SUMMARY OF GEOLOGY AND GROUND-WATER RESOURCES OF PASSAIC COUNTY, NEW JERSEY

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 76–75

Prepared in cooperation with

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION, DIVISION OF WATER RESOURCES

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CONVERSION FACTORS

Factors for converting English units to metric units are shown to four significant figures. However, in the text the metric equivalents are shown only to the number of significant figures consistent with the values for the English units.

English	Multiply by	Metric
feet (ft)	0.3048	metres (m)
cubic feet per second (ft^3/s)	.02832	cubic metres per second (m^3/s)
gallons (gal)	3.785	litres (l)
gallons per minute (gal/min)	.06309	litres per second (l/s)
gallons per minute per foot [(gal/min)/ft]	.2069	litres per second per metre [(l/s)/m]
million gallons per day (Mgal/d)	.04381	cubic metres per second (m^3/s)
inches (in)	25.4	millimetres (mm)
square miles (mi^2)	2.590	square kilometres (km^2)
miles (mi)	1.609	kilometres (km)

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ABSTRACT

Ground water in Passaic County occurs in intergranular openings of unconsolidated stratified deposits of Quaternary age and in joints and fractures in consolidated rocks of Precambrian, Paleozoic, and Triassic age.

The Brunswick Formation of Triassic age is the most important aquifer in the southeastern one-third of Passaic County. Reported yields of public supply and industrial wells range from 50 to 510 gallons per minute (3 to 32 litres per second) and the median yield is 130 gallons per minute (8 litres per second). Most of these wells are 200 to 400 feet (61 to 122 metres) deep. The median yield of all public supply and industrial wells over 300 feet (91 metres) deep and 8 inches (203 millimetres) or larger in diameter is 230 gallons per minute (15 litres per second). Crystalline rocks of Precambrian age are the major source of ground water for domestic use in the northwestern two-thirds of Passaic County. Reported well yields range from 1 to 200 gallons per minute (.06 to 13 litres per second). The median reported yield of domestic wells is 5 gallons per minute (.31 litres per second) and that of public supply wells is 30 gallons per minute (2 litres per second).

Other consolidated rocks--rocks of Paleozoic age and the Watchung Basalt of Traissic age--are utilized primarily for domestic water supplies in Passaic County. Reported yields of wells tapping the Paleozoic rocks range from less than 1 to 35 gallons per minute (.06 to 2 litres per second) and the median yield is 10 gallons per minute (.63 litres per second). Reported yields of domestic wells tapping the Watchung Basalt range from less than 1 to 40 gallons per minute (.06 to 3 litres per second) and the median yield is 12 gallons per minute (.76 litres per second). However, reported yields of nine industrial and commercial wells range from 50 to 180 gallons per minute (3 to 11 litres per second).

Unconsolidated stratified deposits of Quaternary age are locally an important source of ground water for public supply and industrial use in parts of Passaic County. These deposits have not been extensively explored but are potentially an important source of ground water for future development. Reported yields of wells tapping the stratified deposits range from 4 to 920 gallons per minute (.25 to 58 litres per second). The median reported yield of domestic wells is 16 gallons per minute (1 litre per second) and that of public supply and industrial wells is 130 gallons per minute (8 litres per

second. Depths of wells depend upon the thickness of the deposits. Reported depths range from 22 to 170 feet (7 to 52 metres).

The quality of ground water in Passaic County varies from one aquifer to another. Water from the Precambrian rocks is soft to moderately hard (34 to 104 milligrams per litre) and is low in dissolved solids (66 to 159 milligrams per litre). Water from the Brunswick Formation is moderately hard to very hard (89 to 540 milligrams per litre). The dissolved solids content ranges from 129 to 563 milligrams per litre). The occurrence of more highly mineralized water at depth in the Brunswick Formation is indicated by an analysis, made in 1885, of 16,000 milligrams per litre of dissolved solids at a depth of 2,050 feet (625 metres) in a well in Paterson. Water from two wells tapping the Quaternary deposits is moderately hard (65 and 83 milligrams per litre) and has dissolved solids contents of 122 and 133 milligrams per litre).

Water use from both surface and ground-water supplies in Passaic County averaged about 106 million gallons per day (4.6 cubic metres per second) in 1965. Ground water probably accounts for 5 to 10 percent of this total. Ground-water pumpage by the major public supply companies in the county has increased from 2.1 million gallons per day (.09 cubic metres per second) in 1951 to 4.39 million gallons per day (.19 cubic metres per second) in 1968. About 80 percent of the 4.39 million gallons per day (.19 cubic metres per second) was from wells tapping the Brunswick Formation in the southern part of the county.

INTRODUCTION

Purpose and Scope

This is one of a series of County ground-water reports authorized by the Water Supply Act of 1958 and its companion Water Bond Act. These reports present assembled data and interpretation on the availability, occurrence, movement, and chemical quality of ground water in New Jersey. This investigation was made by the U.S. Geological Survey in cooperation with the New Jersey State Department of Environmental Protection, Division of Water Resources. The report was prepared under the supervision of John E. McCall and Harold Meisler, consecutive District Chiefs.

Location and Extent of Area

Passaic County is located in northcentral New Jersey (fig. 1). It is bounded on the north by the State of New York and Bergen County, on the east by Bergen County, on the south by Essex and Morris Counties, and on the west by Sussex County. The county is shaped roughly like an hour glass with the top to the northwest, and the bottom to the southeast. It lies between longitudes 74°06'W and 74°30'W and latitudes 40°48'N and 41°12'N and contains 194 mi^2 (square miles) [502 km^2 (square kilometres)] of land area and 8 mi^2

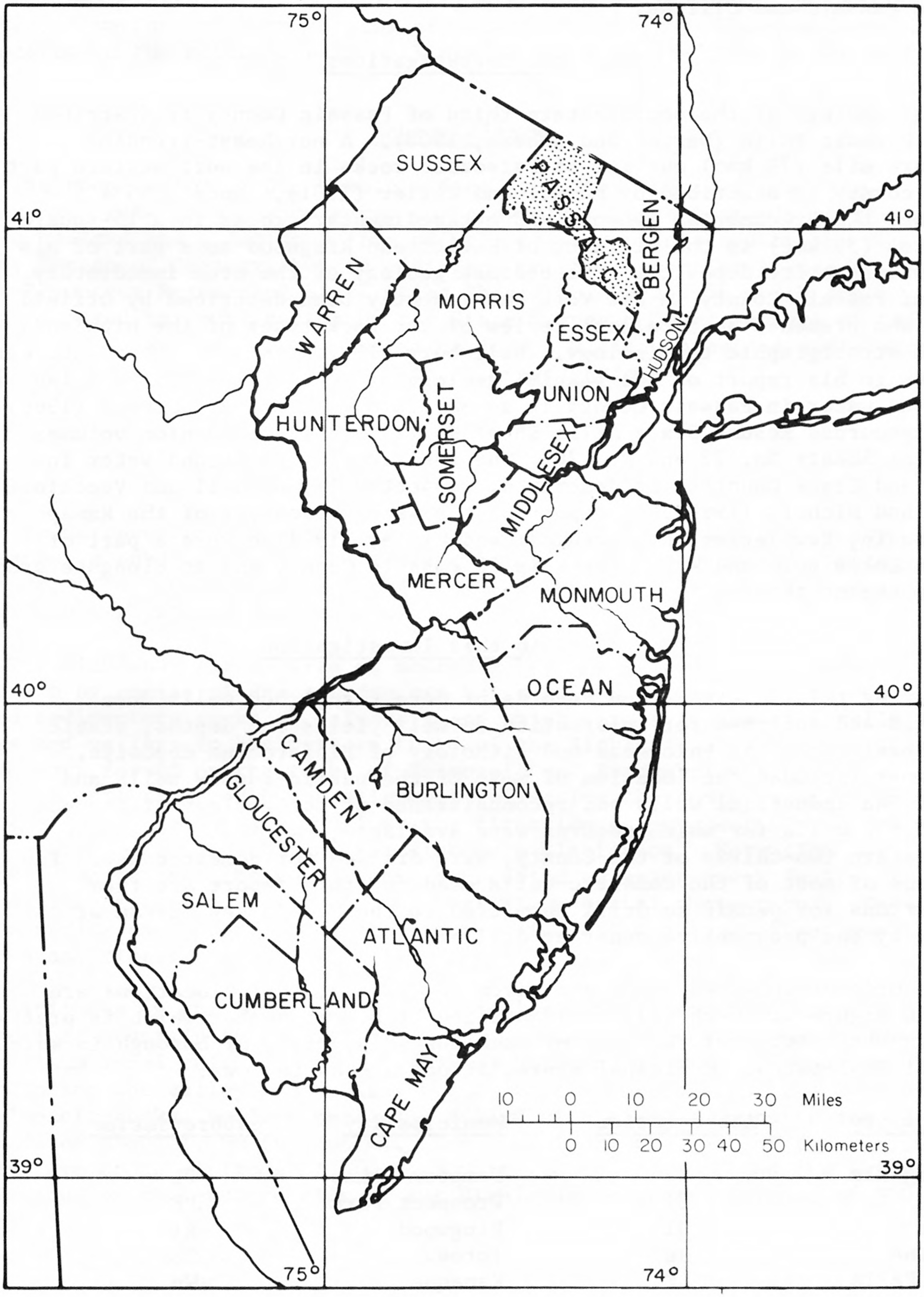

Figure 1.--Map of New Jersey showing location of Passaic County.

(21 km^2) of water. Paterson is the county seat; other major communities include Passaic and Clifton.

Previous Investigations

The geology of the southeastern third of Passaic County is described in the Passaic Folio (Darton and others, 1908). A northeast-trending 30-square mile (78 km^2) outlier of Paleozoic rocks in the northwestern part of the county is described by Kümmel and Weller (1901). Hotz (1953) described the Precambrian igneous and metasedimentary rocks in a 15-square mile area (39 km^2) in the vicinity of Hewitt and Ringwood as a part of his study of magnetite deposits. The bedrock geology of the area immediately north of Passaic County in New York has recently been described by Offield (1967) who presents an excellent review of the rock types of the highlands and the stratigraphic terminology. Salisbury (1902) described the Quaternary deposits in his report on the glacial geology of New Jersey. The availability of ground water in Passaic County is summarized by Widmer and others (1966) in Water Resources Resumé State Atlas Sheet No. 23 and its companion volumes for Atlas Sheets No. 22 and No. 26. The availability of ground water in Morris and Essex Counties is described, respectively, by Gill and Vecchioli (1965) and Nichols (1968). A report on the water resources of the Ramapo River basin, New Jersey, by Vecchioli and Miller (1973) covers a part of Pompton Lakes Boro and Wayne Township in Passaic County and an elongate area just to the northeast of the county.

Methods Used in this Investigation

During this investigation records of more than 1,500 wells were collected and analyzed for information on well yields and depths, static water levels, and the thickness and lithology of Pleistocene deposits. Field work included the location of most of the public-supply wells and many of the industrial wells and reconnaissance of the geology of the county. Many of the wells for which records were available, particularly in the northwestern two-thirds of the County, were drilled for domestic use. The locations of most of the domestic wells used for this report are from applications for permit to drill submitted to the New Jersey Bureau of Geology by the prospective owner or driller.

Records of selected wells are given in table 2; their locations are shown in figure 2. Each well is identified by a well number which is prefixed with an abbreviation of the name of each township, city, or borough in which the well is located. Municipal abbreviations are as follows:

Municipality	Abbreviation	Municipality	Abbreviation
Bloomingdale	Bl	Pompton Lakes	PL
Clifton	Cl	Prospect Park	PP
Haledon	Hl	Ringwood	Ri
Hawthorne	Hw	Totowa	To
Little Falls	LF	Wanaque	Wn
North Haledon	NH	Wayne	Wy
Passaic	Ps	West Milford	WM
Paterson	Pt	West Paterson	WP

The wells within each municipality are numbered serially, generally starting from the northern margins of each municipality. Thus, well Ri-2 is located in the northern part of Ringwood and well Ri-30 is in the southern part.

Acknowledgments

The cooperation of Dr. Kemble Widmer, the State Geologist of New Jersey, is gratefully acknowledged for providing access not only to the well-organized and voluminous file of well records maintained by the New Jersey Bureau of Geology, but in addition, to the manuscript copies of Water Resources Resumés of State Atlas Sheets No. 22 and 26 which are being prepared for publication by the State Survey. Other members of the New Jersey Geological Survey, including Joseph Miller, provided assistance during the data gathering phase of this investigation.

GEOGRAPHY

Topography and Drainage

The northwestern two-thirds of Passaic County is in the New Jersey Highlands, a subdivision of the Reading Prong of the New England physiographic province. The southeastern one-third of the county is the Lowland section of the Piedmont physiographic province.

The Highlands are an area of moderate topographic relief largely underlain by gneiss of Precambrian age but also including an outlier of folded sedimentary rocks of Paleozoic age which form a series of parallel ridges and valleys in the western third of the Highlands area. The ridges and valleys formed on the rocks of Paleozoic and Precambrian age have a prominent northeast-southwest alignment reflecting the dominant structural orientation of the rocks as well as the direction of movement of the ice which overrode the area during the Wisconsin Glaciation. Hotz (1953, p. 159) reports that the topographic expression of major cross faults are well defined trench-like structures apparent on aerial photographs. These faults strike east-west, interrupt minor drainage lines, and offset small valleys and ridges.

Altitudes in the Highlands range from 1,491 ft (feet) [454 m (metres)] on Bearfort Mountain to 200 ft (61 m) on the Wanaque River at Pompton Lakes. The maximum local relief is 850 ft (259 m) between the crest of Bearfort Mountain and the valley immediately to the east. Northwest of the outlier of Paleozoic rocks, valleys partially filled with glacial deposits are at an altitude of about 1,200 ft (366 m). Immediately to the east of the outlier the valleys are at an altitude of 600 to 800 ft (183 to 244 m), and the valley of the Wanaque on the eastern side of the Highlands is at an altitude of 300 ft (91 m).

The Highlands in Passaic County are drained by the Pequannock, Wanaque, and Ramapo Rivers which join to form the Pompton River, a tributary of the Passaic River. A small area in the northwest corner of the County is drained by the northeastward-flowing Long House Creek, a tributary of the northward-flowing Wallkill River.

In the Highlands area, eastward-flowing streams generally have steeper gradients than streams parallel to the regional structure of the Precambrian and Paleozoic rocks. The eastward-flowing streams are presumably controlled by erosion along transverse joints and shear zones associated with cross faults; whereas, the valleys and local topographic lows containing Upper Greenwood Lake, Greenwood Lake, and the lower Wanaque River are all apparently developed along major longitudinal or oblique faults.

The Highlands area in Passaic County is largely developed as a watershed for surface-water supply; approximately one quarter of the land area used for this purpose is municipally owned. This area contains or partially contains Oak Ridge, Clinton, and Charlotteburg Reservoirs, and Echo Lake, which are regulated bodies of surface water in the Pequannock River drainage and are utilized for water supply by the City of Newark. Upper and Lower Greenwood Lakes and Wanaque Reservoir in the Wanaque River drainage are used for surface-water supply by the North Jersey District Water Supply Commission.

The Piedmont Lowland in Passaic County is underlain by igneous and sedimentary rocks of Traissic age. The sedimentary rocks throughout most of the area underlie gently rolling topography one to three hundred feet in altitude. This gently rolling topography is broken by the abrupt arcuate ridges of the First and Second Watchung Mountains and Packanack Mountain which are underlain by three successive sheets of basalt. The highest altitude in the Piedmont area is 885 ft (270 m) on High Mountain, a knob of the Second Watchung Mountain. The lowest altitude is sea level along the tidal portion of the Passaic River on the southeastern boundary of the County. Drainage is to the Passaic River which flows in an irregular but dominantly eastward direction across the Piedmont Lowlands traversing the Watchung Mountains through gaps at Little Falls and Paterson. The Pompton River flows southward from the Highlands across the Piedmont Lowlands joining the Passaic River near Mountain View after passing through a gap in Packanack Mountain. Smaller streams, in general, parallel the ridges of the Watchung Mountains.

Passaic County is entirely within the part of northern New Jersey that has been subject to Wisconsin Stage glaciations. Consequently, the topography shows the effects of both glacial erosion and deposition. In general, the ridges have been scraped clean and contain abundant bedrock outcrops; whereas, the valleys are filled with a variety of unconsolidated deposits which extend part way up the flanks of the adjacent high areas.

Climate

The climate of Passaic County is continental in character being controlled largely by storms which move from west to east across the county. These storms are generally dominated by polar continental air masses in winter and tropical air masses in summer. Although part of the precipitation in Passaic County results from the storms which move from west to east across the county, the heaviest rains are produced when coastal storms of tropical origin move inland.

Precipitation throughout the county averages 48 in (inches) [122 mm (millimetres)] annually and is normally well distributed throughout the year. Because the Highlands area is generally higher in altitude than the Piedmont Lowlands, the temperature in the Highlands averages several degrees cooler than in the Piedmont Lowlands in both summer and winter. Although both areas receive equal precipitation, the cooler Highlands receive more than 6 in (152 mm) more snowfall than the Lowlands.

At Paterson the frost-free periods average 192 days from April 16 to October 25. The frost-free period at Charlotteburg in Passaic County averages only 128 days, from May 20 to September 25. In the northwestern portion of the county the growing season is even shorter. The average July temperature is 75.9°F (24°C) at Paterson and 71.2°F (22°C) at Charlotteburg In January the average temperature is 31.9°F (0°C) at Paterson and 29°F (2°C) at Charlotteburg (U.S. Weather Bureau, 1959).

Population and Economic Development

In 1960 the population of Passaic County was 406,518, a 20 percent increase over 1950. This increase has been predominately in the suburban areas such as North Haledon, Pompton Lakes, Totowa, and Wayne which over the 10-year period had population increases of 69.7, 102.9, 80.3, and 148.3 percent, respectively. Municipalities having the largest population are Clifton (32,084), Paterson (143,663), and Passaic (153,963). The population increased 27.2 percent in Clifton and 3.1 percent in Paterson and decreased 6.5 percent in Passaic.

The northwestern part of the county comprises 124 mi^2 (321 km^2) or 65 percent of the total area of the county, but contains only 6 percent of the total population. This area of the county is used predominantly for recreation and water supply. The reservoirs and watersheds owned by Newark and the North Jersey District Water Supply Commission cover approximately one quarter of the area. The southern part of the county is highly industrialized. Manufacturing includes textile, apparel, leather products, metal products, and electrical and nonelectrical machinery. Only 3 percent of the land area in the county is devoted to agriculture.

GEOLOGY

General Considerations

The bedrock underlying the Highlands is composed of crystalline rocks of Precambrian age, an outlier of sedimentary rocks of Paleozoic age, and a small fault-bounded wedge of black shale of Paleozoic age near Pompton Lakes. The bedrock geology of Passaic County is shown in figure 3. The crystalline rocks include the Franklin Limestone and metasedimentary and igneous gneisses. The outlier of Paleozoic age is bounded on the northwest by a fault which closely parallels the strike of the beds. On the east side of the outlier the sedimentary rocks lie unconformably on the Precambrian gneiss. The southeastern third of Passaic County, the Lowlands, is underlain by mudstone, sandstone, conglomerate, and basalt of Triassic age.

Unconsolidated deposits overlie the bedrock in both the Highlands and the Lowlands and are largely related to the last advance and retreat of the continental glacier across the area in Wisconsin time. These unconsolidated deposits are generally thick and continuous in valleys and on lower hill slopes and thin to absent on hilltops. The deposits on the upper slopes of the hills and hilltops were deposited directly by the glacier and are largely till consisting of an unstratified mixture of clay, silt, sand, gravel, and boulders. The deposits in the valleys and lower slopes of the hills locally contain till in addition to well-sorted stratified clays, sands, and gravels deposited by streams or in lakes.

Precambrian Rocks

The Precambrian igneous and metasedimentary rocks in northwestern Passaic County have been referred to as Pochuck, Losee, and Byram in reports on the geology of the area (Johnson, 1950). These older map units have subsequently been found inadequate for the purposes of detailed mapping and have been discarded by recent workers (Sims, 1958; Hotz, 1953; Offield, 1967; and Smith, 1969). Recent practice has been to assign descriptive mineralogic terms to a much greater number of lithologic units mapped in the field. These units include; hypersthene-quartz andesine gneiss, pyroxene quartz feldspar gneiss, quartz feldspar biotite gneiss, amphibolite, granite and granitic gneiss, and Franklin Limestone. Distribution of these units is shown in figure 3. Because the occurrence and movement of ground water appears to be similar in all these lithologic units they are not described in detail in this report.

The Precambrian rocks are characteristically gneissic, granitoid, foliated, and structurally complex. The gneisses are cut by northeast-trending faults which parallel the regional strike of the rock units and by transverse (east-west) trending faults.

The regolith and soil that had developed on top of the Precambrian rocks during Tertiary time was almost entirely removed by Pleistocene glaciation.

Few drillers' logs indicate the presence of weathered and decomposed gneiss. The gneiss presents a fresh, unweathered appearance in outcrop. Salisbury (1894, p. 17) reported that the surface of the gneiss beneath the till was smooth and polished and that it was the exception to find it weathered.

Paleozoic Rocks

Rocks of Cambrian, Ordovician, Silurian, and Devonian age in western Passaic County underlie a 2- to 3.5-mile (3 to 6 km) wide belt trending northeasterly from the Pequannock River to the New York State line. This belt is part of a synclinal outlier of Paleozoic rocks, approximately 60 mi (97 km) in length. The main outcrop area occurs 25 mi (40 km) to the northwest. The syncline is truncated on the northwest by a fault which places strata of Devonian age in contact with Precambrian gneiss. On the southeast side of the syncline quartzite of Cambrian age and conglomerate of Silurian age lie unconformably upon the gneiss. Kümmel and Weller (1901) have mapped a small syncline within the belt of Paleozoic rocks on the west side of Greenwood Lake. The small syncline contains strata of Silurian and Devonian age and is truncated on the northwest by a fault that extends from the New York State line southeastward to the vicinity of West Milford.

Near Pompton Lakes an area of less than 1 mi^2 (3 km^2) is underlain by black shale of Ordovician age. According to Darton and others (1908) the shale is bounded by faults.

The Paleozoic sedimentary rocks of the outlier in western Passaic County are the Hardyston Quartzite of Cambrian age, the Kittatinny Limestone of Cambrian and Ordovician age, a black shale unit of Ordovician age, the Green Pond Conglomerate, Longwood Shale, and Decker Limestone of Silurian age, and the Kanouse Sandstone, Cornwell Shale, Bellvale Sandstone of Darton (1894), and Skunnemunk Conglomerate of Devonian age. The following brief descriptions of Paleozoic sedimentary rocks of Passaic County are based largely on the descriptions of Kümmel and Weller (1902).

Hardyston Quartzite--The Hardyston Quartzite of Early Cambrian age is the oldest unmetamorphosed sedimentary formation in Passaic County and underlies a narrow belt on the eastern side of the Paleozoic rock outlier. The Hardyston is about 30 ft (9 m) thick and is composed of vitreous blue quartzite which grades upward into calcareous sandstone which is white and very friable where weathered.

Kittatinny Limestone--The Kittatinny Limestone is a massively bedded, silicious, bluish gray limestone of Cambrian and Ordovician age. The contact between the Kittatinny and the underlying Hardyston is gradational. Erosion, prior to the deposition of the overlying Green Pond Conglomerate, has removed all but about 130 ft (40 m) of this unit which is 2,500 to 3,000 ft (762 to 914 m) thick in western New Jersey. The limestone occasionally contains pockets of conglomerate which were considered by Kümmel and Weller (1902, p. 8) to be masses of the overlying Green Pond Conglomerate that filled the fractures and crevices in the deeply weathered and eroded surface developed on top of the Kittatinny.

Black Shale.--This black shale of Ordovician age underlies Pompton Lakes. Although it shows only a moderate degree of metamorphism, it was mapped as Hudson Schist* by Darton and others (1908) because of its presumed equivalence to the schists of Ordovician age which crop out 20 mi (32 km) to the east along the Hudson River. Two small areas (not shown in figure 3) of similar nonfossiliferous black shale are found in the outlier of Paleozoic rocks near Oak Ridge Reservoir in western Passaic County and were referred to as Hudson River Shale* by Kümmel and Weller (1902, p. 8). The black shale is probably equivalent to the Martinsburg Formation in western New Jersey. A few miles north of Passaic County in New York presumed Martinsburg equivalents have been subdivided into a number of distinct formations. Inasmuch as the correlation of the nonfossiliferous shale with either the section in New York or that of the type Martinsburg is uncertain, no formal stratigraphic name is applied to the unit here. As the area underlain by the shale is small, the shale is considered hydrologically unimportant for purposes of this report.

Green Pond Conglomerate.--The Green Pond Conglomerate of Silurian age lies unconformably upon an erosional surface which cuts across rocks of Precambrian, Cambrian, and Ordovician age. The Green Pond characteristically has a pinkish color, is 1,200 to 1,500 ft (366 to 457 m) thick, and is a coarse silicious conglomerate which is interbedded with and grades into quartzite and sandstone. The Green Pond is very resistant to erosion thus forming the comparatively high steep slopes of Kanouse Mountain, a linear ridge extending from Charlotteburg north to West Milford. Locally, the basal beds are friable where they contain significant amounts of reworked Kittatinny Limestone but more typically the Green Pond contains silicious cement and is very hard.

Longwood Shale.--The Longwood Shale of Silurian age crops out intermittently in a narrow belt to the west of Kanouse Mountain. It consists of about 200 ft (61 m) of red shale and conformably overlies the Green Pond Conglomerate. The cleavage in the shale generally obscures bedding.

Decker Limestone.--The Decker Limestone is a dark gray, impure, shaley, and silicious limestone. It is 40 to 50 ft (12 to 15 m) thick and is the youngest Silurian formation in the area.

Kanouse Sandstone.--The Kanouse Sandstone of Devonian age is 215 ft (65 m) thick. It consists of a lower white, thick bedded, fine grained quartzose conglomerate that is about 100 ft (30 m) thick and an upper greenish, hard thin-bedded quartzose sandstone. The conglomerate is usually friable but, locally, cementation with silica has formed a hard quartzite.

Cornwell Shale.--The Cornwell Shale is a black to dark gray slaty shale having gradational contacts between both the overlying Bellvale Sandstone of Darton (1894) and the underlying Kanouse Sandstone. It is about 1,000 ft (305 m) thick.

*The names Hudson Schist and Hudson River Shale have not been adopted by the U.S. Geological Survey.

Bellvale Sandstone of Darton (1894).--The Bellvale Sandstone is a dark-gray, hard, flaggy to thick bedded, fine- to medium-grained sandstone. The formation contains alternating beds of red and green shale, sandstone, and conglomerate near the top. Kümmel and Weller (1902, p. 23) report a thickness of 1,600 to 2,000 ft (488 to 610 m) for the Bellvale Sandstone.

Skunnemunk Conglomerate.--The Skunnemunk Conglomerate is a purple and maroon, massively bedded conglomerate containing beds of reddish sandstone and shale. The formation is 2,500 ft (762 m) thick, very hard, and resistant to erosion. It underlies the comparatively high rugged terrain of Bearfort Mountain.

Triassic Rocks

The rocks of Triassic age that underlie the southern one-third of Passaic County are the Brunswick Formation and the Watchung Basalt. See figure 3. The Brunswick and the Watchung are a part of the Newark Group which elsewhere in New Jersey includes two units (Stockton and Lockatong Formations), not present in Passaic County. The rocks generally have a monoclinal dip of 10° to 15° W., but they contain some gentle open folds such as those expressed by the arcuate form of the Watchung Mountains. The Newark Group is bounded on the northwest by a fault which places it in contact with Precambrian gneiss and Ordovician shale. The rocks are cut by a number of north- to northeast-trending high angle faults which are evident (see figure 3) where they offset the contact between the Watchung Basalt and the Brunswick Formation.

Brunswick Formation

The Brunswick Formation forms broad valleys between the Watchung Mountains and gently rolling lowlands east of First Watchung Mountain. The Brunswick consists of alternating beds of reddish-brown sandstone and mudstone. The texture of the rocks is generally coarser in the northern part of the area than in the southern part. Conglomerates occur a little below the base of the basalt flow underlying First Watchung Mountain and locally along the northwestern border of the outcrop area. These "border conglomerates" are composed of pebble derived from Precambrian gneiss and Paleozoic rocks that cropped out in the Highlands during Triassic time.

Watchung Basalt

Intercalated between the beds of the Brunswick Formation are three sheets of basalt which form the crest of the First and Second Watchung Mountains and Packanack Mountain. Each basalt sheet is made up of a series of lava flows which outpoured during the deposition of the Brunswick Formation. Individual flows usually have vesicular zones at their tops and bases. The basalt sheets that form First and Second Watchung Mountains, and Packanack Mountain are approximately 600, 850, and 300 ft (183, 259, 91 m) thick, respectively (Darton and others, 1908, p. 10).

Quaternary Deposits

Bedrock in Passaic County is largely concealed beneath unconsolidated deposits genetically related to the continental ice sheets that overran the entire county during the Wisconsin Stage of the Pleistocene Epoch. As the glacier advanced across the county existing drainage systems were blocked by ice and modified by glacial erosion and deposition. Stream gradients were temporarily altered by warping of the earth's crust as a result of the weight of the ice. This combination of factors resulted in constant readjustment of drainage in front of the ice sheet as it advanced and withdrew from the area. Many lakes were formed; the largest of these, known as Lake Passaic, covered the area which lies between the Second Watchung Mountain and the Highlands in Passaic, Essex, Morris, Union, and Somerset Counties. The development and subsequent drainage of Lake Passaic is described by Salisbury (1902) and Salisbury in Darton and others (1908).

Glacial deposits consist of boulders, gravel, sand, silt, and clay largely derived from the local bedrock. The deposits are broadly subdivided on the basis of whether they are stratified or unstratified. The unstratified deposits (till) are not sorted, contain rock fragments from clay size to boulders, and were deposited directly from the glacier. The stratified deposits are not only layered but moderately to well sorted as a consequence of their having been transported in meltwater and deposited in streams or lakes.

The stratified deposits of Passaic County are, in this report, grouped into three categories; (1) deposits formed prior to the last advance of the glacier, (2) deposits resulting from the last advance of the glacier, and (3) deposits formed after the retreat of the glacier and associated with present day drainage.

Stratified deposits formed prior to the last advance of the glacier in the county are thin [2 to 50 ft (.61 to 15 m) thick] sands and gravels which overlie bedrock and are overlain by till or lake beds. These deposits occur characteristically in or near the base of buried pre-glacial or inter-glacial stream valleys.

Stratified deposits resulting from the last advance of the ice sheet include kames, which were formed in contact with the ice, coarse outwash deposits, and lake deposits. The kames in general are on the flanks of the Watchung Mountains and between Second Watchung and Packanack Mountains in central Wayne Township. The coarse outwash deposits formed deltas in the highlands. Available well logs do not always permit a clear distinction to be made between coarse outwash deposits and sands and gravels deposited prior to the last advance of the glacier. Both deposits intertongue with and are overlain by finer grained sediments. Lake deposits consist largely of laminated silt and clay which are up to 100 ft (30 m) thick in the valleys between Second Watchung Mountain and the Highlands.

The lake deposits are overlain by deposits associated with present day drainage. These include swamp deposits of organic muck and alluvium on the flood plains of the major streams. Alluvium is composed of silt and fine sand and is generally not more than 20 ft (6 m) thick.

The areal distribution of the surficial deposits of roughly the southern one third of Passaic County is shown in the Passaic Folio (Darton and others, 1908). Surficial geology of the northern two thirds of the county is shown in Salisbury (1902). An indication of the distribution of Quaternary deposits is given by Rogers and others (1951) in an engineering soil survey of Passaic County.

The thickness of the Quaternary deposits and the distribution of known subsurface lithologies in Passaic County are indicated in figure 4. This map is a first approximation as it is based on drillers' logs of variable quality and the locations and altitudes of wells have not been checked in the field. The deposits are thin to absent on the hills and are thickest in the present day valleys, particularly where they fill pre glacial or inter glacial valleys. Maximum known thickness is about 220 ft (67 m) in the valley of the Pequannock River near Pompton Lakes.

Structure

The structural grain in Passaic County is formed by the northeast strike of the layers and foliations of the sedimentary, igneous, and metamorphic rocks, and the parallel trends of fold axis and major faults. The major northeast-trending faults bound large blocks and commonly have vertical displacements of thousands of feet. The northwest part of each structural block is depressed in relation to the adjoining block bringing rocks of Paleozoic and Triassic age adjacent to the much older Precambrian gneisses.

The Precambrian rocks trend northeast, dip southeast, and contain both isoclinal and open folds. They are cut by minor longitudinal and oblique reverse faults and transverse normal faults. Sims (1958, p. 54) reports that faults within the Precambrian rocks of the Dover district in Morris County have small displacements in contrast to the great faults that bound individual structural blocks. Several sets of vertical or steeply dipping joints occur in the Precambrian rocks. One set is parallel to the regional structure. A second set is transverse to it, and a third set is oblique to the regional structure. The transverse joints are the most abundant and the most prominent set (Sims, 1958, p. 47). Another set of joints is nearly horizontal or may dip gently in any direction and presumably is a result of sheeting due to the release of load by erosion.

The outlier of Paleozoic rocks contains a large syncline which is truncated on the west by a major northeast-trending normal fault which places rocks of Devonian age adjacent to rocks of Precambrian age. The Paleozoic rocks are cut by smaller northeast-trending reverse faults at both Newfoundland and Greenwood Lake. Joint sets in the Paleozoic rocks are parallel, transverse, and oblique to the regional strike of the beds and according to Sims (1958,

p. 48) "probably reflects prominent joint sets in the Precambrian rocks." The transverse joints appear to be the most prominent and apparently control the location of streams that transect Bearfort Mountain.

The Triassic rocks are bounded on the northwest by a major northeast-trending normal fault. In general the Triassic rocks have a monoclinal dip of 10° to 15° NW and contain shallow open folds such as those expressed in the arcuate trend of the outcrop of the Watchung Basalt. Minor north-trending normal faults cut the Triassic rocks and are apparent where they offset the contact between the basalt flows and the Brunswick shale. The Brunswick contains vertical joints. The major joint sets are parallel and transverse to the strike of the beds. Many of the flows of the Watchung Basalt contain prominent columnar structure.

A thorough discussion of the origin of vertical or steeply dipping joints is beyond the scope of this report. In a study of jointing, Hodgson (1961, p. 37) concluded that "systematic joints are produced by tidal forces through a fatigue mechanism and the direction of the joints is considered to be inherited by upward reflection of the joint pattern in pre-existing jointed rocks." The systematic joints in Triassic and Paleozoic rocks in Passaic County have the same basic trends as do the joints in the Precambrian rocks.

GROUND WATER HYDROLOGY

Principles

Water is continually being exchanged in a circulatory pattern between the earth and the atmosphere. In general, the amount of precipitation ultimately determines the amount of water available for man's use. Some of the precipitation that falls on land evaporates where it falls, some is absorbed by plants that later transpire the water back to the atmosphere, some flows overland to streams, and some infiltrates into the ground to become ground water. The ground water is discharged to streams, and streams flow to the oceans where the water can be evaporated back to the atmosphere.

Ground water is the subsurface water in the zone of saturation--the zone in which all the rock voids are filled with water under pressure equal to or greater than atmospheric. The water table is the upper surface of this zone and in Passaic County occurs at depths of 20 to 40 ft (6 to 12 m) below land surface on hilltops and intersects the land surface in valleys where it is contiguous with the upper surface of streams, lakes, swamps, and reservoirs.

In unconsolidated deposits, and in friable consolidated rocks, ground water is stored in and moves through the intergranular openings. Ground water in the consolidated rocks of Precambrian, Paleozoic, and Triassic age occurs in and moves through cleavage planes, joints, fractures, and faults. These openings become fewer and tighter with increasing depth below the land surface but tend to be distributed in an orderly geometric attitude within rock units of homogeneous composition. The openings are better developed and enlarged in some rocks than others; however, the openings form a comparatively small volume in comparison to the volume of the rock as a whole.

The movement of ground-water in the Precambrian igneous and metamorphic rocks and the Paleozoic sedimentary rocks is probably largely in a direction transverse to the regional structure of the beds. Openings along the joint set transverse to the regional structure have probably been selectively enlarged by weathering more than those openings along joints parallel and oblique to the regional structure. The greater weathering of transverse joints is indicated by their greater abundance and prominence and by the dominant east-west alignment (parallel to the direction of dominant jointing) of streams cutting the Precambrian and Paleozoic rocks. A further suggestion that the movement of ground water in the Precambrian and Paleozoic rocks is controlled largely by the transverse joints comes from an analysis of streamflow data of West Brook and Ringwood Creek. West Brook, which traverses the regional structure, has higher flow per square mile than Ringwood Creek which parallels the regional structure. The mean flow for West Brook near Wanaque is 1.94 $(ft^3/s)/mi^2$ (cubic feet per second per square mile) [.0212 $(m^3/s)/km^2$ (cubic metres per second per square kilometre)] and for Ringwood Creek it is 1.65 $(ft^3/s)/mi^2$ [0.180 $(m^3/s)/km^2$]. Differences in low flow, which are composed almost entirely of ground-water discharge, between the two streams are shown in the table below. There is no known variation in thickness, composition, or distribution of the Pleistocene deposits, or difference in precipitation that would account for the higher flow of West Brook.

Stream	Average of the minimum mean discharge for designated number of days [$(ft^3/s)/mi^2$]					
	3	7	14	30	60	90
West Brook near Wanaque	0.123	0.138	0.167	0.215	0.332	0.454
Ringwood Creek near Wanaque	.095	.112	.137	.185	.283	.372

Water-bearing openings in the Brunswick Formation in New Jersey occur in discrete zones controlled by bedding. These tabular aquifers extend downdip for several hundred feet and are continuous along strike for thousands of feet. Hydraulic connection between the aquifers is generally poor. The movement of water in these aquifers under pumping and presumably under natural conditions is preferentially along strike (Vecchioli, 1967, and Vecchioli and others, 1969). Thus, discrete water bearing and nonwater bearing zones in the Brunswick form a series of tabular aquifers and aquitards ranging up to tens of feet thick and dipping to the west at approximately 10 to 15 degrees. The basalt flows that are intercalated with the Brunswick generally act as aquitards.

In Passaic County the ground-water reservoir is a few hundred feet thick and can be visualized as composed of a number of small basins separated by divides which at land surface coincide with surface-water drainage divides.

In the subsurface these ground-water divides do not necessarily descend vertically through the zone of fresh water circulation but may in places become essentially horizontal where they form divides between shallow local flow systems and deeper and larger flow systems. Ground-water flow systems in the county are generally small, the largest underlying probably only a few square miles. No regional ground-water flow system underlies the entire area.

Areal variations occur in the thickness, porosity, and permeability of the rock within the zone of fresh-water flow. These variations are partly the result of changes in the chemistry of the water and its ability to weather and dissolve mineral matter as the water moves through the rocks. In the upland areas, water entering the water table contains dissolved oxygen, carbon dioxide, and humic acids which greatly aid in the weathering of rock. In contrast the water moving along the longest flow paths is alkaline and may be much closer to being in chemical equilibrium with the rock. Variations in thickness, porosity, and permeability may also be the result of areal variations in the rates of movement and volume of water transmitted through the rocks. On hilltops or divides a comparatively small volume of water enters and moves through the secondary openings, thus limiting the amount of weathering. On the other hand comparatively large volumes of water move beneath the flanks of major valleys. Movement of ground water in the valleys is generally upward to discharge. Because it is a discharge area, precipitation that falls on the area cannot enter the system and, therefore; certain forms of the weathering and particularly the oxidation of minerals is precluded.

Water-bearing fractures at different depths below land surface contain water under different hydraulic heads. On stream-drainage divides, hydraulic heads decrease with increasing depth and in major valleys they increase with increasing depth below land surface. In intermediate areas, including minor valleys, there may be reversals in the direction of head change with increasing depth below land surface. Most wells in the consolidated rock penetrate more than one producing fracture or zone of fractures which have different hydraulic heads. As a result, the observed water level in a well is characteristically a composite head and does not indicate the hydraulic head of any single water-producing zone. When a well penetrates separate fracture zones having different hydraulic heads some of the natural flow is short circuited through the well from the fracture having a higher hydraulic head to that having the lower head. A consequence of the internal flow in wells under nonpumping conditions may be the cleaning of openings which were partially sealed during drilling. Some of the variation in well yields noted in Passaic County may in part depend upon which part of the flow system the well penetrates and the consequent effect of internal borehole flow upon the cleaning of water-bearing openings.

In a study of the availability of water in igneous and metamorphic rocks in the southern Piedmont province Legrand and Mundorff (1952) found a relationship between well yields and the topographic location of the well. They found that wells located in draws have the highest yields and progressively smaller yields are found from wells in the following topographic locations: valleys, slopes, flats, and hills. Studies in similar terrains throughout the

New England and Piedmont provinces have in general confirmed the relationship between yields and topographic location of the wells. James (1967) in a study of the availability of water in the Precambrian crystalline rocks of the New Jersey Highlands found the same relationship between well yield and topographic location. Yields of wells penetrating the Precambrian rocks in Passaic County probably bear a similar relationship.

Water-Bearing Properties of the Rocks

The rocks of Passaic County differ greatly in their ability to yield water to wells. Figure 5 shows the frequency distribution of reported yields of wells tapping the major rock units in Passaic County. Difference in well yields between rock units and variations in well yield within a rock unit depend in part upon the hydraulic characteristics--permeability, thickness, and storage coefficient--of the aquifer. For consolidated rocks, these characteristics depend upon the number, size and degree of interconnection of secondary openings which occur along structural features such as joints, faults, cleavage, and bedding. Other factors affecting well yields include; well diameter and depth, degree of well cleaning and development, and the hydraulic continuity of the aquifer with a source of induced recharge from a surface-water body.

Precambrian Rocks

The Precambrian rocks are the major source of ground water for domestic use in the northwestern two-thirds of Passaic County. These rocks generally yield smaller quantities of water to individual wells than do the other major geologic units in Passaic County. Reported yields of wells tapping the Precambrian rocks in Passaic County range from less than 1 to 200 gal/min (gallons per minute) [.06 to 13 l/s (litres per second)]. The highest reported yields are obtained from wells that are located in the larger valleys near streams or large surface-water bodies such as Lake Erskine and Greenwood Lake.

The frequency distributions of reported yields of 415 domestic wells and of 21 public-supply wells are shown in figure 5. The median yield of the domestic wells is 5 gal/min (.32 l/s) and that of the public-supply wells is 30 gal/min (2 l/s).

Depths of wells drilled in Precambrian rocks vary considerably in Passaic County. They depend in part on the cost of well construction and on the quantity of water required for a particular use. Maximum reported depths are about 400 ft (122 m) and minimum depths are about 50 ft (15 m). The average reported depth is 160 ft (49 m). The deepest wells were drilled to obtain large public and industrial supplies; whereas, most of the shallower wells were drilled to obtain only small domestic supplies.

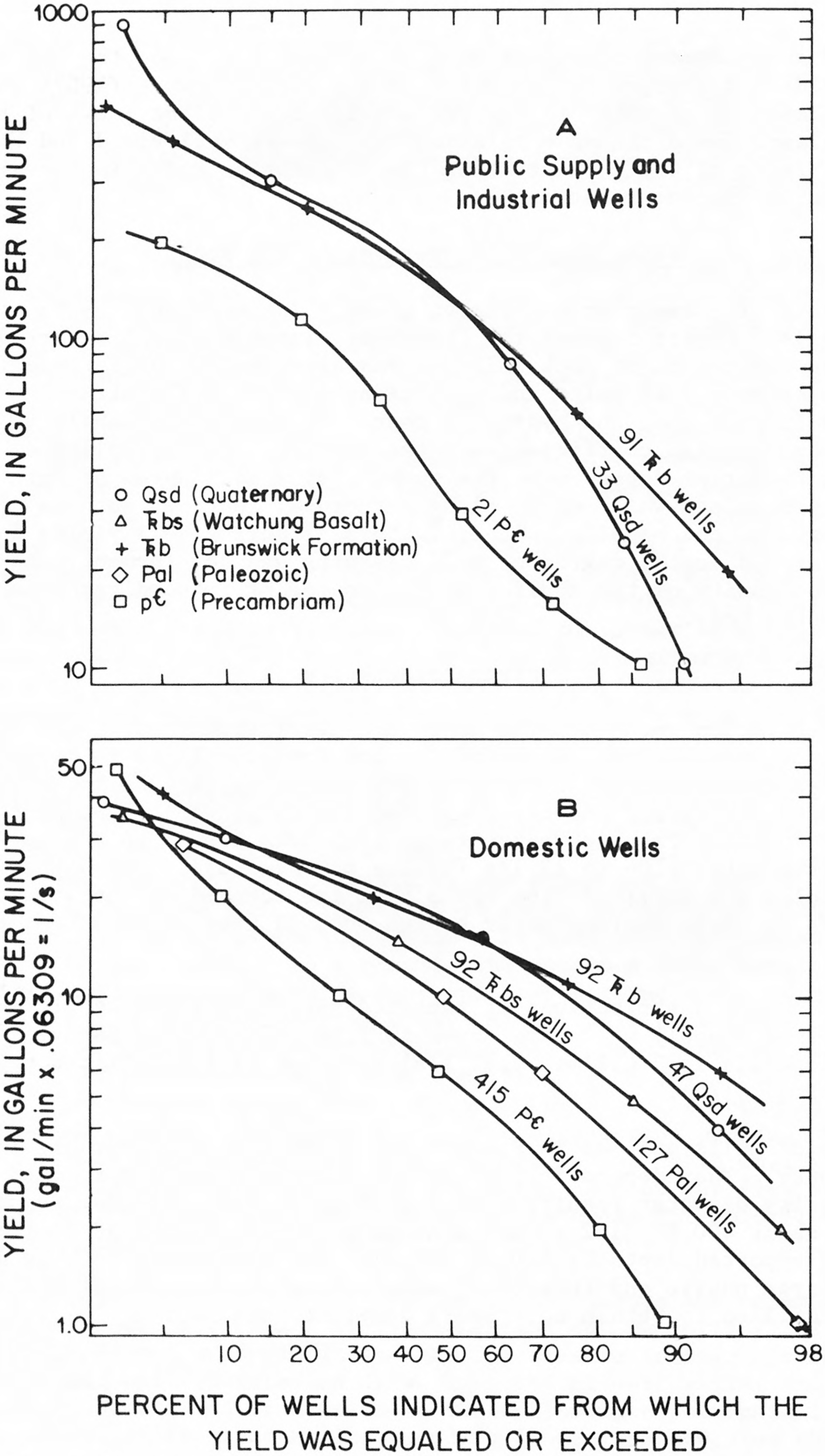

Figure 5.--Graph showing frequency distribution of well yields grouped according to geologic unit.

Paleozoic Rocks

The Paleozoic rocks are utilized primarily for domestic water supplies in Passaic County. Some of the Paleozoic units such as the Kanouse Sandstone, Green Pond Conglomerate, and Hardyston Quartzite (see figure 3) are locally friable and potentially may yield significant quantities of water to properly located wells. Reported yields of wells tapping the Paleozoic rocks in Passaic County range from less than 1 gal/min to 35 gal/min (.06 to 2 l/s). The median reported yield of 127 wells, almost all of which are domestic wells, is 10 gal/min (.63 l/s). The frequency distribution of these well yields is shown in figure 5.

Depths of wells drilled in the Paleozoic rocks in Passaic County range from about 50 ft (15 m) to 400 ft (122 m). The average depth of 32 selected wells listed in table 2 is 150 ft (46 m).

Triassic Rocks

Brunswick Formation

The Brunswick Formation is the most important aquifer in Passaic County. It is the major source of ground water for public supply and industrial use in the county. Reported yields of 91 public supply and industrial wells range from 20 to 510 gal/min (1 to 32 l/s). The median yield is 130 gal/min 8 (l/s) (see figure 5). The median yield of all public supply and industrial wells over 300 ft (91 m) deep is 190 gal/min (12 l/s), and the yield of the deep wells that are 8 in (203 mm) or larger in diameter is 230 gal/min (15 l/s). The higher yields of the larger diameter wells are in part a result of decreased entrance losses to the well and may in part result from better cleaning and development of the well. Most of the high yielding wells are located in valleys in the more industrial areas, in Hawthorne, Paterson, Clifton and Passaic and are in or on the flanks of preglacial valleys containing comparatively thicker unconsolidated deposits. They are thus located in an environment where recharge to the aquifer may be induced. Smaller yields are generally obtained from domestic wells. The median reported yield of 92 domestic wells is 16 gal/min (1 l/s) (see figure 5). These wells have smaller diameters and are shallower and less developed than the public supply and industrial wells. Most domestic wells are between 150 and 250 ft (46 and 76 m) deep; whereas, most public-supply and industrial wells are between 200 and 400 ft (61 and 122 m) deep.

Watchung Basalt

The Watchung Basalt is utilized primarily for domestic water supplies in Passaic County. Reported yields of 92 domestic wells range from less than 1 gal/min (.06 l/s) to 40 gal/min (3 l/s). The median yield is 12 gal/min (.76 l/s). Figure 5 shows the frequency distribution of yields of these domestic wells. Reported yields of nine industrial and commercial wells in Passaic County range from 50 to 180 gal/min (3 to 11 l/s). A few wells in adjacent Essex County have reported yields as high as 400 gal/min (25 l/s) (Nichols, 1968).

Depths of wells tapping the Watchung Basalt range from 30 to 600 ft (9 to 183 m). The average depth of 31 selected wells (table 2) is 250 ft (76 m).

Quaternary Deposits

Stratified deposits of Quaternary age are an important source of ground water for public supply and industrial use in Wanaque and Pompton Lakes and along the western side of Wayne Township. These deposits are major sources of water in adjacent Morris County (Gill and Vecchioli, 1965) and along the Ramapo River in western Bergen County (Vecchioli and Miller, 1974). The deposits in Passaic County have not, for the most part, been extensively explored and are potentially an important source of ground water for future development. Interpretation of the thickness and probable lithology of stratified and unstratified deposits (fig. 4) provides an initial guide to locate probable stratified deposits of sufficient areal extent and thickness to supply suitable quantities of water to wells.

Stratified deposits of Quaternary age generally yield larger quantities of water to individual wells than do the other major geologic units in Passaic County. Reported yields of wells range from 4 to 920 gal/min (.25 to 58 l/s). The frequency distribution of reported yields of 33 public supply and industrial wells and of 47 domestic wells is shown in figure 5. The median yields of the domestic wells are 16 gal/min (1 l/s) and that of the public supply and industrial wells are 130 gal/min (8 l/s).

The maximum depths of wells tapping Quaternary deposits are limited by the thickness of the deposits. Reported depths of 23 wells (table 2) range from 22 to 170 ft (7 to 52 m). Most of the wells are between 50 and 125 ft (15 and 38 m) deep.

Quality of Water

All natural water contains some impurities. Even rainfall is not chemically pure. It absorbs dust and also gases, such as carbon dioxide, from the atmosphere. Water in passing through the atmosphere and over and through the soil and underlying rocks acquires impurities as either dissolved or suspended matter. The physical and chemical nature of the dissolved or suspended matter determines the natural quality of the water and its suitability for any particular use.

The nature and concentration of impurities in water depend chiefly on the chemical composition of the soils and underlying rocks with which the water comes in contact, and upon the length of time that the water and rock have been in contact with each other. Generally, the longer water remains in contact with the soil and rock, the more dissolved matter it will contain. Suspended matter which consists largely of sediment derived from erosion at the land surface is not an important constituent of ground water.

Man's activities may impair the natural water quality. Disposal of industrial wastes and domestic sewage can pollute water supplies. Water can also pick up matter that man has added to the environment such as that found in fertilizers, pesticides, and compounds used in snow and ice removal along highways. Dissolved minerals in natural water may be either harmful or beneficial so it is important to know the kind and concentration of minerals in our water supply and how they affect the use of the water.

Chemical constituents most commonly tested for in water are silica, iron, manganese, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, fluoride, and nitrate. Concentrations of these elements are reported in this report in milligrams per litre (mg/l). Other properties of water that influence its use and degree of treatment are dissolved solids, hardness, specific conductance, pH, and temperature. The chemical composition and physical character of ground-water samples from Passaic County are shown by the results of analyses of samples given in table 3.

Standards of water quality vary considerably according to the intended use. The New Jersey Department of Health (1967) has established standards for maximum concentrations of many constituents in water that are to be used for potable purposes. The recommended maximum concentrations of certain specific chemical substances in New Jersey's potable water-supply systems are listed below:

Constituent	Recommended maximum (milligrams per litre)
Chloride (Cl)	250
Fluoride (F)	1.5
Hardness (as $CaCO_3$)	150
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate (NO_3)	30
Sodium (Na)	50
Sulfate (SO4)	250
Total dissolved solids	500

The N.J. Health Department further states that . . "these chemical substances should not be present in a water intended for potable purposes in excess of . . . the listed concentrations. Their presence may constitute grounds for the rejection of the supply if, in the opinion of the Department such substances, either singly or in combination, are present in such concentrations as would render the water unduly corrosive, unpalatable, hazardous to the consumer, or aesthetically objectionable." Most of the naturally occurring ground water in Passaic County is of better quality than the New Jersey potable standards except for high concentrations of iron, hardness, and dissolved solids in some areas.

Excessive concentrations of iron, 0.3 mg/l or more, cause a reddish-brown staining on laundry and bathroom fixtures and gives the water an astringent taste. Corrosion of metallic surfaces such as copper piping also causes staining; for compounds of copper, it generally leaves a bluish stain.

Soft water and hard water are common terms in describing the quality of water supplies. Very soft water generally causes corrosion of metallic surfaces; whereas, hard water uses excessive amounts of soap in household laundering, also leaves a light scum in wash tubs, and is absorbed into laundered clothing. The hardness of water classification used in this report is as follows:

Hardness description	Range (milligrams per litre)
Very soft	0 - 30
Soft	31 - 60
Moderately hard	61 - 120
Hard	121 - 180
Very Hard	More than 180

The hardness of ground water studied in this investigation from all the different aquifers in Passaic County ranged from soft to very hard (34 mg/l to 540 mg/l).

Standards for water quality for industrial uses differ widely. Most industrial processes require water containing no more than 500 mg/l dissolved solids. Almost all the ground water used in Passaic County contains less than 500 mg/l dissolved solids. Water used for cooling may contain more than 500 mg/l dissolved solids, but should have a relatively constant and cool temperature. Temperatures of ground water are nearly constant throughout the year and generally range from about 10° to 15°C (Celsius) in most areas of Passaic County.

The quality of ground water in Passaic County varies considerably from one aquifer to another and from place to place within the same aquifer. These variations can be attributed mainly to (1) differences in the composition of the rocks within the aquifers, (2) the pattern of ground-water movement from recharge to discharge areas, and (3) the length of time water is in contact with the rocks and the depth of water circulation in each aquifer system.

Water from the Precambrian rocks ranges from soft to moderately hard (34 to 104 mg/l) and is low in dissolved solids (66 to 159 mg/l). (See table 3). Chloride concentrations in four samples ranged from 2.4 to 11 mg/l. Most of the water is slightly alkaline with an average pH of about 7.3. The relatively low mineral content of water from the Precambrian rocks is due mainly to the highly resistant nature of the rocks to weathering.

Only one sample of water was obtained from a well penetrating the Paleozoic rocks (Well WM-48). The water quality of this sample is quite similar to that from the Precambrian rocks.

The quality of water from the Quaternary deposits in Passaic County appears to be very good as indicated by the results of the two analyses

(Wells Wn-2 and Wn-8) in table 3. The water is only moderately hard (65 and 83 mg/l) and is low in dissolved solids (122 and 133 mg/l). It ranges from slightly acidic (pH 6.5) to slightly alkaline (pH 7.6). Although supporting data are not presently available, it is believed that the quality of water from the Quaternary deposits is similar to that in the underlying rocks. Hence, less mineralized and softer water would probably be found in the stratified drift underlain by the Precambrian rocks than in the stratified drift underlain by the Brunswick Formation.

The quality of water in the Brunswick Formation differs from that in the other aquifers in Passaic County. It is generally much more mineralized and its quality varies considerably more from place to place. Dissolved solids in 11 samples listed in table 3 range from 129 to 563 mg/l and average 314 mg/l. However, as much as about 16,000 mg/l of dissolved solids have been reported by Cook (1885, p. 116).

In general the water in the Brunswick is less mineralized in the recharge areas at higher altitudes and more mineralized in discharge areas at low altitudes. Figure 6 shows the general relation of altitudes of tops and bottoms of wells to dissolved solids from typical wells in the Brunswick Formation in Passaic County. Well Wn-3 located near Lionshead Lake in northern Wayne Township is at an altitude of 340 ft (104 m) above sea level and has the lowest dissolved solids--129 mg/l. Wells Hw-2, Hw-5, Hw-6, and Hw-7 are located entirely in Hawthorne Borough on the valley flanks of Goffle Brook. Well Ps-3 in the City of Passaic is at the lowest altitude, and the dissolved solids content is over 500 mg/l.

Water from the Brunswick Formation probably becomes more mineralized with increasing depths below land surface. Increasing mineralization of the water with increasing depth was reported as early as 1885 by Cook (1885, p. 115-117) for a test well drilled to a depth of 2,100 ft (640 m) in Paterson, N. J. During drilling of this well, water samples were collected at about 900 ft (274 m), 1,700 ft (518 m) and 2,050 ft (625 m) below land surface and contained about 230 mg/l, 6,000 mg/l and 16,000 mg/l of dissolved solids, respectively. The water at 1,700 ft (518 m) was mostly "sulfate of lime" while the water at 2,050 ft (625 m) was "strongly saline" and contained "408.46 grains per gallon of chloride of sodium" (about 6,900 mg/l of NaCl). This well is located above the present day tidal area of the Passaic River. The highly mineralized water found at depth is not related to present-day salt-water intrusion but, more likely, is characteristic of a residual saline water. Highly mineralized water probably occurs at similar depths elsewhere in the eastern part of the county.

Water from the Brunswick Formation is moderately hard to very hard. The average hardness for 12 of the 13 analyses (one analysis, well Cl-12, is discussed separately below) in table 3 is 199 mg/l, and the minimum and maximum values are 89 and 340 mg/l, respectively. As the recommended maximum hardness of potable water by the New Jersey Department of Health is 150 mg/l, much of the ground water from the Brunswick used for potable supplies should be treated to reduce its hardness. The hardness is due mainly to the solution of calcium and magnesium sulfate minerals in the rocks. Gypsum (calcium sulfate), a highly soluble mineral, has been observed in cuttings from wells in the Triassic rocks (Herpers and Barksdale, 1951,

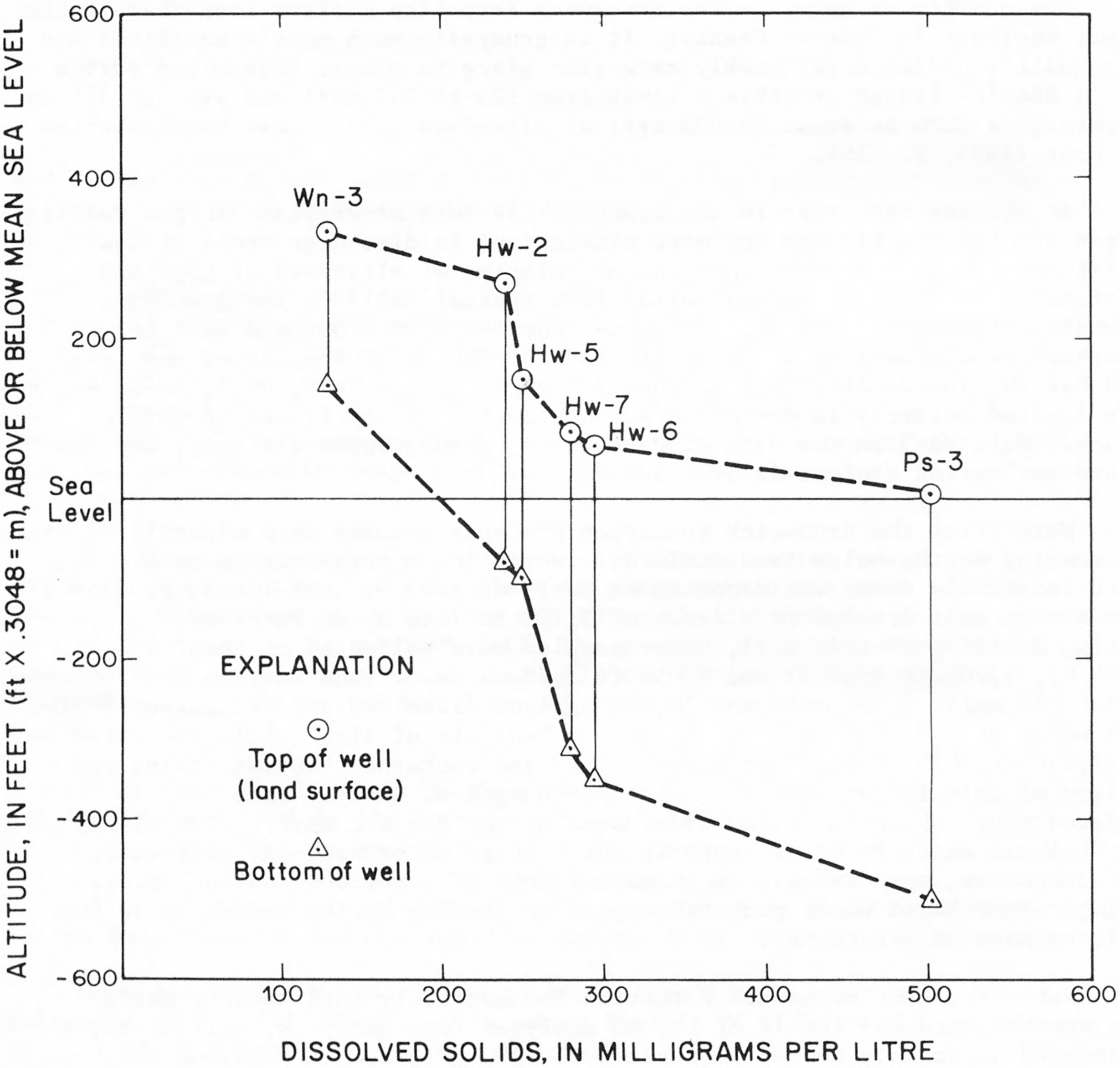

Figure 6.--Relation of dissolved solids to the altitudes of wells tapping the Brunswick formation.

p. 37) and undoubtedly contributes to the hardness of the water.

In some areas, particularly the more industrialized and urbanized parts of the county, the natural quality of water in the Brunswick Formation has been contaminated by man's activities. For example, water from a well in Clifton (Well Cl-12) has been contaminated by industrial waste water from nearby seepage pits. The water contains unusually high concentrations of iron, 25 mg/l; sulfate, 435 mg/l; and hardness, 540 mg/l. This water is acidic (pH 5.9). The low pH, together with a high reported carbon dioxide concentration, make this water excessively corrosive. The exceptionally high concentration of iron in this water is probably due to corrosion of pipes. Although this water is suitable for industrial cooling purposes, it is not suitable for potable supply according to the New Jersey Department of Health Standards. With continued use of this type of highly corrosive water, pipes and other plumbing fixtures would eventually have to be repaired or replaced.

WATER USE

Water use in Passaic County from both surface- and ground-water supplies averaged about 106 Mgal/d (million gallons per day) [5 m^3/s (cubic metres per second)] in 1965 (N. J. Division of Water Resources, (personal commun., 1969). Of this total, demands for public supply accounted for 76 Mgal/d (3 m^3/s); industrial use, 27 Mgal/d (1 m^3/s); and irrigation, 3.0 Mgal/d (.13 m^3/s). Total per capita use averaged 247 gal/d (gallons per day) [935 l/d (litres per day)]. Because of insufficient data, ground water use for all purposes could not be determined for this report. However, only a very small portion of the County's total requirements is presently derived from ground-water sources; probably between 5 and 10 percent of the total demand.

The major purveyors of surface water for use in Passaic County are: (1) Passaic Valley Water Commission which serves most of the public-supply requirements for Clifton, Little Falls, Passaic, Paterson, Prospect Park, and part of West Paterson; (2) Butler Water Bureau which serves Bloomingdale and Pompton Lakes; (3) Haledon Water Department which serves both Haledon and North Haledon; (4) Newark-Pequannock water systems which serve most of Wayne Township. The major purveyors of ground water for public supply and their monthly and annual pumpage in 1968 are shown in table 1. In 1968, ground-water withdrawals for public supply averaged 4.39 Mgal/d (.19 m^3/s). About 80 percent of public supply withdrawals come from wells tapping the Brunswick Formation in Hawthorne and Wayne Townships in the more developed southern part of the county.

Seasonal variations in the total use of ground water can also be seen in table 1. Maximum monthly pumpage for the public supplies averaged about 140 percent greater during July and August 1968 than during February and March.

Table 1.--Use of ground water for public supply in Passaic County, N.J.--1968
(in million gallons per day)

(Data from records of New Jersey Division of Water Resources)

	January	February	March	April	May	June	July	August	September	October	November	December	Annual Average
Hawthorne Water Dept.	2.70	2.79	2.82	3.18	3.26	3.55	3.62	4.19	3.47	3.10	3.09	3.26	3.27
Wanaque Water Dept.	.62	.48	.41	.45	.69	.75	.87	.76	.58	.64	.79	.67	.65
Wayne Twp. Water Dept.	.22	.27	.28	.28	.28	.27	.27	.24	.23	.27	.26	.19	.26
West Milford Twp. Munic. Util. Auth.*	.04	.04	.04	.06	.07	.08	.12	.12	.10	.08	.06	.07	.07
Ringwood Boro (Windbeam Water Co.)	.15	.16	.15	.15[e]	.17[e]	.16[e]	.17[e]	.16[e]	.15[e]	.15[e]	.15[e]	.15[e]	.14[e]
Totals	3.73	3.74	3.70	4.12	4.47	4.81	5.05	5.47	4.53	4.24	4.35	4.34	4.39

[e] Estimated from 1967 data

* Additional unknown quantities of ground water are supplied from about 40 low-producing wells to small communities throughout West Milford Township by about 27 private water companies.

Ground water, derived from wells, is utilized to some extent in all municipalities in the county. However, in the more suburban and rural areas, almost all water supply is from wells. In these less populated areas, wells are used for industiral, commercial, residential, and rural water requirements. In West Milford Township, for example, ground water is supplied to small communities by about 27 private water companies pumping from about 40 wells. Most of these wells tap aquifers in rocks of Precambrian and Paleozoic age and produce small to moderate quantities of water. Ringwood is supplied by many low yielding wells tapping Precambrian and Quaternary rocks.

Trends in ground-water pumpage by the major public-supply companies from 1951 to 1968 are shown in figure 7. Ground water pumpage has increased from 2.1 Mgal/d (.09 m^3/s) in 1951 to 4.39 Mgal/d (.19 m^3/s) in 1968.

Ground water pumpage, as well as total water use, is expected to increase substantially in the next 10 years. Future use will depend largely on an increasing population and an expanding economy. According to the N.J. Division of Water Resources (personal commun., 1969) the total water demand in Passaic County is expected to increase from 106 Mgal/d (5 m^3/s) in 1965 to 142 Mgal/d (6 m^3/s) in 1980. Public supplies are expected to account for about 70 percent of the total demands. Suburban areas and relatively undeveloped rural areas will show the largest increases in population with corresponding increases in water demands. For example, the population from 1960 to 1969 is estimated to have increased about 62 percent in Wayne Township, 80 percent in Ringwood, and 63 percent in West Milford (N.J. Bureau of Research and Statistics, 1970). In these areas ground water will play an important role in supplying the future water demands of the county.

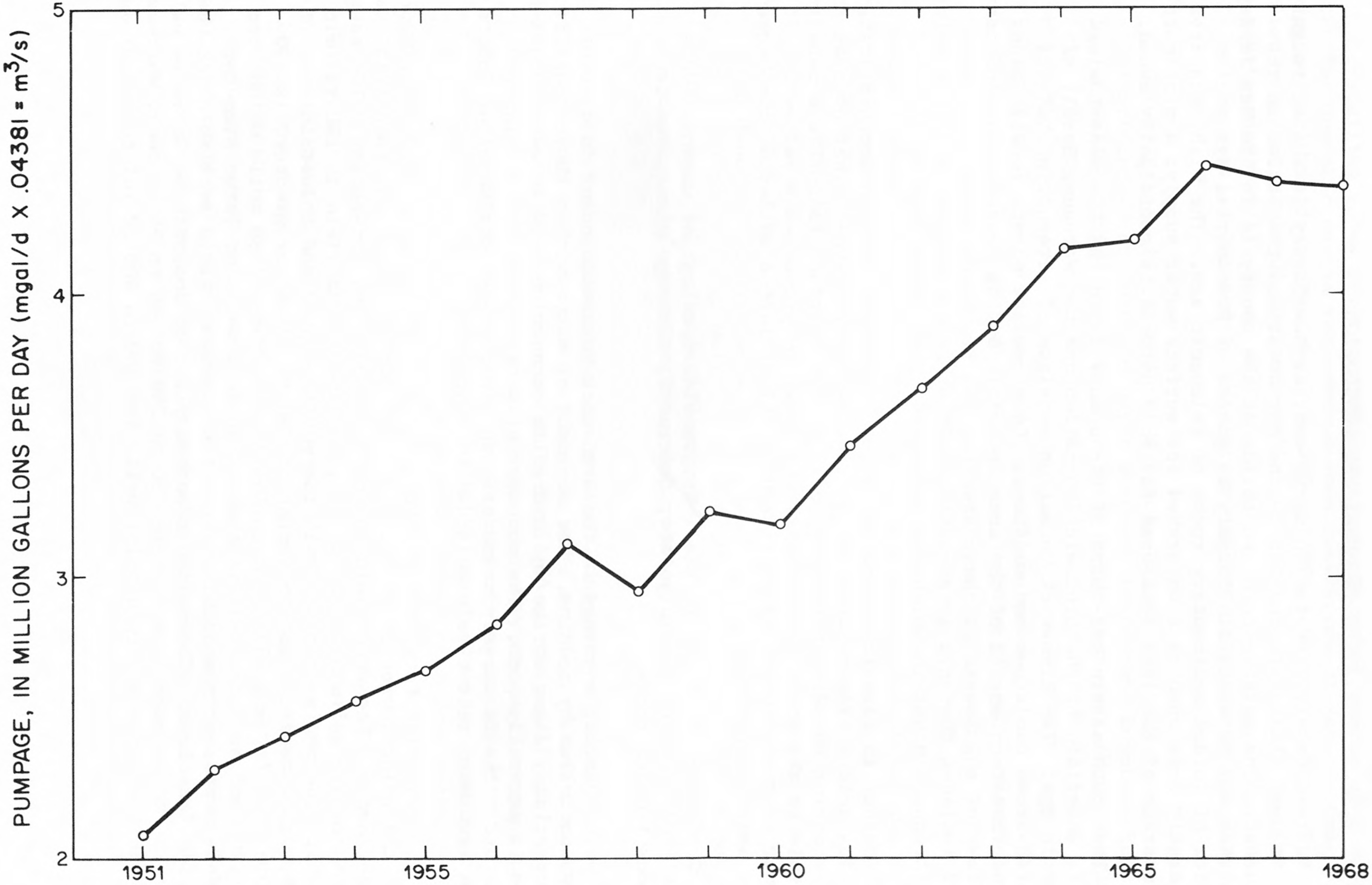

Figure 7.-- Ground-water pumpage by major public-supply companies in Passaic County, 1951-68.

SUMMARY AND CONCLUSIONS

Passaic County, located in north central New Jersey is shaped roughly like an hour glass with the top to the northwest and the bottom to the southeast. The northwestern two thirds of the county is in the New Jersey Highlands and is underlain largely by gneiss of Precambrian age and an outlier of folded sedimentary rocks of Paleozoic age. The Highlands area is largely developed as a watershed for surface water supply; approximately one quarter of the land area used for this purpose is municipally owned.

The southeastern one-third of the county is in the Piedmont Lowland and is underlain by the Brunswick Formation and the Watchung Basalt of Triassic age. The Brunswick Formation consists of alternating beds of reddish-brown sandstone and mudstone. Conglomerate occurs locally along the northwestern border of the area underlain by the Newark Group and near the base of the lowest Watchung Basalt. The Brunswick Formation forms broad lowlands that are interrupted by First and Second Watchung Mountains and Packanack Mountain which are underlain by Watchung Basalt.

Bedrock in Passaic County is largely concealed beneath unconsolidated deposits genetically related to the continental ice sheets that overran the county during the Wisconsin Stage of the Quaternary Period. These deposits are thin to absent on hills and are thickest in present-day valleys. Maximum known thickness is about 220 ft (67 m) in the valley of the Pequannock River near Pompton Lakes.

Ground water occurs in the intergranular openings of unconsolidated stratified deposits and in joints, fractures, cleavage plans, and faults in consolidated rocks.

Water bearing openings in the Brunswick Formation occur in discrete zones controlled by bedding. The movement of water within these zones is preferentially along strike and hydraulic connection between water-bearing zones is generally poor. The movement of water in the Precambrian and Paleozoic rocks is largely transverse to the regional strike along joints which have been selectively enlarged by weathering.

The Brunswick Formation is the most important aquifer in Passaic County. It is the major source of ground water for public supply and industrial use in the county. Reported yields of public supply and industrial wells range from 50 to 510 gal/min (3 to 32 l/s), and the median yield is 130 gal/min (8 l/s). The median yield of all the public supply and industrial wells, which were drilled to depths of 300 ft (91 m) or greater, is 190 gal/min (12 l/s) and 230 gal/min (15 l/s) for those deep wells which were 8 in (203 mm) or larger in diameter. The deep wells of large diameter probably represent reasonable tests of the maximum yield available for their specific locations. The median reported yield of domestic wells is 16 gal/min (1 l/s). Most domestic wells are 150 to 250 ft (46 to 76 m) deep; whereas, most public supply and industrial wells are 200 to 400 ft (61 to 122 m) deep.

Crystalline rocks of Precambrian age are the major source of ground water for domestic use in the northwestern two-thirds of Passaic County. Reported well yields range from 1 to 200 gal/min (.06 to 13 l/s). The median reported yield of domestic wells is 5 gal/min (.32 l/s) and that of public-supply wells is 30 gal/min (2 l/s). The highest yields are obtained from wells located in the larger valleys near streams or large lakes.

Rocks of Paleozoic age and the Watchung Basalt of Traissic age are utilized primarily for domestic water supplies in Passaic County. Reported yields of wells tapping the Paleozoic rocks range from less than 1 to 35 gal/min (.06 to 2 l/s) and the median yield is 10 gal/min (.63 l/s). Reported yields of domestic wells tapping the Watchung Basalt range from less than 1 to 40 gal/min (.06 to 3 l/s) and the median yield is 12 gal/min (.75 l/s). However, reported yields of nine industrial and commercial wells in the basalt range from 50 to 180 gal/min (3 to 11 l/s), and a few wells in adjacent Essex County have reported yields as high as 400 gal/min (25 l/s).

Unconsolidated stratified deposits of Quaternary age are an important source of ground water for public supply and industrial use in parts of Passaic County. These deposits are major sources of water in adjacent Morris County and in western Bergen County. They have not been extensively explored in Passaic County but are potentially an important source of ground water for future development. Reported yields of wells tapping the stratified deposits range from 4 to 920 gal/min (.25 to 58 l/s). The median reported yield of domestic wells is 16 gal/min (1 l/s) and that of public supply and industrial wells is 130 gal/min (8 l/s). Depths of wells depend upon the thickness of the deposits. Reported depths range from 22 to 170 ft (7 to 52 m).

The quality of ground water in Passaic County varies from one aquifer to another and from place to place within the same aquifer. Water from the Precambrian rocks is soft to moderately hard (34 to 104 mg/l) and is low in dissolved solids (66 to 159 mg/l). Water from only one well tapping the Paleozoic rocks has been analyzed. It is similar in quality to water from the Precambrian rocks. Water from two wells tapping the Quaternary deposits is moderately hard (65 and 83 mg/l) and has dissolved solids contents of 122 and 133 mg/l.

Water from the Brunswick Formation is moderately hard to very hard (89 to 540 mg/l). The hardness is due mainly to solution of calcium and magnesium sulfate minerals (such as gypsum) in the rocks. The dissolved-solids content ranges from 129 to 563 mg/l. More highly mineralized water occurs at depth in the Brunswick Formation. This is indicated by an analysis of water which contained 16,000 mg/l dissolved solids at a depth of 2,050 ft (625 m) in a well in Paterson. In general, water in the Brunswick is less mineralized in recharge areas at higher altitudes and more mineralized in discharge areas at lower altitudes.

Water use from both surface and ground-water supplies in Passaic County averaged about 106 Mgal/d (5 l/s) in 1965. Ground water probably accounts for 5 to 10 percent of this total. Ground-water pumpage by the major public-supply companies in the county has increased from 2.1 Mgal/d (.09 l/s) in 1951 to 4.39 Mgal/d (.19 l/s) in 1968. About 80 percent of the 4.39 Mgal/d (.19 l/s) was from wells tapping the Brunswick Formation in the southern part of the county.

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TABLES

Table 2.--Records of selected wells in Passaic County, N.J.

Aquifer: Qsd, Quaternary deposits; Trb, Brunswick Formation; Trbs, Watchung Basalt; Pal, Paleozoic rocks; pC, Precambrian rocks
Use of well: PS, Public supply; In, industrial; Ac, air conditioning; Cm, commerical; Ir, irrigation; D, domestic; TW, test well
Remarks: Includes owners well number, interval screened, and water quality (QW), data available in table 3.

Well no.	Owner or tenant	Driller	Year drilled	Altitude above MSL (ft)	Total depth drilled (ft)	Depth to bedrock below land surface (ft)	Diameter of well (in)	Depth to which well is cased (ft)	Aquifer	Static level below land surface (ft)	Yield (gal/min)	Draw-down (ft)	Specific capacity (gal/min)/ft	Use of well	Remarks
	BLOOMINGDALE BORO														
B1-1	Alfred Brauer	D & F W.D.	1963	--	98	--	6	20	pC	46	6	39	.15	--	
B1-2	Wm. Eibs	Do.	1964	--	198	1	6	23	pC	18	5	162	.03	D	
B1-3	Robert Beams	Mabey Bros.	1966	--	210	2	6	23	pC	15	2	185	.01	D	
B1-4	R. Reinhard	A. Ackerson	1963	--	50	--	6	20	pC	7	6	18	.33	D	
B1-5	J. Thramann	D & F W.D.	1965	--	225	20	6	36	pC	57	1	158	.01	D	
B1-6	J. F. Sisco	H. Henderson	1955	--	90	--	6	70	pC	50	8	6	1.33	D	
B1-7	H. Hohenstein	Do.	1955	--	42	--	5	15	pC	8	10	6	1.67	D	
B1-8	T. B. McGarity	M. W. Ives	1961	--	132	--	6	132	Qsd	45	7	125	.06	--	
B1-9	Mrs. T. D. Gissemer	D & F W.D.	1966	--	121	0	6	20	pC	18	4½	92	.05	D	
B1-10	Fred Santagate	Do.	1964	--	72	6	6	21	pC	10	4	55	.07	D	
B1-11	Wm. Drew	Rinbrand WD	1955	--	100	7	6	7	pC	38	15	--	--	--	
B1-12	Arena Yolman	Mabey Bros.	1966	--	230	90	6	101	pC	65	8	135	.06	D	
B1-13	D. Danielson	Fitzpatrick	1962	--	120	95	6	95	--	45	15	75	.20	D	
B1-14	Robert Sipes	Mabey Bros.	1966	--	105	20	6	31	pC	18	10	46	2.17	D	
B1-15	Laura St. Corp	Do.	1967	--	390	70	6	85	pC	34	3	216	.01	D	
B1-16	Wm. Garcia	Rinbrand WD	1964	--	135	--	6	67	pC	5	5	25	.20	D	
B1-17	Steen Sandal	Dunn & Dunn	1967	--	153	--	6	63	pC	28	25	--	--	D	
B1-18	Harry Van Grolos Sr.	Do.	1964	--	88	19	6	35	pC	17	11	63	.17	D	
B1-19	Pub Ser Elec & Gas	Garden State	1959	--	235	60	6	65	pC	9	7	66	.11	--	
B1-20	Passaic Crushed Stone Co.	Rinbrand WD	1958	--	408	30	6	16	pC	16	25	300	.08	In	
	CLIFTON CITY														
C1-1	Donald Mabey	Mabey Bros.	1965	--	105	4	6	22	Trb	19	20	61	.33	TW	
C1-2	J. Rilkin	Do.	1965	--	392	7	6	30	Trb	70	35	230	.15	In	
C1-3	Allied Distilled Water	D & F W.D.	1962	--	173	--	6	48	Trb	--	--	--	--	In	
C1-4	Miles Chemical Co.	Burrow's WD	1966	--	300	--	12	19	Trb	55	214	125	1.71	TW	
C1-5	John CeDantano	Mabey Bros.	1955	--	230	9	6	33	Trb	80	21	70	.30	D	

Table 2.--Records of selected wells in Passaic County, N.J.--Continued

Aquifer: Qsd, Quaternary deposits; Trb, Brunswick Formation; Trbs, Watchung Basalt; Pal, Paleozoic rocks; p^{C}, Precambrian rocks
Use of well: PS, Public supply; In, industrial; Ac, air conditioning; Cm, commerical; Ir, irrigation; D, domestic; TW, test well
Remarks: Includes owners well number, interval screened, and water quality (QW), data available in table 3.

Well no.	Owner or tenant	Driller	Year drilled	Altitude above MSL (ft)	Total depth drilled (ft)	Depth to bedrock below land surface (ft)	Diameter of well (in)	Depth to which well is cased (ft)	Aquifer	Static level below land surface (ft)	Yield (gal/min)	Drawdown (ft)	Specific capacity (gal/min)/ft	Use of well	Remarks
	CLIFTON CITY--Cont.														
Cl-6	Bolero	Foster W.D.	1954	--	350	--	8	50	Trb	15	200	65	3.04	In	
Cl-7	Daniel Staufenberger	F. Bott	1966	--	131	21	6	25	Trb	43	25	0	--	Ir	
Cl-8	Shulten Inc.	Rinbrand WD	1955	--	300	--	10	28	Trb	8	435	142	3.06	In	
Cl-9	Do.	Do.	1964	--	400	20	10	20	Trb	25	198	175	1.13	Ac	
Cl-10	Do.	Do.	1964	--	300	20	10	21	Trb	20	322	180	1.79	Ac	
Cl-11	Athenia Steel Corp.	Wm. Stothoff	1955	--	389	6	12	31	Trb	34	330	56	5.90	In	
Cl-12	Do.	Do.	1965	--	450	4	12	40	Trb	20	205	130	1.58	In	QW
Cl-13	Eureka Printing Co.	Burrows W.D.	1959	--	60	--	12	40	Qsd	24	282	26	10.1	In	screened, 40'-55'
Cl-14	Federal Sweets & Biscuit Co.	Rinbrand WD	1949	--	400	--	10	49	Trb	45	280	105	2.67	In	QW
Cl-15	Jack Sion	J. Lauritsen	1968	--	120	--	6	15	Trb	20	20	87	.23	Ir	
Cl-16	Vincent Gallo	Rinbrand WD	1965	--	190	--	6	20	Trb	40	30	20	1.50	Ir	
Cl-17	Food Fair Stores	Burrows W.D.	1953	--	207	--	8	55	Trb	13	150	87	1.72	Ac	
Cl-18	Glopro Realty Co.	Rinbrand WD	1958	--	333	--	8	27	Trb	38	92	122	.75	Ac	
Cl-19	Allen B. Dumont Lab.	Do.	1958	--	305	--	10	22	Trb	11	335	104	3.22	In	
Cl-20	Mycalex Corp of Am.	Do.	1966	--	270	39	8	39	Trb	140	60	15	4.00	In	
Cl-21	Rutts Hut Rest.	Burrows W.D.	1956	45	304	--	8	61	Trb	45	105	56	1.91	Ac	QW
	HALEDON BORO														
Hl-1	Tilt Street Spring	--	--	--	0	0	Spring	--	Trb	flows	5-10	--	--	PS	QW
Hl-2	Gingert Laces Inc.	Burrows W.D.	1965	--	290	43	6	43	Trb & Trbs	40	100	--	.40	In	
	HAWTHORNE BORO														
Hw-1	John Oppelasr	H. Ackerman	1955	--	260	--	6	41	Trb	135	25	25	1.00	D	
Hw-2	Hawthorne Water Dept.	Burrows W.D.	1962	270	350	15	10	40	Trb	62	210	109	1.93	PS	Goffle Hill well, QW
Hw-3	Zampco Inc.	Sikkema	1962	--	380	35	6	35	Trb	4	65	196	.33	Ac	
Hw-4	Hawthorne Water Dept.	Grundy Well Works	1928	110	352	--	10	28	Trb	7	472	120	3.94	PS	Main Well Field, 5
Hw-5	Do.	Rinbrand WD	1960	150	300	32	10	52	Trb	43	225	172	1.31	PS	Utter Ave. well, QW

Table 2.--Records of selected wells in Passaic County, N.J.--Continued

Aquifer: Qsd, Quaternary deposits; Trb, Brunswick Formation; Trbs, Watchung Basalt; Pal, Paleozoic rocks; pC, Precambrian rocks
Use of well: PS, Public supply; In, industrial; Ac, air conditioning; Cm, commerical; Ir, irrigation; D, domestic; TW, test well
Remarks: Includes owners well number, interval screened, and water quality (QW), data available in table 3.

Well no.	Owner or tenant	Driller	Year drilled	Altitude above MSL (ft)	Total depth drilled (ft)	Depth to bedrock below land surface (ft)	Diameter of well (in)	Depth to which well is cased (ft)	Aquifer	Static level below land surface (ft)	Yield (gal/min)	Drawdown (ft)	Specific capacity (gal/min)/ft	Use of well	Remarks
	HAWTHORNE BORO--Cont.														
Hw-6	Hawthorne Water Dept.	Rinbrand WD	1966	90	400	15	10	38	Trb	22	213	61	3.50	PS	First Ave. well, QW
Hw-7	Do.	Do.	1966	90	400	22	10	35	Trb	25	213	170	1.25	PS	Rea Ave. well, QW
Hw-8	Do.	Do.	1961	80	300	39	10	51	Trb	10	500	145	3.45	PS	Bamford Ave. well
Hw-9	Do.	Do.	1960	85	300	20	10	40	Trb	14	225	181	1.24	PS	Grand Ave. well
Hw-10	Do.	Do.	1965	70	398	55	10	79	Trb	20	325	152	4.50	PS	Cedar Ave. well
Hw-11	Do.	Do.	1967	55	400	40	10	60	Trb	31	214	105	2.04	PS	Maitland Ave. well
Hw-12	Do.	Wagaraw well field with 9 wells, 8 to 10-inch dia. - all 300 to 400 ft deep. No individual well records available.													QW
Hw-13	Do.	South Wagaraw well field with 3 wells, all 10-inch dia., 300 ft - used for stand-by supply.													
Hw-14	Norris Mftg. Co.	Sikkema	1965	--	300	32	6	32	Trb	15	75	100	.75	In	
	LITTLE FALLS														
LF-1	First Sav. & Loan	Kieffer	1954	--	202	40	6	44	Trb	55	35	10	3.50	D	
LF-2	Ed. Krinski	D & F W.D.	1965	--	146	--	6	56	--	20	22+	30	--	D	
LF-3	S. Paul Calandia	Pine Brook	1966	--	255	166	6	170	Trbs	47	4	240	.02	Ir	
LF-4	V. Ropace	Mabey Bros.	1965	--	250	3	6	23	Trbs	12	35	113	.31	D	
LF-5	G. Landi	Do.	1965	--	125	4	6	20	Trbs	40	20	60	.33	D	
	NORTH HALEDON														
NH-1	Holland Homes Assoc.	Rinbrand WD	--	--	333	--	8	20	Trbs	15	180	218	.83	Cm	
NH-2	Robert A. Dean	Sikkema	1964	--	235	--	6	15	Trbs	flows	12	16	--	D	
NH-3	John Heerema	Do.	1963	--	245	--	6	20	Trb	flows	20	30	.67	D	
NH-4	A. M. Galti	Ackermen	1955	--	217	--	6	21	Trb	91	6	49	.12	D	
NH-5	Eugene Gioriti	Burrows W.D.	1961	--	125	50	6	60	Trbs	60	11	10	1.10	D	
NH-6	Mrs. Spinnler	Do.	1955	--	215	10	6	16	Trbs	22	20	7	2.9	D	
NH-7	Wah Chang	Do.	1960	--	302	38	8	40	Trb	10	510	24	21.2	TW	
NH-8	J. Pascale	Ackermen	1955	--	155	77	6	82	Trb	62	40	3	13.3	D	
NH-9	Ideal Farms Inc.	Do.	1960	--	285	89	8	96	Trb	80	160	80	.20	Cm	Making ice
NH-10	Patrick G. Walsh	Rinbrand WD	1966	--	250	--	6	20	Trb	100	15	80	.19	D	
NH-11	Walter J. Zavacki	Ackermen	1954	--	96	--	6	15	Trbs	50	7	20	.35	D	

Table 2.--Records of selected wells in Passaic County, N.J.--Continued

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Well no.	Owner or tenant	Driller	Year drilled	Altitude above MSL (ft)	Total depth drilled (ft)	Depth to bedrock below land surface (ft)	Diameter of well (in)	Depth to which well is cased (ft)	Aquifer	Static level below land surface (ft)	Yield (gal/min)	Draw-down (ft)	Specific capacity (gal/min)/ft	Use of well	Remarks
	PASSAIC														
Ps-1	Arrow Plastics Corp.	Rinbrand WD	1948	--	501	112	8	114	Trb	40	50	110	.45	In	
Ps-2	Panasote Co.	Do.	1967	--	500	90	8	90	Trb	50	110	150	.73	Ac	
Ps-3	J. L. Prescott Co.	Do.	--	--	500	--	8	--	Trb	--	--	--	--	In	QW
Ps-4	Farmland Dairy	Burrows W.D.	1968	--	300	3	12	53	Trb	20	284	103	2.76	In	
Ps-5	Speedway Car Wash	Rinbrand WD	1960	--	500	--	8	20	Trb	12	80	288	.28	Cm	
Ps-6	Passaic Gen. Hosp.	Do.	1966	--	300	--	6	20	Trb	45	15	275	.05	In	
	PATERSON														
Pt-1	Morris Paper Board	Do.	1950	--	625	--	10	22	Trb	50	119	150	.79	In	
Pt-2	Spotless Cleaners	Do.	1965	--	400	--	8	30	Trb	35	135	215	.63	Cm	
Pt-3	Our Lady of Victories	Do.	1954	--	300	--	6	25	Trb	35	112	115	.97	Ac	
Pt-4	Temple Emanuel	Do.	1954	--	150	--	8	17	Trb	30	150	40	3.76	--	
Pt-5	Magic Clean Car Wash	Do.	1965	--	200	22	8	22	Trb	22	108	85	1.27	Cm	
Pt-6	Ralph Simone	Slater	1969	--	145	--	6	58	Trbs	15	21	--	--	D	
Pt-7	Dugan Brothers	Burrows W.D.	1948	--	190	27	8	27	Trb	33	60	51	1.18	Ac	
Pt-8	Paterson Bd. of Ed.	Waddington	1965	--	312	--	6	63	Trb	55	115	--	--	In	
Pt-9	Heller Candy Co.	Burrows W.D.	1962	--	315	22	8	25	Trb	30	157	22	7.14	In	
Pt-10	United States Pkg.	Do.	1956	--	101	18	6	22	Trb	33	18	37	.48	In	
Pt-11	Food Fair Stores	Do.	1955	--	231	15	8	22	Trb	29	150	121	1.24	Ac	
Pt-12	Paramont Express	F. Bott	1965	--	58	--	6	58	Qsd	25	30	3	10.0	Cm	
Pt-13	Manhattan Casting	Rinbrand WD	1959	--	220	--	8	20	Trb	25	150	75	2.00	Ac	
Pt-14	Denman & Davis	Wm. Stothoff	1956	--	140	--	6	31	Trb	15	35	35	1.00	D	
Pt-15	M & M Lumber Co.	John Hantid	1968	--	125	12	6	30	Trb	18	30	--	--	--	
Pt-16	Fritzsche Bros.	Rinbrand WD	1963	--	600	--	12	21	Trb	25	210	175	1.20	In	
	POMPTON LAKES														
Pl-1	Pompton Lakes Boro	Rinbrand WD	1968	--	228	171	6	171	Qsd	17	200	53	3.8	TW	screened, 160'-170'

Table 2.--Records of selected wells in Passaic County, N.J.--Continued

Aquifer: Qsd, Quaternary deposits; Trb, Brunswick Formation; Trbs, Watchung Basalt; Pal, Paleozoic rocks; pC, Precambrian rocks
Use of well: PS, Public supply; In, industrial; Ac, air conditioning; Cm, commerical; Ir, irrigation; D, domestic; TW, test well
Remarks: Includes owners well number, interval screened, and water quality (QW), data available in table 3.

Well no.	Owner or tenant	Driller	Year drilled	Altitude above MSL (ft)	Total depth drilled (ft)	Depth to bedrock below land surface (ft)	Diameter of well (in)	Depth to which well is cased (ft)	Aquifer	Static level below land surface (ft)	Yield (gal/min)	Drawdown (ft)	Specific capacity (gal/min)/ft	Use of well	Remarks
	POMPTON LAKES--Cont.														
P1-2	Albert Terhums	Mabey Bros.	1964	--	210	2	6	42	pC	12	12	128	.09	D	
P1-3	Pompton Lakes Boro	Artesian WD	1964	--	250	--	8	31	pC	6	140	25	5.6	TW	
P1-4	Do.	Rinbrand WD	1967	--	270	185	6	85	Qsd	6	40	119	.30	TW	screened, 150'-160'
P1-5	Do.	Artesian WD	1962	--	148	147	8	--	Qsd	--	--	--	--	TW	
	RINGWOOD BORO														
Ri-1	Ringwood Manor St. Pk.	Rinbrand WD	1956	--	200	40	6	35	pC	4	12	96	.12	PS	
Ri-2	Mt. Saint Francis	A. McConnell	1966	--	395	--	6	35	pC	--	12	--	--	PS	
Ri-3	Ringwood Country Club	Rinbrand WD	1958	--	263	--	6	130	pC	31	35	99	.35	--	
Ri-4	Igor S. Kowsky	D.J. McBride	1963	--	123	--	6	27	pC	42	2	68	.03	D	
Ri-5	Windbeam Water Co.	D & F W.D.	1967	440	236	16	8	50	pC	90	150	85	1.76	PS	Owner's well 5, QW
Ri-6	Ringwood State Park	B & H Drill.	1964	--	75	3	6	13	pC	15	32	--	--	--	
Ri-7	Mt. Saint Francis	A. McConnell	1966	--	370	--	6	40	pC	--	10	--	--	--	
Ri-8	J. Van Der Weide	Mabey Bros.	1967	--	125	80	6	91	pC	18	12	82	.14	D	
Ri-9	Carl Cremer	Hakieffer	1955	--	100	68	6	72	pC	0	7	45	.16	D	
Ri-10	Jonas VaKarietis	D.J. McBride	1963	--	147	--	6	20	pC	37	3	103	.03	D	
Ri-11	Windbeam Water Co.	--	--	--	--	--	6	--	pC	9	100	--	--	PS	Owner's well 2
Ri-12	Albert Huber	D.J. McBride	1964	--	131	--	6	50	pC	0	25	28	.89	D	
Ri-13	John Captoni	D & F W.D.	1969	--	297	4½	6	50	pC	--	½	--	--	D	
Ri-14	Paul S. Polk	A.J. Greenins	1955	--	130	33	6	33	pC	40	7	70	.10	D	
Ri-15	Philip Schnett	D & F W.D.	1968	--	297	27	6	40	pC	--	0	--	--	--	Dry hole
Ri-16	Peter Constantino	Do.	1968	--	135	25	6	50	pC	40	20	--	--	D	
Ri-17	Otto Snyder	Mabey Bros.	1955	--	190	--	6	150	pC	53	6	105	.06	D	
Ri-18	Len Denhyer	Rinbrand WD	1968	--	330	5	6	30	pC	150	16	100	.16	D	
Ri-19	Viking Const. Co.	Mabey Bros.	1965	--	330	4	6	23	pC	140	½	180	.00	D	
Ri-20	DeDonato Const. Co.	Slater	1966	--	320	--	6	20	pC	90	1	230	.00	D	

Table 2.--Records of selected wells in Passaic County, N.J.--Continued

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Well no.	Owner or tenant	Driller	Year drilled	Altitude above MSL (ft)	Total depth drilled (ft)	Depth to bedrock below land surface (ft)	Diameter of well (in)	Depth to which well is cased (ft)	Aquifer	Static level below land surface (ft)	Yield (gal/min)	Draw-down (ft)	Specific capacity (gal/min)/ft	Use of well	Remarks
	RINGWOOD BORO--Cont.														
Ri-21	L. Downing	D.J. McBride	1964	--	112	53	6	57	pC	59	2½	41	.06	D	
Ri-22	Windbeam Water Co.	H.L. Park-urst	1927	--	164	--	8	124	pC	11	30	--	--	PS	Owner's well 1
Ri-23	Do.	Carl Lewis	1931	--	375	--	8	100	pC	2	65	120	.54	PS	Owner's well 3
Ri-24	Do.	Rinbrand WD	1939	--	242	--	8	43	pC	12	112	26	4.3	PS	Owner's well 4, QW
Ri-25	Do.	Burrows WD	1969	--	52	--	12	43	Qsd	8	214	32	6.7	PS	Owner's well 6, screened 42'-52'
Ri-26	Fountain Spr. Homes	Mabey Bros.	1965	--	165	4	6	20	pC	93	4	57	.07	D	
Ri-27	John Johnson	Rinbrand WD	1959	--	185	--	6	20	pC	25	6	125	.02	D	
Ri-28	G.A. Peduto & Sons	Mabey Bros.	1968	--	350	3	6	21	pC	165	½	175	.00	D	
Ri-29	Charles Barna	Rinbrand WD	1961	--	120	--	6	22	pC	50	7	5	1.4	D	
Ri-30	High Pt. Homes Inc.	Do.	1968	--	417	--	8	70	pC	100	37	152	.24	PS	Housing development
Ri-31	High Pt. Homes 1	D & F W.D.	1967	--	365	--	8	50	pC	1	22	299	.07	PS	Housing development
Ri-32	Edward Jansen	Do.	1961	--	343	--	5	55	pC	51	2½	199	.01	D	
Ri-33	Tara Builders	Slater	1966	--	120	--	6	42	pC	25	4	35	.11	D	
Ri-34	Ringwood Bd. of Ed.	Wm. Stothoff	1966	--	200	12	8	24	pC	38	100	161	.62	PS	School
Ri-35	G. A. Peduto & Sons	Mabey Bros.	1964	--	125	7	6	20	pC	30	1½	95	.02	D	
	TOTOWA														
To-1	Bob Kranik	Mabey Bros.	1965	--	310	2	6	20	Trbs	48	6	152	.04	D	
To-2	Charity Van Way	F. Bott	1966	--	460	8	6	22	Trbs	10	5½	150	.04	D	
To-3	Louis E. Agamie	R. Gentile	1965	--	90	20	6	40	Trbs	--	10	--	--	D	
To-4	Container Corp of North America	N. Jersey Art W.D. Co.	1958	--	600	--	6	32	Trbs	26	65	174	.37	Ac	
To-5	Uddehalm Steel Corp.	D & F W.D.	1966	--	147	5	6	20	Trbs	--	20+	--	--	In	
To-6	Thorton Glove Co. Inc	Do.	1965	--	150	5	6	21	Trb	30	--	--	--	D	
	WANAQUE BORO														
Wn-1	W. Munzlunger	Ackerson WD	1962	--	70?	--	6	70	pC	20	10	20	.50	D	

Table 2.--Records of selected wells in Passaic County, N.J.--Continued

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	WANAQUE BORO--Cont.														
Wn-2	Wanaque Water Dept. Midvale Well	C.W. Lauman	--	--	67	--	12	--	Qsd	--	200	--	--	PS	Midvale well, QW
Wn-3	Gus Petti	Mabey Bros.	1965	--	105	3	6	24	pC	26	8	--	--	D	
Wn-4	Adeline Scrirani	D & F W.D.	1967	--	172	--	6	40	pC	30	5½	120	.04	D	
Wn-5	Joseph Cantella	Rinbrand WD	1955	--	290	--	6	17	pC	10	4	145	.03	D	
Wn-6	Claude Crum	D & F W.D.	1968	--	120	6	6	21	pC	12	20	--	--	D	
Wn-7	Meyer Zendell	Do.	1967	--	297	2	6	20	pC	--	1	--	--	D	
Wn-8	Wanaque Water Dept. Haskell Well	Rinbrand WD	1962	--	115	--	12	90	Qsd	10	920	17	54.1	PS	Haskell well, QW screened, 90'-115'
Wn-9	Magna Mfg. Co. W. 1	Burrows WD	1951	--	175	76	6	76	pC	8	9	112	.08	In	
Wn-10	Magna Mfg. Co.	Do.	1955	--	234	75	6	80	pC	6	6	144	.04	In	
Wn-11	Do.	Do.	1951	--	201	--	6	47	pC	8	16	139	.11	In	
	WAYNE TWP.														
Wy-1	A. G. Hooper	Rinbrand WD	1955	--	214	--	8	27	Trb	76	40	4	10.0	--	
Wy-2	Wayne Twp. W.D.	Do.	1942	--	160	--	8	--	Trb	19	85	78	1.09	PS	Pines Lake, 3-on Green Knolls Rd.
Wy-3	Do.	Do.	Before 1940	--	206	--	6	--	Trb	25	98	123	.80	PS	Pines Lake, 2-on Balsam Rd., QW
Wy-4	Do.	Do.	1949	--	203	--	12	34	Trb	19	133	141	.94	PS	Pines Lake, 1-on Lake Dr. East
Wy-5	Bilevel Const. Co.	Mabey Bros.	1967	--	105	7	6	21	Trbs	7	15	58	--	D	
Wy-6	Frank Briscoe Co.	Rinbrand WD	1961	--	200	120	6	120	Trb	94	10	14	.71	--	
Wy-7	Wayne Twp. W.D.	Do.	1954	340	200	25	8	25	Trb	10	115	140	.82	PS	Lionshead Lake
Wy-8	Do.	Do.	1940	--	260	70	6	--	Trb	40	100	60	1.67	PS	QW
Wy-9	Do.	Do.	1940	--	252	40	8	40	Trb	15	50	50	1.00	PS	
Wy-10	H. A. Laauwe, Jr.	F. Bott	1962	--	325	50	6	54	Trb	40	25	80	.31	D	
Wy-11	Ed Sisco		1966	--	160	29	6	31	Trb	21	14	45	.31	D	
Wy-12	North Jersey Country Club	C.S.K. Kema	1957	--	476	45	6	51	Trbs	20	5	--	--	--	

Table 2.--Records of selected wells in Passaic County, N.J.--Continued

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	WAYNE TWP.--Cont.														
Wy-13	F. Gentile	C.S.K. Kema	1961	--	205	--	6	20	Trbs	12	7	68	--	D	
Wy-14	Wayne Enterprises	Rinbrand WD	1954	--	150	57	6	58	Trb	12	20	3	6.67	Cm	
Wy-15	Fred Bauer	J. Lauritsen	1967	--	290	--	6	140	Trb	6	10	--	--	D	
Wy-16	Louis A. Pekar	D & F W.D.	1965	--	190	--	6	64	Trb	--	--	--	--	--	
Wy-17	Leonard VanDerStad	Mabey Bros.	1961	--	120	7	6	18	Trb	3	20	22	.91	D	
Wy-18	US Army, Corp of Eng	Burrows W.D.	1955	--	153	14	6	35	Trb	6	8	119	.07	D	
Wy-19	VanDedeer Sand So.	Rinbrand WD	1968	--	217	--	10	70	Trbs	10	140	90	1.6	In	
Wy-20	Robert A. Mills	Do.	1960	--	378	--	6	22	Trbs	45	10	205	.05	D	
Wy-21	J. La Motta	Mabey Bros.	1965	--	55	15	6	26	Trbs	22	15	17	.88	D	
Wy-22	Preakness Hills Country Club	Wm. Stothoff	1966	--	342	36	8	40	Trb	23	197	139	1.42	Ir	
Wy-23	Med. & Prof. Pk. Inc	Burrows W.D.	1965	--	240	12	8	15	Trb	30	205	112	1.83	TW	
Wy-24	Wm. Plueinsky	Rinbrand WD	1965	--	173	22	6	25	Trbs & Trb	72	25	48	.57	D	
Wy-25	Pascack Lake Country Club	Do.	1955	--	200	--	8	35	Trb & Trbs	flows 10 gal/min	175	100+	--	Ir	
Wy-26	Do.	Do.	1956	--	165	--	10	32	Trb	2	168	148	1.13	Ir	
Wy-27	Joe D. Angelo	Do.	1969	--	253	--	6	35	Trbs	35	25	185	.52	D	
Wy-28	Frank Avolio	Do.	1955	--	160	34	6	34	Trb & Trbs	48	8	20	.40	D	
Wy-29	B. Gualano	Ackerman	1955	--	142	16	6	21	Trb & Trbs	--	25	--	--	D	
Wy-30	Union Carbide Corp.	Burrows W.D.	1962	--	63	--	8	50	Qsd	No test. - Insufficient water				TW	
Wy-31	Do.	Do.	1962	--	88	--	8	78	Qsd	--	15	80	.19	TW	screened, 78'-88'
Wy-32	Do.	Do.	1962	--	350	92	8	84	Trb	flows	7	300	.02	TW	
Wy-33	Albert Battaglia	D & F W.D.	1968	--	472	100	8	121	Trb & Trbs	10	40	260	.15	--	
Wy-34	Packanack Golf Club	F. Bott	1965	--	84	--	6	85	Qsd	1	40	26	1.5	Ir	
Wy-35	Packanack Lake Country Club & Comm. Assoc.	Burrows WD	1962	--	200	--	10	31	Trb	10	225	102	2.20	--	

Table 2.--Records of selected wells in Passaic County, N.J.--Continued

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	WAYNE TWP.--Cont.														
Wy-36	Carl Presti	J. Lauritsen	1966	--	30	--	6	30	Trbs	25	30	30	1.00	D	
Wy-37	Wayne Township	Rinbrand WD	1965	--	400	98	8	100	Trb	45	151	150	1.00	TW	
Wy-38	Wm. Hasnenberg	Wiltwer	1966	--	152	55	6	60	Trb	43	25	64	.39	D	
Wy-39	Stephen J. Galern	J. Lauritsen	1967	--	50	15	6	20	Trbs	12	20	13	1.5	D	
Wy-40	Neil DeVisser	D & F W.D.	1966	--	100	60	6	93	Qsd	30	22	25	.88	D	
Wy-41	First Nat'l Bank	Rinbrand WD	1963	--	84	--	8	69	Qsd	+1	50	60	.83	Ir	screened, 69'-84'
Wy-42	Shell Oil Co.	Algier	1958	--	213	129	6	129	Trb	8	15	16	.94	Cm	
Wy-43	Mead Industries	F. Bott	1959	--	306	83	6	86	Trb	19	80	81	1.00	In	
Wy-44	Chemway Corp.	Wm. Stothoff	1956	--	90	--	10	62	Qsd	18	400	27	1.48	In	screened, 58'-90'
Wy-45	Do.	Do.	1956	--	91	84	12	73	Qsd	18	50	47	1.06	In	screened, 70'-84'
Wy-46	Willow Br. Sport Ctr	Rinbrand WD	1956	--	480	--	8	40	Trbs	8	60	142	.42	In	
Wy-47	Plastic Serv. Corp.	Do.	1956	--	470	35	10	36	Trbs	--	75	--	--	In	
Wy-48	Richard Zirb	Mabey Bros.	1963	--	63	--	6	63	Qsd	10	25	15	1.67	D	
Wy-49	Anthony Pinto	Pine Brook	1963	--	52	--	6	52	Qsd	11	12	14	.86	D	
	WEST MILFORD TWP.														
WM-1	Twp. Bd. of Ed. Upper Greenwood Lake School	Joe Burd	1966	--	274	--	8	32	pC	35	45	--	--	PS	
WM-2	John F. Lannon	D & F W.D.	1962	--	124	--	5	18	pC	5	3	120	.03	D	
WM-3	John Thomason	G.R. Burgess	1956	--	208	15	6	20	Pal	30	3½	170	.02	D	
WM-4	B. Crawford	D & F W.D.	1967	--	245	1	6	50	pC	26	5	204	.02	D	
WM-5	Valley Br. Shopping Center	M.S. Beard-slee	1962	--	127	--	6	56	pC	15	6	112	.05	Cm	
WM-6	N. Marchese	G.R. Burgess	1954	--	94	65	6	65	pC	20	10	40	.25	D	
WM-7	H. Colville, Jr.	Fitzpatrick	1965	--	108	17	6	30	pC	18	21	23	.91	D	
WM-8	Morris Kaufman	Slater Bros.	1966	--	170	--	6	20	pC	16	4	54	.07	D	
WM-9	P. McKeegan	Fitzpatrick	1963	1400	140	26	6	36	Pal	65	4	75	.05	D	
WM-10	J. Gazerwitz	Do.	1967	--	88	17	6	35	Pal	flows	13	88	.15	D	

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	<u>WEST MILFORD TWP.--Cont.</u>														
WM-11	Unknown	--	--	--	63	--	--	11	Pal	11	5	--	--	--	
WM-12	C. W. Hole	Fitzpatrick	1966	--	188	130	6	130	--	5	17	182	.09	--	
WM-13	W. Milford Twp. Munic. Util. Auth.	M. W. Ives & Sons	1956	700	400	--	8	177	pC	30	200	120	1.66	PS	Formerly Ringwood Co. 2
WM-14	Fred Ferber	D. & F. W.D.	1962	--	195	--	6	26	pC	10	17	170	.10	D	
WM-15	Henry Soladay	G.R. Burgess	1955	--	150	6	6	11	pC	34	2	111	.02	D	
WM-16	L. Raimondi	D. & F. W.D.	1964	--	72	46	--	72	pC	8	20	--	--	D	
WM-17	Do.	Do.	1964	--	90	27	6	50	Pal	5	8	65	.12	D	
WM-18	Elias Lee	G.R. Burgess	1962	--	55	12	6	27	Pal	3	10	37	.70	--	
WM-19	J. Wasson	H.W. Smith	1962	--	265	5	6	30	pC	22	4	--	--	D	
WM-20	W. Otten	Rinbrand WD	1964	--	155	2	6	21	Pal	35	5	45	.11	D	
WM-21	Ted F. Kurtz	Fitzpatrick	1967	--	98	16	6	27	Pal	2	17	96	.18	D	
WM-22	Arthur Storkeck	D. & F. W.D.	1966	--	128	--	6	119	Qsd	flows	3½	80	--	D	
WM-23	David Crum	Fitzpatrick	1961	1400	145	115	6	115	Pal	5	4	140	.02	--	
WM-24	Do.	D. & F. W.D.	1965	--	197	93	6	104	Pal	25	2	155	.01	D	
WM-25	Hobart McVagnew	Joe Burd	1959	1900	96	--	6	96	Qsd	16	10	--	--	D	
WM-26	W. Milford Twp. Munic. Util. Auth.	--	1914	--	125	--	6	--	pC	60	13	110	1.18	PS	Awosting 1, formerly Awemi 1, QW
WM-27	Do.	--	1931	--	360	--	8	--	pC	40	7	--	--	PS	Awosting 2, formerly Awemi 2
WM-28	Robert Carmody	Aaron Slater	1968	--	145	--	6	21	pC	32	7½	--	--	D	
WM-29	C. H. Jacels	Do.	1968	--	120	--	6	82	--	flows	25	--	--	D	
WM-30	B. Beekman	Do.	1968	--	120	--	6	54	pC	--	18	--	--	D	
WM-31	Henry Dykstra	Rinbrand WD	1961	--	153	--	6	67	pC	30	7	100	.07	D	
WM-32	Siemer Packing Co.	Do.	1961	--	150	47	6	47	pC	15	25	5	5.0	--	
WM-33	D. J. Crum	Fitzpatrick	1967	--	102	69	6	69	--	25	10	76	.13	D	
WM-34	Unknown	--	--	--	97	--	--	57	pC	14	6	76	.09	--	

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Remarks: Includes owners well number, interval screened, and water quality (QW), data available in table 3.

Well no.	Owner or tenant	Driller	Year drilled	Altitude above MSL (ft)	Total depth drilled (ft)	Depth to bedrock below land surface (ft)	Diameter of well (in)	Depth to which well is cased (ft)	Aquifer	Static level below land surface (ft)	Yield (gal/min)	Drawdown (ft)	Specific capacity (gal/min)/ft	Use of well	Remarks
	WEST MILFORD TWP.--Cont.														
WM-35	B. Kress	D. & F. W.D.	1966	--	97	--	6	61	Pal	19	20	60	.33	D	
WM-36	Brewster Burns	Do.	1965	--	146	--	--	85	pC	34	3½	106	.03	D	
WM-37	T. B. Hopkins	Fitzpatrick	1967	--	119	116	6	116	Qsd	31	15	87	.19	D	
WM-38	Birch Hill Pk. W.C.	Rinbrand WD	1968	--	453	90	8	110	pC	26	11	350	.03	PS	
WM-39	M. Terhune	D. & F. W.D.	1965	--	125	--	--	105	Qsd	32	2	58	.03	D	
WM-40	Pinecliff Lk. Realty	Parkhurst Well & Pump	1948	--	22	--	8	14	Qsd	flows	50	18	2.78	PS	
WM-41	Unknown	--	--	--	206	--	--	18	Pal	30	35	130	.17	--	
WM-42	Mrs. M. Lebrizzi	D. & F. W.D.	1965	--	110	--	6	92	Pal	60	10	--	--	D	
WM-43	Willard J. Call	Do.	1963	--	322	--	6	141	pC	141	1 qt	109	.00	D	
WM-44	David Provan	Rinbrand WD	1964	--	260	--	6	186	pC	135	8	65	.12	D	
WM-45	Jan Builders	D. & F. W.D.	1965	--	170	138	6	138	Pal	80	7	80	.09	D	
WM-46	L. Rainmondi	Do.	1967	--	125	70	6	80	pC	--	14	--	--	D	
WM-47	Raymond Ganz	Rinbrand WD	1962	--	348	--	6	210	Pal	85	5	165	.03	D	
WM-48	W. Milford Twp. Munic. Util. Auth.	Do.	1965	--	400	--	8	45	Pal	25	30	160	.19	PS	Cresent Park well, QW
WM-49	Unknown	--	--	--	260	--	--	140	pC	70	2	175	.01	--	
WM-50	A. J. Carbone	D. & F. W.D.	1965	--	347	22	--	42	pC	10	1 qt	240	.42	D	
WM-51	Robert Loeb	Dunn & Dunn	--	--	98	--	6	17	pC	10	30	--	--	D	
WM-52	W. Milford Twp. Munic. Util. Auth.	Joe Burd	1966	--	208	8	6	18	pC	30	35	160	.22	PS	Formerly Olde Milford Homes well
WM-53	A. J. Carbone	D. & F. W.D.	1963	--	347	--	6	22	pC	64	1 qt	261	.00	D	
WM-54	Wm. Prince	Do.	1965	--	322	7	6	50	pC	165	1 pt	105	.00	D	
WM-55	J. W. Cahill	Dunn & Dunn	1964	--	147	--	6	75	pC	40	3	60	.05	D	
WM-56	F. J. Florance	D. & F. W.D.	1965	--	147	65	6	84	pC	12	8	128	.06	D	
WM-57	Phillips & DeBlasio	Do.	1964	--	72	0	--	36	pC	6	4	54	.07	D	
WM-58	John Bott	J. F. Mercer	1963	--	162	--	6	21	pC	8	5	117	.03	D	

Table 2.--Records of selected wells in Passaic County, N.J.--Continued

Aquifer: Qsd, Quaternary deposits; Trb, Brunswick Formation; Trbs, Watchung Basalt; Pal, Paleozoic rocks; pC, Precambrian rocks
Use of well: PS, Public supply; In, industrial; Ac, air conditioning; Cm, commerical; Ir, irrigation; D, domestic; TW, test well
Remarks: Includes owners well number, interval screened, and water quality (QW), data available in table 3.

Well no.	Owner or tenant	Driller	Year drilled	Altitude above MSL (ft)	Total depth drilled (ft)	Depth to bedrock below land surface (ft)	Diameter of well (in)	Depth to which well is cased (ft)	Aquifer	Static level below land surface (ft)	Yield (gal/min)	Draw-down (ft)	Specific capacity (gal/min)/ft	Use of well	Remarks
	WEST MILFORD TWP.--Cont.														
WM-59	Wm. Doran	D. & F. W.D.	1964	--	177	--	--	177	Qsd	80	3	80	.04	D	
WM-60	Claudale Constr.	Do.	1966	--	122	27	6	73	pC	47	5	63	.08	D	
WM-61	Herman Wissel, Jr.	Fitzpatrick	1963	1400	101	13	6	23	pC	17	5	84	.06	D	
WM-62	S. Scognamillo	D. & F. W.D.	1965	--	96	72	6	--	Pal	33	4	52	.08	D	
WM-63	Unknown	--	--	--	223	--	6	60	Pal	2	6	198	.03	--	
WM-64	Sundown Farms	D. & F. W.D.	1965	--	80	--	6	71	Qsd	27	18	33	.55	D	
WM-65	A. Carbone	Fitzpatrick	1966	--	131	114	6	114	Pal	18	13	112	.13	D	
WM-66	Bent Pernice	D. Feakins	1963	--	220	--	--	216	Pal	20	6	150	.04	D	
WM-67	Lester DeBow	Geo. Burgess	1966	--	77	--	6	42	Pal	25	5	45	.11	D	
WM-68	John Dondero	Fitzpatrick	1964	--	169	100	6	100	Pal	24	12	75	.16	D	
WM-69	Wm. J. Duffy	Ackerman	1964	450	185	--	6	75	Pal	55	25	35	.71	D	
WM-70	David Crum	Fitzpatrick	1965	--	110	19	6	28	Pal	12	17	98	.17	D	
WM-71	Dalane Inc.	Fitzpatrick	1963	1400	93	51	6	51	Pal	23	5	70	.07	D	
WM-72	Twp. Bd. of Ed.	Burrows W.D.	1955	--	156	--	6	30	Pal	14	30	62	.48	PS	
WM-73	J. B. Bradley	Fitzpatrick	1964	--	112	23	6	33	Pal	8	21	42	.50	D	
WM-74	Joe Cappadona	D. & F. W.D.	1963	--	146	--	6	22	Pal	77	7	49	.14	D	
WM-75	H. Turner	F. Vreeland	1954	--	83	39	6	53	Pal	47	15	18	.83	D	
WM-76	C. Corby	Rinbrand WD	1954	--	205	13	6	13	Pal	35	1½	165	.01	D	
WM-77	Harry A. Kimble	D. & F. W.D.	1966	--	98	5	6	20	Pal	20	10	65	.15	D	
WM-78	Stan Malorgio	Do.	1961	--	325	--	5	124	Pal	82	5	208	.02	D	
WM-79	Chas. G. Cummings	Do.	1964	--	247	--	6	54	Pal	15	1½	225	.00	D	
WM-80	John Sisco	Fitzpatrick	1965	--	107	20	6	46	pC	26	12	81	.15	D	
WM-81	Abram Call	Burrows W.D.	1959	--	85	85	6	72	Qsd	12	30	27	1.11	D	
WM-82	Helen J. Osar	Mabey Bros.	1963	1000	123	--	6	74	pC	25	10	50	.20	D	
WM-83	C. Spangenberg	Dunn & Dunn	1965	--	222	--	6	22	--	10	1½	--	--	D	
WM-84	Kelly & Kelly	Rinbrand WD	1962	--	123	--	6	20	pC	25	6	75	.08	D	
WM-85	David Apgar	D. & F. W.D.	1963	--	172	--	6	24	pC	23	2	137	.01	D	
WM-86	Edwin Bamper	Do.	1967	--	172	33	6	52	pC	8	4½	152	.03	D	

Table 2.--Records of selected wells in Passaic County, N.J.--Continued

Aquifer: Qsd, Quaternary deposits; Trb, Brunswick Formation; Trbs, Watchung Basalt; Pal, Paleozoic rocks; pC, Precambrian rocks
Use of well: PS, Public supply; In, industrial; Ac, air conditioning; Cm, commerical; Ir, irrigation; D, domestic; TW, test well
Remarks: Includes owners well number, interval screened, and water quality (QW), data available in table 3.

Well no.	Owner or tenant	Driller	Year drilled	Altitude above MSL (ft)	Total depth drilled (ft)	Depth to bedrock below land surface (ft)	Diameter of well (in)	Depth to which well is cased (ft)	Aquifer	Static level below land surface (ft)	Yield (gal/min)	Drawdown (ft)	Specific capacity (gal/min)/ft	Use of well	Remarks
	WEST MILFORD TWP.--Cont.														
WM-87	N. Booker	Fitzpatrick	1966	--	125	122	6	122	Qsd	125	17	89	.19	D	
WM-88	Martin Crum	D. & F. W.D.	1964	--	148	4	--	20	pC	20	2½	118	.02	D	
WM-89	Gus Vanarden	Fitzpatrick	1963	--	132	19	6	29	pC	6	20+	101	.20	D	
	WEST PATERSON														
WP-1	Top Burger	Pine Brook	1965	--	201	81	6	85	Trbs	5	38	140	.27	Ac	
WP-2	John Scald	N.J. Artesian W.D.	1954	--	300	--	6	6	Trb	50	5	25	.20	D	
WP-3	J. O. Puda	H. Ackerson	1955	--	217	--	6	12	Trb	110	20	20	1.00	D	

Table 3.--Chemical analyses of water from wells in Passaic County, N.J.

(Results in milligrams per litre, except for pH and specific conductance)

Aquifer: Qsd, glacial deposits; Trb, Brunswick Formation; Pal, Paleozoic rocks; pC, Precambrian rocks.

Well number	Owner and owner's well number or name	Aquifer	Date of Collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$		Specific Conductance (micromhos at 25°C)	pH	Remarks
																Calcium, magnesium	Non-carbonate			
	CLIFTON																			
Cl-12	Athenia Steel Well No. 4	Trb	11-3-65	17	0.25	140	45	5.6	--	24	435	60	--	--	--	540	--	980	5.9	Analysis by Hungerford and Terry. Free carbon dioxide, 111 mg/l as CO_2.
Cl-14	Federal Sweets and Biscuit Co.	Trb	3-21-69	16	.03	48	21	16	1.5	174	42	40	0.0	16	317	207	64	514	8.2	Phosphate (PO_4) 0.00 mg/l.
Cl-21	Rutts Hut Rest.	Trb	6-5-69	17	.03	80	34	36	3.0	246	150	51	.0	18	563	340	138	823	8.4	Manganese (Mn) 0.29 mg/l.
	HALEDON BORO																			
Hl-1	Tilt St. Spring	Trb	4-3-69	24	.05	40	8.2	8.5	.5	100	43	16	.0	13	223	134	54	336	7.7	Phosphate (PO_4) 0.00 mg/l.
	HAWTHORNE BORO																			
	Hawthorne Water Dept.																			
HW-3	Goffle Hill	Trb	4-2-69	13	.04	35	18	.44	.03	157	27	23	.0	15	240	162	33	405	8.2	Phosphate (PO_4) 0.00 mg/l.
HW-5	Utter Avenue	Trb	4-2-69	19	.06	41	12	9.0	.8	136	39	16	.0	17	248	152	41	385	8.1	Phosphate (PO_4) 0.00 mg/l.
HW-4	Well No. 5, Main Field	Trb	4-2-69	15	.04	50	19	15	2.0	183	34	40	.0	17	315	203	53	521	8.1	Phosphate (PO_4) 0.00 mg/l.
HW-6	First Ave.	Trb	9-11-68	--	.6	--	--	11	--	188	32	37	--	2.0	351	224	--	--	7.1	Analysis by N.J. Dept. of Health.
HW-7	Rea Ave.	Trb	9-11-68	--	.3	--	--	15	--	176	28	23	--	2.0	280	186	--	--	7.4	Analysis by N.J. Dept. of Health.
HW-12	Well No. 3, Wagaraw	Trb	4-28-59	--	--	--	--	32		160	86	21	--	12	--	190	59	424	8.0	
	PASSAIC																			
Ps-3	J. L. Prescott Co.	Trb	3-20-69	17	.07	82	26	24	2.3	260	74	54	.0	13	504	312	99	787	7.8	Phosphate (PO_4) 0.00 mg/l.

Table 3.--Chemical analyses of water from wells in Passaic County, N.J.--Continued

(Results in milligrams per litre, except for pH and specific conductance)

Aquifer: Qsd, glacial deposits; Trb, Brunswick Formation; Pal, Paleozoic rocks; pC, Precambrian rocks.

Well number	Owner and owner's well number or name	Aquifer	Date of Collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$		Specific Conductance (micromhos at 25°C)	pH	Remarks
																Calcium, magnesium	Non-carbonate			
	RINGWOOD BORO																			
	Windbeam Water Co.																			
Ri-24	No. 4	pC	4-30-59	--	--	--	--	2.8		58	12	4.4	--	1.2	--	61	14	146	7.2	
Ri-24	No. 4	pC	4-9-69	16	.05	28	5.7	5.2	.5	82	25	11	.0	3.7	155	94	27	229	7.3	Phosphate (PO_4) 0.00 mg/l.
Ri-5	No. 5	pC	4-9-69	16	.04	25	10	14	1.5	136	18	3.5	.3	1.0	159	104	0	269	8.0	Phosphate (PO_4) 0.00 mg/l.
	WANAQUE BORO																			
	Wanaque Water Dept.																			
Wn-2	Midvale	Qsd	4-30-59	18	.08	18	4.9	7.0	1.8	36	26	8.2	.1	19	122	65	36	190	6.5	
Wn-8	Haskell	Qsd	4-9-69	14	.07	23	6.2	6.8	.5	82	26	5.0	.0	1.2	133	83	16	207	7.6	Phosphate (PO_4) 0.00 mg/l.
	WAYNE TWP.																			
	Wayne Twp. Water Dept.																			
Wy-3	Pine Lake	Trb	6-4-64	23	.08	47	17	13	.5	127	76	14	.1	5.2	278	188	84	404	7.8	Phosphate (PO_4) 0.10 mg/l.
Wy-8	Lionshead Lake	Trb	6-4-64	24	.09	21	8.8	5.4	.2	86	21	3.7	.1	1.2	129	89	18	194	7.2	Phosphate (PO_4) 0.20 mg/l.
	WEST MILFORD TWP.																			
	Twp. Mun. Util. Auth.																			
WM-26	Awosting No. 1	pC	4-30-59	26	.47	7.2	3.9	4.8	.5	40	9.1	2.4	.4	.0	66	34	1	92	6.8	
WM-40	Pinecliff Lake Realty Co. 1	Pal or Qsd	4-30-59	--	--	--	--	14		210	24	6.1	--	.1	--	175	3	365	8.1	
WM-48	W. Milford Twp. Mun. Util. Auth. Cresent Park	Pal	4-11-69	11	.27	21	7.5	9.7	.5	95	25	3.5	.0	.0	134	84	6	229	7.1	Phosphate (PO_4) 0.00 mg/l.