THE SURFICIAL GEOLOGY OF THE MAQUOKETA QUADRANGLE CLINTON & JACKSON COUNTIES, IOWA

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Introduction

The purpose for developing the surficial geologic map of the Maquoketa Quadrangle is to obtain geologic data that can be used for county-specific land use planning tools for the city of Maquoketa, IA, the NRCS, local citizens and farmers. The study area is located in eastern Iowa (Fig. 1). The Maquoketa Quadrangle covers the area of 42º 00' to 42º07'30" N latitude and 92º37'30" to 92º45" W longitude.

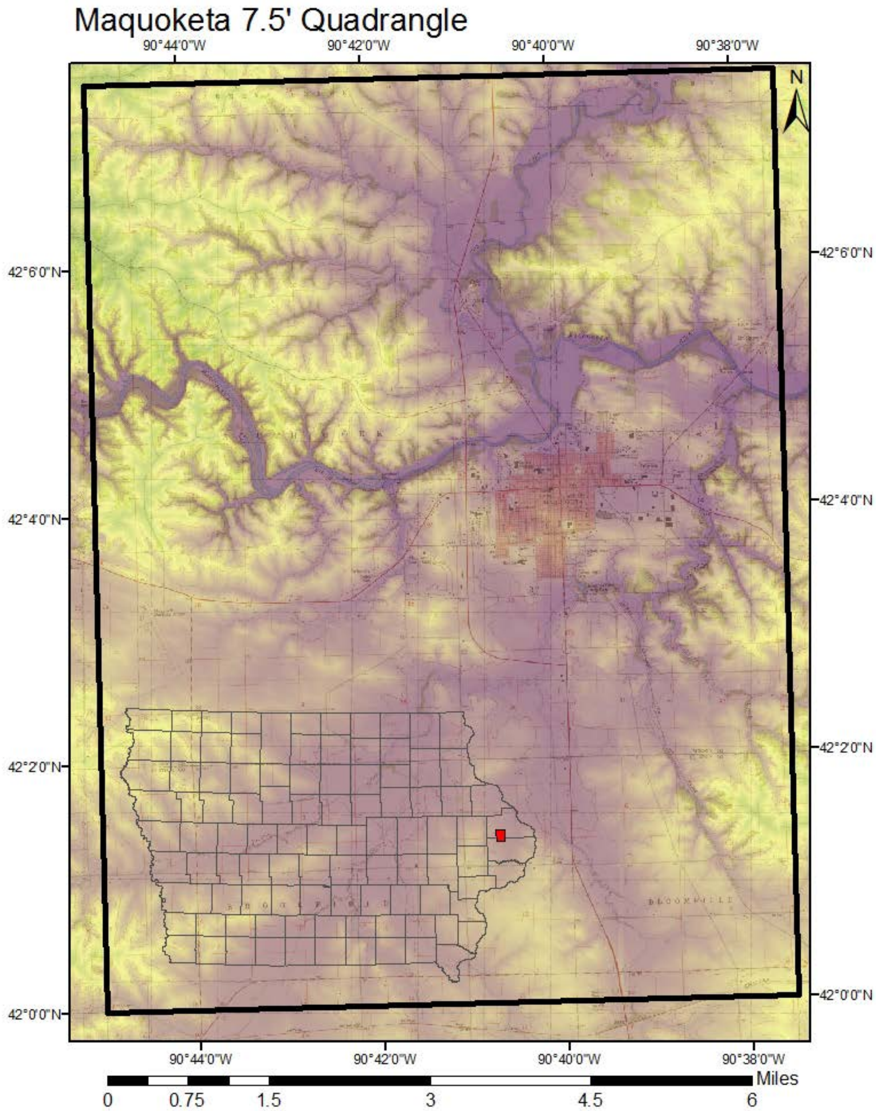

Figure 1. Map of the Maquoketa Quadrangle (including topography, 3m DEM, & 1m Hill shade). Inset (bottom left) are the counties of Iowa with the location of the Maquoketa Quad (RED)

The Maquoketa Quadrangle lies in a terrain of dissected Pre-Illinoian glacial deposits that blanket a bedrock surface with significant relief. The study area is characterized by two primary landform region types the Iowan Erosion Surface and East Central Iowa Drift Plain. The area possesses alluvial surfaces, eolian landforms, and discontinuous outcrops of Paleozoic bedrock. Geologic units within the project area include Silurian carbonate bedrock, Pre-Illinoian glacial sediment and alluvium; Wisconsin loess; Holocene alluvium and eolian sand.

Regional Setting

Four primary factors have shaped Iowa's diverse landscapes: A) Depth to and type of bedrock, B) Pleistocene glaciations, C) On-going fluvial processes, and D) Anthropogenic landscape interactions. During the Pleistocene, continental glaciers advanced over Iowa, depositing sediments during and after ice contact. The main glacial stages from oldest to youngest were the Pre-Illinoian, Illinoian, and Wisconsinan (Fig. 2). The Maquoketa Quadrangle contains representative landforms attributed to the Iowan Surface and the East Iowa Drift Plain (Fig. 3).

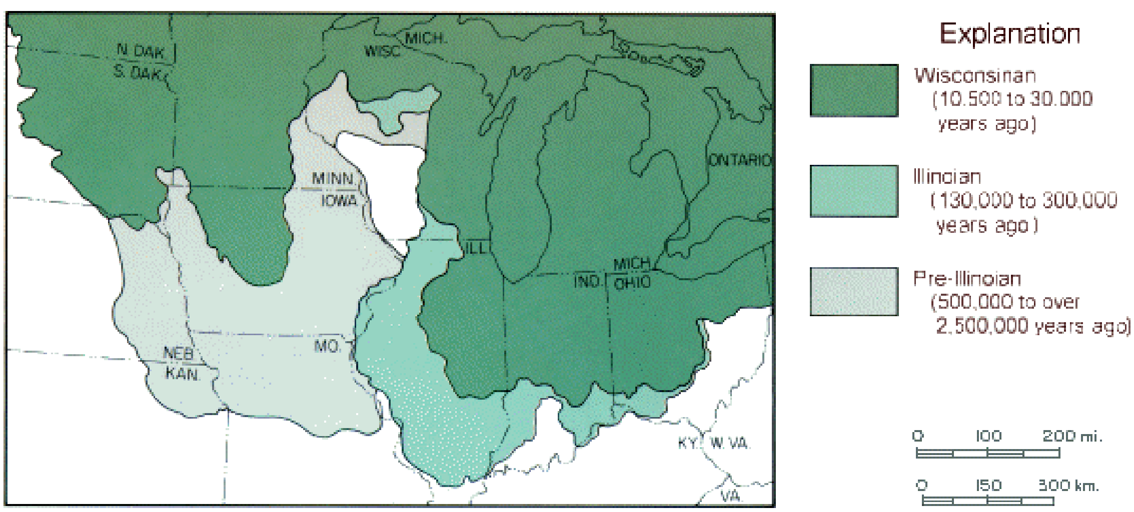

Figure 2. Limits of major Pleistocene glacial advances into the Midwest (Prior, 1991)

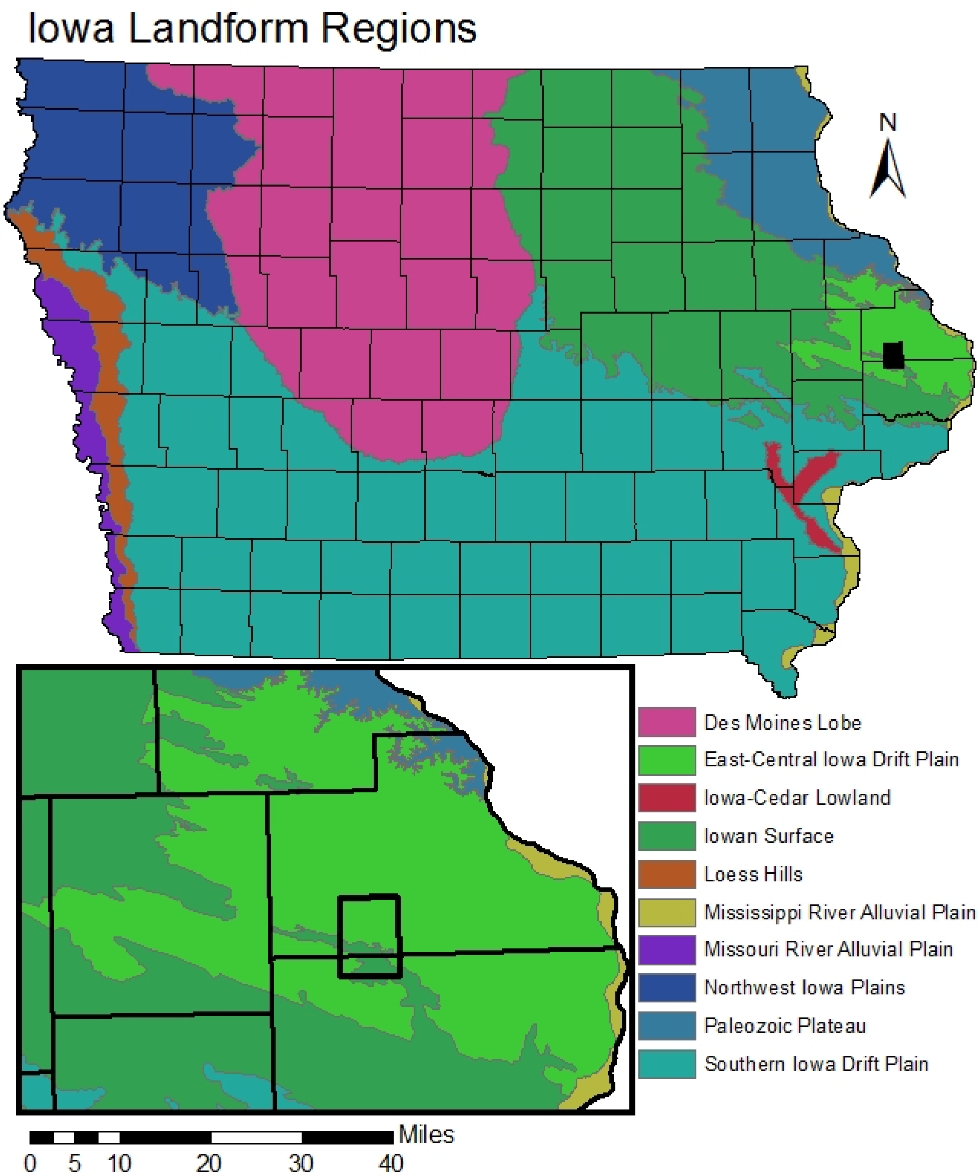

Figure. 3. Landform regions of Iowa.

The Iowan Surface displays sweeping, relaxed, open topography. The surface usually appears slightly inclined to gently rolling with long slopes, low relief, and open views to the horizon (Prior, 1991). This region of Iowa has no constructional features associated with glaciations. There are no moraines, eskers, kames, or outwash plains. The Iowan Erosion Surface was previously known as the Iowan Drift Region. A considerable amount of this region is covered by loess, but the major part of the region is covered by thin loam sediment that overlies a stone line on the till (Ruhe, 1969). The

Iowan Drift does not exist in northeastern Iowa, it is actually an erosion surface (Ruhe, 1969).

The edge of the erosion surface extends under the thick loess, so the erosion surface itself cannot be the primary source for the loess (Hallberg, 1979). It is assumed that much of the Iowan Erosion Surface must have been created before the loess began to be deposited. Radiocarbon ages indicated that loess deposition began on the erosion surface approximately 18,000-23,000 radiocarbon years ago and between 21,000-29,000 radiocarbon years ago on the areas with paleosols. This aging indicates that erosion and loess deposition were occurring simultaneously (Zanner, 1999). The Iowan Surface was last inhabited by glaciers in Pre-Illinoian time and since then has lain exposed to various episodes of weathering and soil development, erosion, and loess deposition (Prior, 1991).

The East Central Iowa Drift Plain is the most recent interpretation of Iowa's landform regions. This unique landform region that makes up the majority of Jackson County Iowa and portions of Clinton, Dubuque, and Jones Counties. This landform region was first interpreted… This area was previously described as being part of the Southern Iowa Drift Plain. This area of eastern Iowa contains similar surficial characteristics as the Southern Iowa Drift Plain, steeply rolling hills and valleys often with loess uplands. The distinguishing factor of the East Central Iowa Drift Plain is that it contains large areas of shallow bedrock in addition to characteristics of the Southern Iowa Drift Plain.

Soils and Landscapes

The Maquoketa Quadrangle contains a diverse assemblage of soil series and catenae (Figure 4). Common Soil Landscape Relationships Uplands Slopes Fluvial

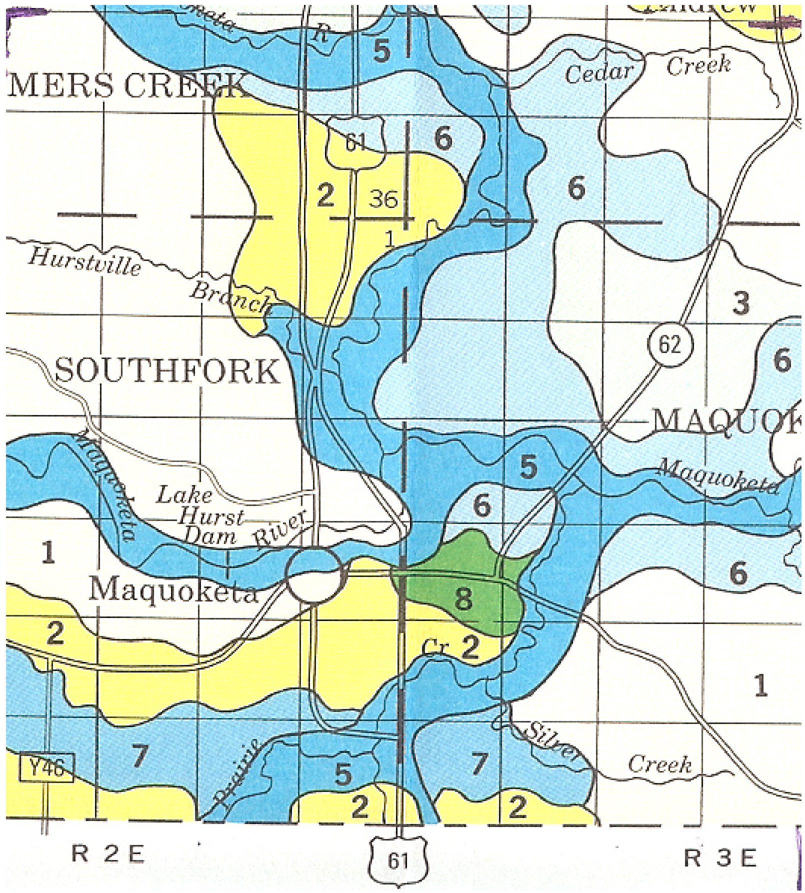

Figure 4. A cropped general soil map of the 7.5’ Maquoketa Quadrangle (LaVan et. al, USDA, SCS, 1992). “Common associations include: 1 = *Fayette-Nordness-Rock Outcrop Association*, Rock outcrop and gently sloping to very steep, well-drained soils formed inn loess or in loess and a thin layer of clayey residuum. 2 = *Downs-Fayette Association* – Gently sloping to very steep, well-drained soils formed in loess; on uplands. 3 = *Orwood-Emeline-Racine Association* – Gently sloping to steep, well-drained and somewhat excessively drained soils formed in loamy and silty eolian material over limestone bedrock, and loamy sediment and the underlying glacial till on uplands. 5 = Chaseburg-Caneek-Orion Association – Nearly level, well to poorly-drained soils formed in silty alluvial sediment, on bottom land along the major streams. 6 = Chelsea-Fayette-Lamont Association – Gently sloping to very steep, well drained and excessively drained soils formed in sandy and loamy eolian deposits and loess on uplands. 7 = Pillot-Rockton-Dinsdale Association – Gently and moderately sloping, well to moderately drained soils formed in loess and the underlying loamy sediment, loamy material and a thin layer of residuum over limestone bedrock, and loess and underlying glacial till on uplands. 8 = Walforn-Atterberry-Downs Association – nearly level to gently sloping, well to poorly drained soils formed in loess on high stream benches.”

Natural and Human History of the Maquoketa Quadrangle

The Maquoketa area originally inhabited for its abundant natural resources (limestone, fertile soils, timber, wildlife and water). The Maquoketa River served as a life line for the area's wildlife and pioneers, the river possesses a North and South fork that join within the quadrangle (T84N, R2E, Sec. 13, NE ¼). The Maquoketa River's North Fork begins just west of Holy Cross in Dubuque County. The longer South Fork begins west of Arlington, Iowa (Fayette County) before flowing southward through Backbone State Park (Buchanan County).

Native Americans thrived in the lands adjacent to the Maquoketa River for thousands of years and are commonly attributed to the Sac, Fox, Sioux, Winnebago, Pottawattamie, and Iowa tribes. (Ellis, 1907, V.4, p. 1). Anson Wilson, one of the area's pioneers, helped document Maquoketa's last known Native American village consisting of approximately two-hundred people was recorded in 1839 along the banks of the Maquoketa River near Bridgeport (Ellis, 1907, p. 1). Wilson also recollected, the primary Native American burial ground existed along a sand ridge near the forks of the Maquoketa and the village of Hurstville, "Mr. Wilson says that when he first saw it there were many dead, but not all buried, some were rolled in blankets or skins of animals and laid on the ground, and a pen of saplings built around them; others were leaned up against a tree, and I have heard that all those who died of smallpox were covered with sand."

J.W. Ellis documented (1907, Annals of Jackson County, V. 4, p.2) the remnants of a Native American Dancing ground, "The dance floor was a smooth level surface enclosed by a circle of cedars that had been planted with great precision at last fifty, if not one hundred years before the first white settler arrived (1836) in the locality. The trees in 1854, when the writer (Ellis) first saw them, were as large as telephone poles. The dance ground was from 50 to 75ft in diameter and was enveloped on three sides by a slough, and on the other a dense growth of brush concealed it from view. An old path leading from a point where the road turned to the river at the Hawkins Ford disclosed the only entrance to this spot where dusky men and maids had danced to the music of the tomtom for ages. The exact location of this historic place as near as the writer is no enabled to locate it, as it is in a corn field on the land owned by hon. A. Hurst, is the northwest quarter of section 12 in the South Fork Township."

The first white settlement within Iowa's current boundaries was Julien Dubuque in 1788 (Ellis, 1910). The Maquoketa Quadrangle appears to have been first settled by a group of companions (Daniel Shinkle, Jesse Pate, Barney White, Jones Edwards, Ben Copeland, David and Thomas Owens from Fever River near Galena Illinois). In 1836 the friends were enjoying a hunting expedition near the junction of the Maquoketa River's North and South Forks when they decided to stake their claim (Ellis, 1906). Quite a few other families including: Steve and Ben Esgate, Nathan and Jesse Said, Anson Wilson also settled the area of the forks in 1836 from the Galena Lead Mining district, some were also veterans of the 1832 Black Hawk War (Ellis 1906, p. 7).

Samuel Calvin, 1910, characterized the geologic data of Jackson County and the Maquoketa Quadrangle (Ellis, 1910). Prior to this characterization Professor T. E. Savage (1906, Iowa Geologic Survey, Volume 16) characterized the area's bedrock, while Frank Leverett (1906, United States Geological Survey) documented the county's glacial record. These initial investigations helped to initiate three interesting geologic possibilities: A) The proposed 'Driftless Area' of eastern Iowa, B) The 1907 G. H. Johnson deep well that explored the potential for Iowa approximately 6 miles north of Maquoketa, and C) Possibility of developing the quadrangle's natural resources stone, timber, and clay (Ellis, 1910, p. 115).

The Silurian, dolostone, bedrock within Maquoketa Quadrangle provided natural resources to form lime production in the late 1800s. Alferd Hurst opened the Hurstville Lime Kilns, two-miles north of Maquoketa, in 1875. Along with his brother William, they developed local mines aimed at processing the Hopkinton dolostone into lime production. This mining activity greatly increased the availability of jobs and wealth to Jackson County from 1875 until 1920 (Anderson, 2001).

Field Work

Soil samples were taken from the field using a bucket-auger and shovel excavations of surficial outcrops. Soil samples were described in the field notebook on the basis of sediment identification methods. In most cases, the maximum range reached for mappable surface geologic units (soil parent material) was 3 to 12 feet. The hand auger was capable of reaching depths of 12 feet, but we were often able to only reach 6ft due to the difficulty of pulling the core out of the ground. The UNI EDMAP team hand drilled 34 cores and had access to well descriptions from 132 Iowa Geosam database https://www.iihr.uiowa.edu/igs/geosam/home (Figure 5). We extensively used soil development patterns, vegetation changes, and landscape position and topography to assist our mapping efforts.

Spatial Data Collection

Geographically referenced data were necessary for this mapping project. This project required obtaining geospatial data (topography, aerial photography, depth to bedrock, and other shapefiles) from the Iowa Natural Resources Geographic Information Systems Library (https://programs.iowadnr.gov/nrgislibx/). Spatial data were also collected in the field using a Trimble GeoXH. Mobile mapping enabled the collection of accurate field data.

GIS Data Processing

Geospatial data were obtained for the Maquoketa Quadrangle from the Iowa Natural Resources Geographic Information Systems Library. While drawing the map features (shape files), a combination of field, supporting geospatial data (aerial photos, topography, LIDAR, etc.), and ArcGIS 10.3.1 editing tools were used.

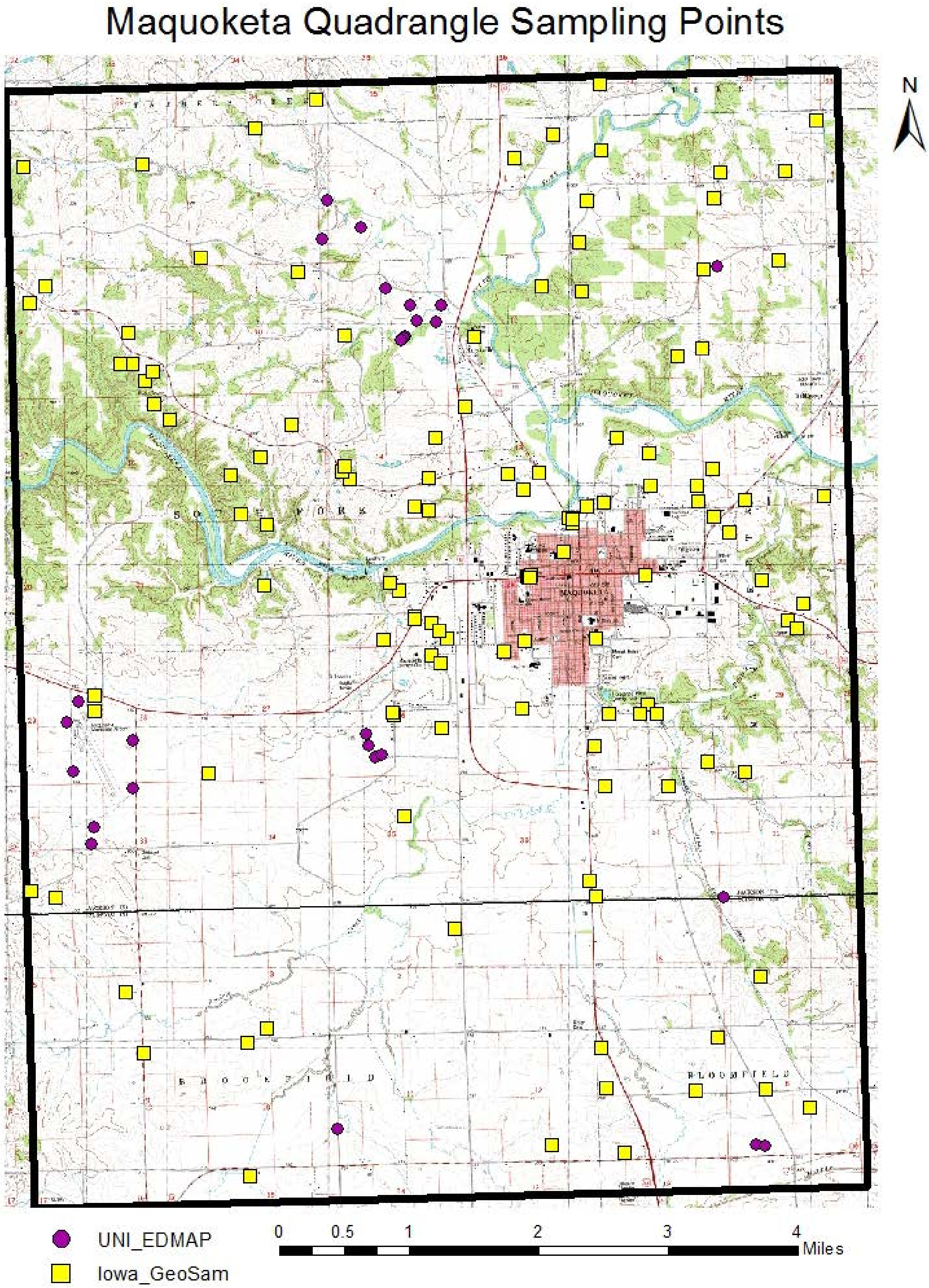

Figure 5. Map exhibiting the sampling points used to interpret the surficial geology of the Maquoketa Quadrangle (34 EDMAP and 132 GeoSam cores)

General Map Discussion

This EDMAP opportunity offered excellent learning opportunities for the University of Northern Iowa students (Figure 6). The Maquoketa Quadrangle presented a complex series of ten mappable Quaternary units (Qal, Qbr, Qallt, Qalht, Qaf, Qe, Qps, Qps1, Qps2, and Qwa2).

Figure 6. A representative group of UNI-EDMAP students Dylan Nielsen, Joe Reinders, Blaize Cabell, and Riley Mullins investigating stratigraphic section 6 within the Maquoketa Quadrangle.

The Maquoketa Quadrangle contains many first and second ordered stream segments (e.g. the Hurstville Branch and Prairie Creek). These low-ordered steam segments continue to modify the area's alluvial valleys through deposition (Qal) and erosion (Qbr). Qal deposits exist on the adjacent floodplains of the area's second and third ordered stream segments. These areas are commonly used to pasture cattle and are prone to flooding. One of the primary characteristics of the East Central Iowa Drift Plain landform region is shallow bedrock; Qbr mapping designations identify areas where first ordered stream segments have down-cut through Wisconsinan upland loess deposits exposing and incising the underlying Silurian (Scotch Grove and Hopkinton) dolostone. The Qbr mapping unit should be associated with the Soil Conservation Service's Nordness soil series designation.

The north and south fork of the Maquoketa River join to form one meandering channel in the north-central portion of the quadrangle (T. 84N, R. 2E, Sec. 13, NE ¼). The two primary mapping units associated adjacent to the Maquoketa River are Qallt and Qalht (lower and high terrace). The lower terrace contains stratified silty clay loam, loam or clay loam associated with the current channel belt of the Maquoketa River valley. The associated water table varies seasonally and contributes to overall discharge of the Maquoketa River. This lower terrace has a high flooding potential. The high terrace contains dark brown silty clay loam, loam alluvium or colluvium. Three localized areas of high terrace were identified two on the west side of the north fork and one more on the south side Maquoketa River after the forks join. Flooding potential for the high terrace is very low.

One of the most interesting areas of Quaternary sedimentation is located in the north central portion of the quadrangle surrounding the Schwenker Farm. The area was previously interpreted as an alluvial fan with areas of oxbow lakes (Ludvigson et al., 1992). The transitions from the loess uplands to the lower alluvial floodplains present complex stratigraphy that warrant further investigations. This project studied two toe slopes (stratigraphic sections six/nine and seven). These sections were first described either by shovel and/or bucket auger then again by a backhoe. Section six/nine has been interpreted as a buried channel to oxbow lake transition (Figure 7). The portion of section 6 and 9 contain coarse grain sand and gravel before finning upwards to medium sand and then gray clay. Subsequent deposition, possibly by channel reactivation, deposited cross-stratified sands and created well-defined flame structures from escaping water below (Figure 8). Nearby section six and nine an elongated sand ridge extends off of the toe slope in the Schwenker Farm front (east) pasture, section seven and eight (Figures 9 and 10). This area was also mapped as Qaf (alluvial fan), but the entire area may be related to fluvial processes related run off from semi-frozen ground and/or large glacial flood that sent floodwaters the Maquoketa River and its tributaries.

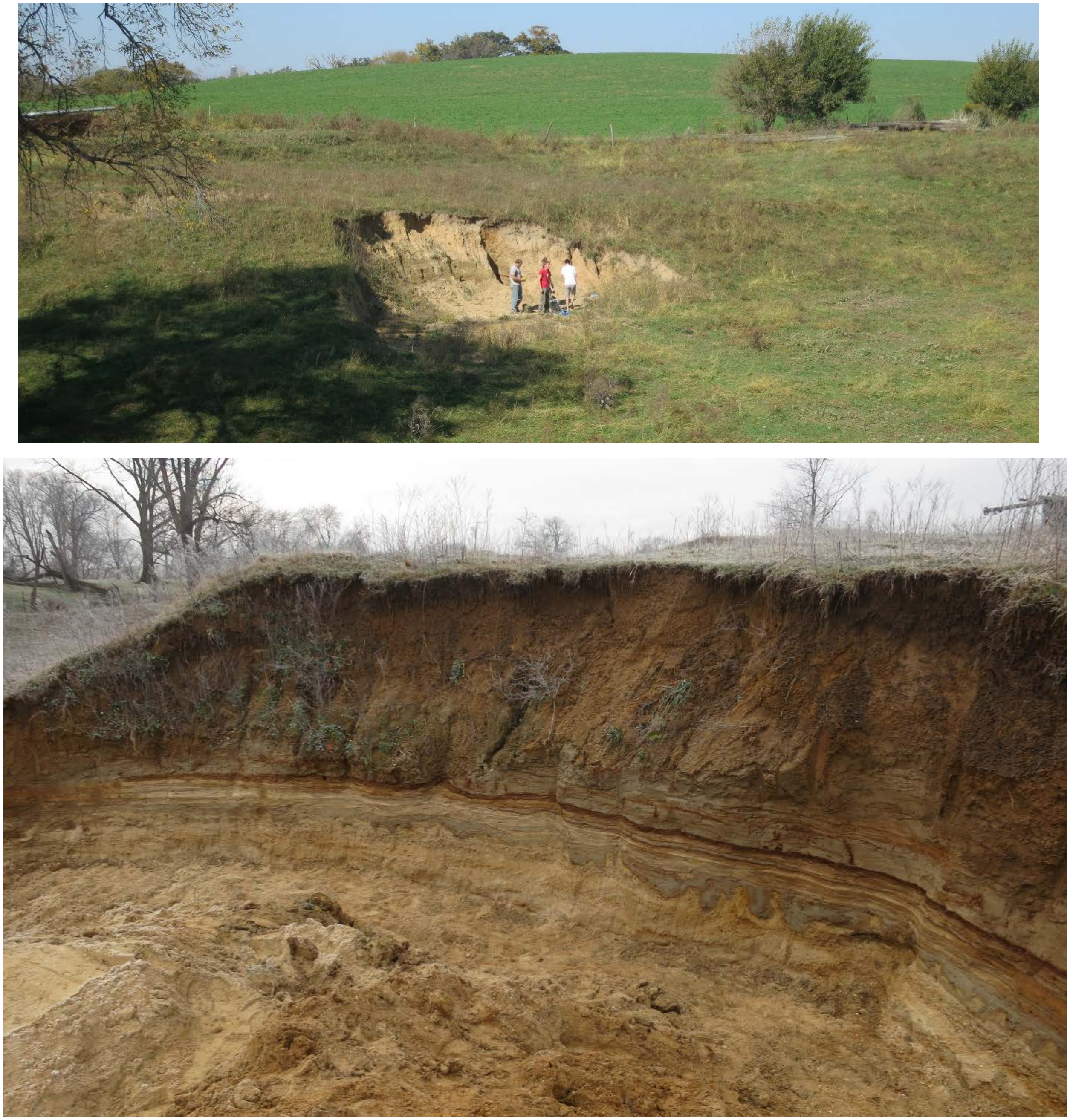

Figure 7. Overview photographs of Maquoketa Quadrangle stratigraphic sections 6 and 9 Schwenker Farm (south pasture). Once excavated with a backhoe and clean the exposure measured 10m by 2m.

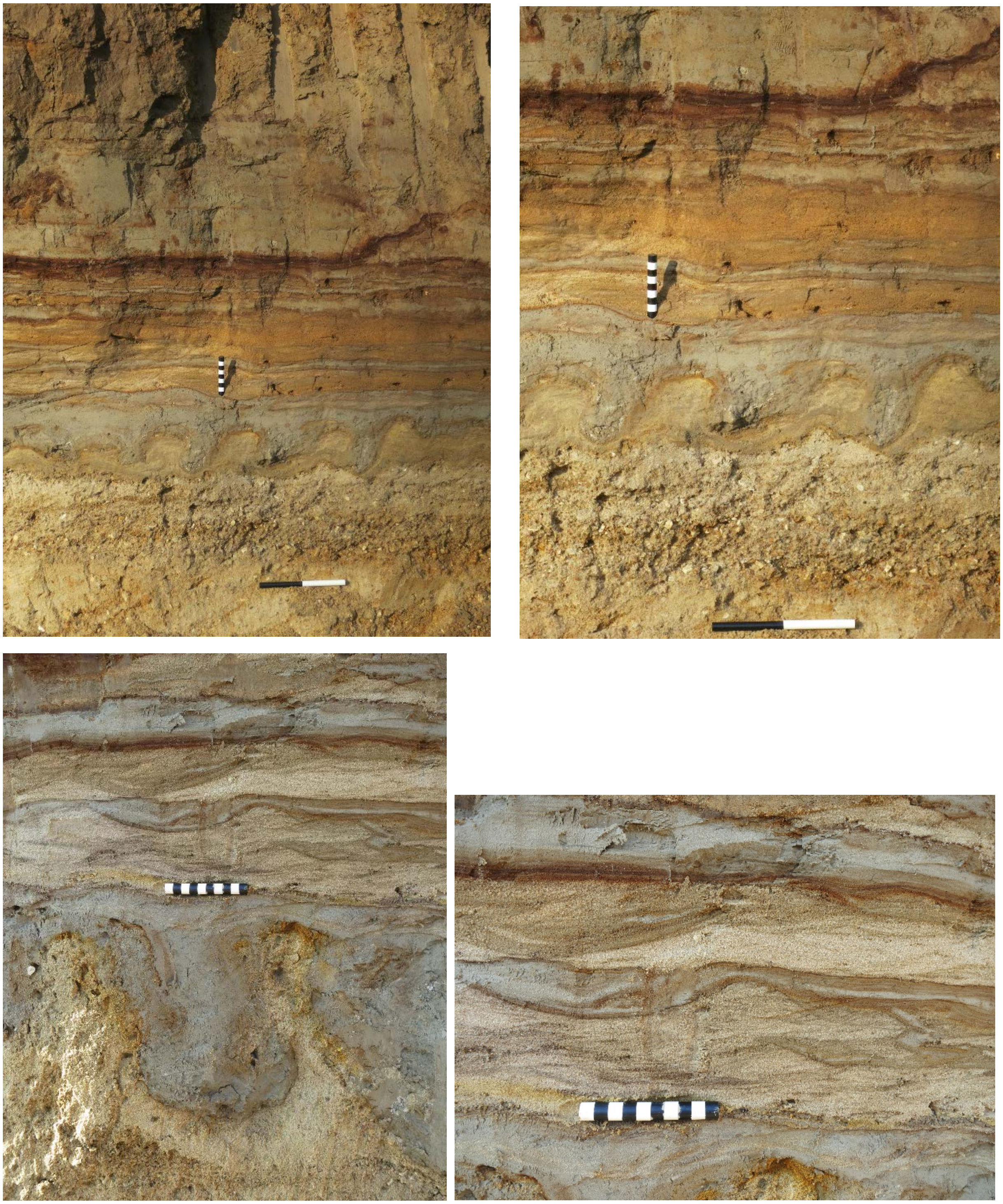

Figure 8. Close up of fining upwards grading, cross-bedding, flame structures, and iron banding. The white and black scale bars are in cm (large 10cm, small 1cm).

Figure 9. Overview of Maquoketa Quadrangle sections seven and eight.

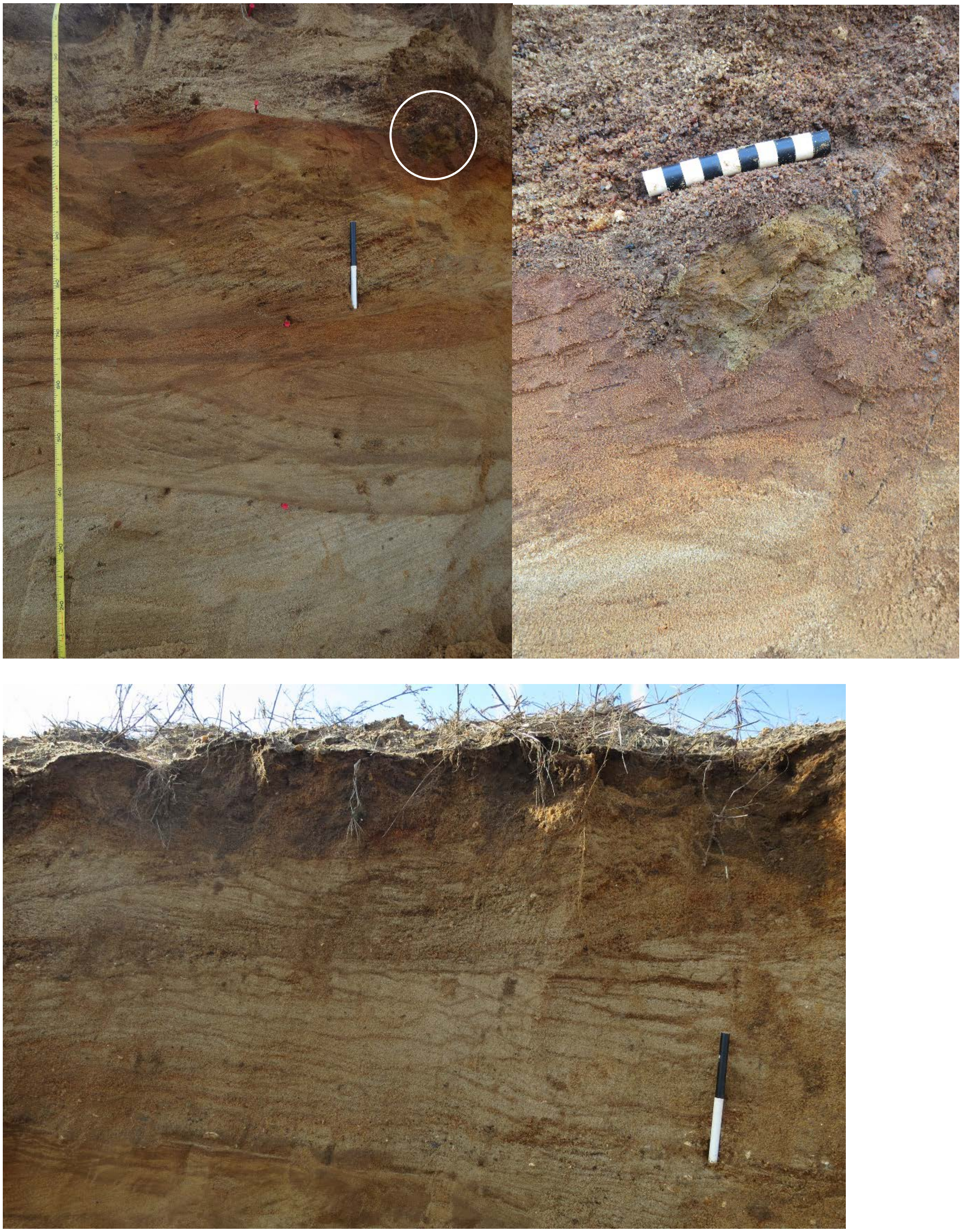

Figure 10. Close up of section seven. The upper photographs exhibit cross-bedding and a clay rip clast (white circle, left) close up of clay body on the upper right. The bottom photograph depicts an interesting series of moderately uniform iron-rich clay bands within the coarse to medium grained sand.

The majority of the Maquoketa Quadrangle is the product of prolonged and intensive eolian activity. The three eolian mapping units interpreted within the Maquoketa Quadrangle were Qe, Qps, Qps1 and Qps2. The northwest portion of the quadrangle was interpreted as Qps because the area contained thick, commonly greater than fifteen feet, deposits of uniform reddish brown loess. North and west of the Maquoketa River first ordered stream segments commonly cut through the loess (Qps) exposing the bedrock below, creating the previously described Qbr unit. South of the Maquoketa River the loess uplands may contain interbeds of clay-loam or sand and were interpreted as Qps1. Northeast of the Maquoketa River, the amount of sand dramatically increased and loess was thin to absent, this area was interpreted as Qps2. Areas that exhibited no loess and possessed relict dune structure (e.g. weak cross-bedding) were interpreted as Qe. Both Qps2 and Qe were frequently underlain by weathered Silurian, dolostone, bedrock.

Another intriguing surficial mapping unit was interpreted as Qwa2, this unit had a northwest to southeast trend and underlies the current Maquoketa Municipal Airport. This area was previously interpreted as the Monmouth-Baldwin-Nashville paleovalley (Ludvigson et al., 1992). Geosam Well-12101 in addition to our work (cores 16, 20, 21, 22, and 32) exhibited characteristics of glacial till (specifically the Pre-Illinoian Alburnett Formation). Cores on the east end of this Qwa2 feature change dramatically. The west end of the feature is predominately till with a mixed pebble assemblage. The east end of the Qwa2 feature (cores 28, 29, and 30) contained well-sorted sand that requires further study and possible a reinterpretation of the mapping units.

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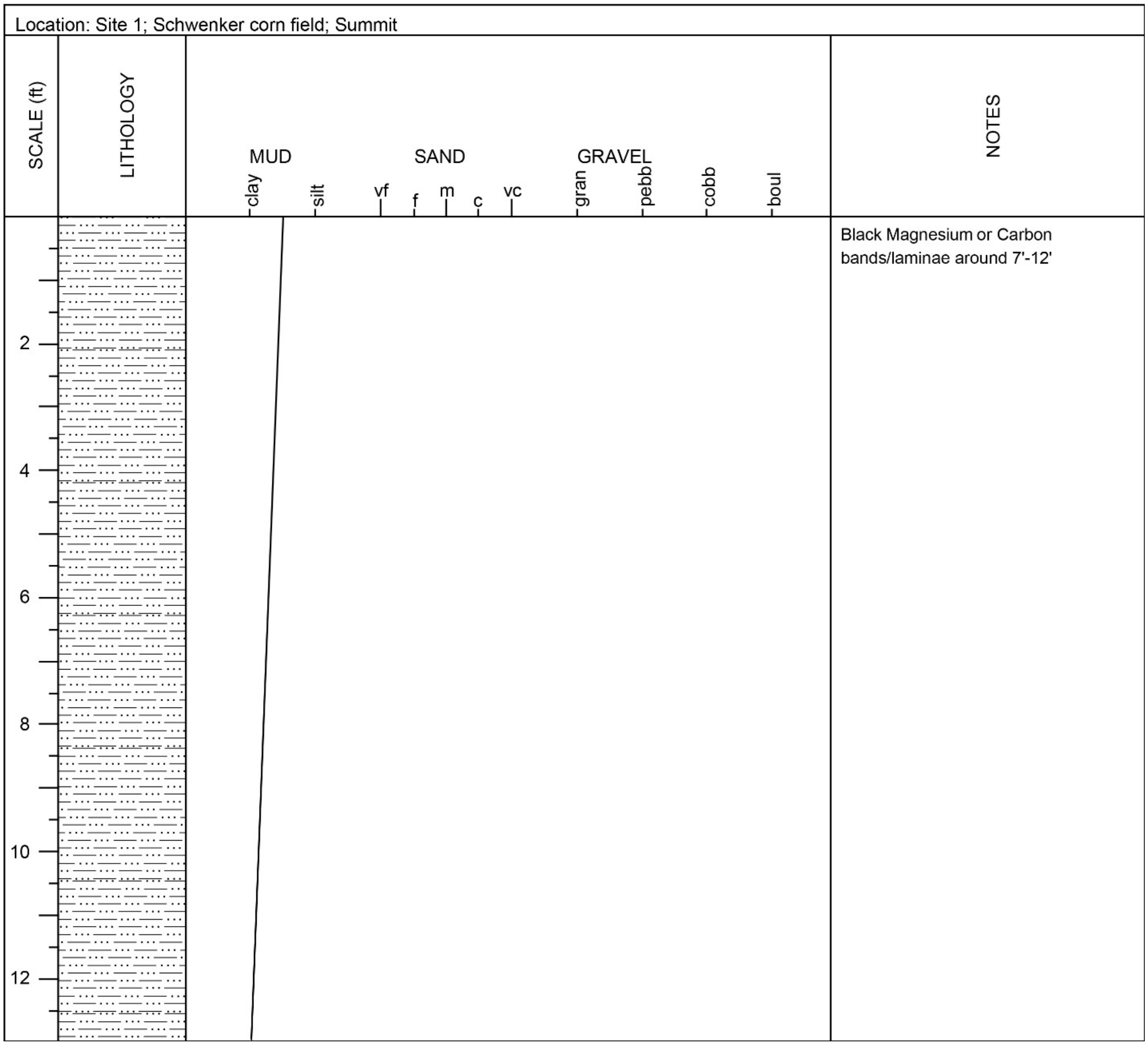
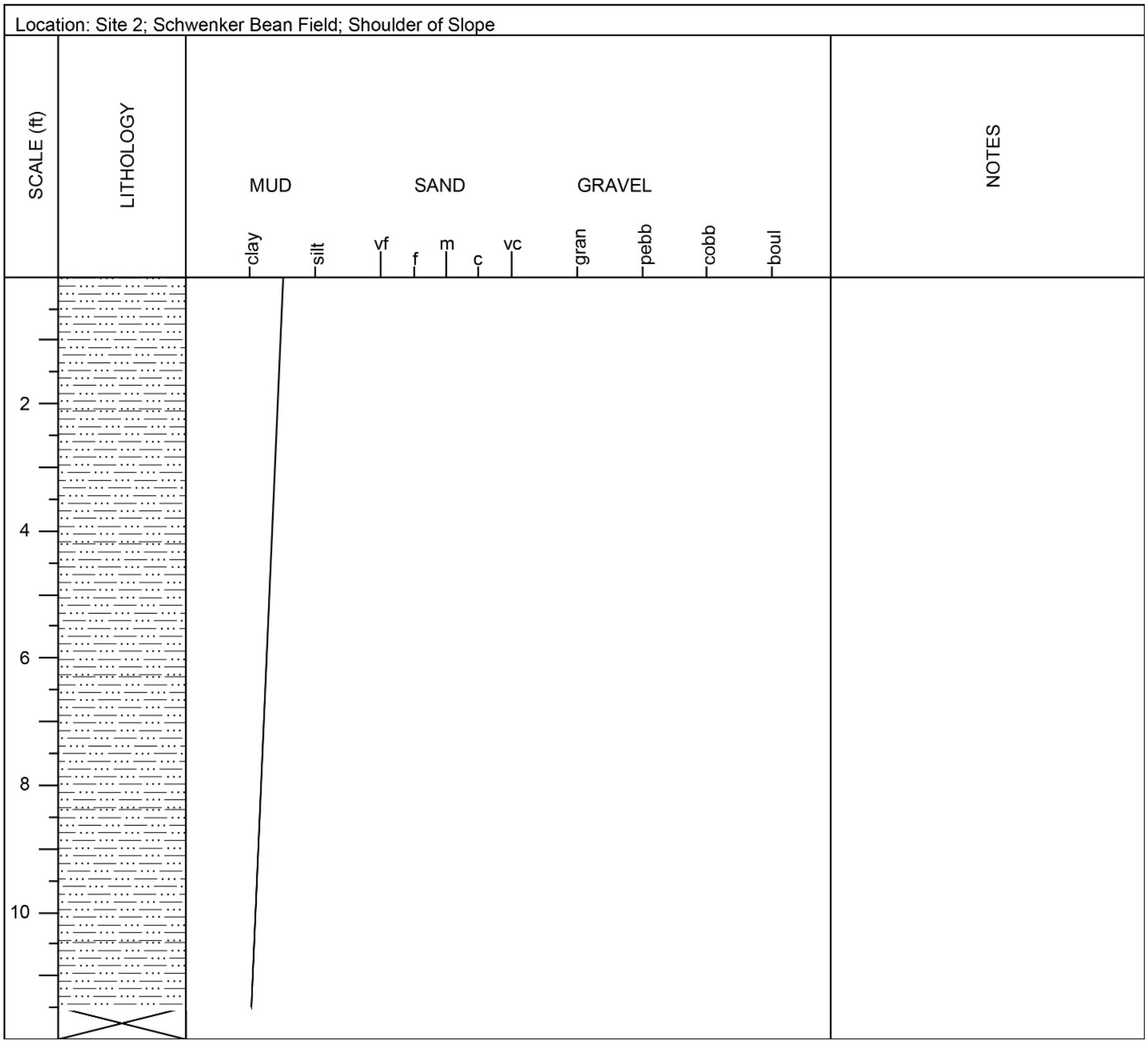
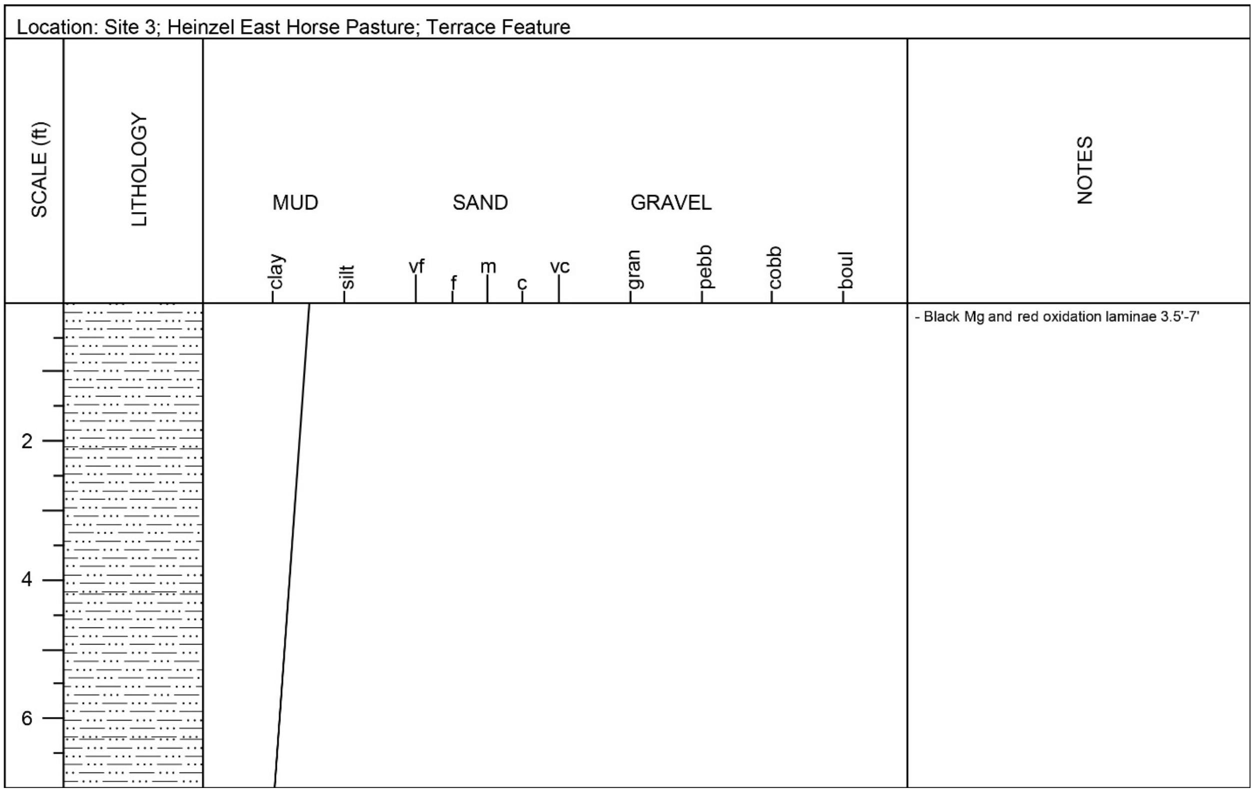
Appendix

Representative Stratigraphic Sections

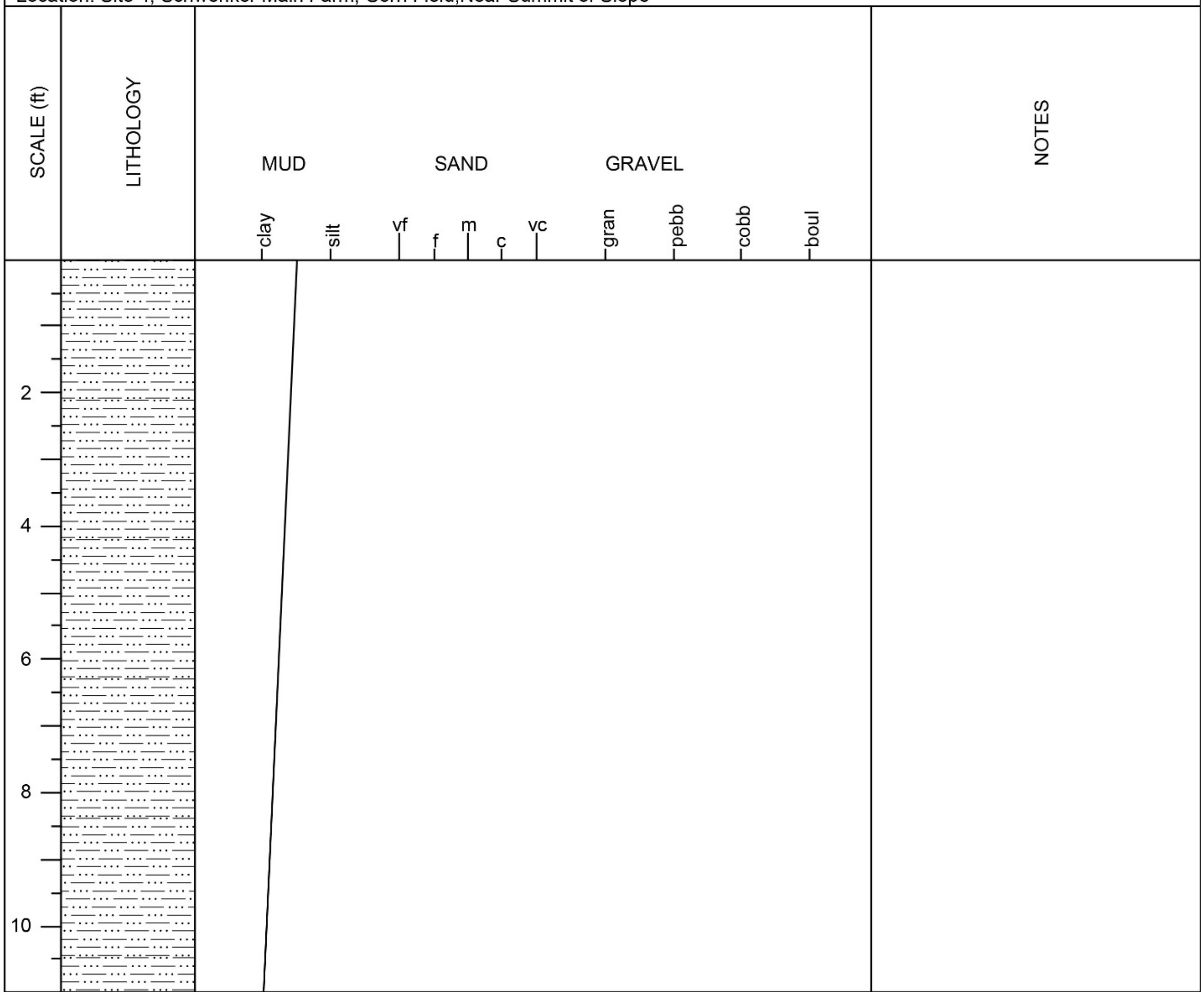

Location: Site 1; Schwenker corn field; Summit
SCALE (ft)
LITHOLOGY
MUD
SAND
GRAVEL
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
NOTES
2
4
6
8
10
12
Black Magnesium or Carbon bands/laminae around 7'-12'


Location: Site 2; Schwenker Bean Field; Shoulder of Slope
SCALE (ft)
LITHOLOGY
MUD
SAND
GRAVEL
NOTES
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
2
4
6
8
10

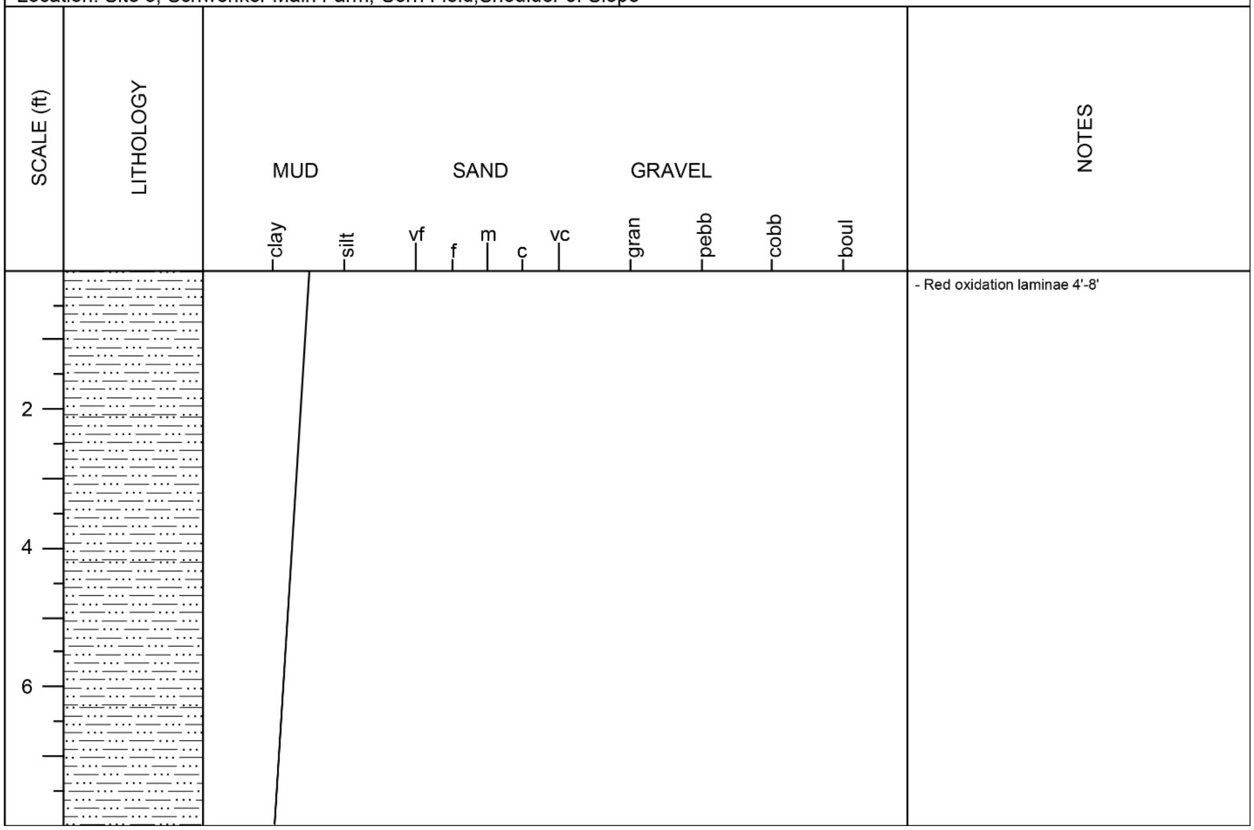


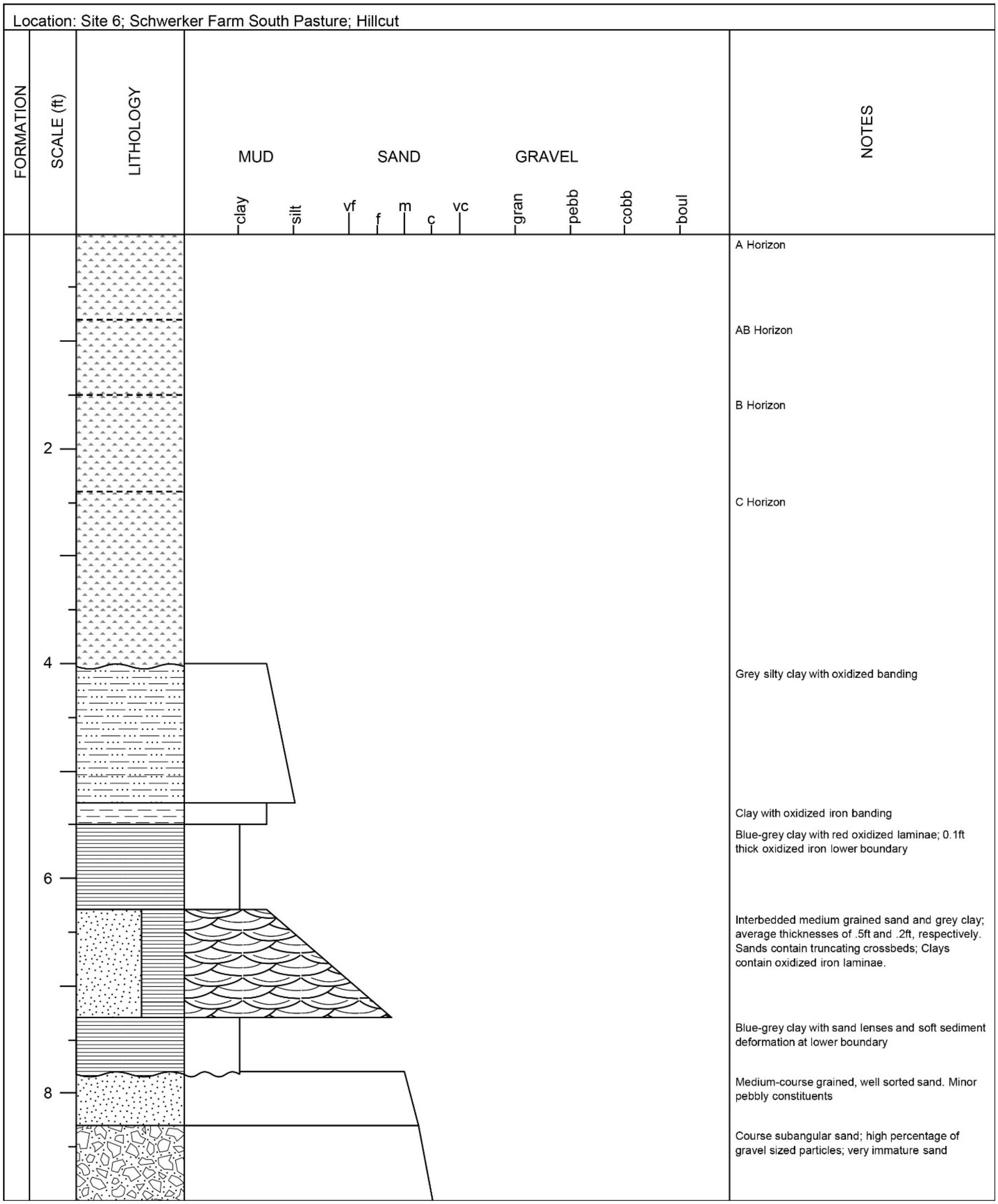
Location: Site 3; Heinzel East Horse Pasture; Terrace Feature
SCALE (ft)
LITHOLOGY
MUD
SAND
GRAVEL
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
NOTES
2
4
6
- Black Mg and red oxidation laminae 3.5'-7'

Location: Site 4; Schwenker Main Farm; Corn Field;Near Summit of Slope

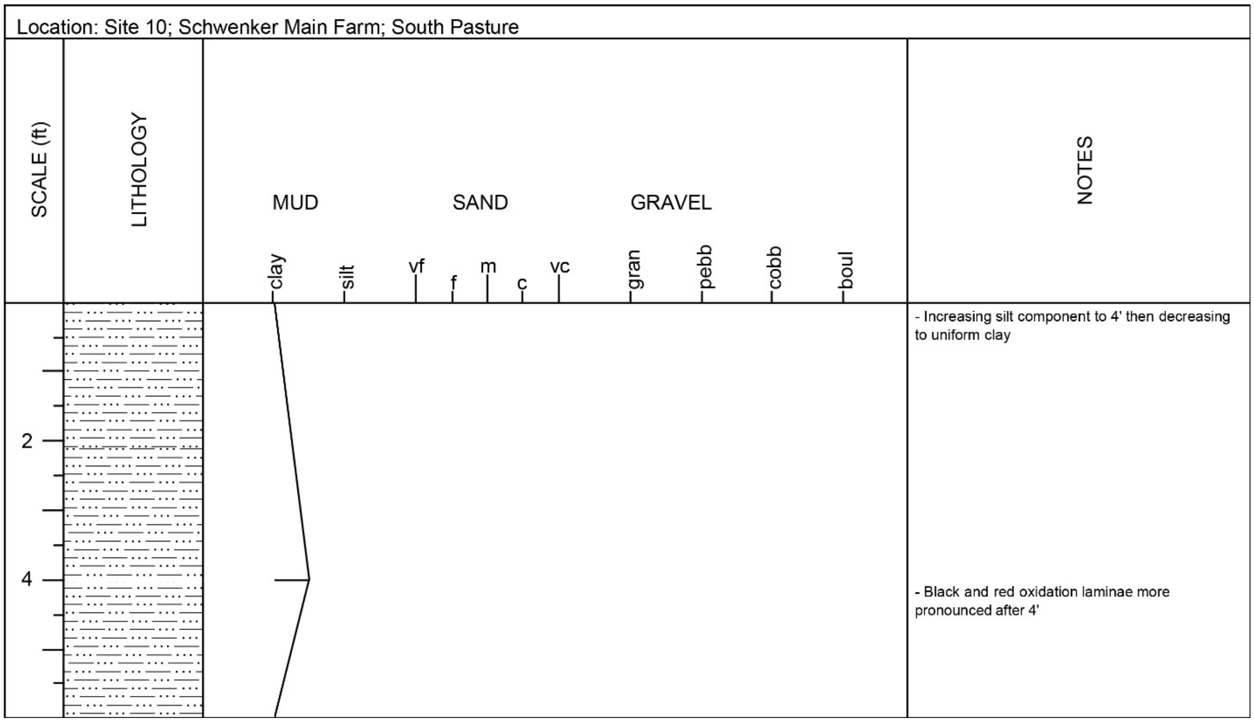


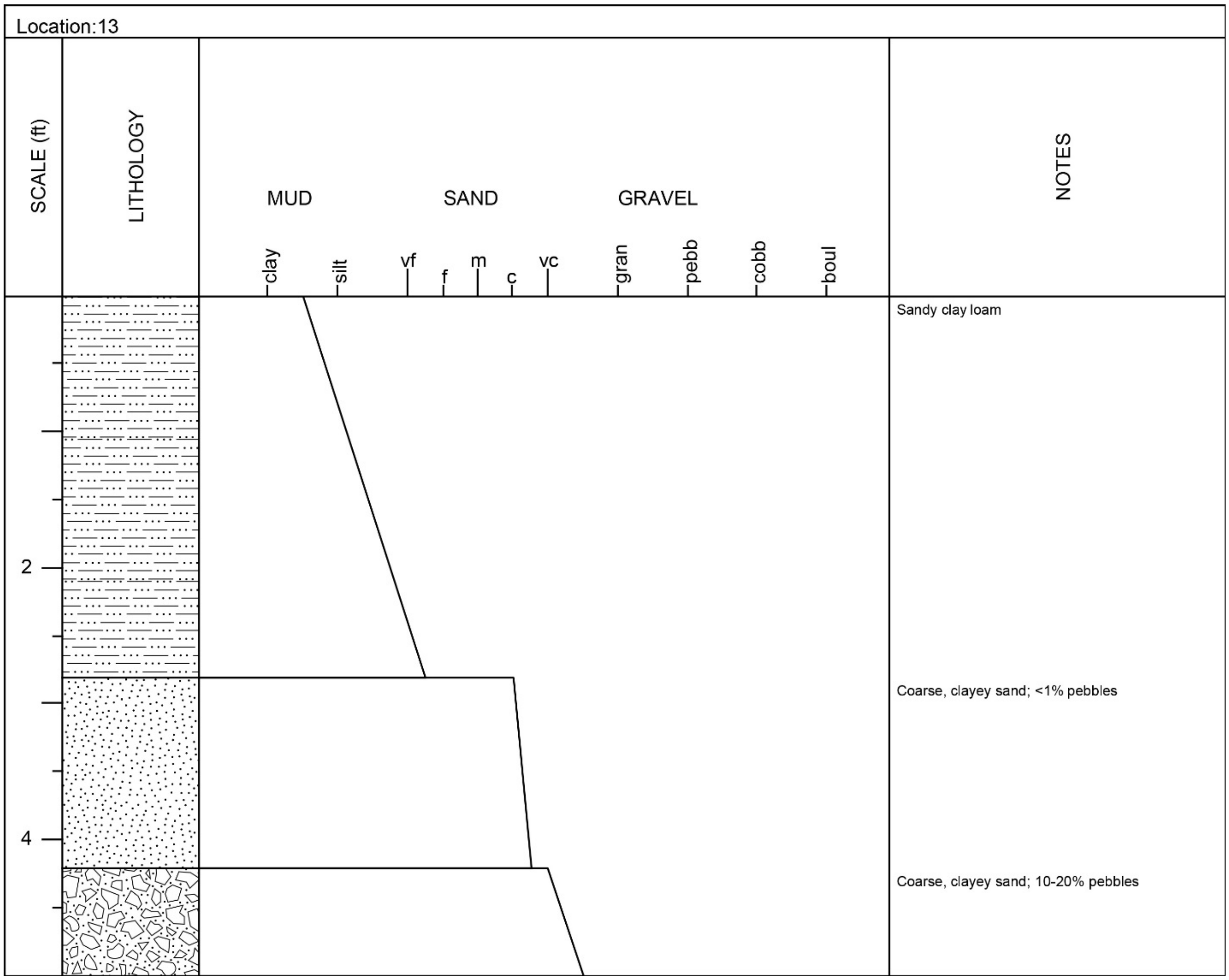
Location: Site 5; Schwenker Main Farm; Corn Field;Shoulder of Slope

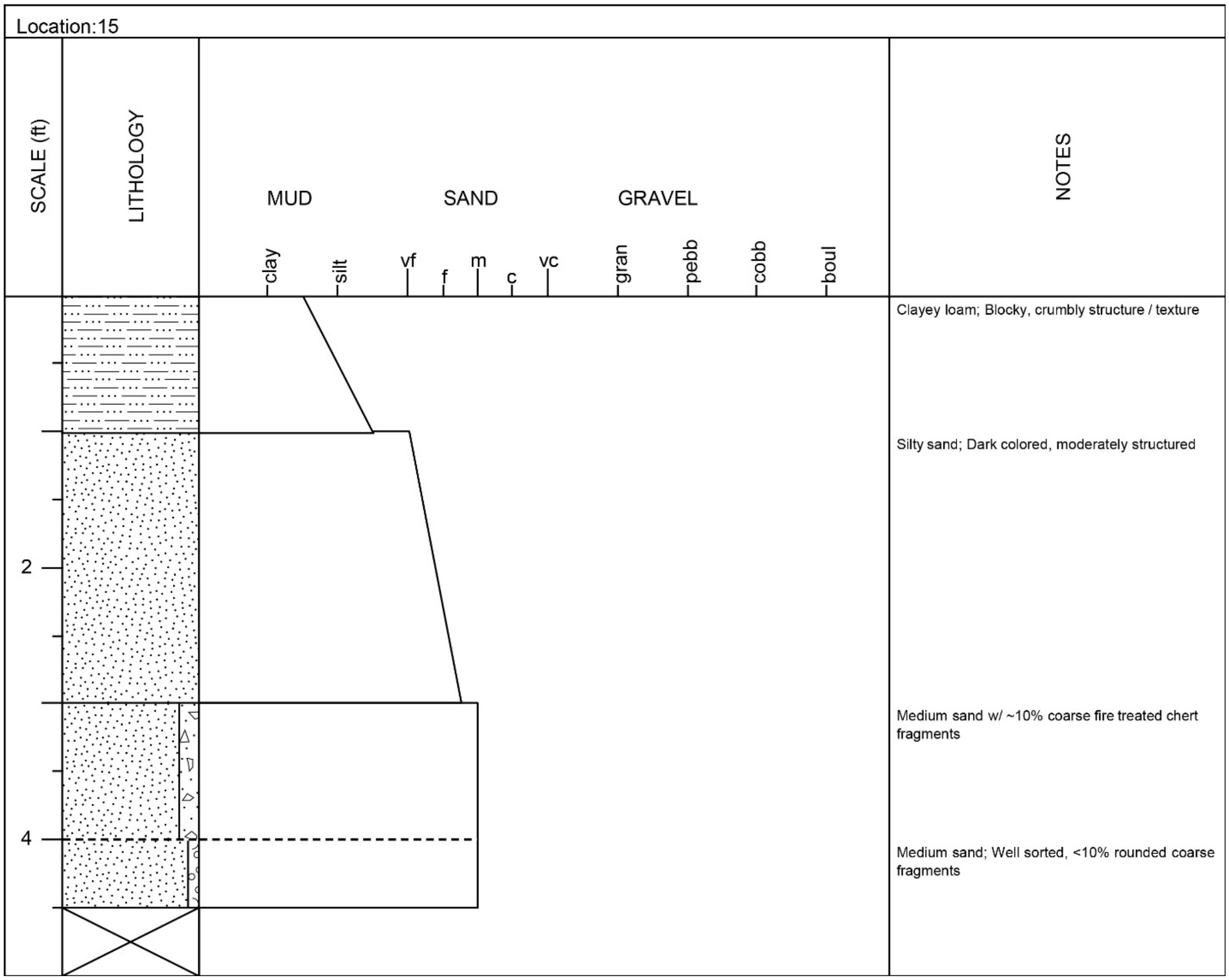




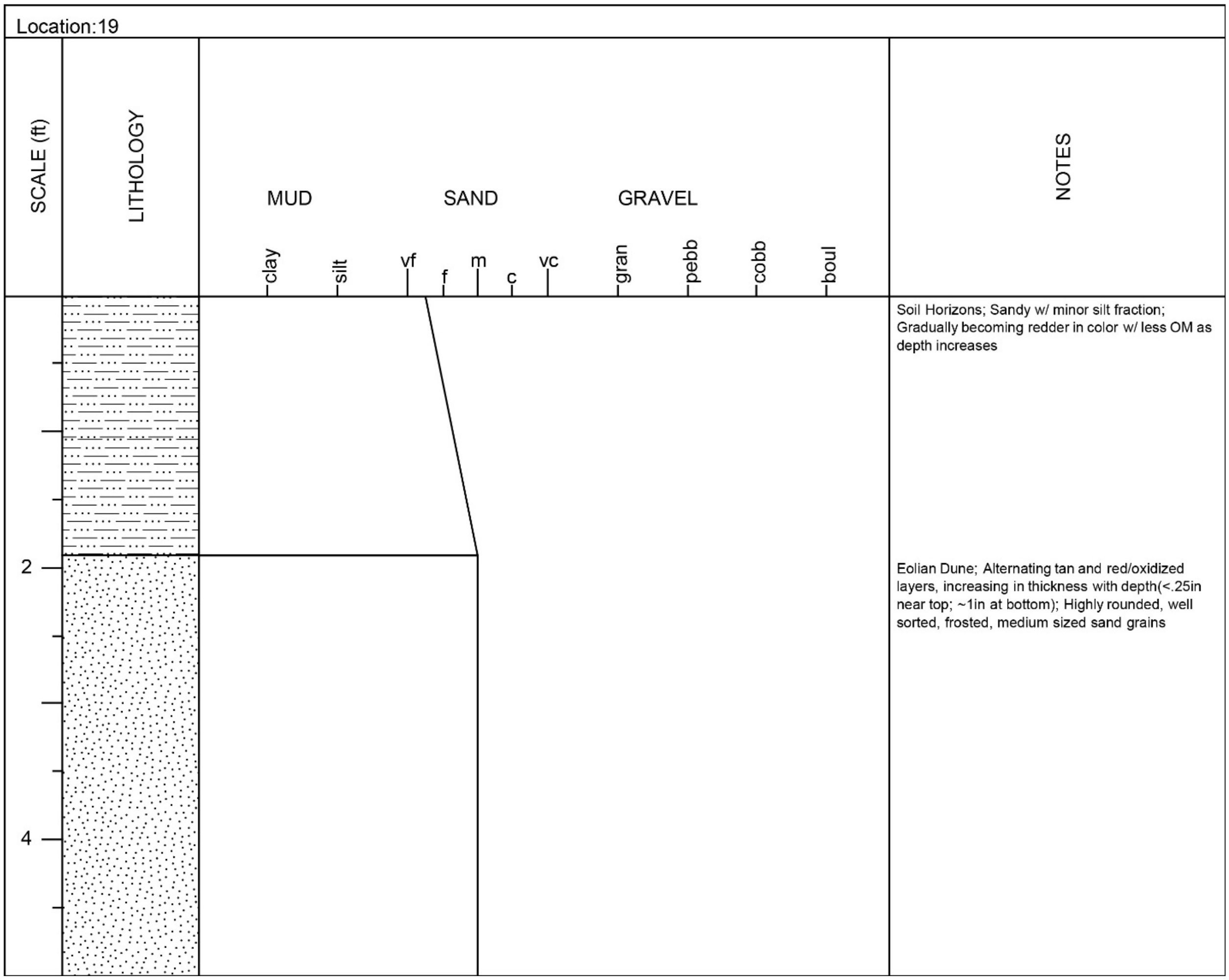
Location: Site 6; Schwerker Farm South Pasture; Hillcut
FORMATION
SCALE (ft)
LITHOLOGY
MUD
SAND
GRAVEL
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
NOTES
2
4
6
8
A Horizon
AB Horizon
B Horizon
C Horizon
Grey silty clay with oxidized banding
Clay with oxidized iron banding
Blue-grey clay with red oxidized laminae; 0.1ft thick oxidized iron lower boundary
Interbedded medium grained sand and grey clay; average thicknesses of .5ft and .2ft, respectively. Sands contain truncating crossbeds; Clays contain oxidized iron laminae.
Blue-grey clay with sand lenses and soft sediment deformation at lower boundary
Medium-course grained, well sorted sand. Minor pebbly constituents
Course subangular sand; high percentage of gravel sized particles; very immature sand

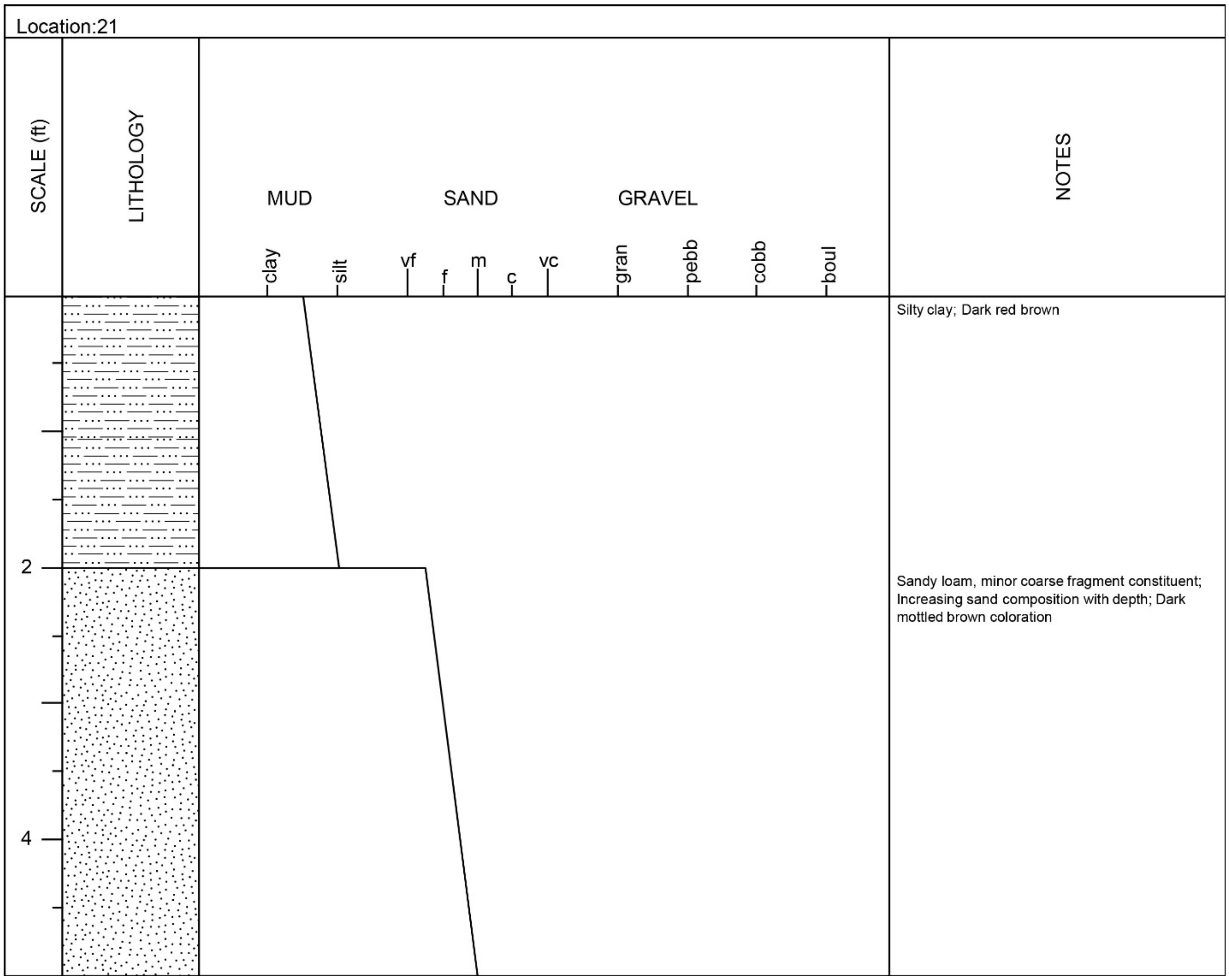

Location: Site 10; Schwenker Main Farm; South Pasture
SCALE (ft)
LITHOLOGY
MUD
SAND
GRAVEL
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
NOTES
2
4
- Increasing silt component to 4' then decreasing to uniform clay
- Black and red oxidation laminae more pronounced after 4'

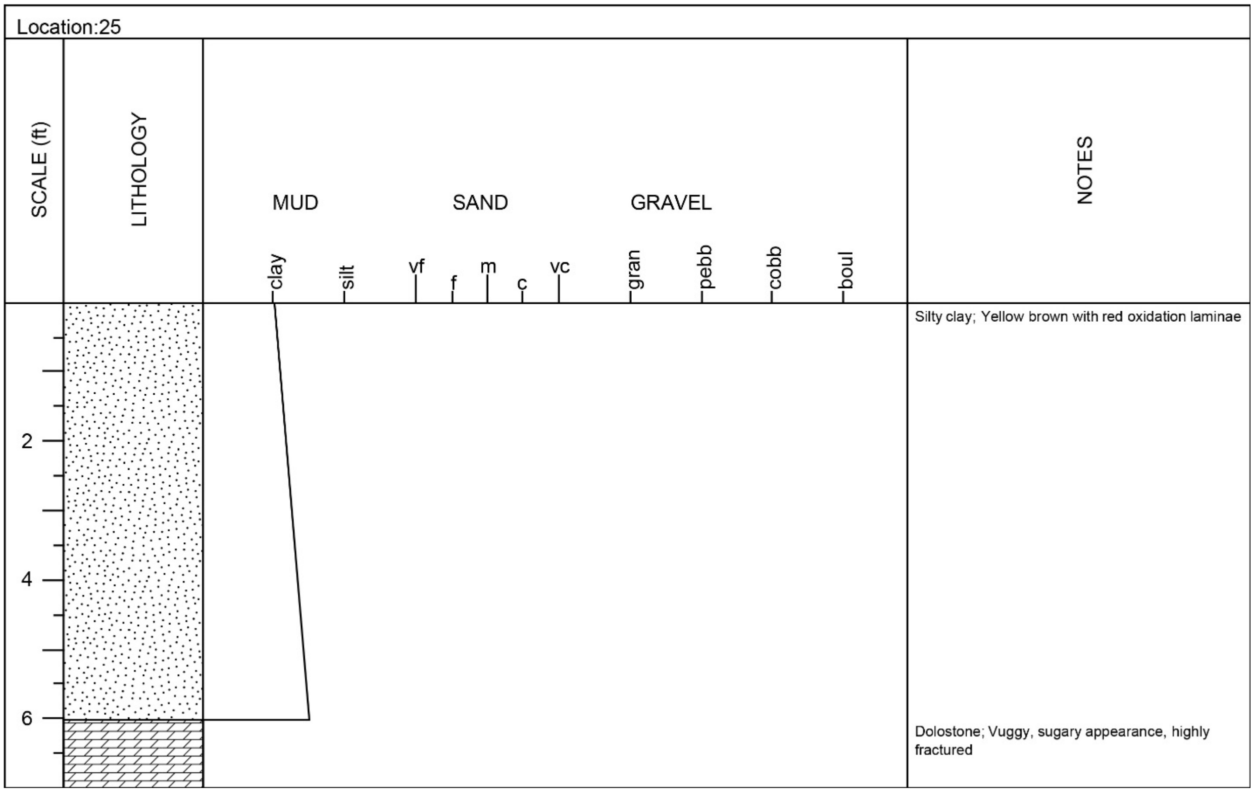

Location:13
SCALE (ft)
LITHOLOGY
MUD
SAND
GRAVEL
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
NOTES
2
4
Sandy clay loam
Coarse, clayey sand; <1% pebbles
Coarse, clayey sand; 10-20% pebbles

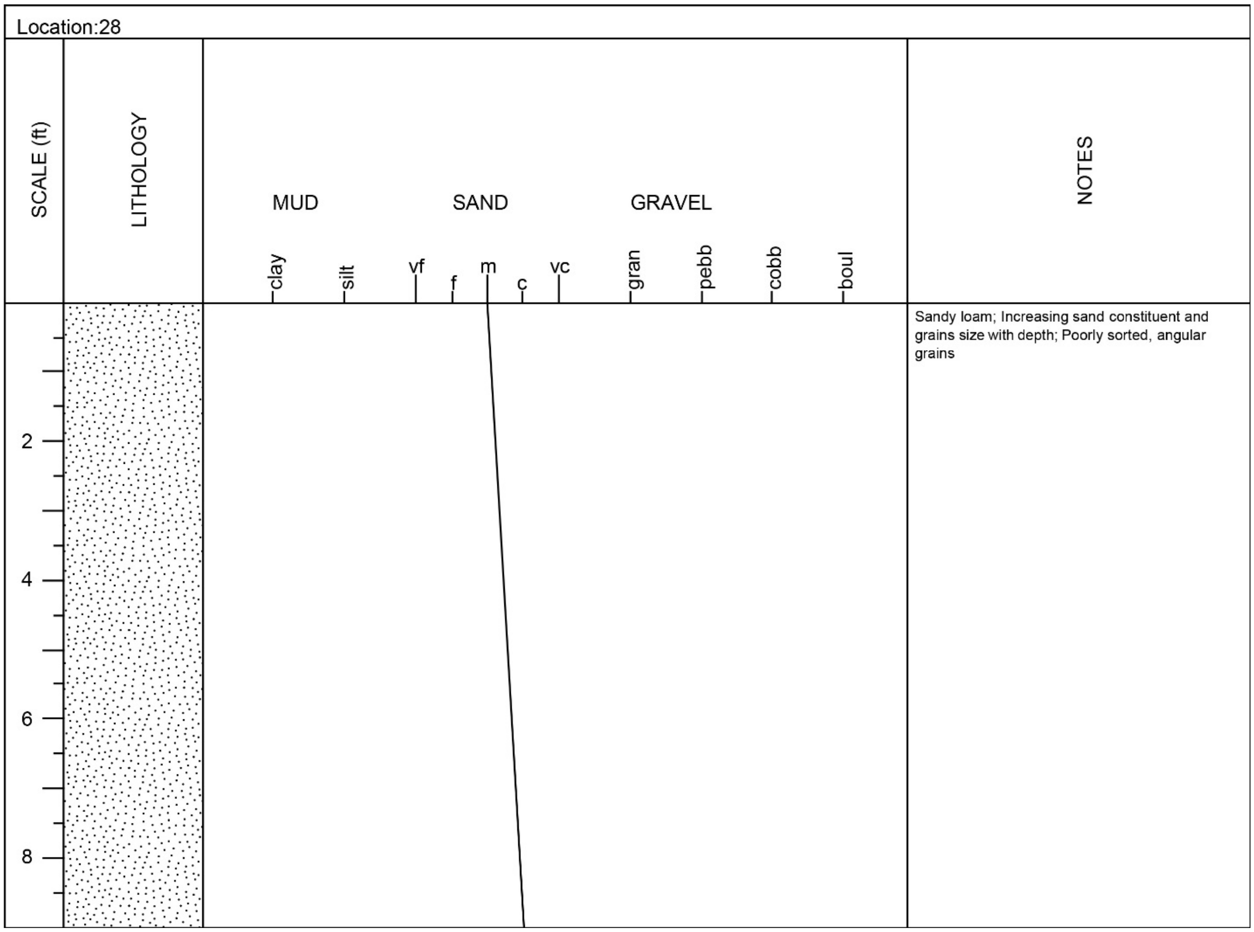


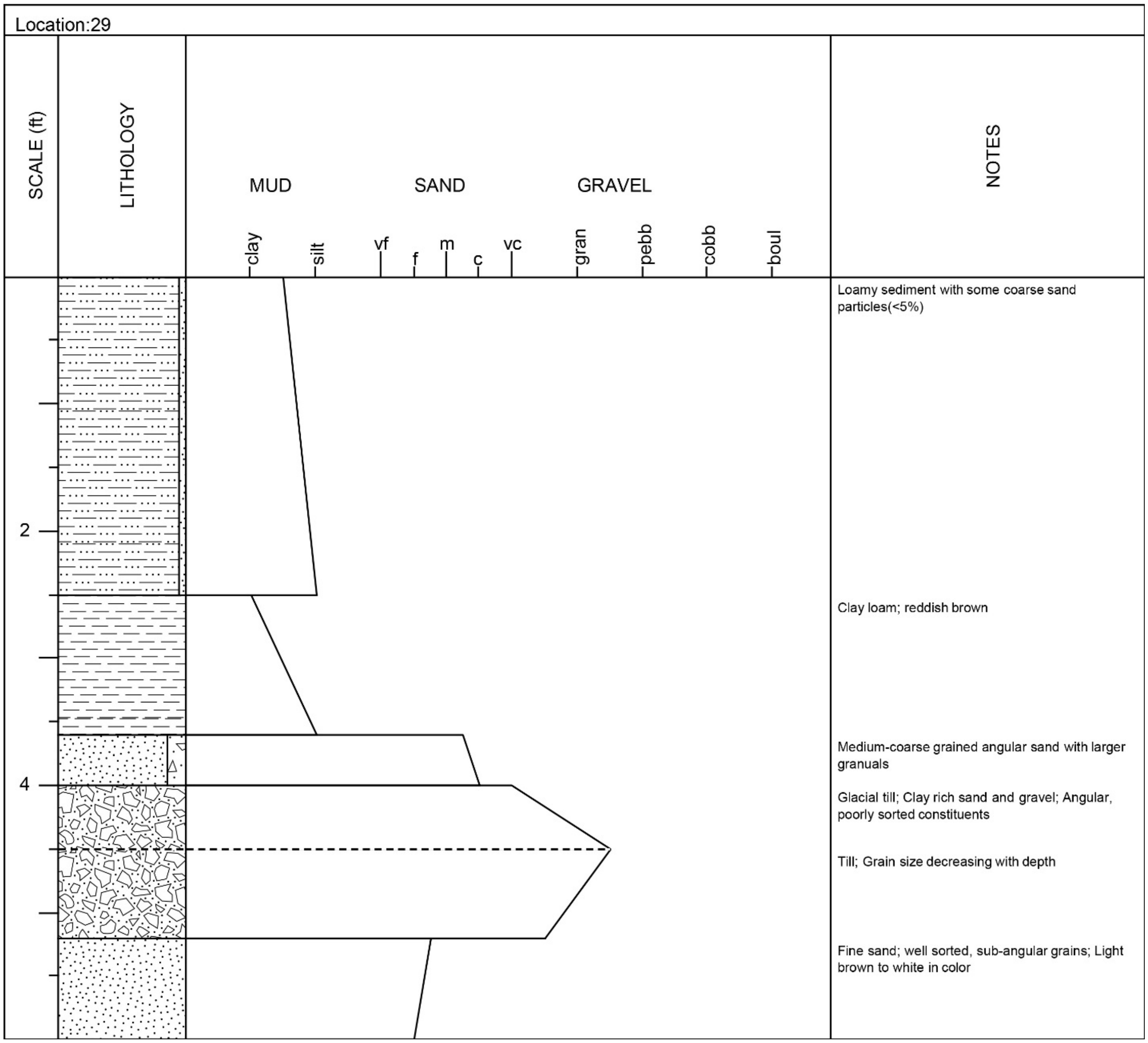
Location:15
SCALE (ft)
LITHOLOGY
MUD
SAND
GRAVEL
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
NOTES
2
4
Clayey loam; Blocky, crumbly structure / texture
Silty sand; Dark colored, moderately structured
Medium sand w/ ~10% coarse fire treated chert fragments
Medium sand; Well sorted, <10% rounded coarse fragments


Location:19
SCALE (ft)
LITHOLOGY
MUD
SAND
GRAVEL
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
NOTES
2
4
Soil Horizons; Sandy w/ minor silt fraction; Gradually becoming redder in color w/ less OM as depth increases
Eolian Dune; Alternating tan and red/oxidized layers, increasing in thickness with depth(<.25in near top; ~1in at bottom); Highly rounded, well sorted, frosted, medium sized sand grains


Location:21
SCALE (ft)
LITHOLOGY
MUD
SAND
GRAVEL
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
NOTES
2
4
Silty clay; Dark red brown
Sandy loam, minor coarse fragment constituent; Increasing sand composition with depth; Dark mottled brown coloration


Location:25
SCALE (ft)
LITHOLOGY
MUD
SAND
GRAVEL
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
NOTES
2
4
6
Silty clay; Yellow brown with red oxidation laminae
Dolostone; Vuggy, sugary appearance, highly fractured


Location:28
SCALE (ft)
LITHOLOGY
MUD
SAND
GRAVEL
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
NOTES
2
4
6
8
Sandy loam; Increasing sand constituent and grains size with depth; Poorly sorted, angular grains


Location:29
SCALE (ft)
LITHOLOGY
MUD
SAND
GRAVEL
clay
silt
vf
f
m
c
vc
gran
pebb
cobb
boul
NOTES
2
4
Loamy sediment with some coarse sand particles(<5%)
Clay loam; reddish brown
Medium-coarse grained angular sand with larger granuals
Glacial till; Clay rich sand and gravel; Angular, poorly sorted constituents
Till; Grain size decreasing with depth
Fine sand; well sorted, sub-angular grains; Light brown to white in color