6. THE INITIAL PHASE OF THE MAGNETIC INVESTIGATIONS OF THE MOUND CITY GROUP (32RO32) AT THE HOPEWELL CULTURE NATIONAL HISTORICAL PARK, ROSS COUNTY, OHIO

By Steven L. De Vore

Abstract

The Mound City Group (Site 32RO32) covers approximately 13 acres. It contained at least 23 mounds when Squier and Davis made the first study of the mound complex in 1846. In the summer of 2009, the Midwest Archeological Center conducted the initial phase of a magnetic survey of the entire site. The magnetic survey in the southern portion of the site covered 11,200 m^2 or 2.77 acres. The magnetic data indicated the presence of numerous magnetic anomalies associated with the Hopewell occupation and with the World War I training facility of Camp Sherman.

Introduction

The Mound City Group (Site 32RO32) is a large mound and earthwork ceremonial center located on the right bank of the Scioto River north of Chillicothe, Ohio (Figure 1). The rectangular earthworks cover approximately 13 acres with at least 23 mounds. The site is associated with the Hopewell Culture that flourished in the region between 200 B.C. and A. D. 500 (Willey 1966:273-280). The enclosure is approximately 625 meters across with the walls approximately one meter high. Since the initial investigations by Ephraim G. Squier and Edwin H. Davis in 1846 (Squier and Davis 1848:54-55 and Plate 14), several mounds within the site have been excavated or destroyed through agricultural practices or the construction of Camp Sherman in World War I; however, the majority has been reconstructed in order to provide the visual effects of the site on the present landscape. The Mound City Group represents the primary interpretive Hopewell site at the Hopewell Cultural National Historical Park (HOCU).

The present project is part of an on-going evaluation of Hopewell sites within the Hopewell Culture National Historical Park and the Midwest Archeological Center's (MWAC) research into earthwork construction at the Hopeton Earthworks (Lynott 2004; Lynott and Weymouth 2002). Geophysical investigations have provided useful information in evaluating the subsurface mound and earthwork construction. Geophysical techniques provide a means of rapid and non-destructive baseline evaluation of buried archeological resources. Keeping with these research interests, the Midwest Archeological Center has conducted the initial magnetic survey of the southern portion of the Mound City Group during the summer of 2009 (Figure 2).

Historical and Archeological Background

The Mound City Group was first documented in 1846 by Squire and Davis (Squier and Davis 1998:54-55) on land belonging to Henry Schriver (Figure 3). Henry Schriver had purchased the land containing the Mound City Group in 1832 (Cockrell 1999:6). The

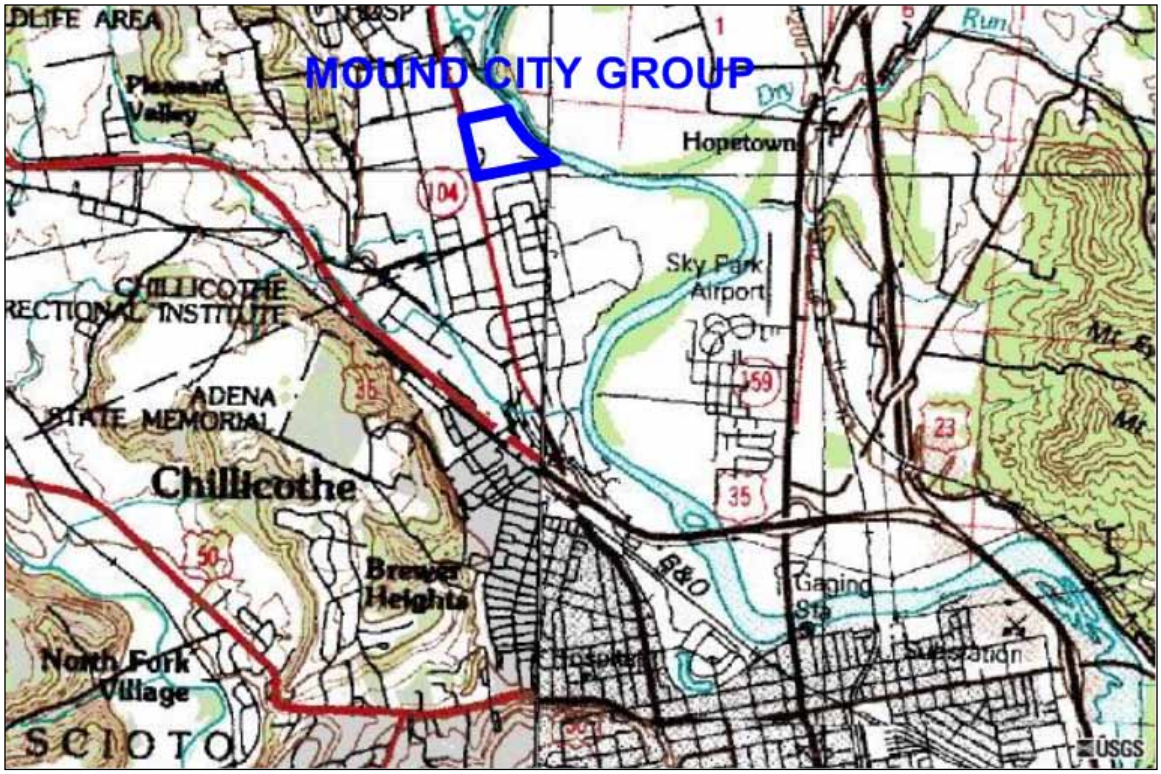

Figure 1. Mound City Group location and vicinity

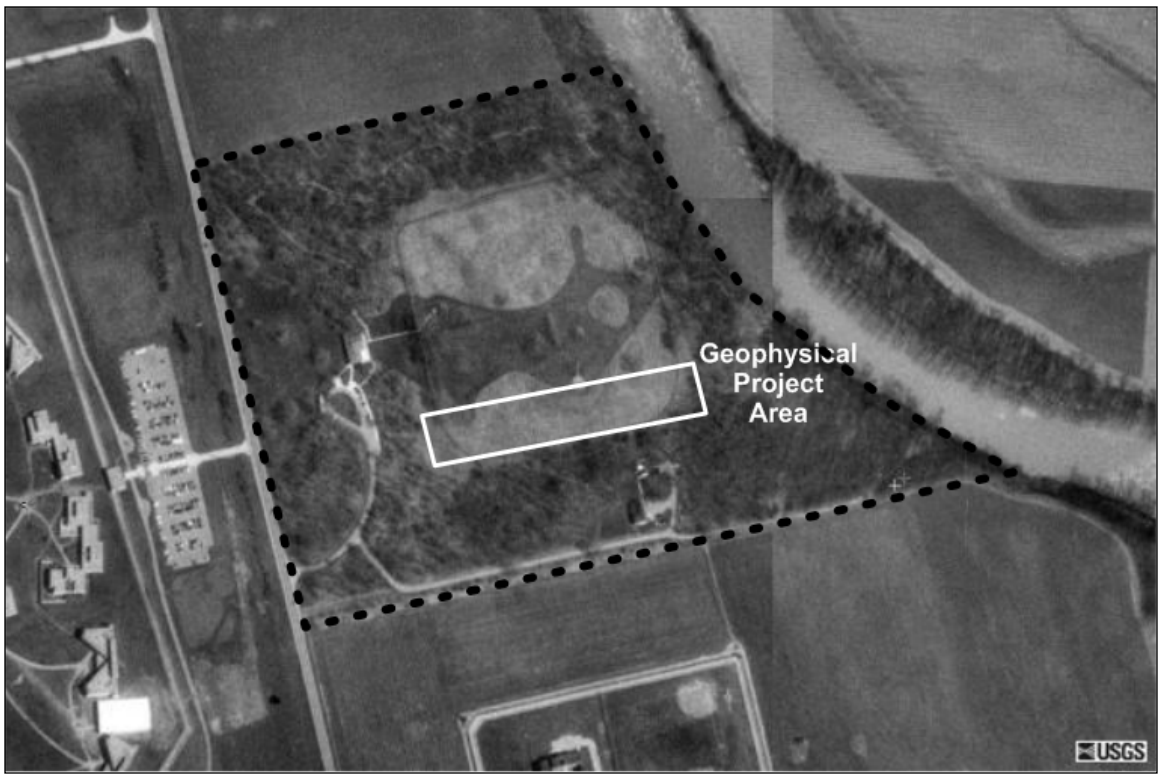

Figure 2. Geophysical project location at the Mound City Group.

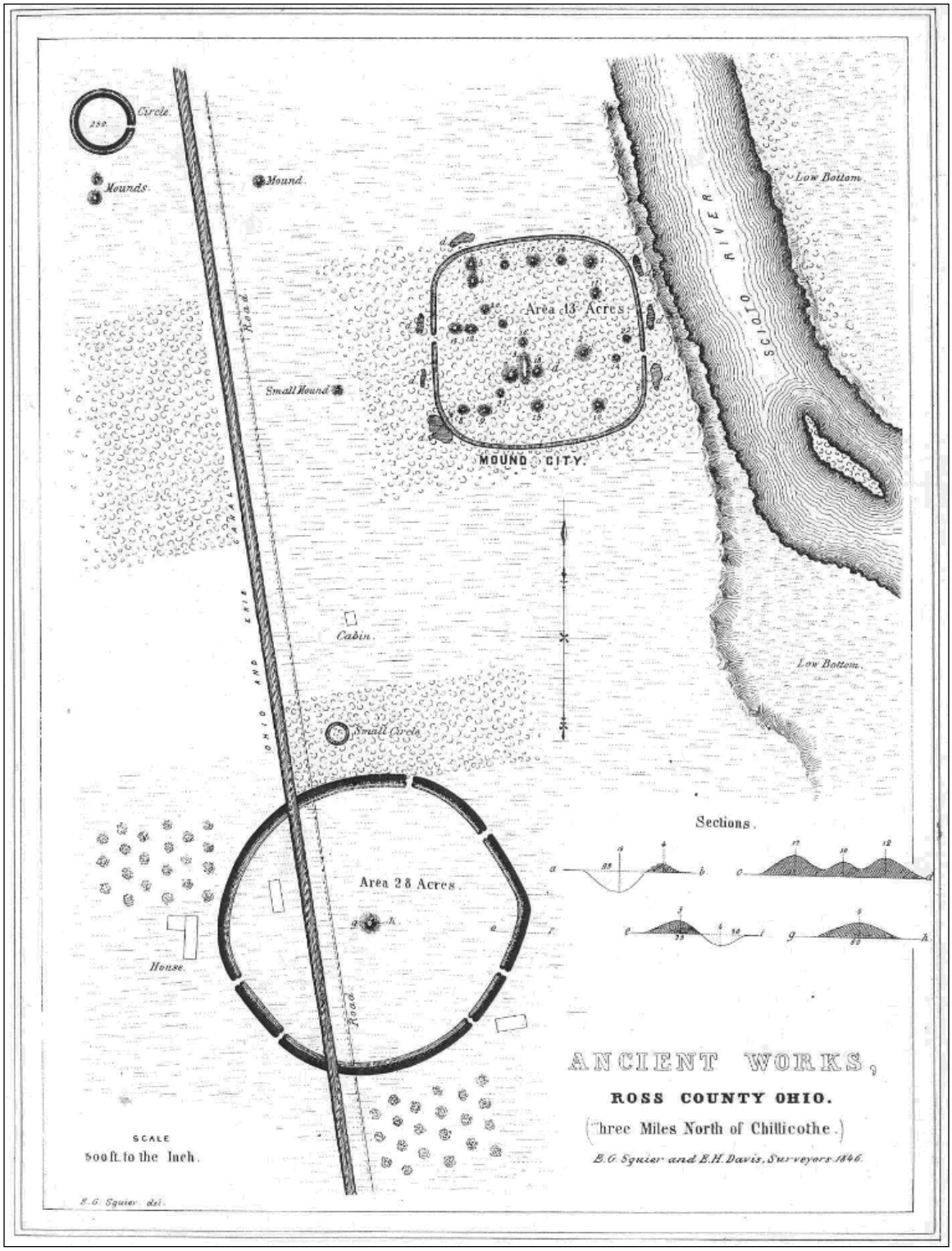

Figure 3. 1846 map of the Mound City Group (Squier and Davis 1998).

Squier and Davis investigations of several mounds within the Mound City Group yielded numerous discoveries including over 200 animal effigy pipes. The mounds appeared to be associated with mortuary activities and contained elaborate objects made from exotic raw materials from across the continent. The Schriver family retained ownership of the land and the site until 1917 when the U.S. Government originally leased the land for the construction of an Army training camp but by 1921 had purchase 2,000 acres along State Route 104 north of Chillicothe (Cockrell 1999:29-36; Ohio Historical Society 2005; Ross County Health District 2009). Camp Sherman contained 2,000 buildings that could accommodate two divisions (40,000 men). The camp consisted of barracks, offices, theaters, a hospital, a library, a farm, and a German Prisoner of War camp (Figure 4). In addition to the buildings, the camp had a railroad system and its own utilities system. Following World War I, the camp served as a trade school for the returning veterans. A veterans' hospital was also established at the camp following the war. The camp was closed during the 1920s and the buildings were dismantled. Over the years since the closure of Camp Sherman, the land has become home for the Veterans Affairs Medical Center, the Chillicothe Correctional Institute, Ross Correctional Institute, Unioto Schools, the Gateway Industrial Park, and the Hopewell Culture National Historical Park.

Archeological investigations at the Mound City Group were undertaken by the Ohio State Archaeological and Historical Society in 1920 and 1921 under the direction of William C. Mills and his assistant Henry C. Shetrone (Mills 1922). Of the 24 mounds mentioned by Squier and Davis, Mills was able to relocate only 12 mounds. Several of these mounds had been severely damaged by grading activities for streets and buildings during the construction of Camp Sherman along with the installation of buried utility lines (Figure 5). The archeological examination of these mounds yielded significant information on the Hopewell Culture in the region and lead to a public drive to preserve the mound group (Cockrell 1999:36). In 1923, President Warren G. Harding proclaimed the Mound City Group as a National Monument (Cockrell 1999:36-43). Ownership of the Mound City Group was transferred from the War Department to the State of Ohio shortly after receiving National Monument status (Cockrell 1999:43-49). With the establishment of several works programs under President Franklin Delano Roosevelt, the Mound City Group was transferred from the Ohio state parks to the Federal Government's National Park Service in the late summer of 1933; however, the State of Ohio continued to oversee the park operations until 1946 when the National Park Service took an active role in the management of the national monument (Cockrell 1999:49-70).

Archeological investigations on the Mound City Group ceased after the Mills and Shetrone excavations in 1920 and 1921. Although a significant site for our understanding of Hopewell Culture, archeological investigations at the site did not resume until 1963 when the National Park Service contracted work with Ohio Historical Society' curator of archeology, Raymond S. Baby to rectify the differences between the Squier and Davis survey with the restoration work by Mills and Shetrone (Cockrell 1999:135-142). James A. Brown from the Illinois State Museum served as Baby's onsite project manager throughout the 1963 field season (Brown 1994; Brown and Baby). The 1963 archeological investigations indicated that Mounds 10 and 13 were reconstructed in the wrong place during the 1920's restoration efforts, as well as the entire southern enclosure wall (Faust

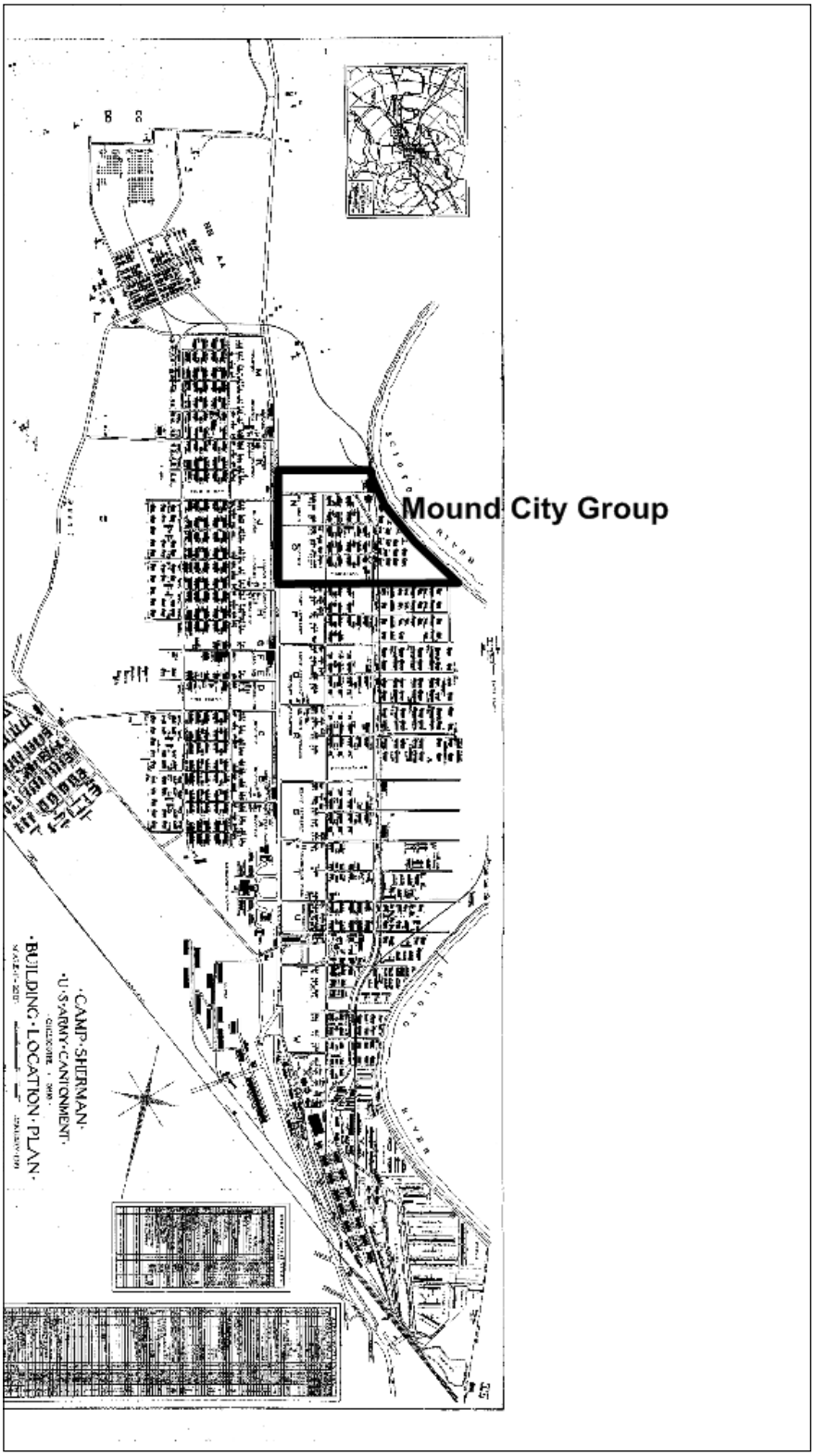

Figure 4. Plat map of Camp Sherman indicating location of the Mound City Group.

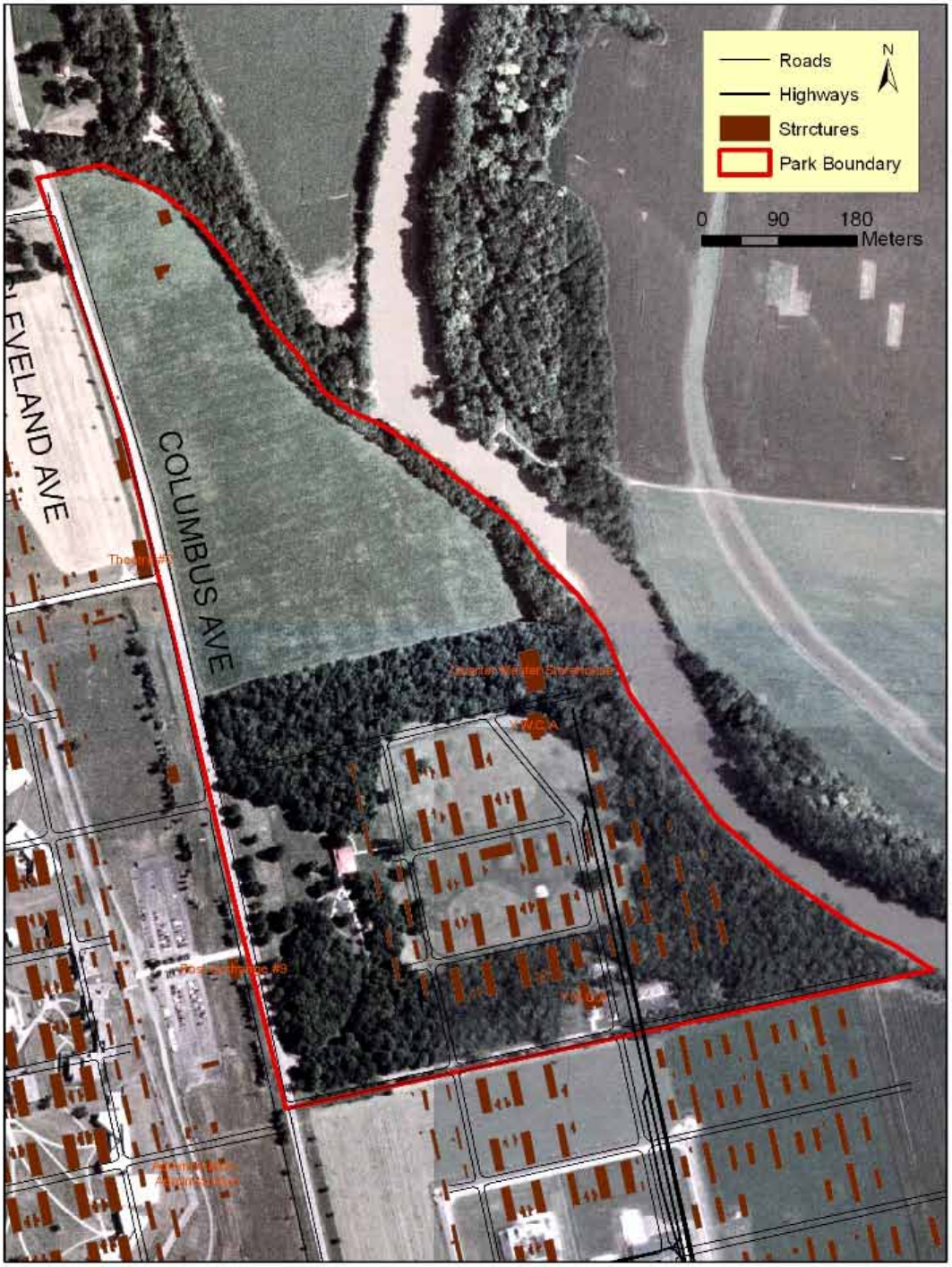

Figure 5. Location of Camp Sherman buildings within the Mound City Group.

1963). In 1964, Richard Faust supervised the restoration of Mounds 4 and 5 (Faust 1965). The National Park Service continued to contract with the Ohio Historical Society of archeological restoration of the mounds within the Mound City Group and landscaping modifications to the site through 1975 (Baby 1976; Baby, Bret, and Langlois 1975; Baby and Langlois 1977; Baby, Potter, and Koleszar 1971; Drennen 1972,1974; Hanson 1965,1966a,1966b,1967; Koleszar 1971a,1971b; Otto 1980; Saurborn 1968). A landscaping project was conducted in 1976 by David S. Brose of the Cleveland Museum of Natural History (Brose 1976). The National Park Service through its Midwest Archeological Center and through the park's archeological staff have conducted several inventory and compliance projects at the Mound City Group beginning in the 1980s to the present time along with an administrative history and ethnographic overview and assessment of the park (Cockrell 1999:154-159; Downs et al. 2002; Lynott 1982; Lynott and Monk 1985; Richner 1989). A geophysical project was conducted for the purpose of locating archeological features associated with the burial mounds (Bennett and Weymouth 1981). With the acquisition of the Hopeton Earthworks in 1990 by the National Park Service, efforts were soon in place to expand the Mound City Group National Monument. President George Bush signed Public Law 102-294 authorizing Hopewell Culture National Historical Park on May 27, 1992 (Cockrell 1999:337). Today, the park preserves five earthwork complexes including the original Mound City Group, Hopeton Earthworks, Hopewell Mound Group, Seip Earthworks, and High Bank Works.

Magnetic Survey Methodology

Geophysical prospection techniques available for archeological investigations consist of a number of techniques that record the various physical properties of earth, typically in the upper couple of meters; however, deeper prospection can be utilized if necessary (Bevan 1998; Weymouth 1986). Geophysical techniques are divided between passive techniques and active techniques. Passive techniques are primarily ones that measure inherently or naturally occurring local or planetary fields created by earth related processes under study (Heimmer and De Vore 2000:55; Kvamme 2001:356,2005:424). The primary passive method utilized in archeology is magnetic surveying. Other passive methods with limited archeological applications include self-potential methods, gravity survey techniques, and differential thermal analysis. Active techniques transmit an electrical, electromagnetic, or acoustic signal into the ground (Heimmer and De Vore 2000:58-59; Kvamme 2001:355-356). The interaction of these signals and buried materials produces altered return signals that are measured by the appropriate geophysical instruments. Changes in the transmitted signal of amplitude, frequency, wavelength, and time delay properties may be observable. Active methods applicable to archeological investigations include electrical resistance/resistivity, electromagnetic conductivity (including ground conductivity and metal detectors), magnetic susceptibility, and ground penetrating radar. Acoustic active techniques, including seismic, sonar, and acoustic sounding, have very limited or specific archeological applications.

A magnetic survey measures the earth's magnetic field at a single point (Aspinall et al. 2008; Bevan 1998:29-43; Weymouth 1986:343). Its application to archeology results from the local effects of magnetic materials on the earth's magnetic field. These anomalous conditions result from magnetic materials and minerals buried in the soil

matrix. Iron artifacts have very strong effects on the local earth's magnetic field. Other cultural features, which affect the local earth's magnetic field, include fire hearths and soil disturbances (e.g., pits, mounds, wells, pithouses, and dugouts), as well as geological strata. Magnetic field strength is measured in nanoteslas. In North America, the earth's magnetic field strength ranges from 40,000 to 60,000 nT with a inclination of approximately 60° to 70° (Weymouth 1986:341). Magnetic anomalies of archeological interest are often in the ±5 nT range, especially on prehistoric sites. Target depth in magnetic surveys depends on the magnetic susceptibility of the soil and the buried features and objects. For most archeological surveys, target depth is generally confined to the upper one to two meters below the ground surface with three meters representing the maximum limit (Clark 2000:78-80; Kvamme 2001:358). Magnetic surveying applications to archeological investigations have included the detection of architectural features, soil disturbances, and artifacts (Bevan 1991; Clark 2000;92-98; Heimmer and De Vore 2000; Weymouth 1986:343).

Two modes of operation for magnetic surveys exist: the total field survey and the gradient survey. The instrument used to measure the magnetic field strength is the magnetometer (Bevan 1998:20). Three different types of magnetic sensors have been used in the magnetometer: 1) proton free precession sensors, 2) alkali vapor (cesium or rubidium) sensors, and 3) fluxgate sensors. The present magnetic survey utilizes a dual fluxgate gradiometer (Figure 6). The fluxgate sensors are highly directional, measuring only the component of the field parallel to the sensor's axis. They also require calibration. The fluxgate gradiometers are capable of high density sampling over substantial areas at a relatively rapid rate of acquisition (Clark 2000:69-71). The dual fluxgate gradiometer sensor configuration of the instrument uses two fluxgate sensor tubes separated by a distance of one meter. The fluxgate sensors in each tube are separated by one

Figure 6. Conducting magnetic survey with dual fluxgate gradiometer.

meter. The dual gradiometer records two lines of data during each traverse reducing the distance walked and the survey time by half compared to the time and distance covered with a single gradiometer system. The sensors must be accurately balanced and aligned along the direction of the field component to be measured. The instrument is carried so the two sensors in each tube are vertical to one another with the bottom sensors approximately 30 cm above the ground. Each sensor reads the magnetic field strength at its height above the ground. The gradient or change of the magnetic field strength between the two vertical sensors is recorded in the instrument's memory for both sensor tubes. These gradients are not in absolute field values but rather voltage changes, which are calibrated in terms of the magnetic field. The dual fluxgate gradiometer also provides a continuous record of the magnetic field strength across each line for each traverse across the grid unit.

Magnetic Data Collection and Interpretation

The survey area (Figure 7) was a rectangular shaped block containing twenty-eight 20-meter by 20-meter grid units measuring 60 meters north-south by 220 meter (east-west). The block was located along the southern part of the Mound City Group inside the perimeter enclosure wall (Figure 8). The grid units were laid out with a total station and wooden stakes were placed at the 20-meter grid unit corners. During the survey, 20-meter ropes were placed between the wooden corner stakes on the north and

Figure 7. General view of magnetic survey area.

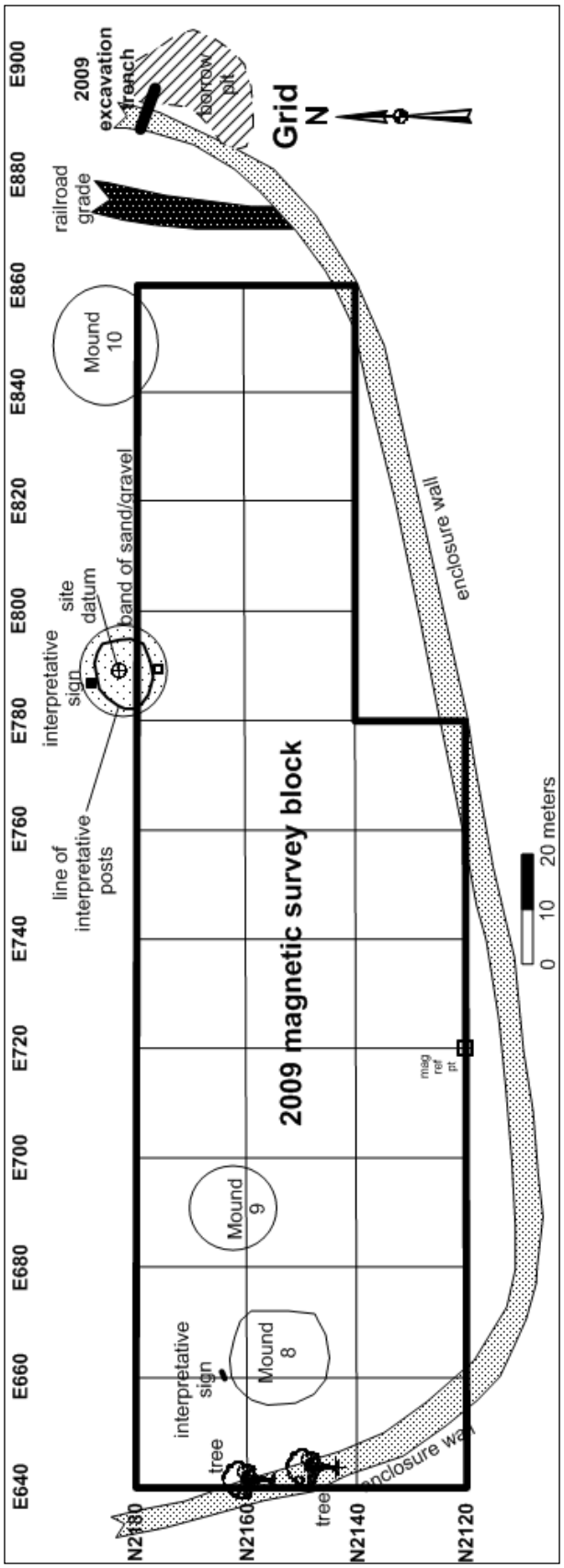

Figure 8. Magnetic survey grid.

south sides of the grid units to form a boundary for the data collection. Additional survey ropes were placed at 2.0-meter intervals across the grid units between the boundary ropes to serve as guides during the collection of the magnetic data. The magnetic survey for the dual fluxgate gradiometer is designed to collect eight samples per meter along 1.0-meter traverses or eight data values per square meter. The data were collected in a zigzag fashion with the surveyor alternating the direction of travel along each traverse across the grid. The reference point for balancing and aligning the dual gradiometer was located at N2120/E720 and the instrument is aligned on Magnetic North. The magnetic data were downloaded from the dual fluxgate gradiometer at the end of each day to a field laptop computer for processing.

Processing of geophysical data requires care and understanding of the various strategies and alternatives. The following series of common steps are used in computer processing of geophysical data (Kvamme 2001:365):

Concatenation of the data from individual survey grids into a single composite matrix;
Clipping and despiking of extreme values (that may result, for example, from introduced pieces of iron in magnetic data);
Edge matching of data values in adjacent grids through balancing of brightness and contrast (i.e., means and standard deviations);
Filtering to emphasize high-frequency changes and smooth statistical noise in the data;
Contrast enhancement through saturation of high and low values or histogram modification; and
Interpolation to improve image continuity and interpretation.

It is also important to understand the reasons for data processing and display (David et al. 2008:45-49; Gaffney et al. 1991:11). They enhance the analyst's ability to interpret the relatively huge data sets collected during the geophysical survey. The type of display can help the geophysical investigator present his interpretation of the data to the archeologist who will ultimately use the information to plan excavations or determine the archeological significance of the site from the geophysical data.

Upon completion of the magnetic survey with the dual fluxgate gradiometer system at the HOCU geophysical project area, the individual grid data files were assembled into a composite file. The data were first destriped to remove any traverse discontinuities that may have occurred from operator handling or heading errors. Upon completion of the destripe function, the data were interpolated by expanding the number of data points in the traverse direction and by reducing the number of data points in the sampling direction to provide a smoother appearance in the data set and to enhance the operation of the low pass filter. This changed the original 8 x 1 data point matrix into a 4 x 4 data point matrix. The low pass filter was then applied over the entire data set to remove any high frequency, small scale spatial detail. This transformation resulted in the improved visibility of larger, weak archeological features. An image map of the dual fluxgate gradiometer data was generated for the survey grid area (Figure 9).

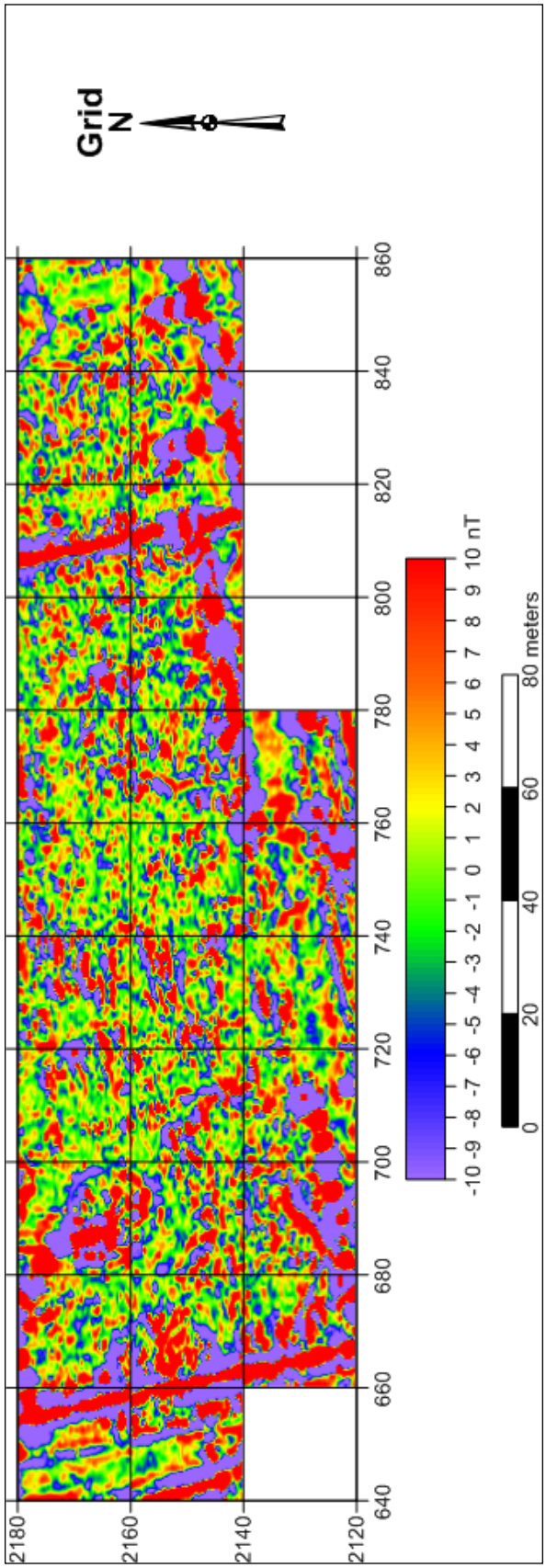

Figure 9. Image of the magnetic survey data.

Andrew David (1995:30) defines interpretation as a "holistic process and its outcome should represent the combined influence of several factors, being arrived at through consultation with others where necessary." Interpretation may be divided into two different types consisting of the geophysical interpretation of the data and the archaeological interpretation of the data. At a simplistic level, geophysical interpretation involves the identification of the factors causing changes in the geophysical data. Archeological interpretation takes the geophysical results and tries to apply cultural attributes or causes. In both cases, interpretation requires both experience with the operation of geophysical equipment, data processing, and archeological methodology; and knowledge of the geophysical techniques and properties, as well as known and expected archeology. Although there is variation between sites, several factors should be considered in the interpretation of the geophysical data. These may be divided between natural factors, such as geology, soil type, geomorphology, climate, surface conditions, topography, soil magnetic susceptibility, seasonality, and cultural factors including known and inferred archeology, landscape history, survey methodology, data treatment, modern interference, etc. (David 1995:30; David et al. 2008:49). It should also be pointed out that refinements in the geophysical interpretations are dependent on the feedback from subsequent archeological investigations. The use of multiple instrument surveys provides the archeologist with very different sources of data that may provide complementary information for comparison of the nature and cause (i.e., natural or cultural) of a geophysical anomaly (Clay 2001). Each instrument responds primarily to a single physical property: magnetometry to soil magnetism, electromagnetic induction to soil conductivity, resistivity to soil resistance, and ground penetrating radar to dielectric properties of the soil to (Weymouth 1986:371).

Interpretation of the magnetic data (Bevan 1998:24) from the project requires a description of the buried archeological feature of object (e.g., its material, shape, depth, size, and orientation). The magnetic anomaly represents a local disturbance in the earth's magnetic field caused by a local change in the magnetic contract between buried archeological features, objects, and the surrounding soil matrix. Local increases or decreases over a very broad uniform magnetic surface would exhibit locally positive or negative anomalies. Magnetic anomalies tend to be highly variable in shape and amplitude. They are generally asymmetrical in nature due to the combined effects from several sources. To complicate matters further, a given anomaly may be produced from an infinite number of possible sources. Depth between the magnetometer and the magnetic source material also affect the shape of the apparent anomaly. As the distance between the magnetic sensor on the magnetometer and the source material increases, the expression of the anomaly becomes broader. Anomaly shape and amplitude are also affected by the relative amounts of permanent and induced magnetization, the direction of the magnetic field, and the amount of magnetic minerals (e.g., magnetite) present in the source compared to the adjacent soil matrix. The shape (e.g., narrow or broad) and orientation of the source material also affects the anomaly signature. Anomalies are often identified in terms of various arrays of dipoles or monopoles. A magnetic object in made of magnetic poles (North or positive and South or negative). A simple dipole anomaly contains the pair of opposite poles that relatively close together. A monopole anomaly is simply one end of a dipole anomaly and may be either positive or negative depending on the orientation of the object. The other end is too far away to have an effect on the magnetic field.

Magnetic anomalies of archeological objects tend to be approximately circular in contour outline. The circular contours are caused by small size of the objects. The shape of the object is seldom revealed in the contoured data. The depth of the archaeological feature or object can be estimated by half-width rule procedure and an approximate mass can be calculated along with the location of the center of the anomaly (Bevan 1998:23-24). It is likely that the depth and mass estimates are too large rather than too small. Archeological features are seldom compact but spread out in a line or lens. The archaeological material may be composed of something other than iron such as fired earth or volcanic rock. Such materials are not usually distinguishable from the magnetic data collected during the survey (Bevan 1998:24). The depth and mass of features comprised of fired earth, like that found in kilns, fireplaces, or furnaces could be off by 100 times the mass of iron. If the archeological feature were comprised of bricks (e.g., brick wall, foundation, or chimney), estimates could be off by more than a 1000 times that of iron. One should also be cautious of geophysical anomalies that extend in the direction of the traverses since these may represent operator-induced errors. The magnetic gradient anomalies may be classified as three different types: linear, 2) dipole, and 3) monopole.

The first step in interpreting the magnetic anomalies from the project area is to identify areas of high magnetic contrast and, especially, the positive magnetic anomalies or the North pole of the dipole and then try to determine the causes of contrasts.. The results of the magnetic survey indicated the presence of numerous magnetic anomalies associated with the Hopewell occupation and twentieth disturbances from World War I activities associated with Camp Sherman (Figure 10). Mounds 8, 9, and 10 are visible in the magnetic data along with streets and buried utilities associated with Camp Sherman. Overlaying the locations of the World War I buildings on the magnetic data resulted in the association of several magnetic anomalies with the Camp Sherman facilities; however, other groupings of magnetic anomalies suggest the presence of Hopewellean features at the site including possible mound remnants or activities areas and possible habitation structures.

Conclusions

During a three day period, twenty-eight 20-m by 20-m grid units were surveyed with a dual fluxgate gradiometer. The magnetic survey covered 11,200 m^2 or 2.77 acres in the southern part of the Mound City Group (Site 32RO32) in Ross County, Ohio. Over all, the magnetic survey resulted in significant information related to the presence of buried archeological resources within the southern part of the Mound City Group and to the extent of the disturbances created by the construction of Camp Sherman. Further ground truthing activities are needed to determine the nature of these magnetic anomalies. The potential for acquiring additional geophysical information about the nature and extent of the buried archeological resources at the site is extremely high and will provide an invaluable baseline data set for future archeological research at the Mound City Group.

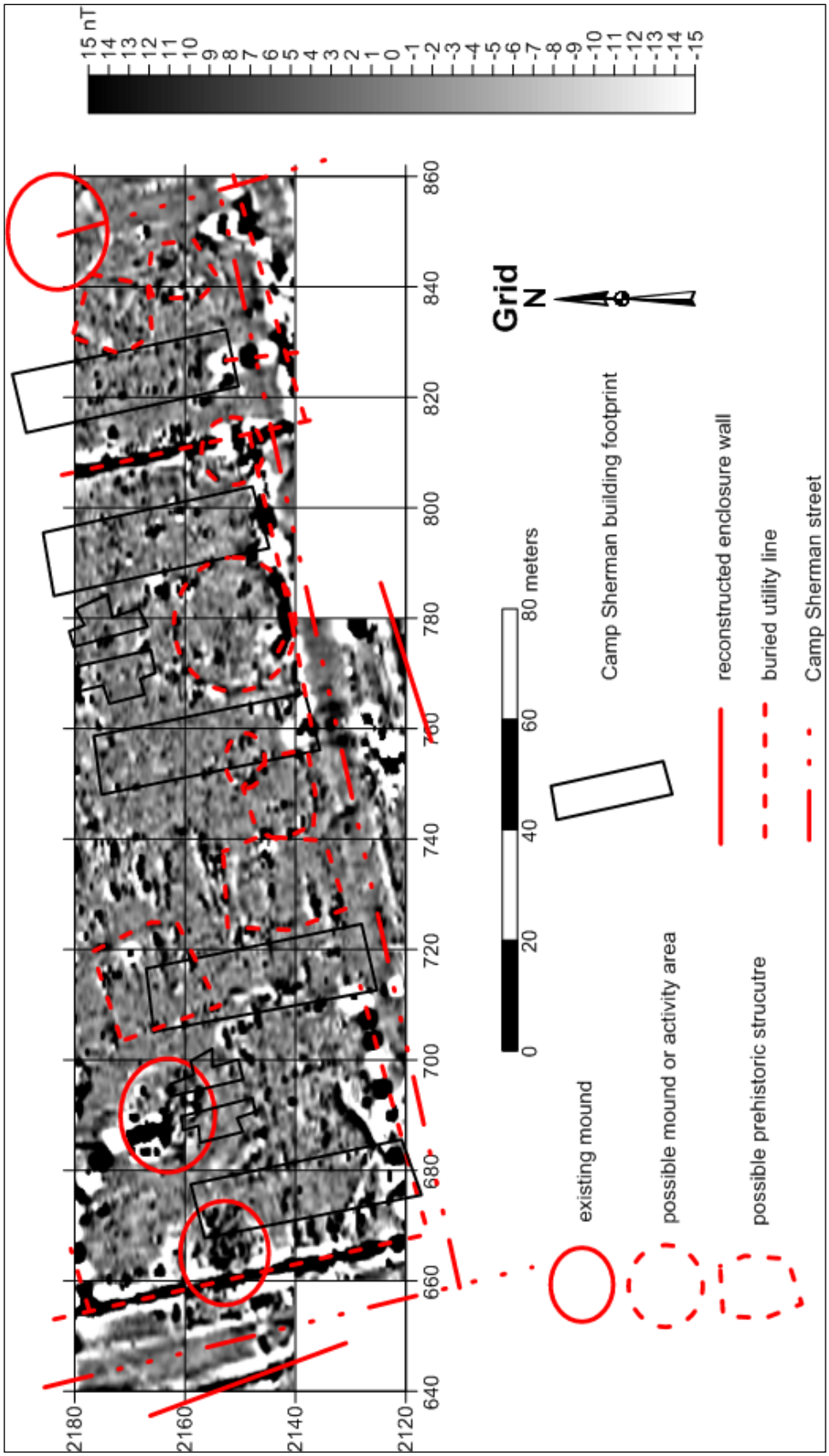

Figure 10. Interpretation of the magnetic data.

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