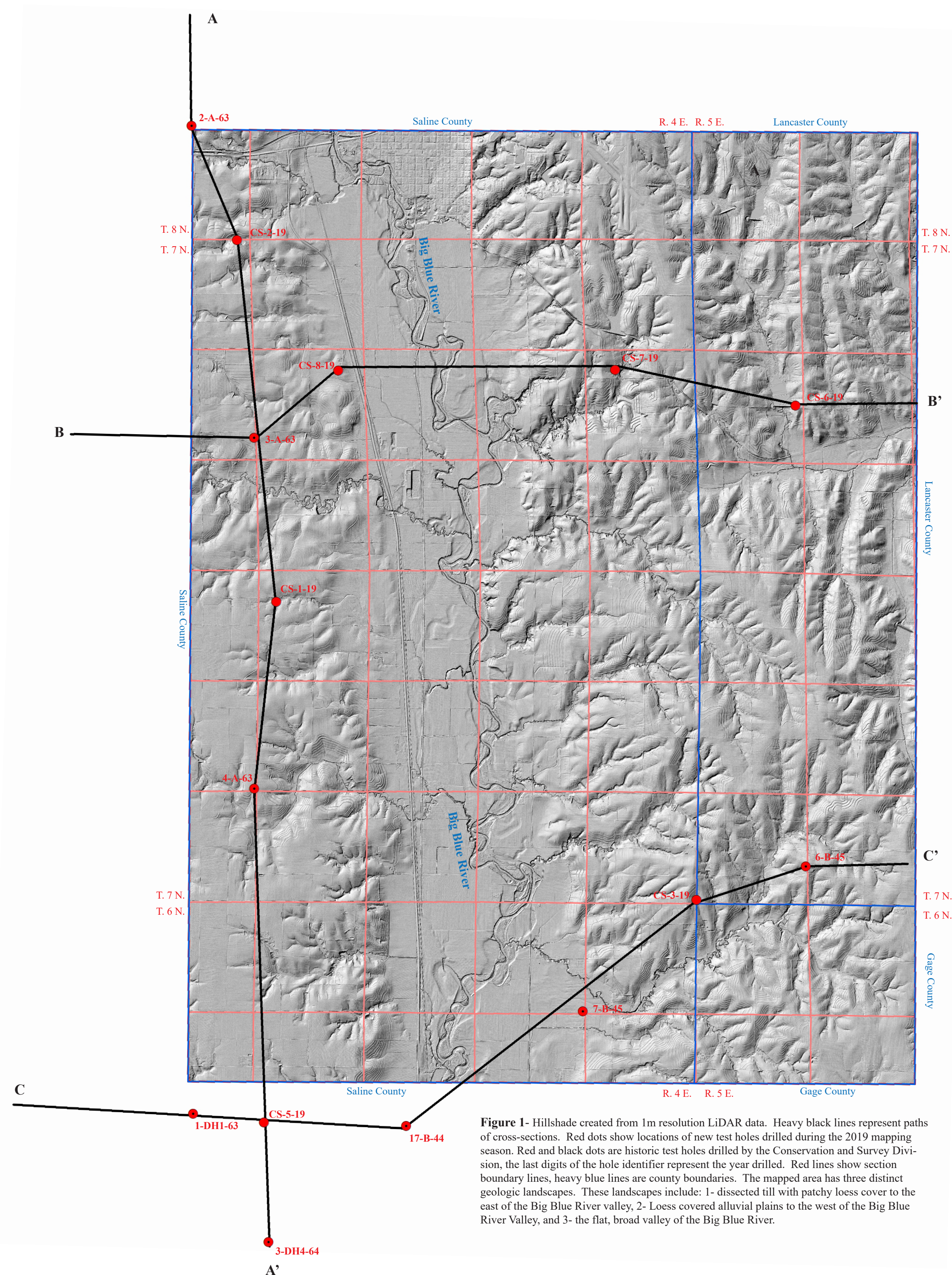


# Surficial Geology of the Crete South 7.5 Minute Quadrangle, Nebraska

A. R. Young, M. M. Waszgis, and L. M. Howard  
 Conservation and Survey Division (Nebraska Geological Survey)  
 Version 1.0, September 2019



**Figure 1-** Hillshade created from 1m resolution LiDAR data. Heavy black lines represent paths of cross-sections. Red dots show locations of new test holes drilled during the 2019 mapping season. Red and black dots are historic test holes drilled by the Conservation and Survey Division, the last digits of the hole identifier represent the year drilled. Red lines show section boundary lines, heavy blue lines are county boundaries. The mapped area has three distinct geologic landscapes. These landscapes include: 1- dissected till with patchy loess cover to the east of the Big Blue River valley, 2- Loess covered alluvial plains to the west of the Big Blue River Valley, and 3- the flat, broad valley of the Big Blue River.

## Geologic setting

The mapping area, located south of the City of Crete in southeast Nebraska (Fig. 1), has had a long and complex geologic history that has included glaciation, stream dissection, and multiple episodes of loess deposition. These events resulted in the accumulation of 100 or more meters of sediment that directly overlies Cretaceous bedrock. Subsequent modification of these sediments during the Pleistocene and Holocene have produced three distinct landscapes with unique features and available resources. The formation of each landscape is described by the following classifications: 1- dissected till, with patchy loess cover to the east of the Big Blue River Valley, 2- loess covered plains, west of the Big Blue River Valley, and 3- the flat, broad valley of the Big Blue River.

## The dissected till landscape

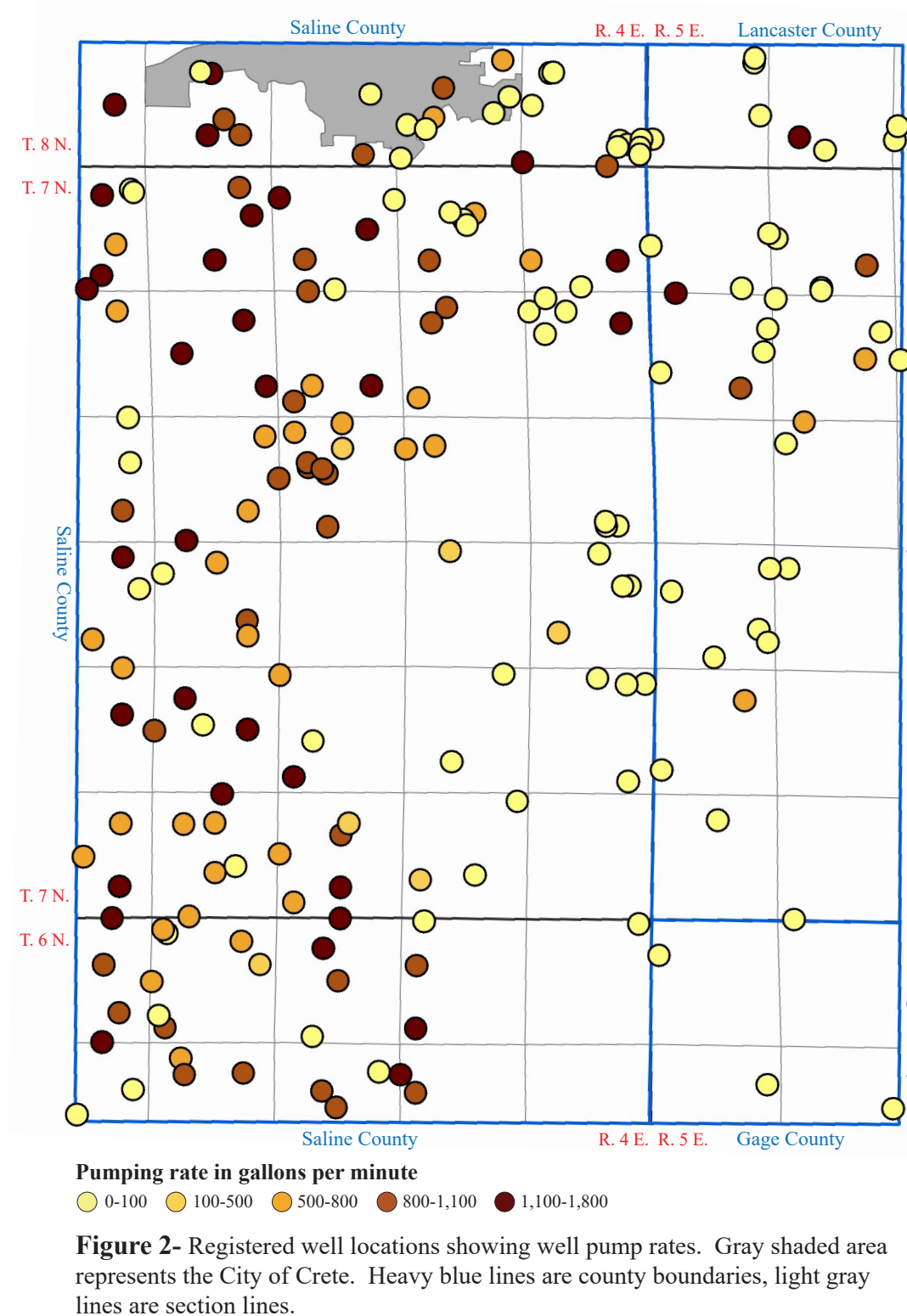
Southeast Nebraska was glaciated during the pre-Illinoian between ~2,000,000 and 600,000 years ago when much of eastern Nebraska was covered by glacial ice (Roy et al., 2004; Balco et al., 2005). As the glaciers receded, large quantities of poorly sorted glacial till were deposited. Locally, the till is blue to brown in color and dominated by clay; however, silt, sand, gravel, and boulders are often incorporated as well. Locally, sand lenses have been observed in the till and provide important sources of groundwater for some domestic wells (Cross Section C). In the Northeast portion of the Quad (Cross section B), glacial till was deposited over the pre-Pleistocene alluvial sands and gravels of the Dorchester-Sterling Paleovalley Aquifer (Divine, 2014). The aquifer is an important groundwater source in the area as the glacial sediments yield little groundwater. Till in the southeast part of the map is deposited directly on Cretaceous aged bedrock (Cross section C). Since the glaciers receded about 600,000 years ago, a dense network of smaller streams and tributaries have deeply dissected the till landscape, creating more than 30 meters of relief along some drainages. During the mid to late Pleistocene, the landscape was subsequently draped with multiple layers of windblown dust, known as the Loveland (Ql) and Peoria Loesses (Qp). Much of the loess deposited on steep slopes and valley walls has since been eroded away exposing the underlying glacial till (Qt). Land use in the dissected till landscape depends on local relief and availability of groundwater, but is generally pasture, irrigated or sub-irrigated row-crop agriculture. Small acreages and residences are increasing on this landscape as well.

## Loess covered alluvial plains

The portion of the Crete South quadrangle to the west of the Big Blue River is mapped as loess covered alluvial plains (see Fig. 1). This landscape was glaciated during pre-Illinoian times similar to the eastern dissected till landscape. Till and related glacial sediments in this region have largely been eroded by stream activity following glacial retreat, however thin (5-10 m) lenses of glacial till still occur at depth across the mapped area (Cross sections A, B and C). Alluvial fills with grain sizes ranging from silts and clays to coarse sands and gravels were subsequently deposited forming the loess covered alluvial plains and comprise the eastern-most portion of the High Plains Aquifer. The resulting alluvial sands and gravels locally approach 90 m in thickness, creating a productive and significant aquifer for the region. During the mid to late Pleistocene, the landscape was subsequently draped with Loveland (Ql) and Peoria Loess (Qp). Land use in the loess covered alluvial plains is predominantly irrigated row-crop agriculture.

## Big Blue River Valley

The Big Blue River Valley separates the loess covered alluvial plains in the west from the dissected till landscape in the east. The Big Blue River Valley formed during the latest Pleistocene, and the valley floor continues to be shaped through the Holocene. The upper portion of the alluvial fills within the valley are largely silts and clays sourced from a combination of silty loess and clayey glacial sediments (See Young et al., 2014, Geoprob 1 and 2). The lower portion of these fills (below 5-10 m depth) show coarse-grained alluvial sands and gravels (see cross sections B and C). Due to historical downstream river modifications, the Big Blue River has been entrenched in a narrow valley to a depth of approximately 4 m. Alluvial sediments deposited in the broad Big Blue River Valley are fertile and farmed extensively.



**Figure 2-** Registered well locations showing well pump rates. Gray shaded area represents the City of Crete. Heavy blue lines are county boundaries, light gray lines are section lines.

## Natural resources

### Soils

Soil fertility in the mapped area ranges from low to high. Deep Mollisols, which formed on the loess covered alluvial plains, tend to be well developed, thick and have high soil fertility. Similarly, alluvial soils deposited in the Big Blue River Valley tend to be silty, thick and fertile. The loess covered alluvial plains have low relief terrain, an abundance of shallow groundwater, and high soil fertility which makes the area prime cropland. Soils formed in the glacial till range from highly fertile Mollisols to thin less fertile Entisols. Soil fertility tends to be less on steep or eroded slopes where the upper most soil horizons are absent or thin. Although no glacial outwash was mapped on the Crete South Quad, small (less than 10 m diameter) patches of sandy glacial outwash are occasionally present in areas mapped as glacial till. Areas of glacial outwash are often identifiable in fields as areas with stunted crop growth. Groundwater for irrigation is difficult to obtain or is of poor quality in many areas mapped as glacial till. In addition, most irrigation techniques proves to be a challenging and inefficient due to the steep terrain. Land use in glacial till soils ranges from pasture to cropland.

Infiltration rates of soils throughout the mapping area are low, and are particularly low in areas mapped as Loveland Loess (Ql) or glacial till (Qt). Generally, soils in the Crete South Quad have infiltration rates greater than 60 minutes per inch, and are therefore not suitable for a standard septic system installation under Nebraska Title 124. Where soil infiltration rates are less than 60 minutes per inch, wastewater lagoons or other engineered systems must be used for onsite waste water disposal. Some locations have a seasonal high water table of less than 2 meters, which requires additional engineering for onsite waste water disposal systems. For those seeking to locate housing developments, purchase land for a rural residence, or plan other developments in the Crete South Quadrangle, performing percolation tests and ensuring proper lot sizing to accommodate such a system should be a primary concern.

### Sand and gravel

Although no active sand and gravel mining operations are known in the mapped area, historically there have been several small sand mining pits on the western slope of the Big Blue River Valley. No known outcrops of sand or gravel currently exist, and such sediments are generally covered by several meters of overburden and are saturated with groundwater. Due to the complexities of mining operations, sand and gravel resources in the mapped area have a limited economic importance.

## Groundwater Resources

Groundwater resources in the Crete South Quad range from abundant to nearly non-existent. Therefore, availability of groundwater should be a primary concern for those seeking to locate housing developments, or plan other developments in the Crete South Quadrangle. Although municipal water supply is available to residents near the City of Crete, most homes rely on a private well to supply water for household use, livestock, and irrigation. When considering land for purchase, it is advisable to drill a test hole(s) on the property to determine if groundwater is available and if the amount will be sufficient for the intended land use.

There are three sources of groundwater in the Crete South Quad: 1- Under the loess covered alluvial plains and the Big Blue River Valley, thick alluvial sands and gravels of the eastern edge of the High Plains Aquifer exist. These sands and gravels are capable of supporting high capacity wells. 2- Crossing the northern half of the map, coarse sand and gravel of the Dorchester-Sterling Paleovalley Aquifer are similarly capable of supporting high capacity irrigation wells. 3- In the dissected till landscape, fine to medium sands in glacial sediments yield small quantities of water for domestic purposes locally, but the locations and thicknesses of these sediments are difficult to predict. Wells screened in glacial sediments are generally located in the southeast portion of the Crete South Quad. These wells yield little water and may be susceptible to drought and over-pumping. A properly designed water storage and delivery system may help reduce water supply problems, but may add significant cost to the installation of a water system (Woldt and Benson, 2013). Although sandstone aquifers exist at greater depth in Cretaceous bedrock, water is generally too salty or of poor quality for domestic or irrigation use.

There are 181 total registered wells in the mapping area, of which 74 wells are domestic, and 107 wells are for irrigation or livestock operations. Well yields vary widely based on local geology and the availability of saturated aquifer material. Well yields in the mapped area range from 3 gallons per minute to 1800 gallons per minute. Pumping rates of wells are mapped in Figure 2. Total depths of wells range from 13-105 meters.

## Key Findings

- 1- The availability of groundwater in the Crete South Quadrangle is highly variable. When considering land for purchase or development, it is advisable to drill a test hole(s) on the property to determine the availability water for the intended land use.
- 2- Soil infiltration rates are low. When considering land for purchase or development it is advisable to perform multiple percolation tests on a property and develop a site plan to allow proper placement of onsite wastewater disposal. Additional engineering and expense may be required to develop such systems on small lots or where the water table is high.
- 3- Processes associated with the geologic evolution of the Crete South area are complex. Forming conclusions about the origin of glacial sediments or the sequence of glacial events in the mapping area is difficult due to the age and subsequent modification of the landscape. Further coring, test hole drilling and mapping are required to better understand this landscape.

## Methods

Surficial geology was interpreted from soil surveys (NRCS-USDA, 2019) in addition to field investigations. LiDAR imagery (NRCS-USDA, 2019) was used to identify breaks in slopes and other geomorphic features while mapping. Subsurface data was obtained using the mud rotary drilling technique at sites CS-01-19 thru CS-08-19. Other subsurface data was obtained from historical CSD test holes.

## Acknowledgements

The authors of this map gratefully acknowledge the following organizations and families for providing access to their land for test hole drilling: Al's Auto Body, Plains Equipment Group, Lower Platte South Natural Resources District, the Lauterbach and Manson Families, and the Saline County Department of Roads. Drilling assistance was provided by Matt Marxsen, John Seamann, and Dana Divine.

## References

Balco, G., Stone, J.O.H., Mason, J.A., 2005. Numerical ages for Plio-Pleistocene glacial sediment sequences by <sup>26</sup>Al/<sup>10</sup>Be Dating of Quartz in Buried Paleosols. *Earth and Planetary Science Letters* 232, 179-191.  
 Divine, D.P., 2014. The Groundwater Atlas of Lancaster County, Nebraska. Conservation and Survey Division, School of Natural Resources, University of Nebraska-Lincoln. Resource Atlas No. 7, 39 p.  
 Natural Resources Conservation Service, United States Department of Agriculture (NRCS-USDA). Geospatial Data Gateway. Available online at <http://datagateway.nrcs.usda.gov/>. Accessed May 1st, 2019.  
 Roy, M., Clark, P.U., Barendregt, R.W., Glasman, J.R., Enkin, R.J., 2004. Glacial stratigraphy and paleomagnetism of late Cenozoic deposits of the north-central United States. *Geological Society of America Bulletin* 116, 30-41.  
 Woldt, W.E., and Benson, L.B., 2013. Managing Low-Capacity Private Drinking Water Wells During Drought. University of Nebraska-Lincoln Extension. Institute of Agriculture and Natural Resources. NebGuide G2188.  
 Young, A.R., Howard, L.M., Hanson, P.R., and Kuzliza, M.S., 2014. Surficial Geology of the Crete North 7.5 minute quadrangle. Conservation and Survey Division, School of Natural Resources, University of Nebraska-Lincoln. Available online at <http://snr.unl.edu/data/geologysoils/STATEMAP/quadsearch.aspx>

