DEPARTMENT OF THE INTERIOR
JOHN BARTON PAYNE, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

WATER-SUPPLY PAPER 449

GROUND WATER IN THE MERIDEN AREA CONNECTICUT

BY

GERALD A. WARING

Prepared in cooperation with the
CONNECTICUT STATE GEOLOGICAL AND NATURAL HISTORY SURVEY
Herbert E. Gregory, Superintendent

WASHINGTON
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GROUND WATER IN THE MERIDEN AREA, CONNECTICUT.

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INTRODUCTION.

In a water-supply paper issued by the United States Geological Survey in 1904 [1] a list of more than 500 wells and springs in Connecticut was published, together with a brief paragraph on the water-bearing rocks and several analyses of water from wells and springs. A similar report, issued in 1905, contains an article on drilled wells in the Triassic area of the Connecticut Valley [2] and specifically describes about 160 wells in the area. The same publication also contains an article on the Triassic rocks as a source of water [3] and a list of 16 analyses of well and spring waters. In the same year a summary of the conditions affecting the occurrence of ground water throughout the State was published.[4] A report issued in 1903 [5] discusses the different kinds of rocks in the State and their water-bearing capacity and gives tabulated data for about 800 wells.

These earlier reports treated of the State as a whole, or of large parts of it, and were necessarily general in character. The increasing need for potable water for municipal and farm use made it advisable to undertake a more detailed study of the State, and this study was undertaken by the United States Geological Survey under cooperative agreement with the Connecticut State Geological and Natural History Survey. As a result eight reports (including the present paper) have been issued or are in preparation covering the areas indicated on Plate I.

The field examination on which this report is based was done under the direction of Prof. H. E. Gregory during six weeks in

[1] Gregory, H. E., Notes on the wells, springs, and general water resources of certain eastern and central States; Connecticut: U. S. Geol. Survey Water-Supply Paper 102, pp. 127–168, 1904.

[2] Pynchon, W. H. C., Drilled wells of the Triassic area of the Connecticut Valley: U. S. Geol. Survey Water-Supply Paper 110, pp. 65–94, 1905.

[3] Fuller, M. L., Triassic rocks of the Connecticut Valley as a source of water supply; U. S. Geol. Survey Water-Supply Paper 110, pp. 95–112, 1905.

[4] Gregory, H. E., Underground waters of eastern United States; Connecticut; U. S. Geol. Survey Water-Supply Paper 114, pp. 76–81, 1905.

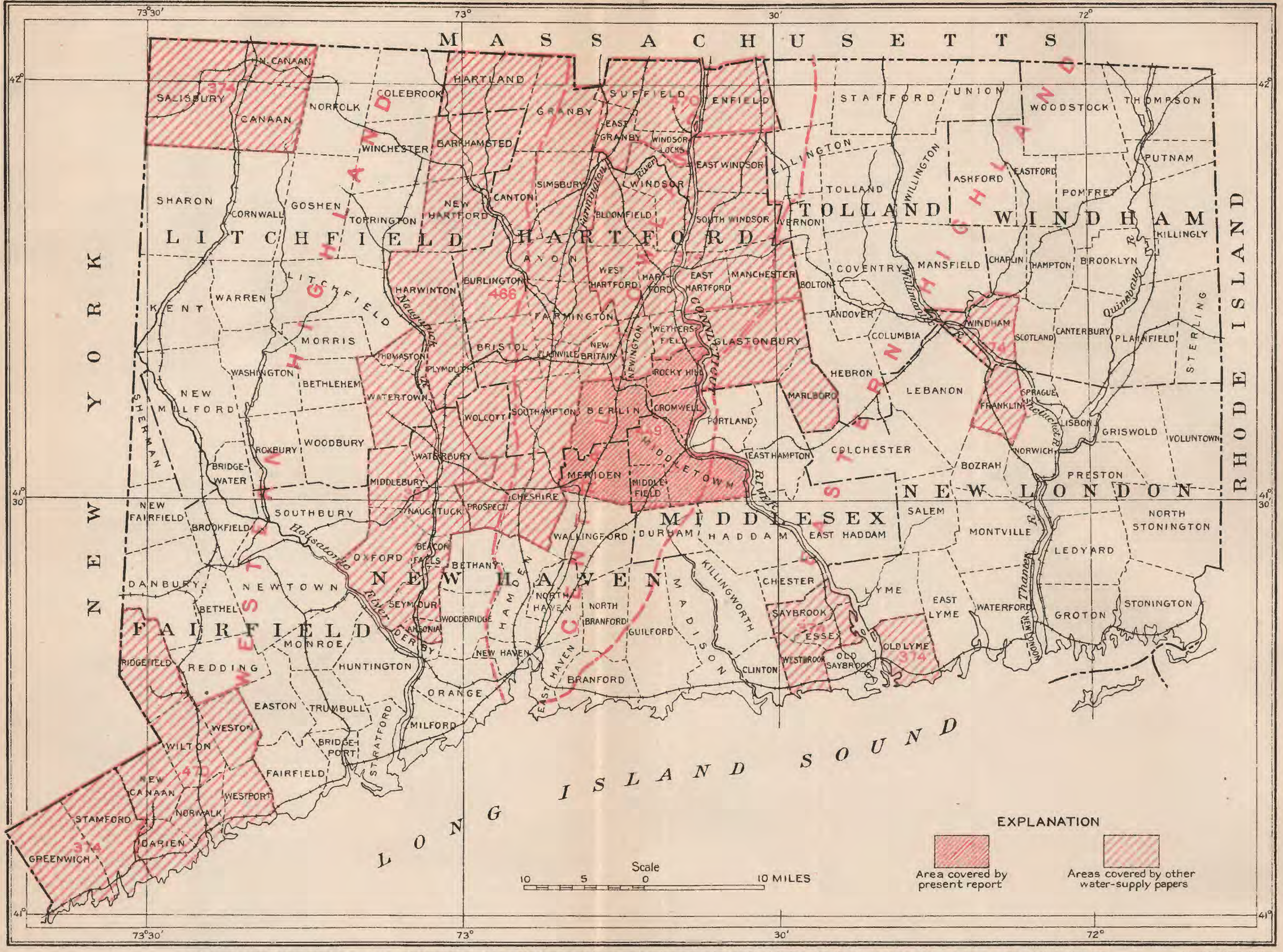
[5] Gregory, H. E., and Ellis, E. E., Underground water resources of Connecticut, with a study of the occurrence of water in crystalline rocks: U. S. Geol. Survey Water-Supply Paper 232, 1909.

April and May, 1915. The area covered comprises about 137 square miles and includes the towns of Berlin, Cromwell, Meriden, Middlefield, Middletown, and Rocky Hill. The work consisted chiefly in collecting records of a sufficient number of wells in each town to furnish adequate data concerning the ground water. In connection with this study, the Pleistocene glacial deposits—till and stratified drift—which cover nearly all the surface, were carefully observed, and as they differ considerably in their water-bearing capacity, they were separately mapped (see Pl. II, in pocket) as well as could be done in the time available for the work. The till consists of unassorted gravel, sand, and clay, deposited by the glacial ice sheet as it melted, and in general is not a good water bearer, because its heterogeneous material is unfavorable to the easy circulation of ground water. The stratified drift consists of bedded deposits of glacial materials which were to some extent assorted and redeposited by streams that were formed largely by the melting ice, and because the materials are thus assorted the circulation of ground water is generally freer in these deposits than in the unassorted deposits of till. The map (Pl. II) shows the areas covered by stratified drift as determined with special reference to water-bearing capacity. Detailed study of the glacial geology of the region based on the origin and source of the material would probably result in considerable changes in the geologic boundaries, especially in places where the transition from stratified drift to till is obscure.

Exposures of the bedrock underlying the glacial material were also noted (see Pl. II, in pocket), but the map of bedrock geology and its structure (Pl. III, in pocket) is copied with only slight changes from geologic maps of the region prepared by Davis[1] and by Gregory and Robinson.[2] This map of the bedrock structure is reproduced with the present report because it is believed that it will be of assistance to property owners and to drillers in forecasting the kind of material that will be encountered in drilling wells. Throughout the area the successive rock formations are present in the order in which they are shown in the legend of Plate III. The first rock encountered at any place in the area will be that indicated by the color at that point on the map, and this rock is in most places successively underlain by the other formations in the order indicated in the legend. For example, in sinking wells in the city of Meriden the first rock reached is the lower sandstone, and this material continues for many hundred feet down to the ancient crystalline rocks, except, possibly, where it may be interrupted by dike rocks.

[1] Davis, W. M., The Triassic formation of Connecticut: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 2, pls. 19 and 20, 1898.

[2] Gregory, H. E., and Robinson, H. H., Preliminary geological map of Connecticut: Connecticut Geol. and Nat. Hist. Survey Bull. 7, 1907.



MAP OF CONNECTICUT SHOWING MAIN PHYSIOGRAPHIC DIVISIONS AND AREAS TREATED IN THE PRESENT AND OTHER DETAILED WATER-SUPPLY PAPERS OF THE U. S. GEOLOGICAL SURVEY

SNYDER & BLACK, LITH. N.Y.

At Middletown, however, the first rock encountered is the upper sandstone, and this rock is believed to be successively underlain by trap sheets and by other sandstones that extend for several thousand feet down to the crystalline rocks. A few exceptions to the regular succession of the beds may be found in localities close to the fault zones, where blocks of the different rocks have been broken off and shifted from their normal positions. Such displacement and crushing may explain the presence of trap rock in the Worthington School well, at Berlin village (Berlin well 46, p. 31), though the geologic structure at this place (section C–D, Pl. III) indicates that the trap is several hundred feet below the surface. It is probable also that there are minor faults whose presence has not been detected.

The wooded areas were mapped incidentally (see Pl. IV, in pocket) because they affect to some extent the storage of ground water. The maps in this report also show certain changes in the roads and other cultural features that have taken place since the area was mapped topographically by the United States Geological Survey.

GEOGRAPHY.

The State of Connecticut may be divided into three physiographic provinces—the central lowland, the eastern highland, and the western highland. (See Pl. I.)

The area described in this report is in the south-central part of the State, and is chiefly in the central lowland, or Connecticut Valley, but its southeastern end lies in the eastern highland. From Connecticut River, which borders it both on the north and the east, the highland area rises in steep slopes that culminate in hills more than 600 feet in elevation. The surface of the lowland to the west is also broken by numerous hills and ridges, but the greater part of it is less than 300 feet above sea level, and it is dotted with lakes, ponds, and marshes.

In the part of the central lowland here considered the hills and ridges trend uniformly north-northeast. The most prominent ridge in the entire lowland area of the State is that which forms the Hanging Hills (Pl. V, *A*) 2 or 3 miles northwest of Meriden and which attains its maximum height, 1,007 feet above sea level, in West Peak.

Connecticut River is a quarter of a mile in average width where it borders the Meriden area, and it is affected by the tide for some distance farther upstream, to the city of Hartford. Mattabesset River, which drains most of the area and enters the Connecticut near Middletown, is also affected by the tide for several miles above its mouth. Quinnipiac River, which crosses the southwestern corner and receives the drainage of the southwestern part of the area, falls 60 feet in the 10 miles between South Meriden and the tidal limit at Quinnipiac.

About 30 per cent of the Meriden area is wooded (see Pl. IV, in pocket), chiefly with chestnut, oak, and maple. Practically all the woods consist of second or later growths, the mature trees having long ago been cut for timber or for fuel. Numerous wood lots in the farming areas furnish fuel and posts for local use, but the lower lands, originally heavily wooded, have been cleared and are given over to agriculture.

The cities of Meriden and Middletown—the principal centers of population—are in the towns of the same names in the southwestern and southeastern parts, respectively, of the area. Each of the other four towns—Berlin, Cromwell, Middlefield, and Rocky Hill—contains a village named for the town, and a few other communities are scattered throughout the area. Meriden and Middletown are manufacturing cities, carrying on factory and foundry industries. At most of the villages there are also factories and mills, but hay farming, fruit raising, and dairying occupy a large part of the population.

Transportation facilities in this part of Connecticut are good. The main line of the New York, New Haven & Hartford Railroad passes through the city of Meriden and the village at Berlin station; the Valley division follows the western bank of Connecticut River and passes through the city of Middletown and the villages of Cromwell and Rocky Hill; and the Air Line division passes through Middlefield and Middletown. Trolley lines connect Middletown, Meriden, and Berlin stations and neighboring villages. The Connecticut still affords transportation between river towns, but navigation on this old trade route has become of minor importance.

The climate of the region is not severe, the latest killing frost usually being in the last part of April,[1] and the earliest in the last part of October.[2] The mean annual temperature is about 47° F.[3]

The average precipitation is about 48 inches and is fairly evenly distributed throughout the year, as shown in figures 1 and 2.

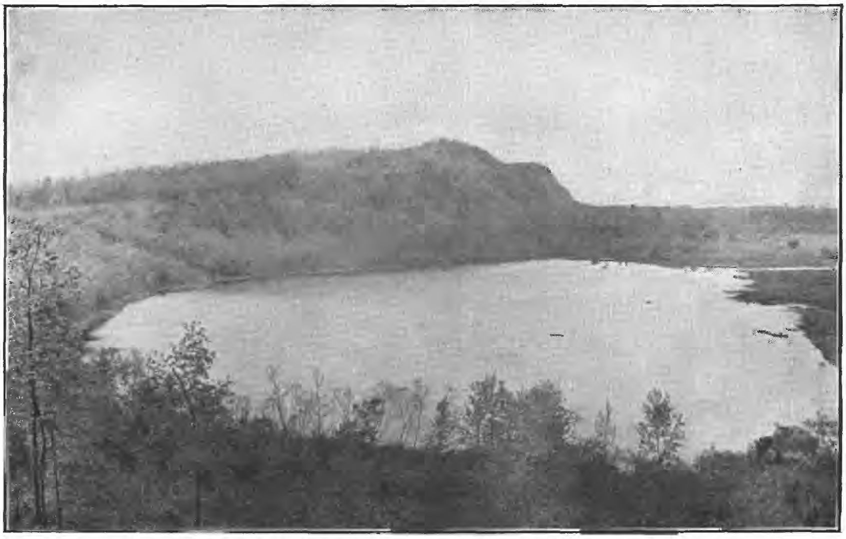
These average figures of temperature and precipitation are believed to represent closely the conditions throughout the greater part of the Meriden area. In the lowlands bordering Connecticut and Mattabesset rivers and on the higher ridges the winter temperatures are probably somewhat lower, however, and on the ridges the precipitation is doubtless somewhat greater than at Middletown, the only station in the area for which a long record is at hand.

[1] Henry, A. H., Climatology of the United States: U. S. Dept. Agr. Weather Bureau Bull. Q, pl. 20, 1906.

[2] Idem, pl. 19.

[3] Idem, p. 122; record for Southington, Conn.

A. HANGING HILLS, MERIDEN, CONN., FROM BUCKWHEAT HILL.



B. BLACK POND, MERIDEN, CONN., FROM THE NORTH.

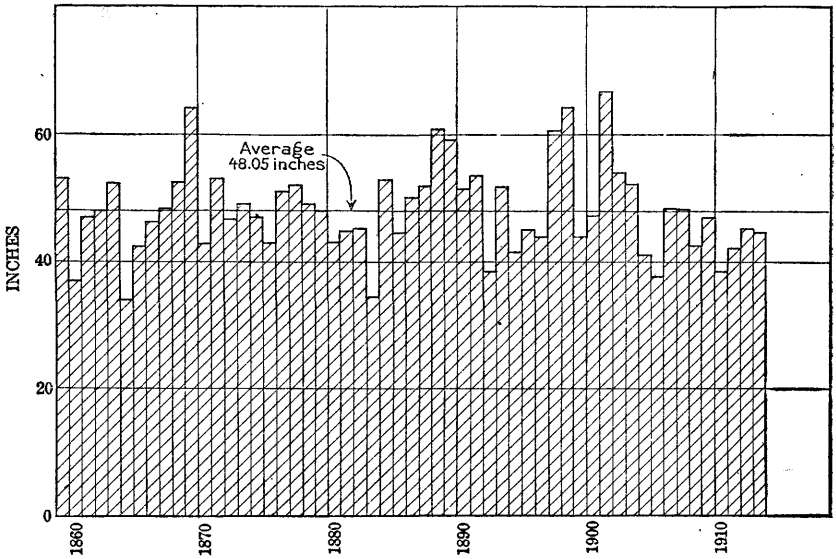


FIGURE 1.—Diagram showing annual precipitation at Middletown, Conn., 1859–1913, inclusive.

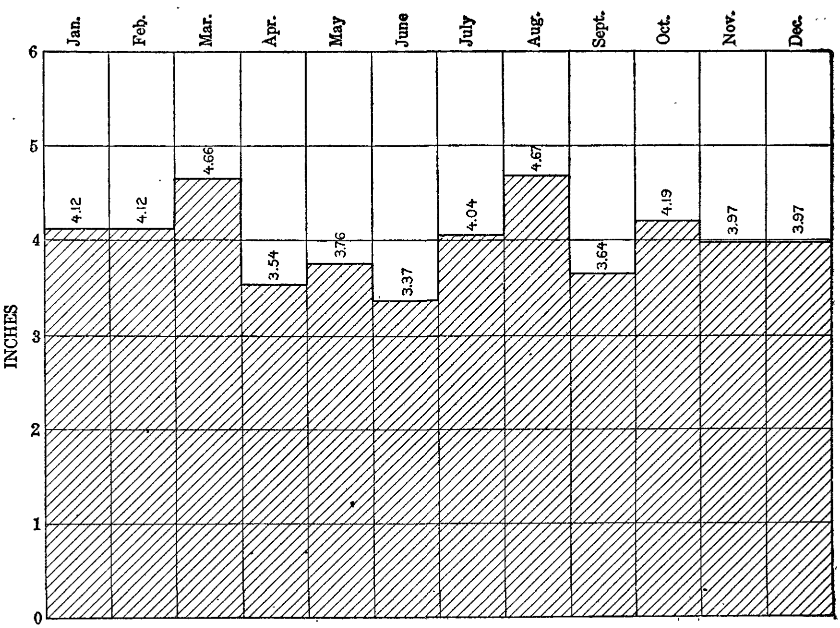


FIGURE 2.—Diagram showing average monthly precipitation at Middletown, Conn., 1859–1913, inclusive.

GEOLOGY.

The sandstones, shales, and lavas of the Meriden area are Triassic in age; the ancient crystalline rocks are the altered equivalents of sediments and igneous rocks which, during Paleozoic time, occupied all Connecticut. Toward the close of the Paleozoic era the previously deposited rocks were folded, broken and uplifted into mountains, and during the long period of erosion that followed the ranges, peaks, and gorges of these Paleozoic mountains were worn into groups of hills separated by shallow valleys. It is believed that at the close of the Paleozoic era central Connecticut was one of these wide-floored valleys near sea level or perhaps submerged. Into this valley was carried rock waste—sand, gravel, and mud—from the surrounding highlands. During the early part of the Triassic period the bottom of the valley was not much lower than its rim, but while sediments were being deposited the floor of the valley was broken and its east side was dropped much lower than the border. This great displacement deepened the valley and the thick deposits of sand and mud were gradually hardened to sandstone and shale. At three periods during the deposition of Triassic sediments molten rock made its way to the surface and spread widely as lava flows. As a result of sedimentation and igneous activity the Triassic deposits between the surface and the floor of the ancient valley form the following sequence:

1. Sandstone and shale (surface).
2. Lava.
3. Sandstone and shale.
4. Lava.
5. Sandstone and shale.
6. Lava.
7. Sandstone and conglomerate.

At the end of the Triassic period, or perhaps early in the succeeding Jurassic period, a mountain-making uplift took place in Connecticut. The sandstones and lavas in the Connecticut lowland were broken by faults and tilted into a series of ridges with steep westward and gentle eastward slope. A period of erosion, very long even in geologic time, then followed. Rivers on the land and the waves of the sea wore down the surface of the entire region—ancient highlands and uplifted lowlands alike—to an undulating plain, above which scattered hills rose a few hundred feet.

During the Tertiary period the region was again uplifted, and though the earth movements were not so great as those of earlier times, they increased the slope and activity of the streams and thus gave new impetus to erosive processes that have carved the whole region into the prominent hills and valleys that now form its main features. Triassic rocks have been worn down much more than the more resistant ancient crystalline rocks on each side, so that a lowland, comparable with the greater depression of Triassic time, has again been formed, bounded by an eastern and a western highland, as indicated in Plate I. Where the edges of the hard layers of trap rock were brought to the surface by the extensive faulting late in Triassic or early in Jurassic time, they have resisted erosion more than the softer shales and sandstones with which they are interbedded, and they now stand out in many places as prominent ridges in the lowland.

During the Pleistocene or glacial epoch all Connecticut probably was covered several times by great sheets of ice, which in its slow movement southward scoured off the soil that had been formed by the weathering of the rocks. When the last of the ice sheets melted, however, it deposited large quantities of gravel, sand, and clay that it had gathered up and thus formed a new coating of loose material over the bedrock; otherwise the greater part of the region would to-day consist of bare, rocky slopes on which agriculture would be practically impossible.

Since the disappearance of the ice there has been little change in the surface features of the Meriden area. The greater part of the area is included in the area of Triassic deposition, and the most prominent ridges in it are formed by the broken and tilted edges of the thickest of the three trap sheets.

These three sheets of trap rock, which have become known as the "Anterior" or lower sheet, the "Main" sheet, and the "Posterior" or upper sheet, have in this area thicknesses, respectively, of about 250 feet, 400 to 500 feet, and 100 to 150 feet. The "Posterior" and "main" sheets are separated by about 1,200 feet of sandstone and shale. Between the "Main" and "Anterior" sheets the sedimentary rocks are considerably thinner, but the series of trap sheets is both underlain and overlain by several thousand feet of sandstone and shale. The manner in which the rocks have been faulted and the prominent ridges have been formed is indicated in the structure sections (Pl. III, in pocket).[1]

Only one noteworthy dike has been found in the area. This dike is exposed along the hillside south of the city of Meriden and seems to have a maximum width of 15 or 20 yards.

The southeastern part of the area is underlain by the ancient gneisses and other crystalline rocks of the eastern highland. It is

[1] The delineation of bedrock areas and fault lines on this plate is reproduced from the map accompanying a detailed report by W. M. Davis on the region (U. S. Geol. Survey Eighteenth Ann. Rept., pt. 2, pl. 19, 1898), modified slightly in accordance with the preliminary geological map of Connecticut, prepared by H. E. Gregory and H. H. Robinson (Connecticut Geol. and Nat. Hist. Survey Bull. 7, 1907). The structure sections are patterned after the section by W. M. Davis (U. S. Geol. Survey Eighteenth Ann. Rept., pt. 2, pl. 20, 1898) and one by Joseph Barrell (Central Connecticut in the geologic past: Connecticut Geol. and Nat. Hist. Survey Bull. 23, fig. 1, 1915).

an area of rugged hills, but the change from the sedimentary lowland to the crystalline highland is not markedly shown by the surface features along this part of the boundary zone.

Although the ice sheet did not materially change the main features of the region by erosion, it caused numerous minor changes and produced certain new features, chiefly drumlins, or rounded hills of till, and sand plains. In a few places eskers, or long, low ridges of stratified drift, like that shown in Plate VI, *A*, were made by material that was probably deposited along stream channels that were formed beneath the ice sheet.

The most notable changes, however, were due to the diversion of drainage by the damming of the former stream channels, either by the ice itself of by its deposits of gravel, sand, and clay. The drainage of the main part of the Meriden area by Mattabesset River to the Connecticut was probably substantially the same for some time prior to the glacial epoch as it is now. The course of Quinnipiac River, however, from Southington to New Haven is believed to have been more direct in Tertiary time than it is now. Some geologists consider that its present course through southwestern Meriden was adopted after the glacial epoch, because of obstruction of its preglacial channel farther west by deposits left by the melting ice. The theory that Quinnipiac Gorge has been cut since the glacial epoch has been questioned by Ward,[1] who believes that the river cut this gorge in preglacial time. He suggests that relatively slight upwarping of the bedrock along an axis trending N. 70° W. may have diverted the river eastward from an earlier, more direct course.

The unstratified glacial material, or till, covers nearly all the higher lands. Along the stream valleys the glacial materials were to some extent sorted by water from the melting ice, and the gravel, sand, and clay were redeposited in more of less stratified layers, as is shown in Plate VI, *B*. This stratified drift and the till have been separately shown on the map of the surface geology (Pl. II, in pocket) because of their different characteristics as water-bearing formations.

The glacial material completely covered the region, but in general the layer of unconsolidated deposits is only a few feet thick. Over most of the higher lands it is too thin to be of value as a water carrier, the underlying rock being visible at numerous points. The localities at which the bedrock was seen by the author are indicated on Plate II by distinctive colors for the sandstone and shale, the trap rock, and the ancient crystalline rocks; doubtless there are other rock outcrops that he did not observe. In many places the outcrop is only a few feet in extent, and the size of the area of exposure is neces-

[1] Ward, Freeman, The "dam" at Cheshire, Conn.: Am. Jour. Sci., 4th ser., vol. 38, pp. 155–156, 1914.

A. ESKER NEAR BAILEYVILLE, BERLIN, CONN.

B. STRATIFIED DRIFT NEAR HARBOR BROOK, MERIDEN, CONN.

sarily exaggerated on the map. The principal rock exposures indicated on Plate II mark the prominent cliffs of the trap ridges, and the distribution of the minor exposures shows that in many places the glacial deposits covering the bedrock are very thin over large areas. Many of the bedrock exposures shown on the maps are along roads, where, of course, they are more readily observed, though the glacial material is in many places so thin that the bedrock is exposed by the road cuts and grades. On the higher lands the till is so thin that it is not easy to delineate the boundaries of the actual rock exposures. This is particularly true of the trap ridges; and the author's mapping of the exposures of trap rock on those ridges, shown on Plate II, might be modified considerably by another investigator carrying on a similar study of the region.

GROUND-WATER SUPPLIES.

WATER IN STRATIFIED DRIFT.

Stratified drift, which covers the lowlands of the Meriden area, consists chiefly of more or less definitely bedded deposits of clay, sand, and gravel, and the material as a whole offers conditions for the storage of water that are similar to those of the deposits of present-day streams, but the stratified drift contains a greater proportion of clay than is contained in those deposits, and in many places it is not so good a water bearer. The more sandy beds of stratified drift readily absorb rain, however, and are therefore important as water-bearing material.

WATER IN TILL.

The deposits of till that cover most of the Meriden area vary in character from relatively loose masses containing stones and some clay and sand to hard, compact masses of stones, sand, and clay cemented into a hardpan. The till contains large quantities of water, most of which is derived directly from precipitation, but its value as a source of supply differs according to its texture. The loose sandy or gravelly masses may yield fairly large and permanent supplies of water to wells, but the areas of sandy material are small, and those in which clay predominates are relatively large, so that till as a whole is a rather poor water-bearing material. In many places water is encountered in till at shallow depths because the clay in the till does not allow water to penetrate far below the surface, but the clay also prevents the rapid inflow of water to wells. Wells in till, therefore, usually furnish only scanty supplies, and many of them are likely to fail during periods of drought.

WATER IN TRIASSIC ROCKS.

The sandstone and shale that underlie the glacial material throughout the greater part of the Meriden area are compact, and, although they are capable of absorbing large amounts of water, they do not readily yield it to wells. The pore spaces in these rocks act as capillary tubes that draw water into the materials, but these tubes are too small to permit the ready outflow of water from the rocks into wells. Considerable water is obtained by some wells in these sedimentary rocks, but it is derived mainly from cracks and seams in the rocks.

WATER IN TRAP ROCK.

Trap is a dense lava rock that contains little pore space and hence allows the storage of only very small quantities of water. Certain kinds of the material are full of holes, but these bubble-like spaces are not connected with one another so as to allow the entrance and storage of water. In the central part of Connecticut, however, the trap, like the sedimentary rocks with which it is associated, is greatly fractured and contains numerous crevices and fissures which yield fairly large quantities of water where they are cut by drilled wells.

WATER IN ANCIENT CRYSTALLINE ROCKS.

In the ancient crystalline rocks, in the southeastern part of the Meriden area, conditions affecting the occurrence of the water are probably less favorable than in the trap and sandstone. The gneiss and other ancient rocks are very compact and absorb little water. At the surface they are traversed by innumerable cracks and fissures, but work in quarries indicates that those that persist beyond shallow depths are relatively few and are not large enough to provide much storage for water. The yield of wells sunk in the crystalline rocks is therefore uncertain and depends directly on the number and size of the fissures that may be intercepted by the drill.

AVAILABILITY OF GROUND-WATER SUPPLIES.

Streams furnish most of the water now used in this area, but ground water is capable of extensive development in certain localities.

Numerous wells that have been drilled in the towns visited and in other parts of the State show that the trap rock, the granite, and the other dense crystalline rocks as a rule yield only small amounts of water, even from wells several hundred feet deep. The water obtained from these rocks is stored almost wholly in the crevices and fissures; and the chance intersection of numerous small crevices or of a few large ones accounts for the unusually large yield of the few deep wells in crystalline rocks from which relatively large amounts of water are obtained.

The sandstone that underlies the greater part of the six towns considered in this report is in some places fairly coarse grained and porous, but examination where it is exposed in ledges and quarries strongly indicates that the available water in this rock is stored almost entirely in crevices. That the sandstone does not act as a great porous water-bearing body seems to be almost conclusively shown by the experience of well drillers, who very commonly find water not at a definite horizon or layer of rock but in one or more crevices from which the water spurts into the well. Sufficient water for ordinary domestic needs can be obtained throughout the areas of sandstone by wells drilled to moderate depth, but the supplies yielded by numerous wells sunk deeper than 500 feet indicate that definite water-bearing layers do not exist in the sandstone.

The chance of obtaining a flowing well in any part of the region is very slight, and depends on the intersection by the drill hole of a favorable system of water-bearing fissures in the rock. Of the 82 drilled wells that were examined, only three flow (Berlin well No. 70, Rocky Hill well No. 5, and Rocky Hill well No. 23), and the flow of two of these is very small; these wells also are relatively shallow, the deepest being only 117 feet deep. The chances for obtaining an artesian flow do not appear to be increased by deep drilling.

The stratified drift that covers the lowlands of the Meriden area contains water at a slightly less average depth than does the till, and domestic wells that are sunk in the stratified drift as a rule obtain more dependable supplies than those sunk in till. Of the 316 dug wells in glacial material that were examined, 106, or about one-third of the number, are in stratified drift and 210, or about two-thirds, are in till. The average depth to water in the wells in stratified drift early in May, 1915, was 13.7 feet, whereas the average depth to water in the wells in till was 14.3 feet, as is shown in the graphic tabulation of the depths to water in the dug wells in figure 3.

Only 12, or about one-sixth of the 73 wells that were reported to fail in dry periods, are supplied from the stratified drift.

Small areas in the stratified deposits of drift in each town that seem favorable for the development of large amounts of ground water have been specifically described in the descriptions of the towns (pp. 21–80), but they may be summarized as follows: In Berlin the most favorable locality for the development of large amounts of ground water seems to be the lowland on the south side of Mattabesset River, near the mouth of Belcher Brook. In Cromwell the most favorable locality is probably the lowland east of the village of Cromwell, where the principal brook in the town aids in replenishing the subsurface supply. The sandy deposits of the plain on the south border of Meriden, west of Quinnipiac River, appears to offer the best material for supplying large amounts of water to wells. In

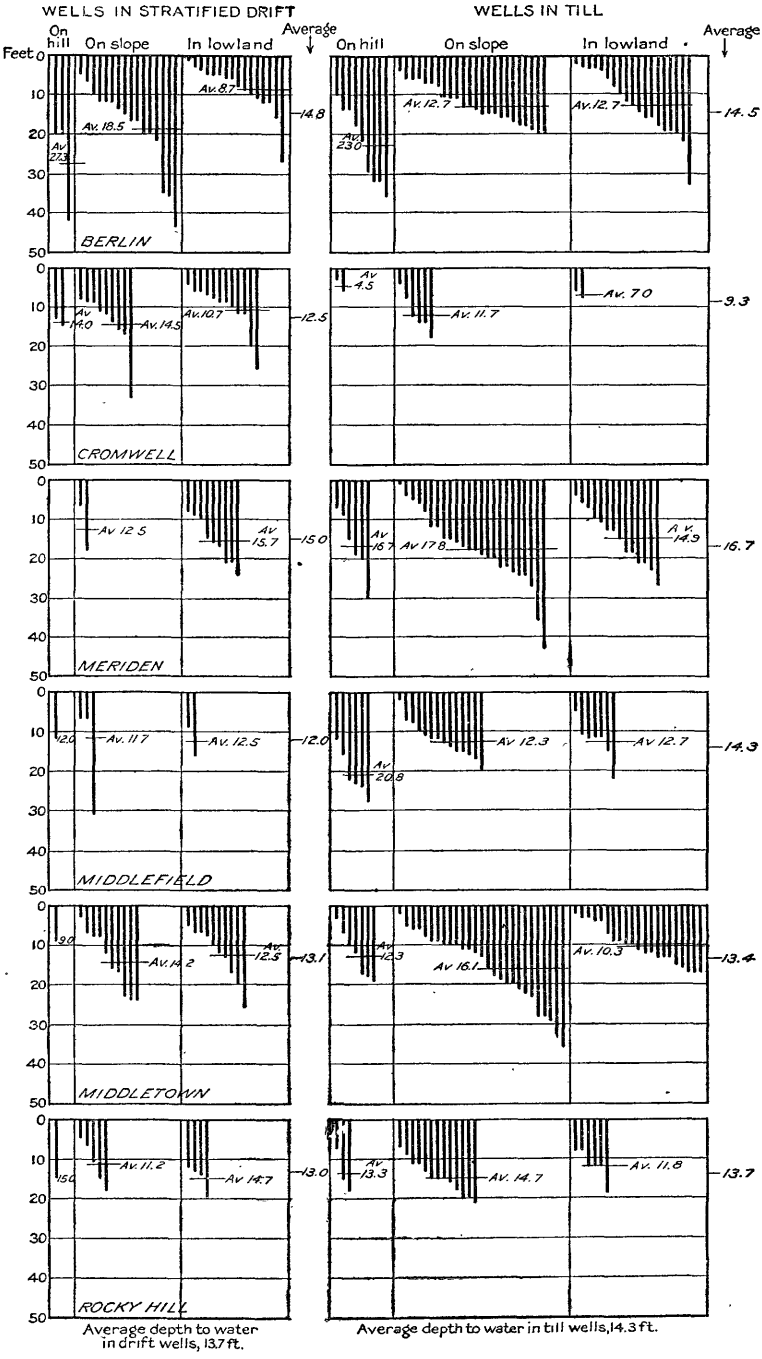


FIGURE 3.—Diagram showing depths to water in dug wells in the Meriden area, Conn., in May, 1915.

Middlefield extensive sandy deposits were not observed, but sandy and gravelly layers, which would yield large quantities of water to wells that were properly cased and screened, probably occur in the marsh land in the south-central portion of the town. In Middletown fairly deep sandy deposits of stratified drift occupy portions of the valley of Sumner Brook, and wells properly spaced throughout these deposits could doubtless obtain a large amount of water. The sand plain in the southern portion of Rocky Hill does not appear, from the available well records, to be capable of yielding much water to individual wells, as the material is fine grained and in places somewhat clayey. The stratified drift in the northern and eastern portions of the town may be capable of yielding much water from wells sunk near the principal drainage channels, but the most favorable area for extensive water-bearing sands is believed to be the wide meadow in the northeast part of the town.

The following quotation is given from a report by H. S. Palmer, on the ground waters of the Southington-Granby area, Conn., concerning water pumped from the stratified drift for public supply at Plainville, a few miles west of the Meriden area, as this development affords an example of the possibilities in areas of similar material in the Meriden area:

In 1909 thirty wells were driven in the sand plain east of Plainville between the railroad and Quinnipiac River by the Plainville Water Co., which supplies most of the inhabitants of Plainville village, in order to supplement the surface water supply. The wells are driven in two rows of 15 wells, each 3 inches in diameter and 25 to 30 feet deep. Pumping tests, when the wells were driven, showed that each yielded about 40 gallons a minute. The wells are connected by a suction main to a 3-cylinder Deane pump with a capacity of 30,000 gallons an hour, driven by a 50-horsepower De la Vergne crude-oil engine of the hot-tube type. Water is pumped directly into the mains, the excess going to gatehouses at the company's reservoir, which act as standpipes. If the pump is operated 10 or 12 hours a day it provides sufficient water. Despite this heavy draft there has not been a permanent reduction in the supply, the depression caused by the day's pumping being overcome during the night.

WELL CONSTRUCTION.

In the area treated in this paper the deposits of stratified drift seem to be the most promising source for obtaining large amounts of ground water. Because few, if any, attempts have been made in this region to obtain large supplies from the drift, some statements concerning the method of sinking wells that will probably be most successful in this material are given. Experience has demonstrated that large quantities of water from sand and gravel can be efficiently obtained from gangs of drilled or bored wells, which should usually be sunk at sufficient distances apart to prevent interference with one another. The proper spacing depends chiefly on the relative coarseness of the water-bearing material; in gravel or coarse sand, which yields its water freely, fewer wells will be required in a given area than in deposits of fine sand, which yields water more slowly; the most efficient spacing of wells ranges from about 15 feet in fine sand to 100 feet in coarse gravel. It is usually advisable to sink wells to the full depth of the water-bearing strata in order that as large yield as possible may be obtained. Wells that are drilled or bored in loose materials must be cased, usually with iron or steel pipe, to prevent caving, and the casings must be perforated or sections of perforated tubing must be used in place of the casing at the water-bearing beds in order that the water may enter. In coarse sand and in gravels the casing may be satisfactorily perforated by drilling many holes one-fourth or three-eighths inch in diameter in it or by slitting the casing after it is placed in the well by means of a powerful cutting device lowered inside the casing. In fine sands various patterns of slotted and wire-gauze screens are used. A satisfactory screen for use in fine material is also sometimes made by winding heavy wire closely around casing in which a great number of holes one-fourth or three-eighths inch in diameter have been drilled. After a well has been finished in unconsolidated materials it is usually advisable to pump it strongly in order to remove the fine sand around the casing. The coarser material that remains will form a protective strainer around the casing that will lessen the tendency of the screen or perforations to become clogged and thus increase the yield of the well. Some screens that become clogged by fine sand against the outside, which can not be removed by strong pumping, can be cleaned by turning air, water, or steam under high pressure into the well.

Some waters deposit mineral matter, usually calcium carbonate or a compound of iron, on the meshes of fine screens and in time seriously reduce the yield. These materials can rarely be loosened while the screen is in the well. In localities where such difficulty is encountered, the diameter of the wells should be sufficiently large so that the sections of screen can be lowered inside the casing and be easily removed for cleaning. If the water level is at so great depth that a cylinder pump, an air lift, or other raising device must be installed in each well, casing 6 or 8 inches or larger in diameter should be used. If the water level remains during pumping within the practicable suction lift of about 25 feet, pumps may be installed at the surface and the water raised by suction, either by a pump on each well or by a pump that is connected by air-tight suction mains to several wells. Centrifugal pumps are extensively used for lifting water from shallow depths, and they are employed for lifting water from greater depths by installing them in pits.

QUALITY OF GROUND WATER.

Twenty-four samples of water were collected by the author on May 18 and 19, 1915, and were analyzed under contract for the United States Geological Survey by S. C. Dinsmore.

These analyses, except those of three waters which were probably contaminated (Berlin well No. 85, Cromwell well No. 41, and Middlefield well No. 26), are grouped in the following table according to the geologic source of the waters—whether stratified drift, till, sandstone, or trap. The springs, although probably they derive their water chiefly from the sandstone or the trap, may also contain water from the overlying glacial materials, and hence their analyses are not grouped with those of the well waters. The analyses are too few to warrant broad deductions as to the quality of the waters, but they seem to indicate certain general differences in the waters from different kinds of material.

The analyses show a range in total dissolved solids from 80 parts per million parts of water in one of the wells ending in till to 367 parts per million in one of the wells ending in trap, the average being 181 parts per million. The lowest average of total solids (104 parts per million) is shown by the analyses of the spring waters, but the lowest amount was found in the water from a well ending in till (Berlin well No. 107). In general the waters from the rock formations (sandstone and trap) are noticeably more highly mineralized than those from the glacial drift (stratified drift and till), the higher total contents being due chiefly to greater amounts of the scale-forming constituents—calcium, magnesium, bicarbonate, and sulphate.

Nearly all the waters are of the calcium-carbonate type. The average amounts of calcium and magnesium are distinctly higher in the waters from the rock than in those from the glacial drift. The average ratio of magnesium to calcium is nearly 1 to 3. In about half the waters the ratio is fairly constant, but in the others it ranges from 1 part of magnesium to 10.95 parts of calcium (Meriden well No. 52), both extremes being found in waters from sandstone.

The content of sodium and potassium is low in all the waters. Only traces of these elements are reported in five of the waters, and they form less than 1 per cent of the total solids in three others. They are highest in a sandstone water (Meriden well No. 52), in which, however, they amount to only 24 parts per million. So far as these few data show, the rock waters contain lower average amounts of these constituents than the waters from the glacial drift.

The average content of sulphates is higher in the rock waters than in the waters from the glacial drift. In only two of the samples, however (Berlin well No. 83 and Meriden well No. 52), does the sulphate radicle exceed 50 parts per million.

Chlorides form only a small percentage of the total dissolved solids, although the quantity shown by most of the analyses much exceeds that indicated by the isochlors that have been drawn for the State.[1] The percentage is higher for the waters from the stratified drift and till than for the waters from the sandstone, but this may be due to the fact that wells ending in drift, many of which are shallow dug wells, are more exposed to pollution than those ending in sandstone, most of which are drilled and are deeper.

Chemical composition of ground water in Meriden area.

[Parts per million.]

Source.	Silica (SiO_2).	Iron (Fe).	Calcium (Ca).	Magnesium (Mg).	Sodium and potassium (Na+K).[a]	Carbonate radicle (CO_3).	Bicarbonate radicle (HCO_3).	Sulphate radicle (SO_4).	Chloride radicle (Cl).	Nitrate radicle (NO_3).	Total dissolved solids at 180° C.
Wells in glacial deposits:											
Stratified drift:											
Berlin No. 20	25	Trace.	42	15	9.6	0.0	197	8.2	7.5	8.0	109
Cromwell No. 6	15	Trace.	14	5.0	8.8	.0	9.7	11	14	44	119
Cromwell No. 7	17	Trace.	11	4.8	10	.0	14	29	14	10	93
Middlefield No. 11	18	Trace.	20	5.6	Trace	.0	48	10	7.0	12	101
Average	19	Trace.	22	7.6	7.1	.0	67	15	11	18	130
Till:											
Berlin No. 51	17	Trace.	40	17	9.5	.0	153	16	17	30	226
Berlin No. 107	20	Trace.	11	3.9	4.9	.0	34	9.8	4.5	12	80
Middlefield No. 6	26	Trace.	25	8.9	16	.0	63	34	18	28	192
Average	21	Trace.	25	9.9	10	.0	83	20	13	23	166
Wells in rock:											
Sandstone:											
Berlin No. 31	22	Trace.	31	22	1.6	.0	143	11	13	30	184
Berlin No. 46	25	Trace.	46	13	2.5	.0	143	16	19	16	213
Berlin No. 83	17	Trace.	65	17	5.3	.0	102	147	5.0	.0	340
Meriden No. 7	17	Trace.	28	7.4	Trace	.0	92	10	5.0	3.0	128
Meriden No. 41	27	Trace.	50	9.6	13	.0	134	46	16	15	235
Meriden No. 52	25	Trace.	69	6.3	24	.0	129	77	23	40	339
Middletown No. 11	15	Trace.	28	14	.6	.0	117	11	7.0	14	159
Middletown No. 16	16	Trace.	33	19	.7	.0	148	10	11	18	187
Middletown No. 104	20	Trace.	41	19	8.5	.0	219	9.0	7.0	.0	213
Average	20	Trace.	43	14	6.2	.0	136	37	12	15	222
Trap:											
Rocky Hill No. 23	23	Trace.	58	32	7.0	.0	251	8.6	36	32	367
Springs:											
Meriden No. 39	27	Trace.	29	4.1	3.0	.0	92	5.3	7.0	6.0	120
Middletown No. 27	16	Trace.	22	7.2	Trace	.0	70	8.6	3.0	.0	96
Middletown No. 37	19	Trace.	21	5.6	Trace	.0	65	Trace	6.0	14	102
Middletown No. 87	15	0.20	23	4.1	Trace	.0	46	16	4.0	8.0	99
Average	19	.05	24	5.2	.8	.0	68	7.5	5.0	7.0	104
Average of all analyses	20	.01	34	11	6.0	.0	108	24	12	16	181

[a] Calculated.

Nitrate is reported to be absent from one spring water and two sandstone waters. It reaches a maximum amount in the water

[1] Jackson, D. D., The normal distribution of chlorine in the natural waters of New York and New England: U. S. Geol. Survey Water-Supply Paper 144, p. 20, 1905.

from Cromwell well No. 6, which ends in stratified drift. The high nitrate content of this water and of some of the other waters may be due to the presence of considerable organic matter, but it is evident that pollution exists in a number of the waters. Although the evidence is based on mineral and not sanitary analyses, any water that contains more than 25 parts per million of nitrate and an amount of chloride much higher than the average should receive a bacteriologic examination before being used for drinking.

Some of the waters analyzed are rather hard and poor for use in boilers, but on the whole their quality compares favorably with that of ground waters in other parts of the country.

The use of drilled wells drawing water from the rock for domestic supplies is advisable in many places, even though the rock water may be somewhat harder than the water from the glacial deposits, because more dependable supplies are assured and the danger of contamination is reduced.

Further discussions of the ground waters and statements pertaining to their economic value[1] are presented in the descriptions of the towns from which they were obtained.

DESCRIPTIONS OF TOWNS.

BERLIN.

HISTORICAL SKETCH.

The town of Berlin occupies the northwestern part of the Meriden area. The first white settler in the present town was Sergt. Richard Beckley, a planter from New Haven, who about 1660 established his home on 300 acres of land in the valley of Mattabesset River, near the present village of Beckley. Within the next few decades a settlement known as Beckleys Quarter was built up in the vicinity, and another settlement, which was known as the Great Swamp, in the lowland to the west. In 1705 these early settlements were organized as a society of the community of Farmington, which originally embraced also the town of New Britain, to the north. This society was for a time known as Farmington Village, but in 1722 the western part adopted the name of Kensington. In 1754 the northern part organized as the society of New Britain, and by 1785 the population had so increased that additional organization was warranted. The three societies of New Britain, Kensington, and the original settlement, then known as Worthington, accordingly incorporated as the town of Berlin. At the time of incorporation and for many years after Worthington (now East Berlin) was the principal place of business. In 1850 the town was again divided, the societies of Kensington and Worthington retaining the original

[1] Dole, R. B., Standards for classification; Ground water in San Joaquin Valley, Calif.: U. S. Geol. Survey Water-Supply Paper 398, pp. 50–81, 1916.

town name and its present boundaries, and the society of New Britain being incorporated as the town of New Britain.

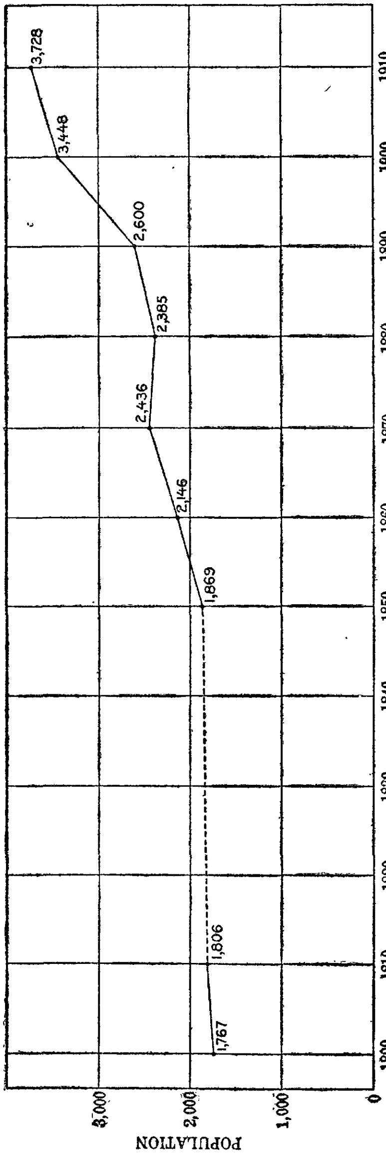


FIGURE 4.—Curve showing population of the town of Berlin, Conn.

The town of Berlin now contains the villages of Berlin, East Berlin, Beckley, and Kensington and includes an area of about 17,700 acres, according to planimeter measurement on the Meriden and Middletown topographic maps.[1] About 36 per cent of the total area is wooded. (See Pl. IV, in pocket.) Nearly 8 per cent is marsh land, comprised almost entirely in a tract between the villages of Berlin and East Berlin. Several ponds and reservoirs in the town cover an area of about 360 acres.

POPULATION AND INDUSTRIES.

Records of the early population within the present limits of the town have not been found by the author. From about 1660 until a number of years after the incorporation of the town in 1785, growth must have been fairly rapid, for in 1800 Kensington had a population of 764 and Worthington 1,003. During the following decade Kensington lost 8 and Worthington gained 47 people,[2] but 40 years later, shortly after the incorporation of New Britain as a separate town, the total population of Kensington and Worthington (forming the town of Berlin) had gained only 60. Since 1850 the growth has been more rapid, as is shown in figure 4.

[1] The assessor's returns for 1915 give a total of 15,185$\frac{5}{8}$ acres. The area given on p. 413 of the Connecticut State Register and Manual for 1915—10,516 acres—is evidently in error.

[2] Camp, D. N., History of New Britain, with sketches of Farmington and Berlin, Conn., p. 196, New Britain, 1889.

This increase has been due largely to the railroads that were built through the town from Meriden in 1839 and from Middletown about 1845, for these transportation lines began in a few years to attract manufacturing industries.

The manufacture of tinware in Connecticut was begun in Berlin about the time of the American Revolution, and a number of other industries were early developed, water power being used for factories as well as for gristmills. At present the chief industries are the manufacture of iron bridges and other structural iron work at Berlin station, jewelry at East Berlin, and envelopes, paper bags, and other paper articles at Kensington.

The uplands of the town are noted for fruit raising, and the lowlands have long been devoted to hay raising and to pasturage. In the lowland near Beckley and near Berlin station brickmaking has also been carried on extensively for many years.

SURFACE FEATURES.

The highest points in the town of Berlin are the crest of South Mountain, on its southwest border, at an elevation of 790 feet, and the crest of Ragged Mountain, on its northwest border, at an elevation of 754 feet. The Hanging Hills, in the southern part of the town, and Lamentation Mountain, in its southeastern part, form prominent highlands that trend east of north. From these prominent ridges the surface slopes northward through rolling hills down to extensive lowlands along Mattabesset River. Where this stream leaves the town and swings eastward its channel is only a few feet above the tide.

The higher parts of the town are densely wooded with second or later growths of chestnut, oak, and other trees, and numerous wooded patches dot the lower hills. The open valley lands are, however, practically free from timber. (See Pl. IV, in pocket.)

STREAMS.

Practically the entire town is drained by Mattabesset River and its tributaries, the only exception being a small area on the southern border, which drains southward through Cathole Gorge. The western and southern boundaries of the town represent approximately the limits of the Mattabesset drainage basin in those directions. In conformity with the main topographic features, the tributaries of the Mattabesset flow in a fairly direct course east of north to the major stream, which winds eastward through the lowland of the northern part of the town, and then, after flowing southward, forming the town line for 3 miles, it turns east and southeast to Connecticut River.

The Mattabesset is a sluggish stream throughout its lower portion. The operation of numerous mill ponds and reservoirs on its tributaries greatly affect its daily discharge, and reliable measurements of the flow of the main stream and its branches are difficult to obtain. The mean flow during the six months of low water has been given as follows:[1]

Mean flow of Mattabesset River during six months of low water.

	Second-feet.[2]
At Berlin station	10
Below mouth of Belcher Brook	20
Above Westfield	[3]50

Since the days of early settlement the Mattabesset has furnished power for mills. The stream is badly polluted in its lower portion by factory wastes and by the effluent from the sewage beds of the city of New Britain, which are in the lowland west of Beckley. (See Pl. IV, in pocket.)

The principal tributary to Mattabesset River in Berlin is Belcher Brook, which heads in Beaver Pond, in the town of Meriden, and thence flows directly northward through a large pond on the town line to the Mattabesset a mile southeast of Berlin station. A short distance above its junction with Mattabesset River Belcher Brook is joined by North Brook, a stream that heads in the gap in Hanging Hills that is occupied by Merimere reservoir of the Meriden city water supply. Overflow water from this reservoir is, however, diverted by a ditch into a lower reservoir on an upper branch of the Mattabesset proper. The drainage of the slopes between Belcher and North brooks enters Belcher Brook through two minor streams that join it at points respectively about one-eighth and five-eighths of a mile above its mouth. The approximate mean discharge of North Brook in its lower course is 3 second-feet, and the mean flow of Belcher Brook in its lower course is about 8 second-feet.[1] Measurements made by the writer at different points in the lower course of each stream indicate, however, that a considerable part of the flow of each stream sinks into the gravel of the lowland and hence is not visible at the junction with the Mattabesset.

A stream system that drains the southwestern part of New Britain also drains the northernmost portion of Berlin. Its three main branches unite in the lowland half a mile north of Berlin station to

[1] Report on the investigation of the pollution of streams, Connecticut State Board of Health, p. 45, 1915.

[2] A second-foot is the rate of discharge in a stream 1 foot wide and 1 foot deep, flowing at the rate of 1 foot a second—that is, 1 cubic foot a second, or 7.48 gallons a second.

[3] On April 14, 1915, the flow of the stream one-half mile west of Westfield station, according to a current-meter measurement made in connection with the present investigation, was 42 second-feet.

form Willow Brook, which flows for more than a mile eastward and southward across the lowland and joins the Mattabesset $1\frac{1}{2}$ miles below the mouth of Belcher Brook. In the saturated lowland Willow Brook is a sluggish stream whose average flow is difficult to determine, and near its mouth the probable accession of water from the New Britain sewage beds renders measurements of the flow of the stream unreliable. The natural flow in its lower course seems to be only 1 or 2 second-feet. Webster Brook, a small, sluggish stream that comes from the north and drains only lowlands, also enters the Mattabesset near the sewage beds.

A fairly straight brook that drains a narrow basin heading in the town of Rocky Hill enters Berlin near its northeast corner and joins the Mattabesset where that river turns from an easterly to a southerly course. The lower mile of this brook has a fairly uniform and steep grade, the fall being nearly 100 feet. Its narrow basin is only $2\frac{1}{2}$ miles long, and its average flow is less than 1 second-foot. Two other streams of about the same size enter the Mattabesset from the Berlin side. One of these streams heads in Middletown on the northeast slope of Lamentation Mountain, flows first northward through a large marshy area between the villages of Berlin and East Berlin, then swings eastward and joins the Mattabesset opposite the Rocky Hill-Cromwell town line. The other stream drains the lower slopes east of Lamentation Mountain and only the lower half mile of its course is in Berlin. It joins the Mattabesset 300 or 400 yards above the Berlin-Middletown town line.

In the southern part of Berlin much of the drainage of the Mattabesset is collected in three reservoirs—Merimere, Hallmere, and Kenmere—for the water supply of the city of Meriden.

Harts Ponds in the northwest and a large pond in the southeast portion of Berlin are in part formed by dams. Ice is harvested from the southeastern pond in winter, but Harts Ponds serve chiefly as storage supplies for the mill ponds farther downstream. Chief of these ponds is that of the American Paper Goods Co., a mile southwest of Berlin station, and a newer pond that is formed by another dam half a mile below.

GEOLOGY.

The Triassic bedrock in the town of Berlin has been greatly displaced from its original position by extensive faulting. The blocks between the fault zones, which trend generally northeast, have been tilted eastward or southeastward at angles of 10° to 20° from the horizontal. The several blocks have also been offset by movements that have in general shoved the rocks on the western side of each fault southward with respect to the rocks on the eastern side. This extensive faulting has brought to the surface the broken edges of the three trap sheets in the manner shown in the cross sections C–D and E–F of Plate III (in pocket).

The rock of the "Anterior" or lower trap sheet has been brought to the surface only near the southeast corner of the town and at one place on its west border. In these places the "Anterior" trap forms only a few small exposures, as is indicated in Plate II (in pocket). The main trap sheet is well exposed in several cliffs in the southern and western portions of the town and also forms the bedrock beneath considerable areas in those portions. (See Pl. III.) The "Posterior" or upper trap sheet has been brought to the surface and forms several bands or zones in the northern and northeastern portions of the town. Three or four of the bands formed by this trap sheet are low but distinct ridges, but the others are so inconspicuous that the courses of the broken edges of the trap sheet are very largely hidden by the overlying glacial deposits.

The beds of sandstone with which the trap sheets are associated have been so displaced from their original position that the "Posterior" sandstone (which underlies the "Posterior" trap sheet) and also the sandstones beneath the other trap sheets, now form the uppermost rock beneath considerable parts of the town, although the original upper sandstone remains as the uppermost rock beneath most of the northeast part of the town. In deep drilling in the areas where the upper sandstone forms the uppermost rock the entire series of sandstones and three trap sheets would therefore be penetrated if the drill hole were continued to sufficient depth.

In the lower lands of the town, which are along the valley of Mattabesset River and its main tributaries, the bedrock is overlain by stratified glacial drift, as shown in Plate II (in pocket). Beds of brick clay are found in these deposits along the Mattabesset and appear to have been laid down in a lake that occupied the river valley for some time after the retreat of the Pleistocene ice.[1]

In a few places the stratified drift forms characteristic features other than flat lowland areas. In the lowland one-half mile to 1 mile southwest of Beckley there is a long, narrow curved ridge or esker (Pl. VI, *A*) composed of sand and gravel that was deposited along the course of a glacial stream that flowed beneath the ice sheet. A small area 1½ miles southeast of Turkey Hill and a few hundred yards west of the railroad contains several depressions that are probably kettle holes, formed by the melting of great blocks of ice that were left with other glacial débris as the main ice front melted and retreated northward.

The higher lands, which form the greater part of the town, are overlain by glacial till. On the higher slopes this loose material is

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[1] Loughlin, G. F., The clays and clay industries of Connecticut: Connecticut Geol. and Nat. Hist. Survey Bull. 4, p. 24, 1905.

in many places very thin, however, and the underlying rock, which is chiefly trap on these slopes, is laid bare at numerous points.

Distinct evidences of glaciation are shown by glacial scratches at several places on the exposed rock surfaces, both in the ridges and in the lower rolling hills. A number of the lower hills are also rounded and elongated in a general northerly direction and are probably drumlins or masses of till (unstratified glacial drift), which were formed beneath the ice sheet in somewhat the same way that sand bars are formed in sluggish streams.

WATER SUPPLIES.

Surface water.—In the southern part of the town of Berlin a few families near the Meriden water main from Kenmere to Elmere reservoirs obtain domestic supplies from that source. In 1914 in the village of Berlin 113 customers were supplied by a line extending southward from the New Britain Water Co.s system.[1]

The Berlin Water Co., organized about 1912, has planned to supply the village of Berlin with water pumped from Mattabesset River, but in the summer of 1917 construction on its system had not been begun.

Except for the families in Berlin village that are supplied by the New Britain Water Co., and those in the southern portion of the town that are supplied from the Meriden main, the people of the town of Berlin depend for water on individual wells, though a few of them obtain their supplies from springs.

Water in stratified drift.—By far the greater number of wells in Berlin are dug in the unconsolidated glacial deposits. Relatively few wells have been dug or drilled into the underlying rocks. The deposits of stratified drift occupy most of the lowland areas in the town, and also cover some of the adjacent hillsides, as is shown in Plate II (in pocket). Of the 87 dug wells[2] in the town that obtain water from the glacial deposits. 35 are in the stratified drift, and although some of them get low and even fail completely during the later part of the summer, they furnish water at relatively shallow depths during most of the year. The depth of the wells differs considerably, the maximum that was noted being 43 feet in well 105 early in May, 1915. The depth of water in the wells ending in stratified drift that were measured in this town differs markedly according to the topographic position, and, as is shown in figure 3 (p. 16), the ground water stands about twice as deep on the hillsides as in the lowlands. The average depth to water in the three wells examined on hilltops was

[1] Connecticut Public Utilities Commission Rept., 1914, p. 661.

[2] Wells 33 and 56 are omitted from this enumeration, as they obtain water from the underlying sandstone.

over three times as great as in the lowland wells. In one lowland well (No. 41), however, the depth to water was greater than in two of the hilltop wells. The analysis of the water of the deepest recorded hilltop well in drift (well 20, p. 32) shows it to be a water of moderate concentration, in which calcium and bicarbonate predominate, making it a moderately hard water for this area, although the amount is not excessive and No. 107 is the only Berlin water analyzed that contains less hardening constituents.

The detached area of stratified drift in the vicinity of Harts Ponds (see Pl. II, in pocket) is thin, and although water is obtained at shallow depths, the wells are liable to fail in summer. The stratified drift in the valley of Belcher Brook and in the stream valley between Berlin and East Berlin is also rather thin, and some of the dug wells in these localities likewise fail. In the lowland north of Mattabesset River there are extensive deposits of clay, and dug wells there do not obtain satisfactory supplies of water.

On the south side of the Mattabesset near the mouth of Belcher Brook, dug wells obtain more reliable supplies of water, for the drift there is more sandy. Large quantities of ground water probably can be developed in this locality by shallow wells drilled or bored to the bottom of the principal water-bearing strata. Wells sunk in this area should be cased to keep out fine sand, and properly screened to allow the rapid inflow of water. Ample supplies of water of good quality for domestic consumption and industrial use could probably be thus developed in this lowland area at a relatively small cost for the neighboring communities of Kensington, Berlin station, and Berlin. Below Beckley the stratified drift is clayey, and consequently good supplies of water are not so commonly obtained there as near the mouth of Belcher Brook.

Water in till.—The greater part of the town of Berlin is covered with glacial till. Over the higher lands the till is too thin to serve as a water-bearing formation, however, and both the underlying trap and the sandstone are exposed in many places. (See Pl. II, in pocket.) The average depth to water in the 52 till wells that were measured was 14.5 feet, or practically the same as in the 35 wells in stratified drift. (See fig. 3, p. 16.) The average depth to water in the wells in till on hills and slopes was noticeably less than in wells in stratified drift in the same topographic positions, however. In the lowlands, on the contrary, the average depth to water was nearly 50 per cent greater in the wells in till than in the wells in stratified drift.

The analyses of water from dug wells 51, 85 (p. 30), and 107 (p. 31), the first two being hilltop wells in till and the last on a slope in the same material, illustrate the marked differences in character in well waters obtained from the till. The water from well 51 is a moderately hard calcium-carbonate water, whereas that from well 107 is unusually free from mineral salts in solution. The high content of calcium, magnesium, and bicarbonate in the water from well 85 shows that it is a very hard water for this area. This well is in a barnyard, and the unusually large amounts of chloride and nitrate indicate that the water is contaminated by the barnyard wastes.

Water in sandstone and trap.—Records were obtained of the water level in only 13 drilled wells in Berlin. These wells range in depth from 50 to 300 feet, the average depth being 120 feet. Most of these wells are drilled into the sandstone and obtain dependable supplies of water sufficient for domestic use. Well 23, however, which is drilled at a brickyard in the lowland near Beckley, probably is sunk its entire depth in the stratified drift and obtains its water from a sandy layer below the clay deposits. Trap was penetrated in wells 46 and 77, but their main water supplies are from the overlying sandstone. Well 70 is of unusual character, as it has an artesian flow. Its natural yield of 100 gallons a minute is much larger than is usually obtained from drilled wells. The trap rock of the posterior sheet is exposed near the well, and the bottom of the well, which is reported to be 117 feet deep, may be a short distance below the bottom of the trap sheet, and the artesian flow may come from the sandstone beneath the nearly impervious trap rock.

The analyses of water from drilled wells 31, 46, and 83 (p. 32) show them to be waters of moderate concentration, in which calcium and bicarbonate, the usual constituents in this region, predominate. The water from well 83 is notable for its high content of sulphate in addition to bicarbonate. It is a rather hard water, but the low content of chloride and the absence of nitrate indicate that it is probably free from contamination. In this respect it is a better water than many others in the town.

Springs.—Only five springs were noticed in the town, and only one of these was used as a domestic supply. Three of the springs issue directly from sandstone. The other two issue from the glacial deposits that overlie the sandstone, but possibly have their principal source also in the water that is stored in crevices in the sandstone. All are of small but perennial flow.

RECORDS OF WELLS AND SPRINGS.

The locations of a number of wells, scattered throughout the town, are indicated on Plate II (in pocket), together with the depth to water in each early in May, 1915. Additional data concerning these wells and the springs that were noticed are given in the following tables and their discussion. The depth to water in the wells listed, and the relative capacity and permanence of their supplies, are believed to be typical of the many other wells in the town.

Dug wells in Berlin.

Map No. [a]	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Method of lift.	Remarks.
		Feet.	*Feet.*	*Feet.*		
2	Slope	210	15	12	Windlass	Gets low but never dry; trap penetrated.
3	.....do	210	19	17	.....do	Does not dry.
4	Swale	160	23	12	Well sweep	Dry every summer.
5	.....do	140	20	10	Rope and bucket	Never dry; 100 yards east of No. 4.
6	Lowland	55	14	8	Chain pump	
7	Base of hill	220	13	3	.....do	
8	.....do	220	32	16	Pitcher pump	Low in summer; 100 yards southeast of No. 7.
10	.....do	190	6	3	Windmill	
11	Slope	110	20	15	Windlass	Trap penetrated.
12	Knoll	120	17	10	Chain pump	
13	Slope	70	19	11	.....do	Dry in summer.
14	Saddle	180	31	6		Unused but never dry.
15	.....do	180	16	10	Pitcher pump	Good supply.
17	Slope	100	20	6	Windlass	
18	.....do	100	22	16	.....do	
19	.....do	70	20	14	Chain pump	
20	Knoll	90	44	42	Wheel and bucket	Dry in summer. C. W. Downe, owner. (See analysis, p. 32.)
21	.....do	120	25	20	.....do	Never dry.
22	Slope	80	38	35	Windlass	
24	.....do	120	18	11	.....do	Dry in summer.
25	.....do	60	38	22	.....do	
26	Knoll	100	33	29	Wheel and bucket	Do.
27	Slope	80	38	36		Unused.
28	.....do	130	19	14	Wheel and bucket	Dry in summer.
29	.....do	140	24	15	Windlass	
30	.....do	230	23	8	.....do	
32	.....do	140	23	18	.....do	
33	.....do	125	28	27		Most of distance in sandstone; domestic supply from spring No. 34.
35	Swale	100	6	4	Windmill	Close to drainage channel.
36	Base of ridge	55	12	5	Windlass	
37	Swale	170	29	12	.....do	
38	Ridge	175	23	14	Wheel and bucket	Low in summer; trap penetrated.
40	Lowland	55	11	6	Chain pump	
41	.....do	60	29	27	Windlass	Never dry.
42	.....do	55	18	16	.....do	Do.
43	.....do	65	14	11	.....do	Do.
44	.....do	65	11	9	.....do	Dry in summer.
45	Slope	110	31	7	Chain pump	Gets low but not dry.
47	.....do	80	21	17	.....do	
48	Knoll	80	27	20	Windlass	Never dry.
49	Slope	180	60	12	Hand pump	Dry in summer.
50	Swale	190	35	33	Windlass	
51	Small ridge	230	31	22	.....do	Algot Larson, owner. (See analysis, p. 32.)
52	Slope	230	14	11	.....do	
53	.....do	190	8	4	Rope and bucket	Never dry; trap penetrated.
55	.....do	80	23	20	Wheel and bucket	Dry in summer.
56	Swale	90	31	16	Chain pump	Nearly entire distance in sandstone.
57	Slope	160	24	20	.....do	
58	Base of hill	110	19	13	Windlass	Dry in summer.
59	Lowland	65	14	12	Chain pump	
60	Knoll	160	38	32	Wheel and bucket	
61	Slope	150	21	20		Unused.
62	.....do	110	15	6	Chain pump	Gets low but not dry.
63	Knoll	100	29	14	Windlass	
64	Slope	80	26	7	.....do	Never dry.
65	Swale	230	21	19	Wheel and bucket	Gets low but not dry.
66	.....do	200	24	20	.....do	Trap penetrated.
67	Slope	205	20	16	.....do	
68	Lowland	185	14	5	Rope and bucket	
69	Slope	190	22	15	Hand pump	Do.
71	Swale	145	19	18	Pitcher pump	Dry in summer.
72	Base of knoll	140	32	16	Wheel and bucket	Do.
73	Swale	100	22	3	.....do	Rarely goes dry; entire distance in sandy material.
74	Slope	110	25	20	Hand pump	Gets low but not dry.
78	Swale	130	26	5	.....do	Sandstone penetrated.
79	Slope	180	20	15	.....do	
81	.....do	180	16	12	Rope and bucket	
82	.....do	180	14	7		Unused.
84	Small ridge	185	21	18	Pitcher pump	Gets low but not dry.
85	Hill	195	33	32	.....do	Dry in summer. C. W. Dyer, owner. (See analysis, p. 32.)

[a] The map number corresponds with the number of the location on Pl. II (in pocket).

Dug wells in Berlin—Continued.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Method of lift.	Remarks.
		Feet.	*Feet.*	*Feet.*		
86	Base of hill	140	6	2	Pitcher pump	Gets low but not dry; sandstone penetrated.
88	Swale	130	28	22	do	Dry in summer.
89	Knoll	100	38	36	Wheel and bucket	Do.
90	Slope	60	14	10		Unused.
91	Swale	230	21	15	Windlass	Never dry; trap penetrated.
92	Slope	245	30	13		Unused.
93	Lowland	205	11	4	Rope and bucket	
94	Base of hill	240	25	19	Windlass	Dry during dry summers.
95	do	230	18	8	Chain pump	Dry in summer.
96	Slope	210	36	18	Wheel and bucket	
98	Base of knoll	200	5	3	Pitcher pump	
99	Slope	190	19	6		Unused.
100	do	210	14	13		Unused; drive point.
101	Lowland	150	9	6	Windmill	Large supply; sandstone penterated.
103	Slope	160	6	5	do	Greenhouse supply; trap penetrated.
104	Swale	180	6	1	Rope and bucket	
105	Flat	190	50	43	Wheel and bucket	Never dry; sandstone penetrated.
106	Slope	300	27	19		Unused but never dry.
107	do	350	21	17	Windlass	Never dry. Dennis Rahaley, owner. (See analysis, p. 32.)

Drilled wells in Berlin.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Depth to rock.	Kind of rock.	Yield.	Remarks.
		Feet.	*Feet.*	*Feet.*	*Feet.*		*Gallons per minute.*	
1	Base of hill	170	100	16		Sandstone		Dug 23 feet; drilled 77 feet. Force pump.
9	do	230	140	20		do		Force pump and electric motor.
16	Swale	110	50	8		do		Hand pump.
23	Lowland	30	73	40		do		Good supply of water at 70 feet.
31	Slope	220	97	25	6	do		Supplies three families. John Ross, owner. (See analysis, p. 32.)
39	Base of ridge	90	80	15		do		Dug 20 feet; drilled 60 feet. Force pump. Trap probably penetrated.
46	Slope	100	120	10		do		At Worthington school. Trap penetrated. (See analysis, p. 32.)
54	do	180	96	20	24	Trap		Force pump.
70	Low ridge	180	117	0	1	do	100	Water struck at 89 feet; temperature 52° F. Flows.
75	Slope	110	80	18	15	Sandstone	12	Engine pumps 7 gallons a minute. Trap penetrated.
77	Swale	140	135	29	60	do		60–127 feet in sandstone; 127–135 feet in trap.
80	Slope	180	300	15		do		
38	Flat	175	176	30		do		Mrs. Mary A. Dunham, owner. (See analysis, p. 32.)

Springs in Berlin.

Map No.	Topographic position.	Elevation above sea level.	Temperature.	Yield.	Bedrock.	Remarks.
		Feet.	*° F.*	*Gallons per minute.*		
34	Swale	110		½	Sandstone	Domestic supply.
76	Base of knoll	100	45	¼	do	Nearly dry in summer.
87	Base of ridge	100		¼	do	Drinking water supply.
97	Base of knoll	200		½		Unused; at roadside.
102	do	140	48	4		Drinking water supply.

ANALYSES OF GROUND WATER.

In the following table are given the analyses of seven samples of ground water collected in the town of Berlin. Of these samples four are from dug wells and three are from drilled wells. These analyses are discussed on pages 19–21.

Chemical composition and classification of water from wells in Berlin.

[Parts per million. Samples collected May, 1915; S. C. Dinsmore, analyst.]

	Dug wells.				Drilled wells.		
	20 [a]	51	85	107	31	46	83
Silica (SiO_2)	25	17	15	20	22	25	17
Iron (Fe)	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.
Calcium (Ca)	42	40	100	11	31	46	65
Magnesium (Mg)	15	17	48	3.9	22	13	17
Sodium and potassium (Na+K) [b]	9.6	9.5	27	4.9	1.6	2.5	5.3
Carbonate radicle (CO_3)	.0	.0	.0	.0	.0	.0	.0
Bicarbonate radicle (HCO_3)	197	153	297	34	143	143	102
Sulphate radicle (SO_4)	8.2	16	27	9.8	11	16	147
Chloride radicle (Cl)	7.5	17	131	4.5	13	19	5.9
Nitrate radicle (NO_3)	8.0	30	60	12	30	16	.0
Total dissolved solids at 180° C	209	226	617	80	184	213	340
Total hardness as $CaCO_3$ [b]	166	170	447	44	168	168	232
Probable scale-forming ingredients [b]	170	160	390	59	150	180	240
Probability of corrosion [b] [c]	N	(?)	(?)	(?)	(?)	(?)	(?)
Quality for boiler use	Fair.	Fair.	Poor.	Good.	Fair.	Fair.	Poor.
Chemical character	Ca-CO_3	Ca-CO_3	Ca-CO_3	Ca-CO_3	Mg-CO_3	Ca-CO_3	Ca-SO_4

[a] Numbers at heads of columns correspond to those on map (Pl. II, in pocket) and in tables (p. 30-31).
[b] Computed.
[c] N=noncorrosive; (?)=corrosion doubtful.

CROMWELL.

HISTORICAL SKETCH.

The town of Cromwell forms a rudely triangular area that is bounded on the east by Connecticut River and on the west by Mattabesset River. On the north a straight boundary line separates Cromwell from the town of Rocky Hill.

The first settlement within the limits of the present town was in 1650, when several families from the vicinity of the present city of Middletown moved to the lowland along Connecticut River near the mouth of the Mattabesset, which was early known as Little River. Provision in the allotment of land was originally made for only 15 families, but in 1670 there were 52 families in the locality. In 1704 the settlement, which had become known as Upper Houses, was organized as Upper Middletown parish. The parish remained a portion of Middletown until 1851, when it was incorporated and named after Oliver Cromwell as a separate town, with its present boundaries.

One post office, at the village of Cromwell, supplies the present needs of the town, as the population is largely concentrated at this village in the southeast, near Connecticut River. North Cromwell, a mile away, is a separate community, though homes are closely spaced along the main highway northward from Cromwell village.

In the western part of the town a small community has grown up, about half a mile northwest of Westfield station, but in the main the houses in the western portion of the town are scattered.

The Valley division of the New York, New Haven & Hartford Railroad passes along the eastern border of the town and through the village of Cromwell. A trolley line extending northward from Middletown parallels the railroad to Cromwell village and thence continues northward along the main highway. The western border of the town is crossed by the trolley line between Middletown and Berlin station.

The area of the town, taking the middle of Connecticut River as its eastern boundary, is about 8,700 acres, according to planimeter measurement on the Middletown topographic map, but 400 acres ot this total is the water surface of Connecticut River.[1] The lower course of Mattabesset River is affected by the tide and adds perhaps 20 acres to the total water surface, and half a dozen small ponds add about 20 acres more.

A wide lowland area along Mattabesset River and a smaller area beside Connecticut River comprise a total of fully 600 acres of marsh land, or 7 per cent of the total area of the town.

Originally the town was very largely wooded, in the lowlands as well as in the hilly portions. From the greater part the timber was long ago removed for fuel and for building, but a large acreage in the northeast is still covered with second and later growths. Numerous small wood lots (see Pl. IV, in pocket) increase the total woodland to about 1,850 acres, or fully 21 per cent of the entire area.

POPULATION AND INDUSTRIES.

Early records of the population of Middle Houses are included in those of Middletown, so that definite figures of the growth of the newer settlement do not seem to be available. It is known, however, that from a population of about 250 in 1704, when the parish was formed, Middle Houses increased to a total of 754 persons in 1776.[2] During the first half of the nineteenth century commerce with the West Indies afforded a substantial industry and growth. In 1850 the proposed town of Cromwell had a population of 1,275, and in the succeeding 20 years the town's population increased nearly 50 per cent. From 1870 to 1880 there was a notable loss, owing to migration to neighboring towns where manufacturing was being more

[1] The area is given as 8,455 acres in the Connecticut State Register and Manual, p. 419, 1915.

[2] Adams, J. C., History of Middletown Upper Houses, p. 57, New York, 1908.

actively developed and to the movement of farmers to lands farther west. A considerable increase in population was attained during the next 10 years, however, and since 1890 there has been a slow but fairly uniform growth. The available records of population of the area embraced by the present town are shown in figure 5.

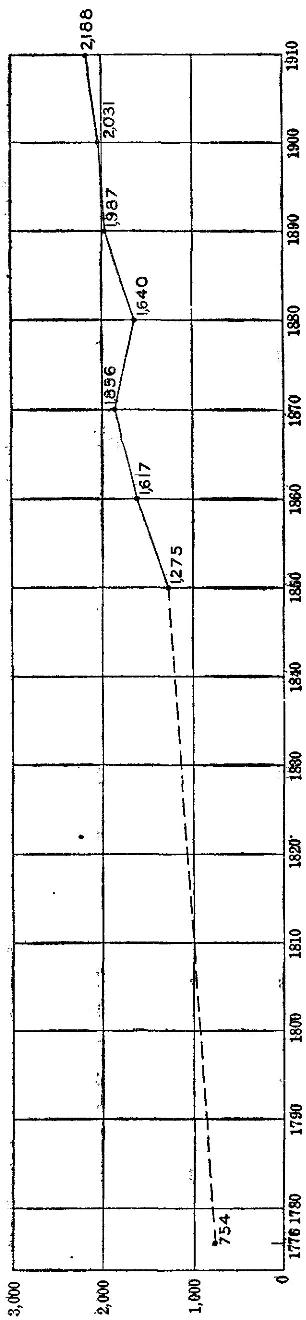


FIGURE 5.—Curve showing population of the town of Cromwell, Conn.

The principal industry in the town is agriculture. Hay and corn are the main crops, but much tobacco is grown in the northeast. A number of dairy farms have also been established within recent years at scattered points throughout the town. Employment to a number of people in the town is afforded by a few long-established factories, the principal ones being a factory for toys and light hardware and a hammer works. Within recent years extensive greenhouses near Cromwell village have also given local employment.

GEOLOGY.

Faulting, which has produced complex structure in the rock formations in Berlin, is not so pronounced in Cromwell, and the upper sandstone is the first rock penetrated in by far the greater portion of the town. The western part of the town is traversed by at least four faults, however, and the "Posterior" or upper trap sheet has thus been brought to the surface. The areas immediately underlain by this trap have been painstakingly worked out by Davis,[1] as is shown on Plate III (in pocket), but the trap rock is actually exposed at only a few places, as indicated on Plate II (in pocket). The great fault that passes between Lamentation and Higby mountains extends northeastward through Cromwell, but in this town the displacement of the rocks along the fault has been sufficient to bring the upper trap sheet to the surface only near the

[1] Davis, W. M., The Triassic formation of Connecticut: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 2, pl. 19, 1898.

southern border of the town. Farther north, although the displacement of the beds is several hundred feet, the upper sandstone forms the rock immediately underlying the trap on each side of the fault. In the western part of the town an extensive fault west of the belt of upper trap rock has brought beds of the "Posterior" sandstone along its eastern side up into juxtaposition with beds of the upper sandstone along its western side. Deep wells drilled between this fault and the belt of trap rock will therefore penetrate the main trap sheet as the first trap, whereas deep wells drilled west of the fault will first penetrate the upper trap sheet. The approximate position of the several trap sheets and sandstone formations beneath the town of Cromwell is shown in the structure section C–D on Plate III (in pocket).

The lowlands along Connecticut and Mattabesset rivers are covered by stratified glacial drift. The central and northeastern portions of the town are also covered by sandy stratified deposits, which are believed to have been spread out as a plain by water from the glacial ice front at a period when ice that still lingered farther south partly dammed up the valleys of Mattabesset River and of Connecticut River near Middletown.[1] Over the sand plain and in the marsh lands along the Mattabesset and the Connecticut, the drift is probably deep, but on the western border of Cromwell village the underlying sandstone is exposed in a large abandoned quarry. Other outcrops of the sandstone in the vicinity show that the drift is only a few feet thick on the slopes near Cromwell village, and the rock has also been exposed in trenches dug for water mains.

The higher portions of the town are formed by rounded hills that are covered by glacial till and are probably, in part at least, molded into drumlin forms by thick layers of the glacial débris. In one locality in the northwest the covering of till is very thin, however, and numerous ledges of sandstone are exposed.

SURFACE FEATURES.

The central and northwestern portions of the town constitute a hilly area whose greatest elevation is reached in a hilltop in the northwest, nearly 300 feet above sea level. A number of other hills are more than 200 feet high, but the area is deeply incised by several streams, and the slopes also drop rapidly to the west and south to Mattabesset River.

In the northeastern portion of the town lies a sand plain that has a mean elevation of about 180 feet, but it has been dissected from the north and from the south by the headwaters of minor streams. On the east the plain drops rapidly to Connecticut River. On the south-

[1] Loughlin, G. F., The clays and clay industries of Connecticut: Connecticut Geol. and Nat. Hist. Survey Bull. 4, p. 24, 1905.

east the surface slopes down to a wide expanse of lowland extending to the river.

The southeast corner of the town is occupied by an extensive marsh land between the Connecticut and the Mattabesset, and this marsh extends up the Mattabesset for nearly 3 miles above its mouth. Connecticut River along the entire eastern side of the town and the Mattabesset to at least the upper limit of the marsh land are within the influence of the tide. All the lowlands of the town are therefore only slightly above sea level.

Most of the hilltops and adjacent slopes have long been cultivated, and only detached areas of woodland remain in the central and western portions of the town. The largest remaining wooded areas are along stream valleys on the northern border, and on the slopes from the sand plain down to the Connecticut.

STREAMS.

Connecticut River has a fairly uniform width of about a quarter of a mile where it forms the eastern boundary of Cromwell. It is navigable from its mouth to the city of Hartford, 15 miles above Cromwell village, and formerly was the principal means of transportation for the region. Since the construction of railroads, however, the river transportation has became of minor importance.

The eastern portion of the town drains fairly directly to Connecticut River through a few small brooks. Dividend Brook, which has its course mainly in Rocky Hill, swings southward and then sharply northeastward to the Connecticut. The southernmost part of its course crosses the Rocky Hill-Cromwell boundary and drains the northeastern border of Cromwell. Its average flow at the road crossing at the southernmost point of its course is probably less than 1 second-foot. On May 6, 1915, it carried 0.6 second-foot of water.

A small tributary that parallels the north border of the town has been locally called Peat Swamp Brook. Peaty deposits in its marsh-land course were intermittently prospected for many years, but the material does not seem to be of commercial value.

A smaller perennial stream drains a portion of the eastern slopes of the town directly to the river.

The greater part of the sand plain in the north-central part of the town is drained by a brook that flows southeastward through North Cromwell village to the Connecticut. In its upper portion this stream is ponded in three places, the upper two ponds regulating the flow to the lowest, which furnishes power to one or more factories. Below North Cromwell the brook flows for nearly a mile across the lowland to Connecticut River. Because of the several ponds and the mill dam at and above North Cromwell a satisfactory estimate of the normal flow of the brook was not obtained. It seems, however, to have a considerably larger discharge per unit drainage area than Dividend Brook. Its upper course is intrenched 60 feet or more in the sand plain, hence it probably receives considerable water by seepage inflow from the deep sandy deposits and perhaps also by springs that issue close to its channel.

The southern and western portions of the town are drained by a number of small brooks that flow directly to Mattabesset River, which forms the town boundary on the south and west. The Mattabesset itself is affected by the tide for half its course along the Cromwell border. Above the limit of the tide it is a sluggish stream, so polluted by factory wastes and sewage that few fish inhabit it. Its average flow during the low water of summer and autumn is about 50 second-feet at the northwest corner of the town. Half a mile above its mouth it is joined from the south by Coginchaug River, and it enters the Connecticut with a mean low-water discharge of about 70 second feet.[1] The stream receives a normal low-water accession of only about 2 second-feet between the northwest corner of Cromwell and the mouth of the Coginchaug. Several of the individual brooks that enter this portion of the Mattabesset both from the south and from the north at times carry more than 2 second-feet, however. On May 5, 1915, the brook that enters the north side of the Mattabesset one-third of a mile west of Westfield station had a discharge of 3.7 second-feet, at a time when the Mattabesset shortly above the mouth of this brook carried 42 second-feet.

The brooks that drain the southern and western slopes of Cromwell are at present almost unused for the development of power, but in former times the largest ones were of some importance for this purpose. A grant to a mill site on Chestnut Brook[2] was obtained in 1655, but of late years this stream has been used little if at all for the development of power.

WATER SUPPLIES.

Surface water.—A few years ago a pumping plant was established shortly below the power dam at North Cromwell, and water from the brook was delivered to consumers in Cromwell village. In 1915 this plant, owned by the Cromwell Water Co., a private corporation, comprised an electrically driven centrifugal pump, lifting water from the brook below the power dam to two standpipes in the highest part of the village. (See Pl. IV, in pocket.) The distribution system comprised 8 miles of mains. The pump was run three to eight hours each night to supply the average daily use of about 175,000 gallons.

[1] Report on the investigation of the pollution of streams, p. 45, Connecticut State Board of Health, 1915.

[2] Adams, J. C., Middletown Upper Houses, p. 15, New York, 1908.

In 1915 the Cromwell Water Co. supplied about 1,500 people,[1] or about two-thirds of the population of the town. The remaining third, scattered throughout the town, depend chiefly on shallow dug wells for water supply. A few drilled wells have been put down in the western portion, however, in places where the glacial material is thin, and a few springs are used.

Water in stratified drift.—As the greater part of Cromwell is covered by stratified drift, most of the dug wells obtain water from this material. The average depth to water in the 23 wells in stratified deposits that were measured early in May, 1915, was 12.5 feet. The water level differed notably in the individual wells, but as shown in figure 3 (p. 16) the average depth on hills, slopes, or lowlands in the stratafied drift did not differ notably. In general the depth to water in the eastern part of the sand plain that occupies the north-central part of the town was greater than in the western portion of the plain and indicated a marked eastward slope of the water table, caused, presumably, by the deeply intrenched drainage course of the brook that flows through North Cromwell. Although the wells in the sand plain obtain ample supplies of water for individual families, the greatest available supplies of ground water in the town are probably stored in the lowland east of Cromwell village and in the more marshy land in the southeast corner of the town. Wells were not seen in either area, and no test borings were reported which might show the character of the stratified drift in either place. It is probable that the lowland along the Mattabesset is underlain by clay beds similar to those of the brick-clay pits near Newfield, and hence large yields of water could not be obtained from wells sunk in these lowlands. The area east of Cromwell village is, however, probably underlain by more sandy material, in which there may be large supplies of water that could be developed by shallow wells and pumping plants for the use of neighboring industrial establishments.

Analyses of water from three dug wells in the stratified drift (see table, p. 40) show that some of the wells, of which Nos. 6 and 7 are examples, yield very soft and pure water. Other domestic wells, however, which are situated adjacent to kitchens or to outhouses may become dangerously polluted by organic wastes, resulting in abnormally high amounts of chloride and nitrate. Well 41 is an example of such a well; the chloride and nitrate radicles constitute more than half of the total solids, which they have increased to an extent that is abnormal for this area.

Water in till.—The records of 10 dug wells in the till, chiefly in the western portion of the town, indicate that the water level is there on an average about three-quarters as deep as in the stratified drift of the lower areas. There is, however, as marked a variation in the

[1] Connecticut Public Utilities Commission Rept. 1915, p. 649.

water level in individual wells in till as there is in the wells in stratified drift.

Water in sandstone.—Four drilled wells were observed in the town. All are in the western part, in localities where the glacial drift is too thin to serve as a reliable water-bearing formation. The wells are drilled 63 to 142 feet deep, the depth to water in them being 20 to 30 feet in May, 1915. In the deepest well (No. 26) the "Posterior" trap sheet was drilled through and a dependable water supply was obtained from the underlying sandstone. In the other three wells only sandstone was penetrated below the till.

Springs.—Three of the four springs noticed in the town are used for domestic supply. Each of these three springs issues from the stratified drift and yields only about half a gallon a minute, but each is said to have a perennial flow. The fourth spring issues from the trap in a small road-metal quarry and supplies a roadside trough.

RECORDS OF WELLS AND SPRINGS.

The wells and springs indicated on Plate II (in pocket) and tabulated in the following list are believed to be typical and to show the ground-water conditions in different portions of the town.

Dug wells in Cromwell.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Method of lift.	Remarks.
		Feet.	*Feet.*	*Feet.*		
1	Knoll	110	22	3	Rope and bucket	Never dry.
4	Slope	140	25	8	Windlass	Dry in summer.
6	Flat	145	15	10	Pitcher pump	Never dry. Benjamin Rooney, owner. (See analysis, p. 40.)
7	Slope	180	37	35	Windlass	Never dry. J. W. Gardner, owner. (See analysis, p. 40.)
8	do	180	23	12	Pitcher pump	Dry in summer; water level affected quickly by rains.
9	Base of hill	190	10	6	Windlass	Never dry.
10	Flat	175	7	4	Rope and bucket.	
11	do	175	21	12	Windlass	Do.
12	Knoll	190	19	13	Hand pump	Do.
13	Flat	185	29	26	Windlass	Gets low but not dry.
14	do	165	23	20	do	Never dry.
15	Swale	50	9	8	do	In small, marshy patch.
16	Slope	150	11	4	Rope and bucket.	Dry in summer.
17	do	110	20	14	Wheel and bucket.	
19	do	170	18	14	Hand pump	Never dry; supplies several families.
20	Flat	170	9	6	Wheel and bucket.	Never dry.
21	Base of knoll	190	18	8	Windlass	Dry in summer.
22	Knoll	200	18	6	do	
23	Slope	50	15	9	do	Never dry.
24	do	55	18	12	do	
25	do	50	15	8	Wheel and bucket.	Dry in dry summers.
27	do	80	18	14	Windlass	Supplies 5 families during summer; trap penetrated.
29	Slope	30	15	9	Wheel and bucket.	
31	Base of hill	30	14	9	Windlass	
33	Swale	30	14	12	Chain pump	Never dry.
34	Knoll	170	18	15	Pitcher pump	Dry in summer.
35	Saddle	130	11	7	Windlass	Never dry.
36	Slope	95	30	16	do	
37	do	110	28	18	do	Only slightly used.
38	do	130	32	11	do	
39	Base of hill	30	17	9	do	
40	Slope	60	20	17	do	Dry in summer.
41	Lowland	20	15	6	do	O. A. Perkins, owner. (See analysis, p. 40.)

Drilled wells in Cromwell.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Depth to rock.	Kind of rock.	Yield.	Remarks.
		Feet.	*Feet.*	*Feet.*	*Feet.*		*Gallons per minute.*	
2	Slope	110	63	30		Sandstone		Water struck at 30 feet.
3	.....do	130	112	30		.....do		Water rose to 8 feet when first struck.
26	.....do	90	142	20		Through trap to sandstone.		
28	Knoll	70	65	20	9	Sandstone	4½	

Springs in Cromwell.

Map No.	Topographic position.	Elevation above sea level.	Temperature.	Yield.	Bedrock.	Remarks.
		Feet.	*°F.*	*Gallons per minute.*		
5	Slope	150	48	½	Sandstone	Part of domestic supply.
18	.....do	120		½	.....do	Domestic supply.
30	.....do	70	50	1	Trap	Supplies roadside watering trough.
32	.....do	70		½	Sandstone	Part of domestic supply.

ANALYSES OF GROUND WATER.

The following table contains the analyses of three samples of water from dug wells in the town of Cromwell. The analyses are discussed on pages 19–21.

Chemical composition and classification of water from wells in Cromwell.

[Parts per million. Samples collected in May, 1915; S. C. Dinsmore, analyst.]

	6 [a]	7	41
Silica (SiO_2)	15	17	22
Iron (Fe)	Trace.	Trace.	Trace.
Calcium (Ca)	14	11	107
Magnesium (Mg)	5.0	0.8	29
Sodium and potassium (Na+K) [b]	8.8	10	170
Carbonate radicle (CO_3)	.0	.0	.0
Bicarbonate radicle (HCO_3)	9.7	14	105
Sulphate radicle (SO_4)	11	29	117
Chloride radicle (Cl)	14	14	102
Nitrate radicle (NO_3)	44	10	500
Total dissolved solids at 180° C	119	93	1,108
Total hardness as $CaCO_3$ [b]	56	47	386
Probable scale-forming ingredients [b]	65	57	390
Probability of corrosion [b] [c]	C	C	C
Quality for boiler use	Bad.	Bad.	Very bad.
Chemical character	Ca-NO_3	Ca-SO_4	Na-NO_3

[a] Numbers at heads of columns correspond to those on map (Pl. II, in pocket) and in table (p. 39).
[b] Computed.
[c] C = corrosive.

MERIDEN.

HISTORICAL SKETCH.

The town of Meriden occupies the southwestern part of the area considered in this report. The area was first organized as a parish of the town of Wallingford, which adjoins Meriden on the south.

The parish is generally considered to have been named from Meriden, in Warwickshire, England, but doubt as to this source of the name has been raised in favor of a farm near Dorking, in Surrey County, England.[1]

In 1730 the population of the parish was only about 250, for immigration was not rapid, and after the French and Indian War migration was westward rather than into the Meriden region. By the close of the American Revolution the population of the parish of Meriden was probably about 500, and in 1806, when the settlement was incorporated as a separate town, it contained about 1,100 people.[2] The present population is concentrated in the center of the town, in the city of Meriden, which was chartered in 1867. South Meriden and East Meriden are communities about a mile beyond the corporate limits of the city.

The area of the town is close to 15,000 acres, according to planimeter measurement on the Meriden and Middletown topographic maps.[3] Nearly 24 per cent of the total area is wooded (see Pl. IV, in pocket) with small second and later growths of chestnut, oak, maple, and other native trees. There is only about 200 acres of marshland in the town, and this land consists largely of strips along the principal brooks. Nearly 300 acres, or 2 per cent of the total area, is covered by the water surfaces of several ponds.

POPULATION AND INDUSTRIES.

During the first few decades after incorporation Meriden gained only slowly in population. The development of manufactures, which were early started in and near the city, soon gave impetus to settlement, however, and between 1840 and 1850 the population nearly doubled. An even greater increase took place in the succeeding decade, and since 1860 the growth has continued at a rapid rate, Meriden being now one of the most important manufacturing cities in the State. The accompanying diagram (fig. 6) shows the growth in population of the town since its incorporation, and of the city since 1880, when the population of the city as distinct from the town first appears in the census reports.

The principal industry of Meriden is the manufacture of sterling silverware and plated ware, on which account it is sometimes called the "silver city." Other important industries are the manufacture of nickel and granite ware, of Britannia ware, cut glass, electric and other lamps, clocks, furniture trimmings, and many minor articles. Cutlery and other small articles are made at South Meriden, and several small factories are located in East Meriden

[1] Curtis, G. M., and Gillespie, C. B., A century of Meriden, p. 46, Meriden, 1906.
[2] Idem, p. 333.
[3] The area of 10,483 acres, given on p. 432 of the Connecticut State Register and Manual, 1915, is evidently in error.

The rolling slopes outside the city are extensively cultivated, field crops being raised chiefly, though there are numerous small orchards of apples and other deciduous fruits.

The double-track line of the New York, New Haven & Hartford Railroad passes through the city of Meriden and gives easy access both to New Haven, on tidewater, 18 miles to the south, and to Hartford, the State capital, at the head of navigation on Connecticut River, 18 miles to the north. Interurban trolley lines connect Meriden with villages to the east and to the west, and the principal

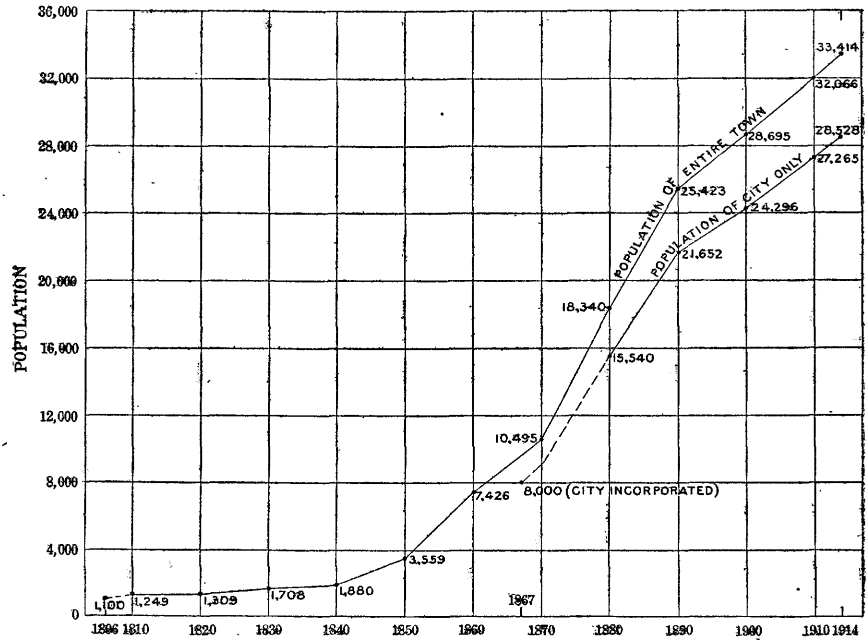


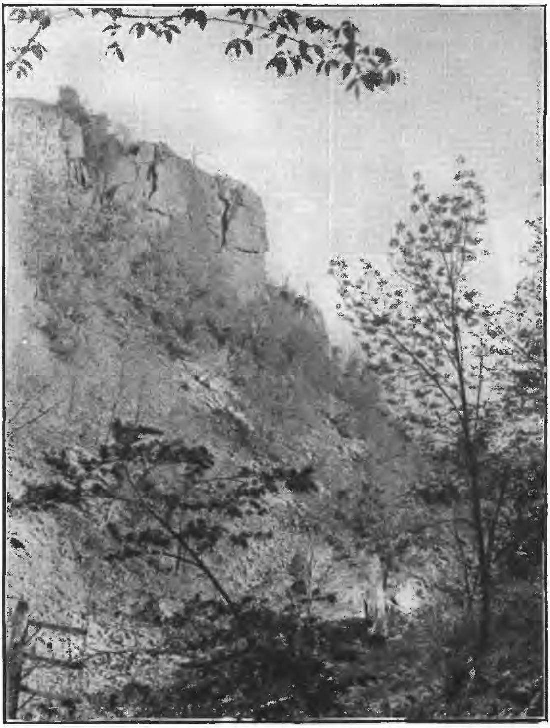
FIGURE 6.—Curves showing population of the town and city of Meriden, Conn.

highways are either concreted or metaled, affording easy means of communication by automobile.

GEOLOGY.

The geologic structure in the town of Meriden is largely determined by two extensive faults that cross it in a northeast-southwest direction. (See Pl. III, in pocket.) Of these major faults the western one is believed to have caused a displacement of not less than 2,000 feet and the eastern one of not less than 1,300 feet.[1] Along these two great fault zones uplift and offset of the rocks has taken place and the "Main" trap sheet has been broken and

[1] Davis, W. M., The Triassic formation of Connecticut: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 2, p. 96, 1898.



A. CLIFF OF TRAP IN CATHOLE GORGE, MERIDEN, CONN.

B. BOULDER-STREWN FIELD NEAR HARBOR BROOK, MERIDEN, CONN.

uptilted, so that its edges now form the cliffs of Hanging Hills, Lamentation Mountain, and the Higby-Beseck mountain mass. A near view of one of these cliffs is shown in Plate VII, *A*. The manner in which repeated faulting has caused the "Main" trap sheet to form the extensive cliffs of the Hanging Hills is shown in the structure section E–F on Plate III. The uplift was so great that the "Anterior" or lower trap sheet is also exposed along the bases of the mountains, as shown on Plate III. This lower trap sheet forms a prominent shelf or bench below the main cliffs of the Hanging Hills, as shown in Plate V, *A*. At the base of Lamentation Mountain it also forms a minor ridge, but along Higby and Beseck mountains it does not appreciably affect the topography. The apparent secondary bench of Beseck Mountain, south of Black Pond, that is shown in Plate V, *B*, is a more distant portion of the cliff formed by the "Main" trap sheet.

In the northern and eastern portions of Meriden the successive rock formations from the lower sandstone upward to the "Main" trap sheet are exposed. The lower sandstone is the uppermost rock in the greater part of the town, and in drilling wells in these areas, except for the remote possibility of penetrating a dike, no trap rock will be met. One dike of diabase rock, which is similar to the trap rock of the several sheets, is exposed at several points south of Meriden, but it is believed to be the only dike of note in the region. A small dike near Baileyville, in Middlefield, has been described by Griswold.[1] The northernmost exposure of this dike that was noticed is in the unpaved roadway of Prospect Halls Avenue. The dike there appears to be only 2 or 3 feet wide, but half a mile southward, in the western portion of Walnut Grove Cemetery, it has a width of 15 feet or more. At this locality it is best exposed in a small quarry or pit, which is probably the Golden Parlor mine, where prospecting for copper was carried on many years ago. Farther south the dike rock is well exposed as a very low rocky ridge. Its surface exposures terminate at a road cut, 4 feet deep, where the dike is about 40 feet wide. The eastern contact between the dike and the sandstone is well shown in this cut.

The lands along the principal streams in the town are covered by stratified drift. The bedded character of this material is shown in numerous gravel banks, such as the one illustrated in Plate VI, *B*. Well records show that in many places this drift is shallow, but along the lower course of Harbor Brook the deposits are deep. Through the center of the city of Meriden the western border of the lowland along Harbor Brook is probably marked by a steep, buried bedrock slope; for it is said that whereas the western portion of Winthrop

[1] Griswold, L. S., A basic dike in the Connecticut Triassic: Harvard Coll. Mus. Comp. Zool. Bull., vol. 16, pp. 239–242, 1893.

Hotel is built on sandstone, the eastern portion rests on piles driven into unconsolidated materials.

South Meriden is situated on a sand plain that extends from Quinnipiac River westward to the hills that limit the river valley and southward down the river valley for several miles. This plain was probably formed by the reassorting and redeposition of sand and finer materials by water that was produced by the melting of the glacial ice and that spread over the valley before a definite channel had been established. In these porous sand-plain deposits the city of Meriden has constructed very successful filter beds a short distance below the town line.

In the southeastern portion of the town there is a low but well-developed esker in the upper part of the valley of Harbor Brook. A road makes use of this low, narrow ridge, which forms a well-drained thoroughfare through the meadow land on each side.

Rolling hills occupy considerable portions of the town. Most of these hills are elongated in a uniform direction east of north. They are drumlins, but around their bases and even on some of the higher slopes the till is very thin. Unstratified material also occupies some of the lower lands and in the lee of the prominent trap ridges occasionally forms boulder-covered areas, like that shown in Plate VII, *B*. In numerous places, especially in road cuts, the underlying sandstone is well exposed for distances ranging from a few yards to several rods. The observed areas of such exposures are necessarily exaggerated on Plate II, in order that they may be shown on the map. Doubtless the sandstone is exposed in many other places that were not seen by the writer.

SURFACE FEATURES.

The highest points in the town, and by far the most prominent elevations in the central lowland of Connecticut, are the Hanging Hills, which reach a maximum elevation of 1,007 feet in West Peak, on the northwest border. East Peak, on which an observation tower 38 feet high has been erected, and South Mountain and Cathole Mountain, farther east, are also prominent though lower summits of the Hanging Hills. In the northeast part of the town Lamentation Mountain proper and its southern extension, known as Chauncy Peak, also form prominent cliff-bordered masses. These higher areas are practically all wooded and have the usual second and later growths of the native trees.

The central portion of the town comprises a belt of lowland extending from the headwaters of small streams in the northeast to the valley of Quinnipiac River in the southwest, the lowest point in the town being where this stream crosses the southern border, at an elevation of about 55 feet.

The lowland of the town is bordered on each side by rolling hills, which form the greater part of the surface.

STREAMS.

Quinnipiac River enters the town of Meriden through a gorge cut 200 feet deep in sandstone and crosses the southwest portion of the town, receiving the drainage from nearly all of it. In its upper portion the stream is used for power development at a number of places, and at South Meriden the Meriden Cutlery Co. obtains power at the outlet of Hanover Pond, a water body of about 35 acres that is formed chiefly by a dam across the river. Mr. Harold T. Burgess, civil engineer, of Meriden, has furnished the curve of discharge of the river at the outlet of Hanover Pond, which is presented in figure 7.

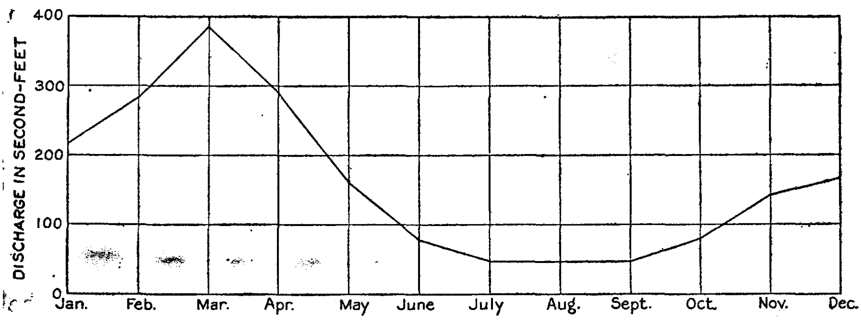


FIGURE 7.—Diagram showing monthly discharge of Quinnipiac River at outlet of Hanover Pond, Meriden, Conn.

This record shows that the maximum flow, which is usually attained in March, is about eight times the minimum flow of the summer months. Storage ponds, however, regulate the flow of the stream sufficiently to make it fairly dependable for the development of power throughout the year.

Harbor Brook, which empties into Hanover Pond, drains the eastern part of Meriden through its North Branch, which heads in marsh land at the base of Chauncy Peak, and through its other branches it drains the southeastern part of the town. In their upper portions these streams are fairly pure, and shortly below their junction they supply a chain of ice ponds, but below these ponds the main stream flows through the city of Meriden and is polluted by factory wastes. The daily flow of the stream is affected by the opening and closing of the pond gates, but the average discharge into Hanover Pond is probably about 10 second-feet.

Cathole Brook drains the slopes on each side of the mountain of the same name, and flows southward through a small valley. Its western branch has been dammed and a small pond has been formed at the entrance to Cathole Gorge. This branch normally carries perhaps 1 second-foot of water, and the main or eastern branch carries somewhat more. About 1 mile above Hanover Pond Cathole Brook joins Sodom Brook, which heads in the slopes of South Mountain. Shortly below the junction of these two streams Crow Hollow Brook, which heads near the base of West Peak, also enters, and the combined discharge into Hanover Pond averages perhaps 5 second-feet of water.

Meetinghouse Brook and its tributary Spruce Dale Brook are small streams that drain a southern portion of the town southward to the Quinnipiac.

WATER SUPPLIES.

Surface water.—The municipal water supply of the city of Meriden is furnished by several reservoirs, which are shown on Plate IV (in pocket). Merimere reservoir, which was constructed in 1888 in the gap between East Peak and South Mountain, has an available capacity of about 341,000,000 gallons and furnishes a gravity water supply. Kenmere reservoir was later built on another stream, and the water is being pumped from it to Elmere distributing reservoir. In 1895 Hallmere reservoir was constructed, higher up on the same stream, for storage of water. Excess water from Elmere reservoir is also diverted into Hallmere reservoir by a ditch across the low divide between the two drainage courses. With the rapid growth of the city the reservoir supply has proved inadequate during the late summer, and emergency pumping stations at Hanover Pond (Hanmere station) and at Baldwin Pond (Baldmere station) have been used for short periods. The quality of the water from these two ponds is poor, however, and in order to provide for a better and more adequate supply, Broad Brook reservoir, in the town of Cheshire, was constructed in 1915. This reservoir has a capacity of 1,200,000,000 gallons. From it the water is lifted by electrically driven centrifugal pumps to a distributing reservoir on Johnson Hill. Thence the water is supplied to the mains by gravity under a head of about 250 feet in the business section of the city. Pollution of this new supply has been guarded against by the purchase of farms adjacent to the reservoir and the removal of the buildings.

In excavating for the foundations of the Broad Brook dam well-preserved glacial scratches were found on the sandstone underlying the till. An average thickness of 28 feet of sandstone was removed until diabase was reached, evidently dike material, containing copper stains. This rock was uncovered at a depth of about 44 feet, entirely across the dam site. Similar dikes a few miles to the south have long been prospected for minerals.

In addition to the people within the city limits, a few families in the northern part of the town of Meriden and in the southern part of Berlin, near whose houses the city mains pass, are supplied with water from this system.

Several industrial establishments in the city have sunk wells to supply their factories. These wells have been only partly successful, however, for the water obtained is too hard to be satisfactory for boiler use, and the factories depend on the city supply for water for this purpose.

The community of East Meriden and the numerous farmhouses throughout the town depend on individual wells for a water supply.

Water in stratified drift.—Only a small part of the town of Meriden is covered by stratified drift and only 11 of the 55 dug wells observed that obtain water from the glacial materials are sunk in stratified drift. Wells 6, 9, 26, 35, and 106 obtain water from the sandstone, and hence are not included in the present discussion. The average depth to water in the 11 wells in stratified drift was 15 feet early in May, 1915, but the water level in the several wells ranged from 7 to 24 feet. (See fig. 3, p. 16.) The stratified drift along the stream valleys above Hanover Pond seems from the available records neither to be very deep nor to contain extensive layers of good water-bearing sand and gravel. In the plain south of Hanover Pond, however, the stratified drift seems to contain extensive water-bearing layers of sand, and ground-water development on a large scale in the town could probably be best undertaken in this lowland. The Meriden sewage beds discharge into the sand a short distance south of the town line, but it is not probable that the effluent seeps northward and contaminates the beds within the town of Meriden.

The average depth to water in the 44 wells in till that were measured was nearly 2 feet greater than in the wells in drift, being 16.7 feet as compared with 15 feet, and a greater range in depth was also found in the wells in till. Both the least depth (1 foot) and the greatest depth (43 feet) to water in dug wells were noted in wells in till on the hillsides.

Water in sandstone.—A large proportion of the dug wells fail in summer, and hence of late years many of them are being improved by drilling deeper, or else the dug wells are abandoned and drilled wells are sunk to furnish better and more permanent domestic water supplies.

Deep wells have been drilled in the city of Meriden by several industrial concerns, in order to obtain supplies for their factories. In general these wells yield moderate amounts of water, but it is only fair for use in boilers, and the softer surface water of the municipal system has been again utilized for making steam. The chemical character of the water from three of the drilled wells is shown by the analyses of water from wells 7, 41, and 52, given on page 52.

The water from well 7 is fairly soft and contains only small amounts of mineral matter in addition to the calcium and bicarbonate radicles, which, combined as calcium bicarbonate, form with the silica the principal constituent of the scale that results from the use of this water in boilers. The water from well 41 contains nearly twice as much total solids and is noticeably harder. Well 52 was drilled in 1905 by the Charles Parker Co. to a depth of 1,000 feet in an attempt to obtain a large supply of water suitable for industrial use. A pumping test of about 50 gallons a minute is said not to have overtaxed the well, and the water is used for some purposes in the factory. This well water forms a very hard white scale in boilers, however, and the city water is used for making steam. The analysis shows that in addition to the relatively high calcium and bicarbonate the water contains a rather large amount of scale-forming sulphate.

Five wells drilled in the grounds of the Edward Miller Co. (well group 43) in 1895 are said to be the first deep wells sunk in Meriden. Three of the wells are 300 feet deep, the other two being respectively 250 and 350 feet in depth. The deepest well was not successful and has been abandoned. The shallowest well is said to have the greatest yield. It and the three 300-foot wells supply the needs of the factory except for making steam, for which purpose the softer municipal water is used. The amount of well water that is pumped varies according to the factory needs, but a supply of 75,000 to 100,000 gallons a day of 10 hours is said to have been obtained at times from the four wells.

The factory of the Meriden Curtain Fixture Co. and the factory of Foster, Merriam & Co. each have a well about 300 feet deep. The well of Foster, Merriam & Co. is said to have a capacity of about 170 gallons a minute, but that of the Meriden Curtain Fixture Co. yields only about 25 gallons a minute. Like the other deep wells of the town, these also yield water that is too hard to be satisfactory for boiler use, but they have supplied other needs of the factories.

The records of the drilled wells in Meriden show that in the sandstone, which throughout most of the town is below the "Anterior" or lowest trap sheet, never-failing domestic supplies can be obtained from wells about 100 feet deep. Supplies of less than 10 gallons a minute are usually developed at this depth, however. The 300-foot wells of the Edward Miller Co. do not seem to have obtained appreciably larger supplies than shallower drilled wells in the town. A 562-foot well drilled by the International Silver Co. did not obtain water that was suitable for their factory needs. The deepest well that was reported is that of the Charles Parker Co. (No. 52). By drilling to 1,000 feet a supply of more than 50 gallons a minute was obtained, but it was not learned whether the main water supply was struck near the bottom of the well in a porous sandstone or whether it was obtained from numerous joints and crevices in the fairly solid sandstone. Although this one well, 1,000 feet deep, is capable of yielding fully 50 gallons a minute, other wells, sunk to equal depth in the sandstone, may not be equally successful in tapping a fairly large supply of water.

Springs.—A number of springs in Meriden have been developed for domestic use, and water from Redrock, Hillside, and Live Oak springs (Nos. 33, 39, and 68) is bottled and sold locally for table use. The analyses of water from Hillside Spring (No. 39, p. 52) shows that it has a fairly low total solid content. Calcium and bicarbonate, two of the substances that render water hard and form scale in boilers, are the principal constituents in this spring water, as in the well waters of the region. Most of the springs issue directly from the sandstone. Spring 4, however, issues at the base of a steep slope in which trap is exposed, and spring 99 seems to derive its supply from the till-covered slopes above it.

RECORDS OF WELLS AND SPRINGS.

The following lists give data concerning certain wells, scattered throughout the town of Meriden, that are indicated on Plate II and are believed to be typical of their respective localities. Data concerning certain springs are also listed. Several of these springs have been developed commercially, and their waters are locally sold for table use.

Dug wells in Meriden.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Method of lift.	Remarks.
		Feet.	*Feet.*	*Feet.*		
2	Base of hill....	200	22	15	Windmill..........	Near marshy tract.
5	Lowland......	170	12	4	Chain pump......	
6	Slope..........	210	26	15	.....do............	Usually dries in summer. Entire distance in sandstone.
9	.....do........	190	42	35	Wheel and bucket.	Entire distance in sandstone.
10	.....do........	170	18	12	Pitcher pump.....	Never dry.
11	.....do........	180	31	23	Wheel and bucket.	Sandstone penetrated.
17	.....do........	210	19	16	Chain pump......	
18	Base of hill....	280	23	19	....	Unused.
19	Slope..........	380	22	20	....	Do.
21	Base of hill....	130	30	19	....	Unused; dry in summer.
22	Swale..........	125	22	16	....	Unused but never dry.
23	.....do........	150	10	9	....	Unused.
25	Lowland......	150	20	17	....	Do.
26	Slope..........	170	35	27	Windlass..........	Dry in summer; sandstone at 15 feet.
27	Lowland......	210	24	7	Pitcher pump.....	150 feet from brook and 14 feet above it.
29	Hilltop.......	390	35	30	Windlass..........	Dry in summer.
30	Swale..........	330	16	11	.....do............	Do.
32	.....do........	300	23	21	.....do............	Do.
35	Hilltop.......	350	28	13	Chain pump......	Dry in summer; most of distance in sandstone.
36	.....do........	350	27	15	Windlass..........	Never dry.
42	Base of hill....	140	12	10	Rope and bucket..	Gets low but not dry.
44	Slope..........	290	30	24	Wheel and bucket.	
45	.....do........	300	50	43	.....do............	Dry in summer.

Dug wells in Meriden—Continued.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Method of lift.	Remarks.
		Feet.	*Feet.*	*Feet.*		
47	Slope	260	32	22	Wheel and bucket	100 yards south of gravel pit.
48	....do	310	21	19	....do	Dry in summer.
51	....do	160	33	20	Windlass	
53	....do	290	44	36		Unused.
55	....do	340	12	4		Do.
56	....do	350	25	17	Windlass	
57	....do	350	38	27	....do	Gets low but not dry.
59	Hilltop	390	43	20	Chain pump	Never dry; sandstone penetrated.
60	Base of hill	270	13	6	....do	Dry in summer.
61	Slope	390	21	8	Air lift	Gets low but not dry.
62	Knoll	400	19	7	Rope and bucket	Good supply.
63	Slope	260	26	24		Unused.
64	Swale	230	18	15	Windlass	Nearly dry in summer.
65	Slope	170	23	22		Unused.
66	....do	180	21	15	Pitcher pump	
67	....do	260	24	18		Unused; dry in summer.
70	....do	370	5	1	Rope and bucket	Stable supply.
71	....do	380	33	15	Windlass	Dry in summer.
72	Swale	300	34	27	Chain pump	Do.
77	Lowland	250	16	8	....do	
78	Slope	270	18	7		Unused.
79	....do	290	21	6	Windlass	
81	Swale	270	18	10		Used as milk cooler; domestic supply from well No. 80.
82	Base of hill	290	20	13	Chain pump	Dry in summer.
84	Lowland	90	26	21	Wheel and bucket	Never dry.
85	Base of hill	70	28	21	Force pump	
88	Lowland	70	31	24	Wheel and bucket	
91	Slope	90	26	18	Chain pump	
92	....do	130	11	5	Rope and bucket	
93	....do	250	25	18	Windlass	
95	....do	230	20	12	Pitcher pump	Dry in summer.
97	Base of slope	300	27	13	Windlass	
98	Swale	310	25	21	Wheel and bucket	
102	....do	380	33	23	Pitcher pump	
103	Knoll	260	28	19	Wheel and bucket	Do.
105	Ridge	345	24	9	....do	Temperature 45° F. Never dry during 65 years.
106	Slope	500	24	18	....do	Temperature 50° F. Mostly in sandstone.

Drilled wells in Meriden.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Depth to rock.	Kind of rock.	Yield.	Remarks.
		Feet.	*Feet.*	*Feet.*	*Feet.*		*Gallons per minute.*	
3	Slope	210	50+	15	1	Sandstone		
7	....do	210	75	20	1	....do		Mr. Litscher, owner. (See analysis, p. 52.)
8	Lowland	170	42	8		....do		Dug 20 feet, drilled 22 feet; dry every summer until drilled.
12	Knoll	190	72	15	1	....do		Drilled about 1895; flowed at first.
13	....do	190	69	40	1	....do		
14	Slope	200	72	30		....do		
15	....do	220	83	43		....do		
16	Knoll	230	125	40	1	....do		
20	Slope	360	124	45	50	....do		Pump 300 gallons daily.
24	Lowland	150	300	10		....do		J. D. Bergen Co.; drilled about 1900; too hard for boiler use; used for sprinkling, etc.
28	Slope	290	70	25		....do		Dug 30 feet; drilled 40 feet.
31	Swale	310	80	22		....do		Dug 28 feet; drilled 52 feet.

Drilled wells in Meriden—Continued.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Depth to rock.	Kind of rock.	Yield.	Remarks.
		Feet.	*Feet.*	*Feet.*	*Feet.*		*Gallons per minute.*	
34	Slope	350	79	30	25	Sandstone		Dug 35 feet; drilled 44 feet.
37	do	345	100+	30	5	do		
38	do	260	150	50		do		
40	Lowland	125	562	10±	100±	do		International Silver Co.; too hard for boiler use; stained silverware; formerly used for sprinkling, etc.; abandoned.
41	do	130	152	7	31	do		Thos. F. Lyons Bottling Works; water struck at 50 feet; rose to 7 feet. (See analysis, p. 52.)
43	Slope	170	250-350		6-10	do		Edward Miller Co., drilled 1895; 5 wells 250-350 feet deep. Factory supply.
46	do	280	120	25		do		Dug 32 feet; drilled 88 feet.
49	do	250	205	54		do		Dug 15 feet, drilled 190 feet.
52	do	260	1,000	70		do		Charles Parker Co., drilled 1905; too hard for boiler use; air lift. Factory use. (See analysis, p. 52.)
58	Hilltop	390	200	30		do		
73	Ridge	370	220	30	20	do	12	
74	Slope	330	48	20	12	do		Water struck at 40 feet; rose to 20 feet.
75	Saddle	305	60	30	40	do	4	
76	Slope	300	76	30	43	do	6	
80	do	300	128	15		do		Gas engine and windmill.
90	Lowland	80	90	20		do		Good supply.
94	Slope	245	93	40		do		Windmill.
96	do	290	75	27		do		
100	do	330	102	20		do		Good supply of water struck at 92 feet.
101	Base of hill	320	50	22		do		
104	Ridge	350	70	15		do		

Springs in Meriden.

Map No.	Topographic position.	Elevation above sea level.	Temperature.	Yield.	Bedrock.	Remarks.
		Feet.	°*F.*	*Gallons per minute.*		
1	Slope	180	49	5	Sandstone	Private drinking water supply.
4	Base of hill	180	47	1	Trap	Domestic supply of several adjacent houses.
33	Swale	250		4	Sandstone	Redrock Spring; bottled and sold locally; also dairy supply; flow noticeably less in dry summers.
39	do	190		5	do	Hillside Spring; bottled and sold locally (See analysis, p. 52.)
50	Base of hill	130	45	6	do	Unused.
54	do	290		5±	do	Supplies fire-protection tank of Edward Miller Co.
68	do	250	49	13	do	Live Oak Spring; bottled and sold locally.
69	do	220		1±	do	Live Elm Spring.
83	do	85	49	2	do	Watering trough at roadside.
86	Swale	100		5	do	Supplies a pond.
87	Base of hill	80		5	do	Domestic water supply.
89	Slope	120		3±	do	Domestic supply for several houses.
99	do	290		3±	do	Domestic supply, raised by hydraulic ram.

ANALYSES OF GROUND WATER.

The following table contains four analyses of ground waters in the town of Meriden, of which three are from drilled wells and one is from a spring. The analyses are discussed on pages 19–21.

Chemical composition and classification of water from Meriden.

[Parts per million. Samples collected May, 1915; S. C. Dinsmore, analyst.]

	Drilled wells.			Hillside Spring.
	7 [a]	41	52	39
Silica (SiO_2)	17	27	25	27
Iron (Fe)	Trace.	Trace.	Trace.	Trace.
Calcium (Ca)	28	50	69	29
Magnesium (Mg)	7.4	9.6	6.3	4.1
Sodium and potassium (Na+K) [b]	0.0	13	24	3.0
Carbonate radicle (CO_3)	0.0	0.0	0.0	0.0
Bicarbonate radicle (HCO_3)	92	134	129	92
Sulphate radicle (SO_4)	10	46	77	5.3
Chloride radicle (Cl)	5.0	16	23	7.0
Nitrate radicle (NO_3)	3.0	15	40	6.0
Total dissolved solids at 180° C	128	235	339	120
Total hardness as $CaCO_3$ [b]	100	164	198	89
Probable scale-forming ingredients [b]	110	190	240	120
Probability of corrosion [b] [c]	(?)	(?)	(?)	(?)
Quality for boiler use	Fair.	Fair.	Poor.	Fair.
Chemical character	Ca-CO_3	Ca-CO_3	Ca-CO_3	Ca-CO_3

[a] Numbers at heads of columns correspond to those on map (Pl. II, in pocket) and in table (pp. 50-51).
[b] Computed.
[c] (?)=corrosion doubtful.

MIDDLEFIELD.

HISTORICAL SKETCH.

The town of Middlefield, which occupies the south-central part of the area under discussion, was settled about 1700 by three families, who took up their homes respectively in the lowland in the southern portion, in the highland in the north, and near the center of the town.

The principal village is at Rock Fall, which had a population of about 250 in 1915. Middlefield Center and Baileyville are communities of about 100 people each. The remainder of the population resides mainly near Coe Hill, in the northern part of the town, and near Middlefield railroad station, in the southern part.

The area of the town is about 8,600 acres, according to planimeter measurement on the Middletown and Guilford topographic maps.[1] About 2,700 acres in the town, or nearly one-third of the total area, is wooded. The woodlands are very largely contained in one body covering uplands in the western part of the town, however, and only four or five areas of more than a few acres each are situated in the eastern two-thirds of the town. A large area of marsh occupies the south-central portion of the town, along the valley of Coginchaug

[1] The area is given as 8,406 acres on p. 432 of the Connecticut State Register and Manual for 1915, which probably is exclusive of the water surface.

River, and together with a smaller area in the northeast makes a total of fully 400 acres of marsh land.

Higby Mountain reservoir of the Middletown city water supply is in the northern part of the town, and Laurel Brook reservoir, of the same system, lies mainly within the eastern border. Black Pond (Pl. V, *B*) on the west border, Beseck Lake in the west-central portion, and a power pond in the east make, together with the two reservoirs, a total water surface nearly equal to that of the marsh land.

POPULATION AND INDUSTRIES.

In 1744, when Middlefield community was organized as a parish, it contained about 50 families, or possibly 350 people. At this time the community was given its present name, signifying that it was a rural portion of Middletown. By 1815 the population had increased only to about 450, but in 1866, when the parish was incorporated as a separate town, its population was more than double this number.

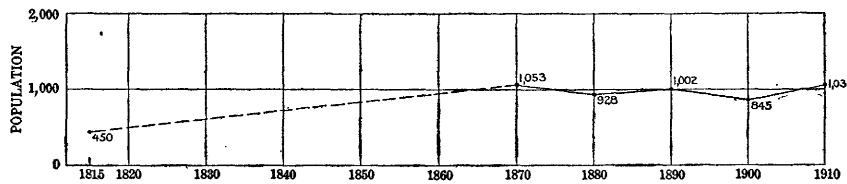


FIGURE 8.—Curve of population of the town of Middlefield, Conn.

Since the incorporation of the town its population has fluctuated somewhat with the activity of factories within its borders, but it has not risen above the figure of the first census after the town was formed. The diagram (fig. 8) shows the fluctuation in population, so far as it is given by the records of the census, taken at 10-year intervals.

The available water power was early utilized by gristmills and other mills, and the manufacture of various small articles was early undertaken. At present factories near Rock Fall and Baileyville produce cording, suspender webbing, and cotton cloth. Other industries in these settlements are the manufacture of gun sights, pistols, and novelties made of ivory and bone.

The greater part of the town is devoted to agriculture. Hay and other field crops are raised on the lower lands, and orchard fruits, especially peaches, are extensively grown in the higher areas. A number of dairy farms have also been established within recent years.

The town is crossed by the Air Line division of the New York, New Haven & Hartford Railroad, which gives direct outlet southward to New Haven and northeastward to Middletown. A trolley line extends from Middletown to Middlefield Center, and the main thoroughfares are surfaced and afford a good means of communication with the neighboring settlements.

GEOLOGY.

The town of Middlefield is not traversed by any extensive faults, and the bedrock structure is therefore simple. The series of Triassic sandstones and interbedded trap sheets dips gently eastward, as is shown in the middle portion of structure section G–H on Plate III (in pocket).

In the northwest corner of the town the "Anterior" or lower trap sheet is well exposed, both in the bed of the brook between East Meriden and Highland and in a very low ridge at the west side of the road. (See Pl. II.) This trap sheet is apparently broken and offset by a small fault in the extreme corner of the town, for it is there replaced by the overlying "Anterior" sandstone, as shown on Plate III. This sandstone forms the uppermost rock along most of the western border of the town, at the base of Higby and Beseck mountains. This northward-trending mountain ridge is formed by the "Main" trap sheet, but this trap dips eastward beneath the "Posterior" sandstone, which forms the uppermost rock through the central part of the town. Eastward this sandstone is succeeded in turn by a band of trap rock of the "Posterior" or upper sheet, which is overlain in the southeastern part of the town by the upper sandstone.

East of the valley of Coginchaug River the upper trap sheet is so far below the surface that it probably would be penetrated only by wells more than 1,000 feet deep. The liability of striking trap rock, which is tough and hard to drill, in wells sunk in the region east of Coginchaug River is therefore remote. The "Posterior" trap sheet, however, immediately underlies portions of Middlefield Center and Rock Fall and the intervening lands, as well as less thickly settled lands to the north and to the south. Wells that are drilled within this area, which is shown on Plate III as underlain by the "Posterior" trap, will therefore reach the trap immediately beneath the glacial deposits. This trap sheet is 100 to 150 feet thick, but it is probable that by drilling through it into the "Posterior" sandstone, fairly large supplies of water can be developed. The lands underlain by the "Posterior" trap are for the most part lower than the area of "Posterior" sandstone to the west. It seems possible, therefore, that artesian flows can be obtained from this sandstone beneath the confining layer of trap rock at some places in the trap area.

Except along its western border the area of "Posterior" sandstone west of the "Posterior" trap sheet is underlain at depths of

500 to more than 1,000 feet by the "Main" trap sheet. There is therefore little liability that trap will be encountered in wells drilled near Coe Hill and near the outlet of Beseck Lake.

Stratified glacial drift fills the valley of Coginchaug River and the adjacent lower lands, but the greater part of the town is covered by deposits of till. Over the slopes in the southeast the material seems to be fairly thick, and throughout the central portion it forms several drumlin hills. Over Higby and Beseck mountains the till is thin, however, and the trap rock is exposed on their eastern slopes, probably at many points in addition to those indicated on Plate II, as well as in the cliffs that form the western fronts of these ridges.

SURFACE FEATURES.

Middlefield is divided topographically into three fairly distinct belts that trend northward. Along the western side Higby and Beseck mountains constitute a prominent ridge whose crest attains an elevation of about 925 feet on the northwest border of the town. Westward the ridge drops abruptly to rolling land along the edge of the town. Eastward the slope is less abrupt, though steep, to a narrow lowland in part occupied by Beseck Lake and Higby Mountain reservoir. East of this lowland a series of narrow, elongated hills constitutes an area that slopes in the main eastward to the valley of Coginchaug River. The lowest point in the town, where this river crosses the northeastern boundary, lies at an elevation of about 80 feet.

The eastern portion of the town constitutes a gently rolling surface that rises less than 200 feet above the river.

STREAMS.

Coginchaug River drains practically all the town except about 2 square miles in the northwestern part, which is tributary to Higby Mountain reservoir. The Coginchaug has its headwaters in Durham and Guilford towns, several miles south of the Middlefield boundary. For fully half its course through Middlefield it is a sluggish stream, flowing through marsh land half a mile wide. The open valley ends near Middlefield Center, however, and thence eastward the stream has a steeper gradient. The drainage of the west and southwest portions of the town is received by Beseck Lake, which discharges directly eastward to the Coginchaug. In the southeast a portion of the drainage is received by Laurel Brook reservoir. This reservoir overflows northward through Laurel Brook, which joins the Coginchaug half a mile below the Middlefield town line. The drainage basin of Coginchaug River above the northeast border of Middlefield comprises about 33 square miles. The basin is situated similarly to that of Quinnipiac River and it has similar climatic conditions. It seems probable, therefore, that the unit run-off from the two basins is approximately the same. On this assumption the discharge of the Coginchaug would appear, by comparison of its drainage area with that of the Quinnipiac and its discharge curve with that of the Quinnipiac (fig. 7, p. 45), to be about 150 second-feet during the spring high water and 16 or 18 second-feet during the summer low-water flow. The daily flow of the Coginchaug and its various tributaries is greatly influenced by mill ponds, however.

A gristmill, built near Rock Fall in the eighteenth century, was replaced about 1800 by a sawmill, and below this a fulling mill was constructed shortly afterward. A snuff mill, a powder mill, and other small factories were early established near Rock Fall and near Baileyville. A cotton factory, constructed near the same place in 1847, was burned in 1874 and was replaced by a larger structure.

A storage dam was built about 1848 at the outlet of Beseck Lake by those interested in manufacturing along the lower Coginchaug, and the dam was in later years increased in height. The original pond has thus been greatly increased in size and still furnishes an important supply of water for power development during the lowest stages of Coginchaug River. The drainage area tributary to the lake is about 1,400 acres, of which the lake covers about 35 acres.

GROUND-WATER SUPPLIES.

Water in stratified drift.—So far as was learned by the writer, all the residents in Middlefield obtain their water supplies from individual wells or springs.

In Middlefield only the lowland along the valley of Coginchaug River is covered by stratified drift, and as the larger part of this area is marsh land, few wells have been sunk in it. In the six wells ending in stratified drift that were examined by the writer in May, 1915, the average depth to water was 12 feet, the extreme depths being 7 and 21 feet. (See fig. 3, p. 16). The deepest well is said to fail in summer, but the others yield perennial supplies. An analysis of water from one of the shallowest drift wells (No. 11), given in the table on page 59, shows this water to be comparatively low in total mineral content, calcium and bicarbonate being the chief constituents.

The most promising part of the town for the development of large quantities of ground water is probably in the marshy valley of Coginchaug River, for sandy layers that would yield good supplies to shallow drilled wells, properly screened, probably are present beneath the surficial layers of soil and silt.

Water in till.—The greater part of Middlefield is covered with glacial till, and most of the domestic water supplies are obtained from wells dug in these unstratified deposits. The average depth to water, in May, 1915, in the 27 wells in till that were measured, was 14.3 feet. (See fig. 3, p. 16.) The average depth to water in wells in till on hillsides and in lowlands was only slightly greater than the average depth in the six wells in drift that were observed, but in several wells in till on the tops of hills and knolls the average depth to water was nearly 21 feet.

The analyses of water from two wells in till (Nos. 6 and 26, p. 59) show larger mineral contents than the water from the well in stratified drift (No. 11), and it is probably true that the waters in the till as a rule contain more mineral matter than the waters in the stratified drift. This condition is indicated by the average mineral contents in all the waters of wells in till and drift that were analyzed. (See table of analyses, p. 59.) The water of well 6 contains rather large amounts of chloride and nitrate, and it is possible that a portion of these substances is due to contamination by the wastes from the adjacent house. Well 26 is dug beside a house and is situated so that it may receive polluted water both from the kitchen and from the adjacent barnyard. Serious contamination of this sort appears to be shown by the large amounts of chloride and nitrate that were found in the water. This water also is noticeably hard, as it contains relatively large amounts of calcium and bicarbonate.

Water in sandstone and trap.—Five drilled wells were noted in the town in localities where the glacial till is too thin to furnish a reliable water supply. Two of these wells penetrate the "Posterior" trap sheet, their total depths being 60 and 106 feet, and they obtain supplies of soft water sufficient for domestic needs. The other three wells are drilled in sandstone, to total depths of 65, 125, and 150 feet. These wells also yield sufficient water for domestic use, though the capacity of each is probably less than 5 gallons a minute.

Springs.—Three springs (Nos. 4, 15, and 16) were noted in the town. All have slight flow, however, and are little used. Other small springs probably issue on the higher slopes of Beseck and Higby mountains, but no springs were reported to be used for domestic supply.

RECORDS OF WELLS AND SPRINGS.

The following lists contain data concerning certain wells and springs whose locations are indicated on Plate II. They are believed to be representative of the ground-water conditions throughout the town.

Dug wells in Middlefield.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Method of lift.	Remarks.
		Feet.	*Feet.*	*Feet.*		
1	Ridge	450	22	12	Wheel and bucket.	Dry in summer.
2	Slope	380	16	7	Chain pump	Do.
3	Ridge	330	26	22	do	Do.
5	Knoll	230	22	12	Windlass	Never dry.
6	Base of hill	370	14	11	do	Never dry; sandstone encountered. W. H. Holmes, owner. (See analysis, p. 59.)
7	Slope	320	23	13	do	Dry in summer.
8	do	330	30	10	do	At schoolhouse.
11	do	150	28	7	Wheel and bucket.	Never dry. Emma L. Beebe, owner. (See analysis, p. 59.)
12	Base of knoll	150	13	9	do	Do.
13	Slope	380	32	15	Hand pump	Do.
14	do	350	41	12	Windlass	Do.
17	do	190	25	21	do	Dry in summer.
19	Swale	220	13	5	do	
20	Saddle	250	26	24	Wheel and bucket.	
21	Slope	250	26	20	Windlass	Do.
22	do	250	24	17	do	Gets low but not dry.
23	Swale	190	16	12	do	60 feet from and 17 feet above brook.
25	Base of knoll	380	29	22	Wheel and bucket.	Dry in summer.
26	Hill	360	39	23	do	Never dry; hard water. Fred Andrews, owner. (See analysis, p. 59.)
27	Base of hill	330	28	15	Chain pump	
28	Ridge	370	39	28	Windlass	Never dry.
29	Base of hill	230	18	12	do	
30	Slope	320	27	11		Unused; dry in summer.
32	do	370	23	12	Windlass	Never dry.
33	do	280	8	2		Unused.
34	Lowland	150	21	16	Pitcher pump	60 feet from brook and 2½ feet above it.
35	Slope	175	30	14	Windlass	Never dry.
36	Flat	170	22	12	do	Dry in summer.
37	Slope	125	13	8	do	
38	do	170	18	15		Unused.
39	do	110	21	16	Wheel and bucket.	Gets low but never dry.
40	do	200	18	7	Hand pump	Never dry.
41	Hilltop	350	32	16	Wheel and bucket.	

Drilled wells in Middlefield.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Depth to rock.	Kind of rock.	Yield.	Remarks.
		Feet.	*Feet.*	*Feet.*	*Feet.*		*Gallons per minute.*	
9	Slope	250	106	60	9	Trap		Soft water.
10	do	190	60	30		do		
18	do	250	125	15		Sandstone		
24	Ridge	385	150	25	11	do		Good supply.
31	Slope	320	65	12		do	4	

Springs in Middlefield.

Map No.	Topographic position.	Elevation above sea level.	Temperature.	Yield.	Bedrock.	Remarks.
		Feet.	*°F.*	*Gallons per minute.*		
4	Slope	400	50	¼	Sandstone	Roadside drinking.
15	do	270		½	Trap	Unimproved.
16	do	290		½	do	Do.

ANALYSES OF GROUND WATER.

The following table contains three analyses of ground water in the town of Middlefield. The analyses are discussed on pages 19–21.

Chemical composition and classification of water from dug wells in Middlefield.

[Parts per million. Samples collected May, 1915; S. C. Dinsmore, analyst.

	Well ending in stratified drift.	Wells ending in till.	
	11[a]	6	26
Silica (SiO_2)	18	26	19
Iron (Fe)	Trace.	Trace.	Trace.
Calcium (Ca)	20	25	118
Magnesium (Mg)	5.6	8.9	37
Sodium and potassium (Na+K)[b]	.0	16	51
Carbonate radicle (CO_3)	.0	.0	.0
Bicarbonate radicle (HCO_3)	48	63	97
Sulphate radicle (SO_4)	10	34	49
Chloride radicle (Cl)	7.0	18	102
Nitrate radicle (NO_3)	12	28	352
Total dissolved solids at 180° C.	101	192	769
Total hardness as $CaCO_3$[b]	73	99	447
Probable scale-forming ingredients[b]	86	110	430
Probability of corrosion[b c]	(?)	(?)	C
Quality for boiler use	Good.	Fair.	Poor.
Chemical character	Ca-CO_3	Ca-CO_3	Ca-NO_3

[a] Numbers at heads of columns correspond to those on map (Pl. II, in pocket) and in table (p. 58.)
[b] Computed.
[c] C=Corrosive; (?)=corrosion doubtful.

MIDDLETOWN.

HISTORICAL SKETCH.

Middletown occupies the central and southeastern portions of the area treated in this report.

The first white settlers established their homes in 1650 in or near the area at present occupied by the city of Middletown, which stands on the site of an Indian village, Mattabesset or Mattabesec, on slopes overlooking Connecticut River. The name Mattabesset is the corruption of a phrase signifying "at the mouth of a large brook." The community was organized in the year following its settlement and was known as Mattabesset until 1653, when the present name was adopted, from the position of the settlement midway between the upper river towns and Saybrook, at the mouth of the Connecticut.

Since the first settlement the population has been concentrated in the city of Middletown, but small communities have also been built up at Westfield, Newfield, and Highland, in the western part of the town, and in the vicinity of Maromas railroad station, in the eastern part.

The town originally included the area that now comprises Chatham and Portland, east of Connecticut River, and also Cromwell, Middlefield, and a portion of Berlin. The present area of the town, considering the center of Connecticut River as its eastern boundary, is about 28,700 acres, according to planimeter measurement on the Middletown, Guilford, and Meriden topographic maps.[1] A relatively large part of the town—35½ per cent—is wooded, the main wooded area being in the southeast, as shown on Plate IV (in pocket). As in other parts of the State, practically all the trees of the original forest have been cut, and the woods now consist almost entirely of small trees of later growth. About 570 acres, or 2 per cent of the area, may be classed as marshy. This area consists largely of land adjacent to Mattabesset River, along the northeast border of the town; but there are also marshy areas of considerable extent near the southern border of the city and in the southern and southeastern portions of the town. The western half of Connecticut River, which is included within the town, constitutes its greatest water body and covers about 650 acres. Several ponds and reservoirs cover a total area less than one-third as great, or only about 200 acres.

POPULATION AND INDUSTRIES.

In 1673 the entire town of Middletown contained only 52 families, and for the next few decades the growth in population was slow. An actual decrease took place in some years, for the country is rough, markets are distant, and the heavily timbered farm lands offered little inducement to immigration. During the half century preceding the American Revolution, however, the town increased notably in population and in prosperity, owing chiefly to the development of trade with the West Indies, where cotton cloth and other finished products were exchanged for rum, molasses, and tropical goods.

The development of industries and the location of institutions near the original settlement have caused the population of the town to remain concentrated near this place. The city was incorporated in 1784 and, as is shown in figure 9, more than half the total population of the town is within the corporate limits. A considerably greater percentage of the total population than is indicated by the diagrams is located within 2 miles of the city hall, for there are built-up districts to the south and southeast, beyond the city limits.

At the time of the Revolution the city of Middletown had become an important shipbuilding and commercial center, and manufacturing was also becoming important. The first steam-driven factory in the State was built in 1812 by the Middletown Woolen Manufacturing Co.[2] The industrial activity of the city continued to increase

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[1] The area is given at 27,287 acres on p. 433 of the Connecticut State Register and Manual for 1915.

[2] Encyclopaedia Britannica, 11th ed., subject Connecticut.

until, in the middle of the nineteenth century, it was one of the principal cities in the State. The development of the rival cities of New Haven, Hartford, and Bridgeport into railroad centers, as well as seaports, gave them a great advantage over Middletown, and beginning about 1850 this city declined in commercial activity for several decades. Within recent years, however, Middletown has shown renewed activity as a manufacturing center. The principal industries at present include the manufacture of pumps and other hydraulic machinery, hardware, automobiles, typewriters, cutlery, and other small articles, and wooden, cotton, rubber, silk, and web goods. Agriculture and dairying are carried on throughout the lower lands of the town. Brickmaking is an extensive industry at Newfield and near Westfield, and feldspar and building stone have been produced in great amounts from pegmatite and granite gneiss in the

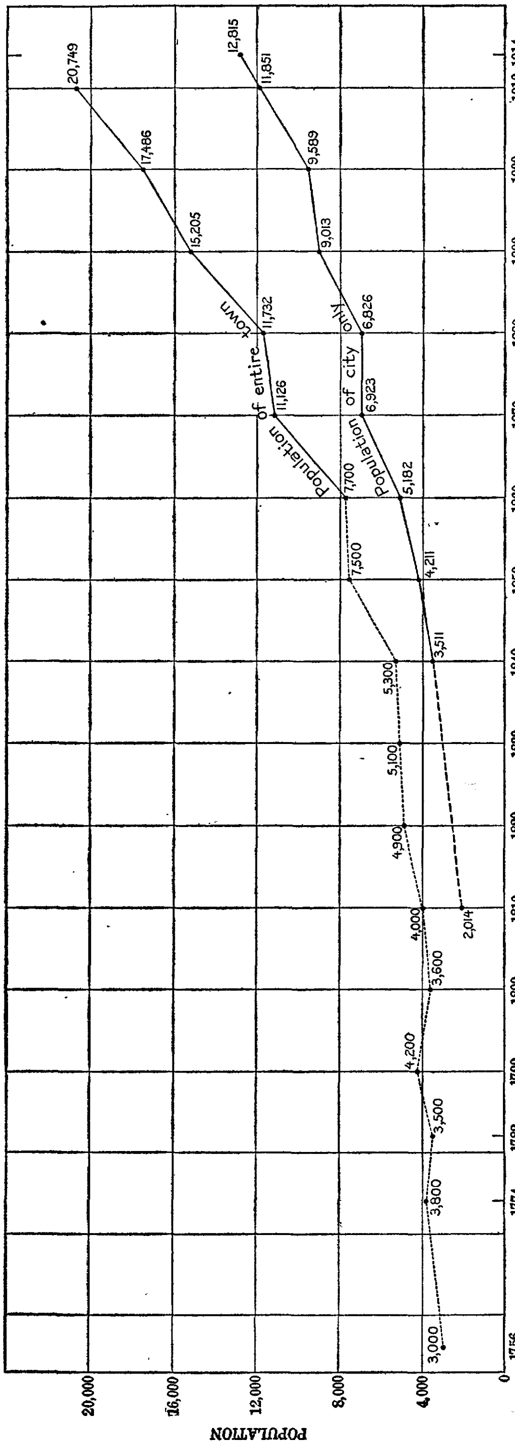

FIGURE 9.—Curves of population of the town and city of Middletown, Conn.

eastern portion of the town. An "old silver-lead mine" near Connecticut River, 2 miles east of the city of Middletown, is reported to have produced some lead during the Revolutionary War, but the workings have long been abandoned. No reports of other prospects of metallic minerals in the town have been obtained by the writer.

In addition to being an industrial city, Middletown is the seat of Wesleyan University, founded in 1831, and of Berkeley Divinity School, founded in 1849. The State Industrial Home for Girls is a short distance south of the city limits, and the State Hospital for the Insane is at South Farms, east of the corporate limits.

GEOLOGY.

In its geologic structure Middletown presents three well-defined zones—an area of complex structure in the west or northwest, a central area immediately underlain by the upper sandstone, and an area of ancient crystalline rocks in the east and southeast.

The northwestern part of the town is traversed by a great fault, along which, according to Davis,[1] the rocks have been vertically displaced not less than 1,300 feet, the rocks east of the fault zone being uplifted with respect to those west of it. In addition to the vertical displacement, the rocks on the east side of the fault have been shoved northeastward with respect to those on the west, and minor faulting has complicated the structure west of the main fault zone. The present surficial positions of the several beds of trap rock and sandstones, as worked out by Davis,[2] are shown on Plate III (in pocket).

The "Anterior" trap sheet is the uppermost rock in Middletown in only a narrow area that extends southward from a point near Highland. The "Main" trap sheet forms both Lamentation and Higby mountains. The parallel trends of these two mountains and their offsetting well illustrate the results of the northeast-southwest movement along the great fault zone that passes between them.

The "Posterior" trap sheet, as a result of minor faulting in addition to the major displacement, appears as the surficial rock in two narrow bands that extend northward from Highland and in a wider belt west of Westfield station. East of Westfield station the "Posterior" trap is again exposed, and it forms the bedrock in a gradually widening zone that extends southward.

No faults of consequence in Middletown are known east of the major one, so that from the southwestern corner of the town the entire series of Triassic rocks, from the lower to the upper sand-

[1] Davis, W. M., The Triassic formation of Connecticut: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 2, p. 96, 1898.

[2] Idem, pl. 20.

stones, appear in successive north-south bands, as one proceeds eastward from the west edge of the town. This succession of beds is shown in the middle portion of structure section E–F, Plate III.

The central portion of the town is underlain by the upper sandstone, beneath which the three trap sheets presumably have their usual relative positions. In the vicinity of Staddle Hill the upper surface of the "Posterior" trap sheet is probably about 500 feet below the surface, and at other points nearer the eastern border of the zone of "Posterior" trap, this rock is of course nearer to the surface.

The Triassic rocks dip eastward at an angle that decreases from about 15° to about 10° from the horizontal. This eastward dip probably carries the "Posterior" trap sheet to a depth of 1,500 feet or more below the city of Middletown, provided this upper trap sheet, the thinnest of the three trap sheets, persists as far eastward as the city.

The central area of upper sandstone is bounded on the east by the great fault zone that forms the eastern border of the central lowland of the State. The ancient crystalline rocks east of the fault have been uplifted with respect to the Triassic rocks. No definite contact of rocks of the two classes has been found at any point along the fault zone in Middletown, but the existence of faulting is shown by the presence of crushed, laminated phases of the sandstone in the transition zone from unaltered sandstone to the granite gneiss and pegmatites.

The belt of lowland nearly a mile wide that extends from the city of Middletown nearly to Mattabesset River is covered by stratified drift. Narrower areas of drift also extend up the valleys of Sawmill and West Swamp brooks, and the lowlands along Coginchaug River and along the main branches of Sumner Brook likewise contain deposits of stratified drift. In the lands along the lower portion of Mattabesset River this drift seems, from the records of wells, to be in some places more than 50 feet in thickness. It contains extensive beds of clay that have long been used for brickmaking. Over parts of the lowland the drift is very thin, however, and the underlying bedrock of sandstone or of trap crops out at a number of places, as is indicated on Plate II (in pocket).

The greater part of the town is overlain by deposits of till, though on the higher lands the till is only a few feet thick and the underlying rocks are exposed in many spots. In Lamentation and Higby mountains the lava rock of the main trap sheet that forms these ridges is well exposed in their cliffs. On their eastern slopes the trap is also exposed over considerable areas beneath the very thin covering of till. On these slopes the trap is doubtless exposed in many places a few yards in extent that can not well be shown on a map of the scale of Plate II. Over the highland area in the southeast the till is also in the main very thin, and ledges of the granite bedrock and numerous prominent dikes of pegmatite are exposed in many places. There are, accordingly, doubtless many exposures of the bedrock in addition to those indicated on Plate II.

SURFACE FEATURES.

Middletown has an irregular shape, being bounded on the north and east by streams—the Mattabesset and the Connecticut—and having a large reentrant in the southwest, caused by the incorporation of its former parish of Middlefield as a separate town.

The southeastern portion of the town is occupied by a rugged, hilly area that forms part of the eastern highland of the State. Within the town Bear Hill and Chestnut Mountain are the highest points of this highland, but their respective elevations are only 650 and 620 feet. Near its western border the town includes portions of Lamentation and Higby mountains, the highest point in the town being on the crest of Higby Mountain, at an elevation of about 925 feet. Between the two high areas in the east and in the west the surface is rolling or hilly, and the drainage is developed along narrow northward-trending valleys.

There is a wide area of lowland in the northern portion of the town, in the vicinity of Mattabesset River and along its tributary, Sawmill Brook. Near the city of Middletown there are also lowlands to the west along Coginchaug River and to the southeast along the main branches of Sumner Brook. East of the city, along the Connecticut, the slopes come down rather abruptly to the river, but there is a narrow lowland extending westward from Maromas railroad station and a meadow a quarter of a mile wide at the mouth of Hubbard Brook.

STREAMS.

Connecticut River, the master stream of the region, borders the eastern side of Middletown for 9 miles. In this portion of its course the stream has a width of one-eighth to three-eighths of a mile and a depth of channel sufficient for small seagoing vessels. The limit to the draft of ships that traverse the river is chiefly determined by a bar at its mouth, 30 miles below Middletown city. The influence of the tide is felt in the river for a number of miles above Middletown.

The drainage from the different parts of Middletown flows in fairly direct lines to the Connecticut. Mattabesset River, which forms the northern border of the town, receives several northward-flowing brooks that drain the northern and western lands. Sawmill Brook, the principal one, heads near the western boundary of the town. Early in May, 1915, it was carrying nearly 2 second-feet of water in its lower course, but its normal summer flow probably is less than half that amount. A considerable part of its flow also sinks in the lowland near Mattabesset River before uniting with that stream.

The flow of Fall Brook, which joins Sawmill Brook near Westfield, is in large part stored in Higby Mountain reservoir. At the falls of the brook, where it cascades across the main trap sheet near Westfield, it had, in May, 1915, a flow of about 0.5 second-foot, but nearly all this water was absorbed by the gravel of the lowland in the half mile between the falls and Sawmill Brook.

The slopes between Westfield and Newfield are drained by West Swamp Brook, which joins the Mattabesset a mile below Westfield station, and by a brook that enters the main stream one-quarter of a mile above the station. Neither of these streams normally carries more than 0.2 or 0.3 second-foot of water.

Coginchaug River, which flows from the southwest through Middlefield, is ponded both in Middletown and in Middlefield, and its daily flow is greatly affected by the storage or release of water at the mill ponds. On May 5, 1915, the discharge of the Coginchaug 1 mile above its junction with the Mattabesset was 52 second-feet, but its average flow during the six months of low water has been given as about 18 second-feet.[1]

The Coginchaug unites with the Mattabesset in the marsh lands half a mile from Connecticut River. The current of the Mattabesset apparently is so checked by its entrance into the larger, more sluggish stream that it deposits a considerable portion of the sediment carried during freshets. Willow Island seems to have been thus built up in the Connecticut opposite the mouth of the Mattabesset.

Sumner Brook drains the southern portion of Middletown and enters Connecticut River at the eastern border of the city. Its western branch, sometimes called Pameachea Brook, drains only slopes that are within the town, but the eastern branch, early known as Sanseer Brook, rises on the border between Durham and Haddam, 2 miles south of the Middletown boundary. Measurements of the west and east branches short distances above their junction three-quarters of a mile from the Connecticut, on May 5, 1915, showed discharges respectively of 20 and 7 second-feet. Both streams are used for power at storage dams short distances above their junction, and these measurements may represent the approximate amounts of water that are normally used during factory hours. Storage dams at Dooley Pond, on the upper course of the west branch, and at a

[1] Report on the investigation of the pollution of streams, p. 45, Connecticut State Board of Health, Hartford, 1915.

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similar reservoir on the east branch aid in controlling the flow for factory use.

The average low-water flow of Sumner Brook probably is proportional to that of Coginchaug River, which has a total drainage area of about 38.7 square miles and an average summer flow at its mouth of 18 second-feet.[1] The entire drainage area of Sumner Brook is about 12.4 square miles, so its mean summer supply to the storage dams along its branches is presumably 5 or 6 second-feet.

The highland area in the eastern part of the town is drained mainly by brooks that flow eastward to the Connecticut. Hubbard Brook and another stream that crosses the southeast border of the town are the largest of these brooks, but each carried only about three-quarters of a second-foot early in May, 1915.

The northwest portion of the highland is drained by two small brooks, whose headwaters have been dammed to furnish a water supply for the State Hospital at South Farms.

WATER SUPPLIES.

Surface water.—In 1866 the city of Middletown constructed Laurel Brook reservoir for a municipal water supply. This reservoir has a mean depth of 10 feet and a capacity of 220,000,000 gallons. Its watershed has an area of 1.05 square miles (672 acres). The growth and increased needs of the city rendered the supply from this reservoir inadequate about 1897, and Higby Mountain reservoir was constructed, with a maximum depth of about 27 feet, a capacity of 308,000,000 gallons, and a drainage area of 2.06 square miles (1,318.4 acres). The total safe daily supply from the two reservoirs, estimated at 2,300,000 gallons, was nearly reached during 1913, it being estimated that in the later part of that year 15,000 people were served, the average daily consumption being 2,000,000 gallons, or 133 gallons per capita. By complete metering of the system and the reduction of all wastes to a minimum, however, it has been estimated that the present supply will suffice for the needs of the moderately growing city for a number of years longer. On the basis of an average daily consumption of 90 gallons per capita and the present rate of growth, the supply has been figured as sufficient until 1940. Beseck Lake is considered by hydraulic engineers to offer an available source when an additional supply is needed.

During the summer months some trouble is experienced from a taste and odor developed by algae in the open reservoirs, but treatment with copper sulphate has very appreciably reduced this un-

[1] Connecticut State Board of Health Rept., p. 45, 1914. See also estimate on p. 37. based on discharge of Quinnipiac River.

favorable condition. The following partial analyses show the general quality of water in the two reservoirs. The low figures for dissolved solids and hardness indicate waters suitable for industrial use and domestic supplies. The water from Laurel Brook reservoir has a higher content of dissolved solids, owing, it is said, to the greater effect of evaporation during this reservoir's longer period of use.

Analyses of water from Laurel Brook and Higby Mountain reservoirs.[a]

[Parts per million.]

Dates of collection of samples.	Total residue.		Chloride radicle.		Hardness.	
	Laurel Brook.	Higby Mountain.	Laurel Brook.	Higby Mountain.	Laurel Brook.	Higby Mountain.
August, 1889, to June, 1891	42	....	2.3	....	18	....
February, 1909, to September, 1910	57	54	3.0	2.8	31	25
July, 1912, to March, 1913 (Laurel Brook), and July, 1913 (Higby Mountain)	63	51	4.9	2.4	31	24

[a] From report of a consulting engineer. Name of analyst not given.

In 1880 a 2,500,000-gallon impounding reservoir was constructed on a branch of Pameachea Brook by an earthen dam 300 feet long, as a water supply for the State Industrial Home for Girls. One or more drilled wells on the grounds have within recent years augmented this surface-water supply.

The State Hospital for the Insane, situated at South Farms, is supplied by five storage reservoirs, as shown on Plate IV (in pocket). Three mains, 6, 8, and 16 inches, respectively, in diameter, conduct the water to the grounds. The two reservoirs that are not thus directly connected contain additional storage supplies that can be turned into the adjacent reservoirs.

The only other surface-water supply reported in the town is a system that pumps water from Laurel Brook to a private estate on a knoll one-third of a mile west of Long Hill.

The available records indicate that in 1915 about 15,000 people were supplied from the Middletown municipal water system and about 3,000 from the systems of the Industrial School and the State Hospital.

As is shown in the preceding paragraph, about 18,000 people, or 82 per cent of the entire population of Middletown, are supplied with surface water. The remaining 4,000 people depend on individual wells and springs.

Water in stratified drift.—The areas of stratified drift in the northwestern part of the town are to a large extent underlain by clay, and although supplies of water sufficient for domestic purposes may be obtained, the fine-textured sediments do not readily yield water. Detailed study of the stratified drift as a water bearer was not made, but so far as was observed it seemed that the stratified deposits in the valley of the main branch of Sumner Brook were more sandy than in the areas farther west and north and offered the most favorable conditions for the development of ground water on a large scale for industrial or municipal use.

The average depth to water early in May, 1915, in the 21 dug wells that obtain water from the stratified drift was 13.1 feet (see fig. 3, p. 16), but the water level ranged in individual wells from 3 feet in a hillside well to 26 feet in a well in the lowland.[1] Only one of these wells (No. 20) is said to go dry in summer.

Water in till.—As the greater part of the town is covered by deposits of till, the majority of the domestic wells obtain supplies from this material. There is marked difference in the depth to water in different wells, owing to the diversity in the surface features of the town, which includes crystalline highlands thinly covered with till in the southeast, sandstone hills in the south, and trap ridges in the northwest, as well as rolling lands more deeply covered with till throughout the central portion. The extremes of water level in the 55 wells in till that were measured were 2 and 36 feet, both extremes being in wells on slopes. The average depth to water in the hillside wells in till was 16.1 feet, early in May, 1915, and 10.3 feet and 12.3 feet, respectively, in wells in lowlands and on hilltops. The fact that the shallowest average depth in wells in till was on hilltops may have been because the relatively thin layer of till and consequent shallow depth to bedrock on the higher lands kept the water table nearer the surface than in localities where the till is thick.

Water in bedrock.—Many of the wells in till go dry in summer, and in localities where these glacial deposits are too thin to furnish reliable water supplies, wells drilled into the bedrock have of late years come into favor. The 16 drilled wells that were noted in the town (see p. 71) range from 57 to more than 200 feet in depth, averaging about 113 feet, and the average depth to water in May, 1915, was about 25 feet. One well (No. 102) furnishes water at the rate of about 20 gallons a minute. So far as was learned, the other drilled wells have smaller capacities, though careful pumping tests might show that they are capable of yielding more than the amounts with which their owners credit them. The lower half of one well (No. 24) is drilled in the "Main" trap sheet but furnishes a supply of about 5 gallons a minute from this rock. The trap here is probably fractured and fissured to a greater extent than usual, as the locality is

[1] In the preparation of figure 3 Middletown dug wells Nos. 17, 70, 72, and 84 were omitted, for they obtain water from the sandstone.

close to one of the largest faults or breaks in the rock structure. (See Pl. III, in pocket.)

The quality of water in the drilled wells is indicated by the analyses of water from three of them included in the table on page 72. They are waters of moderate mineral content, in which the principal constituents are the usual calcium and bicarbonate. These constituents are largely responsible for the rather high hardness of the waters. This hardness would be somewhat objectionable in washing, for soap would be wastefully consumed, and in steam-making, for the formation of scale would gradually lower the efficiency of the boilers and eventually necessitate cleaning them.

Springs.—Several springs in Middletown furnish domestic water supplies, and in 1915 water from three of them (Nos. 35, 37, and 87) was sold locally for table use. Two other springs (Nos. 27 and 103) also were formerly developed commercially. Water from a spring near the southwest border of the town has long been piped southward as a supply for the village of Durham, but in 1915 the spring was not accessible to the writer. The analyses of three of the spring waters given on page 72 show that they contain notably less mineral matter in solution than the average well waters, but the principal dissolved substances in the springs also are calcium and bicarbonate.

RECORDS OF WELLS AND SPRINGS.

The following lists of wells and springs through the town are believed to represent typical conditions in their respective vicinities. The locations of the several wells and springs are indicated on Plate II.

Dug wells in Middletown.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Method of lift.	Remarks.
		Feet.	*Feet.*	*Feet.*		
2	Slope	240	38	33	Hand pump	Dry in summer; sandstone penetrated.
3	....do	105	27	12	Rope and bucket	
4	....do	40	29	17		Unused.
5	....do	230	18	9	Chain pump	Dry in summer.
6	....do	150	38	29	Wheel and bucket	Never dry.
7	Swale	140	21	13	Windlass	Dry in summer.
8	Slope	110	24	20	....do	Do.
9	Lowland	25	13	10	....do	
10	Base of hill	225	15	12	....do	Do.
12	Swale	230	15	9	Pitcher pump	Supplies horse trough; sandston penetrated.
13	Slope	150	14	10	Hand pump	Dry in summer; trap penetrated.
14	....do	145	16	3	....do	Never dry.
15	Saddle	210	15	9	Chain pump	
17	Slope	210	30	25	Windlass	Dry in summer; sandstone below 6 feet.
19	Knoll	60	16	9	....do	
20	Slope	220	21	12	Rope and bucket	Dry in summer.
21	....do	120	29	23	Wheel and bucket	Never dry.
22	Flat	45	23	7	Windlass	

Dug wells in Middletown—Continued.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Method of lift.	Remarks.
		Feet.	*Feet.*	*Feet.*		
23	Slope	220	27	22	Bucket	Never dry.
25	Base of knoll	280	17	13		Unused; dry in summer.
26	Slope	290	40	36	Windlass	Never dry.
28	.....do	250	20	16	.....do	Do.
30	Swale	280	21	17		Unused; have city water.
32	Slope	320	50	23	Hand pump	Sandstone penetrated.
34	.....do	380	26	18	Windlass	Never dry.
36	.....do	130	26	8	.....do	Do.
38	Base of hill	100	23	17	.....do	Dry in summer.
39	Lowland	40	21	13	.....do	Never dry during 30 years; supplies several families.
40	.....do	50	25	17	.....do	33 feet above Connecticut River.
41	Saddle	440	12	4	Hand pump	
43	Slope	380	16	5	Windlass	Seldom dry.
44	Base of hill	120	19	17	.....do	Dry in summer.
45	Slope	160	33	28	.....do	Do.
46	.....do	60	17	8	Chain pump	Gets low in summer; have city water sandstone penetrated.
47	.....do	180	21	19	.....do	Never dry.
48	Lowland	60	25	7	Windlass	
50	Slope	70	28	24	.....do	Never dry; used as milk cooler; have city water.
51	Base of knoll	140	25	7	.....do	Never dry.
52	Slope	70	21	7		Unused.
53	.....do	50	22	16	Rope and bucket	Used only as milk cooler.
54	Swale	80	15	12	Windlass	Not dry during 9 years.
55	.....do	130	20	13	.....do	Dry in summer.
56	Knoll	150	29	18	.....do	Dry in summer; 100 yards from No. 57.
58	Ridge	130	32	19	.....do	
60	Slope	150	24	13	Chain pump	Never dry; last 3 feet in sandstone.
62	Saddle	185	10	3	Windlass	Never dry; supplies 4 families.
64	Slope	120	10	9	Chain pump	Dry in summer.
65	Lowland	15	21	20	Windlass	
67	Slope	140	29	21	.....do	Gets low but not dry.
68	Base of hill	20	29	26	.....do	At Maromas station.
70	Slope	180	25	21	.....do	Gets low but not dry; last 12 feet in sandstone.
72	.....do	140	17	14	.....do	Last 4 feet in sandstone.
73	Knoll	160	31	10	.....do	Gets low but not dry.
74	Slope	180	15	8	Chain pump	Dry in summer.
76	Base of hill	120	11	8	Windlass	Spring No. 75, which is 100 yards north, furnishes drinking water.
77	Slope	210	18	23	Wheel and bucket	
78	.....do	200	41	24	.....do	Gets low but not dry.
79	.....do	270	14	10	Windlass	Do.
80	Swale	350	5	3	Rope and bucket	10 feet south of brook. Pegmatite exposed.
81	Slope	370	28	20	Windlass	
82	.....do	175	20	11	.....do	Never dry.
83	Base of hill	140	18	16	Hand pump	Dry in summer; 300 feet from No. 82.
84	Slope	210	33	24	Windlass	Scant supply; gets low but not dry; last 12 feet in sandstone.
85	Low ridge	190	17	12		Unused; have city water.
88	Lowland	115	13	5	Windlass	Never dry.
89	Swale	210	17	10	Chain pump	
91	Knoll	340	20	17	Windlass	
95	Saddle	360	8	4	Rope and bucket	
96	Swale	300	18	12	Windlass	Dry in summer.
97	Slope	340	14	10	.....do	Do.
98	.....do	400	9	2	Rope and bucket	
99	.....do	410	8	6	.....do	At border of small marsh; 200 feet from No. 98.
100	Base of hill	220	32	15	Chain pump	Never dry.
101	Swale	210	18	10		Unused; 125 feet from and 12 feet below No. 100.
105	.....do	200	16	11	Windlass	
106	.....do	560	18	2	Hand pump	At base of large pegmatite ledge.
107	Slope	300	12	6	Windlass	
108	.....do	120	13	11	Chain pump	
109	Ridge	170	13	7	.....do	
111	.....do	160	14	3	Rope and bucket	In small marshy area.

Drilled wells in Middletown.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Depth to rock.	Kind of rock.	Yield.	Remarks.
		Feet.	*Feet.*	*Feet.*	*Feet.*		*Gallons per minute.*	
1	Slope	130	112	30		Sandstone		
11	Base of hill	225	129	15		do	4	John B. Vadney, owner. (See analysis, p. 72.)
16	Slope	210	90	25		do		At Westfield school. (See analysis, p. 72.)
18	do	220	90	30		do		Good supply.
24	Base of knoll	280	65	15	30	Trap	5	
33	Slope	410	101	34	50	Sandstone	4	Windmill.
42	Knoll	470	200+	16		do		Drilling in dug well that dried; 1 gallon a minute at 35 feet, but no other supply down to 200 feet.
49	Slope	100	150	30	55	do		
57	Knoll	150	98	20		do		
61	Slope	170	115	35	100±	do		
63	do	210	86	20	17	do	8	
86	Knoll	220	120	20		do		Small supply.
90	Swale	270	230	20	18	do	8	Windmill.
92	Base of hill	200	57	20	10	do	7	
102	Base of ridge	140	70	30		do	20	Supplies dairy of 50 cows; gas engine.
104	Slope	200	100	30	3	do		E. E. Harvey, owner. (See analysis, p. 72.)

Springs in Middletown.

Map No.	Topographic position.	Elevation above sea level.	Temperature.	Yield.	Bedrock.	Remarks.
		Feet.	*°F.*	*Gallons per minute.*		
27	Swale	220		2±	Sandstone	Highland Spring. (See analysis, p. 72.)
29	Slope	240			do	Domestic supply.
31	do	300	50	1	do	Supplies roadside watering trough.
35	do	160		(a)	Trap	Crystal Spring; bottled and sold locally.
37	Base of knoll	120		2	Sandstone	Beech Spring; domestic supply, also bottled and sold locally. (See analysis, p. 72.)
59	Slope	120	49	2	do	Whitmore Spring; in small marshy area; domestic supply.
66	do	180			Gneiss	Domestic supply.
69	do	250			Sandstone	Unused.
71	Swale	170	51	2	do	75 feet west of brook; roadside drinking spring.
75	Slope	140			do	Domestic supply.
87	Base of low ridge.	140		16½	do	Oak Spring; bottled and sold locally. (See analysis, p. 72.)
93	Slope	160		½	do	Hubbard Spring; domestic supply and roadside watering trough; flow noticeably less in summer.
94	do	220			do	Domestic supply.
103	Base of slope	150	50	3	do	Mountainview Spring; unused; formerly bottled and sold locally.
110	Slope	160	48	½	Gneiss	Unused.

a Slight.

ANALYSES OF GROUND WATER.

In the following table are given three analyses of water derived from drilled wells and three of water derived from springs in Middletown. The analyses are discussed on pages 19–21.

Chemical composition and classification of water from wells and springs in Middletown.

[Parts per million. Samples collected May, 1915; S. C. Dinsmore, analyst.]

	Wells.			Springs.		
	11 [a]	16	104	27	37	87
Silica (SiO_2)	15	16	20	16	19	15
Iron (Fe)	Trace.	Trace.	Trace.	Trace.	Trace.	.20
Calcium (Ca)	28	33	41	22	21	23
Magnesium (Mg)	14	19	19	7.2	5.6	4.1
Sodium and potassium (Na+K) [b]	.6	.7	8.5	.0	.0	.0
Carbonate radicle (CO_3)	.0	.0	.0	.0	.0	.0
Bicarbonate radicle (HCO_3)	117	148	219	70	65	46
Sulphate radicle (SO_4)	11	10	9.0	8.6	Trace.	16
Chloride radicle (Cl)	7.0	11	7.0	3.0	6.0	4.0
Nitrate radicle (NO_3)	14	18	.0	.0	14	8.0
Total dissolved solids at 180° C.	159	187	213	96	102	99
Total hardness as $CaCO_3$ [b]	127	160	180	84	75	74
Probable scale-forming ingredients [b]	120	140	170	93	90	90
Probability of corrosion [b, c]	(?)	(?)	N	(?)	(?)	(?)
Quality for boiler use	Fair.	Fair.	Fair.	Good.	Good.	Good.
Chemical character	Ca-CO_3	Ca-CO_3	Ca-CO_3	Ca-CO_3	Ca-CO_3	Ca-CO_3

[a] Numbers at heads of columns correspond to those on map (Pl. II, in pocket) and in table (p. 71).
[b] Computed.
[c] N=noncorrosive; (?)=corrosion doubtful.

ROCKY HILL.

HISTORICAL SKETCH.

The town of Rocky Hill forms the northeast corner of the area discussed in this paper. It embraces the land that lies between Connecticut River on the east and Mattabesset River on the west, and between the towns of Newington and Wethersfield on the north and of Cromwell on the south.

The name Rocky Hill first appears in the records of Wethersfield in 1649, and a grant of land at Rocky Hill was made to Samuel Boardman in the same year. Historical records indicate that a small community existed at Rocky Hill in 1680, the immigrants being the sons of settlers in Wethersfield who started a new community at the convenient landing place 4 miles farther south, on the west bank of the Connecticut, where the river swings over to the base of the rocky hill from which the town is named. It is probable that not more than half a dozen families constituted the first settlement, and it was not until 1720 that it was organized as a parish of the town of Wethersfield. The name "Stepney Parish" was adopted in 1723, but the local name of Rocky Hill clung to the community, and this name was formally adopted in 1826.[1] The present town was incorporated from Wethersfield in 1843. The original settlement has remained the principal village, but the population has also spread along the main highway extending to the north and to

[1] The hill has been locally known as Shipmans Hill, from the tavern of Samuel Shipman, early built at its western base.

the south, and a number of farmhouses also dot the western portion of the town.

The area of the town, taking its eastern boundary as the center of Connecticut River, is about 9,100 acres, according to planimeter measurement on the Middletown topographic map.[1] About 240 acres of this total is covered by the river surface, however. There are only three or four small ponds in the town, and their combined area is only 10 or 15 acres, but four areas of marsh in the northern part, near the headwaters of small brooks, cover a total of about 120 acres. About 23 per cent of the town, or 2,100 acres, is wooded. (See Pl. IV, in pocket.) The woods occupy lands that are chiefly in the southern and eastern portions of the town. These wood lots have been repeatedly cut over, so that very few large trees are left.

POPULATION AND INDUSTRIES.

Shipbuilding and maritime commerce, to which the parish had access through Connecticut River, early became the principal industries. In 1779, during the industrial depression caused by the Revolution, the parish had a population[2] of 881, and during the succeeding 30 or 40 years it developed, chiefly as a shipbuilding center, until it probably had greater industrial importance than it has at present. About 1820 shipbuilding at Rocky Hill began to decline, owing to its more favorable development at other river points, and since that time the population of the town has not changed much. The normal increase due to excess of births over deaths has been about balanced by the excess of those who have moved away over the number of newcomers. The maximum population was reached in 1872–1874, immediately after the construction of the New York, New Haven & Hartford Railroad through the town. This development led to an increase of perhaps 150 in the number of inhabitants, but within a few years this temporary gain was lost. Although the population has remained nearly stationary, its character has changed considerably in the last half century, owing to the emigration of the descendants of the English settlers and the incoming of an increasingly large proportion of Irish. Figure 10 shows the population of the town for the periods for which the figures are available.

Transportation by water on Connecticut River and by rail over the Valley division of the New York, New Haven & Hartford Railroad, which traverses the western border of the river valley, afford easy outlet for produce. A trolley line also gives frequent service between Rocky Hill village and other settlements to the north and to the

[1] The area is given as 9,111 acres on p. 444 of the Connecticut State Register and Manual, 1915.

[2] Stiles, H. R., History of ancient Wethersfield, Conn., p. 952, New York, 1904.

south. The main highway, paralleling the trolley line, is metaled and also affords easy transportation to and from the principally settled portions of the town.

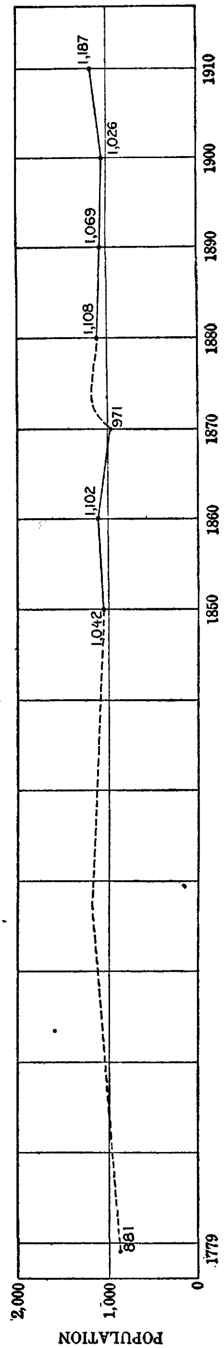

FIGURE 10.—Curve of population of the town of Rocky Hill, Conn.

Since the decline of shipbuilding the chief manufacturing industries in the town have been the making of machinery and of iron castings and forgings. Agriculture and dairying probably are the chief industrial pursuits in the town, however. The northeastern part, between Goff Brook and Connecticut River, is meadow land that is too moist for the successful raising of crops other than the native grasses, but the greater part of the remainder of the town is tilled. Corn and hay are staple crops, though a considerable acreage in the southern portion is devoted to tobacco growing.

GEOLOGY.

Both of the great faults that traverse the region in a southwesterly direction cross the town of Rocky Hill. The eastern fault crosses only the southeast corner of the town, but the western fault extends through its central portion. Several minor faults also displace the rock beds, and the structure within the town is complex. From the northwest portion of the town the successive Triassic rock beds, from the "Main" trap sheet upward to the upper sandstone, inclusive, form the surficial rock eastward through the northern portion of the town. Southeastward, however, the series of beds is traversed before the western of the two major fault zones is reached, and east of this zone the beds above the "Main" trap sheet are repeated. (See Pl. III.)

The most remarkable feature of the bedrock structure is the manner in which the rocks have apparently been rotated by horizontal movement along the major faults, so that in the block between these two great zones of displacement the exposed belts of "Posterior" trap are swung far from the normal north and south trend. The surficial distribution of the several members of the Triassic system that has resulted from the faulting is shown on Plate III (in pocket), and the method by which the faulting has accomplished this distribution is in part indicated by structure section A–B, on the same plate.

The lower lands in the town are covered by stratified glacial drift. Near Mattabesset River, in the southwest corner of the town, and along the branches of Goff Brook, in its northern portion, the stratified deposits are not very prominent, but in the south and southeast they form a sand plain that has an elevation of about 180 feet above sea level. The method of formation of this plain is not clearly understood, but it was probably produced by water from the glacial ice front at a period when the main front of the ice sheet was just north of it and the drainage southward was partly obstructed by glacial débris and remnants of the ice sheet in the lower valley of the Mattabesset and of the Connecticut at Middletown.[1]

The central and western portions of the town are covered by unstratified glacial deposits or till. On the higher hills this material appears to be thick, and some of the hilltops probably are drumlins, but over much of the surface the till is very thin, and the underlying rock is exposed in many road cuts and small cliffs, as is indicated on Plate II.

SURFACE FEATURES.

The most prominent natural feature in the town is the ridge that extends northwestward from the village of Rocky Hill nearly to the town line. It is formed by the "Posterior" or upper trap sheet, which also forms the bedrock immediately below the glacial deposits in other portions of the town. (See Pl. III, in pocket.) Eastward from this rocky ridge a wide, flat meadow only slightly above sea level, extends to Connecticut River. South and west from the ridge the surface is rolling or hilly. In the north-central part of the town the general rolling surface is modified by small marshy areas, and in the south-central portion a sand plain, which continues southward into Cromwell, forms a considerable area of level land.

Although the ridge known as Shipman Hill, near Rocky Hill village, is the most prominent surface feature in the town, it is not the highest, for the slopes on the northwest border reach an elevation of about 310 feet, or fully 100 feet higher than the ridge. Most of the hilltops throughout the rest of the town also attain elevations between 200 and 300 feet. The relief of all these other hills is considerably less, however, as Shipman Hill rises practically from sea level to a height of 200 feet. The lowest portion of the town is of course along Connecticut River, where the influence of the tide is felt.

[1] Loughlin, G. F., The clays and clay industries of Connecticut: Connecticut Geol. and Nat. Hist. Survey Bull. 4, p. 24, 1905.

STREAMS.

The western portion of Rocky Hill, comprising about 2,775 acres, or 30.5 per cent of the total area, drains southwestward to Mattabesset River through three or four small brooks that rise in the town. The largest of these brooks has its course entirely within Rocky Hill and joins the Mattabesset three-eighths of a mile above the southwest corner of the town. Its basin has an area of about 1,250 acres and its normal discharge is perhaps half a second-foot. In the last half mile of its course the stream flows through lowlands and in no portion of its course does it offer possibilities of development of power. The greater part of the remainder of the town is drained by several branches of Goff Brook, which first flows northward across the town line and then returns, flowing southeastward along the eastern base of Shipman Hill to the Connecticut. Throughout most of its course it is a sluggish stream, and it is affected by the tide for its last mile or more. The meadow area that forms the northeast part of the town has no well-defined drainage channels other than Goff Brook, and the precipitation on this land finds its way to the Connecticut, either directly or by way of the brook, chiefly through seepage. The southeastern part of the town is drained by two streams. Hog Brook flows northeastward and enters the Connecticut on the southern border of Rocky Hill village. Although this brook usually flows throughout the year, in May, 1915, it was a stream only a foot wide and an inch deep, in its lower course. Dividend Brook drains the area farther south. It rises in the south-central part of the town at the northwest border of the sand plain, and after flowing east for 1¼ miles it turns southward and continues in this direction across the town line before swinging sharply northeast back into Rocky Hill. From the town line it continues northeastward to the lowland along the Connecticut. About three-eighths of a mile above its mouth Dividend Brook falls over a small ledge. A gristmill was built at this site in 1669, and the small available water power has nearly ever since been used by mill or factory.

WATER SUPPLIES.

Water in glacial deposits.—The domestic water supply throughout the town is obtained from individual wells and from a few springs. Stratified drift covers the extensive meadow in the northeast corner of Rocky Hill, the sand plain in the southern portion, and the lower lands along its eastern, northern, and western borders. The northeastern area is too wet for habitation or cultivation, as water stands nearly at the surface over the greater part of it. This land could be improved by drainage, and it could doubtless furnish large amounts of shallow ground water, but the water from this saturated land may be of unsuitable quality for many purposes. The depths to water in four wells (Nos. 40, 41, 42, and 43) in the sand plain in the southern part of the town indicate that the ground-water level deepens eastward, toward the main channel of Dividend Brook, in the same way that in the southward continuation of the plain in Cromwell the underground drainage is toward the main surface stream. In the other drift-covered portions of Rocky Hill few records of dug wells were obtained, but the shallower water levels seem in general to be found on the lower slopes. The average depth to water in the 10 drift wells measured in May, 1915, was 13 feet (see fig. 3, p. 16), or slightly less than the average depth to water in all drift wells observed in the six towns that were studied.

In the till-covered portions of Rocky Hill the depth to water was measured in 22 dug wells that obtain water from this material. Dug well 28 has been omitted because it probably obtains water from trap rock. The depth in May, 1915, ranged from 7 to 21 feet, both the maximum and minimum depths to water being approximated in individual wells on hilltops, on slopes, and in lowlands. The average depth to water in the 22 wells was 13.7 feet, as compared with 13 feet in the measured wells of the town that end in drift.

Water in sandstone and trap.—Many of the dug wells, especially those sunk in till, go dry in summer. Within recent years, therefore, deeper wells have been put down by drilling machines at a number of places. These drilled wells yield unfailing supplies of water, though the capacity of some of them is very small. Two of the 11 drilled wells that were observed yield small artesian flows. One of these (No. 5) is only 55 feet deep, and only the lower 9 feet is in sandstone, from which rock a flow of half a gallon a minute is obtained. The artesian pressure is very probably due to the chance intersection of a favorable arrangement of fissures in the rock and not to an extensive artesian condition; for in well 4, only 200 or 300 yards to the north, little or no artesian pressure was encountered. Well 23, drilled to a depth of 65 feet in the trap at the southern end of Shipman Hill, has an artesian flow about equal to that of well 5. The artesian pressure in well 23 is apparently furnished by water in fissures in the trap that compose the hill, and the well is doubtless supplied by water that reaches it along the system of fissures and crevices in the trap. The following analysis of water from this well shows that it is noticeably more highly mineralized than the usual shallow-well waters of the region. Calcium, magnesium, and bicarbonate predominate, but the chloride and nitrate constituents are also higher than the average and indicate the possibility of contamination.

Chemical composition and classification of water from drilled well 23 at Rocky Hill.

[Sample collected May, 1915; S. C. Dinsmore, analyst.]

	Parts per million.
Silica (SiO_2)	23
Iron (Fe)	Trace.
Calcium (Ca)	58
Magnesium (Mg)	32
Sodium and potassium (Na+K)[1]	7.0
Carbonate radicle (CO_3)	.0
Bicarbonate radicle (HCO_3)	251
Sulphate radicle (SO_4)	8.6
Chloride radicle (Cl)	36
Nitrate radicle (NO_3)	32
Total dissolved solids determined at 180° C	367
Total hardness as $CaCO_3$[1]	276
Probable scale-forming ingredients[1]	250
Probability of corrosion[1,2]	(?)
Quality for boiler use	Poor.
Chemical character	Ca–CO_3

Another well (No. 12), drilled at the base of Shipman Hill, penetrated the trap sheet and draws part of its water from the underlying sandstone. This well, by means of an electrically operated pump and a small storage tank on the hillside, supplies water to six families near by.

Springs.—Two springs (Nos. 26 and 44) were noticed in Rocky Hill that are used for domestic supply. Each issues near a stream channel from the mantle of stratified drift overlying the sandstone, and though their yields are small they are said to be perennial. No other springs were seen in the town, but similar ones probably issue near the courses of other brooks.

RECORDS OF WELLS AND SPRINGS.

Data concerning a number of wells and springs in the town of Rocky Hill are given in the following table. The locations of these sources of water are indicated on Plate II. The wells listed are believed to be typical of those in the several portions of the town.

[1] Computed. [2] (?)=corrosion doubtful.

Dug wells in Rocky Hill.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Methods of lift.	Remarks.
		Feet.	*Feet.*	*Feet.*		
1	Knoll	220	22	18	Rope and bucket	Dry in summer.
2	Swale	210	15	8	Bucket	Dry in dry summers; 150 feet from and 6 feet above small pond.
6	Slope	130	14	11	Windlass	
8	do	110	18	15	do	Dry in summer; sandstone penetrated.
10	Base of hill	110	18	12	do	
11	do	110	17	12		Unused.
13	Slope	170	28	20	Windlass	
14	do	200	22	18	do	Dry in summer.
15	do	210	23	16	Chain pump	Sandstone penetrated.
17	Base of hill	200	23	19	Windlass	Dry in summer.
18	Slope	220	28	21	Wheel and bucket.	
19	do	210	23	15	Windlass	180 feet northeast of well No. 18 and 6 feet lower.
20	do	180	16	11	do	Dry in summer.
21	Knoll	165	18	15	do	
22	Slope	120	11	7	Chain pump	
24	Ridge	150	26	15	Windlass	
25	Slope	110	12	5	do	Dry in summer; better water obtained from spring No. 26, 200 feet northwest.
27	do	170	18	13	Chain pump	Dry in summer.
28	do	175	11	7	do	In trap; barnyard supply; 200 feet from No. 29.
29	do	170	14	9	Windlass	Low in summer; used mainly as a milk cooler.
30	do	190	27	7	Chain pump	Sandstone penetrated.
32	Base of hill	190	18	12	Windlass	Never dry. Trap quarry 400 feet south; also on east side of road.
33	Saddle	250	27	7	do	Dry only once in 53 years.
34	Swale	160	11	8	Chain pump	Dry in summer.
35	Slope	150	17	11	Windlass	
36	do	170	22	20	Chain pump	Never dry.
38	do	50	19	18	Hand pump	Gets low but never dry.
40	Flat	170	16	13	Windlass	
41	Swale	150	14	12	Chain pump	Never dry; 175 feet from and 13 feet above brook.
42	Flat	170	40	14	Hand pump	Formerly dry in summer; drive point in bottom of well gives good supply.
43	do	165	30	20	Windlass	Dry in summer.
45	Slope	180	18	15	do	Never dry; also supplies neighbors.
46	do	170	25	15	Wheel and bucket.	

Drilled wells in Rocky Hill.

Map No.	Topographic position.	Elevation above sea level.	Total depth.	Depth to water May, 1915.	Depth to rock.	Kind of rock.	Yield.	Remarks.
		Feet.	*Feet.*	*Feet.*	*Feet.*		*Gallons per minute.*	
3	Slope	200	97	16		Sandstone		Dug 20, drilled 77.
4	Low ridge	80	41	20	40	do		Ample domestic supply.
5	do	75	55	0	46	do	½	Flows.
7	Slope	130	120	30				
9	do	110	100	30	16	Sandstone	25	Supplies 180 cows, 16 horses, and several families.
12	Base of hill	110	98	15		Through trap into sandstone.	7	Supplies 6 families; electrically operated pump.
16	Slope	210	40	11		Sandstone		Dug 17, drilled 23; good supply.
23	Base of hill	30	65	0		Trap	½	Flows; domestic supply and horse trough. Frank Holmes, owner. (See analysis, p. 78.)
31	Slope	190	150	15		Sandstone		Windmill.
37	do	180	125	20		do	1½	
39	Swale	110	75	45		do		Small supply.

Springs in Rocky Hill.

Map No.	Topographic position.	Elevation above sea level.	Temperature.	Yield.	Bedrock.	Remarks
		Feet.	° *F.*	*Gallons per minute.*		
26	Slope	120	....	½	Sandstone	Domestic supply.
44	Swale	140	52	1	....do	Do.

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