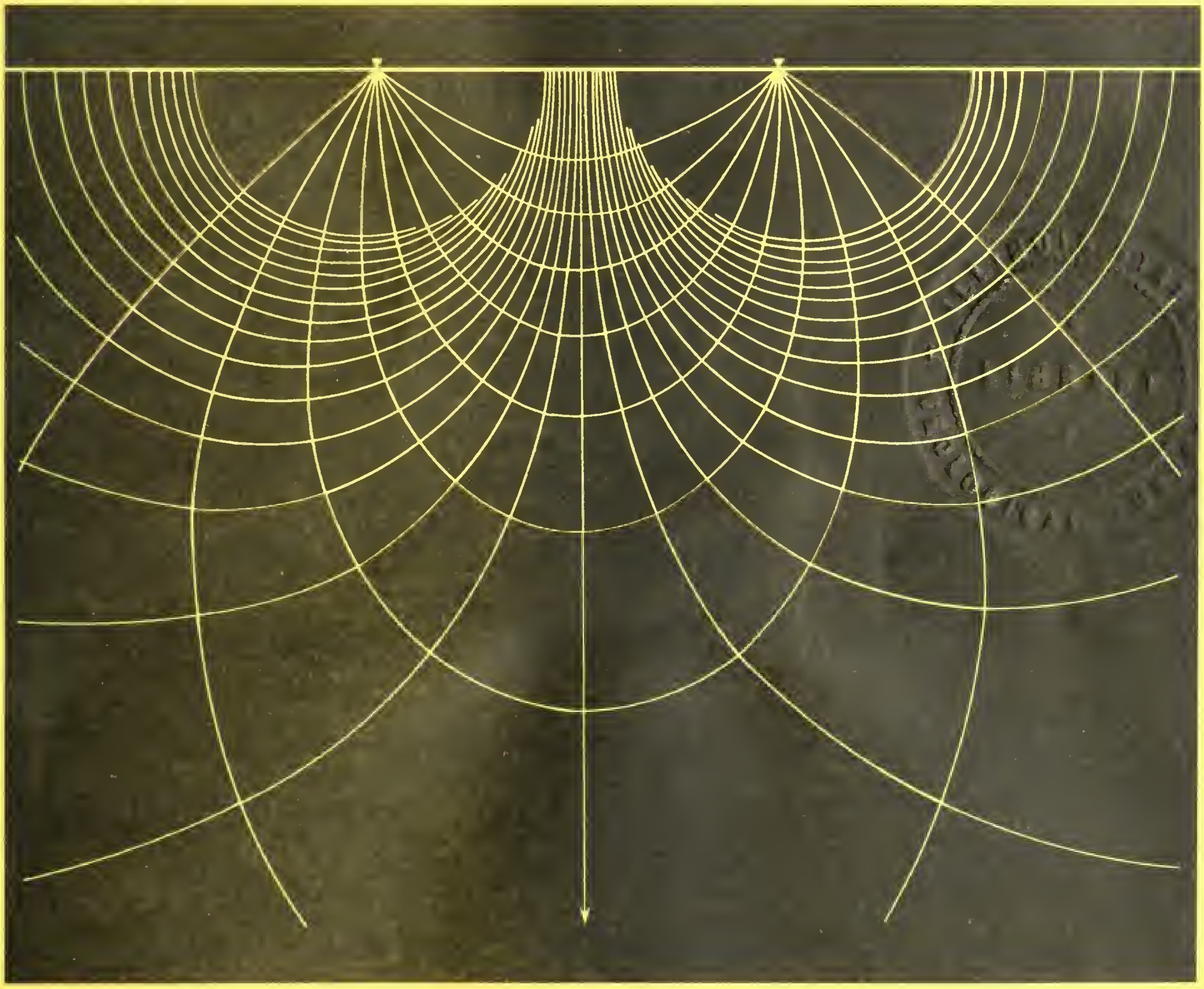
GEOPHYSICAL ASSESSMENT OF AQUIFERS SUPPLYING GROUND WATER TO EIGHT SMALL COMMUNITIES IN ILLINOIS

Vickie L. Poole and Paul C. Heigold



Illinois Institute of Natural Resources
STATE GEOLOGICAL SURVEY DIVISION
Jack A. Simon, Chief

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Cover figure. Potential and current distribution in a vertical plane along the line of electrodes. Adapted from Stefanesco (1929).

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GEOPHYSICAL ASSESSMENT OF AQUIFERS SUPPLYING GROUND WATER TO EIGHT SMALL COMMUNITIES IN ILLINOIS

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Figure 1. Reference cities (circles) and communities (dots) studied for this report.

Abstract

During the drought of 1976-1977, many municipal water systems in Illinois dependent on ground water for supplies experienced water shortages. On the basis of their past shortages, increasing future needs, and possibilities for obtaining greater water supplies from the glacial drift, eight small communities were selected for supplemental geophysical exploration programs as an aid to siting new municipal wells. Electrical earth resistivity surveys were used extensively to evaluate the water-producing capabilities of the unconsolidated glacial deposits and to provide a basis for recommendations for test-drilling locations.

Introduction

During the drought of 1976-1977, water shortages were experienced by many municipal water systems that were dependent on ground water for supplies. A joint study in 1978 by the Illinois Division of Water Resources, the Illinois State Water Survey, and the Illinois State Geological Survey (Visocky et al., 1978) identified 24 towns and villages in Illinois that utilized ground water for supplies. Because of their water shortages in the past and estimated ground-water needs for the future, eight of these small communities (fig. 1), where there are possibilities of obtaining a greater water supply from the glacial drift, were selected for supplemental geophysical exploration programs in 1979 as an aid to siting new municipal wells. This report summarizes the findings of the geophysical work.

The electrical earth resistivity method was chosen to evaluate the water-bearing capability of the unconsolidated glacial deposits. This geophysical method is rapid, inexpensive, and relatively reliable for prospecting for sand and gravel deposits. In unconsolidated sediments where fresh water fills the interstices, this method relies on the fact that coarse-grained sand and gravel exhibit higher resistivities than fine-grained silt and clay-rich deposits.

A Bison Model 2350 B, owned by the Illinois State Geological Survey, was used in the electrical earth resistivity surveys made in 1979. Vertical electrical soundings (VES) were made by expanding Wenner electrode configurations about some point on the earth's surface chosen as a station location. VES data basically provide a knowledge of resistivity as a function of depth below the station location.

Preliminary analyses of the VES data from both past and present surveys were qualitative. Plots of apparent resistivity values versus electrode a-spacings (VES curves) were made for all stations. Of particular interest were the a-spacing values associated with apparent resistivity maxima, minima, and inflection points and the maximum values of apparent resistivities. Besides providing a rough idea of the types and distribution of lithologies in the unconsolidated glacial deposits, this preliminary interpretive work showed those stations where more sophisticated quantitative analyses of the data were warranted.

Quantitative analyses of selected VES curves were provided by an automatic inversion technique developed by Zohdy and Bisdorf (1975). This technique uses the method of convolution (Ghosh, 1971) and modified Dar Zarrouk functions (Zohdy, 1973, 1975) to invert Wenner VES curves into thicknesses and "true" resistivities of horizontal layers.

Recommendations for siting new municipal wells were updated after analyses of old and new electrical earth resistivity data.

This study has been supported, in part, by funds provided by the Illinois Department of Transportation, Division of Water Resources, John K. Flowe, Director.

Colchester

The village of Colchester (population 1,747), located in west-central McDonough County, portions of Secs. 7 and 18, T. 5 N., R. 3 W., and Secs. 12 and 13, T. 5 N., R. 4 W. (fig. 2), experienced water shortages during the drought of 1976-1977 (Visocky et al., 1978). By the year 2000 the population of Colchester is projected to increase, and the estimated ground-water demand is approximately twice the practical sustained yield of the present municipal well field. Because of its past water shortages, estimates of increased need in the future, and the possibility of obtaining a greater water supply from the glacial drift, Colchester was chosen for supplemental electrical earth resistivity surveying during 1979 as an aid to siting new municipal wells.

Colchester is physiographically situated in the central portion of the Galesburg Plain in the Till Plains Section of the Central Lowland Province. It lies on a flat to gently rolling Illinoian-age ground moraine dissected by numerous steep-walled stream valleys that trend southwestwardly. Drainage in the area is to the southwest; it follows a regional slope toward the south-

more than 650 feet above m.s.l. [illegible]

The unconsolidated Pleistocene glacial drift in the Colchester area consists of a complex of ice-laid till, water-laid silt, sand and gravel outwash and alluvium, and wind-blown silt (loess) of pre-Illinoian, Illinoian, and Wisconsinan age. Drift thickness ranges from 0 to 60 feet over shallow bedrock in the uplands and along the East Fork to 165 feet in the deeper portions of the major bedrock valleys. Blanketing loess averages between 6 and 8 feet thick.

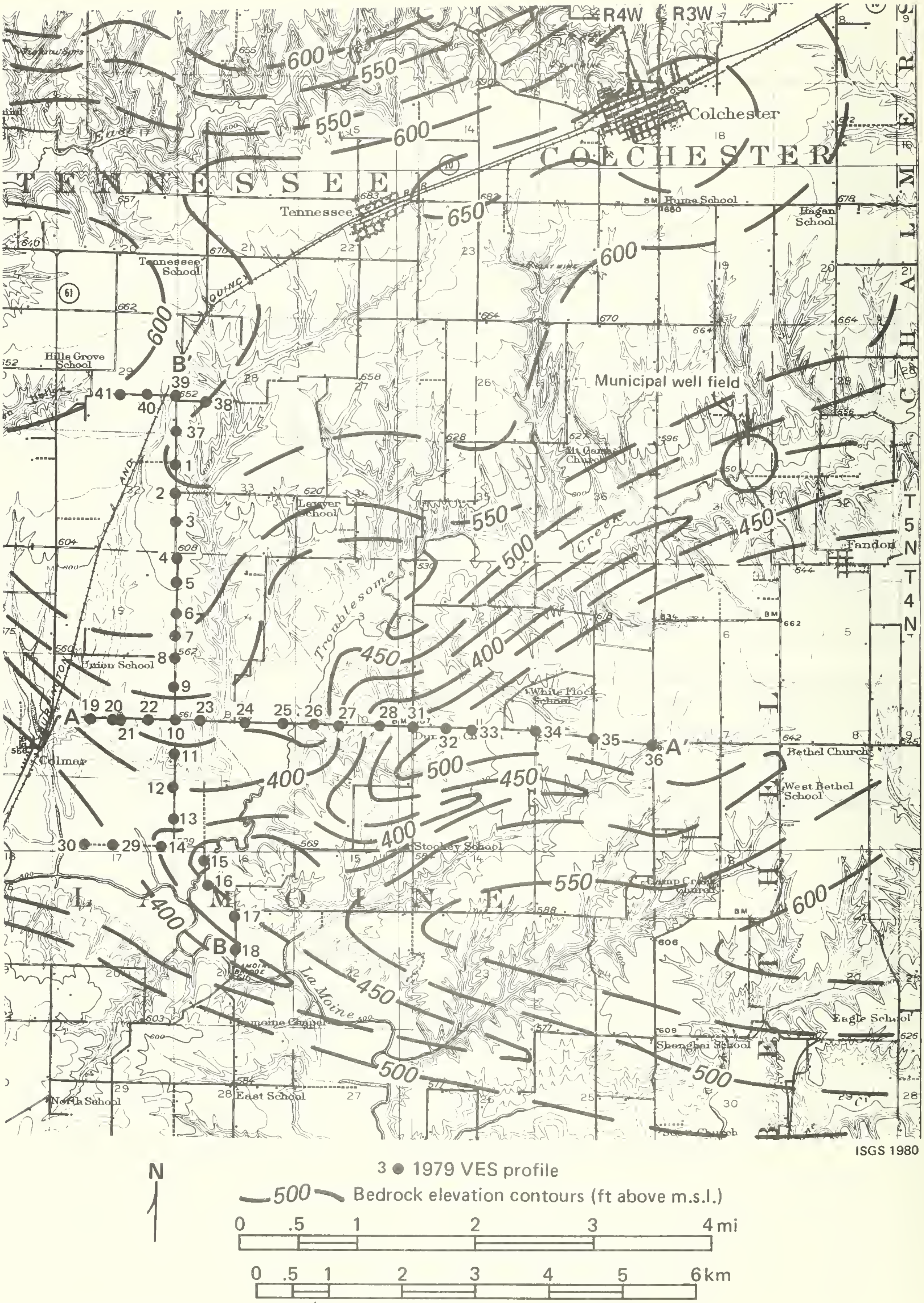

Figure 2. Colchester study area.

Where present in the till, sand deposits are thin, limited in extent, and capable of yielding only small supplies of water for domestic use. Major sand and gravel deposits, capable of producing moderate to large supplies of water, occur in the La Moine River valley and the subjacent buried bedrock valleys.

Municipal Wells 1, 2, 3, and 4 presently provide water for Colchester and are located in the central part of the NE¼ of Sec. 31, T. 5 N., R. 3 W., McDonough County (fig. 2). All of these wells were originally drilled to depths of 32 to 34 feet and all encountered 6 to 10 feet of sand and gravel above limestone bedrock on the northern flank of the buried bedrock valley that lies just south of and parallel to Troublesome Creek. Well 3 was later deepened 35 feet into the limestone bedrock. Well yields are 80 to 100, 70 to 85, 65 to 75, and 35 to 50 gal/min respectively, with total pumpage averaging slightly less than 100,000 gal/day. Well 4 is operated only on a part-time basis because of high iron content. The potential yield of the wells during years of normal precipitation has been estimated to be 185,000 gal/day and the long-term practical sustained yield under drought conditions to be in the range of 90,000 gal/day. Colchester is expected to need 171,000 gal/day by the year 2000, almost twice the production of the present well field under drought conditions.

Visocky et al. (1978) recommended that surface geophysical methods be employed to aid in assessment of the water-yielding potential of sand and gravel deposits within the buried bedrock valleys in an area away from the current municipal well field. The confluence of Troublesome Creek and the La Moine River was an area specifically recommended for exploration.

In response to these recommendations, vertical electrical sounding (VES) profiles were arranged essentially in two long lines AA' and BB' southwest and west of the municipal well field (fig. 2). The center stakes of the VES profiles were spaced at approximately one-quarter mile intervals. Portions of these lines traversed the La Moine River and Troublesome Creek floodplains as well as the projected boundaries of the buried bedrock valleys.

Interpretation of the resistivity data consisted of construction, examination, and inversion of VES curves for all VES profiles. Inversion of a VES curve provides layering parameters ("true" resistivities and thicknesses) for the earth materials below the center stake of the corresponding VES profile. The east-west trending line AA' of VES profiles (fig. 3a), located in Secs. 8 through 12, T. 4 N., R. 4 W., transects a portion of the main bedrock valley as well as the branch in which Colchester's municipal wells are situated. The relatively large "true" resistivity values and their associated parameters and layer thicknesses, noted at VES profiles 10 and 20 (Sec. 8, T. 4 N., R. 4 W.) and VES profiles 26, 27, and 28 (Sec. 10, T. 4 N., R. 4 W.), are indicative of coarse-grained, unconsolidated deposits within the confines of buried bedrock valleys. The fact that "true" resistivity values at VES profile 19 are greater than those determined at VES profiles 26, 27, and 28 probably indicates that the unconsolidated deposits in the main bedrock valley are coarser than those in the smaller bedrock valley just south of Troublesome Creek. The locations of VES profiles 19 and 27 are recommended as future test drilling sites.

The north-south trending line BB' of the VES profiles (fig. 3b) intersects line AA' at VES profile 10. "True" resistivity values typical of coarse-textured, unconsolidated deposits are noted at VES profiles 12, 13, and 14 (Sec. 17, T. 4 N., R. 4 W.) and VES profiles 16, 17, and 18 (Secs. 16 and 21, T. 4 N., R. 12 W.

VES profiles 12, 13, and 14 are located at the projected branching of the main bedrock valley and in the floodplain just north of the present-day confluence of the La Moine River and Troublesome Creek. The location of VES profile 13 is recommended as a future test drilling site. VES profiles 16, 17, and 18 are located along the projection of a small southeast-northwest trending branch of the main bedrock valley and the locations of VES profiles 16 and 18 may be considered as future test drilling sites.

Of the VES curves interpreted individually, 29 and 30 exhibit "true" resistivity values comparable to those obtained from VES curves 12, 13, and 14 of line BB'. VES profiles 29 and 30 are also located on the large floodplain just north of the La Moine River and Troublesome Creek. Both of these sites are recommended for future test drilling.

In summary, it appears from study of the geophysical and well data that test drilling would be most favorable within the buried bedrock valley just south of Troublesome Creek and in the floodplain just north of the confluence of the La Moine River and Troublesome Creek. Specifically recommended test drilling sites are as follows: (1) VES profile 27, or anywhere a sufficient distance southwest of the current municipal well field in the small buried bedrock valley just south of and parallel to Troublesome Creek; (2) VES profiles 13, 29, and 30, or anywhere on the floodplain north of the confluence of the La Moine River and Troublesome Creek; and (3) VES profiles 16 and 18. Profiles 16 and 18 should be given lowest priority.

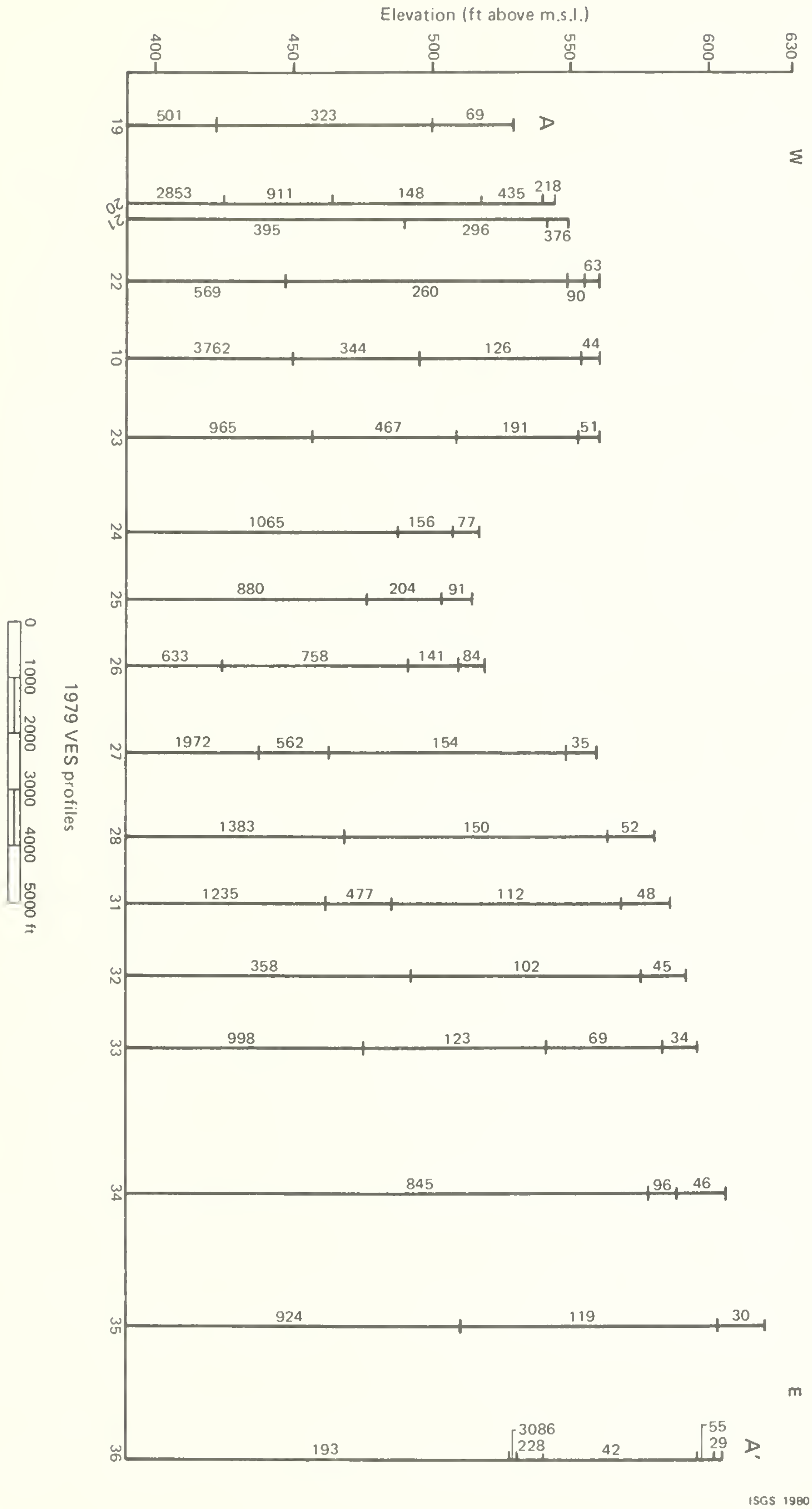

Figure 3a. Colchester study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line AA' (see fig. 2). "True" resistivity values are in ohm-feet.

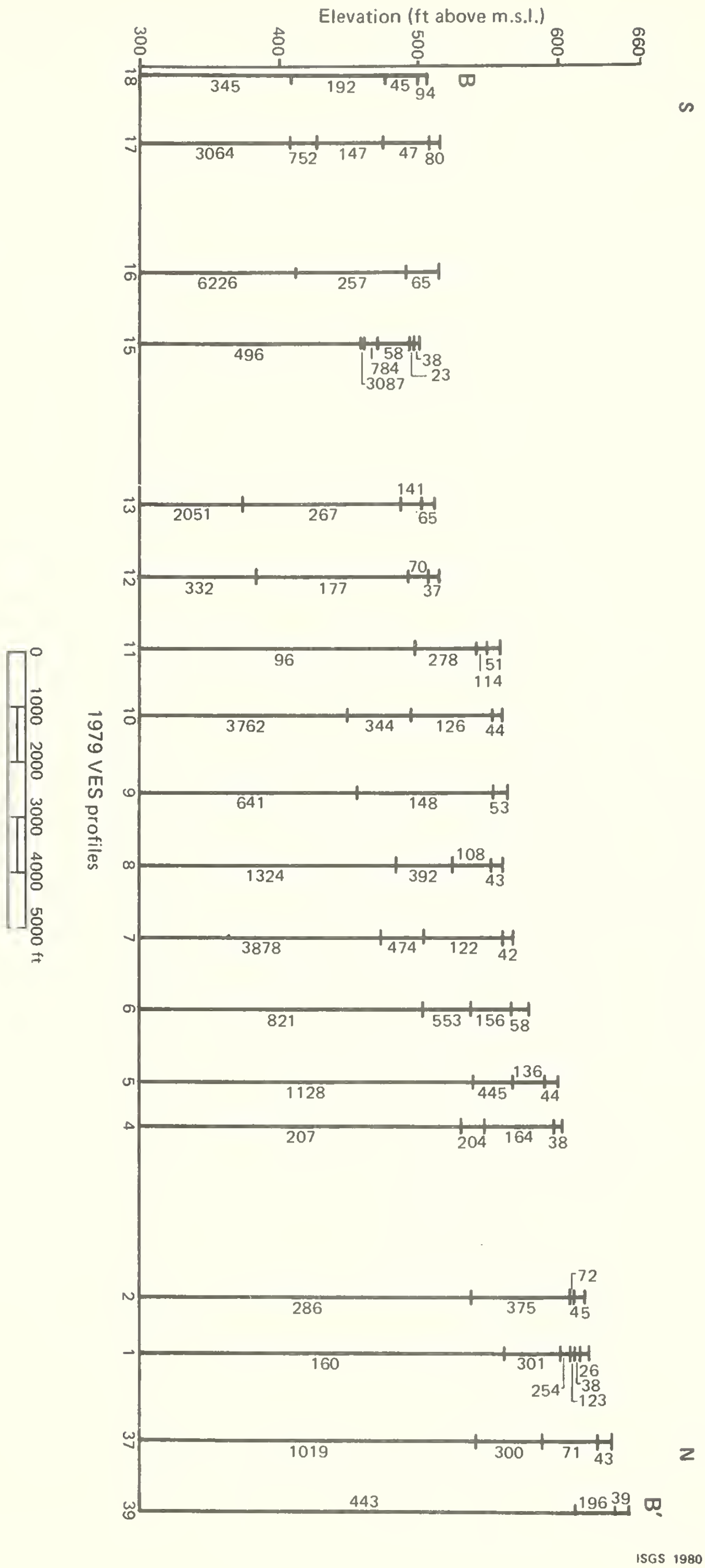

Figure 3b. Colchester study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line BB' (see fig. 2). "True" resistivity values are in ohm-feet.

Hamel

The village of Hamel (population 454) located in north-central Madison County, portions of Secs. 11 and 14, T. 5 N., R. 7 W. (fig. 4), experienced water shortages during the drought of 1976-1977 (Visocky et al., 1978). The population of Hamel is not projected to increase significantly by the year 2000, but according to the State Water Survey the well field was being pumped at or near its practical sustained yield in 1977. It was estimated that the practical sustained yield of the present wells, 75,000 gal/day, would be reduced by more than 10,000 gal/day during periods of drought. The village of Hamel was chosen for a supplemental electrical earth resistivity survey as an aid to siting new municipal wells.

The Hamel area is physiographically situated in the Springfield Plain of the Till Plains Section of the Central Lowland Province. It lies on a slightly rolling ground moraine of Illinoian age. Drainage of the major portion of this area is provided by Silver Creek and its southward-flowing tributaries. Drainage in the far western portion of the area is provided by Cahokia Creek and its tributaries.

The shallow bedrock in the Hamel area consists mainly of shales and limestones of the Pennsylvanian Modesto Formation. If fractured, the limestones at the bedrock surface may be capable of yielding small domestic supplies of water, but they cannot be considered a likely source of moderate to large supplies such as are needed for a municipal supply. The predominant topographic feature of the bedrock surface in the Hamel area is a branch of the buried Macoupin Bedrock Valley, which trends northeast through the center of the area (fig. 4). Bedrock elevations range from slightly less than 400 feet above m.s.l. in the southwestern portion of the valley to almost 500 feet above m.s.l. on its flank. The valley becomes narrower and shallower toward the northeast.

The unconsolidated Pleistocene glacial drift in the Hamel area consists of a complex of ice-laid till, water-laid silt, sand and gravel outwash, and wind-blown silt (loess). The till, water-laid silt, and sand and gravel outwash are pre-Illinoian and Illinoian in age, and the blanketing loess and possibly some sand and gravel outwash are Wisconsinan in age. Drift ranges from 54 feet over shallow bedrock to 163 feet thick over the Macoupin Bedrock Valley. Loess averages a little less than 10 feet thick. Sand and gravel deposits occur at two general intervals within the drift: (1) at depths ranging from 20 to 70 feet in the middle and upper parts of the drift; and (2) at or near the base of the drift in the eastern portion of the study area. The shallower deposits occur mainly as discontinuous lenses and stringers; the deeper deposits, though limited to the eastern portion of the area, are thicker and more extensive.

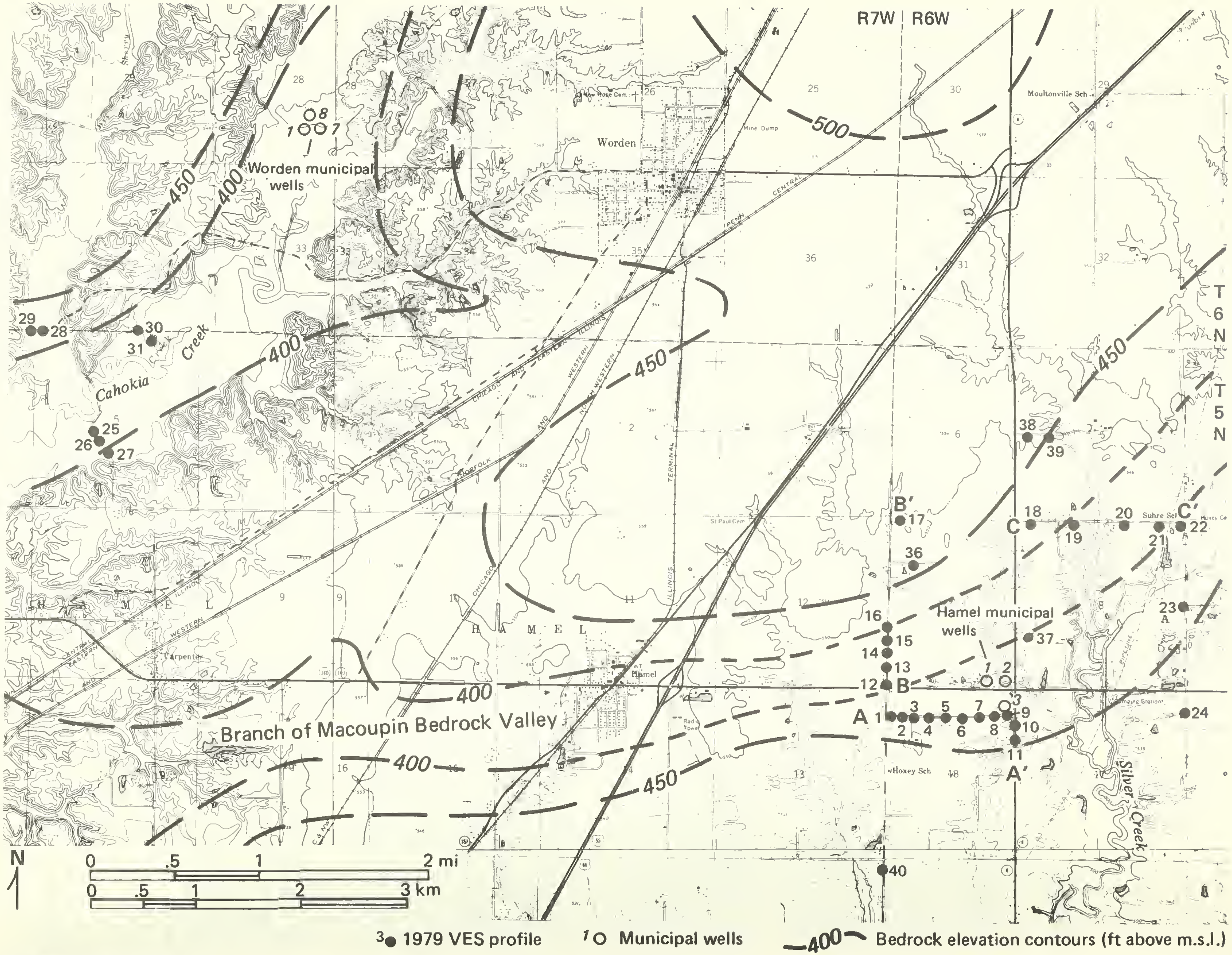

Figure 4. Hamel study area.

The three wells presently providing water for Hamel are located in a 26- to 33-foot thick sand and gravel deposit beneath a tributary to Silver Creek approximately 2 miles east of town in the southeast corner of Sec. 7 and the northeast corner of Sec. 18, T. 5 N., R. 6 W., Madison County (fig. 4). The 26- to 33-foot thickness of sand and gravel observed at the municipal well site is a possible indication of the presence of a branch of the buried Macoupin Bedrock Valley. Municipal Well 1 is located approximately 100 feet north and 700 feet west of the southeast corner of Sec. 7, T. 5 N., R. 6 W. Municipal Well 2 is located 335 feet east of Well 1, and Well 3 is located 469 feet south and 235.5 feet west of the northeast corner of Sec. 18. All wells are drilled to a depth of 110 to 113 feet and are cased to the bottom with slotting between 103 to 111 feet in Well 1 and in the last 20 feet on Wells 2 and 3. The sustained yield of the municipal wells has been calculated to be approximately 86,000 gal/day during years of normal to below normal precipitation and only 73,000 gal/day during periods of drought. At 75,000 gal/day, pumpage of the Hamel wells is considered to be at or near its practical long-term sustained yield.

In their 1978 report, Visocky et al. suggested two ways in which Hamel's present water supply might be supplemented: (1) expansion of the present well field to the south, north, and possibly east; and (2) development of new wells in the glacial drift of the Cahokia Creek bottom in the northwestern portion of the study area. The first suggestion was based on the possible relationship between the aquifer tapped by the current municipal wells and the bedrock channel passing through the region. The second suggestion was based on the fact that the town of Worden, approximately 3 miles to the north of Hamel, obtains its municipal water supply from buried channel deposits of sand and gravel in the Cahokia Creek bottomlands in Sec. 28, T. 6 N., R. 7 W. These deposits are considered likely to continue southward in the Cahokia Creek Valley.

In response to the suggestions of Visocky et al. (1978), supplemental electrical earth resistivity surveying was concentrated around the present well field (mainly within the projected boundaries of the buried bedrock valley) and in Sec. 5, T. 5 N., R. 7 W. in the Cahokia Creek bottomlands.

Interpretation of the resistivity data consisted of construction, examination, and inversion (according to the Zohdy and Bisdorf [1975] inversion technique) of VES curves obtained from VES profiles. The inversion technique provided layering parameters (layer thicknesses and "true" resistivities) for each VES profile. Of particular interest were lines AA', BB', and CC' of VES profiles (figs. 5a, 5b, 5c). These lines were of particular interest because they were thought to cross regions where water-bearing deposits were most likely to occur.

The line AA' of VES profiles (fig. 5a) trends east-west just south of the municipal well field. The VES curves and their inversions indicate a possible expression of the aquifer tapped by the current municipal wells at VES profiles 7, 8, 9, and 10. The inversion of the VES curve obtained from VES profile 5 shows a small, shallow (less than 40 feet from the surface) high resistivity layer that is probably coarse-grained and possibly water-bearing.

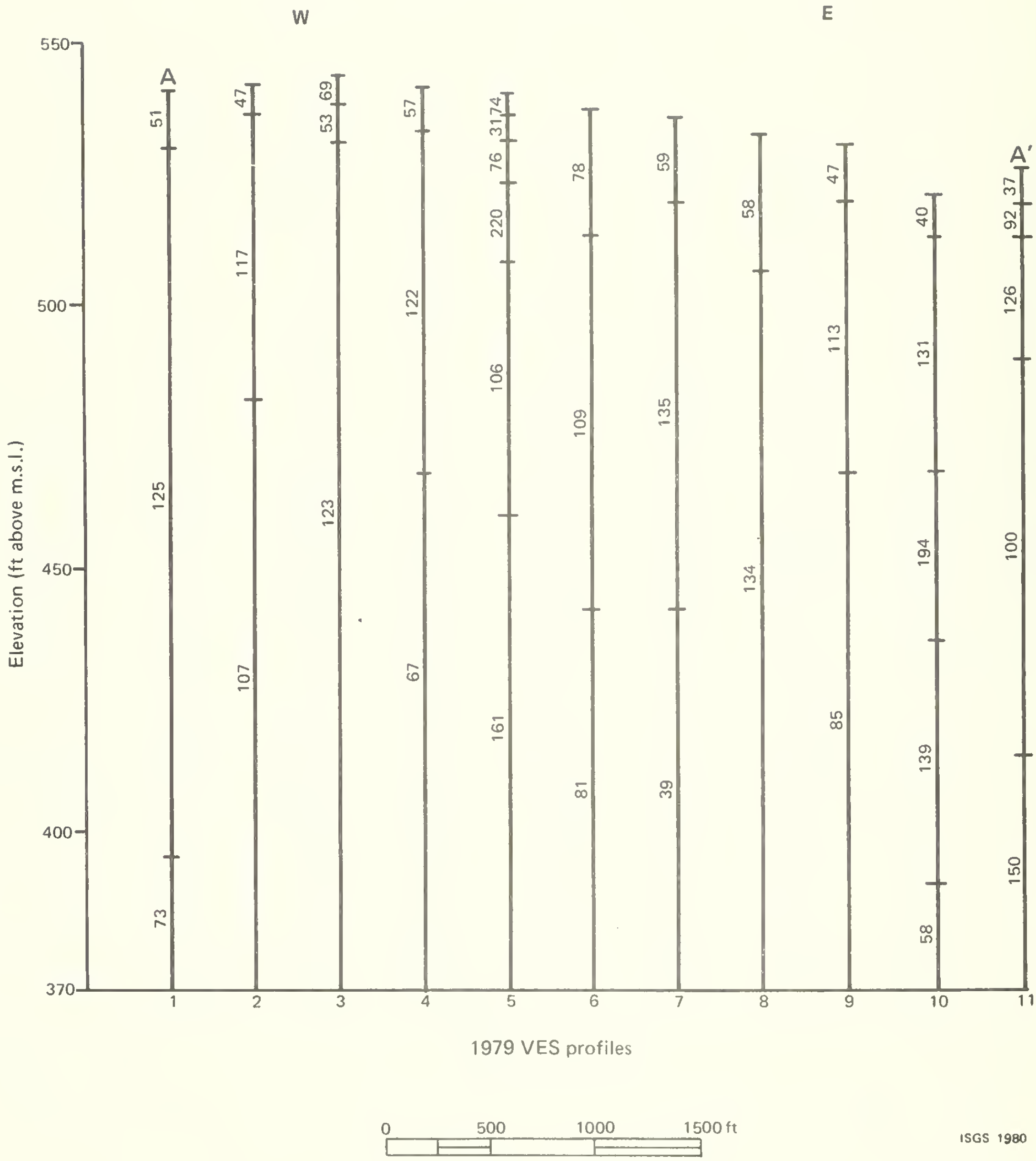

Figure 5a. Hamel study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line AA' (see fig. 4). "True" resistivity values are in ohm-feet.

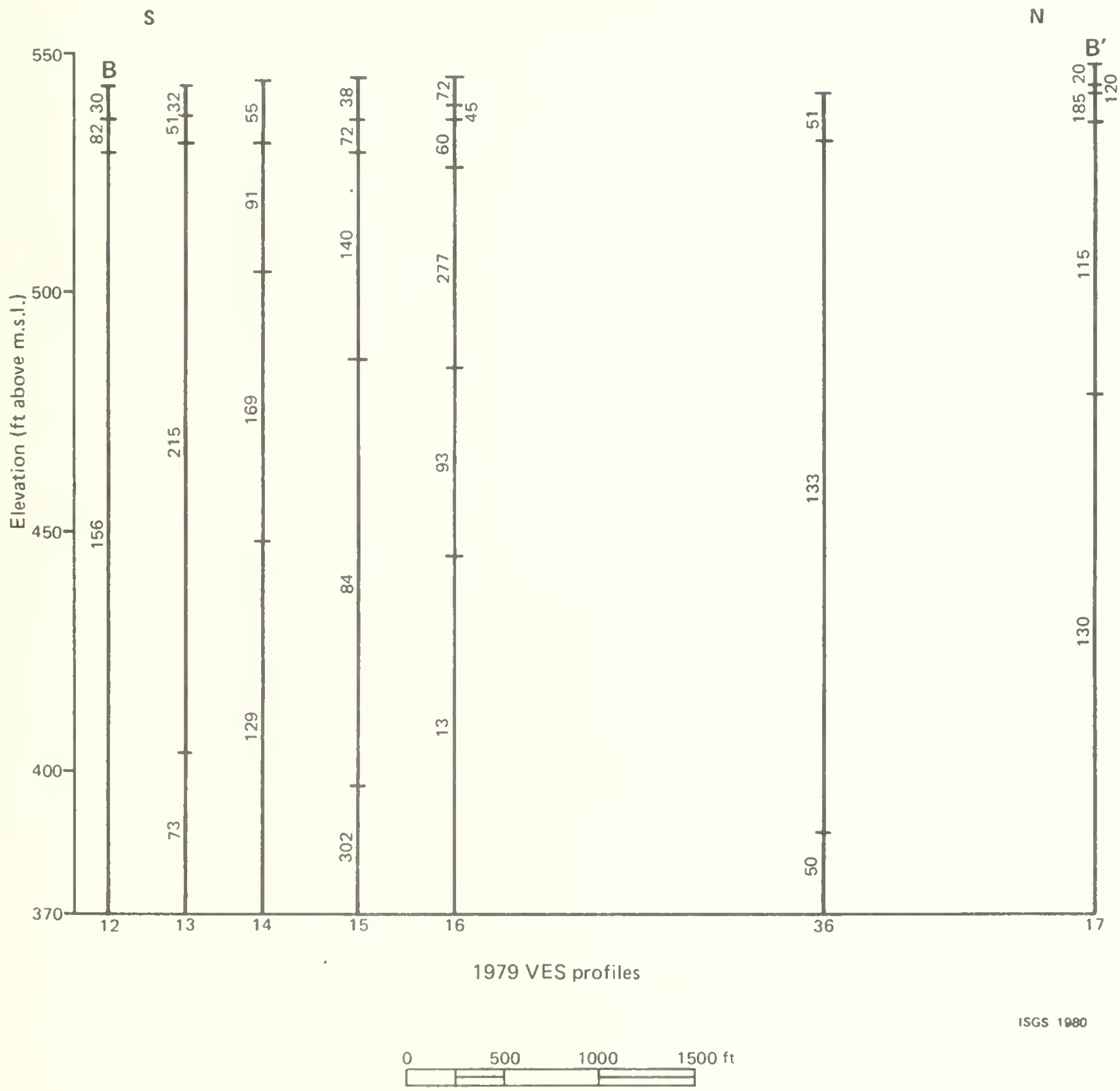

Figure 5b. Hamel study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line BB' (see fig. 4). "True" resistivity values are in ohm-feet.

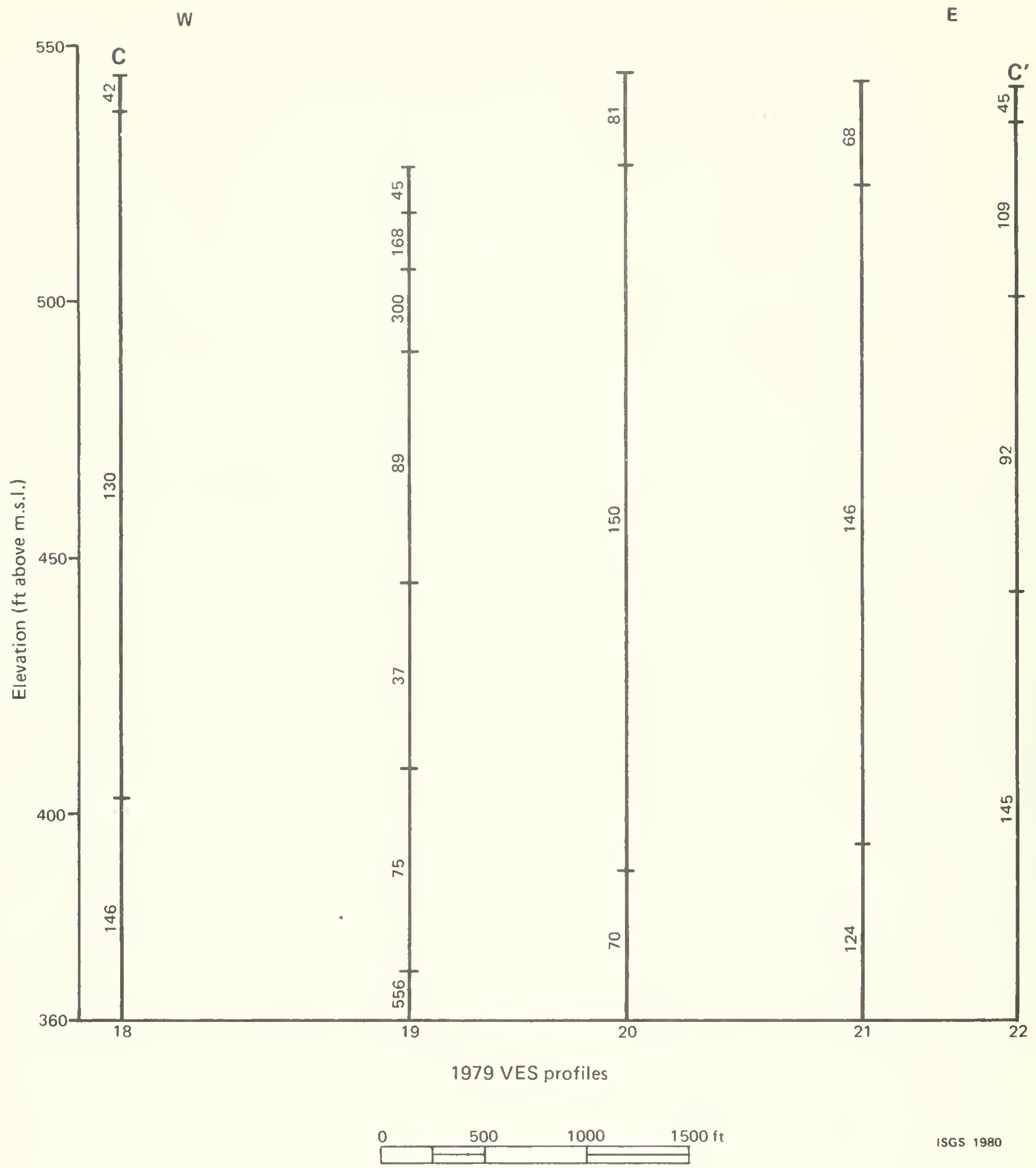

Figure 5c. Hamel study area. Layering parameters ("true" resistivity and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line CC' (see fig. 4). "True" resistivity values are in ohm-feet.

The north-south line BB' of VES profiles (fig. 5b), along the western side of Sec. 7, T. 5 N., R. 6 W., transects the width of the bedrock valley shown by Visocky et al. (1978). Both the VES curves and their inversions substantiate the presence of this valley below VES profiles 12 through 16. Apparent and "true" resistivity values, which are significantly greater here than elsewhere in the area, are indicative of coarse-grained, water-bearing deposits within the bedrock valley.

The east-west line CC' of VES profiles (fig. 5c), is located along the north line of Sec. 8, T. 5 N., T. 6 W. Well data in this area, although sparse, show that the buried bedrock valley turns to the northeast and becomes narrower and shallower in that direction. As a result, the eastern end of this line of VES profiles may lie within the lateral boundaries of the valley although the western end of the line may not. The VES curves and their inversions, obtained from the VES profiles along line CC', do not conclusively indicate the position of the buried bedrock valley. Apparent and "true" resistivity values associated with the unconsolidated deposits along line CC' are slightly greater than those along line AA', but are less than the most promising values along line BB'.

Resistivity data collected in the Cahokia Creek bottomlands indicate that sand and gravel deposits, similar to those from which the town of Worden obtains its current water supply, are present and likely are continuous to the north and the south of the Worden municipal well field. "True" resistivity values of the unconsolidated deposits in the Cahokia Creek bottomlands are equal to or greater than the values associated with the unconsolidated deposits along line BB' (fig. 5b).

In summary, there are two promising locations for test drilling for future municipal well sites: (1) at VES profile 13 or 16 along line BB' in the southwestern portion of Sec. 7, T. 5 N., R. 6 W.; and (2) in the Cahokia Creek bottomlands south of the Worden municipal well field. The first site should be the primary choice owing to its position less than a mile from Hamel's current well field and its proximity to Hamel. The second site would likely have greater water-producing capability, but in addition to the disadvantage of its greater distance from Hamel, any water-supply wells would have to be located to avoid mutual interference with those serving Worden.

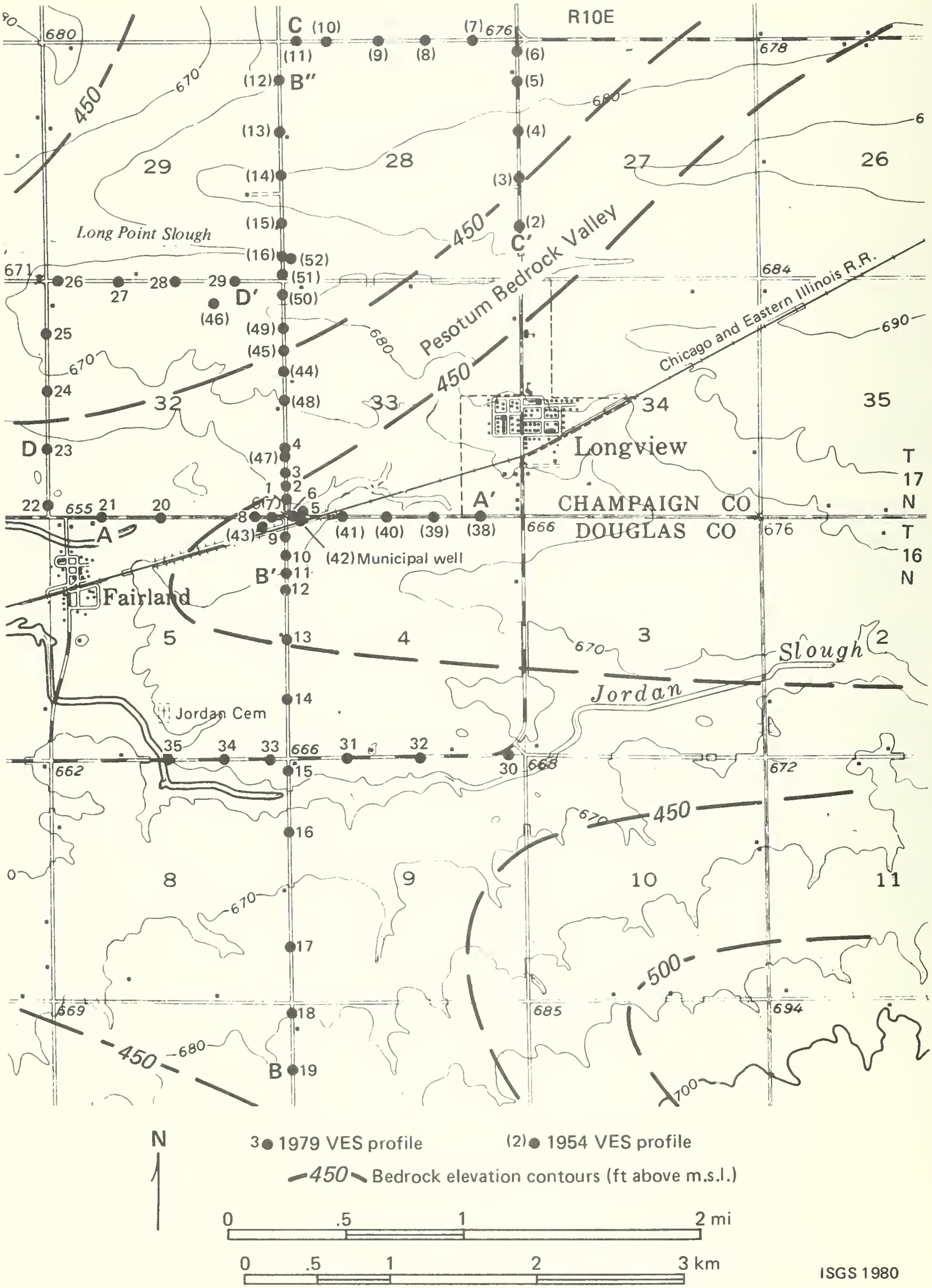

Figure 6. Longview study area.

Longview

The village of Longview (population 224), located in the southeastern portion of Champaign County, Secs. 33 and 34, T. 17 N., R. 10 E. (fig. 6), was identified as having experienced water shortages during the drought of 1976-1977 (Visocky et al., 1978). The population of Longview is not projected to increase by any significant amount by the year 2000; however, based on its past shortages and the fair possibility of obtaining a greater water supply from the glacial drift, the village of Longview was chosen for supplemental electrical resistivity surveying during 1979 as an aid to siting new municipal wells.

Longview physiographically lies in the Bloomington Ridged Plain area of the Till Plains Section of the Central Lowland Province. This area has prominent glacial topography characteristic of Wisconsinan glaciation. Several glacial moraines in the area immediately surrounding Longview give the topography a flat to gently rolling appearance. The Hildreth Moraine, a narrow elongate ridge, lies just to the east of town in Secs. 34 and 35, T. 17 N., R. 10 E. A remnant of the Hildreth Moraine also forms a subdued rise about 2 miles northwest of town in Sec. 29, T. 17 N., R. 10 E. Drainage in the area around Longview is westward through Jordan and Longpoint Sloughs, which join the south-flowing Embarras River at Villa Grove.

The shallow bedrock in the Longview area consists of shale, sandstone, limestone, and coal of the Pennsylvanian Carbondale Formation. Where present, the sandstone and rarely the limestone yield only small domestic supplies of water and cannot be considered a likely source of moderate to large supplies of ground water, such as is needed for a municipal supply. The predominant topographic feature of the bedrock surface is the Pesotum Bedrock Valley (fig. 6). Although this east-west trending tributary of the Mahomet Bedrock Valley is not as well developed as it is to the west, the Pesotum is incised to elevations of less than 450 feet at several locations in the area.

The unconsolidated Pleistocene glacial drift in the Longview area consists of ice-laid till, water-laid silt, sand and gravel outwash, and wind-blown silt (loess). The drift is pre-Illinoian, Illinoian, and Wisconsinan in age and ranges in thickness from 75 feet over shallow bedrock to about 250 feet over the buried Pesotum Bedrock Valley. Sand and gravel deposits within the Pesotum Bedrock Valley appear to be neither as thick nor as extensive as ones found within other valleys of similar type. Where present in the drift, sand and gravel deposits usually occur at three depth intervals: 30 to 70 feet, 80 to 130 feet, and at the base of the drift, below about 170 feet (within the bedrock valley). The scattered well data of the area indicate sizable sand and gravel deposits are present but discontinuous. Most water-producing wells in the area tap these sand and gravel deposits.

The only well presently providing water for Longview is located 36 feet south and 288 feet east of the northwest corner of Sec. 4, T. 16 N., R. 10 E., Douglas County (fig. 6). This well, drilled to a depth of 50 feet, penetrates 20 feet of sand and gravel. Pumpage yields 60 gal/min and currently averages 21,000 gal/day. For years of normal to below normal precipitation, estimates show the sustained yield would be about 20,000 gal/day.

Visocky et al. (1978) recommended three areas near the village of Longview for further electrical earth resistivity surveying: (1) the area around the present municipal well (this deposit may be large enough to support an additional well); (2) those areas where the Pesotum Bedrock Valley is deepest and where sand and gravel deposits may be present at the base of the pre-Illinoian drift; and (3) the area near the northeast corner of Sec. 28, T. 17 N., R. 10 E., where logs of oil wells (generally of questionable accuracy when describing glacial drift) indicate some moderate, but unconfirmed deposits of sand and gravel.

In order to determine whether the present municipal supply deposit is large enough to handle an additional well, east-west (AA') and north-south lines (BB' and B'B") of VES profiles were centered about the municipal well near the northwest corner of Sec. 4, T. 16 N., R. 10 E. (figs. 7a, 7b). Inversion of the VES curves associated with these profiles indicates that within a half-mile radius of the municipal wells, the "true" resistivity values of the near-surface, unconsolidated sediments are essentially uniform. Any future well(s) drilled within that area (half-mile radius) probably would have a water-producing capability similar to the municipal well. Care must be exercised in the placement, construction, and operation of additional wells within this area to avoid deleterious effects at the municipal well. The most favored directions seem to be north, west, and east—not south.

To assess the deepest unconsolidated sediments (pre-Illinoian) in the Longview area as a source of ground water, VES curves from several long vertical electrical sounding profiles over the Pesotum Bedrock Valley were inverted. Inversion of a VES curve provides layering parameters ("true" resistivities and thicknesses) for the earth materials below the center stake of the corresponding VES profile. The results of the inversion technique did not reveal any deep, unconsolidated deposits with "true" resistivity values appreciably greater than those routinely found in the shallower sediments. Resistivity data do not show that drilling for deep aquifers in the unconsolidated sediments in the Longview area is warranted.

Inversion of the curves of line CC' of VES profiles around the northeast corner of Sec. 28, T. 17 N., R. 10 E. (fig. 7c), where an oil test indicated a moderate sand and gravel deposit, shows "true" resistivity values of the shallow, unconsolidated deposits to be similar to those around the Longview municipal well. Along this line, profiles 3 and 4 (1954 survey, fig. 7c, approximately one-half mile south of the

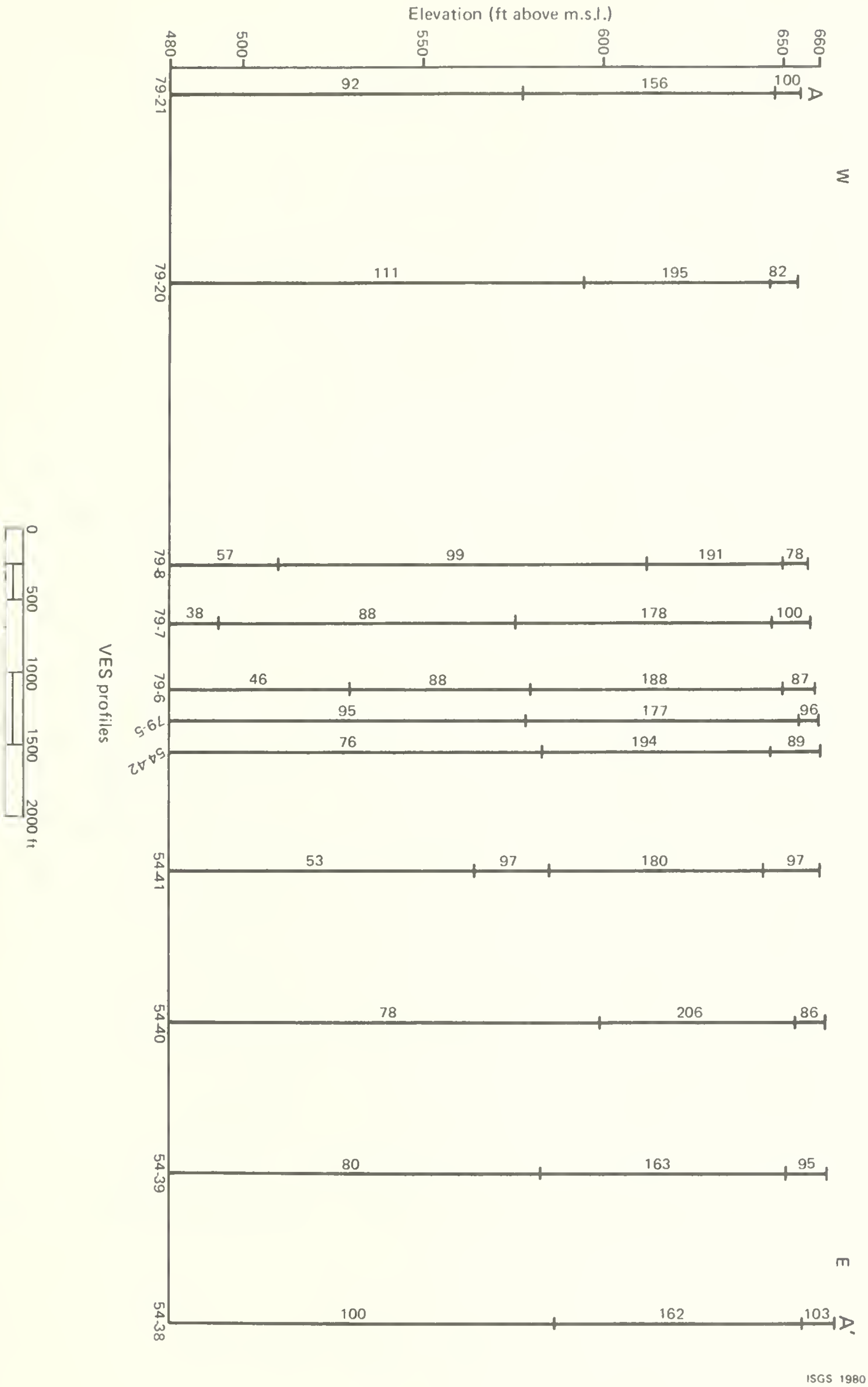

Figure 7a. Longview study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line AA' (see fig. 6). "True" resistivity values are in ohm-feet.

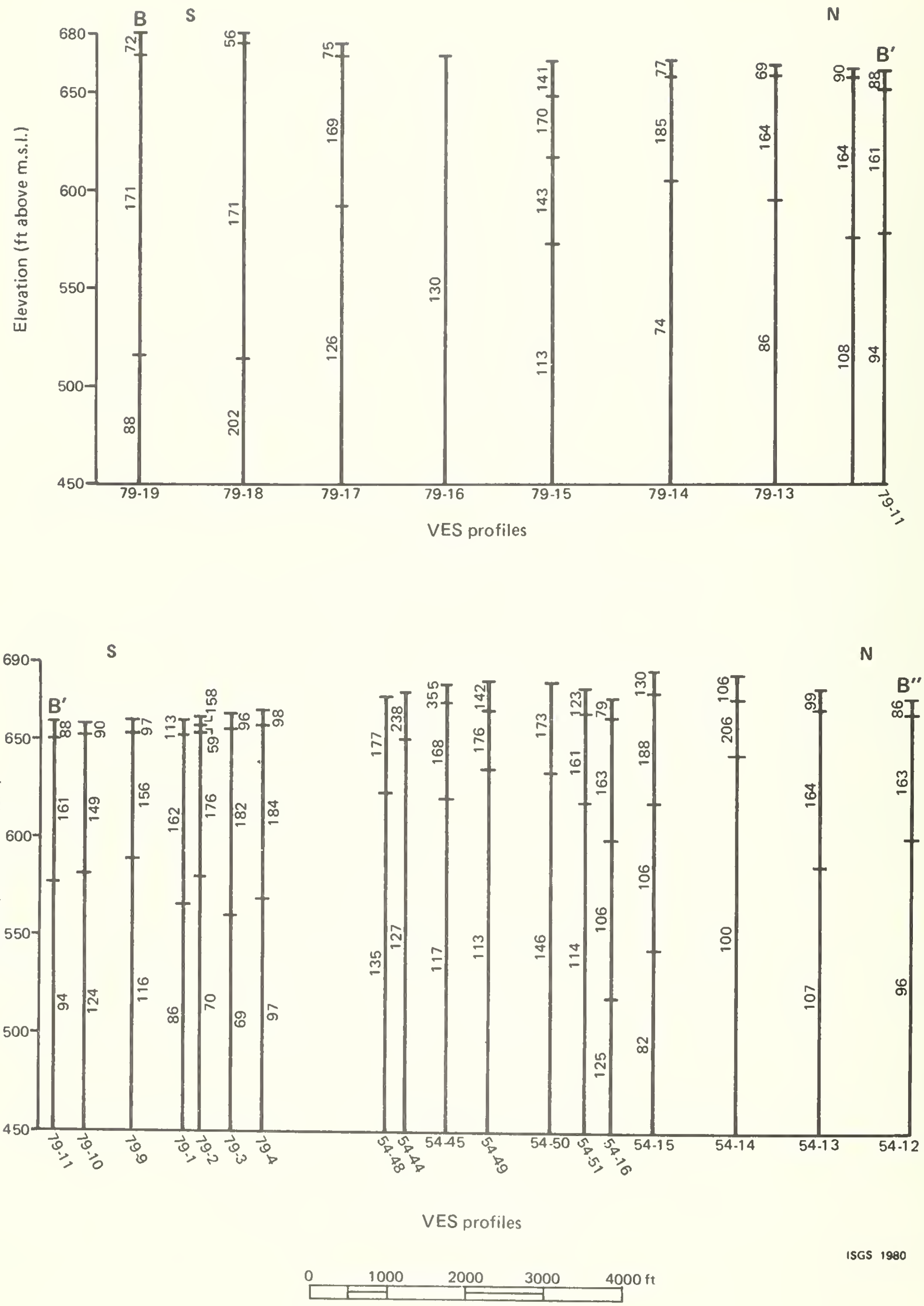

Figure 7b. Longview study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line BB′ (see fig. 6). "True" resistivity values are in ohm-feet.

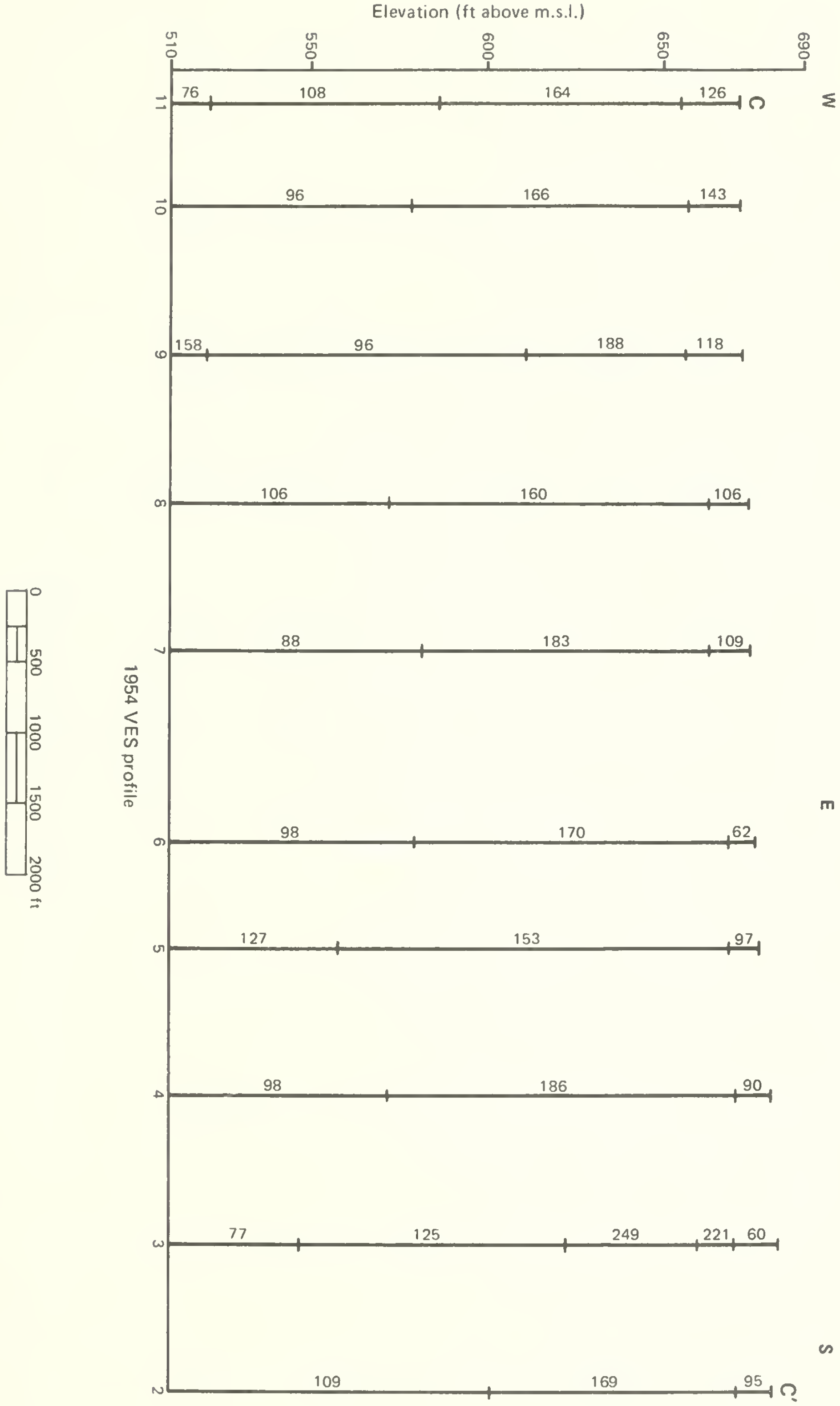

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Figure 7c. Longview study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line CC' (see fig. 6). "True" resistivity values are in ohm-feet.

northeast corner of Sec. 28, T. 17 N., R. 10 E., look most promising as sites where drilling for shallow aquifers should be attempted. These profiles are approximately the same distance (one mile) from town as the present municipal well.

On the basis of all the electrical earth resistivity surveying done in the Longview area, it appears that there are no aquifers in the unconsolidated deposits significantly better than that tapped by the present municipal well. There are locations, such as profiles 3 and 4 (fig. 6) along the east line of Sec. 28, T. 17 N., R. 10 E., and profiles 24 through 28 near the northwest corner of Sec. 32, T. 17 N., R. 10 E. (DD', figs. 6, 7d), where future test drilling can be considered. Although there are no resistivity or well data in the central portion of Sec. 32, T. 17 N., R. 10 E., there is a strong possibility that the deposit tapped by the present municipal well might be continuous in a northwesterly direction. Resistivity values are similar to those at the municipal well at least to the northwest corner of Section 32. A location northwest of the present well would be optimal for test drilling.

In summary, recommended test drilling sites in the Longview area are: (1) within a half-mile radius of the municipal well (to the northwest is the preferred direction); (2) near profiles 3 and 4 of the 1954 survey (east half of east line of Sec. 28, T. 17 N., R. 10 E.); and (3) around profiles 24 through 28 (1979 survey) near the northwest corner of Sec. 32, T. 17 N., R. 10 E., where resistivity values of the shallow unconsolidated deposits are comparable to those found at the present well site.

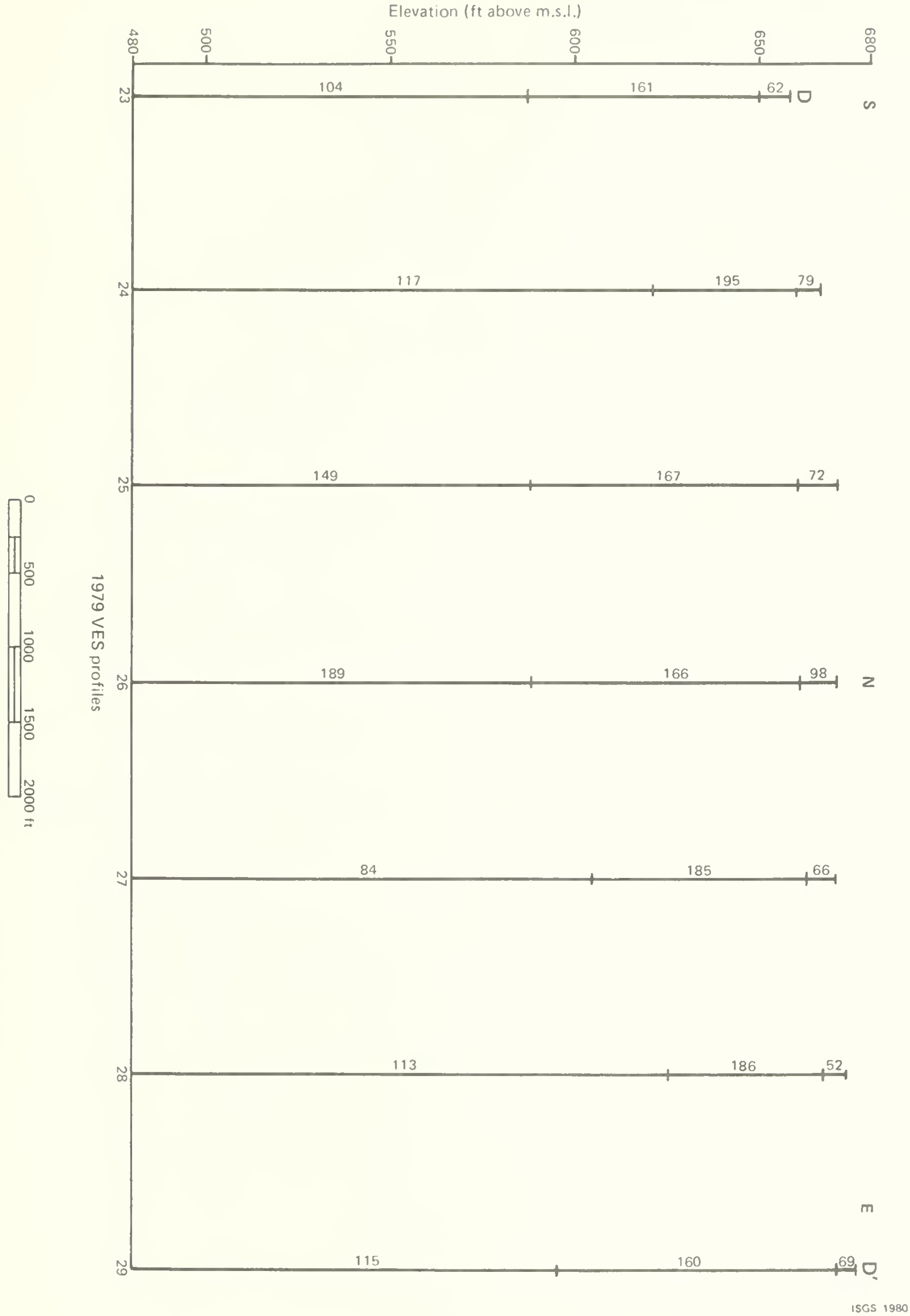

Figure 7d. Longview study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line DD' (see fig. 6). "True" resistivity values are in ohm-feet.

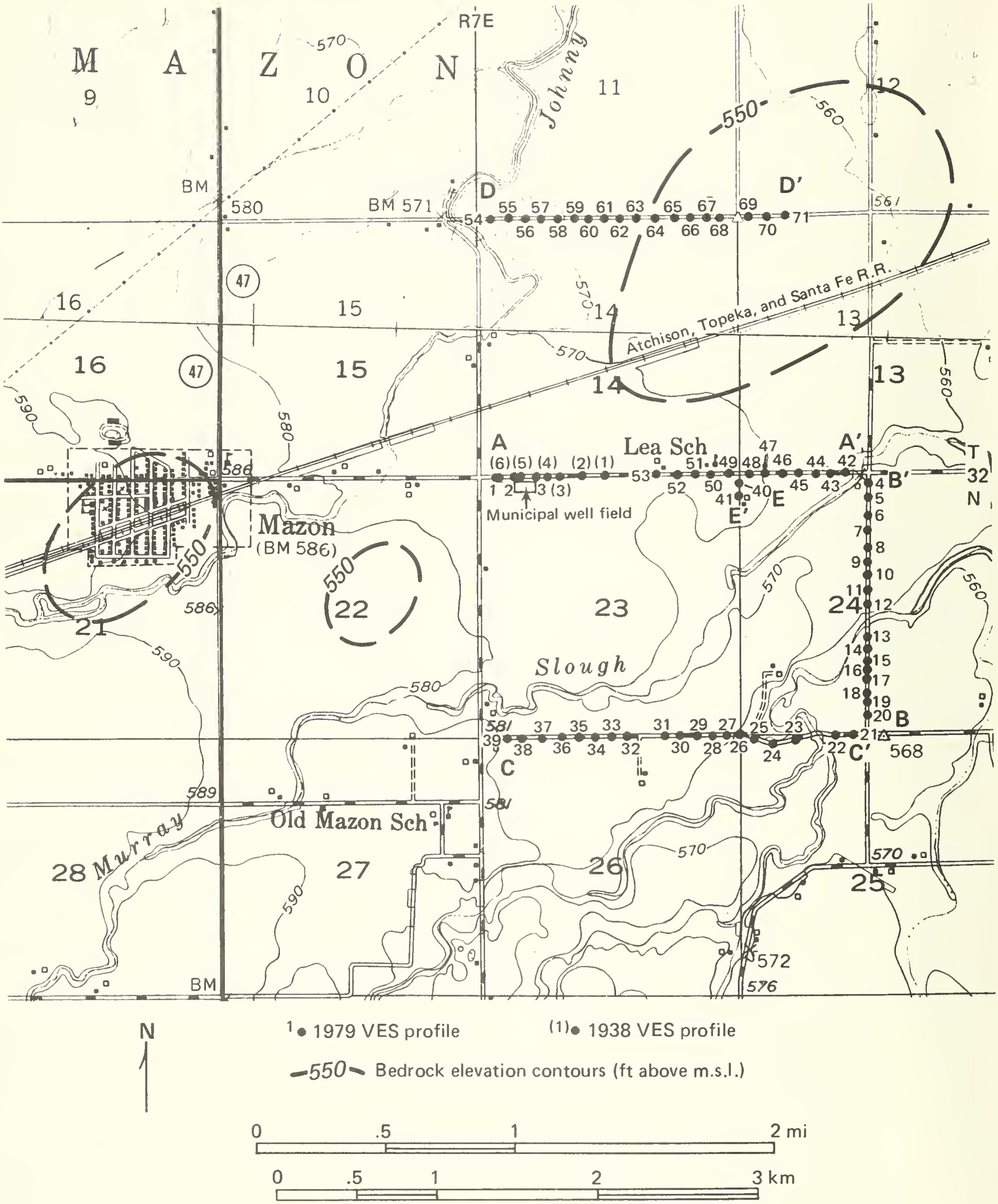

Figure 8. Mazon study area.

Mazon

The village of Mazon (population 727), located in south-central Grundy County, portions of Secs. 15, 16, 21, and 22, T. 32 N., R. 7 E. (fig. 8), experienced water shortages during the drought of 1976-1977 (Visocky et al., 1978). The population of Mazon is projected to remain the same or increase slightly by the year 2000. Pumpage of the current municipal supply is close to the long-term practical sustained yield under normal climatic conditions. The shallow depth of the aquifer that currently provides the municipal water supply makes it extremely sensitive to periods of prolonged drought, when the normal yield can be reduced by as much as 50 percent. On the basis of its frequent past shortages, possible increased need in the future, and the fair possibility of obtaining a greater supply from the glacial drift, the village of Mazon was chosen for supplemental electrical earth resistivity surveying as an aid to siting new municipal wells.

Physiographically, the Mazon area is situated in the Kankakee Plain of the Till Plains Section of the Central Lowland Province. It lies on a nearly flat Wisconsinan till plain (regional slope 10 feet per mile to the northeast) containing thin intercolated lake sediment deposits. Drainage for the area, provided by the small streams Johnny Run, Murray Slough, and the West Fork of the Mazon River, is to the northeast.

The shallow bedrock in the Mazon area consists of shale, sandstone, limestone, coal, and underclay of the Pennsylvanian Carbondale Formation. Wells developed in the bedrock generally yield only very small domestic supplies of water of highly variable quality. Many of the water wells are described as being murky or having an oil show. The unconsolidated Pleistocene glacial drift in the Mazon area consists of a Wisconsinan complex of ice-laid till, water-laid outwash, alluvium and lacustrine deposits, and wind-blown silt (loess). Drift thickness ranges from 7 to 45 feet and the blanketing loess averages less than 26 inches thick. Because many of the shallow deposits of the area were formed in a glacial lake, sand and gravel deposits are likely to be thin and scattered, and contain a high percentage of silt and clay. Sand and gravel deposits such as those currently providing Mazon's municipal water supply developed as a delta, beach, or alluvial fan on the shore of the former glacial Lake Wauponsee and have a lesser amount of silt and clay and are of greater thickness and extent.

The four wells providing water for Mazon as of 1978 are located within a 105 by 110 foot fenced area one mile east of town in the northwest corner of Sec. 23, T. 32 N., R. 7 E., Grundy County (fig. 8). Two additional wells within this area have been abandoned. All wells were drilled to a depth of 25 or 26 feet and are cased to the bottom with screening in the last 6 or 9 feet. The wells reportedly yield 44, 25, 50, and 6 gal/min, and pumpage averages 75,000 gal/day. For years of normal to below normal precipitation it is estimated that the sustained yield would be about 60 gal/min or 85,000 gal/day. Two new wells have recently been finished in the same 105 by 110 foot area. Although specific information on the new wells was unavailable, the revised EPA pumpage estimate for the entire well field has been raised to 108,000 gal/day. This yield can be reduced by as much as 50 percent during periods of prolonged drought.

Visocky et al. (1978) recommended supplemental electrical earth resistivity surveying to ascertain the areal extent of the deposit currently providing the water supply for Mazon. In response to that recommendation, lines of VES profiles were located through and around the current municipal well field (fig. 8).

The east-west line AA' of VES profiles (fig. 9a) is located along the north line of Sec. 23 and west half of the north line of Sec. 24, T. 32 N., R. 7 E. VES profiles 1, 2, and 3 of this line are located in the immediate vicinity of the municipal well field. Heavy pumpage of an aquifer over such a small area often results in a dewatering of the upper portion of the aquifer, an effect more pronounced in seasons of drought. A comparison of 1979 resistivity data (VES profiles 1, 2, and 3) with data obtained prior to the construction of the well field (1938 VES profiles 3, 4, 5, and 6, fig. 9a) indicates a significant dewatering of the aquifer in the immediate vicinity of the well field. No VES profile locations are recommended for test drilling along line AA' (fig. 9a).

The north-south line BB' of VES profiles (fig. 9b) is located along the center line of Sec. 24, T. 32 N., R. 7 E. "True" resistivity values of this line are similar to those of the eastern half of AA' (fig. 9a) and significantly less than those obtained near the municipal well field. No VES profile locations are recommended for test drilling along line BB' (fig. 9b).

The east-west lines CC' and DD' of VES profiles (figs. 9c and 9d) are respectively located 1 mile south and 1 mile north of line AA'. Inversion of VES curves obtained from VES profiles 39, 38, and 32, south of the well field (fig. 9c), and 65, 67, and 68, northeast of the well field (fig. 9d), have yielded layering parameters indicative of the presence of the aquifer tapped by the municipal wells at those locations. However, values obtained at VES profiles 65, 67, and 68 may be due to the shallow depth of bedrock. This evidence, air photos of the area, and the sand and gravel observed in 9 test holes drilled north and south of the municipal well field in 1977 are consistent with interpretation of the lateral extent of the aquifer shown in figure 31

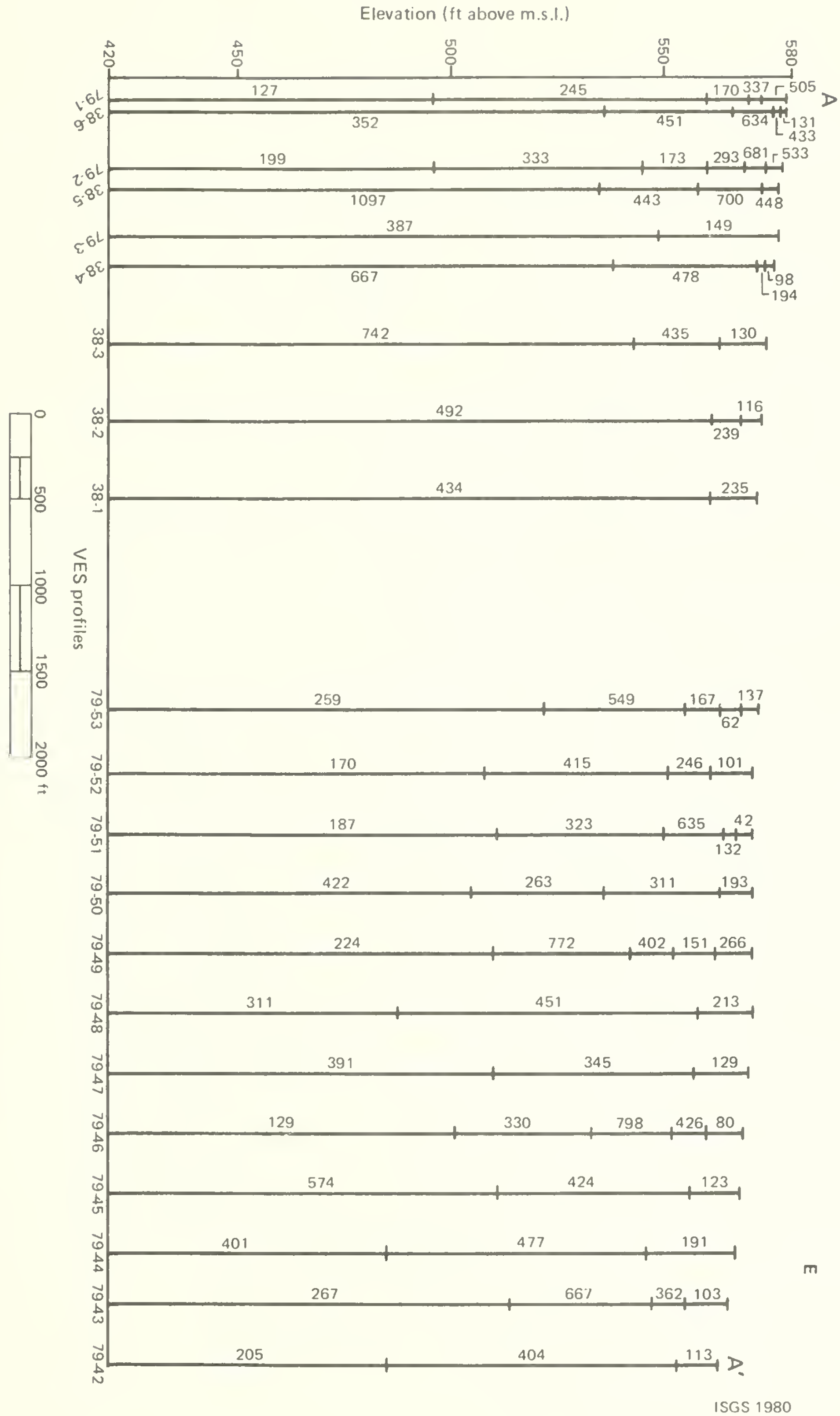

Figure 9a. Mazon study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line AA' (see fig. 8). "True" resistivity values are in ohm-feet.

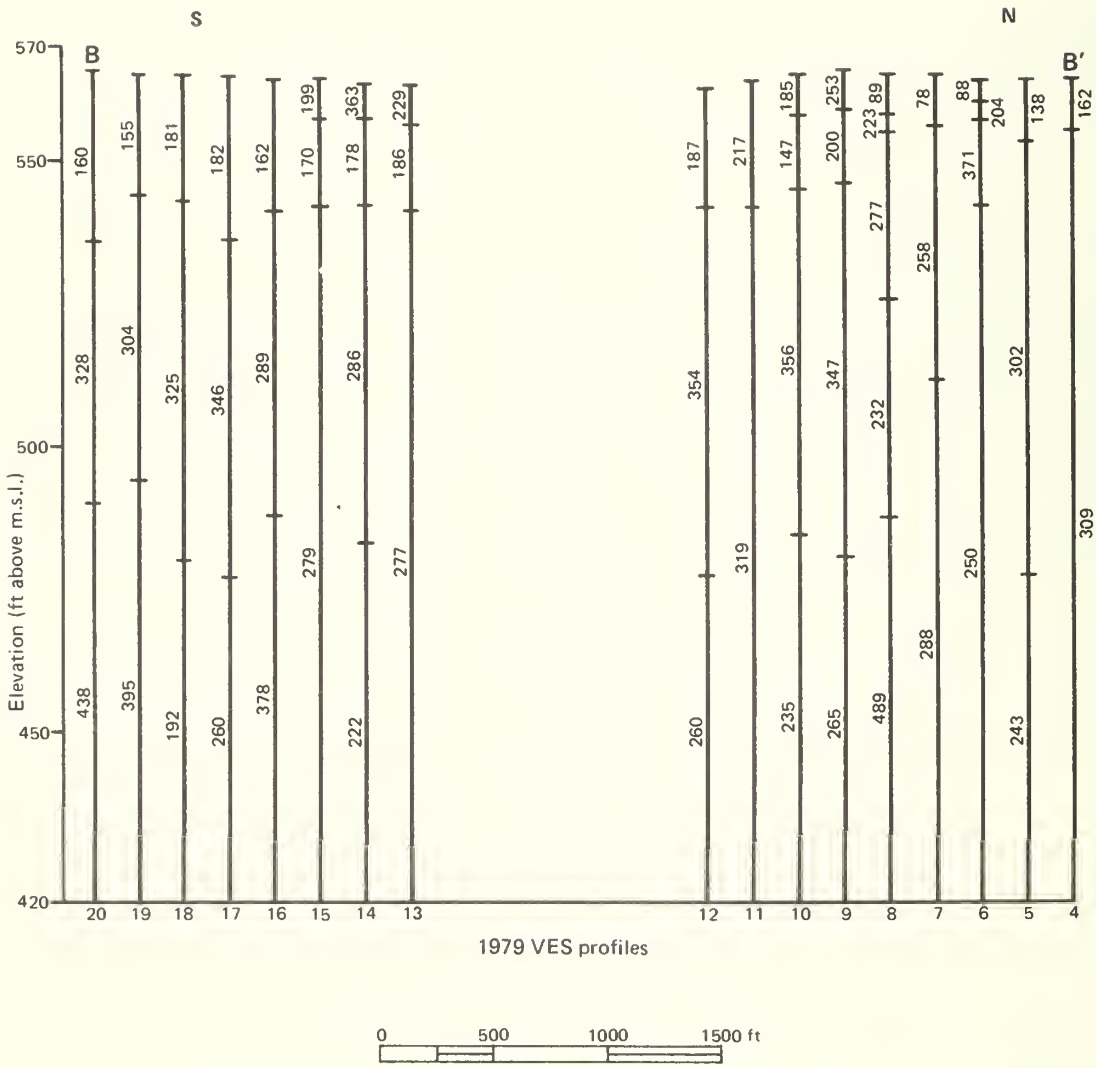

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Figure 9b. Mazon study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line BB' (see fig. 8). "True" resistivity values are in ohm-feet.

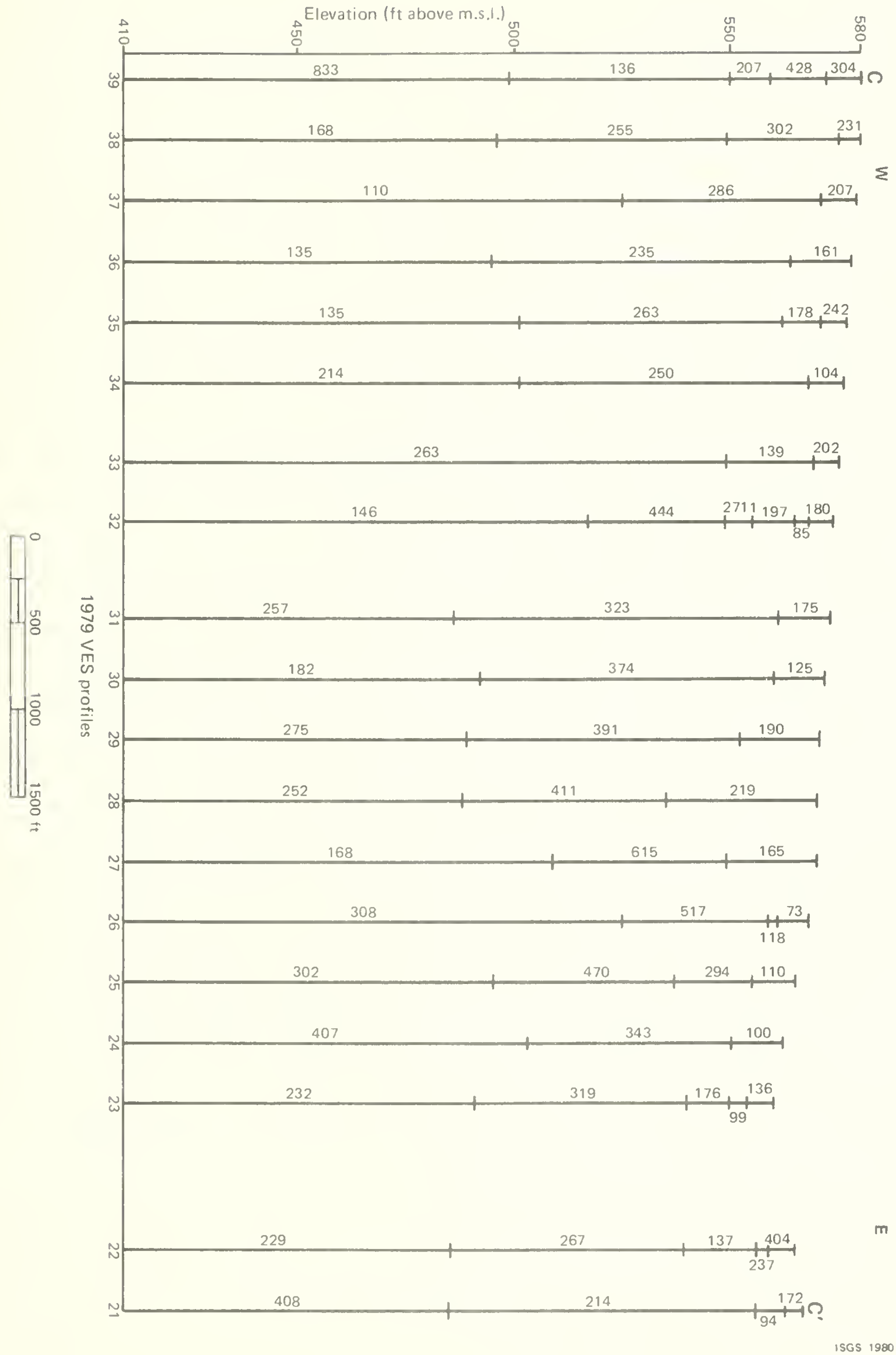

Figure 9c. Mazon study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line CC' (see fig. 8). "True" resistivity values are in ohm-feet.

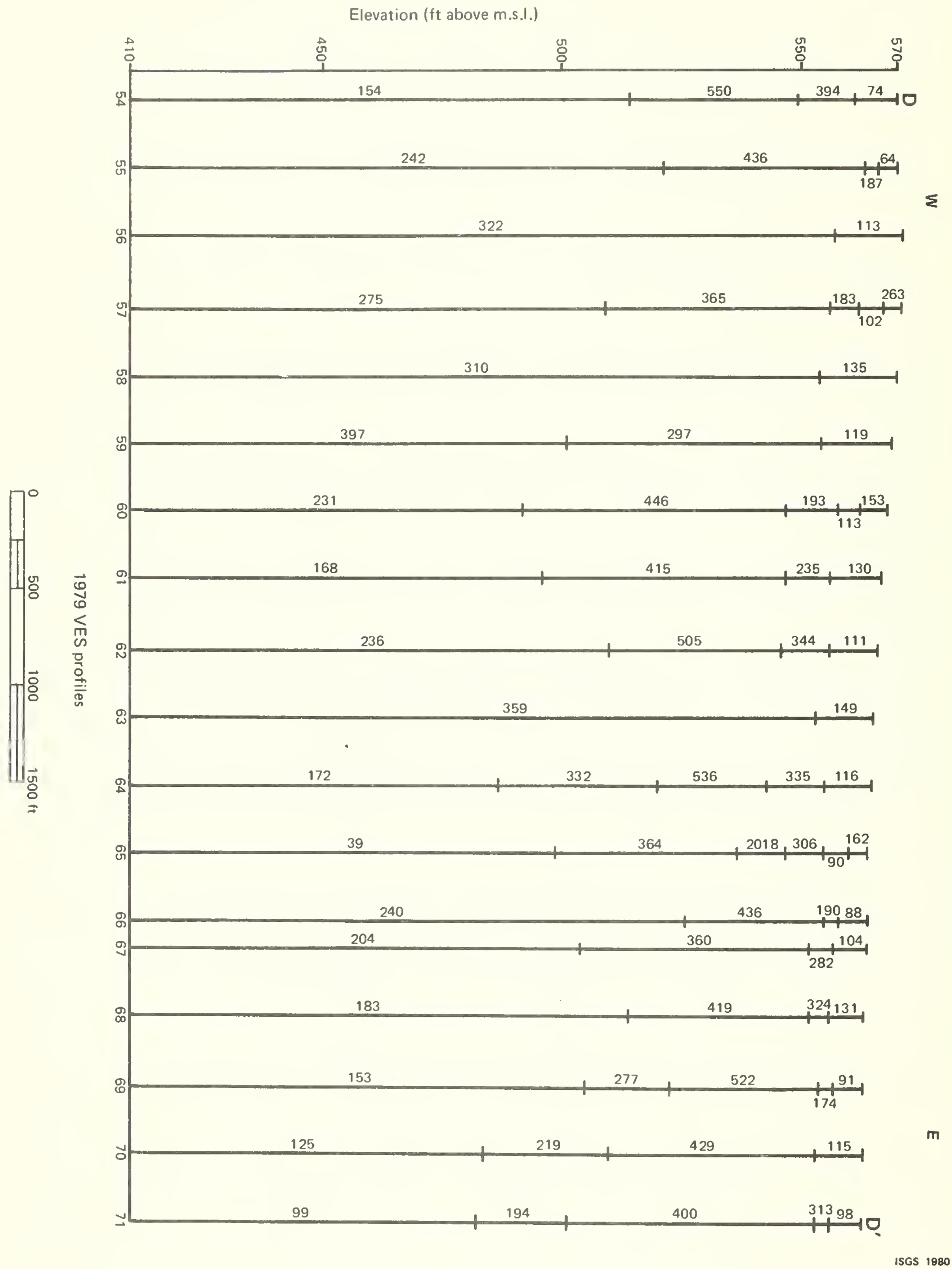

Figure 9d. Mazon study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line DD' (see fig. 8). "True" resistivity values are in ohm-feet.

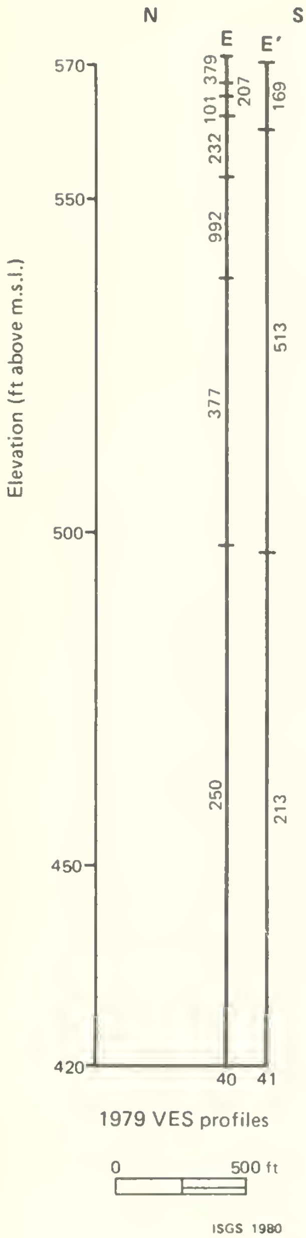

Figure 9e. Mazon study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding curves associated with VES profiles 40 and 41 (see fig. 8). "True" resistivity values are in ohm-feet.

of the Visocky et al. (1978) report. That figure shows that the widest part of the aquifer is located in the central and southern portions of Sec. 23, T. 32 N., R. 7 E.

The north-south line EE' of VES profiles (fig. 9e) is located in the northeast corner of Sec. 23, T. 32 N., R. 7 E. "True" resistivity values of this line are indicative of bedrock lithology at a depth of 20 to 30 feet. No VES profile locations are recommended for test drilling along line EE' (fig. 9e).

In summary, it appears that the aquifer tapped by the current municipal well field extends one-half mile northeast and at least one mile south of the well field. Any test drilling for future well sites should be located between the current well field and VES profiles 65, 67, and 68 to the northeast and VES profiles 39, 38, and 32 to the south; a southern direction should have the higher priority. In the event test drilling confirms the extent of the aquifer indicated by the resistivity data, future municipal wells should be sufficiently spaced to reduce the possibility of mutual interference between wells, which could result in greater dewatering of the aquifer, especially during times when recharge to the aquifer is minimal.

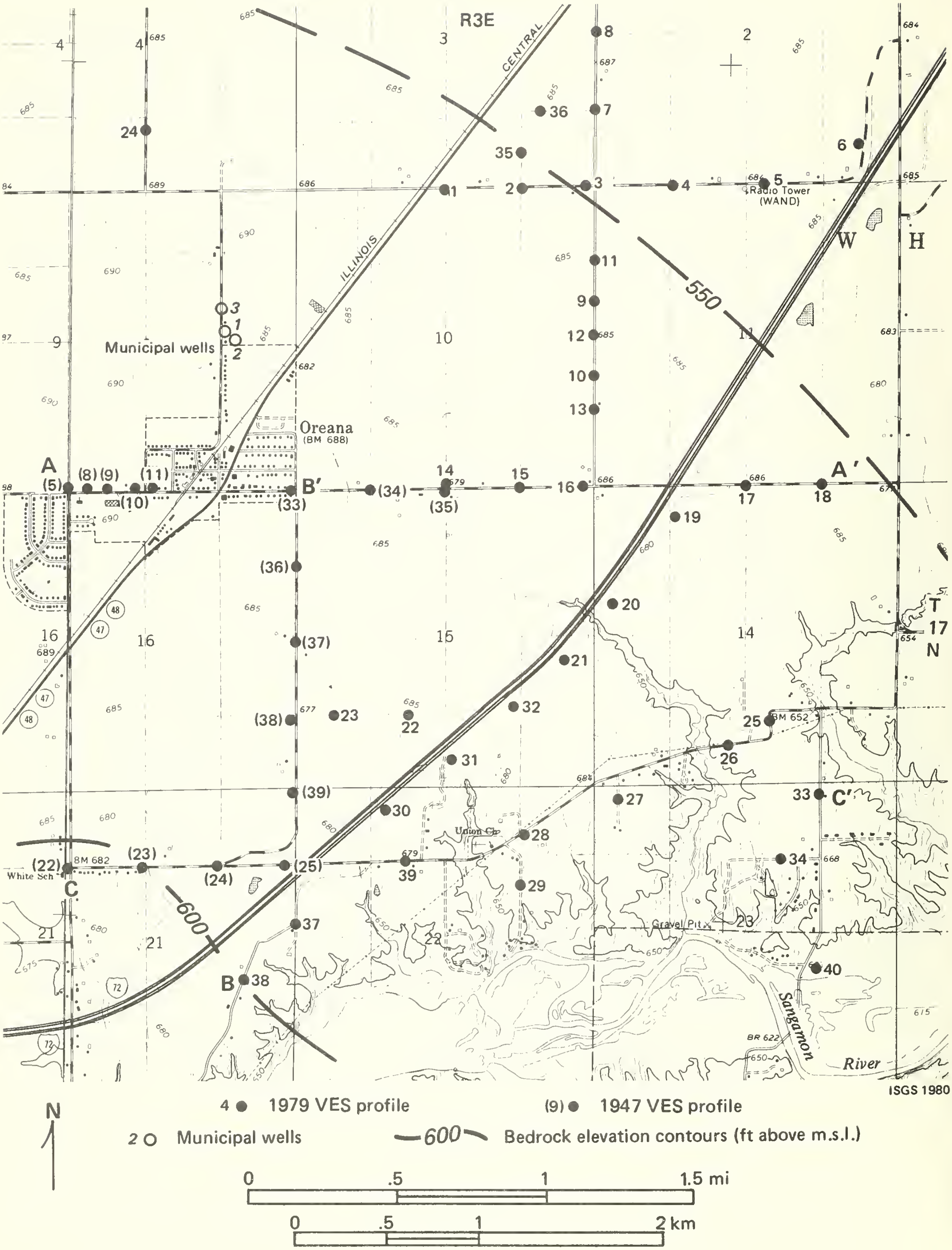

Figure 10. Oreana study area.

Oreana

The village of Oreana (population 1,092), located in the north-central portion of Macon County, portions of Secs. 9 and 16, T. 17 N., R. 3 E. (fig. 10), experienced water shortages during the drought of 1976-1977 (Visocky et al., 1978). The population of Oreana is projected to increase by the year 2000. Water consumption is also expected to exceed the present wells' long-term practical sustained yield. Oreana was chosen for supplemental electrical earth resistivity surveying during 1979 as an aid to siting new municipal wells.

Oreana lies in the Bloomington Ridged Plain area of the Till Plains Section of the Central Lowland Province on a nearly flat upland ground moraine of Wisconsinan age. It is situated east of the Shelbyville Morainic System, west of the Cerro Gordo Moraine, and is approximately 2 miles north of the Sangamon River. Several small streams flow southward following a gentle regional slope toward the Sangamon River. Changes in the topography are locally more pronounced along these streams and the river.

The shallow bedrock around Oreana consists of shale, limestone, sandstone, siltstone, and coal of the Pennsylvanian Bond Formation. Shale and limestone, not water-bearing, are predominant. All water wells are finished in the glacial drift, and there are no wells drilled to bedrock in the study area besides the test holes constructed by Oreana. Water obtained from the deeper bedrock is highly mineralized. Topography of the bedrock surface is nearly flat. Elevation of the bedrock is between 550 and 600 feet m.s.l. and increases slightly toward the south.

The unconsolidated Pleistocene glacial drift in the Oreana area consists of a complex of ice-laid till, water-laid clay, silt, sand and gravel outwash and alluvium, and wind-blown silt (loess) of pre-Illinoian, Illinoian, and Wisconsinan age. Drift ranges from 145 to 170 feet thick and increases to the north. Thickness of the blanketing loess varies from 50 to 75 inches. Water-yielding sand and gravel deposits in the upland area around Oreana can be found throughout the glacial drift. Upper deposits are generally thin (less than 15 feet thick) and discontinuous but are sufficient for individual farm or residential water supplies. The sand and gravel deposit tapped by the Oreana town wells occurs near the base of the drift between elevations 550 and 570 feet and appears to be the most extensive deposit of sufficient thickness in the area to support municipal-size wells. It is possible that this deposit extends either continuously or discontinuously south and east as far as the Sangamon River.

The wells presently providing water for Oreana are located just north of town in the S½NE¼ Sec. 9. T. 17 N., R. 3 E., Macon County (fig. 10). Municipal Well 1 is located 2,950 feet north and 1,250 feet west of the southeast corner of Sec. 9, and Municipal Well 2 is 63 feet to the southeast of Well 1. A third municipal well is located 1,715 feet south and 1,275 feet west of the northeast corner of Sec. 9, T. 17 N., R. 3 E. All wells are about 130 feet deep and are cased to within 15 feet of the bottom. The sand and gravel deposit being tapped by Oreana has its maximum known thickness at Municipal Well 2, thins rapidly to the north, and becomes silty to the west. Although the water supply is currently sufficient during years of normal precipitation, well yield can be reduced by as much as 45 percent during drought. There has been a steady growth of water consumption at Oreana from 1960 to the present. As demand draws closer to the practical sustained yield of the wells, problems during periods of prolonged drought will increase.

In their 1978 report, Visocky et al. recommended that further ground-water exploration, employing a supplemental electrical earth resistivity survey, be expanded southward of the current municipal well through Sections 14, 15, 16, 21, 22, and 23 to and including the Sangamon River floodplain. They believed that new wells drilled within the immediate vicinity of the current wells would only serve to begin dewatering the upper portions of the aquifer in that area, but that any wells constructed around the southeast corner of Section 9, the southwest corner of Section 10, and farther south and east would be sufficiently distant as to avoid mutual interference.

In response to the recommendations of Visocky et al. (1978), VES profiles were located north, east, and south of the current municipal wells in portions of Secs. 2, 3, 4, 10, 11, 14, 15, 21, 22, and 23, T. 17 N., R. 3 E. (fig. 10). The majority of the profiles were located east of the municipal wells and south towards the Sangamon River.

Interpretation of the resistivity data consisted of construction, examination, and inversion (by the inversion technique of Zohdy and Bisdorf, 1975) of VES curves obtained from VES profiles, both present and past, located throughout the areas recommended for further exploration. Inversion of a VES curve provides layering parameters ("true" resistivities and thicknesses) for the earth materials below the center stake of the corresponding VES profile. Of particular interest were the results from three lines of VES profiles, AA', BB', and CC' (figs. 11a, 11b, and 11c).

Line AA' (fig. 11a) extends from VES profile 5 in the southeast corner SW¼ Sec. 9, T. 17 N., R. 3 E. to VES profile 18 in Section 11 and covers the nearest recommended area southeast of the present municipal well field. "True" resistivity values along this line are indicative of coarse-grained deposits within the glacial drift, particularly around VES profiles (33), (34), 14, and (35) along the south line of Sec. 10, T. 17 N., R. 3 E. Relatively large "true" resistivity values were also obtained from VES profiles (8), (11), and 17, from west to east along line AA'.

North-south line BB' (fig. 11b) was selected to determine whether the deposit tapped by the present municipal wells continued to the south. In general, "true" resistivity values associated with the unconsolidated deposits along this line are slightly less than those along line AA'. Individual VES profiles (33), (39), and 38, from north to south, showed "true" resistivity values

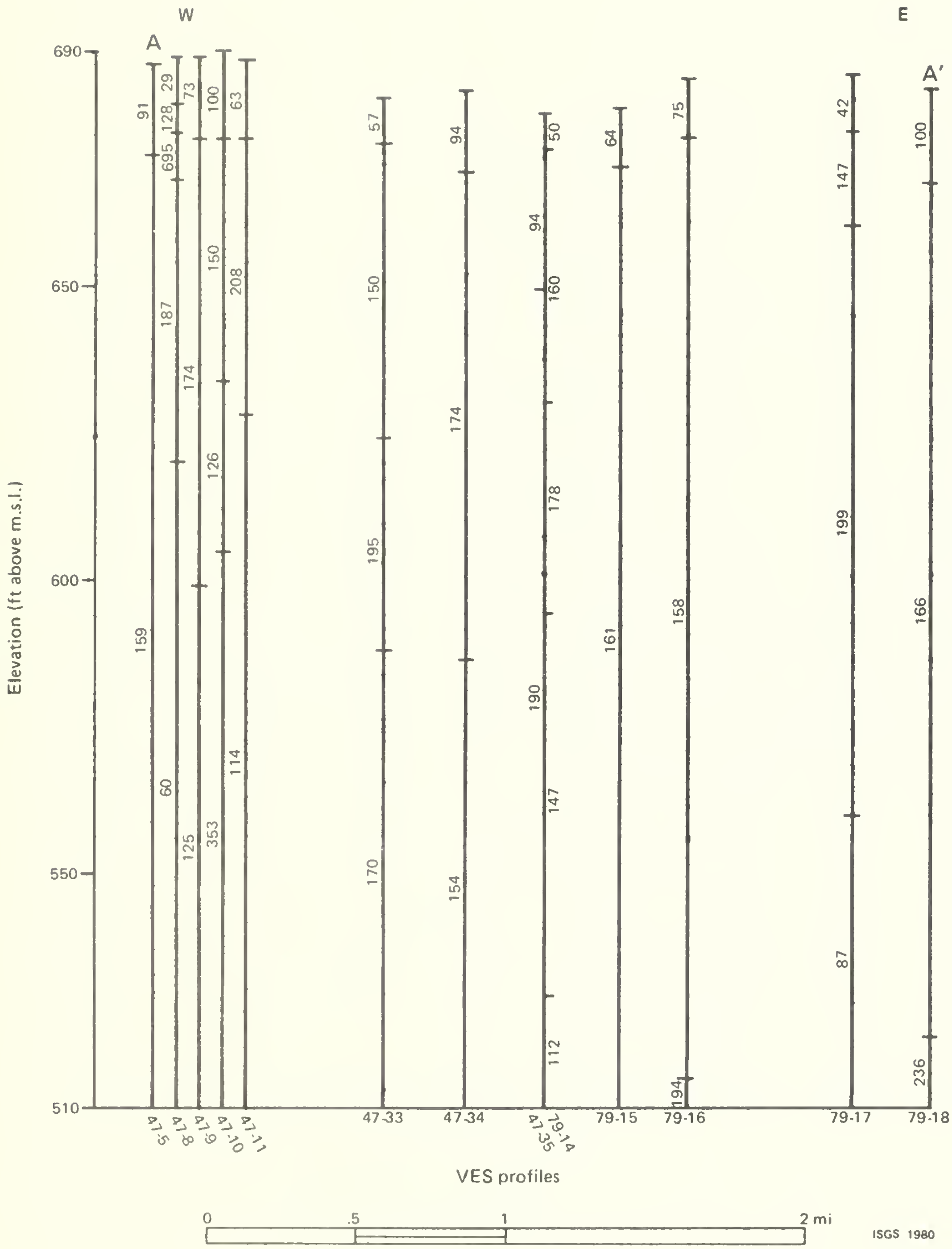

Figure 11a. Oreana study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line AA′ (see fig. 10). "True" resistivity values are in ohm-feet.

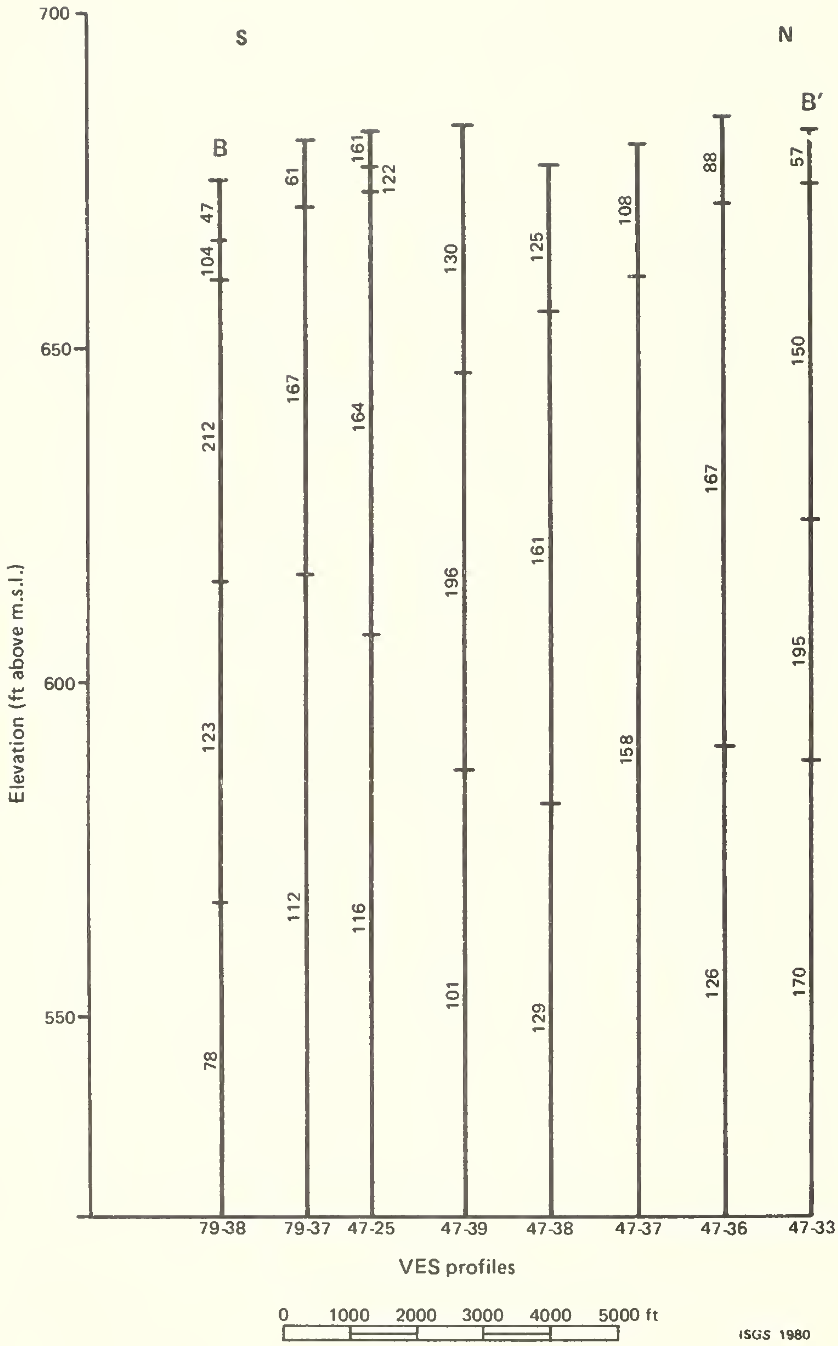

Figure 11b. Oreana study area. Layering parameters ("true"resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line BB' (see fig. 10). "True" resistivity values are in ohm-feet.

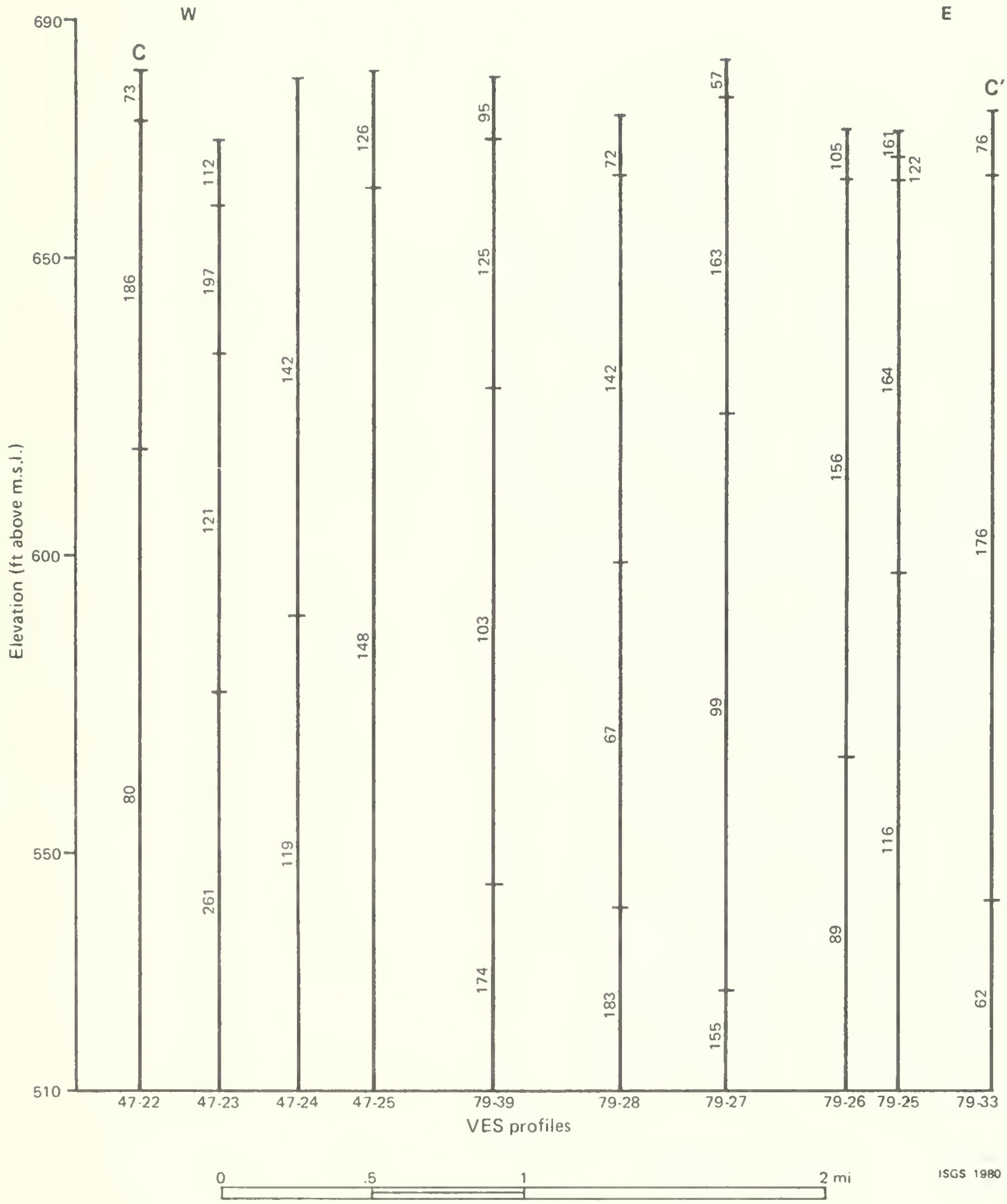

Figure 11c. Oreana study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line CC′ (see fig. 10). "True" resistivity values are in ohm-feet.

indicative of coarse-grained deposits. Of the three, VES profile (33) appears to be the most promising location for test drilling along this line of profiles.

East-west line CC' (fig. 11c) was chosen to examine the water-producing capabilities of the unconsolidated deposits near the Sangamon River. This line crosses the area with greatest change in the surface topography. Overall, "true" resistivity values along this line are slightly less than along lines AA' and BB'. Individual VES profiles 22, 23, and 33 along this line from west to east registered "true" resistivity values indicative of the presence of coarse-grained deposits in the shallower portions of the glacial drift. VES profiles 39, 28, and 27 showed "true" resistivity values that indicated coarse-grained deposits at depths between 130 and 160 feet in the glacial drift. These latter "true" resistivity values can reasonably be attributed to a basal sand and gravel layer, but the possibility of the VES curves being distorted by the presence of resistive bedrock should not be discounted. Well data in this area show that some sand and gravel units are present below a depth of 100 feet, but the estimated depth to bedrock in this area is approximately 150 to 170 feet.

VES profiles 1 and 13 merit mentioning simply because they are places where large "true" resistivity values indicate the presence of coarse-grained deposits in the glacial drift.

In summary, three sites are recommended for test drilling for additional water supplies for Oreana. The first and most favorable site is the southwest corner of Sec. 10, T. 17 N., R. 3 E. The proximity of this site to Oreana makes it especially attractive. The second site is the northern part of Sec. 21, T. 17 N., R. 3 E. Specifically, VES profiles (22), (23), and 38 appear to be the most promising locations. The third site is around VES profile 28 of line CC'. The third site is given the lowest priority because high resistivity values near the base of the drift might be associated with bedrock.

Red Bud

The village of Red Bud (population 2,559), located in the northwest corner of Randolph County, Secs. 4, 5, 8, and 9, T. 4 S., R. 8 W. (fig. 12), was identified in a joint assessment of public ground-water supplies in Illinois as having experienced water shortages during the drought of 1976-1977 (Visocky et al., 1978). By the year 2000, the population of Red Bud is projected to remain approximately the same. The village of Red Bud was chosen for supplemental electrical resistivity surveying during 1979 as an aid to siting new municipal wells.

Red Bud is physiographically situated near the western boundary of the Mt. Vernon Hill Country of the Till Plains Section of the Central Lowlands Province. It lies on a gently rolling Illinoian ground moraine with a topographic regional slope east towards the Kaskaskia River. Approximately 3 miles east of Red Bud and 2 miles west of the Kaskaskia River is a remnant of a north-south trending end moraine of Illinoian age. Drainage of the study area is to the Kaskaskia River via north-flowing Richland Creek and south-flowing Horse Creek.

The shallow bedrock in the immediate area of the village of Red Bud consists of sandstone and some shale of the Pennsylvanian Abbott Formation. The shallow bedrock in the greater Red Bud area is of Mississippian age and consists of sandstones, shale, and limestones of the Lower Chesterian Series that are underlain by sandstones and limestones of the Upper Valmeyeran Series. The uppermost unit of the Valmeyeran Series, the Aux Vases Sandstone, is the only formation of the shallow bedrock capable of yielding moderate to large supplies of ground water and is the source of Red Bud's current municipal water supply. Where present, creviced limestones and other sandstones are capable of yielding only small domestic supplies of ground water. The major topographic feature of the bedrock surface in the Red Bud study area is the Kaskaskia Bedrock Valley, which coincides in general with the present-day Kaskaskia River valley. Bedrock elevation of the Red Bud study area varies from slightly less than 300 feet m.s.l. in the Kaskaskia Bedrock Valley to slightly more than 450 feet m.s.l. in the northwest quarter of T. 4 S., R. 8 W.

The unconsolidated Pleistocene glacial drift in the Red Bud area consists of a complex of ice-laid till, water-laid silt, sand and gravel outwash and alluvium, and wind-blown silt (loess) of pre-Illinoian, Illinoian, and Wisconsinan age. Drift ranges from 10 to 20 feet thick in the area around Red Bud on the upland surfaces to 90 to 100 feet in the Kaskaskia River valley. The Wisconsinan age blanketing loess varies from 4 to 10 feet thick. Sand and gravel deposits within the drift on the uplands are known to occur only as discontinuous thin stringers. Some small domestic wells have been successfully developed from these deposits. Sparse well data indicate that sand and gravel

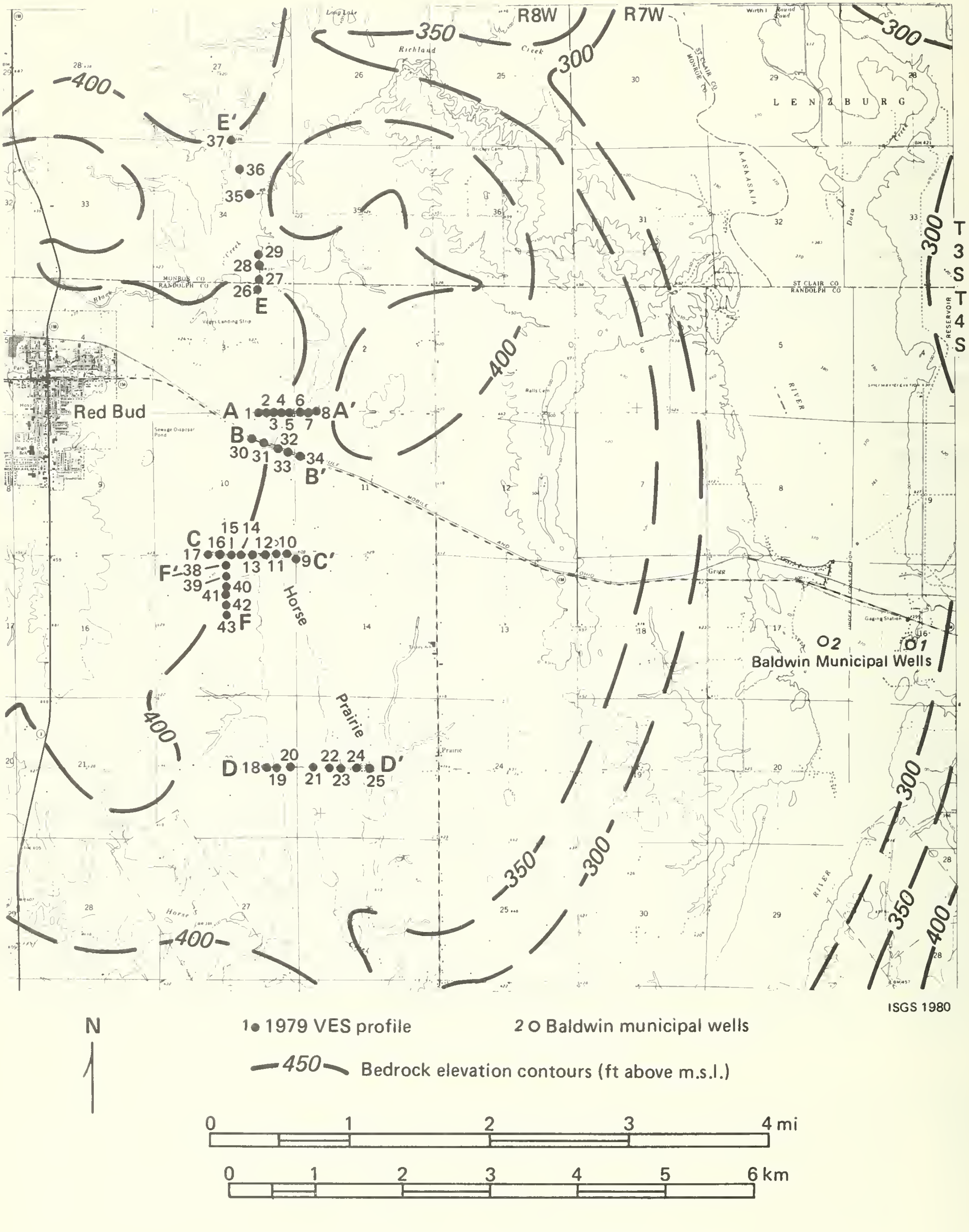

Figure 12. Red Bud study area.

deposits 3 to 8 feet thick may occur in conjunction with a north-south trending topographic low in the Horse Prairie, which is located approximately 1½ miles east of Red Bud (fig. 39, Visocky et al., 1978). Well records also suggest scattered sand and gravel deposits (possibly outwash), 2 to 8 feet thick, west and south of the north-south trending Illinoian end moraine. Extensive sand and gravel deposits in excess of 15 feet are known to occur in the Kaskaskia Bedrock Valley and some are utilized as municipal well sites by the village of Baldwin, which is located slightly more than 2 miles east of the Kaskaskia River.

The village of Red Bud has developed its current municipal water supply from nine wells drilled into the Aux Vases Sandstone. The wells are located near the edges of the village in Secs. 4, 5, 8, and 9, T. 4 S., R. 8 W. (fig. 12) and range from 274 to 293 feet deep. A majority of the wells are located on the north-northwest edge of town. Current pumpage of the wells averages 310,000 gal/day. The maximum daily withdrawal is in excess of 380,000 gal/day, and the practical sustained yield under drought conditions is 250,000 gal/day. The average daily demand by the year 2000 is estimated to be more than 312,000 gal/day. Additional wells developed in the Aux Vases Sandstone, if properly spaced, could increase the water yield under normal climatic conditions; however, because of limitations in aquifer transmissivity and ability to receive recharge, the practical sustained yield under drought conditions would still be approximately 250,000 gal/day.

Visocky et al. (1978) recommended exploration for ground water within the glacial drift on Horse Prairie about 1½ miles east of Red Bud. Sparse well data in that north-south trending drainage show a slightly greater drift thickness than on the uplands—a possible indication of a shallow bedrock channel that might contain water-yielding deposits. The best chance of obtaining a moderate to large ground-water supply, such as is needed by Red Bud, is considered to be in the Kaskaskia River bottomlands, where 15-foot thick deposits of water-bearing sand and gravel deposits are known to occur.

In accordance with the recommendation of Visocky et al. (1978), additional vertical electrical sounding profiles were concentrated in the area of the north-south trending topographic low of the Horse Prairie. Profiles were placed in portions of Secs. 27 and 34, T. 3 S., R. 8 W. and in portions of Secs. 2, 3, 10, 11, 15, 22, and 23, T. 4 S., R. 8 W. (fig. 12).

Interpretation of the electrical earth resistivity data consisted of construction, examination, and inversion (by the inversion technique of Zohdy and Bisdorf, 1975) of VES curves obtained from six lines of VES profiles, AA' through FF' (figs. 13a-13f). Inversion of a VES curve provides layering parameters ("true" resistivities and thicknesses) for the earth materials below the center stake of the corresponding VES profile. Four of the lines of profiles (AA' through DD') cross the width of the Horse Prairie topographic feature, and the other two lines of profiles (EE' and FF') lie along the axis of the feature.

The apparent and "true" resistivity values associated with the unconsolidated deposits along lines AA' and BB', located approximately one mile east of Red

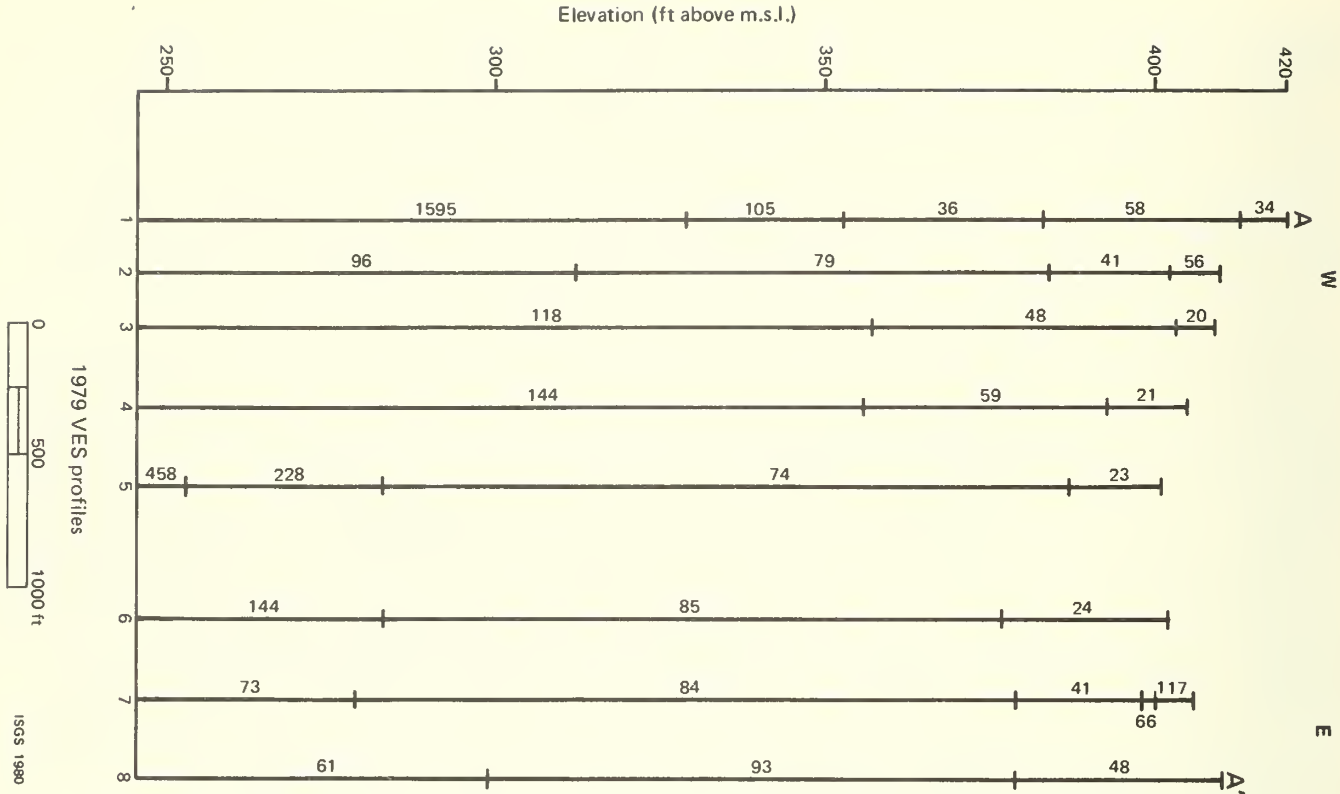

Figure 13a. Red Bud study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line AA' (see fig. 12). "True" resistivity values are in ohm-feet.

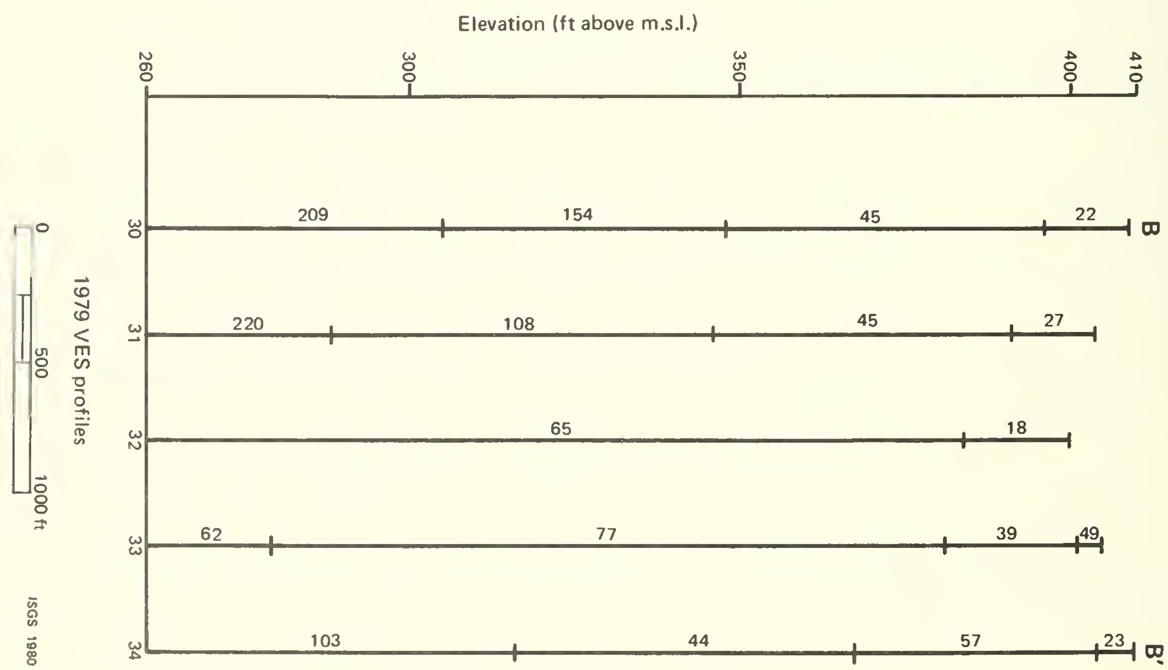

Figure 13b. Red Bud study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line BB' (see fig. 12). "True" resistivity values are in ohm-feet.

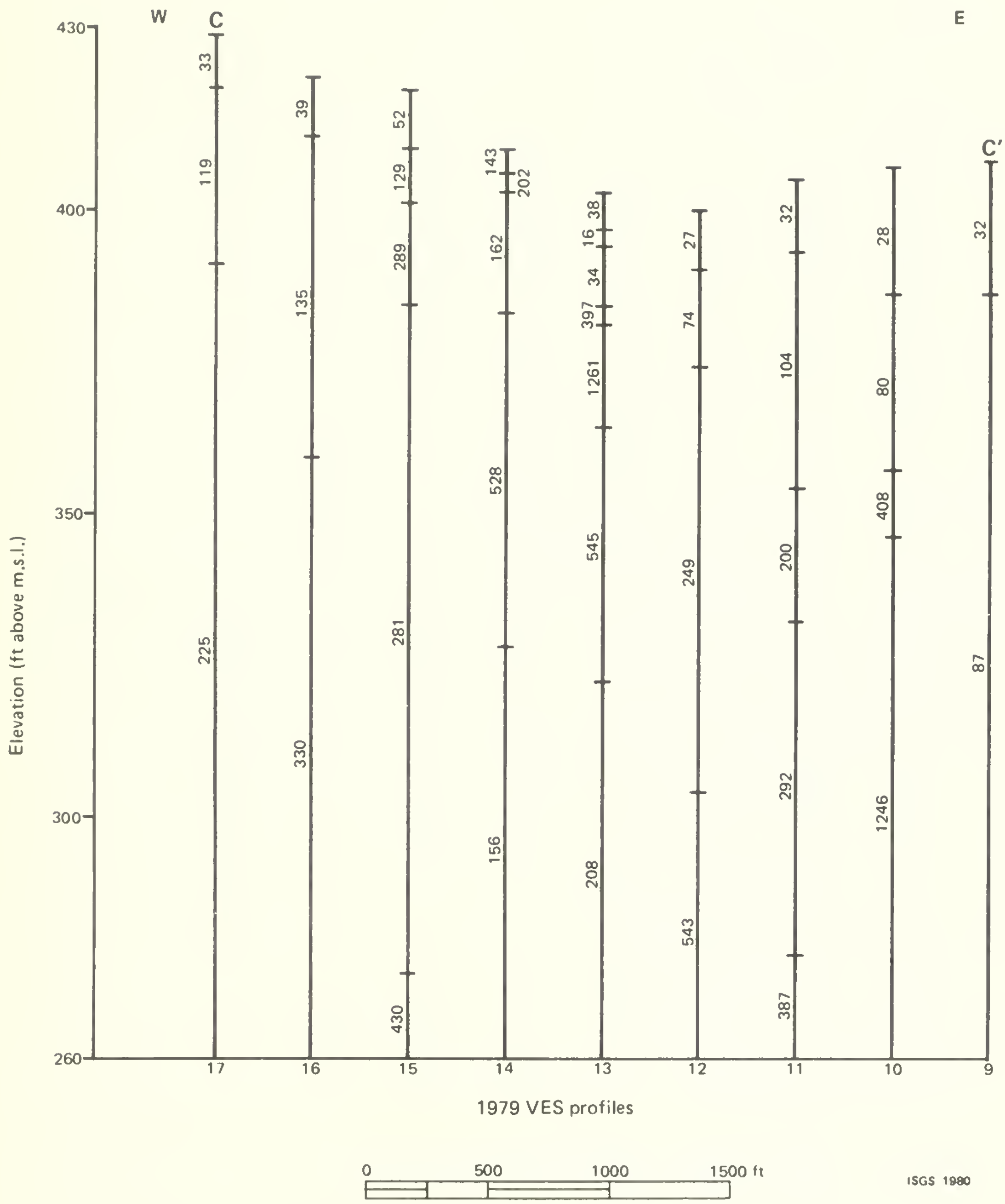

Figure 13c. Red Bud study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line CC′ (see fig. 12). "True" resistivity values are in ohm-feet.

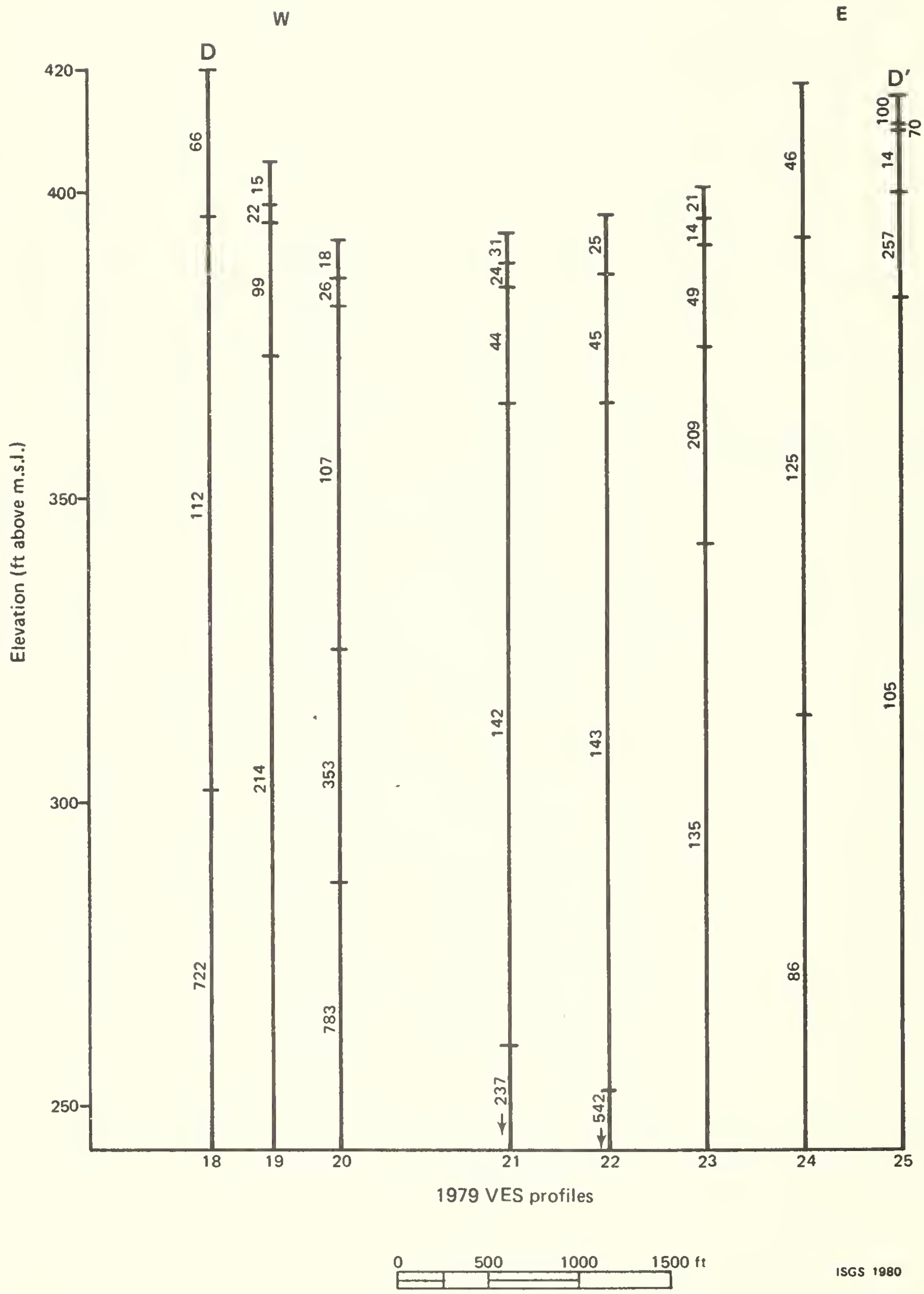

Figure 13d. Red Bud study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line DD' (see fig. 12). "True" resistivity values are in ohm-feet.

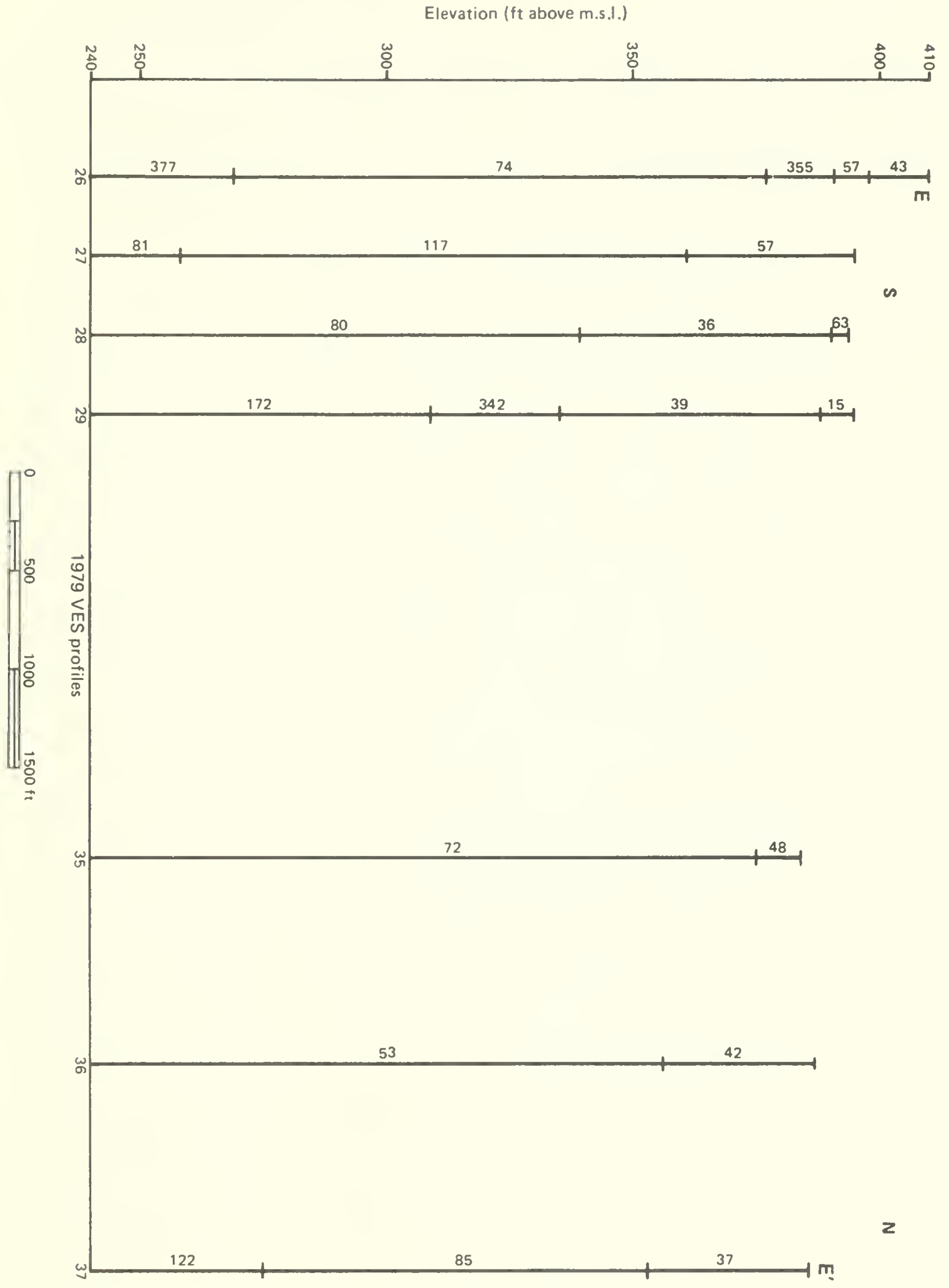

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Figure 13e. Red Bud study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line EE' (see fig. 12). "True" resistivity values are in ohm-feet.

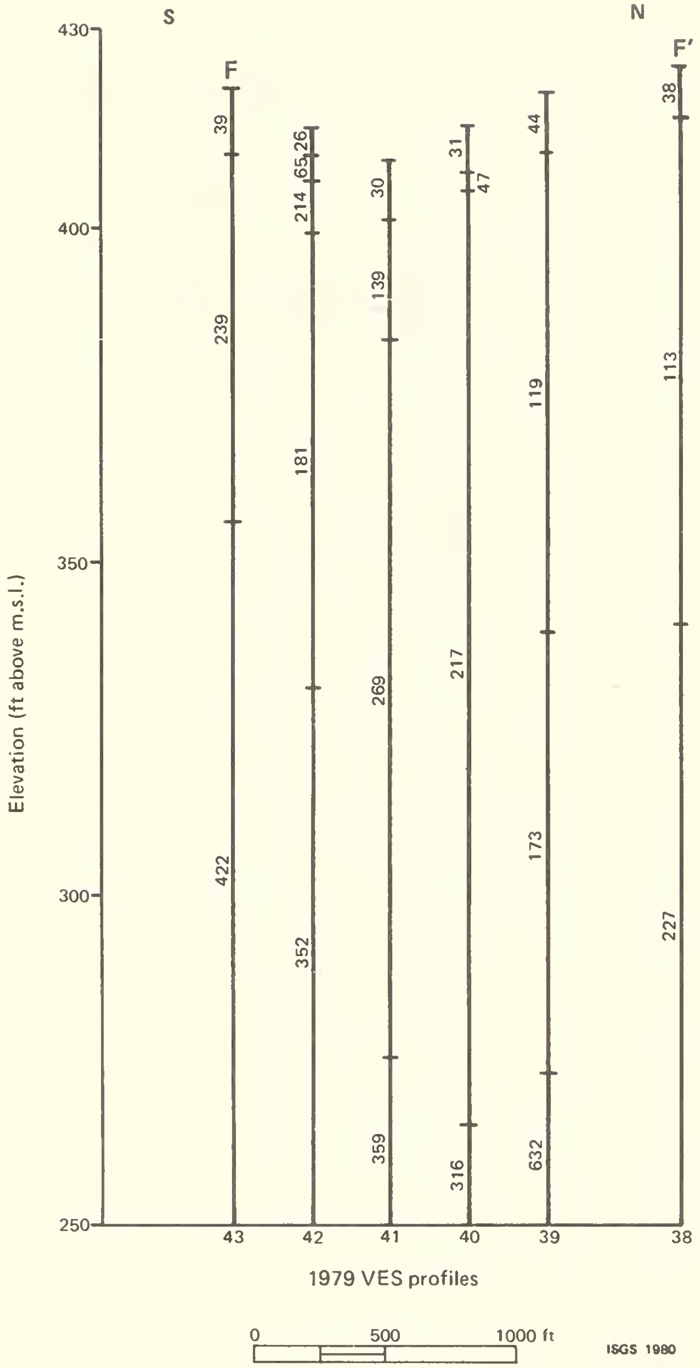

Figure 13f. Red Bud study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line FF' (see fig. 12). "True" resistivity values are in ohm-feet.

Bud (figs. 13a and 13b), indicate that the glacial drift here comprises mainly fine-grained sediments. No significant sand and gravel deposits are in evidence at any point along either of these lines.

Along the east-west line CC', approximately one mile south of line BB' (fig. 13c), apparent and "true" resistivity values associated with the unconsolidated deposits still indicate a preponderance of fine-grained sediments within the drift. "True" resistivity values thought to be indications of bedrock lithologies were obtained at VES profiles 12, 13, and 14 at depths ranging from 18 to 30 feet. Some sandier zones within the fine-grained deposits are possible at these VES profiles.

Resistivity values along line DD' (fig. 13d) seem to substantiate the trend toward coarser deposits within the glacial drift to the south. VES profiles 21 and 22 appear to be the most favorable locations along this line for the occurrence of sandy deposits. Layering parameters ("true" resistivities and layer thicknesses) obtained by inversion of the VES curves of VES profiles 20, 21, and 22 indicate a slight deepening of the shallow bedrock valley subjacent to the topographic low in Horse Prairie.

"True" resistivity values associated with the unconsolidated deposits along the north-south line EE' (fig. 13e) are similar to the values obtained along the east-west lines AA' (fig. 13a) and BB' (fig. 13b). No significant sand and gravel deposits are indicated by the resistivity data gathered along this line.

The apparent and "true" resistivity values associated with unconsolidated deposits along the north-south line FF' of VES profiles (fig. 13f) are similar to those found along the line CC' (fig. 13c). In particular, the shallow sequence of "true" resistivity values at VES profile 42 of line FF' (fig. 13f) is very similar to that at VES profile 14 of line CC' (fig. 13c). Moreover, this sequence, which may be indicative of a sandy zone within 20 feet of the surface, is the most salient feature of either line. However, even if this deposit were confirmed, it is unlikely that it would be capable of supporting a municipal well.

In summary, based on the electrical earth resistivity data and the sparse well data gathered in the Red Bud area, no specific sites for future test drilling for municipal water supplies from the glacial drift can be recommended. There are still two options available, however, in the pursuit of additional municipal water supplies:
(1) the southward increasing "true" resistivity trend noted in the unconsolidated deposits in the Horse Prairie area suggests that more exploration should be done south of line DD' of VES profiles; and
(2) sand and gravel deposits of sufficient thickness and hydraulic conductivity to support municipal water supply wells for Red Bud are known to exist in the Kaskaskia River floodplain. In view of the fact that the distance from Red Bud to the Kaskaskia River floodplain (approximately 5 miles) is only slightly more than the distance from Red Bud to the Horse Prairie area, just south of line DD' where sand and gravel deposits capable of supporting municipal wells are at present undiscovered, it is most reasonable that the second option should be exercised.

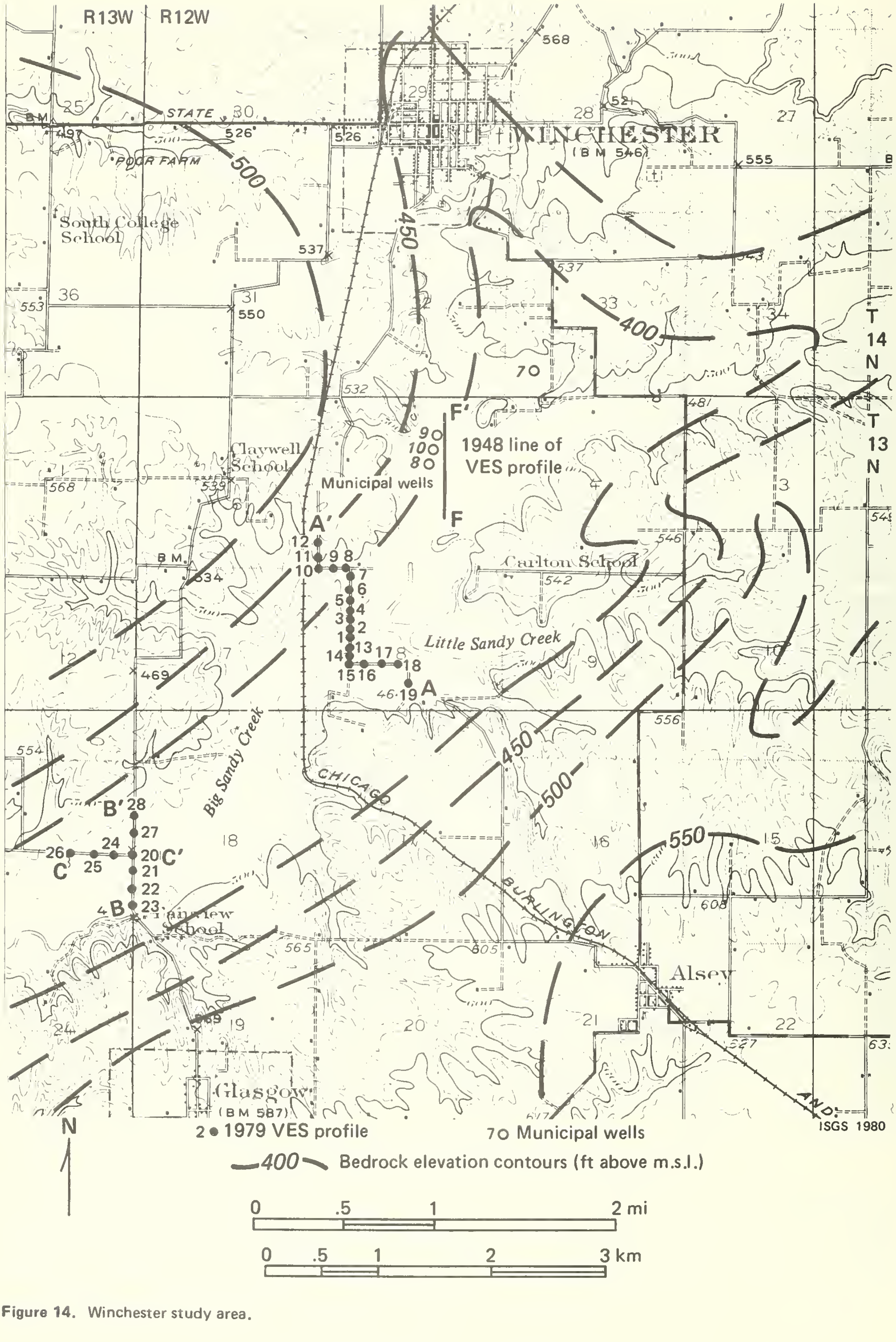

Figure 14. Winchester study area.

Winchester

The village of Winchester (population 1,788) located in central Scott County, Secs. 29 and 32, T. 14 N., R. 12 W. (fig. 14), experienced water shortages during the drought of 1976-1977 (Visocky et al., 1978). By the year 2000 the population of Winchester is projected to be approximately the same as it is now; however, based on its past shortages and the possibility of obtaining a greater supply from the glacial drift, the village of Winchester was chosen for supplemental electrical earth resistivity surveying during 1979 as an aid to siting new municipal wells.

Winchester is physiographically situated near the northwestern boundary of the Springfield Plain of the Till Plains Section of the Central Lowland Province. It lies on a strongly dissected upland ground moraine of Illinoian age. Drainage of the major portion of the study area is provided by westward-flowing Big Sandy and Little Sandy Creeks and their tributaries.

The shallow bedrock in the Winchester area consists of approximately 100 feet of limestone, shale, and sandstone of Middle Mississippian age, overlying the thick shales of the Devonian-Mississippian New Albany Group. The fractured limestones and sandstones at the bedrock surface may yield small domestic supplies of fresh water, but they cannot be considered a likely source of moderate to large supplies such as is needed for a municipal supply. The predominant topographic feature on the bedrock surface in the Winchester area is a small, buried bedrock channel that was cut by an ancient tributary to the Illinois River (fig. 14). Bedrock elevations in the study area range from slightly less than 400 feet above m.s.l. within the channel to slightly more than 550 feet above m.s.l. outside the channel. Scattered bedrock outcroppings are revealed within the area in steep valley sides.

The unconsolidated Pleistocene glacial drift in the Winchester area consists of a complex of ice-laid till, water-laid clay, silt, sand and gravel outwash and alluvium, and wind-blown silt (loess) of pre-Illinoian, Illinoian, and Wisconsinan age. Drift ranges from 43 feet thick over shallow bedrock to slightly more than 100 feet over the buried bedrock channel. The blanketing loess averages 15 feet thick. The major sand and gravel unit in the area occurs as a coarse-textured valley train or outwash deposit on the bedrock surface within the buried bedrock valley. Sediments overlying the deposit consist mainly of fine-grained silt and alluvium with some sandy lenses. Test drilling data indicate that the thickness of the major sand and gravel deposit is 19 to 31 feet in the vicinity of the municipal well field and that the deposit extends across the floodplain between Big Sandy and Little Sandy Creeks and has a texture ranging from silty sand to gravel and boulders.

Wells 7, 8, 9, and 10, currently in use at the Winchester municipal well field, are located in the central portion of Sec. 5, T. 13 N., R. 12 W. and SW¼ Sec. 33, T. 14 N., R. 12 W., Scott County (fig. 14). All other wells have been abandoned. The municipal wells are drilled to depths of 63, 52, 46, and 48 feet, respectively, and have 4 to 10 feet of screen near or at the base. Well yields vary from 85 to 100 gal/min. Current total pumpage averages 200,000 gal/day. For years of normal to below normal precipitation it is estimated that the sustained yield would be on the order of 255,000 gal/day, a figure reduced by as much as 25 percent during years of severe drought.

Based on the glacial history of the area and the possible areal extent of the deposit tapped by the present municipal wells, Visocky et al. (1978) recommended that a supplemental electrical earth resistivity survey be conducted farther downstream from the municipal well field on the Big Sandy Creek floodplain where additional and likely continuous sand and gravel deposits are expected to occur. Although the entire floodplain is to be regarded as a potential ground-water source, variations in texture, thickness, and water-yielding potential of the sediments are expected to be of considerable importance in the placement of future wells.

In accordance with the recommendation of Visocky et al. (1978), VES profiles were located southwest of the present municipal well field on the Big Sandy Creek floodplain. VES profiles were concentrated in the west half of Sec. 8, T. 13 N., R. 12 W. and along the section line between Sec. 18, T. 13 N., R. 12 W. and Sec. 13, T. 13 N., R. 13 W. (fig. 14). Both of these areas are thought to lie within the projected boundaries of the buried bedrock valley.

Interpretation of the resistivity data collected in 1979 consisted of construction, examination, and inversion of VES curves obtained from VES profiles along lines AA', BB', and CC' (figs. 15a, 15b, 15c). Inversion of a VES curve provides layering parameters ("true" resistivities and thicknesses) for the earth materials below the center stake of the corresponding VES profile. The same interpretational procedure was followed for VES curves obtained from VES profiles along line FF' (fig. 15d) collected in 1948. The older resistivity data provide a basis for comparison between the "true" resistivity values of the unconsolidated sediments in the vicinity of the present municipal wells and the "true" resistivity values of the unconsolidated deposits elsewhere in the area.

The north-south line AA' of VES profiles (fig. 15a) is located mainly in the northwest quarter of Sec. 8, T. 13 N., R. 12 W., approximately one-half to one mile southwest of the current municipal wells (fig. 14). The southern edge of the buried bedrock valley can be seen in the "true" resistivity values and layer thicknesses obtained by inversion of VES curves 15, 16, and 17. The northern edge of the buried bedrock valley in this area is not so apparent. This is probably the result of lithologic changes in the bedrock. The unconsolidated deposits within the lateral boundaries of the buried bedrock valley here have "true" resistivity values comparable to those at the municipal well field. Possible test drilling sites along this line are at VES profiles 1, 2, 3, 13, 14, and 15; profiles 2, 14, and 15 are considered most favorable.

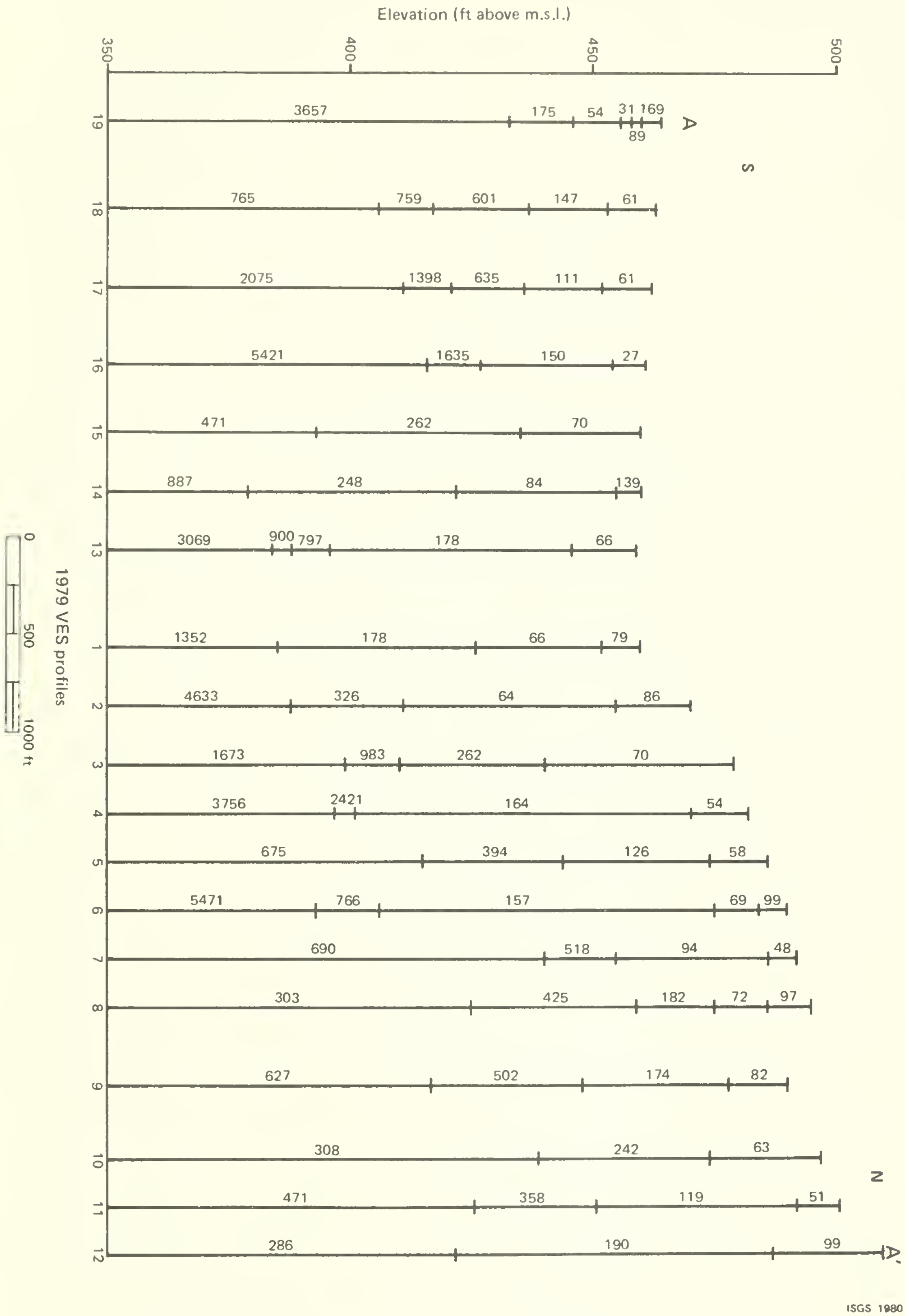

Figure 15a. Winchester study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line AA' (see fig. 14). "True" resistivity values are in ohm-feet.

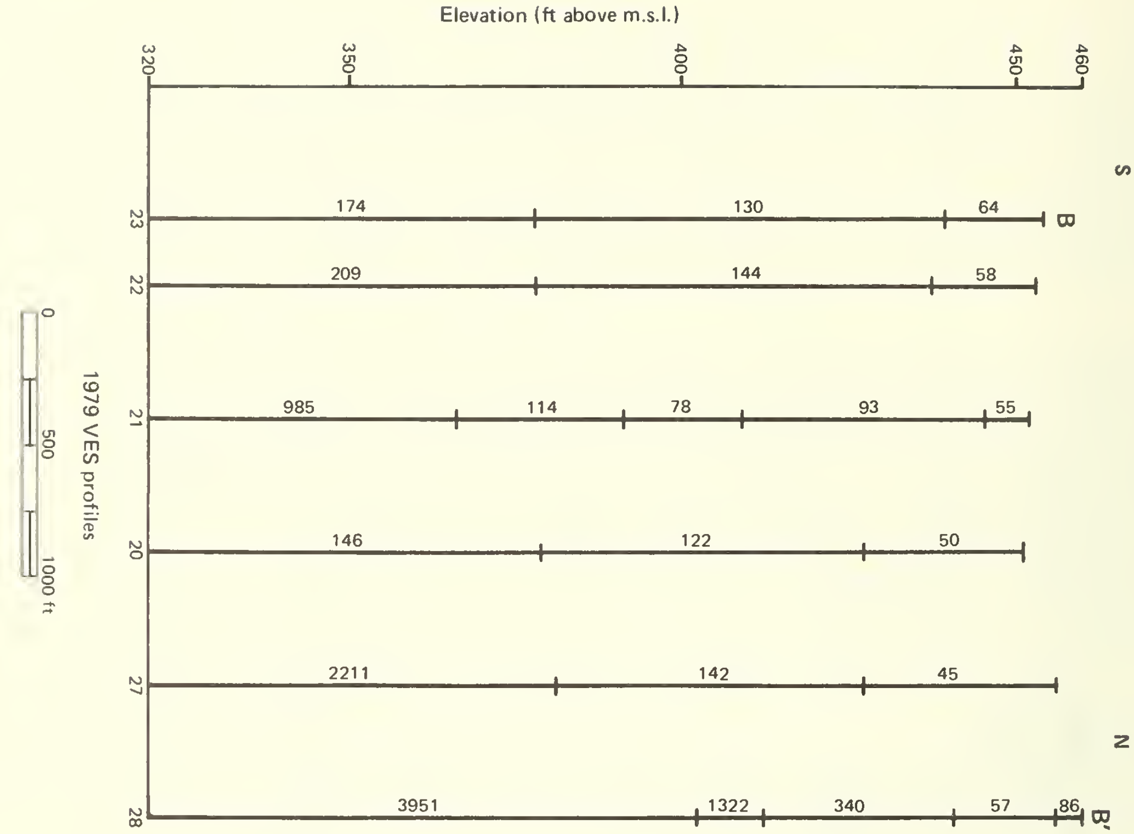

Figure 15b. Winchester study area. Layering parameters ("true"resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line BB' (see fig. 14). "True" resistivity values are in ohm-feet.

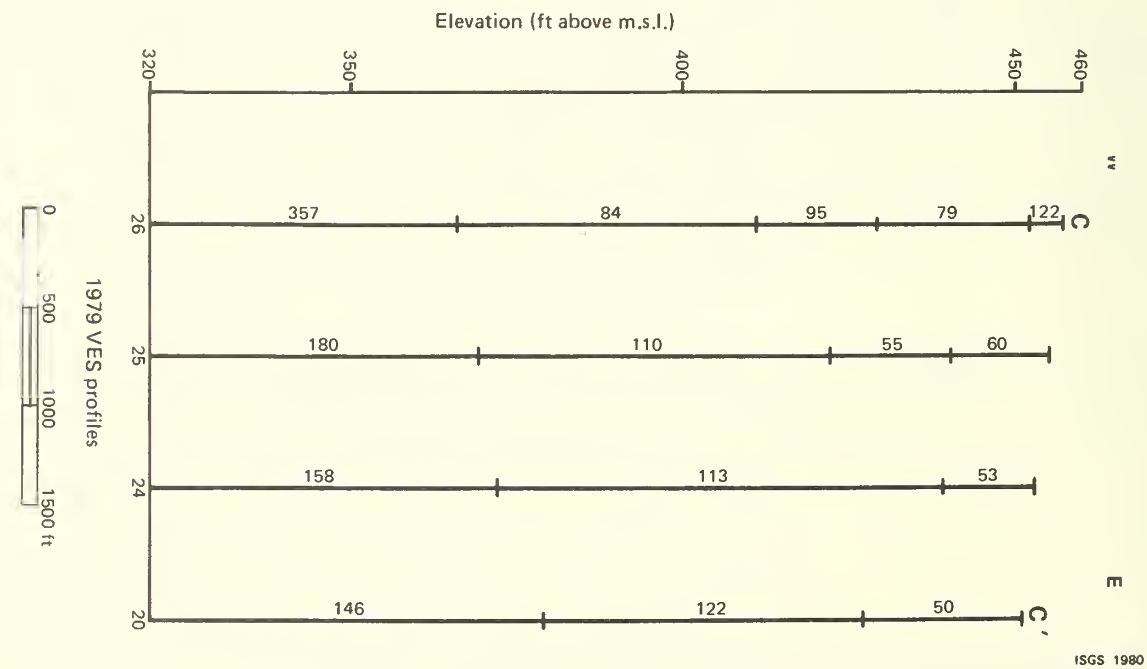

Figure 15c. Winchester study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line CC' (see fig. 14). "True" resistivity values are in ohm-feet.

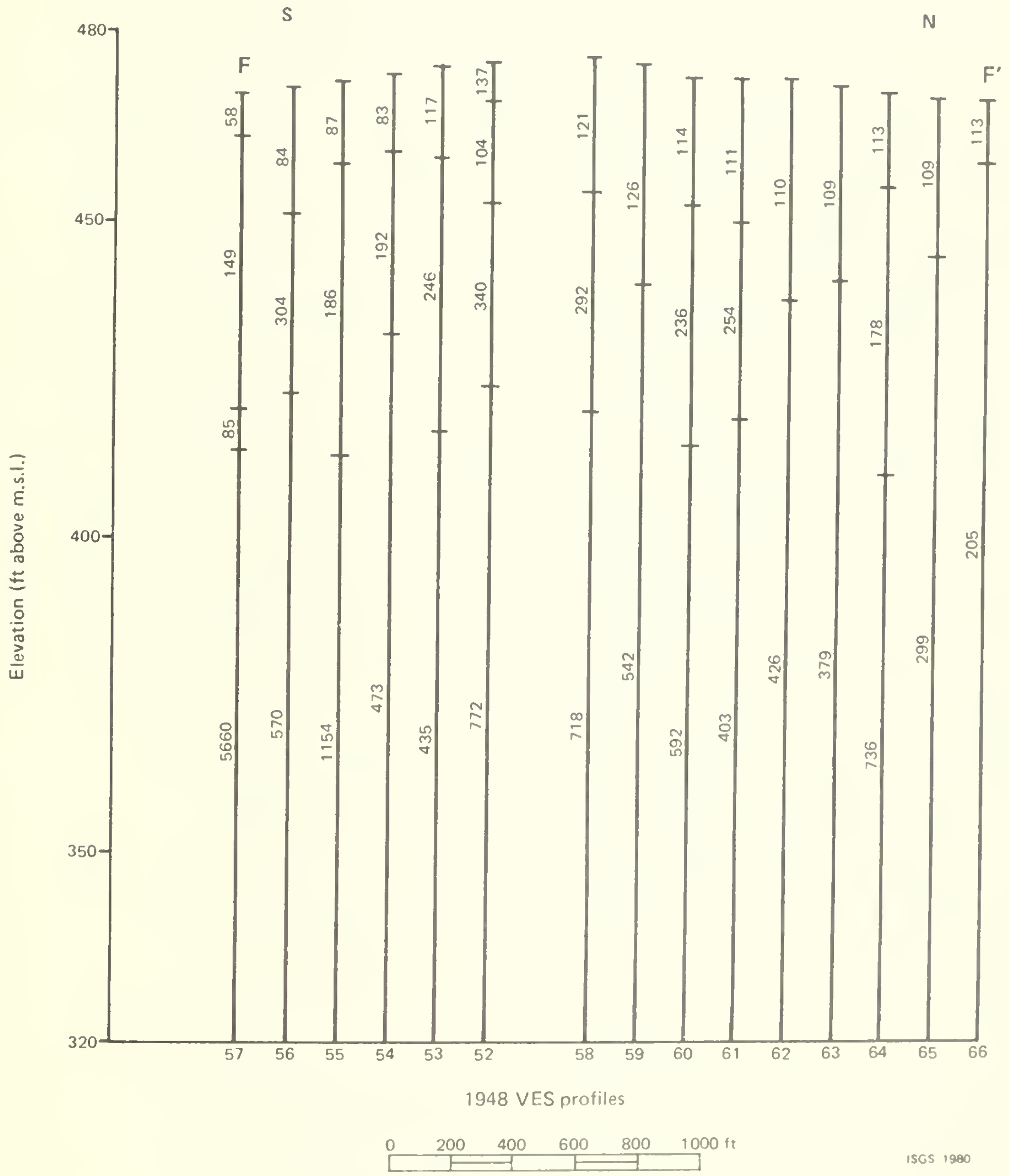

Figure 15d. Winchester study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line DD' (see fig. 14). "True" resistivity values are in ohm-feet.

The north-south line BB' of VES profiles (fig. 15b) is located along the west line of Sec. 18, T. 13 N., R. 12 W. and traverses the width of the Big Sandy Creek floodplain. Apparent and "true" resistivity values of the unconsolidated deposits occupying the buried bedrock valley along this line are significantly smaller than those along line AA'; this indicates generally finer grained deposits along line BB'. VES curves 22 and 23 exhibit slightly greater resistivity values than the other VES curves along line BB'. This may be the result of their close proximity to the present-day course of Big Sandy Creek. Nevertheless, the locations of VES profiles 22 and 23 are considered the only feasible sites along this line for future test drilling.

The east-west trending line CC' of VES profiles (fig. 15c) intersects line BB' (fig. 15b) at right angles in the central portion of Sec. 13, T. 13 N., R. 13 W. (fig. 14). Inversion of the VES curves along this line indicates that the glacial drift is thicker here. "True" resistivity values of the lower portion of the drift increase toward the west, an indication of coarser grained deposits, possibly a basal sand and gravel. VES profile 26 appears to be the best site along this line for future test drilling.

In summary, the following locations are recommended as possible test drilling sites: (1) VES profile 2, along the north-south road 450 feet north of Big Sandy Creek in the northwest quarter of Sec. 8, T. 13 N., R. 12 W.; (2) VES profile 14, along the north-south road 600 feet south of Big Sandy Creek in the southwest quarter of Sec. 8, T. 13 N., R. 12 W., and VES profile 15, 300 feet south of VES profile 14; (3) VES profile 26, located 1,140 feet east of the center of Sec. 13, T. 13 N., R. 12 W.; and (4) VES profile 22, located 1,640 feet north of the southeast corner of Sec. 13, T. 13 N., R. 13 W., and VES profile 23, 250 feet south of profile 22. VES profiles 2, 14, and 15 are the favored test drilling sites because of the large "true" resistivity values found at these sites and because of their proximity to town. VES profiles 22 and 23 are given a lower priority.

Worden

The village of Worden (population 1,019), located in north-central Madison County, portions of Secs. 26 and 35, T. 6 N., R. 7 W. (fig. 16), was also identified in a joint assessment of public ground-water supplies in Illinois as having experienced water shortages during the drought of 1976-1977 (Visocky et al., 1978). The population of Worden is not projected to increase by any significant amount by the year 2000; however, it has been estimated that the practical sustained yield of Worden's present wells is reduced by approximately 50 percent during periods of drought. The village of Worden was chosen for a supplemental electrical earth resistivity survey during 1979 as an aid to siting new municipal wells.

Physiographically, the Worden area is situated in the southwest portion of the Springfield Plain of the Till Plains Section of the Central Lowland Province. It lies on a gently rolling ground moraine of Illinoian age and has a regional slope of 5 to 10 feet per mile to the south-southwest. Drainage of the major portion of the area is accomplished by numerous, small, westward-flowing tributaries to the southward-flowing Cahokia Creek, which passes 2 miles to the west of Worden. The maximum topographic relief of the area is 160 feet. Most of it is due to the moderate dissection of the ground moraine by Cahokia Creek and its tributaries.

The shallow bedrock in the Worden area consists of shales, claystones, sandstones, and limestones of the Pennsylvanian Modesto Formation. Where present, fractured limestones and sandstones near the bedrock surface are sources of small, domestic supplies of water. These rocks are not considered a likely source of moderate to large quantities of water such as are needed for a municipal supply. The most prominent topographic feature on the bedrock surface in the Worden study area is a bedrock valley system which is generally coincident with the present day Cahokia Creek (fig. 16). Bedrock elevation in the study area ranges from slightly less than 400 feet above m.s.l. in the Cahokia Creek bottomlands to slightly more than 500 feet above m.s.l. in the east-northeast portion of the study area.

The unconsolidated Pleistocene glacial drift in the Worden area consists of a complex of ice-laid till, water-laid silt, sand and gravel alluvium, and windblown silt (loess) of Illinoian and Wisconsinan age. Drift varies from 10 to 70 feet thick on the upland surfaces to 45 to 70 feet in the Cahokia Creek bottomlands. The Wisconsinan-age blanketing loess varies from 6 to 10 feet thick. Sand and gravel deposits within the drift on the uplands are scarce and occur only as stringers inches thick and of extremely limited areal extent. Some small domestic wells have been successfully developed from these deposits. Sand and gravel deposits in the Cahokia Creek bottomlands occur

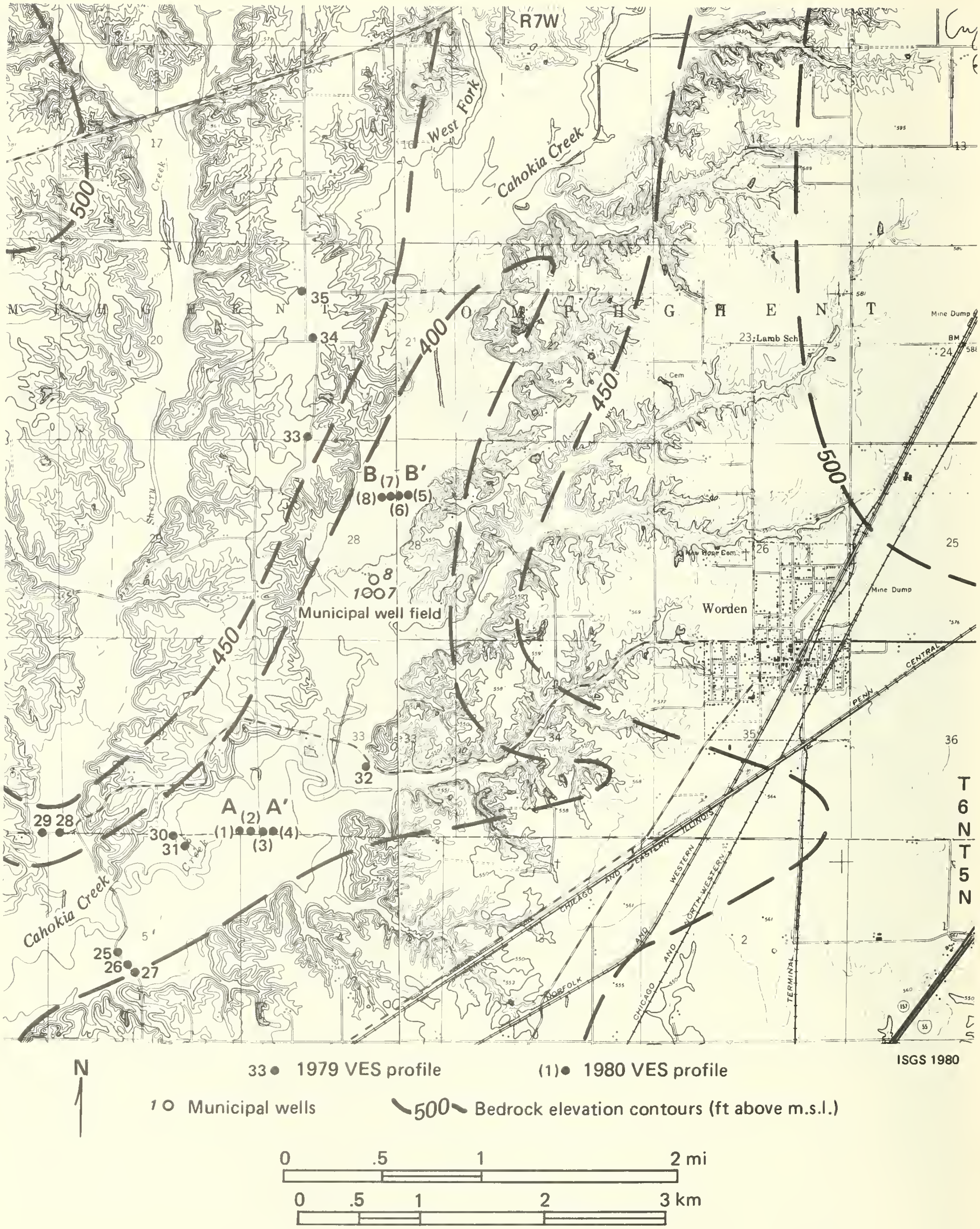

Figure 16. Worden study area.

mainly as outwash deposits in buried channels. Known deposits of this type range from 12 to 27 feet thick.

The village of Worden has developed its current municipal water supply from the buried bedrock channel deposits trending north-south in the Cahokia Creek bottomlands. Eight wells have been finished in these deposits since 1947; however, all but three have been abandoned. The three wells are located in the southeast quarter of Sec. 28, T. 6 N., R. 7 W., Madison County (fig. 16). Municipal Well 1 is approximately 2,342 feet west and 1,058 feet north of the southeast corner of Sec. 28; Well 7 is 60 feet northeast of Well 1; and Well 8 is 1,450 feet north and 2,300 feet west of the southeast corner of Sec. 28. The wells are drilled to depths of 54, 43, and 56 feet, screened intervals are 46 to 54, 36 to 43, and 40 to 46 feet, and yields are 20, 20, and 35 gal/min respectively. The sustained yield of the municipal wells has been calculated at approximately 80,000 gal/day for years of normal precipitation; during periods of drought, the practical sustained yield is as little as 36,000 gal/day. Current average daily demand is 75,000 gal/day. Estimated demand for the year 2000 is 67,000 gal/day.

Visocky et al. (1978) recommended that exploration for ground water within the glacial drift be continued in the Cahokia Creek bottomlands, particularly south of the present municipal well field. The unconsolidated deposits in the Cahokia Creek bottomlands offer the only possibility within the Worden area for moderate to large amounts of ground water such as are needed for a municipal supply.

In accordance with the recommendation of Visocky et al. (1978), the majority of the 1979-1980 VES profiles were located within the boundaries of the Cahokia Creek floodplain, south of the current municipal well. Seven VES profiles were located north of the current wells. Numerous VES profiles from from past resistivity surveys have also been located within the Cahokia Creek floodplain.

The recently collected resistivity data includes two lines (AA' and BB') of VES profiles (figs. 17a and 17b) that are of particular interest. An east-west line, AA' (fig. 17a), south of the municipal well field, extends from 150 feet east of Cahokia Creek in the southeast corner of Sec. 32, T. 6 N., R. 7 W. to the southwest corner of Sec. 33, T. 6 N., R. 7 W. The center stakes of the VES profiles located on this line were spaced at 200-foot intervals. Apparent resistivity values of the VES curves as well as "true" resistivity values, determined from the inversion of the VES curves, compare favorably with those obtained near the municipal well field. This is an indication of the probable continuity of the buried bedrock channel deposits tapped by the municipal wells. Inversion of a VES curve provides layering parameters ("true" resistivities and thicknesses) for the earth materials below the center stake of the corresponding VES profile. The locations of VES profiles 1-80 and 4-80 are considered most favorable as possible test drilling sites. A second line BB' of VES profiles (fig. 17b) north of the municipal well field, extends westward from 200 feet west of Cahokia Creek in the central portion of the northeast quarter of Sec. 28, T. 6 N., R. 7 W. The center stakes of the VES profiles on this line were also spaced at 200-foot

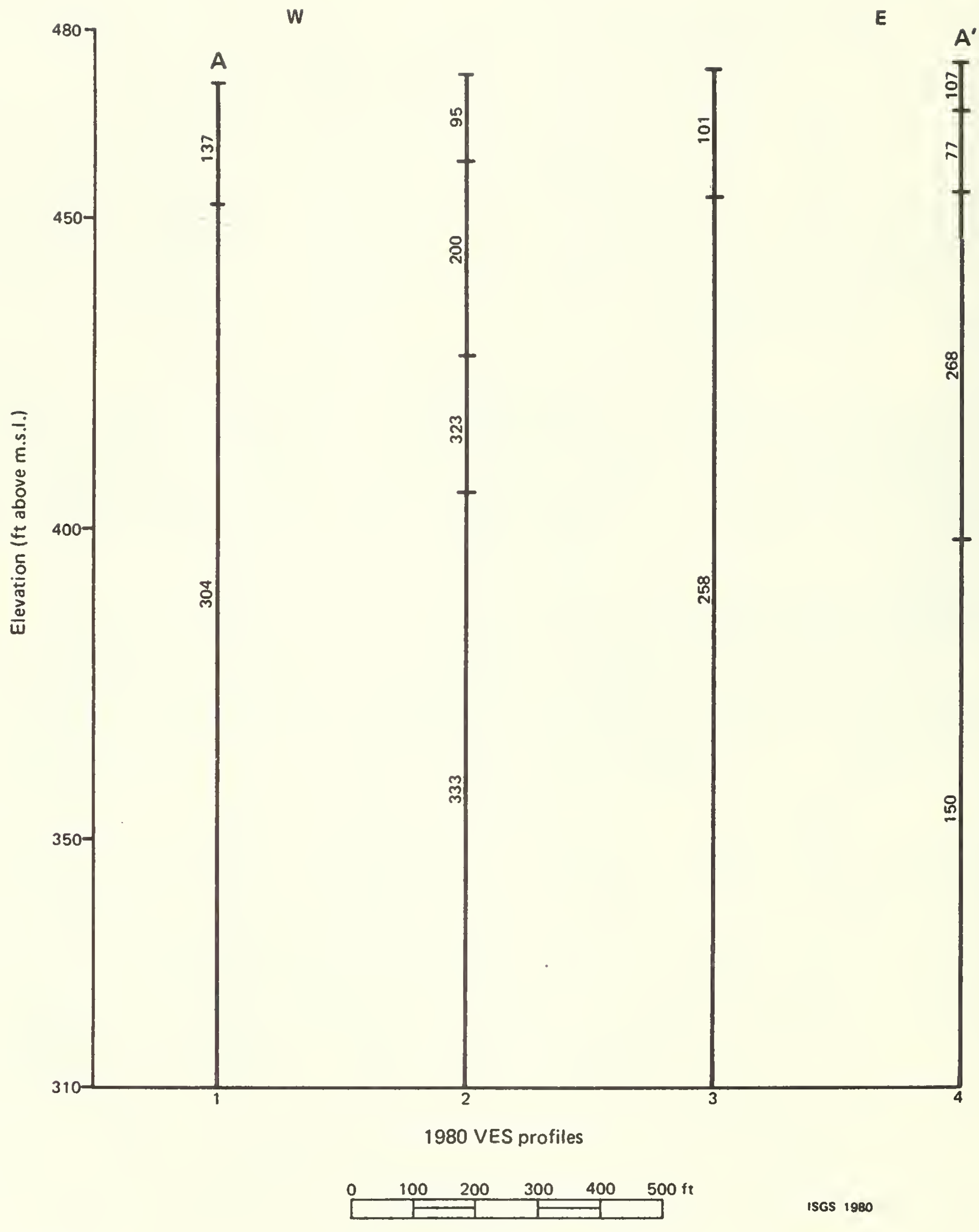

Figure 17a. Worden study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line AA' (see fig. 16). "True" resistivity values are in ohm-feet.

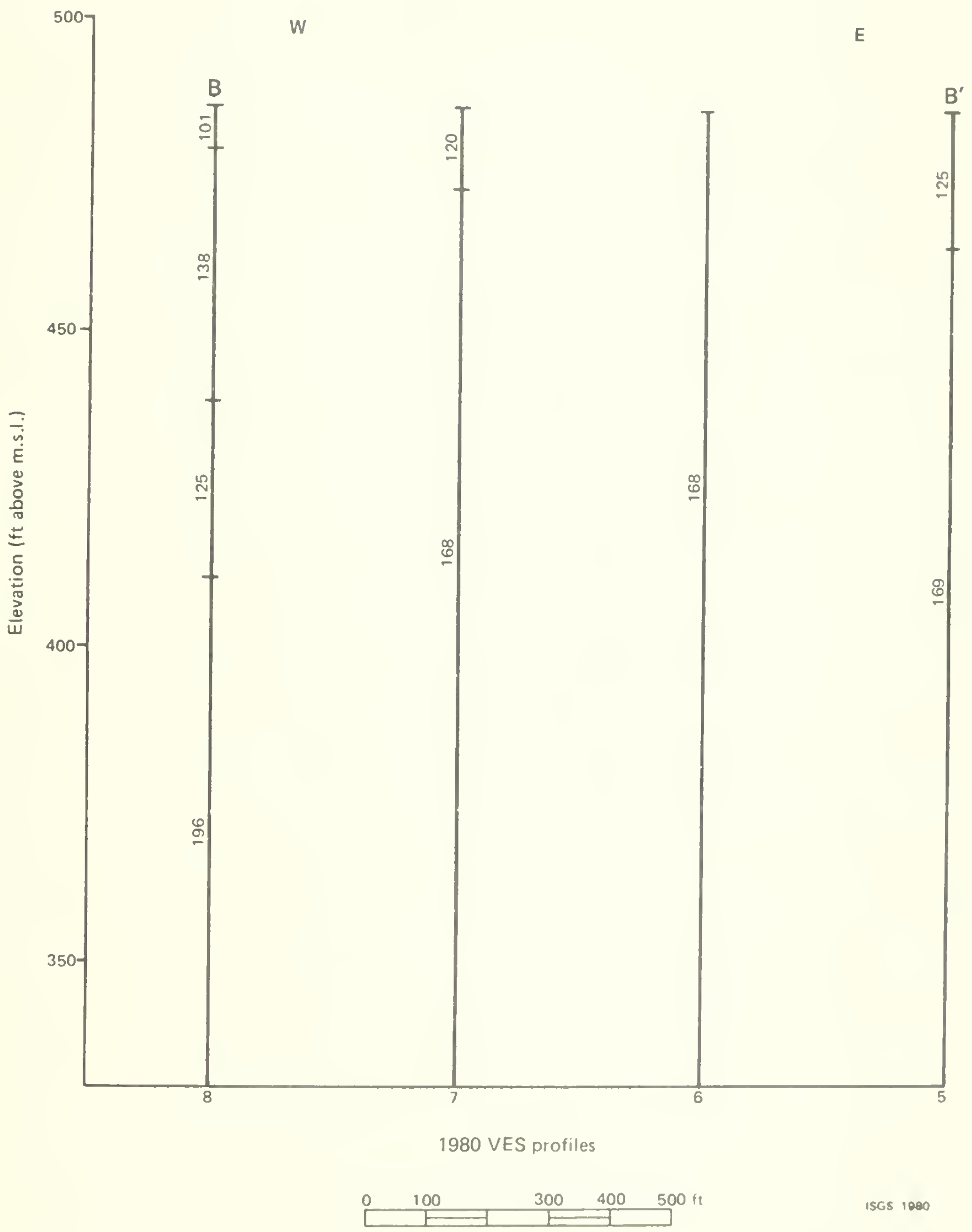

Figure 17b. Worden study area. Layering parameters ("true" resistivities and thicknesses) determined by inversion of vertical electrical sounding (VES) data along line BB' (see fig. 16). "True" resistivity values are in ohm-feet.

intervals. The VES curves (apparent resistivity vs. a-spacing) exhibited significantly smaller amplitudes and less curvature than those obtained along line AA' (fig. 17a) and in the area of the municipal wells. "True" resistivity values obtained by the inversion technique were likewise smaller north of the well field. These low resistivity values, typical of fine-grained deposits, indicate that this line of VES profiles is probably not located above the buried bedrock channel deposits.

The other VES data collected in 1979-1980 did not show apparent or "true" resistivity values large enough to be indicative of coarse-grained, water-bearing deposits.

In summary, any future test drilling programs in the Worden area should attempt to tap the same buried bedrock channel deposits in which the current municipal wells are developed. Moreover, any new wells developed in this aquifer should be enough removed from the present municipal well field to avoid mutual interference. VES profiles 1-80 and 4-80, 150 and 750 feet east of Cahokia Creek, just north of the south line of Sec. 32, T. 6 N., R. 7 W., appear to be located above the buried bedrock channel deposits. Moreover, those locations are far enough removed from the municipal wells to prevent mutual interference.

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