PRELIMINARY REPORT
ON
GROUND WATER CONDITIONS IN THE CLOQUET AREA, CARLTON COUNTY, MINNESOTA

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A study of the geology and ground-water conditions in the area including Cloquet, Minn., was begun by the United States Geological Survey in 1948 in financial cooperation with the Minnesota State Department of Conservation, at the request of the city of Cloquet for assistance in locating large additional ground-water supplies for industrial and municipal use. The location of the area is shown on figure 1. Although the present municipal wells provide a fairly adequate supply for current municipal needs, which averaged about three-quarters of a million gallons a day in 1946, there is great need for large supplies of good water, on the order of 10 million gallons a day, for use by the paper mills and other industries there. At present the industries are using water from the St. Louis River, but the water is unsatisfactory and expensive to use because it contains a large amount of objectionable organic material.

The ground-water study was concentrated in Knife Falls Township (T. 49 N., R 17W.) because of the need for working out the complex relations between the geology and the occurrence of important aquifers and because of the limitations imposed by the available funds. During the study, records were obtained for more than 300 existing wells in the area, 30 test holes were drilled by contract, and 42 electrical-resistivity probes were made. In order to make available the summary of ground-water conditions in the Cloquet area, this preliminary report is being released prior to the full report. A summary of the general geologic and hydrologic features are given in a series of figures. Thus, the areal geology is shown on figure 2; geologic sections and their locations are shown on figures 3 and 4; locations of wells and test holes, depths of wells, and depth to water in wells are shown on figure 4; and generalized contours on the water table are shown on figure 5.

The surface deposits in the area consist principally of glacial drift deposited by the Superior lobe of the late Wisconsin glacier. The materials are reddish brown in color, owing to the presence of iron minerals. The glacial drift consists of till and associated glaciofluvial deposits. The till itself is a heterogeneous mixture of clay, silt, sand, gravel, and boulders which generally does not yield much water; however, in places where the clay and silt content is low enough, the till may be a weak aquifer and may yield small to moderate amounts of water to wells.

By far the most extensive surface materials in the area, however, are glaciofluvial materials which form gently rolling outwash plains, or more pitted outwash areas, and areas where ice-contact features such as eskers and kames are prominent. The material of which all these various land forms are built is a mixture of water-sorted sand and gravel, but it may include some silt and clay. Because of their large areal extent and because the sorted materials commonly are exposed at the surface where they may receive water directly from precipitation, these materials form the most important aquifer in the area. In many places, however, the glaciofluvial materials are so thin that it might be impossible or impractical to develop large water supplies from them. In other places the sorted materials may be unsaturated or may contain only a thin saturated zone.

These surface materials were penetrated in almost all the test holes drilled in the area. In these test holes the material ranged in thickness from 5 to 70 feet.

From the standpoint of developing additional water supplies from wells, the following areas appear to offer the best possibilities:

(1) In the NW¼NE¼SW¼ sec. 20, T. 49 N., R. 17 W., USGS test 49-7 penetrated 60 feet of sand ranging from fine to coarse. In the NE¼NW¼SW¼ of the same section, USGS test 49-6 penetrated 70 feet of sorted material ranging in size from fine sand to gravel. About 20 feet of this material, between depths of 40 to 60 feet, contained considerable clay, which might cause this to be a poor well location. Additional test drilling in the vicinities of these two holes might locate a more favorable spot for the construction of a well.

Chemical analyses of water from existing wells in section 20 indicate it to be low in hardness and iron and entirely satisfactory chemically for most purposes. The water table in the section is shallow, being only about 10 feet or less below the land surface, so that most of the sorted materials found in the test holes is saturated. Because considerable fine sand was encountered in the test holes, it is believed that wells of large yield could not be developed, but it is possible that properly constructed drilled wells yielding 100 to 200 gallons a minute might be obtained. Logically, a field of two or three properly spaced wells could be developed in this area to give a larger total yield.

(2) In the NE¼NE¼SW¼ sec. 23, T. 49 N., R. 17 W., 46 feet of sorted material ranging in size from fine sand to gravel was penetrated in the Cloquet city supply well 4. The water table at the well is about 14 feet below the land surface, so that more than 30 feet of the material is saturated with water. The well is reported to have yielded about 150 gallons a minute but, because the well screen tends to become clogged by incrustation and because the water is hard, the well was abandoned. It is possible that a well could be constructed and operated so as to be free from incrustation, but, of course, the water probably would not differ greatly in chemical quality from that in the present well.

(3) In the NE¼SW¼NE¼ sec. 28, T. 49 N., R. 17 W., from test holes penetrated 45 to 61 feet of sorted material ranging in size from coarse sand to gravel. The thickness of saturated materials probably is as much as 50 feet. Cloquet city supply wells 1 and 3 are a short distance south

of the test holes in the SE$\frac{1}{4}$SW$\frac{1}{4}$NE$\frac{1}{4}$ sec. 28. Well 1 is reported to have been test-pumped at 235 gallons a minute in 1947, and well 3 was test-pumped at 190 gallons a minute in 1946. However, when well 3 is pumped at this rate for any length of time, the water level is drawn down to the end of the pump suction pipe so that air is admitted.

A short pumping test was made on well 3 in April 1948. It was not possible to maintain a constant pumping rate because of pressure changes in the distribution system and because of a lowering water level in the well. The average pumping rate was estimated to be 140 gallons a minute during the test. Water levels were measured in well 1, 47 feet away, and also in well 3 itself. The test showed the coefficient of transmissibility of the water-bearing material to be about 20,000 gallons a day per foot; that is, each mile width of the aquifer would transmit about 20,000 gallons a day for each foot per mile of slope of the water table.

Immediately south of these wells, several springs discharge into a small tributary of Otter Creek, forming a considerable tract of marsh and open-water area. Thick growths of trees and brush along the tributary stream use a considerable amount of water.

The presence of the springs indicate that present developments have salvaged only a part of the natural discharge of ground water, so that considerable additional water could be developed from this area. Individual wells, however, probably could not be expected to yield more than about 150 gallons a minute. Wells should be constructed as near the spring-discharge areas as would be safe from infiltration of surface water into the well. Additional wells probably could be constructed in the vicinity of the USGS test holes and in the area northeast of them along the north line of section 28.

(4) In the NW$\frac{1}{4}$SW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 33, T. 49 N., R. 17 W., USGS test 49-5 was drilled on the south bank of Otter Creek. In this hole, 40 feet of sorted material (principally coarse sand and gravel) was penetrated. About 30 feet of the material is saturated. A well at this location would have a good opportunity to draw water into the aquifer from Otter Creek under pumping conditions, thus assuring a certain amount of recharge from the source. As in section 28, a supply well should be located as near the stream as would be safe from the sanitary standpoint.

(5) USGS test 49-4, drilled a short distance east of Otter Creek in the SW$\frac{1}{4}$NW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 35, T. 49 N., R. 17 W., penetrated largely very coarse sand and gravel to a depth of 34 feet, although there were two beds, each 4 feet thick, that contained considerable clay. Apparently 25 to 30 feet of this material is saturated. A well constructed at this location probably would be near enough to Otter Creek to induce infiltration from the creek under pumping conditions.

USGS tests 49-12 and 49-14 were drilled in the NE$\frac{1}{4}$NW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 35, just east of Otter Creek and north of USGS test 49-4. USGS test 49-12, the northernmost hole, showed sorted material to a depth of only 18 feet, and much of it was very fine grained. On the other hand, USGS test 49-14 penetrated 29 feet of very coarse sand and gravel between 5 and 34 feet, most of which is saturated.

(6) At the Spring Lake pumping station in the SW¼NW¼NW¼ sec. 26, T. 49 N., R. 17 W., there are two open-bottomed concrete-walled underground reservoirs having a combined volume capacity of 800,000 gallons. When the water level in these reservoirs is lowered by pumping, ground water enters through the bottom, so that in effect they are large-diameter wells. From records of pumpage into and out of the reservoirs, engineers estimate that approximately 200,000 gallons a day of the water used by the city in 1945 and 1946 came from this source. Owing to the low suction lift on which the booster pumps operate, and for other reasons, it is not feasible to lower the water in the reservoirs below a certain level. However, if other facilities for storage were available so that the water level in the reservoirs could be lowered further, an additional increment of water could be obtained from this source. The amount of additional water that could be obtained in this way is not known but probably would be as much as 200,000 to 300,000 gallons a day.

Over most of the area, the shallow glaciofluvial deposits rest upon the red till, which at best is a very weak aquifer. However, other glaciofluvial deposits may be included in or may be found below the till. The importance of such bodies as aquifers would depend upon their thickness and areal extent, the character of the sorted material of which they are composed, and their susceptibility to recharge from overlying bodies. In many places these bodies probably are completely covered with the till, so that recharge from precipitation cannot reach them easily. Their value as permanent sources of water supplies may depend, then, on the amount of recharge through the relatively tight till cover.

Glaciofluvial materials included in or otherwise associated with the red till were found in test holes at the following locations:

(1) In the NE¼SE¼NE¼ sec. 20, T. 49 N., R. 17 W., 14 feet of very coarse sand and gravel was found in USGS test 49-18. Because only 10 feet of clayey material separates this sand and gravel bed from the surficial glaciofluvial materials, it is quite possible that the bed may be connected with the upper deposits somewhere in the vicinity. If that is the case, it is likely that a well of moderate yield (on the order of 150 to 300 gallons a minute) could be constructed there. Pumping tests on a finished well at this location, with suitable observation wells, might indicate whether the bed is entirely confined or is connected hydraulically with a substantial source of recharge.

(2) In the NE¼SW¼NE¼ sec. 28, T. 49 N., R. 17 W., 20 feet of sand and gravel was penetrated in USGS tests 48-3 and 48-5 between depths of 75 and 95 feet. This material was not found either in USGS test 48-1, which was drilled between the first-mentioned two holes, or in USGS test 48-2, which

was drilled a short distance south. It is not likely that these aquifers would be of much importance in themselves; but, if wells were drilled in this area to exploit the water from the shallow glaciofluvial deposits, it might be feasible to develop the lower gravel beds as supplemental sources at the same time.

(3) In the SW¼NW¼SW¼ sec. 34, T. 49 N., R. 17 W., 51 feet of sand ranging from fine to coarse was penetrated between depths of 16 to 67 feet. Samples showed some clay in most of this material. It probably is a poor aquifer.

(4) In the SE¼SE¼SE¼ sec. 24, T. 49 N., R. 18 W., 18 feet of very coarse sand and gravel was penetrated in USGS test 49-2 between depths of 107 and 125 feet. The samples contained considerable clay. This bed probably is of little importance as an aquifer.

(5) The most notable aquifer known to be associated with the red till in the area has been developed by the city of Cloquet in its east well field in the SW¼NE¼NE¼ sec. 27, T. 49 N., R. 17 W. At the present time the city has three supply wells in this field, all within 150 feet of each other. Numerous test holes were drilled in a very small area to locate the sites for these wells and in futile attempts to locate additional well sites nearby. The log of city supply well 5 indicates 43 feet of sand and gravel between depths of 68 and 111 feet, and the log of well 6 indicates about 45 feet of sand and gravel between depths of 68 and 113 feet. The log of city supply well 2 indicates 30 feet of sand and gravel between depths of 70 and 100 feet. Test holes drilled very near these wells failed to encounter any important water-bearing materials.

Reported pumping rates of these wells during normal operation are: well 2, about 140 gallons a minute; well 5, about 550 gallons a minute; well 6, about 100 gallons a minute.

A pumping test was made in April 1948. Well 5 was pumped at a rate of 409 gallons a minute and water-level measurements were made in wells 2 and 6. As in the test on well 3, in sec. 28, it was not possible to control the pumping rate closely because of changing pressure in the distribution system. Also, it became necessary to pump one of the other wells in the field before the test was completed, which introduced additional complications. The coefficient of transmissibility estimated from the tests is about 30,000 gallons a day per foot.

Although available water-level data have not indicated a progressive or serious permanent lowering of the water level in this well field, it is not likely that much additional water can be developed from this aquifer.

In some parts of the area, the upper red drift rests upon an older drift which is gray to brown in color. In some places the two drift sheets are separated by a weathered zone, and, as shown in some of the test holes, by a considerable thickness of peat.

Presumably the chances for penetrating glaciogluvial aquifers in or associated with the older drift should be about as good as in the case of the red till above. However, no aquifers of importance were found in the older drift in any of the test holes.

The bedrock of the area consists of interbedded slates, graywacke-slates, and graywackes. It is exposed along the St. Louis River in the southern half of the area.

The bedrock is of little importance as a source of water supply; only three wells in Knife Falls Township are known to yield water from it. They yield but small quantities of water at poor quality, probably from crevices.

In conclusion, it appears that the surficial glaciofluvial aquifers which cover a large part of the area offer the best possibility for development of additional ground-water supplies. Because of the character of the materials composing these aquifers and because they are relatively thin in most places, it probable will not be feasible in most places to develop drilled wells that will yield more than about 100 to 200 gallons a minute. Considerably larger yields might be obtained in some areas, especially areas along Otter Creek.

Supplies adequate to meet additional municipal demands arising from normal growth of the community probably can be developed economically, from the glaciofluvial aquifers. However, to exploit fully the ground-water resources of the area would require a large number of wells of relatively small yield spread over a large part of the township. To develop ground-water supplies totaling 10 million gallons a day from the area for industrial purposes, therefore, would be expensive and probably not economically feasible. Also, it is believed that natural recharge from precipitation within Knife Falls Township would not support such a development; whether sufficient additional recharge could be induced by pumping from wells near streams such as Otter Creek to permit a total withdrawal of 10 million gallons a day cannot be determined with available data.

Interior—Duplicating Section, Washington, D. C. 88826

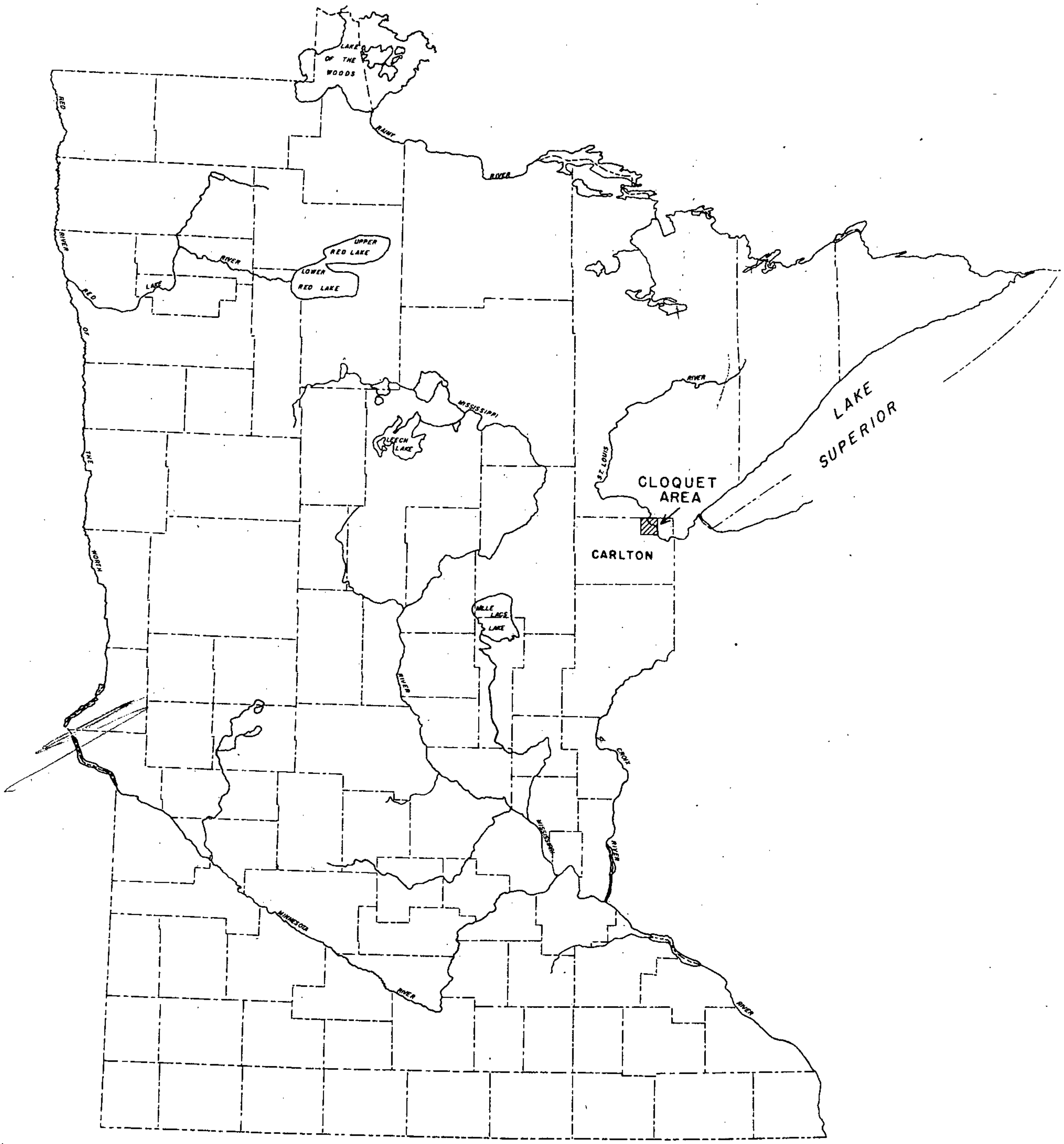

FIGURE 1.

MAP OF MINNESOTA SHOWING CLOQUET AREA.

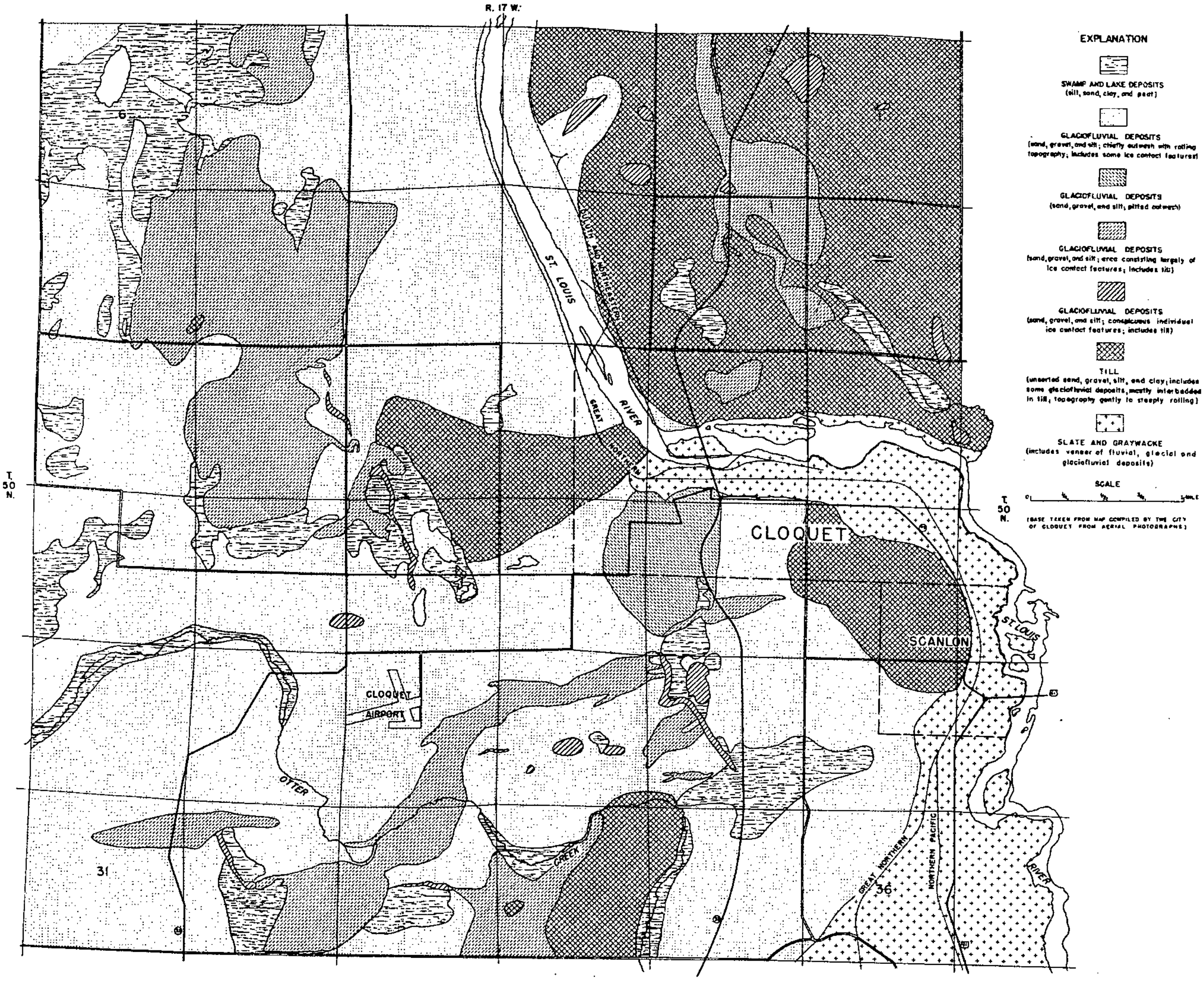

FIGURE 2.—GEOLOGIC MAP OF THE CLOQUET AREA.

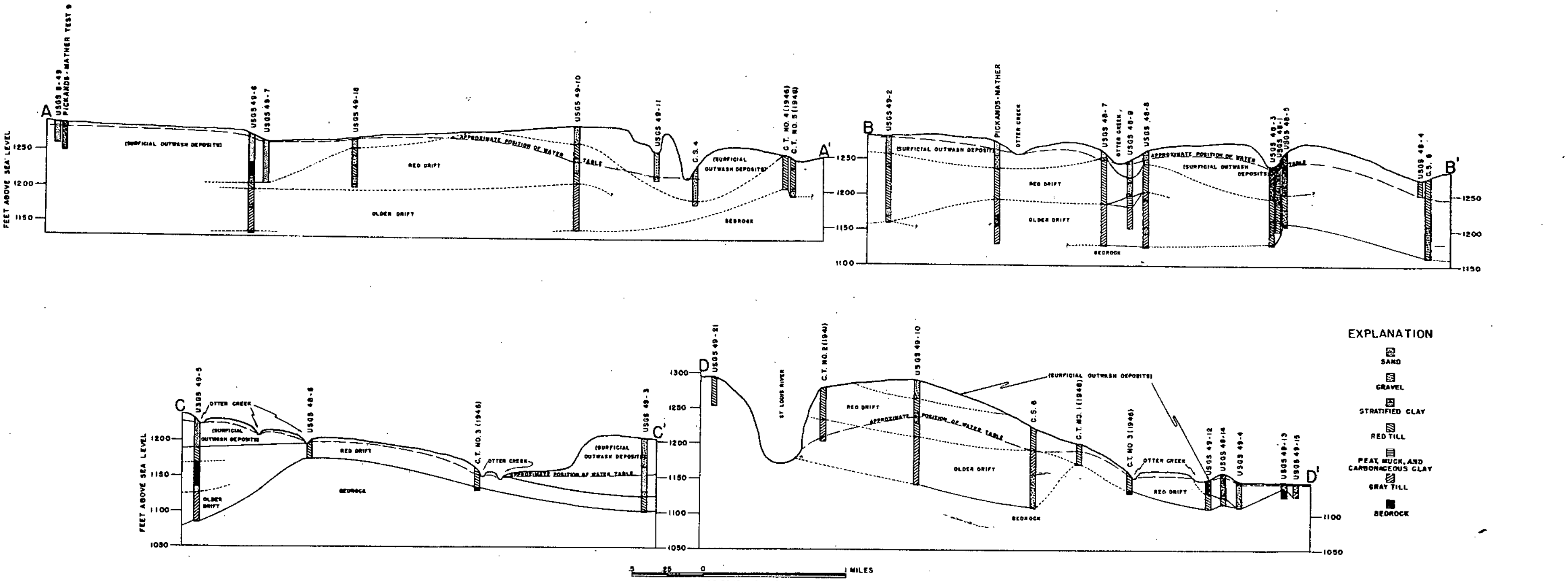

FIGURE 3.-GENERALIZED GEOLOGIC SECTIONS IN THE CLOQUET AREA

(LOCATION OF SECTIONS SHOWN IN FIGURE 4)

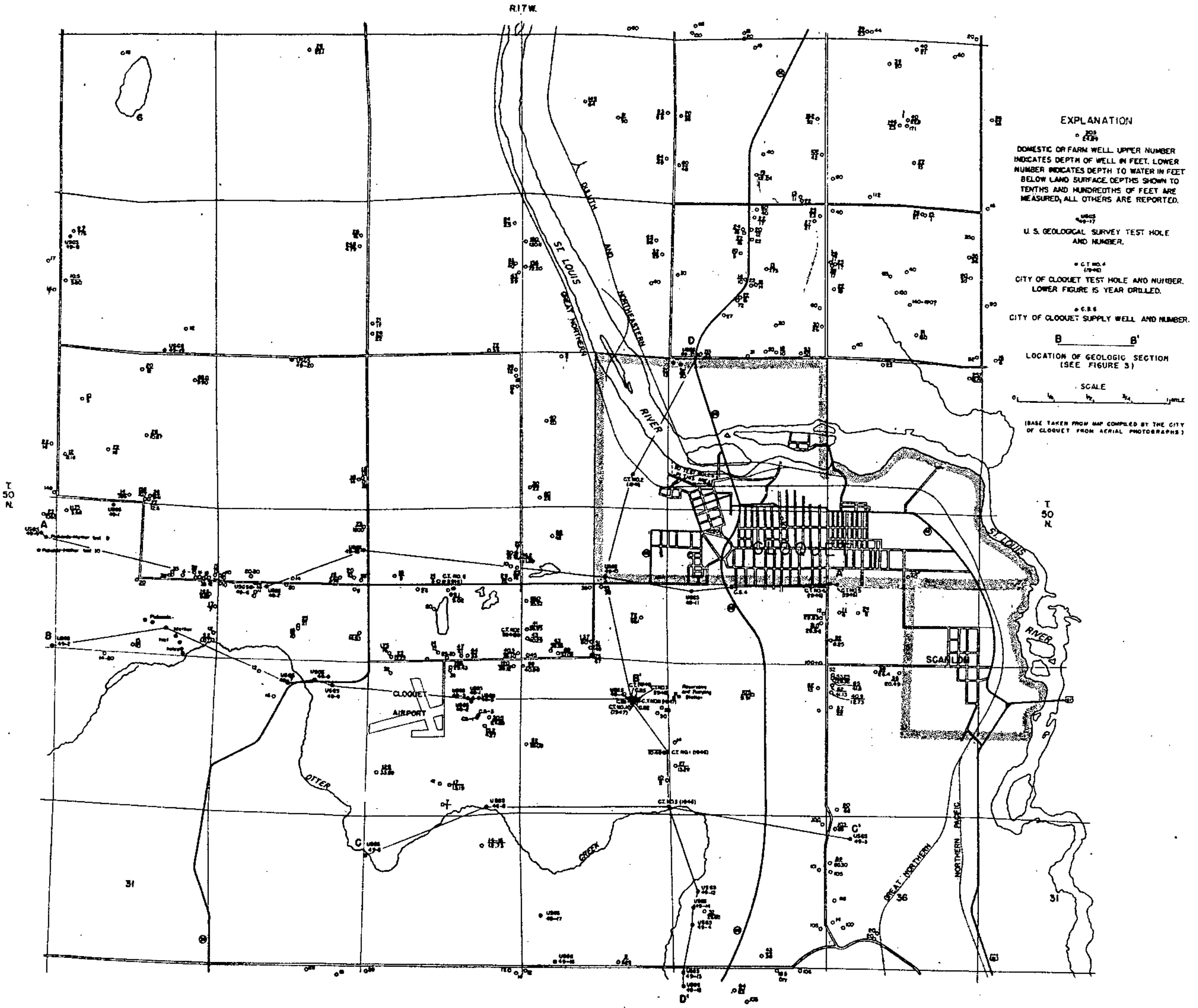

FIGURE 4.—MAP OF CLOQUET AREA SHOWING LOCATIONS OF WELLS AND TEST HOLES, DEPTHS OF WELLS, DEPTHS TO WATER, AND LOCATIONS OF GEOLOGIC SECTIONS.

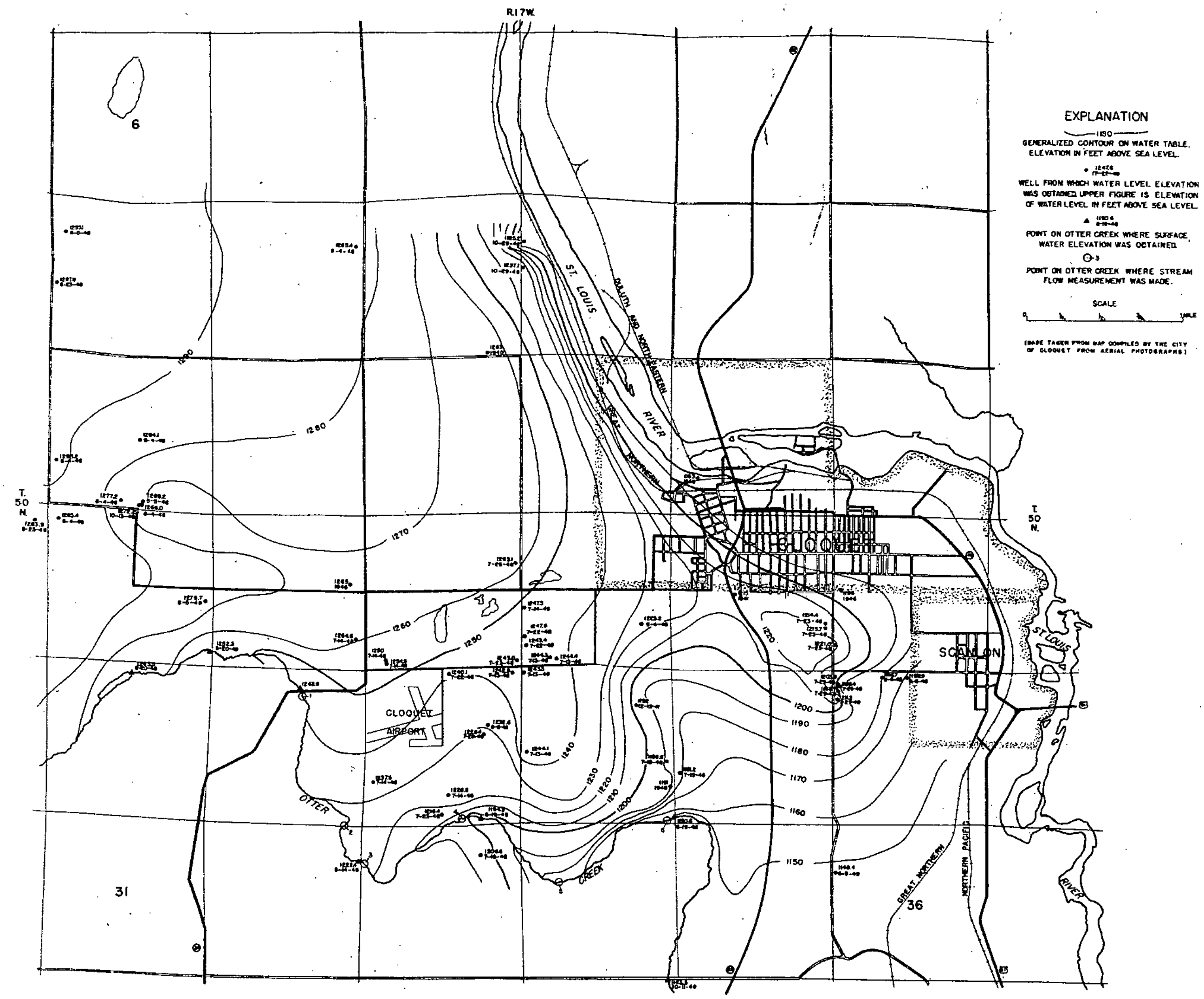

FIGURE 5.—MAP OF CLOQUET AREA SHOWING GENERALIZED CONTOURS ON THE WATER TABLE AND LOCATIONS OF STREAM FLOW MEASUREMENTS ON OTTER CREEK