Water Quality of Streams in the Neshaminy Creek Basin, Pennsylvania

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1999-O

Prepared in cooperation with the Commonwealth of Pennsylvania Department of Environmental Resources

Water Quality of Streams in the Neshaminy Creek Basin, Pennsylvania

By EDWARD F. McCARREN

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1999-O

Prepared in cooperation with the Commonwealth of Pennsylvania Department of Environmental Resources

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1972

UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress catalog-card No. 70-185108

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 30 cents (paper cover)
Stock Number 2401-2097

CONTENTS

ILLUSTRATIONS

TABLES

CONTRIBUTIONS TO THE HYDROLOGY OF THE UNITED STATES

WATER QUALITY OF STREAMS IN THE NESHAMINY CREEK BASIN, PENNSYLVANIA

By Edward F. McCarren

ABSTRACT

The Neshaminy Creek, a tributary of the Delaware River, drains 236.5 square miles of rural countryside in Bucks and Montgomery Counties in southeastern Pennsylvania. The perennial flow of fresh water, which, basically, is of good quality, in Neshaminy Creek is used for public supply and recreation. For these water uses, the protection of the stream's quality is of fundamental importance to the people in Bucks County and to many living in nearby communities. In the lower half of the drainage basin, the average discharge of the main stream exceeds 146 mgd (million gallons per day), part of which is regularly diverted and moderately treated for distribution to consumers living in the suburbs of Philadelphia.

The Neshaminy has carved a scenic route on its way to the Delaware River, thereby helping to increase the value of land. The unabated growth of nearby metropolitan areas and the multiplying needs for water and open space for water storage and recreation in southeastern Pennsylvania have become impelling forces that mark the Neshaminy valley watershed for continued development of its land and water resources. Toward this end the Neshaminy Valley Watershed Association, Inc., which came into existence June 13, 1956, is one of several organizations dedicated to land and water-resources development in the Neshaminy Creek basin. The principal objectives of the Neshaminy Valley Watershed Association are (1) to provide for future water-supply and recreation needs, (2) to safeguard against flood and drought damage, (3) to decrease stream pollution, (4) to preserve wildlife and natural beauty, (5) to reduce soil erosion and siltation, (6) to reforest marginal land, and (7) to improve and protect existing woodland.

This study shows that there is a wide variance in water quality between the West Branch and the North Branch of the Neshaminy. However, the study shows no significant difference between the chemical composition of the Little Neshaminy Creek and the main stream before they come together at Rushland. Just beyond their confluence the main stream has drained more than half its total drainage area. The average flow of the stream at this location is about 85 percent of the average flow at Langhorne.

The continued presence of game fish in most of Neshaminy Creek indicates a degree of water purity that characterizes this stream as suitable for recrea-

tion. However, during the summer and early fall, several small streams feeding the Neshaminy go dry. The diminished flow during these periods and during prolonged drought impairs stream quality by causing a greater concentration of dissolved solids in water. The relatively inferior water during low-flow periods, therefore, necessitates providing more water of good quality to reservoirs for emergency releases, not only to augment supply to users in needful downstream areas but also to improve stream quality by dilution.

INTRODUCTION

This report describes the chemical composition of water and records the discharge of streams in the Neshaminy Creek drainage basin. In planning projects for developing the land and water resources in the Neshaminy Creek drainage system, the qualitative and quantitative assessments of surface water in different segments of the stream should be considered. The report also presents a general description of the area through which the Neshaminy flows and the several factors that introduce significant changes to stream quality.

The discharge of streams in the Neshaminy Creek basin, as well as in other stream basins throughout the Commonwealth, has been measured continuously since 1944, and intermittent and monthly samples of water have been taken at selected locations for chemical analyses. Most of the data obtained during this time has been published annually as basic data in water-supply papers and other reports by the U.S. Geological Survey.

The chemical analyses reported herein represent qualitative and quantitative determinations made for the ionic mineral constituents that most commonly dissolve in water. They include silica, aluminum, iron, manganese, calcium, magnesium, sodium, potassium, bicarbonate, carbonate, sulfate, chloride, fluoride, nitrate, and dissolved solids as residue on evaporation at 180°C. Other determinations were made for pH, color, dissolved oxygen, and specific conductance.

Specific conductance, denoting the electrical conductivity of water, is a measurement frequently used to make preliminary evaluations of water quality in the field. As more ions go into solution, there is a corresponding increase in specific conductance. Variations in conductance observed at different locations along a stream are most useful, therefore, for detecting dissolved solids that enter waterways through seepages of ground water and those that may be in waste discharges from industry and treated and untreated sewage.

PURPOSE AND SCOPE

A primary purpose of this report is to provide an inventory of water-quality analyses for streams in the Neshaminy Creek basin. These analyses form the basis for the interpretations in the report that explain why water quality differs from place to place and changes from time to time. The description of water quality in different areas of the drainage basin will be especially helpful to those directly involved with the further development of land and water resources in the Neshaminy valley watershed. The hydrologic information contained in the report will help in the selection of sites for the dams, reservoirs, pumping stations, and treatment plants that are being planned to facilitate the distribution of water to an increasing number of users.

ACKNOWLEDGMENTS

This report was written under the general supervision of Norman H. Beamer, Pennsylvania district chief, U.S. Geological Survey. The highly informative newsletter of the Nashaminy Valley Watershed Association, Inc., as well as the meteorological information supplied by the U.S. Weather Bureau, have been of considerable help in preparing this report.

NESHAMINY CREEK BASIN

LOCATION

The Neshaminy Creek basin is in southeastern Pennsylvania between lats 40° and 40°30′ N. and longs 74°45′ and 75°30′ W. (fig. 1). The creek, 38 miles long, begins where the North and West Branches of the stream merge at Chalfont, which is in New Britain Township, Bucks County. The stream flows southeasterly into the Delaware River near Eddington, about 15 miles north of Philadelphia. About 86 percent of the area drained by the creek is in Bucks County; the remaining 14 percent is in northeastern Montgomery County.

HISTORY AND ECONOMIC SIGNIFICANCE OF THE AREA

The name "Neshaminy," denoting a double stream or a stream of two branches, comes from the Lenni Lenape, or Delaware Indians, who defined it as "the double drinking place" or "where we can drink twice."

More than 4 million people reside in the cities of Philadelphia and Trenton and their suburbs which are within 25 miles of the Neshaminy Creek basin. Many of these people visit Bucks County and the Neshaminy Creek area from time to time to enjoy a rural atmosphere in an environment of natural beauty. Because of the area's many historic landmarks, dating back to William Penn's time, and the green open space along the streams, the area is attracting more and more visitors each year, many of whom are moving there permanently. The projected population of Bucks County is 522,000 for 1980 and 796,000 for 2010 (Bucks County Planning Commission, oral commun., 1970).

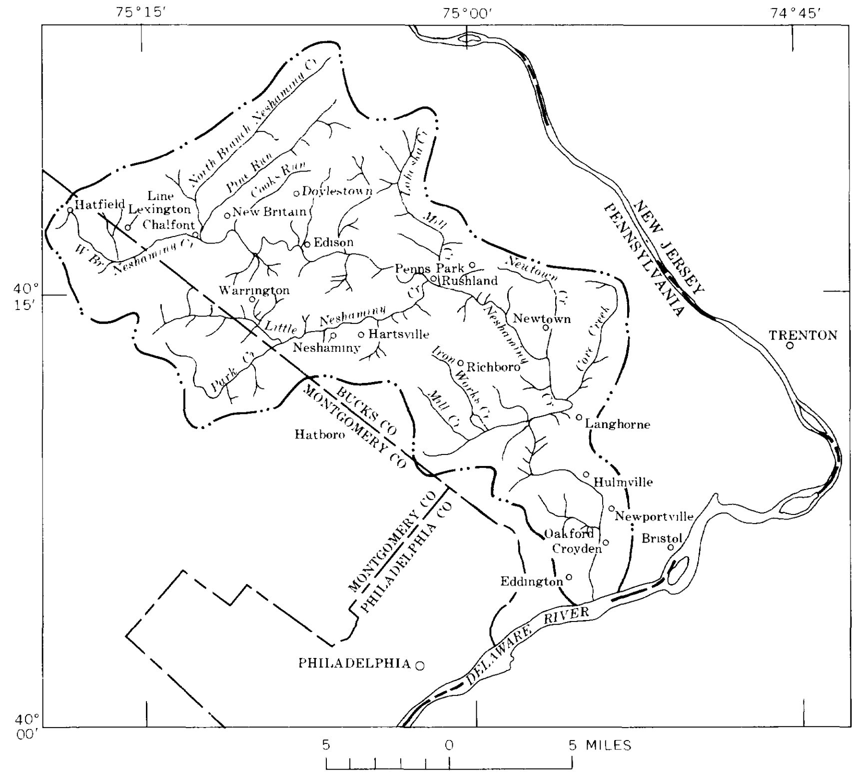


FIGURE 1.—Stream map, Neshaminy Creek basin.

In 1963 Bucks County had more than 600 manufacturing establishments, the production value of which was almost 1 billion dollars. The major industries are primary metals, chemical and allied products, and transportation equipment (Pennsylvania Bureau of Statistics, 1965). The Penn Central Railroad and Reading Railway and the many miles of highways, including the Pennsylvania and New Jersey Turnpikes, help to expedite the products from farms and industry to domestic markets and maritime ports.

TOPOGRAPHY

The land surface of the Neshaminy Creek basin ranges in elevation from 700 feet in the central part of the basin to about 100 feet in the rolling hills and slopes of the Coastal Plain province. The hills and upland slopes are used mostly for agriculture and are patched with neatly laid out farms that produce a large variety of fruit and vegetables for nearby markets. Most of the drainage basin is in the Piedmont province. The valley of the Neshaminy is well defined, and, in some areas, the stream has steep rugged banks that add scenic charm to the stream and surrounding areas.

CLIMATE

The climate of the Neshaminy Creek basin is typical of the mild climate of eastern Pennsylvania: the mean annual temperature is 10°C, and the mean monthly temperature is 0.0°C in January and February and 24°C in July. The mean monthly sunshine throughout the basin is about 210 hours. During December and January the mean monthly sunshine is 120 hours, and during May, June, and July it is 280 hours.

Prevailing winds are from the west, but temperatures rarely go below −18°C in winter because of the moderating influence of the Atlantic Ocean, which is about 60 miles away. Humid weather is frequent during the summer, but temperatures rarely exceed 38°C. The growing season begins in April and ends in October. Temperatures below freezing are not uncommon, and killing frosts usually occur in October and late April. Snowfalls, which occur from November through April, are heaviest during February and early March.

For 62 years of record at Doylestown the mean annual precipitation was 45.75 inches, and for 46 years at the George School in Newtown the mean annual precipitation was 43.24 inches.

GEOLOGY AND GROUND-WATER POTENTIAL

The northern part of the Neshaminy Creek drainage basin is underlain by the Lockatong, Stockton, and Brunswick Formations of Triassic age (fig. 2), and the southern part of the basin around Langhorne is underlain by Precambrian hornblende gneiss and granite gneiss and Quaternary deposits.

Rocks of the Lockatong Formation consist of dark-gray to black argillite and thin layers of impure limestone (Gray and others, 1960). Wells in the Lockatong yield from 20 to 100 gpm (gallons per minute). Generally, water is a calcium bicarbonate ($Ca(HCO_3)_2$) type having alkaline characteristics. The average concentration of dissolved solids in water samples from seven wells was 418 mg/l (milligrams per liter). The temperature of well water is about 12°C (Greenman, 1955). Water from the Lockatong influences the quality of the North Branch of the Neshaminy by seepage through streambeds. The quality of water in central segments of the main stream is also influenced significantly by ground-water seepages from the Lockatong.

Headwaters of the Neshaminy also drain the Stockton Formation. Wells yield from 75 to about 300 gpm, and the water is mostly a

444-540 O - 71 - 2

calcium bicarbonate type. However, where the dissolved-solids concentration in ground water exceeds 400 mg/l, there are generally high concentrations of sulfate, and the water is a calcium sulfate ($CaSO_4$) type (Rima and others, 1962). The temperature of well water in this formation is from 12°C to 14°C.

The Brunswick Formation consists of red shale and some limestone. The headwaters of the West Branch drain this formation, as does Mill Creek before it enters the Neshaminy at Rushland. Wells yield from 50 to about 200 gpm of a generally calcium bicarbonate type water which has alkaline characteristics. The temperature of water from shallow wells is about 10°C and from deep wells about 13°C.

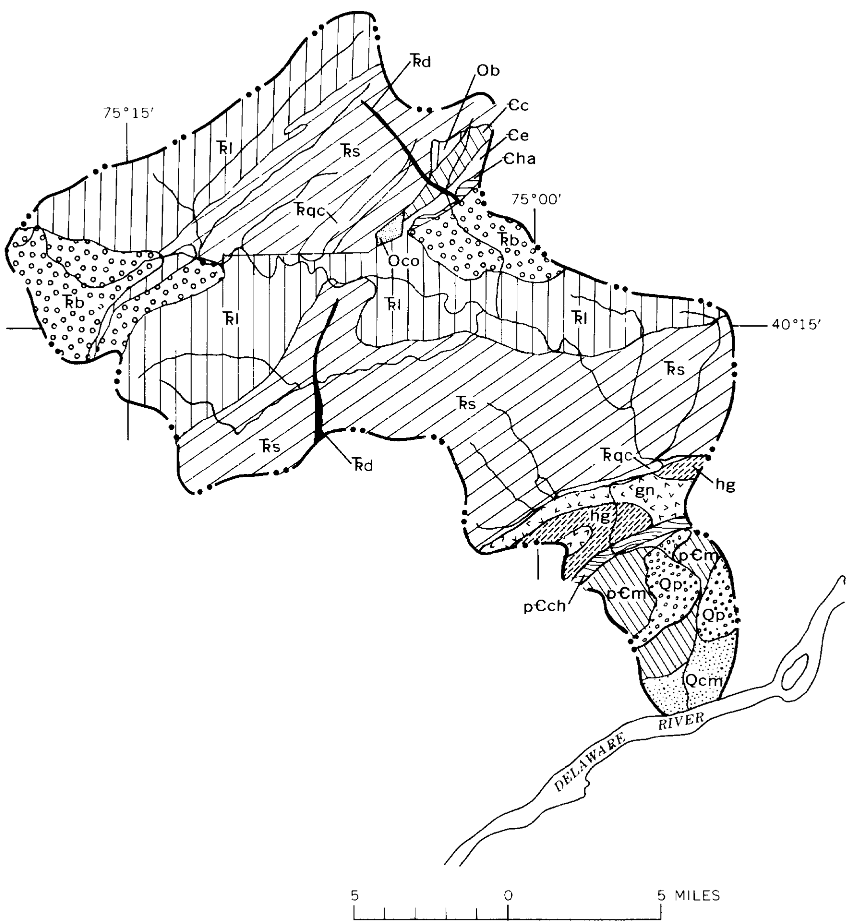


FIGURE 2 (above and facing page).—Geologic map, Neshaminy Creek basin.

EXPLANATION

QUATERNARY

Pleistocene

Qp

Pensauken Formation
Deeply weathered gravels and sandy gravels

Qcm

Cape May Formation
Sands and gravels with clay and silt at the base locally

TRIASSIC

Newark Group

₸b

Brunswick Formation
Red to brown, fine- to coarse-grained quartzose sandstone with red shale interbeds

₸l

Lockatong Formation
Dark-gray to black thick-bedded argillite. Locally has thin layers of impure limestone and calcareous shale

₸s

Stockton Formation
Light-gray to buff coarse-grained arkosic sandstone and conglomerate. Fine-grained siliceous sandstone and red shale

₸d

Diabase dike
Dark gray, medium to coarse grained, composed chiefly of gray plagioclase feldspar and black or green augite

₸qc

Quartz pebble conglomerate

ORDOVICIAN

Ob

Beekmantown Group

Oco

Cocalico Shale
Gray shale, highly phyllitic in places; some interbedded red shale and argillaceous and quartzose sandstone

CAMBRIAN

Ꞓc

Conococheague Group
Gray limestone with siliceous and argillaceous bands and dark- to light-gray dolomite; sandy in lower part; cryptozoon reefs

Ꞓha

Hardyston Quartzite
Quartzite with conglomerate at the base

Ꞓe

Elbrook Formation
Light-gray to yellowish-gray finely laminated siliceous limestone with interbeds of dolomite

PRE-CAMBRIAN(?)

pꞒm

Mica schist

PRECAMBRIAN

pꞒch

Chickies Formation
Light-gray hard massive scolithus-bearing quartzite and quartz schist

hg

Hornblende gneiss

gn

Granite gneiss

The rocks that underlie the lower Neshaminy Creek basin between Langhorne and the Delaware River probably include rocks of sedimentary origin. The largest and most reliable ground-water supply in Bucks County comes from these rocks. Among yields ranging from 10 to 1,050 gpm, the average yield of 43 wells tested was 304 gpm. The water from these rocks is a calcium bicarbonate-sulfate type that contains fairly low concentrations of dissolved solids. The temperature of water from the unconsolidated rocks in this area is from 12°C to 13°C. The water is moderately acidic, however, and some sources of supply may contain as much as 0.13 mg/l of iron, considered undesirable for some purposes (California State Water Pollution Control Board, 1963) and would, therefore, require treatment to remove iron.

WATER-STORAGE CONTROLS AND WATER USE

The open space and topographic characteristics in some areas of the Neshaminy Creek basin favor water impoundments for flood-plain protection. The need for flood-plain regulation in the Eastern United States has often gone unheeded until a severe flood caused the loss of life and enormous damage to property worth millions of dollars.

The most devastating flood affecting the Neshaminy Creek drainage system resulted from hurricane Diane in August 1955. At Langhorne, about 9:00 a.m., on August 19, the Neshaminy overflowed its banks, having a peak flow of 49,300 cfs (cubic feet per second), approximately 22 million gpm. This was about 180 times the average flow of the stream and more than four times the average flow of the Delaware River at Trenton, N.J. Now a flood warning system operates along the Neshaminy to protect lives and to minimize property damage.

A history of peak stages and discharges of Neshaminy Creek at Rushland and Langhorne is on record (Busch and Shaw, 1960). Other flood-plain information, prepared for the Bucks County Planning Commission, is presented in a summary report by the U.S. Army Corps of Engineers (1965).

In order to protect the Neshaminy Valley from floods, the Pennsylvania Department of Forests and Waters (Bourquard, 1966) has investigated 18 sites for reservoirs in the basin. The most feasible places selected, in downstream order, are the North Branch above Chalfont, Pine Run near New Britain, the main stem above its confluence with the Little Neshaminy Creek, Little Neshaminy Creek near Hartsville, and Neshaminy Creek near Newtown. However, some of the desirable reservoir sites may meanwhile be lost to encroaching public improvements, new highways, and airfields.

The Department of Forests and Waters has also taken into consideration other benefits that may accrue to an area through water impoundments. For example, the controlled release of suitable water from reservoirs could stabilize streamflow downstream for domestic and industrial supply and, during low flow, could improve water quality in streams by dilution (McCarren, 1967). Coordinated with the economically beneficial uses, the impounded water could be used also for recreation, which has not reached its full development in the Neshaminy Creek valley. However, toward this objective a State park marina is being built near the mouth of the creek on the Delaware River in Bristol Township, where floating piers with catwalks will accommodate as many as 170 boats. Other proposed accommodations, such as shops, eating places, and an observation tower, when complete, will enhance the marina and attract more people to spur the area's economic growth.

PUBLIC WATER SUPPLY

The average use of municipally supplied water in the Neshaminy Creek basin and vicinity in 1964 was about 23 mgd. As forecast in 1966 by the Bucks County Water and Sewer Authority, the demand for water within the Neshaminy Creek basin will be 58 mgd by 1980. By 2010, 115 mgd will be needed for Bucks County alone.

As envisioned by the several planning commissions and other interested agencies at Federal, State, and local levels, the reservoirs to be built at the five sites under investigation would raise the area's supply of water by 50 mgd. An alternate plan of constructing a single dam above Newtown which would be large enough to impound an equal supply is under consideration. If the dam becomes a reality, it would form a lake of more than 2,000 acres.

Because projections for future needs are based on past and present-day water requirements that differ widely between industrialized urban areas and rural areas, it is possible to significantly underestimate water needs in some rural areas that are rapidly becoming urbanized. Nevertheless, the 50-mgd increase in the water supply in the Neshaminy Valley watershed would service an additional 300,000 people if they were using the reported average of 150 gallons of municipally supplied water each day (Durfor and Becker, 1964).

As many as 15 to 20 water-supply agencies in the Neshaminy Creek basin and adjacent areas in Bucks County rely on wells as their main source of supply. To prepare for the future needs of an increasing population, some of these agencies are likely to need additional sources of water, as well as improved distribution facilities. However, in the water-resources development plans for the Neshaminy, there are schemes to establish strategically placed pumping stations for bringing suitable Delaware River water into the Neshaminy Creek basin. The reserve source would bolster supplies for municipal and industrial use during droughts.

One of the world's largest privately owned water-supply companies, the Philadelphia Suburban Water Company, diverts water regularly from Neshaminy Creek at Neshaminy Falls. The company also has a reservoir (Springfield Lake) on Iron Works Creek, a tributary of Mill Creek. Iron Works Creek has a drainage area of 6.3 square miles. Springfield Lake has a capacity of 650 million gallons and is about 11 miles above the gage on Neshaminy Creek at Langhorne.

INDUSTRIAL USE

The competition and demand for water from relatively small watersheds in the Delaware River basin, such as the Neshaminy Creek watershed, are becoming increasingly greater because of spreading urbanization. In the highly industrialized Delaware River valley, many light industries and commercial establishments have found the quality and temperature of Neshaminy Creek and the ground water underlying the Neshaminy Creek basin to be suitable for processing, cooling, and general use.

Each of about 700 firms in the Neshaminy Creek watershed employ from one to about 3,000 people. Fewer than 25 people are employed by 77 percent of these firms. One hundred and two firms employ from 25 to 100 people; 52 firms, from 100 to 500 people; five firms from 500 to 1,500 people; and two firms, from 2,000 to 3,000 people. The major industries produce chemicals, scientific and processing instruments, fabricated metal products, and machinery.

As in most surface-water systems in Pennsylvania, the quantity of water available for supply in Neshaminy Creek recedes to a minimum in late summer and fall because of evapotranspiration and light precipitation. Although the average daily flow in Neshaminy Creek varies seasonally, there is usually a dependable supply for industrial use during the summer and fall, times when the dissolved solids in the stream are most concentrated and the water warmest. The median dissolved-solids concentration for Neshaminy Creek at Langhorne is 140 mg/l. During the fall, the dissolved-solids concentration at Langhorne has been as high as 254 mg/l. Water temperatures, which normally do not exceed 24°C, go as high as 34°C during June, July, and August.

SIGNIFICANCE OF MINERAL SOLUTES, PHYSICAL CHARACTERISTICS, AND SEDIMENT IN WATER

Varying ionic concentrations of mineral constituents that have been dissolved from rock exist in all waters. Rock composition determines the extent to which rock materials will dissolve and thus influences water quality. The solution of these materials by water is generally more extensive underground than on the surface by reason of the fact that subsurface rock and water are in contact with each other during a longer period of time. Seepage of ground water into streams, therefore, can have a significant influence on stream quality.

Minerals also become components of water as windborne solids which fall into water from the atmosphere by their own weight or are dissolved in the raindrop or snowflake. When in solution, minerals help to nurture aquatic organisms which provide food that fish need to complete their life cycle. Certain minerals in water containing oxygen and free of harmful bacteria help to make water palatable.

Additional solutes are introduced to stream water as a consequence of man's use of this water for cleaning, processing, and carrying waste discharges. Mining, urbanization, and cultivation of land are the principal land-disturbing activities that affect water quality, as they contribute sediment and chemicals—such as fertilizers and pesticides—to the streams.

Dissolved solids.—The total dissolved-solids content of water denotes the amount of inorganic chemicals in solution. Dissolved solids in excess of 1,000 mg/l in water may have adverse physiological effects when ingested, and such water is considered unsuitable for many purposes. That people have tremendous powers of adjustment to mineralized water, however, is demonstrated by the fact that in the United States more than 100 public water supplies contain 2,000 mg/l dissolved solids (Miller, 1962), which has resulted in no apparent harm to the users. The population's broad tolerance range notwithstanding, recommended drinking-water standards of the U.S. Public Health Service and most state agencies limit the concentration to 500 mg/l.

Specific conductance.—Specific conductance is a measure of the ability of water to conduct electricity. As the ionic salts in water become more concentrated, the ability of water to conduct electrical current, hence its specific conductance, increases. Specific conductance is directly related to dissolved-solids content and is therefore very useful as a water-quality criterion.

Hardness as calcium carbonate ($CaCO_3$).—Most water hardness is caused by calcium and magnesium. The aluminum, iron, and manganese, ions of acid-bearing water, such as that from coal mines, also contribute to hardness. Although hard water caused by calcium and magnesium has no demonstrable effects on the health of consumers, these ions form a precipitate with soaps, and thereby increase the amount of soap required to produce a lather. Hardness also affects the transfer of heat by producing scale in boilers, heaters, and pipes. Up to and including concentrations of 60 mg/l of hardness, water is rated as soft; from 61 to 120 mg/l, moderately hard; from 121 to 180 mg/l, hard; and over 180 mg/l, very hard.

Hydrogen ion concentration (pH).—The pH is the measure of the activity of hydrogen ions in water and indicates the intensity of the acid or alkaline condition of water. The neutrality of water at 25°C is indicated by a pH of 7.0. Progressively lower values denote an increasingly acid condition, while progressively higher values denote an increasingly alkaline condition. Either very acidic water or very alkaline water will attack metals and ordinary concrete and might indicate the presence of potential pollutants. Also, a lowered pH may indicate an increase in the carbon dioxide in water, which usually results from the decomposition of organic matter. The pH of most stream waters varies between 6.0 and 8.5.

Iron (Fe).—Iron is dissolved from practically all rocks and is considered undesirable for most purposes when the sum of iron and manganese is in excess of 0.3 mg/l. These limits are based more on aesthetic and taste considerations than on physiological reasons because iron in water stains plumbing fixtures and interferes with some food processing. Iron is also objectionable in procedures such as dyeing, bleaching, and brewing. In water supplies, iron helps to nurture the growth of some bacteria, and its presence adds significantly to the cost of water treatment.

Manganese (Mn).—Manganese is dissolved from rocks and soils. Large amounts of manganese in water are usually associated with large amounts of iron. These ions, commonly found in acid-bearing waters such as coal mine drainage, impart to water the same objectionable properties. Manganese and iron nurture the growth of some micro-organisms such as *Crenothrix*, which colonize in reservoirs and attach to the sides of aqueducts and spillways as a brown or black slimy mass (American Water Works Association, 1950). Beyond trace amounts, the presence of manganese in water adds significantly to the cost of water treatment.

Silica (SiO_2).—Silica appears not to cause adverse physiological effects and, along with other necessary nutrients, favors the growth of diatoms in water. However, silica forms a hard scale in boilers, pipes, and water-cooling systems. It also forms a crust on blades of steam turbines. The suggested tolerance limit for silica in boiler feed water is 40 mg/l for steam pressure of 0–150 pounds per square inch.

Sodium (Na) *and potassium* (K).—Sodium and potassium are dissolved from practically all rock and may be found in sewage and industrial wastes. High concentrations of sodium ions in drinking water may be harmful in certain illnesses, including those of the heart, kidney and liver. In combination with chloride, sodium imparts a salty taste to water, but otherwise sodium chloride has little effect on the general usefulness of water. For the most part, large amounts of sodium salts (brackish water and brines) are undesirable, particularly when used for irrigation. More than 50 mg/l sodium plus potassium in boiler water may cause foaming.

Bicarbonate (HCO_3).—In stream water, the action of carbon dioxide on carbonate rocks such as limestone and dolomite produces bicarbonate which, along with carbonate, causes alkalinity. The decomposition of calcium and magnesium bicarbonate in steam boilers and in hot water causes foaming, facilitates the formation of scale, and releases carbon dioxide, which is corrosive. Excessive bicarbonate adds to the dissolved-solids content of water in some streams, but it also helps to neutralize acidity.

Sulfate (SO_4).—Sulfate is dissolved from rocks containing gypsum, iron sulfide, and other sulfur compounds. Sulfate may also be discharged to streams from coal mines and from tanneries, textile mills, and other manufacturing industries that use sulfate or sulfuric acid. Sulfate, in combination with other ions such as calcium and magnesium, imparts a bitter taste to water and causes a hard scale in boilers. Sulfate adds to the dissolved-solids content of water but in itself is not usually significant. Federal drinking water standards recommend that concentrations not exceed 250 mg/l (U.S. Public Health Service, 1962).

Chloride (Cl).—Almost all stream waters contain chloride which may also be present in sewage, waste brines, and industrial discharges. With sodium it imparts a salty taste to water that can be detected by some people at concentrations as low as 100 mg/l. Chloride adds to the dissolved-solids content and increases the corrosive character of water. The U.S. Public Health Service recommends that chloride concentrations not exceed 250 mg/l.

Fluoride (F).—Usually stream water contains small concentrations of fluoride. Abundant literature, a large part of which treats the subject of the prevention of mottled tooth enamel and tooth decay, describes the beneficial aspects of controlled fluoride concentrations in drinking water (California State Water Pollution Control Board, 1963). The literature also includes implications that fluoridated drinking water has hidden dangers for people with kidney ailments (Lear, 1969). The optimum fluoride level depends on climatic conditions because more water is ingested in warmer climates. Therefore, the U.S. Public Health Service limits the average fluoride concentration in water to 1.7 mg/l where the average maximum air temperatures are 10°C–12°C and 0.8 mg/l where the average maximum air temperatures are 26°C–32.5°C (U.S. Public Health Service, 1962). Usually fluoride in water is of little significance to industry.

Nitrate (NO_3).—Nitrate in water may be caused by decaying organic matter, sewage, or nitrogen-bearing fertilizers washed from soils. In concentrations greater than the local average, nitrate may suggest pollution. High concentrations in water that is used for infant feeding can cause methemoglobinemia—sometimes a fatal disease. The limit of concentration in drinking water, set by the U.S. Public Health Service, is 45 mg/l. Nitrate, which encourages the growth of some algae, is considered useful in controlling boiler-metal embrittlement.

Detergents.—The use of synthetic detergents for household purposes has increased manyfold during the past 25 years. The most widely used detergents contain ABS (Alkyl benzene sulfonate), which is the sodium salt of commercial sulfonated dodecyl benzene. Foaming and the formation of mounds of white suds in some streams is caused by detergent pollution. ABS concentrations above 0.5 mg/l in water supplies are indicative of sewage pollution. The surface-active properties of ABS may produce irritation of the gastrointestinal tract and may also affect proper nutrition, even though studies have shown no significant evidence of intolerance. The U.S. Public Health Service recommends that the ABS concentration be limited to 0.5 mg/l in drinking water.

Dissolved oxygen.—Dissolved oxygen in water is essential to the respiration of nearly all aquatic organisms and to the natural processes of stream purification when organic pollutants decompose. Depletion is usually the result of consumption by organic polluting materials. Oxygen is replenished to streams by reaeration from the atmosphere and by photosynthesis. The ability of water to hold oxygen at equilibrium with a normal atmosphere is a function of the temperature and salinity of water. Dissolved oxygen is more soluble in cold water than in warm water, but it is used by living organisms more rapidly in warm water. Different species of fish have different tolerances to oxygen deficiencies in streams, but most species require at least 4.0 mg/l.

Color.—Water color is normally caused by dissolved and colloidal organic material such as decomposed vegetation. Such color is particularly evident in "swamp water." Industrial wastes that contain metal ions such as iron, manganese, copper, and chromium may also cause discoloration of water supplies. As a rule, color cannot be removed completely by filtration and is difficult to remove by chemical treatment. However, some color can be removed from water by introducing activated carbon or bleaching clay or both. Color affects the use of water for public supply and many industrial purposes such as dyeing, textile and chemical manufacturing, brewing, photography, food processing, and ice making.

Suspended sediment.—Suspended sediment in stream water is due to the erosion of stream channels and land. The usefulness of water for domestic and many industrial purposes is diminished by suspended sediment which, therefore, is regarded as a major pollutant. Sediment reduces the storage capacity of reservoirs and lakes and clogs navigable channels. Before water is distributed through public supply systems, sediment is removed by filtration and in settling basins.

CHEMICAL QUALITY AND DISCHARGE OF STREAMS

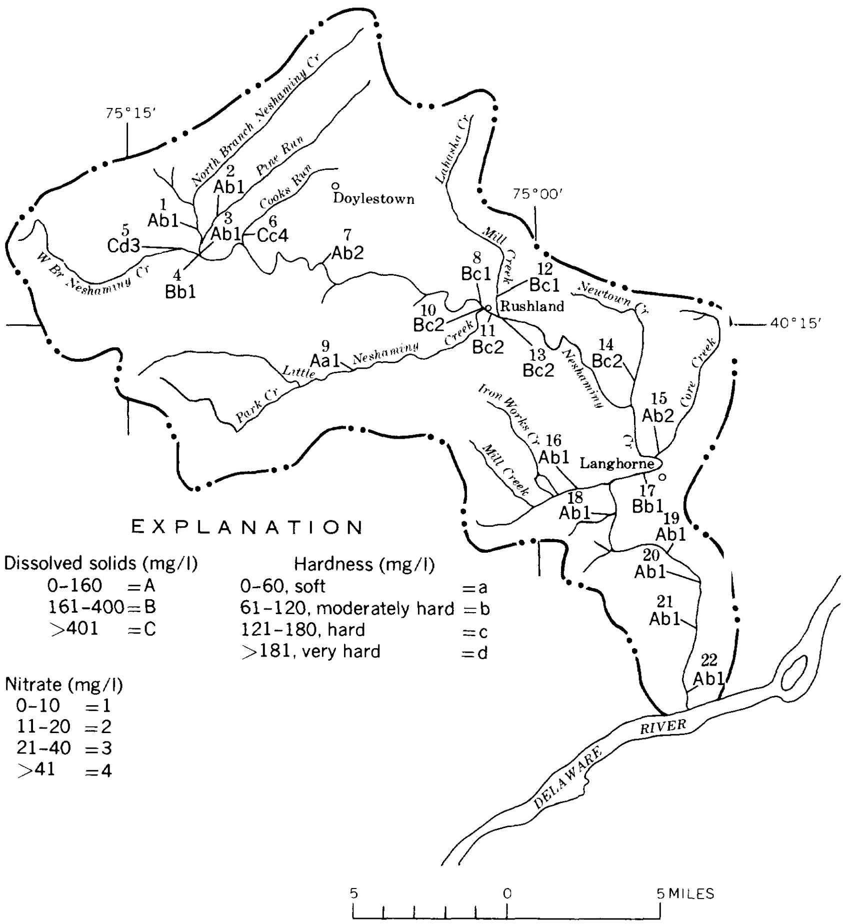
The quality of water in Neshaminy Creek differs from place to place but, after moderate treatment, is suitable for most uses. The changes in dissolved-solids content, hardness, and nitrate in stream segments during low flow are shown in figure 3.

In this study the quality and the discharge of streams are described in a downstream sequence, beginning in the headwaters of the drainage basin at a gaging station on the West Branch Neshaminy Creek at Chalfont.

HEADWATER STREAMS

The streams that form the headwaters of Neshaminy Creek are the West and North Branches of the Neshaminy and Pine and Cooks Runs. Near Chalfont these streams drain approximately 65–75 square miles. In the late summer and into October, parts of the headwater streams are often dry, and their gaging stations are maintained as low-flow partial-record stations. When there is a measurable discharge (usually in spring, autumn, and winter), the water in the West Branch is commonly a sodium chloride ($NaCl$) type during low flow and a sodium sulfate (Na_2SO_4) type during high flow. Dissolved-solids content in samples analyzed was as high as 621 mg/l.

The West Branch originates in Hilltown Township, in western Bucks County, and takes a southerly course into Montgomery County through Hatfield and Colmar before it returns to Bucks County. Waste discharges cause the West Branch to be fairly poor in quality at Chalfont, where prolific algae growths sometimes occur along the



Stations

1. North Branch Neshaminy Creek at Chalfont (above Pine Run)
2. Pine Run near New Britain
3. Pine Run at Chalfont
4. North Branch Neshaminy Creek at Chalfont
5. West Branch Neshaminy Creek at Chalfont
6. Cooks Run near New Britain
7. Neshaminy Creek near Edison
8. Neshaminy Creek at Rushland (above Little Neshaminy Creek)
9. Little Neshaminy Creek at Hartsville
10. Little Neshaminy Creek at Rushland

Stations

11. Neshaminy Creek at Rushland (below Little Neshaminy Creek)
12. Mill Creek at Rushland
13. Neshaminy Creek near Penns Park
14. Newtown Creek at Newtown
15. Core Creek near Langhorne
16. Mill Creek near Langhorne
17. Neshaminy Creek near Langhorne
18. Pine Run near Langhorne
19. Neshaminy Creek at Hulmeville
20. Neshaminy Creek at Newportville
21. Neshaminy Creek near Oakford
22. Neshaminy Creek at Croydon

FIGURE 3.—Water-quality variations during low flow, Neshaminy Creek basin.

streambed. Oxygen consumption by algae may reduce the dissolved oxygen in streams to undesirably low levels. Also, nitrate concentrations in the West Branch at Chalfont are sometimes greater (table 1) than the tolerance level prescribed as safe for drinking.

The North Branch Neshaminy at Chalfont has a calcium sulfate-bicarbonate type water and, from the standpoint of dissolved-solids content, is of better quality than the West Branch. Samples taken from the North Branch from above and below the confluence with Pine Run showed little significant difference in dissolved-solids content. A sample taken from the North Branch Neshaminy at Chalfont September 27, 1967, had 162 mg/l dissolved solids.

Pine Run at Chalfont, when sampled during low flow (Oct. 22, 1964) and during a period of relatively high flow (Apr. 7, 1965), was a calcium bicarbonate-sulfate type water in which dissolved-solids content reached 149 mg/l during low flow. Cooks Run, sampled at New Britain at approximately the same time and during similar flow conditions, was predominantly a sodium chloride type, and the low-flow sample had 812 mg/l dissolved solids. In parts of Pine and Cooks Runs there are trout, smallmouthed bass, sunfish, sucker, crappie, fallfish, and eels (Pennsylvania Fish Commission, 1969).

Down the main stream, near Edison, the water is a calcium sulfate-bicarbonate type. One of the samples analyzed exceeded the limits of iron concentration set by the U.S. Public Health Service. In four samples from Edison, taken during periods of high and low discharge, the pH range was 6.6–7.6, and the dissolved-solids range was 98–133 mg/l. The water was soft to moderately hard (58–84 mg/l) and would be of acceptable quality for most uses after treatment.

LITTLE NESHAMINY CREEK

Little Neshaminy Creek, the largest of the main stream's tributaries, originates in Montgomery Township, eastern Montgomery County. The stream is 16 miles long and drains 43.1 square miles. At Rushland on October 22, 1964, during low flow (4.12 cfs), the water was a sodium bicarbonate-chloride type (pH 7.4) and had a dissolved-solids content of 328 mg/l. Dissolved oxygen in water on that day at the time of sampling was 14.3 mg/l, more than 100 percent saturation. Water hardness caused by calcium and magnesium was 149 mg/l.

During a relatively high flow (58 cfs) at Rushland on April 8, 1965, the water, having a dissolved-solids content of 156 mg/l, was a calcium sulfate type (pH 6.9). Dissolved oxygen was 12.5 mg/l, greater than 100 percent saturation, and the hardness was 84 mg/l. The water was also a calcium sulfate type upstream from Rushland, at Hartsville, during April 1949.

TABLE 1.—*Miscellaneous analyses of streams in the Neshaminy Creek basin 1944–69*

[Chemical analyses in milligrams per liter, except as indicated. DO: dissolved oxygen. Color: zeros indicate clear water; numbers increase with color intensity]

Date of collection	Mean discharge (cfs)	Temperature ° C	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180° C)	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: Noncarbonate	DO	Specific conductance (micromhos at 25° C)	pH	Color
North Branch Neshaminy Creek at Chalfont (above Pine Run)																					
Apr. 21, 1960								11		44	43	8.0		4.6	132	73	37		203	7.7	2
Apr. 7, 1965	15	8	6.3	0.01	0.00	20	8.8	11	1.8	38	53	15	0.1	10	144	86	55	13.1	248	7.1	6
Apr. 19, 1966								12		46	49	9.0		0.5	151	88	51		249	7.0	10
Pine Run near New Britain																					
Apr. 21, 1960								11		33	29	7.0		11	120	52	25		165	7.3	2
Apr. 19, 1966								10		42	29	9.0		9.5	119	62	28		184	6.9	15
Sept. 27, 1967										50	26			8.1	122	65	24		188	7.0	3
Pine Run at Chalfont																					
Oct. 22, 1964	0.45	10	7.6	0.08	0.00	19	8.3	14	5.1	84	24	14	0.1	4.6	149	82	13	8.7	239	7.1	22
Apr. 7, 1965	12	8	12	.02	.00	14	6.6	10	1.8	31	35	10	.1	12	113	62	37	11.3	187	6.7	7
North Branch Neshaminy Creek at Chalfont																					
Apr. 7, 1965	27	9	10	0.01	0.00	17	8.5	11	1.8	34	44	12	0.2	11	132	78	50	12.3	222	7.0	8
Sept. 27, 1967								16		67	45			.0	162	93	38		252	7.3	3

West Branch Neshaminy Creek at Chalfont																					
Oct. 22, 1964	2.71	10	20	0.00	0.00	49	26	110	12	162	124	112	1.0	60	621	230	97	11.2	967	7.2	20
Apr. 6, 1965	20	13	8.8	.04	.00	24	11	31	3.8	60	63	36	.1	27	238	105	56	16	393	6.9	8
Oct. 18, 1968	-----	18	19	.00	.00	55	19	124	13	183	114	132	.3	26	605	215	65	-----	1,030	7.5	18
Cooks Run near New Britain																					
Oct. 23, 1964	-----	7	34	0.02	0.00	30	20	210	20	100	4.3	304	1.2	63	812	158	76	-----	1,390	7.8	30
Apr. 7, 1965	2.5	10	17	.43	.00	19	10	34	4.8	44	46	44	.1	40	226	89	53	12.5	402	6.4	20
Neshaminy Creek near Edison																					
Nov. 25, 1947	-----	7	-----	-----	-----	-----	-----	-----	-----	30	47	12	-----	11	133	84	59	-----	226	6.6	27
Apr. 15, 1948	-----	8	-----	0.39	-----	14	7.9	1.3	-----	27	37	4.0	-----	5.1	98	67	45	-----	166	6.7	28
July 12, 1948	-----	29	6.6	.04	-----	14	5.6	16	-----	50	30	12	0.0	5.1	116	58	17	-----	197	7.6	5
Apr. 5, 1949	-----	11	9.0	.20	-----	18	8.5	2.6	-----	38	34	9.0	-----	7.7	107	80	49	-----	181	7.5	5
Neshaminy Creek at Rushland (above Little Neshaminy Creek)																					
Oct. 22, 1964	4.19	13	2.8	0.01	0.00	40	16	63	8.9	137	86	77	0.1	7.8	392	166	54	17.5	655	7.4	10
Apr. 8, 1965	95	9	5.1	.02	.00	21	9.0	16	2.4	49	49	21	.1	11	162	90	50	12.6	281	7.0	8
Little Neshaminy Creek at Hartsville																					
July 12, 1948	-----	-----	13	0.06	-----	13	4.9	9.8	-----	42	25	7.2	0.0	4.0	106	53	18	-----	165	7.5	3
Apr. 5, 1949	-----	9	11	.25	-----	16	8.3	2.6	-----	38	31	8.0	-----	6.3	-----	74	43	-----	165	7.2	5
Little Neshaminy Creek at Rushland																					
Oct. 22, 1964	4.12	11	9.5	0.02	0.00	38	13	50	7.3	115	63	59	0.1	20	328	149	55	14.3	548	7.4	17
Apr. 8, 1965	58	9	10	.03	.00	21	7.5	15	2.2	42	46	18	.2	15	156	84	49	12.5	263	6.9	9

TABLE 1.—*Miscellaneous analyses of streams in the Neshaminy Creek basin 1944–69*—Continued

Date of collection	Mean discharge (cfs)	Temperature ° C	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180° C)	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: Noncarbonate	DO	Specific conductance (micromhos at 25° C)	pH	Color
Neshaminy Creek at Rushland (below Little Neshaminy Creek)																					
Oct. 22, 1964	6.5	12	3.5	0.01	0.00	38	15	59	8.3	127	77	68	0.1	13	363	157	53	15.6	611	7.4	17
Apr. 8, 1965	145	9	6.3	.03	.01	22	8.3	16	2.2	48	50	22	.2	11	166	89	50	14.4	283	7.0	12
Oct. 18, 1968		17	7.6	.01	.00	38	12	58	8.7	124	62	61	.2	17	324	145	43		558	8.1	14
Mill Creek at Rushland																					
Oct. 23, 1964	0.97	8	7.3	0.00	0.00	28	14	10	3.0	124	32	14	0.1	1.4	174	128	26	10	305	7.6	8
Apr. 8, 1965	23	12	8.8	.01	.00	20	9.5	7.4	1.7	62	32	12	.2	9.8	136	89	38	12.9	226	7.2	8
Oct. 18, 1968		17	7.2	.00	.00	24	11	7.4	2.8	114	18	8.5	.1	1.0	148	105	12		267	7.2	8
Neshaminy Creek near Penns Park																					
Oct. 23, 1964	8.62	12	3.8	0.03	0.00	37	14	52	8.4	125	65	59	0.1	13	336	150	48	11.3	565	7.4	17
Apr. 8, 1965			7.6	.04	.00	21	8.5	13	2.2	47	45	18	.2	12	162	88	49	11.5	270	7.1	8
Newtown Creek at Newtown																					
Oct. 23, 1964	0.27	12	15	0.00	0.00	31	13	13	2.8	120	33	13	0.1	12	190	131	33	12.3	316	7.7	9
Apr. 8, 1965	6.95	13	11	.02	.00	18	7.5	10	2.2	35	47	12	.1	7.8	136	76	48	12.1	221	7.0	7
Oct. 18, 1968		23	8.6	.00	.00	31	15	12	3.4	150	28	12	.2	.3	174	139	16		321	8.4	4
Core Creek near Langhorne																					
Oct. 23, 1964		9						14		65	24	10		11		72	19		208	7.8	10
Apr. 12, 1965	12.6	14	15	0.06	0.03	16	6.6	10	1.9	30	39	11	0.1	16	128	67	43	11.2	201	6.9	7

Mill Creek near Langhorne																					
Apr. 12, 1965	19.2	12	7.9	0.05	0.11	18	6.1	10	1.9	40	36	14	0.1	8.7	120	70	37	12.1	206	7.2	10
Neshaminy Creek near Langhorne																					
July 26, 1944	22.8	27	9.0	0.01		16	6.1	9.8		59	23	7.9	0.1	3.4	109	65	17		180	7.2	9
Apr. 3, 1945	186	19	6.7	.08	0.00	14	5.4	12		45	29	8.5	.0	5.0	104	57	20		171		12
Nov. 15, 1946	34									79	21	13		1.7		93	28		233	7.8	8
Dec. 16, 1946	28									73	30	14		7.4		92	32		241	8.0	7
Jan. 24, 1947	190									34	40	8.0		8.6		81	53		192	7.2	25
Feb. 28, 1947	74			.08		17	7.0	8.4		44	30	10		9.9		71	35		194	7.3	8
May 9, 1947	356			.12		15	5.8	9.1		37	35	7.0		5.6		61	31		168	7.3	12
June 12, 1947	172			.12		16	5.9	8.0		44	31	6.0		6.0		64	28		172		10
July 18, 1947	85			.10		17	7.4	11		60	27	11		5.0		73	24		213	6.9	7
Aug. 16, 1947	54			.10		17	6.9	11		56	29	12		1.9		71	25		199	7.3	7
Sept. 26, 1947	55									59	28	12		4.6					203	7.0	12
Oct. 30, 1947	123	15		.30		15	6.0			50	31	10		5.4		62	21		197	7.0	55
Dec. 9, 1947	146	3		.04		16	8.1	5.9		39	33	9.0		8.6		73	41		187	7.3	4
Jan. 14, 1948	502	1		.07		15	7.3	3.4		28	33	8.0		7.6		67	44		165	7.2	8
Feb. 19, 1948	2,110	3		.31		9.6	4.6	2.8		16	23	4.0		7.6		43	30		107	6.1	30
Mar. 25, 1948	475	14		.15		16	6.6	7.0		34	36	8.0		6.9		67	39		175	7.1	3
Apr. 30, 1948	153	14		.14		16	6.3	7.5		44	29	8.0		5.6		66	30		184	7.6	2
June 4, 1948	211	17		.15		17	6.6	6.4		44	29	9.0		5.6		70	34		179	7.5	3
July 12, 1948	96	27	9.4	.03		15	5.7	12		48	29	8.5	.1	6.0	112	61	22		183	7.5	4
Aug. 13, 1948	246	25		.12		17	7.3	5.5		54	22	9.5		4.6		72	28		197	7.1	5
Oct. 15, 1948	28	13		.18		18	7.7			69	44			1.2		77	20		232	7.2	9
Mar. 15, 1949	245	6	11	.02		15	9.6			34	35	9.0		9.1		77	49		177	7.1	4
Apr. 5, 1949	227		10	.15		14	6.0	9.7		36	35	7.0	.0	6.1	111	60	30		173	7.3	7
May 26, 1949	279	17	8.0							39	30	6.2		5.0					169	6.6	16
June 24, 1949	42	24	15	.01		16	9.6			58	28	13		6.5		79	32		202	7.1	16
July 29, 1949	100	28	2.2	.15		12	5.6	8.0		38	21	9.0		5.8		53	22		141	7.4	35
Aug. 19, 1949	29	25	7.0	.07		17	7.0	14		65	30	10	.1	3.2	139	71	18		207	7.3	10
May 19, 1950	680	13	8.4	.22		14	5.8	10		42	31	7.1	.2	5.4	116	59	24		174	6.9	26
June 8, 1950	129		7.4	.12		16	6.4	7.6	2.0	47	34	7.4	.2	4.1	125	66	28		184	8.3	12
June 23, 1950	74	22	4.1	.22		17	6.8	9.8	2.2	59	31	10	.1	2.9	121	70	22		209	7.7	7
July 28, 1950	67	25	5.6	.14		16	5.7	12		51	31	9.2	.2	3.4	117	63	22		191	7.8	8
Aug. 16, 1950	46	23	5.4	.13		15	5.7	10	2.6	33	30	8.1	.1	3.6	106	61	17		174	8.4	12
Jan. 8, 1957	120							18		41	38	12		14		62	29		221	6.3	2
Oct. 8, 1957	10							23		73	29	25		1.6		76	16		268	6.7	7
Apr. 23, 1959	160	12	2.6	.00	.00	17	7.7	11	1.5	48	36	12	.1	6.8	130	74	35		210	6.3	3
Oct. 23, 1959	73	12	9.4	.00	.00	21	10	14	2.8	70	40	18	.1	6.8	165	94	36		270	7.1	5
Apr. 25, 1960	148		1.4	.32	.01	18	8.0	12	2.2	51	37	12	.1	8.6	136	78	36		220	7.1	8
Sept. 17, 1964	22							34		94	39	36		5.4		109	23		357	7.4	8
Oct. 23, 1964	16	11	6.2	.00	.00	31	10	35	5.6	100	47	42	.1	8.8	253	119	37	12.8	425	7.4	15

TABLE 1.—*Miscellaneous analyses of streams in the Neshaminy Creek basin 1944–69*—Continued

Date of collection	Mean discharge (cfs)	Temperature ° C	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue on evaporation at 180° C)	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: Noncarbonate	DO	Specific conductance (micromhos at 25° C)	pH	Color
Neshaminy Creek near Langhorne—Continued																					
Jan. 6, 1965	112	2						19		50	48	22		17	184	94	53		297	6.9	5
Feb. 10, 1965	693	3	11	.00	.00	18	7.3	9.8	2.5	28	43	16	.0	13	154	75	52		221	6.7	7
Mar. 10, 1965	267		11	.00	.00	20	8.3	13	2.4	39	46	17	.0	13	159	84	52		248	6.9	6
Apr. 12, 1965	236	12	7.1	.06	.03	20	8.3	10	2.6	47	40	15	.1	10	146	84	46	12.8	246	6.9	10
Apr. 14, 1965	190	12	18	.00	.00	21	7.3	13	2.5	[1]49	45	16	.0	6.8	170	83	38		251	8.6	5
May 25, 1965	51	19						28		83	42	33		4.4	205	100	32		306	7.1	15
July 4, 1965	23							26		82	43	24		7.9	206	96	29		346	6.9	10
Aug. 6, 1965 [1]	26	23						26		85	40	29		2.7		98	29		319	6.7	10
Oct. 11, 1965	35		7.7			24	8.4	26		82	47	30		8.6	229	95	28		340	6.8	8
Jan. 25, 1966	36		11			28	10	26	3.8	74	51	34	.3	15	231	111	51		380	7.0	10
Mar. 7, 1966	426							12		31	47	15		13		80	55		241	6.6	18
Apr. 25, 1966	90		5.5			23	8.6	21	3.2	64	45	28	.2	8.9	183	93	41		307	6.9	10
May 23, 1966	290							15		50	44	16		6.1		81	40		242	6.7	25
June 21, 1966	48		3.6			24	8.6	20	3.0	76	41	25	.1	5.0	176	96	33		285	7.2	15
July 13, 1966	16							33		95	41	34		2.9		100	22		335	7.7	15
Sept. 14, 1966	92							26		80	34	30		.0		86	21		295	7.1	3
Oct. 20, 1966	1,770		10	.01	.00	17	6.7	7.5	4.2	32	40	11	.3	11	151	70	44		202	6.3	20
Dec. 3, 1966	124	1	14	.00	.00	26	10	18	3.1	59	55	25	.2	12	215	106	58		315	6.8	7
Jan. 18, 1967	397	2	11	.00	.00	24	9.2	13	2.4	39	48	18	3.6	16	174	98	66		255	6.4	5
Feb. 27, 1967	150		11	.00	.00	25	9.0	17	2.3	45	48	32	.0	14	195	100	63		308	7.1	12
Mar. 22, 1967	422	4	11	.00	.00	20	8.0	16	2.0	37	44	20	.1	14	173	83	53		251	6.8	5
May 4, 1967 [1]	190	16						14		61	42	20		.2		92	42		267	6.8	8
June 16, 1967	61	23						17		88	43	22		7.8		118	46		310	7.3	12
Sept. 7, 1967	115	22						17		67	40	20		11		97	42		272	7.0	8
Oct. 6, 1967	51		11			24	8.8	18	3.9	71	40	21		8.2		96	38		300	7.0	5
Aug. 27, 1968	33					31	11	33		104	49	38		6.6		105	38		414	7.3	4
Oct. 18, 1968			5.5	.01	.01	31	11	38	6.2	104	48	46	.2	6.1	254	123	38		425	8.0	8
Jan. 11, 1969	157					28	10	14		54	46	22		22		111	67		306	6.7	2
Feb. 18, 1969	64	1				29	11	37		68	55	47		22		118	62		418	6.8	4

[1] Includes equivalent of 5 mg/l of carbonate (CO_3).

Pine Run near Langhorne																					
Oct. 23, 1964	0.34	10	15	0.00		16	5.1	14	28	48	30	12		5.8	133	61	22	11.5	204	6.9	8
Apr. 12, 1965	3.2	14	16	.06	0.00	16	4.9	10	1.6	26	35	12	0.1	10	116	60	39	11.0	189	6.7	8
Neshaminy Creek at Hulmeville																					
July 22, 1948		27		0.08		16	6.6	13		55	27	12		6.2	123	67	22		197	6.8	5
Apr. 5, 1949	240	11		.15		14	6.4	9		34	33	9.0		7.4		61	33		167	7.2	6
Neshaminy Creek at Newportville																					
Oct. 28, 1953								9.8		57	25	14		3.4	129	74	24		206	7.0	
Aug. 25, 1954	23.5		3.4	0.14		10	2.7	10		22	22	6.5		6.9	101	36	18		129	7.4	
Neshaminy Creek near Oakford																					
Oct. 30, 1956								11		58	36	12		6.5		84	36		23.4	6.8	
Neshaminy Creek at Croydon																					
July 12, 1948		26	8.6	0.03		14	5.8	12		48	27	8.2	0.1	6.9	111	59	19		181	7.5	4
Apr. 5, 1949	250		11	.09		14	5.9	8.6		34	33	7.0	.2	6.6	111	59	31		169	7.0	9
Oct. 18, 1968		20	2.2	.00	0.00	19	6.2	12	2.8	46	35	14	.2	9.8	127	73	36		225	7.9	8

The principal tributary to the Little Neshaminy Creek is Park Creek, which drains 11.8 square miles. The estimated average annual minimum discharge of Park Creek near Warrington, for 7 consecutive days during a 10-year recurrence interval, was 3.0 cfs or 1.94 mgd (Busch and Shaw, 1966). A sewage treatment plant at the Willow Grove Naval Air Station feeds effluent into Park Creek.

NESHAMINY CREEK AT RUSHLAND

Below the confluence of the Neshaminy with the Little Neshaminy at Rushland, the main stream drains 134 square miles, approximately 57 percent of the main stream's drainage area. The average discharge of Neshaminy Creek at Rushland for 32 years of record (1884–1913, 1931–34) was 226 cfs, about 146 mgd. For the period of this record, the maximum discharge of 10,500 cfs occurred September 8, 1934, and the minimum for the same period was 1.0 cfs (table 2). During this time, the average flow of the Neshaminy at Rushland was exceeded at least 20 percent of the time (Busch and Shaw, 1966).

On April 8, 1965, when discharge at Rushland was 145 cfs (64 percent of average flow), the pH was 7.0, and the predominant ions in

TABLE 2.—*Water discharge, Neshaminy Creek at Rushland, 1884–1934*

Year	Water-supply paper	Water year ending September 30				
		Maximum day		Minimum-day discharge (cfs)	Mean discharge	Discharge per square mile
		Discharge (cfs)	Date			
1884	47					
1885	47	4,480	Feb. 10, 1885	1	175	1.31
1886	47	5,770	Feb. 11, 1886	1	248	1.85
1887	47	3,160	June 23, 1887	2	211	1.57
1888	47	4,890	Jan. 1, 1888	6	259	1.93
1889	47	5,530	July 31, 1889	38	321	2.40
1890	47	3,750	Oct. 27, 1889	10	269	2.01
1891	47	3,280	Aug. 24, 1891	14	252	1.88
1892	47	3,580	Jan. 13, 1892	3	183	1.37
1893	47	3,150	May 4, 1893	4	232	1.73
1894	47	9,010	May 21, 1894	5	[1] 265	[1] 1.98
1895	47	3,230	Apr. 9, 1895	4	224	1.67
1896	47	3,710	Feb. 6, 1896	4	147	1.10
1897	47	4,680	June 9, 1897	19	204	1.52
1898	47	5,080	Feb. 20, 1898	6	207	1.54
1899	47	3,950	Feb. 27, 1899	6	268	2.00
1900	47	3,990	May 19, 1900	5	186	1.39
1901	65	4,620	Mar. 11, 1901	8	191	1.43
1902	82	6,060	Feb. 26, 1902	12	260	1.94
1903	97	4,980	Feb. 28, 1903	11	307	2.29
1904	125	6,980	Oct. 9, 1903	15	268	2.00
1905	166	4,060	Jan. 7, 1905	6	206	1.54
1906	202	3,050	Mar. 4, 1906	14	227	1.69
1907	241	4,630	Sept. 29, 1907	13.5	253	1.89
1908	241	3,060	Dec. 23, 1907	15.0	289	2.16
1909	261	3,760	Feb. 24, 1909	8.0	178	1.33
1910	281	3,540	Mar. 1, 1910	7.2	185	1.38
1911	301	5,330	Aug. 31, 1911	6.7	156	1.16
1912	381	4,070	Mar. 13, 1912	10	258	1.93
1913	381	3,630	Oct. 24, 1912	7	239	1.78
1932	726, 1432	[2] 5,960	Mar. 28, 1932	2.0	[2] 90.0	[2] .672
1933	714	8,100	Aug. 24, 1933	1.4	294	2.19
1934	756	10,500	Sept. 8, 1934	7.5	166	1.24

[1] Corrected.
[2] Revised.

solution (calcium and sulfate) made up 43 percent by weight of the dissolved solids. Dissolved oxygen was 14.4 mg/l, more than 100 percent saturation, and the water was moderately hard (89 mg/l). On the same day, water in the Neshaminy upstream at Penns Park and in the Little Neshaminy at Rushland was also a calcium sulfate type. Water in the Little Neshaminy and in the Neshaminy at Rushland above and below the confluence of these streams has essentially the same composition, as shown by the similar patterns in figure 4.

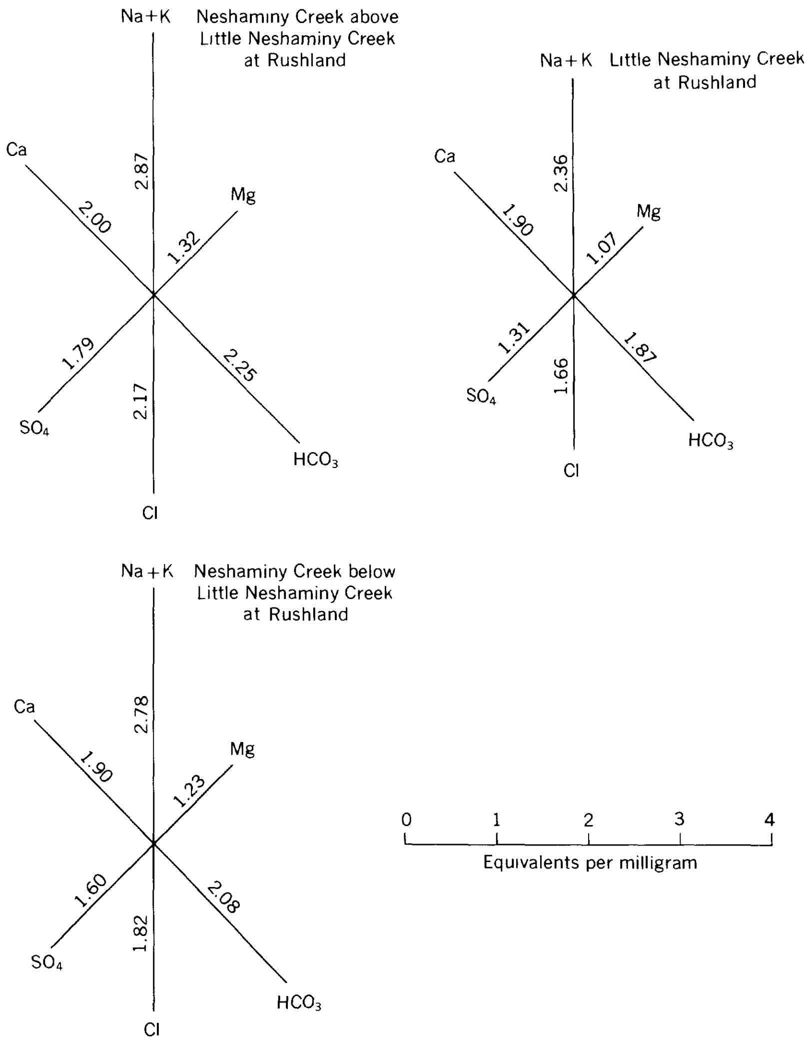


FIGURE 4.—Stream chemical analyses, Neshaminy Creek basin, Rushland, August 22, 1964.

During low flow at Rushland, which usually occurs in summer and early fall, the Neshaminy water is a sodium bicarbonate ($NaHCO_3$) type, and the dissolved solids are more concentrated than during the other seasons, when discharge is higher. The pH on October 22, 1964, and October 18, 1968, was 7.4 and 8.1, respectively. The predominant ions (sodium and bicarbonate) on October 18, 1968, represented 56 percent of the dissolved solids by weight, and the water was hard (145–157 mg/l). The chemical composition of the Neshaminy at Penns Park and the Little Neshaminy at Rushland during October 1964 did not differ significantly from that of the Neshaminy at Rushland on October 18, 1968.

A small stream, Mill Creek, enters Neshaminy Creek at Rushland. The stream is an extension of Lahaska Creek, which is often dry. On April 8, 1965, the flow of Mill Creek at Rushland was 23 cfs or 14.9 mgd. When there was a measurable discharge, the water was a calcium bicarbonate type.

NESHAMINY CREEK—RUSHLAND TO LANGHORNE

Between Rushland and Langhorne the Neshaminy drains an area of 76 square miles. At Langhorne the average discharge of the stream is 18 percent greater than that at Rushland. Two small tributaries, Newtown and Core Creeks, enter the Neshaminy from the north, between Rushland and Langhorne. The streams drain a combined area of about 27 square miles. Parts of both streams have no flow at times. During a time of measurable discharge (6.95 cfs at Newtown Creek and 12.6 cfs at Core Creek in April 1965), water from both streams, the calcium sulfate type, was moderately hard (76 and 67 mg/l, respectively). However, during a base flow on October 23, 1964, water from Newtown Creek was a hard (131 mg/l) calcium bicarbonate type, while water from Core Creek was a moderately hard (72 mg/l) sodium bicarbonate type.

NESHAMINY CREEK NEAR LANGHORNE

Neshaminy Creek near Langhorne drains 210 square miles. The average discharge here for 35 years of record (1934–69) was 265 cfs or 173 mgd. The maximum discharge of the Neshaminy at Langhorne was 49,300 cfs on August 19, 1955; the minimum of 1.9 cfs occurred September 8, 1957. These statistics were obtained from "Water Resources Data for Pennsylvania—Part 1, Surface Water Records" for water year 1970 (available from the U.S. Geological Survey, Harrisburg, Pa.). The flow in the Neshaminy at Langhorne either equals or exceeds 120 cfs 50 percent of the time. About 25 percent of the time, it equals or exceeds the average flow.

The dissolved minerals in the water are commonly at a minimum concentration during the high-flow periods, winter and early spring. Conversely, dissolved solids are generally at a maximum concentration during summer and early fall, when flow is low.

The Neshaminy near Langhorne contains a calcium-sodium sulfate-bicarbonate type water. During low flow the predominant ions are usually calcium, sodium, bicarbonate, and sulfate. Either calcium or sodium, combined with bicarbonate, comprises about 40 percent of the weight of the dissolved solids. At Langhorne, Neshaminy Creek water is soft to moderately hard, depending on the discharge–dissolved-solids relationship. At high flow the water is soft, whereas during low flow it becomes moderately hard.

The dissolved-solids concentration in Neshaminy Creek at Langhorne can be estimated by its specific conductance. Figure 5 shows

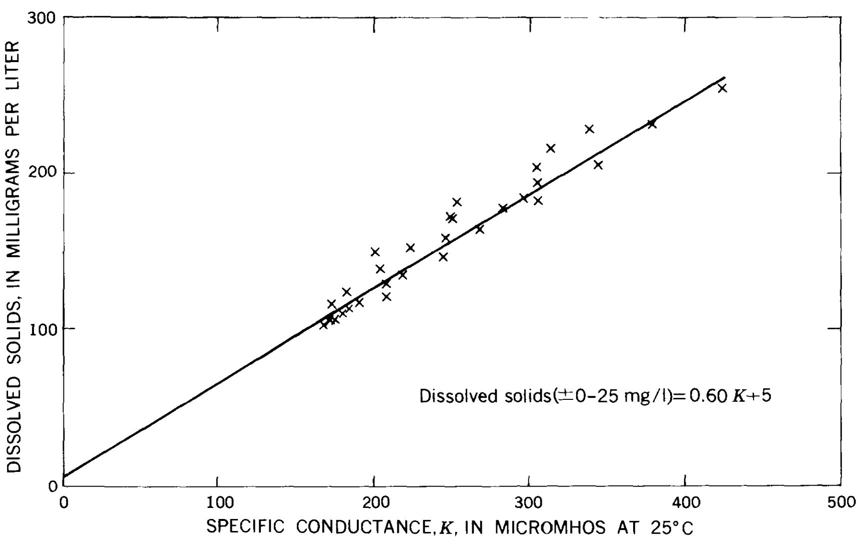


FIGURE 5.—Relationship between dissolved solids and specific conductance, Neshaminy Creek at Langhorne, 1944–69.

the relationship of these variables, where the dissolved solids, in milligrams per liter, are plotted against specific conductance, K, in micromhos at 25°C. The relation of these variables at Langhorne is as follows:

$$\text{Dissolved solids } (\pm 0\text{–}25 \text{ mg/l}) = 0.60K + 5$$

Analysis of Neshaminy Creek water at Langhorne was begun in July 1944 and continued intermittently, during varying flow conditions, through August 1950. There were no analyses done during 1951–56, 1958, or 1961–63. However, from September 1964 to September 1969, monthly and intermittent samples were analyzed. (See table 3.)

The analytical record for these periods shows that, during the first 6 years of record, specific conductance did not exceed 250 micromhos, but, in October 1964 and 1968, specific conductance reached 425 micromhos. (See fig. 6.) In general the specific conductance of

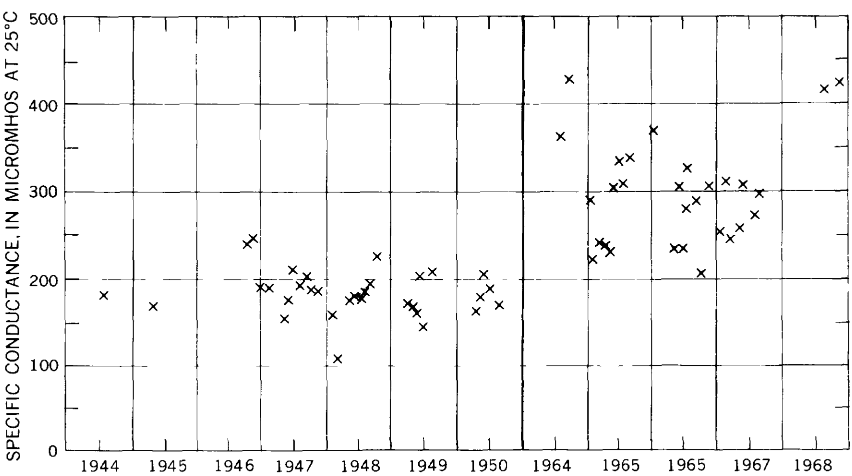


FIGURE 6.—Specific conductance prior to 1950 and during the drought of the 1960's, Neshaminy Creek near Langhorne.

Neshaminy water increased during the 1964–68 period, a fact which indicates a trend of increasing dissolved-solids content. Also, within the same period, the later analyses of the Neshaminy from Langhorne show an increase in the proportion of water-hardness ions (and other ions) to dissolved solids.

The increase of dissolved-solids content in the Neshaminy during the 1964–66 period can be attributed partly to the critical drought of the 1960's, which affected the Northeastern United States from New England to Virginia and from the Atlantic coast to Ohio. Water shortages were particularly evident in the Delaware River basin (Keighton, 1969), as water in the river, reservoirs, and the ground was depleted to subnormal levels. Streams had insufficient water to effectively dilute normal input of sewage and industrial wastes and, as a result, stream quality deteriorated.

Although the increase of dissolved solids in the Neshaminy during the 1964–66 period can be identified with low streamflow and drought, there is evidence that other conditions are causing dissolved solids to increase. Urbanization and the accompanying increased use of the stream for domestic and industrial supply and as a carrier of waste discharges are contributing factors. The cultivation of land in the drainage basin and the use of fertilizers are also increasing the stream's dissolved-solids load by adding nitrate and other solutes. Comparison of the water quality in the main stream at Langhorne during the 1957–69 period to that of the earlier period (1944–50) shows that the mean concentrations of sulfate, chloride, sodium, and nitrate ions and hardness increased by about 57 percent. (See table 3.)

TABLE 3.—*Mean concentrations of mineral constituents, in milligrams per liter, Neshaminy Creek near Langhorne*

	1944–50	1957–69
Sulfate	30	43
Chloride	9.0	24
Hardness	68	94
Sodium	8.7	20
Nitrate	5.4	9.4

SEDIMENTATION

Sediment in water is the aftermath of normal erosion of the land surface by water, ice, and wind. Suspended sediment must be precipitated by chemicals or removed by filtration before water can be used for drinking and most other beneficial purposes.

At the time the sediment samples are taken, the sediment load carried by a stream can be calculated from the suspended-sediment and water-discharge measurements. The average annual sediment load of a stream can be estimated by determining the sediment concentration on intermittent samples and by computing the results from a load-discharge curve. The relation of sediment load to water discharge at the Neshaminy Creek near Langhorne is shown in figure 7. The computation of the average annual sediment load for Neshaminy Creek at Langhorne (1957–58) was 267 tons per square mile. (See table 4.) By comparison, the annual sediment load for the Delaware River at Trenton, based on the 1950–57 suspended load and allowing for the bedload, was 163 tons per square mile (Wark, 1962). The higher sediment yield from Neshaminy Creek can be attributed to the higher percentage of land cultivated in the Neshaminy Creek basin.

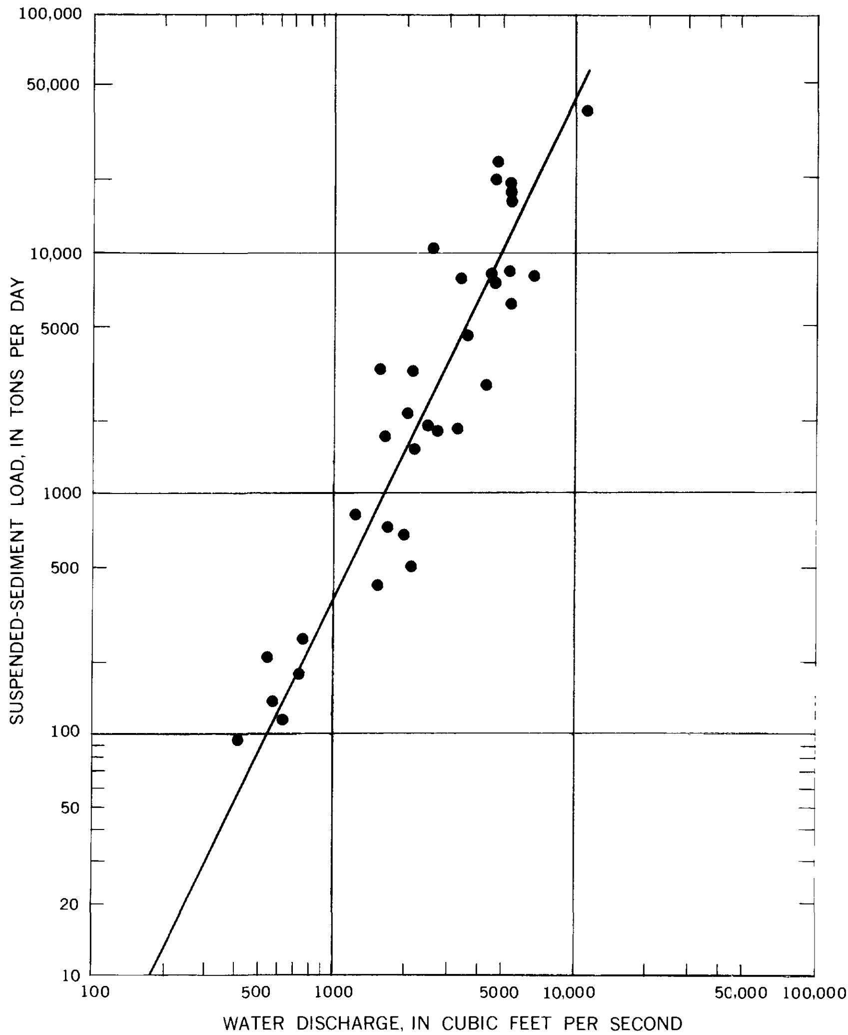


Figure 7.—Relation of sediment load to water discharge, Neshaminy Creek near Langhorne, 1957–58 (Wark, 1962).

TABLE 4.—*Computation of average annual sediment load, Neshaminy Creek near Langhorn, 1957–58*

[Wark (1962)]

Percentage limits	Percentage interval	Percentage midordinate	Stream discharge (cfs)	Sediment load (tons per day)	Percentage interval times sediment load (tons per day)
0.00–0.75	0.75	0.375	5,000	10,000	75.0
0.75–1.5	.75	1.125	2,780	2,900	21.8
1.5–3.5	2.0	2.5	1,600	930	18.6
3.5–7.5	4.0	5.5	900	285	11.4
7.5–15	7.5	11.25	530	92	6.9
15–25	10	20	328	32	3.2
25–35	10	30	220	15	1.5
35–45	10	40	158	7	.7
45–55	10	50	115	3	.3
55–65	10	60	85	1.7	.2
65–75	10	70	60	.8	.1
75–85	10	80	41	.3	
85–95	10	90	23		
95–100	5	97.5	14		
Total					139.7

NOTES.—
Average annual suspended load = 365×139.7 = 50,990 tons per year.
Add 10 percent for bedload = 5,099 tons per year.

Total 56,089 tons per year.

Average annual load $= \frac{56,089 \text{ tons}}{210 \text{ sq mi}} = 267$ tons per sq mi.

SUMMARY

Geology, topography, precipitation, runoff, vegetation, and land and water use are the environmental factors that cause the water of Neshaminy Creek and its tributaries to differ between places and from time to time. The water in the Neshaminy drainage system is also affected by the discharge of effluents from sewage-treatment plants. In the Neshaminy headwaters, during low flow, significantly high concentrations of solutes are common to the West Branch Neshaminy at Chalfont and to Cooks Run near New Britain. Water from both streams is the sodium chloride type. During low discharge in the main stream, sodium ions are in the water as far downstream as Rushland, slightly past the halfway point of the Neshaminy Creek drainage system. Near Rushland the dominant anion, chloride, is replaced by bicarbonate. The bicarbonate-bearing streams that are tributaries of the Neshaminy above or at Rushland are the North Branch Neshaminy Creek, Pine Run, Little Neshaminy Creek, and Mill Creek.

When discharge is above average in the Neshaminy headwaters, calcium, sulfate, and bicarbonate ions normally predominate throughout the length of the stream. At Langhorne, which is about 12 stream miles from the mouth, the average discharge is 265 cfs, or 173 mgd, and the water is a calcium-sodium bicarbonate type or a calcium sulfate-bicarbonate type, depending usually on the rate of discharge. The specific-conductance and water-hardness ranges at Langhorne for the period of record were, respectively, 107–425 micromhos and 43–123 mg/l, the medians being 224 micromhos and 80 mg/l. The pH, having a median of 7.1, ranged from 6.1 to 8.6.

The urbanization of some areas in Bucks County may introduce changes that will influence the area's hydrology, particularly the quality of water, significantly. For example, natural storm-runoff drainage patterns are often altered by urbanization, and the risks of pollution from domestic and industrial wastes become greater. The upturning of soil to make way for new highways, airports, shopping centers, and other public improvements in the drainage area of Neshaminy Creek may affect the quality of the main stream by increasing its sediment load. The continued use of fertilizers and chemicals to control parasitic infestations of fruit trees and crops in agricultural areas adjacent to Neshaminy Creek is also likely to affect the chemistry of surface water, especially after storms and rapid runoff.

The dissolved-solids content in Neshaminy Creek at Langhorne is increasing. The trend of changing quality became noticeable during the early 1960's, when water supplies in the Northeastern United States were reduced to critically low levels by drought. The quality of the stream was adversely affected by the lack of flow for flushing and dilution of effluents that came from treated or untreated sewage and industrial wastes. Nevertheless, large areas of water in the Neshaminy Creek drainage system are commonly of good quality, requiring only a moderate amount of treatment to prepare it for domestic and industrial use. The stream, the habitat of several species of game fish, provides good potential for the development of water recreation.

Neshaminy Creek adds much to the historically rural appeal of Bucks County, where organized groups such as the Neshaminy Valley Watershed Association, Inc., make clearly evident a purpose to preserve some of the natural scene. Through their efforts, an increasing number of visitors from the metropolitan areas of Philadelphia, Trenton, and New York enjoy the open space and wooded areas, the system of reservoirs for water supply and recreation, the new marina and parks, and the historical landmarks in Bucks County.

REFERENCES

American Water Works Association, 1950, Water quality and treatment [2d ed.] : New York, 451 p.

Baumann, D. D., 1969, Perception and public policy in the recreational use of domestic water supply reservoirs: Am. Geophys. Union Water Resources Research, v. 5, no. 3, 204 p.

Bourquard, E. H., and associates, 1966, Water resources study, Neshaminy Creek basin, Pennsylvania: Harrisburg, Pennsylvania Dept. Forests and Waters, Water Resources Bull. 2,

Busch, W. F., and Shaw, L. C., 1961, Floods in Pennsylvania, frequency and magnitude: U.S. Geol. Survey open-file report, 231 p.

——— 1966, Pennsylvania streamflow characteristics, low-flow frequency and flow duration: Harrisburg, Pennsylvania Dept. Forests and Waters, Water Resources Bull. 1, 289 p.

California State Water Pollution Control Board, 1963, Water quality criteria: Pub. 3A, 548 p.

Durfor, C. N., and Becker, Edith, 1964, Public water supplies of the 100 largest cities in the United States, 1962: U.S. Geol. Survey Water-Supply Paper 1812, 364 p.

Gray, Carlyle, and others, 1960, Geologic map of Pennsylvania: Pennsylvania Geol. Survey, ser. 4.

Greenman, D. W., 1955, Ground water resources of Bucks County, Pennsylvania: Pennsylvania Geol. Survey Bull. W–11, 66 p.

Keighton, W. B., 1969, Water quality in the Delaware estuary for two years drought, 1965 and 1966, from Trenton, N.J., to Reedy Island, Del.: U.S. Geol. Survey Hydrol. Inv. Atlas HA–335.

Lear, John, 1969, New facts on fluoridation: Saturday Rev. March 1; v. 52, no. 9, p. 51–56.

McCarren, E. F., 1967, Chemical quality of surface water in the Allegheny River basin, Pennsylvania and New York: U.S. Geol. Survey Water-Supply Paper 1835, 74 p.

Miller, Arthur, 1962, Water and man's health: Washington, D.C., Agency for Internat. Devel., Office of Human Resources and Social Devel., 92 p.

Pennsylvania Bureau of Statistics, 1965, 1965 Industrial directory of the Commonwealth of Pennsylvania [17th ed.] : Pennsylvania Dept. Int. Affairs, 511 p.

Pennsylvania Fish Commission, 1969, Fisherman's Guide: 41 p.

Rima, D. R., Meisler, Harold, and Longwill, Stanley, 1962 Geology and hydrology of the Stockton formation in southeastern Pennsylvania: Pennsylvania Geol. Survey Bull. W–14, Ser. 4, 111 p.

U.S. Army Corps of Engineers, 1965, Flood-plain information report on Neshaminy Creek, Bucks County, Pa.: U.S. Army Corps of Engineers, Philadelphia District, 29 p.

——— 1967, Water resources development by the U.S. Army Corps of Engineers in Pennsylvania: U.S. Army Corps of Engineers, North Atlantic Div., 102 p.

U.S. Public Health Service, 1962, Drinking water standards, 1962: U.S. Public Health Service Pub. 956, 61 p.

Wark, J. W., 1962, *in* Report on the comprehensive survey of the water resources of the Delaware River basin: Appendix H, Fluvial sediment, U.S. Army Corps of Engineers, Philadelphia District, 276 p.

U.S. GOVERNMENT PRINTING OFFICE:1972 O—444-540

Contributions to the Hydrology of the United States, 1970

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1999

This volume was published as separate chapters A–O

UNITED STATES DEPARTMENT OF THE INTERIOP

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

CONTENTS

[Letters designate the separately published chapters]