Contract Publication Series 12-436

GEOPHYSICAL SURVEY OF THE POSSIBLE LOCATION OF CAMP SECURITY ON THE WALTERS PROPERTY IN SPRINGETTSBURY TOWNSHIP, YORK, PENNSYLVANIA

by
Russell S. Quick, Ph.D.

Prepared for

Friends of Camp Security

Springettsbury Township

Prepared by

cultural resource analysts, inc

Kentucky | West Virginia | Ohio
Wyoming | Illinois | Indiana | Louisiana | Tennessee
New Mexico | Virginia | Colorado

Contract Publication Series 12-436

GEOPHYSICAL SURVEY OF THE POSSIBLE LOCATION OF CAMP SECURITY ON THE WALTERS PROPERTY IN SPRINGETTSBURY TOWNSHIP, YORK, PENNSYLVANIA

By Russell S. Quick, Ph.D.

Prepared for

Carol A. Tanzola
Friends of Camp Security
P.O. Box 20008
York, Pennsylvania 17402
Phone: (717) 755-4367
www.CampSecurity.com

and

John J. Holman
Springettsbury Township
1501 Mt. Zion Road
York, Pennsylvania 17402
Phone: (717) 757-3521
www.springettsbury.com

Prepared by

Cultural Resource Analysts, Inc.
151 Walton Avenue
Lexington, Kentucky 40508
Phone: (859) 252-4737
Fax: (859) 254-3747
Email: cmniquette@crai-ky.com
CRA Project No.: K12F005

____
Charles M. Niquette, RPA
Principal Investigator

January 24, 2013

ABSTRACT

From December 10 through 12, 2012, Cultural Resource Analysts, Inc., in cooperation with Friends of Camp Security volunteers conducted a near-surface geophysical survey of the Walters property in Springettsbury Township, York, Pennsylvania, which is the possible location of the Revolutionary War-era prison camp known as Camp Security. The survey was conducted at the request of Carol Tanzola on behalf of The Friends of Camp Security and was approved by John Holman of Springettsbury Township. The survey was conducted to delimit areas of interest relating to the Revolutionary War camp with a goal of informing future research, historic preservation, and township land management efforts. A Geoscan Research FM-256 gradiometer was employed for investigation. The project area was located south of the intersection of Eastern Boulevard with Locust Grove Road. Seventeen survey blocks encompassing 32 ha (77 acres) of the total 46.9 ha (115.8 acres) were surveyed. The wooded and residential portions of the property were not surveyed. A total of 35.4 km (22.0 mi) of magnetic data was collected. Based on the magnetic data and aerial photography analysis, a probable location for the Revolutionary War camp was documented and several other potential areas of interest were defined. The integrity and precise nature of the subsurface features within the fields of the Walters property cannot be determined on the basis of the geophysical survey alone; therefore, the magnetic anomalies should be ground-truthed using appropriate archaeological survey methods prior to any ground disturbance.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

From December 10 through 12, 2012, Cultural Resource Analysts, Inc. (CRA), in cooperation with Friends of Camp Security (FOCS) volunteers, conducted a near-surface geophysical survey of the Walters property in Springettsbury Township, York, Pennsylvania, which is the possible location of the Revolutionary War-era prison camp known as Camp Security (Figures 1 and 2). The survey was conducted at the request of Carol Tanzola on behalf of The Friends of Camp Security and was approved by John Holman of Springettsbury Township. The fieldwork was conducted by Russell Quick (CRA), Elizabeth Roman (FOCS), Steve Warfel (FOCS), and Jonathan Stayer (FOCS) and required approximately 108 person hours to complete.

Purpose of Study

The Walters property was recently acquired by Springettsbury Township and The Conservation Fund, a non-profit land conservation organization. The magnetic survey was conducted to delimit areas of interest relating to the Revolutionary War camp with an eye to informing future research, historic preservation, and Township land management efforts.

Project Description

A Geoscan Research FM-256 magnetic gradiometer was employed for the investigation. The project area was located south of the intersection of Eastern Boulevard with Locust Grove Road (Figures 3–7). Seventeen survey blocks encompassing 32 ha (77 acres) of the total 46.9 ha (115.8) were surveyed. The wooded and residential portions of the property were not surveyed. A total of 35.4 km (22.0 mi) of magnetic data was collected.

Summary of Findings

Based on the magnetic survey, six areas with a high potential for subsurface cultural features were documented. Three of these areas may be related to the Revolutionary War era Camp Security. The three other areas are probably related to the Schultz Farm and its associated infrastructure. The southeastern-most area of high magnetic readings is suggested as the probable location of Camp Security. The integrity and precise nature of the subsurface features within the fields of the Walters property cannot be determined on the basis of the geophysical survey alone; therefore, the magnetic anomalies should be ground-truthed using appropriate archaeological survey methods prior to any ground disturbance.

II. THE PROJECT AREA

The following is a description of the project area. A discussion of the soils and their suitability for geophysical surveying is presented. Field conditions noted during this investigation are also documented.

Description of Project Area

The project area consists of a 46.9 ha (115.8) tract of farmland and woodland that was formerly owned by the Walters family. Generally speaking, the survey area was divided into four parts: two upper fields to the south and two lower fields to the north. The upper fields are separated from each other by a line of trees. The lower fields are separated from each other by a small south–north flowing stream and tree line. This stream is fed by a large spring that is centrally located between the four fields (UTM N 4425835E 359550). This spring provides water to the historic Schultz House, which was constructed on the property before the Revolutionary War. The house and several outbuildings, including a large bank-barn, lie in the northwest part of the project area. A second, “unimproved” spring lies in the south-central portion of the property (UTM N 4426080 E 359915 m), just south of a home currently owned by the Walters family. This spring feeds an intermittent stream that runs south–north along the eastern edge of the surveyed area.

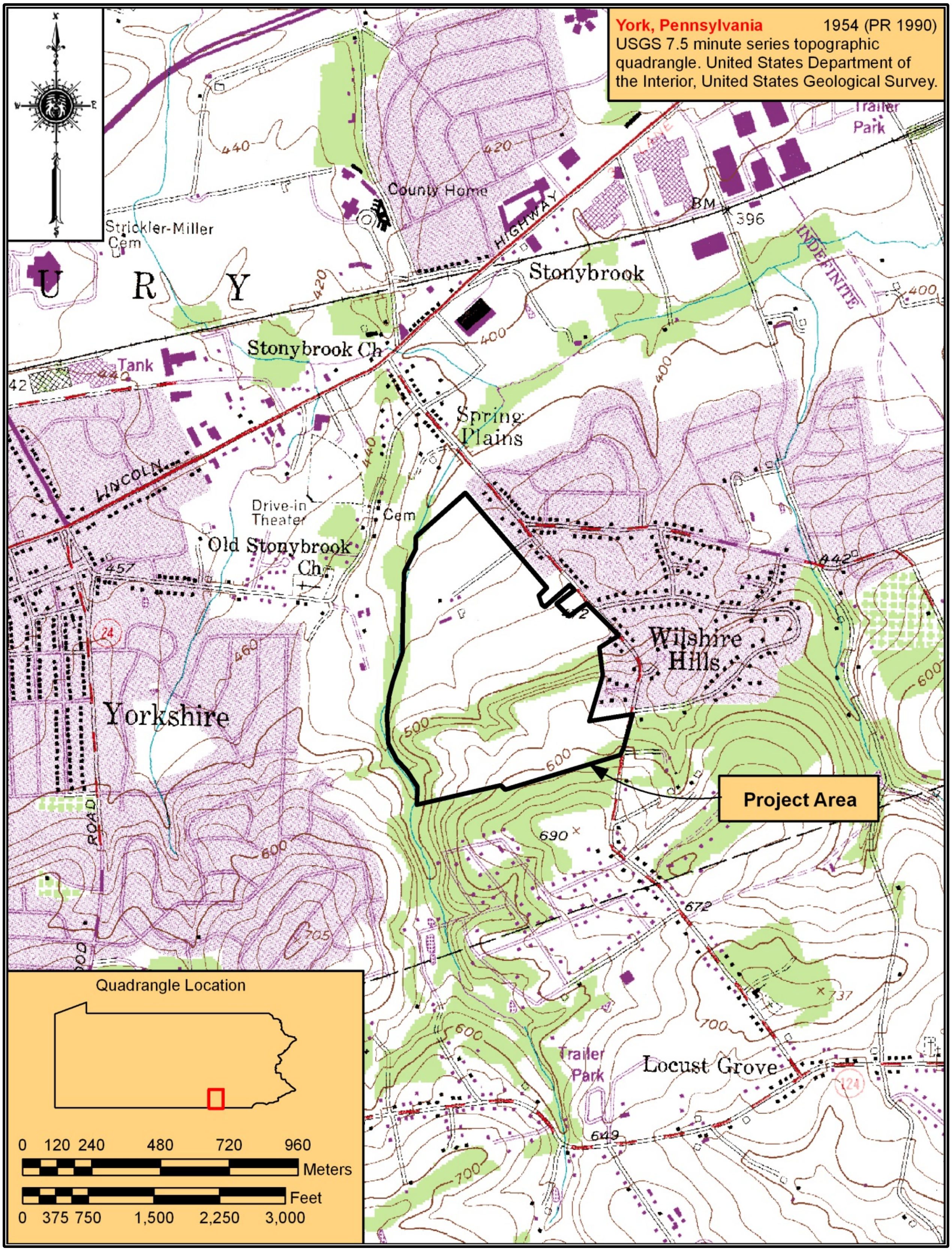

Figure 1. Location of project area on topographic quadrangle.

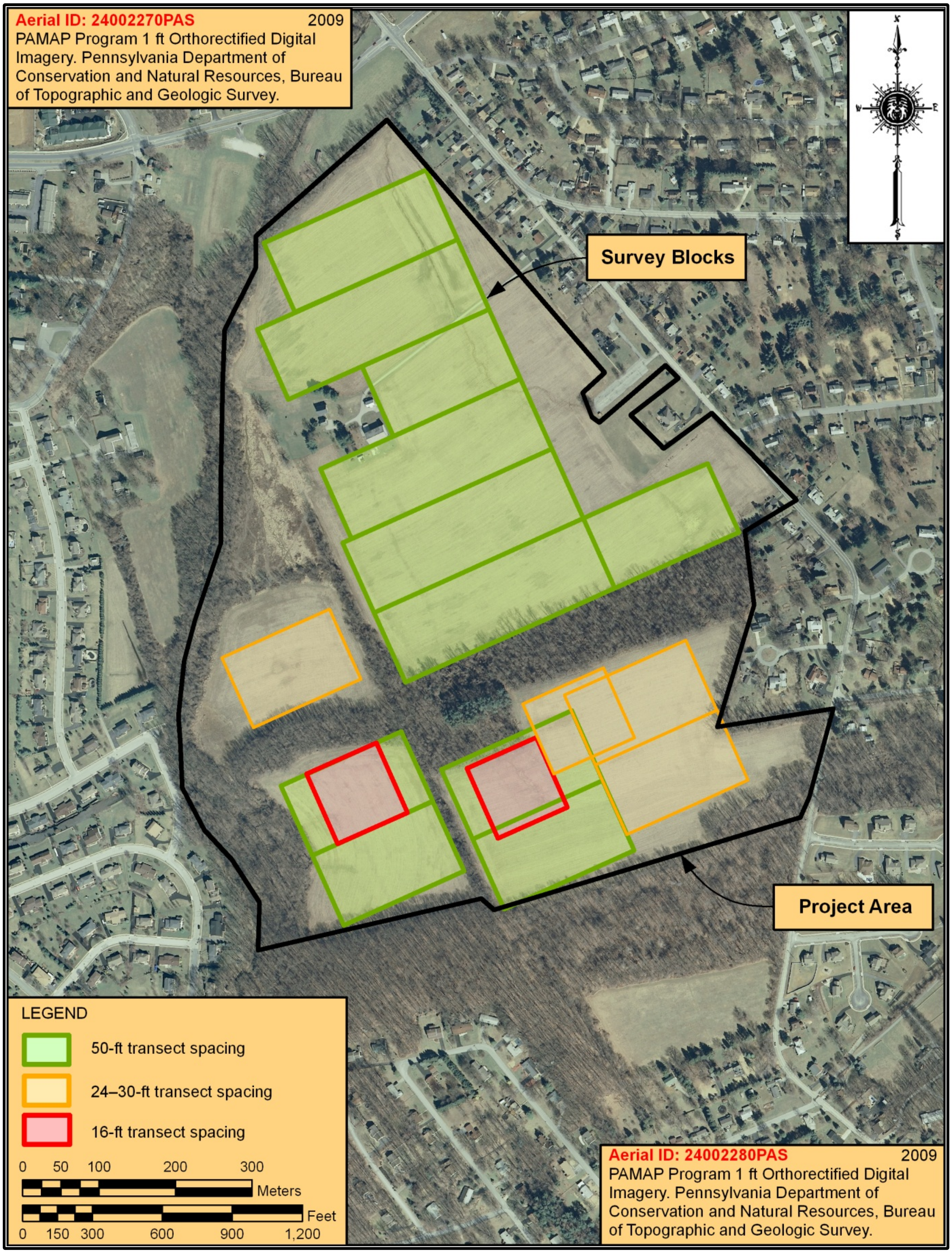

Figure 2. Project area plan map.

Figure 3. Overview of the southwestern project area (Blocks A,B,L), looking northwest.

Figure 4. Overview of the southeastern project area (Blocks C,D,E,F,P,Q), looking northwest.

Figure 5. Overview of the east central project area (Blocks G, H, I, J, M), looking southeast.

Figure 6. Overview of the northeastern project area (Blocks M, N, O), looking northeast.

Figure 7. Overview of the west central project area (Block K), looking northwest.

General Survey Conditions

The survey conditions at the site were moderate due to disturbances from agriculture and recent rain. The weather was clear during the survey and temperatures held steady at approximately 40 degrees Fahrenheit. The conditions made for comparable data across survey blocks because it was unnecessary to re-align the gradiometer sensors repetitively.

Soils

Soils within the project area are mapped as the Chester, Clarksburg, Conestoga, Mt. Airy, and Manor soil series (Table 1). There is a small area along Locust Grove Road mapped as Urban Land–Conestoga Complex that was not surveyed. The Urban Land in the project area probably consisted of the roadside ditch; the majority of the survey area was arable land.

Chester series silt loam (Typic Hapludults) soils were formed in materials weathered from micaceous schist and are found on slopes ranging from 0 to 65 percent. Clarksburg series silt loam (Oxyaquic Fragiudalfs) soils were formed in colluvium, glacial till, or residuum from limestone, shale, and sandstone. They are typically located on uplands with slopes ranging from 0 to 25 percent. Lindside series silt loam (Fluvaquentic Eutrudepts) consists of very deep, moderately well drained soils formed in alluvium washed mainly from lime-influenced soils on uplands. They are typically found on floodplains with slopes ranging from 0 to 3 percent. Mt. Airy series channery silt loam (Typic Dystrudepts) is found in forested areas with slopes ranging from 0 to 75 percent. These soils were formed in the residuum from micaceous crystalline rocks. Manor series loam (Typic Dystrudepts) is found in wooded areas with slopes ranging from 0 to 65 percent. Manor soils formed in residuum weathered from micaceous schist. Conestoga silt loam (Typic Hapludalfs) is typically found on cultivated convex slopes ranging from 0 to 25 percent. These soils formed in the residuum of micaeous limestone and calcareous schist (Soil Survey Staff 2013).

Table 1. Soils in Project Area.

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
CeB	Chester silt loam, 3 to 8 percent slopes	11.2	7.8%
CeC	Chester silt loam, 8 to 15 percent slopes	2.5	1.7%
CkA	Clarksburg silt loam, 0 to 3 percent slopes	9.7	6.8%
CnB	Conestoga silt loam, 3 to 8 percent slopes	55	38.3%
Lw	Lindside silt loam	12.1	8.4%
MOC	Mt. Airy and Manor soils, 8 to 15 percent slopes	38.8	27.0%
MOD	Mt. Airy and Manor soils, 15 to 25 percent slopes	13.8	9.6%
MOE	Mt. Airy and Manor soils, 25 to 35 percent slopes	0.1	0.1%
UeB	Urban land-Conestoga complex, 0 to 8 percent slopes	0.3	0.2%
	Totals for Area of Interest	143.5	100.0%

The majority of the soils in the project area are derived from micaceous schists and limestones. The properties of these soils make them good for near-surface sensing methods such as magnetometry since the proportions of volcanic rock, sand, silt, and clay affect the physical behavior of a soil (National Resource Conservation Service 2009). However, it should be noted that some of the rocks in the field—particularly large blocks of quartz—had distinct magnetic signatures due to the elevated iron content within them.

Disturbances

There were no major areas of disturbance within the project area; however, the land has been used for agricultural purposes for at least 250 years. Much of the southern portion of the project area was sloped and erosion gullies were evident both in the field and on aerial photographs. Aerial photographs also depicted field boundaries and access roads that no longer exist. The immediate area around the historic Schultz farmstead was avoided, but elevated magnetic levels were evident around the outbuildings and a linear magnetic anomaly—probably a water line—was noted running from the larger of the two springs south of the farm to the barn.

III. METHODS

Field

A single Geoscan Research FM-256 fluxgate gradiometer was utilized for investigation of the project area (Figure 8). Due to the large size of the project area and limited time, survey transects were widely spaced in order to obtain a "volume magnetic" overview of the field. Because the goal of the survey was to locate a historic European, rather than prehistoric indigenous site, feet were used as the primary unit of measurement, although for ease of use the gradiometer grids were laid out using metric conversions. Initially, transects were spaced at 50.00 ft (15.24 m) intervals. Higher probability areas near the large spring in the south-central portion of the project area were subsequently re-scanned with transect intervals of either 16.7 ft (5.1 m), 24.9 ft (7.6 m), or 32.8 ft (10 m). In all cases, survey blocks were 328 ft (100 m) north–south. The number of survey blocks east–west varied depending on the available space in each field.

Figure 8. The Geoscan Research FM-256 Gradiometer in dual sensor configuration.

Typically, survey blocks were 13–20 transects (the maximum allowed by the equipment configuration) in width. Eight magnetic readings (of nano-Tesla) were collected per linear meter. A total of 283,200 magnetic readings covering 35.4 km (22.0 mi) of linear distance was collected. Data were processed using a combination of Geoscan Research Geoplot, Golden Software Surfer, and ESRI ArcGIS.

Magnetometry

Magnetometers were originally developed to search for the metallic signatures of submerged submarines. They were later adapted for oil exploration and soil studies (Wynn 1986:245). Tabbagh states that "magnetic properties play a very important part in archaeological prospecting," (Tabbagh et al. 2000:394) but this avenue of exploration is still rarely tapped, in spite of its advantages. There are several varieties of geophysical prospection equipment that rely on the principle of measuring minute variations in the earth's magnetic field and are hence called by the generic term "magnetometer.

All magnetometers rely on the principle of measuring the remanent magnetism of subsurface archaeological features. In order to use a magnetometer, there must "be a clear contrast in magnetic susceptibility between subsoil or bedrock and topsoil, so that silted archaeological features are readily detectable" (Clark 1990:87, 92). Magnetometry can find not only fired kilns and ferrous objects but also soil features, such as ditches and pits (Schmidt 2002:7). Alternatively, the features being targeted must have a contrasting magnetic signature from the background matrix. This is dictated by the principle of remanent magnetism.

Remanent magnetism is tied to variations in the location of the magnetic North Pole. The earth's magnetic pole is not stationary; it wanders around as the earth spins on its axis. When certain substances, like clays that contain iron particles, are heated above the Curie point, their ferrous particles realign to magnetic north and are then "frozen" in place when the substance cools. This process is known as thermoremnance (Clark 1990:64). The clay "donut" hearths of Southeastern Woodland period sites are excellent examples of this process in relation to an archaeological feature. Artifacts that have significant and distinctive remanent magnetism are bricks, kilns, and pottery. The principle of remanent magnetism is often employed to take magnetic dates by comparing the orientation of a sample taken from a hearth or kiln to a chart of the pole's meanderings over the centuries. For the purposes of magnetometry, however, it is not necessary to take a sample back to the lab to have its magnetic properties analyzed. It is enough that the magnetic properties of the hearth contrast with those of the unheated soils around them. The principle applies equally well to pits filled with ceramics—even though their magnetic signatures are all different from each other, they are also different from the surrounding undisturbed soil matrix.

Magnetometers also measure the magnetic susceptibility of materials. Magnetic susceptibility is a more general effect, literally "susceptible to being magnetized." Iron objects that are not, in themselves, permanent magnets, possess magnetic susceptibility (i.e., they are susceptible to being magnetized), as do certain types of igneous rocks. Humic soil, for example in the A horizon of a typical profile, possesses magnetic susceptibility in proportion to the weathering and decomposition that has been involved in its formation. Buried A soil horizons are distinctive in contrast to the horizons above and below that lack magnetic susceptibility for this reason. Of interest to archaeology, remanent magnetism is produced by soil processes involved with a combination of burning and decomposition, often called the burning and rotting factor. A magnetometer survey records the magnetic effects of remanent magnetism and magnetic susceptibility measured in nanoTeslas (nT). Areas of elevated magnetic susceptibility (approximately 2–10 nT) can indicate general areas of midden. Concentrated, tightly bounded magnetic susceptibility anomalies (approximately 2–20 nT) can indicate the location of pits and other features filled with concentrated midden and the products of either burning or organic decomposition.

Concerns for Magnetic Surveys

Near-surface readings of nT can be wildly distorted by the presence of small bits of modern metal (Ambos and Larson 2002:34). These can range from small objects, for example agricultural machine parts, to much larger items. Despite their size, all can create significant distortions of the local magnetic field with their individual magnetic susceptibility. For this reason, it is generally difficult to use magnetometers in the survey of urban properties, beyond using them to identify areas of magnetic disturbance created by iron objects, large and small. Readings are also disturbed by surface modification processes. For example, plowing and disking redistribute and concentrate remanent magnetism generally associated with the topsoil, as can the excavation and refilling of test pits, trenches, and other sorts of archaeological explorations. At times, this redistribution of magnetic materials may mask in situ archaeological features. Also, car motors, electrical power lines, and metal sewer pipes confuse magnetometer readings. Magnetometers are omni-directional—they receive data from all directions, so above-surface variations in the magnetic field caused by a passing car or, in extreme cases, by diesel-electric trains operating 16 km from a survey site (Clark 1990:67) are recorded just like the subsurface ones caused by archaeological features.

Magnetometry is limited in some soils, particularly those that contain high levels of magnetite or those that have been "gleyed," or so saturated with water that their iron particles have been converted to a reduced state (Waters 1992:48). In gleyed soils, magnetic susceptibility is decreased because of the iron shifting from a ferric to a ferrous state (Clark 1990:114). Butler points out that "in the shallow subsurface, the only objects which will typically produce localized magnetic anomalies will be cultural features and artifacts" such as bits of iron, fired clay, and rocks (Butler et al. 1994:461).

Differential Magnetometers and the Fluxgate Gradiometer

The main problem with magnetometry is the nature of the magnetic field itself. Much of the field is generated from within the earth (95 percent), but electromagnetic radiation from the sun and other sources causes fluctuations 5 to 50 nT in the primary field (Clark 1990:67). To counter this, it is often necessary to use another magnetometer set up as a base station to record this "diurnal variation." The two readings can then be subtracted, leaving only the variations recorded by the magnetometer used for conducting the survey (Clark 1990:67; Chavez et al. 2001:1268). This technique can increase a magnetometer's resolution to below .1 nT. Another way to control diurnal variation of the earth's magnetic field is to use two magnetometers aligned with each other on the same staff with a typical vertical separation of 1–2 m (Clark 1990:68). This configuration is known as a gradiometer because it measures the slight differences, or gradients, measured by the two magnetometers (Breiner 1965:188).

One of the most often employed instruments for archaeological survey is the fluxgate magnetometer. This is surprising because it was once considered nearly useless for archaeological survey. The sensors are directionally responsive, meaning that if a single sensor unit is employed, any tilting of the mechanism changes the magnetic field and presents itself as an anomaly (Clark 1990:69). As a result, fluxgate sensors are typically paired to create a gradiometer (Clark 1990:70). Fluxgate gradiometers have to be constructed carefully, with one sensor being rigidly mounted in a tube (typically PVC or aluminum), while the second is mounted so that its axis can be aligned to the first through the use of non-ferrous screws, thereby decreasing interference. A properly aligned system provides (near) continuous data across a site because its charge/read time is only 1/1000 of a second and it has a resolution of .1

nT, making it ideal for archaeological survey (Clark 1990:70). As a result of the speed and resolution of the fluxgate gradiometer, magnetometer surveys are now used more often than electrical resistivity (Wynn 1986:248), and high resolution magnetometry surveys of large areas are now possible (Schmidt 2002:7). Clark even suggests that the fluxgate gradiometer "as an adjunct to standard fieldwalking techniques is much to be recommended" (Clark 1990:89).

Data Collection

The former Walters property is approximately 1,035-x-835 m (3,396-x-2,740 ft) in size and encompasses 46.9 ha (115.8 acres) (see Figure 3). Property boundary data provided by FOCS were input into two handheld global positioning system (GPS) units with 2–5 m horizontal accuracy. The GPS units were used to place flags delineating the initial survey transects. GPS coordinates presented in this report are given using Universal Transverse Mercator (UTM), Zone 18 North, WGS 84.

As noted, the project area was divided into survey grids that would allow the maximum amount of land to be covered in the three available field days. Seventeen survey blocks encompassing 32 ha (77 acres) were ultimately covered. These blocks are labeled A–Q for later discussion (Figure 9). Corner coordinates for the survey grids (Figure 10) are provided in Appendix A.

Analysis

Data were downloaded to a laptop computer in the field using the Geoscan Research program Geoplot. The same program was subsequently used to process the data to remove survey errors, emphasize the results for interpretation, and smooth the results. Processing generally involved the procedures known as clipping and value replacement, zero-mean traverse, destagger, despike, interpolation, and low pass filtering. The processed data were input into ESRI's ArcGIS to manipulate the transect data into their appropriate locations. Once organized, the data were exported to, and contoured in, Golden Software Surfer. Report graphics were prepared in ArcGIS.

The processed data were examined to look for large areas of high magnetic response (both positive and negative) rather than simple magnetic "spikes" caused by pieces of field metal (e.g., tractor parts). Typically, such features show up as hazy expanses that are lighter or darker than areas of normal, less magnetic, background soil. Within these lighter or darker areas, there should be numerous metallic spikes—locations where bright white responses are located directly adjacent to black responses. These magnetic dipoles are indicative of iron objects, which act like small magnets in the ground as shown in Figure 11. Prehistoric features, like those circled in green in Figure 11, tend to be diffuse and monochromatic (e.g., fuzzy black or fuzzy white, but typically not both). The magnetic survey suggested a high potential for subsurface historic cultural features in at least six places. Three of these may be associated with the Revolutionary War-era prison camp. The other three are more likely related to the Schultz Farm and its associated infrastructure. The results of the geophysical survey are described in the following chapter.

Aerial Photography

In addition to the geophysical data, aerial photographs were examined to find potential crop marks or soil stains that might be indicative of historic occupations within the property. The aerials examined included high-resolution United States Geological Survey (USGS) photographs acquired from 1952 through 2008 and modern satellite imagery obtained from Google Earth (USGS 1952a, 1952b, 1968, 1987, 1988, 1999, 2001, 2004, 2009a, 2009b; Google 2012). The aerial photographs helped to explain some of the magnetic anomalies that were found during the survey and indicated those anomalies that require further attention (Figure 12).

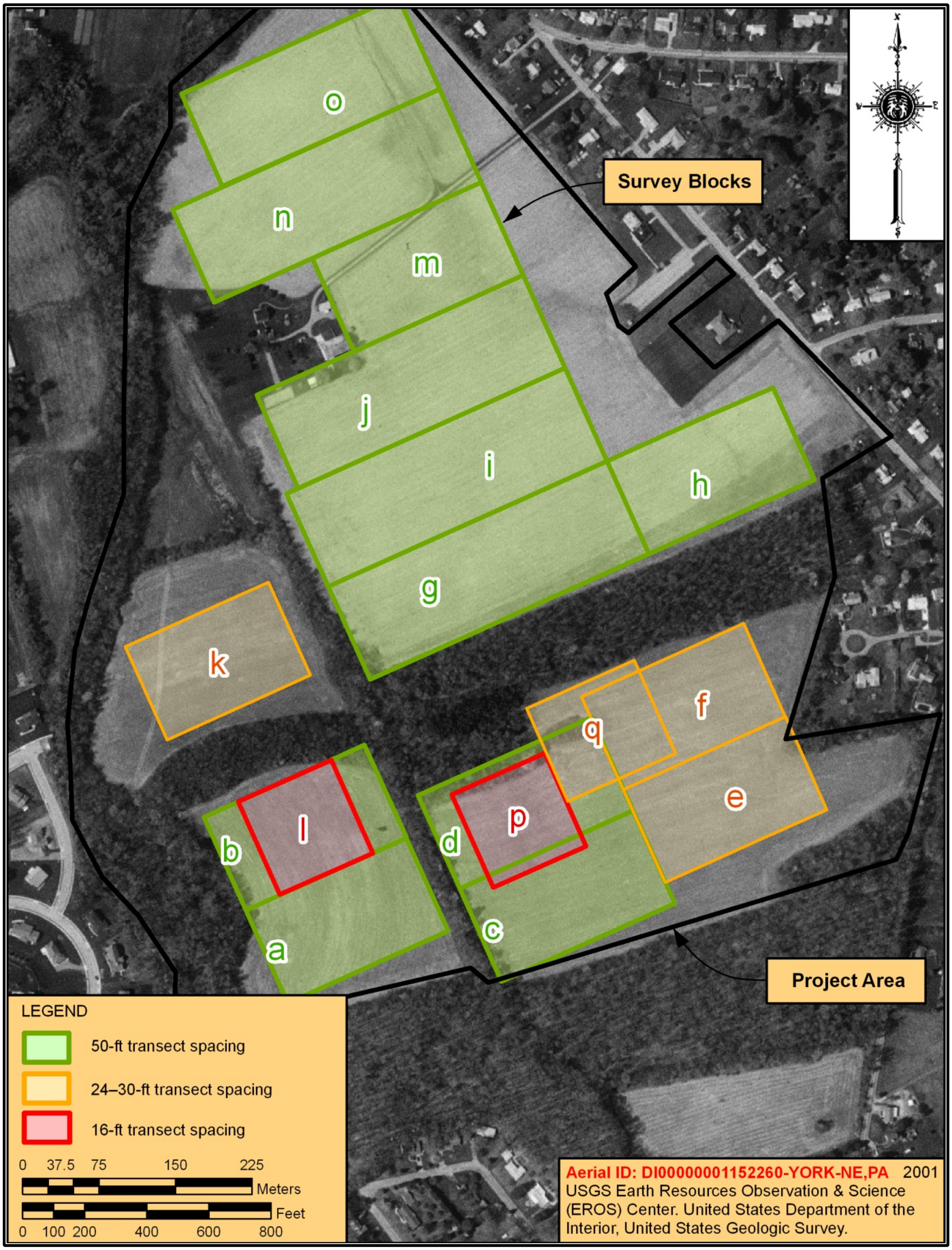

Figure 9. Plan view of survey grids.

Figure 10. Survey grid corner point labels.

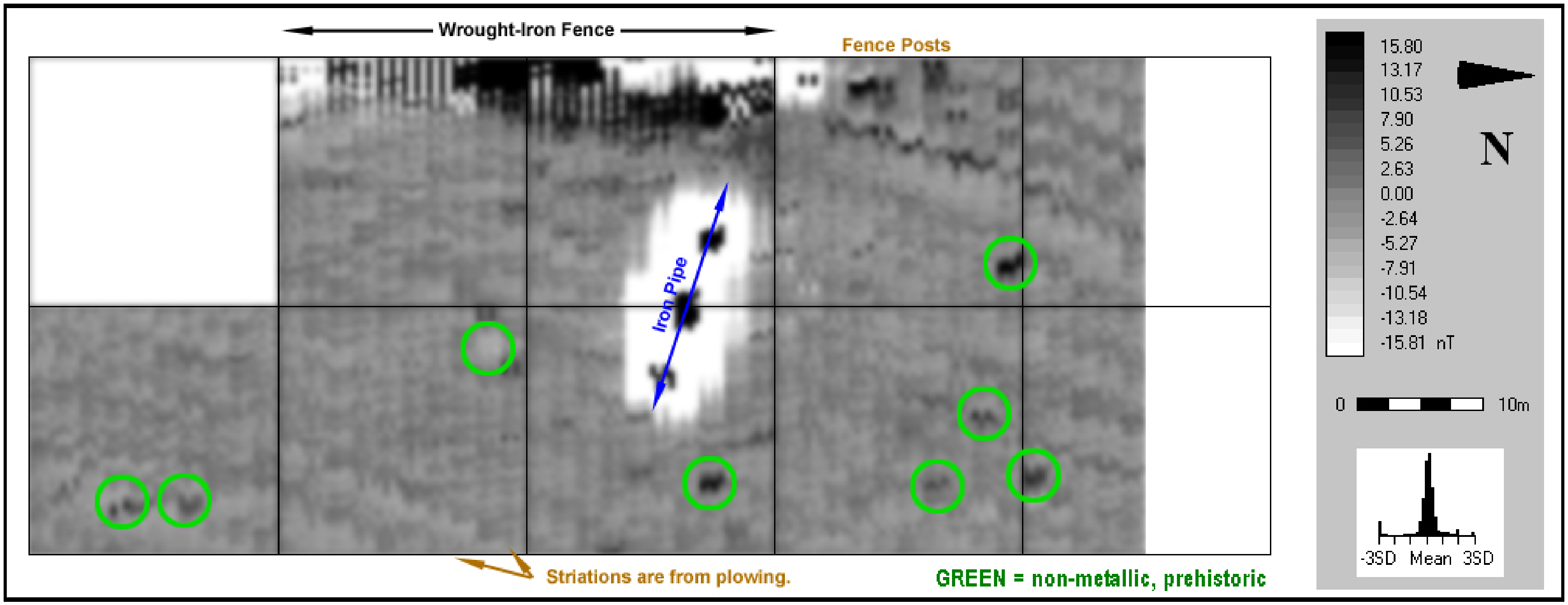

Figure 11. Metallic anomalies from a previous survey.

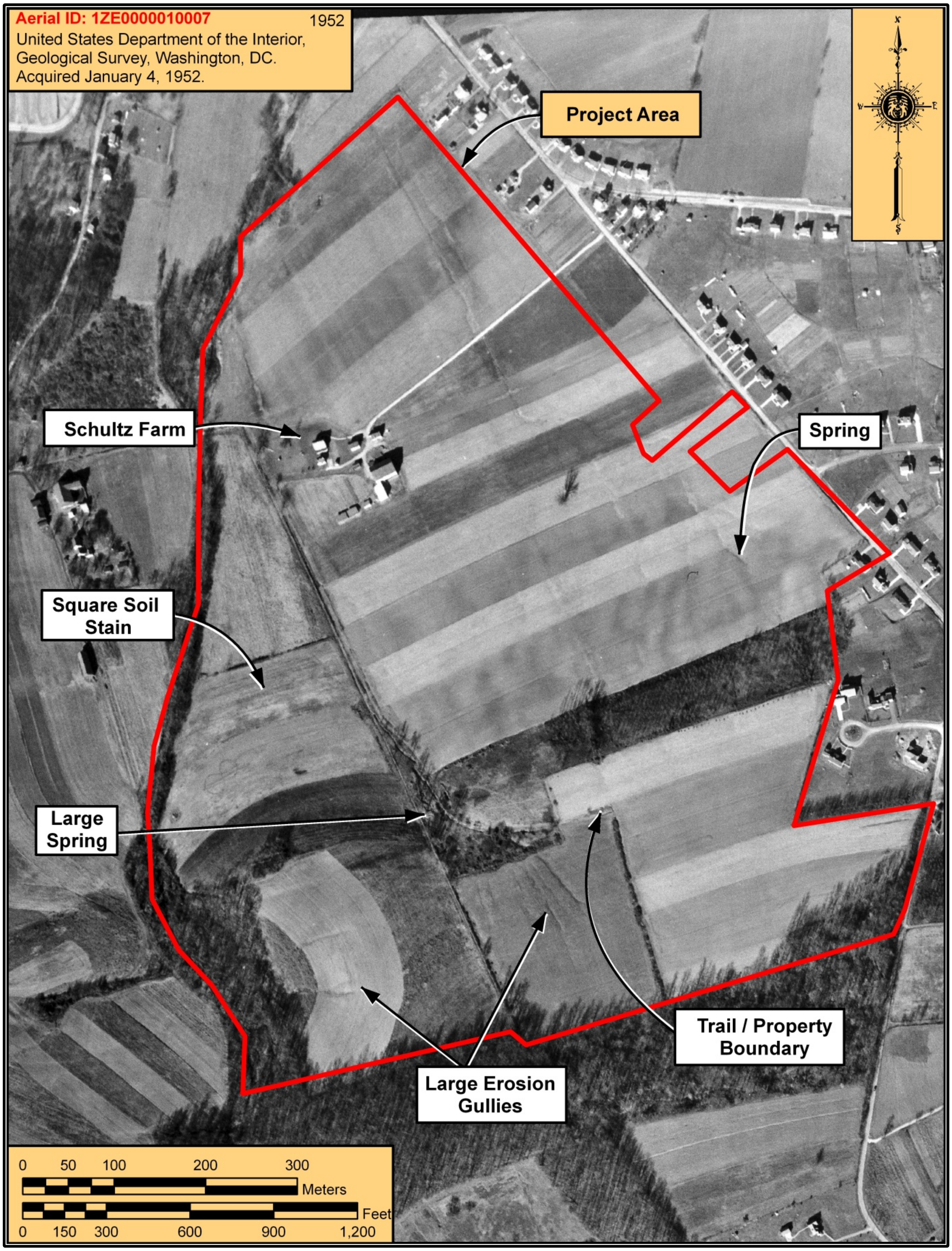

Figure 12. USGS Aerial Photograph.

LiDAR

Light Detection and Ranging (LiDAR) elevation data were obtained from the Pennsylvania Spatial Data Access (PASDA) website (http://www.pasda.psu.edu). These data consisted of Class 1 (the lowest level of processing above raw data) elevation points produced by the PAMAP Program. These data were examined for evidence of earthworks or other topographic features that might indicate the location of the Revolutionary War prison enclosure.

IV. RESULTS

This section presents the results from the geophysical survey, aerial photograph analyses, and LiDar analysis. Six areas with extensive subsurface magnetic features were identified during the geophysical survey (Figure 13). The figures on the following pages present some of these anomalies in various plan views (Figures 14–17). Classification and interpretation of the anomalies are provided when possible.

Magnetic Survey Results

Blocks A, B, L, and K

Block A was surveyed at 15 m intervals. Block B was initially surveyed at 15 m intervals. Because this area had been the site of previous excavations, which documented artifacts potentially associated with the Revolutionary War prison, additional transects were surveyed in between the initial Block B transects to give a final survey interval of 5 m within the confines of Block L. Block K, portions of which had also been excavated previously (with indeterminate results) was surveyed at 7.5 m intervals. The results of the magnetic survey in these areas are presented in (Figure 14a).

Block A appears to have very low potential as a location for the camp or associated facilities. Only a few potential metallic anomalies were documented in this block during the survey (Figure 14b). Blocks B, L, and K, on the other hand, each exhibit both elevated background magnetism and numerous metallic “spikes” indicative of ferrous metal objects (e.g., iron, steel). Block K, in particular, has a large area in its northwest corner that contains multiple metallic anomalies and the level of magnetism in the soil is elevated across the entire northern edge of the block. Interestingly, this is the general area of the square soil stain depicted in Figure 12. The western half of Block L also deserves further attention. Excavations conducted in the area of Blocks B/L during the 1970s recovered the only substantial evidence for the prison camp thus far. The magnetic survey suggests that some metallic artifacts potentially related to the prison camp may be present in the western portions of these blocks.

Blocks C, D, E, F, P and Q

Blocks C, D, E, and F were originally surveyed at 15 m intervals. Additional transects were later added to Blocks E and F to bring the space between transects down to 7.5 m. On the basis of aerial photographic evidence, which shows a roughly square stain in the center of Block D, Block P was later surveyed at 5 m intervals. On the basis of high magnetic readings near the northeast corner of Block D and in the west quarter of Block F, Block Q was later surveyed at 10 m intervals. The theoretical transect interval in the majority of Block Q is, therefore, less than 5 m (Figure 15a).

Block C has almost no evidence for magnetic features and for the most part, neither do Blocks D or P; however, the northeast corner and edge of Block D is highly magnetic (Figure 15b). The readings in this area were some of the highest in the entire project area, including adjacent to large sources of magnetic interference around the Schultz Farm. Block E has one small area of elevated magnetism in the southeast corner, but is generally lacking in elevated magnetism. The western half of Block F is nearly as magnetic as the eastern half of Block D. Block Q, which straddles these areas, exhibits elevated magnet levels across its entire area.

Figure 13. Magnetic areas of the Walters field.

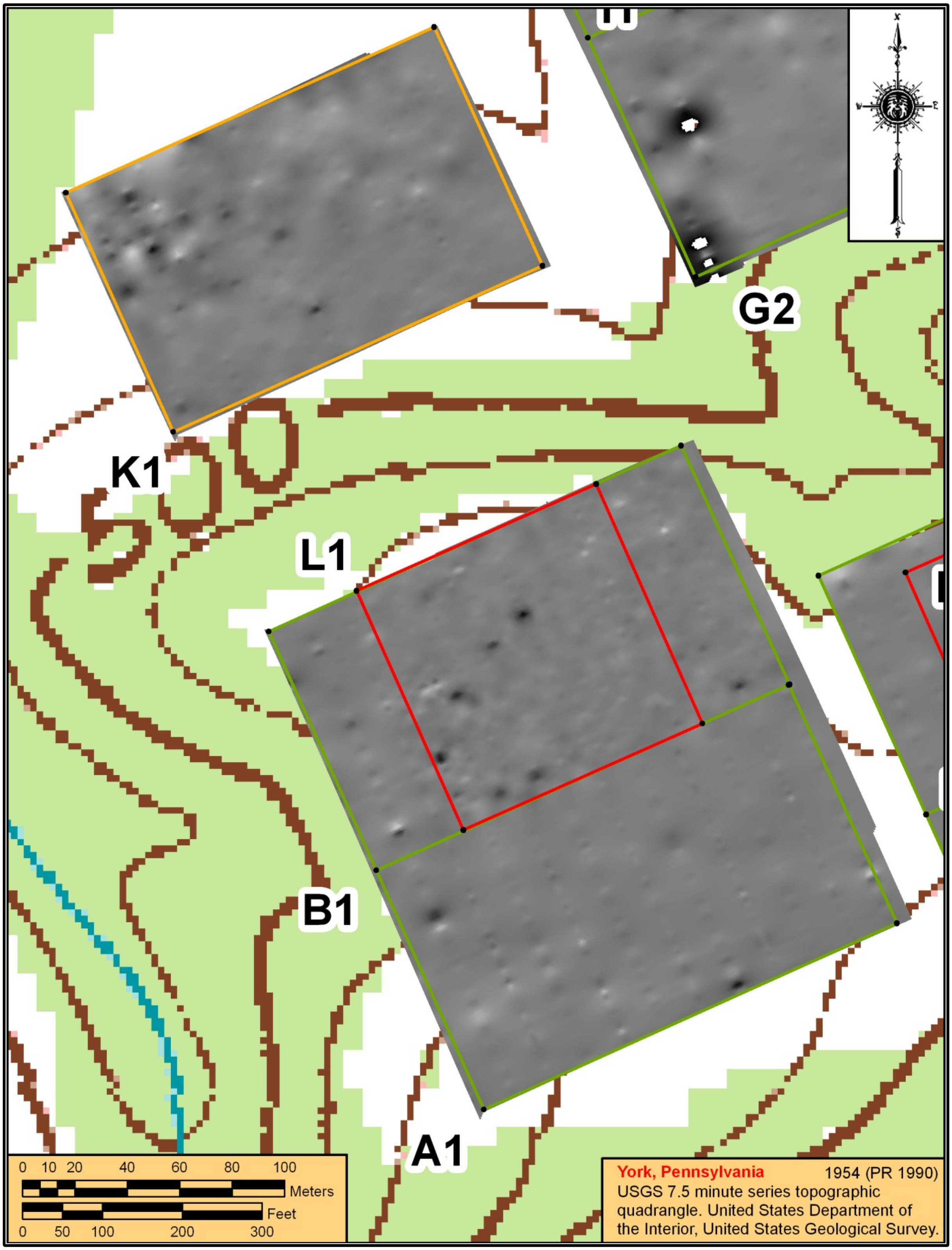

Figure 14a. Magnetic anomalies in Blocks A, B, L, and K.

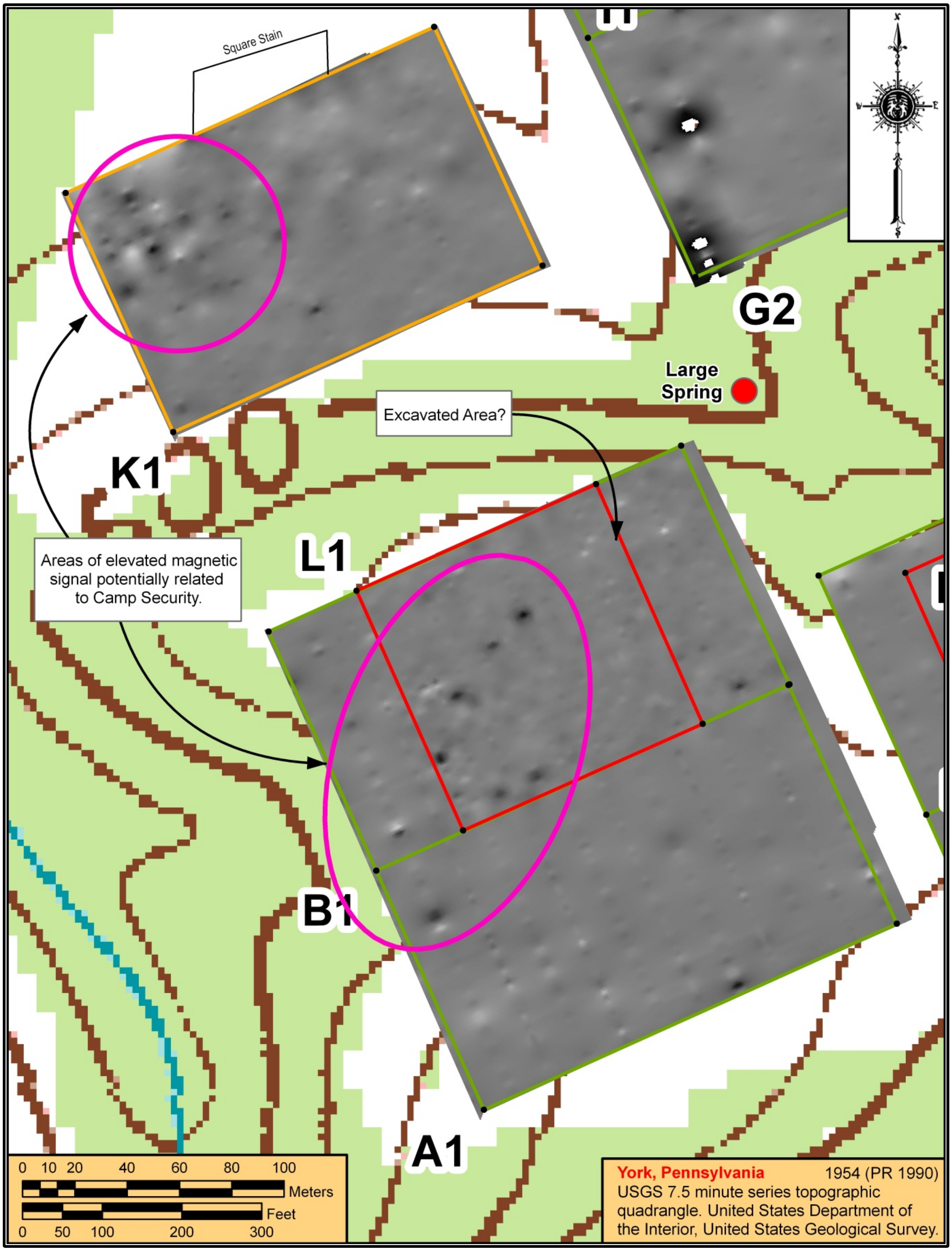

Figure 14b. Classification of magnetic anomalies in Blocks A, B, K, and L.

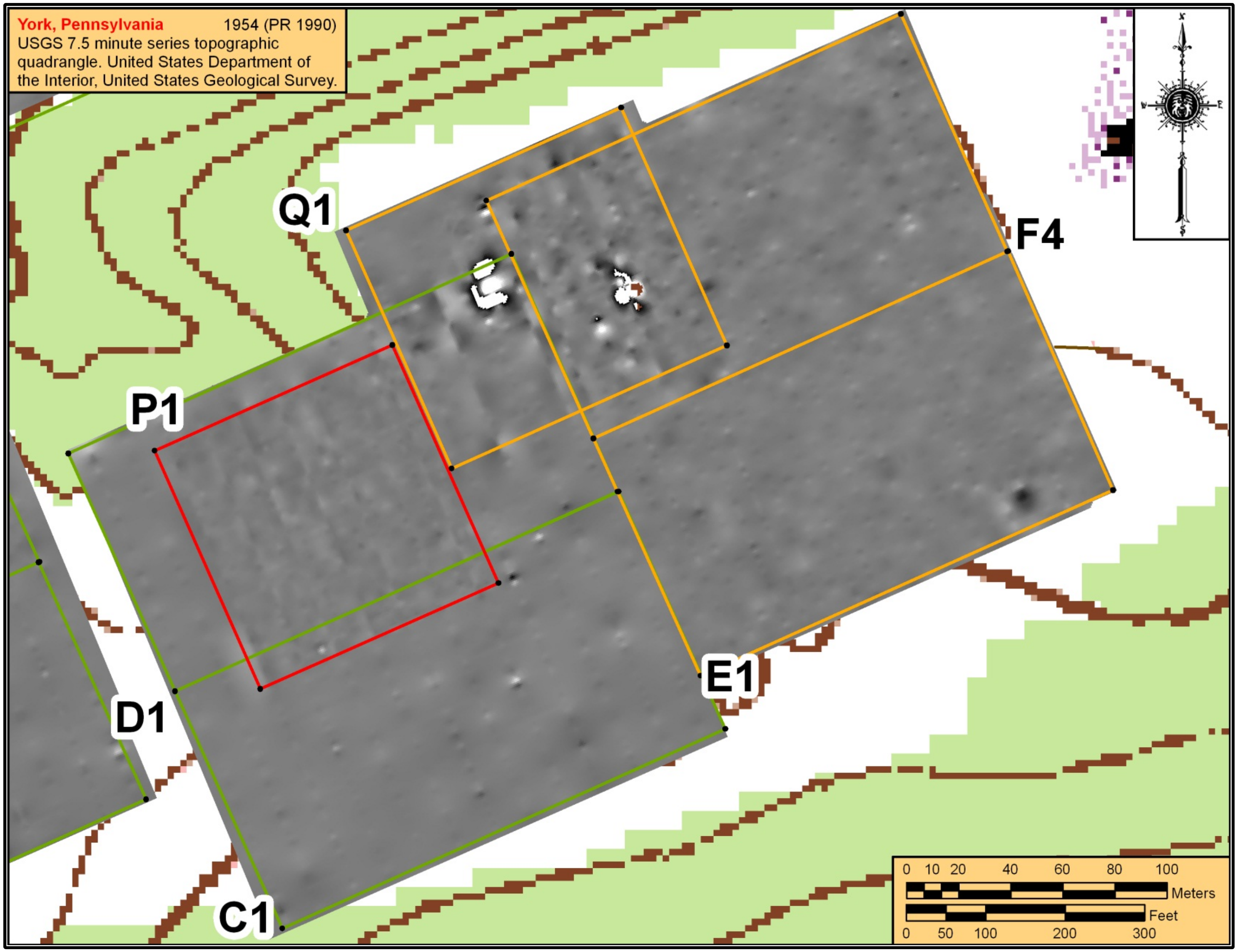

Figure 15a. Magnetic anomalies in Blocks D, E, F, P, and Q.

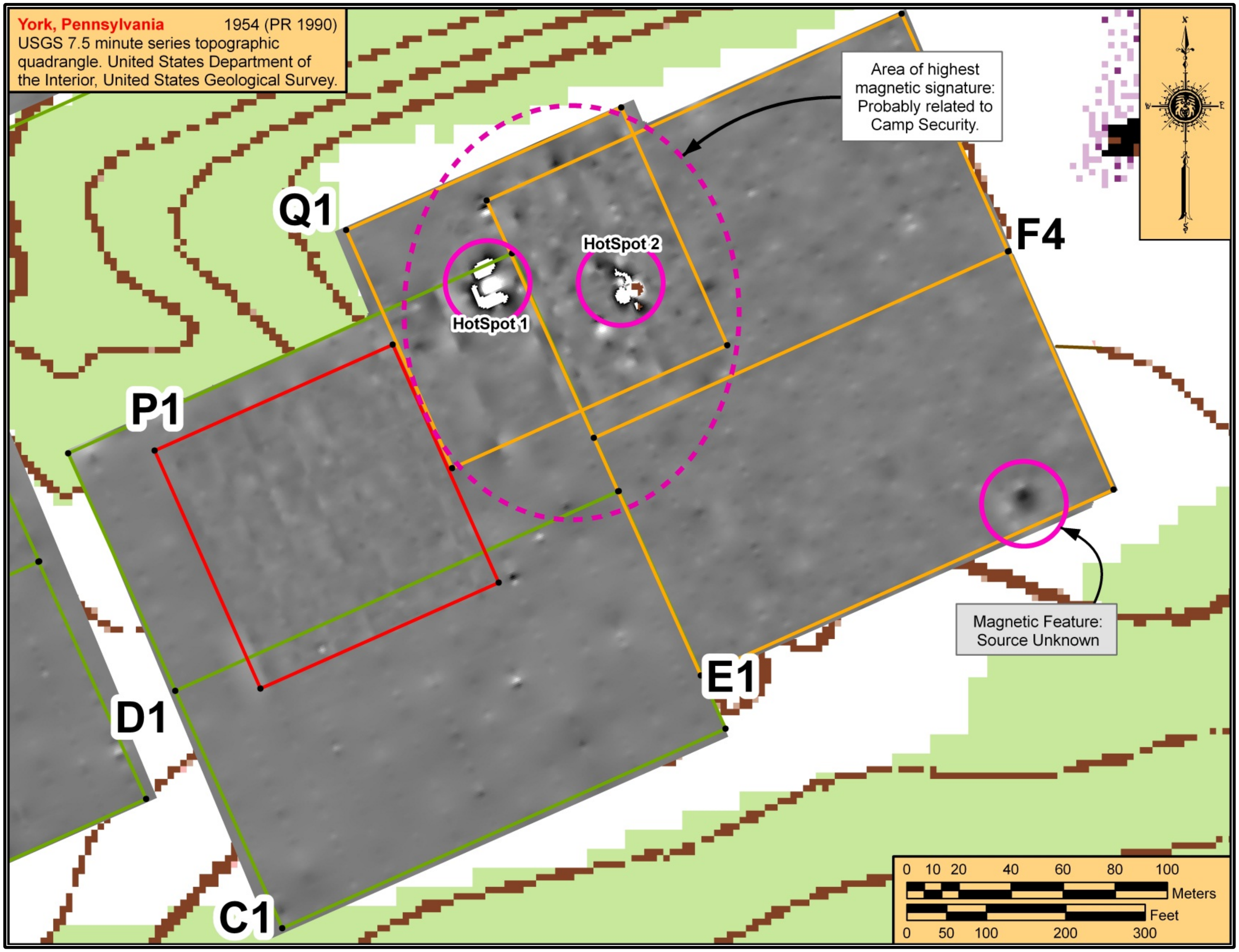

Figure 15b. Classification of magnetic anomalies in Blocks D, E, F, P, and Q.

The almost complete lack of magnetic features in Block P suggests that the relatively square stain seen in historic aerial photographs is more likely related to efforts to fill in the large erosion gullies noted on the 1952 aerial photograph than to the prison camp (Figure 12).

Based on the extremely high levels of magnetic response, Blocks D, F, and Q have the best chance of being related to the Revolutionary War prison camp. The only caveat to this conclusion comes in the form of aerial photographic evidence (see Figure 12), which clearly shows that the trail from the lower field into the upper field terminated 15 m (50 ft) west of the northeast corner of Block D (point D3) and that a field boundary of unknown composition ran south from this location to the tree line 40 m (130 ft) west of point C4. Later aerials show a clump of trees or bushes near point D3. The western magnetic "hot spot" in Blocks D and Q lies almost exactly on top of this point. It should be noted, however, that the elevated magnetic levels extend nearly 62 m (200 ft) east and uphill, from this location. While the western magnetic "hot spot" may be related to the field boundary, the majority of the magnetic response in Blocks Q and F is not being caused by the oxidation of an old fence—its source is currently unknown.

Blocks G, H, I, and J

Blocks G, H, I, and J were all surveyed at 15-m intervals. Because of the relative lack of "inexplicable" magnetic features in these blocks, no effort was made to reduce the transect interval by further surveys. Most of the anomalies in these blocks can be explained on the basis of recent historic occupation rather than any potential use of the fields during the Revolutionary War era (Figure 16a). The series of strong anomalies that traverse the area from the southwest corner of Block G to the barn at the Schultz Farm suggest the presence of a buried metal water pipe carrying water from the large spring south of point G2 (Figure 16b). The area of elevated magnetism immediately south of the barn in Block J is probably caused by a scatter of metal (and possibly historic ceramic) debris from mucking out the barn and chicken coops in this area. The elevated levels of metal in Block H are probably due to the presence of modern houses north and south of that area. Although its relevance to the prison camp is unknown, stone-work was noted during the survey near the location of point M4. This is in the general location of the small intermittent stream that runs from the unimproved spring in Block H towards the northern corner of the project area. A hazy light area that runs from near point G2, past point I1, and passes southeast of the barn is suggestive of an old farm road that crosses the stream near M4. The anomaly at M4 may, therefore, be a stone bridge or culvert. No features that were definitively attributable to the Revolutionary War prison camp were noted in these blocks.

Blocks J, M, N, and O

Blocks J, M, N, and O were all surveyed at 15 m intervals. As with the area south of the Schultz Farm, the relative lack of inexplicable magnetic features in these blocks meant that no further effort was made to reduce the transect interval (Figure 17a). The features in Block J and the southeast corner of Block M were discussed in the previous section. Elevated levels of magnetism follow the line of the intermittent stream from the area near M4 northward, suggesting that there is a source of magnetic material (e.g. a pipe) that is putting iron oxide into the stream (Figure 17b). The line of high magnetic readings that runs east-northeast from the Schultz Farm to just north of point M3 is caused either by the driveway or a buried utility running alongside it. The only area of elevated magnetism that cannot be explained on the basis of field observations is along the south edge of Block O, particularly in the southeast corner of the block where it crosses the intermittent stream. The area of elevated magnetism running nearly due west from the southeast corner of Block O is suggestive of another defunct road and stream crossing. There are no outbuildings near this potential road so it is unclear whether it relates directly to the farm or to a former road that possibly connected

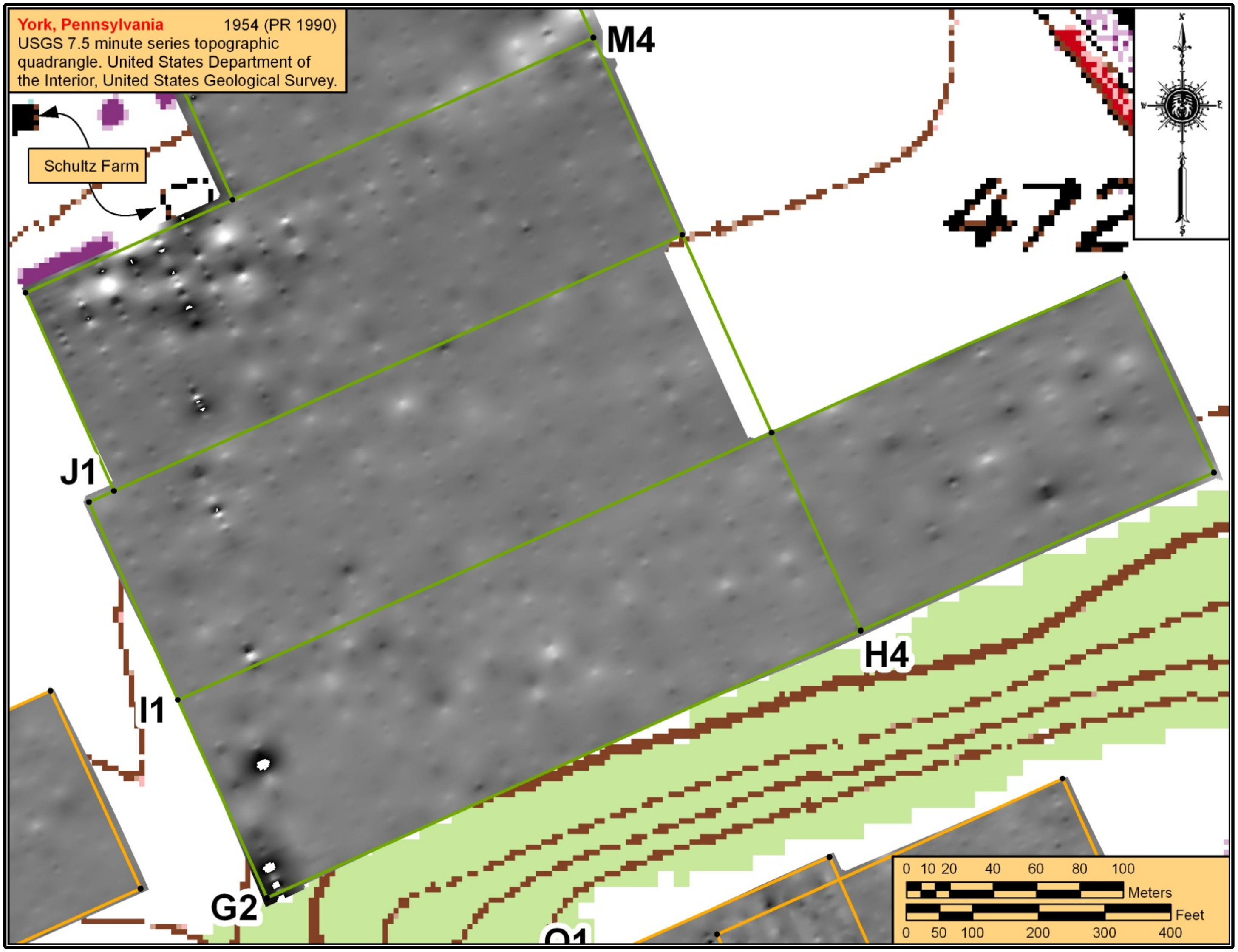

Figure 16a. Magnetic anomalies in Blocks G, H, I, and J.

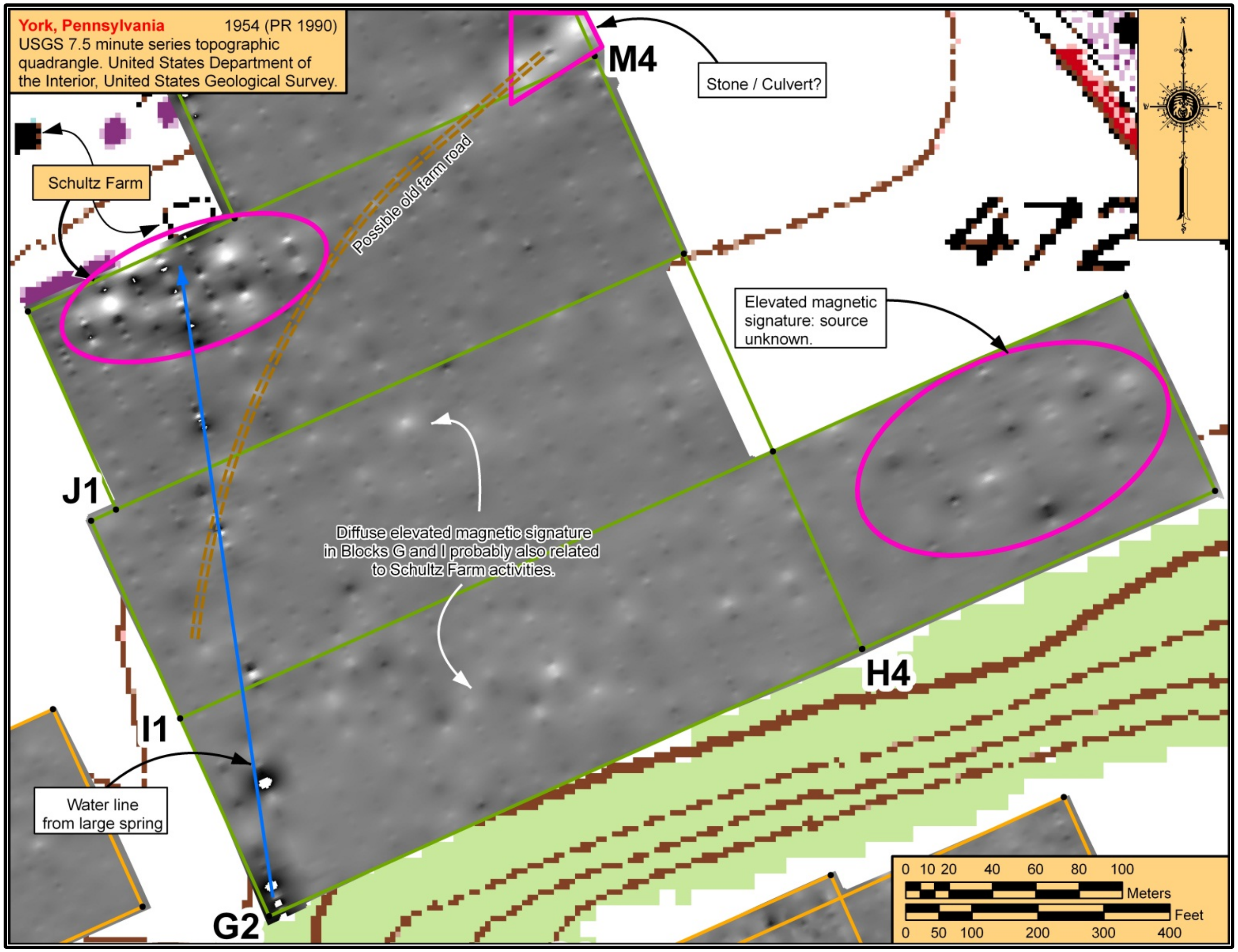

Figure 16b. Classification of magnetic anomalies in Blocks G, H, I, and J.

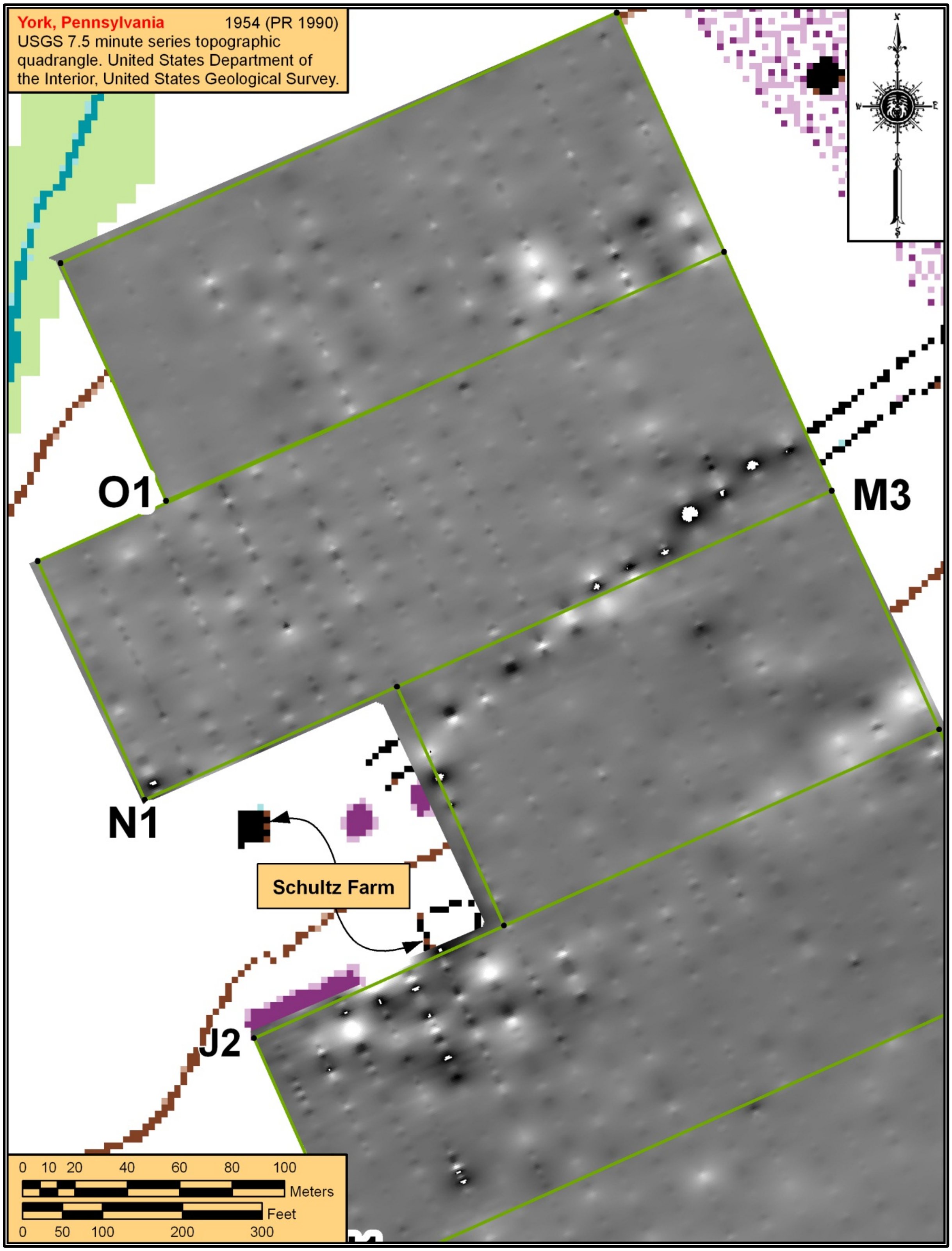

Figure 17a. Magnetic anomalies in Blocks J, M, N, and O.

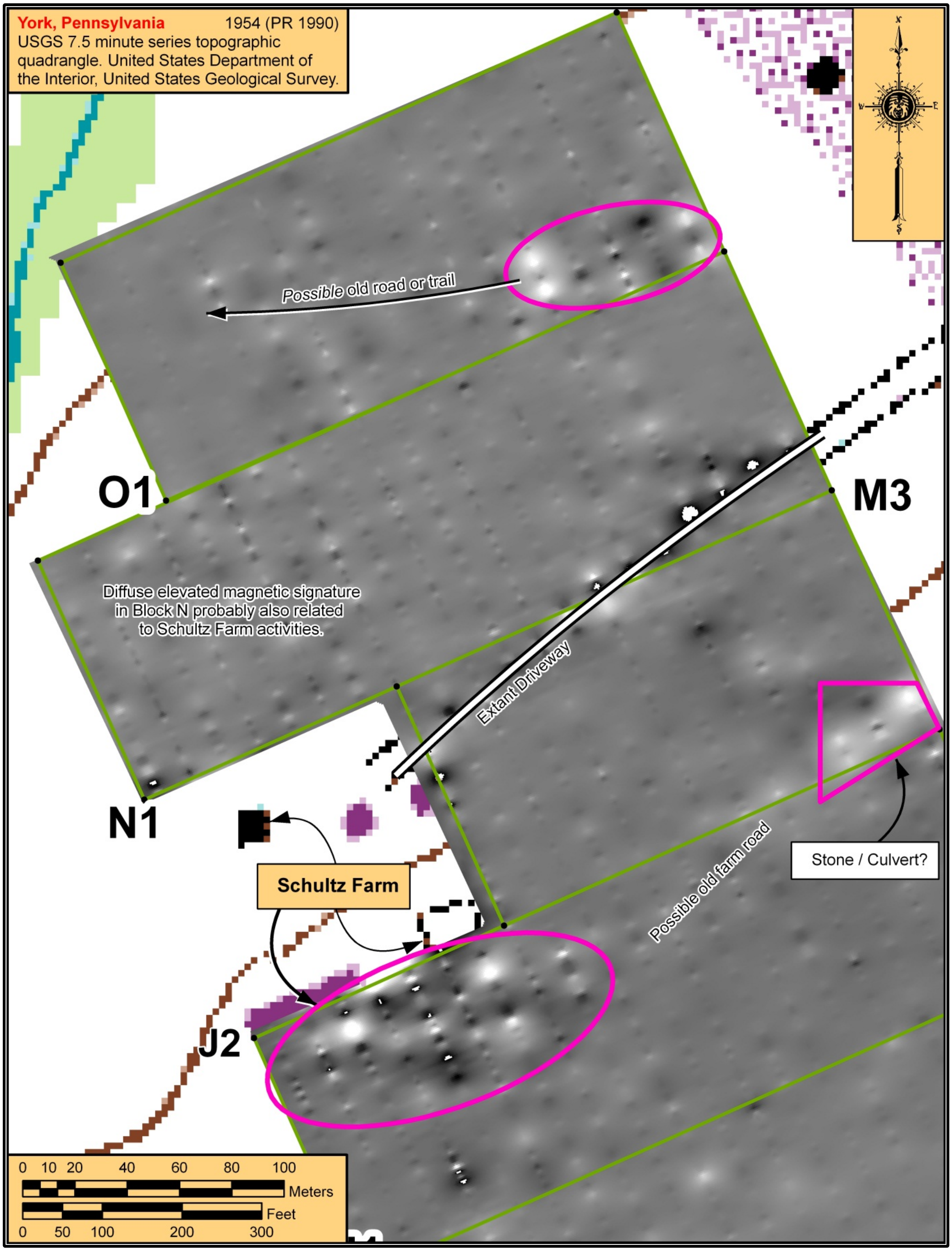

Figure 17b. Classification of magnetic anomalies in Blocks J, M, N, and O.

Stone Ridge Road with Old Orchard Road (or some earlier iteration of these roads). No features that were definitively attributable to the Revolutionary War prison camp were noted in these blocks.

Aerial Photographs and Lidar

Aside from the 1952 USGS aerial, there are few (if any) potential cultural features visible on older photographs. On the 1952 USGS aerial, a reasonably square stain is visible just north of Block K. There is little other evidence for large areas of soil staining caused by fire, historic structures, or other cultural processes. The one exception is an aerial provided by Pennsylvania's PAMAP project to Google Earth (Google 2012). In this photo, near (if not on) the location of the elevated magnetic readings in Blocks Q and F, a clear rectangular crop mark is visible; possibly with two, smaller crop marks attached to its west side and southwest corner (Figure 18).

Crop Marks

Crop marks can often be caused by cultural features such as walls or ditches. They develop because a remnant wall or ditch either limits or increases the amount of nutrients or water available to plants growing on the surface. During particularly wet or dry periods—such as the drought experienced during the summer of 2012—plants growing at the surface above the cultural feature either grow better or worse than those in "normal" unaffected soils. The fill contained in a ditch, for example, might hold more water during a rainy period, thus allowing the plants growing on top of the ditch to grow faster and taller. Plants growing on top of a buried wall might grow slower, or not at all, during a period of drought because their roots have less access to water.

While the crop marks in the 2012 aerial photograph could be totally unrelated to the prison camp, it is suggestive that they align almost perfectly with the areas of elevated magnetism noted in survey Blocks F and Q. In fact, the eastern "hot spot" on the magnetic survey is in the exact center of the largest rectangle. The crop marks start 12 m (31 ft) east of the field boundary depicted in the 1952 USGS aerial and are approximately 70 m (235 ft) in width east–west and 100 m (330 ft) in length north–south (Figure 19).

LiDAR

The "intensity" values of LiDAR data taken over the site provided corroborating evidence for these crop marks. The intensity values of LiDAR data measure the return strength of the laser pulse that generated each point. The value is partially based on the reflectivity of the object struck by the laser. Typically, LiDAR pulses are near infrared, so it is possible to make a coarse infrared "photograph" using the intensity data (ESRI 2013). When the LiDAR intensity data in this area are viewed as a percentage value (i.e., when the intensity value for each LiDAR point is divided by the maximum possible value), two very faint rectangles are visible. These two rectangles overlie the crop marks visible in the PAMAP aerial photograph. Unfortunately, due to the coarseness of the available data, the LiDAR results are too faint to be discernable when printed and a figure is therefore not included.

Discussion

Based on the magnetic surveys, aerial photographs, and (to some extent) the LiDAR data, Blocks D, F, and Q exhibit the most conclusive evidence as the probable site for Camp Security. The magnetic responses in this location are the highest anywhere on the property; even higher than around buildings currently occupied. The crop marks visible on the PAMAP aerial photograph clearly suggest rectangular (i.e., non-natural) features in the same location. The available LiDAR data, although coarse, also appear to show rectangular features. In short, all of the available evidence suggests there is a large, rectangular, highly magnetic feature that extends from the eastern half of Block D, through Q, into the western half of Block F.

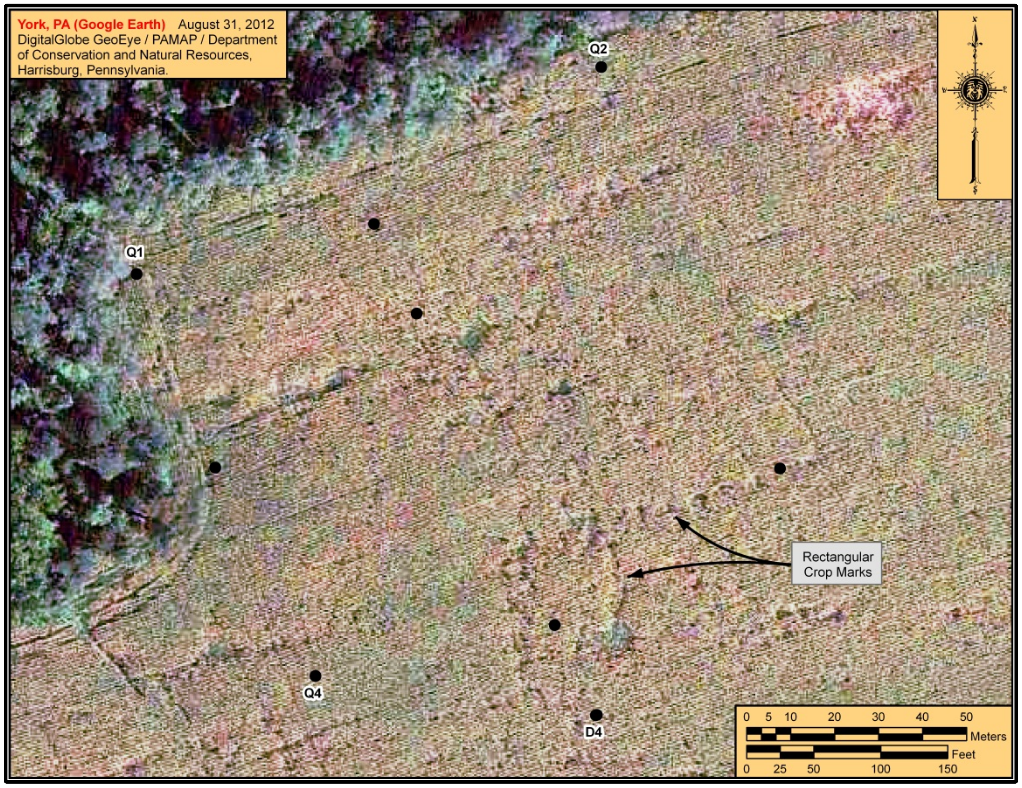

Figure 18a. Crop marks in Blocks D, E, F, and Q.

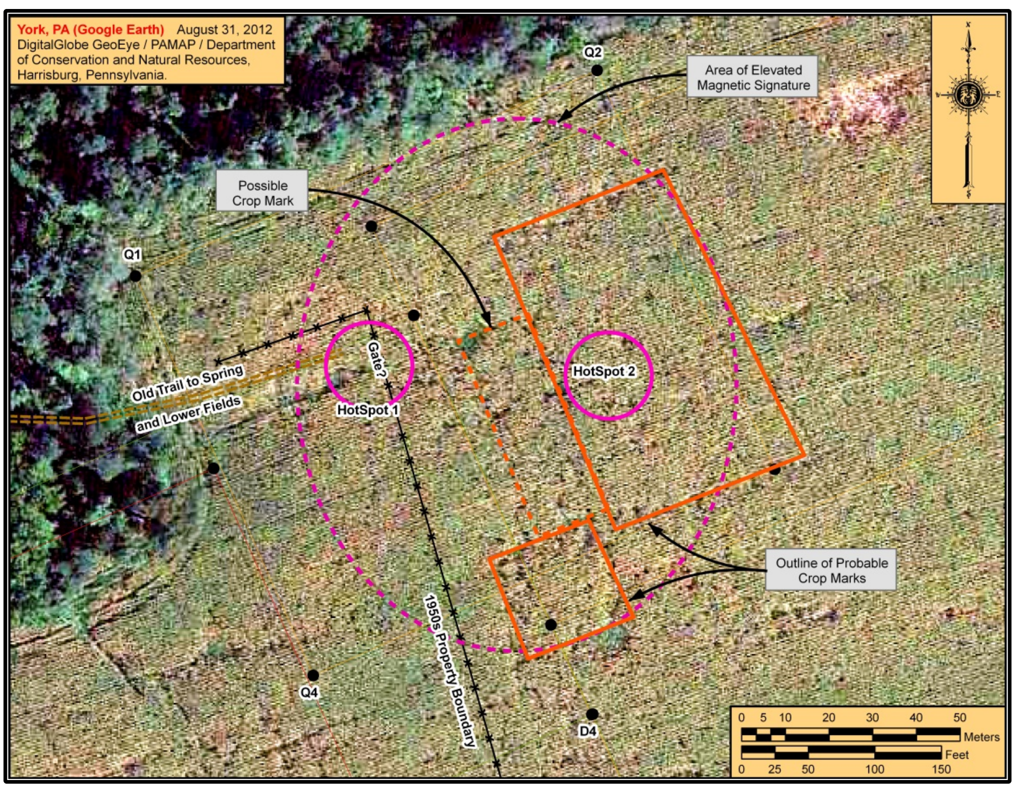

Figure 18b. Crop marks in Blocks D, E, F, and Q, showing magnetic anomalies and historic cultural features.

The feature is approximately 70 m wide and 100 m in length. It is on relatively level terrain ,and it is located at the trail-head that leads down to the large spring southwest of the Schultz Farm. Based upon this evidence, it appears that a feature potentially associated with the Revolutionary War-era prison, Camp Security, is located in these blocks. Only more intensive, close-interval geophysical surveys and/or ground truthing archaeological excavations can determine the level of integrity and precise nature of this feature.

V. CONCLUSIONS AND RECOMMENDATIONS

CRA personnel conducted a near-surface geophysical survey of the former Walters property in Springettsbury Township, York, Pennsylvania. The survey was conducted to delimit areas of interest relating to the Revolutionary War-era camp with a goal of informing future research, historic preservation, and township land management efforts. Seventeen survey blocks encompassing 32 ha (77 acres) of the total 46.9 ha (115.8 acres) were surveyed at 5–15 m intervals with a Geoscan Research FM-256 gradiometer.

The geophysical survey identified subsurface magnetic cultural features in six areas of the former Walters property. Three of these areas may be related to the Revolutionary War-era Camp Security. The other three are probably related to the Schultz Farm and its associated infrastructure. The southeastern-most area is suggested as the probable location of Camp Security based upon the level of magnetic disturbance, crop marks on aerial photographs, and coarse-resolution LiDAR data. The integrity and precise nature of the subsurface features within the field cannot be determined on the basis of the limited geophysical survey alone. Close interval (.5 m) geophysical surveys would be required to better delimit potential facilities associated with the Revolutionary War-era prison and geophysical anomalies should be ground truthed archaeologically by unit excavation or monitored mechanical stripping.

REFERENCES CITED

Ambos, Elizabeth L., and Daniel O. Larson
2002 Verification of Virtual Excavation Using Multiple Geophysical Methods: Case Studies from Navan Fort, County Armagh, Northern Ireland. The SAA Archaeological Record, 2:1:32-38.

Breiner, Sheldon
1965 The Rubidium Magnetometer in Archaeological Exploration. Science, New Series, 150:3693:185–193.

Butler, Dwain K., Janet E. Simms, and Daryl S. Cook
1994 Archaeological Geophysics Investigation of the Wright brothers 1910 Hangar Site. Geoarchaeology 9(6):437–466.

Chavez, R. E., M.E. Camara, A. Tejero, L. Barba, and L. Manzanilla
2001 Site Characterization by Geophysical Methods in the Archaeological Zone of Teotihuacan, Mexico. Journal of Archaeological Science, 28:1265–1276.

Clark, Anthony
1990 Seeing Beneath the Soil: Prospecting Methods in Archaeology. B.T. Batsford, LTD., London.

ESRI
2013 Creating Intensity Images from LiDAR in ArcGIS. Electronic document, http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//00q800000099000000. Accessed January 10, 2013.

Google
2012 Google Earth Aerial Photograph of York, Pennsylvania (08/31/2012), http://maps.google.com/maps?ll=39.972814,-76.64091&z=18&t=h&hl=en, accessed January 10, 2012. Data provided by DigitalGlobe GeoEye, Pennsylvania Department of Conservation and Natural Resources PAMAP/USGS. Harrisburg, Pennsylvania.

National Resource Conservation Service

2009 Ground Penetrating Radar Suitability–Washington (map). United State Department of Agriculture- Natural Soil Survey Center, Lincoln, Nebraska.

Schmidt, Armin

2002 Geophysical Data in Archaeology: A Guide to Good Practice, Second Edition. The Information Press, Eynsham, Oxford, United Kingdom.

Soil Survey Staff

2013 Official Soil Series Descriptions. Available URL: http://soils.usda.gov/technical/classification/osd/index.html, accessed January, 10, 2013. United States Department of Agriculture- Natural Resources Conservation Service, Lincoln, Nebraska.

United States Geological Survey

1952a Aerial ID 1ZE0000010007 (01/04/1952). United States Department of the Interior, Geological Survey, Washington, DC.

1952b Aerial ID 1OX0000030037 (09/01/1952). United States Department of the Interior, Geological Survey, Washington, DC.

1954 (photorevised 1990) York, Pennsylvania, 7.5-minute series topographical quadrangle. United States Department of the Interior, Geological Survey, Washington, DC.

1968 Aerial ID 1VBZE00030175 (05/07/1968). United States Department of the Interior, Geological Survey, Washington, DC.

1987 NAPP ID NP0NAPP000104019 (09/04/1987). United States Department of the Interior, Geological Survey, Washington, DC.

1988 NHAP ID NC1NHAP830309129 (04/13/1983). United States Department of the Interior, Geological Survey, Washington, DC.

1999 Orthophoto ID DI00000000935955-YORK-NE,PA (04/06/1992). United States Department of the Interior, Geological Survey, Washington, DC.

2001 Orthophoto ID DI00000001152260-YORK-NE,PA (04/08/1999). United States Department of the Interior, Geological Survey, Washington, DC.

2004 Aerial ID UPAMAP0040156 (04/03/2003). United States Department of the Interior, Geological Survey, Washington, DC.

2009a High Resolution Orthoimagery ID 1393148_24002270PAS (04/13/2003). United States Department of the Interior, Geological Survey, Washington, DC.

2009b High Resolution Orthoimagery ID 1696495_24002270PAS (04/19/2008). United States Department of the Interior, Geological Survey, Washington, DC.

Tabbagh, Alain, and Michel Dabas, Albert Hesse, Cedric Panissod

2000 Soil Resistivity: A Non-Invasive Tool to Map Soil Structure Horizon. Geoderma 97:393–404.

Tubbs, Donald W., Jon W. Koloski, and Sigmund D Schwarz

1989 Geotechnical Properties of Geologic Materials. Engineering Geology in Washington, V. 1. Washington Division of Geology and Earth Resources.

Waters, Michael R.

1992 Principles of Geoarchaeology. University of Arizona Press. Tuscon, Arizona.

Wynn, Jeffrey C.

1986 A Review of Geophysical Methods Used in Archaeology. Geoarchaeology 1:3.

APPENDIX A. SURVEY GRID CORNERS

GPS coordinates presented in this report are given using Universal Transverse Mercator (UTM), Zone 18 North, WGS 84.

Grid ID	Easting	Northing	Grid ID	Easting	Northing
A1	359462.382729	4425557.34684	J1	359472.471807	4426062.44379
A2	359421.310843	4425648.52304	J2	359431.898651	4426153.84465
A3	359578.614793	4425719.38330	J3	359693.461225	4426271.67000
A4	359619.960148	4425628.33029	J4	359734.533110	4426180.49380
B1	359421.310843	4425648.52304	K1	359343.889397	4425815.81789
B2	359380.238958	4425739.69924	K2	359302.817512	4425906.99410
B3	359537.596504	4425810.58365	K3	359443.429302	4425970.33509
B4	359578.977822	4425719.54684	K4	359484.763700	4425879.27714
C1	359672.227388	4425578.69683	L1	359413.815335	4425755.26839
C2	359631.155502	4425669.87304	L2	359505.180389	4425795.91845
C3	359801.301967	4425746.51847	L3	359545.830443	4425704.55339
C4	359842.320257	4425655.31812	L4	359454.465389	4425663.90334
D1	359631.155680	4425669.87294	M1	359527.271657	4426196.79689
D2	359590.083794	4425761.04915	M2	359486.355594	4426288.05346
D3	359760.365448	4425837.75564	M3	359652.389170	4426362.84610
D4	359801.102476	4425746.42860	M4	359693.461225	4426271.67000
E1	359832.829115	4425675.76390	N1	359390.057615	4426244.83330
E2	359791.757230	4425766.94011	N2	359349.395938	4426336.03537
E3	359951.032613	4425838.68843	N3	359611.317455	4426454.02241
E4	359991.197276	4425747.10356	N4	359652.389340	4426362.84620
F1	359791.757230	4425766.94011	O1	359398.302293	4426358.93225
F2	359750.685345	4425858.11631	O2	359358.057742	4426449.65901
F3	359909.850791	4425929.81512	O3	359570.245569	4426545.19861
F4	359950.705548	4425838.54110	O4	359611.317455	4426454.02241
G1	359816.676881	4425998.14139	P1	359623.220752	4425762.10612
G2	359543.148268	4425874.92573	P2	359714.585806	4425802.75618
G3	359502.076383	4425966.10194	P3	359755.235860	4425711.39112
G4	359775.604996	4426089.31759	P4	359663.870806	4425670.74107
H1	359775.661711	4426089.34314	Q1	359696.726326	4425846.72300
H2	359938.610682	4426161.17755	Q2	359802.318870	4425893.80266
H3	359979.619753	4426071.09205	Q3	359842.931468	4425802.53349
H4	359816.891703	4425998.23816	Q4	359737.376380	4425755.35795
I1	359502.076383	4425966.10194			
I2	359461.004497	4426057.27814			
I3	359734.533110	4426180.49380			
I4	359775.604996	4426089.31759			