GEOLOGY OF THE GROUND WATER RESOURCES OF MERCER COUNTY

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GEOLOGY of the GROUND WATER RESOURCES of MERCER COUNTY

by

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ABSTRACT

Well records on more than 1,000 household and industrial wells in the files of the New Jersey Geological Survey were used in this study. Data from the records were tabulated by geologic formation, by township, and for special or local problems.

Successful domestic wells can be drilled almost anywhere in Mercer County. About one-half of the domestic wells drilled into argillite, basalt, or Pre-Triassic crystalline rocks yield too little or barely enough water. A second well or deeper well may be needed.

Large capacity industrial wells can generally obtain only enough water from the Raritan formation. Industrial wells in the Stockton sandstone and Brunswick shale usually yield about 100 gpm. The Pre-Triassic crystalline rocks yield generally from 20 to 50 gpm. The thick Pleistocene deposits of central Mercer County in some areas are dry, in others will supply enough water for domestic and small industrial requirements, and in a few restricted areas have supplied large capacity wells.

Detailed analyses of well records indicate that (1) there is no correlation between well depth and yield; (2) the availability of ground water decreases in wells over several hundred feet deep; (3) each formation has its own characteristic high and low yields; and (4) there are varying limits to the amount of water which can be safely drawn from a unit area of each formation.

Successful wells can be located near minor geologic structures which are revealed by topographic features.

It is recommended that various minimum lot sizes be used for household and industrial wells in different rock types.

In this study several commonly used mathematical coefficients are not believed to be useful.

It is thought that the information for a specific geologic formation or area as obtained from an adequate-sized sample of drillers' reports, although less precise with respect to the individual well, gives a practical picture of reasonable expectations.

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CONTENTS

APPENDICES

ILLUSTRATIONS

(Plates in pocket at back)

SUMMARY

Engineers, officials, realtors, planners, and citizens with an interest in ground water resources will find in this report summaries of reasonable expectations of depth and yield for wells drilled anywhere in Mercer County. Drillers' reports from over 1,000 wells have been analyzed and summarized by geological formation, by township, and with respect to local problems. Maximums, minimums, averages, and probabilities of depth and yield for domestic or industrial wells for any part of Mercer County can be determined from the data provided. Information and maps concerning watershed areas, industrial zones, and water company service areas are also provided.

All water supplies in Mercer County are derived from: (a) the Delaware River along the western border of the county; (b) the Delaware and Raritan Canal running southward along the Delaware River to Trenton and then northeastward following Assunpink Creek, Shabakunk Creek, Stony Brook, and the Millstone River until it leaves the county northeast of Princeton; (c) surface waters from farm ponds, impoundments, or from the minor streams of the county; or (d) from wells. Surface water supplies and their development or utilization are further complicated by laws which limit the movement of water from the Delaware River Basin, the southwestern two-thirds of the county, into the Raritan River Basin, the northeastern third of the county. At the present time a limited amount of water may be taken through the Delaware and Raritan Canal. There are both legal and physical limits as to the amount of water which can be taken from the canal and utilized in different parts of Mercer County.

Most of the population of Mercer County concentrated in the area around Trenton is supplied by the Trenton Water Company with water drawn from the Delaware River. Other urbanized areas are supplied by water companies depending upon wells. While most of the suburban expansion has so far occurred in areas which can be supplied by existing water companies or where individual wells are not too expensive and are usually adequate, in several townships, particularly in the northern part of the county, pressures have developed in recent years to permit construction of realty improvements whose water requirements exceed or will exceed the ground water supply obtainable within and near their boundaries.

Of the three major industrial zones in Mercer County, all of which cross the Delaware Basin-Raritan Basin Drainage Divide, the southern zone along U. S. Route 130 is supplied by large capacity wells completed in the Raritan formation; the central zone along U. S. Route 1 and the Pennsylvania Railroad mainline has limited ground water supplies but is close to the Delaware and Raritan Canal; and the northern zone, near U. S. Route 69 and the Reading Railroad, has neither surface water supplies nor the expectation of more than moderate supplies from wells.

In short, while most of Mercer County has adequate to moderate water supplies available for domestic and many industrial uses, southern and central Mercer County have the greatest future potential for the development of large supplies from either underground or surface water sources. This generalization, however, must be applied with caution. The areas for some specific uses such as irrigation wells, wells for high rise apartments, or industry with a large water requirement are limited in the county.

Ground water supplies are limited in areas underlain by Precambrian rocks, by argillite and by diabase. Unless surface water supplies or water piped in from outside the area is available, industrial development and housing developments on lots of less than two acres should be discouraged in areas underlain by argillite, by diabase, and perhaps by Precambrian rocks.

The area of Precambrian rocks extends northeastward from Trenton to Princeton Junction. Domestic wells are adequate ranging from 50 gpm to no water with most in the 5 - 9 gpm range. Industrial wells range from 175 gpm to 0 gpm and average about 35 gpm with only about one-third giving more than 50 gpm. Nearly all of the area underlain by Precambrian rocks is covered by Pleistocene sediments which provide well water in some areas.

There are several bands of argillite in northern Mercer County which contain very limited supplies of ground water. Over one-third of the domestic argillite wells give an inadequate 4 gpm or less. One argillite well in ten yields less than 2 gpm. A few industrial wells have been attempted, chiefly in the area between West Trenton and Pennington. The maximum yield for an industrial well was 90 gpm, while over half of the wells gave 20 gpm or less.

Diabase is found in the Rocky Hill sill in northern Mercer County and in several intrusive plugs in Hopewell Township. No industrial wells have been attempted in areas underlain by diabase. Domestic wells range from 100 gpm to nothing with only one well in ten giving water in excess of 10 gpm.

Adequate domestic wells and moderately large industrial wells can be developed in the areas of northern Mercer County underlain by the Stockton sandstone and Brunswick shale. The maximum yield for a domestic well (60 gpm) and the average yield (15 gpm) are the same for both formations. Only about 5% of the shale wells and only 3 out of 118 sandstone wells drilled for domestic water supply are inadequate with a yield of less than 5 gpm. Housing developments in areas underlain by shale and sandstone relying on individual wells and septic tanks will require a minimum lot size in excess of two-thirds of an acre if ground water resources are not to be depleted.

Industrial wells completed in the Brunswick shale have an average yield of 110 gpm and range downward from 470 gpm with more than half of the wells giving in excess of 50 gpm. Industrial wells in the Stockton sandstone average about 20 gpm more than the shale wells and range downward from 905 gpm. Well records suggest that industrial wells will be most successful if the plot is large enough and the location such that wells may be drilled on or near linear topographic features which reflect a geologic structure.

Wells in the Coastal Plain section of Mercer County are completed in either the Magothy-Raritan formation or in the thicker accumulations of the surficial Pleistocene deposits.

The lower Raritan contains too much clay or silt or is too thin to produce water until a stratigraphic thickness of about one hundred feet has been reached. South of this line (shown on Plate V) domestic wells can be completed in the Raritan formation anywhere in the county. The depth of domestic wells usually increases toward the south, but domestic wells can be completed in sand horizons at many different levels in both formations. Magothy-Raritan domestic wells average from 15 - 19 gpm with a maximum yield of 80 gpm.

The larger industrial wells completed in the Magothy-Raritan are usually found drawing from the lower part of the Raritan formation and are located near or along the line of Route 130. Industrial wells range from 1,500 gpm down to 35 gpm with an average and median yield of between 250 gpm and 300 gpm. An industrial well with a capacity of 500 gpm is a reasonable expectation for a carefully constructed well completed in the Raritan formation.

Pleistocene sediments form a surficial cover over a large part of Mercer County. Along the Valley of the Assunpink and Shabakunk from Trenton towards Bakers Basin and Clarksville Pleistocene sediments may be an important source of water because of the poor ground water yields from the underlying crystalline rocks. Thick Pleistocene accumulations in eastern Mercer County from Princeton Junction and Dutch Neck toward Hightstown are a second area of thick water-bearing Pleistocene sediments. Pleistocene wells are seldom more than 100 feet deep because of the limited thickness of the deposits. Domestic wells have an average and median yield of around 15 gpm. The largest Pleistocene industrial well gives 340 gpm and the successful wells average from 50 gpm to 100 gpm. In a number of predictable locations, however, the Pleistocene sediments are dry and repeated attempts to secure water from them have been unsuccessful.

The yields and depths of wells drawing from each formation in the county is given at the end of this section. Yield figures indicate the range, and expected averages. Depth figures must be used with caution because the Raritan is generally deeper in the southern part of the county, the depth of Pleistocene wells is limited by the thickness of the formation, and rock wells are frequently deeper than actually required.

The tabulation of depth figures for rock wells for the county as a whole by geologic formation provides an indication of the maximum range of depths which may be expected in any given formation. The well may or may not have secured most of its water at or near the maximum depth; many records do not indicate the depth at which most of the water was secured. In the case of deep domestic wells, a long hard look at the local relationships should be taken if a satisfactory domestic supply has not been secured after reaching a depth of 300 to 350 feet. In the case of industrial wells, those drilled in excess of 400 feet, while sometimes successful in securing large quantities of water, do not usually give quantities which equal the average of those wells drilled between 200 feet and 400 feet deep.

In the rock formations of the Stockton, Brunswick, Lockatong, Diabase, and Precambrian, most of the deepest wells were probably drilled to the depths indicated in an attempt to get additional water. There may have been no alternative but to go deeper because of the lot size or other local conditions.

In the case of the depth of wells in the sand formations, the Pleistocene and Raritan, it should be recognized that the Pleistocene most frequently is less than 70 feet thick. In several large areas, it is less than 30 feet thick and only occasionally does it exceed a thickness of 100 feet. On the other hand, the Raritan formation is usually found beneath a Pleistocene cover ranging from 10 feet to 150 feet in depth. In southern Mercer County wells must also penetrate as much as 150 feet of younger overlying Cretaceous sediments before reaching the top of the Raritan.

The Raritan has a general dip, or seaward slope, to the southeast which increases about 80 feet for each mile traveled towards the ocean. Wells completed in the Raritan may have been drilled to a deeper horizon in order to secure a better quality of water. It should also be noted that the hard "granite type" rocks of the basement which underlie the Raritan formation have a relief of probably 200 feet and that there are several areas, the most notable around Edinburg, where the Raritan may be very thin or missing. If the depth or thickness of the Raritan is computed on the basis of the average depth of the formation in some of these areas of "high" or "low" basement it would be quite erroneous.

MERCER COUNTY

DOMESTIC WELLS

Formation	*No. of Wells*	*YIELD IN GALLONS PER MINUTE* *Maximum*	*Minimum*	*Average*
Pre-Triassic	26	50	0	10
Stockton	148	60	1	20
Argillite	208	135	1/5	9
Brunswick	186	60	1/2	15
Diabase	100	100	0	9
Raritan	120	80	3	19
Pleistocene	20	80	3	13

INDUSTRIAL WELLS

Formation	*No. of Wells*	*YIELD IN GALLONS PER MINUTE* *Maximum*	*Minimum*	*Average*
Pre-Triassic	41	266	0	41
Stockton	80	905	18	147
Argillite	16	90	1/2	32
Brunswick	29	470	8	110
Diabase	none	..	..	..
Raritan	69	1500	35	327
Pleistocene	27	340	2	112

MERCER COUNTY

DOMESTIC WELLS

Formation	*No. of Wells*	*DEPTH IN FEET BELOW SURFACE* *Maximum*	*Minimum*	*Practical Depth Limit*	*Formation Thickness*
Pre-Triassic	26	350	52	400	Unknown
Stockton	149	670	22	400	3300
Argillite	209	798	40	400	2900
Brunswick	156	397	45	400	4850
Diabase	72	404	42	400	Unknown
Raritan	120	456	55	500 (?)	300
	(Increases in a southerly direction)				
Pleistocene	20	125	20	150	150

INDUSTRIAL WELLS

Formation	*No. of Wells*	*DEPTH IN FEET BELOW SURFACE* *Maximum*	*Minimum*	*Practical Depth Limit*	*Formation Thickness*
Pre-Triassic	41	900	50	500	Unknown
Stockton	80	603	40	500	3300
Argillite	16	436	85	500	2900
Brunswick	28	800	150	500	4850
Diabase	none	..	..	500	Unknown
Raritan	69	537	67	500 (?)	300
	(Increases in a southerly direction)				
Pleistocene	28	135	25	150	150

NOTE: Wells through Raritan enter Precambrian.
Wells through Pleistocene enter Raritan or Precambrian.

GEOLOGY OF THE GROUND WATER RESOURCES OF MERCER COUNTY

INTRODUCTION

For many years the Bureau of Geology and Topography of the Department of Conservation and Economic Development or, as it is more widely known, the New Jersey Geological Survey, has been called upon by well drillers, private citizens, engineers, realtors, industrial developers, planners, officials of other agencies of the State Government, representatives of County Government, and by municipal officers for assistance in ground water problems and particularly in determining the reasonable expectations of depth and yield for water wells at specific locations in the State. In each case, records of nearby wells were consulted to determine the maximum, the minimum, the average, and the probabilities of both depth and yield of the proposed well. These well records—assembled over the last seventy years by the State Geologist's office—contributed by cooperating drillers, and secured since 1947 through the operation of the well drilling law—present a tremendous mass of raw data of varying reliability. Interpreted by the more experienced and better-trained geologists of the State Survey, the predictions have usually been very close to the actual depth and yield of the finished well.

In June of 1956, the Mercer County Industrial Commission asked the New Jersey Geological Survey to prepare a report on the ground water conditions within the County. The New Jersey Geological Survey agreed to undertake this compilation and interpretation of the records in its files with the understanding that it would be done as staff availability and the usual geologic activities permitted. From time to time since 1957 summaries for some of the individual townships have been presented to the Commission; however, it has been impossible to present the county picture until detailed studies of well records in all of the townships had been completed in 1962.

In 1956 and 1957, senior students in geology were used to compile and check the data. Although they did an excellent job, they did not have the necessary experience and judgment to evaluate many of the records. Starting in 1958, therefore, geologists on the New Jersey Geological Survey staff reexamined, recompiled, and reevaluated the records. By 1960 sufficient records had been compiled to indicate that field check of the geology of many specific areas were necessary in order to insure accuracy in the interpretation of the well records.

It is believed that this report, based on over 1,000 wells selected from the well records in the New Jersey Geological Survey files, if properly used, gives a reasonably accurate picture of the ground water conditions within the county, within its municipalities, and within the various geologic formations which underlie the county.

As the study progressed, it became obvious from discussions with municipal officials, realty developers, planning boards and members of the industrial commission that the greatest value of the report would only be secured if the variations in ground water availability could be studied against the political and economic background of the county as determined by such factors as zoning regulations, political boundaries, surface water availability, water company size and franchise areas, land use, and growth trends. Thus recommendations for the location of new wells for Lawrenceville had to consider not only the geology, but also the distance from the Trenton water mains, the location in the township of new major water users, and the probable future growth pattern of the township. On the other hand, the demonstrated inability of wells to provide adequate water supplies from some geologic formations and in some specific areas has already profoundly affected both the operation and location of industrial plants and the type and speed of residential development in Princeton, Hopewell, and West Windsor Township.

Purpose and Objective

It is the purpose of this study to indicate the reasonable expectation for ground water development for various purposes in the different parts of the county. By the examination of a sufficient number of well records for each geologic variation in subsurface conditions, the variables due to human optimism, pessimism and veracity as well as good and poor construction and procedure in the drilling of wells, should be equalized. By a careful evaluation of who is drilling, where they are drilling, how they drilled, and why they drilled, many of the extreme conditions can be recognized and more valid data developed for the prediction of future probabilities of depth and yield.

Anyone who believes in the sixth sense of "dowsers or water witches", in the presence of underground rivers, or in layer-cake-like Coastal Plain aquifers should not waste their time by further reading. Those who like precision, mathematical equations, and evaluation in technical terms will find the report a disappointment. The color, type, and geologic subdivision of the Coastal Plain formation for each foot of a well is of little importance if most of the wells drilled for household use in the area are completed at about the same depth and give an adequate supply. The computations for the transmissibility of the rock, its porosity, and the specific capacity per foot of aquifer are of dubious value when based on driller reports reading "red shell all the way" or "white sand five feet, black clay ten feet, etc." and reports of a drawdown test made with a bailer for an unspecified time. However, if the reports of a number of different drillers for wells in the same geologic formation within an area of a few square miles are compared, a pattern can be determined and will provide useful information for future prediction and planning about the ground water resources of the surrounding area.

In the preparation of this report records have not only been examined for their accuracy and adequacy, but they have also been measured against the criteria of "will the record provide useful information which will help develop a pattern." It is believed that this report shows that a more valid overall prediction can be made by examining a large number of partially wrong or partially completed records than by predicting from a few records whose completeness and accuracy have been established. The variations in geologic and hydrologic conditions for any individual well are still such that in the final analysis all that can be predicted before the well is actually drilled and tested is the trend and range of what may be expected.

Location

Mercer County is the most westerly of the three counties which extend across the narrow "waist" of New Jersey from Sandy Hook to the Delaware. Trenton, the county seat and state capitol at the center of the western border of the county, is found at longitude 74° 46′ West and latitude 40° 14′ North. The area and 1960 population figures for the several municipal subdivisions are given in the appendix. Thirty miles from Philadelphia and fifty miles from New York City, Mercer County is crossed by the mainline of the Pennsylvania and Reading Railroads, U. S. Routes #1, #130, #69 and #206 and the New Jersey Turnpike.

The Delaware River forms the western border of the county; and the Millstone River, which drains into Raritan Bay, forms the eastern boundary of the county. Hunterdon and Somerset Counties are to the north; Burlington and Monmouth Counties are to the south.

Mercer and Middlesex Counties are the only two counties in the state which lie partially in the Piedmont Physiographic Province underlain by the Triassic rocks of the Newark series and the Coastal Plain Physiographic Province underlain by Cretaceous sands, gravels, and clays. Mercer County, however, is unique among the New Jersey counties because of the long, narrow wedge of pre-Triassic crystalline rocks extending northeastward from their outcroppings in the Delaware River and in Trenton to the vicinity of Princeton Junction and because of the thick deposits of Pleistocene gravels which, in many places, overlie the crystalline pre-Triassic rocks in the valley of lower Stony Brook, the lower Assunpink and southward from these two streams.

Rainfall, Runoff and Climate

The average annual rainfall is about 42″ in the Trenton area, about 43″ to 44″ in the southern part of the county, and from 44″ to 45″ in the northern (Hopewell Township) hilly area. During a typical dry year (T.A.M.S. uses 1930) the rainfall varies from 33″ in the Trenton-Princeton area to 36″ in the northwest and 37″ in the southeastern section. Summer rainfall may be thirty to thirty-five percent more than in other seasons unless there is an extreme drought. In a typical wet year (T.A.M.S. uses 1952) rainfall varies from 55″ in the border areas of the county to 61″ at Trenton.

In Mercer County there are stream gauging stations on the Delaware and Assunpink at Trenton and on the Millstone near Kingston. Average surface runoff in Mercer County is from 18″-19″ or 850,000 to 900,000 gallons per day per square mile. During a dry year surface runoff is about 11″ over most of the county, but is 12″ to 13″ in the basin of the Millstone River. During a wet year (T.A.M.S. used 1951-1952) runoff in the Piedmont Province area of Mercer County is 29″-30″ in contrast to the 24″-27″ in the area of the Coastal Plain Province. There is an annual difference of about 25″ between precipitation and runoff in Mercer County.

Precipitation is about evenly divided for the year with from three to five inches per month. About every eleven years there is a 15%-20% reduction in the amount of precipitation. This is usually felt as a drought of lasting at least thirty days which occurs during the growing season. A longer weather cycle may result in an occasional dry year with only 50% of normal precipitation.

Mercer County has moderately cold winters with average temperatures from 30° to 39° F. and extremes from −10° to 72° F. Very low temperatures do not last for more than a few days. Snow may stay on the ground for several weeks and reach a depth of 12 inches. The ground usually freezes to a depth of a foot or more. Summer temperatures range from 41° F. to 105° F. with an average of 72° F. The average growing season is about 195 days from April 16 to October 28. Killing frosts have occurred as late as May 12th and as early as October 11th.

Previous Work

A geologic map of Mercer County and adjacent areas was prepared in 1909 by Bascom, Darton and Kummel and published as the Trenton Folio. The Triassic deposits in Mercer County were described in considerable detail in 1896 and 1897 by Kummel. Salisbury in 1902 in Glacial Geology and in 1917 with Knapp in Quaternary formations described the details of various Pleistocene deposits in Mercer County. The geology of Mercer County including the glacial deposits is shown on the State Geologic Map prepared by Kummel and Lewis in 1910-1912 and revised by M. E. Johnson in 1950. Recent work by McLaughlin and Van Houten has greatly enlarged knowledge about the nature and occurrence of argillite.

Ground water conditions in Mercer County were touched on in 1955 in the T.A.M.S. Report and by Barksdale, et al., in Special Report #13 on the Tri-State Region of the Lower Delaware. Although both reports provided valuable information about ground water conditions and geology of the county, they are too general in scope to be useful in solving the detailed ground water problem.

Detailed information has been available either in the Permanent Notes maintained by the New Jersey Geological Survey since the 1880's or from the well record files. A file of well records from cooperating drillers was maintained until 1947 when the supply of information was greatly increased through well record forms received as a result of the operation of the drilling law. Also in the files of the New Jersey survey are copies of several Princeton University student theses on various subjects related to geology and ground water. A detailed citation of references of the published works mentioned above is given in the bibliography at the end of this report.

Compilation of Well Data

The City of Trenton and the eight townships in Mercer County were chosen as the units for the compilation of well records. The smaller municipal subdivisions such as Princeton Borough, Pennington, Hightstown, or Crosswicks were considered as part of the adjacent or surrounding township. As each well record was examined, it was given the next consecutive number on the compilation sheet for the township being studied. The well location was plotted on the well location map and the number used on the compilation sheet placed next to the location dot. *For each township,* therefore, *there is an indepedent series of numbers.*

It should be recognized at the outset that the figures given are not precise but rather should be used as a guide to reasonable expectations. Summations have been made from well drillers' reports whose locations and figures have varying degrees of accuracy. The sampling has been more or less at random rather than by any fixed statistical method. There are still many geologic factors that are not yet understood which can and do affect the individual wells. Every effort has been made to eliminate errors, to achieve a truly representative sampling, and to give due consideration to the geologic and other factors which affect the compilation and interpretation. Time and time again as compilations were made, both by area and by formation, the results indicated the profound effect which the geologic structure, the changing character of the formation, and the regional geologic history of the area has had upon the ground water availability. Small, almost unnoticed changes in geologic conditions may radically change the ground water conditions in the same geologic formation in a very short distance. The Raritan Formation in its lower part, the area underlain by the pre-Triassic rocks near Edinburg, and the structure and variations in the lithology of the Triassic in western Hopewell Township are excellent examples of the effect of seemingly unimportant or of unpredictable geologic changes within a small area upon the relative success of wells. Each of these geologic factors will be discussed in detail under the appropriate headings.

Within each township compilation, wells were considered as belonging to either a domestic or an industrial group. Wells for public water supply, for industrial use, or for irrigation are *classed as industrial wells.* The larger proportion of wells drilled in the county were for the use of individual households and were, therefore, tabulated as *domestic wells.* In the domestic group also were included wells for stores, churches, banks, filling stations, business offices, and even small industrial plants or other types of use where less than twenty gallons per minute were desired or where the permit or log indicated no special effort was made to get a large supply by increasing the diameter of the well or by drilling deeper than the usual domestic wells in the area.

In general, the industrial well summaries are probably more reliable than the domestic well summaries because wells requiring a large yield are more apt to be under the close supervision of the more reliable and more experienced drillers. The well data and well log for an industrial well are usually more complete because of development and pump test procedures from which more reliable data can be secured.

Upon completion of the township compilations and the well location map, the data were reexamined to provide summaries of depth and yield for wells drawing from each different geologic formation within the township. Summaries were then prepared for both depth and yield for each formation to show both the county-wide picture and a comparative picture for wells drawing water from the same geologic unit within the different townships. Special situations were noted and are discussed under the appropriate township.

Because of a popular concept that the deeper you drill the more water you will get, it must be emphasized again and again that *there is no relationship between the depth and the yield of any of the wells.* In the tabulation, the maximum and minimum depth and yield figures are almost never derived from the same well. Although there are some relationships as to the yield which may be expected in various areas and within various formations which are governed by depth, in general, any effort to derive a statistical or mathematical formula to show a specific depth and yield relationship is about as valid, when applied to a specific well, as a similar system applied to picking the winner of a horse race. The tabulations which follow should not be used to compare depth and yield except to say that a well of average depth will probably give an average yield, or that the range of either factor will be within the range given, or that the large yield of industrial wells is more likely to be secured at a greater depth than is required for a domestic well. It must be emphasized again that there is *no direct mathematical relationship between the depth of a well and its yield.*

The final stage in the compilation of data consisted of cross checking the summaries to be assured of their consistency and then examining the extremes and the averages to determine whether or not there was some unusual condition which would lead to unrealistic averages in the summaries. Some were found, and they are discussed either where these inconsistencies occur or in special sections when such a need arises.

Reliability of Data

Before considering the summaries of data for township areas or for the geologic formations, it would seem advisable to present some of the more significant factors which influence the presentation of information in the well report and thereby cause variation in the reliability of the data upon which the conclusions and estimates of the ground water conditions in Mercer County are based.

Throughout the selection of records and the compilation of the summaries, an effort has been made to eliminate inaccuracies by recognizing the difficulties and applying a *"philosophy of correction"* with respect to the report itself, the driller submitting the report, the time of submission, the use, the depth, the yield, the location, and the area around the well.

The *well report* form itself is designed to secure, with a minimum of effort on the part of the driller filling it out, the salient features of a well drilled either in rock or in sand. Some information requested may not be known when submitted, and some may be omitted or even erroneously given. Previous to 1947, a very similar form was used by the State Survey geologists. Regrettable as it may be, the forms are not always completed and may, in some cases, be inaccurate. However, the information given, although not all that may be desired, may be the best available and under such a circumstance must therefore be used.

The driller submitting the report cannot be forced by the drilling law to submit an accurate report. Most do; some will sometimes; some will on some items; and some few will not under any conditions. Thus one driller, who fortunately does not usually work in Mercer County, always has wells 120 feet deep giving seven gallons per minute from red shale. Fortunately his practice is restricted to wells for single dwellings in a red shale area. Thus the completed well report forms must be evaluated against the knowledge which the State Survey personnel have of the driller, the area, and the availability of better information. Need it be said that the reports of the driller cited above are filed without being used? However, such situations must be recognized, and such well reports excluded from statistical summaries. It should also be noted that bad news travels fast, and the State Geological Survey staff is usually one of the first to hear of unsatisfactory wells or of poor driller performance. At the other extreme of the tabulations the drillers themselves are usually quick to inform us about the exceptional or unusual wells.

The time of submission of the report is also a factor because reports submitted immediately after the drilling of a problem well will have more details and give a more accurate picture than a report written up several months after drilling along with reports on a number of other completed wells. Even more important than the time at which the well record is written is the age of the records themselves. Because drilling techniques and methods have changed over the years, older well records may present quite a different set of conditions as to depth, yield, and well construction than would be presented by a well drilled with a modern rotary, or developed by brushing and surging, or by gravel packing or some other relatively new drilling technique. For example, the use of, and the experience of a driller with, the large rotary drill rigs in the rock wells of Mercer County during the last few years could profoundly affect depth and yield figures if too many records were used in a summary. A reliable experience factor is lacking at this time, but the records received so far suggest that many wells drilled by rotary rigs in some rock types average deeper than those drilled by the cable tool rigs and, more often than not, will give less water *unless careful development procedures are followed.* The percussion-rotary rig using air, on the other hand, may prove better than the cable tool rig in many types of very hard rock.

The use of the well must also be considered because, as indicated earlier, well records for industrial, public supply, and irrigation wells are generally more reliable in the evaluation of the ground water available in a given geologic formation than are the reports on domestic wells. The greater cost of such wells usually results in their being drilled by the more experienced and better equipped drillers. Their construction is usually quite closely supervised and the pump tests and well development procedures are of much greater duration and more precise in measurement. Since such wells may call for the maximum amount of water than can be secured, they usually provide a better test of the ground water characteristics of the formation than do the small household wells where the desired small quantity of water is usually easily secured. If this is the case, the type duration and completeness of the pump test become very significant since they often will indicate whether the well can yield much or little more water than was required at the time of construction. It should be remembered, however, that in some areas of Mercer County where diabase, argillite, or Precambrian crystallines are the underlying rocks, an adequate domestic household water supply may require a well which in diameter, depth, and cost may approach the characteristics of a small industrial well. Thus the use of the well is an important factor in evaluating the ground water characteristics of a formation or an area, but the evaluation must always be made with due allowance for the overlap of depth and yield figures between domestic and industrial wells.

The depth of the well must always be carefully considered since the well may have been drilled much deeper than necessary or, in rare instances, prematurely abandoned before the desired supply could reasonably be expected. The topographic position of the well influences the depth since, all other things being equal, a well on a hilltop is usually deeper than one in a valley. Rock wells, because the water is secured from fractures which become less abundant and less open with depth, have rather definite limits as to the depth beyond which the probabilities of securing water decrease and finally cease. A few wells drawing water from Pleistocene gravels are limited in depth by the thickness of the formation. The sand wells of the Coastal Plain formations of southern Mercer County and South Jersey, on the other hand, must go deep enough to penetrate the water-bearing beds or aquifers which have a slope or dip to the southeast toward the ocean. Extremely deep rock wells should be checked against all known facts to determine, if possible, where the water was actually secured and whether or not they were drilled deeper in an effort to get more water than was found nearer the surface. Sand wells should be checked in a similar manner, but a good thick water-bearing sand is not usually ignored unless the quality of the water is poor or there is reason to believe there is a better sand at a greater depth. The ultimate depth of a sand well is the depth of the crystalline basement rocks or the economic limits imposed by possible alternate aquifers nearer the surface.

The yield figures for industrial wells are probably the most reliable. Industrial wells are generally closely supervised and usually provide for the installation of a pump and a pump test of several hours duration to indicate how much water the well will actually give. Under ideal conditions, the well should be pumped down and stabilized at the pumping level for a period of from 24 to 48 hours after the water level has ceased to drop. In the case of household wells, very few are tested with pumping equipment. Most tests are of short duration and by rather crude means. The reported yields of domestic wells depend a great deal on the driller's experience.

In the case of domestic wells, therefore, the Bureau of Geology finds the following relationships generally useful in judging whether or not a well should be considered poor, good, or exceptional. In general, if a yield is reported as less than five gallons per minute, we assume that the driller is probably rendering a correct report because he wishes it on the record that this was not a particularly good well in order to cover himself if the well goes dry at some future date. Where the yield is reported between five and twenty gallons per minute, we consider the well satisfactory for household use and assume that the test and the driller's experience indicate that the well is satisfactory as a domestic supply, but that the well test is, or may be, unreliable and the actual yield may be seven to ten gallons per minute for a well reported as yielding five, or perhaps the yield is only five gallons per minute even though the well is reported capable of yielding fifteen. The driller knows that the probabilities are that no one is going to check up on his figures with precise measurements. He knows the well will be satisfactory for the purpose and, therefore, puts down a figure which is only more or less accurate. In actual fact, wells reported as yielding fifteen or twenty gallons per minute have, in several instances when tested with a pump at a later date, given as little as seven or, in other cases, as high as sixty gallons per minute. Where the yield is reported for a domestic well in excess of twenty gallons per minute, it is assumed that the well is exceptionally good. Depending upon the amount of the test information given and the method of testing, there may be some indication that it is very much better than the yield reported or that the well is somewhere near the reported figure. For those wells which are reported as giving a great deal more water than twenty gallons per minute, it should be assumed that the industrial well averages, maximums, and minimums would apply.

The location of a well given on the permit is usually fairly good, but once in a great while errors in location of a mile or more from the actual location are found in the records. In general, most well drillers can read the topographic maps accurately enough so that the well location given is probably within one-quarter mile of the actual location. However, some drillers are notoriously poor at reading topographic maps and sometimes even the best efforts are confused by a location on one of two parallel local roads. Where the well location as given in the record is obviously wrong, for one reason or another, every effort has been made to establish the correct location or the well hasn't been used in the tabulation. Field checks of the locations given by the drillers have been made in many, but not all, cases. It is believed that a slightly erroneous location will have very little effect upon the averages as long as the well appears in the correct general area and in the proper geologic setting with respect to the formation from which it is drawing water.

The area around the well is the final variable which may cause an error when using the well records. Careful consideration must be given to the immediate area around any potential well site. There may be very few records because heretofore the area has been one of farms with large acreage. Under these conditions, there are usually very few wells, and most of these have been drilled for domesic use. A tabulation of a number of small domestic wells in a given area would not give the answer as to whether or not a satisfactory industrial supply could be obtained. With no industrial well records available, it would be necessary to consider not only other areas in the county underlain by the same rock type, but also other areas where an attempt has been made to bring in large industrial wells. Naturally, the nearest possible area should be selected, and also the area should be along the strike of the formation so that the geologic conditions in the area from which the information is being secured will be, as nearly as possible, the same as the area for the potential well site. As a last resort, the county-wide figures for the proper formation may be used to arrive at an estimate of reasonable expectations of depth and yield.

Using the Report

Many regional ground water reports give the maximum and minimum yield of each geologic formation. The sample may be eight or ten wells or even several hundred. Usually mathematical values, also with extreme ranges, such as coefficient of storage, transmissibility, or specific capacity are also quoted. In many instances there is undoubted merit in such values and they do provide a standard criteria. However, when geologic conditions make it impossible to evaluate the pump test or when such statements as "The effect of the withdrawal is generally not transmitted any great distance from the well, probably no more than a few hundred feet in most localities. . . .," or ". . . . coefficients of transmissibility and storage determined by the analysis of field pumping tests must be considered in the light of local conditions and may not be compared with coefficients from other tests. In some cases the coefficients may be meaningless because they represent combined effects of withdrawals from aquifers of different types" (Barksdale 1958) there would seem to be something missing in the application of the report to local problem. The evaluation of a rock well 160 feet deep using a value for the thickness of the "aquifer" of 160 feet seems slightly ridiculous when the driller has gotten no water at 150 feet and then brings in a well giving 60 gpm.

This report is an effort to offset these deficiencies in a regional analysis by examining a large sample in many different areas and grouping the samples in such a way that an analysis can be made of equivalent past experience. To this end the entire report has been divided into tables and discussion of the domestic and industrial well groups. The costs, methods, desired yields, and practical depths are different in each group although the extreme values of depth and yield may be nearly the same in any formation.

After making the primary division as to type of well which best represents the problem and consulting Plate I or V for the geology, attention should be given to the spread of values as compared to the average yield for the geologic formation in which the well is to be constructed. The accompanying table, showing the four highest well yields for each formation in Mercer County, supplies the second most important factor in developing a reasonable expectation of yield. The county summaries of yield and depth at the end of the summary section in this report indicate whether the geologic formation at the proposed well site can meet the desired needs. If a well still seems to be in order, the section on the appropriate geologic formation may next be consulted to determine possible local limitations or alternatives.

If the county and the geologic formation values are favorable or indicate a reasonable possibility of success in securing the desired water, then the township summary may be consulted to get clues as to local geologic problems which may exist. This information may show that local conditions may limit the proposed well program. From nearby wells a set of rather detailed and specific data as to what is a reasonable expectation may be secured.

A typical inquiry may be used as an example. The question is asked as to whether or not 100 gpm can be secured for an industrial plant to go in just east of Trenton along the Pennsylvania Railroad. The industrial well classification is used. The "four highest vs. average" table and the county summary show that the well is possible in the pre-Triassic and probable in the Pleistocene, the two geologic units found in the area. The Hamilton Township summary would confirm this and indicate the nature of local problems. From the Hamilton Township and Trenton summaries a specific set of maximums, minimums, averages, and probabilities for the nearest Precambrian and Pleistocene wells could be prepared. Plate I gives the geology; Plates II and III indicate the general geologic relationships; and Plate V shows the areas of surface water supply and the general ground water evaluation of the area (in this case poor). Final details would be worked out with the driller who might be instructed to test the Pleistocene gravels. If they proved to be inadequate, he would then be instructed to drill to 300 feet into the Precambrian in an effort to get the needed water.

If the request had been one for 500 gpm, the problem would be quickly solved because summaries and discussions would indicate that it is extremely unlikely that any well would be successful in securing this amount of water. An alternate area, southern Mercer County, with a Raritan well or an alternate source of water, the Delaware and Raritan Canal, could be suggested.

Plates I, IV, and V were prepared from the State Atlas Sheets which may be used to secure the details of topography such as the presence of linear structures and the elevation of the well site as compared to the adjacent wells. A difference in elevation in excess of fifty feet should be compensated for in the depth estimates.

A discussion of the hydrologic cycle as it applies to Mercer County is included in the appendices.

Four Highest Yields and Average* Yield in Gallons per Minute of Industrial and Domestic Wells in Various Rock Formations in Mercer County

Rock Formation	No. of Domestic Wells in Sample	Yield in Gallons per Minute														No. of Industrial Wells in Sample
		Domestic							Industrial							
		1st	2nd	3rd	4th	Aver.	Ratio 1st-4th**	Ratio 4th-Aver.**	1st	2nd	3rd	4th	Aver.	Ratio 1st-4th**	Ratio 4th-Aver.**	
Pre-Triassic (Precambrian and Hardyston)	26	50	30	20	20	10	2½/1	2/1	266	175	150	100	41	2½/1	2/1	41
Stockton Sandstone	148	60	60	60	50	20	1½/1	2½/1	905	700	602	600	147	1½/1	4/1	80
Argillite	208	135	55	35	30	9	4½/1	3½/1	90	50	50	50	32	1½/1	1½/1	16
Brunswick Shale	186	60	60	60	45	15	1½/1	3/1	470	460	412	201	110	2/1	2/1	29
Diabase	100	100	60	27	25	9	4/1	3/1	..	..	..	..	..	..	..	none
Raritan (Magothy-Raritan)	120	80	66	60	60	19	1½/1	3½/1	1500	1150	1125	1040	327	1½/1	3/1	69
Pleistocene	20	80	40	30	20	13	4/1	1½/1	340	240	228	200	112	1½/1	2/1	27

* Arithmetic Mean

** Nominators rounded to nearest one-half.

THE GEOLOGY OF MERCER COUNTY IN BRIEF

A ridge of pre-Triassic quartzites, gneisses, and schists, which crops out in the Delaware River forming the falls of Trenton, extends eastward at or very close to the surface as far as Princeton Junction. These crystalline rocks, which form the so-called "basement," underlie the northwesterly dipping sandstone, argillites and shales of the Triassic Newark Group of the Piedmont Physiographic Province of northern Mercer County and underlie the southeasterly dipping Cretaceous and Tertiary Continental Shelf sediments which form the Coastal Plain Physiographic Province of southern Mercer County.

Except for outcropping in the Delaware River, along the beds of some of the creeks, and at one or two other locations, the crystalline rocks are capped and masked by a veneer of Pleistocene sediments. Most of Trenton, much of northeastern Hamilton Township and a considerable part of West Windsor Township are underlain by these crystalline rocks. South of the main line of the Pennsylvania Railroad, the crystalline rocks are close enough to the surface in the vicinity of Quaker Gardens, Dutch Neck and Edinburg to effectively limit the amount of water obtained from industrial and irrigation wells. The pre-Triassic rocks range from gabbros to granites and pegmatites, from schists to gneisses and include a wide band of quartzite.

In that part of Mercer County which is within the Coastal Plain Province, only four of the Coastal Plain Formations are exposed. Nearly half of this part of Mercer County is underlain by the Magothy and Raritan Formations which are a series of alternating clays and sands. The sand beds and lenses in the Raritan Formation, particularly when they are well-sorted and free of interstitial clay and silt, are extremely important as aquifers. The sands of the Magothy Formation are frequently satisfactory for domestic household well supplies; but it is the coarser, thick, well-sorted sands of the Raritan Formation which provide water to most of the industrial wells along Route 130 and the Pennsylvania Railroad freight line from Bordentown to South Amboy. Southeastward of the above-mentioned railroad and highway, the Merchantville and Woodbury clays underlie most of the rest of the county.

Most of Mercer County in the Coastal Plain Physiographic Province lies between elevations of sixty and one hundred feet. Streams generally flow northwestward until they join the Delaware River or Assunpink Creek both of which turn and flow westward near Trenton, generally along the northern boundary of the Coastal Plain parallel to the strike of the formations. The relatively flat terrain and the sandy soil of the Coastal Plain Province has led to the rapid growth of housing developments in southern Mercer County (Hamilton, Washington, East and West Windsor Townships). Many areas underlain by clays close to the surface are very swampy and have remained wooded while the sandier soils have been cleared for farming.

Northern Mercer County in the Piedmont Physiographic Province is underlain by the Stockton sandstone and Brunswick shale which rise to an elevation of about one hundred sixty feet and are cut by streams which flow into the Delaware, the Shabakunk, or Stony Brook. The areas underlain by Lockatong argillite or diabase intrusives form the highest terrain in the county with flat-topped ridges reaching the general elevation of two hundred feet. The main argillite zone extends from Scudder's Falls on the Delaware River to and through Princeton Borough. The diabase intrusives of Pennington Mountain on the Delaware in the northern part of the county reach elevations of just over four hundred feet. The westward extension of the Palisades sill forms Mt. Lucas north of Princeton and Mt. Rose (Elevation 415') south of Hopewell. The Sourland Mountains and the high ground, with a general elevation in excess of three hundred feet, in the northern part of the county in the vicinity of Harbourton, Woodsville and north of Hopewell are underlain by sandstone, argillite or diabase.

The geologic structure of Mercer County is rather simple, with a normal sequence of Triassic strata dipping northwestward, and Cretaceous and Tertiary clays, sands, and gravels dipping southeastward from the ridge of crystalline rocks extending from Trenton to Princeton. Faults have been mapped in the crystalline rocks. A major fault in the Triassic on the north side of Hopewell Borough causes repetition of the Triassic sequence in most of northern Mercer County. Minor faulting occurs near the west end and on the south sides of the diabase intrusives of Mt. Rose, Pennington Mountain, and Baldpate Mountain.

Sections A-A' and B-B' on Plate II show the stratigraphy and structure described above.

Pleistocene deposits ranging from thick sheets of wind-blown loess, in the Stony Brook watershed near Pennington, to the coarse yellow gravels of the Pennsauken formation of the southern half of Mercer County conceal the bedrock and Coastal Plain formations in much of the county. Many of these deposits act as a sponge for the storage of water, make the soil more permeable, at times more fertile, and in a few places are thick enough by themselves to be used as aquifers or worked for their gravel.

STRATIGRAPHIC COLUMN FOR MERCER COUNTY

Geologic time intervals are arbitrary divisions of unequal length. Each may be matched by one or more geologic formations. An era, the largest division of geologic time, is subdivided into smaller units called periods. Formations, which are mappable rock units, are usually assigned to periods or smaller subdivisions of geologic time, on the basis of distinctive fossils, if present, or distinctive lithology. In the columns below the number in parenthesis indicates the total millions of years before the present when each geologic period began. The rock type given after the formation name is the most common variety. Other types of rocks are also usually present within the formation.

Era	*Period*	*Thickness In County*	*Formation and Rock Type*
	Recent (1/10)	30'?	Soil and alluvium
Cenozoic	Quaternary (1)		
	Pleistocene	150'	Glacial deposits
	Pliocene		
	Tertiary (70)		Not present in county
	Paleocene		
			Higher Cretaceous formations not present in county.
	Cretaceous (135)	30'	Marshalltown–clay (most exposures outside county)
	(Coastal Plain)	120'	Englishtown–sand
	(Hamilton, Washington, Windsors,	50'	Woodbury–clay
	Hightstown area)	60'	Merchantville–clay
Mesozoic		250–300'	Magothy-Raritan–sand and clay
	Jurassic (180)		Not present in New Jersey.
	Triassic (225)		
		4850'	Brunswick–shale
	(Hopewell, Ewing, Lawrence, Princeton area). Igneous rock-intrusive	2900'	Lockatong–argillite
		3300'	Stockton–sandstone
	diabase (Hopewell, Princeton)	1300'	Igneous-diabase
	Permian (270)		Not present in state
	Pennsylvanian		" " " "
	Mississippian (350)		" " " "
Paleozoic	Devonian (400)		Not present in county
	Silurian (440)		" " " "
	Ordovician (500)		" " " "
	Cambrian (600) (Trenton area)	Unknown	Hardyston–quartzite
	Precambrian (Began billions of years ago) (Trenton area)	Unknown	No named formations in county. Gabbros; pegmatites; gneisses; schists.

PRECAMBRIAN (PRE-TRIASSIC) ROCKS

Pre-Triassic rocks are found exposed in the Delaware River opposite Trenton, within the bed of Assunpink Creek and elsewhere in excavations in the city, eastward in Lawrence Township, and formerly as far east as Princeton Junction. This group of rocks consists of the Cambrian Chickies or Hardyston quartzite, an alleged equivalent of the Wissahickon schists which may be either Precambrian or early Paleozoic (post-Hardyston) and a meta-gabbro and other igneous rocks such as pegmatite and granite gneiss, which are generally classed as Precambrian in age. The outcrops in Mercer County are too sparse to permit the correlation with certainty of these formations to the more extensive outcrop area and exposures west of the Delaware River. The quartzite has a rather striking continuous outcrop across the river on either side of the Calhoun Street Bridge to Morrisville.

In the 1909 Trenton Folio these rocks are shown as outcropping from beneath the Pleistocene formations as far east as Bakers Basin. On the 1950 State Geologic Map, an outcrop area is indicated just west of Princeton Junction. Well drilling operations in the past few years in the area between Princeton Junction, Edinburg and Trenton suggest that the crystalline rocks lie close to the surface below a thin cover of Pleistocene deposits and underlie a much more extensive area and are much nearer the surface than has heretofore been indicated.

Since all of these rocks are hard crystallines, yielding water only from fractures, the age and lithologic differences are not important for the present study. However, when these rocks are close to the surface, are not capped by Triassic sandstones or Raritan sands and are covered only by Raritan clays or thin Pleistocene deposits containing much silt, the area underlain by these pre-Triassic rocks becomes important in studies of the ground water potential of Mercer County. For convenience in this study, in maps, sections, and discussion, these crystalline rocks are hereafter referred to as Precambrian without regard as to whether they are actually Precambrian gneisses or meta-gabbros, Cambrian quartzites, or younger gneisses and schists.

Field reconnaissance was conducted by the New Jersey Geological Survey in Mercer County during May, 1960 as a preliminary step in the preparation of a geologic base map for the ground water report on the area. The existing geologic maps did not seem to agree with information from new exposures and well data that were not available when the geologic map was revised in 1950.

Prior to commencement of field work, considerable research was conducted on published data on the pre-Triassic rocks shown in the Trenton and Princeton Junction areas on the State Geologic Map. Outcrop localities given in the permanent notes were noted on the new U.S.G.S. 1:24000 quadrangle sheets.

Field checking was started in the Trenton area. Precambrian gneiss in a highly weathered state was found beneath a few feet of overburden in the excavation for a large building 1,500 feet southeast of U. S. Route #1 on that part of the highway between Texas Avenue and the Lawrence Drive-In Theatre. This area was formerly mapped as Triassic on the geologic map. The occurrence of Precambrian gneiss at this locality and as outcrops to the west necessitated moving the Triassic-Precambrian contact in a northwesterly direction nearly one-fourth of a mile.

Reconnaissance was continued in a zone about three miles wide from Trenton to Princeton Junction on both sides but chiefly southeast of U. S. Route #1. All roads in this area crossing the Cretaceous-Triassic contact as shown on the geologic map were traveled. All areas of potential outcrop or exposure were examined including road cuts, stream banks, and excavations for buildings and garbage burial. It soon became evident that the contact zone as mapped was based on inference rather than on outcrop. No identifiable outcrops of Cretaceous or Triassic deposits were found within one-fourth mile of either side of the contact zone as previously mapped. Intensive search disclosed only Pleistocene deposits at or near the surface. Clay was found in the area between the Delaware and Raritan Canal and Assunpink Creek just south of Bakersville. The white and gray clay, upon cursory examination, appeared to be Cretaceous, however, detailed examination and comparison of samples suggests that this clay is a Pleistocene deposit, consisting largely of reworked Raritan Formation and/or Precambrian saprolite materials.

Mention was made in the permanent geologic notes of several Precambrian outcrop areas which apparently were utilized in preparing the State Geologic Map. All of these localities were visited and field-checked for this report, and all apparently have been covered by sanitary land fill or other construction in recent years. One of these locations was on the north side of the railroad at a crossing near Duckpond Run, two miles southwest of Princeton Junction. This, apparently, was concealed by the fill for the construction of a highway overpass. The most famous locality, a few hundred yards southwest of the Princeton Junction Station, is now utilized by West Windsor Township as a dump, and the Precambrian outcropping is no longer visible. However, the yellow and white conglomerate, typical of the basal Triassic, is still visible north of the dump. A newly constructed farm pond, south of the railroad tracks on the Old Post Road several hundred yards southwest of the above-mentioned dump, showed that it bottomed in clays containing blue quartz pebbles characteristic of the nearby Precambrian. All of the area listed as Precambrian was very carefully searched for outcrop, and it is concluded that earlier mapping was based on information from well logs, just as in the case in this report, and on now-vanished outcrops.

Simultaneously with the field check operations, all well records on file in the office were consulted for the area between Trenton and Princeton Junction on either side of the Pennsylvania Railroad main line. The study of well records was made over an area sufficiently wide so that all areas which anyone had previously mapped as Precambrian, as well as those areas where there was reason to believe that the Precambrian was close to the surface, were encompassed.

Twenty-one well records were found adjacent to but outside of the areas formerly mapped as Precambrian. All of these wells first penetrate Pleistocene deposits of one kind or another. Some end in identifiable Precambrian rock, while others penetrate a few feet of either gray or yellow clay. In some of the records, this clay has been interpreted as Cretaceous. It is believed, in view of the material found in other wells in the general area which have penetrated thick sequences of Pleistocene and in view of the character of some of the clays observed at the surface in known Pleistocene deposits, that these clays in the above-mentioned wells are probably reworked Precambrian material. Some of the well logs for these wells were prepared by geologists, but others were prepared by the local drillers who are believed to have sufficient experience in the area to be able to identify the various geologic materials. Only those drillers' logs whose location was surrounded by reliable sample logs which had been described by geologists were used in the study and in the preparation of the geologic cross-sections.

West Windsor Township well 25, although a drillers' log, seems to indicate the existence of a Cretaceous filling in a channel in the Precambrian because the interval between 25 and 80 feet is described as white clay and white sand.

There is a lack of reliable subsurface information in the Great Bear Swamp area. Hamilton Township wells 73, 74, and 75 to the south and southeast of the swamp according to the drillers' logs may penetrate a thin section of Cretaceous before ending in Precambrian rocks. Hamilton Township well 76 appears to penetrate Pleistocene for its entire depth. The Precambrian-Cretaceous contact has therefore been arbitrarily located along the southern portion of Great Bear Swamp. A well drilled in November, 1960 after the revised contact had been drawn in was located just north of the inferred Precambrian boundary. The well struck dark green Precambrian schist at a depth of nine feet.

The shape of the Precambrian outcrop area beneath the Pleistocene suggests that, at several points, valleys or channels trending north-south, or northeast-southwest may have been eroded in the Precambrian basement. One such channel filled with Pleistocene may be indicated by West Windsor well 64 and 95 drilled for Wing Hing Farms. Other well records and geophysical traverses in the area suggest that there are other such channels which may have thin deposits of Cretaceous sediments, a thin residual layer of Triassic rocks, or uneroded weathered Precambrian material in the valley bottom. However, in most of this area between Trenton and Princeton Junction the Cretaceous or Triassic cover has apparently been eroded away until the Precambrian has been exposed and the valleys thus formed have been entirely filled with Pleistocene sediments.

Wells Tapping the Precambrian

In the study of the Precambrian rock area of Mercer County, 119 wells and test borings were plotted on the 1:2400 scale U.S.G.S. Quadrangle maps of the area. Of this group 26 domestic and 41 industrial wells were found to be getting their water from the Precambrian. Twenty other wells were drilled to the Precambrian but secure their water from the overlying formation.

Only four industrial wells in Ewing Township, all close to the Trenton City line draw from the Precambrian. Twenty of the Precambrian wells are industrial wells in Trenton. There are 17 domestic and 7 industrial wells in West Windsor Township all in or around Princeton Junction. The remainder of the Precambrian wells with one exception are in Hamilton and Lawrence Township within a mile of the Pennsylvania Railroad main line. The exception is an unsuccessful irrigation test well in Washington Township nearly three and a half miles south of the railroad.

Domestic wells tapping the joints and fissures in the Precambrian may be expected to yield about 10 gallons per minute from a depth of about 120 feet as shown on the tables below.

DOMESTIC WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		YIELD IN GALLONS PER MINUTE			
West Windsor	17	50	0	11*	7
Hamilton	4	20	1	9	4½
Lawrence	3	14 (6)	5	..	..
Trenton, City of	2	20	15	..	..

* 5 gpm without the 50 gpm and 30 gpm wells.

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		DEPTH IN FEET BELOW SURFACE			
West Windsor	17	350	52	111	91
Hamilton	4	205	135	169	203
Lawrence	3	123 (113)	65	..	..
Trenton, City of	2	194	36	..	..

Industrial wells in Mercer County drilled to the Precambrian have an average yield of 35 gpm. Only four out of 37 wells gave 100 gpm or more although nine others gave at least 50 gpm. It should be noted that four wells from 50 - 117 feet deep gave no water and one drilled to 448 gave only 2 gpm. There is no indication as to where the 100 gpm of water was struck in the 900 foot-deep well for the Globe Rubber Works (Trenton #48), the deepest well in the county.

INDUSTRIAL WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		YIELD IN GALLONS PER MINUTE			
Trenton, City of	20	175**	0	38	16
West Windsor	7	266	17	86*	60
Lawrence	4	70	5	..	15
Ewing	4	40	1	..	30
Hamilton	5	60	7	..	15
Washington	1	..	Test	..	..

* See West Windsor Township.
** See Stokely-Van Camp below.

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		DEPTH IN FEET BELOW SURFACE			
Trenton, City of	20	900	50	365	360
West Windsor	7	393	103	266	283
Lawrence	4	350	59	..	304
Ewing	4	423	145	..	337
Hamilton	5	280	50	..	121
Washington	1	244		..	..

Among the well records considered for the tabulation in Mercer County was one, #23 in Trenton, an eight-inch diameter well drilled in 1912 for Stokely-Van Camp, Incorporated, about one-half mile from the Delaware River. The report indicates that this well was eight inches in diameter and was drilled 520 feet into the Precambrian rocks. It had a static level approximately equal to that of the Delaware River, and it is believed that it hit a very open fracture in the Precambrian which was directly connected to the river. The yield reported was 2,000 gpm with a 20-foot drawdown in a pumping test, whose duration is not indicated. In 1953 it was tested and allegedly gave 50 gpm. This well is so exceptional, for not only the Precambrian, but also for any rock formation, that it is not included in any tabulation.

Its reported yield is not given as the maximum Precambrian well, since this seems to be grossly exaggerated on the basis of the many wells that have been drilled in this type of rock. While such yields are possible in this type of rock or in sandstones or limestones, and indeed do occur at one or two locations elsewhere in the state upstream from Trenton in limestones, where the well is close to the Delaware River, such openings cannot be predicted and the probabilities of putting down any one well and intersecting such an opening are fantastically slim. A note on the well record indicates that the storage tank was filled in seven or eight hours of pumping. This indicates that the well was pumped at an actual rate of about 175 gpm. Even this rate is greater than any other Precambrian well in Mercer County.

As it is with most rock wells, so it is in the Precambrian wells of Mercer County; there is no correlation between depth and yield. The following table gives the yield in gallons per minute for fifty-foot increments of depth.

	YIELD IN GALLONS PER MINUTE	
Depth (feet)	*Industrial Wells (41)*	*Domestic Wells (26)*
0 – 50	0, 7½	20
51 – 100	0, 0, 60, no test	10, 30, 10, . ., 0, 1½, 15, 10, 7, 5
101 – 150	11, 16, 20, 30, 15, 17	5, 50, 10, . ., 4½, 12, 6, 14, 4½, 10
151 – 200	0	15, 18
201 – 250	Tested abandoned, 60, 70	20, 1
251 – 300	1, 15, 60, 47, 40	
301 – 350	60, 37, 5, 70, 20, 266, 25	5
351 – 400	40, 15, 150	
401 – 450	2, 85, 15, 40	

and also the following six industrial wells with the indicated total depth.

480′– 84 gpm, 520′– 175 gpm, 598′– 70 gpm, 713′– 25 gpm, 730′– 0 gpm, 900′– 100 gpm.

For the deeper wells there is no assurance that the water was not struck at some elevation well above the bottom of the hole.

TRIASSIC ROCKS

Rocks of Triassic age are exposed in eastern North America in several elongated disconnected patches roughly paralleling the Atlantic Coast from Nova Scotia to North Carolina. One of the largest, widest and most complex of these areas, which mark the position of the ancient Triassic valleys, extends from the Hudson River southwestward through New Jersey into Pennsylvania and thence westward and southward into Virginia. Within this area the strata are tilted gently (10° - 25°) to the north or northwest. The Piedmont Physiographic Province of New Jersey coincides with this area of Triassic rocks. Two-thirds of New Jersey's citizens live in the Piedmont which constitutes about one-fifth of the state. In Mercer County everything north of a line nearly coincident with the main line of the Pennsylvania Railroad lies within the Piedmont Physiographic Province.

The series was first named by Redfield in 1856 for the area around Newark. After detailed work prior to 1897 by H. B. Kummel, then State Geologist of New Jersey, the name "Newark Group" was generally accepted as standard for the Triassic rocks in North America. The Newark Group in most of the basins consists of two formations—a lower sandstone, or arkose, and an upper series of shales which are most typically red. Either basalt lava flows or, in the southern states, diabase sills or, as in New Jersey, both types of igneous rock are found interbedded with or intruding the sediments.

Along the Delaware River and in adjacent Mercer and Hunterdon Counties in New Jersey and in Bucks and Montgomery Counties in Pennsylvania exposures of the Triassic rocks are widest (about thirty miles) in the largest of the Triassic basins in eastern North America.

Within this area, also, are nearly all of the outcroppings of the Lockatong formation. As a result of recent geologic work in the area, it now seems debatable as to what is and what is not within the Lockatong formation or whether this rock type should be called a formation at all. Because the Lockatong argillite most obviously interfingers with and is of the same geologic age as the Brunswick shale, and because the Lockatong also interfingers with or has a gradational contact with the underlying Stockton, the term "lithofacies" has been applied (McLaughlin and Willard 1949) to the Lockatong argillite lithology. While the argillite is found as mappable units, its repetition and interfingering lead to difficulties when the time of deposition is considered, and an attempt is made to establish formational boundaries.

Such a delineation of the outcroppings of various rock types (as formations or as lithofacies), while each has some merits, becomes awkward in detailed mapping of an area such as Mercer County where there are several repetitions and interfingering. In this report, therefore, the Triassic is divided into and mapped as the Stockton sandstone, the Brunswick shale, and the Lockatong argillite. This procedure, while leaving the problem of formation names unresolved, permits the preparation of a geologic map, of geologic cross-sections and the discussion of the effect of lithologic variation upon ground water resources without ignoring field work done for this report, recent unpublished and uncompleted studies of the Lockatong rocks, or detailed studies of Pennsylvania geology which have recently been completed. Later, work may resolve the problem of formation boundaries and may slightly change the shape and size of the areas in Mercer County mapped as one rock type or another.

The Triassic basin begins near Stony Point, New York, on the west side of the Hudson. To the south and southwest, Brunswick shale is intruded by diabase and to the northwest is in fault contact with the Precambrian rocks of the Highlands. Fanglomerates and coarse conglomerates are found in the western part of the basin near the border fault. From Nyack, New York, southward the Stockton sandstone is found beneath the Palisades and southward of Piermont, New York, also above the intrusive sill. In the western part of the basin from near Oakland, New Jersey, southwestward to near Far Hills and Somerville, basaltic lava flows (which form the Watchung Mountains and several other high ridges) are found interbedded with the shales in the upper or younger part of the stratigraphic column. The eastern border of the Triassic is covered by overlapping Coastal Plain sediments from Bayonne southwestward to Princeton Junction where the contact of Triassic rocks with the older Precambrian and Paleozoic metasediments is infrequently exposed from beneath a veneer of Pleistocene deposits.

In contrast to the very thick apparently unrepeated stratigraphic sequence of several thousand feet of slightly folded and almost unfaulted northwestward dipping sediments and usually concordant igneous rocks, the New Jersey Triassic west of a line through Far Hills, Somerville and New Brunswick is much more intensely folded, is broken into several blocks by major faults which cause at least three repetitions of the stratigraphic sequence, and is intruded by a number of discordant igneous rock bodies. As mentioned above, this western part of the New Jersey Triassic basin has extensive exposures of Lockatong argillite. West of Far Hills the northwestern border of the Triassic is, characteristically, an unconformable contact with older rocks rather than a prominent border fault as is the case northeast of Far Hills. For several miles east of the Delaware River and at one or two other places in Hunterdon and Somerset Counties, faults again mark the northwest border of the Triassic basin. In Hunterdon County extensive areas of Triassic fanglomerate are found adjacent to the northwestern border.

In Mercer County the southeastern border is generally masked by Pleistocene deposits. However, outcroppings of Triassic, Stockton sandstone are frequently only a few hundred feet from areas known to be underlain by pre-Triassic rocks or from exposures of these rocks. The unconformable contact could at one time be observed near Princeton Junction. Construction work in and near Trenton has, in the past few years, created transitory exposures which have permitted the contact to be mapped more precisely. Geophysical work and well records in the border area suggest that at several places in Mercer County the Triassic is in fault contact with the underlying older rocks. The southeastern border of the Triassic is very close to the line of U. S. Route #1.

A normal stratigraphic succession of Stockton sandstone, Lockatong argillite, and Brunswick shale is found from Trenton and Princeton Junction northward to Moore and Hopewell. The Hopewell fault has caused an uplifted block of Triassic rocks to repeat the normal stratigraphic sequence a second time in northern Mercer and southern Hunterdon County. In the northern part of the first or Mercer County structural block, the westward extension of the Palisades diabase sill is found north of Princeton intruding and baking both the Brunswick shale and Lockatong argillite. West of Mount Rose the intrusion becomes more and more like a dike until it is terminated by the Hopewell fault. Four other diabase intrusions are found in Mercer County west of the Rocky Hill or Palisades sill before one reaches the Delaware River at Moore.

A small part of the diabase sill in the Hunterdon County block is found in extreme northeastern Mercer County. Beds belonging to the fanglomerates of northern Hunterdon County do not reach as far south as Mercer County. The basal Triassic exposed near Princeton Junction is a yellow, arkosic conglomerate with sizable quartz pebbles which apparently has been derived from the southeast.

In this report a number of changes have been made in the boundaries of all of the Triassic rocks as shown on earlier maps. All of these changes were made as the result of field checks by staff members of the New Jersey Geological Survey and other geologists working on problems of the Triassic in Mercer

County. The question of formation boundaries is left unresolved for the present. The major difference between the geologic map in this report and the 1950 geologic map of New Jersey is in the areas mapped as argillite or shale. The borders between the two types of rock and between the argillite and the Stockton sandstone may, as the result of later work, be slightly changed. However, the contacts between "formations" have always been described as, and are, transitional so that new exposures, well records or more detailed studies will modify the thickness and precise location of the bands of the various rock types. Each band of argillite shown on the Mercer County map also occurs west of the river in Bucks County (Dorf, 1951, Field Trip #2). In Mercer County each argillite area is topographically high, has a large number of poor wells, and some exposures of argillite rock. The interfingering with shale or sandstone and the lens-like form of the argillite bodies cannot be precisely portrayed on the map (Plate I) at the scale used in this report. In this report, however, each of the belts or bands of argillite shown contains a sufficient thickness of argillite to have an appreciable effect upon local ground water conditions.

Unrepeated by faulting or folding between the southern boundary of the Triassic basin and the Hopewell fault in Mercer County, the Triassic formations have the following approximate stratigraphic thicknesses:

Stockton sandstone	2,500′ – 3,300′
Main band of Lockatong argillite	1,000′ – 1,900′
All other bands of Lockatong argillite	900′ – 1,000′
Brunswick shale (including first or southerly band)	4,350′ – 4,850′
Less an overlap of the 2nd and 3rd bands of Lockatong with the Brunswick shale	500′ – 700′
Total Triassic Sedimentary Section in Mercer County	8,250′ – 10,350′
Palisades or Rocky Hill sill at Mt. Lucas (Princeton)	900′ – 1,300′

In northern Mercer County, the normal stratigraphic sequence is partially repeated north of the Hopewell fault. However, faulting and diabase intrusions in Hunterdon County complicate the geology and, therefore, the ground water conditions so that Mercer County is a better area than most parts of the state to study the difference in ground water conditions between the several Triassic formations.

The areas underlain by Stockton sandstone and Lockatong argillite are relatively small outside of Hunterdon and Mercer Counties. In the other New Jersey counties underlain by Triassic rocks, the Brunswick shale is the predominant rock type. Diabase and Stockton sandstone are found in Hudson and Bergen Counties, but most of the area is served by water companies and well records are relatively scarce.

Although about 90% of the areas in Mercer County underlain by Brunswick shale are found in Hopewell Township, the area of the township is large enough so that the wells completed in the shale may be compared to wells finished in the other Triassic formations. By comparing wells in the Hopewell Township shale areas with wells in Montgomery and Bridgewater Townships in Somerset County, it is possible to compare ground water conditions in a large area of geologically uncomplicated shale with a sizable area of shale which is interbedded with argillite, intruded by diabase and is, geologically, moderately complex.

In this report, wells in the Brunswick shale will be summarized for various areas of Hopewell Township and then compared with compilations of well records in Montgomery Township, and in two structurally different areas of Bridgewater Township. The wells in the Stockton sandstone and the diabase will be compared between townships. This will also be done for the Lockatong argillite, the wells in the several bands, and to a lesser extent wells in the argillite of southern Hunterdon County.

STOCKTON SANDSTONE

The Stockton sandstone is found in two areas of Mercer County. The main area of outcrop extends eastward from the Delaware River through the City of Trenton and the Townships of Ewing, Lawrence, Princeton, and West Windsor. It continues eastward into Plainsboro Township in Middlesex County. The second area lies north of the Hopewell fault where the Stockton sandstone is found on the north side of the fault from a point near Harbourton northeastward into Montgomery Township, Somerset County.

The main area underlain by Stockton sandstone is approximately thirty-five square miles in extent. The Stockton sandstone is exposed along the Delaware River for a distance of approximately three and three-fourths miles starting about one mile north of the Calhoun Street Bridge in Trenton. Along the Millstone River on the eastern border of the county the area underlain by sandstone is only about two and one-half miles wide.

There is reason to believe that in the western part of Mercer County (particularly in the vicinity of Wilburtha) one or more small faults may repeat part of the Stockton sandstone stratigraphic sequence. The Stockton sandstone in Mercer County is some 2,500 to 3,500 feet thick. It lies unconformably upon early Paleozoic and Precambrian rocks in the vicinity of Princeton Junction and Clarksville. The Stockton sandstone is also in fault contact with the underlying pre-Triassic rocks at several places which are buried by Pleistocene or Cretaceous cover. The upper or northern contact of the formation is usually gradational for about two hundred feet into the Lockatong argillite. However, in the vicinity of Ewing, West Trenton, and Scudders Falls there probably is a fault contact between the Stockton sandstone and the Lockatong argillite.

The second or Hopewell Township occurrence of the Stockton sandstone covers an area of a little more than five square miles. It is wedged out south of Harbourton by the Hopewell fault but rapidly widens eastward until it represents a stratigraphic thickness of 500 to 800 feet. Extending eastward into Montgomery Township of Middlesex County, it again is pinched out by the Hopewell fault within about one and one-half miles of the Mercer County line. This area of Stockton sandstone is topographically high forming the southerly slopes of the Hunterdon Plateau north of Hopewell and a high ridge south of Harbourton. The ridge of sandstone is traversed by Stony Brook in a narrow ravine about one mile northwest of Glen Moore. Although the Stockton sandstone, in general, is higher topographically than the Brunswick shale to the south and in places forms the southerly slopes of moderately high ridges, it is not as resistant to erosion as either the diabase intrusives or the Lockatong argillite which lie on either side of the sandstone between Harbourton and Hopewell Borough. As is the case in the main exposure of Stockton sandstone, the Hopewell Township occurrence has a gradational contact of about two hundred feet into the overlying Lockatcong argillite. In the area of this occurrence of the Stockton sandstone, most of the land is devoted to farms and country homes of several acres. There is no industry and there are only three wells which could be classified as industrial wells in the area. Two of these draw water from the fault zone of the Hopewell fault which forms the southern boundary of this area of Stockton sandstone.

In the main Mercer County area of Stockton sandstone there is a great deal of industry along U. S. Highway #1 and the Pennsylvania Railroad in the vicinity of Trenton and Penns Neck. Although there are still a great many areas still devoted to farms in Lawrence, Princeton, and West Windsor Townships, many areas are now or soon will be housing developments with either individual wells or wells supplying water to small water companies. There are some 77 industrial and public water supply wells drawing water from cracks, crevasses, and openings in this main Stockton sandstone area. The industrial wells completed in the Stockton sandstone have minimum yields of between 18 and 30 gallons per minute and average 100 gpm per well. The best well in the Stockton sandstone originally gave 905 gpm on a pump test.

There are some 149 domestic wells drawing water from the Stockton sandstone. Of these, only three give less than 5 gpm. Most domestic Stockton sandstone wells give between 5 and 20 gpm. Most of the wells are to be found in the more sparsely settled areas of Ewing, Lawrence, Princeton, and West Windsor Townships. Most of the more heavily populated areas are served by water companies which draw their water from wells in the Stockton sandstone. A large area underlain by Stockton sandstone is served by the Trenton Water Company which is supplied from the Delaware River, but within this water service area there are a number of small water companies which get their water from sandstone wells.

During World War II the experience of homeowners in the settlement of Penns Neck illustrated the difficulties which may be expected in areas underlain by "hard rock" formations when a major water user suddenly moves into or adjacent to an area already rather densely populated and relying on many individual wells for a water supply. Most domestic wells in the Penns Neck area were around 100 feet deep. A penicillin plant was erected just west of the settlement. Four deep, large capacity wells, which were pumped on a 24-hour basis, were completed in the Stockton sandstone. Very soon after this major industrial use of water started, most of the domestic wells in the settlement went dry. Protests were made without effect and many homeowners deepened their wells. The continued pumping of the formation proved unsatisfactory so that in less than two years the owners were forced to drill an additional well and finally a water supply had to be obtained from the Delaware and Raritan Canal approximately half a mile to the north of the plant site. At the present time only two of these wells are held in a stand-by condition, two have been abandoned, and one was never used. The ground water is no longer being overpumped and has probably returned to its former static level.

STOCKTON FORMATION

DOMESTIC WELLS

Township	No. of Wells	Maximum	Minimum	Average	Median
		YIELD IN GALLONS PER MINUTE			
Hopewell	22	50	1	35	12
Ewing	64	60	5	17	15
Trenton	1	15	..	..	..
Lawrence	33	35	5	15	15
Princeton	11	60	12	26	20
West Windsor	17*	60	6	19	15

* No yield given for one well.

INDUSTRIAL WELLS

Township	No. of Wells	Maximum	Minimum	Average	Median
		YIELD IN GALLONS PER MINUTE			
Hopewell	4	124 (50)	18 (40)	..	..
Ewing	18	207	50	121	110
Trenton	8	602	45	164	121
Lawrence	20	340	30	94	75
Princeton	3	905 (600)	200	..	..
West Windsor	27	700	25	165	100

STOCKTON FORMATION

DOMESTIC WELLS

Township	No. of Wells	Maximum	Minimum	Average	Median
		DEPTH IN FEET BELOW SURFACE			
Hopewell	22	271	52	129	129
Ewing	64	670	22	108	..
Trenton	1	90	..	..	..
Lawrence	33	242	55	100	95
Princeton	11	190	85	140	131
West Windsor	18	188	52	97	85

INDUSTRIAL WELLS

Township	No. of Wells	Maximum	Minimum	Average	Median
		DEPTH IN FEET BELOW SURFACE			
Hopewell	4	362 (251)	159 (243)	..	..
Ewing	18	603	150	274	205
Trenton	8	588	200	351	322
Lawrence	20	402	83	177	164
Princeton	3	583	302 (304)	..	..
West Windsor	27	518	40	269	300

ARGILLITE

About thirty-five square miles (13%) of Mercer County in the four northern townships (Hopewell, Ewing, Lawrence, and Princeton) are underlain by Lockatong argillite. As explained elsewhere in this report, the argillite is a rock type (lithofacies) in the normal Triassic stratigraphic sequence which is interbedded with, and is in part equivalent to, the Brunswick shale. Earlier workers mapped the argillite as a formation, and in this report it is so shown on maps and sections and so treated in the discussion. No attempt will be made here to solve this geologic problem; for simplicity the argillite will be treated as a formation.

On the maps and sections wherever there is a sufficient stratigraphic thickness of argillite beds to have an effect upon the ground water conditions, it has been shown as a formation. Within the areas mapped as argillite there are shale beds, small faults, and structures which cause some argillite wells to be better than average.

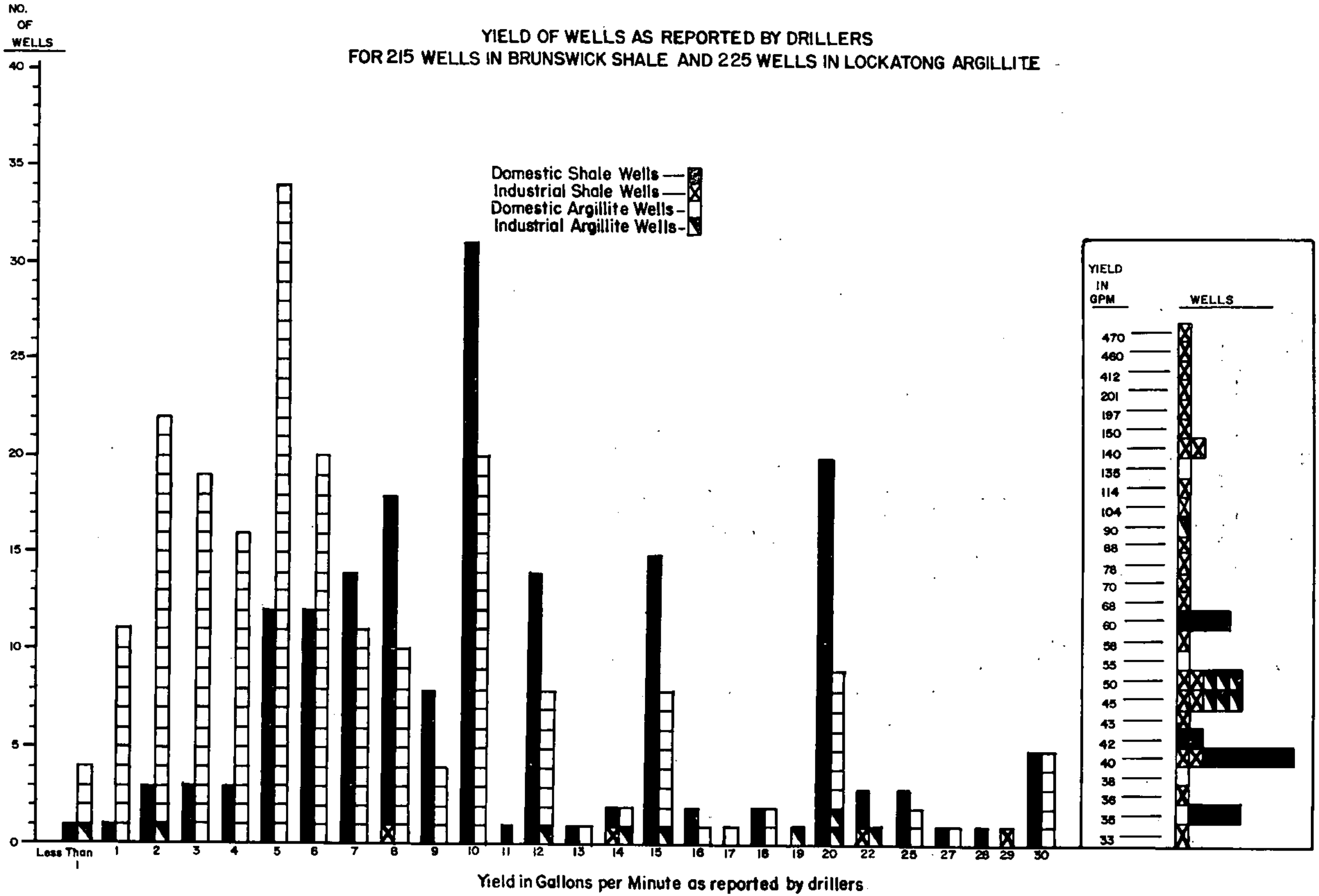
Within areas shown as shale, there may be occasional beds of argillite of limited extent. There will be a slightly reduced ground water potential and expectation for a number of homes or for a small housing development in such areas. However, while this may cause an individual problem, the effect will not be enough to warrant modification of the average values for wells in shale. Most contacts between the argillite and the Brunswick shale or Stockton sandstone are gradational with alternating beds of different lithology over a hundred feet or more of stratigraphic thickness. This transition can be most effectively observed in the road cut of Washington Road just north of Lake Carnegie as one approaches Princeton from the south. It is less obvious but can be observed in the pattern of surface outcroppings along Route #569 northward from Route #206 to Elm Ridge Road. This transitional contact has been recognized and reported by drillers in at least six well records located along the contacts shown on the map. These wells in the alternating transition beds of argillite and sandstone or argillite and shale, more often than not, are slightly better than the average yield for wells in either formation.

On the geologic map of the state and in some of the earlier works the Lockatong argillite is shown as a single formation between the Stockton sandstone and the Brunswick shale in Ewing, Lawrence, and Princeton Townships. More recent work by Van Houten (1962) and McLaughlin (1959) supplemented by field reconnaissance for this report suggests that the area previously mapped as argillite consists of a main area of massive argillite some 1,000 to 1,900 feet thick, a shale zone 400 to 600 feet thick (shown as Brunswick) and a second continuous but thinner (300 to 400 feet) argillite band. Where this argillite band is found in Princeton Township, it has, on occasion, been mapped and described as metamorphosed Brunswick shale because of its proximity to the Rocky Hill diabase intrusive. In the county tabulation of depth and yield, the two bands of argillite and all other occurrences are discussed as a single lithologic unit.

In addition to the two bands of argillite extending eastward from the Delaware River into Princeton Township, there are other areas in Hopewell Township underlain by argillite. The largest of these areas is in northern Hopewell Township and in adjacent West Amwell and East Amwell of Hunterdon County. Its southern border is the Hopewell fault as far east as Harbourton where it is conformably above Stockton sandstone. In central Hopewell Township, there are two belts of argillite extending eastward from the Delaware River to the vicinity of Pennington and to the vicinity of Glen Moore. The area underlain by argillite represents several hundred feet of stratigraphic thickness of argillite interbedded with very minor amounts of shale. Each of these separate areas of argillite has been analyzed in the Hopewell Township discussion, but all 116 wells drawing water from argillite in Hopewell Township are treated as a single unit.

Since the argillite is more of a ridge-former than the shale or sandstone, the areas underlain by argillite have proved to be attractive for residential development—generally with large expensive houses on fairly large lots. Except for the area of Princeton Borough which is served by a water company with wells outside the argillite area, there are no dense concentrations of people in the argillite area. West of Mercer County Airport over to the Delaware River south of Jacobs Creek and north of Scudders Falls, there are several realty developments which, up to the present time, have depended upon individual wells and septic tanks. There are similar concentrations of individual homes on moderate-size lots in Hopewell Township north of Ewingville and in argillite areas north of the village of Lawrenceville. Water problems in these areas are discussed in the Princeton, Lawrence, and Hopewell Township discussions.

The concentration of housing in argillite areas along the Delaware River in Ewing Township south of Jacobs Creek deserves particular attention. Approximately thirty of the Ewing Township domestic wells are found in this area. With two notable exceptions which may fortuitously be located on a minor fault, the wells are notably unsatisfactory, giving an average and a median which is just acceptable as a minimum requirement. In this area most of the home sites are on one to one-and-one-half acre lots. Over the years we have been asked to advise on problems of pollution, on where to locate a second well, and on what to do about sudden diversion of water from an existing well because a new well has been drilled next door. We also have one instance in which there was actual highjacking of a domestic water supply during a drought period. In this instance a neighbor wishing to fill his children's wading pool attached his hose to another neighbor's outside faucet, believing the neighbor would not be home until five o'clock. The neighbor arrived home early and, of course, was irate. Later in the evening when an attempt was made to do some laundry the domestic water supply had been so depleted in filling the wading pool that red silt was pumped into the washing machine.



NOTE: Due to a lack of space, the yield in gallons per minute of the better wells is continued in the vertical column to the right.

With respect to the other deficiencies of domestic wells drawing from the argillite, there are three or four domestic water systems in the area of discussion which because of pollution require chlorinators and probably nearly a dozen others which either should have them or will eventually be forced to install them. The writer has advised as to the location of a second well on at least three occasions in the area for homes where the original well was insufficient to meet domestic needs. In the last instance mentioned above, one of the home owners who was an early settler in the area had a very satisfactory well giving 10 gpm from 116 feet. Some twelve years after his home was built a new home was erected (in 1958) on the lot next door. The lots in this area were approximately one acre in size. The new neighbor did not get water until his well reached 628 feet at which time he secured 10 gpm and the original older well immediately went dry.

In an analysis of 225 argillite wells and 215 shale wells (both domestic and industrial) in Mercer County, we find that 33% of the argillite wells gave 4 gpm or less and may, therefore, be considered inadequate. Two of these wells were industrial wells. In contrast, only 5% of the shale wells gave 4 gpm or less and none of these were industrial wells. The comparison also shows that the lowest 10% of the argillite wells gave 2 gpm or less, whereas half of the lowest 10% of shale wells gave 5 gpm which is a minimum adequate supply. The lowest 50% of the argillite wells gave 6 gpm or less, whereas the lowest 50% of the shale wells gave 11 gpm or less.

Of the industrial wells drilled in argillite, half gave 20 gpm or less and the other half, with two exceptions, gave between 20 and 50 gpm. One domestic argillite well gave 135 gpm. In contrast, of the 30 industrial wells drilled in shale only three gave less than 20 gpm, while half gave in excess of 50 gpm with 5 giving 200 gpm or over.

Since only occasional argillite wells give more than 20 gpm, an effort was made to determine whether or not there was any geologic control over the better argillite wells. No certain pattern was developed, but four argillite wells giving 20 to 30 gpm in the vicinity of Woodsville were located close to a linear topographic feature which is not parallel to the strike of the argillite. In the previously described Mercer Airport and Ewing Township residential concentration to the west, nine argillite wells (including four industrial wells) were much better than average, giving from 20 to 90 gpm. Several of these wells are found to be on linear features and one giving 90 gpm is close to the contact between the Stockton sandstone and the Lockatong argillite which in this area is almost certainly a fault contact. The position of the other argillite wells giving more than 20 gpm suggests that the satisfactory argillite wells are dependent upon minor faults, major joints, and perhaps lenses of interbedded shale, all of which will result in more frequent, more open, and more closely spaced fractures than can be found in the normal argillite.

LOCKATONG ARGILLITE

DOMESTIC WELLS — *YIELD IN GALLONS PER MINUTE*

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hopewell	115*	35	¾	7	5
Ewing	35	20	1	5	5
Lawrence	32	30	2	10	7
Princeton	26	55	⅕	8**	6

* One well 135 gpm from 116′ not included.

** Average of 25 wells without 55 gpm wells is 6 gpm.
One-third of wells give 3 gpm or less.

INDUSTRIAL WELLS — *YIELD IN GALLONS PER MINUTE*

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hopewell	4	50	½	29	..
Ewing	4	90	12	39*	..
Lawrence	6	50	2	25	..
Princeton	2	50	38	..	..

* Average of three wells 23 gpm.

LOCKATONG ARGILLITE

DOMESTIC WELLS		*DEPTH IN FEET BELOW SURFACE*			
Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hopewell	116	400	48	153	130
Ewing	35	798	62	159	123
Lawrence	32	350	50	147	125
Princeton	26	610	77	218	175

INDUSTRIAL WELLS		*DEPTH IN FEET BELOW SURFACE*			
Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hopewell	4	413	120	241	..
Ewing	4	436	123	298	..
Lawrence	6	327	208	256	250
Princeton	2	300	85	..	..

BRUNSWICK SHALE

Most of the Brunswick shale is a very fine-grained, thin-bedded, bright red, argillaceous shale which will quickly weather into thin flakes or flat angular fragments and eventually into a soft, sticky, red mud. Some siltstones and occasional beds of black, gray, greenish or bluish shales are found. Adjacent to the diabase intrusions the shale is a uniform, gray weathering, hard hornfels. In the older reports, such as the Raritan Folio and Bulletin #50, lithologic characteristics found in the argillite are also attributed to the Brunswick shale. In studies by McLaughlin, the Brunswick formation is mapped and described as containing red and dark gray argillite members and the Lockatong formation is mapped and described as including some red shales.

Older descriptions of the Brunswick formation mention abundant plant fossils as being found, but these may properly belong to the interbedded argillites. Dinosaur footprints and some skeletal material from vertebrates have been found in the shale beds of the Brunswick formation. Fossils, however, are extremely rare in the shales as are distinctive minor structures such as bedding, ripple marks, mud cracks, and rain drop impressions. All are described as belonging to the shales of the Brunswick formation, but more recent work suggests that most of these would seem to be more commonly found in the argillite beds.

Areas underlain by shale are topographically low. Outcroppings decompose rapidly to a slumped bank of mud and fragments. Fresh red argillite and red shale are at first glance easily confused, as many a homeowner who sought to use slabs of rock excavated from his basement for a garden wall has found to his sorrow. In from two to four years the pieces of shale or siltstone will crumble to a mass of small fragments. Areas of heavy red clay soil without exposures of rock are apt to be areas underlain by shale. Outcroppings are more frequently argillite or sandstone. The depth to which the shale is weathered depends not only upon the slope, but also upon the presence or absence of Pleistocene surficial deposits. In general, the Brunswick shale will be easily broken up to depths of seven to ten feet where land slope is not a factor. In well drilling, twenty to thirty feet of casing is in order most of the time. Cuttings will produce a sticky mud to a considerable depth and may "mud-off" small amounts of water in cracks near the surface. Drillers become more hopeful of water when harder beds are hit or when "white spots" appear. These "white spots" would seem to be calcite in shale or analcime in the interbedded argillite.

Nearly ninety percent of the area underlain by shale in Mercer County is to be found in Hopewell Township. Within Hopewell Township, shale underlies slightly more than fifty percent of the total area and all of this, except two or three square miles in the southern part of the township and less than a square mile west of Woodsville, is found beneath the lower ground through the central part of the township from the Delaware River northeastward to Pennington, Hopewell, and beyond into Montgomery Township. From the point of view of area and the availability of well records, ground water conditions in the Brunswick shale of Hopewell Township are the ground water conditions to be found in this formation in Mercer County.

The Brunswick shale, for all practical purposes, is an impermeable rock. Water is derived from cracks and fissures whether they be joints, bedding planes, or faults. The more frequent and open the joints, the more severe the faulting with related shattering of the rock, or the more variation between hard or competent beds and soft or less competent beds in slightly folded rocks, the greater the probability of being able to drill and bring in successful wells with higher than average yields. On the other hand, intrusion by diabase with its accompanying baking and metamorphism, interbedding with appreciable thicknesses of argillite, or folding or other deformation of less competent shales between thick bands of competent strata may reduce, seal, or otherwise eliminate the number or openness of cracks and fissures in the rock and thereby reduce the reasonable expectations of the quantity of ground water which may be secured from wells.

All of these varying conditions are illustrated in the three areas of Brunswick shale found in Hopewell Township. There are no wells in the small area of shale in Hopewell Township west of Woodsville on the northern border of Mercer County. Stratigraphically above a thick argillite zone, it is intruded by diabase on the north in East and West Amwell Township in Hunterdon County and is, in part, baked by the intrusion. It is also a relatively narrow belt of shale between two broad bands of more competent rock. Seven available well records in West Amwell Township indicate yields of from 2½ gpm to 9 gpm with an average and median yield of 4 gpm. Depths range from 108′ to 200′ with an average depth of 135′. Although the depths of the wells are about average or slightly less than in Hopewell Township and Mercer County, the reported yields are all very low and with an average and median yield of less than half of what may normally be expected.

The second area underlain by the Brunswick shale in Mercer County is chiefly in southern Hopewell Township. It extends as a narrow belt of shale between two much thicker bands of argillite from the Delaware River northeastward through the northern tip of Lawrence Township into Princeton Township and continues into Somerset County just north of the village of Kingston. Two domestic wells in Lawrence Township, eight in Princeton Township, and twenty in Hopewell Township tap water-bearing fissures in this belt of shale. Also found in this band of shale are three of the Hopewell Township industrial wells and the five industrial wells in shale in Princeton Township. The domestic wells are all average and conform to the over-all pattern in every way except that a slightly higher number of minimum producers giving around 5 gpm are offset by few wells giving 15 gpm or more. The three industrial wells in the Bristol-Myers tract in Hopewell Township and the five industrial Princeton Township wells include seven of the top ten yields for industrial wells in shale in the county. All are eight inches in diameter or larger and have a range in depth rather evenly distributed from the third shallowest to the deepest but one.

The better-than-average yield for the industrial wells in this belt of shale may be accounted for by two conditions as compared to the other industrial wells in shale in Mercer County. All have been drilled in the last ten years and at least five were located by geologists using their knowledge of local structural conditions to try to make the wells intercept major joints or minor faults.

Of the domestic wells in this belt of Brunswick shale, 13 (#250 - #262) were drilled during 1960, 1961, and 1962 for a realty development in Hopewell Township on the Lawrenceville Road in an area about 500 - 700 feet north and stratigraphically above the approximate top or northern contact of the main band of argillite. Of these wells, nine are from 75′ to 125′ deep and are reported as giving 20 gpm from 75′, 16 gpm from 98′, 12 gpm from 106′, 25 gpm from 115′, 5½ gpm from 123′, and notice, 8 gpm from 124′, on two occasions, and 5 gpm from 125′. The remaining four wells are the poorest in the group and all are in excess of 183′ deep, giving 4 gpm from 183′ and from three wells, each 225′ deep, 3½, 2½, and 5 gpm. The yields, depths and location relationships suggest that the wells over 125′ deep are completed in the underlying argillite.

A similar local geologic relationship is found in the case of wells #267 - #288 for a Washington Hills Development on the Pennington-Titusville Road. Even discounting over-optimistic reports of yields from the particular driller who constructed most of the wells, all are adequate from the 10 gpm at 142′ down to 60 gpm at 240′. With three exceptions, the 17 wells in this depth range give in excess of 10 gpm; the three exceptions give 7 gpm from 160′ and 175′ and 9 gpm from 175′. In this group the three largest producers reported are 60 gpm from 240′, 42 gpm from 175′ and 40 gpm from 215′. However, of the five deepest wells, four drilled to a depth of 250′ give 8, 7, 15, and 1½ gpm; and one drilled to 257′ is reported as giving 2 gpm. Again, in this instance, the wells have been drilled just north of an argillite band which forms a prominent ridge extending eastward from the Delaware River for about two miles to Jacobs Creek and then as a less distinct ridge eastward beyond Jacobs Creek to the high ground northwest of Pennington, suggesting that the deeper wells with low yields were completed in argillite.

The remaining 134 domestic wells and 20 industrial wells in Hopewell Township are scattered throughout the area underlain by shale with the majority sufficiently far away from the upper argillite contacts so that the argillite will not be encountered at any reasonable depth. In western Hopewell Township (west of Route #69), two large diabase intrusions and three bands of argillite, two of which have already been mentioned above, are found dividing the broad belt of Brunswick shale into several smaller areas. East of Pennington and Glen Moore, the argillite bands die out and the shale in the eastern part of the township is only interrupted by the intrusion of the Rocky Hill diabase and the small intrusive plug of diabase near Glen Moore.

Included in the 134 wells mentioned above are 28 wells in a development along Dublin Road just west of Pennington. All the wells have been completed in, and the entire tract is underlain by, typical red Brunswick shale. The wells, in depth and yield, are as good as any other group as indicated in the summary of Hopewell Township domestic wells which gives the statistics for the five groups of wells mentioned in this discussion. The well records are all from more reliable drillers and most are from one driller whose reports are known to be reliable. Each house has an individual well and septic tank system. The building lots in the development range in size from one-half to two-thirds acre or slightly more. Although not all wells were considered in the sample, those included cover wells for houses in the first unit built in 1954 and wells completed in 1961. In this eight year period, the depths of the wells in the area have increased from the 134′- 165′ range in 1954 to the 175′- 249′ range of 1961 and reported yields have dropped from an average of 15 gpm in 1954 (6 - 28 gpm range) to a 10 gpm average in 1961. During the summer of 1962 one family in the first section of the development had to deepen their well and a second lowered the intake.

A comparison of the Mercer County shale wells (given at the end of this section), with groups of similar wells in Montgomery Township bordering Mercer County on the northeast and Bridgewater Township further east in Somerset County, shows that, because of the diabase intrusions and more complex structure and stratigraphy, the Mercer County domestic wells are slightly deeper, are spread over a greater range of yields, and have a slightly higher percentage of low yields than is the case with the wells in wide areas of shale uncomplicated by argillite, intrusions of diabase or basaltic lava flows.

The depth and yield figures for wells in the shale of Washington Valley in Bridgewater Township, which lies between the two more competent bands of the Watchung basalts, indicate that the average ground water conditions there are almost identical to those found in the Brunswick shale in Mercer County where the shales are intruded by diabase or are found between bands of argillite.

A comparison of industrial wells in the several shale areas (because of geographic factors, the greater range in diameters, and the smaller size of the sample) is not as significant as a comparison of domestic wells. However, such an industrial well summary is included at the end of this section.

In attempting to solve individual well problems and give reasonable accurate answers as to reasonable expectations of depth and yield, the characteristics of depth and yield reported for the nearest wells are, of course, used when checking against the local subsurface conditions. However, the question often arises as to how large a sample is necessary in order to secure at least some of the best and some of the worst yields. Five wells would not seem to be an adequate sample; ten wells give a general indication of what may be expected. A sample of at least twenty wells would seem to be the minimum size desirable, if the effects of several common variables are to be reduced. In order to come up with reasonable expectations as to maximum, minimum, averages and probabilities, the several compilations seem to indicate that a desirable sample size for any township analysis is in excess of fifty wells. Put in a different way, local variations in any one square mile may seriously affect the results of any statistical summary unless the results are compared against samples of adequate size from other nearby areas. The two tabulations given at the end of this section illustrate some of the problems involved in securing a significant sample of well records.

Because of the large size of the sample of well records used in Hopewell Township, three additional comparisons would seem in order: (1) depth - yield; (2) diameter - yield relationships; (3) percentage of wells in the various yield ranges.

With respect to depth and yield, the twenty-nine industrial wells completed in shale were tabulated in order of depth from the deepest (800′) to the shallowest (150′) with the following results:

Diam. (Inch.)	*Depth (Feet)*	*GPM*	*Diam. (Inch.)*	*Depth (Feet)*	*GPM*
6	800	29	8	512	40
10	708*	140	8	501	33
10	657	45	6	500	43
12	572	88	10	422	470

* The 708′ well got its water at 230′. If this comparison indicates anything, it would seem to be that drilling a well to depths of over 500′ is hardly worthwhile and that drilling to a depth over 200′ is desirable unless a yield of 50 gpm or more has been secured at a lesser depth.

Diam. (Inch.)	Depth (Feet)	GPM	Diam. (Inch.)	Depth (Feet)	GPM
10	407	14	6	228	8
12	403	197	8	201	50
8	400	78	8	188	104
10	393	460	6	186	50
8	300	45	6	183	11
6	300	412	8	179	140
8	300	70	10	178	22
8	300	68	10	178	22
10	273	201	6	159	40
8	250	36	6	150	150
8	230	114			

A tabulation by yield with the diameter of the well given in the second column suggests that 8″ or 10″ diameter wells may be more successful than a 6″ well. Perhaps, however, since it is the size of the fracture that is the governing factor, the large diameter permits a greater yield if the fracture is there in the first place.

Industrial Wells in Hopewell Township
Diameter in Inches Compared to Yield in Gallons Per Minute

Diameter In Inches	10″	8″	6″	10″	8″	6″
	470	..	..	..	..	68
Yield	460	..	..	..	50	50
	..	412	..	45	45	43
In	201	..	..	..	40	40
	*	..	..	38	..	..
Gallons	..	..	150	..	36	..
	140	..	..	..	33	..
Per	..	114	..	..	..	29
	..	104	..	22	..	..
Minute	..	78	..	14	..	..
	..	70	..	..	..	11
				..	..	8

* A 12″ well gave 197 gpm.

Using the reported yield of the 200 industrial and domestic wells in Hopewell Township, we find two-thirds of the industrial wells are in the top 10% of yields. This might be expected. One industrial well, however, is in the lowest 10% of all yields. Twenty percent of the wells give 30 gpm or more and 20% give 7 gpm or less with only 5% giving less than 5 gpm.

BRUNSWICK SHALE

DOMESTIC WELLS — *YIELD IN GALLONS PER MINUTE*

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hopewell	176	60	½	15	10
Princeton	8	30	5	11	8
Lawrence	2	7	5	..	..
All Shale (Mercer Co.)	186	60	½	15	..
Montgomery	43	40	3	13	14
Bridgewater					
a. Washington Valley	95	25	8	12	10
b. South of 1st Watchungs	144	35	2	13	12

INDUSTRIAL WELLS		*YIELD IN GALLONS PER MINUTE*			
Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hopewell	24	412	8	76	50
Princeton	5	470	88	271	197
Lawrence	..	..	..	..	..
All Shale (Mercer Co.)	29	470	8	110	50
Montgomery	15	296	22	100	106
Bridgewater					
a. Washington Valley	4	(50, 50, 30, 20)			
b. South of 1st Watchungs	46	664	32	183	137

NOTE: Montgomery and Bridgewater Townships are in Somerset County.

BRUNSWICK SHALE

DOMESTIC WELLS		*DEPTH IN FEET BELOW SURFACE*			
Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hopewell	176	397	45	154	145
Princeton	8	350	98	210	181
Lawrence	..	204	131	..	..
All Shale (Mercer Co.)	156	397	45	156	..
Montgomery	43	251	90	146	139
Bridgewater					
a. Washington Valley	95	205	84	131	130
b. South of 1st Watchungs	144	300	77	135	152

INDUSTRIAL WELLS		*DEPTH IN FEET BELOW SURFACE*			
Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hopewell	23	800 (708)	150	283*	300
Princeton	5	572	179	394	403
Lawrence	..	..	..	..	..
All Shale (Mercer Co.)	..	800	150	349	300
Montgomery	16	532	100	290	303
Bridgewater					
a. Washington Valley	4	(350, 300, 300, 165)			
b. South of 1st Watchungs	47	707	128	343	310

NOTE: Montgomery and Bridgewater Townships are in Somerset County.
* Well 800′ deep not included.

DIABASE

Six intrusions of diabase are found in the northern part of Mercer County in Hopewell Township; only one, the westward continuation of the Rocky Hill or Palisades sill, is found outside Hopewell Township in adjacent Princeton Township. Approximately twelve square miles of Mercer County is underlain by diabase. The diabase areas are usually wooded and, topographically, noticeably above the surrounding countryside. For the last several years in Princeton Township and where the diabase is crossed by roads in Hopewell Township, there has been considerable home building. Ground water conditions in diabase areas are such that wells are frequently inadequate; septic tanks often break out and occasionally wells become contaminated a few years after initial construction.

There are no industrial wells drilled in diabase in Mercer County or in adjacent townships to the north or east. Records were examined for fifty-five Mercer County domestic wells that were completed in diabase. There are no wells in the most westerly diabase plug at the Mercer County Work House. Eleven wells (about a third of the homes) were checked on Baldpate Mountain. Records were used for seven wells on Pennington Mountain and in the small plug at Moore. Twenty wells in Princeton Township and eleven wells in Hopewell Township were completed in the diabase sill.

The largest area underlain by diabase is the Rocky Hill sill found in Princeton Township and in northeastern Hopewell Township. The sill has an outcrop area nearly a mile wide and a low angle (14°) northerly dip in the Mt. Lucas area of Princeton Township. West of Province Line Road and in Hopewell Township the dip steepens and the diabase cross-cuts the shale, becoming a dike from Mt. Rose westward. The intrusion is abruptly terminated by the Hopewell fault. In Hopewell Township all homes in the area underlain by diabase rely on their own wells, in Princeton Township a considerable area of the ridge is served by the Princeton Water Company.

In the northern tip of Mercer County, north of Hopewell, there is an outcrop area of the Sourland Mountain sill which is also found in adjacent East and West Amwell Townships in Hunterdon County and Montgomery Township in Somerset County. Records from five wells completed in this diabase mass in Hopewell Township are included in the summary. In Montgomery Township to the east, there are no well records from the diabase. In East Amwell Township, this diabase sill is found both to the north and east and to the west of the outcrop area in Hopewell Township. The entire area is sparsely settled and heavily wooded. In the summary of diabase wells, seven wells from East Amwell Township and ten wells from West Amwell Township (most in the vicinity of Lambertville) completed in this Sourland Mountain sill are included, for comparative purposes.

It is believed high-cost-per-foot for wells drilled in diabase influences the statistical picture. The cost-per-foot, when a cable tool rig is used for a well in diabase, is two or three times the cost-per-foot for a well drilled in shale. Many drillers will only give an hourly rate for diabase drilling and the cost-per-foot in several instances has been unbelievably high. Rotary rigs are faster and seemingly cheaper when used in diabase. Because of this, the well in diabase is apt to be drilled much deeper than any well drilled with a cable tool rig. The homeowner, therefore, does two things when contracting for a well in diabase: First he is willing to accept a smaller amount of water, and second, he will accept the first water found. If his well were drilled with a cable tool rig, he may give up before water is found, even at a relatively shallow depth, because of the high cost of drilling. On the other hand, with the rotary rig the tendency to go deeper to try to get more water is increased. Where the well record shows no water or very little water, the homeowner may already have, or may construct a large diameter hand-dug shallow well. He will rely on his neighbors for water in the late summer and at a later date he may again contract for a drilled well. A drilled well, which will not go dry in the summer and the hope for a yield which will permit him to be less saving in his use of water is the goal of each homeowner living in an area underlain by diabase.

In view of the above, it should be noted that while the range in depth and yield for domestic diabase wells is much the same as for domestic wells drilled in the argillite areas, the average and median depth of diabase wells is less than the shale wells—apparently because of the above mentioned attitude of the homeowner. The difference in depth would be greater if the usually-much-deeper rotary holes were not included in the average.

The probabilities of securing large amounts of water from wells drilled in diabase are slim indeed. If the well intersects a fault or a large open joint, 100 gpm more may be obtained, but only 10% of the diabase wells give in excess of 10 gpm in contrast to 60% of the shale wells giving 10 gpm or more.

There are no industrial wells in diabase in Mercer County or in the two townships in Hunterdon County used in this summary.

DOMESTIC WELLS — *YIELD IN GALLONS PER MINUTE*

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hopewell	35	27	½	8	6
Princeton	20	100	0	16*	4**
East Amwell (Hunterdon)	7	5	¼	2½	2
West Amwell (Hunterdon)	10	15	0	4	1
For comparison:					
Brunswick Shale (Hopewell)	176	60	½	15	10

* Average of 18 wells without 100 gpm and 60 gpm wells is 6 gpm.
** One-half of the wells give less than 4 gpm.

DOMESTIC WELLS		*DEPTH IN FEET BELOW SURFACE*			
Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Hopewell	35	404	50	128	100
Princeton	20	338	50	139	108
East Amwell (Hunterdon)	7	351	42	116	..
West Amwell (Hunterdon)	10	200	48	95	90
For comparison:					
Brunswick Shale (Hopewell)	176	397	45	154	145

Median and average yields are about half as good in diabase as they are in the Brunswick shale. In diabase 40% - 50% of the domestic wells are inadequate (less than 5 gpm) in contrast to 5% for such wells in shale.

TOPOGRAPHIC EXPRESSION OF MINOR GEOLOGIC STRUCTURES

Faults, joints, and stratigraphic variations often show as linear topographic features in areas when surficial cover is thin or the depth of weathering is shallow. In the areas of northern Mercer County underlain by the Brunswick shale, argillite, diabase, and in some of the area underlain by Stockton sandstone, bedrock is sufficiently close to the surface so that linear topographic features giving surface expression to the underlying geologic conditions are nearly always present. In southern Ewing, Lawrence, and Princeton Townships thick deposits of Pennsauken or "Trenton" gravels conceal these features on the bedrock surface. In southern Mercer County the Pleistocene and Cretaceous sediments are capable of producing sufficient water so that the detailed structures of the underlying crystalline rocks are only of academic interest.

In the solution of several problems for industrial or municipal water supplies in the northern part of Mercer County, efforts were made to locate the wells along and in these linear features as indicated by intermittent streams, swales, or other alignments of topographic features. The mile-to-the-inch State Atlas sheets, the 1:24,000 Federal quadrangle sheets, aerial photographs, and field visits have been utilized in locating specific wells along linear features. There has been sufficient success in the actual practice to suggest that this is a valuable way of locating wells in areas where the bedrock is not concealed by surficial deposits, deep weathering or Coastal Plain sediments. Recent work with aerial photographs suggests that, even with a thick cover of unconsolidated materials, major features of the underlying bedrock may be reflected at the surface.

In order to test the significance of linear features, ninety-one of the best wells and twenty-eight of unusually poor wells were plotted on an overlay for the mile-to-the-inch topographic map in northern Mercer County. A geologist who had not worked on the well problems prepared a second overlay showing the linear features in the same area as indicated by the topographic map. The overlay of linear features was then placed on the overlay of the wells. The number of wells that were on or within the zone of influence of the linear features were counted. A well more than an eighth of a mile off of the linear features was considered as one which would not be affected by the linear, whatever its nature. It is believed the results obtained are significant. Of 15 industrial wells which were exceptionally good, 13 or 87% were found to be located on linear features. Of these 15 wells, 8 were in the Stockton sandstone, 3 were in the Lockatong argillite, and 2 were in the Brunswick shale. One of the Brunswick shale wells was on the shale-argillite contact and one of the exceptional argillite wells was not apparently related to any linear topographic feature.

Of the low-yield industrial wells which were considered, only three wells, all in the Brunswick shale, were on the linear features. The remaining ten (four in the Brunswick, ten in the Lockatong, and two in the Stockton) were not related to any linear feature.

Fifty-two of the better domestic wells out of 76 considered, or 68%, fell within the area of the linear features. Six were on or close to geologic contacts between the Brunswick shale and the Lockatong argillite. Only 18 of the better wells (nine in the Brunswick, five in the Lockatong, and four in the Stockton) were not found to be related to any linear feature. Twenty-six out of twenty-nine poor domestic wells were found to be unrelated to linear features. Only three (two in the Brunswick and one in the Lockatong) were found to be on or in the specified zone of influence of the linear features. Considering all of the domestic wells, ninety-five percent of the domestic wells on linear features are much better than average.

The major faults in northern Mercer County are marked by abrupt topographic changes or by deeply incised valleys. In Hopewell Township wells #61 and #62, with exceptionally high yields, drilled for the Hopewell Borough Water Company (see Hopewell Township discussion) and #164, #172 and #173 drilled for the Pennington Quarry Company and Pennington Borough with moderate yields have been completed in fault zones with marked topographic expression. Four of the better argillite wells in Hopewell Township, #117, #188, #189 and #361 (yields of 30, 30, 27, and 20 gpm respectively), are in such alignment and so located that a fault or major joint without topographic expression may be suspected. Ewing well #89 for State Police Headquarters is in a fault zone without topographic expression as shown by the well cuttings which contained fault gouge and calcite vein filling. The yield is exceptionally good.

The surface expression of major joints or closely spaced joints is more frequent than is generally realized. Swales on the ground, parallel darker lines on aerial photos, and the alignment of streams or swales across one or more ridges are indicators of major joints or concentrations of joints that have been utilized to locate better than average wells. In this group are wells #95 and #100 for Bristol-Myers in Hopewell Township, wells #175 and #179 for Pennington Borough (Hopewell Township summary), #207 and #209 for Western Electric (Hopewell Township), #1 through #4 for Educational Testing Service (Lawrence Township) and other wells which usually have very high yields.

Outcroppings on the west side of Stony Brook near Pennington show closely spaced joints at either end of a half mile section. Wells #179 and #156 to #161 are parallel to this bank in the order given starting with #179 at the north end. In the same order the wells give 38, 60, 12, 15, 15, 9, and 40 gpm. The largest yields are opposite and in line with the jointing that is most closely spaced.

In contrast to the above, open joints are not always desirable. When the first well for #159 was drilled it intersected an open joint at about 125 feet which was apparently directly connected to Stony Brook. The water was equal to that in the brook in every way—smell, color, turbidity, temperature, and algae. The well was filled with cement and a new well, #159, was drilled at the diagonally opposite corner of the house. The house is about 100 yards west of and some thirty feet higher than Stony Brook.

Two other wells illustrate dramatically the importance of major open joints. Hopewell #177 was located near the center of a topographic block bordered by pronounced swales and minor streams. The ten-inch well for the Pennington Water Company was abandoned at 407 feet depth when it only gave 14 gpm. The case of Ewing #4, a 568-foot-deep well, is described in the argillite discussion. Here the same joint utilized by an earlier well at a lesser depth was tapped and drained by the deeper well when it reached its full depth.

In Hopewell Township the alternation of thicknesses of argillite and shale in the stratigraphic column give the topography a ribbed appearance with ridges parallel to the strike of the formations. A number of linear topographic features are therefore due to a change in the type of rock and follow the geologic contacts. Hopewell wells #15, #162, #52, #90 and #40 are all in the top third of the sandstone yields; each of these wells is in the transition zone from sandstone into argillite and in many instances the drillers have reported this variation as "hard and soft" rock layers. The importance of the change in geologic formations and the way in which it seems to affect the yield of wells is illustrated and discussed with respect to two housing developments in Hopewell Township. The deeper wells completed in argillite are notably poorer than the shallower wells completed in shale.

Folding is slight in the formations of northern Mercer County. Most of the strata have a monoclinal dip to the northwest. While it may be presumed that folds have an effect on ground water they would seem to be unimportant in this area.

Diabase intrusions, as a sill and as plugs, form several "mountains" or "ridges" in northern Mercer County. The bordering shales and argillites are usually metamorphosed and give less water than normal unless unaltered shale can be reached below the sill. Hopewell #208 for Western Electric near the Rocky Hill sill was driven deeper than would normally be expected until it penetrated the underlying less metamorphosed shale. The effect of jointing within the plugs is discussed in the Diabase section. At a number of places better than usual diabase wells can be correlated with topographic lows which seem to mark faults in the diabase ridge. Princeton #1, the best of all diabase wells, apparently is either unrelated to geologic structure or is a well crossing a bedding plane fault along a formation contact.

Experience of the staff of the New Jersey Survey seems to indicate beyond all doubt that careful attention to the minor geologic structures in an area "pays off" when used in locating wells. Small yields can often be secured in difficult areas and larger yields at lesser depths seem to be more probable when topography is used to indicate the more important local geologic structures.

COASTAL PLAIN FORMATIONS

The southern 40% of Mercer County, some 92 square miles, is within the New Jersey section of the Coastal Plain Physiographic Province. The Coastal Plain contains Upper Cretaceous and Tertiary sediments which dip toward the ocean from an inner margin along a line which nearly coincides with that of the Pennsylvania Railroad from Trenton to east of Princeton Junction.

Six of the eleven Cretaceous formations of the Coastal Plain underlie Mercer County although exposures are found only along the steep banks of major streams where the drainage is incised into the very flat Coastal Plain topography. Nearly all of southern Mercer County is covered by Pleistocene sands and gravels which have filled all the pre-Pleistocene and early Pleistocene valleys which were cut in the Cretaceous formations. The Pleistocene sediments have effectively buried the Cretaceous formations, except as noted above, as far south as the area underlain by the Englishtown formation in extreme southern Mercer County.

The lower-most Cretaceous formation, the Raritan, rests unconformably on a surface of low relief composed of Precambrian, early Paleozoic, and Triassic rocks. Wells indicate that this surface of older rocks has a relief of nearly two hundred feet. The Raritan formation consists predominately of light colored sands and clays which vary rapidly in color, sorting, and grain size, both vertically and horizontally, throughout their thickness. Disconformably above the Raritan, and in wells extremely difficult to differentiate, is the Magothy formation which is from 25 - 125 feet of fine white sands and clays characterized by mica and carbonized wood. The sands of the Magothy and Raritan formations are so interconnected that the two units act as a single aquifer and are so treated in this report. The overlying Pleistocene sands are part of the same hydrologic unit when they are in contact with the Magothy and Raritan. However, where the Pleistocene sediments are thick they can be distinguished from the Cretaceous sediments. North of the inner and stratigraphically lower margin of the Coastal Plain the Pleistocene sediments overlie crystaline rocks and are frequently thick enough to yield water. The Pleistocene sediments are therefore treated as a separate ground water unit. About twenty-four square miles of Mercer County have the Pleistocene sediments in contact with the underlying Magothy and Raritan formations.

From 70 to over 100 feet of black clays of the Merchantville and of the overlying Woodbury formations are found above the Magothy in a band from two and one-half to three miles wide, extending from Yardville and Crosswicks through Robbinsville and Windsor to and beyond Hightstown. Like the other Cretaceous formations, these clays are covered by Pleistocene sands which may be from 10 to 30 feet thick. Usually wells in this area are completed in the underlying Magothy-Raritan formation.

In extreme southern Mercer County the white to yellow quartz sands of the Englishtown formation lie above the Woodbury clays. Except for about one square mile south of Hightstown the dark gray sandy clays of the Marshalltown formation are found just south of Mercer County overlying the Englishtown sands. The Pleistocene cover becomes thin and patchy over the areas underlain by the Englishtown and Marshalltown formations which were not as deeply eroded in pre-Pleistocene times as the sandy Magothy and Raritan formations to the north.

A few domestic wells have been completed in the Englishtown formation in Mercer County. Even the sand lenses in the Merchantville formation have supplied water to a very few domestic wells. Most domestic wells and all industrial wells in and adjacent to the southern boundary of Mercer County are drilled to depths in excess of 150 feet in order to draw water from the sands of the Magothy or Raritan formations.

Although the Cretaceous formations of the Coastal Plain have been compared to the layers in a cake, the analogy should not be carried further because of the extreme variation of sediments within the water-bearing formations. The aquifers in the above-mentioned layer cake might be considered as "marble cake" in contrast to the solid cake layers of the clay formations.

The assumption of a uniform or average dip or increase in depth toward the ocean for the Coastal Plain formations, while useful, may be misleading when applied too strictly to predicting the depth at which water-bearing sands may be encountered. At three locations industrial wells less than one-quarter mile apart have been completed at depths in the 80 to 100 feet range and in the 250 or 300 feet range. Any attempt to correlate these depth ranges with specific horizons or members such as the Old Bridge or Farrington sands, as has been done in the Raritan formation in the type locality along Raritan Bay in Middlesex County, is without merit or basis in fact. The Farrington, Old Bridge, and other members of the Raritan cannot be identified in western Middlesex County nor in Mercer County. In Mercer County some of the most productive sands are found just above the "basement rock" in the stratigraphic position of Raritan Fire Clay further to the east.

Ground water may be secured in the Coastal Plain section of Mercer County from the Magothy-Raritan, from the Englishtown, and from the Pleistocene formations. Industrial wells most often rely on the Raritan formation, but in the northern part of the Coastal Plain this may have too much clay, be too thin, or be missing so that only Pleistocene or rock wells will be successful.

RARITAN FORMATION

The principal water-bearing sediments south of Trenton, Bakers Basin, Clarksville and Princeton Junction are the sands of the Raritan and Magothy formations. As used in this report, the term "Raritan" includes the overlying Magothy formation.

At times drillers and geologists have attempted to differentiate between the two formations. At times this can be done, but most of the time any such distinction between the two formations is debatable. In a general way if a driller is getting very fine white sand with "charcoal" fragments, he is in the Magothy. In general it would be, and in a number of cases it has been proved to be, a mistake to try to complete an industrial well in the Magothy. Aside from these two generalizations, the two formations are lithologically and hydrologically very similar.

Sections C-C, D-D, E-E and F-F of Plates II and III show the variation in sediments to be found in the Magothy-Raritan along lines nearly perpendicular to the strike of the formations. The section lines are shown on Plate I. Attention is called to the variation in thickness and position of the sands in the lower part of the formation and the rapidity with which the sands and clays lens in and out or interfinger as one moves down dip to the south. At first glance the most easterly section C-C′ would seem to have some similarity to the standard section of Middlesex County except for the addition of an extra sand member at the top of the section. Within three to five miles however, the seven formation members (Section E-E) have been reduced to two with some minor lenses of sand in the clay. Eight miles further to the west sands have replaced clays at the base of the section and there are four main members in the formation.

The full extent of the rapid change in the grain size and character of the Raritan formation can best be appreciated by an examination of Section G-G′-G″ on Plate III. The borings plotted on this section are thirteen of a series of borings made every thousand feet, extending from near Bordentown east to Raritan Bay along the line of a proposed trans-Jersey ship canal. All borings were made by the same company and logged and described by the same geologist. The rapid changes in the character of the sediments are typical of all parts of the section. Most of the bore holes penetrate five or six sedimentary units in the Raritan Formation; however, most of the section for hole B-119 is a single unit of very fine white sand. Hole B-113 is at the other extreme in that there are thirteen changes in the Cretaceous sediments penetrated. Conditions shown on this section help to explain why in the Raritan domestic wells less than 100 feet apart may have a difference of 50 feet in the depth at which the screen is set or why there is such a great variation in yield from nearby wells.

A study of the depth of 164 domestic and industrial wells completed in the Raritan formation indicates that the area underlain by the Raritan formation should be divided into three sub-areas. The first or most northerly sub-area extends southward from the northern or lower contact of the Raritan formation as shown on Plates I and IV and is outlined on Plate V. In this sub-area there are only a few shallow Raritan wells. The formation is either missing, too thin or a clay. North of Edinburgh and around Dutch Neck the basement rocks are within a hundred feet of the surface. The second sub-area starts with this line drawn through the most northerly Raritan wells (from one to four miles south of the Pennsylvania Railroad) and extends as far south as the northern Merchantville contact. Within the second sub-area Raritan wells are usually less than 100 feet deep. Wells over 200 feet deep begin to appear about a mile north of the northern Merchantville contact and are found in the third sub-area which extends to the southern border of Mercer County. Most wells which are approaching 300 feet in depth are south of Route 130.

Most Raritan wells in southern Mercer County are 250 feet or more in depth because of the overlying clay formation. Near Hightstown domestic Raritan wells a half mile apart on a line roughly parallel to the strike have been completed at 60 feet and at 317 feet. The latter well was drilled deeper to get a better quality water with less iron. Close to the Delaware River in the southern part of Trenton, wells for Trenton Brewing Company have been completed in the Raritan, which here fills a pre-Cretaceous Delaware River Valley, at several depths from 80 feet to and including 280 feet. Domestic wells can at times be completed near the top of the Magothy formation, but industrial wells are usually completed in, and give more water from, the lower sands of the Raritan. In southern Mercer County there are many areas where the Raritan formation is thick enough to have good water-bearing sands for large yield industrial wells at two or more horizons. These lower horizons are, at present, not always needed or used for industrial development.

It is nearly certain that an adequate domestic well can be constructed in the Raritan once it has attained a stratigraphic thickness of about 100 feet. Industrial wells are more successful where the formation is nearer 200 feet thick. Only one-sixth of the industrial wells are 100 feet or less in depth.

With respect to yield, nearly one-third of the industrial wells are reported as giving in excess of 400 gpm when first tested and another quarter of the industrial wells give between 200 gpm and 400 gpm. If started with a sufficiently large diameter, ten inches or more, a properly constructed industrial well may reasonably be expected to give at least 500 gpm. Efforts, however, to increase the first large yield by sustained development and surging have resulted in the complete collapse of at least two industrial wells. Large yields may be obtained by using long screens in thick sections of fine-grained sands or by the more usual construction which uses a shorter screen in a coarse sand or gravel sought and found at a greater depth. If the best well is to be constructed for the least money, the rapid variation in the sedimentary character of the Raritan formation will require the driller and owner to keep an open mind and a flexible set of specifications until the well has been completed.

Merchantville Clay

The Merchantville is a black glauconitic micaceous clay from 50 to 60 feet thick which rests disconformably on the Magothy. Three domestic wells, East Windsor #22 and two wells outside Mercer County (Raritan #10 and #15), are reported as having been completed in this formation, probably at or near its lower contact.

Woodbury Clay

The Woodbury clay is also black and about 50 feet thick, but it is a non-glauconitic clay. It is conformable with the Merchantville below and the Englishtown above. No wells are reported as drawing from this formation.

Englishtown Formation

Along the southern border of Mercer County the white-to-yellow quartz sands of the Englishtown formation underlie patches of Pleistocene sands and gravels or are exposed at the surface. The formation has a thickness of about 120 feet in Mercer County. East of the extreme southern tip of the county domestic wells with yields from 5 to 60 gpm have been completed in the Englishtown. Elsewhere industrial wells give up to 250 gpm. The lack of industrial wells in the area covered in this report reflects the rural land use rather than an inability of the formation to supply water.

Marshalltown Formation

The Englishtown sands are capped by the dark sandy clays of the Marshalltown formation which is not known to supply water to any wells. Less than a square mile of the Marshalltown formation is found in Mercer County; most of the formation is found to the south.

RARITAN FORMATION

DOMESTIC WELLS

Township	*No. of Wells*	*YIELD IN GALLONS PER MINUTE* *Maximum*	*Minimum*	*Average*	*Median*
Hamilton	44	47	7	15	15
West Windsor	15	50	5	19	15
Washington	24	55	7	24	23
East Windsor	24	60	3	19	15
Kmr south of Mercer County	13	80	7½	32	30
Englishtown formation	15	60	5	19	12

NOTE: No domestic wells in Trenton.

INDUSTRIAL WELLS

Township	*No. of Wells*	*YIELD IN GALLONS PER MINUTE* *Maximum*	*Minimum*	*Average*	*Median*
Trenton	11	1,040	60	383	350
Hamilton	27	700	35	246	200
West Windsor	2	520	335	..	..
Washington	3	260	40 (60)	..	..
East Windsor	14	1,500	55	470	363
Kmr south of Mercer County	12	580	40	361	503

NOTE: No industrial wells in Englishtown Formation.

RARITAN FORMATION

DOMESTIC WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		DEPTH IN FEET BELOW SURFACE			
Hamilton	44	317 (304)	55	115	100
West Windsor	15	205	55	103	92
Washington	24	248*	82	163	129
East Windsor	24	315	70	175	181
Kmr south of Mercer County	13	456	76	230	200
Englishtown formation	15	212	35	118	134

NOTE: No domestic wells in Trenton.

* Does not include Washington #31, a test well driven to 365 feet and abandoned.

INDUSTRIAL WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		DEPTH IN FEET BELOW SURFACE			
Trenton	11	280	80	150	117
Hamilton	27	334	67	194	220
West Windsor	2	100	90	..	..
Washington	3	310	218 (230)	..	..
East Windsor	14	280	137	213	216
Kmr south of Mercer County	12	537	73	268	358

NOTE: No industrial wells in Englishtown Formation.

PLEISTOCENE DEPOSITS

At least forty-seven wells in Mercer County draw from Pleistocene sands and gravels. Nearly half of these wells are in or near Trenton and have been completed in the "Trenton gravels" or, as it is shown on the State Geologic Map, the "stratified drift." Most of the remaining wells are found to the east around Clarksville and Dutch Neck with a scattering of wells in the Coastal Plain from White Horse to Hightstown. These wells probably draw water from the Pennsauken formation, but one or two wells may draw from deposits mapped as belonging to the Cape May formation.

Pleistocene deposits are shown on the geologic map as covering much of the surfaces of Mercer County to the south of West Trenton, Ewingville, Lawrenceville and Princeton. More recent work by Tedrow and MacClintock indicates that Pleistocene loess deposits cover much of the area underlain by Triassic rocks south of Titusville, Glen Moore, and Hopewell to the northern border of the above-mentioned deposits of Pennsauken gravel. Thus only those parts of Mercer County found above 250 feet in elevation or on the lower slopes of the most recently eroded valleys would seem to be free of Pleistocene deposits. Usually the loess deposits are only two or three feet thick and usually the older water-laid Pleistocene deposits are only ten to fifteen feet thick. Loess deposits may reach a thickness of ten feet while the Pennsauken is known to be over one hundred feet thick in some areas in southern Mercer County.

Most of the descriptions of the Pleistocene deposits are found either in "Glacial Geology," Volume V, or "Surface Deposits," Volume VIII of the Reports of the State Geologist of 1902 and 1916 by Salisbury and others. The present-day concepts of Pleistocene stratigraphy were not fully developed at the time of publication of either of the above works. While multiple glaciations were recognized at the time (1902) of the publication of "Glacial Deposits," Volume V, the Iowan (now considered as a stage of the Wisconsin) was believed to be a pre-Wisconsin glaciation occurring before the Wisconsin. By 1916 the situation was somewhat improved. The three formations, Bridgeton, Pennsauken, and Cape May, into which the whole complex of "yellow gravels" or the "Columbia formation" was divided in "Surface Deposits," Volume VIII, were considered to be fluvial deposits formed during periods of higher sea levels in valleys eroded during the previous time of lower sea levels. In short, the deposits were considered to have formed during the interglacial stages. Sands and gravels most obviously related to the time of the Wisconsin maximum were called "unclassified," "the Trenton gravels" or in later publications "stratified drift." Separation of the several Pleistocene formations was based on lithology, degree of weathering, topographic expression and elevation, or a combination of all of these characteristics. The great difficulty with this method is that in some areas and in some lithologies it is almost impossible to distinguish one or another of the "formations." With our present-day knowledge of Pleistocene events, it would seem that each of the "formations," while they may be primarily interglacial deposits, must also in part be related to the next glacial stage. The problems of correlation and origin have not yet been resolved on a state-wide basis, nor even on a county basis; so it would seem to be more practical, at least from the ground water point of view, to refer to the whole series as "yellow gravels" or "Pleistocene deposits."

From a theoretical point of view some of these deposits, because of their origin or the nature of their sediments, should not be favorable for the occurrence of ground water while others would be most desirable. Thus well sorted gravels deposited by rapidly flowing streams would be much better aquifers than deposits of silt and clay laid down in a sluggish estuary. If such a distinction can be made in a local area as the result of abundant exposures and well logs, it may make considerable difference in the way in which a water development program is carried out in a restricted area. In general, however, this cannot be done.

The Bridgeton so resembles the Pennsauken that they can be treated as a single hydrologic unit, and are considered by some authorities as a single formation. In Mercer County the Cape May formation is supposedly found between the Pennsauken and the "Trenton gravels." Its occurrence, however, as compared to the older Pennsauken and younger "Trenton gravels" or "stratified drift," is so restricted in area and so difficult to determine from well samples that the Cape May formation also can be ignored and treated as a part of the Pennsauken. As indicated earlier, almost as many wells have been completed in the "Trenton gravels" as in the Pennsauken so that the two formations have very similar ground water and geologic characteristics.

Whatever the ultimate division and classification of the various Pleistocene deposits or "yellow gravels" in Mercer County in so far as their origin and classification is concerned, they may be divided into four types of Pleistocene materials: (1) loess; (2) poorly sorted, brown, reddish-brown or almost pink sands, silts, clays and gravel with large boulders; (3) well sorted yellow coarse gravels and sands; and (4) mixed yellow to brown gravels and sands of considerable thickness.

The yellow loess deposits, described by Tedrow and MacClintock, cover large areas along the ridge tops east of the Delaware River from Jacobs Creek northward to Titusville and as far east as Lawrenceville and southwestern Montgomery Township in Somerset County. No wells are completed in this material, but its presence on the surface permits a much more rapid percolation of rainfall than that permitted by the heavy clay soils normally developed on the Brunswick shale, Lockatong argillite, or diabase. It would seem likely that domestic wells drilled in areas with a thick loess cover would have a slightly better yield and higher static level than wells in similar Triassic formations without this cover. No effort was made to evaluate this possible effect.

Poorly sorted brown, reddish-brown, or almost pink sands, silts, clays, and gravels with large boulders are found south of the loess deposits chiefly in Ewing Township, but also in western Lawrence Township and the northern parts of Trenton. Usually shown as belonging to the Pennsauken formation, this group of Pleistocene deposits includes some "stratified drift" or "Trenton gravels," some terrace deposits in Hopewell Township, and some small isolated thin coverings of gravel on hilltops in Princeton Township.

Gravel terraces rise some thirty feet above the normal level of the Delaware River on the New Jersey side in the vicinity of Titusville. A similar terrace starting south of Scudders Falls extends through Wilburtha into Trenton and as far south as the State House in Trenton. Wells for homes built on these stream terraces are normally completed in the underlying Triassic rocks. Up river on similar terraces, industrial wells of the "caisson" type have provided large amounts of water which is a little cleaner than water taken directly from the Delaware River. Ground water in these terrace deposits responds rapidly to changes in river level. Where bedrock is above river level, the overlying gravels are usually dry and thus useless as a reliable source of ground water.

North of Titusville and north of Jacobs Creek gravel terraces whose tops are some sixty feet above the Delaware River have been mapped as Pennsauken deposits. Neither these terraces nor gravels, also mapped as Pennsauken, found along ridge tops in eastern Lawrence Township and western Princeton Township are thick enough to affect the general ground water conditions in their vicinity.

Most of the poorly sorted brown to pink gravels are found in Ewing Township south of West Trenton and Ewingville. These "Pennsauken gravels," as originally mapped, included only the materials found above elevation eighty. Gravels in the valley of the Shabakunk and its tributaries were apparently considered as Recent deposits. However, examination of excavations in both areas in recent years suggest that there is no significant difference between the two deposits. The length of well casing required in several "Pennsauken" areas also suggests that the present drainage is still above the bottom of the gravels and thus suggests that the gravel sheet is continuous across the minor streams in Ewing Township.

These "Pennsauken deposits" underlie a hummocky terrace containing several small lakes, ponds, and marshy areas. Several of the old farmsteads have large spring houses and hand-dug shallow wells. A few also have farm ponds. Although there seem to be no records of drilled wells completed in this material, a study of the wells in Ewing Township indicates that all but three out of twenty-nine domestic wells in argillite, which underlies the higher ground in northern Ewing Township, have casings less than thirty feet long. However, two-thirds of the sandstone wells, nearly all of which are found in the area covered by thick deposits of these brown-to-pink "Pennsauken" gravels have casings from 31 to 110 feet in length. Of these, eleven wells have casings from 40 to 49 feet long and eight wells have casings in excess of fifty feet. The pockets of boulders described in the early geologic reports as a characteristic feature of the Pennsauken Formation made it difficult to drive casing to bedrock at Fernwood (New Jersey Highway Department) in Western Ewing Township. Other boulder pockets may have been encountered by drillers and excavations frequently turn up boulders. Usually less than a foot long in any direction some boulders have been found with a volume of several cubic feet.

These thick accumulations of brown to pink poorly sorted gravels, sands, silts, and clays with the occasional large boulders probably store a considerable amount of ground water above the bedrock and should improve the potential yield of wells completed in the area of their occurrence. A comparison between wells completed in the Stockton sandstone in Ewing Township shows that they are slightly better than the Stockton sandstone wells in Hopewell Township. A comparison with the sandstone wells in Lawrence, Princeton, and West Windsor Townships is not valid because most of these wells are found in areas where the sandstone is capped by thick deposits of the "Trenton gravels."

A veneer of well sorted yellow gravels and sands covers an extensive area from the junction of Stoney Brook and the Millstone River southwestward along the valley of Stoney Brook and the Assunpink to Trenton. The upper surface of this formation is quite flat, but the gravels were deposited on a highly irregular surface. Perhaps most often twenty-to-thirty-feet-thick bedrock may be less than ten feet below the surface, or the gravels may fill deep channels in the bedrock. Variously described as "Trenton gravels," "stratified drift" or "unclassified deposits", the gravels seem to be related to the last or Wisconsin Ice and represent the valley train of a river carrying melt water from the ice front which then extended from the Plainfield area north and northwestward until it crossed the upper reaches of the Raritan River. For a time a stream of melt water ran southwestward from Bound Brook through the Rocky Hill Gap to the Delaware at Trenton.

This reversal of the present-day drainage happened at least once before because the "Trenton gravels" along the southern margin are found resting on older Pennsauken and/or Cape May gravels which have filled other deeper preglacial valleys to the south. In the original mapping of the "Trenton gravels" it was also suggested that the valley extending westward from Princeton Junction followed by Little Bear Brook and including the area of Upper Bear Swamp might also have been filled by Trenton gravels. However, the problem of whether the lowest parts of the present valleys were actually filled with Trenton, Cape May, or Pennsauken gravels was left unresolved. One domestic Pleistocene well near Princeton Junction has been completed in the above-mentioned southerly channel. Seven domestic wells and nineteen industrial wells completed or attempted in the "Trenton gravels" are located in Trenton or immediately adjacent parts of Hamilton Township. In addition to the twenty-seven Pleistocene wells in Mercer County which were completed in the "Trenton gravels," another fourteen industrial wells and several domestic wells were completed in the underlying rock. In areas where the "Trenton gravels" can, and probably do, provide ground water storage, wells in bedrock can sustain higher than normal yields. The Princeton Water Company wells along the banks of Lake Carnegie and the Millstone River are excellent examples of rock wells whose large yields are both maintained and polluted by water moving freely through thick overlying gravels.

West of Bakersville the underlying Precambrian bedrock is unfavorable for the development of industrial water wells, and several industries have had to rely on shallow Pleistocene wells. In the Trenton area the Assunpink effectively recharges these gravels. However, the gravels overlying the higher bedrock elevations (southern Trenton) drain rapidly. Trenton wells #17 and #21 and Hamilton #85 were abandoned because the gravels gave so little water or resulted in dry holes. Trenton wells #5, #6, and #7, drilled for Roebling, were dry in the gravels and were not continued far enough in the underlying rock to get any water. By definition, the Roebling wells are classed as Precambrian wells, since they got no water in either formation but were finished in Precambrian rock. A number of gravel wells in the Trenton area were abandoned soon after completion because of pollution.

In planning to utilize the "Trenton gravels," therefore, a great deal of attention must be paid to the thickness of the gravel. The elevation and location of the well with respect to surface streams and lakes and the elevation of the underlying bedrock will determine whether water can be secured at all and the quantity which may be expected. Consideration of sources of pollution is essential because of the free movement of water in the gravels. The character of the underlying bedrock will determine whether the gravels are the only good source of water or whether they can be used for storage above the rock well.

The mixed yellow to brown gravels and sands of considerable thickness, which are described as the Pennsauken formation, also include the sediments assigned to the Cape May formation and provide water to domestic and industrial wells in Hamilton, Washington, East Windsor, and West Windsor Townships. The Pennsauken and Cape May formations are found south of the Trenton gravels in Hamilton and West Windsor Townships. As indicated above, Pennsauken gravels have also been mapped north of the Trenton gravels. The ridge from Clarksville to Penns Neck is capped by a thin veneer of Pennsauken which may be separated from the main mass of the formation to the south by a deposit of Trenton gravels in the above-mentioned valley of Little Bear Brook and Upper Bear Swamp.

Some gravels in the general area, south of the Trenton gravels, have been mapped as belonging to the Cape May formation. Both formations filled in the pre-Pleistocene valleys and buried the topography beneath an extensive sheet of sediments. Erosion removed some of the Pennsauken formation before later Pleistocene events deposited the Cape May formation. Erosion again partially removed the earlier Pleistocene formations before deposition of the "Trenton gravels."

This sequence of events and the distinction between Cape May and Pennsauken is significant from the ground water point of view only if the remnants of the Cape May formation are predominately estuarian. The low topography and presence of swamps in many areas mapped as underlain by Cape May gravels suggest that this may be the case. West Windsor well #93 gave 100 gpm from 41 feet and was completed in Pennsauken gravels. West Windsor well #2 located on lower ground to the east and in an area shown on some maps as underlain by Cape May formation was abandoned without a test because of the lack of water although the gravels fraction in wells #93 and #2 seemed identical in appearance. The Cape May formation in general is described as finer grained and less weathered than the Pennsauken formation.

The Pennsauken deposits vary from coarse, well sorted gravels to well sorted sands to sands and gravels with a high porosity to local areas of gravel so choked with silt and/or clay as to be almost impermeable. In general, however, the formation is about 90% sand with cut-and-fill stratification and rapid abrupt changes in grain size and is extremely permeable and porous. In the vicinity of Clarksville and Penns Neck the Pennsauken formation is generally only a few tens of feet in thickness. To the south where the Pennsauken overlies the Raritan formation and to the east along the county border where the sediments fill pre-Pleistocene valleys the formation may exceed 100 feet in thickness. Section CC′, Plate II shows the great thickness (125 feet West Windsor well #32) in the area near Penns Neck and Hightstown. Sections DD′ and EE′, Plate II and FF′ and GG′, Plate III shows the extreme variation in thickness of the Pleistocene cover in southern Mercer County.

In the vicinity of Edinburg the Precambrian bedrock is very close to the surface and probably is covered only with Pleistocene sediments. For about a mile south of the Pennsylvania Railroad the lower or northern contact of the Raritan, the Raritan formation is predominately clay and silt. In this area, shown on Plate V as an area of poor ground water supply, south of the area of Precambrian and Hardyston quartzite in central Mercer County, the Pennsauken formation provides the only potential water supply for domestic, industrial, and irrigation wells. Usually adequate for domestic wells throughout the above-mentioned area the Pennsauken does not seem to be thick enough to support industrial or irrigation wells requiring large yields. West Windsor #94 and #95, industrial wells in this area, give 70 gpm and 190 gpm as compared to industrial wells #86 and #91 completed in thicker Pleistocene to the south and east, which give 340 gpm and 240 gpm respectively.

In the area between Princeton Junction and Hightstown, the Pennsauken fills a pre-Pleistocene river valley and is an important source of ground water. Elsewhere it may be thick and underlain by sandy parts of the Raritan formation so that the two formations can be treated as a single unit.

Lenses containing abundant clay and silt may cause poor surface drainage, perched water tables, and poor yields from shallow or small diameter wells completed in the Pennsauken formation. Such areas are usually at most an acre or two in extent and the lenses are only a few feet think.

In the table of Pleistocene well yields and depths which follows, the Industrial wells in Trenton and Hamilton Township have been completed in the "Trenton gravels." Nearly all of the remaining industrial wells and all of the domestic wells were completed in the Pennsauken formation (or the Cape May formation which is here included with the Pennsauken).

PLEISTOCENE WELLS IN MERCER COUNTY

There are no domestic Pleistocene wells in Trenton, no industrial Pleistocene wells in Washington Township and only one industrial Pleistocene well (60 gpm from 73 feet) in East Windsor Township.

DOMESTIC WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		YIELD IN GALLONS PER MINUTE			
West Windsor	6*	80	10	29*	15
East Windsor	5	15	7	12	12
Washington	2	30	12	..	..
Hamilton	7	15	3	9	10
		DEPTH IN FEET BELOW SURFACE			
West Windsor	6	125	20	63	59
East Windsor	5	85	38	68	73
Washington	2	108	67	..	..
Hamilton	7	62	17	50	55

* Average of six wells is 29 gpm, excluding 80 gpm well, average of five is 19 gpm.

INDUSTRIAL WELLS

Township	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
		YIELD IN GALLONS PER MINUTE			
Trenton	8	200	5	62	50
Hamilton	12	228	2	117	132
West Windsor	7	340	50	162	145
		DEPTH IN FEET BELOW SURFACE			
Trenton	8	135	26	84	89
Hamilton	12	61	25	42	42
West Windsor	8*	113	27	67	78

* Includes one well that was never tested.

LOT SIZE AS RELATED TO WELLS

The most troublesome problem for realtors, planners, and local governing officials who must approve sub-division plans and industrial sites is the determination of lot sizes where individual wells and septic tanks are to provide water and dispose of sewage. A growing awareness of pollution problems and of inadequate or competing water supplies, has focused attention on the need for some kind of guide-lines as to lot size, or well spacing, or other methods for protecting the ground water resource. It was overdrawn at Penns Neck in West Windsor Township during World War I. It should be protected from pollution and development beyond its capacity as has occurred at several places in the northern townships.

Precipitation provides a little more than 2,000,000 gallons per day per square mile in Mercer County. Usually at least half of this is lost to evaporation and transpiration. The remaining 1,000,000 gallons per day per square mile goes into runoff and recharge.

The northern part of Mercer County which is underlain by shale, sandstone, argillite, and diabase has a much higher runoff component than the southern part of the county underlain by the unconsolidated sands, gravels, and clays of the Coastal Plain. Streams draining the Coastal Plain area have a much more uniform flow and a higher dry weather flow than streams which drain the rock country. This indicates that the recharge component is substantially greater in the Coastal Plain than in the northern "rock country" of Mercer County.

Several approaches may be made to determine a safe sustained yield for wells in the two different areas of Mercer County. These efforts to evaluate the total actual or potential recharge component indicate that the sediments of the Coastal Plain have a safe sustained yield of about 1,000,000 gallons per day per square mile. The Brunswick shale areas of northern New Jersey and southern Mercer County have a safe sustained yield of about 500,000 gallons per day per square mile. It is at once obvious that the value for the safe sustained yield of the relatively flat to rolling shale lowlands of the shale areas is greater than that for areas of greater slope, thinner soil, and less frequent and less open fractures found in the harder rocks which underlie the ridges.

The geologic history of northern Mercer County and central New Jersey has been such that soil type and thickness, land use, topographic expression, slope, and relative abundance and openness of fractures is very similar for areas with the same type of bedrock. The variation in climate is not such that it will cause any appreciable difference between rock types in soil, slope, or amount of runoff. Slope, soil type, and land use provide factors usable in determining runoff and even percolation rates so that much can be determined about runoff and the potential availability of the surface water supplies. The ground water potential is a more difficult problem because in rock formations wells must intersect open water-bearing fractures. If a lot of fractures are cut by a lot of wells, the wells give a lot of water. If only a few fractures are cut by a lot of wells, then most of the wells are poor or inadequate and there is less ground water available. The fracture systems are not always uniform nor interconnected so that each individual well becomes a separate problem. A set of values developed for one well are not readily comparable or related to the capacity of the next well because the fracture system may change considerably in a few tens of feet.

The maximum, minimum, average, median, and mean values of depth and yield for a large number of wells completed in one rock type should, if compared to a similar large number of wells in another type of rock, give some indication of the relative abundance and openness of fractures. To put it in a different way, if the safe sustained yield of one rock type is known, then by comparing a large sample of wells in a second rock type an approximate safe sustained yield can be computed for the second rock type. If 225 wells drilled in areas underlain by argillite are compared to 215 wells drilled in an area underlain by Brunswick shale, as has been done in the discussion of argillite, the comparison which indicates that the maximum yield, average yield, median yield, and relative distribution of the various amounts of water secured in the argillite wells are each only about half as good as the wells underlain by shale, then it logically follows that only half as much of the total rainfall is going into the ground in the argillite area as is going into the ground in the shale area. The comparative size of the two areas, since they are not greatly different is irrelevant. The wells are both scattered and grouped in both formations, giving a truly random sample. The random sample can then be applied to a specific equal area to determine the probabilities of securing various amounts of water.

If a given quantity of water is required, there would of necessity, then, have to be twice as many wells and twice as big an area from which they could draw water in order to have an average chance of securing the same amount of water in an area underlain by argillite as would be required in an area underlain by shale. However, in our comparison we must also consider the probabilities of securing any particular amount of water and the probabilities of securing no water or minimum yields. A study of these conditions would indicate that in an argillite area our chance is not half as good, but something less than half as good, as it is in an equivalent sized area underlain by shale. There are in nature, of course, many other variables, particularly in small areas such as a fault zone, which might radically change the expected figures for any single individual well. However, the more wells that are drilled, the more they will approach the average conditions. In this study a sampling of 250 wells in Hopewell Township gave the same results as a sampling of 750 wells.

As indicated above for the areas of the Triassic shale of the Brunswick formation and the sandstone of the Stockton formation in New Jersey, estimates and studies of the percent of rainfall which is available from the ground water reservoir can be attempted from a number of different starting points, and all will ultimately end up with a value close to 25% of the average rainfall being available from ground water sources. This amounts to something slightly more than 500,000 gallons per day per square mile as a safe sustained yield. If, then, 600,000 gallons per day per square mile were removed from any one square mile area underlain by these Triassic formations every day, year in and year out, the ground water would gradually be removed from the area since the average amount of rainfall could not replace, by natural processes, the full amount of water removed from the fractures and openings in the rocks which are tapped by the wells. If no water were removed from adjacent areas, lateral replenishment of ground water might maintain the supply. This, however, would then be equivalent to drawing from a larger area.

If an attempt is made to use ground water availability as one criteria for the determination of minimum lot sizes for properties with individual wells and individual septic tanks, the ground water yields must be related to the average per capita consumption and average family size to determine how large an area is required to supply the needs of each household.

Statewide figures from water companies indicate that the per capita consumption per day ranges somewhere between 25 and 250 gallons per person. The larger figures are from water companies which have a large amount of industrial services. The smaller figures are from water companies where many households within the franchised area are drawing water from individual wells. A generally accepted figure at the present time is about one hundred gallons per person per day. It is believed this figure will increase over the years. If we assume an average per capita consumption of one hundred gallons per person per day and an average suburban family of five persons, we find an average family uses about 500 gallons per day. This figure of 500 gallons per day per household is more convenient than accurate, but it is fully satisfactory for the estimates being given here because of the two compensating variables, family size and water use, which tend to work in opposite directions to produce the same average figures. A family of five using 100 gallons per person per day uses as much as the statistical average suburban family of 3.9 or 4.3 persons using 130 or 115 gallons per person per day. Obviously, small water use of the retired couple is offset by the large water use of the young family with five small children and Aunt Matilda.

Applying this demand of 500 gallons per day per household to an area underlain by red shale, we find that if there were 1,000 individual households drawing from individual wells in a one-square-mile area, they would have a daily water requirement which would equal the 500,000 gallons per day per square mile safe sustained yield of the shale. One thousand families on 640 acres would give a minimum average lot size of two-thirds of an acre per house. Access roads would reduce the actual lot size to slightly below this average size.

It should be clearly understood that this water would not actually leave the one-square-mile area since it would be dumped into the household septic tank system where it would probably again find its way underground. However, if this ground water effluent is not continually diluted by rainfall or some other new water supply, it will very shortly become contaminated. The shales and sandstone in themselves probably do not aid in filtering or otherwise purifying septic tank effluent. Most of what purification is done in nature occurs as oxidation above the weathered rock zone or is accomplished by plants, by the soil, and by the action of bacteria in the septic tank system.

As previously explained, argillite has something less than one-half of the ground water potential of a shale area. If we assume that argillite is only one-third as good as shale, we could then take the minimum lot size for shale (two-thirds acre), multiply it by three, and arrive at the minimum lot size of two acres for areas underlain by argillite. Similarly, if it is only one-fourth as good as shale, the minimum lot size would be two and one-half acres. If a water supply system and sewerage system are provided in an argillite area, the minimum lot size could be substantially reduced.

It is up to each developer and each group of citizens in an affected area or in a municipality to determine whether they should have a water supply system, a sewerage system, or both; or require a minimum lot size sufficiently large to permit the construction of individual wells and septic tanks.

It should be clearly understood that the inadequacies of the ground water supply would not appear in any area under development until most of the area has been taken up and most of the wells have been drilled. Until the full development has taken place, the net effect is the same as though the wells were drawing from the larger lot sizes. It would also hold to a lesser extent that adjacent areas of no or low water use would in effect also increase the lot size. A comparison of the county summaries for argillite and diabase show that the two formations are about equally bad.

For those who may question the validity of a two-acre minimum lot size for argillite areas, we can only reply that in a few developments which have been brought to our attention where the underlying rock is either argillite or its ground water equal, diabase, we have had contamination cases, complaints of inadequate wells, and other problems resulting from a water supply deficiency whenever the lot size averaged less than two acres. The well records from one housing development in Hopewell Township, as indicated in this report, suggest that the minimum lot size of two-thirds acres in shale areas may be too small to support the needs of individual household wells.

The lot sizes for industry or the spacing of industrial wells is a more difficult problem. A need for 500,000 gallons per day would seem to require a square mile of plant site. However, adjacent land use may not require large amounts of water or adjacent properties may be served by a water system. Such factors should be considered and each large industrial water requirement should probably be treated as an individual case. When the industrial requirement has been ignored, expensive solutions may be required at a later date. Since a 500,000-gallon-per-day requirement is equal to almost 350 gpm on a 24-hour basis, a rough rule of thumb planning figure of one acre of plant site for each one gpm required on a twenty-four hour basis is suggested. This does not meet the full requirement as indicated above—only half of it; but industrial needs are often increased by fire protection requirements which are seldom used or by cooling water which may be returned to the ground. Even the suggested figure is considered too high by most industrial realtors, but it will provide a basis for negotiation.

A minimum lot size for the coastal plain areas is even more difficult to compute. At first glance it would seem that one-third-acre lots would be adequate if the wells in the coastal plain sediments are twice as good as wells in shale, which industrial wells are, but such a lot size is not big enough to allow the wells to be separated from septic tanks and sewerage lines the distance required by health laws. The comparison of the domestic wells shows that the yields are nearly the same for shale or sandstone and the Raritan formation. This is probably due to construction of wells capable of meeting the household need rather than a lack of water available to wells in the formation. The biggest problem in the estimates of ground water potential in the coastal plain is caused by the fact that the area of a formation which can be tapped by wells is much larger than the area of outcrop of the formation. Each square mile of outcrop is thus supplying a much larger use area. The control over the use of the ground water in a coastal plain formation does not rest solely with the local government unit that controls the outcrop area.

CONCLUSIONS

There is an abundance of ground water in many parts of Mercer County which will enable wells to meet most water needs for many years to come. Some areas, however, even at the present time, are problem areas with meager supplies and many will always remain so if dependence for water is placed on wells.

The ground water resource is not always available in the areas of greatest need, nor can it be supplemented in some areas with the surface water supplies available from the Delaware River or the Delaware and Raritan Canal. The Delaware River and the canal at present provide water to the larger portion of the population and to water-using industry of Mercer County.

Domestic wells are usually adequate from moderate depths in the areas of Brunswick shale and Stockton sandstone. From one-half to one-third of the wells completed in argillite or diabase are inadequate. If the individual homeowner is willing to spend the money to drill a deep enough well, or wells, and will maintain a large enough house lot, an adequate potable domestic water supply can be obtained from the argillite and diabase. Domestic wells are not always successfully completed in the Precambrian or pre-Triassic crystalline rocks although almost all wells will give some water. Raritan wells are adequate, but in some instances have had to be deepened to get good quality water. The potential for hand dug or drive point domestic wells completed in the Pleistocene and/or the near surface Raritan sands has been utilized in only a few areas.

Industrial zoning now in effect in the county will limit industrial development to three general areas: (1) in southern Mercer County along and near Route #130 and the Bordentown line of the Pennsylvania Railroad; (2) in central Mercer County along U. S. Route #1 and the Pennsylvania mainline; and (3) in the northern part of the county along the Reading Railroad and Route #69 and county route #518.

Deep wells to the lower Raritan in the southern industrial zone, if properly constructed, can be expected to yield 500 gpm or more from depths between 200 feet and 350 feet.

Ground water resources in the central industrial zone are moderate in some selected areas and negligible in some of the western parts of the area. The Delaware and Raritan Canal is within or close enough to the Central industrial zone to serve as a source of water.

The northern industrial zone of Mercer County has several areas with no ground water potential; others with only a moderate potential, and lacks any nearby large surface water supplies because much of the area is along the high ground forming the drainage divide between the Delaware and the Raritan Rivers.

Moderate industrial or public water supplies can be developed in areas underlain by the Brunswick shale or the Stockton sandstone by either careful attention to the location of minor geologic structures which may substantially increase the yield of a well or by drilling multiple wells to depths between 200 feet and 400 feet on spacings of at least 200 feet in the hopes of securing a total yield which will be equivalent to an average yield in excess of 100 gpm from each well.

Industrial or large-capacity public supply wells should not be attempted in areas underlain by argillite or basalt. The pre-Triassic crystalline rocks would also seem inadequate for wells requiring large amounts of water.

Housing developments relying on individual wells and septic tanks with two-thirds of an acre minimum lot sizes in areas underlain by shale and sandstone and two acres minimum lot sizes in areas underlain by argillite and diabase can probably secure adequate potable domestic water supplies without the attendant danger of contamination. Public water supply and sewage systems would seem to be desirable if lot sizes are planned below the above minimum values.

The determination of lot-sizes for industrial plants depends on many factors of land use and neighboring water requirements and should be considered on an individual basis. A rough figure of one acre for each one gallon per minute of water required on a twenty-four hour basis would seem to be a reasonable starting estimate for lot size, which would be modified up or down as the investigation is made.

Minimum domestic lot sizes in the Coastal Plain Formation would probably be about two-thirds of an acre. Local permeability problems might make a larger size desirable.

Industrial lot size and spacing of wells should be determined within the framework of the relationship of the area within which wells are completed to the Raritan as compared to the outcrop and recharge area. All of the latter is found in Mercer County while the former area extends a considerable distance to the south of the county boundary.

RECOMMENDATIONS

1 Residential areas where reliance is placed on individual household wells and septic tanks should be zoned in accordance with the underlying rock to a minimum lot size as follows:

Pre-Triassic Crystalline	1 Acre
Stockton Sandstone	⅔ Acre
Argillite	2 Acres
Brunswick Shale	⅔ - 1 Acre
Raritan and Coastal Plain	⅔ Acre

If public water supply and sewerage systems are installed, the minimum lot size can be smaller.

2 Planning for the integrated development of existing and future public water supply systems in the areas of poor ground water availability should be instituted and made a continuing program. Such an approach is particularly important in the Princeton-West Windsor Township area.

3 Programs leading to greater availability of surface water supplies in the central and northern industrial zones should be inaugurated. Proposals in the TAMS Report and those supported by Oldis and others in the Stony Brook and Jacobs Creek Watershed could serve as a starting point for such studies. Mercer and Somerset Counties, Hopewell and Montgomery Townships and Pennington and Hopewell Boroughs can achieve only very limited industrial development with the existing availability of water in the northern industrial zone. The proposed programs could be linked to open space and recreation for the general benefit of the entire area.

Symbols Used in Township Well Tabulations

Boroughs, towns or other local government units with a small area are included in surrounding or adjacent township units.

Well Number	Well number as indicated on well location map. Each township has a separate series of numbers.
Casing Diameter (inches)	Final diameter of the well or diameter of screen. Six inch well unless indicated otherwise.
GPM	Yield in gallons per minute as reported by driller.
Well Depth (feet)	Depth of well in feet from surface as reported by driller.
Fm	Geologic formation from which water is secured. Fm (P) well pumping from fm indicated. Fm (B) well bottoms in fm indicated. See geologic map for formation symbols. PC = pre-Cambrian Pleistocene is undifferentiated in tables.
Casing Length (feet)	Length of casing used in well. This usually indicates the top of sound rock or top of screen.
Static Water Level (feet)	Static level of water in well as feet below the surface as reported by driller.
Owner	Owner as given on well permit at time well was drilled. Where a change in ownership is known to the Bureau, the newer name is used.
Year Drilled	Year well was drilled. '00 - '63 = 1900 to 1963; '80 - '99 = 1880 to 1899.
Use	Type of well; I = industrial. Otherwise well is classed as a domestic well.
Water Level/ Hours Pumped	Pumping level and duration in hours as given by driller on well report form. If hours are not specified, assume a two hour or less bailer test. Any pertinent remarks or unusual conditions are given as a second line.
. . . .	For value indicates no figure is available from well record information.

The townships are not placed in alphabetical order, because it was felt that the report could most conveniently be used if adjacent townships with the same geology were described in the same section of the report. Thus, Hamilton, Washington, and East Windsor, which are predominantly Coastal Plain, are described immediately after the city of Trenton. West Windsor, which has more Coastal Plain and some Triassic, is next described. Princeton, Lawrenceville, and Ewing, which have predominantly Triassic shales and sandstones, are described next. Hopewell, the largest township and the one with the most complex geology, is described last.

CITY OF TRENTON

All of the City of Trenton is served by the Trenton Water Department which gets its water from the Delaware River. However, there are a large number of industrial water wells, most of which were drilled before 1940, in center city and in the industrial zones to the south and east. This Bureau also has records for three domestic wells.

Trenton is shaped like a stubby "T" with the top of the "T" against the Delaware River and the stem extending northeastward along the Assunpink Creek and the Pennsylvania Railroad. Of Trenton's 7.5 square mile area, approximately 3 square miles of the stem and the immediately adjacent top of the bar are underlain by Precambrian rocks. The northern tip of the bar, approximately 1.7 square miles, is underlain by Triassic rocks in which 9 wells have been drilled. With one exception, a domestic well, these wells were drilled for the Trenton State Hospital and the State Home for Girls. The 2.9 square miles of the southern part of the "T" is underlain by only a moderate thickness of the Raritan formation resting on Precambrian crystallines capped by a veneer of Pleistocene sands and gravels. In many cases an effort has been made to obtain water from the overlying unconsolidated sediments whether they be Pleistocene sands and gravels or the sands of the Raritan formation. Eleven wells in this part of Trenton obtain water from the Raritan formation and some 15 have been driven to or obtain water from the underlying Precambrian rocks. Eight wells obtain water from the Pleistocene sands and gravels. Three wells, numbers 5, 6, and 7 were apparently drilled in an unsuccessful effort to obtain water from the Pleistocene gravels and/or the sands of the Raritan formation, both of which were dry at these locations. The wells were drilled a short distance into the Precambrian rocks to depths of only 50 to 55 feet.

Records for 47 industrial wells, drilled within the City of Trenton between 1892 and 1961, are summarized below:

		YIELD IN GALLONS PER MINUTE			
Formation	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Precambrian	20	175	0	38	23
Pleistocene	8	200	5	62	50
Stockton	8	602	45	164	121
Raritan	11	1,040	60	383	350

		DEPTH IN FEET BELOW SURFACE			
Formation	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Precambrian	20	900	50	365	353
Pleistocene	8	179	26	84	89
Stockton	8	588	200	351	322
Raritan	11	317	80	154	113

The yield was given as "plenty" for well number 21 and a value of 50 gpm was used in the tabulation. Well number 23, giving 550 gpm, is an exceptional case which is discussed in the section on Precambrian wells.

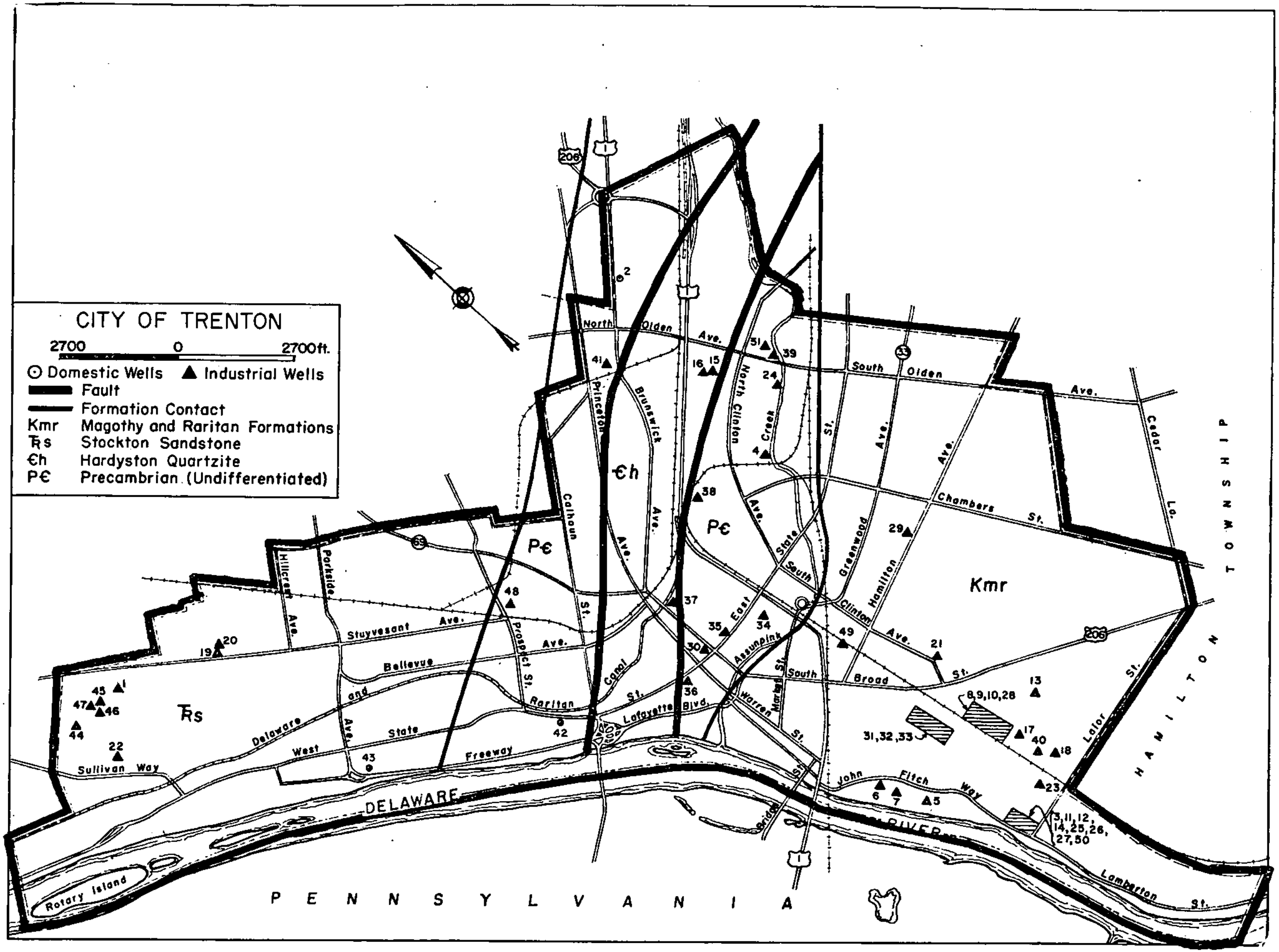
As explained in the section on the Precambrian, depth figures as given should be used with caution. Water may have been obtained at almost any point above the bottom, particularly in the deeper wells; there is no relationship between depth and yield. Average depths for industrial wells are probably fairly reliable for use as a budget figure.

CITY OF TRENTON

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
1	10	602	402	Trs	39	25	Trenton State Hosp.	'57	I	136/24
2	6	15	194	pC	74	30	St. Michaels Church	'55		60/—
3	8	264	117	Kmr	109	39	Metropolis Brewery	'56	I	60/8
4	8	15	75	Qp (P)	. .	. .	Am. Bilt. Rubber Co.	'52	I	28/—
				pC (B)						
5	6	0	55	pC	18	. .	Am. Bridge Company	'46	I	. . . .
6	6	0	50	"	10	. .	"	"	I	. . . .
7	6	0	55	"	20	. .	"	"	I	. . . .
8	8	60	90	Kmr (P)	. .	. .	Columbian Carbon Co.	'52	I	45/—
		(Contaminated-Abandoned)		pC (B)	. .	. .	(Magnetic Pigment Div.)			
9	8	84	480	pC	103	25	Magnetic Pig. Div. #1	'36	I	160/6
10	8	25	713	"	. .	75	" #2	'37	I	250/24
11	8	400	109	Kmr	. .	30	Trenton Brewery Co.	'33	I	66½/—
12	8	380	317	Kmr (P)	274	. .	"	"	I	. . . .
				pC (B)	Rock at 280		Qp 36′ Kmr from 36′ or Elev.—3′			
13	8	25	179	Qp (P)	135	57	Chambersburg Dairy	'37	I	83/—
				pC (B)						
14	8	350	86	Kmr	. .	30	Trenton Brewing Co.	'45	I	. . . .
15	12	70	598	pC	49	. .	Hamilton Rubber Co.	'04	I	170/—
16	8	40	360	"	30	60	Hamilton Rubber Co.	'44	I	180/—
17	8	5	122	Qp (P)	. .	. .	Roebling & Sons Co.	'36	I	. . . .
		(Abandoned, no water below 67′)		pC (B)						
18	6	560	224	Kmr	208	28	Roebling & Sons Co.	"	I	53/—
19	8	100	200	Trs	. .	21	State Home for Girls	'21	I	38/—
		(Condemned and abandoned 1930)								
20	8	130	337	"	304	28	State Home for Girls	'31	I	57/7½
21	6	50	103	Qp (P)	. .	28	Roebling & Sons	'36	I	. . . .
		(Contaminated, not used)		pC (B)						
22	8	124	372	Trs	. .	41	State Hosp. #11	'43	I	56/20
23	8	175	520	pC	. .	60	Stokeley-Van Camp Inc.	'12	I	40/—
		(Yield that is used in Summary; tested at 550 GPM in 1953)								
24	12	100	26	Qp (P)	. .	8	Stokes Rubber Co.	'38	I	. . . .
				pC						
25	14	1,040	90	Kmr	. .	. .	Trenton Brewing Co.	'37	I	60/—
		(Hardness—274 PPM)								

CITY OF TRENTON (Continued)

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
26	..	300	150	Kmr	..	..	Trenton Brewery	..	I	....
27	..	100	264	"	..	..	"	'92	I	....
28	8	50	104	Qp (P)	50	30	Magnetic Pigment Div.	'37	I	....
				Kmr (B)						
	(Well is polluted and hard)			pC						
29	..	11	115	"	..	..	Ingersol Watch Factory	'10	I	....
30	8	50	32	Qp	..	8	S. P. Dunham & Co.	'37	I	....
31	8	15	376	pC	87	..	Trenton State Prison	'11	I	....
32	10 & 8	47	300	"	69	30	"	"	I	100/½
	(Hard and polluted)									
33	8	2	448	"	79	..	"	"	I	....
34	8	60	330	"	..	28	Trenton Times	'37	I	80/—
35	..	0	730	"	..	..	Am. Mechanics Bldg.	..	I	....
36	8	85	415	"	26	16	Stacy-Trent Hotel	'36	I	86/—
	(Down to 30 gpm in 1938, hardness 374 ppm)									
37	..	0	170	"	..	..	Kerns	'08	I	....
38	..	15	415	"	..	..	Trenton Packing Co.	'24	I	....
39	..	200	30	Qp	..	..	Crescent Insulated Wire Co.	'38 (Prior)	I	....
40	8	340	170	Kmr	134	39	Roebling & Sons	'39	I	133/—
41	6	16	142	pC	54	7	Pierce-Roberts Rub. Co.	'41	I	87/—
42	6	20	36	"	..	1½	N. J. Manufacturing Assoc.	?		25/7½
	(Tested in 1954)									
43	..	15	90	Trs?	..	..	Bergen	'12		....
44	8	117	302	Trs	..	24	State Hospital	'47	I	90/—
45	..	125	305	"	..	..	"	'08	I	....
	(Static level lowered 65′ in 24 hours)									
46	..	75	307	"	..	..	"	"	I	100/24
47	..	45	588	"	..	65	"	"	I	....
48	..	100	900	pC	..	..	Globe Rubber Works	'98	I	....
	(Shut with dynamite, very hard)									
49	..	20	125	"	..	..	Trenton Coal Yard	'07	I	....
	(Lowered in 6 hours)									
50	10	400	80	Kmr	70	30	Metropolis Brewery	'61	I	55/8
51	5 wells yielded small supply			pC	..	..	Crescent Insulated Wire	'14 (Prior)	I	Rock at about 42′


CITY OF TRENTON
2700 0 2700 ft.
Domestic Wells
Industrial Wells
Fault
Formation Contact
Kmr Magothy and Raritan Formations
Ћs Stockton Sandstone
Ꞓh Hardyston Quartzite
PꞒ Precambrian (Undifferentiated)
HAMILTON TOWNSHIP
PENNSYLVANIA
DELAWARE RIVER
Rotary Island
North Olden Ave.
South Olden Ave.
Princeton Ave.
Brunswick Ave.
North Clinton Ave.
Creek
State St.
Greenwood Ave.
Hamilton Ave.
Chambers St.
Cedar Lo.
Calhoun St.
East State St.
South Clinton Ave.
Assunpink
South Broad St.
Market St.
Warren St.
Lafayette Blvd.
Canal St.
Raritan St.
Prospect St.
Stuyvesant Ave.
Bellevue Ave.
Hillcrest Ave.
Parkside Ave.
Delaware and West State St.
Sullivan Way
Freeway
John Fitch Way
Bridge St.
Lalor St.
Lamberton St.
Kmr
PꞒ
Ꞓh
Ћs
206
1
33
69
8,9,10,28
31,32,33
3,11,12,
14,25,26,
27,50

HAMILTON TOWNSHIP

About one-fourth of Mercer County's population is found within Hamilton Township's 39.4 square miles. Somewhat more than a third of this area and more than half the people are served by the Trenton Water Department, which obtains water from the Delaware River. An area of about one square mile is served by the Hamilton Square Water Company from wells drawing from the Magothy and Raritan formations.

Since all of Hamilton Township lies within the Delaware River watershed, other surface supplies using river water may be developed if the need arises. The northern half of the township is in the drainage basin of the Assunpink Creek, about half being in the Trenton Water Department service area. About six square miles south of Trenton, all in the area being served by the Trenton Water Department, is drained by minor tributaries of the Delaware. The rest of the township is in the drainage basin of Crosswicks Creek with most of the area, about fifteen square miles, outside the service areas of water companies.

With the exception of a little more than two square miles in the northwestern part of the township south and east of Assunpink Creek, Hamilton Township is underlain by the Magothy and Raritan formations. As one proceeds southeastward the clays of the younger Merchantville and Woodbury formations and the sands of the Englishtown formation overlie the Magothy and Raritan formations in successively higher layers. Pleistocene sand and gravel formations overlie all of the older formations except in some of the deeper stream valleys. The Pleistocene formations usually occur as a thin veneer, but thicknesses of 40-60 feet are not uncommon and in a few places there may be 100 feet or more.

In Hamilton Township the Magothy and Raritan formations are the principal sources of ground water. In the northeastern part of the township where these formations are missing, thin, or are predominately clay or silt, wells have been completed in both the underlying Precambrian rock and in the overlying Pleistocene deposits. The Pleistocene as a source of water in central and southern Hamilton Township has, in general, been overlooked possibly because its most effective utilization will depend on large diameter caisson type or hand-dug wells rather than on the smaller diameter drilled wells. Shallow wells have been completed in the Englishtown formation in and near the extreme southeastern part of the township. In the low-lying western portions of this township adjacent to the Delaware River, there are no well records, but caisson or Raney type wells in the river gravels would probably yield moderate to large amounts of water for industry. This low-lying area, however, is within the service area of the Trenton Water Department.

Records of four domestic and five industrial wells completed in the crystalline rocks of the Precambrian and Hardyston quartzite are, with one exception (#4), within the outcrop area of these formations in the northeastern part of the township. Well #4 apparently encountered no sand in the Raritan and got 1 gpm from the Precambrian.

In the area underlain by the Precambrian and Hardyston rocks, 3 domestic and 12 industrial wells draw from the Pleistocene deposits. In central Hamilton Township 4 other domestic wells have also been finished in the Pleistocene sand and gravel.

All of the remaining 73 wells in Hamilton Township used in this study, with the exception of one well completed in the Englishtown formation in the southern part of the township, draw from the Magothy and Raritan formations. One (#45), a domestic well, was a test and apparently was never used; 43 are domestic wells, and 28 are industrial or public supply wells. Domestic wells drawing from the Raritan will be from 60 to 150 feet deep in the Mercerville-Hamilton Square area, from 120 feet to 180 feet deep in the White Horse-Robbinsville area, and from 150 feet to over 200 feet deep south of U. S. Highway 130. The average depth and median depth have no significance because the Magothy and Raritan sands are increasingly deeper towards the southeast. The deepest domestic well (#45) drawing from the Raritan in Hamilton Township is 304 feet deep; the shallowest (#49), only 40 feet deep, may be drawing from a sandy phase of the Pleistocene deposits. Well #7 is 317 feet deep but draws from the Raritan at less than 156 feet after the casing was pulled back.

The overall geologic relationships and well data suggest that the Magothy and Raritan formations should not be expected to yield large quantities of water north and west of Mercerville; but since the formation thickens to the southeast, wells south and east of Mercerville and Hamilton Square should nearly always be satisfactory if drilled deep enough. Southeast of a line from White Horse to Robbinsville, industrial wells giving 300 - 500 gpm may be expected if properly constructed. Wells of 100 gpm to 200 gpm may not have to be as deep as the larger capacity wells. The depths of industrial wells range from 150 to 220 feet in the Hamilton Square area to in excess of 300 feet deep near the New Jersey Turnpike.

That part of Hamilton Township which lies south of the New Jersey Turnpike cannot be compared to other parts of Mercer County because comparable parts of the geologic formations encountered are found either to the southwest in Burlington County or to the east in Monmouth County. In addition to #83 an Englishtown well and three Hamilton Township wells south of the Turnpike drawing from the Raritan, a tabulation of 15 Englishtown wells and 27 Raritan wells located outside of Mercer County follows the Hamilton Township tabulation. The location of these wells is shown on Plate IV. The Raritan formation is trapped at depths of from 76 to 456 feet for domestic wells and from 73 feet deep to 537 feet deep for industrial and irrigation wells. A few wells have been completed in the overlying Merchantville and several shallow Raritan wells may actually be drawing from the Merchantville or the Pleistocene.

The records for the nine wells in northern Hamilton Township completed in the Hardyston quartzite or Precambrian rocks is summarized below.

	No. of Wells	*YIELD IN GALLONS PER MINUTE* Maximum	Minimum	Average	Median
Domestic	4	20	1	9	7
Industrial	4*	60	7½	30	28

	No. of Wells	*DEPTH IN FEET BELOW SURFACE* Maximum	Minimum	Average	Median
Domestic	4	203	60	170	169
Industrial	5	280	50	151	121

A summary for the Raritan and Pleistocene wells and for Raritan wells south of Mercer County follows. The southern tip of Hamilton Township is at present an area of large farms from which very few well records could be obtained.

* #71 not tested.

DOMESTIC WELLS

Formation	*No. of Wells*	*YIELD IN GALLONS PER MINUTE* Maximum	Minimum	Average	Median
Pleistocene deposits (undifferentiated)	7	15	3	9	10
Magothy and Raritan	44*	47**	7	15	15
Kmr South of Mercer Co.	13	80	7½	32	30

Formation	*No. of Wells*	*DEPTH IN FEET BELOW SURFACE* Maximum	Minimum	Average	Median
Pleistocene deposits (undifferentiated)	7	62	17	50	55
Magothy and Raritan	44	317 (304)	55	115	100
Kmr South of Mercer Co.	13	456	76	230	200

INDUSTRIAL WELLS

Formation	*No. of Wells*	*YIELD IN GALLONS PER MINUTE* Maximum	Minimum	Average	Median
Pleistocene deposits (undifferentiated)	12	228	2	117	132
Magothy and Raritan	27	700	35	246	200
Kmr South of Mercer Co.	12	580	40	361	503

Formation	*No. of Wells*	*DEPTH IN FEET BELOW SURFACE* Maximum	Minimum	Average	Median
Pleistocene deposits (undifferentiated)	12	61	25	42	42
Magothy and Raritan	27	334	67	194	220
Kmr South of Mercer Co.	12	537	73	268	358

* #45 was not tested.

** Well #41 giving 100 gpm was not included in average. Average of wells 17 gpm.

HAMILTON TOWNSHIP

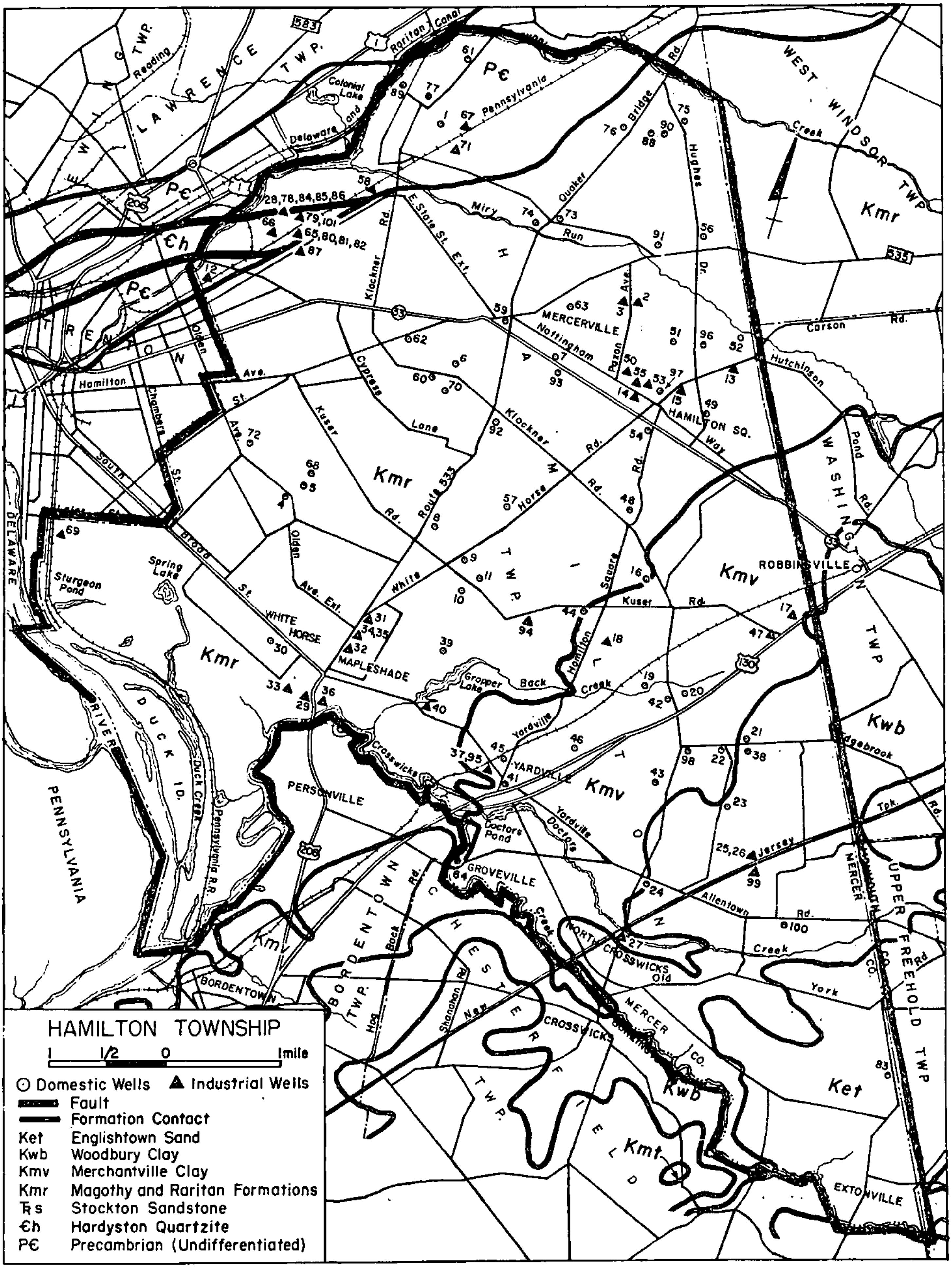
Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
1	6	20	203	pC	101	11	Amer. Radiator Standard	'55		187/2
2	10	500	150	Kmr	130	18	Hamilton Sq. Water Co.	'56	I	59/168
		(Abandoned)								
3	10	700	144	"	124	26	" " " "	'58	I	45/8
4	6	1	205	pG	183	36	Cacavio Bros.	'55		....
5	4	10	64	Kmr	60	18	Wilson	"		45/2
6	6	25	55	"	52	16	S.P.C.A.	'58		19/6
7	6	30	317	Kmr (P)	226(?)	23	Agabiti	'54		60/—
				pC (B)	(Rock at 156 Casing pulled back into Raritan)					
8	6	15	51	Qp	48	25	Jarzyk	'57		40/6
9	6	10	52	"	39	25	Armsparger	"		"
10	6	15	85	Kmr	75	40	Pintinalli	"		52/6
11	8	10	142	"	128	50	Emil	"		90/6
12	8	75	60	Qp (P)	35	23	Acme Rubber Co.	'56	I	26/6
				pC (B)						
13	10	460	230	Kmr	200	37	Hamilton Sq. Water Co.	'58	I	160/9
14	8	150	218	"	164	53	" " " "	'54	I	120/—
15	8	50	190	"	175	47	Mercer Rubber Co.	'57	I	130/6
16	3	10	62	"	57	37	Rickard	'54		38/8
17	6	270	259	"	239	56	Walter Reade Theatres	'56	I	110/16
18	8	50	186	"	171	54	Mercer Rubber Co.	'54	I	66/—
19	4	20	215	"	..	45	Gardiner	'57		50/2
20	6	15	125	"	122	25	Amer. Legion Post #33	'59		34/6
21	6	20	236	"	203	35	Biermuth	'55		85/—
22	6	15	141	"	138	25	L. Chryanowski	'57		50/6
23	6	20	162	"	159	25	E. Woods	'60		157/6
24	3	10	127	"	122	40	Nelson	'54		41/10
25	8	300	207	"	..	55	N. J. Turnpike Authority	'55	I	130/9
26	8	250	200	"	173	55	"	"	I	126/12
27	8	500	299	"	249	13	Crosswicks Water Co.	'59	I	....
28	12	183	25	Qp (P)	20	8	Thermoid Rubber	'37	I	....
				pC (B)						
29	8	100	246	Kmr	..	45	White Horse Bowl. Alley	'45	I	65/—
30	6	15	140	"	..	..	So. Broad Street School	'23		....
31	6	100	198	"	..	..	Maple Shade School	'24 ?	I	....
32	6	80	217	"	..	140	Hartz & Knopf Dairy	'33	I	....
		(Pumps 10 gpm)								
33	8	144	126	"	113	28	Hamilton Twp. Sewerage Plant	'49	I	55/18
34	..	40	70	"	30	30	Mc Galliard	'08	I	....

HAMILTON TOWNSHIP (Continued)

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
35	8	150	220	Kmr	. .	73	McGalliard	'25	I	. . . .
36	2	35	67	"	. .	. .	City of Bordentown	'19	I	. . . .
		(Flows 35 gpm)								
37	6	140	92	"	90	40	Kaye-Tex Manufacturing Co.	'30	I	70/—
38	6	8	155	"	152	68	Tulli	'54		71/—
39	6	15	134	"	. .	30	Kopf	'32		. . . .
		(Irony water, Abd.)								
40	6	100	198	"	. .	. .	Yardville School	'23	I	. . . .
41	. .	100	295	"	. .	. .	Mautz	'09		. . . .
42	6	20	123	"	. .	17	Buckley	'53		58/—
43	6	47	141	"	. .	32	Karzor	'43		100/—
		(Irony)								
44	4	10	73	"	. .	42	Salmon	'51		63/—
45	6	Test	304	"	. .	. .	Chandler	'35		. . . .
		(Slightly irony)								
46	6	15	100	"	. .	. .	Vollwieder	. .		. . . .
47	8	40	110	"	100	50	Reader Bros.	'51	I	70/24
48	4	10	64	"	. .	30	Scalzo	'52		42/—
49	4	10	40	"	. .	18	Brenton	"		30/—
50	12	300	186	"	154	60	Hamilton Sq. Water Co. #5	'54	I	110/—
51	. . .	15	200	"	. .	40	Sayer	. .		. . . .
52	6	15	69	"	65	19	Bowes	'53		45/—
53	8	500	220	"	187	51	Hamilton Sq. Water Co. #4	'49	I	82/8
54	4	10	64	"	. .	30	Vorhees	'52		42/—
55	12	600	217	"	. .	45	Hamilton Sq. Water Co.	'34	I	. . . .
56	6	15	65	"	51	. .	Rutkowski	'51		. . . .
57	6	15	117	"	. .	45	Scheidnage	'41		. . . .
58	8	7½	50	pC	28	8	Pennsylvania Railroad	'47	I	42/—
59	6	40	128	Kmr	118	40	Smith	'49		42/4
60	4	15	64	"	. .	25	Gareth	'53		35/—
61	6	4½	135	pC	60	11	Masterson	'49		100/—
62	4	10	90	Kmr	. .	30	Hutchinson	'53		55/—
63	6	20	68	"	63	25	Kundow	'49		27/6
64	6	15	68	"	. .	. .	Anchor Thread Co.	'36		. . . .
65	8	50	38	Qp	23	14	Natl. Sponge Cush. Co.	'57	I	34/6
66	8	80	39	"	. .	. .	Natl. Auto. Fibres Inc.	'40	I	30/—
67	8	60	225	pC	. .	. .	Amer. Rad. & Stan. Sani. Corp.	'24	I	68/—
68	6	15	60	Kmr	57	33	Dringus	'54		. . . .
69	. .	240	198	"	. .	37	Roebling & Sons	'24	I	0/—

HAMILTON TOWNSHIP (Continued)

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
70	..	10	68	Kmr	..	30	Shaw	'53		42/—
71	8	?	81	pC	..	..	Sloane-Blabon Corp.	'41	I	....
72	4	3	58	Qp	51	18	Licciardello	'51		40/—
73	6	15	83	Kmr (P) pC (B)	80	6	Mercer Contracting Co.	'55		48/—
74	6	15	60	Kmr (P) pC (B)	57	8	Chevron or Calso Sta.	'57		12/6
75	3	10	61	Kmr	56	56	G. Finkle	'60		50/6
76	6	10	62	Qp	59	15	B. Clark	'57		40/6
77	6	10	135	pC	40	15	G. McCullic	"		135/6
78	6	52	36 (Polluted)	Qp (P) pC	..	..	Thermoid Rubber Co. #4	'20	I	....
79	8	40	280	"	..	18	Sterling Drug Co.	'36	I	130/—
80	8	140	46	Qp (P) pC (B)	27	11	Nearpara Rubber Co.	'52	I	....
81	8	140	49	Qp (P) pC (B)	20	8	"	'41	I	....
82	8	185	35	Qp	25	11	"	'58	I	25/8
83	..	10	35	Ket	..	10	Ewert	'52		....
84	8	15	121	pC	63	8	Thermoid Rubber Co. #9	'20	I	....
85	..	2	36	Qp	..	..	Thermoid Rubber Co. #1	'20	I	....
	(Abandoned for lack of water)									
86	18 & 12	228	61	Qp (P) pC (B)	..	9	" #2	'37	I	20/8
	(50 gpm in 1953)									
87	10	125	50	Qp	..	..	Bona Fide Mills	'48	I	....
88	3	5	58	"	55	15	J. Cooper	'61		58/6
89	3	10	17	"	14	..	W. Beebe	"		....
90	3	10	55	"	52	12	D. Perferi	"		....
91	6	15	72	Kmr	65	1	C. Green	'57		15/6
92	6	10	89	"	86	41	Mrs. A. Svochak	'54		45/—
93	3	20	80	"	77	40	Brake Tire & Alignment	'61		....
94	8	50	84	"	78	25	Italian American Club	"	I	68/6
95	8	200	88	"	68	40	Kaye Tex Manufacturing Co.	'60	I	50/5
96	3	15	120	"	114	38	G. Gatson, Jr.	'61		75/6
97	3	12	101	"	..	38	L. Bainbridge	"		40/6
98	4	10	118	"	115	..	J. Karch	'62		....
99	10	600	334	"	317	65	N.J.T.P. Authority	'60	I	154/8
100	4	7	195	"	192	69	T. Cruzlovic	'61		115/6
101	18 & 12	150	45	Qp	26	3	Sterling Drug Co.	'38	I	20/—
	(Down to 50 gpm in 1940)									


HAMILTON TOWNSHIP
1 1/2 0 1mile
Domestic Wells
Industrial Wells
Fault
Formation Contact
Ket Englishtown Sand
Kwb Woodbury Clay
Kmv Merchantville Clay
Kmr Magothy and Raritan Formations
T̄Rs Stockton Sandstone
Єh Hardyston Quartzite
PЄ Precambrian (Undifferentiated)
LAWRENCE TWP.
EWING TWP.
WEST WINDSOR TWP.
WASHINGTON TWP.
UPPER FREEHOLD TWP.
CHESTERFIELD TWP.
BORDENTOWN TWP.
HAMILTON TWP.
TRENTON
PENNSYLVANIA
DELAWARE RIVER
DUCK ID.
MERCERVILLE
HAMILTON SQ.
ROBBINSVILLE
WHITE HORSE
MAPLESHADE
YARDVILLE
PERSONVILLE
GROVEVILLE
BORDENTOWN
NORTH CROSSWICKS
CROSSWICKS
EXTONVILLE
MERCER CO.
Delaware and Raritan Canal
Colonial Lake
Spring Lake
Sturgeon Pond
Gropper Lake
Doctors Pond
Miry Run
Back Creek
Crosswicks Creek
Duck Creek
Pennsylvania R.R.
Kmr
Kmv
Kwb
Ket
Kmt
PЄ
Єh

WELLS DRAWING FROM THE MAGOTHY-RARITAN FORMATION IN AREAS SOUTH OF MERCER COUNTY

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
1	6	365	79	Kmr	45	12	Bzura Chemical Co.	'60	I	42/24
2	8	90	247	"	238	55	St. John's R. C. Church	'55	I	90/—
3	8	500	537	"	515	72	John Fields & Son	'58	I	220/9
4	10	350	358	"	336	88	Wm. Dryer	'57	I	183/8
5	12 & 8	524	475	"	435	142	Boro of Roosevelt	"	I	172/8
6	4	36	456	"	. .	157	William Lee	'61		. . . .
7	10	580	464	"	437	77	George Wilson	'58	I	131/9
8	6	145	160	"	147	54	Jersey Maid Dairies	'56	I	69/6
9	6	80	131	"	. .	55	Bordentown Diner	'55		75/5
10	3	20	48	Kmv (1)	43	19	Premium Pet. Co.	'58		. . . .
11	6	15	195	Kmr	192	75	Thomas Dryer	'59		147/—
12	16 & 8	572	388	"	330	86	City of Bordentown	'56	I	103/8
13	6	430	73	"	44	9	Bzura Chemical Co.	'60	I	40/36
14	6	25	208	"	. .	80	John Marincas	'54		149/—
15	4	25	150	Kmv (1)	120	150	Thomas Bunting	'60		85/10
16	6	40	133	Kmr	328	75	Anchor Thread Co.	'60	I	160/12
17	6	30	200	"	. .	65	Richard Potts	'51		90/—
18	4	7½	76	"	73	44	Richard Nelson	'62		75/6
19	6	30	330	"	. .	55	Chas. Barclay	'47		125/—
20	6	35	348	"	. .	58	Sadowski Bros.	'51		0/—
21	6	20	194	"	. .	40	Hunt and Brown	'53		53/—
22	12	503	392	"	350	86	N. J. Reformatory	'51	I	127/8
23	8	66	243	"	. .	65	N. J. Dept. of Defense	'52		85/—
24	10	230	181	"	. .	73	Bordentown State Farm	'45	I	160/—
25	6	35	271	"	. .	40	Chas. Wooley	'47		75/—
26	6	25	170	"	. .	48	Robert Wilson	'54		65/4
27	6	10	173	"	170	75	Richard Dubell	'57		80/6

(1) Well in Merchantville Formation close to Magothy-Merchantville contact.

WELLS DAWING FROM THE ENGLISHTOWN FORMATION IN AREAS SOUTH OF MERCER COUNTY

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
1	4	5	134	Ket	..	37	Mrs. E. P. Errickson	1954		130/–
2	4	25	193	Ket	..	38	Edward Harvey	1960		120/–
3	4	5	174	Ket	..	40	Henry Otterson	1959		120/–
4	4	±5	114	Ket	10	..	Mrs. Joseph Burg	1952		....
5	4	10	43	Ket	..	24	G. Oser	1951		40/–
6	6	60	212	Ket	..	22	W. R. Meirs, Jr. #2	1952		86/6
7	4	10	170	Ket	..	40	A. C. Bowken	1950		80/–
8	6	15	157	Ket	148	24	Imlaystown Bd. of Ed.	1951		145/6
9	6	20	139	Ket	..	25	Chas. Smith	1953		....
10	4	enough	89	Ket	..	..	Victor Booth	1950		....
11	4	10	85	Ket	..	40	E. W. Harvey	1948		60/4
12	6	60	100	Ket	..	+6	R. W. Meirs	1914		....
13	4	12	31	Ket	..	4	Angelo Trampano	1953		21/–
14	..	10	35	Ket	..	10	Ewert	1952		....
15	6	15	94	Ket	86	60	F. A. Lyle	1948		75/6

WASHINGTON TOWNSHIP

Only a very small portion of Washington Township is outside of the Delaware River watershed. This area, about one-half mile wide along the eastern border, will, like neighboring East Windsor Township, have to rely on its ground water resources. Most of Washington Township, if the necessity arises, could draw water from the Delaware River by means of the Trenton City Water Supply. However, all of the township is underlain by the Raritan formation, which in most areas would seem to be capable of supplying all domestic and most industrial water requirements.

A thin veneer of Pleistocene gravels covers the Raritan formation in a small area of northwestern Washington Township. The Pleistocene sands and gravels which range from a few feet to over fifty feet in thickness overlie the Merchantville and Woodbury clays throughout the rest of Washington Township. Wells in the southern part of the township driven to the Raritan must therefore be at least 100 feet deeper than Raritan wells to the north.

In Washington Township two wells, #10 and #29, have been completed in, and draw water from, the Pleistocene veneer. Well #10 is a four-inch diameter domestic well giving 12 gpm from the upper part of its 108 feet, and #29 is a six-inch diameter well giving 30 gpm from 67 feet. There undoubtedly are hand dug, drive point, or unrecorded wells getting water from the Pleistocene sands. For domestic water supplies in any part of Washington Township, it would seem prudent to investigate the possibility of using a dug well or drive point well drawing water from the Pleistocene. Drilled wells may also use this formation in some areas of Washington Township, but most drilled wells are completed in the Magothy-Raritan formation.

In the northwestern part of Washington Township a test well, #1, was drilled through Pleistocene, Raritan and into the underlying Precambrian to a total depth of 244 feet. This well (#1) gave so little water that no pumping test was made. While it may have been adequate for a domestic supply, it was not suitable as an irrigation well. Further to the south #31 was also drilled well into the Precambrian but was finally abandoned because the water could not be freed of clay. In West Windsor Township to the north there is every indication that the Precambrian is fairly close to the surface and that the Raritan is either missing or chiefly silt and clay so that large supplies of water are not to be expected.

There are only three industrial wells in Washington Township: #5, 40 gpm from 310 feet deep; #20, 260 gpm from 218 feet deep; and #25, 60 gpm from 230 feet deep. The remaining twenty-seven wells in Washington Township were completed in the Raritan formation. The following summary shows the depth and yield.

DOMESTIC WELLS

		YIELD IN GALLONS PER MINUTE			
Formation	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Raritan	24	25	7	24	23

		DEPTH IN FEET BELOW SURFACE			
Formation	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Raritan	24	248	82	163	129

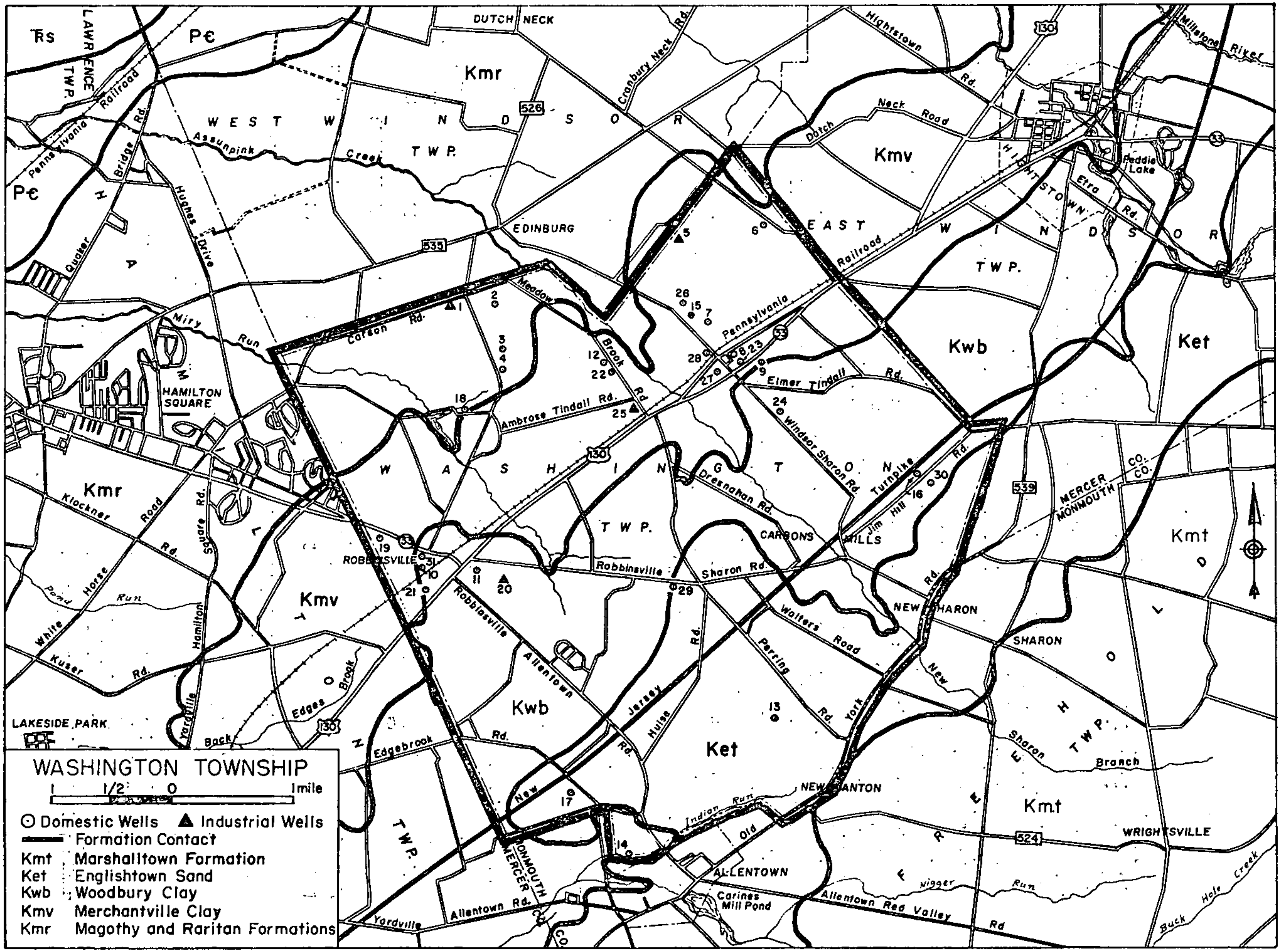
Depth increases toward the southeast at about 60 feet per mile starting with a depth of betweeen 120 feet and 150 feet.

WASHINGTON TOWNSHIP

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
1	8	No Test	244	pC	244	..	Cubberley	'54	I	....
2	6	15	108	Kmr	105	32	Hobe	'54		35/—
3	6	15	82	"	79	33	Tantum	'57		43/6
4	6	30	96	"	93	35	Schauer	'59		60/6
5	6	40	310	"	290	60	Deckers Dairy	'55	I	90/—
6	6	15	108	"	105	25	Melichank	'56		....
7	6	20	121	"	..	41	Rue	'54		50/—
8	4–3	12	125	"	119	31	Ashwood	'55		40/16
9	6	35	171	"	164	31	Astbury	'57		40/8
10	4	12	108	Qps (P) Kmv (B)	22	10	Cubberly	'54		25/10
11	6	25	207	Kmr	204	70	James	'54		77/—
12	..	23	120	"	..	..	Roszei	'59		90/6
13	4	30	224	"	..	70	Duncan	'59		85/2
14	4	10	193	"	..	50	Richardson	'54		100/—
15	6	12	121	"	118	34	Sefeik	'57		60/6
16	6	20	248	"	245	58	Geller	'53		80/4
17	6	15	243	"	240	68	Madar	'54		155/—
18	6	50	140	"	..	19	Sherwin	'36		....
19	6	55	168	"	159	56	Francis	'52		80/6
20	8	260	218	"	198	75	Vahlsing	'42	I	125/—
21	6	30	160	"	150	40	Mathay	'48		70/6
22	4	12	129	"	126	38	Raho	'61		120/6
23	6	30	169	"	..	25	Drake	'49		55/—
24	6	20	230	"	200	32	Fedasz	'53		55/—
25	6	60	230	"	..	35	Dromboski Bros.	'49	I	100/—
26	6	7	132	"	..	18	Ray	'40		....
27	6	23	134	"	..	20	Thompson	'48		....
28	6	30	170	"	..	30	Kennedy	'34		80/—
29	6	30	67	Qps	57	34	Wash. Twp. Bd. of Education	'57		63/—
30	6	20	248	Kmr	245	58	A. Geller	'53		....
31*	6 (?)	none	365	Kmr(P)304 pC(B)360	..	..	Robbinsville Hotel	'47		Could not clear clay from water

* Not included in tabulations.

Shown on Section EE, Plate II


WASHINGTON TOWNSHIP
1 1/2 0 1mile
Domestic Wells
Industrial Wells
Formation Contact
Kmt Marshalltown Formation
Ket Englishtown Sand
Kwb Woodbury Clay
Kmv Merchantville Clay
Kmr Magothy and Raritan Formations
DUTCH NECK
LAWRENCE TWP.
WEST WINDSOR TWP.
EAST WINDSOR TWP.
WASHINGTON TWP.
HAMILTON TWP.
UPPER FREEHOLD TWP.
Pennsylvania Railroad
Assunpink Creek
Miry Run
Millstone River
Hightstown Rd.
Cranbury Neck Rd.
Dutch Neck Road
Etra Rd.
Peddie Lake
EDINBURG
HAMILTON SQUARE
Quaker Bridge Rd.
Hughes Drive
Carson Rd.
Meadow Brook Rd.
Ambrose Tindall Rd.
Elmer Tindall Rd.
Windsor Sharon Rd.
Dresnahan Rd.
Turnpike Rd.
Jim Hill Rd.
CARSONS MILLS
ROBBINSVILLE
Robbinsville Sharon Rd.
Robbinsville Allentown Rd.
NEW SHARON
SHARON
Walters Road
Perrine Rd.
New York Rd.
Jersey Rd.
Hulse Rd.
Klockner Road
Square Rd.
White Horse Rd.
Pond Run
Kuser Rd.
Yardville Hamilton Rd.
LAKESIDE PARK
Back Rd.
Edges Brook
Edgebrook Rd.
New Rd.
Indian Run
Old Rd.
NEW SHARON
ALLENTOWN
Carines Mill Pond
Allentown Red Valley Rd
Yardville Allentown Rd.
MONMOUTH CO.
MERCER CO.
Sharon Branch
WRIGHTSVILLE
Buck Hole Creek
Run

EAST WINDSOR TOWNSHIP

All of East Windsor Township, except about one square mile in the southwestern corner, lies within the drainage basin of the Millstone River. Water supplies must, therefore, come from wells, unless at some future date additional diversion of Delaware River water outside the basin is permitted. Should this be permitted, and it would seem unlikely, the township is several miles from either the Delaware and Raritan Canal or from the nearest mains of the Trenton system so that it would seem uneconomical to secure the Delaware River water through either of these two systems. East Windsor Township, therefore, more than any other township in Mercer County, is probably entirely dependent upon ground water development for its future growth.

Most wells in East Windsor Township obtain water from Pleistocene deposits or from the Magothy-Raritan formation.

At least six wells have been completed in the Pleistocene sand and gravels which constitute the uppermost geologic formation underlying East Windsor Township's 15.9 square mile area. Yields from five Pleistocene domestic wells average 11 gpm (gallons per minute). The one industrial well in the township, which is known to pump from the Pleistocene sand and gravel, yields 60 gpm. There are probably other wells in the township drawing water from the Pleistocene formations, but most wells are drilled into the Magothy-Raritan formation.

The Magothy-Raritan formation underlies the entire township, but crops out in only 1.8 square miles of the township. The rest of the Raritan formation is capped by the overlying Merchantville or Woodbury clays and Pleistocene deposits. Magothy-Raritan wells in the township are from about 70 to 317 feet deep. Domestic supplies are adequate from wells with an average depth of 162 feet. Industrial wells are drilled to lower water-bearing horizons in the Magothy-Raritan formation for the larger quantities of water which are required and, therefore, are between 152 and 315 feet deep.

The following summary shows yields and depths of industrial and domestic wells in East Windsor Township. Depths of Magothy-Raritan wells are excluded because the formation increases in depth about 35 feet per mile from northwest to southeast and an average would be misleading.

INDUSTRIAL WELLS		*YIELD IN GALLONS PER MINUTE*			
Formation	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Pleistocene	1	..	..	..	(60)
Raritan	14	1,500	55	470	363

DOMESTIC WELLS		*YIELD IN GALLONS PER MINUTE*			
Formation	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Pleistocene	5	15	7	11	15
Raritan	24	60	3	19	15

		DEPTHS IN FEET BELOW SURFACE			
Formation	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Pleistocene	5	55	38	68	..

Other formations in East Windsor Township are potential sources of water for domestic use. In the southern part of the township, the Englishtown sands may be thick enough to provide water for shallow domestic wells. In Monmouth County within a mile of the southeastern corner of the township, domestic wells from 30 to 90 feet deep have been completed in the Englishtown formation. Well #22 was completed in a sand bed in the Merchantville formation at a depth of 93 feet. Such sand layers might yield useable quantities of water at other locations if carefully tested by the driller.

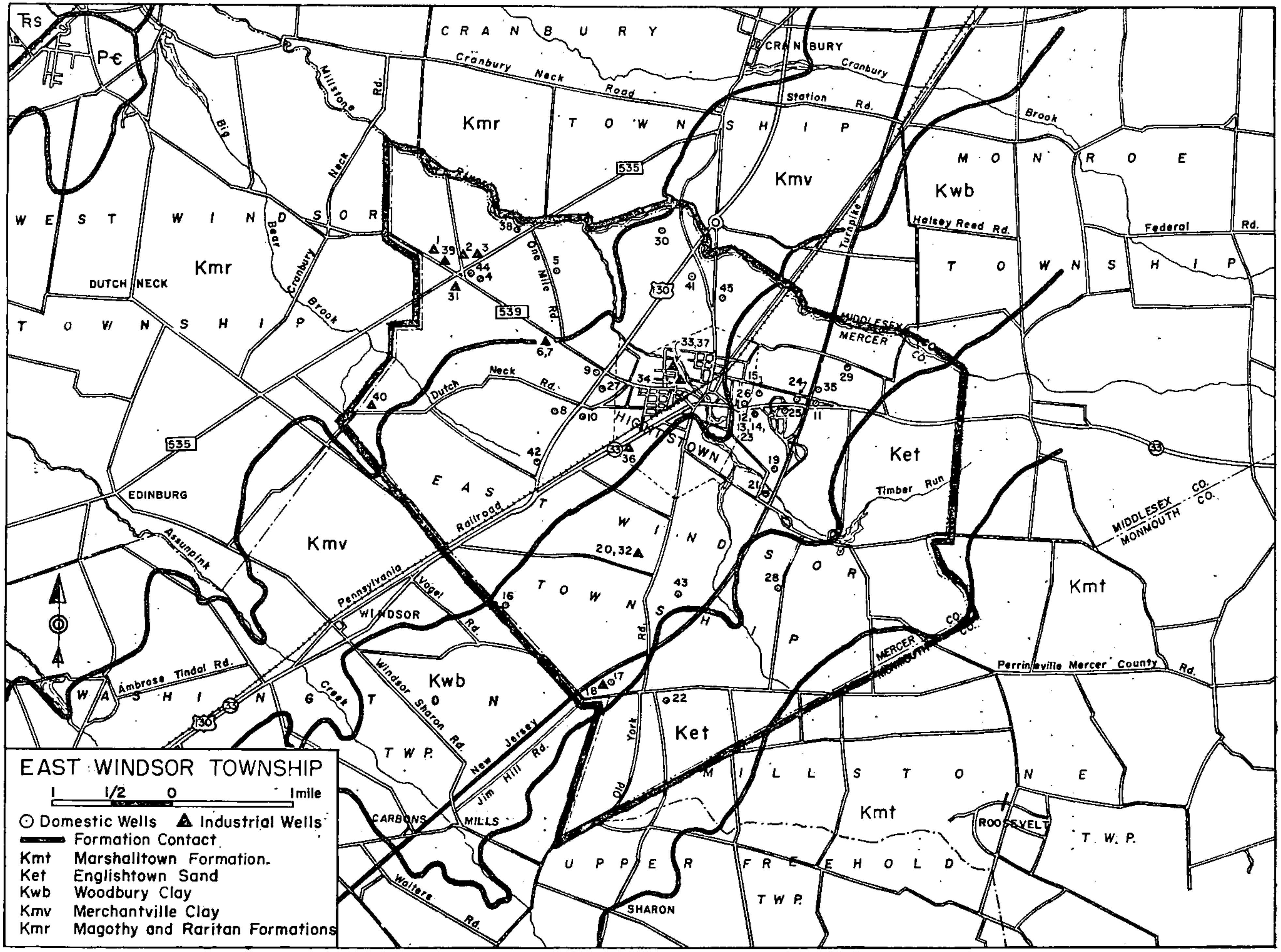
Several of the Magothy-Raritan formation wells in the Hightstown area are reported to yield water having a high iron concentration. Neither total depth nor well location seems to be a factor controlling the iron concentration which might be expected in a new well. In one instance (well #29) irony water with a sulfur odor was cased off at 224 feet and the well was completed at 315 feet with a smaller yield, but with better quality water.

EAST WINDSOR TOWNSHIP

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
1	8	200	216	Kmr	205	33	Hightstown Rug Co.	'54	I	50/8
2	8	650	228	"	201	27	Applied Science Corp.	'57	I	58/8
3	8	200	210	"	192	24	Creative Playthings, Inc.	'60	I	115/2
4	4	10	82	Qal?	..	40	Buitenhuis	'56		56/–
5	4	10	73	"	..	22	Slapack	'56		24/–
6	8	100	152	Kmr	134	35	Mettler Intru. Co.	'56	I	45/8
7	12	363	173	"	155	39	McGraw-Hill Pub. Co.	'58	I	140/9
8	6	10	141	"	138	50	Consumer's Oil Co.	'57		55/6
9	6	15	141	"	138	42	C. B. Aremore	'57		65/6
10	4	20	150	"	144	52	Ragno	'59		57/8
11	3	10	118	"	109	29	Mom's Drive In	'55		35/10
12	4	7	193	"	189	40	Martin	'59		100/6
13	4	18	218	"	212	34	Davison	'59		70/6
14	4	10	201	"	195	6	Pierson	'59		85/6
15	4	16	192	"	186	34	Kendall	'59		65/6
16	4	12	147	"	..	38	Schwartz	'51		65/–
17	6	15	38	Qal	10	7	Hancock	'56		35/6
18	12	372	280	Kmr	243	65	"	'56	I	154/8
19	6	35	219	"	209	43	N. J. Credit Union	'60		96/8
20	6	160	259	"	251	8	Conover's Dairy	'59	I	36/9
21	6	15	247	"	244	50	E. Windsor Twp.	'58		60/6
22	6	10	93	Kmv	90	35	Bellardo	'53		66/–
23	4	4	111	Kmr	105	30	W. Henderson	'59		110/6
24	6	3	114	"	108	35	Shekiro	'49		100/6
25	6	60	181	"	171	41	N. J. Turnpike #MB45 (Irony)	'51		130/8
26	4	6	113	"	10	31	R. Cottrell	'60		108/6
27	4	10	70	"	..	40	Gilbert (Irony & Sulfur odor)	'49		50/4
28	6	15	198	"	..	84	Weinen	'52		120/8
29	6	30	315	"	224	57	Jessen	'51		85/–
	(60 gpm of Fe water with sulfur odor at 224' cased off)									
30	4	15	97	"	..	12	Salvenimi	'52		63/–

EAST WINDSOR TOWNSHIP (Continued)

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
31	4	60	73	Qal	69	35	S. T. White Realty Co.	'61	I	50/4
	(Well abandoned because it pumped sand—the casing was pulled)									
32	6	55	270	Kmr	..	68	C. C. Conover	'32	I	....
33	6	100	240	"	..	..	Boro of Hightstown (6 wells—100 gpm each) (Irony)	'22	I	....
34	12	1,150	200	"	..	..	Boro of Hightstown (Irony)	'47	I	....
35	6 (25 gpm in 1934)	60	205	"	..	30	Gerard Sinclair Fill. Station (Irony)	'32		....
36	8	120	192	"	..	57	Hightstown Swimming Pool	'35	I	....
37	12	1,500	193	"	..	10	Boro of Hightstown	'46	I	33/—
38	6	15	63	Qal?	..	21	Slapack	'52		40/—
39	12	1,125	229	Kmr	206	33	Hightstown Rug Co.	'54	I	125/8
40	10	480	137	"	110	24	G. Cranston	'54	I	100/144
41	4	20	132	"	..	30	E. Archer	'61		60/80
42	..	30	314	"	311	40	Stevens Const. Co.	'60		60/6
43	..	20	192	"	20	85	B. Weiner	'60		160/8
44	..	7	85	Qal	7	35	W. R. Dyre	'58		78/4
45	..	30	185	Kmr	..	45	Klein	'41		....


EAST WINDSOR TOWNSHIP
1 1/2 0 1 mile
Domestic Wells
Industrial Wells
Formation Contact
Kmt Marshalltown Formation
Ket Englishtown Sand
Kwb Woodbury Clay
Kmv Merchantville Clay
Kmr Magothy and Raritan Formations
CRANBURY TOWNSHIP
CRANBURY
MONROE TOWNSHIP
WEST WINDSOR TOWNSHIP
EAST WINDSOR TOWNSHIP
WASHINGTON TWP.
MILLSTONE TWP.
UPPER FREEHOLD TWP.
HIGHTSTOWN
DUTCH NECK
EDINBURG
WINDSOR
CARBONS MILLS
SHARON
ROOSEVELT
MIDDLESEX CO.
MERCER CO.
MONMOUTH CO.
Cranbury Neck Road
Cranbury Station Rd.
Cranbury Brook
Halsey Reed Rd.
Federal Rd.
Millstone River
Big Bear Brook
Dutch Neck Rd.
One Mile Rd.
Pennsylvania Railroad
Assunpink Creek
Ambrose Tindal Rd.
Windsor Sharon Rd.
Vogel Rd.
Jim Hill Rd.
Old York Rd.
Walters Rd.
New Jersey Turnpike
Timber Run
Perrineville Mercer County Rd.
535
539
130
33
TRs
P€
Kmr
Kmv
Kwb
Ket
Kmt

WEST WINDSOR TOWNSHIP

West Windsor Township, in many ways, reproduces on a small scale all of the ground water problems and the general ground water relationships that are found in Mercer County as a whole. In the township, wells draw water from cracks and fissures in two consolidated rock formations—the Stockton sandstone in the north and the Precambrian crystallines in the central area, and from sand and gravel lenses in two unconsolidated formations, the Raritan on the south and the thicker parts of the Pleistocene sand and gravel veneer in the central and southwestern areas.

Along both sides, but to a greater extent on the southerly side, of the main line of the Pennsylvania Railroad, the hard crystalline Precambrian rocks are found at or very close to the surface. The ancient land surface cut across these rocks has left, below the present surface and the younger overlying formation, a sort of wedge-shaped mass with a keel roughly parallel to the Pennsylvania Railroad plunging from the surface along Province Line Road on the west to a few feet below the surface at Princeton Junction on the east. The northwest side of this mass descends abruptly northwestward beneath the overlying Stockton sandstone. The southern side of this Precambrian core of West Windsor Township has a gradual southeasterly tilt, a surface relief of eighty feet or more, and is overlain by the clays and sands of the Raritan formation except for the above-mentioned exposed central zone which varies from one-half to nearly two miles in width. Within the area bounded by Province Line Road, the Pennsylvania Railroad, a line from Princeton Junction to Edinburg, and County Route 535, the Precambrian rocks are close enough to the present land surface to be the controlling factor in solving ground water problems in the area.

A Pleistocene veneer covers most areas of the township underlain by the Stockton sandstone, the Precambrian rocks, and the Raritan formation. Usually thin and of little significance in the ground water picture, the Pleistocene yellow sands and gravels are thick enough to produce water in a small area near Clarksville, and in a broad belt from Princeton Junction through Dutch Neck toward Windsor.

In the sampling of well records used to study the ground water conditions in West Windsor Township, 44 of the 100 wells draw water from the Stockton formation and 24 from the Precambrian rocks in the most intensely developed northern part of the township around Penns Neck, Princeton Junction and U. S. Highway #1. Fourteen wells have been completed in the thick portions of the Pleistocene and eighteen, along the eastern and southern borders of the township, draw from the sands of the Raritan formation.

The geologic relationships of the several formations from which water is obtained are shown on Section CC′ of the Geologic Cross Sections, Mercer County Plate II.

The table listed below gives the number of wells used in this study getting water from each of the four geologic formations. Industrial wells also include those for public water supply and for irrigation. For each formation and for domestic and industrial wells, the maximum, minimum, average and median depth and yield figures are given. Yield figures are not given for four wells (two Stockton and one Raritan domestic and one Pleistocene industrial test) and they are not, therefore, included in the tables below.

DOMESTIC WELLS — *YIELD IN GALLONS PER MINUTE*

Formation	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Stockton	17	60	6	19	15
Precambrian	14	50	..	12	10
Raritan	15	50	5	19	15
Pleistocene*	5	80	10	19*	17

* Average of six wells is 29 gpm.
Average excluding 80 gpm maximum well is 19 gpm.

INDUSTRIAL WELLS		*YIELD IN GALLONS PER MINUTE*			
Formation	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Stockton	27	700	25	165	100
Precambrian*	7	266 (150)	17	38*	60
Raritan	2	520	335	..	..
Pleistocene	7	340	50	162	145

* Average of six wells is 86 gpm.
Average excluding 150 gpm well and 266 gpm well is 38 gpm.

Estimates as to the depth of a well will depend to a large extent on the formation from which it is proposed to get the water. For the rock formations (Stockton and Precambrian) averages and medians are significant. For the sand formations, however, this is not the case, although the range in depth is useful in making an estimate. The Pleistocene sands and gravels are only usable in the areas of thickest accumulation and, therefore, all wells will probably be completed within the limits of the maximum and minimum depths. The Pleistocene and the Raritan often act as a single ground water unit. Successful wells to the Raritan formation will, therefore, start within the depth range of the Pleistocene wells and will become progressively deeper toward the southern part of the township. For a "rule of thumb" estimate for depth of wells to the Raritan formation, add 80 feet for each mile that you must go toward the ocean in a south-southeasterly direction from a known well. Correction, of course, should also be made for difference in the surface elevation between the known well and the proposed site.

DOMESTIC WELLS		*DEPTH IN FEET BELOW SURFACE*			
Formation	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Stockton	18	188	52	97	85
Precambrian	17	350	52	112	91
Raritan	15	205	55	103	92
Pleistocene	6	125	20	63	59

INDUSTRIAL WELLS		*DEPTH IN FEET BELOW SURFACE*			
Formation	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Stockton	27	518	40	269	300
Precambrian	7	393	103	281	298
Raritan	2	100	90	..	..
Pleistocene	8	113	27	67	78

There should be no difficulty in developing adequate household or domestic water wells in any part of West Windsor Township. In some areas underlain by Precambrian rock or where the Pleistocene gravels are thin and the underlying Raritan formation is high in its clay content, the well will probably be deeper than average or yield less water than average. If the lot sizes are small (½ acre or less) and reliance is placed in individual wells and individual septic tanks, trouble from pollution or inadequate water supplies may be expected. In areas underlain by Precambrian rock or the Stockton sandstone, the minimum lot size should be in excess of the one-half acre minimum.

The affect of a number of heavily pumped industrial wells upon a nearby intensely developed residential area with individual wells was illustrated by the experience of the Penns Neck area during the early 1940's. Wells Nos. 53, 55, 56 and 57 were drilled, heavily pumped and the domestic wells nearby were dried up or had the static water level lowered below the level of the pumping equipment. Eventually the industrial wells proved inadequate and a pipeline to the canal was built. Static water levels have probably been restored since heavy pumpage has been discontinued.

Light industry or research facilities with large water requirements may have difficulty in meeting their needs in several areas of West Windsor Township. The light industry zone north of U. S. Route #1 (zoning map revised 4/12/57) can draw water from the Delaware and Raritan Canal or secure an average yield between 100 and 130 gallons per minute from properly constructed and properly spaced wells completed in the Stockton formation. South of U. S. Route #1 between Penns Neck and Princeton Junction the light industry and research zone has been developed by wells of American Cyanamid Heyden Plant, R. C. A., Wildermuth, and others to a point close to the limit of available ground water if all the existing wells are used. West of Penns Neck (Alexander Road) it would still be possible to develop the usual wells expected for the Stockton formation.

Of the five wells drilled for the Heyden Chemical in the middle 1940's #5 was never used, #2 and #4 were abandoned, and #1 and #3 are in a standby condition. Water is now pumped from the canal. The yield of #1 and #2, R. C. A. wells, has dropped about one-third in the nearly twenty years since their installation. The Wildermuth wells and others for industry or business, where large amounts of water were not required, are apparently still giving satisfactory yields.

Because the Precambrian crystalline rocks are close to the surface, the light industry and research zone along the Pennsylvania Railroad and the Dutch Neck and Edinburg Village residential zones may not be expected to develop more than very modest water supplies from wells. Most of this part of the township lies within the Assunpink and the Delaware River watershed. Although few industrial wells have been tried, none of these wells, industrial or domestic, can be considered highly successful. On the fringes of the area, three wells have given in excess of 100 gpm: At Clarksville #93 was reported as giving 100 gpm, but #2 was not tested; at Dutch Neck #94 gave 190 gpm, but #30 nearby was not tested; and in the southeast corner of the township #38 gave 335 gpm from the Raritan, but #37 drilled to the Precambrian at a depth of 80 feet gave no water. One industrial well, #4, gives 30 gpm and most of the other wells in or near this area give 12 gpm or less. It would seem prudent, therefore, for the future development of these areas to plan for the importation of water either within the basin through the Trenton and Hamilton Square water systems or from the eastern and southern parts of the township from wells drawing from the Raritan formation.

During the past ten years in the area around Princeton Junction there have been a variety of well problems ranging from pollution, through decreasing yield of wells, to failure to secure water from the underlying Precambrian rocks. South and southeast of Princeton Junction, where the Raritan formation or the Pleistocene becomes thick enough and sandy enough, large yield wells have been completed and others may be anticipated. Since this area of West Windsor Township is in the Millstone (Raritan) watershed with the most intensely developed part of the township underlain by geologic formations unfavorable to the development of large ground water supplies, consideration should be given to plans for linking the existing water systems and larger wells to one another and the eventual tapping of the Delaware and Raritan Canal or construction of large supply wells in the southern part of the township.

There is still a great deal of water available to West Windsor Township (something in the neighborhood of 10 million gallons per day if it all could be utilized), but the areas of greatest potential industrial development and future concentration of people do not coincide with the areas of greatest availability of ground water.

WEST WINDSOR TOWNSHIP

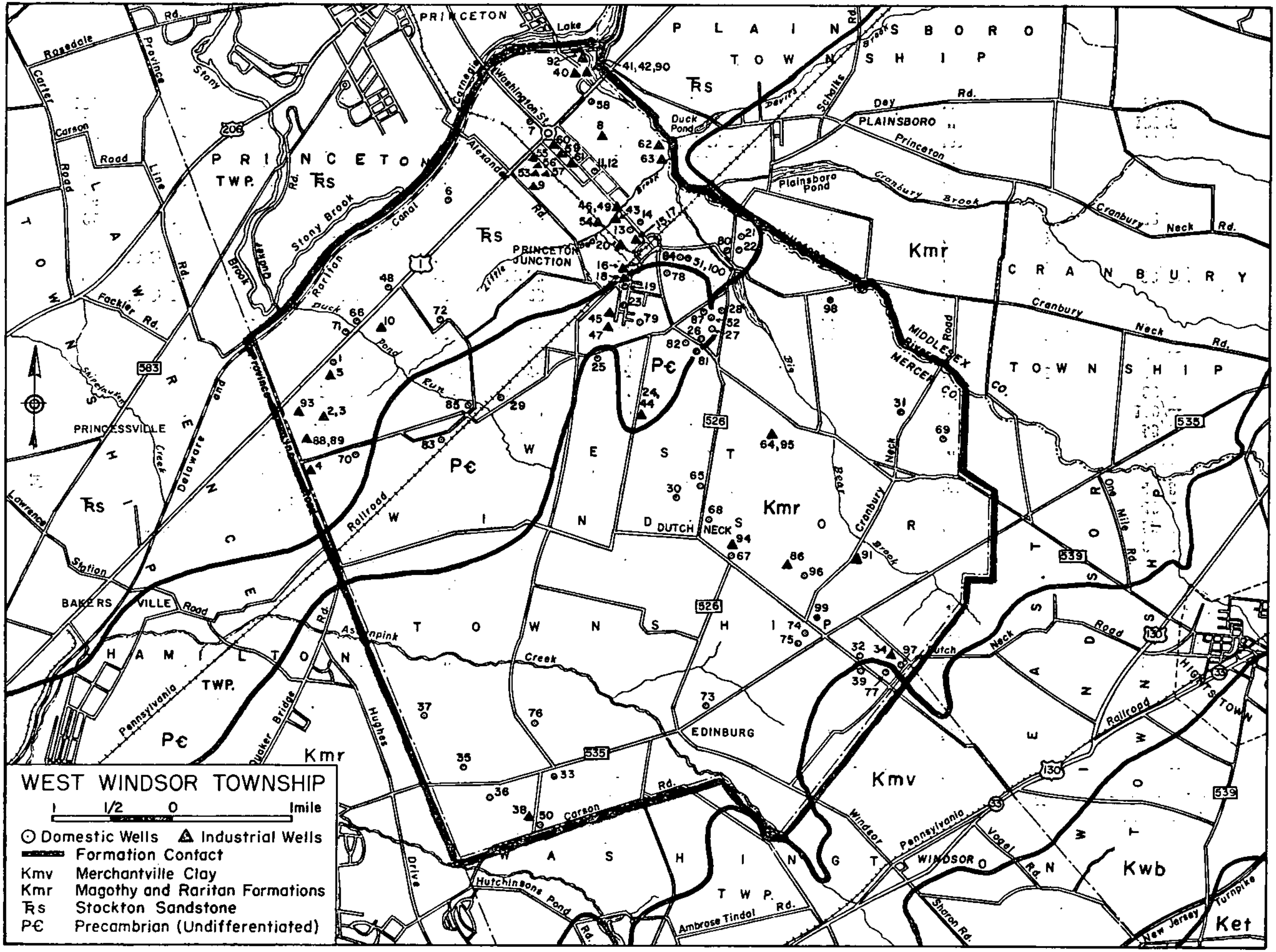
Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
1	6	8	82	Trs	22	15	Design for Living	'57		75/3
2	8	no test	36	Qal	36	. .	American Cyanamid #6	'59	I	. . .
3	8	25	300	Trs	. .	26	" #3	'58	I	158/8
4	8	30	202	"	92	44	Winkler	'57	I	79/30
5	12	80	169	"	34	7	American Cyanamid #4	'59	I	138/9
6	6	15	83	"	35	. .	Nelis	'56		75/3
7	6	6	67	"	30	28	Public Service	'59		22/2
8	10	108 (60 gpm 1961)	436	"	35	16	R. C. A.	'55	I	200/12
9	6	55	200	"	37	11	Springdale Whse. Corp.	'59	I	93/8
10	8 & 6	34	320	"	37	2	Paradise Pool	'54	I	155/15
11	8 & 6	20	52	"	38	5	Stanfield Corp.	'57		10/—
12	8 & 6	6	78	"	32	15	"	"		65/—
13	8 & 6	7	74	"	54	16	Bowers	'54	I	50/—
14	6	15	157	"	57	11	Good	'56		15/—
15	6	30	155	"	44	10	R. Williams, Inc.	'56	I	28/6
16	6	30	178	"	70	10	Aero. Res. Asso. of Princeton	'57	I	40/6
17	6	60	107	"	35	. .	Tower Construction	'56	I	22/7
18	8 & 6	20	312	pC	74	2½	Princeton Jct. Water Co.	'55	I	170/8
19	6	30	52	"	35	11	Valinotino	'54		32/4
20	6	70	229	"	150	17	Warner	'59	I	142/12
21	6	40	175	Trs	60	27	F. Steward	'57	I	34/14
22	6	9	135	"	45	21	H. Raylinek	'58	I	60/4
23	6	5	135	pC	35	17	Poenio	'54	I	120/½
24	8	60	283	"	33	3	Princeton Colonial Park	'58	I	170/8
25	6	20	143	Kr (P) pC (B)	119	5	Holcombe	'56	I	60/4
26	8 & 6	10	84	pC	67	12	Ziff	'58	I	50/—
27	6	50	109	"	64	21	F. M. Smith	'54		85/6
28	6	10	129	"	67	25	Malach	'57		101/6
29	6	10	91	"	47	18	Zerman	"		60/6
30	10	. .	62	"	60	. .	Reed	'54		. . .
31	6	15	85	Kmr	82	28	Perrine	'57		34/6
32	6	20	125	Qal	. . .	24	R. R. Black	"		42/6
33	3	12	74	Kmr	71	28	W. C. Dye	'62		45/6
34	10	520	170	"	83	13	Zaitz & Son	'55	I	32/8
35	3	20	78	"	73	35	Schumacher	'56		40/1½

WEST WINDSOR TOWNSHIP (Continued)

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
36	6	15	70	Kmr	67	24½	Harle	'54		34/—
37	4	0	80	pC	58	..	Applegate	'57		....
38	10	335	180	Kmr	76	27	Cubberly	"	I	60/8
39	6	15	92	"	89	20	Arendt	"		....
40	13½ & 10	450	302	Trs	..	4	Princeton Water Co. B-4	'30	I	55/—
41	12 & 10	300	275	"	..	1	" "	'27	I	89?/—
42	14 & 10	350	301	"	30	0	" B-3	'29	I	90/48
43	8	150	393	pC	89	0	McLean Engineering	'53	I	80/8
44	8	266	339	"	47	8	Princeton Colonial Park	'58	I	84/9
45	6	25	306	"	62	58	Princeton Jct. Water Co. #2	'38	I	165/—
46	8	50	400	Trs	..	4	Princeton Natatorium	'33	I	130/—
47	6	17	103	pC	..	23	Princeton Jct. Water Co.	'25	I	85/—
		(Contaminated)								
48	6	10	84	Trs	..	4	Boyd	'28		....
49	8	100	40	"	..	..	Princeton Natatorium	'31 (or '32)	I	27/—
50	6	50	82	Kmr	..	40	Cubberly	'13		40/—
51	6	15	188	Trs	100	32	Dixon	'51		80/6
52	6	18 (Irony)	185	pC	..	29	Allen	'53		52/—
53	10	105	353	Trs	..	7	Heyden Chem. Co. #3	'44	I	155/—
54	16 & 10	96	518	"	83	flows	" #5	'46	I	182/48
55	12 & 10	300	249	"	..	122	" #4	'44	I	163-172/—
56	12	525	300	"	..	7	" #1	'43	I	136/—
57	12	70	406	"	..	12	" #2	'44	I	182/—
58	6	60	89	"	30	11	Hartpence	'36		40/—
59	..	55	135	"	..	1	Wildermuth #1	'26	I	....
60	8	55	129	"	..	15	Wildermuth #2	'37	I	40/8
61	8	60	252	"	49	30	" #3	'50	I	57/6
62	16 & 10	180	400	"	53	10	R. C. A. Labs #1	'44	I	140/48
		(125 gpm 1961)							deepened	
63	10	296	205	"	..	11	" #2	'41	I	49/24
		(200 gpm 1961)								
64	8	50	113	Qal (P) pC (B)	..	33	Wing Hing	'45	I	70/—
65	4	12	69	Qal	..	25	Bordon	'54		....
66	..	36	80	Trs	..	10	Levine	'30		....

WEST WINDSOR TOWNSHIP (Continued)

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
67	6	17	57	Qal	48	14	Dutch Neck School #1	'51		50/10
68	6	?	105	pC	80	..	Wyckoff Farm	'31		....
69	4	6	55	Kr	..	40	Smith	'55		50/—
70	.. (Dug well)	10	20	Qal	..	17	Dilatush	'50		....
71	6	22	100	Trs	..	..	Frank Bros.	'29		....
72	6	18	86	"	45	18	Amabile	'50		20/2
73	4	10	70	Kr	4	6	Sampson	'54		15/—
74	..	5	169	"	..	..	Hand	'32		....
75	..	..	205	Kr (P) pC (B)	..	..	"	"		....
76	..	5	350	pC	..	8	Robinson	..		....
77	4	25	104	Kmr	100	25	Rhoades	'52		60/6
78	6 & 4	40	45	Qal	43	15	L. Gibbs	'57		25/6
79	6	1½	52	pC	46	15	H. Schonader	'55		40/2
80	6	20	52	Trs	47	19	J. Bastian	'55		40/3
81	6	15	65	pC	51	13' 6"	J. Marini	'59		....
82	6	4½	115	"	107	41	"	"		....
83	6	12	110' 6"	"	84' 3½"	8	V. Moratkowski	'58		93/6
84	6	6	137	Trs	64	32	J. Luther	"		100/—
85	6	10	90' 6"	pC	64' 6"	15	C. Jolly	'57		80/6
86	10	340	91	Qal	72	15	L. Grover, Jr.	'55	I	60/10
87	6	7	87	pC	70	13	J. Ziff	'58		60/—
88	18	80	300	Trs	..	..	American Cyanamid	'59	I	....
89	24	145	27	Qal	27	..	American Cyanamid	'59	I	....
90	18 & 12	700	335	Trs	63	12	Princeton Water Co.	'56	I	....
91	10	240	82	Qal	64' 3"	3	W. Schenck & Sons	'55	I	80/8½
92	16 & 12	250	300	Trs	59	15	Princeton Water Co.	'45	I	....
93	8	100	41	Qal	32	9	American Cyanamid	'60	I	....
94	10	190	70	"	20' 1"	16	Gordon Tindall, Jr.	'55	I	62/9
95	8	70	78	"	..	28	Wing Hing	'45	I	....
96	6	80	61	"	42	3	Mullen Bros.	'55		....
97	6	38	125	Kmr	121	27	Hawley	"		....
98	4	10	68	"	65	40	W. C. Wilson	'61		....
99	4	30	129	"	126	38	W. Vernon	"		125/6
100	6	10	120	Trs	55	62	D. Armstrong	'60		36/1


WEST WINDSOR TOWNSHIP
1 1/2 0 1mile
⊙ Domestic Wells ▲ Industrial Wells
Formation Contact
Kmv Merchantville Clay
Kmr Magothy and Raritan Formations
T̶Rs Stockton Sandstone
P€ Precambrian (Undifferentiated)
PRINCETON
PLAINSBORO TOWNSHIP
PRINCETON TWP.
LAWRENCE TOWNSHIP
CRANBURY TOWNSHIP
WEST WINDSOR TOWNSHIP
HAMILTON TWP.
WASHINGTON TWP.
EAST WINDSOR TOWNSHIP
MIDDLESEX CO.
MERCER CO.
PRINCETON JUNCTION
DUTCH NECK
EDINBURG
PRINCESSVILLE
BAKERSVILLE
PLAINSBORO
WINDSOR
HIGHTSTOWN
Kwb
Ket

PRINCETON TOWNSHIP

Princeton Township's 18.8 square miles, which include Princeton Borough, can be divided roughly into five zones each underlain by a different type of rock. The northern and higher part of the township, the Mt. Lucas area, is underlain by diabase. Included in this zone, which lies south of Cherry Valley Road and is about a mile wide, is some baked shale found along the northern diabase-shale contact. The second zone composed chiefly of normal and baked argillite, is a narrow zone one-quarter to one-half a mile wide forming the hills south of the diabase. The third zone is underlain by Brunswick shale which forms the valley from Pretty Brook Road, eastward near Township Hall to the Princeton Shopping Center and the basin of Harry's Brook. The fourth zone, or main argillite zone, includes the height of land followed by Rosedale Road and Nassau Street and includes nearly all of Princeton Borough. The remainder and topographically lower part of the township to the south of Princeton Borough is underlain by the Stockton sandstone.

All of Princeton Borough and large areas of Princeton Township to the east of Stony Brook and to the north and northwest of the borough are served by the Princeton Water Company. Most of the Princeton Water Company wells are near Carnegie Lake (#55, #56, and #57) and draw from the Stockton sandstone. Several of these wells are actually in West Windsor Township, but two #16 and #17 draw from the Brunswick shale valley to the north of Princeton Borough.

There are only ten industrial wells in the Princeton Township tabulation. In addition to the five for the Princeton Water Company mentioned above, there are two others (#37 and #38) drawing from the Brunswick shale zone in the Shopping Center area. All are notable for their large diameter (10" or 12"), depth (in excess of 300 feet), and, with one exception, yield (in excess of 197 gpm). An eight inch well for Bambergers (#41) in the Brunswick shale is about average, as are the two wells (#46 and #48) drilled in the Lockatong formation although for this formation they are rather good. Industrial wells may be summarized as follows:

Formation	*Diameter Inches*	*Yield GPM*	*Depth (feet)*	*Map No.*	*Owner*
Stockton	10	600	304	55	Princeton Water Company
"	10	200	583	56	" " "
"	12	905	302	57	" " "
Brunswick	12	197	403	16	" " "
"	12	88	572	17	" " "
"	10	460	393	37	Shopping Center
"	10	470	422	38	" "
"	8	140	179	41	Bambergers
Lockatong	8	50	300	48	University Laundry
"	6	38	85	46	Rockwood Dairy

From the above it might be assumed that a greater diameter or depth for a well will give a greater yield. However, the 6" dometic wells for T. Chin (#1) gives 100 gpm from 85'; and that for Cresswell (#28) gives 60 gpm from 167' out of fractures in diabase. An 8" domestic well in argillite (#9, Foulet) gives 30 gpm from 240' and a 6" domestic also in argillite (#24, Schultes) gives 55 gpm from 155 feet. Three other 6" domestic wells in the Stockton formation give 60 gpm from 190 feet; 50 gpm from 107 feet; and 43 gpm from 85 feet. No other wells in Princeton Township give in excess of 30 gpm although there are a number of deep 8" wells drilled in the Lockatong argillite which are notably unsuccessful (#8, 3 gpm from 452 feet; #26, no water from 108 feet; and #72, 6½ gpm from 396 feet).

A study of the wells in Princeton Township, because of the variety of rock types and the limited number of industrial wells, indicates quite clearly that domestic wells can overlap the yield range of industrial wells, that there is no correlation between depth and yield in rock wells and that if a water bearing fracture is encountered, the large diameter well will yield more water.

Records in the office of the New Jersey Survey indicate that the five Lambert wells for domestic use were located in Lockatong argillite by a "professional dowser" with the following results of something less than average yields and greater than average depth:

Well No.	Diameter in Inches	Yield—GPM	Depth in Feet
8	8	3	452
39	6	1/5	378
71	8	10	276
72	8	6½	396
73	6	2	287

Obviously, other allegedly highly successful wells have been located by "dowsers"; but the records also show that the several highly successful industrial wells have been located by geologists. Most of the wells, however, including many good ones, have been drilled where the well driller and owner found it most convenient to locate the well in relation to the house, the septic tank, and other features on the lot.

The abundance of domestic wells in any given area of Princeton Township has been to a considerable extent controlled by the water company service area and the fact that the more intense residential development has been in a more rugged terrain of the township. The largest number of domestic wells have, therefore, been drilled in the diabase and the Lockatong argillite, frequently with unsatisfactory results.

Only seven out of the sixty-five domestic wells in the township give in excess of 30 gpm, but some of these are reported as giving such a high yield that the average yield values are substantially increased. About fifteen wells, on the other hand, give less than the 5 gpm minimum required for a satisfactory domestic well. There is no obvious geologic reason for these much better or much worse than average wells, although most of the better wells are located on rather marked topographic linear features suggesting major joints or minor faults. A number of the poorer wells are not as deep as the average depth in their rock type, suggesting that their failure is due to an inadequate and half-hearted effort, perhaps induced by a lean pocketbook, to secure the desired water.

DOMESTIC WELLS

Formation	No. of Wells	YIELD IN GALLONS PER MINUTE Maximum	Minimum	Average	Median
Stockton	11	60	12	26	20
Lockatong	26	55	1/5	8*	6
Brunswick	8	30	5	11	8
Diabase	20	100	0	16**	4

* Average of 25 wells, without 55 gpm well is 6 gpm. One-third of the wells give 3 gpm or less.
** Average of 18 wells without 100 gpm and 60 gpm wells is 6 gpm. One-half of the wells give less than 4 gpm.

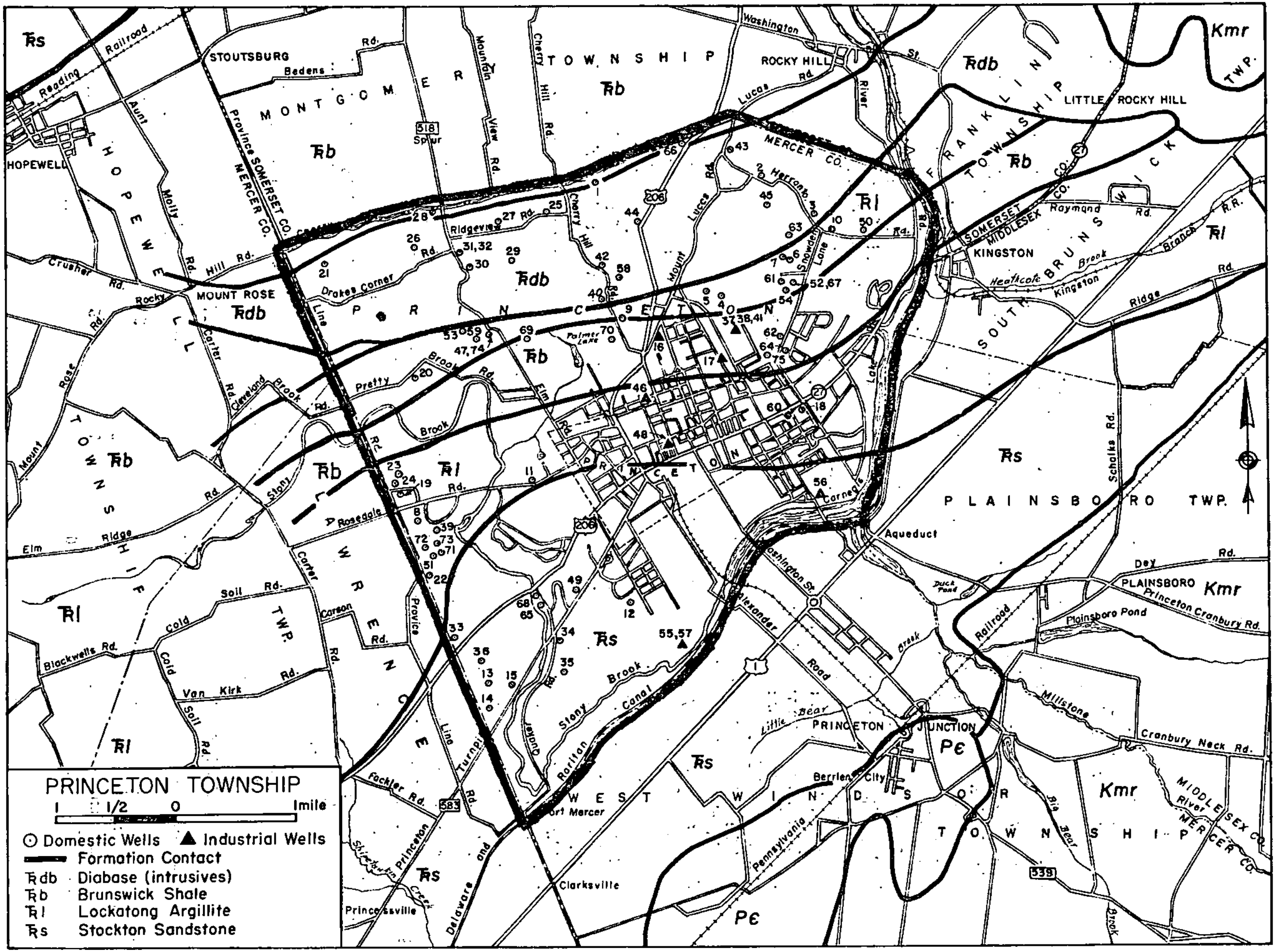
Formation	No. of Wells	DEPTH IN FEET BELOW SURFACE Maximum	Minimum	Average	Median
Stockton	11	190	85	140	131
Lockatong	26	610	77	218	175
Brunswick	8	350	98	210	181
Diabase	20	338	50	139	108

PRINCETON TOWNSHIP

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
1	6	100	85	Trdb	. .	12	T. Chin	'58		. . . .
2	8	½	338	"	136	32	A. Io	'57		. . . .
3	6	10	140	"	23	18	Seaman	'56		100/—
4	6	6	400	Trl	20	16	Ital. Amer. Sportsmans Club	'53		150/—
5	6	3	115	"	24	8	"	"		90/—
6	6	2½	200	"	24	21	Bayer	'56		135/2
7	6	10	163	"	27	10	Humphreys	'57		100/6
8	8	3	452	"	32	12	Lambert #5	'55		212/6
9	8	30	240	Trb	181	37	Foulet	'57		150/9
10	8	2½	229	Trl	. .	8	Mrs. Pyne	'28		. . . .
11	8	16	77	"	29	3	Fox	'57		65/6
12	6	15	150	Trs	22	18	Inst. for Advanced Study	'56		50/—
13	6	10	110	"	23	23	Cashvan	'59		. . . .
14	6	28	100	"	23	23	Miller	"		. . . .
15	6	43	85	"	23	18	"	"		. . . .
16	12	197	403	Trb	36	13	Princeton Water Co.	'58	I	200/8
17	12	96	572	"	. .	70	"	'57	I	183/8
18	6	5	108	Trl	24	15	Harris	'59		70/—
19	6	5	175	Trb	24	7	Snedaker & Son	'54		160/4
20	6	10	95	Trl	18	10	Vancleve	'52		40/5
21	6	2	100	Trdb	. .	20	Hall	'51		95/—
22	6	5	97	Trl	15	18	Flag	'52		85/—
23	6	6	137	"	23	18	Endersky	"		70/—
24	6	55	155	"	28	6	Schluter	'49		50/—
25	. .	0	138	Trdb	. .	. .	Pettit	'26		. . . .
26	8	0	108	"	. .	. .	Laughlin	'31		. . . .
27	6	0	101	"	. .	. .	Grecy	'26		. . . .
28	6	60	167	"	41	10	Cresswell	'25		. . . .
29	6	½	169	"	20	70	Beller	'47		. . . .
30	8	25	174	"	53	8	Sayer	'51		133/—
31	. .	1	322	"		. .	Howe #2	'26		. . . .
32	6	17	100	"	25	. .	" #1	"		. . . .
33	6	50	107	Trs	25	8	Stokes	'41		25/—
34	6	30	91	"	21	26	Princeton Quaker Meeting	'53		28/2
35	8	60	190	"	30	17	Eno	'43		45/—
36	. .	12	158	"	. .	50	Lauck	'47		145/—
37	10	460	393	Trb	38	1	Princeton Shopping Center	'52	I	50/12

WEST WINDSOR TOWNSHIP (Continued)

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
38	10	470	422	Trb	30	8	Princeton Shopping Center	'52	I	88/12
39	6	1/5	378	Trl	27	32	Lambert #1	'49		....
40	6	20	70	Trdb	..	12	Behrens	'29		60/8
41	8	140	179	Trb	31	30	Bambergers	'53	I	65/—
42	6	4	70	Trdb	23	6	Zullig	'54		60/—
43	6	8	75	"	52	7	Geherty	'52		25/—
44	6	12	270	"	57	18	Cook	"		....
45	6	0	90	"	20	..	Levine	"		....
46	6	38	85	Trl	..	10	Rockwood Dairy	'38	I	....
47	6	1½	165	"	16	15	Yates	'27		....
48	8	50	300	"	..	flows	University Laundry	'49	I	100/—
49	6	15	109	Trs	7½	20	Tuska	'48		64/2
50	6	8	175	Trl	18	20	Todd	'50		80/—
51	6	6	182	"	23	19	Swan	'48		93/—
52	6	6	230	Trb	22	25	Stockton	"		90/—
53	6	3	610	Trl	..	..	Mathey	'26		....
54	6	10	141	"	23	14	Funkhouser	'52		38/2
55	10	600	304	Trs	..	13	Princeton Water Co.	'15	I	....
56	10	200	503	"	..	..	"	'29	I	....
57	12	905	302	"	27	15	"	'37	I	100/—
58	6	1	87	Trdb	25	22	Salzman	'47		87/2
59	6	6	140	Trl	24	19	Pretty Brk. Corp. Lot A	'28		....
60	6	12	186	"	..	8	Parker	'10		....
61	6	20	156	"	34	5½	Bower	'52		45/2
62	6	16	181	Trb	33	28	Howell	'38		56/—
63	6	4	125	Trdb	..	25	Goodwin	'51		80/—
64	6	5	92	Trb	..	25	Davidson	"		60/—
65	6	20	149	Trs	..	32	Cullen	'49		90/—
66	6	5	50	Trdb	..	15	Cramer & Bogert	'47		....
67	6	10	202	Trl	22	16	Bond	'48		60/2
68	6	15	131	Trs	22	55	Birch	"		70/—
69	6	12	180	Trb	..	..	Benson	'28		....
70	8	8	350	"	..	..	Pardee	'38		....
71	8	10	276	Trl	..	23	Lambert #4	'49		276/—
72	8	6½	396	"	22	10	" #3	'48		140/—
73	6	2	287	"	27	23	" #2	'49		....
74	6	1	160	"	15	4	Yates	'26		....
75	6	8	252	Trb	30	30	Kilgore	'53		....


PRINCETON TOWNSHIP
1 1/2 0 1mile
Domestic Wells
Industrial Wells
Formation Contact
Ꞧdb Diabase (intrusives)
Ꞧb Brunswick Shale
Ꞧl Lockatong Argillite
Ꞧs Stockton Sandstone
STOUTSBURG
HOPEWELL
ROCKY HILL
LITTLE ROCKY HILL
KINGSTON
MOUNT ROSE
PRINCETON
PLAINSBORO
PRINCETON JUNCTION
Berrien City
Port Mercer
Clarksville
Princessville
Aqueduct
MONTGOMERY TOWNSHIP
FRANKLIN TOWNSHIP
SOUTH BRUNSWICK
HOPEWELL TOWNSHIP
LAWRENCE TWP.
PLAINSBORO TWP.
WEST WINDSOR TOWNSHIP
SOMERSET CO.
MERCER CO.
MIDDLESEX CO.
Delaware and Raritan Canal
Stony Brook
Millstone River
Kmr
Pє

LAWRENCE TOWNSHIP

Most of Lawrence Township is underlain by either the Stockton sandstone or the Lockatong argillite. A narrow zone of Brunswick shale is found along Stony Brook in the northern part of the township. Most of the township south of U. S. Route #1 is underlain by Precambrian rocks.

All of the area underlain by Precambrian rocks is served by the Trenton Water Company. About half of the area underlain by the Stockton sandstone is served by the Trenton Water Company or by the Lawrenceville Water Company. Most of the township south of Route #206 is close enough to the Delaware and Raritan Canal for industrial water supplies to be drawn from the canal by the construction of a pipeline.

Of the seven wells in Lawrence Township drawing from Precambrian rocks, four are industrial wells that can hardly be considered adequate and three are domestic wells that are satisfactory—with yields of 5, 6, and 14 gpm from 65, 123 and 113 feet, respectively. Two of the industrial wells, giving 5 gpm from 304 feet and 15 gpm from 253 feet, would meet the sanitary needs of a small plant or a domestic well. The other two industrial wells, giving 70 gpm from 330 feet and 60 gpm from 59 feet, are adequate for some industrial uses where a large yield is not required. Two other industrial wells, #78 and #82, were driven into the Precambrian rocks but draw from the overlying sandstone just above the harder crystalline rocks. These wells are 265 and 180 feet deep, respectively.

The two domestic wells, #59 and #62, drawing water from a narrow band of Brunswick shale, are adequate but are below average wells for the formation, giving, respectively, 5 gpm from 204 feet and 7 gpm from 131 feet.

The higher northern part of Lawrence Township, north of Route #206, except for the above-mentioned shale zone, is underlain by the Lockatong argillite. Only a small part of this highly desirable residential area is served by the Lawrenceville Water Company. At the present time (1962) most of the area is in small farms with some houses along the main roads. Most of the houses are on one acre lots with several on even larger lots. It remains to be seen, but it seems unlikely, that ground water will be adequate for the full development of the area on lots averaging one acre or less. Experience elsewhere in Mercer County suggests that lot sizes for intensive residential development of areas underlain by argillite should be at least two acres if all houses are relying upon individual wells and individual septic tanks.

Two large tracts of the argillite zone are occupied by industry. One, occupied by Educational Testing Service, has four of the six argillite industrial wells. The other, an overseas radio transmitting area, has no industrial water requirement. The remaining two argillite industrial wells are for the Buxton Dairy and give a minimum supply for this type of activity (19 gpm from 250 feet and 15 gpm from 250 feet). Three of the Educational Testing Service wells are adequate for normal sanitary water requirements (50 gpm from 223 feet 45 gpm from 208 feet and 20 gpm from 281 feet) but the fourth (2 gpm from 281 feet) is hardly adequate for domestic use.

The yields and depths of the thirty-two domestic wells drawing from the Lockatong formation are summarized below. Although there were no failures, two wells give only 2 gpm and five wells give 5 gpm or less, showing that about 20% of the wells in the Lockatong are inadequate.

In the area of Lawrence Township underlain by the Stockton Formation (south of Route #206 and north of U. S. Route #1) a sampling of thirty-three domestic wells and nineteen industrial wells indicates that domestic wells are always adequate and that industrial wells are adequate for moderate demands. The type of industry for which most of the industrial wells were drilled suggests that when larger supplies of water were required, the wells were successful and that the moderate yield of the Stockton wells results more from a moderate requirement than from an inability to obtain water from the wells.

INDUSTRIAL WELLS

		Yield in GPM			
Formation	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
Stockton	20	340	30	94	75
Lockatong	6	50	2	25	19
Precambrian	4	70	5	..	..
Brunswick	0	..	..	..	..

Formation	No. of Wells	Depth in Feet Maximum	Minimum	Average	Median
Stockton	20	402	83	177	164
Lockatong	6	327	208	256	250
Precambrian	4	330	59	..	..
Brunswick	0	..	..	..	..

DOMESTIC WELLS

Formation	No. of Wells	Yield in GPM Maximum	Minimum	Average	Median
Stockton	33	35	5	15	15
Lockatong	32	30	2	10	7
Precambrian	3	14	5	..	..
Brunswick	2	7	5	..	..

Formation	No. of Wells	Depth in Feet Maximum	Minimum	Average	Median
Stockton	33	242	55	100	95
Lockatong	32	350	50	147	125
Precambrian	3	123	65	..	..
Brunswick	2	131	204	..	..

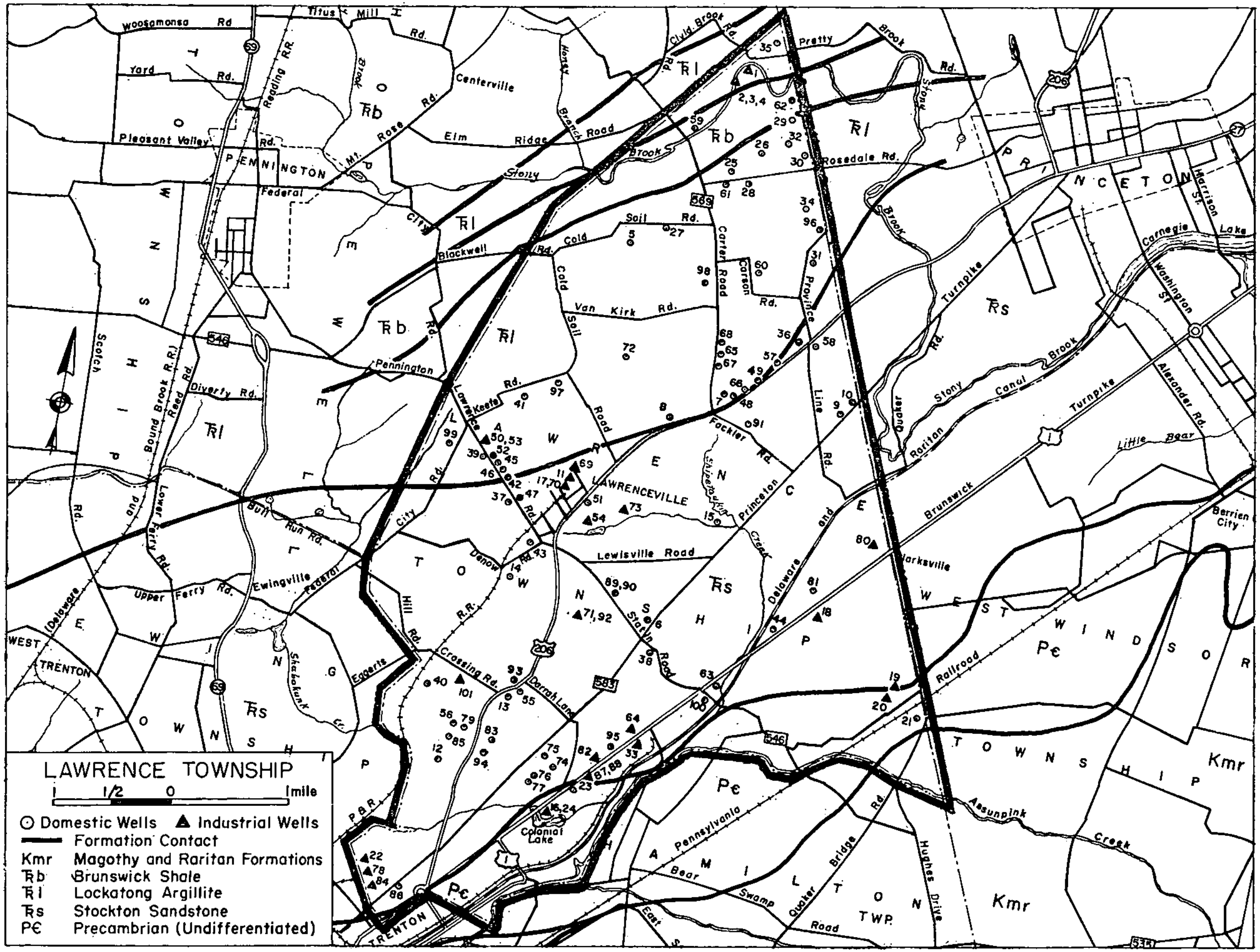
LAWRENCE TOWNSHIP

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
1	12–8	45	248	Trl	45	13	Education Testing Service	'57	I	161/48
2	12–8	20	281	"	45	13	"	"	I	158/48
3	12–8	2	317	"	45	26	"	"	I	....
4	12–8	50	223	"	50	5	"	'56	I	160/48
5	8–6	6	350	"	21	6	Woods	"		245/4
6	6	30	103	Trs	26	40	Albert Chemical	'57		45/4
7	8–6	5	100	Trl	18	22	Thompson	'54		90/—
8	8–6	10	169	"	28	22	Rusling	"		70/—
9	6	18	146	Trs	23	..	Cashvan	'59		....
10	6	15	146	"	38	20	"	"		....
11	8	30	230	"	..	..	Lawrenceville Water Co. #2	'24	I	....
12	6	6	123	"	36	10	Charles Long (Bldr.)	'62		100/4
13	6	20	75	"	27	18	Wenzel	'56		48/4
14	8	25	121	"	42	10	Darby	'54		19/6
15	6	20	80	"	32	9	Campbell	'56		30/4
16	8	5	304	pC	31	11	Colonial Bowling Alley	'49	I	....
17	12–8	300	150	Trs	..	8	Lawrenceville Water Co.	'37	I	35/—
18	8	75	164	"	57	flowed	N. J. Motor Vehicle Station	'56	I	69/24
19	12–8	70	350	pC	87	9	Curtiss Wright	'58	I	150/48
20	12	60	59	"	29	7	Curtiss Wright	'58	I	50/24
21	6	6	123	"	55	14	Halper	'59		97/6
22	6	50	145	Trs	..	4	Para Lab Supply Co.	'48	I	31/8
23	6	14	113	pC	35	17	Cunningham	'54		80/4
24	8	15	253	"	30	12	Colonial Bowling Lanes	'56	I	134/8
25	8–6	7	80	Trl	21	5	LaPlaca	'51		35/—
26	8	15	337	"	24	4	Schleuter	"		140/6
27	6	25	103	"	22	10	Goldstine	'50		45/6
28	8–6	9	130	"	22	5	Beacraft	'51		50/—
29	6	7	130	"	21	10	Hannah	'29		100/8
30	6	15	119	"	24	9	Cowan	"		60/6
31	6	2	199	"	24	15	Katzenbach	'41		150/—
32	..	6	201	"	..	18	Batton	'30		127/—
33	10	340	212	Trs	..	13	Lawrence Hose Co.	'47	I	65/9
34	..	25	185	Trl	..	11	Goodridge	'38		108/—

LAWRENCE TOWNSHIP (Continued)

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
35	6	12	248	Trl	22	62	Gemmell	'49		....
36	..	18	242	Trs	..	..	Rakin	'29		....
37	6	10	95	"	34	22	Hance	'51		50/—
38	6	5	157	"	35	16	Hunter	'49		60/6
39	6	12	83	Trl	22	14	Kocon	'51		50/—
40	6	20	70	Trs	..	19	Muskewitz	"		33/4
41	6	20	90	Trl	28	5	Newman	'47		20/—
42	6	7	100	Trs	..	11	Rich	'52		50/—
43	6	12	63	"	35	14	Robinson	'51		14/8
44	6	8	140	"	57	6	F. Carlisi	'61		68/6
45	6	5	77	Trl	24	8	Vanderbilt	'52		76/2
46	6	4	121	"	23	6	VanDoren	'52		40/2
47	6	8	90	Trs	20	12	VanSyckle	'51		25/—
48	6	8	106	Trl	44	25	Raymond	'53		60/—
49	6	4	100	"	35	28	D. Penrose	'53		70/—
50	8	19	250	"	26	2½	Buxton Dairy	'48	I	140/—
51	6	25	60	Trs	..	6	Costello	'51		8/4
52	6	13	144	Trl	22	8	Demowski	'53		84/2
53	8	15	250	"	..	30	Buxton's Dairy	'38	I	....
54	6	125	201	Trs	..	..	Lawrenceville School	'14 or '15	I	15/—
55	6	15	56	"	35	12	Bruschi	'52		12/5
56	6	15	72	"	38	8	A. Colligan	'51		30/—
57	6	7	198	Trl	23	22	Lauck	'50		104/6
58	6	20	115	Trs	17	45	Luccarelli	'52		90/—
59	4	5	204	Trb	..	35	Prickett	'34		150/—
60	6	30	105	"	28	3	Hazeltine	'49		15/—
61	6	6	76	Trl	..	4	LaPlaca	'51		55/—
62	6	7	131	Trb	18	12	J. Kelly	'52		70/—
63	6	35	116	Trs	33	1	Kaplan	'49		40/8
64	6	72	150	"	34	4	S & F Theatres Inc.	"	I	58/4
65	6	5	149	Trl	24	18	Hutchinson	'52		90/3
66	6	15	125	"	31	26	Houghton	'53		70/—
67	6	7	160	"	22	10	Mitchell	'50		100/1
68	6	8	152	"	..	70	Waring	'51		70/1

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
69	12	90	286	Trs	. .	8	Lawrenceville Water Co. No. 4	'51	I	50/24
70	8	60	110	"	. .	6	" No. 3	'32	I	18/—
71	6	33	112	"	50	. .	Green Acres	'31	I	26/—
72	6	9	123	Trl	. .	20	Houghton	'34		. . . .
73	10	152	402	Trs	41	8	Lawrenceville School	'47	I	145/24
74	6	18	65	"	. .	8	Aldrich	'51		12/4
75	6	7	108	"	. .	10	Bayless	. .		. . . .
76	6	8	122	"	20	20	Biddle	'51		40/4
77	6	6	65	"	. .	15	Commiso	"		30/—
78	8	33	265	Trs (P) pC (B)	55	15	Integro Inc. #2	'52	I	140/6
79	6	25	70	Trs	34	6	Thompson	'52		30/4
80	8	30	85	"	41	17	Clarksville Diner	'60	I	23/6
81	6	8	73	"	. .	3	Nadi	'29		. . . .
82	6	45	180	Trs (P) pC (B)	23	7	Transport Mfg. & Equip. Co.	'52	I	15/8
83	6	7	72	Trs	. .	10	Gallimore	'51		25/—
84	6	30	187	"	59	19	Integro Inc.	'50	I	63/4
85	6	15	78	"	32	15	Schino	. .		15/5
86	6	5	65	pC	34	9	Seaman	'51		60/½
87	8	90	147	Trs	. .	18	Howard Johnson Rest. #1	'41	I	92/—
88	8	30	156	"	. .	. .	" #2	"	I	. . . .
89	8	75	86	"	. .	30	Mrs. W. Ziegler #1	'36	I	. . . .
90	8	80	117	"	47	38	" #2	'37	I	. . . .
91	6	25	104	"	40	20	H. Fackler	'35		70/—
92	8	160	204	"	32	18	Green Acres Country Club	'46	I	50/—
93	6	10	55	"	32	12	J. Antoniszym	'51		. . . .
94	6	20	65	"	37	3	C. Rossa	'52		12/4
95	6	10	61	"	35	10	W. J. Takash	'51		22/6
96	6	10	100	Trl	23	8	A. Maruca	'61		50/—
97	6	10	95	"	22	18	F. Lonska	"		"
98	6	2	250	"	25	2	J. Kerney, Jr.	'60		. . . .
99	6	8	145	"	26	20	J. Lovero	'62		100/4
100	6	30	105	Trs	55	10	Hester Realty Corp.	'60		80/4
101	8	79	195	"	37	11	National Guard	'27	I	65/9


LAWRENCE TOWNSHIP
1 1/2 0 1mile
Domestic Wells
Industrial Wells
Formation Contact
Kmr Magothy and Raritan Formations
Ꞧb Brunswick Shale
Ꞧl Lockatong Argillite
Ꞧs Stockton Sandstone
P€ Precambrian (Undifferentiated)
LAWRENCEVILLE
PENNINGTON
PRINCETON
TRENTON
WEST TRENTON
Colonial Lake
Berrien City
Clarksville
HOPEWELL TOWNSHIP
EWING TOWNSHIP
WEST WINDSOR TOWNSHIP
HAMILTON TWP.
Woosamonsa Rd
Titus Mill Rd.
Yard Rd.
Pleasant Valley Rd.
Centerville Rd.
Elm Ridge Road
Cold Soil Rd.
Van Kirk Rd.
Carter Road
Province Line Rd.
Rosedale Rd.
Blackwell Rd.
Pennington Rd.
Keefe Rd.
Fackler Rd.
Lewisville Road
Bull Run Rd.
Upper Ferry Rd.
Lower Ferry Rd.
Scotch Rd.
Diverty Rd.
Federal City Rd.
Denow Rd.
Crossing Rd.
Darrah Lane
Eggerts Crossing Rd.
Bear Swamp Road
Quaker Bridge Rd.
Hughes Drive
Carnegie Lake
Washington St.
Alexander Rd.
Harrison St.
Stony Brook
Shipetaukin Creek
Shabakunk Cr.
Assunpink Creek
Little Bear Brook
Delaware and Raritan Canal
Brunswick Turnpike
Princeton Pike
Reading R.R.
Pennsylvania Railroad
Kmr

EWING TOWNSHIP

Only a small portion of the northern part of Ewing Township's 15.1 square mile area is underlain by the Lockatong argillite. About a fifth of a square mile adjacent to Trenton along Calhoun Street is underlain by Precambrian crystalline rocks. The rest of the township is underlain by Stockton sandstone which gives adequate domestic and moderately good industrial wells.

All of the area underlain by Precambrian rocks and a large part of the area underlain by the Stockton sandstone is served by the Trenton Water Company or other small local water companies near Ewingville and West Trenton. The area underlain by argillite in the northern part of the township, where water systems would seem most desirable, must depend almost entirely on individual wells.

North of Ewingville and Upper Ferry Road the higher terrain of the township is underlain by Lockatong argillite. Four industrial wells north or west of the Mercer County Airport tapping this formation give 12 gpm from 123 feet, 14 gpm from 436 feet, 43 gpm from 201 feet and 90 gpm from 232 feet. These wells give an average yield for the three smaller wells of 23 gpm, or 39 gpm if the 90 gpm well is included, from an average depth of 248 feet.

Domestic wells are not always successful; although all give some water, nearly half of the 35 argillite wells used in this study give less than 5 gpm. The wells have an average depth of 159 feet and a median depth of 123 feet.

Most of the industrial wells in the township draw their water from cracks and fissures in the Stockton sandstone. Eighteen Stockton industrial wells give from 207 gpm to 50 gpm with an average yield of 121 gpm from depths between 200 and 300 feet. Domestic wells in the Stockton have always given at least the minimum water required for a household from depths of around 100 feet.

Near Calhoun Street four industrial wells have been completed in the Precambrian rocks which underlie most of Trenton. These four wells are not very successful industrial wells, ranging from 1 gpm from 270 feet, 37 gpm from 337 feet, and 30 gpm from 145 feet to 40 gpm from 423 feet.

The lack of correlation between depth and yield in rock formations is demonstrated by each of the formations in Ewing Township. The yield and depth for the largest and smallest yield, and the deepest and shallowest wells in each formation, are tabulated below.

	Deepest Well	*Shallowest Well*	*Biggest Yield*	*Smallest Yield*
Precambrian	40 gpm/423′	30 gpm/145′	40 gpm/423′	1 gpm/270′
Argillite	1 gpm/798′	3 gpm/62′	90 gpm/232′	1 gpm/798′ also 95′
Stockton Domestic	10 gpm/670′	15 gpm/22′	60 gpm/99′	5 gpm/60′
Stockton Industrial	120 gpm/603′	110 gpm/150′	207 gpm/155′	50 gpm/300′

INDUSTRIAL WELLS

Formation	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
			Yield in GPM		
Precambrian	4	40	1	27	30
Lockatong	4	90	12	39 (23) *	14
Stockton	18	207	50	121	110
			Depth in Feet		
Precambrian	4	423	145	293	337
Lockatong	4	436	123	248	232
Stockton	18	603	150	274	205

* Average of three wells.

*DOMESTIC WELLS**

Formation	*No. of Wells*	*Maximum*	*Minimum*	*Average*	*Median*
			Yield in GPM		
Stockton	64	60	5	17	15
Lockatong	35	20	1	5	5
			Depth in Feet		
Stockton	64	670	22	104	85
Lockatong	35	798	62	159	123

* No domestic wells draw from the Precambrian in Ewing Township.

EWING TOWNSHIP

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
1	6	2	133	Trl	22	2	R. Penlee	'56		130/2
2	6	5	177	"	6	37	J. Notorion	'54		177/—
3	6	3	125	"	21	27	Jacobella	"		125/1
4	6	10	568	"	30	90	Forman	'57		318/9
5	8–6	6	176	"	21	55	C. Barber	'49		70/—
6	10–6	5	113	"	22	25	Fraulino	'54		90/—
7	10–8	2½	120	"	23	50	Dowdell	'55		100/—
8	8–6	2½	156	"	20	40	Walker	'54		80/—
9	6	20	100	"	45	15	Duralski	'56		40/40
10	8	100	250	Trs	35	19	Hampton Hill Water Co.	'55	I	....
11	8–6	20	150	"	31	24	J. Castelize	"		120/6
12	6	17	80	"	24	19	J. Wylie	'54		42/2
13	6	7	100	"	44	20	Scott	'56		40/4
14	6	40	100	"	43	10	Sun Oil Co.	'57		35/10
15	6	30	170	"	86	25	Ezennick	"		60/5
16	8–6	12	90	Trl	25	17	Geo. Brewster Inc.	'59		80/4
17	6	25	70	Trs	21	19	Procascon	'54		40/4
18	6	10	87	"	22	40	Cunningham	'56		80/4
19	6	20	100	"	23	17	Maio	'54		23/3
20	10	50	300	"	39	15	N. J. Highway Dept.	'54	I	150/9
21	10–8	50	500	"	47	14	"	'54	I	177/9
22	8–6	10	670	"	32	6	Gilbert	'59		20/—
23	6	30	55	"	22	7	Davis	'54		15/4
24	6	15	85	"	28	19	Costello	'56		40/4
25	6	20	55	"	32	8	Peterson	'54		25/4
26	8	60	350	"	41	6	A & H Young	'55	I	120/8
27	6	20	82	"	36	25	Bongrazio	'54		75/6
28	6	15	70	"	25	9	Loncenchok	"		20/4
29	6	10	86	"	34	30	Tilton	'52		....
30	6	5	111	Trl	20	28	Lambert	'48		....
31	6	15	125	Trs	22	20	Zwick	'51		....

EWING TOWNSHIP (Continued)

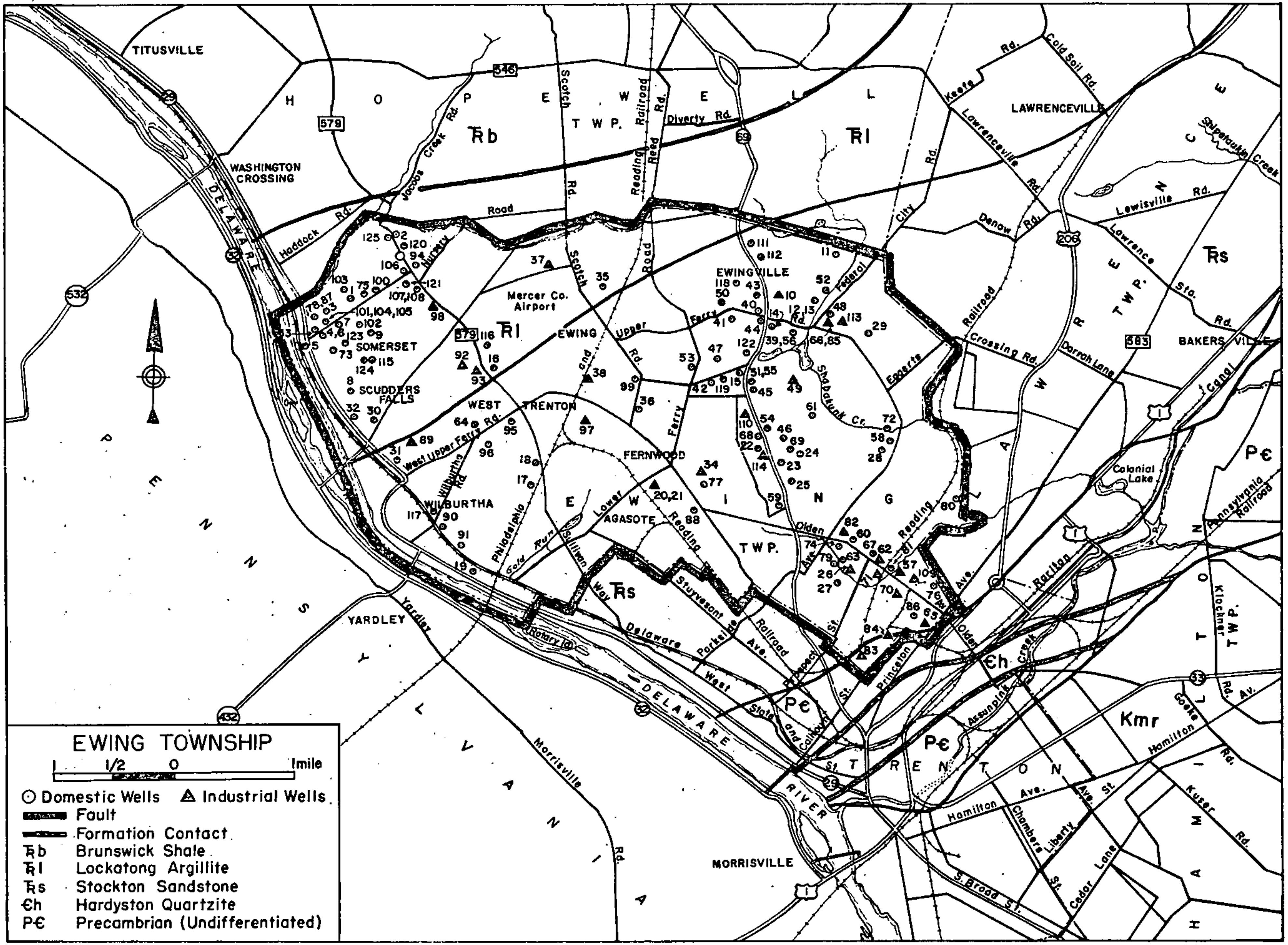
Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
32	6	1	798	Trl	. .	. .	Maddock	'16		. . . .
33	6	5	84	"	23	20	Dowdell	. .		. . . .
34	8	150	203	Trs	37	12	Food Fair	'51	I	. . . .
35	6	10	72	Trl	21	8	Huff	"		. . . .
36	6	16	81	Trs	. .	14	Jove	'31		. . . .
37	8	90	232	Trl	. .	9	Mercer Co. Airport	'43	I	100/8
38	8	120	603	Trs	. .	11	Naval Air Testing Sta.	"	I	137/—
39	6	15	60	"	35	17	Hooper	'51		30/4
40	6	20	92	"	. .	29	Scott	'54		54/20
41	6	30	85	"	27	24	Van Horn	'51		36/6
42	6	12	63	"	23	21	Tilton	. .		21/6
43	6	25	90	"	60	42	Kittell	'51		45/4
44	6	12	80	"	33	19	Northcutt	"		40/4
45	6	15	71	"	33	10	Longo	'52		10/6
46	6	15	81	"	40	10	Howard	. .		12/—
47	6	15	70	"	31	14	Morris	. .		14/—
48	6	12	81	"	17	40	Schenck	. .		60/4
49	. .	110	150	"	. .	25	Trenton State College	'31	I	30/—
50	6	7	67	"	. .	50	Jackson	'40		. . . .
51	. .	45	162	"	. .	13	Hook	'14		. . . .
52	6	7	106	"	22	40	Anderson	'51		80/3
53	6	12	79	"	34	18	Johnson	"		32/5
54	6	10	65	"	36	15	Nathulkiewicz	"		. . . .
55	6	30	160	"	52	15	Smith	'49		42/6
56	6	18	80	"	. .	13	Borello	'53		40/4
57	8	200	201	"	43	5	Arctic Ice Cream Co.	'49	I	34/—
58	6	12	72	"	23	14	Bernhardt	. .		. . . .
59	6	10	75	"	. .	18	Beyer	'51		22/6
60	5	15	82	"	34	10	Briehler	. .		10/5
61	6	12	85	"	32	40	Columbus Devel. Co.	. .		45/4
62	8	100	200	"	15	35	Martindell Plastics Co.	'57	I	45/8

EWING TOWNSHIP (Continued)

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
63	6	7	92	Trs	. .	. .	Ehret	'45		. . . .
64	6	5	95	"	34	15	Buck	'56		. . . .
65	. .	30	145	pC	. .	. .	Gray Rock Art. Water Co.	. .	I	. . . .
66	6	50	165	Trs	45	10	Hillwood Manor Water Co. #1	'52	I	50/10
67	6	12	230	"	80	15	Valet Cleaners	'51		50/8
68	6	12	196	"	23	17	Predhome	'48		60/8
69	. .	15	65	"	. .	11	Revella	'52		27/4
70	8	60	205	"	35	12	Richardson & Son	'51	I	60/6
71	6	100	225	"	38	8	Stoy Dairy	'49	I	35/8
72	4	15	22	"	. .	12	Ewingville Twp. Schools	'59		14/2
73	6	8	104	Trl	. .	40	F. Kreiguer	'52		65/6
74	6	12	200	Trs	100	8	Trenton Auto Clinic	'48		45/6
75	6	3½	62	Trl	. .	15	R. Holmes	'51		60/—
76	6	15	197	Trs	. .	30	Mercer Marble & Granite Co.	'50		100/—
77	6	30	65	"	38	8	Mastrangello	'51		30/6
78	8	2½	225	Trl	. .	. .	C. Wilber	'29		. . . .
79	6	20	65	Trs	. .	. .	Novel-T-Craft Co.	'46		. . . .
80	6	18	45	"	35	14	Osbrene	'53		40/4
81	6	12	210	"	110	15	Johnston Cadillac	'51		50/10
82	8	207	155	"	23	10	Kreuger Brewing Co.	'46	I	66/—
83	. .	1	270	pC	. .	1½	Sanitary Earthenware Co.	'10	I	to bottom
84	. .	40	423	"	. .	. .	Essex Rubber Co.	'14	I	. . . .
85	8	50	165	Trs	48	15	Hillwood Manor Water Co. #2	'54	I	60/8
86	6	12	75	"	. .	6	Keystone Struct. Steel	'37		29/—
87	6	2	123	Trl	22	30	O. Peterson	'53		123/1
88	6	15	60	Trs	40	7	Fasaline	'52		20/4
89	12–6	100	200	"	. .	38	State Police	'35	I	85/8
90	6	5	60	"	. .	. .	P. deFlesco	'37		. . . .
91	6	10	70	"	42	. .	Stout	'50		. . . .
92	. .	12	123	Trl	. .	. .	State Hosp. Dairy Farm	. .	I	90/—
93	12–8	14	436	"	30	17	"	'44	I	173/24
94	6	10	105	"	21	20	W. Harman	'48		65/—

EWING TOWNSHIP (Continued)

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
95	6	27	110	Trs	29	19	P. Klim	'48		38/2
96	6	15	94	"	32	40	M. Clemend	'53		45/5
97	10	280	272	"	..	22	General Motors Corp.	'41	I	67/18
98	8	45	201	Trl	..	36	Luscombe Airplane Corp. #2	'43	I	105/—
99	6	15	100	Trs	..	32	M. Bashford	'51		35/4
100	6	1½	142	Trl	16	15	A. McElwee	'51		130/—
101	..	2½	123	"	..	24	Trinity Church, Trenton	'21		....
102	6	1½	153	"	20	8	Russo	'56		....
103	6	2	140	"	..	10	Landwehr Restaurant	'52		140/—
104	6	5	163	"	..	15	T. Usher	'29		....
105	6	2	200	"	..	..	Owens	'43		....
106	6	10	72	"	..	15	L. Calvanelli	'51		30/—
107	6	20	80	"	22	19	T. Kotovach	'52		26/4
108	6	15	81	"	22	12	A. Perlone	'52		40/4
109	12–8	37½	337	pC	65	..	Union Op	'58	I	....
110	10–8	110	200	Trs	63	20	Ewing Water Supply Co.	'54	I	155/10
111	8–6	10	90	"	23	4′ 6″	E. Brophy	'57		80/—
112	8–6	20	70	"	21	8	S. Lentini	'58		40/3
113	8	200	306	"	45	12	Hillwood Manor Water Co. #3	'59	I	70/4
114	6	150	185	"	..	0	Crestmont Park Water Co.	Pre-'10	I	....
115	6	2	200	Trl	22	20	Tren-Dell Con	'58		150/5
116	8–6	1	95	"	..	18	McLauglin	'57		18/1
117	6	25	96	Trs	22½	80	Panara	'46		....
118	6	30	90	"	26	25	Lentini & Grice	'56		....
119	6	12	63	"	23	21	Allen	..		....
120	6	4½	135	Trl	21	40	Gencey Co.	'56		....
121	6	5	148	"	21	32	" "	'56		....
122	6	60	99	Trs	34	8	" "	'56		....
123	6	10	115	Trl	22	18	Statler Blds.	'57		....
124	6	8	110	"	33	14	Jacobelli	'57		....
125	6	10	110	"	21	14	Statler Blds.	'57		....


EWING TOWNSHIP
1/2
0
1mile
Domestic Wells
Industrial Wells
Fault
Formation Contact
Ŧb Brunswick Shale
Ŧl Lockatong Argillite
Ŧs Stockton Sandstone
Єh Hardyston Quartzite
PЄ Precambrian (Undifferentiated)
TITUSVILLE
WASHINGTON CROSSING
HOPEWELL TWP.
LAWRENCEVILLE
LAWRENCE TWP.
BAKERSVILLE
EWINGVILLE
Mercer Co. Airport
SOMERSET
SCUDDERS FALLS
WEST TRENTON
FERNWOOD
WILBURTHA
AGASOTE
EWING TWP.
YARDLEY
MORRISVILLE
PENNSYLVANIA
DELAWARE RIVER
TRENTON
HAMILTON TWP.
Colonial Lake
Kmr

HOPEWELL TOWNSHIP

Hopewell Township, the largest of the four northern townships in Mercer County which must rely entirely on rock wells for their ground water supplies, has an area (59.7 square miles) which exceeds the total area of Ewing, Lawrence, and Princeton Townships combined. The geology of Hopewell Township is far more complex and the area underlain by three of the four Triassic formations much more extensive than in the other above mentioned townships. Nearly ninety percent of the Brunswick shale, fifty percent of the argillite, and forty percent of the diabase found in Mercer County is found in Hopewell Township.

The Brunswick shale, which underlies about half of Hopewell Township, is the least resistant to erosion of the four rock types that are found and it therefore underlies the lower ground. Diabase intrusions form Baldpate (470′) and Pennington Mountains (460′), the Mount Rose (420′) extension of the Mount Lúcas-Rocky Hill ridge, part of the Sourland Mountains in the extreme northern part of the county, and two other small areas making a total of about seventeen square miles of the township underlain by diabase.

In the northern part of the township there is a ridge (380-400′) of Stockton sandstone extending eastward from near Harbourton into Montgomery Township which, north of Hopewell Borough, forms the southerly scarp of Sourland Mountain. A very small area of Stockton sandstone, part of a broad belt through Ewing and Lawrence, is also found in the southeastern corner of the township. The Lockatong argillite underlying southern Hopewell Township is part of a wide band of argillite extending from Scudder Falls in Ewing, eastward through Lawrence, and Princeton to Monmouth Junction. A second and thinner band of argillite to the north is separated from the main argillite mass by a narrow band of Brunswick shale. A thin argillite zone forms a narrow ridge from Titusville into the northern part of Pennington and a fourth band of argillite extends from south of Fiddlers Creek, (northern Titusville) through Glen Moore nearly to the Mount Rose diabase ridge.

In northern Hopewell Township the Hopewell fault repeats the normal stratigraphic sequence of Triassic rocks causing the above-mentioned sandstone ridge and a broad belt of argillite to underlie the high land of the northern part of Hopewell Township. Where the terrain is underlain by argillite between the ridges of sandstone and diabase, a valley (250′-300′) will be formed, but if shale lies on either side, the argillite will form the ridges, (200′-220′).

Hopewell Township as shown on the U.S.G.S. quadrangle maps, 1:24000, with forest cover, illustrates in a dramatic way the importance of rock type, in the formation of topography and in land utilization. All of the areas underlain by diabase are high ground and very heavily wooded. The ridge areas underlain by argillite, while much less heavily wooded, can be identified at many places and constitute the bulk of the remaining wooded areas except those along the major streams. Wooded areas along streams are particularly heavy when the streams cut across the trend of the ridges or "grain of the county" where the ridges are formed by argillite, sandstone or diabase.

The drainage divide between the Delaware River Basin and the Raritan River Basin divides Hopewell Township nearly in half in a southeast-northwest direction from west of Lawrenceville through Pennington to north of Harbourton, and causes some shale areas to be nearly as high as the ridges of interbedded argillite. The Reading Railroad and the main north-south highway, U. S. Route #69, closely parallel the crest of this drainage divide from the Ewing Township line northward to Pennington. North of Pennington, near Marshall's Corner and Glen Moore, the highway diverges westward climbing the side hills along upper Stony Brook while the railroad curves around the end of the Mount Rose-Rocky Hill Ridge and follows Bedens Brook eastward into Hopewell Borough and Montgomery Township.

Since Industrial Zoning and the concentrations of population, except along the Delaware River on the western border of Hopewell Township, have developed along the Reading Railroad route, surface water supplies cannot be readily developed along or close to the areas of greatest need. Since reliance must be placed on wells, which in several areas tap formations with rather poor yields, the rate of industrial and urban growth in Hopewell Township has not been as great as in other parts of Mercer County. Further development, particularly for industry, will depend on special solutions to the problems arising from the need to secure adequate water supplies. These solutions will require imagination, far-sighted planning, and cooperation between industry and several agencies and levels of government.

First efforts to tabulate several hundred wells in Hopewell Township were unsuccessful because the local complexities of the geology of the township were not fully appreciated. The results were neither consistent in themselves nor with what had been found to be the case in other townships. Poor well locations and poor records by some drillers further confused the statistical picture.

The 281 well records used in Hopewell Township have been field checked as to location, compared with nearby wells drilled by different drillers, selected for their geographic distribution and selected to include special situations where there was more than the usual information available about one or more wells. At one point some 750 well records had been tabulated, but this mass of information proved unwieldy and redundant in several areas so that the present selection is believed to represent not only the best and most reliable of all the records available, but also a sufficiently large and diverse sample in time (year of drilling), drillers, and location to give a well balanced picture of reasonable expectations and special conditions.

Sufficient new field work and checking of earlier investigations was done so that the revised geology eliminates the confusion caused by the tabulation of well records in wrong locations or reported as drawing water from the wrong geologic formations. In many cases careful rechecking of the drillers logs revealed consistancies in minor lithologic details of geologic formations which could not be readily observed in the field. Where doubts still remained the well location was again field checked and the files were combed for records from other drillers in the same area.

In the discussion and summations which follow the Lockatong argillite wells are treated with respect to their location in one of the five bands or zones. The other formations are handled as single units except that in the Brunswick shale, there are several concentrations of wells which can be studied as separate groups. All but two Stockton sandstone wells are in the northerly sandstone belt extending northeastward from Harbourton toward Hopewell Borough.

The Stockton sandstone is found at two locations in Hopewell Township. In the southeast corner of the township along Bull Run and Federal City roads the Stockton sandstone provides water for the well for the Blue Ribbon Water Company (40 gpm from 159') and wells for several private homes. Well #149 (15 gpm from 90') is representative of the yield and depth of domestic wells in the area. The remaining twenty-four wells drawing from the Stockton sandstone area are found along the ridge extending from Harbourton northeastward to Montgomery Township.

Except for the immediate vicinity of Hopewell Borough and a few small housing developments along main paved roads, all the area underlain by Stockton sandstone is sparsely settled either with farms or homes on very large plots of several acres. The average domestic Stockton sandstone well gives a better yield at a shallower depth than wells completed in the other three formations.

The four industrial wells completed in the Stockton sandstone are all for water companies, either the previously mentioned Blue Ribbon Water Company in southern Hopewell Township or the Hopewell Water Department supplying water to Hopewell Borough.

Well #376, Hopewell Water Department, was one of the earliest water supply wells drilled in Mercer County. Completed to a depth of 362 feet in 1904, it originally gave 50 gpm even though located on the top of the ridge near the reservior. The completion of a flowing well at the foot of the ridge east of Hopewell Borough influenced the water company to make an effort to drill an equally successful well and resulted in the completion of wells #61 and #62, the present source of supply, in 1914 and 1915. The well records in addition to giving the details about the wells and pumping equipment at the turn of the century indicate that the farmer who owned the flowing well sued the water company for having damaged his well by drilling and pumping their new wells. Ultimately the early wells were abandoned in favor of the newer wells down the hill (#61, #62). Both wells probably draw from the fractured rock adjacent to the Hopewell fault.

Drillers logs suggest that the northern contact of the Stockton sandstone with the Lockatong argillite is transitional for a few hundred feet stratigraphically with an alternating series of sandstone and argillite beds. Such a sequence seems to give wells with a better yield than can usually be expected for wells in either the sandstone or, obviously, the argillite alone. The five wells located in this transition zone (#15, #162, #52, #190 and #40) have four wells in the top third of yields for all sandstone wells.

The thirty-five wells in Hopewell Township drawing their water from diabase are completed in five separate occurrences of this intrusive rock. The four wells in the large diabase sill north of Hopewell Borough in the Sourland Mountains and the twelve wells in the intrusive of Mount Rose Ridge show the average distribution of depth and yield that may be expected for wells completed in diabase. The small plugs near Glen Moore and Pennington Mountain are tapped by seven wells, which although too few in number to be significant, have an expected distribution pattern. The second and third highest yields for domestic diabase wells in the township, however, are found in the small plug near Glen Moore. This may in part be due to the fact that a small intrusive in cooling is more apt to develop joints and cracks, particularly when weathering takes place, than a larger more slowly cooled mass. The eleven well records from the larger Baldpate Mountain intrusive mass would seem to confirm this assumption since seven of these eleven wells have less than the median yield for diabase wells.

There are no industrial wells in Hopewell Township which have been completed in the diabase although the Pennington Quarry well, and two of the older Pennington Borough wells have been completed in shale very close to the border of the Pennington Mountain Intrusion. These wells and some of the diabase wells with the highest yield are probably all completed in the shattered rock of major fault zones. No well records are available from two diabase intrusives, the dike and the plug, near the Mercer County Workhouse, in the northwest corner of the township.

The yield and depth figures for diabase wells are given at the end of this section so that they may be compared with the other rock types. However, it should be noted that forty percent of the domestic wells in diabase give less than the five gallons per minute which is considered a desirable minimum yield for domestic wells. Also, it should be noted that less than ten percent of the wells give more than 20 gpm and only about one quarter of the wells give in excess of 10 gpm.

Areas underlain by diabase are not favorable for industrial development except for quarrying. Because of the heavy clay soil and shallow zone of weathered rock together with a hardly satisfactory ground water potential, intensive residential development should be discouraged in areas underlain by diabase unless both water supply and sewage systems are provided.

A large part of both northern-most and of southern-most Hopewell Township are underlain by Lockatong argillite. These slightly higher and partially wooded sections of the township have proved attractive for residential development so that in several areas it has been possible to study a concentration of wells in argillite and to compare them with similar concentrations of wells in areas underlain by Brunswick shale.

About one-fourth of Hopewell Township is underlain by argillite which is found in five narrow bands extending in a northeast—southwest direction. The main band of outcroppings of the Lockatong formation, as shown on the older geologic maps, is found along the southern border of Hopewell Township with most of the area underlain by argillite in Ewing and Lawrence Township. North of the main argillite and separated from it by a band of shale from one-quarter to one-half mile wide is a band of argillite rock type (here called band #1) which is also from one-quarter to one-half mile in width and also extends across the entire township from the Delaware River into the northern part of Princeton Township. Most of these areas of Lockatong outcropping and the intervening shale have been mapped as the Lockatong formation on the state geologic map.

In the main argillite outcrop area, which is now beginning to develop as a residential area, twenty-four domestic well records were tabulated. In the narrow argillite band to the north, nineteen domestic wells were tabulated with eleven of these wells (#230-#240) in one housing development near Washington's Crossing. Other domestic wells are found concentrated around Route #69 south of Pennington.

Argillite predominates as the rock type in a second narrow band which starts on the Delaware River south of Titusville and extends northeastward to the vicinity of Pennington with a width of about one quarter mile and a length of about three miles. Fifteen wells drawing water from the argillite are found in this argillite band either in the vicinity of Bear Tavern or just to the northwest of Pennington.

A third narrow argillite band about an eighth of a mile wide starts north of Titusville and extends northeastward for about seven miles to the vicinity of Glen Moore. Because of the proximity of this argillite occurrence to several of the diabase intrusions, the band is less distinct; however, it should be noted that of the nineteen wells in this argillite band only one gave ten gallons per minute and seven gave less than five gpm.

The largest area in Hopewell Township underlain by argillite is found north of Harbourton and Hopewell. Like the main occurrence of Lockatong argillite in southern Hopewell Township and adjacent Ewing and Lawrence Townships, this area of Lockatong argillite outcropping is found on the state geologic map and other geologic maps of the area because it is a repetition by faulting of the main argillite occurrence. East of the Delaware River and north of Moore's Creek, the diabase intrusion of Belle Mountain (Mercer County Workhouse Quarry) and a diabase dike are but two of several indications that the geologic structure of the area is complex. All that is shown on the older geologic maps as argillite may not actually be this rock type. Much of the area is argillite, but there is some shale and some baked argillite. Six well records were used in this area (Nos. 90, 91, 92, 216, 340, and 359). Of these #216 may actually be either along one of several minor faults in the area which are not shown on the Mercer County Geologic map or it may actually be drilled in red shale. In any event, it is the best domestic well (30 gpm from 92 feet) in the northern argillite area of Hopewell Township. The other wells mentioned above are typical of argillite wells elsewhere giving from 2½ gpm to 7 gpm from depths ranging from 73 feet to 313 feet.

From the Delaware River to the vicinity of Harbourton the Lockatong argillite, except for the outcropping previously mentioned in the vicinity of Belle Mountain, is in fault contact with the Brunswick shale or diabase of Baldpate Mountain to the south. East of Harbourton this fault brings Stockton sandstone to the surface and a thick sequence of argillite is again found in the usual stratigraphic succession above the Stockton sandstone. The area of outcroppings of this main argillite sequence continues north of Harbourton and Hopewell, along Route 518, in the vicinity of Woodsville, and on both sides of Feather Bed Lane with an outcrop area which average about one and one-half miles wide. In this band of argillite extending across northern Hopewell Township thirty-nine well records were examined, including the six already mentioned near the Delaware River. Except for a number of new houses in the Woodsville and Hopewell Borough area, the argillite ridge is occupied by large farms or country estates.

One well, #201, drilled about 1932 for a large dairy and cattle farm near Harbourton, is reported as giving 135 gpm from a depth of 116 feet. This well, the largest yield for any argillite well in Hopewell Township, is classed as a domestic well since it is six inches in diameter, and would not have been drilled in the hopes of getting any more than a usual large domestic supply of water. It is not included in the summations of yields because of the affect it would have upon the average and median figures.

In Hopewell Township there are only four industrial wells drilled in areas underlain by argillite. All are in the main argillite near its northern edge so that the wells are in argillite for their entire depth. These wells were drilled for National Dairy Products, Purity Milk Company, or Bristol Myers on what is now known as the Bristol-Myers Tract southwest of Pennington between the Reading Railroad and Scotch Road south of Route 546. In all, seven wells were drilled between 1929 and 1955. All seven wells were drilled in an area underlain by Brunswick shale according to the state geologic map and the geologic map of the Trenton Folio of 1919. Only the four southerly wells, #96, #97, #98 and #101 are in argillite. Well #97, a six-inch diameter well drilled in 1929, gives 50 gpm from 120 feet; the second largest yield for an argillite well in Hopewell Township. Wells #101, 45 gpm from 230 feet and #98, 20 gpm from 413 feet are third and eleventh largest producers respectively of the 120 argillite wells in Hopewell. On the other hand, well #96, eight inches in diameter, gives one-half gpm from 207 feet and is the poorest argillite well in Mercer County.

It should also be noted that well #99, a ten-inch diameter well started in shale, gave 140 gpm—all according to the driller—from above 240 feet. This well located by Henry Gross, a professional water dowser, was drilled at his direction to a total depth of 700 feet. The hole was logged electrically by personnel from the Trenton office of the U.S.G.S. upon its completion. Fractures are indicated to a depth of about 250 feet after which there are no "kicks" in the log to the bottom of the hole. The remaining two wells in this series were located by geologists, #95 in 1929 and #100 prior to the location of well #99 in 1955, in an area underlain by shale. These wells give 104 gpm for #95, an eight-inch diameter well 188 feet deep, and 114 gpm for #100, an eight-inch diameter well 230 feet deep.

To recapitulate the efforts to obtain an industrial water supply from a tract in Hopewell Township underlain by shale and argillite, we have for seven wells:

In Shale	*In Argillite*
#95— 8″—104 gpm—188′	#96—8″—½ gpm—207′
#99—10″—140 gpm—240′ (700′)	#97—6″—50 gpm—120′
#100— 8″—114 gpm—230′	#98—. .—20 gpm—413′
	#101—8″—45 gpm—230′

With respect to all 120 wells in Hopewell Township completed in argillite, we find that one well gave 135 gpm, one gave 50 gpm, one 45 gpm, one 35 gpm, four gave 30 gpm and the remaining three of the top 10% of yields were respectively 27 gpm, 22 gpm, and 20 gpm. Only one-fourth (21 wells) give 10 gpm or more while four wells are reported as giving five gpm and 42 wells (over one-third) give less than five gpm, the twelve wells with the lowest yield giving 2½ gpm or less. It should be noted that the four industrial wells and the top two domestic wells together give more water than the lowest 60% of all the other domestic wells in spite of the fact that one industrial well has the lowest yield of all.

If an analysis is made of the maximum, minimum, average and median yield and depth of the wells in each outcrop area of argillite, there is not as much variation as one might expect. Argillite seems to give uniformly poor expectations for a high yield and a good probability of having to drill deeper than the average homeowner would wish.

Excluding #101—135 gpm 116′ from the yield figures the domestic argillite wells in Hopewell Township may be summarized as follows:

	No. of	*YIELD IN GALLONS PER MINUTE*			
ARGILLITE	*Wells*	*Maximum*	*Minimum*	*Average*	*Median*
All Wells	115	35	¾	7	5
Main Area	24	35	¾	9	6
1st Band	19	18	¾	5	4
2nd Band	15	15	2½	6	5
3rd Band	19	10	2	5	5
Northern Area	37	30	1	9	5

ARGILLITE	No. of Wells	DEPTH IN FEET BELOW SURFACE Maximum	Minimum	Average	Median
All Wells	116	400	48	153	130
Main Area	24	380	62	150	125
1st Band	19	275	105	153	140
2nd Band	15	210	102	150	144
3rd Band	19	400	91	160	125
Northern Area	39	380	48	153	124

The Brunswick shale underlies about 30 square miles, about half, of Hopewell Township. The area underlain by Brunswick shale in Hopewell Township is about 90% of the Brunswick shale occurrence in Mercer County. Almost all of the centers of population, Pennington Borough, Hopewell Borough, Titusville, or larger housing developments—Dublin Hills (Tobiason) Dolphin Shores Estates, or Washington Hills are for the most part underlain by the Brunswick shale.

Except for a previously mentioned narrow band of Brunswick shale between the main and first band of argillite outcroppings in the southern part of the township and a small area west of Woodsville, for which there are no well records, in the extreme northern part of the township the Brunswick shale forms a broad belt through the center of Hopewell Township in a northeasterly direction from the Delaware River. This belt of shale extends into Montgomery, Hillsboro and Bridgewater Townships in Somerset County.

From Mount Rose along Crusher Road to Route 518 west of Hopewell the area of Brunswick shale is intruded by the diabase of the westward prolongation of the Rocky Hill sill which here has most of the characteristics of, and probably is, a dike. To the west of Route #69 the Brunswick shale is intruded by large diabase plugs and is interbedded at several places with considerable thicknesses or bands of argillite.

The above mentioned narrow band of shale betweeen bands of argillite in southern Hopewell Township is the only area of shale extending into or found in other townships in Mercer County. In the northern tip of Lawrence Township less than a square mile of shale is tapped by only two domestic wells. Further to the east in Princeton Township this occurrence of shale has a total area of between two and two and a half square miles. Five industrial wells and eight domestic well records were studied in this area of Brunswick shale in Princeton Township although about half of the area is served by water mains.

In comparison to the 176 domestic wells, 33 in the southern shale band, and 24 industrial wells, three in the southern shale band, in Hopewell Township the ten domestic and five industrial wells drawing water from the Brunswick shale outside of Hopewell Township hardly supply significant information about depth and yield. The discussion of the occurrence of ground water in the Brunswick shale in Hopewell Township is therefore best taken up in the county discussions of the ground water conditions in each formation. The township summation for wells in the Brunswick shale follows, however, to permit comparison of the ground water conditions for the various rock types found in Hopewell Township.

HOPEWELL TOWNSHIP
DOMESTIC WELLS

	No. of Wells	YIELD IN GALLONS PER MINUTE Maximum	Minimum	Average	Median
(1) Southerly shale zone between two bands of argillite	20	40	2½	12	10
(2) Washington Hills development on Pennington-Titusville Road just north of argillite	22	60	1½	18	15
(3) Dublin Road area west of Pennington, all wells in shale	28	28	5	12	10
(4) Random sampling of 50 other wells in township	50	45	½	12	10
(5) Random sampling of remaining wells in township	56	60	2	18	10

DOMESTIC WELLS	No. of Wells	*DEPTH IN FEET BELOW SURFACE* Maximum	Minimum	Average	Median
(1) Southerly shale zone between two bands of argillite	20	397	71	142	124
(2) Washington Hills development on Pennington-Titusville Road just north of argillite	22	257	142	210	215
(3) Dublin Road area west of Pennington, all wells in shale	28	249	134	169	165
(4) Random sampling of 50 other wells in township	50	287	45	130	132
(5) Random sampling of remaining wells in township	56	300	45	138	148

DOMESTIC WELLS Formation	No. of Wells	*YIELD IN GALLONS PER MINUTE* Maximum	Minimum	Average	Median
Brunswick Shale	176	60	½	15	10
Lockatong Argillite	115*	35	¾	7	5
Stockton Sandstone	22	50	1	35	12
Diabase	35	27	½	8	6

* The top Domestic well giving 135 gpm is not included.

INDUSTRIAL WELLS Formation	No. of Wells	*YIELD IN GALLONS PER MINUTE* Maximum	Minimum	Average	Median
Brunswick Shale	24	412	8	76	50
Lockatong Argillite	4	50 (45)	½ (20)	29*	..
Stockton Sandstone	4	124 (50)	18 (40)	..	..
Diabase	..	..	..	..	..

* Average of three wells 23 gpm.

DOMESTIC WELLS Formation	No. of Wells	*DEPTH IN FEET BELOW SURFACE* Maximum	Minimum	Average	Median
Brunswick Shale	176	397	45	154	145
Lockatong Argillite	116	400	48	153	130
Stockton Sandstone	22	271	52	129	129
Diabase	35	404	50	128	100

INDUSTRIAL WELLS Formation	No. of Wells	*DEPTH IN FEET BELOW SURFACE* Maximum	Minimum	Average	Median
Brunswick Shale	23	800	150	283*	300
Lockatong Argillite	4	413 (230)	120 (207)	241	..
Stockton Sandstone	4	362 (251)	159 (243)	..	..
Diabase	..	..	..	..	..

* Well 800′ deep not included.

HOPEWELL TOWNSHIP

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
1	8 & 6	4	90	Trdb	46	12	J. Lake	'54		80/—
2	6	29	153	Trs	27	27	W. McKelvy	'56		88/6
3	8 & 6	15	67	Trdb	55	16	H. Hodnett	'55		25/3
4	8	15	85	Trs	. .	12	H. B. Newbanks, Inc.	'60		60/—
5	10 & 6	15	173	Trdb	23	35	Hodson Hart	'54		120/4
6	6	4	85	Trl	25	10	Habourton Cemetery	'60		60/—
7	8 & 6	5	100	"	24	26	Pennington Bldrs. #2	"		70/—
8	8 & 6	3	108	"	23	12	" #1	'54		80/—
9	8 & 6	15	190	Trb	23	110	R. Theoblad	'55		160/6
10	8 & 6	20	230	"	25	83	J. Kirby	"		120/4
11	8 & 6	5	184	Trl	21	60	R. Nickerson	'54		150/3
12	10 & 6	10	110	Trb	46	27	Titusville Lumber & Coal Co.	'58		60/4
13	6	1½	404	Trdb	24	96	Armen Yazujian	'55		. . . .
14	6	3	175	"	20	20	Oliver Doll	"		162/6
15	8 & 6	3	190	Trl	21	43	C. Grove	'57		140/—
16	8 & 6	3	262	"	30	33	H. Whyte	'55		150/4
17	8 & 6	12	60	Trb	24	18	R. Anderson	'60		40/—
18	8 & 6	10	153	"	22	55	J. Nehalyak	'56		90/—
19	6	4	300	Trl	22	60	C. V. Hill	'58		250/6
20	6	1	380	"	22	60	"	"		350/6
21	10 & 6	5	400	"	30	12	Hopewell Valley Golf Club	'59		200/10
22	10 & 6	60	180	Trb	25	8	" #2	"		50/—
23	8 & 6	2	170	"	22	30	A. B. Newbanks, Inc.	'60		140/—
24	6	27	170	"	37	60	W. Abbey	'50		105/6
25	6	20	138	"	30	50	T. Anderson	'55		100/6
26	8 & 6	8	124	"	24	18	C. Raswieler	"		65/—
27	8 & 6	7	112	"	21	24	E. Macdonald	'57		100/—
28	6	7	200	Trl	24	20	Ogden Nursing Home	'61		150/—
29	8 & 6	22	205	Trb	22	30	Howe Nurseries	'57		150/4
30	8 & 6	8	240	"	23	23	G. Young	'55		150/—
31	8 & 6	11	183	"	21	40	Howe Nurseries	'57	I	150/6
32	8 & 6	8	228	"	23	6	"	"	I	150/4

HOPEWELL TOWNSHIP (Continued)

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
33	6	7	230	Trb	23	31	H. Himes	'54		160/4
34	8 & 6	6	142	Trl	23	12	C. Doherty	"		142/½
35	8	5	150	"	32	28	David Barbour	'61		140/4
36	8 & 6	10	147	"	21	19	Trenton Banking Co.	'58		60/—
37	6	15	80	"	21	9	J. Vickers	'55		40/4
38	8 & 6	5	100	"	23	16	Blue Ribbon, Inc.	'57		70/—
39	4 & 6	3	202	"	80	37	J. Toten	'54		160/1
40	10 & 8	40	159	Trs	35	17	Blue Ribbon Water Co.	'56	I	120/—
41	6	5	92	Trl	24	25	Badinski #2	'61		....
42	8 & 6	2	150	"	23	30	Shauer	'54		140/2
43	10 & 6	15	91	Trdb	63	12	Brookstone Bldrs.	'60		60/—
44	6	20	211	Trs	36	18	Pomeroy	'57		40/6
45	6	2½	105	Trdb	80	45	G. Smith	'54		87/5
46	8 & 6	3	100	"	33	22	Philco Co.	'57		70/—
47	6	20	100	Trb	24	22	Queenston Bldrs.	'60		100/6
48	6	10	125	"	27	18	"	"		125/—
49	6	60	185	"	24	24	"	"		185/—
50	6	40	116	"	24	12	"	"		116/—
51	8	5	373	Trl	46	5	Lane Farms, Inc.	'61		244/6
52	6	10	85	"	22	25	Hutchinson	'56		25/4
53	6	15	89	"	29	12	James Potts	'62		60/—
54	6	12	125	"	21	23	J. Toter	'62		"
55	6	3	350	"	34	12	W. A. Blackwell	"		350/—
56	8	14	300	Trb	..	15	Eisner & Mazar	'36		200/—
57	6	8	130	"	15	23	Carom	'51		70/—
58	6	10	155	"	23	16	Voorhees	'48		50/—
59	8	50	208	Trs	21	18	Collins	'53		60/8
60	6	10	100	Trl	24	18	Badinski #3	'61		....
61	8	124	243	Trs	..	..	Boro of Hopewell #1	'14	I	....
62	8	18	251	"	..	..	" #2	'15	I	....
63	6	8	210	Trb	23	50	Magers	'52		95/5
64	6	10	93	Trdb	53	27	Barna	'49		39/—

HOPEWELL TOWNSHIP (Continued)

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
65	6	12	110	Trs	24	19	E. Udy	'58		60/4
66	6	16	282	Trdb	20	16	Scarpati	'48		28/2
67	6	5	81	Trs	20	15	Pierson	'52		. . . .
68	6	7	82	Trl	9½	15	Snyder	"		65/—
69	6	7	139	Trb	21	17	Van Sant	"		70/—
70	6	15	100	"	26	10	O. J. LaCross	'61		. . . .
71	6	12	163	"	24	50	Basil DiGuiseppe	"		. . . .
72	8	45	168	Trs	32	25	Stover—now Wierdsma	'41		100/—
73	6	6	75	Trdb	. .	20	Mulford	'51		34/—
74	6	6	114	Trl	22	10	Wombwell	"		60/—
75	6	2	140	Trs	26	6	Bellot	'50		140/2
76	6	20	118	Trb	. .	18	Chorley	'51		38/—
77	6	3	76	Trl	. .	4	Conoven	"		76/—
78	6	2	271	Trs	31	19	Cole	'50		130/6
79	6	12	75	"	32	29	Chafey	'49		60/6
80	6	5	140	Trb	18	17	Capner	'48		50/—
81	. .	4	119	Trl	. .	19	Novohilsky	'49		50/2
82	6	5	79	Trdb	53	22	Van Sant	"		60/6
83	6	8	100	Trb	25	50	Basil DiGuiseppe	'61		. . . .
84	6	27	75	Trdb	34	13	Valents	'49		36/6
85	8	70	300	Trb	41	45	Bear Tavern School	'61	I	. . . .
86	6	8	214	Trl	22	7	Denaci	'49		24/8
87	6	1	129	Trs	23	16	Brooks	'48		125/4
88	6	4	124	Trl	25	12	Robert Totten	'61		. . . .
89	6	20	190	Trdb	40	19	Swick	'48		21/—
90	6	2½	313	Trl	. .	. .	P. Vischer	'37		. . . .
91	6	5	200	"	. .	. .	P. Vischer	'37		. . . .
92	6	7	185	"	. .	5	Gardner—now Vischer	"		160/—
93	6	5	151	"	20	35	Kostar	'50		69/—
94	6	14	130	"	20	40	Wood	'51		80/5
	95-101 **Bristol Myers Tract—Industrial wells**									
95	8	104	188	Trb	42	19	Nat'l Dairy Products Co.	'29	I	69/—

HOPEWELL TOWNSHIP (Continued)

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
96	8	½	207	Trl	38	35	Purity Milk Co.	'29	I	....
97	6	50	120	"	..	..	Nat'l Dairy Products Co.	'29?	I	....
98	..	20	413	"	..	..	Purity Milk Co.	'29	I	15/—
99	10	140	708	Trb	..	..	Bristol Myers	'55	I	....
	(All water above 240')									
100	8	114	230	"	..	..	"	"	I	....
101	8	45	230	Trl	..	..	"	"	I	....
102	8	50	201	Trb	..	55	(Hicks) Soc. Mobile Research	'47 (Prior)	I	120/—
103	6	5	275	Trl	25	60	Green	'46		150/—
104	6	10	110	Trs	20	16	E. E. Panacek	'55		....
105	6	20	62	Trl	24	9	Fernwood Mercer	'53		31/4
106	6	30	85	"	66	19	R. Backus	"		40/4
107	6	1	150	"	..	70	Ed Seckle—now Anderson	'56		....
108	6	10	145	Trb	22	28	M. Bard	'50		50/1
109	6	5	165	Trl	30	25	NJCED (Bear Tavern)	"		85/1
110	6	6	196	Trb	..	..	" (McKonkey)	'29		....
111	6	35	144	"	40	27	" (Washington Grove)	"		100/¾
112	6	42	200	"	219	70	" (Sullivan Grove)	'36		125/7
113	8	8	397	"	32	25	J. Postley	'53		260/8
114	6	1½	68	Trl	20	15	A. Cioppi	'56		42/3
115	6	10	66	Trdb	43	12	W. Lake	'57		60/—
116	6	10	83	Trb	26	8	Titusville Methodist Church	'60		30/—
117	6	30	65	Trl	27	8	L. Holcomb	'58		20/6
118	6	3	65	Trdb	20	8	Schire Deer Club	'59		50/—
119	6	1¼	250	Trl	25	35	R. Hunt, Jr.	'60		250/—
120	6	18	173	"	24	20	T. Engle	'56		75/—
121	6	35	150	Trb	23	27	E. Meredith	"		47/8
122	6	20	140	"	26	10	City Service Oil Co.	'57		20/4
123	6	8	135	"	24	51	J. Cullen	'49		100/3
124	6	5	215	Trl	42	69	P. Keffer	"		125/—
125	6	4½	165	"	21	45	G. Beemen	'48		75/—

HOPEWELL TOWNSHIP (*Continued*)

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
126	6	5	124	Trl	21	13	P. Hilbert	'56		100/—
127	6	5	160	"	22	24	M. Lauter	'50		90/—
128	6	6	185	"	22	50	C. Corbishley	"		100/—
129	..	20	121	Trb	..	20	A. Cooley	'09		....
130	6	10	150	Trl	..	15	W. Ehret	'51		....
131	6	6	181	"	20	40	J. Hayes	'48		80/—
132	6	2½	143	"	22	16	F. Jury	"		80/8
133	6	9	121	Trb	21	32	P. Illian	'48		45/—
134	6	4	200	Trdb	22	20	E. Antrobus	'58		180/—
135	6	3	155	Trl	22	59	M. Niski, Jr.	'47		90/—
136	6	4	170	Trdb	20	30	H. Bueschel	'59		170/—
137	6	1½	110	Trl	22	31	H. Banacei	'53		bottom/1
138	6	8	204	Trb	23	20	A. Winkler	'52		50/6
139	6	3½	119	"	43	37	R. Wilson	'51		80/—
140	6	4	110	"	21	18	J. Hoffman	'50		90/—
141	6	40	205	"	23	60	D. Seltzer	..		0/8
142	6	2	50	Trdb	26	8	R. VanDyke	'50		50/2
143	6	25	100	"	25	20	E. J. Kettenberg & Son	'61		70/4
144	6	6	100	"	24	20	"	"		80/4
145	6	20	104	Trb	24	18	S. Tizik	'48		25/8
146	6	4	143	Trdb	..	..	Wm. Swick	'46		25/8
147	6	29	800	Trb	..	60	Cointreau 1937—29 gpm 1938— 8 gpm	'37 (prior)	I	....
148	6	68	300	"	25	..	Cointreau	'38	I	....
149	6	15	90	Trs	23	17	Frank Dayizak	'59		23/4
150	6	10	52	"	46	25	John A. Pierson	'56		42/2
151	6	25	115	"	28	12	C. B. Katzenbach	'56		23/5
152	6	6	126	Trb	41	16	A. Salnaggio	'48		70/—
153	6	20	137	Trs	22	43	F. A. Comstock Architect	'56		90/—
154	6	6	32	Trdb	31	13	Steven Prozeralich	'55		....
155	6	4½	120	Trs	20	18	Perry Preckwinkle	'56		62/—
156	6	60	127	Trb	31	32	H. Rockwell	'38		55/—

HOPEWELL TOWNSHIP (Continued)

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
157	6	12	110	Trb	30	30	N. Phillips	'51		35/5
158	6	15	121	"	46	32	W. Hausdorfer	'56		60/—
159	6	15	133	"	26	24	W. Antheil	'51		55/—
160	6	9	90	"	21	24	J. Rein	"		33/—
161	6	40	95	"	21	8	Tulli Rossi	"		....
162	6	12	77	Trs	22	15	Chester S. Waleski	'56		50/—
163	6	7	171	Trdb	31	44	T. P. Reed, Jr.	'49		....
164	6	25	45	Trb	39	16	Pennington Quarry Co.	'51		40/5
165	6	12	250	"	22	22	E. Oldis	'49		150/—
166	6	5	225	"	130	6	Palmer Nurseries	'29		....
167	6	58	256	"	30	19	Mrs. Gertrude Holler	'42		128/—
168	6	10	100	"	21	9	F. Himmelsbock	'53		50/1
169	6	35	109	"	20	12	H. Herpers	'51		20/6
170	6	8	128	Trl	20	12	R. Hoagland	'50		30/—
171	6	4	150	"	..	6	W. Elliot	'51		100/4
172	6	50	186	Trb	..	8	Pennington Boro. #1 Penn. Mt.	'07	I	....
173	6	40	159	"	..	8	#2 "	"	I	....
174	10	45	657	"	57	38	#3 Del. Ave.	'27	I	....
175	10	201	273	"	43	83	#8 Del. Ave.	'57	I	145/24
176	10	22	178	"	..	..	#4 Park	'40	I	....
177	10	14	407	"	33	44	(abandoned) #5 Howe	'46	I	170/3
178	8	40	512	"	38	46	#6 Park	"	I	136/12
179	10	38	178	"	43	19	#7 K. G. Rd.	'54	I	160/24
180	6	10	122	"	..	60	F. K. Fees	..		80/8
181	6	5	140	"	22	95	R. L. Williams	..		98/—
182	6	6	70	"	..	40	C. Gill	'51		46/3
183	6	3	122	"	24	55	N. Colello	'49		90/—
184	6	4	120	"	42	54	A. Clee	'51		56/—
185	6	10	127	"	21	...	Engler	'27		......
186	6	6	105	"	23	63	L. Chamberlin	'47		68/—
187	6	7	105	"	18	55	E. Anderson	'51		80/1

HOPEWELL TOWNSHIP (Continued)

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
188	6	30	96	Trl	..	5	Brookside Inn	'31		....
189	6	27	96	"	..	..	H. Titus	'30		57/8
190	6	30	154	Trs	..	..	Hunts Park	'35		....
191	6	3	100	Trl	..	9	J. Kurylo	'51		40/8
192	6	12	158	Trb	..	70	T. Cart	'40		....
	(Deepened in 1956 to 352 feet—no increase in yield)									
193	6	½	150	Trb	..	65	"	'53		146/—
194	6	5	70	Trdb	40	10	H. Burd	"		45/5
195	6	5	150	"	22	10	J. Klein	"		50/—
196	6	½	150	"	14	30	G. Betjemann	"		149/—
197	6	7	112	Trb	..	20	N. T. Kessler	'36		....
198	6	9	126	Trl	22	9	L. Czaiko	'50		60/5
199	6	4½	249	"	..	10	J. Wilson	'36		29/—
200	6	5	180	"	37	6	R. Maddox	'32		98/—
201	6	135	116	"	..	14	E. Rose	..		30/—
202	6	22	255	"	..	15	F. Roebling	'49		134/—
203	6	10	110	Trb	64	8	W. Holden	'48		80/¾
204	6	10	262	Trl	23	3	F. Roebling	'50		100/6
205	6	17	150	"	20	45	Lynch	'51		70/5
206	8	36	250	Trb	26	17	Penn Brook Club	'57	I	130/12
207	8	412	300	"	35	22	Western Electric Co.	'60	I	90/16
208	8	33	501	"	42	27	"	'57	I	218/12
209	8	78	400	"	37	17	"	'60	I	200/8
210	6	20	150	Trs	24	40	J. Fauseet	..		75/3
211	6	10	126	Trb	22	9	Pennington Grange	'56		70/—
212	6	9	120	"	22	18	W. Bruce, Jr.	'55		80/—
213	6	15	115	"	21	25	E. Nelson	'55		40/5
214	6	12	131	"	22	30	A. Nelson	"		55/5
215	6	20	150	"	32	32	C. Knowlton	"		102/6
216	6	30	92	Trl	21	5	Mercer County Work House	'59		40/4
217	6	18	380	"	23	10	Fiddlers Creek Farm	'58		225/8
218	6	150	150	Trb	..	5	H. A. Smith Machine Co.	'39 (Prior)	I	80/—

HOPEWELL TOWNSHIP (Continued)

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
219	8	45	370	Trb	..	..	Pennington Prep	'20	I	....
220	6	10	90	"	21	15	W. Suydam	'57		65/—
221	6	5	148	Trl	39	10	W. Martin	'51		125/—
222	6	4½	184	"	34	12	E. Tobiason	'49		80/5
223	6	20	85	"	21	2	H. Burton	'50		40/2
224	6	10	76	Trb	28	20	C. Cannon	'52		25/—
225	6	10	92	"	46	42	J. Ingalsbe	"		60/—
226	6	3	165	Trl	23	25	J. Adams	'59		110/8
227	6	6	120	"	22	50	F. Schometzer	'50		60/1
228	6	8	133	"	20	45	J. Seitz	"		90/1
229	6	5	71	Trb	..	15	T. VonSchmidt	'51		25/—
230-240 Specker Development—Washington Crossing—Lafayette, Patterson, Burroughs, Morgan, Washington Avenue.										
230	6	4	133	Trl	30	28	W. Bolz	'47		70/—
231	6	5	131	"	35	68	J. Specker	'49		90/—
232	6	3½	116	"	23	40	"	'47		....
233	6	¾	215	"	23	70	"	'49		190/—
234	6	2½	125	"	23	32	"	"		90/—
235	6	3	125	"	22	25	"	"		"
236	6	2½	120	"	23	24	"	"		99/—
237	6	1½	130	"	20	50	R. Roos	'47		90/—
238	6	4	140	"	25	40	J. Specker, Jr.	"		80/—
239	6	5	160	"	43	40	E. Cole	'48		77/9
240	6	4	150	"	41	34	H. Bollman	"		65/—
241	6	10	135	Trb	22	59	Tobiason—Valley Road	'51		100/—
242	..	13	240	"	..	..	J. Robeson	'13		....
243	6	8	91	Trl	27	17	L. Haldeman	'51		30/—
244	6	12	95	Trb	21	13	J. Fabian	'52		60/1
245	6	10	130	"	21	35	W. Furneisn	'50		90/—
246	8	6	114	"	28	15	M. DiGaetano	'52		75/—
247	6	9	135	"	21	22	P. Applegate	'51		32/—
248	6	3	250	Trdb	30	3	Dr. E. J. S. Anderson	'61		150/4
249	6	30	148	Trb	22	30	DiCocco, Honey Brook Drive	'61		100/4

HOPEWELL TOWNSHIP (Continued)

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
250	6	20	75	Trb	24	10	Dolphin Shores	'61		50/4
251	6	4	183	"	22	12	"	"		140/4
252	6	8	124	"	28	10	"	'62		80/4
253	6	8	124	"	25	15	"	"		100/4
254	6	5½	123	"	22	20	"	'60		80/4
255	6	16	98	"	21	15	"	"		70/4
256	6	5	125	"	20	15	"	"		80/4
257	6	3½	225	"	22	15	"	"		160/4
258	6	40	123	"	22	15	"	"		60/4
259	6	25	115	"	21	20	"	"		65/4
260	6	12	106	"	23	20	"	"		80/4
261	6	2½	225	"	23	15	"	"		200/4
262	6	5	225	"	23	15	"	"		160/4
263	6	18	111	"	34	14	P. Narozniak	'49		78/6
264	6	8	190	"	22	62	H. Moses, Jr.	'50		90/—
265	6	15	144	Trl	26	43	G. McGuire	"		80/—
266	6	5	102	"	23	65	C. Heyen	'51		90/—
267	6	10	142	Trb	26	80	Washington Hills Bldrs.	'57		110/—
268	6	15	190	"	21	40	"	'60		120/4
269	6	40	215	"	21	60	"	"		"
270	6	18	215	"	20	60	"	"		"
271	6	15	205	"	20	70	"	"		160/4
272	6	9	175	"	22	50	"	"		120/4
273	6	7	160	"	21	40	"	"		"
274	6	12	240	"	23	50	"	"		"
275	6	40	225	"	23	50	"	"		100/4
276	6	7	250	"	21	4	"	"		120/4
277	6	15	250	"	23	50	"	"		"
278	6	12	162	"	22	20	"	"		100/4
279	6	7	175	"	23	50	"	"		120/4
280	6	8	250	"	24	40	"	"		"
281	6	35	206	"	20	70	"	"		"

HOPEWELL TOWNSHIP (Continued)

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
282	6	15	228	Trb	23	60	Washington Hills Bldrs.	'60		120/4
283	6	42	175	"	20	60	"	"		"
284	6	22	185	"	21	60	"	"		"
285	6	60	240	"	21	60	"	"		120/6
286	6	15	225	"	20	60	"	"		160/6
287	6	1½	250	"	22	32	"	"		—/—
288	6	2	257	"	22	..	"	"		250/—
289	6	43	500	"	31	35	Washington Cross. Park Estates	'61	I	206/6
290	6	10	143	"	20	60	C. Pierson	'51		120/—
291	6	45	150	"	24	90	E. Ehret	'53		90/3
292	6	8	202	"	22	70	C. Hansen	'49		90/—
293	6	6	130	"	..	18	L. Vankmanvich	'51		73/—
294	6	6½	138	Trl	22	..	Trooper Boyle	'40		90/—
295	6	10	132	Trb	22	45	L. Balain	'50		80/—
296	6	8	110	Trs	20	24	Anton F. Panacek	'55		90/—
297	6	7	125	Trl	23	43	George Roman	'56		100/4
298	6	20	110	Trb	48	31	Woolsey & Cadwallader	'55		65/3
299	6	5	210	Trl	21	45	J. M. Golden	'50		90/—
300	6	10	101	Trs	22	16	C. Betjemann	'58		70/—
301	6	8	160	Trb	30	42	Lester Dean	"		120/—
302	6	15	118	Trdb	22	18	A. Utt	'60		70/—
303	6	9	140	Trb	31	40	Expanded Living Search Ave.	'61		140/—
304	6	1	200	Trdb	12	35	Joseph McVeigh	"		180/—
305	6	9	75	Trb	21	18	C. Cooper—Fiddlers Creek Rd.	"		40/—
306-333 Tobiason Builders—Dublin Road—Pennington.										
306	6	6	160	"	31	61	Tobiason A-1 West	'54		140/4
307	6	20	180	"	27	80	" B-2 "	'55		—/—
308	6	15	155	"	21	55	" #1 East	'56		101/4
309	6	20	140	"	20	65	" B-2 "	'55		100/4
310	6	20	160	"	34	65	" B-1 "	"		120/4
311	6	15	167	"	22	75	" 7-A "	'57		124/4
312	6	7	135	"	22	70	" 3-A "	'56		120/3

HOPEWELL TOWNSHIP (Continued)

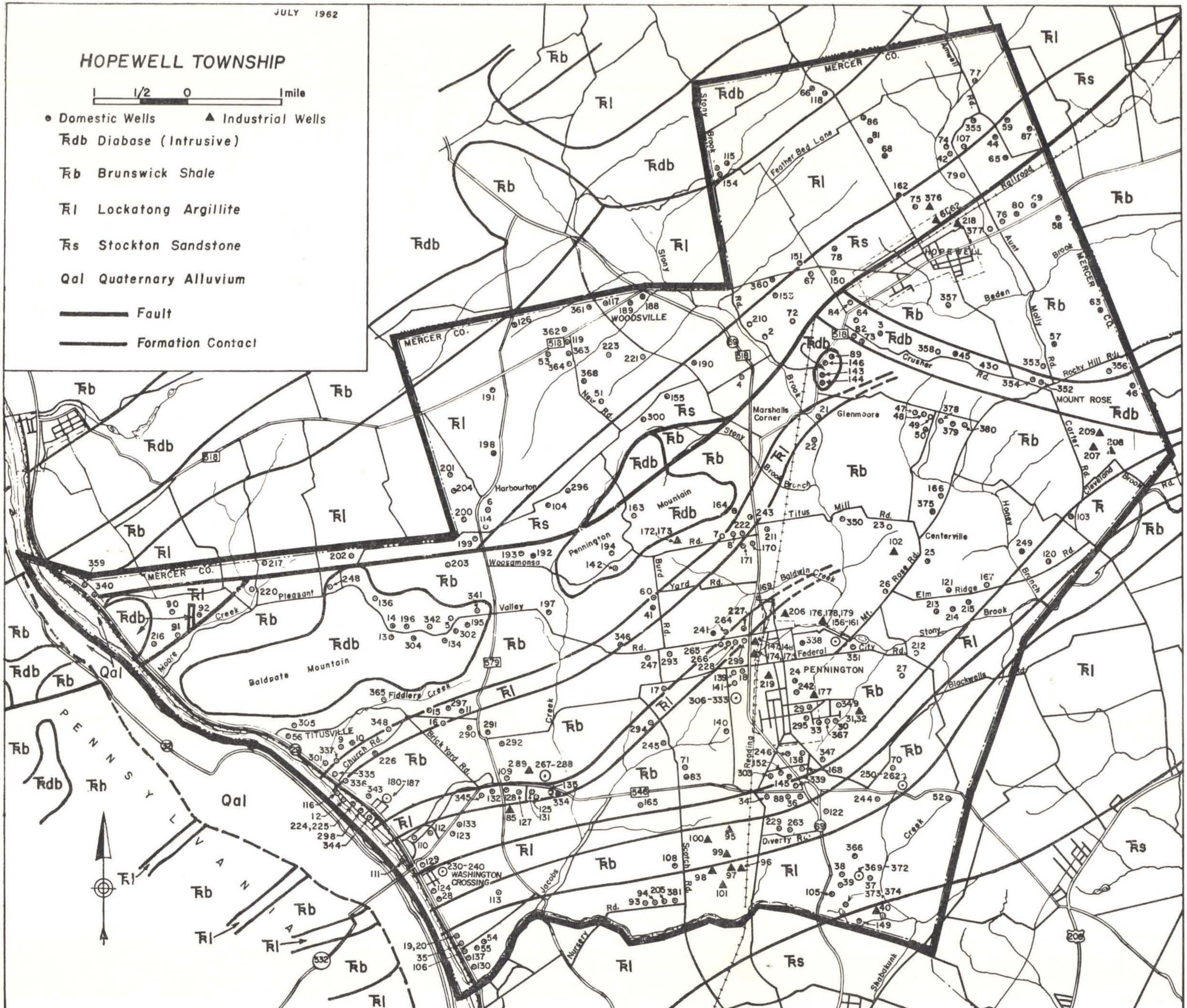
Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
313	6	20	185	Trb	24	75	Tobiason 6-A East	'56		100/3
314	6	6	165	"	22	80	" 4-B West	'57		140/4
315	6	10	160	"	24	95	" #9	'60		125/—
316	6	15	175	"	24	100	" #12	"		130/—
317	6	10	249	"	23	115	" #23	'61		150/—
318	6	10	200	"	26	103	" #22	'60		"
319	6	20	134	"	22	72	" 5-B West	'54		125/4
320	6	20	139	"	31	73	" A-4 "	'54		127/4
321	6	7	165	"	32	85	" B-3 "	"		140/4
322	6	28	158	"	32	75	" B-4 "	"		120/5
323	6	5	155	"	24	80	" B-2 "	"		140/4
324	6	20	155	"	32	78	" A-2 "	"		120/4
325	6	20	145	"	24	75	" 4-A East?	'56		....
326	6	6	145	"	23	33	"	"		....
327	6	10	249	"	35	115	"	'61		150/—
328	6	10	175	"	24	83	" #19	"		100/—
329	6	10	180	"	24	102	" #20	"		110/—
330	6	6	200	"	23	75	"	'59		175/—
331	6	8	200	"	25	70	"	'58		140/—
332	6	12	135	"	24	80	"	'57		120/4
333	6	7	185	"	25	75	"	'58		140/—
334	6	5	125	Trl	22	28	E. Wilson	'49		70/—
335	6	6	119	"	22	79	R. Yates	'49		83/—
336	6	6	119	"	22	60	E. Trimmer	'51		70/—
337	6	6	135	"	22	55	H. Leming	"		90/—
338	6	30	180	Trb	..	55	C. McCoy	'39		85/5
339	6	5	105	Trl	..	30	Atlantic Gas Station	'39		....
340	6	5	109	"	52	45	Bernard Groen	'51		90/—
341	6	6	115	Trdb	43	5	H. Murray	'49		69/—
342	8	10	85	"	25	32	F. Neiderer	'54		65/7
343	6	10	122	Trb	..	60	F. Fees	'50		80/8
344	6	40	127	"	76	37	A. Cooley	'15		80/—

HOPEWELL TOWNSHIP (Continued)

Well Number	*Casing Diam. (Inches)*	*GPM*	*Well Depth (Feet)*	*Fm.*	*Casing Length (Feet)*	*Static Water Level (Feet)*	*Owner*	*Year Drilled*	*Use*	*Water Level/ Hours Pumped*
345	6	7	130	Trl	28	50	F. Shestko	'61		70/—
346	6	9	93	"	22	38	C. J. Niewojna	"		70/—
347	6	10	100	Trb	23	30	Robert Rogers	"		"
348	6	2	300	Trl	26	8	Robert Fosbrook	"		280/—
349	6	10	108	Trb	26	18	James R. Potts (Howe Tract)	"		55/—
350	6	15	165	"	30	37	N. H. Bayard	'61		130/—
351	6	7	111	"	21	22	E. Zigleniski	"		80/—
352	6	15	95	Trdb	76	18	Annamae Kiefer	'57		52/—
353	6	15	90	Trb	22	15	E. D. Koppach	'59		60/—
354	6	10	70	Trdb	32	12	Stanley Poleski	'57		65/—
355	6	12	82	Trl	24	+2 flow 3 gpm	E. B. Whitcraft	'56		62/—
356	6	12	175	Trb	20	5	Princeton Manor Const.	'59		120/5
357	6	10	80	"	24	16	John E. Thompson	'56		40/—
358	6	2	63	Trdb	21	30	Raymond Hunt—Builder	'57		....
359	6	3	73	Trl	21	15	K. Robinson	"		65/—
360	6	3	130	"	21	30	L. Bonano	"		95/1
361	6	20	85	"	23	20	Malcolm Lord	'61		50/—
362	6	4	100	"	23	15	George Maul	"		....
363	6	6	49	"	20	15	Gilbert Mudge	'60		35/2
364	6	12	48	"	20	8	"	'61		23/2
365	6	7	287	Trb	21	60	George P. Maul	'61		160/4
366	6	10	90	Trl	22	20	John Donigan, Jr.	'57		50/—
367	6	20	150	Trb	34	32	W. S. Kerr	'58		60/4
368	6	2½	222	Trl	25	10	Stanley Moticha	'61		180/4
369	6	6	101	"	20	10	R. Perlee—Orchard Ave.	'56		70/1
370	6	5	94	"	21	12	" "	"		90/1
371	6	7	95	"	20	18	" "	"		70/1
372	6	3	94	"	20	15	" "	"		94/½
373	6	4	135	"	21	12	Abe Weitzman	'58		78/—
374	6	6	84	"	22	18	"	"		70/—

HOPEWELL TOWNSHIP (Continued)

Well Number	Casing Diam. (Inches)	GPM	Well Depth (Feet)	Fm.	Casing Length (Feet)	Static Water Level (Feet)	Owner	Year Drilled	Use	Water Level/ Hours Pumped
375	6	10	122	Trb	24	21	H. DiCocco	'60		70/—
376	6	50	362	Trs	30	42	Hopewell Boro. Water Co. (Top of hill by old reservoir)	'08	I	....
377	6	9	166	Trb	40	35	Herbert Voorhees	'55		70/—
378	6	20	100	"	24	16	Colonial Const. Co.	'58		40/—
379	6	12	130	"	24	20	"	"		100/—
380	6	25	80	"	23	5	"	"		25/2
381	6	5	140	Trl	27	12	M. Strano	'61		....



JULY 1962
HOPEWELL TOWNSHIP
1 1/2 0 1 mile
Domestic Wells
Industrial Wells
Ꞧdb Diabase (Intrusive)
Ꞧb Brunswick Shale
Ꞧl Lockatong Argillite
Ꞧs Stockton Sandstone
Qal Quaternary Alluvium
Fault
Formation Contact
MERCER CO.
HOPEWELL
WOODSVILLE
Harbourton
Marshalls Corner
Glenmoore
MOUNT ROSE
PENNINGTON
Centerville
TITUSVILLE
WASHINGTON CROSSING
Baldpate Mountain
PENNSYLVANIA
Feather Bed Lane
Stony Brook
Railroad
Aunt Molly Rd.
Beden Brook
Crusher Rd.
Rocky Hill Rd.
Carter Rd.
Cleveland Rd.
New Rd.
Pennington Mountain Rd.
Titus Mill Rd.
Burd Rd.
Yard Rd.
Baldwin Creek
Rose Rd.
Elm Ridge Rd.
Stony Brook
Federal City Rd.
Blackwells Mills Rd.
Honey Branch
Woosamonsa Rd.
Pleasant Valley Rd.
Moore Creek
Fiddlers Creek
Church Rd.
Brick Yard Rd.
Jacobs Creek
Scotch Rd.
Reading Railroad
Diverty Rd.
Nursery Rd.
Shabakunk Creek
518
579
546
69
32
206

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APPENDIX—A

HYDROLOGIC CYCLE

The rain and eventually snow upon falling on New Jersey, or anywhere else, divides into three components: (1) Evaporation and transpiration, (2) Runoff, and (3) Recharge. Each component is affected by various physical conditions and not infrequently some physical condition may affect the amount of two or even three components. The relationship has often been expressed as:—
RAINFALL = EVAPOTRANSPIRATION + RUNOFF + RECHARGE.

The percentage of rainfall lost to evaporation and transpiration is nearly always large, ranging usually from 30% to 60% of the rainfall, although under some conditions there may be either very little evaporation loss or, exceptionally, all of the rain may evaporate. The season of the year, the temperature, the humidity, the wind velocity, and the kind and abundance of vegetation all affect the amount of water evaporated or lost by transpiration. Thus in the winter when many plants are dormant evaporation becomes the major portion of this loss of rainfall although the loss would be low in comparison to the evaporation loss on a hot, dry, windy summer day. On such a summer day transpiration losses would also be high, but the losses from a pine forest would, other conditions being equal, not be as great as from willows, alders, and other leafy trees and bushes with a great water need. A hot, humid, still summer day may show a reduced evaporation loss because of the high humidity but will have a considerable transpiration loss because of plant growth. There would be no transpiration losses from a plowed field, but there would be a considerable transpiration loss from a field of corn or tomatoes during the growing season. There is also a difference in the amount of water taken up for transpiration and the amount lost by evaporation between the above-mentioned plowed field, a pasture, and a wood lot with its cover of mulch or organic litter which acts as a sponge and retards evaporation from the ground surface.

For the evaporation-transpiration component, the humidity, the temperature, the wind conditions, and the type, amount and kind of vegetation are the important factors which will determine whether this component accounts for a small fraction or nearly all of the rainfall. Actually, transpiration may rob water in considerable quantities from the ground water or recharge, and the surface water or runoff components during the periods between rainfall. A number of investigations have secured data as to the amount of water lost by evaporation from the surface of a lake or by transpiration through bushes and trees lining a river or canal. However, the several variables which must be considered make it difficult to estimate the quantities of water lost by evapo-transpiration except in general terms.

After allowances have been made for the evaporation-transpiration losses, many of the same factors will affect the increase or decrease in the amount of runoff and recharge. The general weather condition is perhaps of primary importance. A short summer cloudburst, a hurricane, and a prolonged rain storm might each deposit the same amount of rain on a given area. In the first instance in an hour or two most of the rain goes to runoff thereby causing flash floods. The hurricane would take a day or two with considerable runoff during some periods. In the third instance, rain for several days, most of the rain would go into recharge. The rate as well as the amount of rainfall is most important. The effectiveness of recharge and the amount of runoff depends on whether we have, as the farmers would say, a "gully-washer" or "ground-soaker."

The type of vegetation is very important. Bare fields encourage runoff and wood lots tend to absorb larger quantities of water as recharge. Eventually, given enough rain, even wooded areas will be unable to absorb the rainfall and runoff would result. It should be remembered that the type of vegetation is in part at least determined by the type of soil, the kind of underlying rock, and the slope of the land.

The runoff component will be increased by steep slopes, no or sparse vegetation, thin soil, rock at or near the surface, and a soil or weathered rock zone with a great deal of impermeable or nearly impermeable clay. The runoff component would be expected to be, and is, high from the top of a trap rock ridge with many rock outcroppings, from a steep slope, and from heavy clay soils. In contrast, it would be expected to be, and is, negligible or nonexistent in the flat, sandy, pine-covered highly permeable soils of the coastal plain. A glance at any New Jersey State Atlas sheet will show many more streams and rivers in the rock country of northern New Jersey than in the sandy areas of the coastal plain.

Although both the evapo-transpiration component and runoff are dependent on the existing weather conditions, the importance of the immediate and long-term past weather conditions must be considered when dealing with runoff. Two New Jersey storms illustrate the importance of the immediately preceding weather. In southern New Jersey, because of the highly porous soil, runoff is normally a very small part of any rainstorm. However, in 1936 a very heavy rainstorm followed a period of intense cold which had frozen the ground. Severe flooding occurred because it was impossible for normal recharge to occur. This normally large fraction of the rainfall greatly increased the usually small runoff component, resulting in destructive and severe flood conditions. In 1955, Hurricane Diane followed nearly the same path followed by Hurricane Connie of a few days before. Severe flooding occurred because the ground had been saturated by the earlier storm. Such unusual but significant combinations of weather can occur at any season.

The third component of rainfall, recharge, is not only affected by more variables than the other two, but, so to speak, has the last crack at the total precipitation. Since recharge gets only what's left of the rainfall, it may be small. As mentioned previously, weather conditions and vegetation determine how fast rainfall is made available to the ground surface. In a ploughed field with no vegetation the runoff-recharge relationship will depend on the slope and ability of the soil to absorb water. In a pasture the grass and its roots will encourage a certain amount of recharge and will hold or reduce the speed of some runoff. A wooded area not only has the trees to intercept the rainfall, but it also, usually has a heavier mulch zone and a much deeper and more open root zone which will hold large quantities of rainfall and encourage recharge.

The snow component of precipitation has its own runoff recharge relationships. If the ground is frozen, recharge may not occur. If there is a cold spell with temperature maximums each day, only slightly above freezing, most of the snow may evaporate. If a sudden thaw sets in, much of the snow melt may go to runoff.

The recharge component first enters the soil, then the weathered rock, and finally the openings in the rock body itself. The percolation rate of the several soil types is known or can be determined. In the soil zone, the degree of development of the soil profiles, the presence or absence of hard pan or of a "sole-pan" (caused by plowing at the same depth for several years) will all affect the rate at which rain can enter the weathered rock zone. The weathered rock or C horizon of the soil profile develops from the underlying rock and its character and thickness are determined by slope, weather, and age of soil development. In argillite, diabase and crystalline rock this zone may be thin and not very porous. The Raritan or other sandy coastal plain formations will be both porous and permeable in the soil profile and in the rock body except where local accumulations of silt or clay form lenses of impermeable material.

In the Coastal Plain there is little difference between the C horizon of the soil zone and the underlying sandy formations. In areas where silt and clay occur in the underlying formation the downward movement of ground water is extremely slow and a local "perched water table" may be formed. In the northern New Jersey areas underlain by the "rock" formations ground water movement except along faults, joints, or bedding planes is very restricted or nonexistent. The rock itself usually has a very low permeability and at times a very low porosity. In clay and rock formations much ground water moves more rapidly parallel to the "top of the rock" or to the clay beds rather than vertically downward.

At some level, usually only a few feet or tens of feet in New Jersey, all openings in the rock, whether they are pores or intergranular space in sands, sediments, or porous rocks or joints and other openings in the relatively non-porous rocks, are filled with water. This level is called the water table and all openings below this surface are filled with water. In the rock formations the weight of the overlying rock usually closes most of these openings at depths of from 800 to 1,000 feet below the surface. Pore space and openings in the lighter sediments may contain water to even greater depths.

In a general way the water table reflects the topography. It rises under the hills to a level above that of the nearby lakes, streams, and swamps. In valleys the water table is close to the surface and where lakes, streams, marshes, or springs are found, the water table is at the surface. Where the water table is at the surface, discharge of ground water to the runoff component will take place.

In the ground, water moves downward if not diverted or absorbed by root and plant needs until it reaches the water table. The water then moves laterally in a direction more or less parallel to the water table surface (the deeper the water movement, the less it is parallel to the surface) to the nearest stream, spring, or swamp for discharge to runoff.

The rate of movement both downward and parallel to the water table depends on the size and interconnection of the openings (pores, joints, etc.) in the soil, in the overburden, and in the bedrock, upon the hydraulic gradient of the water table or water moving toward a well and upon the velocity of the water moving in the ground.

Wells draw their water from the openings below the water table which they penetrate. When pumped, the water table near the well is always lowered, but the lowering, when a well is pumped at much less than capacity, may not be obvious. In a uniform porous sand this lowering of the water table would resemble a cone with its apex pointed downward and located at some point, called the pumping level, in the well. If pumping is stopped, the water will return, slowly in a poor well and rapidly in a good well, to the original water table or static level.

In the areas adjacent to rock wells this theoretical drawdown cone has a most irregular shape which is determined by the openness and interconnection of faults, joints, and bedding planes. Wells quite close together may not intersect the same fractures and thus be quite independent. Other wells as much as a mile apart may intersect the same open fracture and interfere with each other when pumped. The drawdown cone in rock becomes a skeletal or flower-like geometric shape with the actual cone of water surface drawdown restricted to the area of the fractures which intersect the particular well.

Impermeable layers of rock or sediments below the surface may confine the water below the water table so that it is under pressure and will rise above the level in the well at which it was first encountered, giving an artesian well. Water may actually flow out at the surface until the pressure and the water table causing the pressure has been lowered.

Water held above the general water table level by a clay lens or other impermeable material may form a restricted pocket of water or a perched water table. In the Raritan formation such perched water tables are usually only a few acres in extent.

Variations in the occurrence and movement of water beneath the surface and the relationship of ground water to wells are discussed in the many texts on the general subject of ground water.

APPENDIX—B

MERCER COUNTY STATISTICS

Major Municipality	*Area (Square Miles)*	*Population (1960 Census)*	*Population Density (Per Square Miles)*
East Windsor Township	15.60	2,298	147.30
Ewing Township	15.13	26,628	1,159.62
Hamilton Township	39.38	65,035	1,651.47
Hightstown Borough	1.23	4,317	3,509.76
Hopewell Borough	.75	1,928	2,570.67
Hopewell Township	58.00	7,818	134.79
Lawrence Township	21.87	13,665	624.83
Pennington Borough	.99	2,063	2,083.31
Princeton Borough	1.76	11,890	675.56
Princeton Township	16.25	10,411	640.67
Trenton City	7.50	114,167	15,222.26
Washington Township	20.70	2,156	104.15
West Windsor Township	26.84	4,016	149.63
Total	226.00	266,392 (15.93% increase since 1950)	

Average Population Density	1,178.72
Average Population Density Excluding Trenton	696.68

In 1959 43% of the land was devoted to farming, a 12% reduction from 1950 when 55% of the county was farmed. In 1959 there were 628 farms, 101 acres average, which sold products valued at $8,851,000. Five percent of Mercer County's land is forested, but most of this woodland is on farms. Only 2.2% (5.8 square miles) of the land is utilized for industry. Residential areas cover 29.5 square miles with 72,900 households.

APPENDIX—C

AREAS OF WATERSHEDS

(Drainage divides and watersheds shown on Plate V)

	Total (Square Miles)	*Within County (Square Miles)*
Moores Creek	9.9	5.2
Jacobs Creek	13.3	13.2
Stony Brook	64.8	52.2
Bedens Brook	49.9	8.5
Assunpink Creek	89.6	73.9
Millstone River	285.7	33.7
Crosswicks Creek	114.6	20.7
Shabakunk (Part of Assunpink Watershed)	(15.2)	(16.8)
Shipetankin (Part of Assunpink Watershed)	(9.8)	(9.7)
Delaware #1 (County Workhouse)	?	1.1
Delaware #2 (East of Titusville)	5.7	5.7
Delaware #3 (Ewing and Trenton)	8.2	8.2
Delaware #4 (South of Trenton)	6.6	6.6

APPENDIX—D

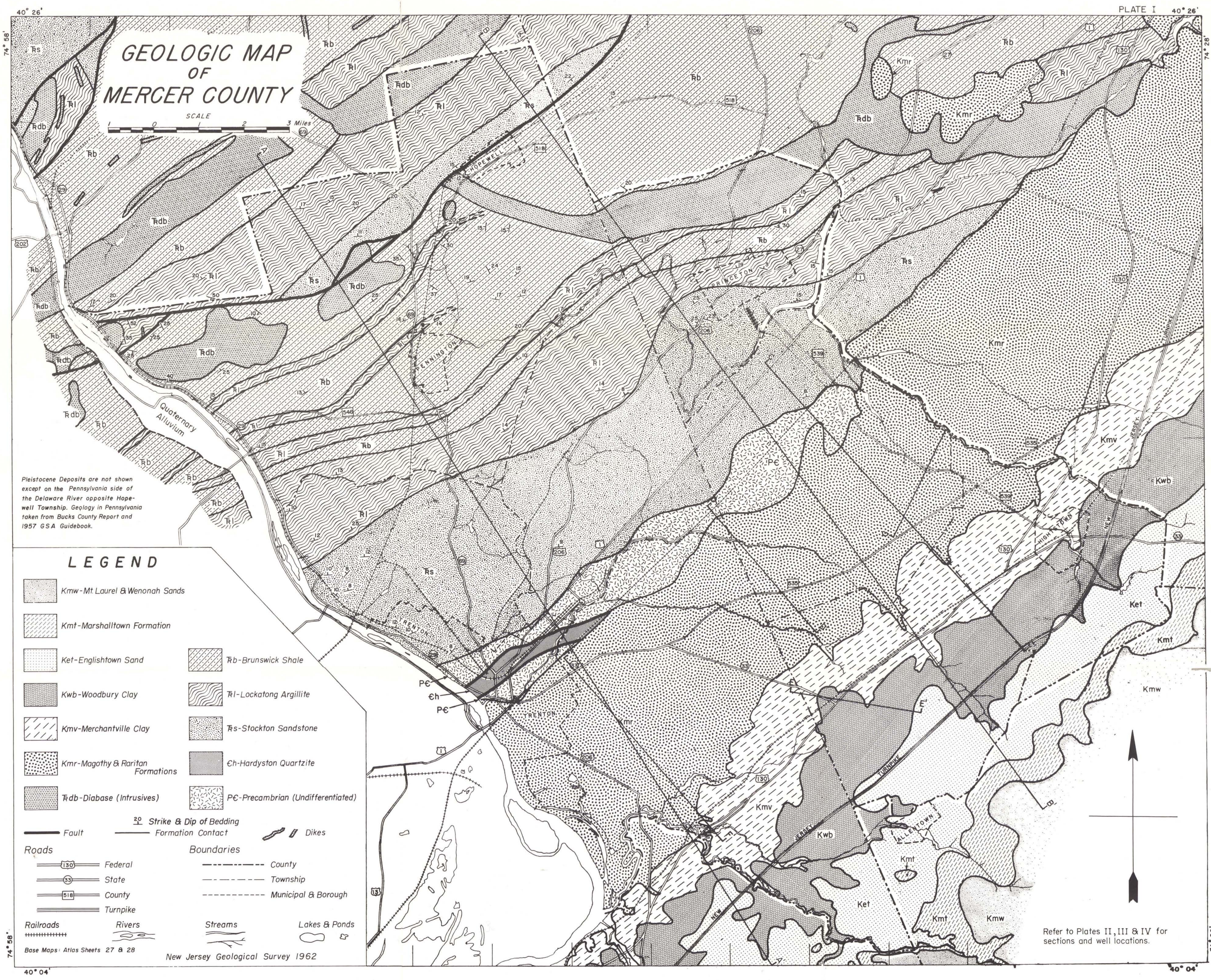
Mercer County's Mineral History in Brief

Mercer County has been a natural center of commerce and industry since early colonial days.

It is located on the "Fall line" which is where the Coastal Plain and Piedmont Plateau meet. The name "Fall line" is derived from the fact that most of the streams, including the Delaware River, in crossing this line, have falls or rapids. Since Trenton Falls marks the head of navigation of the Delaware River, Mercer County soon became a "crossroads" for commerce along the Eastern Seaboard.

Access to raw materials and to markets, and an abundant supply of water and water power supplied the basic needs for industrial growth. The first industry was a grist mill established around 1679. Later pottery, brick, tile, iron, and rubber became major enterprises. Fire clay for the ceramic industry was extracted from the Raritan Formation. Bog iron ore came from South Jersey and magnetite was shipped down the Delaware from Easton. Coal came from eastern Pennsylvania. Building stone was secured using Stockton sandstone (brownstone) and Lockatong argillite along the Delaware River with one or two quarries inland.

Today Mercer County is still a manufacturer of ceramic, steel, and rubber products. However, the clays for the ceramic industry are usually shipped from outside of New Jersey. Iron and steel products are still manufactured. There are now no forges, furnaces, or metal producers. No sandstone or argillite have been quarried in Mercer County in recent years. Diabase (trap rock) is quarried for road metal and concrete aggregate, and is now Mercer County's most valuable mineral raw material.


GEOLOGIC MAP
OF
MERCER COUNTY
SCALE
1 0 1 2 3 Miles
Pleistocene Deposits are not shown except on the Pennsylvania side of the Delaware River opposite Hopewell Township. Geology in Pennsylvania taken from Bucks County Report and 1957 GSA Guidebook.
LEGEND
Kmw-Mt Laurel & Wenonah Sands
Kmt-Marshalltown Formation
Ket-Englishtown Sand
Kwb-Woodbury Clay
Kmv-Merchantville Clay
Kmr-Magothy & Raritan Formations
Ꞁdb-Diabase (Intrusives)
Ꞁb-Brunswick Shale
Ꞁl-Lockatong Argillite
Ꞁs-Stockton Sandstone
Ꞓh-Hardyston Quartzite
PꞒ-Precambrian (Undifferentiated)
Fault
Strike & Dip of Bedding
Formation Contact
Dikes
Roads
Federal
State
County
Turnpike
Boundaries
County
Township
Municipal & Borough
Railroads
Rivers
Streams
Lakes & Ponds
Base Maps: Atlas Sheets 27 & 28
New Jersey Geological Survey 1962
Quaternary Alluvium
Refer to Plates II, III & IV for sections and well locations.
40° 26'
74° 58'
74° 28'
40° 04'
HOPEWELL
PENNINGTON
PRINCETON
TRENTON
HIGHTSTOWN
ALLENTOWN
NEW JERSEY TURNPIKE

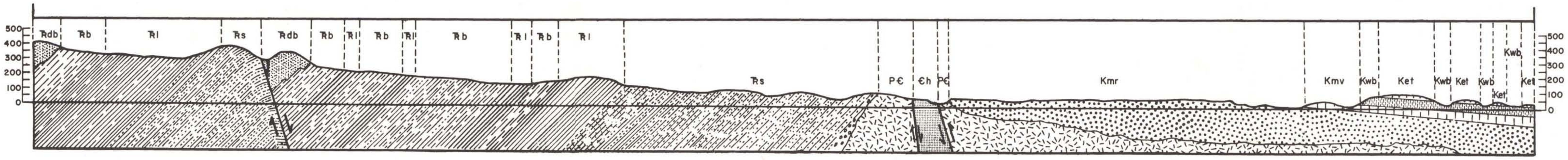
GEOLOGIC CROSS SECTIONS OF MERCER COUNTY

New Jersey Geological Survey 1962

GENERAL SECTIONS

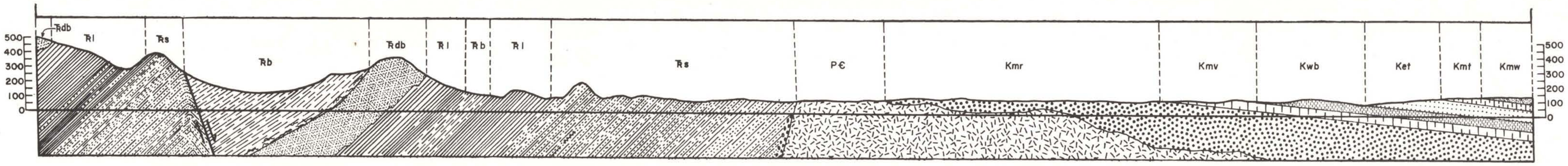
SECTION A—A'

HORIZONTAL SCALE 1"= 1 mile VERTICAL SCALE 1"= 500'
VERTICAL EXAGGERATION 10
Thin mantle of Pleistocene not shown



SECTION B—B'

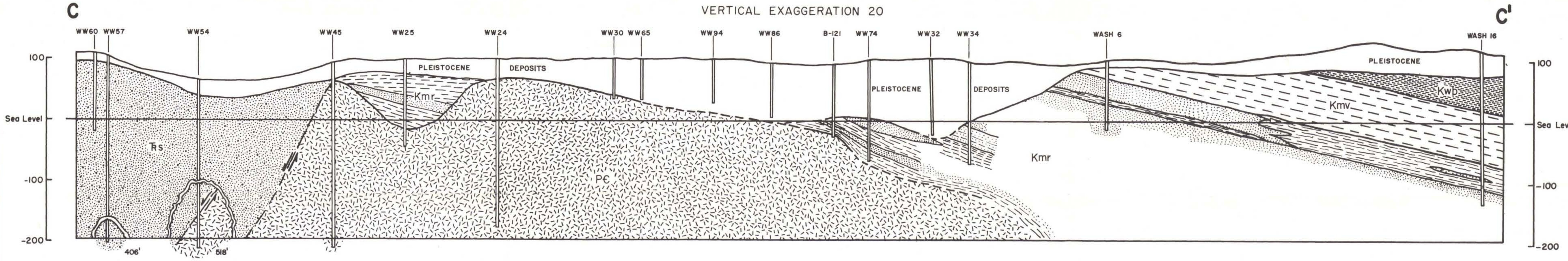
HORIZONTAL SCALE 1"= 1 mile VERTICAL SCALE 1"= 500'
VERTICAL EXAGGERATION 10
Thin mantle of Pleistocene not shown



COASTAL PLAIN SECTIONS

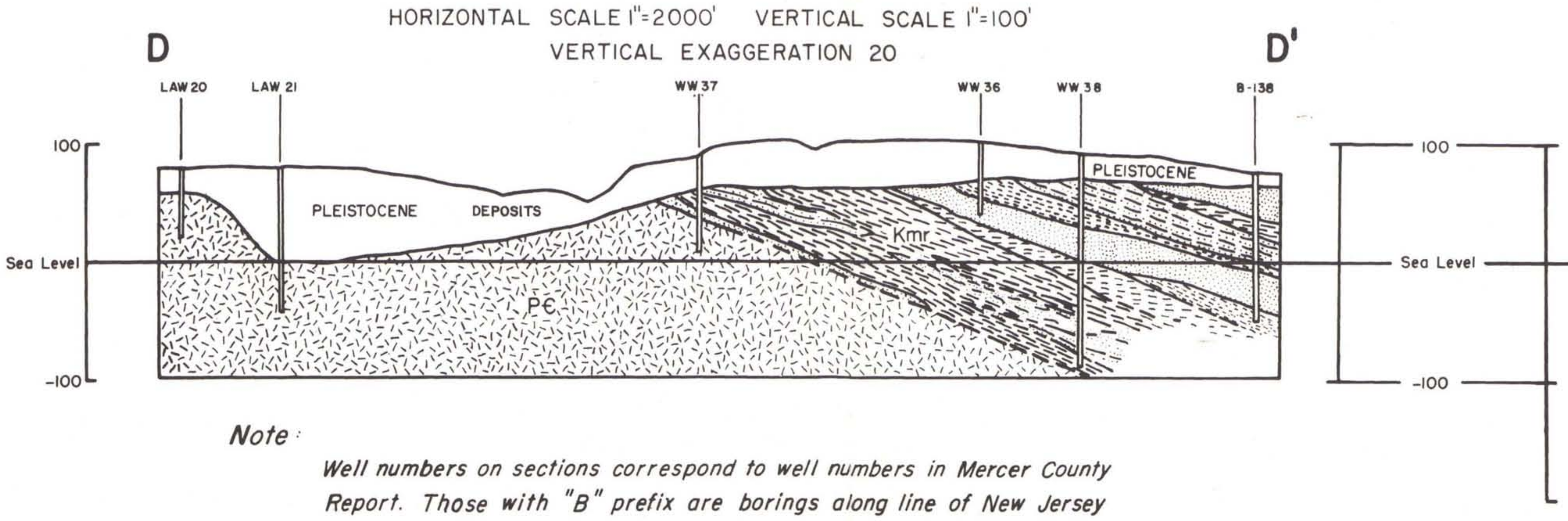
SECTION C—C'

HORIZONTAL SCALE 1"= 2000' VERTICAL SCALE 1"= 100'
VERTICAL EXAGGERATION 20



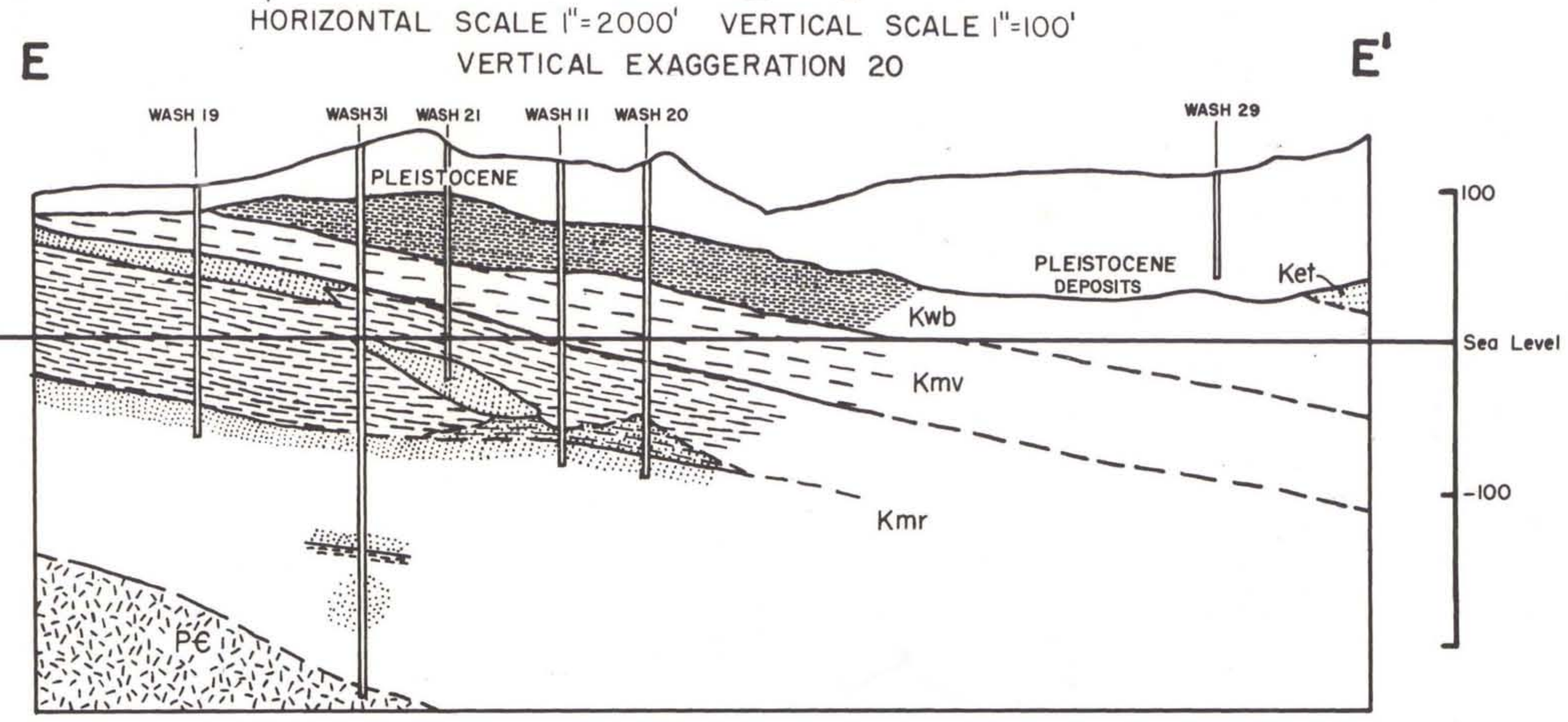
SECTION D—D'

HORIZONTAL SCALE 1"= 2000' VERTICAL SCALE 1"= 100'
VERTICAL EXAGGERATION 20



SECTION E—E'

HORIZONTAL SCALE 1"= 2000' VERTICAL SCALE 1"= 100'
VERTICAL EXAGGERATION 20

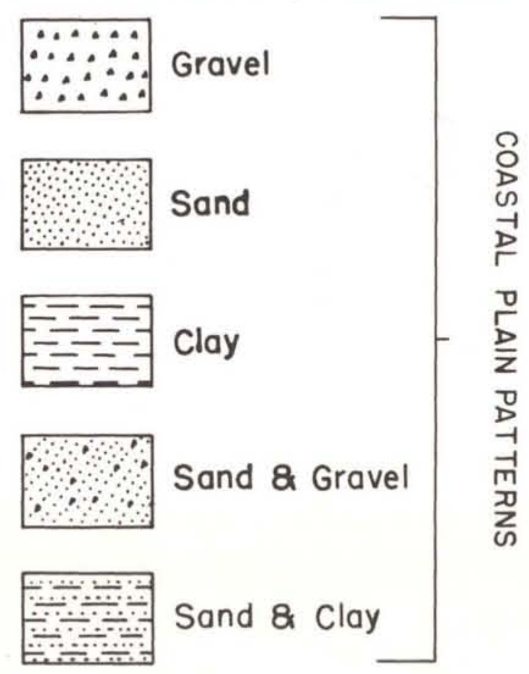


Note:

Well numbers on sections correspond to well numbers in Mercer County Report. Those with "B" prefix are borings along line of New Jersey Ship Canal.

LEGEND OF SECTIONS

Kmw - Mt. Laurel & Wenonah Sands
Kmt - Marshalltown Formation
Ket - Englishtown Sand
Kwb - Woodbury Clay
Kmv - Merchantville Clay
Kmr - Magothy & Raritan Formations
Ꞧdb - Diabase (intrusive)
Ꞧb - Brunswick Shale
Ꞧl - Lockatong Argillite
Ꞧs - Stockton Sandstone
€h - Hardyston Quartzite
P€ - Precambrian (undifferentiated)



Refer to Plate I for Geology & Plate IV for well locations.

GEOLOGIC CROSS SECTIONS OF MERCER COUNTY

New Jersey Geological Survey 1962

LEGEND OF SECTIONS

P€ - Precambrian (undifferentiated)
Kmr- Magothy & Raritan Formations
Kmv- Merchantville Clay
Kwb- Woodbury Clay

Gravel
Sand
Clay
Sand & Gravel
Sand & Clay

Refer to Plate I for Geology & Plate IV for well locations.

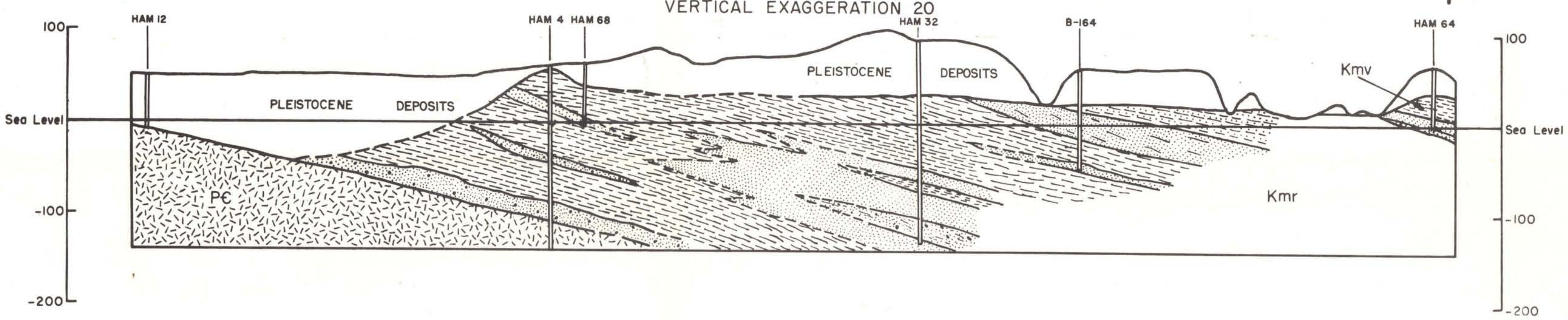
Note:

Well numbers on sections correspond to well numbers in Mercer County Report. Those with "B" prefix are borings along line of New Jersey Ship Canal.

COASTAL PLAIN SECTION

SECTION F—F'

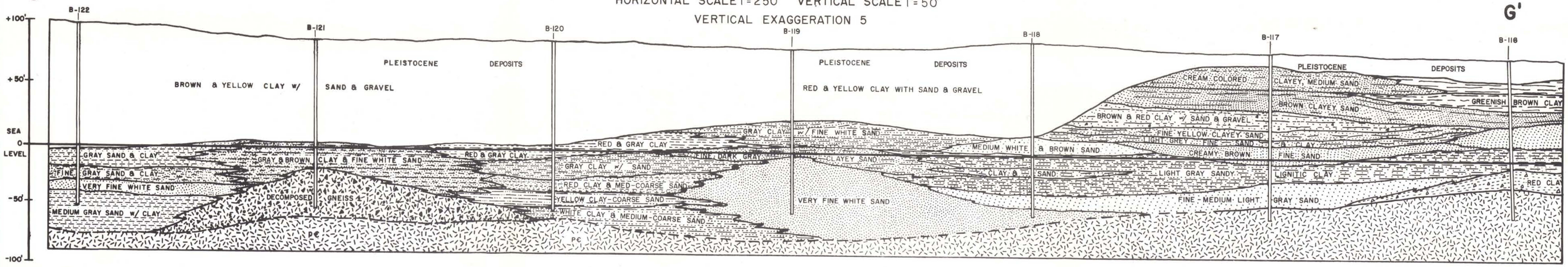
HORIZONTAL SCALE 1"=2000' VERTICAL SCALE 1"=100'
VERTICAL EXAGGERATION 20



SHIP CANAL SECTION

SECTION G—G'

HORIZONTAL SCALE 1"=250' VERTICAL SCALE 1"=50'
VERTICAL EXAGGERATION 5



SECTION G'—G"

HORIZONTAL SCALE 1"=250' VERTICAL SCALE 1"=50'
VERTICAL EXAGGERATION 5

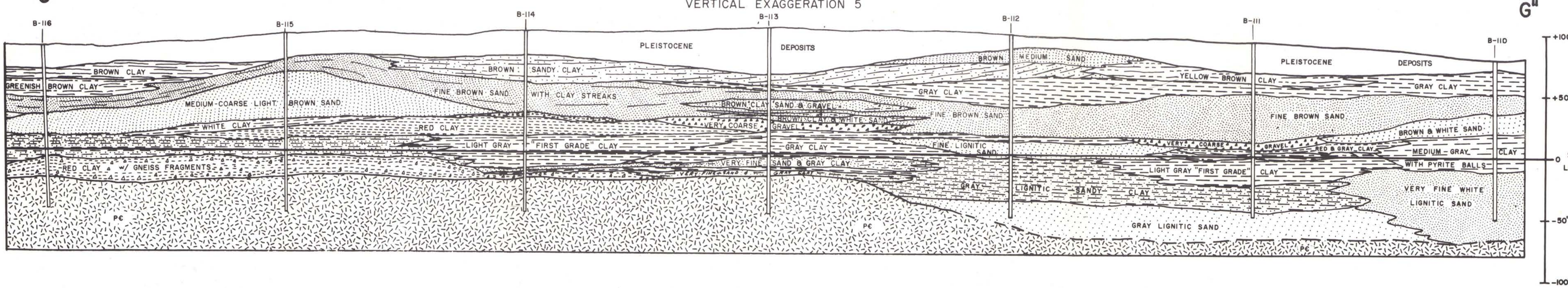


Plate IV

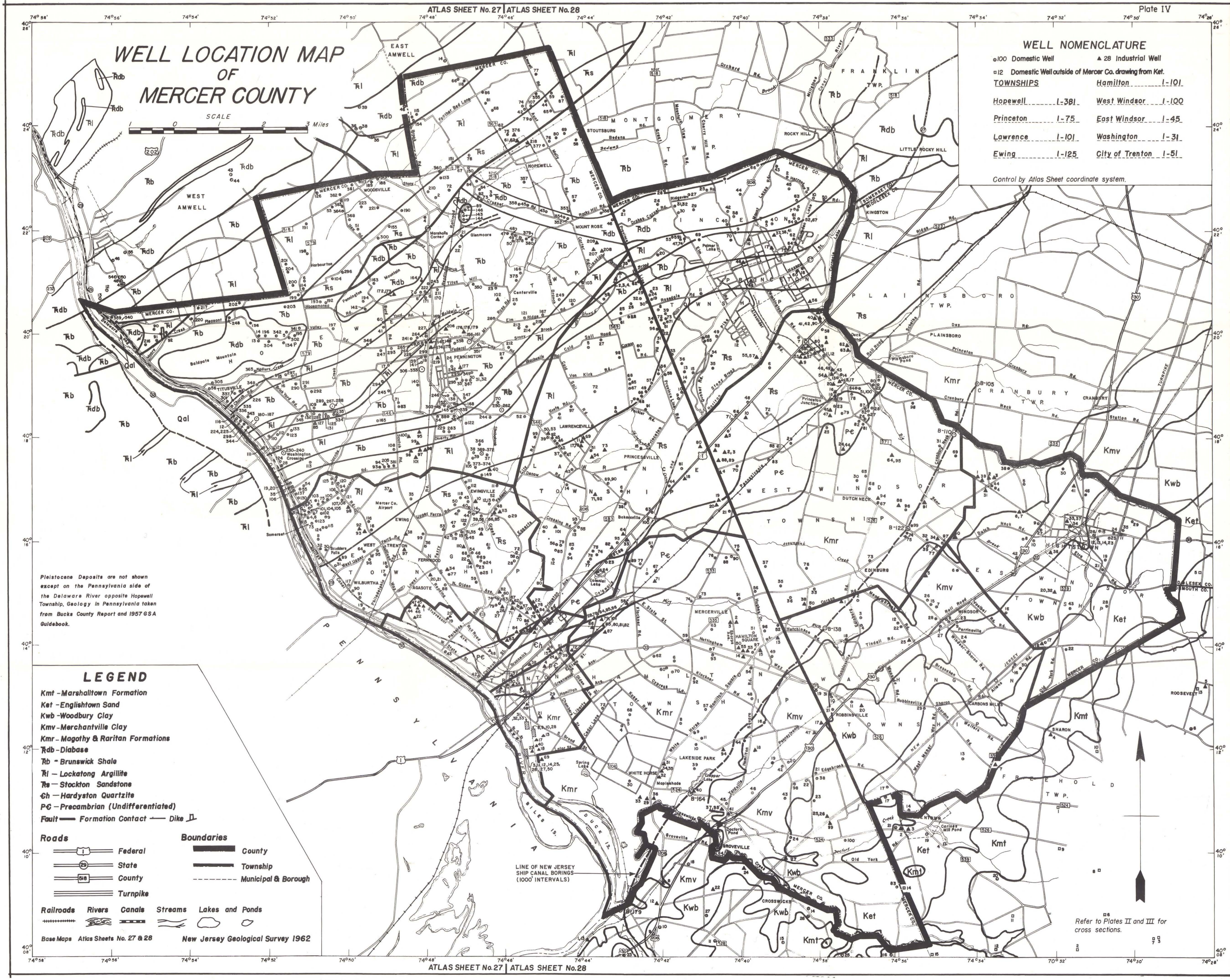
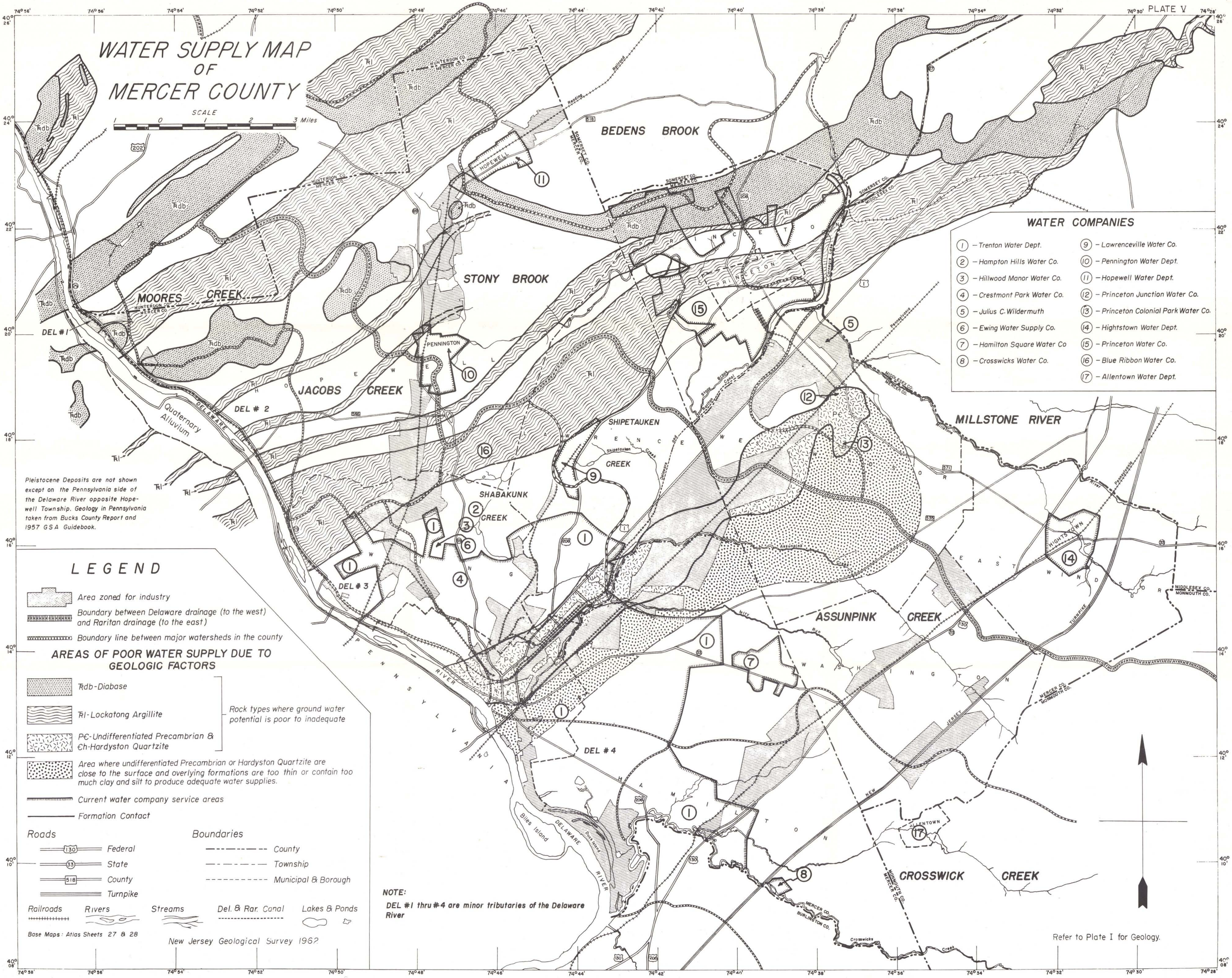

ATLAS SHEET No. 27 | ATLAS SHEET No. 28
WELL LOCATION MAP OF MERCER COUNTY
SCALE
1 0 1 2 3 Miles
WELL NOMENCLATURE
○100 Domestic Well
▲28 Industrial Well
□12 Domestic Well outside of Mercer Co. drawing from Ket.
TOWNSHIPS
Hopewell 1-381
Princeton 1-75
Lawrence 1-101
Ewing 1-125
Hamilton 1-101
West Windsor 1-100
East Windsor 1-45
Washington 1-31
City of Trenton 1-51
Control by Atlas Sheet coordinate system.
Pleistocene Deposits are not shown except on the Pennsylvania side of the Delaware River opposite Hopewell Township. Geology in Pennsylvania taken from Bucks County Report and 1957 GSA Guidebook.
LEGEND
Kmt - Marshalltown Formation
Ket - Englishtown Sand
Kwb - Woodbury Clay
Kmv - Merchantville Clay
Kmr - Magothy & Raritan Formations
Ꞧdb - Diabase
Ꞧb - Brunswick Shale
Ꞧl - Lockatong Argillite
Ꞧs - Stockton Sandstone
Ꞓh - Hardyston Quartzite
PꞒ - Precambrian (Undifferentiated)
Fault Formation Contact Dike
Roads
Federal
State
County
Turnpike
Boundaries
County
Township
Municipal & Borough
Railroads Rivers Canals Streams Lakes and Ponds
Base Maps Atlas Sheets No. 27 & 28
New Jersey Geological Survey 1962
LINE OF NEW JERSEY SHIP CANAL BORINGS (1000' INTERVALS)
Refer to Plates II and III for cross sections.
ATLAS SHEET No. 27 | ATLAS SHEET No. 28

PLATE V



WATER SUPPLY MAP
OF
MERCER COUNTY
SCALE
1 0 1 2 3 Miles
WATER COMPANIES
1 – Trenton Water Dept.
2 – Hampton Hills Water Co.
3 – Hillwood Manor Water Co.
4 – Crestmont Park Water Co.
5 – Julius C. Wildermuth
6 – Ewing Water Supply Co.
7 – Hamilton Square Water Co
8 – Crosswicks Water Co.
9 – Lawrenceville Water Co.
10 – Pennington Water Dept.
11 – Hopewell Water Dept.
12 – Princeton Junction Water Co.
13 – Princeton Colonial Park Water Co.
14 – Hightstown Water Dept.
15 – Princeton Water Co.
16 – Blue Ribbon Water Co.
17 – Allentown Water Dept.
BEDENS BROOK
STONY BROOK
MOORES CREEK
JACOBS CREEK
SHIPETAUKEN CREEK
SHABAKUNK CREEK
MILLSTONE RIVER
ASSUNPINK CREEK
CROSSWICK CREEK
DEL #1
DEL # 2
DEL # 3
DEL # 4
HOPEWELL
PENNINGTON
PRINCETON
HIGHTSTOWN
ALLENTOWN
Quaternary Alluvium
DELAWARE RIVER
PENNSYLVANIA
Biles Island
Pleistocene Deposits are not shown except on the Pennsylvania side of the Delaware River opposite Hopewell Township. Geology in Pennsylvania taken from Bucks County Report and 1957 GSA Guidebook.
LEGEND
Area zoned for industry
Boundary between Delaware drainage (to the west) and Raritan drainage (to the east)
Boundary line between major watersheds in the county
AREAS OF POOR WATER SUPPLY DUE TO GEOLOGIC FACTORS
Ŧdb-Diabase
Ŧl-Lockatong Argillite
P€-Undifferentiated Precambrian & €h-Hardyston Quartzite
Rock types where ground water potential is poor to inadequate
Area where undifferentiated Precambrian or Hardyston Quartzite are close to the surface and overlying formations are too thin or contain too much clay and silt to produce adequate water supplies.
Current water company service areas
Formation Contact
Roads
Federal
State
County
Turnpike
Boundaries
County
Township
Municipal & Borough
Railroads
Rivers
Streams
Del. & Rar. Canal
Lakes & Ponds
Base Maps: Atlas Sheets 27 & 28
New Jersey Geological Survey 1962
NOTE:
DEL #1 thru #4 are minor tributaries of the Delaware River
Refer to Plate I for Geology.