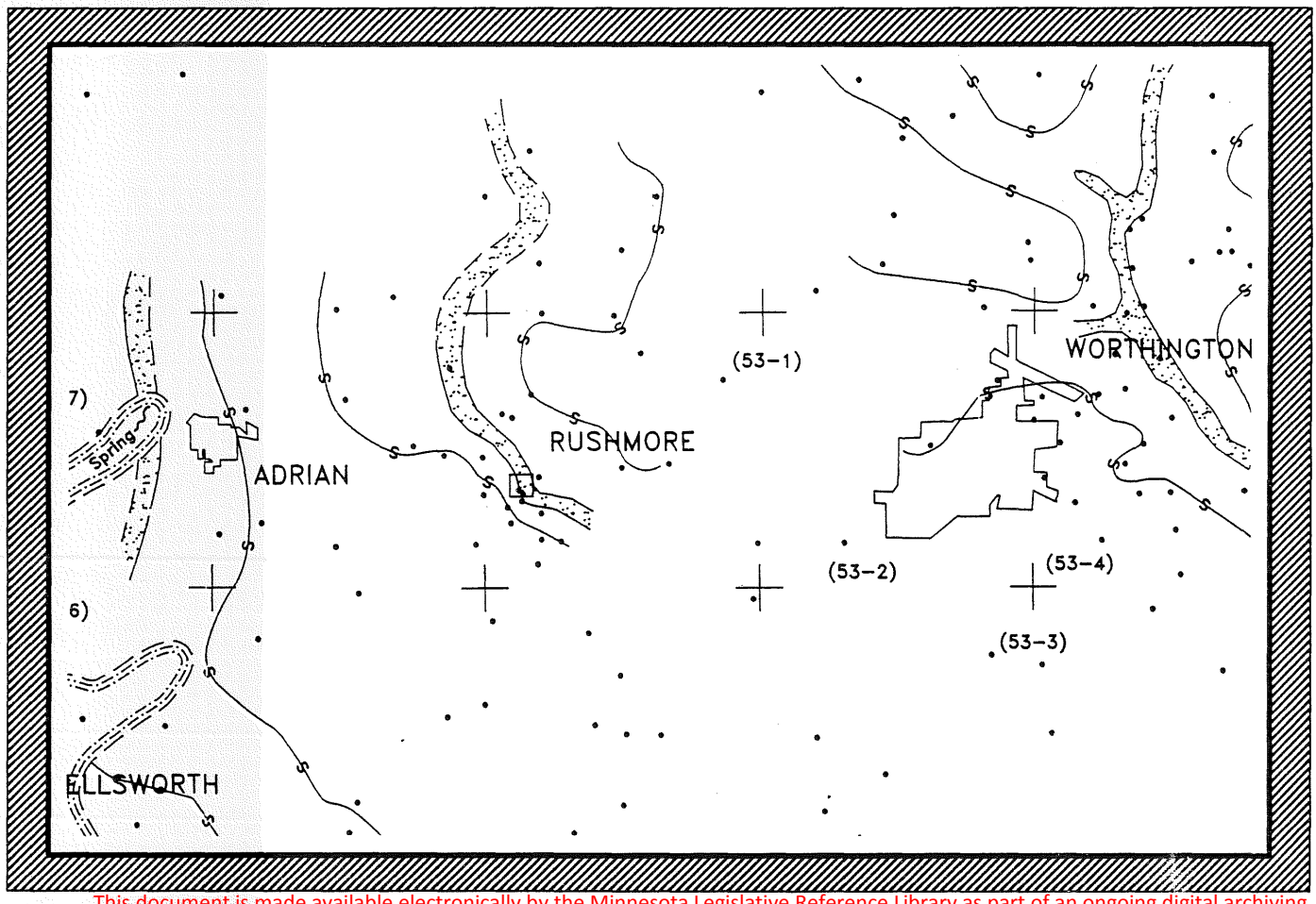
SOUTHWESTERN MINNESOTA GROUNDWATER EXPLORATION PROJECT 1996-1997

Progress Report



February 1997

Minnesota
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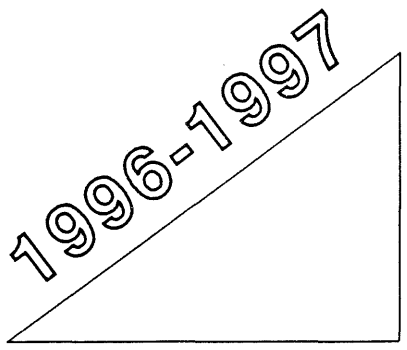

SOUTHWESTERN MINNESOTA GROUNDWATER EXPLORATION PROJECT

Progress Report

by James A. Berg
February 1997

Report to the Minnesota Legislature by the
Minnesota Department of Natural Resources
Division of Waters
St. Paul, MN

The 1995 Minnesota Laws, Chapter 220,
Section 5, Subdivision 3

This report was prepared by staff of the Department of Natural Resources, Division of Waters. It is intended to fulfill the requirement of the 1995 Minnesota Laws, Chapter 220, Section 5, Subdivision 3 to report on the progress of the Southwestern Minnesota Drilling Project. The cost to develop and duplicate this report was approximately **$7,000.00.**

For additional information or copies, contact:
DNR, Division of Waters
500 Lafayette Road, St. Paul, MN 55155
(612) 296-4800 Fax: (612) 296-0445

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Department of Natural Resources/Division of Waters support that made this project possible includes: project management, mud logging, and report review by Tom Gullett and Brian Rongitsch; mud logging and report review by Evan Drivas, mud logging by Mike Liljegren; drafting by Jerry Johnson; geophysics and report review by Todd Petersen; and report review by Sarah Tufford, Jennie Leete, and Dave Leuthe. Finally, we also appreciated the dedicated drilling services provided by LTP Enterprises, Inc. and Don Hejtmanek.

Funding for this project was approved by the 1995 Minnesota Laws, Chapter 220, Section 5, Subdivision 3, as recommended by the Minnesota Legislative Water Commission.

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High quality/high capacity aquifers are difficult to find in many portions of southwestern Minnesota since the area is underlain by silt and clay rich Quaternary glacial sediments and shale rich Cretaceous bedrock. In cooperation with five major water appropriators in the region (City of Luverne, Rock County Rural Water, City of Worthington, Lincoln-Pipestone Rural Water, and the City of Marshall), the Minnesota Department of Natural Resources (DNR) has drilled 17 mud rotary test holes at selected locations in Rock, Nobles, Yellow Medicine, and Lincoln Counties. Ten additional test holes are planned for the 1997 field season. These test holes will be located in Yellow Medicine, Lyon, and Pipestone Counties. The purposes of these test holes include: 1) finding the most productive aquifers in areas closest to the major water appropriators, and 2) obtaining geological information to help predict the locations of the best aquifers for future use.

The test holes drilled during the summer and fall of 1996 ranged in depth from 400 to 979 feet. Most of the test holes penetrated both the Quaternary and Cretaceous sections. In the Worthington area (Nobles County), potentially productive sand layers (thickness of 20 feet or more) were found in the Quaternary section at depths of 134 to 426 feet below ground surface at thicknesses ranging from 20 to 37 feet. Maximum Cretaceous sandstone thicknesses ranged from 68 to 124 feet at depths of 363 to 744 feet below ground surface. The Worthington area appears to have several options for future groundwater exploration and development.

Rock County appears to have fewer options for groundwater supplies than Nobles County, since the area is underlain by a thinner section of Quaternary materials and Cretaceous bedrock. However, even with these limitations, this study has shown that additional groundwater resources may be available in this area. Two new potential large capacity aquifers were discovered by this project consisting of sand layers at the base of the Quaternary section. One aquifer was found in the area around the Rock River and Kanaranzi Creek valleys near the Iowa border at depths of approximately 200 to 250 feet. The other aquifer was found between Magnolia and Adrian at a depth of approximately 250 feet. The maximum sand thickness of these potential large capacity aquifers ranges from 38 to 46 feet. Aquifer testing, water quality testing, and additional drilling is required to determine if these units can supply the capacity and quality demands of the water producers in the area.

Shallow buried outwash units (Prairie Coteau aquifer) in the Lincoln-Pipestone Rural Water Burr Well Field area (Yellow Medicine County) have a dominant northwest-southeast orientation. Thick sections of these outwash units were found in DNR test holes 41-1 and 87-7, located 4-5 miles south-southeast of the Burr Well Field, at depths of 70 to 312 feet below ground surface. In addition, 35 to 38 foot thick accumulations of sand were found at the base of the Quaternary section (Altamont aquifer) in test holes 41-1 and 87-7. The depth to the top of the Altamont aquifer in this area ranges from 365 to 461 feet below ground surface.

The distribution and orientation of the deeper aquifers in the Burr Well Field/Lake Cochrane area (Unit 5 outwash and Altamont aquifer) are not known since very few boreholes penetrate these units in the area. The Altamont aquifer is an attractive target since it is relatively thick, widespread, and produces relatively good quality water. In addition, based on stratigraphic relationships, this aquifer appears to be hydraulically isolated from the overlying Prairie Coteau aquifer. Additional test drilling is required to locate the thickest portions of this aquifer.

1.0 Introduction

The 1995 legislature funded this project from a proposal that was initiated by the Minnesota Water Well Contractors Association. The purpose of the project is to help characterize the geologic and hydrologic conditions in southwestern Minnesota where water supplies are difficult to locate. The original name of the project was the "Grid Drilling Program". One of the exploration strategies considered during the early stages of the project was to drill test holes at regularly spaced intervals or in a grid pattern. However, the test holes were located based on available geologic information and the name has been changed to the Southwestern Minnesota Groundwater Exploration Project 1996-1997.

An amount of $50,000 was appropriated from the General Fund to the DNR Division of Waters to be matched by an equal amount of money from non-state sources for a total program budget of $100,000 for the biennium. The non-state sources included: the City of Worthington, City of Luverne, Rock County Rural Water System, Lincoln-Pipestone Rural Water System, and the City of Marshall. The study area (Figure 1) was defined based on regional geology and the locations of the water suppliers that chose to participate. Specifically the project was designed to: 1) find potentially productive aquifers near the major water appropriators, and 2) obtain geological information to help predict the locations of the best aquifers for future investigations.

The purpose of this progress report is to summarize information gathered during the 1996 field season from portions of Rock, Nobles, Yellow Medicine, and Lincoln Counties. The remainder of the project, including planned test drilling in portions of Pipestone, Lyon and Yellow Medicine Counties, will be completed during the 1997 field season.

The test hole drilling locations (Figure 2) were chosen based on regional subsurface geology that was researched and compiled by the DNR for this project. The Minnesota Geological Survey (MGS), the U.S. Geological Survey (USGS), the project participants, and a consulting firm representing three of the participants reviewed the drilling plan and provided suggestions. The regional subsurface geology and target areas were discussed with all of these parties in meetings during the spring of 1996.

2.0 Regional Geology

Previous work in the study area was reviewed prior to drilling in order to locate promising test hole sites. Understanding the regional geology of the area was important for locating areas suitable for test drilling and for interpreting the results of the test drilling.

2.1 Stratigraphy

2.1.1 Cretaceous

The general stratigraphy of the area is shown in Figure 3. The Precambrian basement consists of hard rock such as quartzite and other metamorphic rock types. The Precambrian basement is overlain by a softer bedrock layer composed of Cretaceous shale, sandstone and silty marlstone units. The Cretaceous bedrock is overlain by unconsolidated Pleistocene glacial sediments and

other Quaternary deposits. The Cretaceous sandstone and Quaternary sand layers are the primary aquifers in the area.

The Cretaceous sedimentary rocks of southwestern Minnesota were deposited near the eastern shore of a large inland sea (Setterholm, D.R., 1990). The floor of the inland sea had very little topographic relief. The east-west trending Sioux Ridge which occurs in the southwestern portion of the study area (Figure 4) was partly exposed during the Cretaceous period.

At least two sandstone units within the Cretaceous bedrock have important aquifer potential: the Split Rock Creek Formation and the Dakota Formation. The Split Rock Creek sandstone occurs in South Dakota and the southwestern portion of the study area. This unit was deposited in a marginal marine setting (beach and offshore sand bar) at the edge of the exposed Sioux Ridge. The Dakota Formation, which occurs at the base of the Cretaceous section, was deposited in marginal marine and non-marine settings. This unit appears to be widespread and has a highly variable thickness.

2.1.2 Quaternary

The Quaternary section consists of Pleistocene or glacial age sediments deposited from 8,000 years to 2 million years before the present (B.P.) and Holocene (recent post-glacial) unconsolidated sediments. The Quaternary sediments are separated from the Cretaceous bedrock by a long period during which no deposition occurred (unconformity). The Cretaceous deposits were exposed and eroded for a very long time, creating a distinctive layer just above the Cretaceous bedrock. This layer is referred to in this report as the basal Quaternary (BQ) because it is found at the base of the Quaternary. The exact age of this layer is unknown. The basal Quaternary sediments are composed of unconsolidated sand and clay deposited in non-marine fluvial (stream deposits) and lacustrine (lake deposits) settings.

The remaining overlying portions of the Quaternary sediments can be divided based on surface exposures and subsurface evidence indicating boundaries between till layers (Patterson, 1995). The upper two units of Quaternary sediments (Units 1 and 2) were deposited as silty clay tills and outwash sands from Wisconsin and Late Wisconsin advances of the Des Moines glacial lobe (Figure 5). These units were deposited over most of the study area with the exception of Rock County, southwestern Pipestone County, and extreme southwestern Lincoln County.

The Pre-Wisconsin till/outwash units have been divided based on evidence from drill cuttings indicating previous land surface exposure. Where driller's or geologist's logs noted a change from an unoxidized color (such as gray) to an oxidized color (such as yellow, yellow-brown or tan), the color change was interpreted as the upper contact of a glacial unit that had previously been exposed to the land surface. In addition, thick sand layers and boulder/cobble zones were interpreted as representing the top or near top of the glacial till/outwash unit. Three glacial till/outwash units (Units 3, 4 and 5) can be identified in the Pre-Wisconsin section within the areas investigated to date.

2.1.3 Area Type Logs

Gamma and resistivity logs that represent typical geologic conditions in the area (type logs) have been included from Rock and Nobles Counties (Figures 6 and 7) and the Burr Well Field/Lake Cochrane area (Figure 8). The stratigraphic designations were made by referring to the

geologist's mud logs and by comparing with other gamma and resistivity logs in the area. The gamma and resistivity logs are a continuous depth records of the natural radiation and electrical resistivity of the subsurface formations measured from inside the drill hole. The geologist's mud log is a depth record of the subsurface geology created by identifying pieces of rock and sediment in the drilling mud that are circulated to the surface from the bottom of the drill hole. The till unit tops were commonly identified by a lower gamma reading indicating a higher quartz sand content. The higher quartz sand content was interpreted as evidence of deposition in an exposed environment during a glacial recession.

The unit designations within Rock and Nobles Counties are considered equivalent since correlations were made across the area with a network of cross sections (Section 3.2). For instance, that portion of the glacial deposits in the Worthington area identified as Unit 5 was deposited by the same glaciation as a Unit 5 interval in Rock County. No attempt has been made at this stage of the project to correlate between Rock and Nobles Counties and the Burr Well Field/Lake Cochrane area.

2.2 Topography

Much of the study area topography is depicted in the top layer of Figure 4. The region consists of a topographically high surface to the west, called the Prairie Coteau, and a low relief, lower elevation surface in the eastern portion of the area where Marshall and Worthington are located. The Prairie Couteau strongly influences groundwater flow direction (Bradt, R., 1996). The Prairie Coteau was created by deposition from successive glaciations and erosion of the adjoining lowland to the northeast by glaciation (Patterson, C. J., 1995).

3.0 Rock and Nobles Counties

3.1 Summary of Test Hole Information

Tables 1 and 2 (pages 6 and 7) are a summary of the potentially productive sand and sandstone layers that were encountered in the Rock and Nobles County test holes. The locations of the Rock and Nobles County test holes are shown in Figure 2. These test hole locations were chosen based on sand thickness maps that were created by the DNR from available well logs and published information. Geophysical information was also used to help locate the test holes in Rock County. The strategy in this area was to try to locate low areas in the top of the Cretaceous bedrock surface on the assumption that these low areas may have been occupied by streams prior to glaciation. Low gravity areas from a published gravity survey of Rock County (Chandler, V. W., 1994) were used to help locate test holes. Refraction seismic data collected at three locations in Rock County by the DNR geophysicists, also influenced the locations of the test holes.

The depth ranges of these intervals were determined from drilling rates, lithology from cuttings (mud log or drillers log), resistivity log responses, and gamma log responses. A fast drilling rate is often a good indicator of sand, sandstone, and gravel layers. A low gamma response (recorded by the line on the right side of the log), interpreted in conjunction with the mud log, indicates a high quartz sand content. These characteristics often correspond to material with good aquifer potential. The electrical resistivity of the layers is recorded as the solid line on the left portion of

the log. The resistivity values are controlled by the groundwater chemistry and the permeability/porosity of the layers.

Due to scheduling and drilling problems we were unable to log test holes 67-4 and 67-5 for gamma and resistivity. In addition, due to hole obstructions, we were only able to obtain a partial log of 67-1. A partial gamma and resistivity log was also obtained for test hole 53-7 due to scheduling difficulties for the logging equipment. The logged segment from 320 to 430 feet in test hole 53-6 is inaccurate due to a logging tool malfunction.

Most of the test holes in Rock and Nobles Counties were drilled to hard rock (Precambrian basement). Only test holes 67-1, 67-2 and 53-7 were not. Test holes 67-1 and 67-2 were only drilled into the Cretaceous bedrock due to the budgetary limitations. The 53-7 test hole was drilled to a depth just short of the hard rock due to difficulties in interpreting the geology from drill cuttings.

Table 1 Quaternary Sand Layers - Rock and Nobles Counties

Test Hole #	Depth Range (feet)	Thickness (feet)	Comments	Unit
53-2	134-154	20	Drilled very fast. Rough drilling indicated cobbles and gravel in this interval. Cuttings consisted of coarse to very coarse sand with gravel and rock fragments. Medium gamma response possibly due to a low quartz/high rock fragment composition of the sand and gravel.	2
53-2	224-261	37	Drilled very fast. Silty very fine to very coarse sand. Low gamma response, high resistivity.	3
53-3	400-426	26	Drilled fast. Silty medium to coarse sand. Medium to high gamma response, high resistivity.	BQ
53-4	320-346	26	Drilled fast. Silty very fine to very coarse sand. Low to medium gamma response, medium to high resistivity.	5
53-7	256-277	21	Drilled fast. Very fine to medium sand. Low gamma response, high resistivity.	BQ
67-5	176-198	22	Drilled fast. Medium to coarse sand. No gamma or resistivity log.	BQ
67-6	290-310	20	Drilled fast. Very fine to medium sand with some coarse sand. Low gamma response, medium resistivity.	BQ
67-7	260-284	24	Drilled very fast. Very fine to medium sand. Low gamma response, high resistivity.	BQ
67-8	204-232	28	Drilled very fast. Very fine to medium sand. Low gamma response, high resistivity.	BQ

Table 2 Cretaceous Sandstone Layers - Rock and Nobles Counties

Test Hole #	Depth Range (feet)	Thickness (feet)	Comments
53-3	620-744	124	Drilled very fast. Fine to medium sandstone with some coarse layers. Low gamma response, medium resistivity.
53-4	672-740	68	Drilled very fast. Fine to medium sandstone with some coarse layers. Low gamma response, medium resistivity.
53-6	456-508	52	Drilled very fast. Very fine to medium grained sandstone with some coarse sand. Low gamma response, medium resistivity.
67-6	395-455	60	Drilled very fast. Poor recovery, siltstone or very fine sandstone. Low gamma response, medium resistivity.
67-7	363-410	47	Drilled very fast. Poor recovery, some siltstone and very fine sandstone. Low gamma response, high resistivity.

3.2 Aquifer Distribution

The information from the test holes was used to revise and update maps (Figures 9 through 13) that were created at the beginning of the project. For each unit map all the available well logs in the area were used. The classification of the sand and sandstone layers (Units 1 through 5, BQ, and Cretaceous bedrock) from available well log data (driller, gamma and resistivity logs) were made by comparing each well log with an extensive system of geologic cross sections. Selected cross sections have been included in this report as Figures 14 through 19. Many Cretaceous bedrock classifications were obtained from the Minnesota Geological Survey (MGS) County Well Index database.

Cross section locations are shown on Figure 9. Prominent regional features are visible on the cross sections. The sloping Precambrian basement surface shown on Cross Sections A-A' (Figure 14), B-B'(Figure 15) and E-E' (Figure 18) is the southern slope of the buried Sioux Ridge. The Cretaceous section thins toward the north along this slope and is absent beneath the City of Luverne. Cross sections C-C' (Figure 16) and D-D' (Figure 17) are oriented perpendicular to the direction of lateral ice movement in the Wisconsin and Late Wisconsin, and perpendicular to the Bemis (Late Wisconsin) moraine. The highest topographic portions of these cross sections represent the Bemis moraine.

3.2.1 Quaternary Sand Thickness Maps

The general orientation of the subsurface sand units as drawn on these maps is based on a regional understanding of glacial ice movement and the associated sediment transport from the melting ice during glacial retreat (Wright, H.E., 1972). Glaciations that resulted in the deposition of the upper two units (Units 1 and 2) originated northwest of Minnesota and moved to the southeast. These ice movement directions are known from the orientation of surface exposures. Many of the major outwash channels, created during the recession of the glacier from the southeast to the northwest, probably had a similar northwest/southeast orientation. During glacial recession, outwash channels could have formed between the southwestern edge of the glacier and the northeastern slope of the topographically higher areas to the southwest (Southwick, D.L. et al., 1993). Schematic block diagrams illustrating this process are shown in Figure 20.

The orientation of basal Quaternary sand bodies in Rock County were derived by connecting sand thickness trends in southeastern South Dakota (Lindgren, R.J., 1992) with the Cretaceous bedrock topography trends of northwestern Iowa (Hansen, R.E., 1986). Less information is available regarding the orientation of Units 3, 4, and 5. Studies of Early Pleistocene deposits in Kansas, Nebraska, Iowa, and South Dakota, however, indicate significant glacial advances that affected southwestern Minnesota originated north and northwest of Minnesota (Patterson, C.J., 1993). Therefore, the dominant orientation of outwash units 3, 4, and 5 may also be northwest/southeast as suggested by the maps in this report.

The maps included in this report were created with this orientation information along with interpolations between data points. Therefore, the maps are interpretations from the drill hole data combined with the historical geology of the region. Actual subsurface conditions will be different in some areas, but the use of these maps for subsurface exploration should increase chances for success in finding productive sand layers.

3.2.2 Basal Quaternary (BQ)

The BQ sand occurs within an elevation range of 1,100 to 1,290 feet above the National Geodetic Vertical Datum (NGVD) in Rock and Nobles Counties (Figures 14 through 19). The known trend of the BQ in the Worthington area is shown in Figure 10. This unit was encountered in DNR test hole 53-3 and appears to have a northeast-southwest trend southeast of Worthington. Very little information exists regarding the width or maximum thickness of this unit.

More information on the BQ exists in Rock County which is mainly due to the 1996 DNR and the 1995 USGS test hole drilling programs. DNR test holes 67-4 through 67-8 in southeastern Rock County penetrated a laterally continuous BQ sand layer with an average thickness of 20 to 25 feet. Test holes 67-1 through 67-3 were drilled in an effort to find the northwesterly extension of this layer. Unfortunately, the thickest portion of this unit between Steen and Beaver Creek was not found. The maximum thickness of this unit along the Steen/Beaver Creek appears to be is at least 46 feet based on a domestic or farm well located approximately midway between test holes 67-2 and 67-3.

Test hole 53-7, located approximately 3 miles west of Adrian, penetrated 21 feet of BQ. A domestic or farm well located approximately 3.5 miles north-northwest of test hole 53-7 encountered 38 feet of BQ. This information suggests a general north-south trend of the BQ sand layer in this area.

3.2.3 Unit 5

The known trend of Unit 5 outwash in the Worthington area is shown in Figure 11. This unit was encountered in DNR test hole 53-4. This unit and Unit 4 have been objectives of a recent exploration and evaluation project northeast of Worthington completed by a Minneapolis consulting firm (B.A. Liesch and Associates, November 1996). Maximum sand thickness may range from 20 to 30 feet and the width of the thickest sandy intervals appear to be less than a half a mile.

Less information exists regarding this unit in Rock County. Thick intervals of this unit were not encountered in any of the DNR test holes in this area. The Unit 5 outwash occurs within an elevation range of 1,210 to 1,390 feet (NGVD) in Rock and Nobles Counties.

3.2.4 Unit 4

Unit 4 outwash in the Worthington area appears to have a maximum thickness of 20 feet and the width of the thickest sandy intervals is less than a half mile (Figure 12). Unit 4 outwash is thin or absent in the Rock County. A buried channel appears to exist just southwest of Luverne; however, the northwest and southeast ends of this channel terminate at the Beaver Creek and Rock River Valleys, respectively, limiting the extent of the aquifer. This outwash unit is found within an elevation range of 1,300 to 1,500 feet (NGVD) in Rock and Nobles Counties.

3.2.5 Unit 3

The data availability for Unit 3 outwash in the entire Worthington area is generally good (Figure 13). In the Worthington area, a buried system of channels exists which converge to the south.

This unit was encountered in test hole 53-1 with a thickness of 6 feet and in test hole 53-2 with a thickness of 37 feet. The maximum thickness of sand and gravel in this unit (72 feet) was encountered in a domestic well approximately one mile west of test hole 53-3. Typical of most of these Quaternary units, the width of the thickest sandy intervals is less than one half mile. Unit 3 outwash in Rock County and has been eroded or mixed with younger deposits. The elevation range of this unit in the area is 1,380 to 1,550 feet (NGVD).

3.2.6 Unit 2

Unit 2 has not been mapped but was encountered in test hole 53-2 with a thickness of 20 feet. In the Worthington area this unit has an elevation range of 1,440 to 1,650 feet (NGVD).

3.2.7 Cretaceous Sandstone

Some thick sandstone layers were encountered in five of the test holes. The thicker layers (greater than 20 feet) ranging from 47 feet (test hole 67-7) to 124 feet (test hole 53-3). These thick sandstone layers occur in the middle to lower portions of the Cretaceous bedrock. The sandstone layer at the base of the Cretaceous bedrock found in test holes 53-3 and 53-4 is the Dakota Formation (Figure 17, Cross Section D-D'). This unit was deposited predominantly in a stream environment (Setterholm, D.R., 1990). Therefore, sandstone bodies within the formation tend to be localized and do not extend over a wide area. For instance, the 124 foot thick sandstone layer penetrated in test hole 53-3 is mostly absent in wells or test holes approximately 2 miles to the north or south.

Some potential large capacity aquifers appear to exist in the Cretaceous sandstone in the vicinity of test holes 53-6, 67-6, and 67-7 (Figure 16, Cross Section C-C'). A 47-60 foot thick zone with a low gamma response exists in the middle portion of the Cretaceous section. The gamma log trace of this layer is very similar in each test hole. The unit may be marine in origin (deposited in a beach or sand bar setting) and, if so, would tend to be widespread or laterally continuous making it easier to find in the subsurface. In test hole 53-6, the unit was composed predominantly of medium sand grains. To the southwest, only small amounts of silt and very fine sand were recovered from this interval in test holes 67-6 and 67-7 indicating that the unit is very fine grained in this area.

3.3 Pumping Capacity

Evaluating maximum aquifer pumping rates and groundwater quality were not among the objectives of this project. However, for the participants in this project this information is obviously important for making decisions about the future development of these resources. None of the aquifers described in this report in Rock and Nobles Counties are used for municipal water supply by any of the larger communities or rural water companies. Major water appropriators in the area to date have been using shallower sources of groundwater. However, some information is available from Valley Springs, South Dakota; Rushmore, Minnesota; and the City of Worthington.

Valley Springs has two municipal wells in the BQ unit which is also called the Valley Springs aquifer in South Dakota (Lindgren, R.J., 1992). The maximum thickness of the Valley Springs aquifer occurs 1 to 2 miles northwest of the City of Valley Springs. The City of Valley Springs municipal wells produce from a medium to coarse sand with a thickness of 8 and 15 feet in wells

#1 and #2, respectively. Well #1 was tested for 12 hours at 200 gpm with 60 feet of drawdown. Well #2 was test pumped at 150 gpm for an unknown time period with a drawdown of 32 feet. Current production from municipal wells #1 and #2 is 88 gpm and 202 gpm, respectively.

The City of Rushmore has a well (Minnesota Unique #475657) that has been completed in a 31 foot Unit 4 sand layer. According to Larry Lupkas, the City of Rushmore Maintenance Supervisor, this well typically produces at a rate of 120 gallons per minute (gpm) which is all they need to meet their water supply needs. Mr. Lupkas indicted that this rate produces very little drawdown of the water level in the well. Water quality information was not available for samples from this well.

The City of Worthington contracted B.A. Liesch and Associates to evaluate buried Quaternary sand aquifers (Units 4 and 5) approximately 2 miles northeast of the city limits. A test production well, which was screened across 26 cumulative feet of medium to coarse sand, was pumped for approximately 4 days at 569 gpm. According to the report, the test could not run long enough to determine a long term sustainable yield due to farm well interferences. The drawdown data indicate a long term sustainable yield less than the 569 gpm test pumping rate.

This limited amount of information from these three municipalities seems to indicate sustainable yields from 20 to 30 foot thick buried Quaternary sand channels may range from 200 to 500 gpm.

3.4 Water Quality

Water quality information from Quaternary sand or Cretaceous sandstone aquifers was not generated as part of this project, however, limited water quality data were developed for another DNR project (Bradt, R., 1996) and from private sources (B.A. Liesch and Associates, 1996). The samples from both studies were analyzed for a wide range of chemical parameters. Only total dissolved solids (TDS) and sulfates have been summarized in this report. TDS was calculated by summing the reported constituents (total, as reported).

Six farm wells and five observation wells completed in buried Quaternary sand layers within a 2 mile radius of Worthington were sampled in the DNR and Liesch studies, respectively. Groundwater samples from the Units 2 through 5 are represented in these studies. The TDS concentrations ranged from 972 milligrams per liter (mg/l) to 2,591 mg/l. The average TDS concentration was 1,931 mg/l. Concentrations of sulfate ranged from 325 mg/l to 1,580 mg/l, with an average concentration of 1,150 mg/l.

Four Rock County samples were collected from buried Quaternary sand aquifers according to the Bradt report. Three of these samples were collected within a 2 mile radius of Luverne from the Unit 4, Unit 5, and BQ sand layers. The TDS concentrations of these samples ranged from 523 mg/l to 2,517 mg/l with an average concentration of 1,381 mg/l. The sulfate concentrations from these samples ranged from 37 mg/l to 1,217 mg/l with an average of 561 mg/l.

In addition, the City of Valley Springs supplied water quality information from their #1 municipal well at our request. The water sample from the BQ sand layer in this well contained 970 mg/l TDS and 105 mg/l sulfate.

Only one reliable Cretaceous sandstone groundwater sample was collected near the areas investigated in this drilling study. The sample was collected 3 miles east of Ellsworth and contained 2,988 mg/l TDS and 1,660 mg/l sulfate.

Concentrations of TDS and sulfate from the buried Quaternary sand aquifers in the Worthington area are high and somewhat uniform. The water quality appears to improve some in Rock County and the variability appears to increase.

4.0 Burr Well Field/Lake Cochrane Area

4.1 Summary of Test Hole Information

Three test holes were drilled in this area at locations shown in Figure 2. Test hole depths ranged from 484 feet (87-8) to 724 feet (87-7). The test holes in this area were drilled to the base of the Quaternary section. Test holes 41-1 and 87-7 were drilled 102 to 259 feet, respectively, into the Cretaceous bedrock. The most promising sand layers in the glacial till, with a thickness of 20 feet or greater, are shown in Table 3.

The shallow sand layer in 87-7 (70-153 feet) correlates with the upper aquifer that is being pumped at the Burr Well Field. This aquifer is referred to in South Dakota, and locally, as the Prairie Coteau aquifer (Kame, Jack, 1985). According to South Dakota naming conventions, the Prairie Coteau aquifer consists of outwash deposits that are found between surface/near-surface aquifers and the Altamont aquifer at the base of the Quaternary section. In the Burr Well Field/Lake Cochrane area the Prairie Coteau aquifer is composed of four hydraulically connected outwash sand layers (Units 2, 3, 4a, and 4b) which are discussed in Sections 4.2 and 4.3.

The deepest sand layers in 41-1 (461-496 feet) and 87-7 (355-393 feet) are part of the basal Quaternary unit which locally, and in South Dakota, are referred to as the Altamont aquifer (Kame, Jack, 1985). The name of the Altamont aquifer has nothing to do with the Altamont phase of the Des Moines lobe glacier and no depositional relationship is suggested by this shared name. The Altamont is also being pumped at the Burr Well Field.

Many thin (less than 20 feet) sand layers were encountered in the 87-8 test hole; otherwise, there is nothing notable about the aquifer potential at this location. The deepest test hole, 87-7, penetrated 230 feet of the Cretaceous section. A unit with a low gamma response occurs from 600-630 feet. This unit is the Niobrara siltstone or a silty marlstone without any aquifer potential.

Table 3 Quaternary Sand Layers
Burr Well Field/Lake Cochrane Area

Test Hole #	Depth Range (feet)	Thickness (feet)	Comments	Unit
87-7	70-153	83	Drilled very fast. Complex layers of different grain sizes ranging from very fine to fine sand and coarse to very coarse sand. Low gamma response with a ragged appearance indicating thin clay interbedded layers. Medium to high resistivity.	3
87-7	180-202	22	Drilled very fast. Medium to very coarse sand overlying very fine to medium sand. Low gamma response, medium resistivity.	4a
87-7	355-393	38	Drilled very fast. Silty very fine to coarse sand. Low gamma response, medium to high resistivity.	BQ
41-1	277-312	35	Drilled fast. Medium sand. Low gamma response, medium to high resistivity.	4b
41-1	461-496	35	Drilled fast. Fine to coarse sand, predominantly medium grained. Low gamma response, medium to high resistivity.	BQ

4.2 Aquifer Distribution

Abundant high quality test hole information is available from South Dakota northwest of the DNR test hole locations (Figures 21 through 23). Information from DNR test holes 87-7, 87-8, and 41-1 was integrated with information from this area.

The orientation of the outwash units 4, 3, and 2, described in the following sections (Figures 21 through 23), is dominantly northwest-southeast and the thickest portions of these units occur within the same localized trend.

4.2.1 Basal Quaternary (Altamont aquifer)

Only a few boreholes in the Burr Well Field/Lake Cochrane Area have penetrated the basal Quaternary unit. Sand thicknesses range from 10 feet to 100 feet in the South Dakota test holes. Sand thicknesses in the basal Quaternary unit from the same general area in Minnesota range from approximately 10 to 35 feet. The thickest sand in South Dakota was encountered in DU-73A approximately 2 miles west-northwest of DNR test hole 41-1 (Cross Section D-D', Figure 27). The unit has an elevation range of approximately 1,200 to 1,300 feet (NGVD).

The basal Quaternary sand layers found in the DNR test holes were associated with a dark brown clay unit that is interpreted as lacustrine. Similar to the overlying outwash sand units, thick sand portions of the BQ may have a northwest - southeast orientation. Not enough information is available to create a useful sand thickness map. This unit appears to be hydraulically isolated from the overlying sand units according to stratigraphic relationships (Figures 24 through 27).

4.2.2 Unit 5

This unit has an elevation range of approximately 1,300-1,380 feet (NGVD). The maximum sand thickness in this unit (28 feet) is at a domestic well located approximately 3 miles east of DNR test hole 87-8 (Cross Section D-D', Figure 27). Not enough data were available to create a useful sand thickness map. No major water production occurs from this unit. This unit appears to be hydraulically isolated from the overlying sand layers (Figures 24 through 27). Unit 5 and all the overlying units are absent in the eastern portion of the mapped area due to erosion by subsequent glaciation.

4.2.3 Unit 4

Unit 4 appears to have two identifiable sections, Unit 4a and Unit 4b, in the central portion of the mapped area. The two sections are shown on cross-section D-D' (Figure 27) with the tops of the subunits occurring at the tops of sand layers. Elsewhere, the tops of these subunits have been interpreted to occur at the oxidized till layers. These two subunits appear to merge near the trace of cross section A-A' (Figure 21). No evidence of a division in Unit 4 exists in boreholes along Cross Section A-A'. This division of Unit 4 may be due to a minor advance and retreat of the glacier within a 6 to 7 mile central portion of the mapped area.

The maximum thickness of Unit 4a outwash is 40 feet at the Burr Well Field (Figure 26, Cross Section C-C'). The Unit 4 outwash units occur at an elevation range of approximately 1,400 to 1,530 feet (NGVD). These subunits and the overlying outwash units appear to be hydraulically connected.

4.2.4 Unit 3

Sand thicknesses of 80 feet and greater are common within the Unit 3 outwash (Figure 22). Two southeast trending channels converge southeast of Lake Cochrane and extend into Minnesota through the DNR 87-7 test hole location. The typical width of the thick sand and gravel portion of this unit (greater than 20 feet) is approximately 2.5 miles. Unit 3 outwash occurs at an elevation range of approximately 1,500 to 1,620 feet (NGVD).

4.2.5 Unit 2

Thick Unit 2 outwash exists along a northwest southeast trend southwest of Lake Cochrane and probably extends into Minnesota somewhere between DNR test holes 41-1 and 87-7 (Figure 23). While this outwash unit is somewhat thinner than the underlying Unit 3, the width of the thick outwash is approximately the same 2 to 2.5 miles. Unit 2 outwash has an elevation range of approximately 1,600 to 1,780 feet above sea level.

4.3 Pumping Capacity

The Prairie Coteau aquifer was tested from the Burr Well Field during January 1991 (B.A. Liesch and Associates, 1991) and again during July 1993 (B.A. Liesch and Associates, 1993). The first test consisted of pumping from Well No. 1 (MN Unique #440325) for 72 hours at 750 gpm. The late time transmissivity from this test averaged 51,000 gallons/day/ft. The second test consisted of pumping from the same well for 7 days with an average discharge of 818 gpm. The late time transmissivities from this test average approximately 56,000 gallons/day/ft. Using the 56,000 gallons/day/ft value and assuming an aquifer thickness of 160 feet, the Prairie Couteau aquifer in this area has a hydraulic conductivity of 350 gallons/day/foot squared.

The basal Quaternary sand layer is locally referred to as the Altamont aquifer. This aquifer was tested at the Burr Well Field for six days during November/December 1994 (B.A. Liesch and Associates, 1995). The test consisted of pumping from well ALT-TPW-94 (MN Unique #550052) at approximately 465 gpm. The average transmissivity from this test was approximately 8,700 gallons/day/ft. Using an aquifer thickness of 30 feet, the Altamont aquifer has a hydraulic conductivity of 290 gallons/day/foot squared. This value and the hydraulic conductivity value of the Prairie Coteau aquifer are about average for silty sand aquifers (Freeze and Cherry, 1979).

4.4 Water Quality

Water quality information is also available from the Burr Well Field wells. Water samples from the Prairie Coteau and Altamont aquifers were collected from the same production wells that were described in the previous section (B.A. Liesch and Associates, 1991 and B.A. Liesch and Associates, 1993). Water samples from Well #1 (Prairie Coteau aquifer) contained an average sulfate concentration of 370 mg/l and an average TDS concentration of 1,532 mg/l (total, as reported) . Water samples collected from ALT-TPW-94 (Altamont aquifer) contained an average sulfate concentration of 284 mg/l and an average TDS of 1,442 mg/l (total, as reported).

5.0 Recommendations

5.1 Worthington Area

The Worthington area is underlain by at least one Cretaceous sandstone and five Quaternary outwash units with aquifer potential. The Quaternary units are attractive targets for groundwater development because they occur at relatively shallow depths and are typically composed of medium to coarse grained sand and gravel. In addition, the water quality in the Quaternary outwash units appears to be a little better than groundwater from the Cretaceous sandstone. The disadvantage of pursuing the buried Quaternary sand layers for municipal water supplies include the narrow width and thinness of some buried channel deposits, and the potential for interference with nearby farmstead wells. Pursuing the lower units (BQ, Unit 5, and Unit 4) in areas west and south of Worthington may help avoid well interference problems since few existing wells penetrate these units in this area.

The Unit 3 trends identified in this study west and south of Worthington may also be good exploration targets. A relatively thick sand (37 feet) in this unit was encountered in test hole 53-2 located approximately one mile west of Worthington. The few farm wells that penetrate Unit 3 combined with the recently drilled DNR test holes provide enough information to determine the general trend of this unit. Unit 3 is also a good development objective since it appears to have some of the thickest sands of all the buried Quaternary units in Rock and Nobles Counties.

The 124 foot thick sandstone layer at the base of the Cretaceous section in test hole 53-3 was also a significant discovery. The development of this aquifer will be determined by the extra cost caused by the greater depth of this sandstone and the limitations of it's poorer water quality.

5.2 Rock County

The Rock County Rural Water System and the City of Luverne have fewer options for groundwater supplies than the City of Worthington. Units 1 and 2 were never deposited in the area and Units 3 and 4 are highly eroded west of Adrian. In addition, the Precambrian Sioux Quartzite is exposed at the surface north of Luverne along the Sioux Ridge which eliminates the possibility of finding high capacity aquifers in that area. Even with these limitations, this study has shown that groundwater resources are available in this area.

One of the major objectives of this exploratory drilling project was to search for a basal Quaternary sand that we expected to be present in the area from southeast of Beaver Creek to west of Ellsworth. A new aquifer unit was discovered by this project in the basal Quaternary sand in the test hole 67-5 through 67-8 area. The aquifer at that location consists of 20 to 28 feet of predominantly medium grained sand which may not suit the high capacity (>500 gpm) needs of the City of Luverne and the Rock County Rural Water System. However, one farm well (Minnesota Unique #113705) located along the northwestern trend of this aquifer encountered 46 feet of sand. The driller's log did not specify the grain size of the sand. This information suggests that the thickest part of the aquifer has not yet been defined and the potential for finding a high capacity aquifer in this area may still exist.

Additional exploration, to better determine the potential of this unit, should be focused along the trend between Steen and Beaver Creek that is shown in Figure 10. Aquifer testing of the BQ in the vicinity of 67-5 through 67-8 could determine whether this portion of the aquifer can sustain the desired levels of pumping. Information from the Valley Springs municipal well #1 (105 mg/l sulfate) suggests that the water quality in this aquifer may be better than most in the area.

Another suspected basal Quaternary sand unit east of Magnolia appears to have been confirmed by test hole 53-7. This test hole encountered a 20 foot thick BQ sand approximately 3.5 miles south-southeast of a 38 foot BQ sand in a farm well. This sand unit may also have potential as a high capacity aquifer. Additional test drilling, to better define the potential of this unit, should be focused along the trend between Adrian and Magnolia shown in Figure 10.

Another potential aquifer of Cretaceous age appears to exist in the area around test holes 53-6, 67-6, and 67-7. The 47-60 foot thick zone appears to be laterally continuous but the unit appears to be very fine grained around test holes 67-6 and 67-7 which will limit the aquifer's capacity. No information is available regarding the quality of water in this unit.

5.3 Burr Well Field Area

The distribution of the deeper aquifers in this area (Unit 5 outwash and Altamont aquifer) is not known since very few boreholes penetrate these units. The Altamont aquifer is an attractive target since it is relatively thick, possibly widespread, and produces relatively good quality water. In addition, based on stratigraphic relationships, this aquifer appears to be hydraulically isolated from the overlying Prairie Coteau aquifer. This isolation should might prevent water level drawdown in nearby wetlands and other wells completed in shallower aquifers. Additional test drilling is required to define the thickest portions and extent of this aquifer.

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Glossary

Aquifer — A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs.

Cretaceous — A period that lasted from 136 million years to 64 million years before the present.

Fluvial — Pertaining to streams and the deposits and landforms produced by streams.

Formation — A rock unit distinguished from adjacent deposits by some common character such as composition or origin.

Gamma/ resistivity log — A continuous depth record of the natural radiation and electrical resistivity of the subsurface formations measured from inside the drill hole. Low gamma readings and higher resistivity readings together may suggest that an aquifer is present.

Glacial till — Unsorted and unstratified glacial material, generally unconsolidated, directly deposited by and underneath a glacier without subsequent reworking by meltwater. Consisting of a heterogeneous mixture of clay, silt, sand, gravel, and boulders ranging widely in size and shape.

Groundwater — The water contained in interconnected pores in an aquifer.

Hydraulic conductivity — A coefficient of proportionality describing the rate at which water can flow through a permeable medium. Specifically, the flow rate of a water volume per unit of time through a given cross sectional area (i.e. gallons/day/square foot). A larger number indicates a better aquifer.

Lacustrine — Pertaining to lakes and the deposits and landforms produced by lakes.

Lithology — The composition of a rock or formation.

Mud log — A depth record of the subsurface geology created by identifying pieces of rock and sediment in the drilling mud that are circulated to the surface from the bottom of the drill hole.

Outwash — Stratified sand and gravel removed or washed out from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of an active glacier.

Permeability	The property or capacity of porous rock, sediment, or soil for transmitting a fluid; it is a measure of the relative ease of fluid flow under unequal pressure. The more permeable the formation, the better it functions as an aquifer.
Porosity	The percentage of the bulk volume of a rock or soil that is occupied by interstices, whether isolated or connected. Higher porosity values that are connected indicate a better aquifer.
Pleistocene	The first epoch of the Quaternary Period. Characterized by the spreading and recession of continental ice sheets.
Precambrian	The earliest geologic era covering all the time before the Cambrian Period.
Quaternary	A latest period of time in the stratigraphic column occurring 0 to 2 million years before the present. This period consists of glacial (Pleistocene) and post-glacial (Holocene) deposits.
Sandstone	A bedded sedimentary rock composed largely of sand grains which are cemented together by various binding materials such as silica or calcite.
Shale	A fine grained sedimentary rock formed by the consolidation of clay, silt, or mud. It is characterized by finely laminated structure.
Sulfate	Dissolved mineral found in some groundwater composed of one sulfur atom and four oxygen atoms. Derived from the dissolution of gypsum or anhydrite. Higher values indicate water that is less desirable for general use without treatment.
Stratigraphy	The study of stratified rocks or sediments especially their sequence in time, the character of the rocks or sediments and the correlation of beds in different localities.
Topography	Representing the surface features of a region including its relief, lakes, and rivers etc.
Transmissivity	The rate at which water is transmitted through a unit width of an aquifer, under a unit hydraulic gradient, extending the full saturated height of the aquifer. A larger value indicates a better aquifer.
Wisconsin	The last glaciation of the Pleistocene Epoch.

Appendix 1 - Figures

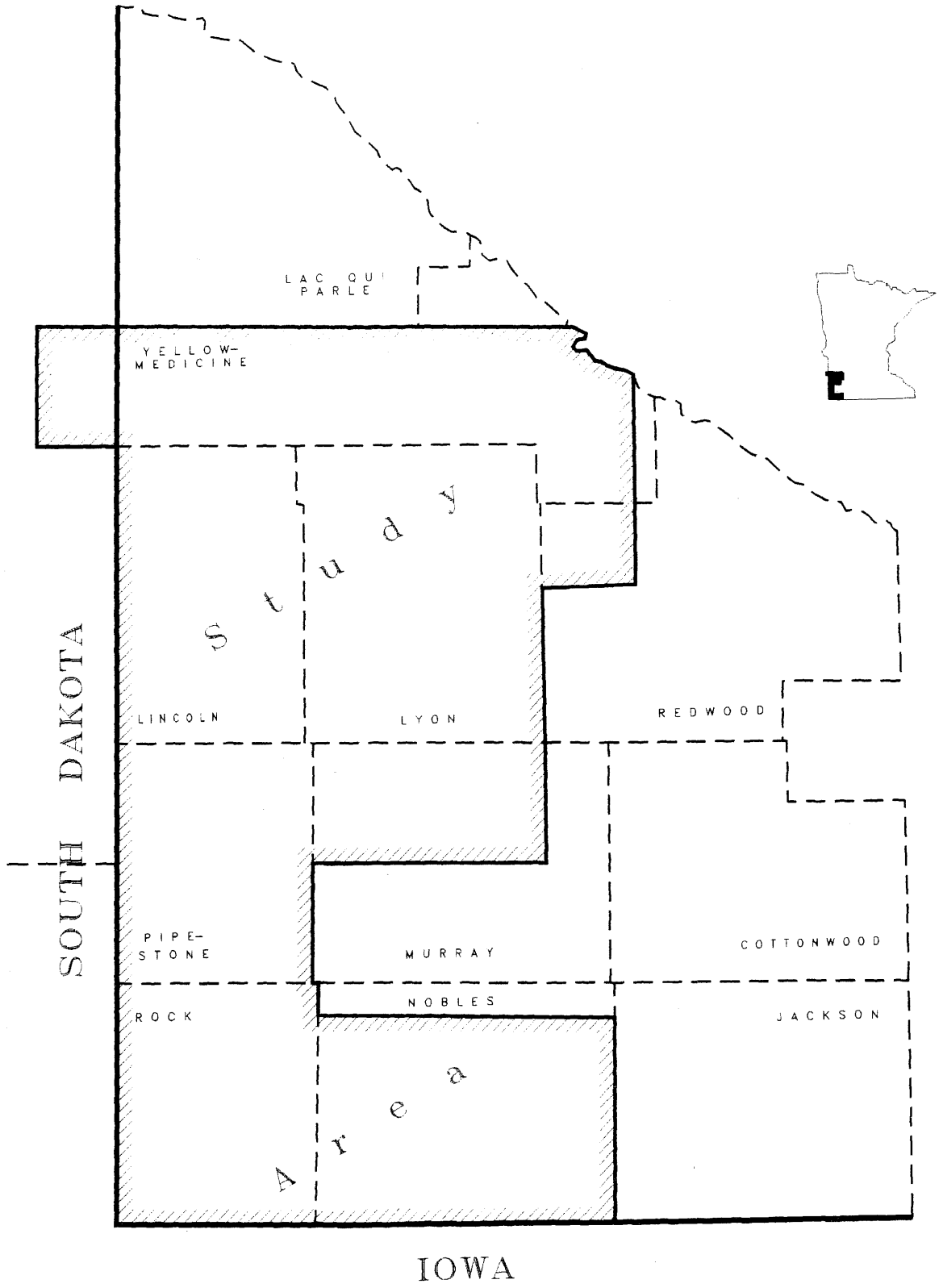

Figure 1 Study area

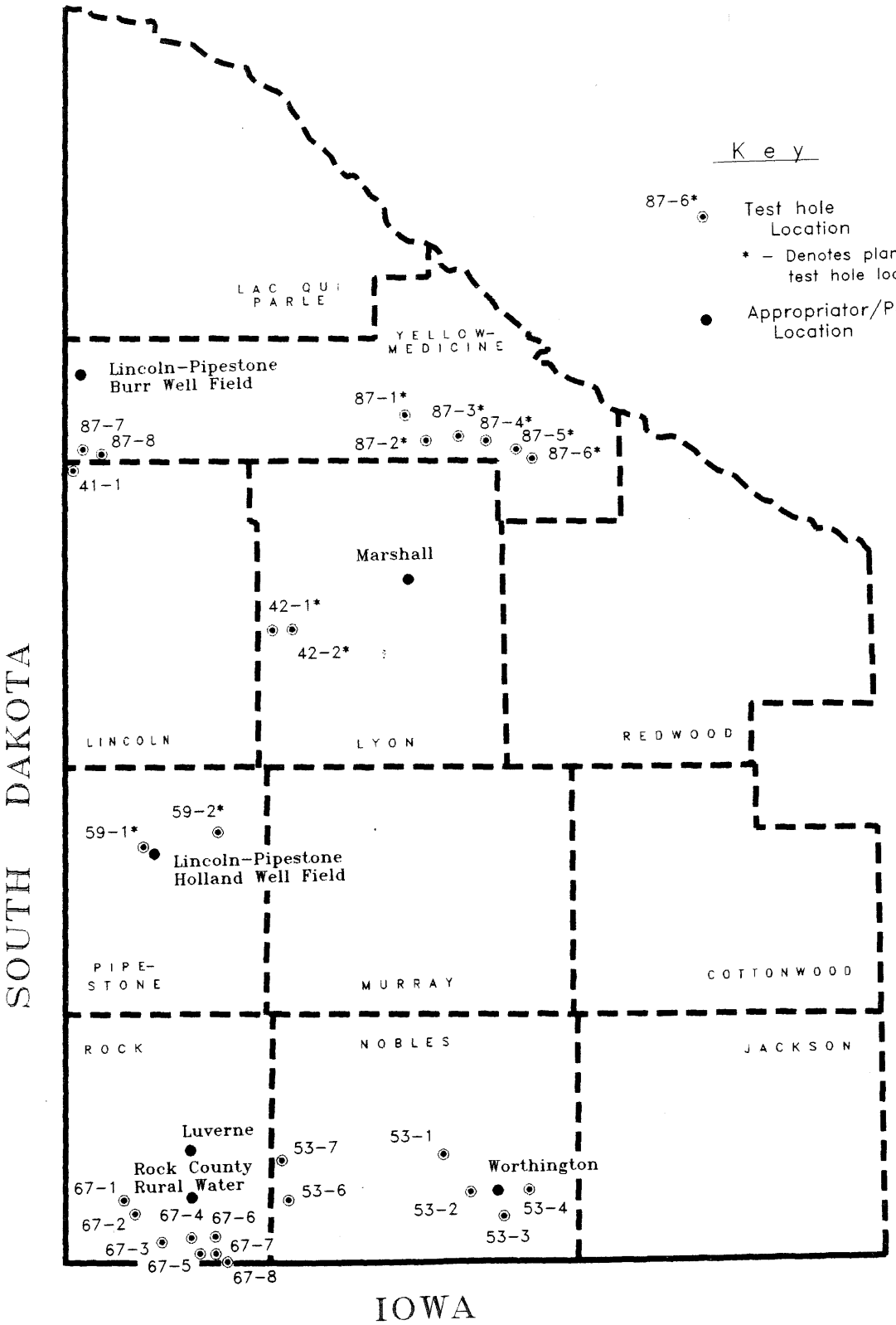

Figure 2 Test hole and planned test hole locations

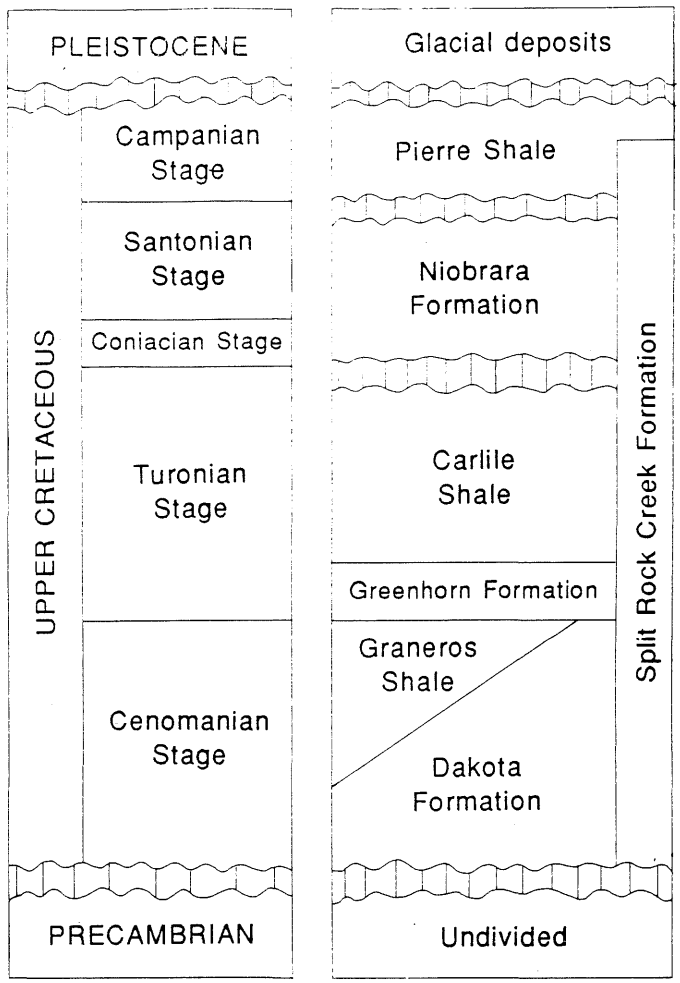

Figure 3 Stratigraphy of southwestern Minnesota (Modified from Setterholm, D.R. 1990)

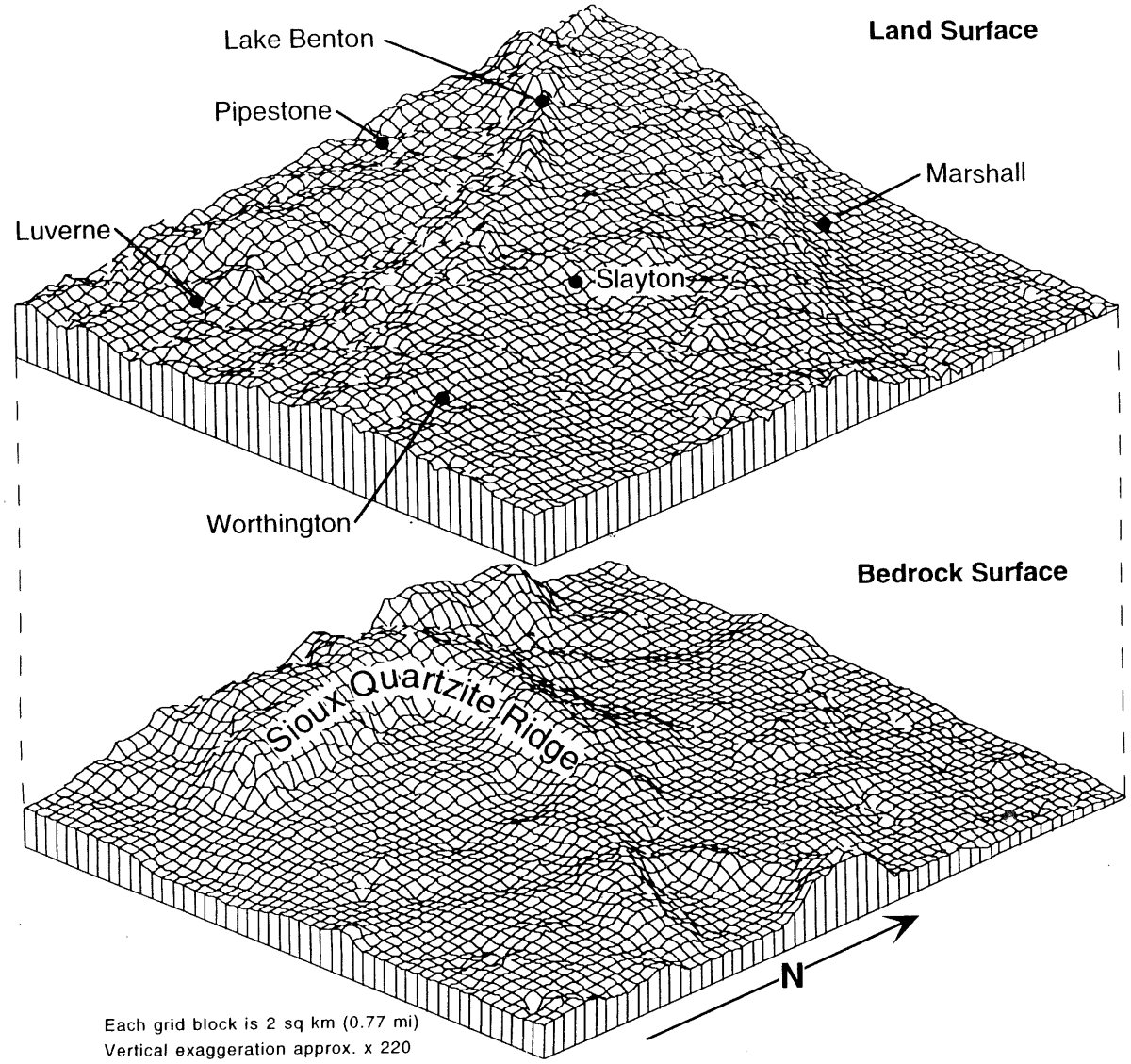

Figure 4 Topography of land and bedrock surfaces in southwestern Minnesota and contiguous areas of South Dakota and Iowa (Patterson, C. 1995)

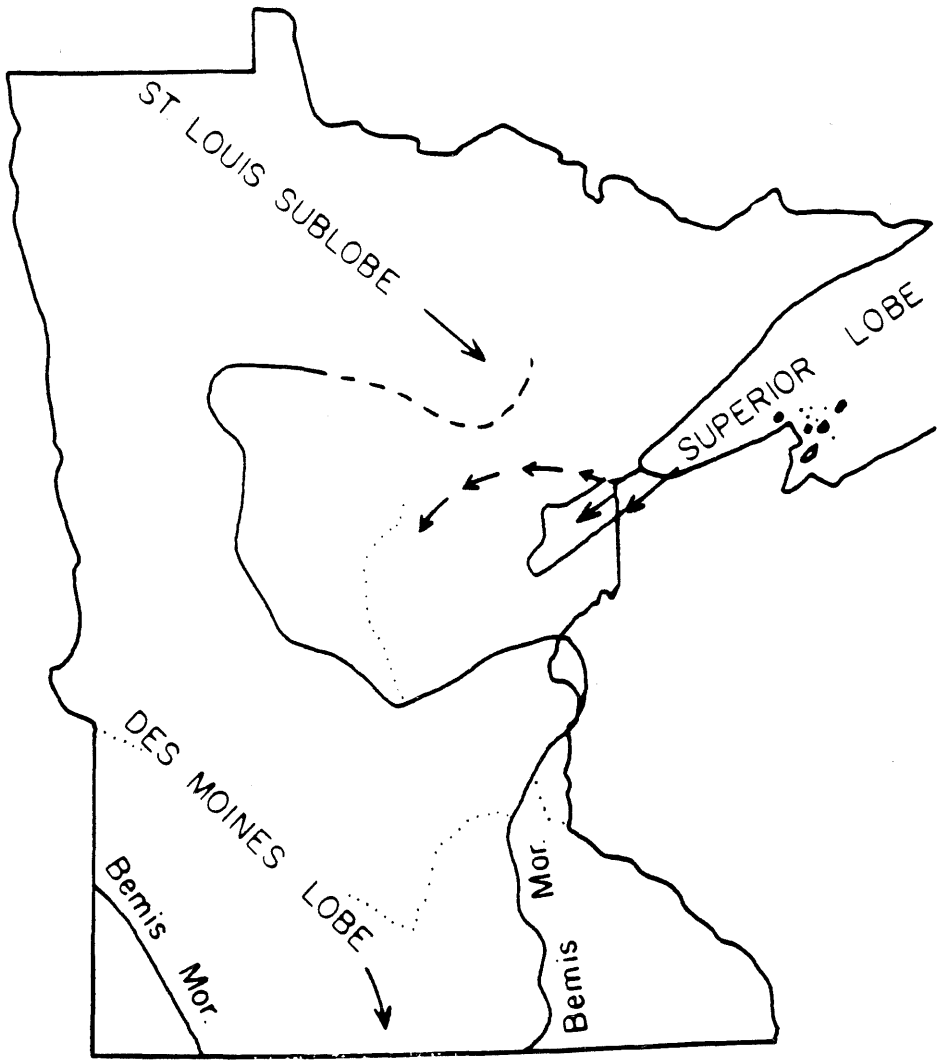

Figure 5 Des Moines lobe glacier in Minnesota during the Late Wisconsin (Modified from Wright, H.E. 1972)

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St. Paul MN 55114
Dept. Phone(612)627-4780

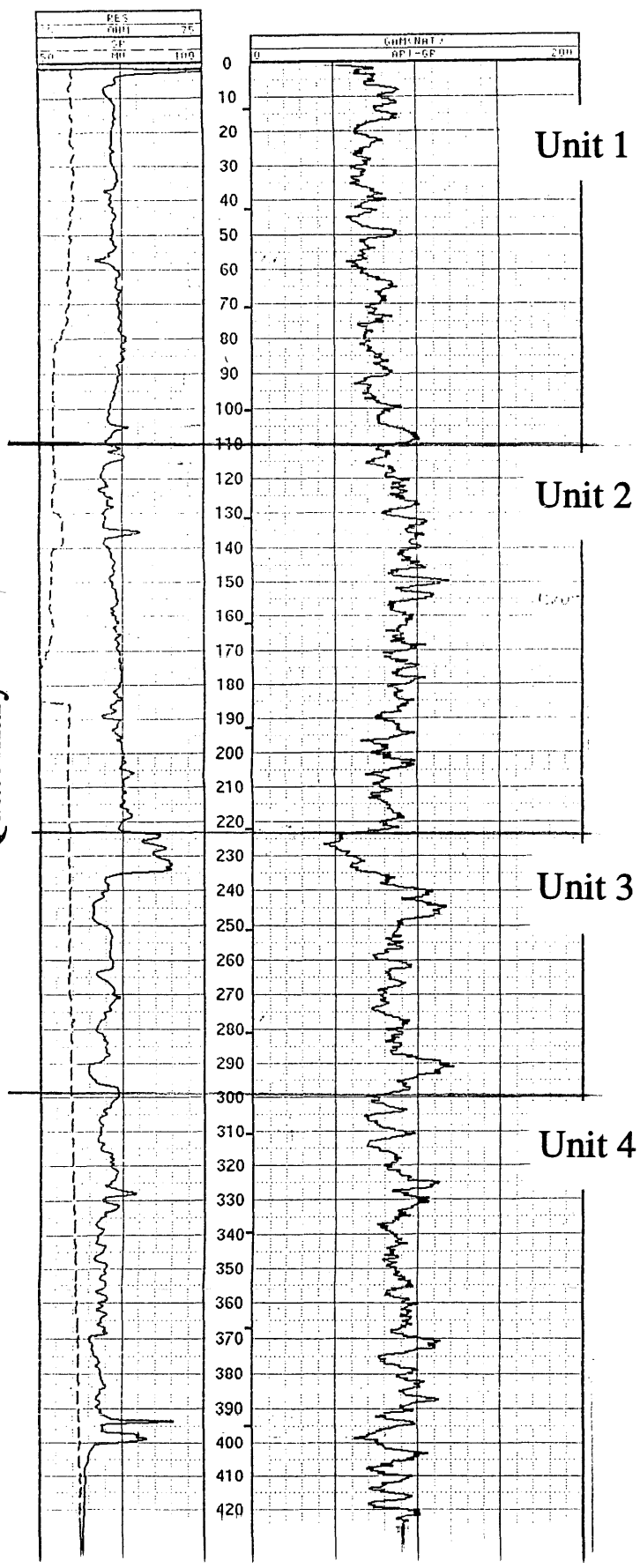
MINNESOTA GEOLOGICAL SURVEY 1872

DNR 53-1

IDENTIFIER	: DNR 53-1			OTHER SERVICES:	
UNIQUE NUMBER	: DNR 53-1				
QUADRANGLE	: READING 15M				
COUNTY	: NOBLES				
SUBSECTION	: NWNWSW				
SECTION	: 13	TOWNSHIP	: 102	RANGE	: 41
DATE	: 08/27/96	STATIC LEVEL	: 1	ELEVATIONS	
DEPTH DRILLER	: 987	M.G.S. CUTTINGS	:	KB	:
LOG BOTTOM	: 996.10	LOG MEASURED FROM:	GL	DF	:
LOG TOP	: 0.90	DRL MEASURED FROM:		GL	: 1655.3
CASING DEPTH	:	LOGGING UNIT	: C-1		
CASING TYPE	: NONE	FIELD OFFICE	: TRUCK		
CASING DIAMETER	:	RECORDED BY	: SETTERHOLM		
BIT SIZE	:	BOREHOLE FLUID	: MUD	FILE	: ORIGINAL
MAGNETIC DECL.	:	RM	:	TYPE	: 98690
MATRIX DENSITY	:	RM TEMPERATURE	:	LOG	: 0
FLUID DENSITY	:	MATRIX DELTA T	:	PLOT	: 98690 0
NEUTRON MATRIX	:	FLUID DELTA T	:	THRESH:	
REMARKS	:				

NO CABLE STRETCH CORRECTION USED.

THIS LOG MAY NOT BE USED TO FULFILL CONTRACTUAL OBLIGATIONS



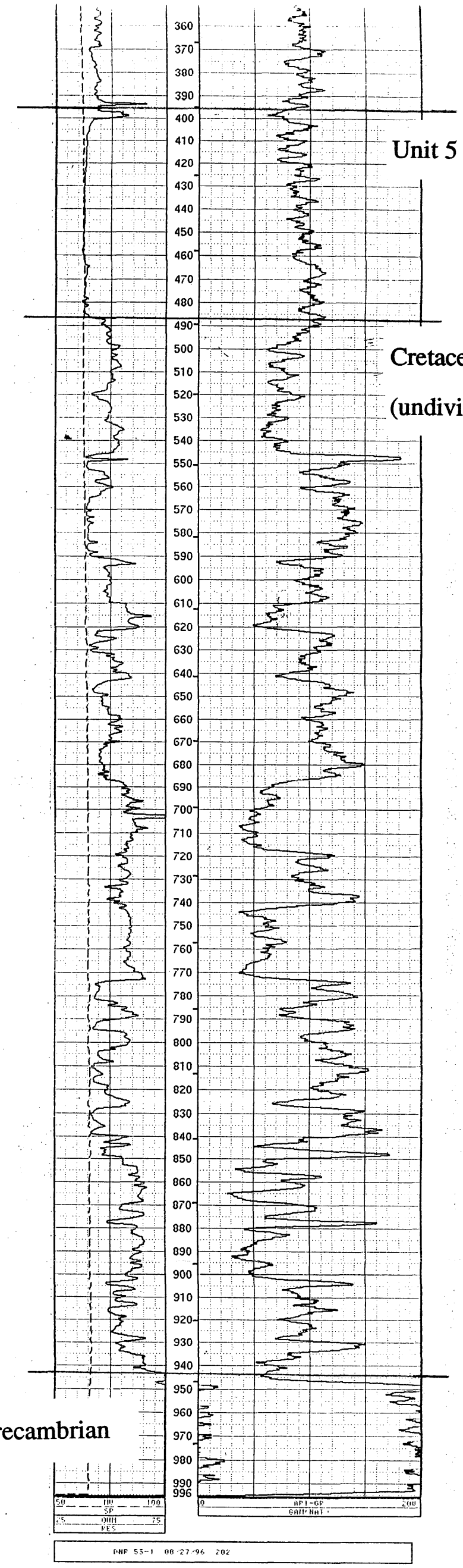


Figure 6 Type gamma/resistivity log - Worthington area

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MINNESOTA GEOLOGICAL SURVEY 1872

DNR 67-8

IDENTIFIER	: DNR 67-8			OTHER SERVICES:	
UNIQUE NUMBER	: DNR 67-8				
QUADRANGLE	: ASH CREEK 21C				
COUNTY	: ROCK				
SUBSECTION	: DDDDDC				
SECTION	: 32	TOWNSHIP	: 101	RANGE	: 44
DATE	: 10/10/96	STATIC LEVEL	: 1	ELEVATIONS	
DEPTH DRILLER	: 489	M.G.S. CUTTINGS	:	KB	:
LOG BOTTOM	: 489.50	LOG MEASURED FROM	: GL	DF	:
LOG TOP	: 0.40	DRL MEASURED FROM	:	GL	: 1397 '
CASING DEPTH	:	LOGGING UNIT	: C-1		
CASING TYPE	: NONE	FIELD OFFICE	: TRUCK		
CASING DIAMETER	:	RECORDED BY	: SETTERHOLM		
BIT SIZE	:	BOREHOLE FLUID	: MUD	FILE	: ORIGINAL
MAGNETIC DECL.	: .	RM	:	TYPE	: 96600
MATRIX DENSITY	:	RM TEMPERATURE	:	LOG	: 1
FLUID DENSITY	:	MATRIX DELTA T	:	PLOT	: 96600 0
NEUTRON MATRIX	:	FLUID DELTA T	:	THRESH.	
REMARKS	:				

THIS LOG MAY NOT BE USED TO FULFILL CONTRACTUAL OBLIGATIONS

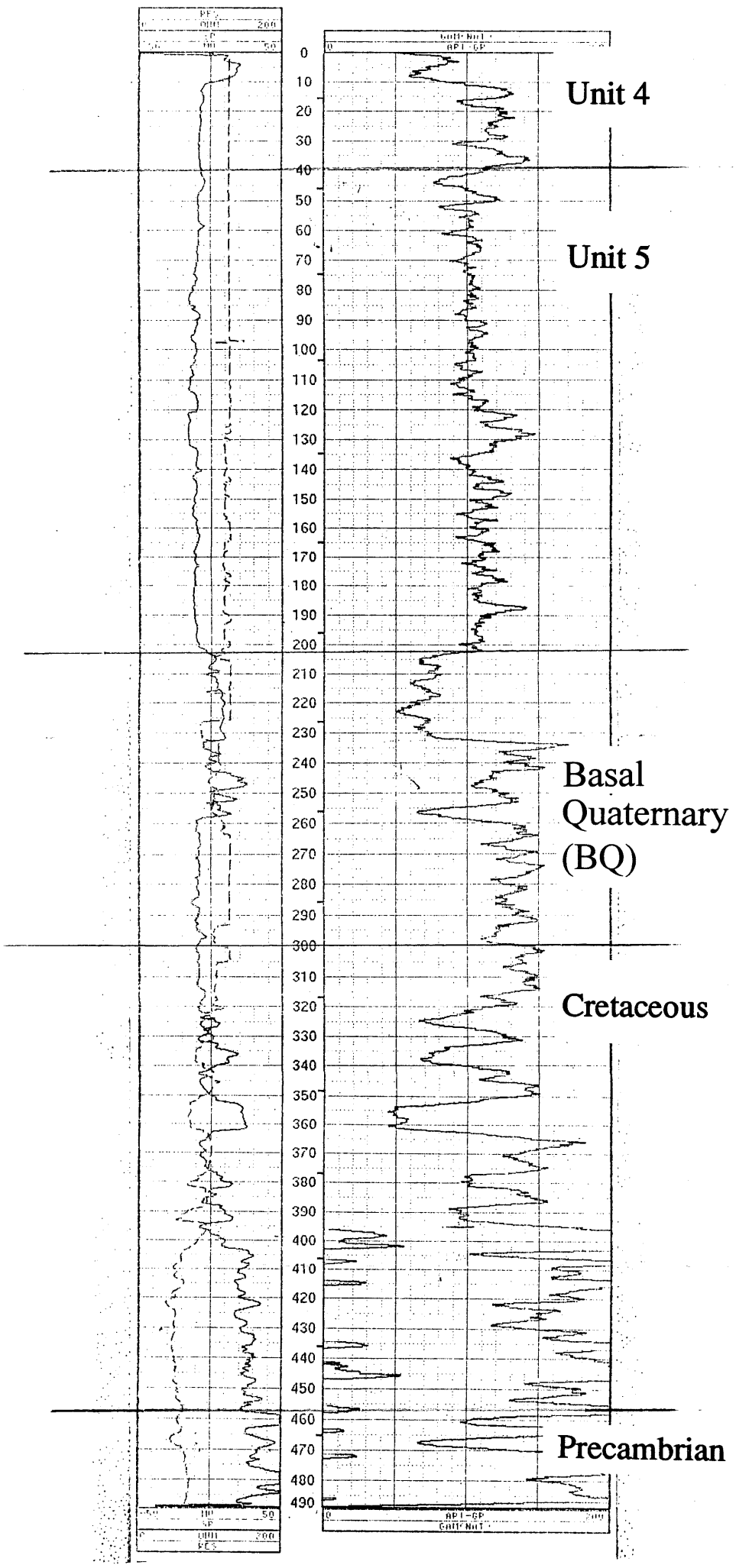
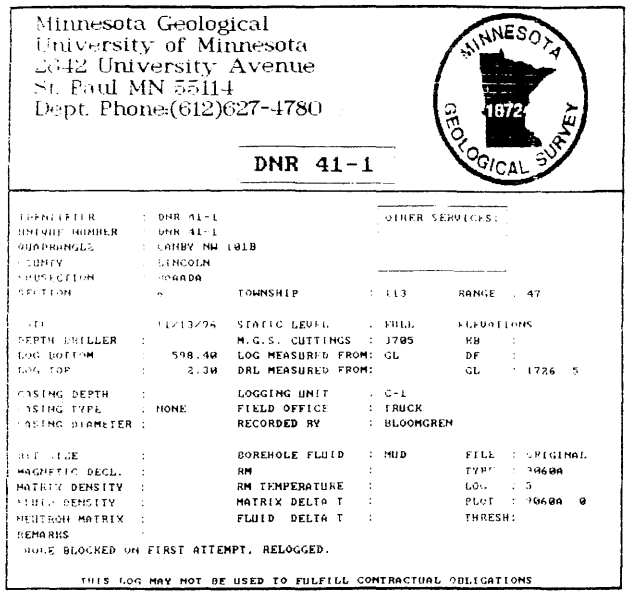
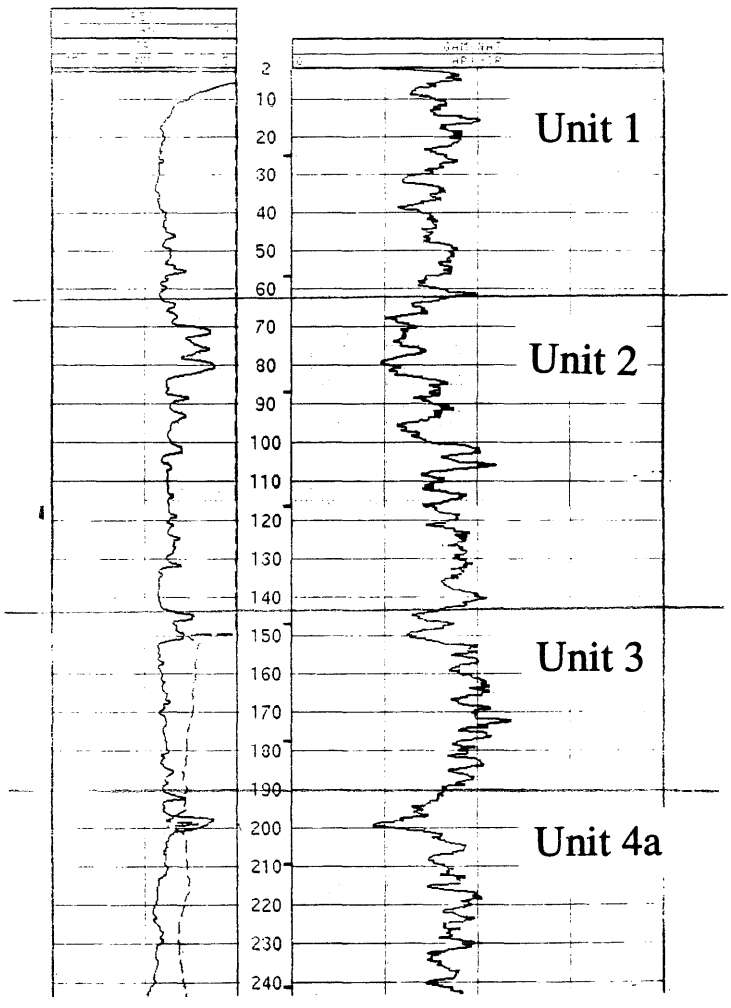


Figure 7 Type gamma/resistivity log - Southern Rock County





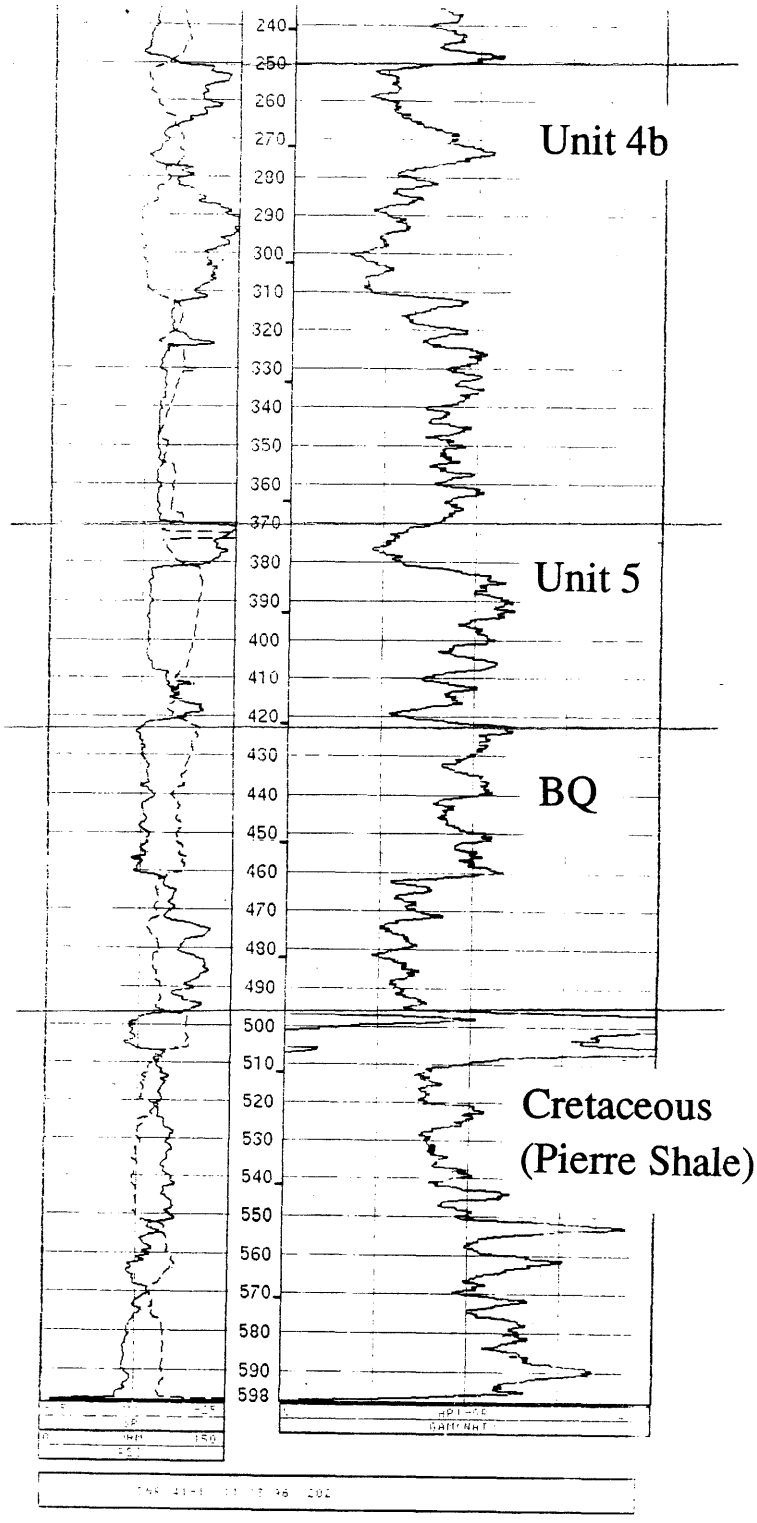
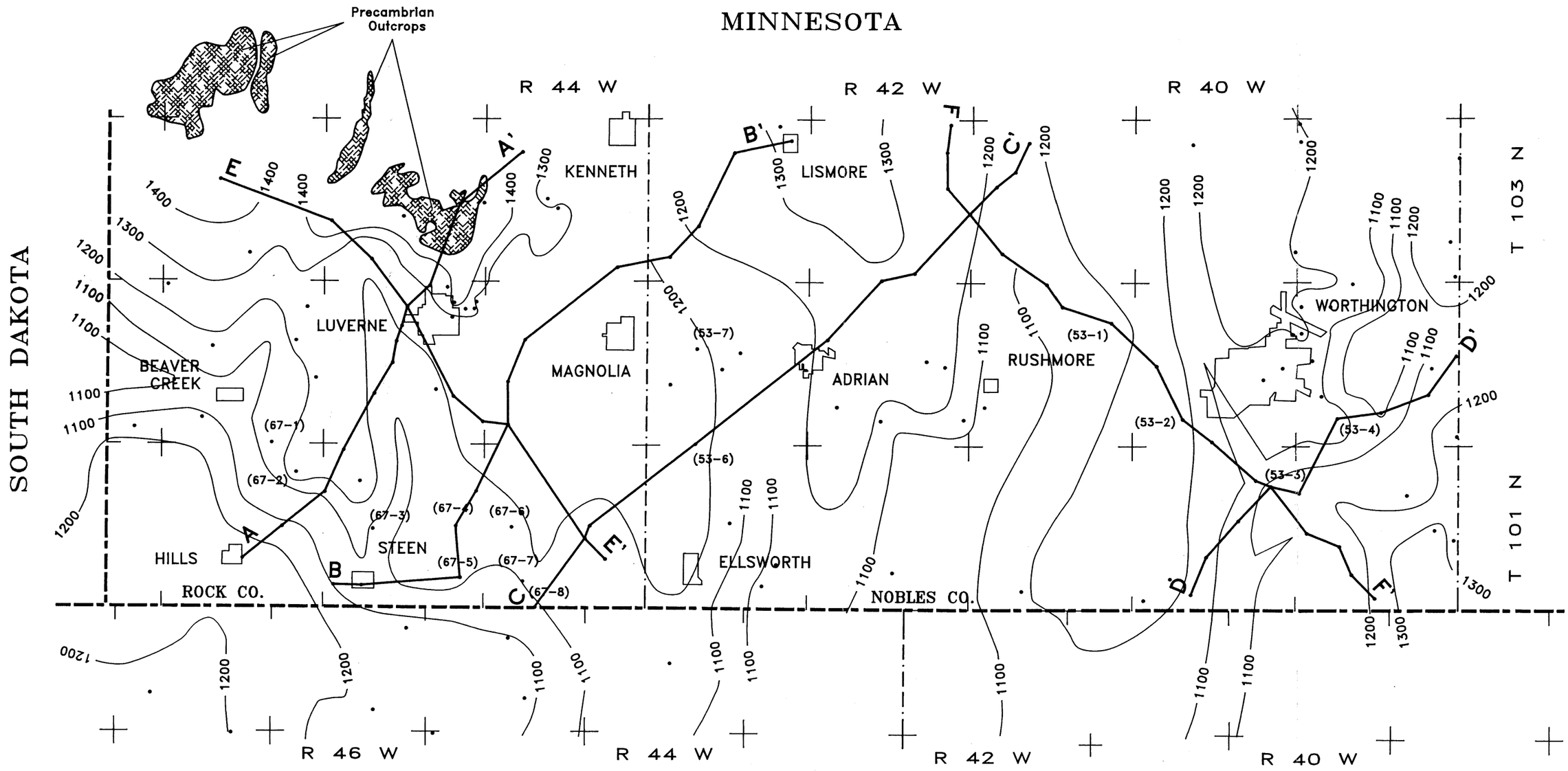


Figure 8 Type gamma/resistivity log - Burr Well Field/Lake Cochrane Area



KEY

- Data point
- (53–7) DNR test hole number
- B B' Cross section location
- —1200— Top of Cretaceous elevation contour (feet)
- Precambrian Outcrop

0 1 2 3 4
Scale in Miles

N

Note: Iowa contours modified from Hansen, 1986 and 1996 Iowa Geological Survey Bureau Home Page http://www.igsb.uiowa...s/infosch/brtopo

CROSS SECTION	FIGURE NUMBER
A–A'	14
B–B'	15
C–C'	16
D–D'	17
E–E'	18
F–F'	19

Figure 9

Pre-Quaternary topography and cross section location map Rock and Nobles Counties

MINNESOTA

R 44 W

R 42 W

R 40 W

T 103 N

T 101 N

SOUTH DAKOTA

KENNETH

LISMORE

LUVERNE

BEAVER CREEK

MAGNOLIA

ADRIAN

RUSHMORE

WORTHINGTON

(67-1)

(67-2)

(67-3)

(67-4)

(67-5)

(67-6)

(67-7)

(67-8)

(95-6)

(53-1)

(53-2)

(53-3)

(53-4)

(53-6)

(53-7)

HILLS

ROCK CO.

STEEN

ELLSWORTH

NOBLES CO.

R 46 W

R 44 W

R 42 W

R 40 W

IOWA

KEY

- Data point
- Sand Extent
- >20 foot thickness

0 1 2 3 4

Scale in Miles

N

Note: South Dakota sand thickness data from Lindgren (1992)

Figure 10

Basal Quaternary sand thickness
Rock and Nobles Counties

MINNESOTA

SOUTH DAKOTA

R 46 W

R 44 W

R 42 W

R 40 W

T 103 N

T 101 N

KENNETH

LISMORE

LUVERNE

BEAVER CREEK

MAGNOLIA

ADRIAN

RUSHMORE

WORTHINGTON

(67-1)

(67-2)

(67-3)

(67-4)

(67-5)

(67-6)

(67-7)

(67-8)

(53-1)

(53-2)

(53-3)

(53-4)

(53-6)

(53-7)

STEEN

HILLS

ROCK CO.

ELLSWORTH

NOBLES CO.

R 46 W

R 44 W

R 42 W

R 40 W

IOWA

KEY

- Data point
- Sand Extent
- >20 foot thickness

0 1 2 3 4

Scale In Miles

N

Figure 11

Unit 5 sand thickness
Rock and Nobles Counties

MINNESOTA

SOUTH DAKOTA

R 44 W

R 42 W

R 40 W

T 103 N

T 101 N

KENNETH

LISMORE

LUVERNE

BEAVER CREEK

MAGNOLIA

ADRIAN

RUSHMORE

WORTHINGTON

(67-1)

(67-2)

(67-3)

(67-4)

(67-5)

(67-6)

(67-7)

(67-8)

(95-6)

(53-1)

(53-2)

(53-3)

(53-4)

(53-6)

(53-7)

Spring

HILLS

STEEN

ELLSWORTH

ROCK CO.

NOBLES CO.

R 46 W

R 44 W

R 42 W

R 40 W

IOWA

KEY

- Data point
- Sand Extent
- >20 foot thickness
- Outwash layer absent due to erosion
- Precambrian Outcrop

0 1 2 3 4

Scale in Miles

N

Figure 12

Unit 4 sand thickness
Rock and Nobles Counties

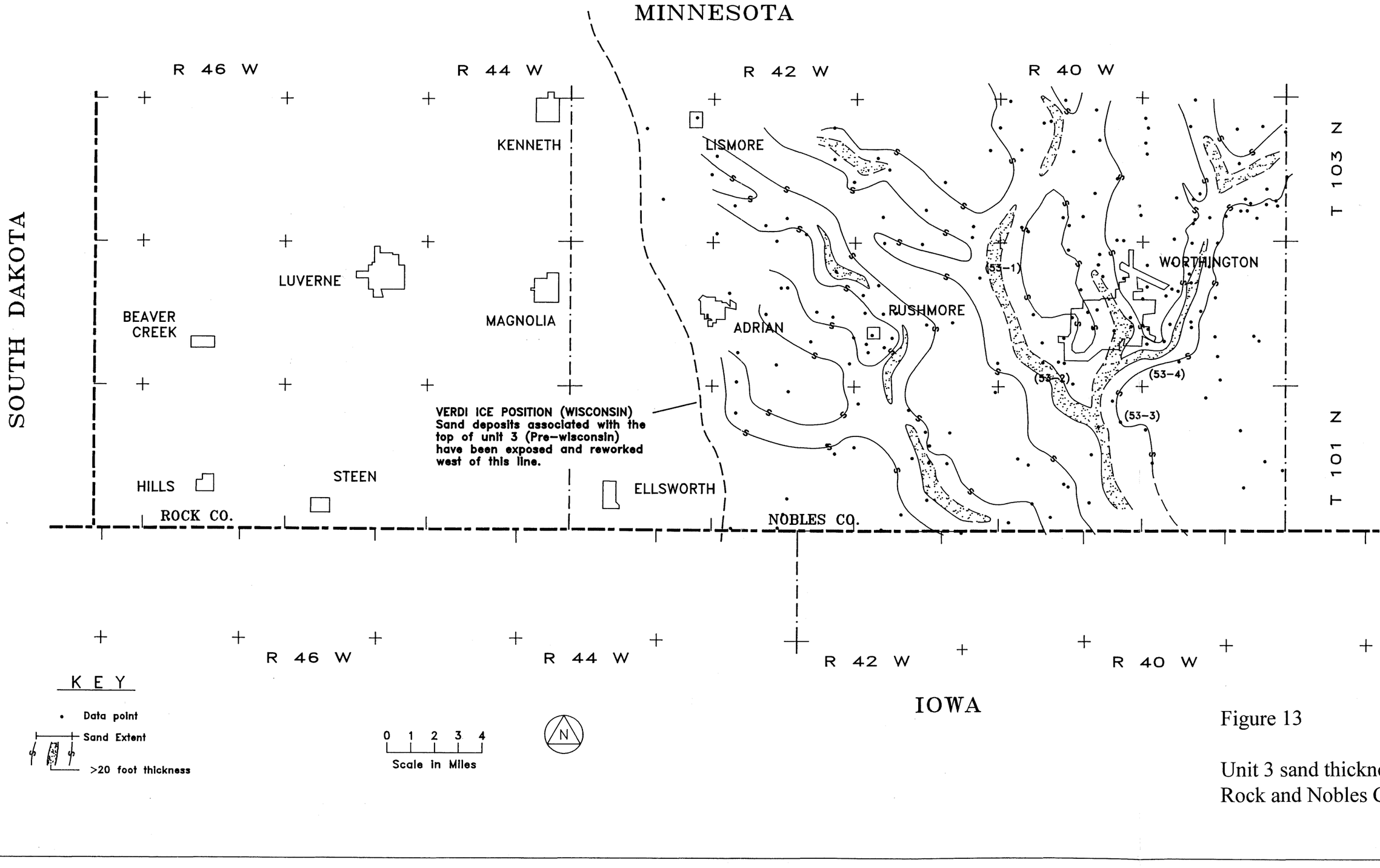


Figure 13

Unit 3 sand thickness
Rock and Nobles Counties

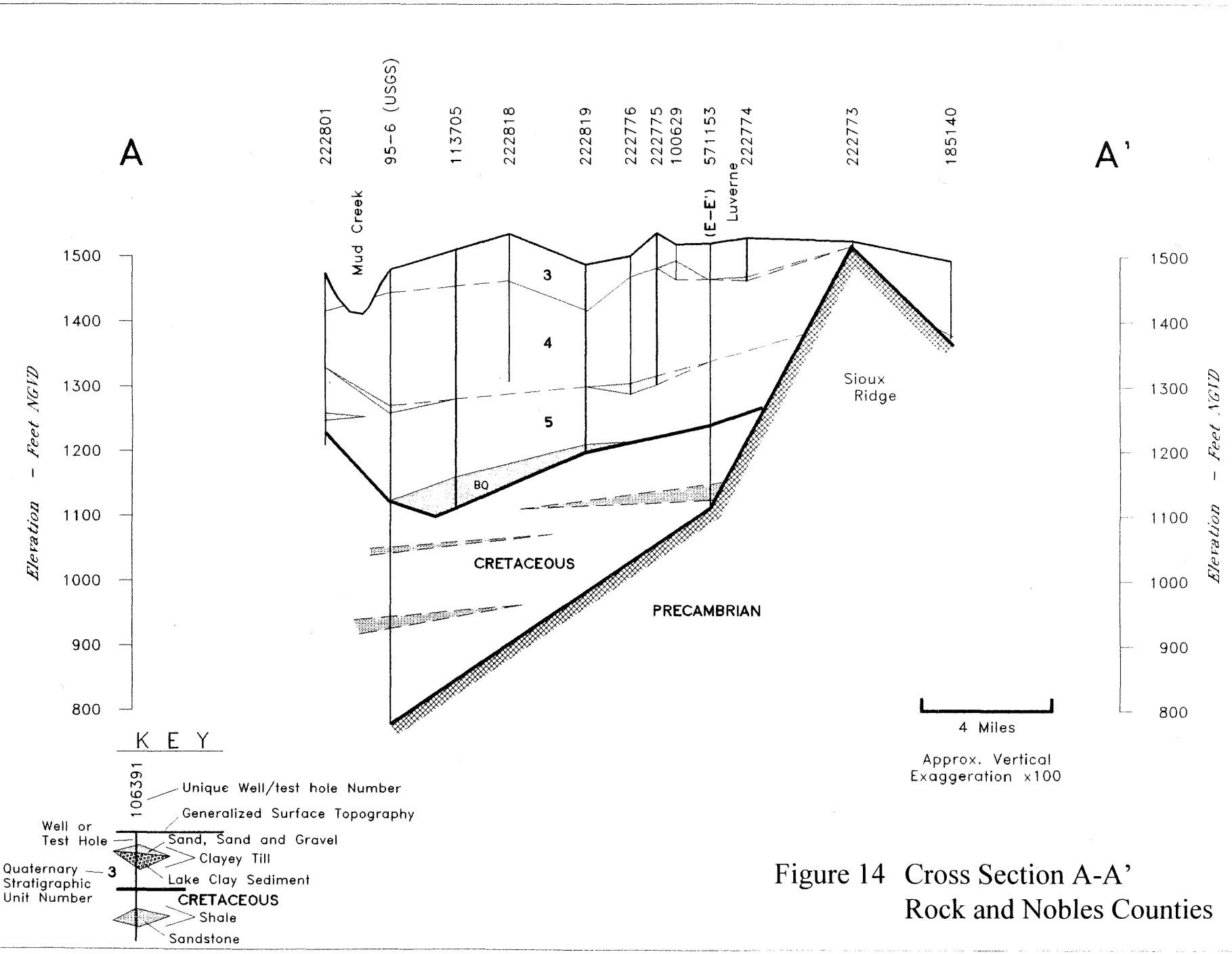


Figure 14 Cross Section A-A'
Rock and Nobles Counties

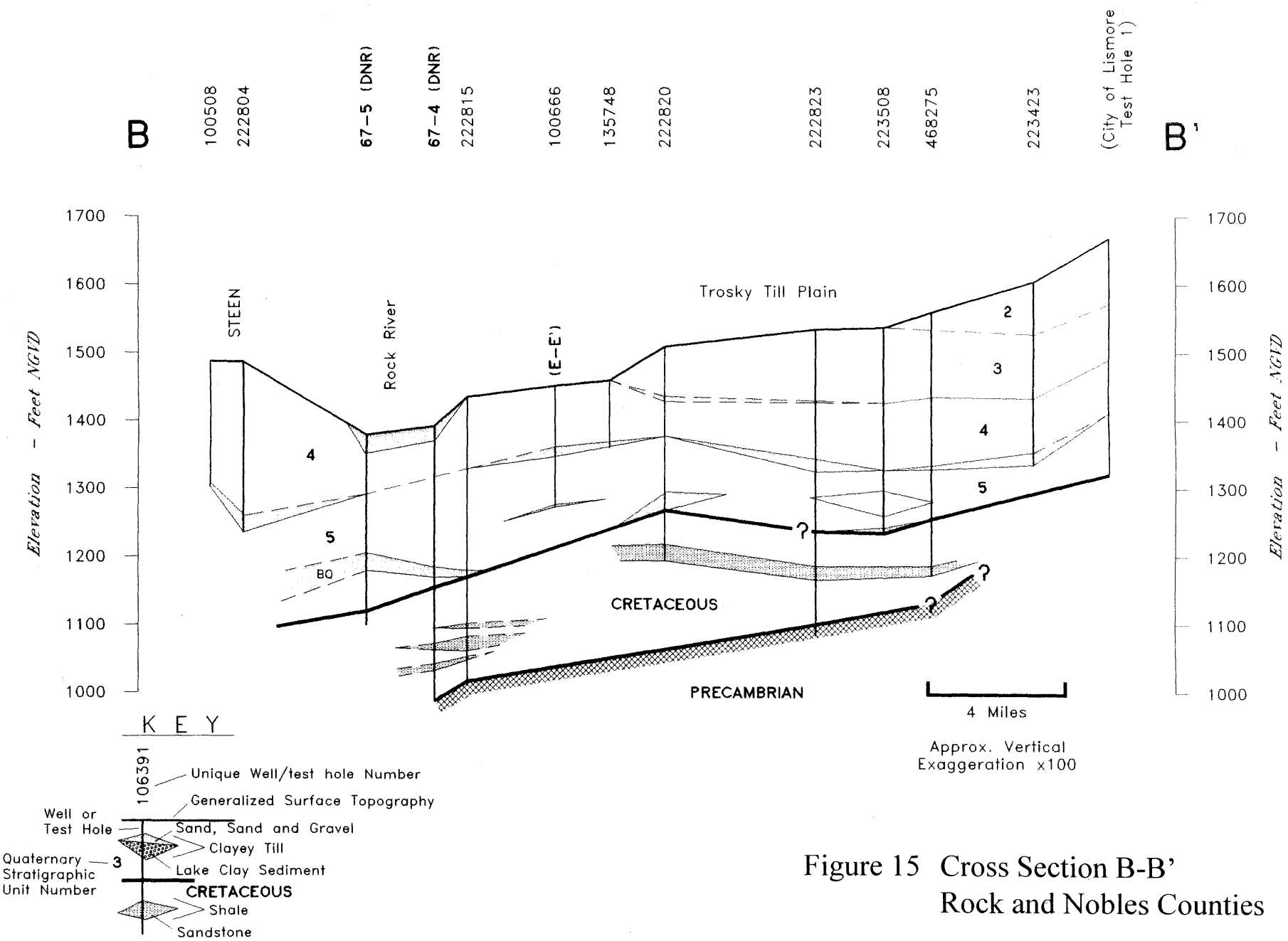


Figure 15 Cross Section B-B'
Rock and Nobles Counties

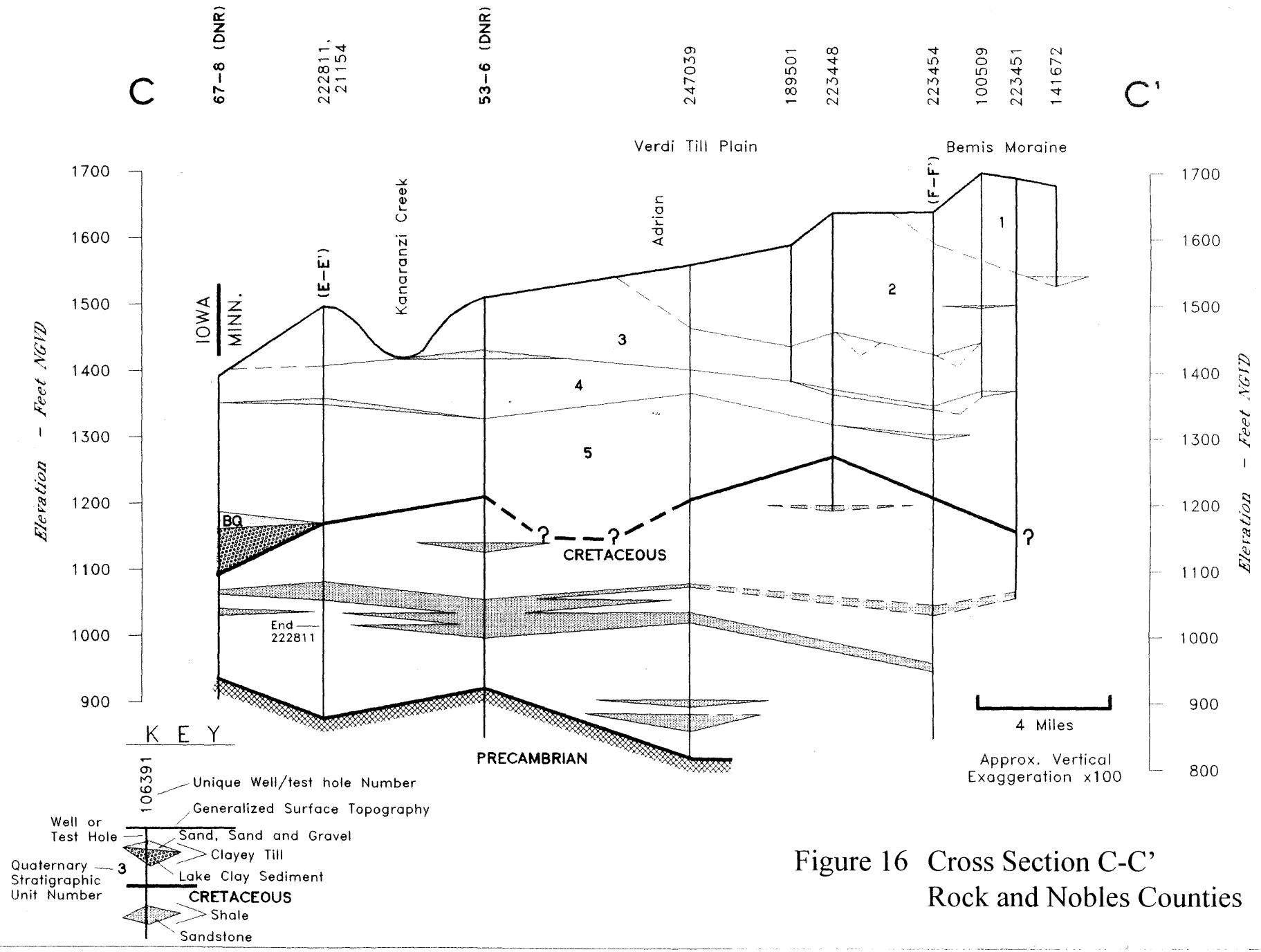


Figure 16 Cross Section C-C'
Rock and Nobles Counties

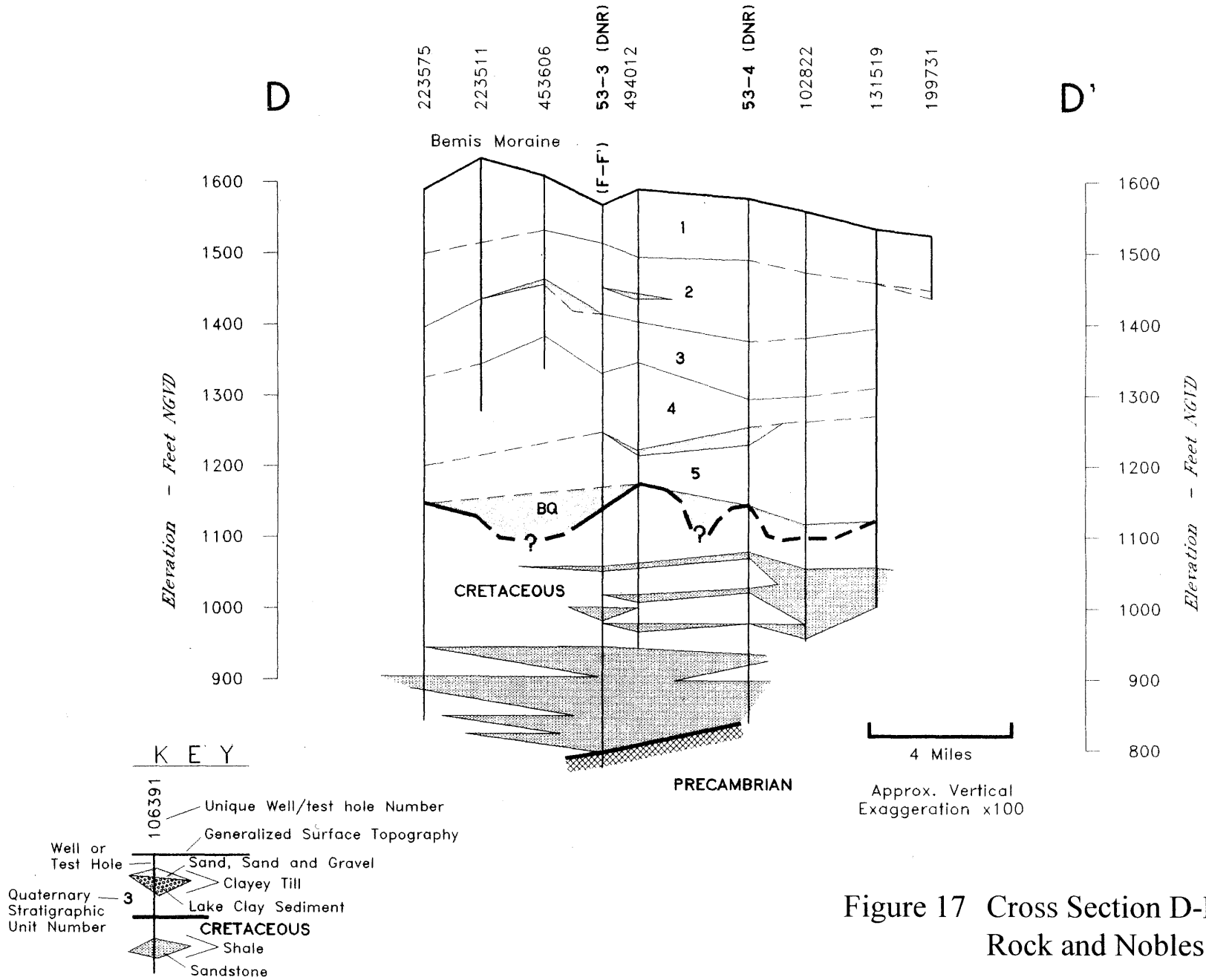


Figure 17 Cross Section D-D'
Rock and Nobles Counties

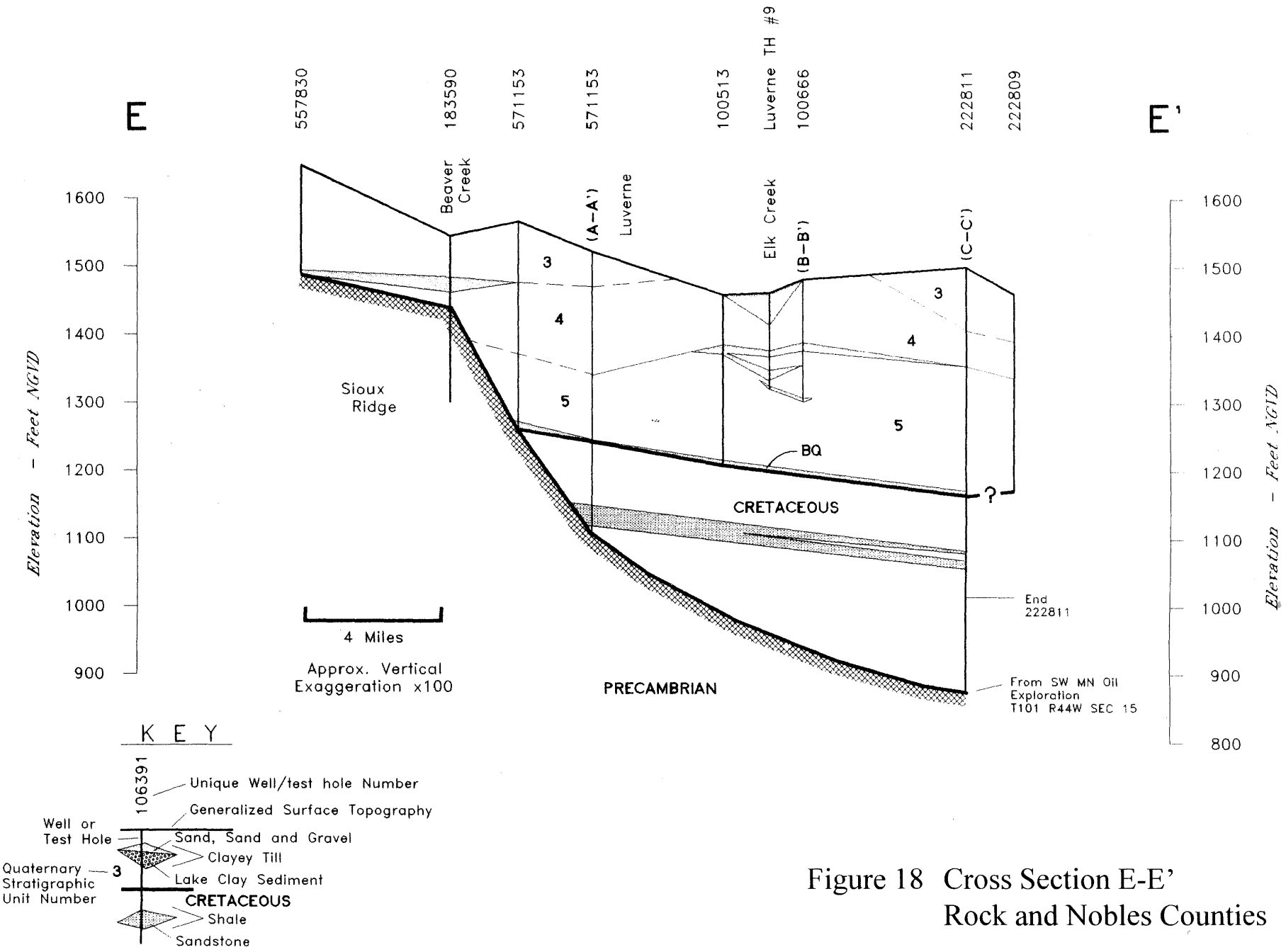


Figure 18 Cross Section E-E'
Rock and Nobles Counties

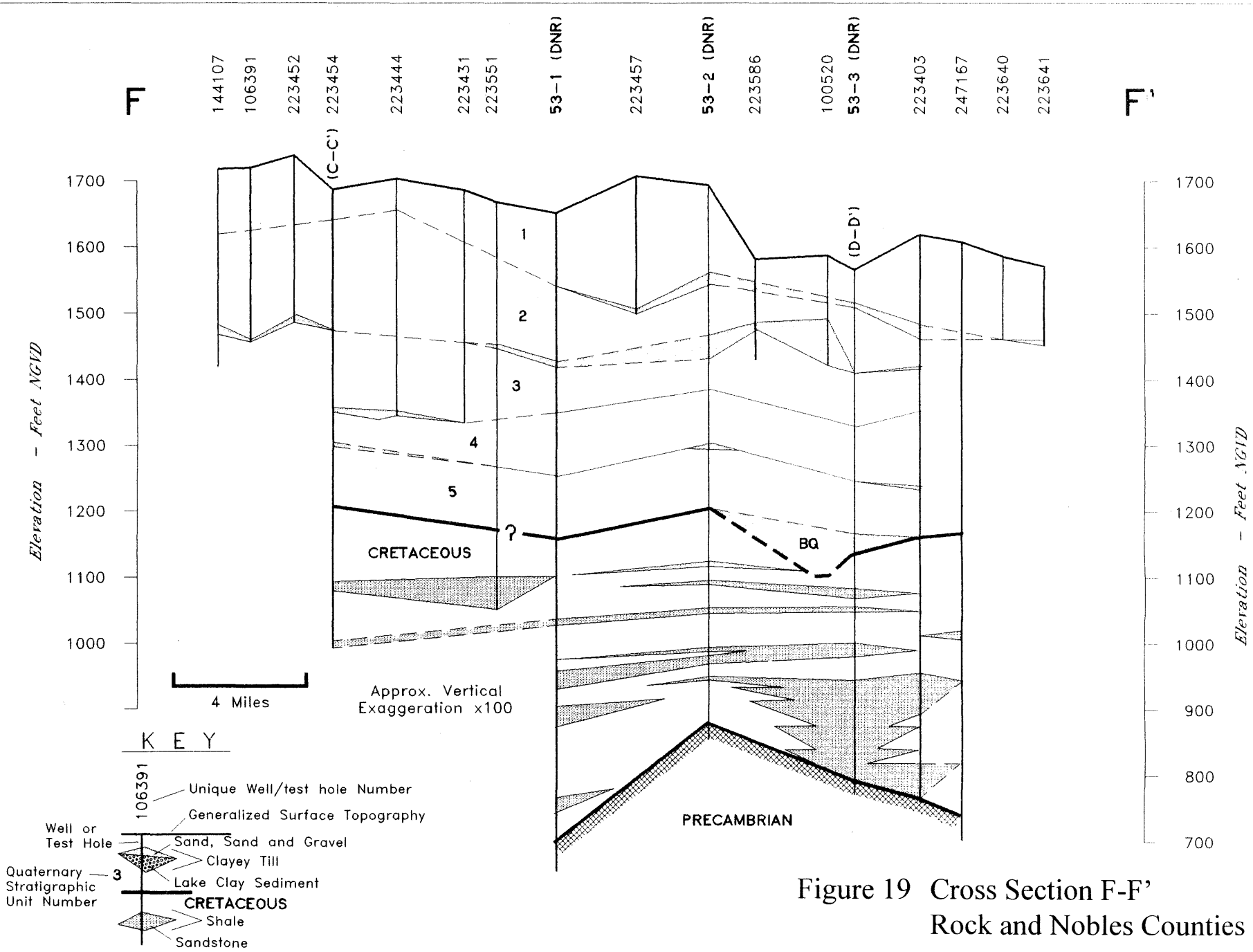
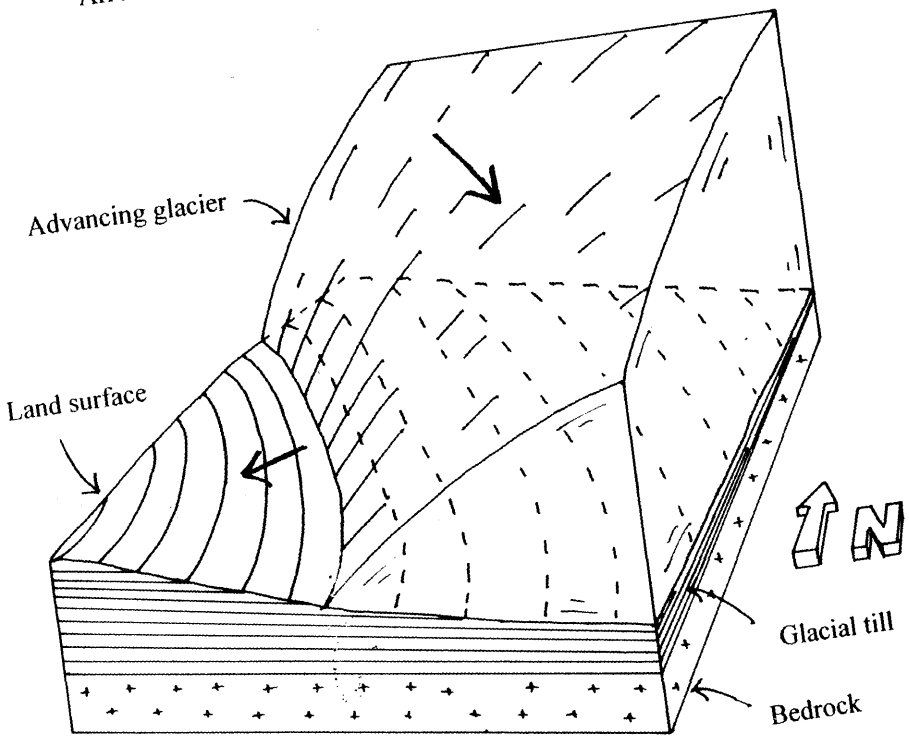


Figure 19 Cross Section F-F'
Rock and Nobles Counties

1) Advancing glacier.
Arrows show southeastern and lateral ice movement.



2) Receding glacier.
Arrows show meltwater drainage from the glacier forming an outwash channel between the lateral glacier edge and the higher southwestern land surface.

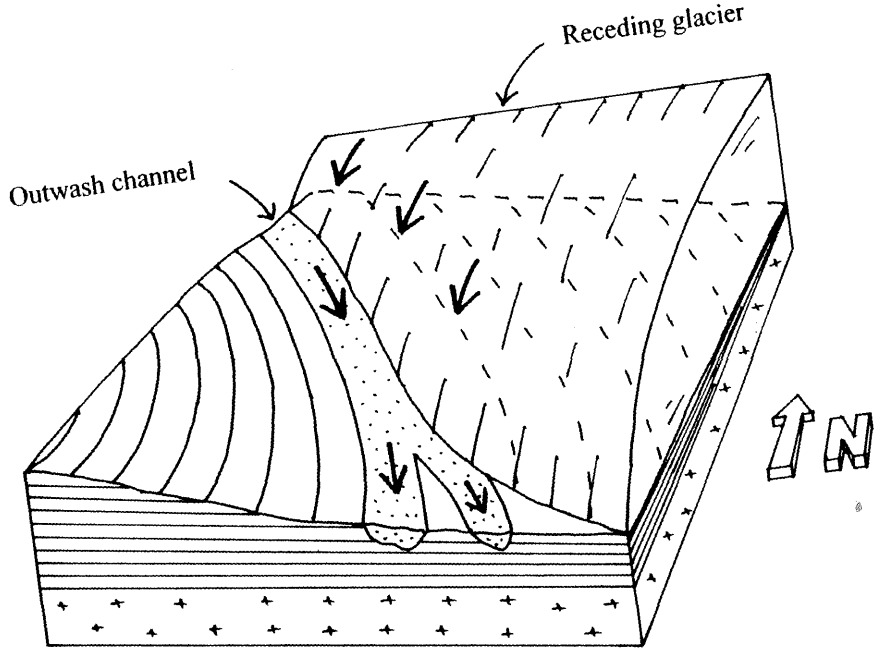


Figure 20

Deposition of northwest-southeast oriented buried glacial outwash channels in southwestern Minnesota

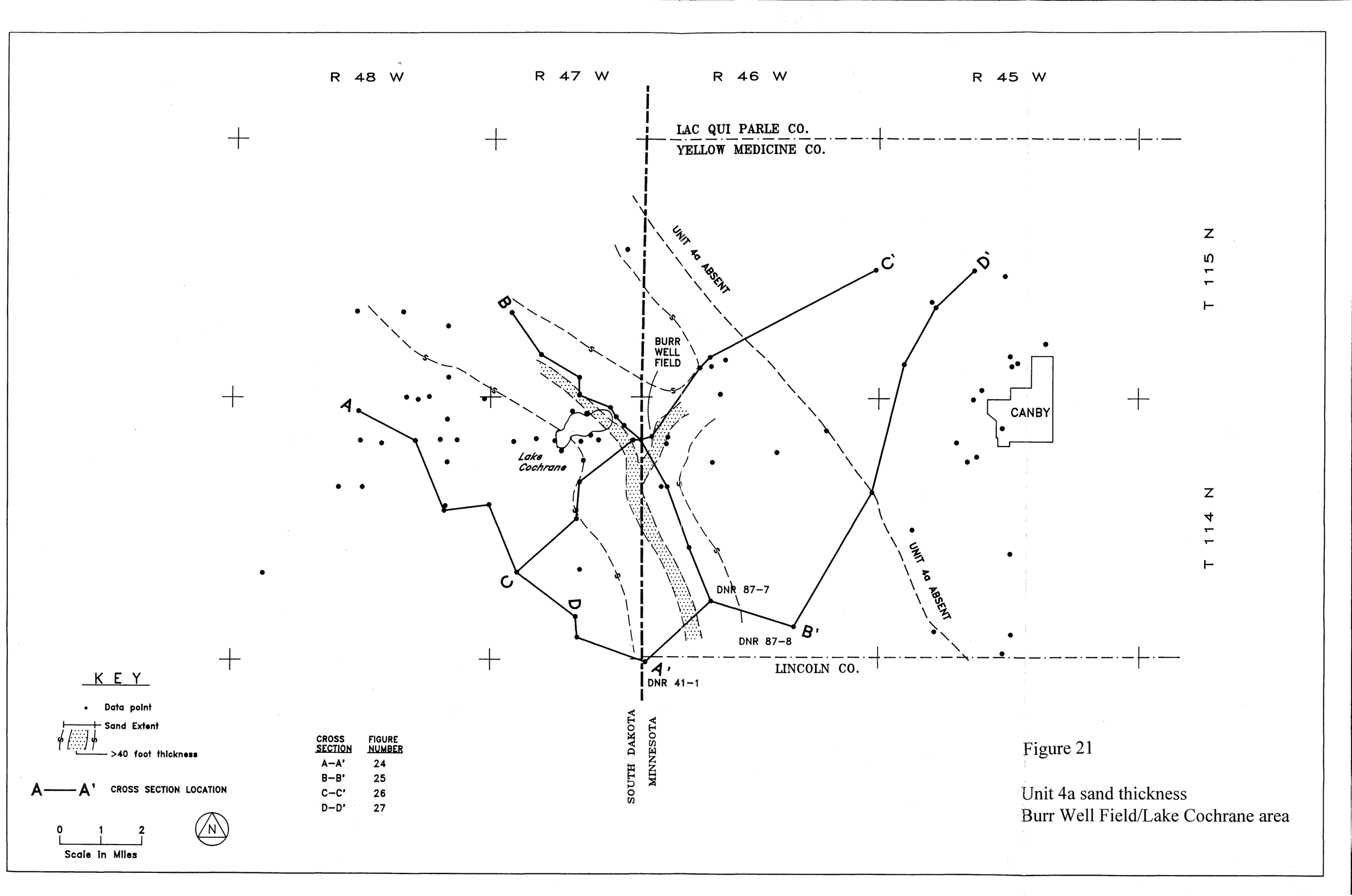


Figure 21

Unit 4a sand thickness
Burr Well Field/Lake Cochrane area

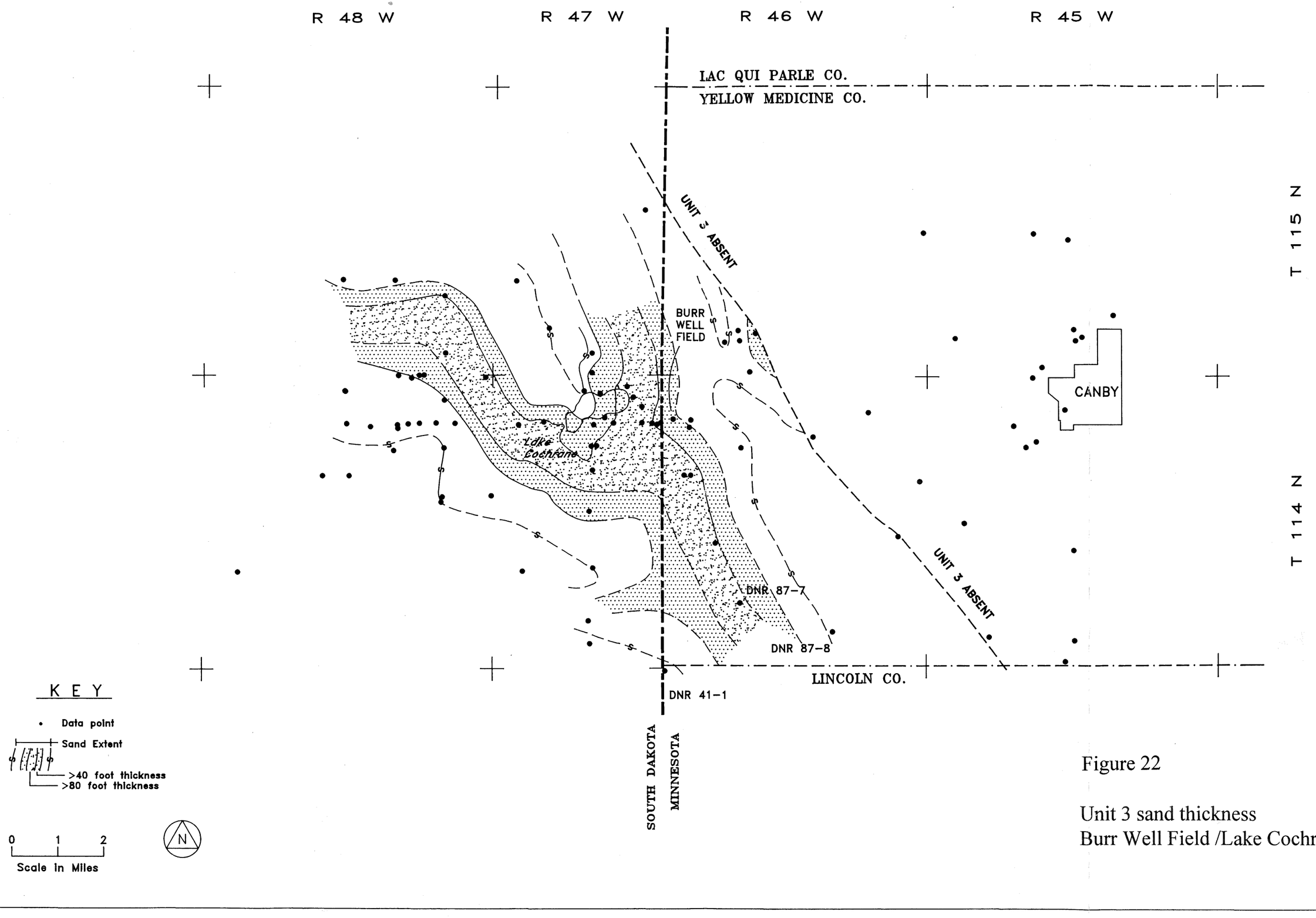


Figure 22

Unit 3 sand thickness
Burr Well Field /Lake Cochrane area

R 48 W

R 47 W

R 46 W

R 45 W

LAC QUI PARLE CO.

YELLOW MEDICINE CO.

T 115 N

T 114 N

UNIT 2 ABSENT

BURR WELL FIELD

CANBY

Lake Cochrane

DNR 87-7

DNR 87-8

UNIT 2 ABSENT

LINCOLN CO.

DNR 41-1

SOUTH DAKOTA

MINNESOTA

KEY

- Data point
- Sand Extent
- >40 foot thickness
- >80 foot thickness

0 1 2

Scale in Miles

N

Figure 23

Unit 2 sand thickness
Burr Well Field /Lake Cochrane area

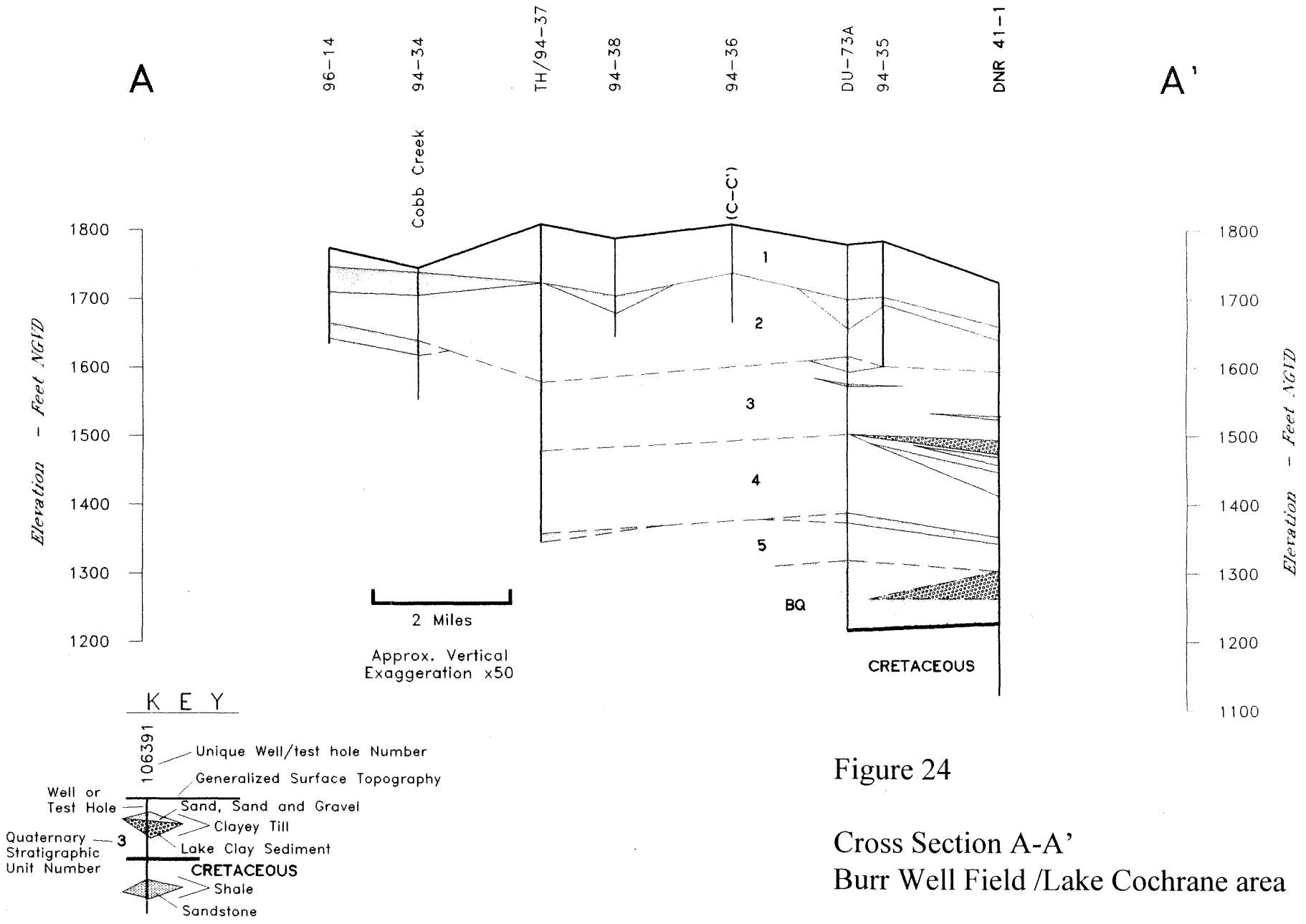


Figure 24

Cross Section A-A'
Burr Well Field /Lake Cochrane area

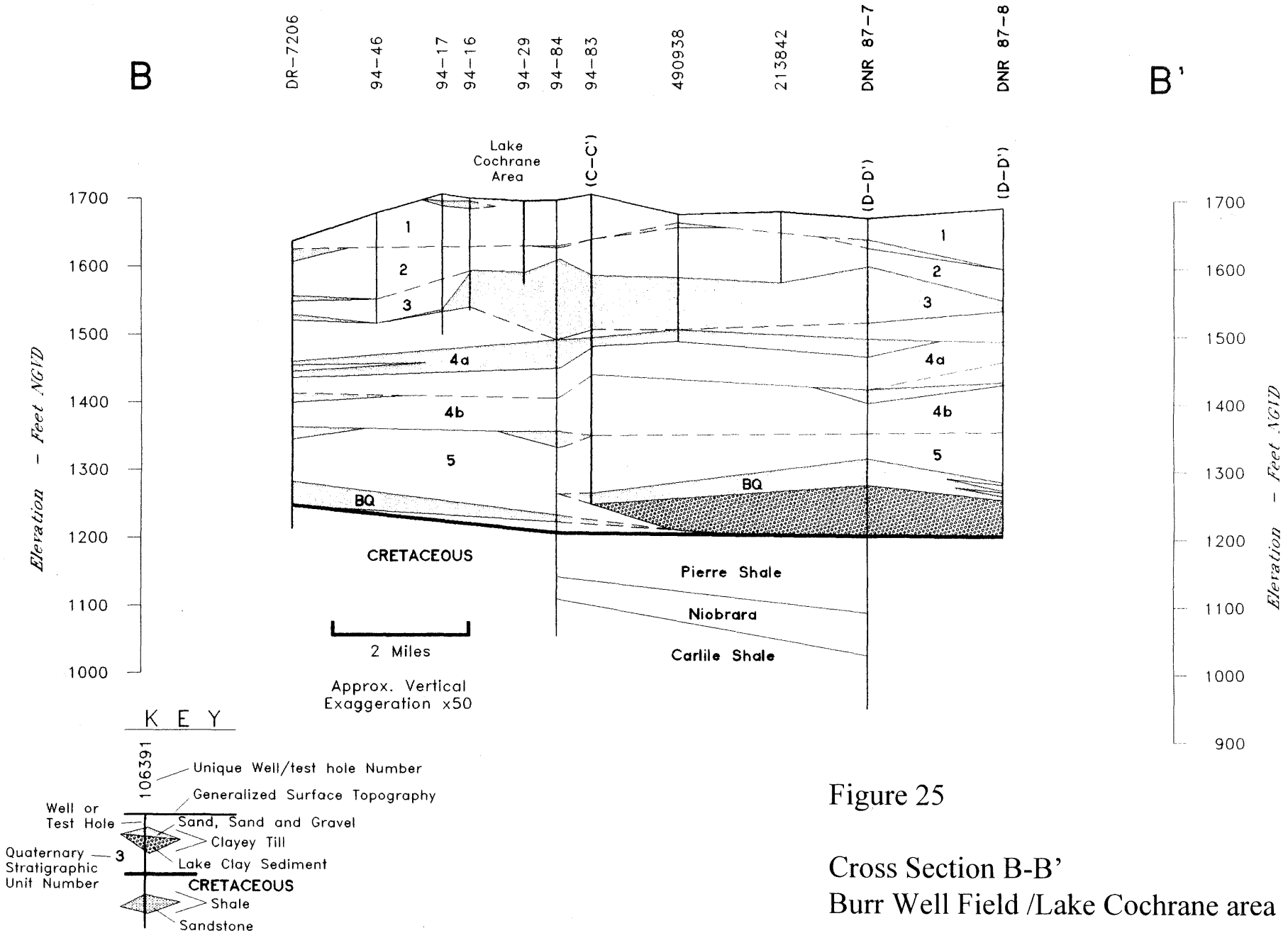


Figure 25

Cross Section B-B'
Burr Well Field /Lake Cochrane area

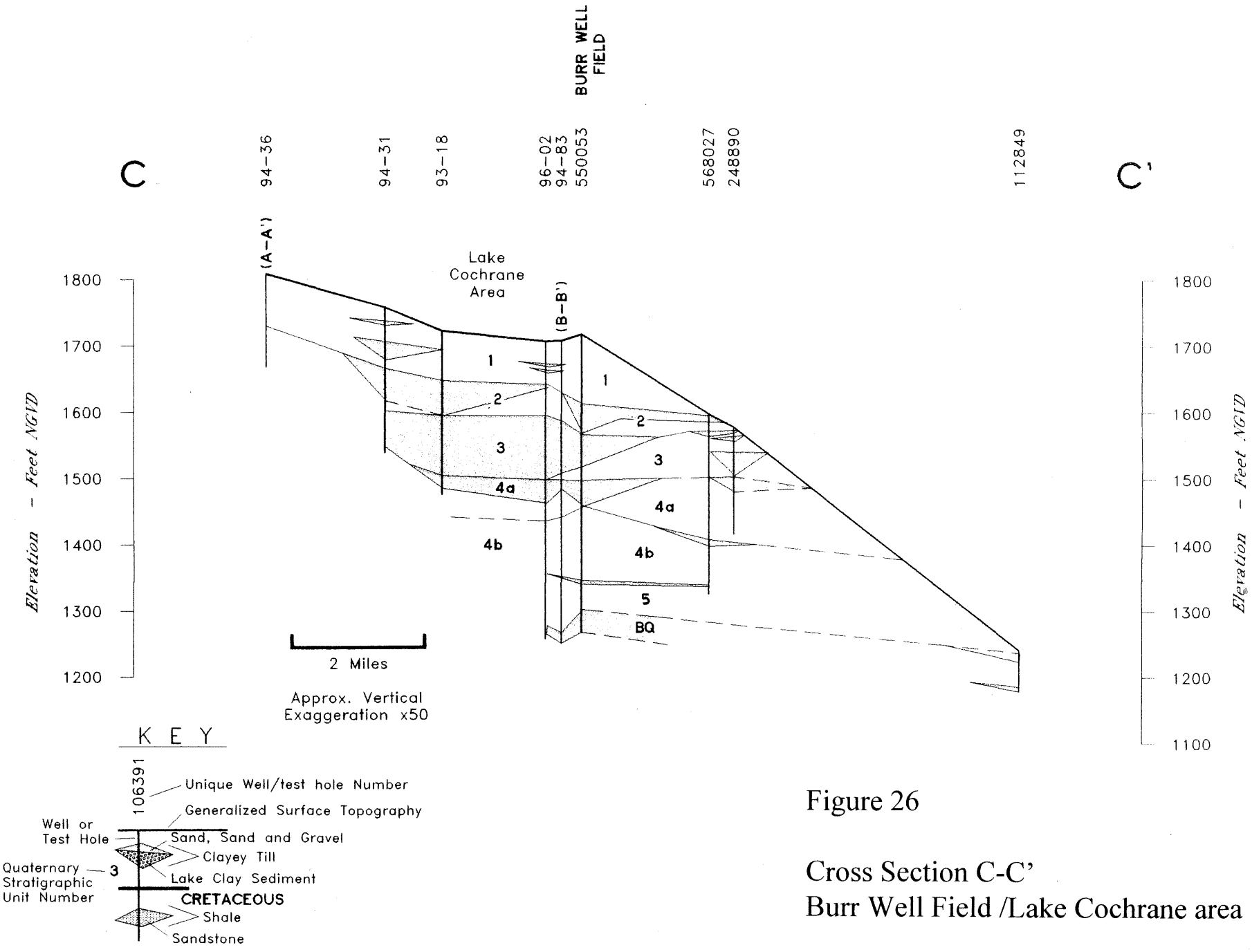


Figure 26

Cross Section C-C'
Burr Well Field /Lake Cochrane area

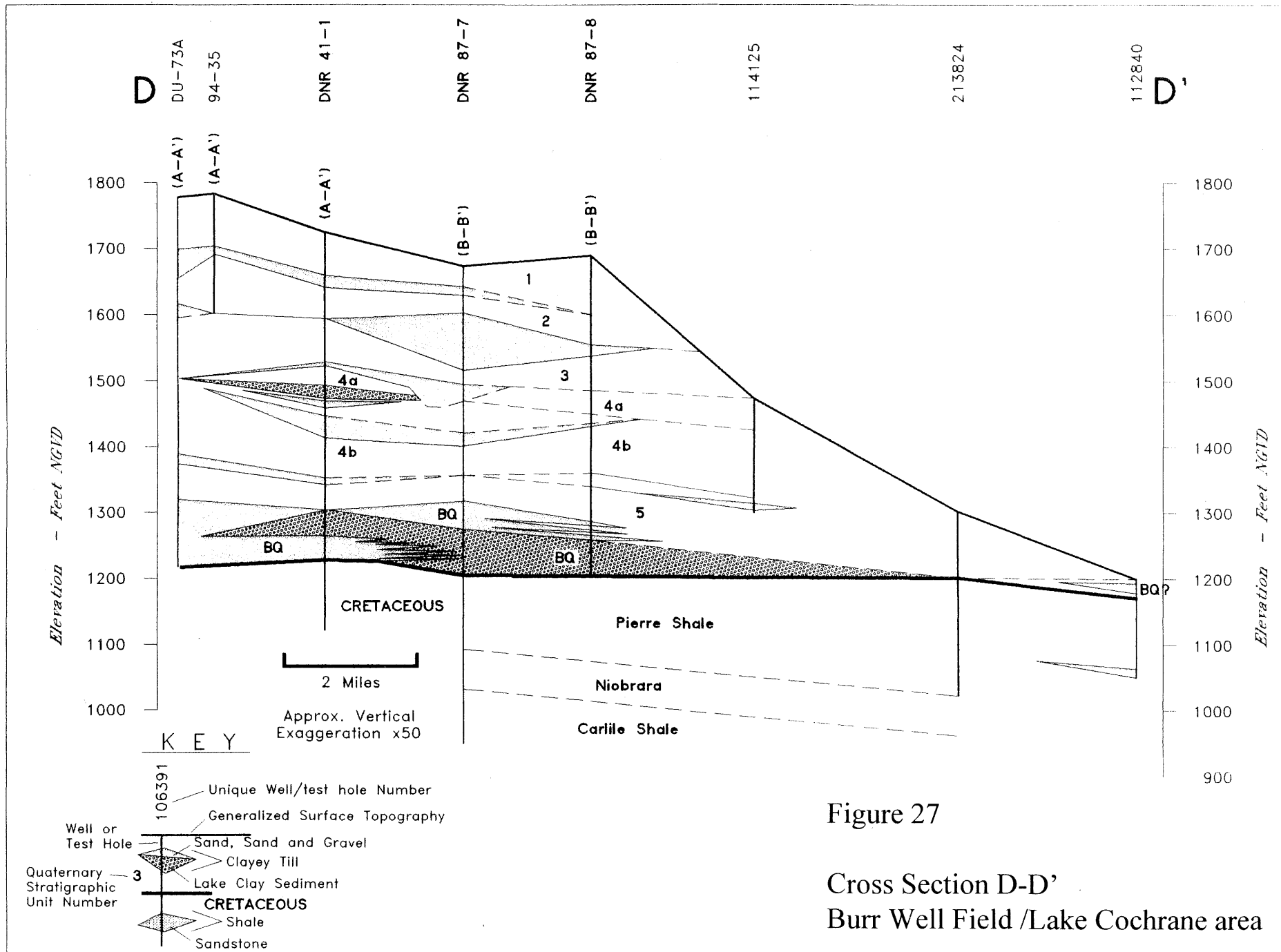


Figure 27

Cross Section D-D'
Burr Well Field /Lake Cochrane area

Appendix 2

Drilling Logs and Sealing Records

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 2
Site ID # 53-1		County: Nobles	
Geologist: Jim Berg, Tom Gullett		Driller: Don Hejtmanek - LTP	
Date: 8/21/96		Drilling Method: 6" Mud rotary	
Location: T102N R41W Section 12 BDDCBB			
Depth (ft)	Description	Thickness	Drilling Notes
0	Clay, black	3	
3	Clay, sandy, gray	106	
109	Clay, sandy, yellow	10	
119	Clay, sandy, gray	5	Chatter @ 122' and 132-134'
204	Clay, sandy, gray, and some black shale	20	
224	Sand	6	Chatter @ 229'
230	Clay, sandy, gray and some black	19	
249	Clay, sandy, yellow and green	80	
329	Clay, sandy, gray	50	
379	Clay, sandy, yellow	130	Chatter @ 387-388'
509	Clay, black	10	
519	Sand, clayey	5	
524	Clay, sandy, gray and black	55	Chatter @ 537'
579	Sandstone	2	
581	Shale, gray and black, soft	16	
597	Sandstone, silty very fine to medium	10	
607	Shale, gray and black, soft	12	
619	Shale with sandstone layers	15	
634	Shale, black and tan	54	Very slow
688	Sandstone, silty very fine to medium with shale layers	30	
718	Shale	22	
740	Sandstone	34	Rough @ 754'
774	Shale with sandstone layers	106	
880	Sandstone, orangish-red at 884 feet	23	

Drilling Log - Minnesota Department of Natural Resources			Page 2 of 2
Site ID # 53-1		County: Nobles	
Geologist: Jim Berg, Tom Gullett		Driller: Don Hejtmanek - LTP	
Date: 8/21/96		Drilling Method: 6" Mud rotary	
Location: T102N R41W Section 12 BDDCBB			
Depth (ft)	Description	Thickness	Drilling Notes
903	Shale with sandstone layers	31	
934	Mudstone, orangish-red	9	
943	Hard rock	36	Very slow
979	Bottom of hole		
	Interpreted from geologist's mud log and gamma/resistivity log		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID # 53-2		County: Nobles	
Geologist: Jim Berg, Evan Drivas, Mike L.		Driller: Don Hejtmanek - LTP	
Date: 8/29/96		Drilling Method: 6" Mud rotary	
Location: T102N R40W Section 32 AAAABA			
Depth (ft)	Description	Thickness	Drilling Notes
0	Topsoil, black	4	
4	Clay, sandy, yellow	5	
9	Clay, sandy, gray	92	Chatter @ 74'
101	Sand	3	
104	Clay, sandy, gray	30	
134	Sand, coarse to very coarse with gravel and cobbles	20	Rough
154	Clay, sandy, gray	49	
203	Sand	2	
205	Clay, sandy, gray	18	
223	Sand, silty, very fine to very coarse	36	
259	Clay, gray	129	Rough @ 339
388	Sand, medium to very coarse	7	
395	Clay, gray and clayey sand	90	
485	Sandstone, medium, with shale layers	68	
553	Shale, black, with sandstone layers	57	
610	Shale, black	25	
635	Shale, black, with sandstone layers and lignite	70	
705	Sandstone	11	
716	Shale with sandstone layers	93	
809	White clay with angular quartz grains	15	
824	Bottom of hole		
	Interpreted from the geologist's mud log and the gamma/resistivity log		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID # 53-3		County: Nobles	
Geologist: Evan Drivas, Tom Gullett, Mike L.		Driller: Don Hejtmanek - LTP	
Date: 8/14/96		Drilling Method: 6" Mud rotary	
Location: T101N R40W Section 12 CBBCCD			
Depth (ft)	Description	Thickness	Drilling Notes
0	Sand with gravel	20	
20	Clay, sandy, gray	32	
52	Sand	3	
55	Clay with sand and gravel lenses	41	
96	Clay, sandy, gray	38	
134	Gravel and cobbles	1	
135	Clay, sandy, gray	264	
399	Boulder	1	
400	Sand, clayey	5	
405	Sand, silty medium to coarse	22	
427	Shale	37	
484	Shale, with sandstone layers	82	
566	Sandstone, fine	34	Chatter
590	Shale	9	
599	Sandstone, fine	171	
770	Hard rock		
775	Bottom of hole		
	Interpreted from the geologist's mud log and the gamma/resistivity log		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 2
Site ID # 53-4		County: Nobles	
Geologist: Jim Berg, Evan Drivas		Driller: Don Hejtmanek - LTP	
Date: 8/7/96		Drilling Method: 6" Mud Rotary	
Location: T102N R 39W Section 32 ABAABA			
Depth (ft)	Description	Thickness	Drilling Notes
0	Topsoil	4	
4	Clay, sandy, yellow	3	
7	Sand, silty, fine	2	
9	Clay, silty, yellow	11	
20	Clay, sandy, gray	41	
61	Clay, gray and sand lenses	5	
66	Clay, sandy, gray	41	
107	Sand, silty very fine to coarse	26	
125	Clay, sandy, gray	5	
130	Sand	3	
133	Clay, sandy with lenses of sand	13	
146	Sand	8	
148	Clay, sandy	8	
156	Sand	5	
161	Clay, sandy, gray	118	Rough @ 165'
279	Sand	1	
280	Clay, sandy	6	
286	Sand	1	
287	Clay, sandy	25	
312	Sand, silty, very fine to very coarse	28	
346	Clay, sandy	97	Chatter @ 370,407
443	Sandstone, very fine to medium	21	Rough @ 470
464	Shale, soft with interbedded sandstone	53	
517	Shale, black with sandstone layers	38	Very slow

Drilling Log - Minnesota Department of Natural Resources			Page 2 of 2
Site ID # 53-4		County: Nobles	
Geologist: Jim Berg, Evan Drivas		Driller: Don Hejtmanek - LTP	
Date: 8/7/96		Drilling Method: 6" Mud Rotary	
Location: T102N R 39W Section 32 ABAABA			
Depth (ft)	Description	Thickness	Drilling Notes
555	Shale, dark gray, lignite, fossil @ 591	45	
600	Shale , black, with pieces of limestone	10	
610	Shale, black, with sandstone layers	25	Chatter @ 620
635	Sandstone, fine to medium	15	
650	Shale	18	
668	Sandstone, fine	56	
724	Hard rock	2	very slow
726	Bottom of hole		
	Interpreted from geologist's mud log and gamma/resistivity log		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID # 53-6		County: Nobles	
Geologist: Tom Gullett, Brian Rongitsch		Driller: Dan Hejtmanek - LTP	
Date: 9/11/96		Drilling Method: 6" Mud rotary	
Location: T102N R43W Section 32 DDA			
Depth (ft)	Description	Thickness	Drilling Notes
0	Sand with small amount of clay	8	
8	Gravel, quartz and limestone	10	
18	Sand, coarse	6	
24	Gravel	25	
59	Clay, sandy, olive green	25	Chatter @ 69
84	Sand, medium	10	
94	Sand and clay	5	
99	Clay, sandy, olive green	70	
169	Clay, medium dark gray, calcareous	160	Chatter @ 264'
329	Clay, medium dark gray, calcareous with some white clay	10	
339	Shale, dark gray, soft, non-calcareous	26	
365	Sandstone	15	
380	Shale, dark gray	69	
449	Sandstone, medium	51	
500	Shale, dark gray and black	34	
534	Shale, dark gray with bits of lignite	110	
644	Fragments of feldspar and quartz	5	
649	Bottom of hole		
	Interpreted from geologist's mud log and gamma/resistivity log		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID # 53-7		County: Nobles	
Geologist: Tom Gullett		Driller: Don Hejtmanek - LTP	
Date: 9/9/96		Drilling Method: 6" Mud rotary	
Location: T102N R43W Section 17 ADD			
Depth (ft)	Description	Thickness	Drilling Notes
0	Clay, light olive brown	8	
8	Clay, yellow brown with pebbles	26	
34	Clay, sandy, gray	35	
69	Clay, sandy, yellow	17	
86	Sand	3	
89	Sand and clay	5	
94	Clay, sandy, yellow	15	Chatter @121-122
109	Clay, sandy, gray	35	
144	Sand	3	
147	Clay, sandy, gray	112	
259	Sand, medium	5	
279	Clay, dark reddish brown, non-calcareous	5	
284	Clay, gray	125	
409	Shale, dark gray and medium sandstone	11	
420	Sandstone	5	
425	Shale, dark gray	53	
478	Shale, dark gray, with sandstone layers	26	
504	Sandstone	15	
519	Shale, dark gray with some white clay	90	Chatter @ 568'
609	Sandstone, fine to coarse	15	
624	Sandstone and shale	20	
644	Shale, dark gray	15	
659	Bottom of hole		
	Interpreted from geologist's mud log and gamma/resistivity log		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID # 67-1		County: Rock	
Geologist: Evan Drivas`		Driller: Don Hejtmanek - LTP	
Date: 10/22/96		Drilling Method: 6" Mud rotary	
Location: T102N R46W Section 35 CCC			
Depth (ft)	Description	Thickness	Drilling Notes
0	Clay, brown	8	
8	Clay, sandy, gray	5	
13	Sand, medium to coarse	18	
31	Clay, tan, sandy	13	
44	Clay, gray, sandy	100	Chatter @ 63'
144	Clay, light gray with some white	15	
159	Clay, light gray with sand	15	
174	Sand, very fine	10	
184	Clay, light gray	24	
208	Sand, silty, very fine	6	
214	Clay, light gray	5	
219	Clay, very sandy, gray	43	
262	Clay, sandy, gray	72	
334	Sand, medium	10	
344	Clay, sandy, gray	15	
359	Shale, gray	41	
400	Bottom of hole		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID # 67-2		County: Rock	
Geologist: Tom Gullett		Driller: Don Hejtmanek	
Date: 10/16/96		Drilling Method: 6" Mud rotary	
Location: T101N R46W Section 1 CCCB			
Depth (ft)	Description	Thickness	Drilling Notes
0	Soil, dark gray, organic	3	
3	Clay, sandy, olive green	5	
8	Clay, gray with pebbles	10	
18	Clay, olive brown, sandy	41	
59	Clay, sandy, gray	195	
254	Sand, very fine	4	
258	Clay, sandy, gray	24	
282	Sand	2	
284	Clay, ash gray, non-calcareous	50	
334	Shale, black	66	
400	Bottom of hole		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID # 67-3		County: Rock	
Geologist: Tom Gullett		Driller: Don Hejtmanek - LTP	
Date: 10/14/96		Drilling Method: 6" Mud rotary	
Location: T101N R45W Section 20 AAB			
Depth (ft)	Description	Thickness	Drilling Notes
0	Clay, sandy, brown	8	
8	Clay, sandy, olive green	15	
23	Sand, medium	1	
24	Clay, sandy, olive green	5	
29	Clay and sand	10	
39	Clay, sandy, olive green	123	Chatter @ 80-89'
160	Sand, medium	19	
179	Clay, sandy, dark gray	5	
186	Sand	7	
192	Clay, sandy, gray	152	
344	Shale, black	73	
417	Sandstone, fine to medium	12	
429	Shale, black	55	
484	Shale, black with abundant white clay	40	
524	Weathered metamorphic rock	36	Chatter @ 551'
560	Bottom of hole		
	Interpreted from geologist's mud log and gamma/resistivity log		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID # 67-4		County: Rock	
Geologist: Brian Rongitsch		Driller: Don Hejtmanek	
Date: 9/18/96		Drilling Method: 6" Mud rotary	
Location: T101N R45W Section 23 AAAAAD			
Depth (ft)	Description	Thickness	Drilling Notes
0	Sand, medium to coarse with gravel	21	
21	Clay, sandy, yellow	3	
24	Clay, gray, sandy	180	
204	Sand, fine to coarse	16	
220	Clay, gray, sandy	14	
234	Shale, dark gray, soft	84	
318	Sandstone, fine to medium	8	
326	Shale, dark gray with pieces of lignite	22	
349	Sandstone, fine to medium	8	
357	Shale, black, soft	12	
369	Shale and layers of sandstone	15	
384	Sandstone, fine to medium	10	
394	Clay, whitish	5	
399	Hard rock	3	Took 20 minutes to drill 2 feet
402	Bottom of hole		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID # 67-5		County: Rock	
Geologist: Evan Drivas		Driller: Don Hejtmanek - LTP	
Date: 9/23/96		Drilling Method: 6" Mud rotary	
Location: T101N R 45W Section 25 CCCDDD			
Depth (ft)	Description	Thickness	Drilling Notes
0	Clay, brown	4	
4	Sand and gravel	19	Chatter @ 14-18'
23	Clay, light gray, sandy	20	Chatter @ 34-35'
43	Clay, sandy, tan	10	
53	Clay, sandy, gray	123	
176	Sand, medium	17	
193	Sand, medium to coarse	5	
198	Clay, sandy, gray	30	
228	Sand	3	
231	Clay, sandy, gray	25	
256	Sand	2	
258	Clay, sandy, gray	3	Chatter @ 258
261	Boulder	2	Very slow drilling
263	Clay, dark gray, calcareous	15	
278	Bottom of hole		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID # 67-6		County: Rock	
Geologist: Evan Drivas		Driller: Don Hejtmanek - LTP	
Date: 9/23/96		Drilling Method: 6" Mud rotary	
Location: T101N R44W Section 20 ABBBBC			
Depth (ft)	Description	Thickness	Drilling Notes
0	Soil, dark brown, organic	3	
3	Clay, brown, sandy	20	
23	Clay, gray, sandy	25	
48	Clay, brown, sandy	35	
83	Clay, gray, sandy	20	
103	Clay, olive-green, sandy	183	
286	Sand medium to coarse	7	
293	Sand, medium	17	
310	Clay, gray, sandy	3	
313	Shale, dark gray	81	
394	Sandstone, very fine	54	Chatter @ 396'
448	Shale, dark gray with gypsum	5	
453	Sandstone	2	
455	Shale, dark gray	32	
487	Sandstone, very fine to fine	7	
494	Shale, dark gray	20	
514	Shale, dark gray with some white clay	10	
524	Hard rock	8	Very slow
532	Bottom of hole		
	Interpreted from geologist's mud log and gamma/resistivity log		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID # 67-7		County: Rock	
Geologist: Tom Gullett, Jim Berg		Driller: Don Hejtmanek - LTP	
Date: 9/30/96		Drilling Method: 6" Mud rotary	
Location: T101N R 44W Section 32 BBBBB			
Depth (ft)	Description	Thickness	Drilling Notes
0	Clay, yellow-brown, sandy	13	
13	Clay, gray, sandy	25	
38	Clay, light brown, sandy	30	
68	Clay, gray, sandy	45	
113	Clay, olive-green, sandy	15	
128	Clay, yellow, sandy	30	
153	Clay, reddish gray, sandy	15	Rock at 162'
168	Clay, gray, sandy	95	
263	Sand, medium	25	
288	Clay, blue, sandy	15	
303	Clay, dark brown	60	Chatter @ 314'
363	Sandstone, fine	30	
393	Sandstone, medium	8	
401	Shale, black	4	
405	Sandstone, fine-medium	8	
413	Shale, black	45	
458	Clay, white	35	
445	Hard rock, weathered	10	498-503 took 35 minutes to drill
503	Bottom of hole		
	Interpreted from geologist's mud log and gamma/resistivity log		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID # 67-8		County: Rock	
Geologist: Jim Berg		Driller: Don Hejtmanek - LTP	
Date: 10/9/96		Drilling Method: 6" Mud rotary	
Location: T101N R 44W Section 32 DDDDDC			
Depth (ft)	Description	Thickness	Drilling Notes
0	Sand, coarse to very coarse	13	
13	Clay, yellow, sandy	5	
18	Clay, gray, sandy	24	
40	Clay, yellow, sandy	10	
50	Clay, gray, sandy	152	Rough @ 51'
202	Sand, very fine to medium	30	
232	Clay, dark brown, soft	68	
300	Shale, dark gray	20	
320	Shale and sandstone	30	
350	Sandstone, very fine	15	
362	Shale, dark gray	95	
450	Metamorphic rock, weathered, greenish-white	40	
490	Bottom of hole		
	Interpreted from geologist's mud log and gamma/resistivity log		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID # 41-1		County: Lincoln	
Geologist: Jim Berg, Tom Gullett		Driller: Don Hejtmanek - LTP	
Date: 10/31/96		Drilling Method: 6" Mud rotary	
Location: T113N R 47W Section 6 BAAADA			
Depth (ft)	Description	Thickness	Drilling Notes
0	Topsoil, black	3	
3	Clay, yellow with pebbles	26	
29	Clay, gray, sandy	43	
67	Sand, medium to very coarse with some gravel	16	
83	Clay, gray, sandy	46	
129	Clay, yellow, sandy	5	
134	Clay, gray, sandy	95	
229	Clay, dark brown, soft	25	
250	Sand, fine to coarse	18	
268	Clay (no sample return)	7	
275	Sand, fine to coarse	35	
310	Clay (no sample return)	60	
370	Sand, coarse to very coarse	12	
382	Clay (no sample return)	35	
418	Sand	3	
421	Clay (no sample return)	40	
461	Sand, fine to coarse	41	
496	Clay (no sample return)	8	
504	Shale, dark gray	55	
559	Shale, black, soft with some lignite	45	
604	Bottom of hole		
	Lithologic interpretations from geologist's mud log and gamma/resistivity log		

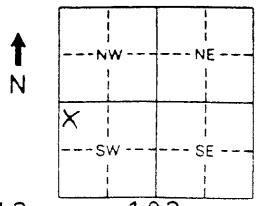
Drilling Log - Minnesota Department of Natural Resources			Page 1 of 2
Site ID # 87-7		County: Yellow Medicine	
Geologist: Jim Berg, Evan Drivas		Driller: Don Hejtmanek - LTP	
Date: 10/24/96		Drilling Method: 6" Mud rotary	
Location: T114N R 46W Section 28 CCBBBA			
Depth (ft)	Description	Thickness	Drilling Notes
0	Clay, brown, sandy	3	
3	Clay, gray, sandy	5	Chatter @ 9-10'
8	Clay, tan, sandy	5	
13	Clay, gray, sandy	29	
36	Sand, coarse to very coarse	9	
45	Clay, gray, sandy	23	
68	Sand, coarse to very coarse	34	
99	Sand, medium to very coarse	55	
154	Sand, fine to medium	10	
164	Sand, fine	5	
169	Sand, very fine	10	
179	Sand, fine to medium	5	
184	Sand, medium to very coarse	15	
199	Sand, very fine to medium	5	
204	Clay, gray, sandy	10	
214	Clay, brown, sandy	25	
239	Clay, light gray, sandy	22	
250	Sand, silty fine to medium	20	
270	Clay, brown, sandy	55	
339	Clay, medium gray, sandy	15	
354	Sand, silty, very fine to fine	10	
374	Sand, silty, very fine to coarse	19	
393	Clay, dark brown, soft	52	
449	Clay, dark brown with sand layers	5	

Drilling Log - Minnesota Department of Natural Resources			Page 2 of 2
Site ID # 87-7		County: Yellow Medicine	
Geologist: Jim Berg, Evan Drivas		Driller: Don Hejtmanek - LTP	
Date: 10/24/96		Drilling Method: 6" Mud rotary	
Location: T114N R 46W Section 28 CCBBBA			
Depth (ft)	Description	Thickness	Drilling Notes
454	Clay, dark brown, soft	40	
494	Shale, medium gray	15	
509	Shale with sand layers (no sample return)	20	
529	Shale, black, soft	75	
604	Shale, medium gray, hard	5	
609	Siltstone, marl? (no sample return)	21	
630	Siltstone and shale (no sample return)	15	
645	Shale, medium gray, hard	79	
724	Bottom of hole		
	Lithologic interpretations from geologist's mud log and gamma/resistivity log		

Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID # 87-8		County: Yellow Medicine	
Geologist: Jim Berg, Tom Gullett		Driller: Don Hejtmanek - LTP	
Date: 11/13/96		Drilling Method: 6" Mud rotary	
Location: T114N R 46W Section 34 ADADAD			
Depth (ft)	Description	Thickness	Drilling Notes
0	Topsoil, brown	3	
3	Clay, olive brown, sandy	51	
54	Clay, gray, sandy	80	Chatter @116'
134	Sand, fine to very coarse with gravel	19	
153	Clay, gray, sandy	16	
169	Clay, gray with sand layers	30	
199	Clay, yellow, sandy	43	
242	Boulder	2	
244	Clay, yellow-brown, sandy with sand layers	26	
270	Clay, gray, sandy	134	Chatter @275'
404	Sand	4	
408	Clay, yellow-brown sandy	10	
418	Sand, fine to coarse	16	
434	Sand and yellow brown clay	5	
439	Clay, dark brown, soft	45	
484	Bottom of hole		
	Lithologic interpretations from geologists mud log and gamma/resistivity		

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec. 12 T 102 R 41

DRILLERS LOG

Drilled for DNR Div. of Waters By Page 1 Office

Location of Test Hole see map T 102 R41 Sec.12

Test Hole No. 53-1 Well No.

Size of test hole 6 1/4 Date started 8-21-96 3:10 Date completed 8-28-96 Total Hours

FORMATIONS DRILLED

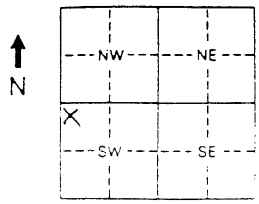
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top Soil	Black	G.L.	4'	4'
Clay	Brown	4'	8'	4'
Sand	Brown	8'	11'	3'
Clay	Brown	11'	15'	4'
Clay (soft)	Grey	15'	59 1/2'	44 1/2'
Sand	Grey	59 1/2'	60 1/2'	1'
very soft sandy clay	Grey	60 1/2'	108'	47 1/2'
Clay	Yellow	108'	124'	80'
Clay	Grey	124'	204'	80'
Clay & Shale	Blk,Grey	204'	226'	22'
Sand & Shale	Grey,Blk	226'	233'	7'
Clay & Shale	Grey,Blk	233'	240'	7'
Clay & Shale	light green	240'	334'	94'
Clay & Shale	Grey,Blk	334'	387'	53'
Rock	[illegible]	387'	388'	1'
Clay & Shale	Grey,Blk	388'	486'	98'
very Sandy Clay & Shale	Grey,Blk	486'	510'	24'
Lenses of Sand & Shale	Tan,Grey,Blk	510'	516'	6'
Very sandy Shale	Grey,Blk	516'	519'	3'
Very dirty sand (120)	Tan,Grey,Blk	519'	524'	5'
Harder Shale	Grey,Blk	524'	579'	55'
Sand	Grey	579'	581'	3'
Very soft sandy clay or shale	Grey	581'	597 1/2'	16 1/2'
Sand (drilled good)	Grey	597 1/2'	605 1/2'	5'

Signed _____ Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec 12 T 102 R 41

DRILLERS LOG

Drilled for DNR Div. of Waters By Page 2 Office

Location of Test Hole See map T 102 R41 Sec. 12

Test Hole No. 53-1 Well No.

Size of test hole 6¼ Date started 8-21-96 Date completed 8-28-96 Total Hours

FORMATIONS DRILLED

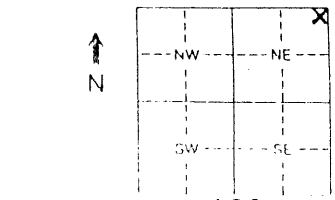
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Rock	Gray	602½'	603'	½
Sand (drilled good)	Gray	603'	607'	4'
Sandy Clay & Shale (soft)	Gray,tan	607'	646'	39'
Hard sandy clay & shale	Gray,tan	646'	676'	30'
Lenses of shale,clay & dirty sand	Gray,tan	676'	688'	12'
Very sandy clay & shale (firm)	Gray,tan	688'	703'	15'
Sand (drilled dirty)	Gray,tan	703'	717'	14'
Dirty sand stone w/lenses of	Gray,tan	717'	755½'	38½'
shale (not sticky)				
Rock		755½'	756'	½
Stocky Shale	Gray,tan	756'	779'	43'
Hard Shale	Gray	779'	804'	25'
Shale w/lenses of sand	Gray	804'	809'	5'
Very soft dirty sand & shale	Gray	809'	843'	34'
Cleaner sand	Gray	843'	849'	6'
Lenses of dirty sand & shale	Gray	849'	864'	15'
Very soft sand stone	Gray	864'	883'	19'
sandy shale hole started taking	water Gray,blk	883'	893'	10'
Hard shale (mud turned reddish)	Tan,Org.Gray, Green	893'	914'	21'
Shale (brittle)	Orange,lime	914'	924'	10'
Shale (brittle)	Green Gray,Org.	924'	980'	56'

Signed _____ Driller

FORM #20

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec. 32 T 120 R 40w

DRILLERS LOG

Drilled for DNR Div of Waters By Page 1 Office

Location of Test Hole T 102 R 40w

Test Hole No. 53-2 Well No.

Size of test hole 6 3/4 Date started 8-29-96 Date completed 9-5-96 Total Hours

FORMATIONS DRILLED

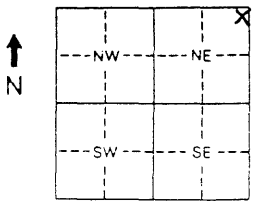
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top Soil	Black	GL	2	2
Clay	Brown	2	19	17
Clay	Gray	19	24½	5½
Rock	Colored	24½	25	½
Clay	Blue,Gray	25	101	76
sand w/lenses of clay	Gray	101	104	3
Soft sand clay	Gray	104	134	30
Sand, gravel & cobbles	Colored	134	144½	10½
lenses of clay & gravel	Colored	144½	149½	4½
Sand and light gravel (drilled dirty)	Colored	149½	154	5
Sandy Clay (soft)	Gray	154	203	49
Sand	Gray	203	205½	2½
Sandy clay	Gray	205½	223	17½
Sand	Gray	223	259½	36½
Sandy clay	Gray	259½	383	123½
Sand	Gray	383	391	8
Sandy clay & shale	Tan,Blk,Gray	391	479	88
Very sandy clay & shale	Tan,Blk,Gray	479	489	10
Very dirty sand w/shale	Gray,Tan	489	504	15
Sand (drilled good)	Gray	504	514	10
Sand (drilled dirty)	Gray	514	532	18
Very sandy clay-shale	Gray,Tan	532	549	17
Sand (drilled good)	Gray	549	553	4
Soft sandy clay-shale w/small lenses of sand	Gray,Blk, Tan	553	580	27

Signed Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec. 32 T 120 R 40w

DRILLERS LOG

Drilled for DNR Div. of Waters By _____ Office

Location of Test Hole T102 R 40w

Test Hole No. 53-2 Well No. _____

Size of test hole 6¼ Date started 8-29-96 Date completed _____ Total Hours _____

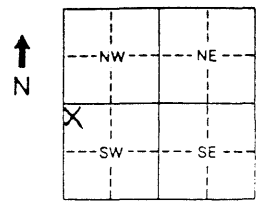
FORMATIONS DRILLED

TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Sandy clay & shale (soft)	Blk, Gray, Tan	580	654	74
Very hard shale	Tan, Gray, Grn.	654	671	17
Shale & Clay	Tan, Gray	671	734	63
Sand (drilled Good)	Gray	734	737	3
Sandy Clay -Shale	Blk Gray, Tan	737	800	63
Soft shale	White, Gray, Blk	800	824	24

Signed _____ Driller

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec 3 101 T 40 R 3

DRILLERS LOG

Drilled for DNR Div. of Waters By Page 1 Office

Location of Test Hole T 101 R 40 Sec. 3

Test Hole No. 53-3 Well No.

Size of test hole 6 3/4 Date started 8-14-96 (3:30) Date completed Total Hours

FORMATIONS DRILLED

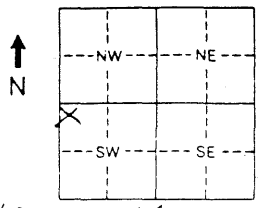
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top Soil	Black	GL	2'	2'
Sand and gravel	Brown	2'	18'	16'
Sandy clay	Gray	18'	50'	32'
Sand	Gray	50'	53'	3'
Lenses of sandy clay & sand	Gray	53'	59'	6'
Lenses of sand &gravel &clay (no water loss)	Gray,Col.	59'	73'	14'
sandy clay w/pebbles	Gray	73'	92'	19'
Sand w/lenses of clay (washed)	Gray,Blk	92'	96'	4'
sandy clay	Gray	96'	134'	38'
gravel & rock	Colored	134'	135'	1'
Sandy clay	Gray	135'	195'	60'
sandy clay	Yellow	195'	242'	47'
very sandy clay w/shale	Blk.Yellow	242'	283'	41'
soft sandy clay & shale	Blk.Gray	283'	399½'	116'
soft rock	Gray	399'	399½'	½'
Sand (drilled fair) took a little water	Gray	399½'	419½'	20'
rock	Gray	419½'	421½'	2'
sandy clay (soft)	Gray	421½'	466'	44½'
hard sticky clay -shale	Gray	466'	506'	40'
Softer sandy clay shale	Gray,Blk.	506'	550'	44'
soft sandy shale	Gray,Blk,red	550'	569'	19'
very soft shale (sandy) 90 sec.	Blk.Gray	569'	589'	20'
very dirty sand stone	Gray	589'	604'	15'
fine sand (drilled good)	Gray	604'	639'	35'

Signed Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec 10 T 40 R 3

DRILLERS LOG

Drilled for DNR Div. of waters By page 2 Office

Location of Test Hole

Test Hole No. 53.3 Well No.

Size of test hole 6 1/4 Date started 8-14-96 Date completed Total Hours

FORMATIONS DRILLED

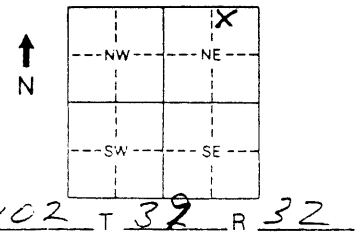
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Dirty Sand	Gray,Blk	639	649	10
Lenses of dirty sand and shale	Gray,Blk	649	664	15
Fine sand (drilled good)	Gray,Blk	664	669	5
Lenses of dirty sand & shale(poor sample)	Gray,Blk	669	684	15
Sandy Shale	Gray,Blk	684	704	20
Sand (drilled good)	Gray	704	710	6
Lenses of sand & shale	Gray	710	724	14
Very sandy shale	Gray,Blk	724	744	20
Hard shale	Gray	744	755	11
Shale	Grn,Gray,White	755	775	20

Signed Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec. 102 T 39 R 32

DRILLERS LOG

Drilled for DNR Div. of Waters By page 1 Office

Location of Test Hole 102 39 32 (see map)

Test Hole No. 53-4 Well No. _____

Size of test hole 6 3/4 Date started 8-7-96 Date completed 8-13-96 Total Hours 33

FORMATIONS DRILLED

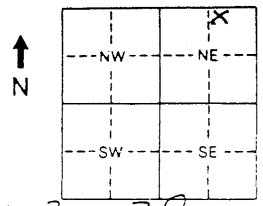
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top soil	Black	GL	3	3
Clay	Brown	3	7	4
Sand	Brown	7	9	2
Clay	Brown	9	18	9
Clay (sticky)	Gray	18	33	15
Softer sandy clay	Gray	33	46	13
very sandy clay	Gray	46	61	15
Lenses of sand & clay	Gray	61	66	5
Soft sandy clay	Gray	66	88	22
Very soft sandy clay	Gray	88	107	19
Very dirty sand(70 sec) w/lenses of clay	Gray	107	130	23
Sand (fine)	Gray	130	133	3
Very sandy clay w/lenses of fine sand	Gray	133	146	13
Sand	Gray	146	148	2
Very sandy clay	Gray	148	156	8
Sand (came in over night)	Gray	156	161½	5½
Sandy clay w/pebbles	Gray	161½	207	45½
Sandy clay (hard)	Gray	207	209	2
Sandy clay	Gray	209	279	70
Sand	Gray	279	280	1
Sandy clay	Gray	280	286	6
Sand	Gray	286	287	1
Sandy clay	Gray	287	304	17
Very soft sandy clay	Gray	304	312½	8½

Signed _____ Driller

FORM #30

LTP Enterprises, Inc. Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec. 102 T 39 R 32

DRILLERS LOG

Drilled for DNR Div. of Waters By Page 2 Office

Location of Test Hole 102 39-32

Test Hole No. 53-4 Well No.

Size of test hole 6 3/4 Date started 8-7-96 Date completed 8-13-96 Total Hours 33

FORMATIONS DRILLED

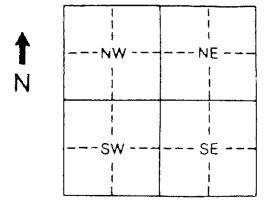
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Sand (drilled good) took a Little water	Gray	312½	340	27½
Sandy clay	Gray	340	443	103
Very fine sand (poor sample) dirty drilled	Gray	443	464	21
Lenses of sand (fine) and clay	Gray,Tan	464	474	10
Hard sandy clay	Gray,Tan	474	488	14
Lenses of sand & clay	Gray,Tan	488	501½	13½
Rock	Gray	501½	502	½
Lenses of dirty sand &clay	Gray,Tan	502	517	15
Hard clay - shale	Gray,Tan	517	525	8
Sandy clay	Gray	525	555	30
Hard sticky clay w/shale - coal	Gray,Blk	555	610	55
Very sandy clay - shale	Gray	610	639	29
Sandy clay - shale	Gray	639	659	20
Dirty sand (fine)	Gray	659	665	6
Very dirty sand (fine)	Gray	665	671	6
Very sandy clay- shale	Gray,Blk	671	724	53
Hard shale 1hr. last 2'	Blk,Gray,Grn	724	726	2

Signed _____ Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec. 20 T 101 R 44

DRILLERS LOG

Drilled for DNR Div. of Waters By _____ Office

Location of Test Hole 6½ mi. S. of Luverne, MN on Hwy 75 Appox 3½ mi. E.

_____ Test Hole No. 67-6 Well No. _____

Size of test hole 6 3/4 Date started 10-2-96 Date completed 10-8-96 Total Hours _____

FORMATIONS DRILLED

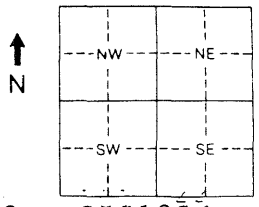
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top Soil	Black	GL	2	2
Sandy clay w/lenses of gravel	Brown	2	23	21
Sandy clay	Brown,Gray	23	84	61
Sandy Clay	Brown,Gray	84	211½	127½
Rock	Pink	211½	212	½
Sandy clay	Gray	212	286	74
Sand (fair)	Gray	286	290	4
Very sandy clay w/lenses of sand	Gray	290	297	7
Fine sand (drilled dirty) looked clean	Gray	297	310½	13½
Sandy shale firm	Gray	310½	386	75½
Soft sandy shale	Blk,Gray	386	396	10
Fine sand (drilled fair)(poor sample)	Gray	396	448	52
Sandy shale	Blk,Brown,Gray	448	453	5
Fine sand	Gray	453	455	2
Firm shale	Blk,Gray	455	487	32
Sandstone	Gray	487	494	7
Sandy shale	Blk,Gray	494	510	16
Sandy shale w/layers of rock	White,Gray	510	524	14
Rock	White,Gray	524	532	8

Signed _____ Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec 32 T 101 R 44

DRILLERS LOG

Drilled for DNR Div. of Water By _____ Office

Location of Test Hole Approx 6 ½ S. of Luverne, MN on Hwy 75, 3 E, 2,5,

_____ Test Hole No. 67-7 Well No. _____

Size of test hole 6 3/4 Date started 9-30-96 Date completed 10-2-96 Total Hours 23 3/4

FORMATIONS DRILLED

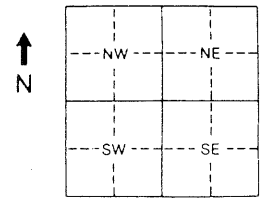
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top Soil	Brown	GL	1	1
Soft clay	Brown	1	15	14
Clay	Gray	15	113	98
Soft sandy clay	Gray	113	162	49
Rock		162	162½	½
Soft Clay	Gray,Brown	162½	263	100½
Fine sand (drilled good) TALW 6-8-10	Gray	263	288	25
Sandy shale	Blk,Brown,Gray	288	346	58
Fine sand stone TW (drilled good)	White	346	401	55
Shale	Blk, Gray	401	405	4
Fine sandstone (drilled good) w/small Shale lenses	Gray	405	413	8
Shale	Blk,Gray, Brown	413	439	26
Very soft sandy shale	Blk,Gray, Brown	439	445	6
Hard shale	Blk,Brown	463	484	21
Rock (very hard at bottom)	Red,Gray	484	503	19

Signed _____ Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec. 35 T 102N R 46W

DRILLERS LOG

Drilled for DNR Div of Waters By _____ Office

Location of Test Hole Approx 3½ S. of Luverne MN on Hwy 75, 5 3/4 W on Co 15

_____ Test Hole No. 67-1 Well No. _____

Size of test hole 6 3/4 Date started 10-22-96 Date completed 10-23-96 Total Hours 14 3/4

FORMATIONS DRILLED

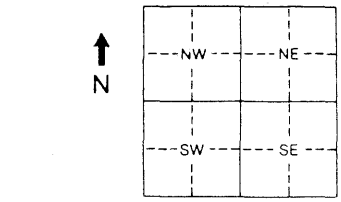
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top soil	Black	GL	2	2
Clay	Brown	2	15	13
Sand	Brown	15	31	16
Sandy clay	Brown	31	59	28
Sandy clay	Gray	59	132	73
Very soft sandy clay w/dirt fine sand	Grn,Gray	132	174	42
Very fine sand	Gray	174	184	10
Sandy clay	lt.Gray,Brown	184	208	24
Very dirty sand (fine)	Gray,Brown	208	214	6
Sandy clay	Gray,Brown	214	219	5
Very fine dirty sand (no sample) (drilled good)	Gray	219	262	43
Sandy clay	Gray	262	321	59
Sticky clay - shale	Gray,Brown	321	389	68
Clay-shale	Blk,Gray,Brown	389	400	11

Signed _____ Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec. 1 T 101 R 46

DRILLERS LOG

Drilled for DNR Div of Waters By _____ Office

Location of Test Hole Approx 5½ of Luverne on 75, 5 W, 1¼ N.

_____ Test Hole No. 67-2 Well No. _____

Size of test hole 6 3/4 Date started 10-16-96 Date completed 10-17-96 Total Hours _____

FORMATIONS DRILLED

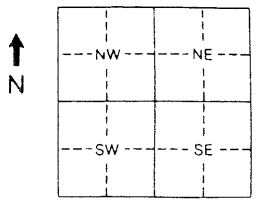
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top soil	Black	GL	2	2
Clay	Brown	2	7	5
Gravel	Brown	7	11	4
Sandy clay w/lenses of sand	Gray	11	17	6
Clay	Brown	17	60	43
Clay	Gray	60	190	130
Softer clay	Gray	190	221	31
Very sandy clay w/lenses of sand	Gray	221	227	6
Very sandy clay (soft)	Gray,Blk	227	254	27
Sand (drilled good)	Gray	254	258	4
Very sandy clay	Gray,Blk	258	282	24
Sand (drilled good) w/lenses of clay	Gray,Grn	282	293	11
Sandy shale and clay	Gray,Grn	293	334	41
Sandy clay and brittle shale	Gray,Blk	334	400	66

Signed _____ Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec. 20 T 101 R 45

DRILLERS LOG

Drilled for DNR Div of Waters By _____ Office

Location of Test Hole Approx 6½ S. of Luverne, MN on Hwy 75, W 2½ mi.

_____ Test Hole No. 67-3 Well No. _____

Size of test hole 6 3/4 Date started 10-14-96 Date completed 10-16-96 Total Hours 21

FORMATIONS DRILLED

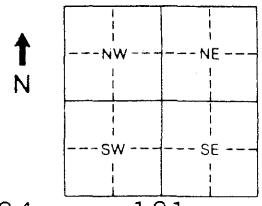
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top soil	Black	GL	1	1
Clay	Brown	1	18	17
Sandy Clay	Brown	18	124	106
Silty Clay (soft)	Tan	124	162	38
Fine sand 8-10 (drilled good) took water	Gray	162	179	17
Shale	Grn,Brown	179	188	9
Fine sand	Gray	188	192½	4½
Shale Tan	Gray,Brown	192½	224	31½
Hard clay - shale	Brown,Gray	224	265	41
Very sandy clay-shale (much softer)	Gray,Brown	265	324	59
Hard shale (stocky)	Gray,Brown	324	384	60
Sandy shale	Gray,Brown	384	417	33
Very fine sand (poor sample)	Gray,Blk	417	429	12
Very soft sandy shale	Blk,Gray	429	449	20
Very fine sand (no sample) drilled quick	Blk,Gray	449	462	13
Shale (soft)	Black	462	494	32
Shale de-comp.	Blk,white	494	519	25
De-comp.-rock-shale	Blk,white	519	560	41

Signed _____ Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec. 24 T 101 R 45

DRILLERS LOG

Drilled for DNR Div. of Waters By _____ Office

Location of Test Hole Approx 6½ mi S. of Luverne on 75, 1 E see map

Test Hole No. 67-4 Well No. _____

Size of test hole 6 3/4 Date started 9-18-96 Date completed 9-19-96 Total Hours _____

FORMATIONS DRILLED

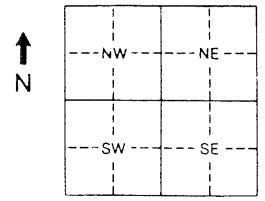
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top soil	Black	GL	1	1
Sand & gravel	Brown	1	21	20
Sandy clay	Brown	21	24	3
Sandy clay	Gray	24	196	172
Very sandy clay (soft)	Gray	196	204	8
Very fine sand (drilled good)	Gray	204	209	5
Sand (drilled good) took water	Blue	209	220½	11½
Sandy clay-shale	Gray,Tan	220½	318	97½
Very fine sand	Gray	318	326½	8½
Sandy shale	Blk,Gray,Tan	326½	348	21½
Fine sandstone	Gray	348	357	9
Sandy shale	Blk,Gray,Tan	357	372	15
Fine sandstone	Gray	372	374	2
Sandy shale w/lenses of sandstone (fine)	Blk,Gray,White	374	382	8
Sandstone	White	382	390	8
Hard decomp. & solid granite	White,Pink	390	403	13

Signed _____ Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec. 25 T 101 R 45

DRILLERS LOG

Drilled for DNR Div. of Waters By _____ Office

Location of Test Hole Approx 8½ S. of Luverne, MN on Hwy 75 1.1 mi. E.

_____ Test Hole No. 67-5 Well No. _____

Size of test hole 6 3/4 Date started 9-23-96 Date completed 9-24-96 Total Hours _____

FORMATIONS DRILLED

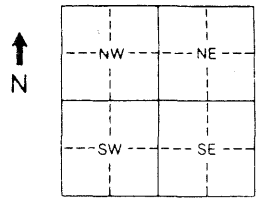
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top soil	Black	GL	4	4
Sand & gravel	Brown	4	16	12
Rock	Brown	16	16½	½
Sand & gravel	Brown	16½	24	7½
Rock		24	24½	½
Sandy clay	Brown	24½	60	35½
Clay	Gray	60	136	76
Clay	Tan,Gray	136	176	40
Dirty sand	Gary	176	181	5
Fine sand (drilled good) took a little water	Gray	181	200	19
Clay-shale	Gray,Blk	200	227	27
Dirty sand	Gray	227	230	3
Clay-shale	Blk,Gray	230	261	31
Rock (hard)	Red	261	262½	1½
	White	262½	267	4½
Rock	White,Pink	267	278	9

Signed _____ Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec. 32 T _____ R _____

DRILLERS LOG

Drilled for DNR Div. of Waters By _____ Office

Location of Test Hole T 102 N R 43 W, S 32, N ¼, SE ¼, SE ¼ DDA

_____ Test Hole No. 53-6 Well No. _____

Size of test hole 6¼ Date started 9-11-96 Date completed _____ Total Hours _____

FORMATIONS DRILLED

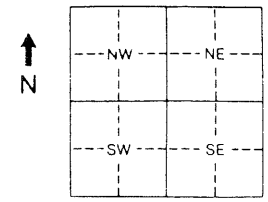
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top Soil	Black	GL	1	1
Sand	Brown	1	8	7
Gravel	Brown	8	24	16
Sand	Brown	24	42	18
Dirty sand & clay	Brown	42	49	7
Sand	Brown	49	54	5
Very sandy clay	Brown	54	76	22
Harder clay	Brown	76	84	8
Sand	Brown	84	94	10
Sandy clay	Brown	94	105	11
Sandy Clay	Gray, Brn	105	188	83
Sandy Clay	Gray,Tan	188	302	114
Soft sandy clay	Gray,Tan	302	352	50
Hard clay-shale	Gray,Blk	352	448	96
Sand stone (drilled good) took a little water	Gray,white	448	500	52
Hard sticky shale	Blk, Gray	500	578	78
Hard shale Tan	Gray,Blk	578	649	71

Signed _____ Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec 17 T 102 R 43

DRILLERS LOG

Drilled for DNR Div. of Waters By _____ Office

Location of Test Hole T 102 R 43 W , 517 SE ¼, SE¼ , NE ¼ ADD

_____ Test Hole No. 53-7 Well No. _____

Size of test hole 6¼ Date started 9-9-96 Date completed 9-11-96 Total Hours _____

FORMATIONS DRILLED

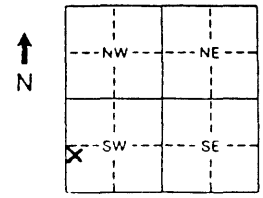
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top soil	Black	GL	2	2
Clay	Brown	2	60	58
Clay Brn,	Drk Gray	60	74	14
Soft sand clay	Brn,Gray	74	86	12
Sand	Brown	86	90	4
Sandy clay	Gray	90	121	31
Rock	Red	121	122	1
Sandy clay	Gray	122	143	21
Sand	Gray	143	147½	4½
Sandy clay	Gray	147½	197	49½
Sandy clay	Tan,Gray	197	260	63
Sand (drilled fair) (60)	Gray	260	276	16
Sandy clay	Gray	276	324	48
Very soft sandy clay	Gray	324	352	28
Sandy clay	Gray	352	404	52
Shale	Drk Gray	404	480	76
Very sandy shale Tan,	Drk Gray	480	495	15
Very fine sand (drilled good) poor sample	Gray	495	510½	15½
Sticky hard shale Tan,	Blk,Gray	510½	588	77½
Sandy shale w/lenses of sand	Blk,Gray	588	602	14
Sand (drilled good)	Gray	602	606½	4½
Sandy shale	Gray	606½	609	2½
Sandstone	White,Grn	609	624	15
Very sandy shale Tan,	Gray,Blk	624	651	47
Quarsite	Pink	651	659	8

Signed _____ Driller

FORM #30

LTP Enterprises, Inc. Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec 28 T 114N R 46W

DRILLERS LOG

Drilled for DNR Div of waters pgl By _____ Office

Location of Test Hole 7 mi. W of Canby, 4 3/4 mi. S. east side of rd.

Test Hole No. 87-7 Well No. _____

Size of test hole 6 3/4 Date started 10-24-96 Date completed 10-31-96 Total Hours _____

FORMATIONS DRILLED

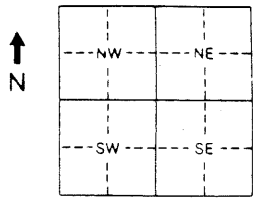
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top soil	Black	GL	2	2
Soft clay w/pebbles	Brown	2	10	8
Rock	Red	10	10½	½
Soft clay	Gray	10½	41	30½
Sand and light gravel	Gray	41	50	9
Sandy clay	Gray	50	65	15
Lenses of sand and clay	Gray	65	74	8
Sandy clay	Gray	74	78	4
Sand	Gray	78	82	4
Dirty fine sand and clay	Gray	82	99	17
Sand (took water) drilled fair	Gray	99	157	58
Very fine sand (drilled fair)Poor sample	Gray	157	179	22
Coarse sand	Gray	179	199	20
Very fine sand (no sample)	Gray	199	205	6
Sandy clay	Gray	205	256	51
Lenses of sand and clay	Gray	256	262	6
Sand (drilled good)	Gray	262	266	4
Fine dirty sand	Brown,Tan	266	278	12
Sandy clay	Brown,Gray	278	364	86
Dirty sand	Gray	364	374	10
Fine sand (drilled fair)	Gray	374	384	10
Very fine sand (poor sample)	Gray	384	397	13
Sandy clay-shale w/small lenses of fine sand	Gray	397	500	103
Very softsandy shale	Gray	500	517	17

Signed _____ Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec _____ T _____ R _____

DRILLERS LOG

Drilled for DNR Div of waters page 2 By _____ Office

Location of Test Hole 7 mi. W of Canby, 4 3/4 mi. S. east side of rd.

_____ Test Hole No. 87-7 Well No. _____

Size of test hole 6 3/4 Date started 10-24-96 Date completed 10-31-96 Total Hours _____

FORMATIONS DRILLED

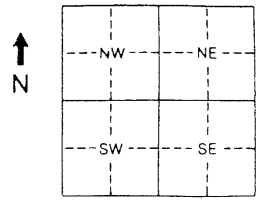
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Sandy shale	Gray,Blk	577	597	80
Very fine sand (poor sample)	Gray	597	635	38
Lenses of very fine sand and shale	Gray,Blk	635	659	24
Shale -rock (drilled slow) Gray,	Colored	659	724	65

Signed _____ Driller

FORM #30

LTP Enterprises, Inc.
Well Drilling

FARGO, N.D.
HUTCHINSON, MN.



Sec. 32 T 101N R 44W

DRILLERS LOG

Drilled for DNR Div. of Water By _____ Office

Location of Test Hole Approx 6½ S. of Luverne, MN on Hwy 75, 4E, 3S.

_____ Test Hole No. 67-8 Well No. _____

Size of test hole 6 3/4 Date started 10-9-96 Date completed 10- -96 Total Hours _____

FORMATIONS DRILLED

TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top soil	Black	GL	2	2
Clay	Brown	2	10	8
Sand	Brown	10	16	6
Sandy clay	Gray	16	48	32
Sandy clay	Brown	48	101	53
Sandy clay	Gray	101	140	39
Hard sticky clay	Gray	140	171	31
Soft sandy clay	Gray,Brown	171	207	36
Lenses of clay and sand	Gray	207	219	12
Fine sand (drilled good) THLW 6-8	Gray	219	236	17
Sandy shale	Blk,Gray	236	326	90
Sandy shale w/small lenses of sand	Gray,Blk	326	336	10
Fine sand	Gray	336	340	4
Sandy Shale	Gray,Blk	344	354	14
Fine sand (drilled fair)	Gray	354	364	10
Sandy shale	Gray	364	400	36
Very soft sandy shale (brittle shale)	Gray,Blk	400	451	51
Sandy Shale Gray	Grn,White	451	489	38

Signed _____ Driller

FORM #30

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING SEALING RECORD

Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. **H 101116**

Minnesota Unique No. or W-series No. (Leave blank if not known)

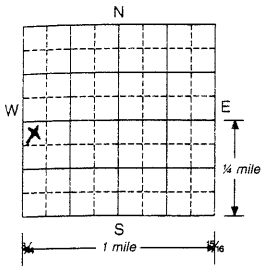
WELL OR BORING LOCATION

County Name: NORCES

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
OSWALD	162	41	12	NW¼ NW¼ SW¼

Numerical Street Address or Fire Number and City of Well or Boring Location

Show exact location of well or boring in section grid with "X".



Sketch map of well or boring location, showing property lines, roads, and buildings.

TEST HOLE # 53-1

PROPERTY OWNER'S NAME: STATE OF MN.

Property owner's mailing address if different than well location address indicated above.

MINN. DNR
500 LAFAYETTE
ST. PAUL, MN. 55155

WELL OWNER'S NAME: STATE OF MN.

Well owner's mailing address if different than property owner's address indicated above.

Date Sealed: 8-28-96

Date Well or Boring Constructed: 8-21-96

Depth Before Sealing: 980 ft.

Original Depth: 980 ft.

AQUIFER(S)
☐ Single Aquifer ☐ Multiaquifer

WELL/BORING
☐ Water Supply Well ☐ Monit. Well
☒ Env. Bore Hole ☐ Other _____

STATIC WATER LEVEL
☐ Measured ☐ Estimated
_____ ft. ☐ below ☐ above land surface

CASING TYPE(S)
☐ Steel ☐ Plastic ☐ Tile ☐ Other _____

CASING

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

SCREEN/OPEN HOLE
Screen from _____ to _____ ft. Open Hole from _____ to _____ ft.

OBSTRUCTION/DEBRIS/FILL
☐ Obstruction ☐ Debris ☐ Fill ☐ No Obstruction
Type of Obstruction/Debris/Fill _____
Obstruction/Debris/Fill removed? ☐ Yes ☐ No

PUMP
Type _____
☐ Removed ☐ Not Present ☐ Other _____

GEOLOGICAL MATERIAL	COLOR	HARDNESS OF FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
☐ No Annular Space Exits
☐ Annular space grouted with tremie pipe
☐ Casing Perforation/Removal
_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed
_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed
Type of perforator _____
☐ Other _____

GROUTING MATERIAL(S)
Grouting Material: NEAT CEMENT from 0 to 980 ft. 9.5 yards _____ bags
_____ from _____ to _____ ft. _____ yards _____ bags
_____ from _____ to _____ ft. _____ yards _____ bags
_____ from _____ to _____ ft. _____ yards _____ bags

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

UNSEALED WELLS AND BORINGS
Other unsealed well or boring on property? ☐ Yes ☐ No

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

L.I.P. ENTERPRISES, INC. — 91686
Contractor Business Name — *License or Registration No.*

Authorized Representative Signature — 9-12-96 *Date*

DON HEJTMANEK
Name of Person Sealing Well or Boring

IMPORTANT-FILE WITH PROPERTY PAPERS-WELL OWNER COPY — H 101116

HE-01434-02

10/95R

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING SEALING RECORD

Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. **H 101117**

Minnesota Unique No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION

County Name: NOBLES

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
WORTHINGTON	102	40	29	NE NE NE

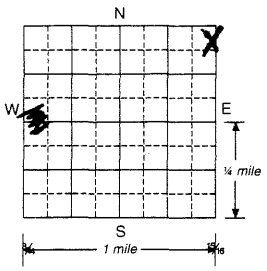
Numerical Street Address or Fire Number and City of Well or Boring Location: NE NE NE

Date Sealed: 9-5-96

Date Well or Boring Constructed: 8-29-96

Depth Before Sealing: 824 ft. Original Depth: 824 ft.

Show exact location of well or boring in section grid with "X".



Sketch map of well or boring location, showing property lines, roads, and buildings.

TEST HOLE # 53-2

AQUIFER(S)
☐ Single Aquifer ☐ Multiaquifer

WELL/BORING
☐ Water Supply Well ☐ Monit. Well
☒ Env. Bore Hole ☐ Other

STATIC WATER LEVEL
☐ Measured ☐ Estimated
____ ft. ☐ below ☐ above land surface

CASING TYPE(S)
☐ Steel ☐ Plastic ☐ Tile ☐ Other

CASING

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
____ in.	from ____ to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in.	from ____ to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in.	from ____ to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

SCREEN/OPEN HOLE
Screen from ____ to ____ ft. Open Hole from ____ to ____ ft.

OBSTRUCTION/DEBRIS/FILL
☐ Obstruction ☐ Debris ☐ Fill ☐ No Obstruction
Type of Obstruction/Debris/Fill
Obstruction/Debris/Fill removed? ☐ Yes ☐ No

PUMP
Type
☐ Removed ☐ Not Present ☐ Other

PROPERTY OWNER'S NAME: STATE OF MN.

Property owner's mailing address if different than well location address indicated above.
MINN. DNR
500 LAFAYETTE
ST PAUL, MN. 55155

WELL OWNER'S NAME: STATE OF MN.

Well owner's mailing address if different than property owner's address indicated above.

GEOLOGICAL MATERIAL	COLOR	HARDNESS OF FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
☐ No Annular Space Exits
☐ Annular space grouted with tremie pipe
☐ Casing Perforation/Removal
____ in. from ____ to ____ ft. ☐ Perforated ☐ Removed
____ in. from ____ to ____ ft. ☐ Perforated ☐ Removed
Type of perforator
☐ Other

GROUTING MATERIAL(S)
Grouting Material: NEAT CEMENT from 0 to 824 ft. 8.5 yards ____ bags
____ from ____ to ____ ft. ____ yards ____ bags
____ from ____ to ____ ft. ____ yards ____ bags
____ from ____ to ____ ft. ____ yards ____ bags

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

UNSEALED WELLS AND BORINGS
Other unsealed well or boring on property? ☐ Yes ☐ No

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

LTP ENTERPRISES, INC. — Contractor Business Name
91686 — License or Registration No.
C. Don Hejtmanek — Authorized Representative Signature
9-12-96 — Date
DON HEJTMANEK — Name of Person Sealing Well or Boring

IMPORTANT-FILE WITH PROPERTY PAPERS-WELL OWNER COPY

H 101117

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING SEALING RECORD

Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No
Minnesota Unique No or W-series No. (Leave blank if not known)

H 101118

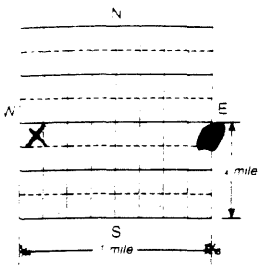
WELL OR BORING LOCATION

County Name: AUBLES

Township Name: BIGELOW | Township No: 101 | Range No: 40 | Section No: 3 | Fraction: sm. → lg.: NW NW SW

Numerical Street Address or Fire Number and City of Well or Boring Location: NW NW SW

Show exact location of well or boring in section grid with "X"



Sketch map of well or boring location, showing property lines, roads, and buildings.

TEST HOLE # 53-3

Date Sealed: 8-20-96

Date Well or Boring Constructed: 8-14-96

Depth Before Sealing: 775 ft.

Original Depth: 775 ft.

AQUIFER(S)
☐ Single Aquifer ☐ Multiaquifer

WELL/BORING
☐ Water Supply Well ☐ Monit. Well
☒ Env. Bore Hole ☐ Other

STATIC WATER LEVEL
☐ Measured ☐ Estimated
_____ ft ☐ below ☐ above land surface

CASING TYPE(S)
☐ Steel ☐ Plastic ☐ Tile ☐ Other

CASING

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
_____ in.	from _____ to _____ ft	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

SCREEN/OPEN HOLE
Screen from _____ to _____ ft. Open Hole from _____ to _____ ft.

OBSTRUCTION/DEBRIS/FILL
☐ Obstruction ☐ Debris ☐ Fill ☐ No Obstruction
Type of Obstruction/Debris/Fill _____
Obstruction/Debris/Fill removed? ☐ Yes ☐ No

PUMP
Type _____
☐ Removed ☐ Not Present ☐ Other _____

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
☐ No Annular Space Exits
☐ Annular space grouted with tremie pipe
☐ Casing Perforation/Removal
_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed
_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed
Type of perforator _____
☐ Other _____

GROUTING MATERIAL(S)

Grouting Material: NEAT CEMENT	from 0	to 775 ft.	9 yards	_____ bags
_____	from _____	to _____ ft.	_____ yards	_____ bags
_____	from _____	to _____ ft.	_____ yards	_____ bags
_____	from _____	to _____ ft.	_____ yards	_____ bags

PROPERTY OWNER'S NAME: STATE OF MINN.

Property owner's mailing address if different than well location address indicated above:
MINN. DNR
500 LAFAYETTE
ST. PAUL, MINN. 55155

WELL OWNER'S NAME: STATE OF MINN.

Well owner's mailing address if different than property owner's address indicated above:

GEOLOGICAL MATERIAL	COLOR	HARDNESS OF FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

UNSEALED WELLS AND BORINGS
Other unsealed well or boring on property? ☐ Yes ☐ No

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

L.T.P. ENTERPRISES INC — 91686
Contractor Business Name — *License or Registration No.*

C Dan Hein — 9-12-96
Authorized Representative Signature — *Date*

DON HEITMANEK
Name of Person Sealing Well or Boring

IMPORTANT-FILE WITH PROPERTY PAPERS-WELL OWNER COPY

H 101118

HE-01434-02

10/95R

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING SEALING RECORD

Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. H 101119

Minnesota Unique No. or W-series No. (Leave blank if not known)

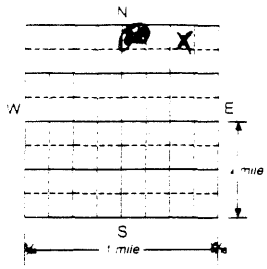
WELL OR BORING LOCATION

County Name: NOBLES

Township Name	Township No.	Range No.	Section No.	Fraction (sm → lg.)
LORAIN	102	39	32	NW NE

Numerical Street Address or Fire Number and City of Well or Boring Location:

Show exact location of well or boring in section grid with "X"



Sketch map of well or boring location, showing property lines, roads, and buildings

TEST HOLE # 53-4

Date Sealed: 8-14-96

Date Well or Boring Constructed: 8-6-96

Depth Before Sealing: 726 ft.

Original Depth: 726 ft.

AQUIFER(S)

☐ Single Aquifer ☐ Multiaquifer

WELL/BORING

☐ Water Supply Well ☐ Monit. Well ☒ Env. Bore Hole ☐ Other

STATIC WATER LEVEL

☐ Measured ☐ Estimated

ft. ☐ below ☐ above land surface

CASING TYPE(S)

☐ Steel ☐ Plastic ☐ Tile ☐ Other

CASING

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
in. from	to ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
in. from	to ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
in. from	to ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

SCREEN/OPEN HOLE

Screen from ____ to ____ ft. Open Hole from ____ to ____ ft.

OBSTRUCTION/DEBRIS/FILL

☐ Obstruction ☐ Debris ☐ Fill ☐ No Obstruction

Type of Obstruction/Debris/Fill:

Obstruction/Debris/Fill removed? ☐ Yes ☐ No

PUMP

Type:

☐ Removed ☐ Not Present ☐ Other

PROPERTY OWNER'S NAME: STATE OF MN.

Property owner's mailing address if different than well location address indicated above:

MINN DNR
500 LAFAYETTE
ST PAUL, MN. 55155

WELL OWNER'S NAME: STATE OF MN.

Well owner's mailing address if different than property owner's address indicated above.

GEOLOGICAL MATERIAL	COLOR	HARDNESS OF FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:

☐ No Annular Space Exits

☐ Annular space grouted with tremie pipe

☐ Casing Perforation/Removal

in. from ____ to ____ ft. ☐ Perforated ☐ Removed

in. from ____ to ____ ft. ☐ Perforated ☐ Removed

Type of perforator:

☐ Other

GROUTING MATERIAL(S)

Grouting Material: NEAT CEMENT from 0 to 726 ft. 7.5 yards ____ bags

____ from ____ to ____ ft. ____ yards ____ bags

____ from ____ to ____ ft. ____ yards ____ bags

____ from ____ to ____ ft. ____ yards ____ bags

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

UNSEALED WELLS AND BORINGS

Other unsealed well or boring on property? ☐ Yes ☐ No

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

L.T.P. ENTERPRISES, INC — 9686

Contractor Business Name — License or Registration No.

C. Dan Olson — 8-12-96

Authorized Representative Signature — Date

DAN HEITMANEK

Name of Person Sealing Well or Boring

IMPORTANT-FILE WITH PROPERTY PAPERS-WELL OWNER COPY

H 101119

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING SEALING RECORD

Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No.
Minnesota Unique No. or W-series No.
Leave blank if not known

H 101139

WELL OR BORING LOCATION

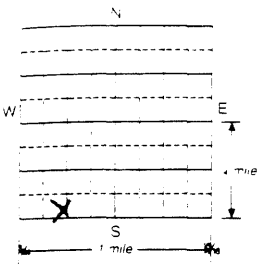
County Name: ROCK

Township Name: BIGELOW CREEK | Township No.: 102 | Range No.: 46 | Section No.: 35 | Fraction (sm. → lg.): SE¼ SW¼ SW¼

Numerical Street Address or Fire Number and City of Well or Boring Location:

Show exact location of well or boring in section grid with "X"

Sketch map of well or boring location, showing property lines, roads, and buildings.



TEST HOLE # 67-1

Date Sealed: 10-22-96

Date Well or Boring Constructed: 10-22-96

Depth Before Sealing: 400 ft.

Original Depth: 400 ft.

AQUIFER(S)
☐ Single Aquifer ☐ Multiaquifer

WELL/BORING
☐ Water Supply Well ☐ Monit. Well
☒ Env. Bore Hole ☐ Other

STATIC WATER LEVEL
☐ Measured ☐ Estimated
_____ ft. ☐ below ☐ above land surface

CASING TYPE(S)
☐ Steel ☐ Plastic ☐ Tile ☐ Other

CASING

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

SCREEN/OPEN HOLE
Screen from _____ to _____ ft. Open Hole from _____ to _____ ft.

OBSTRUCTION/DEBRIS/FILL
☐ Obstruction ☐ Debris ☐ Fill ☐ No Obstruction
Type of Obstruction/Debris/Fill: _____
Obstruction/Debris/Fill removed? ☐ Yes ☐ No

PUMP
Type: _____
☐ Removed ☐ Not Present ☐ Other

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
☐ No Annular Space Exits
☐ Annular space grouted with tremie pipe
☐ Casing Perforation/Removal
_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed
_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed
Type of perforator: _____
☐ Other

GROUTING MATERIAL(S)
Grouting Material: NEAT CEMENT from 0 to 400 ft. 3 3/4 yards _____ bags
_____ from _____ to _____ ft. _____ yards _____ bags
_____ from _____ to _____ ft. _____ yards _____ bags
_____ from _____ to _____ ft. _____ yards _____ bags

PROPERTY OWNER'S NAME: STATE OF MINN.

Property owner's mailing address if different than well location address indicated above:
MINN. DNR
500 LAFAYETTE
ST PAUL, MN. 55155

WELL OWNER'S NAME: STATE OF MINN.

Well owner's mailing address if different than property owner's address indicated above.

GEOLOGICAL MATERIAL	COLOR	HARDNESS OF FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

UNSEALED WELLS AND BORINGS
Other unsealed well or boring on property? ☐ Yes ☐ No

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

LTP ENTERPRISES, INC. 91686
Contractor Business Name *License or Registration No.*

Authorized Representative's Signature 11-11-96 *Date*

RON HEJTMANEK
Name of Person Sealing Well or Boring

IMPORTANT-FILE WITH PROPERTY PAPERS-WELL OWNER COPY

H 101139

HE-01434-02

10/95R

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING SEALING RECORD

Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. / Minnesota Unique No. or W-series No. (Leave blank if not known): H 101138

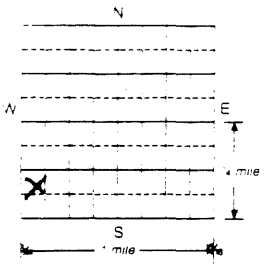
WELL OR BORING LOCATION

County Name: Rock

Township Name: Martin | Township No.: 101 | Range No.: 64 | Section No.: 1 | Fraction (sm. → lg.): NW SW

Numerical Street Address or Fire Number and City of Well or Boring Location:

Show exact location of well or boring in section grid with "X"



Sketch map of well or boring location, showing property lines, roads, and buildings.

test Hole # 67-2

Date Sealed: 10-17-96

Date Well or Boring Constructed: 10-16-96

Depth Before Sealing: 400 ft.

Original Depth: 400 ft.

AQUIFER(S)

☐ Single Aquifer ☐ Multiaquifer

WELL/BORING

☐ Water Supply Well ☐ Monit. Well

☒ Env. Bore Hole ☐ Other

STATIC WATER LEVEL

☐ Measured ☐ Estimated

_____ ft ☐ below ☐ above land surface

CASING TYPE(S)

☐ Steel ☐ Plastic ☐ Tile ☐ Other

CASING

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

SCREEN/OPEN HOLE

Screen from _____ to _____ ft. Open Hole from _____ to _____ ft.

OBSTRUCTION/DEBRIS/FILL

☐ Obstruction ☐ Debris ☐ Fill ☐ No Obstruction

Type of Obstruction/Debris/Fill:

Obstruction/Debris/Fill removed? ☐ Yes ☐ No

PUMP

Type:

☐ Removed ☐ Not Present ☐ Other

PROPERTY OWNER'S NAME: STATE OF MINN.

Property owner's mailing address if different than well location address indicated above:

MINN - DNR
500 LAFAYETTE
ST PAUL, MN 55155

WELL OWNER'S NAME: STATE OF MINN

Well owner's mailing address if different than property owner's address indicated above.

GEOLOGICAL MATERIAL	COLOR	HARDNESS OF FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:

☐ No Annular Space Exits

☐ Annular space grouted with tremie pipe

☐ Casing Perforation/Removal

_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed

_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed

Type of perforator:

☐ Other

GROUTING MATERIAL(S)

Grouting Material: NEAT CEMENT from 0 to 400 ft. 3 3/4 yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

REMARKS, SOURCE OF DATA, DIFFICULTIES ENCOUNTERED

UNSEALED WELLS AND BORINGS

Other unsealed well or boring on property? ☐ Yes ☐ No

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

LTP ENTERPRISES, INC. — Contractor Business Name

91686 — License or Registration No.

Authorized Representative Signature

11-11-96 — Date

RON HEJTMANEK — Name of Person Sealing Well or Boring

IMPORTANT-FILE WITH PROPERTY PAPERS-WELL OWNER COPY

H 101138

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING SEALING RECORD

Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No / Minnesota Unique No or W-series No (Leave blank if not known): H 101137

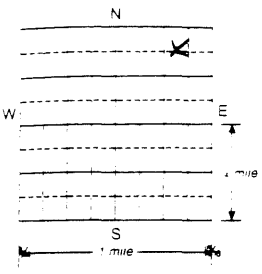
WELL OR BORING LOCATION

County Name: Rock

Township Name: CLINTON | Township No: 101 | Range No: 45 | Section No: 20 | Fraction (sm → lg.): NONE ME

Numerical Street Address or Fire Number and City of Well or Boring Location:

Show exact location of well or boring in section grid with "X"



Sketch map of well or boring location, showing property lines, roads, and buildings.

TEST HOLE #67-3

Date Sealed: 10-16-96

Date Well or Boring Constructed: 10-14-96

Depth Before Sealing: 560 ft.

Original Depth: 560 ft.

AQUIFER(S)

☐ Single Aquifer ☐ Multiaquifer

WELL/BORING

☐ Water Supply Well ☐ Monit. Well

☒ Env. Bore Hole ☐ Other

STATIC WATER LEVEL

☐ Measured ☐ Estimated

_____ ft ☐ below ☐ above land surface

CASING TYPE(S)

☐ Steel ☐ Plastic ☐ Tile ☐ Other

CASING

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

SCREEN/OPEN HOLE

Screen from _____ to _____ ft. Open Hole from _____ to _____ ft.

OBSTRUCTION/DEBRIS/FILL

☐ Obstruction ☐ Debris ☐ Fill ☐ No Obstruction

Type of Obstruction/Debris/Fill: _____

Obstruction/Debris/Fill removed? ☐ Yes ☐ No

PUMP

Type: _____

☐ Removed ☐ Not Present ☐ Other _____

PROPERTY OWNER'S NAME: STATE OF MINN.

Property owner's mailing address if different than well location address indicated above:

MINN. DNR
500 LAFAYETTE
ST PAUL, MINN. 55155

WELL OWNER'S NAME: STATE OF MINN.

Well owner's mailing address if different than property owner's address indicated above.

GEOLOGICAL MATERIAL	COLOR	HARDNESS OF FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:

☐ No Annular Space Exits

☐ Annular space grouted with tremie pipe

☐ Casing Perforation/Removal

_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed

_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed

Type of perforator: _____

☐ Other _____

GROUTING MATERIAL(S)

Grouting Material: NEAT CEMENT from 0 to 560. 6 yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

REMARKS, SOURCE OF DATA, DIFFICULTIES ENCOUNTERED

UNSEALED WELLS AND BORINGS

Other unsealed well or boring on property? ☐ Yes ☐ No

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

LT ENTERPRISES INC — 91686

Contractor Business Name — *License or Registration No.*

C Dan Quen — 11-11-96

Authorized Representative Signature — *Date*

DON HEITMANEK

Name of Person Sealing Well or Boring

IMPORTANT-FILE WITH PROPERTY PAPERS-WELL OWNER COPY — H 101137

HE-01434-02

10/95R

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING SEALING RECORD

Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. H 101134

Minnesota Unique No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION

County Name: Rock

Township Name: KANARANZI | Township No: 101 | Range No: 44 | Section No: 20 | Fraction: SW NW NE

Numerical Street Address or Fire Number and City of Well or Boring Location:

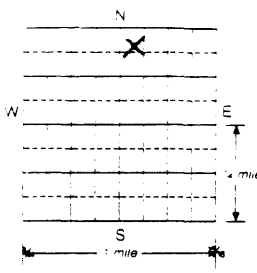
Date Sealed: 10-8-96

Date Well or Boring Constructed: 10-2-96

Depth Before Sealing: 532 ft.

Original Depth: 532 ft.

Show exact location of well or boring in section grid with "X"



Sketch map of well or boring location, showing property lines, roads, and buildings.

TEST HOLE # 67-6

AQUIFER(S)

☐ Single Aquifer ☐ Multiaquifer

WELL/BORING

☐ Water Supply Well ☐ Monit. Well

☒ Env. Bore Hole ☐ Other

STATIC WATER LEVEL

☐ Measured ☐ Estimated

_____ ft ☐ below ☐ above land surface

CASING TYPE(S)

☐ Steel ☐ Plastic ☐ Tile ☐ Other

CASING

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

SCREEN/OPEN HOLE

Screen from _____ to _____ ft. Open Hole from _____ to _____ ft.

OBSTRUCTION/DEBRIS/FILL

☐ Obstruction ☐ Debris ☐ Fill ☐ No Obstruction

Type of Obstruction/Debris/Fill: _____

Obstruction/Debris/Fill removed? ☐ Yes ☐ No

PUMP

Type: _____

☐ Removed ☐ Not Present ☐ Other

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:

☐ No Annular Space Exits

☐ Annular space grouted with tremie pipe

☐ Casing Perforation/Removal

_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed

_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed

Type of perforator: _____

☐ Other

GROUTING MATERIAL(S)

Grouting Material: NEAT CEMENT from 0 to 532 ft. 6 3/4 yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

GEOLOGICAL MATERIAL	COLOR	HARDNESS OF FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

UNSEALED WELLS AND BORINGS

Other unsealed well or boring on property? ☐ Yes ☐ No

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

LTP ENTERPRISES, INC — Contractor Business Name

91686 — License or Registration No.

Authorized Representative Signature

11-11-96 — Date

Name of Person Sealing Well or Boring

IMPORTANT-FILE WITH PROPERTY PAPERS-WELL OWNER COPY

H 101134

PROPERTY OWNER'S NAME: MN. DNR - STATE OF MN.

Property owner's mailing address if different than well location address indicated above:

MINN. DNR
500 LAFAYETTE
ST. PAUL MN 55155

WELL OWNER'S NAME: STATE OF MN.

Well owner's mailing address if different than property owner's address indicated above.

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING SEALING RECORD

Minnesota Statutes Chapter 103I

Minnesota Well and Boring Sealing No / Minnesota Unique No. or W-series No. (Leave blank if not known): H 101135

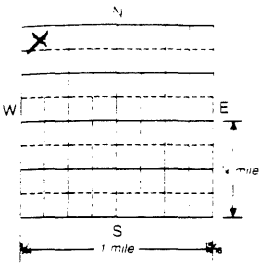
WELL OR BORING LOCATION

County Name: Rock

Township Name: KANARANZI | Township No: 101 | Range No: 44 | Section No: 32 | Fraction: NW NW NW

Numerical Street Address or Fire Number and City of Well or Boring Location:

Show exact location of well or boring in section grid with "X"



Sketch map of well or boring location, showing property lines, roads, and buildings:

TEST HOLE # 67-7

Date Sealed: ~~503~~ 10-2-96

Date Well or Boring Constructed: ~~503~~ 9-30-96

Depth Before Sealing: 503 ft

Original Depth: 503

AQUIFER(S): ☐ Single Aquifer ☐ Multiaquifer

WELL/BORING: ☐ Water Supply Well ☐ Monit. Well ☒ Env. Bore Hole ☐ Other

STATIC WATER LEVEL: ☐ Measured ☐ Estimated ____ ft ☐ below ☐ above land surface

CASING TYPE(S): ☐ Steel ☐ Plastic ☐ Tile ☐ Other

CASING

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
____ in.	from ____ to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in.	from ____ to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in.	from ____ to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

SCREEN/OPEN HOLE: Screen from ____ to ____ ft. Open Hole from ____ to ____ ft.

OBSTRUCTION/DEBRIS/FILL: ☐ Obstruction ☐ Debris ☐ Fill ☐ No Obstruction

Type of Obstruction/Debris/Fill:

Obstruction/Debris/Fill removed? ☐ Yes ☐ No

PUMP

Type:

☐ Removed ☐ Not Present ☐ Other

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:

☐ No Annular Space Exits

☐ Annular space grouted with tremie pipe

☐ Casing Perforation/Removal

____ in. from ____ to ____ ft. ☐ Perforated ☐ Removed

____ in. from ____ to ____ ft. ☐ Perforated ☐ Removed

Type of perforator:

☐ Other

GROUTING MATERIAL(S)

Grouting Material: NEAT CEMENT from 0 to 503 ft. 6 yards ____ bags

____ from ____ to ____ ft. ____ yards ____ bags

____ from ____ to ____ ft. ____ yards ____ bags

____ from ____ to ____ ft. ____ yards ____ bags

GEOLOGICAL MATERIAL	COLOR	HARDNESS OF FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

UNSEALED WELLS AND BORINGS

Other unsealed well or boring on property? ☐ Yes ☐ No

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

LTP ENTERPRISES, INC — Contractor Business Name

9686 — License or Registration No.

Authorized Representative Signature

11-11-96 — Date

DON HEITMANEK — Name of Person Sealing Well or Boring

IMPORTANT-FILE WITH PROPERTY PAPERS-WELL OWNER COPY

H 101135

PROPERTY OWNER'S NAME: STATE OF MINN.

Property owner's mailing address if different than well location address indicated above:

MINN. DNR
500 LAFAYETTE
ST PAUL, MN 55155

WELL OWNER'S NAME: STATE OF MINN.

Well owner's mailing address if different than property owner's address indicated above:

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING SEALING RECORD

Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. H 101136

Minnesota Unique No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION

County Name: Rock

Township Name: Kanaranki | Township No.: 101 | Range No.: 44 | Section No.: 32 | Fraction (sm → lg.): SE SE SE

Numerical Street Address or Fire Number and City of Well or Boring Location:

Date Sealed: 10-10-96

Date Well or Boring Constructed: 10-9-96

Depth Before Sealing: 489 ft.

Original Depth: 489 ft.

Show exact location of well or boring in section grid with "X"

Sketch map of well or boring location, showing property lines, roads, and buildings

N / W / E / S, 1 mile

TEST HOLE # 67-8

AQUIFER(S)

☐ Single Aquifer ☐ Multiaquifer

WELL/BORING

☐ Water Supply Well ☐ Monit. Well

☒ Env. Bore Hole ☐ Other

STATIC WATER LEVEL

☐ Measured ☐ Estimated

_____ ft ☐ below ☐ above land surface

CASING TYPE(S)

☐ Steel ☐ Plastic ☐ Tile ☐ Other

CASING

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
_____ in.	from _____ to _____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

SCREEN/OPEN HOLE

Screen from _____ to _____ ft. Open Hole from _____ to _____ ft.

OBSTRUCTION/DEBRIS/FILL

☐ Obstruction ☐ Debris ☐ Fill ☐ No Obstruction

Type of Obstruction/Debris/Fill _____

Obstruction/Debris/Fill removed? ☐ Yes ☐ No

PUMP

Type _____

☐ Removed ☐ Not Present ☐ Other _____

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:

☐ No Annular Space Exits

☐ Annular space grouted with tremie pipe

☐ Casing Perforation/Removal

_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed

_____ in. from _____ to _____ ft. ☐ Perforated ☐ Removed

Type of perforator _____

☐ Other _____

GROUTING MATERIAL(S)

Grouting Material: NEAT CEMENT from 0 to 489 ft. 4½ yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

_____ from _____ to _____ ft. _____ yards _____ bags

GEOLOGICAL MATERIAL	COLOR	HARDNESS OF FORMATION	FROM	TO

If not known, indicate estimated formation log from nearby well or boring.

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

UNSEALED WELLS AND BORINGS

Other unsealed well or boring on property? ☐ Yes ☐ No

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

LTP Enterprises, Inc. — 91686

Contractor Business Name — *License or Registration No.*

C. Dan Olson — 11-11-96

Authorized Representative Signature — *Date*

Ron Hejtmanek

Name of Person Sealing Well or Boring

IMPORTANT-FILE WITH PROPERTY PAPERS-WELL OWNER COPY

H 101136

PROPERTY OWNER'S NAME: STATE OF MINN.

Property owner's mailing address if different than well location address indicated above.

MINN. DNR
500 LAFAYETTE
ST. PAUL MN 55155

WELL OWNER'S NAME: STATE OF MINN.

Well owner's mailing address if different than property owner's address indicated above.

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING SEALING RECORD

Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. / Minnesota Unique No. or W-series No. (Leave blank if not known): H 101140

WELL OR BORING LOCATION

County Name: YELLOW MEDICINE

Township Name: FORTIER | Township No: 114 | Range No: 46 | Section No: 28 | Fraction: NW¼ NW¼ SW¼

Numerical Street Address or Fire Number and City of Well or Boring Location:

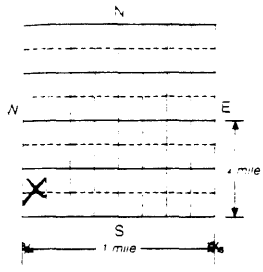
Date Sealed: 10-31-96

Date Well or Boring Constructed: 10-24-96

Depth Before Sealing: 724 ft.

Original Depth: 724 ft.

Show exact location of well or boring in section grid with "X"



Sketch map of well or boring location, showing property lines, roads, and buildings.

TEST HOLE # 87-7

AQUIFER(S): ☐ Single Aquifer ☐ Multiaquifer

WELL/BORING: ☐ Water Supply Well ☐ Monit. Well ☒ Env. Bore Hole ☐ Other

STATIC WATER LEVEL: ☐ Measured ☐ Estimated ____ ft ☐ below ☐ above land surface

CASING TYPE(S): ☐ Steel ☐ Plastic ☐ Tile ☐ Other

CASING

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
____ in.	from ____ to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in.	from ____ to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in.	from ____ to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

SCREEN/OPEN HOLE: Screen from ____ to ____ ft. Open Hole from ____ to ____ ft.

OBSTRUCTION/DEBRIS/FILL: ☐ Obstruction ☐ Debris ☐ Fill ☐ No Obstruction

Type of Obstruction/Debris/Fill:

Obstruction/Debris/Fill removed? ☐ Yes ☐ No

PUMP

Type:

☐ Removed ☐ Not Present ☐ Other

PROPERTY OWNER'S NAME: STATE OF MN.

Property owner's mailing address if different than well location address indicated above:

MINN. - DNR
500 LAFAYETTE
ST. PAUL, MN. 55155

WELL OWNER'S NAME: STATE OF MN.

Well owner's mailing address if different than property owner's address indicated above.

GEOLOGICAL MATERIAL	COLOR	HARDNESS OF FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:

☐ No Annular Space Exits
☐ Annular space grouted with tremie pipe
☐ Casing Perforation/Removal

____ in. from ____ to ____ ft. ☐ Perforated ☐ Removed

____ in. from ____ to ____ ft. ☐ Perforated ☐ Removed

Type of perforator:

☐ Other

GROUTING MATERIAL(S)

Grouting Material: NEAT CEMENT from 0 to 724 ft. 7¼ yards ____ bags

____ from ____ to ____ ft. ____ yards ____ bags

____ from ____ to ____ ft. ____ yards ____ bags

____ from ____ to ____ ft. ____ yards ____ bags

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

UNSEALED WELLS AND BORINGS

Other unsealed well or boring on property? ☐ Yes ☐ No

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

LTP ENTERPRISES, INC. 91686
Contractor Business Name *License or Registration No.*

C. Don Heitmanek 11-11-96
Authorized Representative Signature *Date*

DON HEITMANEK
Name of Person Sealing Well or Boring

IMPORTANT-FILE WITH PROPERTY PAPERS-WELL OWNER COPY | H 101140

HE-01434-02

10/95R