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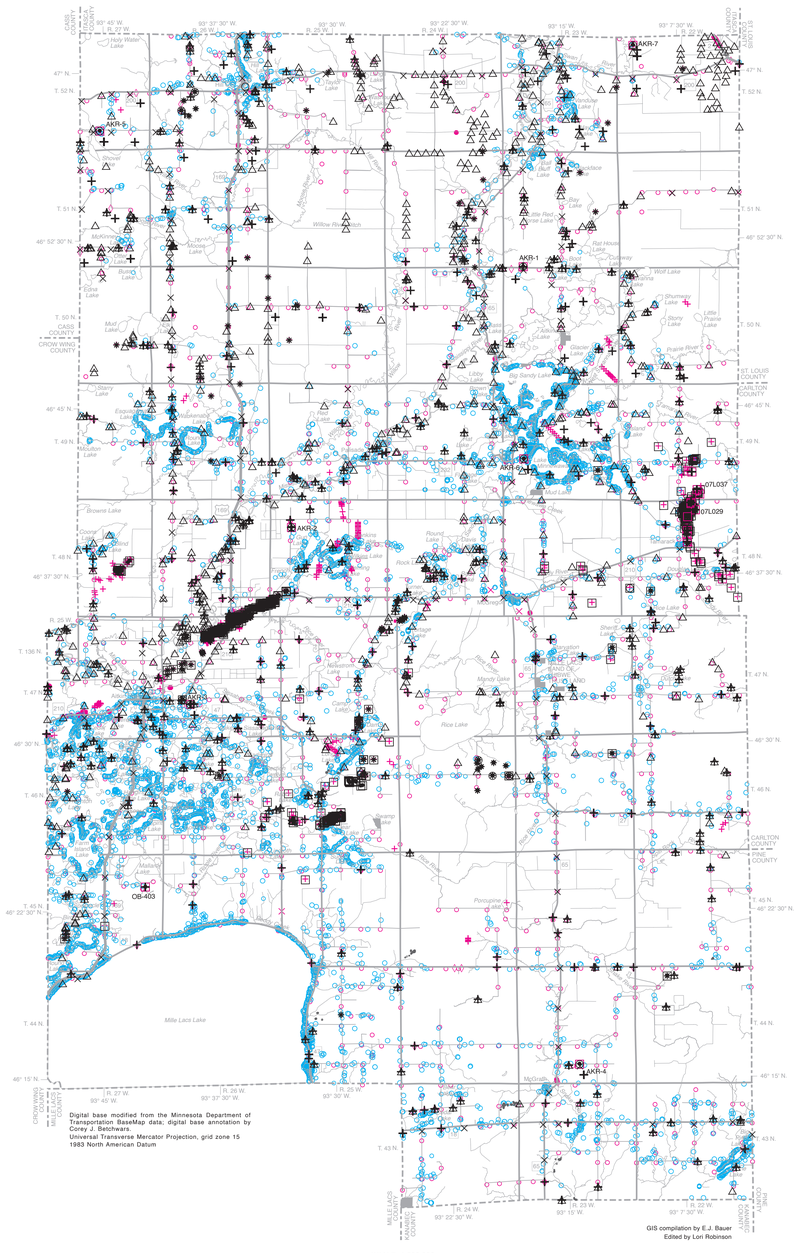
COUNTY ATLAS SERIES
ATLAS C-52, PART A
Aitkin County
Plate 1—Database Map



Digital base modified from the Minnesota Department of Transportation BaseMap data; digital base annotation by Corey J. Batchwara.
Universal Transverse Mercator Projection, grid zone 15
1983 North American Datum

GIS compilation by E.J. Bauer
Edited by Lori Robinson

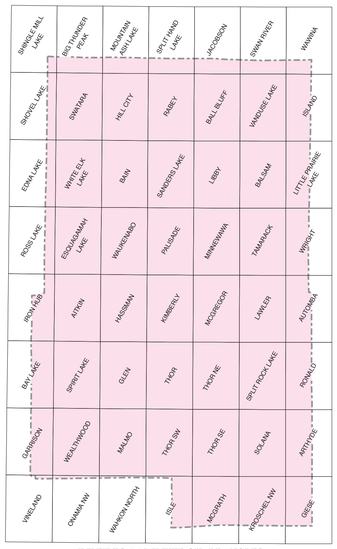
SCALE 1:200 000

5 0 5 10 MILES
5 0 5 10 15 KILOMETERS

MAP SYMBOLS

- Record of water-well construction (well driller's log)
- Exploratory boring (exploration hole)
- Scientific investigation hole
- Rotary-sonic core sample with detailed geologist's log
- Core sample
- Cutting sample
- Borehole geophysical log
- Soil boring
- Giddings probe hole
- Field site
- Textural analysis
- Gravity data
- Passive seismic sounding
- Seismic refraction sounding
- Bedrock outcrop
- Tribal land

Note: More than one symbol can occur at the same location.



INDEX TO 7.5-MINUTE QUADRANGLES

DATABASE MAP

By

Emily J. Bauer and V.W. Chandler

2022

INTRODUCTION

The public health and economic development of Aitkin County are directly dependent on the wise use and management of its land and water resources. Geologic and hydrologic information are essential before decisions are made that affect natural resources. Although the amount of geologic information required for making specific decisions can vary, the information will not be used if it is unavailable when needed, or if it is available only in a highly technical form, or scattered in many different maps and reports. The databases described here address this need.

County Geologic Atlases, prepared jointly by the Minnesota Geological Survey and the Minnesota Department of Natural Resources, present detailed geologic and hydrologic information in an interpretive as well as descriptive form. Maps and texts summarize basic geologic and hydrologic conditions at a county scale, and interpret these conditions in terms of the impacts of possible land- and water-use decisions.

Several sources commonly provide information about an area or an individual property, but they may use different classification schemes to describe the same geologic materials. As a result, discrepancies in interpreting the data may arise or the different sources may appear to contradict each other. For example, water-well drillers may describe glacial till as "clay," but engineering records will describe it as "clayey sand." Both descriptions are acceptable for their original purpose of describing the physical attributes of the material. "Clay," the term used by well drillers, defines the general inability of the till to yield groundwater to a well. "Clayey sand," the term from the engineering record, defines the physical composition of the till relative to particle size and engineering properties. The geologist must take the analysis one step further and define the material in terms of how it formed rather than how it is to be used. In this example, till consists of an unsorted mixture of rock fragments ranging in size from clay to cobbles and boulders, and it is interpreted by the geologist to have been deposited directly by glacial ice. Understanding the process by which the material formed allows geologists to make predictions about what lies between and beyond data points.

All of the types of data described on this plate were interpreted by geologists or hydrogeologists to make them meaningful for mapping purposes. The 1:200,000 scale of the maps in this atlas was chosen because it shows the geologic and topical studies of the county while keeping the physical size of each plate to a manageable level. As a result, some detailed information that was gained by data interpretation and mapping cannot be shown on these maps or discussed in the texts. Some of this information is available in digital files that accompany the atlas.

Whether to use the atlas alone, or in combination with the databases, depends on the amount of detail needed. Generally, database information must be used to evaluate site-specific conditions.

THE DATABASE MAP

The types, locations, and density of information used to prepare the Aitkin County atlas are shown on this map. The data are described below to aid the user in assessing what types may be useful for a particular information need. The Database Map serves as a guide to the precision of the other maps in the atlas. It shows where data are sparse or lacking and interpretation and extrapolation were required to prepare the maps.

DRILL-HOLE INFORMATION

A **record of water-well construction (well driller's log)** is a water-well contractor's description of the geologic materials penetrated during drilling and the construction materials used to complete the well. Included are holes drilled by water-well contractors that were not completed as wells due to insufficient water quantity. Hydrologic data, such as the static water level and test-pumping results, are commonly included. Before any driller's log can be used, the location of the well must be verified, and a geologist must interpret the log. Driller's logs are the primary source of subsurface geologic and hydrologic data for Aitkin County; about 8,000 logs were used for this atlas.

An exploratory boring (exploration hole) is an explorationist's description of the geologic materials penetrated during mineral exploration. Exploratory work may include the collection of core and cuttings samples of bedrock for descriptive and analytical purposes. When studies are complete, the samples collected are sent to the Drill Core Library in Hibbing (the state repository for bedrock and earthen material core samples collected during minerals exploration, engineering, and geoscience research programs across Minnesota) and are available for inspection.

Scientific investigation holes are drilled by various agencies to study the nature of the subsurface material. Geologic logs were generated that describe the material penetrated for each hole and samples may have been taken for further analysis or study. In Aitkin County, this includes holes drilled by the Minnesota Department of Natural Resources, the Department of Iron Range Resources and Rehabilitation, and the now-defunct U.S. Bureau of Mines to study the mineral potential in the area; the Minnesota Geological Survey drilled investigation holes to better understand the glacial deposits and Precambrian bedrock.

Core samples were collected at various sites throughout Aitkin County as a means to establish the nature of the subsurface material. Most of the core sampling was done by several different mineral exploration companies and agencies regulating or promoting the use of natural resources, such as the Minnesota Department of Natural Resources, the Department of Iron Range Resources and Rehabilitation, and the U.S. Bureau of Mines, but the Minnesota Geological Survey collected a number of cores to better understand the subsurface materials. Coring methods employed include diamond drilling and rotary-sonic coring. Rotary-sonic coring is a technique that enables recovery of a continuous core, 3.5 inches (8.9 centimeters) in diameter, from glacial deposits and bedrock (where intersected). It provides excellent subsurface samples for detailed study and comparison with cuttings, geophysical logs, and driller's logs from surrounding sites. Bedrock core is most commonly collected using a diamond bit rotating at the end of a drill rod. A column of rock moves up the drill pipe and is recovered at the surface for study. Minerals exploration in the Tamarack (Tps. 48 and 49 N., R. 22 W.) area in the past couple of decades has involved using both the diamond drilling and the rotary-sonic coring techniques, sometimes at the same drill site. Detailed geologist's logs describing the glacial deposits for 21 of the rotary-sonic cores were completed by Minnesota Geological Survey geologists and are shown on Plate 4, *Quaternary Stratigraphy*. These include core collected by the Minnesota Geological Survey for this project from 7 sites in the county (labelled AKR-1 through AKR-7) to aid the interpretation of the Quaternary deposits and to determine bedrock depth and nature, 3 cores collected by the Minnesota Department of Natural Resources to help determine mineral potential (labelled OB-403, 07L037, and 07L029), and 11 cores collected by Kennecott Exploration Company during minerals exploration in the Tamarack area. The Minnesota Department of Transportation collected core at 91 sites for road and bridge foundations, and one core was collected by the Minnesota Department of Natural Resources during installation of a groundwater observation well. The rotary-sonic cores collected for this atlas are stored at the Drill Core Library in Hibbing and are available for inspection.

Soil borings are test holes drilled to obtain information about the physical properties of subsurface materials for engineering, mapping, or exploration purposes. They are logged by an engineer or a geologist using a variety of classification schemes based on particle size, penetration rate, moisture content, and color. Soil-boring data collected by the Minnesota Department of Transportation are concentrated along U.S. Highway 169 and Minnesota Highways 65, 200, and 210. Descriptions of the geologic materials penetrated are interpreted by Minnesota Geological Survey geologists for mapping purposes. The records may be accessed online at the Minnesota Department of Transportation's web portal (http://dotapp7.dot.state.mn.us/geotechnical/FoundationBorings/).

Cutting samples collected during drilling and exploration provide physical evidence of subsurface geologic materials. Cuttings are the samples generated as the drill bit cuts through the subsurface material and are used to interpret and verify driller's logs. They are logged and stored at either the Minnesota Geological Survey or the Drill Core Library in Hibbing.

Borehole geophysical logs are collected by Minnesota Geological Survey staff and other government agencies and private entities by lowering instruments down a well or drill hole and measuring the physical and chemical properties of the geologic materials through which the hole passes. Different logging techniques measure naturally occurring gamma radiation, spontaneous potential, and resistivity. Gamma logs characterize in graphic form the geologic formations penetrated. Spontaneous potential and resistivity are mainly used to locate water levels in wells and the depth of the well casing. An interpretive log is prepared by a geologist from the geophysical log and correlated with drilling samples from the same hole, information obtained from nearby outcrops, or a geophysical log from a nearby drill hole. Geophysical logs can provide high-quality subsurface geologic and hydrologic information for wells that have little or no other information available. Logs can be viewed at the Minnesota Geological Survey or accessed online (http://z.umn.edu/borehole_geo). The geologic interpretations are available through the County Well Index database described below.

Giddings probe holes are borings of glacial materials, 2 inches (5.1 centimeters) in diameter, collected by Minnesota Geological Survey staff using a truck-mounted hydraulic auger. A description was generated at every site and samples were taken for textural analyses at most locations. Samples were generally taken about every 5 feet (1.5 meters), at unit contacts, or where the geologist believed it was important.

OTHER INFORMATION

Field sites are natural and artificial exposures of unconsolidated Quaternary deposits that were described in detail; samples from many sites were texturally analyzed. Field sites include stream and river cuts, gravel pits, excavations, and road cuts. Data from field sites can be found in Minnesota Geological Survey files.

Textural analyses express the proportion of sand-, silt-, and clay-sized particles that make up a sample. The samples analyzed were taken from natural and artificial exposures, Giddings holes, and the rotary-sonic cores. They are helpful in determining the origin, correlation, and hydrologic properties of unconsolidated sediments. The data are available in Minnesota Geological Survey files.

Passive seismic soundings provide information based on measurement and analysis of shear- and surface-wave energy in the ground that allow a calculation of the depth to bedrock (thickness of unconsolidated deposits) beneath that point. The measurements employ a recording seismograph system that is implanted into the ground surface and records ambient ground vibrations in three orthogonal directions (2 horizontal and 1 vertical) during a 16-minute interval. The method is called passive because no energy is directly input into the ground at the time of measurement; the unit measures background vibrations from a variety of natural and artificial sources such as wind or traffic. The averaged horizontal spectra of the seismic noise is divided by the corresponding vertical spectrum, and the resulting Horizontal to Vertical Spectral Ratio (HVSR) should display a prominent peak that closely approximates the resonant frequency (shear wave) of the unconsolidated sequence overlying the bedrock surface (Chandler and Lively, 2014). In general, depth to bedrock calculated by this method can have errors up to 25 percent of the depth; however, in areas with little to no other data, this is still useful information and many soundings can be inexpensively collected over a short period of time with one or two operators. A total of 153 passive seismic soundings have been collected within Aitkin County, of which 140 were acquired as part of this Geologic Atlas.

Seismic refraction soundings measure the time required for sound or pressure waves to travel from a source through the subsurface and be refracted back to a receiver. Travel time can be correlated with the density and rigidity of the geologic material. Precambrian and Paleozoic rocks commonly exhibit pressure-wave velocities that are 1.5 to 2.5 times those of unconsolidated Quaternary sediments below the water table. The spacing of the receivers (geophones) and the arrival times (measured in milliseconds) are used to calculate the depth to bedrock. Seismic refraction soundings are more labor intensive than passive seismic soundings, but can provide velocity information and higher-quality depth estimates. A total of 11 seismic refraction soundings have been acquired in Aitkin County by the Minnesota Department of Natural Resources, 10 of which were completed for this Geologic Atlas.

Statewide gravity and aeromagnetic (airborne-magnetic) data that are available at the Minnesota Geological Survey are used to assist mapping Precambrian geology. The utility of these two datasets relies on the strong contrasts in density and magnetization that commonly exist between various Precambrian rocks. Apart from some isolated patches of Cretaceous strata, Precambrian rocks form the bedrock surface beneath Aitkin County. The aeromagnetic data in Aitkin County were acquired 500 feet (152 meters) above ground along flight lines spaced 0.25 mile (0.4 kilometer) apart, and were compiled into a 328-foot (100-meter) grid (line data not indicated on map due to high density). The gravity data are based on ground stations that are generally spaced 1 to 2 miles (1.6 to 3.2 kilometers) apart along roads and driveable trails, and these data are compiled into a 3,281-foot (1,000-meter) grid. Derivative-enhanced grids of the gravity and aeromagnetic data, used in conjunction with information from bedrock wells, are most commonly used for mapping bedrock geology.

Bedrock outcrops are natural exposures of solid rock at the land surface that can be found in the southern half of the county. They serve as reference points for mapping and for checking the accuracy of subsurface data. Bedrock at or near the surface must be considered in land-use planning decisions such as pipeline routing, sewage-system design, and excavation.

DATABASE MANAGEMENT

All of the data shown on the map were plotted on maps at 1:24,000 or finer resolution and assigned inventory numbers. Included with the Aitkin County Atlas are regularly updated databases containing digital GIS files, developed to provide easy access and rapid retrieval of these site-specific data.

Computer storage and retrieval systems are ideal for manipulating large amounts of data because automated geologic databases can be designed to interact with other computer files, such as land-use data. Such interaction permits more efficient assessment of cause-and-effect relationships concerning natural resources than is commonly possible with manual files.

DIGITAL DATABASES

Computerized files were developed for point-source data such as wells and borings in Aitkin County. They use Public Land Survey descriptions, Universal Transverse Mercator (UTM), and latitude-longitude coordinates as location criteria; thus, they are compatible with the natural-resource databases housed at the Minnesota Land Management Information Center (LMIC). One computerized database developed for Aitkin County by the Minnesota Geological Survey is the County Well Index (CWI).

County Well Index (CWI)—Information from water-well records and other subsurface drill-hole data, such as exploration holes, is entered into this statewide database. Each record is assigned either a five- or six-digit unique number. These reference numbers are also used by state agencies and the Water Resources Division of the U.S. Geological Survey. Elevations are expressed in feet above sea level and were determined from either topographic maps (see the index to 7.5-minute quadrangles) or Minnesota's lidar high-resolution elevation dataset. Elevations from the topographic maps are generally accurate to plus or minus 5 feet (1.5 meters) and the lidar elevations are generally accurate to 3 feet (1 meter) or less. The street address of each well is also included wherever possible to provide data users with a well-location system that is compatible with local regulatory programs. Software at the Minnesota Geological Survey is used to display and tabulate many of the data elements contained on the original well log. The program also denotes if there are additional data, such as borehole geophysical logs, cutting samples, or core, for an individual record.

The County Well Index is stored in a database that consists of 10 related tables. These tables contain information such as well depths, well construction, addresses, aquifers, dates drilled, static water levels, and pumping-test data. They also contain the trend and plunge of angled drill holes, alternate well identifiers such as permit numbers or emergency-service numbers, and the well stratigraphy (the geologic materials encountered during drilling).

CWI application software developed by the Minnesota Department of Health provides two types of reports:

WELL LOG contains all the information about the well as it was reported by the contractor (Fig. 1). There may also be additional location information, land-surface elevation, aquifer designation, and remarks about the drill holes.

WELL STRATIGRAPHY contains the geologic log described by a well driller (Fig. 2). A geologist makes stratigraphic interpretations based on this description, and on her or his knowledge and understanding of the geology of Aitkin County. The interpretations are augmented in some cases by additional data sources, such as cuttings, borehole geophysical logs, or core. Only those drill holes with verified locations have stratigraphy assigned to them.

Other digital data—Details about other types of data shown on this plate are available in attribute tables for individual GIS shapefiles included in the atlas products. This includes information that is part of the Quaternary Data Index (QDI), an internal working database. The Quaternary Data Index contains information from field sites, rotary-sonic cores, soil borings, Giddings probe holes, soil auger holes, and textural analyses. Some detailed information associated with these data sources is not included in digital files that are part of this atlas. This includes descriptions of cutting samples, borehole geophysical logs, and additional information on passive seismic data. It is stored in various formats and can be obtained by request from the Minnesota Geological Survey.

Soil borings commonly contain detailed information that is not part of the files included in this atlas. The information can be accessed in other digital and paper files from the Minnesota Geological Survey. In addition, data may be obtained from the sources of the soil borings, such as the U.S. Geological Survey and the Minnesota Department of Transportation, Foundations Unit.

FUTURE DATA COLLECTION

Additional geologic information is generated continuously as new water wells or exploration holes are drilled, construction activities expose more bedrock, or additional wells are tested for water quality. To address this, the library of information prepared for Aitkin County is flexible so that old data can be reevaluated in light of new information, and new forms of data can be added if required. The need to manage groundwater and other natural resources wisely will never become outdated. Future demands on these resources will require current data to assess the impacts.

ACKNOWLEDGEMENTS

The staff from the Department of Environmental Services—Planning and Zoning and the Geographic Information Systems Office of Aitkin County contributed greatly to the development of the County Well Index database. We thank local water-well contractors, landowners, and Kennecott Exploration Company for their valuable assistance.

REFERENCE

Chandler, V.W., and Lively, R.S., 2014, Evaluation of the horizontal-to-vertical spectral ratio (HVSR) passive seismic method for estimating the thickness of Quaternary deposits in Minnesota and adjacent parts of Wisconsin: Minnesota Geological Survey Open-File Report 14-1.

Unique Well Number	County Aitkin	MINNESOTA DEPARTMENT OF HEALTH	Entry Date 2001/08/15
658890	Quad Aitkin	WELL AND BORING RECORD	Update Date 2018/02/21
	Quad Id 229C	MINNESOTA STATUTES CHAPTER 1031	Received Date

Well Name AITKIN OB-1 — Township 47 N — Range 27 W — Dir — Section 25 — Subsection ABACDD — Field Located Elevation MGS 1234.00 ft.

well address AITKIN OB-1; 550 BUNKER HILL DR; AITKIN MN 56431 Changed
contact address CITY OF AITKIN; 109 1ST AV NW; AITKIN MN 56431 Changed

Description	Color	Hardness	From	To (ft.)
CLAY	TAN		0	2
CLAY	WHITE		2	4
SANDY CLAY	TAN		4	14
CLAY	GRAY		14	34
SAND & GRAVEL			34	44
CLAY	BROWN		44	50
BOULDER	BLACK		50	51
CLAY	BROWN		51	65
CLAY	GREEN		65	74
CLAY	BROWN		74	83
SANDY CLAY	RED/BRN		83	100
SAND W/CLAY SEAMS			100	153
GRAVEL & SAND			153	173
CLAY	RED/GRN		173	177

Well Depth 177.00 ft — Depth Completed 175.00 ft — Date Well Completed 2001/05/30
Drillhole Angle
Drilling Method Non-specified Rotary
Drilling Fluid Bentonite — Well Hydrofractured? NO — From — ft. to
Use test well
Casing Type Plastic — Drive Shoe? NO — Hole Diameter (in.)
Diameter 2 — Depth 165
2.00 in. from 0.00 to 165.00 ft. — lbs/ft
Screen Yes — Open Hole(ft.) From — to
Make JOHNSON — Type stainless steel
Diameter 2.00 — Slot 10 — Length 165 — Set ft. to 175 ft.
Static Water Level 20.30 ft. land surface — Date measured 2001/05/30
Pumping Level (below land surface) ft. after — hrs. pumping — g.p.m.
Wellhead Completion
Pitless adapter manufacturer — Model
Casing Protection — 12 in. above grade
At-grate (Environmental Wells and Borings ONLY) — Basement offset
Grouting Information Well grouted? YES — NOT SPECIFIED
Material high solids bentonite From 0.0 To 150.0 ft. 7.00 Sacks
Nearest Known Source of Contamination 50 feet — Direction — SDF — Type
Well disinfected upon completion? YES — NO
Pump: Not Installed — Date Installed — Manufacturer's name — Model number — HP — Volts — Length of drop pipe — Material — Capacity — g.p.m — Type
Abandoned Wells: Does property have any not in use and not sealed well(s)? NO
Variance: Was a variance granted from the MDH for this well? NO
Well Contractor Cerfication: Thein Well Co. 34625
License Business Name GRABOWSKI, D. — Lic. or Reg No.

Remarks: WELL SEALED 11-01-2004 BY 01310

First Bedrock UREG — Aquifer multiple — Last Strat UREG — Depth to Bedrock 173.00 ft.

County Well Index v.5 — REPORT — Printed on 4/16/2020 — Name of Driller — Date — HE-01205-07 (Rev. 2/99)

Figure 1. Example of a WELL LOG record, showing all the information about the well as reported by the well driller.

Unique Well Number	County Aitkin	MINNESOTA DEPARTMENT OF HEALTH	Entry Date 2001/08/15
658890	Quad Aitkin	WELL AND BORING RECORD	Update Date 2018/02/21
	Quad Id 229C	MINNESOTA STATUTES CHAPTER 1031	Received Date

Well Name AITKIN OB-1 — Township 47 N — Range 27 W — Dir — Section 25 — Subsection ABACDD — Depth Drilled 177 ft — Depth Completed 175 ft — Date Completed 2001/05/30 — Lic/Reg. No. 34625 — Driller Name GRABOWSKI, D.

Elevation 1234.00 ft. — Method LiDAR 1m DEM (MNDN — Aquifer multiple — Depth to Bedrock 173 ft. — Screen 165-175 — SWL 20.3

Field Located — Minnesota Geological Survey — Location Method — Universal Transverse Mercator(UTM) - NAD83 - Zone 15 - Meters
Program — Input Source — Minnesota Geological Survey — UTM Easting (X) — 446867 — UTM Northing (Y) — 5153353
Uni No.Verified — Site Plan — Input Date — 2017/10/02
Geologic Interpretation — Dale Setterholm — Agency — MGS — Interpretation Method — Geologic study 1:24k to 1:100k

Geological Material	Color	Hardness	DEPTH From	DEPTH To	DEPTH Thick	ELEVATION From	ELEVATION To	Stratigraphy	LITHOLOGY Primary	LITHOLOGY Secondary	LITHOLOGY Minor
CLAY	TAN		0	2	2	1234	1232	clay-brown	clay		
CLAY	WHITE		2	4	2	1232	1230	clay-white	clay		
SANDY CLAY	TAN		4	14	10	1230	1220	clay+sand-brown	clay	sand	
CLAY	GRAY		14	34	20	1220	1200	clay-gray	clay		
SAND & GRAVEL			34	44	10	1200	1190	sand +larger	sand	gravel	
CLAY	BROWN		44	50	6	1190	1184	clay-brown	clay		
BOULDER	BLACK		50	51	1	1184	1183	boulder or boulders-black	boulder		
CLAY	BROWN		51	65	14	1183	1169	clay-brown	clay		
CLAY	GREEN		65	74	9	1169	1160	clay-green	clay		
CLAY	BROWN		74	83	9	1160	1151	clay-brown	clay		
SANDY CLAY	RED/BRN		83	100	17	1151	1134	clay+sand	clay	sand	
SAND W/CLAY SEAMS			100	153	53	1134	1081	clay+sand	sand	clay	
GRAVEL & SAND			153	173	20	1081	1061	sand +larger	gravel	sand	
CLAY	RED/GRN		173	177	4	1061	1057	weathering residuum unc.age	regolith		

Figure 2. Example of a WELL STRATIGRAPHY record, which contains a geologist's interpretation of the geologic materials listed by the driller in the WELL LOG record (Fig. 1). Additional downhole information for this well (as noted in the Interpretation Method on the record above) controls the geologist's interpretation, which may not match the driller's description of the geologic material penetrated.

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ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

Every reasonable effort has been made to ensure the accuracy of the factual data on which this map interpretation is based; however, the Minnesota Geological Survey does not warrant or guarantee that there are no errors. Users may wish to verify critical information; sources include both the references listed here and information on file at the offices of the Minnesota Geological Survey in St. Paul. In addition, effort has been made to ensure that the interpretation conforms to sound geologic and cartographic principles. No claim is made that the interpretation shown is rigorously correct, however, and it should not be used to guide engineering-scale decisions without site-specific verification.