
**INVESTIGATION TO IDENTIFY
A SUPPLEMENTAL WATER SUPPLY
IN BOTTINEAU COUNTY, NORTH DAKOTA
FOR THE CITY OF MOHALL**

by

Alan Wanek

**North Dakota Ground-Water Studies
Number 104
North Dakota State Water Commission
David Sprynczynatyk, State Engineer**

**Prepared by the
North Dakota State Water Commission
In cooperation with the
Bottineau County Water Resource District**



ND State Water Commission

1993

**INVESTIGATION TO IDENTIFY
A SUPPLEMENTAL WATER SUPPLY
IN BOTTINEAU COUNTY, NORTH DAKOTA
FOR THE CITY OF MOHALL**

**North Dakota Ground Water Studies
Number 104**

by

Alan Wanek, Hydrologist

**Prepared by the
North Dakota State Water Commission
in cooperation with the
City of Mohall**

1993

TABLE OF CONTENTS

	Page
INTRODUCTION	1
Statement of the Problem	1
Study Area	2
Previous Investigations	3
Mohall Municipal Water Source	4
Mohall Municipal Water Use	6
Field Methods	8
Location-Numbering System	9
GEOLOGIC SETTING	11
Depositional Setting of the Mohall Aquifer	11
Occurrence of Sand and Gravel Along Cut Bank Creek Valley	13
Geohydrology of the Mohall Aquifer	18
WATER QUALITY	43
Properties and Characteristics of Water	43
Quality of Water in the Mohall Aquifer	48
RECOMMENDATIONS	56
Location	56
Well design considerations	56
Pumping rate	58
Number of wells	59
Well spacing	59
Monitoring water levels and water quality	60
REFERENCES	62
APPENDIX - LITHOLOGIC LOGS	63

ILLUSTRATIONS

Figure	Page
Figure 1 - Location of study area	1
Figure 2 - Location of proposed cross sections.....	2
Figure 3 - Mohall municipal well fields.....	4
Figure 4 - Reported (total) Mohall municipal water use	8
Figure 5 - Location-numbering system.....	10
Figure 6 - Gradient of Cut Bank Creek valley.....	12
Figure 7 - Test hole locations along Cut Bank Creek valley	14
Figure 8 - Thickness of sand and gravel (in feet below land surface)	15
Figure 9 - Thickness of surficial sand & gravel - from earlier investigations.....	16
Figure 10 - Saturated thickness of the Mohall aquifer (in feet).....	17
Figure 11 - Location of geohydrologic sections.....	18
Figure 12 - Geohydrologic section a - a'	19
Figure 13 - Geohydrologic section b - b'	20
Figure 14 - Geohydrologic section c - c'.....	20
Figure 15 - Geohydrologic section d - d'	21
Figure 16 - Geohydrologic section e - e'.....	21
Figure 17 - Geohydrologic section f - f'	22
Figure 18 - Geohydrologic section g - g'.....	22
Figure 19 - Geohydrologic section h - h'	23
Figure 20 - Geohydrologic section i - i'	24
Figure 21 - Geohydrologic section j - j'	25
Figure 22 - Geohydrologic section k - k'	26
Figure 23 - Geohydrologic section l - l'	27
Figure 24 - Geohydrologic section m - m'	28
Figure 25 - Geohydrologic section n - n'	29
Figure 26 - Geohydrologic section o - o'	30
Figure 27 - Geohydrologic section p - p'	31
Figure 28 - Geohydrologic section q - q'	32
Figure 29 - 1990-1992 municipal well field.....	33
Figure 30 - Hydrograph from monitoring well near 161-83-3AAA7	34

Illustrations (cont.)

Figure	Page
Figure 30 - Hydrograph from monitoring well near 161-83-3AAA7	34
Figure 31 - Hydrograph from monitoring wells near 161-83-3AAA5.....	35
Figure 32 - Hydrograph from monitoring well near 161-83-3AAD3.....	36
Figure 33 - Hydrograph from monitoring wells near 161-83-3AAD4.....	37
Figure 34 - 1951 municipal well field.....	38
Figure 35 - Hydrograph from monitoring well near 161-83-14DAA2	39
Figure 36 - Hydrograph from monitoring well near 161-83-13CAC2	40
Figure 37 - Water-level elevations on 21 October 1993	42
Figure 38 - Locations of sampled wells	49
Figure 39 - Schoeller diagram using a sample typical of each well field	52
Figure 40 - Locations of wells in 1990-1992 well field.....	53
Figure 41 - Recommended location for municipal water supply wells	57
Figure 42 - Projected water level drawdown after pumping at 31 gpm	60
Figure 43 - Index of test hole locations	65
Figure 44 - Index of test hole locations - well field /proposed well field area.....	66
Figure 45- Index of test hole locations - 1951 well field	67

TABLES

Table	Page
Table 1 - Specific capacity of municipal water supply wells.....	6
Table 2 - Reported water use	7
Table 3 - Water quality in 1993 installed monitoring wells	50
Table 4 - Water quality in older municipal well fields	51
Table 5 - Water quality comparison of wells sampled in 1990 and 1993.....	54

INTRODUCTION

Statement of the Problem

In a letter dated 2 March 1993 Wanda Emerson, Mayor of Mohall, requested technical assistance from the North Dakota State Water Commission in locating a water source for the city of Mohall to supplement the city's municipal supply, which has been experiencing a declining water level. In a letter dated 27 May 1993 a work plan was submitted by the Water Commission for exploratory drilling and aquifer analysis to be undertaken along East Cut Bank Creek in western Bottineau County (fig. 1).

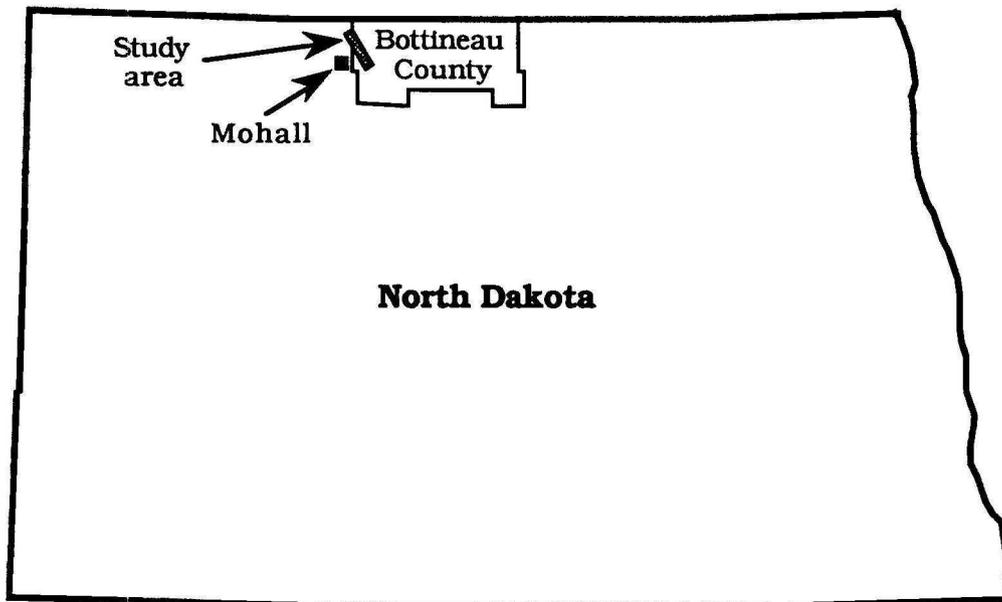


Figure 1 - Location of study area

An agreement was signed by the Mayor of Mohall on 14 June 1993 and by the North Dakota State Water Commission on 15 June 1993. The agreement calls for the Water Commission to conduct an investigation along East Cut Bank Creek to identify a water source for the city. Costs of the study are to be paid jointly by the two parties. This report is in partial fulfillment of the agreement.

Study Area

The study area is located along the flood plain of (East) Cut Bank Creek, between a point 10.5 miles north of Mohall and a point eight miles east and three miles south of Mohall (fig 2). The creek is generally named on maps as Cut Bank Creek. The 7 1/2 minute topographic quadrangle map names the segment of the creek between its confluence with West Cut Bank Creek and a point about seven miles to the north as "East Cut Bank Creek," north of which the creek is again shown on the topographic quadrangle map as Cut Bank Creek. The creek in this report will be referred to as "Cut Bank Creek."

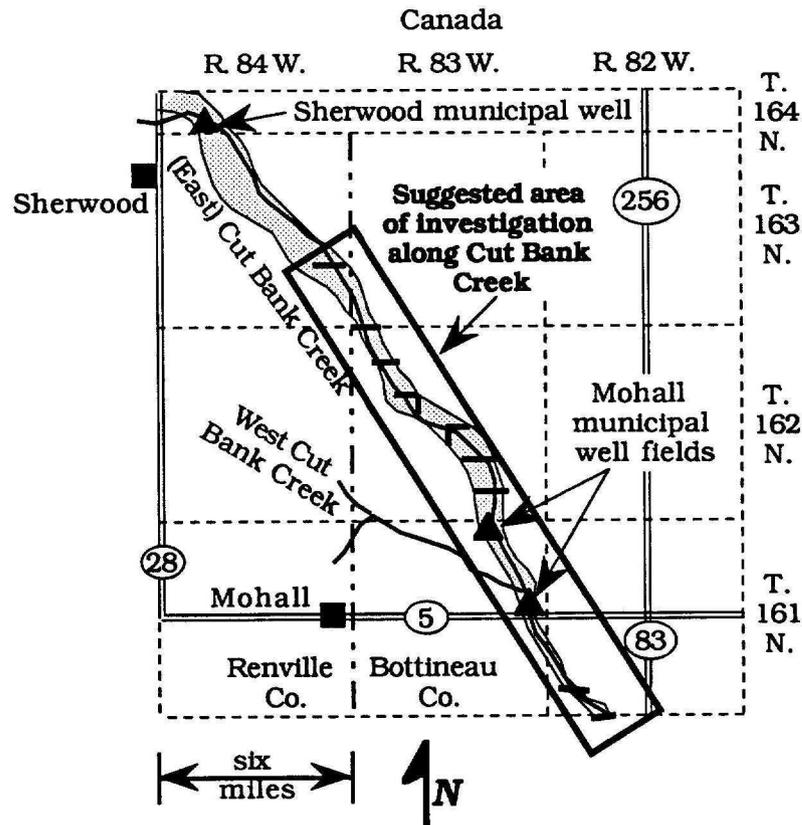


Figure 2 - Location of proposed cross sections

A shallow alluvial aquifer in Cut Bank Creek valley is comprised of up to 28 feet of coarse sand or sand and gravel, directly underlying the soil horizon. The aquifer along Cut Bank Creek is unnamed. "Cut Bank Creek aquifer" has been applied to a buried outwash aquifer in northern McHenry County, named after

another intermittent stream called "Cut Bank Creek." Therefore, the name "Mohall aquifer" will be used to refer to the sand and gravel immediately underlying land surface in the Cut Bank Creek valley between the U. S. - Canada border two miles north of Sherwood and a point about six miles south of Maxbass where a delta deposit along Cut Bank Creek grades into the Lake Souris sand plain deposit.

Previous Investigations

A city water source study was undertaken by P. D. Akin (1951), concentrating on the alluvial valley fill along West Cut Bank Creek two to three miles northeast of Mohall. The 1951 study also included an area at the confluence of Cut Bank Creek and West Cut Bank Creek, which subsequently became the site of Mohall's older municipal water well field.

The geology of Bottineau County was described by Bluemle (1985) as part of the county ground-water studies program. Kuzniar and Randich (1982) compiled the ground-water data of Bottineau and Rolette Counties and Randich and Kuzniar (1984) described the ground-water resources of Bottineau and Rolette Counties.

Unpublished water supply investigations for the City of Mohall were undertaken by LTP, Inc. in 1977 and by C. A. Simpson & Son in 1988 and 1990. Eighty-seven test holes, monitoring wells, or production wells have been drilled or installed in Cut Bank Creek valley between ND Highway 5 and the most recently installed municipal well field three miles farther north.

Mohall Municipal Water Source

Mohall currently obtains its municipal water supply from two well fields in Cut Bank Creek valley (fig. 3). The well fields are connected to the city water treatment plant and to the city water tower by an eight inch diameter pipeline. The treatment plant has a water holding capacity of 95,000 gallons. The water tower has a capacity of 55,000 gallons.

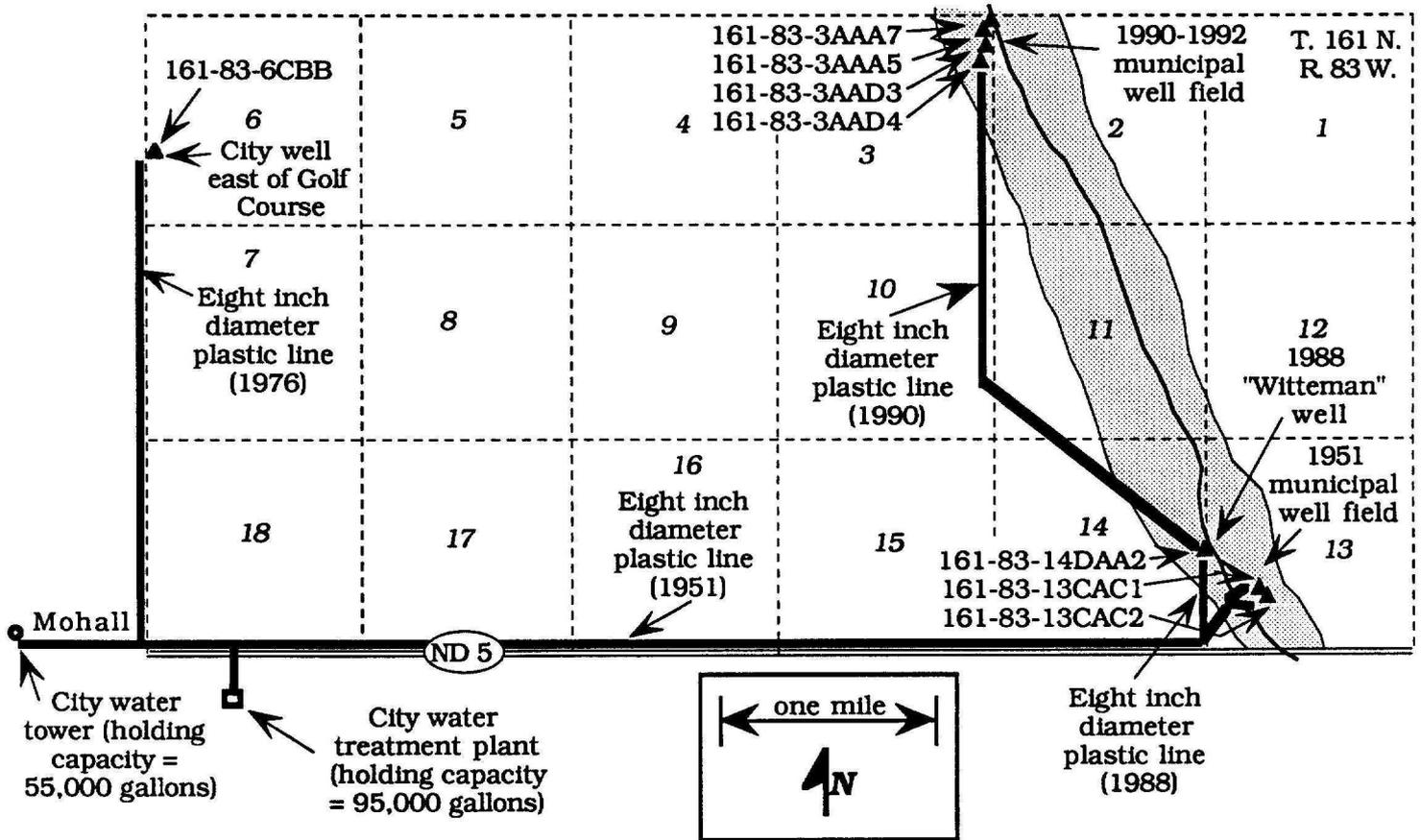


Figure 3 - Mohall municipal well fields

The southern of the two well fields is comprised of three wells. Two of the three wells are located near the center of the southwest quarter of Section 13, T. 161 N., R. 83 W., and were completed in 1951. Well driller's reports are not available for the two wells completed in 1951 and specific completion details of the wells are not available. The wells are 12 inches in diameter and are thought to be 24 feet deep.

The third well in the southern well field, at 161-83-14DAA, is located about 1/4 mile northwest of the 1951 wells and is called the "Witteman" well. The Witteman well was installed on 22 November 1988. The well has eight inch diameter casing and is screened between 14 and 20 feet depth with 0.040 inch slot screen and an initial reported static water level 9 feet below land surface. In 1989 reported water use from the Witteman well was 43.6 acre-feet. Water use was discontinued in 1990 because of a declining water level in the aquifer.

The northern of the two well fields consists of four wells in the northeast corner of Section 3, T. 161 N., R. 83 W. The northern well field is along Cut Bank Creek, about three miles north-northwest of the original (1951) well field. The four wells in Section 3 were installed in 1990 and 1992 and are eight inches in diameter and completed with five feet of stainless steel, wire wound, V-slot screen. The north most well, 161-83-3AAA7, (Mohall well #3) is screened between 15 and 20 feet depth, with 0.035 inch slot screen. The second from the north well, 161-83-3AAA5, (90-38 production well) is screened between 16.2 and 21.2 feet depth with two feet of 0.030 inch slot screen and three feet of 0.040 inch slot screen. The third from the north well, 161-83-3AAD3, (90-39 production well) is screened between 16 and 21 feet depth with three feet of 0.030 inch slot screen and two feet of 0.050 inch slot screen. The southernmost of the four production wells, 161-83-3AAD4, (Mohall well #4) is screened between 15 and 20 feet depth with 0.035 inch slot screen.

One additional well was used between 1977 and 1990 as a municipal water supply well. The well is near the city golf course, 2.5 miles north of Mohall at 161-83-6C. The well is 22 feet deep. No other completion details are available for the well.

The specific capacities of the municipal supply wells were calculated from test pumping information collected at the time the wells were completed and provided by the well driller. No completion reports are available for the 1951 wells. Specific capacities of the Witteman well and the four wells in the northern well field are in the range of 15 to 25 gallons per minute per foot of water level drawdown, as listed in table 1.

Table 1 - Specific capacity of municipal water supply wells

Well location	Pumping time	Pumping rate	Water level drawdown	Specific capacity
161-83-3AAA5	2 hours	117.5 gpm	11.1 feet	10.6 gpm/ft
161-83-3AAA7	4 hours	70 gpm	2.48 feet	28.2 gpm/ft
161-83-3AAD3	24 hours	95 gpm	6.4 (?) feet	14.8 gpm/ft
161-83-14ADD	"short run"	55 gpm	2 feet	27.5 gpm/ft

Mohall Municipal Water Use

The city has three water permits. Permit #886 allows 125 acre-feet of water per year to be withdrawn for municipal purposes from 161-83-13C, the 1951 well field. Permit 1945 allows 35 acre-feet of water per year to be withdrawn for municipal purposes from 161-83-6C, north of Mohall near the golf course. Permit 4359 allows 233 acre-feet per year to be withdrawn for municipal purposes from 161-83-3A, the 1990-1992 well field. Water use under the three permits has been reported, or interpreted, as indicated in table 2 and figure 4.

In a letter received 31 August 1993 Ken Shobe, city water works superintendent, reported that when no restrictions are in place the city used 85,000 to 95,000 gallons per day (59 - 66 gpm, constant pumping), and that the city's peak unrestricted use was 125,000 gallons per day (87 gpm, constant pumping). The supply wells are each pumped at a rate of 25 to 30 gallons per minute.

Table 2 - Reported water use

Year	161-83-13C (1951 field) in acre-feet	161-83-14A (Witte-man) in acre-feet	161-83-6CB (golf course) in acre-feet	161-83-3AA (90-92 field) in acre-feet	Total in acre-feet
1973	43.0 a-f				43.0 a-f
1974					
1975					
1976	123.2 a-f				123.2 a-f
1977	140.0 a-f				140.0 a-f
1978	112.0 a-f		2.1 a-f		114.1 a-f
1979	142.7 a-f		2.9 a-f		145.6 a-f
1980	141.4 a-f		5.9 a-f		147.3 a-f
1981	142.7 a-f		2.9 a-f		145.6 a-f
1982	127.6 a-f		14.2 a-f		141.8 a-f
1983	124.4 a-f		13.8 a-f		138.2 a-f
1984	131.6 a-f				131.6 a-f
1985	144.2 a-f				144.2 a-f
1986	133.0 a-f		14.8 a-f		147.8 a-f
1987	136.0 a-f		11.8 a-f		147.8 a-f
1988	125.8 a-f				125.8 a-f
1989	101.8 a-f	43.6 a-f			145.4 a-f
1990	38.9 a-f		33.1 a-f		72.0 a-f
1991	21.2 a-f			89.5 a-f	110.7 a-f
1992				98.0 a-f	98.0 a-f

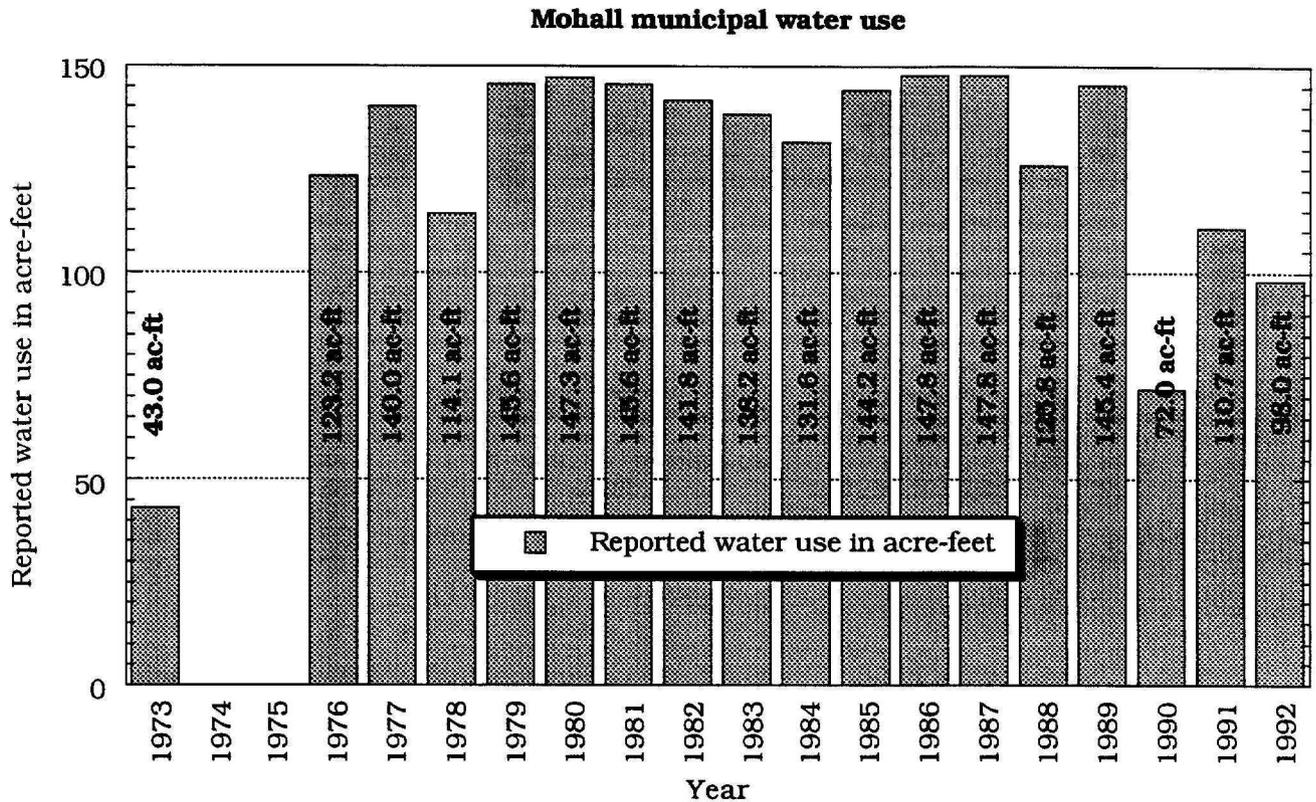


Figure 4 - Reported (total) Mohall municipal water use

Field Methods

As part of this investigation, 42 test holes were drilled totaling 1623 feet of drilling, using a forward, mud-rotary drilling rig. Test holes were drilled through alluvial or glacial fluvial sand and gravel until the underlying glacial till was encountered. Three test holes were drilled through the glacial drift to the underlying bedrock.

Nine monitoring wells were installed using two-inch diameter, polyvinyl chloride (PVC) casing and five feet of slotted PVC screen for each well. The monitoring wells were developed by collapsing *in situ* sand and gravel against the screen. The annular space between the casing and the wall of the drilled hole was filled with granular bentonite and drill cuttings. Mean sea level elevations of the

monitoring wells were determined by third order differential leveling. Water levels in the wells were measured using a chalked steel tape. Lithologic descriptions of sediments encountered in the test holes and monitoring well completion details are included in Appendix 1.

Water samples were collected from the monitoring wells and from six older city monitoring wells and two city water supply wells to determine the quality of the water. The samples were analyzed for common ions and for selected metallic elements. The analyses were performed by the North Dakota State Water Commission Laboratory.

Location-Numbering System

The number and letter designation used to describe the location of a monitoring well or test hole is based upon the federal system of rectangular surveys of public land, the township and range system, (fig. 5). In the designation, 161-83-3ABC, the first number is the township north of a base line, the second number is the range west of the fifth principal meridian, and the third number is the section in which the well is located. The first letter is the quarter section, the second letter is the quarter-quarter section, and the third letter is the quarter-quarter-quarter section (10 acre tract) in which the well is located. The letter "A" designates the northeast subdivision, the letter "B" the northwest subdivision, the letter "C" the southwest subdivision, and the letter "D" the southeast subdivision.

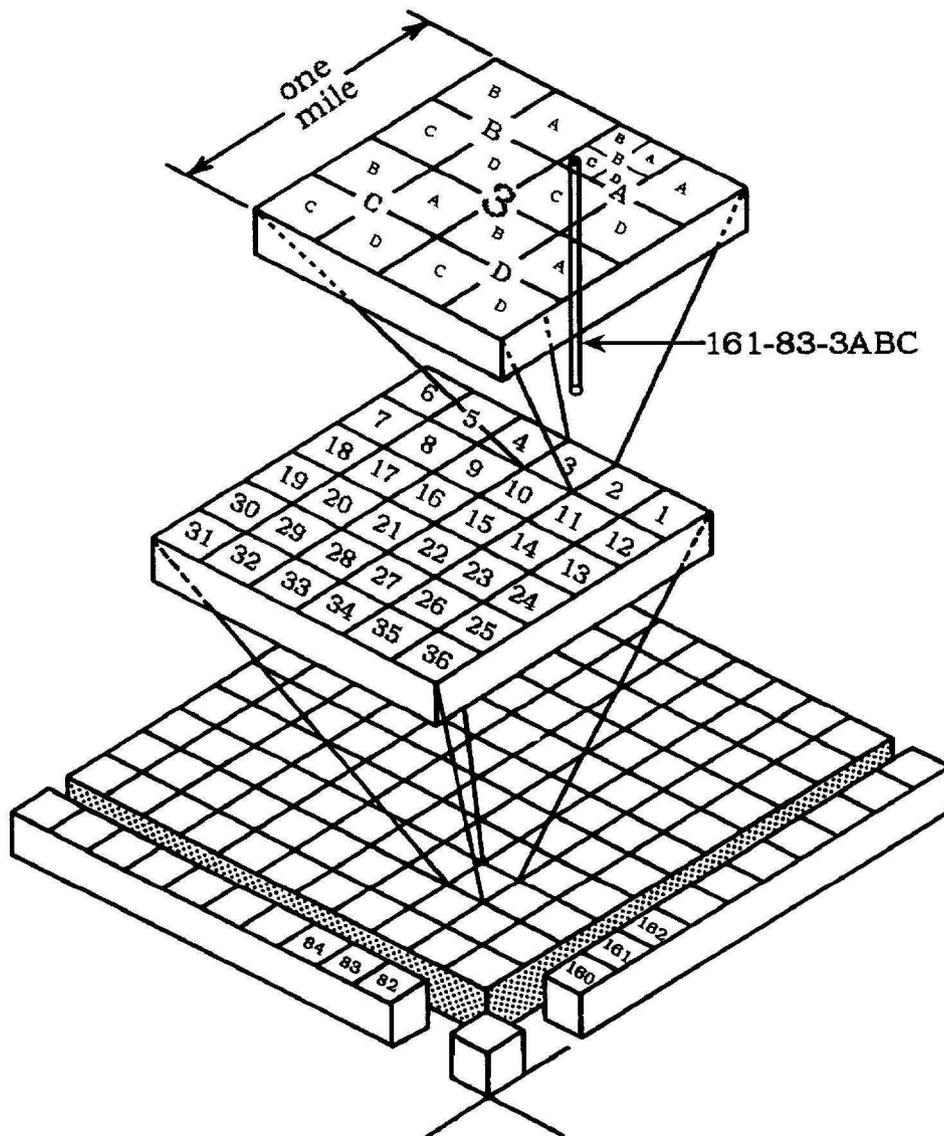


Figure 5 - Location-numbering system

GEOLOGIC SETTING

Depositional Setting of the Mohall Aquifer

The area investigated is in the valley of Cut Bank Creek. In the Late Pleistocene Epoch, about 12,000 years ago, Cut Bank Creek carried more water than it does now, depositing sand and gravel alluvium along its flood plain, particularly where the water flowing in the creek lost velocity as it entered Lake Souris. Lake Souris at its maximum extent rose to an elevation of about 1525 - 1550 feet above sea level (Bluemle, 1985). The southern portion of the shallow alluvial aquifer investigated is along Cut Bank Creek valley between 1525 and 1555 feet elevation.

The overall slope of the land surface along the valley floor of Cut Bank Creek valley between the Sherwood municipal well and two miles north of the northern Mohall well field is five feet per mile (fig. 6). The gradient of the valley flattens to about three feet per mile to the southeast, to a point about six miles south of Maxbass. The change in valley slope may mark the upper end of the Late Pleistocene delta formed along glacial Lake Souris.

The presence of a thicker and wider section of alluvium in Sections 34 and 35 of T. 161 N.,-R. 83 W., as compared to other locations up and down the valley, may be related to the change in gradient of Cut Bank Creek valley. The lower energy depositional environment may have caused the coarse grained sediments to drop out of suspension. The location of the change in gradient of Cut Bank Creek river valley may be related to high water level of glacial Lake Souris.

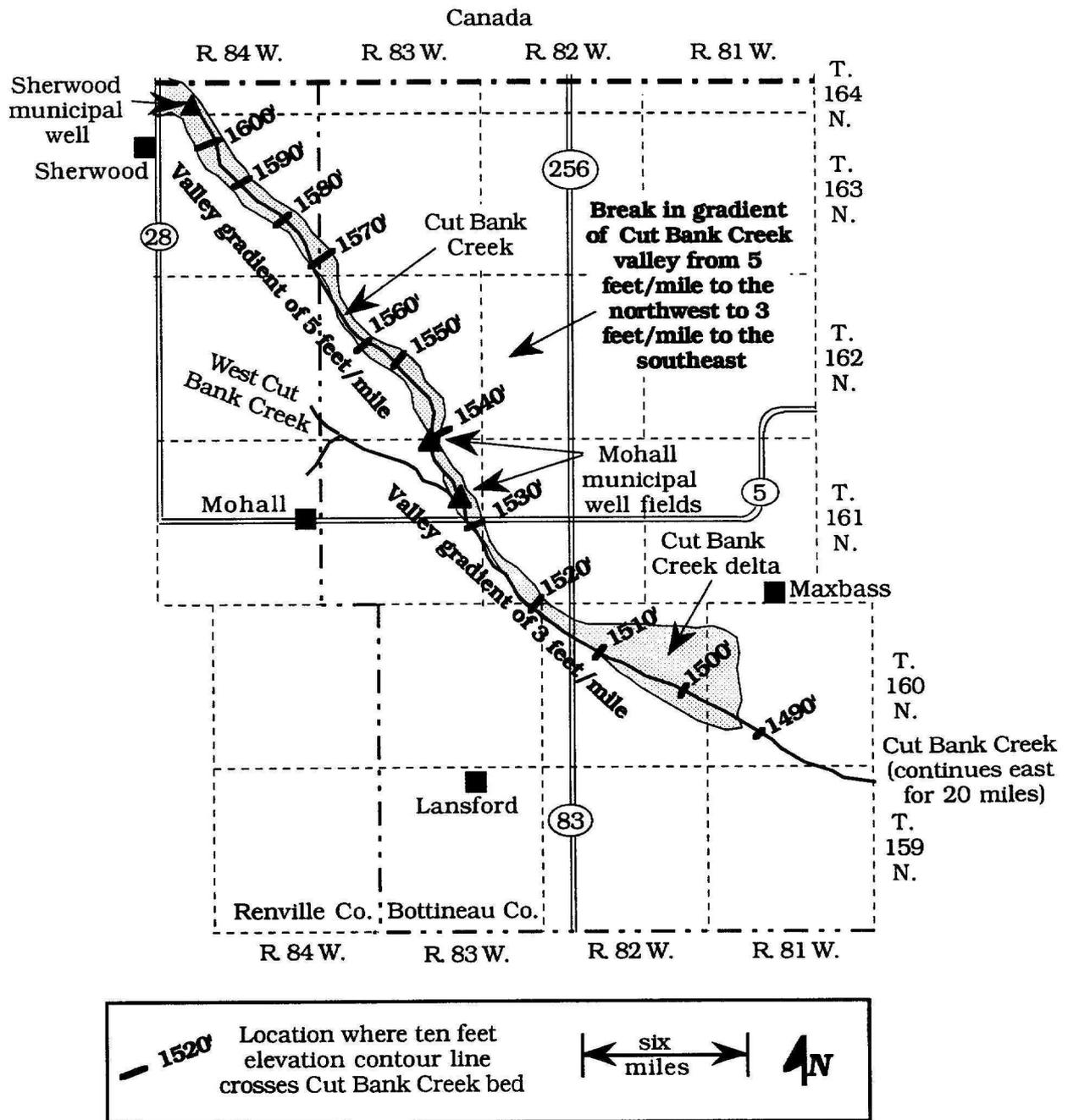


Figure 6 - Gradient of Cut Bank Creek valley

Occurrence of Sand and Gravel Along Cut Bank Creek Valley

Forty-two test holes were drilled in nine sections across Cut Bank Creek valley to determine the thickness and width of the sand and gravel occurring in the Mohall aquifer, (fig. 7). Test holes were drilled until the glacial till underlying the alluvial valley fill was encountered. Three test holes were drilled until bedrock was encountered. Bedrock consists of fine sand, silt, and clay of the Hell Creek Formation. Additional lithologic information was gained from earlier test drilling completed as part of the Bottineau County ground water study. The thickness of sand and gravel determined from test hole drilling is indicated in figure 8.

The three mile long segment of Cut Bank Creek valley between Highway 5 and Mohall's northern well field has been extensively test drilled in the past, as part of municipal water supply investigations. Surficial sand and gravel thickness, as indicated on well driller's reports is shown in figure 9.

At locations where monitoring wells have been installed the thickness of sand and gravel below the water table can be determined. The saturated sand and gravel thickness on 17 August 1993 is shown in figure 10.

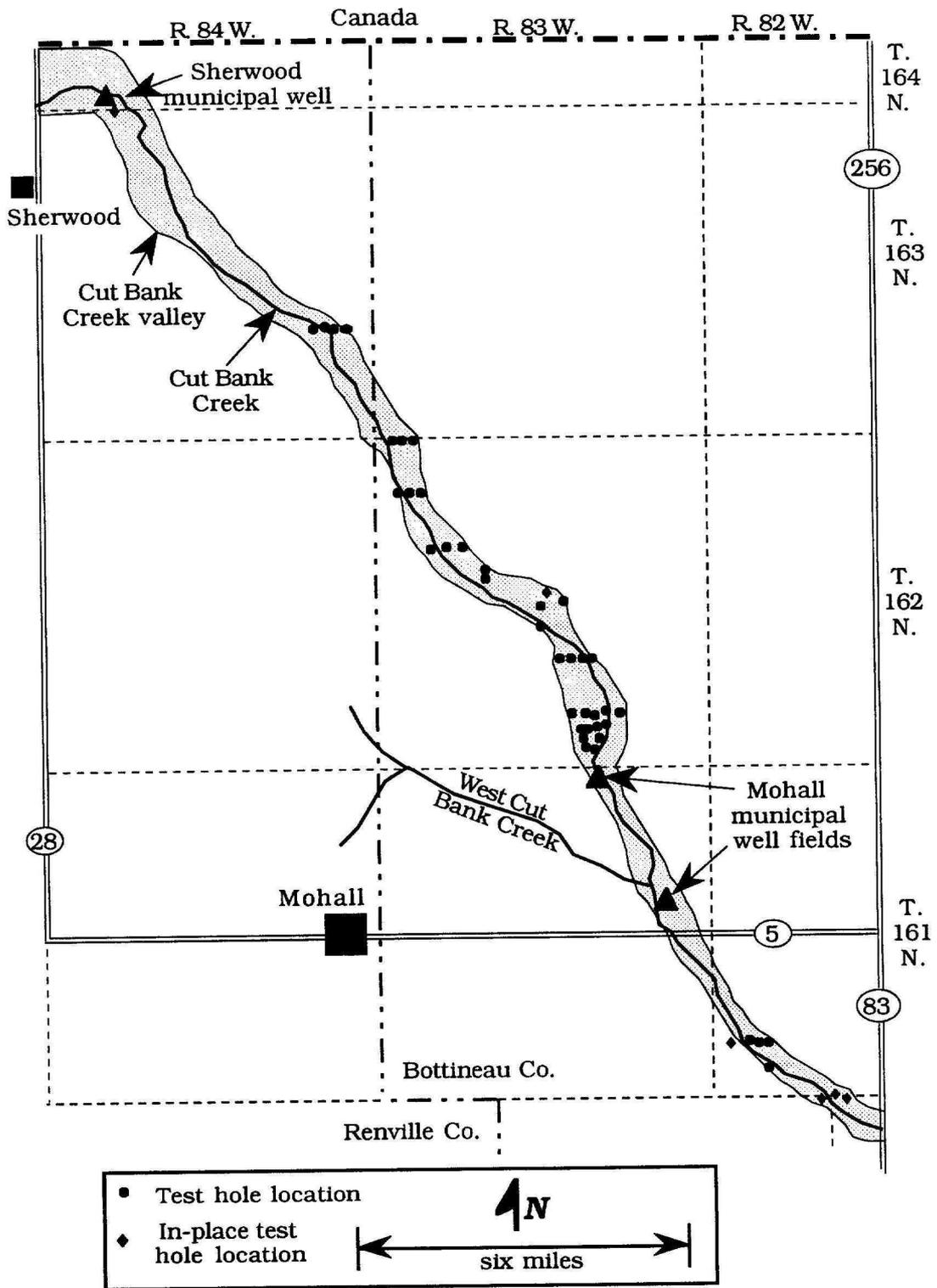


Figure 7 - Test hole locations along Cut Bank Creek valley

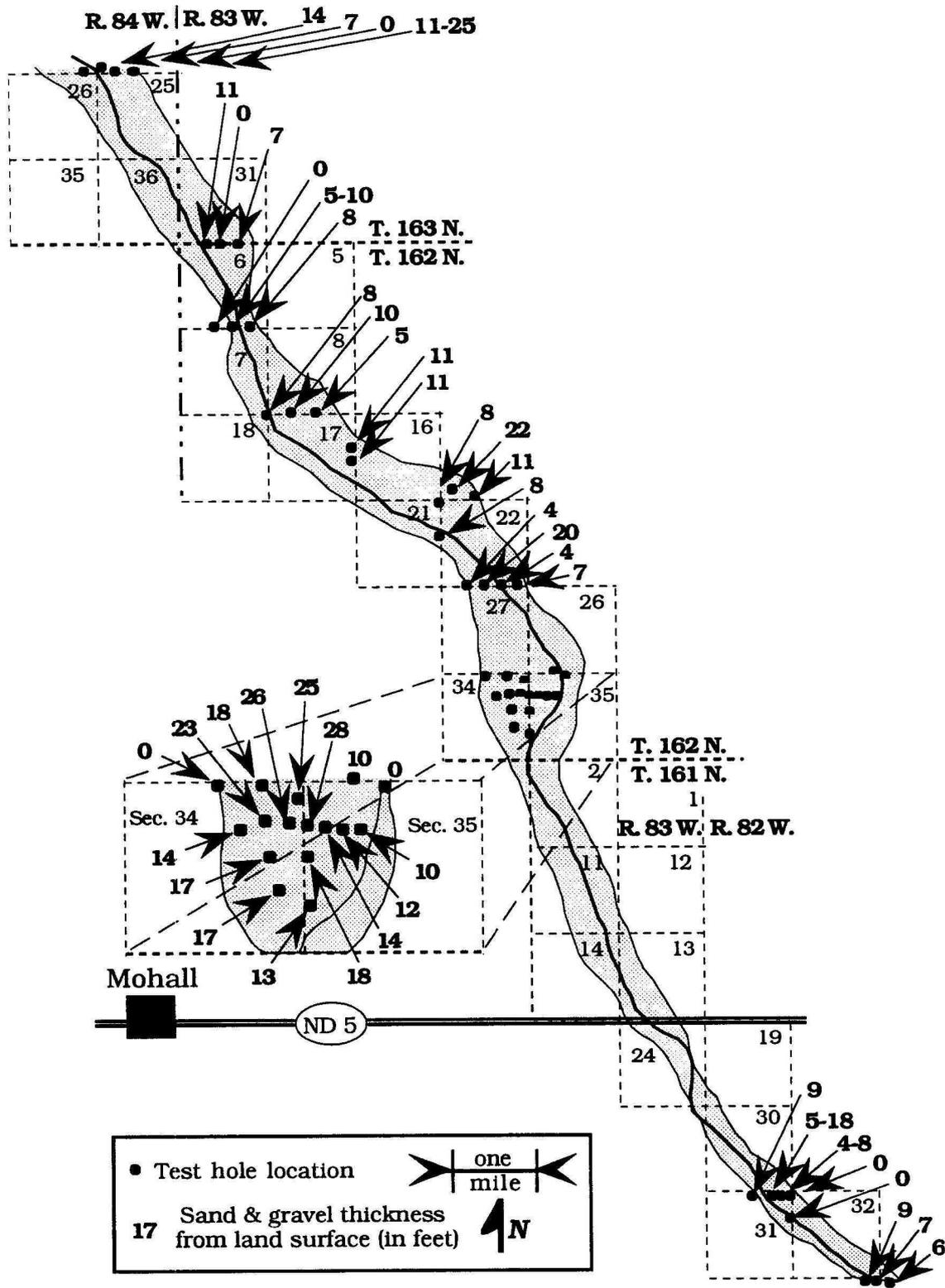


Figure 8 - Thickness of sand and gravel (in feet below land surface)

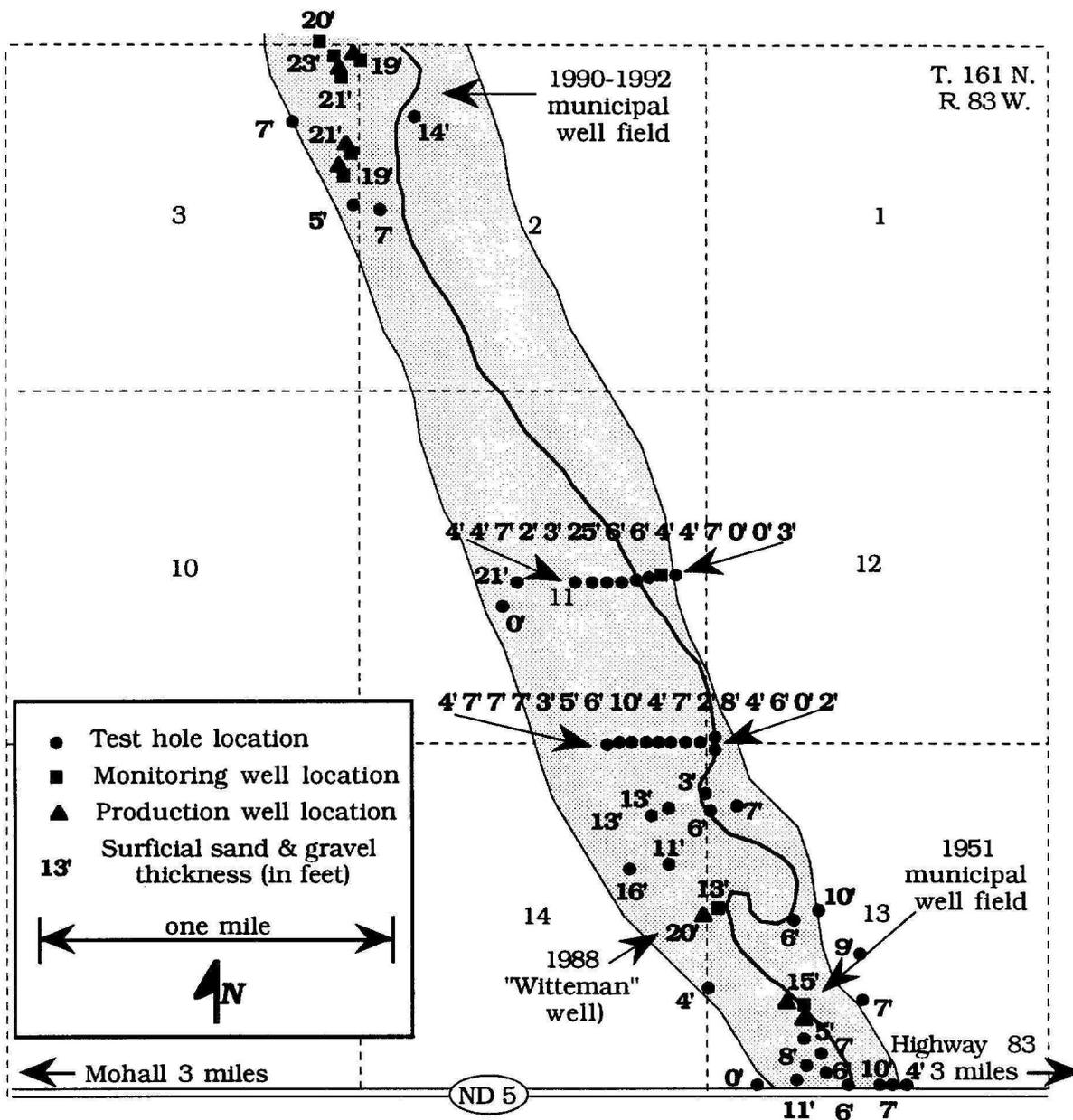


Figure 9 - Thickness of surficial sand & gravel - from earlier investigations

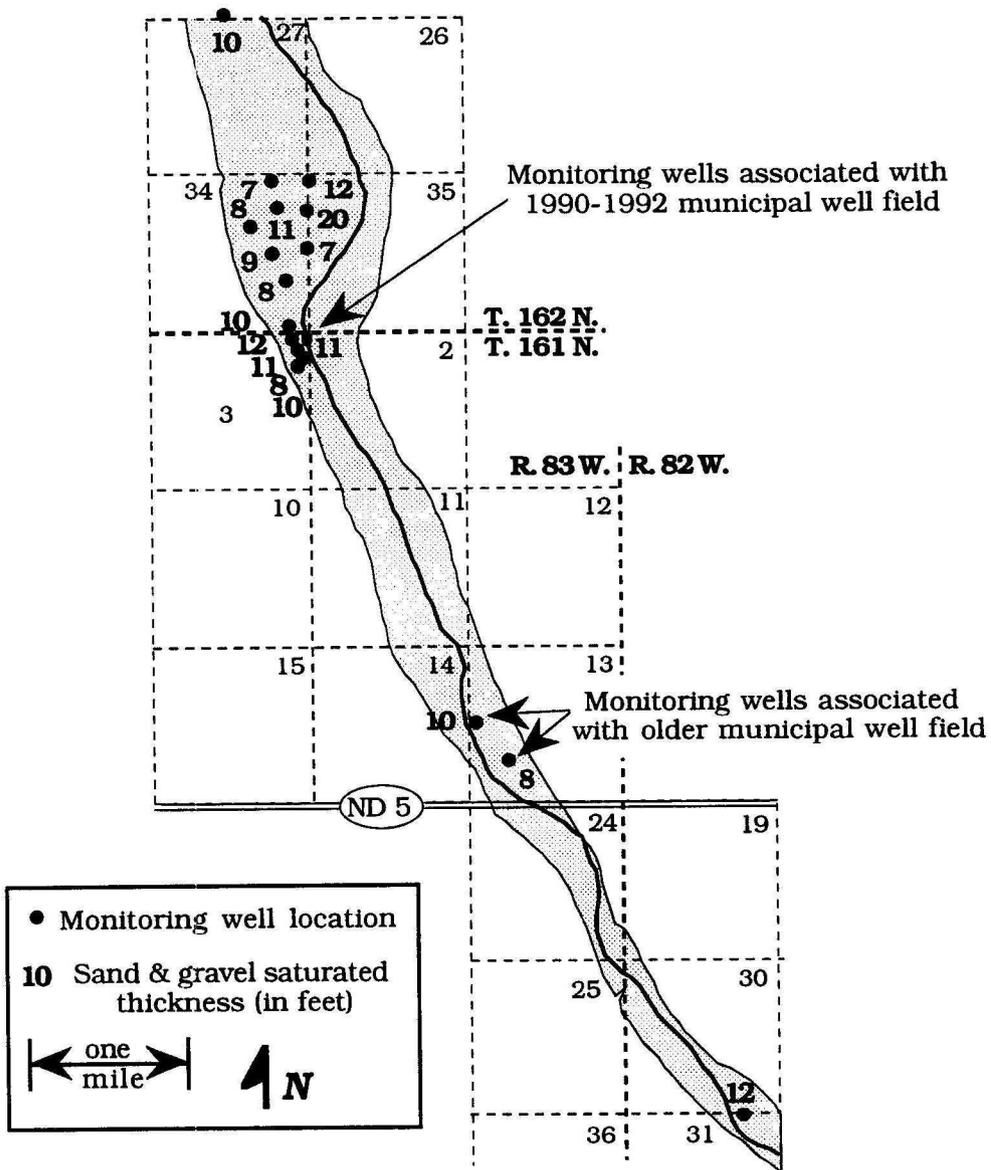


Figure 10 - Saturated thickness of the Mohall aquifer (in feet)

Geohydrology of the Mohall Aquifer

Information gathered from test drilling is shown in geohydrologic sections, a - a' through q - q'. The locations of the geohydrologic sections are shown (fig. 11).

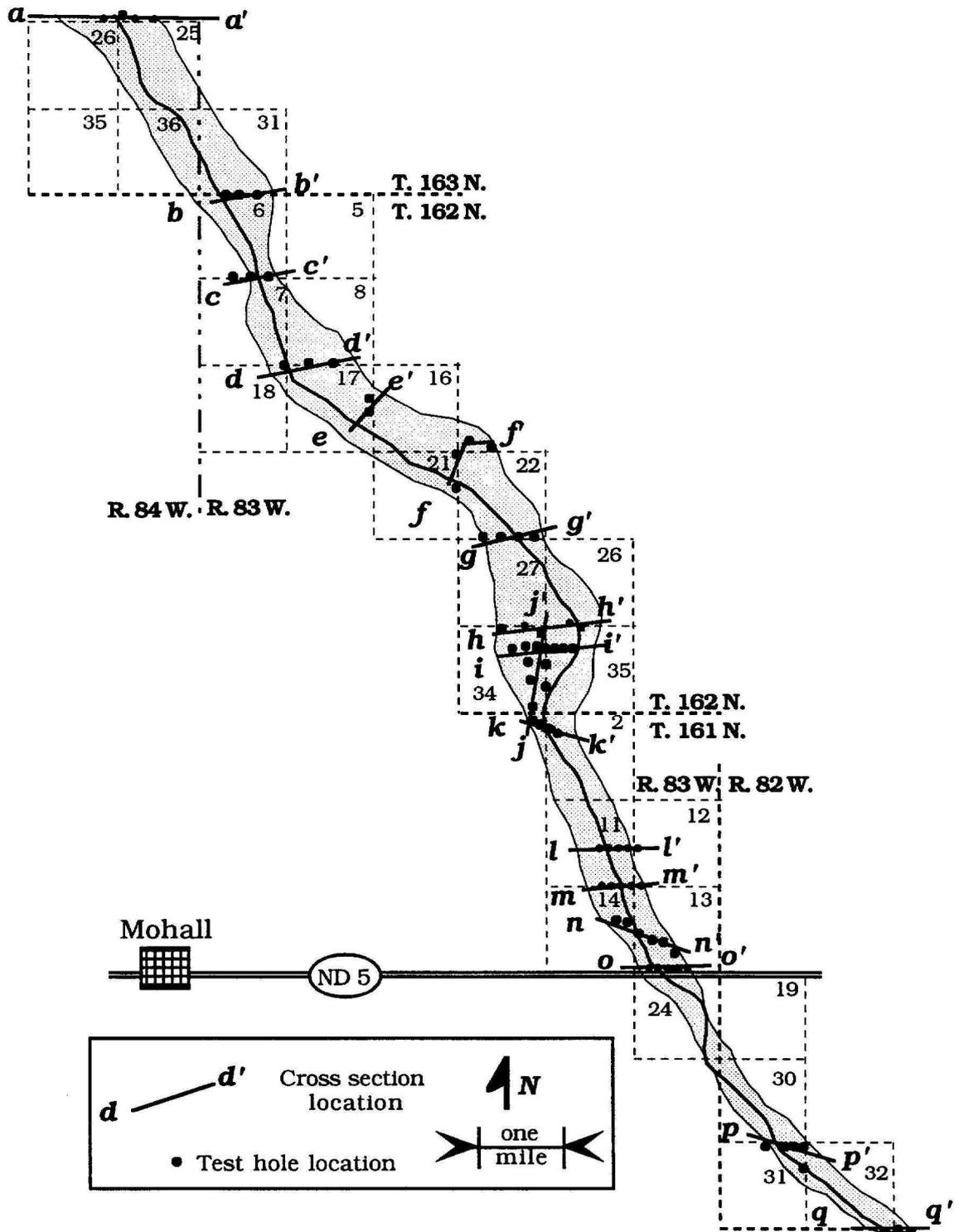


Figure 11 - Location of geohydrologic sections

Geohydrologic section a - a', (fig. 12), is a west to east section made up of four test holes, located one half mile west of the Bottineau-Renville County line and ten miles north of Mohall. Section a - a' includes one test hole drilled to bedrock. The east most test hole penetrated medium to coarse sand between 11 and 25 feet depth. A test hole about 1000 feet farther west did not penetrate any sand through the 11 - 25 feet depth interval. The sand lens, like narrow lenses in 161-83-11, twelve miles to the southeast, which C. A. Simpson & Son encountered during test drilling in 1990, may have an origin related to a short term, late Pleistocene fluvial event.

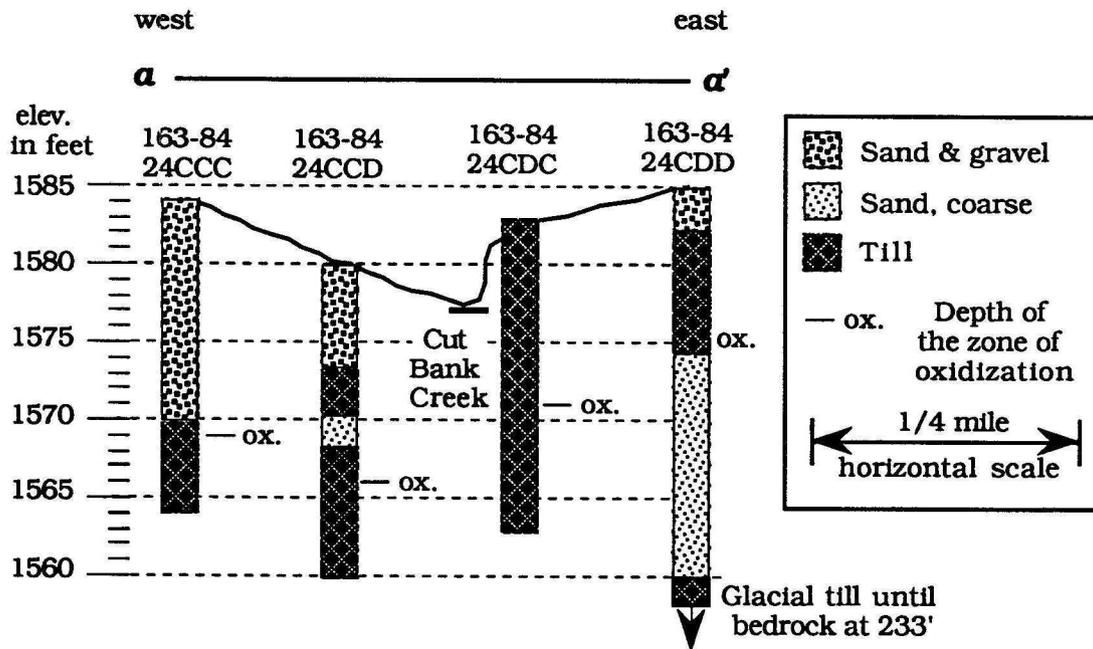


Figure 12 - Geohydrologic section a - a'

Geohydrologic sections b - b' through g-g' (figures 13 - 18) are similar, west to east or south to north sections across the valley of Cut Bank Creek. The geohydrologic sections are spaced at about one mile intervals along the creek valley. The sand and gravel encountered in the test drilling along sections a-a' through g-g' was too limited in thickness and extent to merit monitoring well installation or further investigation. Commonly, the zone of sediment oxidization extends through the sand and gravel and about one foot into the underlying till, indicating that at least at one time since the deposition of the sediments the water table has declined below the base of the gravel. The depth of the zone of oxidization is indicated by "- ox." on some of the columns.

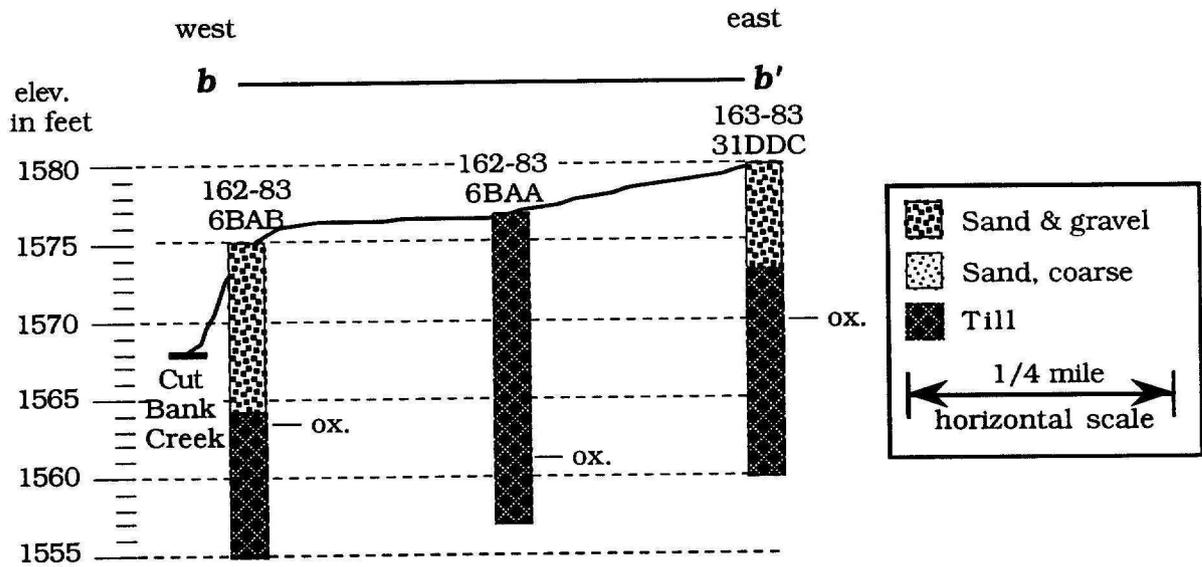


Figure 13 - Geohydrologic section b - b'

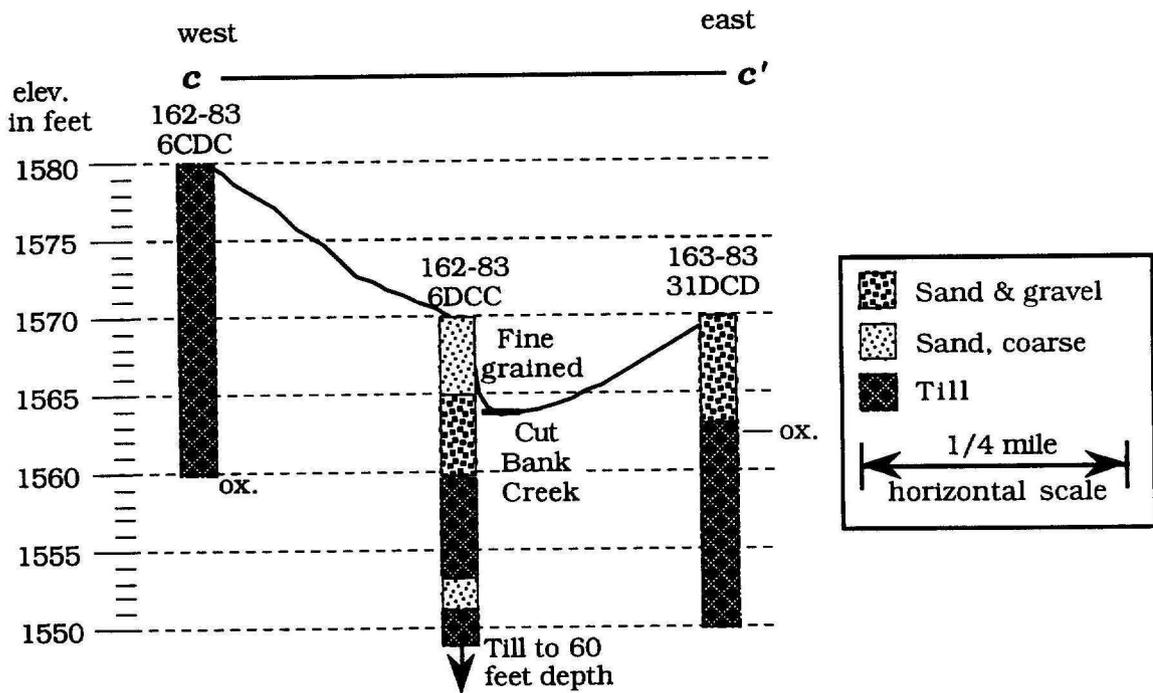


Figure 14 - Geohydrologic section c - c'

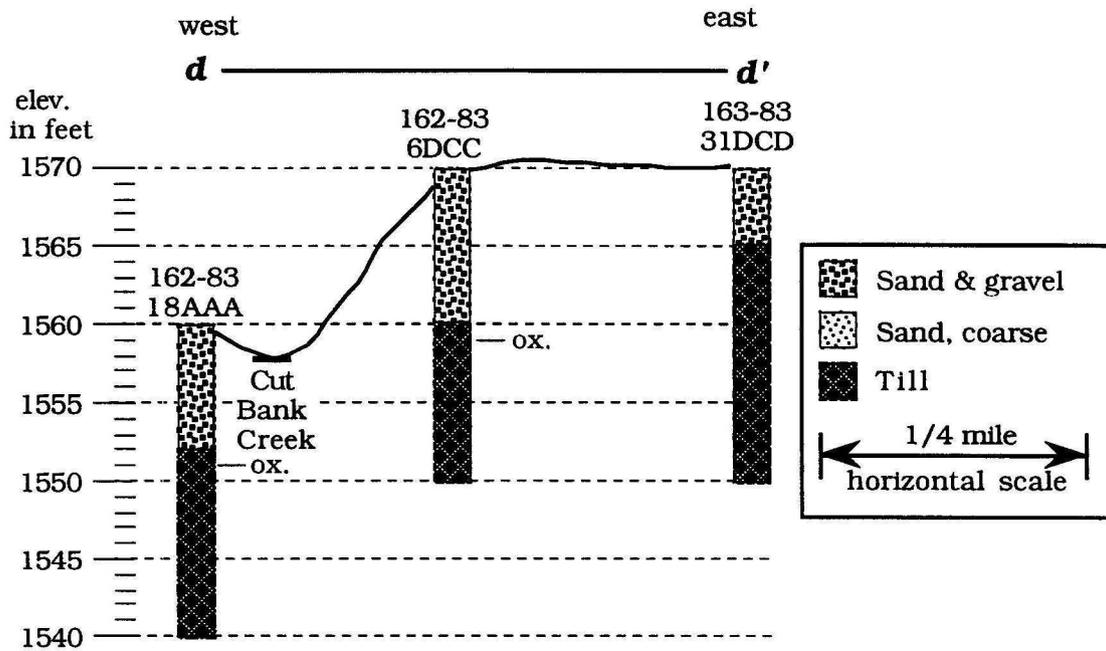


Figure 15 - Geohydrologic section d - d'

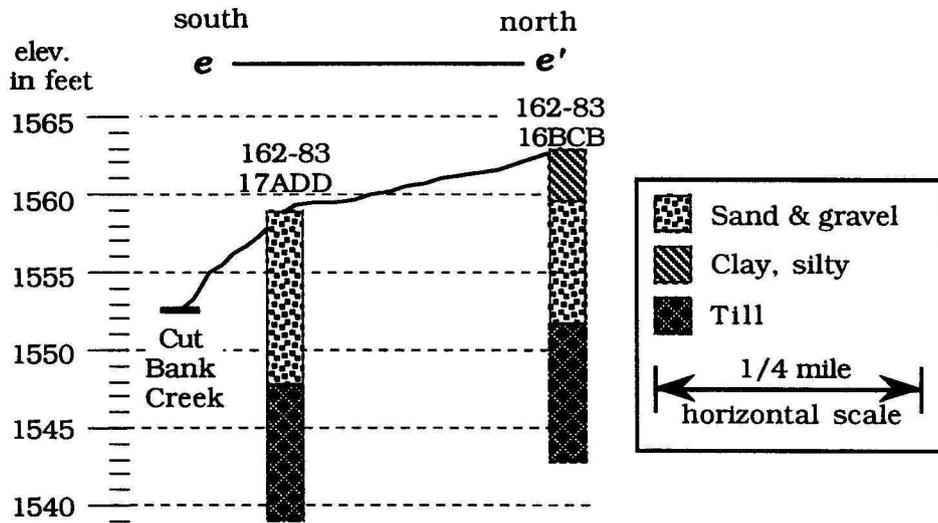


Figure 16 - Geohydrologic section e - e'

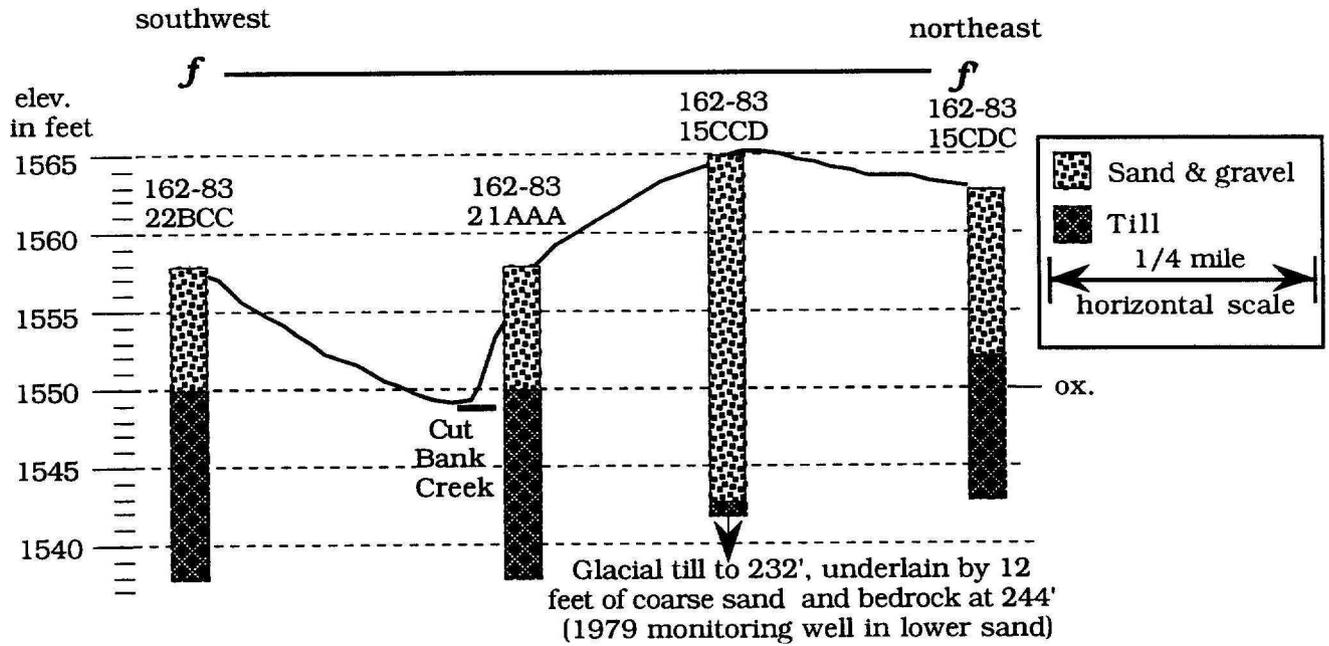


Figure 17 - Geohydrologic section f - f

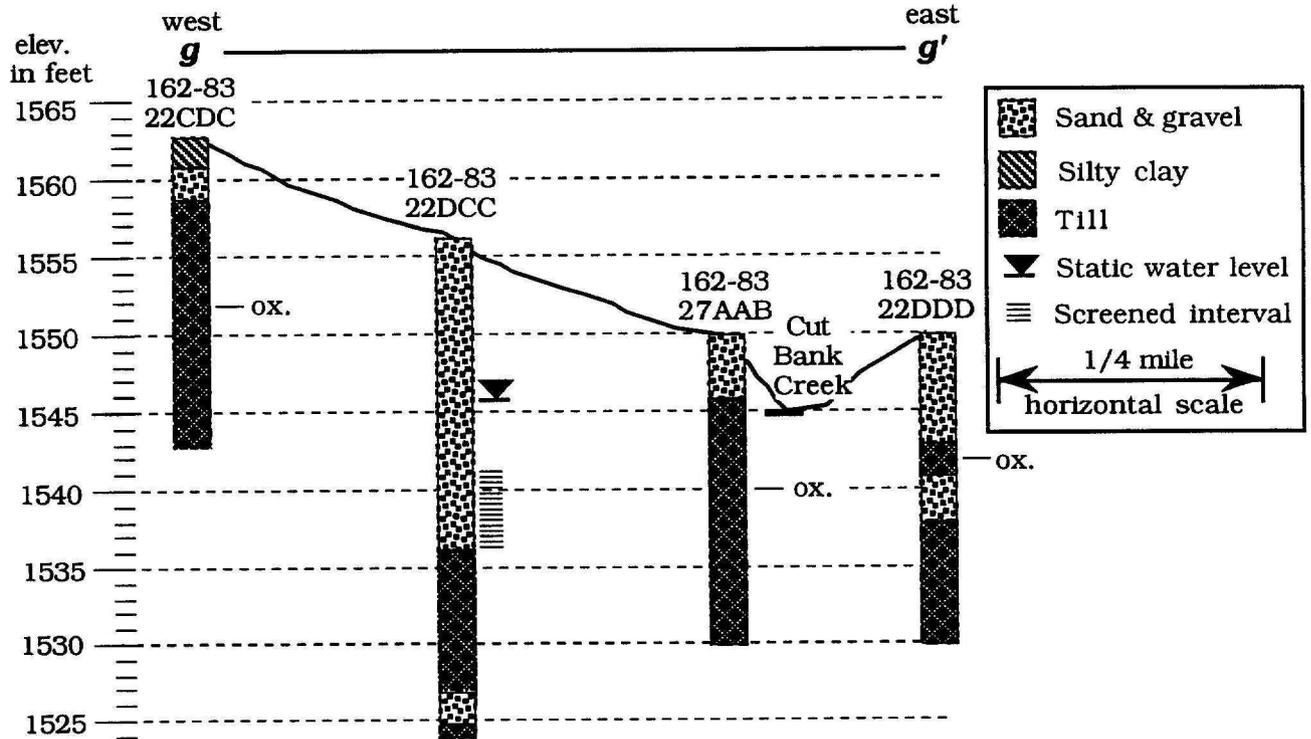


Figure 18 - Geohydrologic section g - g'

Section g - g' includes one test hole in which a monitoring well was installed. The test hole penetrates 20 feet of sand and gravel, half of which is water saturated. Geohydrologic section h - h' is located one mile farther south, along the section line between Sections 27 and 34, where sand and gravel was encountered in test drilling from land surface to depths of 18, 25, and 10 feet in the center three test holes (fig. 19). Wells were installed in the two test holes in which sand and gravel was found to depths of 18 and 25 feet. The water level in the two wells on 17 August 1993 was 11.26 and 12.82 feet below land surface, respectively.

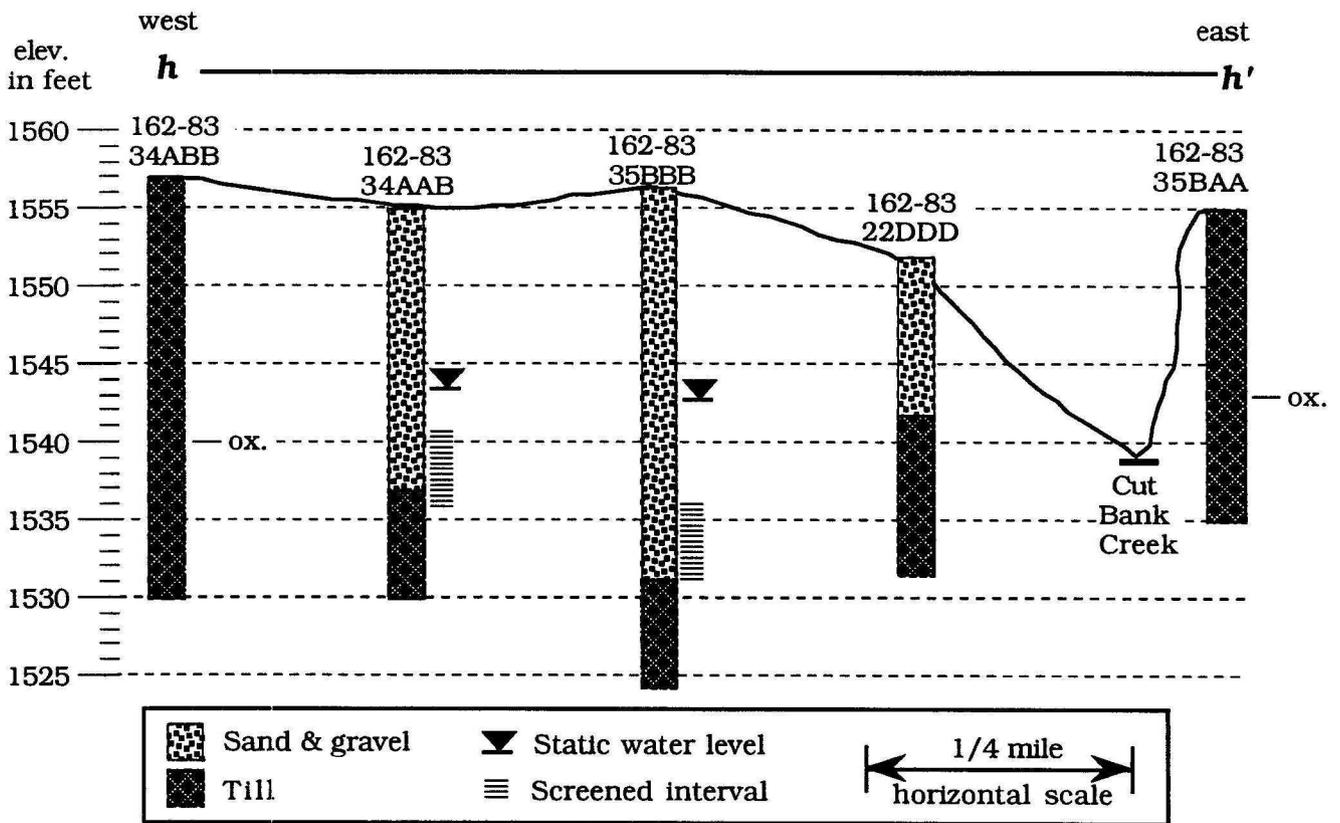


Figure 19 - Geohydrologic section h - h'

Additional test holes were drilled about 1/4 mile south of the line between Sections 27 and 34 to better determine the extent and saturated thickness of the sand and gravel. The information is shown in geohydrologic section i - i', (fig. 20). The sand and gravel thickens eastward to the north-south section line between Sections 34 and 35 where 28 feet of sand and gravel was encountered, 19 feet of which is water saturated. Three hundred feet east northeast of the test hole encountering 28 feet of sand and gravel, a test hole encountered coarse sand to only 14 feet depth, indicating a fairly abrupt thinning to the east of the coarse alluvial sediments comprising the Mohall aquifer.

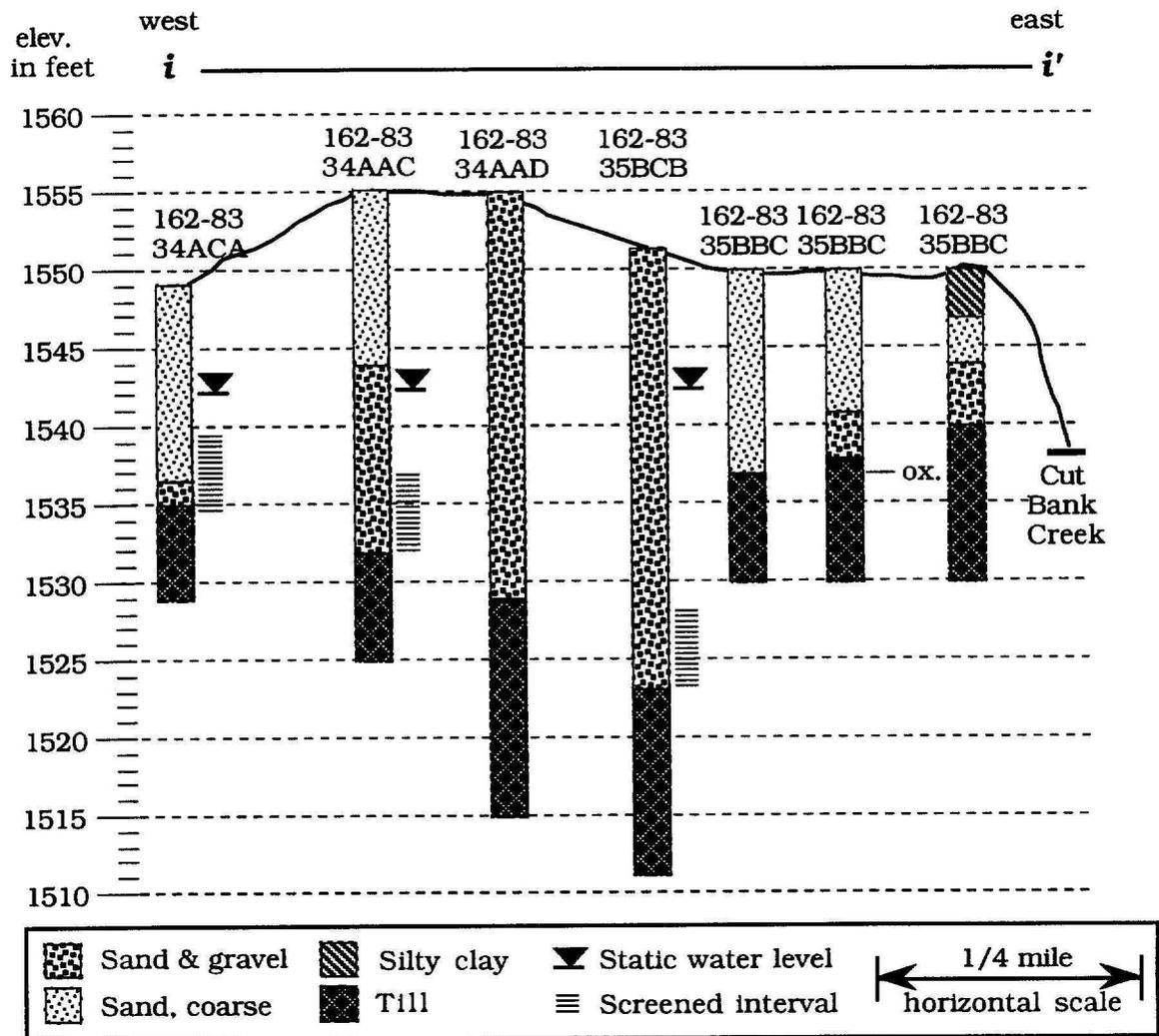


Figure 20 - Geohydrologic section i - i'

Additional test drilling was undertaken in Section 34, in Cut Bank Creek valley, to determine the extent and thickness of the Mohall aquifer. North-south section j - j' (fig. 21) includes the test holes and monitoring wells in Sections 34 and 35 which are not otherwise included in sections a - a' through i - i', plus the drilling information from the northern municipal water supply well in Section 3 and a 1990 test hole located at 162-83-34DDD. The latter test hole penetrated fine to medium sand to 39 feet below surface.

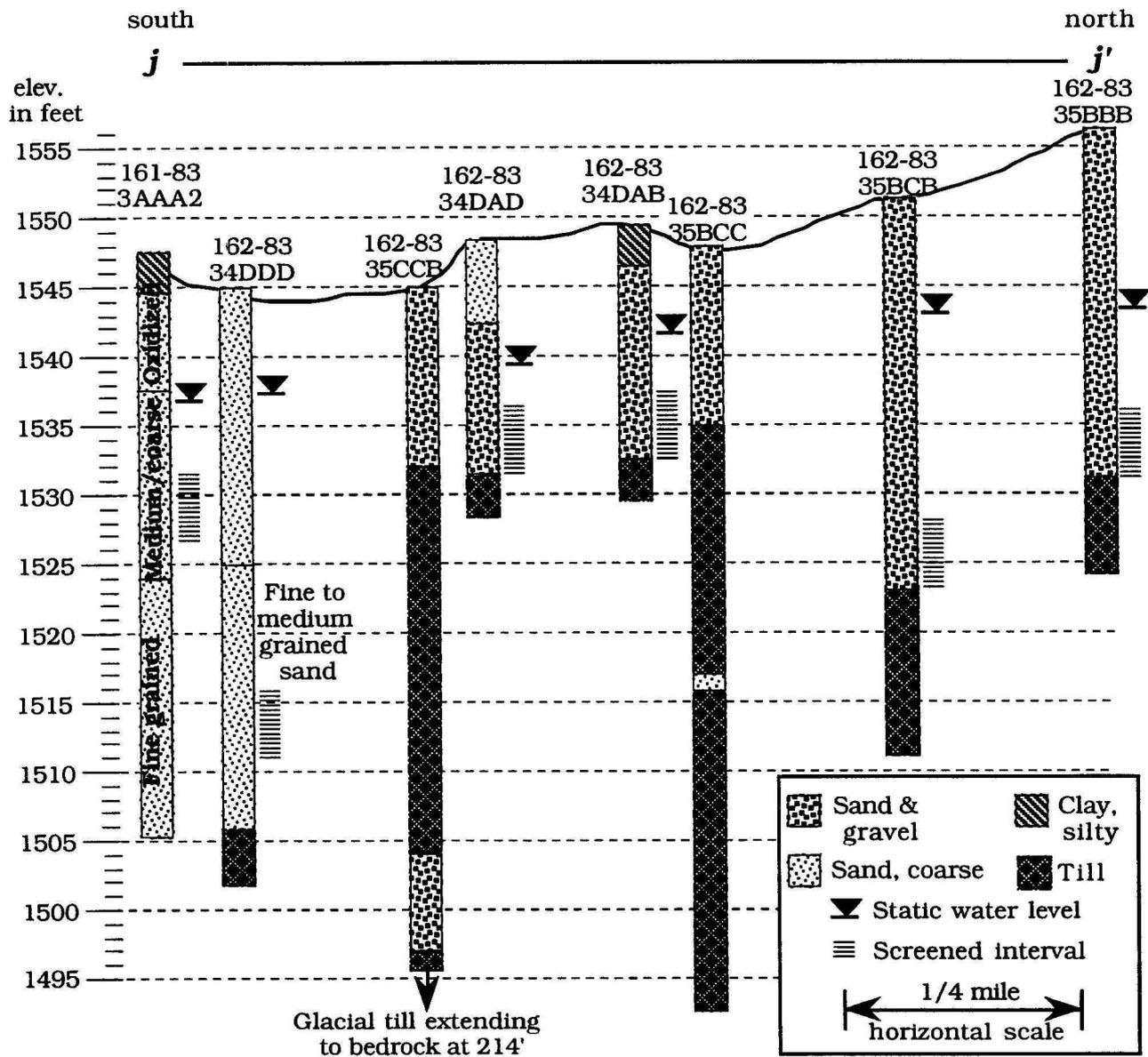


Figure 21 - Geohydrologic section j - j'

Five geohydrologic sections were constructed using test drilling information from previous municipal water supply studies. Section k - k' is through the well field constructed in 1990 and 1992 (fig. 22).

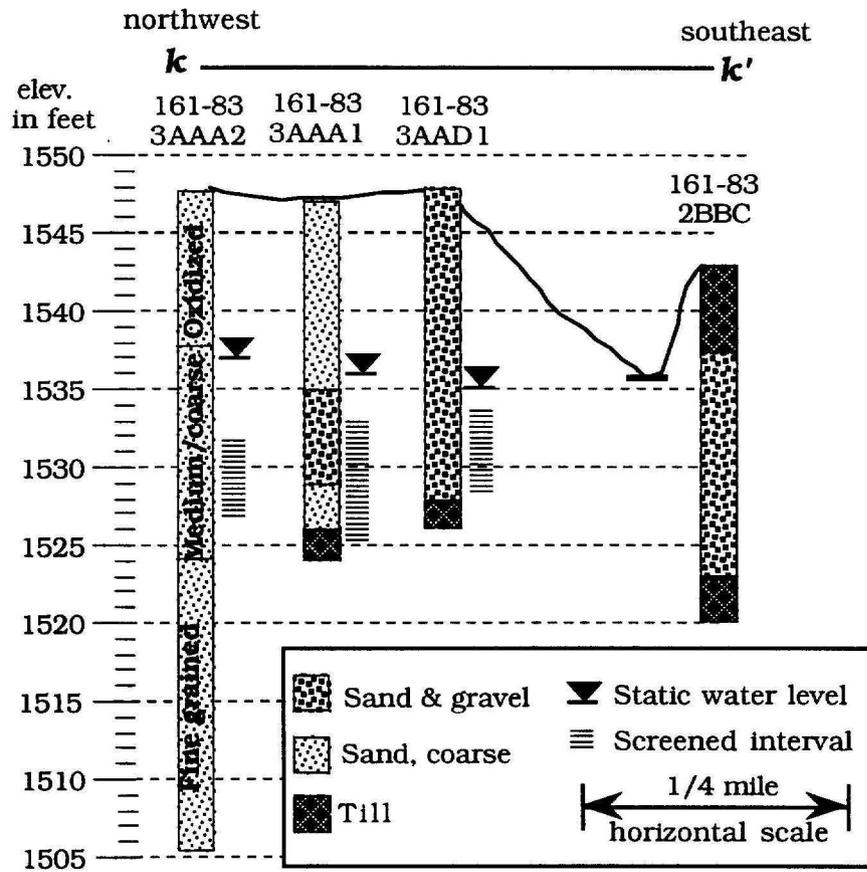


Figure 22 - Geohydrologic section k - k'

During the 1990 drilling a location in east-central Section 11, T. 161 N., R. 83 W., indicated sand and gravel extending to 60 feet depth. Test pumping, however, resulted in rapid water level declines. Added test drilling indicated very narrow, sand and gravel filled channels. Section 1 - 1' includes most of the test holes drilled along the east-west quarter line traversing through the center of Section 11 (fig 23).

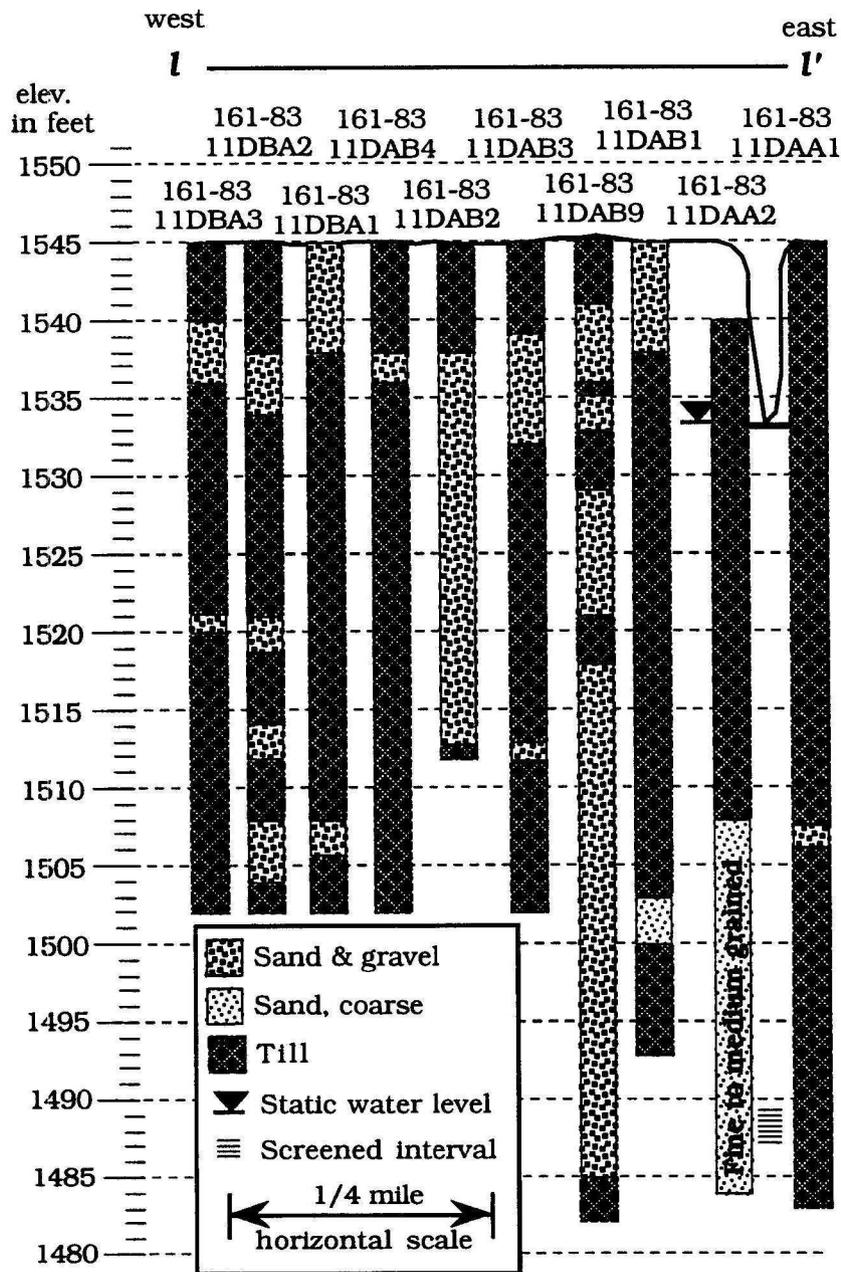


Figure 23 - Geohydrologic section 1 - 1'

During the 1990 drilling a location in east-central Section 11, T. 161 N., R. 83 W., indicated sand and gravel extending to 60 feet depth. Test pumping, however, resulted in rapid water level declines. Added test drilling indicated very narrow, sand and gravel filled channels. Section 1 - 1' includes most of the test holes drilled along the east-west quarter line traversing through the center of Section 11 (fig 23).

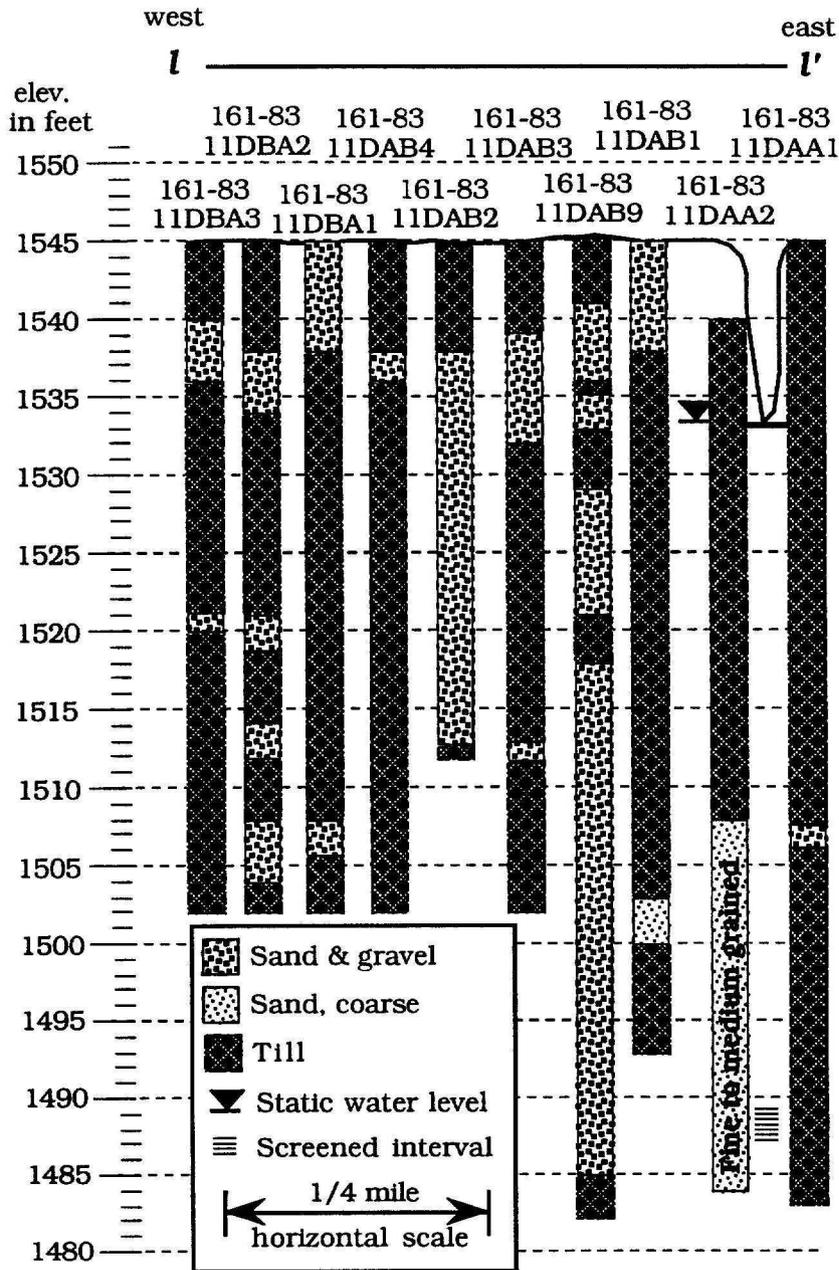


Figure 23 - Geohydrologic section 1 - 1'

Test holes were drilled in 1990 along the section line between Sections 11 and 14, 1/2 mile north of the "Witteman well," in an effort to extend the aquifer to the north. The thickness of sand and gravel was determined to be insufficient for a supplemental water source. Section m - m' shows the lithology penetrated through (fig. 24).

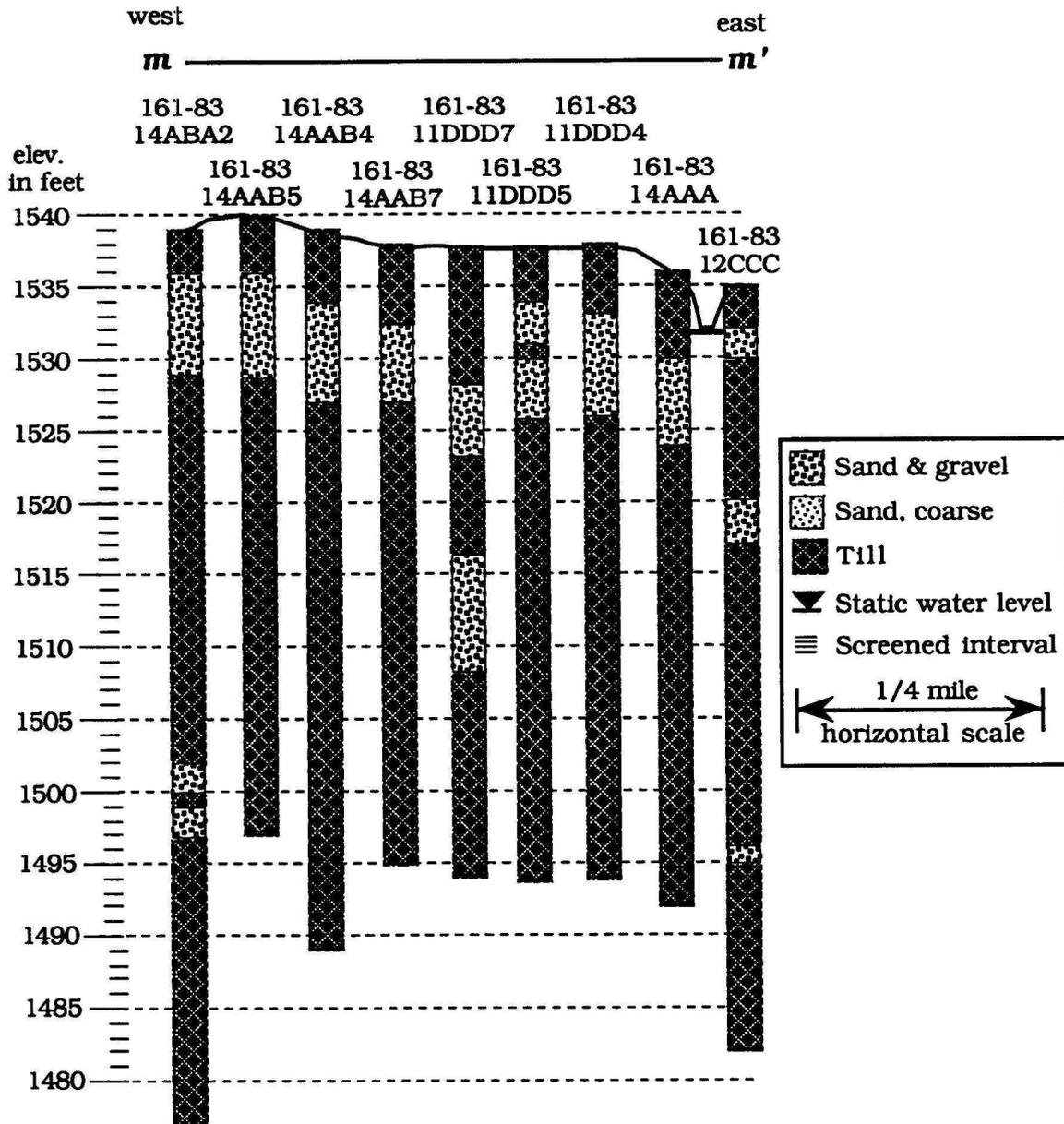


Figure 24 - Geohydrologic section m - m'

Section n - n' indicates the lithology penetrated in test drilling associated with the 1951 well field near the center of 161-83-13C (fig 25).

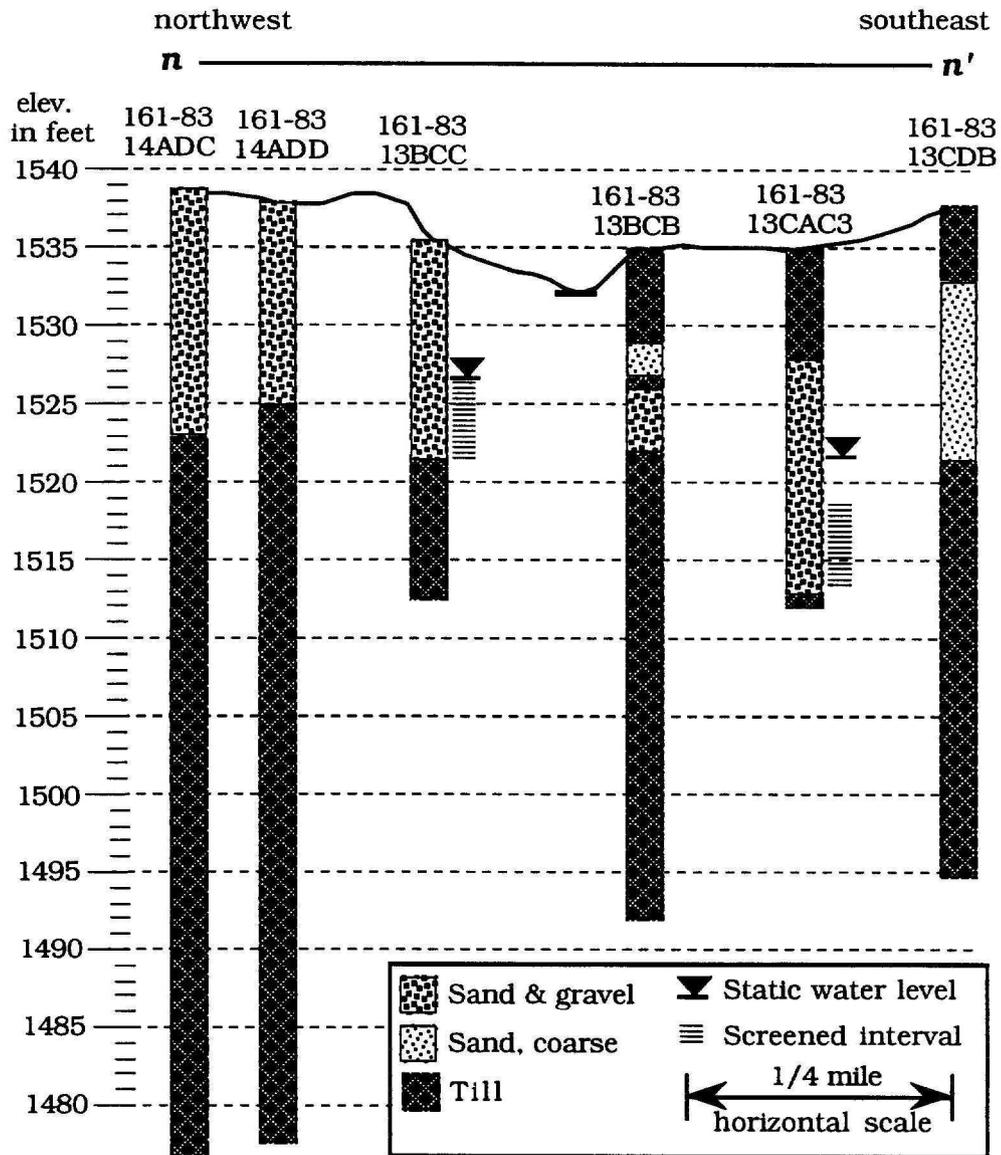


Figure 25 - Geohydrologic section n - n'

Section o - o' was prepared from test drilling completed in 1961 by the State Water Commission and included in the report, "Ground-Water Data for Bottineau and Rolette Counties, North Dakota (1982), (fig. 26).

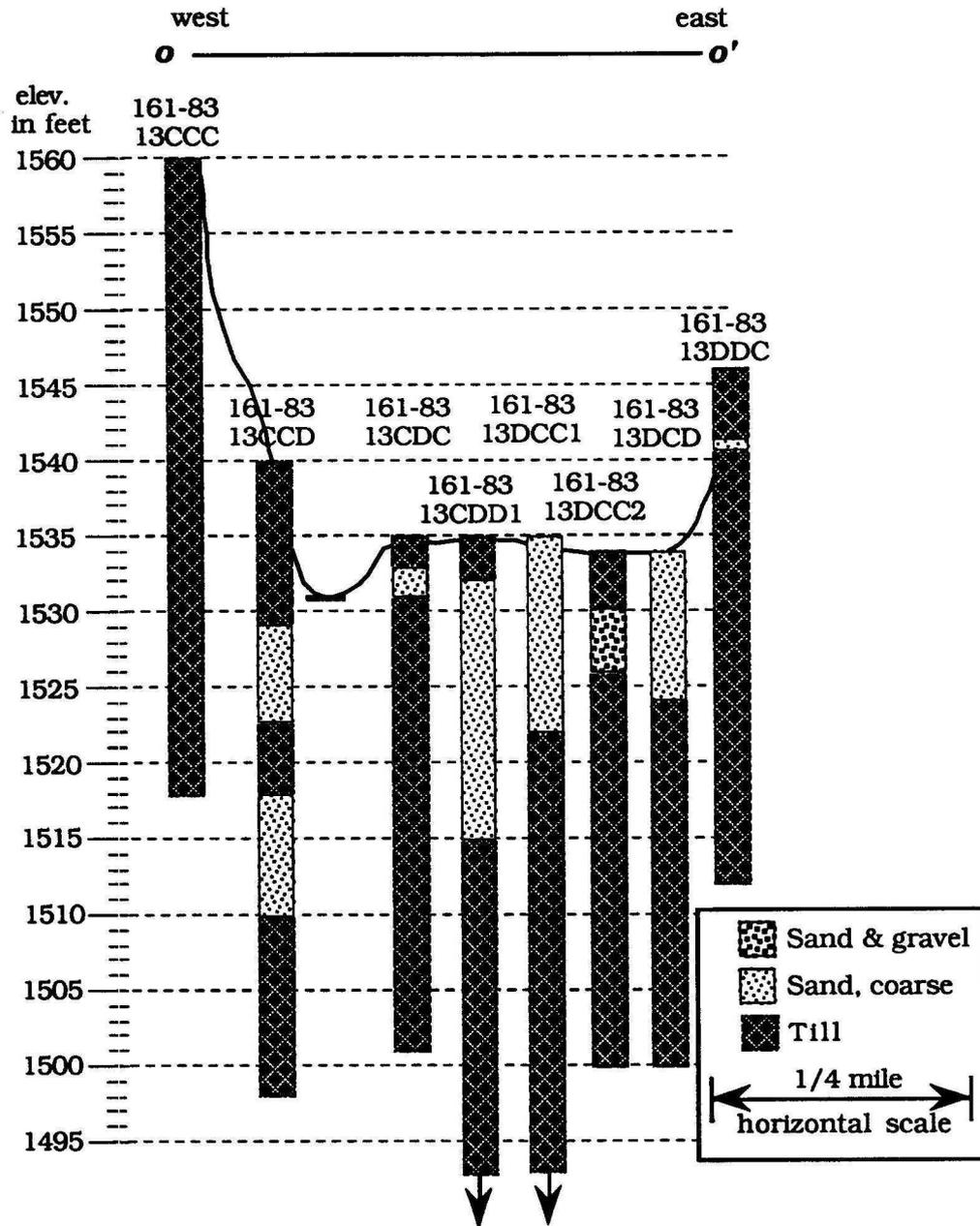


Figure 26 - Geohydrologic section o - o'

A request was made to investigate the Cut Bank Creek valley alluvium south of ND Highway 5. The section line was not accessible one mile south of the highway. Two miles south of Highway 5 four test holes were drilled as shown in section p - p' (fig. 27), which includes one test hole drilled in 1973. Twelve feet of saturated sand and gravel was penetrated in one test hole, near Cut Bank Creek, in which a monitoring well was installed. A test hole 410 feet farther east penetrated only four feet of sand, probably all unsaturated. Sections o - o' and p - p' indicate sufficient depth of aquifer may extend south of the 1951 well field, however, the aquifer width is quite narrow which limits the potential of this part of the aquifer to yield a significant amount of water.

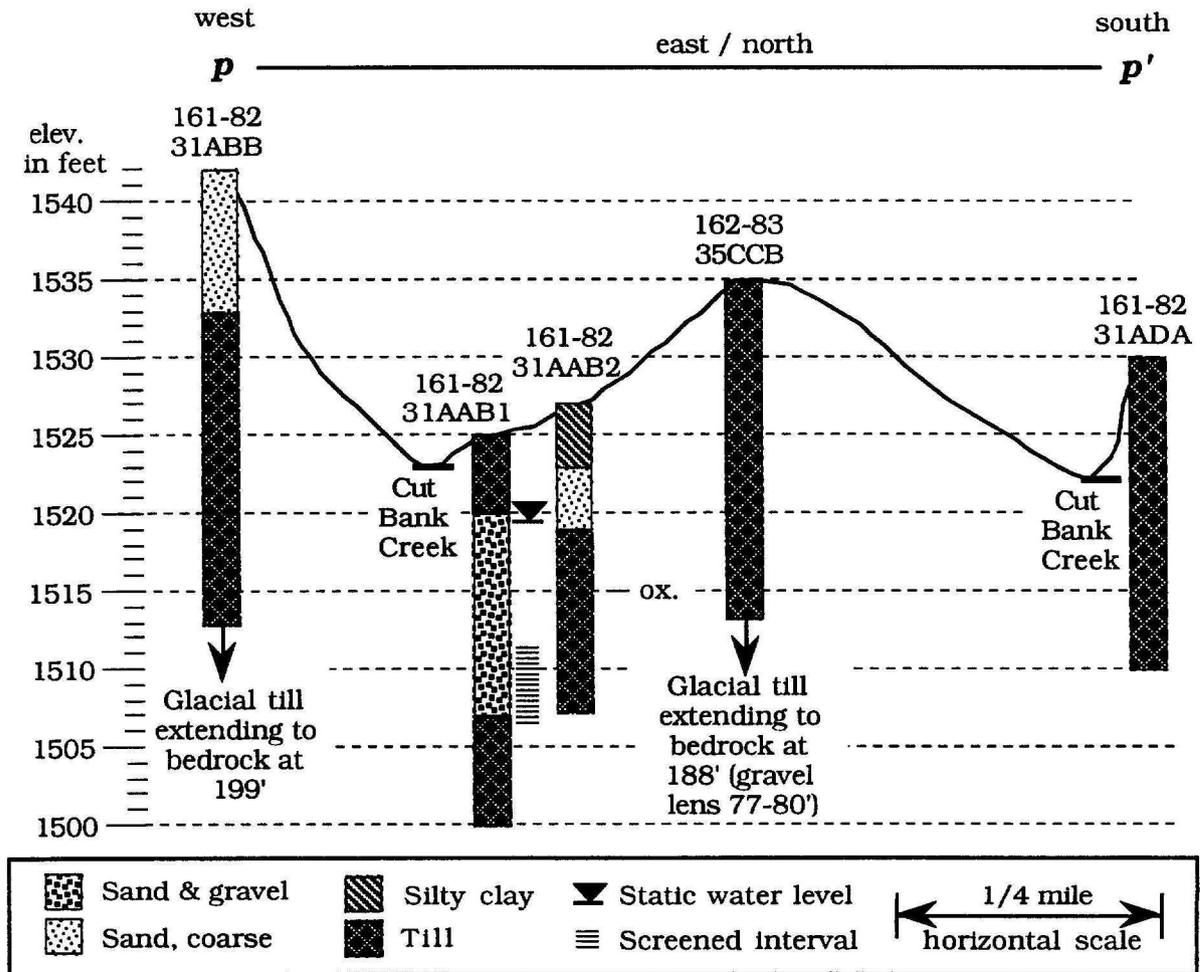


Figure 27 - Geohydrologic section p - p'

Three test holes were drilled in 1973 along Cut Bank Creek one mile southeast of section p - p' (fig. 28). Only a few feet of coarse sand was encountered. The alluvium seems to be grading finer in a downgradient direction.

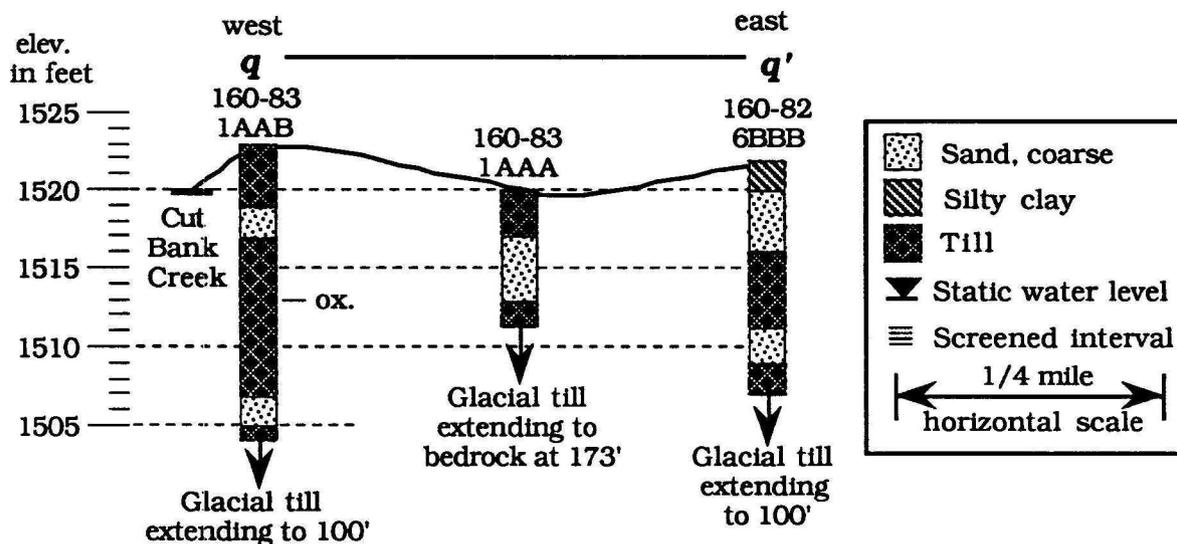


Figure 28 - Geohydrologic section q - q'

Hydrology of the Mohall aquifer

Since 1990 water levels have been measured in selected observation wells near the 1951 and 1990-1992 well fields by Ken Shobe, Mohall Water Works Superintendent. Following the June 1993 drilling program water levels are also being measured monthly by the State Water Commission.

Measured water levels in the 1990-1992 well field have been converted to feet above sea level datum and are plotted as hydrographs in figures 30 - 33. Also indicated on each of the hydrographs is the screened interval of the nearby city water supply well. The hydrographs in the well field are shown from north to south. The saturated thickness of the Mohall aquifer in the developed well fields is about ten feet. Therefore, a water level change of two feet corresponds to a 20% change in saturated thickness.

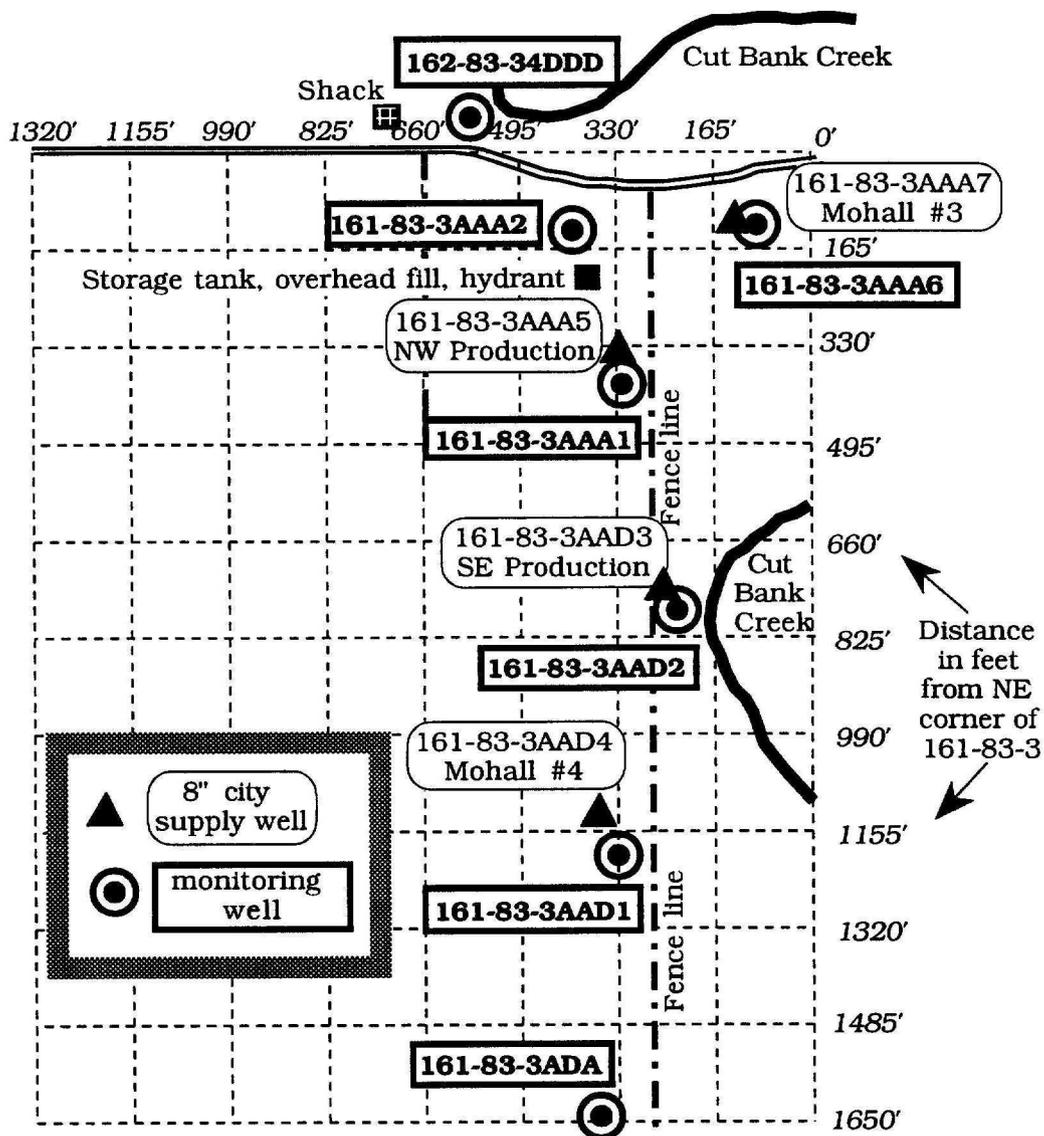


Figure 29 - 1990-1992 municipal well field

**Water level in monitoring well 161-83-3AAA6
located 23' east of 161-83-3AAA7 (Mohall well #3)**

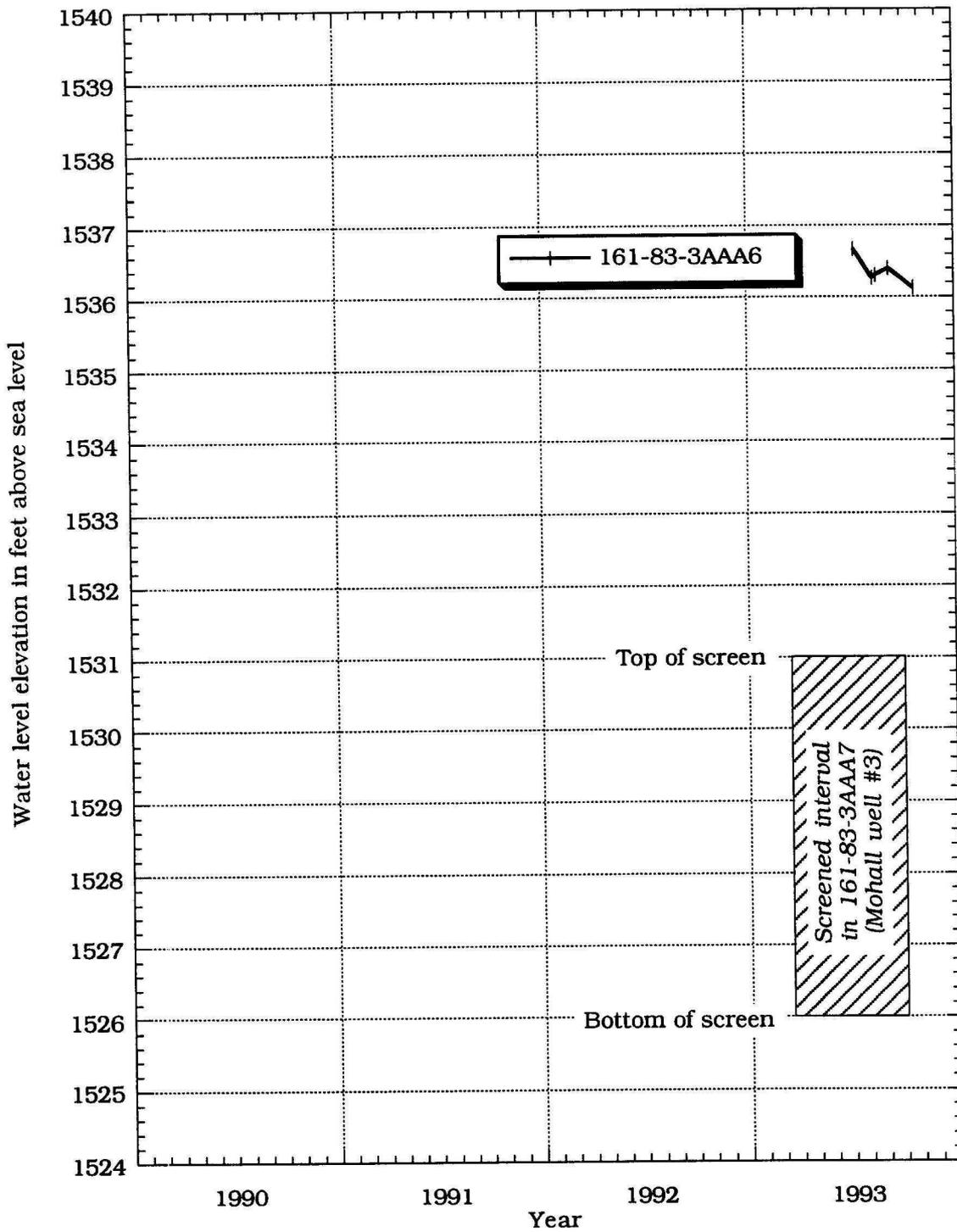


Figure 30 - Hydrograph from monitoring well near 161-83-3AAA7

Water level in monitoring wells 161-83-3AAA1 (60' south of 161-83-3AAA5) & 161-83-3AAA2 (200'NNW of 161-83-3AAA5)

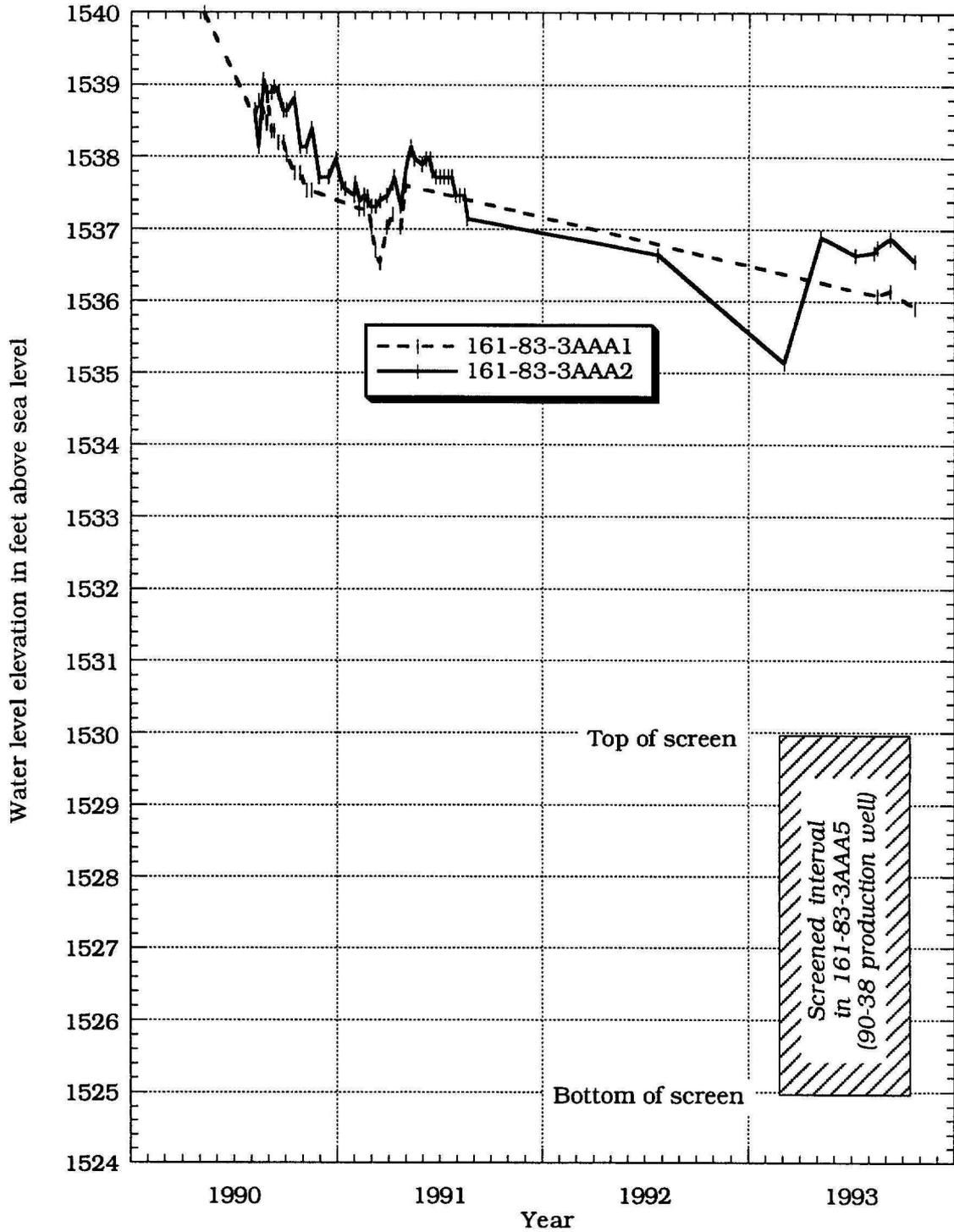


Figure 31 - Hydrograph from monitoring wells near 161-83-3AAA5

**Water level in monitoring well 161-83-3AAD2 located
3' south of 161-83-3AAD3 (SE production well)**

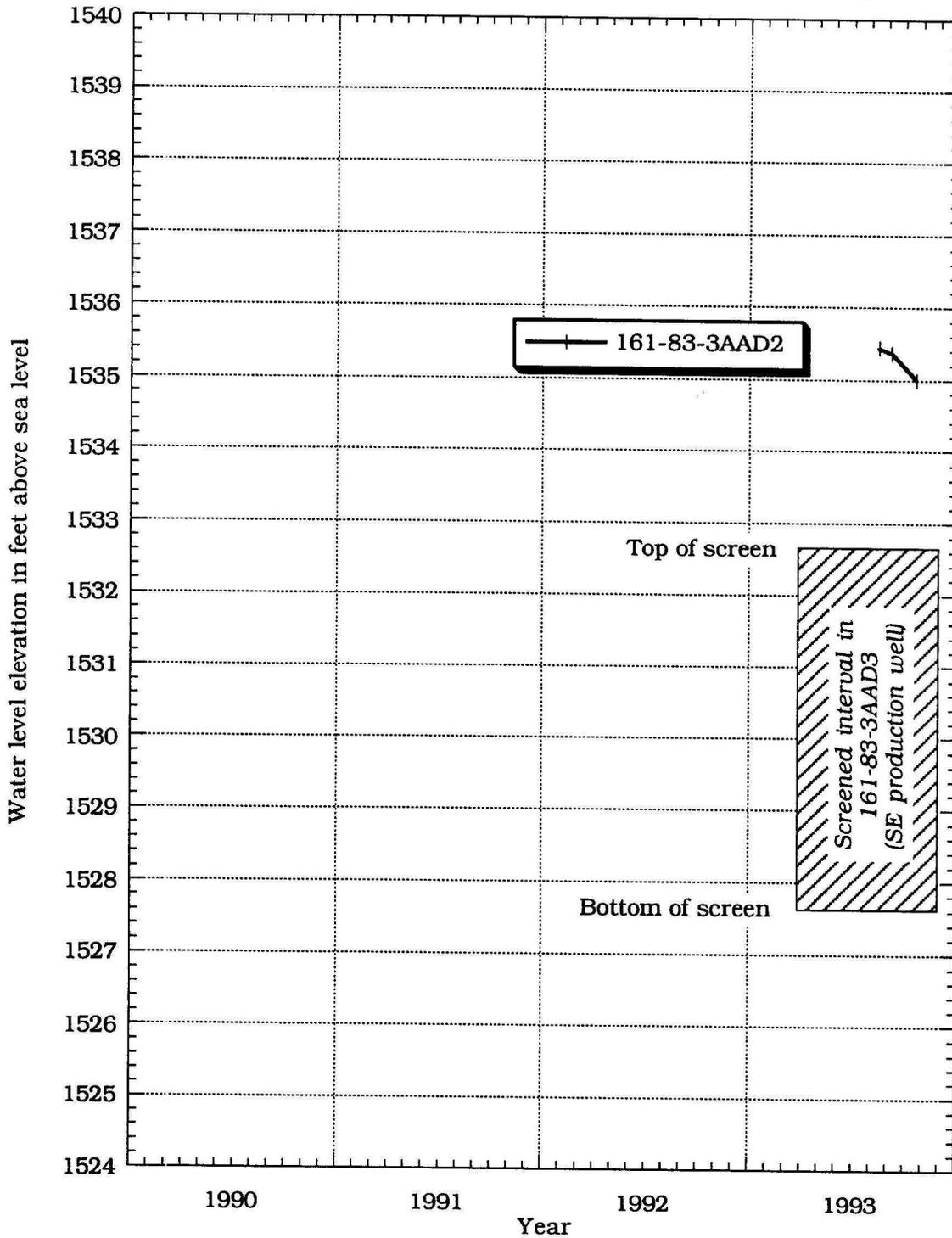


Figure 32 - Hydrograph from monitoring well near 161-83-3AAD3

Water levels in monitoring wells 161-83-3AAD1 located 40' south & 30' east of 161-83-3AAD4 (Mohall well #4) and in 161-83-3ADA located 500' south of 161-83-3AAD4

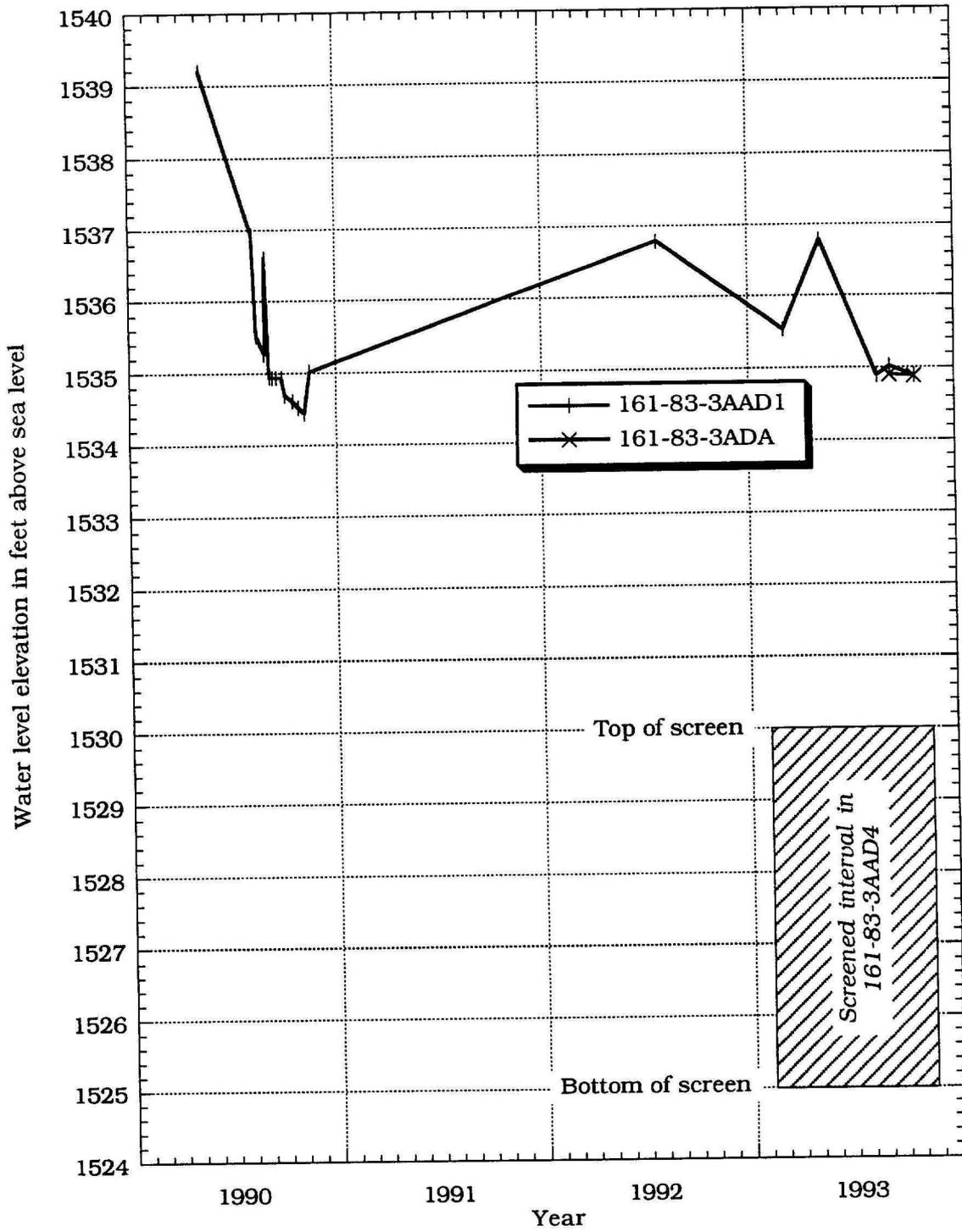


Figure 33 - Hydrograph from monitoring wells near 161-83-3AAD4

Measured water levels in the 1951 well field, converted to feet above sea level datum, are plotted as hydrographs in figures 35 and 36. Also indicated on each of the hydrographs is the screened interval of the nearby city water supply well.

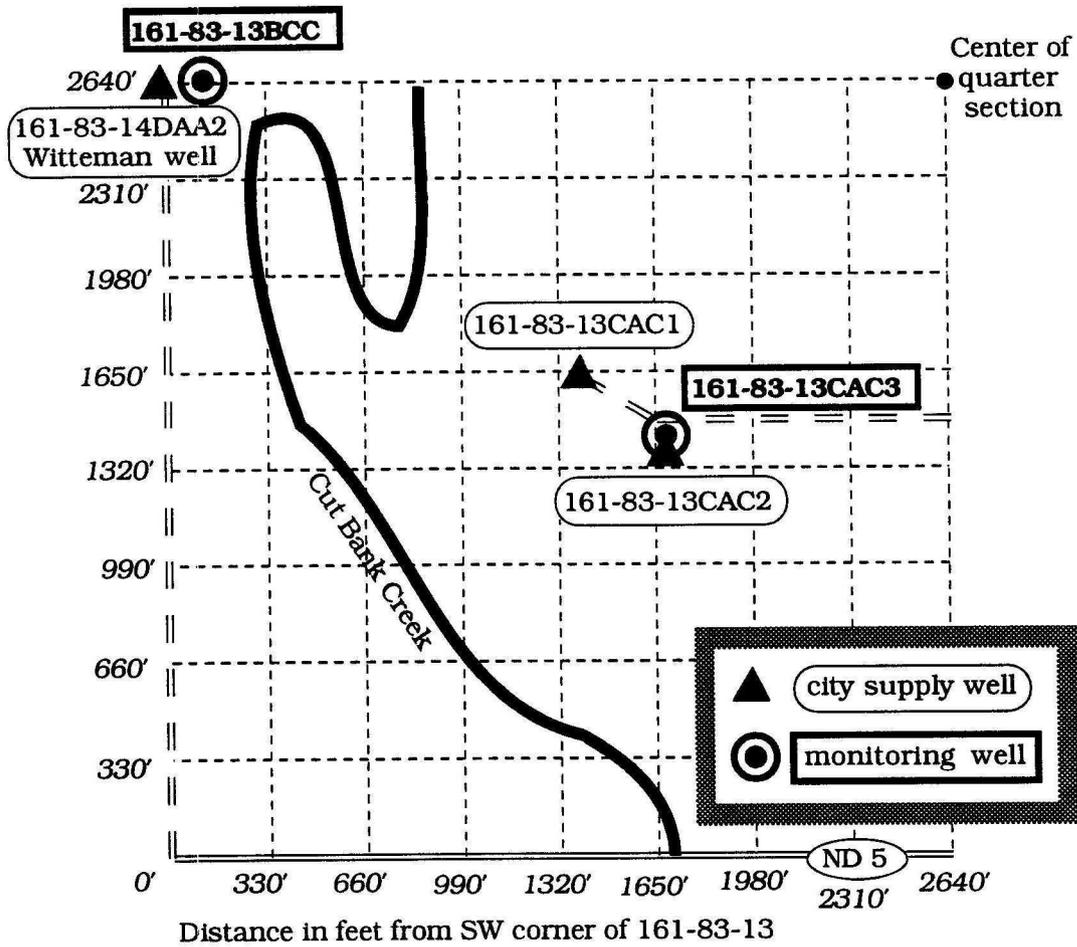


Figure 34 - 1951 municipal well field

**Water level in monitoring well 161-83-13BCC located
135' east of 161-83-14DAA2, the "Witteman well"**

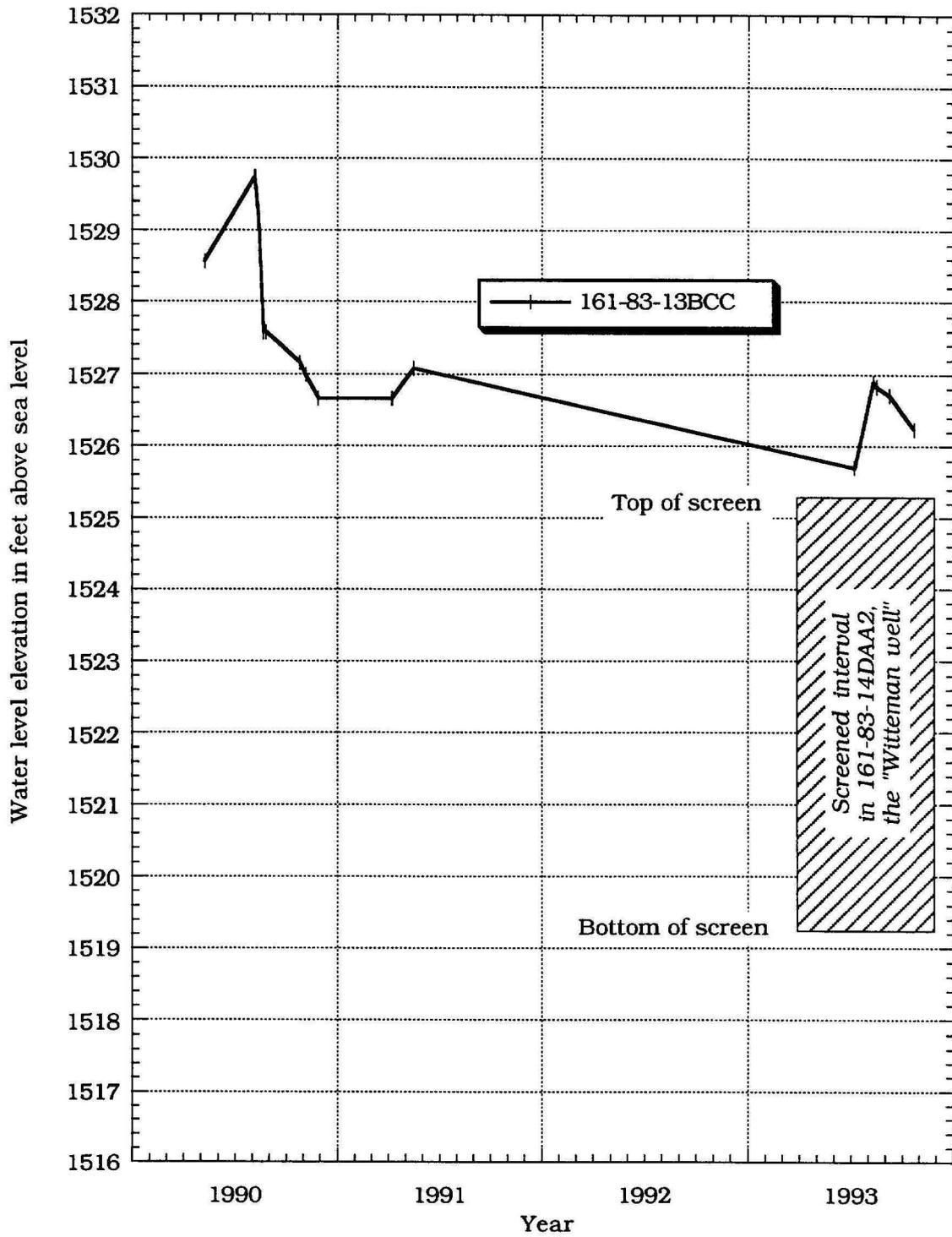


Figure 35 - Hydrograph from monitoring well near 161-83-14DAA2

**Water level in monitoring well 161-83-13CAC3
located 30' north of 161-83-13CAC2**

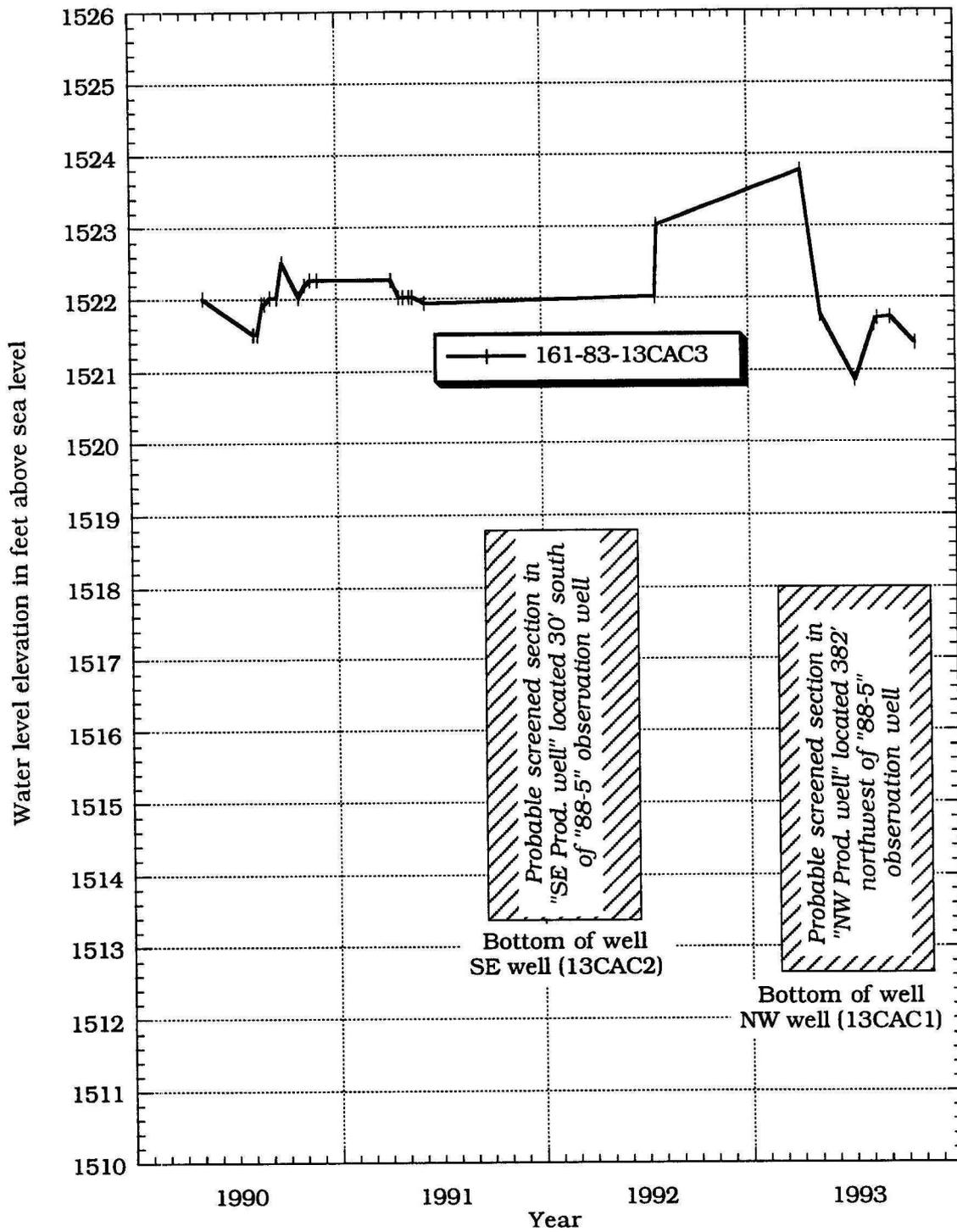


Figure 36 - Hydrograph from monitoring well near 161-83-13CAC2

The hydrographs indicate a water level decline of about two feet between 1990 and 1993 in the well field in 161-83-3A and near the Witteman well in 13BCC. The hydrographs indicate a water level decline of about one half foot between 1990 and 1993 in the 1951 well field in 161-83-13C. The city has been reporting water use primarily from the 1990-1992 well field in recent years. The decline in water level is due to a combination of low precipitation and the use by the city.

Ground water recharge to the Mohall aquifer takes place primarily from precipitation falling on the land surface overlying the aquifer. Overland flow of water from surrounding areas to Cut Bank Creek valley and overbank flooding of Cut Bank Creek may at times add to aquifer recharge. Most aquifer recharge takes place in the spring and early summer of the year when snow melt and spring rains saturate the soil, allowing additional water to reach the water table. Occasional heavy or sustained summer and fall rains may also recharge the aquifer.

The amount of water stored in the Mohall aquifer is limited by the relatively small physical dimensions of the aquifer, about 1/2 mile wide by about ten feet thick. Assuming a specific yield of 0.2 and a usable thickness of six feet, about 400 acre-feet of water is available from storage over a one mile length of Cut Bank Creek valley in the vicinity of 161-83-2 and 3 and 162-83-34 and 35.

Water is removed from the aquifer by discharge to Cut Bank Creek, evaporation, transpiration (uptake of water by plants), and by pumping. Because of the relatively small volume of water stored in the aquifer, the addition of municipal water pumping to the other discharge mechanisms may cause a significant decline in the water level, particularly during drought conditions when less recharge reaches the aquifer.

Water-level elevations on 21 October 1993 in the Mohall aquifer are shown on the water table map (fig. 37). The map indicates a southern trending water table gradient of about 3.4 feet per mile between the northernmost and southernmost monitoring wells. The water table gradient becomes steeper in the areas of water use from the well fields.

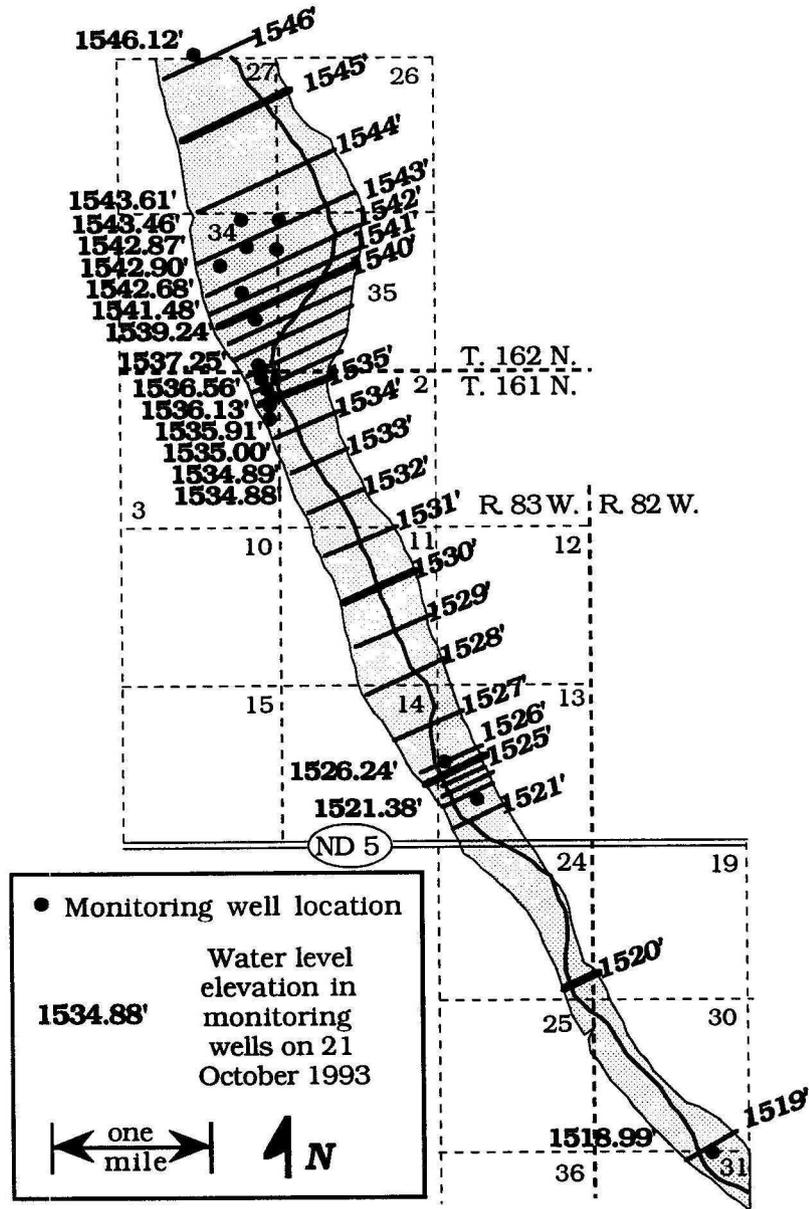


Figure 37 - Water-level elevations on 21 October 1993

WATER QUALITY

Properties and Characteristics of Water

Eighteen water samples were collected and analyzed from the Mohall aquifer. The physical properties and mineral constituents of water reported include those that have a practical bearing on the value of the water for most purposes. The analyses include determinations of:

- Specific conductance
- pH
- Temperature
- Hardness
- Sodium-adsorption ratio
- Residual sodium carbonate
- Percent sodium

and dissolved mineral concentrations of:

CATIONS:

- Silica
- Calcium
- Magnesium
- Potassium
- Sodium
- Iron
- Manganese

ANIONS:

- Fluoride
- Bicarbonate
- Carbonate
- Sulfate
- Chloride
- Nitrate
- Boron

and total dissolved solids.

The samples were analyzed for 'trace' dissolved mineral concentrations of:

- Selenium
- Lead
- Mercury
- Arsenic
- Lithium
- Molybdenum
- Strontium

The water samples obtained during the study were collected in polyethylene bottles, and the analyses were made by the North Dakota State Water Commission Laboratory in Bismarck.

Dissolved mineral constituents in water are usually reported in milligrams per liter (mg/l) or micrograms per liter ($\mu\text{g/l}$). A milligram per liter is one-thousandth (0.001) of a gram of dissolved material per liter of solution. A microgram per liter is one millionth (0.000001) of a gram of dissolved material per liter of solution. Milligrams per liter can be converted to grains per gallon by dividing milligrams per liter by 17.12 (Hem, 1970, p.81).

Equivalent per million (epm) is the unit chemical combining weight of a constituent in a million weights of water. These units are usually not reported, but are used to calculate percent sodium, the sodium-adsorption ratio, or to check the accuracy of a chemical analysis.

Specific conductance (micromhos per centimeter at 25^o Celsius): Specific conductance is a measure of the ability of water to conduct an electric current. Approximately 65 to 70 percent of the specific conductance (in micromhos) is an estimate of the amount of dissolved solids (in milligrams per liter) in water; however, this relation is not constant and will vary with the chemical composition of the water (Hem, 1970).

Hydrogen-ion concentration (pH): Hydrogen-ion concentration (activity) is expressed in terms of pH units. The values of pH often are used as one measure of the solvent capacity of water. The hydrogen-ion concentrations affect the corrosiveness of water. A pH of 7.0 indicates the water is neutral, neither acidic nor basic. Readings progressively lower than 7.0 denote increasing acidity, and those progressively higher than 7.0 denote increasing alkalinity.

Temperature: Temperature is important for its influence upon concentrations of dissolved gases and mineral matter in water. Water temperatures given in the tables are expressed in degrees Celsius (Centigrade). Degrees Celsius can be converted to degrees Fahrenheit using the following equation:

$$\text{Degrees Fahrenheit} = (9/5) \text{ degrees Celsius} + 32.$$

Hardness:: Calcium and magnesium are the principal cause of hardness. Hardness exhibits the characteristic of requiring greater quantities of soap to produce a lather as the hardness increases. Hard water also can contribute to the formation of scale in boilers, water heaters, radiators, and pipes, with a resultant decrease in the rate of water flow and/or heat transfer.

The hardness that is equivalent to the alkalinity is called carbonate hardness, and any excess is called noncarbonate hardness. The carbonate hardness is the quantity that will contribute scale on heating, and the noncarbonate hardness is the quantity of hardness that will remain after removal of the carbonate hardness. As a general reference, the U. S. Geological Survey often uses the following classification of water hardness (Hem, 1970).

Calcium and magnesium hardness, as CaCO₃ (mg/l)

0-60	soft
61-120	moderately hard
121-180	hard
more than 180	very hard

Sodium-adsorption ratio (SAR): The term "sodium-adsorption ratio" was introduced by the U. S. Salinity Laboratory Staff (1954). Their experiments shown that the SAR relates to the degree water enters into cation-exchange reactions with soil. Sodium-adsorption ratio as expressed by the equation:

$$SAR = \frac{Na^+}{\sqrt{\frac{[Ca^{++}] + [Mg^{++}]}{2}}}$$

where the concentrations of the ions are expressed in milli-equivalents per liter. The U. S. Salinity Laboratory Staff (1954) divided water into 16 classes, depending upon the SAR and specific conductance. The classifications indicate the usefulness of water for irrigation of different crops on different types of soil.

Residual sodium carbonate (RSC): Residual sodium carbonate is twice the amount of carbonate or bicarbonate a water would contain after subtracting an amount equivalent to the calcium plus the magnesium, that is, $RSC = 2(HCO_3 + CO_3 - CA - Mg)$, in milliequivalents per liter.

Percent sodium: The percent sodium is the percentage of sodium to all cations, with the cations in milliequivalents per liter. The displacement of calcium and magnesium by sodium in soils is slight unless the percent sodium is considerably higher than 50.

Silica (SiO₂): Weathering processes dissolve silica from practically all rocks. Silica affects the usefulness of water because it can contribute to the formation of scale in pipes, water heaters, and boilers in the presence of calcium and magnesium.

Calcium and Magnesium (Ca and Mg): Limestone and similar rocks are the principal source of calcium and magnesium in natural water. Calcium and magnesium cause water hardness and, with anions, can form scale on utensils and in water heaters, boilers, and pipes.

Sodium and Potassium (Na and K): Sodium and potassium are present in many rocks. Sodium dissolves readily and when brought into solution it tends to remain in solution. Potassium is dissolved with greater difficulty and exhibits a stronger tendency to be reincorporated into solid weathering products, especially clay minerals. In most natural water, the concentration of potassium is much lower than the concentration of sodium. Water that contains a large proportion of sodium salts may be unsatisfactory for irrigation on certain types of poorly drained soils. The presence of several hundred milligrams per liter of sodium in water can make it unsuitable for use in sodium-restricted diets (North Dakota State Department of Health, 1962).

Iron (Fe): Iron is a widespread constituent in rocks and is easily leached by ground water under reducing conditions or in acidic water. Water containing more than 300 µg/l of iron, after exposure to air, may become discolored. Reddish-brown stains on porcelain or enamelware and fixtures and on fabrics washed in the water result from the iron.

Manganese (Mn): Manganese in concentrations as low as 200 µg/l may cause a dark-brown or black stain on fabrics and porcelain fixtures. Ground water that contains high concentrations of iron may also have considerable amounts of manganese.

Fluoride (F): Fluoride in the ground water probably is derived from solution of fluorite, apatite, and hornblende minerals. High fluoride content (depending on annual average maximum daily air temperature) may cause mottling of tooth enamel in children's teeth during calcification.

Bicarbonate and Carbonate (HCO₃ and CO₃): Bicarbonate and carbonate ions are the major cause of alkalinity in most water. The significance of alkalinity to the domestic, agricultural, and industrial user is usually dependent upon the nature of the cations (Ca, Mg, Na, and K) associated with it. However, moderate amounts of alkalinity do not adversely affect most uses. Alkalinity can be calculated from the analyses by using the formula:

$$\text{Alkalinity (as CaCO}_3\text{)} = 0.82 (\text{HCO}_3) + 1.67 (\text{CO}_3)$$

Sulfate (SO₄): Metallic sulfide minerals may be converted to sulfates upon weathering or with bacterial action. Sulfate also may be dissolved from beds of gypsum and deposits of sodium sulfate and other sulfosalts.

Chloride (Cl): Chloride is present in all natural waters, but the concentrations usually are low. Important sources of chloride are sedimentary rocks that were deposited under marine conditions. Chloride concentrations in excess of 400 mg/l impart a noticeable salty taste for most people.

Nitrate (NO₃): The occurrence of high nitrate concentrations in shallow ground water has been attributed to leaching in feedlots or to fertilizer from irrigated fields where nitrogen compounds have been applied. High nitrate content is undesirable in drinking water because of its bitter taste and it has been reported to cause methemoglobinemia (blue babies) in infants (Comly, 1945).

Boron (B): Boron is a constituent of the mineral tourmaline and may be present in biotite and amphiboles. In small quantities, boron is essential for plant growth.

Excessive concentrations in soil and in irrigation water are harmful for some plants.

Total dissolved solids: (TDS): The concentration of total dissolved solids (TDS) is calculated from the weight of residue on evaporation at 180° Celsius from a known volume of water.

Trace elements: The metallic elements selenium, lead, mercury, arsenic, lithium, molybdenum, and strontium may be found in low ("trace") concentrations in water supplies. Maximum allowable concentrations for drinking water have been established for the elements selenium, lead, mercury and arsenic.

Quality of Water in the Mohall Aquifer

Water samples were collected in July 1993 from the nine monitoring wells installed in the Mohall aquifer in June 1993 (fig. 38). Water samples were also collected in July and September 1993 from six of the seven monitoring wells in the city's 1990-1992 well field plus a blended sample from the production wells pumping at the time of the September sampling. Samples were also collected in June 1993 from the production wells in 161-83-13C and in September 1993 from the remaining monitoring well, 161-83-11DAA2, located in Cut Bank Creek valley between the two well fields.

The analyses of samples collected from the monitoring wells constructed in 1993 indicate a good quality water, low in the concentration of dissolved minerals. The water is a calcium-bicarbonate type with total dissolved solids concentrations ranging between 195 mg/l and 457 mg/l, with a median of 270 mg/l. The mean, or average total dissolved solids concentration was 299 mg/l. Hardness ranged between 170 mg/l (as CaCO₃) and 340 mg/l, with a median of 210 mg/l and a mean of 227 mg/l. Iron concentration ranged between 0.01 mg/l and 0.06 mg/l, with a median of 0.03 mg/l. and a mean of 0.03 mg/l

The quality of the water in Sections 34 and 35 had dissolved solids concentrations ranging between 195 mg/l and 294 mg/l. The samples from the wells

one mile farther north (162-83-22DCC) and five miles to the south (161-82-31ABB) had somewhat higher concentrations of dissolved solids, 457 mg/l and 425 mg/l respectively. Sulfate concentrations, in particular, were higher in those wells.

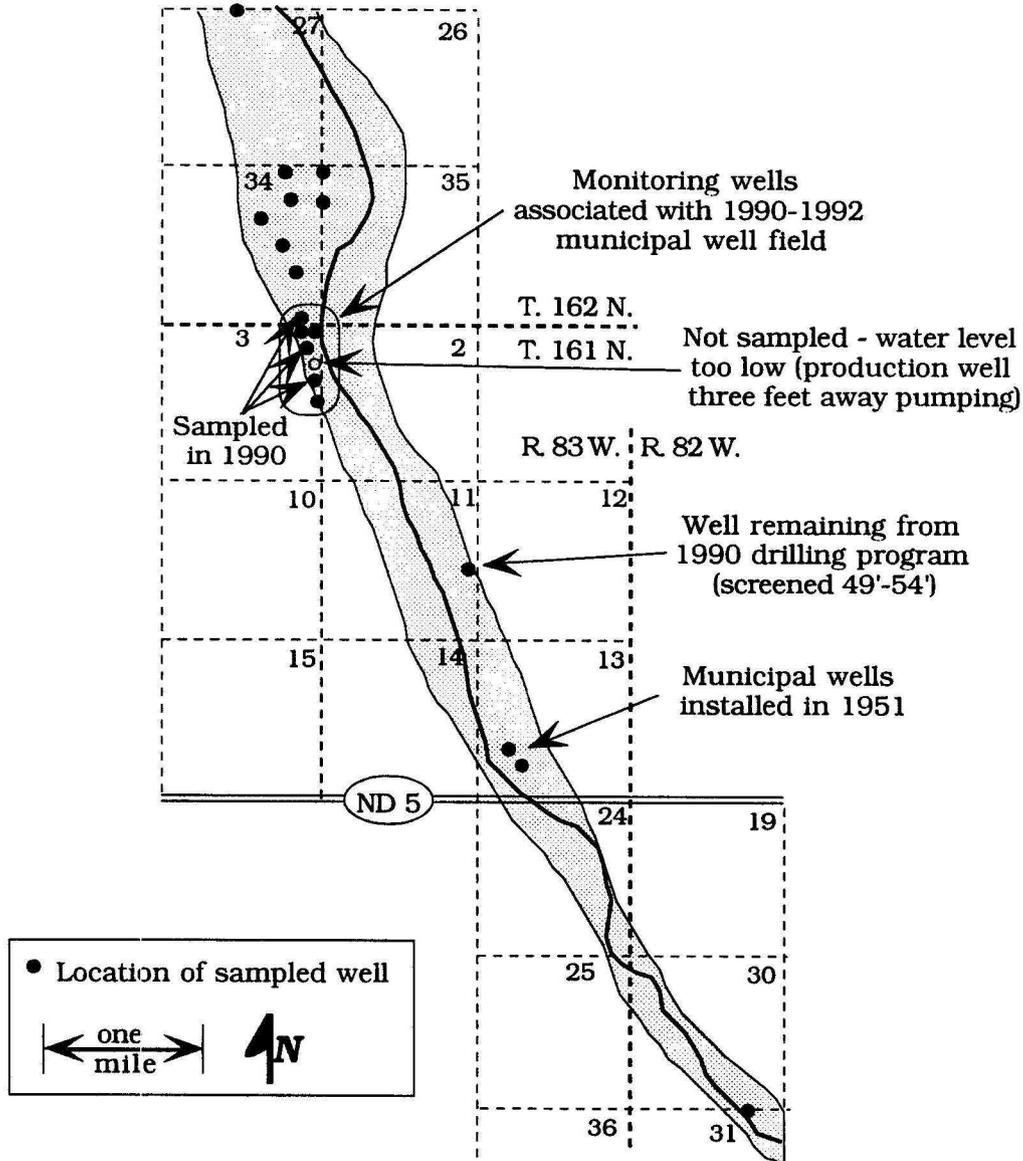


Figure 38 - Locations of sampled wells

Results of the analyses are summarized in table 3. Included under the column labeled "Standard" are the Environmental Protection Agency's "non-mandatory guidelines" which are concentration limits recommended for drinking and other domestic water use (U. S. Environmental Protection Agency, 1973b). The values shown for selenium, lead, mercury, and arsenic are maximum permissible

limits. The permissible limits for selenium, lead, mercury, and arsenic were not exceeded in the five samples analyzed for those elements. Limits have not been set for lithium, molybdenum, and strontium. Concentrations of lithium, molybdenum, and strontium in the samples are in the low to normal range of North Dakota ground water samples. The only constituent which exceeded set standards was manganese.

Table 3 - Water quality in 1993 installed monitoring wells

	stan dard	161-82 31ABB	162-83 22DCC	162-83 34AAB	162-83 34AAC	162-83 34ACA	162-83 34DAB	162-83 34DAD	162-83 35BBB	163-83 35BCE
Date sampled		7/9/93	7/8/93	7/8/93	7/8/93	7/8/93	7/8/93	7/8/93	7/8/93	7/8/93
Screen depth (ft)		14'-19'	15'-20'	14'-19'	18'-23'	10'-15'	12'-17'	12'-17'	20'-25'	23'-28'
Depth to water (ft)		7.26'	10.31'	11.54'	12.57'	6.74'	8.60'	9.55'	13.60'	8.69'
Cond. (µmhos)		663	721	510	486	408	349	440	418	466
pH		7.60	7.57	7.69	7.74	7.49	7.48	7.68	7.69	7.69
Temp. (°C)		10	9	10	10	11	10	10	10	10
Hardness (CaCO ₃)		310	340	210	230	180	170	210	180	210
SAR		0.5	0.3	0.8	0.4	0.5	0.2	0.4	0.5	0.5
RSC		0	0	0	0	0	0	0	0	0
% Sodium		12	8	21	12	15	8	12	16	13
Silica (mg/l)		12	18	18	19	16	18	18	21	17
Calcium (mg/l)		77	82	53	59	48	46	54	51	57
Magnesium (mg/l)	125	29	33	20	20	15	14	19	14	17
Potassium (mg/l)		7.9	2.4	3.1	3.0	2.2	2.7	2.3	2.1	2.3
Sodium (mg/l)		21	13	26	15	15	7	13	16	15
Iron (mg/l)	0.3	.03	.01	.01	.03	.04	.04	.03	.02	.06
Manganese (mg/l)	0.05	.9	.02	.07	.13	.92	.07	.13	.03	.24
Fluoride (mg/l)	1.5	.1	.1	.1	.1	.1	.1	.1	.1	.1
Bicarbonate (mg/l)		270	172	266	273	235	206	250	277	242
Carbonate (mg/l)		0	0	0	0	0	0	0	0	0
Sulfate (mg/l)	250	100	110	35	14	11	7	15	21	37
Chloride (mg/l)	250	20	2.6	4.3	6.8	3.8	2.6	3.1	1.2	2.4
Nitrate (mg/l)	45	0	140	4.7	.3	0	0	0	.3	.1
Boron (mg/l)	1	.02	.03	.04	.04	.03	.04	.02	.04	.04
TDS (mg/l)	500	425	457	294	288	240	195	270	255	269
Selenium (µg/l)	50	1	2	2	1	0	1	4	0	1
Lead (µg/l)	50	0	0	0	0	0	0	0	0	0
Mercury (µg/l)	2	0	0	0	0	0	0	0	0	0
Arsenic (µg/l)	50	0	1	1	3	1	0	1	2	2
Lithium (µg/l)		20	20	10	10	10	0	10	10	20
Molybdenum (µg/l)		1	0	1	2	3	3	1	0	2
Strontium (µg/l)		260	290	294	288	240	170	270	180	260

The results of the water quality analyses of samples collected from older wells are included in tables 4 and 5. Table 4 includes an analysis of a sample

collected in 1991 by the ND Department of Health from the faucet in the kitchen of city hall after it had passed through the city's water treatment plant. Municipal water at the time the sample was collected came primarily from the wells installed in 1990 in 161-83-3AAA. Table 4 also includes an analysis of a blended sample taken from the production wells in the 1990-1992 field which were pumping at the time of the September sampling. Also in table 4 are analyses of samples taken from three of the monitoring wells in the 1990-1992 field, an analysis of a sample taken from the remaining monitoring well in Cut Bank Creek valley between the two well fields (161-83-11DAA2), and analyses of samples from the two production wells currently being pumped in the 1951 well field. The Witteman well (161-83-14DAA2) was not being pumped in 1993 and the water level in the nearby monitoring well was too low for collection of a sample.

Table 4 - Water quality in older municipal well fields

	Standard	Jun '91 sample treated	161-83 3AAA blended	161-83 3AAA2	161-83 3AAA6	161-83 3ADA	161-83 11DAA 2	161-83 13CAC1 (NW)	161-83 13CAC2 (SE)
Date sampled		6/25/91	9/8/93	7/8/93	7/8/93	9/8/93	9/8/93	7/8/93	7/8/93
Screen depth (ft)		City hall	from 4 wells	18'-21'	14'-17'	7'-12'	49'-54'	-24'	-24'
Depth to water (ft)			11.00	7.96	8.20	6.40			
Cond. (µmhos)		504	854	948	1080	519	3270	1600	1580
pH		8.72	6.92	8.17	8.1	7.84	7.74	7.15	7.38
Temp. (°C)			14	10	9	12	10	8	9
Hardness (CaCO3)		316	460	500	610	260	950	910	850
SAR		1.54	.2	.3	.2	.4	6.6	.5	.8
RSC			0	0	0	0	0	0	0
% Sodium		36.4	4	6	5	10	51	8	11
Silica (mg/l)			24	27	21	14	22	21	18
Calcium (mg/l)		38.7	110	99	150	71	250	210	200
Magnesium (mg/l)	125	19.9	44	62	57	20	80	94	84
Potassium (mg/l)		10.6	9.1	13	7.4	3.5	14	19	16
Sodium (mg/l)		47.3	10	15	14	13	470	36	51
Iron (mg/l)	0.3	.12	.36	.51	.02	.01	4.5	9.6	5.6
Manganese (mg/l)	0.05	.01	.99	.33	.65	.10	.43	2.1	2.2
Fluoride (mg/l)	1.5	1.27	.1	.1	.1	.1	.2	.1	.1
Bicarbonate (mg/l)		97	205	294	276	287	499	418	449
Carbonate (mg/l)		8	0	0	0	0	0	0	0
Sulfate (mg/l)	250	103	300	270	370	50	1400	610	490
Chloride (mg/l)	250	38.6	8	8	11	4.7	56	23	63
Nitrate (mg/l)	45	.44	6.5	1.5	2.6	1.5	7.1	7.5	0
Boron (mg/l)	1		.06	.03	0.6	.03	.63	.04	.05
TDS (mg/l)	500	316	630	678	850	325	2660	1280	1180

The dissolved solids concentration of water samples collected in 1993 from the 1990-1992 well field in 161-83-3A, is about double that of the recently installed monitoring wells located 1/4 to one mile to the north in Sections 34 and 35 of T. 162-R. 83. The dissolved solids concentration in the 1951 field in 161-83-13CAC is about four times that of the wells in Sections 34 and 35 of T. 162 N., R. 83 W. The higher dissolved solid concentrations in the older well fields is due primarily to higher concentrations of calcium, magnesium, and particularly, sulfate (fig 39).

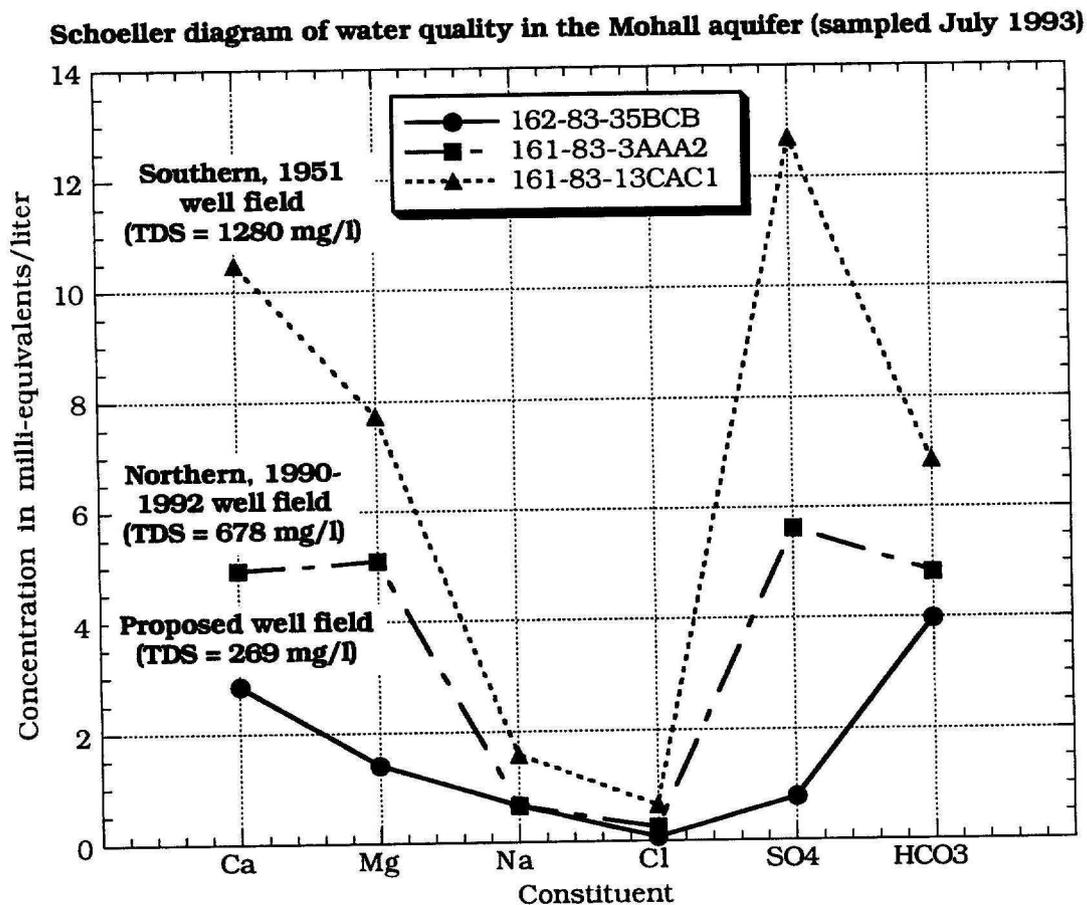


Figure 39 - Schoeller diagram using a sample typical of each well field

The dissolved solids concentration in the well in Section 11 of T. 162 N., R. 83 W., between the well fields and screened between 49 and 54 feet depth, is ten times the concentration of the wells in Sections 34 and 35. The chemical quality of water from the 161-83-11DAA2 well is poor (total dissolved solids of 2660 mg/l), being high in sodium (470 mg/l) and sulfate (1400 mg/l) in particular. Test drilling in

Section 11 indicates that the well is completed in an isolated sand and gravel lens in the surrounding till.

Three monitoring wells in the 1990-1992 well field were sampled in 1990 at the time the wells were installed, prior to development of the production field, and again 1993 (fig. 40). Well 161-83-3AAA1 is 60 feet south of a 1990 production well. Well 161-83-3AAD1 is 50 feet southeast of a 1992 production well. Well 162-83-34DDD is about 500 feet from the northern two production wells. The water quality analyses from the three wells are compared in table 5.

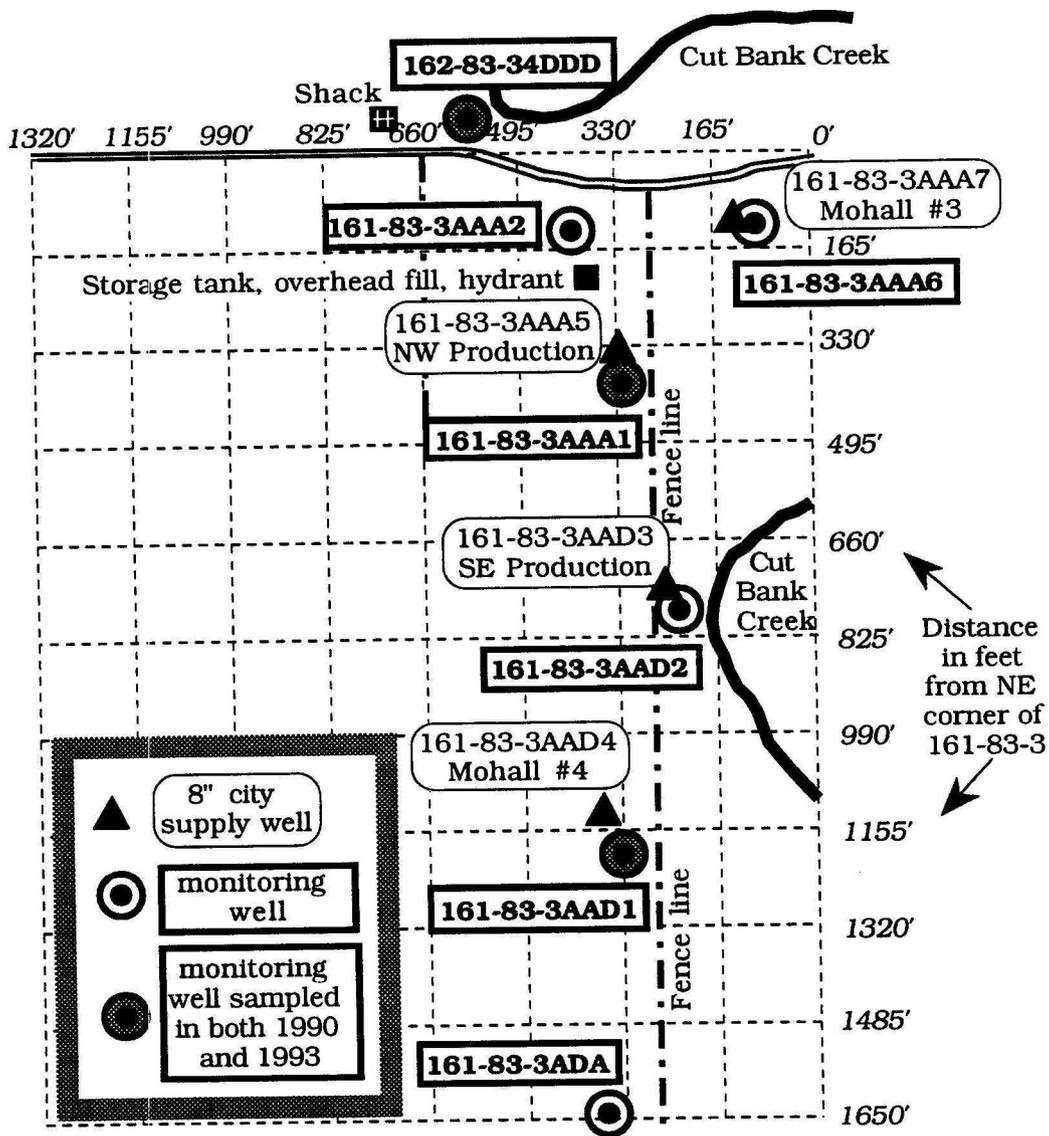


Figure 40 - Locations of wells in 1990-1992 well field

Table 5 - Water quality comparison of wells sampled in 1990 and 1993

	161-83-3AAA1			161-83-3AAD1			162-83-34DDD		
	1990	1993	change	1990	1993	change	1990	1993	change
Date sampled	5/9/90	9/8/93		5/9/90	9/8/93		5/9/90	9/8/93	
Screen depth (ft)	17'-22'	17'-22'		15'-21'	15'-21'		34'-39'	34'-39'	
Depth to water (ft)	6.44	10.32		5.64	9.82		7.30	10.23	
Cond. (µmhos)	865	728	-16%	520	657	+26%	665	612	-8%
pH	7.54	7.37		7.07	7.89		6.85	6.97	
Temp. (°C)	6	9		5	10		8	14	
Hardness (CaCO ₃)	386	360	-7%	263	330	+25%	314	300	-4%
SAR	.8	.2	-75%	.3	.4	+33%	.5	.4	-20%
RSC	0	0	0%	0	0	0%	0	0	0%
% Sodium	9	10	-11%	8	93	+1062	12	11	-8%
Silica (mg/l)	29	23	-21%	21	21	0%	25	22	-12%
Calcium (mg/l)	77	87	+13%	66	81	+23%	78	74	-5%
Magnesium (mg/l)	47	35	-26%	24	31	+29%	29	28	-3%
Potassium (mg/l)	12	4.5	-62%	2.7	2.9	+7%	5.6	4.3	-23%
Sodium (mg/l)	35	10	-71%	10	15	+50%	20	17	-15%
Iron (mg/l)	1.2	1.6	+33%	.02	.02	0%	5.4	3.8	-30%
Manganese (mg/l)	.31	.56	+81%	.02	.08	+300%	.40	.44	+10%
Fluoride (mg/l)	.1	.1	0%	.1	.1	0%	.1	.1	0%
Bicarbonate (mg/l)	460	245	-47%	238	289	+21%	369	248	-33%
Carbonate (mg/l)	0	0	0%	0	0	0%	0	0	0%
Sulfate (mg/l)	22	200	+809%	92	120	+30%	26	120	+362%
Chloride (mg/l)	51	11	-78%	6	3.9	-35%	28	9.3	-67%
Nitrate (mg/l)	1	2.5	+150%	1.2	11	+817%	1	3.7	+270%
Boron (mg/l)	.04	.03	-25%	.03	.03	0%	.04	.04	0%
TDS (mg/l)	519	507	-2%	335	434	+30%	399	403	+1%

Between 1990 and 1993 the water quality in well 161-83-3AAA1, 60 feet from a production well operating for the past three years, has changed primarily in that the bicarbonate concentration has decreased from 460 mg/l to 245 mg/l while the sulfate concentration has increased from 22 mg/l to 200 mg/l. The total dissolved solids concentration has decreased 2%. A somewhat similar water quality change has taken place in well 162-83-34DDD, about 500 feet to the northwest. The bicarbonate concentration decreased from 369 mg/l to 248 mg/l and the sulfate concentration increased from 29 mg/l to 120 mg/l, for an overall increase in total dissolved solids of 1%.

Between 1990 and 1993 the water quality in well 161-83-3AAD1, 50 feet from a production well operating for the past year has shown a 30% increase in dissolved solids. The major dissolved mineral constituents have shown similar increases in

concentration with, calcium up 23%, magnesium up 29%, sodium up 50% (from 10 mg/l to 15 mg/l), bicarbonate up 25%, and sulfate up 30%.

The producing well fields have water with higher concentrations of calcium and sulfate than the wells in Sections 34 and 35. Water from well 161-83-3ADA at the southern end of the 1990-1992 well field has a quality similar to that from the monitoring wells in Sections 34 and 35, one mile to the north. Water from well 161-83-3AAD2, 450 feet north of 161-83-3ADA and 50 feet from the southernmost producing well, has a water quality intermediate between that in the 1990-1992 field and that one mile to the north in Sections 34 and 35.

The quality of water from the two more distant wells completed in the Mohall aquifer, in 161-82-31AAB, three miles southeast of the 1951 well field and in 162-83-22DCC, one mile north of the group of monitoring wells installed in Sections 34 and 35, have dissolved solid concentrations similar to that found in the 1990-1992 well field in 161-83-3A.

The concentration of dissolved minerals in water in the Mohall aquifer differs up and down the aquifer. The dissolved mineral concentration in the producing well fields may be increasing, or at least changing with time and pumping; however, the location along the aquifer is also an important factor in determining the water quality.

An increase in dissolved solid concentration, particularly in calcium and sulfate, may be caused by 1) water movement from the surrounding and underlying glacial till, partially composed of clay, into the cones of depression created by the city's pumping from the Mohall aquifer, or 2) mineral (particularly gypsum and anhydrite - calcium sulfate) dissolution and precipitation at or near the changing water table surface in the pumping well's cone of depression.

RECOMMENDATIONS

Location

Based on the test drilling performed in June 1993 and on other available information, the Mohall aquifer in Cut Bank Creek valley in the east half of Section 34, T162 N., R. 83 W., is recommended as a source for a supplemental water supply for the City of Mohall (fig. 41). Individual well locations are recommended to be in the central portion of the aquifer, in the approximate area outlined in figure 38.

The proposed well field should supplement, not replace the two older well fields. Spreading the 100-140 acre-feet of annual water use over a larger area of the aquifer will reduce the water level decline in an individual field and at an individual well location.

Well design considerations

A grain size analysis of the sand and gravel in the Mohall aquifer was not performed; however, about half the material is thought to be coarse sand, very coarse sand, or gravel. About half the material is thought to be medium sand or finer. The dividing line between medium and coarse sand is a grain diameter of one millimeter, or 0.039 inch.

The screens previously used for municipal wells in the Mohall aquifer have 0.030 inch, 0.035 inch, 0.040 inch, and 0.050 inch openings, which appear to be in the proper range, that is, a slot size which will retain 40% or 50% of the aquifer material. A sieve grain size analysis should be performed for the design of a well screen for a particular location.

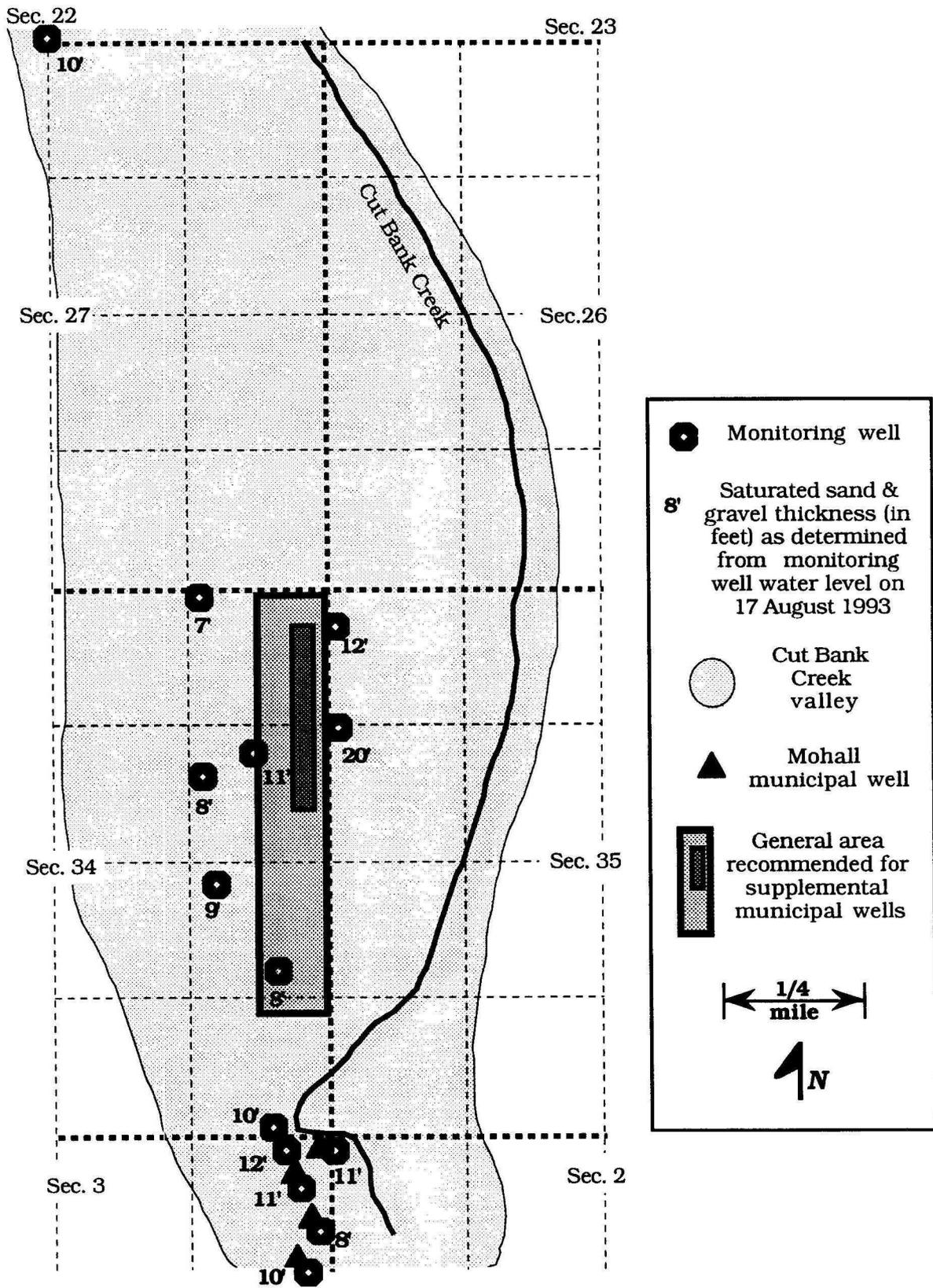


Figure 41 - Recommended location for municipal water supply wells

To maximize the open area per foot of screen and thus reduce entrance velocity, continuous V-slot, wire wrapped screen is recommended. A screen with relatively more openings and less material between the openings is recommended. The screen will have less strength, but will allow easier passage of water. In the shallow setting of the Mohall aquifer the added strength is probably not necessary.

The optimum design for a well in an unconfined aquifer is to screen the lower 1/3 of the aquifer's saturated thickness (Johnson Division, UOP 1975). The aquifer saturated thickness in the east half of Section 34, T. 162 N., R83 W. is about nine feet, as indicated in figure 10. A water supply well in nine feet of saturated aquifer should therefore have the lower three feet screened. Where the aquifer is up to 20 feet thick along the east side of Section 34, about 1/4 mile south of the north section line a longer screen is recommended.

Pumping rate

If the bottom three feet of aquifer is screened, about six feet of saturated aquifer thickness remains above the screen. If one half of the available six feet of saturated thickness is used for a pumping rate design consideration, three feet of aquifer saturated thickness is available, to be drawn down by the pumping well.

The specific capacity of the supply wells in the northeast quarter of Section 3, as determined when the wells were installed, is about 15 to 25 gallons per minute per foot of water level drawdown (gpm/ft). Five feet of aquifer were screened in the wells in the northeast of Section 3. If three feet rather than five feet of aquifer is screened, a slightly lower specific capacity may be expected, possibly at the lower end of the 15 to 25 gpm/ft drawdown range. If a specific capacity of 15 gpm/ft is projected, three feet of available drawdown allows for a design pumping rate of 45 gallons per minute.

The Mohall aquifer is subject to water level changes with wet and dry weather cycles. A natural or pumping induced water level change of one or two feet can cause a significant change in the hydraulic head available in a pumped well

completed in the Mohall aquifer. The six Mohall water supply wells are reported to each be pumped at 25 to 30 gallons per minute, 56-67% of the 45 gpm design pumping rate discussed. A pumping rate of 25 to 30 gpm is recommended for additional wells in the Mohall aquifer.

Number of wells

The average daily water use by the city is reported to be approximately 95,000 gallons with a peak use of approximately 125,000 gallons per day (Ken Shobe, written communication, 1993). Two wells pumping 12 hours per day at 31.25 gpm will meet one half the city's daily average water use. Three wells each pumping at 29 gpm for 12 hours per day will meet one half the city's reported peak water use.

Three wells are therefore recommended to be located in Section 34 of T. 161 N., R. 83 W. A fourth well could be added to increase the area over which the water is withdrawn from the aquifer.

Well spacing

A Theis analytical model was made to estimate the effect of withdrawing water from the east half of Section 34, T. 162 N., R83 W. An aquifer transmissivity of 2,000 ft²/day, a storativity: 0.2, boundaries at 1/4 mile, and no recharge were assumed. The projected aquifer water level drawdown after one year and after four years of pumping a well at 31 gpm (50 acre-feet/year at constant pumping), is shown on the distance - drawdown graph (fig. 42). Using the graph as a guide, spacing individual wells at least 200 feet apart will avoid the highest area of well interference.

The parameters used to create the graph in figure 42, transmissivity, storativity, boundaries, and pumping rate are estimated. The actual drawdown

away from a pumped well may be somewhat different. It is therefore recommended that production wells be spaced about 400 feet apart, oriented along the axis of the river valley, as has been done in the two existing well fields.

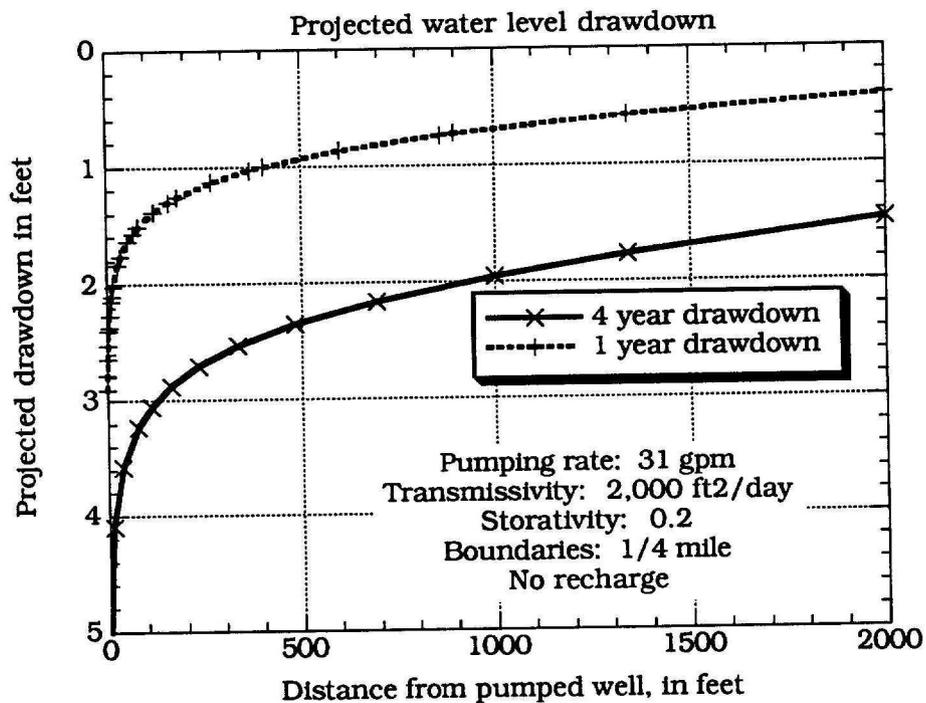


Figure 42 - Projected water level drawdown after pumping at 31 gpm

Monitoring water levels and water quality

It is recommended that water level measurements be taken and recorded for selected wells in each of the well fields. Monitoring of the water levels in the well fields will allow for decisions to be made concerning adjusting the quantities of water to be taken from each of the fields and will allow for timely decisions to be made about a possible future need for expanding the well field.

It is understood that water level measurements are being made in selected wells by the city. Beginning in May 1993 the Water Commission has also been making monthly water level measurements in the areas of the Mohall well fields.

The two programs should be coordinated, or consolidated. A monthly frequency of water level measurements is recommended.

It is also recommended that the chemistry of the water be determined periodically. The dissolved mineral concentrations of calcium, magnesium, sodium, iron, manganese, bicarbonate, sulfate and chloride in particular are of interest, as well as the total dissolved solids concentration in the water from each well field.

Monitoring the water quality periodically is important for identifying changes that may occur due to pumping and from natural processes. This information would be useful in managing withdrawals from individual well fields and adjusting treatment processes. Current data suggests that the chemical quality of the water from the 1951 well field may have changed. Annual water quality measurements are recommended initially from each of the three well fields.

REFERENCES

- Akin, P. D., 1951, Ground Water in the Mohall Area, Bottineau and Renville Counties, North Dakota, North Dakota Ground-Water Studies No. 17, 76 p.
- Bluemle, J. P., 1985, Geology of Bottineau County, North Dakota: North Dakota State Water Commission County Ground-Water Studies 35, part I, 57 p.
- Comly, H. H., 1945, Cyanosis in infants caused by nitrates in well water: Journal of American Medical Association, v. 129, no. 2, p. 112-116.
- Goddard, E. N., Chairman, (reprinted 1975), Rock-Color Chart, Rock-Color Chart Committee, Geol. Soc. Am., 16 p.
- Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water (2 nd ed.): U. s. Geological Survey Water-Supply Paper 1973, 363 p.
- Johnson Division, UOP, Inc., 1975, Ground Water and Wells: Saint Paul, MN, Edward E. Johnson, Inc. 440 p.
- Kuzniar, R. L., and Randich, P. G., 1982, Ground-water Data for Bottineau and Rolette Counties, North Dakota: North Dakota State Water Commission County Ground-Water Studies 35, part II, 742 p.
- LaRocque, G. A., Jr., Swenson, H. A., and Greenman, D. W., 1963, Tables of hydrologic data, Crosby-Mohall area, North Dakota, 1945-1951: Geological Survey open-file report, 508p.
- North Dakota State Department of Health, 1962, The low sodium diet in cardiovascular and renal disease: Sodium content of municipal waters in North Dakota: 12 p.
- Randich, P. G., and Kuzniar, R. L., 1984, Ground-water Resources of Bottineau and Rolette Counties, North Dakota: North Dakota State Water Commission County Ground-Water Studies 35, part III, 41 p.
- U. S. Environmental Protection Agency, 1973b. Water Quality Criteria 1972, EPA R3 73033, Government Printing Office, Washington D. C.
- U. S Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkali soils: Department of Agriculture, Agriculture Handbook 60, 160 p.
- Wentworth, C. K., 1922, A scale of grade and class terms for clastic sediments: Journal of Geology, v. 30, p. 377-392.

APPENDIX - LITHOLOGIC LOGS

The following logs are summaries of data from 134 driller's logs and geologist's sample descriptions. Color descriptions are of wet samples and are based upon color standards of the Geological Society of America's Rock-color chart committee (Goddard, 1975). Grain-size classification is C.K. Wentworth's scale (1922).

Forty-two test holes were drilled and nine monitoring wells installed between 21-24 June 1993 by the ND State Water Commission. The lithologic logs of the test holes are included below. Also included are the logs from 18 older ND State Water Commission test holes, drilled between 1948 and 1980, and from 74 privately contracted test holes, including 10 monitoring wells and 7 municipal supply wells, drilled between 1951 and 1992.

Map indices of the locations of the test holes for which lithologic logs are included are shown in figures 43 - 45.

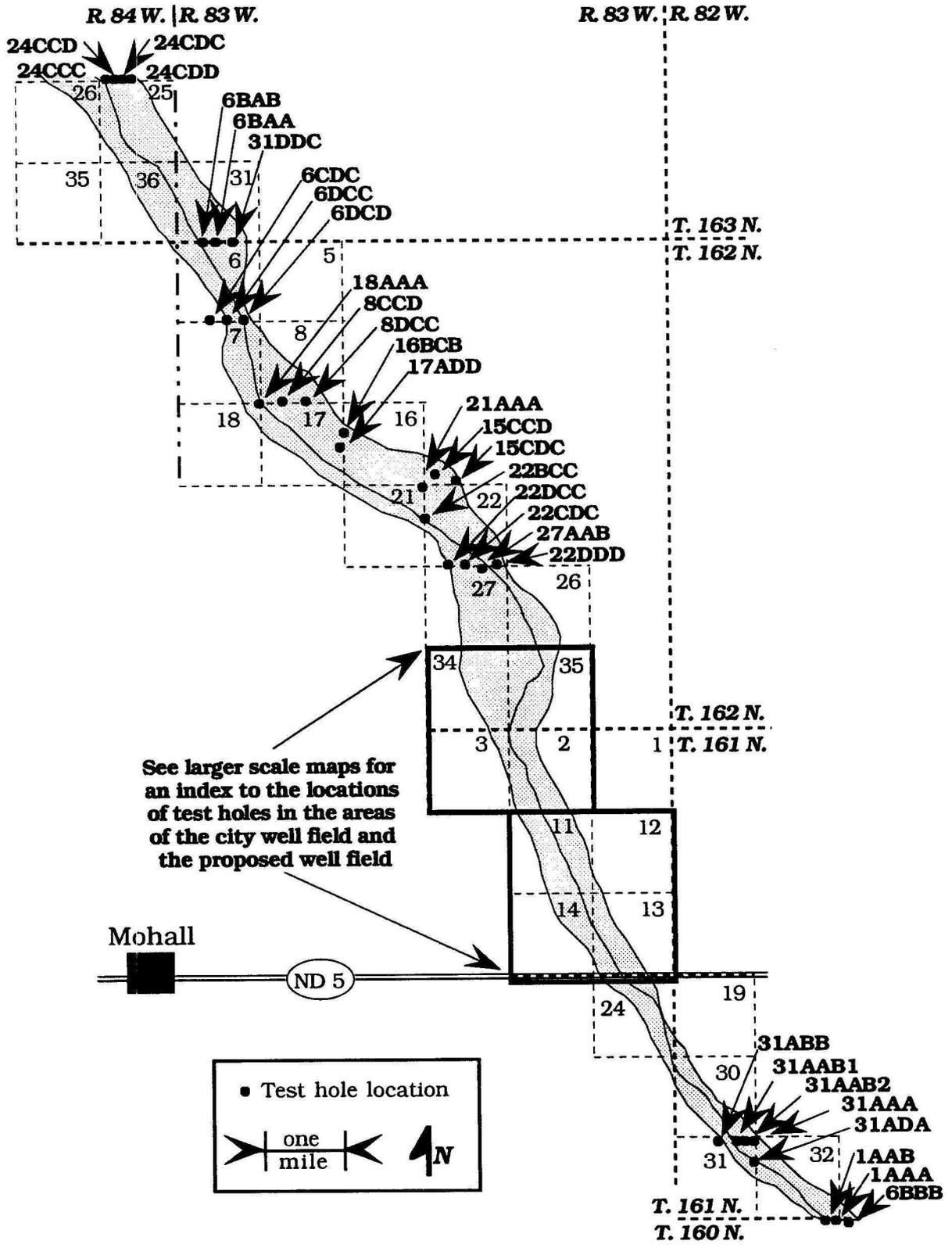


Figure 43 - Index of test hole locations

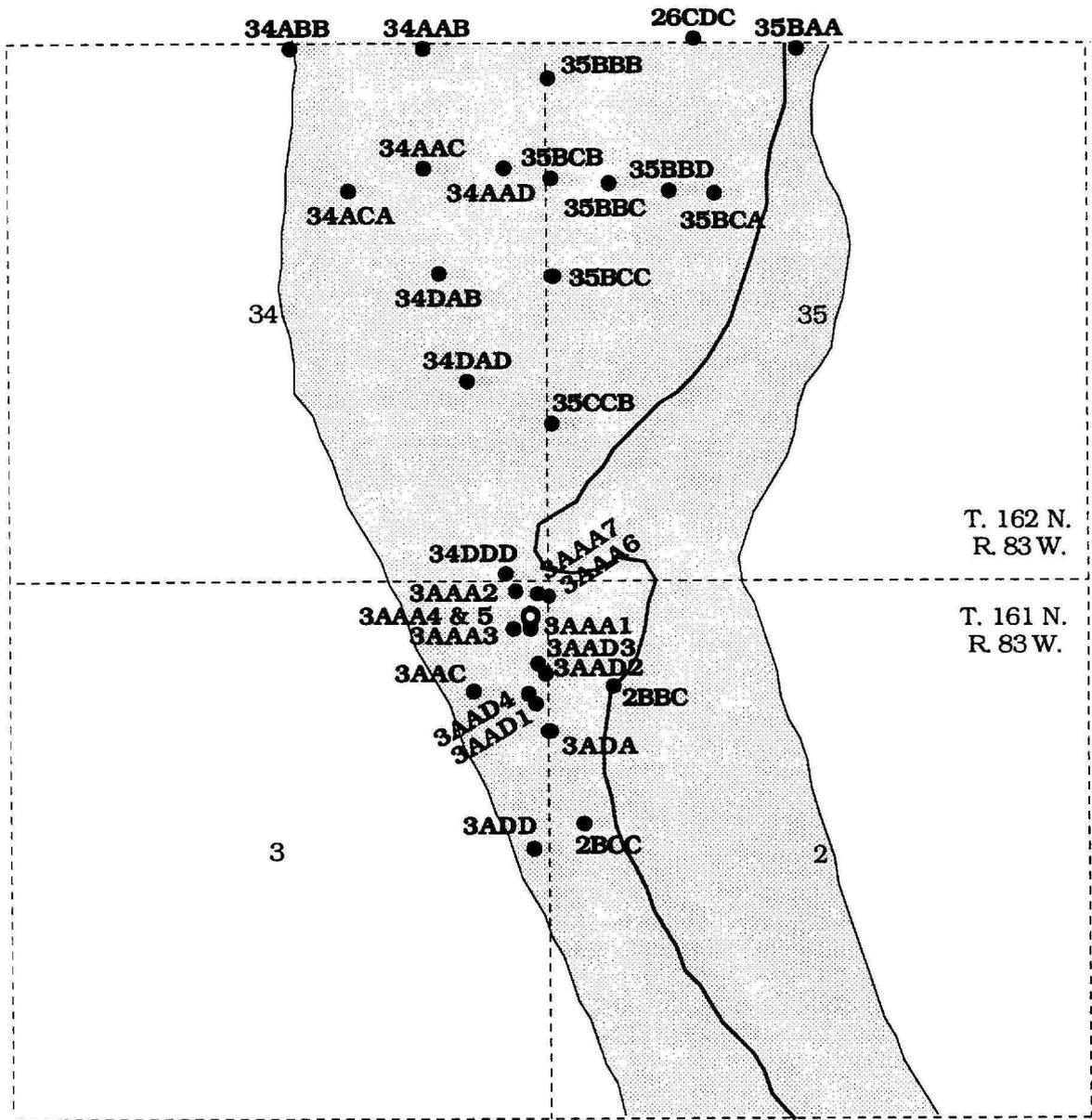


Figure 44 - Index of test hole locations- well field /proposed well field area

160-082-06BBB
NDSWC 8904

Date Completed: 9/27/73 Purpose: Test Hole
L.S. Elevation (ft): 1522
Depth Drilled (ft): 100
Source: NDSWC

Completion Info:
Remarks: Located in ditch east of road

Lithologic Log

Unit	Description	Depth (ft)
SILT	Clayey, sandy, moderate yellowish brown, moderately cohesive, plastic, sticky, oxidized	0-2
SAND	Fine to medium grained, subrounded, fair sorting, medium gray, shaley, clean	2-6
CLAY	Silty, pebbly, olive gray, cohesive, moderately plastic, calcareous (till)	6-11
SAND	Silty, very fine to medium grained, subangular, fair sorting, gray, washes into drilled hole	11-13
CLAY	Silty, pebbly, olive gray, moderately cohesive, moderately plastic, calcareous, a few thin sand stringers, (till)	13-100

160-083-01AAA
NDSWC 11440

Date Completed: 10/29/80 Purpose: Test Hole
 L.S. Elevation (ft): 1520
 Depth Drilled (ft): 200
 Source: NDSWC

Completion Info:
 Remarks: Located in ditch 40 feet south and five feet west of road intersection

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Dark yellowish brown, moderately cohesive, 30%, w/silt, sand, & gravel (oxidized till)	1-3
SAND	Yellowish orange (oxidized), coarse grained, fair sorting, subrounded, silicates & carbonates	3-7
CLAY	Olive gray, moderately cohesive, 35%, w/silt, sand, & gravel, sand & gravel lens at 95', 104', 118', 137-141' (till)	7-173
LIGNITE	Brownish black (bedrock)	173-178
SILT	Brownish black, sandy, argillaceous (bedrock)	178-182
SAND	Fine grained, well sorted, w/greenish clay, (bedrock)	182-200

160-083-01AAB
NDSWC 8905

Date Completed: 9/27/73 Purpose: Test Hole
L.S. Elevation (ft): 1523
Depth Drilled (ft): 100 Source: NDSWC

Completion Info:
Remarks: Located in ditch on south side of road

Lithologic Log

Unit	Description	Depth (ft)
CLAY	Very silty, pebbly, moderate yellowish brown, cohesive, moderately plastic, oxidized (till)	0-4
SAND	Medium to coarse grained, dark yellowish brown, angular, caving, oxidized	4-6
CLAY	Silty, pebbly, moderate yellowish brown, cohesive, moderately plastic, oxidized (till)	6-10
CLAY	Same as above, only olive gray (till)	10-16
SAND	Fine to coarse, subangular, well sorted, loose, caving & washing out	16-18
CLAY	Silty, pebbly, olive gray, cohesive, moderately plastic, calcareous (till)	18-100

161-082-31AAA
NDSWC 13249

Date Completed: 6/24/93 Purpose: Test Hole
L.S. Elevation (ft): 1535
Depth Drilled (ft): 200
Source: NDSWC

Completion Info:
Remarks: Located on south side of section line trail, along fence, 80' west of sec. line road

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Dark yellowish brown, 35%, w/silt, sand, & gravel, (clayey, oxidized till)	1-20
CLAY	Olive gray, 35%, w/silt, sand, & gravel, stiff, (till)	20-77
SAND & GRAVEL	30% gravel, graded, primarily silicates & carbonates	77-80
CLAY	Olive gray, as above (clayey till)	80-125
CLAY	Olive gray, 25%, w/silt, sand, & gravel (sandy till)	125-188
SAND	Very fine grained, silty, clayey, greenish gray with brownish gray silt (bedrock - Hell Creek)	188-200

161-082-31AAB1
NDSWC 13248

Date Completed:	6/24/93	Purpose:	Observation Well
L.S. Elevation (ft):	1524.95	Well Type:	2" PVC
Depth Drilled (ft):	25	Aquifer:	Mohall
Screened Interval (ft):	14-19	Source:	NDSWC

Completion Info:

Remarks: Used .008 inch slotted screen, sealed with one bag of hole plug
Located on south side of section line trail, along fence, 120 feet east of creek & missile cable marker

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	Dark yellowish brown, 30% w/silt & sand (probably till, or sandy, silty alluvial clay)	2-5
SAND & GRAVEL	25% gravel, moderate to poor sorting, primarily silicates & carbonates	5-18
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	18-25

161-082-31AAB2
NDSWC 13250

Date Completed:	6/24/93	Purpose:	Test Hole
L.S. Elevation (ft):	1530		
Depth Drilled (ft):	20	Source:	NDSWC

Completion Info:

Remarks: Located along fence line, south of trail, about 750 feet west of sec. line, 410 feet east of AAB1 well

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Silty, sandy, dark yellowish brown	1-4
SAND	V. coarse grained, poorly sorted, silicates & carbonates, some (15%) gravel	4-8
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till)	8-12
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	12-20

161-082-31ABB
NDSWC 11462

Date Completed: 11/13/80 Purpose: Test Hole
L.S. Elevation (ft): 1542
Depth Drilled (ft): 220
Source: NDSWC

Completion Info:
Remarks:

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	Fine to very coarse, gravelly, oxidized	1-9
CLAY	Silty, pebbly, olive-gray, (till), sand and gravel lens at 30', 61', 87', 103', 115'	9-199
SAND	Very fine to fine, argillaceous, quartzose, moderately indurated, greenish gray	199-220

161-082-31ADA
NDSWC 13251

Date Completed: 6/24/93 Purpose: Test Hole
L.S. Elevation (ft): 1530
Depth Drilled (ft): 20
Source: NDSWC

Completion Info:
Remarks: Located in ditch west of road, along edge of creek valley, 300' south of bridge

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Dark yellowish brown, 35%, stiff, moderately plastic, w/silt, sand, & gravel (oxidized, clayey till)	1-12
CLAY	Olive gray 35%, w/silt, sand, & gravel (clayey till)	12-20

161-083-02BBC
Mohall 90-33

Date Completed: 5/9/90 Purpose: Test Hole
L.S. Elevation (ft): 1543
Depth Drilled (ft): 23
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Mohall hole #90-33, Simpson log #1053, 319' east & 1146' south
of NW section corner (?)

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-6
SAND		6-8
CLAY	Black	8-9.5
SAND		9.5-16
GRAVEL		16-20
CLAY	Blue	20-23

161-083-02BCC
Mohall 90-32

Date Completed: 5/9/90 Purpose: Test Hole
L.S. Elevation (ft): 1543
Depth Drilled (ft): 23
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1052, City of Mohall hole # 90-32, located 363 feet east and 86 feet north of SW corner of NW 1/4 of Section 2, according to contractor

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Gray, yellow	1-6
SAND	Oxidized	6-8
CLAY	Blue	8-9.5
SAND	Fine to medium, blue	9.5-14
GRAVEL	Blue	14-15.5
CLAY	Blue	15.5-23

161-083-03AAA1
Mohall 90-30

Date Completed:	5/8/90	Purpose:	Observation Well
L.S. Elevation (ft):	1546.43	Well Type:	1.25" PVC
Depth Drilled (ft):	23	Aquifer:	Mohall
Screened Interval (ft):	17-22	Source:	C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1050, Mohall monitoring well #90-30, located
327 feet west & 400 feet south of sec. corner (ARW pacing)
Originally labeled AAAD

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND		1-12
GRAVEL		12-18
SAND		18-21.5
CLAY	Blue	21.5-23

161-083-03AAA2
Mohall 90-34

Date Completed:	1990	Purpose:	Observation Well
L.S. Elevation (ft):	1547.64	Well Type:	1.25" PVC
Depth Drilled (ft):	42	Aquifer:	Mohall
Screened Interval (ft):	18-23	Source:	NDSWC

Completion Info: Sealed with hole plug & cuttings
 Remarks: C. A. Simpson & Son log #1054, Mohall monitoring well #90-34, located 260' west & 10' south of northwest production well (2nd prod well from north), generally north of overhead fill, tank

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	Very coarse, oxidized	2-10
SAND & GRAVEL	Primarily coarse, v. coarse sand & granules, silicates, carbonates, shale, lignite	10-21
SAND	Very coarse	21-23
SAND	Coarse	23-28
SAND	Medium, moderate sorting	28-43

161-083-03AAA3
Mohall 90-36

Date Completed:	5/9/90	Purpose:	Test Hole
L.S. Elevation (ft):	1547		
Depth Drilled (ft):	22	Source:	C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
 Remarks: Simpson log #1056, Mohall hole #90-36, 344' west & 466' south of NE section corner, according to contractor

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	Sandy	0-1
SAND & GRAVEL		1-18
CLAY	Blue	18-22

161-083-03AAA4

Mohall 90-37

Date Completed: 5/9/90 Purpose: Test Hole
 L.S. Elevation (ft): 1548
 Depth Drilled (ft): 21.5 Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug and cuttings
 Remarks: Simpson log #1057, Mohall hole #90-37, 296' west & 406' south of NE corner of Sec 3

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	Sandy clay	0-1.5
SAND	Coarse	1.5-21
CLAY	Blue	21-21.5

161-083-03AAA5

Mohall 90-NW Production well

Date Completed: 6/1990 Purpose: Municipal Well
 L.S. Elevation (ft): 1548.19 Well Type: 8" Steel
 Depth Drilled (ft): 21.5 Aquifer: Mohall
 Screened Interval (ft): 16.2-21.2 Source: C. A. Simpson & Son

Completion Info: Grouted with cement from 7' to 15.5'
 Remarks: Simpson log #1058, Mohall NW Prod Well (2nd from north prod. well) at 90-37; 2' of .030 inch slotted stainless steel screen & 3' of .040 inch slotted screen; MP is top of green cap where pipe screws in

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	Sandy clay	0-1.5
SAND	Coarse	1.5-21
CLAY	Blue	21-21.5

161-083-03AAA6

Mohall 92-1

Date Completed:	4/1/92	Purpose:	Observation Well
L.S. Elevation (ft):	1544.62	Well Type:	1.25" PVC
Depth Drilled (ft):	0	Aquifer:	Mohall
Screened Interval (ft):	14-17	Source:	C. A. Simpson & Son (log of production well 25' west)

Completion Info: No log filed, only log for accompanying production well
 Remarks: Simpson 92-1

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	Sandy, black	0-3
SAND	Coarse, oxidized	3-8
GRAVEL	Oxidized	8-19
CLAY	Sandy, blue	19-20

161-083-03AAA7

Mohall Production well 3

Date Completed:	4/1993	Purpose:	Municipal Well
L.S. Elevation (ft):	1546.13	Well Type:	8" Steel
Depth Drilled (ft):	20	Aquifer:	Mohall
Screened Interval (ft):	15-20	Source:	C. A. Simpson & Son

Completion Info: 5' of stainless steel screen, .035 inch openings; sealed with hole
 plug
 Remarks: Mohall well #3, 23' west of obs hole 92-1 (north most production
 well) MP is top of green cap where pipe screws in

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	Sandy, black	0-3
SAND	Oxidized, coarse	3-8
GRAVEL	Oxidized	8-19
CLAY	Sandy, blue	19-20

161-083-03AAC
Mohall 90-28

Date Completed: 5/3/90 Purpose: Test Hole
 L.S. Elevation (ft): 1445
 Depth Drilled (ft): 43

Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings, drilling fluid disinfected
 Remarks: Simpson log #1048, Mohall hole #90-28, located 780' west & 1503' north of SE corner of NE 1/4 of Sec. 3

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-0.5
GRAVEL		0.5-7
CLAY	Yellow	7-8
CLAY	Blue	8-20.5
SAND		20.5-23.5
CLAY	Blue	23.5-43

161-083-03AAD1
Mohall 90-31

Date Completed: 5/8/90 Purpose: Observation Well
 L.S. Elevation (ft): 1544.84 Well Type: 1.25" PVC
 Depth Drilled (ft): 23 Aquifer: Mohall
 Screened Interval (ft): 15-21 Source: C. A. Simpson & Son

Completion Info: Perforated pipe used, annulus sealed with hole plug
 Remarks: Simpson well #90-31 - Located 40 feet south & 30 feet east of 3AAD4, Mohall well #4, southernmost production well

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-4
GRAVEL		4-20.5
CLAY	Blue	20.5-23

161-083-03AAD2

Mohall 90-35

Date Completed:	5/9/90	Purpose:	Observation Well
L.S. Elevation (ft):	1548.54	Well Type:	1.25" PVC
Depth Drilled (ft):	23	Aquifer:	Mohall
Screened Interval (ft):	15-20	Source:	NDSWC

Completion Info: Slotted screen, hole plug in annular space
 Remarks: Simpson log #1055, Mohall monitoring well #90-35, Well is located 3 feet south-southeast of 8 inch production well (1990 SE well, second prod. well from south)

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	Primarily coarse to very coarse sand & gravel granules, silicates, carbonates, secondary shale, lignite & greenish sand (reworked Fox Hills?), oxidized to 13'	1-21
CLAY	(till)	21-23

161-083-03AAD3

Mohall SE Production well

Date Completed:	5/1/90	Purpose:	Municipal Well
L.S. Elevation (ft):	1548.72	Well Type:	8" Steel
Depth Drilled (ft):	21	Aquifer:	Mohall
Screened Interval (ft):	16-21	Source:	C. A. Simpson & Son

Completion Info: 8 inch stainless steel .030 inch slotted screen from 16'-19', .050 inch screen from 19'-21', cement in annulus from 7' to 15.5'
 Remarks: Simpson log #1059, Mohall SE Prod. well, at 90-35, MP is top of green cap where pipe screws in

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	Yellow	1-11
SAND	Blue, medium to coarse	11-15
SAND	Medium	15-19
GRAVEL	Coarse	19-21

161-083-03AAD4
Mohall productionwell 4

Date Completed:	4/1992	Purpose:	Municipal Well
L.S. Elevation (ft):	1545.87	Well Type:	8" Steel
Depth Drilled (ft):	26	Aquifer:	Mohall
Screened Interval (ft):	15-20	Source:	C. A. Simpson & Son

Completion Info: 5' of stainless steel screen with .035 inch slotted openings, grouted with hole plug
 Remarks: Mohall well #4, southernmost production well, 360' west & 1135' south of NE section corner, on a mound to the east of a pasture fence

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	Coarse, oxidized	1-19.5
CLAY	Blue	19.5-26

161-083-03ADA
Mohall 92-?

Date Completed:	4/1/92	Purpose:	Observation Well
L.S. Elevation (ft):	1543.1	Well Type:	1.25" PVC
Depth Drilled (ft):	0	Aquifer:	Mohall
Screened Interval (ft):	7-12	Source:	

Completion Info: Simpson did not send in a completion report
 Remarks: Located 500 feet south of Mohall #4, the southernmost pumping well in the 161-83-3A city well field.

Lithologic Log

Unit	Description	Depth (ft)
------	-------------	------------

161-083-03ADD
Mohall 90-27

Date Completed: 5/3/90 Purpose: Test Hole
 L.S. Elevation (ft): 1545
 Depth Drilled (ft): 63 Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
 Remarks: Simpson log #1047, Mohall hole #90-27, located 111' west & 41' north of SE corner of NE 1/4, Sec. 3

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-0.5
GRAVEL	Oxidized	0.5-5
CLAY	Yellow	5-9
CLAY	Blue	9-19
SILT	Blue	19-20
CLAY	Blue	20-23
SAND	Silty, blue, very fine	23-27
CLAY	Blue	27-28
SILT		28-29
CLAY	Blue	29-41.5
SAND		41.5-42.5
CLAY	Blue	42.5-63

161-083-11ACD
Mohall 90-26

Date Completed: 5/3/90 Purpose: Test Hole
L.S. Elevation (ft): 1540
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1046, Mohall hole #90-26, located 456' north &
1572' west of SE corner of NE 1/4, Sec 11

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-6.5
GRAVEL	Oxidized	6.5-8.5
CLAY	Yellow	8.5-9.5
SAND	Green, clayey	9.5-10.5
CLAY	Blue	10.5-23
SAND		23-23.5
CLAY	Blue	23.5-43

161-083-11CBA
Mohall 88-20

Date Completed: 10/1988 Purpose: Test Hole
L.S. Elevation (ft): 1565
Depth Drilled (ft): 63
Source: C. A. Simpson & Son

Completion Info: Sealed with cement
Remarks: Simpson log #881, Mohall hole #88-20

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-0.5
GRAVEL		0.5-21
CLAY	Blue	21-63

161-083-11CBD
Mohall 88-21

Date Completed: 11/1988 Purpose: Test Hole
L.S. Elevation (ft): 1545
Depth Drilled (ft): 43 Source: C. A. Simpson & Son

Completion Info: Sealed with cement
Remarks: Simpson log #882, Mohall hole #88-21, located in flat 330' west & south of 88-20

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-13
CLAY	Blue	13-20.5
GRAVEL		20.5-21
CLAY	Blue	21-43

161-083-11DAA1
Mohall 90-1

Date Completed: 5/1/90 Purpose: Test Hole
L.S. Elevation (ft): 1545
Depth Drilled (ft): 62 Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug and cuttings
Remarks: Simpson log #1021, Mohall hole #90-1, located 240' south & 150' west of NE corner of SE 1/4, writes contractor

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-13
CLAY	Blue	13-38
GRAVEL		38-38.5
CLAY	Blue	38.5-62

161-083-11DAA2
Mohall 90-2

Date Completed:	4/1990	Purpose:	Observation Well
L.S. Elevation (ft):	1540	Well Type:	1.25" PVC
Depth Drilled (ft):	56	Aquifer:	Mohall
Screened Interval (ft):	49-54	Source:	C. A. Simpson & Son

Completion Info: .018 inch slotted screen, grouted to 25' with hole plug
 Remarks: Simpson log #1022, Mohall monitoring well # 90-2, Located on east side of Cut Bank Creek valley about 500 feet west of section line & 300 feet south of quarter line

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Gravely, yellow	1-4
CLAY	Yellow	4-12
CLAY	Blue	12-32
SAND	Fine to medium grained	32-40
SAND	Very fine	40-47
SAND	Fine to medium	47-51
SAND	Medium grained	51-55
CLAY	Blue	55-56

161-083-11DAB1
Mohall 90-3

Date Completed: 5/1/90 Purpose: Test Hole
 L.S. Elevation (ft): 1545
 Depth Drilled (ft): 52 Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
 Remarks: Simpson log #1022 (same # as DAA2), Mohall hole #90-3,
 described by contractor as being located 240' south and 794' east
 of NE corner of SE 1/4

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
GRAVEL	Oxidized	2-7
CLAY	Blue	7-42
SAND	Medium	42-45
CLAY	Blue	45-52

161-083-11DAB2
Mohall 90-4

Date Completed: 5/1/90 Purpose: Test Hole
 L.S. Elevation (ft): 1545
 Depth Drilled (ft): 33 Source: C. A. Simpson & Son

Completion Info: .025 inch slotted screen, sealed with hole plug, later pulled or
 destroyed, details not known
 Remarks: Simpson log #1024, Mohall hole #90.4, log gives location as
 240' south & 955' west of NE corner of SE 1/4

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	Gravelly	2-7
GRAVEL		7-32.5
CLAY	Blue	32.5-33

161-083-11DAB3

Mohall 90-14

Date Completed: 5/2/90 Purpose: Test Hole
L.S. Elevation (ft): 1545
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1034, Mohall hole #90-14, located 240' south & 835' west of NE corner of SE 1/4

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-3
GRAVEL	Oxidized	3-9
CLAY	Blue	9-10
SAND	Fine, blue	10-11
CLAY	Blue	11-32
SAND	Trace	32-32
CLAY	Blue	32-43

161-083-11DAB4

Mohall 90-15

Date Completed: 5/2/90 Purpose: Test Hole
L.S. Elevation (ft): 1545
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1035, Mohall hole #90-15, located 240' south & 1055' west of NE corner of SE 1/4

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Gray blue	1-7
SAND	Fine, blue	7-9
CLAY	Blue	9-43

161-083-11DAB5
Mohall 90-16

Date Completed: 5/3/90 Purpose: Test Hole
L.S. Elevation (ft): 1545
Depth Drilled (ft): 43 Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1036, Mohall hole #90-16, located 240' south & 1010' west of NE corner of SE 1/4, Sec. 11, 55' west of 90-4

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Gray, blue	1-5
SAND	Blue	5-8
CLAY	Blue	8-43

161-083-11DAB6
Mohall 90-17

Date Completed: 5/3/90 Purpose: Test Hole
L.S. Elevation (ft): 1545
Depth Drilled (ft): 63 Source: C. A. Simpson & Son

Completion Info: perforated (slotted?) pipe set in well, cemented to 25', later well was destroyed, reported water level 6' below ground
Remarks: Simpson log #1037, Mohall well #90-17, located 240' south & 905' west of NE corner of SE 1/4, Sec. 11, 50' east of 90-4

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-3
GRAVEL	Oxidized	3-9
CLAY	Blue	9-18
GRAVEL	Coarse	18-61
CLAY	Blue	61-63

161-083-11DAB7
Mohall 90-23

Date Completed: 5/3/90 Purpose: Test Hole
L.S. Elevation (ft): 1545
Depth Drilled (ft): 63
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1043, Mohall hole #90-23, located 248' south &
915' west of NE corner of SE 1/4, Sec. 11, 16' SW of 90-17

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-4
GRAVEL	Oxidized	4-9
CLAY	Blue	9-14
SAND		14-16
CLAY	Blue	16-20
SAND		20-21
CLAY	Blue	21-44
GRAVEL	Coarse	44-59.5
CLAY	Blue	59.5-63

161-083-11DAB8
Mohall 90-24

Date Completed: 5/3/90 Purpose: Test Hole
 L.S. Elevation (ft): 1545
 Depth Drilled (ft): 55 Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug, cuttings, & cement
 Remarks: Simpson log #1044, Mohall hole #90-24, located 235' south & 900' west of NE corner of SE 1/4, Sec. 11, 8' NE of 90-17

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-4
GRAVEL	Oxidized	4-8
CLAY	Blue	8-19
GRAVEL	Oxidized	19-52
CLAY	Blue	52-55

161-083-11DAB9
Mohall 90-25

Date Completed: 5/8/90 Purpose: Test Hole
 L.S. Elevation (ft): 1545
 Depth Drilled (ft): 63 Source: C. A. Simpson & Son

Completion Info: .040 inch stainless screen set, pulled materials out the following day & abandoned well, sealed with hole plug & cuttings
 Remarks: Simpson log #1045, Mohall hole #90-25, located 241' south & 910' west of NE corner of SE 1/4

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-4
GRAVEL	Oxidized	4-8.5
CLAY	Blue	8.5-16
GRAVEL		16-24

161-083-11DBA1
Mohall 90-5

Date Completed: 5/2/90 Purpose: Test Hole
L.S. Elevation (ft): 1545
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1025, Mohall hole #90-5, located 240' south &
1363' west of NE corner of SE1/4

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1.5
CLAY	Gray, yellow	1.5-5
SAND	Yellow	5-7
GRAVEL	Blue	7-11
CLAY	Blue	11-35
GRAVEL		35-37
CLAY	Blue	37-38.5
SAND		38.5-39.5
CLAY	Blue	39.5-43

161-083-11DBA2
Mohall 90-6

Date Completed: 5/2/90 Purpose: Test Hole
L.S. Elevation (ft): 1545
Depth Drilled (ft): 43 Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1026, hole #90-6, located 240' south & 1657' west
of NE corner of SE 1/4

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Gray, blue	1-7
GRAVEL	Oxidized	7-11
CLAY	Blue	11-25
SAND		25-25.5
CLAY	Blue	25.5-31
SAND		31-33
CLAY	Blue	33-37
SAND		37-41
CLAY	Blue	41-43

161-083-11DBA3
Mohall 90-7

Date Completed: 5/2/90 Purpose: Test Hole
L.S. Elevation (ft): 1545
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1027, Mohall hole #90-7, located 240' south &
1955' west of NE corner of SE 1/4

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-5
GRAVEL	Oxidized	5-9
CLAY	Blue	9-25
SAND		25-26
CLAY	Blue	26-43

161-083-11DDD1
NDSWC - USGS 2

Date Completed: 9/1948 Purpose: Test Hole
L.S. Elevation (ft): 1535
Depth Drilled (ft): 50
Source: NDSWC

Completion Info:

Remarks: Log modified from Akin, 1951, in Bottineau Basic Data report

Lithologic Log

Unit	Description	Depth (ft)
SOIL	Sandy, black	0-1
SAND	Very fine, light gray	1-2
SAND & GRAVEL	Graded	2-10
CLAY	Silty, dark gray (glacial drift - overlying listed as alluvium)	10-16
SAND	Medium to coarse	16-18
CLAY	Silty, pebbly, dark gray	18-23
SAND	Medium to coarse	23-25
GRAVEL	Fine to medium, clean; partly shale	25-37
CLAY	Sandy, dark gray	37-50

161-083-11DDD2
Mohall 88-19

Date Completed: 10/1/88 Purpose: Test Hole
L.S. Elevation (ft): 1538
Depth Drilled (ft): 63
Source: C. A. Simpson & Son

Completion Info: Sealed with cement
Remarks: Simpson log #880, Mohall hole #88-19, located 600' north & east of 36 inch well

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-8
GRAVEL		8-13
CLAY	Yellow	13-14
CLAY	Blue	14-63

161-083-11DDD3
Mohall 90-8

Date Completed: 5/2/90 Purpose: Test Hole
L.S. Elevation (ft): 1538
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings, drilling fluid disinfected
Remarks: Simpson log #1028 (?), Mohall hole #90-8, located 108' north & 618' west of SE corner of SE 1/4, Sec. 11

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-5
SAND & GRAVEL	Yellow	5-13
CLAY	Blue	13-43

161-083-11DDD4
Mohall 90-9

Date Completed: 5/2/90 Purpose: Test Hole
L.S. Elevation (ft): 1538
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1029, Mohall hole #90-9, located 103' north &
168' west of SE corner of SE 1/4

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-7
GRAVEL	Oxidized	7-11
CLAY	Blue	11-43

161-083-11DDD5
Mohall 90-10

Date Completed: 5/2/90 Purpose: Test Hole
L.S. Elevation (ft): 1538
Depth Drilled (ft): 42
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1030, Mohall hole #90-10, located 103' north &
393' west of SE corner of Sec 11

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-4
GRAVEL	Oxidized	4-7
CLAY	Yellow	7-8
GRAVEL	Oxidized	8-12
CLAY	Blue	12-42

161-083-11DDD6
Mohall 90-18

Date Completed: 5/2/90 Purpose: Test Hole
L.S. Elevation (ft): 1538
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1038, Mohall hole #90-18, located 103' north &
288' west of SE corner of SE 1/4, Sec. 11, between 90-8 and 90-10

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-7
GRAVEL	Oxidized	7-11
CLAY	Blue	11-13
SAND	Fine, blue, trace	13-13
CLAY	Blue	13-18
GRAVEL	Trace	18-18
CLAY	Blue	18-43

161-083-11DDD7
Mohall 90-19

Date Completed: 5/3/90 Purpose: Test Hole
L.S. Elevation (ft): 1538
Depth Drilled (ft): 43 Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1039, Mohall hole #90-19, located 103' north &
498' west of SE corner of Sec 11

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-11
GRAVEL	Oxidized	11-12.5
CLAY	Blue	12.5-18
SAND	Blue, trace	18-18
CLAY	Blue	18-22.5
GRAVEL		22.5-23
CLAY	Blue	23-43

161-083-12CCC
NDSWC - USGS 1

Date Completed:	9/29/48	Purpose:	Test Hole
L.S. Elevation (ft):	1535		
Depth Drilled (ft):	230	Source:	NDSWC

Completion Info:
 Remarks: Log modified from Akin, 1951

Lithologic Log

Unit	Description	Depth (ft)
SOIL	Silty, black	0-1
GRAVEL	Fine to coarse, and some silty light-gray clay	1-3
SAND	Medium to coarse	3-5
CLAY	Silty, buff and gravel (beginning of glacial drift - Akin interpretation of older driller's log)	5-12
CLAY	Silty, pebbly, gray	12-15
SAND	Medium to coarse	15-18
CLAY	Pebbly, gray	18-39
SAND	Fine to coarse	39-40
CLAY	Silty, gray	40-60
CLAY	And abundant very coarse sand	60-197
CLAY	Slightly sandy, dark-gray (Hell Creek Formation)	197-205
CLAY	Dark-gray; some carbonaceous material present (Hell Creek Fm.)	205-220
SILT	Light gray	220-225
CLAY	Dark gray	225-230

161-083-13BBB
Mohall 90-21

Date Completed: 5/3/90 Purpose: Test Hole
L.S. Elevation (ft): 1537
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1041, Mohall hole #90-21, located 60' east & 12'
south of NW corner, Sec. 13, on road shoulder, 52' west of bridge

Lithologic Log

Unit	Description	Depth (ft)
ROAD BED		0-3
TOPSOIL		3-4
CLAY	Yellow	4-14
CLAY	Blue	14-32.5
GRAVEL		32.5-33.5
CLAY	Blue	33.5-37
SAND		37-39
CLAY	Blue	39-43

161-083-13BCA
Mohall 88-8

Date Completed: 10/1988 Purpose: Test Hole
L.S. Elevation (ft): 1538
Depth Drilled (ft): 103
Source: C. A. Simpson & Son

Completion Info: Sealed with cement & cuttings
Remarks: Simpson log #869, Mohall hole #88-8, located in coulee flat,
west side, north of city wells

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-5
SAND		5-10
CLAY	Blue	10-11
GRAVEL		11-13
CLAY	Blue	13-73
SAND	Trace	73-73
CLAY	Blue	73-103

161-083-13BCB
Mohall 88-9

Date Completed: 10/1988 Purpose: Test Hole
L.S. Elevation (ft): 1535
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #870, Mohall hole #88-9

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-6
SAND		6-8
CLAY	Blue	8-9
GRAVEL	Blue, very coarse, good	9-13
CLAY	Blue	13-20
SAND		20-21
CLAY	Blue	21-43

161-083-13BCC
Mohall 88-18

Date Completed: 1/1988 Purpose: Observation Well
L.S. Elevation (ft): 1535.46 Well Type: 1.25" PVC
Depth Drilled (ft): 23 Aquifer: Mohall
Screened Interval (ft): 9-14 Source: C. A. Simpson & Son

Completion Info: 0.020 inch slotted screen used
Remarks: Simpson log #879, Mohall monitoring well 88-18, near Witteman well, or city well #3. Original water level reported on well driller's report is 6.86 feet below surface.

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
GRAVEL		1-14
CLAY	Yellow	14-15
CLAY	Blue	15-23

161-083-13CAB
Mohall/LTP #3

Date Completed: 11/29/77 Purpose: Test Hole
L.S. Elevation (ft): 1545
Depth Drilled (ft): 40
Source: LTP Enterprises Inc.

Completion Info:
Remarks: LTP test hole #3, located 1000' north of wells

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-0.5
CLAY	Silty, soft, light brown	0.5-2.5
CLAY	Sandy, light brown	2.5-13.5
CLAY	Sandy, blue	13.5-40

161-083-13CAC1
Mohall 1951 NW production well

Date Completed: 1/1/51 Purpose: Municipal Well
L.S. Elevation (ft): 1537.43 Well Type: 12" Steel
Depth Drilled (ft): 0 Aquifer: Mohall
Screened Interval (ft): 0-24 Source:

Completion Info: Northwest old city well
Remarks: Surveyed elevation is the cement floor

Lithologic Log

Unit	Description	Depth (ft)
------	-------------	------------

161-083-13CAC2
Mohall 1951 SE production well

Date Completed:	1/1/51	Purpose:	Municipal Well
L.S. Elevation (ft):	1536.75	Well Type:	12" Steel
Depth Drilled (ft):	0	Aquifer:	Mohall
Screened Interval (ft):	0-24	Source:	

Completion Info: City of Mohall old, southeast production well
Remarks: Elevation is cement floor of well house

Lithologic Log

Unit	Description	Depth (ft)
------	-------------	------------

161-083-13CAC3
Mohall 88-5

Date Completed:	9/23/88	Purpose:	Observation Well
L.S. Elevation (ft):	1534.92	Well Type:	2" PVC
Depth Drilled (ft):	23	Aquifer:	Mohall
Screened Interval (ft):	16.5-21.5	Source:	C. A. Simpson & Son

Completion Info: 0.018 inch slotted screen used, sealed with benseal
Remarks: Simpson log #866, Mohall hole #88-5, 50' north of SW production well, original water level reported on well driller's report as 11.31' below surface

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-7
SAND & GRAVEL	Sand grading to coarse gravel	7-22
CLAY	Blue	22-23

161-083-13CAD
Mohall/LTP #2

Date Completed: 11/29/77 Purpose: Test Hole
L.S. Elevation (ft): 1545
Depth Drilled (ft): 40
Source: LTP Enterprises Inc.

Completion Info:
Remarks: LTP Enterprises test hole #2, located 500' north of wells

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-0.5
CLAY	Silty, soft, light brown	0.5-4
CLAY	Brown	4-7
SAND	Some coarse	7-17
CLAY	Sandy, blue	17-28.5
SAND		28.5-29.5
CLAY	Sandy, blue	29.5-40

161-083-13CBA
Mohall 88-6

Date Completed: 10/1988 Purpose: Test Hole
L.S. Elevation (ft): 1535
Depth Drilled (ft): 63 Source: C. A. Simpson & Son

Completion Info: Sealed with cement & cuttings
Remarks: Simpson log #867, Mohall hole #88-6, located north of well house, along fence

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-17
CLAY	Blue	17-33
SAND	Fine to medium	33-37
CLAY	Blue	37-41
SAND	Fine	41-42
CLAY	Blue	42-49
GRAVEL		49-50.5
CLAY	Blue	50.5-63

161-083-13CBD
Mohall/LTP #8

Date Completed: 11/30/77 Purpose: Test Hole
L.S. Elevation (ft): 1535
Depth Drilled (ft): 47
Source: LTP Enterprises Inc.

Completion Info:
Remarks: LTP test hole #8, located 500' west northwest of well

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-0.5
CLAY	Soft, silty, light brown	0.5-4
SAND	Some coarse	4-12
CLAY	Sandy, blue	12-37
SAND	A little washed into hole	37-39
CLAY	Sandy, blue	39-47

161-083-13CCA
Mohall 88-7

Date Completed: 10/1988 Purpose: Test Hole
L.S. Elevation (ft): 1535
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with cement & cuttings
Remarks: Simpson log #868, Mohall hole #88-7, located south of coulee,
SW of wells

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-0.5
GRAVEL	Yellow	0.5-8
CLAY	Yellow	8-10
CLAY	Blue	10-17
GRAVEL		17-18.5
CLAY	Blue	18.5-43

161-083-13CCB
Mohall/LTP #1

Date Completed: 11/28/77 Purpose: Test Hole
L.S. Elevation (ft): 1542
Depth Drilled (ft): 77 Source: LTP Enterprises Inc.

Completion Info:
Remarks: LTP test hole #1, located 750' west of well

Lithologic Log

Unit	Description	Depth (ft)
SAND & GRAVEL		0-4
CLAY	Sandy, brown	4-12
CLAY	Sandy, blue	12-77

161-083-13CCC
NDSWC - Mohall 1

Date Completed: 3/24/61 Purpose: Test Hole
L.S. Elevation (ft): 1560
Depth Drilled (ft): 42 Source: NDSWC

Completion Info:
Remarks:

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Silty, yellow	1-12
CLAY	Silty, yellowish-brown (till); contains coal fragments	12-22
CLAY	Silty, gray (till); with coal fragments	22-42

161-083-13CCD1
NDSWC - Mohall 4

Date Completed: 3/27/61 Purpose: Test Hole
L.S. Elevation (ft): 1540
Depth Drilled (ft): 42
Source: NDSWC

Completion Info:
Remarks:

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Silty, yellow	1-11
SAND	Fine to medium	11-17
CLAY	Silty, yellow	17-22
SAND	Medium to coarse	22-28
CLAY	Silty, gray (till); with coal fragments	28-42

161-083-13CCD2
Mohall/LTP #4

Date Completed: 11/29/77 Purpose: Test Hole
L.S. Elevation (ft): 1535
Depth Drilled (ft): 40 Source: LTP Enterprises Inc.

Completion Info:
Remarks: LTP test hole #4, 500' south of wells

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY		2-3
CLAY	Silty	3-6
CLAY		6-8
SAND	Took water	8-19
CLAY	Sandy	19-25
CLAY	Sandy, harder	25-34
CLAY	Sandy	34-40

161-083-13CDA
Mohall/LTP #5

Date Completed: 11/30/77 Purpose: Test Hole
L.S. Elevation (ft): 1535
Depth Drilled (ft): 40
Source: LTP Enterprises Inc.

Completion Info:
Remarks: LTP test hole #5, located 500' southeast of wells

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Brown	1-4
SAND	Dirty, light brown	4-7
CLAY	Brown	7-13
SAND	Brown	13-16.5
GRAVEL	Blue	16.5-40
CLAY	Sandy	40-40

161-083-13CDB
Mohall/LTP #9

Date Completed: 11/30/77 Purpose: Test Hole
L.S. Elevation (ft): 1538
Depth Drilled (ft): 40
Source: LTP Enterprises Inc.

Completion Info:
Remarks: LTP test hole #9, located 400' SSW of wells, according to log

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Soft, silty, light brown	1-7
SAND		7-11
SAND	Coarser	11-13
CLAY	Sandy, blue	13-40

161-083-13CDC
NDSWC - Mohall 8

Date Completed: 3/28/61 Purpose: Test Hole
L.S. Elevation (ft): 1535
Depth Drilled (ft): 34
Source: NDSWC

Completion Info:
Remarks:

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Silty, yellow (till)	1-2
SAND	Fine to medium	2-4
CLAY	Silty, yellow (till)	4-20
CLAY	Silty, gray (till); with coal fragments	20-34

161-083-13CDD1
NDSWC - Mohall 9

Date Completed: 3/28/61 Purpose: Test Hole
L.S. Elevation (ft): 1535
Depth Drilled (ft): 42
Source: NDSWC

Completion Info:
Remarks:

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Silty, yellow	1-3
SAND	Medium to coarse	3-20
CLAY	Silty, gray (till); with coal fragments	20-42

161-083-13CDD2
Mohall/LTP #10

Date Completed: 12/1/77 Purpose: Test Hole
L.S. Elevation (ft): 1533
Depth Drilled (ft): 40
Source: LTP Enterprises Inc.

Completion Info:
Remarks: LTP test hole #10, located 1000 feet southeast of wells

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-0.5
CLAY	Brown	0.5-3
SAND	Brown	3-6
SAND	Coarser, brown	6-10
SAND	Brown	10-13
CLAY	Sandy, blue	13-18
SAND		18-19.5
CLAY	Sandy, blue	19.5-40

161-083-13DBC
Mohall/LTP #7

Date Completed: 11/30/77 Purpose: Test Hole
L.S. Elevation (ft): 1533
Depth Drilled (ft): 40 Source: LTP Enterprises Inc.

Completion Info:
Remarks: LTP test hole #7, located 1000' east of wells

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-0.5
CLAY	Brown	0.5-3
SAND & GRAVEL	Brown	3-11
CLAY	Blue	11-16
SAND	Washed out	16-18.5
CLAY	Sandy, blue	18.5-40

161-083-13DCB
Mohall/LTP #6

Date Completed: 11/30/77 Purpose: Test Hole
L.S. Elevation (ft): 1533
Depth Drilled (ft): 40 Source: LTP Enterprises Inc.

Completion Info:
Remarks: LTP test hole #6, located 1000' SSE of wells

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Brown	1-6
SAND	Took water, brown	6-11
SAND	Coarse, took water, colored	11-16.5
CLAY	Sandy, blue	16.5-40

161-083-13DCC1
NDSWC - USGS 56-47

Date Completed: 7/26/47 Purpose: Test Hole
L.S. Elevation (ft): 1535
Depth Drilled (ft): 205
Source: NDSWC

Completion Info:
Remarks: Log modified from LaRocque and others, 1963)

Lithologic Log

Unit	Description	Depth (ft)
SOIL		0-1
SAND & GRAVEL		1-13
CLAY	Sandy, gray	13-50
CLAY	Sandy, gray; with some gravel and lignite fragments	50-148
CLAY	Sandy, gray and fine sand	148-155
CLAY	Sandy, silty, gray	155-185
SAND & GRAVEL		185-199
LIGNITE	Hard (bedrock)	199-203
CLAY	Brown (bedrock)	203-205

161-083-13DCC2
NDSWC - Mohall 1

Date Completed: 3/29/61 Purpose: Test Hole
L.S. Elevation (ft): 1534
Depth Drilled (ft): 34
Source: NDSWC

Completion Info:
Remarks:

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Silty, graying-yellow	1-5
GRAVEL	Medium to coarse; with small clay layers	5-9
CLAY	Silty, gray (till); with coal fragments	9-34

161-083-13DCD
NDSWC - Mohall 4

Date Completed: 4/4/61 Purpose: Test Hole
L.S. Elevation (ft): 1545
Depth Drilled (ft): 34
Source: NDSWC

Completion Info:
Remarks:

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	Fine to medium; with thin gravel layers	1-10
CLAY	Silty, gray (till); with coal fragments	10-34

161-083-13DDC
NDSWC - Mohall 7

Date Completed: 4/5/61 Purpose: Test Hole
L.S. Elevation (ft): 1546
Depth Drilled (ft): 34
Source: NDSWC

Completion Info:
Remarks:

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Silty, yellow (till); with coal fragments	1-4.5
SAND	Fine to medium	4.5-5
CLAY	Silty, yellow (till); with coal fragments	5-14
CLAY	Silty, gray (till); with coal fragments	14-34

161-083-14AAA
Mohall 90-20

Date Completed: 5/3/90 Purpose: Test Hole
L.S. Elevation (ft): 1536
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1040, Mohall hole #90-20, located 64' west & 12'
south of NE corner of NE 1/4

Lithologic Log

Unit	Description	Depth (ft)
Road bed		0-3
TOPSOIL		3-4
CLAY	Yellow	4-6
GRAVEL		6-12
CLAY	Blue	12-14
SAND	Trace	14-14
CLAY	Blue	14-43

161-083-14AAB1
NDSWC - USGS 3

Date Completed: 10/2/48 Purpose: Test Hole
L.S. Elevation (ft): 1540
Depth Drilled (ft): 40 Source: NDSWC

Completion Info: Log modified from Akin, 1951, in Bottineau basic data
Remarks:

Lithologic Log

Unit	Description	Depth (ft)
SOIL	Clayey, black	0-1
CLAY	Gravelly, light gray	1-7
SAND	Medium and coarse, and some fine gravel (alluvium)	7-27
SILT	And clay, pebbly, dark gray (glacial drift)	27-40

161-083-14AAB2
Mohall 88-14

Date Completed: 10/1988 Purpose: Test Hole
L.S. Elevation (ft): 1539
Depth Drilled (ft): 83 Source: C. A. Simpson & Son

Completion Info: Sealed with cuttings and cement
Remarks: Simpson log #876, Mohall hole #88-14, located 250' west of 36 inch auger well

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Sandy, yellow	1-5
GRAVEL		5-12
CLAY	Yellow	12-14
CLAY	Blue	14-71
SAND		71-72.5
CLAY	Blue	72.5-83

161-083-14AAB3
Mohall 90-11

Date Completed: 5/2/90 Purpose: Test Hole
L.S. Elevation (ft): 1540
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1031, Mohall hole #90-11, located 1118' west & 114' south of NE corner of NE 1/4, Sec 14, about 500' west of old 36 inch well

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-3
GRAVEL	Oxidized	3-11
CLAY	Yellow	11-12
CLAY	Blue	12-13.5
ROCK		13.5-14
CLAY	Blue	14-43

161-083-14AAB4
Mohall 90-13

Date Completed: 5/1990 Purpose: Test Hole
L.S. Elevation (ft): 1539
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1033, Mohall hole #90-13

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-8
GRAVEL	Oxidized	8-11
CLAY	Yellow	11-12
CLAY	Blue	12-20
SAND		20-25
CLAY	Blue	25-43

161-083-14AAB5
Mohall 90-22

Date Completed: 5/3/90 Purpose: Test Hole
L.S. Elevation (ft): 1538
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1042, Mohall hole #90-22, located 700' west & 12'
south of NE corner of NE 1/4, 70' east of well on road shoulder

Lithologic Log

Unit	Description	Depth (ft)
ROAD		0-2
TOPSOIL		2-3
CLAY		3-5.5
GRAVEL	Oxidized	5.5-11
CLAY	Blue	11-18
SAND	Fine, blue	18-19
CLAY	Blue	19-36
CLAY	Gravely	36-38
CLAY	Blue	38-43

161-083-14AAC1
Mohall 88-10

Date Completed: 10/1988 Purpose: Test Hole
L.S. Elevation (ft): 1538
Depth Drilled (ft): 43
Source: C. A. Simpson & Son

Completion Info: Sealed with cement & cuttings
Remarks: Simpson log #871, Mohall hole #88-10

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-0.5
GRAVEL	Yellow	0.5-13
CLAY	Yellow	13-15
CLAY	Blue	15-43

161-083-14AAC2
Mohall 88-12

Date Completed: 10/1988 Purpose: Test Hole
 L.S. Elevation (ft): 1538
 Depth Drilled (ft): 64
 Source: C. A. Simpson & Son

Completion Info: Sealed with benseal and cement, monitoring well pulled or plugged at time of drilling
 Remarks: Simpson log #874, Mohall hole #88-12, located 60' northeast of 88-10, static water level reported as 12.3' below land surface

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-0.5
GRAVEL		0.5-12.5
CLAY	Yellow	12.5-15
CLAY	Blue	15-53
SAND	Fine	53-55
CLAY	Blue	55-56.5
SAND		56.5-60
CLAY	Blue	60-61
SAND		61-64
CLAY	Blue	64-64

161-083-14AAC3
Mohall 88-15

Date Completed: 10/1988 Purpose: Test Hole
L.S. Elevation (ft): 1538
Depth Drilled (ft): 64
Source: C. A. Simpson & Son

Completion Info: Sealed with cement
Remarks: Simpson log #877, Mohall hole #88-15, located 4' south of 88-12

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-0.5
GRAVEL		0.5-12.5
CLAY	Yellow	12.5-15
CLAY	Blue	15-40
SAND	Trace	40-40
CLAY	Blue	40-53
SAND		53-55
CLAY	Blue	55-57
SAND		57-60
CLAY	Blue	60-61
SAND		61-64
CLAY	Blue	64-64

161-083-14AAD1
Mohall 88-11

Date Completed: 10/1988 Purpose: Test Hole
 L.S. Elevation (ft): 1538
 Depth Drilled (ft): 87 Source: C. A. Simpson & Son

Completion Info: Sealed with cement, well destroyed (cemented) near time of drilling
 Remarks: Simpson log #872, Mohall hole #88-11, static water level reported as 11.78 feet below surface

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-0.5
CLAY	Yellow	0.5-6
GRAVEL	Yellow	6-8.5
CLAY	Yellow	8.5-10
CLAY	Blue	10-16
SAND		16-17
CLAY	Blue	17-31
SAND		31-32
CLAY	Blue	32-37
SAND	Clean	37-49
CLAY	Blue	49-50
SAND	Fine	50-53
SAND	Clean	53-77
CLAY	Blue	77-82.5
GRAVEL		82.5-83
CLAY	Blue	83-87

161-083-14AAD2
Mohall 5 inch test well

Date Completed: 10/3/88 Purpose: Test Hole
 L.S. Elevation (ft): 1538
 Depth Drilled (ft): 89
 Source: C. A. Simpson & Son

Completion Info: Materials retrieved and hole cemented
 Remarks: Simpson log #873, Mohall 5 inch diameter test well located 40'
 NW of 88-11, static water level reported as 10.78' below surface

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-7
GRAVEL	Coarse	7-8.5
CLAY	Yellow	8.5-10
CLAY	Blue	10-35
GRAVEL		35-38
CLAY	Blue	38-40
SAND		40-43
CLAY	Blue	43-45
SAND		45-48
CLAY	Blue	48-57
SAND	Clayey	57-61
SAND	Fine, clean	61-83
CLAY	Trace	83-83
SAND	Fine	83-86
CLAY	Blue	86-89

161-083-14ABA1
NDSWC - USGS 4

Date Completed: 10/4/48 Purpose: Test Hole
L.S. Elevation (ft): 1542
Depth Drilled (ft): 220 Source: NDSWC

Completion Info:
Remarks: Log modified from Akin, 1951

Lithologic Log

Unit	Description	Depth (ft)
SOIL	Clayey, black	0-1
CLAY	Light gray (Alluvium)	1-3
SAND	Medium, brown, and some coarse gravel	3-8
CLAY	Silty, pebbly, gray (glacial drift)	8-81
SAND	Fine to medium, quartzose; abundant clay and silt	81-97
CLAY	Silty, pebbly, gray	97-202
CLAY	Sandy, light gray to white (Hell Creek Formation)	202-205
CLAY	Silty, brown to black (Hell Creek Fm.)	205-220

161-083-14ABA2
Mohall 90-12

Date Completed: 5/2/90 Purpose: Test Hole
L.S. Elevation (ft): 1539
Depth Drilled (ft): 63
Source: C. A. Simpson & Son

Completion Info: Sealed with hole plug & cuttings
Remarks: Simpson log #1032, Mohall hole #90-12, located 114' south &
1420' west of NE corner of NE 1/4

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Yellow	1-3
GRAVEL		3-10
CLAY	Blue	10-37
SAND & GRAVEL		37-40
CLAY	Blue	40-41
GRAVEL		41-42
CLAY	Sandy, blue	42-63

161-083-14ADC
Mohall 88-16

Date Completed: 10/1988 Purpose: Test Hole
L.S. Elevation (ft): 1539
Depth Drilled (ft): 63
Source: C. A. Simpson & Son

Completion Info: Sealed with cement
Remarks: Simpson log #878, Mohall hole #88-16

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
GRAVEL		1-16
CLAY	Yellow	16-17
CLAY	Blue	17-63

161-083-14ADD1
NDSWC 11444

Date Completed: 10/31/80 Purpose: Test Hole
L.S. Elevation (ft): 1537
Depth Drilled (ft): 20 Source: NDSWC

Completion Info:
Remarks:

Lithologic Log

Unit	Description	Depth (ft)
SOIL		0-1
SILT	Clayey, yellowish brown (oxidized glacial drift)	1-5
SAND	Fine to coarse; 30% fine to granular subangular to subrounded gravel; predominately silicate, carbonate, and quartz grains	5-13
CLAY	Silty, sandy, gravelly, olive gray (till)	13-20

161-083-14ADD2
Mohall 88-13

Date Completed: 10/1988 Purpose: Test Hole
L.S. Elevation (ft): 1537
Depth Drilled (ft): 163
Source: C. A. Simpson & Son
Completion Info: Sealed with cement
Remarks: Simpson log #875, Mohall hole #88-13, located 450' west of Witteman well

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
GRAVEL		2-13
CLAY	Yellow	13-16
CLAY	Blue	16-40
SAND	Trace, coarse	40-40
CLAY	Blue	40-68
SAND	Clayey	68-69
CLAY	Blue	69-163

161-083-14DAA1
Mohall 88-17

Date Completed: 10/1988 Purpose: Test Hole
L.S. Elevation (ft): 1536
Depth Drilled (ft): 33
Source: C. A. Simpson & Son
Completion Info: Sealed with cement
Remarks: Simpson log #879, Mohall hole #88-17, located 150' east & south of Witteman's well along fence

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-0.5
GRAVEL		0.5-20
CLAY	Yellow	20-21
CLAY	Blue	21-33

161-083-14DAA2
Mohall Witteman production well

Date Completed:	11/22/88	Purpose:	Municipal Well
L.S. Elevation (ft):	1539.3	Well Type:	8" Steel
Depth Drilled (ft):	34	Aquifer:	Mohall
Screened Interval (ft):	14-20	Source:	C. A. Simpson & Son

Completion Info: .040 inch stainless steel screen, grouted from 8 to 13' with cement
 Remarks: Simpson log #882, Mohall Witteman well

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
GRAVEL		1-20
CLAY	Blue	20-34

162-083-06BAA
NDSWC 13242

Date Completed:	6/23/93	Purpose:	Test Hole
L.S. Elevation (ft):	1577		
Depth Drilled (ft):	20	Source:	NDSWC

Completion Info: Hole sealed with two bags of hole plug
 Remarks: Located south of section line trail, 100' west of 1/4 line fence, SW of farmstead

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till), sand lens at 9', rocky in places	1-16
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	16-20

162-083-06BAB
NDSWC 13243

Date Completed: 6/23/93 Purpose: Test Hole
L.S. Elevation (ft): 1575
Depth Drilled (ft): 20
Source: NDSWC

Completion Info: Hole sealed with two bags of hole plug
Remarks: Located along south side of section line trail, 250' east of creek

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	25% gravel, well graded, primarily silicates & carbonates	1-11
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till)	11-12
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	12-20

162-083-06CDC
NDSWC 13240

Date Completed: 6/23/93 Purpose: Test Hole
L.S. Elevation (ft): 1580
Depth Drilled (ft): 20
Source: NDSWC

Completion Info:
Remarks: Located along side of trail & along fence line, north between cultivated land & pasture/creek land

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till)	1-20

162-083-06DCC
NDSWC 13239

Date Completed: 6/23/93 Purpose: Test Hole
 L.S. Elevation (ft): 1570
 Depth Drilled (ft): 60
 Source: NDSWC

Completion Info: Hole sealed with two bags of hole plug
 Remarks: Located along side of trail, just west of approach & 70' east of creek

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	Fine grained, silty, clayey (alluvial)	1-5
SAND & GRAVEL	20% gravel, silicates, carbonates and shale	5-10
CLAY	Olive gray, 30%, w/silt, sand/ & gravel (till)	10-17
SAND	V. coarse, similar to above	17-19
CLAY	Olive gray, as above (till)	19-60

162-083-06DCD
NDSWC 13238

Date Completed: 6/23/93 Purpose: Test Hole
 L.S. Elevation (ft): 1570
 Depth Drilled (ft): 20
 Source: NDSWC

Completion Info: Hole sealed with one bag of hole plug
 Remarks: Located along edge of approach, north of trail, 100' east of cultivated field east of drainageway

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	25% gravel, silicates & carbonates	1-7
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till)	7-8
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	8-20

162-083-08CCD
NDSWC 13236

Date Completed: 6/23/93 Purpose: Test Hole
L.S. Elevation (ft): 1570
Depth Drilled (ft): 20

Source: NDSWC

Completion Info: Hole plugged with one bag of hole plug
Remarks: Located in ditch south of road, 50' west of approach at 1/4,1/4
line

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	25% gravel, silicates & carbonates	1-10
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till)	10-11
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	11-20

162-083-08DCC
NDSWC 13235

Date Completed: 6/23/93 Purpose: Test Hole
L.S. Elevation (ft): 1570
Depth Drilled (ft): 20

Source: NDSWC

Completion Info:
Remarks: Located in ditch north of road, 50' west of approach, about .4
mile west of section line

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	30% gravel, silicates & carbonates	1-5
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	5-20

162-083-15CCD
NDSWC 5561

Date Completed:	9/12/79	Purpose:	Observation Well
L.S. Elevation (ft):	1565	Well Type:	1.25" PVC
Depth Drilled (ft):	272	Aquifer:	Mohall
Screened Interval (ft):	235-238	Source:	NDSWC

Completion Info:
Remarks: NDSWC 5561

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	Very fine to [very] coarse, 10% gravel, mostly quartz & carbonate grains	1-22
CLAY	Olive gray, silty to very sandy, pebbly (till)	22-55
CLAY	Olive gray, Very sandy and gravelly (sandy till)	55-120
SAND	Very fine to coarse, quartz, carbonate, shale	120-124
CLAY	Olive gray, very sandy, gravelly (till)	124-176
SILT	Argillaceous, mixed with fluvial material (till) [?], (shove block)	176-196
CLAY	Olive gray, silty, very sandy, pebbly (till)	196-232
SAND	Medium to coarse grained, well rounded, predominately quartz and shale	232-244
SILT	Dusky yellowish brown, argillaceous, carbonaceous (bedrock - Hell Creek Fm.)	244-257
SAND	Very fine to fine grained, argillaceous, glauconitic, quartzose, indurated, grayish green (bedrock - Hell Creek Fm.)	257-278

162-083-15CDC
NDSWC 13232

Date Completed: 6/23/93 Purpose: Test Hole
L.S. Elevation (ft): 1563
Depth Drilled (ft): 20
Source: NDSWC

Completion Info:
Remarks: Located in ditch north of road, along ridge

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	Primarily v. Coarse sand & gravel granules, moderate sorting, primarily silicates & carbonates	1-11
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till)	11-13
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	13-20

162-083-16BCB
NDSWC 13234

Date Completed: 6/23/93 Purpose: Test Hole
L.S. Elevation (ft): 1563
Depth Drilled (ft): 20
Source: NDSWC

Completion Info:
Remarks: Hole sealed with one bag of hole plug
Located along east side of section line R.O.W., where trail from north angles east onto sec. line.

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Light gray-yellow, silty	1-3
SAND & GRAVEL	30% gravel, well graded, lighter colored than other gravels in valley, more carbonates	3-11
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	11-20

162-083-17ADD
NDSWC 13233

Date Completed: 6/23/93 Purpose: Test Hole
L.S. Elevation (ft): 1559
Depth Drilled (ft): 20
Source: NDSWC

Completion Info: Located on the west side of the section line R.O.W., 50' north of
Remarks: the 1/4 line

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	20% gravel, well graded, silicates & carbonates	1-11
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	11-20

162-083-18AAA
NDSWC 13237

Date Completed: 6/23/93 Purpose: Test Hole
L.S. Elevation (ft): 1560
Depth Drilled (ft): 20
Source: NDSWC

Completion Info: Hole sealed with one bag of hole plug
Remarks: Located in ditch south of road, 100' west of section line

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	25% gravel, silicates & carbonates	1-8
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till)	8-9
CLAY	Olive gray 30%, w/silt, sand, & gravel (till)	9-20

162-083-21AAA
NDSWC 13231

Date Completed: 6/22/93 Purpose: Test Hole
L.S. Elevation (ft): 1558
Depth Drilled (ft): 20
Source: NDSWC

Completion Info:
Remarks: Located in ditch west of road, 100' south of section line approach

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	20% gravel, well graded, primarily silicates & carbonates	1-8
CLAY	Olive gray, 30%, w/silt, sand, & gravel, (till), some interbedded sand lenses 10'-12'	8-20

162-083-22BCC
NDSWC 13230

Date Completed: 6/22/93 Purpose: Test Hole
L.S. Elevation (ft): 1558
Depth Drilled (ft): 20
Source: NDSWC

Completion Info: Hole sealed with two bags of hole plug
Remarks: Located in ditch east of road, about 600 feet north of 1/4 line

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	20% gravel, well graded, primarily silicates & carbonates, oxidized	1-8
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	8-11
SAND	Coarse grained, poorly sorted, primarily silicates	11-12
CLAY	Olive gray, as above (till)	12-20

162-083-22CDC
NDSWC 13229

Date Completed: 6/22/93 Purpose: Test Hole
 L.S. Elevation (ft): 1563
 Depth Drilled (ft): 20 Source: NDSWC

Completion Info: Hole sealed with one bag of hole plug
 Remarks: Located along north side of trail, midway between shelter belt
 N-S tree rows, 700' east of farmstead

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Subsoil	1-2
SAND & GRAVEL	30% gravel	2-4
CLAY	Dark yellowish brown, 30% w/silt, sand, & gravel (oxidized till)	4-11
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	11-20

162-083-22DCC
NDSWC 13228

Date Completed: 6/22/93 Purpose: Observation Well
 L.S. Elevation (ft): 1556.28 Well Type: 2" PVC
 Depth Drilled (ft): 33 Aquifer: Mohall
 Screened Interval (ft): 15-20 Source: NDSWC

Completion Info: .018 inch slotted screen
 Remarks: Located in ditch north of trail, 70' east of 1/4 line

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	25% gravel, graded, coarse sand to pebbles, primarily silicates, carbonates, some shale, sandstone	1-20
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	20-30
SAND & GRAVEL	As above	30-32
CLAY	Olive gray, as above (till)	32-33

162-083-22DDD
NDSWC 13226

Date Completed: 6/22/93 Purpose: Test Hole
L.S. Elevation (ft): 1550
Depth Drilled (ft): 20
Source: NDSWC

Completion Info:

Remarks: Located in ditch north of trail, SW of trail following NW along side of Cut Bank Creek valley

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND & GRAVEL	15% gravel, graded, primarily carbonates & silicates, oxidized	2-7
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till)	7-8
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	8-9
SAND & GRAVEL	As above, interbedded w/clay, more shale in gravel than upper section	9-12
CLAY	Olive gray, as above (till)	12-20

162-083-26CDC
NDSWC 13220

Date Completed: 6/21/93 Purpose: Test Hole
L.S. Elevation (ft): 1582
Depth Drilled (ft): 20
Source: NDSWC

Completion Info:

Remarks: Located on the north side of the section line road, 1/4 mile east of the section line, in ditch east of approach

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	20% gravel, well graded, primarily silicates & carbonates, appears to be oxidized to 10'	1-10
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	10-20

162-083-27AAB
NDSWC 13227

Date Completed: 6/22/93 Purpose: Test Hole
 L.S. Elevation (ft): 1545
 Depth Drilled (ft): 20 Source: NDSWC

Completion Info:
 Remarks: Located in ditch south of trail, 400' west of bridge

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	25% gravel, well graded	1-4
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till)	4-10
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	10-20

162-083-34AAB
NDSWC 13222

Date Completed: 6/22/93 Purpose: Observation Well
 L.S. Elevation (ft): 1554.93 Well Type: 2" PVC
 Depth Drilled (ft): 25 Aquifer: Mohall
 Screened Interval (ft): 14-19 Source: NDSWC

Completion Info: .018 inch slotted screen used, annulus sealed with one bag of hole plug
 Remarks: Well is located in ditch south of gravel road, along a slight rise about 1/4 mile west of the section line

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	25% gravel, well graded, primarily silicates & carbonates, mostly oxidized	1-18
CLAY	Olive gray, 30%, with silt, sand, & gravel (till)	18-25

162-083-34AAC
NDSWC 13253

Date Completed:	6/24/93	Purpose:	Observation Well
L.S. Elevation (ft):	1555.2	Well Type:	2" PVC
Depth Drilled (ft):	30	Aquifer:	Mohall
Screened Interval (ft):	18-23	Source:	NDSWC

Completion Info: Used .018 inch slotted screen, annulus sealed with 2 bags of hole plug
 Remarks: Located 600 feet west of test hole 13252, & 880 feet west of well 13224 (27' deep well along section line)

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	Medium grained, fair sorting, quartz, darker silicates predominate	1-11
SAND & GRAVEL	25% gravel, silicates & carbonates	11-23
CLAY	Olive gray, 30% w/silt, sand, & gravel (till)	23-30

162-083-34AAD
NDSWC 13252

Date Completed:	6/24/93	Purpose:	Test Hole
L.S. Elevation (ft):	1555		
Depth Drilled (ft):	40	Source:	NDSWC

Completion Info:
 Remarks: Located 280' west of well #13224 (35BCB)

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	30% gravel, moderate to poorly sorted, primarily very coarse sand & gravel granules, primarily silicates & carbonates	1-26
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	26-40

162-083-34ABB
NDSWC 13223

Date Completed: 6/22/93 Purpose: Test Hole
 L.S. Elevation (ft): 1557
 Depth Drilled (ft): 20
 Source: NDSWC

Completion Info: Hole plugged with two bags of hole plug
 Remarks: Located in ditch south of road and 70 feet east of 1/4 line

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Dark yellowish brown, 30%, w/silt, sand/ & gravel (oxidized till)	1-13
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	13-20

162-083-34ACA
NDSWC 13254

Date Completed: 6/24/93 Purpose: Observation Well
 L.S. Elevation (ft): 1549.16 Well Type: 2" PVC
 Depth Drilled (ft): 20 Aquifer: Mohall
 Screened Interval (ft): 10-15 Source: NDSWC

Completion Info: Used .008 inch slotted screen, annulus sealed with one bag of hole plug
 Remarks: Located in field along topo. low west of ridge, near the south end of tree grove, 150' west of 1/4,1/4 line, 570' WSW of well 13253

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	Coarse grained, poorly sorted, primarily silicates & carbonates, grading coarser w/depth	1-12
SAND & GRAVEL	20% gravel, similar to sand, above	12-14
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	14-20

162-083-34DAB
NDSWC 13255

Date Completed: 6/24/93 Purpose: Observation Well
L.S. Elevation (ft): 1549.71 Well Type: 2" PVC
Depth Drilled (ft): 20 Aquifer: Mohall
Screened Interval (ft): 12-17 Source: NDSWC

Completion Info: Used .008 inch slotted screen, annulus sealed with one bag of hole plug
Remarks: In grass field, 200' south of 1/4 line & 200' east of 1/4, 1/4 line

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Silty, dark yellowish brown	1-3
SAND & GRAVEL	20% gravel, primarily silicates & carbonates	3-17
CLAY	Olive gray, 30% w/silt, sand & gravel (till)	17-20

162-083-34DAD
NDSWC 13256

Date Completed: 6/24/93 Purpose: Observation Well
L.S. Elevation (ft): 1548.62 Well Type: 2" PVC
Depth Drilled (ft): 20 Aquifer: Mohall
Screened Interval (ft): 12-17 Source: NDSWC

Completion Info: Used .008 inch slotted screen, annulus sealed with one bag of hole plug
Remarks: In field, along low about 1/4 mile NNW of shed

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	Coarse grained, poorly sorted, primarily silicates & carbonates	1-6
SAND & GRAVEL	25% gravel, primarily silicates & carbonates	6-17
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	17-20

162-083-34DDD
Mohall 90-29

Date Completed: 5/8/90 Purpose: Observation Well
L.S. Elevation (ft): 1547.7 Well Type: 2" PVC
Depth Drilled (ft): 43 Aquifer: Mohall
Screened Interval (ft): 34-39 Source: C. A. Simpson & Son

Completion Info: C. A. Simpson & Son log 1049, Mohall well #90-29
Remarks: Located 70 feet north of road, 100 feet west of creek & about 300 feet east of shack, where road begins to curve off section line because of creek meander

Lithologic Log

Unit	Description	Depth (ft)
SAND	Oxidized	0-9
SAND	Coarse, oxidized	0-11
SAND	Blue	11-20
SAND	Fine to medium	20-39
CLAY	Blue	39-43

162-083-35BAA
NDSWC 13221

Date Completed: 6/22/93 Purpose: Test Hole
L.S. Elevation (ft): 1555
Depth Drilled (ft): 20 Source: NDSWC

Completion Info:
Remarks: Located in ditch south of road & 100 yards east of Cut Bank Creek, 50' east of fence line along field

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Dark yellowish brown, 30% w/silt, sand, & gravel (oxidized till), sand lens 8'-9'	1-12
CLAY	Olive gray, 30% w/silt, sand, & gravel (till)	12-20

162-083-35BBB
NDSWC 13225

Date Completed: 6/22/93 Purpose: Observation Well
L.S. Elevation (ft): 1556.37 Well Type: 2" PVC
Depth Drilled (ft): 30 Aquifer: Mohall
Screened Interval (ft): 20-25 Source: NDSWC

Completion Info: Used .018 inch slotted screen, annulus plugged with one bag of hole plug
Remarks: Located on the east side of the section line along a fence, about 300' south of the gravel road

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	25% gravel, well graded, primarily silicates & carbonates, some shale	1-25
CLAY	Olive gray, 30% w/silt, sand, & gravel (till)	25-30

162-083-35BBC
NDSWC 13259

Date Completed: 6/24/93 Purpose: Test Hole
L.S. Elevation (ft): 1550
Depth Drilled (ft): 20
Source: NDSWC

Completion Info: Hole sealed with two bags of hole plug
Remarks: Located 300' ENE of well #13224 at 35BCB

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	Coarse grained, poorly sorted, silicates & carbonates	2-13
SAND & GRAVEL	As above, 20% gravel	13-14
CLAY	Olive gray, 30% w/silt, sand, & gravel (till)	14-20

162-083-35BBD
NDSWC 13258

Date Completed: 6/24/93 Purpose: Test Hole
L.S. Elevation (ft): 1550
Depth Drilled (ft): 20
Source: NDSWC

Completion Info:
Remarks: Located 630 feet west & 40 feet north of center of fence corner in center of quarter

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	Coarse grained, poorly sorted, silicates	2-9
SAND & GRAVEL	25% gravel, poorly sorted, silicates & carbonates	9-12
CLAY	Dark yellowish brown, 30% w/silt, sand, & gravel (oxidized till)	12-13
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	13-20

162-083-35BCA
NDSWC 13257

Date Completed: 6/24/93 Purpose: Test Hole
L.S. Elevation (ft): 1550
Depth Drilled (ft): 20
Source: NDSWC

Completion Info:
Remarks: Hole sealed with one bag of hole plug
Located 70 feet west & 20 feet south of fence corner in center of NW quarter

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Dark yellowish brown, silty	1-3
SAND	Coarse grained, poorly sorted, silicates & carbonates	3-6
SAND & GRAVEL	25% gravel, well graded, silicates & carbonates	6-10
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	10-20

162-083-35BCB
NDSWC 13224

Date Completed: 6/22/93 Purpose: Observation Well
L.S. Elevation (ft): 1551.33 Well Type: 2" PVC
Depth Drilled (ft): 40 Aquifer: Mohall
Screened Interval (ft): 22-27 Source: NDSWC

Completion Info: Used .018 inch slotted screen, annulus sealed with hole plug
Remarks: Located along east side of section line right of way, along fence,
about .3 mile south of the section corner

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	25% gravel, well graded, primarily silicates & carbonates, oxidized to about 16 feet, rock at 18 feet	1-28
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	28-40

162-083-35BCC
NDSWC 13219

Date Completed: 6/21/93 Purpose: Test Hole
L.S. Elevation (ft): 1553
Depth Drilled (ft): 60
Source: NDSWC

Completion Info:
Remarks: Located along the east side of the section line right of way, 50'
north of the 1/4 line

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND & GRAVEL	20% gravel, well graded, primarily silicates & carbonates, some shale	2-18
CLAY	Olive gray, 30%, w/silt, sand, & gravel, (till), some small gravel lenses 30'-32'	18-60

162-083-35CCB
NDSWC 13218

Date Completed: 6/21/93 Purpose: Test Hole
 L.S. Elevation (ft): 1545
 Depth Drilled (ft): 240 Source: NDSWC

Completion Info:
 Remarks: Located along east side of section line R.O.W., where trail diverges west off the section line

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	15% gravel, well graded, primarily silicates & carbonates, a little green sandstone, (appeared to be oxidized, creek water 100' away is about 10' lower in elevation.)	1-13
CLAY	Olive gray, 35%, moderately cohesive, w/silt, sand, & gravel (clayey till), sand & gravel lens at 31'-32'	13-41
SAND & GRAVEL	20% gravel, primarily silicates, carbonates, & shale, interbedded lenses of clay, some lignite in gravel	41-48
CLAY	Olive gray, as above (till), sand lens 101'-102'	48-214
SAND	V. fine grained, w/clay, carbonaceous brownish color underlain by greenish gray clayey sand & olive gray silt/clay (bedrock - Hell Creek Fm.)	214-240

163-083-31DDC
NDSWC 13241

Date Completed: 6/23/93 Purpose: Test Hole
L.S. Elevation (ft): 1580
Depth Drilled (ft): 20
Source: NDSWC

Completion Info:
Remarks: Located in ditch north of road, 50' east of approach

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	30% gravel, well graded	1-7
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till)	7-10
CLAY	Olive gray 30%, w/silt, sand, & gravel (till)	10-20

163-084-24CCC
NDSWC 13247

Date Completed: 6/23/93 Purpose: Test Hole
L.S. Elevation (ft): 1584
Depth Drilled (ft): 20
Source: NDSWC

Completion Info:
Remarks: Hole sealed with one bag of hole plug
Located near corner of section, along fence

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	30% gravel, well graded, primarily silicates & carbonates	1-14
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till)	14-15
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	15-20

163-084-24CCD
NDSWC 13246

Date Completed: 6/23/93 Purpose: Test Hole
L.S. Elevation (ft): 1580
Depth Drilled (ft): 20
Source: NDSWC

Completion Info: Hole sealed with two bags of hole plug
Remarks: Located north of fence line, north of section line road, midway
between creek & sec. line

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	.	0-1
SAND & GRAVEL	10% gravel, graded, silicates & carbonates (oxidized)	1-7
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till)	7-10
SAND	Coarse grained, similar to above	10-12
CLAY	dark yellowish brown, as above (till)	12-14
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till)	14-20

163-084-24CDC
NDSWC 13245

Date Completed: 6/23/93 Purpose: Test Hole
L.S. Elevation (ft): 1483
Depth Drilled (ft): 20
Source: NDSWC

Completion Info:
Remarks: Located in ditch north of road, 200' east of bridge

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till)	1-12
CLAY	Olive gray, 30%, w/silt, sand, & gravel (till), gravel lens at 16'-17'	12-20

163-084-24CDD

NDSWC 13244

Date Completed: 6/23/93 Purpose: Test Hole
L.S. Elevation (ft): 1585
Depth Drilled (ft): 240
Source: NDSWC

Completion Info:

Remarks: Located in ditch north of road, 100' west of 1/4 line approach

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND & GRAVEL	25% gravel, well graded, primarily silicates & carbonates	1-3
CLAY	Dark yellowish brown, 30%, w/silt, sand, & gravel (oxidized till), sand lens at 5'	3-11
SAND	Medium to coarse grained, moderate sorting, quartz, other silicates, carbonates	11-25
CLAY	Olive gray, 25% w/silt, sand, & gravel (sandy till)	25-233
SILT	Dark greenish gray and light greenish gray, some v. fine sand, & some bentonitic clay (bedrock - Hell Creek Fm.)	233-240