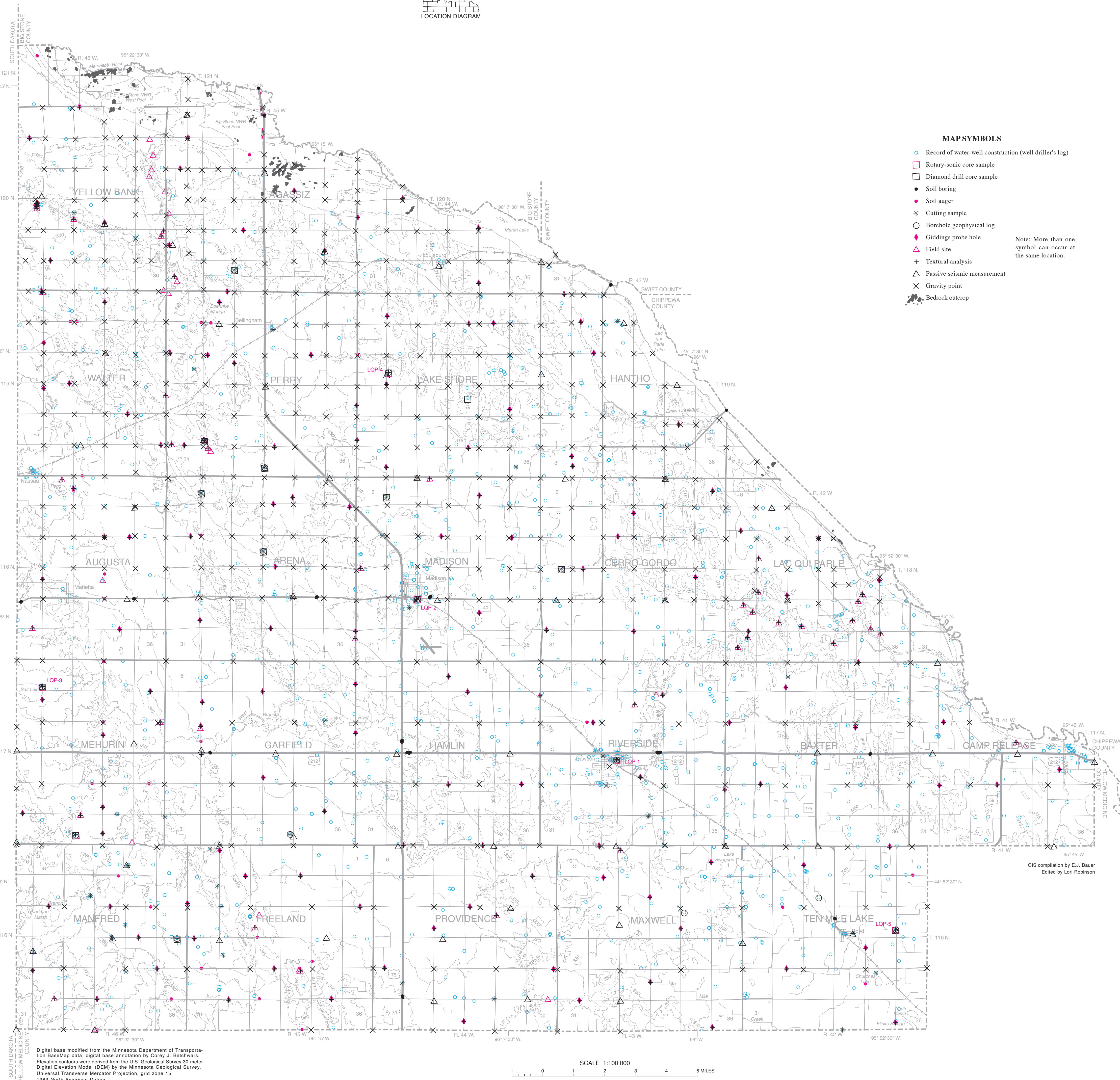


DATABASE MAP

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- ### MAPSYMBOLS
- Record of water-well construction (well driller's log)
 - Rotary-sonic core sample
 - ◇ Diamond drill core sample
 - Soil boring
 - Soil auger
 - ✱ Cutting sample
 - Borehole geophysical log
 - △ Giddings probe hole
 - ▲ Field site
 - ▲ Textural analysis
 - ▲ Passive seismic measurement
 - ▲ Gravity point
 - ▲ Bedrock outcrop
- Note: More than one symbol can occur at the same location.

INTRODUCTION

The public health and economic development of Lac qui Parle 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 in 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 the types of data described on this plate were interpreted by geologists or hydrologists to make them meaningful for mapping purposes. The 1:100,000 scale of the maps in this atlas was chosen because it shows the geologic and topographic details of the county while keeping the physical size of each place 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 Lac qui Parle 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 or lack of water. 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 Lac qui Parle County; about 1,250 logs were used for this atlas.

Core samples were collected at various sites throughout Lac qui Parle County as a means to establish the nature of the subsurface material. Rotary-sonic coring is a technique that enables recovery of a continuous core, 3.5 inches (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. The Minnesota Geologic Survey's 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. Prior to this atlas, the Minnesota Geological Survey collected diamond drill core at 10 sites to determine the nature of the underlying bedrock. All core samples are eventually transferred to the Drill Core Library in Hibbing (the state repository for bedrock and other material core samples collected during minerals exploration, engineering, and geoscience research programs across Minnesota) and maintained by the Minnesota Department of Natural Resources.

Cuttings samples collected during drilling and exploration provide physical evidence of subsurface geologic materials. Cuttings are the samples generated by the drill bit cuts through the subsurface material and are used to interpret and verify driller's logs. They are logged and stored at the Minnesota Geological Survey. There are 41 cuttings samples that were used in the preparation of these maps.

Borehole geophysical logs are collected by Minnesota Geological Survey staff, other government agencies, or private enterprises 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 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://mnsu.edu/borehole_logs). 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 4 feet (1.2 meters), at unit contacts, or where the geologist believed it was important.

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 grain size, penetration rate, moisture content, and color. Soil boring data collected by the Minnesota Department of Transportation is concentrated along U.S. Highways 73 and 212, and State Highway 40. Descriptions of the geologic materials penetrated are interpreted by Minnesota Geological Survey geologists for mapping purposes. The records may be accessed online at the Department of Transportation's web portal (<http://www.dot.state.mn.us/materials/foundations.html>).

Soil auger holes were drilled by the U.S. Geological Survey, Water Resources Division to determine the hydrologic properties of local and regional aquifers.

OTHER INFORMATION

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

Textural analyses express the proportion of sand-, silt-, and clay-sized particles that make up a sample. The Minnesota Geological Survey analyzed samples 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.

Passive seismic measurements provide information based on the analysis of ambient shear- and surface-wave energy in the ground that allow for a calculation of the depth to bedrock (thickness of Quaternary deposits) beneath that point. The measurements employ a seismic recording device that is planted into the ground surface and records ambient ground vibrations in three orthogonal directions (two horizontal and one vertical) during a 16-minute interval. The method is considered passive because no energy is directly input into the ground at the time of measurement, such as is the case for conventional seismic reflection/refraction surveys. Instead, the unit measures background vibrations from a variety of natural sources that include wind and anthropogenic noise like machinery and 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 (surface and shear waves) of the unconsolidated sequence overlying the bedrock surface (Chandler and Livy, 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 69 passive seismic points were collected in Lac qui Parle County for this atlas. The data are stored in Minnesota Geological Survey databases and are available upon request.

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. The aeromagnetic data surveys covering Lac qui Parle County were flown between 1983 and 1989 and were acquired 500 to 650 feet (152 to 198 meters) above ground along flight lines spaced 0.25 to 0.3 mile (0.4 to 0.5 kilometer) apart, and are 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 0.5 to 1 mile (0.8 to 1.6 kilometers) apart along roads and trails, and these data are compiled into a 3,281-foot (1,000-meter) grid.

Bedrock outcrops are exposures of solid rock at the land surface and can be found in the Minnesota River valley, and in the Lac qui Parle County. In addition to natural valley exposures like river or stream cuts, they may also be human-made excavations such as road cuts and quarries. 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 the data shown on the map were plotted on maps at 1:24,000 or finer resolution and assigned inventory numbers. Included with the Lac qui Parle 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 data bases 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 Lac qui Parle 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 developed by the Minnesota Land Management Information Center (LMIC). One computerized database developed for Lac qui Parle 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 Minnesota 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 within 3 feet (1 meter). The street address for each well is included whenever 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 in the original data files. The program also checks 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). They 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 their knowledge and understanding of the geology of Lac qui Parle 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 geochemistry data, 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 and soil auger holes 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 borings, such as the U.S. Geological Survey. Soil-boring data from the Minnesota Department of Transportation, Foundations Unit may be found on their web page (<http://www.dot.state.mn.us/materials/foundations.html>).

Lidar (light detection and ranging) is an optical remote-sensing technique that uses a sensor, pulsed laser light, and a GPS receiver to sample the Earth's surface and produce highly accurate land-surface information. Lidar data in the Minnesota River basin region were produced by the Minnesota Department of Natural Resources during a regional acquisition in 2010 and are available from the Minnesota Geospatial Commons website (<https://gisdata.mn.gov/dataset/lev-lidar-swmm2010>). Data quality for the Minnesota River basin region is reported at the 90-percent confidence level: a 1.0 foot (30 centimeters) for the horizontal direction and a 0.33 foot (10 centimeters) for the vertical direction. Lidar elevation data are used to map bedrock exposures and glacial landforms. They help mappers more accurately delineate contacts between geologic units in unconsolidated Quaternary sediments and bedrock units. Lidar can also help define the structure of a bedrock unit based on visible features such as fractures, faults, bedding, and weathering profile.

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 Lac qui Parle 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.

ACKNOWLEDGMENTS

The staff from the Lac qui Parle County Soil and Water Conservation District contributed greatly to the development of the County Well Index database. We thank local water-well contractors and landowners for their valuable assistance.

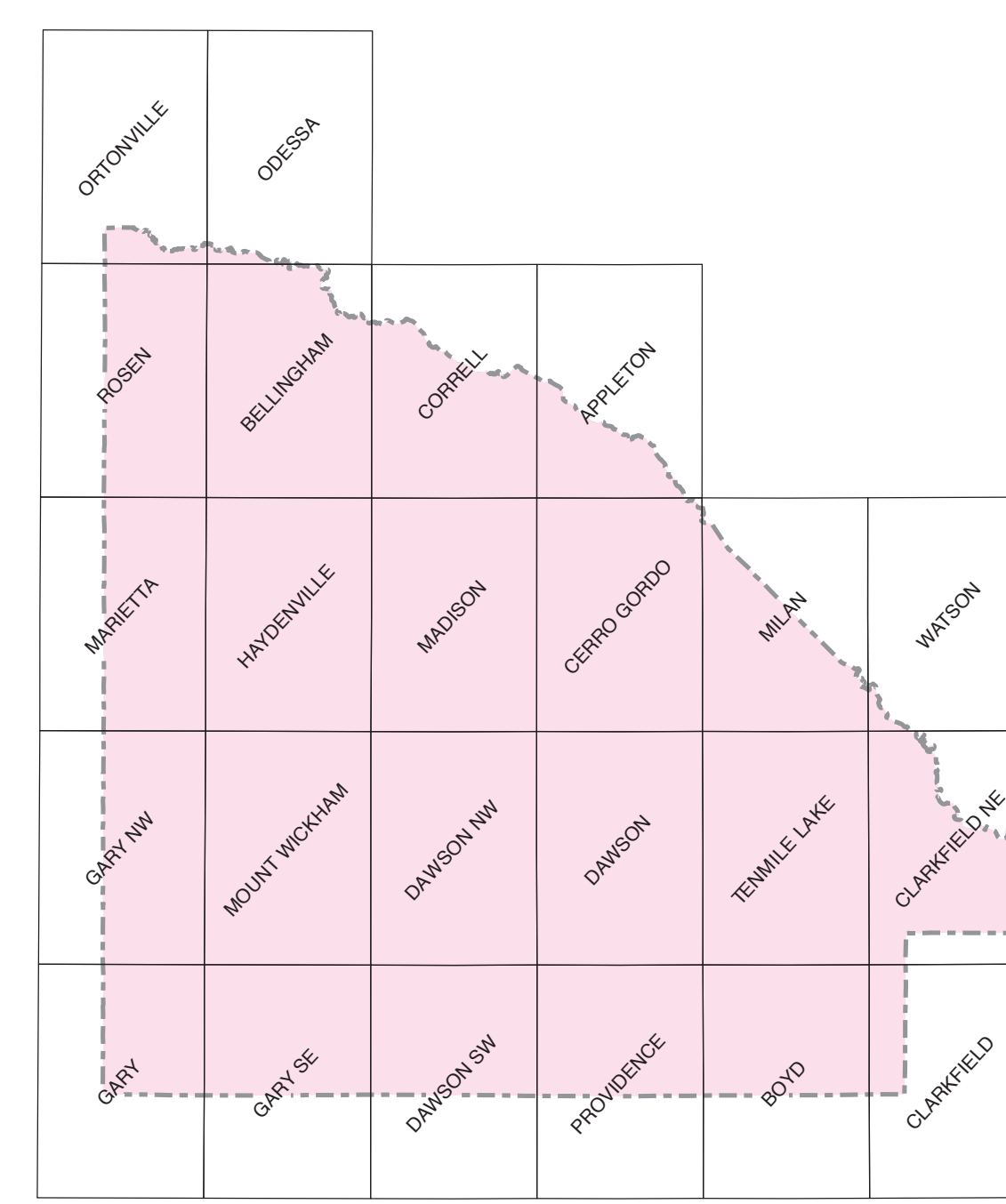
REFERENCE

Chandler, V.W., and Livy, 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 14-01.

| Unique Well Number | County | Lac Qui Parle | MINNESOTA DEPARTMENT OF HEALTH WELL AND BORING RECORD MINNESOTA STATUTES CHAPTER 193F | Entry Date | 1991/12/30 |
|---------------------------------------|---|---|---|---------------------|-----------------|
| 440363 | Lac Qui Parle | Quart 131D | WELL AND BORING RECORD MINNESOTA STATUTES CHAPTER 193F | Update Date | 2022/07/18 |
| Well Name | IND. SCH. DIST. 6011 | Section | 119 43 W 33 BCDACC | Field Located | MDH 1046.00 ft. |
| Township | 119 43 W 33 BCDACC | Subsection | 223 10 | Depth Completed | 209.50 ft. |
| Well and contact address | IND. SCH. DIST. 6011 602 2 BOX 60A MADISON MN 56256 | Drilling Method | Non-specified Rotary | Date Well Completed | 1999/10/27 |
| Drilling Fluid | Water | Well Hydrofractured? | <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No | | |
| Use | public supply/non-comm./non-transient | | | | |
| Casing Type | Steel (black or low-alloy steel) | Hydr. Seal | <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No | How Drilled (in.) | |
| Drill Bit | 1 1/2" Dia. 18 1/2" Length | Drill Bit | 18 1/2" Dia. 18 1/2" Length | | |
| Drill Bit | 6.00 in. from 0.00 to 189.50 in. | | | | |
| Description | Color | Hardness | From To (ft.) | | |
| CLAY | YELLOW | SFT-MED | 0 24 | | |
| CLAY | GRAY | SFT-MED | 24 110 | | |
| CLAY | GRAY | SFT-MED | 110 189 | | |
| SAND FINE | GRY-BLK | 187 203 | 203 209 | | |
| SAND MEDIUM-COARSE | GRY-BLK | 203 208 | 208 210 | | |
| BOULDER | HARD | 208 210 | 210 210 | | |
| CLAY | GRY-BLK | MED-HRD | 210 223 | | |
| Static Water Level | 63.40 | land surface | data measured | 1999/10/24 | |
| Pumping Level (below land surface) | 88.75 | in. after | 72.00 | hrs. pumping | 150.00 gal. m. |
| Without Completion | | | | | |
| Screen | Yes | Open Hole (ft.) | From | To | |
| Material | stainless steel | | | | |
| Grouting Information | Well grouted? | <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | not specified | | |
| Mixture | neat cement | From | 0.00 | to | 180.00 ft. |
| Nearest Known Source of Contamination | | | | | |
| Well Contractor Certification | Ervin Well Co. | 65252 | | | |
| License Business Name | Ervin, B. | | | | |
| License No. | 65252 | | | | |
| Driller | Ervin, B. | | | | |
| Date | 10/27/99 | | | | |

| Unique Well Number | County | Lac Qui Parle | MINNESOTA DEPARTMENT OF HEALTH WELL AND BORING RECORD MINNESOTA STATUTES CHAPTER 193F | Entry Date | 1991/12/30 |
|--------------------------|---|----------------------|---|--------------------------------|-------------------------|
| 440363 | Lac Qui Parle | Quart 131D | WELL AND BORING RECORD MINNESOTA STATUTES CHAPTER 193F | Update Date | 2022/07/18 |
| Well Name | IND. SCH. DIST. 6011 | Section | 119 43 W 33 BCDACC | Field Located | MDH 1046.00 ft. |
| Township | 119 43 W 33 BCDACC | Subsection | 223 10 | Depth Completed | 209.50 ft. |
| Well and contact address | IND. SCH. DIST. 6011 602 2 BOX 60A MADISON MN 56256 | Drilling Method | Non-specified Rotary | Date Well Completed | 1999/10/27 |
| Drilling Fluid | Water | Well Hydrofractured? | <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No | | |
| Use | public supply/non-comm./non-transient | | | | |
| Casing Type | Steel (black or low-alloy steel) | Hydr. Seal | <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No | How Drilled (in.) | |
| Drill Bit | 1 1/2" Dia. 18 1/2" Length | Drill Bit | 18 1/2" Dia. 18 1/2" Length | | |
| Drill Bit | 6.00 in. from 0.00 to 189.50 in. | | | | |
| Description | Color | Hardness | From To (ft.) | Stratigraphy | Primary Secondary Minor |
| CLAY | YELLOW | SFT-MED | 0 24 | clay yellow | clay |
| CLAY | GRAY | SFT-MED | 24 110 | clay gray | clay |
| CLAY | GRAY | SFT-MED | 110 187 | clay gray | clay |
| SAND FINE | GRY-BLK | 187 203 | 203 209 | sand | |
| SAND MEDIUM-COARSE | GRY-BLK | 203 208 | 208 210 | sand | |
| BOULDER | HARD | 208 210 | 210 210 | boulder or boulders | |
| CLAY | GRY-BLK | MED-HRD | 210 223 | weathering residuum ungl. cap. | ngolith |

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 and nearby data points control the geologist's interpretation, which may not match the driller's description of the geologic material encountered.



INDEX TO 7.5-MINUTE QUADRANGLES



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 references listed here and information on file at the office of the Minnesota Geological Survey in St. Paul. In addition, efforts have been made to ensure that the interpretation conforms to sound geologic and cartographic principles. No claim is made that the interpretation shown is optimally correct; however, it should not be used to guide engineering-type decisions without site-specific verification.