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STATE GEOLOGICAL SURVEY
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Report of Investigations
No. 91

SHALLOW OUTWASH DEPOSIT IN HURON-WOLSEY AREA, BEADLE COUNTY, SOUTH DAKOTA

by

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ABSTRACT

The Huron-Wolsey area is in east-central South Dakota in the central part of the James Basin of the Central Lowlands Physiographic Province. The area occupies about 250 square miles and is drained southward by the James River.

Pierre shale of Cretaceous age forms the bedrock of the area, and is mantled by an average of 75 feet of Pleistocene glacial deposits.

About 73 square miles of the Huron-Wolsey area is underlain by buried glacial outwash deposits. The deposits are 30 or more feet thick in about 20 percent of the area, and the sand and gravel is interfingered with clay and glacial till to such an extent that the amount of water available for irrigation and domestic use cannot be computed accurately.

Irrigation pumping in the area in the summer of 1960 caused the artesian head of water in the buried outwash deposits to decline as much as 13 feet.

The quality of this shallow water for irrigation is fair to poor.

INTRODUCTION

Present Investigation

The farm wells in the Huron-Wolsey area (fig. 1) have been drawing water from either the Dakota artesian sandstone or from shallow sand and gravel deposits. Until recently the shallow deposits have yielded adequate supplies of water for domestic use, except for a short period in the early 1930's when the city of Huron had to pump water from shallow wells west of the city, thus reportedly withdrawing from the supply available in the shallow sand and gravel deposits. However, since the advent of irrigation in 1956, when two irrigation wells were drilled west of the city, water levels have fallen in many of the farm wells which are known to be drawing water from the shallow deposits. For this reason, the State Water Resources Commission in 1959 requested that the State Geological Survey make a study of the area to determine the limits and the geologic relations of the water-bearing shallow sand and gravel deposits.

The field work for the present investigation was completed between August 8 and August 31, 1960. The State Geological Survey provided the writer as geologist, Robert Bliven as assistant, and an earth-resistivity team of Richard Bruce and Charles Mickel; the U. S. Geological Survey and the U. S. Bureau of Reclamation provided the facilities of their Huron offices.

The limits of the shallow sand and gravel deposits were picked solely on the basis of well log information and an inventory of farm wells. Well logs from 85 wells were available. Included were Huron city test wells, State Water Resources Commission observation wells, U. S. Army Corps of Engineers test wells, U. S. Bureau of Reclamation test holes and observation wells, and test holes and irrigation wells drilled for individuals. Because of the abundance of well information and the questionable accuracy of the resistivity interpretations, the data obtained with the resistivity instrument were not used in outlining the limits of the sand and gravel deposits.

Acknowledgments

The preparation of this report was greatly facilitated by the cooperation of the residents in the Huron-Wolsey area. Special thanks are due to Fred E. Blechschmidt and O. Barr Doolittle of the U. S. Bureau of Reclamation office in Huron for their readiness to offer advice and to provide unpublished drilling, surveying, and earth-resistivity records. The present study was performed under the supervision of M. J. Tipton, Geologist in Charge of Ground Water Studies for the State Geological Survey.

Previous Investigations

Many test wells have been drilled west of the city of Huron in attempts to find additional water supplies for the city and for irrigation projects. The first of these test wells were drilled in the 1930's, when the James River was too low to be used as a source of water for the city.

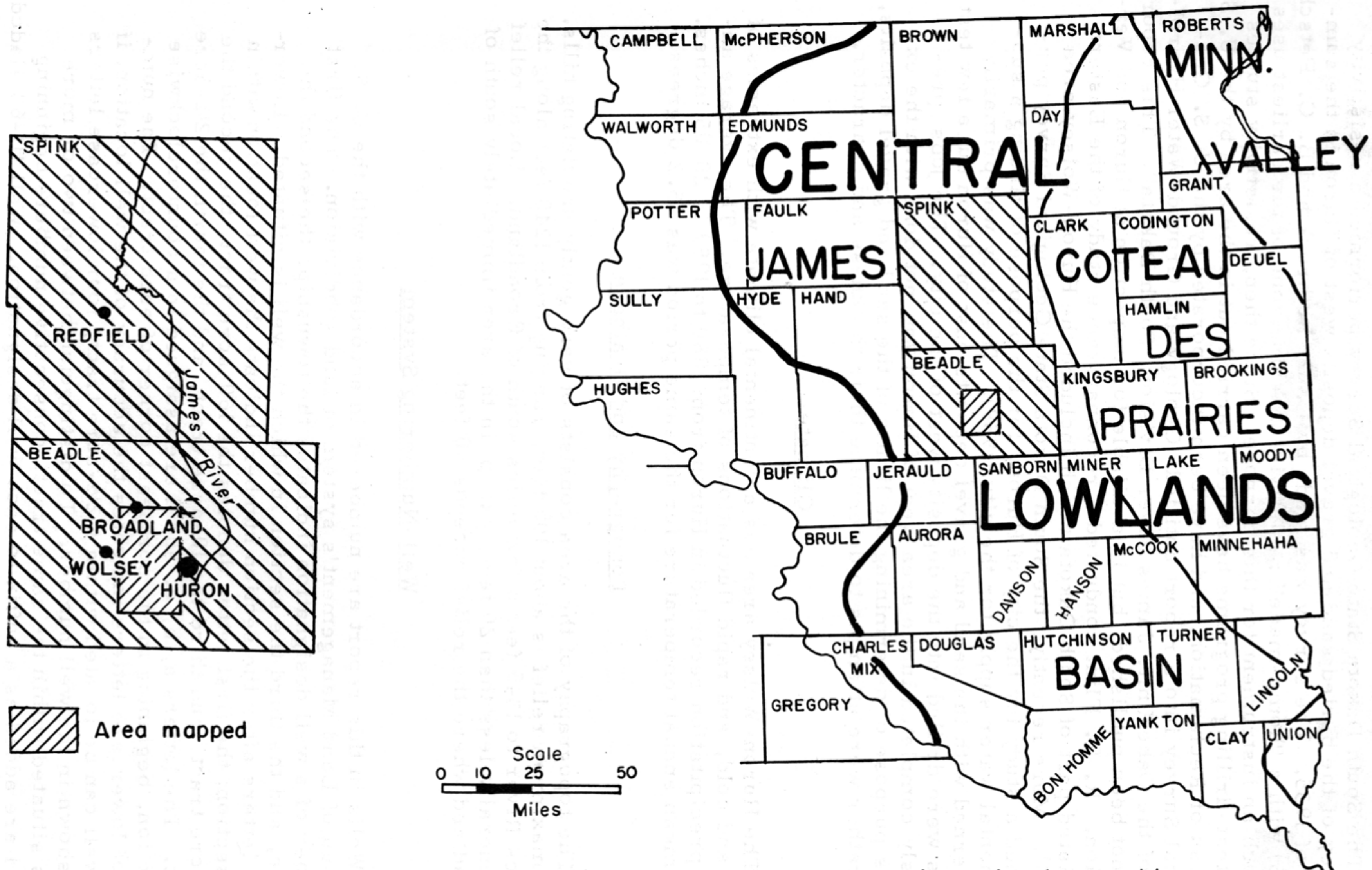

Figure I Index map of Eastern South Dakota showing major physiographic divisions, Beadle and Spink Counties, and the location of the Huron–Wolsey area.

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The South Dakota State Geological Survey performed a resistivity survey of the buried sand and gravel deposits west of Huron in the summer of 1935. The survey was made by E. P. Rothrock and B. C. Petsch (1935) with a "home-made" resistivity machine, one of the earliest uses of such an instrument for this purpose. Since then, resistivity studies and test-drilling programs have been carried out in the area by the U. S. Bureau of Reclamation, and have been incorporated by the U. S. Geological Survey into a report entitled "Geology and Ground-Water Hydrology of the Oahe Unit, James River Division, South Dakota".. This report has not been published, but is available for inspection at Huron and Vermillion. R. F. Flint conducted a reconnaissance study of the Eastern glaciated part of South Dakota which included the Huron-Wolsey area (1955). More recently, the South Dakota State Geological Survey performed a study for the city of Huron, for the purpose of finding a supplemental water supply for the city (1959). The study was primarily concerned with the sand and gravel deposits east of Huron but a few test holes were drilled into the deposits west of the city. The jobs previously completed in the area west of Huron were not done with the express purpose of determining the limits of the sand and gravel deposits, but rather were attempts to determine their thickness and character.

Climate

The Huron-Wolsey area has a continental climate with extremes of heat and cold, and rapid fluctuations of temperature. The average annual precipitation recorded in Huron from 1880 to 1959 is 20.05 inches. The mean annual temperature for the same period was 45.2 degrees.

Topography and Drainage

The topography of the area consists of very gently undulating hills. The maximum relief is about 105 feet, ranging from 1240 feet along the James River to 1345 feet a few miles south of Broadland. Local relief is generally less than 20 feet, except in the area immediately south of Broadland where the relief exceeds 60 feet.

Well-Numbering System

Wells in this report are numbered in accordance with the U. S. Bureau of Land Management's system of land subdivision. The first number of a well designation indicates the township, the second the range, and the third the section in which the well is situated. Lowercase letters after the section number indicate the well location within the section; the first letter denotes the 160-acre tract, the second the 40-acre tract, and third the 10-acre tract, and the fourth the 2½-acre tract. The letters a, b, c, and d are assigned in a counterclockwise direction, beginning in the northeast corner of each tract. The number of lowercase letters indicates the accuracy of the well location; if the well can be located within a 2½-acre tract, four lowercase letters are shown in the well number. To distinguish between two or more wells situated within the same tract, consecutive numbers beginning with 1 are added as a suffix to each well designation. Well 111-63-11adcd2 is the second well described in the SE¼SW¼SE¼NE¼ sec. 11, T. 111 N., R. 63 W; the method of designation is shown by the illustration on the following page (fig. 2).

GENERAL GEOLOGY

Surficial Deposits

The surface deposits in the Huron-Wolsey area, with the exception of the alluvium along the floodplain of the James River, were deposited by the last glacial ice sheet to cover Eastern South Dakota, during the Pleistocene Epoch. This Cary glacier, which retreated about 12,000 years ago, was preceded by five other glaciers which deposited material in this area prior to the deposition of the Cary deposits. These deposits, called drift, consist of till and outwash. Till, having been deposited directly by the ice, is a jumbled mass of unsorted clay, silt, sand, gravel, and boulders. Outwash deposits were laid down by the meltwaters of the retreating glacier and consist principally of sand and gravel derived from the till. It is these outwash deposits which often contain large amounts of water and which usually transmit it readily.

The outwash deposits in the Huron-Wolsey area are irregular in thickness and in outline (fig. 3). They underlie about 73 square miles and are as much as 50 feet thick although they average 20 feet. The deposits are overlain by tills that are 50 to 60 feet thick except near Broadland (fig. 3), where the buried outwash deposits are within 13 feet of the surface. The outwash deposits are believed to be part of a large pre-Cary outwash plain that once filled most of the old James River Valley. Reconnaissance maps prepared by the U. S. Bureau of Reclamation from drilling and resistivity data show extensive outwash deposits between Huron and Redfield, South Dakota (fig. 1). However, such maps do not differentiate between Cary and pre-Cary outwash deposits. Within the area of study the sands and gravels are interbedded with one or more layers of till; thus they may represent more than one age of deposition. It is believed that these deposits were even more extensive in pre-Cary time, but were partially removed by the advancing Cary ice.

The glacial deposits in the Huron-Wolsey area are underlain by bedrock which in most places is Pierre shale but in at least one locality is Niobrara chalk (Appendix A, Test Hole H-22). The Pleistocene deposits are as little as 62 feet thick and are consistently less than 100 feet thick; thus the bedrock is generally near the surface.

Extent of the Glacial Outwash Deposits

Prior to the present study the U. S. Bureau of Reclamation and the U. S. Geological Survey made different interpretations of the extent of the buried glacial outwash on the basis of test well and resistivity information (fig. 4). They are reconnaissance

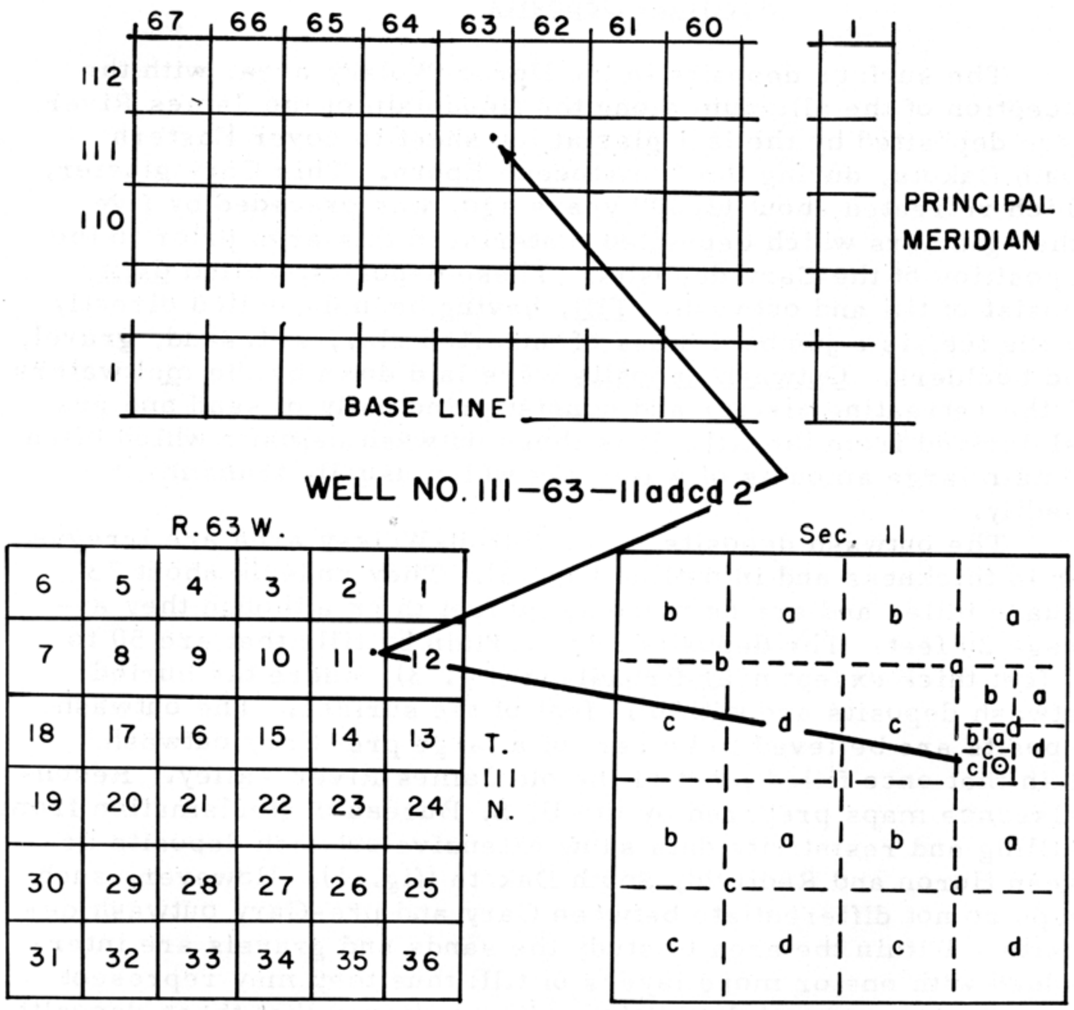

Figure 2 Explanation of well location and numbering system.

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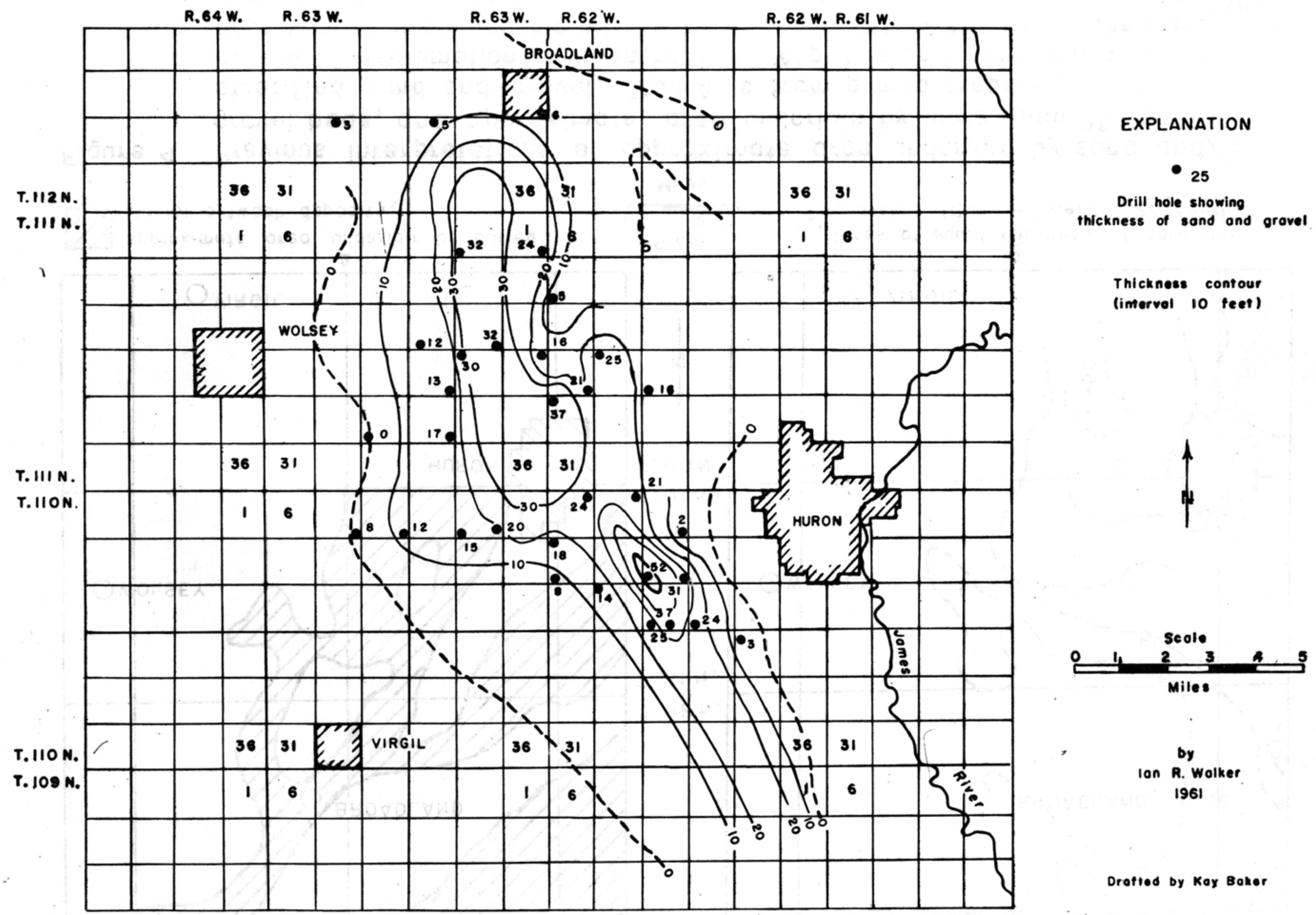

Figure 3 Map showing outline and thickness of buried outwash deposits in the Huron-Wolsey area.

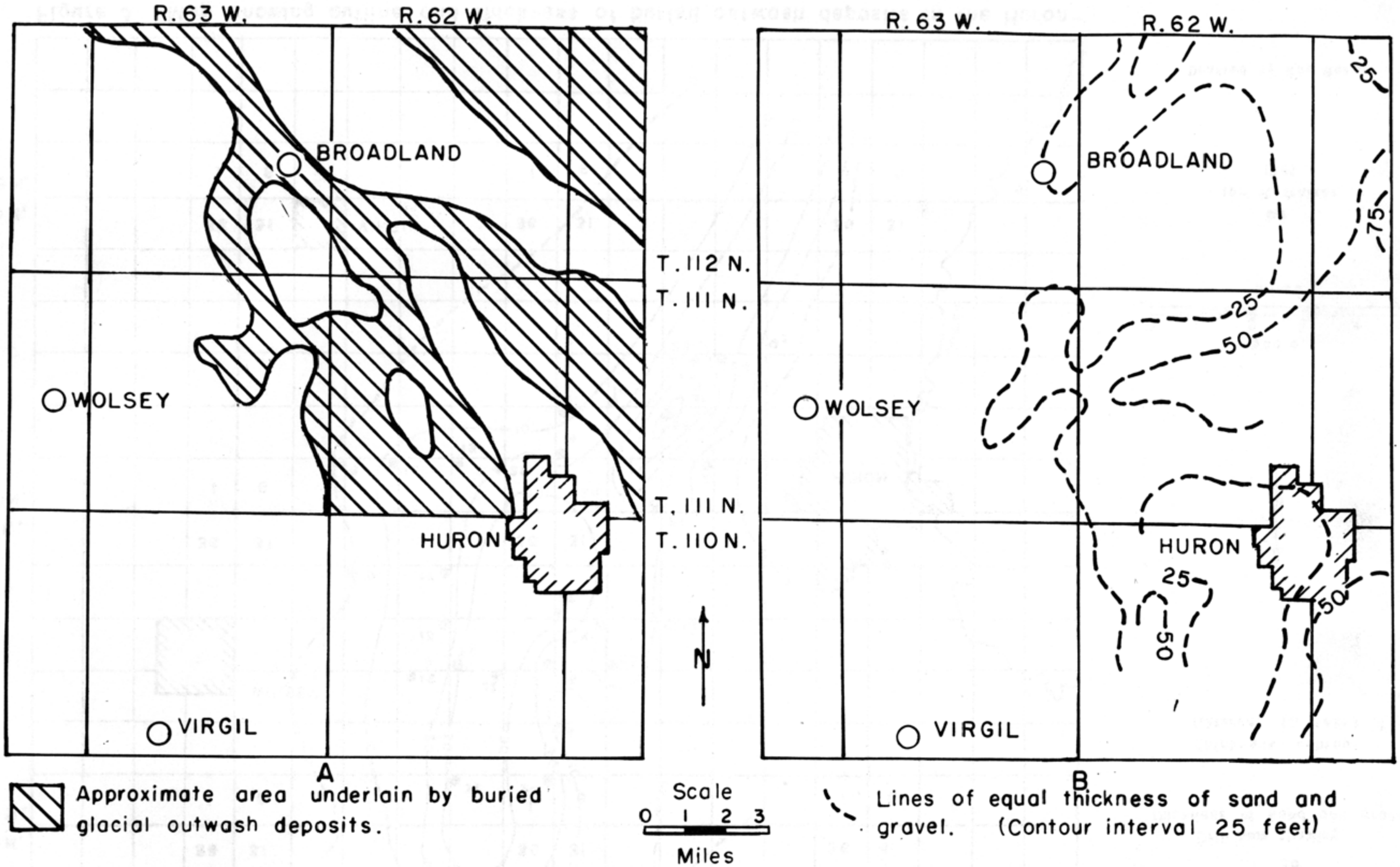

Figure 4 Previous interpretations of approximate area underlain by sand and/or gravel beds, and approximate area underlain by more than 25 feet of stratified sand and gravel. Map A is from a map prepared by the U.S. Bureau of Reclamation (Revised 1952). Map B is an interpretation of the approximate area underlain by more than 25 feet of stratified sand and gravel, and was prepared by J.R. Jones of the U.S. Geological Survey (1956).

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maps only, and are subject to change as additional data are obtained. The writer's interpretation of the outer limits and the varying thickness of the buried outwash is shown on Figure 3.

In compiling data for the map showing the thickness of the outwash deposits, only the thickest sand and gravel layers from each well were used, or in some cases, the total thickness of two or more sands if they were separated by only a foot or so of till or clay. Therefore, the total thickness of all the sand and gravel at a particular location may be greater than is shown by the map. For example, test hole H-21 (Appendix A and fig. 5) penetrated four sand layers with a combined thickness of 34 feet. There is no assurance that these layers are part of the same deposit, so only the thickest layer, or the 16 foot layer, was included on the map.

The numerous thin sand and gravel layers in the Huron-Wolsey area make it difficult to establish boundaries for the major outwash deposits in the area. There are apparently many deposits of varying size (fig. 6). Test hole H-17 (Appendix A) penetrated two thin sand layers which are assumed to be part of the thickest buried outwash body (fig. 7). On the basis of the two layers penetrated in test hole H-17, and on the basis of an inventory of farm wells in the area, the western limit of the buried outwash deposit was placed immediately west of test hole H-17 (fig. 5). However, these thin sand layers may be only localized sand lenses and stringers. If this is the case, wells tapping these localized deposits would probably produce only limited supplies of water; thus they would probably not be affected by decreases in water levels resulting from pumping of irrigation or city wells because of the lack of communication between them and the water sands that supply the latter.

Except in the center of the Huron-Wolsey area where about 13 square miles are underlain by sands and gravels at least 30 feet thick, the buried outwash deposits are interfingered with layers of clay and till. Within the area of interfingering sand, gravel, clay, and till, the thickness of sand which is supplying the irrigation wells may be but a fraction of the total thickness of the outwash deposits. For this reason, the total volume of sand and gravel, and the amount of water available for irrigation and domestic use, cannot be computed accurately.

With the information available, there is no way of determining whether the buried outwash deposits near the surface at Broadland are part of or are connected with the deeper buried outwash deposits west of Huron. The Broadland deposits apparently are linear stream channel deposits (fig. 6). In August, 1960, a well was bored to 65 feet in the center of Broadland, and no sand and gravel deposits more than 6 inches thick were penetrated. A new well was bored 100 feet away, and at 13 feet a coarse sand and gravel deposit of unknown thickness was tapped. The top of this coarse sand and gravel deposit is at an elevation of 1291 feet. The upper surface of the buried outwash deposits immediately west of Huron, about 9 miles south of Broadland, is at an elevation of about 1255 feet. The four feet per mile gradient between the two points is not excessive for the surface of a glacial outwash deposit. However, this

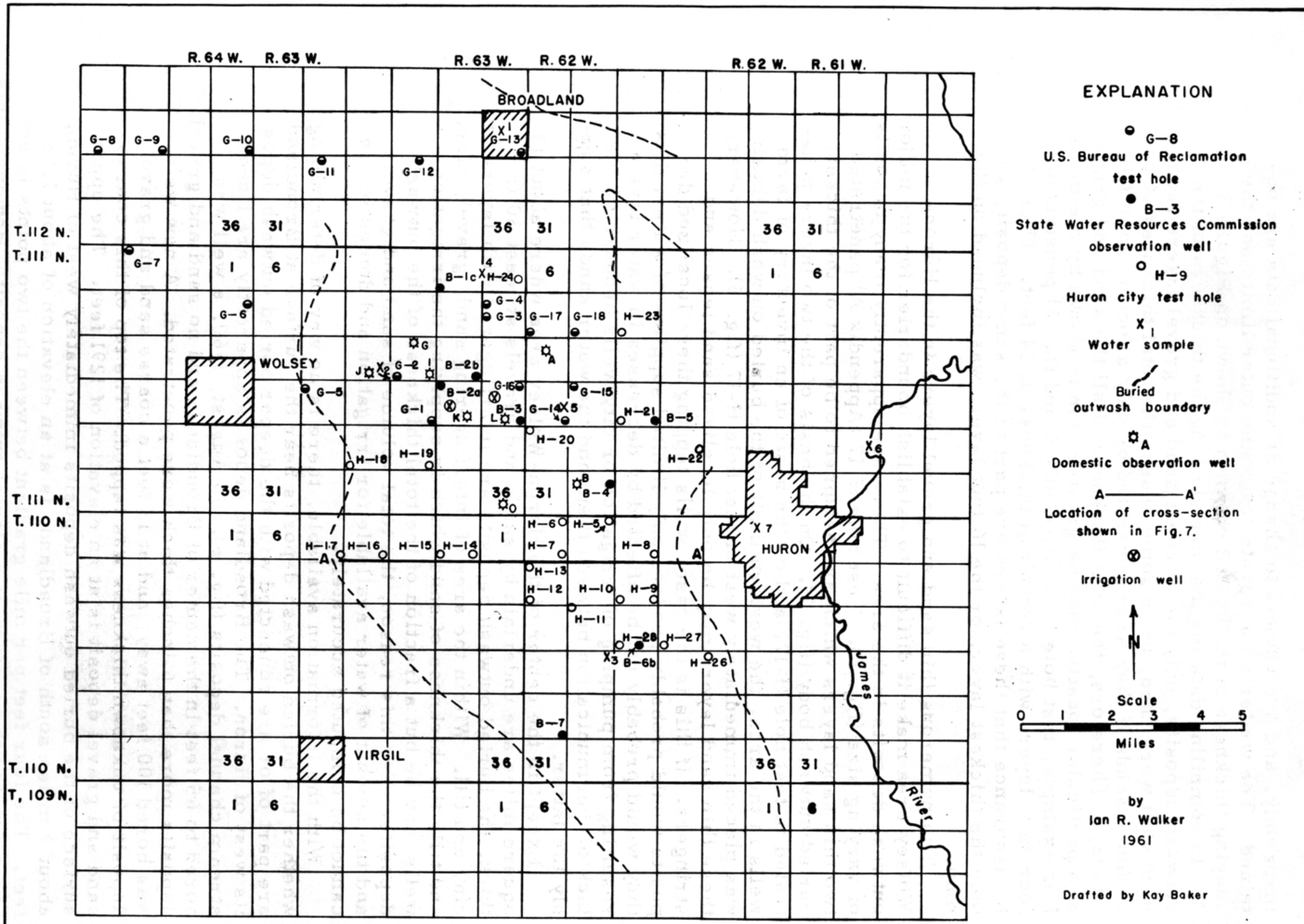

Figure 5 Data map of the Huron—Wolsey area.

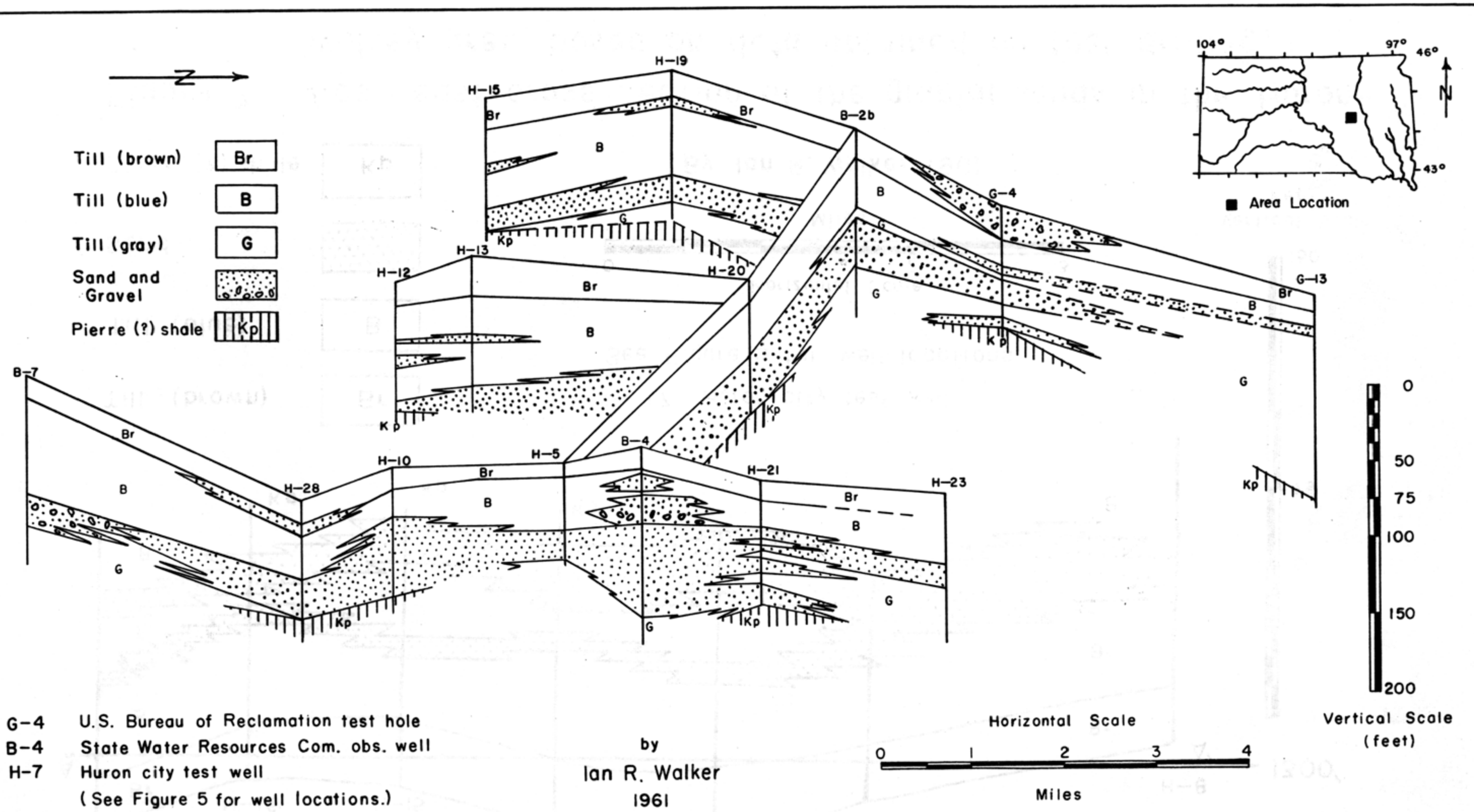

Figure 6 Panel diagram of the unconsolidated surficial deposits in the Huron–Wolsey area, based on data obtained from test-drilling.

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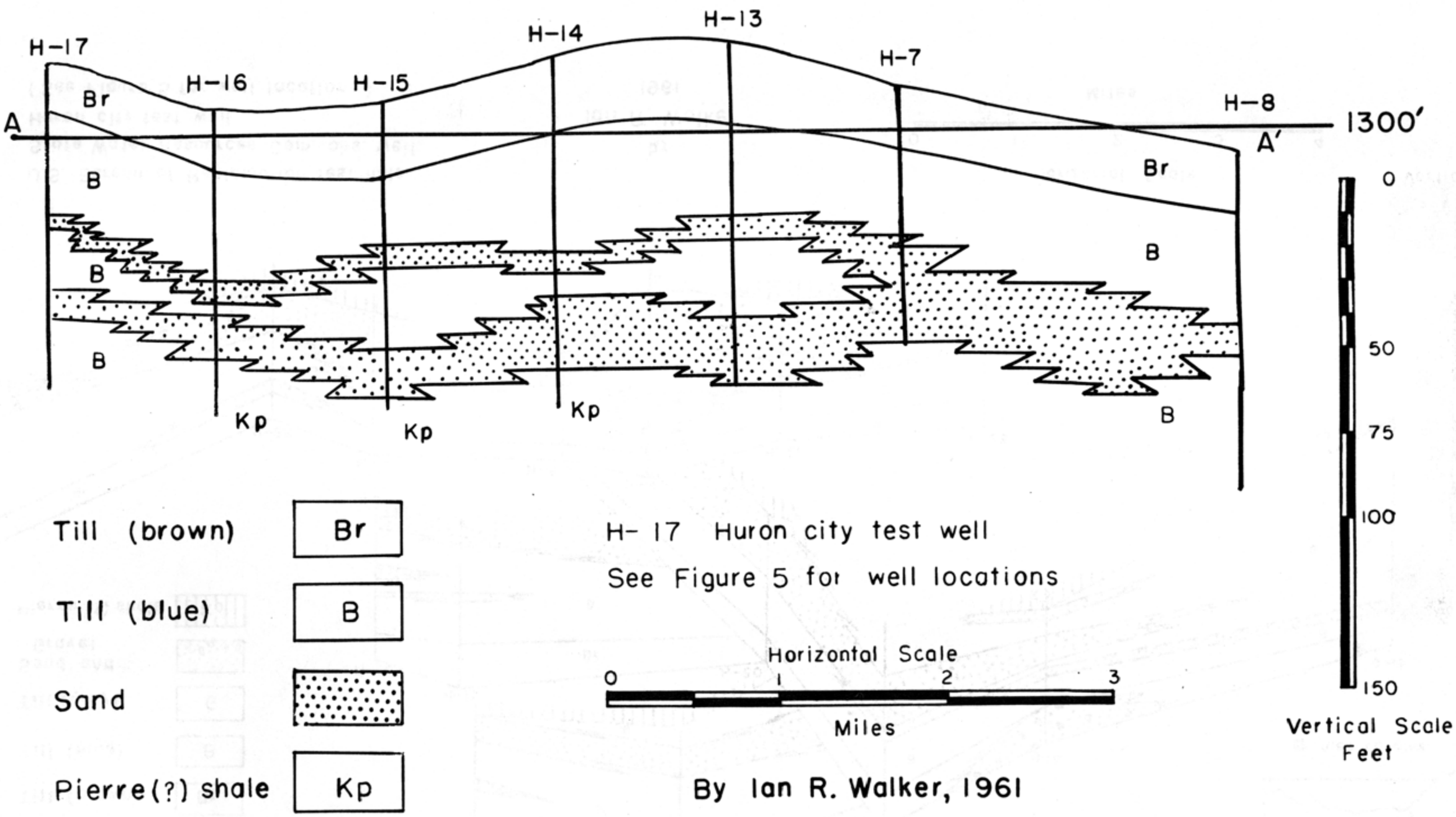

Figure 7 West–east cross-section of the glacial sands in the Huron–Wolsey area, based on data obtained by test drilling.

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does not necessarily mean that the surface outwash deposits at Broadland are connected with the buried outwash deposits immediately west of Huron.

Bedrock

Stratified sedimentary rocks are found beneath the unconsolidated surficial deposits of glacial drift. The stratified rocks present immediately beneath the drift in the Huron-Wolsey area are in descending order the Pierre shale and the Niobrara chalk. Both are of Cretaceous age.

The Pierre Formation, light- to dark-gray fissile shale with many thin bentonites and layers of concretionary iron manganese, has been considerably eroded and its true thickness in the Huron-Wolsey area is unknown.

The Niobrara Formation, blue-gray calcareous chalk and marl, is about 50 feet thick in the area.

Niobrara chalk was penetrated in only one test well so it is concluded that the unconsolidated surficial deposits lie on the Pierre shale throughout most of the area.

SHALLOW GROUND WATER

Occurrence

Some geologic formations are known as aquifers--formatinns having properties that permit an appreciable amount of water to move through them under ordinary field conditions. Two properties, porosity and permeability, determine the amount of water which will move through an aquifer. Porosity is the percentage of voids in a given volume of material. The percentage of voids in samples of well-sorted fine sand and of well-sorted coarse gravel is about the same. If the material were poorly sorted--that is, consisting of varying sizes of sands and gravels--the percentage of voids, and therefore the porosity, would be low. Permeability, or the rate at which a fluid will flow through a material, is greater for gravel than for sand. The larger voids offer less resistance to flow than the smaller voids in finer sands, so more water will flow through the coarser material in a given time.

Two types of aquifers are present in the Huron-Wolsey area. In the type found at Broadland, the water table stands within the body of sand and only that part of the sand below the water table is saturated. Wells in this type of aquifer are called non-artesian or water-table wells. In the type of aquifer immediately west of Huron, the water-bearing sand is confined between layers of relatively impervious glacial till. The full thickness of the sand is saturated and the water is under enough pressure, or head, to cause the water level to rise above the top of the sand when a well is drilled into it. Such a well is said to be artesian. The surface to which the water in an artesian aquifer will rise is called the piezometric surface.

Most of the wells in the Huron-Wolsey area that are drilled into the buried glacial outwash deposits are artesian wells. The head averages about 35 feet above the level of the sand and gravel, but none of the wells flow.

Following the advent of irrigation in the area in 1956, the State Water Resources Commission conducted pumping tests to determine the effects of irrigation pumping on water level fluctuations. With increased irrigation pumping, water levels in most domestic observation wells declined. When irrigation pumping was reduced, a rise in water level in the observation wells definitely reflected the shutdown of irrigation pumping (State Water Resources Commission, unpublished information). The Water Resources Commission concluded that the buried outwash deposit was absent in those areas where observation wells showed no fluctuations resulting from the pumping tests.

Fluctuations of water in wells penetrating artesian aquifers result primarily from changes in pressure rather than from changes in storage volume. The pumping of water for irrigation in the Huron-Wolsey area has caused the piezometric surface to be lowered considerably as a result of a decrease in the artesian pressure from the buried outwash aquifer (table 1).

Table 1. --Water level fluctuations in feet in domestic observation wells (May 24-August 8, 1960)

(for locations see fig. 5)

Well	Depth to Water as of 5/24/60	Depth to Water as of 8/9/60	Depth to Water as of 8/16/60	Depth to Water as of 8/22/60
A	23.4	29.5	33.3	---
B	21.0	30.3	33.0	---
G	30.6	31.6	33.0	33.8
I	24.0	26.6	26.9	25.5
J	24.8	22.7	22.8	22.8
K	37.0	42.1	Dry	Dry
L	27.0	35.1	40.5	35.5
O	33.4	39.2	41.8	40.0

However, it is not always valid to conclude that, just because a domestic observation well shows no fluctuation in water level, the buried outwash deposit is not present in the area. In the Huron-Wolsey area the State Water Resources Commission used abandoned bored wells as observation wells. Most of these shallow wells are more than fifty years old, most of them were bored but a few feet into the buried outwash, and many have become filled with as much as 25 feet of sand and mud. A case in which an observation well showed no water level fluctuations in an area underlain by the buried outwash is illustrated in Figure 8.

The map and cross-section in Figure 8 show the locations of an abandoned farm well serving as an observation well, the Edward Kahre farm well, two irrigation wells, five test holes, and their relationship to the buried outwash. Edward Kahre, the owner of the farm, stated that the irrigation wells were affecting his domestic well. Measurements of water levels in the abandoned well show little or no fluctuation. On this basis, the State Water Resources Commission assumed that the outwash was absent in this area and that Mr. Kahre's complaint was not justified. However, a cross-section of the area shows two outwash sand layers throughout. The abandoned well was probably completed in the first sand, the usual procedure. According to Mr. Kahre, his newer well is deeper than the abandoned farm well and was apparently bottomed in the major outwash deposit. If this is the case, a relationship between irrigation pumping and the water level in the newer well can be demonstrated. Conversely, the owner of a well pumping from the upper sand would not be justified in complaining against the irrigators, who are pumping from the lower sand.

Mr. Kahre's case indicates the difficulty in determining the thickness and areal extent of the major outwash sand in the Huron-Wolsey area. Sand lenses and stringers may be in hydrologic continuity with, or may just as well be isolated from the major buried deposit.

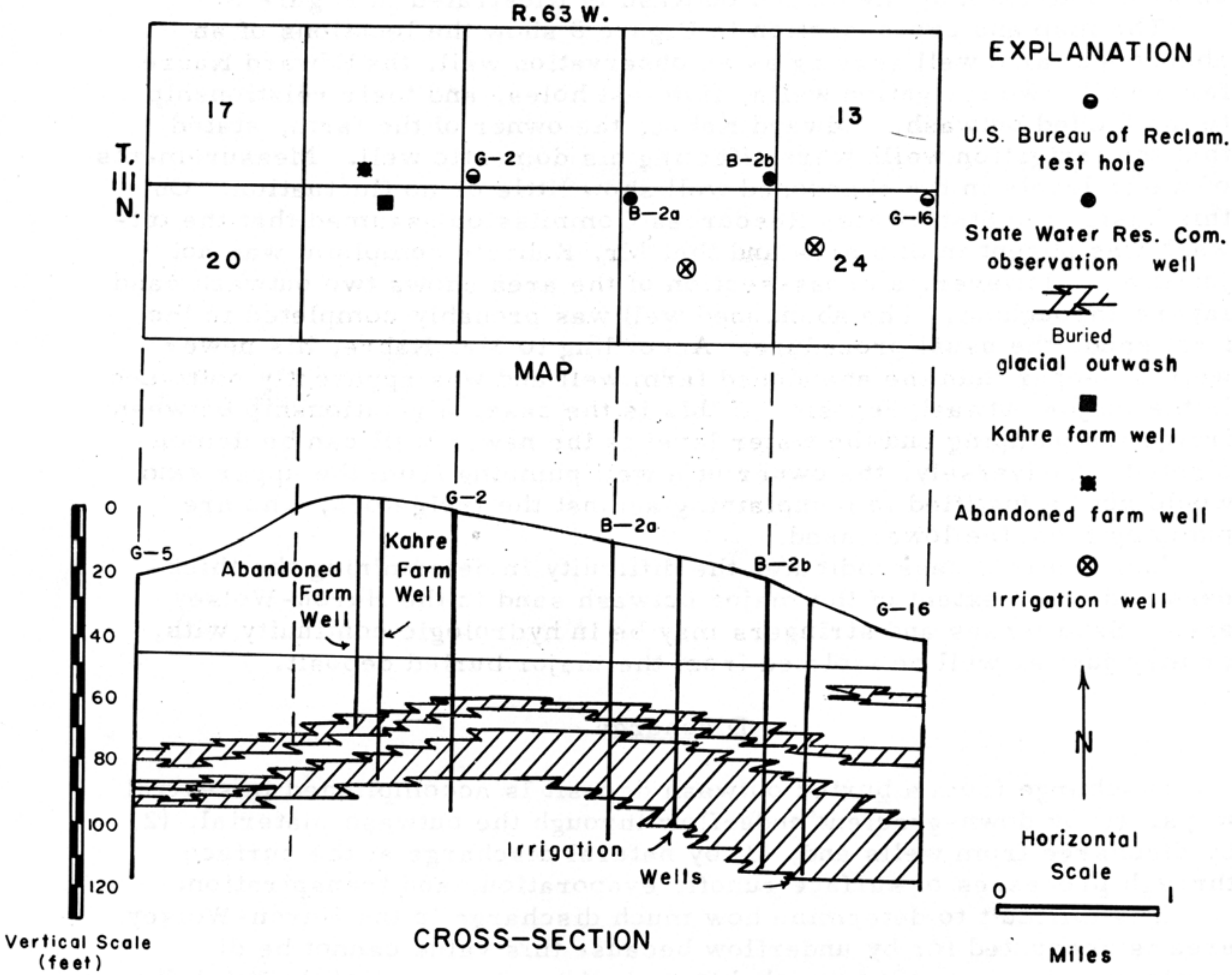
Discharge

Discharge from a buried outwash deposit is accomplished in several ways: (1) by down-gradient underflow through the outwash material, (2) by discharge from wells and, (3) by natural discharge at the surface through processes of surface runoff, evaporation, and transpiration.

It is difficult to determine how much discharge in the Huron-Wolsey area is accounted for by underflow because this value cannot be directly measured, but it is probably a significant amount of the total discharge.

Irrigation pumping accounts for the largest volumes of water pumped from the buried outwash deposit. Reliable records have been kept on irrigation pumping since 1956 when the first irrigation wells were drilled in the area (State Water Resources Commission, unpublished information). It would be possible to estimate the amount of water pumped for domestic purposes but this amount is probably only a small part of the total discharge.

Evaporation and transpiration from the buried aquifer in the Huron-Wolsey area are probably only small factors in the total discharge, because of the covering of till on most of the outwash materials which provides an effective seal against upward movement of water. Tipton (1960, p. 5) reported springs along the James River which may account for some of the discharge from the buried aquifer. It is not known how many of these springs are discharging into the river but if the water is supplied



Depth to water level in abandoned farm well

	5-24-60	8-9-60	8-16-60	8-22-60
Abandoned farm well	24.8 ft.	22.7 ft.	22.8 ft.	22.8 ft.

Figure 8 Map and cross-section showing locations of the Edward Kahre farm well, the abandoned farm well, the irrigation wells, and their relationship to the buried outwash.

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from the buried aquifer west of Huron the springs could account for a large amount of the discharge. There is no surface runoff from the buried aquifer between Huron and Wolsey.

The buried outwash in the Huron-Wolsey area has a head or artesian pressure of about 35 feet. This head could be produced in several ways: (1) by a decrease in permeability of the sands to the south, (2) by a decrease in cross-sectional area, causing a "bottle neck" to the south, or (3) by a higher elevation of the sediments to the north.

No data are available on the permeability of the sands and gravels or on changes of permeability from north to south. There is a decrease in cross-sectional area of the buried outwash deposit to the south but it is not known whether there is a sufficient decrease in area to produce the 35-foot head. The difference in elevation between the top of the gravel deposits at Broadland and the top of buried outwash deposits west of Huron is about 36 feet. If the deposits in the two areas are in hydrologic continuity, the loss in head between Broadland and the area west of Huron is about six feet. This would be a reasonable explanation for the average 30-foot head in the Huron-Wolsey area but, as in the cases of the two other possible explanations already discussed, enough data are not available to warrant any conclusions concerning the cause of the head in the Huron-Wolsey area.

Recharge

Recharge to the buried outwash deposits occurs directly or indirectly from precipitation in the form of rain or snow. Direct recharge can occur from percolation of rain or meltwater downward through the overlying till. This is possible in the Huron-Wolsey area. Throughout most of the area where the overlying till is 50 to 60 feet thick, direct recharge is probably slow. However, near Broadland where outwash deposits are only a few feet below the surface, some rapid recharge undoubtedly occurs. It is not known whether the Broadland deposits are recharging the buried deposits west of Huron. Recharge by precipitation to either the deposits west of Huron or to the Broadland deposits would be difficult to evaluate since it is not easily measured. It is also possible that the water in the sand and gravel is being recharged by the James River and its tributaries upstream from Huron. More test well data are needed before any conclusions can be drawn concerning the James River as a source for recharge to the buried outwash deposits.

Another possibility of recharge is through seepage upward from underlying bedrock formations. Because no domestic wells are known to be pumping from formations other than the Dakota sandstone, a comparison can be made only between samples from the buried outwash and samples from the Dakota sandstone. The Dakota water (sample 7, table 2) is harder and has higher concentrations of calcium, sulfate, and total solids than does the water from the buried outwash deposits (samples 1-5, table 2). The water from the Dakota sandstone appears not to be recharging the sand and gravel deposits. Water from the Niobrara Formation may supply some water to the buried outwash deposits. However, the Niobrara was penetrated beneath the surficial deposits in only one test well (H-22, Appendix A). In that well, 75 feet of blue clay (till) separates the Niobrara Formation from the nearest overlying outwash sand.

Table 2.--Chemical Analyses of Water Samples from the Huron-Wolsey Area *

Water Sample No. and date collected (for location see fig. 5)	Depth of Well	Calcium	Sodium	Magnesium	Chloride	Sulphate	Iron	Manganese	Nitrate	Fluoride	Hardness $CaCO_3$	Total Solids	Class for Irrigation***
U. S. Dept. of Public Health Drinking Water Standards **	--	--	--	50	250	250	0.3	.1	10	1.0	---	500 to 1000	--
#1 Oct. 1960	20'	180	53	57	83	400	8.5	0.8	0	1.1	682	682	II
#2 Oct. 1960	70'	64	188	29	13	350	****<0.1	0.7	0	0.8	279	1092	II
#3 Oct. 1960	89'	68	218	32	30	470	0.1	<0.2	0	0.9	298	1156	II
#4 Oct. 1960	63'	32	486	39	183	420	0.7	<0.2	3	0.9	238	1692	III
#5 Oct. 1960	?	50	380	18	50	460	1.8	0.4	0	1.3	199	2508	III
#6 Aug. 1959	?	76	--	37	46	326	0.3	1.3	-	0.6	342	771	
#7 Oct. 1954	1000'	164	406	41	132	1110	2.4	---	-	2.4	1020	1970	III

* analyses by State Chemical Laboratory, Vermillion, 1960.
** not to exceed
*** Class I. Excellent to Good
Class II. Good to Injurious
Class III. Injurious to Unsatisfactory
**** "<" means less than

No wells are known to pump water from the Niobrara in the area mapped, so a comparison between water samples from the buried outwash and samples from the Niobrara Formation cannot be made.

Chemical Analyses

All ground water contains minerals which are obtained (1) from the atmosphere as the water vapor condenses and falls, (2) from soil and underlying deposits as the water moves downward to the water table, and (3) from deposits below the water table, in which the water is circulating. In general, the more minerals that a water contains, the poorer its quality.

The U. S. Department of Public Health has established standards for public drinking water (table 2), which show the maximum concentrations of chemical constituents that are permitted.

Table 2 shows the analyses of water samples taken from the Huron-Wolsey area. Samples 1-5 are from the buried outwash channel west of Huron, sample 6 is from the James River, and sample 7 is from the Dakota sandstone. Samples 1-6 exceed the Public Health standards for a few of the chemical constituents but generally can be used for human consumption. Sample 7 is unsuitable for drinking.

The standards for irrigation water classification are dependent upon the conditions under which the water is to be used. Consideration must be given to soil texture, infiltration rate, drainage, and salt tolerance of the crop. Large deviations from the optimum for one or more of these conditions would make it unwise to use a water that would otherwise be satisfactory.

Table 2 shows that samples 1-3 are class II for irrigation purposes. These waters, with proper management, could be used on porous well-drained soils. Samples 4 and 5 are class III for irrigation purposes and would be injurious to unsatisfactory even under average conditions.

The soils in the Huron-Wolsey area are formed from fine-textured glacial till. The resulting low infiltration rate of irrigation water into these soils make it unsafe to use class III water.

CONCLUSIONS AND RECOMMENDATIONS

The results of this study by the State Geological Survey show that the buried glacial outwash deposits underlie about 73 square miles in the Huron-Wolsey area. Less than one-fifth of the area, or 13 square miles, is underlain by sand and gravel deposits 30 or more feet thick. The remainder of the area is underlain by outwash deposits that are interfingered with clay and glacial till to such an extent that the total volume of sand and gravel in the Huron-Wolsey area, and therefore the amount of water available for irrigation and domestic use, cannot be computed accurately.

The limits of the major buried outwash deposit in the Huron-Wolsey area are difficult to determine because of the many thin lenses and stringers of sand. It is impossible to determine whether these smaller deposits are in hydrologic continuity with the major outwash deposit, without extensive pumping tests.

At Broadland, buried outwash deposits are within 13 feet of the surface. If these deposits are continuous with the deposits immediately west of Huron, they are probably responsible for a large part of the recharge to the buried outwash deposits in the Huron-Wolsey area.

The artesian head of 35 feet developed in the buried outwash deposits is sensitive to irrigation pumping, and declined as much as 13 feet in the immediate area of irrigation pumping in 1960.

The water from the buried outwash deposits is satisfactory for domestic use but is of doubtful quality for irrigation purposes in some areas.

The following recommendations are made concerning further development of water resources from the buried outwash deposits in the Huron-Wolsey area:

1. Controlled pumping tests of several irrigation wells should be made before beginning long-term use of water from the buried outwash deposits for irrigation.
2. Additional irrigation wells should be drilled only in the center of the area, where the buried outwash deposits are relatively free from interfingering sand and clay layers.
3. If class II water is used for irrigation in the area, special management for salinity control will be required, and plants with high salt tolerance should be selected.
4. In evaluating complaints against the irrigators, except in those wells which are known to tap the major buried outwash deposit, it is desirable if pumping tests can be made of the irrigation wells in conjunction with frequent water level readings in the well of the complainant.

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APPENDIX A

Logs of Huron City Test Holes

(for locations see fig. 5)

Test Hole H-5 (There are no holes H-1 to H-4)
Location: 110-62-5aa (see fig. 2)
Surface Elevation: 1303 feet

Pleistocene and Recent deposits, undifferentiated:

0-11	clay, yellow
11-43	clay, blue
43-64	sand
64-66	clay and sand
66	total depth

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Test Hole H-6
Location: 110-62-6aa
Surface Elevation: 1310 feet

Pleistocene deposits:

0-52	till
52-76	sand
Pierre (?) shale	
76	shale (total depth)

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Test Hole H-7
Location: 110-62-6dd
Surface Elevation: 1312 feet

Pleistocene deposits:

0-44	till
44-50	shale, broken, and sand
50-76	sand
76	total depth

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Test Hole H-8
Location: 110-62-4dd
Surface Elevation: 1295 feet

Pleistocene and Recent deposits, undifferentiated:

0- 18 clay, yellow
(continued on next page)

Test Hole H-8--continued

18- 54	clay, blue
54- 56	sand
56-100	clay, blue
100	total depth

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Test Hole H-9
Location: 110-62-9dd
Surface Elevation: 1289 feet

Pleistocene and Recent deposits, undifferentiated:

0-20	clay, yellow
20-30	clay, yellow, and gravel
30-42	clay, blue
42-48	gravel, fine
48-73	sand
Pierre (?) shale	
73-92	shale, blue
92	total depth

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Test Hole H-10
Location: 110-62-9cc
Surface Elevation: 1307 feet

Pleistocene and Recent deposits, undifferentiated:

0-15	clay, yellow
15-33	clay, blue
33-85	sand
Pierre (?) shale	
85-97	shale
97	total depth

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Test Hole H-11
Location: 110-62-17b
Surface Elevation: 1322 feet

Pleistocene and Recent deposits, undifferentiated:

0-18	clay, yellow
18-48	clay, gravelly, blue
48-62	sand
62-68	clay
68-73	sand
Pierre (?) shale	
73-92	shale
92	total depth

* * * * * * * *

Test Hole H-12
Location: 110-62-7cc
Surface Elevation: 1310 feet

Pleistocene and Recent deposits, undifferentiated:

0-15	clay, yellow
15-37	clay, blue
37-39	sand
39-48	clay, blue
48-56	sand
56-78	clay, blue
78-85	sand
Pierre (?) shale	
85-92	shale
92	total depth

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Test Hole H-13
Location: 110-62-7bb
Surface Elevation: 1326 feet

Pleistocene and Recent deposits, undifferentiated:

0- 25	clay, yellow
25- 51	clay, blue
51- 55	sand
55- 85	clay, blue
85-103	sand
103	total depth

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Test Hole H-14
Location: 110-63-2dd
Surface Elevation: 1323 feet

Pleistocene and Recent deposits, undifferentiated:

0- 22	clay, yellow
22- 61	clay, blue
61- 63	sand
63- 70	clay, blue
70- 90	sand
Pierre (?) shale	
90-105	shale
105	total depth

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Test Hole H-15
Location: 110-63-2cc
Surface Elevation: 1311 feet

Pleistocene and Recent deposits, **undifferentiated:**

0-22	clay, yellow
22-43	clay, blue
43-50	sand
50-73	clay, blue
73-88	sand
Pierre (?) shale	
88-92	shale
92	total depth

* * * * * * * * *

Test Hole H-16
Location: 110-63-4dd
Surface Elevation: 1307 feet

Pleistocene and Recent deposits, **undifferentiated:**

0-18	clay, yellow
18-50	clay, blue
50-56	sand
56-61	clay, blue
61-73	sand
Pierre (?) shale	
73-90	shale
90	total depth

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Test Hole H-17
Location: 110-63-5dd
Surface Elevation: 1323 feet

Pleistocene and Recent deposits, **undifferentiated:**

0-15	clay, yellow
15-48	clay, blue
48-50	sand
50-68	clay, blue
68-76	sand
76-98	clay, blue
98	total depth

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Test Hole H-18
Location: 111-63-28cc
Surface Elevation: 1323 feet

Pleistocene and Recent deposits, undifferentiated:

0- 19	clay, yellow
19- 21	sand
21-119	clay, blue (total depth)

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Test Hole H-19
Location: 111-63-27dd
Surface Elevation: 1321 feet

Pleistocene and Recent deposits, undifferentiated:

0-19	clay, yellow
19-21	sand
21-69	clay, blue
69-86	sand
86-98	clay, blue (total depth)

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Test Hole H-20
Location: 111-62-30bb
Surface Elevation: 1313 feet

Pleistocene and Recent deposits, undifferentiated:

0-18	clay, yellow
18-55	clay, blue
55-92	sand
Pierre (?) shale	
92	shale, blue (total depth)

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Test Hole H-21
Location: 111-62-21cc
Surface Elevation: 1300 feet

Pleistocene and Recent deposits, undifferentiated:

0-15	clay, yellow
15-32	clay, blue
32-38	sand
38-42	clay, blue

(continued on next page)

Test Hole H-21--continued

42-46	sand, coarse
46-52	clay, blue
52-60	sand
60-66	clay, blue
66-82	sand

Pierre (?) shale

82	shale, blue (total depth)

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Test Hole H-22
Location: 111-62-27ad
Surface Elevation: 1292 feet

Pleistocene and Recent deposits, undifferentiated:

0- 4	soil
4- 10	sand, red
10- 34	clay, blue
34- 38	sand
38- 52	clay, blue
52- 57	sand
57- 70	till
70- 85	sand
85-160	clay, blue

Niobrara Formation

160-200	chalk
200	total depth

* * * * * * * *

Test Hole H-23
Location: 111-62-9cc
Surface Elevation: 1293 feet

Pleistocene deposits:

0-47	till
47-63	sand
63-99	clay, blue (total depth)

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Test Hole H-24
Location: 111-63-1da
Surface Elevation: 1306 feet

Pleistocene and Recent deposits, undifferentiated:

0-12	clay, yellow
12-44	clay, blue
44-48	sand, fine

(continued on next page)

Test Hole H-24--continued

48-54	gravel, fine
54-68	sand
68-99	clay, blue
99	total depth

* * * * * * * *

Test Hole H-26
Location: 110-62-23bb
Surface Elevation: 1305 feet

Pleistocene and Recent deposits, undifferentiated:

0- 15	clay, yellow
15- 40	clay, blue
40- 43	sand and rock
43- 85	clay, blue
85- 87	sand
Pierre (?) shale	
87-115	shale
115	total depth

* * * * * * * *

Test Hole H-27
Location: 110-62-15cc
Surface Elevation: 1316 feet

Pleistocene and Recent deposits, undifferentiated:

0-15	clay, yellow
15-22	gravel
22-44	clay, blue
44-68	sand
Pierre (?) shale	
69-91	shale
91	total depth

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Test Hole H-28
Location: 110-62-16c
Surface Elevation: 1309 feet

Pleistocene and Recent deposits, undifferentiated:

0-15	clay, yellow
15-23	sand, red, and clay
23-52	clay, blue
52-77	sand
Pierre (?) shale	
77-93	shale
93	total depth

* * * * * * * *

APPENDIX B

Logs of U. S. Bureau of Reclamation Test Holes

(for locations see fig. 5)

Test Hole G-1
Location: 111-63-22dd (see fig. 2)
Surface Elevation: 1317 feet

Pleistocene and Recent deposits, undifferentiated:

0- 4	soil
4- 8	sand and gravel
8-18	till, yellow
18-25	till, gray
25-38	till, gray
38-55	gravel, sandy at base
55-58	till (sandy clay)
58-61	till, gray, hard
61-67	sand
67-71	till, gray
71-77	sand, coarse
77-84	sand, lignitic
Pierre (?) shale	
84-90	shale, fragmented in part
90	total depth

* * * * * * * *

Test Hole G-2
Location: 111-63-15cc
Surface Elevation: 1345 feet

Pleistocene deposits:

0-30	till, yellow
30-54	till, gray
54-55	lignite
55-59	till, gray
59-61	sand
61-69	till, gray
69-81	sand
81-93	till
Pierre (?) shale	
93-94	shale
94	total depth

* * * * * * * *

Test Hole G-3
Location: 111-63-12db
Surface Elevation: 1315 feet

Pleistocene deposits:

0-16	till, yellow
16-19	sand
19-23	till, yellow
23-52	till, gray
52-74	sand, lignitic and clayey from 65 to 71 feet
74-80	clay, lignitic
Pierre (?) shale	
80-82	shale, gray
82	total depth

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Test Hole G-4
Location: 111-63-12bc
Surface Elevation: 1301 feet

Pleistocene and Recent deposits, undifferentiated:

0- 2	soil
2-24	gravel and sand
24-25	till, yellow
25-26	gravel
26-42	till
42-46	sand
46-48	clay
48-49	sand
49-65	clay, lignitic from 49 to 60 feet
65-74	sand, silty from 66½ to 74 feet
74-80	sand and clay, greasy and petroliferous
Pierre (?) shale	
80-92	clay, black
92	total depth

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Test Hole G-5
Location: 111-63-20bb
Surface Elevation: 1322 feet

Pleistocene and Recent deposits, undifferentiated:

0- 1	soil
1-15	till, yellow
15-17	sand
17-55	till, gray
55-56	sand, fine

(continued on next page)

Test Hole G-5--continued

56-63	clay, hard
63-65	sand
65-67	clay
67-69	sand
69-96	clay (total depth)

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Test Hole G-7
Location: 111-64-3bb
Surface Elevation: 1325 feet

Pleistocene and Recent deposits, undifferentiated:

0-10	silt, buff
10-25	sand, lignitic
25-26	clay
26-27	sand
27-32	clay, sandy, gray
32-35	sand
35-40½	clay
Pierre (?) shale	
40½-50	shale
50	total depth

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Test Hole G-8
Location: 112-64-21cd
Surface Elevation: 1330 feet

Pleistocene and Recent deposits, undifferentiated:

0- 1	soil
1- 3	sand, brown
3- 8	clay and silt
11-13	clay, sandy
13-24	till, gray
24-37	till, gray, and fine sand
Pierre (?) shale	
37-42	shale, black
42	total depth

* * * * * * * *

Test Hole G-9
Location: 112-64-22dd
Surface Elevation: 1342 feet

Pleistocene deposits:

0- 10	till, yellow

(continued on next page)

Test Hole G-9--continued

10-38	till, gray
38-51	sand, very coarse at base
51-58	till and weathered shale
Pierre (?) shale	
58-62	shale
62	total depth

* * * * * * * *

Test Hole G-10
Location: 112-64-24dd
Surface Elevation: 1328 feet

Pleistocene deposits:

0-10½	till, yellow
10½-15	sand, coarse, brown
15-51	till, gray
51-53	sand
53-54	till
54-58	sand
58-62	clay, sandy
62-63	gravel, silty
Pierre (?) shale	
63-67	shale
67	total depth

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Test Hole G-11
Location: 112-63-29ab
Surface Elevation: 1325 feet

Pleistocene deposits:

0-17	till, yellow
17-44	till, gray
44-47½	sand
47½-51	till
51-52	sand
52-57½	clay, sandy
57½-61½	clay, contains coal
61½-62½	sand
Pierre (?) shale	
62½-68	shale, fragmented
68-73	shale (total depth)

* * * * * * * *

Test Hole G-12
Location: 112-63-27ab
Surface Elevation: 1301 feet

Pleistocene and Recent deposits, undifferentiated:

0- 2	soil
2- 6	gravel
6-11	till, yellow
11-35	till, gray
35-40	sand, coarse at top
40-67	clay, sandy
67-69	till, gray
69-73	clay, sandy
73-74	till, gray
74-78	clay, sandy
78-80	till, gray
80-85	clay, sandy
85-88	till and weathered shale
Pierre (?) shale	
88-93	shale
93	total depth

* * * * * * * *

Test Hole G-13
Location: 112-63-24dd
Surface Elevation: 1294 feet

Pleistocene deposits:

0- 12	till, yellow
12- 22	till, black; contains sand and some coal
22- 28	sand, coarse to fine
28- 40	till, (sandy)
40- 77	till, gray
77- 78	till (sandy), cemented
78- 88	till, gray
88- 94	till (sandy); contains some coal
94-135	till, gray
Pierre (?) shale	
135-138	shale, chalky
138	total depth

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Test Hole G-14
Location: 111-62-19dd
Surface Elevation: 1304 feet

Pleistocene deposits:

0-13	till, yellow

(continued on next page)

Test Hole G-14--continued

13-31	till, gray
31-34	sand
34-49	till, gray
49-68	sand
68-70½	sand, clayey
70½-84	sand, lignitic, clayey
84-89	sand, clayey, cemented
89-91½	till, black
Pierre (?) shale	
91½-93	shale
93	total depth

* * * * * * * *

Test Hole G-15
Location: 111-62-20bb
Surface Elevation: 1305 feet

Pleistocene deposits:

0- 14	till, yellow
14- 15½	sand
15½- 47½	till, gray
47½- 51	sand
51- 54	till (sandy clay), cemented
54- 55	sand
55- 56	till (sandy clay)
56- 58	sand
58- 61	till (sandy clay), cemented
61- 86	sand
86- 92½	till, black
92½- 99½	sand, cemented
99½-100	gravel
100-109½	sand, gray, fine
109½-111½	till, black
Pierre (?) shale	
111½-114	shale (total depth)

* * * * * * * *

Test Hole G-16
Location: 111-63-24aa
Surface Elevation: 1307 feet

Pleistocene deposits:

0-16	till, yellow
16-18	sand
18-34	till, gray
34-38	sand
38-44	till, gray

(continued on next page)

Test Hole G-16--continued

44-60	till (sandy clay), cemented
60-75½	sand
75½-79	till, black
79	total depth

* * * * * * * *

Test Hole G-17
Location: 111-62-7cc
Surface Elevation: 1306 feet

Pleistocene deposits:

0-15	till, yellow
15-48½	till, gray
48½-52	sand, clayey
52-55	clay, sandy
55-58	sand, clayey
58-67½	till (sandy clay)
67½-72	sand
72-81	till (sandy and gravelly clay)
81-88	till, gray
88	total depth

* * * * * * * *

Test Hole G-18
Location: 111-62-8cc
Surface Elevation: 1294 feet

Pleistocene and Recent deposits, undifferentiated:

0- 9	clay, yellow
9- 12	clay, gray
12- 13	sand
13- 27	till, gray
27- 30	till (gravelly clay), hard
30- 75	till, gray
75- 77	till (gravelly clay), hard
77- 94	sand
94-102	till (sandy clay)
102-112	sand
112-115	till, soft
115-117	till (sandy clay)

Pierre (?) shale

117-120	shale, green
120	total depth

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APPENDIX C

Logs of State Water Resources Commission Observation Wells

(logged by Water Resources Commission; for locations see fig. 5)

Well B-1c
Location: 111-63-2cc (see fig. 2)
Surface Elevation: (?)
Depth to saturated material: 50 feet
Depth to static water level: 8 feet

Pleistocene deposits:

0- 3	surface soil
3- 15	sandy clay, brown; some pebbles
15- 50	clay, blue
50- 60	sand, clayey, gray
60- 92	sand, fine-medium, gray; some lignite
92-100	clay, gray, sandy
100	total depth

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Well B-2a
Location: 111-63-23bb
Surface Elevation: 1321 feet
Depth to saturated material: 50 feet
Depth to static water level: 22 feet

Pleistocene deposits:

0- 3	surface soil
3-30	sand, clayey, brown
30-50	sand, clayey, gray
50-80	sand, gray; some coal
80-95	coarse rock
95	total depth

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Well B-2b
Location: 111-63-14dd
Surface Elevation: 1343 feet
Depth to saturated material: 52 feet
Depth to static water Level: 20 feet

Pleistocene deposits:

0- 3	surface soil

(continued on next page)

Well B-2b--continued

3- 17	clay, sandy, brown
17- 19	clay, sandy, brown
19- 52	clay, blue
52- 60	clay, sandy, gray
60- 92	sand, gray, fine-medium, lignitic
92-125	clay, gray
125	total depth

* * * * * * * *

Well B-3
Location: 111-63-24dd
Surface Elevation: 1315 feet
Depth to saturated material: 52 feet
Depth to static water level: 10 feet

Pleistocene deposits:

0- 3	surface soil
3- 15	clay, sandy, brown
15- 39	clay, blue
39- 52	sand, clayey, gray
52- 92	sand, gray, fine-medium
92-100	clay, sandy
100-125	clay, gray
125	total depth

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Well B-4
Location: 111-62-32a
Surface Elevation: (?)
Depth to saturated material: 18 feet
Depth to static water level: 13 feet

Pleistocene deposits:

0- 3	surface soil
3- 15	clay, sandy, brown
15- 18	clay, blue
18- 30	sand, gray, medium-coarse, lignitic
30- 32	clay, gray
32- 50	sand, coarse, brown; gravel
50- 60	sand, clayey
60-115	sand, gray, fine-medium
115-130	clay, sandy, gray
130	total depth

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Well B-5
Location: 111-62-21d
Surface Elevation: 1286 feet
Depth to saturated material: 15 feet
Depth to static water level: 7 feet

Pleistocene deposits:

0- 3	surface soil
3- 10	sand, clayey, brown
10- 15	clay, sandy, gray
15- 75	clay, sandy, gray
75-120	clay, gray
120	total depth

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Well B-6b
Location: 110-62-16cd
Surface Elevation: (?)
Depth to saturated material: 38 feet
Depth to static water level: 28 feet

Pleistocene deposits:

0- 3	surface soil
3-17	clay, brown, sandy
17-38	clay, brown
38-55	gravel, some sand and clay
55-92	sand, gray, fine-medium, clean
92	total depth

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Well B-7
Location: 110-62-30d
Surface Elevation: (?)
Depth to static water level: 13 feet

Pleistocene deposits:

0- 3	surface soil
3- 15	clay, brown
15- 78	clay, blue
78- 98	gravel, clayey
98-125	clay, gray
125	total depth

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APPENDIX D

IRRIGATION AND DOMESTIC WELL RECORDS

Name	Location	Type of Well	Geologic Source	Depth of Well (feet)
Bies, Don	112-63-12c	Artesian	Dakota Group	
McFarland, Homer	112-63-14a	Artesian	Dakota Group	
Corcoran,	112-63-14c	Artesian	Dakota Group	
Ragler,	112-63-23b	Artesian	Dakota Group	
	112-63-33d		Outwash	49.7
Braun,	112-63-32d	Artesian	Dakota Group	
	112-63-29b	Artesian	Dakota Group	
Boomsma, Sam	112-63-12d	Artesian	Dakota Group	
	112-63-15c		Outwash	100?
Metamaugh, James	112-62-19b	Artesian	Dakota Group	
Hiles, Richard	112-62-7a	Artesian	Dakota Group	
Haeder, R.	111-63-7ba			
	111-63-6b	Artesian	Dakota Group	700
Haeder, Otto	111-63-7c		Outwash	67
Wagner, Dave	111-63-7dc	Artesian	Dakota Group	
Haeder, R. Jr.	111-63-8d	Artesian	Dakota Group	
Woodard, William	111-63-9bc	Bored	Outwash	68

Appendix D--Irrigation and Domestic Well Records - Continued

Name	Location	Type of Well	Geologic Source	Depth of Well (feet)
Allison, Cliff	111-63-4bc	Bored	Outwash	
Wagner, Melvin	111-63-3cb	Bored	Outwash	
	111-63-4d	Bored	Outwash	
	111-63-10b	Bored	Outwash	
Pullman, Joe	111-63-9d	Artesian	Dakota Group	805
Kuehl, Otto	111-63-12c	Artesian	Dakota Group	900?
Houck, Cecil	111-63-1c	Bored	Outwash	63
Unruh, Venie	111-63-1b	Artesian	Dakota Group	
Stuffacker, Orvil	111-63-2a	Artesian	Dakota Group	
Krutzfeldt, Ervin	111-63-13b	Bored	Outwash	
	111-63-15dc	Bored	Outwash	50?
McFarling, C.	111-63-22ab		Outwash	60
Wagner, George	111-63-15c		Outwash	70
Wagner, Isaac	111-63-15bc	Bored	Outwash	
Kahne, E.	111-63-21ab		?	126?
Christopherson, A.	111-63-17c	Artesian	Dakota Group	
Haeder, Hugo	111-63-20a	Artesian	Dakota Group	
Hiles, H. G.	111-63-21c		Outwash	36
Bartel, Elmer	111-63-28b		Outwash	100-

Appendix D--Irrigation and Domestic Well Records - Continued

Name	Location	Type of Well	Geologic Source	Depth of Well (feet)
Dunnick, E.	111-63-28cb		Outwash	100?
	111-63-33b	Artesian	Dakota Group	
Brandup, L.	111-63-35ad	Artesian	Dakota Group	
Betz,	111-63-34a	Artesian	Dakota Group	
	111-63-26c	Artesian	Dakota Group	
Beck, Knute	111-63-22d			
Doolittle, J.	111-63-23cd		Outwash	97
Thomas, Frances	111-63-7a	Artesian	Dakota Group	
	111-62-6c	Artesian	Dakota Group	
Lancer, Ted	111-62-7b		Outwash	45?
	111-62-16b		Outwash	27?
Doolittle, Harold	111-62-8c	Artesian	Dakota Group	
	111-62-8d		Outwash	33?
Doolittle, W.	111-62-17b	Artesian	Dakota Group	
Rycraft, H.	111-62-19d		Outwash	41
	111-62-28b		Outwash	65
DeBush,	111-62-21c			65
Salmon, L.	111-62-21a	Dug	Outwash	
	111-62-22a	Artesian	Dakota Group	
	111-62-27d		Outwash	23

Appendix D--Irrigation and Domestic Well Records - Continued

Name	Location	Type of Well	Geologic Source	Depth of Well (feet)
	111-62-34b		Outwash	20
Renecke, Herman	110-63-1a	Artesian	Dakota Group	
Miedema, Andy	110-63-2ab	Dug	Outwash	
Kahre, Art	110-63-5ad	Dug	Outwash	70?
Petersen, K.	110-63-5d		Outwash	87
Petersen, K.	110-63-5d	Artesian	Dakota Group	
Scneel, Marvin	110-63-9ba	Bored	Outwash	63
Friese, Clarence	110-63-3c		Outwash	90
	110-63-11b	Bored	Outwash	
Smith, Elmer	110-63-10d	Artesian	Dakota Group	
Mendel, Ray	110-63-9d			
Shield, Lee	110-63-6b	Artesian	Dakota Group	
Garnity, John	110-63-15c	Artesian	Dakota Group	
Liebnow, H.	110-63-7ab	Dug	Outwash	65
Larsen,	110-63-8ba	Dug	Outwash	
Reilly, Charles	110-63-22c	Artesian	Dakota Group	
Ortbahn, R.	110-63-23c		Outwash	80
Reilly, Donald	110-63-26c	Artesian	Dakota Group	
Mencke,	110-63-25c	Artesian	Dakota Group	

Appendix D--Irrigation and Domestic Well Records - Continued

Name	Location	Type of Well	Geologic Source	Depth of Well (feet)
Coranson, C.	110-63-25a		Outwash	53
Meyer, T.	110-63-24d	Artesian	Dakota Group	
Boltzer, Oscar	110-63-31b	Artesian	Dakota Group	
Wahl, Harold	110-62-5b	Artesian	Dakota Group	
Volesky, Leroy	110-62-5a			
Loban, L.	110-62-3b	Artesian	Dakota Group	
Berg,	110-62-9	Bored	Outwash	40+
Barnes, E.	110-62-9b		Outwash	80
Owens, Harold	110-62-22b	Artesian	Dakota Group	
Meyer, Loie	110-62-20a		Outwash	89
Winter, R.	110-62-28a	Artesian	Dakota Group	
Winter, D.	110-62-27b	Artesian	Dakota Group	
Winter, Jim	110-62-22c		?	102
Meyer, Edwin	110-62-29a	Artesian	Dakota Group	
Heiss, Walter	110-62-30b			
	110-62-31a	Artesian	Dakota Group	
Schroeder, W. O.	110-62-33c	Artesian	Dakota Group	
Berguist, Basil	110-62-26a	Artesian	Dakota Group	
Tschelter, D.	110-62-25d	Artesian	Dakota Group	

Appendix D--Irrigation and Domestic Well Records - Continued

Name	Location	Type of Well	Geologic Source	Depth of Well (feet)
Hollister,	110-62-36c		Outwash	45?
	110-61-31b	Artesian	Dakota Group	
Rodgers, T. A.	110-61-31c	Artesian	Dakota Group	
	109-62-5a	Artesian	Dakota Group	
	109-62-4a	Artesian	Dakota Group	
Wheeler, F.	109-62-1a	Artesian	Dakota Group	
Hill,	109-62-1d		Outwash	40?
Eden, Ray	109-62-12a	Artesian	Dakota Group	
Johnson, Lee	109-62-2c	Artesian	Dakota Group	
	109-62-3d		Outwash	37
Peterson, A.	109-62-3cd			
Erickson, H.	109-62-9a	Artesian	Dakota Group	
Erickson, H.	109-62-9a		Outwash	26+
	109-62-8a	Artesian	Dakota Group	
Goriggs,	109-62-9c	Artesian	Dakota Group	
Goriggs,	109-62-9c		Outwash	42?
Svec, John	109-62-10d	Artesian	Dakota Group	
	109-62-14b	Artesian	Dakota Group	
Eden, Willie	109-62-13a	Artesian	Dakota Group	

Appendix D--Irrigation and Domestic Well Records - Continued

Name	Location	Type of Well	Geologic Source	Depth of Well (feet)
Heuther, Leonard	109-61-6a	Artesian	Dakota Group	
	109-61-6c	Artesian	Dakota Group	
Hill,	109-61-7b	Artesian	Dakota Group	