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GEOLOGICAL SURVEY CIRCULAR 315

WATER RESOURCES OF THE PITTSBURGH AREA PENNSYLVANIA

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WATER RESOURCES OF THE PITTSBURGH AREA, PENNSYLVANIA

By Max Noecker, D. W. Greenman, and N. H. Beamer

Washington, D. C., 1954

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PREFACE

This report is one of a series concerning water resources of selected industrial areas of national importance and has been prepared at the request of the Business and Defense Services Administration of the Department of Commerce. The series is intended to provide information of value for national defense and related purposes and is being prepared in the Water Resources Division under the technical guidance of J. B. Graham and K. A. MacKichan. This report was prepared by Max Noecker, under the supervision of J. W. Mangan, district engineer (Surface Water); by D. W. Greenman, under the supervision of P. H. Jones, district geologist (Ground Water); and by N. H. Beamer, district chemist (Quality of Water).

Most of the data summarized in this report were collected over a period of many years by the U. S. Geological Survey in cooperation with the Corps of Engineers, Department of the Army, and the following agencies of the Commonwealth of Pennsylvania: Department of Forests and Waters, Department of Internal Affairs, and the State Planning Board of the Department of Commerce.

The information on water used by industry in Allegheny County was obtained largely by the Pennsylvania Department of Internal Affairs. The first attempt to collect reliable data of this kind in Pennsylvania on a statewide basis was made in 1951 when the Pennsylvania Department of Internal Affairs revised its annual questionnaire sent to more than 20,000 industries in Pennsylvania so that specific information could be obtained on industrial water use from all sources of supply.

All public water-supply agencies have cooperated by furnishing detailed data on water supply within the areas that they serve. Additional data were obtained from industries, State and local government officials, and individuals. A few of those deserving special mention are the United States Weather Bureau, the Pennsylvania Department of Health, the United States Bureau of the Census, the Allegheny Conference on Community Development, the Duquesne Light Co., the West Penn Power Co., and the Pressed Steel Car Co., Inc.

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WATER RESOURCES OF THE PITTSBURGH AREA, PENNSYLVANIA

By Max Noecker, D. W. Greenman, and N. H. Beamer

ABSTRACT

The per capita use of water in the Pittsburgh area in 1951 was 2,000 gallons per day (gpd) or twice the per capita use in Pennsylvania as a whole. An average of about 3,040 million gallons of water was withdrawn from the streams and from the ground each day. Of this amount, nearly 190 million gallons per day (mgd), or 6 percent, was for domestic public water supply. Industry, including public utilities generating steam for electric energy, used approximately 2,900 mgd, of which about 42 mgd was purchased from public supply sources. In spite of this tremendous demand for water, a sufficient quantity was available to satisfy the needs of the area without serious difficulty.

Acid mine drainage presents the greatest single pollution problem in the Pittsburgh area at the present time (1953) because no practical means has been found for its control. The waters of several of the rivers are strongly acid for this reason. Of the three major rivers in the area, Monongahela River waters have the greatest acid concentration and Allegheny River waters the least. Untreated domestic and industrial wastes are additional sources of stream pollution in the area. Much of the water is hard and corrosive, and occasionally has objectionable color, odor, and taste. The treatment used by public water-supply systems using river water is adequate at all times for removal of water-borne causes of disease. Attention is being concentrated on improving the quality of present supplies rather than developing new supplies from upstream tributaries. Present supplies are being improved by providing treatment facilities for disposal of wastes, by reduction of acid mine drainage discharged into the streams, and by providing storage to augment low flows.

The underground water resources are vitally important to the area. The use of ground water in the Pittsburgh area has doubled in the past two decades and in 1951 more ground water was used in Allegheny County than in any other county in Pennsylvania. On the average about 63 mgd was pumped from the ground, not including 1.5 mgd pumped for air conditioning.

Most of the present-day wells in the "Triangle area" of Pittsburgh have large yields and many operate continuously throughout the summer. The result has been a marked seasonal decline in water levels in some parts of the Triangle area, especially near the center of pumping. It appears that the maximum rate of summertime use has been reached in this localized area.

Water from wells near rivers often has chemical characteristics similar to those of water from the adjacent stream because the well water is supplied largely by river infiltration. The ground water in the Pittsburgh area is generally more highly mineralized than surface water, harder, and contains higher concentrations of iron and manganese, all the result of solution of aquifer minerals by the water during its passage through the ground. Nevertheless, ground water commonly is less corrosive than surface water, contains little or no suspended sediment, and is free of pathogenic bacteria. Both sediment and bacteria are present in considerable quantities in the river water of this area. Water from wells supplied largely by river infiltration may have a temperature variation throughout a year of as much as 30 to 35 F and a variation in hardness of as much as 130 ppm. Certain types of chemicals having objectionable tastes and odors are not always removed by the natural infiltration of the river water to wells but pathogenic bacteria and sediment are. There is only a small range throughout a year in the temperature and chemical quality of water in individual wells farther from the rivers. Such water is generally harder and contains more dissolved solids than water supplied by river infiltration.

There is no immediate likelihood of a shortage of water in the area. Present withdrawals of surface water are spread throughout the major river valleys so that the water returned to the stream after use is available for reuse in essentially undiminished quantity. Ground-water use can be increased manyfold without depleting the supply if advantage is taken of the favorable opportunities for inducing the infiltration of surface water into the alluvial aquifers in the major stream valleys. Ground-water recharge supplied by the rivers will reduce the local flow of the rivers by the amount of the infiltration; however most of the ground water used is discharged to streams near the areas of withdrawal.

INTRODUCTION

Purpose and Scope of Investigation, and Location of Area

The purpose of this report is to summarize all available information on the water resources of the Pittsburgh area in Pennsylvania and to evaluate these resources as to present and potential use so far as is possible.

The report will not resolve all questions which relate to water supplies for municipal and industrial development in any specific location. The many factors involved will always call for detailed investigations. However, it will give valuable data on water resources which should guide industries in their initial plans for new works or the expansion of existing facilities. It also contains data which will be of interest to State and local groups planning an orderly growth.

This report is on all of Allegheny County. The county has a land area of 730 square miles and includes most of the Pittsburgh industrial area. The city of Pittsburgh is in the middle of Allegheny County at the confluence of two major river systems—the Allegheny and the Monongahela. These two rivers, which join at Pittsburgh to form the Ohio River, drain an area of 19,105 square miles comprising parts of four States, as follows:

	Drainage area (square miles)
Allegheny River:	
In New York	1,921
In Pennsylvania	9,806
	11,727
Monongahela River:	
In Maryland	419
In West Virginia	4,219
In Pennsylvania	2,740
	7,378
Ohio River (at source at Pittsburgh)	19,105

Description of Area

Topography and Drainage

Allegheny County lies within a region characterized by rounded hills in which the smaller drainage channels occupy steep-walled valleys and the major streams have developed flat-floored valleys. By far the greater part of the land surface is steeply sloping. The present surface features were formed by erosion of an ancient flatland or peneplain now preserved only on the crests of the higher hills. The remnants of the ancient peneplain lie at elevations between 1,200 and 1,250 feet above sea level. The floors of the larger valleys have minimum elevations of about 720 feet; thus the maximum relief in Allegheny County is about 500 feet.

The only flat areas of significant extent are in the valleys of the Allegheny, Monongahela, and Ohio Rivers. Most of the industrial plants and a majority of the commercial establishments of the Pittsburgh area are in these valleys to gain the advantage of simplicity in construction and nearness to transportation and sources of large water supplies. Much of the residential growth in the Pittsburgh area has spread into the hilly areas away from the major rivers.

The Ohio River is formed at the "Point" in downtown Pittsburgh by the confluence of the Allegheny and Monongahela Rivers. In Allegheny County the Allegheny River flows generally southwestward until it joins the Monongahela. The Allegheny River has no important tributaries in this area. The Monongahela River flows approximately northward to Pittsburgh. At McKeesport it is joined by the northwestward-flowing Youghiogheny River and below McKeesport by Turtle Creek. From Pittsburgh the Ohio River flows northwestward out of the county. Its only important tributary within the area is Chartiers Creek which flows northward and empties into the Ohio River at McKees Rocks.

The major streams and their principal tributaries follow courses which are largely independent of the geologic structure of the region. The drainage pattern was established on the ancient peneplain. Subsequently the area was uplifted, but the process was so gradual that downcutting of stream channels kept pace with the uplift.

The Pittsburgh area was not overrun by glacial ice during Pleistocene time, but the drainage was nonetheless greatly influenced by glaciers to the north. It is believed that before the advance of the ice all drainage in western Pennsylvania flowed northward into the St. Lawrence River basin. (See fig. 1.) A stream followed the present Clarion and Allegheny River valleys from north-central Pennsylvania, southwestward to its confluence with the Monongahela River at Pittsburgh, and then along the present Ohio River course northwestward to Beaver. From Beaver it flowed northward along the Beaver River to the Grand River and drained into the area now occupied by Lake Erie. During this period the ancestral Ohio River below Beaver rose at a divide near New Martinsville, W. Va., and flowed north, joining the master stream at Beaver. The Monongahela River followed its present course and was the principal southern tributary in the preglacial master stream.

With the coming of the glaciers to northern Pennsylvania the outlet of the master stream to the north was dammed by ice and glacial debris. The stream was ponded until its flow was diverted along the ice front, overtopping the headwater divides of tributary streams. In this manner, the direction of flow of the Ohio and Beaver Rivers was reversed, and western Pennsylvania drainage was diverted to the Mississippi River valley. These changes in drainage pattern caused by glaciation just north of Allegheny County are of great significance in the occurrence and present distribution of the highly productive alluvial deposits of the Pittsburgh area. Had these changes not occurred, the valley-fill materials of the Allegheny and Ohio River valleys would be far less favorable for the development of large supplies of ground water.

Geology

Consolidated rocks are exposed throughout Allegheny County except in the flood plains of the major stream valleys where they are buried beneath alluvium. The consolidated rocks, chiefly sandstone and shale, are all of sedimentary origin. They were deposited more than 200 million years ago in shallow inland seas and broad swamps which intermittently covered the area. During the long period of time when these sediments were accumulating, part of the lush vegetation was buried, forming the extensive coal beds that have played so important a part in the industrial history of the region. Vegetal and animal remains deposited in even earlier times formed the source material for the accumulation of oil and gas, now found in rock strata beneath the coal measures.

The unconsolidated deposits in Allegheny County are very much younger than the bedrock formations. They were deposited during glacial and recent times, probably within the last million years. These beds are composed of silt, sand, and gravel, some of which was carried into the area by glaciers and the rest was derived from the erosion of the local land surface. These

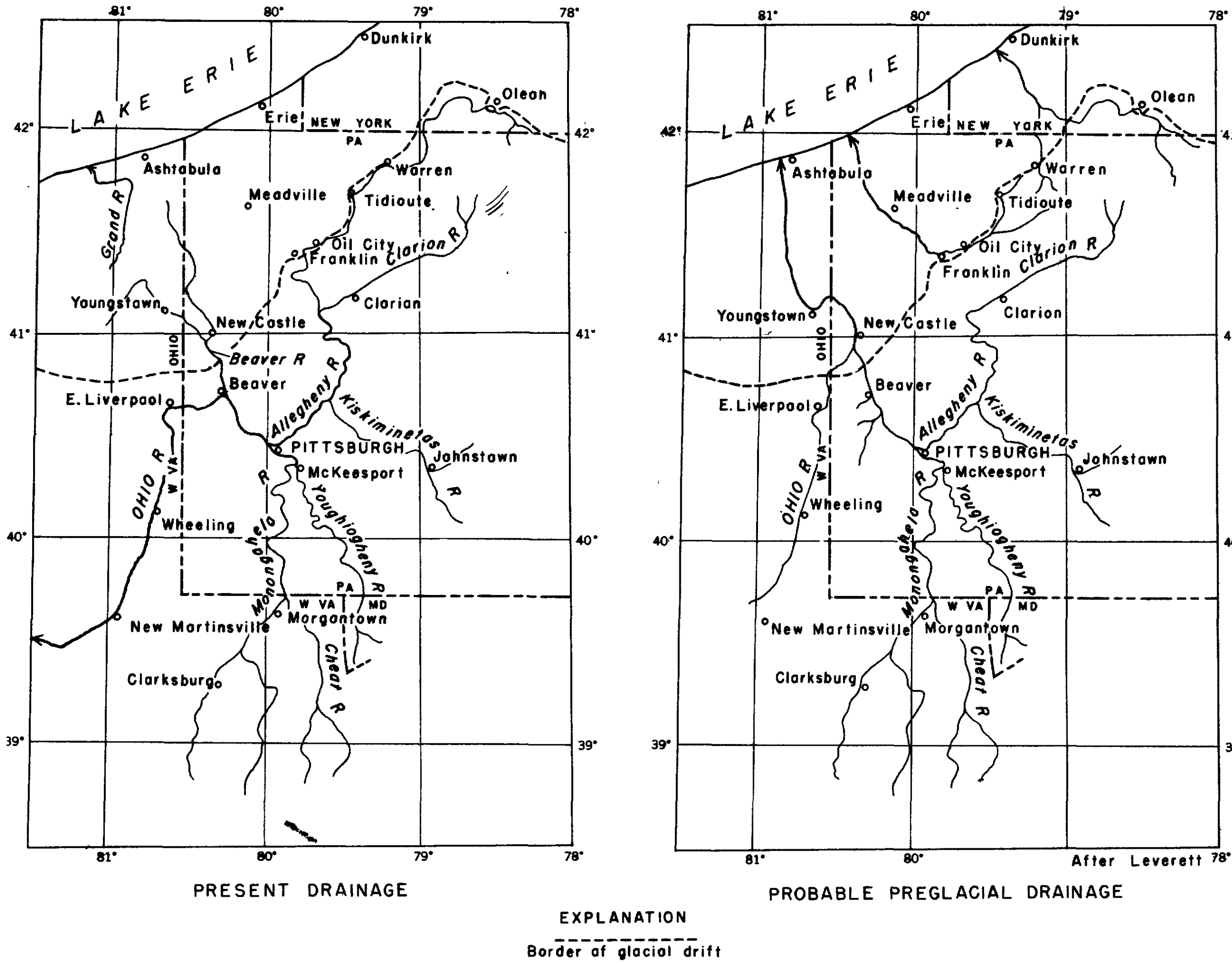

Figure 1.—Present and probable preglacial drainage patterns of the Ohio-Allegheny River system in western Pennsylvania.

sediments partly fill the major valleys that in former time had been eroded to depths below the present stream levels.

Climate

Pittsburgh has a humid continental climate modified only slightly by its nearness to the Atlantic seaboard and to the Great Lakes. The predominate type of air which influences the climate of this region has a polar continental source in Canada. Frequent invasions of air from the Gulf of Mexico produce warm, humid weather during the summer and alternate periods of freezing during the winter. The last killing frost usually occurs in late April and the first in late October. The average growing season is about 180 days.

Precipitation is well distributed throughout the year, a factor of great importance in the hydrology of the area. During the winter about one-fourth of the precipitation occurs as snow, and there is about an even chance that there will be measurable precipitation on any given day. The first appreciable snowfall is generally in late November and the last in early April. Snow lies on the ground an average of about 33 days during the year.

Precipitation at Pittsburgh, as recorded by the U. S. Weather Bureau, has averaged 36.2 inches a year since 1871. Maximum annual precipitation was 50.6 inches in 1891, and minimum annual precipitation was 22.6 inches in 1930. Annual precipitation and cumulative departure from average precipitation for the period 1872-1951 are shown by the graphs in figure 2.

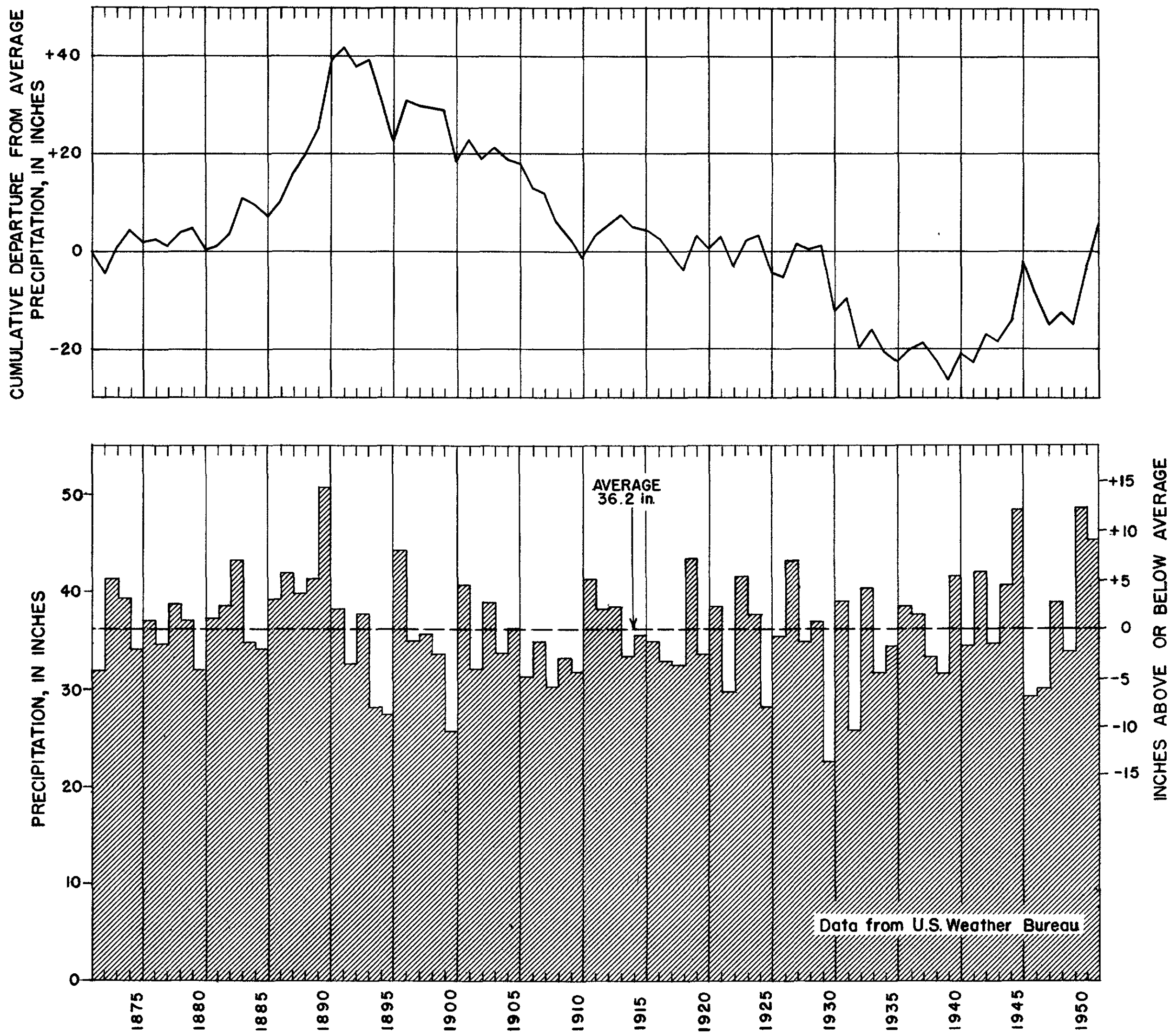

Figure 2.—Annual precipitation and cumulative departure from average precipitation at Pittsburgh.

Additional precipitation and temperature data for Pittsburgh are given in figure 3. The average monthly relative humidity, average monthly wind speed, and the highest average wind speed for the time that is required for a mile of wind to pass the recording station, are shown in figure 3.

Droughts do not affect the availability of water supplies at Pittsburgh so seriously as in many other sections of Pennsylvania because the major water-supply systems depend more on the large rivers than on local precipitation. Dams and reservoirs on the Allegheny, Youghiogheny, and Monongahela Rivers provide storage which partly offsets below-normal inflow from headwater areas. In 1930-31, drought conditions resulted in severe water shortages in the rural sections of Allegheny County and intensified the problems of water treatment for users of river water. As shown in

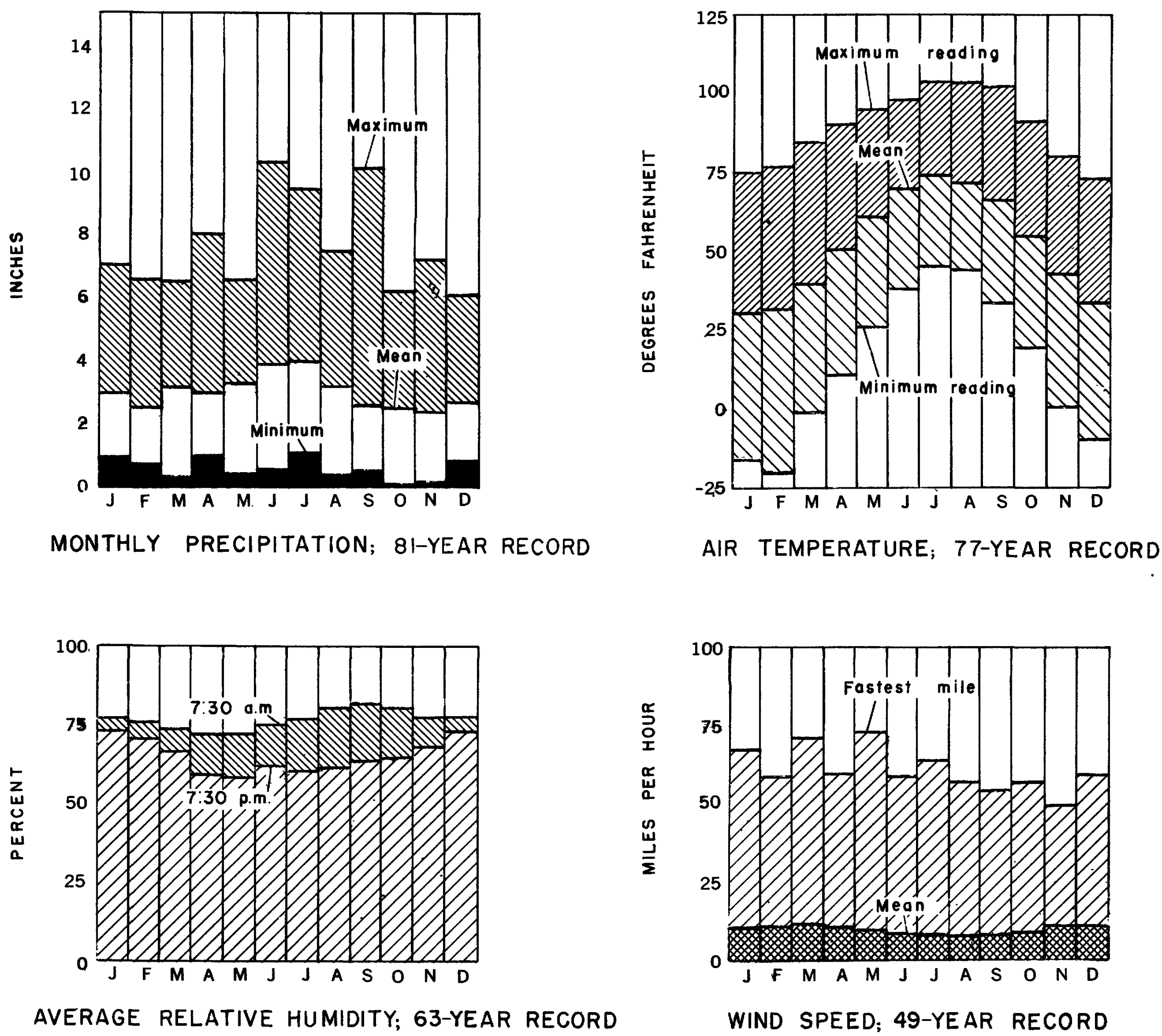

Figure 3.—Climatological data for Pittsburgh to 1951.

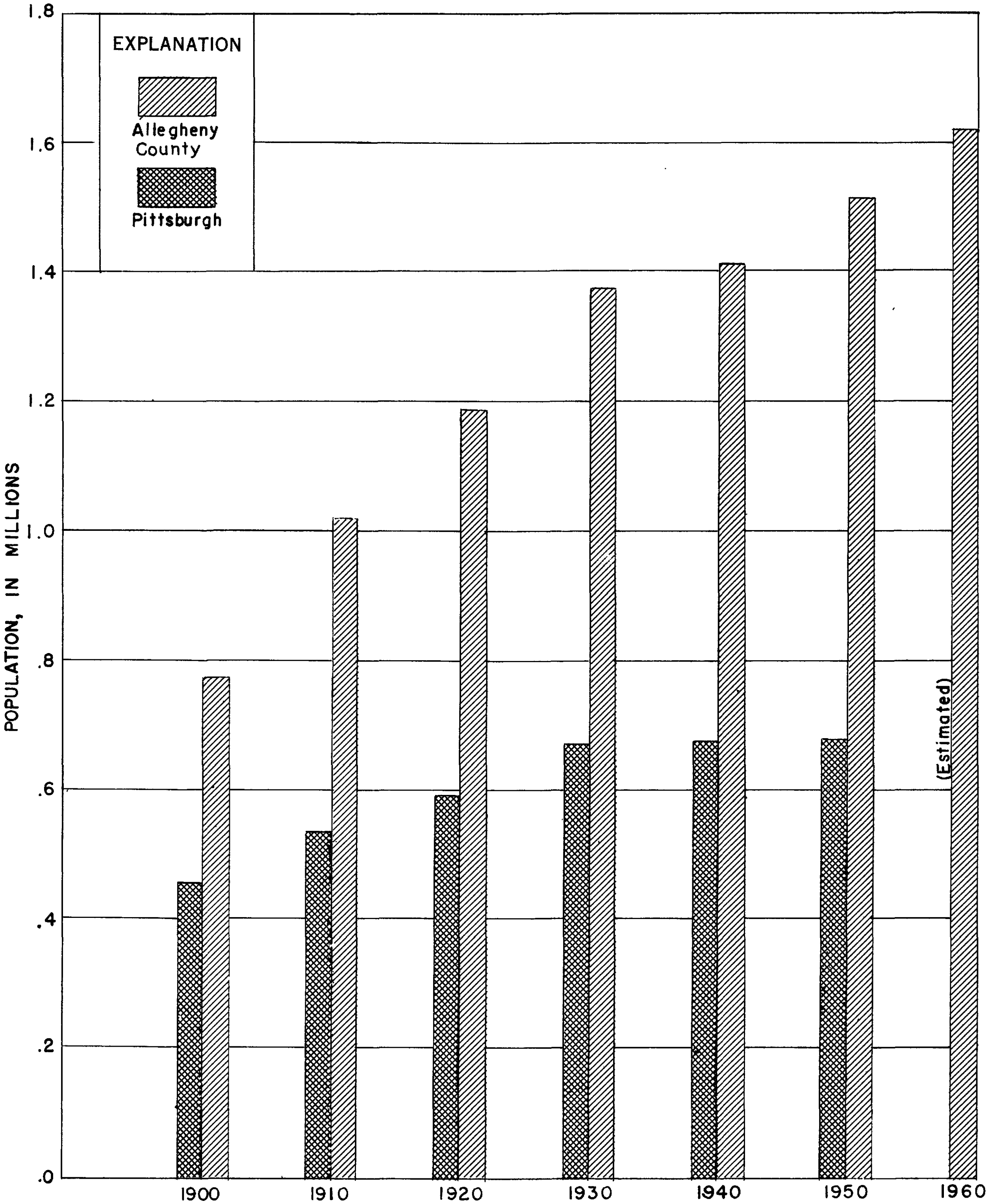

Figure 4.—Growth in population of Pittsburgh and Allegheny County, 1900–50.

figure 2, precipitation in 1930 was nearly 14 inches less than normal. The cumulative deficiency continued for the next 20 years.

Natural Resources

Other than water, the primary natural resource in Allegheny County is bituminous coal. The coal reserves in the Pittsburgh and Upper Freeport coals are estimated by the Commonwealth to be from 2 to 3 billion tons, of which about one-half is regarded as recoverable under present conditions.

Much of the progress in the area was made possible by its richness in other mineral products besides coal. These products include natural gas, petroleum, clay, shale, limestone, sandstone, sand, and gravel. All of these are still of great importance but most are consumed in quantities greater than the area's resources can supply. Much of the raw material now used in the Pittsburgh area is imported from neighboring counties or more distant sources of supply, particularly iron ore from the Lake Superior district. An extensive deposit of rock salt deeply underlies the area but it is not of present commercial importance.

Population

Allegheny County is outranked only by Philadelphia as the most densely populated county in Pennsylvania. Allegheny County has shown a continuous and steady growth of population throughout its history. According to the United States census of 1950, Allegheny County had a total population of 1,515,237, of which 676,806, or 45 percent, resided in the city of Pittsburgh. The rural population was reported to be 142,825, or only about 9 percent of the total. The population of the county and city at each census from 1900 to 1950 is shown in figure 4.

The 1950 population of major political subdivisions (more than 15,000) follows:

Braddock Borough	16,488
Clairton City	19,652
Duquesne City	17,620
Harrison Township	15,116
McKeesport City	51,502
McKees Rocks Borough	16,241
Mount Lebanon Township	26,604
Munhall Borough	16,437
Penn Township	25,280
Pittsburgh City	676,806
Ross Township	15,744
Shaler Township	16,430
Swissvale Borough	16,488
West Mifflin Borough	17,985
Wilkinsburg Borough	31,418

During the past 30 years about one person in every six in the Pittsburgh area has been employed by industry. About two-thirds of these are employed by the metal industries.

The Pittsburgh area shows the same general trend in growth that is typical of any large industrial area. Industry and its people have been moving steadily from the Pittsburgh center into adjacent areas, settling principally along the waterways which are so necessary to support industry. There also has been a trend during the past several years for people to move to suburban and rural areas often far removed from their places of employment. This exodus has often caused problems in water supply where little provision had been made for expansion.

According to "Population trends," published by the Federation of Social Agencies of Pittsburgh and Allegheny County, it is estimated that the population of Allegheny County will be 1,620,000 in 1960.

Industrial Development

The early industrial growth of the Pittsburgh area was primarily a result of its geographic position and natural resources. The completion of a canal system across Pennsylvania in 1834, placed Pittsburgh on a through east-west line of water transportation connecting the Ohio River with the eastern seaboard. The mining of coal and the importation of iron ore began about 1840, and oil and natural gas were discovered in 1850.

The heavy industries of the Pittsburgh area use tremendous quantities of water. The Pittsburgh area had become the Nation's center of iron production before the outbreak of the Civil War and continues to maintain its dominance in the ferrous industries. It is estimated that the production of steel in 1951 was 23 million tons, or 22 percent of the total produced in the United States. Production in the Pittsburgh area alone is believed to equal the total production in Soviet Russia.

Though the manufacturing of iron and steel and related products are much more important than all others, industry in the Pittsburgh area is considerably diversified. Other principal classes of industry include those producing chemicals and kindred products, processed food, paper and printing, bituminous coal and byproducts, electrical equipment, railroad supplies, meat and meat products, plate glass, paints, and varnishes.

Definition of Hydrologic Terms

The records for quantities of water, as presented in this report, are in units of million gallons per day (mgd), gallons per day (gpd), gallons per minute (gpm), cubic feet per second (cfs), and acre-feet. Second-feet was formerly used in U. S. Geological Survey reports as an abbreviation of cubic feet per second.

A cubic foot per second (cfs) is the rate of discharge equivalent to that of a stream whose channel is 1 square foot in cross-sectional area and whose average velocity is 1 foot per second.

Cubic feet per second per square mile is the average number of cubic feet of water flowing per second from each square mile of area drained, on the assumption that the runoff is distributed uniformly as regards time and area.

An acre-foot is equivalent to 43,560 cubic feet and is the quantity required to cover an acre to a depth of 1 foot.

1 cfs = 449 gpm.
1 cfs = 646,317 gpd.
1 mgd = 694 gpm.
1 mgd = 1.55 cfs.
1 acre-foot = 0.504 cfs for 1 day.

The results of chemical analyses are reported in parts per million (ppm). One part per million is a unit weight of a constituent present in a million unit weights of water.

Specific conductance is a measure of the capacity of water to conduct an electrical current. Conductance varies with the quantities of dissolved mineral constituents and the degree of ionization of these constituents, as well as with the temperature of the water. It is useful in indicating the degree of concentration of mineral matter in water.

Hydrogen-ion concentration, or pH, denotes the acidity or alkalinity of the water. Ordinarily, water having a pH of 7.0 is regarded as neutral; a pH value of less than 7.0 indicates acidic properties, and a pH greater than 7.0 indicates alkaline properties. Some of the analyses included in this report are from sources other than the Geological Survey, and because of the complexities inherent in analytical procedures and the constituents analyzed, presentation of these analytical data needs explanation. The Geological Survey determines the pH value by a line-operated meter on which the lower limit for bicarbonate alkalinity is about 4.5, and reports individual quantities of carbonate and bicarbonate. The reason for this is that a changing interrelationship among alkalinity, acidity, and free carbon dioxide exists in the pH scale between 7.0, the neutral point, and about 4.5, and results in the free carbon dioxide lowering the pH. When free carbon dioxide combines with the carbonate, as it does, to form bicarbonate in solution, it raises the pH value of water. In other words, bicarbonate, as well as carbonate, produces alkalinity even though bicarbonate is a weak acid to a point as low as 4.5 on the pH scale. The upper limit of waters containing free mineral acids, like sulfuric, hydrochloric, and nitric, is a pH of about 4.5, when determined by the line-operated pH meter. Another method of determining the pH value of some of the data given in this report is the use of the methyl red indicator. The lower limit of alkalinity when this method is used is about 5.6 instead of 4.5. The difference in acidity as determined by the two methods is not significant.

SOURCES OF WATER

Precipitation is the condensed moisture from the atmosphere reaching the earth in the form of rain, snow, hail, or sleet. It is the source of essentially all fresh-water supply. In the endless cycle of water going from clouds to earth and back again, part returns directly to the atmosphere through evaporation and transpiration, part runs off the land into natural waterways on its way to the sea, and the rest seeps into the ground and eventually reaches the ground-water zone, from which it is discharged later by seepage into surface-water bodies or by evapotranspiration.

The principal sources of water in the Pittsburgh area are the Ohio, Allegheny, and Monongahela Rivers, and wells. The tributary streams that drain the Pittsburgh area are of little importance as sources of public water supply. However, considerable water is withdrawn from Chartiers and Turtle Creeks by industries in their drainage basins.

Ground water occurs in practically all rocks in the Pittsburgh area. The largest supplies have been developed from unconsolidated sands and gravels in the valleys of the Allegheny and Ohio Rivers. The consolidated rocks in the upland areas and underlying the valley-fill deposits yield small amounts of ground water for domestic and commercial use.

All natural waters contain dissolved mineral matter, the result of leaching of soluble material from the soil and rock with which the water has been in contact. Other impurities, both mineral and organic, are introduced by human activities; such activities include the use of streams and wells for disposal of sewage and industrial waste, and for drainage of coal mines and oil fields.

Contamination or pollution of any source of water may affect other sources over a wide area, for water is a mobile resource and is not restricted to either surface or subsurface occurrence. A drop of water may be alternately surface and subsurface (ground) water several times during its movement toward the sea. Water released from storage in the ground sustains the dry-weather flow of most streams, but during periods of high flow or when heavy ground-water pumpage has lowered the water table below the adjacent river level, the direction of movement may be reversed. Under these conditions, the stream recharges the ground-water supply.

When a source of water supply is being developed, if both ground water and surface water are available, the choice between them may rest on the requirements of the process or processes for which the water is to be used. Both sources of water have obvious advantages. Surface water in this area is softer than ground water, generally contains less iron and manganese, and is less mineralized if the supply is taken upstream from sources of pollution. Ground water has a more consistent chemical composition and temperature than surface water and, more important, a lower temperature during the warm months when cooling demands are greatest. Also, in the Pittsburgh area, where the streams are highly polluted with acid mine drainage, industrial wastes, and municipal sewage, the ground water is chemically neutral or very slightly alkaline (pH = 7.0 to 7.4) and is generally free from bacterial pollution and suspended material.

SURFACE WATER

Hydrology

Hydrologic data for the Pittsburgh area have been compiled for more than half a century. Precipitation records since 1871 are available. Some flood stages at Pittsburgh have been recorded since 1762, and a continuous record of floods is available since 1858. The Geological Survey placed some river gages in operation at points upstream from Pittsburgh before the beginning of the present century. These gages were soon discontinued, but stream-gaging work was carried on shortly

Table 1.—Types of hydrologic data available for streams in Allegheny County

Stream	Drainage area (square miles)	Information available on—		
		Daily streamflow	Discharge measurements	Chemical quality
Allegheny River	11,727	X		X
Buffalo Creek	170	X		
Bull Creek	50.0		X	X
Wilson Run	6.1			
Pucketa Creek	36.2		X	X
Riddle Run	1.7			
Tawney Run	2.6			
Blacks Run	.6			
Deer Creek	51.3		X	X
Powers Run	.9			
Plum Creek	20.8		X	X
Sandy Creek	3.4			
Squaw Run	8.6			
Guyasuta Run	1.0			
Pine Creek	67.2		X	X
Girty Run	13.4		X	
Spring Garden Run	2.0			
Monongahela River	7,378	X		X
Becket Run	3.4			
Sunfish Run	1.5			
Kelly Run	2.2			
Perry Mill Run	4.0			
Lobbs Run	3.8			
Hayden Run	4.6			
Wiley Run	4.1			
Peters Creek	52.1		X	X
Youghiogheny River	1,764	X		X
Crooked Run	3.6			
Bull Run	5.3			
Turtle Creek	147	X		X
Abers Creek	11.0	X		X
Whitaker Run	2.3			
Ninemile Run	7.4			
Streets Run	10.3		X	
Becks Run	2.7			
Ohio River	19,105	X		
Sawmill Run	19.0		X	
Chartiers Creek	278	X		X
Jacks Run	2.3			
Spruce Run	2.3			
Lowrie Run	16.7		X	
Toms Run	2.2			
Kilbuck Run	5.3			
Moon Run	5.4			
Montour Run	36.4		X	X

Table 1.—Types of hydrologic data available for streams in Allegheny County—Continued

Stream	Drainage area (square miles)	Information available on—		
		Daily streamflow	Discharge measurements	Chemical quality
McCabe Run	1.0	....	....	....
Haysville Run	.8	....	....	....
Thorn Run	1.9	....	X	....
Narrows Run	2.3	....	....	....
Little Sewickley Creek	10.3	....	....	....
Flaugherty Run	8.9	X	....	....
Shouse Run	1.0	....	....	....
Sewickley Creek	30.8	....	X	X

afterwards by the Water Supply Commission of Pennsylvania. The flood of 1907 created new interest in river flow. The Flood Control Commission of Pittsburgh cooperated with the Water Supply Commission to begin a river-gaging program. This program has been carried on by the Pennsylvania Department of Forests and Waters and the Geological Survey with the assistance of the Corps of Engineers, Pittsburgh district.

Pittsburgh's attention to river flow has been directed chiefly to floods. Damage from floods has been so great that the attention devoted to floods has overshadowed the attention to water supply. In recent years, the poor quality of the river water during low flow has been of considerable concern. Fortunately, the records of river flow compiled for use in studying floods are very useful in studying water supply. The river gaging stations discussed in this report are within or near Allegheny County (pl. 1). In addition, records are available for many sites upstream. Table 1 shows the streams and the type of information available.

Allegheny River

Discharge.—A gaging station has been maintained on the Allegheny River at Natrona (drainage area, 11,410 square miles) since October 1938. Some records of flow are available for points upstream and on tributary streams before that date. The maximum discharge known at Natrona is 365,000 cfs on March 18, 1936. The minimum discharge since establishment of the gaging station is 672 mgd (1,040 cfs) on September 29, 1941. The mean discharge for the period 1939-51 is 12,640 mgd (19,560 cfs).

The flow characteristics of the stream during a period when there was no appreciable regulation, 1928-37, are shown by one of the flow-duration curves in figure 5. This curve was computed from records for upstream stations. The selected period includes the years of the most severe drought and the most serious flood experienced in western Pennsylvania. The effect of flood-control regulation on the flow characteristics is shown by what the flow characteristics would have been for the period 1928-37 if the four flood-control reservoirs (Tionesta Creek, Mahoning Creek, Crooked Creek, and Loyalhanna Creek) had been operated in the same manner as they were between 1942 and 1951. Since the construction of these reservoirs parts of the flood flows are stored and then released on receding stages as soon as feasible. Hence, flood flows are reduced and medium-stage flows are increased. The storage has not materially affected lower flows although extreme low flows have been increased by a small amount. Conemaugh River and East Branch Clarion River reservoirs, recently put in operation, may be expected to increase greatly the effects and benefits of upstream flood storage. The drainage area upstream from these two dams is greater than the combined areas upstream from the dams on Mahoning Creek, Loyalhanna Creek, Crooked Creek, and Tionesta Creek. The combined reservoir capacity for flood control of the system has been increased from 378,000 to 686,700 acre-feet. The reduction of flood flows indicated by the example on figure 5 will be further reduced.

Quality.—The water of the Allegheny River in Allegheny County is a composite of diversified water types. The Allegheny River above the Kiskiminetas River is of very good quality (table 2). The tributary Kiskiminetas River is highly polluted and carries a heavy acid load which has a very noticeable effect on the quality of Allegheny River water although a mine-sealing program became effective in 1937, which has reduced the acidity of the Allegheny River. In the water year October 1, 1946 to September 30, 1947, the lowest pH recorded at Kittanning, above the Kiskiminetas River, was 6.5 (table 2); whereas during the same period the West Penn Power Co., using methyl red indicator, found that the water below the Kiskiminetas River had a pH value less than 5.6 for 45 days (fig. 6).

A survey of the Kiskiminetas River basin in August 1952 revealed that the waters of Conemaugh River, Loyalhanna Creek, Little Conemaugh River, Storey Creek, Blacklick Creek and Two Lick Creek were acid, the pH ranging from 3.30 to 3.85.

In many river systems there is a marked correlation between the rate of flow and the concentration of minerals in solution in the water, with the lower chemical concentration corresponding to the higher flows as a result of dilution (table 3). However, changes in flow of the Kiskiminetas River do not necessarily change

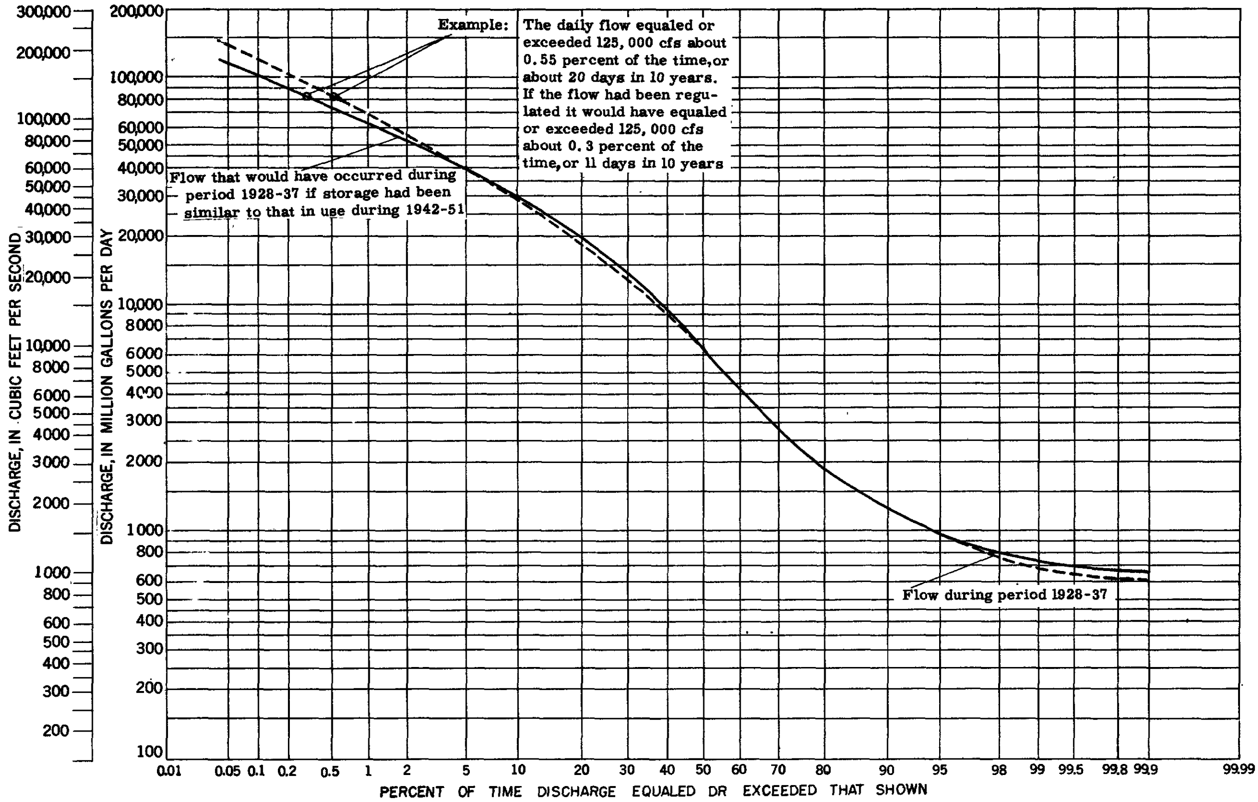

Figure 5.—Duration curve of daily flows, Allegheny River at Natrona, 1928-37.

the acidity of its water. In the 12 months, October 1, 1946 to September 30, 1947, Kiskiminetas River water was acid (pH less than 4.5) 99 percent of the time.

The West Penn Power Co. has observed the pH value of Allegheny River water at Springdale since 1934. During the 18 years, 1934-51, the river water was acid to methyl red (pH value less than 5.6) an average of 70 days per year (fig. 6). In the methyl red determination it is assumed that zero free acidity occurs at a pH of about 5.6, and in the electrometric method at a pH of about 4.5. Free acidity and alkalinity in parts per million as determined by either method are about the same. The longest period when the water was acid is 96 days in 1934 and the maximum observed total acidity is 93 ppm in 1934. Total acidity indicates the sum of mineral acids and acid salts.

The Pittsburgh Water Works has collected data on the quality of Allegheny River water at Aspinwall since 1909. The water at Aspinwall is acid on fewer days than at Springdale. Figure 6 shows the monthly average acidity-alkalinity at Aspinwall. The average hardness (as $CaCO_3$) for the 13-year period, 1939-51, is 92 ppm (fig. 7); the highest observed is 221 ppm, and the lowest observed is 42 ppm.

Water on the east side of the Allegheny River has a slightly higher concentration of dissolved solids than water on the west side. The Geological Survey has collected five samples at about 200-foot intervals in the cross section at the Sharpsburg bridge once each month since September 30, 1948. The average results of analyses made between October 1, 1948 and September 30, 1949 are given in table 3. The average observed

Table 2. --Summary of chemical quality of waters from the major streams in the area

[Item: A, average; HSC, composite sample having highest specific conductance; LSC, composite sample having lowest specific conductance. Chemical results in parts per million]

Item	Period of collection	Discharge (cfs)	Temperature (°F)	Sodium and potassium (Na and K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Hardness Total	Hardness Noncarbonate	Specific conductance (micromhos at 25 C)	pH	Color
	Allegheny River at Kittanning												
A	Oct. 1, 1944 to Sept. 30, 1951	16,610	53	16	34	39	25	0.9	69	42	230	7.0	10
HSC	Oct. 11-20, 1948	3,633	-	-	64	75	69	.3	[1]120	[1]70	488	7.2	10
LSC	April 1-10, 1950	64,880	43	-	14	20	7.0	1.4	37	26	98.0	6.7	5
	Kiskiminetas River at Leechburg												
A	Oct. 1, 1946 to Sept. 30, 1951	3,259	58	-	0	265	7.8	12	196	196	904	3.30	4
HSC	Oct. 1-10, 1948	581	61	48	0	821	19	26	838	838	2,200	2.60	15
LSC	July 22-23, 1950	1,050	78	-	14	53	5	3.2	63	52	178	6.6	2
	Monongahela River at Charleroi												
A	Oct. 1, 1944 to Sept. 30, 1951	9,913	57	-	0	146	6	1.6	116	116	385	4.10	3
HSC	Sept. 11-20, 1946	603	72	78	0	514	16	1.0	399	399	1,210	3.20	2
LSC	Nov. 21-30, 1945	21,360	43	8.9	0	60	2.9	1.9	57	56	163	4.6	5
	Youghiogheny River at Sutersville												
A	Oct. 4, 1947 to Sept. 30, 1950	3,173	54	[2]15	1	83	3	2.2	74	72	227	4.7	5
HSC	Oct. 11-20, 1947	321	65	53	0	393	7.5	1.2	301	301	1,060	3.20	3
LSC	Feb. 1-10, 1950	10,140	41	-	4	38	2	1.3	40	37	113	6.0	5
	Ohio River at Ambridge												
A	Oct 1, 1945 to Sept. 30, 1951	36,977	56	19	6	115	17	2.5	106	90	336	5.6	5
HSC	Oct. 1-10, 1946	3,454	68	59	0	353	40	8.8	302	302	921	3.70	3
LSC	April 1-10, 1950	93,090	45	-	10	33	8	.7	44	36	125	6.0	5

[1]Estimated from conductance-hardness curve.
[2]Average for 1948 water year (Oct. 1, 1947 to Sept. 30, 1948).

Table 3.--Chemical quality of surface waters in the Pittsburgh area

[Results in parts per million except as indicated]

Source	Date of collection	Discharge (cfs)	Temperature (°F)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na and K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness Total	Hardness Non-carbonate	Total acidity (as H_2SO_4)	Specific conductance (micromhos at 25C)	pH	Color
Allegheny River basin																							
Allegheny River at Natrona	Sept. 8, 1944	1,890	69	6.2	4.2	0.05	2.0	57	15	35	0	...	243	39	...	0.6	419	233	233	39	648	4.2	8
	Mar. 31, 1945	37,000	54	5.1	...	.02	.4	15	4.4	7.3	5	...	54	7.0	0.1	1.2	100	56	51	...	164	5.3	2
Allegheny River at Sharpsburg	Oct. 1948 to Sept. 1949[1]	...	...	...	...	...	...	...	...	...	9.3	...	109	23	...	2.3	...	111	...	...	340	5.5	...
Little Buffalo Creek near Freeport	Sept. 5, 1951	...	72	2.4	...	.02	...	31	9.4	22	74	...	65	24	.1	.5	201	116	55	...	372	7.6	10
	Apr. 21, 1952	32.8	60	...	...	...	...	...	...	4.7	10	...	33	5.0	...	3.2	...	42	34	...	132	7.0	5
Bull Creek at Tarentum	Sept. 5, 1951	...	70	2.6	...	.02	...	76	26	158	33	...	539	35	.1	3.4	924	296	269	...	1,300	7.7	15
	Apr. 21, 1952	72.3	55	...	...	...	...	...	...	15	13	...	90	8.5	...	1.3	...	84	...	...	283	6.5	5
Pucketa Creek near Parnassus	Sept. 6, 1951	4.85	68	2.1	...	.05	...	146	38	301	109	3.9	800	172	.1	5.0	1,610	521	425	...	2,340	8.3	15
	Apr. 21, 1952	35.6	63	...	...	...	...	...	...	30	4	...	204	12	...	2.0	...	168	165	...	517	5.9	5
Deer Creek at Harmarville	Sept. 5, 1951	...	64	...	...	...	...	...	...	...	0	...	1,420	49	...	3.2	...	560	560	74	2,930	3.6	8
	Apr. 21, 1952	73.0	58	7.5	...	.02	...	52	16	128	32	...	409	14	.1	2.6	670	196	169	...	997	6.8	5
Plum Creek at Vevona	Sept. 6, 1951	...	68	4.1	...	.02	...	43	11	405	50	...	585	268	.1	7.3	1,410	153	112	...	2,090	7.7	15
	Apr. 21, 1952	31.8	65	...	...	...	...	...	...	34	0	...	320	28	...	1.4	...	300	300	48	762	4.6	5
Pine Creek at Etna	Sept. 5, 1951	...	77	...	...	...	...	...	...	...	0	...	718	50	...	17	...	240	240	466	2,440	2.5	8
	Apr. 21, 1952	104	54	7.4	...	.1	...	25	7.6	20	15	...	106	10	0	1.2	201	94	81	...	323	7.0	8
Monongahela River basin																							
Peters Creek at Wilson	Sept. 6, 1951	...	67	...	...	...	...	...	...	...	0	...	1,050	53	...	16	...	625	625	85	2,360	3.6	8
	Apr. 21, 1952	104	54	9.6	...	0.05	...	106	38	72	32	...	479	34	0.1	7.6	807	421	396	...	1,060	6.6	8
Pigeon Creek at Monongahela	Sept. 6, 1951	4.0	...	...	...	...	...	...	...	426	22	...	1,180	113	...	1.8	...	480	455	...	3,070	7.7	8
Sewickley Creek at Gratztown	Sept. 6, 1951	60.2	67	...	...	...	...	...	...	...	...	...	1,680	28	...	19	...	900	900	356	4,010	2.7	8
Turtle Creek at Trafford	Sept. 6, 1951	7.18	78	...	13	...	...	...	...	...	0	...	681	23	...	.4	...	510	510	180	1,340	4.0	5
	Apr. 21, 1952	84.8	53	10	...	1.3	2	56	13	53	0	...	339	22	.1	1.2	565	269	269	120	861	3.3	8
Abers Creek near Murrysville	Sept. 6, 1951	...	...	2.2	...	.02	...	40	18	6.8	108	4.9	76	8.0	.1	1.5	245	174	77	...	398	8.2	12
	Apr. 21, 1952	6.34	54	...	...	...	...	...	...	2.7	53	...	77	3.5	...	1.6	...	124	81	...	293	7.3	5
Ohio River basin																							
Chartiers Creek at Carnegie	Sept. 5, 1951	71.4	71	...	...	...	...	...	...	...	0	...	1,590	106	...	15	...	675	675	342	3,720	2.8	10
	Apr. 21, 1952	440	55	7.9	...	0.02	...	80	30	91	38	...	423	33	0.1	2.4	752	323	292	...	1,030	6.5	5
Little Chartiers Creek at Linden	Sept. 5, 1951	...	74	2.0	...	.02	...	55	14	20	187	...	45	26	.1	1.2	298	195	42	...	470	8.0	12
	Apr. 21, 1952	43.7	57	...	...	...	...	...	...	3.6	114	...	60	5.0	...	1.2	...	156	63	...	343	8.1	5
Montour Run near Coraopolis	Apr. 21, 1952	41.4	60	...	...	...	...	...	...	...	0	...	529	12	...	1.3	...	460	460	115	1,050	3.8	5
Sewickley Creek at Ambridge	Apr. 21, 1952	37.5	60	8.6	...	.02	...	19	6.6	12	32	...	49	15	.1	3.1	...	...	...	...	...	...	...
		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	136	75	48	...	233	6.8	5

[1]Five samples taken in the stream cross section once a month.

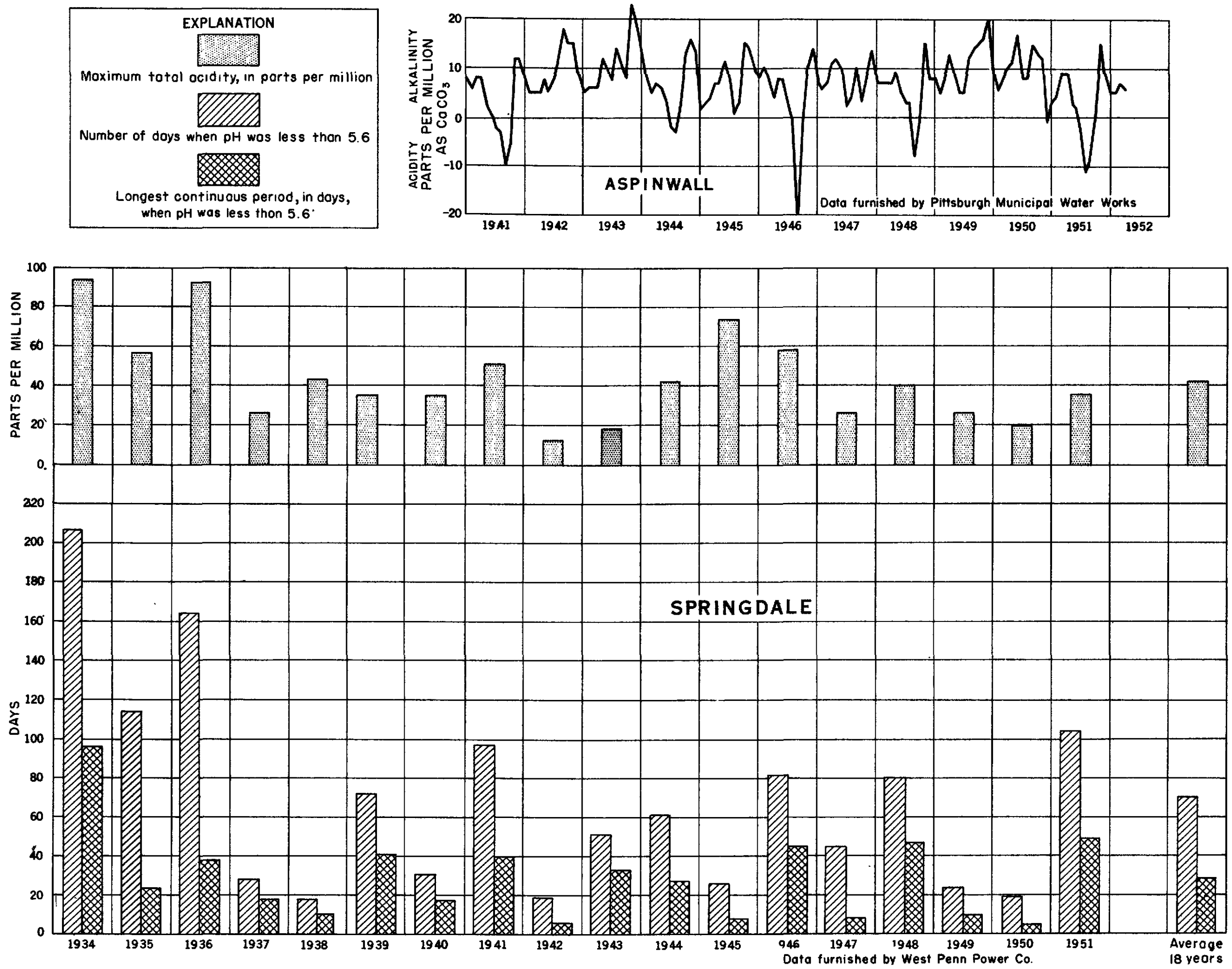

Figure 6.—Acidity-alkalinity of Allegheny River water to methyl red.

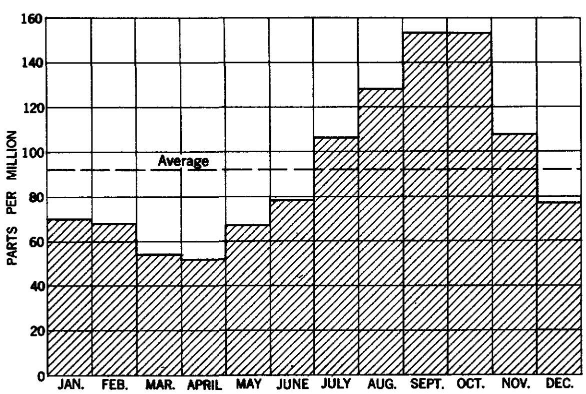

Figure 7.—Average monthly hardness as $CaCO_3$, Allegheny River at Aspinwall, 1939-51. (Data furnished by the Pittsburgh Water Works.)

specific conductance of water on the east side was 356 micromhos and that on the west side was 338 micromhos. The conductance in the middle of the river was 340 micromhos.

Analyses of water samples taken from the Allegheny River at the 16th Street Bridge in Pittsburgh show less dissolved solids than at Aspinwall.

The available data indicate that there is a slight improvement in the chemical quality of Allegheny River water between the Kiskiminetas River and the confluence of the Allegheny and Monongahela Rivers.

Buffalo Creek

Discharge.—Buffalo Creek enters the Allegheny River at the extreme northeast corner of Allegheny County and has been gaged since November 1940. The drainage area of the stream above the gaging station near Freeport is 137 square miles. Maximum dis-

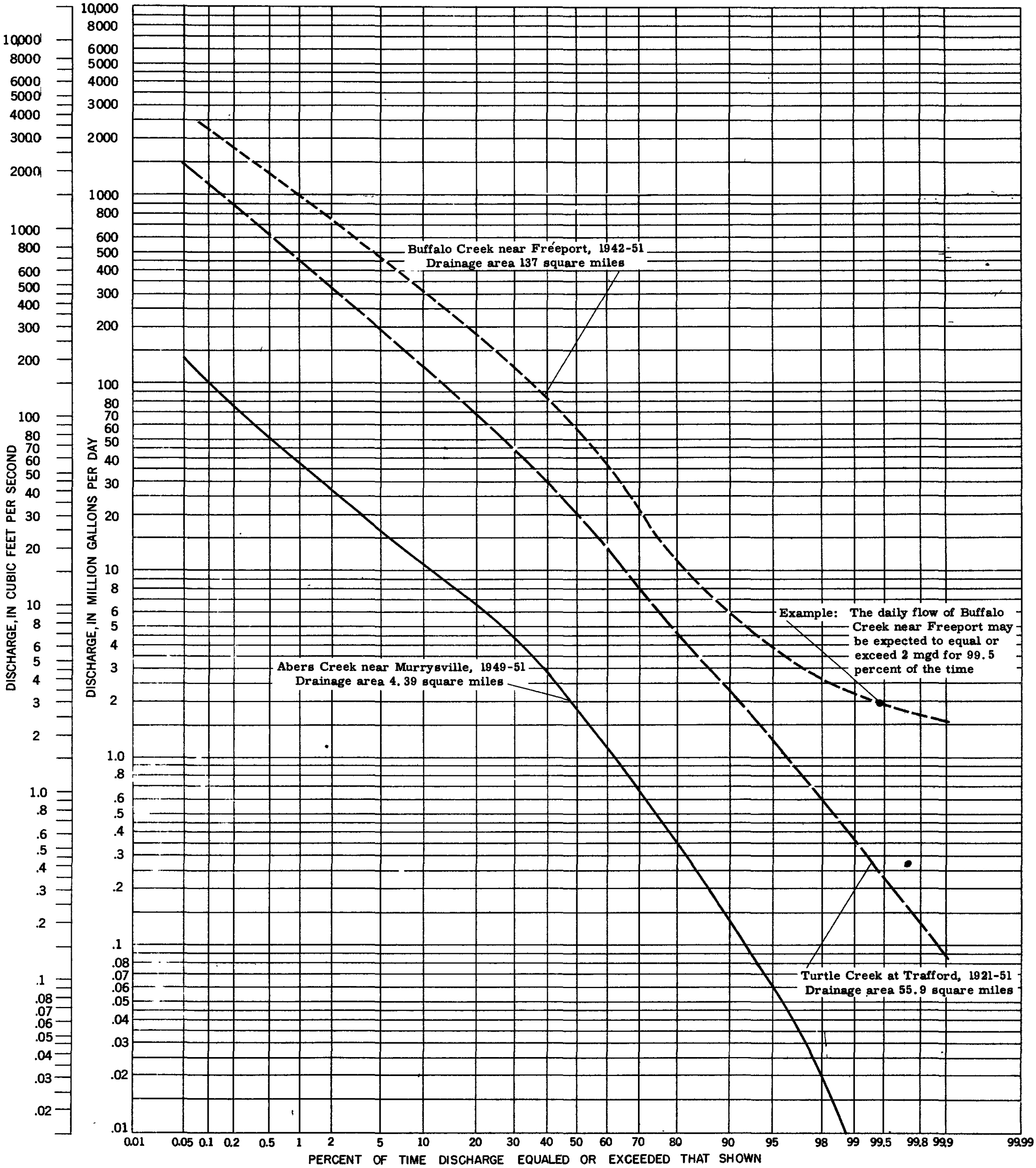

Figure 8.—Duration curve of daily flows, Buffalo Creek, Turtle Creek, and Abers Creek.

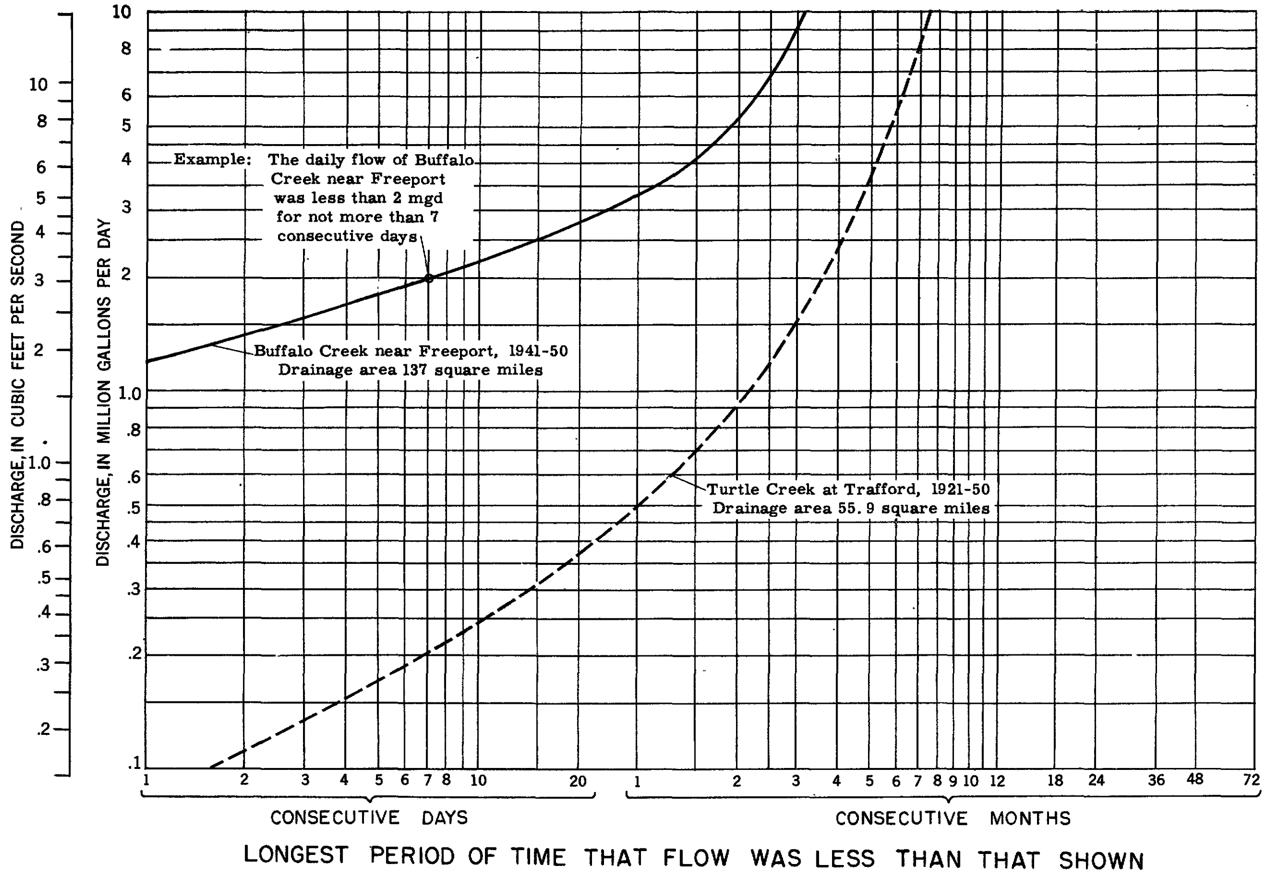

Figure 9.—Maximum period of deficient discharge, Buffalo Creek and Turtle Creek.

charge during the period of record is about 6,500 cfs (47.4 cfs per square mile) measured on January 27, 1952. Minimum discharge since 1940 is 1.3 mgd (2.0 cfs) on several days in September 1945. Mean discharge for the 10-year period 1941-51 is 128 mgd (198 cfs). The duration curve (fig. 8) indicates the flow characteristics of the stream. The maximum period of deficient discharge during the period 1941-50 is shown by graph on figure 9. For example, during this period the daily flow of Buffalo Creek near Freeport was less than 2 mgd for not more than 7 consecutive days. There were no extreme droughts during the period 1941-50. If the period of record had included a severe drought the flow would have been less than 2 mgd for more than 7 consecutive days.

Monongahela River

Discharge.--A gaging station has been operated on the Monongahela River at Braddock (drainage area, 7,337 square miles) since January 1939. Some records of flow before that date, at points upstream and for tributary streams, are available. The maximum discharge known is 210,000 cfs on March 18, 1936. The minimum discharge since 1939 is 361 mgd (559 cfs) on September 20, 22,and 23, 1946. The minimum daily discharge may have been as low as 85 mgd (132 cfs) in 1930. Mean discharge for the 11-year period 1940-51, is 8,415 mgd (13,020 cfs).

The flow characteristics of the stream during a period when there was no appreciable regulation, 1928-37, are shown by the flow-duration curve (fig. 10). This curve was computed from records for upstream stations. The effect of flood regulation on the flow characteristics is also shown. Another curve shows what the flow characteristics would have been for the period 1928-37 if Tygart and Youghiogheny Reservoirs had been operated in the same manner as they were between 1948 and 1951. Changes in method of operation of storage reservoirs might result in further changes in the duration curve.

Tygart Reservoir, in addition to affording flood protection, provides 100,000 acre-feet of storage for release during summer and fall to insure a minimum flow of 220 mgd (340 cfs) at Point Marion. Youghiogheny Reservoir provides for 149,300 acre-feet of storage to be released as necessary during summer and early fall to increase the flow. Water is released from Youghiogheny Reservoir at a rate which varies with the natural river flow, the quantity of water in storage, and the season of the year. Storage reservoirs are usually operated to provide certain flows at a given place downstream. The flow-duration curve (fig. 10) indicates that during the period 1928-37 the daily flow at Braddock equaled or exceeded 100 mgd 99.9 percent of the time and would have been increased from 100 mgd to 650 mgd if Tygart and Youghiogheny Reservoirs had been built and operated as they were

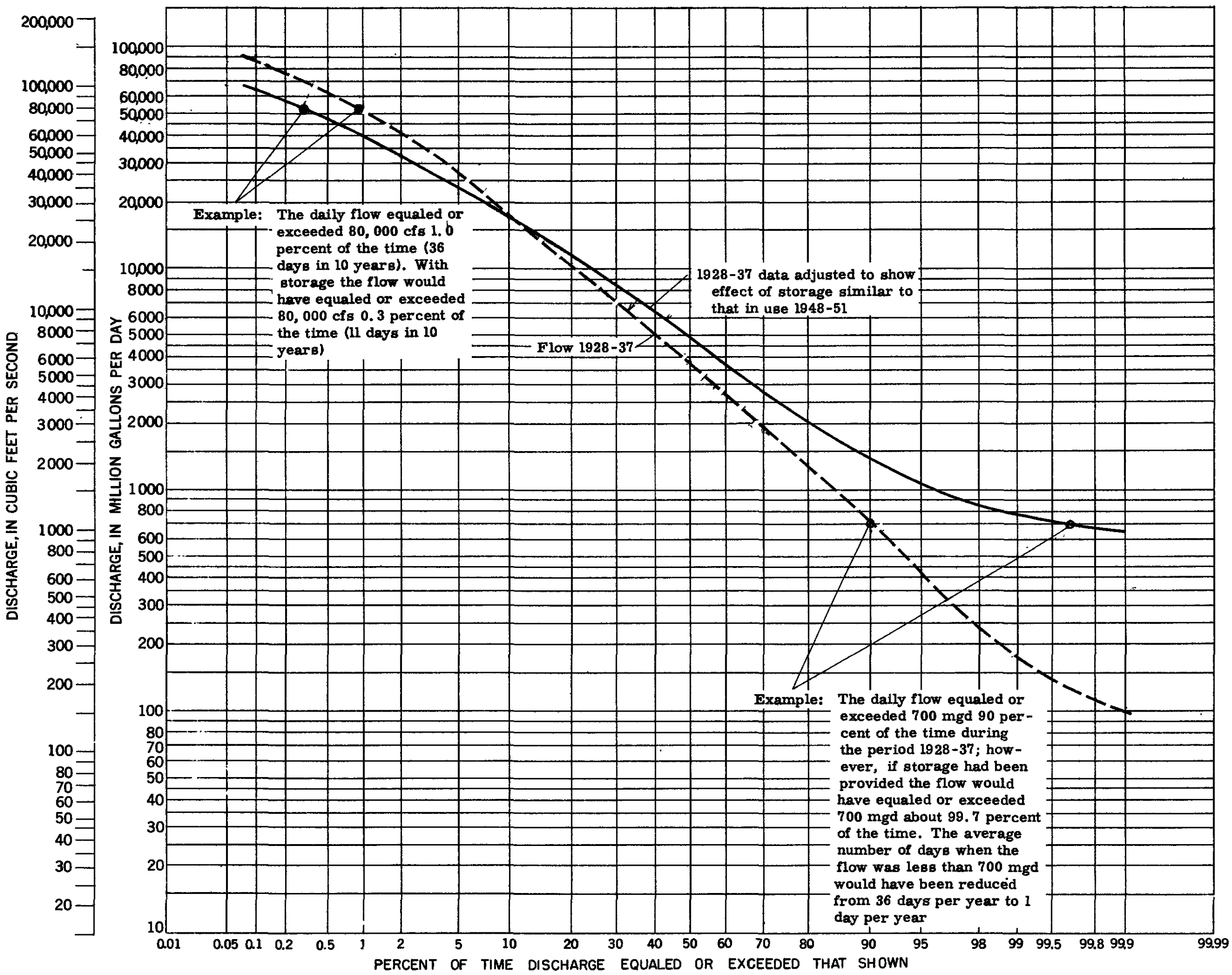

Figure 10.—Duration curve of daily flows, Monongahela River at Braddock, 1928-37.

for the years 1948 to 1951. The increase in flow is dependent on many factors. Therefore, the increase in figure 10 is an average and does not indicate that the flow will necessarily be 650 mgd with regulation whenever it would have been 100 mgd without regulation.

Quality. --The Geological Survey has collected data on the quality of the Monongahela River at Charleroi, 4 miles upstream from the Allegheny County line, since 1944. Data for the 6-year period, 1944-50, shows that the concentration of chemical constituents may change tenfold (fig. 11).

The Monongahela River at Charleroi is heavily polluted with acid wastes. Analyses of waters of several Monongahela River tributaries, specifically, Peters Creek, Sewickley Creek, and Turtle Creek, show that they contribute acid water to the Monongahela River (table 3). During the year October 1, 1946 to September 30, 1947, the river water had an average pH of 4.15, the pH being less than 4.5 for 85 percent of the time. The acid characteristics of Monongahela River water are very persistent. For example, during February 1945, the pH of 10-day composite samples ranged from 3.50 to 4.35, although the discharge for the same 10-day periods changed from 6,610 to 33,300 cfs. The average hardness of the Monongahela River water at Charleroi, for the period October 1944 to September 1951, was 116 ppm. Hardness increases as the acidity increases.

Monongahela River water at Elizabeth had a pH less than 4.6 for an average of 166 days per year during

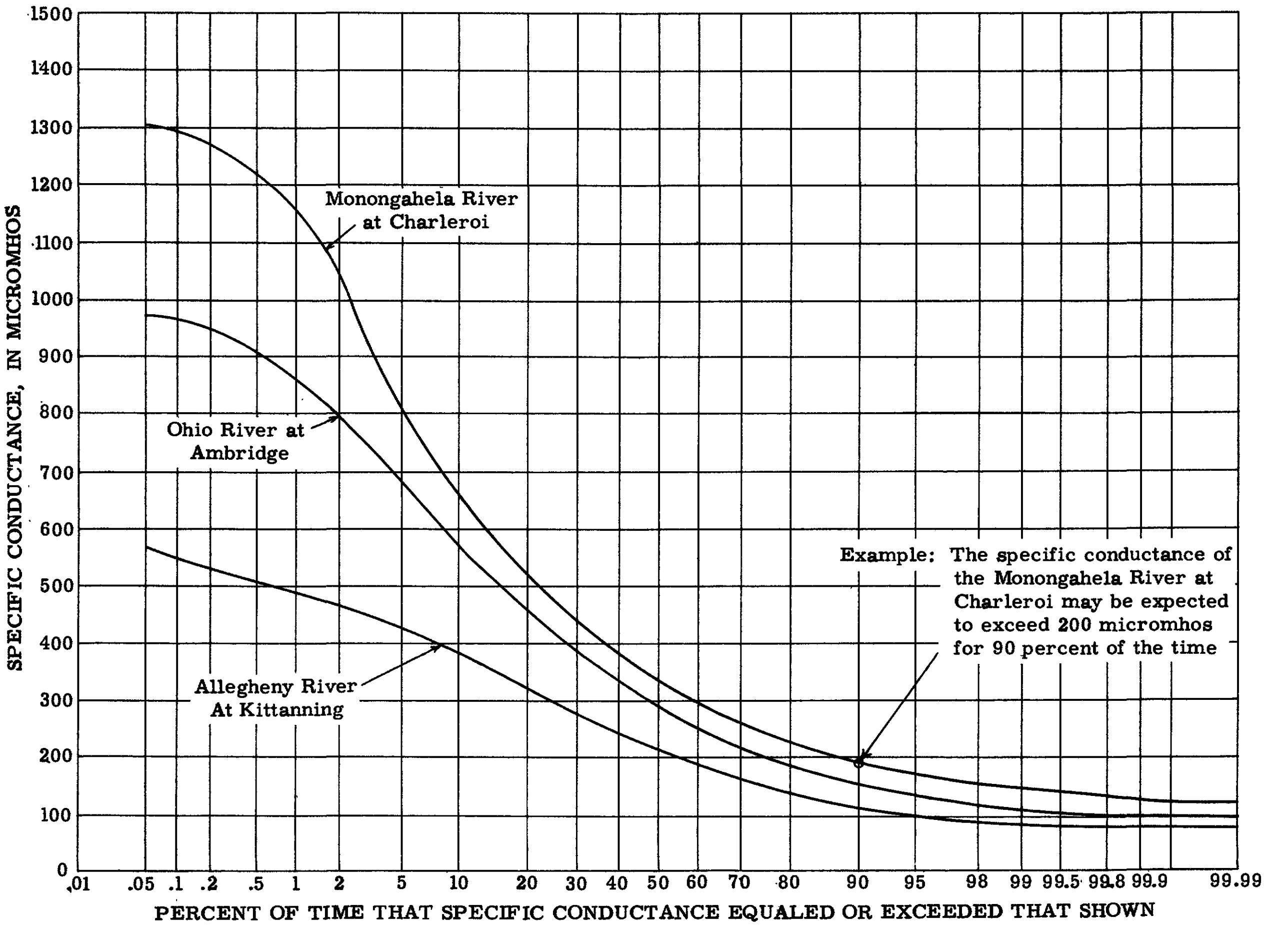

Figure 11.—Cumulative frequency curve of specific conductance, Allegheny, Monongahela, and Ohio River waters, 1944-50.

the years 1945-49 (fig. 12). The free acidity, as sulfuric acid, averaged 27 ppm. The longest period during which the river water had a pH continuously less than 4.6 is 157 days in 1946.

Table 4 shows the monthly hardness and acidity of water in the Youghiogheny River at McKeesport for the period 1948-51. The chemical quality of the river water was better in 1950 than in 1951, probably because the flow in 1950 was about 16 percent greater than in 1951.

Hardness of Monongahela River water at a point 3 miles above the mouth of the river averaged 136 ppm and ranged from 57 to 479 ppm for the period 1926-51. Averages are given in figure 13. The water is usually hardest in October and least hard in March, corresponding generally with low and high runoff in the basin. During the drought of 1930 unusually high hardness values were recorded from July through December.

Youghiogheny River

Discharge.—The Youghiogheny River, which enters the Monongahela River at McKeesport, has been gaged at Sutersville. Records of discharge have been published for the periods October 1920 to September 1929, June 1931 to September 1936, and since December 1938. The drainage area above the gaging station is 1,715 square miles. Maximum discharge during the period of record is 100,000 cfs on March 18, 1936. The minimum discharge during the period of record is 37 mgd (57 cfs) on September 29 and 30, 1922. The average discharge for 26 years (1920-29, 1931-36, 1939-51) is 1,948 mgd (3,014 cfs).

The flow-duration curve (fig. 14) shows the flow characteristics of the stream for the years 1928-37, and an adjusted curve reflects the effect of operation of Youghiogheny Reservoir if operated as it was for the years 1948-51. The record for 1943-48 could not be used in the comparison because Youghiogheny

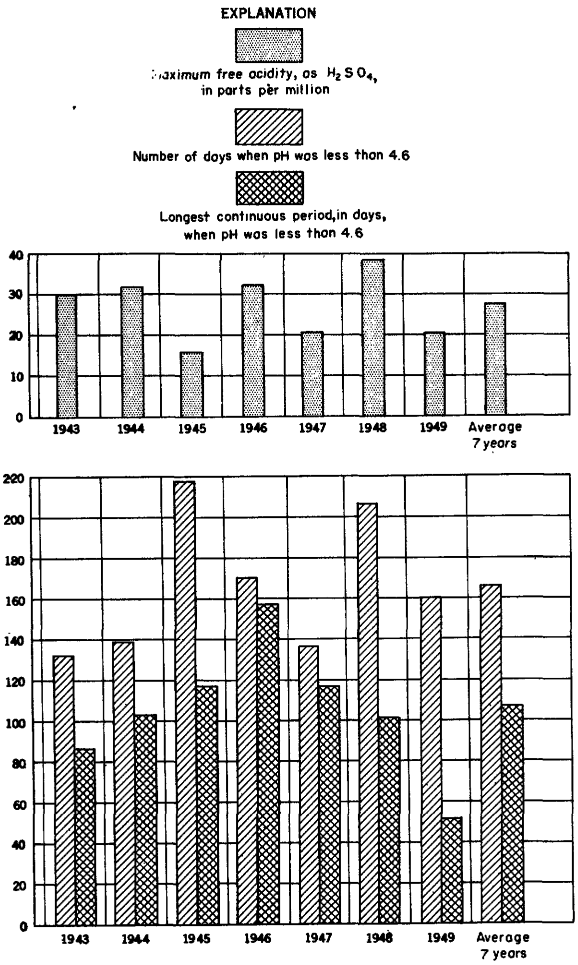

Figure 12.—Acidity of Monongahela River water at Elizabeth. (Data furnished by the Monongahela Valley Water Co.)

Reservoir was not used to augment low flow during those years.

The limitations discussed in regard to the Monongahela River minimum flows and the amount of increase that would have been realized for the years 1928-37 also apply to the Youghiogheny River. Youghiogheny Reservoir is operated to augment low flow based upon flow at Connellsville and upon the net available storage in the reservoir. The example given in figure 14 shows the increase that would have been realized on the average and might not reflect accurately the extremes.

Quality.—The chemical character of Youghiogheny River water in Allegheny County is affected by acid mine drainage in the upper reaches. Free acidity, pH less than 4.5, can be expected in the water about 50 percent of the time. The average pH for the year October 1947 to September 1948 was 4.65

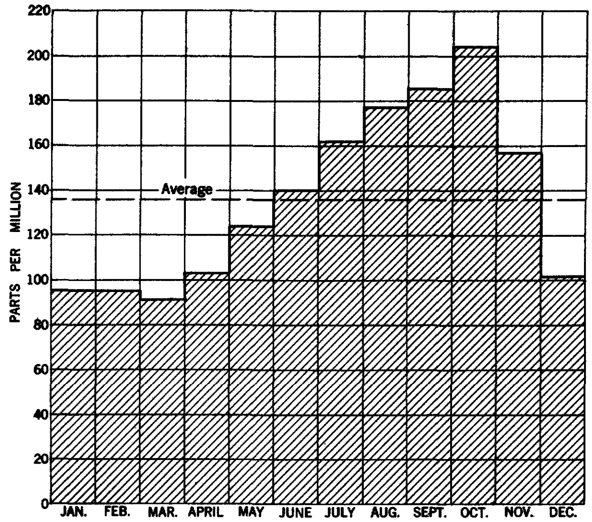

Figure 13.—Average monthly hardness as $CaCO_3$, Monongahela River water at Mount Oliver station. (Data furnished by the South Pittsburgh Water Co.)

The chemical character of Youghiogheny River water was extremely erratic until Youghiogheny Reservoir was put into use (fig. 15). After January 1948 Youghiogheny Reservoir was used to maintain the flow at 1,000 cfs or more and the water was of a much more uniform quality. The McKeesport Municipal Water Works is designed to draw water from either the Monongahela River, or the Youghiogheny River, or from both; however, the slightly better average quality and more consistent Youghiogheny River water is preferred because of the savings in cost of treatment. Monthly hardness and total acidity of Youghiogheny River water is given in table 4.

Turtle Creek

Discharge.—Turtle Creek, a tributary of the Monongahela River downstream from the Youghiogheny River, has been gaged from July to September 1914, and since January 1916. Records of discharge since October 1920 have been published. The drainage area above the gaging station at Trafford is 55.9 square miles. Maximum discharge since 1920 is 5,200 cfs (93.0 cfs per square mile) on May 27, 1946. The minimum flow observed is 0.06 mgd (0.1 cfs) on October 6 and 7, 1922, and on September 16, 17, and 28, 1939. The flow-duration curve for Turtle Creek is shown on figure 8. The maximum period of deficient discharge during the period 1921-50 is shown on figure 9.

Quality.—Two samples of Turtle Creek water were analyzed in 1951 and 1952. The water was extremely acid at both high and low flow (table 3).

Table 4.—Monthly hardness and total acidity of water, Youghiogheny and Monongahela Rivers at McKeesport
[Parts per million. Total acidity determined by phenolphthalein indicator. Data furnished by McKeesport Municipal Water Works]

Period	Youghiogheny River						Monongahela River					
	Hardness			Total acidity			Hardness			Total acidity		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
1948												
Jan.	139	52	90	81	7	31	124	60	86	116	12	35
Feb.	144	47	95	152	4	39	146	55	71	102	11	34
Mar.	93	39	70	29	5	16	90	50	70	34	9	24
Apr.	130	45	95	40	5	19	172	59	91	65	16	30
May	184	64	107	54	8	26	128	59	96	40	12	27
June	148	56	96	57	7	27	160	67	110	55	4	28
July	124	43	86	31	7	16	156	60	102	45	8	22
Aug.	156	90	116	52	8	30	146	75	108	47	14	27
Sept.	140	92	118	58	18	37	222	104	170	90	26	55
Oct.	150	95	115	49	15	31	168	98	110	48	21	33
Nov.	138	70	96	30	10	18	196	84	123	54	4	33
Dec.	105	54	74	37	7	20	77	45	60	32	9	17
Annual	184	39	96	152	4	26	222	45	79	116	4	30
1949												
Jan.	122	51	79	82	3	31	121	47	81	92	6	48
Feb.	116	50	80	24	5	15	96	54	76	29	11	20
Mar.	136	65	90	38	7	24	102	68	88	42	15	27
Apr.	130	77	103	44	17	27	110	60	91	42	9	23
May	160	75	122	60	16	38	194	116	150	61	21	38
June	150	67	125	40	7	28	170	124	146	54	9	16
July	140	71	103	27	10	16	154	82	115	32	9	19
Aug.	111	60	85	16	7	11	176	81	120	42	7	22
Sept.	36	77	88	21	9	15	158	92	126	38	9	23
Oct.	108	78	92	35	15	25	182	134	158	81	21	49
Nov.	102	59	75	39	8	16	154	48	80	67	4	20
Dec.	81	52	67	12	5	8	76	48	60	14	6	9
Annual	160	50	92	60	3	21	194	47	108	92	4	26
1950												
Jan.	92	66	78	19	5	12	108	56	83	37	6	23
Feb.	97	52	70	24	5	12	134	62	88	45	11	26
Mar.	101	51	76	42	7	17	136	52	85	49	9	24
Apr.	121	50	89	30	5	20	174	62	114	62	11	28
May.	94	54	69	21	7	11	134	62	89	36	7	19
June	108	50	75	22	7	12	148	48	87	31	7	16
July	116	75	96	21	7	13	160	49	100	38	6	16
Aug.	142	88	104	32	10	19	224	112	157	64	16	37
Sept.	136	62	105	49	7	16	220	79	123	69	6	24
Oct.	101	75	87	21	7	12	160	102	129	34	4	17
Nov.	108	72	86	19	6	10	152	64	90	34	3	9
Dec.	104	71	88	47	6	17	146	67	93	47	4	20
Annual	142	50	85	49	5	14	224	48	103	69	3	22
1951												
Jan.	102	65	80	21	6	13	126	45	89	31	3	16
Feb.	109	50	84	27	9	15	121	49	92	67	2	22
Mar.	125	79	105	23	7	16	112	78	94	31	3	16
Apr.	128	67	100	19	6	12	104	76	82	27	7	14
May	168	64	114	24	7	14	152	95	116	31	11	18
June	160	58	106	32	4	11	178	59	118	54	5	24
July	154	120	136	33	5	17	208	104	149	62	4	26
Aug.	156	116	138	33	17	25	245	140	197	62	14	33
Sept.	168	128	146	34	19	28	293	192	257	62	31	50
Oct.	160	130	142	39	23	27	289	154	250	67	2	39
Nov.	165	71	129	27	4	17	300	76	227	72	2	43
Dec.	98	54	82	16	3	9	89	54	73	31	4	11
Annual	168	50	114	19	3	17	300	45	145	72	2	26

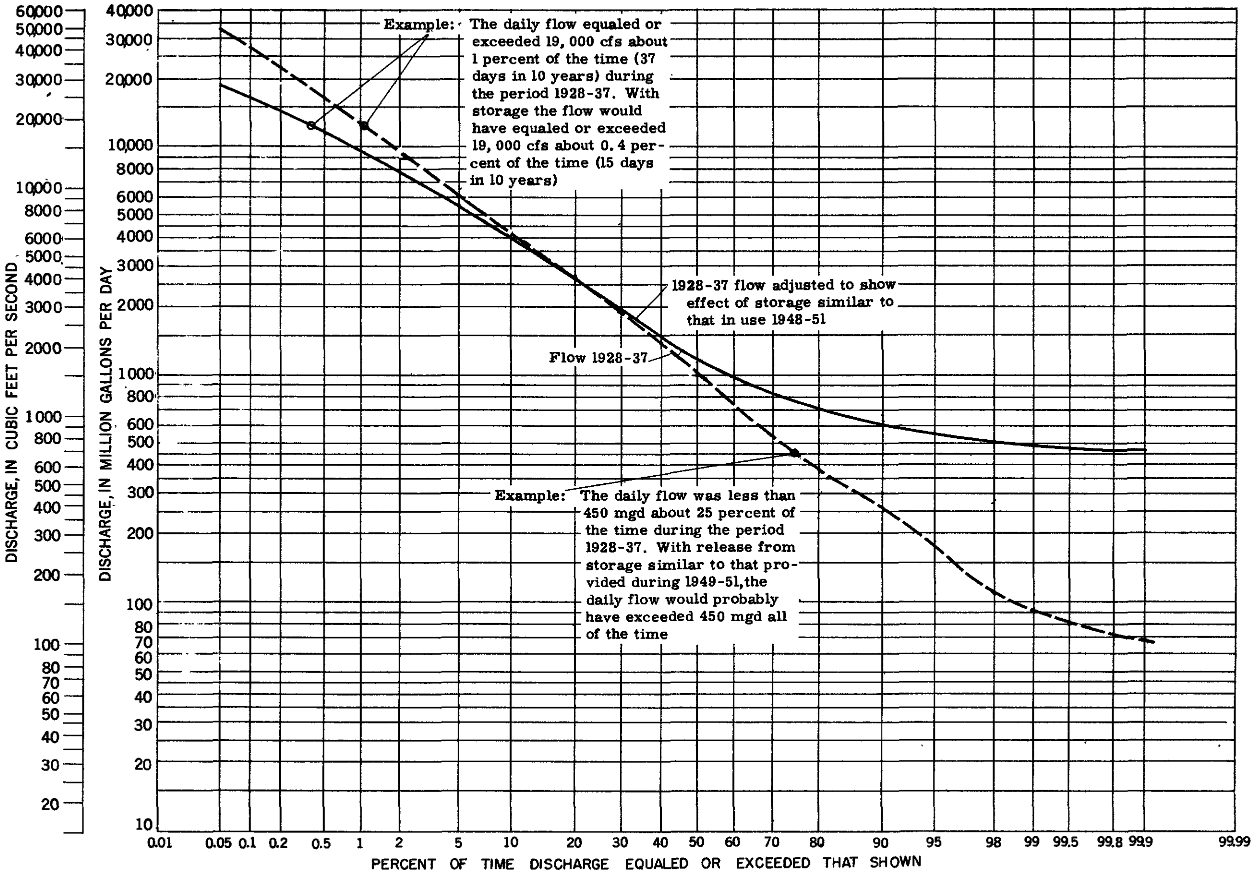

Figure 14.—Duration curve of daily flows, Youghiogheny River at Sutersville, 1928-37.

Abers Creek

Discharge. —Abers Creek, a tributary of Turtle Creek, has been gaged near Murrysville (drainage area, 4.39 square miles) since October 1948. The maximum discharge during the period of record is 1,600 cfs (373 cfs per square mile) on July 5, 1950. No flow occurred at various times from July to September 1949, and on September 12, 1950. The average discharge for the 2 years, 1949-51, is 4.52 mgd (6.99 cfs). The flow-duration curve (fig. 8) shows the low-flow characteristics of the stream.

Quality. —Two analyses of Abers Creek water are given in table 3. These indicate that the water is of much better chemical quality than Turtle Creek water. The samples were moderately alkaline and relatively low in dissolved solids.

Ohio River

Discharge. —A gaging station has been maintained on the Ohio River at Sewickley (drainage area, 19,500 square miles) since October 1933. The flow of the Ohio River is regulated by several upstream reservoirs on tributaries. Two reservoirs, Deep Creek Lake (capacity, 106,060 acre-feet) and Lake Lynn (capacity, 72,300 acre-feet), were constructed for power generation. Regulation by Deep Creek Lake was begun in 1925 and by Lake Lynn, in 1926. Several reservoirs provide storage for flood control. (See page 30.)

The flow characteristics of the Ohio River before flood-control reservoirs were constructed and as they might have been after the first six flood-control reservoirs (Tygart, Tionesta Creek, Crooked Creek,

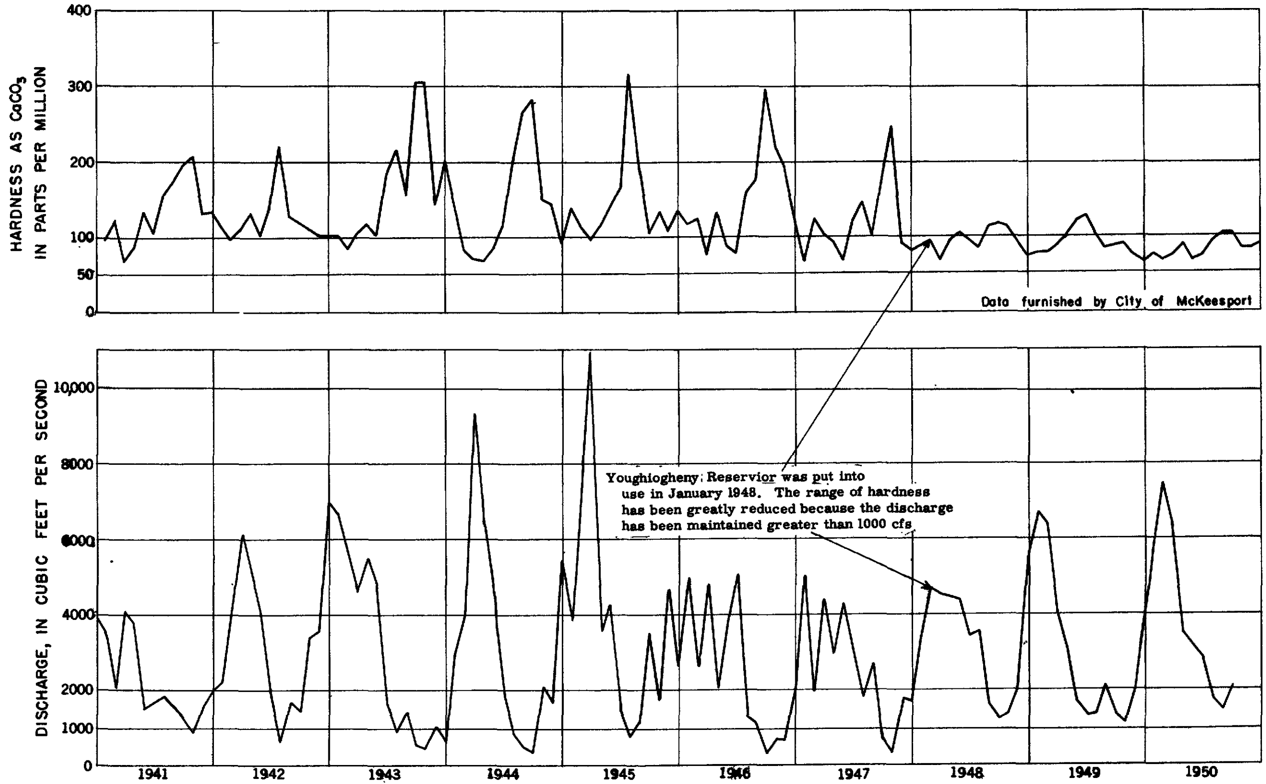

Figure 15.—Relation between streamflow and hardness of Youghiogheny River water at McKeesport, 1941-50.

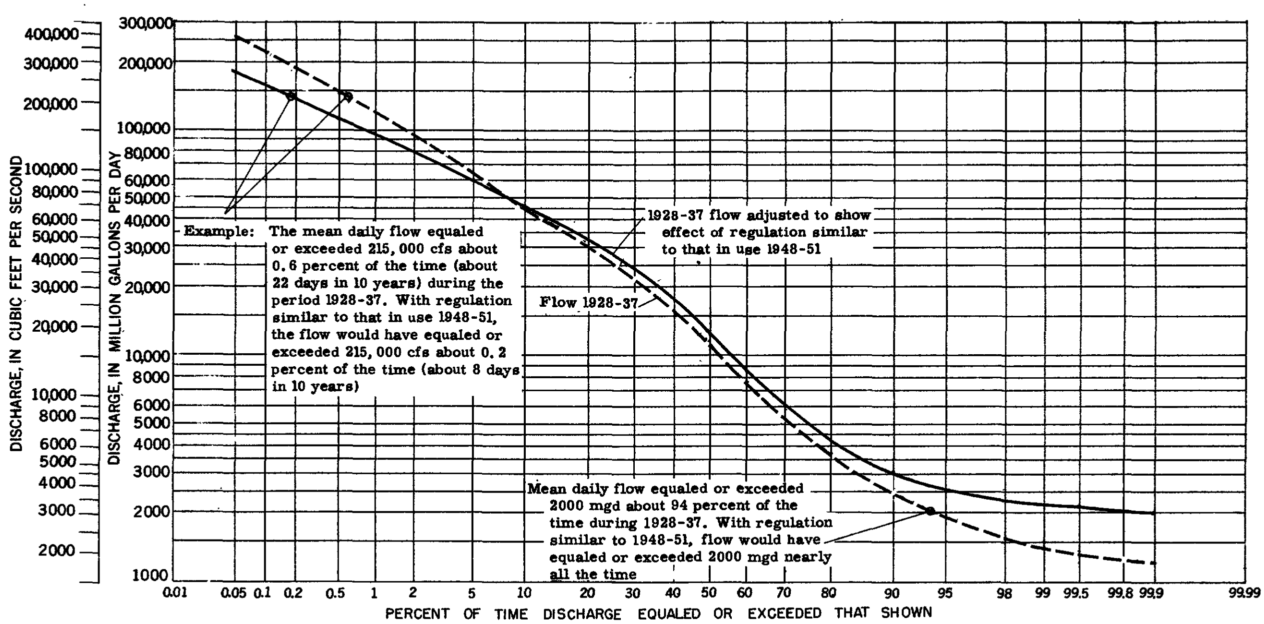

Figure 16.—Duration curve of daily flows, Ohio River at Sewickley, 1928-37.

Mahoning Creek, Loyalhanna Creek, and Youghiogheny) were constructed are indicated by the flow-duration curves (fig. 16). One curve shows the flow characteristics during the 10-year period, 1928-37. The other curve shows the flow characteristics as they might have been during this 10-year period if the six reservoirs had been built and operated in the same manner as they were in the period 1948-51. Flood flows have been reduced and low flows augmented since starting reservoir operation. The streamflow during the period 1928-37 is considered as about average. The most severe drought and the most serious flood known in western Pennsylvania occurred during the period 1928-37. The examples shown for flood-flow reduction on figures 5, 10, and 16 have been selected because, on the average, when flood stage (25 feet) occurs at Pittsburgh the discharge at Sewickley is about 215,000 cfs. Should such a flow result from runoff proportional to the drainage area of the basins, about 125,000 cfs would flow past the gage at Natrona, about 80,000 cfs would flow past the gage at Braddock, and the rest would come from the intervening area. Although the entire area would seldom contribute to a flood at a uniform rate, an average of many floods may be studied using this assumption. In the 10 years being considered, 13 floods exceeded 25 feet at Pittsburgh. The stage was more than 25 feet for a total of 32 days or parts of days. The daily mean flow exceeded the amount necessary to produce a flood stage for 20 days. With storage similar to that in use in 1948-51, this latter group of days would have been reduced from 20 to 8. Further reduction of flood flows can be expected because Conemaugh River and East Branch Clarion River reservoirs were not operated before 1952 and their effect on natural flow was not taken into consideration when the flow-duration data were computed. No appreciable low-flow benefits should be expected from Conemaugh River reservoir because it was not designed to store flood waters for augmenting low flow. East Branch Clarion River dam, having been designed primarily for benefits to the Clarion River, will have little effect on either low or flood flows at Pittsburgh.

Figure 17 shows flood-frequency curves, furnished by the Corps of Engineers, for the Ohio River at Pittsburgh with and without operation of storage reservoirs. The flood-frequency curve without storage is based on all floods at Pittsburgh since 1855. The difference between the curves indicates the average reduction in stage and will not necessarily indicate the reduction for an individual flood.

Studies by the Corps of Engineers indicate that, if the present completed system of reservoirs had been in operation at the time of the March 1936 flood, the stage at Pittsburgh would have been reduced from 46.0 to 35.9 feet and the discharge at Sewickley from 574,000 to 380,000 cfs. Without flood control, a flood of the magnitude of the 1936 flood could be expected on an average of once in about 300 years.

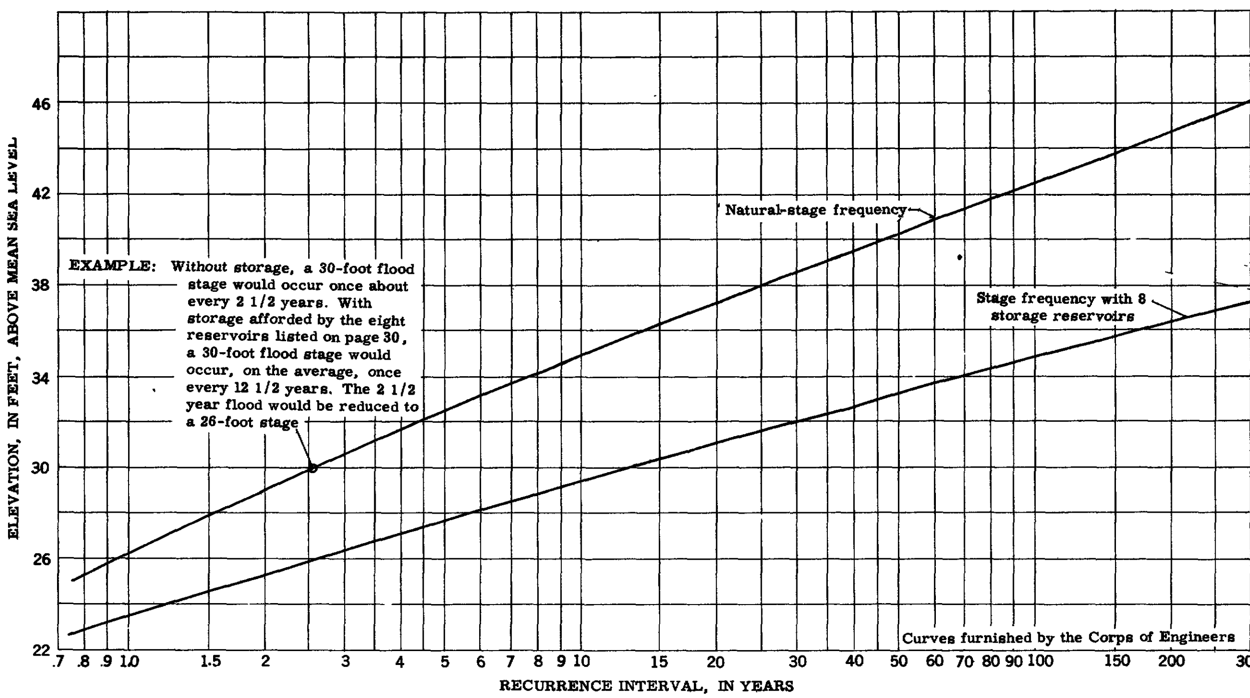

Figure 17.—Flood-stage frequencies, Ohio River at Pittsburgh.

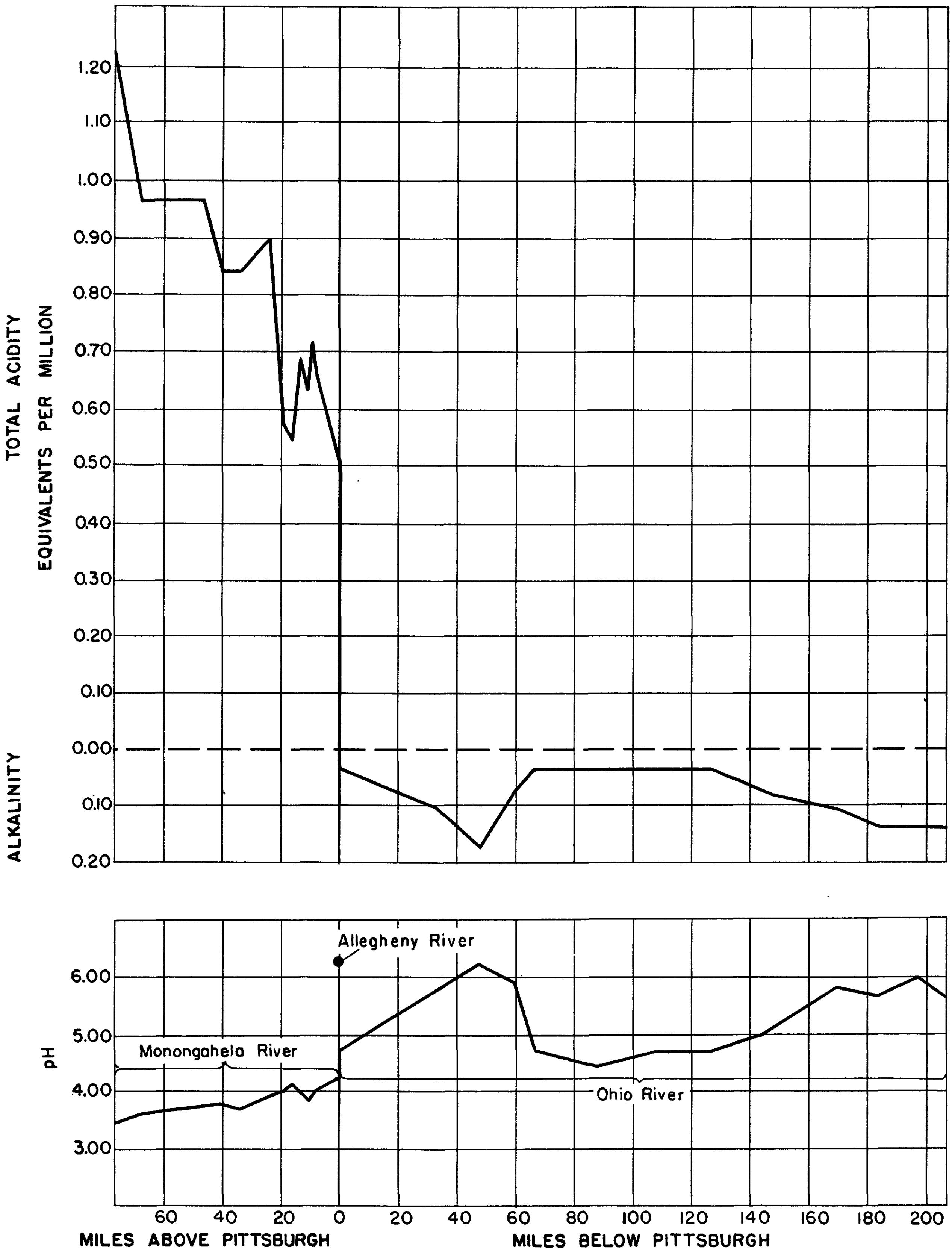

Figure 18.—Characteristics of the water, Monongahela and Ohio Rivers, July 13—24, 1941.

The brief table below, taken from data furnished by the Corps of Engineers, shows data on floods which have occurred at Pittsburgh in recent years, including the stage which would have been reached if no storage was available, and the stage which would have been reached if the present system of reservoirs had been in operation at the time of the flood. It should be noted that the Ohio River has been partly controlled by storage reservoirs since 1938.

Date	Actual stage reached	Stage if no storage had been available	Stage expected if all reservoirs existing in 1952 had been in operation
Mar. 18, 1936	46.0	46.0	35.9
Dec. 31, 1942	36.6	39.4	34.4
Mar. 7, 1945	33.4	35.2	31.3
Apr. 15, 1948	29.8	33.1	27.8

The minimum discharge recorded at Sewickley since 1933 is about 1,290 mgd (2,000 cfs) on July 25, 1934. In 1930 and 1932, the discharge may have been considerably less. Some regulation may have occurred in 1930 and 1932 because of operation of Deep Creek Lake and Lake Lynn reservoirs for power generation. With reservoirs, as operated since 1948, low flow at Sewickley on the Ohio River would have been increased in a similar manner to the Monongahela River at Braddock (fig. 16). The example shown on figure 16 is based upon an average of conditions as they were from 1928 to 1937, and from 1949 to 1951. The same varying factors described as applying to the Monongahela River apply to the Ohio River. Therefore, it is expected that the amount by which low flows will be increased in the future may vary somewhat from that shown.

Quality. --The chemical characteristics of Ohio River waters in Allegheny County are affected by the flow and chemical concentration of the Monongahela and Allegheny Rivers. The less concentrated Allegheny River has the greater discharge and therefore dilutes the more concentrated acid waters of the Monongahela River (fig. 18).

The concentration of dissolved solids was greater at Ambridge than at Brunot Island during 1946-47 (fig. 19). Brunot Island is 3 miles below the head of the Ohio River at Pittsburgh and Ambridge is at the Allegheny County line, 15 miles below the head.

Several conclusions can be made by comparing the pH of the river waters at Brunot Island and Ambridge:

1. The pH is higher at Brunot Island than at Ambridge during most of the year (fig. 20). The data shown in figure 20 are for a year, 1951, when the acidity of Ohio River water was slightly higher than average.

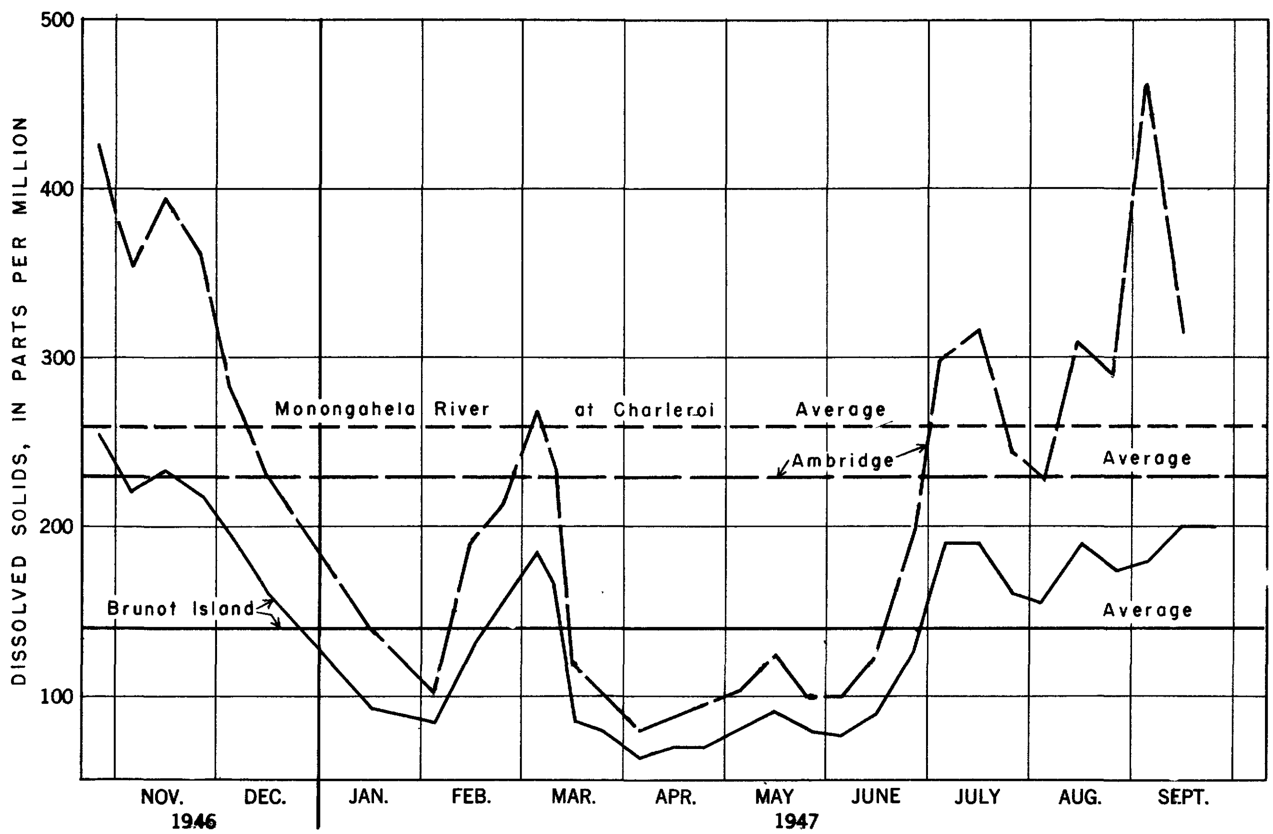

Figure 19.—Dissolved solids in Ohio River water at Ambridge and Brunot Island, 10-day composite samples, November 1946 to September 1947.

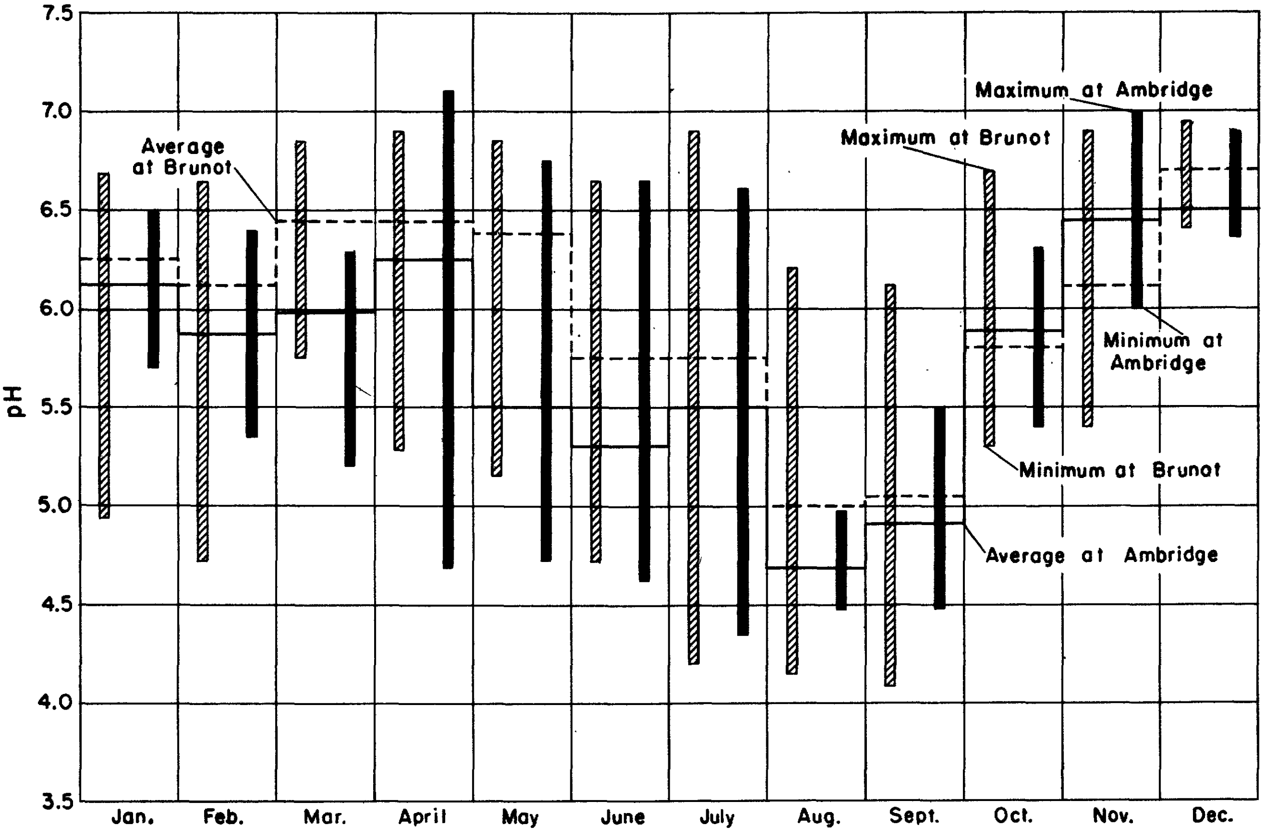

Figure 20.—Monthly average, maximum, and minimum 10-day composite pH values of Ohio River water at Brunot Island and Ambridge, 1951. (Data at Brunot Island furnished by Duquesne Light Co.)

2. The range in pH of river water at both Brunot Island and Ambridge is greatest during the spring and summer. In the spring and summer of 1951 the maximum pH range was from 4.1 to 6.9 at Brunot Island, and at Ambridge it was from 4.4 to 7.1.

3. Part of the pollution observed at Ambridge can be attributed to Montour Run and Chartiers Creek. Montour Run water at Coraopolis had a pH of 3.8 in April 1952, and Chartiers Creek at Carnegie had a pH of 2.8 on September 5, 1951 (table 3).

A cumulative frequency curve of specific conductance for Ohio River water in Allegheny County is given in figure 11. During the period 1944-50 the specific conductance ranged from 150 to 975 micromhos. The average hardness during the period 1942-51 was 106 ppm (fig. 21). The observed hardness ranged from 42 to 276 ppm.

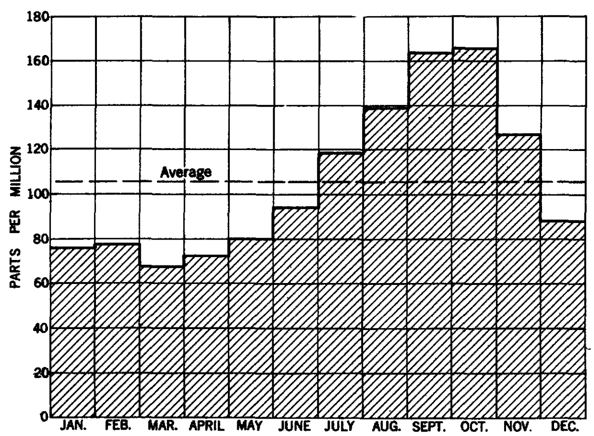

Figure 21.—Average monthly hardness as $CaCO_3$, of Ohio River water at Brunot Island, 1942-51.

Chartiers Creek

Discharge. —Chartiers Creek has been gaged since 1915 at Carnegie (drainage area, 257 square miles).

Table 5.—Monthly and annual water temperatures, Allegheny, Monongahela, Youghiogheny, and Ohio Rivers

[Degrees Fahrenheit]

Month	River, station, and period of record									
	Allegheny			Monongahela				Youghiogheny	Ohio	
	Aspinwall 1911–45	Colfax 1935–45	Springdale 1935–45	Rankin 1936–45	Duquesne 1935–45	Dravosburg 1940–45	Clairton 1935–45	Connellsville 1935–45	Brunot Island 1935–45	McKees Rocks 1935–45
October	60	61	58	69	62	61	62	54	62	65
November	46	46	44	53	49	50	50	42	48	50
December	38	37	35	46	40	38	40	....	37	42
January	35	36	34	43	38	36	38	....	36	40
February	35	36	34	43	38	37	38	....	36	40
March	39	39	38	47	44	45	44	....	40	44
April	49	49	47	57	52	53	52	49	49	53
May	61	61	61	68	62	63	64	62	63	65
June	72	73	71	78	72	74	74	70	74	76
July	78	78	76	83	78	80	78	74	79	81
August	77	80	77	84	79	78	80	73	80	82
September	72	74	70	79	73	73	74	66	73	76
Water year	55	56	54	62	57	57	58	....	56	60

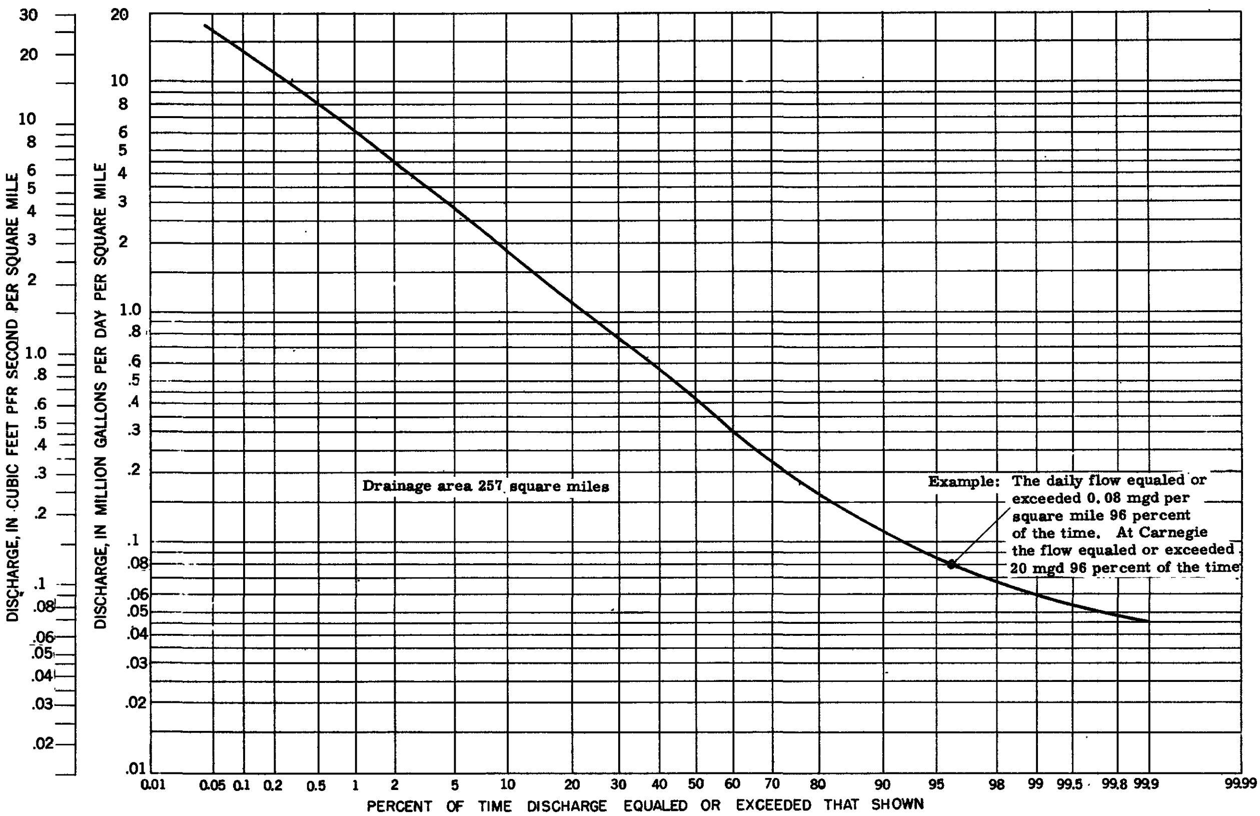

Figure 22.—Duration curve of daily flows, Chartiers Creek at Carnegie, 1920-30, 1933, 1942-51.

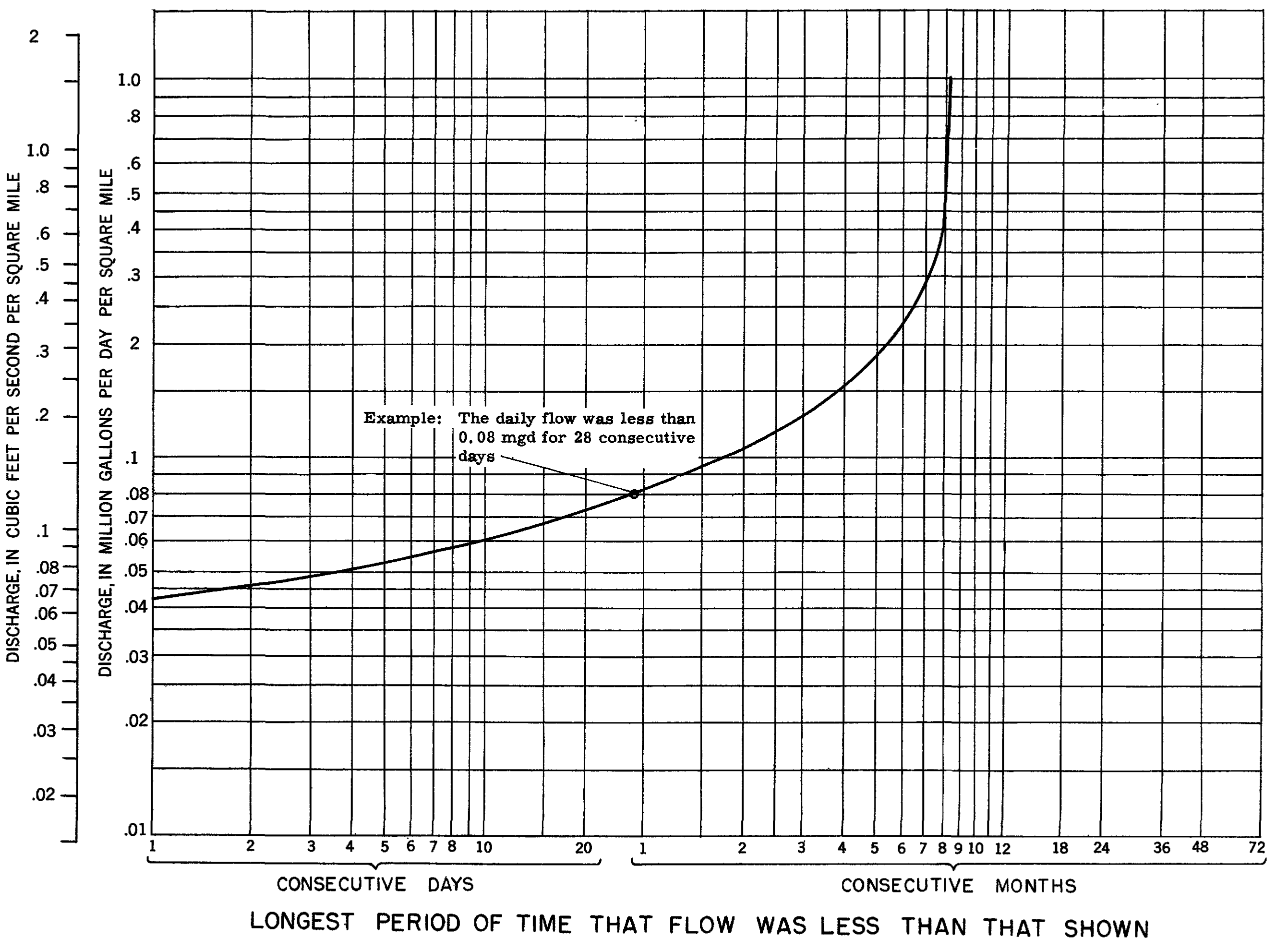

Figure 23.—Maximum period of deficient discharge, Chartiers Creek at Carnegie, 1920–30, 1932, 1941–50.

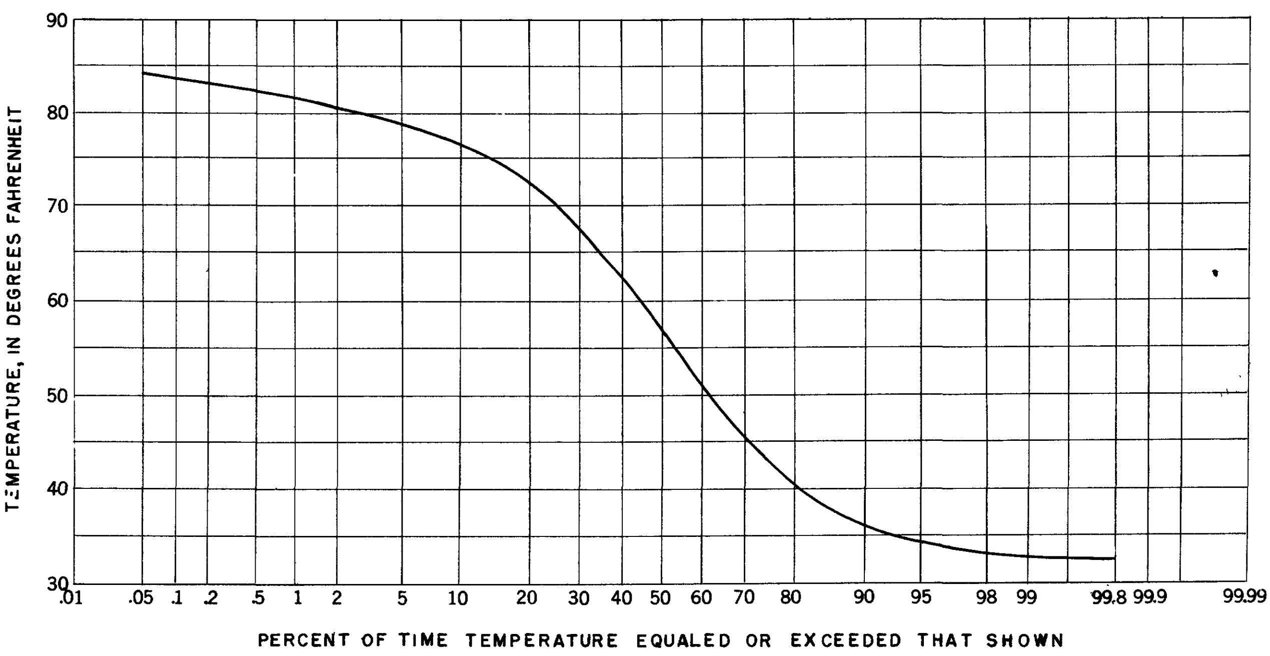

Figure 24.—Cumulative frequency curve of water temperature, Monongahela River at Charleroi, 1944–49.

Records of discharge have been published for periods from October 1919 to September 1933, and November 1940 to date. The maximum discharge has not been determined. Minimum discharge observed is 10 mgd (16 cfs) on August 9, 1926, and at times in September 1932. General characteristics of the stream are shown by the flow-duration curve (fig. 22) and by the graph showing the maximum number of days of deficient discharge (fig. 23).

Quality.--Two analyses of Chartiers Creek water are given in table 3. The chemical quality of the water fluctuates widely in response to changes in flow of the stream. At low flow, the waters of Chartiers Creek are extremely acid.

Water Temperature

The temperature of surface water varies with air temperature, usually reaching a maximum in July and August and a minimum in January and February. During months when the air temperature is above freezing and the water temperature is not altered by industrial use or effluent wastes, the monthly surface-water temperature is nearly the same as the monthly air temperature. However, in Allegheny County temperature of water in the larger streams is increased by use for cooling. The temperature of water discharged by powerplant in the area shows an average increase of about 14 F. The average air temperature in Allegheny County is 53 F and the average surface-water temperature of the large streams is 57 F.

The monthly and annual water temperatures of selected streams are given in table 5. Allegheny River water is cooler than Monongahela River water. The median water temperature of the Allegheny River at Kittanning for the 5-year period 1944-49 was 55 F and the median water temperature of the Monongahela River at Charleroi for the same period was 57 F. The cumulative frequency curve of water temperature for the Monongahela River at Charleroi is shown in figure 24.

Pollution and Its Control

Waste disposal in the Pittsburgh area was of minor concern for many years because the streams had sufficient flow and quality to dilute the process wastes and sewage discharged into them. This is no longer true. The abatement of pollution is now a major problem which is increasing in seriousness.

The waters of the Monongahela, Youghiogheny, and Allegheny Rivers are grossly polluted when they reach the Pittsburgh area. The local tributary streams also carry considerable pollution. The Pittsburgh area greatly increases the pollution load before the water leaves the region. Only very little of the sewage of the entire Monongahela and Allegheny basins is treated, and none of consequential amount in the Pittsburgh area. While industry is required by law to neutralize all strong pickling liquors before discharging them into streams, many other objectionable wastes are discharged directly into the waterways. Many industries utilize community sewage systems to dispose of both sanitary wastes and process wastes that can be discharged without treatment. About equal amounts of sewage in the Pittsburgh industrial area are discharged into the Allegheny, the Monongahela, and the upper Ohio River drainage basins.

Iron and steel producers use large amounts of sulfuric acid in their finishing processes. The Commonwealth prohibits the discharge of leavings of high acid content into the streams. However, the industry is the source of acid pollution because rinse waters containing some acid are usually discharged directly to the streams.

Acid mine drainage presents one of the most serious pollution problems in the Monongahela River basin. In coal mining, the exposure of sulfur-bearing minerals to air and water produces sulfurous acid which finds its way into the natural watercourses. Consequently, water from these streams must be treated to make it satisfactory for human consumption and for use by many industries.

Acid mine drainage is also a source of pollution in the Allegheny River. Large amounts of acid water reach the Kiskiminetas River and lesser amounts reach the Clarion River and Redbank and Mahoning Creeks. However, the Allegheny River water generally becomes slightly alkaline as it approaches the mouth of the river except at times of low flow.

The Ohio River water in Allegheny County is generally alkaline. However, during low-flow periods it contains varying quantities of mineral acid, the degree of acidity being dependent on the rates of flow and the acidity of the two principal tributaries.

The Commonwealth of Pennsylvania now requires all communities and industries to provide some treatment of all wastes. Communities and industries must submit plans for methods to be employed to meet these requirements. To work out a practical integrated plan for the disposal of the wastes from Allegheny County, the Allegheny County Sanitary Authority was established in 1946. The city of Pittsburgh and 65 adjacent municipalities are under the Authority's jurisdiction. Some industrial concerns are operating under the Authority and will have the wastes from their plants treated along with the sewage. A single intermediate-degree treatment works will be built in the northwest section of Pittsburgh on the Ohio River. Final plans are being prepared. The remaining 37 communities and many industries are not committed to the undertaking. They are either working out other arrangements individually or with other communities or industries.

No completely satisfactory solution has yet been found for preventing the formation of acid water in operating mines. Chemical treatment of the drainage with lime or other acid neutralizers is not practical. Acid drainage can be materially reduced by preventing surface waters from entering the mines. As the progress of the Pittsburgh area depends upon the continued mining of coal, studies may show practical means for minimizing the formation of acid in active coal mines. If these means are found, one of the most serious problems in the area will have been solved.

Floods and Flood Control

The Pittsburgh area has been plagued by floods from the time of its settlement. The history of floods in the

Ohio River at Pittsburgh begins with the occupancy of Fort Duquesne by the French in 1756. Frequent mention of trouble from floods appeared in letters that emanated from that fort and later from Fort Pitt. The first flood crest recorded was in January 1762, and a record of the heights of 16 major floods before 1855 has been preserved. An unbroken record of flood crests has been obtained since 1855. Before flood-control reservoirs were constructed, Pittsburgh could expect high water which would cause at least minor flooding on an average of once in every 9 months.

Severe storms originating in either the Allegheny River basin, or the Monongahela River basin, or in both, cause floods at Pittsburgh's "Golden Triangle." (This area, hereinafter referred to as the Triangle area, is composed of the downtown section of Pittsburgh between the Allegheny and Monongahela Rivers; see figs. 31 and 32.) There have been times when severe storms have caused severe flooding along the banks of one of these river systems but have not materially affected the other or caused serious flooding along the Ohio River. Many factors govern the paths of storms across the river basins and it is not probable that the Allegheny and Monongahela Rivers simultaneously would ever contribute peak flow from very severe storms to the Ohio River. In March 1936 when such a condition was more nearly approached than at any other time in modern history, Pittsburgh had its greatest flood.

The first concerted effort to study the flood problem was made by the Pittsburgh Chamber of Commerce in 1908. A committee of local citizens known as the Flood Commission of Pittsburgh was appointed to ascertain the damages caused by past floods, to investigate causes of floods, and to determine the nature and the cost of the best method of protection. The results of these surveys and investigations were released by the commission in a detailed report in 1912. The commission recommended the construction of 17 reservoirs in the upper reaches of the Allegheny and the Monongahela River basins. Studies indicated that these storage reservoirs would reduce all floods at Pittsburgh to a stage of 40 feet. Flood walls would provide protection for stages as much as 40 feet. However, no flood control works were in operation in March 1936 when the most devastating flood in 174 years of record hit Pittsburgh. This flood reached a stage of 46.0 feet, exceeding by 4.9 feet the second highest flood of record which occurred in 1763.

Immediately after the flood of March 1936 engineers of the Corps of Engineers, the Pennsylvania Department of Forests and Waters, and the U. S. Geological Survey, visited all important streams in the flooded areas of Pennsylvania in order to record and preserve marks showing flood crests before they were obliterated by weathering or otherwise removed. These flood marks were later referred to bench marks of known elevation above mean sea level (Sandy Hook datum).

The flood profiles for the flood of March 1936 on the Ohio, Allegheny, Monongahela, and Youghiogheny Rivers in Allegheny County are given in figures 25, 26, and 27. These diagrams were compiled for the most part from data collected by the Corps of Engineers, Pittsburgh district. The same diagrams show pool stage elevations, the minimum river elevations which are maintained by the navigation dams.

Since 1936 great strides have been made toward providing the Pittsburgh area with flood protection. A system of 13 flood-control reservoirs, recommended by the Corps of Engineers, has been authorized by Acts of Congress and 8 are in operation. Construction of the other 5 reservoirs has not yet begun (1953). The total net storage of the system when completed will be 2,364,000 acre-feet. This quantity of water, if distributed evenly over Allegheny County, would cover it to a depth of more than 5 feet.

The list of flood-control reservoirs, in operation, follows:

Reservoir	Storage (acre-feet) Gross	Storage (acre-feet) Net for flood control	Date storage began
Tygart	289,600	278,400	May 1938
Tionesta Creek	133,400	125,600	1940
Crooked Creek	93,900	89,400	May 1940
Mahoning Creek	74,200	69,700	Before June 1941
Loyalhanna Creek	95,300	93,300	June 1942
Youghiogheny	254,000	151,000	Before July 1943
Conemaugh River	274,000	270,000	1952
East Branch Clarion River	84,300	38,700	1952

When the complete system of flood-control reservoirs is in operation, most of the storms which have plagued the upper Ohio River basin for many years will be of only passing interest to the people of Pittsburgh.

It is entirely possible for the Pittsburgh area to be visited by a storm even more severe than that of March 1936. Studies by the Corps of Engineers indicate that it would be reasonable to expect a crest stage of 50.6 feet at Pittsburgh if no protection was afforded by storage reservoirs. However, storage reservoirs will reduce materially the flood crest and damage at Pittsburgh. In a similar manner, the frequency of floods will be reduced, and many potential damaging floods will be eliminated or reduced below the stage of significant damage.

Studies by the Corps of Engineers indicate that, if the eight reservoirs now in operation in the Allegheny and Monongahela River basin had been in operation in

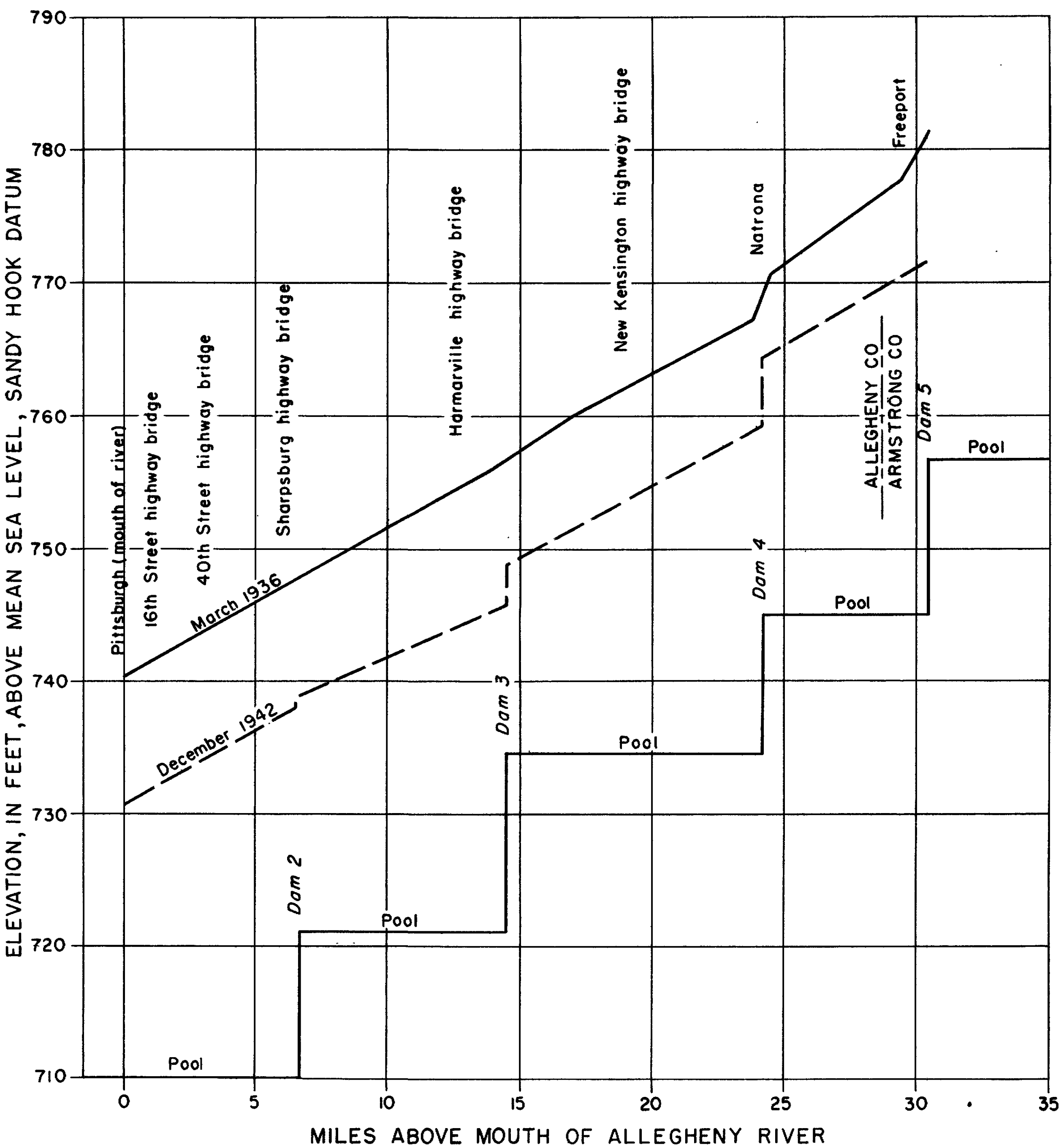

Figure 25.—Water-surface profiles of Allegheny River for floods of March 1936 and December 1942.

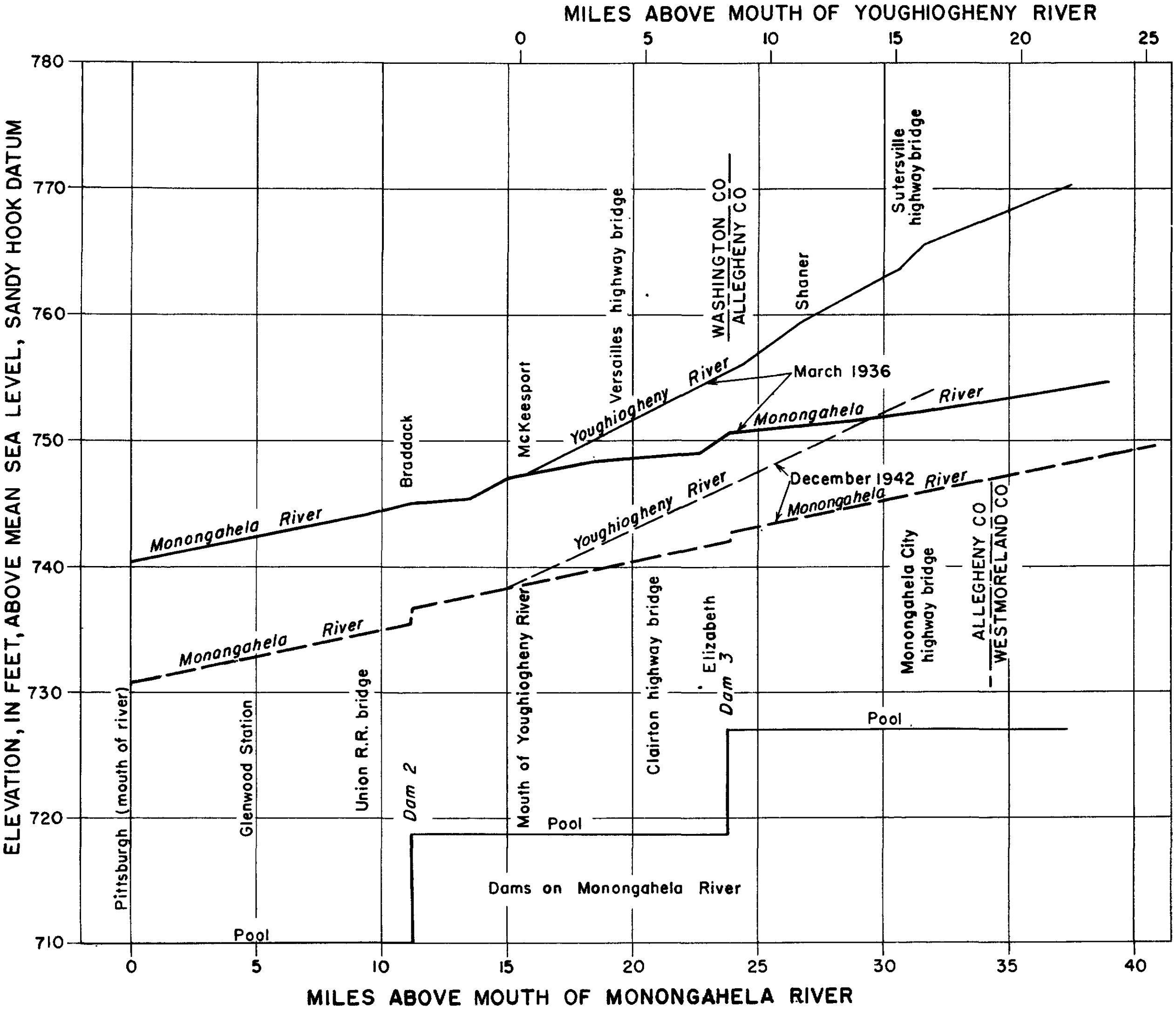

Figure 26.—Water-surface profiles of Monongahela and Youghiogheny Rivers for floods of March 1936 and December 1942.

March 1936, the flood crest at Pittsburgh would have been reduced by 10.1 feet.

A further means of reducing flood damage at Pittsburgh is the flood warning system of the Federal-State flood forecasting service as carried out by the U. S. Weather Bureau. Any rise of the river is closely watched. Probable crest stages are forecast whenever the river at Pittsburgh is expected to go out of "pool stage." Flood stage is considered to be 25 feet but the flood damage below 30 feet is not serious if ample warning is provided. Flood forecasting permits the reduction of damage by initiating measures to safeguard or remove property about to be flooded.

While the primary purpose of the Corps of Engineers in constructing the reservoirs was for flood control, the reservoirs also serve other useful purposes. Tygart, Youghiogheny, and East Branch Clarion River reservoirs, in periods of low flow, provide water for pollution

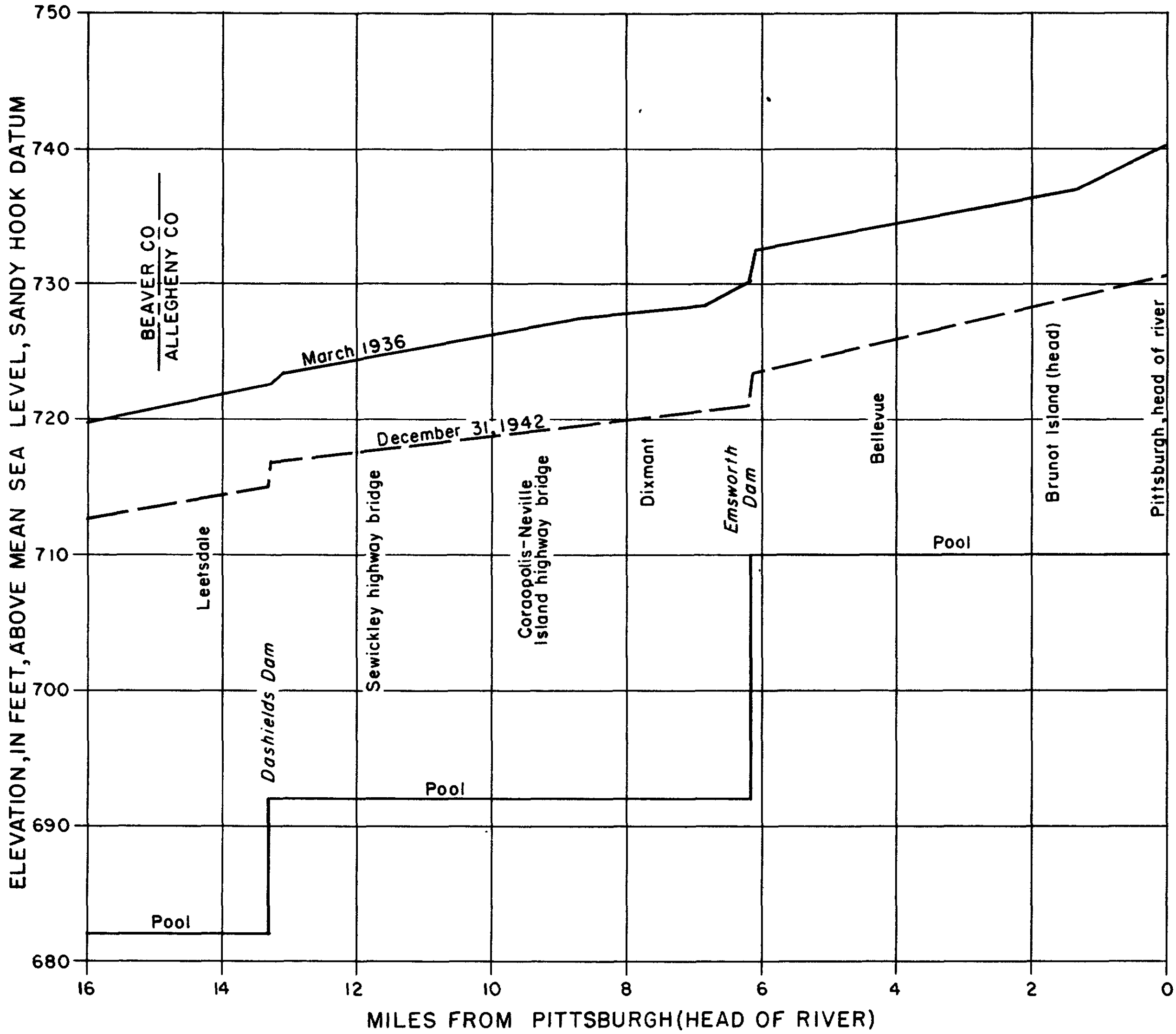

Figure 27.—Water-surface profiles of Ohio River for floods of March 1936 and December 1942.

abatement and navigation. The reservoirs on Turtle Creek, French Creek, and the Allegheny River will also serve these purposes.

Dead storage has been provided in all reservoirs to create permanent lakes, and the Corps of Engineers is encouraging the use of these for recreation. Except for Loyalhanna Creek and Conemaugh River reservoirs, which impound some acid mine drainage, all reservoir areas are becoming increasingly popular for recreation.

Navigation

Water transportation has been an important factor in the growth and prosperity of Pittsburgh since the time of its settlement. For many years the rivers, in their natural conditions, afforded the only avenues of trade. During high and medium stages, flatboats and rafts were floated down the Allegheny and Monongahela Rivers and on into the Ohio River. The first steamboat on western waters was built in Pittsburgh in 1811 and shortly thereafter steamboats were in general use throughout the area. Because of rocks and shoals, navigation during low water was always hazardous and at times impossible.

The early settlers recognized the need for major improvements to the river systems of the area to aid navigation. The depth available for navigation over the shoals in the Ohio River at extreme low water ranged from a minimum of 1 foot between Pittsburgh and Cincinnati to 2 feet between Cincinnati and the mouth of the river.

The first river improvement by the Federal Government was the dredging of several shoals in the Ohio

River in 1827. However, it was not until 1875 that work was begun to provide 6-foot slack-water depth by means of locks and movable dams. Since that time improvements to navigation on the Ohio, Monongahela, and Allegheny Rivers have moved slowly but continuously. These rivers are now a part of the improved inland-waterways system of the Mississippi River basin. Eight dams and locks provide slack-water navigation on the Allegheny River from its mouth at Pittsburgh to a point 72 miles upstream. The controlling depth is 9 feet. A system of 12 dams and locks provide slack-water navigation on the lower 129 miles of the Monongahela River. The controlling depth from Pittsburgh to mile 100.3 is 9 feet; from mile 100.3 to mile 100.9 it is 8 feet; above this point, 7 feet. The Youghiogheny River has not been improved by the Federal Government.

Based on tonnage handled, Pittsburgh is the most important river port in the United States. The total tonnage handled in 1950 in the Corps of Engineers' Pittsburgh district, by rivers, follows:

Allegheny River	3,593,713
Monongahela River	28,509,901
Ohio River	25,002,293

When commodities move from one river into another the tonnage is counted more than once. The total 1950 commerce on the three rivers in the Corps of Engineers' Pittsburgh district, with duplications eliminated, was as follows:

Commodity	Tonnage
Coal	27,325,029
Coke	366,270
Sand and gravel	4,770,581
Iron and steel	2,718,061
Oil and gasoline	2,919,204
Other commodities	1,089,047
Total	39,188,192

Interruptions to local navigation by ice and high water are summarized as follows:

River	Years of record	Average number of days per year traffic was suspended for--	
		Ice	High water
Allegheny	1927-1947	30.0	4.3
Monongahela to Morgantown, W. Va.	1916-1947	4.1	3.7
Ohio to Pennsylvania-Ohio State line	1933-1946	4.4	1.8

GROUND WATER

Summary of Geology

Rocks of Pennsylvanian, Permian, and Quaternary ages are exposed in the Pittsburgh area. (See table 6.) The consolidated rocks belong to the Allegheny, Conemaugh, and Monongahela formations of the Pennsylvanian system, and to the Washington formation of the Permian system. These consist mostly of shale and sandstone interbedded with thin layers of limestone, fireclay, and coal. Most of the deposits are of freshwater origin, but occasional thin limestone beds carry marine fossils which indicate that there were temporary encroachments of sea water. The best known bedrock deposit is the Pittsburgh coal, which is persistent throughout the southern part of Allegheny County and which extends southward into West Virginia and westward into Ohio. The coal has an average thickness of about 6 feet.

The consolidated rocks in this area have a slight regional dip toward the southwest and the land surface slopes in the same direction but to a lesser degree, therefore, progressively younger rocks are exposed toward the southwest. In places the regional dip is modified by parallel folds. At least six folds of this type cross the area, trending toward the northeast. In the areas underlain by folded rocks, the slope of the strata may range from almost horizontal to 200 feet per mile, and the general sequence of beds at the outcrop—from older to younger southwestward—may be locally reversed.

Unconsolidated deposits of Quaternary age overlie the bedrock in the larger valleys in the Pittsburgh area. The distribution of these deposits is shown on plate 1. They consist of glacial outwash and alluvium of Pleistocene age and alluvium of Recent age. The recent alluvium constitutes the surficial flood-plain deposits of the valleys. It is composed of clay, silt, and fine-grained sand. Older, coarse-grained deposits of Pleistocene age underlie the Recent alluvium. Pleistocene sediments occur also at higher elevations as terrace deposits along the valley walls. The Allegheny River system, which discharged debris-laden glacial melt waters southward from the ice front, commonly deposited coarse-grained outwash—sand and gravel—derived from crystalline rocks in remote areas. The northward-flowing Monongahela River and its tributaries, which did not carry melt water, deposited generally finer-grained sediments—clay, silt, and fine sand—derived from local sources. The channel fill of Pleistocene age in the Ohio River valley is a mixture of the materials carried by its tributaries. It is considerably coarser grained than the channel fill of the Monongahela River valley, but contains somewhat more clay and silt than the Allegheny River fill.

The contact between deposits of Pleistocene age and those of Recent age is in most places obscure, and is especially so in the Monongahela River valley where there is little or no difference in the texture of the materials. In the Allegheny and Ohio River valleys the

Table 6.—Geologic units and their water-bearing properties in the Pittsburgh area.

Era	System	Series	Formation	Thickness (feet)	Description	Water-bearing characteristics
Cenozoic	Quaternary	Recent	Alluvium	0–25	Locally derived clay, silt, and fine-grained sand; may include small amount of reworked Pleistocene gravel.	Not consistently water-bearing. Frequently lies above saturated zone; where saturated, yields small supplies but strata commonly too fine grained to be source of large supplies.
Cenozoic	Quaternary	Pleistocene	Alluvium	0–100?	Valley-fill deposits in the Monongahela drainage basin and in other tributaries to the Ohio and Allegheny Rivers. Consists of locally derived clay, silt, and sand and occasional lenses of gravel.	Fine-grained deposits yield small supplies; gravel lenses yield as much as 300 gpm in the Monongahela River valley. Water is hard and moderately mineralized; may contain high concentration of iron.
Cenozoic	Quaternary	Pleistocene	Glacial outwash	0–100?	Valley-fill deposits in the valleys of the Ohio and Allegheny Rivers. Outwash was deposited contemporaneously with Pleistocene alluvium but was derived from crystalline rocks in remote areas. Consists chiefly of gravel and sand with some silt and clay.	Source of practically all large ground-water supplies in the Pittsburgh area. Yields range from about five to several thousand gallons per minute. Water is hard and moderately mineralized; may contain high concentration of iron.
Paleozoic	Permian		Washington	1/150	Alternating beds of shale and sandstone with several thin, discontinuous beds of limestone and coal.	Yields no water to wells; in Allegheny County it lies above saturated zone.
Paleozoic	Pennsylvanian	upper Pennsylvanian	Monongahela	300–400	Massive and thin-bedded limestone interbedded with discontinuous sandstone, shale, and coal. Contains five beds of coal, including the Pittsburgh coal which marks the base of the formation.	Not a reliable source of water. Limestones may yield as much as 25 gpm near their outcrop, but are generally not water-bearing beneath deep cover. Sandstones yield small supplies where they have not been drained as a result of mining activity. Water from shallow depths is hard and moderately mineralized. Hardness decreases but mineral content of water increases with depth.
Paleozoic	Pennsylvanian	upper Pennsylvanian	Conemaugh	600–700	Includes five massive and fairly persistent sandstone beds separated by discontinuous beds of red and gray shale and thin-bedded sandstone, limestone, and coal.	Massive sandstone members yield as much as 100 gpm and are the most reliable bedrock aquifers in the area. Of these, the Morgantown, Saltsburg, and Mahoning sandstones are the best. Water is hard and moderately mineralized. Hardness decreases and mineral content of water increases with depth; brines yielded at depths greater than about 100 feet below drainage level. Shales, limestones, and thin-bedded sandstones yield small supplies near their outcrops; water generally is highly mineralized regardless of depth of well.

Table 6.—Geologic units and their water-bearing properties in the Pittsburgh area—Continued

Era	System	Series	Formation	Thickness (feet)	Description	Water-bearing characteristics
			Allegheny	250–370	Green and gray shale with thin discontinuous beds of sandstone and limestone. Contains several economically important coal beds.	Uppermost sandstone beds yield small supplies in the northeastern part of the county. In the rest of the area the beds lie at too great depth to be a source of fresh water.

1/Upper part of formation not present in this area.

glacial outwash deposits of Pleistocene age are generally coarser grained than the Recent alluvium, but the materials grade into each other and the contact is not distinct. The total thickness of the valley fill ranges from a feather edge at the valley walls to 100 feet or more in the deeper parts of the buried channel. The average thickness is probably 60 feet, of which perhaps the uppermost 10 feet is Recent alluvium.

Figures 28, 29, and 30 are sections indicating the character of the valley-fill deposits and the bedrock configuration at selected places in the river valleys. The locations of the sections are shown on plate 1. The thickness of the unconsolidated sediments underlying the Triangle area is indicated as the difference in elevation between the surface and bedrock contours on figure 31.

Hydrology

Principles of Ground-Water Occurrence

The flow of springs and the water obtained from wells is supplied by ground water. Ground water is defined as that part of the water under the surface of the earth that is in the zone of saturation, the upper surface of which is called the water table. Below the water table all the connected pores, crevices, and cavities in the rock are saturated with water. The number, size, and shape of the rock pores or cavities, and the degree of interconnection between them, determine the effectiveness of any saturated rock unit as a source of water. A rock stratum that yields sufficient water to make it a usable source of supply is called an aquifer or water-bearing formation. If the ground water is not confined, it is said to occur under water-table conditions, and the water level in a well marks the top of the saturated zone, or water table. When confined under pressure between relatively impermeable strata, ground water is said to occur under artesian conditions, and the water level in a well is above the saturation zone. The imaginary surface to which the water will rise is called the piezometric surface.

As a part of the earth's natural drainage system, ground water moves by gravity from intake areas toward lower levels, and ultimately to points of discharge. Unlike flow on the surface, where water moves freely in open channels, ground-water flow is through openings in the rocks. Because these openings are generally small, they offer considerable resistance to the flow of water. Consequently, the natural rate of ground-water movement is slight compared to that of surface water, and is commonly measured in terms of feet or fractions of a foot per day, or even per year.

The source of practically all ground water is precipitation. Ground water may be derived from either local precipitation or from streams whose channels have been cut into water-bearing beds. In the Pittsburgh area both conditions occur. In general, ground-water supplies in the bedrock formations of the upland areas are replenished entirely by precipitation which falls in those areas. Under natural conditions, local precipitation would probably be the principal source of water in the valley-fill deposits, but since the time wells first tapped the valley deposits a part of the recharge has been furnished by infiltration of water from the rivers nearby or by diversion of water that otherwise would have flowed into the rivers.

Ground water is obtained for use through wells and springs. Springs are natural outlets of ground-water discharge. In Allegheny County many springs issue from bedrock outcrops along the valley walls. They were used in the early days of settlement but have long since been replaced by wells as the principal suppliers of ground water.

Wells intercept ground water as it moves through the rocks toward points of natural discharge. The long-term yield of a well is determined by the water-bearing capacity of the aquifer, the amount of water in storage, the rate of replenishment of water to the aquifer, and the size and condition of the well. A properly designed well obtains its supply either by diverting water from natural discharge or by inducing infiltration of water from a surface source, such as a lake or stream.

The largest yields from wells in Allegheny County are generally obtained from those that are supplied by river infiltration. These wells tap aquifers that are freely connected to a surface source. Infiltration is induced when pumping is sufficient to lower the water table below the level of the adjacent body of surface water and create a gradient from the surface-water body to the well. In the Pittsburgh area, supplies obtained by infiltration from river channels constitute much of the present ground-water use, and the expansion of future supplies will depend largely upon this source.

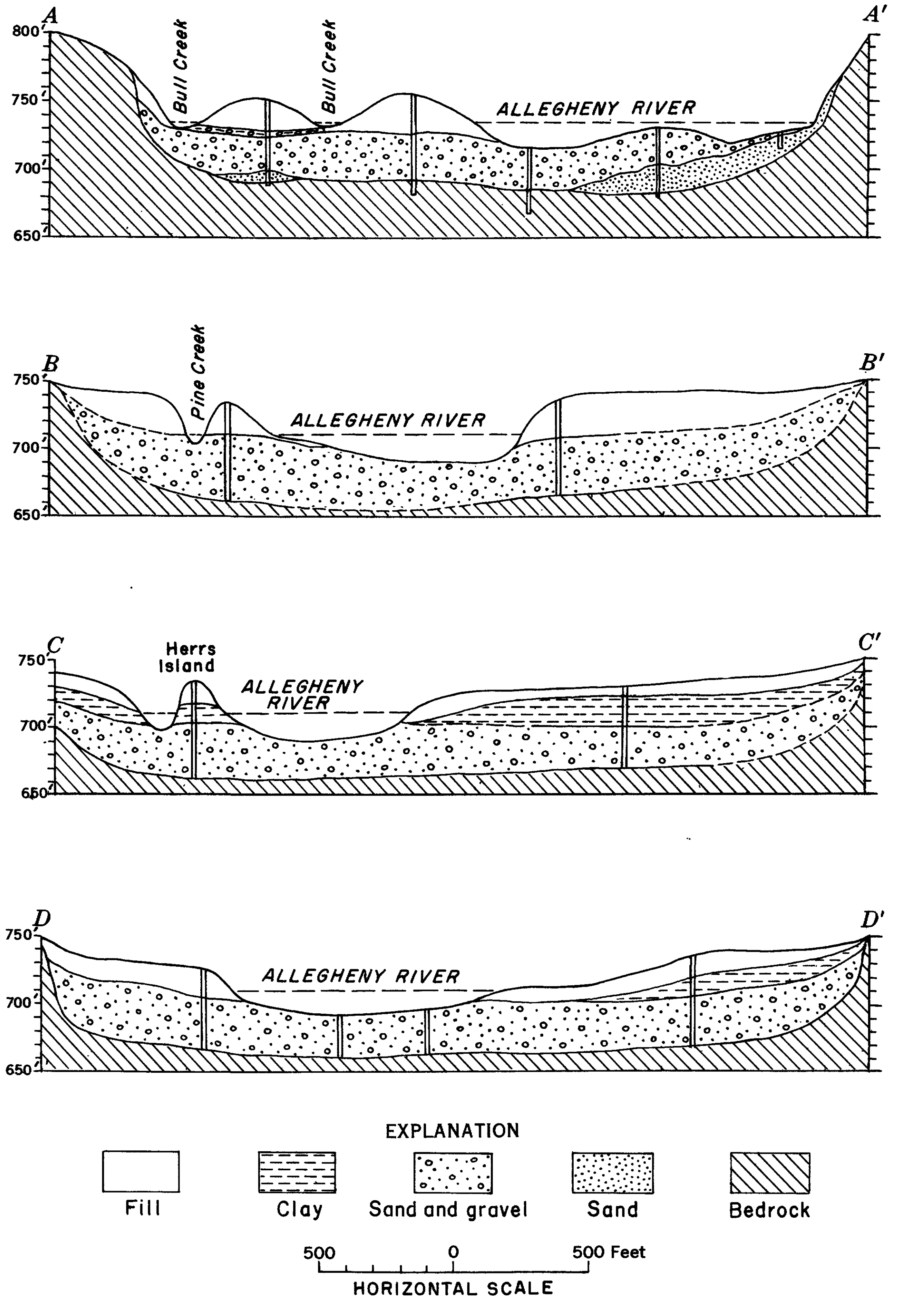

Figure 28.—Geologic sections showing the character of the valley-fill deposits in the Allegheny River valley.

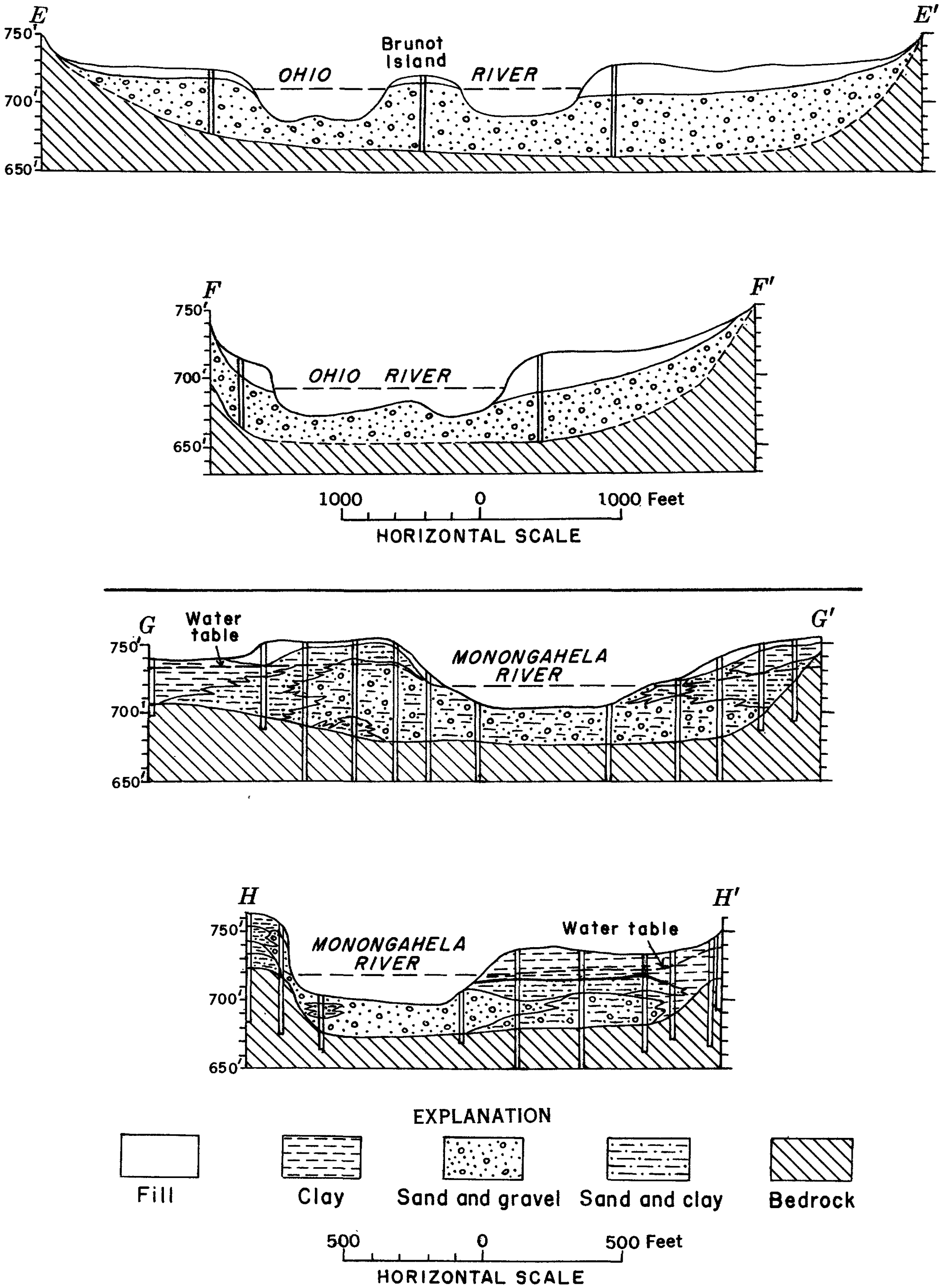

Figure 29.—Geologic sections showing the character of the valley-fill deposits in the Ohio and Monongahela River valleys.

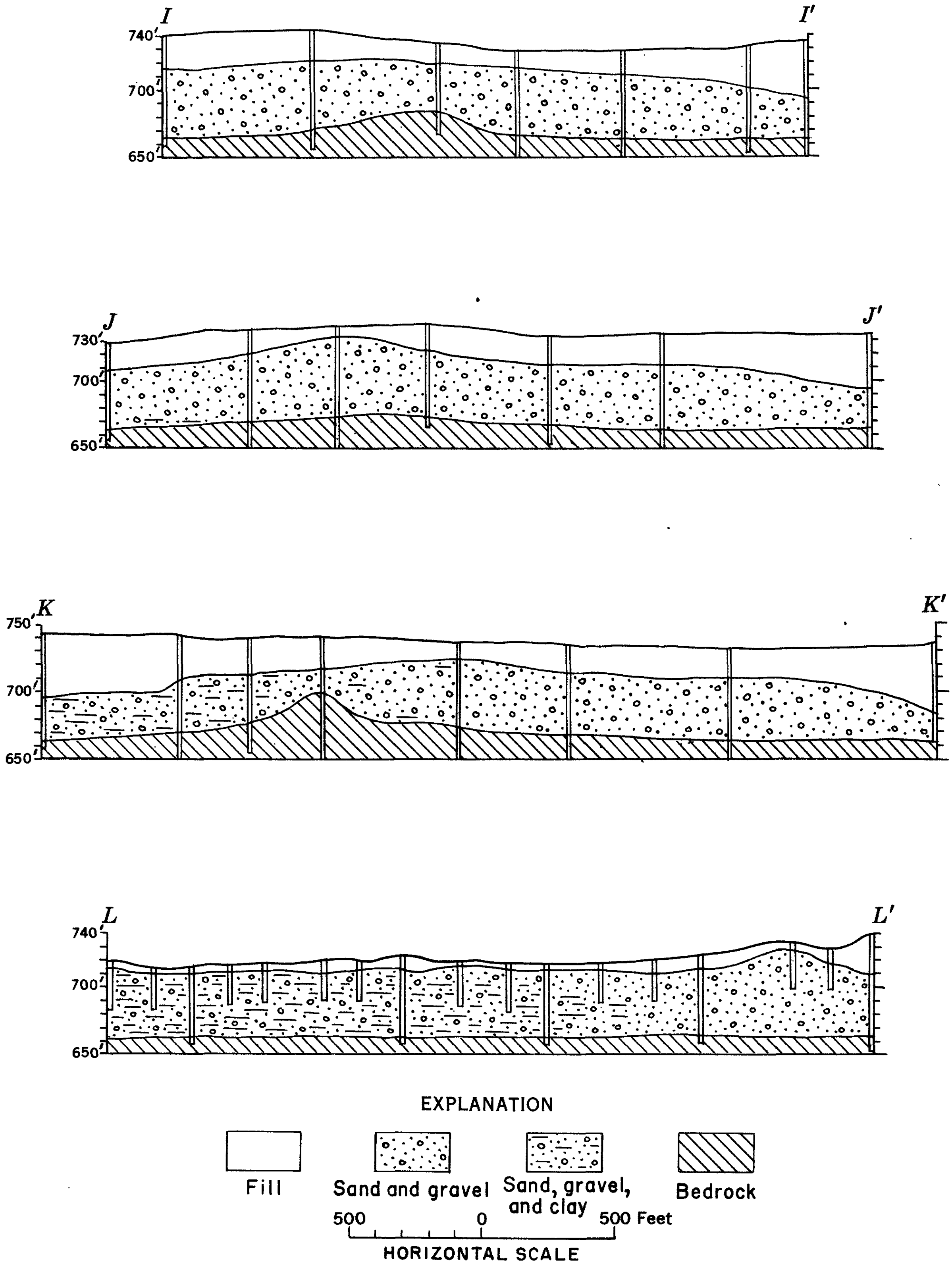

Figure 30.—Geologic sections showing the character of the valley-fill deposits in the Triangle area.

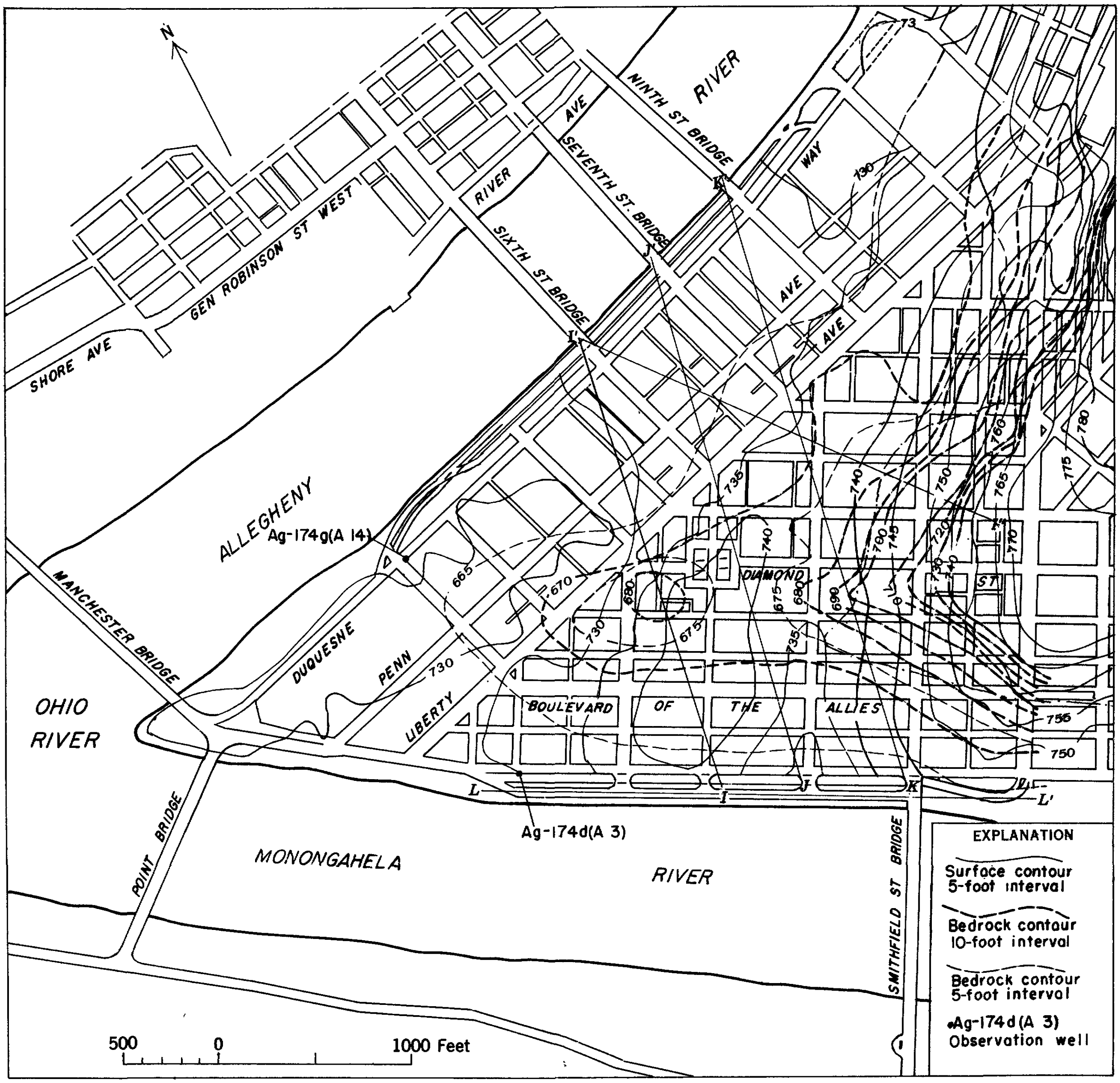

Figure 31.—Map of the Triangle area showing contours on the land and bedrock surfaces.

Sources of Ground Water

Bedrock.--In Allegheny County no large supplies of ground water are obtained from the consolidated rocks (bedrock). Wells tapping aquifers at depths greater than about 100 feet below the valley flood plains commonly yield salty water. In the past, the brines were used for the commercial production of salt, but their only current use in the county is for generating zeolite softener units of the West View Municipal Water Authority and the Coraopolis Borough Water Plant. Wells tapping shallower bedrock aquifers generally yield fresh water. In the upland areas bedrock aquifers are the chief sources of domestic supply. Yields of wells tapping bedrock range from less than 5 to about 100 gpm, the average being about 20 gpm.

All bedrock formations exposed in Allegheny County yield ground water to wells, but the importance of the individual formations as sources of fresh water varies greatly. The oldest and least permeable water-bearing rocks occur in the Allegheny formation of Pennsylvanian age. The upper beds of the Allegheny formation crop out in the deeper valleys in the northeasternmost part of the county. Because the regional dip is toward the southwest they are found at progressively greater depths in that direction, and throughout most of the county they occur at too great a depth to be sources of fresh water. In the outcrop area a few wells tap the Allegheny formation but yields are small and in some localities the water is highly mineralized.

The most important bedrock source of ground water is the Conemaugh formation of Pennsylvanian age. One or more of five sandstone members are found at any given place in the county. They are extensive beds and, where conditions are favorable, are dependable sources of moderate supplies of fresh water. Of these aquifers the best are the Mahoning, the Saltsburg, and the Morgantown sandstone members. The Mahoning sandstone member is at the base of the Conemaugh formation and owing to its regional dip to the southwest it is penetrated by wells only in the northern half of the county. The maximum yield reported for bedrock wells in the county is 100 gpm, obtained from a well tapping the Mahoning sandstone member. However, the average yield of wells tapping this source is about 25 gpm. Less is known of the ground-water characteristics of the Saltsburg member, but it also appears to be most favorable for development of ground-water supplies in the northern half of the county. Yields of as much as 40 gpm are reported and larger supplies can probably be obtained. The Morgantown sandstone member, which occurs in the upper part of the formation, lies about 350 feet above the top of the Mahoning member. It underlies almost all of the county and is the most widely used source of ground water in bedrock. Wells tapping the Morgantown member yield as much as 75 gpm, and the average yield is more than 30 gpm. Scattered wells tap the other sandstone members of the Conemaugh formation but yields are generally low. In most of the county either the Mahoning or Morgantown members are the most accessible and productive bedrock sources.

The Monongahela formation is of little importance as a source of water in Allegheny County, although a few wells in the southern part tap limestone beds in the upper part of the formation. The yields are very small and the supplies are not dependable.

Unconsolidated deposits. —The principal sources of ground water in the Pittsburgh area are the unconsolidated deposits of Pleistocene age. Most large industrial ground-water supplies and almost all ground-water withdrawals for municipal and air-conditioning uses are obtained from the coarse-grained deposits of Pleistocene age which comprise the basal part of the valley fill.

Although the valley-fill deposits along the principal streams average less than a mile in width and only about 60 feet in thickness, they are generally highly permeable. The effectiveness of recharge from the streams nearby largely compensates for the comparatively small storage capacity of the aquifers. The quantity of ground water stored during high water levels in the aquifer underlying the Triangle area of Pittsburgh is equivalent only to about 50 to 80 days of pumping at summer rates of withdrawal. However, recharge, derived mainly from the Allegheny River, effectively restores the summer overdraft, so that water levels usually recover completely by the beginning of the following summer.

The most productive deposits are the beds of outwash sand and gravel in the Allegheny and Ohio River valleys. These sediments were carried southward into the area by glacial melt waters. They are coarser grained and are consequently more permeable than the alluvial fill of the same age in the Monongahela River valley, which was derived largely from the fine-grained rocks of Pennsylvanian age that underlie the area. Yields of wells tapping the valley fill of the Allegheny and Ohio River valleys range from a few gallons per minute to more than 3,000 gpm. A dug well near the Allegheny River at the Colfax station of the Duquesne Light Co. yields more than any other well in Pennsylvania. It is pumped continuously at an average rate of slightly more than 3,000 gpm, but its estimated capacity is more than 9,000 gpm. In general, the best wells tapping the outwash valley fill are in the Allegheny River valley above Pittsburgh. In that part of the area, 85 representative wells have an average specific capacity of 83 gpm per foot of drawdown. Along the Ohio River 80 representative wells have an average specific capacity of 52 gpm per foot of drawdown. The smaller yield of the wells tapping valley-fill deposits in the Ohio River valley is probably the result of mixing of the glacial outwash with finer materials derived chiefly from the drainage area of the Monongahela River.

The alluvial fill in the valleys of the Monongahela River and its principal tributaries, the Youghiogheny River and Turtle Creek, and of a tributary to the Ohio River, Chartiers Creek, constitutes the second most important source of ground water in the county. The most productive wells probably tap lenses of coarse sand and gravel within finer grained alluvium. Seven large wells in the Monongahela River valley, all owned by the Duquesne Water Co., yield 200 to 250 gpm each. Where the sediments penetrated are predominantly clay and silt, wells yield considerably less. Data upon which to base reliable appraisals are not available, but the average specific capacity of wells in the Monongahela River valley for which records have been obtained is about 15 gpm per foot of drawdown.

Average yields from wells tapping each of the aquifers, as given in the preceding discussion, probably are less than the average maximum yield that could be expected with present-day well-construction methods. Many of the wells included in the compilation were made before the development of modern well-construction techniques, and therefore are not so effective as modern wells. Also, many of the wells are used for standby or intermittent service and therefore are not properly maintained—that is, periodically cleaned and redeveloped. If only modern, properly maintained wells were considered, the average yields computed for wells in the three major river valleys would be appreciably greater.

Water-Level Fluctuations

Ground-water levels rise and fall with changes in the amount of water stored in the subsurface reservoirs. These fluctuations may reflect both natural and manmade changes in the rates of discharge and replenishment. Under natural conditions, the greatest fluctuations occur in response to seasonal variations in evaporation, transpiration, precipitation, and river level. In Allegheny County, ground-water levels are commonly highest in late winter or early spring, following the period of minimum loss of water by evapotranspiration and use for air-conditioning and other cooling purposes. Ground-water levels are lowest in

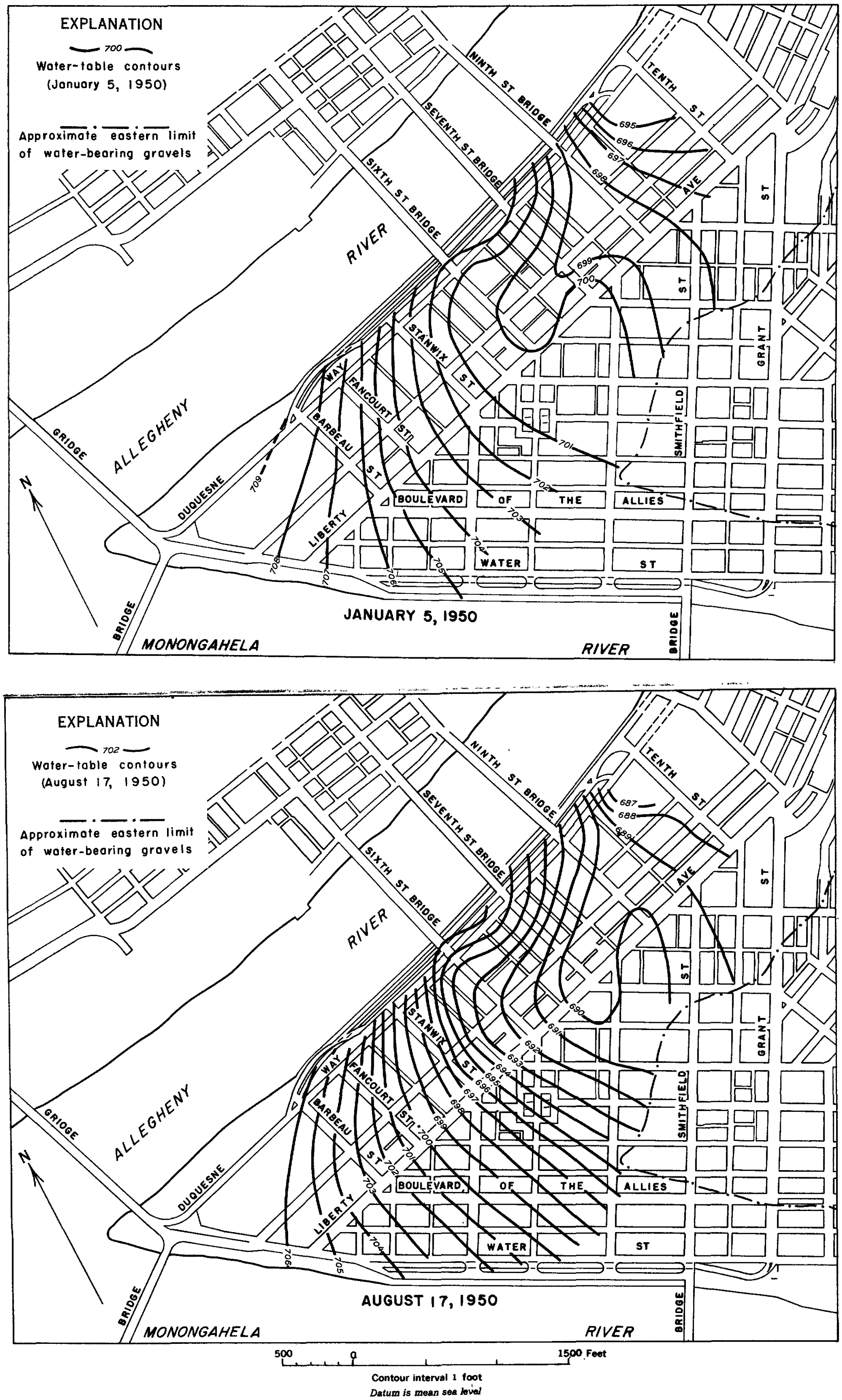

Figure 32.—Map showing contours on the water table in the Triangle area, January 5 and August 17, 1950.

the late summer or early fall at the end of the growing season and the period of maximum use of ground water for cooling.

The water-level fluctuations in the bedrock aquifers that supply the upland areas are most affected by evapotranspiration. Other factors vary only slightly; precipitation is fairly evenly distributed throughout the year and withdrawals by man, chiefly for domestic and stock use, do not change appreciably from season to season.

The shape of the water table in the bedrock aquifers is a subdued replica of the surface topography. In a hilly and humid area such as Allegheny County, the stream valleys are generally cut below the level of the water table in the adjacent upland. Consequently, the ground water drains from the highlands towards the valleys and may be discharged from springs and seeps along the valley walls and in the stream beds. The effect, if precipitation were to cease, would be to depress the upland water table to the level of the surface drainage. However, this is never entirely accomplished because of the relatively slow rate of ground-water movement and the frequent recharge from precipitation. Therefore, the general features of the surface relief are reflected in the configuration of the water table, but irregularities are not so pronounced.

Fluctuations of water level in wells tapping the valley fill are chiefly the effects of pumping and of infiltration from the adjacent rivers. Changes in storage as a result of precipitation and evapotranspiration are slight during all seasons of the year because most of the flood plains are covered with manmade structures.

In the appraisal of the ground-water resources of the Pittsburgh area, the important factors are those affecting ground-water levels in the valley-fill deposits, because from these deposits more than 95 percent of all ground water used in the area is obtained.

Ground-water levels in aquifers hydraulically connected with streams rise and fall with changes in river level. Under natural conditions, the water table slopes toward the river during most of the year, but during high stages of the river the slope near the river is reversed, and surface water recharges the adjacent aquifers causing ground-water levels to rise. The net effect of the river is to offset, in some degree, the effect of pumping from wells. Large withdrawals may cause the ground-water level to decline below river level, but the loss in ground-water storage is soon met, at least in part, by induced recharge from the river.

When heavy pumping from wells is continued indefinitely, the ground-water level in the area is permanently lowered and river infiltration occurs the year round. This condition exists in at least two areas in Allegheny County, in the Triangle area in downtown Pittsburgh, and at the upstream end of Neville Island in the Ohio River. At Neville Island large withdrawals are made by the Pittsburgh Coke & Chemical Co., and by the West View Municipal Authority. West View has increased withdrawals in recent years and is planning additional wells on Davis Island nearby.

In the Triangle area, the greatest withdrawals are made during the summer when the use of ground water for air conditioning is at a maximum. Many years of pumping have created a perennial depression in the water table. (See fig. 32.) Ground-water levels in nonpumping observation wells fluctuate as much as 10 or 12 feet, often to within 10 or 15 feet of the bottom of the aquifer. The contour maps and hydrographs do not show the maximum drawdown, because all water-level data used in their preparation were obtained from measurements in nonpumping wells. The water levels in pumped wells are always several feet below those shown on the maps, and during the period of peak withdrawal are probably within 5 or 6 feet of bedrock in several places.

The geology and hydrology of the Triangle area are shown in part by section I'—I'' in figure 33. The section crosses the center of the area as shown on figure 31. The elevations of the original land surface, the water table, and the river surface are approximations, but they serve to indicate some of the manmade effects on the hydrology of the area. Recharge from the Allegheny River and movement from water-bearing beds

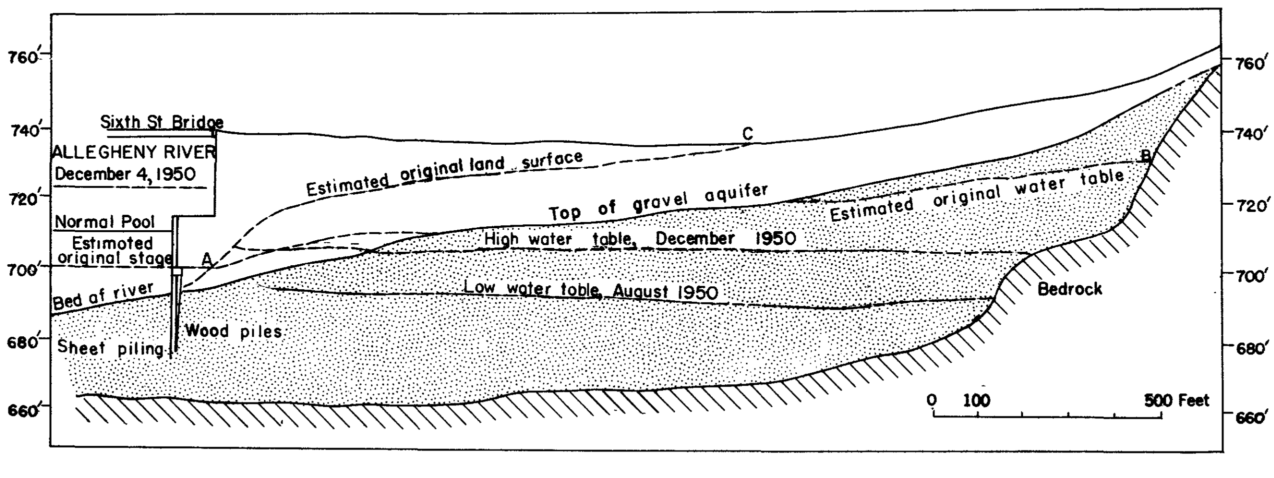

Figure 33. —Generalized geologic section in the Triangle area showing changes in water-table conditions.

beneath and on the other side of the river have been greatly reduced by a sheet-pile cutoff wall installed to a depth 33 feet below normal river level and extending for 3,750 feet along the Triangle waterfront. If the conditions indicated in figure 33 are representative, the original storage in the aquifer has been reduced by about one-third, and during the air-conditioning season is reduced by one-half. As a consequence, the original slope of the water-table has been reversed and recharge is now being induced from the river.

Hydrographs of water levels in five wells in the Triangle area, river level, and precipitation are shown in plate 2. The graphs show clearly the relation between river stage and ground-water levels. For each significant rise in river level there is a corresponding rise in ground-water levels. Local precipitation has little direct affect on ground-water levels or on river stage (pl. 2) because the locks and dams control the river stage at low flows within fairly narrow limits.

Despite the concentrated withdrawals of ground water from the aquifers of the valley fill, there has been no regional lowering of ground-water levels in the Pittsburgh area; and only at the upstream end of Neville Island and in the Triangle area have water levels approached the lowest practicable limits.

Quality of Ground Water

Chemical character.—Standards of chemical quality differ according to the use of the water. In general, however, the constituents most likely to be present in objectionable quantities in ground water are ions of calcium, magnesium, iron, manganese, bicarbonate, carbonate, sulfate, and chloride, together with dissolved carbon dioxide gas. Calcium and magnesium account for most of the hardness in ground water—"temporary" hardness when combined with the bicarbonate (HCO_3) radical, and "permanent" hardness when combined with sulfate (SO_4) or chloride (Cl). Water containing large amounts of magnesium and chloride is likely to be corrosive. Iron and manganese in water cause stains on fixtures and textiles if their combined concentration is greater than about 0.3 ppm.

Ground water in the Pittsburgh area cannot be characterized by any typical chemical analysis, nor can an individual sample, by its chemical character, be identified with a particular aquifer. However, along the major river valleys there appears to be a general relationship between the chemical quality of a water, the permeability of the saturated materials in which it occurs, and the character of the river water that may contribute recharge. Table 7 shows the range in concentration and the average concentration of the common constituents in the ground water from valley-fill deposits in the Pittsburgh area. The average chemical concentration of both surface and ground water is lowest in the Allegheny River valley, intermediate in the Ohio River valley, and highest in the Monongahela River valley. The permeability of the water-bearing deposits is highest in the Allegheny River valley and lowest in the Monongahela River valley, thus providing the most favorable recharge conditions in the area of better quality of river recharge.

Greater concentrations of iron and manganese than are shown in table 7 have been noted in some wells that penetrate old slag dumps along the valleys. If care is taken in selecting the site of a well, the total concentration of iron and manganese in the ground water will probably be less than 1 ppm.

The chemical quality of the ground water in the valley-fill deposits is modified in varying degree by the quality of the surface water, from which, under existing conditions of large withdrawals of ground water, much

Table 7.—Concentration of the common chemical constituents of ground water in valley-fill deposits

[Analyses in parts per million]

	Monongahela River valley				Ohio River valley				Allegheny River valley			
	Number of samples	Max.	Min.	Avg.	Number of samples	Max.	Min.	Avg.	Number of samples	Max.	Min.	Avg.
Silica (SiO_2)	0	....	....	....	16	15.6	6	10.5	11	22	2.7	8.8
Iron (Fe)	8	5.4	0.1	2.1	37	8.1	0	.9	24	2.2	0	.4
Manganese (Mn)	5	1.6	.1	.6	19	3.4	0	.9	16	2.3	0	.8
Calcium (Ca)	4	306	105	224	27	175	24	81	14	265	34	87
Magnesium (Mg)	4	105	42	67	30	70	2	18	14	32.7	6	14
Sulfate (SO_4)	8	840	119	354	29	325	25	114	17	219	15	94
Chloride (Cl)	11	64	8	29	38	140	14	37	22	119	3.5	34
Dissolved solids 1/	5	614	302	462	18	567	260	424	20	535	210	332
Total hardness as $CaCO_3$	12	990	120	416	30	528	93	246	19	358	111	176
Alkalinity as $CaCO_3$	6	260	42	161	29	294	60	155	21	265	44	109
Hydrogen-ion concentration (pH)	12	7.5	5.4	7.0	39	7.6	6.1	7.2	24	8.1	5.8	7.2

1/ Dissolved solids data are not available for many of the more concentrated waters for which mineral constituents are shown.

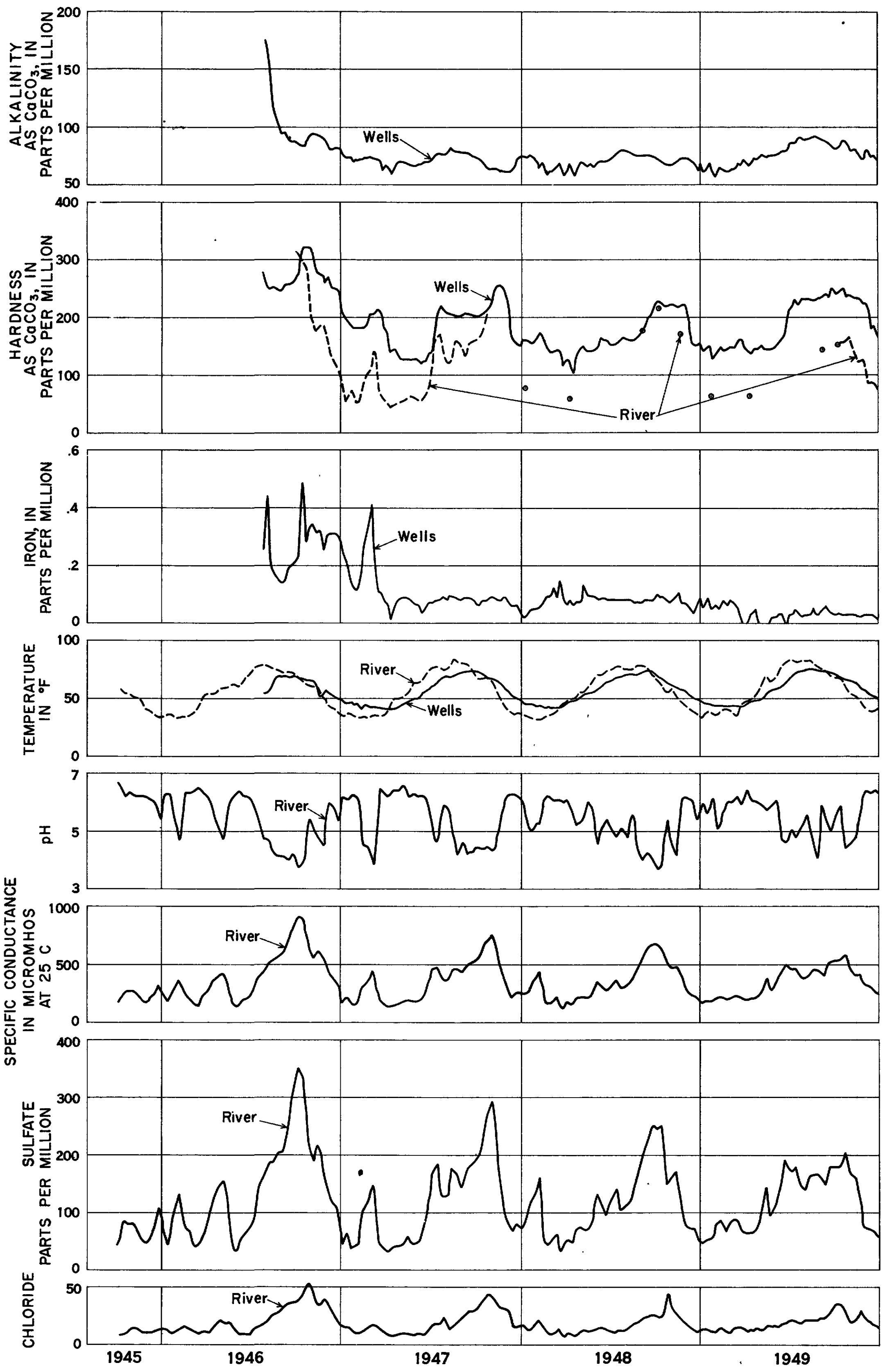

Figure 34.—Some chemical and physical characteristics of water at Ambridge from the Ohio River and from wells.

of the ground-water recharge is obtained. Most of the wells in the valleys are so close to a river that some part of their yield has been derived from the river by infiltration. The influence of river infiltration on the quality of the ground water at Ambridge is indicated in figure 34, which shows some chemical and physical characteristics of the Ohio River water and the ground water from municipal wells. The alkalinity and iron content of ground water declined markedly soon after the wells were put in use. A change of source from ground water in storage to river infiltration was definitely indicated. The hardness of the ground water also declined slightly and since then has fluctuated according to the concentrations of mineral constituents in the river water, as typified by figure 34.

Not all the effects of induced infiltration are beneficial to the ground-water supply. Recharge from the river may carry waste phenolic compounds, which when present in water supplies, even in minute quantities, impart an objectionable taste and odor. Studies made by the Pennsylvania State Board of Health indicate that when the concentration of phenols in the Ohio River exceed 0.02 ppm, ground-water supplies recharged by infiltration are contaminated. One or two days after the phenols appear in the river water, the water from wells nearby has the characteristic phenolic medicinal taste and odor, which, though it lasts for only a short period, is extremely disagreeable when it occurs in the potable supply.

A comparison of the chemical characteristics of surface water, and water from wells nearby, is given in figure 35. The closest similarity between the quality of ground water and surface water is in the Ohio River valley at Neville Island, where infiltration supplies have reached their greatest development in this area. At Duquesne, in the Monongahela River valley, surface water and ground water differ greatly in chemical character, probably because infiltration is not very effective through the relatively impermeable alluvial fill.

Little is known of the chemical quality of the water in the bedrock aquifers. Studies made in the Pittsburgh area by Piper (1933) show no well-defined relation between water quality and geologic source. In general, Piper found that the concentration of dissolved solids in the ground water increased with depth. Wells tapping bedrock yield fresh water from depths to about 100 feet below the beds of the principal streams. Below that depth, the rocks are generally filled with salty water.

Temperature.--In general, the temperature of ground water fluctuates only slightly during the year. The temperature of water from wells between 30 and 100 feet in depth is approximately equal to the mean annual temperature of the air of the region. In the Pittsburgh area, the ground-water temperature is about 53 F, except where influenced by artificial factors or recharge from streams.

The effect of river water infiltration on the temperature of ground water at Ambridge is shown by the temperature graphs in figure 34. The temperature of ground water from the municipal wells fluctuates through an annual range of 35 F, from 40 to 75 F. The cycle of temperature fluctuation of the ground water is

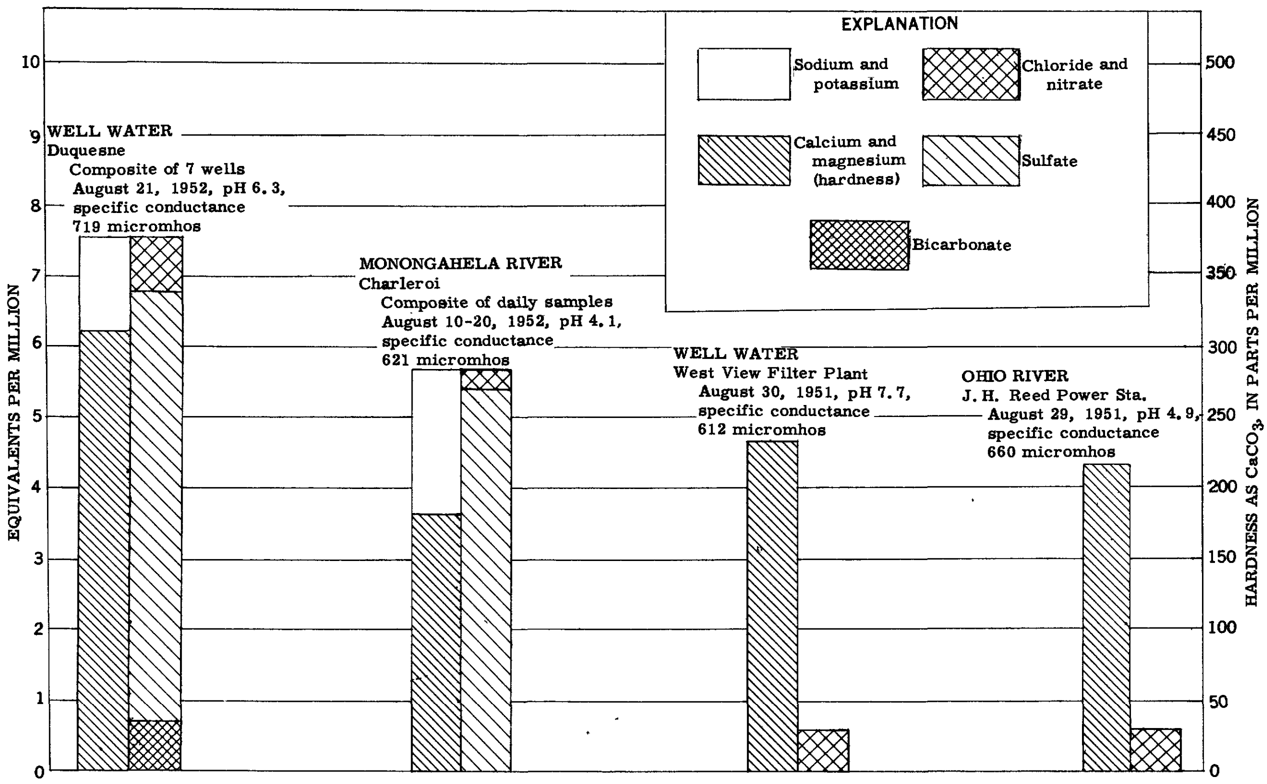

Figure 35.—Chemical characteristics of untreated surface water and untreated water from wells nearby.

almost identical to that of the river water, but the amplitude is less and the peaks lag about a month behind those of the river.

Similar effects have been noted elsewhere in the area. In the Triangle area, the average annual water temperature in the Joseph Horne Co. well, about 250 feet from the Allegheny River, has been raised nearly 7 F by river infiltration to about 60 F. The annual temperature fluctuation of the water in the well varies according to the seasonal withdrawals, but generally ranges between 50 to 70 F. The cycle of temperature fluctuation of the water in the Horne Co. well lags 2 to 5 months behind that of the river water. Temperature effects are believed to be less noticeable in wells more distant from the river. Water-well contractors report that, for wells located about 1,000 feet or more from the river's edge, the annual variation in water temperature is only about 8 to 12 F and the maximum temperature never exceeds 60 F.

Another important factor that influences the temperature of ground water in the valley-fill deposits is heat loss into the ground from industrial plants that are close to wells. Well water from the city of Duquesne municipal supply, which adjoins a large steel plant, is reported to attain temperatures higher than 100 F. In other areas of the county, ground-water temperatures of nearly 80 F have been recorded.

PUBLIC WATER SUPPLIES

There are 32 public water-supply systems in Allegheny County, supplying a total of nearly 1,500,000 people, or 98 percent of the population. The larger communities and most of the industries in the county are concentrated along the flood plains of the major rivers, with the result that the water systems have convenient access to the rivers and valley-fill deposits as water-supply sources.

In 1952 an inventory was made of 27 of the water-supply systems serving the county. Those not listed in this report serve a very small percent of the total population. An effort was made in each case to obtain a brief description of the source of supply, use of water, physical facilities, and information about the chemical character of the water. The chemical data shown in table 8 were obtained from the individual public water-supply systems on the same day, September 11, 1952. For comparison, chemical analyses data of an earlier date are given for several of the supplies. The range in chemical constituents in treated Allegheny River water at the Pittsburgh Water Works Aspinwall plant in 1950 and 1951 is shown in table 9.

The principal features of the major public water-supply systems in Allegheny County are summarized as follows:

ASPINWALL. Population served: 4,054. Source: 2 drilled wells. Treatment: None. Pumping capacity: 500,000 gpd. Average daily use, 1951: 388,000 gpd. Storage: 280,000 gallons. Division of use: Domestic 82 percent, industrial 18 percent. Proposes increasing the storage capacity to 500,000 gallons.

BRACKENRIDGE: Population served: 6,178. Source: Allegheny River. Treatment: Coagulation, sedimentation, and chlorination. Rated capacity of treatment plant: 3.5 mgd. Pumping capacity: 2.5 mgd. Some storage is provided. Average daily use, 1951: 800,000 gallons. Maximum daily use: 1.5 million gallons (estimated). Division of use: Domestic 80 percent, industrial 20 percent.

BRADDOCK. Population served: 16,500. Source: Monongahela River. Treatment: Lime and soda ash. Rated capacity of treatment plant: 3.6 mgd. Storage: 15.4 million gallons. Average daily use, 1951: 1.7 million gallons. Maximum daily use: 2.5 million gallons (estimated). Division of use: Domestic 34 percent, industrial 26 percent, other 40 percent.

CHESWICK. Population served: 1,680. Serves Cheswick, and Springdale Township. Source: 2 drilled wells. Treatment: Filtration, softening, and chlorination. Rated capacity of treatment plant: 216,000 gpd. Pumping capacity: 360,000 gpd. Storage: 75,000 gallons. Average daily use, 1951: 100,000 gallons. Maximum daily use: 170,000 gallons. Division of use: Domestic and commercial 98 percent, industrial 2 percent. Proposes installation of new pump to provide an additional 216,000 gpd.

CORAOPOLIS. Population served: 15,000. Serves Borough of Coraopolis and parts of Robinson and Moon Townships. Source: 26 drilled wells. Treatment: Filtration (zeolite and sand) and chlorination. Rated capacity of treatment plant: 5.4 mgd. Storage: 3 million gallons. Average daily use in 1951: 1.59 million gallons. Maximum daily use: 2 million gallons (estimated). Division of use: Domestic 99 percent, industrial 1 percent.

DUQUESNE. Population served: 20,600. Source: 7 drilled wells. Treatment: Rapid sand filtration and hydrated lime. Rated capacity of treatment plant: 2.52 mgd. Storage: 2.65 million gallons. Average daily use in 1951: 1.56 million gallons (estimated). Maximum daily use: 2.29 million gallons. Division of use: Domestic 72 percent, industrial and commercial 26 percent, other 2 percent. Proposes a new 18- or 20-inch well.

EDGEWORTH. Population served: 7,100. Source: 5 drilled wells. Treatment: Softening and chlorination, and reduction of manganese. Rated capacity of treatment plant: 1.25 mgd. Capacity of wells: 1.5 mgd. Storage: 750,000 gallons. Average daily use in 1951: 430,000 gallons. Maximum daily use: 770,000 gallons. Division of use: Domestic 94 percent, industrial 6 percent.

ELIZABETH TOWNSHIP. Population served: 4,000 (estimated). Serves approximately half of Elizabeth Township. Source: Youghiogheny River. Treatment: Rapid sand filtration, softening with lime and soda ash, and chlorination. Pumping capacity: 800,000 gpd. Storage: 100,000 gallons. Average daily use in 1951: 180,000 gallons. Maximum daily use: 420,000 gallons. Division of use: Domestic 100 percent. Proposes 300,000 gallons additional storage to be completed in 1953.

ETNA. Population served: 6,750. Source: 3 drilled wells. Plant has an emergency connection with the Pittsburgh supply. Treatment: Chlorination and corrosion correction. Rated pumping capacity: 1.30 mgd.

Table 8. --Chemical analyses of water from selected public supplies in Allegheny County

[Constituents in parts per million. All water treated unless otherwise indicated]

Location	Date of collection	Temperature (°F)	Color	pH	Specific conductance (micromhos at 25°C)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na and K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$	
																		Total	Noncarbonate
Aspinwall 1/	Sept. 11, 1952	55	5	7.5	466	......	.....	....	....	13	109	....	85	22	....	3.1	....	184	95
Brackenridge	......do........	77	5	6.8	681	......	.....	....	....	22	8	....	236	40	....	4.2	....	264	257
Braddock	......do........	....	5	8.0	658	......	.....	....	....	48	18	....	259	14	....	2.7	....	202	187
Cheswick	......do........	68	8	7.4	780	......	.....	....	....	154	186	....	132	32	....	11	....	8	8
Coraopolis	......do........	....	5	7.4	723	......	.....	....	....	89	110	....	180	32	....	2.3	....	132	41
Duquesne	......do........	....	8	7.1	742	......	.....	....	....	54	32	....	284	22	....	4.4	....	238	212
Edgeworth	......do........	....	8	7.4	671	......	.....	....	....	85	96	....	174	34	....	.3	....	124	45
Monongahela Valley Water Co.	......do........	....	10	8.2	738	......	.....	....	....	45	14	....	308	14	....	1.9	....	256	245
Etna	......do........	71	8	7.4	636	......	.....	....	....	29	79	....	166	46	....	1.2	....	240	175
Fox Chapel	......do........	76	5	6.8	695	......	.....	....	....	41	16	....	241	45	....	3.3	....	240	227
McKeesport	......do........	....	8	8.9	597	......	.....	....	....	39	15	2.0	240	13	....	1.9	....	200	188
Do...........	Aug. 24, 1951	75	4	9.3	853	7.3	0.30	70	21	28	14	5.9	273	10	0.1	1.0	460	261	240
Millvale	Sept. 11, 1952	74	30	7.6	583	......	.....	....	....	17	128	....	102	37	....	3.3	....	228	123
Natrona	......do........	77	5	8.1	683	......	.....	....	....	37	26	....	239	39	....	.5	....	246	225
North Versailles Township	......do........	....	5	7.2	615	......	.....	....	....	51	20	....	246	12	....	1.3	....	180	164
Oakdale	......do........	....	8	7.7	1,120	......	.....	....	....	20	228	....	238	10	....	.0	....	406	219
Oakmont	......do........	72	10	7.8	693	......	.....	....	....	41	16	....	245	45	....	.6	....	244	231
Pittsburgh 1/	......do........	....	8	6.4	604	......	.....	....	....	46	22	....	176	52	....	2.9	....	176	158
Do............	......do........	....	10	6.9	557	......	.....	....	....	41	16	....	165	50	....	.9	....	166	153
South Pittsburgh Water Co.	Aug. 24, 1951	86	6	7.6	822	......	.....	....	....	94	46	....	298	14	.1	3.6	554	166	128
Sewickley	Sept. 11, 1952	....	8	7.8	734	......	.....	....	....	104	146	....	156	34	....	4.1	....	108	108
Shaler	......do........	....	10	7.7	554	......	.....	....	....	46	110	....	115	30	....	1.1	....	152	62
Sharpsburg	......do........	....	5	7.2	562	......	.....	....	....	24	78	....	142	36	....	1.9	....	212	148
Springdale	......do........	72	5	7.8	602	......	.....	....	....	106	84	....	143	32	....	.4	....	32	32
Tarentum	......do........	....	5	7.7	730	......	.....	....	....	12	26	....	55	42	....	4.1	....	116	95
West View	......do........	....	5	7.4	876	......	.....	....	....	96	108	....	199	81	....	2.5	....	204	116
Do............	Aug. 30, 1951	63	5	7.7	612	......	.....	....	....	....	108	....	168	28	....	3.5	....	234	146
Wilkinsburg	Sept. 11, 1952	....	5	7.4	619	......	.....	....	....	33	24	....	192	44	....	2.2	....	212	192
Do............	Aug. 21, 1951	83	......	7.3	656	7.6	.12	78	18	16	19	....	238	28	.1	1.4	463	269	253

1/ Untreated water.

Table 9.—Chemical analyses of treated Allegheny River water at the Aspinwall plant of the Pittsburgh Water Works

[Parts per million of weekly composites of daily samples]

Analysis	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na and K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrogen N	Nitrogen (NO_3)	Total solids	Total hardness	Free carbon dioxide (CO_2)
1950															
Sample having lowest total solids	1.5	0.4	0.10	0	9.6	4.0	5.6	3.7	34	10	0.10	0.4	97	37	1
Sample having highest total solids	7.6	2.0	.50	.1	38	13	19	17	135	30	.55	2.4	331	148	4
Average for year	4.2	1.1	.20	....	21	7.3	11	9.2	69	18	.33	1.4	180	82	2
1951															
Sample having lowest total solids	1.0	.4	.10	0	11	4.0	5.0	2.1	37	8	.10	.4	80	44	1
Sample having highest total solids	6.6	4.1	.30	1.3	60	18	49	17	248	58	.60	2.7	507	224	6
Average for year	4.2	1.2	.10	.3	28	8.7	17	....	105	23	.31	1.3	236	108	3

Average daily use in 1951: 1 million gallons. Maximum daily use: 1.25 million gallons. Division of use: Domestic 73 percent, commercial 24 percent, industrial 3 percent.

FOX CHAPEL. Population served: 5,000. Source: Allegheny River. Treatment: Carbon filtration, and softening with lime and soda ash. Rated capacity of treatment plant: 600,000 gpd. Pumping capacity: 1.6 mgd. Storage: 800,000 gallons. Average daily use in 1951: 400,000 gallons. Maximum daily use: 720,000 gallons. Division of use: Domestic 90 percent, commercial and industrial 10 percent. Proposes additional filters and storage space for chemicals, enlargement of plant capacity to 1.8 mgd for completion in 1953.

HARMER. Population served: 3,450. Source: 3 drilled wells and one spring. Treatment: Chlorination. Pumping capacity: 345,000 gpd. Storage: 52,000 gallons.

McKEESPORT. Population served: 61,256. Serves Boroughs of Port Vue, Liberty, Versailles, White Oak, and Eden Park, and part of North Versailles Township. Source: Youghiogheny and Monongahela Rivers. Intake pump capacity on Youghiogheny River (8 mgd) is fully utilized. Treatment: Rapid sand filtration, softening with lime and soda ash, alum, activated carbon, ammonia, and chlorine. Rated capacity of treatment plant: 10 mgd. Storage: 7 million gallons. Average daily use; 9.9 million gallons in 1951, and 10.2 million gallons in 1952. Maximum monthly use in 1952: 11 mgd. A steel strike during the normal period of maximum use in 1952 averted an extreme shortage during that summer. Division of use: Domestic 37 percent, commercial and industrial 63 percent.

MILLVALE. Population served: 7,200. Source: Filter crib in bed of Allegheny River. Treatment: Liquid chlorine, caustic soda, and Calgon. Rated capacity of treatment plant: 2 mgd. Storage: 400,000 gallons. Average daily use in 1951: 1.5 million gallons. Maximum daily use in 1952: 1.89 million gallons. Division of use: Domestic 87 percent, commercial and industrial 13 percent.

MONONGAHELA VALLEY WATER CO. Population served: 36,000. Serves Boroughs of Clairton, Dravosburg, Elizabeth, West Elizabeth, and Glassport; and Forward, Jefferson, Lincoln, West Mifflin, and part of Elizabeth Townships. Source: Monongahela River. Treatment: Rapid sand filtration, lime, chlorination, and occasionally alum. Rated capacity of treatment plant: 8 mgd. Pumping capacity: 15.2 mgd. Storage: 2.3 million gallons. Average daily use in 1951: 4.5 million gallons. Maximum daily use: 5.4 million gallons.

NATRONA. Population served: 15,120. Serves Natrona, and Harrison Township. Source: Allegheny River. Treatment: Rapid sand filtration, chlorination, softening with lime and soda ash, and chlorine dioxide. Rated capacity of treatment plant: 1.25 mgd. Pumping capacity: 1.30 mgd. Average daily use in 1951: 908,000 gallons. Maximum daily use: 1.3 million gallons. Division of use: Domestic 54 percent, commercial and industrial 46 percent.

NORTH VERSAILLES TOWNSHIP. Population served: 5,000. Serves North Versailles Township and part of Borough of White Oak. Source: Monongahela River. Treatment: Rapid sand filtration, softening with lime and soda ash, alum, and chlorination. Rated capacity of treatment plant: 500,000 gpd. Storage: 160,000 gallons. Average daily use in 1951: 442,000 gallons. Maximum daily use: 575,000 gallons. Maximum monthly use in 1952: 457,000 gpd. Division of use: Domestic 52 percent, commercial and industrial 13 percent. Proposes to expand treatment and storage facilities.

OAKDALE. Population served: 1,759. Source 5 drilled wells. Treatment: Aeration, filtration, and chlorination. Rated capacity of well pumps: 648,000 gpd. (One 72,000-gpd pump not yet installed.) Storage: 325,000 gallons. Average daily use in 1952: 85,000 gallons. Maximum daily use: 130,000 gallons. Division of use: Domestic 100 percent.

OAKMONT. Population served: 28,000. Serves the Boroughs of Oakmont and Verona, and parts of Penn, Plum, Harmer, Indiana, and West Deer Townships. Source: Allegheny River. Treatment: Pre- and post-chlorination, lime, alum, permanganate, rapid mix, floculation, sedimentation, and filtration. Rated capacity of treatment plant: 3 mgd. Pumping capacity: 6 mgd. Storage: 5.62 million gallons. Average daily use in 1952: 3.4 million gallons. Maximum daily use: 4.15 million gallons. Division of use: Domestic 27 percent, commercial and industrial 46 percent, other 27 percent. Proposes increasing plant capacity to 6 mgd.

PITTSBURGH WATER WORKS: Population served: 600,000. (Other parts of Pittsburgh are served by the Wilkinsburg-Penn Joint Water Authority, the South Pittsburgh Water Co., and the Municipal Water Authority of the Borough of West View.) Source: Allegheny River. Treatment: Slow sand filtration and chlorination, and soda ash when river water is acid. Capacity of treatment plant: Varies from 120 to 140 mgd, according to condition of plant; estimated 130 mgd February 1953. Untreated water storage: 100 million gallons. Treated water storage: 459.5 million gallons. Average daily use in 1951: 98.7 million gallons. Maximum daily use: 110 million gallons.

SOUTH PITTSBURGH WATER CO: Population served: 300,000. Serves part of Pittsburgh; the Boroughs of Baldwin, Bethel, Brentwood, Bridgeville, Carnegie, Castle Shannon, Crafton, Dormont, Dravosburg, Green Tree, Heidelburg, Ingram, Mt. Oliver, Munhall, Pleasant Hills, Rosslyn Farms, Thornburg, West Homestead, West Mifflin, Whitaker, and Whitehall; and the Townships of Collier, Jefferson, Mt. Lebanon, Robinson, Scott, Snowden, South Fayette, Upper St. Clair, and Baldwin. Source: Monongahela River. Treatment: Rapid sand filtration, softening with lime and soda ash, alum, chlorination, and activated carbon. Rated capacity of treatment plant: 33 mgd. Storage: 6.36 million gallons. Average daily use in 1951: 32 million gallons. Maximum daily use: 38 million gallons. Proposes storage increase during 1953 by one 7.25-million-gallon standpipe and two 2.5-million-gallon elevated tanks. Additional filtration capacity of 20 mgd is under construction.

SEWICKLEY. Population served: 6,800. Serves Sewickley, Osborne, Edgeworth, Hayesville, and Sewickley Heights. Source: Ohio River. Treatment: Filtration (zeolite and sand), caustic soda, sodium chlorite, and chlorination. Capacity of treatment plant is 2 mgd. Rated pumping capacity: 1.87 mgd. Storage: 10.2 million gallons. Average daily use in 1951: 718,000 gallons. Maximum daily use: 1.67 million gallons. Division of use: Domestic 100 percent.

SHALER. Population served: 14,700. Serves Shaler, and parts of Hampton, O'Hara, and Indiana Townships. Source: 3 drilled wells. Treatment: Filtration (zeolite and sand), chlorination, and Calgon. Rated pumping capacity: 1.95 mgd. Storage: 800,000 gallons. Average daily use in 1951: 680,000 gallons. Maximum daily use: 850,000 gallons (estimated). Division of use: Domestic 80 percent, commercial and industrial 20 percent. Proposes addition of 2 new wells in 1953 and increasing pumping capacity to 2 mgd.

SHARPSBURG. Population served: 8,000. Source: 12 drilled wells. Treatment: Chlorination. Rated pumping capacity: 3.50 mgd. Average daily use in 1951: 1.74 million gallons. Maximum daily use in 1951: 2.22 million gallons. Maximum daily use in 1952: 2.5 million gallons.

SPRINGDALE. Population served: 5,200. Source: 4 drilled wells. Treatment: Zeolite filtration, caustic soda, and chlorination. Rated pumping capacity: 1.4 mgd. Storage: 595,000 gallons. Average daily use in 1951: 350,000 gallons. Maximum daily use: 440,000 gallons (estimated). Division of use: Domestic 42 percent, commercial and industrial 58 percent.

TARENTUM. Population served: 17,000. Serves Tarentum, and East Deer Township. Source: Allegheny River. Treatment: Rapid sand filtration, softening with lime and soda ash in summer, lime and alum in winter. Capacity of treatment plant: 2 mgd. Rated pumping capacity: 2.4 mgd. Storage: 1.35 million gallons. Average daily use in 1952: 1.63 million gallons. Maximum daily use: 1.86 million gallons. Division of use: Domestic 80 percent, industrial 20 percent. Proposes to increase plant capacity.

WEST VIEW. Population served: 90,000. Serves Boroughs of Avalon, Bellevue, Ben Avon, Ben Avon Heights, McKees Rocks, and West View, and Townships of Kennedy, Kilbuck, McCaudless, Neville, Reserve, Ross, and Stowe, and part of the 28th Ward of Pittsburgh. Source: 62 drilled wells. Treatment: Filtration (zeolite and sand), and chlorination. Rated capacity of treatment plant: 12 mgd. Untreated water storage: 500,000 gallons. Treated water storage: 12.2 million gallons. Average daily use in 1951: 6.35 million gallons. Maximum daily use: 8.49 million gallons. Division of use: Domestic 62 percent, commercial and industrial 33 percent, other 5 percent. Proposes additional wells.

WILKINSBURG-PENN JOINT WATER AUTHORITY: Population served: 206,420. Serves part of 13th Ward of Pittsburgh, Boroughs of Braddock (4th Ward), Braddock Hills, Chalfont, Churchill, East Pittsburgh, Edgewood, North Braddock, Pitcairn, Swissvale, Trafford, Turtle Creek, Wilkinsburg, and Wilmerding, and the Townships of Penn, Wilkins, and part of North Versailles and Patton. Redistributed in the Boroughs of East McKeesport, Rankin, Wall, and part of Monroeville. Source: Allegheny River. Treatment: Sedimentation, filtration, alum, lime, potassium permanganate, chlorination, and activated carbon. Rated capacity of treatment plant: 24 mgd. Pumping capacity: 28mgd. Treated water storage: 44.7 million gallons. Average daily use in 1951: 16.8 million gallons. Maximum daily use: 24 million gallons. Division of use: Domestic 34 percent, commercial and industrial 46 percent, other 20 percent. Proposes improvement of sludge removal equipment and mixing and chemical feed facilities.

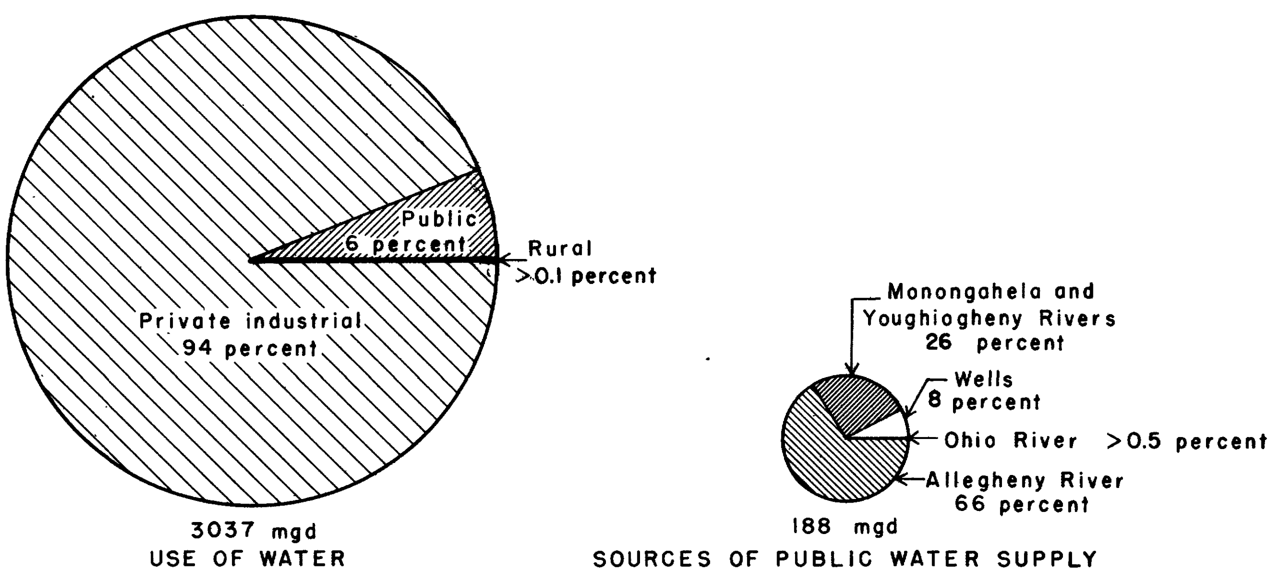

Figure 36.—Use of water in Allegheny County, 1951.

USE OF WATER

The average daily use of water in the Pittsburgh area was about 3,040 mgd in 1951. Nearly 2,900 mgd was required to satisfy the needs of industry and about 190 mgd, or only 6 percent of the total water withdrawn, was for public water supply (fig. 36). About 28 percent of all water used in Pennsylvania is used in the Pittsburgh area.

Of the water withdrawn by industry, it is estimated that at least 2,400 mgd was used for cooling and processing and returned to the streams. On an average, about a fourth of the water was reused in plant operations. For the 10 years, 1928-37, the daily flow of the Ohio River at Sewickley was less than the 1951 average daily use of water in the Pittsburgh area about 15 percent of the time. However, the present withdrawals of water for industrial use are spread widely throughout the major river valleys of the area and there has been no shortage of supply at any industrial location along the larger streams. Reuse of water by industry has been a result of operational economy rather than any indication of inadequate water supply.

More than 98 percent of the population of the area is served by public water-supply systems, which during 1951 provided an average of 187 mgd. The total per capita municipal use of water in the area averaged about 127 gpd. If the amount of the municipal supply used by industry is excluded, the per capita use was about 98 gpd. Pertinent water-use data applying to Allegheny County in 1951 are given in table 10.

In table 10, and in most other presentations of water-use data in this report, the data are given as average use in millions of gallons per day on an annual basis. This method of reporting the data may be misleading to the reader if it is not noted that water use fluctuates greatly with the seasons. Maximum use for practically all purposes occurs during the summer. An extreme case is that of air conditioning, pumpage for which is almost entirely concentrated during the 100 to 120 warmest days of the year. Therefore, the maximum and minimum total daily use in the area may be as much as 60 to 70 percent more or less than the average daily use.

Public Supplies

Surface water.—In 1951 public water-supply systems obtained from surface sources, 173.3 mgd, or 92 percent of the water distributed. Seventeen public and privately-owned water plants supplied about 1,300,000 people with surface water. About 77 percent of the surface water furnished by public water systems was for domestic, commercial, and municipal uses and 23 percent was used by industry. The water from public supplies used by industry, although an important factor in water supply, constitutes about 1 percent of the water used by industry in the area.

Ground water.—Withdrawals of ground water by public-supply agencies in Allegheny County averaged 15.5 mgd in 1951. Twelve public water-supply plants, which served more than 174,000 people, pumped nearly 14 mgd; the rest was supplied by public institutions.

There has been a steady increase in the use of ground water for public supply in Allegheny County. The increase in pumpage by the West View Municipal Water Authority in the period 1939-51 (fig. 37) is typical of the municipal

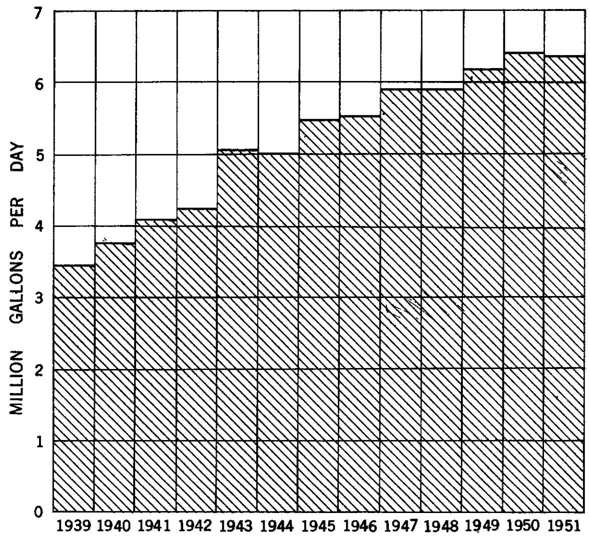

Figure 37. —Average annual pumpage from wells of the West View Municipal Water Authority, 1939-51.

Table 10.—Average use of water in Allegheny County, 1951

[Million gallons per day]

Use	Public supply: Surface water	Public supply: Ground water	Public supply: Total	Private supply: Surface water	Private supply: Ground water	Private supply: Total	Grand total
Municipal a/	134.2	12.5	146.7	....	....	....	146.7
Industrial	39.1	3.0	42.1	2,799.4	b/50.0	2,849.4	2,891.5
Rural	....	....	....	c/ .1	d/ 1.3	1.4	1.4
Total	173.3	15.5	188.8	2,799.5	51.3	2,850.8	3,039.6

a/ Residential, fire protection, commercial establishments, sprinkling, etc. (population served, 1,491,000).
b/ Includes 1.5 mgd used for air conditioning.
c/ Livestock.
d/ Rural, domestic, and livestock (population served, 24,200).

Table 11.—Summary of ground-water pumpage for private industrial supplies in Allegheny County, 1951

Industrial use	Valley-fill aquifers		Bedrock aquifers		Total	
	Number of supplies	Average daily pumpage (mgd)	Number of supplies	Average daily pumpage (mgd)	Number of supplies	Average daily pumpage (mgd)
Metals and metal products	53	15.16	13	0.56	66	15.72
Chemicals	11	4.41	3	.02	14	4.43
Railroads	3	5.26	....	....	3	5.26
Power and light	2	4.00	....	....	2	4.00
Food products	17	5.50	5	.12	22	5.62
Clay, glass, and stone products	12	1.93	5	.18	17	2.11
Cold storage and ice manufacture	3	2.59	....	....	3	2.59
Meatpacking	5	3.15	3	.04	8	3.19
Air conditioning	33	1.41	8	.12	41	1.53
Miscellaneous	41	5.42	7	.14	16	5.56
Total	148	48.83	44	1.18	192	50.01

systems. The trend is expected to continue indefinitely. Most of the municipalities using ground-water supplies are on the fringe of the Pittsburgh metropolitan area, and thus are free to expand into the county. They are among the most rapidly growing communities in this area, and already the water systems are overtaxed to supply the demand. Most of the municipalities are in the process of expanding pumping facilities the better to supply present needs, and are formulating long-range plans to meet future demands of the communities.

Private Industrial Supplies

Surface water. —Industry used an average of 2,800 mgd of surface water from private supply systems in 1951. More than 57 percent of the water used by industry is for cooling in steam-power generation of electricity. More than 41 percent is for use in the manufacture of iron, steel, and allied products. Less than 1 percent is for other industrial uses. Fortunately, the water can be reused several times for most industrial purposes.

Ground water. —Industry used an average of more than 47 mgd of ground water from private supplies in 1951. Pumping was concentrated in the major stream valleys, primarily along the Ohio and Allegheny Rivers. A summary of the private industrial supplies is given in table 11.

Industrial pumping of ground water has decreased in recent years. Many private supplies have been abandoned, and practically all others have reduced pumpage. Ground-water pumpage at 116 representative industrial plants for the years 1946 and 1951 are given in table 12. For all types of industry there was a decline in pumpage, and all except railroads and meatpacking showed a decrease in the number of private supplies.

The decline was due chiefly to improved manufacturing techniques and plant design which were adopted in the post-war years. These often resulted in decreased demand for water, or required water of a quality unavailable from a particular ground-water source. For some uses water requirements were reduced to a level where it was not economical to maintain a private supply. Other supplies were abandoned because of well failure, a change in the quality of the ground water, or because of decreased consumer demand for the product, such as ice.

Table 12.—Comparison of ground-water pumpage in 1946 and 1951 of 116 representative industrial plants

Industrial use	1946		1951	
	Number of private supplies	Average daily pumpage (mgd)	Number of private supplies still in use	Average daily pumpage (mgd)
Metals and metal products	49	15.77	41	14.58
Chemicals	14	8.45	9	4.39
Railroads	2	6.05	2	5.26
Power and light	5	6.81	2	4.00
Food products	15	6.07	14	5.18
Clay, glass, and stone products	8	2.00	5	1.86
Cold storage and ice manufacture	9	6.21	3	2.59
Meatpacking	5	3.22	5	3.15
Miscellaneous	9	3.19	8	2.70
Total	116	57.77	89	43.81

The only industrial use for which pumpage of ground water increased between 1946 and 1951 is air conditioning. Accurate figures for the entire area are not available, but in the Triangle area air-conditioning withdrawals increased more than 20 percent during the period.

Rural Supplies

Practically all rural water supplies in Allegheny County are obtained from wells that tap bedrock aquifers. Pumpage is not metered, but assuming a per capita consumption of 50 gpd, rural use is about 1.3 mgd.

Rural use of surface water is insignificant in the Pittsburgh area. Irrigation is not practiced and livestock needs are estimated to be only 0.1 mgd.

POSSIBILITY OF INCREASING WATER SUPPLY

Surface Water

There has been an increasing trend by our larger cities to favor clean, upland sources of public water supply rather than to use the waters of rivers nearby which are also used for the disposal of domestic and industrial wastes. Plans to do this have been proposed for Pittsburgh in the past.

One plan, considered in 1937, proposed supplying water to Pittsburgh from French Creek and several other tributaries of the Allegheny River and from tributaries of the Beaver River. This elaborate plan contemplated the construction of 20 dams and 12 dikes, together with water conduits and channels totaling 74.5 miles in length. It was estimated that 550 million gallons could be delivered daily from these sources.

Other suggestions, not so costly, have been submitted for improving the quality of the present supply, such as moving the present city intake upstream above the highly polluted Kiskiminetas River. No known detailed engineering studies have been made with a view of changing the present sources of supplies.

The present sources of surface water appear to be adequate to provide the quantities required for the future growth of the area. Although the present total withdrawal of water exceeds the low flow of the Ohio River at the Allegheny County line, most of the water used is for industrial cooling at widely separated localities in the river valleys, and the water is returned to the streams essentially undiminished in volume, and is available for reuse at downstream points.

While it is probable that the present quantity of water withdrawn can be increased severalfold without danger of a shortage of supply, an increase in the reuse of water progressivley downstream generally results in greater pollution and higher water temperatures. The adequacy of the surface-water supply will depend in large measure upon the antipollution measures practiced by the water users.

It is not likely that quantity will prove a limiting factor in the foreseeable future, if the quality is satisfactory. Nevertheless construction of the authorized multipurpose Allegheny River reservoir would provide insurance against a possible water shortage.

Ground Water

Because of the many factors involved and the inadequacy of hydrologic data, it is difficult to estimate the potential ground-water supply available in the Pittsburgh area. However, it is likely that in many places in Allegheny County, especially in the valleys of the Allegheny and Ohio Rivers, ground-water withdrawal can be increased many times without depletion of the supply.

Present withdrawals appear to be approaching the maximum perennial supply available only at the upstream end of Neville Island, where there is concentrated pumping for industrial and municipal supplies, and in the Triangle area, during the summer, when there is heavy pumping for air-conditioning use. In the Triangle area natural recharge to the valley-fill aquifers is retarded by artificial barriers. Direct infiltration of precipitation is prevented in much of the area by pavements and buildings, and infiltration from the Allegheny River is partially obstructed by a sheet-pile cutoff wall. As about half of the withdrawal from wells in the Triangle area during the summer is for air conditioning and this does not impair the quality of the water, the utilization of return wells would add appreciably to the potential supply of ground water in the area. Without the use of return wells, development of additional supplies is possible only along the periphery of the Triangle area, the area near the Point being the most favorable. At Neville Island, the development of additional supplies will require the installation of new wells at some distance from the locus of concentrated pumping. The construction of new public supply wells on Davis Island nearby probably would provide the increase required for the next few years.

The parts of the Pittsburgh area most favorable for future ground-water development are the valleys of the Allegheny and Ohio Rivers. Conditions are good for obtaining additional large supplies from the valley-fill deposits. The glacial-outwash sediments commonly consist of coarse sand and gravel which yield water freely to wells. Although recharge from precipitation is limited owing to the small areal extent of the outwash deposits, infiltration of water from the streams generally can be induced in large quantities. Such infiltration can be accomplished by lowering water levels in wells near the streams to elevations below stream levels, thereby causing water from the streams to move through the permeable deposits to the wells. The chemical quality of water developed by induced infiltration from streams will be affected by the quality of the water induced.

Other promising sources of additional ground water are the valley-fill sediments of the Monongahela River and its major tributaries. The occurrence of beds of highly permeable sand and gravel in tnese deposits is uncertain, but good yields probably can be obtained in some localities where ground-water supplies have not yet been developed. When selecting locations for new wells the presence of permeable deposits should first be determined by test drilling or geophysical surveys.

It is doubtful that there will be any further decline in industrial use of ground water in the Pittsburgh area. Plant modernization is probably well advanced and inadequate supplies have largely been abandoned or replaced. Industrial expansion and the influx of new industry probably will cause increased demand, and the increased and widespread use of air conditioning will add greatly to the requirements. Further, the current trend in industrial location and expansion is toward the suburban fringes of the larger cities where public water facilities are slow to keep pace with the rapid growth of industry. Consequently, private supplies may be required on an increasing scale until public facilities become adequate. The ground-water resources available to industry in suburban areas of the major river valleys are favorable for greatly increased development.

The bedrock aquifers are capable of further exploitation. However, it is not likely that perennial yields much in excess of 100 gpm will be obtained from single wells, and most wells may be expected to yield considerably less. The chief use of wells tapping consolidated rock will continue to be to supply consumers who do not require much water, and who are outside the areas served by public water mains. It is possible, as urban areas encroach more upon the country, that the use of water supplies from bedrock sources will decline.

The future development of all sources of ground water will be affected by advances in drilling and well-maintenance techniques. An important condition limiting the yield of any ground-water development is the hydraulic efficiency of wells. Through the years, yields of wells have been greatly increased through improved methods of construction and development, and this trend may be expected to continue. However, expansion of ground-water use ultimately will depend upon the ability of aquifers to store and transmit the water in quantities equivalent to withdrawals.

Except for the limitations previously described for the Triangle area and Neville Island, much greater use of ground water in the Pittsburgh area appears possible. The present rate of withdrawal from the sand and gravel aquifers, particularly those along the Allegheny and Ohio River valleys, can be increased manyfold if new developments are designed to induce recharge from the rivers.

WATER LAWS

All public agencies or private interests contemplating development involving the natural waterways within the Commonwealth should communicate with the proper State water agency at Harrisburg.

The Water and Power Resources Board of the Pennsylvania Department of Forests and Waters has jurisdiction over the construction of dams and other obstructions which in any way might change the course, velocity, or cross-section of any waterway. They are also empowered to allocate all surface water used for public water supply.

The Commonwealth of Pennsylvania has effective laws relating to pollution from sewage or industrial wastes. In mining, substantially all solids must be removed from colliery wastes before being discharged into the waterways; also no new coal deposits may be opened where drainage from the mines constitutes actual or potential pollution to clean streams. These laws and regulations are administered through the Sanitary Water Board of the Pennsylvania Department of Health. The Pennsylvania Department of Mines requires all abandoned mines to be sealed by the operator.

The Allegheny, Monongahela, Youghiogheny, and Ohio Rivers are classified by the Federal Government as navigable waterways. Consequently, projects involving these rivers in the Pittsburgh area are subject to the jurisdiction of the Corps of Engineers, Pittsburgh district.

It has long been recognized that stream-pollution control in the Ohio River basin cannot be accomplished by any one State acting alone; it can result only from the cooperative action by all States that lie in its drainage area. On June 30, 1948, Pennsylvania together with the States of Indiana, West Virginia, Ohio, New York, Illinois, Kentucky, and Virginia, formally executed the Ohio River Valley Water Sanitation Compact. The basic objective of the compact is the control of future pollution and the abatement of existing pollution in the Ohio River basin. To carry out the provisions of the compact in this large industrial region is a tremendous undertaking. However, the work of the compact has moved steadily along and reports real accomplishment to date.

Pennsylvania has no specific statutes relating to the withdrawal of its underground waters.

In the interest of health and sanitation, the Sanitary Water Board considers the disposal of wastes to the ground, through boreholes or otherwise, as potential pollution of State waters to be permitted only under exceptional conditions. The regulations of the Sanitary Water Board specifically prohibit the discharge of wastes into abandoned wells and prohibit the discharge of inadequately treated wastes, except inorganic matter, into active or abandoned mines, wells, or other underground workings.

SOURCES OF ADDITIONAL INFORMATION

Inquiries relating to current water-resources information for Pennsylvania may be addressed to the following offices:

Quality of Water:	District Chemist U. S. Geological Survey U. S. Custom House Second & Chestnut Sts. Philadelphia 6
Ground Water:	District Geologist U. S. Geological Survey 229 Walnut St. Harrisburg
	Geologist in Charge U. S. Geological Survey P. O. Box 25 Pittsburgh 30

Surface Water:	District Engineer U. S. Geological Survey P. O. Box 421 Harrisburg
	Engineer in Charge U. S. Geological Survey 4th Floor, Victory Bldg. 9th St. & Liberty Ave. Pittsburgh 22
Topographic maps:	Chief of Distribution U. S. Geological Survey Washington 25, D. C.

SELECTED REFERENCES

Adamson, J. H., Graham, J. B., and Klein, N. H., 1949, Ground-water resources of the valley-fill deposits of Allegheny County, Pa.: Pennsylvania Dept. of Internal Affairs, Topog. and Geol. Survey Bull. W 8.

Flood Commission of Pittsburgh, 1912, Report of Flood Commission of Pittsburgh.

Grover, N. C., 1937, The floods of March 1936, part 3, Potomac, James, and upper Ohio Rivers: U. S. Geol. Survey Water-Supply Paper 800. [1938]

Leverett, Frank, 1934, Glacial deposits outside the Wisconsin terminal moraine in Pennsylvania: Pennsylvania Dept. of Internal Affairs, Topog. and Geol. Survey Bull. G 7.

Mangan, J. W., 1936, Floods of March 1936 in Pennsylvania: Pennsylvania Dept. of Forests and Waters.

______1940, Natural water losses from Pennsylvania drainage basins: Pennsylvania Dept. of Forests and Waters.

Mangan, J. W., 1942, Elevations of major floods along Pennsylvania rivers: Pennsylvania Dept. of Forests and Water.

______1946, Temperatures of natural waters of Pennsylvania: Pennsylvania Dept. of Forests and Waters.

Pennsylvania State Planning Board, 1947, Industrial utility of water in Pennsylvania, chemical character of surface water, 1944-46: Pub. 17.

Pennsylvania Water Supply Commission, 1917, Water resources inventory report, part 3, Gazeteer of streams.

Piper, A. M., 1933, Ground water in southwestern Pennsylvania: Pennsylvania Dept. of Internal Affairs, Topog. and Geol. Survey Bull. W 1.

United States Geological Survey, issued annually, Quality of surface waters of the United States (in several parts beginning in 1948): U. S. Geol. Survey Water-Supply Papers.

______issued annually, Surface water supply of the United States, part 3, Ohio River basin: U. S. Geol. Survey Water-Supply Papers.

______issued annually, Water levels and artesian pressure in observation wells, part 1, Northeastern States: U. S. Geol. Survey Water-Supply Papers.

Van Tuyl, D. W., 1950, Ground-water resources of the valley-fill deposits in the Pittsburgh area: Proc., Pa. Acad. Sci., v. 24, p. 155-160.

______1951, Ground water for air conditioning at Pittsburgh, Pa.: Pennsylvania Dept. of Internal Affairs, Topog. and Geol. Survey Bull. W 10.

White, W. F., Jr., 1951, Industrial utility of water in Pennsylvania, chemical character of surface water, 1946-49: Pennsylvania State Planning Board, Pub. 23.

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