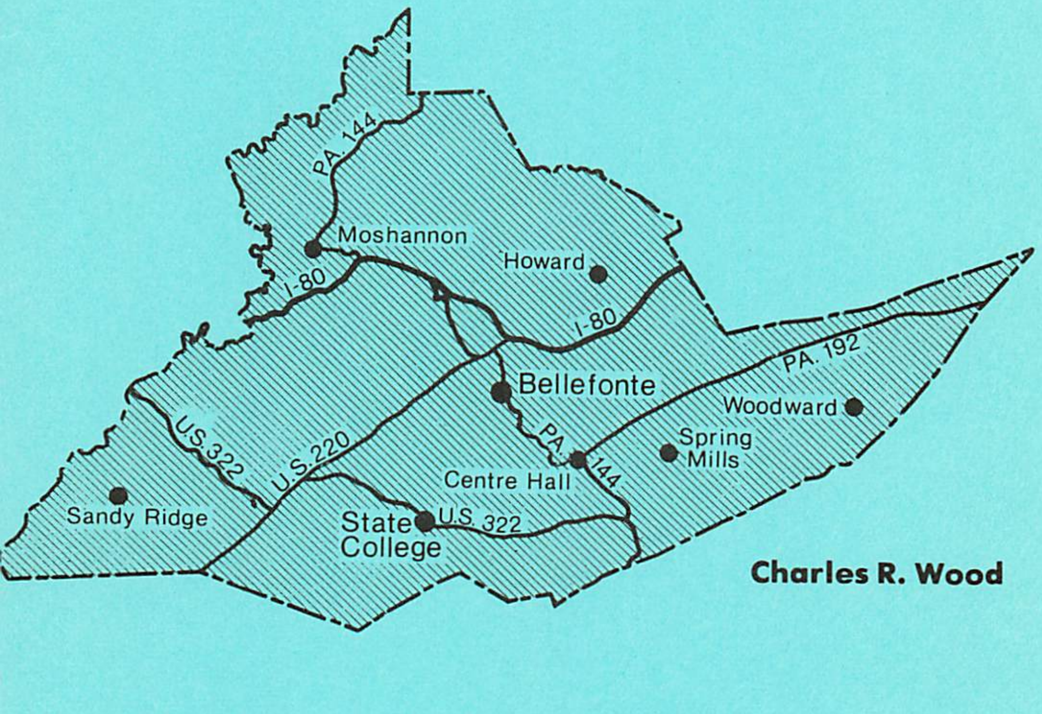
Water Resource Report 48

1980

SUMMARY GROUNDWATER RESOURCES OF CENTRE COUNTY, PENNSYLVANIA



Charles R. Wood

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

NOTE: Due to poor printing, the following lines in this book may be unreadable:

page 6, lines 1-2: are at Bellefonte, which has 0.8 inch less precipitation, and at Clarence, Millheim, and Philipsburg, which have 1.5, 4.5, and 2.0 inches more pre-

page 8, line 2: Penns Creek, the Juniata River, and the West Branch of the Susquehanna

page 14, lines 1-2: blue baby disease, if such water is used for infant feeding. The ranges of some of the other parameters measured by Langmuir were pH, 7.1 to 8.2;

page 16, last two lines of table under "Water-bearing characteristics": Probably similar to Keyser Formation above.

page 26, line 2: The Bald Eagle Formation (Late Ordovician age) underlies and grades

Water Resource Report 48

SUMMARY GROUNDWATER RESOURCES OF CENTRE COUNTY, PENNSYLVANIA

by Charles R. Wood
U. S. Geological Survey

Prepared by the U. S. 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 groundwater resources available in Centre 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. Groundwater, 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 groundwater available in any part of the county, and it will aid in choosing the locations, depths, and conditions most favorable for the desired groundwater yield.

While this publication has attempted to include all available groundwater data for the county, the Pennsylvania Topographic and Geologic Survey will continue to collect groundwater and water well data for the area; such data will be kept on 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 Centre County to develop and manage their water resources so as to accommodate their water needs.

ARTHUR A. SOCOLOW

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(in envelope)

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SUMMARY GROUNDWATER RESOURCES OF CENTRE COUNTY, PENNSYLVANIA

by
Charles R. Wood

ABSTRACT

The northwest third of Centre County lies in the Appalachian Plateaus physiographic province. The higher altitudes are underlain by the Conemaugh, Allegheny, and Pottsville Groups, which consist of sandstone, shale, and thin limestone and coal beds. The average yield of nondomestic wells in the Allegheny Group is 20 gpm (gallons per minute) and that in the Pottsville Group 100 gpm. Water from wells in these groups commonly has a high concentration of iron. Most of the rest of the Appalachian Plateaus province is underlain by the Burgoon Sandstone. The Burgoon yields soft water, and the average yield of nondomestic wells is 70 gpm.

The southeast two thirds of the county lies in the Appalachian Mountain section of the Valley and Ridge physiographic province. The 33 formations that crop out there consist chiefly of sandstone, shale, limestone, and dolomite. The average yield of nondomestic wells is less than 100 gpm from most of these formations. However, several formations yield large supplies. Wells in the Old Port Formation generally yield more than 200 gpm, but about half the wells drilled in the Ridgeley and Shriver Members of the Old Port collapse if not screened or cased properly. The average yield of wells in the Keyser and Tonoloway Formations is 200 gpm, but the water is very hard, and in places the sulfate concentration may be too high for most uses. The average yield of wells in the Wills Creek Formation is more than 200 gpm, but more than half the wells deeper than 200 feet yield water having sulfate concentrations in excess of 500 mg/l (milligrams per liter). Some wells yield water containing objectionable amounts of hydrogen sulfide. The Nittany and Gatesburg Formations, which consist chiefly of dolomite, have average well yields of 500 and 415 gpm, respectively. About half the high-capacity wells in these formations pump sand or eventually collapse. They generally yield very hard water.

Water in the noncarbonate rocks in Centre County is contained in and moves through fractures that are discontinuous, limited in areal extent, and poorly interconnected hydraulically, so that pumping effects are not distributed equally in all directions. In the noncarbonate rocks, heavy pumping may produce overdrafts. In the carbonate rocks, some of the fractures have been enlarged by solution cavities. Thus, much water may be stored and transmitted. However, such water is much more likely to be contaminated. Ten percent of the domestic wells sampled in the car-

bonate rocks of the Nittany Valley contained more than 10 mg/l of nitrate (as nitrogen). Eleven of 12 springs sampled had fecal coliform bacteria present. A substantial part of the groundwater discharge is from large springs, at least 10 of which have average discharges in excess of 1,000 gpm.

Many of the wells in the northwest third of the county tap the Allegheny and Pottsville Groups. Water from these units is commonly high in iron, and, where the coal has been mined, the water is almost always high in iron. Manganese may also be present in objectionable amounts. Very high sulfate concentration is common in water from rocks of Silurian age.

Wells on fracture traces generally have much higher yields than those off fracture traces. Wells in valleys generally have higher yields than those on hillsides and hilltops.

INTRODUCTION

PURPOSE AND SCOPE

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

LOCATION AND GENERAL GEOGRAPHIC FEATURES

Centre County encompasses an area of 1,115 square miles in central Pennsylvania (Figure 1). It is bordered by the following counties: Clinton to the north; Clearfield to the west; Blair, Huntingdon, and Mifflin to the southeast; and Union to the east. The borough of Bellefonte, the county seat, is 90 miles northwest of Harrisburg.

POPULATION TRENDS

The population has more than doubled during the past 50 years. In the past decade, population increased by 26 percent. Table 1 shows results of the census from 1920 to 1970. The 1970 population density was 89 per square mile.

LANDFORMS

The southeast two thirds of Centre County lies in the Appalachian Mountain section of the Valley and Ridge physiographic province. The topography is characterized by a prominent northeast-southwest alignment of a succession of narrow steep-sided ridges and valleys. Some karst features (caves

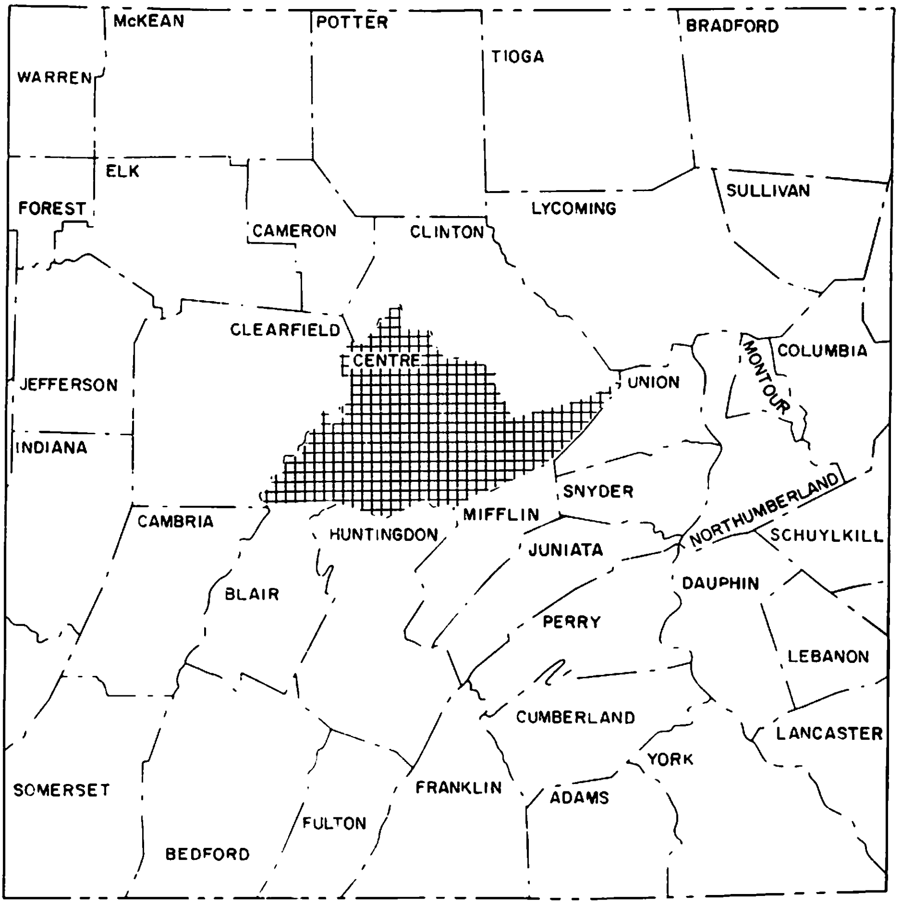


Figure 1. Map of central Pennsylvania showing the location of Centre County.

Table 1. *Population of Centre County, 1920-70*

Year	Population
1920	44,304
1930	46,294
1940	52,608
1950	69,922
1960	78,580
1970	99,267

and sinkholes) are present in the valleys. Bottoms of principal valleys lie generally between altitudes of 900 and 1,400 feet, and the crests of higher ridges lie between 1,700 and 2,200 feet. Relief between ridge crests and adjacent valley bottoms is greater than 1,000 feet in several places and is commonly greater than 400 feet.

The northwest third of the county lies in one of three sections of the Appalachian Plateaus physiographic province (Pennsylvania Geological Survey, 1963). A strip of land 4 miles wide lying just northwest of Bald Eagle Creek is in the Allegheny Mountain section. This area is strongly dissected and generally lies between altitudes of 700 and 1,600 feet. The northern part, in the Allegheny High Plateaus and the Pittsburgh Plateaus sections, is a dissected plateau having steep valley sides. The upland surfaces are flat and generally lie between altitudes of 1,400 and 2,300 feet.

The highest point in the county, altitude 2,630 feet, is in Rush Township almost on the Blair County line. The lowest point, 572 feet, is near the borough of Beech Creek where Bald Eagle Creek leaves the county.

LAND USE

In 1970, 3 percent of the land was classified as developed, that is, used for residential, commercial, industrial, public, and semipublic purposes or for transportation and communication. Slightly more than one fourth was used for agriculture or was open land; 2 percent was used for strip mining and quarrying. That remaining, slightly more than two thirds of the county, was wooded. Twenty-nine percent of the woodland and 2 percent of the open land was publicly owned (Centre County Planning Commission, 1970).

WHERE THE WATER COMES FROM

HYDROLOGIC CYCLE

Water constitutes the major part of most living things. Man depends upon it, yet water supplies are taken for granted by most. As shown in Figure 2, water evaporates from the oceans and is carried as vapor until it condenses and falls. Part of the precipitation on the land is either used by vegetation, evaporates back to the atmosphere, or runs overland as streamflow. The remainder enters the soil and bedrock to recharge water-bearing formations (aquifers). Part of the groundwater is evaporated or transpired by plants, but most is discharged to streams or flows directly to the ocean. The water moves at varying rates, depending on its environment, but all of it eventually returns to the oceans.

PRECIPITATION

Precipitation is the source of all fresh water in the county. The average yearly precipitation from 1885 to 1974 was 38.27 inches at State College. Other precipitation stations having shorter periods of record (24 to 32 years)

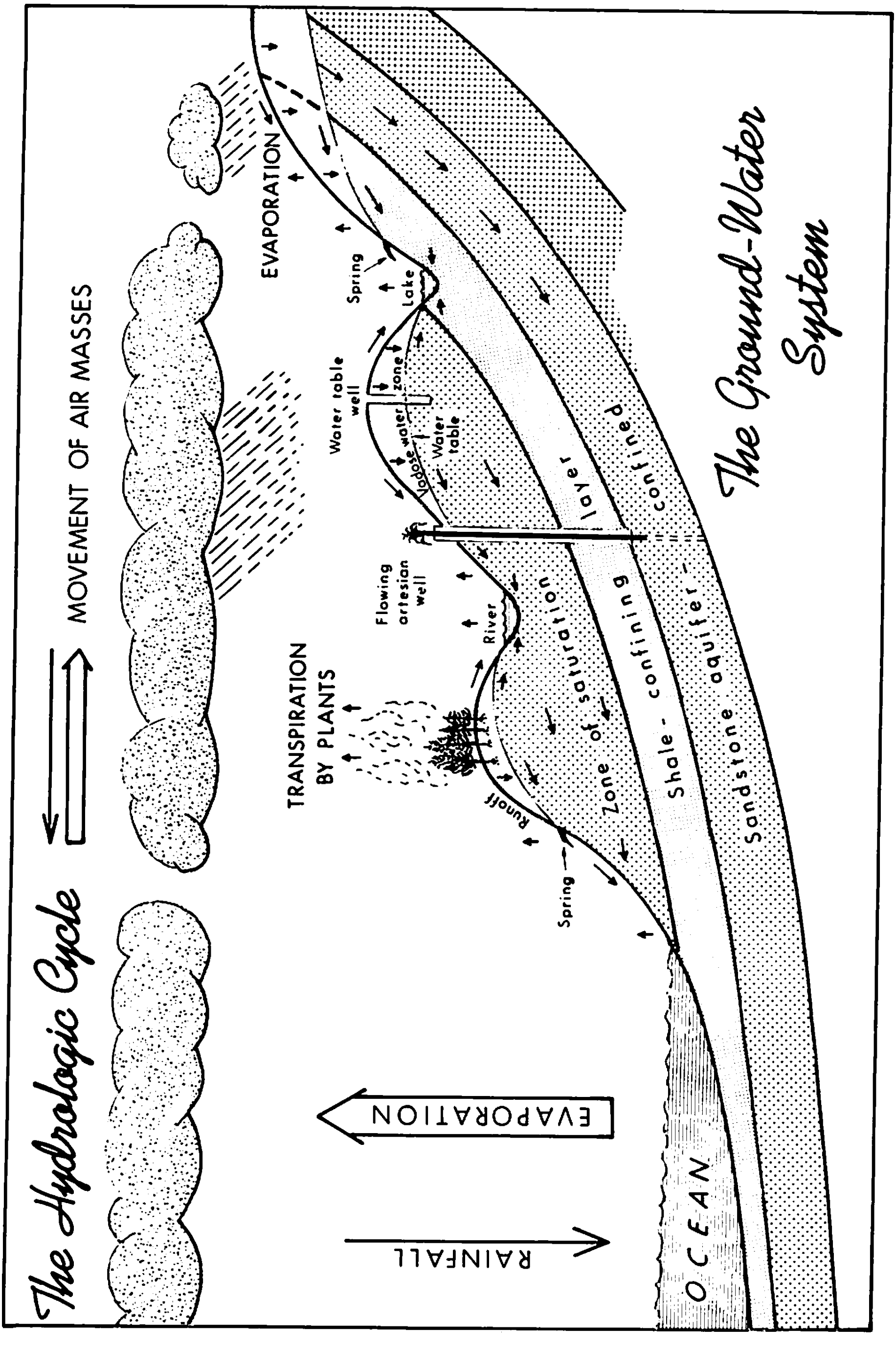


Figure 2. The hydrologic cycle (after Newport, 1971).

are at Bellefonte, which has 0.8 inch less precipitation, and at Clarence, Millheim, and Philipsburg, which have 1.5, 4.5, and 2.0 inches more precipitation. Long-term average precipitation is about 40 inches (U. S. Department of Commerce). Not all the water in the streams is derived from precipitation on the county, as some streams carry runoff from areas outside the political boundaries.

Precipitation is distributed evenly throughout the year, but the summer has a little more rainfall than other seasons. Much of the summer rain falls during intense storms of short duration. Twenty-three percent of the precipitation is snow.

WHERE THE WATER GOES

EVAPORATION AND TRANSPIRATION

Water returns to the atmosphere as vapor as a result of both transpiration and evaporation. In the process of transpiration, soil moisture returns to the atmosphere as a by-product of plant growth. In the evaporation process, water changes directly from a liquid to a vapor. Based on the difference between long-term average precipitation and runoff, the total annual water loss from Centre County by both evaporation and transpiration is 21 inches.

Measurements of evaporation from a free-water surface by the U. S. Department of Commerce, National Weather Service, at their station at Ford City, Armstrong County—the nearest station to Centre County where such measurements have been made—indicate an average annual evaporation (May through October) of 28 inches. The evaporation rate from a free-water surface, however, is greater than the combined evaporation and transpiration rate from other surfaces. Direct measurements of transpiration have not been made.

STREAMFLOW

Most of the water not evaporated and transpired leaves the county as discharge of streams. This discharge accounts for 19 inches of the annual precipitation. The larger streams and the locations of gaging stations that measure streamflow are shown on 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 for water years from 1961-74, and from *Water Resources Data for Pennsylvania, Volume 2, Susquehanna and Potomac River Basins,* published annually by the U. S. Geological Survey starting with the data for the 1975 water year.

Table 2. *Discharge Data, Gaged Streams*

Station number	Location	Drainage area (square miles)	Period of record	Average discharge (cubic feet per second)	Maximum discharge (cubic feet per second)	Date of maximum discharge	Minimum discharge (cubic feet per second)	Date of minimum discharge
01546500	Spring Creek near Axemann, Pa.	87.2	Oct. 1940 to 1979	86.8	5,410	June 23, 1972	9.6	Nov. 24, 1941
01547100	Spring Creek at Milesburg, Pa.	142	May 1967 to 1979	218	8,170	June 23, 1972	60	Sept. 30, 1969
01547200	Bald Eagle Creek below Spring Creek at Milesburg, Pa.	265	Oct. 1955 to 1979	383	21,300	June 23, 1972	50	Aug. 3, 1966
01547500	Bald Eagle Creek [1] at Blanchard, Pa.	339	May 1954 to 1979	433	10,100	Mar. 10, 1964	0	Several dates
01547700	Marsh Creek at Blanchard, Pa.	44.1	Oct. 1955 to 1979	56.0	4,870	June 23, 1972	0	Aug. 30, 31, 1966
01547800	South Fork Beech Creek near Snow Shoe, Pa.	12.2	May 1969 to 1979	22.6	1,170	June 23, 1972	1.7	Oct. 9, 10, 1970
01547950	Beech Creek at Monument, Pa.	152	Aug. 1968 to 1979	282	9,740	June 23, 1972	17	Sept. 4, 5, 1971
01548000	Bald Eagle Creek [1] at Beech Creek station, Pa.	559	July 1910 to 1979	795	25,600	Mar. 18, 1936	29	Aug. 22, 1930

[1] Flow regulated by Foster Joseph Sayers Lake.

All streams in Centre County flow to the Susquehanna River by way of Penns Creek, the Juniata River, and the West Branch of the Susquehanna River.

The average discharge per square mile of drainage area is much less for Spring Creek at Axemann than for any other gage. This indicates that a substantial part of the outflow from the upper part of the Spring Creek basin occurs as groundwater flow.

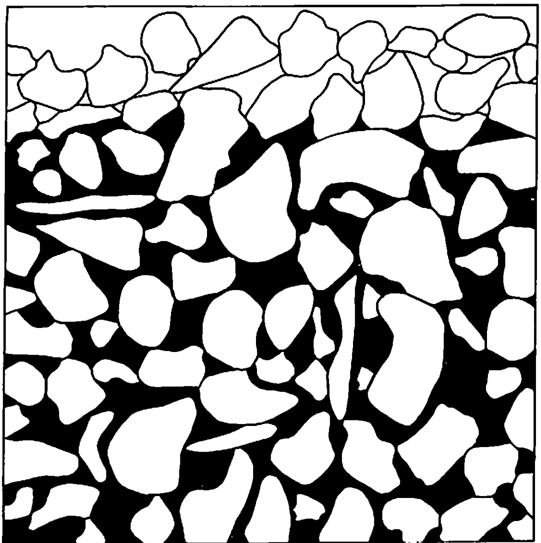
GROUNDWATER

Part of the precipitation on the land surface returns to the atmosphere or reaches streams as overland runoff. The remainder infiltrates the soil and moves through fractures and other voids in the underlying rock. Its downward movement continues until it reaches the water table, below which all interconnected voids are filled with water. After reaching the saturated zone, the water moves downward and laterally toward lower altitudes and eventually returns to land surface, either from springs or from wells. In areas underlain by carbonate rocks, overland runoff may be small. In the Spring Creek basin, groundwater runoff accounts for 86 percent of total runoff (Giddings, 1974, p. 68).

Water occurs under both water-table and artesian conditions. Water-table conditions are those in which water is unconfined, and the upper surface of the water, or water table, is free to rise or fall. Artesian conditions exist where the 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 surface to which water will rise in wells tapping an artesian aquifer is called the artesian or confined potentiometric surface.

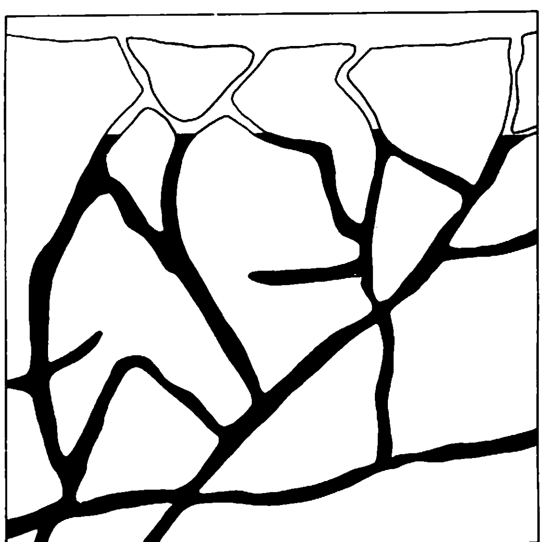
Groundwater occurs in and moves through interconnected openings (Figure 3) of either primary or secondary origin. Primary openings are the spaces between individual grains (chiefly in unconsolidated material). Secondary openings are those formed after the consolidation and cementation of the sediments and generally result from fracture or dissolution of the rock by external forces.

Solution plays a particularly important role in developing secondary openings in carbonate rocks (limestone and dolomite). Many caves and sinkholes are formed as a result of solution along fractures and bedding planes in the carbonate rocks. Within the zone of water-table fluctuation, however, cavernous limestone that has a high porosity seems to be the exception, as Giddings (1974, p. 71) found that the specific yield (see glossary) of the carbonate rocks of the Spring Creek basin was only 1.5 percent. This specific yield is essentially the same as that determined by Konikow (1969, p. 82) in two basins underlain by sandstone and shale.



Sand ⊢0.01'⊣

Primary openings in unconsolidated material



Creviced rock ⊢ 10' ⊣

Secondary openings in consolidated rock

Figure 3. Sketches showing how water occurs in rocks.

Water Levels

The water table fluctuates according to the relative recharge (additions to the aquifer) and discharge (losses through springs and wells). Because evaporation and transpiration are large during the growing season (April to October), little recharge reaches the saturated zone during that period, and water levels decline. Water levels generally rise during the rest of the year. The hydrograph of well Ce–226 in the Reedsville Formation is shown in Figure 4. The seasonal pattern of this hydrograph is probably typical of most wells in Centre County.

Water levels in areas underlain by the Gatesburg Formation do not seem to follow this general pattern. The hydrograph of well Ce–118 in the Gatesburg Formation is also shown in Figure 4. Water levels respond to long periods of below or above normal precipitation. Also, water levels sometimes rise through the summer and decline in the fall and winter. The depth to the water table is usually great in the Gatesburg Formation—the average depth to water is 168 feet, and water levels in the Scotia mine area 4 miles west of State College are more than 300 feet below land surface. Passage through such thicknesses of unsaturated material may substantially delay the arrival of recharge to the aquifer. This is substantiated by Giddings (1974, p. 22), who stated that:

> A range in the response time of water-table levels to rainfall was observed on hydrographs of . . . recorder wells. Where surface-water runoff had direct connection with ground water, an immediate response to rainfall was observed in the water-table hydrographs . . . . Where the water table was relatively deep (50 to 300 ft), a slow response to rainfall was observed . . . .

The water table fluctuates as much as 40 feet adjacent to sinkholes where the groundwater reservoir is recharged by large volumes of surface water entering the sinkholes (Giddings, 1974, p. 70). Because pumping draws water levels below the lowest levels encountered under static conditions, fluctuations are even greater in and near pumped wells. For example, the level in well Ce–102 rose 56 feet between June 1965 and January 1967 (Lane, 1969, p. 35).

The water table is a subdued replica of the land surface. Except in some areas underlain by carbonate rocks, water levels in the county are at or near the land surface in the valleys. Although the water table may be more than 100 feet below the crest of the highest ridges, it is within 50 feet of the land surface on most slopes and hillsides underlain by shale and sandstone. Because the carbonate rocks are extremely permeable, the water-table slope is low in most of the valleys underlain by carbonate rocks.

The low gradients are apparent in Figure 5, a map of the water table in Spring Creek basin. Because water flows from areas of high head to areas of low head, approximate directions of groundwater flow can be determined from the map. Note the considerable difference between the position of the

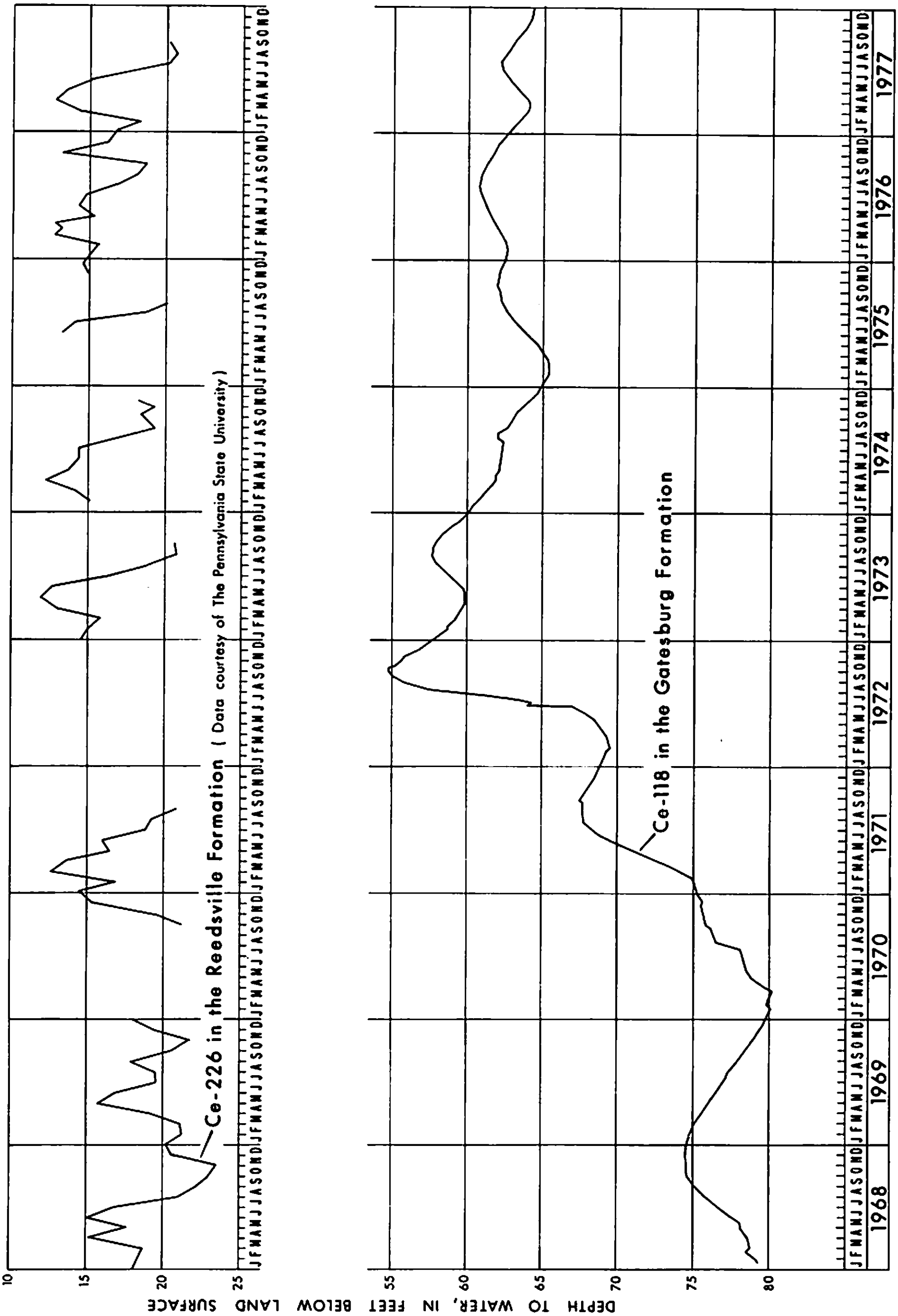


Figure 4. Hydrographs of observation wells.

groundwater and surface-water divides, especially west of State College. The groundwater basin has an area of 175 square miles, even though the surface-water basin has a drainage area of only 147 square miles.

Well Yields

The ability of a well to yield water is generally estimated by the driller at the time the well is completed by measuring the amount of water that must be removed from the well in a given time in order to lower and hold the water level near the bottom of the well. The value obtained is in this report called the reported yield of the well and is progressively less accurate as the yield increases because of the increasing difficulty of lowering the water level to the bottom of the well.

Another measure of a well's productivity is made by pumping the well at a constant rate and measuring the amount that the water level has been lowered after a given time. The value obtained by dividing the pumping rate by the drawdown is the specific capacity and is a more accurate appraisal of the productivity than the reported yield. The specific capacity may be multiplied by any drawdown that might result from pumping to obtain an estimate of well yield.

Springs

In the areas underlain by limestone and dolomite, drainage density—the length of the stream channels divided by the unit area—is very low. Most valleys are dry or occupied by intermittent or disappearing streams. Large sinkholes have developed where the limestone crops out along the base of the mountains. These sinkholes convey runoff from the mountains directly to the underground drainage system. Much of this subsurface flow is discharged through large springs to a small number of perennial streams (Lane, 1969, p. 30-31).

The springs issuing from the limestone and dolomite have been classified into two types by Shuster and White (1971). In the diffuse type, water flows at low velocities along joints, fractures, partings, bedding planes, and other openings less than an inch wide. In the conduit type, flow, often turbulent, is through solution openings that range from an inch to 10 feet in diameter; the conduit system approximates flow through irregular pipes. Recharge to conduit systems is commonly through sinkholes. Generally, total hardness is greatest for diffuse springs. Also, total hardness and temperature vary less with time for this type of spring.

Tables 6 and 7 give physical and chemical data for springs. Of the carbonate springs listed in Table 6, Shuster and White (1971) have identified Thompson (Ce-Sp-1), Big (Ce-Sp-5), Weaver (Ce-Sp-23), and Coburn (Ce-Sp-24) Springs as having diffuse-flow systems and Penns Cave

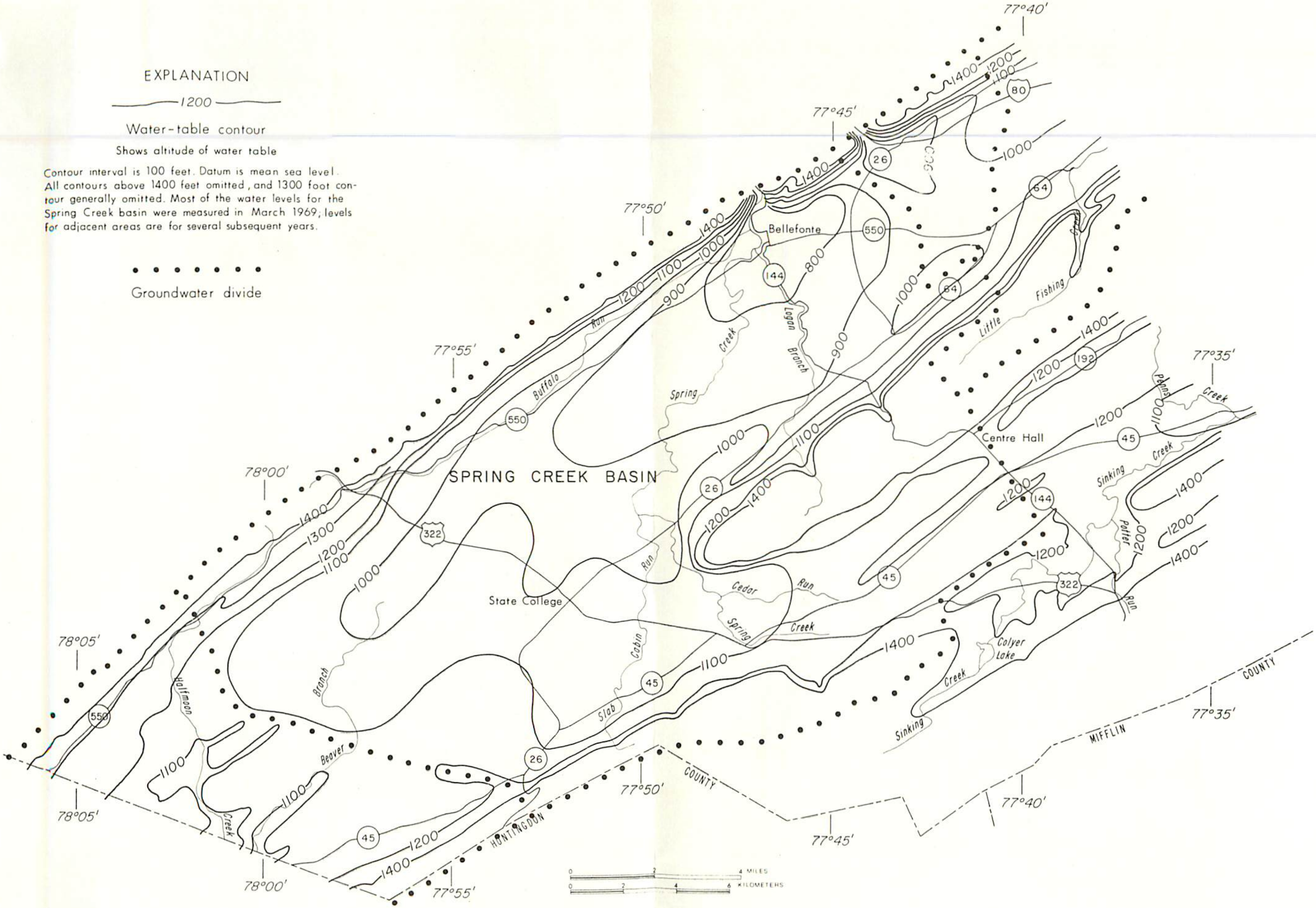


Figure 5. Water-table map of the Spring Creek basin. Compiled by C. R. Wood after Giddings (1974), Hunter (1977), Eby (1975), and Meiser (1974). Base map adapted from U. S. Geological Survey 1:50,000 county map, 1977.

(Ce–Sp–3), Rock (Ce–Sp–14), Spring Bank (Ce–Sp–25), and Elk Creek (Ce–Sp–26) Springs as having conduit-flow systems.

Jacobson (1973, p. 65) noted that, "springs generally increase markedly in discharge within several hours of an important rainfall." The increase is greatest for springs of the conduit type. He (1973, p. 22) observed that Rock Spring, which exhibits conduit flow, discharges 50 percent of the water recharged during a major storm within six days. For Thompson Spring, which exhibits diffuse flow, the same percentage of discharge required 60 days.

Of the springs listed in Table 6 that discharge from limestone and dolomite, at least 10 have average discharges in excess of 1,000 gpm (gallons per minute), and some conduit springs have high flows in excess of 30,000 gpm. Many springs issue from sandstone and shale, but their discharges usually are less than 100 gpm.

Groundwater Quality

As precipitation enters the ground, it dissolves parts of the soil and rock, and, thus, picks up various mineral constituents. Groundwater generally contains more dissolved mineral matter than surface water, and may contain so much that it is not fit to drink. Water containing more than 500 mg/l (milligrams per liter) dissolved solids is not desirable for domestic supplies, though more highly mineralized water is used where better water is not available. The soil and rocks through which water has percolated tend to filter solid suspended materials and bacteria so that groundwater is generally clear and has fewer bacteria than surface water. The solution openings in carbonate rocks, however, are too large to filter the water, and contamination in these rocks may travel miles with little change. Siddiqui (1969, p. 119) noted that wells near sinkholes or surface streams are generally polluted.

Twelve springs in Centre County were sampled for fecal coliform bacteria in November 1971. Of these, only one, Big Spring (Ce–Sp–5), was free of fecal coliform. Four springs had from 170 to 500 fecal coliform bacteria per 100 ml (milliliters), and the remaining seven springs had from 1 to 33 (Flippo, 1974, p. 35-36).

Analyses of 13 samples of water from seven wells and of 19 samples from 14 springs are listed in Table 7. All except three are from carbonate rocks. Most of the water is of acceptable chemical quality. However, the maximum concentration of iron in drinking water, set by the U. S. Environmental Protection Agency (1975) at 300 μg/l (micrograms per liter), is exceeded in two samples and the maximum concentration of 50 μg/l of manganese is exceeded in four samples. Langmuir (1969) observed that in late 1967, 10 percent of the domestic wells in the carbonate rocks of the Nittany Valley contained more than 10 mg/l of nitrate (as nitrogen). Nitrate concentrations greater than 10 mg/l may cause methemoglobinemia, or "blue baby" disease, if such water is used for infant feeding. The ranges some of the other parameters measured by Langmuir were pH, 7.1 calcium, 17 to 97 mg/l; magnesium, 11 to 61 mg/l; sodium, 0.3 to 13 mg/l; and temperature, 9.1 to 14.4°C.

Water from the carbonate rocks generally ranges from hard to very hard, whereas water from shale and sandstone is relatively soft. Concentrations of most constituents are lower in water from springs than from wells. This relationship is even more pronounced when concentrations for conduit springs are compared to those for wells. Additional data on the chemistry of water from wells and springs in carbonate rocks have been given by Langmuir (1971), Shuster and White (1971, 1972), and Jacobson and Langmuir (1973).

Many of the wells in the northwest third of the county tap the Allegheny and Pottsville Groups. Water from these units is commonly high in iron, and where coals have been mined, the water is almost always high in iron. Manganese may also be present in objectionable amounts. Very high sulfate concentration is common in water from rocks of Silurian age.

HOW AND WHERE GROUNDWATER IS FOUND

Groundwater in Centre County is under both artesian and water-table conditions. Reported well yields range from less than 1 to 8,000 gpm. Data on 234 wells drilled or dug in geologic formations that underlie the county are listed in Table 5. Data on 30 springs are listed in Table 6. Plate 1 shows the locations of the wells, springs, and geologic units.

THE ROCKS AND THEIR WATER-BEARING CHARACTERISTICS

A summary of the water-bearing characteristics of the geologic formations in Centre County is given in Table 3. A more detailed description of the lithology and water-bearing characteristics of each formation is given in this section. The descriptions are arranged from youngest units to oldest units.

Alluvium

Alluvium (Quaternary age) fills some of the valleys to depths of as much as 100 feet. It consists of clay, sand, and gravel that has been weathered from the local formations. The alluvium yields from 1 to 10 gpm of water to dug wells.

Conemaugh Group

The Conemaugh Group (Late Pennsylvanian age) is the youngest consolidated rock in the county and crops out on the tops of a few of the

Table 3. *Composite Stratigraphic Section for Centre County*

System	Geologic unit [1]	Thickness (feet)	Character of strata	Water-bearing characteristics
Quaternary	Alluvium	0–100	Soil, clay, sand, and gravel; deposited by streams.	Yields about 1 to 10 gpm to dug wells.
Pennsylvanian	Conemaugh Group	<100	Sandstone, shale, limestone, thin coal beds, and red beds.	Probably lies entirely above the water table and does not yield water to wells.
	Allegheny Group	270–315	Sandstone (in thin channels in places), shale, limestone, and several commercial-grade coal beds.	Average well yield is about 20 gpm. Usually yields water high in iron.
	Pottsville Group	40–140	Sandstone, shale, and several thin coal beds.	Based on limited data this is probably a fair aquifer. Well yields may average about 100 gpm. Commonly yields water high in iron.
Mississippian	Mauch Chunk Formation	0–90	Red and green shale.	Yields small supplies of water adequate for domestic use (3 to 10 gpm). Water is generally of good quality.
	Burgoon Sandstone	1,650	Thick-bedded, coarse-grained, micaceous, slightly arkosic sandstone at top; red and green shale, and thin beds of sandstone below.	Average well yield is about 70 gpm. Some wells located in valleys yield several hundred gallons per minute. Water is soft.
Mississippian and Devonian	Rockwell Formation/ Huntley Mountain Formation of Berg and Edmunds (1979)	600	Gray and greenish-gray, fine- to coarse-grained sandstone, siltstone, and shale containing grayish-red interbeds.	Probably similar to Catskill Formation.
Devonian	Catskill Formation	600–1,000	Shale and mudstone, mostly red; thick-bedded sandstone, mostly red or brown.	Average well yield is about 50 gpm. Water is generally of good quality.
	Lock Haven Formation	2,700	Mostly green or chocolate-brown and green sandstone; a few beds of conglomerate, chocolate-brown in upper part.	Generally yields adequate amounts for domestic use. Average well yield is about 25 gpm. Water is generally of good quality.

Table 3. *(Continued)*

System	Geologic unit [1]	Thickness (feet)	Character of strata	Water-bearing characteristics
Devonian	Brallier Formation	1,500	Green shale and thin, evenly bedded, fine-grained, green or gray sandstone.	Generally yields adequate amounts for domestic use (3 to 10 gpm).
	Harrell Formation	300	Soft gray fissile shale; about 60 feet of black fissile shale at base (Burket Member).	Poor aquifer. Some wells fail to yield adequate domestic supplies.
	Hamilton Gp.: Mahantango Formation	610	Olive-green shale; thin fine-grained sandstone; 0 to 50 feet of gray limestone and shale at top (Tully Member).	Average well yield is about 80 gpm. Some wells yield water having high concentrations of hydrogen sulfide.
	Hamilton Gp.: Marcellus Formation	100	Black fissile shale.	Water-bearing properties are unknown.
	Onondaga Formation	0–50	Greenish-blue shale and dark-blue to black, medium-bedded limestone.	Probably a fair aquifer but too thin to be important.
	Old Port Formation	225–280		Well yields range from 5 gpm to more than 500 gpm. Average yield is about 200 gpm. About half of the wells drilled in the Ridgeley and Shriver Members collapse if not supported by screens or slotted casings. Water from the Corriganville and New Creek Members is very hard and occasionally the sulfate concentration may be too high for most uses.
	Ridgeley Member		Coarse-grained, calcareous, brown to white, fossiliferous sandstone.	
	Shriver Member		Thin-bedded siliceous limestone, shale, calcareous sandstone, and chert.	
	Corriganville Member		Medium-gray limestone and light-gray chert.	
	New Creek Member		Coarsely crystalline, medium-dark-gray, massive-bedded limestone.	
Devonian and Silurian	Keyser Formation	150	Dark-gray, thick-bedded, crystalline to nodular limestone, thin-bedded and shaly near the top.	Well yields are similar to those given above for the Old Port Formation. Sulfate concentrations in water from wells deeper than 200 feet are occasionally too high for most uses.
Silurian	Tonoloway Formation	400	Dark thin-bedded limestone.	Probably similar to the Keyser Forn tion above.

	Wills Creek Formation	400	Olive-gray and yellow, calcareous shale.	Average well yield more than 200 gpm; more than half of the wells deeper than 200 feet yield water having sulfate concentrations in excess of 500 mg/l. A few wells yield water containing objectionable amounts of hydrogen sulfide.
	Bloomsburg Formation	40–400	Red and gray shale.	Wells generally yield adequate amounts of water for domestic use (3 to 10 gpm). The deeper wells will probably yield water of poor quality.
	Mifflintown Formation	400	Olive-gray and yellowish-brown shale, interbedded with medium-gray to dark-gray limestone. Interbedded sandstone and limestone at base.	Yields small to moderate supplies to drilled wells. Water from deep wells may be too hard for most uses.
	Rose Hill Formation	800	Olive-gray shales weathering pale yellowish brown. Interbedded thin sandstones and limestones.	Generally yields small supplies of soft water, adequate for domestic use (3 to 10 gpm). Wells located on the high ridges near the gaps may yield less than 1 gpm.
	Tuscarora Formation	550	Hard, thick-bedded, white or gray quartzitic sandstone.	Generally yields small supplies of soft water, adequate for domestic use. Wells located on the high ridges near the gaps may yield less than 1 gpm.
Ordovician	Juniata Formation	500–1,000	Dominantly red, fine-grained sandstone, siltstone, and shale.	Average well yield is about 25 gpm. Water is soft.
	Bald Eagle Formation	700–800	Brown to gray, fine- to coarse-grained sandstone.	Average well yield is about 20 gpm. Water is soft.
	Reedsville Formation	900–1,400	Dark-gray to brownish-gray shale; somewhat calcareous near the base; sandy near the top.	Average well yield is about 30 gpm and yields range from 10 to 180 gpm. Water is generally of good quality and soft to moderately hard.

Table 3. *(Continued)*

System	Group	Geologic unit [1]	Thickness (feet)	Character of strata	Water-bearing characteristics
Ordovician	Trenton Group	Coburn Formation	300	Thin-bedded limestone containing shale interbeds.	Average well yield of the Trenton Group is about 10 gpm.
	Trenton Group	Salona Formation	180–300	Thin-bedded limestone containing shale partings.	
	Trenton Group	Nealmont Formation	70	Thin- to thick-bedded, impure limestone.	
		Benner Formation	150	Dark-gray, laminated, thick- to thin-bedded limestone.	Generally yields adequate water for domestic use. Many springs issue from this formation.
		Snyder Formation	80	Medium-bedded limestone and dolomite.	Generally yields adequate water for domestic use (3 to 10 gpm).
		Hatter Formation	75	Medium-bedded limestone and laminated, argillaceous and arenaceous dolomite.	Generally yields adequate water for domestic use (3 to 10 gpm).
		Loysburg Formation	50–450	Laminated, medium- to thin-bedded limestone and dolomite.	Generally yields adequate water for domestic use (3 to 10 gpm).
	Beekmantown Group	Bellefonte Formation	1,400	Light-gray thick-bedded dolomite; some chert; sandstone bed in upper part.	Although the average yield is only about 20 gpm, about one well in four yields more than 300 gpm. Some of the high-capacity wells pump sand. Some large springs issue from this formation. Water is generally of good quality.
	Beekmantown Group	Axemann Formation	400–700	Blue thin-bedded limestone; some dolomite layers.	Very few data available for wells. At least two large springs issue from this formation, solution channels are common, and sinkholes are common near the base. May yield moderate to large supplies to some wells. Water is generally of good quality, but hard.

Ordovician	Beekmantown Group	Nittany Formation	1,200	Blue, thick-bedded, coarsely crystalline dolomite.	Average well yield is about 500 gpm. Probably a little less than half of the high-capacity wells in this formation pump sand or collapse. Generally yields very hard water.
		Stonehenge Formation	250–600	Blue thin-bedded limestone; some dolomite.	Most wells yield adequate water for domestic use (3 to 10 gpm).
Cambrian		Gatesburg Formation	1,800		
		Mines Member		Dark-gray coarse-grained dolomite and subordinate light-gray fine-grained dolomite. Abundant oolitic chert.	Yield data are available for only one well (310 gpm). Based on the data for this well and the lithology of this formation, the Mines is probably an excellent aquifer.
		Upper sandy member		Dolomite and interbedded orthoquartzite and sandy dolomite.	Wells in the upper sandy member have an average yield of 415 gpm. However, more than half of the high-yielding wells in this unit pump sand or collapse. Not suited to the development of domestic supplies because of the large amounts of casing required and high cost of construction and development. Water is generally of good quality but hard. Very few data are available for the lower members of the Gatesburg Formation.
		Ore Hill Member		Dark-gray dolomite.	
		Lower sandy member		Dolomite and interbedded orthoquartzite and sandy dolomite.	
		Warrior Formation	1,300	Blue impure limestone and dolomite; thin sandy partings.	Yield data are available for only one well (12 gpm). Based on the data for this well and the lithology of this formation, the Warrior is probably a poor aquifer.

[1] The stratigraphic nomenclature is that of the Pennsylvania Geological Survey and does not necessarily conform to usage of the U. S. Geological Survey.

highest hills in the southwest. It conformably overlies the Upper Freeport coal at the top of the Allegheny Group and consists of sandstone, shale, thin beds of limestone and coal, and a few beds of red shale; the thickness is less than 100 feet. The group probably lies entirely above the water table and does not yield water to wells.

Allegheny Group

The Allegheny Group (Middle Pennsylvanian age) underlies the Conemaugh Group. It consists of sandstone, shale, coal, and limestone and ranges in thickness from 270 to 315 feet.

The average yield of wells is 20 gpm. The water is generally very high in iron.

Pottsville Group

The Pottsville Group (Middle and Early Pennsylvanian age) underlies the Allegheny Group. It consists of sandstone, conglomerate, shale, coal, and limestone and ranges in thickness from 40 to 140 feet. It is probably a fairly good aquifer; well yields may average 100 gpm, but data are scanty. Water from the Pottsville Group is generally very high in iron.

Mauch Chunk Formation

The Mauch Chunk Formation (Late Mississippian age) underlies the Pottsville Group unconformably. The Mauch Chunk consists of micaceous, yellowish and greenish sandstone and sandy shale, and red shale. It ranges in thickness from 0 to 90 feet and is generally too thin to be important as an aquifer. In adjacent counties, it yields small supplies of water adequate for domestic use (3 to 10 gpm).

Burgoon Sandstone

The Burgoon Sandstone (Early Mississippian age) underlies the Mauch Chunk Formation unconformably or the Pottsville Group where the Mauch Chunk is absent. The Burgoon consists of thick-bedded, coarse-grained, micaceous, slightly arkosic, locally conglomeratic sandstone at the top, and gray, green, and red shale and thin beds of sandstone and conglomerate below. It is about 1,050 feet thick and caps several high ridges.

Except for some limestone and dolomite, the Burgoon Sandstone is one of the best aquifers. Reported yields of four nondomestic wells averaged 62 gpm. Data from other counties suggest that some wells in valleys will yield several hundred gallons per minute, whereas wells on high ridges will usually yield only a few. Water levels in wells on ridges and hilltops are often 200 to 300 feet below land surface. Water from the Burgoon is soft and is generally of good quality.

Rockwell Formation and Huntley Mountain Formation

The Rockwell Formation and its lateral equivalent, the Huntley Mountain Formation of Berg and Edmunds (1979) (Early Mississippian and Late Devonian ages), underlie the Burgoon Sandstone. They consist of gray, fine- to coarse-grained sandstone, siltstone, and shale that has grayish-red interbeds and, locally, interbeds of pebbly mudstone. The Rockwell and Huntley Mountain Formations are about 600 feet thick.

Very few data are available from wells in Centre County, but data from nearby counties suggest that the average well yield for these formations is 50 gpm. Water is generally of good quality.

Catskill Formation

The Catskill Formation (Late Devonian age) underlies the Rockwell Formation in the southern part of the county and the Huntley Mountain Formation in the northern part. It consists of red, brown, and greenish-gray siltstone and shale, and red and gray to light-gray sandstone. The sandstones are generally fine grained and thin bedded. The Catskill varies in thickness from 1,200 to 1,600 feet.

Very few data are available from wells in Centre County. Data from nearby counties suggest that the average well yield is 50 gpm. Water is generally of good quality.

Lock Haven Formation

The Lock Haven Formation (Late Devonian age) grades upward into the Catskill Formation. It consists chiefly of gray, green, chocolate-brown, and purple shale and shaly sandstone, and a few thin beds of quartz sandstone and conglomerate. The upper part of the formation consists of greenish shales that are underlain by about 1,000 feet of rock that has many bands of purple or chocolate-brown shale and thin-bedded sandstone. Fossils are relatively abundant. The Lock Haven is about 2,700 feet thick. That part of the section designated Lock Haven in this report was called Chemung Formation by Butts and Moore (1936, p. 68).

Data are available from only two wells in Centre County. However, based on data from other areas of Pennsylvania, the average well yield is 25 gpm, and most wells yield adequate domestic supplies. Water from the Lock Haven is generally of good quality.

Brallier and Harrell Formations

The Brallier Formation (Late Devonian age) underlies the Lock Haven Formation. It was described by Butts and Moore (1936, p. 67) as a firm green shale, finely and strongly micaceous, of which the main constituent is quartz in extremely small grains. In fresh exposures it appears to be a thick-bedded fine-grained sandstone, but on weathering the thick, apparently solid layers break down into thin laminae. The Brallier is about 1,500 feet thick.

Very few data are available on the water-bearing properties of the Brallier. However, it generally yields adequate supplies for domestic use (3 to 10 gpm) and may yield more. The water is generally of good quality, but moderately hard.

The Harrell Formation (Late Devonian age) underlies the Brallier and consists of soft, pale-gray to olive-green, fissile shale except for about 60 feet of black fissile shale at the base (Burket Member). The Harrell is a poor aquifer and some wells fail to yield sufficient water for domestic use. It generally yields moderately hard water of good quality.

Hamilton Group

The Hamilton Group (Middle Devonian age) is divided into two formations in Centre County. These are the Marcellus Formation and the overlying Mahantango Formation. The Mahantango underlies the Harrell. It consists chiefly of olive-green and bluish-gray shale, a few beds of brown to yellow shale, some thin beds of fine-grained sandstone, and about 50 feet of interbedded gray limestone and shale and shaly limestone at the top of the formation (Tully Member). The Tully is about 50 feet thick in the eastern part of the county and thins westward so that it is no more than a foot thick in the central part. The Mahantango Formation is about 600 feet thick.

Very few data are available. Reported yields of six nondomestic wells in the Mahantango Formation in Lycoming County ranged from 30 to 355 gpm. Half these wells yielded 83 gpm or more (O. B. Lloyd, Jr., 1977, written communication). Almost all of the water in these wells was obtained within 200 feet of the land surface. The shaly nature of the limestone suggests that well yields from the Tully are low. However, this member is too thin to be important. Water from the Mahantango is soft to moderately hard. It is generally of good quality, although some wells yield water having high concentrations of hydrogen sulfide. (Well Ce–87 was abandoned because of high concentrations of iron and hydrogen sulfide.)

The Marcellus Formation consists of black, fissile, carbonaceous shale and is about 100 feet thick. Its water-bearing properties are unknown, but it will probably yield a few gallons per minute to wells, although the formation is too thin to be important.

Onondaga and Old Port Formations

The Onondaga Formation (Middle Devonian age) underlies the Marcellus and consists of greenish-blue shale and dark-blue to black, medium-bedded limestone, 0 to 50 feet thick. It is probably a fair aquifer (well Ce-178 yields 50 gpm), but is too thin to be important.

The Old Port Formation (Early Devonian age) underlies the Onondaga and has been divided into four members—the Shriver and the overlying Ridgeley (Oriskany of earlier authors) and the Corriganville and New Creek Members (Helderberg of earlier authors). The Ridgeley and Shriver were described by Lohman (1938, p. 97) as follows:

> The Shriver chert varies greatly in character, ranging from a thin-bedded, highly siliceous limestone or calcareous sandstone to a gray or black shale, in part calcareous. Generally there is more or less chert, locally in beds as much as 6 inches thick. The thickness of the Shriver in most of the area ranges from 40 to 50 feet to 300 feet . . . .
>
> The overlying Ridgeley sandstone ranges in character from an impure calcareous soft brown sandstone to a pure-white fine- to coarse-grained quartzose sandstone. In most places it is highly calcareous in the unweathered condition, and upon removal of the calcareous cement by weathering it crumbles to loose sand. Locally it is conglomeratic. In general the Ridgeley is highly fossiliferous, although in many places the fossils have been leached out, leaving fossil molds or casts. This feature readily distinguishes the Ridgeley from practically all other sandstones in the area. Although relatively thin, its outcrops generally form sandy ridges rising above the shale and limestone valleys.

The combined thickness of the Ridgeley and Shriver Members ranges from about 75 to 130 feet.

The Corriganville Member consists of dark-gray, calcareous, thin-bedded shale at the top; dark-gray, cherty, thin-bedded, fossiliferous limestone; and some local sandstones at the base. The New Creek Member consists of dark-gray, medium- to thick-bedded, crystalline limestone that is sandy and shaly in places and contains some chert nodules (Siddiqui, 1969, p. 73). The Corriganville Member is about 130 feet thick and the New Creek Member is about 20 feet thick.

Very few data on yields of wells in the Ridgeley and Shriver Members are available from Centre County. Based on data from other nearby counties, wells in these members generally yield several hundred gallons per minute. However, about half of the drilled wells collapse if not screened or properly cased. Most water from these members is of good quality, soft and low in dissolved solids.

Reported yields of seven nondomestic wells in the Corriganville and New Creek, and in most cases the underlying Keyser Formation as well, range from 5 to 550 gpm. Three of these seven wells yield more than 200 gpm and four yield 43 gpm or less. Yielding zones have been penetrated at depths of at least 350 feet below land surface.

Keyser, Tonoloway, Wills Creek, Bloomsburg, and Mifflintown Formations

The Keyser Formation (Early Devonian and Late Silurian age) underlies the Old Port Formation and consists of dark-gray, thick-bedded, crystalline to nodular limestone that contains some chert and is argillaceous near the top. It is about 150 feet thick.

The Tonoloway Formation (Late Silurian age) underlies the Keyser and consists of dark-bluish-gray to black, fine-grained, thin-bedded limestone that may locally contain calcareous shale. It is about 400 feet thick (Butts and Moore, 1936, p. 57). The water-bearing properties of the Keyser and Tonoloway Formations are probably similar to those of the Corriganville and New Creek Members of the Old Port Formation. Water from these formations is very hard, and the concentration of calcium sulfate in water from wells more than 200 feet deep may be too high for most uses.

The Wills Creek Formation (Late Silurian age) underlies the Tonoloway and consists of bluish-gray, calcareous, fissile shale that weathers to a yellow-green color and of thin beds of coarsely crystalline limestone. It is about 400 feet thick.

Although data on the yield of wells in the Wills Creek in Centre County are sparse, Lloyd (1977, written communication) reports yields of 11 non-domestic wells in Lycoming and Union Counties range from 66 to 380 gpm. Half yield 275 gpm or more.

The water is commonly very high in calcium sulfate hardness. More than half the wells deeper than 200 feet yield water having sulfate concentrations in excess of 500 mg/l. Some wells yield water containing objectionable amounts of hydrogen sulfide.

The Bloomsburg Formation (Late Silurian age) underlies the Wills Creek Formation. It consists of red and greenish-gray claystone, siltstone, and clayey, very fine to coarse-grained sandstone. The Bloomsburg ranges in thickness from about 40 feet in the southwest to about 400 feet in the northeast.

Very few data are available in the county, but data from adjacent counties suggest wells will generally yield adequate amounts of water for domestic use. Average well yield is probably 10 gpm. Many wells deeper than 200 feet yield water very high in calcium sulfate.

The Mifflintown Formation (Middle Silurian age) underlies the Bloomsburg. The upper part of the formation consists of light-olive-gray and yellowish-brown shale and siltstone interbedded with medium- to dark-gray, fine- to medium-grained, crystalline limestone. The basal 50 feet consists of light-gray, limonite-speckled, fossiliferous, thin- to thick-bedded, quartzitic sandstone; light-bluish-gray or grayish-red, thin-bedded, coarsely crystalline, fossiliferous limestone; and oolitic hematite (Flueckinger, 1969). It is about 400 feet thick.

Very limited data suggest that the Mifflintown Formation generally yields adequate quantities of water for domestic use (3 to 10 gpm). Some wells deeper than 200 feet may yield water very high in calcium sulfate.

Rose Hill Formation

The Rose Hill Formation (Middle Silurian age) underlies the Mifflintown Formation. The Rose Hill (Clinton Formation of earlier authors) consists of olive-gray fossiliferous shale that weathers pale yellowish brown. Pale-red shales are present near the base. These lithologies are interbedded with light-gray, fine-grained, well-indurated quartzitic sandstone and a few thin beds of medium-dark-gray, coarsely crystalline, highly fossiliferous limestone. Most of the limestone beds are in the upper part of the formation. The formation is about 800 feet thick (Flueckinger, 1969).

The Rose Hill forms the steep slopes of most of the high ridges in the Valley and Ridge physiographic province. As a result of its high topographic positions this formation is rarely tapped by wells. The formation generally yields small supplies of soft water adequate for domestic use (3 to 10 gpm), but wells on the slopes of the high ridges near the gaps may yield less than a gallon per minute.

Tuscarora Formation

The Tuscarora Formation (Early Silurian age) underlies the Rose Hill and consists of white to gray, fine-grained to conglomeratic, generally thick-bedded, quartzose sandstone. It is commonly crossbedded, ripple marked, and weathered into angular blocks. Locally the formation may have up to 75 feet of olive-gray and red sandstone at the top. It is about 550 feet thick.

The Tuscarora Formation forms the crest of most of the high ridges in the Valley and Ridge physiographic province, and is rarely tapped by wells. It generally yields small supplies of soft water sufficient for domestic use (3 to 10 gpm), but wells located on the high ridges near the gaps may yield less than a gallon per minute.

Juniata Formation

The Juniata Formation (Late Ordovician age) underlies the Tuscarora and consists of red sandstone and some interbedded red shale. The sandstone is generally fine-grained and crossbedded, and sometimes contains ripple marks. The thickness of the Juniata ranges from 500 to 1,000 feet.

Reported yields of five nondomestic wells range from 16 to 80 gpm. Half of the wells yield 25 gpm or more. Data are available on only one well that was drilled to a depth of more than 250 feet. This well (Ce-128) is 600 feet deep and obtained most of its yield of 50 gpm from a zone 412 feet below the land surface. Water from the Juniata is usually of good quality and soft. Well Ce-12, however, yields water that is hard.

Bald Eagle Formation

The Bald Eagle Formation (Late Ordovician age) underlies and g[illegible] into the Juniata Formation. It has been called the Oswego Sandstone by some authors. It consists of hard, coarse-grained, greenish-gray sandstone that weathers to a light-brown or whitish color. Locally it contains conglomerate that has quartz and shale pebbles and some beds of greenish, gray, or red shale. Crossbedding is common. It is about 700 to 800 feet thick.

Reported yields of nine nondomestic wells range from 0 to 60 gpm and half of these wells yield 20 gpm or more. The average depth to water was only 16 feet, which suggests that the primary cause of its relatively low average yield is not its position on high ridges. Water from the Bald Eagle is generally very low in dissolved solids (see the analysis for Ce–Sp–6).

Reedsville Formation

The Reedsville Formation (Late Ordovician age) underlies the Bald Eagle Formation conformably. The lower part consists of dark-gray calcareous shale that breaks into sliverlike fragments. This part of the formation, which was called the Antes Shale by Kay (1944), is about 400 feet thick. The upper part of the Reedsville is more massive, less brittle, and brownish gray in color. It grades upward into the gray sandstones of the Bald Eagle Formation. The Reedsville ranges in thickness from 900 to 1,400 feet.

Reported yields of 16 nondomestic wells range from 10 to 180 gpm and half of the wells yield 40 gpm or more. Only two of the 16 wells yield more than 60 gpm. Lohman (1938, p. 89) suggests that very little water is obtained deeper than 200 feet. Water from the Reedsville is generally of good quality and soft to moderately hard.

Coburn, Salona, and Nealmont Formations

The Coburn, Salona, and Nealmont Formations make up the Trenton Group (Middle Ordovician age). This group underlies the Reedsville Formation conformably.

The Coburn Formation consists of black, thin-bedded, fossiliferous, argillaceous limestone and calcareous shale that weathers to medium light gray. The underlying Salona Formation is quite similar in appearance and lithology except that it is sparsely fossiliferous and weathers yellowish gray, and the calcareous shale beds are less numerous.

The Nealmont Formation, as used in this report, includes the Rodman Member and the underlying Centre Hall Member. The Rodman consists of medium-dark-gray, thin- and irregularly bedded, argillaceous, fossiliferous limestone. Abundant crinoidal plates and stems stand out clearly on surfaces that weather light gray to light olive gray, although most of the fossiliferous material is bryozoan debris. The Rodman ranges in thickness from about 15 to 30 feet. The Centre Hall Member consists of medium-dark-gray, light-bluish-gray-weathering, thin-bedded, fossiliferous limestone interbedded with thick-bedded, sparsely fossiliferous, coarse-grained limestone. It is about 45 feet thick.

Reported yields of 10 nondomestic wells in the Trenton Group range from 2 to 400 gpm. Half these wells yield more than 10 gpm, but only one yields more than 50 gpm. Because their argillaceous character inhibits solution, almost no high-yielding wells are encountered in the Coburn and Salona Formations. Many caves are developed in the Nealmont Formation (Rauch, 1972, p. 376), which suggests that some wells might have high yields. Water from the Trenton Group is usually of good quality, but very hard.

Benner, Snyder, Hatter, and Loysburg Formations

The name Benner Formation (Middle Ordovician age) is used in this report for the limestones that conformably overlie the Snyder Formation and are separated by a regional unconformity from the overlying Nealmont Formation. A number of different formation and member names have been used previously to describe these limestones. These names have been summarized by Rones (1969, p. 44), who used the name Linden Hall in place of Benner.

The Benner Formation consists of light- to dark-gray, medium- to thick-bedded, fine- to coarse-grained limestone, containing fossiliferous zones and some irregular dolomite streaks. It is about 150 feet thick.

Very few data are available for the Benner Formation. However, as many caves are developed in this formation (Rauch, 1972, p. 377), at least a few wells should penetrate large solution openings and have high yields. Most wells will probably yield enough water for domestic use (3 to 10 gpm). The water is generally of good quality, but hard.

The Snyder Formation (Middle Ordovician age) consists of medium-dark-gray, fine-grained, medium-bedded limestone that weathers to light gray. The upper part of the formation is more thinly bedded than the lower, and the bedding surfaces show ripple marks and mud cracks. It contains interbeds of conglomerate containing limestone pebbles that weather almost white. The Snyder is about 80 feet thick.

Very few data are available for the Snyder Formation, but most wells will probably yield enough water for domestic use (3 to 10 gpm). The water is generally of good quality, but hard.

The Hatter Formation (Middle Ordovician age) underlies the Snyder conformably. It consists of medium- to dark-gray, medium- to thin-bedded limestone. The upper part weathers tannish gray and is dolomitic near the top. The lower beds have a worm-eaten appearance and weather to dark gray. The Hatter is about 75 feet thick.

Very few data are available for the Hatter Formation. However, many caves are developed in the lower part of the formation (Rauch, 1972, p. 377), suggesting that at least a few of the wells will penetrate large solution openings and have high yields. Most wells will yield enough water for domestic use (3 to 10 gpm). Water is generally of good quality, but hard.

The Loysburg Formation (Middle Ordovician age) underlies the Hatter Formation unconformably. The upper part of the Loysburg Formation (Clover Member) consists of dark-gray, thin-bedded, very dense, fossiliferous limestone; it is about 60 feet thick.

The lower part of the Loysburg Formation (Milroy Member) ranges in thickness from 0 to 400 feet. Chafetz (1969, p. 8) notes that:

> The Milroy Member has also been referred to as the Tiger-striped Member of the Loysburg Formation. This name is the result of the occurrence of very thin alternating ribbonlike bands of limestone and dolomite . . . . Weathering yields the "tiger-striped" pattern which prompted the name by Kay (1944). The light brownish-gray dolomite bands stand out in relief against the less resistant very light gray limestone layers.

Very few data are available for wells in the Loysburg Formation. However, some caves are developed in the upper two thirds of the Clover Member of the Loysburg Formation (Rauch, 1972, p. 377), suggesting that at least a few of the wells will penetrate large solution openings and have high yields. Most wells in this formation will yield enough water for domestic use (3 to 10 gpm). Water is generally of good quality, but hard.

Bellefonte, Axemann, Nittany, and Stonehenge Formations

The Bellefonte, Axemann, Nittany, and Stonehenge Formations make up the Beekmantown Group (Early Ordovician age). This group underlies the Loysburg Formation conformably.

The upper 200 feet of the Bellefonte Formation consists of medium-light-gray fine-grained dolomite that weathers to a yellowish or whitish gray and breaks with a conchoidal fracture. Weathered surfaces show characteristic gashes along fractures. A few thin dark-gray shale beds may be present. The lower 1,000 to 1,200 feet consists of medium-dark-gray, thin-bedded, very fine to medium-crystalline dolomite. Two or three beds of sandy dolomite or sandstone may be present within the lower part of the formation (Wagner, 1966, p. 21). The total thickness is about 1,400 feet.

The Bellefonte is the poorest yielding of the dolomite aquifers. Reported yields of 16 nondomestic wells ranged from 2 to 500 gpm. Eight of these 16 wells yield 20 gpm or more. About one well in four yields 300 gpm or more. Some of the high-capacity wells pump sand and may penetrate one of the two or three sandy dolomite or sandstone beds in this formation. Some large springs issue from the Bellefonte. The water is generally of good quality, but hard. Siddiqui (1969, p. 119) reports that two wells produced water having an odor of sulfur (hydrogen sulfide).

The Axemann Formation consists of dark-bluish-gray, thin-bedded microcrystalline limestone that weathers light gray and contains a few beds of dolomite. Its thickness ranges from about 400 feet at Bellefonte to about 700 feet at Lamar, 14 miles northeast (Spelman, 1966, p. 33).

Very few data are available for the Axemann Formation. However, at least two large springs issue from this formation, and sinkholes are common near the base. These solution features suggest that the Axemann may yield moderate to large supplies to some wells. Water from this formation is generally of good quality, but hard.

The Nittany Formation consists of alternating beds of light- to dark-gray dolomite about 1,200 feet thick. The lower part of the formation contains abundant nodular and bedded chert.

The Nittany is one of the two best carbonate aquifers. Reported yields of 23 nondomestic wells ranged from 0 to 2,200 gpm. Only three of these wells yield less than 100 gpm, and one half yield 500 gpm or more. A little less than half the high-capacity wells pump some sand, and a few collapse or fill in with sand.

Water-bearing zones have been penetrated at depths of 400 feet, but the somewhat limited data available suggest that most zones yielding more than a few gallons per minute are within 300 feet of the land surface. Water from the Nittany is generally of good quality, but very hard (average hardness is 205 mg/l).

The Stonehenge Formation consists of relatively pure, blue limestone, mottled, laminated, or banded with dolomite in 6-inch to 6-foot interbeds. The formation is moderately fossiliferous. The basal portion is characterized by thin beds that give a flaggy appearance to the outcrop, and by the common occurrence of edgewise conglomerates and a reddish, thin-bedded, fossiliferous limestone conglomerate (Butts and Moore, 1936, p. 21). Chert nodules are also present near the base of the formation. The thickness of the Stonehenge ranges from 250 to 600 feet.

All of the available data on wells are from wells drilled for domestic and stock use. Reported yields ranged from 1 to 30 gpm and suggest that most wells yield enough water for domestic use.

Gatesburg Formation

The Gatesburg Formation (Late Cambrian age) has been divided into four members in Centre County. From youngest to oldest these are the Mines Member, upper sandy member, Ore Hill Member, and lower sandy member. A fifth, lowermost member (Stacy Member) has been recognized southwest of Centre County and is probably a facies of the lower sandy member that is absent in Centre County. The Gatesburg Formation underlies the Stonehenge Formation conformably.

The Mines Member consists chiefly of dark-gray coarse-grained dolomite, but light-gray fine-grained dolomite is also present. The soil developed on the Mines contains clay and abundant chert, which is oolitic and composed largely of little black spherules embedded in a groundmass of white or light-gray silica. A few thin beds of sandy dolomite and dolomite containing quartzite stringers may be present, but by definition thick quartzitic beds should be absent (Landon, 1963, p. 33). The thickness ranges from 150 to 230 feet in Centre County.

Data are available for only one well (Ce–132), which was test pumped at 490 gpm. Thus, some high-capacity wells can be obtained from the Mines Member.

The upper sandy member of the Gatesburg Formation is composed chiefly of dark, thin-bedded, aphanitic silty dolomite that weathers to a buff color; thin-bedded, finely crystalline and in part shaly dolomite; and medium- to coarse-grained orthoquartzite, commonly conglomeratic at the base. These lithologies were deposited in cycles, which range in thickness from about 3 to 50 feet. Individual beds of orthoquartzite range in thickness from 6 inches to 8 feet and make up 10 to 20 percent of the upper sandy member. The thickness of the upper sandy member is about 650 to 700 feet.

The soil derived from the upper sandy member is composed chiefly of sand and boulders of orthoquartzite. The outcrop area is generally not farmed and is covered by a forest of scrub oak, known locally as barrens. Caruccio (1963, p. 54) notes that the average thickness of overburden penetrated by wells is 87 feet, compared to 47 feet for the Mines Member.

This member is one of the highest yielding aquifers in Centre County. Reported yields of 30 nondomestic wells range from 7 to 8,000 gpm and the median yield is 415 gpm. Almost 90 percent of all nondomestic drilled wells in this unit will yield 100 gpm or more.

Water-bearing zones have been penetrated at depths of 400 feet below land surface. Most of the water probably comes from the orthoquartzite beds, which weather to loose sand that flows into or fills up more than half the wells drilled in this member.

The relatively high permeability of the Gatesburg, combined with its tendency to form a ridge, have resulted in very deep water levels over much of its outcrop area. Levels west of State College are commonly more than 300 feet below land surface. These deep water levels and the flowing-sand problem make the upper sandy member a poor source of domestic supplies. Also, the cost of drilling is usually high. The water from the upper sandy member is generally of good quality, but hard.

The Ore Hill Member consists chiefly of dark-gray, massive, coarsely crystalline dolomite. It is finely crystalline near the top. No sandy beds have been found in this member. The thickness of the Ore Hill ranges from 130 to 310 feet. It is more resistant to weathering than the upper and lower sandy members and commonly forms a moderately steep scarp between them. Several abandoned iron ore pits are present in the overburden. The largest pit is at the site of the Scotia mine (Landon, 1963, p. 24-26).

No data are available on the water-bearing properties of the Ore Hill Member.

The lower sandy member is nearly identical in lithology to the upper sandy member, except that the former has fewer beds of orthoquartzite. Landon (1963, p. 24) notes that "appreciably less quartzitic float and sand, with subsequently greater clay content, characterizes the mantle overlying the Lower sandy member in contrast to the predominantly sandy mantle that overlies the Upper sandy member." The thickness of the lower sandy member ranges from 500 to 700 feet.

Nothing is known about the hydrology of the lower sandy member. However, as it is similar in lithology to the upper sandy member, it may yield large supplies to favorably located wells.

Warrior Formation

The Warrior Formation (Late Cambrian age) is the oldest rock exposed in Centre County. It is composed of blue, thick- to thin-bedded limestone and dolomite and some thin beds of siliceous shale or sandstone, quartzite, oolite, and, in places, edgewise conglomerate. The formation is about 1,300 feet thick, but only the upper 925 feet is exposed (Wilson, 1952, p. 279).

Data are available for only one well. Based on the data from this well and the lithology of the formation, the Warrior Formation will probably yield enough water for domestic and stock use, but rarely enough for public-supply or industrial use. Water should be of good quality, but hard.

FACTORS AFFECTING WELL YIELDS

Well yield is dependent on geologic controls (lithology and structure), depth of overburden, topography, water level, the character of the groundwater flow system, well spacing, and construction (diameter, depth, and method of development). Depth, geology, topography, and well spacing are probably the most important factors, and these are discussed in the following sections.

Depth

As many of the deeper wells penetrate several yielding zones, yields increase with increased well depth. However, many of the high yielding zones are in the first 300 feet, and most are within 400 feet of land surface.

Siddiqui (1969, p. 108) observed that, "the joints, fractures and solution openings in the limestone mines near Bellefonte are almost absent below a depth of about 500 feet." Only four of the wells (Ce-104, Ce-128, Ce-134, and Ce-186) listed in Table 5 obtained any water below 400 feet and none obtained large amounts.

Although no data are available, the lithology of the Gatesburg and Old Port Formations suggests that large amounts of water might be encountered below 400 feet in these formations.

Topography

All wells for which data are given in Table 5 were placed in one of three categories that best describe their topographic position: (1) hilltop, (2) slope or hillside, and (3) creek valley or river valley. A comparison of the specific capacities of wells in each of these positions shows that they are significantly influenced by topography. The greatest median specific capacities were obtained from wells in valleys, and the smallest were obtained from wells on hilltops. Valleys are probably formed in areas of intense fracturing and solution activity; thus permeability and porosity are increased. In hilltop and hillside areas, fewer fractures are generally present. Also, more saturated overburden is present in the valleys.

Siddiqui (1969, p. 97) found that wells on hillsides were about five times as productive as those on hilltops, and that wells in valleys were about eight times as productive as those on hilltops. The Gatesburg Formation tends to be very permeable in all topographic positions, and the contrast in yield and specific capacity between hilltops and valleys is not as great as in most of the other formations.

Lithology

As a whole, the carbonate rocks are the best aquifers in Centre County. However, depending on their lithology, they range from very low yielding (Trenton Group) to very high yielding (Gatesburg and Nittany Formations). Although limestone is, in theory, more soluble than dolomite, the dolomites are generally the best aquifers. This is due largely to the coarseness of impurities in the rocks. Thus, clayey limestones or limestones containing shale or clay-rich beds, such as the Trenton Group, are poorly soluble, develop little secondary porosity, and have low yields. As the percentage of silt and sand increases, development of secondary porosity increases. Thus, the relatively sandy Gatesburg and Nittany Formations are highly soluble, develop substantial secondary porosity, and have high yields. Smith (1966) found the porosity of the Gatesburg Formation to be about 4 percent. The high yields from the Gatesburg are thought by Lane (1969, p. 29-30) to be due in part to recharge through the very sandy soil developed over the formation.

In addition to the above, Rauch (1972, p. 361-371) found that development of secondary porosity was also a function of grain size and the nature of the bedding. In general, the poorest yielding units are the shales and massive sandstones, whereas the units containing interbedded sandstones and shales have moderate yields.

Geologic Structure

The rocks of Centre County have been folded into a series of large, gently plunging anticlines and synclines whose axes trend southwest to northeast. The amplitude of folding is greatest in the southeastern part of the county and diminishes toward the northwest. There are numerous minor folds and also several normal faults and thrust faults.

Structural setting, faulting, jointing, and fracturing all appear to influence well yields. Siddiqui (1969, p. 123-124), who worked in the carbonate rocks of Centre County, has noted that, ". . . wells located in gently dipping bedrock strata are better producers than those in beds with steep dip." He also observed that, "analysis of the well-yield data indicated that wells located in the anticlinal areas are better producers than those located in synclines." However, he also notes that, "wells in the same rock type but different structural settings are not significantly different." This suggests that part of the observed differences were due to different lithologies or formations being present in the different structural settings. Rauch (1972, p. 372), in his study of cave development, observed that, "cave size generally increases as the dip of the strata decreases from 90° to 0°." As well yield is related to solution activity in the carbonate rocks, this supports the conclusion that well yield does decrease with increasing dip.

The relation of faulting to well yield is not well documented. However, well yields may be greater near faults, as Siddiqui (1969, p. 404-405) observed that,

> . . . a zone of increased porosity and permeability follows the Birmingham thrust and wells located in its vicinity generally produce high yields; association of the thrust with the Gatesburg Formation and anticlinal structure in this area may also partly account for high yields of the wells.

To have a good yield, wells in consolidated rocks must intercept fractures or solution cavities in which water occurs, though the locations of such openings are difficult to determine. Fracture traces are natural linear features consisting of topographic (including straight stream segments), vegetational, or soil-tonal alignments that are visible primarily on aerial photographs. They are probably the surface expression of vertical or nearly vertical fractures (individual joints, zones of closely spaced joints, or small-scale faults) in the underlying bedrock.

Maps of fracture traces in the State College area by Lattman and Parizek (1964, p. 77) and Parizek and Drew (1966, p. 9) show that fracture traces are abundant and tend to have, in general, north-south and east-west strikes, giving rise to large, irregular, rectangular blocks. The spacing between adjacent parallel fracture traces varies from about 200 feet to more than one-half mile; the usual distance is 600 feet or less.

Several workers in Centre County have observed that wells drilled on fracture traces have higher yields than those off fracture traces (Lattman and Parizek, 1964; Parizek and Drew, 1966). Siddiqui (1969) analyzed the influence of several controls on the productivity of wells and concluded that, "fracture traces are the most important factor to influence the productivity of wells . . . . Wells located on single fracture trace or on intersection of two yield 10 times to 100 times more water than wells located in zones between fracture traces." Lattman and Parizek (1964, p. 89) also suggested that zones of concentrated fracturing serve as effective conduits for transmitting water to drilled wells, localize springs, fix the location and influence the headward erosion of valleys, facilitate the development of karst features such as sinkholes, solution zones, and dry valleys, facilitate deep weathering and solution, and provide vertical and horizontal zones of increased permeability.

When locating wells on fracture traces, care must be taken to distinguish fracture traces from man-made features such as fence lines, pipelines, and trails. 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 along straight reaches.

Well Spacing

The location and spacing of wells is a major factor affecting 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 dimensions are distorted into an elongate shape that has its longest axis 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 generally arranged 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 connected or if the wells tap the same fracture, the pumping of one of the wells produces nearly as much drawdown in the unpumped well as in the one that is pumped.

In summary, wells on fracture traces tend to yield more water than other wells; wells on different fractures, or as far apart as practicable, interfere with one another to a minimum extent.

DEVELOPMENT OF GROUNDWATER 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 the 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 contaminated because their sides were loosely lined with stone, permitting ready access of water without the benefit of slow filtration; also, burrowing animals sometimes tumbled into dug wells and drowned.

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

As more people settled close to one another, the drilled well next to the owner's home could no longer be counted on to supply adequate amounts of pure water. In some places the close proximity of many families discharging wastes into cesspools exceeded the ground's capacity to filter the water, and some or all of the wells were contaminated.

The latest step in the development of groundwater 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 contamination.

PUBLIC WATER SUPPLIES

Approximately 90 percent of the population of Centre County uses water from a public supply. The water is supplied by 40 water authorities, water companies, boroughs, and associations. Sixteen of the suppliers use wells and/or springs, seven use surface-water sources, and 13 use ground and surface supplies. Four purchase water from one of the other suppliers. These suppliers are listed in Table 4 together with the areas they serve and their sources of supply. More than half of the water used in the county is taken from wells and springs.

Table 4. *Public Water Supplies*

Water authority or company and communities supplied	Source
Aaronsburg Water Pipe Co.: Village of Aaronsburg in Haines Township.	1 spring and 2 wells (Ce-138, Ce-139).
Beech Creek Borough Water Authority: Beech Creek Borough, Clinton County, Beech Creek Township, Clinton County, and Liberty Township, Centre County.	Stream, well, and reservoir in Marion Township, Centre County.
Bellefonte Borough Authority: Bellefonte Borough and Benner Township.	Big Spring (Ce-Sp-5).
Boggs Township Water Authority: Boggs Township.	2 wells (Ce-170, Ce-171).

Table 4. *(Continued)*

Water authority or company and communities supplied	Source
Cedar Hills Water Co., Inc.: Ferguson Township.	2 wells (Ce-179, Ce-180).
Centre Association, Inc.: Ridgemont in Patton Township.	2 wells (Ce-133, Ce-134).
Centre Hall Municipal Water Authority: Centre Hall Borough and Potter Township.	Sharer Run, 7 springs (standby) and 8 wells (Ce-30, Ce-31, Ce-128, Ce-124, Ce-127, Ce-128, Ce-129, Ce-130).
Clarence Water Co.: Village of Clarence in Snow Shoe Township.	2 springs (Ce-Sp-10); purchases some water from Snow Shoe Borough Authority.
Ferguson Township Water Authority: Ferguson Township.	Slab Cabin Run and 3 wells (Ce-214, Ce-215, Ce-216) standby.
Harris Township Authority: Village of Boalsburg and Harris Township.	Galbraith Gap Run and 1 well (Ce-174) standby.
Howard Borough: Howard Borough and Howard Township.	Lick Run and 1 well (Ce-209).
Lemont Water Co.: Village of Lemont and College Township.	2 springs (Ce-Sp-2, Ce-Sp-27) and 1 well (Ce-162).
Madisonburg Water Co.: Village of Madisonburg in Miles Township.	3 springs (Ce-Sp-7).
Milesburg Borough Authority: Milesburg Borough and Boggs Township.	Wallace Run and Fisher Run.
Millheim Borough: Millheim Borough and Penn Township.	Phillips Creek.
Monument Water Association: Liberty Township.	Monument Run.
Moshannon Valley Water Co.: Philipsburg Borough, S. Philipsburg Borough, Rush Township, and part of Clearfield County.	Cold Stream and Blue Spring.
Mountain Top Area Water: Burnside Township and Snow Shoe Township.	Bulk water from Snow Shoe Borough Authority.
Nittany Water Co.: Village of Nittany in Walker Township and part of Clinton County.	Roaring Run, 1 spring and 1 well in Clinton County.
Oak Hall Water Co.: Village of Oak Hall in College Township.	Markle's Gap Run.
Oak Ridge Authority: Taylor Township and part of Blair County.	1 spring.
Orvison Water Association: Curtain Township.	Big Hayes Creek.

Table 4. *(Continued)*

Water authority or company and communities supplied	Source
Patton Township Authority: Patton Township.	Bulk water from State College Borough Authority.
Penn Township Water District: Penn Township.	Stillhouse Run and 1 well (Ce-206).
Pennsylvania State University: Pennsylvania State University.	7 wells (Ce-99, Ce-101, Ce-102, Ce-106, Ce-112, Ce-114, Ce-117) and 1 spring.
Pine Glen Development Co.: Burnside Township.	Miles branch of Sterling Run and 1 spring (Ce-Sp-20).
Pleasant Gap Water Supply Co.: Village of Pleasant Gap and Spring Township.	6 springs and 2 wells (Ce-78, Ce-207).
Port Matilda Borough: Port Matilda Borough and Worth Township.	1 spring (Ce-Sp-13) and 2 wells (Ce-136, Ce-137).
Rebersburg Water Co.: Village of Rebersburg and Miles Township.	1 well (Ce-208) standby and 1 spring.
Rock Spring Water Co.: Ferguson Township.	Schalls Gap Run and 1 well (Ce-213) standby.
Sandy Ridge Water Users Association: Rush Township.	1 spring and 1 well (Ce-191).
Snow Shoe Borough Authority: Snow Shoe Borough and Snow Shoe Township.	Stinktown Run and springs (Ce-Sp-9).
Spring Creek Area Authority: Spring Township and Benner Township.	Bulk water from Bellefonte Township.
Spring Mills Water Co.: Village of Spring Mills and Gregg Township.	1 spring (Ce-Sp-4).
State College Borough Authority: State College Borough, College Township, Ferguson Township, Harris Township, and Patton Township.	Roaring Run and 5 wells (Ce-145, Ce-146, Ce-149, Ce-152, Ce-163).
Tyrone Pike Authority: Village of Glass City in Rush Township.	Bulk water from Moshannon Valley Water Co.
Unionville Water Co.: Unionville Borough.	4 springs (Ce-Sp-8) and 1 well (Ce-177) standby.
Upper Halfmoon Creek Water Co.: Halfmoon Township and Patton Township.	2 wells (Ce-210, Ce-211) and 2 reservoirs.
Walker Township Water Authority: Village of Hubersburg, Village of Mingoville, Village of Snydertown, Village of Zion, Spring Township, and Walker Township.	Little Fishing Creek.

Table 4. *(Continued)*

Water authority or company and communities supplied	Source
Winburne Water Co.: Village of Casanova in Rush Township and part of Clearfield County.	Black Bear Run.
Woodward Water Co.: Village of Woodward and Haines Township.	Spring.

WATER PROBLEMS RESULTING FROM THE ACTIVITIES OF MAN

Inherent in man's use of an area are two potential effects on the area's water. His use of the water may produce overdrafts and the disposal of his wastes may contaminate the water.

In consolidated rocks overdrafts are more likely to occur in the noncarbonate than in the carbonate rocks. In the noncarbonate rocks, the principal artesian zones are discontinuous, limited in areal extent, and poorly interconnected hydraulically. For these reasons pumping effects, though transmitted rapidly in some directions, may not be transmitted in other directions, so that water levels in some wells near the pumped well may not be affected even after years of pumping. Because wells in such an environment are unable to draw water from storage over a large area, heavy pumping of them during periods of little recharge (as during the growing season) results in large drawdowns in the wells and dewatering of the adjacent bedrock. Recharge during the winter and spring months has been adequate so far to restore water levels so that there are at present (1979) no known cases of overdraft in Centre County. However, water levels have been lowered in the vicinity of limestone mines and quarries that pump groundwater to dewater workings.

Carbonate rocks are less susceptible to local overdraft than noncarbonates because dissolution has enlarged many of the fractures into large conduits that both store and transmit large amounts of water. However, this property makes the carbonate rocks more susceptible to pollution than the noncarbonate rocks because the water moves along these conduits rapidly without filtration so that bacteria, which would normally be removed by the slow percolation of the water, are undiminished. Further, many large sinkholes have been used as open dumps, and some receive large quantities of surface runoff.

The greater solubility of the carbonate rocks is reflected in greater dissolved-solids concentration and greater hardness of the water. The chief chemical contaminant is nitrate; it is derived from barnyard wastes, cesspools and septic tanks, and from overfertilizing of fields. In noncarbonate rocks the slow movement of the water would confine much of this contamination to small, local areas; however, in the carbonates, movement is rapid—groundwater flow rates near State College are known to approach 50 feet per hour—and the contamination is apt to be widespread (Lane, 1969, p. 1). Great care should be taken in selecting well sites to avoid known or suspected sources of pollution.

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 by bailing. 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 generally 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 space between the casing and the wall of the well to seal the space tightly and prevent contaminants from entering the well.

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 plug 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.

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 Centre 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 the Survey's office in Harrisburg.

The Division of Water Quality, Bureau of Water Quality Management, Pennsylvania Department of Environmental Resources, Harrisburg, can supply information on well construction requirements, biological reports on well water, and the chemical quality of groundwater. The division, through various regional offices, tests water samples for bacterial pollution. The division 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, Harrisburg, has information on stream discharges, flood data, reservoir requirements, and power plant discharges.

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

The U. S. Geological Survey office in Harrisburg and The Pennsylvania State University at State College have data on wells, springs, and streams, and on the chemical quality of water.

Local well drillers and pump installers usually 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 water indicates treatment is necessary, commercial water-treatment companies can provide the necessary information and equipment. Equipment for water treatment may be purchased or rented, and it will generally be serviced by the supplier if desired.

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GLOSSARY

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

Artesian conditions. The occurrence of groundwater in a confined aquifer under sufficient hydrostatic head so that in a well bore it will rise above the upper surface of the aquifer.

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

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

Cone of depression. A conical depression, on a water table or other potentiometric surface in the subsurface, produced by a pumping well.

Direct runoff. The water that moves directly over the land surface 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, groundwater. The process by which water is removed from the saturated zone; also the quantity of water removed.

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

Fault. A fracture or fracture zone along which there has been displacement of the two sides relative to each other. The displacement may range from a few inches to many miles.

Formation. A fundamental unit in rock stratigraphic classification. It is a body of rock characterized by uniform rock characteristics; it is generally tabular and is mappable at the earth's surface, or traceable in the subsurface through borings.

Fracture. A break in rocks.

Generalized geologic section. The description of the prominent features in a sequence of rocks. Minor features are not included.

Groundwater 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 that can be supported by the static pressure.

Hydraulic gradient. Change in static head per unit of distance in a given direction.

Overdraft. Lowering of the water level or artesian head in an aquifer caused by withdrawal in excess of recharge.

Perched groundwater. Groundwater separated from an underlying body of groundwater by a low-permeability or impermeable, unsaturated zone.

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

Porosity. The ratio of the total volume of openings in a rock to the total volume of the rock, expressed as a percentage.

Potentiometric surface. The surface that represents the static groundwater head; the potentiometric surface for an unconfined aquifer is the water table.

Primary openings. Openings or voids within the rock when it was formed. In sedimentary rocks, openings result from the arrangement and nature of the original sediment.

Recharge, groundwater. The process by which water is added to the saturated zone; 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.

Saturated zone. The zone in which interconnected openings are saturated with water.

Secondary openings. Voids produced in rocks, subsequent to their formation, by solution, weathering, or movement.

Soil tonal alignments. The linear arrangement of similar tones or shades of color observable on aerial photographs; believed to be due to a similarity in the properties of the soil.

Specific capacity. The yield (in gallons per minute) of a well divided by the drawdown (in feet) of water level in the well.

Specific yield. The ratio of the volume of water that a saturated rock or soil will yield when drained by gravity to the volume of rock or soil.

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 above older rocks.

Vadose water. Water in the zone of aeration above the water table.

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

Table 5. *Record of Wells*

Well location: The number is that assigned to identify the well. It is prefixed by a two-letter abbreviation of the county. The lat-long 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; I, irrigation; N, industrial; P, public supply; R, recreation; S, stock; T, institution; U, unused; W, waste; Z, other.

Topographic setting: H, hilltop; S, hillside; V, valley.

Aquifer: Qal, alluvium; Pp, Pottsville Group; Mb, Burgoon Sandstone; Dck, Catskill Formation; Dlh, Lock Haven Formation; Db, Brallier Formation; Dha, Harrell Formation; Dh, Hamilton Group; Dhm, Mahantango Formation; Don, Onondaga Formation; Do, Old Port Formation; Su, Silurian rocks, undifferentiated; Sto, Tonoloway Formation; Swc, Wills Creek Formation; St, Tuscarora Formation; Oj, Juniata Formation; Obe, Bald Eagle Formation; Or, Reedsville Formation; Ocn, Trenton Group; Oc, Coburn Formation; Obl, Benner, Snyder, Hatter, and Loysburg Formations, undifferentiated; Obn, Benner Formation; Olb, Loysburg Formation; Obf, Bellefonte Formation; Oa, Axemann Formation; On, Nittany Formation; Os, Stonehenge Formation; Cg, Gatesburg Formation; Cgm, Mines Member of Gatesburg Formation; Cgu, upper sandy member of Gatesburg Formation; Cgl, lower sandy member of Gatesburg Formation; Cw, Warrior Formation.

Lithology: dol, dolomite; gr, gravel; ls, limestone; qtz, quartzite; sh, shale; ss, sandstone.

Static water level: Depth--F, flowing, +, above land surface; date--month/last two digits of year.

Reported yield: gpm, gallons per minute.

Specific capacity: gpm/ft, gallons per minute per foot of drawdown.

Hardness: gpg, grains per gallon.

Specific conductance: Deg C, degrees Celsius.

Table 5.

Well location		Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting	Aquifer/ lithology
Number	Lat-Long							
Ce- 1	4056-7747	O. V. Scholl	---	---	U	700	V	Qal/gr
2	4056-7747	G. C. Benner	---	---	U	698	V	Do/ls
3	4054-7803	Black Moshannon St. Pk.	---	---	U	1870	V	Mb/ss
4	4057-7753	Ganderstep Camp	Harrisburg's Kohl Bros.	1935	H	1600	S	Dck/sh
5	4051-7734	Spring Mills Water Co.	---	---	P	1270	S	Or/sh
6	4053-7813	Philipsburg Brewing Co.	---	---	N	1420	V	Pp/sh
7	4053-7813	Pa. State Taxidermy Co.	---	---	U	1440	V	Pp/ss
8	4051-7814	Penn Central R. R.	---	---	U	1460	V	Pp/ss
9	4048-7813	General Refractories Co.	---	---	N	1920	S	Mb/ss
10	4048-7813	Penn Central R. R.	---	---	H	1930	S	Mb/ss
11	4059-7742	Howard Nursery	Wieand Brothers	1976	U	700	H	Dhm/sh
12	4049-7759	P. C. and O. J. Shivery	Elliot	1916	H	1720	S	Oj/sh
13	4050-7752	W. E. Brennan	---	---	S	1150	S	Cgu/dol
14	4050-7752	Earl Crust	---	---	H	1140	V	Cgu/dol
15	4051-7753	Brockerhoff	L. E. Gladfelter	---	S	1040	V	Cg/ss
16	4042-7758	Fred Rossman	do.	---	H	1200	V	Obf/dol
17	4044-7756	Walter Dreibelbis	---	---	S	1220	S	On/dol
18	4044-7756	John Gummo	---	---	S	1200	V	Cgu/dol
19	4044-7758	Isaac Harpster	---	---	H	1140	S	On/dol
20	4044-7800	E. E. Rider	---	1880	S	1300	S	Os/ls
21	4045-7759	Robert Harpster	L. E. Gladfelter	---	H	1290	S	Os/ls
22	4046-7747	Ralph Rischel	---	---	U	1100	V	Obf/dol
23	4045-7750	Elmer Witmer	---	---	H	1080	V	On/dol
24	4045-7749	J. E. Osman	---	---	H	1120	V	Obf/dol
25	4045-7749	State College Bor.	Harrisburg's Kohl Bros.	1931	U	1300	S	Obf/dol
26	4045-7749	do.	---	---	U	1350	V	Or/sh
27	4045-7749	do.	Harrisburg's Kohl Bros.	1922	U	1370	V	Or/sh
28	4045-7749	do.	do.	---	U	1380	V	Obe/ss
29	4045-7749	do.	do.	1920	U	1400	V	Obe/ss
30	4051-7741	Centre Hall Bor.	do.	1916	P	1500	S	Obe/ss
31	4051-7741	do.	do.	1930	P	1415	S	Oc/ls
32	4050-7742	Detwiler	---	---	H	1820	H	Obe/ss
33	4050-7742	H. E. Coldren	Yarrison	1929	H	1810	H	Obe/ss
34	4050-7740	Sheffield Farms	---	---	N	1280	V	Ocn/ls
35	4049-7739	Brockeroff	L. E. Gladfelter	---	H	1300	H	Obf/dol
36	4049-7738	P. P. Henshell	do.	1934	H	1220	S	Obl/ls
37	4047-7737	T. H. Davis	---	---	H	1270	S	Oc/ls
38	4045-7737	R. D. Rearich	---	---	H	1720	V	Oj/sh
39	4047-7740	Klinefelter	---	---	H	1200	V	Or/sh
40	4048-7743	Roy Garbick	---	---	H	1210	V	Olb/ls
41	4049-7750	Mr. Aleman	---	---	H	945	V	On/dol
42	4049-7752	Pa. State Univ.	---	1933	U	1039	V	Cgu/dol
43	4049-7752	do.	---	1934	U	1045	V	Cgu/dol
44	4049-7752	do.	---	1934	U	1048	V	Cgu/dol
45	4048-7751	Anna Hartswick	---	---	U	1190	S	On/dol
46	4047-7751	Pa. State Univ.	---	1937	U	1140	S	On/dol
47	4047-7752	State College Bor.	F. L. Bollinger & Sons	1921	P	1221	H	On/dol
48	4047-7812	O. F. Adamitz	---	---	H	2190	S	Mb/ss
49	4049-7740	Centre Hall Bor.	Harrisburg's Kohl Bros.	1973	U	1280	V	Obf/dol
50	4048-7749	O. W. Houtz	---	---	H	1000	V	Obf/dol
51	4048-7749	John Corman	---	---	H	1000	V	Obl/ls
52	4054-7803	Black Moshannon St. Pk.	---	---	H	1880	V	Mb/ss
53	4054-7803	do.	---	---	H	1880	V	Mb/ss
54	4051-7734	Sheffield Farms	Yarrison	---	N	1100	V	Oc/ls
55	4051-7734	Dairymen's Coop. Assoc. Inc.	---	---	N	1100	V	Oc/ls
56	4054-7741	J. B. Stover	L. E. Gladfelter	1929	H	1000	V	On/dol
57	4055-7739	William Corman	---	---	H	1082	S	Oa/dol
58	4057-7737	B. R. Ingram	White	---	H	980	S	Os/ls
59	4057-7736	C. L. Krape	Harrisburg's Kohl Bros.	1932	H	935	V	Oa/dol
60	4058-7735	Frank Long	L. E. Gladfelter	---	H	900	V	Oa/dol
61	4057-7723	John Boob	---	---	H	1290	V	Ocn/ls
62	4054-7722	L. P. Fiedler	---	---	H	1175	S	Or/sh
63	4051-7727	Sheffield Farms	---	---	N	1030	V	Oc/ls
64	4100-7736	M. S. Betts	---	---	H	940	V	Olb/ls
65	4047-7801	John Way	---	---	H	1310	S	Obf/dol
66	4054-7745	Triangle Filling Station	---	---	H	900	S	Os/ls
67	4053-7745	Johnson	---	---	H	840	V	On/dol
68	4053-7745	White	---	---	H	840	V	On/dol
69	4054-7743	Harvey Corman	Rider	---	S	1000	S	On/dol
70	4054-7743	Roy Zimmerman	L. E. Gladfelter	---	H	1060	S	Obf/dol
71	4054-7743	Kyle Corman	do.	---	H	1020	S	Oa/dol

(Continued)

Total depth below land surface (feet)	Casing		Depth(s) to water-bearing zone(s) (feet)	Static water level		Reported yield (gpm)	Specific capacity (gpm/ft)	Hard-ness (gpg)	Specific conduc-tance (micro-mhos at 25°C)	pH	Well number
	Depth (feet)	Diameter (inches)		Depth below land surface (feet)	Date measured (mo/yr)						
9	---	---	---	6	---	30	---	---	---	---	Ce- 1
22	---	48	---	14	5/46	---	---	---	---	---	2
35	---	6	---	6	7/51	---	---	---	---	---	3
641	---	---	---	---	---	2	---	---	---	---	4
---	---	---	---	---	---	---	---	---	---	---	5
425	180	8	---	15	---	75	1.5	---	---	---	6
160	18	6	---	35	---	---	---	---	---	---	7
180	100	6	---	+5	---	160	13	---	---	---	8
701	---	8	---	100	---	17	---	---	---	---	9
60	22	---	---	20	---	5	---	---	---	---	10
298	---	6	---	---	---	1	.01	---	---	---	11
110	23	6	---	+1	---	45	4.5	---	---	---	12
220	213	6	---	190	---	20	---	---	---	---	13
247	236	6	---	207	---	20	---	---	---	---	14
122	26	6	---	60	---	30	30	---	---	---	15
78	16	6	---	12	---	30	30	---	---	---	16
143	37	6	---	63	---	---	---	---	---	---	17
97	30	6	---	77	---	6	---	---	---	---	18
50	30	6	---	15	---	20	---	---	---	---	19
300	30	8	---	205	---	30	---	---	---	---	20
276	90	6	---	215	---	20	---	---	---	---	21
200	160	6	---	8	---	---	---	---	---	---	22
64	15	6	---	16	---	30	30	---	---	---	23
67	32	6	---	30	---	30	---	---	---	---	24
301	246	6	---	30	---	500	10	6	---	7.8	25
80	80	---	---	---	---	---	---	---	---	---	26
616	23	8	---	12	---	45	.45	---	---	---	27
200	50	8	---	10	---	20	.12	---	---	---	28
342	48	8	---	2	---	55	.55	---	---	---	29
250	---	6	---	12	---	30	.25	---	---	---	30
300	---	6	---	12	---	50	---	---	---	---	31
132	40	8	---	82	---	5	---	---	---	---	32
150	21	6	---	---	---	200	---	---	---	---	33
22	22	168	---	14	1934	---	---	---	---	---	34
216	42	6	---	100	---	30	30	---	---	---	35
127	8	6	95;125	91	7/34	30	30	---	---	---	36
122	23	6	---	65	---	6	---	---	---	---	37
43	22	6	---	30	---	15	1.1	---	---	---	38
50	18	6	---	20	---	5	---	---	---	---	39
187	30	6	---	107	---	3	---	---	---	---	40
45	23	6	---	8	---	30	---	---	---	---	41
270	---	12	---	55	11/33	485	21	---	---	---	42
334	5	12	---	45	6/34	260	3.1	8	---	---	43
305	48	12	---	43	6/34	375	6.6	6	---	7.6	44
207	0	6	---	---	---	0	---	---	---	---	45
365	---	---	---	80	---	500	---	13	---	7.6	46
609	49	12	---	213	---	185	12	---	---	8.0	47
126	15	8	---	45	---	10	---	---	---	---	48
450	35	8	107;150;165; 185;230;292; 297;330;390	113	10/73	430	9.2	13	---	7.7	49
71	11	6	---	11	---	20	20	---	---	---	50
43	22	6	---	2	---	30	---	---	---	---	51
30	28	6	---	3	---	8	---	---	---	---	52
45	20	6	---	20	---	10	---	---	---	---	53
107	30	8	---	20	---	400	---	---	---	---	54
280	---	6	---	---	---	50	---	---	---	---	55
176	40	6	90;170	30	---	40	---	---	---	---	56
128	---	6	---	---	---	---	---	---	---	---	57
120	---	6	---	---	---	5	---	---	---	---	58
117	112	6	117	52	---	22	22	---	---	---	59
46	9	6	46	12	---	30	---	---	---	---	60
160	---	6	---	---	---	5	---	---	---	---	61
78	---	---	---	10	---	3	---	---	---	---	62
120	---	8	---	---	---	50	---	---	---	---	63
95	20	6	---	20	---	5	---	---	---	---	64
57	10	6	---	36	---	5	---	---	---	---	65
143	30	6	---	40	---	30	---	---	---	---	66
37	20	6	---	18	---	5	---	---	---	---	67
102	12	6	---	60	---	20	---	---	---	---	68
200	60	---	---	130	---	15	15	---	---	---	69
214	76	6	---	174	---	20	20	---	---	---	70
280	18	6	---	160	---	20	---	---	---	---	71

Table 5.

Well location		Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting	Aquifer/ lithology
Number	Lat-Long							
Ce- 72	4054-7742	Transcont. & Western Air, Inc.	L. E. Gladfelter	---	H	1080	S	Obf/dol
73	4053-7744	Harvey Hoy	---	---	H	1035	S	Oa/dol
74	4053-7743	William Hoffman	Lee Sampsel	---	U	1105	S	Obf/dol
75	4053-7742	White Rock Quarry	do.	---	H	1125	S	Obn/ls
76	4052-7743	Frank Brooks	do.	---	H	1000	S	Obl/ls
77	4051-7743	R. C. Noll	---	---	U	1400	S	Or/sh
78	4051-7743	Pleasant Gap Water Supply Co.	L. E. Gladfelter	1930	P	1240	V	Or/sh
79	4052-7751	Lyman Bickle	---	---	H	1030	S	Os/ls
80	4052-7748	Boyd Corl	---	---	H	1080	S	Os/ls
81	4052-7746	Rockview St. Corr. Inst.	---	---	S	1050	S	Os/ls
82	4052-7756	Daniel Shuey	Lee Sampsel	---	H	900	V	Obf/dol
83	4051-7756	J. H. Turner	---	---	H	850	V	Dhm/sh
84	4056-7749	John Martin	---	---	H	760	V	Db/sh
85	4055-7752	John Askins	L. E. Gladfelter	---	H	1080	S	Db/sh
86	4056-7749	J. Davidson	do.	---	H	760	V	Dha/sh
87	4056-7747	Luther Peters	do.	---	U	700	V	Dh/sh
88	4056-7747	Walker	do.	---	H	700	V	Dh/sh
89	4058-7744	H. L. Curtin	---	---	H	700	V	Do/ss
90	4102-7740	C. I. Yarrison	Yarrison	1933	H	740	V	Db/sh
91	4101-7739	Sheffield Farms	---	---	U	660	V	Su/---
92	4046-7805	J. T. Beckwith	---	---	H	1030	V	Dhm/sh
93	4045-7810	Tyrone Rod and Gun Club	---	---	H	1340	S	Dlh/sh
94	4042-7756	Pa. State Univ.	---	1961	H	1226	V	Ocn/ls
95	4048-7752	do.	---	1962	U	1092	V	Cgu/dol
96	4048-7751	do.	Sprague & Henwood, Inc.	1962	U	1130	H	On/dol
97	4051-7750	do.	Harrisburg's Kohl Bros.	1962	P	1240	H	Cgu/dol
98	4050-7752	do.	---	1962	P	1208	H	Cgu/dol
99	4049-7752	do.	Layne-New York Co., Inc.	1963	P	1038	V	Cgu/dol
100	4049-7752	do.	Harrisburg's Kohl Bros.	1965	U	1045	V	Cgu/dol
101	4048-7752	do.	Layne-New York Co., Inc.	1965	P	1080	V	Cgu/dol
102	4048-7752	do.	Hoffman Bros. Drlg. Co.	1938	P	1065	V	Cgu/dol
103	4047-7752	do.	Pennsylvania Drilling Co.	1972	U	---	V	On/dol
104	4047-7752	do.	do.	1972	U	---	V	On/dol
105	4049-7752	do.	Hoffman Bros. Drlg. Co.	1938	U	1090	V	Cgu/dol
106	4047-7751	do.	Harrisburg's Kohl Bros.	1938	P	1161	S	On/dol
107	4047-7751	do.	do.	1938	U	1161	S	On/dol
108	4047-7751	do.	do.	1938	U	1180	S	On/dol
109	4047-7751	do.	do.	1939	U	1190	S	On/dol
110	4047-7751	do.	do.	1938	U	1175	S	On/dol
111	4046-7746	do.	---	1940	U	1480	S	Or/sh
112	4047-7751	do.	Harrisburg's Kohl Bros.	1948	P	1149	S	On/dol
113	4047-7751	do.	do.	1948	U	1150	S	On/dol
114	4049-7751	do.	do.	1948	P	1042	V	Cgu/dol
115	4049-7752	do.	do.	1948	U	1050	V	Cgu/dol
116	4049-7752	do.	do.	1948	U	1092	V	Cgu/dol
117	4049-7752	do.	do.	1949	P	1076	V	Cgu/dol
118	4045-7757	U. S. Geol. Survey	Russell R. Brooks	1967	U	1150	V	Cgu/dol
119	4046-7757	Pa. Game Commission	Moody Drilling Co., Inc.	1970	R	1215	V	Cgu/dol
120	4047-7752	Pa. State Univ.	Pennsylvania Drilling Co.	1972	U	---	V	On/dol
121	4100-7739	U. S. Army	U. S. Army	1973	U	630	V	Su/---
122	4103-7736	do.	do.	1973	U	620	V	Dh/sh
123	4052-7739	Centre Hall Bor.	Lester E. Gladfelter, Jr.	1959	P	1420	S	Or/sh
124	4052-7739	do.	do.	1959	P	1410	S	Or/sh
125	4051-7741	do.	R. S. Carlin Inc.	1961	U	1510	S	Obe/ss
126	4051-7741	do.	do.	1961	U	1820	S	Oj/ss
127	4051-7741	do.	do.	1961	P	1860	S	Oj/sh
128	4051-7741	do.	Kohl Bros., Inc,	1962	P	1740	S	Oj/ss
129	4049-7740	do.	Harrisburg's Kohl Bros.	1973	U	1275	V	Obf/dol
130	4050-7741	do.	Oscar Dearmit	1965	P	1435	S	Or/sh
131	4050-7741	do.	do.	1965	U	1435	S	Or/sh
132	4045-7754	Kenneth Bennet	Harrisburg's Kohl Bros.	1960	H	1225	V	Cgm/dol
133	4049-7757	Centre Association, Inc.	Lester E. Gladfelter, Jr.	1958	P	1320	H	Obf/dol
134	4049-7757	do.	Paul Klinger	1963	P	1320	H	Obf/dol
135	4047-7802	Port Matilda Bor.	---	---	U	1215	S	Swc/sh
136	4047-7802	do.	Harrisburg's Kohl Bros.	1938	P	1230	S	Swc/sh
137	4047-7802	do.	---	1957	P	1230	S	Swc/sh
138	4054-7726	Aaronsburg Water Pipe Co.	---	---	P	1470	S	Obe/ss
139	4054-7726	do.	---	---	P	1320	S	Or/sh
140	4054-7726	do.	---	---	U	1320	S	Or/sh
141	4047-7756	Pa. Game Commission	---	1894	U	1360	S	Cgu/dol
142	4047-7756	do.	---	1894	U	1351	S	Cgu/dol
143	4047-7752	State College Bor.	F. L. Bollinger & Sons	1938	U	1220	H	On/dol
144	4045-7749	do.	Harrisburg's Kohl Bros.	1940	U	1230	S	Obf/dol

(Continued)

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 (mo/yr)	Reported yield (gpm)	Specific capacity (gpm/ft)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH	Well number
367	26	6	---	8	---	3	---	---	---	---	Ce- 72
100	20	6	---	100	---	10	---	---	---	---	73
85	15	6	---	70	---	---	---	---	---	---	74
120	18	8	---	95	---	1	.06	---	---	---	75
175	143	6	---	140	---	20	---	---	---	---	76
102	0	8	---	5	---	---	---	---	---	---	77
215	50	6	---	90	1/61	50	.5	2	---	8.2	78
207	90	6	---	45	---	6	---	---	---	---	79
231	---	6	---	196	---	---	---	---	---	---	80
227	7	6	---	100	---	1	---	---	---	---	81
50	10	8	---	15	---	---	---	---	---	---	82
150	---	6	---	15	---	---	---	---	---	---	83
376	30	6	---	30	---	1	---	---	---	---	84
142	20	6	---	60	---	20	---	---	---	---	85
122	20	6	---	30	---	20	---	---	---	---	86
112	76	6	70;110	---	---	30	---	---	---	---	87
93	33	6	---	---	---	3	---	---	---	---	88
80	---	6	---	---	---	5	---	---	---	---	89
140	35	6	---	2	---	3	---	---	---	---	90
625	---	8	---	---	---	80	---	---	---	---	91
45	---	6	---	5	---	4	---	---	---	---	92
95	44	6	---	20	---	3	---	---	---	---	93
200	135	6	---	150	1961	25	.14	---	---	---	94
400	32	12	---	94	---	60	.46	---	---	---	95
375	26	7	---	156	---	15	.18	---	---	---	96
340	98	6	---	305	---	70	5.8	7	---	8.0	97
267	105	6	---	---	---	27	6.9	---	---	---	98
310	64	12	---	45	1/63	500	15	6	---	8.3	99
180	76	4	---	71	---	---	---	---	---	---	100
400	40	12	---	98	8/66	1000	13	7	279	8.1	101
330	39	12	---	30	8/56	485	21	6	---	---	102
400	32	8	35;83;120;250	95	1/72	130	.52	16	497	7.7	103
473	23	8	48;53;405	45	1/72	150	.59	17	572	7.6	104
450	73	12	---	94	---	315	---	---	---	---	105
340	---	10	---	161	---	458	13	12	---	---	106
405	40	12	---	158	---	490	26	12	---	---	107
565	---	---	---	---	---	---	---	---	---	---	108
405	92	10	---	83	1939	180	---	---	---	---	109
400	---	12	---	---	---	---	---	---	---	---	110
100	42	---	---	---	---	---	---	---	---	---	111
353	26	12	---	142	---	460	---	---	---	---	112
357	26	12	---	---	---	700	---	---	---	---	113
220	53	12	165;212	100	10/48	400	11	9	---	7.8	114
102	---	---	---	---	---	---	---	---	---	---	115
230	43	10	---	92	12/48	450	9.0	6	---	---	116
336	34	12	---	50	1/49	450	29	7	---	---	117
130	40	6	---	82	1/67	---	110	17	725	---	118
506	179	8	---	152	4/70	510	146	4	---	8.0	119
203	108	8	---	---	---	---	---	---	---	---	120
20	---	6	---	7	7/73	---	---	---	---	---	121
26	---	6	---	1	7/73	---	---	---	---	---	122
154	17	8	33;67;81;107	4	10/59	30	.22	---	---	---	123
150	31	8	37;83;113	6	10/59	30	.22	---	---	---	124
---	---	6	---	---	---	0	---	---	---	---	125
235	63	6	---	---	---	16	---	2	---	7.7	126
175	21	6	---	---	---	22	---	2	---	6.7	127
600	34	8	412	26	4/62	50	.22	3	---	6.5	128
530	61	8	95;150;195;245	115	10/73	400	20	---	---	---	129
231	20	6	30;48;80;171	---	---	180	---	---	---	---	130
278	37	6	48;60	20	---	110	---	---	---	---	131
250	40	6	---	78	10/60	310	9.4	---	---	---	132
219	37	6	105;205	105	---	19	---	15	---	7.3	133
420	70	6	226;420	---	---	18	---	16	---	7.4	134
65	28	6	---	11	---	20	2.0	26	---	7.4	135
213	52	6	---	---	---	---	---	23	---	7.5	136
160	35	6	---	---	---	60	---	11	---	6.6	137
160	50	6	---	40	---	15	---	---	---	---	138
310	90	8	---	---	---	18	---	---	---	---	139
---	---	6	---	---	---	10	---	---	---	---	140
368	---	8	---	340	---	1000	---	---	---	---	141
366	284	10	---	322	---	140	79	---	---	---	142
603	10	16	---	195	12/38	575	19	11	---	7.6	143
264	174	6	---	25	6/40	350	18	---	---	---	144

Table 5.

Well location		Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting	Aquifer/ lithology
Number	Lat-Long							
Ce-145	4046-7750	State College Bor.	Harrisburg's Kohl Bros.	1948	P	1075	V	On/dol
146	4046-7750	do.	do.	1950	P	1075	V	On/dol
147	4045-7750	do.	do.	1954	U	1130	V	Obf/dol
148	4045-7750	do.	do.	1955	U	1180	V	Obf/dol
149	4046-7750	do.	Kohl Bros., Inc.	1960	P	1080	V	On/dol
150	4049-7755	do.	F. L. Bollinger & Sons	1974	U	1200	V	Cgl/dol
151	4049-7755	do.	do.	1974	U	1190	V	Cg/dol
152	4046-7750	do.	Harrisburg's Kohl Bros.	1964	P	1075	V	On/dol
153	4047-7756	do.	Layne-New York Co., Inc.	1963	U	1341	S	Cgu/dol
154	4047-7756	do.	do.	1964	U	1351	S	Cgu/dol
155	4047-7756	do.	Harrisburg's Kohl Bros.	1967	U	1360	S	Cgu/dol
156	4047-7757	do.	do.	1966	U	1308	V	Cgu/dol
157	4047-7757	do.	do.	1967	U	1333	V	Cgu/dol
158	4049-7755	do.	F. L. Bollinger & Sons	1974	U	1200	V	Cgl/dol
159	4045-7749	do.	Harrisburg's Kohl Bros.	1947	U	1120	V	Obf/dol
160	4045-7749	do.	do.	1947	U	1120	V	Obf/dol
161	4045-7749	do.	do.	1947	U	1120	V	Obf/dol
162	4048-7749	Lemont Water Co.	R. S. Carlin Inc.	1966	P	995	V	Obl/ls
163	4046-7749	State College Bor.	Moody Drilling Co., Inc.	1969	P	1068	V	On/dol
164	4046-7750	do.	do.	1969	U	1062	V	On/dol
165	4046-7750	do.	do.	1969	U	1064	V	On/dol
166	4057-7745	Boggs Twp.	do.	1971	U	708	V	Do/ls
167	4057-7744	do.	do.	1971	U	800	V	Do/ls
168	4058-7744	do.	do.	1971	U	718	V	Do/ls
169	4057-7744	do.	do.	1971	U	735	V	Do/ls
170	4057-7746	do.	do.	1971	P	685	V	Do/ls
171	4057-7746	do.	do.	1971	P	685	V	Do/ls
172	4056-7742	Herbert R. Imbt, Inc.	do.	1972	N	880	V	Cgu/dol
173	4047-7802	Port Matilda Water Co.	Oscar Dearmit	1966	U	1340	S	Sto/ls
174	4046-7745	Harris Township Auth.	H. W. Klinger	1966	P	1340	S	Or/sh
175	4055-7800	Pa. State Univ.	Harrisburg's Kohl Bros.	1971	H	1248	H	Mb/ss
176	4045-7751	do.	Max Hickernell	1970	H	1115	V	Oa/ls
177	4054-7751	Unionville Bor.	Russell R. Brooks	1967	P	1065	S	Su/ls
178	4103-7736	U. S. Army	Kohl Bros., Inc.	1969	Z	630	V	Don/sh
179	4043-7754	Cedar Hills Water Co.	Oscar Dearmit	1966	P	1390	S	Oc/ls
180	4043-7754	do.	do.	1966	P	1285	S	Ocn/ls
181	4052-7739	Centre Hall Bor.	Harrisburg's Kohl Bros.	1968	U	1340	S	Ocn/ls
182	4051-7739	do.	do.	1969	U	1300	V	Obl/ls
183	4052-7738	do.	do.	1969	U	1265	V	Obl/ls
184	4052-7739	do.	do.	1969	U	1350	S	Ocn/ls
185	4051-7741	do.	R. S. Carlin Inc.	1964	P	1725	S	Oj/sh
186	4051-7809	Pa. Dept. of Transportation	Harrisburg's Kohl Bros.	1973	T	2105	H	Mb/ss
187	4049-7728	Poe Valley St. Pk.	Russell R. Brooks	1968	W	1290	V	Or/sh
188	4053-7750	Continental Courts, Inc.	Oscar Dearmit	1972	P	900	V	Obf/dol
189	4047-7756	Pa. Game Commission	---	1894	U	1350	S	Cgu/dol
190	4047-7752	Pa. State Univ.	Moody Drilling Co., Inc.	1969	U	1150	V	On/dol
191	4047-7813	Sandy Ridge Water Users Assoc.	---	1954	P	2024	V	Mb/ss
192	4054-7803	Black Moshannon St. Pk.	Ollie L. Whaling	1955	H	1868	V	Mb/ss
193	4054-7804	do.	do.	1954	H	1982	S	Mb/ss
194	4054-7803	do.	do.	1958	U	2020	S	Mb/ss
195	4055-7802	do.	Harrisburg's Kohl Bros.	1963	H	2222	H	Mb/ss
196	4049-7728	Poe Valley St. Pk.	Lester E. Gladfelter, Jr.	1953	H	1270	V	Or/sh
197	4049-7728	do.	do.	1959	H	1300	V	Or/sh
198	4049-7728	do.	do.	1953	H	1300	V	Or/sh
199	4049-7728	do.	do.	1953	H	1290	V	Or/sh
200	4051-7746	Corning Glass Co.	Russell R. Brooks	1966	U	1005	V	Obf/dol
201	4051-7746	do.	do.	1967	U	980	V	Obf/dol
202	4049-7748	Nease Chemical Co.	do.	1967	---	1154	S	Obf/dol
203	4049-7748	do.	do.	1967	---	1125	S	Obf/dol
204	4053-7805	Mid-State Airport	Oscar Dearmit	1974	C	1905	H	Mb/ss
205	4046-7755	L. W. Nixon	Harrisburg's Kohl Bros.	1966	I	1215	V	On/dol
206	4051-7727	Penn Twp. Water Dist.	---	1965	P	1180	V	Obe/ss
207	4051-7743	Pleasant Gap Water Supply Co.	Russell R. Brooks	1965	P	1450	V	Obe/ss
208	4055-7726	Rebersburg Water Co.	do.	1965	P	1480	S	Ocn/ls
209	4100-7738	Howard Bor.	---	1966	---	800	V	St/qtz
210	4047-7801	Upper Halfmoon Water Co.	Oscar Dearmit	1976	P	1430	S	Or/sh
211	4047-7801	do.	---	1964	P	1415	S	Or/sh
212	4047-7846	do.	---	---	U	1310	V	Obf/dol
213	4044-7757	Rockspring Water Co.	Gilbert R. Zechman	1967	P	1120	V	Cgu/dol
214	4043-7753	Ferguson Twp. Water Auth.	---	---	P	1460	V	Obe/ss
215	4043-7753	do.	Russell R. Brooks	1967	P	1460	V	Obe/ss
216	4043-7753	do.	do.	1967	P	1480	V	Obe/ss
217	4043-7753	do.	---	---	U	1420	V	Or/sh

(*Continued*)

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 (mo/yr)	Reported yield (gpm)	Specific capacity (gpm/ft)	Hardness (gpg)	Specific conductance (micromhos at 25°C)	pH	Well number
165	72	12	130	9	---	1000	143	11	---	8.0	Ce-145
165	72	12	---	11	11/50	1200	600	13	---	7.6	146
400	21	8	---	28	---	400	---	---	---	---	147
500	15	8	---	10	---	50	---	---	---	---	148
155	83	14	---	13	---	1650	236	12	383	7.6	149
440	59	6	---	---	---	---	---	---	---	---	150
440	350	12	---	---	---	---	---	---	---	---	151
142	82	12	---	30	11/64	1420	109	12	---	7.4	152
458	361	12	---	349	---	---	---	---	---	---	153
453	286	8	---	362	---	350	136	---	---	---	154
450	297	10	---	404	---	7	.13	---	---	---	155
500	359	10	340;362	350	---	725	192	---	---	---	156
505	434	16	379;400	369	1/68	495	24	---	---	---	157
502	352	12	---	---	---	15	---	---	---	---	158
513	18	8	---	---	---	60	5	---	---	---	159
85	0	12	---	---	---	0	---	---	---	---	160
330	0	6	---	---	---	2	---	---	---	---	161
304	99	8	---	10	---	---	---	---	---	---	162
228	---	16	---	14	9/70	1500	69	12	372	7.7	163
280	---	16	---	8	9/70	1500	104	11	378	7.9	164
260	---	16	---	6	1/69	2200	525	11	382	7.9	165
386	101	8	---	46	---	202	3.7	---	---	---	166
310	---	---	---	---	---	20	---	---	---	---	167
386	---	---	---	---	---	10	---	---	---	---	168
300	---	---	---	---	---	5	---	---	---	---	169
385	73	8	---	20	6/71	550	100	17	---	7.5	170
385	76	8	---	20	6/71	500	13	14	---	7.6	171
304	164	8	---	25	7/72	980	9.4	---	---	---	172
249	71	8	85;175	---	---	60	---	7	---	6.9	173
189	31	6	28;142;165	28	11/66	30	30	---	---	---	174
250	26	8	110;230	215	2/71	5	.14	---	---	---	175
88	20	8	56;72;84	52	5/70	20	.93	---	---	---	176
185	107	6	---	46	6/67	43	.37	---	---	---	177
178	66	6	76;105;164	60	11/69	50	.64	---	---	---	178
185	22	6	19;103;175	40	11/66	10	.07	---	---	---	179
248	22	6	145;185;212	52	---	50	---	---	---	---	180
300	110	6	220;235	160	11/68	2	.02	---	---	---	181
300	50	6	140;210	90	---	2	.01	---	---	---	182
338	74	6	160;235	160	1969	30	.17	---	---	---	183
350	80	6	220;260;320	150	9/69	7	.04	---	---	---	184
172	30	6	---	27	---	25	---	---	---	---	185
480	41	6	192;370;400; 435;465	200	3/73	32	.68	---	---	---	186
98	48	6	50;81;91	4	6/68	25	.98	---	---	---	187
40	29	6	30	10	1/72	100	3.3	---	---	---	188
429	---	6	---	329	---	146	---	---	---	8.3	189
275	165	12	20;60;100	114	6/69	500	7.8	13	---	7.4	190
90	---	---	---	27	1954	100	33	---	---	---	191
44	42	6	42	11	2/55	15	.88	---	---	---	192
151	18	6	---	44	3/54	12	.13	---	---	---	193
117	20	6	103	85	5/58	12	1.2	---	---	---	194
500	43	8	326;390	305	5/63	25	.28	1	---	6.7	195
72	53	6	54	16	5/53	10	.91	---	---	---	196
80	66	8	71;74	1	5/59	50	3.4	---	---	---	197
63	51	6	51;63	F	4/53	---	---	---	---	---	198
54	46	6	47	7	5/53	10	.59	---	---	---	199
175	36	6	140;168	62	9/66	15	.13	---	---	---	200
250	25	6	133;196;242	18	1/67	10	.04	---	---	---	201
150	74	6	99;126	70	4/67	6	.08	---	---	---	202
70	38	6	50	14	4/67	130	2.4	---	---	---	203
183	52	8	176	49	11/74	100	.75	---	---	---	204
325	217	6	---	111	9/66	56	1.3	---	---	---	205
128	15	6	---	15	1/65	80	---	---	---	---	206
225	29	6	---	40	6/65	60	6.0	---	---	---	207
350	72	6	---	23	8/65	60	.62	---	---	---	208
350	51	6	---	11	1/66	10	.04	---	---	---	209
220	20	6	24;30;54;75	17	9/76	32	.51	---	---	---	210
165	28	8	---	11	11/64	42	.37	---	---	---	211
83	60	6	---	---	---	---	---	---	---	---	212
322	60	6	---	25	1967	100	10	4	---	7.0	213
29	23	6	---	13	---	10	---	---	---	---	214
75	30	6	35;68	7	5/67	15	.24	1	---	6.0	215
75	42	6	46;69	5	1967	25	1.2	1	---	6.3	216
350	---	6	---	30	2/68	---	---	---	---	---	217

Table 5.

Well location		Owner	Driller	Date completed	Use	Altitude of land surface (feet)	Topographic setting	Aquifer/ lithology
Number	Lat-Long							
Ce-218	4048-7757	J. Alvin Hawbaker, Inc.	Harrisburg's Kohl Bros.	1961	U	1278	V	Cw/ls
219	4047-7752	Pa. State Univ.	Layne-New York Co., Inc.	1974	U	1150	V	On/dol
220	4052-7738	Centre Hall Bor.	Harrisburg's Kohl Bros.	1969	U	1300	V	Obl/ls
221	4049-7740	do.	do.	1972	U	1300	V	Obf/dol
222	4049-7740	do.	do.	1972	U	1280	V	Obf/dol
223	4046-7749	State College Bor.	Moody Drilling Co., Inc.	1968	U	1070	V	On/dol
224	4048-7748	Lemont Water Co.	L. E. Gladfelter	1936	U	1300	S	Or/sh
225	4048-7748	do.	do.	1936	U	1280	S	Or/sh
226	4048-7748	do.	---	1936	U	1300	S	Or/sh
227	4051-7749	Pa. Fish Commission	Ehmke Well Drillers	1975	Z	1005	V	Cgu/dol
228	4051-7749	do.	do.	1975	Z	1010	V	Cgu/dol
229	4053-7474	do.	do.	1975	Z	840	V	Cgu/dol
230	4050-7746	Rockview State Corr. Inst.	Moody Drilling Co., Inc.	1966	U	1150	S	Obf/dol
231	4047-7751	Pa. State Univ.	Harrisburg's Kohl Bros.	1978	P	1180	S	On/dol
232	4050-7736	Norse Paddle Co.	Gilbert R. Zechman	1977	N	1200	V	Obl/ls
233	4102-7738	U. S. Army	Harrisburg's Kohl Bros.	1967	P	720	S	Do/ls
234	4102-7738	do.	do.	1967	P	720	S	Do/ls

(*Continued*)

Total depth below land surface (feet)	Casing		Depth(s) to water-bearing zone(s) (feet)	Static water level		Reported yield (gpm)	Specific capacity (gpm/ft)	Hard-ness (gpg)	Specific conduc-tance (micro-mhos at 25°C)	pH	Well number
	Depth (feet)	Diameter (inches)		Depth below land surface (feet)	Date measured (mo/yr)						
445	413	6	---	---	---	12	---	---	---	---	Ce-218
399	170	18	176;200;208	118	1974	600	11	---	---	---	219
300	69	6	80;130	190	5/69	2	.02	---	---	---	220
390	48	6	---	151	2/72	44	7.5	14	---	---	221
415	75	12	---	152	2/72	50	.25	12	---	7.7	222
242	22	8	---	12	1/69	500	110	11	---	7.8	223
50	---	6	---	3	1936	10	---	---	---	---	224
137	---	6	---	---	---	10	---	---	---	---	225
217	---	6	---	30	1936	10	.06	---	---	---	226
100	37	18	---	5	2/75	1600	53	---	---	---	227
100	24	18	41;85	14	6/75	1956	93	---	---	---	228
125	36	16	---	10	4/75	8000	380	---	---	---	229
420	125	6	---	105	1/68	12	.57	---	---	---	230
405	118	8	---	65	1978	600	40	---	---	---	231
201	130	6	148;196	70	5/77	30	---	---	---	---	232
300	120	8	---	89	8/67	120	---	6	---	7.8	233
300	134	8	---	92	8/67	200	---	5	---	7.7	234

Table 6. *Record of Springs*

Spring number: A serial number assigned to the described spring (see Plate 1).

Location number: Degrees, minutes, and seconc of latitude and longitude, respectively.

Discharge: M, measured; E, estimated; R, reported.

Use: C, commercial; H, domestic; N, industrial; P, public supply; R, recreation; U, unused; Z, fish hatchery.

Aquifer: Rock unit from which the spring issues.

Spring number	Location (latitude-longitude)	Owner (Spring name)	Altitude above sea level (feet)	Aquifer	Dis-charge (gpm)		Date measured or estimated	Estimated discharge characteristics (gpm) Maximum	Median	Minimum	Use	Temper-ature (°C)	Remarks
Ce- 1	404808 0775049	Pennsylvania State University (Thompson Spring)	1,010	Axemann Formation	3,750 2,700	M M	6-19-44 11-09-71	10,000 ---	4,000 ---	2,000 ---	U ---	10.0- 10.3	Partial flow records by Pa. State Univ.
2	404852 0775016	Lemont Water Co. (O. H. Bathgate Spring)	1,000	Nittany Formation	520 540	R M	1904 11-09-71	--- ---	--- 500	--- ---	P ---	11.0 ---	--- ---
3	405300 0773631	(Penns Cave Spring)	1,160	Nealmont Formation	6,000 4,700 3,420	R M M	bef. 1934 8-13-44 11-15-71	--- --- 32,000	--- --- 4,000	--- --- 400	--- R ---	7.6- 10.8	--- --- ---
4	405121 0773431	(Rising Spring)	1,100	Benner Formation	3,000 5,400	R M	1934 11-16-76	--- ---	--- 6,000	--- ---	--- P	9.5 ---	--- ---
5	405432 0774654	Bellefonte Borough (Bellefonte (Big) Spring)	740	Axemann Formation	8,000 7,900 7,500	M M M	4-06-28 6-16-44 11-11-71	--- --- 14,000	--- --- 8,000	--- --- 6,000	P --- ---	10.1- 10.7	Borough maintains complete flow record.
6	405551 0772611	Rebersburg Water Co.	1,420	Bald Eagle Formation	200 30	E E	7-11-34 7-23-62	--- 50	--- 30	--- 20	P ---	--- ---	--- ---
7	405607 0773123	Madisonburg Water Co.	1,440	Bald Eagle Formation	---	---	---	---	---	---	P	---	---
8	405420 0775133	Unionville Municipal Water Auth.	1,070	Tonoloway Formation	---	---	---	---	---	---	P	---	---

9	400138 0775556	Snow Shoe Borough Auth.	1,690	Mauch Chunk Formation	300	E	---	---	---	---	P	---	---
10	410211 0775629	Clarence Water Co.	1,470	Burgoon Sandstone	20	E	---	---	---	---	P	11	Two openings.
11	405145 0774526	Pa. Fish Comm. Bellefonte Fish Hatchery (Blue (Shutgart) Spring)	900	Loysburg Formation	3,500	E	1934	---	---	---	Z	11.0	Discharge includes two smaller springs.
					5,180	M	7-03-44	---	3,500	2,500	---	10.0	Do.
					2,270	M	11-09-71	---	---	---	---	---	Only discharge of Blue Spring measured and sampled for chemical analysis.
12	405300 0774737	Pa. Fish Comm. Bellefonte Fish Hatchery	820	Gatesburg Formation	3,000	R	1933	---	---	---	Z	11.0	---
13	404746 0780243	Port Matilda Water Co.	1,250	Tonoloway Formation	25	E	7-00-34	---	---	---	P	9.5	---
14	404221 0775805	Mr. Walker (Rock Spring)	1,160	Benner Formation	1,000	E	7-16-34	---	---	---	---	6.4-	Issues from a cave.
					1,710	M	11-09-71	34,000	2,000	200	H,Z	12.3	
15	404348 0775307	Ferguson Township Water Auth.	1,400	Bald Eagle Formation	120	E	7-00-34	---	---	---	P	9.0	---
16	405248 0774740	Pa. Fish Comm. (Forked Spring or Paradise Spring)	830	Gatesburg Formation	2,580	M	7-03-44	5,000	3,500	2,500	Z	8.1-	---
					3,930	M	11-10-71	---	---	---	---	13.6	---
17	405324 0774537	Bond C. White (Axemann Spring)	840	Nittany Formation	2,030	M	6-17-44	---	---	---	U	10.0	---
					920	M	11-10-71	---	900	---	U	---	---
18	405105 0774921	Benner Research Station (Benner (Rock) Spring)	910	Mines Member of Gatesburg Formation	7,300	M	7-03-44	---	---	---	Z	10.0	---
					4,080	M	11-10-71	---	4,000	---	---	---	---
19	405420 0774642	Titan Mfg. Co. (Kelly Spring)	765	Nittany Formation	7,000	M	7-03-44	---	---	---	N	9.5	---
					8,600	M	11-10-71	---	7,000	4,300	---	---	---
20	410602 0780243	Pine Glen Devel. Co. (Big Sterling Spring)	1,400	Burgoon Sandstone	85	R	3-03-56	---	75	---	P	---	Discharge reported by owner.
21	410602 0780240	Pine Glen Devel. Co. (Sterling Spring)	1,400	Burgoon Sandstone	85	R	---	---	---	---	U	---	Discharge reported by owner.

Table 6. (Continued)

Spring number	Location (latitude-longitude	Owner (Spring name)	Altitude above sea level (feet)	Aquifer	Discharge (gpm)		Date measured or estimated	Estimated discharge characteristics (gpm) Maximum	Median	Minimum	Use	Temperature (°C)	Remarks
Ce-22	404735 0773639	Mt. Acres Country Club	1,540	Juniata Formation	2	M	11-08-71	---	2	---	C	11.5	---
23	405241 0772802	(Weaver Spring)	1,060	Benner Formation	5,400 1,300	R R	4-00-67 8-00-68	9,000 ---	2,700 ---	450 ---	U ---	9.4- 10.1	Partial flow records maintained by Pa. State Univ.
24	405213 0772716	(Coburn Spring)	1,030	Benner Formation	2,400 220	R R	11-14-67 9-09-67	2,400 ---	500 ---	220 ---	--- ---	10.1- 10.5	Partial flow records maintained by Pa. State Univ.
25	405525 0772904	(Spring Bank)	1,212	Nealmont Formation	270 2,100	R R	10-26-67 8-23-67	2,100 ---	730 ---	270 ---	--- ---	8.6- 9.7	Partial flow records maintained by Pa. State Univ.
26	405535 0772808	(Elk Creek Spring)	1,215	Nealmont Formation	--- ---	--- ---	--- ---	--- ---	--- ---	--- ---	U ---	6.5- 12.9	--- ---
27	404851 0775020	Lemont Water Co. (John Bathgate Spring)	970	Nittany Formation	---	---	---	---	---	---	P	---	---
28	404544 0781412	Oak Ridge Auth. (Able Spring)	1,600	Rockwell Formation	115 ---	R ---	1978	---	---	---	P	---	---
29	405608 0773122	Madisonburg Water Co.	1,470	Bald Eagle Formation	30	E	---	---	---	---	P	---	---
30	405607 0773117	Madisonburg Water Co.	1,480	Bald Eagle Formation	35	E	---	---	---	---	P	---	---

Table 7. *Chemical Analyses of Groundwater*

(Results in milligrams per liter except where indicated)

Aquifer: Dh, Hamilton Group; Su, Silurian rocks, undifferentiated; Sto, Tonoloway Formation; Oj, Juniata Formation; Obe, Bald Eagle Formation; Ocnn, Nealmont Formation; Obn, Benner Formation; Olb, Loysburg Formation; Obf, Bellefonte Formation; Oa, Axemann Formation; On, Nittany Formation; Cgm, Gatesburg Formation, Mines Member; Cgu, Gatesburg Formation, upper sandy member.

Well or spring number	Aquifer	Date of sampling	Temperature (degrees C)	Silica (SiO_2)	Iron (Fe) (µg/l)	Manganese (Mn) (µg/l)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Sodium plus potassium, as Na	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3), as N	Orthophosphorus (P)	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 degrees C)
Ce- 12	Oj	7-16-34	---	---	---	---	32	17	---	2.0	---	161	20	0.8	0.1	0.00	---	---	---	150	18	---
25	Obf	6-14-34	---	5.5	10	---	14	3.8	1.3	---	0.7	55	6.3	.6	.0	.05	---	59	60	51	5	---
46	On	6-14-34	11.7	7.2	30	---	49	27	5.4	---	1.2	239	12	10	.0	4.5	---	257	249	230	37	---
47	On	6-14-34	---	7.2	30	---	43	21	3.5	---	1.1	202	9.4	4.8	.0	4.1	---	206	208	190	28	---
118	Cgu	11-16-71	---	5.5	20	0	22	11	2.5	---	1.1	116	1.9	1.9	.1	.11	0.04	85	104	100	5	186
121	Su	7-13-73	---	9.1	280	90	61	4.7	12	---	13	197	34	6.0	.4	.01	.00	253	237	170	10	402
		11- 9-73	---	3.6	760	70	54	13	16	---	18	200	59	23	.2	.00	.00	343	285	190	24	549
		5-23-74	11.0	5.0	110	10	110	19	18	---	30	334	79	34	.0	4.4	.00	518	479	350	79	580
		10-10-74	16.0	4.9	140	20	110	21	15	---	29	328	79	30	.1	4.7	.00	433	472	360	92	760
122	Dh	7-13-73	---	4.4	30	80	47	7.8	6.5	---	10	142	32	8.5	.2	1.1	.04	203	191	150	33	332
		11- 9-73	---	8.3	570	60	50	4.9	13	---	12	160	39	6.4	.4	.00	.00	316	213	150	14	406
		5-23-74	18.0	10	250	20	65	5.2	12	---	12	203	44	5.7	.4	.20	.00	266	256	180	17	450
		10-10-74	15.0	9.8	120	20	68	5.4	11	---	11	207	52	5.1	.3	.19	.00	275	266	190	22	450
Sp- 1	Oa	11- 9-71	10.0	---	---	---	51	21	---	5.5	---	230	14	7.3	---	3.4	.01	---	---	210	25	446
2	On	5-10-63	---	---	0	---	---	---	---	---	---	274	---	9.0	---	---	---	300	---	255	30	---
		11- 9-71	11.0	---	---	---	60	26	---	8.7	---	266	28	7.9	---	5.2	.01	---	---	260	39	572

Table 7. (Continued)

Well or spring number	Aquifer	Date of sampling	Temperature (degrees C)	Silica (SiO_2)	Iron (Fe) (µg/l)	Manganese (Mn) (µg/l)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Sodium plus potassium, as Na	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3), as N	Orthophosphorus (P)	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 degrees C)
Sp- 3	Ocnn	11-15-71	10.0	---	---	---	55	8.0	---	16	---	200	20	7.0	---	3.0	.04	---	---	170	6	384
4	Obn	11-16-71	9.5	---	---	---	31	6.8	---	9.7	---	124	13	6.4	---	.80	.18	---	---	110	4	250
5	Oa	7-10-34	---	11	---	---	27	13	4.7	---	1.0	135	7.7	6.2	.2	.54	---	---	140	120	10	---
		11-11-71	10.0	---	---	---	27	13	---	8.7	---	140	6.3	11	---	.90	.00	---	---	120	6	262
6	Obe	7-23-62	---	---	0	---	---	---	---	---	---	13	---	.0	---	---	---	18	---	12	1	---
11	Olb	11- 9-71	10.0	---	---	---	39	11	---	40	---	199	51	1.8	---	3.2	.09	---	---	140	0	468
13	Sto	7-16-34	---	8.6	20	---	60	6.2	2.3	---	1.0	193	16	1.1	.1	.07	---	---	191	180	17	---
14	Obn	11- 9-71	10.0	---	---	---	28	3.9	---	10	---	87	13	12	---	1.9	.01	---	---	86	15	202
16	Cgu	8-12-44	11.5	6.4	20	---	46	19	---	4.1	---	220	11	2.5	.1	1.7	---	207	---	190	13	367
		11-10-71	10.0	---	---	---	51	20	---	8.5	---	222	20	5.3	--	5.1	.33	---	---	210	28	468
17	On	11-10-71	10.0	---	---	---	67	27	---	1.4	---	276	28	3.0	---	6.2	.01	---	---	280	52	535
18	Cgm	8-12-44	10.0	5.4	20	---	37	14	---	2.9	---	171	5.8	1.9	.0	2.1	---	162	---	150	10	287
		11-10-71	10.0	---	---	---	46	12	---	2.1	---	120	11	33	---	3.4	.00	---	---	160	66	345
19	On	8-12-44	---	6.0	80	---	32	14	---	4.8	---	161	5.8	4.5	1.0	.93	---	150	---	140	5	272
		11-10-71	---	---	---	---	27	11	---	23	---	158	7.2	13	---	1.7	.00	---	---	110	0	299
22	Oj	11- 8-71	11.5	---	---	---	2.6	1.8	---	9.4	---	9	3.0	15	---	.80	.04	---	---	14	7	53