TECHNICAL REPORT

Surficial Geology of the Dowagiac 7.5 Minute Quadrangle, Cass County, Michigan

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Abstract

Surficial geologic mapping of the Dowagiac 7.5 Minute Quadrangle, located in Cass County, Michigan was completed by the Michigan Geological Survey. The map area is located in complex interlobate deposits of the Lake Michigan and Saginaw Lobes of the Laurentide Ice Sheet.

Major glacial geological features mapped in the quad are the prominent landforms of a glacio lucustrian scarp in the center of the quad and a north-south trending ice margin along the east side and a large northwest-southeast trending tunnel valley in the NE quarter of the quad formed when the area was covered by the Lake Michigan Lobe.

Recommended Citation

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Acknowledgements

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The Edward Lowe Foundation and the City of Dowagiac

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Introduction

In Oct. 2011, the Michigan State Legislature transferred responsibility for applied geological research and geological mapping within the state to the Michigan Geological Survey (MGS), which was created by this act within the Geosciences Dept. at Western Michigan University. The Geological Survey Division of the Michigan Dept. of Environmental Quality (MDEQ), which previously conducted geologic mapping, was renamed the Office of Oil, Gas, and Minerals.

This quadrangle was part of a larger project initiated by MGS in Cass County under the USGS STATEMAP program and Great Lakes Geologic Mapping Coalition, composed of eight state geological surveys and USGS and this product was produced through the National Cooperative Geologic Mapping Program, STATEMAP.

Location and Geologic Setting

The Dowagiac Quadrangle, which was mapped as part of the larger Cass County project area, is underlain by unconsolidated deposits of glacial and post-glacial origin from the Lake Michigan Lobe (Leverett and Taylor 1915) of the Laurentide Ice Sheet, Kehew et. al. Kehew et al. (2005) discuss the dynamics of the Lake Michigan Lobe. The sediments include diamicton (till), sand and gravel and interbedded silt and clay. Till is a characteristic type of glacial deposit that is unsorted and has a range of grain sizes from clay to boulders.

Diamicton, where present, is mapped as Qdlm. The relief of the areas mapped as Qdlm is moderate to high and it is likely that stagnant, debris-covered ice was present throughout much of the area at the time of deposition. The diamicton is not uniform in thickness and does not cover the entire mapped area. Sand and gravel, also deposited on the stagnant ice (Qsg2) appears to be fairly common in areas mapped as Qdlm, and vice versa.

The glacial deposits are late Wisconsinan (~30,000 to ~15,000 yr Before Present) in age, although some deeply buried deposits may be middle Wisconsinan or older (Winters and Rieck 1982). Borings CAS-18-01 encountered sands and finer sediments of lacustrine origin overlying very coarse gravels, and CAS-18-02 encountered a thick diamicton (>60') then a thick (>75) sequence of sand and gravel just above bedrock. The total thickness of glacial deposits typically ranges between 50 and 500 ft. (15-150 m) in Cass County.

Purpose and Justification

The mission of the National Cooperative Geologic Mapping Program (NCGMP) includes mapping the surficial geology in the high priority areas of Michigan and the adjoining glacial states. This project is within one of the Michigan high priority areas. This task fulfills the mapping priorities of the NCGMP by providing these previously unavailable detailed surficial geologic map products to the public within these priority areas and it will deliver scientific information in formats readily usable by public policymakers. It also supports sustainable development of resources and understanding of environmental issues. Cass County includes portions of the Kalamazoo Moraine

of the Lake Michigan Lobe in the western part of the county transitioning to the east into Saginaw Lobe terrain. Detailed mapping began in 2015 in this area and will incorporate subsurface information from drilling and review of subsurface data in developing a projected 3D mapping network. This project will also contribute to the effort to develop a Quaternary stratigraphic framework for the Lake Michigan and Saginaw Lobes.

Cass County lies just south and east of I-94, the major interstate connecting Chicago and Detroit. This project fits well with Michigan's long-range plan of mapping around development corridors and to consolidate areas where mapping has already been done. Berrien County to the west has been mapped by the U.S.G.S. and St. Joseph and Van Buren Counties to the east and north, respectively, have been mapped by the Michigan Geological Survey.

One of the most pressing and significant scientific problems in Michigan is management of groundwater resources using the Michigan Water Withdrawal Assessment Tool (MI-WWAT). Every new high capacity well (>70 gal per min) must be permitted using this tool, which is based on modeling of stream flow response from water withdrawals from aquifers connected to streams and aquatic ecosystems. Wells that are predicted to produce an adverse response by the tool then must proceed to and pass the site specific review (SSR) process, in which owners must submit site specific drilling and hydrogeologic data. For areas utilizing aquifers in glacial deposits, the SSR currently uses the statewide Quaternary geology map (Ferrand, 1982), which is highly generalized and outdated. Detailed surficial geologic maps and more accurate subsurface data (relative to water well logs which are currently used) are urgently needed. These maps make a huge contribution to the accuracy of the MI-WWAT process where they are available. Cass County is located in the southwest part of the state, in which the demand for new irrigation wells is the highest in the state.

There are several objectives to this project in sequential order, namely:

- To produce surficial geological maps in a high priority area having complex geology with little available public domain surficial and subsurface geological data and incorporate this data into a 3D format for a more comprehensive understanding of the geologic setting.

- Make these maps available to the geological community, groundwater management staff of MDEQ, engineering firms, aggregate industry, water supply industry, researchers, teachers, and to the public.

- To complete the detailed mapping in Cass County.

- To map the interlobate area between the Lake Michigan and Saginaw Lobes. New subsurface data will be used for correlation with deep boreholes in Saginaw Lobe deposits in Barry County to the north and in Kalamazoo and St. Joseph Counties to the northeast and east, respectively. The Lake Michigan Lobe portion of the county will be correlated with borings in Van Buren County to the north. The ultimate goal is to develop a regional

stratigraphic framework for the Wisconsinan deposits of both lobes, which can be tested against future borings.

•To delineate the occurrence and stratigraphy of aquifers and sand and gravel deposits, the abundance of which are not known in this and adjoining quads. This project will provide support for the proposed aquifer study and modeling project being implemented by a coalition composed of MDEQ and private Cass County entities.

Methods and Personnel

Surficial geologic maps are produced by field investigation of surficial materials observed in natural exposures, road and stream cuts, building and construction excavations, shallow hand-augered borings, and small pits dug by the investigators. Depth of the majority of the investigation is generally around 6 feet except in areas of greater exposure like deep road cuts and gravel pits. In addition, aerial photographs, topographic maps, digital elevation models (DEMs), county soil surveys, existing geologic maps, reports, and the geologic literature for the area are reviewed. Farmers often provided valuable insight into the soils in the area. LiDAR data, which include high-resolution elevations of the land surface, are now available for Cass County and were used to create DEMs. The recently produced LiDAR data was a critical tool to allow interpretation of subtle features like ice-walled lake plains, ice-marginal positions and lacustrine/fluvial scarps. Without the LiDAR data many of these features would not have been recognized. Subsurface information concerning the thickness, extent, and stratigraphic position of surficial geologic units was obtained to the extent possible by reviewing and validating digital well log data from the MDEQ Wellogic and historical scanned water-well log databases.

Test borings using the rotary wireline coring methods were then drilled as part of this mapping project and are plotted on the maps. The glacial sediments cored in the two holes during this program exhibited a poorer core recovery, a result of a greater percentage of sand and gravel with lesser amounts of clay and fine material to support the recovery of core. As a result, there were minimal samples available this year to do a complete grain size analysis to correlate the interpretation of the glacial stratum. Those remaining core and sample residuals are archived at the MGRRE facility at the Michigan Geological Survey. High quality borings are essential to understanding and correlating the subsurface glacial deposits and developing a 3D mapping data set. Gamma-ray logs are made of the borehole at the time of drilling. This method involves measurement of the natural gamma ray content of surficial materials detected as a probe is lowered down and up the borehole within the drill pipe. Clays and other fine-grained materials emit more gamma radiation than sands and gravels and the gamma ray log is compared to the cores for interpretation of the contacts between different types of strata. Geologic cross-sections are created from the digital water well data and at least one representative cross-section is shown on each map. For mapping projects in areas of thick glacial drift, logs from oil and gas test wells are reviewed.

A Tromino passive seismic instrument was used at 68 locations and 21 Oil and Gas wells were combined for a total of 89 data points within the Dowagiac quad boundary to determine the depth

to bedrock and the bedrock topography. The Tromino technique uses the horizontal-to-vertical spectral ratio (HVSR) method to record ambient seismic noise with 3-component geophones (Lane, et al., 2008). Bedrock topographic maps are a subset of the mapping when using Tromino geophysical data, a Passive Seismic (Horizontal/Vertical Spectral Ratio – HVSR) meter. This data is now being collected and used to present a greater understanding of the depth to bedrock and the topography on that bedrock surface. This information can assist in developing a better understanding of groundwater models and the use of 3D maps can present a greater understanding of the subsurface geology. This indirect mapping does not replace drill holes and logging water well cuttings but can greatly assist the selection of drill holes to capture the greatest thickness of the glacial sequence. This mapping product also is used to map for possible bedrock valleys below the glacial sediments, potential sources of untapped groundwater resources. These derivative maps are then available for others to assist their mapping of subsurface resources.

Primary field mapping of the Dowagiac Quad was done by Alan Kehew with support from John Esch (contract mapper) and John Yellich with the drilling, data compilation and review. GIS input was directed by Ms. Guzalay Sataer.

Results Dowagiac 7.5 Minute Quad

The elevation ranges from 920 to 760 above mean sea level (AMSL).The quad contains an ice-marginal position of the Lake Michigan Lobe along the eastern boundary. Near Cassopolis, a large kame lies along this boundary. To the east of this margin, large fans of outwash sand and gravel spread into adjacent quadrangles. The central part of the quad is mostly underlain by sand and gravel with low- (QSG1) to high-(Qsg2) relief topography. A large tunnel valley extends from Dowagiac in the northwest to north of Cassopolis to the east. This valley was cut by subglacial meltwater and brought meltwater to the ice margin that fed large outwash fans to the east. Boring CAS-18-01 was sited within the valley on land owned by the Edward Lowe Foundation. The boring contained nearly 90 feet of lacustrine sands, silts, and clays, underlain by extremely coarse gravel. The lacustrine sediment was likely deposited as the roof of the ice tunnel collapsed downward into the tunnel valley, leaving a depression on the land surface which contained a lake or lakes for some period of time after ice retreat. In the extreme northwestern corner of the quadrangle, a well-defined scarp separates the higher ground in the center of the quad from the low-lying plain of glacial Lake Dowagiac, which formed between two uplands (Kalamazoo and Valparaiso moraines) of the Lake Michigan Lobe. Peat and muck (Qp) occur in lowlands throughout the quadrangle. The exact ages of the glacial deposits have not been determined in the study area but are correlated to dated features elsewhere. Some recent optically stimulated luminescence (OSL) dates suggest that the Kalamazoo Moraine of the Saginaw Lobe, which lies northeast of the Dowagiac Quadrangle, was probably formed about 19,000 years ago (Kehew and Esch, unpublished). Studies of tunnel valleys observed in the Saginaw Lobe (Kehew et al. 1999, 2005, 2013) northeast of Cass County indicate that the Saginaw and Lake Michigan Lobes were not synchronous in the timing of their advances and retreats. The orientation of tunnel valleys is generally perpendicular to the ice margin (Clayton et al. 1999). Kehew et al. (1999, 2005, 2013)

found morainal deposits and outwash fans within the Lake Michigan Lobe portion of the Kalamazoo Moraine that were deposited across northeast-southwest trending Saginaw Lobe tunnel valleys. This relationship indicates that the Saginaw Lobe tunnel valleys formed first and were filled with ice and debris during retreat of the lobe. The Lake Michigan Lobe then advanced over these buried tunnel valleys and deposited till and outwash. This advance would have terminated in the area of the Dowagiac Quadrangle. Two OSL dates from the Jones and Vandalia Quad, east of the Dowagiac Quad, suggest an age of about 19,000 years, similar to the Kalamazoo Moraine of the Saginaw Lobe.

Two deep borings with continuous wireline coring were drilled as part of this project and their logs are shown on the published map sheet and within this report. CAS-18-01 in the large tunnel valley described earlier and had a total depth of 310 feet. It contained a thick sequence (~175 ft) of mainly well sorted sands, silts and clays, partially of lacustrine origin. The lower part of the boring contained very coarse gravels with almost no core recovery. It reached bedrock of the Mississippian Coldwater Shale at a depth of 298 feet. The Coldwater Shale was weathered and greenish in color. Core hole 18-02 had a sand and gravel to 32 feet, then a an compact diamicton at 32-120 feet with interbedded coarse sand and gravel from 40 – 52 feet followed by the lower compact diamicton from 52-118. A thick interbedded sand, gravel (~80') having layers of lacustrine clay was encountered from 118 to bedrock Coldwater Shale at 198 feet and terminated at 210 feet. CAS-18-02 had a generally similar looking glacial stratigraphy within the glacio lacustrine sequence as CAS 18-01.

Conclusions

Dowagiac: Mapping of the Dowagiac 7.5 Minute quadrangle has provided additional new, detailed information on surficial landforms and deposits within the Lake Michigan and Saginaw Lobes in southern Michigan. This mapping project is part of a larger project to map Cass County. The map produced in this project will be of use for aggregates producers exploring for new deposits, planners, and hydrogeologists in MDEQ who must evaluate permits for high-capacity water wells that now require a permit and must be shown to not deplete streams in the area beyond an amount that will not affect fish populations.

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Associated Maps

Maps previously produced from STATEMAP project can be downloaded from the Michigan Geological Survey website.

Figures

Figure 1: Dowagiac Topographic Quadrangle

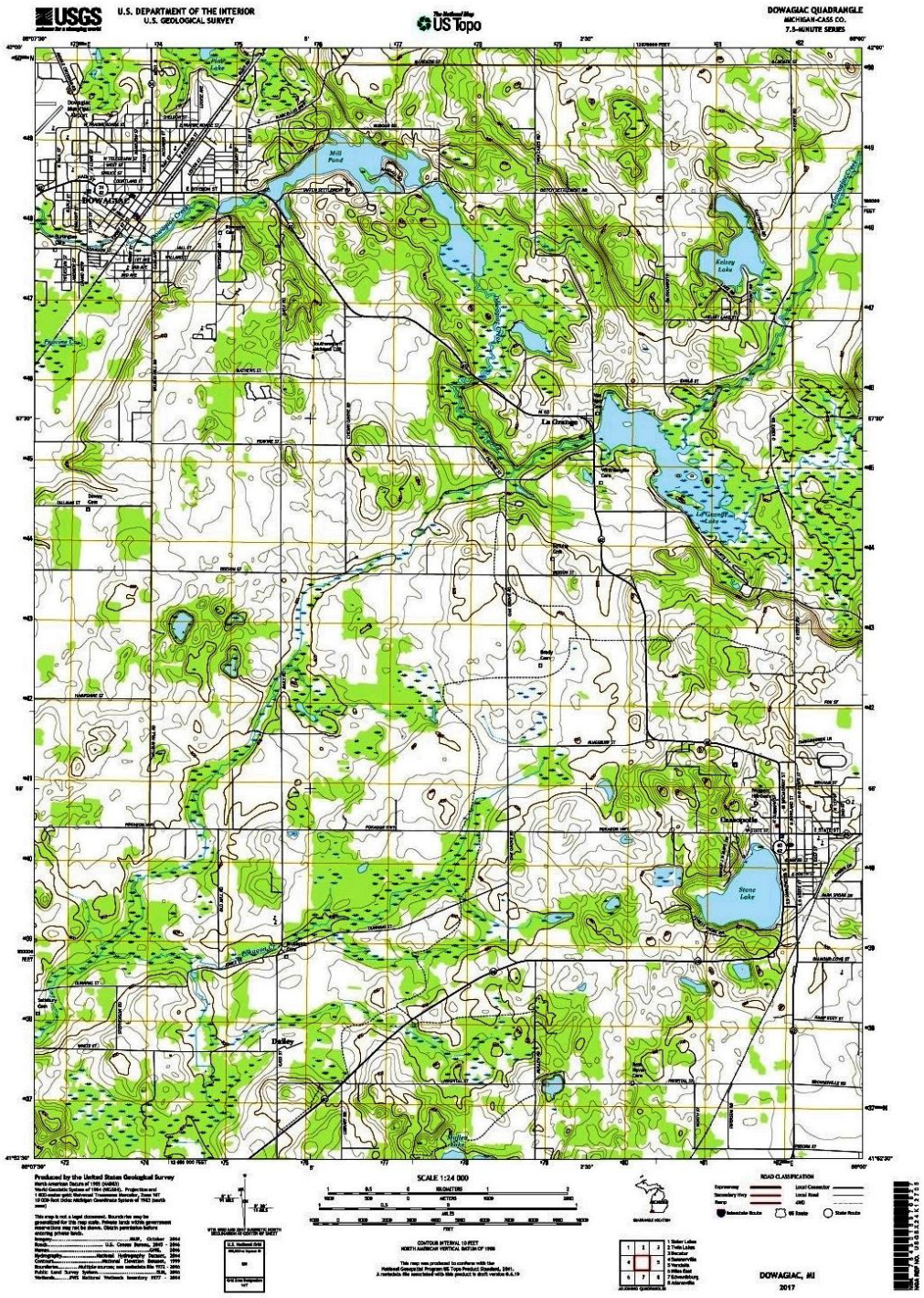


Figure 2: Dowagiac Quad LiDAR Shaded Relief

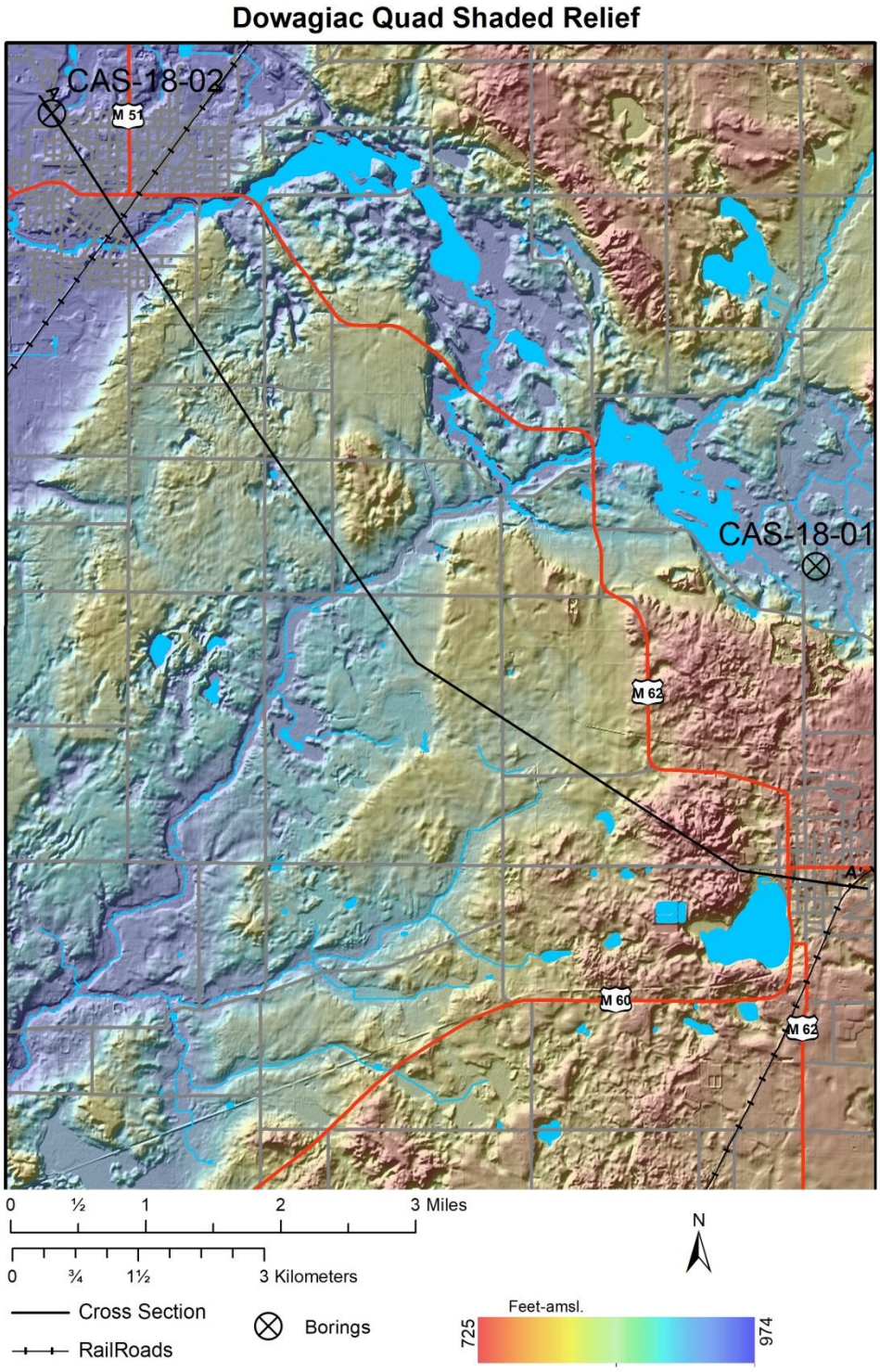


Figure 3: Dowagiac Quad Hillshade

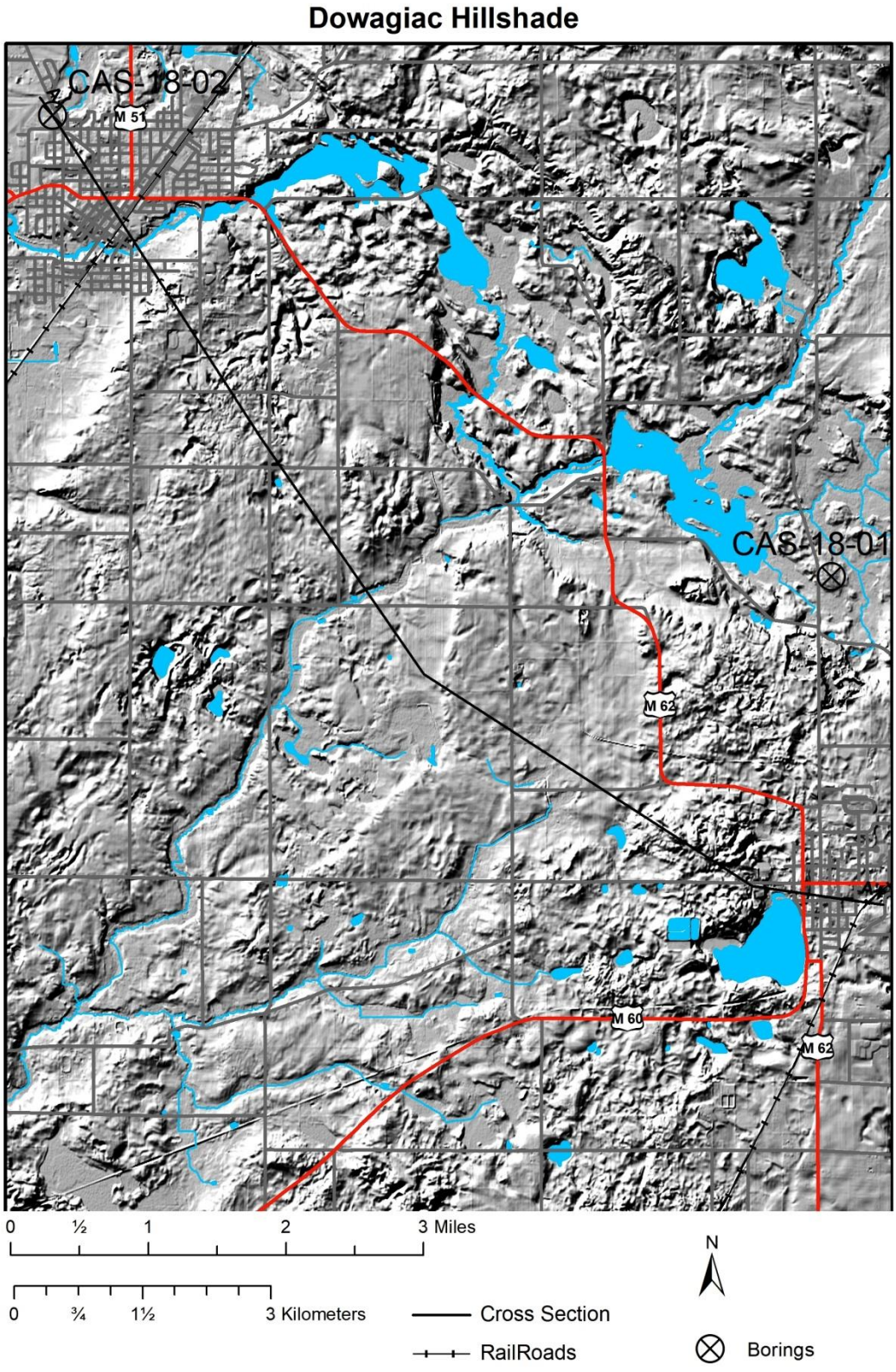


Figure 4: Dowagiac Quad Geologic Map

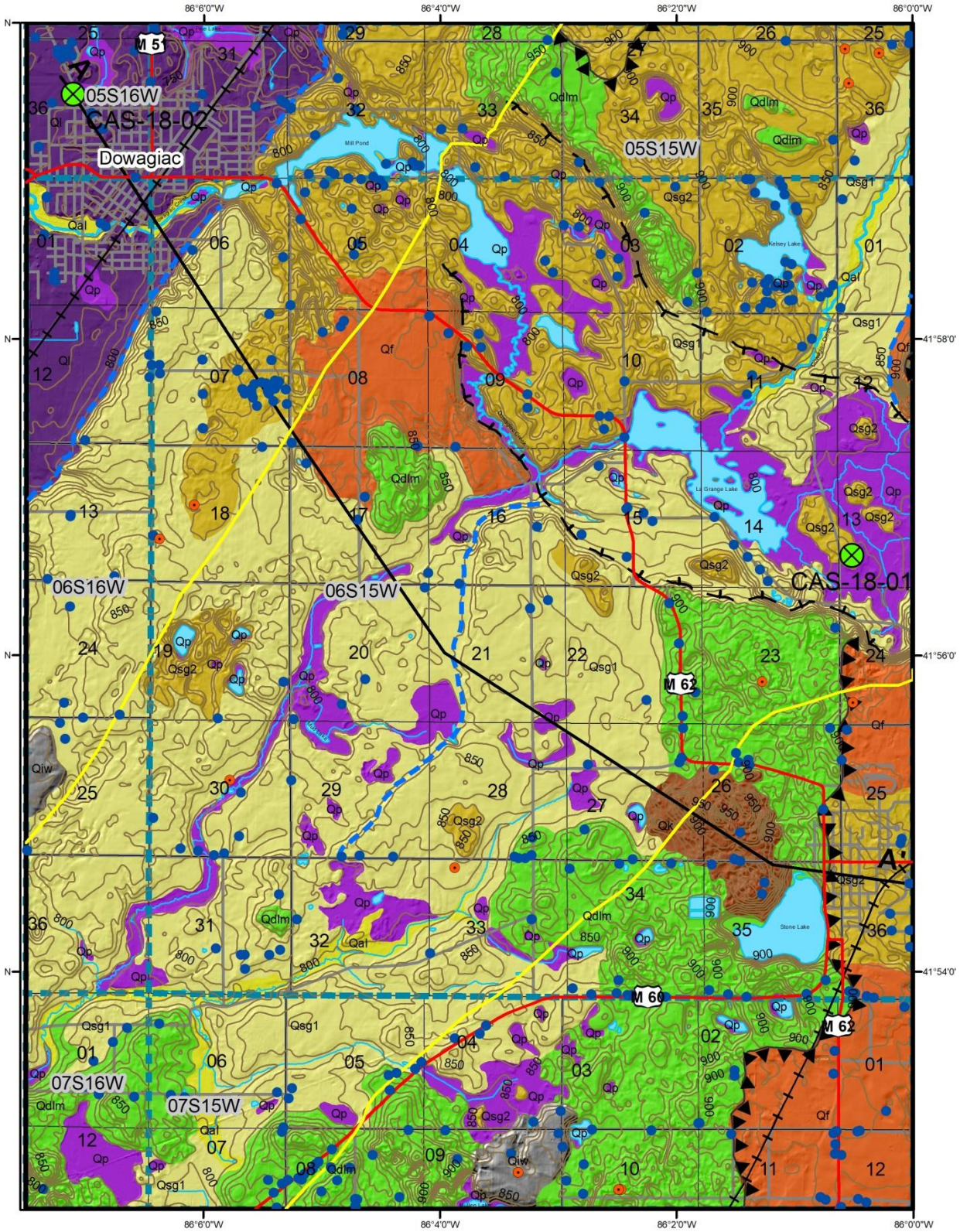


Figure 5: Dowagiac Quad Lakes, Muck (Qp), Shallow Water and Streams

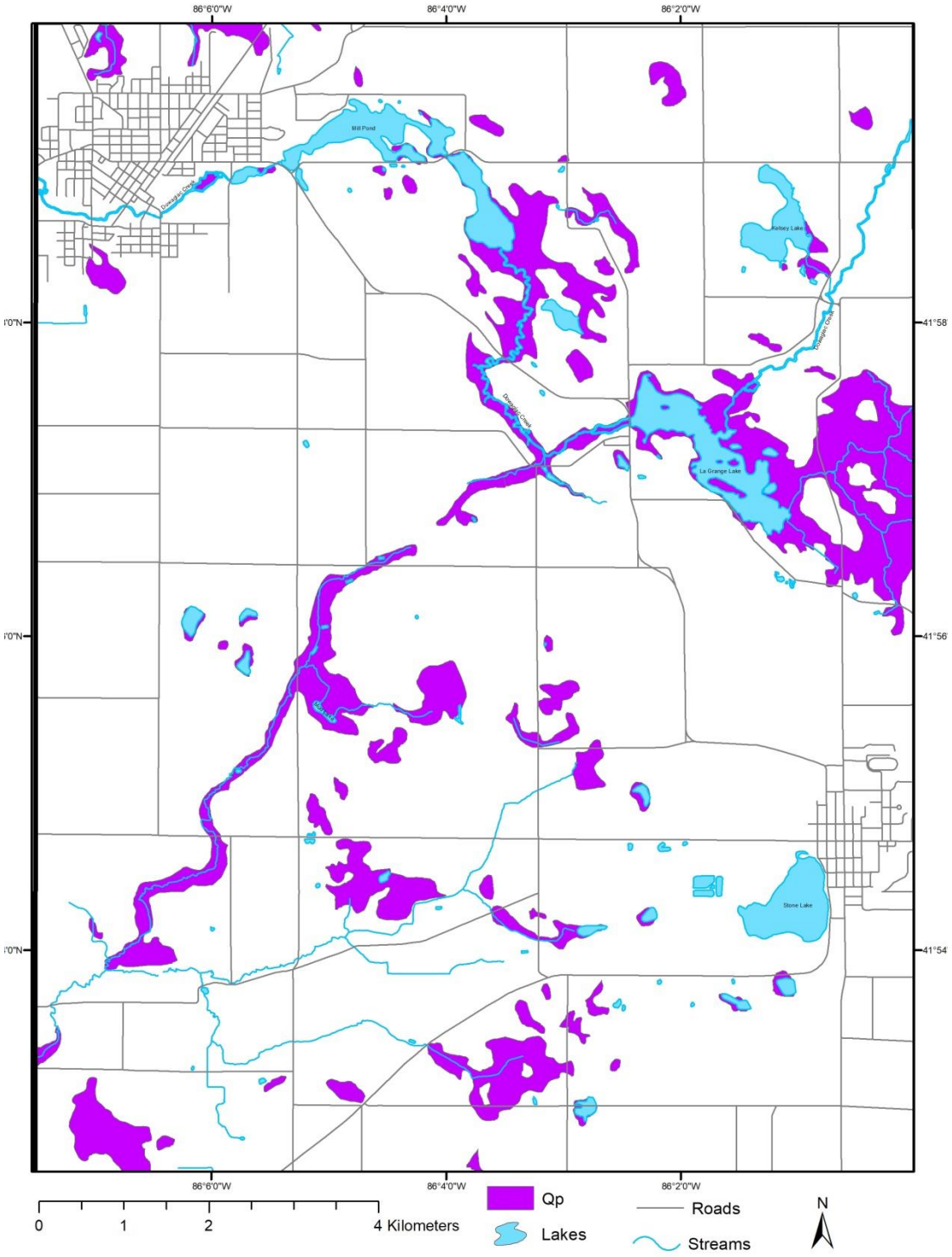


Figure 6: Dowagiac Quad Regional Water Table

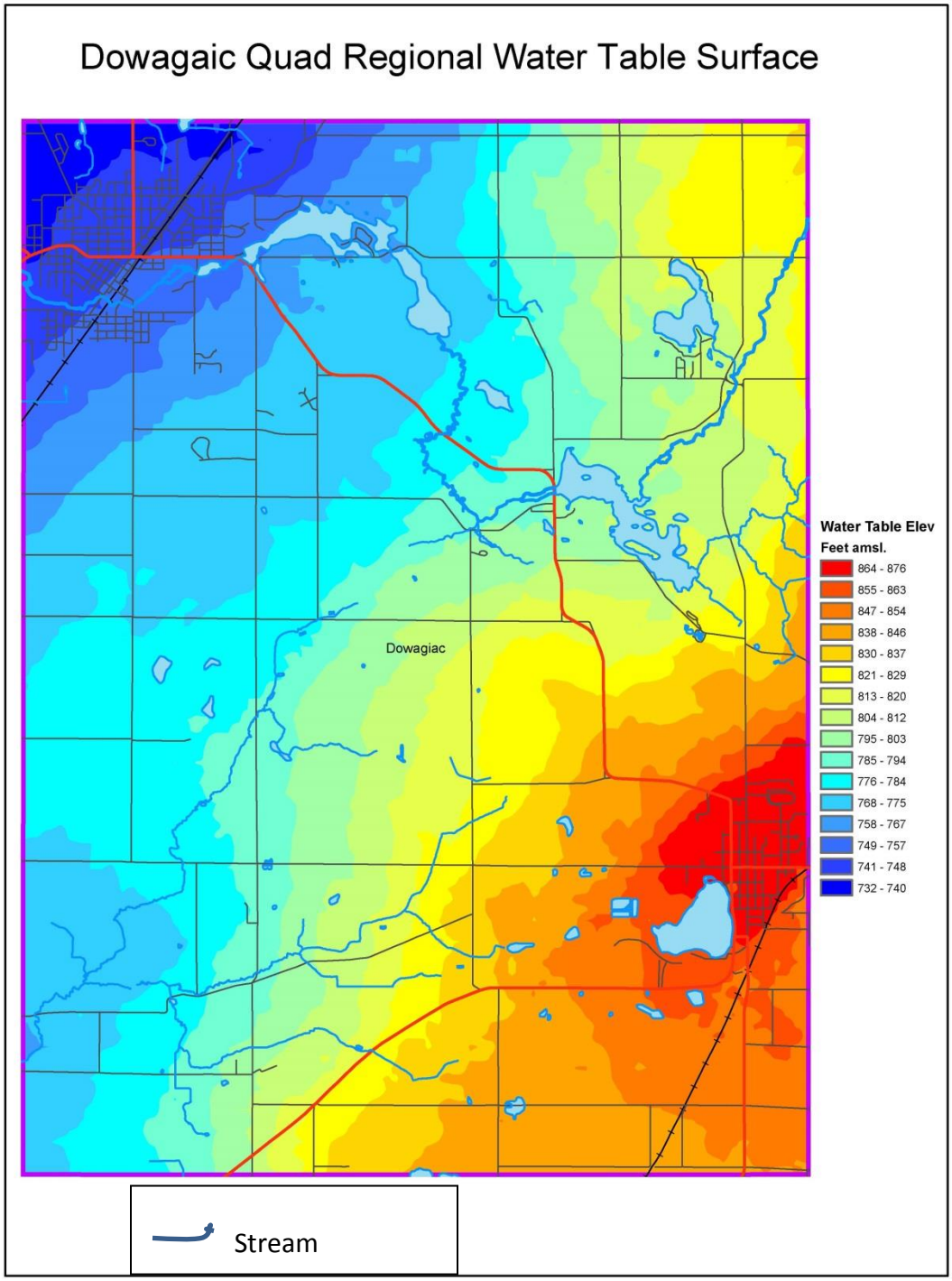


Figure 7: Wireline log and Gamma Log CAS 18-01 & 18-02

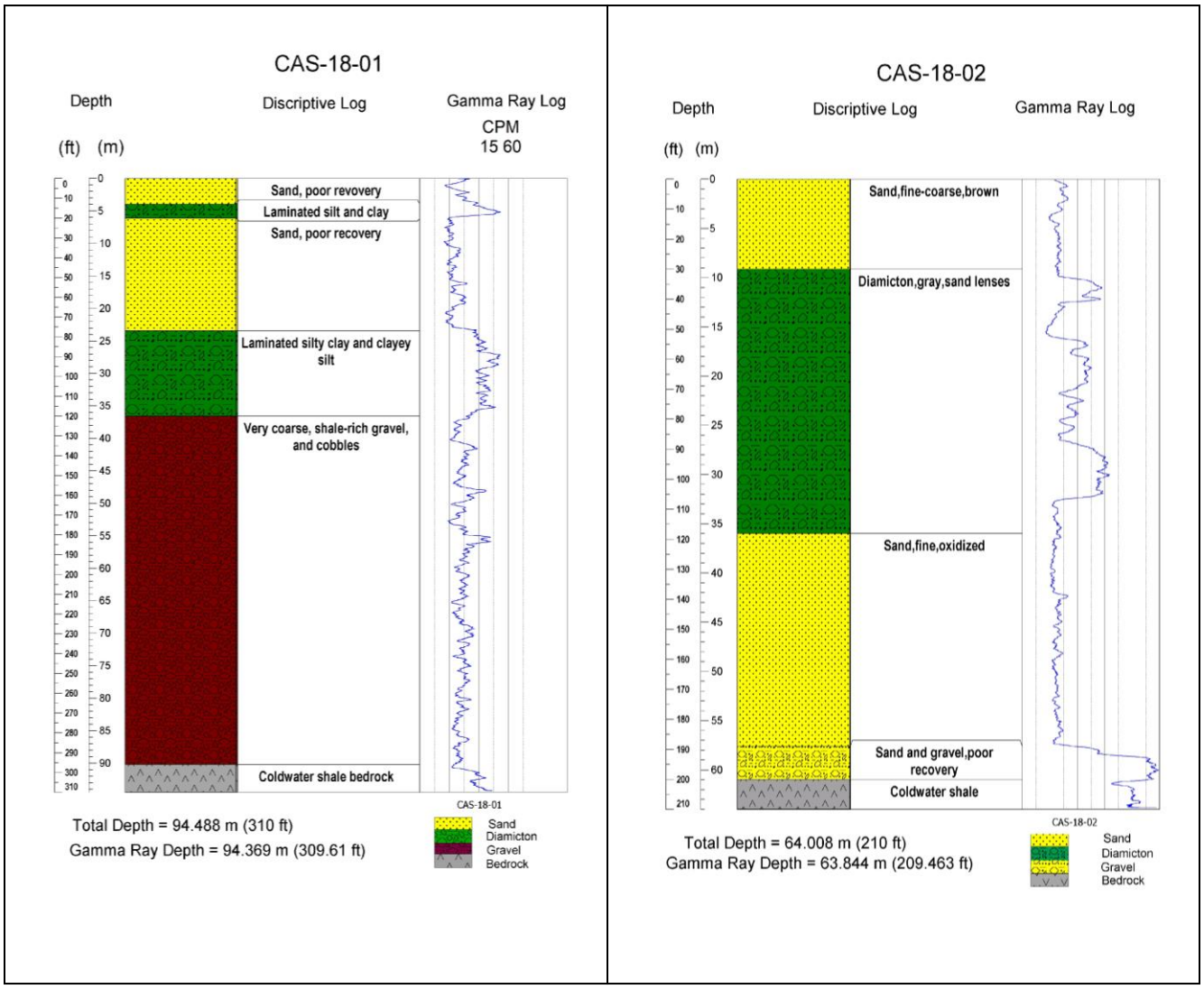


Figure 8: Drift Thickness, Dowagiac Quad

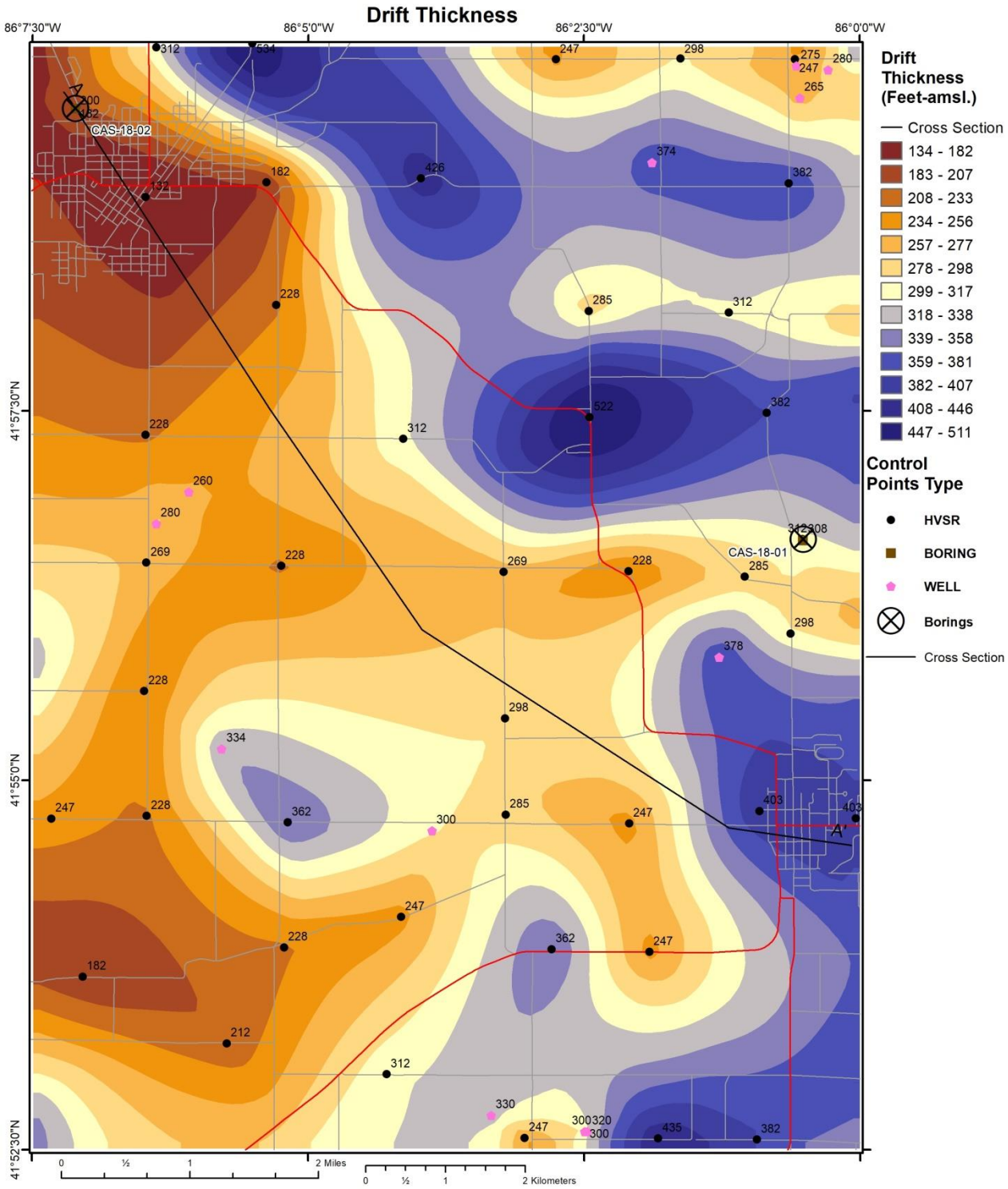
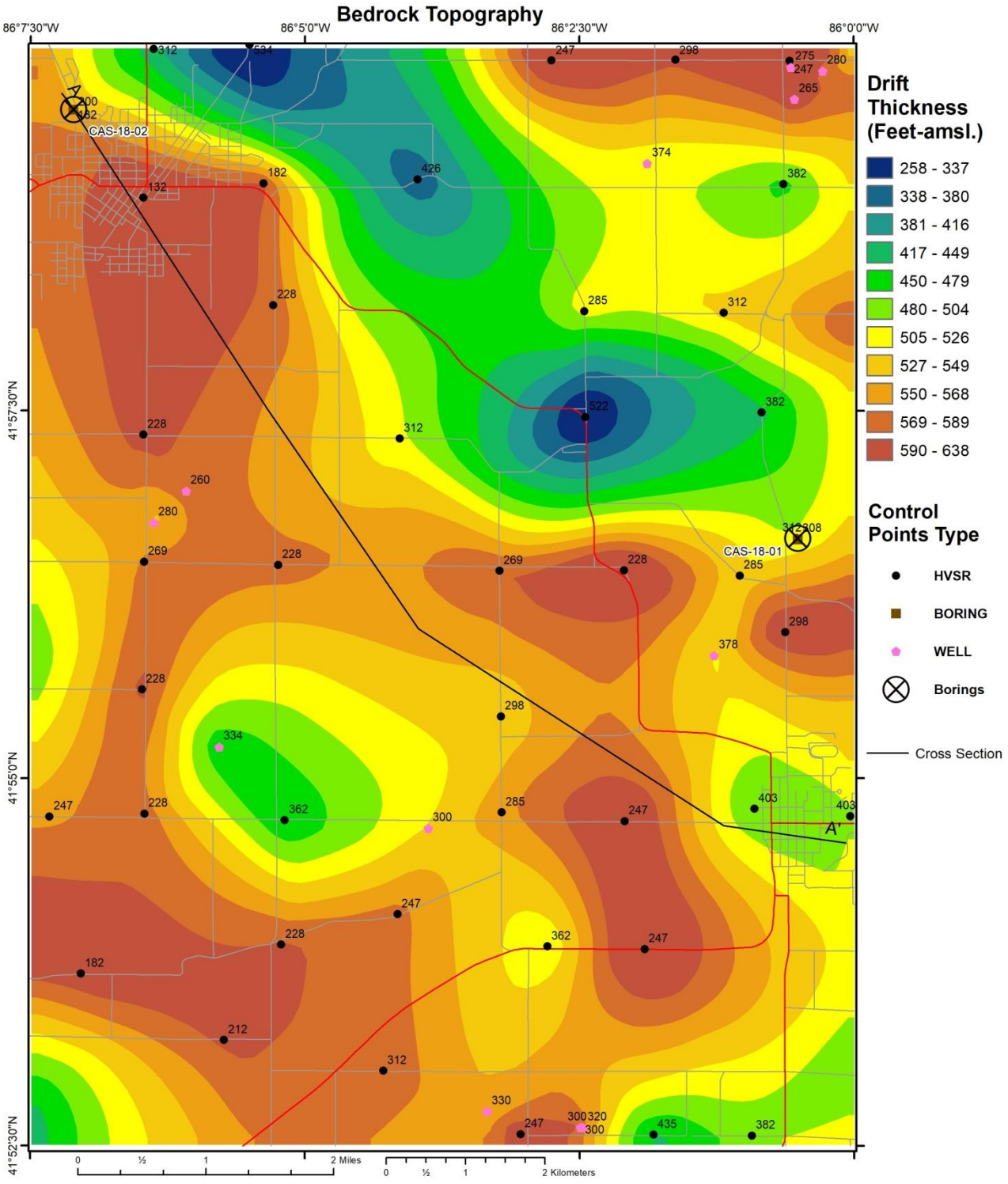


Figure 9: Bedrock Topography, Dowagiac Quad



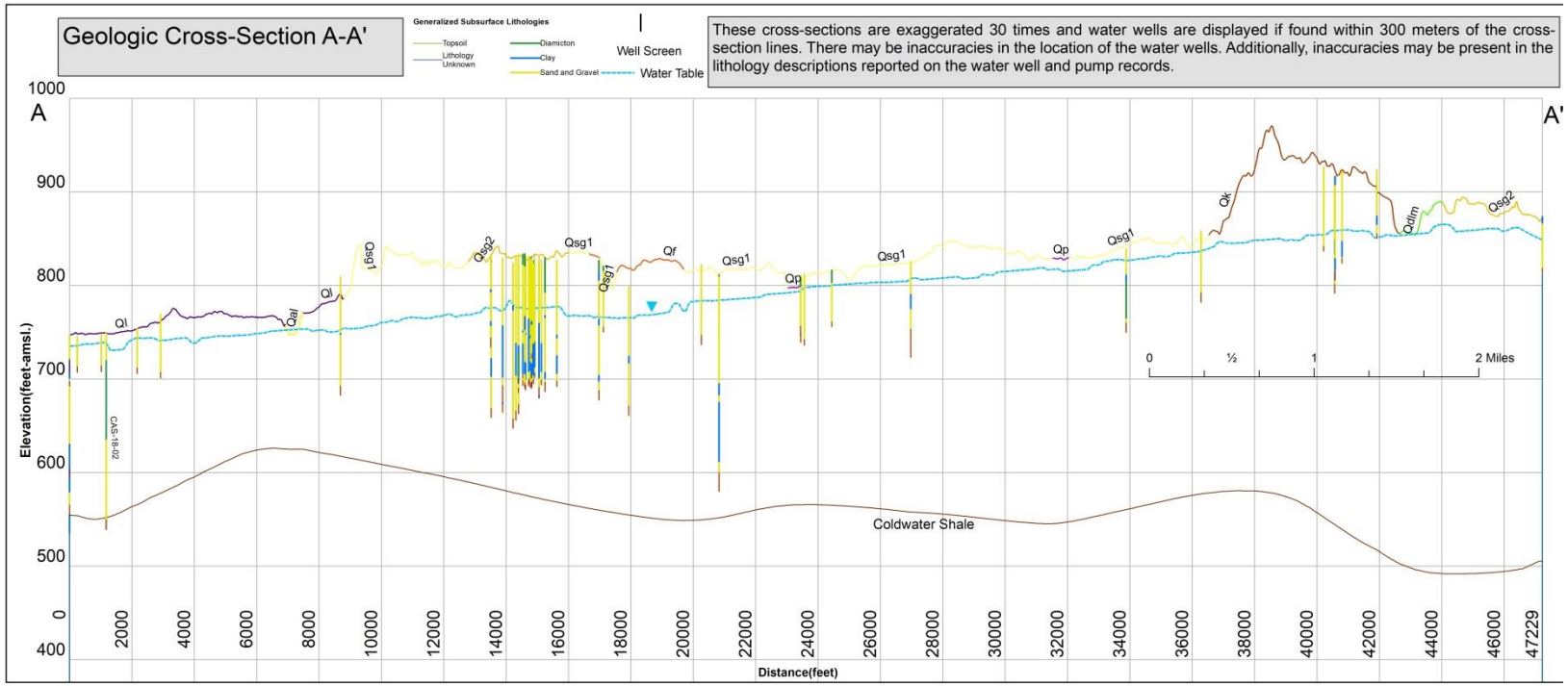


Figure 10: Dowagiac Quad Cross-Section

Northwest to Southeast A-A'