GROUND WATER NEAR BUXTON, TRAILL CO., NORTH DAKOTA

BY

P. E. Dennis

North Dakota Ground-Water Studies No. 5

January, 1948

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Prepared in cooperation between the Geological Survey, U. S. Department of the Interior; the North Dakota State Water Conservation Commission; and the North Dakota State Geological Survey

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ABSTRACT

Ground waters in the Buxton area include artesian waters from wells 160 to 450 feet deep and shallow waters from wells 7 to 120 feet deep. The artesian wells commonly yield only 2 or 3 gallons a minute of water which is too highly mineralized to be satisfactory for domestic uses. The shallow waters are largely confined to ridges of fine sand and gravel which lie upon the clay beds of glacial Lake Agassiz. Existing wells and four test holes indicate that the sand and gravel does not extend more than 3 feet below the water table in the ridge east of Buxton and in the first ridge west of town. The second ridge west of town furnishes water for farm wells from gravel at depths of 18 to 115 feet. Two of three test holes encountered the deeper gravels underlying this ridge. The water-bearing beds underlying this second ridge appear to be a part of one or more glacio-fluvial bodies which underlie the lake deposits from the region east of Hatton to Hillsboro. They offer promise of containing important water supplies for farms and municipalities and possibly for irrigation and industry. So far as known, their closest point of approach to Buxton lies about 3 miles southwest of the southwestern corner of the town in the SE¼ of sec. 4, T. 147 N., R. 51 W. They have been penetrated by wells also about 4½ miles west of town. Test wells on which pumping tests can be made would be desirable in one or more of these areas.

INTRODUCTION

Scope and purpose of investigation

This memorandum is a progress report on the general study of the geology and ground-water resources of Traill County being made by the U. S. Geological Survey in cooperation with the State Water Conservation Commission and the State Geological Survey. These general studies are being made to determine the occurrence, movement, discharge, and recharge of the ground water and the quantity and quality of such water available for all purposes including municipal, domestic, irrigation, industrial, and other uses. However, the most critical need at the present time is for adequate and perennial water supplies for numerous towns and small cities throughout the State which are attempting to construct municipal water-supply systems for the first time. For this reason, the County studies are being started in the vicinity of those towns which have requested the help of the State Water Conservation Commission and the State Geologist. Progress reports are being released as soon as possible in order that the preliminary data may be available for use in connection with the solution of water-supply problems in the towns shortly after they are obtained and before the general studies and conclusions can be completed. The study described in this report was confined chiefly to obtaining information on ground water in that part of Traill County which might be of interest to the village of Buxton in its search for sources of municipal water supply.

Location and general features of the area

Buxton is located on the Great Northern Railway, 1 mile west of U. S. Highway 81 and about 23 miles south of Grand Forks, North Dakota. It has a population of 404 (1940 census) and serves as a shipping point and trading center for the Red River Valley farming area which surrounds it.

The Red River Valley, in which Buxton is situated, is the lake plain of glacial Lake Agassiz. It has a width at the latitude of Buxton of about 55 miles. The Red River flows northward along the axis of the valley with a gradient of 1 to 3 feet per mile, and the valley floor has similar gentle gradients toward the river from either side. In the vicinity of Buxton the gradient is about 2 feet per mile eastward. The river and its scattered, and for the most part intermittent, tributaries have entrenched their courses 15 to 40 feet below the plain but have accomplished very little additional erosion of its surface. Three of those intermittent streams cross the area shown on the map (fig. 1). A tributary of the Goose River flows southward, Buffalo Coulee flows north-eastward, and an unnamed coulee flows southeastward within the area of the map. They carry water for only a few days of each year following heavy rains or the melting of snow.

The nearly flat surface of the area is relieved only by a series of northwesterly trending ridges which rise 8 to 20 feet above the general surface of the plain. They are beach ridges formed in Lake Agassiz and represent, at least in part, the successive shorelines of the Lake as it receded northward. Three series of those ridges cross the Buxton area. They are described more fully in a subsequent section of this report.

Previous investigations and acknowledgments

The only comprehensive report on the geology of the Buxton area is contained in Upham's monograph on Lake Agassiz. 1/ Subsequent studies of local areas and features of the lake have not included the Buxton area. A general discussion of the ground water in Traill County with specific date on a few wells in and near Buxton is contained in Simpson's paper on the ground-water resources of North Dakota. 2/ Analyses of waters from two wells at Buxton are given in the paper by Abbott and Voodisch. 3/ The work of Loverett on Lake Agassiz 4/ did not reach as far north as the Buxton area.

The present study was facilitated by the ready cooperation of towns-people, farmers, and local well drillers. Thanks are due especially to Leo Beidonback and Roy Lockon, who furnished records of the depths and other features of numerous wells in the area.

1/ Upham, Warren, the glacial Lake Agassiz; U. S. Geol. Survey Mon. 25, 1896.
2/ Simpson, H. E., Geology and ground-water resources of North Dakota: U. S. Geol. Survey Water-Supply Paper 598, pp. 240-243, 1929.
3/ Abbott, G. A., and Voodisch, F. W., The municipal ground-water supplies of North Dakota: North Dakota Geol. Survey Bull. 11, p. 80, 1938.
4/ Leverett, Frank, Quatornary geology of Minnesota and parts of adjacent states: U. S. Geol. Survey Prof. Paper 161, 1932.

Present water supply and future needs

An artesian well, reported to have been drilled in 1914, is still being used in Buxton. The water is rather salty (see analysis, p. 23) and has been used principally for stock. Recently the water has been pumped into the local hotel where it is used for purposes other than drinking and cullinary. Another artesian well yielding water of similar quality is just outside the village limits east of the railroad. It is owned by LeRoy Kobbervig and is used for stock. At least one and perhaps two other artesian wells are reported to have been drilled in town but have long since been filled and abandoned.

A shallow well was dug by the town of Buxton in the beach ridge about 1 mile west of town in June 1921. Water from this well, and from its replacement, which was dug by a Works Projects Administration crew in 1936, has been the principal source of supply for most of the village although some water is hauled from Grand Forks.

The artesian well water and the water hauled from the W. P. A. well and from Grand Forks, is supplemented in many homes by rain water which is caught from the roofs of buildings and run into cisterns.

The estimated minimum requirement for a municipal waterworks supply at Buxton is said to be 20,000 gallons a day. To permit the watering of lawns and shrubs, and to provide for some growth may require double that supply. Many towns and cities with municipal water systems use from 50 to 200 gallons per day per person. This would require from 20,000 to 80,000 gallons per day for Buxton.

GEOLOGY AND HYDROLOGY

General

Essentially all ground water is derived from precipitation. The water may enter the ground by direct penetration from rainfall or from melting snow, and by percolation from streams which cross the area. A part of the ground water in some areas comes from adjacent regions, entering the ground at higher elevations and moving slowly to lower elevations through the more permeable beds. The unconsolidated rocks such as clay, sand, and gravel are generally more porous than consolidated rocks such as sandstones, limestones, etc., although in some areas the consolidated rocks are highly porous. The amount of water that a rock can hold is measured by its porosity. If the pore spaces are large and interconnected, as they commonly are in sand and gravel, the water is transmitted more or less freely and the rock is said to be permeable, but where the pore spaces are very small, as they are in clay, the water is transmitted very slowly or not at all and the rock is said to be impermeable. Below a relatively shallow depth in practically all regions the pore spaces in the rocks are filled with water and the rocks are said to be saturated. This is true of the clay as well as the sand and gravel, but because of the difference in permeability it is possible to obtain wells only in the coarser materials. Where some part of the water-transmitting bed (aquifer) is exposed at the surface or comes in contact with another aquifer which is so exposed the water discharged naturally or through wells has an opportunity to be replenished each year in this "recharge area." Where the aquifer is more or less completely surrounded by clay, natural recharge may be very slow and the water taken by wells from storage in the aquifer is not fully replenished each year. The initial yield of wells in aquifers cut off from natural recharge may be as large as that from wells in aquifers having good recharge areas, giving an erroneous impression that an abundant perennial supply is available.

As ground water moves through an aquifer it dissolves a part of the more soluble mineral constituents of the rock particles. The amount of mineral matter dissolved in a ground water is determined by the amount of the soluble materials present and the length of time the water is in contact with them. Therefore the waters which have been underground longest and have traveled the greatest distance are commonly more highly mineralized than those which are relatively near the recharge area.

Water-bearing formations

The geological formations in the Buxton area are, in order from the surface down: (1) Deposits of glacial Lake Agassiz, (2) Glacial drift, (3) Cretaceous shales, (4) the Dakota sandstone also of cretaceous age, and (5) Pre-cambrian granite and other crystalline rocks. The lake deposits consist of clay and silt except for the fine sand and sand and gravel which compose most of the beach ridges. The beach ridges contain the only water-bearing beds of importance in the lake deposits of the Buxton area. The glacial drift consists largely of boulder clay but contains interbedded glacio-fluviatile deposits of sand and gravel. Most of the artesian wells of the Buxton area probably obtain water from glacio-fluviatile beds in or at the base of the drift. None of the test holes were drilled through the glacial drift in the Buxton area and it is not possible to tell from the information available whether the Cretaceous shales are present below the drift in this area. However, it is possible that some of the artesian wells derive their water from sand beds intercalated with the Cretaceous shales. Several of the deeper artesian walls west of the Buxton area probably derive their water from the Dakota sandstone and much of the water in the shallower artesian beds is probably derived indirectly from that formation. The granite and other crystalline rocks are not water-bearing.

Information as to the amount and character of water contained in the various water-bearing beds was obtained largely from a study of existing wells and by drilling test holes.

The artesian wells

In the Buxton area there are commonly from one to five farms in each section. Each farm has at least one well and four or five have been drilled on some farms. Therefore, the general ground-water conditions of the area have been studied largely by means of these farm wells. Most of the wells encountered only clay, or clay with occasional boulders, to a depth of about 160 feet. From a depth of about 160 feet to 450 feet, thin sand beds are encountered in the clay and yield varying amounts of rather saline water.

The depth at which the first sand bed will be encountered differs from place to place but whatever its depth the well is ordinarily "made" in the "first sand". Occasionally the yield of the "first sand" is so small that the well is drilled deeper to a "second flow." Drillers report that a few wells have been drilled into the granite without encountering sufficient water for a farm well but, so far as could be learned, none of these "dry holes" has been drilled in the vicinity of Buxton or within the area shown on the map (fig. 1). The depths of all wells in the area were determined as nearly as possible from records kept by local drillers. Most of the wells have 2 or 3 inch casing and the pump cylinders are placed directly in the casing so that measurements of water level or depth of the wells are impossible except at such times as the pump cylinder is removed.

The great range in the depth at which water-bearing beds will be encountered is evident when the reported depths of the wells are plotted on a map (fig. 1). Because the land surface is very flat, the same feature can be demonstrated graphically by plotting the number of wells against their depth (fig. 2A). If the reported depths of the wells are reliable, they give evidence of a lack of continuity of the water-bearing beds which is suggestive of glacio-fluviatile deposits rather than of sand beds in the marine Cretaceous shales.

As contrasted to their variability in depth, the water levels in the artesian wells are about the same. A few of the wells on the lowest ground flow, and the depth to water in the others ranges from 1 or 2 feet to 12 or 15 feet. These differences are no greater than the differences in elevation of the land surface at the wells. None of the wells within the area studied has the high pressure commonly associated with wells in the Dakota sandstone. Because of the extreme difficulty of measuring water level in most of the wells, no attempt was made to prepare a contour map of the water surface. Seasonal variations in water levels are reported to occur in most of the wells, and in a few which flow into open tanks a high water mark was clearly defined a few feet above the summer water level. Highest water levels were generally reported to occur in the late winter or early spring. It is quite generally agreed that high water levels are slowly attained during periods when the wells are not being pumped. The high levels attained in the spring of the year quite possibly result from this slow recovery of water levels after heavy summer usage, as the winter season is commonly the time of smallest withdrawals from the wells. Most wells are reported to have had a somewhat higher head when drilled. For example, the Sidney Lohman well, half a mile east of Buxton, is reported to have flowed when drilled and the high water mark is now 3 feet below the surface. In October 1946 the water level stood 6.7 feet below the surface. Local well drillers state that water levels in all artesian wells in the area have slowly declined over a period of 20 years or more. However, there has been no appreciable decline in the Buxton town well since 1921. The water is reported to have stood 4 feet below the surface at that time, and in October 1946 it was 3.3 feet below the surface.

Most of the artesian wells have yields ranging from less than 1 to about 3 gallons a minute but a few have yields ranging from 3 to 12 gallons a minute. The largest discharge measured was 12 gallons a minute from the Jennie Soderberg well, located about 2 miles southwest of Buxton. It is reported that the well has been pumped at this rate for periods as long as 24 hours. If a well will yield 3 or 4 gallons a minute for several hours without "pumping dry" it is considered a "strong well."

The shallow wells

The near-surface material in most of the Buxton area is clay which transmits water so slowly that shallow wells cannot be obtained. Sand or sand and gravel deposits lie at and near the surface chiefly in or near the beach ridges. For this reason, the shallow wells are concentrated along the lines of the beach ridges (fig. 1). Most farms obtain water from the shallow wells where it is available because the water is generally less mineralized than that from the artesian wells (see analysis, p. 23). However, many of the shallow wells reportedly fail to yield water during dry years and it is then necessary to drill down to an artesian aquifer. Many of the farms on the ridges have shallow dug wells for domestic uses and a drilled artesian well for stock watering and for general use when the supply from the shallow wells fails.

There are three principal lines of beach ridges in the Buxton area and all have a general northwest-southeast trend (fig. 1). They are associated with the shore lines named by Upham[5] the Hillsboro beach, Lower Blanchard beach, and Upper Blanchard beach. The positions of the beaches as shown on the small-scale map of Upham are reproduced on fig. 1, together with the locations of the principal sand and sand and gravel ridges in the vicinity of Buxton as determined in the field with the aid of aerial photographs. The exact origin of the ridges and their relationship to the shore lines of the lake are not known. The most important phase of this question, as related to the ground-water supplies, concerns the origin of the sand and gravel which composes the ridges. In any attempt to determine the probable thickness and extent of the water-bearing beds it is important to know if the sand and gravel of the beach ridges was derived locally or was brought into the area by streams or longshore currents. Unfortunately, the scope of this study did not permit a complete solution of this problem. As far as could be determined from field examination, Upham's map, and aerial photographs, no large streams exptied into the lake

5/ Op. cit., pl. XXIX

in the Buxton area. It was found that the materials of the ridges differ considerably from place to place. For example, the Hillsboro beach ridges, east and north of Buxton, are composed of silt and sand with little or no gravel. Dug wells reach the base of the sand at depths of 6 to 15 feet, which is about the height of the ridges above the plain. It appears that such ridge materials might have been derived locally by wave work on the boulder clay. Two of the ridges associated with the Lower Blanchard beach are also composed of fine-grained material which extends to only a very shallow depth. However, the third ridge, which is nearest to Buxton, is made up chiefly of sand and gravel. Two ridges about 5 miles west of Buxton, possibly associated with the Upper Blanchard beach of Upham, are composed of sand and gravel. The differences in the materials of the ridges, the absence of any known source from streams or longshore currents, and the presence of what appear to be glacio-fluvial gravels beneath one of the ridges have led to the tentative conclusion that the materials of the beach ridges in the vicinity of Buxton were derived by wave action upon the local drift materials. Where sand and gravel deposits in the form of eskers, kame terraces, and other glacio-fluvial deposits were present, relatively massive ridges of sand and gravel were built up in the waters of the lake. Where such materials were scarce or absent, the waves probably piled up only low ridges of fine-grained material or built no beach ridges at all.

The general experience of those who have dug and drilled farm wells in the beach ridges indicates that the sand or sand and gravel of which they are composed is merely a shallow pile upon the land clay, and test holes 1 to 4 (fig. 2B) drilled in the first ridge west of Buxton support this concept of the general character of the ridges. However, if the supposition is correct that the gravels are locally derived from earlier glacio-fluvial deposits it seems probable that some of these earlier deposits may have been sufficiently thick that only their upper parts were re-worked by the waves of the lake and glacio-fluvial gravels might be encountered beneath some portions of beach ridges which are composed chiefly of gravel. That some wells in the area had encountered such gravel beds was suggested by the reported depths of 30 to 120 feet for a number of wells extending in a rather narrow belt across the area from a point about 5 miles west of Buxton southeasterly to the region of Hillsboro (fig. 1). Among these wells are those of Ernest James in sec. 3, T. 148 N., R. 51 W.; of Eddie Oslund and Gertie Leo in sec. 4, T. 147 N., R. 51 W.; and of Enoch Olson and Mr. Sundeen in sec. 9 and of Mr. Eliason in sec. 15 of the last-named township. This group of wells is similar in that they are all reported as "strong wells" which do not go dry in drought years, as bottomed in gravel, and as yielding excellent drinking water. Other shallow wells of similar character are reported to occur southeast of this area as far as the vicinity of Hillsboro, where the town well is reported to have completely penetrated the sand at a depth of 94 feet. One well serves the town and is reported to pump at an average rate of about 50 gallons a minute and at a maximum rate of 150 gallons a minute. It is by no means certain that all these wells draw from the same aquifer, but their general alignment and the absence of wells of this depth and character elsewhere in the area suggest that they may derive their water from pre-lake glacio-fluvial deposits which have a southeasterly trend.

Water levels in the shallow wells are reported to rise rapidly after heavy rains and with the melting of snow in the spring. During long dry seasons and dry years, the water levels decline in all wells and the shallowest wells go dry. Only where the sand or sand and gravel extends well below the general surface of the plain are the wells a safe source of a perennial supply. The water level in the old Buxton town well was reported to be 8 feet below the surface in 1921. It was 9.24 feet below the surface on October 2, 1946, but in 1936 the level must have dropped to about 16 feet below the surface, for the well is reported to have gone dry.

Test Holes

The test holes drilled in the Buxton area were located on the beach ridges because shallow deposits of productive sand and gravel seemed to be largely confined to the ridges and the waters from the artesian wells are generally unsatisfactory for municipal supply. Holes 1 and 2 were drilled in the ridge located about 3/4 mile west of Buxton. The first well was located in the borrow pit about 80 feet southeast of the town well, the second about 600 feet west of the first in the borrow pit northwest of the road intersection. The first well encountered 11 feet of gravel and then entered lake clay to a depth of 29 feet; the second encountered sand and gravel to 10 feet and then entered lake clay to a depth of 17 feet. Accurate water levels in the test holes could not always be obtained without casing them and flushing out the drilling mud. However, by measuring the depth to water in the town well and leveling across to the test holes, it was found that only about 3 feet of the sand and gravel in the test holes was saturated (fig. 2B A-A').

Holes 3 and 4 were drilled on the same ridge $\frac{1}{2}$ mile south of the first two. Hole 3 was started in a gravel pit where it had been dug down to the water table. It penetrated 7 feet of sand and then went into lake clays to a depth of 14 feet. Hole 4 was drilled about 750 feet west of no. 3 and encountered 16 feet of sand and gravel and then entered lake clay to a depth of 35 feet (fig. 2B B-B').

Holes 5 and 6 were drilled in the vicinity of the State and County owned gravel pits about 3 miles southwest of Buxton. Hole 5 was drilled in the bottom of the County gravel pit about 100 feet west of the property-line fence and about 300 feet south of the quarter-section line fence. It penetrated 12 feet of sand and gravel, 8 feet of lake clay, 24 feet of sand and gravel, and 1 foot of heavy lake clay or till. The lower gravel was not so well assorted and was more angular than the surface gravel. Hole 6 was drilled about 750 feet west of hole 5 and encountered 20 feet of sand and gravel and then entered lake clay to a depth of 39 feet (fig. 3 C-C').

Test hole 7 was drilled in the bottom of the Eddie Oslund gravel pit near the southeast corner of the section. It encountered 8 feet of sand and gravel, 17 feet of clay and interbedded gravel, 9 feet of fine gravel, well-rounded and well-assorted, 18 feet of lake clay, and 1 foot of till (fig. 3, D-D').

Descriptive logs of the test holes are given on page 29.

Recharge, movement, and discharge of water in the beach ridges

Most of the recharge to the shallow ground-water reservoirs underlying the beach ridges probably comes from direct penetration of rainwater and from melting snow. The exposed surfaces of sand and gravel of these ridges afford an excellent opportunity for the penetration of the moisture which falls upon them. Some recharge is also possible from surface runoff from the land west of the ridges. The slope of the plain is to the east in this area and water following the imperfectly developed drainage lines eastward is, in many places, blocked by a ridge, the water either percolating into the ridge or standing behind it and evaporating.

The areas of the beach ridges are so small that the amount of recharge from rainfall would rarely be sufficient to assure a perennial supply of water to wells pumping more than a few gallons a minute continuously. For example, the first ridge west of Buxton has a total area of less than 1 square mile. Using a figure of 18 inches for the mean annual precipitation in the Buxton area and assuming that 20 per cent of the precipitation reaches the water table, the amount of water entering the aquifer would be less than 200 acre-feet per year. Because of the shape and slope of the ridge it is doubtful if more than 10 percent of this amount would be available to any one well, which would be insufficient to supply a well pumping continuously at the rate of 10 gallons a minute even if it were assumed that all the water would be held in storage until used by the well--a fallacious assumption as pointed out below.

The downward movement of water in the materials of the ridges is largely stopped where the lake clays are encountered. For this reason and because the gravels of the ridges permit a much greater penetration of precipitation than the adjacent clay of the plain, a water-table mound is built up beneath the ridges (figs. 2 and 3). The movement of water is down the slopes from this mound to the edges of the ridge, and the mound tends to flatten out when not being built up by new additions of water from the surface. Where the permeable materials of the ridges are underlain by gravel and sand deposits of considerable thickness and extent a ground-water reservoir of large capacity is formed. Such a reservoir or series of reservoirs probably occurs about 3 to 5 miles west of Buxton and for several miles northwestward and southeastward from that area.

The surface upon which the ridges were built has a general eastward slope and in some areas the westward side of a ridge receives recharge from surface waters that pile up against it. An important amount of recharge from this source appears to occur on the west side of the ridge which lies 3 to 5 miles west of Buxton. The principal area of natural discharge from those aquifers is along the eastern base of the ridges. Marsh areas are present along the eastern margins of all the ridges near Buxton, but those east of the ridge which lies from 3 to 5 miles west of the town are much more extensive than the others. In addition, a number of springs issue from the base of this ridge, indicating that the amount of natural discharge is greater from this ridge than from the others.

The aquifers underlying the ridge which lies 3 to 5 miles southwest and west of Buxton thus appear more likely to contain sufficient water to sustain wells of moderate capacity through periods of dry years than do those contained in other ridges in the area. This is chiefly so because of their greater horizontal extent and greater thickness and depth below the water table and consequently their greater storage capacity. They seem also to be more favorably situated to receive recharge from the temporary streams which flow generally eastward in the area. Evidence that they receive and transmit more water than the other shallow aquifers is furnished by their proportionately greater amount of natural discharge.

QUALITY OF THE GROUND WATER

The quality of the ground waters in the Buxton area with respect to their dissolved mineral content is indicated by analyses of 17 samples taken from representative wells throughout the area (see tables, pp. 23-24). In general, the deeper artesian wells show the highest concentrations of dissolved solids, dug wells the lowest concentrations, and the artesian wells of intermediate depth an intermediate concentration. Sodium chloride and sodium sulphide make up a large percentage of the mineral content in most of the artesian waters and calcium and magnesium bicarbonate are the chief constituents in most of the shallow waters. The relatively low concentration of dissolved solids in the water from the Jennie Soderberg artesian well is of interest in view of the fact that it also has the largest discharge of the wells measured. It is not known whether the large amount of mineral water in the Jens Molvig dug well is caused by contamination from artesian waters or from other sources.

Waters having more than 1,000 parts per million of total dissolved solids are not generally considered satisfactory for municipal supply or general domestic use, although waters of considerably higher concentrations are used where less highly mineralized waters are not available. The waters from the shallow wells are rather hard but most of the hardness can be removed by the common softening processes.

An analysis of the water from the artesian well in Buxton, made about 1937, is given by Abbot and Voodisch.6/ The analysis is very similar to

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6/ Op. cit., p. 80.

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analyses made by the North Dakota State Health Department in 1946, and so far as can be determined from those data it appears that there has been little change in the quality of this water over a period of years. On the other hand, there appears to have been a progressive increase in mineral content of the water from the shallow wells used for the town supply. Other shallow wells along this same ridge yield water showing considerable differences in character and concentration of dissolved solids but, in general, the northernmost wells seem to be more highly mineralized.

As shown by the analyses of water from the Eddie Oslund and Ernest James wells it appears that the shallow ground water in the ridge about 3 to 5 miles west of Buxton ranges considerably in composition. All three analyses show a somewhat higher mineralization than those from the shallow Buxton town wells but a considerably lower mineralization than most of the artesian waters. A wider sampling of waters for analysis would appear desirable in this or other areas which are considered as a source of municipal supply.

SUMMARY AND CONCLUSIONS

The round waters in the Buxton area may be divided into two principal classes, artesian waters and shallow waters. The artesian water occurs in beds of sand at depths between about 160 feet and 450 feet. Few wells drilled into these sands yield more than 2 or 3 gallons a minute. The waters generally carry a high load of dissolved mineral matter which makes them unsuitable for general domestic use.

The shallow aquifers are largely confined to the beach ridges of glacial Lake Agassiz and range from a few feet to about 90 feet in thickness, although a few are as much as 100 to 120 feet thick. Where the ridges are composed of silt and fine sand, the water-bearing materials do not extend much below the level of the clay base which composes the surrounding plain. Wells in these ridges are reported to fail during dry years. Two ridges composed of sand and gravel occur within 5 miles of Buxton. In the first of these, which is about 3/4 mile west of town, the existing wells and four test holes have not penetrated sand and gravel at depths greater than 3 feet below the water table. This does not prove that such deeper gravel is not present but the investigation disclosed no evidence of it. The second ridge, the closest point of which lies about 3 miles southwest of town, furnished farm wells in gravel at depths of from 18 to 115 feet. Two of three test holes encountered the deeper gravels underlying this ridge. Springs and marshy areas along the eastern base of the ridge indicate that it has a much greater natural discharge of ground water than any of the other ridges in the region.

Unfortunately, it was not possible during the present study to determine accurately the boundaries, depth, and characteristics of the promising aquifers which appear to be associated with this second ridge. However, the aquifers appear to be present in all or much of a relatively narrow area extending from the region east of Hatton southeastward to the vicinity of Hillsboro. These aquifers offer promise of important water supplies for farms and municipalities and possibly for irrigation and industry. In view of the general scarcity and poor quality of most of the ground water in the area it would seem desirable to make a more accurate determination of the extent and characteristics of these aquifers and to make pumping tests and other quantitative studies to determine the amount of water available from them.

Owner	Location Number	Date Collected	Source of analysis 1/	Depth of Well	Iron (Fe)	Calcium (Ca)
Jennie Soderberg	147-51-2adc	10-8-46	A	174	3.6	27
Eddie Osland	147-51-4dac	10-15-46	A	18	1.2	81
Hilma Eliason	147-51-11bab	10-8-46	A	440	4.4	140
Henry Hagelie	148-50-30abb	10-15-46	A	372	.3	63
O. J. Sorlie	148-50-30bcd	10-15-46	A	14	.9	60
Eken Bros.	148-51-21daa	10-2-46	B	293	1.0	264
Town of Buxton	148-51-25ccc1	6-24-21	C	17	Tr.	56
" " "	148-51-25ccc2	1937 (?)	D	19	.6	87
" " "	148-51-25ccc2	10-2-46	B	19	.1	117
Henning Johnson	148-51-25ccc3	10-2-46	B	10	.08	230
LeRoy Kobbervig	148-51-25dac	10-15-46	A	374	1.0	126
Town of Buxton	148-51-25dcd	1937 (?)	D	212(?)	4.8	261
" " "	" " "	9-5-46	B	212(?)	3.7	273
Joseph Soderberg	148-51-26cdd	10-8-46	A	275(?)	8.4	50
Jens Molvig	148-51-26dda	10-8-46	A	16	.9	172
T. & M. Asheim	148-51-28aad	10-2-46	B	320	1.0	236
Ernest James	148-51-30ddd1	10-15-46	A	115	1.4	30
" "	148-51-30ddd2	10-15-46	A	14	.4	---
Melvin Johnson	148-51-36bbb1	10-2-46	B	16	0	80

1/ A State Laboratories Department, Bismarck, North Dakota
B State Department of Health, Bismarck, North Dakota
C Simpson, H. E. Geology and ground water resources of North Dakota, U. S. Geol. Survey, W. S. P. 598, p. 303, 1929.
D Abbott, G. A. and Voedisch, F. W., Municipal ground water supplies of North Dakota, North Dakota Geol. Survey Bull. 11, p. 81, 1938.

BUXTON AREA, IN PARTS PER MILLION

Magnesium (Mg)	Sodium (Na)	Carbonate (CO3)	Bicarbonate (HCO3)	Sulfate (SO4)	Chloride (Cl)	Total dissolved solids	Total hardness as CaCO3
7	423	34	405	283	376	1553	96
11	46	22	359	349	114	1235	250
23	1207	7	200	1363	1633	5375	445
13	966	31	212	1293	816	3592	213
10	0	22	243	124	50	789	189
124	862	---	244	1470	930	4004	1100
18	6.9	0	232	24	2.0	250	214
25	3	---	278	64	8.3	343	276
37	39	---	305	235	20	446	364
46	90	---	402	108	375	1196	764
23	1286	26	146	1331	1721	5145	410
88	1302	--	312	1340	1551	4825	1020
93	----	---	306	1360	1500	4872	1060
10	491	38	344	525	472	2109	164
41	229	0	856	801	518	3871	598
55	968	---	249	1363	765	3690	825
5	226	22	134	86	376	978	96
---	----	22	151	131	43	800	419
34	0.1	---	249	76	20	354	340

Location Number	Owner or Name	Depth of well (FT.)	Diameter (Inches)	Type	Date completed	Depth to water below land surface (FT.)
147-51-2adc	Jennie Soderberg	174	2	Drilled2/	Old	4.01
147-51-2dbc	Enoch Larson	187	2	Drilled	1915	7.0
147-51-4bab	Howard Spaith	22	36	Dug	Old	20.80
147-51-4cdc	Gertie Lee	80	3	Drilled	1936	29.40
147-51-4dac	Eddie Osland	18	8	Augered	1946	11.19
147-51-4dba	USGS test hole	45	4	Drilled	1946, refilled	
147-51-4dbb	USGS test hole	40	4	Drilled	1946, refilled	
147-51-4ddd	USGS test hole		4	Drilled	1946, refilled	
147-51-11bab	Hilma Eliason	440	2	Drilled	1942	3.0
148-50-19ccd	Selmer Sondrol	315	2	Drilled	1934	16.0
148-50-30abb	Henry Hagelic	372	2	Drilled	1940	Flows
148-50-30bcc1	O. J. Sorlie	385	2	Drilled	1943	11.0
148-50-30bcc2	O. J. Sorlie	275(?)	2	Drilled	1927	11.0
148-50-30bcd	O. J. Sorlie	14	48	Dug	1925	6.51
148-50-31baa	Sidney Lohman	165	3	Drilled	Old	6.70
148-51-21daa	Eken Bros.	293	2	Drilled	1946	Flows
148-51-25ccc1	Town of Buxton	17	96	Dug	1921	10.24
148-51-25ccc2	Town of Buxton	19	144	Dug	1936	13.24
148-51-25ccc3	Henning Johnson	10	72	Dug	Old	8.52
148-51-25ccc4	USGS test hole	29	4	Drilled	1946, refilled	
148-51-25dac	LeRoy Kobbervig	374	2	Drilled		7.23

Date of Measurement	Used1/	Remarks
8-8-46	S	Reported as strong well. Has been pumped at 25 gpm for 24 hrs. without breaking suction. See chemical analysis.
Reported	S	Shallow wells formerly used at this farm went dry in drought years.
8-15-46	D,S	
8-15-46	D,S	Reported as a strong well.
8-15-46	D	See chemical analysis. A second dug well at barn furnishes adequate stock water.
	U	See log.
	U	See log.
	U	See log.
Reported	S	See chemical analysis. First weak vein reported struck at 250 feet.
Reported	S	15 ft. of gravel reported from 300 to 315 ft.
	S	See chemical analysis. Earlier flowing well at this loc. rptd. to have been 400 feet deep.
Reported	S	
Reported	S	
8-15-46	D	See chemical analysis. Reported through sand to top of blue clay at 14 ft.
8-15-46	S	Reported to have flowed when drilled. Seasonal high-water level near 3 ft. below surface.
	S	Reported to have seasonal variation with larger flow in spring of year. See chemical analysis.
8-2-46	U	See chemical analysis. Old town supply well. Now abandoned.
8-2-46	PS D	See chemical analysis. Dug by W.P.A.
8-2-46	D,S	See chemical analysis.
	U	See log.
8-15-46	S	See chemical analysis. Reported "good flow".

Location number	Owner or Name	Depth of well (ft.)	Diameter (inches)	Type	Date completed	Depth to water below land surface (ft.)
148-51-25dcd	Town of Buxton	212(?)	2	Drilled	1914	3.32
14-51-26bab1	Tommy Thompson	18	36	Dug		13.9
148-51-26bab2	Tommy Thompson	448	2	Drilled	1936	12.6
148-51-26cdd	Joseph Soderberg	275(?)	2	Drilled	Old	20.0
148-51-26dda	Jens Molvig	16	48	Dug		
148-51-26ddd1	Jens Molvig	7	72	Dug	Old	4.09
148-51-26ddd2	USGS test hole	17	4	Drilled 1946, refilled		
148-51-28aad	T. & M. Asheim	320	2	Drilled	1944	9.0
148-51-30ddd1	Ernest James	115	4	Drilled	1941	8.0
148-51-30ddd2	Ernest James	14	6	Augered	1941	6.0
148-51-32acc	Otto Bjerke	350	2	Drilled	1918	
148-51-35aaa	Jens Molvig	11	60	Dug	Old	10.32
148-51-36bbb1	Melvin Johnson	16	48	Dug	Old	
148-51-36bbb2	Melvin Johnson	12	60	Dug	Old	8.22
148-51-36cab	USGS test hole	14	4	Drilled 1946, refilled		
148-51-36cbb	USGS test hole	35	4	Drilled 1946, refilled		

1/ S, stock; D, domestic: U, unused: PS, public supply.
2/ Practically all wells listed as drilled were put down by a combination jetting and drilling method.

Date of measurement	Used 1/	Remarks
8-2-46	PS	Used in hotel for washing, flushing toilets, etc. See chemical analysis.
8-2-46	U	
8-2-46	S	
Reported	S	See chemical analysis.
	D	See chemical analysis. Unused at present Reported to have "gone bad".
8-2-46	U	Dug in bottom of old gravel pit.
	U	See log.
Reported	S	See chemical analysis. Reported struck "weak vein" of good water at 170 ft.
Reported	S,D	See chemical analysis. Gravel reported, 95 to 115 ft.
Reported	D	See chemical analysis.
	S	Shallow wells at this location dried up in dry years.
8-8-46	U	Reported bottomed in clay.
	D	Yield only sufficient for home use. See chemical analysis.
8-2-46	S	Reported bottomed in clay.
	U	See log.
	U	See log.

Logs of test holes-Traill County

No. 1, 148-51-25ccc4

	Thickness	Depth
Sand and gravel	11	11
Silt, clay, soft, gray and sand, fine	7	18
Clay, silty, gray with interbedded sand, fine	11	29

No. 2, 148-51-26ddd2

Gravel, mostly pea size	2	2
Sand with some gravel fine	8	10
Clay, silty, gray and sand, fine. In thin beds.	7	17

No. 3, 148-51-36cab

Sand, fine to very fine	7	7
Clay, soft, gray	7	14

No. 4, 148-51-36cbb

Gravel, fine and sand coarse	12	12
Sand, fine to coarse	4	16
Clay, silty, gray with interbedded fine sand	16	32
Clay, sticky, blue	3	35

No. 5, 147-51-4dba

	Thickness	Depth
Gravel, med. well rounded	10	10
Sand	2	12
Clay, gray, with interbedded sand	8	20
Gravel and sand	24	44
Clay, sticky, blue	1	45

No. 6, 147-51-4-dbb

Top soil clay, black, sandy	1½	1½
Gravel	18½	20
Clay, gray, with interbedded sand	16	36
Clay, sticky, blue	3	39

No. 7, 147-51-4ddd

Gravel and sand	8	8
Gravel with interbedded clay	17	25
Gravel, fine, well rounded, well assorted	25	34
Clay, gray, with interbedded silt layers, some sand and gravel	34	52
Boulder		52

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FIG. 1

MAP OF BUXTON AREA SHOWING GEOLOGIC AND HYDROLOGIC FEATURES

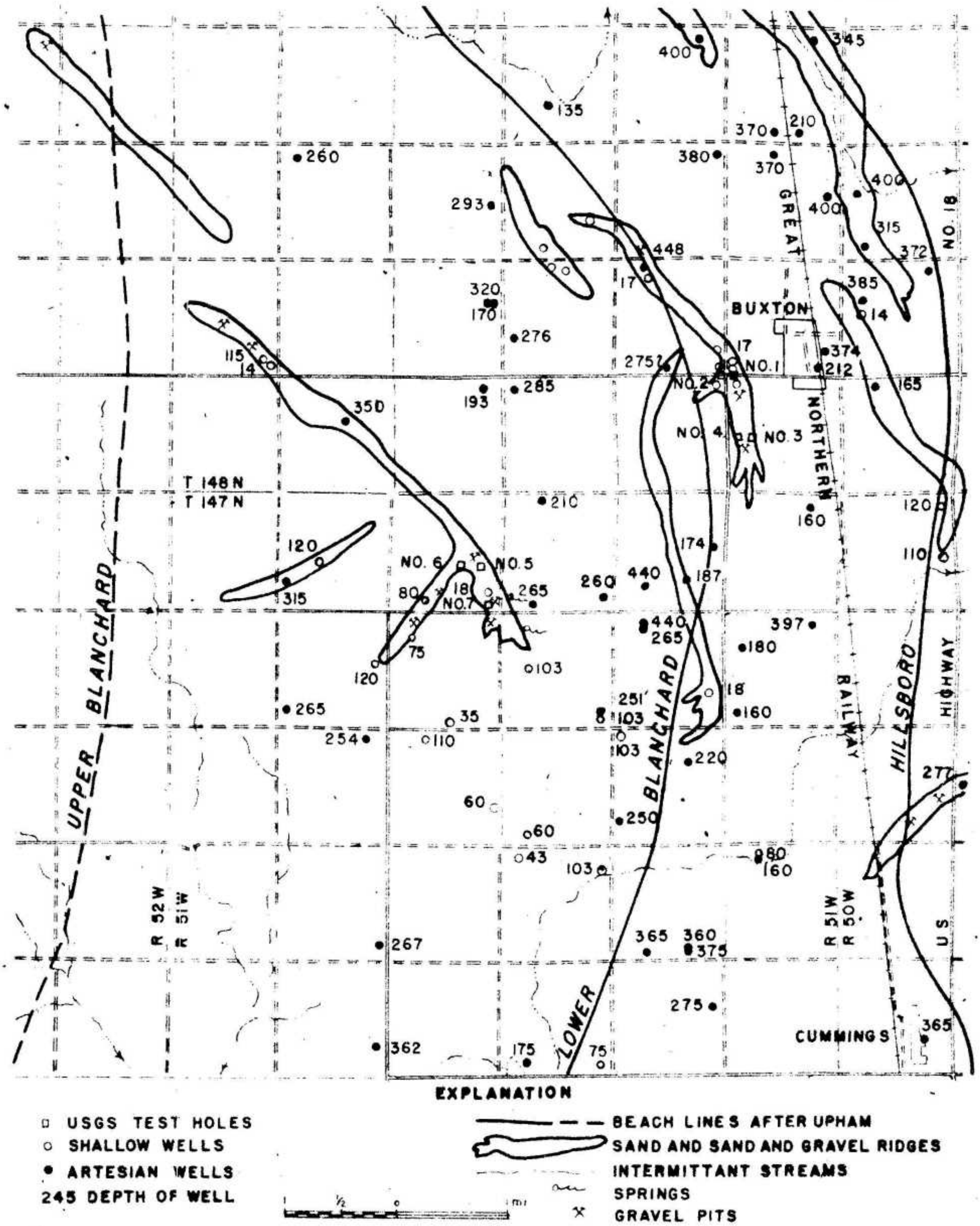

FIG. 2A

DEPTH DISTRIBUTION OF WELLS

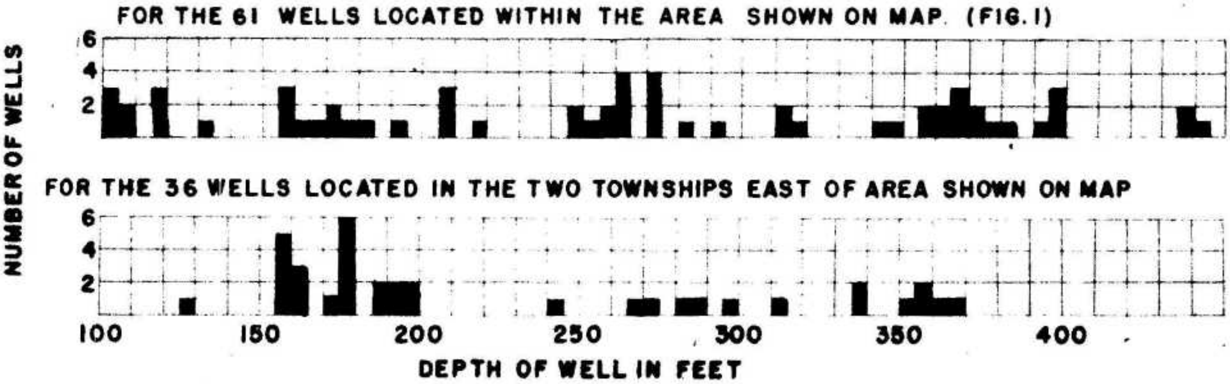

FIG. 2B

CROSS-SECTIONS OF RIDGE 3/4 MILE WEST OF BUXTON

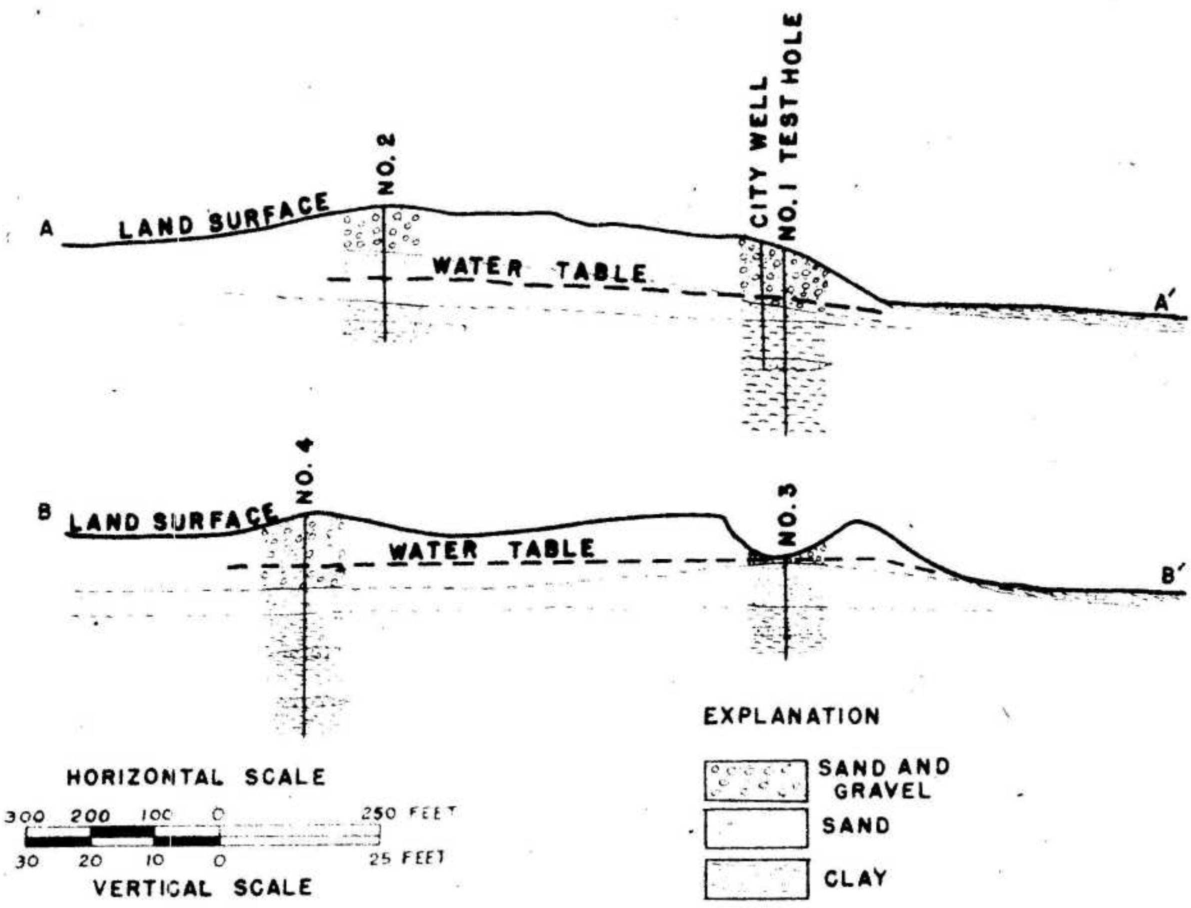

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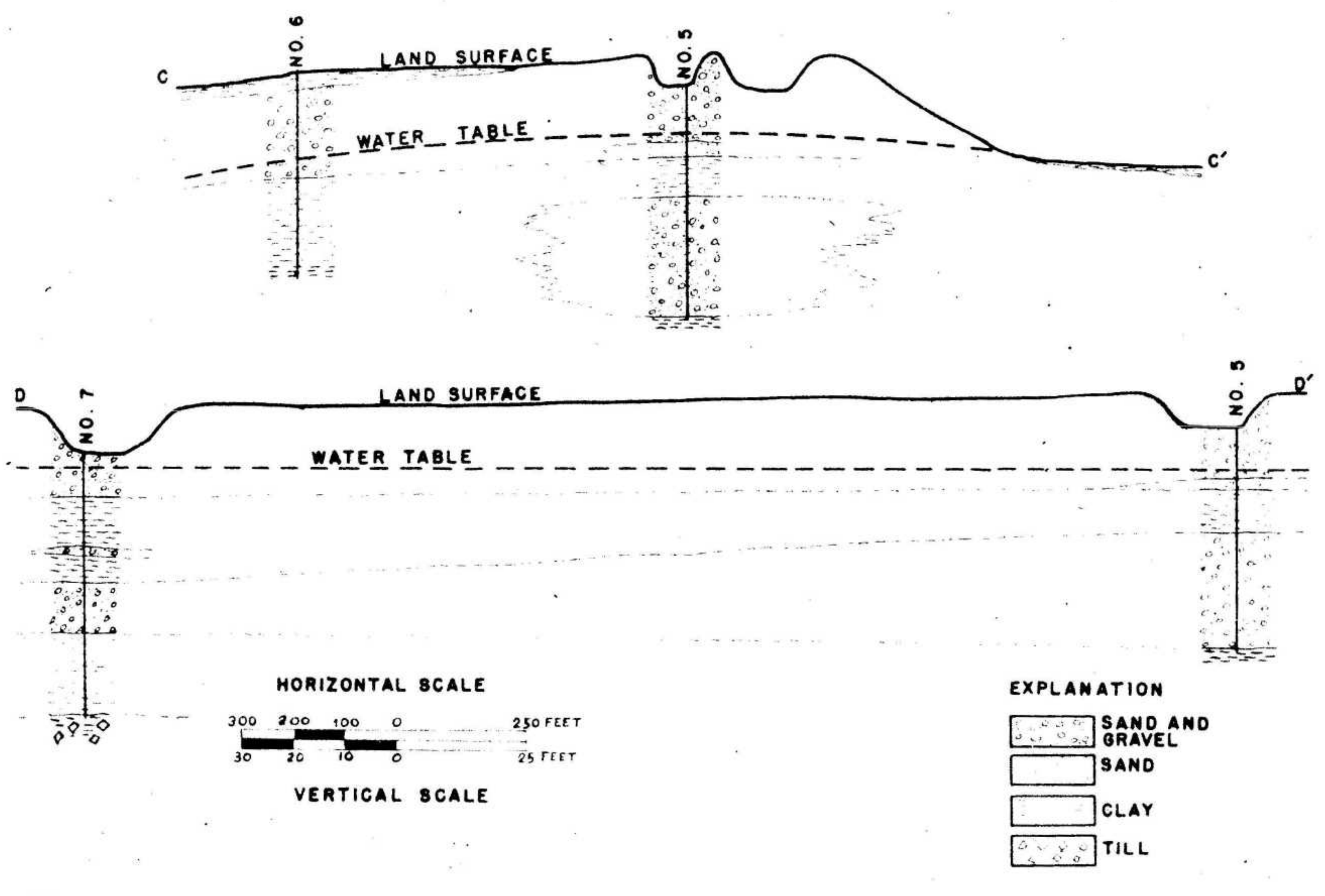
FIG. 3

SECTIONS OF RIDGE 3 MILES SOUTH-WEST OF BUXTON



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