STATE OF NEW JERSEY
DEPARTMENT OF CONSERVATION
AND ECONOMIC DEVELOPMENT

DIVISION OF WATER POLICY
AND SUPPLY

SPECIAL REPORT NO. 28

GROUND-WATER RESOURCES OF ESSEX COUNTY, NEW JERSEY

Prepared in cooperation with
United States Department of the Interior
Geological Survey

1968

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By

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Hydrologist, U. S. Geological Survey

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DEPARTMENT OF CONSERVATION
AND ECONOMIC DEVELOPMENT

ROBERT A. ROE, *Commissioner*

DIVISION OF WATER POLICY AND SUPPLY
GEORGE R. SHANKLIN, *Director and Chief Engineer*

CONTENTS

ILLUSTRATIONS

TABLES

LETTER OF TRANSMITTAL

Honorable Robert A. Roe, *Commissioner*
Department of Conservation and
Economic Development
John Fitch Plaza
Trenton, New Jersey

Dear Sir:

I am transmitting a report entitled "Ground Water Resources of Essex County, New Jersey," which was completed by the Ground Water Branch, Water Resources Division, U. S. Geological Survey, in cooperation with the New Jersey Division of Water Policy and Supply, as part of the state-wide program authorized by the 1958 Water Supply Law.

The report evaluates the relative importance of the aquifers of Essex County as to their present use and suitability for future development. It indicates which areas are being overpumped and those areas where further ground water exploration would be profitable.

The information in this report is of vital interest and importance to the growth of the county and provides a basis for the protection and safe development of the ground water resources essential for such growth. I, therefore, recommend that this report be published as a Special Report of the Division of Water Policy and Supply.

Respectfully submitted,
George R. Shanklin
Director and Chief Engineer

September 9, 1968

GROUND-WATER RESOURCES OF ESSEX COUNTY, NEW JERSEY

By William D. Nichols

ABSTRACT

Ground water in Essex County occurs in joints and fractures in consolidated rocks and in the voids of unconsolidated statified drift deposits. Wells in sandstone and shale of the Brunswick Formation of Triassic age yield from 35 to 820 gpm; the most productive water-bearing zones are commonly between depths of 300 to 400 feet. Drawdown due to pumping is greatest in the direction of strike of the formation (about N 30′ E in Essex County) and least in the direction perpendicular to strike. Wells in the Watchung basalt, which is intercalated with rocks of the Brunswick Formation commonly yield small to moderate supplies but may occasionally yield up to 400 gpm. Large yields, ranging from 410 to 1,593 gpm, are common from wells tapping the stratified drift deposits in the western part of the county.

Quality of ground water is acceptable for most uses throughout the county. However, heavy pumpage in the Newark area has lowered water levels to more than 100 feet below sea level. The low water levels have reversed the natural gradient and induced the flow of salt water into the bedrock aquifer, seriously impairing ground-water quality there. Recent analyses of ground-water samples from Newark indicate that the chloride concentration in the aquifer has increased since the preliminary study of the problem by Herpers and Barksdale in 1951.

Highly productive stratified drift deposits are found primarily in that part of the county west of Second Watchung Mountain. They occur as valley-fill material in stream valleys cut into the underlying bedrock before the last glaciation. These deposits in Essex County are part of an extensive valley-fill aquifer system underlying the eastern Morris-western Essex County area. Water levels in these deposits in western Millburn Township have declined 36 feet since 1950, probably as a result of below normal rainfall for most of the period 1953 to 1966 together with constantly increasing pumpage throughout the area.

Withdrawals of ground water from all aquifers in Essex County for public supply averaged about 26 mgd (million gallons per day) in 1966. Pumpage for public supply from aquifers in unconsolidated sediments averaged 20.9 mgd, about 81 percent of the total from all aquifers.

Most of the productive aquifers in Essex County are currently being developed. Although the optimum potential of the stratified drift aquifers

in western Essex County and the Brunswick Formation in the northeastern part of the county probably has not been realized, development of these resources must be undertaken with care if anticipated increase in water needs of the county are to be met.

INTRODUCTION

PURPOSE AND SCOPE

This study was made as part of a statewide program of investigation of the ground-water resources of New Jersey, authorized by the New Jersey Water Supply Act of 1958 and its companion, Water Bond Act. The purpose and scope of these studies are to assemble the available data on geologic and hydrologic factors relating to the occurrence, movement, availability, and chemical quality of ground water in New Jersey; to evaluate and interpret the data; and to make the results of the investigation available to the public. This report represents the results of the ground-water investigation of Essex County made by the U. S. Geological Survey in cooperation with the New Jersey State Department of Conservation and Economic Development, Division of Water Policy and Supply. The work was under the general supervision of Allen Sinnott, formerly District Geologist.

LOCATION AND EXTENT OF AREA

Essex County is located in northeastern New Jersey between longitudes 74°05′W and 74°25′W, and latitudes 40°40′N and 40°55′N. It is bounded on the north by Passaic County; on the east by Bergen County, Hudson County, and Newark Bay; on the south by Union County and on the west by Morris County (fig. 1). The county is 127.44 square miles in area. Newark is the county seat. Other major communities include Orange, East Orange, South Orange, West Orange, Irvington, Belleville, Nutley, Montclair, and Bloomfield.

PREVIOUS INVESTIGATIONS

The geology of Essex County is described in detail by Darton and others (1908) in the Passaic folio. Salisbury (1894) discussed the surficial geology of the county as part of a regional investigation. Rogers and others (1951) described the engineering characteristics of the soils and glacial deposits in the county. Ground-water conditions in the extreme southwestern part of the county were described by Thompson (1932). Herpers and Barksdale (1951) discussed ground-water conditions in the Newark area.

ACKNOWLEDGMENTS

The author wishes to thank the numerous well drillers, State, municipal, and industrial officials and private individuals who supplied data on which this report is based. Acknowledgment is made for the records and logs of wells that were furnished from the files of the New Jersey Bureau of Geology and Topography. The cooperation of those who permitted use of their wells for water-level observation, collection of water samples, and pumping tests is gratefully acknowledged. Most of the well inventory for this report was made by the late O. J. Coskery of the U. S. Geological Survey.

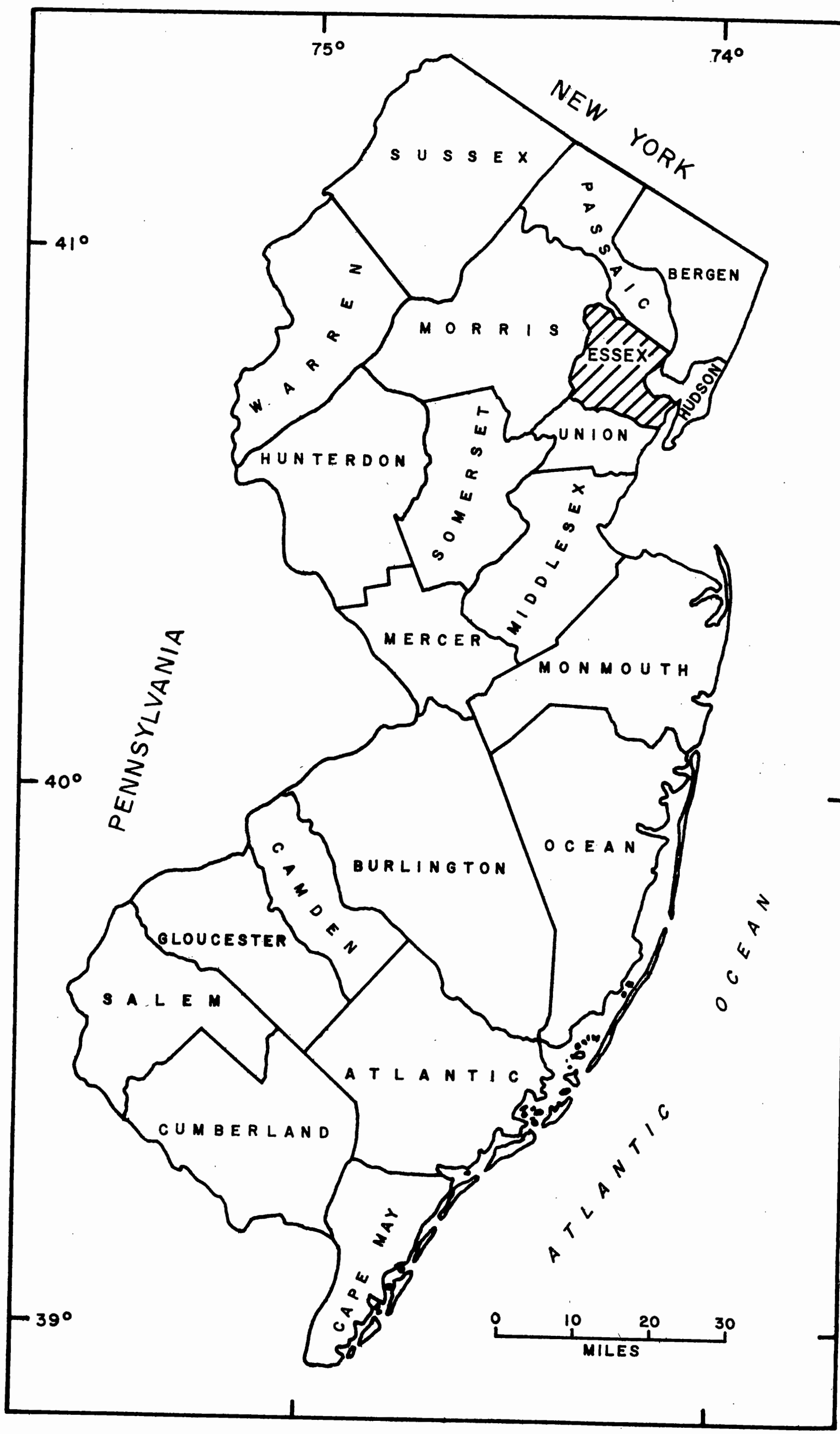

Figure 1.—Map of New Jersey showing the location of Essex County.

GEOGRAPHY

TOPOGRAPHY

Essex County is situated entirely on the Triassic lowlands of the Piedmont Province, one of six physiographic provinces included in the Appalachian Highland physiographic division. The province consists primarily of lowland and gently rolling hills above which rise the ridges of the Watchung Mountains. Altitudes in Essex County range from sea level in the southeastern part of the county to 650 feet along the ridges of the Watchung Mountains. The escarpment of the First Watchung Mountain, trending from northeast to southwest across the middle part of the county, rises 400 feet above the gently rolling plain to the east; the breadth of the First and Second Watchung Mountains varies from 1 to 2 miles. The major streams draining Essex county are the Passaic, Rahway, and Elizabeth Rivers.

CLIMATE

The climate of Essex County, like that of much of New Jersey, is mainly continental because of the predominance of winds from the continental interior. The prevailing wind is from the northwest from October to April and from the southwest for the remaining months. As a consequence, winter weather is controlled by cold continental air masses and summer by tropical air masses. Precipitation in the county averages more than 48 inches annually, and is commonly well distributed throughout the year. Part of the precipitation is received from storms which cross the Great Lakes region and pass down the St. Lawrence Valley. However, the heaviest general rains are produced by coastal storms of tropical origin. The centers of these storms usually pass some distance offshore, with rainfall heaviest and winds strongest near their center (U. S. Department of Agriculture, page 1010, 1941). The average January temperature for the eastern part of the county is 39°F and that of the western part of the county about 28°F. Average temperatures in July range from about 74°F in the eastern part of the county to about 72°F in the western part of the county.

POPULATION AND ECONOMY

Compared with the other counties in New Jersey, Essex County ranks only nineteenth in area, but ranks first in population as of the 1960 census. The population increased from 905,949 in 1950 to 923,545 in 1960—an increase of 1.9 percent; less than in any preceding 10 year period since 1900, except for 1930-40.

Population of Essex County 1900-60

1900	359,053
1910	512,886
1920	652,089
1930	833,513
1940	837,340
1950	905,949
1960	923,545

Nearly 90 percent of the county's population is located in the 71.5 square miles (55.6 percent of total area) east of the Watchung Mountains.

The economy of Essex County is primarily industrial. The principal manufactured products include food products, electrical goods and machinery, chemicals, machinery (excluding electrical machinery), fabricated metal products, and apparel. In 1960, only about 5 percent of the total land area of the county was utilized as farmland.

GEOLOGY

INTRODUCTION

The Brunswick Formation and Watchung Basalt of the Newark Group of Late Triassic age underlie all of Essex County. The Brunswick Formation is dominantly shale and sandstone, but also includes minor amounts of conglomerate. The Watchung Basalt consists of three extensive sequences of lava flows intercalated with the shale and sandstone of the Brunswick Formation. The generalized bedrock geologic map (fig. 2) shows the areal extent of the rocks of Triassic age underlying Essex County. Overlying the rocks of the Newark Group are unconsolidated clay, sand, and gravel deposited during the Pleistocene and Recent Epochs. Pleistocene deposits are the most widespread and are found throughout the county. Deposits of Recent age are confined to the present-day stream valleys. Figure 3 shows the general distribution of the unconsolidated Pleistocene deposits.

Parts of Fairfield and Millburn Townships and Newark are underlain by valleys cut (fig. 3) in bedrock by streams that drained the area before the last glaciation. The valley were subsequently filled in and buried by glacial debris and have little present-day surface expression.

DISTRIBUTION AND LITHOLOGY OF ROCK UNITS

Consolidated Rocks

Rocks of the Brunswick Formation, the uppermost unit of the Newark Group, underlie most of Essex County. The formation consists dominantly of interbedded brown, reddish-brown, and gray shale, sandy shale, sandstone, and some conglomerate. Three sheets of gray to black basalt are intercalated with sandstone and shale beds of the Brunswick Formation. The total thickness of the Brunswick Formation is not known, but probably exceeds 6,000 feet (Kümmel 1940, p. 102).

In the southern part of the county east of the Watchung Mountains, the Brunswick Formation is predominantly a soft red shale. These rocks become coarser grained toward the north. In the northern part of the county the rocks are mostly sandstone and some interbedded shale; conglomerate is found in the extreme northern part of the county. This change from soft, easily weathered, shale to more resistant sandstone is reflected in the change of topography from the rather flat low-lying plain with few hills in southern Newark to hills of low relief in the northern part of the county.

Between First and Second Watchung Mountains, the Brunswick Formation is dominantly sandstone. West of Second Watchung Mountain, the formation is covered with thick deposits of unconsolidated sediments of glacial origin and few outcrops can be found. As indicated from records of wells drilled in this area, the rocks are mainly shale and some interbedded sandstone.

Two prominent ridges, First and Second Watchung Mountains, extend from northeast to southwest across the county (fig. 2). These are the two lowest sequences of basalt flows of the Watchung Basalt. The third, uppermost, sequence of flows is represented by Ricker Hill in Livingston Township. These basalt sheets were formed by lava which was extruded at three different times during the accumulation of the sedimentary rocks of the formation. Each of these sheets is made up of several lava flows. Scoriaceous zones occur at the top of many of the individual flows. In some places, thin beds of shale occur between successive flows. The lower part of the Watchung Basalt, which comprises First Watchung Mountain, is from 600 to 650 feet thick; the Watchung Basalt in Second Watchung Mountain varies from 750 to 900 feet in thickness; the uppermost Watchung Basalt ranges from 225 to 350 feet in thickness (Darton and others, 1908, p. 10).

First and Second Watchung Mountains are parallel, and in places have double-crested ridges reflecting the presence of interbedded sedimentary rocks; the ridges generally rise between 300 and 400 feet above the adjacent country. The trend of the ridges reflect the general strike of the sedimentary rocks of the Brunswick Formation. The beds dip about 10 degrees toward the northwest.

Pleistocene and Recent Deposits

Unconsolidated sediments deposited by glaciers or by glacial meltwater during the Pleistocene Epoch cover most areas of Essex County. These deposits can be divided roughly into several types. Unstratified drift called till or ground moraine is a heterogeneous mixture of clay, silt, sand, gravel, cobbles, and boulders which was deposited by the ice. Unstratified drift that has accumulated in a ridgelike deposit along the margin of a glacier is called an end moraine. Stratified drift is deposited by glacial meltwater in streams (glaciofluvial deposits) and lakes (glaciolacustrine deposits). Glaciofluvial deposits are generally stratified sand, and sand and gravel, and glaciolacustrine deposits are usually bedded or laminated silt and clay. Figure 3 is a map showing the generalized distribution of the Pleistocene deposits in Essex County.

Streams and rivers draining the Essex County area before the last glaciation cut deep valleys into the Triassic rocks (fig. 3). These valleys were subsequently buried by glacial debris, and the thickness of the glacial deposits is largely controlled by the underlying bedrock topography. The altitude of the floor of the buried bedrock valley under the Newark area is as much as 280 feet below sea level (fig. 4), and the glacial drift is as much as 300 feet thick. In the southwestern corner of Essex County in Millburn Township, the altitude of the valley floor is 17 feet above sea level and the drift averages 150 feet in thickness. In the northwestern part of the county in Fairfield Township, the floor of the valley is as much as 35 feet below sea level and the drift has a maximum thickness of about 200 feet. In the areas between the valleys, where the bedrock surface is high, the drift ranges from 0 to 70 feet thick.

East of the Watchung Mountains and west of the buried valley under the Newark area, the glacial deposits consist dominantly of till. The valley under the Newark area, however, is filled largely with stratified drift and interbedded lenses of till. In the central and southern part of Newark the main valley (fig. 4) is filled with as much as 200 feet of lacustrine clay and sandy clay, which is overlain by 50 to 100 feet of other stratified or unstratified glacial drift. In the northern part of Newark, where the valley (fig. 4) parallels the Passaic River, the valley contains several deposits of sand and gravel interbedded with clay and till. The sand and gravel ranges from 1 to 19 feet in thickness and is encountered mostly at depths of less than 50 feet and depths of more than 220 feet below land surface.

The present-day valley between First and Second Watchung Mountains is underlain by approximately 100 feet of stratified drift in both Cedar Grove in the north and Millburn Township in the south. These deposits consist mostly of stratified sand and gravel. Their maximum thickness appears to occur under that part of the valley west of the Rahway and Peckman Rivers; east of the rivers, the bedrock surface is shallow (30 to 50 feet below the valley floor), and the unconsolidated deposits are thin. There are not enough data to define the thickness and character of the subsurface glacial deposits in the valley in Verona and most of West Orange.

West of Second Watchung Mountain, the stratigraphy of the glacial deposits is moderately complex, especially in the buried valleys. The drift in the main buried valley in Livingston and Millburn Townships (fig. 3) has a maximum thickness of about 170 feet and consists of interbedded sand, sand and gravel, clay and till. Thicknesses of sand and gravel outwash range from 20 to 80 feet. Farther north, in north-western Fairfield, the main buried valley (fig. 3) is filled with as much as 200 feet of drift consisting almost exclusively of 140 to 170 feet of laminated silt and clay underlain by 10 to 30 feet of till. Deposits of fine- to medium-grained sand ranging in thickness from 0 to 20 feet occur on the surface.

The tributary buried valleys in Fairfield Township (fig. 3) contain from 30 to 50 feet of silty sand, sand, and gravel overlain by clay and till near the confluence with the main buried valley. Where the bedrock surface is high, between buried valleys, the glacial deposits consist dominantly of till. However, some stratified sand and gravel are found in the subsurface in eastern Roseland and Essex Fells which do not occur as valley-fill deposits.

Unconsolidated sediments of Recent age are confined to areas adjacent to present-day streams. These deposits consist of clay, silt, and fine sand with gravel. (Rogers and others, 1957, p. 7).

GROUND-WATER HYDROLOGY

INTRODUCTION

Ground water is derived from that part of precipitation that does not run off the surface of the land to streams or return to the atmosphere through evaporation and transpiration. Factors which determine the amount of water that infiltrates to the ground-water reservoir include (1) the porosity and permeability of the surficial material, (2) the slope of the land, (3) the amount and kind of natural and artificial cover, and (4) the intensity and amount of precipitation.

The permeability of a rock, or its ability to transmit water, depends on its porosity, that is, on the number and size of the interstices and on the extent to which the interstices are interconnected. The porosity of a rock, in turn, depends largely on: "the shape and arrangement of its constituent particles, the degree of assortment of its particles, the cementation and compacting to which it has been subjected since its deposition, the removal of mineral matter through solution by percolating waters, and the fracturing of the rock, resulting in joints and other openings" (Meinzer, 1923, p. 3). Porosity is expressed quantitatively as the ratio between the volume of void to the total volume of the rock, that is, as the percentage of the total volume of rock occupied by interstices.

On the basis of the type of openings in which ground water may occur, the geologic formations in Essex County may be divided into two groups: (1) consolidated rocks of Triassic age, and (2) unconsolidated sediments of Pleistocene age.

The primary pore spaces in consolidated rocks of the Brunswick Formation in Essex County are commonly so small that an insignificant quantity of water, if any, moves through them under the natural hydraulic gradients or those established by pumping. However, a joint and fracture system that has developed in the consolidated rocks provides secondary porosity and it is largely in and through these openings that the storage and movement of ground water takes place. In addition, vesicles and scoriaceous zones in the basalt add to the porosity in these rocks. Limited interconnected void space occurs in sandstone beds where cementing material is lacking. The volume of all of these openings constitute only a very small percentage of the total volume of the Brunswick Formation and, consequently, their capacity to store and transmit water is limited.

In unconsolidated sediments, water occurs in the pore spaces between the constituent grains. The capacity of unconsolidated sand and gravel deposits to store and transmit water is commonly much greater than that of the consolidated rocks. The reason for this is that the ratio of the volume of void to the total volume of unconsolidated sediment is considerably greater than the ratio of the volume of fracture openings to the total volume of rock. The interstitial openings in clays and silts are so small, however, that they restrict the movement of water, even though the percentage of void space may be great.

WATER-BEARING PROPERTIES OF MAJOR GEOLOGIC UNITS

Consolidated Rocks

Rocks of the Brunswick Formation are the main source of ground water in Essex County. The shales and sandstones are generally capable of sustaining moderate to large yields to wells. The Watchung basalt commonly is capable of yielding only small to moderate quantities of water.

Water in these rocks occurs under both unconfined and confined conditions. Unconfined ground water occurs mainly in the upland areas where overlying unconsolidated deposits are thin or absent. Confined and semiconfined ground water conditions exist in lowland areas in Newark, parts of Fairfield, and along the Passaic River where clay beds in the unconsolidated Quaternary deposits mantle the underlying rocks. Wherever such confinement occurs, water beneath the relatively impermeable confining layers is commonly under artesian pressure. In many areas, such as parts of Fairfield and in the northern part of the county, water in wells tapping the confined aquifers will rise above the top of the aquifer and sometimes near or above land surface. In areas subjected to heavy pumping, such as the Newark area and western Millburn Township, the artesian pressure may be considerably reduced. Parts of the confined aquifer may even become dewatered as has happened in part of Newark, in which case the water remaining in the aquifer is no longer confined.

Confined ground water is also encountered in the shales and sandstone directly beneath the basalt flows in the western part of the county downdip from the outcrop area. Confined or semiconfined ground-water conditions may occur in some areas because of differences in permeability within the rock layers resulting from variations in fracturing or weathering or a combination of both.

Some of the various systems of joints and fractures in the consolidated rocks intersect so that water can move vertically as well as horizontally and zones of high secondary porosity are then interconnected. Most wells tapping these rocks draw water from more than one water-bearing zone. However, these zones in the Brunswick Formation have not yet been accurately defined. They are certainly within the first 600 feet below land surface, and for most practical purposes are probably within the first 400 feet. The best producing wells in the Brunswick Formation in

Essex County are for the most part between 300 and 400 feet deep. Nevertheless, the lack of any precise known boundaries makes it difficult to determine the optimum depth to which a well should be drilled in any given location. Also it is impossible to predict the yield of a proposed well except in very general terms based on the average yield of other wells in the area.

Two pumping tests, both at the same locality, were conducted by the U. S. Geological Survey in January 1949 on wells tapping the Brunswick Formation in Essex County. The wells (owned by P. Ballantine and Sons, Newark), shown on figure 5, were selected to provide the best possible spread of observation wells in as many directions as possible. As the results of the tests have been reported by Herpers and Barksdale (1951, p. 28-31) they will be only summarized here.

In the first test, the centrally located well I-1 was pumped and water levels were observed in the seven surrounding wells indicated on figure 5. Well II-9 was pumped during the second test and the same wells were used to observe water levels. In both tests, observation wells lying along the strike of the Brunswick Formation with respect to the pumping well showed the greatest drawdown. When well I-1 was pumped, there was a prompt and distinct decline of the water level in observation well II-8. When well II-9 was pumped, the water level in observation well II-10 responded promptly and distinctly. No significant response was seen in observation wells aligned in directions other than along the strike during either test.

In these tests, as well as in several others conducted, it is invariably noted that aquifers in the sedimentary rocks of Triassic age of northern New Jersey are anisotropic, that is, they do not transmit water equally in all directions (Vecchioli, 1967). The greatest drawdowns are observed in those wells aligned along the strike of the sedimentary layers with respect to the pumping well. The least amount of drawdown is observed in observation wells that are located transverse to the strike. These observations have been interpreted to indicate that water moves more readily along joints and fractures which strike parallel to the strike of the bedding than along joints and fractures which strike in other directions. It is useful, when planning future well locations, to know the direction in which wells will interfere most with each other and with existing wells. In general, wells should be spaced far apart along the direction of strike (approximately N 30° E for most of Essex County) because it is in this direction that the greatest interference occurs. They may be placed closer together perpendicular to the strike since interference is less in that direction.

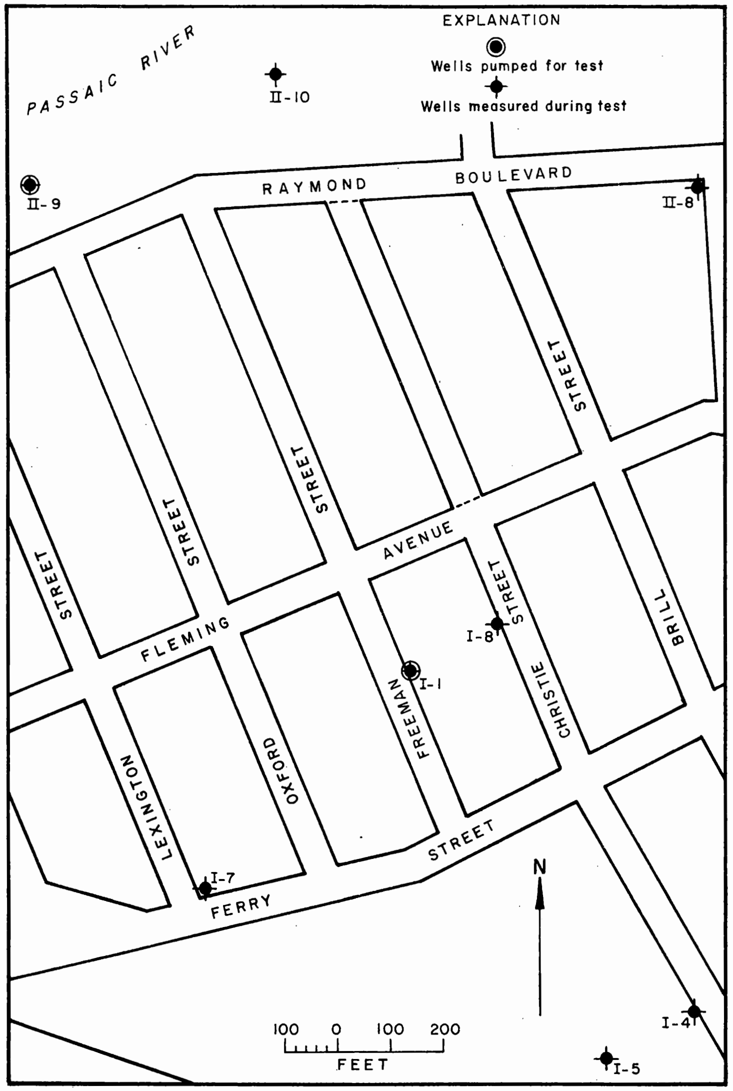

Figure 5.—Location of wells at plants of P. Ballantine and Sons, Newark, N. J., used during pumping tests in January 1949 (after Herpers and Barksdale, 1951, fig. 3, p. 30).

Well Yield and Specific Capacity

Yields of 35 large diameter public-supply, industrial, and commercial wells tapping the Brunswick Formation range from 35 to 820 gpm (gallons per minute) (Table 2) and average 364 gpm. The distribution of the yields is as follows:

Yields	*No. of wells*
0-150	4
151-300	12
301-500	12
>500	7

Depths of the same wells in the Brunswick Formation range from 115 to 856 feet; the average depth is 381 feet. Specific capacities of the 35 wells range from 0.21 to 70.00 gpm per foot of drawdown and average 11.07 gpm per foot of drawdown.

Wells tapping the Watchung Basalt commonly produce small to moderate quantities of water. Yields of 26 wells range from 7 to 400 gpm (Table 2) and average 116 gpm. The distribution of the yields is as follows:

Yields	*No. of wells*
0-100	15
100-199	5
200-300	5
>300	1

Specific capacities of wells in the basalt range from 0.05 to 5.66 gpm per foot of drawdown and average 1.74 gpm per foot of drawdown. Several moderate to high yielding public supply and industrial wells have been developed in the Essex Fells-West Caldwell-Fairfield area. These higher yields may be the result of increased fracturing of the basalt which has been slightly folded in this area.

Figures 6, 7, and 8 are specific capacity cumulative frequency distribution graphs for wells in the Brunswick Formation in Essex County. In figure 6, specific capacities are grouped on the basis of well depth. Wells drilled between 300 and 399 feet deep appear to have consistently higher specific capacities than wells of other depths (fig. 6). This relationship suggests that the best water-bearing zones in the Brunswick Formation will be

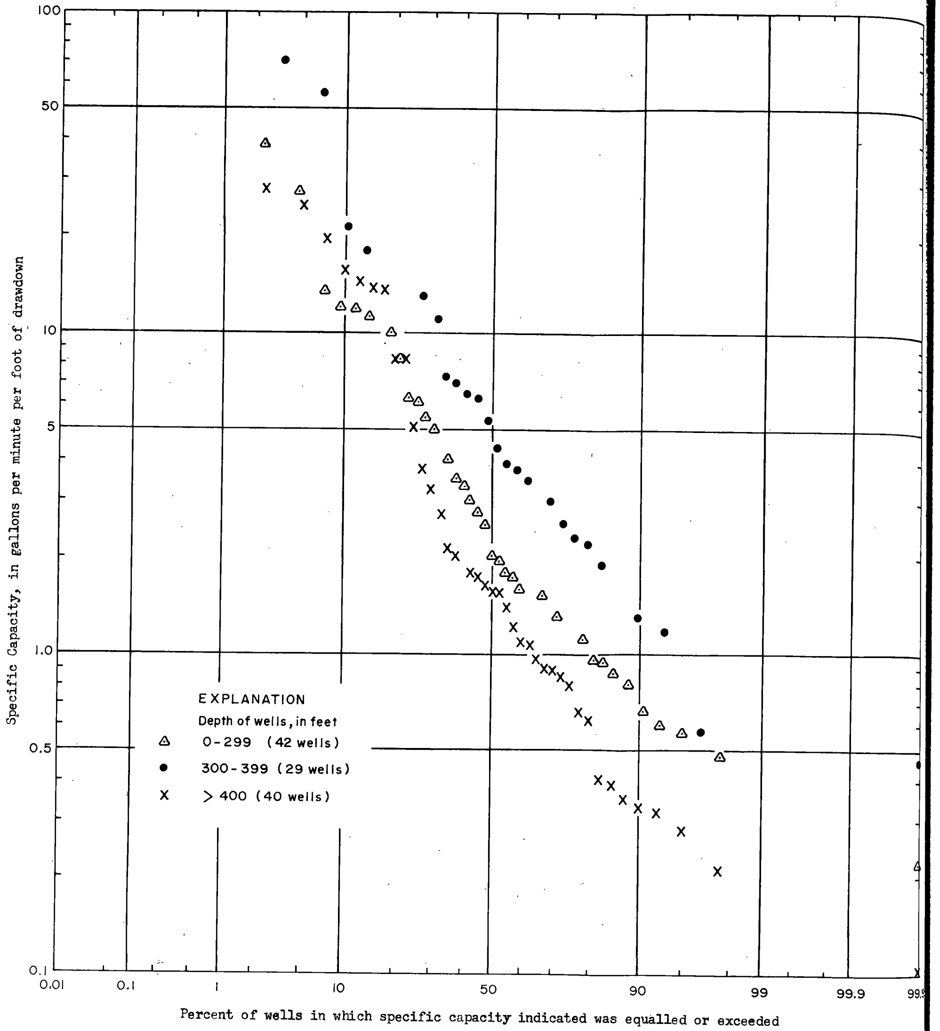

Figure 6.—Cumulative frequency distribution of specific capacities of wells penetrating the Brunswick Formation grouped according to depth.

encountered between depths of 300 and 400 feet and that significantly greater quantities of water generally will not be obtained by drilling below 400 feet. The specific capacities of wells grouped according to geographic area are shown in figure 7. These areas divide Essex County into three strips which are approximately parallel to the strike of the Brunswick Formation. The eastern strip is further divided into a northern part covering Belleville, Bloomfield, Glen Ridge, and Nutley, and a southern part covering East Orange, Irvington, and Newark. From this graph it readily can be seen that wells in Maplewood, Montclair, Orange, South Orange, and West Orange, have generally higher specific capacities than wells in other parts of Essex County. The wells in these communities are located in the area immediately east of First Watchung Mountain. In figure 8, specific capacities are related to well diameter. As should be expected, larger diameter wells have higher specific capacities.

Quality of Water

Except for hardness-forming constituents and local salt-water contamination, water from the Triassic rocks commonly does not contain objectional concentrations of any chemical constituents throughout most of the county (Table 3). The hardness of water ranges from 104 ppm (parts per million) to 273 ppm. In the Newark area, salt-water contamination has seriously impaired the quality of ground water and chloride concentration are as high as 1,900 ppm.

Ground water has high chloride concentrations in areas of relatively heavy pumpage in eastern Newark adjacent to Newark Bay and the Passaic River. By 1900, water levels in these areas, notably in the southeastern section, were considerably below sea level (fig. 9). The major pattern of ground-water development had changed slightly by 1960. More significant however is the extent to which water levels had been lowered below sea level and the incerase in the size of the area affected by 1960 (fig. 10). Heavy ground-water withdrawals have lowered the general water level in these areas (fig. 10), reversing the natural gradient between the ground- and surface-water bodies, and have induced a flow of salt water from the river and bay into the underlying water-bearing formations A water sample collected in 1879 from a well owned by the Celluloid Works, located in this part of Newark, contained only 6.2 ppm chloride. In 1948, water with 1,900 ppm chloride was collected from a well in the same area owned by P. Ballantine and Sons. A probable contributing factor in salt-water intrusion is the dredging of ship canals in Newark Bay and the Passaic River. In deepening these canals, semipervious Recent and Pleistocene sediments were removed which had acted as an imperfect barrier to the infiltration of salt water.

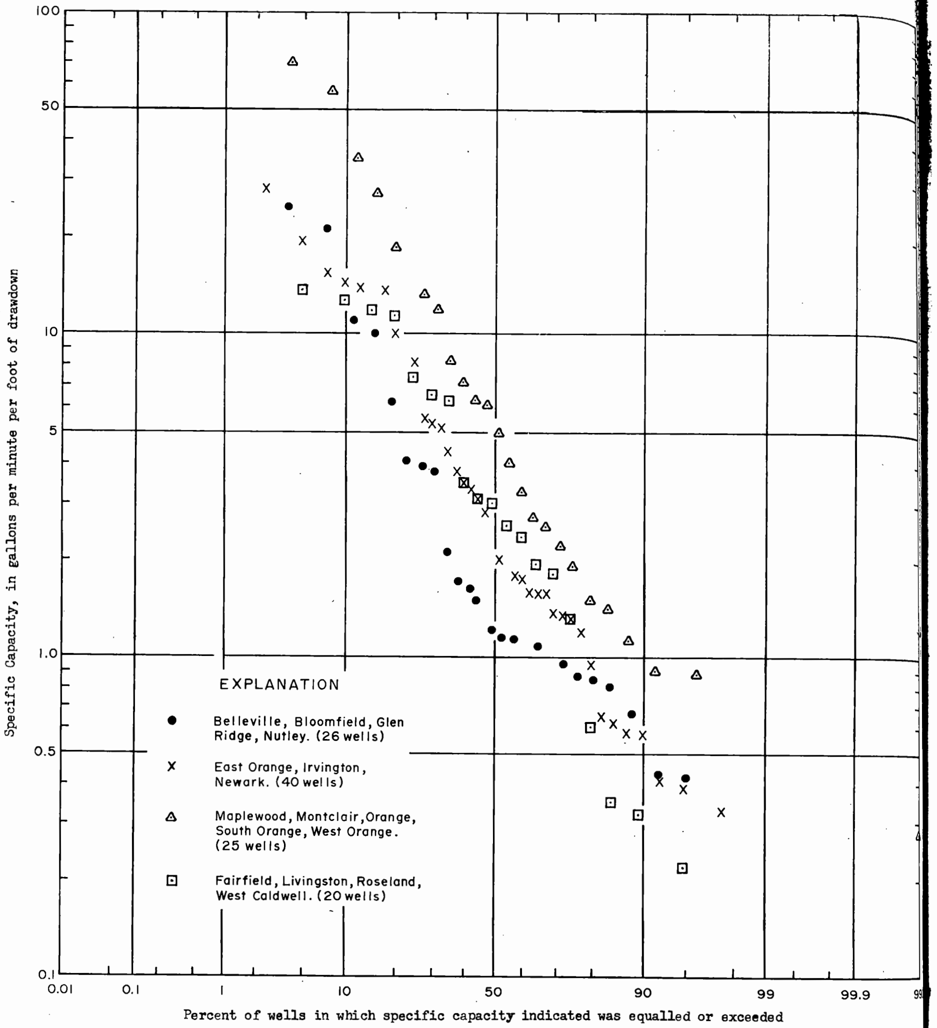

Figure 7.—Cumulative frequency distribution of specific capacities of wells penetrating the Brunswick Formation grouped according to geographic area.

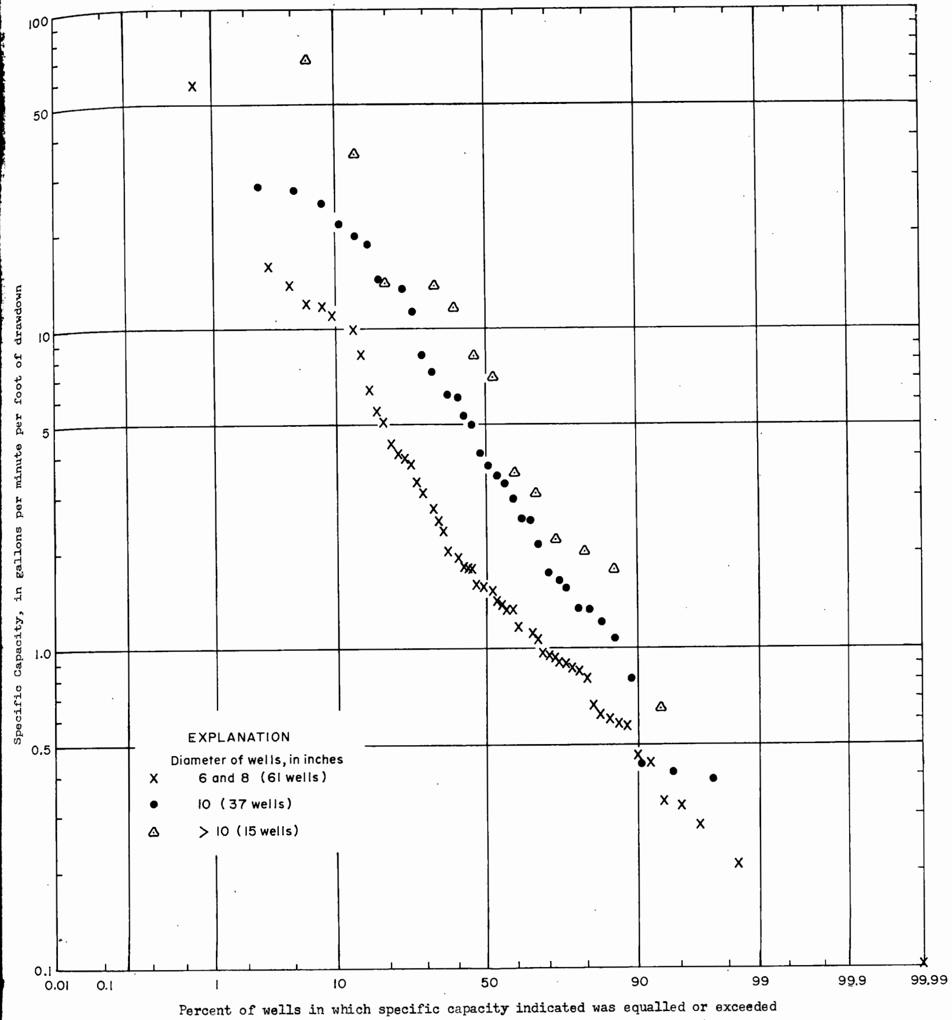

Figure 8.—Cumulative frequency distribution of specific capacities of wells penetrating the Brunswick Formation grouped according to well diameter.

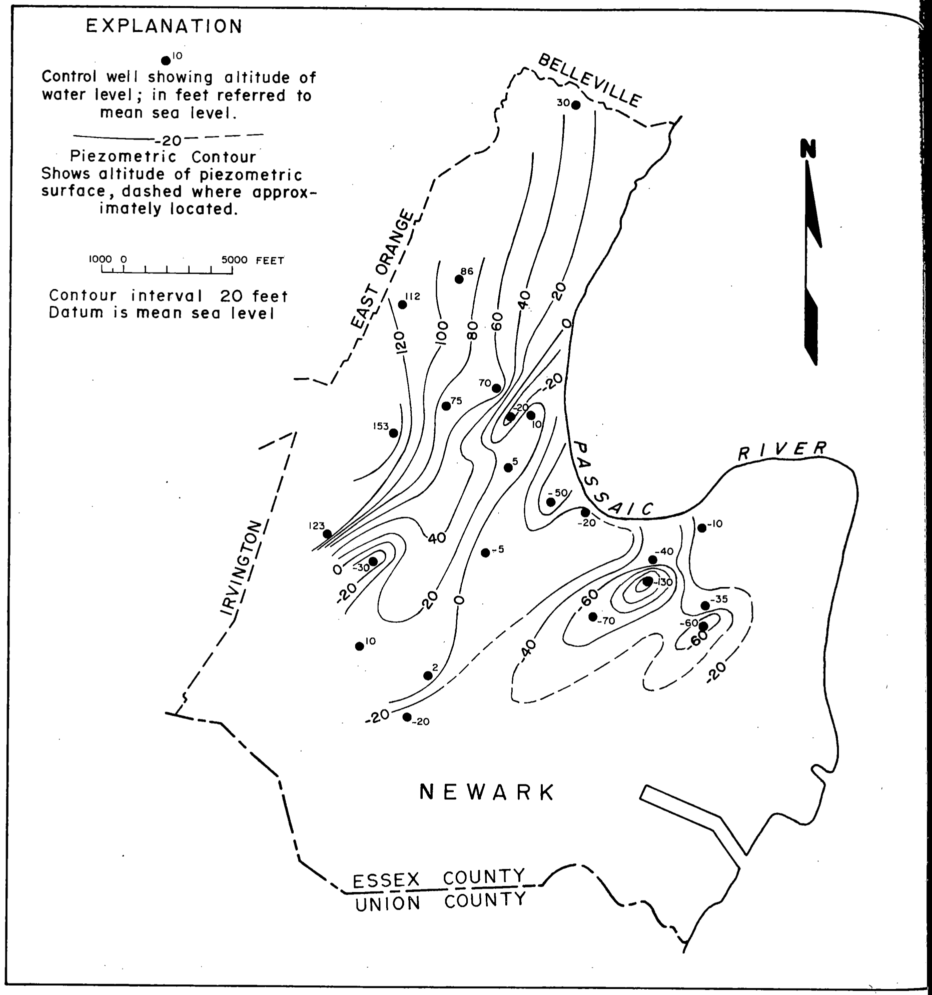

Figure 9.—Generalized piezometric contours for the Brunswick Formation in the Newark area based on water levels in wells drilled between 1890 and 1900.

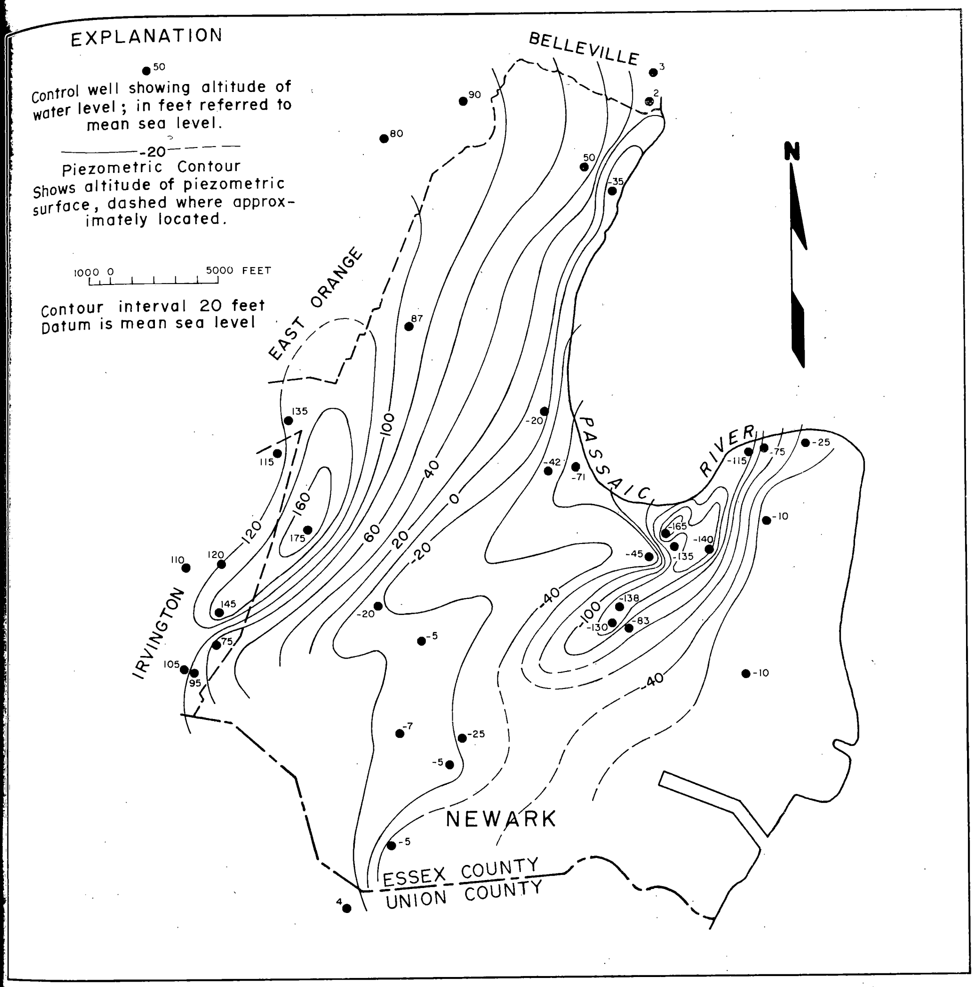

Figure 10.—Generalized piezometric contours for the Brunswick Formation in the Newark area based on water levels in wells drilled between 1950 and 1960.

Salt-water contamination of the Brunswick Formation in the Newark area has been investigated by Herpers and Barksdale (1951). Their study was based on analyses of water samples collected in 1942 by the city of Newark. More recent analyses suggest there has been additional encroachment of saline water since 1942 throughout the problem area. In 1942, water from the Wilbur Driver Company's well No. 2 along the Passaic River in northern Newark contained 72 ppm chloride. In 1961, water from this same well contained 330 ppm chloride. Water from a well drilled by Mutual Benefit Life Insurance Company, 520 Broad Street, in 1965 contained 1,145 ppm chloride. Samples collected from other wells in this area contained less than 500 ppm chloride in 1942.

Pleistocene Deposits

Unconsolidated sediments of Pleistocene age mantle the bedrock throughout much of Essex County (fig. 3). They consist of clay, silt, sand, gravel, and boulders and can be divided into two general categories—stratified drift and unstratified drift. Only sand and gravel aquifers in stratified drift deposits contain sufficient quantities of water to warrant discussion of their water-bearing properties.

Water in the stratified drift occurs under both unconfined (water table) and confined (artesian) conditions. Unconfined ground water occurs where sand and gravel deposits are not covered by clay, silt, or glacial till and are exposed at the surface. The distribution of these deposits is shown on figure 3. For the most part however, these sand and gravel deposits do not yield large quantities of water as they are commonly less than 20 feet thick and are not areally extensive. The unconfined aquifers are recharged directly from precipitation on the outcrop area. Confined and semiconfined ground water occurs where sand and gravel deposits have been covered by lake clay or silt, or by glacial till. These deposits are largely confined to the buried valley so they are not visible on the surface and their regional extent and distribution are therefore not readily apparent. The confined and semiconfined aquifers are recharged by leakage through overlying confining beds and by precipitation falling on outcrop areas outside Essex County. Some recharge may also be derived from the underlying and adjacent Brunswick Formation.

The most productive artesian and semi-artesian aquifers in the stratified drift in Essex County occur as valley fill in stream valleys that were cut in the bedrock before the last glaciation. Consequently the size, shape, and distribution of the aquifers conform to the size, shape, and distribution of the bedrock valleys. The bedrock valley underlying the Newark area (shown on fig. 4) is filled with till and clay, and contains only minor amounts of water-bearing sand. Extensive subsurface exploration in western

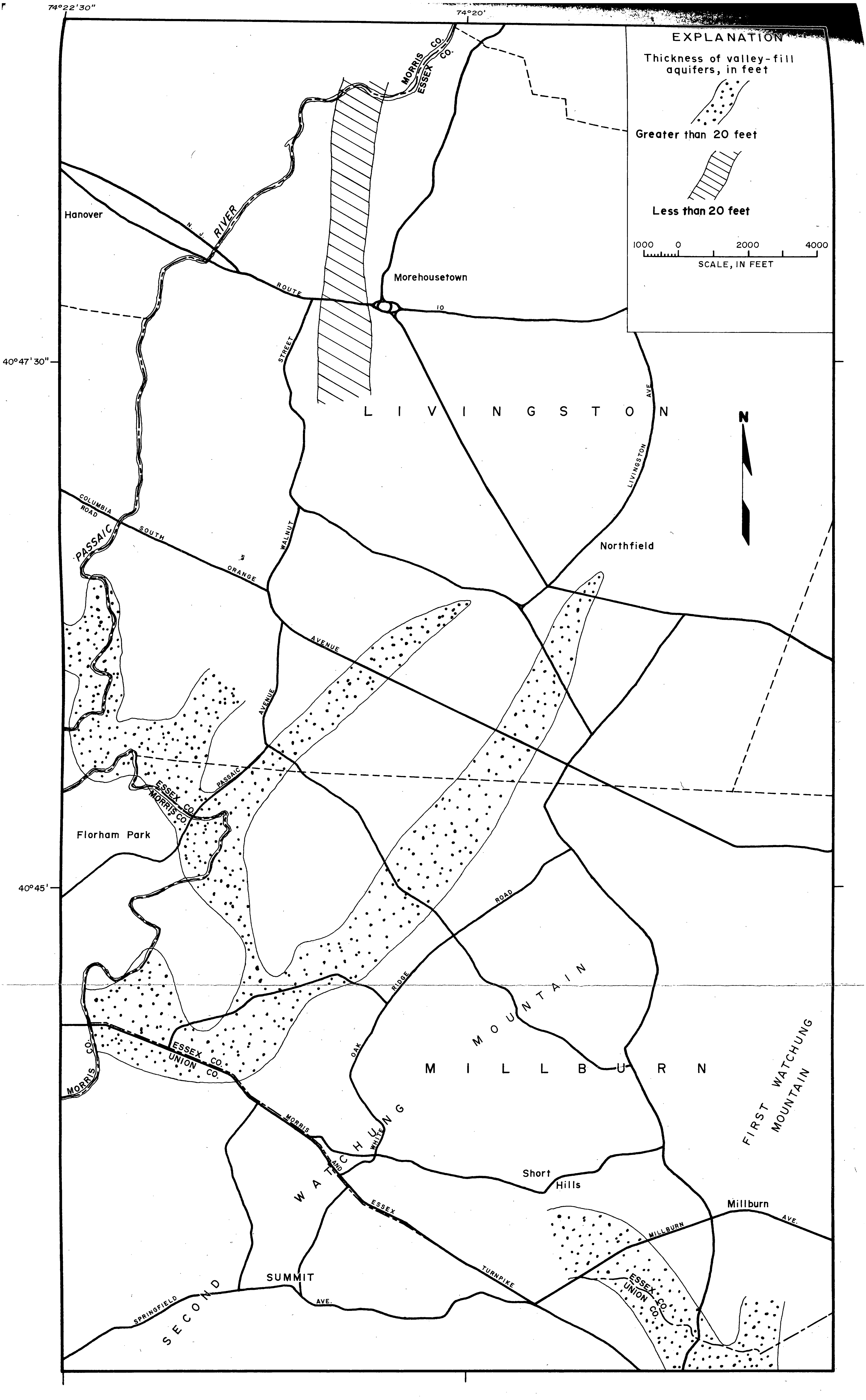

Figure 11.—Distribution of valley-fill aquifers in Millburn and Livingston Townships, Essex County, N. J.

Essex and eastern Morris Counties has demonstrated that the valley-fill aquifers in Essex County are part of an extensive valley-fill aquifer system underlying much of these two counties (Vecchioli and others, 1968). Figure 11 shows the known distribution of valley-fill aquifers in western Essex County.

The most highly developed part of the valley-fill aquifer system is in western Millburn and southwestern Livingston. Four well fields tapping the Pleistocene sand and gravel are located in an area of less than 4 square miles. During 1965 an average of 13.6 mgd (million gallons per day) was pumped from these fields. Such continued heavy development has, naturally, lowered water levels in the aquifer. In 1925, the depth to water in the Canoe Brook well field of Commonwealth Water Company was about 30 feet below land surface. By 1965, the average depth to water in the same field had dropped to 83.5 feet below land surface.

Figure 12 shows the annual mean depth to water in the Commonwealth Water Company's Canoe Brook well field for the 20-year period 1947 to 1966. The water level has declined almost continuously since 1947. This is due in large part to increased demands placed on the adjacent Canoe Brook well fields of the Commonwealth Water Co. and East Orange Water Dept. for most of the period 1947 to 1961. Commonwealth Water Company's Passaic River well field was put into service in 1956 and although the demands on their Canoe Brook field were lessened, the combined pumpage (not shown) continued to increase. However, in spite of the fact that from 1961 to 1966 pumpage from the Commonwealth and East Orange Canoe Brook fields decreased, the water level in the Commonwealth Canoe Brook field continued to decline (fig. 12). Several factors probably have caused this continuing lowering of water level. The Passaic River well field taps the same aquifer and withdrawals there have undoubtedly had some effect on area water levels. In addition, Commonwealth's Canoe Brook well field area has had below average rainfall for 12 of the 13 years since 1953 with a consequent reduction in the amount of available recharge. The reduction in recharge together with increased demands during extended dry periods, especially from 1961 to 1966, have contributed to the steady decline of the water level in the aquifer.

Aquifer tests on the stratified drift deposits have been conducted by the U. S. Geological Survey at two localities in Essex County and at several places in Morris County. The reliability of the results of these tests are questionable for the following reasons: (1) the aquifers are not areally extensive; (2) it is impossible to control or eliminate outside interference; (3) it is seldom possible to establish pre-test water-level

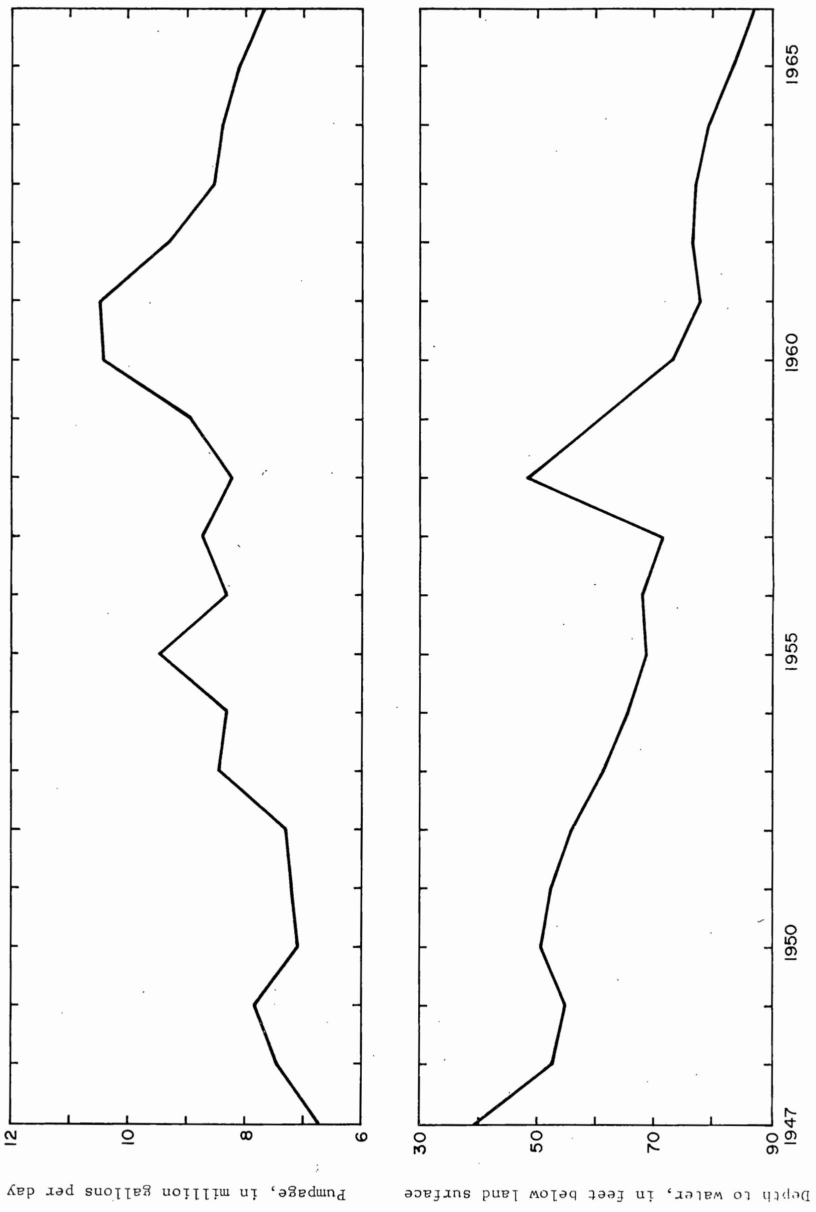

Figure 12.—Depth to water in the Commonwealth Water Company Canoe Brook well field and ground-water pumpage from the Commonwealth Water Company and East Orange Water Dept. Canoe Brook fields, 1947-66.

trends; and (4) observation wells commonly are insufficient in number or not properly located. It is therefore difficult to apply average figures for permeability, transmissivity, and the coefficient of storage to the valley fill aquifer and then use these figures to determine long-range effects of pumpage throughout the aquifer system Each area must be evaluated in context with the numerous variables by which it is affected.

Stratified drift deposits are the most productive aquifers in Essex County. Yields of 27 large-diameter wells tapping these deposits range from 410 gpm to 1,593 gpm (table 2) and average 908 gpm. The distribution of the well yields is as follows:

Yields	*No. of wells*
<500-gpm	3
501- 800 gpm	11
801-1,200 gpm	9
>1,200 gpm	4

Water from the stratified drift deposits ranges in hardness from 104 ppm to 212 ppm (table 3). Most of the samples analyzed had sulfate concentrations of 40 ppm or less, chloride concentrations of less than 11 ppm, and nitrate concentrations of 3 ppm or less. However, water from one well in Essex Fells had chloride and nitrate concentrations of 28 ppm and 6.4 ppm, respectively, and water from two wells in Millburn had sulfate concentrations of 67 ppm and 77 ppm. The higher concentrations of these constituents suggests a low-grade pollution problem, probably resulting from either sewage or the use of chemical fertilizers in the area. Manganese concentrations slightly in excess of the Public Health Service's recommended maximum limit of 0.05 ppm occur locally in the Commonwealth well field.

WATER SUPPLY

UTILIZATION OF GROUND WATER

Public and industrial use of water in 1962 in Essex County averaged about 147 mgd. Of this amount, about 43 mgd were pumped from ground-water sources. This represents about 28 percent of the total water used in the county during 1962.

An average of 25.833 mgd of ground water was withdrawn for public supply from aquifers in Essex County in 1966 (Table 1). Of this an average of about 20.9 mgd, or 81 percent, was pumped from Quaternary stratified drift deposits. Pumpage in Millburn Township, amounting to about 15 mgd, exceeded by far the public-supply pumpage of ground water from any other municipality Figure 13 shows the pumpage for public supply from aquifers in Essex County from 1947 to 1966.

Table 1.—Ground-water pumpage for public supply from aquifers in Essex County in 1966.

Water Department or Company	*Average mgd*
Commonwealth Water Co.	11.754
East Orange Water Dept.	4.571
Essex Fells Water Dept.	2.582
Fairfield Water Dept.	.071
Livingston Water Dept.	2.112
Orange Water Dept.	3.026
South Orange Water Dept.	1.717
Total	25.883

FUTURE DEMAND AND DEVELOPMENT

Future demand for water supply from all sources in Essex County depends largely on population trends and trends in water-consuming industries and devices. Per capita consumption of water in Essex County in 1960 was 131 gpd (gallons per day). This is expected to rise to about 223 gpd by the year 1990 (New Jersey Division of Water Policy and Supply, 1967, unpublished data). Estimates of total future water use by the New Jersey Division of Water Policy and Supply (unpublished data, 1967) suggest that about 230 mgd of potable water will be needed in the year 1990 on the basis of the above per capita consumption. Most of this increase will probably have to come from surface sources.

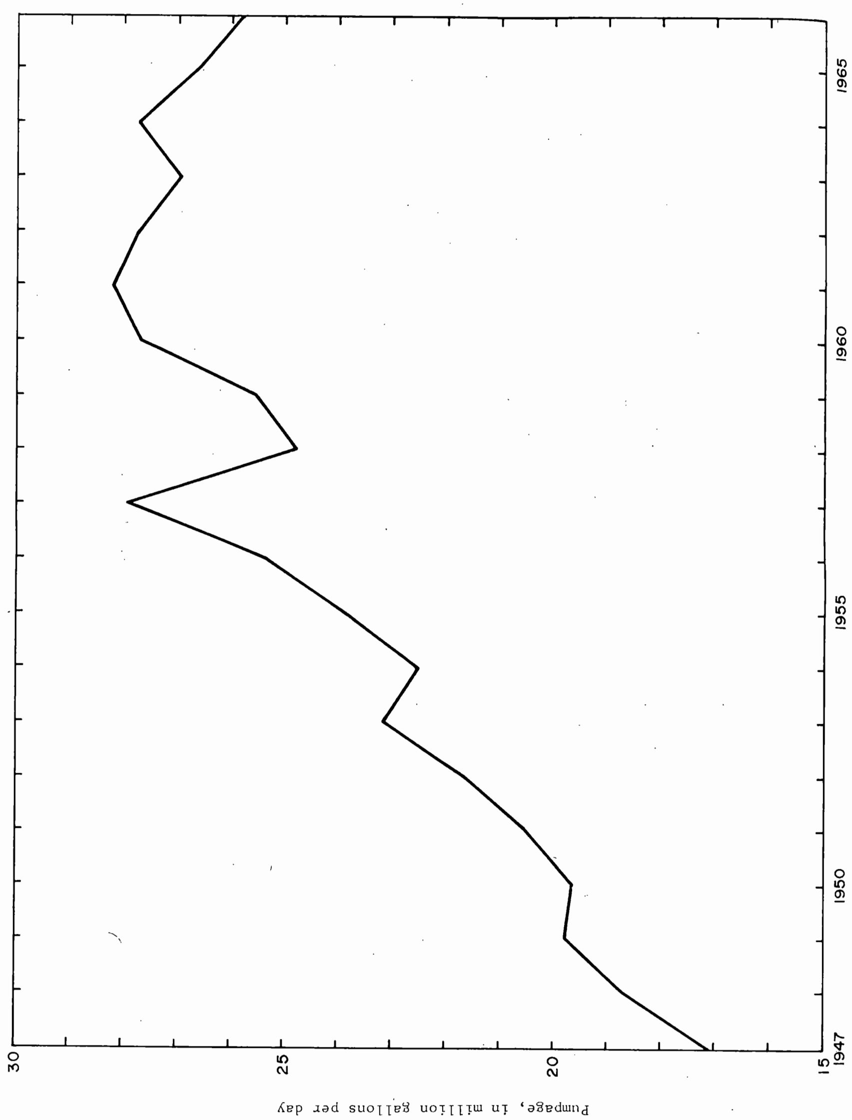

Figure 13.—Ground-water pumpage for public supply, 1947 to 1966.

The aquifers of the Brunswick Formation under part of the Newark area are currently overdeveloped and potable ground water is being mined. Water levels in this area will remain excessively low, as they have for the past 70 years, even if no additional development is attempted. Extensive development of the Brunswick Formation in western Essex County may have an adverse effect on water levels in the overlying stratified drift deposits since some of the recharge to these deposits may be derived from the underlying rocks.

The extent and distribution of aquifers in the stratified drift deposits have been fairly well determined for most of the western part of the county. These aquifers are being utilized throughout much of this part of the county and have been highly developed in parts of Millburn and Livingston Townships. Although the full potential of these deposits has probably not been realized, their optimum potential will not be known until more detailed hydrologic studies are made on the entire aquifer system.

Aquifer name:
Qsd, Stratified drift
TRb, Brunswick Formation
TRwb, Watchung Basalt

TABLE 2.—RECORDS OF SELECTED WELLS IN ESSEX COUNTY, N. J.

Remarks:
O.W., Owners well number

Well	Owner or Tenant	Driller	Date Drilled	Altitude above mean sea level (ft)	Total depth drilled below land surface (ft)	Diameter of well (inches)	Depth to which well is cased (ft)	Screen setting (ft)	Aquifer	Static level below land surface (feet)	Yield (gpm)	Drawdown (ft)	Specific capacity (gpm/ft)	Remarks
					BELLVILLE (TOWN)									
1	Federal Leather Co.	Rinbrand Well Drilling Co.	6-26-51	40	802	10	30	none	TRb	65	60	135	0.44	O.W.4
2	Van Ness Plastic Moulding	F. J. Bott	8-18-58	60	144	6	22	none	TRb	69	27	18	1.5	O.W.1
3	Fada Radio & Elec. Co.	Rinbrand Well Drilling Co.	Aug. 1952	10	400	10	69	none	TRb	8	493	130	3.8	O.W.3
4	Mansal Ceramics Co.	Burrows Well Drilling Co.	2-10-54	70	250	8	27	none	TRb	45	100	115	.87	
5	Amer. Dyewood Co.	----------------------	1941	10	420	10	62	none	TRb	6	820	33	24.85	
6	Eastwood-Neally Co.	------------------	1936	12	360	8	71	none	TRb	13	220	56	3.93	
7	Eastern Tool & Mfg. Co.	Rinbrand Well Drilling Co.	Aug. 1950	105	400	10	23	none	TRb	35	188	115	1.63	O.W.2
8	Miller and Son	Algeier Bros.	9- 4-51	18	206	6	67	none	TRb	13	60	17	1.76	
9	A. J. Crowhurst & Sons	Wm. Stothoff Co., Inc.	11-21-50	15	83	10	67	67-82	Qsd	12	325	53	6.13	O.W.2
10	Jack Frost Dairy	Rinbrand Well Drilling Co.	5- 3-56	120	185	8	60	none	TRb	25	50	75	.66	O.W.1
					BLOOMFIELD (TOWN)									
1	Brookdale Beverage Co.	F. J. Bott	11-18-57	---	430	8	46	none	TRb	50	85	100	.85	O.W.2
2	J. Talmidge	Burrows Well Drilling Co.	11- 2-56	185	201	6	46	none	TRb	15	60	135	.44	
3	Glen Ridge Country Club	H. A. Keiffer	9-15-58	---	353	10	52	none	TRb	17	300	14	21.40	O.W.2
4	Triples Auto Laundry, Inc.	Burrows Well Drilling Co.	12-16-57	115	185	6	23	none	TRb	22	60	---	---	
5	Leonora Corp.	F. J. Bott	6-21-57	---	200	8	33	none	TRb	6	70	74	.95	
6	Maurice H. Cooper	Burrows Well Drilling Co.	11-26-56	120	205	8	69	none	TRb	11	180	89	1.12	
7	Schering Corp.	Wm. Stothoff Co., Inc.	10- 2-54	120	478	10	29	none	TRb	30	127	124	1.21	O.W.1
8	MGM Record Div.	F.J.Bott	1-20-58	140	404	8	20	none	TRb	60	160	150	1.07	O.W.3
9	MGM Record Div.	F. J. Bott	11-12-59	130	211	8	23	none	TRb	58	115	102	1.13	O.W.4
10	MGM Record Div.	F. J. Bott	2-11-60	130	579	8	36	none	TRb	50	120	150	.80	O.W.5
11	Warner Mfg. Co.	Algeier Bros.	5-19-57	---	395	8	35	none	TRb	25	220	20	11.	

Aquifer name:
Qsd, Stratified drift
TRb, Brunswick Formation
TRwb, Watchung Basalt

TABLE 2.—RECORDS OF SELECTED WELLS IN ESSEX COUNTY, N. J.—Continued

Remarks:
O.W., Owners well number

Well	Owner or Tenant	Driller	Date Drilled	Altitude above mean sea level (ft)	Total depth drilled below land surface (ft)	Diameter of well (inches)	Depth to which well is cased (ft)	Screen setting (ft)	Aquifer	Static level below land surface (feet)	Yield (gpm)	Drawdown (ft)	Specific capacity (gpm/ft)	Remarks
					CALDWELL BOROUGH									
1	Mt. St. Dominic Acad.	----------------------	--------	420	876	---	100	none	TRb	---	25	---	---	
					CEDAR GROVE TOWNSHIP									
1	Rich-Tex, Inc.	Burrows Well Drilling Co.	8- 4-51	250	300	6	97	none	TRwb	47	11	58	.18	O.W.1
2	Rich-Tex, Inc.	Burrows Well Drilling Co.	11- 5-52	250	105	6	89	75-99	Qsd	43	80	32	2.5	O.W.2
3	Brindell Goat Dairy	Algeier Bros.	6-24-58	---	110	6	28	none	TRwb	6	10	84	.13	
4	Board of Freeholders	Rinbrand Well Drilling Co.	12- 3-57	---	125	6	117	none	TRwb	70	198	35	5.66	
					EAST ORANGE (CITY)									
1	Colonial Life Ins. Co.	Artesian Well & Equip. Co.	5-10-49	180	357	10	34	none	TRb	26	323	93	3.47	
2	Michael Stein & Co.	Parkhurst Well & Pump Co.	6- 3-49	180	150	8	45	none	TRb	75	50	25	2.0	
3	F. H. Taylor & Sons, Inc.	Burrows Well Drilling Co.	June, 1955	190	254	8	37	none	TRb	38	160	122	1.31	
4	Food Fair Stores, Inc.	Burrows Well Drilling Co.	1956	180	210	8	44	none	TRb	24	---	21	---	
5	New Munn Apts	Rinbrand Well Drilling Co.	6-10-55	---	200	8	39	none	TRb	20	80	60	1.33	
					ESSEX FELLS BOROUGH									
1	Borough of Essex Fells	Artesian Well & Equip. Co.	2-28-42	243	423	10	110	none	TRwb	+8	300	108	2.8	O.W.8
2	Borough of Essex Fells	Artesian Well & Equip. Co.	March, 1959	280	92	17	61	61-88	Qsd	13	457	55	8.31	O.W.14
3	Borough of Essex Fells	Artesian Well & Equip. Co.	10-18-41	285	93	10	72	72-92	Qsd	+3	410	50	8.2	O.W.7
4	Borough of Essex Fells	Artesian Well & Equip. Co.	6-14-46	310	364	10	85	none	TRwb	10	250	114	2.19	O.W.9
5	Borough of Essex Fells	American Water Co.	Sept. 1927	345	97	24 16	45 68-81	45-68 81-97	Qsd	10	627	45	13.9	O.W.1A
6	Borough of Essex Fells	----------------------	1933	325	565	10	65	none	TRwb	+9	146	151	.97	O.W.6
7	Borough of Essex Fells	----------------------	1929	225	295	8	---	none	TRwb	8	400	92	4.35	O.W.5
8	A. Howard	H. A. Kieffer	4-15-56	---	250	6	92	none	TRwb	72	30	54	.56	
9	E. Stearns, Inc.	----------------------	1959	---	196	6	100	none	TRwb	63	40	43	.93	
10	Essex Fells Country Club	H. A. Kieffer	8-15-56	500	300	8	38	none	TRwb	7	55	108	.50	

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TABLE 2.—RECORDS OF SELECTED WELLS IN ESSEX COUNTY, N. J.—Continued

Remarks:
O.W., Owners well number.

Well	Owner or Tenant	Driller	Date Drilled	Altitude above mean sea level (ft)	Total depth drilled below land surface (ft)	Diameter of well (inches)	Depth to which well is cased (ft)	Screen setting (ft)	Aquifer	Static level below land surface (feet)	Yield (gpm)	Drawdown (ft)	Specific capacity (gpm/ft)	Remarks
					FAIRFIELD BOROUGH									
1	Fairfield Borough	W. Beatty	1962	---	90	8	79	79-90	Qsd	---	350	---	---	
2	Republic Tool & Mfg. Co.	Algeier Bros.	7-30-52	170	53	6	53	---	Qsd	2	40	8	5.00	
3	Curtiss Wright Corp.	Artesian Well & Equip. Co.	1941	170	560	10	---	none	TRwb	11	155	136	1.14	O.W.4
4	Fairfield Borough	H. A. Kieffer	12-26-53	170	185	6	83	none	TRb	20	36	20	1.80	O.W.1
5	Fairfield Borough	Burrows Well Drilling Co.	7- 9-64	167	350	10	85	none	TRb	--4	500	64	7.35	
6	De Witt Rubber Mfg. Co.	Algeier Bros.	7-16-54	170	142	6	86	none	TRb	2	25	13	1.92	
7	Curtiss Wright Corp.	Artesian Well & Equip. Co.	4- 5-43	175	490	10	---	none	TRwb	32	275	85	3.24	O.W.6
8	Industry Publications	Algeier Bros.	9-15-54	180	100	6	57	none	TRwb	15	15	10	1.5	
9	Williamson & Co., Inc.	H. A. Kieffer	5-15-53	190	510	6	74	none	TRwb	13	25	55	.45	
10	Green Brook Country Club	H. A. Kieffer	1958	---	300	8	53	none	TRb & TRwb	20	335	28	11.96	O.W.4
					GLEN RIDGE BOROUGH									
1	S. Mendelsohn	Wm. Stothoff Co., Inc.	1-12-51	240	166	6	22	none	TRb	45	30	3	10.00	
2	Chicle Products Co.	-------------	1920	---	757	6	110	none	TRb	18	50	52	.96	
					IRVINGTON (TOWN)									
1	Fezem Memorial Home	Wm. Stothoff Co., Inc.	5-19-52	185	304	8	66	none	TRb	75	78	25	3.1	
2	Kles Diner, Inc.	Parkhurst Well & Pump Co.	3-10-55	---	250	8	47	none	TRb	31	65	69	.94	
3	American Stores	Parkhurst Well & Pump Co.	7-17-51	160	402	8	45	none	TRb	40	126	80	1.57	O.W.1
4	Olympic Park	A. J. Connally, Inc.	1928	158	300	10	---	none	TRb	52	420	78	5.38	
5	Irvington Smelting & Refining Works	Wm. Stothoff Co., Inc.	3-25-53	---	304	10	62	none	TRb	40	300	22	13.6	
6	Jersey Plastic & Die Casting Co.	Wm. Stothoff Co., Inc.	3-26-54	155	400	10	38	none	TRb	94	183	106	1.74	
7	Gallo Asphalt Co.	F. J. Bott	6- 9-61	150	201	6	107	none	TRb	46	200	24	8.3	
8	Palnut Co.	Parkhurst Well & Pump Co.	1-27-50	170	229	8	80	none	TRb	45	60	6	10.0	

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TABLE 2.—RECORDS OF SELECTED WELLS IN ESSEX COUNTY, N. J.—Continued

Remarks:
O.W., Owners well number

Well	Owner or Tenant	Driller	Date Drilled	Altitude above mean sea level (ft)	Total depth drilled below land surface (ft)	Diameter of well (inches)	Depth to which well is cased (ft)	Screen setting (ft)	Aquifer	Static level below land surface (feet)	Yield (gpm)	Drawdown (ft)	Specific capacity (gpm/ft)	Remarks
2					LIVINGSTON TOWNSHIP									
1	Livingston Township	Artesian Well & Equip. Co.	7- 5-55	174	83	36	43	43-83	Qsd	3	700	27	25.7	O.W.3
2	G. V. Control Co.	Rinbrand Well Drilling Co.	4- 7-58	---	300	10	96	none	TRb	10	180	134	1.34	O.W.1
3	Chatham Electronics Corp.	Wm. Stothoff Co., Inc.	10- 2-52	175	202	12	68	none	TRb	9	340	25	13.6	O.W.3
4	Chatham Electronics Corp.	Wm. Stothoff Co., Inc.	5-26-52	180	200	8	68	none	TRb	9	260	22	11.8	O.W.1
5	Livingston Township	Artesian Well & Equip. Co.	5-21-65	---	301	12	70	none	TRb	6	395	31	12.74	O.W.7
6	The Daven Co.	Wm. Stothoff Co., Inc.	3-16-55	---	450	12	175	none	TRb	31	35	169	.21	O.W.1
7	The Daven Co.	Wm. Stothoff Co., Inc.	4-30-55	---	68	8	44	40-60	Qsd	+	212	50+	---	O.W.3 Flowed 10 gpm at Surface
8	Livingston Township	Artesian Well & Equip. Co.	April, 1964	200	181	6	177	----	---	---	---	---	---	Test hole
9	Livingston Township	Artesian Well & Equip. Co.	May 1966	---	100	17	72	72-100	Qsd	40	450	45	10.00	O.W.6
10	Livingston Township	Artesian Well & Equip. Co.	Nov. 1958	302	372	10	72	none	TRb	13	175	68	2.57	O.W.1
11	Livingston Township	Wm. Stothoff Co., Inc.	5-21-55	---	442	10	67	none	TRb	20	97	275	.35	
12	Livingston Township	Wm. Stothoff Co., Inc.	7-16-55	---	313	10	89	none	TRb	16	230	174	1.32	
13	Livingston Township	Wm. Stothoff Co., Inc.	3- 2-55	311	384	10	69	none	TRb	62	290	97	2.99	O.W.2
14	Livingston Township	Wm. Stothoff Co., Inc.	9-26-55	279	291	10	38	none	TRb	70	412	66	6.24	O.W.4
15	City of East Orange	Layne-New York Co.	4-17-59	173	130	16-14	88	88-130	Qsd	41	1000	20	50	
16	City of East Orange	Layne-New York Co.	5-22-59	173	120	16-14	89	89-120	Qsd	35	1000	36	27.7	
17	City of East Orange	Layne-New York Co.	3-24-59	174	133	16-14	81	81-133	Qsd	40	1000	18	55.6	
18	City of East Orange	--------------------	1927	181	360	7	100	none	TRb	---	---	---	---	Slough Brook Field Middle Well
19	City of East Orange	--------------------	1927	182	---	8	125	none	TRb	---	---	---	---	Slough Brook Field North Well
20	Leemac Construction Co.	H. A. Kieffer	3-10-54	230	284	10	128	none	TRb	56	215	19	11.3	

Aquifer name:
Qsd, Stratified drift
TRb, Brunswick Formation
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TABLE 2.—RECORDS OF SELECTED WELLS IN ESSEX COUNTY, N. J.—Continued

Remarks:
O.W., Owners well number

Well	Owner or Tenant	Driller	Date Drilled	Altitude above mean sea level (ft)	Total depth drilled below land surface (ft)	Diameter of well (inches)	Depth to which well is cased (ft)	Screen setting (ft)	Aquifer	Static level below land surface (feet)	Yield (gpm)	Draw-down (ft)	Specific capacity (gpm/ft)	Remarks
					LIVINGSTON TOWNSHIP - Continued									
21	Wynne's Press Clipping Co.	Parkhurst Well & Pump Co.	11- 1-54	- - -	275	8	110	none	TRwb & TRb	40	150	60	2.5	
22	E. Wilkerson	-----------------------	1950	380	153	6	46	none	TRwb	0	25	8	3.01	
23	City of East Orange	Layne-New York Co.	1958	213	103	16-14	71	71-102	Qsd	35	700	4.5	155	
24	City of East Orange	Layne-New York Co.	1958	196	110	16-14	79	79-110	Qsd	33	700	8	87.5	
					MAPLEWOOD TOWNSHIP									
1	Village of South Orange	Artesian Well & Equip. Co.	Nov. 1950	133	156	10	46	none	TRb	20	225	55	4.09	O.W.5A
2	Village of South Orange	Artesian Well & Equip. Co.	1950	132	299	10	42	none	TRb	22	340	56	6.07	O.W.7A
3	Maplewood Theater	Burrows Well Drilling Co.	1-31-53	150	230	8	57	none	TRb	43	120	107	1.12	
4	H. O. Baetzner	Algeier Bros.	8- 2-54	215	140	6	22	none	TRb	15	15	10	1.50	
5	Plura-Plastics	Algeier Bros.	8- 9-60	- - -	200	6	50	none	TRb	45	60	5	12.00	
					MILLBURN TOWNSHIP									
1	Commonwealth Water Co.	A. C. Schultes & Sons	— — —	175	124	12	84	84-121	Qsd	29	1034	24	42	O.W.51
2	Commonwealth Water Co.	A. C. Schultes & Sons	8-18-55	175	123	12	88	86-118	Qsd	34	1018	20	50.90	O.W.50
3	Commonwealth Water Co.	Wm. Stothoff Co., Inc.	— — —	179	148	12	104	104-144	Qsd	23	1000	10.5	95	O.W.49
4	Commonwealth Water Co.	Kelly Well Co.	Dec. 1925	167	135	25	59	59-134	Qsd	23	1481	32	46.3	O.W. Kelly #1
5	Commonwealth Water Co.	— — — — — — — — — —	— — —	- - -	105	25	- - -	— — —	— — —	- - -	— —	— — —	— — —	O.W.43
6			1954	- - -	130	12	- - -	— — —	— — —	- - -	— —	— — —	— — —	O.W.45
7			— — —	- - -	309	8	- - -	— — —	TRwb	- - -	— —	— — —	— — —	O.W.38
8	Commonwealth Water Co.	Kelly Well Co.	11-21-38	- - -	133	25	- - -	— — —	Qsd	33	— —	— — —	— — —	O.W. Kelly #4
9	Commonwealth Water Co.	Kelly Well Co.	1932	- - -	134	25	- - -	— — —	Qsd		1200	38	31.6	O.W. Kelly #5
10	Commonwealth Water Co.	Layne-New York Co.	11- 6-46	170	128	20-12	108	108-128	Qsd	49	— —	— — —	— — —	O.W.D

Aquifer name:
Qsd, Stratified drift
TRb, Brunswick Formation
TRwb, Watchung Basalt

Remarks:
O.W., Owners well number

Well	Owner or Tenant	Driller	Date Drilled	Altitude above mean sea level (ft)	Total depth drilled below land surface (ft)	Diameter of well (inches)	Depth to which well is cased (ft)	Screen setting (ft)	Aquifer	Static level below land surface (feet)	Yield (gpm)	Drawdown (ft)	Specific capacity (gpm/ft)	Remarks
				MILLBURN TOWNSHIP - Continued										
11	Commonwealth Water Co.	Layne-New York Co.	1-17-47	173	139	20-12	129	129-139	Qsd	20	596	103	5.8	O.W.E
12	Commonwealth Water Co.	Kelly Well Co.	1932	---	134	25	---	-------	Qsd	---	1200	38	31.6	O.W.Kelly #6
13	Commonwealth Water Co.	Wm Stothoff Co., Inc.	8-14-54	---	163	12	119	117-153	Qsd	70	200	---	---	O.W.46
14	Commonwealth Water Co.	Wm Stothoff Co., Inc.	Nov. 1954	---	165	---	---	---	Qsd	---	---	---	65	O.W.47
15	Commonwealth Water Co.	Wm. Stothoff Co., Inc.	6-20-53	---	154	12	120	119-154	Qsd	55	690	19	36.3	O.W.44
16	Commonwealth Water Co.	Wm Stothoff Co., Inc.	---	---	---	---	---	---	Qsd	---	---	---	---	O.W.48
17	Commonwealth Water Co.	Kelly Well Co.	5-15-25	192	135	25	25-120	---	Qsd	24	1593	22	72.4	O.W.Kelly #2
18	City of East Orange	-------------------	1927	176	257	10	107	---	TRb	---	---	---	---	Slough Brook Field, South Well
19	City of East Orange	Artesian Well & Equip. Co.	1958	199	130	16	82	82-112	Qsd	43	775	10	77.50	
20	City of East Orange	Artesian Well & Equip. Co.	1958	195	130	16	80	80-120	Qsd	54	760	21	36.19	
21	A. E. Jones	H. A. Kieffer	8- 1-56	380	400	6	307	none	TRwb	265	30	55	.54	
22	City of Orange	Artesian Well & Equip. Co.	1949	255	100	36-18	89	89-99	Qsd	46	1480	35	42.28	O.W.4
23	City of Orange	Harris-Harmon Long Island Well Co.	10- 9-41	226	76	36-18	46	51-76	Qsd	5	1400	15	93.33	O.W.3
24	City of Orange	Sprague & Henwood	Feb. 1933	253	113	24-18	83	83-113	Qsd	40	1090	15	72.67	O.W.2
25	City of Orange	Artesian Well & Equip. Co.	7-15-60	---	106	16	74	74-104	Qsd	25	700	20	35.0	O.W.5
26	City of Orange	Layne-New York Co.	April, 1932	199	50	24-18	27	27-47	Qsd	3	700	29	24.14	O.W.1
27	Elizabethtown Water Co.	Artesian Well & Equip. Co.	1949	85	71	20	55	55-65	Qsd	18	760	30	25.33	O.W.53
28	Elizabethtown Water Co.	Artesian Well & Equip. Co.	8-10-49	86	70	12	46	46-66	Qsd	17	717	32	22.4	O.W.54
29	Elizabethtown Water Co.	Artesian Well & Equip. Co.	9-28-49	82	68	12	48	48-68	Qsd	25	440	26	16.92	O.W.55

Aquifer name:
Qsd, Stratified drift
TRb, Brunswick Formation
TRwb, Watchung Basalt

TABLE 2.—RECORDS OF SELECTED WELLS IN ESSEX COUNTY, N. J.—Continued

Remarks:
O.W., Owners well number

Well	Owner or Tenant	Driller	Date Drilled	Altitude above mean sea level (ft)	Total depth drilled below land surface (ft)	Diameter of well (inches)	Depth to which well is cased (ft)	Screen setting (ft)	Aquifer	Static level below land surface (feet)	Yield (gpm)	Drawdown (ft)	Specific capacity (gpm/ft)	Remarks
					MONTCLAIR (TOWN)									
1	Rapt & Ruden	Parkhurst Well & Pump Co.	4-29-48	360	250	10	23	none	TRb	5	145	180	.81	
2	Bond's Ice Cream, Inc.	Parkhurst Well & Pump Co.	3-10-50	510	157	8	21	none	TRb	15	150	55	2.73	
3	Town of Montclair	-----------------	1966	---	300	10	41	none	TRb	24	950	51	18.62	
4	Hahne & Co.	Parkhurst Well & Pump Co.	8- 9-49	280	350	8	31	none	TRb	18	350	182	1.92	O.W.2
5	M. Quadrel	Burrows Well Drilling Co.	June, 1955	260	151	6	18	none	TRb	33	75	---	----	
6	Montclair Auto Minit Man	Rinbrand Well Drilling Co.	1-10-50	---	200	6	16	none	TRb	40	60	---	----	
					NEWARK (CITY)									
1	Aluminum Finishing Co.	J. Foster	7-20-53	50	150	6	55	none	TRb	30	100	30	3.33	
2	Wilbur B. Driver Co.	Rinbrand Well Drilling Co.	7- 2-53	15	400	10	93	none	TRb	45	240	155	1.55	O.W.5
3	Pittsburgh Plate Glass Co.	Lauman & Co.	1940	12	---	12	90	none	TRb	9	390	---	----	
4	Mc Evoy Court Apartments	Parkhurst Well & Pump Co.	Oct. 1939	200	206	6	35	none	TRb	84	60	106	.57	
5	Columbia Theaters, Inc.	Wm. Stothoff Co., Inc.	6- 9-53	---	312	8	26	none	TRb	20	140	32	4.38	
6	Pabst Brewing Co., Inc.	Artesian Well & Equip. Co.	3-14-49	190	685	14	39	none	TRb	59	557	67	8.31	O.W.4
7	Pabst Brewing Co., Inc.	Artesian Well & Equip. Co.	7-17-50	185	687	14	55	none	TRb	108	240	120	2.00	O.W.5
8	Newark Milk & Cream Co.	Rinbrand Well Drilling Co.	Feb. 1949	25	700	10	80	none	TRb	60	75	190	.39	
9	Continental Ins. Co.	S. P. D'Alessio	July 1965	---	300	8	58	none	TRb	77	85	72	1.18	
10	Newark Center Corp.	Garden State Artesian Well & Pump Co.	2-18-55	---	700	10-6	150	none	TRb	81	89	144	.62	O.W.1
11	Kolker Chemical Works	Wm. Stothoff Co., Inc.	12-11-51	12	802	12	127	none	TRb	117	600	43	13.95	O.W.2
12	Kolker Chemical Works	Wm. Stothoff Co., Inc.	4-27-49	8	359	10	98	none	TRb	76	300	22	13.63	O.W.1
13	Eureka Construction Co.	Rinbrand Well Drilling Co.	1-23-59	10	500	8	90	none	TRb	25	75	225	.33	
14	P. Ballentine & Sons	-----------------	1937	12	875	16	95	none	TRb	227	375	153	1.79	O.W.8, Plant #2

Aquifer name:
Qsd, Stratified drift
TRb, Brunswick Formation
TRwb, Watchung Basalt

TABLE 2.—RECORDS OF SELECTED WELLS IN ESSEX COUNTY, N. J.—Continued

Remarks:
O.W., Owners well number

Owner or Tenant	Driller	Date Drilled	Altitude above mean sea level (ft)	Total depth drilled below land surface (ft)	Diameter of well (inches)	Depth to which well is cased (ft)	Screen setting (ft)	Aquifer	Static level below land surface (feet)	Yield (gpm)	Draw-down (ft)	Specific capacity (gpm/ft)	Remarks
				NEWARK (CITY) - Continued									
Celanese Corp. of Amer.	P. H. & J. Colan	1924	12	805	16-10	95	none	TRb	176	400	28	14.29	O.W. 26
Celanese Corp. of Amer.	Layne-New York Co.	5-16-47	14	856	16-10	75	none	TRb	147	778	40	19.45	O.W. 27
J. Hensler Brewing Co.	P. Chaffitelli	12-14-49	12	700	10-8	57	none	TRb	60	450	240	1.79	O.W. 4
Synthetic Plastics Co.	Industrial Well & Pump Co.	1-15-63	14	600	8	145	none	TRb	150	300	110	2.73	O.W. 1
Ablon Finishes, Inc.	Frank Bott	7-12-60	15	500	8	86	none	TRb	30	360	70	5.14	
Cotan Corporation	-------	1930	10	290	8	---	none	TRb	140	160	95	1.59	
Universal Grain Co.	Wm. Stothoff Co., Inc.	10-18-51	10	303	8	79	none	TRb	143	200	53	3.77	
Mother's Food Products, Inc.	---------	1959	11	400	8	107	none	TRb	94	125	8	15.62	
Kar Auto Service Co.	P. Chaffitelli	2- 8-50	208	300	6	35	none	TRb	23	60	104	.58	
Food Fair Stores	Burrows Well Drilling Co.	April, 1955	100	298	8	35	none	TRb	105	250	45	5.56	
S. & S. Super Service Corp.	Rinbrand Well Drilling Co.	2-18-50	50	190	6	94	none	TRb	45	20	---	----	
Rutherford & Delaney Holding Co.	Garden State Artesian Well & Pump Co.	7-31-56	---	220	8-6	42	none	TRb	22	100	73	1.37	O.W. 1
Linde Air Products Co.	Artesian Well & Equip. Co.	July, 1954	10	500	12	44	none	TRb	17	124	190	.65	
C-O Two Fire Equipment Co.	Parkhurst Well & Pump Co.	4-27-50	10	603	10	127	none	TRb	35	89	215	.41	
Suburban Motor Lodge, Inc.	Rinbrand Well Drilling Co.	June, 1950	10	555	8	126	none	TRb	15	20	235	.08	
S. B. Penick & Co.	Wm. Stothoff Co., Inc.	6- 7-61	---	400	10	75	none	TRb	60	644	23	28.00	O.W. 2
				NORTH CALDWELL BOROUGH									
Green Brook Country Club	H. A. Kieffer	July, 1951	310	300	8	33	none	TRwb	2	25	81	.31	O.W. 3
Green Brook Country Club	H. A. Kieffer	March, 1925	290	301	8	---	none	TRb & TRwb	flowing 25 gpm	60	---	----	O.W. 1. Redrilled 1962
A. Struss	H. A. Kieffer	8-16-55	---	182	6	42	none	TRwb	65	25	5	5.00	
A. F. Leitner	Algeier Bros.	5-24-58	---	195	6	25	none	TRwb	25	7	125	.05	

Aquifer name:
Qsd, Stratified drift
TRb, Brunswick Formation
TRwb, Watchung Basalt

TABLE 2.—RECORDS OF SELECTED WELLS IN ESSEX COUNTY, N. J.—Continued

Remarks:
O.W., Owners well number

Well	Owner or Tenant	Driller	Date Drilled	Altitude above mean sea level (ft)	Total depth drilled below land surface (ft)	Diameter of well (inches)	Depth to which well is cased (ft)	Screen setting (ft)	Aquifer	Static level below land surface (feet)	Yield (gpm)	Draw-down (ft)	Specific capacity (gpm/ft)	Remarks
					NUTLEY (TOWN)									
1	Hoffman-La Roche, Inc.	---------------	1940	---	600	10	32	none	TRb	35	180	85	2.12	O.W.4
2	Food Fair Stores, Inc.	Burrows Well Drilling Co.	6-25-53	75	350	8	23	none	TRb	22	60	128	.46	O.W.2
3	Federal Telecommunications Laboratory	---------------	1958	---	500	10	39	none	TRb	27	145	133	1.09	
4	H. Coopersmith	Rinbrand Well Drilling Co.	8-29-55	85	250	6	36	none	TRb	53	110	27	4.07	
					ORANGE (CITY)									
1	Carl. Del Spina & Co.	---------------	1958	---	400	10	25	none	TRb	22	330	40	8.25	
2	Monroe Calculating Machine Co., Inc.	---------------	1948	170	350	10	40	none	TRb	12	400	64	6.25	
3	City of Orange	---------------	1958	---	551	6	35	none	TRb	22	300	22	13.64	
4	Orange Products	---------------	March, 1960	---	500	10	35	none	TRb	15	257	78	3.29	
					ROSELAND BOROUGH									
1	Borough of Essex Fells	Artesian Well & Equip. Co.	6-15-52	195	195	18-12	58	none	TRb	+12	755	155	4.87	O.W.10 Flowed 90 gpm when drilled
2	Borough of Essex Fells	Artesian Well & Equip. Co.	10-20-53	213	220	18-12	73	none	TRb	11	450	127	3.54	O.W.12
3	Borough of Essex Fells	Artesian Well & Equip. Co.	3- 6-54	222	205	18-12	83	none	TRb	+13	400	133	3.08	O.W.11 Flowed 20 gpm when drilled
4	Kidde Precision Tool Corp.	H. A. Kieffer	5-15-54	---	350	8	86	none	TRb	8	65	28	2.32	O.W.2
5	Kidde Precision Tool Corp.	H. A. Kieffer	3-15-54	---	405	8	101	none	TRb	18	30	92	.32	O.W.1
6	Harold Cowan	Algeier Bros.	10- 2-54	---	183	6	126	none	TRb	40	15	25	.60	
7	Richard Ebersbach	Algeier Bros.	10-22-56	---	167	6	42	none	TRb	40	10	45	.22	

Aquifer name:
Qsd, Stratified drift
TRb, Brunswick Formation
TRwb, Watchung Basalt

TABLE 2.—RECORDS OF SELECTED WELLS IN ESSEX COUNTY, N. J.—Continued

Remarks:
O.W., Owners well number

Well	Owner or Tenant	Driller	Date Drilled	Altitude above mean sea level (ft)	Total depth drilled below land surface (ft)	Diameter of well (inches)	Depth to which well is cased (ft)	Screen setting (ft)	Aquifer	Static level below land surface (feet)	Yield (gpm)	Draw-down (ft)	Specific capacity (gpm/ft)	Remarks
					SOUTH ORANGE (VILLAGE)									
1	Village of South Orange	----------------	1913	132	274	8	---	none	TRb	---	200	---	----	O.W.1
2	Village of South Orange	Artesian Well & Equip. Co.	1950	133	182	10	40	none	TRb	25	170	67	2.54	O.W.2
3	Village of South Orange	Artesian Well & Equip. Co.	1950	134	115	10	40	none	TRb	28	300	11	27.27	O.W.3
4	Village of South Orange	Artesian Well & Equip. Co.	1950	132	122	10	49	none	TRb	28	250	50	5.00	O.W.8
5	Village of South Orange	----------------	1947	132	355	14	---	none	TRb	---	190	---	----	O.W.14
6	Village of South Orange	Burrows Well Drilling Co.	6- 1-56	148	350	12	45	none	TRb	9	560	41	13.66	O.W.16
7	Village of South Orange	Burrows Well Drilling Co.	3-11-63	148	200	18-12	36	none	TRb	14	847	24	35.29	O.W.15
8	Village of South Orange	J. P. Harris	1929	134	301	8	35	none	TRb	1	520	9	57.78	O.W.11
9	Village of South Orange	J. P. Harris	1931	137	382	16-12	52	none	TRb	20	200	90	2.22	O.W.12
10	Village of South Orange	J. P. Harris	6-20-30	138	349	16-12	48	none	TRb	7	490	7	70.00	O.W.13
11	Village of South Orange	Burrows Well Drilling Co.	5- 1-56	209	343	12	26	none	TRb	+3	550	78	7.05	O.W.17
					VERONA BOROUGH									
1	C. E. Drehman	H. A. Kieffer	10- 1-57	---	200	6	38	none	---	45	18	39	.46	
2	Montclair Golf Club	Rinbrand Well Drilling Co.	1-10-64	---	500	10-8	16	none	---	20	138	210	.66	
3	Claremont Diner, Inc.	Algeier Bros.	5-14-54	500	400	8	15	none	TRb & bs	15	45	135	.33	

Aquifer name:
Qsd, Stratified drift
TRb, Brunswick Formation
TRwb, Watchung Basalt

TABLE 2.—RECORDS OF SELECTED WELLS IN ESSEX COUNTY, N. J.—Continued

Remarks:
O.W., Owners well number

Well	Owner or Tenant	Driller	Date Drilled	Altitude above mean sea level (ft)	Total depth drilled below land surface (ft)	Diameter of well (inches)	Depth to which well is cased (ft)	Screen setting (ft)	Aquifer	Static level below land surface (feet)	Yield (gpm)	Drawdown (ft)	Specific capacity (gpm/ft)	Remarks
					WEST CALDWELL BOROUGH									
1	Mal Bros. Contracting Co.	Algeier Bros.	11-15-57	180	135	6	32	none	TRwb	4	30	81	.37	
2	Mt. Ridge Country Club	Parkhurst Well & Pump Co.	1933	- - -	252	8	119	none	TRwb	42	85	44	1.93	
3	Ferncliff Golf Club	H. A. Kieffer	2-28-55	180	305	8	79	none	TRb	14	90	14	6.43	
4	Elm-Tre Pool & Club	H. A. Kieffer	1926	260	170	---	---	none	TRb	---	60	---	----	
5	Caldwell Enterprises	Burrows Well Drilling Co.	3- 9-56	190	100	8	61	none	TRwb	+3	110	63	1.75	Flowed 30 gpm at --3
6	Borough of Essex Fells	Artesian Well & Equip. Co.	1957	335	254	18-12	100	none	TRwb	13	262	164	1.59	O.W.13
7	Borough of Essex Fells	Rinbrand Well Drilling Co.	1927	240	360	12-8	80	none	TRwb	+	175	— — —	— — —	O.W.4B Flowed 40 gpm
8	Borough of Essex Fells	Rinbrand Well Drilling Co.	1924	240	185	---	---	none	TRwb	0	225	80	2.81	O.W.4A
9	S. Crane	H. A. Kieffer	12-10-51	- - -	250	8	87	none	TRwb	8	90	43	2.09	
					WEST ORANGE									
1	Borough of Essex Fells	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _	1940	495	37	52-24	28	27-37	Qsd	8	190	27	7.03	O.W.2
2	Bow & Arrow Manor, Inc.	H. A. Kieffer	11-20-58	540	126	8	22	none	TRwb	28	50	37	1.35	O.W.3
3	Essex County Country Club	Parkhurst Well & Pump Co.	9- 8-54	560	115	8	21	none	TRb & TRwb	+2	100	102	.98	O.W.1
4	Nickle Alkaline Battery	Rinbrand Well Drilling Co.	3-21-62	— — —	505	8	58	none	TRb	12	190	213	.89	O.W.2
5	Nickle Alkaline Battery	Rinbrand Well Drilling Co.	9-26-61	— — —	520	8	46	none	TRb	15	190	210	.90	O.W.1
6	Rock Spring Country Club	H. A. Kieffer	2-28-56	510	406	8	20	none	TRb	110	25	90	.28	O.W.1
7	Rock Spring Country Club		1957	- - -	750	8	22	none	TRb	273	35	25	1.40	O.W.2

Aquifer name:
Qsd, Stratified drift
TRb, Brunswick Formation
TRwb, Watchung Basalt

TABLE 3.—CHEMICAL ANALYSES OF WATER FROM SELECTED WELLS IN ESSEX COUNTY

(Results in parts per million except as indicated)

(1) I, industrial
P.S., public supply

Location no. on map	Owner and well number	Water-bearing formation	Date of collection	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	Color	Source of analysis	Use
	ESSEX FELLS BOROUGH																							
1	Boro. of Essex Fells, No. 8	TRwb	9- 1-66	53	25	.09	.00	32	6.9	14	.3	84	36	19	.0	6.3	192	109	40	281	7.6	2	U.S.G.S.	P.S.
4	Boro. of Essex Fells, No. 1	Qsd	9- 1-66	52	27	.02	.00	42	16	7.2	.5	122	40	28	.0	6.4	265	171	71	358	8.1	3	U.S.G.S.	P.S.
	LIVINGSTON TOWNSHIP																							
5	Livingston Twp. No. 1	TRb	2-25-59	---	---	---	---	---	---	6.7	---	127	26	8.5	---	9.6	---	104	32	299	7.8	2	U.S.G.S.	P.S.
15	Livingston Twp. No. 4	TRb	8-31-66	55	23	.00	.00	32	14	8.7	.7	124	31	13	.0	8.4	220	138	36	306	7.8	2	U.S.G.S.	P.S.
18	City of East Orange	Qsd	8-18-66	---	19	.14	.00	52	20	13	.8	166	7.8	9.4	.1	6.1	309	212	76	433	7.5	2	U.S.G.S.	P.S.
22	City of East Orange	TRb	8-18-66	---	24	.10	.00	34	13	8.7	.7	140	25	6.7	.0	3.8	191	139	24	288	7.3	---	U.S.G.S.	P.S.
	MILLBURN TOWNSHIP																							
3	Commonwealth Wtr. Co. No. 49	Qsd	8-19-66	53	20	.00	.00	53	14	13	.8	155	67	13	.0	6.1	298	190	63	407	8.1	2	U.S.G.S	P.S.
9	Commonwealth Wtr. Co. No. 5	Qsd	8-19-66	54	21	.10	.00	44	15	12	.8	164	40	10	.0	1.1	240	172	37	358	7.6	2	U.S.G.S.	P.S.
11	Commonwealth Wtr. Co., E	Qsd	2-24-59	53	22	.00	.00	40	13	19	.8	124	77	7.7	.0	1.2	256	104	52	242	7.9	3	U.S.G.S.	P.S.
13	Commonwealth Wtr. Co. No. 46	Qsd	8-19-66	53	20	.04	.10	40	10	23	.4	158	47	11	.1	0.6	240	141	12	368	7.6	3	U.S.G.S.	P.S.
19	City of East Orange	Qsd	8-18-66	---	25	.03	.00	50	13	3.6	1.8	158	32	15	.0	2.5	256	179	49	347	8.0	2	U.S.G.S.	P.S.
26	City of Orange, No. 1	Qsd	2-24-59	---	---	---	---	---	---	5.2		55	33	11	---	1.1	---	45	39	203	6.9	2	U.S.G.S.	P.S.
	NEWARK (CITY)																							
14	P. Ballentine & Sons	TRb	1- 9-48	59	31	.15	---	865	173	447	7.0	210	911	1900	.0	6.2	4780	---	---	6960	7.3	0	U.S.G.S.	I
17	Hensler Brewing Co.	TRb	10-18-37	---	---	---	---	152	31	---	---	162	240	12	---	---	---	---	---	---	---	---	U.S.G.S.	I
	SOUTH ORANGE (VILLAGE)																							
2	City of South Orange, No. 2	TRb	2-24-59	---	19	.06	.00	80	7.4	23	2.0	198	76	35	.0	8.6	343	162	68	546	7.0	3	U.S.G.S.	P.S.
3	City of South Orange, No. 3	TRb	9- 2-66	54	17	.08	.00	93	10	40	2.6	204	51	92	.0	4.9	489	273	106	708	7.0	2	U.S.G.S.	P.S.

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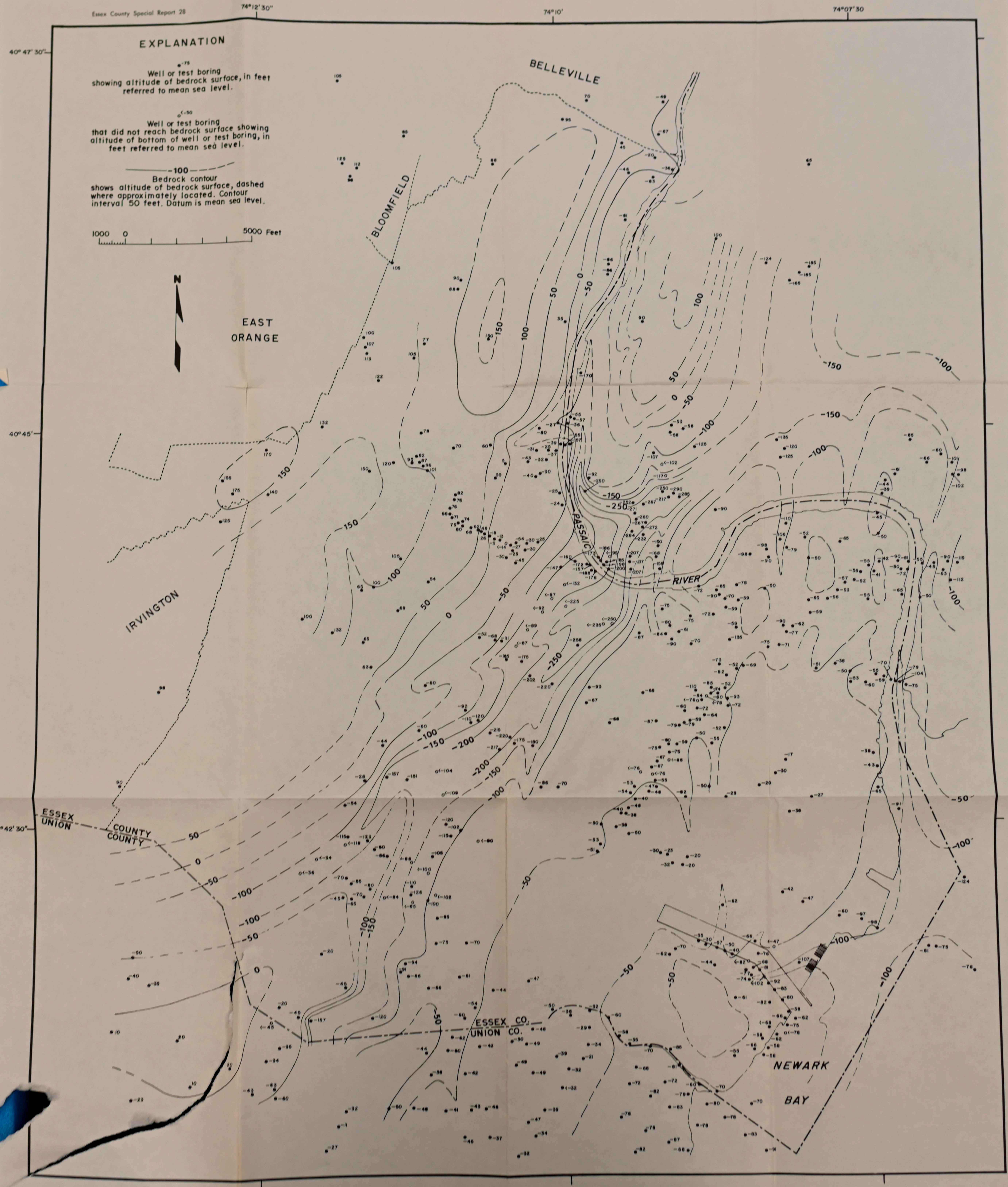

Figure 4.—Bedrock topography of the Newark area, Essex County, N. J.

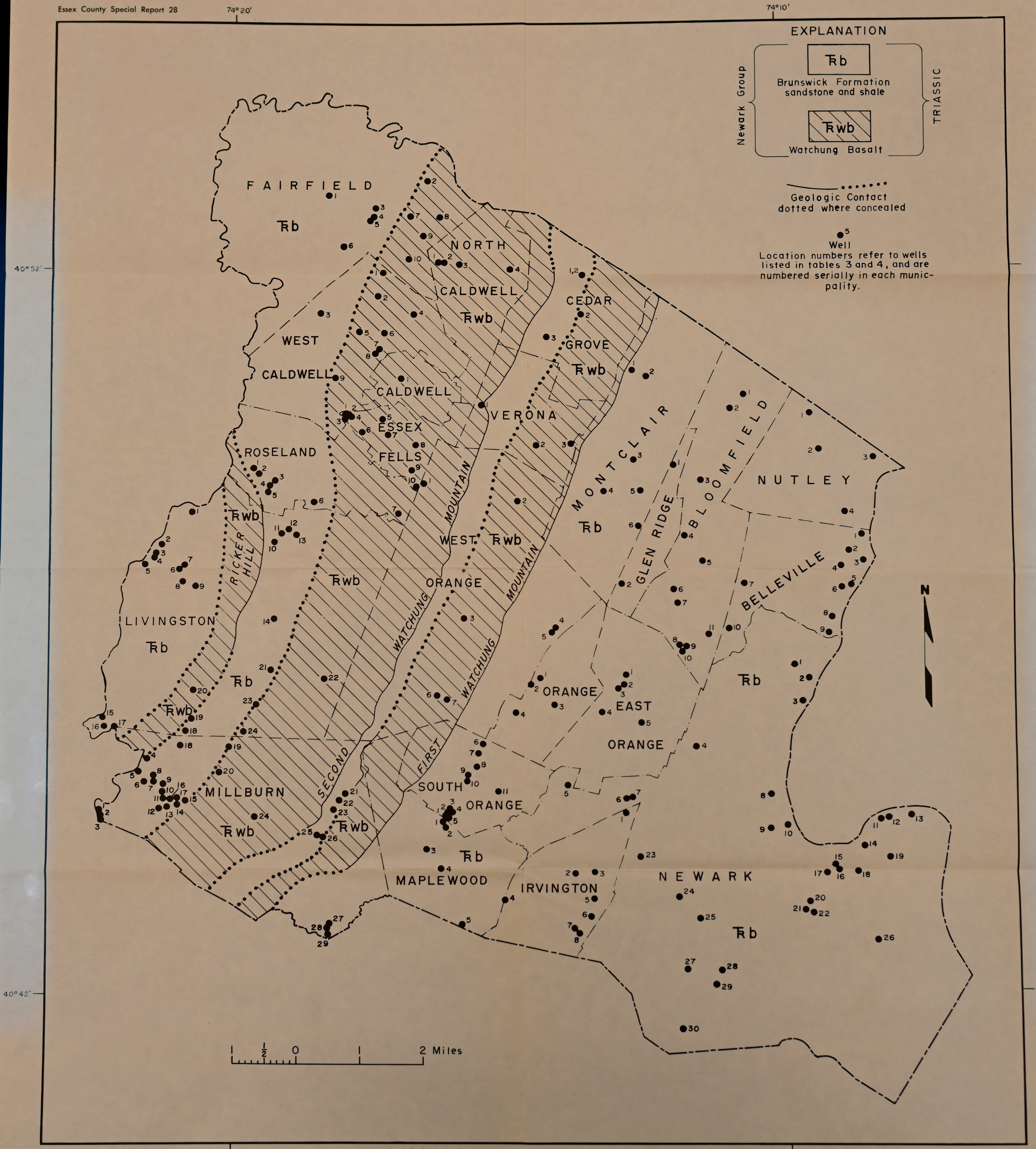

Figure 2.—Generalized bedrock geologic map of Essex County, N. J. showing locations of selected wells.

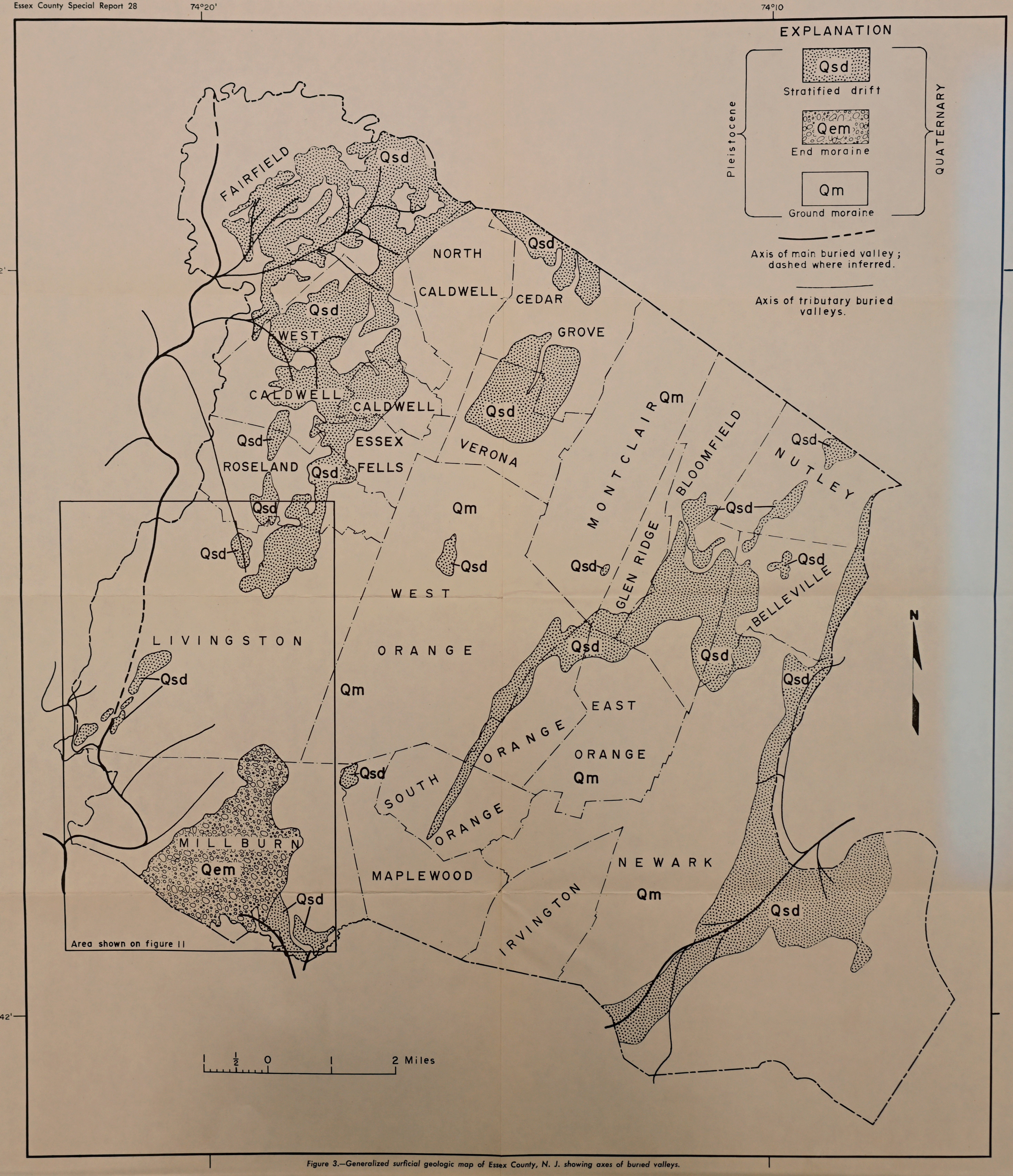

Figure 3.—Generalized surficial geologic map of Essex County, N. J. showing axes of buried valleys.