MINNESOTA GEOLOGICAL SURVEY

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MINNESOTA GEOLOGICAL SURVEY SUBSURFACE GEOLOGY DATA BASE: WATER WELLS

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MINNESOTA GEOLOGICAL SURVEY SUBSURFACE GEOLOGY DATA BASE: WATER WELLS

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INTRODUCTION

Subsurface geologic information is essential to much of the research performed by the Minnesota Geological Survey. The principal research activities that draw upon this data are bedrock and surficial geologic mapping, hydrogeologic mapping, and mineral resource evaluation. In addition, the Minnesota Geological Survey provides subsurface geologic information to the public and to government organizations such as the Minnesota Department of Natural Resources, Minnesota Department of Health, Regional Development Commissions, Soil and Water Conservation Districts, and the U.S. Geological Survey. Each of these activities is made more efficient by maintaining subsurface data in computer data bases.

The principal sources of subsurface geologic data are records of water-well drilling, engineering test boring, and mineral exploration drilling. These three different kinds of records vary in data content and quality. For this reason the Minnesota Geological Survey employs three separate but compatible subsurface geology data bases, one corresponding to each type of data source.

This report describes the water-well portion of the subsurface geology data base. Water-well records contain high-quality water-level observations and low- to medium-quality geologic information on the materials encountered during drilling. In addition, they often include data on pumpage tests and well use, and a description of the well construction. Water-well data is used extensively in mapping by the Minnesota Geological Survey and is frequently supplied in map or tabular form to the public and to a wide variety of government organizations. Because the water-well data base includes Public Land Survey coordinates for each well, the data is readily transmitted to the Minnesota Land Management Information System. Water-well data so transmitted will be a major component of the newly created Systems for Water Information Management (SWIM) of the Water Planning Board.

The purpose of this report is twofold: 1) to acquaint current and potential users of the water-well data base with its contents and usefulness, and 2) to serve as a detailed user's reference manual.

OVERVIEW

The water-well data base of the Minnesota Geological Survey consists of both paper files and computer files. The paper files contain records for approximately 80,000 water wells selected for statewide coverage and quality of information. Each well is assigned a six-digit unique number. The unique numbers are written on the well records which are stored in the paper files by township, range, and section. All state agencies reference a particular well by the same unique number.

In response to the needs of geologic investigations conducted by the Minnesota Geological Survey, appropriate water-well records from the paper files are selected for entry into the computer files. Usually, the complete paper files for a given geographic area are entered together, so that the computer files provide in-depth local coverage. Currently (June, 1979), the computer files contain about 9,000 water-well records giving thorough coverage of parts or all of the following counties:

Blue Earth	286 records
Carver	84
Dakota	898
Faribault and Freeborn	45
Hennepin	2,585
Kandiyohi	1,214
LeSueur	178
McLeod	542
Meeker	585
Nicollet	93
Ramsey	488
Renville	353
Rice	102
Scott	914
Steele	87
Waseca	379
Total	8,833

Projected growth of the computer files is 5,000 to 10,000 water-well records per year for the next few years.

Before a water-well record is entered into the computer files, additional information about the well is acquired. Its location is checked in the field and plotted on a topographic map, which is then used to obtain precise geographic coordinates and surface elevation. In addition, a geologist examines the driller's description of the subsurface geology in order to classify the rock units and materials encountered during drilling.

The augmented water-well record is then transcribed onto a standardized coding form in preparation for keypunching, verifying, and editing. The punched and edited data is then entered into existing fixed-format sequential files on the University of Minnesota Control Data Cyber 74 computer and stored by county on magnetic tape.

A brief index containing the most often needed information for each well is prepared for each county file. It is printed twice, once sorted by unique number and once sorted by township, range, and section. These indices provide rapid access to the data base for frequent site-specific demands.

More complex retrievals from the data base are handled in two stages. A custom FORTRAN program is written to extract the needed information, which is then processed by more general programs designed to display it. The principal products are computer-generated reports and maps.

The details of the above procedures are presented in the following sections of this report.

DATA ACQUISITION

Records made by water-well drillers form the core of the water-well data base. Until recently, such records were made and kept by contractors solely for their own use in repairing or modifying wells and as predictive aids in drilling new wells. Consequently, many, but not all, contractors possess files that contain records of wells drilled over a span of many years. All such records were maintained independently with no standard way of recording the information. These so-called "historic" records form the largest body of geologic observations available for many parts of Minnesota. They are particularly important for bedrock geology and hydrogeology because so much of the state is covered with glacial drift. Therefore, in spite of the problems of dealing with such variable records, the Minnesota Geological Survey canvassed all of the state's water-well contractors and obtained photocopies of virtually all useful historic records for its water-well data base. Incoming records were assigned six-digit "unique" numbers for identification and then filed by township, range, and section in paper files.

Since the implementation of the 1973 Water-Well Contractors Licensing Act in 1975, drillers have been required to submit records of new water wells on standard forms supplied by the Minnesota Health Department (see Figure 1). A copy of each record submitted is received by the Minnesota Geological Survey. The standard form is generally more comprehensive than the various forms used in the past by water-well contractors. Identification numbers are pre-assigned when the forms are printed. All such incoming records are filed by geographic location with historic records.

Both historic and new water-well records contain information of some or all of the following kinds:

1) Geographic locations in terms of township, range, and section. These reported locations contain many errors and cannot be trusted for the precise locations needed for geologic studies.

2) Well ownership and address--often useful in obtaining information for more precise geographic locations. The addresses, however, are those of the owners and may not refer to the properties on which the wells were drilled.

3) Well use.

4) Pumping test results. Includes pumping rate, duration, and drawdown. Accuracy ranges from poor (± 10 ft) to good (± 1 ft). Results are usually most accurate for municipal wells and least accurate for domestic wells.

5) Well construction. Usually very accurate. Geologically useful in determining the aquifer used.

6) Static water level. Usually very accurate (± 1 ft) <u>at time of completion</u> of the well.

STATE OF MINNESOTA DEPARTMENT OF HEALTH

WATER WELL RECORD

Minnesota Statutes 156A.01-.08

MINNESOTA UNIQUE WELL NO. for Water Sample 164451

1. LOCATION OF WELL

County Name

Township Name	Township Number (N or S)	Range Number (E or W)	Section No.	Fraction ¼ ¼ ¼

Distance and Direction from Road Intersections or Street Address and City of Well Location

Show exact location of well in section grid with "X." N W E S — ½ mi. — 1 mile

Sketch map of well location.

Addition Name

Block Number

Lot Number

3. PROPERTY OWNER'S NAME

Address

4. WELL DEPTH (completed) ______ ft. Date of Completion

5. 1☐ Cable tool 2☐ Hollow rod 3☐ Rotary 4☐ Reverse 5☐ Air 6☐ Jetted 7☐ Driven 8☐ Bored 9☐ Power Auger 10☐ Dug 11☐ ______

6. USE 1☐ Domestic 2☐ Irrigation 3☐ Test Well 4☐ Public Supply 5☐ Municipal 6☐ Air Conditioning 7☐ Industry 8☐ Commercial 9☐

7. CASING 1☐ Black 2☐ Galv. 3☐ Plastic 4☐ Threaded 5☐ Welded 6☐

HEIGHT: Above/Below Surface ______ ft. Drive Shoe? Yes ___ No ___

______ in. to ______ ft. Weight ______ lbs./ft.

______ in. to ______ ft. Weight ______ lbs./ft.

______ in. to ______ ft. Weight ______ lbs./ft.

HOLE DIAM. ___ in. to ___ ft. ___ in. to ___ ft. ___ in. to ___ ft.

8. SCREEN Make ______ Type ______ Dia. ______ Slot/Gauze ______ Length ______

Or open hole from ______ ft. to ______ ft.

Set between ______ ft. and ______ ft. ______ ft. and ______ ft. ______ ft. and ______ ft.

FITTINGS

9. STATIC WATER LEVEL ______ ft ☐ below ☐ above land surface Date Measured ______

10. PUMPING LEVEL (below land surface) ______ ft. after ______ hrs. pumping ______ g.p.m. ______ ft. after ______ hrs. pumping ______ g.p.m.

11. WELL HEAD COMPLETION 1☐ Pitless adapter 2☐ Basement offset 3☐ At least 12" above grade

12. Well grouted? ☐ Yes ☐ No Cu. Yds. ______ 1☐ Neat Cement 2☐ Bentonite 3☐ ______

Depth: from ______ ft. to ______ ft. from ______ ft. to ______ ft.

13. Nearest sources of possible contamination ______ feet ______ direction ______ type

Well disinfected upon completion? Yes☐ No☐

14. PUMP Date installed ______ ☐ Not installed

Manufacturer's Name ______

Model Number ______ HP ______ Volts ______

Length of drop pipe ______ ft. capacity ______ g.p.m.

Material of drop pipe ______

Type: 1☐ Submersible 2☐ Jet 3☐ L. S. Turbine 4☐ Centrifugal 5☐ Reciprocating 6☐ ______

2. FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO

Use a second sheet, if needed.

15. REMARKS, ELEVATION, SOURCE OF DATA, etc.

16. WATER WELL CONTRACTOR'S CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

______ *Licensee Business Name* ______ *License No.*

Address ______

Signed ______ Authorized Representative Date ______

______ Name of Driller Date ______

WATER WELL CONTRACTOR COPY 164451

5/74 30M
7/76 30M
7/78 30M

Figure 1--Minnesota Department of Health water-well recording form.

7) Log containing depth intervals and descriptions of the materials encountered during drilling. Accuracy of the depth intervals ranges from about ± 1 ft to ± 10 ft, depending on the driller. Descriptions also vary in quality and terminology, again depending on the driller.

Well locations. The location of each well must be known accurately if the remaining information in the water well record is to be geologically useful. For this reason, considerable time and effort are spent locating water wells as accurately as possible. Well locations are recorded in the data base in two ways: 1) by township, range, and section, and 2) by Universal Transverse Mercator (UTM) coordinates. The former provides locations in terms of a commonly used geographic reference system while the latter facilitates manipulation of well data by computer--primarily in the production of computer-generated maps.

Locating is the second step in the processing of incoming water-well records. The approximate locations of wells as reported by the drillers are first plotted on 7-1/2- or 15-minute topographic maps. Field crews then visit each well site in order to determine the precise location, which is plotted on one of an index set of topographic maps. From these maps, accurate UTM and Public Land Survey coordinates of each well can be determined.

The township, range, and section are read directly from the topographic maps. Within a section, the location is specified by quarter section, quarter-quarter section, and so on up to six levels of quartering. Letter designations are used to record the quarters--A, B, C, and D representing, respectively, the northeast, northwest, southwest, and southeast quarters of the next larger subdivision. A complete locational description, then, is the township, range, and section followed by six letters indicating, from largest to smallest, the section subdivisions in which the well is located. As an example, the location of a well given as 1132136BBCADC corresponds to the SW1/4 of the SE1/4 of the NE1/4 of the SW1/4 of the NW1/4 of the NW1/4 of section 36, Range 21 West, Township 113 North. A description of this type specifies the well location to within an area of about one fifth of an acre (0.08 hectare). Although the accuracy is not this high, the resolution provided is needed in some areas of dense data coverage. The Public Land Survey coordinates, including a code for the county name (Appendix E) are written on the reporting forms received from the drillers in preparation for later coding and entry into the computer.

UTM coordinates of well locations are obtained by digitizing the index maps. A Talos S660 digitizer having a resolution of 0.001 inch and an accuracy of 0.005 inch is first used to measure electronically the positions (in inches) of wells plotted on each map. Digitized coordinates are transmitted by cable to a Texas Instruments 733ASR data terminal, where they are recorded on magnetic tape. They are later transmitted by telephone to the University of Minnesota Control Data Cyber 74 computer.

Typically, all wells located on a given index map are digitized as a single data set. Each data set consists of the digitizer coordinates and the latitudes and longitudes of the same two corners of the index map followed by the unique numbers and digitizer coordinates of the wells. A FORTRAN program is used to compute transformation coefficients from the digitizer and geographic coordinates of the two corners and, using these coefficients, perform the rotation, translation, and scaling of digitized well locations to UTM coordinates. The standard error of locations determined in this manner is less than 10 meters, which exceeds the accuracy possible in field locating and plotting the wells on topographic maps.

Elevations. In addition to locations, an accurate collar elevation of each well (usually the same as the land surface elevation at the well) is essential. This information is occasionally recorded in the original record received from the driller. In rare cases where the recorded elevations have been determined by surveying, they are used directly as reported. More typically, the elevation either is not reported or is at best an approximation. In these cases elevations are estimated from the corrected locations on topographic maps and from field observations. Elevations are written on the reporting forms received from drillers prior to entry into the computer files. The accuracy of estimated elevations is ± 5 feet.

Geologic interpretation. As a water well is being drilled, the driller in charge records observations about the materials encountered. Typically this includes depth intervals and brief descriptions of each different type of material penetrated by the drill rig. Occasionally these intervals may be described using the formal names of stratigraphic units, for example Platteville Formation. More often, however, the same rock would be recorded simply as gray limestone or, perhaps, limerock. These descriptions and the associated depth intervals make up the driller's log, which is geologically the most important part of each water-well record.

Before a water-well record is entered into the computer data base a geologist at the Minnesota Geological Survey writes another version of the driller's log. The new log, called the interpreted log, is standardized in form and terminology. It eliminates problems in the driller's description that result from missing or incorrect formation names and nonuniform terminology. It also facilitates computer retrievals based on stratigraphic or lithologic criteria. The contents of the interpreted log reflect the geologist's current knowledge about subsurface geology in Minnesota, and the reliability varies depending on how well the local geology is known.

A single, four-letter stratigraphic code is assigned to each reported depth interval. Most of these correspond to named geologic formations. Most glacial deposits, however, cannot be assigned reliably to formations and so receive codes containing their age (Quaternary) and information related to their origin. A few nongeologic codes are used for man-made materials encountered during drilling. The stratigraphic codes employed are listed and explained in more detail in Appendix C.

Lithologic codes corresponding to common geologic descriptive terms are used to standardize the driller's descriptions. Each described depth interval is assigned from one to three codes describing the first, second, and third most important constituents of the material encountered. A list of these four-letter lithologic codes appears in Appendix D.

CODING, KEYPUNCHING, AND EDITING

In order to facilitate keypunching and to ensure accuracy of the final punched data, the information from the original water-well records is transcribed onto the standardized coding forms shown in Appendix A. This procedure is necessary because of the variety of recording forms that have been used by drillers. In addition it reduces keypunching costs. After coding, water-well records are stamped "CODED" and returned to the paper files.

The contents of the coding forms are punched onto cards or keyed onto magnetic tape according to the format in Appendix B by keypunch vendors outside the Minnesota Geological Survey. After keypunching, the data is verified, that is, re-keyed onto a machine that compares each re-keyed character to the corresponding original punched character. Keypunch errors found in this way are corrected before delivery of the data. The result is an extremely low error rate in the final punched data.

After coding and keypunching, the data is entered into disc storage on the University of Minnesota Control Data Cyber 74 computer. The resulting temporary file is then sorted by unique number and card number. A FORTRAN program pre-edits the file, checking for duplicate logs and cards, cataloging the contents of each log, and writing the catalog on the first card of each log. Corrections are made using a remote timesharing terminal at the Minnesota Geological Survey. The temporary file is then scanned by a FORTRAN editing program that checks for alphabetic versus numeric fields and checks the spelling of the geographic and geologic codes. The editing program also determines, wherever possible, if numeric values fall within expected limits. An error report is generated for use in correcting errors. The editing program is then rerun to check the file again. The file is then listed on a line printer and scanned visually for errors that cannot be detected by the editing program. Universal Transverse Mercator coordinates are then added to each log. Finally, the temporary file is compared with the existing data base file to check for duplication before the two files are merged.

DATA STORAGE

In view of the expense of manipulating very large computer files and the massive quantity of water-well data to be processed, a separate data base file is maintained for each county. Each file is composed of a number of individual water-well records. The individual records, in turn, consist of from 1 to 99 card images or lines, corresponding to the card numbers indicated on the coding form. The first card of each record, which must be present, contains location, elevation and depth, plus an index of supplementary information on cards 2 through 9 and a count of the total number of cards, exclusive of the first, in the well record. The index and card count, added during the editing process, permit efficient retrieval. Well records entered into the data base are sorted by unique number and card number and written 80 characters per line on the appropriate county file.

Once a data base file has been sorted and edited and has had UTMs added, it is copied to magnetic tape for permanent storage. ARCHIVE, a

University Computer Center utility package, is used to manage the water-well data base archive tapes and conveniently provides for backup tapes. Two copies of each tape are stored at the University Computer Center. A third copy of each tape is created using standard copying routines and is stored at the Minnesota Geological Survey.

DATA RETRIEVAL

The fixed format structure of the data base files permits flexible and relatively low-cost retrieval of information by means of FORTRAN computer programs. Existing software developed specifically for retrieval of data from the water well data base includes the following: 1) An indexing program which scans each well record and produces for each well a single line of output containing the most important general information about the well, i.e., location, collar elevation, depth, static water level, aquifers used, depth to bedrock, and the first and last bedrock units encountered in the well. The output from this program provides both an index to the information contained in the data base file, and input data for applications programs. 2) A general subroutine that determines the top and bottom elevations and thickness of any specified stratigraphic unit. 3) A subroutine that retrieves data useful in determining potential Quaternary aquifers and confining layers.

Most often, however, data retrieval is accomplished by simple special-purpose FORTRAN programs designed to meet specific retrieval requests.

Specific instructions for accessing the data base files directly by computer are contained in a public access permanent file on the University of Minnesota Control Data Cyber 74 computer (file name: WWINFO, user number: XQB6006). Potential users of the computerized data base files may obtain this information by listing the file or by contacting the Minnesota Geological Survey.

APPLICATIONS

Large-scale retrievals from the water-well data base usually result in subfiles containing all or parts of selected water-well records. These files are then processed in order to display the selected data in some readily usable form. A wide variety of such products have been produced, most of them in the form of reports or maps.

Reports. One of the principal functions of the water-well data base is providing basic subsurface geologic data that can be used as reference material by geologists and hydrologists. This is accomplished by means of a FORTRAN report-generating program, which prints complete water-well records in an easily readable format. A sample report is shown in Figure 2. Such reports are produced primarily for use within the Minnesota Geological Survey. Whenever possible, however, reports are made available at cost to others. Future publications by the Minnesota Geological Survey may include computer-produced reports that are automatically typeset. Test reports have been typeset by way of telephone transfer to a CPT word processor followed by magnetic tape transfer to the automated typesetter at the University of Minnesota Printing Department.

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***************************************************************************************
MINNESOTA GEOLOGICAL SURVEY
WATER WELL DATA BASE - SAMPLE REPORT.


   UNIQUE NO.: 201154
   WELL NAME : U OF M GOLF COURSE

   COUNTY     : RAMSEY
   ADDRESS    : CLEVELAND AND LARPENTEUR       ST PAUL
   QUADRANGLE: ST PAUL WEST 7.5 MINUTE

   TOWNSHIP   : 029 NORTH                  UTM-EASTING : 485139
   RANGE      :  23 WEST                   UTM-NORTHING: 4982257
   SECTION    :  17/DADCCD                 UTM-ZONE     : 15

   ELEVATION :  990 FT.                    WATER LEVEL : 210 FT.
   DEPTH      :  525 FT.                   DATE         : 69/01/04
   COMPLETED : 69/01/04                    AQUIFER(S)   : PRAIRIE DU CHIEN GROUP

   WELL USE   : IRRIGATION
   DRILLER    : (AND/OR DATA SOURCE) KEYS WELL CO.
   CASING     : STEP DOWN
              : 024 INCH TO 0182 FEET
              : 016 INCH TO 0395 FEET
   SCREEN     : DATA UNAVAILABLE
   PUMP
    MAKE/NO. : PEERLESS
    SIZE      : 00125 HP. 00460 VOLTS  CAPACITY     : 00675 G.P.M.
    TYPE      : SUBMERSIBLE            DROP PIPE    : -NA-  FT.

   REMARKS    : M. G. S. 483
 ------------------------------------------------------------------------------

                                 PUMPAGE TEST
 ------------------------------------------------------------------------------
 DATE: 69/01       TEST 1  TEST 2  TEST 3  TEST 4  TEST 5  TEST 6
 ------------------------------------------------------------------------------
 HOURS                007     004     009     001     001
 RATE(GPM)           0851    1062    0681    0654    0618
 DRAWDOWN(FT)         016     045     010     010     015
 ------------------------------------------------------------------------------

                                 GEOLOGIC LOG
 ------------------------------------------------------------------------------
  DEPTH
 INTERVAL                                       COLOR      STRATIGRAPHIC UNIT
 (IN FEET) LITHOLOGY                              HARDNESS SYSTEM/GROUP/FORMATION     AGE       DRILLER'S  DESCRIPTIO
 ------------------------------------------------------------------------------      --------------------
    0    74 BOULDER,SAND,GRAVEL                            PLEISTOCENE               PLS       ROCK, SAND, GRAVEL
   74    95 SAND,GRAVEL                                    PLEISTOCENE               PLS       SAND AND GRAVEL
   95   110 CLAY                                         M PLEISTOCENE               PLS       CLAY
  110   115 HARDPAN                                        PLEISTOCENE               PLS       HARDPAN
  115   145 SAND,GRAVEL                                    PLEISTOCENE               PLS       SAND AND GRAVEL
  145   183 SHALE                           GRAY         S DECORAH                   ORD       SOAPSTONE
  183   218 LIMESTONE                                      PLATTEVILLE               ORD       PLATTEVILLE
  218   222 SHALE                                          GLENWOOD                  ORD       SHALE
  222   319 SANDSTONE                       WHITE        S ST.PETER                  ORD       SANDROCK
  319   329 SANDSTONE,SHALE                                ST.PETER                  ORD       SHALEY SANDROCK
  329   340 SHALE                                          ST.PETER                  ORD       SHALE
  340   383 SANDSTONE                                    H ST.PETER                  ORD       SANDROCK
  383   525 DOLOMITE                                     H PRAIRIE DU CHIEN GROUP    ORD       SHAKOPEE ONEOTA
 ------------------------------------------------------------------------------      --------------------
          HARDNESS CODES: H=HARD; S=SOFT; M=MEDIUM; V=VARIED.

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Figure 2--Sample computer-generated report.

Maps. Computer-generated maps are produced by means of two general-purpose FORTRAN programs that are supported by the Minnesota Geological Survey and are available for public use.

Most of the mapping is done using SURFACE II, a program developed by the Kansas Geological Survey. It is available on the University of Minnesota Cyber 74 operating system under the name SURFACE. SURFACE II produces three kinds of graphic output. These are: postings showing data point locations, with or without labels; isopleth or "contour" maps displaying the shape of any real or hypothetical surface in three dimensions; and transects, or oblique views, of such surfaces. Examples of these three products are shown in Figures 3, 4, and 5. Input consisting of arbitrarily spaced data points is used to generate a gridded surface, which is in turn contoured or displayed in oblique view. A wide variety of gridding options is available.

Postings involving closely spaced data points are made with a FORTRAN program named MGSMAP, which is under continuing development at the Minnesota Geological Survey. MGSMAP permits labels in congested areas to be displaced and connected by lines to the data points. In addition, it provides a capability for adding standard map legends and titles. Future versions of MGSMAP are scheduled to include 1) coordinate transformations involving Universal Transverse Mercator and latitude-longitude coordinates, 2) variable map projections, 3) automatic topographic quadrangle base map generation including geographic coordinate grid overlays, 4) an inset map of Minnesota showing the location of the primary map, and 5) a shaded choropleth map-generating capability.

Interface with MLMIS. Subsets of the water-well data base have been transmitted to the Minnesota Land Management Information System (MLMIS) of the State Planning Agency, where a variety of products have been produced using MLMIS software. Such transfers will be the primary mode of communication among the various data bases of the newly created Systems for Water Information Management (SWIM) of the Water Planning Board.

Miscellaneous. A variety of utility subroutines applicable to the water-well data base have been developed and are being maintained by the Minnesota Geological Survey. These routines, all available to the public, include:

- CENTAR - computes the area and centroid of a polygon
- LLUTM - transforms latitude-longitude to UTM coordinates
- PLOTDIP - plots dip and strike symbols
- ROTRAN - performs rotation, translation, and scaling of a two-dimensional coordinate system
- THREEPT - solves a three point dip and strike problem
- UTMLL - transforms UTM coordinates to latitude-longitude

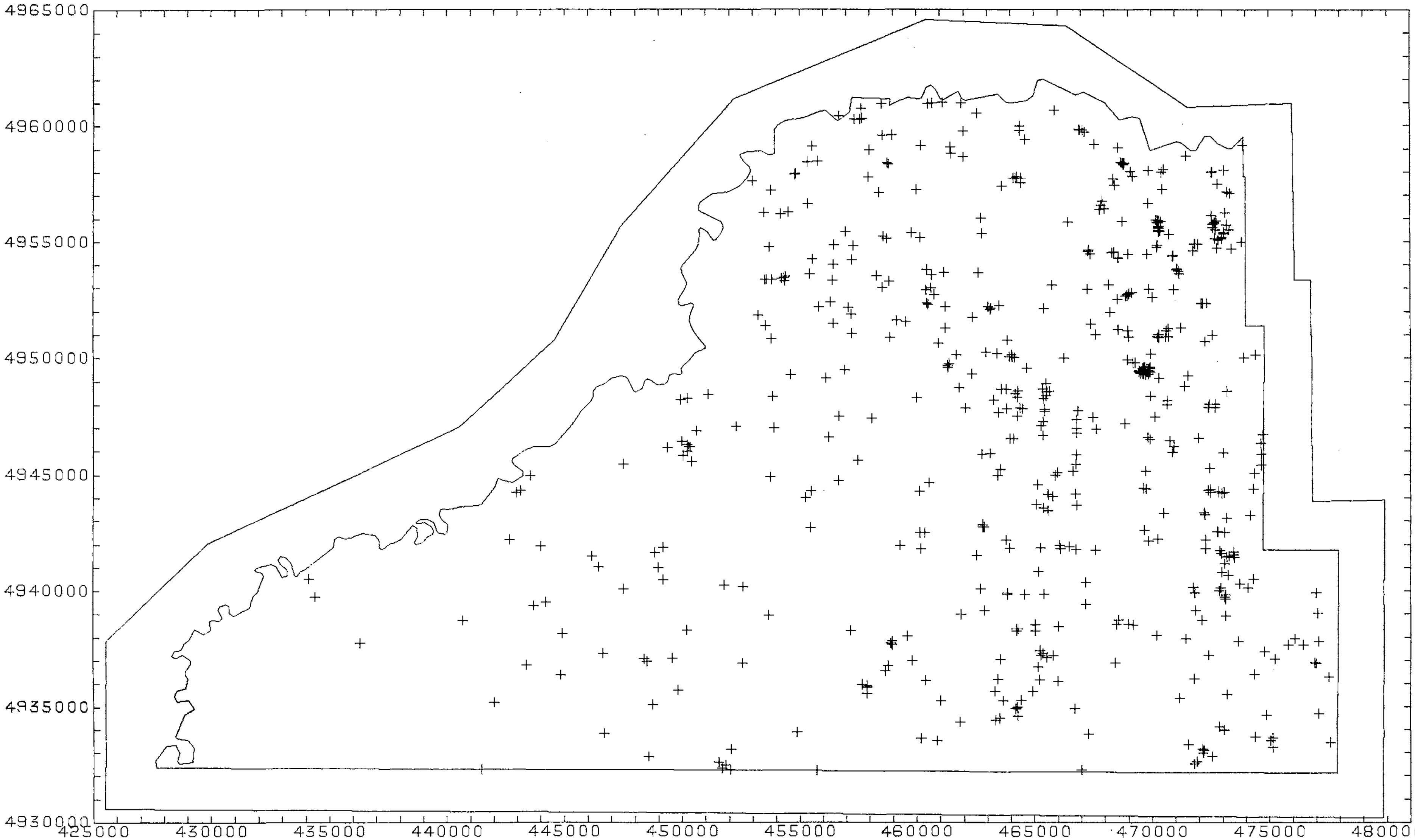

Figure 3--Location map of bedrock topography data, Scott County, Minnesota. UTM grid in meters.

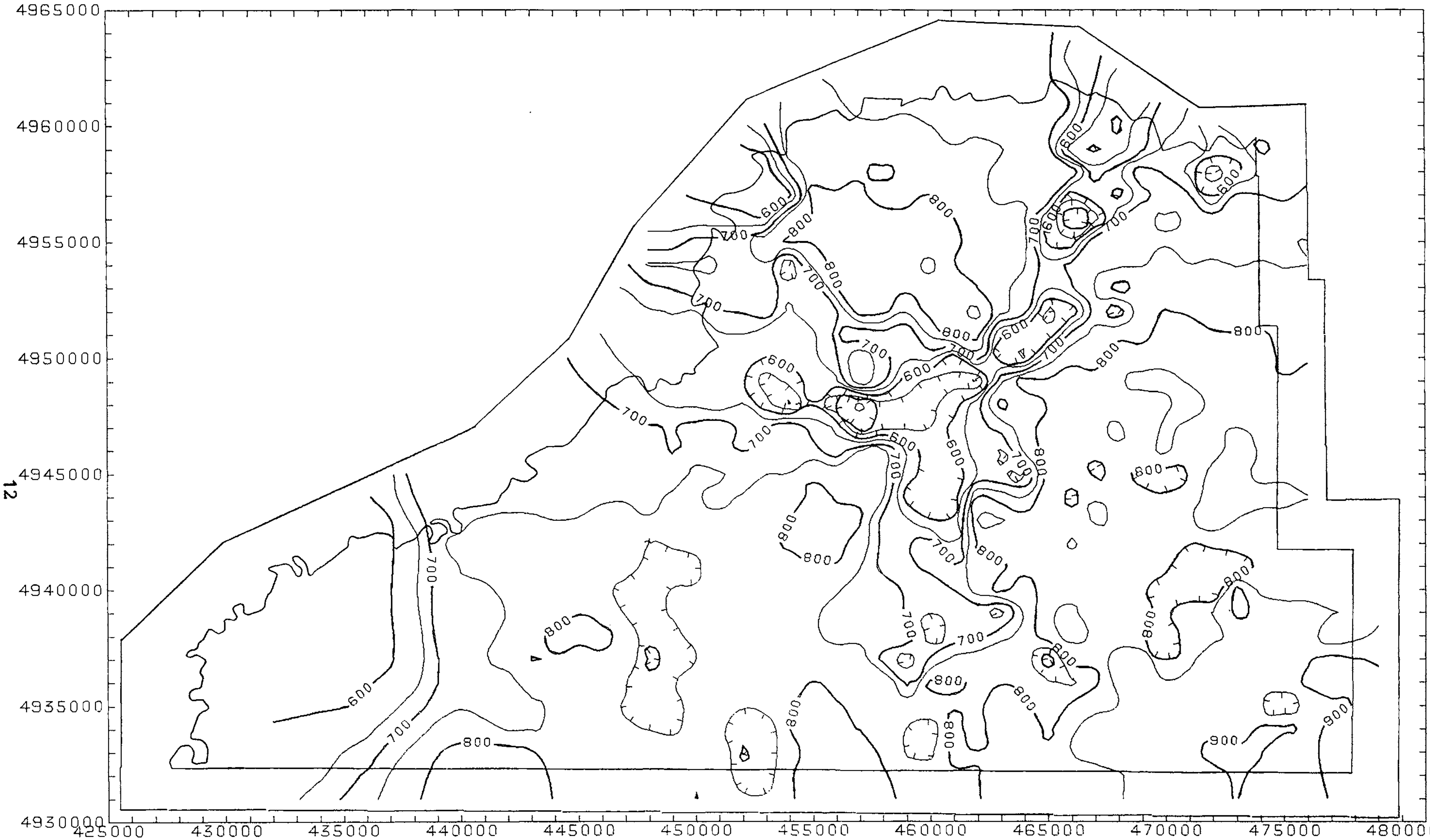

Figure 4--Map of bedrock topography of Scott County, Minnesota. UTM grid in meters, bedrock elevation in feet.

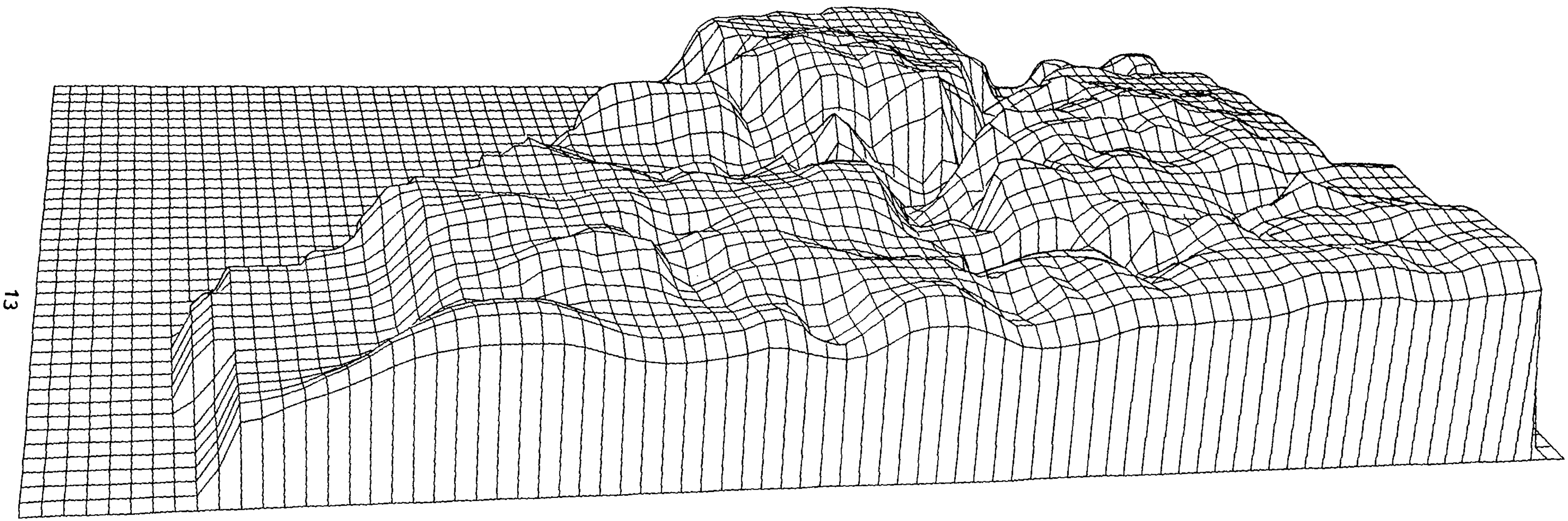

Figure 5--Oblique view of bedrock surface, Scott County, Minnesota.
Vertical exaggeration about 50.

APPENDIX A

CODING FORMS

MINNESOTA GEOLOGICAL SURVEY
WATER WELL CODING FORM NO. 1

1

Unique No. (1–6) | 0 1 Card (7–8) | County (9–10) | Quadrangle (11–14)

Y Y / M M / D D Date completed (15, 16 / 17, 18 / 19, 20)

Township (21–23) | Range (24–25) | Section (S 26, Q, 33)

Elevation (ft.) (34–37) taken from (X or V = 1): 7.5 minute (38); 15 minute (39)

Located by (68)

X or V = 1: Chemical Data (69); Confidential (70)

Depth (ft.) (40–43) | Static Water Level (44–46)

Y Y / M M / D D Water level date (47–52)

2

Unique No. (1–6) | 0 2 Card (7–8) | Pumpage Test: Y Y / M M Date (9, 10 / 11, 12)

hrs. (13–15) | gpm (16–19) | ft. drawdown (20–22)

hrs. (23–25) | gpm (26–29) | ft. drawdown (30–32)

hrs. (33–35) | gpm (36–39) | ft. drawdown (40–42)

hrs. (43–45) | gpm (46–49) | ft. drawdown (50–52)

hrs. (53–55) | gpm (56–59) | ft. drawdown (60–62)

hrs. (63–65) | gpm (66–69) | ft. drawdown (70–72)

3

Unique No. (1–6) | 0 3 Card (7–8)

Well Name (9–36)

Address (37–64)

City (65–80)

4

Unique No. (1–6) | 0 4 Card (7–8)

Data Source (9–28) | Aquifer (s) (29–32) – (33–36)

Well Use: (V or X = 1)

- 37 ☐ Domestic
- 38 ☐ Irrigation
- 39 ☐ Test Well
- 40 ☐ Public Supply
- 41 ☐ Air Conditioning
- 42 ☐ Industry
- 43 ☐ Commercial
- 44 ☐ (45–59)

MINNESOTA GEOLOGICAL SURVEY
WATER WELL CODING FORM NO. 2

5

Unique No. [1–6] Card [0 5] (7 8) Remarks: [9–18]

[19–49]

[50–80]

6

Unique No. [1–6] Card [0 6] (7 8) Remarks: [9–18]

[19–49]

[50–80]

7

Unique No. [1–6] Card [0 7] (7 8) Casing: ☐ Telescoping (9) ☐ Step-Down (10) V or X = 1

[11–13] in. to [14–17] ft.

[18–20] in. to [21–24] ft.

[25–27] in. to [28–31] ft.

[32–34] in. to [35–38] ft.

[39–41] in. to [42–45] ft.

Source of Possible Contamination:

[46–50] feet [51–55] direction

[56–80] type

8

Unique No. [1–6] Card [0 8] (7 8) Screen

Make [9–28]

Type [29–43] Dia. [44–48]

Slot/Gauze [49–51] Length [52–56] Set between [57–60] ft. and [61–64] ft.

[65–68] ft. and [69–72] ft.

[73–76] ft. and [77–80] ft.

9

Unique No. [1–6] Card [0 9] (7 8) Pump

Manufacturer's Name [9–32]

Model Number [33–45] H.P. [46–50] Volts [51–55]

Length of drop pipe [56–60] ft. Capacity [61–65]

Type: (66) ☐ Submersible (68) ☐ L.S. Turbine V or X = 1 (70) ☐ Reciprocating

(67) ☐ Jet V or X = 1 (69) ☐ Centrifugal (71) ☐ [72–80]

MINNESOTA GEOLOGICAL SURVEY
WATER WELL CODING FORM NO. 3

(10+)

Unique No. (1–6)   Card (7 8)

	Driller's Description	Color	Hardness	Top of Unit (feet)	Strat. Unit	Lithology 1	Lithology 2	Lithology 3
	9	44 45	52 53	60 61	64 65	68 69	72 73	76 77 80
(10)								
(11)								
(12)								
(13)								
(14)								
(15)								
(16)								
(17)								
(18)								
(19)								
(20)								
(21)								
(22)								
(23)								
(24)								
(25)								
(26)								
(27)								
(28)								
(29)								
(30)								
(31)								
(32)								
(33)								
(34)								
(35)								
(36)								

APPENDIX B

RECORD STRUCTURE

Information on water wells is stored as card images in sequential computer files according to the format:

CARD	COL	FIELD	REMARKS
1	1-6	Unique No.	
1	7-8	Card No.	=01 Location
1	9-10	County	For codes see Appendix E
1	11-14	Quadrangle	Coded for internal use
1	15-20	Date completed	Zero filled unless all blank
1	21-23	Township	
1	24-25	Range	Positive if west, negative if east
1	26-33	Section	
1	34-37	Elevation	in feet
1	38	7 1/2 minute	=1 if checked
1	39	15 minute	=1 if checked
1	40-43	Depth	in feet
1	44-46	Static water level	in feet
1	47-52	Date	Zero filled unless all blank
1	53-58	UTM easting	
1	59-65	UTM northing	
1	66-67	UTM zone	
1	68	Field location method	coded for internal use
1	69	Chemical data availability	=1 if checked

1	71-78	Index of cards 2-9	=1 if present
1	79-80	Number of cards following card 1	
2	1-6	Unique No.	
2	7-8	Card No.	=02 Pumpage tests
2	9-12	Date	Zero filled unless all blank
2	13-15	Hours	
2	16-19	Gallons per minute	Repeated in 23-32, 33-42, etc. to max. of 6 sets (applies to columns 16-19 and 20-22)
2	20-22	Ft. drawdown	
3	1-6	Unique No.	
3	7-8	Card No.	=03 Well ownership
3	9-36	Well name	
3	37-64	Address	Abbreviations used: Mile = MI County Road = CRD Quarter = QTR Half = HLF
3	65-80	City	
4	1-6	Unique No.	
4	7-8	Card No.	=04 Aquifer/Well use
4	9-28	Data source	
4	29-36	Aquifer	See stratigraphic codes in Appendix C

4	37	Domestic	=1 if checked
4	38	Irrigation	
4	39	Test well	
4	40	Public supply	
4	41	Air cond.	
4	42	Industry	
4	43	Commercial	
4	44	Other	
4	45-59	Other--write in	
5	1-6	Unique No.	
5	7-8	Card No.	=05 Remarks
5	9-80	Remarks	
6	1-6	Unique No.	
6	7-8	Card No.	=06 Remarks (cont.)
6	9-80	Remarks	
7	1-6	Unique No.	
7	7-8	Card No.	=07 Casing record/contamination
		Casing:	
7	9	Telescoping	=1 if checked
7	10	Step-down	
7	11-13	Diameter	In inches repeat in 18-20, 25-27, 32-34, 39-41 as needed
7	14-17	Depth	In feet repeat in 21-24, 28-31, 35-38, 41-45 as needed

		Contamination:	
7	46-50	Distance	In feet
7	51-55	Direction	
7	56-80	Type	
8	1-6	Unique No.	
8	7-8	Card No.	=08 Well construction
		Screen:	
8	9-28	Make	
8	29-43	Type	
8	44-48	Diameter	In decimal inches
8	49-51	Slot/Gauze	
8	52-56	Length	
		Set between depths:	
8	57-60	ft. and	
8	61-64	ft.,	
8	65-68	ft. and	
8	69-72	ft.,	
8	73-76	ft. and	
8	77-80	ft.	
9	1-6	Unique No	
9	7-8	Card No.	=09 Pump
9	9-32	Manf. Name	
9	33-45	Model	
9	46-50	H.P.	May include decimal point
9	51-55	Volts	

9	56-60	Length of drop pipe	
9	61-65	Capacity	
		Pump type:	
9	66	Submersible	=1 if checked
9	67	Jet	=1 if checked
9	68	L.S. Turbine	=1 if checked
9	69	Centrifugal	=1 if checked
9	70	Reciprocating	=1 if checked
9	71	Other	=1 if checked
9	72-80	Other--write in	
10+	1-6	Unique No.	
10+	7-8	Card No.	Sequential starting with 10; Geologic log
10+	9-44	Driller's description	
10+	45-52	Color	
10+	53-60	Hardness	
10+	61-64	Depth to top of unit	In feet
10+	65-68	Strat. unit	See Appendix C for stratigraphic codes
10+	69-72	Primary lithology	See Appendix D for lithologic codes
10+	73-76	Secondary lithology	See Appendix D for lithologic codes
10+	77-80	Minor lithology	See Appendix D for lithologic codes

APPENDIX C

STRATIGRAPHIC CODES

Pleistocene Series

Codes for these deposits have the form "WXYZ" where W, X, Y, and Z may have the following designations:

W	=	R	Denotes Recent deposits
		Q	Denotes Quaternary deposits
X	=	F	Fluvial (outwash) deposits
		L	Lacustrine deposits
		T	Till deposits
		U	Deposit type unknown
Y	=	C	Calcareous deposits primarily containing dolomite or limestone pebbles
		S	Deposits containing shale pebbles or shale partings
		U	Materials unknown or undifferentiated
Z	=	B	Brown-colored deposit
		R	Red-colored deposit
		G	Gray-colored deposit
		U	Color unknown

Cretaceous System	
Cretaceous undifferentiated	KRET
Cretaceous regolith (southeastern and western Minnesota)	KREG
Coleraine Formation	KCLR
Windrow Formation	KWND
Possible Cretaceous units of western Minnesota	
Pierre Shale	KPRR
Niobrara equivalent	KNBR
Carlile Shale	KCRL
Greenhorn equivalent	KGRN
Graneros Shale	KGRS
Dakota Formation	KDKT
Pre-Cretaceous of northwestern Minnesota	
Jurassic System	
Jurassic-Hallock red beds	JURA
Ordovician System	
Stonewall Formation	OSTW
Stony Mountain Formation	OSTM
Red River Formation	ORRV
Winnipeg Formation	OWIN
Pre-Cretaceous of southeastern Minnesota	
Devonian System	
Cedar Valley Formation	DCVA

Ordovician System	
Ordovician undifferentiated	ORDO
Maquoketa Formation	OMAQ
Maquoketa-Galena Formations	OMQG
Dubuque Formation	ODUB
Dubuque-Galena Formations	ODGL
Galena Formation	OGAL
Galena Formation-Decorah Shale	OGDC
Decorah Shale	ODCR
Decorah Shale-Platteville Formation	ODPL
Platteville Formation	OPVL
Platteville Formation-St. Peter Sandstone	OPSP
Platteville-Glenwood Formations	OPGW
Glenwood Formation	OGWD
Glenwood Formation-St. Peter Sandstone	OGSP
St. Peter Sandstone	OSTP
St. Peter Sandstone-Prairie du Chien Group	OSPC
Prairie du Chien Group	OPDC
Prairie du Chien Group-Jordan Sandstone	OPCJ
Cambrian System	
Cambrian undifferentiated	CAMB
Jordan Sandstone	CJDN
St. Lawrence Formation	CSTL
St. Lawrence-Franconia Formations	CSLF
Franconia Formation	CFRN
Franconian Stage (Franconia-Ironton)	CFRA
Ironton Sandstone	CIRN
Ironton-Galesville Sandstones	CIGL
Galesville Sandstone	CGSL
Dresbachian Stage (Galesville-Mt. Simon)	CDRE
Eau Claire Formation	CECR
Mt. Simon Sandstone	CMTS
Mt. Simon-Hinckley Sandstones	CMSH
Precambrian System	
Upper Precambrian (Precambrian Y: 1600-800 MYBP)	
Upper PC sedimentary rocks, undifferentiated	PYSU
Hinckley Sandstone	PYHN
Hinckley Sandstone-Fond du Lac Formation	PYHF
Fond du Lac Formation	PYFL
Solor Church Formation	PYSC
Beaver Bay Complex	PYBB
Chengwatana Volcanic Group	PYCV
Duluth Complex	PYDC
Anorthositic series-Duluth Complex	PYDA
Felsic series-Duluth Complex	PYDF
Troctolitic series-Duluth Complex	PYDT
Logan Intrusions	PYLG
Nopeming Sandstone	PYNP
North Shore Volcanic Group, undivided	PYNS
Puckwunge Formation	PYPK
Sioux Quartzite	PYSX
Pigeon River Intrusions	PYPR
Upper Precambrian rocks, undivided	PYUD
Keweenawan volcanic rocks, undivided	PYVU

Middle Precambrian (Precambrian X: 2500-1600 MYBP)

Animikie Group, undivided	PXAG
Biwabik Iron-Formation	PXBI
Bradbury Creek Granodiorite	PXBC
Cedar Mountain Complex	PXCM
Denham Formation	PXDN
Freedhem Granodiorite	PXFH
Glen Township Formation	PXGT
Gunflint Iron-Formation	PXGI
Hillman Migmatite	PXHL
Isle Granite	PXIL
Little Falls Formation	PXLF
Mille Lacs Group, undivided	PXML
Mahnomen Formation	PXMN
Pierz Granite	PXPZ
Pokegama Quartzite	PXPK
Rabbit Lake Formation	PXRB
Rabbit Lake Formation, lower member	PXRL
Rabbit Lake Formation, Emily Member	PXRE
Rabbit Lake Formation, upper member	PXRU
Reformatory Granite	PXRF
Rockville Granite	PXRK
Randall Formation	PXRD
Rove Formation	PXRV
St. Cloud Granite	PXSC
Stearns Granitic Complex, undivided	PXST
Thomson Formation	PXTM
Trommald Formation	PXTR
Trout Lake Formation	PXTL
Middle Precambrian rocks, undivided	PXUD
Virginia Formation	PXVR
Warman Granite	PXWR
Middle Precambrian granitic plutons, undivided	PXGU

Lower Precambrian (Precambrian W: >2500 MYBP)

Algoman granites, undivided	PWAU
Bellingham Granite	PWBL
Burntside Gneiss	PWBR
Deer Lake Complex	PWDL
Ely Greenstone, undivided	PWEY
Fort Ridgely Granite	PWFR
Giants Range Granite, undivided	PWGR
Granite Falls Gneiss	PWGF
Knife Lake Group	PWKG
Laurentian granites, undivided	PWLG
Lac La Croix Granite	PWLL
Lake Vermilion Formation	PWLV
McGrath Gneiss	PWMC
Montevideo Gneiss	PWMV
Morton Gneiss	PWMR
Newton Lake Formation	PWNL
Odessa Granite	PWOD
Ortonville Granite	PWOR
Richmond Gneiss	PWRG
St. Wendel Metagabbro	PWSW

Sacred Heart Granite	PWSH
Saganaga Tonalite	PWSG
Sauk Rapids Metamorphic Complex	PWSR
Sartell Gneiss	PWST
Seaforth Gneiss	PWSF
Ely Greenstone, Soudan Iron-Formation Member	PWES
Lower Precambrian rocks, undivided	PWUD
Vermilion Granitic Complex	PWVC
Watab Amphibolite	PWWT
Lower Precambrian granitic plutons, undivided	PWGU

Miscellaneous Codes

Basement (building)	BSMT
No Record	NRCD
Pit	PITT
Pavement (man-made)	PVMT
Recent man made fill	RMMF
Weathering residuum of uncertain age	UREG

APPENDIX D

LITHOLOGIC CODES

Actinolite	ACTN	Gravel	GRVL
Agglomerate	AGLM	Graywacke	GRWK
Amphibolite	AMPH	Greenschist	GRSC
Andalusite	ANDL	Greenstone	GRSN
Andesite	ANDS	Gypsum	GYPS
Anorthosite (rock)	ANOR	Hardpan	HDPN
Argillite	ARGI	Hematite	HEMA
Arkose, Arkosic	ARKS	Hornblende	HRNB
Augite	AUGT	Hornblendite	HNBT
Basalt	BSLT	Hornfels	HNFL
Bedrock	BDRK	Hypersthene	HYPS
Bentonite, Bentonitic	BENT	Iron Ore	IRON
Biotite	BIOT	Jasper	JASP
Boulder	BLDR	Kaolinite, Kaolinitic	KAOL
Breccia, Brecciated	BREC	Kyanite	KYAN
Carbonate	CARB	Lamprophyre	LAMP
Cavern, Cavernous	CVRN	Latite	LATI
Chalcedony	CHAL	Lignite	LGNT
Chalcopyrite	CPRT	Limestone	LMSN
Chalk, Chalky	CHLK	Limonite; Limonite-Goethite	LMNT
Chert, Cherty	CHRT	Magnetite	MGNT
Chlorite, Chloritic	CHLR	Marl	MARL
Clay	CLAY	Mica	MICA
Claystone	CLSN	Migmatite	MGMT
Coal	COAL	Monzonite	MNZT
Cobble	COBL	Muck	MUCK
Conglomerate	CNGL	Mud	MUDD
Cordierite	CORD	Mudstone	MDSN
Crevice	CRVC	Muscovite	MUSC
Dacite	DACT	Mylonite	MYLN
Diabase	DIAB	Norite	NORT
Diopside	DIOP	Olivine	OLVN
Diorite	DIOR	Oolite, Oolitic	OOLT
Dolomite	DLMT	Organic Deposits	ORGD
Drift	DRFT	Orthoclase	ORTH
Duricrust	DURI	Peat	PEAT
Enstatite	ENST	Pebbles	PEBL
Epidote	EPID	Peridotite	PRDT
Feldspar	FELD	Phonolite	PHON
Felsite	FELS	Phosphatic	PHOS
Fill	FILL	Phyllite	PHYL
Flint	FLNT	Plagioclase	PLAG
Gabbro	GBRO	Pyrite, Pyritized	PYRT
Garnet	GARN	Pyroxenite	PYRX
Glauconite	GLAU	Quartz, Quartzose	QUTZ
Gneiss	GNIS	Quartzite	QRZT
Granite	GRAN	Regolith	REGO
Granodiorite	GNDI	Rhyolite	RHYT
Granulite	GNLT	Sand	SAND

Sand	SAND
Sandstone	SNDS
Schist	SHST
Serpentine	SERP
Shale	SHLE
Siderite, Sideritic	SIDR
Silica	SILC
Sillimanite	SILM
Silt	SILT
Siltstone	SLSN
Slate	SLTE
Soil	SOIL
Staurolite	STAU
Syenite	SYEN
Taconite	TACT
Till	TILL
Tonalite	TONT
Trachyte	TRGT
Tremolite	TREM
Troctolite	TROC
Tuff	TUFF
Water	WATR
Wood	WOOD
Zeolite, Zeolitic	ZEOL

Miscellaneous Codes

Basement (Building)	BSMT
Fill	FILL
No Record	NRCD
Pit	PITT
Pavement (man-made)	PVMT

APPENDIX E

COUNTY CODES

01. Aitkin
02. Anoka
03. Becker
04. Beltrami
05. Benton
06. Big Stone
07. Blue Earth
08. Brown
09. Carlton
10. Carver
11. Cass
12. Chippewa
13. Chisago
14. Clay
15. Clearwater
16. Cook
17. Cottonwood
18. Crow Wing
19. Dakota
20. Dodge
21. Douglas
22. Faribault
23. Fillmore
24. Freeborn
25. Goodhue
26. Grant
27. Hennepin
28. Houston
29. Hubbard
30. Isanti
31. Itasca
32. Jackson
33. Kanabec
34. Kandiyohi
35. Kittson
36. Koochiching
37. Lac qui Parle
38. Lake
39. Lake of the Woods
40. Le Sueur
41. Lincoln
42. Lyon
43. McLeod
44. Mahnomen
45. Marshall
46. Martin
47. Meeker
48. Mille Lacs
49. Morrison
50. Mower
51. Murray
52. Nicollet
53. Nobles
54. Norman
55. Olmsted
56. Otter Tail
57. Pennington
58. Pine
59. Pipestone
60. Polk
61. Pope
62. Ramsey
63. Red Lake
64. Redwood
65. Renville
66. Rice
67. Rock
68. Roseau
69. St. Louis
70. Scott
71. Sherburne
72. Sibley
73. Stearns
74. Steele
75. Stevens
76. Swift
77. Todd
78. Traverse
79. Wabasha
80. Wadena
81. Waseca
82. Washington
83. Watonwan
84. Wilkin
85. Winona
86. Wright
87. Yellow Medicine
88. Iowa
89. Wisconsin
90. N. Dakota
91. S. Dakota
92. Canada