WATER RESOURCES OF THE CLARION RIVER AND REDBANK CREEK BASINS, NORTHWESTERN PENNSYLVANIA

By Theodore F. Buckwalter, Clifford H. Dodge, George R. Schiner, and Harry E. Koester

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U. S. GEOLOGICAL SURVEY

Water-Resources Investigations
Open-File Report 81-70

Prepared in cooperation with the
PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL RESOURCES

UNITED STATES DEPARTMENT OF THE INTERIOR

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[Plate is in pocket]

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GLOSSARY

Acidity.--The capacity of a water for neutralizing a basic solution. Acidity, as used in this report, is primarily caused by the presence of hydrogen ions produced by hydrolysis of the salts of strong acids and weak bases.

Alkalinity.--The capacity of a water for neutralizing an acid solution. Alkalinity in natural water is caused primarily by the presence of carbonate and bicarbonate.

Alluvium.--Sand, gravel, or other similar particle material deposited by running water.

Annual mean.--For ground water, the arithmetic average of the monthly means for a given year.

Anticline.--An upfold or arch of stratified rock in which the beds dip in opposite directions from the crest.

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

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

Bedding.--Layers of sedimentary rocks of the same or different lithology.

Bedrock.--A general term for the rock, generally solid, that underlies soil or other unconsolidated or semiconsolidated surficial material.

Benthic invertebrate.--An animal without a backbone living in or on the bottom of an aquatic environment.

Benthic region.--The bottom of a body of water.

Bilogical community.--All the plant and animal populations living together in a habitat and functioning as a unit by virtue of food and other relationships.

Clean-water association.--An association of organisms, generally characterized by many different kinds (species). The associations occur in unpolluted environments. Because of competition, predation, and other factors, however, relatively few individuals represent any particular species.

Colluvium.--Loose and incoherent deposits of rock debris generally found at the foot of a slope and brought there chiefly by gravity.

Contamination.--The state of being unfit, impure, or unclean for use by the introduction of undesirable elements.

Cubic feet per second (ft^3/s).--The rate of discharge representing a volume of 1 cubic foot passing a given point during 1 second (equivalent to 7.48 gallons per second or 448.8 gallons per minute).

Cubic feet per second per square mile [$(ft^3/s)/mi^2$].--The average number of cubic feet of water per second flowing from each square mile of area drained by a stream, assuming that the runoff is distributed uniformly, in time and area.

Dip.--The angle or rate of drop at which a layer of rock is inclined from the horizontal.

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

Discharge.--The volume of water (or more broadly, volume of fluid including dissolved minerals and suspended sediment) that passes a given point within a given period of time.

Dissolved solids.--The dissolved mineral constituents in water; they form the residue after evaporation and drying at a temperature of 180° Celsius; they may also be calculated by adding concentrations of anions and cations.

Drainage basin.--A part of the surface of the earth that is occupied by a drainage system, which consists of a stream or a body of impounded water, together with all tributary streams and bodies of impounded water.

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

Duration curve.--(See flow-duration curve).

Evapotranspiration.--Evaporation of water from land and water surfaces plus transpiration by vegetation.

Fault.--A fracture or fracture zone along which the sides have been displaced relative to each other.

Flood.--Any relatively high streamflow overtopping the natural or artificial banks in any reach of a stream.

Flow-duration curve.--A cumulative frequency curve that shows the percentage of time that specified discharges are equaled or exceeded.

Fold.--A bend or flexure produced in rock strata by forces operating after deposition of the rock.

Fold axis.--A continuous line on a folded surface formed by connecting points of maximum curvature on that surface.

Formation.--The fundamental unit in rock-stratigraphic classification. It is a body of internal homogeneous rock; it is prevailingly but not necessarily tabular and is mappable at the earth's surface or traceable in the subsurface.

Fracture.--A general term for any break in rock due to mechanical failure by stress, including cracks, joints, and faults.

Gaging station.--A particular site on a stream, canal, lake, or reservoir where water level or discharge is observed systematically.

Ground water.--That part of the subsurface water in the zone of saturation.

Ground-water discharge.--Release of water in springs, seeps, or wells from the ground-water reservoir.

Ground-water recharge.--Addition of water to the ground-water reservoir by infiltrating precipitation or seepage from a streambed.

Ground-water reservoir.--See aquifer.

Hardness.--A physical-chemical charateristic of water attributable primarily to the presence of dissolved calcium and magnesium and expressed as equivalent calcium carbonate ($CaCO_3$). The following scale is used to appraise hardness:

Hardness description	Hardness range (milligrams per liter of $CaCO_3$)
Soft	0-60
Moderately hard	61-120
Hard	121-180
Very hard	More than 180

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

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

Invertebrate.--An animal without a backbone. Common examples include worms, insects, snails, and crayfish.

Joint.--A fracture in a rock, generally more or less vertical, along which no movement has taken place.

Lithology.--The physical characteristics of a rock, generally as determined by examination with the naked eye or with the aid of a low-power magnifier.

Low-flow frequency curve.--A graph showing the magnitude and frequency of minimum flows for a period of given length. Frequency is generally expressed as the average interval, in years, between recurrences of an annual minimum flow equal to or less than shown by the magnitude scale.

Macroinvertebrate.--An invertebrate, in this report, generally a benthic organism, that is retained on a U.S. Standard No. 30 sieve (0.595-mm mesh opening).

Marker bed.--A bed that is distinctive enough to make it easily identifiable over a wide area. Marker beds, such as coal beds, are commonly used as boundaries for a formation.

Micrograms per liter (μg/L).--A unit for expressing the concentration of chemical constituents in solution. It represents the mass of solute per unit volume of solution. One thousand micrograms per liter are equal to one milligram per liter.

Milligrams per liter (mg/L).--A unit for expressing the concentration of chemical constituents in solution. It represents the mass of solute per unit volume of solution.

Mine drainage.--Surface-water and ground-water drainage from coal mines containing a high concentration of acidic sulfates, especially ferrous sulfate.

Monthly mean.--For ground water, the arithmetic average of the daily low water levels for a given month.

Nutrients.--Nitrate and phosphate; needed for plant or animal growth.

Observation well.--A well in which periodic measurements of water level or water quality are made.

Permeability.--The capacity of a porous rock, sediment, or soil to transmit a fluid under a hydraulic head; it is a measure of the relative ease of fluid flow under unequal pressure.

pH.--A measure of the acidity or alkalinity of water. A pH of 7.0 indicates a neutral condition. An acid solution has a pH less than 7.0, and a basic or alkaline solution has a pH more than 7.0.

Plunge.--The angle or inclination between a fold axis and its horizontal projection measured in a vertical plane.

Porosity.--The ratio of the aggregate volume of open spaces in a rock or soil to its total volume. It is usually stated as a percentage.

Primary productivity.--The rate at which radiant energy is stored by photosynthetic and chemosynthetic activity of producer organisms (chiefly green plants) in the form of organic substances which can be used as food materials.

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

Recurrence interval.--The average interval of time, in years, within which the given discharge will be equaled or exceeded once. The reciprocal of the recurrence interval is the probability of occurrence during any year.

Regolith.--The unconsolidated to semiconsolidated residual mantle of weathered rock material, including the soil profile, that lies between land surface and the unweathered bedrock.

Regulation.--The manipulation of the flow of a stream.

Reported well yield.--The short-term yield of a well as reported by well drillers.

Runoff.--That part of the precipitation that appears in streams. It is the same as streamflow unaffected by diversions, storage, or other works of man in or on the stream channels.

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

Sediment.--Fragmental material that originates mostly from rocks and is transported by, suspended in, or deposited from water or air.

Sediment discharge.--The rate at which sediment passes a section of a stream, usually expressed in tons per day.

Sedimentary rocks.--Rocks formed from sediments.

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

Specific capacity.--The well yield divided by the drawdown (pumping water level minus static water level) necessary to produce this yield. It is usually expressed as gallons per minute per foot [(gal/min)ft].

Specific conductance.--A measure of the capacity of a water to conduct an electrical current. It is expressed in micromhos per centimeter at 25°C. Specific conductance is related to the type and concentration of ions in solution and can be used for approximating the dissolved solids content of the water. Commonly, the concentration of dissolved solids (in milligrams per liter) is about 65 percent of the specific conductance (in micromhos).

Static water level.--The depth to water in a well that is not being affected by withdrawal of ground water.

Strata.--Sedimentary beds or layers, regardless of thickness.

Stream gage.--An instrument that measures the stage or water level of a stream. These stream water levels can be converted into corresponding streamflow through the use of a rating curve.

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.

Structure.--The sum of the features produced in rocks by movement after deposition and commonly after consolidation of the rock.

Surface water.--That water on the surface of the earth. Surface water is generally a combination of overland runoff and ground-water discharge, the proportions ranging from almost 100 percent overland runoff during periods of high-intensity rain to 100 percent ground-water discharge during periods of little or no rain.

Syncline.--A downfold or depression of stratified rock in which the beds dip inward toward the axis of the fold.

Taxon.--Any classification category of organisms, such as phylum, class, order, family, genus, or species.

Taxonomy.--The division of biology concerned with the classification and naming of organisms.

Tons per days.--A unit for expressing the weight, in tons, of a substance in solution or suspension that passes a stream section during a 24-hour period.

Trace element.--Elements that typically occur in concentrations of less than a milligram per liter.

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

Unconformity.--A surface of erosion and (or) nondeposition that separates younger and older rocks.

Water year.--The 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends. Thus, the year that ended September 30, 1975, is called the "1975 water year."

Well yield.--The quantity of water pumped, or withdrawn, from a well per unit of time; for example, the number of gallons per minute.

Zone of water-level fluctuation.--The range between highest and lowest level for any given time period.

CONVERSION FACTORS

FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

Multipy inch-pound units	By	To obtain SI units
acres	0.4047	square hectometers (hm^2)
acre-feet (acre-ft)	0.001233	cubic hectometers (hm^2)
barrels (bbl), (petroleum, 1 bbl = 42 gal)	0.1590	cubic meters (m^3)
cubic feet per second (ft^3/s)	0.2832	cubic meters per second (m^3/s)
cubic feet per second per square mile [$(ft^3/s)/mi^2$)	0.0193	cubic meters per second per square kilometer [$(m^3/s)/km^2$)
feet (ft)	0.3048	meters (m)
gallons (gal)	3.785	liters (L)
gallons per day (gal/d)	3.785	liters per day (L/d)
gallons per minute (gal/min)	0.06309	liters per second (L/s)
gallons per minute per foot [(gal/min)/ft]	0.3070	liters per second per meter [(L/s)/m]
grains per gallon (gr/gal)	17.1	milligrams per liter (mg/L)
inches (in.)	2.54	centimeters (cm)
micromhos (μmho)	1.0	microsiemeus (μS)
miles (mi)	1.609	kilometers (km)
million gallons (Mgal)	3785	cubic meters (m^3)
million gallons per day (Mgal/d)	3785	cubic meters per day (m^3/d)
square miles (mi^2)	2.590	square kilometers (km^2)
tons (short)	0.9072	metric tons or tonnes (t)

Equations for temperature conversion for degrees Celsius (°C) and degrees Fahrenheit (°F):

$$°C = 5/9\ (°F-32)$$
$$°F = (9/5°C) + 32$$

WATER RESOURCES OF THE CLARION RIVER AND REDBANK CREEK BASINS, NORTHWESTERN PENNSYLVANIA

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ABSTRACT

The Clarion River and Redbank Creek basin occupy 1,280 and 545 square miles, respectively, in northwestern Pennsylvania. The area is mostly in Clarion, Elk, and Jefferson Counties and is approximately 70 miles long and 30 miles wide. All drainage is to the Allegheny River.

Sedimentary rocks of Late Devonian, Early Mississippian, and Pennsylvanian age underlie the area. Rocks of Late Devonian age underlie the entire area and crop out in the deep stream valleys in the north. Lower Mississippian rocks generally crop out in strips along major stream valleys; the strips are narrow in the south and broaden northward. Pennsylvanian rocks cover most of the interfluvial areas between major streams. The Upper Devonian and Lower Mississippian rocks are composed mostly of alternating sandstone and shale. Sandstone may intertongue laterally with shale. The Pennsylvanian rocks are more heterogeneous and contain many commercial coal beds.

The major mineral resources are bituminous coal, petroleum, and natural gas. Nearly all coal production is from strip mining in Clarion, Elk, and Jefferson Counties. Total coal production exceeded 8 million short tons in 1976. The basins are south and east of the major oil-producing regions in Pennsylvania, but more than 50,000 barrels of crude oil were produced here in 1975. Commercial quantities of natural gas are also obtained.

Thirty-three public water-supply systems furnish about two-thirds of the water for domestic use. Surface water is the source of about 90 percent of public-supply water. The remainder is from wells and springs.

In an average year, 64 percent of the precipitation in the Clarion River basin and 60 percent in the Redbank Creek basin leave the area as streamflow. The percentage of annual discharge from each basin that is base runoff averaged 53 and 51 percent, respectively, during 1972-75. Only 4 of 10 stream-gaging stations recorded an average 10-year 7-consecutive-day low flow of at least 0.15 cubic feet per second per square mile.

Most wells are completed in bedrock. Yields of bedrock wells are affected mostly by rock type, type of overburden, topography, depth of water-bearing zones, and by the rate and duration of pumping. Water in the bedrock occurs chiefly along fractures and bedding planes. Most wells get water from several zones. Yielding zones occur less frequently as depth increases, but are reported as much as 400 feet below land surface. Optimum well depth is about 350 feet.

Well yields range from less than 1 to more than 550 gallons per minute. The best bedrock aquifers are the Lower Mississippian rocks, which have a median specific capacity of 4.3 gallons per minute per foot of drawdown compared to medians between 0.38 and 0.67 in the Conemaugh, Allegheny, and Pottsville Groups.

The major water-quality problems are due to high concentrations of iron, manganese, hardness, and acidity. Some of these problems are related to coal mining that has degraded water quality in parts of Clarion, Clearfield, Elk, and Jefferson Counties. Water-quality problems result from the rock composition. Many streams have low alkalinity concentrations and, consequently, have little capacity to neutralize the acid water from coal mines. Large forested areas, with little development, in Elk, Forest, and Jefferson Counties, have good quality water. The water from over three-quarters of the bedrock wells sampled has dissolved-solids concentrations less than 250 milligrams per liter. Water from aquifers of Pennsylvanian age is generally lower in dissolved solids than that from Lower Mississippian aquifers. Salt water is not a problem, except locally in Devonian rocks.

Water from wells on hilltops is generally of better quality than that from wells in valleys (median dissolved solids 140 versus 340 milligrams per liter). In many valleys in Clarion and Jefferson Counties, old abandoned flowing oil and gas wells contribute highly mineralized water to streams. Iron concentrations from these wells may be as much as 100 milligrams per liter and dissolved solids commonly exceed 1,500 milligrams per liter.

A large variety of aquatic invertebrates, mostly insects, inhabit the clean-water streams. In many other streams, the aquatic invertebrate populations have been eliminated or drastically reduced because of exposure to mine drainage.

INTRODUCTION

Purpose and Scope

This report describes and evaluates the water resources of the Clarion River and Redbank Creek basins in northwestern Pennsylvania. Special emphasis is placed on water quality as effected by coal mining and by rock composition. This appraisal should provide information needed for the orderly management and development of the water resources.

This is the third of three reports on the area by the U.S. Geological Survey in cooperation with the Pennsylvania Department of Environmental Resources, Office of Resources Management, and Bureaus of Water Quality Management and Topographic and Geologic Survey. The first two reports (Koester and Lescinsky, 1976; Buckwalter and others, 1979) were compilations of hydrologic data and provide much of the information used for interpretation in this report.

Location and Topography

The study area is in northwestern Pennsylvania and includes 1,850 mi^2 (see cover). It is 70 mi long and 30 mi wide and extends over parts of seven counties. The Clarion River and Redbank Creek basins include 1,280 and 545 mi^2, respectively. An area of 25 mi^2 lies between the two basins. All drainage is to the Allegheny River.

The basins lie entirely in the nonglaciated region of the Allegheny Plateaus. The topography is characterized by rounded hills, steep-sided valleys, and some flat upland. Flood plains are generally narrow and discontinuous.

Climate

Winters are cold and summers mild. December, January, and February temperatures average below freezing. Temperatures in July and August average about 70°F and may exceed 90°F for 5 to 10 days each year. The frost-free season averages 160 days a year at East Brady in the southwest and 80 days at Clermont in the northeast.

Precipitation is fairly evenly distributed throughout the year, though winter precipitation is usually 3 or 4 in. less than summer rainfall. Figure 1 shows the distribution of mean annual precipitation during 1971-77.

Population and Culture

The population is about 126,000 or 70 per square mile. (From data of the U.S. Bureau of Census, 1971.) Approximately 64 percent of the population live in communities of more than 500. The population decreased slightly during the 1960's, but the Pennsylvania Department of Commerce (1975) predicts a slight increase for the 1970-80 period because of the recent completion of Interstate Highway 80 and the anticipated expansion of activities concerned with the extraction of coal, gas, and oil for energy needs.

A large part of the area is forested; most of the remainder is classified agricultural. Table 1 gives the percentage distribution of land use in the categories of forests, agriculture, urban areas, and strip mines.

Mining, lumbering, and oil and gas extraction are the mainstays of the economy, but agriculture and manufacturing are also important. Hunting, fishing, and camping are seasonally important in some areas. In places, the seasonal recreational population commonly exceeds the permanent population.

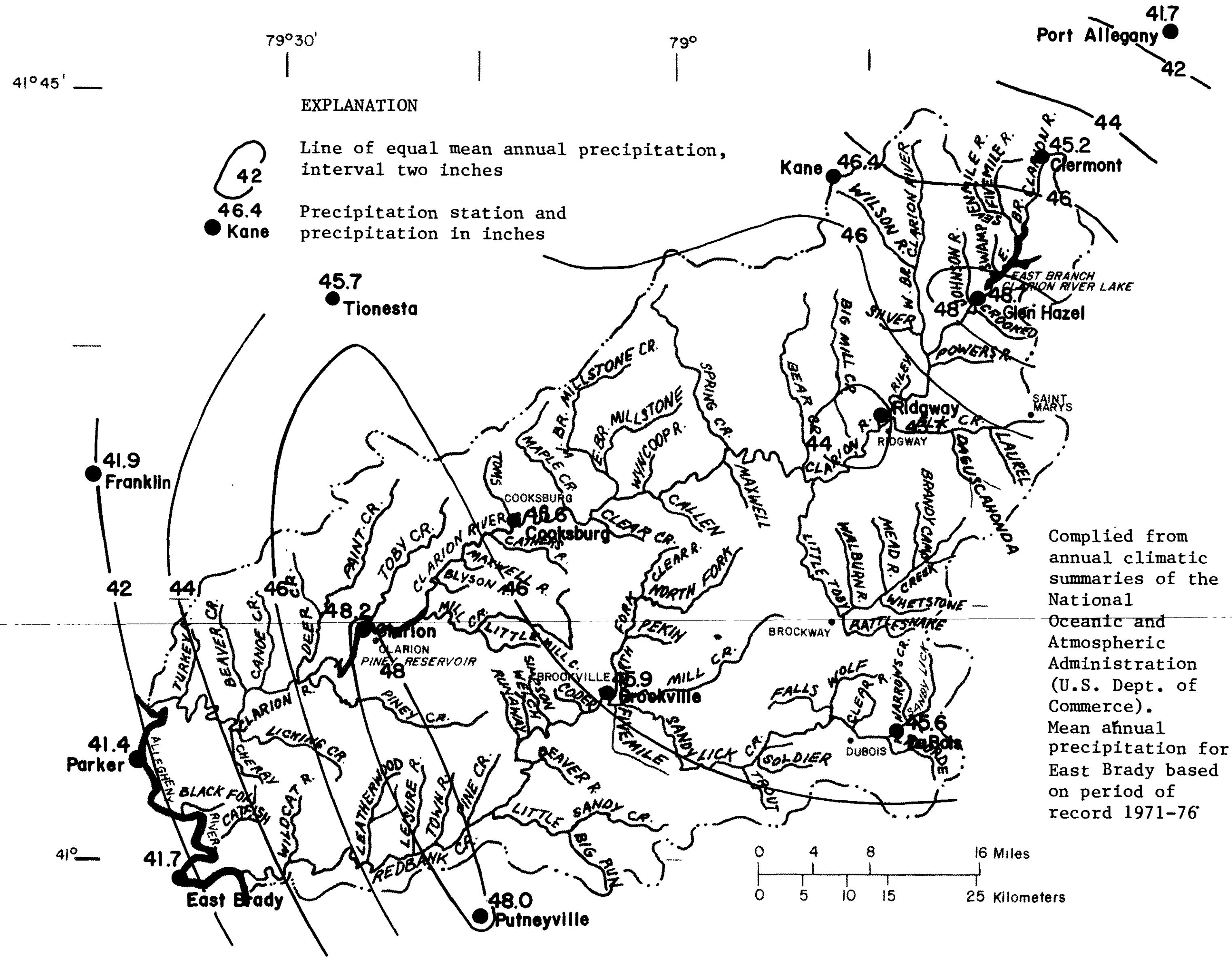


Figure 1.--Distribution of mean annual precipitation, 1971-77.

Table 1.--Percentage distribution of land use

County	Area		Percentage distribution of land use			
	Square mile	Percentage of total	Forests	Agriculture[1/]	Urban[2/] areas	Strip mines
Armstrong	26	1.4	53	37	7.7	2.3
Clarion	541	29.2	62	24	6.5	7.5
Clearfield	65	3.5	54	12	24	10
Elk	529	28.6	90	4.9	3.7	1.4
Forest	101	5.5	92	6.0	2.0	.0
Jefferson	512	27.7	68	19	7.5	5.5
McKean	76	4.1	93	5.5	1.2	.3
Total	1,850	100.0				

[1/] Includes open area, crop land, and pasture.

[2/] Includes right-of-way, roads, and highways.

Water Use

Both surface water and ground water are used for supply. Thirty-three public water-supply systems furnish about two-thirds of the water for domestic use. The other third is from privately owned wells and springs. The total average daily pumpage for all public supplies is approximately 10 Mgal, nearly 1.4 Mgal of which is imported from outside the area. The total average daily pumpage for all private supplies, assuming an average use per person of 50 gal/d, is estimated at 2 Mgal. Surface water is the source of about 90 percent of all public-supply water. The other 10 percent is from wells and springs. Data on public-supply facilities are given in table 2.

An average household can be supplied by a well that is pumped on demand at 3 gal/min. A well yield of 1 gal/min may also suffice, if adequate storage is available and water is conserved. Two wells that each yield 25 gal/min may be adequate to supply 125 homes, assuming 500 gal/d per family, if storage is sufficient and a standby for emergencies is dependable.

GEOLOGY

General

Sedimentary rocks of Late Devonian, Early Mississippian, and Pennsylvanian age underlie the area (plate 1). A composite stratigraphic section is presented in table 3. The stratigraphic nomenclature in this report generally follows the usage of the Pennsylvania Topographic and Geologic Survey.

Stratigraphy

Devonian System

Catskill Formation

The Catskill Formation is composed of nonmarine, red, grayish-red, and greenish-gray shale and siltstone with thick sandstone interbeds locally present. The proportion of red clastic rocks decreases westward. This formation is equivalent to the marine Venango Formation of Crawford, Erie, and Venango Counties. The Catskill Formation crops out only in one valley in the east-central part.

Oswayo Formation

The Oswayo Formation is composed of interbedded greenish-gray to gray shale, siltstone, and sandstone and becomes increasingly shaly westward. It is equivalent to the Riceville Formation of Crawford, Erie, and Venango Counties. The Oswayo Formation crops out along streams in the deep valleys in the north, but is not differentiated in plate 1.

Table 2.--Public water supplies

[Data from Pennsylvania Department of Environmental Resources files, State Water Plan, 1970]

Water company or authority	Source	Population served	Average daily pumpage (gal)
Clarion County			
Corner Water Supply and Service	2 wells, 2 standby wells	522	44,000
East Brady Water Works Co.	1 well, 1 spring	1,181	51,000
Foxburg Area Water and Sewer Authority	3 wells	380	23,000
Fryburg Water Co.	3 wells	181	12,000
Hawthorn Area Water Authority	Redbank Creek	832	53,000
Knox Borough	7 wells	1,306	99,000
Perryville Water Association	3 springs	133	6,000
Redbank Valley Municipal Authority	Redbank Creek	2,342	317,000
Rimersburg Water Works	2 wells	1,352	72,000
Shippenville Borough Water Works	3 wells	641	47,000
Sligo Borough Water Department	1 well	825	60,000
St. Petersburg Borough Water Co.	2 springs	461	33,000
West Freedom Water Association	3 wells, 1 spring	60	6,000
Western Pennsylvania Water Co., Clarion District	Clarion River, 7 wells	7,759	565,000
Clearfield County			
City of DuBois Water Department	Anderson Creek	13,038	1,395,000 [1/]
Treasure Lake of Pennsylvania, Inc.	1 well	1,000	170,000
Elk County			
Brockport Area Water Association, Inc.	Brockway Borough Municipal Authority.	279	14,000
Crystal Springs Park Water Co.	2 springs	400	20,000
Fox Homes Improvement Association, Inc.	1 well, 2 springs	521	30,000

Table 2.--Public water supplies--Continued
[Data from Pennsylvania Department of Environmental Resources files, State Water Plan, 1970]

Water company or authority	Source	Population served	Average daily pumpage (gal)
Elk County (continued)			
Johnsonburg Municipal Authority	Powers Run, Silver Creek, 5 wells.	4,304	410,000
Municipal Authority of the Township of Fox	Lost Run	298	16,000
Ridgway Borough Water Works	Big Mill Creek	6,976	1,882,000
St. Marys Area Joint Water Authority	Laurel Run	12,951	2,324,000
Wilcox Water Co., Inc.	2 wells, 5 springs	605	23,000
Forest County			
Marienville Water Supply Co.	4 wells, 3 springs	1,200	42,000
Jefferson County			
Brockway Borough Municipal Authority	Rattlesnake Creek, Whetstone Branch, 2 wells.	3,858	737,000
Brookville Borough Water Department	North Fork	4,814	530,000
Falls Creek Borough Water Department	Falls Creek	1,286	170,000
Knoxdale Water Co.	1 well	152	8,000
Peoples Water Co. of Summerville	2 wells, 2 springs	816	34,000
Reynoldsville Water Authority	East Branch Pitch Pine Run, Pitch Pine Run, 4 wells, 4 springs.	2,871	172,000

Table 2.--Public water supplies--Continued

[Data from Pennsylvania Department of Environmental Resources files, State Water Plan, 1970]

Water company or authority	Source	Population served	Average daily pumpage (gal)
McKean County			
Western Pennsylvania Water Co., Mount Jewett District.	4 wells, 4 springs	1,000	70,000

1/ All water is imported from outside the study area.

Table 3.—Composite stratigraphic section

System	Series, group or formation	Maximum thickness (ft)	Lithology	Water-bearing characteristics
Quaternary	Alluvium	0 - 70+	Unconsolidated, heterogeneous deposits of clay, sand, gravel, and boulders.	Yields of wells range widely depending on sorting and thickness of deposits. Few data available; yield could probably exceed 500 gal/min.
	Colluvium	0 - 40+	Unconsolidated, heterogeneous deposits of silt, sand, gravel, and boulders.	Yields of wells probably small. Few data available.
Pennsylvanian	Conemaugh Group	450	Sandstone, siltstone, shale, thin limestones, thin coals, and some red beds.	Yields of wells range from 1 to 30 gal/min. Median yield is 10 gal/min.
	Allegheny Group	300 - 325	Sandstone, siltstone, shale, limestone (Vanport Limestone), and several commercial coals.	Yields of wells range from 0 to 254 gal/min. Median yield is 10 gal/min.
	Pottsville Group	60 - 240	Generally two massive sandstones separated by shale and coal. Upper sandstone is thin or absent locally.	Yields of wells range from 0 to 300 gal/min. Median yield is 10 gal/min.
Mississippian	Lower Mississippian Series.	200 - 700	Sandstone, siltstone, shale, some red beds, and locally flat-pebble conglomerate.	Yields of wells range from 1 to 550 gal/min. Median yield is 25 gal/min.
Devonian	Oswayo Formation	150 - 200	Interbedded shale and sandstone.	Yields of wells probably small. No data available.
	Catskill Formation	0 - 350	Red to grayish-red shale with some sandstone.	Probably not an aquifer.

Mississippian System

Lower Mississippian Series, undifferentiated

The rocks of the Lower Mississippian Series consist of greenish-gray to gray sandstone, siltstone, and shale; locally flat-pebble conglomerate; and some red beds. They generally crop out in the south in narrow strips that broaden northward along major stream valleys. In ascending order, the formations are the Cussewago Sandstone, Bedford Shale, and Corry Sandstone (or their equivalent the Knapp Formation), the Cuyahoga Group, Shenango Formation, and Burgoon Sandstone. In the southeast corner, the stratigraphic interval is correlative with the Lower Mississippian part of the Huntley Mountain Formation of Late Devonian and Early Mississippian age (Berg and Edmunds, 1979).

The Mississippian and Pennsylvanian rocks in northwestern Pennsylvania are separated by an extensive, though somewhat obscure, regional unconformity. Evidence for the unconformity has been reviewed by Berg and Glover (1976) and by Edmunds and Berg (1971). The unconformity truncates southward-dipping Mississippian strata, so that the thickness of the strata range from 200 feet in the north to 700 feet in the south.

Pennsylvanian System

Pottsville Group

The Pottsville Group generally consists of two gray to white sandstones separated by subordinate amounts of gray to black shale and several coal beds. The base of the lower sandstone may be conglomeratic. Locally, some coal beds are of economic value. In ascending order, the group consists of the Olean Conglomerate, and the Connquenessing, Mercer, and Homewood Formations. The Olean is present only in the north. Locally, the Homewood Formation may be thin or absent. The Pottsville Group generally crops out in small valleys in the south and over much of the interfluvial areas of the major streams in the north.

Allegheny Group

The Allegheny Group is composed of cyclic sequences of tan to white sandstone, tan to gray siltstone, gray shale, limestone, and coal. Locally, the sandstones are massive and many commercial coal beds are present. The group consists, in ascending order, of the Clarion Formation, Vanport Limestone, and Kittanning and Freeport Formations and extends from the base of the Brookville coal to the top of the Upper Freeport coal. The Allegheny Group crops out over much of the interfluvial regions of the major streams in the south but is generally confined to the high hills in the north.

Conemaugh Group

The Conemaugh Group is composed of cyclic sequences of tan to white sandstone; tan to gray siltstone; red and gray shale; thin, fresh water limestone; and thin, nonpersistent coal. The sandstone may be massive to thin bedded. Locally, the Conemaugh contains commercial coal beds. The group extends from the top of the Upper Freeport coal to the base of the Pittsburgh coal and, in ascending order, consists of the Glenshaw and Casselman Formations. The boundary between the two formations is the top of the Ames Limestone Member of the Glenshaw (commonly a marine limestone). The massive Mahoning Sandstone Member of the Glenshaw is commonly present at the base of the group. The Glenshaw is confined to the higher hills in the southern and east-central parts of the area. The Casselman Formation is present only on hilltops in the southeast corner.

Quaternary System

Colluvium

The colluvium is composed of unconsolidated, heterogeneous deposits of silt, sand, gravel, and boulders. It is derived from weathered bedrock, and is generally found at the base of slopes, where it has moved chiefly by gravity.

Alluvium

The alluvium consists of unconsolidated and generally heterogeneous, water-laid deposits of clay, sand, gravel, and boulders. It generally occurs as discontinuous terrace and flood-plain deposits. The alluvium in the major valleys may be as thick as 70 ft, but is commonly less than 50 ft. Along tributary streams, both the terrace and flood-plain deposits become thinner with increased distance from the main streams. Little data are available on the thickness and texture of these deposits.

Structure

Folds

The rocks have been deformed into a series of gentle folds whose axes trend northeast (plate 1). These folds or structural ridges (anticlines) and troughs (synclines) are superposed on a broader structure beneath the Mississippian-Pennsylvanian unconformity that dips southward.

Folding is least in the northwest, but becomes more pronounced southeastward. Fold heights (structural relief), wavelengths, and dips along flanks of folds all increase southeastward. Most folds plunge southwest, although many are doubly plunging. Vertical distances between the bottom of synclines and the top of adjacent anticlines generally range from 50 ft in the northwest to 1,350 ft in the southeast. Wavelengths, measured between two adjacent anticlinal or synclinal axes, range from 6 to 9 mi. Dips along the flanks of folds commonly range from 30 to 250 ft/mi and the rate of plunge from 15 to 150 ft/mi.

Fractures

Faults

Although faults have been indentified in the Allegheny Plateau in the subsurface (Cate, 1961), those that have topographic expression are rare. Of particular significance, therefore, is the major fault recognized by Berg and Glover (1976) that has topographic expression along Mountain Run on the southern flank of Boone Mountain anticline (plate 1). This fault follows the same northeast trend as the fold axes. Berg and Glover interpret the Mountain Run fault as a nonplanar, steeply dipping reverse fault that has the upthrown block in the northwest side. The maximum displacement along the fault is approximately 400 ft.

Joints

Most joints are nearly vertical and consist of two prominent sets bearing N. 30°-60° E., and N. 30°-50° W. Thus, the sets are roughly at right angles and are parallel and at right angles to the axes of the major folds.

Fracture traces

Fracture traces are natural linear features consisting of topographic, vegetal, or soil tonal alinements visible primarily on aerial photographs. They may appear on land surface as shallow, straight-line depressions and may be found in any topographic position. Parizek and others (1971) report that in Illinois fractures are detectable as fracture traces, although covered by as much as 150 ft drift. The traces are probably the surface expression of concentrated fracture zones (faults or joints) in the underlying bedrock; in places where the fractures are not concentrated, the traces may be discontinous. Field evidence indicates that the rock fractures associated with traces are near vertical in attitude (Blanchet, 1957).

Mineral Resources

The major mineral resources are bituminous coal, petroleum, and natural gas. Other mineral resources include clay and shale, limestone, sand and gravel, and construction stone.

The Clarion River and Redbank Creek basins have been important producers of coal for over a century. Most of the coal seams mined are in the Allegheny Group. Coal production is now nearly all from strip mines in Clarion, Elk, and Jefferson Counties. In 1976, for example, deep mining accounted for only about 1 percent of the total coal production of these counties. Total coal production that year exceeded 8 million short tons. Annual coal production data for the three counties for 1945-76, inclusive, are presented in figure 2.

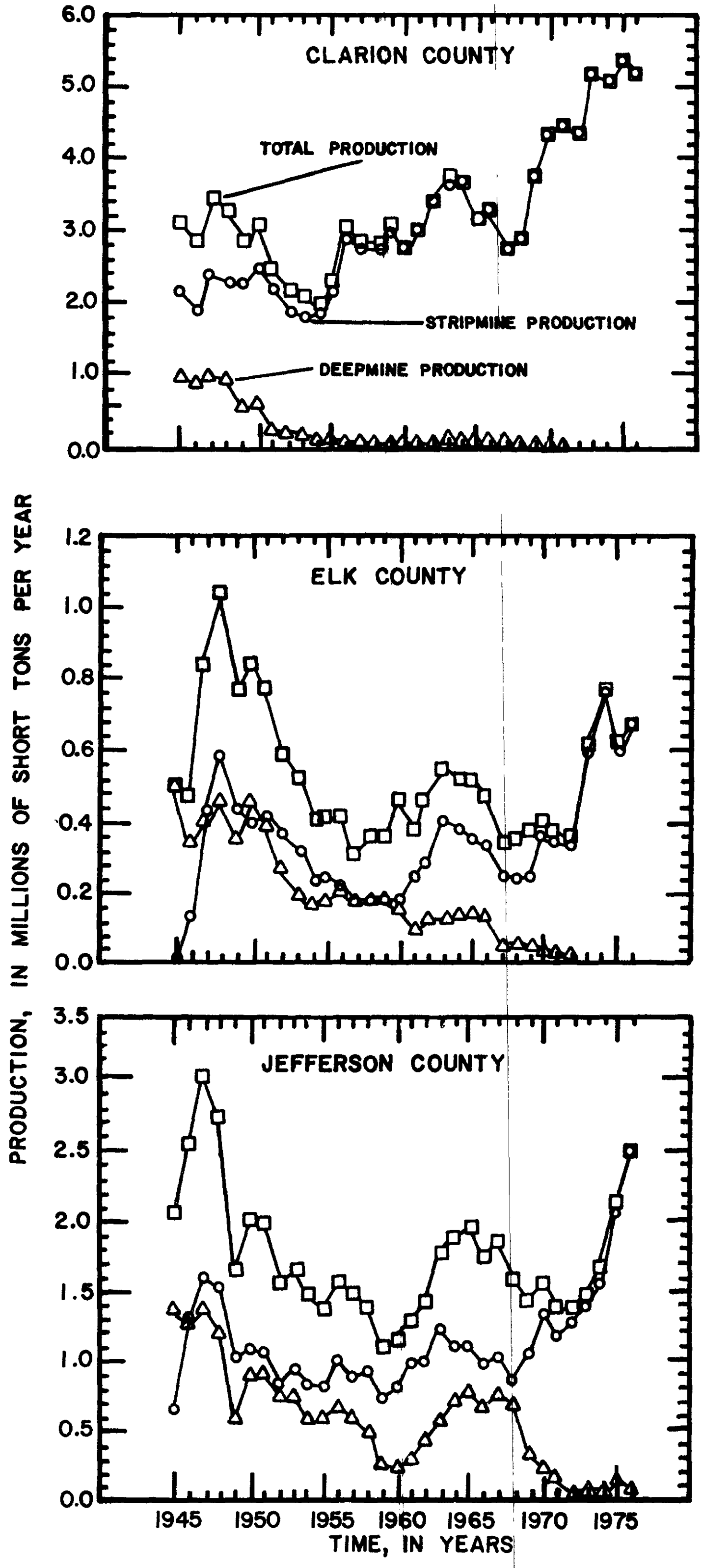


Figure 2.--Annual coal production for Clarion, Elk, and Jefferson Counties for 1945-76, inclusive. (Data from Pennsylvania Department of Mines and Mineral Industries and from Pennsylvania Department of Environmental Resources.)

Clarion County ranked 8th out of the 27 bituminous coal producing counties in total coal production in 1976, with nearly 5.2 million short tons; Elk County ranked 16th, with over 670 thousand short tons; and Jefferson County ranked 12th, with nearly 2.5 million short tons. Recoverable coal reserves for Clarion County are estimated at 630 million short tons, and strippable coal reserves are estimated at 189 million short tons. Recoverable coal reserves for Elk County are estimated at 140 million short tons. Recoverable coal reserves for Jefferson County are estimated at 1,200 million short tons, and strippable coal reserves are estimated at nearly 140 million short tons. (See Edmunds, 1972.)

The recent upward trend in total coal production in Clarion, Elk, and Jefferson Counties reflects increased demand. Nearly all production comes from strip mines, and this will probably continue. The outlook for continued growth of the coal industry is good, owing to abundant strippable coal reserves and encouragement from the Federal Government to develop domestic energy resources.

The Clarion River and Redbank Creek basins are south and east of the major oil-producing regions in Pennsylvania, but, nevertheless, produce modest amounts of crude oil. Oil production has fluctuated somewhat during the past decade, but significant increases are unlikely. Clarion County ranked 11th of 18 counties in crude oil production in 1975, with 23,264 bbl; Elk County ranked 10th, with 24,239 bbl; and Jefferson County ranked 16th, with 2,714 bbl. (See Lytle and others, 1977, p. 20.) Commercial quantities of natural gas are also produced in these counties.

SURFACE-WATER HYDROLOGY

General

Streamflow data have been collected by the Geological Survey as part of a long standing cooperative, systematic monitoring program. These data have been published annually for water years 1961-74 in "Water Resources Data for Pennsylvania, Part 1: Surface Water Records." Beginning with the 1975 water year and continuing as an annual series, surface-water and water-quality records are published in "Water Resources Data for Pennsylvania, Volume 3: Ohio River and St. Lawrence River Basins."

Surface-water and water-quality data were collected at 11 continuous record stream-gaging stations. Their locations are shown in figure 3, and their period of record is given in table 4. Data from about 140 miscellaneous sites were also collected. These are summarized in a report by Koester and Lescinsky (1976). All analyses of streamflow are based on records for water years (October 1 to September 30), unless otherwise noted. Streamflow on the Clarion River is affected by two impoundments: East Branch Clarion River Lake and Piney Reservoir (see fig. 3). Selected physical data on the impoundments are given in table 5.

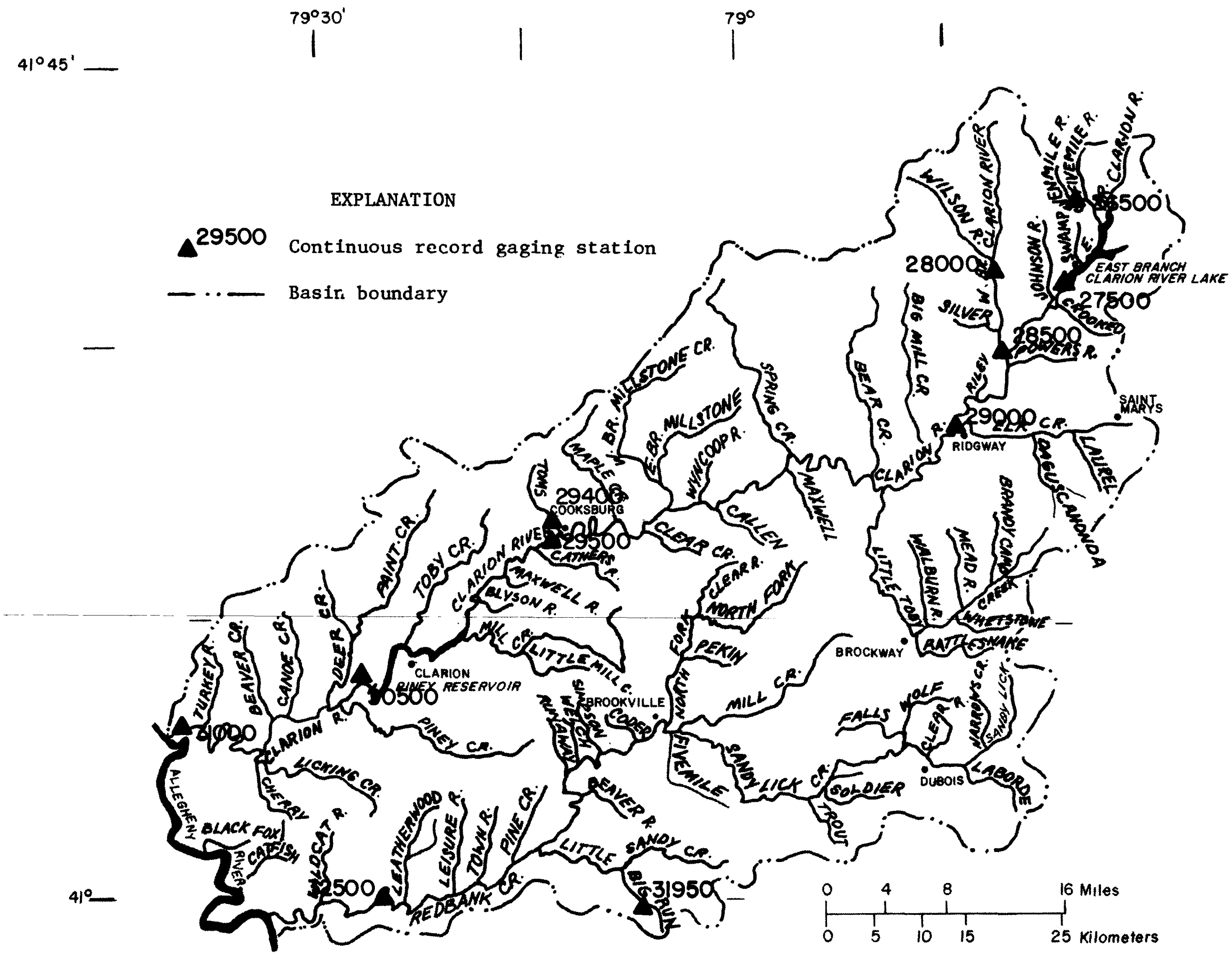


Figure 3.--Location of stream-gaging stations.

Table 4.--Continuous streamflow stations

Station number and name		Location (7½-minute quadrangle)	Drainage area (mi^2)	Period of record
26500	Sevenmile Run near Rasselas.	Hazel Hurst	7.84	1951 to present.
27500	East Branch Clarion River at East Branch Clarion River Dam.	Glen Hazel	73.2	1948 to present.[1/]
28000	West Branch Clarion River at Wilcox.	Wilcox	63.0	1953 to present.
28500	Clarion River at Johnsonburg.	Ridgway	204	1945 to present.[1/]
29000	Clarion River at Ridgway.	Ridgway	303	1954 to present.[1/,2/]
29400	Toms Run at Cooksburg.	Cooksburg	12.6	1959 to 1978
29500	Clarion River at Cooksburg.	Cooksburg	807	1938 to present.[1/]
30500	Clarion River near Piney.	Clarion	951	1944 to present.[3/]
31000	Clarion River at St. Petersburg.	Emlenton	1,246	1942 - 1953 1972 - 1977[2/]
31950	Big Run near Sprankle Mills.	Valier	7.38	1963 to present.
32500	Redbank Creek at St. Charles.	Templeton	528	1910 to present.

1/ Flow regulated since June 1952 by East Branch Clarion River Dam.
2/ Record unpublished.
3/ Flow regulated by East Branch Clarion River Dam since June 1952 and by hydroelectric plant at Piney Dam.

Table 5.--Selected information for East Branch Clarion River Lake and Piney Reservoir

Reservoir name	East Branch Clarion River Lake	Piney Reservoir
Stream impounded	East Branch Clarion River	Clarion River
County	Elk	Clarion
7 1/2-minute quadrangle	Glen Hazel	Clarion, Strattanville
Dam location		
latitude	41°33'35"	41°11'30"
longitude	78°35'40"	78°26'02"
Drainage area (mi^2)	72.4	957.0
Surface area (acres)1/	1,160	690
Capacity (acre-ft)	84,300	33,800
Length (mi)1/	5.7	12
Year built	1952	1924
Owner	U.S. Army Corps of Engineers	Pennsylvania Electric Co.
Purposes	Flood control Low-flow augmentation Recreation	Electric power generation Recreation

1/Summer pool.

Runoff

Runoff has a distinct seasonal pattern. The period of greatest runoff is generally March and April, the least, August and September. Due to melting of snow, runoff commonly exceeds precipitation during March and April when about 25 to 30 percent of the total runoff for the year occurs (table 6). The minimum runoffs, in August, result mostly from the high evapotranspiration rates.

In an average year, over half the annual precipitation reaches the streams. For the stations Clarion River at St. Petersburg and Redbank Creek at St. Charles, the average annual runoff is 64 and 60 percent, respectively, of the precipitation.

Low-Flow Frequency

Low-flow frequency characteristics provide information useful for planning utilization of streamflow. The low-flow frequency most often used is the 7-day, 10-year low flow. The State Water Plan (Chiang and others, 1975, p.50) recommends a 7-day, 10-year low flow of at least 0.15 $(ft^3/s)mi^2$ to prevent degradation of water quality and to aid in the assimilation of pollutants. Table 7 shows that only 4 of the 10 continuous recording stations (27500, 28500, 29000 and 29500) have low flows of this magnitude. Low-flow discharge at stations 27500, 28500, 29000 and 29500 is regulated.

Low-flow characteristics for ungaged streams can be computed by correlating base-flow measurements with records from a nearby long-term gaging station. Table 8 gives data on low-flow frequency for four stations, derived from such correlation. (See figure 10 for locations.)

Flow Duration

The magnitude and variability of streamflow are dependent upon basin characteristics such as size, slope, shape, altitude, geology, and stream density as well as climatic conditions. Because basins have different physical characteristics and climatic conditions, their streamflow also differs. These differences in streamflow can be shown by flow-duration curves. A flow-duration curve shows the percentage of time any magnitude of discharge was equaled or exceeded during a given period, regardless of the flow sequence.

The shape of the duration curve reflects the hydrologic and geologic characteristics of the drainage basin. The high-flow end of the curve is related chiefly to climate, topography, and land cover. The low- or base-flow end is related mostly to the geology of the basin. A curve that is steep throughout indicates flows of a highly variable stream that has much direct runoff. A flat curve indicates the availability in the basin of enough surface-water or ground-water discharge from storage to moderate streamflow.

Table 6.--Average monthly precipitation and streamflow for the Clarion River and Redbank Creek basins, 1971-75

Month	Precipitation (in.)	Streamflow (in.)
Clarion River at St. Petersburg (1,246 mi^2)		
October	3.0	1.0
November	3.3	1.6
December	3.7	2.4
January	2.8	3.3
February	3.0	3.5
March	3.7	3.7
April	3.0	3.7
May	4.0	3.5
June	6.5	3.7
July	3.4	1.2
August	4.3	.5
September	4.5	.9
Total	45.2	29.0
Redbank Creek at St. Charles (528 mi^2)		
October	2.6	1.0
November	3.2	2.0
December	4.0	3.0
January	3.0	3.4
February	3.4	3.7
March	3.9	4.0
April	3.1	3.6
May	3.8	2.6
June	6.3	2.1
July	3.5	.9
August	4.4	.5
September	4.9	1.1
Total	46.1	27.9

Table 7.--Magnitude and frequency of annual low flow

Station number	Station name Period of record Drainage area	Period of consecutive days	Discharge, in cubic feet per second, for indicated recurrence interval, in years: 2	5	10	20	40	50	7-day 10-year discharge in $(ft^3/s)/mi^2$
26500	Sevenmile Run near Rasselas	7	0.4	0.2	0.1	0.1	0.1	0.09	0.01
	1953-72	14	.5	.3	.2	.2	.1	.1	
	7.84 mi²	30	.7	.4	.3	.2	.2	.2	
		60	1.0	.5	.4	.3	.2	.2	
		120	1.7	.8	.5	.4	.4	.3	
27500	East Branch Clarion River at	7	22.7	16.5	14.1	12.4	11.2	10.8	.19
	East Branch Clarion River Dam	14	24.9	18.3	15.7	13.9	12.5	12.1	
	1953-75	30	29.7	21.0	17.6	15.3	13.5	13.0	
	73.2 mi²	60	37.0	25.5	21.1	18.1	15.9	15.3	
		120	62.3	37.1	28.1	22.2	18.2	17.0	
28000	West Branch Clarion River at	7	9.4	8.5	5.8	5.3	4.6	4.5	.09
	Wilcox	14	10	7.0	6.2	5.8	4.8	4.7	
	1955-72	30	12	7.7	6.8	6.3	5.6	5.4	
	63.0 mi²	60	14	9.4	8.6	8.0	6.6	6.4	
		120	23	13	11	9.6	9.0	8.8	
28500	Clarion River at Johnsonburg 1/	7	114	79.3	61.7	48.4	38.5	35.4	.30
	1952-75	14	121	84.2	65.4	51.3	40.5	37.5	
	204 mi²	30	137	91.8	70.9	55.8	45.2	41.4	
		60	178	114	84.1	62.6	47.0	42.8	
		120	228	147	105	75.3	54.4	48.5	
29000	Clarion River at Ridgway 1/	7	120	85	70	58	46	43	.23
	1954-75	14	135	96	77	64	50	46	
	303 mi²	30	150	105	81	71	56	49	
		60	180	127	111	84	67	62	
		120	250	158	130	106	86	80	
29400	Toms Run at Cooksburg	7	1.1	.7	.5	.4	--	--	.04
	1961-72	14	1.2	.8	.6	.5	--	--	
	12.6 mi²	30	1.4	.9	.7	.6	--	--	
		60	1.7	1.2	1.1	1.0	--	--	
		120	2.6	1.7	1.4	1.3	--	--	

Table 7.—Magnitude and frequency of annual low flow—Continued

Station number	Station name Period of record Drainage area	Period of consecutive days	Discharge, in cubic feet per second, for indicated recurrence interval, in years: 2	5	10	20	40	50	7-day 10-year discharge in $(ft^3/s)/mi^2$
29500	Clarion River at Cooksburg 1/	7	260	179	139	110	88.0	81.4	0.17
	1954-75	14	280	191	150	119	96.0	90.0	
	807 mi^2	30	304	205	163	133	111	105	
		60	346	233	189	159	137	130	
		120	469	300	232	186	152	142	
30500	Clarion River near Piney 2/	7	225	127	89.2	64.6	48.5	43.5	.09
	1953-75	14	286	180	134	102	79.0	73.0	
	951 mi^2	30	317	211	167	137	116	109	
		60	394	261	210	174	150	141	
		120	534	343	267	216	178	168	
31950	Big Run near Sprankle Mills	7	0.58	0.45	0.42	--	--	--	.06
	1965-72	14	.67	.52	.47	--	--	--	
	7.38 mi^2	30	.92	.65	.54	--	--	--	
		60	1.2	.88	.72	--	--	--	
		120	2.0	1.4	1.1	--	--	--	
32500	Redbank Creek at St. Charles 3/	7	49	36	32	28	26	25	.06
	1920, 1923-72	14	55	40	35	32	29	28	
	528 mi^2	30	70	50	43	38	34	33	
		60	87	60	50	44	39	38	
		120	145	86	69	57	49	47	

1/ Low flows affected by releases from East Branch Clarion River Lake and by Industrial plants above station.
2/ Low flows affected by releases from East Branch Clarion River Lake and by hydroelectric plant at Piney Dam.
3/ Some regulation by mills above station.

Table 8.--Annual low-flow frequency of four ungaged streams

Gaging station Drainage area		Discharge for 7 consecutive days, in cubic feet per second, for indicated recurrence interval, in years	
		2	10
29185	Spring Creek near Hallton[1/] 86.0 mi^2	10	5.9
30100	Toby Creek near Miola[2/] 29.6 mi^2	5.2	2.9
30860	Little Licking Creek at Sligo[2/] 4.29 mi^2	3.0	2.3
30900	Licking Creek at Callensburg[3/] 51.9 mi^2	46	33

1/From relationship with West Branch Clarion River at Wilcox, using five discharge measurements.

2/From relationship with Toms Run at Cooksburg, using seven discharge measurements.

3/From relationship with Redbank Creek at St. Charles, using four discharge measurements.

Table 9 gives flow durations of 12 gaging stations for selected percentages of time. The data for four nonrecording stations (29185, 30100, 30860, 30900) were estimated by correlation with recording stations. Figures 4 and 5 are flow-duration curves of eight streams on a unit-area (discharge per square mile) basis. Comparison of runoff on this basis removes basin size as a hydrologic factor and leaves climate, geology, topography, and man-made regulation as the chief controls of streamflow. The discharges of small streams are similar in about the 5 to 60 percent range and diverge most at low flow. This divergence probably reflects differences in the geology of the basins because the streams are not regulated. The slight divergence at the high-flow end probably reflects differences in topography or land cover (fig. 5).

Figure 5 shows the effect on the Clarion River by regulation of the East Branch Clarion River Lake. The effect is an increase in low flows at stations Clarion River at Johnsonburg and Clarion River at Cooksburg and a reduction in high flows at Johnsonburg.

When compared to the other mainstream gages, the discharge per square mile of the Clarion River at St. Petersburg is smaller after the 90 percentile is exceeded (fig. 5). These low flows are primarily a result of discharge management at the electric generating facility at Piney Dam, 20 miles upstream. Discharges are restricted, especially during dry periods, to less than 50 ft^3/s to conserve water for generating periods.

Base Runoff

Streamflow can be separated into direct runoff and base runoff. Base runoff is the sustained or fair weather runoff and is largely ground-water discharge. When direct runoff and base runoff separation of streamflow hydrographs are made, the percentage of total flow that is base runoff can be calculated. It is then possible to decide which of several drainage basins has the greatest sustained yield. This information is useful in evaluating streams for potential water supply. The calculated base runoffs for the St. Petersburg and Redbank Creek gages during 1972-75 average 53 and 51 percent, respectively.

A base-runoff recession curve indicates the amount of water released from ground-water storage. The curve may be used to compare ground water yields of stream basins. A high sustained streamflow indicates that a relatively large amount of ground water is available from storage; a low sustained flow indicates the opposite.

Table 9.--Duration of daily discharge

	Gaging station Period of record	Drainage area (mi^2)	Discharge, in cubic feet per second, that was equaled or exceeded for indicated percent of time												
			2	5	10	20	30	40	50	60	70	80	90	95	98
26500	Sevenmile Run near Rasselas, 1953-75	7.84	74	46	32	20	15	10	7.5	5.2	3.2	1.6	0.7	0.5	0.3
28000	West Branch Clarion River at Wilcox, 1954-75	63.0	590	400	280	180	130	94	70	48	33	22	13	9.9	7.6
28500	Clarion River at Johnsonburg, 1953-75	204	1,400	990	750	490	370	300	250	220	190	160	120	94	54
29185	Spring Creek near Hallton[1/]	86.0	780	500	340	220	140	95	65	45	30	20	15	12	9.5
29400	Toms Run at Cooksburg, 1961-75	12.6	104	69	47	30	20	14	8.8	6.0	3.8	2.2	1.4	1.1	.8
29500	Clarion River at Cooksburg, 1953-75	807	6,100	4,500	3,200	2,100	1,500	1,100	840	610	470	370	290	220	150
30100	Toby Creek near Miola[2/]	29.6	190	130	90	65	45	35	25	20	10	8.5	6.0	4.6	3.5
30860	Little Licking Creek at Sligo[2/]	4.27	22	17	13	10	9.0	7.5	6.5	5.5	4.5	3.8	3.2	2.8	2.4
30900	Licking Creek at Callensburg[3/]	51.9	320	200	130	90	65	50	38	30	22	16	12	9.5	7.5
31000	Clarion River at St. Petersburg, 1942-53, 1971-75	1,246	10,500	7,800	5,500	3,600	2,600	1,800	1,200	840	540	320	180	96	66
31950	Big Run near Sprankle Mills, 1963-75	7.38	71	44	29	18	13	10	6.3	4.4	2.9	1.8	1.1	.8	.6
32500	Redbank Creek at St. Charles, 1919-75	528	4,500	3,100	2,200	1,300	890	600	410	280	180	120	75	56	42

1/ Estimated from relationship with West Branch Clarion River at Wilcox.
2/ Estimated from relationship with Toms Run at Cooksburg.
3/ Estimated from relationship with Redbank Creek at St. Charles.

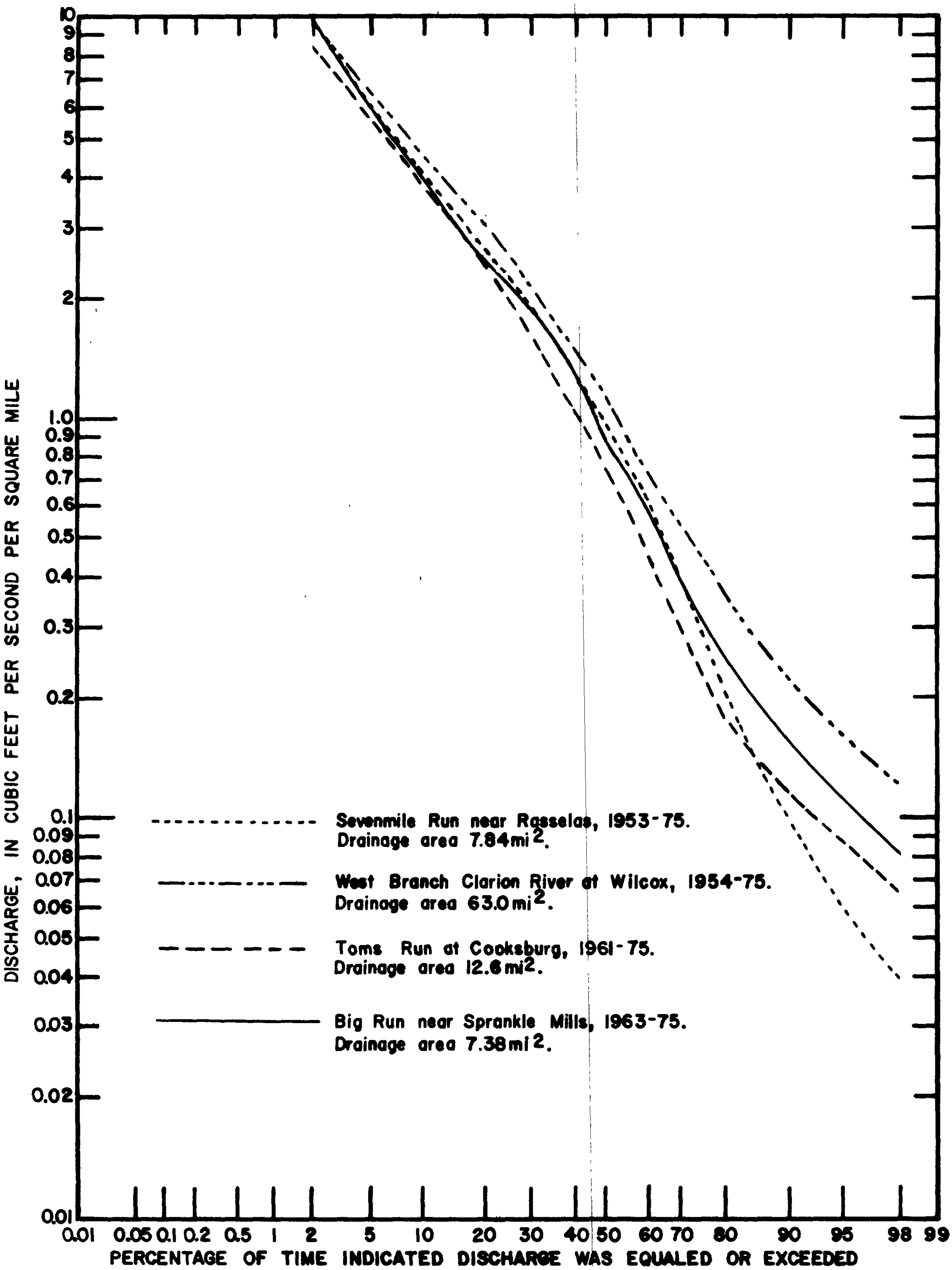


Figure 4.--Duration curves of daily discharge per unit area for selected small streams.

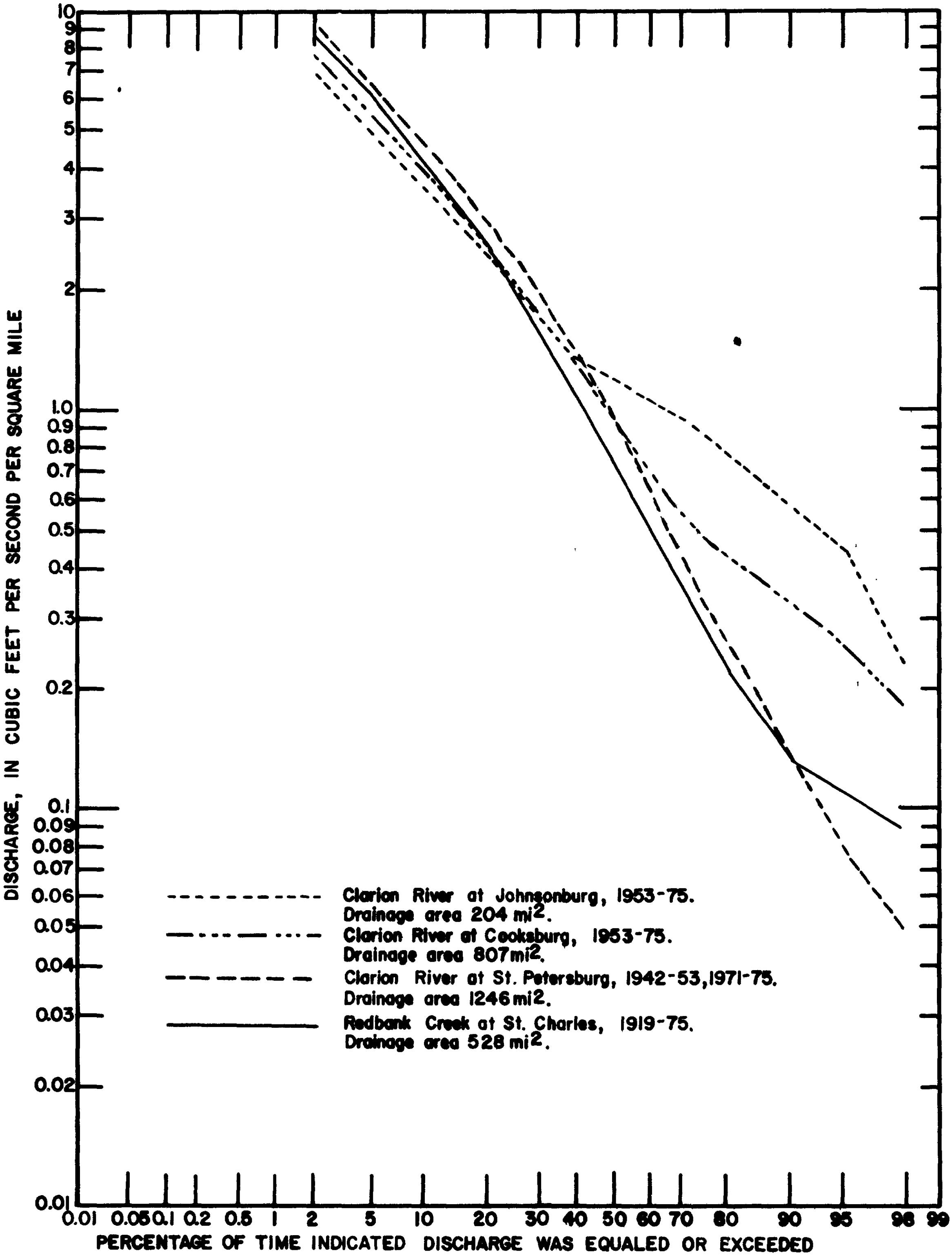


Figure 5.--Duration curves of daily discharge per unit area for selected mainstream gages.

Base-runoff recession curves of selected streams are shown in figure 6. The curves were developed for summer runoff conditions. The base-runoff recession curve for the gaging station Clarion River at Cooksburg shows the greatest sustained streamflow.

Flooding

Knowledge of the frequency, extent, and magnitude of potential floods is essential for the management of flood-prone lands. Flooding may occur at any time of year and is influenced by the size of the basin. Most flooding in basins of more than about 100 mi^2 is in the spring, when melting of accumulated snow cover combines with rain. Small basins are more likely to have floods during the summer, as a result of heavy local thunderstorms.

The flood-frequency characteristics of a stream depend upon many factors. Some of the more significant are the drainage area, precipitation pattern, and topography. Flood-frequency characteristics can be calculated from streamflow records. The reliability of the calculations depends largely upon the length and quality of the records available. Annual peak discharges for several recurrence intervals are shown for five streams in table 10.

For ungaged sites on unregulated streams in Pennsylvania the flood magnitudes for various recurrence intervals can be estimated from equations developed by Flippo (1977). Flood information for regulated streams can be obtained from the Flippo report through the use of discharge profile models.

Flood-Prone Area Maps

Maps showing areas that have a 1 in 100 chance on the average of being inundated during any year are available through several Federal and State agencies. The maps are on standard U.S. Geological Survey 7½-minute topographic sheets and were compiled to assist in minimizing flood losses by identifying areas of potential flood hazards. Figure 7 is an index map that shows the status of the mapping in 1978. More detailed flood information may be required for purposes such as structural designs, economic studies, or formulation of land-use regulations. This detailed information may be obtained from the Geological Survey, other Federal agencies, or State, local, and private agencies.

GROUND WATER HYDROLOGY

Ground water occurs in the Earth in that zone where all openings are saturated. It is in slow but constant movement from areas of recharge to areas of discharge. The materials in which water occurs constitute a complex hydrogeologic framework for the storage and transmission of the water and consist of bedrock, regolith which overlies the bedrock nearly everywhere, and alluvial deposits. Each unit has characteristics and water-bearing properties that determine its utility as a source of supply. If a layer of rock acts as a hydrologic unit and is sufficiently permeable to yield water in usable quantities, the layer is referred to as an aquifer.

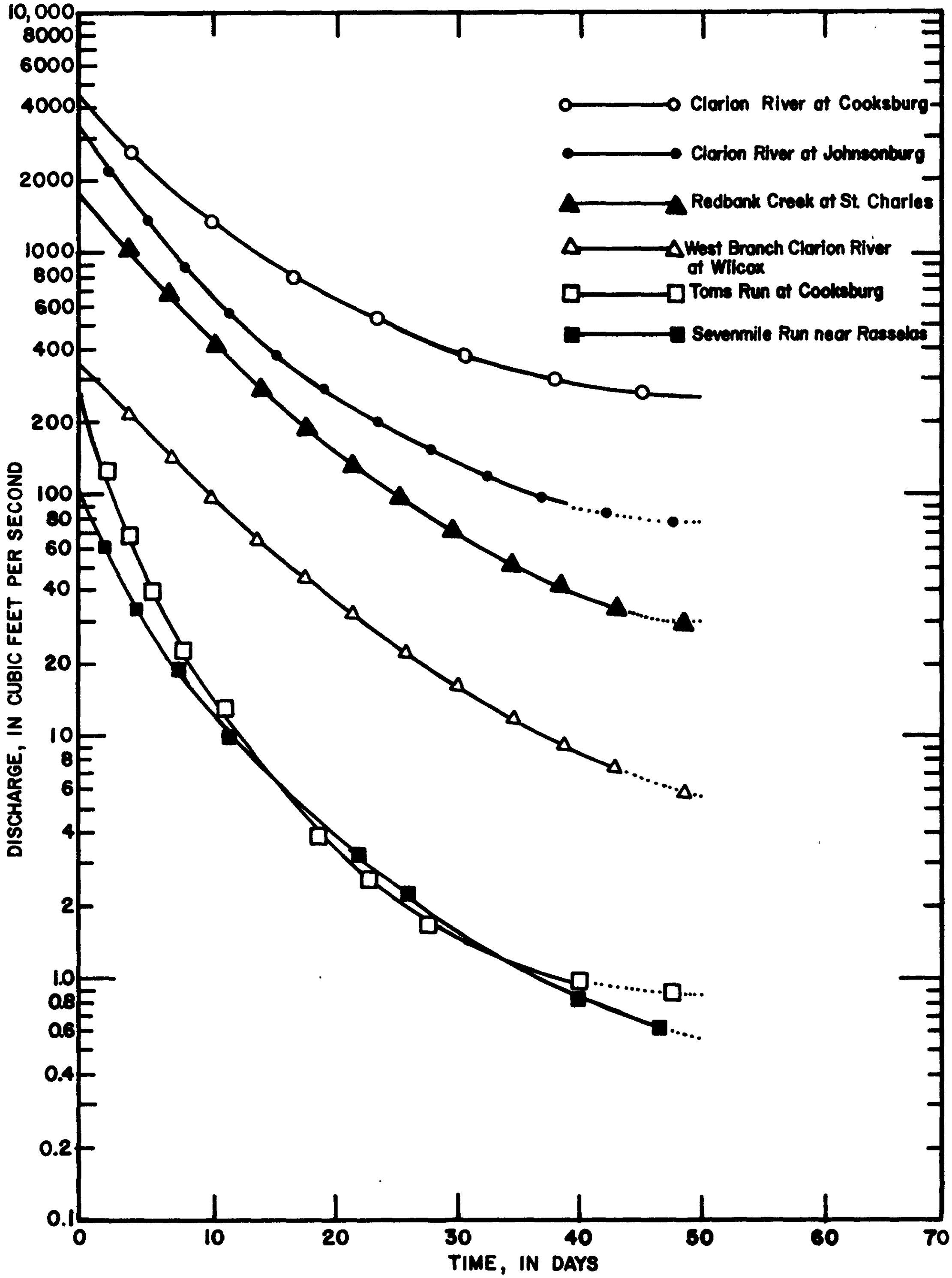
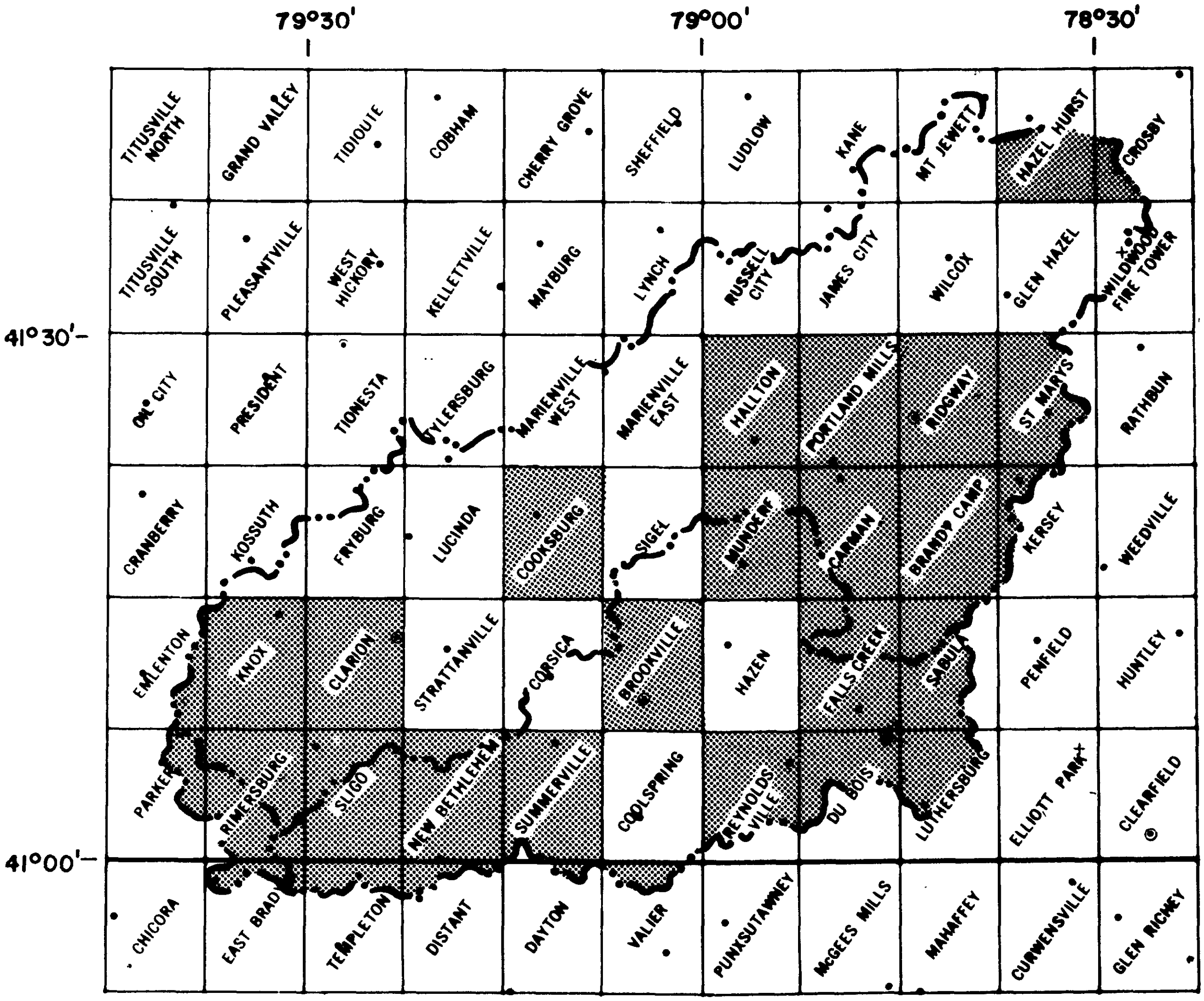


Figure 6.--Base-runoff recession curves of selected streams.

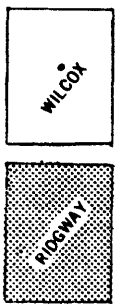
Table 10.--Magnitude of annual peak discharges at selected gaging stations

Gaging Station Period of Record	Drainage area (mi^2)	Discharge, in cubic feet per second, for indicated recurrence interval, in years					
		2.33	5	10	25	50	100
26500 Sevenmile Run near Rasselas, 1952-75	7.84	485	757	1,020	1,410	1,750	1/ --
28000 West Branch Clarion River at Wilcox, 1954-75	63.0	2,300	3,290	4,170	5,400	6,390	1/ --
29400 Toms Run at Cooksburg, 1960-75	12.6	348	484	604	767	896	1/ --
31950 Big Run near Sprankle Mills, 1964-75	7.38	527	712	871	1,080	1/ --	1/ --
32500 Redbank Creek at St. Charles, 1910-75	528	13,100	18,400	23,100	29,900	35,500	41,500

1/ Insufficient period of record to warrant calculation.



EXPLANATION



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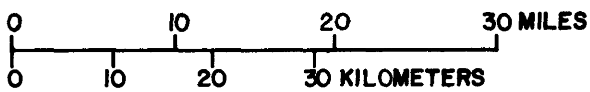


- • Locality for which quadrangle is named
- + Other feature for which quadrangle is named
- ◉ County seat

Figure 7.--Index to flood-prone area maps, 1978.

The yields of wells depend upon the ease of movement of the water through the rock and the amount the rocks can release from storage. In the bedrock, ground water occurs along bedding planes and joints or fractures (called secondary openings) and in spaces between mineral grains (called primary openings). The intensity and distribution of fracturing is related to the lithology and structural history of the rocks. In the alluvium, and to a lesser extent in the regolith, water occurs in primary openings. The character and thickness of the alluvium and regolith are important because, water moving through them will recharge the underlying bedrock. Additionally, the alluvium may be an excellent aquifer; the regolith is not widespread and, thus, is less important.

Recharge, Discharge, and Movement

The pattern of movement of ground water is controlled mostly by the topography, which is highly dissected by major and minor valleys into bedrock "islands", more or less hydrologically isolated. The movement of water in these bedrock islands is downward and then outward toward the valley sides.

Water moves from areas of high head to those of lower head; the paths of flow may be shallow, intermediate, or deep. In most places, recharge moves nearly vertically into a shallow aquifer and eventually into deeper-lying aquifers through overlying units. Under natural conditions, most recharge is on the highlands; discharge occurs in the valleys to small streams descending from the uplands, to major streams, as seeps or springs along hillsides, or from flowing wells. Figure 8 is a generalized sketch showing theoretical paths of movement of water in a multi-aquifer system. Actual movement may differ considerably in places because of the complexity of geologic controls and the activities of man.

Water Levels

Water-level fluctuations are most affected by precipitation patterns and the duration of the growing season. Levels are generally highest in early spring and fall and lowest during the late spring, summer, and early winter. However, midwinter thaws or summer storms can temporarily reverse this seasonal pattern. An analysis of water-level data from observation wells in the report by Buckwalter and others (1979) indicated no annual downward trend between 1971 and 1977.

Depth to water from land surface is dependent chiefly on the topographic position of the well and ranges between wide limits--from wells in valleys that flow, to wells on hilltops in which water levels may be more than 300 ft below the land surface. The median depth to water in bedrock is 28 ft in 11 valley wells and 50 ft in 170 hilltop wells. Water levels in the unconsolidated deposits generally fluctuate less than in bedrock in the same topographic position because the storage capacity and permeability of unconsolidated deposits is greater.

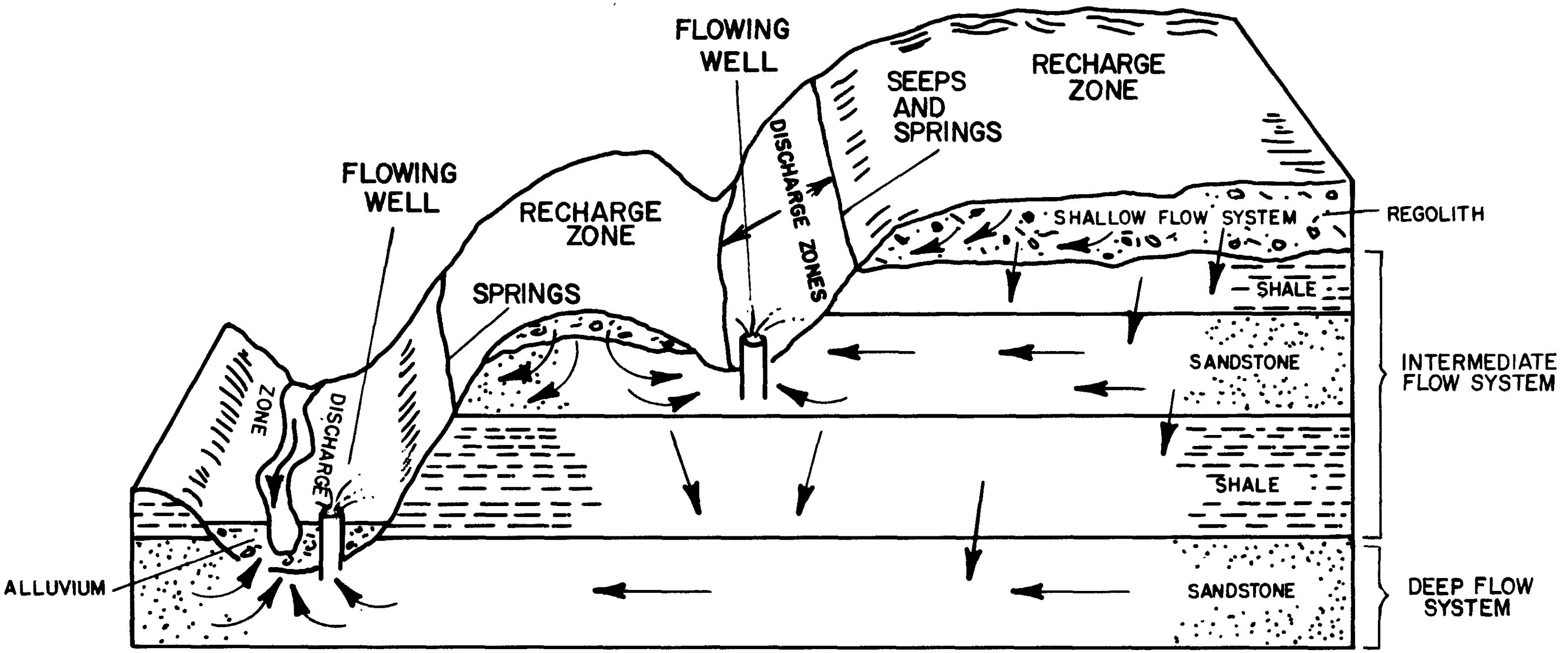


Figure 8.--Sketch showing generalized directions of ground-water movement in a multiaquifer system.

Depth to water below land surface in domestic and nondomestic wells is presented in Buckwalter and others (1979). The depth-to-water data are related to well construction practices of the drillers. Over half of the wells inventoried were finished openhole, with less than 25 ft of surface casing (Buckwalter and others, 1979). Few water bearing zones were reported at depths less than 30 ft; therefore, casing generally did not seal off water-bearing zones. As a well is deepened in a hilltop or recharge area, the head, and thus water level generally is lower as the well casing penetrates points of progressively lower head. Conversely, in a discharge area there is an increase in head with increasing depth of an open end casing, and a corresponding higher water level. Also, where water-bearing zones are separated by layers of low permeability, water levels in wells of the same depth may be different in those wells with less perforated casing, because any shallow water-bearing zones that could have effected the water level are sealed off.

Availability of Ground Water

The availability of ground water is indicated in plate 1 and table 3. Information on yield, specific capacity, depth of wells, and depth to water is summarized in tables 11-13. Hydrologic data on wells are contained in a report by Buckwalter and others (1979).

All geologic units in the study area are water bearing. In general, wells in the north tap aquifers lower in the geologic section than wells in the south and have higher yields. Small to moderate supplies can be obtained in most of the highlands. In places, large yields are obtained from wells in the major stream valleys. However, the quality may not be suitable for domestic use where streams carry acid-mine drainage water. Yields of individual wells, dependent upon complex interrelationships of geology, hydrology, and depth, can differ by hundreds of gallons per minute within a 1-acre lot.

Specific Capacities and Well Yields

The specific capacity of a well is the rate of water, in gallons per minute, that can be pumped for each foot that the water level in the well is lowered. It is roughly linear through moderate ranges. Thus if the specific capacity of a well were constant, the sustained yield of the well could be obtained by multiplying the specific capacity by the number of feet the water level could be lowered. However, specific capacity is not constant, but decreases with increased pumping rates and time. Therefore, a well pumped at 10 gal/min, with 10 feet of drawdown, will not necessarily discharge 20 gal/min, with a 20-foot drawdown. Additionally, with prolonged time, the discharge will decrease or the water level will continue to decline or both.

Specific capacity and reported yield data given in tables 11-13 can be used as a guide in assessing the availability of water in the various geologic units. The data are based mostly on drillers' reports of pumping rate, drawdown, and test duration and thus are subject to errors caused by variations in test conditions and recording of data.

Table 11.--Summary of data on yield, specific capacity, well depth, and depth to water of domestic wells

Aquifer	Number of wells	Range	Percentage of wells in which indicated yield or specific capacity is equaled or exceeded				
			90	80	50	20	10
Yield of wells (gal/min)							
Quaternary System							
Alluvium	8	1- 30	-	-	12	-	-
Pennsylvanian System							
Conemaugh Group	35	1- 30	3	4	9	15	25
Allegheny Group	274	0- 60	2	3	10	20	30
Pottsville Group	328	0-105	3	4	10	20	30
All groups, combined	637	0-105	3	4	10	20	30
Mississippian System							
Lower Mississippian rocks	65	1- 65	3	5	10	29	34
Bedrock, combined	702	0-105	3	4	10	20	30
Specific capacity of wells [(gal/min)/ft]							
Quaternary System							
Alluvium	-	-	-	-	-	-	-
Pennsylvanian System							
Conemaugh Group	6	0.06-2.0	-	-	0.38	-	-
Allegheny Group	62	.03-10	0.05	0.11	.62	1.8	5.9
Pottsville Group	112	.02-24	.08	.10	.38	1.5	4.0
All groups, combined	180	.02-24	.07	.10	.40	1.6	4.0
Mississippian System							
Lower Mississippian rocks	15	.05-10	.05	.20	.55	4.3	9.2
Bedrock, combined	195	.02-24	.07	.10	.40	1.7	4.6

Table 11.--Summary of data on yield, specific capacity, well depth, and depth to water of domestic wells--Continued

Aquifer	Number of wells	Range	Percentage of wells in which indicated yield or specific capacity is equaled or exceeded				
			90	80	50	20	10
Depth of wells (ft)							
Quaternary System							
Alluvium	9	27- 69	-	-	35	-	-
Pennsylvanian System							
Conemaugh Group	37	14-300	49	60	89	141	196
Allegheny Group	335	12-357	45	57	80	130	169
Pottsville Group	450	15-360	50	60	93	143	198
All groups, combined	822	12-360	49	60	88	140	185
Mississippian System							
Lower Mississippian rocks	84	30-418	47	60	106	248	349
Bedrock, combined	906	12-418	49	60	90	141	200
Depth to water below land surface (ft)							
Quaternary System							
Alluvium	7	[1] F- 28	-	-	10	-	-
Pennsylvanian System							
Conemaugh Group	17	3-100	10	19	40	72	83
Allegheny Group	198	F-166	10	20	36	60	90
Pottsville Group	248	0-250	15	20	40	70	100
All groups, combined	463	F-250	12	20	40	69	100
Mississippian System							
Lower Mississippian rocks	47	F-307	14	25	56	101	211
Bedrock, combined	510	F-307	12	20	40	70	100

[1] Flowing.

Table 12.--Summary of data on yield, specific capacity, well depth, and depth to water of nondomestic wells

Aquifer	Number of wells	Range	Percentage of wells in which indicated yield or specific capacity is equaled or exceeded				
			90	80	50	20	10
Yield of wells (gal/min)							
Quaternary System							
Alluvium	-	-	-	-	-	-	-
Pennsylvanian System							
Conemaugh Group	-	-	-	-	-	-	-
Allegheny Group	20	2-254	2	5	14	44	130
Pottsville Group	48	4-300	5	8	31	150	195
All groups, combined	68	2-300	4	6	25	116	178
Mississippian System							
Lower Mississippian rocks	57	6-550	20	27	78	271	368
Bedrock, combined	125	2-550	6	14	40	160	267
Specific capacity of wells [(gal/min)/ft]							
Quaternary System							
Alluvium	-	-	-	-	-	-	-
Pennsylvanian System							
Conemaugh Group	-	-	-	-	-	-	-
Allegheny Group	11	0.13- 11	0.15	0.25	3.0	6.6	10
Pottsville Group	20	.04- 20	.12	.28	1.8	5.9	11
All groups, combined	31	.04- 20	.13	.28	2.6	5.6	10
Mississippian System							
Lower Mississippian rocks	28	1.1 -186	1.3	3.7	5.0	18	38
Bedrock, combined	59	.04-186	.27	1.0	4.0	9.2	20

Table 12.--Summary of data on yield, specific capacity, well depth, and depth to water of nondomestic wells--Continued

Aquifer	Number of wells	Range	Percentage of wells in which indicated depth is equaled or exceeded				
			90	80	50	20	10
		Depth of wells (ft)					
Quaternary System							
Alluvium	-	-	-	-	-	-	-
Pennsylvanian System							
Conemaugh Group	-	-	-	-	-	-	-
Allegheny Group	24	37-300	64	96	125	265	294
Pottsville Group	63	30-417	84	112	180	319	388
All groups, combined	87	30-417	85	100	165	295	345
Mississippian System							
Lower Mississippian rocks	69	42-542	60	105	201	300	410
Bedrock, combined	156	30-542	70	100	180	300	352
		Depth of water below land surface (ft)					
Quaternary System							
Alluvium	-	-	-	-	-	-	-
Pennsylvanian System							
Conemaugh Group	-	-	-	-	-	-	-
Allegheny Group	20	[1] F-175	1	8	35	82	100
Pottsville Group	46	F-281	5	17	51	141	245
All groups, combined	66	F-281	5	10	46	100	225
Mississippian System							
Lower Mississippian rocks	54	F-180	F	2	19	70	107
Bedrock, combined	120	F-281	F	9	33	160	267

[1] Flowing.

Table 13.--Summary of data on yield, specific capacity, well depth, and depth to water of all wells

Aquifer	Number of wells	Range	Percentage of wells in which indicated yield or specific capacity is equaled or exceeded				
			90	80	50	20	10
Yield of wells (gal/min)							
Quaternary System							
Alluvium	10	1-200	-	-	20	-	-
Pennsylvanian System							
Conemaugh Group	37	1- 30	3	4	10	15	26
Allegheny Group	294	0-254	2	3	10	20	30
Pottsville Group	376	0-300	4	5	10	29	36
All groups, combined	707	0-300	3	4	10	25	32
Mississippian System							
Lower Mississippian rocks	122	1-550	5	8	25	100	248
Bedrock, combined	829	0-550	3	5	10	30	40
Specific capacity of wells [(gal/min)/ft]							
Quaternary System							
Alluvium	-	-	-	-	-	-	-
Pennsylvanian System							
Conemaugh Group	6	0.06- 2.0	-	-	0.38	-	-
Allegheny Group	73	.03- 11	0.06	0.12	.67	3.0	6.5
Pottsville Group	132	.02- 24	.08	.12	.41	2.2	5.0
All groups, combined	211	.02- 24	.07	.12	.46	2.2	5.0
Mississippian System							
Lower Mississippian rocks	43	.05-186	.26	.99	4.3	10	22
Bedrock, combined	254	.02-186	.08	.13	.68	4.0	7.5

Table 13.--Summary of data on yield, specific capacity, well depth, and depth to water of all wells--Continued

Aquifer	Number of wells	Range	Percentage of wells in which indicated depth is equaled or exceeded				
			90	80	50	20	10
Depth of wells (ft)							
Quaternary System							
Alluvium	12	27- 69	-	-	42	-	-
Pennsylvanian System							
Conemaugh Group	39	14-300	49	61	92	145	200
Allegheny Group	359	12-357	45	58	82	135	180
Pottsville Group	516	15-578	50	64	100	165	229
All groups, combined	914	12-578	49	60	92	155	210
Mississippian System							
Lower Mississippian rocks	154	30-542	51	64	146	290	370
Bedrock, combined	1,068	12-578	50	60	97	174	245
Depth to water below land surface (ft)							
Quaternary System							
Alluvium	9	[1] F- 28	-	-	20	-	-
Pennsylvanian System							
Conemaugh Group	18	3-100	10	20	40	71	81
Allegheny Group	219	F-175	9	19	37	65	100
Pottsville Group	296	F-281	15	20	40	80	100
All groups, combined	533	F-281	10	20	40	70	100
Mississippian System							
Lower Mississippian rocks	102	F-307	F	14	36	78	145
Bedrock, combined	635	F-307	10	19	40	72	103

[1] Flowing.

Specific capacities shown in the tables have a wide range, even where the thickness of the unit is constant, because of differences in depth of penetration of the wells; variations in the number, size, and degree of interconnection of fractures and pore spaces; and the use of test data of different durations and pumping rates. As few data are available for alluvial wells, the following discussion relates only to the bedrock.

Most specific capacities calculated from drillers' data are based on low rates of withdrawal from a well and on tests of short duration (generally less than a half hour). Results of controlled tests, however, based on higher withdrawal rates and longer pumping under uniform conditions, indicate that the actual sustained yield may be 50 to 70 percent smaller than the potential yields calculated from most drillers' tests. Therefore, the median specific capacities shown in the tables are probably representative of better than average yielding wells. Typically, the specific capacities are one-half to one-third the median shown in the table. For example, the median specific capacity of 0.41 (gal/min)/ft for the Pottsville Group multiplied by 100 ft of available drawdown indicates a potential yield of 40 gal/min--about the expected yield of a good well. If the specific capacity of 0.41 (gal/min)/ft were reduced by two-thirds, the average predicted yield for the Pottsville Group would be 14 gal/min--about the median yield of the formation as shown in table 13.

Wells generally penetrate more water-bearing zones as they are deepened and thus their yields increase with depth. However, drilling deeper in shale will generally yield little or no additional water. The relation between depth of wells and yield is illustrated by data on nondomestic wells (generally deep) and domestic wells (relatively shallow). The median depth of nondomestic bedrock wells is about 180 ft (table 12), whereas that of domestic wells is 90 ft (table 11). The median yield of 40 gal/min and specific capacity of 4.0 (gal/min)/ft of nondomestic wells are 4 and 10 times respectively, those of domestic wells. Thus, in some places, yields of shallow wells may be improved by drilling deeper, to as much as 350 ft.

Water-bearing zones decrease with increasing depth. The deepest reported zone for a water well (Buckwalter and others, 1979, table 1) is 396 ft. Many high-yielding nondomestic wells have intercepted water-bearing zones at depths of 300-350 ft.

Geologic Structure

As a general rule, wells tapping the same formation yield more water along axes of synclines than along axes of anticlines. This is because water tends to move downward, away from the axes of anticlines and toward the axes of adjacent synclines, so that depths to water on anticlines may be greater than depths to water on synclines. Therefore, a formation may be above the water table and dry at the axis of an anticline and saturated along a synclinal axis.

Water in bedrock is found chiefly in fractures and along bedding planes. Openings are generally widest near the land surface and tend to close at depth due to the weight of the overlying rock. Fractures or zones of fractures may be several hundreds or thousands of feet in length and hundreds of feet in depth, and divide the bedrock into many irregularly shaped blocks of solid rock. The spacing or distance between fractures has a significant influence on well yield and is related to major structural features (such as fold position) and to the lithology. The bedrock seems to be more fractured in valleys and along slopes than on the uplands, and, consequently, yields are higher in valleys and along slopes.

Topographic Position

The relation between topographic position and well yield is shown in table 14. Wells are arranged by their position in a valley, on a hillside, or a hilltop, and are also grouped by use into "domestic, nondomestic," and "all wells." Table 14 shows that wells in valleys have the highest median specific capacity and yield. Also, the median of wells on hillsides is somewhat higher than that of wells on hilltops.

Valley wells have the highest yields for several reasons: (1) the rock underlying valleys is more fractured, making it more permeable and increasing the storage capability; (2) the alluvial materials, which are commonly highly permeable, are confined mostly to valleys and serve as a recharge reservoir to the bedrock; (3) water levels are shallowest and fluctuate less in valley wells, allowing more available drawdown than that in hillside or hilltop wells of equal depth; and (4) streams in the valleys may provide recharge.

Fractures and Fracture Traces

The capacity of fractured rocks to store and transmit water is directly related to the rock type. Yields of wells in shale are low because fractures are small. Most sandstones and many siltstones, on the other hand, are hard and tightly cemented and thus develop clean breaks than are more extensive and less likely to heal after fracturing. In addition, the spaces between grains in sandstones are larger and more permeable than those in shales. As a result, sandstone and siltstone aquifers have higher yields than shale. In general, the more siltstone and sandstone penetrated by a well the more water-bearing openings tapped and the greater the yield.

Many wells are completed in the fractured bedrock, so that the location of the surface traces of fractures is an aid in choosing sites for optimum well yields. The most advantageous location is probably at the intersection of two or more traces. Because the width of traces is generally small, it may be difficult to locate them accurately in the field.

Where the bedrock consists of siltstone and sandstone, wells located on fracture traces have significantly higher yields. However, according to Lattman (oral commun., 1974), where the bedrock consists of shale, drilling on a fracture trace will probably not increase a well's yield.

Table 14.--Summary of data on yield and specific capacity of bedrock wells by topographic position

	Number of wells	Specific Capacity [(gal/min)/ft]		Number of wells	Reported yield (gal/min)	
		Range	Median		Range	Median
			Domestic wells			
Valley	13	0.25- 10	0.75	59	2.0- 60	15
Hillside	118	.03- 24	.40	447	0-105	10
Hilltop	59	.02- 15	.32	187	0- 50	8
			Nondomestic wells			
Valley	30	0.27-186	5.2	53	5.0-550	100
Hillside	15	.13- 17	3.0	43	3.0-350	30
Hilltop	12	.04- 20	1.0	29	2.0-220	20
			All wells			
Valley	43	0.25-186	4.1	112	2.0-550	30
Hillside	133	.03-24	.48	490	0-350	10
Hilltop	71	.02-20	.40	216	0-220	8

Regolith and Alluvial Aquifers

The study area is covered by a mantle of weathered bedrock, or regolith, that ranges in thickness from 0 to about 50 ft and averages about 20 ft. It stores more water per unit volume than the underlying fractured rock. However, its hydrologic importance is not as a direct source of water to wells, but, rather, as a reservoir that sustains the yields of wells in the underlying bedrock.

Alluvium is an unconsolidated mixture of silt, sand, and gravel as originally deposited, generally by rivers or streams. It is present in most stream valleys but is generally thin or of small areal extent. Even in the large stream valleys, which contain the greatest thickness of material, the alluvium occurs as remnants of terraces in discontinuous, narrow bands and patches. Along the Clarion River, wells penetrate as much as 70 ft of alluvium.

The alluvium has hydrologic properties similar to those of the regolith but is commonly more permeable. Wells completed in bedrock at sites overlain by alluvium generally have substantially higher yields than wells at sites not overlain by alluvium. For example, where the Lower Mississippian rocks are covered by alluvium, the median reported yield is 45 gal/min, and the specific capacity is 5.5 (gal/min)/ft. Where it is not covered by alluvium, the median yield and specific capacity are 15 gal/min and 2.2 (gal/min)/ft, respectively. The highest reported yields (as much as 550 gal/min) are from wells in alluvium-covered bedrock. Where openings in the bedrock are small, few, or discontinous (commonly characteristic of shale), yields are low regardless of the alluvial cover.

Bedrock Aquifers

Bedrock is the source of water for households, schools, shops, industries, and municipalities that need small to large amounts of water. However, well yields are extremely variable and depend on lithology, degree of cementation, and thickness of the aquifer; the amount of fracturing and the permeability; and the amount of saturation of the overlying alluvium. Each control may change considerably over relatively short distances.

The relative water-yielding properties of the geologic units are shown by the specific-capacity graphs in figure 9. The Lower Mississippian rocks are clearly much more productive than the other units with a median specific capacity of 4.3 (gal/min)/ft. The other units range from 0.38 to 0.67 (gal/min)/ft.

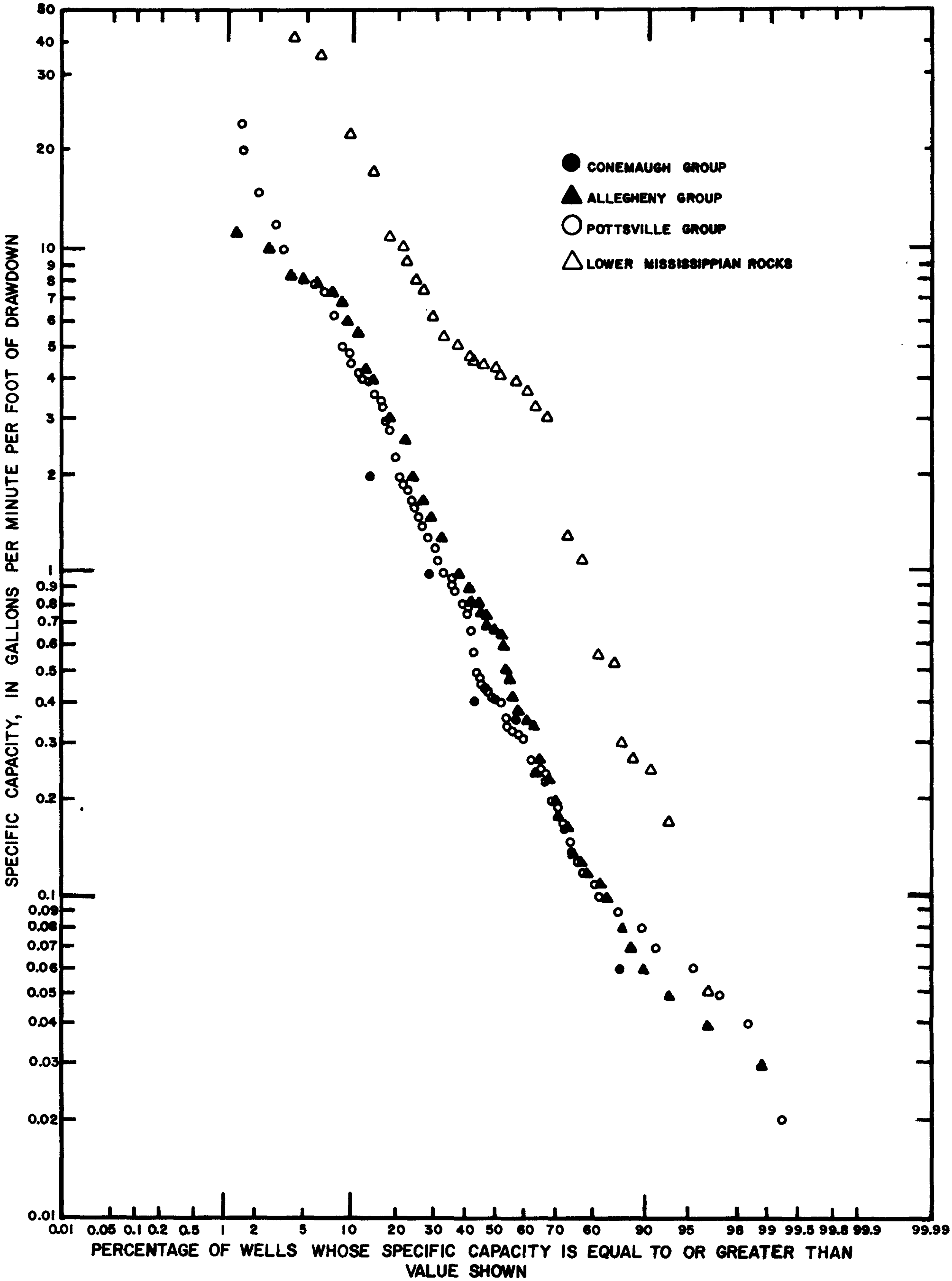


Figure 9.--Frequency distribution of specific capacities in four bedrock units.

Lower Mississippian Series, undifferentiated

The largest yields are from the Lower Mississippian rocks, which consist of interbedded sandstone, siltstone, and shale, although the sandstone predominates. The unit underlies most of the area and crops out along major stream valleys in the south in narrow strips that widen northward. Few wells are drilled deep enough to penetrate the Lower Mississippian rocks in the south. Specific capacities of 43 wells range from 0.05 to 186 (gal/min)/ft and have a median of 4.3 (gal/min)/ft. The median reported yield of 122 wells is 25 gal/min. Yields of as much as 550 gal/min are reported.

Pottsville Group

More wells tap the Pottsville Group than any other aquifer. The Pottsville, which consists largely of sandstone, is used mostly in the north, but is also used in the south, where overlying formations are thin or unsaturated. Specific capacities of 132 wells range from 0.02 to 24 (gal/min)/ft and have a median of 0.41 (gal/min)ft. The median reported yield of 376 wells is 10 gal/min, but yields of 300 gal/min are reported.

Allegheny Group

The Allegheny Group is a major aquifer in the south, where it contains thick channel sands and is more completely preserved. In the north, it is generally thin, more shaly, and confined to the higher hills. Specific capacities of 73 wells in the Allegheny range from 0.03 to 11 (gal/min)/ft and have a median of 0.67 (gal/min)/ft. The median reported yield of 294 wells is 10 gal/min, but yields of 250 gal/min are reported from several wells.

Conemaugh Group

The Conemaugh Group is mostly sandstone and yields small to moderate supplies of water. As the Conemaugh is confined to uplands in the south and much of it is unsaturated, it is less used than the other rocks. Specific capacities of six wells range from 0.06 to 2.0 (gal/min)/ft and have a median value of 0.38 (gal/min)/ft. The median reported yield of 37 wells is 10 gal/min, and the highest is 30 gal/min.

WATER QUALITY

The composition and concentration of dissolved substances in water change continuously as water moves through the hydrologic cycle. The quality of water at any point is the result of all prior changes. Some of the principal natural factors that control water quality are the composition of soil and bedrock, climate, vegetation, and length of time the water is in contact with the soil and rocks.

Abundant water-quality information is available from studies of the basins. Table 15 gives information on the types of data collected for 30 studies by Federal or State agencies, colleges or universities, and consultants. Citation of reports in table 15 are given in the selected references.

The constituents and properties commonly used to evaluate water quality are acidity, alkalinity, chloride, hardness, iron, manganese, nitrate, pH, phosphate, specific conductance, and sulfate. Definitions of water-quality terms are in the glossary. Table 16 shows the sources and significance of selected constituents and properties in water. This information is helpful in understanding what controls the quality of water. The combination of hardness, pH, and specific conductance are used frequently as general indicators of quality because of their chemical significance and ease of measurement. Constituents and properties of water used in the detection and assessment of mine drainage are discussed later in this section.

Mandatory maximum limits for selected inorganic contaminants of drinking water have been established by the U.S. Environmental Protection Agency (table 17) to protect public health. The limits apply to virtually all public water systems and are enforced. Recommended limits for other contaminants of drinking water, not Federally enforced, are intended as guidelines for regulation by the States (table 17).

Pennsylvania has established water-quality criteria based on use of the water (Pennsylvania Department of Environmental Resources, 1971, 1978). The 1978 recommendations are given in table 18.

Disease-causing bacteria from sewage and animal wastes can be carried considerable distances by water. To insure public safety, the U.S. EPA (1975) and the PaDER (1978) established regulations concerning the bacteriological contamination of water supplies. PaDER enforces the regulations. Major effects of several types of contamination are summarized in table 19.

Coal mining is the most significant influence on water quality in the basins. The characteristics of mine drainage result from the oxidation of iron sulfide (commonly pyrite, FeS_2) associated with the coal and in adjacent rock through contact with water and air. The major products of the oxidation are ferrous sulfate ($FeSO_4$) and sulfuric acid (H_2SO_4). Ferrous sulfate is further oxidized to ferric sulfate [$Fe_2(SO_4)_3$], which then hydrolyzes to insoluble ferric hydroxide [$Fe(OH)_3$] and more sulfuric acid. The following equations summarize the reactions:

$$2FeS_2 + 7O_2 + 2H_2O \longrightarrow 2FeSO_4 + 2H_2SO_4$$
$$4FeSO_4 + 2H_2SO_4 + O_2 \longrightarrow 2Fe_2(SO_4)_3 + 2H_2O$$
$$Fe_2(SO_4)_3 + 6H_2O \longrightarrow 2Fe(OH)_3 + 3H_2SO_4$$

Table 15.—Guide to water-quality date in the Clarion River and Redbank Creek basins

References	Types of collection										
	Chemical					Physical			Biological		Other
	Pertial analyses 1/	Complete analyses 2/	Trece metals 3/	Nutrients 4/	Parameters indicating mine dreinages 5/	Mine drainage discharge measurements 6/	Streamflow measurements	Water temperature	Benthic invertebrate	Fish	
Federal Government											
Buckwalter, T. F., end others, 1979, (U.S. Geological Survey).	X	X	X	X	X	X	X	X	X	--	Well and spring inventory
U.S. Geological Survey, 1976-78, (annual series).	X	X	X	X	X	--	X	X	--	--	Bacteria, chlorophylls, pesticides, phytoplankton, periphyton, sediment
Koester, H. E., and Lescinsky, Joseph, 1976, (U.S. Geological Survey).	X	X	X	X	X	--	X	X	X	--	Bacteria
U.S. Geological Survey, 1962-75, (annual series).	X	X	X	X	X	--	X	X	X	--	Bacteria, chlorophylls, pesticides, phytoplankton, periphyton, sediment
Newport, T. G., 1973, (U.S. Geological Survey).	X	X	--	X	X	--	--	X	--	--	Geologic, hydrologic, well inventory
U.S. Army Corps of Engineers, 1972, (Pittsburgh District).	--	--	--	--	X	--	X	--	--	--	--
U.S. Environmental Protection Agency, 1971, (Office of Water Programs, Wheeling, West Virginia).	--	--	--	--	X	X	X	X	--	--	--
U.S. Army Corps of Engineers, 1969, (Pittsburgh District).	--	--	--	--	X	--	X	--	--	X	Biologic, economic, engineering, geologic, hydrologic
U.S. Federal Water Pollution Control Administration, 1967, (Wheeling Field Station, West Virginia).	--	--	--	--	X	X	X	--	--	--	Social, economic

Table 15.—Guide to water-quality data in the Clarion River and Redbank Creek basins—Continued

References	Types of collection										
	Chemical					Physical			Biological		Other
	Partial analyses[1]	Complete analyses[2]	Trace metals[3]	Nutrients[4]	Parameters indicating mine drainage[5]	Mine drainage discharge measurements[6]	Streamflow measurements	Water temperature	Benthic invertebrate	Fish	
					Federal Government—Continued						
McCarren, E. F., 1967, (U.S. Geological Survey).	X	X	—	X	X	—	X	X	—	—	—
Beamer, N. H., 1953, (U.S. Geological Survey).	X	X	—	X	—	—	—	X	—	—	—
Leggette, R. M., 1936, (U.S. Geological Survey).	X	—	—	X	X	—	—	X	—	—	Geologic, hydrologic, well inventory
					Commonwealth of Pennsylvania						
Pennsylvania Department of Environmental Resources, Bureau of Water Quality Management, 1975.	X	X	X	X	X	—	X	X	—	—	—
Merritt, G. L., and Emrick, G. H., 1970, (Pennsylvania Department of Health, Bureau of Sanitary Engineering).	X	—	—	—	X	X	—	X	—	—	Geologic, hydrologic
Pennsylvania Department of Health, and Pennsylvania Fish Commission, 1970.	X	—	—	X	X	—	—	X	X	X	—
Pennsylvania Bureau of Engineerings, Mine Wastes Divison, 1953.	—	—	—	—	X	—	—	—	—	—	—
					College or University						
Alexander, D.J., 1976, (Clarion State College).	X	—	—	—	X	—	X	X	X	—	—
Kay, G.G., 1974 (Clarion State College).	X	—	—	—	X	—	—	X	X	—	—

Table 15.--Guide to water-quality data in the Clarion River and Redbank Creek basins--Continued

References	Types of collection: Chemical: Partial analyses[1]	Chemical: Complete analyses[2]	Chemical: Trace metals[3]	Chemical: Nutrients[4]	Chemical: Parameters indicating mine drainage[5]	Physical: Mine drainage discharge measurements[6]	Physical: Streamflow measurements	Physical: Water temperature	Biological: Benthic invertebrate	Biological: Fish	Other
College or University--Continued											
Gang, M. W., and Langmuir, Donald, 1974, (Pennsylvania State University).	—	X	X	—	X	X	X	X	—	—	Geologic, hydrologic
Moore, J. R., 1974, (Clarion State College).	X	—	—	X	X	—	—	X	—	X	Chlorophylls, phytoplankton
Linton, K. J., 1970, (Clarion State College).	X	—	—	—	X	—	—	X	X	X	—
Dinsmore, B. H., 1968, (Clarion State College).	X	—	—	—	X	—	X	X	X	X	Algae, periphyton
Bardarik, D. G., 1960, (University of Pittsburgh).	X	—	—	—	X	—	X	X	—	X	—
Private Consultants											
Green International Inc., 1975-78 and continuing.	X	X	X	X	X	—	X	X	—	X	Economic, geologic, hydrologic, social
Gwin, Dobson, and Foreman, Inc., 1977, 1979.	—	—	—	—	X	X	X	—	—	—	Economic, geologic, hydrologic
Engineering and Associate Design Services, 1977.	—	—	—	—	X	X	X	—	—	—	Economic, geologic, hydrologic
Lee-Simpson Associates, Inc., 1976.	—	—	—	—	X	X	X	—	—	—	Economic, geologic, hydrologic
Buchart-Horn, 1974.	—	—	—	—	X	X	X	—	—	—	Economic, geologic, hydrologic
Michael Baker, Jr., Inc., 1970.	—	—	—	—	X	X	X	—	—	—	Economic, geologic, hydrologic
Camp, Dresser, and McKee, 1949.	X	—	—	—	X	—	X	X	—	—	Biochemical oxygen demand

1/Water-quality data that usually include acidity, alkalinity, chloride, iron, manganese, pH, sulfate, and total hardness.
2/Water-quality data including all major constituents in water silica, nutrients, iron, and manganese.
3/Cadmium, chromium, cobalt, copper, nickel, lead, silver, strontium, and zinc. Because of high concentrations, iron, manganese, and aluminum are not considered trace metals.
4/Nitrates and phosphates.
5/Water-quality data including acidity, alkalinity, iron, pH, and sulfate.
6/Effluent acid-mine water from deep mines, seepages from spoil piles, and discharges from strip-mine pools.

Table 16.—Source and significance of constituents and properties of ground water and surface water

Constituent or property	Source or cause	Significance in ground water	Significance in surface water
Acidity	Primarily free mineral acids and carbonate acid. Common in areas where coal has been mined.	Corrodes pipes, pumps etc; dissolves minerals, notably iron-bearing minerals.	A limiting factor to aquatic organisms, especially fish life. Considerations for water supply are the same as for ground water.
Alkalinity	Primarily due to the presence of bicarbonate, carbonate, and hydroxide.	Ability to neutralize acids. Alkalinity can be undesirable for public supplies when in excessive concentrations.	See significance in ground water.
Chloride (Cl)	From rocks and soils in small quantities. Large amounts from sewage, industrial wastes, and highway-salting practices. Large quantities naturally in rocks at depth.	In large quantities, chloride increases the corrosiveness of water; with sodium gives a salty taste. Above-average levels of chloride can indicate contamination by sewage, industrial wastes, or road-deicing chemicals.	See significance in ground water.
Dissolved oxygen (O_2)	From the atmosphere and the photo-synthetic activity of aquatic plants.	Dissolved-oxygen content is important in determining whether iron remains in solution or precipitates	Required for respiration of aquatic life. Reduction of dissolved oxygen concentrations can cause fish kills.
Dissolved solids	Solution of minerals in rocks by acid water; frequently excessive in coal-mining areas.	Excessive hardness, taste, mineral deposition, or corrosion are common properties of water high in dissolved solids. Industries using water for boiler makeup of cooling are concerned with dissolved solids.	Waters with very low concentrations of dissolved solids often do not support aquatic life due to lack of nutrients and essential elements. See also significance in ground water.
Hardness	Due mostly to calcium and magnesium. Iron, manganese, aluminum, and free acid also cause hardness.	Increases the amount of soap required to produce lather, roughens clothes, and shortens fabric life. Hard water is not suitable for some industrial processes, because it leaves a scaly deposit on the inside of pipes, radiators, water heaters, and boilers.	See significance in ground water.
Iron (Fe)	From practically all rocks and soils. High in coal-mine drainage, from coal preparation plants, and from landfills. Also derived from iron pipes, pumps, and other equipment.	On exposure to oxygen, ferrous iron oxidizes to a reddish-brown precipitate. More than about 0.3 mg/L of iron; stains laundry and porcelain. In higher concentrations, gives an unpleasant taste.	In streams affected by coal-mine drainage, reddish-brown iron precipitates blanket stream bottoms. Taste and staining characteristics are the same as for ground water.
Manganese (Mn)	From many rocks and soils. Can be found in unusually high concentrations in coal-mine drainage.	More than 0.05 mg/L can cause brown spots in laundry and dark precipitates. Manganese imparts an unpleasant taste.	May coat rocks on stream bottoms. See also significance in ground water.
Nitrate (NO_3)	Decaying organic matter, sewage, and fertilizers are principal sources; human and animal wastes.	More than 45 mg/L may cause methemoglobinemia (a disease often fatal in infants).	Excessive nitrate can cause blooms of algae and over-abundance of aquatic vegetation. Decomposition of this vegetation can cause oxygen depletion, odor, and taste problems. Health hazards for water supply are the same as for ground water.
pH	Summary effect of the acid and alkaline constituents in solution. Acid < pH=7.0 < alkaline, pH=7.0 is neutral.	Water from wells in the study area ranges in pH from about 2.9 to 8.2. Sulfuric acid from coal-mine drainage lowers pH.	The pH of surface water in the study area ranges from 2.0 to 8.0. About two-thirds of the streams sampled for pH were less than 7.0.

Table 16.--Source and significance of constituents and properties of ground water and surface water--Continued

Constituent or property	Source or cause	Significance in ground water	Significance in surface water
Phosphate (PO_4)	In very small quantities from most rocks and soils. The chief sources are fertilizer and detergents.	Not a problem at concentrations generally encountered.	May stimulate overabundance of aquatic vegetation; see under nitrate.
Sulfate (SO_4)	By solution and oxidation of sulfide minerals, especially iron sulfide (pyrite). Concentrated in coal-mine drainage. Also present in some industrial wastes and sewage.	Chief anion in mine drainage and in all high dissolved-solids water. Forms sulfuric acid. Sulfate may cause detectable tastes at concentrations of 300-400 mg/L. At concentrations above 600 mg/L sulfate may have laxative effect.	See significance in ground water.
Suspended solids	Caused by a wide variety of constituents including sediments, organic material, metal hydroxides, and microorganisms.	Suspended solids are a problem in water supply for esthetic reasons and because of abrasive effects on pipes, pumps, and turbine blades.	High concentrations affect aquatic life by inhibiting light penetration, influencing temperature, and interfering with respiration and reproduction of fish. Factors concerning water supply are the same as for ground water.
Temperature	At depths less than 30 to 60 feet temperatures fluctuate seasonally and nearly equal the average annual air temperature. At depths greater than 60 feet, temperatures increase about 1°F/100 ft.	Nearly constant temperature, which makes it desirable for cooling.	Controls physical, chemical, and biological processes.
Trace elements	Rocks, landfill leachates, domestic and industrial wastes. Some, such as copper and zinc, from pipes carrying the water.	Depends on element, much not known.	See significance in ground water.

Table 17.--Federal mandatory and recommended limits for selected contaminants of drinking water for public supply systems

[Limits in milligrams per liter except as indicated]

Contaminant	Mandatory limit [1]	Recommended limit [2]
Arsenic (As)	0.05	--
Barium (Ba)	1.	--
Cadmium (Cd)	.010	--
Chromium (Cr)	.05	--
Lead (Pb)	.05	--
Mercury (Hg)	.002	--
Nitrate (N)	10.	--
Selenium (Se)	.01	--
Silver (Ag)	.05	--
Chloride (Cl)	--	250
Color (color units)	--	15
Copper (Cu)	--	1
Corrosivity	--	Noncorrosive
Foaming agents	--	.5
Hydrogen sulfide	--	.05
Iron (Fe)	--	.3
Manganese	--	.05
Odor (threshold odor number)	--	3
pH (units)	--	6.5 - 8.5
Sulfate (SO_4)	--	250
Total dissolved solids	--	500
Zinc (Zn)	--	5

1/ U.S. Environmental Protection Agency (1975, p.5957).
2/ U.S. Environmental Protection Agency (1977, p.17146).

Table 18.--Selected water-quality criteria for Pennsylvania[1]

[Water-quality criteria are based on water use. The selection of numerical values for toxic substances is to insure protection of the water having the most restrictive use criteria and to provide a basis of control for these substances. Protected uses include aquatic life, water supply, recreation, and special protection waters][1]

Constituent	Recommended criterion
Alkalinity as $CaCO_3$	Alkalinity shall be 20 mg/L or more as $CaCO_3$, except where natural conditions are less.
Aluminum (Al)	Not to exceed 0.1 of the 96-hour LC50 for representative important species.[2]
Arsenic (As)	Not to exceed 0.05 mg/L of total arsenic.
Chromium (Cr)	Not to exceed 0.05 mg/L as hexavalent chromium.
Copper (Cu)	Not to exceed 0.1 of the 96-hour LC50 for representative important species.
Cyanide (CN)	Not to exceed 0.005 mg/L as free cyanide.
Flouride (F)	Not to exceed 2.0 mg/L.
Iron (Fe)	Not to exceed 1.5 mg/L as total iron; not to exceed 0.3 mg/L as dissolved iron.
Lead (Pb)	Not to exceed 0.05 mg/L.
Manganese (Mn)	Not to exceed 1.0 mg/L as total manganese.
Nickel (Ni)	Not to exceed 0.01 of the 96-hour LC50 for representative important species.
Nitrite plus nitrate as N	Not to exceed 10 mg/L as nitrate nitrogen.
pH	Not less than 6.0 and not more than 9.0.
Phenol	Not to exceed 0.005 mg/L.
Sulfate (SO_4)	Not to exceed 250 mg/L.
Zinc (Zn)	Not to exceed 0.01 of the 96-hour LC50 for representative important species.

1/ Pennsylvania Department of Environmental Resources (1978, p. 522-526).

2/ The 96-hour LC50 value is the concentration of a pollutant in test waters that is lethal to 50 percent of the test organisms during continuous exposure for a period of 96 hours. Representative important species are defined as those species of aquatic life whose protection and propagation will assure the sustained presence of a balanced community of aquatic life and waterfowl in and on the waters of the Commonwealth. Such species are representative in the sense that maintenance of water-quality criteria will assure both the natural completion of the species' life cycle and the overall protection and propagation of the balanced community.

Table 19.--Major effects of selected types of contamination

Effects	Types of Contamination																			
	Agriculture				Manufacturing					Logging		Mining		Urban						
																Sewage				
	Nutrients from fertilizers	Organic loading	Pesticides, herbicides	Sediment	Inorganic chemicals	Metals	Organic chemicals	Solid wastes	Thermal	Sediment	Storm runoff	Sediment	Metals	Solid wastes	Storm runoff	Bacteria	Metals	Nutrients	Organic loading	Suspended solids
Contamination of ground water	X	X	X	--	X	X	X	X	--	--	--	--	X	X	--	X	X	X	X	--
Contamination of surface water	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Large concentrations can restrict use for public supply	X	X	X	X	X	X	X	--	--	X	--	X	X	--	--	X	X	X	X	X
Health hazard	--	--	X	--	X	X	X	X	--	--	--	--	--	X	X	X	--	--	--	--
Linked to causing cancer	--	--	X	--	X	--	X	--	--	--	--	--	--	--	--	--	--	--	--	--
Odor problems	--	X	--	--	--	--	--	X	--	--	--	--	--	X	--	X	--	--	X	--
Taste problems	--	--	--	--	X	X	X	--	--	--	--	--	X	--	--	--	--	--	--	--
Esthetically displeasing	X	X	--	X	X	X	X	X	--	X	X	X	--	X	X	--	--	--	X	X
Increases flood hazard	--	--	--	X	--	--	--	--	--	X	X	X	--	--	X	--	--	--	--	--
Fills reservoirs	--	--	--	X	--	--	--	--	--	X	X	X	--	--	X	--	--	--	--	--
Decrease in dissolved oxygen	--	X	--	--	--	--	X	X	X	--	X	--	--	X	X	--	--	--	X	--
Overabundance of algae and/or aquatic vegetation	X	X	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	X	X	--
Disrupts the food chains of aquatic life	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Reduction in number and kinds of naturally occurring aquatic organisms	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	--
Toxic to selected aquatic organisms	--	--	X	--	X	X	X	X	X	--	--	--	X	--	X	--	X	--	--	--

The oxidation of pyrite contributes large quantities of sulfuric acid and iron compounds to receiving waters. As a result, the pH of the water is commonly below 4. Effects of mine drainage on the chemistry of a stream include depletion of bicarbonate, increase in the titratable acidity, lowering of pH, introduction of various cations, and in places and at times, reduction in the quantity of oxygen dissolved in the stream.

Constituents and properties routinely measured in water in the detection and assessment of mine drainage include acidity, alkalinity, ferric and ferrous iron, hardness, manganese, pH, specific conductance, and sulfate.

Quality of Ground Water

Data Base

Field data, chiefly pH, hardness, and specific conductance, of water from 350 wells are given in table 1 of Buckwalter and others (1979); about 300 chemical analyses, including major anions, cations, and nutrients of water from 196 wells and 43 springs in table 3; and 66 trace-element analyses in table 4. Temperature, hardness, specific conductance, pH, and total iron measurements are also reported for 47 springs in table 2. Chemical analyses of water from abandoned flowing oil and gas wells are given in tables 3 and 4 of both Buckwalter and others (1979) and Koester and Lescinsky (1976). Locations of wells, springs, and mine drainages are given in figures 2-51 of Buckwalter and others (1979) and abandoned flowing oil and gas wells in figure 1 of Koester and Lescinsky (1976).

Quality of Water in Aquifers

Summary statistics of laboratory analyses of selected quality characteristics of water from aquifers are presented in table 20. Table 21 gives summary statistics of field analyses of pH, hardness, and specific conductance of water from wells and springs in selected aquifers.

Specific conductance can be used to estimate dissolved-solids concentration, as the two are proportional. Because specific-conductance measurements are cheaper and many more were made than dissolved-solids determinations, information on approximate dissolved-solids concentration can be greatly extended. Median ratios of dissolved solids (residue on evaporation at 180°C) to specific conductance were computed for selected aquifers:

Aquifer	Ratio
Allegheny Group	0.60
Pottsville Group	0.67
Lower Mississippian rocks	0.63

Through the use of these ratios, the dissolved-solids statistics in the following sections were calculated from specific-conductance data in table 21.

Table 20.—Summary statistics of laboratory analyses of selected quslity characteristics of water in the aquifers[1/]

Constituent or property	Numbers of samples	Range	Percentage of samples in which indicated value of constituent or property is equaled or exceeded				
			90	75	50	25	10
Quaternary alluvium							
Dissolved iron (Fe) (μg/L)	7	0 - 150	--	--	80	--	--
Ferrous iron (Fe) (μg/L)	1	30	--	--	30	--	--
Dissolved manganese (Mn) (μg/L)	6	0 - 10	--	--	0	--	--
Dissolved sulfate (SO_4) (mg/L)	7	15 - 45	--	--	28	--	--
Dissolved chloride (Cl) (mg/L)	8	3 - 52	--	--	7.6	--	--
Total acidity as H^+ (mg/L)	4	.0	--	--	.0	--	--
Bicarbonate (HCO_3) (mg/L)	7	3 - 32	--	--	10	--	--
Dissolved solids (residue at 180°C) (mg/L)	3	50 - 123	--	--	61	--	--
Quaternary colluvium							
Dissolved iron (Fe) (μg/L)	9	130 - 1,500	--	--	700	--	--
Ferrous iron (Fe) (μg/L)	0	--	--	--	--	--	--
Dissolved manganese (Mn) (μg/L)	9	0 - 19,000	--	--	56	--	--
Dissolved sulfate (SO_4) (mg/L)	3	25 - 790	--	--	260	--	--
Dissolved chloride (Cl) (mg/L)	6	3.4 - 55	--	--	7.2	--	--
Total acidity as H^+ (mg/L)	7	0 - 8.5	--	--	.2	--	--
Bicarbonate (HCO_3) (mg/L)	8	0 - 16	--	--	4	--	--
Dissolved solids (residue at 180°C) (mg/L)	2	134 - 1,100	--	--	617	--	--
Allegheny Group							
Dissolved iron (Fe) (μg/L)	65	40 - 2,100,000	170	300	840	5,200	24,000
Ferrous iron (Fe) (μg/L)	16	0 - 425,000	0	110	1,100	4,000	28,000
Dissolved manganese (Mn) (μg/L)	62	0 - 40,000	0	0	250	1,200	2,600
Dissolved sulfate (SO_4) (mg/L)	33	.4 - 2,500	6.9	14	40	190	530
Dissolved chloride (Cl) (mg/L)	34	.8 - 160	1.2	2.0	4.0	12	27
Total acidity as H^+ (mg/L)	32	.0 - 120	.0	.0	.0	.2	2.3
Bicarbonate (HCO_3) (mg/L)	64	0 - 420	0	8	38	88	140
Dissolved solids (residue at 180°C) (mg/L)	17	57 - 3,680	56	60	188	400	728

Table 20.—Summary statistics of laboratory analyses of selected quality characteristics of water in the aquifers[1]—Continued

Constituent or property	Numbers of samples	Range	Percentage of samples in which indicated value of constituent or property is equaled or exceeded				
			90	75	50	25	10
Pottsville Group							
Dissolved iron (Fe) (μg/L)	96	0 - 280,000	110	590	2,300	18,800	53,000
Ferrous iron (Fe) (μg/L)	27	0 - 135,000	0	100	7,500	31,000	70,300
Dissolved manganese (Mn) (μg/L)	95	0 - 280,00	0	100	520	1,300	7,800
Dissolved sulfate (SO_4) (mg/L)	42	.2 - 6,200	2.9	9.9	34	320	1,000
Dissolved chloride (Cl) (mg/L)	47	.5 - 900	.9	3.2	6.2	26	63
Total acidity as H^+ (mg/L)	41	.0 - 45	.0	.0	.0	1.0	5.6
Bicarbonate (HCO_3) (mg/L)	97	0 - 240	0	2	16	39	120
Dissolved solids (residue at 180°C) (mg/L)	25	13 - 7,400	21	42	227	564	1,225
Lower Mississippian rocks							
Dissolved iron (Fe) (μg/L)	37	0 - 250,000	60	360	2,600	10,100	34,000
Ferrous iron (Fe) (μg/L)	10	830 - 50,000	1,100	1,200	3,200	8,100	9,000
Dissolved manganese (Mn) (μg/L)	33	0 - 40,000	10	140	380	1,200	2,000
Dissolved sulfate (SO_4) (mg/L)	30	.2 - 950	1.2	3.1	17	40	480
Dissolved chloride (Cl) (mg/L)	35	.6 - 1,670	1.7	5.2	12	86	332
Total acidity as H^+ (mg/L)	9	.0 - 4.9	—	—	.2	—	—
Bicarbonate (HCO_3) (mg/L)	34	0 - 240	2	26	74	160	210
Dissolved solids (residue at 180°C) (mg/L)	26	31 - 2,710	50	71	176	388	875

[1] Computed from chemical analyses in Buckwalter and others (1979, table 3, p. 110-117).

Table 21.--Summary statistics of field analyses of hardness, specific conductance, and pH of water in selected aquifers [1], [2]

Constituent or property	Number of wells and springs	Range	Percentage of wells in which indicated value of constituent property is equaled or exceeded				
			90	75	50	25	10
Quaternary alluvium							
Hardness (Ca, Mg) as $CaCO_3$ (mg/L)	2	30 - 120	--	--	70	--	--
Specific conductance (micromhos at 25°C)	2	165 - 220	--	--	192	--	--
pH	1	5.0	--	--	5.0	--	--
Quaternary colluvium							
Hardness (Ca, Mg) as $CaCO_3$ (mg/L)	8	20 - 410	--	--	40	--	--
Specific conductance (micromhos at 25°C)	9	50 - 1,500	--	--	185	--	--
pH	6	3.6 - 6.5	--	--	5.0	--	--
Conemaugh Group							
Hardness (Ca, Mg) as $CaCO_3$ (mg/L)	1	100	--	--	100	--	--
Specific conductance (micromhos at 25°C)	4	155 - 920	--	--	515	--	--
pH	0	--	--	--	--	--	--
Allegheny Group							
Hardness(Ca, Mg) as $CaCO_3$ (mg/L)	52	20 - 630	30	30	90	140	290
Specific conductance (micromhos at 25°C)	55	44 - 5,500	89	138	215	380	1,240
pH	40	4.3 - 7.7	5.0	5.6	6.4	6.8	7.5

Table 21.--Summary statistics of field analyses of hardness, specific conductance, and pH of water in selected aquifers [1], [2]--Continued

Constituent or property	Number of wells and springs	Range	Percentage of wells in which indicated value of constituent property is equaled or exceeded 90	75	50	25	10
Pottsville Group							
Hardness (Ca, Mg) as $CaCO_3$ (mg/L)	117	20 - 990	30	30	90	150	390
Specific conductance (micromhos at 25°C)	106	23 - 5,800	73	115	225	412	1,190
pH	84	3.2 - 8.2	4.3	5.4	6.2	6.8	7.5
Pennsylvanian rocks, combined							
Hardness (Ca, Mg) as $CaCO_3$ (mg/L)	170	20 - 990	30	30	90	140	290
Specific conductance (micromhos at 25°C)	165	23 - 5,800	80	120	225	400	1,190
pH	124	3.2 - 8.2	4.4	5.4	6.2	6.8	7.5
Lower Mississippian rocks							
Hardness (Ca, Mg) as $CaCO_3$ (mg/L)	51	20 - 500	30	70	90	140	270
Specific conductance (micromhos at 25°C)	37	52 - 4,230	93	145	350	965	1,890
pH	41	4.5 - 7.9	5.2	6.2	6.6	7.0	7.2
Bedrock, combined							
Hardness(Ca, Mg) as $CaCO_3$ (mg/L)	221	20 - 990	30	50	90	40	70
Specific conductance (micromhos ar 25°C)	202	23 - 5,800	80	20	35	31	1,270
pH	165	3.2 - 8.2	4.7	5.6	6.3	6.8	7.5

[1] Computed from field chemical data in Buckwalter and others (1979, tables 1 and 2, p. 58-109).
[2] Springs were sampled only in Quaternary colluvium.

The ranges in tables 20 and 21 indicate that water quality is highly variable within an aquifer. The median values of hardness, specific conductance, and pH are similar in water from the Allegheny and Pottsville Groups. Conductances are slightly higher in the Lower Mississippian rocks.

Data on the quality of water in the Quaternary alluvium pertain chiefly to springs in Clarion County. Median values indicate the water is soft, acidic, and does not exceed U.S. EPA recommended limits for iron, manganese, and sulfate. The water is generally of better quality than that from bedrock in the same area. The quality of the water that discharges from springs in the alluvium is probably due to its shorter flow path and residence time from the recharge to discharge area.

Data on the quality of water in the Quaternary colluvium are also derived primarily from springs in Clarion County. The quality is highly variable. Iron, manganese, and sulfate exceed the recommended limits of EPA in more than half the samples. The maximum values of manganese, sulfate, and acidity in table 20 were obtained from several springs near abandoned strip mines.

More than half of the wells sampled in the Allegheny Group had moderately hard to very hard water. Iron exceeded the EPA recommended limit of 0.3 mg/L in 75 percent of the samples; manganese, the 0.05 mg/L recommended limit in over 50 percent (and by a factor of 10 or 0.50 mg/L in over 25 percent); and sulfate, the recommended limit of 250 mg/L in over 10 percent of the samples. Mercury concentrations were above the EPA mandatory limit of 0.002 mg/L in two samples from well Fo-11 in the Clarion Formation of the Allegheny Group. Water from 50 percent of the wells sampled for pH was in the recommended range of 6.5-8.5. Less than 25 percent of the samples had dissolved-solids concentrations greater than the recommended limit of 500 mg/L.

In over half the wells sampled in the Pottsville Group, the water was moderately hard to very hard. Iron equaled or exceeded 2.3 mg/L and manganese 0.52 mg/L in half of the samples, and both exceeded the EPA recommended limits in over 75 percent. More than 25 percent of the samples contained more than the recommended amount of sulfate. Samples from three wells exceeded the limit for chloride. Mandatory EPA limits for cadmium were exceeded in two springs and for chromium in one spring. Excessive zinc (5 mg/L) was present in one spring and one well in Clarion County. Water from over 50 percent of the wells sampled for pH are below the recommended range of 6.5-8.5. Less than 25 percent of the water had too much dissolved solids (500 mg/L). Several samples from wells and springs in Clarion County were among the highest recorded for specific conductance, iron, manganese, and sulfate.

In more than half the wells sampled in the Lower Mississippian rocks, the water was moderately hard to very hard. The recommended limits for iron (0.3 mg/L) and manganese (0.05 mg/L) were exceeded in more than 75 percent of the samples, and for sulfate in less than 25 percent of the samples. Water from five wells contained excessive chloride. More than 50 percent of the pH values are in the recommended range of 6.5-8.5. Less than a fourth of the samples had more than 500 mg/L dissolved solids.

Quality of Water from Flowing Wells

Highly mineralized water flows into many tributaries of the Clarion River and Redbank Creek from some abandoned oil and gas wells. In the Clarion River basin, most of these wells flow into the Little Toby Creek, Toms Run, Mill Creek, Toby Creek, Piney Creek, Deer Creek, and Licking Creek watersheds. In the Redbank Creek basin, flows are mostly into the Little Sandy Creek, Welch Run, Simpson Run, and Coder Run watersheds.

It is commonly impossible to determine the aquifer responsible for the water that flows from these abandoned oil and gas wells. Most wells are bridged (or closed off) near the surface, making it difficult to measure depth, log geophysically, or determine water-bearing zones. In some places, the wells cannot be exactly located because the well casings have been destroyed. Most of the water probably comes from the Pottsville Group or Lower Mississippian aquifers below valleys because (1) the flowing wells that have been studied derive their flow from these aquifers, (2) the high chloride concentrations and brines typical of the Devonian (Poth, 1962) were not found, and (3) local storms commonly resulted in increased flows, which would not be expected if the water came from the deeper aquifers.

Most of the flowing wells studied were in watersheds that have been extensively mined for coal. Because of the mining, water from the flowing wells commonly contains high concentrations of iron, manganese, sulfate, acidity, and trace-elements. Specific conductances over 2,000 μmho are common. The median ratio of dissolved-solids concentration to specific conductance is 0.73. Thus, dissolved solids commonly exceed 1,500 mg/L. A pH of 2.9 was measured at a flowing well in the Mill Creek watershed of the Clarion River basin. Concentrations over 100 mg/L of iron and 300 mg/L of sulfate were reported for flowing wells in many watersheds, including Welch Run, Mill Creek, Licking Creek, Deer Creek, and Toby Creek.

Relation of Topography to Water Quality

Summary statistics of hardness, specific conductance, and pH in water from wells drilled on hilltops, hillsides, and in valleys are given in table 22. The statistics indicate that water from wells on hilltops generally has slightly better quality than that from wells on hillsides. The calculated median dissolved-solids concentrations of water from hilltop and hillside wells are 140 and 215 mg/L, respectively. Several factors may account for this observation. In places, hilltop wells are less likely to penetrate coal beds and the associated poor-quality water than hillside wells. Water in hillside wells has moved along longer flow paths and so has longer residence time in aquifers, resulting in dissolution of more minerals. In addition, wells on hillsides have a greater probability of penetrating an aquifer of wide areal extent and below local drainage than wells on hilltops. Contaminants in these aquifers, such as those caused by coal mining, may move long distances and degrade the quality of the water several miles away.

Table 22.--Summary statistics of field analyses of hardness, specific conductance, and pH of water from wells in hilltop, hillside, and valley topographies

Constituent or property	Number of wells	Range	Percentage of wells in which indicated value of constituent property is equaled or exceeded				
			90	75	50	25	10
Hilltop							
Hardness (Ca, Mg) as $CaCO_3$ (mg/L)	61	20 - 600	20	30	70	140	310
Specific conductance (micromhos at 25°C)	64	23 - 5,500	70	119	230	495	1,190
pH	50	4.2 - 7.7	4.5	5.2	6.2	6.6	7.1
Hillside							
Hardness (Ca, Mg) as $CaCO_3$ (mg/L)	131	20 - 1,500	30	50	100	200	620
Specific conductance (micromhos at 25°C)	153	52 - 5,800	100	160	340	888	1,860
pH	128	3.2 - 8.2	4.3	4.9	6.0	6.6	7.1
Valley							
Hardness (Ca, Mg) as $CaCO_3$ (mg/L)	49	20 - 1,370	30	70	90	120	340
Specific conductance (micromhos at 25°C)	70	50 - 5,200	130	260	545	1,200	2,370
pH	65	2.9 - 8.0	4.5	5.5	6.4	7.0	7.5

Water from bedrock wells in valleys has the highest median specific conductance. The median dissolved-solids concentration in valley wells is 340 mg/L. Wells in valleys generally tap water that has a long residence time. As stream valleys are areas of ground-water discharge, they may receive ground water from mined areas on hilltops and hillsides. Furthermore, the tendency of municipalities and industries to locate in valleys and dispose of wastes there may result in ground-water contamination.

Areal Ground-Water Quality

Measurements of hardness, specific conductance, and pH of ground water in the Clarion River and Redbank Creek basins are summarized in table 23. The statistics indicate that ground water in the Clarion River basin is slightly more acidic and generally higher in dissolved solids than in the Redbank Creek basin.

The quality is generally better in the northern half of the Clarion River basin than in the southern half except in the East Branch Clarion River, Elk Creek, and Little Toby Creek watersheds. In these watersheds, particularly the Swamp Creek and Johnson Run watersheds of the East Branch Clarion River and the Daguscahonda Creek watershed of the Elk Creek drainage area, ground-water quality has been degraded because of coal mining. In much of the northern half of the Little Toby Creek basin, coal mining has caused higher than normal concentrations of iron, manganese, and sulfate (for example, in Limestone Run, Kyler Run, Sawmill Run, Brandy Camp Creek, and Mead Run). In watersheds in the northern half of the Clarion River basin not influenced by mining (for example, West Branch Clarion River, Big Mill Creek, Bear Creek, Spring Creek, and Millstone Creek), median dissolved-solids concentrations are lower than in watersheds affected by mining. However, even in a few watersheds unaffected by mining (Spring Creek, Millstone Creek), iron and manganese may naturally occur in concentrations exceeding EPA recommended limits.

In the southern half of the Clarion River basin, much ground water is severely degraded in areas that have been extensively mined for coal; some areas, however, have ground water of good quality. Degradation has occurred in many watersheds, including those of Mill, Toby, Piney, Deer, and Licking Creeks, where water of poor quality discharges from numerous flowing wells. Water of good quality is present in the basins of Maple Creek, Coleman, Cathers, Maxwell, and Blyson Runs, and in the headwater area of Mill Creek.

In the Redbank Creek basin, ground-water quality ranges from fairly good to severely degraded. It is best in some of the northern areas, including the basins of North Fork, Mill Creek, and several tributaries to Sandy Lick Creek. Downstream from Brookville, the ground water in many tributary watersheds is degraded, primarily as a result of coal mining (for example, in Coder, Welch, Runaway, Beaver, Town, Leisure, and Wildcat Runs, and Little Sandy Creek).

Table 23.--Summary statistics of field analyses of hardness, specific conductance, and pH of water from wells in the Clarion River and Redbank Creek basins

Constituent or property	Number of wells	Range	Percentage of wells in which indicated value of constituent property is equaled or exceeded				
			90	75	50	25	10
Clarion River basin							
Hardness (Ca, Mg) as $CaCO_3$ (mg/L)	189	20 - 1,500	30	30	70	150	460
Specific conductance (micromhos at 25°C)	242	23 - 5,800	96	160	360	931	2,060
pH	209	2.9 - 8.2	4.3	5.0	6.0	6.6	7.1
Redbank Creek basin							
Hardness (Ca, Mg) as $CaCO_3$ (mg/L)	54	20 - 1,370	50	90	120	240	800
Specific conductance (micromhos at 25°C)	53	52 - 5,500	129	198	330	748	1,740
pH	38	3.3 - 7.9	5.4	6.0	6.4	7.4	7.6

Areal ground-water quality can also be assessed through the use of surface-water quality data collected at base flow. Streams at base flow, discharge ground water, largely or entirely, although the flow may also be augmented from industries or municipalities or from reservoirs. Information on which stations are affected by reservoir regulation is given in the surface-water hydrology section. With the exception of Elk Creek in Elk County, the contribution to streamflow at base flow by industrial or municipal discharge is relatively small.

Evaluation of ground-water quality through the use of base-flow stream-quality data is particularly valuable in areas of few water wells, such as the large undeveloped and forested parts of Elk and Forest Counties.

Base-flow samples were collected at all gaging stations and in selected tributary streams during 1971-76 to assess ground-water quality. Most of the chemical analyses given in Koester and Lescinsky (1976, tables 6a-c) collected during August, September, and October represent base-flow conditions. Chemical analyses of base-flow sampling are also given in Buckwalter and others (1979, table 6).

The quality of water in specific aquifers can also be assessed, as the base flow at a particular site reflects the general quality of aquifers upstream. By plotting the location of a stream-sampling site on the bedrock geologic map (plate 1), the aquifers that contribute the water can be identified. Millstone Creek, for example, drains an undeveloped and heavily forested area in Elk and Forest Counties, where few water wells are available. Stream-quality data were collected at base flow on October 11, 1972, at two sites (Koester and Lescinsky, 1976, table 6a). The sample at the mouth of the creek consisted mostly of water from the Pottsville Group plus a little from the Allegheny and Lower Mississippian rocks. The sample upstream on the East Branch Millstone Creek was comprised of water chiefly from the Pottsville Group and a little from the Allegheny. Both samples were similar in composition, soft, low in sulfate and chloride, and contained some alkalinity. There was no acidity or ferrous iron. The only excessive constituent was dissolved ferric iron, which averaged 0.88 mg/L.

Quality of Surface Water

Data Base

Most of the chemical analyses of streams are in Koester and Lescinsky (1976). Tables 6a-c give analyses of about 800 samples collected during 1969-75 at 164 stream sites. Station descriptions, drainage areas, and selected discharge measurements are listed for the data-collection sites. Buckwalter and others (1979) also gives data on stream quality (also in table 6) and locations of the sites on page-size reductions of 7½-minute topographic quadrangle maps. In the present report, figure 10 shows the major tributary streams and the locations of selected gaging and chemical quality stations. Table 24 gives information on the stations.

Some data are also published annually since 1961 in the Survey's "Water Resources Data for Pennsylvania."

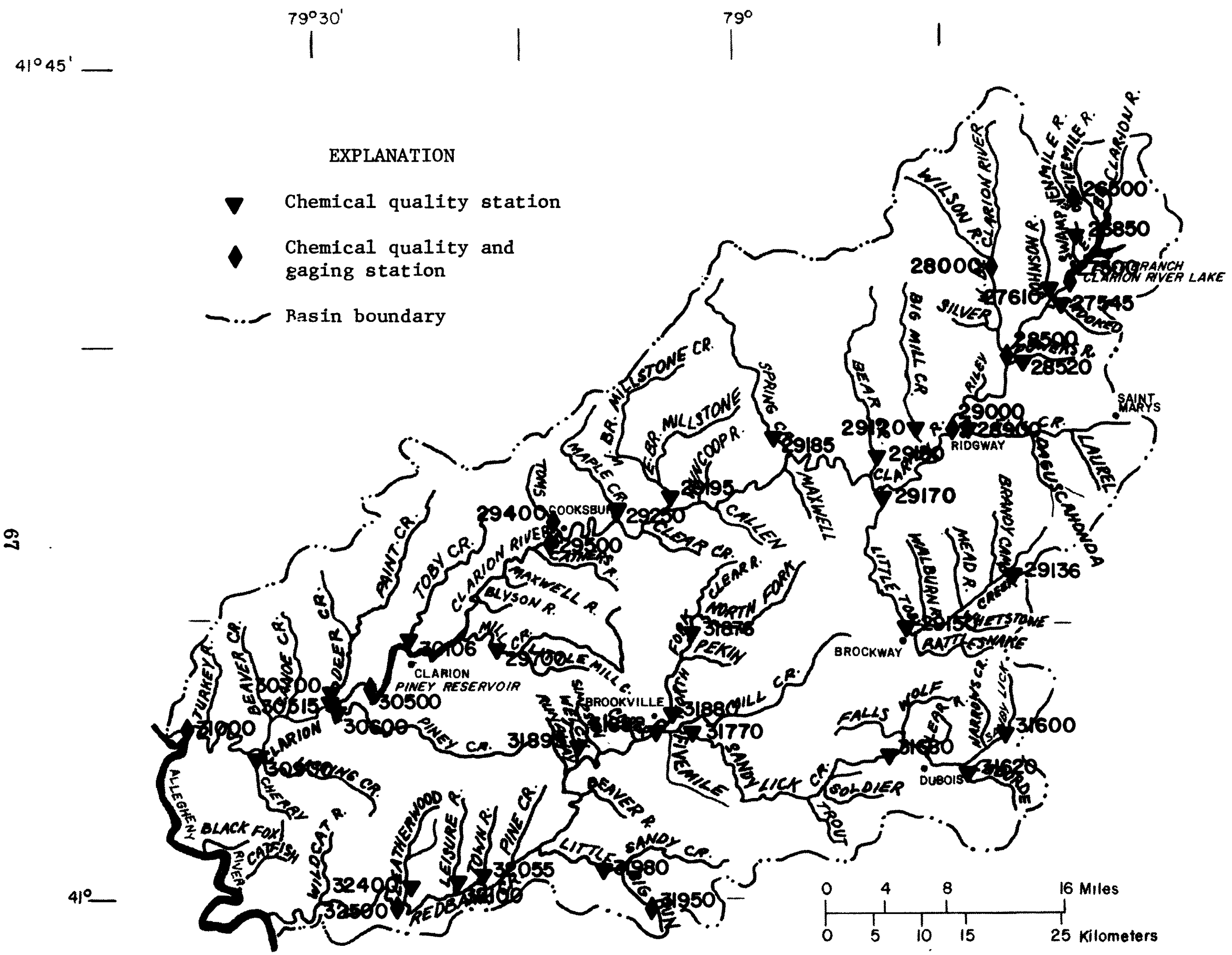


Figure 10.--Location of selected surface-water stations.

Table 24.—Selected data collection sites

Station number	Station name	Drainage area (mi^2)	$7^1/2$-Quadrangle	Latitude	Longitude	Figure number 2/
			Clarion River basin			
26500	Sevenmile Run near Rasselas 1/	7.84	Hazel Hurst	41°37'52"	78°34'37"	19
26850	Swamp Creek near Rasselas	3.61	Glen Hazel	41°35'30"	78°35'46"	17
27500	East Branch Clarion River at East Branch Clarion River Dam 1/	73.2	Glen Hazel	41°35'11"	78°35'47"	17
27545	East Branch Clarion River above Glen Hazel	80.1	Glen Hazel	41°32'40"	78°36'50"	17
28000	West Branch Clarion River at Wilcox 1/	63.0	Wilcox	41°34'31"	78°41'33"	50
28500	Clarion River at Johnsonburg 1/	204	Ridgway	41°29'10"	78°40'43"	37
28520	Powers Run at mouth	11.8	Ridgway	41°28'45"	78°40'12"	37
28900	Elk Creek at Ridgway	64.1	Ridgway	41°25'31"	78°43'38"	37
29000	Clarion River at Ridgway 1/	303	Ridgway	41°25'15"	78°44'10"	37
29120	Big Mill Creek near Ridgway	9.04	Portland Mills	41°24'58"	78°46'31"	35
29136	Little Toby Creek at Kylers Corners	6.44	Brandy Camp	41°19'05"	78°38'26"	2
29150	Little Toby Creek at Brockway	54.0	Carman	41°15'09"	78°47'48"	4
29170	Little Toby Creek at Portland Mills	126	Carman	41°21'53"	78°49'22"	4
29180	Bear Creek near Ridgway	38.8	Portland Mills	41°23'52"	78°49'23"	35
29185	Spring Creek near Hallton	86.0	Hallton	41°24'59"	78°56'52"	18
29195	Millstone Creek near Clarington	54.2	Sigel	41°21'19"	79°04'18"	42
29250	Maple Creek near Clarington	18.7	Cooksburg	41°20'32"	79°08'19"	6
29400	Toms Run at Cooksburg 1/	12.6	Cooksburg	41°20'16"	79°12'50"	6
29500	Clarion River at Cooksburg 1/	807	Cooksburg	41°19'50"	79°12'33"	6
29700	Mill Creek near Strattanville	66.1	Strattanville	41°14'15"	79°17'11"	44
30106	Toby Creek near Clarion	35.0	Clarion	41°14'05"	79°23'06"	5
30500	Clarion River near Piney 1/	951	Clarion	41°11'33"	79°26'25"	5

Table 24.--Selected data collection sites--Continued

Station number	Station name	Drainage area (mi^2)	7 1/2-Quadrangle	Latitude	Longitude	Figure number 2/
			Clarion River basin--Continued			
30515	Clarion River at Piney	967	Clarion	41°10'12"	79°28'21"	5
30600	Piney Creek at Piney	72.3	Clarion	41°10'12"	79°28'20"	5
30700	Deer Creek at Piney	74.2	Clarion	41°10'24"	79°28'41"	5
30750	Canoe Creek near Callensburg	18.8	Knox	41°09'46"	79°31'57"	24
30900	Licking Creek at Callensburg	51.9	Rimersburg	41°07'25"	79°34'06"	38
31000	Clarion River at St. Petersburg	1,246	Emlenton	41°08'57"	79°39'37"	14
			Redbank Creek basin			
31600	Sandy Lick Creek near Sabula	4.65	Sabula	41°08'26"	78°41'00"	40
31620	Laborde Branch near Homecamp	15.5	Luthersburg	41°06'18"	78°42'52"	27
31680	Sandy Lick Creek near Falls Creek	86.9	DuBois	41°07'29"	78°49'25"	12
31770	Sandy Lick Creek near Brookville	158	Brookville	41°09'20"	79°03'12"	3
31876	North Fork near Richardsville	71.3	Brookville	41°13'44"	79°02'57"	3
31880	North Fork at Brookville	98.2	Brookville	41°09'36"	79°04'29"	3
31882	Redbank Creek at Brookville	327	Brookville	41°09'29"	79°04'52"	3
31895	Welch Run at Summerville	4.24	Corsica	41°07'30"	79°10'58"	8
31950	Big Run near Sprankle Mills 1/	7.38	Valier	40°59'30"	79°05'26"	49
31980	Little Sandy Creek near North Freedom	67.2	Summerville	41°01'58"	79°11'05"	45
32055	Town Run near Hawthorn	9.41	New Bethlehem	41°00'56"	79°17'56"	33
32100	Leisure Run at New Bethlehem	6.47	New Bethlehem	41°00'13"	79°19'41"	33
32400	Leatherwood Creek near New Bethlehem	18.1	Sligo	41°01'12"	79°23'14"	43
32500	Redbank Creek at St. Charles 1/	528	Templeton	40°59'40"	79°23'40"	46

1/ Continuous-record streamflow gaging station.
2/ Figure number of 7 1/2-minute topographic maps showing data collection sites given in Buckwalter and others (1979).

The Pennsylvania Department of Environmental Resources operates the Pennsylvania Water-Quality Network that includes sites on streams in the Clarion River and Redbank Creek basins. Many of these chemical analyses from network sites were reported in Koester and Lescinsky (1976, tables 6a-c). Beginning with the 1976 water year, data from the State's network are included in "Water Resources Data for Pennsylvania, Volume 3: Ohio River and St. Lawrence River Basins." Information on the Pennsylvania Water-Quality Network and other surface-water-quality programs concerning the Clarion River and Redbank Creek basins is available in the Comprehensive Water Quality Management Planning Program for Study Area 8 (Green International Inc., 1975-78).

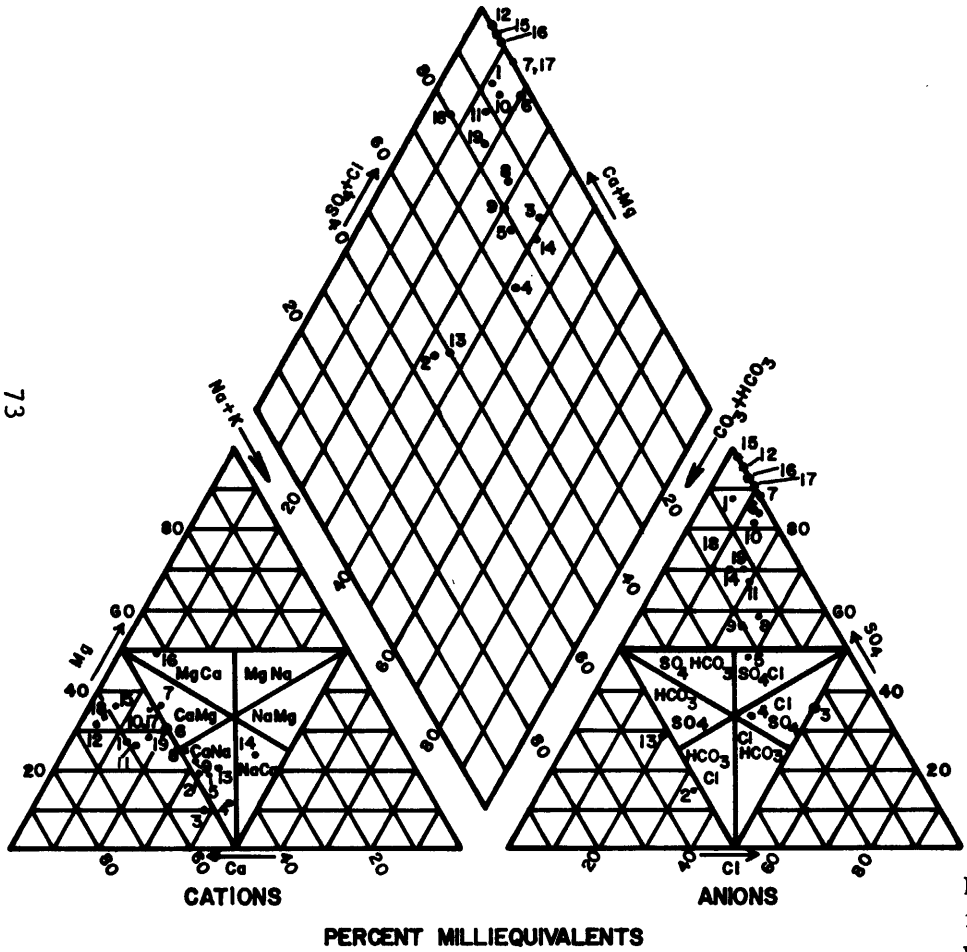
Chemical Characteristics

Concentration of dissolved solids in streams generally varies inversely with stream discharge. During low (or base) flow, stream discharge is sustained by ground-water discharge that generally has a high concentration of dissolved solids, although during high flow, stream discharge is from precipitation and overland flow that has low concentrations of dissolved solids. The relation of dissolved-solids concentration to the variation in discharge of streams is shown for small drainage areas in figure 11, and large areas in figure 12.

Concentration of dissolved solids has a fixed ratio to specific conductance of about 0.65. Specific conductance can be obtained quickly, easily, accurately, and inexpensively in the field, whereas reliable dissolved solids concentrations can only be obtained by time-consuming and expensive laboratory methods. Therefore, specific conductance is generally used to extend the analyses of dissolved-solids concentrations.

The chemical characteristics of 19 surface-water samples collected during base flow is shown on a trilinear water analysis diagram (fig. 13). Cations in solution are assumed to be calcium, magnesium, sodium, and potassium, and the anions are assumed to be bicarbonate, carbonate, sulfate, and chloride. Any minor constituents present are summed with major constituents that are chemically related. The diagram was prepared by first plotting the percent milliequivalents per liter (meq/L) of cations and anions of each sample in small triangles in the lower part of the figure. Cation and anion plots were then extrapolated to the diamond-shaped field to form a single point representing the composition of the principal solutes of the sample.

In order to identify the chemical type of a water sample, small triangles were subdivided and labeled on the basis of predominance of cations and anions expressed in percentage reacting values. When an ion makes up 50 percent or more of its ionic group, the water is classified according to the type designated by that ion. For example, sample 11 represents a calcium sulfate water. When no ion composes 50 percent or more of the cationic or anionic group, the hydrochemical type is designated by the first and second most abundant ions. Sample 4 represents calcium sodium chloride sulfate water.



EXPLANATION

	Station name	STATION NUMBER	DISSOLVED SOLIDS (RESIDUE AT 180 DEGREES CELSIUS, IN MILLIGRAMS PER LITER)
1	East Branch Clarion River at East Branch Clarion River Dam	27500	42
2	West Branch Clarion River at Wilcox	28000	91
3	Clarion River at Johnsonburg	28500	181
4	Clarion River at Ridgway	29000	106
5	Clarion River at Cooksburg	29500	136
6	Clarion River near Piney	30500	177
7	Clarion River at St. Petersburg	31000	298
8	Sandy Lick Creek near Brookville	31770	174
9	Redbank Creek at Brookville	31882	162
10	Redbank Creek at St. Charles	32500	330
11	Sevenmile Run near Rasselas	26500	26
12	Little Toby Creek at Portland Mills	29170	480
13	Spring Creek near Hallton	29185	40
14	Toms Run at Cooksburg	29400	156
15	Toby Creek near Miola	30100	876
16	Piney Creek at Piney	30600	618
17	Deer Creek at Piney	30700	425
18	Big Run near Sprankle Mills	31950	116
19	Little Sandy Creek near North Freedom	31980	211

Note.--All samples were collected during base flow in October 1971 except for samples 11 and 18, which were collected in April 1972.

Figure 13.--Water analysis diagram showing percent composition of chemical constituents of surface waters.

Although there are many combinations, the predominant type of water found is calcium sulfate ($CaSO_4$) (fig. 13). The most abundant cation and anion are calcium and sulfate for 13 samples. Only three samples do not contain sulfate as their first or second most abundant anion. Calcium sulfate waters high in dissolved solids (for example, samples 12, 15, and 17) indicate contamination by acid mine drainage, whereas calcium sodium bicarbonate waters (for example, samples 2 and 13) indicate good quality water.

Relative downstream changes in the chemical composition of water in the Clarion River and Redbank Creek are shown in figure 13. A comparison of the water composition of the upper part (samples 3 and 4) of the Clarion River to the lower part (samples 6 and 7) shows the following trends for cations and anions: (1) little change in calcium, (2) increase in magnesium, (3) decrease in sodium plus potassium, (4) decrease in bicarbonate, (5) large increase in sulfate, and (6) large decrease in chloride. A comparison of the water composition of the upper part (samples 8 and 9) of the Redbank Creek to the lower part (sample 10) shows these trends: (1) little change in calcium, (2) increase in magnesium, (3) decrease in sodium plus potassium, (4) decrease in bicarbonate, (5) increase in sulfate, and (6) decrease in chloride.

Water in both the Clarion River and Redbank Creek is dominantly calcium sulfate in type. Secondary constituents include magnesium, sodium, potassium, bicarbonate, and chloride. As the water moves downstream, slight changes in composition result--magnesium increases, as sodium plus potassium decrease, and sulfate increases at the expense of bicarbonate and chloride.

Areal Water Quality

Figure 14 shows streams with good quality and those affected by coal mine drainage. The areal variation of specific conductance, iron, sulfate, alkalinity, and nitrate is shown in figures 15-19. Range and mean values for water-quality parameters for selected stations are given in table 25. The data for figures 15-19 and table 25 were collected during 1969-76. Mean values of selected water-quality parameters for the period 1962-75 for sampling stations on the Clarion River are given in table 26. The areal water-quality characteristics of the Clarion River and Redbank Creek are discussed in the following sections starting in the headwaters and proceeding toward the mouth.

Clarion River basin water-quality assessment

During the 1930's and 1940's, the Clarion River was severely contaminated by organic substances from industries and municipalities (Camp, Dresser, and McKee Consulting Engineers, 1949). Presently (1978), it is relatively free of organic contamination; the major water-quality problem is mine drainage.

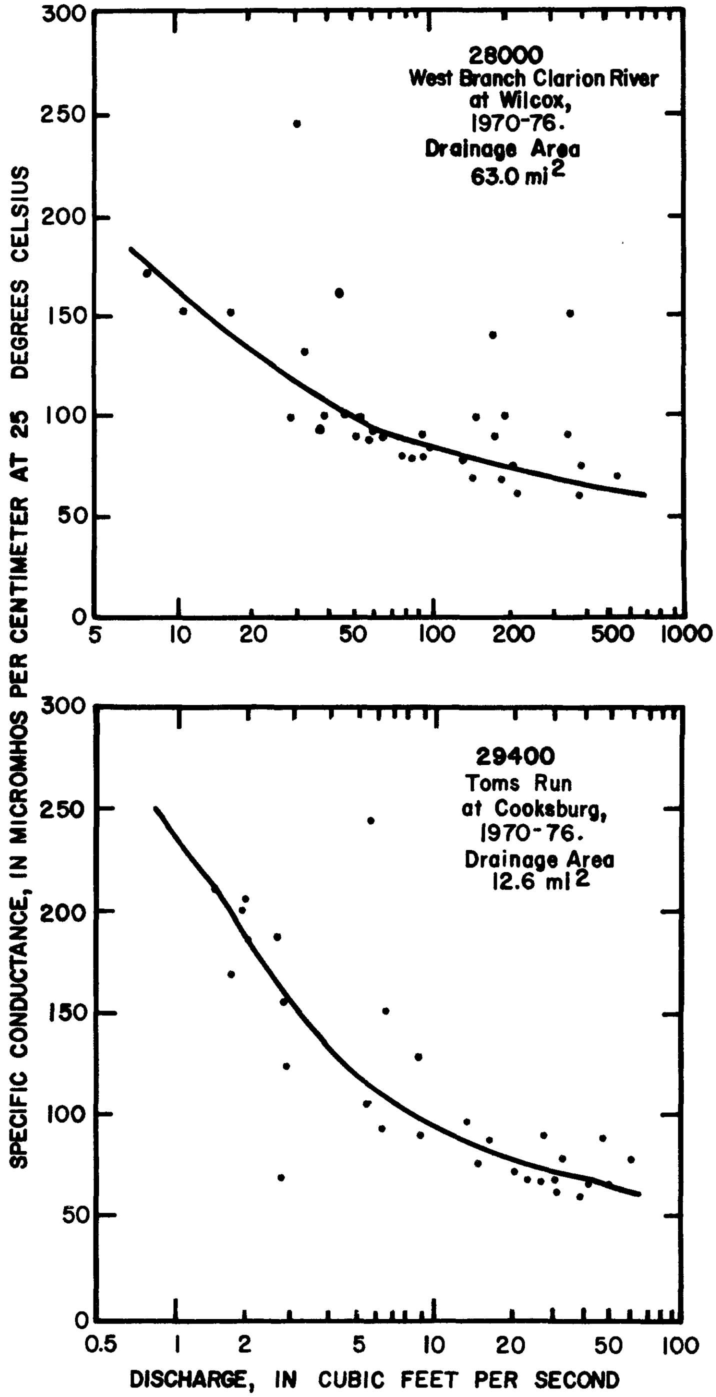


Figure 11.--Variation of specific conductance with instantaneous discharge in two streams having small drainage areas.

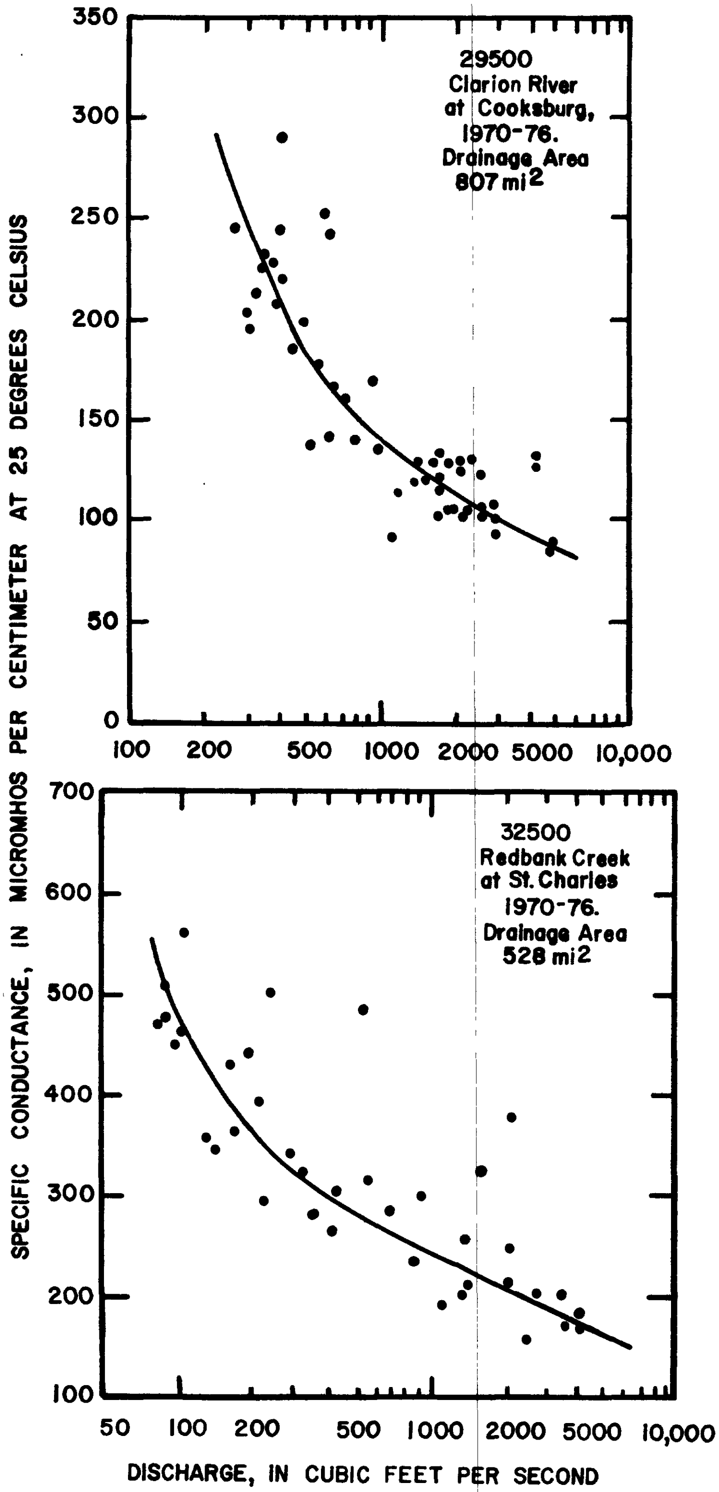


Figure 12.--Variation of specific conductance with instantaneous discharge in two streams having large drainage areas.

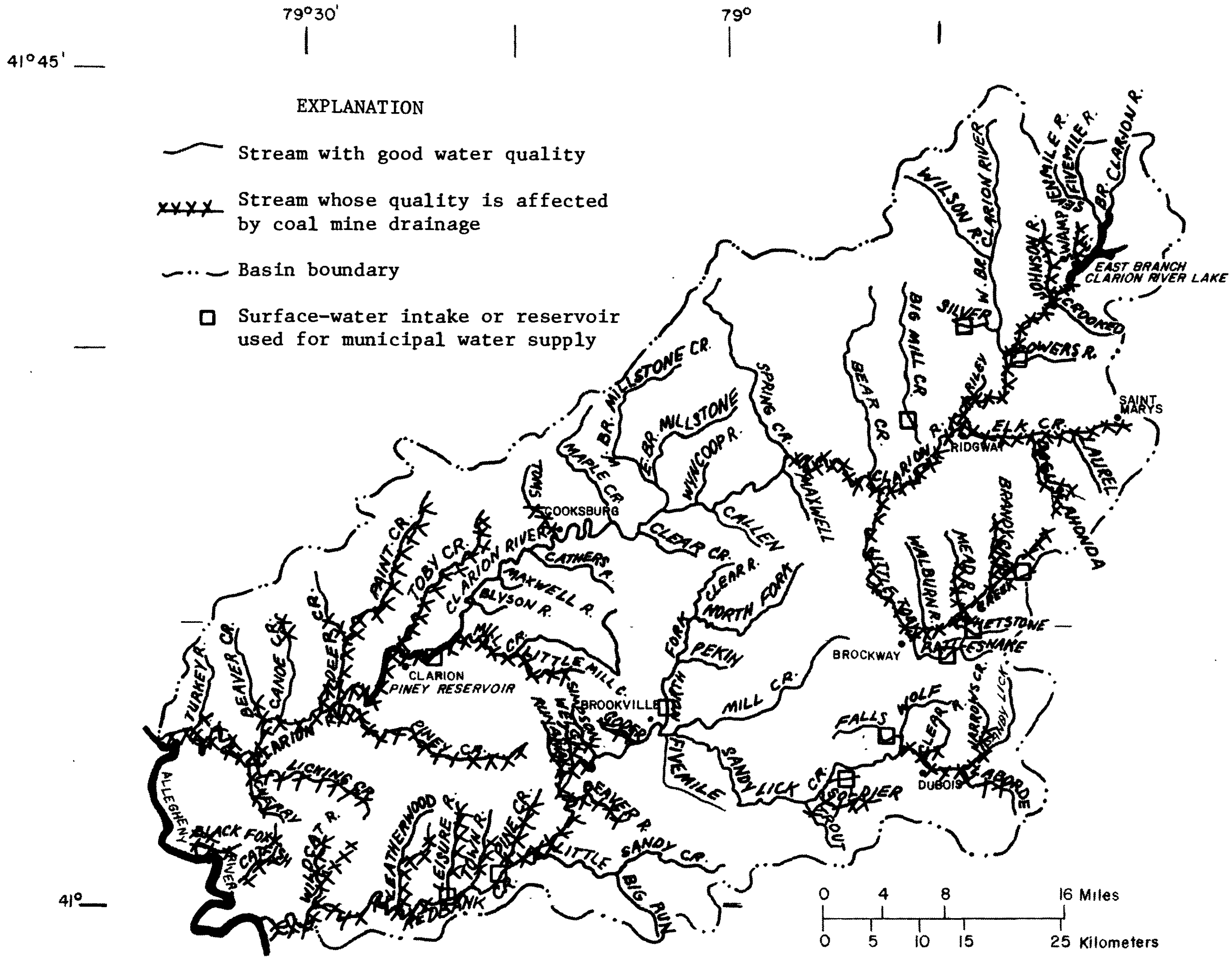


Figure 14.--Stream quality of the Clarion River and Redbank Creek basins.

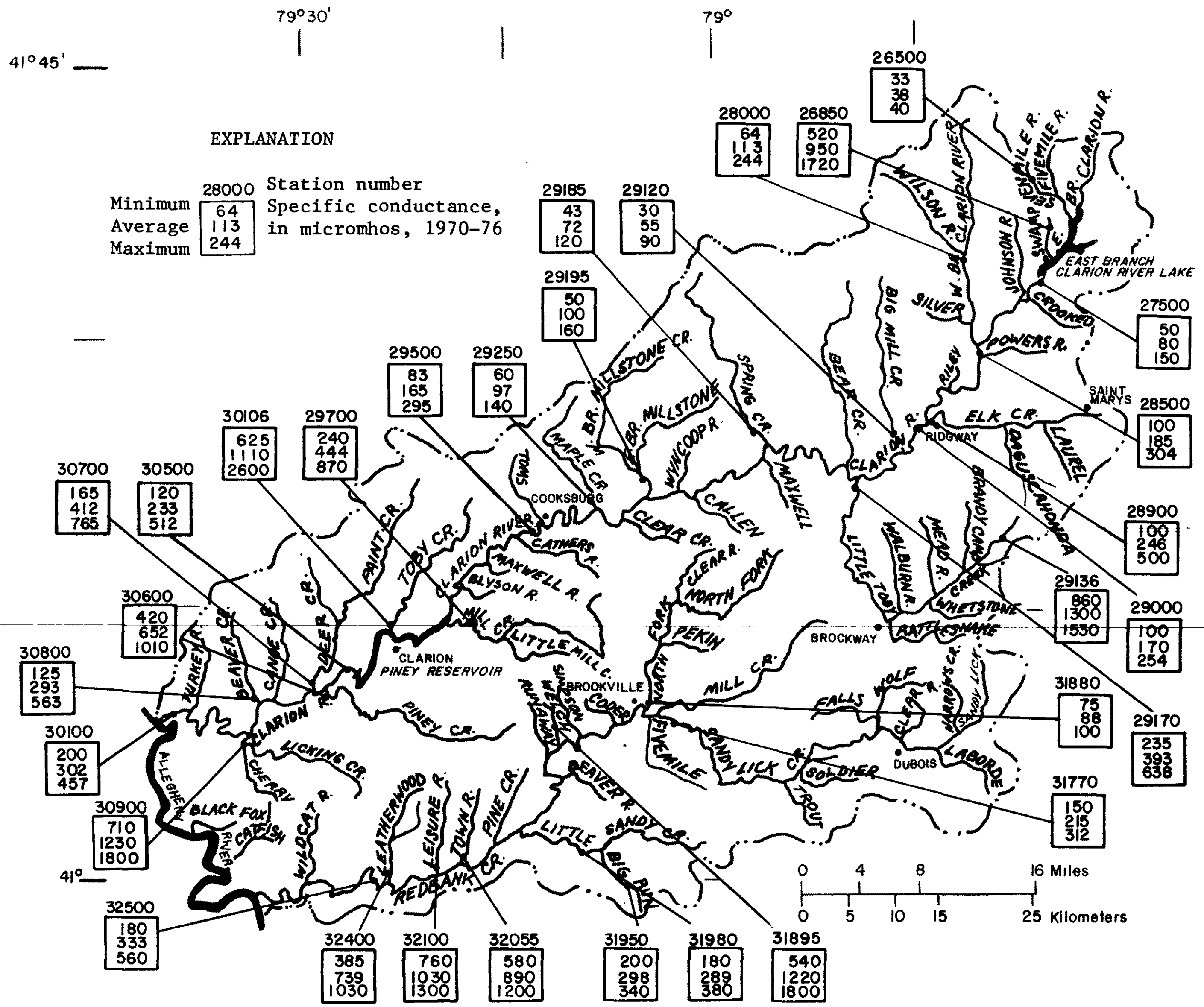


Figure 15.--Areal variation of specific conductance of surface-water samples.

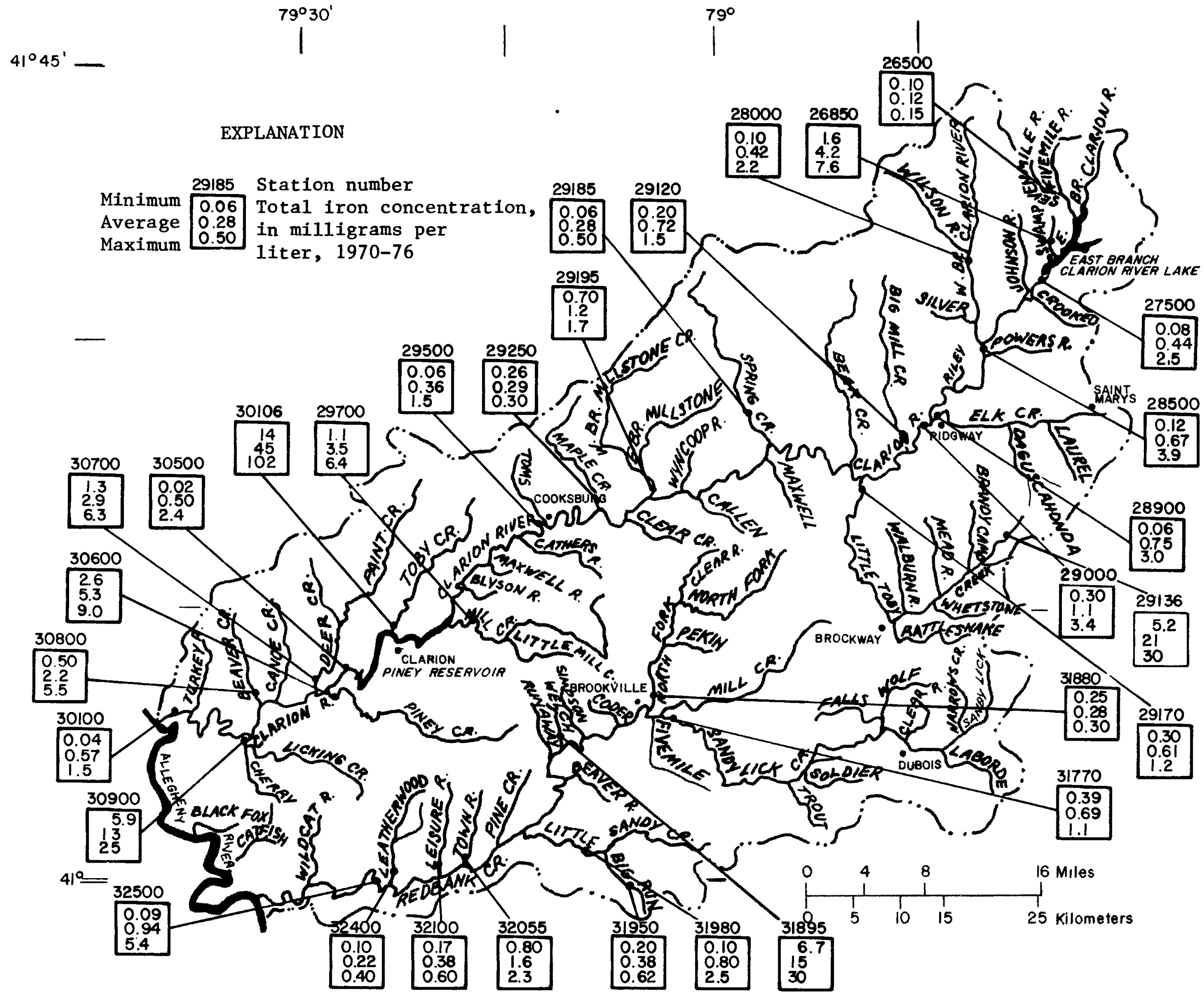


Figure 16.--Areal variation of iron concentrations in surface-water samples.

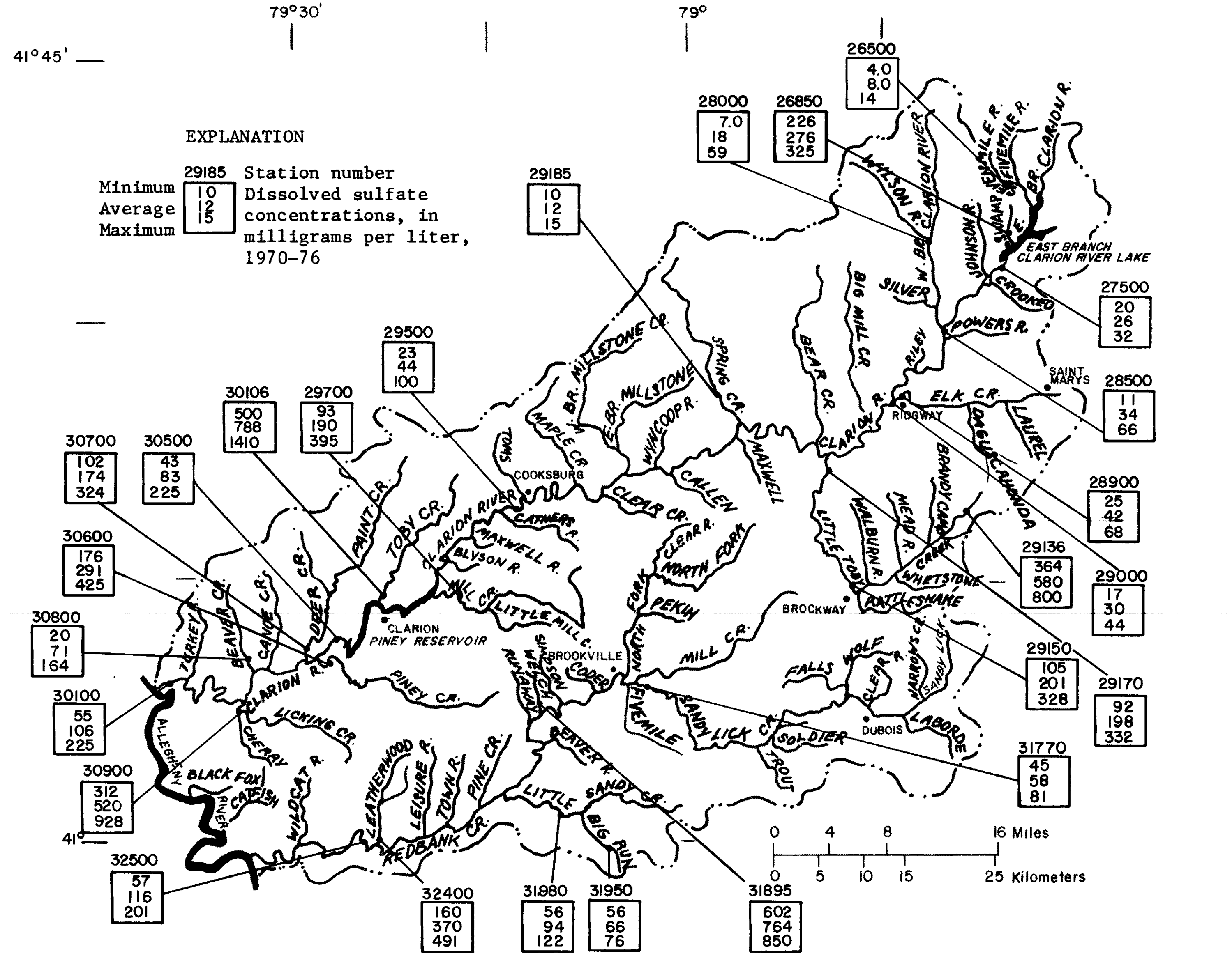


Figure 17.--Areal variation of sulfate concentrations in surface-water samples.

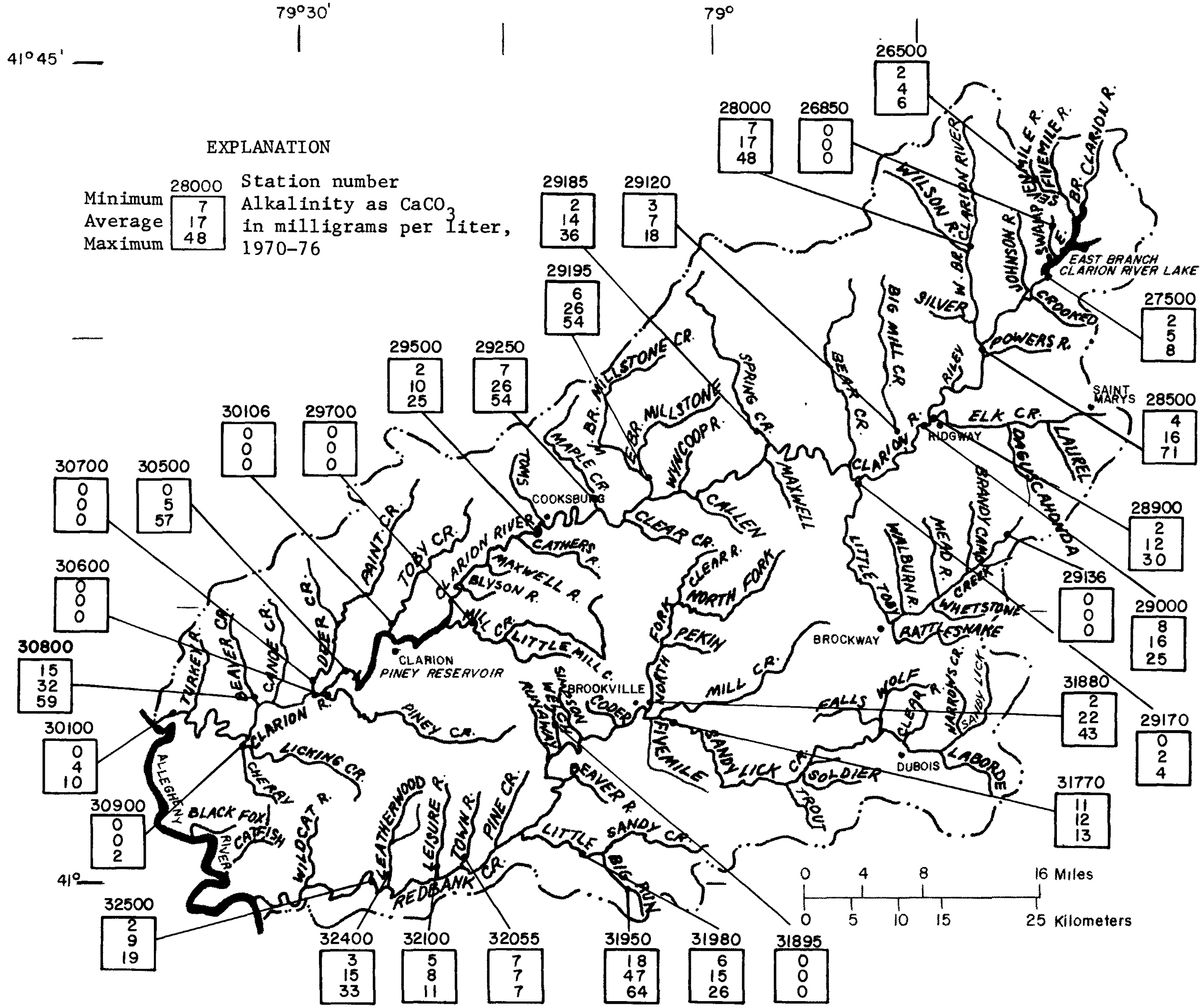


Figure 18.--Areal variation of alkalinity concentrations in surface-water samples.

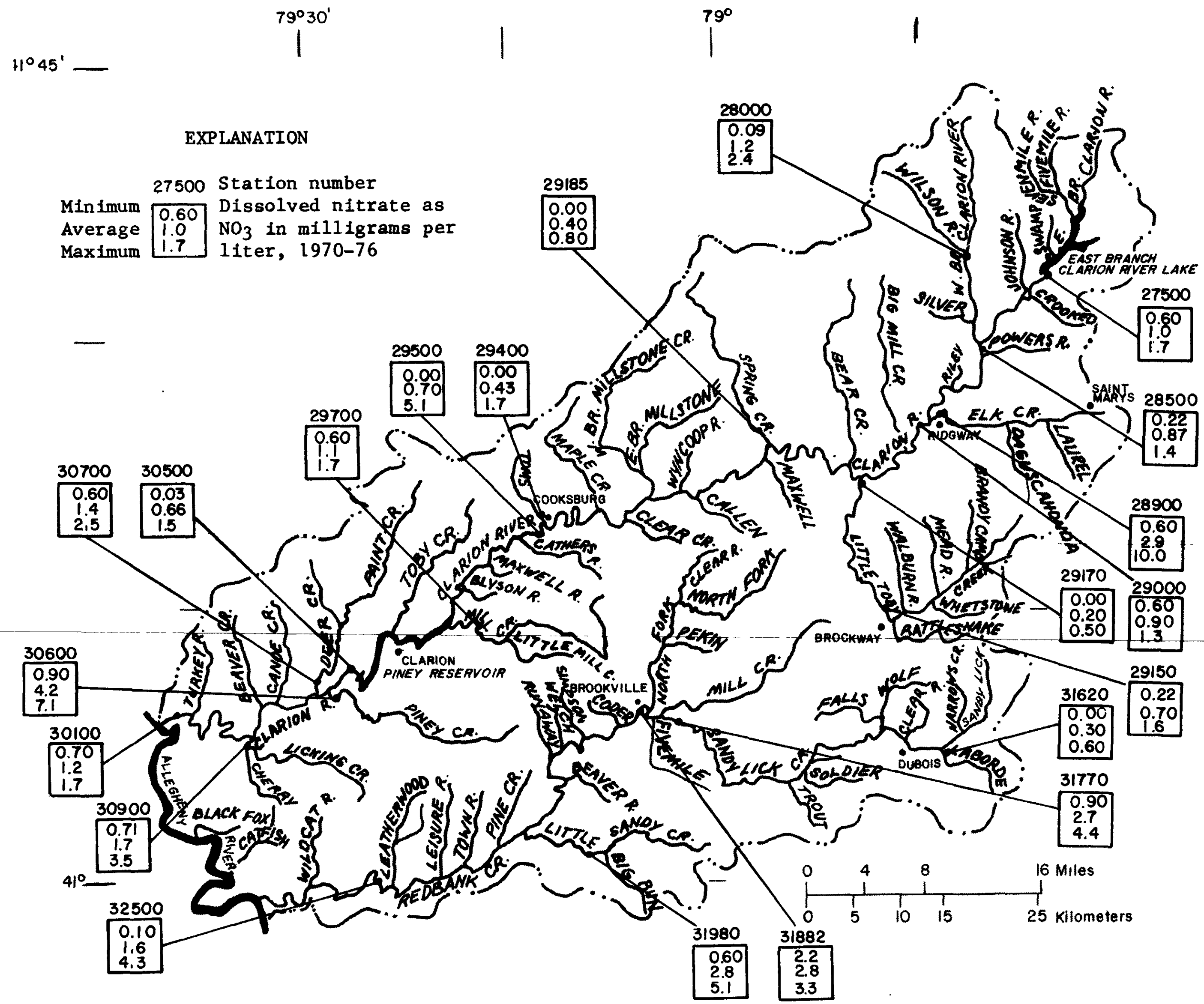


Figure 19.--Areal variation of nitrate concentrations in surface-water samples.

Table 25.—Range and mean values of chemical analyses of surface water

	Discharge (ft^3/s)	Temperature (Degrees Celsius)	pH	Specific conductance (micromhos at 25°C)	Dissolved oxygen (O_2)	Silica (SiO_2)	Total iron (Fe)	Ferrous iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na + K)	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Hardness as $CaCO_3$	Dissolved solids (Residue at 180°C)
					milligrams per liter																
	CLARION RIVER BASIN																				
	Station 03026490 Fivemile Run at Williamsville 41°38'18" 78°34'18"																				
Range	1.2-30	2.5-13.6	5.5-7.4	44-70	10.0-14.8	-	0.10-.45	0.00	0.00-.40	-	-	-	2.7	0.0-2.0	13-24	0.8-10	-	-	-	9-48	-
Mean	16	-	-	54	12.2	-	.29	.00	.12	-	-	-	5	.6	18	4.0	-	-	-	32	-
	Station 03026500 Sevenmile Run near Rasselas 41°37'52" 78°34'37"																				
Range	25-28	3.9-4.5	5.6-7.3	33-40	13.0	3.4	.10-.15	.10	.00-.05	3.0	0.9	1.1	2.3	.0	.8-8.2	1.7-7.6	0.0	0.53	0.01	10-11	26
Mean	26	-	-	36	-	-	.12	-	.02	-	-	-	2	-	7.0	4.6	-	-	-	10	-
	Station 03026850 Swamp Creek near Rasselas 41°35'30" 78°35'46"																				
Range	.72-14	.4-13.8	3.8-4.2	520-1720	8.4-10.8	-	1.6-7.6	.70-1.1	1.0-18	-	-	-	0	55-134	226-325	1.5-3.8	-	-	-	170-1000	-
Mean	5.6	-	-	950	9.8	-	4.2	.90	12	-	-	-	0	87	276	2.6	-	-	-	470	-
	Station 03027500 East Branch Clarion River at East Branch Clarion River Dam 41°33'11" 78°35'47"																				
Range	37-450	2.5-22.5	4.9-7.1	50-150	9.0-14.1	3.6-4.1	.08-2.5	.00	.10-.93	4.0-12	1.0-5.4	2.2-2.5	2.8	0.5	17-46	1.2-10	.1	.60-1.7	.00-16	18-52	40-82
Mean	146	-	-	80	11.5	3.8	.44	-	.55	6.8	3.0	2.4	5	1.3	27	4.8	-	1.0	.06	33	53
	Station 03027550 Crooked Creek at Glen Hazel 41°32'15" 78°36'49"																				
Range	1.2-69	.6-17.5	5.0-7.2	55-82	9.0-15.6	-	.10-.50	.00	.00-.04	-	-	-	7-26	.0	11-13	1.8-3.8	-	-	-	17-39	-
Mean	146	-	-	66	12.0	-	.32	.00	.01	-	-	-	14	.0	12	2.8	-	-	-	30	-
	Station 03027589 Johnson Run near Ketner 41°34'11" 78°37'14"																				
Range	.78-12	2.4-15.8	3.4-3.6	580-1750	9.8-13.2	-	1.2-7.0	.8-1.8	2.3-20	-	-	-	0	35-120	256-775	7.0-8.4	-	-	-	190-700	-
Mean	6.0	-	-	1190	11.3	-	3.2	1.2	11	-	-	-	0	82	516	7.8	-	-	-	430	-
	Station 03027610 Johnson Run near Ketner 41°32'23" 78°37'34"																				
Range	1.3-108	1.0-16.2	4.0-5.3	320-950	8.6-15.4	-	.33-1.5	.0-.45	2.1-10	-	-	-	1-8	1.0-65	134-460	3.4-7.8	-	-	-	120-500	-
Mean	35	-	-	619	11.6	-	.76	.24	5.1	-	-	-	2	36	297	5.6	-	-	-	270	-

Table 25.--Range and mean values of chemical analyses of surface water--Continued

	Discharge	Temperature	pH	Specific conductance	Dissolved oxygen (O_2)	Silica (SiO_2)	Total iron (Fe)	Ferrous iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na + K)	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Hardness as $CaCO_3$	Dissolved solids (Residue at 180°C)
	(ft^3/s)	Degrees Celsius		micromhos at 25°C	milligrams per liter																
	Station 03027690	East Branch Clarion River at Johnsonburg				41°29'38"		78°40'22"													
Range	220-1600	6.9-21.2	5.5-6.2	60-85	8.8-14.0	-	0.25-.80	0.00-.10	0.00-.10	-	-	-	2-10	0.0-1.0	20-32	3.6-4.6	-	-	-	30-39	-
Mean	824	-	-	72	10.8	-	.40	.04	.38	-	-	-	4	.5	26	4.1	-	-	-	34	-
	Station 03027850	West Branch Clarion River at Wilcox				41°34'45"		78°41'22"													
Range	7.1-122	1.2-18.3	5.6-7.4	75-180	10.0-14.6	-	.10-.40	.00	.00-.05	-	-	-	11-46	.0	12-17	8.6-21	-	1.5	-	19-88	-
Mean	58	-	-	123	12.2	-	.26	.00	.01	-	-	-	27	.0	14	14	-	-	-	50	-
	Station 03027990	Wilson Run at Dahoga				41°35'56"		78°43'35"													
Range	3.3-151	4.0-15.4	6.0-8.0	60-160	10.8-12.4	-	.28-.70	.00-.03	.00-.05	-	-	-	8-43	.0	8.8-12	10-11	-	-	-	21-68	-
Mean	53	-	-	101	11.6	-	.49	.01	.02	-	-	-	24	.0	10	10	-	-	-	45	-
	Station 03028000	West Branch Clarion River at Wilcox				41°34'31"		78°41'33"													
Range	8.1-405	2.0-26.0	6.5-7.7	64-244	8.0-14.0	2.0-3.7	.10-2.2	.00	.02-.10	5.6-16	1.0-5.4	4.2-14	7-48	.0	7.0-59	0.6-37	.1	.09-2.4	.00-1.2	21-58	39-104
Mean	151	-	-	113	11.0	2.8	.42	-	.04	8.7	2.9	9.1	17	-	18	13	.1	1.2	.15	38	72
	Station 03028500	Clarion River at Johnsonburg				41°29'43"		78°40'43"													
Range	126-1510	2.0-26.0	6.0-7.6	100-304	7.0-19.0	4.6-11	.12-3.9	-	.03-.65	7.2-30	2.2-8.8	5.5-28	4-71	.0-2.0	11-66	4.0-50	.1-.2	.22-1.4	01-1.9	22-90	56-181
Mean	448	-	-	185	11.2	7.8	.67	-	.33	14	4.0	17	16	.8	34	15	.2	.87	.21	45	121
	Station 03028520	Powers Run at mouth				41°28'45"		78°40'12"													
Range	3.5-57	3.8-16.0	5.6-7.6	55-110	10.2-12.0	-	.10-.25	.00-.10	.00-.06	-	-	-	5-20	.0-1.2	11-19	7.6-12	-	-	-	14-38	-
Mean	30	-	-	80	11.4	-	.19	.02	.02	-	-	-	12	.3	15	9.8	-	-	-	28	-
	Station 03028530	Riley Run near Johnsonburg				41°28'08"		78°42'00"													
Range	3.0-10	5.8-23.2	6.7-7.8	1,600-2,600	1.9	24	.30-1.2	.00	1.0-1.6	170	6.3	376	294-410	.0	78-88	550-590	.1	15	1.2	260-450	1490
Mean	5.5	-	-	2,290	-	-	.75	1.2	1.2	-	-	-	362	.0	83	563	-	-	-	360	-
	Station 03028550	Little Mill Creek near Johnsonburg				41°30'04"		78°43'44"													
Range	1.6-36	12.1-18.0	5.1-7.2	30-55	9.2-12.2	-	.21-.80	.00	.05-.16	-	-	-	2.8	.0-5.0	-	-	-	-	-	12-21	-
Mean	18	-	-	45	10.7	-	.42	.00	.09	-	-	-	4	1.7	-	-	-	-	-	17	-

Table 25.--Range and mean values of chemical analyses of surface water--Continued

	Discharge	Temperature	pH	Specific conductance	Dissolved oxygen (O_2)	Silica (SiO_2)	Total iron (Fe)	Ferrous iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na + K)	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Hardness as $CaCO_3$	Dissolved solids (Residue at 180°C)
	(ft^3/s)	Degrees Celsius		micromhos at 25°C	milligrams per liter																
	Station 03028740 Elk Creek at St. Marys							41°25'16"	78°34'33"												
Range	11-92	11.8-17.9	5.5-6.2	270-500	8.6-11.0	-	1.9-4.1	0.00-1.0	1.0-1.5	-	-	-	2-31	0.0-2.0	58	98	-	-	-	86-170	-
Mean	39	-	-	380	9.7	-	2.8	.50	1.2	-	-	-	17	.7	-	-	-	-	-	129	-
	Station 03028750 Laurel Run near St. Marys							41°25'07"	78°36'18"												
Range	.10-24	4.6-14.6	6.2-6.8	80-150	9.0-13.0	-	.40-1.8	.00-.10	.10-.50	-	-	-	2-36	.0-5.0	25-32	1.2-8.0	-	-	-	31-68	-
Mean	9.0	-	-	123	11.0	-	1.0	.03	.37	-	-	-	22	1.7	28	4.6	-	-	-	50	-
	Station 03028800 Daguscahonda Creek at Daguscahonda							41°25'09"	78°38'32"												
Range	6.4-117	4.0-13.6	4.2-4.9	160-200	11.0-12.0	-	.25-3.8	.00-1.3	.30-1.6	-	-	-	0	12-65	61-64	7.6-23	-	-	-	44-86	-
Mean	46	-	-	184	11.3	-	1.7	.52	.98	-	-	-	0	28	62	15	-	-	-	62	-
	Station 03028900 Elk Creek at Ridgway							41°25'31"	78°43'38"												
Range	13-450	2.0-25.0	5.4-7.5	100-500	8.0-13.6	1.7-4.7	.06-3.0	.00-.55	.00-.62	7.7-22	1.5-11	7.9-49	2-30	.0-5.0	25-68	11-98	.1-.2	.60-10	.04-.86	28-120	63-316
Mean	129	-	-	246	10.4	3.2	.75	.19	.30	12	4.5	28	12	1.7	42	35	.2	2.9	.42	54	148
	Station 03029000 Clarion River at Ridgway							41°25'15"	78°44'10"												
Range	166-1770	3.5-22.0	6.2-7.4	100-254	6.0-15.0	4.2-5.8	.30-3.4	.0	.04-.40	10-16	2.1-5.4	6.8-19	8-25	.0-5.0	17-44	9.7-33	.1	.60-1.3	.03-.44	24-82	62-156
Mean	769	-	-	170	9.7	5.0	1.1	-	.20	12	3.4	13	16	2.0	30	20	.1	.9	.12	46	104
	Station 03029120 Big Mill Creek near Ridgway							41°24'58"	78°46'31"												
Range	8.1-288	8.0-17.0	5.5-6.4	30-90	10.2-12.0	-	.20-1.5	.00-.19	.00-.26	-	-	-	3-18	.0-2.0	-	-	-	-	-	13-34	-
Mean	97	-	-	55	11.1	-	.72	.06	.12	-	-	-	7	.5	-	-	-	-	-	20	-
	Station 03029136 Little Toby Creek at Kylers Corners							41°19'05"	78°38'26"												
Range	1-35	5.8-15.6	3.3-3.6	860-1530	6.2-10.6	-	5.2-30	3.6-24	1.5-5.5	-	-	-	0	100-460	364-800	3.8-11	-	-	-	140-680	-
Mean	19	-	-	1300	8.9	-	21	13	3.6	-	-	-	0	250	580	7.4	-	-	-	440	-
	Station 03029140 Brandycamp Creek near Elbon							41°17'10"	78°41'22"												
Range	.8-48	3.1-15.2	3.4-4.4	360-1100	9.2-10.2	7.9	2.6-22	3.6-6.0	1.0-5.9	28	23	5.6	0	39-106	160-422	4.1-18	.5	.88	.00	120-33	331
Mean	22	-	-	628	9.7	-	9.8	4.8	3.0	-	-	-	0	60	257	8.4	-	-	-	220	-

Table 25.--Range and mean values of chemical analyses of surfece water--Continued

	Discharge	Temperature	pH	Specific conductance	Dissolved oxygen (O_2)	Silica (SiO_2)	Total iron (Fe)	Ferrous iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na + K)	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Hardness as $CaCO_3$	Dissolved solids (Residue at 180°C)
	(ft^3/s)	Degrees Celsius		micromhos at 25°C	milligrams per liter																
Station 03029142	Bear Run near Elbon							41°16'24"	78°41'38"												
Range	3.0-19	3.0-12.8	5.0-6.2	40-55	11.0-13.2	-	0.10-.30	0.00	0.00	-	-	-	2.8	0.0-5.0	13-14	3.5-4.2	-	-	-	17-22	-
Mean	12	-	-	48	11.7	-	.20	.00	.00	-	-	-	4	1.6	14	3.8	-	-	-	20	-
Station 03029145	Little Toby Creek at Brockport							41°15'46"	78°43'16"												
Range	30-133	6.0-15.7	3.8-4.1	438-1200	8.8-12.8	7.8	1.2-5.5	.60-1.6	2.0-3.0	42	16	4.1	0	24-110	186-528	5.8-21	.3	.10	-	170-470	271
Mean	76	-	-	708	10.8	-	3.0	1.2	2.6	-	-	-	0	58	306	12	-	-	-	300	-
Station 03029148	Rattlesnake Creek at Lane Mills							41°13'13"	78°46'25"												
Rang	3.0-59	3.5-16.8	5.3-6.4	240-400	11.0-12.4	-	.50-1.5	.10-.40	.04-1.0	-	-	-	16-38	.0	88-150	8.0-12	-	-	-	99-100	-
Mean	33	-	-	327	11.6	-	1.1	.28	.53	-	-	-	24	.0	119	10	-	-	-	150	-
Station 03029150	Little Toby Creek at Brockway							41°15'09"	78°47'48"												
Range	36-263	4.2-17.7	4.2-6.4	267-700	8.6-10.8	5.3-10	.13-6.7	.05-1.7	.50-5.3	25-87	10-32	4.7-10.1	0-7	.0-51	105-328	6.7-15	.2-.3	.22-1.6	.00-.01	100-350	183-507
Mean	149	-	-	456	10.2	7.6	2.0	.66	2.7	47	18	7.4	2	18	201	11	.2	.70	.00	210	345
Station 03029170	Little Toby Creek at Portland Mills							41°21'53"	78°49'22"												
Range	25-585	9.5-22.0	4.2-5.9	235-638	10.8-11	6.0-10	.30-1.2	.00-.10	1.0-3.8	24-85	8.9-26	4.1-11	0-4	.0-25	92-332	4.9-12	.3	.00-.50	.00-.01	97-320	144-480
Mean	210	-	-	393	10.9	8.0	.61	.06	2.2	54	17	7.4	2	9.7	198	8.8	.3	.20	.00	188	312
Station 03029180	Bear Creek near Ridgway							41°23'52"	78°49'23"												
Range	21-58	10.0-16.2	5.6-6.9	45-90	8.0-11.4	-	.05-.40	.00	.00-.40	-	-	-	6-21	.0	14-17	3.4-5.2	-	-	-	12-46	-
Mean	5	-	-	61	9.7	-	.20	.00	.14	-	-	-	10	.0	16	4.3	-	-	-	26	-
Station 03029184	Wolf Run at Parrish							41°29'27"	78°59'49"												
Range	2.8-14	7.2-16.2	5.5-7.2	30-85	12.2-12.8	-	.05-.60	.00	.00-.12	-	-	-	1-21	.0	-	-	-	-	-	12-34	-
Mean	8.3	-	-	55	12.5	-	.25	.00	.07	-	-	-	10	.0	-	-	-	-	-	21	-
Station 03029185	Spring Creek near Hallton							41°24'59"	78°56'52"												
Range	13-288	3.3-14.5	5.6-7.1	43-120	10.2-14.0	4.6	.06-.50	.00-.10	.00-.14	3.0-6.2	1.0-1.7	6.3	2-36	.0	10-15	2.7-5.2	0.1	.00-.80	.00-.01	12-51	40
Mean	132	-	-	72	11.6	-	.28	.02	.04	4.6	1.4	-	14	.0	12	4.0	-	0.40	.01	24	-

Table 25.—Range and mean values of chemical analyses of surface water—Continued

	Discharge	Temperature	pH	Specific conductance	Dissolved oxygen (O_2)	Silica (SiO_2)	Total iron (Fe)	Ferrous iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na + K)	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Hardness as $CaCO_3$	Dissolved solids (Residue at 180°C)
	(ft^3/s)	Degrees Celsius		micromhos at 25°C	milligrams per liter																
	Station 03029188	Maxwell Run at mouth					41°23'05"	78°56'08"													
Range	0.09-175	9.7-14.4	4.8-6.6	50-75	11.0-13.2	-	0.31-1.2	0.00	0.00-.50	-	-	-	2-21	0.0	11	3.5-4.2	-	-	-	17-31	-
Mean	60	-	-	58	12.1	-	.67	.00	.23	-	-	-	9	.0	-	3.8	-	-	-	24	-
	Station 03029194	East Branch Millstone Creek at Loleta					41°23'58"	79°04'51"													
Range	7.9-150	7.2-17.4	5.6-6.8	50-90	11.0-12.2	-	.70-1.7	.00	.05-.27	-	-	-	7-21	.0	21	1.8	-	-	-	19-34	-
Mean	79	-	-	70	11.6	-	1.2	.00	.16	-	-	-	14	.0	-	-	-	-	-	26	-
	Station 03029195	Millstone Creek near Clarington					41°21'19"	79°04'18"													
Range	5.6-227	8.8-17.2	5.7-6.6	50-160	10.0-12.8	-	.50-.88	.00-.10	.00-.17	-	-	-	6-54	.0	14	11	-	-	-	17-54	-
Mean	87	-	-	100	11.0	-	.66	.03	.08	-	-	-	26	.0	-	-	-	-	-	35	-
	Station 03029205	Clear Creek at mouth					41°19'48"	79°06'11"													
Range	1.4-64	8.4-12.3	5.5-6.3	50-80	10.6-11.2	-	.09-.40	.00-.10	.00-.08	-	-	-	7-26	.0	5.8	10	-	-	-	17-39	-
Mean	24	-	-	67	10.9	-	.23	.03	.03	-	-	-	18	.0	-	-	-	-	-	30	-
	Station 03029250	Maple Creek near Clarington					41°20'32"	79°08'19"													
Range	1.7-72	7.2-13.6	5.7-6.5	60-140	10.0-13.0	-	.26-.30	.00	.00-.08	-	-	-	7-54	.0	10	12	-	-	-	26-38	-
Mean	28	-	-	97	11.1	-	.29	.00	.04	-	-	-	26	.0	-	-	-	-	-	33	-
	Station 03029400	Toms Run at Cooksburg					41°20'16"	79°12'16"													
Range	1.0-59	0-24.0	5.3-7.6	60-255	11.2-13.5	1.6-7.0	.17-.70	.00-.12	.05-.40	4.0-20	1.6-7.1	3.4-23	1-30	.0	14-81	2.7-16	.00-.50	.00-1.7	.00-.21	17-76	40-156
Mean	17	-	-	125	12.0	5.1	.31	.03	.19	8.1	3.6	8.3	7	.0	35	7.1	.10	.43	.01	37	80
	Station 03029500	Clarion River at Cooksburg					41°19'50"	79°12'33"													
Range	264-5590	.5-27.0	4.5-7.6	83-295	7.5-12.0	.6-6.5	.06-1.5	.00	.05-.08	7.2-22	2.1-7.8	2.8-19	2-25	.0-2.0	23-100	4.2-22	.00-.30	.00-5.1	.00-1.8	27-110	51-188
Mean	1590	-	-	165	9.3	3.9	.36	-	.06	13	4.2	9.6	10	.7	44	12	.10	.70	.11	54	103
	Station 03029510	Cathers Run at mouth					41°19'00"	79°13'59"													
Range	4.8-129	8.4-15.6	5.7-6.7	45-130	10.8-11.4	-	.27-.30	.00-.10	.05-.50	-	-	-	10-39	.0	2.8	.8	-	-	-	18-54	-
Mean	50	-	-	82	11.1	-	.29	.03	.21	-	-	-	23	.0	-	-	-	-	-	35	-

Table 25.--Range and mean values of chemical analyses of surface water--Continued

	Discharge	Temperature	pH	Specific conductance	Dissolved oxygen (O_2)	Silica (SiO_2)	Total iron (Fe)	Ferrous iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na + K)	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_3)	Hardness as $CaCO_3$	Dissolved solids (Residue at 180°C)
	(ft^3/s)	Degrees Celsius		micromhos at 25°C	milligrams per liter																
	Station 03029680	Mill Creek near Strattanville						41°14'25"	79°14'06"												
Range	23-62	4.8-14.8	5.7-6.8	65-90	11.4-13.0	-	0.32-1.4	0.00-1.4	0.25-.50	-	-	-	2-5	0.0	17-33	5.0-11	-	-	-	34-44	-
Mean	42	-	-	75	12.4	-	.74	.50	.33	-	-	-	3	.0	25	8.0	-	-	-	38	-
	Station 03029700	Mill Creek near Strattanville						41°14'15"	79°17'11"												
Range	19-348	2.5-16.4	3.1-4.6	240-870	7.5-13.1	5.8-9.1	1.1-6.4	.70-2.4	1.5-11	17-71	11-42	5.3-16	0	12-79	93-395	5.0-15	.20-.30	.60-1.7	.00-.03	92-350	166-569
Mean	148	-	-	444	10.5	6.9	3.5	1.6	5.1	36	22	10	0	38	190	10	.20	1.1	.01	150	308
	Station 03030007	Toby Creek near Helen Furnace						41°17'59"	79°19'48"												
Range	1.8-70	5.4-16.2	2.9-3.8	500-1070	9.2-13.2	-	2.3-5.3	.50-3.5	3.8-12	40-67	46-64	10-19	0	20-84	213-502	17-23	-	-	-	170-430	-
Mean	36	-	-	694	11.4	-	3.6	1.3	7.0	54	55	14	0	64	335	20	-	-	-	270	-
	Station 03030089	Step Creek at mouth						41°15'33"	79°22'07"												
Range	.2-5.8	.7-19.1	2.8-3.5	675-1400	8.6-9.5	-	14-37	.80-7.0	5.5-17	64-102	50-57	12-27	0	93-402	535-555	8.1-10	-	-	-	390-460	-
Mean	2.0	-	-	1000	9.0	-	22	3.0	13	77	54	17	0	320	545	9.0	-	-	-	420	-
	Station 03030100	Toby Creek near Miola						41°15'29"	79°22'06"												
Range	3.9-140	3.8-15.5	2.9-3.8	380-1490	8.2-12.8	8.9	3.0-47	2.4-12	.50-21	90-100	55-89	24-26	0	46-205	162-795	8.0-17	.20	-	-	140-620	879
Mean	62	-	-	840	10.7	-	24	5.6	8.4	95	72	25	0	114	461	12	-	-	-	320	-
	Station 03030106	Toby Creek near Clarion						41°14'05"	79°23'06"												
Range	5.1-33	1.6-19.1	2.0-4.1	625-2600	8.0-9.3	11	14-102	6.0-27	5.5-43	47-147	47-172	8.1-29	0	88-430	500-1410	3.5-25	.6	-	-	310-1100	-
Mean	19	-	-	1110	8.7	-	45	15	17	91	99	16	0	184	788	17	-	-	-	580	-
	Station 03030500	Clarion River near Piney						41°11'33"	79°26'25"												
Range	33-5430	1.0-27.0	4.0-6.6	120-512	.7-12.0	.8-8.9	.02-2.4	1.8	1.2-7.0	9.0-43	4.0-21	4.5-15	0-57	5.0-30	43-225	5.6-29	.0-.4	.03-1.5	.00-.14	38-194	86-396
Mean	2200	-	-	233	8.2	4.7	.50	-	3.6	19	8.7	8.9	5	12	83	11	.2	.66	.02	81	164
	Station 03030540	Little Piney Creek near Limestone						41°08'24"	79°20'48"												
Range	31	18.4	3.8	1000	9.0	-	8.5	.90	17	-	-	-	0	100	-	-	-	-	-	360	-
Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 25.--Range and mean values of chemical analyses of surface water--Continued

	Discharge	Temperature	pH	Specific conductance	Dissolved oxygen (O_2)	Silica (SiO_2)	Total iron (Fe)	Ferrous iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na + K)	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Hardness as $CaCO_3$	Dissolved solids (Residue at 180°C)
	(ft^3/s)	Degrees Celsius		micromhos at 25°C	milligrams per liter																
	Station 03030550		Piney Creek near Limestone					41°08'44"	79°21'49"												
Range	118	6.5	4.8	260	12.8	-	2.5	0.40	0.05	-	-	-	0	15	112	9.9	-	-	-	120	-
Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Station 03030560		Reids Run at Reidsburg					41°08'50"	79°24'09"												
Range	20	18.4	6.0	480	9.8	-	.37	.00	1.1	-	-	-	34	0	-	-	-	-	-	210	-
Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Station 03030580		Brush Run at Williamsburg					41°10'24"	79°23'56"												
Range	4.8-63	6.8-18.5	3.2-4.5	560-1000	10.0-12.0	-	.94-7.0	.10-3.0	7.7-22	-	-	-	0	30-80	480-510	16-20	-	-	-	260-480	-
Mean	27	-	-	850	10.8	-	4.1	1.5	13	-	-	-	0	63	500	18	-	-	-	390	-
	Station 03030600		Piney Creek at Piney					41°10'12"	79°28'20"												
Range	13-235	3.5-20.8	3.3-4.1	420-1010	7.4-11.6	6.4-7.6	2.6-9.0	1.3-4.4	3.1-15	32-80	19-58	7.9-22	0	25-72	176-425	8.2-26	.3-.6	.90-7.1	.00-.01	140-500	260-618
Mean	111	-	-	652	9.2	7.0	5.3	2.8	7.9	48	33	15	0	44	291	15	.5	4.2	.00	260	460
	Station 03030610		Licking Creek at Huefner					41°18'53"	79°23'20"												
Range	2.1-50	7.8-13.8	3.0-3.9	260-925	10.8-11.0	-	2.0-8.4	1.1-6.5	2.5-5.9	-	-	-	0	27-85	-	-	-	-	-	85-90	-
Mean	26	-	-	592	10.9	-	5.2	3.8	4.2	-	-	-	0	56	-	-	-	-	-	88	-
	Station 03030660		Paint Creek at Shippenville					41°14'47"	79°23'20"												
Range	5.7-95	3.8-17.8	2.8-4.1	330-750	7.6-14.0	-	4.6-8.0	.72-1.6	1.0-5.5	-	-	-	0	49-95	146	16	-	-	-	150-240	-
Mean	56	-	-	530	11.2	-	6.7	1.2	3.3	-	-	-	0	68	-	-	-	-	-	190	-
	Station 03030690		Deer Creek at Shippenville					41°15'26"	79°28'25"												
Range	.22-29	6.4-18.8	3.4-4.2	690-950	9.6-12.0	-	8.0-20	1.9-10	5.5-8.1	-	-	-	0	61-120	300	18	-	-	-	250-400	-
Mean	12	-	-	850	11.1	-	15	4.8	6.3	-	-	-	0	82	-	-	-	-	-	320	-
	Station 03030700		Deer Creek at Piney					41°10'24"	79°28'41"												
Range	9.1-460	2.5-19.0	3.1-4.1	165-765	8.8-14.0	7.2-8.9	1.3-6.3	.40-2.3	.50-5.4	16-49	9.4-23	7-22	0	30-100	102-324	9.0-23	.2	.60-2.5	.00-.01	81-250	156-427
Mean	209	-	-	412	10.7	8.0	2.9	1.2	2.7	27	14	14	0	47	174	15	.2	1.4	.00	130	292

Table 25.--Range and mean values of chemical analyses of surface water--Continued

	Discharge	Temperature	pH	Specific conductance	Dissolved oxygen (O_2)	Silica (SiO_2)	Total iron (Fe)	Ferrous iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na + K)	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Hardness as $CaCO_3$	Dissolved solids (Residue at 180°C)
	(ft^3/s)	Degrees Celsius		micromhos at 25°C	milligrams per liter																
	Station 03030750	Canoe Creek near Callensburg						41°09'46"	79°31'57"												
Range	1.5-48	2.0-18.4	6.4-7.1	330-494	8.2-9.6	-	0.17-1.1	0.00-.35	0.00-2.3	40	13	-	7-33	0.0-5.0	104-130	26-58	-	4.9	0.00	94-170	-
Mean	20	-	-	439	8.9	-	.46	.18	.68	-	-	-	19	1.7	117	42	-	-	-	130	-
	Station 03030800	Beaver Creek near Turkey City						41°10'53"	79°33'41"												
Range	3.5-50	4.3-19.9	6.5-7.6	125-563	10.0-11.2	-	.50-5.5	.00-.09	.28-1.1	45	18	-	15-59	.0	20-164	19-47	-	.00	.00	48-190	-
Mean	30	-	-	293	10.7	-	2.2	.04	.59	-	-	-	32	-	71	32	-	-	-	102	-
	Station 03030858	Licking Creek at Sligo						41°06'31"	79°28'58"												
Range	2.3-10	2.9-12.9	5.1-6.2	360-870	8.2	-	5.0-32	3.0-32	2.1-12	91	72	19	3-20	34-35	547	19	-	-	-	520	-
Mean	6.2	-	-	600	-	-	15	11	6.2	-	-	-	10	34	-	-	-	-	-	-	-
	Station 03030860	Little Licking Creek at Sligo						41°06'30"	79°29'44"												
Range	2.1-15	5.0-21.0	3.9-5.8	1700-3000	4.8	12	30-84	15-48	20-52	278-350	180-263	17-22	0-4	64-190	1300-2120	4.5-10	.7	-	-	1500-1800	2080
Mean	6.0	-	-	2420	-	-	60	38	3	306	211	19	1	126	1680	7.2	-	-	-	1600	-
	Station 03030890	Cherry Run at Callensburg						41°06'47"	79°33'56"												
Range	7.2-40	12.0-20.0	5.1-5.3	1100-1200	10.0	-	2.0-6.7	.80-.90	5.5-5.6	-	-	-	2-3	4.9-9.8	570	6.8	-	-	-	570-590	-
Mean	24	-	-	1150	10.0	-	4.4	.85	5.6	-	-	-	2	7.4	-	-	-	-	-	580	-
	Station 03030900	Licking Creek at Callensburg						41°07'25"	79°34'06"												
Range	20-180	3.0-20.4	3.3-6.2	710-1800	8.0-11.0	8.9-9.3	5.9-25	.90-14	4.4-21	76-178	40-95	15-32	0-2	12-105	312-928	8.5-27	.4-.5	.71-3.5	.00	330-840	597-1350
Mean	87	-	-	1230	9.4	9.1	13	7.8	12	116	64	24	0	45	520	14	.4	1.7	.00	550	909
	Station 03030950	Turkey Run near St. Petersburg						41°10'02"	79°37'18"												
Range	.80-84	11.0-19.8	6.5-7.2	400-565	10.0-10.6	-	.32-2.5	.00-.10	.05-.28	43	14	36	23-66	.0	94	57	-	-	-	160-280	-
Mean	28	-	-	470	10.3	-	1.1	.05	.16	-	-	-	39	-	-	-	-	-	-	200	-
	Station 03031000	Clarion River at St. Petersburg						41°08'57"	79°39'37"												
Range	200-5730	5.0-27.5	4.6-6.5	200-457	7.3-10.1	4.4	.04-1.5	.00-.38	1.0-3.3	14-53	7.8-25	19	0-10	.0-15	55-225	8.0-34	.3	.70-1.7	.00-.03	67-240	144-446
Mean	1640	-	-	302	8.6	-	.57	.19	2.3	26	12	-	4	6.8	106	17	-	1.2	.02	106	225

Table 25.--Range and mean values of chemical analyses of surface water--Continued

	Discharge	Temperature	pH	Specific conductance	Dissolved oxygen (O_2)	Silica (SiO_2)	Total iron (Fe)	Ferrous iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na + K)	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Hardness as $CaCO_3$	Dissolved solids (Residue at 180°C)
	(ft^3/s)	Degrees Celsius		micromhos at 25°C	milligrams per liter																
	INTERBASIN AREA (direct to Allegheny River)																				
	Station 03031520	Black Fox Run near West Monterey					41°04'17"		79°37'34"												
Range	3.7-30	11.0-13.8	4.2-6.2	650-780	10.2-11.4	-	2.9-5.8	0.60-1.2	1.6-1.7	-	-	-	0-10	4.9	345	1.0	-	-	-	320-380	-
Mean	17	-	-	715	10.8	-	4.4	.93	1.6	-	-	-	5	-	-	-	-	-	-	350	-
	REDBANK CREEK BASIN																				
	Station 03031620	Laborde Branch near Homecamp					41°06'18"		78°42'52"												
Range	13-27	9.0-20.8	6.0-7.5	212-413	8.8-13.2	-	.40-5.2	.00	.05-2.8	22-42	9.8-13	-	2-36	.0-2.0	84-137	8.5-27	-	.00-.60	.59	90-170	-
Mean	23	-	-	335	11.0	-	2.0	.00	1.6	32	11	-	12	.5	112	19	-	.30	-	140	-
	Station 03031640	Wolf Run at Falls Creek					41°08'58"		78°48'00"												
Range	13-15	6.2-20.4	6.6	90-100	8.8-12.4	-	.22-.40	.00-.10	.00-.13	-	-	-	4-8	.0	36	7.2	-	-	-	34-50	-
Mean	14	-	-	95	10.6	-	.31	.05	.07	-	-	-	6	.0	-	-	-	-	-	42	-
	Station 03031680	Sandy Lick Creek near Falls Creek					41°07'29"		78°49'25"												
Range	107-150	5.8-19.0	6.0-6.8	240-280	4.4-11.8	-	1.1-4.2	.20-.50	.05-1.2	-	-	-	7-20	.0	92	12	-	-	-	100-120	-
Mean	128	-	-	260	8.1	-	2.4	.40	.78	-	-	-	12	.0	-	-	-	-	-	110	-
	Station 03031700	Soldier Run at Reynoldsville					41°05'20"		78°53'12"												
Range	19-22	6.0-18.0	3.5-3.6	400-496	8.4-10.6	-	3.5-11	2.1-2.5	.05-1.1	-	-	-	0	44-80	212	12	-	-	-	120-190	-
Mean	20	-	-	448	9.5	-	7.2	2.3	.58	-	-	-	0	62	-	-	-	-	-	160	-
	Station 03031720	Trout Run near Reynoldsville					41°04'43"		78°54'07"												
Range	6.2-19	6.8-17.8	6.0-6.7	180-300	6.0-12.2	-	.15-1.2	.00	.00-.61	-	-	-	7	.0	115	15	-	-	-	68-140	-
Mean	12.6	-	-	240	9.1	-	.68	.00	.30	-	-	-	7	.0	-	-	-	-	-	104	-
	Station 03031770	Sandy Lick Creek near Brookville					41°09'20"		79°03'12"												
Range	30-753	4.0-19.4	5.5-7.2	150-312	9.0-12.0	.3-6.0	.39-1.1	.00-.12	.00-.50	15-29	4.6-8.8	7.0-21	2-23	.0	45-81	10-25	.2	.90-4.4	.00-.04	57-110	93-184
Mean	310	-	-	215	10.7	3.2	.69	.07	.26	20	6.1	14	8	.0	58	17	.2	2.7	.01	80	138

Table 25.--Range and mean values of chemical analyses of surface water--Continued

	Discharge	Temperature	pH	Specific conductance	Dissolved oxygen (O_2)	Silica (SiO_2)	Total iron (Fe)	Ferrous iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na + K)	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Hardness as $CaCO_3$	Dissolved solids (Residue at 180°C)
	(ft^3/s)	Degrees Celsius		micromhos at 25°C	milligrams per liter																
Station 03031785	Mill Creek near Allens Mills							41°14'06"	78°52'46"												
Range	2.3-8.5	11.5-18.5	5.8-6.7	265-315	7.6-10.3	-	0.80-2.3	0.00	0.40-.69	-	-	-	44-48	0.0	54	11	-	-	-	130-140	-
Mean	5.4	-	-	290	9.0	-	1.6	.00	.55	-	-	-	46	.0	-	-	-	-	-	140	-
Station 03031870	Mill Creek at Brookville							41°09'23"	79°03'12"												
Range	8.0-222	8.0-16.4	5.9-7.4	160-257	9.9-17.0	-	.30-.50	.00	.00-.19	22	5.7	-	3-49	.0	26-38	17-24	-	.10	.00	57-85	-
Mean	71	-	-	198	12.4	-	.45	.00	.05	-	-	-	25	.0	32	21	-	-	-	71	-
Station 03031872	Fivemile Run at Brookville							41°08'39"	79°04'42"												
Range	4.0-51	6.8-18.5	5.8-7.2	108-270	9.4-11.2	-	.10-.27	.00-.03	.11-.30	26	7.9	-	5-34	.0	35-88	8.7-13	-	.05	.00	98-100	-
Mean	22	-	-	213	10.3	-	.19	.02	.21	-	-	-	20	.0	65	11	-	-	-	99	-
Station 03031874	North Fork near Munderf							41°16'01"	78°56'45"												
Range	27	16.4	7.1	60	12.0	-	.44	.00	.07	-	-	-	7	.0	14	4.3	-	-	-	24	-
Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Station 03031875	North Fork at Richardsville							41°14'43"	79°14'43"												
Range	69	17.4	7.1	80	10.0	-	.97	.00	.06	-	-	-	16	.0	11	8.2	-	-	-	34	-
Mean	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Station 03031876	North Fork near Richardsville							41°13'44"	79°02'57"												
Range	96-101	10.4-17.4	6.7-7.2	75-80	11.0	-	.20-.86	.00	.00-.09	-	-	-	5-18	.0	14	4.8	-	-	-	27-34	-
Mean	98	-	-	78	-	-	.53	.00	.05	-	-	-	12	.0	-	-	-	-	-	31	-
Station 03031880	North Fork at Brookville							41°09'36"	79°04'29"												
Range	32-117	10.4-15.1	6.3-6.7	75-100	9.6-16.0	-	.25-.30	.10	.00	-	-	-	2-43	.0	-	-	-	-	-	34-39	-
Mean	74	-	-	88	12.8	-	.28	-	.00	-	-	-	22	.0	-	-	-	-	-	36	-
Station 03031882	Redbank Creek at Brookville							41°09'29"	79°04'52"												
Range	43-510	7.0-14.8	6.1-7.4	168-295	9.6	.8-5.5	.50-.78	.00	.00-.47	14-26	5.1-7.7	7.3-21	2-33	.0	49-70	12-24	.1-.2	2.2-3.3	.00-.02	56-100	103-162
Mean	184	-	-	240	-	3.2	.65	-	.14	20	6.4	14	16	.0	60	18	.2	2.8	.01	80	132

Table 25.--Range and mean values of chemical analyses of surface water--Continued

	Discharge	Temperature	pH	Specific conductance	Dissolved oxygen (O_2)	Silica (SiO_2)	Total iron (Fe)	Ferrous iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na + K)	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Hardness as $CaCO_3$	Dissolved solids (Residue at 180°C)
	(ft^3/s)	Degrees Celsius		micromhos at 25°C	milligrams per liter																
Station 03031895 Welch Run at Summerville 41°07'30" 79°10'58"																					
Range	3.0-17	3.1-16.5	3.1-5.1	540-1800	8.3-10.0	-	6.7-30	1.8-13	7.5-27	56-154	48-102	12-23	0	24-152	602-850	12-28	-	-	-	460-960	900
Mean	6.7	-	-	1220	8.9	-	15	6.9	19	105	80	17	0	80	764	18	-	-	-	688	-
Station 03031900 Beaver Run at Heathville 41°05'25" 79°10'52"																					
Range	2.5-36	8.0-17.3	3.9-6.0	345-1000	10.1-15.0	-	1.8-11	.50-2.5	1.8-7.3	90	35	-	0-7	14-68	144-420	8.0-14	-	.90	.00	150-530	-
Mean	20	-	-	700	12.1	-	5.3	1.3	4.2	-	-	-	2	35	323	11	-	-	-	370	-
Station 03031935 Little Sandy Creek at Coolspring 41°02'30" 79°05'03"																					
Range	19-24	13.5-20.6	5.8-6.5	315-335	10.0-10.6	-	.13-2.8	.00-.13	.34-1.1	-	-	-	11-13	.0	115	11	-	-	-	140-150	-
Mean	22	-	-	325	10.3	-	1.5	.06	.72	-	-	-	12	.0	-	-	-	-	-	140	-
Station 03031955 Big Run at Worthville 41°01'14" 79°07'43"																					
Range	8.4-25	13.5-19.0	6.0-7.0	280-340	10.2-12.4	-	.36-.90	.00-.05	.31-.40	-	-	-	26-49	.0	105	12	-	-	-	140-150	-
Mean	17	-	-	310	11.3	-	.63	.02	.36	-	-	-	38	.0	-	-	-	-	-	140	-
Station 03031980 Little Sandy Creek near North Freedom 41°01'58" 79°11'05"																					
Range	11-369	7.0-22.8	6.0-7.5	180-380	9.8-14.0	5.6	.10-2.5	.00-.30	.00-.90	17-38	6.1-12	14	6-26	.0	56-122	11-18	.2	.60-5.1	.00-.02	68-180	211
Mean	122	-	-	289	12.3	-	.80	.09	.43	28	9.1	-	15	.0	94	15	-	2.8	.01	120	-
Station 03032025 Pine Creek at Mayport 41°02'17" 79°15'31"																					
Range	7.4-15	12.0-19.0	6.0-6.7	320-550	10.0-13.4	-	.09-.20	.00	1.3-2.1	-	-	-	10-21	.0	225	9.0	-	-	-	150-240	-
Mean	11	-	-	440	11.7	-	.14	.00	1.7	-	-	-	16	.0	-	-	-	-	-	200	-
Station 03032055 Town Run near Hawthorn 41°00'56" 79°17'56"																					
Range	14-17	14.0-18.5	6.1-6.5	580-1200	9.6	-	.80-2.3	.55-1.0	4.8-14	-	-	-	7	.0	460	25	-	-	-	290-500	-
Mean	16	-	-	890	-	-	1.6	.78	9.4	-	-	-	7	.0	-	-	-	-	-	400	-
Station 03032100 Leisure Run at New Bethlehem 41°00'13" 79°19'41"																					
Range	8.4-9.0	13.0-18.6	5.6-5.9	760-1300	10.2	-	.17-.60	.00-.10	2.6-7.8	-	-	-	5-11	0-2.4	508	30	-	-	-	380-600	-
Mean	8.7	-	-	1030	-	-	.38	.05	5.2	-	-	-	8	1.2	-	-	-	-	-	490	-

Table 25.—Range and mean values of chemical analyses of surface water—Continued

	Discharge	Temperature	pH	Specific conductance	Dissolved oxygen (O_2)	Silica (SiO_2)	Total iron (Fe)	Ferrous iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium + Potassium (Na + K)	Alkalinity as $CaCO_3$	Acidity as $CaCO_3$	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Hardness as $CaCO_3$	Dissolved solids (Residue at 180°C)
	(ft^3/s)	Degrees Celsius		micromhos at 25°C	milligrams per liter																
	Station 03032400	Leatherwood Creek near New Bethlehem					41°01'12"		79°23'14"												
Range	2.4-67	7.3-18.2	5.6-7.2	385-1030	9.4-12.2	-	0.10-.40	0.00-.03	0.40-12	-	-	-	3-33	0.0	160-491	4.4-15	-	1.4	0.00	190-580	-
Mean	27	-	-	739	10.8	-	.22	.01	4.0	-	-	-	15	.0	370	11	-	-	-	400	-
	Station 03032500	Redbank Creek at St. Charles					40°59'40"		79°23'40"												
Range	93-4110	1.0-24.5	5.5-7.4	180-560	8.0-14.4	.6-5.2	.09-5.4	.03-.13	.35-4.2	14-52	5.8-21	14-20	2-40	.0-5.0	57-201	7.0-30	0-.3	.10-4.3	.00-.77	58-240	130-330
Mean	1060	-	-	333	10.1	3.0	.94	.08	1.4	31	13	17	9	1.5	115	16	.2	1.6	.13	130	220
	Station 03032770	Fiddlers Run near Rimersburg					41°00'51"		79°28'40"												
Range	.64-5.0	11.0-16.0	6.6-6.8	400-420	11.4-11.6	-	.29-.38	.00-.15	.30-.50	-	-	-	46-57	.0	98	11-13	-	-	-	140-190	-
Mean	2.8	-	-	410	11.5	-	.34	.08	.40	-	-	-	52	.0	-	12	-	-	-	160	-

Table 26.--Mean values of selected chemical constituents for sampling stations on the Clarion River, 1962-75

Station		Dissolved oxygen (mg/L)	Total iron (mg/L)	Total dissolved solids (mg/L)	Temperature (°C)	Ammonia as (N) (mg/L)	Total phosphorus (P) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)
27545	East Branch Clarion River above Glen Hazel	10.9	0.33	61	11.4	0.9	0.02	6
28000	West Branch Clarion River at Wilcox	10.7	.38	74	10.7	.08	.02	26
28500	Clarion River at Johnsonburg	8.9	.45	91	13.5	.15	.05	19
29000	Clarion River at Ridgway	8.2	.40	63	12.4	.25	.06	23
30515	Clarion River at Piney	9.0	.74	113	12.0	.18	.05	10
31000	Clarion River at St. Petersburg	8.1	.71	228	24.8	.15	.02	6

The East Branch Clarion River watershed (drainage area 108 mi^2) contains streams of good quality and streams affected by mine drainage. Fivemile Run, a tributary to East Branch Clarion River Lake, has good water; dissolved solids average less than 50 mg/L. However, Swamp Creek, another tributary to East Branch Clarion River Lake, is affected by mine drainage. Samples from Swamp Creek indicate the pH ranges from 3.7 to 4.2, manganese commonly exceeds 10 mg/L, and sulfate concentrations are generally above 200 mg/L.

East Branch Clarion River Lake has low concentrations of alkalinity, phosphate, and nitrate. Iron and manganese concentrations are generally less than 1.0 mg/L at all lake depths. The lake has low primary biological production and, as a result, supports only marginal fish populations (Moore, 1974).

Water samples half a mile below the East Branch Clarion River Dam occasionally contain iron and manganese concentrations in excess of natural levels. This is interpreted as the effect of the input of mine drainage to the reservoir. Johnson Run, that enters the East Branch Clarion River 4 mi above Johnsonburg, additionally degrades the East Branch Clarion River with mine drainage.

Water from the West Branch Clarion River watershed (drainage area 93.7 mi^2) is generally soft, low in manganese and sulfate, and contains no acidity. The West Branch has diverse aquatic invertebrate life and trout--both indicators of good quality water.

The East and West Branches of the Clarion River join at Johnsonburg in Elk County to form the Clarion River. The higher quality water of the West Branch mixes and dilutes the poorer quality water of the East Branch. The quality of the Clarion River at Johnsonburg varies, but is generally soft to moderately hard; contains little nitrate, phosphate, or chloride; and has an average alkalinity of about 16 mg/L. The average dissolved-solids concentration from 1971-74 was about 120 mg/L.

Powers Run (drainage area 11.8 mi^2) is one of several sources of water supply for the Borough of Johnsonburg (table 4). Samples collected near the mouth sometimes exceed EPA recommended limits for pH and manganese (Koester and Lescinsky, 1976, table 6a, p. 52).

Riley Run (drainage area 1.96 mi^2), is a small severely degraded tributary entering the Clarion River between Johnsonburg and Ridgway. The water is high in organic material, dissolved solids (average 1,500 mg/L), chloride (average 550 mg/L), and alkalinity (average 350 mg/L). A dissolved-oxygen concentration of only 1.9 mg/L was recorded on April 8, 1974 (Koester and Lescinsky, 1976, p. 53).

Data in table 27 were collected in downstream order within a 3-hour span. A 5.2 percent decrease in dissolved oxygen occurred between Johnsonburg and Ridgway, despite a substantial addition from Elk Creek. Reduction was due chiefly to reaction with organic substances introduced into the Clarion River between Johnsonburg and Ridgway.

Elk Creek (drainage area 64.1 mi^2) enters the Clarion River at Ridgway. Because of mine drainage and industries, Elk Creek has dissolved-solids concentrations higher than those of streams in nondeveloped areas to the north. Laurel Run, a tributary to Elk Creek and a municipal supply for St. Marys, has iron and manganese concentrations in three samples that exceed EPA recommended limits. Daguscahonda Creek, an Elk Creek tributary downstream from Laurel Run, is degraded by coal mining. Elk Creek at Ridgway reflects the influence of mine drainage and has high iron, manganese, and sulfate concentrations.

Big Mill Creek (drainage area 32.7 mi^2) supplies water for the Borough of Ridgway. The water is soft, low in alkalinity and dissolved solids, and ranges in pH from about 5.5 to 6.4. Recommended limits for iron and manganese are exceeded in three water samples collected below the reservoir.

Little Toby Creek (drainage area 126 mi^2) enters the Clarion River about 8 mi below Ridgway. Water quality of the upper half and many of its headwater tributaries is severely degraded by drainage from mines. Several tributaries that enter the lower half improve its quality; however, it still has excessive hardness, manganese, and sulfate, and little or no alkalinity.

A large part of the 504 mi^2 drainage area of the Clarion River between Ridgway and Cooksburg is in the Allegheny National Forest, where the water quality is generally good. Trout are common in these waters. Several good quality streams (each more than 40 mi^2 in drainage area) are Bear Creek, Spring Creek, and Millstone Creek; these and several other smaller streams (Maxwell Run, Callen Run, Wyncoop Run, Clear Creek, Maples Creek) contribute alkaline water low in dissolved solids to the Clarion River, that helps to neutralize and dilute water contributed by poorer quality streams, especially Little Toby Creek.

The quality of the Clarion River at Cooksburg is generally good. Iron and manganese concentrations are less than those at Ridgway. The water is generally soft to moderately hard (average 54 mg/L) and has low alkalinity (average 10 mg/L). The dissolved-solids concentration averages about 100 mg/L.

Table 27.—Dissolved oxygen in the Clarion River basin, January 10, 1973

Station number	Station name	Temperature (°C)	pH	Specific conductance (micromhos at 25°C)	Concentration of dissolved oxygen (mg/L)	Saturation percent
28000	West Branch Clarion River at Wilcox	3	6.2	142	12.6	93.3
26500	Sevenmile Run near Rasselas	4	5.7	49	11.6	88.5
28500	Clarion River at Johnsonburg	6	5.6	140	11.2	89.6
28900	Elk Creek near Ridgway	5	5.8	135	12.0	93.8
29000	Clarion River at Ridgway	5	5.8	150	10.8	84.4
29500	Clarion River at Cooksburg	4	5.7	125	12.0	91.6

Suspended-sediment discharge data were collected at the Clarion River-at-Cooksburg gaging station from January 1971 to September 1973 and are reported in the annual series "Water Resources Data for Pennsylvania-Part 2." The estimated suspended-sediment discharge for the 1971, 1972, and 1973 water years was 58, 104, and 34 tons/mi^2, respectively. The 1972 value is exceptionally high because of flooding and soil erosion caused by Hurricane Agnes in June. About 67 percent of the total suspended sediment discharged in 1972 occurred during that month. The relation between daily sediment load and streamflow for the Clarion River at Cooksburg is illustrated in figure 20.

Before entering Piney Reservoir, the Clarion River below Cooksburg is augmented by several tributaries (Cathers, Maxwell, and Blyson Runs) that have low dissolved-solids concentrations.

Mill and Toby Creeks (drainage areas 59.4 and 35.0 mi^2), which empty into Piney Reservoir, contribute excessive quantities of iron, manganese, aluminum, sulfate, and acidity. Little Mill Creek, a tributary to Mill Creek, is primarily responsible for the poor quality of Mill Creek. In the Toby Creek basin, surface and deep mines and abandoned flowing wells contribute mine drainage to the stream. Concentrations of cadmium and chromium in an unnamed tributary of Toby Creek (30103 sampling site) exceed mandatory limits of the EPA.

Little aquatic life is present in Piney Reservoir chiefly because the water quality is degraded by Mill and Toby Creeks. Acidity intermittently reaches levels harmful to aquatic life (Eggers, 1973).

Discharge from Piney Dam fluctuates as water is released periodically for electric-power generation, causing concentrations and loads of constituents to vary below the dam; the water quality is poor. Average concentrations of manganese and sulfate are about 3.5 mg/L and 80 mg/L, respectively. Dissolved aluminum averages 1.0 mg/L. Acidity concentrations average about 12 mg/L expressed as $CaCO_3$.

Piney and Deer Creeks (drainage areas 72.2 and 74.2 mi^2, respectively) join the Clarion River about 2 mi below Piney Dam. Both are severely contaminated by drainage from mines and abandoned flowing oil and gas wells. In 1975, the Pennsylvania Department of Environmental Resources plugged flowing wells in the northern part of Deer Creek basin to reduce the flow of highly mineralized acid water.

Canoe and Beaver Creeks (drainage areas 18.8 and 17.6 mi^2, respectively) enter the Clarion River south of Knox. The streams have marginal water quality and show a slight influence of mine drainage, but can support trout. Canoe Creek has moderate concentrations of iron (average 0.50 mg/L), manganese (average 0.70 mg/L), and sulfate (average 120 mg/L) near its mouth. Beaver Creek has slightly better water. The average specific conductance of three samples at station 30800 is 293 micromhos.

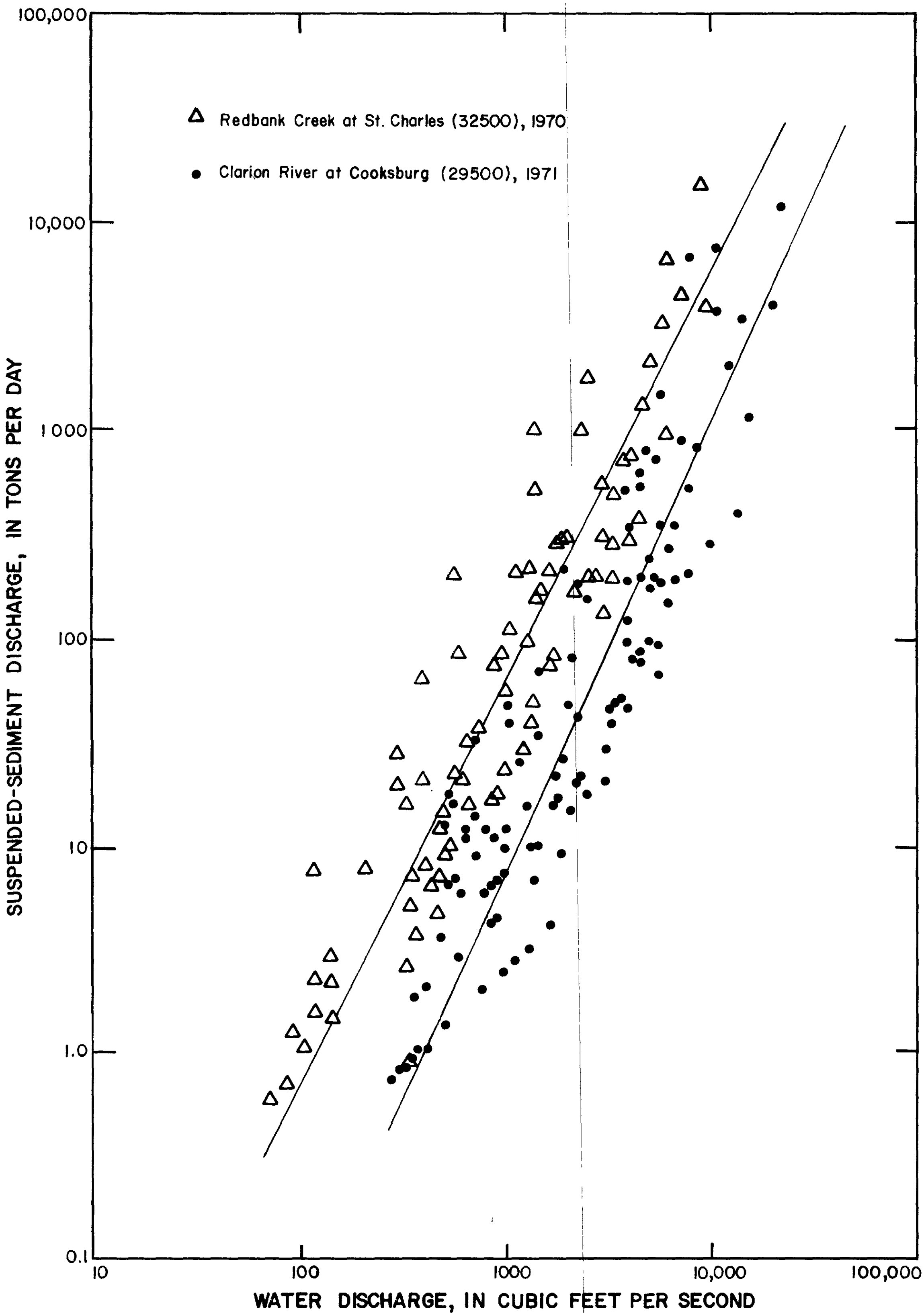


Figure 20.--Relation of daily sediment discharge to streamflow at Cooksburg on the Clarion River and St. Charles on the Redbank Creek.

Licking Creek (drainage area 51.9 mi^2) joins the Clarion River below Beaver Creek, and is severely polluted by drainage from surface and deep mines. Much surface mining has taken place during the 1970's. Water at the Callensburg site has excessive concentrations of iron, manganese, sulfate, and acidity. From 1971-76, average concentrations for these constituents were 13, 12, 520, and 45 mg/L, respectively.

Clarion River quality at St. Petersburg is poor. The concentration of dissolved solids is higher than upstream at the gaging station below Piney Dam, mostly because of the highly mineralized water contributed by Piney, Deer, and Licking Creeks. It is most noticeable during low flows. During flood flows, and during releases of large volumes of water from Piney Dam, the water tends to be lower in solids because of dilution. The concentration generally ranges from 130 mg/L to 300 mg/L, and averages about 200 mg/L (estimated from specific conductance data). The water is generally moderately hard to hard, low in alkalinity, and high in sulfate. In 1971-74, average concentrations of hardness, alkalinity, and sulfate were 106, 4, and 106 mg/L, respectively. The pH is frequently below 5.5.

In summary, general trends in the quality of the Clarion River are shown in figures 11-20 and tables 25-27. From the mouth of the Clarion to the confluence of Mill Creek, the average dissolved-solids concentration is higher than in the reach above Mill Creek. The higher solids concentration is caused mostly by mine drainage from Mill, Toby, Piney, Deer, and Licking Creeks. Alkalinity concentrations tend to decrease downstream, and are sometimes absent at the Piney and St. Petersburg sites. Nitrate does not appear to be a problem, as concentrations are low. Based on data collected during 1974-78, dissolved oxygen (more than 5 mg/L) is present throughout the Clarion River in sufficient concentrations to support the propagation of sport fish.

Redbank Creek basin water-quality assesment

Redbank Creek is formed by the confluence of Sandy Lick and North Fork Creeks at Brookville in Jefferson County. The quality of Sandy Lick Creek (drainage area 229 mi^2) ranges from good to poor. Several of the good-quality tributaries are Falls and Mill Creeks and Wolf Run. The Borough of Falls Creek uses Falls Creek for its water supply. Iron in only two samples and manganese in one exceed EPA recommended limits (Koester and Lescinsky, 1976, table 6c). The quality is degraded by mining in Clear and Soldier Runs. Data from the sampling station on Sandy Lick Creek near Brookville indicate the water is moderately hard, contains no acidity, and has moderate concentrations of sulfate (average 60 mg/L).

The North Fork (drainage area 98.2 mi^2) is used for water supply by the Borough of Brookville. The water at the mouth is characteristically soft, and low in alkalinity, dissolved solids, iron, and manganese. The North Fork and several of its tributaries (Clear and Peking Runs, for example) support trout. Aquatic invertebrate life is diverse. Although the basin of the North Fork contains sizable coal reserves, little mining has been done. In order to protect the quality of water in the basin, permits for surface mining are not being issued at present (1978) by the Pennsylvania Department of Environmental Resources.

Between Brookville and New Bethlehem, Redbank Creek receives much mine drainage. Polluted tributaries include Coder, Simpson, Welch, Runaway, Beaver, Town, and Leisure Runs, and Pine Creek.

Welch Run (drainage area 4.24 mi^2) is one of the most polluted streams in the study area. It has been contaminated by highly mineralized and acidic water from surface and deep mines, and from abandoned flowing oil and gas wells. Dissolved solids are about 1,000 mg/L, and aluminum, sulfate, and ferrous iron concentrations are excessive. The cadmium concentrations frequently equal or exceed the mandatory limit of 0.010 mg/L established by the EPA.

Little Sandy Creek (drainage area 73.2 mi^2) joins Redbank Creek about 6 mi upstream from New Bethlehem. Although the creek is in a heavily surface-mined area, several tributaries show less influence of mine drainage than streams to the north. For example, Big Run supports trout and its alkalinity is high, averaging 46 mg/L at Sprankle Mills and 38 mg/L at Worthville. Undoubtedly, its quality is due both to the adherence of coal operators to mining laws, and the scarcity of pyritic material in the overburden associated with the coal seams.

Several other streams polluted by mine drainage enter Redbank Creek between New Bethlehem and the mouth; Leatherwood Creek and Wildcat Run have unusually high concentrations of dissolved solids.

The water quality at the gaging station Redbank Creek at St. Charles is poor. The water is generally hard and low in alkalinity (average 9 mg/L). The average (1970-74) concentration of sulfate (120 mg/L), manganese (1.4 mg/L), aluminum (0.55 mg/L), and dissolved solids (200 mg/L) are excessive.

Annual suspended-sediment discharge of the Redbank Creek at St. Charles for water years 1969, 1970, and 1977 was 192, 123, and 245 tons/mi^2, respectively. Although little data are available, the suspended-sediment discharge rates seem to be greater here than the Clarion River at Cooksburg. These yields can probably be attributed to a greater percentage of land in agricultural and mining use.

AQUATIC BIOLOGY

Introduction

Valuable information on the quality of streams can be gained by studying the number and types of bottom dwelling invertebrates (benthic macroinvertebrates), due to their environmental sensitivity. Because the organisms lack sufficient mobility to flee areas of pollution and their life cycles are commonly a year or more, they reflect past and present environmental conditions. Chemical surveys, on the other hand, indicate conditions only for a single moment. Thus, if a transient toxic chemical or other pollutant destroys these environmentally sensitive macroinvertebrates, an extended period typically weeks or months is required to reestablish the community. A chemical sample collected during this post-pollution period would probably show no evidence of pollution. Because continuous comprehensive monitoring for chemical constituents is costly, benthic-macroinvertebrate surveys provide a relatively economical means of assessing many past and present water-quality characteristics.

Several previous studies of aquatic biology were made in the Clarion River and Redbank Creek basins. Selected reports that contain data on aquatic biology are listed in table 15.

Data Base

Benthic-invertebrate data were collected at 136 sampling stations during 1973 and 1974. The locations of the stations are shown in figures 2-51 of Buckwalter and others (1979) and in figure 1 of Koester and Lescinsky (1976). Table 7 of Buckwalter and others (1979), lists the common names and taxonomic classification of the benthic-invertebrates collected from streams of the Clarion River and Redbank Creek basins. The station number and name, date of collection, and number of individuals per taxon are listed for benthic-invertebrate samples in table 8 of Buckwalter and others (1979).

Methods

Interpretations of macroinvertebrate data depend upon the methods of collection and the time of sampling. A single sample of macroinvertebrates from a stream provides only an estimate of what was living at that site at a particular time. A sample made at another time from the same site may have a different selection of species and numbers of individuals. Life cycles of aquatic insects are an important influence on the species and numbers found in a stream. Mayflies, for example, have three life stages: egg, aquatic nymph, and terrestrial adult. Stream sampling during the nymph stage may show an abundance of a species, but sampling several months later may reveal no nymphs because they have hatched into flying, terrestrial adults.

Aquatic invertebrate collections at sampling stations were made primarily with D-shaped dip nets used on the stream bottom. Invertebrates were also collected with forceps from randomly selected stream-bed rocks and debris. To obtain representative samples, collections were made from pools, riffles, and undercut banks. The sampling was primarily for benthic organisms, but some invertebrates that normally dwell at the water-air interface also were collected. Sampling time at each site was 30 minutes.

The techniques of collection were a modification of the qualitative methods described by Hahn, Slack, and Tilley (1977). The methods were chosen to permit rough quantifications. Specimens were sorted, counted, and identified in the laboratory. Identification was done with manuals of Pennak (1953), Burks (1953), and Usinger (1971). The recent revisions in the taxonomy of selected aquatic insect groups (Merritt and Cummins, 1978) are followed in reporting the aquatic insect data.

Invertebrate collecting was mostly during base or low-base flow conditions. These flows were selected because wading is relatively easy and the water is generally clear. Also, the dissolved solids are high because at these times, any pollutants present would be concentrated sufficiently to affect sensitive fauna.

Numbers and species of invertebrates may vary along a stream. Thus, moving a sampling site upstream or downstream may markedly affect the composition of the sample. Sample stations on major tributaries were near the mouth and at several sites upstream; smaller streams were sampled only near the mouth.

Results and Discussion

A large variety of invertebrates inhabit the streams, the majority are insects. Mayflies, caddisflies, stoneflies, and members of the order Diptera comprise over three-fourths of the total number of individuals collected.

Mine drainage is an important influence on the distribution and occurrence of aquatic invertebrates. The bottoms of affected streams are commonly covered by blankets of "yellowboy", a deposit of iron, manganese, and other compounds and sediment. Numerous sites, especially in the south, contained "yellowboy."

Dissolved ferrous iron, common in mine drainage, probably limits invertebrate life in the study area. Laboratory tests have shown ferrous iron to be toxic to some aquatic invertebrates at concentrations exceeding 0.32 mg/L (Warnick and Bell, 1969). Such concentrations were found at 73 sampling sites.

At 21 of the 136 sampling sites (17 in the Clarion River basin and 4 in the Redbank Creek basin), no benthic invertebrates were found. Most of these sites were on streams receiving continuous, highly concentrated, mine drainage.

At sites less severely affected by mine drainage, invertebrates were present only in select taxa and in reduced numbers. The following taxa were found in these streams:

Megaloptera: Sialis
Hemiptera: Genera of Corixidae and Gerridae
Coleoptera: Genera of Dytiscidae
Trichoptera: Diplectrona, Hydropsyche, Oligostomis
Diptera: Genera of Chironomidae

The effects of mine drainage on aquatic life have also been studied by Parsons (1968), Roback and Richardson (1969), Weed and Rutschky (1972), and Woodrum and Tarter (1973). They are in general agreement with the findings of this study concerning the fact that aquatic insect fauna are eliminated or drastically reduced when exposed to mine drainage.

The northern part of the area contains many forested watersheds whose stream quality is little influenced by man. These areas support large populations of aquatic invertebrates of many taxa. Examples of sampling sites having unpolluted waters are Crooked Creek at Glen Hazel, Bear Creek near Ridgway, Clear Creek at its mouth, and the North Fork at Richardsville for which 17, 14, 14, and 21 taxa were collected, respectively. The natural stream environment is most likely responsible for these diverse invertebrate communities. Stoneflies and mayflies are especially common, and their abundance and occurrence commonly correlates with high-quality streams.

Diversity indices are mathematical expressions that summarize large quantities of data on biological communities. The indices were calculated through the use of the methods of Wilhm and Dorris (1968), who suggest the health of a stream can be assessed quantitatively by the indices--the index is generally between 3 and 4 in clean-water streams, from 1 to 3 in areas of moderate pollution, and less than 1 in heavily polluted streams (Wilhm, 1970). This relationship is generally supported by the data for the streams in the study area.

Table 28 gives examples of diversity indices of some aquatic invertebrate samples.

CONCLUSIONS

Surface-water and ground-water sources are able to supply enough water for most industrial, municipal and private uses. However, in parts of Clarion, Clearfield, Elk, and Jefferson Counties, the water quality of both have been degraded by coal mining; in places, it is not economically feasible to treat the water. Most municipalities are supplied by surface water.

During 1971-75, runoff was about 60 percent of the average annual precipitation of about 45 in. Base runoff averaged about 50 percent of the annual streamflow. Only 4 of 10 continuous-gaging stations have an average 10-year 7-consecutive-day low flow of at least 0.15 $(ft^3/s)/mi^2$.

Table 28.--Diversity indices for selected aquatic invertebrate samples

Station number	Station name	Date of collection	Diversity index
26490	Fivemile Run at Williamsville[1]	4-09-74	4.19
31875	North Fork at Richardsville[1]	6-06-74	3.80
29180	Bear Creek near Ridgway[1]	5-20-74	3.41
30106	Toby Creek near Clarion[2]	6-02-74	1.58
30104	Rapp Run at mouth[2]	6-02-74	1.46
29140	Brandy Camp Creek near Elbon[2]	4-09-74	1.00
29136	Little Toby Creek at Kylers Corners[2]	4-09-74	.81

[1] Clean-water stream.
[2] Stream degraded by mine drainage.

Most wells are completed in bedrock, as the alluvium is limited in areal extent. Yields of bedrock wells are affected mostly by rock type, type of overburden, topography, depth of water-bearing zones, and by the rate and duration of pumping. In general, the regolith, which covers the bedrock in most places, serves as a reservoir that recharges the bedrock.

Due to their lithologic variability and the effects of fracturing, bedrock aquifers differ considerably from place to place in their capacity to yield water. Yields of wells are least on hills, larger on slopes, and largest in valleys. Most wells obtain water from several zones, generally less than 350 ft.

The Lower Mississippian rocks are the highest yielding--some reported yields exceed 550 gal/min. Their median specific capacity is 4.3 (gal/min)/ft, whereas the median specific capacity of wells in the Conemaugh Group is 0.38, in the Allegheny is 0.67, and in the Pottsville is 0.41. No data are available for rocks of Devonian age, but they are probably poor aquifers because they consist mostly of shale and are deeply buried.

Problems of excessive iron, manganese, hardness, and acidity in the water are related chiefly to coal mining. Nonmined areas generally have good-quality water, but parts of these areas may be contaminated if regional aquifers and streams have carried the poor-quality water long distances. Poor-quality water is present in large parts of Clarion, Elk, and Jefferson Counties.

Water from most bedrock wells has a dissolved-solids content of less than 250 mg/L. Water from aquifers of Pennsylvanian age is lower in dissolved solids than that from the Lower Mississippian rocks. Water from hilltop wells is generally of better quality than that from valley wells. There are some abandoned flowing oil and gas wells that discharge highly mineralized water to streams in Clarion and Jefferson Counties. These wells may have iron concentrations in excess of 100 mg/L, and dissolved solids that exceed 1,500 mg/L.

Aquatic invertebrates can be used to assess stream quality. In many streams, their populations have been eliminated or drastically reduced because of exposure to mine drainage.

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