2021

A Survey of and Site Treatment Plan for the Belle Creek Mounds Archeological Site, 21GD0072, in Goodhue County, Minnesota

Alexander T. Anton
Minnesota State University, Mankato

A Survey of and Site Treatment Plan for the Belle Creek Mounds Archeological Site, 21GD0072, in Goodhue County, Minnesota

By

Alexander T. Anton

A Thesis Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Science

In

Applied Anthropology

Minnesota State University, Mankato

Mankato, Minnesota

September 2021

September 30, 2021

A Survey of and Site Treatment Plan for the Belle Creek Mounds Archeological Site, 21GD0072, in Goodhue County, Minnesota

Alexander T. Anton

This thesis has been examined and approved by the following members of the student's committee.

____

Dr. Ronald C. Schirmer (Advisor)

____

Dr. Phillip H. Larson (Committee Member)

____

Dr. Kathleen T. Blue (Committee Member)

Acknowledgements

This thesis and its associated project would not have been possible without the support of Prairie Island Indian Community who provided property access, funding, personnel, and equipment to conduct the following research. Thank you to all members and friends of the Prairie Island Indian Community, I am grateful for the opportunity to have conducted thesis research at Belle Creek Mounds and for your warm reception and your light-heartedness during all of my work with you. I would also like to thank the members of the Prairie Island Indian Community Tribal Council for their interest in this project that makes it all the more meaningful. Thank you to Dr. Ronald Schirmer for allowing me to make Belle Creek Mounds the subject of my thesis and for all of his patience and effort in attempting to help me improve as an archeologist. Thank you to Andrew Brown who generated many of the datasets used for analysis in this thesis including a LiDAR derived digital elevation model and hillshade and relative soil resistance and magnetometry rasters, in addition to his other innumerable contributions to this project. Thank you to Donald Johnson who provided geophysical equipment and training to the archeological surveying crew to allow us to collect relative soil resistance and magnetometry data. Thank you to Franky Jackson for transporting personnel and equipment to and from the site, day in and day out, helping clear vegetation in preparation for geophysical data collection, assisting with geophysical data collection, and for his advocacy for this research. Thank you to Luke Burds for helping with fieldwork, and his assistance with collecting magnetometry and ground penetrating radar data, as well as walking me through using software to process ground penetrating radar data in particular. Thank you to Anna Wiitanen-Eggen for her assistance with fieldwork, especially in establishing the geophysical grid and collecting relative soil resistance data. Thank you to Matt Jackson who cleared much of the vegetation in preparation for the geophysical survey and assisted the archeological surveying crew with shovel testing. Thank you to Drs. Phillip Larson and Kathleen Blue for serving on my thesis committee, giving me invaluable feedback to improve this thesis, and for taking the time to participate in and contribute to this project's fieldwork. I would also like to thank Noah White and Joey Taylor for their support of research done at the Prairie Island Indian Community Tribal Historic Preservation Office used in this thesis. Lastly, a sincere thank you to any and all who have come out to the site in support of the project related to this thesis.

Any errors in this document are mine alone.

Table of Contents

A Survey of and Site Treatment Plan for the Belle Creek Mounds Archeological Site, 21GD0072, in Goodhue County, Minnesota

Alexander T. Anton

A Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Applied Anthropology

Minnesota State University, Mankato
Mankato, Minnesota
September, 2021

Abstract

The Prairie Island Indian Community (PIIC) recently purchased property, on which a portion of a prominent archeological site, encompassing 67 formerly documented burial mounds, resides. In order to better protect the burial mounds and other culturally significant material on the site, as well as on sites residing on the remainder of their new property, the PIIC enlisted the support of Minnesota State University, Mankato's Earth Science, Archeology, Resources, and Terrestrial Hazards (EARTH) Systems Research Laboratory in developing a site treatment plan. Developing a useful site treatment plan necessitated conducting a geoarcheological survey of a portion of the archeological site, known as the Belle Creek Mounds site, on the acquired property. The survey included both geospatial and geophysical survey to locate and identify burial mounds, impacts to burial mounds, and evidence of site usage. Limited excavation took place to better understand the extent to which buried cultural materials need protection, how ancient people used the archeological site in the distant past, and how Belle Creek Mounds relates to other sites in the surrounding area. Geophysical techniques produced results supporting their effectiveness at identifying impacted and previously unmapped mounds on site. The artifacts recovered during limited excavation at Belle Creek Mounds are similar to artifacts recovered at previously investigated aggregation villages within the Red Wing Region. This thesis is for use by PIIC, in combination with geospatial and geophysical datasets generated by this and related projects, to assist in protecting the Belle Creek Mounds site and surrounding sites and in setting a precedent supporting greater use of geophysical techniques in archeological investigations of potential mortuary features.

Table of Figures

Chapter 1 – Introduction

The Prairie Island Indian Community (PIIC), in southeastern Minnesota, is facilitating a rekindling of its relationship with locations significant to its ancestry. The community has recently purchased a property (Figure 1-1) encompassing six archeological sites, most of which are associated with pre-Euro-American contact Native American earthworks commonly referred to as mounds.

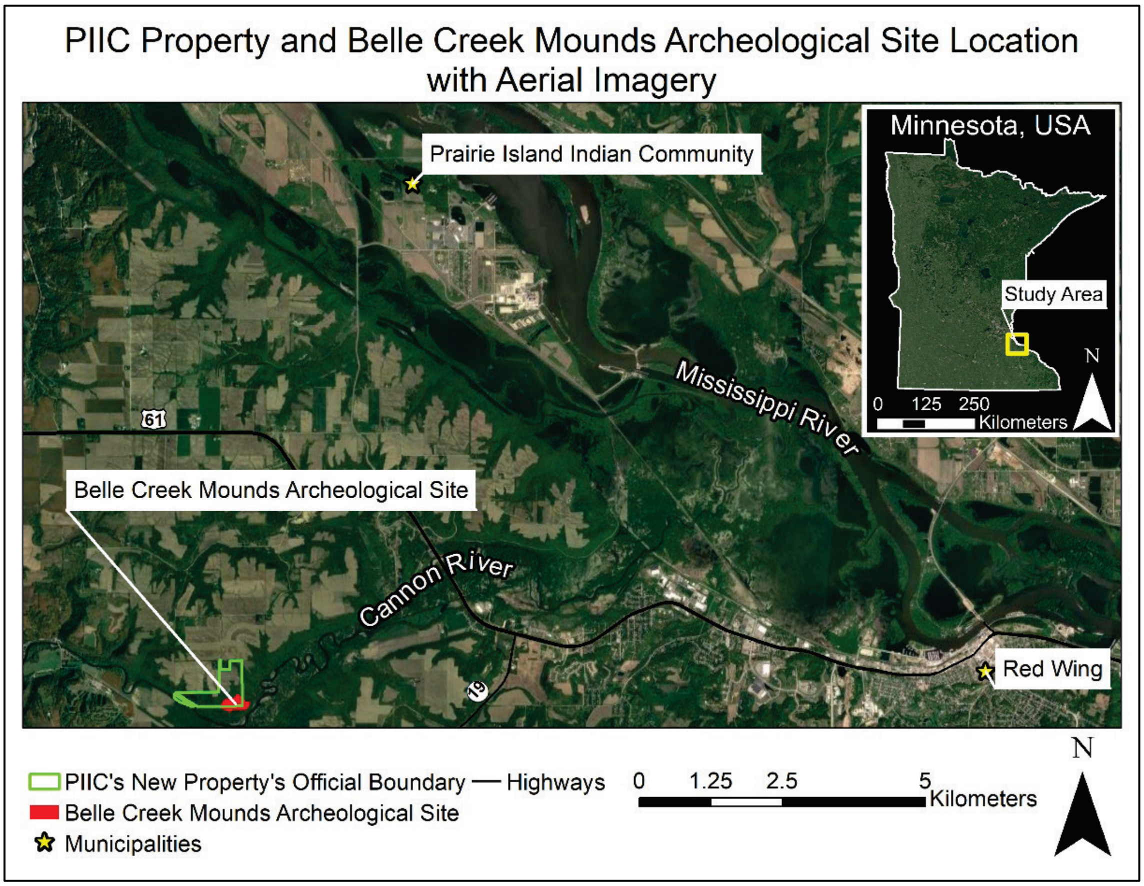

Figure 1-1: Geographic location of PIIC property and Belle Creek Mounds Archeological Site.

Mounds are normally primarily constructed of soils surrounding and within 30 meters of their boundary and tend to be roughly circular (Arzigian and Stevenson 2003:65 and 136).

Those that are roughly circular average 12.29 meters in diameter and 1.09 meters in height (Arzigian and Stevenson 2003:65). Mounds regularly contain ritually buried human remains, containing human remains more than 75% of the time (Arzigian and Stevenson 2003:232). The most prominent of the archeological sites located on PIIC's new property is formally identified as 21GD0072 and known as the Belle Creek Mounds site, which archeologists interpret as being associated with the Woodland Tradition, Middle Mississippian Tradition influenced Silvernale Phase, as well as the Oneota Tradition commonly encountered throughout southern and central Minnesota (Minnesota Office of the State Archaeologist 2021b). To protect the Belle Creek Mounds site, as well as the other associated archeological sites residing on their new property, the PIIC worked with Minnesota State University, Mankato's Earth Science, Archeology, Resources, and Terrestrial Hazards (EARTH) Systems Research Laboratory, on a project to develop a site treatment plan informed through a geoarcheological survey, supervised by Dr. Ronald Schirmer.

A site treatment plan for the Belle Creek Mounds site, because of its cultural and archeological importance, its similarity to the other archeological sites also present on PIIC's newly acquired property, and its greater visibility and accessibility, gave the EARTH Systems Research Laboratory (ESRL) an opportunity to facilitate an understanding of the nature, extent, and conditions of archeological and cultural material on PIIC's new property. This site treatment plan seeks to aid the PIIC in both protecting and interpreting the archeological materials present on the Belle Creek Mounds site in addition to the remainder of their newly acquired property. It also seeks to supplement southeastern Minnesota's archeological record and further establish the use of geophysical and geospatial techniques in archeological site protection. This thesis is one part of what will certainly need to be a more extensive site treatment plan; only the cultural resources are considered here, but other types of resources and situations (e.g., plants, erosion, etc.) will need to be considered in a broader treatment plan for the whole property.

The PIIC's acquisition of the northern portion of the Belle Creek Mounds archeological site is significant due to North American indigenous communities experiencing, especially over the last 200 years, forced disconnection from the sense of place and meaning derived through physical interaction with areas of cultural-historical importance. The United States of America's Indian Removal Act of 1830 formalized a long period of intensive displacement, dispossession of Native American homelands, and in some cases, genocide of Native American peoples (Colwell-Chanthaphonh 2005:377). However, immigrants to North America began displacing Native American people long before the Indian Removal Act, throughout the colonization of North America and creation and growth of the United States (Littlefield and Parins 2011:xiii–xv).

Following the government of the United States coercing Native American tribes into ceding their lands, indigenous people within the United States lost rights to access many of the properties linked with their past. The enactment of the National Historic Preservation Act (NHPA) of 1966 involved Native American tribes in a consultation process revolving around the preservation of areas of historical significance potentially impacted by federally associated projects within the United States (U.S.) (U.S. Congress 1966:35–36). However, this act did not grant federally recognized tribes the right to unilaterally disallow the destruction of sites that tribes deemed important to protect. The NHPA also failed to give tribal members the right to access sites, associated with their past, preventing cultural connection with them through presence or ceremony.

Years of Native American advocacy and protest spurred the U.S. government's passage of stronger legislation allowing tribes and federal agencies to protect areas of cultural significance from destruction and looting, as well as granting Native Americans access to culturally significant areas to perform religious ceremonies (Horton 2017:23). The Indian Religious Freedom Act of 1978 allowed Native Americans to access places they regarded as sacred, and the Archaeological Resource Protection Act of 1979 made it illegal for an individual to excavate and remove artifacts from federal or tribal lands with the exception of arrowheads and excavation and removal done with federal or tribal permission (U.S. Congress 1978, 1979:139–145). These acts still allowed for the destruction of Native American burial grounds on private land and possession of Native American remains and cultural patrimony from burial sites located on public land. In the state of Minnesota, Statute 307.08 was updated in 1980 to prevent the molestation of all human remains and burials found on public and private land without permission from the State Archaeologist and Indian affairs inter-tribunal board, now the Minnesota Indian Affairs Council (Minnesota Legislature 1980). This included protections against looting and excavating Pre-Contact Native American burial mounds. The Native American Graves Protection and Repatriation Act of 1990 gave tribes the ability to repossess Native American human remains and cultural patrimony held in public institutions or recovered from public lands (U.S. Congress 1990).

Unfortunately, despite the relatively recent passage of meaningful legislation encouraging the protection of Native American burials and archeological sites in the U.S. and Minnesota, many Native American burial sites, including mound sites, continue to be damaged and neglected. People continue to be ignorant or disrespectful of indigenous wishes as to how Native American burial grounds, including mound sites, should be treated. One Minnesotan, in 2014, expressed a negligent perspective on Native American mounds when he reported being bothered by not having the ability to build onto his house or move his garage because of a mound on his property that he believed was looted and was therefore meaningless to Native Americans (Smetanka 2014). Additional damage to previously impacted burial mounds likely took place in Red Wing, Minnesota, in 2013, when a new trail was constructed in an area that once contained mounds, without proper review including the Office of the State Archaeologist (Minnesota Office of the State Archaeologist 2014:25). Moreover, construction of a border wall by the United States along its southern border, knowingly threatened indigenous burial grounds (Ortiz 2020).

If indigenous communities own the land on which sites with special religious and cultural significance reside, the communities have more rights in terms of protection and use, resulting in fewer threats to a significant area's integrity as well as ease of access for religious rites (Post 2006). In order to promote the best possible practices in preserving, using, and appreciating archeological and cultural sites, it is necessary to understand the types and extent of archeological and culturally significant materials present, what their condition and history is, and possible threats to their preservation. For this reason, an archeological survey is important to perform on newly acquired properties.

As is shown in Chapter 4, some of the cultural resources that were formerly visible at the site no longer have determinable surface expression and must be sought using advanced geophysical means. However, a larger mound in a highly impacted area on site, and mounds in formerly uncultivated wooded areas remain visible and have discrete geophysical signatures lending complementary data to the identification of mounds damaged beyond the point of visual identification and previously unidentified visible mounds. Recovered and noted cultural material present among and adjacent to the mound group allows for more refined interpretation of the people who potentially used, built, and lived among the Belle Creek mound group in the distant past, and gives tangible support to substantial village or ceremonial archeological deposits being present in close proximity to the mound group.

Appropriate cultural protocols congruent with the wishes and traditions of the Prairie Island Indian Community were followed upon arriving at the site.

Chapter 2 – Background

Location

The Belle Creek Mounds archeological site is located within Goodhue County in southeastern Minnesota partially on property recently purchased by the Prairie Island Indian Community in Welch Township, approximately 2 kilometers west of the city limits of Red Wing, Minnesota (Figure 1-1) (Minnesota Department of Transportation and Minnesota Geospatial Information Office 2009). The Prairie Island Indian Community's property consists of 48.87 hectares of land, 5.58 of which make up the northwestern half of the 10.03-hectare Belle Creek Mounds archeological site (Esri Inc. 2020; Goodhue County 2020; Minnesota Department of Transportation 2017). The project's primary area of investigation within the Belle Creek Mounds site is a 100 x 40-meter rectangular area with a 20 x 20-meter square area appended on to its western edge at its northwestern corner. The area of investigation is 0.45 hectares in size, and just northeast of the approximate center of the Belle Creek Mounds site, on PIIC property (Figure 2-1). The site occupies a terrace positioned along the northern bank of the Cannon River at elevations of approximately 245 to 250 meters above mean sea level (MAMSL), about 40 meters higher than the elevation of the Cannon River adjacent to the site location (Minnesota IT Services - Geospatial Information Office 2011). The site and property are fairly close to the Cannon River's confluence with the Mississippi River, which is approximately 10 kilometers east.

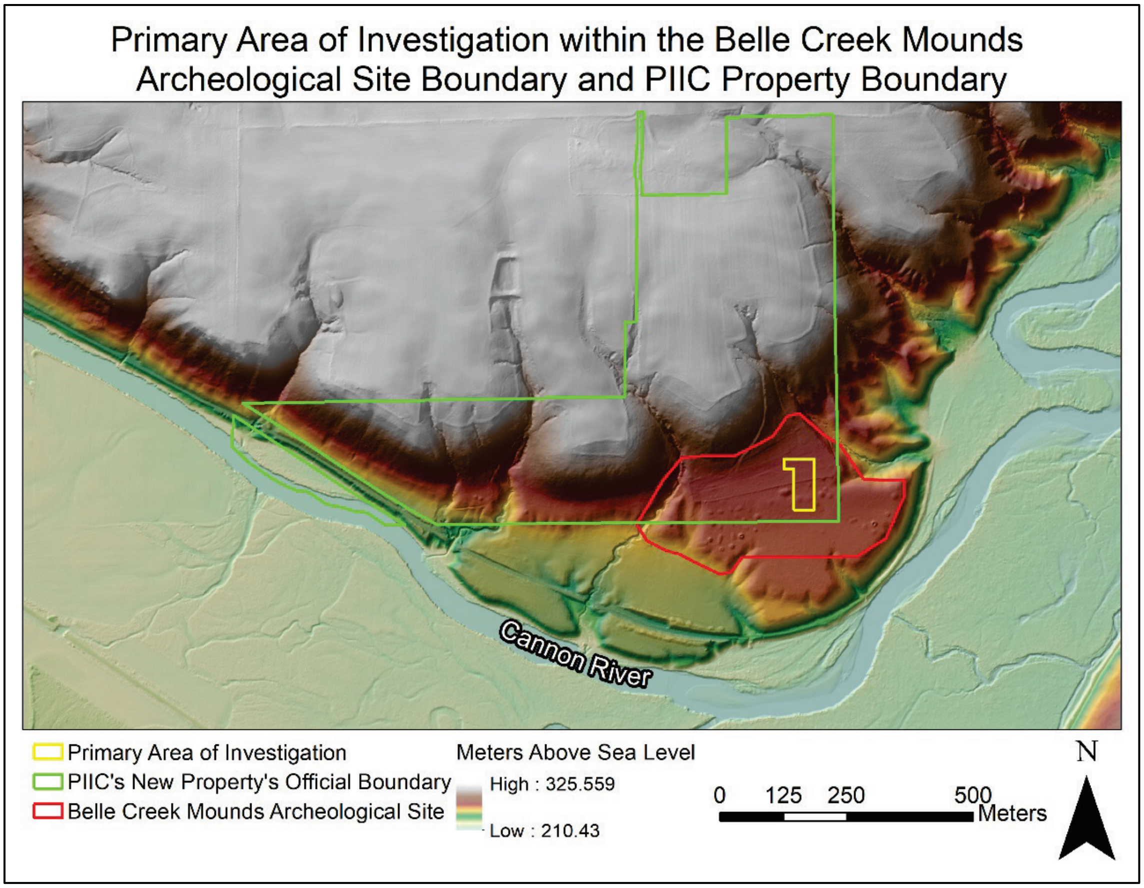

Figure 2-1: Primary area of investigation within the Belle Creek Mounds site boundary and PIIC property boundary.

The site and property are both located within the U.S. Department of Agriculture's Natural Resource Conservation Service's (NRCS's) Eastern Iowa and Minnesota Till Prairies Major Land Resource Area (United States Department of Agriculture Natural Resources Conservation Service 2006:324). This area is within the U.S. Interior Plains' Central Lowland Physiographic Provence described as being mostly associated with dissected till plains, but in small part with the less-recently glaciated Wisconsin Driftless Section in its northeastern portion (United States Department of Agriculture Natural Resources Conservation Service 2006:324). Surficial geological geospatial data indicates that the Belle Creek Mounds archeological site resides upon glacio-fluvial outwash sands from the

Late Wisconsin Subdivision of the Late Pleistocene Epoch or Early Holocene Epoch, ~10,000 – 8,000 BCE, surrounded by uplands associated with Pre-Illinoian Till, with a depositional age less than ~700,000 BP, but greater than ~300,000 BP. This geospatial data indicates that the site was not glaciated during any of the Wisconsin Sub-divisions or Illinoian Sub-division on the geological time scale (Fullerton et al. 2003; National Soil Survey Center 2012:5–9; Ojakangas and Matsch 1982:104 and 233).

The Wisconsin Driftless Area was likely glaciated during far less recent Pre-Illinoian glaciations, but hundreds of thousands more years of wind and water related erosion and deposition created a landscape with greater relief and far fewer lakes than the more recently glaciated surrounding areas (Ojakangas and Matsch 1982:233). The reason there are so few lakes in the area is because of its well-drained soils and extensive dendritic drainage pattern. *Minnesota's Geology* describes the landscape near Red Wing, Minnesota as:

> one of rolling hills and well-established stream networks… considerably eroded and displaying numerous bedrock outcrops on the valley sides. Mantling the drift and bedrock is a thin blanket of loess, a fine-textured silt, powdery to the touch, deposited by the wind during the last glaciation (Ojakangas and Matsch 1982:104).

Loess deposits can range from 9 meters in depth on broad ridges to less than 30 centimeters in depth along valley walls (Minnesota Department of Natural Resources 2021).

The underlying bedrock geology near Red Wing, Minnesota consists of Paleozoic, 542 Ma – 251 Ma, marine sandstones, carbonates, like dolomite and limestone, and shales containing fossils. This material is occasionally topped with more recent Cretaceous age material, 145 Ma – 65.5 Ma, reflecting both marine and continental environments just below glacial deposits from the early and middle Pleistocene, 2.6 Ma – 300,000 BP, and post-glacial sediments from the Holocene, 10,000 – 0 BP (National Soil Survey Center 2012:5–9; Ojakangas and Matsch 1982:234). The area's river valleys are filled with recent alluvium made up of clay, silt, sand, and gravel (United States Department of Agriculture Natural Resources Conservation Service 2006:325).

Red Wing, Minnesota's current climate is classified as a humid continental climate using the Köppen climate classification system. The average annual temperature in Red Wing is 7.1°C or 44.8°F with seasonal fluctuations, including a low monthly average of –10.8°C or 12.6°F in January and a high average of 22.3°C or 72.1°F in July; the average annual precipitation is 774 mm. or 30.5 inches (Climate-Data.org 2021). According to the Minnesota Department of Natural Resources' (MNDNR) and United States Forest Service's (USFS's) ecological classification system, the posited pre-Euro-American settlement vegetation within the Belle Creek Mounds archeological site's ecological subsection consists of tallgrass prairies on broad ridge tops, bur oak savannas on ridge tops and dry high slopes, red oak, white oak, shagbark hickory, and basswood forests on moister slopes, and red oak, basswood, and black walnut forests in protected valleys (Minnesota Department of Natural Resources 2021). As the Belle Creek Mounds archeological site is on a broad higher terrace with a south-facing slope within a river valley, a red oak, basswood, and black walnut forest or a tallgrass prairie are two probable candidates for its pre-Euro-American settlement vegetation. The present land usage distribution for the Blufflands Subsection, which the study area resides within, is 30% cropland, 20% pasture, and 50% woodland (Minnesota Department of Natural Resources 2021).

Making sense of an archeological site, especially while attempting to use geophysical methods to do so, is made easier by understanding the soils in the areas being analyzed. The soils within the area of investigation at the Belle Creek Mounds archeological site consist of moderately eroded Lindstrom silt loam associated with 12 to 18 percent slopes, moderately eroded Lindstrom silt loam associated with 6 to 12 percent slopes, and moderately eroded Lilah sandy loam associated with 0 to 6 percent slopes (Soil Survey Staff 2021). Both Lindstrom series soils are taxonomically classified as fine-silty, mixed, superactive, mesic, Cumulic Hapludolls and tend to develop in loess or alluvial sediments on foot slopes or toe slopes of dissected uplands (Soil Survey Staff 2005). The Lilah series soil is taxonomically classified as a mixed, mesic, Psammentic Hapludalf and tends to form in loamy sediments and in underlying gravelly outwash (Soil Survey Staff 2007). The Lindstrom series soils comprise the northern 2/3 of this project's area of investigation and the Lilah series soil comprises the remaining southern 1/3 (Figure 2-2) (Soil Survey Staff 2016). The native vegetation associated with the soil types on site is consistent with the MNDNR/USFS ecological classification system's posited pre-settlement vegetation, noted above. Lindstrom series soils are reported as having mixed tall grass prairie and deciduous forest as native vegetation. Lilah series soils are reported as having mixed big bluestem, switchgrass, and other tall grass prairie grasses and deciduous trees as native vegetation.

Although the Lindstrom and Lilah series soils have similar native vegetation, their typical pedons have significant differences. The profile of the Lindstrom type soil can be broken down as: Ap 0–23 cm., black (10YR 2/1) silt loam; A1 23–56 cm., very dark brown (10YR 2/2) silt loam; A2 56–74 cm., very dark grayish brown (10YR 3/2) silt loam; Bw1 74–97 cm., dark brown (10YR 3/3) silt loam; Bw2 97–112 cm., brown (10YR 4/3) silt loam; Bw3 112–152 cm., dark yellowish brown (10YR 4/4) silt loam; C 152–178 cm., yellowish brown (10YR 5/4) loam (Soil Survey Staff 2005). The profile of the Lilah type soil can be broken down as: Ap 0–15 cm., very dark grayish brown (10YR 3/2) sandy loam; BA 15–23 cm., dark yellowish brown (10YR 3/4) sandy loam; Bt1 23–38 cm., brown (7.5YR 4/4) gravelly sandy loam; 2Bt2 38–71 cm., strong brown (7.5YR 5/6) gravelly loamy sand; 2Bt3 71–99 cm., strong brown (7.5YR 5/8) sand; 2C 99–203 cm., strong brown (7.5YR 5/8) loamy sand (Soil Survey Staff 2007). The Lindstrom soil series has a much thicker A horizon, weakly developed B horizons, as well as a consistently silty texture associated with a smaller particle size. The Lilah soil series has a sandy texture associated with a larger particle size, thinner A horizon, 3 well developed clay rich B horizons, two of which are derived from different parent material than the horizons above them, and excessive drainage.

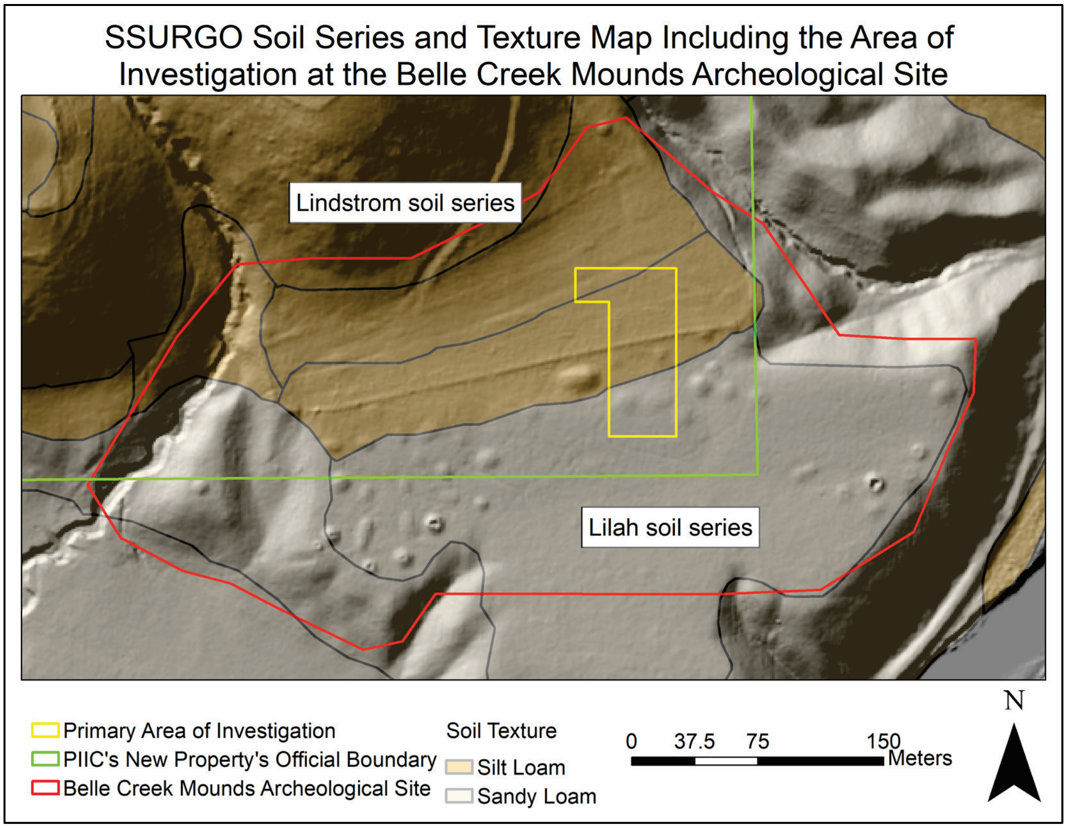

Figure 2-2: SSURGO soil map including the area of investigation at the Belle Creek Mounds Archeological Site.

The genesis of Lindstrom soil series within the area of investigation (AOI) can be explained using the soil catena concept. The Lindstrom soil likely has a much thicker topsoil than the Lilah series further south because in the area where the Lindstrom soil is located, colluvium from the slope to the north accumulates as a result of the area within the northern part of the AOI residing on a toeslope. The two different parent material types present in the Lilah soil series profile are explained by eolian loess covering a terrace tread comprised of glacial outwash following the outwash's deposition.

The formation process of the area's river channels and their associated terraces is of concern to geomorphologists. Local terrace formation on the tributaries of the Upper

Mississippi River in the Wisconsin Driftless Area is inferred as beginning with the aggradation or buildup of glacial outwash sediment in tributary channels during glacial melting followed by stream incision and partial removal of the deposited outwash facilitated by drops in water elevation at streams' mouths (Faulkner et al. 2016:85 and 89–92). Following incision, a relatively smaller accumulation, aggradation, of sediment on either side of streams created somewhat-flat floodplains during minor flood events with major riverbed armor breaching flood events and further drops in water elevation at streams' mouths beginning further incision leaving behind portions of unincised former floodplain as terraces, higher than where new floodplains formed (Faulkner et al. 2016:85 and 89–92). For a more detailed description of these fluvial geomorphological processes read Faulkner et al. 2016.

Archeological Theoretical Foundations and Setting

In attempting to discern the reasons for the presence of and relationships between various artifacts and features associated with past people, archeologists developed artificial artifact and feature based taxonomies that are ultimately combined to define manifestations of specific artificially defined archeological cultural groupings (Hegmon 1992:530–531). Here, "artifact" is defined as a human used, modified, or manufactured object, and "feature" is defined as non-portable evidence of past human activity including refuse and storage pits, architectural remains, fire hearths, artifact clusters, and anthropogenic soil stains (Kelly and Hurst Thomas 2017:2 and 29). The stylistic characteristics of artifacts and features are inextricably linked to adaptive human technological production, function, and exchange, social organization, communication of ethnic affiliation, and/or expression of a particular ideology (Hegmon 1992:519 and 531–532; Schortman 1989:56–59). However, ethnographic observations indicate that the artifacts used in distinguishing a person's specific identity may not preserve well, preventing archeologists from ever fully reconstructing a past society's system of affiliations (Schortman 1989:56). Even so, through analyses and determinations of associated types of preserved stylistic variations in spatially and temporally distinct artifacts and features, cultural associations can be created or assigned in connection with inferred past populations that manufactured the recovered artifacts and features found at archeological sites (Schortman 1989:56–57). It then stands to reason that through analyses of artifacts and features' stylistic variations, evidence of changes within and interactions between cultural groupings can be indicated with the adoption of stylistic characteristics lacking presence earlier in a population's timeline. Analogical inference is central to the previously discussed analytical approach, with one archeologist and philosopher supporting the validity of analogical inference citing existing methodological strategies for evaluating the strength of inferences, for adding support for or against specific inferences, and for rejecting false analogies (Wylie 1985:107).

Archeological cultural classifications in North America consist of a system based primarily on Gordon Willey and Phillip Phillips' system outlined in *Method and Theory in Archeology* (Kelly and Hurst Thomas 2017:141–143). Willey and Phillips' work defines spatial divisions, basic archeological units, temporal series, and integrative units for use in organizing archeological data to facilitate its interpretation (Willey and Phillips 1958). The spatial divisions are defined as the locality, varying in size from a single site to a district not larger than might be occupied by a single community; the region, a unit of area loosely applied but very apt to coincide with minor physiographic subdivisions in which cultural homogeneity cannot be assumed; and the area, a large spatial unit similar to a cultural area of the ethnographer like the Southwest in the United States (Willey and Phillips 1958:18–21). Basic archeological units consist of the phase, a basic unit designed as being limited spatially to a locality or region and chronologically to the briefest possible amount of time that is characterized by distinctive and highly specific artifact types that distinguish it from all similarly conceived units, and the component, defined as the manifestation of a phase within soil stratum or strata that are presumed to be culturally homogenous (Kelly and Hurst Thomas 2017:143; Willey and Phillips 1958:21–24). Ideally components are eventually combined to create broader archeological phases spanning across space (Willey and Phillips 1958:27). Many phases are associated with specific projectile point and pottery styles and some extend into multiple regions in practice. Examples of temporal series are the local sequence, a formerly exclusively soil stratigraphy-based series of components describing the order in which components are present at a single site or locality; the regional sequence, the product of correlating similar local sequences at the regional level that can result in the extension of defined phases across regions; and the period, a relatively long length of time defined through associations with gross changes in archeological remains related to highly generalized subsistence methods and material culture (Kelly and Hurst Thomas 2017:143; Willey and Phillips 1958:24–29). Integrative units consist of the horizon, a wide distribution of recognizable stylistic characteristics occupying a relatively brief period of time; the tradition, essentially an archeological manifestation comprised of many phases defined through a broad consistency in observed house styles, settlement patterns, pottery or lack thereof, and subsistence systems present through a large span of time; and climax, the phase or phases of maximum cultural intensity of a tradition (Kelly and Hurst Thomas 2017:142; Willey and Phillips 1958:29–40).

Traditions are sometimes named in association with archeological periods, but often exceed the bounds of the period they are associated with and can overlap in time and space with other traditions. People associated with particular phases and traditions are often referred to as the phase or tradition's name followed by culture or people or, in some instances, simply a demonymization of the name itself, with the related term cultural complex describing an apparent interrelated clustering of cultural traits or characteristics. The most frequently applied elements of the previously discussed organizational system in the background research related to this project seem to be the locality, phase, component, period, and tradition, though sequences are occasionally referenced. It is important to note that past people that appear to have been using similar artifacts are not definitively part of common cultures, though their association with each other is often inferred as previously stated (Anfinson 1979:xi). Though much of the research related to archeology around Red Wing, Minnesota refers to the culturally occupied space near what is now Red Wing as the Red Wing Locality, recent research combined with the previously cited terminology discussed by Willey and Phillips suggests that the Red Wing Region is a more appropriate classification for the location. Archeological materials suggest the permanent and long-term presence of multiple distinct groups, thus invalidating locality as a potential taxonomic unit (Schirmer in preparation:4). Cited research referring to an inappropriately named Red Wing Locality has been adjusted in this research to refer to the Red Wing Region.

Prior to listing and briefly describing archeological sites within set distances of the project's area of investigation, identified using the Minnesota Office of the State Archaeologist's web portal, a review of a portion of the interpreted archeological timeline and archeological research related to southeastern Minnesota's human past, is warranted to ensure a clearer understanding of archeological data discussed in a more detailed manner. The Paleoindian Period in Minnesota, spanning from ~9500 – 6000 BCE, was its first period of human occupation that is supported by archeological evidence (Arzigian and Stevenson 2003:74; Fleming 2009:2). Beginning around 9500 BCE, wide-ranging hunter-gathers lived in an environment in transition, as glaciers that once covered the landscape retreated. The artifacts most commonly affiliated with the period's associated Paleoindian Tradition are long, sometimes fluted, lanceolate points used to hunt large fauna, including mammoth and mastodon early in the period (Arzigian and Stevenson 2003:74; Fleming 2009:2). In the late Paleoindian Period and early Archaic Period global temperature began to rise significantly, ~5°F, reaching a relative high during the Climatic Optimum at ~5800 BCE, transforming many formerly wooded areas, in what is now Minnesota, into prairie (Gibbon 2012:66). The Archaic Period, spanned from ~6000 – 1000 BCE generally and ~6000 to ~500 or 0 BCE in Minnesota (Arzigian and Stevenson 2003:75). The associated Archaic Tradition is characterized by regional differentiation in material culture and apparent adaptations in hunting and gathering techniques that took advantage of a greater number of resources, some of which were specific to particular landforms in various ecological zones, including many species of freshwater fish, mussels, nuts, and berries, with the main animal resource being deer in wooded areas and bison on the plains (Arzigian and Stevenson 2003:75). The Woodland Period ranges from ~500 BCE or ~0 CE – 1000 or 1650 CE in Minnesota with the period ending far more quickly in southeastern Minnesota than in remote northern parts of Minnesota (Arzigian and Stevenson 2003:79). The period's associated Woodland Tradition is characterized by the broad onset, creation, and usage of pottery, burial mounds, the bow and arrow, and horticulture (Arzigian and Stevenson 2003:79).

People residing in southeastern Minnesota during its Late Woodland Period, ~500 – 1100 CE, may be effectively described as belonging to regional and sub-regional groups, with heterogeneous archeological traits, possessing local knowledge and wide-ranging trading and interaction networks spanning Minnesota, from Wisconsin to the Dakotas, and spilling south, well into what is now Iowa and Illinois (Hildebrant Iffert 2010:38 and 43; Schirmer 2002:5 and 36–37). These people, referred to as Late Woodland cultural groups, are inconsistently archeologically documented in southeastern Minnesota's Driftless Area, possibly due to their relatively mobile and dispersed lifeway (Gibbon and Dobbs 1991, 302). As a result, little is known specifically about Late Woodland cultural groups in the Red Wing Region. Broadly speaking, warm weather lowland villages associated with primarily hunting and gathering, including shellfish collection, and some small scale crop production, like the cultivation of goosefoot, knotweed, sunflower, maize, and squash; and cold weather dispersed mobile sheltered-upland-based family camps, allowing for more effective deer hunting, comprise the known pattern of regional Late Woodland cultural subsistence (Hildebrant Iffert 2010:39; Schirmer 2002:36–37). Mound groups regularly consisting of two to 15 conical, linear, and effigy shaped mounds are indicative of a Late Woodland cultural origin (Hildebrant Iffert 2010:42). Importantly, Late Woodland cultures have been regarded as being distinct from the contemporaneous and descendent cultures of the Oneota, Middle Mississippian, and Middle Missouri traditions (Schirmer 2002:5).

The culturally Late Woodland effigy mound building groups, sometimes referred to collectively, and arguably too specifically, as the Effigy Mound Tradition or culture, occupied an area encompassing southern Wisconsin, northwestern Illinois, northeastern Iowa, and land along the Mississippi River in eastern Minnesota around 1000 CE (Rosebrough 2010:1; Schirmer 2002:37). Effigy mound building cultures constructed zoomorphic effigy mounds thought to be associated with adapted alliance rituals of Late Woodland populations more mobile than their predecessors (Rosebrough 2010:556 and 573). Through the tangible representation of identity, sodality, or social totem, using upperworld and lowerworld associated animal symbolism related to particular resources, effigy mounds may have allowed builders to bury their dead in multiple locations, without returning to communal burial grounds, and claim access to local resources (Rosebrough 2010:573; Schirmer 2002:122). Claims to burial rights and resources were likely established by people involved in carefully planned mound construction, as following the completion of effigy mounds, the mounds were regularly obscured with vegetation preventing future visibility (Rosebrough 2010:573). Five phases are taxonomically regarded as belonging to a defined Effigy Mound variant: the Keyes Phase in northeastern Iowa, the Lewis Phase in northwestern Wisconsin, the Eastman Phase in southwestern

Wisconsin, the Horicon/Kekoskee Phase in southeastern Wisconsin, and the Des Plaines Phase in northeastern Illinois (Rosebrough 2010:111). All these phases have traits that set them apart from each other, but their commonly held characteristics are shell midden formation, Madison pottery-ware usage, and the use of a specific ceramic motif (Rosebrough 2010:111).

Multiple zoomorphic mounds were, at one time, present on the Mero village's terrace, with others being present throughout the Red Wing Region (Fleming 2009:253; Rosebrough 2010:107–108; Schirmer 2002:57). However, unlike the effigy mounds in what are now Iowa or Wisconsin that were built in association with other effigy mounds, effigy mounds in the Red Wing Region are isolated among groups of circular or conical mounds indicating that effigy mound building near Red Wing was merely a small part of a larger aggregational mortuary tradition (Fleming 2009:254). Effigy mound building groups manufactured and used pottery consisting primarily of grit-tempered cord-impressed jars (Rosebrough 2010:2 and 93). The presence of or interaction with effigy mound building cultural groups in the Red Wing Region is supported by locally recovered pottery sherds (Hildebrant Iffert 2010:39 and 42).

Madison ware, a pottery type, often consisting of vertically cord-marked, sometimes cord-wrapped stick impressed, conoidal to sub-conoidal grit-tempered jars with thin walls (4–6 mm.), wide mouths, slightly constricted necks, and straight to slightly out flaring rims, directly associated with studied effigy mounds, appears to have been used by Late Woodland people on the Dike archeological site, on Prairie Island, just north of Red Wing (Anfinson 1979:74; Hildebrant Iffert 2010:39). Late Woodland Angelo Punctated ware, hypothesized to be associated with effigy mound building groups, was recovered at the Mosquito Terrace archeological site, near the confluence of the Cannon and Mississippi rivers (Hildebrant Iffert 2010:39; Rosebrough 2010:25). Angelo Punctated pottery consists of grit-tempered jars with punctates and incised to thin-trailed line decorations in geometric patterns similar to Mankato Incised pottery affiliated with the Cambria Phase, potentially indicating that the Lewis Phase associated with Angelo Punctated pottery interacted with cultural groups on the prairie (Anfinson 1979:51; Fleming 2009:146; Rosebrough 2010:113 and 216). This type of pottery was used after 1000 CE and has been found in association with Middle Mississippian jars (Rosebrough 2010:113).

Pottery associated with other Late Woodland cultural groups, unaffiliated with effigy mounds, is also present in the Red Wing Region. Clam River Cord-stamped and Onamia-like pottery, present at the Dike site, indicate a southward movement of culturally Late Woodland peoples into the Red Wing Region from near Lake Mille Lacs in eastern Minnesota and the Clam River in western Wisconsin (Hildebrant Iffert 2010:39). Clam River Cord-stamped ware is defined as having grit temper, exterior surface treatment with a crisscross cord wrapped paddle, a globoid body with rounded shoulders and a constricted neck, a high neck-rim with outcurve, cord-wrapped stick impressions in simple geometric patterns in the rim-neck area, and occasionally cord-wrapped stick punctates forming a border below the geometric patterns (Anfinson 1979:67). Clam River pottery is associated with non-effigy compound burial mounds (Anfinson 1979:67).

Although regarded as non-local, Late Woodland pottery consisting of Grant Cord Impressed ware and Fred Edwards Cord Impressed ware with shell tempering, are present at the Mero and Bryan pre-contact village areas near Red Wing, on opposite sides of the Mississippi River (Fleming 2009:218). The presence of these two pottery types indicates interaction with Late Woodland peoples with evidence of having resided in southwestern Wisconsin ~1000 – 1200 CE, when the pottery was likely manufactured (Rosebrough 2010:230). Rosebrough asserts that the use of shell temper indicates that Edwards Cord-Impressed pottery should be considered a Late Woodland/Middle Mississippian hybrid pottery type (Rosebrough 2010:233). In discussing the Late Woodland cultural presences in the Red Wing Region, Schirmer explains that, although some are associated with eastern and northern groups, the majority are related to south-southeastern, western, and southwestern Plains/Prairie groups (Schirmer 2002:58).

From ~1050 to ~1300 CE, an area encompassing the confluences of the Wind and Mississippi, Cannon and Mississippi, and Trimbelle and Mississippi rivers, surrounding and including what is now Red Wing, Minnesota, was arguably the most densely occupied area in the Upper Mississippi Valley, with an estimated resident population of more than 500 people and archeological evidence supporting its function as an interaction center between Late Woodland cultures and Oneota Tradition, Cambria Phase, Middle Mississippian Tradition, and Silvernale Phase related cultural groups (Fleming 2009:11–12 and 297; Gibbon and Dobbs 1991:295; Hildebrant Iffert 2010:34; Schirmer 2002:6). Research focusing on the archeology of the Red Wing Region during this period identifies more than 6 major village sites present including: Silvernale, Bryan, Belle Creek, Energy Park, Mero/Diamond Bluff, Double, Bartron, and Adams, and puts forth ~150 people as the ethnographically supported ideal population size for maintaining social harmony in a relatively egalitarian community, suggesting that the resident population could easily be greater than 1,000 people (Fleming 2009:12; Hildebrant Iffert 2010:34–35; Schirmer 2002:57). These larger villages affiliated with the previously mentioned time period are regularly surrounded by mound groups that were of great interest to early antiquarians and archeologists of Minnesota and the Midwest, with the number of locally present individual mounds exceeding 2,000 (Fleming 2009:20).

Archeological research pertaining to the Red Wing Region defines the Oneota Tradition as a cultural manifestation associated with the Upper Mississippi River, having characteristics including villages located to allow access to multiple econiches and the use of large, globular, shell-tempered pottery vessels with smoothed surface treatment, high or out-slanting rims, tool impressions on rims with occasional rim notches, and rectilinear decorations made with trailed lines, including chevrons (Anfinson 1979:39–40; Hildebrant Iffert 2010:49; Schirmer 2002:5). Oneota villages are thought to have mainly been located on terraces and seasonally occupied, with inhabitants procuring shellfish, bison, and deer, cultivating maize, squash, beans, tobacco, sunflower, and little barley, and gathering acorns, walnuts, fruits and berries, and wild rice (Hildebrant Iffert 2010:46). Oneota emergence is complex, with Oneota presence being established with apparent independence in both eastern Wisconsin approximately 923 CE and eastern Minnesota approximately 1050 – 1100 CE and another independent Oneota origin point located in northeastern Illinois, near Lake Michigan (Fleming 2009; Henning and Schirmer 2020:149–156; Rosebrough 2010; Schirmer 2002, 2016). Oneota artifactual assemblages comprised the majority of artifacts at the Bartron and Adams archeological village sites in the Red Wing Region and contributed artifacts to the village sites, including multi-cultural aggregation village sites, on both sides of the Mississippi River near Red Wing. Research suggests a southerly, later, purer Oneota phase in the Red Wing Region at the Burnside School and McClelland sites dating to 1222 – 1419 CE at 2-sigma and 1350 – 1400 CE, respectively, following the large-scale occupation of aggregation village sites (Koncur 2018:13 and 52; Schirmer 2016).

The Middle Mississippian Tradition was centered around the massive pre-contact population center referred to as Cahokia, near modern day St. Louis, Missouri, and had an estimated peak population of ~15,000 people, with estimates being as low as under 5,000 people and as high as greater than 40,000 people (Woods 2004:255–256). The Middle Mississippian cultures, associated with the Emergent Mississippian Period (~800 – 1050 CE) and the Mississippian Period (~1050 – 1350 CE), spread along the Mississippi River and its tributaries (Fleming 2009:15). Middle Mississippians are probable descendants of Woodland Tradition related populations from around the American Bottom Region, the broad 16-kilometer-wide eastern floodplain spanning from the confluence of the Illinois and Mississippi and Missouri and Mississippi rivers to where the Mississippi floodplain begins to tighten ~20 km. south of St. Louis (Schirmer 2002:23; Woods 2004:255–256). These Woodland populations gradually transitioned from living in small unorganized upland and lowland clusters of houses with a disorganized structure of cooking and storage pits to highly concentrated, floodplain focused, socially stratified communities with numerous domestic compounds and a uniform system of pits organized around a central open space with its own pit cluster surrounding a central post. These communities engaged in task specialization and subsisted using an organized system of large-scale agricultural food production (Schirmer 2002:5 and 23). Additional characteristics associated with Middle Mississippian culture include: platform mounds, wall-trench structures, tri-notched projectile points, chipped stone Middle Mississippian hoes, spades, and knives, discoidals (also referred to as chunkey stones), pottery trowels, pans, water bottles, and shell-tempered pottery with rolled rims and curvilinear decorations (Emerson 1999:224; Fleming 2009:242; Gibbon and Dobbs 1991:288–289).

The Cambria Phase consists of mounds and three core villages along the Minnesota River (Henning and Schirmer 2020:158). Recent assays date the phase, that includes imitations of Stirling Phase Cahokia rolled rimmed angled shouldered jars decorated by broad curvilinear designs, from 1000 – 1200 CE or 1050 – 1200 CE with a later variant dating from 1200 – 1300 CE (Holley and Michlovic 2013:22). Henning and Toom as well as Holley and Michlovic indicate that the Cambria Phase falls within the Northeastern Plains Village Tradition due to its lack of artifacts indicating interaction with Initial Middle Missouri cultures and its geographic displacement from the Great Oasis Phase that is purported to have played a role in the genesis of the Initial Middle Missouri Tradition, which Cambria has been placed within previously (Holley and Michlovic 2013:22–26; Mollerud 2016:72). The placement of Cambria outside of the Initial Middle Missouri Tradition is supported by Cambria's notable similarities to the Mill Creek and Over phases to the west and the Silvernale and Cahokia phases to the east (Holley and Michlovic 2013:26). However, Mollerud identifies four Great Oasis rim sherds at the Cambria Phase type site (Mollerud 2016:182). Other characteristics of the Cambria Phase include: plains side-notched projectile points, semi-subterranean house forms, bell shaped storage pits, snub-nosed thumbnail scrapers, sandstone abraders, pottery gaming pieces, scapulae hoes, clay elbow pipes, and quantities of bone, shell, and maize refuse (Anfinson 1979:51; Gibbon and Dobbs 1991:303). Over 93.7% of 442 individual vessels analyzed through rim sherds from the Cambria type site were fragments of grit-tempered jars that had a smoothed surface treatment with nearly half exhibiting evidence for polish, reflecting light (Mollerud 2016:98, 113, and 180). Decorative designs associated with the Cambria Phase are incised or trailed, with occasional punctates and rare cord impressions, and are mainly comprised of linate horizontal fields, chevrons, meanders, spirals, and filled triangles (Anfinson 1979:51). The Cambria Phase shares a host of vessel shapes and rim and decorative treatments with neighbors to the south and west (Holley and Michlovic 2013:22).

The Silvernale Phase (~1100 – 1300 CE), has its type site within the Red Wing Region and is present in both southeastern Minnesota and extreme western Wisconsin. Artifact and feature characteristics associated with this phase are small notched and unnotched triangular projectile points, end scrapers, side scrapers, sandstone arrow shaft abraders, bison scapula hoes, storage and refuse pits, and flexed primary burials in subsurface pits with an indicated mixed hunting and gathering and agricultural economy (Anfinson 1979:183; Gibbon and Dobbs 1991:298). Village sites of this phase reside on terraces above the floodplains of the Cannon and Mississippi rivers (Fleming 2009:23). Silvernale culture seemed to disappear from the Upper Midwest by 1300 CE following the collapse of Cahokia and the affiliated Middle Mississippian Tradition with the disappearance posited as resulting from Red Wing Region Silvernale groups disaggregating due to their function as a prairie-related trading node in a wide-spread Middle Mississippian trading network no longer being necessary (Gibbon and Dobbs 1991:301). Recent research has concluded that formerly aggregated groups moved away from the Mississippi trench at the end of the Silvernale Phase and created villages near more minor drainages in the Red Wing Region, identified as Oneota (Henning and Schirmer 2020:151). Village sites that have a majority Silvernale component are Silvernale, Bryan, Belle Creek, Energy Park, and Mero/Diamond Bluff (Hildebrant Iffert 2010:35).

Shell tempering is by far the most commonly identified temper type for Silvernale pottery and its surfaces are typically wiped smooth with some vessels, usually formed from incompletely oxidized grayish paste, appearing to have exhibited polish (Holley in preparation:10). Whole and nearly complete Silvernale vessels invariably have hachured scrolls and Silvernale nested chevrons were very often rounded or curving as opposed to rigid (Holley in preparation:11).

> Isolated scrolls and hachured units… were identified, sometimes in association with parallel horizontal lines. Finally, a bull's-eye, possibly a variant of the scroll, was identified in Silvernale deposits as were sherds with seemingly unbounded rounded punctations (Holley in preparation:11).

Holley identifies some of the diagnostic aspects of the Silvernale I facet of Silvernale pottery as weakly protruding rolled-rim jars or faceted-rim jars with plain or polished black surfaces and moderate width with deeply scribed decoration on angled-shoulder bodies. The archetypal pottery vessels within the Silvernale II facet are rolled-rim jars, sometimes having large rims, with wide scribed decoration with strong intaglio-effect on the interior wall (Holley in preparation:16).

Diagnostic characteristics of Link pottery, a pottery type related to the Silvernale Phase, include angled-rim and curved-neck jars, intermediately angled to rounded shoulders, and rim tabs, which are clay pads added to the rim as a form of decoration that follow the flow or direction of the rim (Holley in preparation:17–18). Link scribed decorations resemble the previously discussed Silvernale facets' filling in large areas of the upper jar, but sometimes have disconnected scrolls or spirals and large areas of the vessel undecorated (Holley in preparation:18). Recent results from the Silvernale site date Bartron pottery, an Oneota pottery, at ca. 1170 – 1280 CE and Silvernale and Link pottery at ca. 1190 – 1240 CE indicating that multiple pottery types appear to have been in use at the same time over a period of 100 years (Henning and Schirmer 2020:154). The new data support Oneota cultural development being a process separate from Middle Mississippian-related activities (Henning and Schirmer 2020:154).

Project Area of Investigation Archeological Background and Selection Rationale

The Belle Creek Mounds archeological site was chosen as the focal point of this research due to it having features representative of other mound groups on PIIC's newly acquired property, as well as greater prominence and relatively easy accessibility, which facilitates study and makes adverse effects to its already impacted mounds more probable. Through studying the geophysical results associated with a highly visible mound group, other mounds within less prominent mound groups will likely be easier to identify through comparison with data collected at Belle Creek Mounds.

There are 166 recorded archeological sites in Minnesota within 10 km. of the Belle Creek Mounds archeological site (Minnesota Office of the State Archaeologist 2021a). Eighty-seven of the 166 recorded archeological sites are classified as sites encompassing burial mounds, and 16 of the sites are documented as confirmed locations of former aboriginal habitation or village locations. Some of the sites formally classified as villages are associated with different archeologically derived cultures and traditions that include Woodland, Oneota, and Middle Mississippian, affiliated most strongly with Silvernale Phase groups.

Within 1 km. of the Belle Creek Mounds archeological site there are 9 recorded archeological sites (Minnesota Office of the State Archaeologist 2021a). Eight of the sites are areas encompassing small mound groups, with fewer than 5 identified mounds, and 1 of the sites is referred to in name as Belle Creek Village. The northeastern portion of the Belle Creek Village's site boundary encompasses the southwestern third of the Belle Creek Mounds site. The property, upon which the northern portion of the Belle Creek Mounds site (21GD0072) resides, is now owned by the Prairie Island Indian Community (PIIC) along with two complete archeological sites, McGregor Mounds I (21GD0066) and McGregor Mounds II (21GD0067), and portions of three other archeological sites, McGregor Mounds III (21GD0068), Foreman Mounds (21GD0065), and Belle Creek Village (21GD0200) (Figure 2-3) (Goodhue County 2020; Minnesota Department of Transportation 2017).

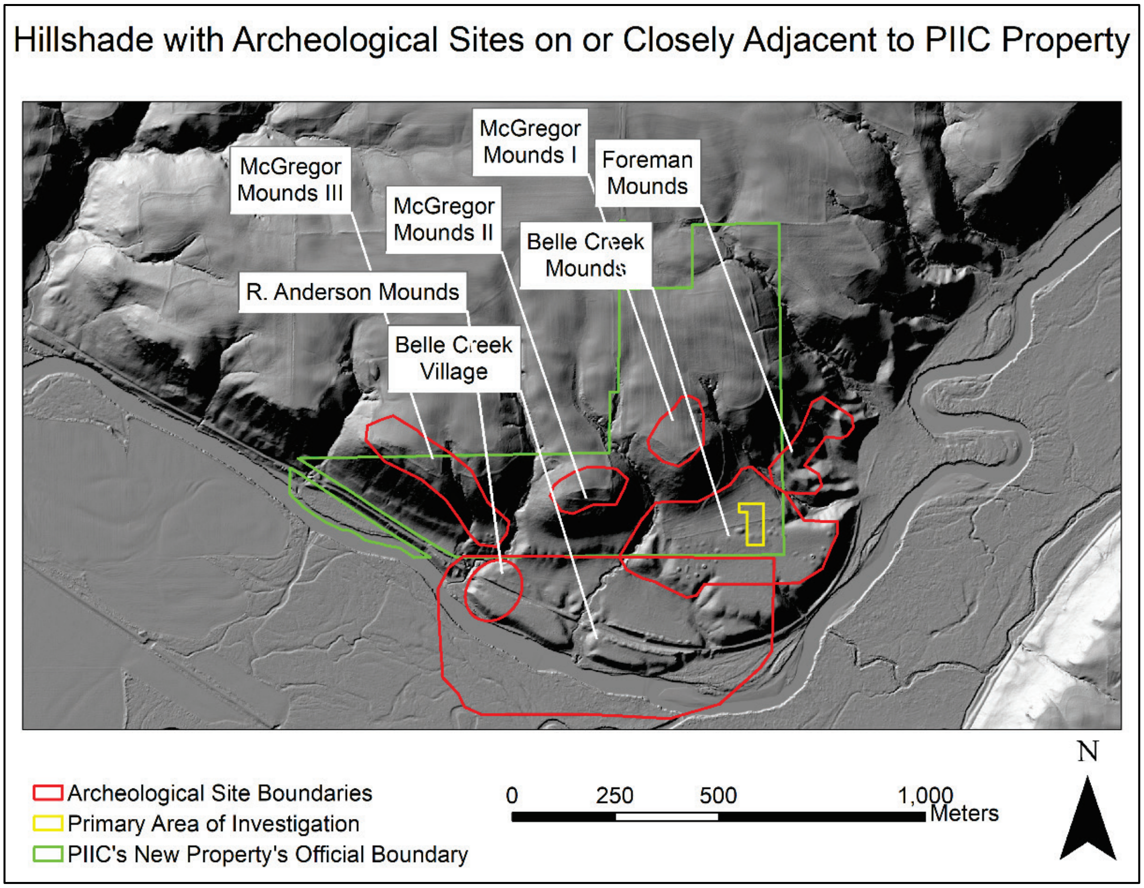

Figure 2-3: A hillshade map depicting archeological sites on or closely adjacent to PIIC's newly acquired property.

The mound sites located on PIIC's property, apart from the Belle Creek Mounds site, are relatively small and do not encompass many mounds. The Foreman Mounds site is documented as having 3 mounds on 0.81 hectares of land, McGregor Mounds I is documented as having 4 mounds on 1.82 hectares of land, McGregor Mounds II is documented as having 3 mounds on 1.42 hectares of land, and McGregor Mounds III is documented as having 1 mound on 0.4 hectares of land (Minnesota State Historic Preservation Office 1990a, 1990b, 1990c, 1990d). All of these sites are assigned as having a probable cultural-temporal affiliation with the Woodland Tradition. The Belle Creek Village site is documented as having associated depressions, pottery, and debitage, and as occupying 25.1 hectares of land within and south and west of the Belle Creek Mounds site (Minnesota Department of Transportation 2017; Minnesota Office of the State Archaeologist 2021a; Minnesota State Historic Preservation Office 1990e). The Belle Creek Village is documented as being associated with the Oneota Tradition along with a high probability of being associated with the Mississippian Tradition (Minnesota State Historic Preservation Office 1990e).

The interpretations present on Belle Creek Village's site form are likely derived from an excavation done on the site with cursory documentation. In the Minnesota Office of the State Archaeologist's (OSA's) site files there is digitized correspondence written by former State Archaeologist Elden Johnson in which he describes flying over the Belle Creek Village site, seeing [Pre-Contact Era] house outlines, and, eventually, conducting a test excavation on the site that "produced a few pottery sherds much like those from the Bryan site downstream" (Minnesota Office of the State Archaeologist 2021b). Because Bryan is a complex aggregation site with multiple types of local pottery, Johnson's description of the pottery at Belle Creek is unclear. Johnson went on to note that Belle Creek Village offers a good opportunity to potentially answer some of the questions raised at Bryan, but that could not be answered due its level of destruction (Minnesota Office of the State Archaeologist 2021b). Although the aforementioned excavation is informally documented by Johnson, a more detailed summary or report of the work could not be located and does not seem to have ever existed (Schirmer 2020, personal communication).

An 1885 effort to map mounds is the only previous formally documented archeological survey that had taken place investigating Belle Creek Mounds. Because of the site's gross characteristics (i.e., position on the landscape and pattern of mounds), it is thought to be associated with the Silvernale Phase or the Bartron Phase Oneota regional occupation, whose artifacts are present at mound sites along major drainages near Red Wing, Minnesota (Gibbon and Dobbs 1991). With Johnson's interpretation in mind, the most likely nearby sites that may reveal what to expect in terms of cultural affiliation and archeological deposits at Belle Creek Mounds would also have villages in close association with mound groups on terraces along the Cannon River and possibly the Mississippi River, villages like Bryan (21GD0004) and Area 51 (21GD0290) and mound groups like Bryan Mounds (21GD0045) and Bryan II (21GD0051) (Minnesota Office of the State Archaeologist 2021a).

Another informally documented excavation took place at Belle Creek Mounds archeological site prior to Johnson's excavation in the late 1960's or 1970. Dr. Edward W. Schmidt assisted in excavating and documented the excavation of a "six-foot conical mound" that had load marks and contained 3 dozen cobblestones at varied depths, but no other evidence of human presence (Schmidt 1940). Schmidt also excavated a "62 foot mound that was 3 feet high at its eastern end but older looking at its western end" (Schmidt 1940). Schmidt's excavation located a spall with chipping at the far western end of the mound during the excavation of a 12-foot trench. In the eastern end of the mound, excavators found bone fragments. Then after hours of careful digging, recovered larger human bone fragments from above the hips, a femur and tibia of a right leg, as well as small bits of cranium, but no ribs, hand bones, or foot bones (Schmidt 1940). Further analysis of the previously mentioned remains, once part of the H188 Goodhue County

Historical Society collection that were originally accessioned as 2413 – 2426, reveal that the remains are associated with a minimum of four individuals (Blue in preparation). The remains indicate the presence of one probable adult male, a possible adult female, and two sub-adults associated with skull fragments, a clavicle, and sacral fragments (Blue in preparation). The skull fragments and clavicle associated with one of the sub-adults exhibit copper staining (Blue in preparation). Schmidt also discussed a mound in an alfalfa field at Belle Creek that contained pieces of charcoal that "could not possibly have been introduced by roots or animals" and circular and rectangular depressions on the eastern portion of the terrace that were surrounded by low embankments, possible hut rings, but excavation could not confirm the depressions as such. Though Schmidt's informal excavation of mounds is now seen as unethical, the associated documentation of the features within the mounds at the Belle Creek Mounds archeological site gives a modern survey a better idea of what mounds contain and how nearby human made mounds might be distinguished from natural landforms.

On September 28th and 29th of 1885, archeologist and surveyor T.H. Lewis mapped 67 mounds at Belle Creek Mounds long before the archeological site was formally established (Lewis 1885:1–3). When looking at a LiDAR derived digital elevation model (DEM) colored hillshade, Lewis' work appears to accurately reflect the various mound locations within the Belle Creek Mounds site's mound group (Figure 2-4). When comparing Lewis' 1885 mound survey to the previously mentioned hillshade, agricultural practices look to have disturbed 22 of the mounds documented in the 1880's, while 45 of the mounds seem to have avoided cultivation. Horse drawn scrapers could be used to quickly remove mound fill (Arzigian and Stevenson 2003:57). However, some of the uncultivated mounds appear to have been looted. A preliminary survey and the appearance of the mounds on the hillshade confirm the presence of fairly recently dug human-made pits in the centers of 13 of the mounds on site. Thirty-two mounds appear intact and undisturbed. Approximately 0.6 hectares of the 2.5 hectares that seem to have been under cultivation on 21GD0072 were recently in use as a hay field.

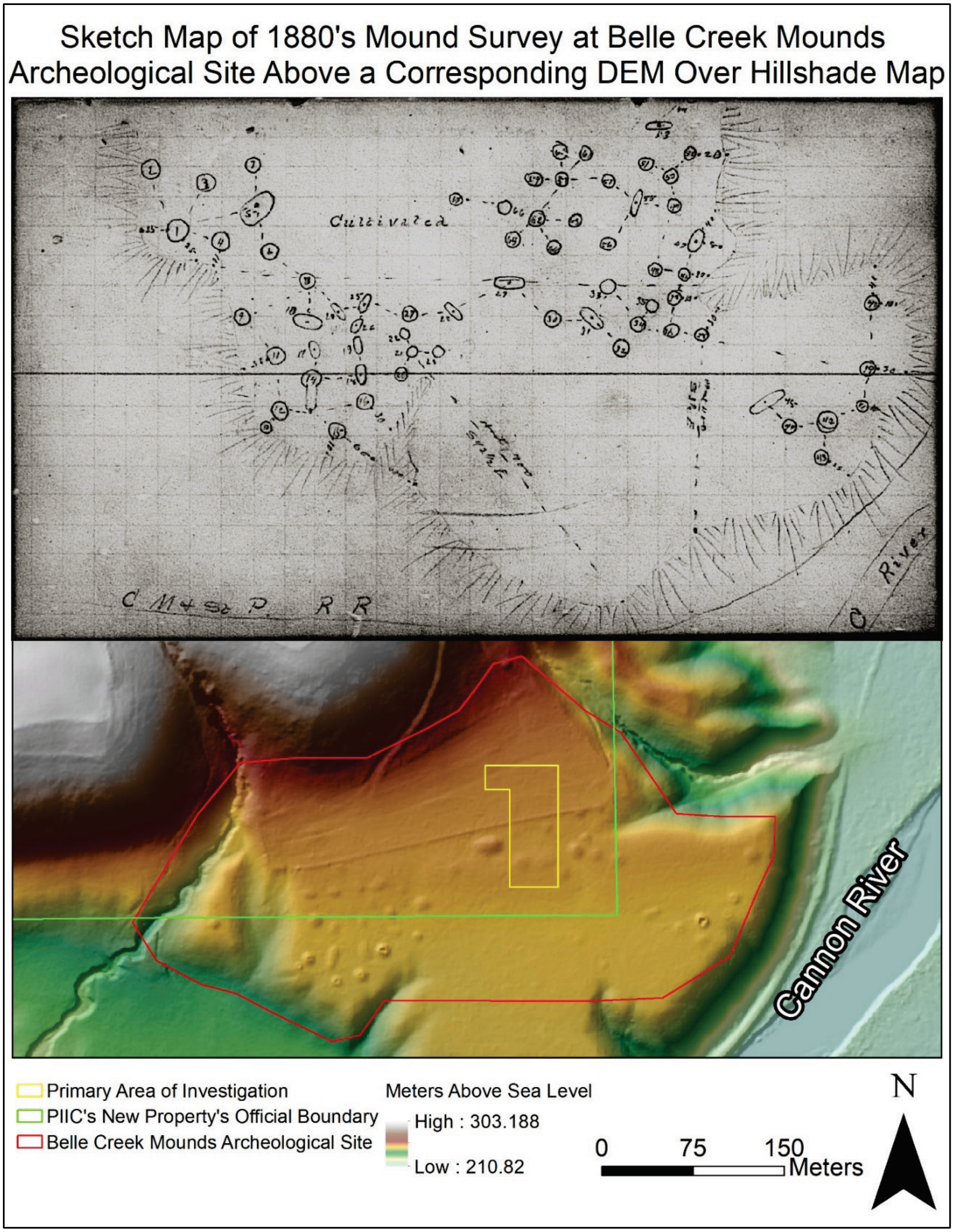

Figure 2-4: Lewis sketch map with Belle Creek Mounds depicted on a DEM colored hillshade.

Mound and Geophysical Background

The reasons attributed to local mound construction and its cessation are discussed in research related to the Red Wing Region and broader area. *Community and Aggregation in the Upper Mississippi River Valley* contends that mounds were not necessarily territorial markers, but symbols of cultural interaction and ritual linked to cultural aggregation related events (Fleming 2009:234). Another hypothesis explains mound building and burials as part of a corporate social strategy to decrease resource related risks across cultural groups through establishing shared symbolic claims to resources in multiple areas that waned with the onset of horticultural sedentism in favor of then more useful network-based social strategies associated with the use of individual burials containing grave goods (Rosebrough 2010:110 and 239). A poor understanding of mound composition and contents makes mound documentation difficult. In order to better understand the internal structure and physical nature of Native American mounds, archeologists Constance Arzigian and Katherine Stevenson compiled and analyzed data from all well-documented mound excavations in Minnesota (Arzigian and Stevenson 2003:1). However, detailed information related to mound excavations is fairly difficult to come by, as no excavations have been done for solely scientific purposes since the early 1970's, when legislation began to legally protect mounds from human disturbance (Arzigian and Stevenson 2003:1). Also, Arzigian and Stevenson found that early surveyors who mapped mounds sometimes mistook natural or Euro-American features as Native American mounds and occasionally failed to map some of the mounds within surveyed mound groups (Arzigian and Stevenson 2003:56).

Artifacts within or near mounds are not necessarily associated with the construction period of a mound. Not only are mounds constructed over the course of decades and centuries, but people have used village fill containing artifacts associated with time periods and cultural groups existing hundreds to thousands of years earlier than the mound construction event(s) to build mounds (Arzigian and Stevenson 2003:61). Mounds often contain burials and artifacts that were added to them hundreds of years after they were constructed. The most reliable method of dating a burial feature is the identification of intentionally placed diagnostic artifacts or directly associated radiometrically dateable material (Arzigian and Stevenson 2003:104).

Mounds frequently contain primary burials and secondary burials interred one of four ways: in pits below the ground surface; placed on the ground surface and covered; placed in a pit dug into an existing mound and buried; or placed on top of an existing mound and buried by making the mound larger (Arzigian and Stevenson 2003:168). Secondary burials have been posited as a potentially non-cultural seasonal practice when the ground is frozen, making immediate burial difficult (Arzigian and Stevenson 2003:228). Burials are more common near the center of a mound but can occur out to nearly the margin of the mound. Arzigian and Stevenson's research showed confirmed burials as being present within 75.9% (217) of 286 well-documented mounds with only 2.8% (8) of mounds not having any evidence of burials present (Arzigian and Stevenson 2003:232). Eighty-seven-and-a-half percent of studied mounds greater than 3 feet in height contained burials with none of them confirmed as being negative for a burial (Arzigian and Stevenson 2003:194). The few mounds excavated in the Red Wing Region have contained human burials (Fleming 2009:253).

Features within mounds are nearly equally split between three vertical positions: in fill, on the original ground surface, and in pits in subsoil (Arzigian and Stevenson 2003:169). Burial features had a maximum depth of ~3 ft. or ~0.9 meters. below the original ground surface in archeological region 3e where the Belle Creek Mounds archeological site resides, with the maximum statewide depth being slightly greater than 6 ft. or ~1.85 meters (Arzigian and Stevenson 2003:177). The most common types of features in burial mounds are: pits, which are identifiable due to their dark stained fill contrasting with lighter surrounding subsoil; human remains interred without a visible pit; a cluster of bundle burials; a special burial complex; pit interred human remains; fireplaces/hearths; rocks/cairns; animal bones; cremated human remains; caches; scattered human remains; charcoal; clay ridges; stone vaults; and lithic concentrations (Arzigian and Stevenson 2003:156). There are also occasionally logs documented above burials. The pits included in the study averaged ~5 ft. x ~4 ft. x ~2 ft. or 1.5 meters x 1.2 meters x 0.6 meters.

The soils on and around mounds differ from their less altered surroundings. At Effigy Mounds National Monument, mounds have stripped topsoil at their bases resulting in truncated soil strata around the mound’s base (Arzigian and Stevenson 2003:134). Mound A horizons have shown that they can stabilize relatively quickly, within 1,000 years, of mixed topsoil and subsoil being deposited from areas where fill is taken (Arzigian and Stevenson 2003:125). This results in a thicker A horizon on top of the mound than the borrow area surrounding the mound from where fill was taken. However, E and B horizons within the mound fill do not develop as rapidly. The borrow areas have been documented as having A horizons roughly half as thick as the surrounding soils more than 100 feet away from mounds (Arzigian and Stevenson 2003:126).

Arzigian and Stevenson's discussion of how mound groups change their area's soil horizonation draws attention to the anthropogenic driven alterations to mound fill borrow areas among mound groups. The negative space created by borrow areas likely contribute to the local relief, increasing elevation differences between mounds and their surroundings, contributing to the appearance of the mounds themselves. Through Arzigian and Stevenson's research it can be inferred that borrow areas among mound groups could contribute to mound relocation through comparisons of soil horizon thicknesses. Some of the previously reviewed research emphasizes the significance of the areas between mounds, within mound groups. Rosebrough writes:

> Ritual at mound centers was not likely to have been limited to the mounds themselves. Earthen enclosures are sometimes found adjacent to the mound groups. Large pits have been noted in patterned association with mounds at the only two sites where significant inter-mound areas have been stripped of sod (Rosebrough 2010:96).

Rosebrough goes on to emphasize that studies have not been done to confirm the breadth of ritual practices associated with mound groups and that previous research has neglected the space between mounds (Rosebrough 2010:96). *Community and Aggregation in the Upper Mississippi River Valley: The Red Wing Locality* describes mound groups surrounding aggregation villages near Red Wing as cemeteries, tacitly emphasizing mound groups' complex social function as a whole (Fleming 2009:305).

The Belle Creek Mounds archeological site's mound group is characterized as the least disturbed mound group in the Red Wing Region and is possibly representative of the appearance of other mound groups if they had escaped cultivation (Yamada 2007:46). Several developed techniques, related to geographic information systems, were used on this project to more effectively identify, digitize, and estimate mound locations on the Belle Creek Mounds site. One technical procedure relating to determining the locations of mounds surveyed in the 1880's, using a compass and canvas measuring tapes, consists of: determining a mound group location with noted legal descriptions, georeferenced aerial photography, and visualizable digital elevation datasets, as well as notes collected during the original survey; converting noted bearing direction based shots from mound to mound into azimuths; subtracting magnetic declination to convert azimuths into true north related directional azimuths, as opposed to magnetic north related directional azimuths; and, finally, building a digital mound group, using calculated true north related azimuths and the distances documented between mounds in the original survey notes, through creating connected digital lines corresponding to the determined directions and distances (Yamada 2007:31–32). At individual and shared vertices of the created surveying shot lines where mounds are indicated in the survey notes, relatively accurate geospatial representations of mounds can be created by building a digital polygon corresponding to survey noted measured mound lengths, widths, or radii.

Other research was used to improve the accuracy of the process of building digital geospatial representations of individual mounds at approximated or verified mound group locations. In attempting to locate mounds within the approximate area that the original mound survey described, a method was used in which a LiDAR derived hillshade was overlain by a partially transparent colored DEM, with different coloring representing small changes in elevation, to ensure that small rises on the represented landscape depicting mounds were not obscured by larger rises due to the specific lighting angle of the hillshade (Artz et al. 2013:17). This technique was used to more accurately locate mounds which the previously mentioned digital geospatial representations of mound groups needed to be tied to for a spatially accurate depiction of a mound group to be achieved. Using dynamic range adjustment to allow the coloration of the DEM to represent different ranges of elevations upon zooming or panning within ArcMap 10.7 was helpful in locating individual mounds.

Because mounds have spiritual significance and legal protection against their disturbance due to their regular association with burials, inherently low-impact geophysical techniques, which use the properties of magnetism and electromagnetic radiation in prospection and analysis, can be highly effective and appropriate in mound related research. Archeologists typically use geophysical methods to measure physical properties of near-surface deposits within 2 meters of the ground surface, usually to attempt to locate or define features of cultural origin (Kvamme et al. 2006:45). An area's soil properties can greatly affect the utility of different geophysical methods (Kvamme et al. 2006:45). The main geophysical methods used in archeology, three of which are used in this project, are: electrical resistivity, magnetometry, electromagnetic induction, and ground penetrating radar (Kvamme et al. 2006:45). It is important to note that geophysics involves the interpretation of detected differences in collected geospatially specific data, referred to as anomalies, from small sections of a broad area over which geophysical data were collected at set intervals. As archeological features regularly have different physical and chemical properties than the soils that surround them, geophysical data anomalous to their surroundings can be used to assist in interpreting archeological sites and features (Kvamme et al. 2006:45).

Resistivity or relative soil resistance survey involves introducing a known electrical current into soil and measuring and recording the ease at which the current flows through the soil at specific points in space by measuring a drop in voltage between probes in contact with the ground (Somers 2006:113). The electrical resistance measurement is traditionally represented in ohms. The electrical resistance measured by the equipment used to conduct a resistivity or relative soil resistance survey indicates an average electrical resistance of all of the soil the current injected into the soil passes through on its way to a probe associated with measuring resistance via voltage drop (Somers 2006:113). These measurements are usually recorded at regular intervals across a site to locate areas with geophysically anomalous readings in relation to more widely prevalent ranges of readings across a surveyed area. Soil moisture, soil grain size, temperature, soil compaction, and soil salinity contribute to the electrical resistance of a particular portion of a soil matrix (Somers 2006:111). Anomalous areas of high resistance in relative soil resistance data can be associated with buried walls, mounds, banks, cobbled areas, rubble filled pits, and underground voids. Anomalous areas of low resistance are often associated with ditches, soil filled pits, hut circles, foundation trenches, and gullies (Geoscan Research 2009:6-3). Buried archeological features with higher amounts of organic material than the surrounding soil matrix often retain relatively more moisture making them lower in electrical resistance where as those with less organic material (e.g., a refuse pit with a large amount of stone debris) often appear as resistance highs (Somers 2006:120). Variations in soils, sediments, and geology are also apparent in resistivity surveys (Somers 2006:118). Relative soil resistance survey results, like other geophysical methods' survey results, can vary in seemingly counter-intuitive and difficult to predict ways making related interpretations of anomalies as specific archeological features tentative (Cuenca-Garcia 2019:70).

Magnetometry passively measures local variations in the earth's magnetic field near the ground surface, with a practical limit of ~3m in depth (Kvamme 2006:206 and 222). Common causes of detected variation in soil magnetism include: differences in the magnetic susceptibilities of various deposits and soils, the magnetic enrichment of topsoil resulting from chemical and physical processes like weathering and biogenic processes involving bacterial excretion of the magnetic material magnetite, and firing increasing magnetism due to the thermoremanent effect, in which the normally randomly oriented magnetic domains in the iron oxides of soils, clays, or stones become aligned to earth's magnetic field at the time of firing at above 600 degrees Celsius. Magnetic domains in a material's iron oxides freeze in a reset magnetic alignment during and after cooling, following the material reaching 600 degrees Celsius (Kvamme 2006:207 and 214). With respect to the previously mentioned causes of magnetic variation, human activities that reveal why magnetometry is a useful tool in archeological prospection include: people making fires, people making constructions and artifacts from fired materials, human occupation increasing the magnetic enrichment of surface soils, human constructions accumulating topsoil, human constructions removing topsoil, people importing materials for constructions, and people making and using iron artifacts (Kvamme 2006:216–221). Cultural anomalies often show up as geometric shapes, including lines, circles, and rectangles, in magnetometry survey data as well as in other types of geophysical data (Kvamme 2006:222). Mounds may be represented as anomalies with high magnetism due to their likely association with the accumulation of anthropogenically altered topsoil or the burned prepared surfaces they are often built upon (Betts and Stay 2017:49–50; Kvamme 2006:217–218).

Ground Penetrating Radar sends radar waves into the ground through a surface antenna that are then reflected off of buried objects, features, bedding contacts, or soil units and detected by a receiving antenna (Conyers 2006:136). As radar pulses are transmitted through the ground their velocity changes depending on the physical and chemical properties of the material they travel through (Conyers 2006:136). The more significant the contrast in electrical properties of two materials at a subsurface interface, the greater the strength, amplitude, of a detected reflected signal associated with the interface (Conyers 2006:136). This geophysical method has the ability to produce high resolution 3-dimensional subsurface data due to radar waves' known speed being able to be converted to distance below the ground and the waves' capability to continue to propagate through the ground following their partial reflection by velocity changes associated with shallower fluctuations in subsurface material's electrical properties (Conyers 2006:136). Areas associated with the reception of low amplitude reflections usually indicate a uniform soil matrix (Conyers 2006:142). Hyperbolas visible in ground-penetrating radar related reflection profiles are generated because energy is recorded from a high contrast point source before and after the receiving antenna is directly above the aforementioned point source, which is represented by the apex of a hyperbola (Conyers 2006:137).

> Reflections occur at buried discontinuities where there are changes in the electrical properties of the sediment or soil, variations in water content, lithologic changes, or changes in bulk density. Reflections can also be produced at interfaces between anomalous archaeological features and the surrounding soil or sediment. Void spaces in the ground such as caskets in cemeteries, tunnels, and buried pipes or conduits made of either metal or plastic will also generate strong radar reflections as a result of a significant change in radar-wave velocity. These features tend to produce reflection hyperbolas generated from a distinct "point feature" in the subsurface…(Conyers 2006:136)

Non-invasive geophysical methods including relative soil resistance, magnetometry, and ground penetrating radar (GPR) surveys were used throughout the area of investigation to attempt to identify geophysical anomalies present on site. The various areas of investigation consist of intact mounds, mounds disturbed by cultivation, areas between mounds, and areas between mounds and the mound group's apparent boundary on site. Through analyzing the size, shape, location, and the relationship geophysical anomalies have with each other and the visible environment, later analyses of the collected data will be able to facilitate the development of interpretations of what identified anomalies indicate and the broader implications of those indications.

Advocates for using geophysical survey as a primary method of archeological investigation for architecture and landscape-based research think that non-invasive geophysical survey can be used as far more than a prospective tool to assist in successful archeological excavations (Thompson et al. 2011: 197–198). They cite identification of: construction variation in the built environment, continuities and discontinuities in the use of space, natural and cultural modifications to the landscape, and regularities in the use of space and architecture at a regional level, as information that analyses of geophysical anomalies can potentially contribute to studies of past people without necessarily requiring the application of other investigatory methods (Thompson et al. 2011:197–198). Through analyzing geophysical anomalies, geophysicists can make inferences about how past people used and viewed space. One small example of geophysical interpretation would be interpreting a low-resistance oval shaped anomaly below a mound as a likely mortuary feature, like a burial or offering pit, or the result of previous physical examination or testing.

The current project applies the previously mentioned conceptual methods of geophysical anomaly interpretation later in this thesis. Application of these methods stands to increase understanding about how the Belle Creek Mounds site was used in the past and what areas of the site may warrant protection, including future avoidance of ground disturbance, due to areas of the ground's geophysically anomalous profiles that suggest the possible presence of buried culturally sensitive material.

As alluded to previously, in order to better understand the archeological built environment at the Belle Creek Mounds site, geophysical data were collected on mounds, places identified as the former locations of now highly disturbed mounds, spaces between mounds, and areas with no visible mounds, not identified as previously having mounds by Lewis' 1885 survey. These data allow for the comparison and interpretation of the geophysical profiles of these different types of features on the landscape and contribute information related to the construction processes and compositions of various types of mounds and the geophysical appearances of likely culturally and naturally built features.

The amount and quality of conducted archeological research limits understanding of the Red Wing Region's archeological record. Archeologists have excavated very little of the culturally complex major archeological village sites in the Red Wing Region in relation to their total mapped areas, while using inconsistent documentation methods (Schirmer and Fleming in preparation). In some instances, Middle and Late Woodland components have been mostly destroyed by later occupations (Schirmer and Fleming in preparation). Archeologists have not performed research on some of the known archeological sites in the region due to accessibility difficulties. The Belle Creek Mounds site is one of the sites that was, until recently, inaccessible to archeologists. Due to the lack of archeological information pertaining specifically to the Belle Creek Mounds site, it was essential to provide an interpretive context based on nearby archeological sites and a review of local archeological research. Keeping an open mind about what archeological evidence may be present is important in avoiding biasing the interpretation of collected data and preventing the destruction of previously unknown archeology.

Establishing the area of investigation within the Belle Creek Mounds archeological site boundary allowed the interpretation of the Belle Creek Mounds archeological site as being associated with a village site, as other large nearby mound sites are, to be preliminarily tested. Members of the Minnesota State University, Mankato (MSU, Mankato) ESRL's archeological surveying team visited the site twice, prior to when fieldwork was planned, to gain a better understanding of how best to go about conducting a survey for the purpose of developing a site treatment plan. One of these visits involved a walkthrough with PIIC Land and Environment and Tribal Historic Preservation Office staff to help establish appropriate field procedures and gauge the amount of time and equipment needed to perform fieldwork. The primary concern the ESRL archeological surveying team and PIIC staff addressed during their collective walkthrough related to brush clearing in preparation for geophysical data collection.

Chapter 3 – Methodology

The initial generational step in preparing for fieldwork, related to the development of an archeological site treatment plan, at the Belle Creek Mounds archeological site involved creating shapefiles approximating the locations of visible and non-visible mounds, as well as Prairie Island Indian Community's property boundary in relation to the previously mentioned archeological site on PIIC's newly acquired property. Members of the ESRL's archeological surveying crew used ArcMap 10.7.1 software in combination with: a LiDAR derived hillshade, a LiDAR derived digital elevation model (DEM), T.H. Lewis' notes from an 1885 survey of the mound group, satellite imagery from Mapbox, property boundary data from the Goodhue County GIS Office, and archeological site boundary data from the State of Minnesota to generate the aforementioned shapefiles.

Using previously discussed geospatial datasets, archeological surveying crew members Dr. Ronald Schirmer, and the author, Alexander Anton were able to determine a viable area of investigation (AOI) to attempt to fulfill the research goals necessary to develop an informed site treatment plan safely within PIIC's property boundary. A 40 x 100-meter AOI was settled upon due to the anticipated difficulty of removing large amounts of brush and fallen trees (Schirmer 2020, email message to author, May 28th). The AOI's location encompassed adversely impacted mounds, relatively undisturbed mounds, area between mounds, and mound-free area in its southernmost portions. Schirmer thought it appropriate to attempt to collect data over a large rectangular contiguous area as it would be easier to track (Schirmer 2020, email message to author, May 29th). Schirmer additionally advised the collection of geophysical data between mounds to provide data possibly allowing for interpretation as to how past people used those areas as well as the vicinity of the mound group as a whole (Schirmer 2020, conversation with author, April 21st). The AOI is divisible into 20 x 20-meter squares facilitating the collection of geophysical data. An additional 20 x 20-meter grid portion was added onto the western edge of the northwesternmost 20 x 20-meter grid portion in the original AOI to attempt to collect geophysical data over a likely highly impacted mound within the pasture area previously used as a hay field.

After ESRL archeological crew members determined a viable AOI, crew members used ArcMap 10.7.1 software to fishnet the AOI creating digital, geospatially located 20 x 20-meter squares. The corners of each 20 x 20-meter square were then turned into points with geospatial, UTM coordinates to aid in the tangible establishment of each 20 x 20-meter square's corners during fieldwork.

The initial task done at the beginning of fieldwork involved transporting the materials needed for brush clearing and archeological surveying from MSU, Mankato to an unloading area within PIIC's new property's boundary, above the terrace that Belle Creek Mounds archeological site resides upon. Two pickup trucks and two cars owned by archeological surveying crew members were used in initial transportation of the materials. A UTV operated by PIIC Compliance Officer Franky Jackson then transported the materials down to the terrace upon which the determined AOI resides. ESRL Geospatial Data Manager Andrew Brown constructed a 4 ft. x 8 ft. x 3 ft. padlock-able box, out of 2-inch x 3-inch boards for the frame and oriented strand board (OSB) to cover all of its sides, which when covered with a large tarp, could keep sensitive and expensive equipment safe and dry on site. Franky Jackson provided a game camera to monitor activity in the vicinity of the locked box while the crew was off site for added security. The box allowed the crew to avoid multiple trips transporting materials from parking areas to the AOI or vice versa before work could start and end each day.

Following transporting equipment on site, the ESRL crew approximated the location of all of the 20-meter x 20-meter grid portion corners within the original 40 x 100-meter AOI, using a Trimble Geo7x GNSS receiver. The ESRL archeological field crew, consisting of Dr. Ronald Schirmer, Andrew Brown, Anna Wiitanen-Eggen, Luke Burds, and Alexander Anton, used plastic stakes to mark the approximate location of each of the original eighteen 20 x 20-meter grid portion corners and flagging tape on a tree selected near each stake to make the locations of the stakes visible through the thick brush initially located throughout most of the AOI. These staked and flagged GNSS receiver-based approximations, though not sub-meter accurate, allowed for work on brush clearing to begin without the establishment of permanent physical datums near the AOI.

In the next four days of fieldwork following the informal establishment of the location of the desired gridded AOI, the ESRL archeological surveying crew, Franky Jackson, and PIIC's Native Food Sovereignty Fellow Esther Lui, as well as Franky's brother Matt Jackson and, for a half of a day, journalist Casey Ek, cleared brush, fallen trees, and small standing trees from the AOI to allow for the collection of geophysical data. Gabe Miller, PIIC Land and Environment Department Manager/Wildlife Biologist and Ronald Schirmer agreed that removing living vegetation smaller than 3 inches in diameter as well as dead vegetation from the AOI would be acceptable in terms of its environmental impacts (Miller et al. 2020, conversation via conference call, May 20th). The crew had slight difficulty in operating equipment initially, but after a few hours assembling the field and brush mower purchased for the project and struggling to start the ESRL's ECHO string trimmer, which are notorious for flooding, equipment issues were resolved and brush clearing was well underway. The brush clearing crew used a DR field and brush mower, ECHO string trimmer, Stihl chainsaw, and safety glasses to cut brush and downed logs. Gloves, log chains, and a motorized cart with 4-wheel drive and a rear box were used to transport brush and large downed logs out of the AOI. The PIIC Land and Environment Department allowed the brush and logs to be placed in a pile approximately 200 meters west of the survey's AOI, on the western portion of the terrace upon which the Belle Creek Mounds archeological site rests (Miller et al. 2020, conversation via conference call, May 20th).

Figure 3-1: Luke Burds, Andrew Brown, Anna Wiitanen-Eggen, and Ronald Schirmer clear brush in northern grid portions.

While finishing up clearing vegetation, the ESRL archeological surveying crew determined viable spots to establish two permanent physical datums to the north and west of the AOI. The crew planned to establish these datums to setup a Trimble M3 DR 5” total station to more accurately pinpoint the physical locations of the previously approximated grid portion corners for use during geophysical data collection. Ronald Schirmer selected a location approximately 20 meters north of the center of the northern edge of the eventual central northernmost grid portion, referred to as grid portion 9. The crew chose this location for Datum 1 because the majority of the previously approximated grid portion corners were visible through field glasses from there and it fell between the estimated locations of disturbed mounds. The surveying crew loaded a shapefile with the estimated locations of the disturbed mounds, based on Lewis' 1885 survey of the then more extant mound group, onto a Geo7x GNSS receiver for the purpose of avoiding disturbing difficult-to-see mound remnants with excavation involved in placing permanent datums. The spot for Datum 2 was selected, while accounting for estimations of the locations of disturbed mounds, at a location roughly 165 meters southwest of Datum 1 near the western edge of the treeless pasture area. The crew ensured that Datum 1 and Datum 2 were within each other's viewshed so that Datum 2 could provide a visible point to back-sight to from Datum 1. Two points with known geospatial coordinates that are within each other's viewshed allow total station operators to setup a total station able to determine its geographical coordinates and sight's azimuth. The crew marked spots chosen for datum locations with plastic pin flags for future reference.

The day following the determination of ideal permanent datum locations, the ESRL archeological surveying crew excavated shovel tests at the previously selected spots. Neither of the shovel tests, the shovel test excavated for Datum 1, ST 1, or the shovel test excavated for Datum 2, ST 2, yielded artifacts. The crew performed bucket augering, approximately 1 meter below the base of Datum 2's shovel test, to gain a better understanding of the site's deeper soils in the interest of determining the likelihood of different archeological features, as well as a preliminary interpretation of the area's soil genesis. Ronald Schirmer concluded that the soils present near ST 2 were not well-drained enough to allow Pre-Contact Period peoples to construct effective sub-surface storage or cache pits in the nearby area.

After the crew excavated and formally documented each shovel test, they mixed concrete powder and water in a wheelbarrow with a shovel to make concrete to dump in the hole associated with the shovel test. A metal concrete anchor that would later be punched using a hammer and nail to create a precise stationary point in space that could be used as a datum point was then placed flush in the center of the still wet concrete pad.

Figure 3-2: Ronald Schirmer putting the finishing touches on Datum 2.

Following the creation of the permanent physical datum points, the field crew needed to determine the datums' precise spatial locations. The crew used a Trimble Geo7x GNSS receiver, with Trimble CenterPoint Real Time eXtended (RTX) Correction Services activated, linked to a Zephyr 2 RoHS antenna fixed atop a 2.6-meter SECO range pole with an attached bipod and circular level to collect both datums' geospatial coordinates. Center Point RTX functions using real-time satellite measurements, from multiple satellite constellations, received at an international network of tracking stations to account for satellite clock and orbit position errors (Trimble Navigation Limited 2019:7). RTX uses algorithmic atmospheric modeling to differentially correct GNSS signals' atmospheric error at the location of the receiver to produce viable real-time corrections for GNSS without the need for a local base station (Chen et al. 2011). The GNSS corrections generated are available to receivers through an internet connection or through an additional satellite signal (Chen et al. 2011). In order for the GNSS receiver to use RTX it had to be linked to a device with access to the internet. Mobile phones with the ability to use their phone signals to setup wireless internet hotspots were used to connect the Geo7x GNSS receiver to the internet in the field allowing the GNSS receiver to access correction information to achieve a high level of geospatial accuracy.

In determining the datums' precise locations, the field crew lengthened the telescoping range pole with the antenna affixed to its threaded top and entered the appropriate antenna height information into the Geo7x GNSS receiver previously attached to the range pole's center. The range pole was lengthened to give the antenna better access to unadulterated GNSS satellite signals. The crew then leveled the range pole after placing its base spike into the punched point in the center of the previously placed concrete anchor. After this, the crew operated the GNSS receiver to collect a point through the collection of multiple points at a one second interval at sub-decimeter accuracy, which the GNSS receiver would later amalgamate to improve the accuracy of the final single point. The multiple points collected seemed to average around 7-centimeter accuracy. That the accuracy was slightly worse than RTX's advertised 2-centimeter accuracy could be due to the high number of trees surrounding the open area within which the crew established the datums, obstructing GNSS satellite signals. The GNSS receiver determined Datum 1 to reside at UTM Zone 15 4933987.868 N 523951.332 E at 247.685 meters above mean sea level (MAMSL) and Datum 2 at UTM Zone 15 4933917.777 N 523803.912 E at 246.08 MAMSL.

Figure 3-3: A Trimble Geo7x GNSS Receiver with an antenna collects Datum 2's geographic coordinates.

With the new datums established, the crew setup the Trimble M3 DR 5" total station to accurately stake out the 20 x 20-meter grid portions, which included the project area boundaries. The first step in setting up the total station involved leveling the instrument directly over Datum 1 to maximize the accuracy of the instrument. The crew extended a heavy-duty fiberglass tripod to approximately 5 feet in height after unlocking its extendable legs. The three legs were splayed and locked and the tripod's head was visually leveled directly over the punched point on Datum 1's datum spike. Then, the M3 5" total station, also commonly referred to as the instrument, was centered and fixed to the tripod head with a screw, permanently attached to the tripod, that could be threaded into the instrument. Following securing the instrument to the tripod, the person setting up the total station gazed through the plummet sight and gently lifted and moved two of the tripod legs to center the sight over the physical datum point. The previous step differs from the setup method suggested in the total station's manual, but the author found it incredibly helpful in positioning the total station directly above a fixed datum point (Trimble Navigation Limited 2010:27). Though repositioning legs of the total station's tripod puts the instrument at greater risk of damage due to droppage, the crew found it necessary for expediency following difficulty in positioning the total station over a fixed physical datum point using Trimble's recommended method.

After initial positioning of the total station above the physical datum point, a bubble level on the evened-out tribrach, an adjustable component attached to the instrument that allows the total station to be connected to the tripod head, was used to approximately level the instrument through making small adjustments to the tripods legs' length until leveling centered the bubble level's bubble. Then, the sharp feet of the tripod were pressed into the ground and the tribrach bubble level was used to level the instrument again using adjustments to leg length. Following the second bubble leveling, the operator setting the instrument up gazed through the plummet sight again, slightly loosened the screw attaching the instrument to the tripod, and slid the instrument along the tripod's head until the plummet sight was again centered on the physical datum point. After that, the operator turned on the instrument and used its onboard digital level, while the screen of the instrument was centered between two of the tribrach's leveling screws, to adjust the tribrach screws to level the instrument with extreme accuracy.

After the crew leveled the instrument, they setup the instrument, entering weather information procured from the National Oceanic and Atmospheric Administration's National Weather Service's webpage for nearby Red Wing Airport in order to get an accurate measurement of local temperature and pressure to allow the instrument to adjust for atmospheric conditions that can affect the speed and calculated distance of total station shots. Following setting up the instrument, the crew manually keyed in coordinates of Datum 1 and Datum 2, putting them into the total station's digital memory, and then indicated to the total station where it was positioned in space, at Datum 1. The crew then used the total station's prism mode Class 1 laser distance meter to shoot a back-sight to Datum 2, targeting a prism attached to a leveled range pole, with a bipod, positioned directly above Datum 2 (Trimble Navigation Limited 2010:8). Before beginning using range poles in locating and determining geospatial coordinates with the total station, the crew purchased adapters that made measurement marks on range poles accurate. The marks are designed to correspond to the center of a range pole affixed prism's height above the ground. The previously mentioned back-sight allowed the total station to determine its azimuth, in simpler terms the direction its pointing, with ~5 second accuracy.

Figure 3-4: Luke Burds and Anna Wiitanen-Eggen setup the Trimble M3 DR 5" Total Station.

An estimation of the instrument's accuracy can be achieved through the calculation of the equation ±(10 + 5 parts-per-million (ppm) or 0.000005 * distance in millimeters (D)) mm. (Trimble Navigation Limited 2010:53). If the equation is solved for a shot of 200 meters, greater than any shot taken during fieldwork at the Belle Creek Mounds archeological site in the summer of 2020, the result is 11 mm. Considering that one shot is required for azimuth orientation and a second is required for the determination of a geospatial point's coordinates with the total station, less than ±22 mm. of error would be expected when shooting or staking out points with the M3 DR 5" using the aforementioned setup for shots under 200 meters in length. This means that in combination with the ~±7 cm. accurate datum points, shot and staked out points would have ~±9 cm. total potential error in geospatial accuracy, though the survey crew anticipates the true accuracy of the points to be higher due to the general likelihood that the amalgamation of hundreds of individually recorded high-accuracy coordinates used to create each datum point are well within the area of potential error.

The surveying crew then imported the 18 sets of UTM coordinates corresponding to the previously created 20 x 20-meter grid corners into the total station from a flash drive. These coordinates were exported out of ArcMap 10.7 to Microsoft Excel and then saved as a .csv on the flash drive before being imported into the instrument. The crew then used the total station's stake out feature, which uses the instrument's orientation and Class 1 laser to determine the range pole's geospatial position, and a second range pole with a prism and bipod to locate the grid portion corners in space. Anna Wiitanen-Eggen had the presence of mind to use pink plastic pin flags to indicate the locations of grid portion corners that had been formally shot in and orange flags to indicate that their positions had, as yet, only been roughly approximated using a GNSS receiver during the first day of fieldwork due to encountered visual obstructions.

Twelve of the eighteen grid portion corners were staked out without physically measuring off of the range pole or repositioning the total station to make obscured grid portion corners visible. The crew performed one resection, R1, which involved moving the total station approximately 14.4 meters south-southwest of Datum 1, where the instrument had previously been setup, and back-sighting to Datum 1 and Datum 2 from the total station's new location to allow the total station to determine its geospatial position and orientation via triangulation. Crew members were able to shoot in three more of the grid portion corners following the resection because of the different vantage point the resection provided. The sightlines from the total station to the three remaining, roughly approximated, grid portion corners continued to be obstructed by tree trunks following the resection. In the interest of providing the crew more time to collect geophysical data within the AOI, the three-remaining tree-obstructed grid portion corners were located by physically measuring off of the range pole with a tape measure. Measuring took place after the range pole's position matched either the total station's provided in/out range pole repositioning directive or its left/right range pole repositioning directive, associated with placing the range pole at unestablished grid portion corners' appropriate azimuth or distance from the total station. The respective remaining unmatching or unzeroed repositioning directive was made as close to 0 cm. as the total station's sight line allowed for by carefully moving the range pole either left, right, out, or in incrementally. The individual holding the range pole then secured the pole in place with its bi-pod and measured from the range pole's spike in a distance and direction matching the total station's unmatching or unzeroed repositioning directive, placing a flag in the ground at the true physical location of the grid portion corner as determined by the total station.

Following shooting in the grid portion corners, the survey crew used 100-meter long metric fiberglass tape measures to determine the level of precision with which the total station was geospatially locating the grid portion corners. The crew found that the sides of all measured grid portions were within a centimeter of 20 meters in length indicating that the total station stake out was a success. The crew's decision to number grid portions from 1 to 10 starting in the southwest corner, with 1, moving to the east, with 2, and then to the portion north of 1, with 3, and east of 3, with 4 and so on, helped crew members keep communication clear and geophysical data organized (Figure 3-5). In order to collect geophysical data over a potential highly disturbed mound, to determine whether or not the potential mound had geophysical signatures similar to other known mounds within the project's original AOI, the archeological surveying crew shot in an additional grid portion to the west of grid portion 9, grid portion 11. The potential highly disturbed mound in grid portion 11 was not clearly visible on a LiDAR derived hillshade, but there was an observable change in vegetation corresponding to its location.

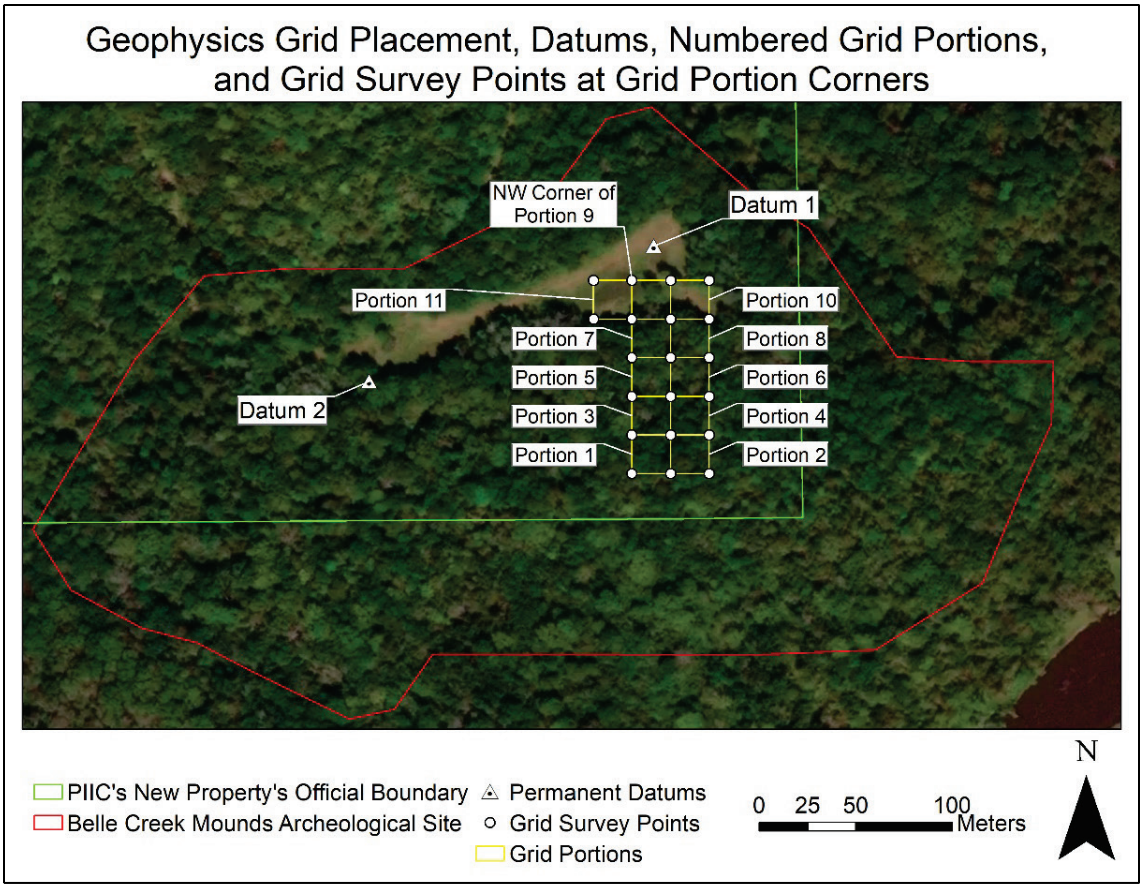

Figure 3-5: Map of the locations of permanent datums and the geophysics grid with numbered portions and its survey points.

At the same time as part of the survey crew finished up staking out grid portion corners, geophysical data collection began. Retired geophysicist Donald Johnson generously provided training, advice, and equipment to allow for the collection of relative soil resistance and magnetometry data. Johnson and survey crew member Luke Burds began geophysical data collection, collecting measurements of relative soil resistance in grid portion 7. The ESRL possesses a ground penetrating radar system that the crew used on this project.

Non-invasive geophysical methods including relative soil resistance, magnetometry, and ground penetrating radar (GPR) surveys were used throughout the study area to attempt to identify geophysical anomalies present on site. Through analyzing the size, shape, location, and the relationship geophysical anomalies have with each other and the visible environment, analyses of the collected data can develop interpretations of what identified anomalies indicate and the broader implications of those indications.

The preparation for mappable relative soil resistance data collection involved extending two fiberglass tape measures from the northwest and southwest corners of a grid portion to its northeast and southeast corners, respectively. Following setting up tapes to run along the top and bottom of a grid portion, the crew placed stakes in the ground along the previously mentioned top and bottom tape measures starting at 50 centimeters in two-meter increments. After the crew placed the stakes, 20-meter-long guide lines, with flagging tape marking every even meter of their length and red lines marking every odd meter of their length, were strung across the grid in a north-south direction and held in place by stakes at matching distances from the starting grid corners with respect to the previously placed tape measures. This physical visualization of cells within grid portions allowed the crew to document, relatively quickly and accurately, where a specific relative soil resistance measurement was recorded.

The soil resistance meter used is a Geoscan Research RM 15 Resistance Meter. This approximates soil resistance between its mobile electrical probes that are pushed into the ground ~3–10 centimeters. The Geoscan Research RM 15 Resistance Meter is outfitted with two fixed mobile probes, spaced approximately 0.5 meters apart, in addition to two supplementary attachable wings that result in the frame having two more mobile electrical probes, approximately 1 meter apart, making the frame's base roughly 1 meter in length. The array used in determining relative soil resistance on site was a twin array. A twin array utilizes electrical current traveling between one mobile current probe and one stationary remote current probe providing electrical current for the detection of soil resistance readings with one potential mobile probe, to measure relative soil resistance at a location of interest, and one potential remote probe to measure a stationary background reading to determine and account for changes in background voltage as the mobile probes are moved around a sampling grid (Geoscan Research 2009:5-9–5-11). The potential probes detect the amount of remaining voltage of the current emitted from the current probes in the soil where the potential probes are placed and work together to approximate the electrical resistance of the arc of soil between the mobile current probe and mobile potential probe relative to the remote potential probe's background reading (Geoscan Research 2009:5-9–5-11). When extra mobile probes are attached to the mobile probe frame, they can be used to take readings of relative soil resistance at a greater depth. Current cannot run through two or more pairs of mobile probes simultaneously as this would not allow for soils electrical resistance at consistently deeper and shallower depths to be sampled. Creating a wider mobile probe spaced twin array with 1 meter between a current and potential probe allows for the resistance meter to detect the relative soil resistance at roughly 1 meter in depth as opposed to roughly 0.5 meters with the original array, which has a mobile probe spacing of 0.5 meters.

The crew placed the remote probes ~20 meters from the nearest boundary of the grid being sampled so that the remote potential probe's background reading would not encounter significant interference (Geoscan Research 2009:5-9). The remote probes were separated ~3 feet during sampling of grids 7 and 5 and at 155 cm. for the other grid portions. The reason remote probe placement spacing differed between grid portions 7 and 5 and all other grid portions was due to miscommunication regarding establishment of a standard separation distance. Fortunately, while attempting to make adjustments to allow for the successful collection of relative soil resistance readings in higher resistance soils, the crew observed that slight differences in the spacing distance of the resistance meter's remote probes had negligible effects on displayed relative soil resistance readings. The crew set the RM15 to use an operating frequency of 137 Hz and used an output voltage of 40 V. A Constant current range of 1 mA was used in grid portions 5–11 and a range of 0.1 mA was used in grid portions 1–4. The crew switched to using a 0.1 mA range for relative soil resistance reading collection in the four southernmost grid portions because their sandier soil was too resistive to allow the RM15 to display a numerical Ohm reading. Instead, the RM15 displayed a message indicating that its reading was out of range. Changing to a lower constant current allowed for the RM15 to display a numerical resistance reading in the soils of the 4 southernmost grid portions.

Figure 3-6: Franky Jackson and Anna Wiitanen-Eggen collect relative soil resistance data as Ronald Schirmer observes.

The archeological surveying crew collected relative soil resistance readings at a 0.5-meter north-south interval and a 1-meter east-west interval in a boustrophedonic fashion within each of the 11 grid portions, alternating between moving north and south with the completion of each data collection transect to make the relative soil resistance survey quicker. Data collection was greatly facilitated by the previously mentioned fiberglass tape measures laid out along the north and south grid portion boundaries, as well as the guide lines, clearly dividing grid portions into many sampling cells. During relative soil resistance data collection, one person would move the mobile probe frame to a new cell at the established interval and take a shallow and a deep reading with the resistance meter, telling a second person the readings who recorded them in either a notebook for grid portions 1, 2, 3, 4, 5, 6, 7 and 11 or Google Sheets for grid portions 8, 9, and 10. When relative soil resistance data collection began crew members wrote readings in a physical notebook, transferring them from the notebook to Google Sheets to allow for easier data visualization. After grid portions 5 and 7 were collected, the crew switched to entering the readings directly into Google Sheets while surveying grid portions 8, 9, and 10. After the crew determined that entering data directly into Google Sheets slowed down fieldwork and left no paper hardcopy to refer back to if readings seemed erroneous, the crew reverted back to the method of data recordation used initially. Having to rely on multiple pieces of old and heavily used equipment and proprietary software functioning properly to export an entire day or two's worth of collected relative soil resistance data made using the RM15's automatic data logger too big of a risk because of the possibility of not being able to export, and effectively losing, collected data. The crew spent much time during ten of the days of fieldwork collecting relative soil resistance data over all of the 11 grid portions established on site.

While other crew members were collecting relative soil resistance data, the ESRL's Geospatial Data Manager Andrew Brown developed computer code to allow the manually collected data to be normalized across all grid portions and displayed on ArcMap10.7 digital geospatial mapping software. The reason relative soil resistance data from different grid portions needed to be normalized was so that resistance readings collected in different grid portions under different soil moisture conditions using different remote probe placement locations could be made comparable to one another and seamlessly visualized together. Seamless visualization of relative soil resistance data facilitates more controlled data interpretation. Brown's Python code creates points for each relative soil resistance reading, normalizes data values between adjacent readings in separate grid portions, and then uses Empirical Bayesian kriging, an interpolation method for generating raster datasets that produces little error with small sample sizes, to generate rasters effectively visualizing collected relative soil resistance data, predicting values for the areas between points within an established AOI (Esri Inc. 2020). Brown's Python code allows for collected relative soil resistance data to be processed without the use of Surfer, commonly used software for processing and visualizing geophysical data.

Following the collection and in-field analysis of some of the initial relative soil resistance data, Ronald Schirmer, Franky Jackson, and Andrew Brown took ¾-inch soil probes to attempt to locate and better understand existing geophysical anomalies, including attempting to infer how the area north of apparent field edge push had been affected compared to the relatively agriculturally undisturbed area south of the apparent field edge push. They used an Oakfield soil probe to take 13 soil probes in approximated locations determined by measuring off of measuring tapes stretched along grid portion borders to discern their position within the AOI. These soil probe locations were documented with a GeoXH 6000 Series GNSS receiver, as the crew's CenterPoint RTX demo had expired. The GeoXH 6000 Series, linked to a Zephyr 2 RoHS antenna fixed atop a 2.6-meter SECO range pole with an attached bipod and circular level, was given access to Minnesota's State differential correction system MNCORS, via a Wi-Fi hotspot. Access to MNCORS allowed the device to determine its location with submeter accuracy through using corrective data generated by determining to what degree and direction a nearby GNSS receiver was inaccurate in determining its location at a geospatially known point in space, due to common sources of GNSS error.

During the long process of the archeological surveying crew collecting relative soil resistance data, Luke Burds collected magnetometry data in all ten of the original grid portions. The bulk of the magnetometry data collection was done in three partial days of fieldwork by Burds alone. Donald Johnson instructed Burds on using his Geometrics G858 MagMapper Gradiometer, a device with two magnetometers, placed one above the other, with its console in gradiometer mode so Burds could independently collect data over the established 20 x 20-meter grid portions. Burds and Johnson set the gradiometer to record readings every 0.1 second while Burds walked over transects spaced 1 meter apart marked by moving two stakes along two tapes outstretched on the northern and southern edges of grid portions. Burds wore clothing and shoes with no metal components during magnetometry data collection as metal near the gradiometer's two cesium sensors can disrupt the sensors' reading of Earth's localized magnetic field. The gradiometer subtracts its top sensor's reading from its bottom sensor's reading to derive a measurement referred to as a vertical gradient, which eliminates the effects of background temporal variations in earth magnetism from the measurement of magnetic readings associated with specific sections of the soil matrix in the area being surveyed (Geometrics 2001:20–21; Kvamme 2006:210). Burds walked at an even speed to attempt to allow the collected magnetometry data to be geospatially accurate. The magnetometer determines where it takes readings through estimating its geospatial location by recording the time it takes for an equipment operator to walk a full transect and spatially distributes data points along the transect based on when the points were recorded. The equipment operator indicates on the console when they start and finish walking a transect by hitting the console's MARK and END LINE buttons. All of the magnetometry data were recorded while walking transects in the same direction within grid portions to ensure that the vertical magnetic gradient would have more geospatial consistency. The gradiometer stored collected data in its console making the collection process much quicker than collecting relative soil resistance data on site.

Figure 3-7: Luke Burds collects geophysical data with a Geometrics G858 MagMapper Gradiometer.

Following magnetometry data collection, while assessing magnetically anomalous areas Ronald Schirmer located a metal seat belt along the western border of grid portion 1, indicating that it had affected vertical gradient readings in its vicinity (Burds 2021, email message to author, January 21st). Ronald Schirmer and Luke Burds located a burned area that included metal fragments on the ground surface in the northwestern part of grid portion 7, explaining an associated large dipole (Burds 2021, email message to author, January 21st). The survey crew found barbed wire and a shotgun shell in the northeastern part of grid portion 10, which could have contributed additional vertical gradient dipoles in the northeastern portion of the 2020 fieldwork's magnetometry results.

Following data collection, Burds and Brown used MagMap2000 software to export the gradiometer readings collected over the AOI's grid portions to a spreadsheet. Brown made alterations to the previously created relative soil resistance visualization code in order to create raster maps, using Empirical Bayesian kriging to interpolate between readings at geospatially documented points, to approximate and visualize the geophysical magnetic signatures associated with the entire grid.

Geomorphologists and earth scientists came out to the Belle Creek Mounds site to bucket auger to develop a clearer understanding of how the terrace, upon which the Belle Creek Mounds site resides, formed. These scientists, Dr. Phillip Larson, Dr. Garry Running, Dr. Douglas Falkner, Dr. Andrew Wickert, and Jabbari Jones, are interested in the genesis of the Cannon River. Their conclusions, based on topography and soils encountered during bucket augering, resulted in interpretations related to the terrace's genesis helpful in developing more cogent interpretations of geophysical results.

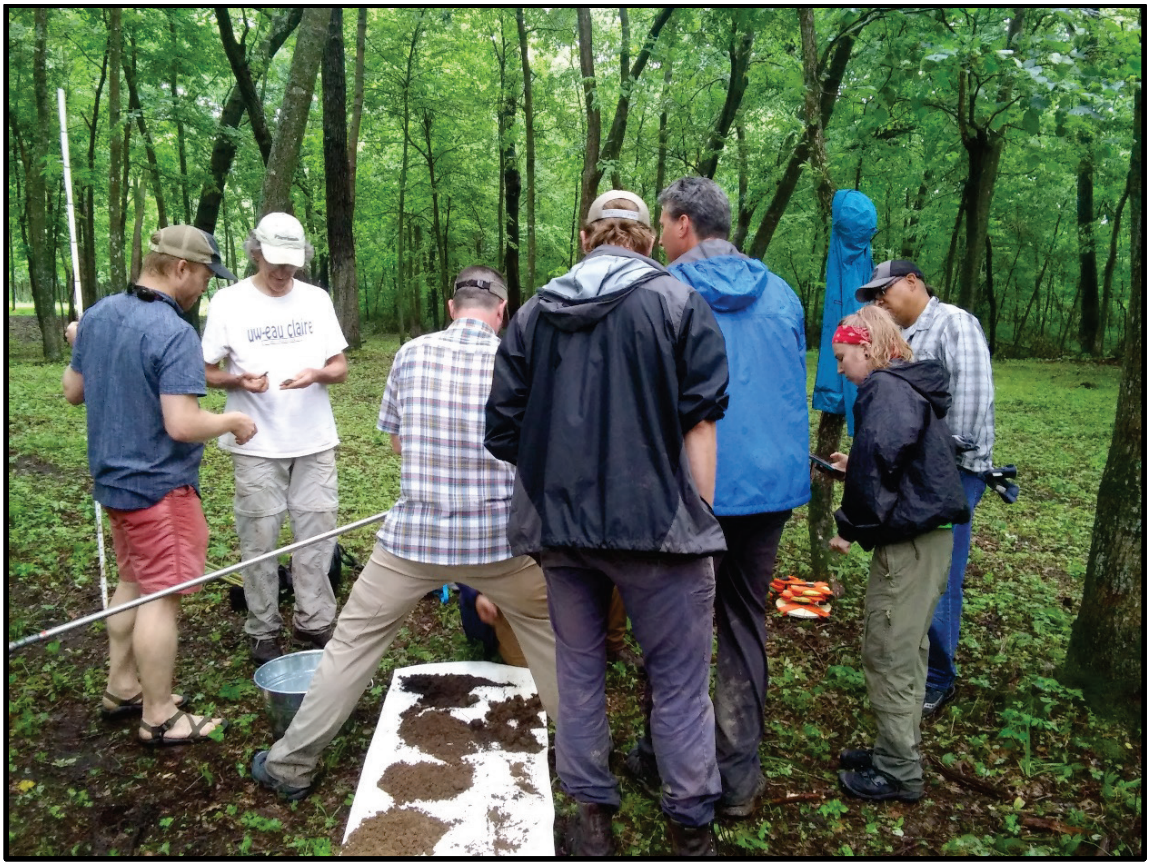

Figure 3-8: Geomorphological bucket augering.

The ESRL archeological surveying crew collected ground penetrating radar data during and following collection of relative soil resistance data. The crew used 100, 200, and 500 MHz antennae to collect data to help develop a greater understanding of what definitively cultural mound signatures look like in GPR data to help identify potential mounds and partially destroyed mounds. The 100, 200, and 500 MHz antennae were pulled north to south across the entire AOI to see transitions in subsurface geomorphology in addition to determining the depth of the base of the most prominent mound within the AOI. Three transects were done north to south with each type of antennae and two were done west to east. One transect was collected over the two mounds in the southern portion of the AOI and one transect over one potential mound and one mapped mound was collected, which ran through grid portions five and six.

The 500 MHz GPR antennae collected data over parts of seven grid portions within the AOI. X and Y lines were collected over grid portion 11 and spanning grid portions 1 and 3. Y lines were collected over grid portion 9 and in the western halves of grid portions 5 and 7. Archeological surveying crew members collected 500 MHz GPR at 0.5-meter line spacing, using the pull speed dependent Dyna Q setting to determine the number of stacks used in data collection and a GPR velocity of 0.06 m/ns for effective results in wet soil. Before data collection could start the GPR's odometer had to be calibrated to ensure that the GPR equipment was properly documenting where it was recording data within grid portions, in addition to documenting the location of the first break in the radar waves emitted by the transmission antenna and detected by the receiving antenna. Following setup, a crew of two, one person pulling the antennae and the other wearing the digital video logger (DVL) and tending the cables hooking the antennae to the DVL, collected GPR data by moving the running equipment over portions of the AOI where GPR data were desired.

Figure 3-9: Luke Burds and Anna Wiitanen-Eggen collect GPR data with a 500 MHz antenna.

In two of the final four days on site, the crew conducted shovel testing immediately south of grid portions 1 and 2 to attempt to determine if the probable former site of a Pre-Contact Era village, which are common inside the arcs of the Red Wing Region's mound groups, encroached onto the PIIC's property (Fleming 2009:20). Shovel testing was also done to gain a better understanding of the cultural affiliation of the people who likely constructed the mound group.

Figure 3-10: Anna Wiitanen-Eggen and Luke Burds excavate a shovel test.

Due to the thickness of the vegetation south of the area cleared to collect geophysical data over mounds and areas in between mounds, 100-meter fiber glass tapes were used to lay in the shovel test grid. The grid began at the bottom of grid portions 1 and 2 and extended south 20 meters. The archeological surveying crew excavated 45 shovel tests at an interval of 5 meters from the southwest corner of grid portion 1 moving east 40 meters to the southeast corner of grid portion 2 and south 20 meters at intervals of 5 meters in columns starting from each of the initial shovel tests. This created a grid in which there were 9 north-south columns of 5 shovel tests. These shovel tests were excavated to 30 x 30-centimeter dimensions laterally and to depths determined on a test-by-test basis based on artifact presence in previous levels, often to around 40 centimeters below surface (cmbs), typically after a sandy, culturally sterile, glacial outwash associated B horizon was encountered. Soils were screened through ¼-inch hardwire mesh, onto tarps, to facilitate complete artifact recovery and backfilling, minimizing the evidence of disturbance.

Following collection, artifacts recovered during shovel testing were washed, organized, cataloged, and accessioned into the Minnesota State University, Mankato (MSU, Mankato) Museum of Anthropology's archeological repository on MSU, Mankato's campus in Mankato, Minnesota. The cataloging procedures used followed the format outlined in the Minnesota Archeological Integrated Database's (MAID's) catalog guide. These artifacts will be held in MSU, Mankato's Museum of Anthropology's archeological repository per PIIC's existing agreement with the institution to temporarily hold collections for purposes of analysis and general curation until the tribe requests their return. Artifact analysis conducted during cataloging involved the use of MSU, Mankato's lithic comparative collection in addition to using comparative pottery specimens derived from other collections held at the repository.

One final task done in the interest of gauging the extent to which trees interfered with collected geophysical data, which Geospatial Data Manager Andrew Brown suggested, involved documenting the locations of trees within the AOI. Over the final two days of fieldwork Alexander Anton worked using the total station's Class 3R reflector-less direct ranging function and laser sight, and two temporarily placed datums, TEMP DATUM A and TEMP DATUM B, established off of Datum 1, to document tree locations. Four separate resections were done to allow all 248 trees within the AOI to be mapped from five separate shooting locations. Tree trunks were marked with high visibility paint as soon as a tree had been mapped with the total station to ensure the same trees were not mapped repeatedly. The approximated sizes of trees were documented as falling within one of three size classes: small, less than 25 cm. in diameter, medium, 25 to 50 cm. in diameter, and large, greater than 50 cm. in diameter. The archeological surveying crew generated two shapefiles from the tree data to be used to aid in geophysical data interpretation, tree points and tree polygons.

All geophysical and geospatial data will be provided to and made available to the PIIC with delivery of the Belle Creek Mounds site's site treatment plan. Physical data collected during excavation is curated in the Archeology Division of the Minnesota State Mankato, Museum of Anthropology during analysis and held there under the terms of an ongoing curation agreement, until such time as requested for return to the PIIC.

Chapter 4 – Results

Geophysical datasets produced by this project are represented by relative soil resistance, magnetometry, and ground penetrating radar generated rasters, as well as imagery of ground penetrating radar related profiles. Though these data merely indicate anomalous areas within the soil matrix, as discussed in a previous chapter, anomalies could be cogently interpreted as archeological features if they are in a suitable context and there is adequate supporting evidence (Kvamme 2006:206). Shovel testing produced a small assemblage of artifacts of precisely-documented 3-dimensional geospatial origin. In the interest of communicating this project's results in a comprehensible manner, the geophysical survey results will be presented in one third of the area of investigation at a time, to allow for visualization of smaller relative differences within data. Following the presentation of the geophysical survey results over the entire area of geophysical investigation, shovel testing results are summarized and interpreted.

Before discussing geophysical results, the mound boundary and shot data used in approximating the locations of mounds in disturbed areas warrant more explanation. Polygons were generated from T.H. Lewis' survey of the Belle Creek Mound's mound group that was conducted when, now no longer visibly present, mounds were still identifiable on the landscape (Lewis 1885:1–3). Lewis used an open traverse method of surveying to map identified locations of the individual mounds comprising mound groups in relation to each other during the Northwestern Archaeological Survey. An open traverse method of surveying links each measurement of directional bearing and distance to the measurement before it with the initial measurement being tied to physical space via landmarks, which in the Northwestern Archaeological Survey's case was often a conveniently located mound identified within a quarter of a quarter section at a specified township and range (Dobbs 1991:9; Lewis 1885). There is a potential for both systematic and random error in Lewis' survey data.

> Lewis appears to have used an open surveyor's compass, canvas tape, and an engineer's level [while surveying mound groups]. Conversations with modern surveyors indicate that the open compass had an accuracy of plus or minus one degree. Thus, a reading of 37 degrees could in reality, actually [be recorded as 36, 37, or 38 degrees] … Lewis' distance measurements can also contain small errors. Although these potential errors are not necessarily significant on small groups of mounds, they can create very real problems as the errors compound over a large area (Dobbs 1991:9).

After redrafting Lewis' mound map of the Belle Creek Mounds mound group with polygons and polylines in ArcMap using the original survey data, the general pattern of mounds was clearly correct, but the fit was not precisely correct based on clearly visible and identifiable mounds on a LiDAR derived hillshade. Consequently, this process corroborates that Lewis' survey contains errors.

The digital mound polygons and survey shot polylines spatially oriented with respect to each other, created with Lewis' survey data, have been adjusted to pattered elevational rises corresponding closely, but not exactly, with the Lewis survey (Figure 4-3). In digital shapefiles separate from the shapefiles depicting Lewis' original survey results, polylines representing survey shots have been adjusted to more accurately represent what their directions and distances should have been had they been taken with greater accuracy and polygons representing locations of mounds not visible on the LiDAR derived hillshade have been adjusted to more accurately estimate formerly mapped mound locations, through moving them with the surveyed mound polygons having visible mound expressions on the hillshade, from which mound locations without visible expressions were ultimately shot. Where groups of mounds are present on a highly accurate LiDAR generated hillshade, those mounds and all of the mounds surveyed later in sequence from mounds visible on the hillshade had their polygons' locations adjusted, in a previously alluded to newly created polygon shapefile in ArcMap, to correspond with the mound locations visible on the hillshade (Figure 4-3). The survey shot polylines were adjusted in a similar fashion. Through comparing 40 of the LiDAR hillshade adjusted mounds' locations to their corresponding unadjusted locations communicated by Lewis' survey, differences in Lewis' shot distances and shot directions between surveyed points and the approximate actual shot distances and shot directions between surveyed points, usually mound center points, were calculated. Mean absolute percentage error was calculated to determine the average percentage of distance error between hillshade related "actual" mound locations and Lewis survey derived predicted mound locations using the formula:

$$M = (1/n) \sum_{t=1}^{n} \text{abs}((A_t - F_t)/A_t)$$

A_t represents hillshade adjusted distances between surveyed points or actual values and F_t represents Lewis' derived distances between surveyed points or forecasted values. The returned value associated with this process was a 6% error. Degree measurements of the absolute values of differences between the hillshade related and Lewis associated mound locations were averaged to determine a mean absolute error for Lewis' shot azimuths. The returned value associated with this process was 3.4°. The mean distance of Lewis' survey shots at Belle Creek Mounds is 22.61 meters. Using these values an approximation of expected spatial error per shot may be determined for Lewis' survey at Belle Creek Mounds:

[0.94x = 22.61] x = 24.05 (the longer of two expected true distance values based on calculated 6% error). To determine the distance between points in space at different angles and distances from an origin, representing expected error, two formulas were used (Guichard 2021:12; Strang and Herman 2021:55).

We can see that for a point $P = (x, y)$ on a circle of radius r with a corresponding angle θ, the coordinates x and y satisfy

$$\cos\theta = \frac{x}{r}$$
$$x = r\cos\theta$$

and

$$\sin\theta = \frac{y}{r}$$
$$y = r\sin\theta.$$

Figure 4-1: Formula to determine point locations from distance and angle from an origin point (Strang and Herman 2021:55).

x1=22.61*cos(0), y1=22.61*sin(0), x2=24.05*cos(3.4), y2=24.05*sin(3.4)

x1=22.61, y1=0, x2=24.01, y2=1.43

$$\text{distance} = \sqrt{(\Delta x)^2 + (\Delta y)^2} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}.$$

Figure 4-2: Formula to determine distance between points (Guichard 2021:12).

$\sqrt{((24.05–22.61)^2 + (1.43–0)^2)} \approx 2$ meters of average spatial error per Lewis survey shot

Error compounds with multiple shots in open surveying.

The average shot distance error of 2 meters indicates how much Lewis' survey shot based predictions of the location of mound center points and by association mound boundaries themselves are expected to vary from their approximate actual locations, which implies that mounds lacking a discernable visible surface expression may deviate slightly from where Lewis' survey data suggest they are. Using the previously discussed formulas to predict expected spatial error for an uncommonly long 100-meter-shot with an average azimuth error of 3.4° yields an expected spatial error value of 8.84 meters. The maximum 1885 Lewis survey recorded azimuth error of ~13° for a shot of ~17 meters recorded as 15.24 meters, produced a distance difference of 4.3 meters between Lewis and LiDAR hillshade adjusted mound center points. This 4.3-meter distance difference prevented the Lewis and the hillshade adjusted mound polygons from overlapping due to the mound radius' size being 3.6576 meters, smaller than the distance difference between the unadjusted Lewis survey and hillshade determined center points. If a mound that another mound's location is being predicted off of is in a location unconfirmed via hillshade, then the mound location that is being predicted is likely to further deviate from its actual location. With more and more expected deviation from true mound locations in long sequences of mound locations not visible on the LiDAR derived hillshade, the mound locations represented in the adjusted polygon layer become less and less reliable in terms of their ability to accurately represent the former locations of mounds visible on the landscape.

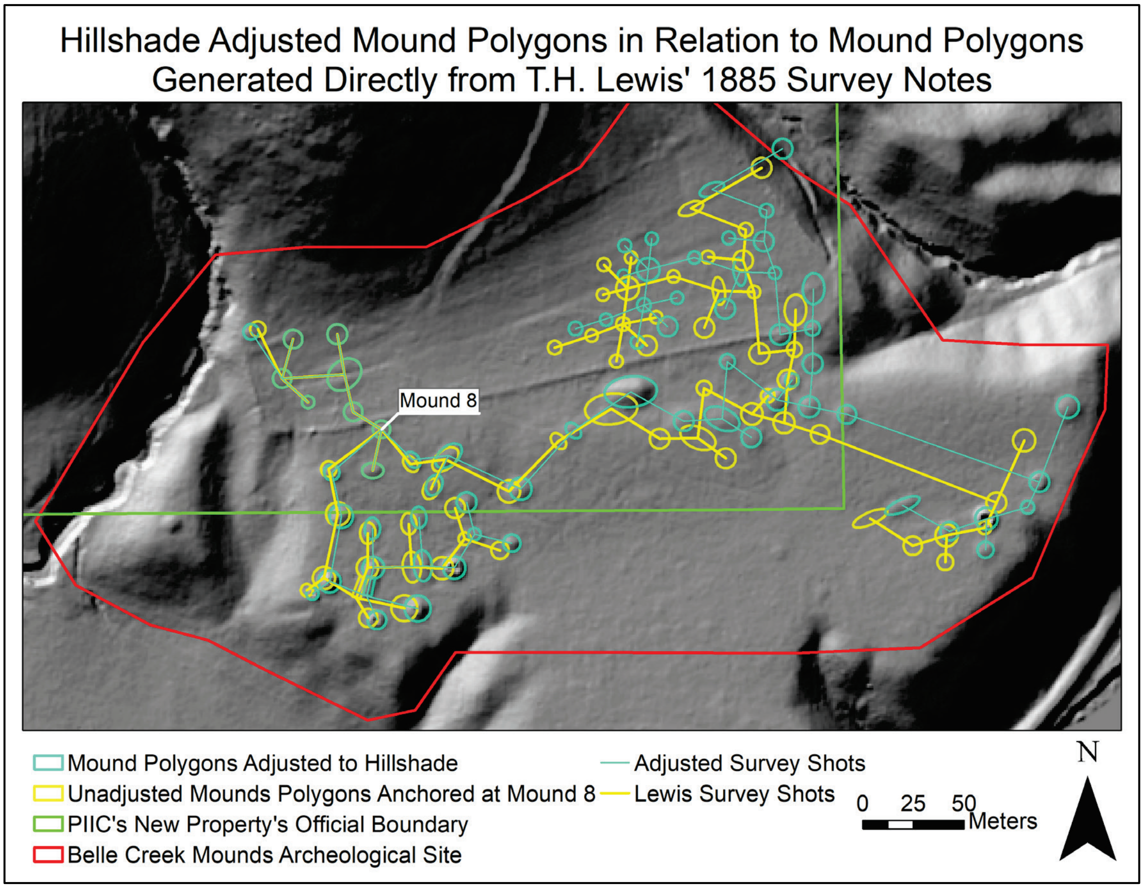

Figure 4-3: Hillshade adjusted mound polygons represented with mound polygons generated from Lewis' 1885 survey notes anchored at Mound 8.

To attempt to adjust for mound center point location errors in the 1885 survey data where mounds are no longer visible, a linear regression analysis was performed on the Lewis survey distance data, using the LiDAR hillshade adjusted mound location data as known actual values, with Shapiro-Wilk, skewness, and kurtosis tests indicating that the residual data had a normal distribution (Rogerson 2015). The null hypothesis that the observed subtracted from the predicted residuals come from a normal distribution could not be rejected. The distance data's real minus predicted value's mean is –6.12843109593e –15, distribution is approximately symmetric at 0.283619201603, excess kurtosis value is

0.417650712365, R^2 is 0.990500968463, standard deviation is ±1.42063739255, two standard deviations from the mean are represented as [2.8412747850975335, –2.8412747850975211].

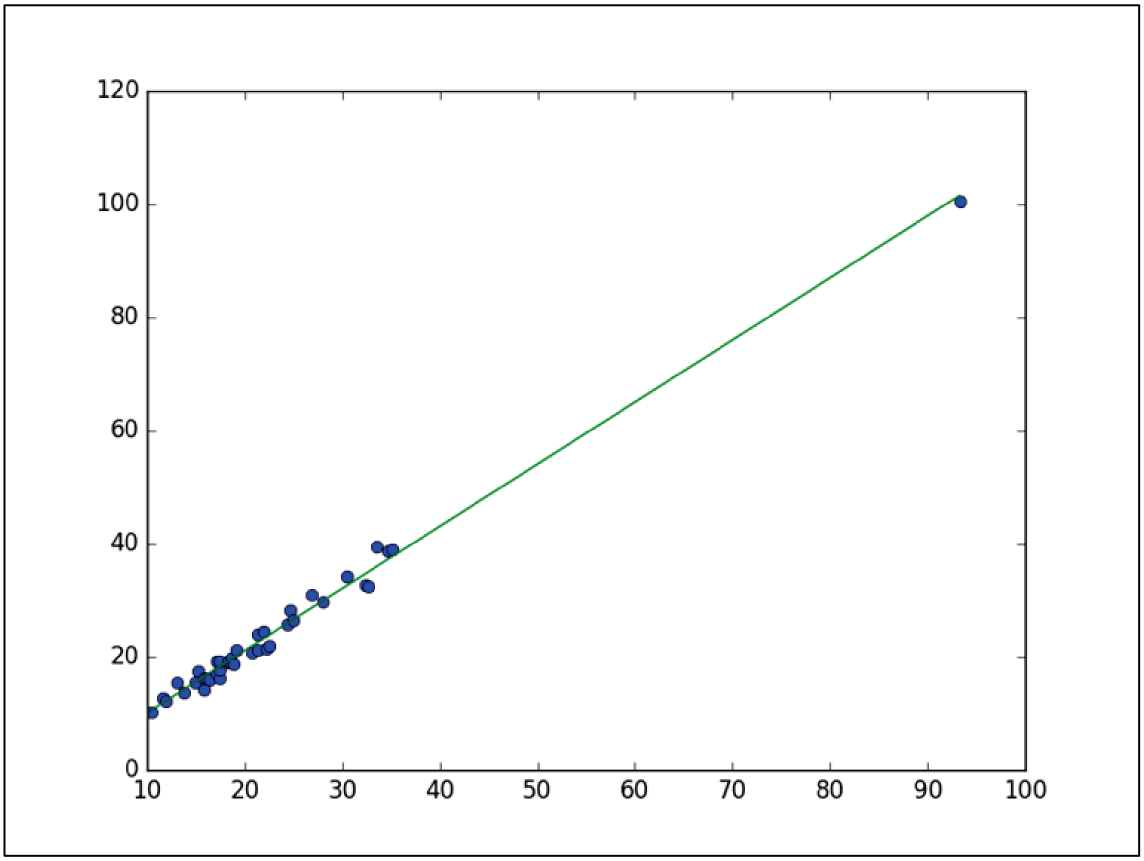

Figure 4-4: Lewis distance linear regression line Y_hat = –0.816013963143 + 1.0972812151x represented with points contributing to its creation (numbers indicate meters with points' x-values representing Lewis survey shot distances and y-values representing corresponding hillshade shot distances).

Linear regression did not produce residual data with a normal distribution for shot azimuth values from the 1885 Lewis survey and the LiDAR hillshade adjusted survey as the data failed the kurtosis test. The null hypothesis that the observed minus predicted residuals come from a normal distribution could be rejected. The azimuth data's mean is –2.1505011946, standard deviation is ±4.00158711373, distribution is approximately symmetric at 0.27005917329, and excess kurtosis value is 2.01392761903. Due to data being non-normal, Chebyshev's theorem, which allows for the creation of non-parametric confidence intervals, was used to infer an upper bound and lower bound for the percentage of shot azimuth difference data likely to be inside of maximum and minimum observed values (Shafer and Zhang 2015:36–41).

Chebyshev's theorem is written as:

k = ((mean + mean_adjusted_interval_value) – (mean – mean_adjusted_interval_value)) / standard_deviation

The likely percentage of values falling within the interval created using Chebyshev's theorem is determined with:

likely_percentage_of_values_in_created_bounds = (1 – (1 / (k * k))) * 100

The lower bound is the determined mean adjusted interval value subtracted from the mean and the upper bound is the determined mean adjusted interval value added to the mean. Together these limits create a range or interval.

The range or interval, which bounds sample azimuth values to achieve a confidence interval above 95%, produced for this project using Chebyshev's theorem with mound survey shot azimuth difference data, was (–13.005986213684089, 8.7049838244915065) and encompasses at least 96.6% of population azimuth values. The values in the determined range can be subtracted and added, respectively, to unadjusted Lewis survey azimuths to account for their possible errors with 96.6% certainty.

This bound for azimuth values was used in combination with the generated shot distance related linear regression line and its associated standard deviation values to produce a geospatial boundary encompassing the area in which a mound center point would fall with greater than 95% certainty (Figure 4-5). Though this method can produce boundaries that have a high likelihood of containing mound center points in areas where mound locations are no longer visibly identifiable, its produced areas become unwieldy when attempting to predict the location of a mound center point from visually or geospatially unconfirmed mound center point locations. This is merely a preliminary exploration of a mound center point location prediction process and the discussed techniques need refinement, but their discussion establishes useful avenues for future research to promote better preservation of mound remnants and fewer disturbances of mound related burials.

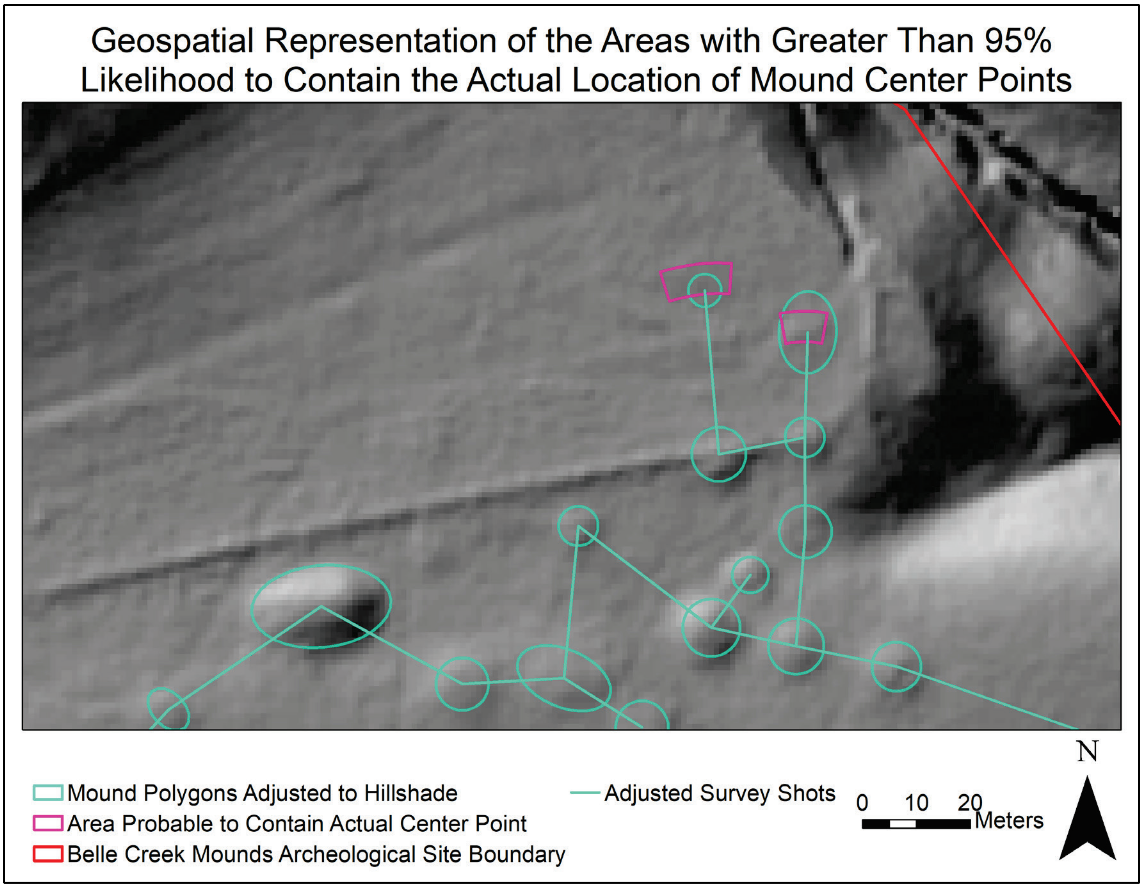

Figure 4-5: Geospatial boundaries with greater than 95% certainty to contain actual mound center point locations at Belle Creek Mounds archeological site.

Geophysics

Relative elevation and soil texture can have significant impacts on the results of geophysical tests, especially in assessments of soil resistance (Geoscan Research 2009:6-3; Somers 2006:118). With the potential impact of elevation and soil texture in mind, in addition to further establishing the locations of the geophysical grid portions where data were collected, a map is provided for reference (Figure 4-6).

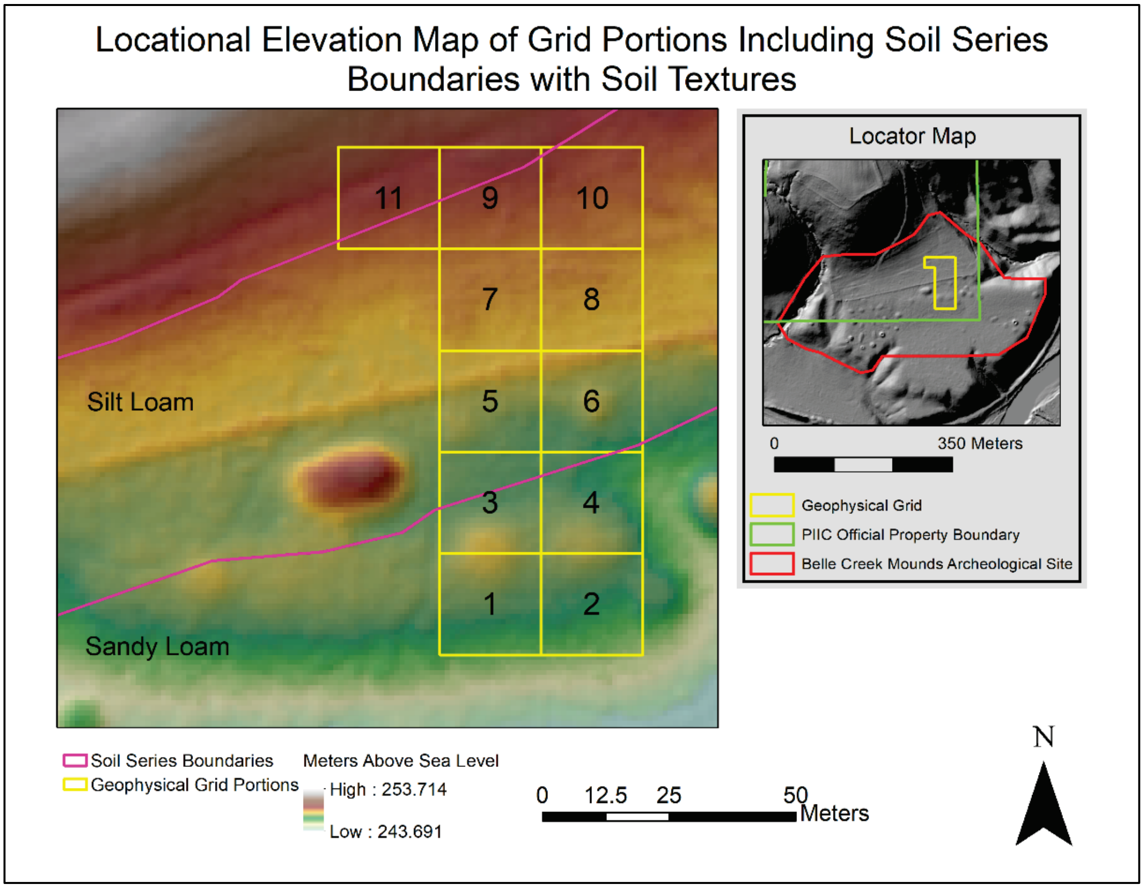

Figure 4-6: Locational elevation map of grid portions including soil series boundaries with soil textures.

In presenting data collected during the aforementioned geophysical survey, grid portions 1, 2, 3, and 4 are covered first. The reasoning behind presenting this southern third of the geophysical grid initially, has to do with highly visible, previously mapped, mounds providing information regarding what type of geophysical signature to expect from highly impacted and previously unidentified mounds. Lewis' LiDAR hillshade adjusted 1885 survey, depicted in Figure 4-3, indicates that previously disturbed mound locations lacking an associated elevational physical surface expression are present within this project's geophysical grid, north of the linear field edge push that runs northeast near the northern boundary of grid portions 5 and 6 and the southern boundary of grid portion 8 (Lewis 1885:1–3). The field edge push can be seen in Figure 4-6.

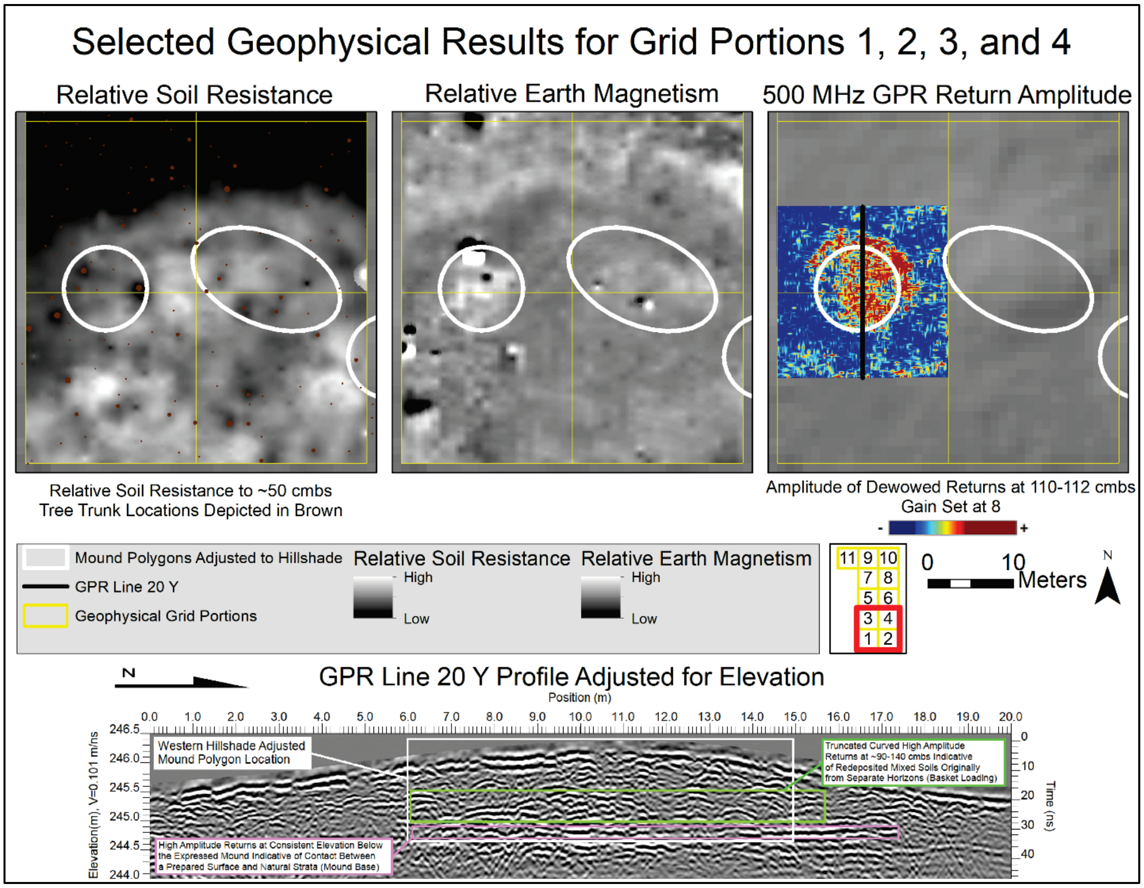

Figure 4-7: Selected geophysical results for grid portions 1, 2, 3, and 4.

The geophysical results for grid portions 1, 2, 3, and 4, summarized in Figure 4-7, present data collected over two documented mound locations with elevational physical surface expression. One of the most noticeable aspects of the relative soil resistance data related to grid portions 3 and 4 is the stark contrast in broadly higher relative soil resistance values in their southern halves and broadly lower values in their northern halves. This dramatic shift in electrical resistance is likely attributable to a change in soil texture from silt loam to sandy loam. The southern soil series line on Figure 4-6 corresponds with the changes seen in soil resistance (Soil Survey Staff 2016).

Though the manual for the soil resistance meter used in collecting data on this project suggests that mounds tend to result in the measurement of electrical resistance highs with respect to their surroundings, it is apparent here that is not entirely the case (Geoscan Research 2009:6-3). This may also be explained as resulting from the apparent abrupt change in soil composition. Due to an accumulation of soil being needed from nearby to construct mounds and a likely borrow area, represented by an elevational low, immediately to the north of the mounds, these mounds may be built on sandy loam with a mixture of silt loam and sandy loam, which would be a less electrically resistive material than the material that is prevalent in the areas to the west, east, and south of the mounds' locations. The mounds are still relative highs in relation the majority of the land in the grid portions that they occupy, probably partially attributable to their greater elevation and the possibility of prepared resistive surfaces within the mounds, but the relatively high, in relation the grid portions as a whole, area between the mounds is still measured as more resistive. A lack of less resistive material deposited in between the mounds in combination with it being relatively high in elevation may explain why it is more resistant than the mounds.

Another factor involved in the mounds lack of noticeably high relative electrical resistance may be the trees growing on each of them. Tree root systems may hold more moisture than surrounding soils, especially in well-drained courser textured soils, and moisture is associated with less electrical resistance (Geoscan Research 2009:6-3). In the window displaying the relative soil resistance raster, trees are depicted as brown specks of different sizes relative to their trunk diameter, small under 25 cm., medium 25 to 50 cm., and large greater than 50 cm. The two large trees on the western mound, between grid portions 1 and 3, are associated with significant drops in soil resistance. Trees present off of the mounds appear to be associated with drops in relative soil electrical resistance as well. A small pit was present at the time of surveying near where the eastern low on the west mound was measured. The presence of this pit probably resulted in more moisture accumulation and retention in its location. Going forward, the precedent set by the geophysics collected in association with these documented, mounds with elevational physical surface expressions is that mounds on site will be represented as relative resistance highs either exceeding or comparable to other resistance highs in soils residing in locations beyond purported mound boundaries.

Through observing the relative earth magnetism detected over the southern grid portions, it is apparent that the mounds have a stronger magnetic signature than the immediately adjacent soils. This is in accordance with expectations because of how mounds appear in previous geophysical mound studies and are described as appearing in theoretical explanations, potentially due to an accumulation of topsoil (Betts and Stay 2017:48–50; Kvamme 2006:217–218). An area of low magnetism, similar to what is seen surrounding both of the mounds, has been documented in a previously cited mound study (Betts and Stay 2017:49–50). There also appear to be smaller magnetic anomalies present within the mound boundaries, which might be explained as representative of burned stones, magnetized through the thermoremanent effect, buried within the mound (Arzigian and Stevenson 2003:140 and 156–158; Kvamme 2006:207–208). Buried burned stones may be detected as a dipolar field, with paired positive and negative magnetic extremes depicted within isolated spots (Kvamme et al. 2006:48).

Curiously, seemingly in contrast to the explanations provided in some of the previously cited sources, the relatively topographically low area to the north of both of the mounds appears as a magnetically high anomaly like the mounds, with the strongest magnetism depicted in congruence with the low area's lowest spot. In making sense of the magnetically high anomaly in the elevational low, erosional deposition of enriched topsoil including magnetic materials from accumulated topsoil more easily put in suspension due to a smaller size and density and moved via splash and sheet erosion may be the reason for its existence (Kvamme 2006:218–219; Kvamme et al. 2006:48). To conclude magnetic interpretations, the small dipole to the southwest of the westernmost mound, positioned along the western boundary of grid portion 1, is associated with the location an old seatbelt was found in following data collection in the grid portion with the gradiometer.

The results of the ground penetrating radar data collection in grid portions 1 and 3, over the western mound, are striking. From roughly one to two meters in depth below the ground surface, the ground penetrating radar detected high amplitude returns in a circular pattern when viewed in plan. GPR returns are explained as resulting from the contrast in electrical properties between two materials at their underground interface, the greater the difference between the materials, the higher the amplitude of the return (Conyers 2006:136). This explanation of what GPR returns signify suggests that the equipment detected significant soil contrasts within the mound's underlying soils (Figure 4-7). According to research discussed previously, the presence of significant inconsistencies in soil properties within the soil matrix may be the result of the mixing of soils or sediments during the construction of a mound, possibly through a process referred to as basketloading (Arzigian and Stevenson 2003:133; Betts and Stay 2017:46). In basketloading, basket loads of earth are taken from mixed or different strata or borrow area locations and deposited together, often onto a prepared surface from which the topsoil has been removed in preparation for mound construction, resulting in a mound having irregular stratigraphy, including lenses of gravel or subsoil along with other types of material (Arzigian and Stevenson 2003:133; Betts and Stay 2017:46). Basketloading is described as being present within the first mound that Edward Schmidt excavated at the Belle Creek Mounds mound group, making it all the more likely that effects of basketloading would be observed in geophysical data collected over a mound at the same archeological site (Arzigian and Stevenson 2003:133).

The depiction of GPR results, associated with data collected over the western mound, in profile corroborates the results viewed in plan from 110–112 cmbs. When viewed in profile, data collected over the mound's location indicate many curved truncated soil strata at ~90–140 cmbs with properties that appear to be consistent with the interpretation of being associated with basketloading-based construction. The mound signatures derived from these southern grid portions are used in attempting to understand and make sense of the geophysical results in grid portions 5, 6, 7, and 8 and 11, 9, and 10.

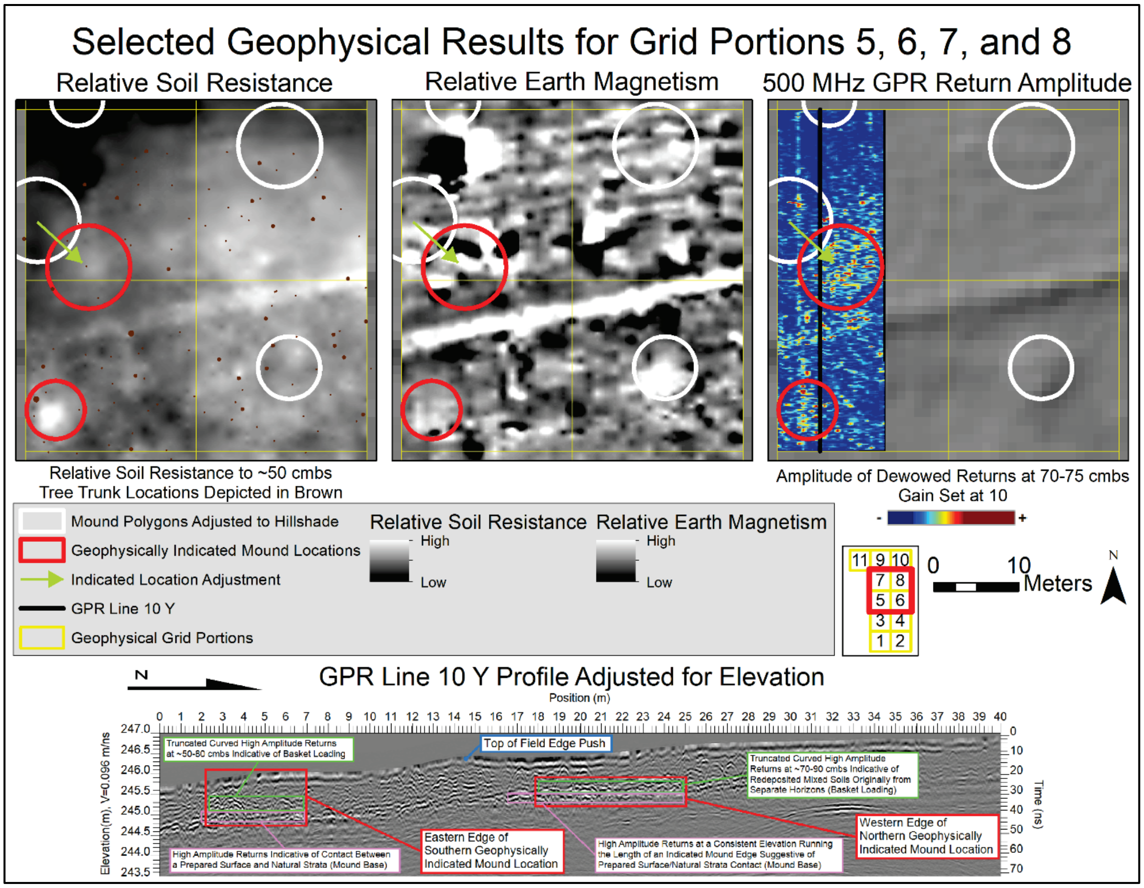

Figure 4-8: Selected geophysical results for grid portions 5, 6, 7, and 8.

The geophysical results in grid portions 5, 6, 7, and 8 were collected over: one previously mapped mound with elevational physical surface expression in grid portion 6, the field edge push running west-southwest to east-northeast near the northern boundaries of grid portions 5 and 6 and the southern boundary of grid portion 8, one circular slight elevational rise not previously mapped as a mound in grid portion 5, and three previously mapped, impacted mound locations where mounds no longer have elevational physical surface expressions, in addition to the areas in between the previously stated current, former, and possible mound locations. The previously mapped mound with elevational physical surface expression in grid portion 6 has relative soil resistance and earth magnetism readings similar to those of the previously mapped mounds in grids 1, 2, 3, and 4. Relative soil resistance values are slightly higher than the area's resistance values outside of the mapped mound's boundary. Trees present on the mound could be contributing to the relative electrical resistance lows within the mound boundary's western third, as they did on the mound straddling grid portions 1 and 3. However, it appears that with the soil transitioning from sandy loam to silt loam with the northward movement out of the southernmost four grid portions, trees are not as clearly associated with lower values in relative electrical resistance in soils, with some trees appearing to be associated with relative resistance highs in grid portions 5, 6, 7, and 8. The recorded earth magnetism is higher within the mound's boundary than over adjacent areas. Like the mounds in more southern grid portions discussed previously, the earth magnetism increase over the mound could be interpreted as being the result of topsoil accumulation or the creation of a buried burned prepared surface, although the lack of dipoles indicative of thermoremanent magnetism give more credence to the former interpretation.

The linear field edge push running through grid portions 5 and 6 near their northern boundaries and through grid portion 8 along its southern boundary, in its southeastern corner, provides an interesting test case for how geophysical data are impacted by elevational rises and topsoil accumulation. The boundary of an apparently cultivated area associated with the location of the field edge push is present in an aerial image from 1938 indicating that the field edge push was established prior to the aerial photo, possibly in leveling the area for ease of cultivation (United States Department of Agriculture 1938). The processes involved in preparing a field for cultivation and cultivation itself appear to have adversely impacted the mounds north of the field edge push, with many no longer having elevational physical surface expression. The field edge push is easily identifiable in relative soil resistance data, being represented as a relative high, possibly due to its higher elevation than immediately adjacent areas, promoting less moisture retention (Geoscan Research 2009:6-3). The field edge push is represented as a magnetic high much like the mound in grid portions 1 and 3. The magnetically high signature of the field edge push may be the result of the accumulation of magnetically rich topsoil much like the magnetic highs associated with the previously discussed mapped mounds (Betts and Stay 2017:48–50; Kvamme 2006:217–218). The field edge push's ground penetrating radar related signature consists of high amplitude returns indicative of significant soil mixing, similar to what is seen in the mapped mound in grid portions 1 and 3 (Conyers 2006:136).

Within the southwestern corner of grid portion 5, there is a subtle elevational rise that looks much like the rises previously mapped as mounds on a LiDAR-based hillshade (Lewis 1885:1–3). This rise has associated with it, highs in relative soil resistance, discussed as being expected over mounds (Geoscan Research 2009:6-3). The rise is also depicted as being high in relative earth magnetism, reminiscent of previously mapped mounds and indicative of magnetite rich topsoil accumulation (Betts and Stay 2017:48–50; Kvamme 2006:217–218). Ground penetrating radar returns from 70–75 cmbs viewed in plan show high amplitudes associated with the rise, which as mentioned previously could be the result of mixing due to construction via basketloading, but in any case matches the general tendency of the ground penetrating radar signature of the mapped mound in grid portions 1 and 3. The GPR data depicted in profile indicates truncated curved stratigraphy from

~50–80 cmbs in the area of the elevational rise, encompassed by a green box within a red box labeled as the eastern edge of the southern geophysically indicated mound location (Figure 4-8). This elevational rise's geophysical signature appears to match those of previously mapped mounds. Although not absolutely conclusive, it is highly likely that this is in fact an unmapped mound. It is not uncommon for Lewis to have not mapped all mounds in any specific location. In some nearby instances he simply missed them (see, e.g., 21GD51), and in other instances he specifically notes that indistinct mounds or sections of mound groups were not mapped (see, e.g., 21GD45).

The southernmost previously mapped mound location in grid portion 7, depicted in white, which T.H. Lewis' 1885 survey, adjusted to a LiDAR-based hillshade, depicts as straddling the western boundary of grid portion 7, is geophysically supported as being in a slightly different location to the southeast, depicted in red (Figure 4-8). The reasoning behind the geophysically indicated mound location differing from the surveyed mound location has to do with the discussion earlier in this chapter regarding the differences between mound locations visible on a LiDAR derived hillshade and mound locations determined solely through the usage of Lewis' 1885 survey notes, as well as the characteristics of geophysical data collected over the area. Interestingly, a relative soil electrical resistance high is depicted in an area slightly lower in elevation than the area around it, in the center of the geophysically indicated mound location (Figure 4-8). Due to a lower elevation promoting more moisture accumulation and a lower resistance value, this area is anomalous. This anomaly might be explained by soils being burned or by soils from other surrounding or underlying strata being mixed in with topsoils during mound construction, potentially decreasing water retention (Conyers 2012:32–34). The GPR data depicts high amplitude returns, known to be associated with mounds, both in plan view from 70–75 cmbs and profile from ~70–90 cmbs, where high amplitude returns are encompassed by a green box within a red box depicting the northern geophysically indicated mound location in Figure 4-8. The strongest supporting evidence for this being the former location of the previously discussed surveyed mound is the size and shape of the ground penetrating radar high amplitude returns matching the circular, highly geometric, dimensions of the Lewis surveyed mound (Kvamme 2006:222). There are also magnetic dipoles more strongly associated with the geophysically indicated mound location than with the hillshade adjusted surveyed mound location (Figure 4-8). These dipoles may be associated with a hearth or cairn within the mound, as are discussed as being common mound associated features in the background chapter.

The hillshade adjusted 1885 Lewis survey mound polygon present along the northern border of grid portion 7 does not appear to be represented by a relative soil resistance high or any clear ground penetrating radar high amplitude returns. The earth magnetism data over the surveyed mound polygon are also unhelpful due to the presence of recently deposited metallic debris found in combination with evidence of a small fire, both of which contributed to a substantial dipole obscuring subtler magnetism that tends to be associated with mounds (Kvamme 2006:222). The hillshade adjusted 1885 Lewis survey mound polygon within grid portion 8 does not seem to have any significant associated relative soil resistance highs. This location is represented by a magnetic high as known mounds are on site; however, magnetic data appear to be obscured slightly by linear anomalies that may indicate previous plowing efforts (Kvamme 2006:222). GPR data necessary for generating a plan view map or digital subsurface profiles were not collected over grid portion 8.

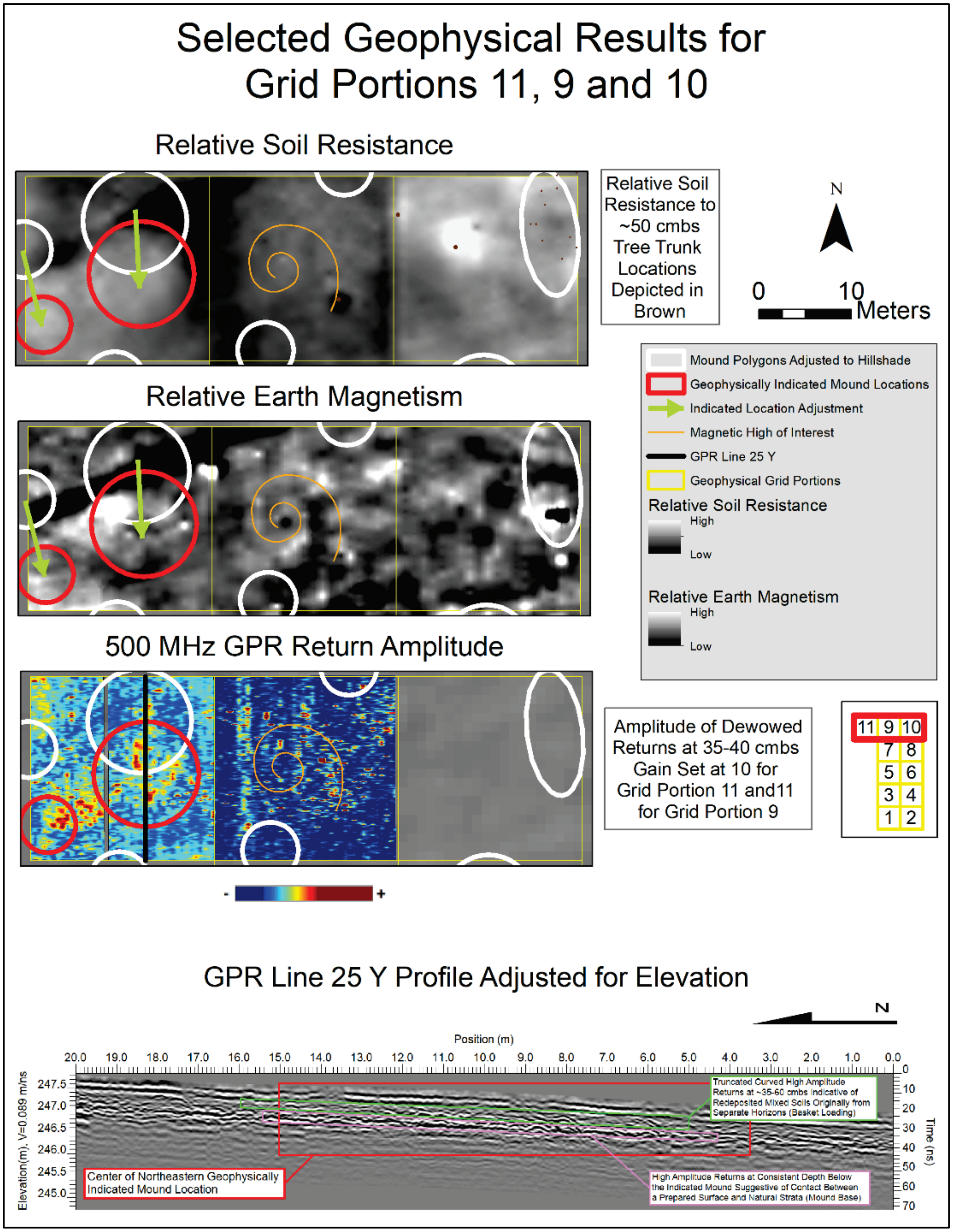

Figure 4-9: Selected geophysical results for grid portions 11, 9, and 10.

Grid portions 11, 9, and 10 appear to have been disturbed to a greater degree than geophysical grid portions one through eight to the south, due to their position in long used artificial pasture (Lewis 1885:1–3; United States Department of Agriculture 1938). Despite inferred heavier agricultural usage, geophysical data collected over the three northernmost grid portions supports the presence of mounds. Although the two hillshade adjusted 1885 Lewis survey mound polygons mostly within grid portion 11 do not encompass geophysical data suggestive of a mound, if both of these polygons are moved south and slightly east, representative geophysical signatures indicative of mounds of the sizes specified by Lewis' 1885 survey exist in relative soil resistance data, relative earth magnetism data, and GPR returns from 35–40 cmbs, when viewed in plan and profile (Figure 4-9). These geophysical signatures support the geophysically indicated mound locations depicted in Figure 4-9 as being the true spatial locations of the previously surveyed mounds. The linear low in relative soil resistance, relative earth magnetism, and the amplitude of GPR returns, running to the northeast and southwest across the northern half of grid portion 11, is representative of a ditch cut that can be clearly seen in Figure 4-6.

Both hillshade adjusted Lewis 1885 survey mound polygons partially present in grid portion 9 seem to lack clearly associated geophysical anomalies. This may be because of previous disturbance. There is, however, a curiously shaped anomaly especially visible in relative earth magnetism data (Figure 4-9). This anomaly appears as a spiral, a very common decoration on Silvernale pottery representative of the underworld (see Chapter 2). The anomaly's shape and presence within a burial mound group that functioned as a cemetery, though it cannot be cogently attributed to any earthwork at this point, draws attention to the potential existence of subtler features that may be present among mound groups. This anomaly might be associated with intaglio, a three-dimensional reversal of an effigy mound dug into the ground (Rosebrough 2010:369). In grid portion 10, the hillshade adjusted 1885 Lewis survey mound polygon that is nearly completely encompassed appears to have both associated relative soil resistance and relative earth magnetism highs. These geophysical data support that its current orientation is representative of a true mound location.

Geophysical indications of mound locations, no longer easily identifiable via changes in elevation, could contribute to refining understandings related to Lewis' errors in surveying as well as the known locations of other, individual, mounds lacking elevational physical surface expression. Geophysical data provides another means of correcting Lewis survey data to more accurately determine mound locations and isolate Lewis survey shot errors to allow for a more accurate interpretation of mound groups as they were when originally surveyed.

Shovel Testing

Prior to and following the collection of geophysical data, the EARTH Systems Research Laboratory with the assistance of Franky and Matt Jackson excavated a total of 47 shovel tests. The initial two shovel tests were excavated in the pasture area, to the north and west of the area of geophysical investigation, in preparation for the placement of permanent datums on site. The latter 45 were excavated immediately south of the area of geophysical investigation on Prairie Island Indian Community property. Shovel test excavation took place to discern which types of artifacts are present on site and in what concentrations. Shovel testing helped with gaining a better understanding of the archeological cultural material present on Belle Creek Mounds archeological site and PIIC property that warrants protection and with the attempted furthering of archeological knowledge of the Red Wing Region.

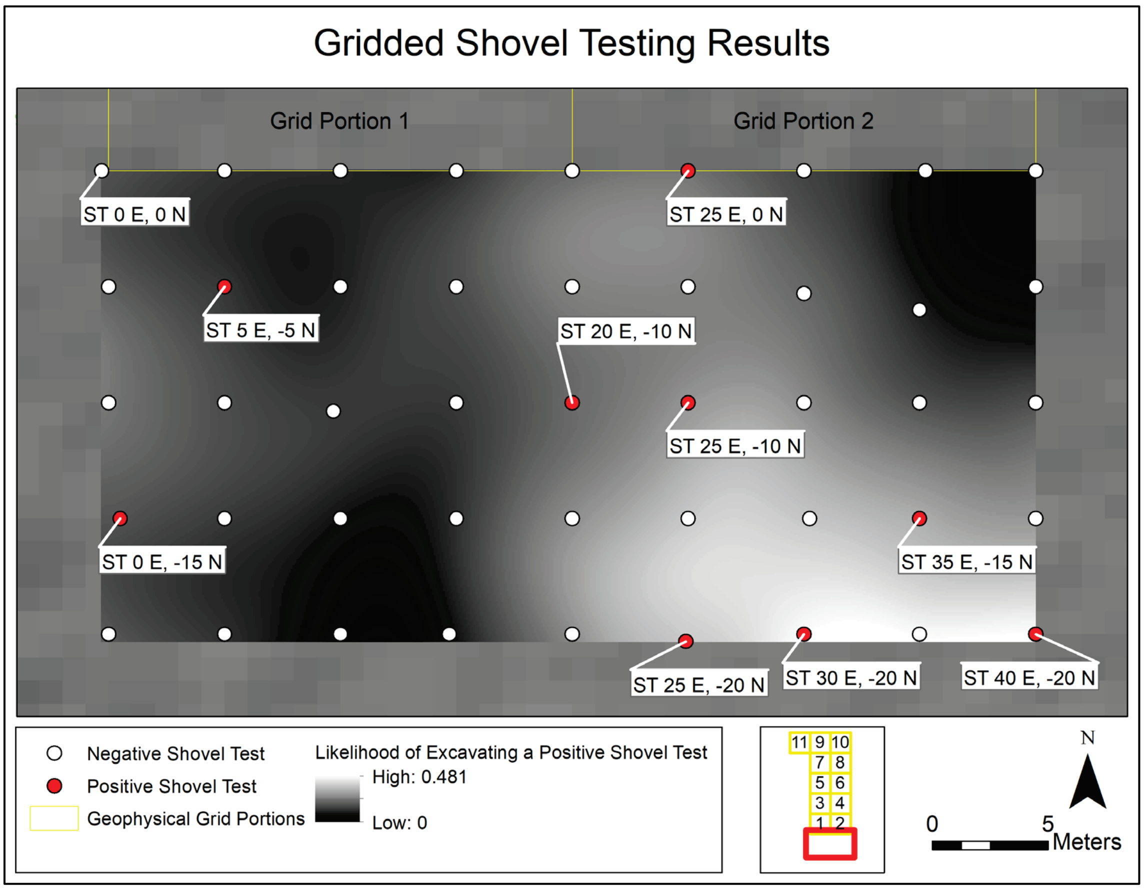

Figure 4-10: Gridded shovel testing results immediately south of the geophysics grid.

Of the 47 shovel tests excavated on site, 9 were positive for cultural material. Both shovel tests excavated in preparation for the placement of Datum 1 and Datum 2 on site were negative, yielding no artifacts. The artifacts associated with the 9 positive shovel tests consisted of pottery sherds, lithic debitage, and fire-cracked rock, with 5 yielding pottery sherds, 5 yielding lithic debitage, and 2 yielding fire-cracked rock. In total 7 pottery sherds, 5 pieces of lithic debitage, 65 pieces of charcoal unassociated with any recognized archeological features, and 2 pieces of fire-cracked rock were collected, cataloged, and accessioned at the Minnesota State University, Mankato Museum of Anthropology, Archeology Division's curation facility. The surveying crew found pottery sherds in each of the three easternmost positive shovel tests, and shovel test 40 E, –20 N encountered a buried organically enriched layer that may be part of a feature associated with human activity during the Pre-Contact Era.

The 45 southern shovel test locations are displayed in Figure 4-10. Some of the locations had to be slightly repositioned from their initially intended placement, with precise 5-meter spacing, to allow for the avoidance of obstructions. Empirical Bayesian kriging was used to generate the raster underlying the depicted shovel test points, approximating the probability of excavating a positive shovel test in the area encompassed by the shovel testing grid, based on whether each of the 45 shovel tests in the grid were positive or negative for artifacts.

> Empirical Bayesian kriging differs from other kriging methods by accounting for the error introduced by estimating the underlying semivariogram… For each prediction location, the prediction is calculated using a new semivariogram distribution that is generated by a likelihood-based sampling of individual semivariograms from the semivariogram spectrums in the point's neighborhood (Esri Inc. 2016).

All 5 pieces of lithic debitage recovered during sub-surface testing were determined to be Prairie Du Chien chert with one piece having clear evidence of heat treatment, used in making lithic raw material fracture easily so that it may be more readily knapped and pressure-flaked into stone tools. Both pieces of fire-cracked rock were classified as granite. Four of the 7 pottery sherds collected were cataloged as having shell temper with one having an incised line decoration (Figure 4-11). Shell tempering was indicated by lacunae, negative space on the surface of pot sherds where shell has since been leeched out of the pottery (Figure 4-12). One pottery sherd has a cordmarked surface treatment and grit tempering (Figure 4-13 and Figure 4-14), and two have indeterminate temper and surface treatment.

Figure 4-11: Smoothed sherd with lacunae.

Figure 4-12: Smoothed sherd with lacunae, zoomed in.

Figure 4-13: Cordmarked grit-tempered sherd.

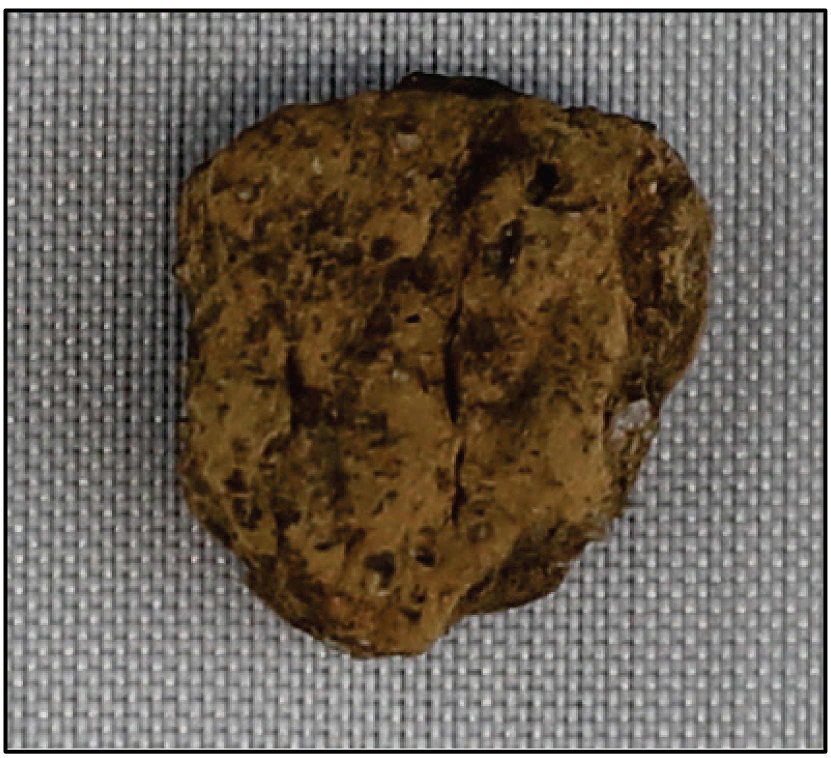

Figure 4-14: Cordmarked grit-tempered sherd, zoomed in.

Chapter 5 – Discussion and Conclusions

This research supports that geospatial and geophysical methods including relative soil resistance, magnetometry, and ground penetrating radar can be used to assist in locating Pre-Contact Native American earthworks and, by association, burials on the Belle Creek Mounds site and, quite likely, in similar settings throughout the Red Wing Region. Geophysical methods may also provide inroads toward a clearer understanding of how mound groups functioned as ritual spaces through the identification of anomalies potentially representing previously unencountered or overlooked archeological features that can be further explored using other methods. However, the effectiveness of geophysics in mound group relocation appear to be contingent on the amount and types of previous disturbances in an area. For example, the field edge push visible in Figure 4-8 has a geophysical expression similar to known mounds with the exception of its highly linear shape.

Because archeological geophysical data interpretation is dependent on the analysis of relative differences in soil properties across space, the presence of borrow areas used in mound construction and lack of recent artificial soil build-up, removal, or mixing, facilitate the interpretation of geophysical surveys over mound groups. If a mound group has fewer significant modifications since its construction and initial usage in rituals, fewer equifinal variables need to be taken into serious consideration when interpreting collected geophysical data. The relative nature of archeological geophysical data collected and interpreted in this project highlights the importance of the negative spaces around mounds within a mound group in creating recognizable mound related geophysical signatures.

Some of the mounds present in Lewis' 1885 survey did not seem to have an associated geophysical signature generated by relative soil resistance, magnetometry, or ground penetrating radar. These mound locations, lacking elevational physical surface expressions and a nearby associated geophysical signature, further illustrate the detrimental impact that ground disturbing activity can have on an archeological site with earthworks. A lack of Post-Contact Era agricultural practices on site would have likely resulted in identification of more mound related geophysical signatures in this location. The formerly cultivated area within the established geophysical grid was the only part of the grid in which geophysical signatures could not be tied to previously identified mounds.

The use of T. H. Lewis' 1885 survey proved to be invaluable in geophysical data interpretation due to its depiction of mound dimensions and their positions in relation to each other. Without referencing this past survey, it would have been far more difficult to assess anomalies as evidence of locations of previously visible mounds. One heartening result of this project is its contribution in beginning to quantify the error present in Lewis' mound survey data that could allow these 19th century mound surveys to be applied with greater care in protecting and understanding mound groups. Future geospatial research contributing to knowledge regarding the sources and types of errors present in these surveys would likely be of great value in archeological work on formerly mapped mound groups. Lewis' survey in combination with other research cited in earlier chapters, may be used to assist in developing boundaries around mound groups accounting for the presence of mound related activity areas.

Previous research discusses entire mound groups' sociocultural function as ritual spaces and cemeteries (see Chapter 2). With disturbances to mound groups, not only are mounds without elevational physical surface expression, with possible intact underlying burials, more difficult to identify and more likely to be subjected to further disturbance, the feeling, otherwise known as the property's expression of the aesthetic or sense of the time in which the mounds were constructed, is greatly diminished (U.S. Department of the Interior National Park Service Cultural Resources Division 2000:36). With a decreased sense of the time in which mound group construction and rituals initially happened, these places lose some of their value in providing people, particularly indigenous people, with opportunities to commune with their past.

The shovel testing conducted south of the geophysical grid yielded a very small number of artifacts mainly consisting of pottery sherds and lithic debitage. The 5-meter spacing used for the placement of shovel tests proved to be important in generating a sample of artifacts useful for archeological interpretation. If a wider shovel test spacing was used immediately outside of the mound group, preliminary results relating to the Belle Creek Mounds archeological site's cultural affiliation would lose significant supporting evidence. The presence of pottery is generally associated with and supports the interpretation of past habitation within the arc of mounds present on site, comparable to archeologically similar settings nearby. The combination of pottery sherds with varied characteristics can be tentatively interpreted as indicating that the habitation associated with the mound group is an aggregation village due to cordmarked grit-tempered pottery affiliated with Late Woodland groups being present among smoothed shell-tempered pottery affiliated with Silvernale and Oneota groups. However, more substantial research needs to be done before this interpretation can be made with confidence because of the incredibly small size of the analyzed artifactual collection.

The findings of this project promote the future application of hillshade adjusted Lewis mound survey results and geophysical methods around and within a generously estimated mound group boundary prior to development or land usage that may have adverse impacts on mounds, mound remnants, burials, or other possible mound group features to allow for their identification to prevent their disturbance or destruction. This recommendation is made because of the promising results of this Lewis mound survey informed geoarcheological survey.

References

Anfinson, Scott F.
1979 *A Handbook of Minnesota Prehistoric Ceramics*. Minnesota Archaeological Society.

Artz, Joe Alan, Emilia L. D. Bristow, and William E. Whittaker
2013 *Mapping Precontact Burial Mounds in Sixteen Minnesota Counties using Light Detection and Ranging (LiDAR)*. Office of the State Archaeologist, Iowa City, Iowa.

Arzigian, Constance M., and Katherine P. Stevenson
2003 *Minnesota's Indian Mounds and Burial Sites: A Synthesis of Prehistoric and Early Historic Archaeological Data*. The Minnesota Office of the State Archaeologist, St. Paul, Minnesota.

Betts, Colin, and Marshall Stay
2017 Geophysical Investigations at the Ward Long Mound Site, Allamakee County, Iowa. *Journal of the Iowa Archeological Society* 64:45–51.

Blue, Kathleen
in preparation Chapter 9: Human Skeletal Remains from the Red Wing Locality. In *Mounds Villages and Feasts: the archaeology of Red Wing*, edited by Ronald C. Schirmer. Minnesota Archaeological Society, St. Paul, Minnesota.

Chen, Xiaoming, T Allison, W Cao, K Ferguson, S Grünig, V Gomez, Adrian Kipka, J Köhler, H Landau, R Leandro, G Lu, R Stolz, and Nick Talbot
2011 Trimble RTX, an innovative new approach for network RTK. In *24th International Technical Meeting of the Satellite Division of the Institute of Navigation 2011, ION GNSS 2011*, 3:pp. 2214–2219.

Climate-Data.org
2021 Red Wing climate: Average Temperature, weather by month, Red Wing weather averages - Climate-Data.org. https://en.climate-data.org/north-america/united-states-of-america/minnesota/red-wing-16524/, accessed February 3, 2021.

Colwell-Chanthaphonh, Chip
2005 The Incorporation of the Native American Past: Cultural Extermination, Archaeological Protection, and the Antiquities Act of 1906. *International Journal of Cultural Property*(12):375–391.

Conyers, Lawrence B.

2006 Ground-Penetrating Radar. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by Jay K. Johnson, pp. 131–160. The University of Alabama Press, Tuscaloosa, Alabama.

2012 *Interpreting Ground-penetrating Radar for Archaeology*. Left Coast Press Inc., Walnut Creek, California.

Cuenca-Garcia, Carmen

2019 Soil geochemical methods in archaeo-geophysics: Exploring a combined approach at sites in Scotland. *Archaeological Prospection* 26(1):57–72.

Dobbs, Clark A.

1991 *The Northwestern Archaeological Survey: An Appreciation and Guide to the Field Notebooks*. Institute for Minnesota Archaeology, Minneapolis, MN.

Emerson, Thomas E.

1999 Some Perspectives on Cahokia and the Northern Mississippian Expansion. In *Cahokia and the Hinterlands: Middle Mississippian Cultures of the Midwest*, edited by Thomas E. Emerson and R. Barry Lewis. 1st ed. University of Illinois Press, Champaign, Illinois.

Esri Inc.

2016 What is Empirical Bayesian kriging? https://desktop.arcgis.com/en/arcmap/10.3/guide-books/extensions/geostatistical-analyst/what-is-empirical-bayesian-kriging-.htm, accessed June 7, 2021.

2020 *ArcMap*. Esri Inc, Redlands, CA.

Faulkner, Douglas J., Phillip H. Larson, Harry M. Jol, Garry L. Running, Henry M. Loope, and Ronald J. Goble

2016 Autogenic incision and terrace formation resulting from abrupt late-glacial base-level fall, lower Chippewa River, Wisconsin, USA. *Geomorphology* 266:75–96.

Fleming, Edward Paul

2009 Community and Aggregation in the Upper Mississippi River Valley: The Red Wing Locality. Unpublished PhD Dissertation, University of Minnesota.

Fullerton, David S., Charles A. Bush, and Jean N. Pennell
2003 *Map of Surficial Deposits and Materials in the Eastern Central United States (East of 102°West Longitude)*. United States Geological Survey.

Geometrics (editor)
2001 *G-858 MagMapper Operation Manual*. 25309th-OM Rev. D2nd ed. Geometrics, San Jose, California.

Geoscan Research (editor)
2009 *Resistance Meter RM15-D Instruction Manual*. 2.98. Geoscan Research, Clayton, Bradford, West Yorkshire, United Kingdom.

Gibbon, Guy E.
2012 *Archaeology of Minnesota*. University of Minnesota Press, Minneapolis, Minnesota.

Gibbon, Guy E., and Clark A. Dobbs
1991 The Mississippian Presence in the Red Wing Area, Minnesota. In *New Perspectives on Cahokia: Views from the Periphery*, edited by James B. Stoltman, pp. 281–306. Prehistory Press, Madison, Wisconsin.

Goodhue County
2020 *Goodhue County Parcel Data*. Goodhue County.

Guichard, David
2021 *Calculus*. LibreTexts.

Hegmon, Michelle
1992 Archaeological Research on Style. *Annual Review of Anthropology* 21:517–536.

Henning, Dale R., and Ronald C. Schirmer
2020 Cahokia and the Northwest Quarter. In *Cahokia in Context: Hegemony and Diaspora*. University of Florida Press, Gainesville, Florida.

Hildebrant Iffert, Emily
2010 Villagers and Archaeologists: An Examination of Past Behaviors at the Bartron Site (21GD02). Unpublished Master's Thesis, Minnesota State University, Mankato.

Holley, George R.
in preparation Chapter 11: The Red Wing Region Late Prehistoric Ceramic Sequence. In *Mounds Villages and Feasts: the archaeology of Red Wing*, edited by Ronald C. Schirmer. Minnesota Archaeological Society, St. Paul, Minnesota.

Holley, George R., and Michael G. Michlovic
2013 *The Prehistoric Village Cultures of Southern Minnesota*.

Horton, Jessica L.
2017 Places to Stand: Art After the American Indian Movement. *Wasafiri* 32(2):23–31.

Kelly, Robert L., and David Hurst Thomas
2017 *Archaeology*. 7th ed. Cengage Learning, Boston, MA.

Koncur, Jasmine
2018 The McClelland Site (21GD258) and the Oneota Tradition in the Red Wing Region. Unpublished Master's Thesis, Minnesota State University, Mankato.

Kvamme, Kenneth L.
2006 Magnetometry: Nature's Gift to Archaeology. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by Jay K. Johnson, pp. 205–234. The University of Alabama Press, Tuscaloosa, Alabama.

Kvamme, Kenneth L., Eileen Ernenwein, Michael Hargrave, Thomas Sever, Deborah Harmon, and Fred Limp
2006 *New Approaches to the Use and Integration of Multi-Sensor Remote Sensing for Historic Resource Identification and Evaluation*. Environmental Security Technology Certification Program, Herndon, Virginia.

Lewis, T. H.
1885 Archaeological Surveys: Cannon River Valley Near Red Wing, Minn. (Goodhue Co. Minn. Trempealeau Co. Wis. 1885, 1886, 1887).

Littlefield, Daniel F., and James W. Parins
2011 *Encyclopedia of American Indian Removal*. Greenwood, Santa Barbara, California.

Minnesota Department of Natural Resources
2021 The Blufflands Subsection | Minnesota DNR. https://www.dnr.state.mn.us/ecs/222Lc/index.html, accessed February 3, 2021.

Minnesota Department of Transportation
2017 *Minnesota Archaeological Site Boundaries Shapefile*. Minnesota Department of Transportation.

Minnesota Department of Transportation and Minnesota Geospatial Information Office
2009 *City, Township, and Unorganized Territory in Minnesota*. Minnesota Department of Transportation and Minnesota Geospatial Information Office (MnGeo).

Minnesota IT Services - Geospatial Information Office
2011 *LiDAR Elevation Data for Minnesota [LAZ]*. Minnesota IT Services - Geospatial Information Office.

Minnesota Legislature
1980 Private Cemeteries. *Minnesota Statutes, Ch. 307.*

Minnesota Office of the State Archaeologist
2014 *Archaeology in Minnesota: Annual Report of the State Archaeologist (Fiscal Year 2013)*.

2021a Office of the State Archaeologist (OSA) Portal. https://osa.gisdata.mn.gov/OSAportal/, accessed February 4, 2021.

(editor)
2021b Minnesota Office of the State Archaeologist Site File 21GD0072 Belle Creek Mounds. Minnesota Office of the State Archaeologist.

Minnesota State Historic Preservation Office (editor)
1990a MNSHPO Archaeological Database Site Form 21GD0065.

1990b MNSHPO Archaeological Database Site Form 21GD0066.

1990c MNSHPO Archaeological Database Site Form 21GD0067.

1990d MNSHPO Archaeological Database Site Form 21GD0068.

1990e Minnesota Archaeological Site Form 21GD0200.

Mollerud, Katy J.
2016 The Cambria Connection: Identifying Ceramic Production and Community Interaction in Late Prehistoric Minnesota, AD 1050-1300. Unpublished PhD Dissertation, University of Wisconsin-Milwaukee.

National Soil Survey Center (editor)
2012 *Field Book for Describing and Sampling Soils*. 3.0. National Soil Survey Center Natural Resources Conservation Service U.S. Department of Agriculture.

Ojakangas, Richard W., and Charles L. Matsch
1982 *Minnesota's Geology*. University of Minnesota Press, Minneapolis.

Ortiz, Erik
2020 Ancient Native American Burial Site Blasted for Trump Border Wall Construction. https://www.nbcnews.com/news/us-news/ancient-native-american-burial-site-blasted-trump-border-wall-construction-n1135906.

Post, Tim
2006 Rapid Development Running into Minnesota's Indian Burial Mounds. *MPR News*. https://www.mprnews.org/story/2006/04/28/effigymounds.

Rogerson, Peter A.
2015 *Statistical Methods for Geography: A Student's Guide*. 4th ed. SAGE Publications, Thousand Oaks, California.

Rosebrough, Amy L
2010 Every Family a Nation: A Deconstruction and Reconstruction of the Effigy Mound 'Culture' of the Western Great Lakes of North America. Unpublished PhD Dissertation, University of Wisconsin-Madison.

Schirmer, Ronald C.
2002 Plant-Use Systems and Late Prehistoric Culture Change in the Red Wing Locality. Unpublished PhD Thesis, University of Minnesota.

2016 *Radiocarbon Dating Early Oneota Sites in Southern Minnesota*.

in preparation Chapter 2: Red Wing and the Archaeological Community: Taxonomic and Interpretive History. In *Mounds Villages and Feasts: the archaeology of Red Wing*, edited by Ronald C. Schirmer. Minnesota Archaeological Society, St. Paul, Minnesota.

Schirmer, Ronald C., and Edward P. Fleming

in preparation Chapter 6: Aggregation Villages in the Red Wing Region. In *Mounds Villages and Feasts: the archaeology of Red Wing*, edited by Ronald C. Schirmer. Minnesota Archaeological Society, St. Paul, Minnesota.

Schmidt, E. W.

1940 Articles and Correspondence by Dr. E. W. Schmidt of Red Wing in regard to the archaeology of this area 1939-1940.

Schortman, Edward M.

1989 Interregional Interaction in Prehistory: The Need for a New Perspective. *American Antiquity* 54(1):52–65. DOI:10.2307/281331.

Shafer, Douglas S., and Zhiyi Zhang

2015 *Introductory Statistics*. Saylor Foundation.

Smetanka, Mary Jane

2014 2009: Indian Burial Grounds: Rest in Peace. *Star Tribune*, October 2014.

Soil Survey Staff

2005 Official Series Description - LINDSTROM Series. https://soilseries.sc.egov.usda.gov/OSD_Docs/L/LINDSTROM.html, accessed February 3, 2021.

2007 Official Series Description - LILAH Series. https://soilseries.sc.egov.usda.gov/OSD_Docs/L/LILAH.html, accessed February 3, 2021.

2016 *Gridded Soil Survey Geographic (gSSURGO) Database for Minnesota*. United States Department of Agriculture, Natural Resources Conservation Service.

2021 Web Soil Survey - Home. https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm, accessed February 3, 2021.

Somers, Lewis

2006 Resistivity Survey. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by Jay K. Johnson, pp. 109–130. The University of Alabama Press, Tuscaloosa, Alabama.

Strang, Gilbert, and Edwin Herman
2021 *Calculus*. LibreTexts.

Thompson, Victor D., Philip J. Arnold, Thomas J. Pluckhahn, and Amber M. Vanderwarker
2011 Situating Remote Sensing in Anthropological Archaeology. *Archaeological Prospection* 18(3):195–213. DOI:10.1002/arp.400.

Trimble Navigation Limited (editor)
2010 *Trimble M3 DR Series Total Station User Guide*. 1.00 Revision B. Trimble Navigation Limited, Dayton, Ohio.

2019 Trimble RTX Frequently Asked Questions. *Trimble Positioning Services*. https://positioningservices.trimble.com/wp-content/uploads/2019/02/Trimble-RTX-FAQ-2020-Brochure.pdf.

United States Department of Agriculture
1938 Aerial Photo of Welch Township. United States Department of Agriculture.

United States Department of Agriculture Natural Resources Conservation Service
2006 Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin.

U.S. Congress
1966 National Historic Preservation Act of 1966.

1978 American Indian Religious Freedom Act of 1978.

1979 Archaeological Resources Protection Act of 1979.

1990 Native American Graves Protection and Repatriation Act of 1990.

U.S. Department of the Interior National Park Service Cultural Resources Division
2000 National Register Bulletin: Guidelines for Evaluating and Registering Archeological Properties.

Willey, Gordon R., and Philip Phillips
1958 *Method and Theory in American Archeology*. The University of Chicago Press, Chicago, Illinois, U.S.A.

Woods, William I.
2004 Population nucleation, intensive agriculture, and environmental degradation: The Cahokia example. *Agriculture and Human Values* 21(2/3):255–261. DOI:10.1023/B:AHUM.0000029398.01906.5e.

Wylie, Alison
1985 The Reaction against Analogy. In *Advances in Archaeological Method and Theory*, 8:pp. 63–111. Springer.

Yamada, Rie
2007 The Spatial Relationships Among Mounds in the Red Wing Locality, MN and WI. Unpublished Master's Thesis, Minnesota State University, Mankato.