the following discussion name and describe, in descending order, the formations most commonly used as aquifers. The rank and classification of many of these units are similar to those used in earlier reports describing the geology and ground-water resources of the area. Berryhill and Swanson (1962) revised the nomenclature for Pennsylvanian and Permian rocks in Washington County. As redefined, the Washington Formation is of Permian age. A geologic map of the county is shown in Plate 1.

ALLUVIUM

Lithology

Unconsolidated deposits (alluvium) overlie the bedrock in a few places in the major stream valleys in the county. They consist of rock material that was transported and deposited by moving water. The material includes clay, silt, sand, gravel, and some boulders, and most of the particles have been rounded during transportation. Alluvium ranges in texture from poorly sorted to well sorted.

Water-Bearing Characteristics

Alluvium is generally permeable and, where saturated, will yield moderate to large supplies of water to wells. However, permeability may change significantly over short distances, because of the change in the degree of sorting. Well yields depend principally upon the permeability and thickness of saturated deposits penetrated by the wells.

Well Depths and Yields

Few data are available for wells completed in the alluvium. Yields of only two wells (200 and 350 gpm) are reported. The depths of wells in the alluvium range from 28 to 63 feet. Some of the shallow wells probably do not penetrate the full thickness of the material.

Well Location and Spacing

Well location and spacing are important considerations in planning a well field. The best wells are those that fully penetrate the alluvium, are in a line parallel to the streams, and are close enough to the streams to induce recharge. Well spacing in alluvium can best be established after determining how the shape of the cone of depression around one or more pumping wells changes with time

Table 5. *Record of Wells in Washington County*

Well number: Identification number that relates record in this table to well's location on map. The letter "S" following number indicates the record was obtained from the Pennsylvania Geological Survey.
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: C, commercial; H, domestic; N, industrial; P, public supply; R, recreation; S, stock; T, institutional; U, unused.
Topographic setting: H, hilltop; S, hillside; V, valley; T, terrace; C, stream channel.
Aquifer: Qa, alluvium; Pg, Greene Formation; P₱w, Washington Formation; ₱m, Monongahela Group; ₱c, Conemaugh Group; ₱a, Allegheny Group.
Lithology: s, sand; sg, sand and gravel; ss, sandstone; sh, shale; shls, shaly limestone; shss, shaly sandstone; ls, limestone.
Static water level: F, flowing.
Pumping data: gpm, gallons per minute; dd, drawdown; ft, feet; hr, hours.

										Casing			Static Water Level		Pumping Data		
Well	Location	Owner	Driller	Date Completed	Use	Altitude of Land Surface (feet)	Topographic setting	Aquifer/ Lithology	Total Depth Below Land Surface (feet)	Depth (feet)	Diameter (inches)	Depth(s) to Water-Bearing Zone(s) (feet)	Depth Below Land Surface (feet)	Date Measured	Yield (gpm)	dd (feet)	Time (hour)
Ws- 1	4002-8012	King, Floyd			U	1190		P ₱w	36	4	40		34	Aug. 1936	3	2	1
2	4010-8015	Albert Packing Co.			N	1030	V	₱ m	200		6		25	June 1937	32		
3	4010-8015	O'Brien Steel Construction Co.		1913	U	1025	V	₱ m	160		6		100				
4	4010-8016	Tygart Valley Glass Co.	Joseph P. Hedelmeyer	1935	N	1020	V	₱ m	135		8		100		50		
5	4010-8016	Findlay Clay Products		1920	N	1020	V	₱ m	80		6		60		8		
6	4004-7951	Moose Brewing Co.		1900	N	760	V	₱ c	145		4		5		35		
7	4008-7953	Corning Glass Co.	Layne-New York Co., Inc.	1944	U	750	V	Qa/sg	63	52	18		14	Mar. 1944	200	39	
7S	4006-8010	Desmond, James	George Young	1968	H	1120	S	P ₱w/sh	115	34	6	20, 95	60	May 1968	35		
8	4011-7952	France Slag Co.	John W. Mitchell	1942	N	740		₱ c	200		6		75				
9	4013-7957	West Penn Power Co.	Pennsylvania Drilling Co.	1947	U	740	V	₱ c	255	70	10		30	Jan. 1947	160	16	24
10	4015-8000	Finleyville Borough	Pennsylvania Drilling Co.	1946	U	1000	V	₱ c	125	78	10		84	Sept. 1949	43	2	
10S	4005-8009	Ankrom, Paul	George Young	1968	H	1060	S	P ₱w/sg	52	25	6	6, 30	15	June 1968	7	37	
11	4015-8000	Finleyville Borough	Hixon & Jones	1935	U	1005	V	₱ c	105		10		30	May 1950	50		
12	4019-8011	Village of Cecil	Phil S. Gray	1940	P	940		₱ c	250								
13	4004-8010	Carnegie Natural Gas Co.	Frank S. Wiley	1926	H	980	V	₱ m	85		6		7	July 1950			
13S	4002-8008	Iams, I. L.	L. P. Shipman	1968	H	1220	S	Pg/s	118	21	8	75, 95		Aug. 1968	2		
14	4010-8015	Washington Ice Co.		1905	U	1030	V	₱ m	135		6		20	Sept. 1949	25		
15	4016-8016	Johnson Eng. & Mgmt. Services		1930	P	1020	V	₱ c	90		6		40		22	30	
16S	4005-8010	Johnson, Leeman	Pioneer Drilling & Pump Co.	1969	H	1060	S	P ₱w/sh	133	30	8	33, 70, 85		Jan. 1969	20		
17	4007-8009	Tanneyhill	Frank S. Wiley	1926	C	1175		Pg/sh	32		6						
18	4007-8008	Hootman, William	Frank S. Wiley	1926	R	1085	C	₱ m/ss	182	16	6		13		30		
18S	4005-8011	Frazee, Howard	Weir Walker	1968	H	1100	S	Pg/sh	85	20	8	38, 55		Sept. 1968			
19	4004-8010	Carnegie Natural Gas Co.	Frank S. Wiley	1926	N	1080	C	₱ m/shls	90		6		7				
20	4004-8010	McCrory, G. E.	G. E. McCrory		H	1070		₱ m	75	40			40				
21	4004-8010	Clements, A. B.	G. E. McCrory		H	1135		₱ m/ls	75		6						
22	4004-8010	Lewis, Clinton	Frank S. Wiley	1925	H	1135		₱ m	85	74	6						

23	4004-8012	Keeney, Ralph H.	Frank S. Wiley	1925	H	1330	H	Pg	64		6		50				
24	4003-8012	Wiley, Neal	G. E. McCrory		H	1225	S	P ₱w/shss	40		6						
25	4002-8012				H	1200		P ₱w	90		6						
26	4003-8001	Hill, W. B.	John W. Mitchell	1925	C	1160	S	P ₱w/ss	70	22	6		5				
27	4007-8000	Hertzog, Herbert	John W. Mitchell		H	1025	S	₱ m/shls	105	56	6						
28	4007-8000	Hopkins, Nettie, Mrs.	John W. Mitchell		H	1025	S	₱ m/shls	125	50	6		F				
29	4011-8000	Nottingham Township School	Walter Jones		H	1225		₱ m	134		6						
30	4011-8059	National Mining Co.	Walter Jones		U	785		₱ m/shls	400	400	11						
31	4018-8009	Deblasoi, Sam	George Hall	1916	H		C	Qa/sg	28		6						
32	4017-8009	McConnel, Logan	George Hall	1916	H	1225		P ₱w	92		6	32, 40, 55			1		
32S	4005-8011	Powell, George	Allen Burns	1970	H	1260	S	Pg/sh	110	35	8	68		Apr. 1970	1		
34	4018-8007	Ofsay, Sam		1916	H	1020	T	₱ m	80		6		30		0.5		
35	4018-8007	Quarturi, Joe			H		S	₱ m	73		6		50				
35S	4000-8011	Jenkins, James	George Young	1970	H	1020	S	P ₱w/ls	52	17	6	19	10	July 1970	15	10	2
36	4018-8006	Simpson, A. F.		1916	H	860	V	₱ m/ls	85		6						
36S	4000-8011	Nagleman, A.	L. P. Shipman	1966	H	1260	S	Pg/s	161	30	8	44, 76, 153	44	July 1966	≤0.1		3
37	4003-8001	Nemacolin Country Club	John W. Mitchell	1925	H	1280	H	Pw	95	26	6		80				
37S	4004-8014	Kiskadden, Waren	L. P. Shipman	1966	H	1040	C	P ₱w/ls	49	28	8	43		Sept. 1966	15	8	
38	4002-7955	Grimes and Bakewell	John W. Mitchell	1925	H	1200		₱ m	100	24	6		80				
39	4002-7954	Butler, Charles	John W. Mitchell	1925	H	1180		₱ m	100	28	6		85				
40	4008-7953	McBeth-Evans Glass Co.	Guaranteed Water Eng. Corp.	1925	N	765		Qa/sg							350		
41S	4005-8009	Fausnaught, Dale	George Young	1967	H	1030	S	P₱ w/ls	90	37	6	32, 45, 70		Apr. 1967	2		
42	4015-8014	McCloy and Campbell	James Skwart	1926	N	1015	V	₱ c	123	14	8		30		2		
42S	4003-8012	Amity School	George Young	1967	T	1345	H	Pg	146		6			June 1967	35		
43S	4003-8012	Amity School	George Young	1967	T	1345	H	Pg	260		10			June 1967	2		
44	4007-8025		James Skwart		H		S	P₱ w	75		6						
44S	4007-8012	Stolfer, Robert	George Young	1966	H	1100	S	P₱ w/ls	150	33	8	60	40	Dec. 1966	0.7		
45	4007-8025	Williams	A. E. McCarty	1924	H	1125		P₱ w	100	40	6		40	1924			
46	4006-8003	Bethlehem Mines Corp.	John W. Mitchell	1922	P	1095	S	₱ m/sh	175	40	6		145				
46S	4004-8010	Horne, Wm. J.	Charles Edward Wright	1967	H	1015	S	P₱ w/ss	200	73	8	45, 120, 170		June 1967	4		
47	4019-8024		L. K. Elder		H	1350	H	P₱ w/ls	50		6						
49	4017-8022	Nosio Hall School	J. A. McClurg	1921	T	1100	S	₱ m	67	20	6						
50	4016-8021	Shaffer, Henry	James Skwart	1926	H	1345	H	P₱ w	98		6		90				
53	4004-8021	Pleasant Grove School	James Skwart		T	1400		P₱ w/ls	148		6		119				
54	4000-8022	Marshall School	James Skwart		T	1225	V	ls			6						
54S	4010-8025	YMCA	Charles Edward Wright	1967	T	1025	S	P₱ w	212		6	60, 150	55	Apr. 1967	10		
55	3959-8024	Newland School	James Skwart		T	1390	S	Pg/ss	75		6						
56	4002-7953	Elliot, Thomas	John W. Mitchell	1923	S	1125	H	₱ m	114	45	6		95				
57	4001-7954	Nixon, A. J.	John W. Mitchell	1923	H	1150	S		69	30	6		55				
57S	4009-8022	Bobson, Arthur	Charles Edward Wright	1967	H	1020	S	P₱ w/ls	150	25	8	50	40	Apr. 1967	0.3		
59	4007-7957	Haynan, Harrison	G. H. Clark	1918	H	1225	T	₱ m/ls	70		6		57				
60	4007-7957	Cole, J. S.	G. H. Clark	1918	H	1200		P ₱w	40		6		25		20		
61	4027-8029	Manufacturers Light & Heat Co.	L. K. Elder		N	1000	V	₱ c/ss	100		8		5		110		
62	4027-8026	Fullerton, E. O.			H	1190		₱ c	60		6		30				
63	4027-8028	Purdy School	L. K. Elder		T	1255		₱ c/ss	140		6						

Table 5. *(Continued)*

Well	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)
64	4028-8026	Fullerton, H.	Fitzgibbons Oil & Gas Co.	1902	U	1075	V	₱ c/ss									
70	4016-8028	Schoolhouse of Avella	J. A. Gray & Son	1924	H	925	V	₱ c	100		6						
71	4021-8028	Dimit, Jacob	J. A. McClurg	1909	H	1275		₱ m/ls	92		6						
74	4018-8018	Hickory High School	James Skwart	1914	H	1300		₱ m/ls	126	126	6		100				
75	4017-8018	Farmers National Bank	J. A. McClurg	1926	C	1300	H	₱ m/ls	165	48	6		75				
76	4017-8021	Stewart, Jim	James Skwart		H	1120	V	₱ m/ls	75		6		30				
77	4017-8016	Adams Brothers	James Skwart	1925	H	1055	V	₱ c/ls	150		6						
80S	4014-8006	Burns, John	William J. McCormick	1968	H	1200	S	P₱ w/sh	168	22	6	46		Oct. 1968	1		
86	4014-8003	Venctia Schoolhouse	Walter Jones		T	1010	V	₱ c	199	100	6		140				
91	4026-8021	West Penn Water Co.		1895	P	910	V	₱ c/ss	90		10		7		120		
92	4022-8022	Beabout, S. G.	L. K. Elder	1926	H	1100	V	₱ c/ls	60	38	6		36				
93	4022-8017	Carnegie Coal Co.	L. K. Elder	1919	P	1060	V	₱ c/ss	48	40	6		F		22		
100	4022-8023	Burgettstown Coal Co.	J. A. McClurg	1917	P	1050	S	₱ c	90		6						
102	4021-8024	Ptrucci, D.	J. A. McClurg	1917	H	1050	S	₱ c	114	27	6						
103	4022-8024	Greensburg-Connellsville Coal & Coke Co.	J. A. McClurg		H	1100	S	₱ c	70		6				10		
104	4022-8024	Greensburg-Connellsville Coal & Coke Co.	J. A. McClurg		H		V	₱ c	145		6						
105	4019-8023	Adams, Mrs.	J. A. McClurg		H	1020	V	₱ c	101	40	6						
106	4023-8021	Racoon Schoolhouse	J. A. McClurg	1913	T		S	₱ c/sh	85		6		25				
107	4023-8022	Pittsburgh, Cincinnati, Chicago & St. Louis R. R.	J. A. McClurg	1918	U	975	V	₱ c	125		8						
107S	4017-8006	Ayers, Chester	William J. McCormick	1966	H	910	S	₱ m/ls	108	22	6	29		Nov. 1966			
109S	4019-8010	Brehm, John	David F. Weaver	1966	H	1090	S	₱ m/ls	86	20	6	27	50	1966	0.5		
113	4022-8023	Tennyson, Henry	J. A. McClurg		C	1020	S	₱ c	87		6				2		
114	4023-8023	Burgettstown High School	J. A. McClurg	1925	T	1000	S	₱ c	83	37	8						
116	4022-8019	Bulger Schoolhouse	J. A. McClurg	1916	H	1180		₱ m	82	20	8						
118	4021-8024	American Zinc and Coal Co.	J. A. McClurg	1914	H	1190	H	₱ m	112		6						
127	4010-8008	Grange Hall	John W. Mitchell	1925	H	1000	V	P₱ w/ss	52	20	6		35				
129	4007-8014	Vankirk Schoolhouse	Frank S. Wiley	1925	H	1375		Pg/ls	120	94	6		75				
130	4009-8012		G. E. McCrory		H	1380	H	Pg	100		6						
135	4016-8001	Mineral Beach	Walter Jones	1925	R	1050	V	₱ c	438	100	8				65		16
136	4016-8001	Mineral Beach	Walter Jones	1925	R	1050	S	₱ a	790	300	8				35		
137	4015-8000	H. D. Benn Garage	Walter Jones		C	1010	V	₱ c	44		6		F		2		

140	4013-7958	Diamond Coal Co.	James Stewart		N	850	V	₱ m	153		8						
141S	4013-8013	Meadowlands Farm	Pioneer Drilling & Pump Co.	1969	H	1055	S	₱ c/sh	103	31	8	75		July 1969	6		
142	4010-8016	Washington Ice Co.	A. E. McCarty		N	1030	V	₱ m/ss	200	30	6		60		25		
143S	4013-8013	Meadowlands Farm	Pioneer Drilling & Pump Co.	1969	H	1040	S	₱ c	98					June 1969			
144S	4013-8013	Meadowlands Farm	Pioneer Drilling & Pump Co.	1969	H	1050	S	₱ c/sh	132	35	8	80		July 1969	5		
145S	4002-8023	Glover, Kenneth	E. Byron Braddock	1970	H	1150	S	P ₱ w/ss	90	15	8	40, 65		May 1970	6		
147	4001-8007	Franklin Schoolhouse	Frank S. Wiley		H	975	S	P ₱ w	95		6		25				
155	4002-8026	U.S.G.S.		1971	U	1110	V	P ₱ w/ss	160	19	6		38	June 1971	2	17	1
159S	4007-8030	Kuthy, Zonie	Harold Durbin	1967	H	1340	S	Pg/ls	106	23	8	29, 66, 89	66	May 1967	8	57	
162S	4001-8027	Apton, J. P.	Pioneer Drilling & Pump Co.	1967	H	1020	S	P ₱ w/ss	162	30	8	24, 38		Aug. 1967	4		
163S	4008-8024	Ford, Ruby	James F. McComas	1970	H	1360	S	Pg/ls	87	85	9	50, 70	35	May 1970	25	20	
164S	4006-8028	Hunter, Garret	Charles Edward Wright	1966	H	1310	S	Pg	220		13	75	50	Oct. 1966	1		
166S	4007-8030	Pitman, Roy	Charles Edward Wright	1966	H	1305	S	Pg/sh	204	36	8	65, 85, 170	60	Nov. 1966	5		
167S	4007-8031	Pasco, Ella	Harold Durbin	1966	H	1325	S	Pg/ls	61	22	8	26, 56	41	Nov. 1966	2	3	0.25-0.50
168S	4009-8029	Simms, Orren	Harold Durbin	1966	H	1305	H	Pg/ls	90	31	8	63	58	Nov. 1966	1	3	
194S	4006-7957	Ross, John	Carroll Drilling Co.	1967	H	1130	S	₱ m/sh	50	20	8	35		June 1967	20		
195S	4006-7955	Clineman, Bucky	Carroll Drilling Co.	1967	H	980	S	₱ c/ls	50	20	7	35	30	Sept. 1967	5		
197S	4011-8000	U.S. Steel Corp.	William J. McCormick	1967	N	1120	S	₱ m/shss	375	28	24	23, 60	60	Oct. 1967	50		
207S	4023-8030	Cunningham, Will	Domineck Presutti	1966	H	1180	S	₱ c/ss	154	22	6	78, 139	78	July 1966			
220S	4013-8021	Denning, Homer	George Young	1967	H	1280	S	P ₱ w/ls	70	25	6	16, 27	17	Nov. 1967	15	3	
222S	4014-8027	Carl, Harry L.	George Young	1966	H	1280	S	P ₱ w	145	22	6						
235S	4002-8016	Stickle, Harry	James F. McComas	1969	H	1000	C	Pg/sh	91			42, 75	50	Oct. 1969	18	46	
245S	4018-8021	Serenity Farms	Pioneer Drilling & Pump Co.	1970	H	1145	S	₱ m/sh	120	36	8	32, 45		June 1970	14		
246S	4018-8021	Serenity Farms	Pioneer Drilling & Pump Co.	1970	H	1190	S	P ₱ w/ls	160	30	8	20, 32		Apr. 1970	7		
250S	4019-8020	Robinson, Lee	Walter L. Marcott	1966	H	1320	S	P ₱ w/sg	140	17	8	7, 14, 90	90	May 1966	40		1
257S	4020-8016	Toth, Casper	James W. McCrory	1967	H	1300	S	P ₱ w/sh	49	30	6	49	49	Nov. 1967	2	136	96
266S	3959-8006	Donahue, Albert	Carroll Drilling Co.	1966	H	1290	S	Pg/sh	308	20	7	150, 210	100	Nov. 1966	3	200	1
287S	4013-8010	Septer, Walter	William J. McCormick	1966	H	1150	S	P ₱ w/sh	138	22	6	70		June 1966			
290S	4014-8005	Mathies Coal Co.	William J. McCormick	1967	N	1120	C	P ₱ w/shss	304	304	6	32	10	Mar. 1967	12		
294S	4014-8006	Withrow, Blair	William O. Young	1967	H	1150	S	P ₱ w/ls	69	25	8	45	26	Nov. 1967	40	14	0.25-0.50
308S	4012-8005	Klingensmith, D.	William O. Young	1967	H	1080	S	P ₱ w/ls	60	21	8	35	20	Aug. 1967	70	10	
310S	4013-8007	Mathies Mine	William J. McCormick	1967	N	1040	S	₱ m/sh	315	315	6	30	25	Nov. 1967	10		
320S	4015-8007	Wagg, Fred	David F. Weaver	1966	H	990	S	₱ m/ls	130	21	6	40	30	Oct. 1966	2		
332S	4015-8005	Lehner, Hilda	Charles Edward Wright	1968	H	1120	S	₱ m/ls	126	30	8	85	45	Sept. 1968	2	0	
348S	4024-8021	Bubenheim, George		1968	H	1000	S	₱ c/ss	80			35, 70	30	1968			
367S	4009-8001	Carl, Ray	Carroll Drilling Co.	1967	H	1000	S	₱ m/shls	130	22	8	83	75	Sept. 1967	2	55	
371S	4008-8005	Robertson, E. E.	William O. Young	1967	H	1070	C	₱ m/ls	80	22	8	32, 55	24	Dec. 1967	50		
380S	4010-8005	Pigeon Creek C.	Carroll Drilling Co.	1969	H	1190	S	P ₱ w/sh	170	32	8	95, 110	80	Oct. 1969	15		
382S	4010-8006	Science, John	William J. McCormick	1968	H	1240	S	P ₱ w/sh	108	22	6	23, 29		Oct. 1968	3		
385S	4008-8006	Bandell, Robert	David F. Weaver	1966	H	1180	S	P ₱ w/sh	52	20	6	51	30	Nov. 1966	20		
402S	4010-8006	Moore, Fred	Charles Edward Wright	1967	H	1245	S	P ₱ w/ss	153	27	6	50, 85	45	June 1967	2		
414S	4007-8015	Gray, Ellis	Charles Edward Wright	1966	H	1450	S	Pg/ls	230	30	8	65	100	Aug. 1966	1		
420S	4007-8015	Gray, Ellis	Charles Edward Wright	1967	H	1450	S	Pg	236		8		50	Apr. 1967	2		
432S	4010-8009	Castillenti, Guy	Pioneer Drilling & Pump Co.	1968	H	1080	S	P ₱ w/sh	160	27	8	29, 68		Oct. 1968	2		
434S	4010-8010	Klempay, Paul	Pioneer Drilling & Pump Co.	1966	H	1140	S	P ₱ w/shls	190	19	10	135		July 1966	1		

Table 5. *(Continued)*

Well	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)
436S	4010-8010	Lukas, Paul G.	Pioneer Drilling & Pump Co.	1966	H	1180	S	PIP w/s	124	30	8	45, 89					
439S	4010-8010	Lukas, Paul G.	Pioneer Drilling & Pump Co.	1967	H	1180	S	PIP w/s	124	30	8	45		Feb. 1967			
455S	4010-8011	Redman, Frank	Pioneer Drilling & Pump Co.	1969	H	1180	S	PIP w/shls	130	29	8	38		Apr. 1969	2		
466S	4005-8011	Powell, George	Allen Burns	1970	H	1240	S	Pg/ls	103	27	8	53, 61	30	Apr. 1970	8		
470S	3959-8007	Chapel, Winnett	George Young	1966	H	982	C	PIP w/ls	100	27	6	15, 45, 80	26	1966	18	54	
472S	4000-8006	Bennington, Wm.	George Young	1968	H	1060	S	PIP w/sh	60	18	8	22	18	Mar. 1968	1	37	
473S	4000-8004	Rep. Steel Corp.	William J. McCormick	1968	N	880	S	IP m/shls	298	280	16	44, 78	40	Aug. 1968	3		
474S	4000-8004	Rep. Steel Corp.	William J. McCormick	1968	N	880	S	IP n/sh	397	380	4	170, 243	150	Oct. 1968	4		
475S	4000-8004	Rep. Steel Corp.	William J. McCormick	1968	N	880	S	IP m/ss	325	315	4	55		Oct. 1968	0.2		
490S	4006-8030	Durbin, Edith	Harold Durbin	1966	H	1360	S	Pg/ls	150	22	8	109, 146	96	Feb. 1966	3	51	
491S	4006-8030	Durbin, Blaine	Harold Durbin	1966	H	1280	S	Pg/ss	83	20	10	34	57	Mar. 1966	6	23	
494S	4006-8030	Davis, John	Harold Durbin	1966	H	1300	S	Pg/ss	181		8	103, 114, 167	93	Aug. 1966	2	3	
495S	4006-8030	Murphy, Earl	Harold Durbin	1966	H	1300	H	Pg	112		8	63	63	Oct. 1966	1	3	
496S	3959-8028	Mahan, Roy	E. Byron Braddock	1970	H	1220	S	Pg	90	21	8		50	Jan. 1970	2		
498S	4004-8027	Sutherland, Roy	Harold Durbin	1966	H	1400	S	Pg	131	20	6	30	23	June 1966	1	103	≤0.25
499S	4000-8027	Cadawallader, Wm.	Charles Edward Wright	1967	H	1100	S	PIP w/ls	101	32	8	55, 65, 75	12	Apr. 1967	2		
501S	3958-8028	Watkins, John	E. Byron Braddock	1967	H	1360	S	Pg/ss	90	20	10	35, 56	38	Apr. 1967	8		
502S	3958-8028	Watkins, John	E. Byron Braddock	1967	H	1370	S	Pg/ss	133	20	8	75, 90	75	Mar. 1967	2	58	
503S	3958-8028	Watkins, John	E. Byron Braddock	1967	H	1340	S	Pg/ss	160	22	8	100	100	Sept. 1967	0.5	60	
506S	3959-8027	Archer Bros.	E. Byron Braddock	1968	H	1330	S	Pg/ss	138	17	10	65, 82	65	Sept. 1968	0.5		
509S	4004-7958	Ristamaki Reino	Carroll Drilling Co.	1969	H	1260	S	PIP w/ls	100	21	8	40, 80	30	Oct. 1969	15		
510S	4006-7959	Hoak, John	Carroll Drilling Co.	1969	H	1240	S	PIP w/ls	200	22	7	150	100	Oct. 1969	3	100	
511S	4004-7958	Walsh, Joe	Carroll Drilling Co.	1966	H	1165	S	IP m/ls	188			175	175	May 1966	10		
513S	4005-7959	Ghrist, Joe	Carroll Drilling Co.	1968	H	1110	S	PIP w/sh	110	22	8	34, 85	34	June 1968	15		
520S	4000-8005	Fulton, Kenneth	L. P. Shipman	1970	H	920	S	PIP w/ls	53	22	8	35	26	July 1970	2	1	
526S	4006-8027	L and H Manufacturing	James F. McComas	1970	N	1005	C	PIP w/ls	60	23	6	37, 50		Aug. 1970	20		
527S	4003-8024	Wright, Elmer	E. Byron Braddock	1970	H	1220	C	Pg/ss	85	20	8	50		June 1970	6		
529S	4028-8022	Nadik, Leo	Ross Swogger	1970	H	1025	S	IP c/sh	100	35	7	36		Sept. 1970	2		
534S	4018-8026	Arbuckle Homes	James F. McComas	1970	H	1020	C	IP m/ls	96	20	9	77, 85	43	July 1970	20	36	

pumped and with distance from the center of pumping. This information can be obtained from standard pumping tests made on developed production and observation wells.

Water Quality

Ground water from alluvium is generally hard and has a high iron, manganese, and dissolved-solids content. It also has low turbidity and generally is bacteriologically pure. The quality of water from wells changes considerably when water is induced to flow from streams into the cones of influence of the wells. When this occurs, the well water quality is intermediate in character between the quality of the surface water and ground water. Temperature of the mixed waters will vary; they are lower during the winter and higher in the summer.

GREENE FORMATION

In Washington County the Greene Formation is composed of the Fish Creek Sandstone and the Donley Limestone Members and associated beds.

Lithology

This geologic unit is composed of sandstone that grades irregularly into thin-bedded shaly sandstone and encloses several discontinuous thin shaly beds of limestone. A sandstone 10 to 40 feet thick is the most important water-yielding unit in this formation.

Water-Bearing Characteristics

Where this formation is saturated, the water occurs in the pore spaces between the sand grains, in the joints, and along the bedding planes. Permeability of the sandstone differs greatly, according to grain size, degree of sorting, amount of cementing material or extent of fracturing. The shale is a fine-grained rock of low permeability, but it generally contains water in fracture or joint systems.

Well Depth and Yields

The yields of wells in the Greene Formation are low because of the shale members and the smallness and scarcity of fractures. Well yields range from less than 1 to 35 gpm, and the median yield is about 2 gpm. Yields greater than those required for domestic purposes are not available from wells in this formation.

Well depths range from 32 to 308 feet, and most of the wells are less than 120 feet deep.

Table 6. *Generalized Section of Geologic Units*

System or stage	Group or Formation	Thickness (feet)	Lithologic character	Hydrologic character
Quaternary Holocene and Pleistocene	Alluvium	0-63	Well to poorly sorted deposits of clay, sand, gravel and cobbles.	Yields generally large, depending upon degree of sorting by grain size.
Permian	Greene Formation	61-260	Shale and shaly sandstone, a few thin limestone beds, and thin coal beds; much red shale in lenticular beds.	Moderate yields from sandstone; small yields from shale bedding-plane openings.
Permian – Pennsylvanian	Washington Formation	36-304	Alternating layers of shale and fine-grained sandstone, thin-bedded limestone and several coal beds.	Sandstone members are best producers. Rest of formation is a poor producer.
Pennsylvanian	Monongahela Group	48-397	Limestone beds of variable thickness, discontinuous sandstone beds, and several coal beds.	Limestone beds yield moderate water supplies from joints and bedding planes. Sandstone beds are less productive. Not water-bearing beneath thick cover.
	Conemaugh Group	44-438	Gray, green and red shale with discontinuous sandstone beds, some thin limestone beds and coal; all members variable in thickness.	Water-yielding capacity ranges greatly from place to place. Sandstones are best producing beds.

Well Location and Spacing

Well spacing is generally not critical when water is being pumped for domestic purposes. Locating an adequate water supply in the Greene Formation can be difficult for the reasons stated in the preceding section. It is possible to develop modest household supplies from the thicker sandstone members where they occur below the water table.

Water Quality

Only two partial chemical analyses of water from the Greene Formation are available – dissolved solids, 411 and 436 mg/l, and iron, 0.81 and 0.93 mg/l. The water is of good quality, but moderately hard.

WASHINGTON FORMATION

Lithology

The Washington Formation consists of alternating beds of shale and sandstone and several coal beds. There are some thin-bedded discontinuous limestone members. The basal member is a dark-colored sandy shale.

Water-Bearing Characteristics

In general the Washington Formation is a poor water bearer. The soft shale that constitutes the major part of the section is a very poor water bearer, although a small amount of water is available from bedding planes. The basal sandy shale yields water in larger quantities where it is not deeply buried.

Well Depths and Yields

Well yields in this formation range from less than 1 to 70 gpm, and the median yield is 2 gpm. Several wells in this formation do not yield water. The yields of wells in the Washington Formation are generally low because of the shale members and the scarcity of fractures. Well depths range from 36 to 304 feet.

Well Locations and Spacing

Small household water supplies can be developed from the sandy units in the Washington Formation. Domestic well location and spacing is generally not critical.

Water Quality

Only one chemical analysis of water from the Washington Formation is available. Dissolved-solids content was 318 mg/l, and iron content was 0.5 mg/l.

MONONGAHELA GROUP

Lithology

The Monongahela Group, which is divided into the Pittsburgh (lower) and Uniontown (upper) Formations, consists of limestone, shale, sandstone, and coal. The limestone is dense and massive to thin bedded. The shale and sandstone are discontinuous. There are several mineable coal beds in the group, including the Pittsburgh, Redstone, Fishpot, Sewickley, Uniontown, and Little Waynesburg coals.

Water-Bearing Characteristics

Most of the porosity and permeability in limestone is the result of enlargement of the fractures through the solution and removal of minerals by moving ground water. Permeability of sandstone ranges greatly, according to grain size, degree of sorting, and amount of cementing material. Secondary porosity may be developed by solution and removal of cementing material or by fracturing. Shale is a fine-grained, rather impermeable rock, but generally contains water in fracture or joint systems.

Well Depths and Yields

The yields of wells in the Monongahela Group are low because of the smallness and scarcity of fractures. Well yields range from 0.1 to 50 gpm, and the median yield is about 1 gpm. Yields greater than those required for domestic purposes are very difficult to obtain from this group. Large-diameter wells in this formation will yield larger volumes of water than small-diameter wells for short periods, because the amount of stored water is greater in the large-diameter wells. Aside from the storage factor, the drilling of deeper wells in the Monongahela Group does not increase the potential yield of wells. The low yields are partly the result of dewatering of the rocks due to coal mining.

Well depths range from 50 to 400 feet, and most of the wells are over 100 feet deep.

Well Location and Spacing

The spacing of domestic wells is not critical because of the modest water requirements. Locating an adequate water supply in the Monongahela Group is difficult for the reasons stated in the preceding section.

Water Quality

Ground water in the Monongahela Group is largely of the calcium bicarbonate type. Where the unit lies approximately 100 feet below major streams, chloride concentrations are high. The dissolved-solids content ranges from 330 to 1120 mg/l. Iron content ranges from 0.07 to 0.22 mg/l.

CONEMAUGH GROUP

Lithology

The Conemaugh Group is divided into the Glenshaw (lower) and Casselman (upper) Formations. It is much less calcareous than the overlying Monongahela Group and is composed primarily of sandstone and shale and lesser amounts of limestone and coal. This group occurs in the northern, central, and eastern parts of the county.

Water-Bearing Characteristics

The best water-producing formations in the Conemaugh Group are sandstone beds. Well yields depend on local permeability of the aquifers and on the thickness of saturated rock. Below stream drainage level, the aquifers are likely to be saturated; above drainage level, the upper part of the rocks is unsaturated and, thus, well yields are reduced.

In the shale and limestone members, the water is generally obtained from bedding-plane passages and from joint planes.

Well Depths and Yields

The Conemaugh Group is a source of small to moderate supplies of ground water. Some wells yield more than 50 gpm, but the median yield for wells in this aquifer is 5 gpm. The deepest water well reported in the Conemaugh Group was drilled 438 feet deep and produced 65 gpm. The highest reported yield was 160 gpm from a well 255 feet deep. Three wells, 80, 98, and 154 feet deep, were dry.

Sufficient water for domestic purposes can be obtained at almost any location from wells that are 100 feet below the water table, but yields large enough for industrial and municipal purposes are more difficult to obtain. If large supplies are sought, test wells help to determine if sufficient water is available for a production well.

Well Location and Spacing

Domestic well spacing is generally not critical but industrial and municipal well spacing is. Where several pumping wells are closely spaced the cones of depression overlap, the draw down is increased, and, consequently, the yield of each well is reduced. Wells less than 500 feet apart in the Conemaugh Group generally interfere with each other when pumped simultaneously.

Water Quality

Chemical analyses of the ground water in the Conemaugh Group show a wide range in chemical character. The extremes of dissolved solids are 220 and 2600 mg/l. The range in hardness is from 127 to 1840 mg/l. Iron ranges from 0.17 to 2.3 mg/l and may need to be removed from the water where it exceeds 0.3 mg/l, in order to meet U.S. Public Health Service (1962) drinking water standards.

HOW MAN HAS CHANGED THE HYDROLOGIC SYSTEM

PRESENT STATUS OF DEVELOPMENT

Population and industrial growth of the county have greatly altered water demands and the means of satisfying those demands. In the early days the people had their own wells or obtained water from nearby springs or streams. By the late 1960's, 80 percent of the county population received water from public water-supply facilities. An inventory in 1970 showed public supplies to average 17 mgd (million gallons per day). Of this total, less than 1 mgd was from ground-water sources.

No recent inventory of commercial and industrial water supplies has been made, but there has probably been a decrease in the amount of ground water used for most purposes. The water is used primarily for cooling and processing, and about one-fourth of it is reused. Water requirements of some companies have been reduced to the point where it is more economical to purchase water from public supplies than to maintain private wells.

GROUND-WATER PUMPAGE

Reports from two municipalities using ground water in Washington County indicate that about 300,000 gpd (gallons per day) is being pumped from wells or obtained from springs.

Union Township pumps two wells at about 220,000 gpd. Fallowfield Township utilizes a spring and surface-water source. As stated above, no recent inventory of industrial supplies has been made, but there has probably been a decrease in the amount of ground water for most purposes.

SURFACE-WATER PUMPAGE

The water supplies for most of the municipalities in Washington County are obtained from surface-water sources. Available data indicate that 17 million gallons of water a day are used to supply the municipalities in the county. Surface-water supplies are taken from reservoirs on many smaller streams and directly from the larger streams.

WATER PROBLEMS RESULTING FROM THE ACTIVITIES OF MAN

COAL-MINING OPERATIONS

The greatest water problem in Washington County is pollution of the water resources by drainage from coal-mining operations. The waste material left behind during the removal of coal is rich in iron and sulfur-bearing minerals. Exposure of these minerals to air and water produces soluble iron and sulfuric acid, which may be temporarily pooled in the mine areas or may move directly into streams. Wells near such areas that are open at or below the level of these pools tap water polluted by the iron and sulfuric acid.

Streams draining coal-mining areas are polluted to varying degrees. The Monongahela River, Chartiers Creek, Brush Creek, Pigeon Creek, and Pike Run and many of their tributaries carry mine drainage.

The many reservoirs in watersheds of streams entering Washington County benefit the area in two ways. They diminish potential flood hazards by retaining much of the excess water during periods of high surface runoff. They also reduce the degree of pollution by releasing water during periods of low river stage, thus diluting the otherwise highly mineralized streams.

DEWATERING OF AQUIFERS

Collapse of unsupported roof material in worked-out coal mines has caused fracturing and dewatering of the overlying aquifers in some parts of the county. In the western and north-central parts of the county, the sandstone overlying the Pittsburgh coal has been extensively dewatered wherever the coal has been mined. In other parts similar dewatering of the sandstone beds occurs above mines in the Waynesburg coal.

OIL AND GAS WELLS

Oil and gas production is of great significance, as the county is ranked sixth in the Commonwealth for natural gas production and fourth for crude petroleum production. During the search for oil and gas, thousands of wells were drilled. Many of the well casings have been removed or are severely corroded. The result is that salt water under artesian pressure has, in many areas, moved up the boreholes and out into the shallower freshwater aquifers, degrading water quality.

DEVELOPMENT OF WELLS

DRILLING METHODS

Dug wells were common around the turn of the century, but they are now a rarity. Most wells currently in use in Washington County are drilled by either percussion or rotary methods. In the percussion or cable tool method, wells are drilled by the alternate lifting and dropping of a heavy drilling bit in the borehole. The bit action breaks up consolidated rock material or loosens unconsolidated material so that the smaller fragments may be removed by bailing. The rotary method uses a rotating bit to cut rock or to loosen alluvial material; drill cuttings are carried from the borehole to the surface by circulating water, drilling mud, or air.

WELL CONSTRUCTION

Wells are generally cased with pipe to prevent collapse of the borehole. In consolidated material the casing may be driven only a few feet into the rock or may line the hole to very near its bottom. In unconsolidated material, casing must be used to prevent collapse of the hole, and it is common practice to replace the casing with screen opposite water-bearing zones. An alternative to a screen is slots or drilled holes in the casing. The purpose of the screen or slotted casing is to allow entry of water into the well while excluding the rock material. Gravel packing is a further refinement available for use in construction of wells in alluvium. In this technique, clean coarse gravel is used to fill the annular space between the well screen and the outside of the borehole. The purpose of a gravel pack is to increase the effective screen diameter, reduce the entrance velocity of water entering the well, and lessen the likelihood that fine sand will clog the well screen.

In the interest of sanitation it is necessary to fill the upper part of the annular space between the casing and the earth with grouting material, such as concrete. The grout extends down far enough to prevent the entry of surface pollutants into the zone of water withdrawal.

WELL DEVELOPMENT

The method commonly used to increase well yields consists of heavy pumping of the borehole for a short period of time to remove drill cuttings and the fine material from the water-bearing zones. 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 the 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. This method is most successful in unconsolidated material, sandstone, and conglomerate.

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

MANAGEMENT OF WATER SUPPLIES

PROTECTION FROM OVERDRAFT

Water levels in wells may drop below the pumps, and production ceases or becomes inadequate. Possible remedies are deepening wells, reducing pumpage, artificially recharging aquifers, adding wells, spacing and orienting additional wells properly, and lowering pump-intake settings.

As ground water is little used in Washington County, there is no known overdraft. Overdraft would most likely occur where wells are spaced closely together or in areas some distances from the streams where induced infiltration is not possible.

PROTECTION FROM POLLUTION

Water moves rather freely between surface and subsurface environments; therefore, anything that affects the quality of surface water may also affect the quality of ground water. The reverse is also true. This interrelation is most apparent in heavily industrialized areas where large amounts of waste are discharged into rivers and much river water is induced into nearby wells from the river alluvium. River-water contamination is generally highest during the time of greatest ground-water pumpage and this can (and in many cases does) adversely affect the quality of water yielded by such wells.

Government agencies are becoming increasingly active in the field of pollution prevention. The Pennsylvania Department of Health has set standards for length and cementing of casing in wells, and the Pennsylvania Department of Environmental Resources has established regulations concerning the reclamation of strip mines to reduce the formation of acid water. As mentioned previously, however, the discharge from abandoned mines is still a major source of pollution. Snowmelt and heavy rains throughout the year flush out the acid water accumulated in the mines and carry it into the streams. When this happens, dilution by less mineralized water reduces the degree of contamination.

A large part of the ground water used by industry is for cooling purposes. After use, much of this warmer water is discharged to streams. The higher temperature makes the water less suitable for similar use in downstream areas.

Ground-water supplies may be contaminated by pollutants carried downward from the land surface by percolating water. Because ground water moves slowly, such pollution is slow to accumulate and just as slow to flush out after the contaminating source is removed. Common sources of pollution are septic systems, nitrate from fertilizers, and household detergents; other sources are industrial wastes, accidental oil spills, and waste material in sanitary landfills.

In the future, controlling water quality will probably be a greater problem than obtaining sufficient quantities of water. Surface-water quality is now monitored at many points in the area. A similar system to monitor the quality of ground water in and around cities, industrial sites, and unpopulated areas would be valuable.

WHERE TO GET INFORMATION ABOUT WATER

The Pennsylvania Topographic and Geologic Survey has information on the geology of Washington County and has published reports describing the aquifers and chemical quality of ground water. Well drillers' logs and reports on new wells also are available.

The Private Water Supply section, Division of Sanitation, Pennsylvania Department of Health, can supply information on proper well construction requirements, biological reports on well water, and the chemical quality of ground water in this and other counties. The Pennsylvania Department of Health, through various regional offices, can test water samples for bacterial pollution; they also can advise on corrective measures to be taken when pollution is reported.

The Engineering and Construction section of the Pennsylvania Department of Environmental Resources 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.

When information on water supplies is requested, an accurate location of the site should be given. This will help the above-listed agencies to give assistance and advice.

The local well drillers and pump installers can provide prices and suggest the type of equipment needed to develop a water supply. The drillers may know the well depth necessary to obtain desired yields and how much surface casing is required. They can also suggest the proper well diameter for the desired pumping equipment. Pump installers can supply information concerning the size of the pump, depth of the pump setting, and the pressure-tank capacity.

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

GLOSSARY

Anticline: An arch in stratified rock in which the layers bend downward in opposite directions from the crest and which has the oldest rocks in the core; reverse of syncline.

Aquifer: A formation, group of formations, or a part of a formation that contains sufficient saturated material to yield significant quantities of water to wells or springs.

Artesian water: Ground water that occurs under sufficient hydrostatic head to rise above the level at which it was found when drilling.

Cubic feet per second: The rate of discharge equivalent to 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 funnel-shaped depression, in a water table or potentiometric surface, centered at a pumping well or other discharge point.

Drainage, or drainage level: In this report refers to the level of the beds of the principal streams.

Drainage system: A stream and its tributaries.

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

Discharge, ground-water: The water that leaves the saturated zone.

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

Fracture: Break in a rock due to applied stresses.

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

Head, static: The height above a standard datum of the surface of a column of water (or other liquid) that can be supported by the static pressure at a given point.

Induced infiltration: The process through which the cones of depression are lowered to a point where they intercept the water of a perennial stream, reversing the normal direction of the ground-water gradient; also, the water drawn into the aquifer by this process.

Joint: A fracture that has opened with no displacement of adjacent walls along the fracture; often vertical and occurring in sets crossing one another at high angles.

Overdraft: Overdraft of an aquifer exists when water levels in the aquifer show a persistent declining trend as a result of pumping.

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.

Plunge: The inclination of the crest of structures (as anticlines and synclines) from a horizontal plane.

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

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

Runoff: That part of precipitation that appears in streams.

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

Specific capacity: The rate of discharge of a well, in gallons per minute, divided by the drawdown in the well, in feet.

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

Surface water: Water on the surface of the earth.

Syncline: A trough in stratified rock in which the layers dip toward the center from either side, and which has the youngest rocks in the core; reverse of anticline.

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

Water table: That surface in an unconfined water body at which pressure is atmospheric.

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

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