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Geophysical Surveys and Archaeological Insights at Fort Pierre Chouteau a Frontier Trading Post on the Middle Missouri

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GEOPHYSICAL SURVEYS AND ARCHAEOLOGICAL INSIGHTS AT FORT PIERRE CHOUTEAU
A FRONTIER TRADING POST ON THE MIDDLE MISSOURI

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of the requirements for the degree of
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ABSTRACT

Fort Pierre Chouteau in present day South Dakota was the most important fur trading post of the American Fur Company in the 1830s, serving as a regional hub for the fur trade. The Fort was sold to the U.S. Military in 1855 for use as a base in the Sioux Wars but was abandoned in 1856. Geophysical surveys and previous excavations indicate evidence of both occupations. Geophysics is an important tool for determining the extent of archaeological sites, yet the relationships between geophysical anomalies and excavation features may not be readily evident. Initial geophysical surveys (Kvamme 2007) were completed to determine the extent of the fur trading Fort, and additional surveys in August 2012 used magnetometry and electrical resistance to determine if evidence of military structures exists outside of the Fort. This study examines connections between excavation features and geophysical anomalies in order to better interpret anomalies inside the Fort palisade. The palisade builder's trench, adobe pavement, post holes, and unknown structures are characterized through the analysis of the excavations and anomalies. The location of one of the military structures outside of the palisade is also identified. As many sites have histories of excavations prior to any geophysical surveys, combining the two sets of information is important in order to more fully understand site layout and the archaeological causes of geophysical anomalies.

This thesis is approved for recommendation
to the Graduate Council.

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DEDICATION

For M.

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I. CHAPTER 1: INTRODUCTION

A. Geophysics and Archaeology

Geophysical techniques are tools increasingly used in archaeology in North America, but the direct connection between anomalies visible in geophysical surveys and features present in excavations is not always apparent. Ideally, "ground-truthing" is completed after geophysical surveys to verify interpretations. However, it is not always feasible to complete ground-truthing for every geophysical survey. In addition, some sites have extensive excavation histories prior to any geophysical surveys. Understanding the connection between features and anomalies allows a better interpretation of geophysical data and therefore a more complete understanding of a site.

The North American Fur Trade was the basis for many interactions between Europeans and Native Americans, and a crucial component of the opening of the frontier to European and Euroamerican settlement. Fort Pierre Chouteau (3ST0237) in present day South Dakota was a regional hub for one of the largest fur trading companies in the United States, the American Fur Company. From 1845 through 1852, the Fort consistently maintained the largest inventory of supplies, equipment, and trade goods compared to other forts in the company, emphasizing its importance within the region and within the fur trade (Schuler 1990:138).

This paper analyzes magnetometry and electrical resistance surveys of the Fort, along with limited areas of magnetic susceptibility and conductivity from two separate years of surveys. Surveys using these techniques covered the main Fort area in 2007 (Kvamme 2008). Additional work completed in 2012 extended the magnetometry and electrical resistance surveys to cover the field west of the Fort. The Fort has been excavated twice – first in 1980-81 by Steven Ruple of the South Dakota State Historical Preservation Center and then again from 1997-2001 by Jay Vogt and Michael Fosha of the South Dakota State Historical Society. Interpretations of the geophysical

anomalies are presented, followed by analysis of the anomalies using features discovered in the excavations. A clearer picture emerges of the location of buildings and activity areas within the Fort, providing insight into the Fort's history and use.

Fort Pierre Chouteau was built in the 1830s as a replacement for the nearby decaying Fort Tecumseh which allowed the American Fur Company to network its trading posts and seasonal trading camps for the collection of furs and the distribution of trade goods in the area (Schuler 1990:42). During its occupation, the Fort hosted various travelers exploring the western frontier as they moved up the Missouri River. Many visitors recorded details about the Fort and compiled detailed ethnographies about the Native American tribes on the Great Plains. Prince Maximilian of Wied (1832-33), Karl Bodmer (1832-33), and Thaddeus A. Culbertson (1850) all visited the Fort as part of their explorations of the frontier. The Fort served as a crucial backdrop and center of interactions between Native Americans and Euroamericans during the expansion of the United States after the Louisiana Purchase.

By 1855, the Fort had outlasted its usefulness to the American Fur Company and was sold to the U.S. Military to act as a base of operations for the "Sioux Expedition" led by Colonel William Harney against the Brule Sioux (Ball 2001:44). Fort Pierre Chouteau was in such poor condition that the military abandoned the Fort in 1856, using materials from the Fort to build Fort Lookout and Fort Randall (Nowak 2002:109). However, before its abandonment, the Fort served as the location for treaty negotiations between Colonel Harney and the Sioux (Clow 1986:243). Late in the Fort history, the site was homesteaded and functioned as a ranch before donation to the state of South Dakota in 1930.

B. Research Approach and Questions

This project combines geophysical surveys with excavation information in order to better interpret anomalies present in the surveys. The three main questions of this project are: *What is the layout and structure location within the Fort? What do the excavation features tell us about the types and interpretations of the geophysical anomalies?* and *Is there any evidence of the military occupation outside of the Fort palisade?* Ideally, geophysical surveys are completed prior to excavations in order to ground-truth interpretations, but in this case the excavation results are used to interpret later geophysical surveys.

Chapter 1 provides the research approach and archaeological background, along with a brief discussion of the North American Fur Trade. The background and history of the Fort Pierre Chouteau site is included in Chapter 2, detailing the establishment, active occupation, and post Fort period. Chapter 3 discusses the survey methods and data processing for aerial photography, magnetometry, electrical resistance, magnetic susceptibility, and conductivity. Results are presented in Chapter 4 with discussion of anomalies and their relationship to structures based on historic maps. Chapter 5 compares features found in the excavations with corresponding geophysical anomalies to better characterize how those features appear in the geophysics. The conclusion is located in Chapter 6.

C. Archaeology

1980-1981 Excavations

Excavations were first conducted at Fort Pierre Chouteau in 1980 and 1981 by Steven Ruple of the South Dakota State Historical Preservation Center, South Dakota State Archaeologist Dr. Robert Alex, and the South Dakota Archaeological Society (Ruple 1990:3). According to

Ruple, the Fort Pierre Chouteau excavations were the first project in South Dakota to use non-professional volunteers for excavation (Ruple 1990:3). The excavations focused on identifying whether any archaeological evidence of the Fort still existed as there was concern that it had been destroyed by the 1952 Missouri River flood. The existence of the site was established in the early excavations. Test units and trenches were then placed in an attempt to identify the purpose of two visible depressions, and trace the potential palisade line in the southeast corner of the Fort.

The 1980 excavations identified a western depression as a cellar possibly dating to the Fort period (1832-1856) that was filled with much later material dating to the ranch period (Ruple 1990:17). Many of the artifacts were interpreted to represent the family's occupation of the site (Ruple 1990). Based on the changing composition of artifacts, Ruple interprets both depressions as present when James Phillips arrived on the site in the late 1800s and partially filled during his family's residence at the Fort. Artifacts included fabric, building materials, beads, tinkler bells, beams and post holes, a moccasin, ceramics, and nails. Excavations in 1981 located a section of the south palisade, but did not locate the southeast blockhouse. Ruple noted that the south palisade line of post holes ran down the edge of the terrace, but he did not encounter any features that seemed related to the blockhouse at its expected location. The excavations provided evidence that much of the Fort was still present beneath the surface.

1997-2001 Excavations

In 1997, Jay Vogt of the South Dakota State Historical Society along with the U.S. Army Corps of Engineers jointly excavated the site to help develop a management plan (Fosha 2010a:2). Excavations continued over the next 5 years ending in 2001. In 2010, Michael Fosha published the

full report of the excavations, *The 1997-2001 Excavations at Fort Pierre Chouteau Volume 1: The Excavations* and *The 1997-2001 Excavations at Fort Pierre Chouteau Volume 2: Material Culture.*

According to Fosha, the 1997-2001 excavations were designed primarily to establish the Fort's dimensions and the location of structures (2010a:29). Features were usually not fully excavated, but were left intact once identified, so the extents and full dimensions of many features are largely unknown. Excavation units were 1 x 1 meter and arranged in trenches and blocks with additional isolated test units. Figure 1 details the locations of the units in comparison to the 1833 and 1855 outlines of the Fort. Volume 1 of Fosha's report includes those features interpreted as directly representing structures and activities at the Fort.

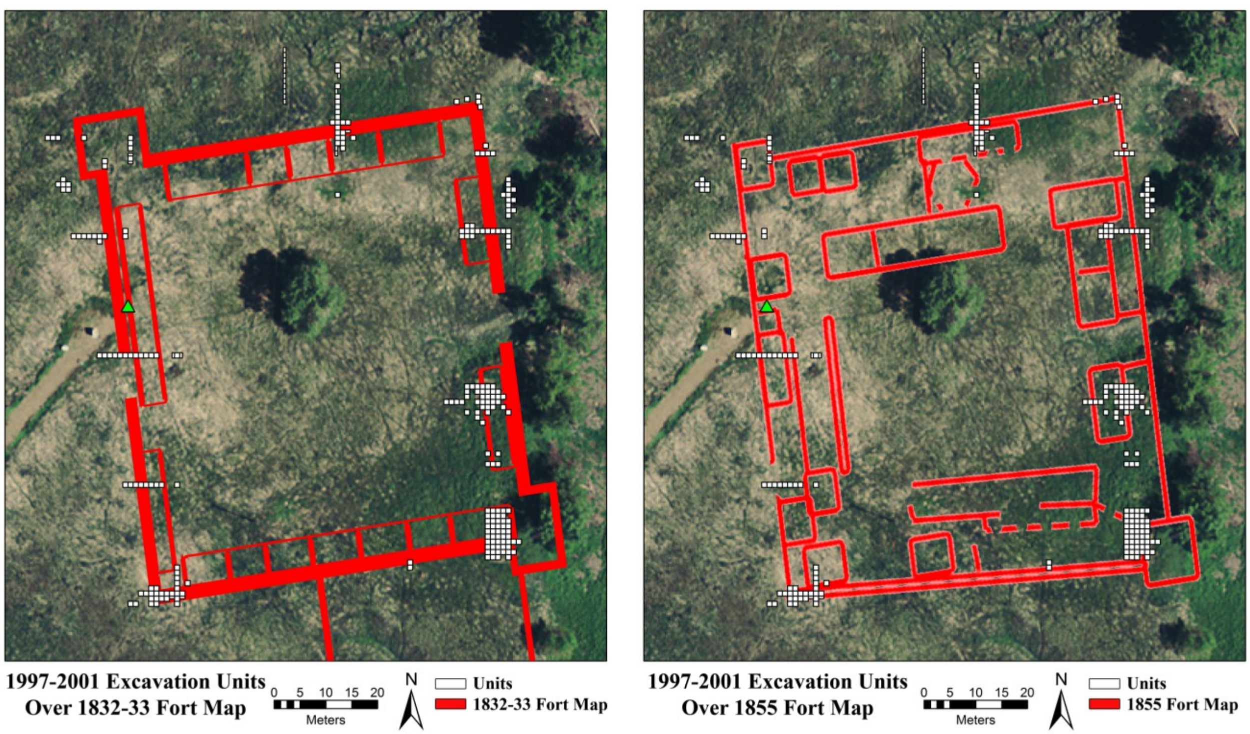

Figure 1: 1997-2001 excavation units overlaid on the 1832-33 and 1855 outlines of the Fort maps. Recreated from unit location data in the excavation report (Fosha 2010a).

Fosha's work identified the extent of the palisade, along with multiple post molds and several instances of adobe blocks and adobe derived soil. During the five year project, excavation units sampled the edges of the Fort, particularly across the estimated locations of the palisade. No units were placed in the Fort's interior, in keeping with the goal of establishing its exterior dimensions. The southwest corner of the palisade was well-defined with the bases of palisade timbers present (Fosha 2010a:35). The palisade builder's trenches were identified in all areas intersecting the palisade wall, with the exception of one of the east palisade wall excavations. Fosha (2010a:83) interpreted the absence of a palisade builder's trench at this location to be due to erosion of the terrace edge. Both circular and rectangular post molds were prevalent in the excavations, many of which were not directly relatable to known Fort buildings. The exact locations of many structures were not identified through the excavations. Adobe brick was identified in excavations along the west wall, just inside the palisade builder's trench, and puddled adobe and adobe-derived soils along the interior and exterior of the western and eastern palisades.

D. The North American Fur Trade and the American Fur Company

Extensive trade networks existed on the North American continent prior to European arrival. Furs and other goods such as shell, animal teeth, and stone were widely traded at regional centers where tribes gathered for trade and the exchange of news (Van Sickle and Rodewald 2011:2). On the Great Plains, the Yanktonai, Sisseton, Yankton, and Teton Dakota groups traded at the mouth of the James River in present day Nebraska, while the Apache, Kiowa, and Comanche traveled to the Rio Grande (Van Sickle and Rodewald 2011:3). When Europeans arrived, they began trading with Native Americans at existing gathering sites and also established new trading locations.

In eastern North America, fur trade interactions between Native American groups and Europeans dates to the early 1500s with the arrival of European explorers, although Norse explorers in the 11th century likely traded with Native Americans as well (Van Sickle and Rodewald 2011:13; Dolin 2010:8, 10). Native Americans exchanged furs as part of trade activities, with furs and other items collected and then transported throughout North America (Van Sickle and Rodewald 2011). The Russians traded with Native Americans on the West Coast, transporting North American fur to the Chinese (Van Sickle and Rodewald 2011:76; Chittenden 1935:96).

The popularity of furs in Europe and China fueled interest in utilizing North America as a supply source. The French fully established North American trade operations by 1599, followed by the Dutch in the early 1600s (Dolin 2010:11; Van Sickle and Rodewald 2011). The English and others soon followed with the hope of making profits, and European colonies were quick to also establish trade relationships with their Indian neighbors. Indians traded beaver, mink, buffalo, fox, and other furs for bells, beads, liquor, and other trade goods (Chittenden 1935). By the mid 1700s the fur trade was well established in North America and major fur hub cities such as St. Louis, Missouri, did brisk business with clients in the eastern United States and Europe (Dolin 2010:123; Chittenden 1935:109). Large fur companies in the United States did not arise until around 1810, due to the impact of political changes from the Revolutionary War and the increased territory from the Louisiana Purchase (Chittenden 1935:96). The War of 1812 also affected the American fur trade. The struggle between the United States, Native American tribes, and Great Britain spilled over to the fur companies, affecting the availability and trade of furs in various areas (Chittenden 1935).

Fur companies acquired stock through three sources: trade with Native Americans, hunters

and trappers under contract, and independent hunters and trappers (Chittenden 1935:5; Dolin 2010:180,227). The American Fur Company, which built and controlled Fort Pierre Chouteau, did business with all three sources. Within Native American tribes, men hunted fur-bearing animals while women did most of the processing, particularly the time consuming processing of buffalo hides (Wishart 1979:97). Trappers under contract were paid a set wage and were required to submit all their takings to the company. Independent trappers were able to choose companies with which to do business (Dolin 2010:227). Trappers worked in groups from established base camps for protection and would cache furs and supplies during the trapping season. Furs would be retrieved at the end of the season and sold at a fur trading post (Dolin 2010:230-231). Early fur trade on the Missouri relied more heavily on Native Americans than on Euroamerican Trappers, particularly for buffalo hides. By the 1870s, the extension of the railroads and new technology enabled the use of previously unusable hides initiated a period of Euroamerican buffalo hunters (Dolin 2010:299,305-305). Fort Pierre Chouteau, when established as a fur trade Fort in 1832, served as a regional hub for the American Fur Company based on a foundation of over three hundred years of economic interactions between Native Americans, Euroamericans, and Europeans.

The American Fur Company

John Jacob Astor incorporated the American Fur Company in 1808 as part of his attempts to establish a broader presence in the fur trade (Dolin 2010:194; Chittenden 1935:313; Van Sickle and Rodewald 2011:23). Astor presented the American Fur Company to the United States Government as being composed of a group of investors with the goal of improving Indian relations and expanding settlement of the West, yet his goal was actually to create a monopoly of the fur

trade (Dolin 2010:195). He planned to open trading posts along the Missouri River and gain control of the trade within the lands included in the Louisiana Purchase. Competitors in the early 1800s included the Missouri Fur Company and the Rocky Mountain Fur Company, both of which were based in St. Louis, Missouri (Chittenden 1935:126).

Astor first created a subsidiary called the Pacific Fur Company designed to directly compete with Canadian traders. Although the Pacific Fur Company had contracts with many Canadian fur traders, the American Wilson Price Hunt was its chief agent (Dolin 2010:196). The company planned to establish posts and trade on the West Coast near the mouth of the Columbia River and then move up the Missouri River from St. Louis to dominate overland trade. This plan was interrupted by the War of 1812, which impacted not just Astor's company but other fur trading companies as well. Fur traders on both the British and American sides supported the war, hoping to strengthen their rights and improve access to the West's fur resources (Dolin 2010:212). The war forced fur companies to directly compete with each other for trade.

By the 1820s the American Fur Company was one of the largest fur companies in the United States, controlling the fur trade in the Upper Mississippi River and Great Lakes areas (Dolin 2010:266). Astor intended to expand his operations to the Missouri River and during the 1820s began making contacts in St. Louis, the hub of the Missouri-based trade (Dolin 2010:266; Van Sickle and Rodewald 2011:200). The Western Department of the American Fur Company (headquartered in St. Louis) was established in 1822 with the direct goal of expanding up the Missouri River (Dolin 2010:270). One of the small fur trade competitors at the time included Berthold, Chouteau and Company, headed by Pierre Chouteau Jr. (after whom Fort Pierre Chouteau was later named) and Bartholomew Berthold (Lecompte 1982:29). Berthold, Chouteau and Company had been trying to purchase an interest in the American Fur Company for several

years, and finally in 1826 competition forced Astor to contract management of the American Fur Company's Western Department to Pierre Chouteau Jr. under the reorganized and renamed Bernard Pratte and Company (Chittenden 1935:327; Van Sickle and Rodewald 2011: 201-202).

The dissolving of the United States Government-sponsored factory system provided the opportunity Astor needed to consolidate his control over the Missouri River fur trade. The United States had established a "factory system" of government controlled trading posts to "create strong bonds between the Indians and the government, eliminate Indian aggression on the frontier, and civilize and Christianize the supposedly savage Indians, ultimately leading them to give up their way of life and merge into the American mainstream" (Dolin 2010:266-267). However, the officials running the factory posts were unfamiliar with the fur trade and struggled to provide items the Native Americans wanted in trade. Although Native Americans sold their worst furs to the factory posts for high prices, the system still was competition for privately owned fur companies (Dolin 2010:268). After successfully campaigning to remove the government competition, Astor was able to expand his operations up the Missouri River (Chittenden 1935).

In 1827, Astor succeeded in driving a rival company named the Columbia Fur Company out of business, purchased its trading posts, and took over its employee contracts (Lecompte 1982:36). Operations on the Missouri were renamed the Upper Missouri Outfit or U.M.O. (Chittenden 1935:328). By 1830, the American Fur Company was the dominant fur company on the Missouri River, often referred to as 'The Company' (Dolin 2010:269; Chittenden 1935:329). Pierre Chouteau Jr., then manager of the Western Department, adopted Kenneth McKenzie's idea of using steamboats to transport furs and supplies to the upper Missouri River posts in 1831. A successful trip in 1832 prompted the company to utilize steamboats as a primary method of transportation up and down the river (Lecompte 1982:39). The Upper Missouri Outfit established

and managed forts along the upper Missouri, including Fort Pierre Chouteau, Fort Clark, Fort Union and Fort McKenzie (Van Sickle and Rodewald 2011:203).

In 1834, Astor sold the Western Department (including Fort Pierre Chouteau) to Pierre Chouteau Jr., Bernard Pratte and J.P. Cabanné (as part of Pratte, Chouteau and Company), and the Northern Department (which managed the area around the Great Lakes) to Ramsey Crooks, both of whom were active managers within the company (Dolin 2010:280). Confusingly, both new companies still were referred to as the American Fur Company, although Chouteau's company was officially named Pratte, Chouteau and Company (Lecompte 1982:42). Competition from other companies proved to be difficult for Chouteau, resulting in reorganization of the company and the departure of many prominent employees such as William Laidlaw.

The European fur market began to fade in 1841 by which time many Native American tribes had been decimated by smallpox reducing the number of people able to focus on trading furs with Euroamericans (Lecompte 1982:49). The decline in fur value as well as the lack of available credit also affected the fur companies. Although he remained active in the company, Chouteau slowly began retiring from the direct fur trade business allowing his son, Charles Pierre Chouteau, to fully take over the company in 1850. In 1855, the company sold Fort Pierre Chouteau to the U.S. Military and focused on the Upper Missouri fur trade (Athearn 1967:36; Lecompte 1982:52).

II. CHAPTER 2: BACKGROUND

A. Location and Basic Geology

Fort Pierre Chouteau is located on the west bank of the Missouri River, about three kilometers northwest of Pierre, the South Dakota state capitol (Figure 2). The small town of Fort Pierre, two kilometers to the south, takes its name from the Fort. The Fort sits on the first terrace above the river, with the present active river channel located 0.5 kilometers to the east, making it susceptible to periodic flooding by the Missouri River (Figure 3). Hills are located approximately 1.5 kilometers to the west. Farmland and pasture make up fields immediately to the north, west, and between the site and the river to the east. To the south is a small housing development and golf course, along with additional fields. Houses are located along the western shore of the Missouri River in the floodplain.

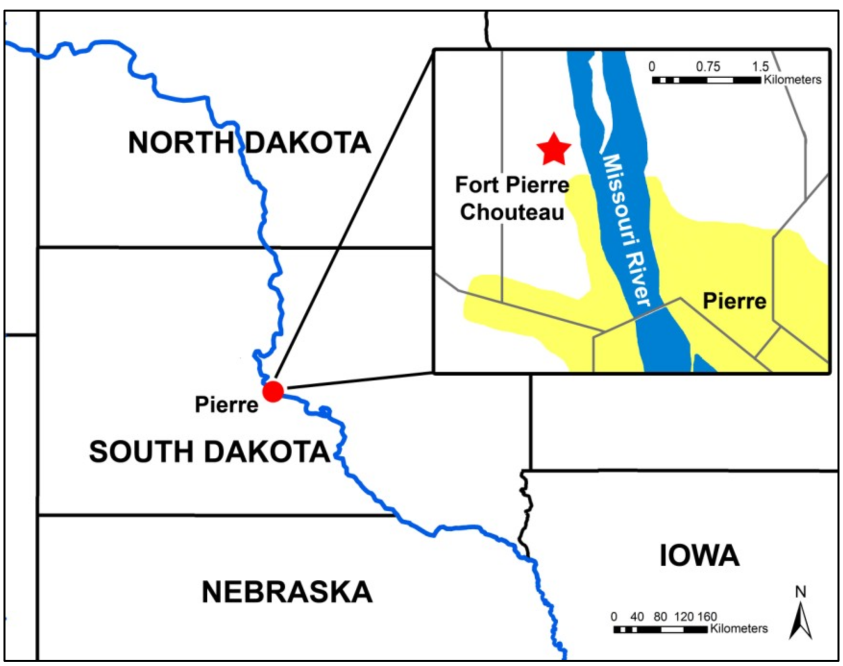

Figure 2: Location of Fort Pierre Chouteau.

Figure 3: Google Earth Image of Fort Pierre Chouteau. The location of the Fort is marked by the red rectangle. (Google Earth 2013).

Fort Pierre Chouteau falls within the area classified as Pierre Hills, within the Missouri Plateau (Flint 1955:5). The hills are composed of Pierre Formation shale, which weathers to clay (Flint 1955:16; Rothrock 1943:47). The area was glaciated during the Pleistocene and since that time the formation of the Missouri River trench has cut terraces through the glacial deposits down into the Pierre Formation (Flint 1955). Soils in the immediate vicinity include silty clay loam, Promise Clay, Bullcreek Clay, and Wendte Clay (USDA 2013).

B. Fort Pierre Chouteau: Fur Trading Period, 1832 – 1855

Establishment

Fur trading forts could be temporary or more permanent structures as needed by the nature of the trade and many forts abandoned by one company were reopened and renamed by another

company (Chittenden 1935:45). Hundreds of trading forts were established, with varying degrees to a complete absence of fortification. Simple trader's cabins, as well as large multi-building constructions with palisade walls, were called forts (Grant 1965:12).

The earliest fur trading fort established along the Middle Missouri was Fort La Fromboise (also called Fort Teton) in 1817 (Grant 1965:202). In 1822 the Fort was rebuilt by the Columbia Fur Company at a new location just south of the later Fort Pierre Chouteau and renamed Fort Tecumseh (Schuler 1990:9; Grant 1965:202). The American Fur Company purchased Fort Tecumseh in 1827 during its takeover of the Columbia Fur Company and the Fort served as a small regional center for the fur trade (Shuler 1990:13; Lecompte 1982:36). Pierre Chouteau Jr. decided to found a new post to replace Fort Tecumseh but at a location less susceptible to flooding from the Missouri River (Athearn 1967:23; Schuler 1990:11,14,29). In 1832 the new fort named Fort Pierre Chouteau was founded on a terrace about two miles north of Fort Tecumseh to serve as the headquarters of the American Fur Company on the Missouri River (Athearn 1967:23). The location allowed the American Fur Company to network its nearby trading posts (smaller 'forts' although many were unfortified) and nearby seasonal trading camps with Fort Pierre Chouteau serving as a regional hub for the collection of furs and the distribution of trade goods (Schuler 1990:42). Other fur trading forts on the Plains that served similar functions included Fort Vermillion at the mouth of the Vermillion River, Fort Lisa near present day Omaha, Nebraska, Fort Union at the mouth of the Yellowstone River, and Fort Clark in present day North Dakota (Grant 1965:191-204).

Descriptions

Fort Pierre Chouteau followed a standard pattern for American Fur Company forts. Chittenden describes the general layout of a company fort:

> "The ground plan of the typical trading post was always a rectangle, sometimes square, but generally a little longer in one direction than the other. The sides varied in length from one to four hundred feet depending upon the magnitude of the trade which the post must accommodate. In order to ensure the necessary protection the fort was enclosed with strong walls of wood or adobe. There were a few posts built of adobe, but these were the exception. The typical fort was protected by wooden palisades or pickets varying from twelve to eighteen feet high and from four to eight inches thick….The main reliance for defense consisted of two bastions, or blockhouses, as they were commonly called, placed at diagonally opposite corners of the fort" (Chittenden 1935:46).

Fort Pierre Chouteau's palisade was constructed of cottonwood log pickets surrounding about twenty buildings. Wood was mainly transported from an island upriver called the Navy Yard, but other sources included Farm Island and Cedar Island (Athearn 1967:23; Schuler 1990:33). Parts of Fort Tecumseh were dismantled and transported to the site of the new Fort. Initial construction began on January 31, 1832 but the Fort was not complete until 1833 (Schuler 1990:34). Individual buildings were arranged within the Fort based on the needs of employees and visitors. Wishart (1992:88) indicates that building locations were directly connected to the status of the individuals at the Fort.

One of the earliest descriptions of Fort Pierre Chouteau and its layout comes from Prince Maximilian of Wied, who visited the Fort on his journey up the Missouri River, accompanied by Swiss artist Karl Bodmer. After meeting in St. Louis with Pierre Chouteau Jr., of the American Fur Company, Maximilian joined a steamboat traveling up the Missouri on a trip to provision fur trading posts. Frequent stops for supplies and business allowed Maximilian and his companions ample opportunities to explore, gather plant and animal specimens, and purchase (or steal) Native

American items. When the company arrived at Fort Pierre Chouteau, they spent six days there (May 31, 1833 to June 5, 1833) before moving up the Missouri River (Witte and Gallagher 2008). Maximilian kept detailed journals of his travels, including descriptions of Fort Pierre Chouteau. Bodmer completed several paintings and sketches, including a view of Fort Pierre Chouteau looking from the hills back east toward the Missouri (Figure 4).

Figure 4: Fort Pierre on the Missouri by Karl Bodmer, 1832. (After Karl Bodmer (Swiss, 1809-1893), Frédéric Salathé, engraver, *Fort Pierre on the Missouri,* aquatint, etching, engraving, and roulette on paper, Joselyn Art Museum, Omaha, Nebraska, Gift of the Enron Art Foundation, 1986.49.517.10). Used with permission.

Maximilian spent two years exploring North America before returning to Germany and publishing accounts of his journey with illustrations created by Bodmer. Three published versions

were produced, one in German: *Reise in das innere Nord-America in den Jahren 1832 bis 1834*, one in French: *Voyage dans l'intérieur de L'Amerique du Nord, execute pendant les années 1832, 1833 et 1834*, and an abridged English version: *Travels in the Interior of North America, 1832-1834*. An English version has recently been published containing the entirety of Maximilian's journal entries (Witte and Gallagher 2008, 2010, and 2012). Witte and Gallagher indicate that the location of Maximilian's original field notes is unknown (2008:xxviii).

One of the descriptions of Fort Pierre Chouteau is from a translation from a set of manuscript journals Maximilian created later, likely after his return to Germany. *The North American Journals of Prince Maximilian of Wied, Volumes 1, 2, and 3* are based on these journals. These journals, called *Tagebuch* by Maximilian, contain references to events that occur prior to certain dates, indicating they were written at a later time. Witte and Gallagher describe the *Tagebuch* as "a compilation of notes and data prepared sometime following the fieldwork, perhaps in Europe" (2008:xxviii). Maximilian writes:

> "31 May…I visited the fort and their [tipis]. This fort measures [-----] paces in a square around its outer plank enclosure and is built entirely of wood, which had to be brought from 40 to 60 miles downriver, since little timber grows in the vicinity. On the inside the buildings are arranged in a square, and in the western corner there is a blockhouse with firing slits and two tiers that commands two sides. On the diagonally opposite corner, a similar structure is being built. On the lower level, preparations have been made for two cannon; in the second level, for musket fire; and on the roof, next to the flag, there is a gallery from which one can survey the whole region. Mr. Laidlaw's house has [only] one storey but is well built, paneled inside, and very comfortable. In the lower room of the blockhouse, some of the merchandise and baggage that Mr. Fontenelle's people were to take along was on hand. There was small shot in packs of 60 pounds each, tobacco, powder, and various other articles. One [employee] was just driving the horses in, of which the company owns more than two hundred" (Prince Maximilian of Wied in Witte and Gallagher 2008:155).

An alternative description of Fort Pierre Chouteau by Maximilian appears in Thwaites' *Early Western Travels*, which reprints the original abridged English version. This description

includes the Fort dimensions missing from the *Tagebuch*, along with different details.

> "Fort Pierre is one of the most considerable settlements of the Fur Company on the Missouri, and forms a large quadrangle, surrounded by high pickets, round which the buildings stood in a manner already described. At the north-east and south-west corners there are blockhouses, with embrasures, f, f, [*letter references are to Figure 5 below*] the fire of which commands the curtain; the upper story is adapted for small arms, and the lower for some cannon, each side of the quadrangle is 108 paces in length; the front and back, g, g, each 114 paces; the inner space eighty-seven paces in diameter. From the roof of the blockhouses, which is surrounded with a gallery, there is a fine prospect over the prairie; and there is a flag-staff on the roof on which the colours are hoisted. The timber for this fort was felled from forty to sixty miles up the river, and floated down, because none fit for the purpose was to be had in the neighborhood. Mr. Laidlow's dwelling house, d,d, consisted of a story only, but was very conveniently arranged, with large rooms, fire-places, and glass windows. Next this house was a smaller building e, for the office and residence of a clerk. The other clerks, the interpreters for the different Indian nations, the engages and their families, altogether above 100 persons, lived in the other buildings, a, a, a, a, opposite, in c, c, were the stores, at that time the value of 80,000 dollars; and in other rooms, the furs obtained from the Indians by barter. The Fort has two large doors, g, g, Opposite each other, which are shut in the evening; in b there was an enclosed piece of garden ground. The situation of the settlement is agreeable; the verdant prairie is very extensive, animated by herds of cattle and horses, of the latter, Fort Pierre possessed 150, and of the former, 36, which afforded a sufficient supply of milk and fresh butter. Indians, on foot and on horseback were scattered over the plain, and their singular stages for the dead were in great numbers near the Fort; immediately behind which the leather tents of the Sioux Indians, of the branches of the Tetons and the Yanktons, stood, like a little village; among them the most distinguished was the tent of the old interpreter Dorion, a half Sioux, who is mentioned by many travelers, and resides here with his Indian family" (Prince Maximilian of Wied in Twaites 1906:317).

Maximilian's journal entries from his return trip downriver in April 1834 provided additional description of the environmental setting where the Fort was located and a map of the Fort's layout (Figure 5) that indicates the locations of several buildings within the Fort and the attached garden.

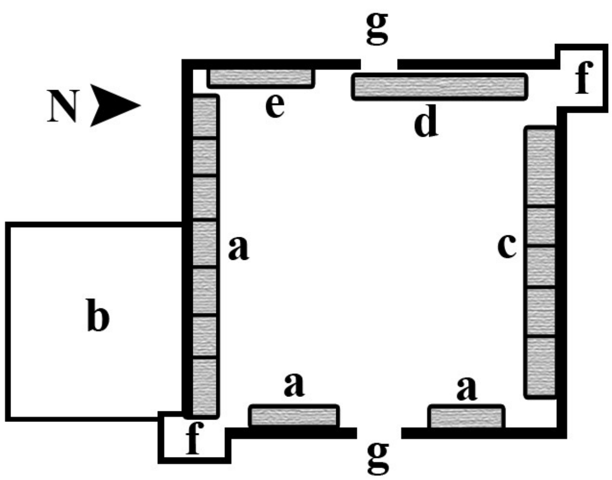

Figure 5: Maximilian's 1832 map. a: living quarters, b: garden, c: storehouses, d: manager's house, e: clerk office and residence, f: g: gates. Redrawn from Witte and Gallagher 2008 and 2010.

Many fur trading forts practiced agriculture to supplement food supplies. Buffalo meat was obtained from the Native Americans and other food was shipped up the Missouri River. Fort Pierre initially had a small fenced garden located to the south outside the palisade, but most crops were grown downriver on Farm Island. Additional supplies and luxury items were seasonally brought in by steamboat. William Laidlaw, manager of Fort Pierre, reported in 1834 that Fort Pierre Chouteau was capable of supporting itself with the harvest from the garden and preserved meat (Wishart 1992:103). The Fort also maintained a dairy herd and by 1850 kept chickens (Culbertson 1952:78).

In 1850, Thaddeus A. Culbertson visited the Fort and provides the most detailed description available, including a description of the graveyard for Fort Pierre Chouteau:

> "The main object of the view was the fort itself, having a white appearance-lying four square, surrounded by a square palisade wall 15 feet high and 500 feet on each side with bastions at the N.W. and S.E. corners; then the Indian lodges were seen around the fort, by their irregularity of position, their conical shape and varied colours giving life and a picturesque air to the scene and for a couple of miles below the fort and between it and the bluffs the whole plain was dotted with horses grazing and moving leisurely about, while the bold bluffs, a mile west of the fort afforded a fine background for the picture. The

shores immediately opposite the fort are high bluffs almost from the waters edge, and with their steep barren, sandy sides look as if determined to wrap themselves up forever in the dignity of their own sterility. The main channel runs along this shore although at present there is a probability that the boat will be able to land at the fort. The fort is situated on a beautiful piece of bottom land which extends for some miles along the bank of the river and is skirted by a range of bluff hills on the west by which you rise to the rolling prairie beyond. This bottom land affords fine pasture and has a beautiful appearance when the grass and flowers are out on in, but the company pastures their horses on the Bad River about 8 miles from the fort, as the Indians always have so many horses here. But let me know introduce you to the inside of the fort; you perceive their are two large gates over each of which there is a large picture intended to represent scenes of interest to the Indian; we will enter by the one to your left, as the other leads to the stable yard and we will choose a dry day for our vista as on any other our shoes will suffer very much from the mud. A number of Indians, men & women, with their robes or blankets wrapped around them, their bare legs, painted faces and curiously ornamented heads will probably be lounging in perfect listlessness about the gate, but don't be afraid, they wont hurt you. The main building that you see opposite the gate and occupying nearly the whole length of that side, with a porch along its whole front, windows in the roof and a bell on top and above it the old weather cock, looking for all the world like a Dutch tavern-that is the main building containing the mess hall, kitchen and rooms for the traders; to the right of it you see a neat log house with a pleasant little portico in front and five [fine?] oil painted blinds-that is the boujier or boss' house, and the long one storied building painted red and occupying almost the whole of the north side of the fort is the store and warehouse where the goods and robes are kept. To your immediate right as you enter the gate are the blacksmith shop and several rooms for the men and to your left is a small building containing the carpenter shop and a room for the men; nearly the whole south side is occupied by a low building divided into seven rooms occupied by the laborers and traders. These low houses are covered with dirt roofs: none of the houses are built against the fort walls, but behind them is a space of about 25 feet, and this is occupied in various ways. The north side has a house for the deposite of harness and implements of labor-the powder house-milk house for they have quite a good dairy-the stable and stable yard; the south side has two large buildings for their corn, meat and skins while the S:West corner is occupied by the office, a one story building ranging with the main buildings and having behind it a house occupied by one of the clerks and a yard in which the feathered tribe live and lay eggs. This arrangement of the buildings leaves quite a large fine square in the center from the middle of which rises generally a tall flag staff, but a present there is none as the last was blown down by the wind last summer.

The Fort Pierre grave yard lies about 1/4 of a mile south of the fort; it is a square piece of ground which has been well fenced in but not ornamented in any way; it contains the bodies of a number of dead both Indians and whites; the latter are

> in the ground and their graves are marked with wooden crosses or with tombstones, recording their names, & dates of their death. The Indians however have followed their own customs in disposing of the dead, which is to place them on a scaffold about 8 or 10 feet from the ground" (Culbertson 1952:75-77).

Culbertson provides the only known description of Fort Pierre Chouteau as well as the Middle Missouri from 1850 (McDermott 1952:7). Culbertson arrived at the Fort May 4, 1850, stayed for several days, then continued up the river. He returned to Fort Pierre Chouteau on May 18th and stayed until June 5, 1850 (Culbertson 1952).

Sale to the United States Military

With the decline in the fur market, the American Fur Company decided to sell Fort Pierre Chouteau. The Fort was sold to the U.S. Military on April 14, 1855 for $45,000, with the American Fur Company promising to repair buildings not in good condition at the time of the sale (Frazer 1965:136; De Land 1902:350). Prior to the sale, the American Fur Company sent the U.S. Military a painting by Frederick Behman detailing the layout of the Fort (Figure 6). The purchase of Fort Pierre Chouteau created the first military Fort in the Middle Missouri region (Kapler 1990:2). The Fort did not quite meet the rosy picture presented to the U.S. Government in Behamn's watercolor. Fort Pierre Chouteau was in extremely poor condition and was too small for the four companies of dragoons and ten companies of infantry expected to winter at the Fort (Athearn 1990:40). The military shipped additional housing to increase living space and attempted to negotiate with the American Fur Company for a discounted price due to the Fort's poor condition.

Figure 6: View of Fort Pierre, Dakota Territory, 1855 by Frederick Behman. Watercolor given to the War Department. (Records of the Office of the Quartermaster General, RG 92, courtesy National Archives).

C. United States Military Policy and the Sioux

The U.S. Military was the federal government's enforcement agency for Indian policy on the frontier, protecting Euroamerican settlements and opening Native American land to new settlement while enforcing treaties between the tribes and the U.S. Government (Ball, 1960:13). The Bureau of Indian Affairs (BIA) was officially established in 1824 as part of the War Department from the earlier loosely organized departments with the goal of "civilizing" Indians and enforcing the laws of interaction with tribes (Jackson 1977:43).

The military presence on the frontier in the 1840s served as a federal police force for law enforcement, as well as enforcing the policies of the Bureau of Indian Affairs. An extension of this

duty involved retaliating against Indian tribes and enforcing U.S. sovereignty (Ball 2001). Mounted troops were the primary force employed against Native Americans while infantry maintained the forts and posts (Ball 2001:xx-xxi). Military posts were scattered throughout the West, primarily along settlement trails. Conflicts between the U.S. Army and Indians were widespread on the frontier by 1849 (Ball 2001:xxv).

The U.S. Government's decision to purchase Fort Pierre Chouteau was directly related to military operations against the Brule Sioux. The Brule had been attacking travelers along the Platte River Road and in 1854 destroyed a 29-man detachment under the command of Second Lieutenant John L. Grattan. The detachment had been ordered to arrest a Miniconjou Sioux camped with the Brule Sioux for killing a settler's cow. The incident quickly exploded when the soldiers fired into the camp and the Sioux counterattacked, killing all of the soldiers and their second lieutenant (Ball 2001:44). Colonel William A. Harney was charged with leading the so-called "Sioux Expedition" in 1855 as a retaliation against the Brule. As part of the expedition, the U.S. Military purchased Fort Pierre Chouteau to serve as a base of operations for Colonel Harney and his troops. After campaigning against the Sioux, Harney marched to Fort Pierre Chouteau for the winter. The condition of the Fort was not what Harney expected: buildings were in poor condition, supplies of timber and animal fodder were insufficient, and the Fort was not large enough to contain all the troops.

D. Fort Pierre Chouteau: Military Occupation, 1855-1856

Construction and Layout

The War Department did not permit construction of permanent buildings from stone or brick at posts designated as temporary, relegating soldiers and officers to live in standard-issue

canvas tents (Nowak 2002:97). The commanding officer was responsible for determining the fort layout and forts tended to follow a standard plan with officers quarters and barracks for enlisted men surrounding a central parade ground, while additional buildings were built off to the side (Hoagland 1999). Resident soldiers constructed most western military posts out of locally available materials in the mid 1800s as the Army did not use civilian contractors until the standardization of fort architecture (Hoagland 1998). Forts built on the Great Plains quickly depleted nearby wood supplies for both construction and fuel. In 1849, troops at Fort Laramie (another former fur trading fort purchased by the U.S. military) had to travel 12 miles to gather timber. By 1851, the nearest timber was 25 miles away, and the constant demand for fuel resulted in the nearest timber being 45 miles away by 1864 (Hoagland 1998:300). The lack of available fuel was a constant problem for many forts, including Fort Pierre Chouteau.

Major Albermarle Cady, 6th U.S. Infantry occupied Fort Pierre Chouteau in June 1855 to prepare for the arrival of Colonel Harney's troops. Second Lieutenant Gouverneur K. Warren drafted maps of the Fort in July 1855. Assistant Quartermaster Captain Parmenus T. Turnley included a tracing of Warren's map with labeled buildings as part of an official military inventory (Figure 7) (Nowak 1998:5). The Fort's poor condition caused much discussion between the U.S. Army and the American Fur Company, with the army demanding a discount of $22,000 in order to cover repairs. An army property memo referenced by Charles De Land (1902:349) lists the Fort's buildings and the cost of repair, totaling $19,420. Necessary repairs included new roofs and the shoring up of collapsing walls and buildings. Multiple buildings were described as "worthless" and one as "now falling down, eminently dangerous to inhabit" (De Land 1902:348). The American Fur Company representative Charles Galpin responded to the military's complaint by commenting "certainly the Government did not mean to purchase a new fort" (Athearn 1967:42).

After attempting to negotiate with the American Fur Company, the army finally paid the full price of $45,000 (Schuler 1990:134).

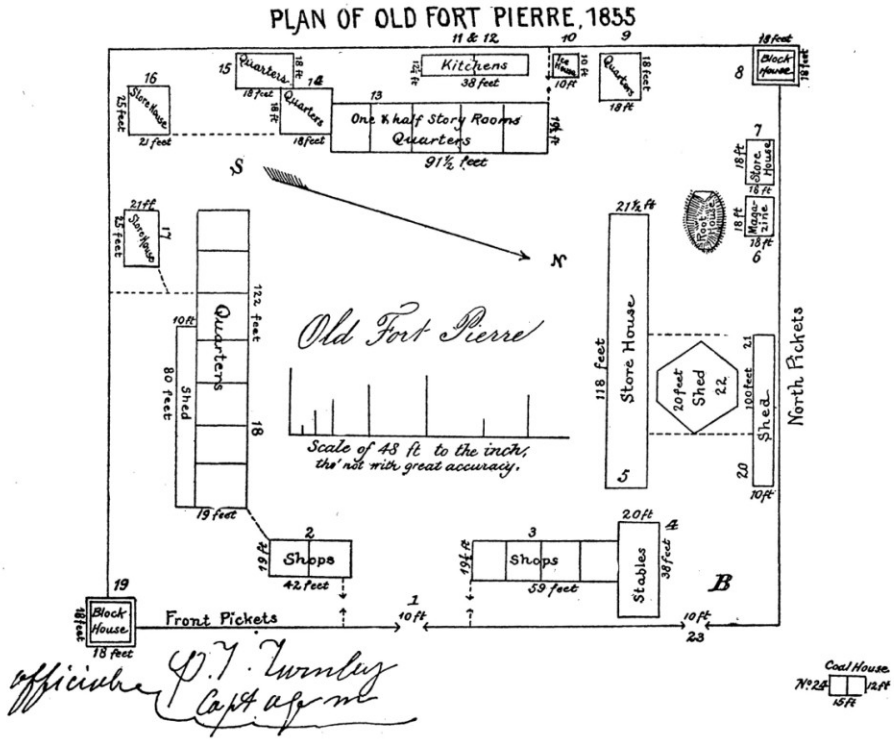

Figure 7: 1855 Military Inventory Map by Captain Parmenus T. Turnley. (From Wilson 1902).

A map, marked as "Traced from Plan Drawn by G.K. Warren Lt. Topg. Engrs," details the proposed layout of the military Fort Pierre Chouteau with the locations of portable housing, the sutler's store, hospital, and parade ground (National Archives, Record Group 92, Consolidated File Fort Pierre). This map is included as Figure 8. Officer's quarters are located to the far west of the parade ground, and also to the north and south. Enlisted men's barracks were located much closer to the main Fort, along with the hospital. Descriptions recorded by De Land (1902) from the army property memo provide details on the construction and condition of the buildings in 1855. Most of the buildings were of wood construction with mud roofs, while others had shingle roofs

and possibly shingle siding. Specific places of interest are the powder magazine (Figure 7, Number 6) and a house (Figure 7, Number 13), both described as being constructed out of adobe, with additional detail describing the powder magazine as being "covered with metal" (De Land 1902:349). Information regarding use of the buildings is also included, such as the stables, blacksmith, tin, carpenter, and saddler's shops, the saw mill, kitchens, storehouses, and a shed for horses working in the sawmill. A description of each building in reference to Turnley's inventory map is included in Appendix A.

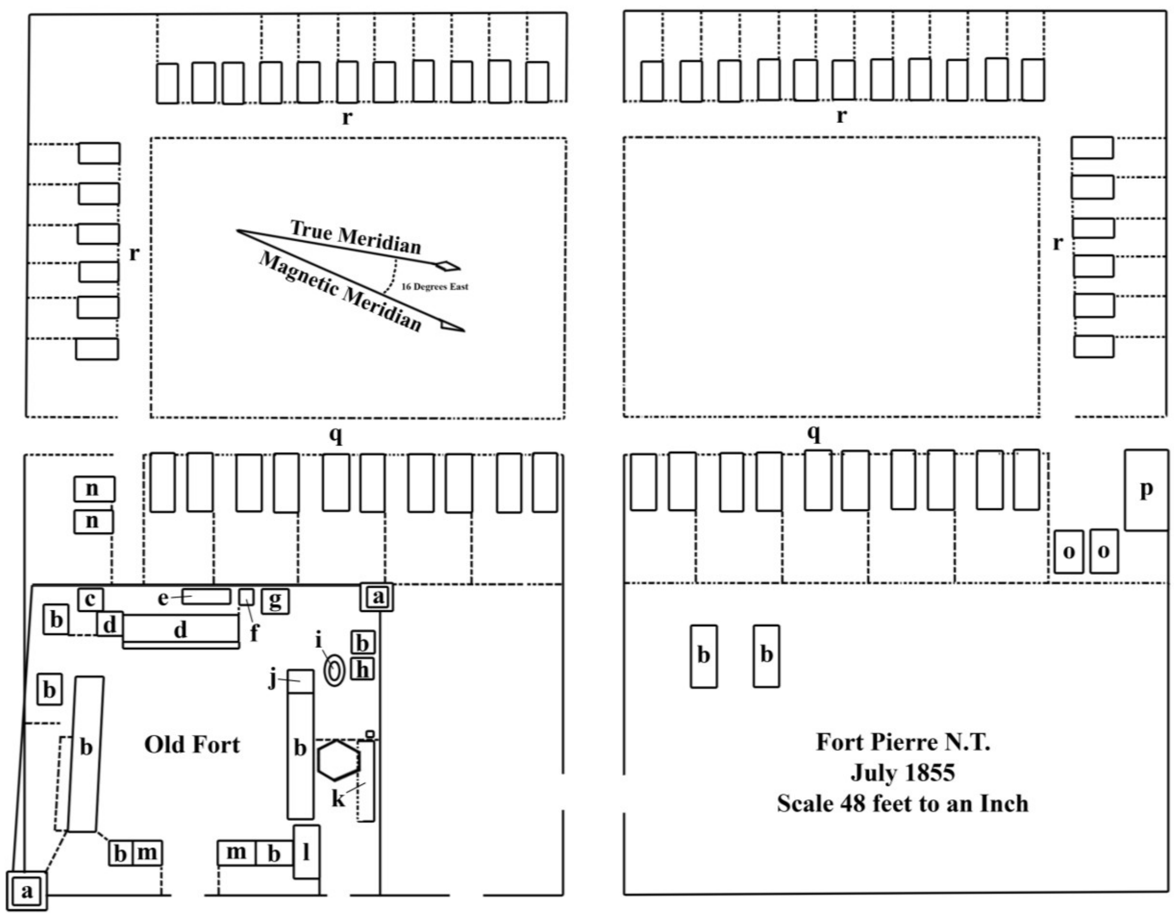

Figure 8: Tracing of G.K. Warren's Military Plan map. Redrawn from map in National Archives, Record Group 92, Consolidated File Fort Pierre. a – Blockhouse/commissary stores, b – Commissary stores, c – Office, d – Quarters, e – Kitchens, f – Ice House, g – Quarters, h – Magazine, i – Root House, j – Commissary Office, k – Shed, l – Stables, m – Shops, n – Hospital, o – Bake Houses, p – Sutler's Store, q – Line of Soldiers Quarters, r – Line of Officer's Quarters.

At the time of purchase, the military knew that Fort Pierre Chouteau was too small to house the number of soldiers expected to be stationed there, although the poor condition of the Fort was not expected. The Quartermaster's Department planned to ship newly-designed portable housing to the Fort to solve the housing issue. These buildings, named "portable cottage"' by their designer, would be placed outside the palisade to create the military outpost. However, the number of portable cottages recorded as shipped to the Fort is less than the number of cottages depicted on the map (Figure 8), indicating that this map was likely an early planning document that does not depict final building locations.

Portable Cottages

The move to standardize the design of fort buildings began in the 1840s with early designs for portable buildings being submitted to the War Department by entrepreneurs. Although the U.S. Military standardized many other aspects of its operation such as uniforms, weapons and equipment, architecture was not standardized in 1855 (Hoagland 1998:298). Captain Parmenus Turnley was familiar with the disadvantages of frontier living in military posts and designed two sizes of portable cottages he deemed suitable for use as barracks, officer's quarters, and storage rooms. He was able to convince the military of their potential use at frontier forts (Nowak 2002:97).

Turnley's designs were identical in construction and materials, differing only in size. Cottages designed for officer's quarters were 30 feet by 15 feet (9.1 meters by 4.6 meters) with a movable partition, while the Barracks cottages were 40 feet by 18 feet (12.2 meters by 5.5 meters) (Turnley 1892:128). Both buildings were constructed of 10 inch (25 cm) wide pine boards sitting in grooved sills. Grooved stanchions were placed between the pine boards to lock them in place

and support the roof and the stanchions were anchored to the sill with iron screw bolts. An upper wall plate sat on top of the pine boards and stanchions. Doors and windows were pre-assembled, and could be placed at any point along the walls (Turnley 1892:128). Floor joists fit into notches on the sills and were placed 22 1/2 inches (57 centimeters) apart and covered with floorboard sections. The entire cottage was supported by wooden posts 2 feet (61 cm) above the ground (South Dakota Historical Collections 1920:135).

Corner posts supported rafters placed approximately one meter apart and were covered with pine batten boards. The rafters interlocked with the upper wall plates, while the pine batten board roof sections were dovetailed together (Nowak 2002:100). Asphalt roofing paper covered the batten boards, and was then painted and coated with sand. Each barracks cottage had heat provided by two sheet iron stoves. The interior and exteriors were painted red. According to Turnley, three men could assemble a cottage in four hours (Turnley 1892:128).

Turnley wrote that he designed the cottages for use in Texas, yet in March 1855 received notice from the military that the cottages would be shipped to Nebraska Territory (Turnley 1892). A total of thirty-seven cottages were listed in use at Fort Pierre Chouteau in 1856, but additional cottages may have been initially shipped. The cottages and other military supplies were loaded onto three steamboats for shipment up the Missouri, yet not all of the steamboats made it to the Fort. The steamboat *Australia* hit a snag on the river and sank while transporting soldiers and supplies, causing the loss of much of the cargo (Meyers 1914:56). It is not clear if any of the cottages were loaded on the *Australia,* but it is likely that the cottages were divided between three steamboats as they were present on the other two steamboats.

Augustus Meyers, a thirteen-year-old army musician, was sent with the Second Infantry, U.S. Army, to Fort Pierre Chouteau shortly after it was purchased by the U.S. Military (Meyers

1914:49; South Dakota Historical Collections 1920:132). Meyers provides a description of Fort Pierre Chouteau and of living in the portable cottages that had been assembled under the direction of Captain Turnley (Turnley 1892:148). Meyer's describes the layout of the military Fort:

> "These houses were placed a short distance behind the stockade, around three sides of a large parallelogram, forming the parade ground-officers' houses on one side, company quarters opposite and other houses on one end. The necessary storehouses were erected on the river front" (Meyers 1914:72).

Captain Alfred Sully created watercolors of the military Fort in 1856, depicting the red portable cottages to the west of the Fort at approximately the same locations that Meyers describes (Figure 9 and Figure 10).

Figure 9: Inside of Fort Pierre Nebraska Territory, Now Dakota, 1856 by Alfred Sully. (Watercolor, courtesy Gilcrease Museum, Tulsa, Oklahoma. Accession Number 0226.1332). Used with permission.

Meyers also provides a description of the military cottages the soldiers stayed in for the

first part of the winter:

> "They were single-story affairs with but one room and of the flimsiest wood construction. The sills and floor beams were entirely too light for the live weight to be carried, the upright studding was about three by two inches, grooved on two sides to receive panels made of three-quarter inch boards, which was all the protection there was against the intense winter cold of that latitude. There was no interior finish of any kind. The roof was of thin boards covered with tarred paper and had a low pitch from a ridge to the sides. The houses were set on wooden posts about two feet above the ground.
>
> Each house was furnished with two sheet iron stoves for burning wood and had stove pipes passing through the roof. The officers' houses were the same, except that they were smaller and were divided into two rooms by a thin board partition. These houses were very easily set up. There was but little work on them except driving nails. They had been previously painted a dark red color, both inside and out. Whoever designed these cardboard houses — for they proved to be but little better — had but a small conception of the requirements of that climate. The winters were long, with deep snow and frequent blizzards. The architect of these shelters was indirectly the cause of much suffering. We built log huts for company kitchens, but we had no mess-rooms" (Meyers 1914:72-73).

Each barracks cottage held thirty men, yet the design was too light for the weight of the occupants and of the building itself, causing the floor beams to sag. The lack of insulation and finishing made the buildings poorly suited for the harsh Plains winter. Even with the portable cottages, there was not enough room for all the soldiers when General Harney arrived with the rest of the troops in November. Several companies were immediately placed in small military camps (cantonments) about six miles upriver, where they built log cabins for shelter (Meyers 1914:75).

The portable cottages were not the only new constructions in 1855, nor were they the only portable buildings. The sutler (a civilian supply merchant) brought his own portable buildings to Fort Pierre Chouteau to use as his home and as a storehouse. Turnley describes the two sutler's buildings as "a frame storehouse about 45x20 feet [13 by 6 m], one story, made in St. Louis, also a small dwelling with two stories for his family, consisting of wife and infant son" (Turnley 1892:159). The exact locations of the sutler's buildings are not clear. Sully's 1856 watercolor

"Inside Pierre" (Figure 9) depicts a two story building to the west of the Fort which is likely the sutler's house as no other two story buildings are described outside the palisade and all the portable cottages were single story. The other Sully watercolor (Figure 10) depicts two buildings between the Fort itself and the cottages. One of these buildings could be the sutler's store and storehouse. The 1855 planning map (Figure 8) places the sutler's store to the north, with no indication of the location of the sutler's house.

Figure 10: Fort Pierre Looking South, 1856 by Alfred Sully. (Watercolor, courtesy Gilcrease Museum, Tulsa, Oklahoma. Accession Number 0226.1337). Used with permission.

Winter of 1855-1856

The winter of 1855-1856 was particularly harsh for the U.S. Army at Fort Pierre Chouteau. In November, cold weather set in freezing the Missouri by the end of the month (Meyers 1914:90).

The insides of the portable cottages became covered in frost and cold air seeped up through the floors because the elevated cottages allowed winter winds to blow underneath. The soldiers dug trenches and heaped earth against the sides of the buildings to block the airflow (Meyers 1914:90). Embankments are visible against buildings in the right of one of Sully's 1856 images of Fort Pierre (Figure 10).

A severe storm in late November destroyed several cottages and damaged many others. A few of the remaining cottages were repaired, but several companies, including Meyers', were sent into cantonments elsewhere on the river (Meyers 1914:91). Meyers describes a difficult winter, where the extremely cold temperatures and lack of food resulted in deaths of several of the men at the main Fort as well as at the cantonments. Meyers summed up his experiences at Fort Pierre Chouteau: "I look back on the winter passed at Fort Pierre as one of great suffering and hardship, by far the worst that I went though during my service" (Meyers 1914:107).

Abandonment

The U.S. Military ordered the abandonment of Fort Pierre Chouteau in June 1856 (South Dakota Historical Collections 1920:169). Meyers attributes the harsh November storm and the necessity of dispersing troops to cantonments as part of the decision to abandon Fort Pierre. The lack of firewood, remote location, and consistent severe winters were also contributing factors (Meyers 1920:155; Frazer 1965:136). Building materials and supplies were transferred to the newly-designated Fort Lookout (near present day Chamberlain, South Dakota) and the remaining cottages were there and reassembled as officers' quarters. Fort Pierre Chouteau was officially abandoned on May 16, 1857 with the transfer of the remaining personnel, yet the military continued to transfer buildings and materials from the site until at least late 1859 (Schuler

1990:136; Wilson 1899:254). In September 1859, Captain W. F. Reynolds of the Engineers described the remains of Fort Pierre as little more than a row of houses, which was being dismantled for transfer to Fort Randall (on the Missouri River near the South Dakota and Nebraska border) (Wilson 1899:254).

E. Post-Fort Ranching Period, 1868 – 1991

The site of Fort Pierre Chouteau was included in the Treaty of Laramie which transferred land to the Sioux in 1868 (Schell 1961:88-89; Kapler 1990:20). However, Euroamericans had established a community south of the site, and named it Fort Pierre (Ruple 1986:19). In 1899, the Sioux Reservation was reduced, officially opening approximately 9,000,000 acres (3.6 million hectares) to white homesteaders, including land in and around the site of Fort Pierre Chouteau (Schell 1961:247). A Scottish immigrant named James "Scotty" Philip lived with his family at the site of the Fort for a period of time while running a ranch, and filed a homestead claim about 1903 (Philips 1935:28-29,33). Later, the family moved to a location northwest of the Fort. After Phillip's death in 1911, the land had multiple owners until it was given to the State of South Dakota in 1930 (Ruple 1986:20). It appears that the site was never plowed and was simply used as pasture until its donation to the State (Kapler 1990:21). In 1930, a depression marking the palisade line was still visible and two corners were marked with metal stakes (Ruple 1986:20). The same year, a stone monument was installed near the Fort's west palisade wall. In 1967, a pipeline easement was granted to Ole Williamson and a pipeline was constructed through the Fort connecting a barn to the west and a pump on the shore of the Missouri River (Kvamme 2008:27). Additional land around the site was donated to the state in 1970 by Ole Williamson (Ruple 1986:20; Kapler 1990:21).

National Historic Register Status

On July 17, 1991, the Fort Pierre Chouteau site was placed on the National Historic Register, Number 76001756 (Bell 2003). The site was described as significant to the expansion of the frontier, particularly on the Great Plains, due to its history as a trading post that formed the central hub of American Fur Company operations and its history as a military outpost. The interactions between Native Americans, Europeans, and Euroamericans at the Fort were influential in shaping the relationships between people on the Plains during the 19th century.

Figure 11: Fort Pierre Chouteau in 2012, looking north. The tree is located at the approximate center of the Fort's interior open area. Photo taken by author.

In 2012, no traces of Fort Pierre Chouteau are visible on the surface except for two small depressions. The stone monument installed in 1930 marks the end of a gravel path leading from the edge of the site. Interpretive signs have been installed detailing some of the Fort's history. The Missouri River is now located almost 0.5 kilometers to the east, creating a bottom land below the

terrace which is currently under cultivation. Westward erosion of the terrace edge continues and has already damaged portions of the Fort's eastern edge. To the south, a housing development and golf course have been built, possibly destroying any evidence of the Fort's small cemetery. The site itself is protected by a fence, and the public is allowed access. A large sign stands at the entrance to the site marking the site as a National Historic Landmark.

Figure 12: Walkway to monument with interpretive signs. View is to the northeast. Photo taken by author.

Figure 13: Monument installed circa 1930. View is to the northeast. The tree is approximately in the center of the Fort. Photo taken by author.

Figure 14: Terrace edge eroding into the Fort. View is to the north. The terrace drop off in the right of the image is only 1-2 meters in places. Photo taken by author.

III. CHAPTER 3: METHODS

A. Methods

Geophysical techniques allow the examination of archaeological sites without disturbing the soil. All methods depend on the existence of a measureable difference in the physical properties between the archaeological remains and the surrounding soil in order for cultural features to be visible as anomalies in the data. Pattern identification is a crucial tool in interpreting geophysical anomalies as straight lines, circles, and right angles do not usually occur as a result of natural processes and when present, indicate evidence of possible human activity. Patterns between different anomalies are also important – combinations of specific anomaly shapes or intensities can also indicate evidence of human activity. Active and passive methods are used in this study: aerial photography and magnetometry are passive methods as they do not transmit a physical signal and only record existing characteristics, while electrical resistance, conductivity, and magnetic susceptibility are active methods which require the application of an external energy source to create the measurements.

Aerial Photography

The use of aerial photography in archaeology dates back to the early 1900s, initially as simply a method of documenting known archaeological sites (Giardino and Haley, 2006:48; Conant, 1990:358; Kvamme, 2005:446). In the 1920s aerial photography began to be used for identifying vegetation changes and shadow marks influenced by archaeological sites (Riley, 1987:11). Generally, subtle changes in otherwise uniform vegetation are good indicators of potential archaeological features (Johnson, 2006:311). Positive and negative crop marks (abrupt

changes in vegetation) reveal indications of subsurface remains such as walls, roads, and foundations. Natural features and recent man-made landscape changes can be misinterpreted as archaeological indications. Paleochannels, geology, and modern constructions can be visible in aerial photography either as different vegetation, shadow marks, or soil marks. Vegetation changes are highly dependent on soil moisture which can vary seasonally and from year to year (Giardino and Haley, 2006:60). Soil chemistry affected by buried archaeological features can also cause variations in vegetation between areas with and without buried features. Potential archaeological features are identified by regular shapes such as circles and right angles. High image resolutions are necessary to see specific site details as low resolutions do not include enough detail.

Magnetometry

Magnetometry has been used in archaeology since the 1950s (Gaffney, 2011:61). The technique's ability to detect various indications of human activity such as burnt areas, construction, and metal artifacts, makes it a useful tool for identifying areas of human occupation. Magnetometers measure the strength of a magnetic field by comparing its strength at a specific location to the strength of the field at another location, then correcting for the Earth's magnetic field (Kvamme 2006:210). There must be sufficient magnetic contrast between materials in order for archaeological features to be detected (Gaffney, 2011:34; Kvamme, 2006:221).

Types of magnetism include remnant and induced magnetism. Both are measured by magnetometry as the instrument records the total amount of magnetism at a specific location. Remnant magnetism is the magnetism of a material in the absence of a magnetic field, while induced magnetism is magnetism that only exists in the presence of a magnetic field (Kvamme 2006:208). Magnetic susceptibility can detect the ability of a material to be magnetized and will be

discussed below.

Excavations that create ditches and pits can be detectable using magnetometry if filled with a magnetically contrasting soil. Wooden structures generally do not directly leave magnetic indications, although the accumulation of magnetically enriched top soil at the base of walls can leave magnetic traces defining these structures. Human activity such as fires, the removal and addition of soil through construction, and metal artifacts create anomalies in the magnetometry data giving indications of activity areas and site use (Kvamme 2006; Gaffney 2011:37).

Electrical Resistance

Electrical resistance, first used on an archaeological site in 1946, is now becoming a commonly used technique on archaeological sites (Clark 2006:11; Gaffney 2011:16; Drahor, 2008:160). Electrical resistance is the ability to pass an electrical current through a material, and is therefore a measureable physical property.

Soil resistance is highly dependent on the amount of moisture in the ground at the time of measurement, along with the degree of compaction of soil grains (Clark 2006:48; Burger et al. 2006:505). Poorly compacted soils have more space between grains promoting a better flow of ions within fluids (Burger et al. 2006:505). Clays are particularly conductive. Overall, the ability to detect archaeological features is variable depending on the soil and the moisture component at the time of survey (Drahor et al. 2008:168). Studies of specific features over several months have revealed that the ability to see anomalies in electrical resistance data is created over months of moisture, rather than moisture right before or during the survey (Clark 2006:56). Without sufficient electrical resistance differences between an archaeological feature and the surrounding soil, features can be virtually invisible whether the ground has sufficient moisture or not. Electrical

resistance can be used on sites where magnetometry is less effective due to high amounts of metallic debris, as electrical resistance measurements are not affected by the presence of metal on the surface (Somers 2006:110).

Magnetic Susceptibility

Magnetic susceptibility is the ability of a material to be magnetized by the presence of a magnetic field (Dalan 2006:162; Gaffney 2011:45). Topsoil generally has greater magnetic susceptibility than other soil layers. Human activity can enhance or reduce the topsoil's magnetism either by extended occupation which enhances soil magnetism or by construction activities which displace soils typically revealing layers below (Clark 2006:99). Metal and other highly magnetically susceptible materials become magnetized when exposed to a magnetic field, allowing detection by instruments. Fires and chemical reactions within the soil can also increase magnetic susceptibility by concentrating iron or magnetite (Dalan 2006:162-163). As with other geophysical techniques, a contrast is required between an archaeological feature and the surrounding soil for an anomaly to be generated.

Conductivity

Conductivity is the inverse of electrical resistance, and therefore is a physical property of materials – the ability of a material to conduct an electrical current. Conductivity was first used in an archaeological survey in Europe in the 1960s and in North America in the 1970s (Clay 2006:81). As an active method, an electromagnetic signal is introduced into the soil which induces electrical currents in the subsurface. The currents are measured showing soil conductivity, with the spacing between the instrument's transmitter and receiver largely determining the approximate

depth of the signal (Clay 2006:82). As with other techniques, the movement of soil by humans significantly contributes to conductivity differences between features of disturbed and undisturbed soils. Conductivity is useful for detecting earthworks, stonework, fired features, and highly-conductive metals (Clay 2006:84).

B. Data Collection

Aerial Photography

Aerial photographs and high resolution orthoimagery were downloaded from the United States Geological Survey (USGS) EarthExplorer (http://earthexplorer.usgs.gov/). Earth Explorer provides online search and download features for many map sets in addition to satellite and aerial imagery. Aerial photos used in this project are part of the single-frame records collection of the United States Government, compiled from various federal agencies. All images that covered the Fort Pierre Chouteau site were examined, with the earliest available photo on Earth Explorer dated May 1966. Photos available are May 1966, May 1973, May 1975, April 1984, July 1991, and October 1997. High resolution orthoimagery is derived from aerial photography that has been geometrically corrected to yield map characteristics and they typically have higher resolutions than older aerial photos. High resolution orthoimagery for Fort Pierre Chouteau is available for April 2005, April 2007, May 2009, and May 2012, with pixel resolution of 0.3 meters. Aerial photography was examined in Adobe Photoshop CS, while the high resolution orthoimagery was imported into ArcMap and georeferenced.

2007 Geophysical Survey

Dr. Kenneth Kvamme of the Archeo-Imaging Lab at the University of Arkansas conducted

geophysical surveys at Fort Pierre Chouteau in 2007 in order to determine the extent of the Fort and to identify a pipeline trench built through the field in 1967 (Kvamme 2008). The survey covered the main area of the Fort with magnetometry and electrical resistance, along with some magnetometry transects extended to the west of the Fort. Electromagnetic induction (magnetic susceptibility and electrical conductivity) and ground penetrating radar (GPR) surveys were also conducted in limited areas of the Fort. Ground penetrating radar is not included in this analysis due to its limited area and lack of visible anomalies in the results.

The survey grid was rotated east of magnetic and geographic north to allow the survey transects to cross possible archaeological features at a sharp angle. The grid was tied into the site datum at North 1000 East 1000, with 20 x 20 meter grid squares. Surveys were not extended to the very edge of the terrace in some places of the Fort due to erosion of the terrace edge. The extent of the 2007 survey is detailed in Figure 15. Most of the surveys utilized half-meter transects and equal interval data sampling along each transect to acquire suitable resolution to see small anomalies. Ideally, the resolution of the survey should be half the size of the smallest features of interest. Magnetometry was collected using a Bartington Grad- 601 gradiometer, at a resolution of eight readings per linear meter. Electrical resistance was collected using a TR/CIA Resistance Meter with probes set at a 0.5 m separation in a twin-probe array at a resolution of 1 reading every half meter. Magnetic susceptibility and conductivity were collected simultaneously using the Geonics EM38B at a spatial resolution of four measurements per linear meter, with half meter transects.

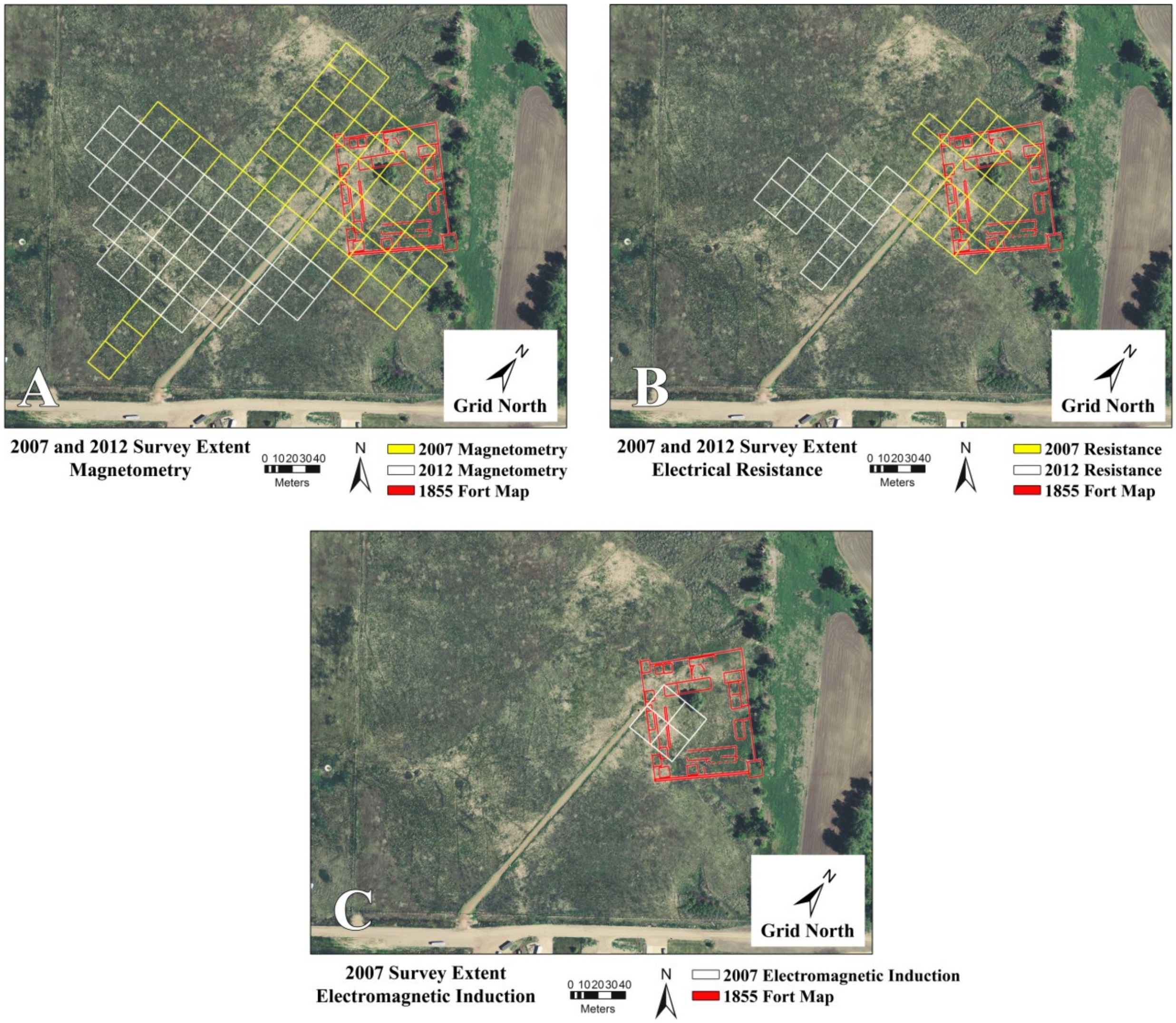

Figure 15: Extent of 2007 and 2012 surveys for A: magnetometry, B: electrical resistance, and C: electromagnetic induction.

2012 Geophysical Survey

Additional geophysical work at Fort Pierre Chouteau was completed August 6 through August 8, 2012. The fieldwork focused on expanding the area outside of the Fort covered by magnetometry and electrical resistance. The area examined is detailed by Figure 15. The 2012 survey followed the grid layout established in 2007 to connect the two data sets, and attempted to link the two grids through the datum. Unfortunately, the datum was not locatable in 2012, possibly

due to a recent layer of gravel laid down on the trail and around the stone monument at the Fort. Attempts to locate the datum with magnetic susceptibility were also unsuccessful. To place a new datum, measurements from the original datum location to two semi-permanent site features (a metal post and wooden power pole, both located inside the Fort) were used to triangulate the datum location. Estimates in the field placed the new datum approximately 1.0-1.5 meters south of the original datum location which was apparent when combining the magnetometry data from the 2007 and 2012 surveys. Several magnetometry grid blocks collected in 2007 were recollected in 2012 to aid in correcting the datum offset.

Individual grid blocks were 20 x 20 meters marked with PVC pipe or wooden stakes at the corners. Grid block corners were laid out using a transit and fiberglass surveyor's tapes. Two fiberglass tapes were laid on the Grid North and Grid South edges of the grid block, and two additional tapes were laid on each grid block two meters apart running Grid North and Grid South. Each tape had meter markings to aid in pacing during the walking of each transect. Transects were spaced at half-meter intervals for magnetometry collection, while one meter transects were used for the electrical resistance survey. Grid blocks were collected in zig-zag surveys, starting the next transect moving in the opposite direction of the previous one. Magnetometry was collected using a Bartington Grad- 601 gradiometer, at a resolution of eight readings per meter. Electrical resistance was collected using a TR/CIA Resistance Meter with probes set at a 0.5 m separation in a twin-probe array at a resolution of one reading per meter.

C. Data Processing

Data were processed using Geoplot software by Geoscan Research Ltd, followed by importing the data into ArcMap GIS software by the Environmental Systems Research Institute

(ESRI) to create maps and interpretations. The 2007 data was combined with the 2012 data and reprocessed. Issues visible in the initial magnetometry data included staggering, striping, extremely strong dipolar anomalies, and mismatching of the data grids due to the missing datum issue. Electrical resistance issues included data spikes, mismatched edges, and resolution differences between the 2007 and 2012 surveys. Magnetic susceptibility and conductivity data collected in 2007 were also reprocessed for comparison to the 2012 interpretations.

Magnetometry

Initial assembly of a composite of the 2007 and the 2012 data surveys revealed the amount of offset between the two surveys. Identical anomalies in both surveys, particularly along the edges of grid blocks, allowed the 2012 data to be shifted to fit the 2007 datum. The offset was approximately 1 meter to grid south (1.2 meters measured with the ruler tool in ArcMap). The cut and paste function in Geoplot was used to insert the 2012 survey data into the correct position in reference to the 2007 datum. The shift is visible in the gap between the edge of the magnetometry data and the grid at the southern edge of the surveys.

Magnetometry processing steps eliminated data collection errors and enhanced subtle anomalies. The magnetometry data was destriped using the “Zero Mean Traverse” tool in Geoplot. Striping occurs due to heading errors caused by switching directions during zig-zag surveys (Aspinall et al. 2008:120). Gradiometers, such as the one used in this project, are particularly susceptible to these errors. In certain grid blocks with strong dipolar anomalies, a “data bleeding” effect was created near the dipolar anomalies (Figure 16a).

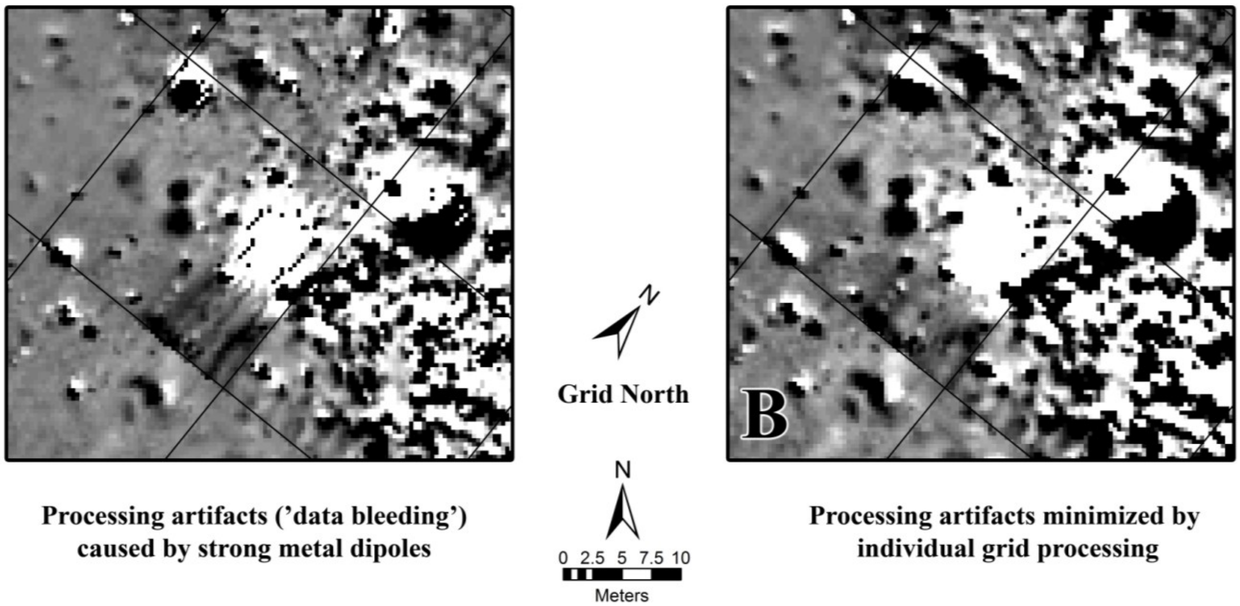

Figure 16: "Data bleeding" processing errors due to strong dipolar anomalies. A: Processing errors created by Zero Mean Traverse, B: Processing errors removed by processing individual grid blocks.

These processing artifacts were corrected by individually destriping affected grids. In some grid blocks, processing the grid block alone did not correct the processing errors. These grid blocks were corrected by removing the dipolar anomaly by overwriting the anomaly with a no data value (2047.5), applying Zero Mean Traverse, and then placing the metal-generated anomaly back in the grid block. The majority of the ‘bleeding effect’ caused by processing was correctable (Figure 16b), but a cluster of metal anomalies southwest of the Fort could not be corrected.

Staggering of data lines within a grid block is caused by the slight differences in operator pacing between lines. “Destaggering” corrects these slight offsets within a grid by shifting alternating lines until anomalies visible in consecutive lines are correctly aligned. Each magnetometry grid block was individually destaggered. Following destriping and destaggering, three consecutive 1 x 1 Gaussian low pass filters were applied to smooth out the data. The

magnetometry data was interpolated to 0.25 by 0.25 meter resolution and imported into ArcMap. The dataset was then resampled and rectified to its correct location based on site aerial photos which were rectified to UTM zone 14N for interpretation and map creation. It must be noted that this process alters anomaly representation from the original field data through resampling of the actual data values.

Electrical Resistance

The 2007 electrical resistance survey was completed at a 0.5 x 0.5 meter spatial resolution, while the 2012 survey was completed at a 1 x 1 meter spatial resolution. Due to the resolution differences each survey was processed separately in Geoplot although with identical processing steps. The surveys were then combined in ArcMap.

Instrument errors during data collection cause extremely high data values called data spikes which must be corrected before additional processing. The electrical resistance data sets were first “despiked” in Geoplot, a process for the removal of the data spikes. This process removed the majority of data spikes, but some extremely high values in the 2007 dataset were not corrected by this algorithm due to their location near the edge of the monument walkway. These data spikes were manually corrected to the average value of the surrounding electrical resistance pixels. The 2012 dataset did not have any pixels the software was not able to automatically correct.

After the data were despiked, grid blocks were “edge matched” to correct slight variations in average values between the data from grid block to grid block due to their collection at different times. A high pass filter using a 10 x 10 Gaussian matrix was applied to bring out subtle features in the data by enhancing small trends in data values. Next, three consecutive 1 x 1 Gaussian low pass filters were applied to smooth the data and to consolidate anomalies. The above steps were

separately applied to both the 2007 and 2012 resistance surveys, and both datasets were interpolated to a 0.25 by 0.25 meter resolution. After importing into ArcMap, image rectification allowed the 2012 survey to be shifted 1 meter to grid north in order to tie it to the 2007 datum.

Magnetic Susceptibility

The 2007 magnetic susceptibility data were first despiked to remove exceptionally high data values, followed by destriping using the Zero Mean Traverse tool. Destaggering and edge matching were applied and three consecutive 1 x 1 Gaussian low pass filters were applied. Finally, the data were interpolated to a 0.25 by 0.25 meter resolution. Magnetic susceptibility was then imported, resampled and rectified to the map base in ArcMap.

Conductivity

Conductivity was processed similar to magnetic susceptibility. The dataset was despiked to remove exceptionally high data values, followed by destriping and destaggering. Edge matching was used to match the edges of the grids, and three consecutive 1 x 1 Gaussian low pass filters were applied. Finally, the data were interpolated to a 0.25 by 0.25 meter resolution and the data then imported, resampled and rectified to the map base in ArcMap.

D. Identification of Metal Clusters

The distribution and density of iron artifacts likely indicate some types of activity areas on historic sites. Dipolar anomalies illustrated later identified and mapped during the analysis of the magnetometry serve as a proxy for iron artifact distribution, and they appear to be clustered particularly near the trading post. Kintigh and Ammerman's (1982) K-means cluster analysis

procedures were used to identify possible dipole clusters and therefore building and activity areas within the Fort. Apparent clusters are essentially a “summary” of the metal from all historic periods of occupation, influenced by the current extent of the magnetometry survey and the interpretations of the geophysical data. Issues that could influence calculated cluster results include the presence of modern metal, gaps in the arbitrarily defined survey area that will appear as “holes” between activity clusters, and accurate identification of dipoles. Dipolar anomalies caused by obviously modern sources, such as the power poles, the monument plaque, and metal located within excavation units, were removed prior to cluster analyses. All other metal was included in the dataset as its age and potential archaeological association are unknown. The inadvertent inclusion of metal not related to the Fort’s occupation would affect any defined cluster that could represent potential activity areas. Large gaps in the survey could also affect the analysis by creating artificial empty areas that could create the illusion of activity areas where there are none biasing the results. As the identification of dipolar anomalies was done through visual recognition of the high-low magnetic dipole pattern, observer bias is likely to influence which dipoles are identified and included in the dataset. It is also likely that many dipoles were not identified due to the weakness of the dipole signal or due to observer bias.

Cluster analysis should help reveal the locations of metal clusters not definitively visible to the eye, both inside and outside of the Fort palisade. However, Kintigh and Ammerman (1982:48) note that a drawback of the k-means procedure is a tendency to form circular clusters. The dispersion of metal artifacts during Fort activities, human disposal of garbage, and the Fort’s dismantling, should cause patterns in the distribution of metal items within the Fort. Metal could be clustered near buildings forming debris areas, but the overall dispersion within the Fort may not indicate intentional human action but rather indirect placement of items.

Clusters of metal were identified using a combination of spatial analysis and structure locations based on historic maps. Dipolar anomalies were visually identified in the magnetometry and plotted in ArcMap. Metal identified in the magnetic susceptibility and conductivity surveys were either matched up with corresponding dipolar anomalies in the magnetometry, or added to the dipole map. Dipoles resulting from known modern objects such as the monument plaque, metal corner posts, and power poles were removed from the dataset. Extremely strong dipolar anomalies in the location of excavation units were interpreted as related to the archaeological excavations and removed. The dipole anomaly plot was then converted to a binary raster, with each dipole represented by a pixel plotted at the center of the dipole. Only pixels containing a dipolar anomaly point were exported with x,y coordinates.

The statistical software program R was used to calculate dipole clusters using the K-means procedure developed by Kintigh and Ammerman (1982). The procedure identifies two dimensional clusters of points by minimizing the distances between points within a cluster while maximizing the distance between clusters, based on a number of clusters defined by the user (Kintigh and Ammerman 1982:39). Plotting the log10 of the Sum Square Error (SSE) percentage for each cluster creates a graph indicating likely number of clusters, along with the presence or absence of spatial clustering. A sharp change in slope indicates possible numbers of clusters based on the strength of group clustering. By comparing the plot of actual data to randomized data, the presence or absence of clustering can be indicated by the location of the actual data line relative to the randomized data line (Kintigh and Ammerman 1982:45-47). Randomized data were generated using Kintigh and Ammerman’s method of randomizing the order of x values to y values within the actual dataset (1982:45). Calculation of SSE and the corresponding cluster plots were created through a programmed R module created by Dr. Kenneth Kvamme (2012).

The K-means procedure run on the entire dataset of dipoles (inside and outside the Fort palisade, n = 893) did not yield any distinctive clusters based on slope changes in the K-means plot (Figure 17). Actual SSE percentages that decrease more quickly than the random SSE percentages indicate spatial clustering (Kintigh and Ammerman 1982:46). There is a difference between the log10 of SSE percentages and the randomized percentages (Figure 17), indicating a slight spatial clustering of dipolar anomalies in the entire dataset. User selection of a cluster level of five produces groups of dipoles within the Fort that are mostly separate from other clusters in the field, although some dipoles which should be included in the outside Fort clusters are grouped with clusters inside the Fort palisade. Defining eight clusters results in a better solution (Appendix C, Figure 38), but some points remain grouped with clusters outside the palisade (particularly some near northwest corner) and some dipoles located outside the palisade in the south are grouped with the inside Fort clusters. Other clusters identified outside of the Fort palisade in the field do not appear to form any visually apparent cluster patterns.

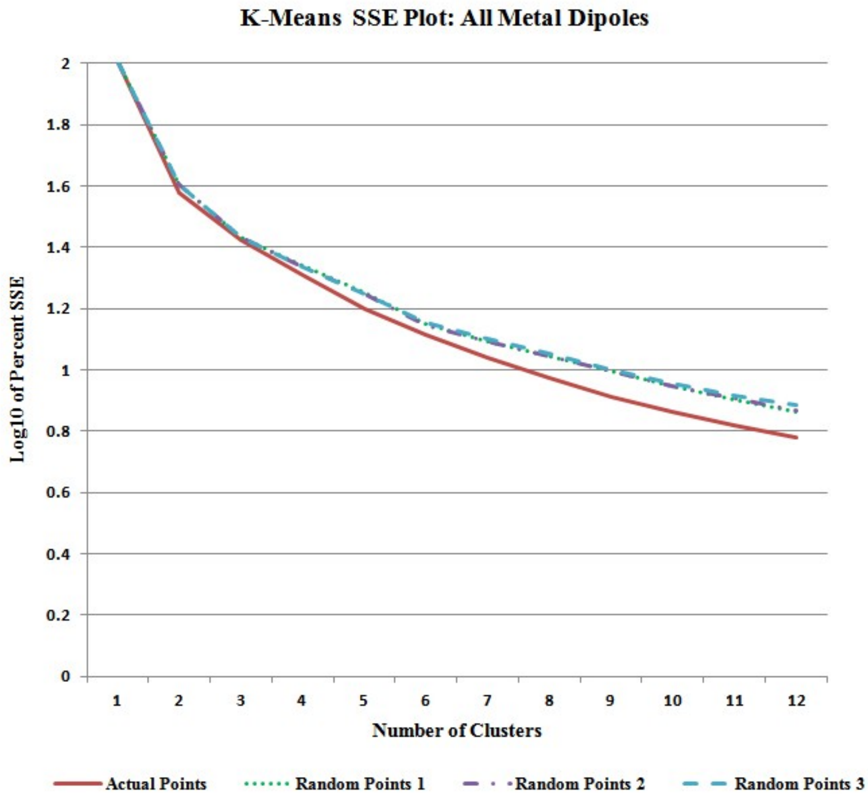

Figure 17: K-means plot of log10 percentage of Sum Square Error for all points in survey area and three randomized sets of points. The drop of the Actual Points line below the Random Points lines indicates a slight clustering within the entire set of points.

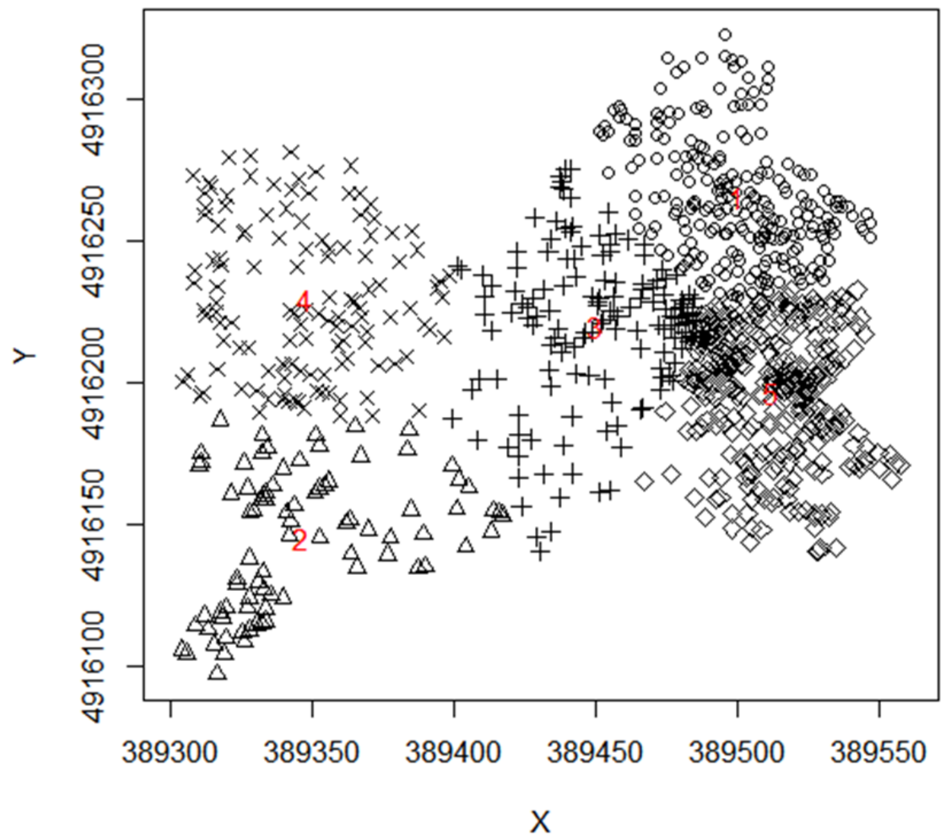

Figure 18: R generated five cluster solution, all points in survey.

Restricting the cluster analysis to dipoles which are located within the Fort palisade (n = 368) does not definitively result in clusters that correspond to possible activity areas and structures within the Fort. The K-means plot does not indicate any spatial clustering of dipoles in the data subset (Figure 19) which is surprising as there visually appears to be clusters inside the palisade. The majority of the dipoles appear to follow a random pattern, indicated by the overlap of the actual percentages with the random percentages (Kintigh and Ammerman 1982:48). Dipoles within the Fort have a possible grouping at the eight or nine cluster level (Appendix C, Figure 57), although the difference between the actual and random percentages is so slight it could merely be an indication of the random distribution of the dipolar anomalies and not actual clustering. The

nine cluster solution (Appendix C, Figure 58) evenly divides up the dipoles within the Fort. The final interpretation of dipole clustering is a combination of the nine cluster solution with visual interpretation of the magnetic strength of particular dipoles (Appendix C, Figure 59).

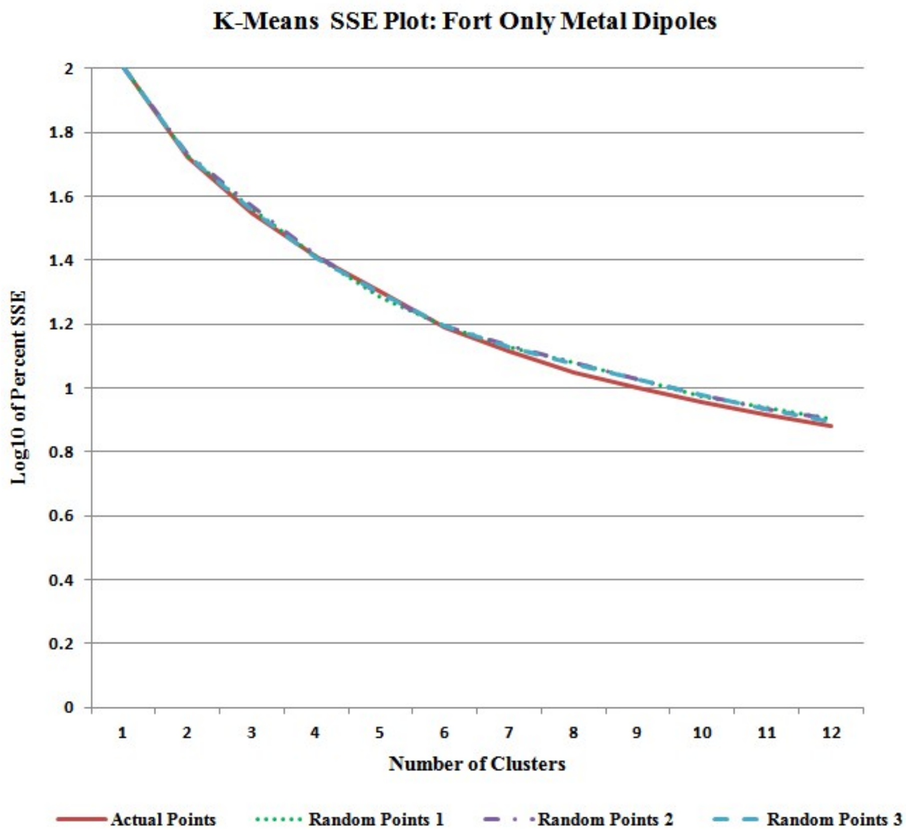

Figure 19: K-means plot of log10 percentage of Sum Square Error for points inside the palisade and three randomized sets of points. The overlap of the Actual Points line by the Random Points lines indicates lack of clustering in the points located inside the palisade.

The K-means plot indicated slight clustering in the data set containing all metal in the site, while an evaluation of a data subset for only metal inside the Fort palisade did not indicate clustering. Large gaps in the survey area have likely affected the results for the entire site, creating the appearance of artificial clusters. Even though clusters were not able to be clearly defined mathematically, metal-caused dipoles do visually form clusters inside the palisade. Therefore, the

final determination of metal clustering within the Fort was completed through the combination of the cluster analysis results and cluster association with anomalies interpreted as related to structures (the final identified clusters are visible later in Figure 25). Specific iron-based activity clusters are discussed in Chapter 4 within the study areas in relation to other anomalies.

IV. CHAPTER 4: RESULTS

A. Aerial Photography

A review of aerial photography from the early images taken in the mid-1960s to the imagery collected in 2012 provides information about the site use during the past 50 years. In Figure 18, the area surrounding the Fort is marked by a north-south fence to the west, with an active farm or ranch visible west of this fence line. An additional fence line running east-west is located to the south. A streambed delineates the northern boundary, with the edge of the terrace to the east marked by a nearly north-south line of trees. Aerial photography is available for several years, with the earliest year available 1966. USGS High Resolution Orthoimagery shows the most detail of all the aerial imagery and is available for 2005, 2007, 2009, and 2012. Table 1 describes the features visible in different aerial imagery years and all aerial imagery described here is included in Appendix D.

Aerial Imagery Feature Summary								
Photo Year	**Fort Visible**	**Structures Visible**	**Tree Visible**	**North-South Lines Visible**	**Road Visible**	**Excavation Units Visible**	**1967 Pipeline Trench Visible**	**Monument Path Visible**
May 1966	Yes	No	Yes	Yes	Yes	No	No	No
May 1973	Yes	No	Yes	No	Yes	No	No	No
May 1975	Yes	No	Yes	No	Yes	No	No	No
April 1984	No details visible due to low resolution							
July 1991	Yes	No	Yes	No	Yes	No	No	No
October 1997	Yes	No	Yes	No	Yes	No	No	Yes
2005	Yes	No	Yes	No	No	Yes	No	Yes
2007	No	No	Yes	No	No	No	No	Yes
2009	Yes	No	Yes	Yes	No	No	Yes	Yes
2012	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes

Table 1: Features visible in Aerial Photography and High Resolution Orthoimagery. All Aerial photography and Orthoimagery is included in Appendix D.

Differential plant growth reveals varying traces of the Fort in different years, along with other site characteristics. In Figure 20, the main area of the Fort has only a slight vegetation difference compared to the rest of the field. The Fort appears as a roughly rectangular darker pattern of vegetation and no structures are visible on the property. The Fort is visible in all years except for 1984. The 1984 aerial photograph does not show any details due to the low resolution of the imagery. Structures are not visible on the site in any of the years, although the tree located in the approximate center of the Fort is visible in all years. Excavation units are visible in the later high resolution orthoimagery as patches of lighter vegetation. Roughly parallel north-south lines of an unknown origin are intermittently visible over the years as differential vegetation marks.

Figure 20: May 1966 Aerial Imagery. Red outlines the study area. The single isolated tree to the west of the north-south tree-lined terrace edge marks the approximate location of Fort Pierre Chouteau's center. Image contrast has been enhanced.

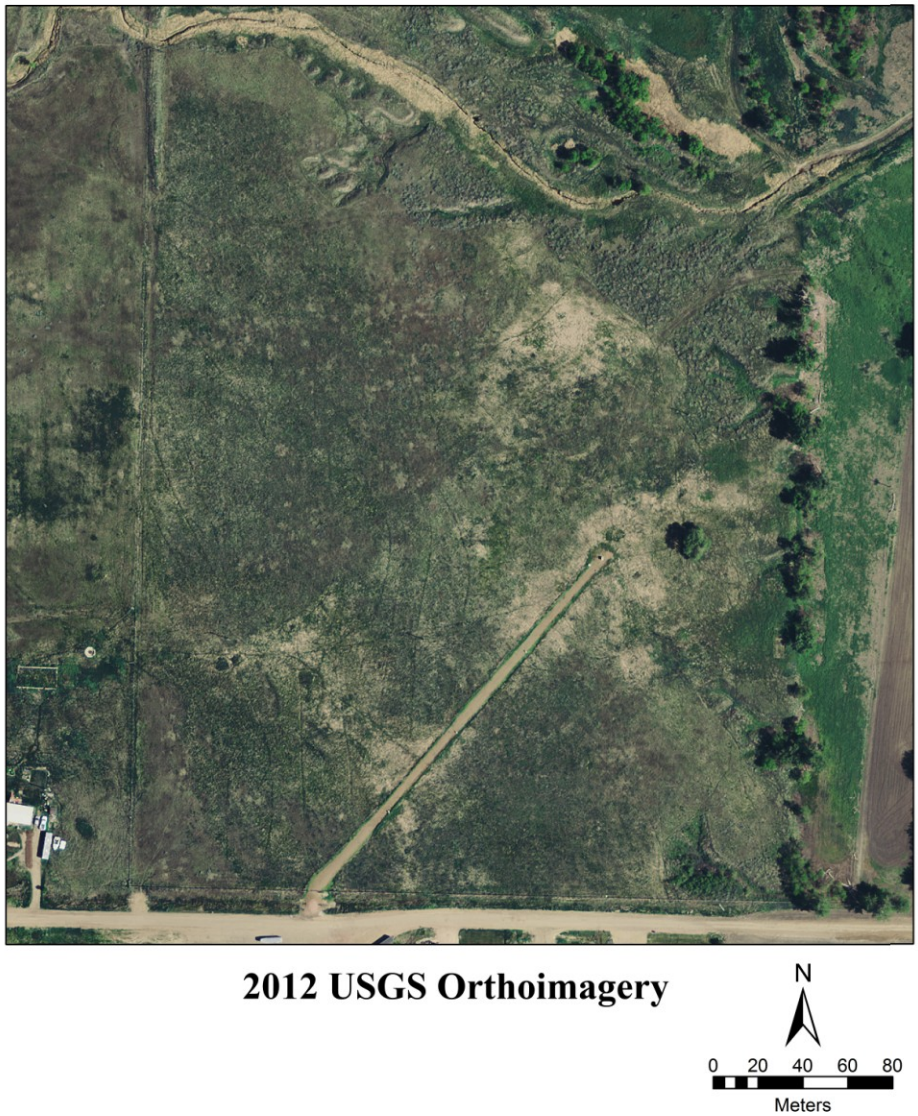

Figure 21: 2012 USGS High Resolution Orthoimagery. The single isolated tree to the west of the tree-lined terrace edge marks the approximate location of Fort Pierre Chouteau's center. Image contrast has been enhanced.

The 2012 orthoimagery shows all the characteristics identified in previous years. Interpretation of these aerial features is provided in Figure 22. The aerial imagery does not show plowing on the property and the presence of the north-south lines appear to confirm the sites use as

pasture only as they would likely have been destroyed by agriculture. Cattle trails can cause signatures similar to the north-south lines, further supporting the use of the field for pasture.

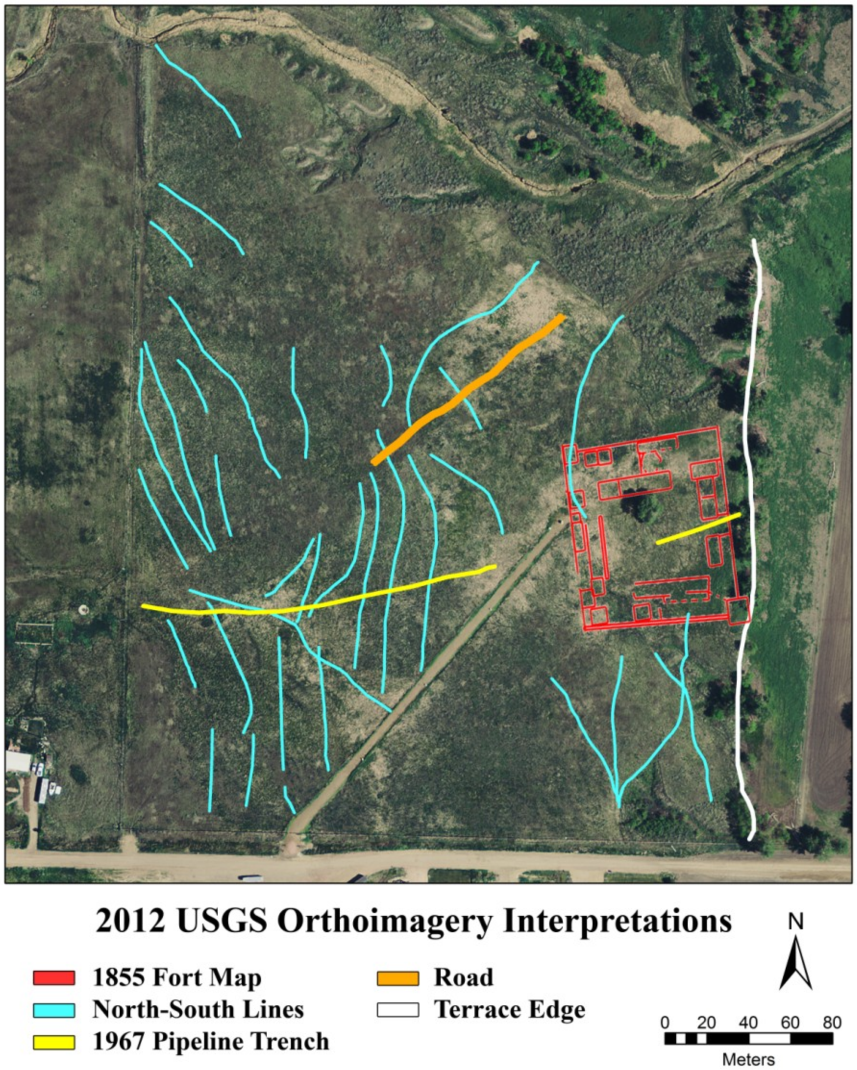

Figure 22: 2012 USGS High Resolution Orthoimagery Interpretations

B. Geophysical Survey Results

The geophysical surveys allowed identification of specific anomaly types based on their location, strength, and association to other anomalies. A general discussion of the magnetometry,

electrical resistance, magnetic susceptibility and conductivity surveys is presented followed by analysis of specific anomaly types and interpretations. Next, the study region is divided into five areas as shown in Figure 23, each allowing a closer look at the anomalies. Area A covers the northern half of the Fort, extending slightly outside the palisade. Area B covers the southern half of the Fort and the area south of the palisade. Area C is to the northwest of the Fort, exterior to the palisade. Area D covers the area immediately west of the Fort, including much of the monument walkway and field. Area E is far west of the Fort, covering an area near the west fence line. The magnetometry survey covers all five areas, while the electrical resistance survey only covers areas A, B, and D. Magnetic susceptibility and conductivity cover limited parts of A and B. Each area contains a summary table of anomalies, plus discussion of specific anomalies of interest.

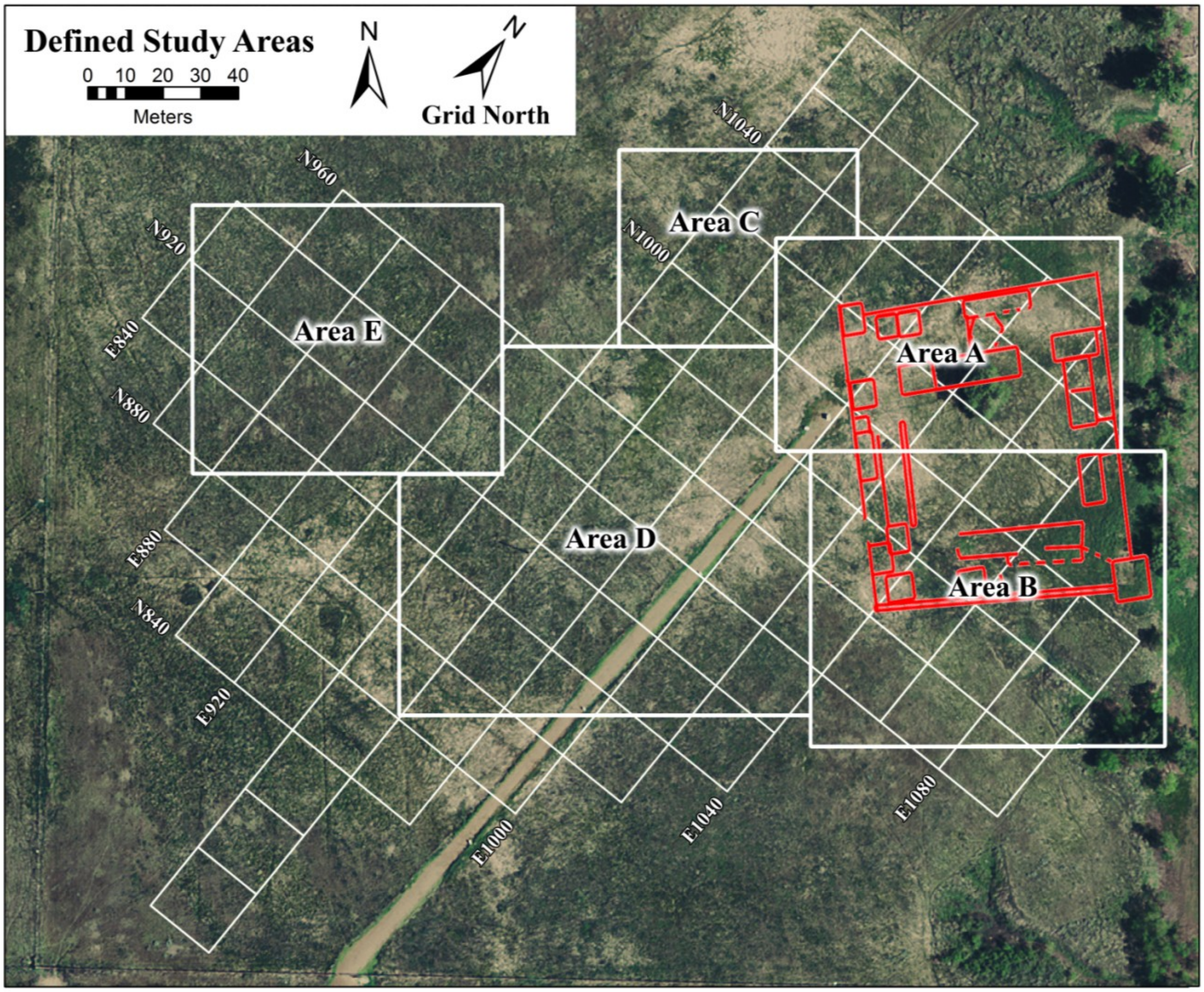

Figure 23: Defined study areas overlaid on the USGS 2012 High Resolution Orthoimagery. The red outline is the 1855 Fort map at the Fort's approximate location. Magnetometry surveys covered Areas A through E; Electrical resistance surveys covered areas A, B, and part of D; Conductivity and magnetic susceptibility surveys cover limited parts of Areas A and B.

Magnetometry General Discussion

Magnetometry survey results are presented in Figure 24, and interpreted in Figure 25. Areas of historic activities are visible magnetically either as areas of high and low magnetism relative to the background or as dipolar anomalies. A dipolar anomaly is composed of a high

magnetic peak paired with a negative magnetic peak, indicating the orientation of a material causing a bar magnet effect (Schmidt 2009:78). Concentrated dipolar anomalies can indicate highly magnetic metal such as iron. Groups of dipolar anomalies caused by numerous iron artifacts can be associated with historic activities at this site. The highest concentration of dipolar anomalies is within and close to the vicinity of the Fort, obscuring much of its interior. Clusters of metal-caused dipoles reveal structures and activity areas within the Fort. Some areas of high magnetism are visible inside and outside the Fort, indicating the locations of structures, such as buildings or the palisade line. Due to the historic nature of this site, most of the dipolar anomalies in this project are interpreted as iron-caused.

Magnetometry data varied from -3619.74 nT to 3669.43 nT, with a mean of -5.89 nT. Extremely strong dipole anomalies contributed to the large data range, including several anomalies caused by power pole guidelines and an electrical box. Processing of the magnetometry data is discussed in Chapter 3, including the application of a high pass filter to the data in order to bring out subtle trends. A high pass filter amplifies subtle trends by increasing the strength of measurements through subtracting the background average. This process changes the data so that values close to the average are suppressed, while values different from the background are enhanced. Enhancement of subtle anomalies is useful in geophysical datasets with subtle anomalies which may not be visible otherwise.

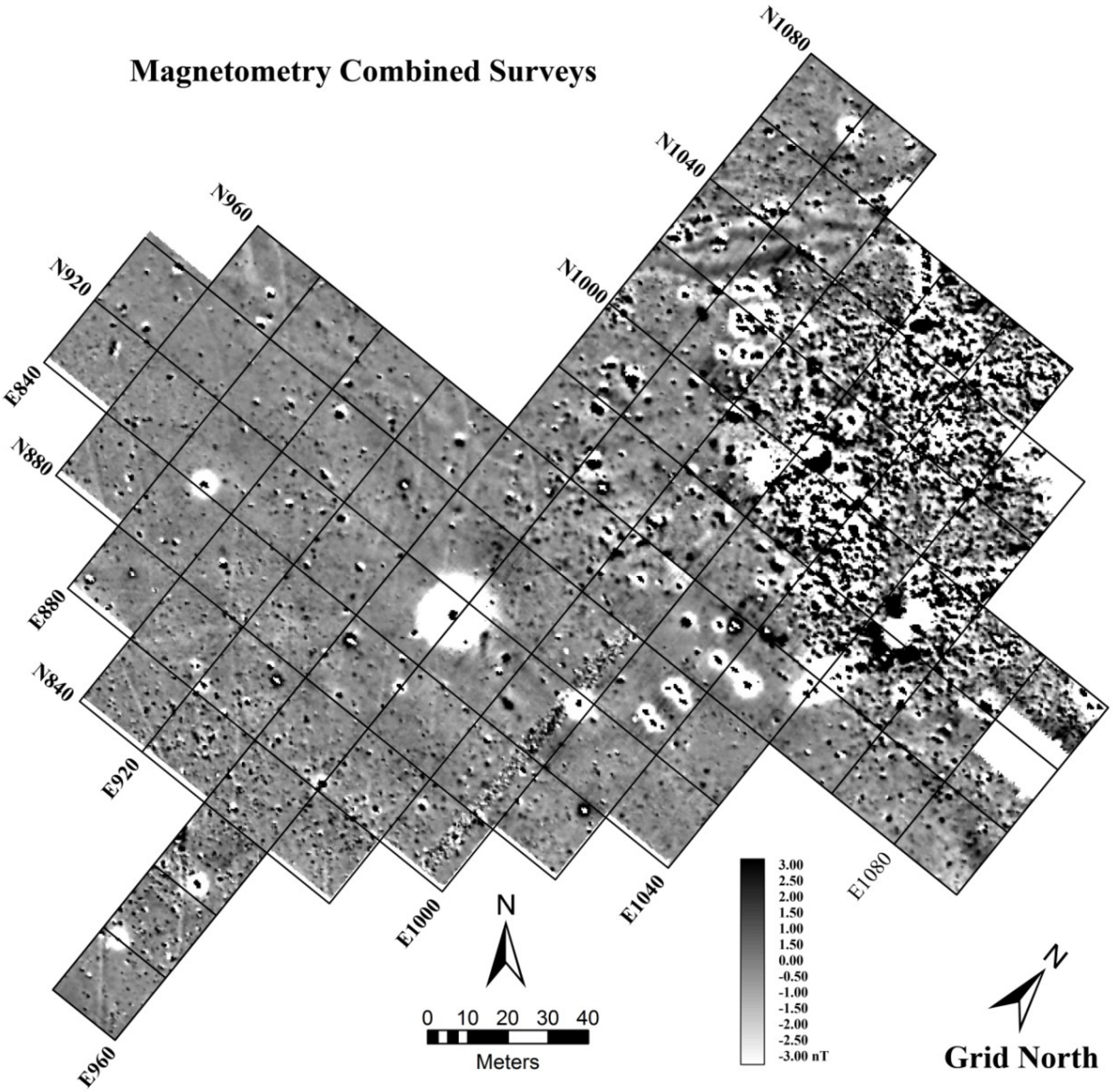

Figure 24: Combined magnetometry surveys. The gap visible at the grid's southwest edge is because the 2012 survey was shifted northeast to match the 2007 datum.

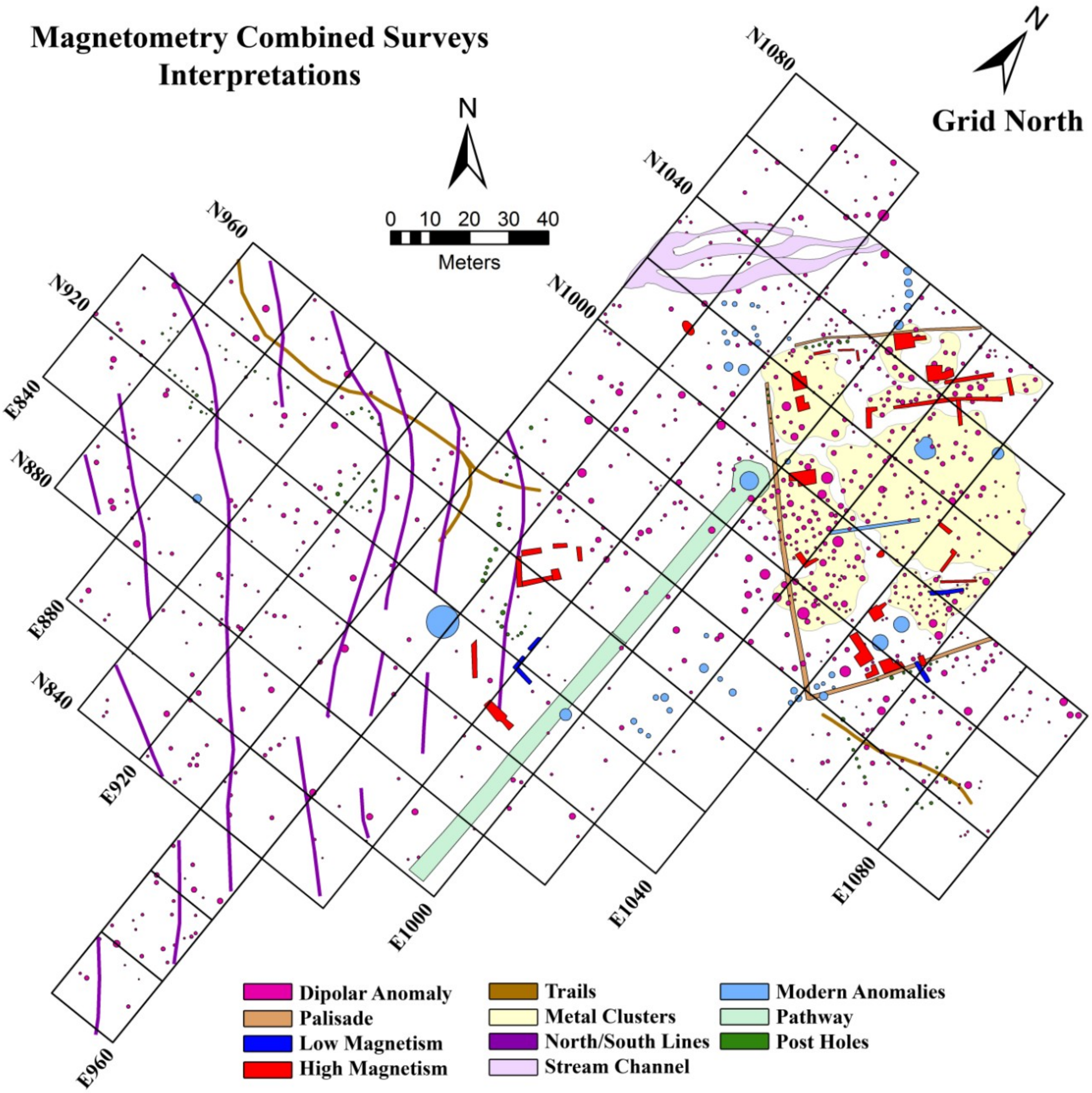

Figure 25: Interpreted magnetometry anomalies.

Electrical Resistance General Discussion

The electrical resistance data presented in Figure 26 reveals more detail of the interior of the Fort including the palisade location along with walls and floors of structures. Visual differences between the two electrical resistance surveys are partially due to the data collection at

different sampling densities and likely partially due to moisture differences between the survey years. The 2007 electrical resistance survey was conducted at a spatial resolution of 0.5 m, while the 2012 survey was completed using 1 meter sampling. Under ideal conditions, the higher spatial resolution of the 2007 survey should allow the identification of smaller anomalies. Dry conditions in 2012 contributed to the noisiness of the data and therefore so that a higher sampling density would not have significantly improved the results (Kvamme, personal communication, March 23, 2013). Interpretations of electrical resistance anomalies are presented in Figure 27. Patterns of high and low resistance, potentially show different feature types, construction materials, and therefore possibly structures and activity areas representing different occupational periods. The 2007 resistance data varied from -1.378 ohms to 4.25 ohms (approximately -2.16 to 6.68 ohm meters with a mean of 0.0002 ohms. Most (97%) of the data is between -0.378 and 0.322 ohms. The 2012 resistance data varied from -3.423 ohms to 6.618 ohms (approximately -5.38 to 10.4 ohm meters) with a mean of 0.02 ohms. Most (92%) of the data is between -2.52 and 1.68 ohms.

A high pass filter was applied to both electrical resistance surveys after initial processing, as discussed in Chapter 3. As mentioned above, a high pass filter alters the data to emphasize subtle trends by enhancing values that are different from the average background. This process results in a lower overall range of data with subtle features at the extreme edges of the range.

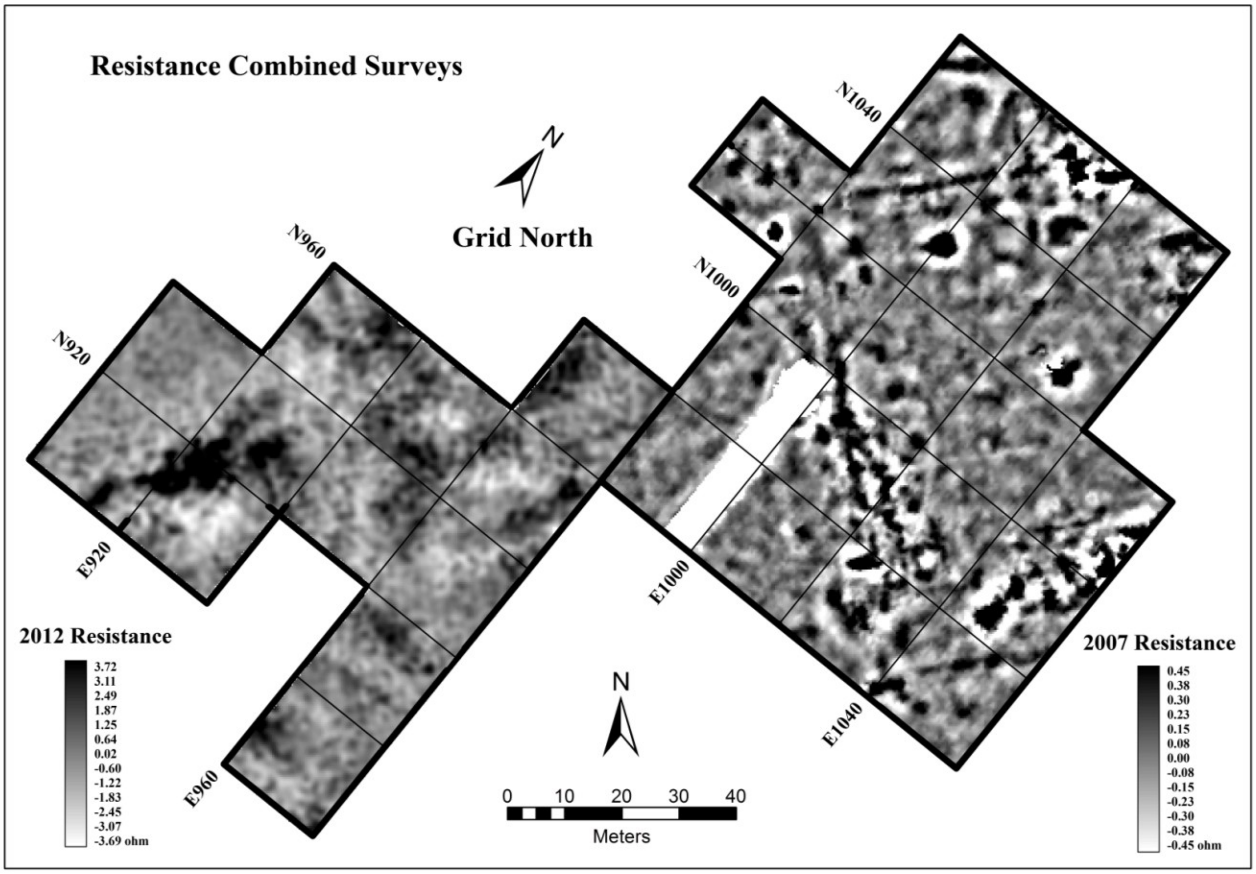

Figure 26: Combined Electrical resistance Surveys. The 2007 survey and the 2012 survey have been combined into a single image. Each survey has a slightly different ohms scale as labeled in the image.

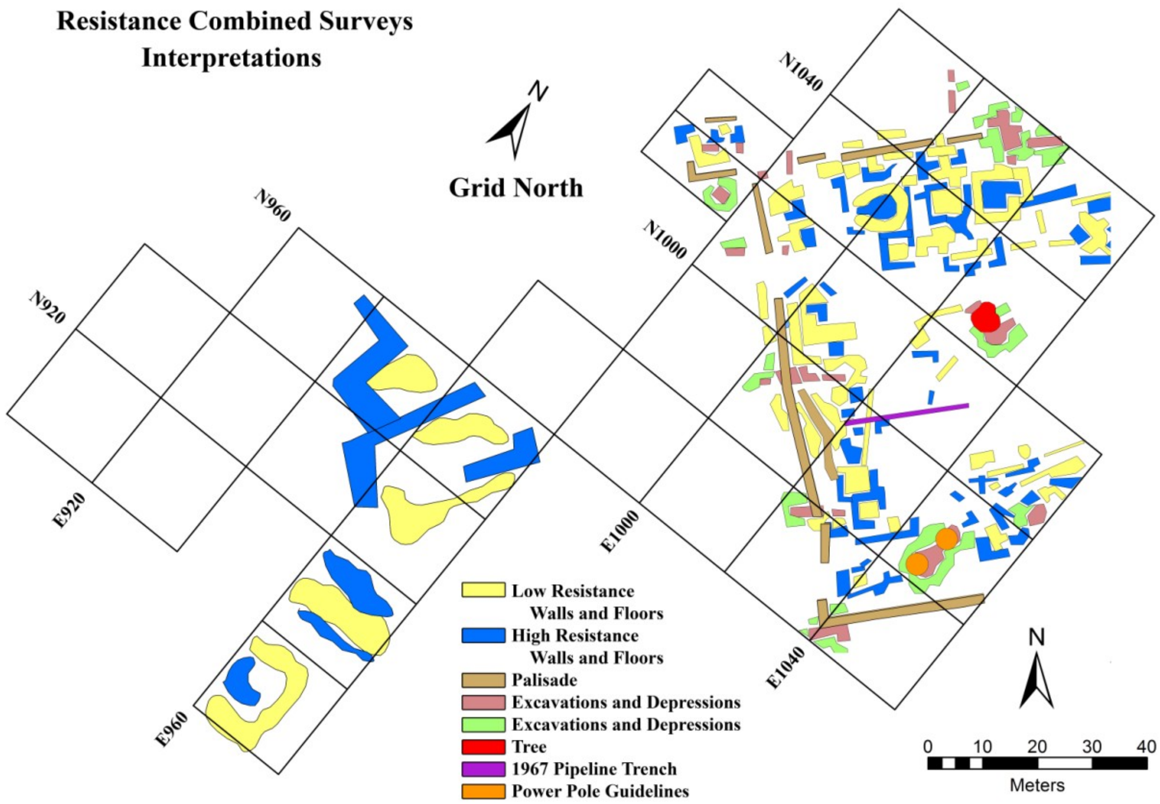

Figure 27: Electrical Resistance Interpretations.

Magnetic Susceptibility and Conductivity General Discussion

Magnetic susceptibility and conductivity mirror some of the results of the magnetometry and resistance. While both surveys only cover a limited area of the Fort, they provide complementary information to the other surveys regarding the western palisade and the structure nearby. The magnetic susceptibility results and interpretations are presented in Figure 28, while the conductivity results and interpretations are presented in Figure 29. Numbered anomalies are discussed in the appropriate table in the following sections.

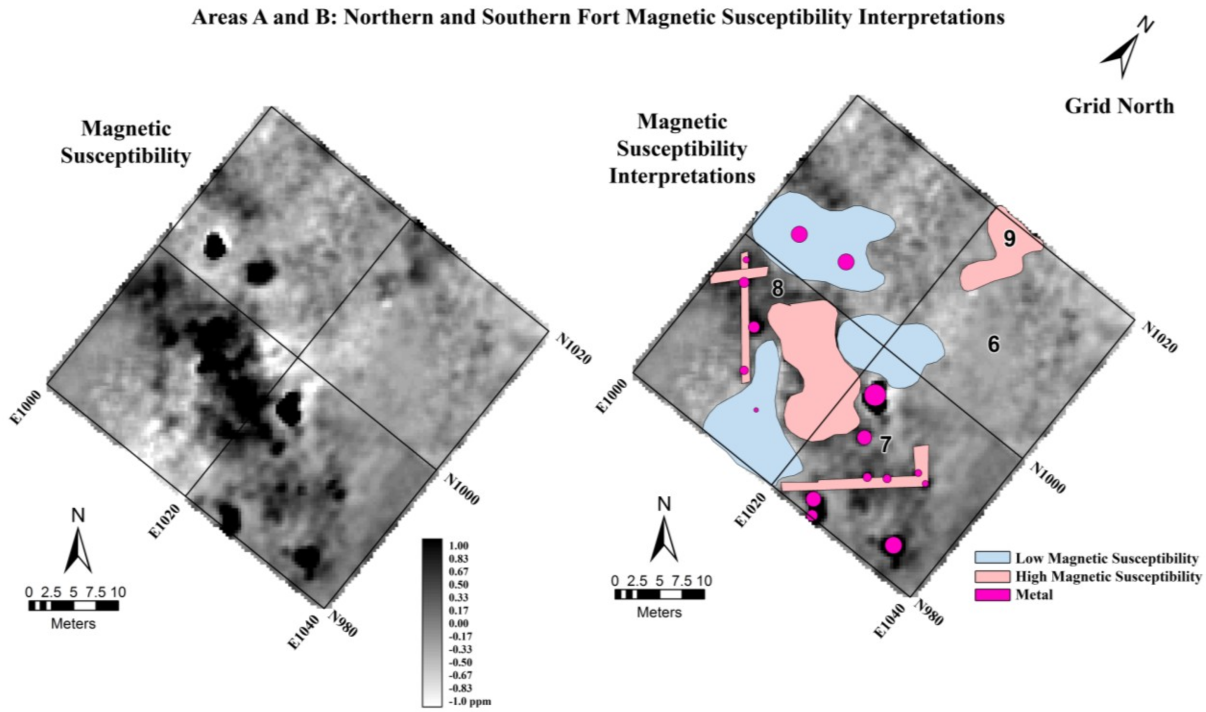

Figure 28: Areas A and B: Northern and Southern Fort Magnetic Susceptibility Interpretations.

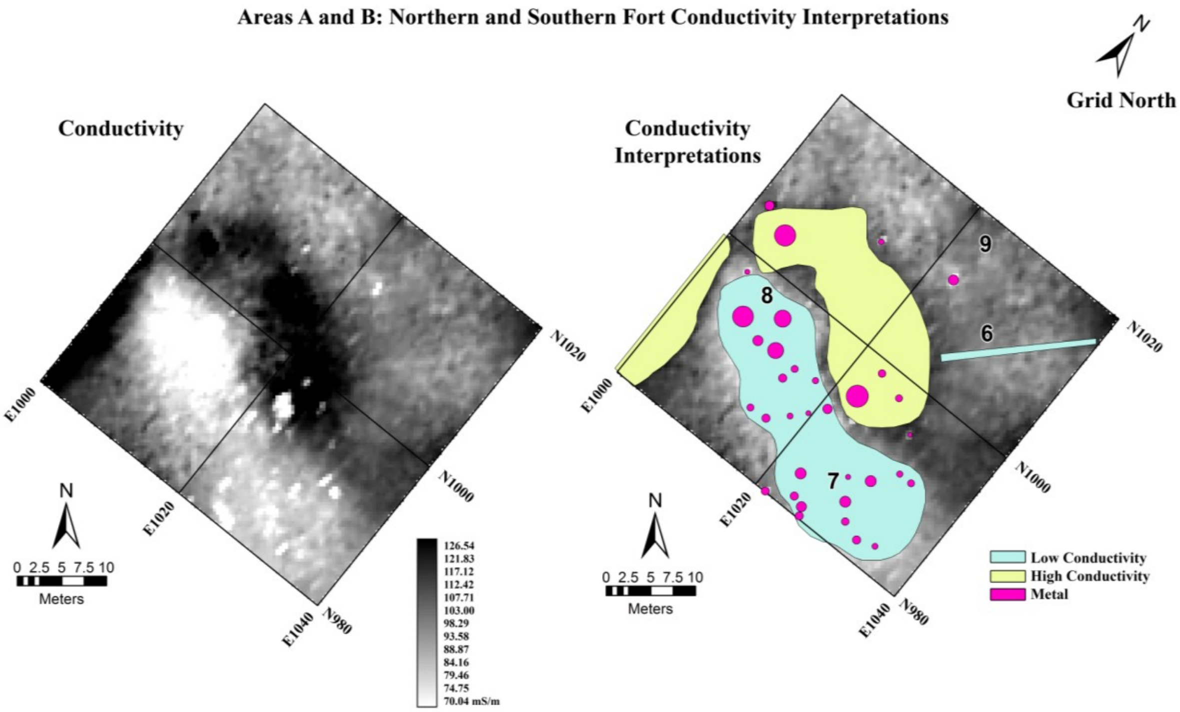

Figure 29: Areas A and B: Northern and Southern Fort Conductivity Interpretations.

Builder's Trenches

Builder's trenches within the Fort are visible in the magnetometry, electrical resistance, and magnetic susceptibility. Circular high magnetic anomalies are present within builder's trenches on the north, south, and west palisade, indicating the bases of posts located within the trenches. The decomposition of organic material can cause concentrations of magnetic materials, allowing the presence of the post bases to be detected (Schmidt 2009:75). In the electrical resistance, the builder's trench appears as a high resistant linear anomaly when compared to the background, likely caused by differential drainage or compaction of soil. Less moisture within the trench and/or more compaction of soil grains would cause a high resistance anomaly due to the decreased ability of the electric current to pass through the soil matrix (Clark 1990:37; Burger et al. 2006:505). Multiple builder's trenches appear throughout the Fort as part of the palisade

construction and the construction of other structures. At least 6 builder's trenches are identified in the northern Fort area based on the above patterns. Magnetometry examples of builder's trenches are visible in Figure 30 and Figure 31, Anomaly Groups 1 and 2. Electrical resistance examples of builder's trenches are visible in Figure 32 and Figure 33, Anomaly Groups 1 and 2. Builder's trenches at the site have readings of about 0.1 to 0.5 ohms in the electrical resistance.

Walls

Walls tend to exhibit patterns similar to the builder's trench discussed above, and in many cases structures within the Fort may have been constructed using builder's trenches. The use of builder's trenches to construct walls would cause similar responses in the geophysics. Other walls within the Fort were constructed using different materials and/or techniques, or at different periods resulting in different geophysical signatures. Structure walls within the Fort that do not follow the builder's trench pattern exhibit low resistant linear anomalies, and in some areas of the Fort linear high and low resistant anomalies do not obviously outline rectangular rooms. However, the pattern of low-high-low-high resistant anomalies follows with the idea of structures with multiple rooms, each with an outside entry. There are at least 7 linear low resistant anomalies which appear to be related to buildings within the Fort. Electrical resistance examples of low resistant walls are visible in Figure 32 and Figure 33, Anomaly Group 6.

Floors and Roofs

Geophysical indications of floors vary within the Fort, depending on the floor type. Packed earth floors could cause both higher magnetism and higher resistance than the surrounding background soil. A packed earth floor may appear as more magnetic due to the addition of topsoil

to create a smooth floor surface (Kvamme 2006:218). A higher resistant anomaly could be caused by a packed earth floor due to the decreased ability of the electrical current to pass through the soil matrix due to soil compaction (Burger et al. 2006:505). However, not all areas of high magnetism or high resistance are necessarily floors. Historic documents indicate that several buildings were roofed with sod and soil, or constructed of adobe (Culbertson 1952:76; De Land 1902:348-349). These constructions would also cause areas or high magnetism due to erosion if the source material was magnetically enriched. A packed floor could also cause a low resistant anomaly if the composition and compaction of the floor allows water to pool above the floor level. Erosion of adobe covered walls and soil roofs would likely cause low resistance as the resulting soil would not be compacted. Examples of packed earth floors are visible in Anomaly Group 5 in Figure 30 and Figure 31 (magnetometry) and Anomaly Group 4 in Figure 32 and Figure 33 (electrical resistance). Floors have readings of about 10.0 to 28.0 nT in the magnetometry and 0.2 to 0.4 ohms in the electrical resistance.

Post Holes

Post holes are identifiable as circular high magnetic anomalies both inside and outside of the Fort. Kvamme (2008:22) first identified post holes relating to the palisade line in 2008. The decomposition of organic material, such as the bases of posts, can create higher magnetism due to the breaking down of organic materials by microbes (Schmidt 2009:76). Lines of post holes indicate the location of the palisade line and other structures. Multiple anomalies identified as post holes are visible in the magnetometry survey, but most prominent in Area A Anomaly Groups 1 and 2, Area B Anomaly Group 8, and Area E Anomaly Group 2.

Excavation Units and Depressions

Areas where soil has been removed exhibit particular patterns in the electrical resistance, revealing the locations of excavation units and historic cellars. Removal of soil at Fort Pierre Chouteau creates a high resistant anomaly surrounded by a low resistant anomaly. Modern excavations tend to have stronger intensity of both high and low resistance, while cellars likely in use during the Fort's occupation have less intense high and low resistance values. Modern excavations have resistance values of about 1.0 to 1.7 ohms, while depressions at the site (locations of historic earth movement) have resistance values of about 0.4 to 0.8 ohms.

This difference allows identification of modern soil movement as opposed to historic soil movement. Areas of soil removal likely have higher resistance due to a combination of differential drainage and soil compaction, similar to the builder's trenches. Backfilled archaeological excavations may have more compaction that the surrounding soil causing a high resistant anomaly. The areas of low resistance surrounding the excavation units may be the result of looser soils piled up during excavation. Electrical resistance examples of modern excavations are visible in Figure 32 and Figure 33 as part of Anomaly Groups 1 and 5, while historic excavations are visible as part of Anomaly Groups 4 and 7. However, the resistance values in Anomaly Group 7 are likely being affected by the nearby tree, with roots drawing moisture out of the soil.

Area A – Northern Fort

Area A, covering the northern half of the Fort, encompasses anomalies that likely represent the Fort's palisade, and such features as post holes, structure walls and floors, metal clusters, and the modern walkway and monument (Figure 31). The 2007 surveys covered this area with both magnetometry and electrical resistance. A small section of Area A was also covered with conductivity and magnetic susceptibility in 2007. A close-up of Area A magnetometry is presented

in Figure 30, with interpretations in Figure 31. Electrical resistance is presented in Figure 32 with interpretations in Figure 33. Groups of anomalies are identified by numbers in the above mentioned figures. This section will discuss anomaly types and patterns followed by Table 2 which provides a summary of anomalies within anomaly groups. Specific anomalies of interest are discussed following the table.

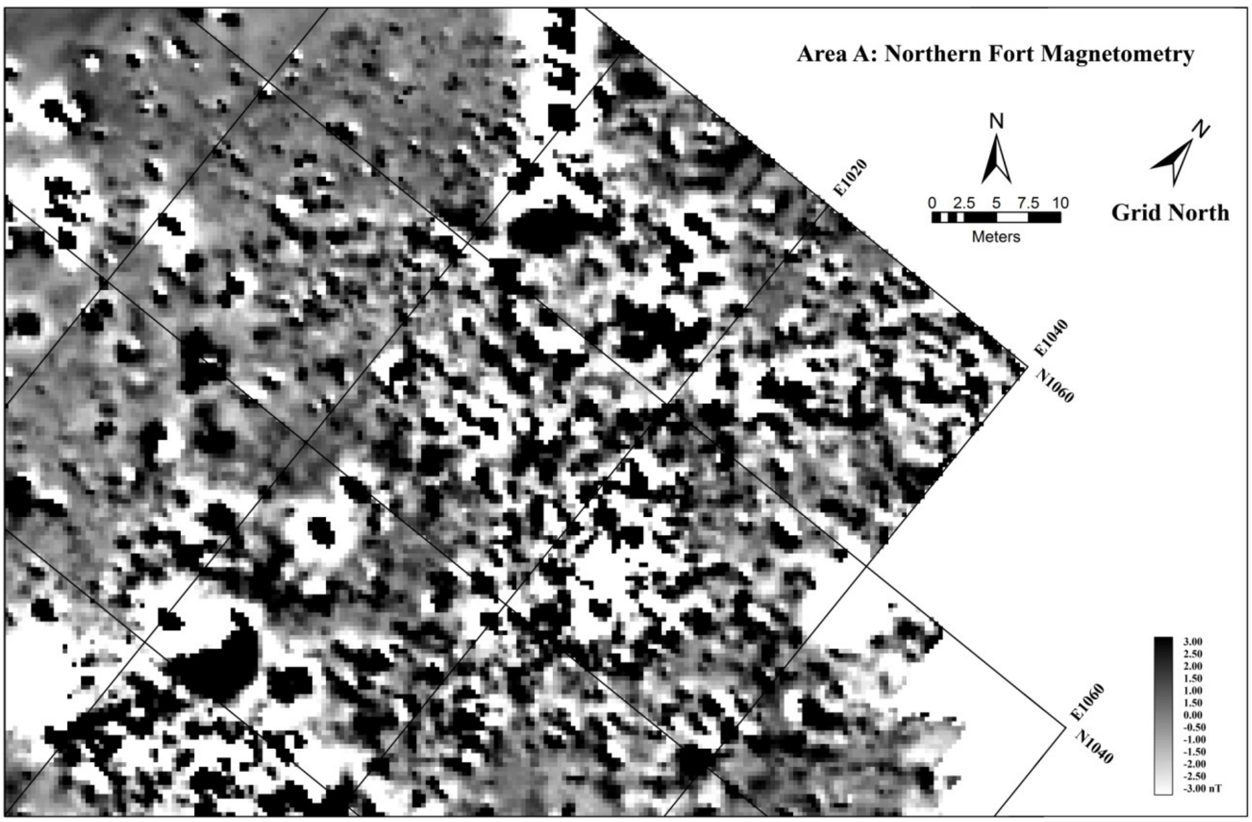

Figure 30: Area A-Northern Fort Magnetometry

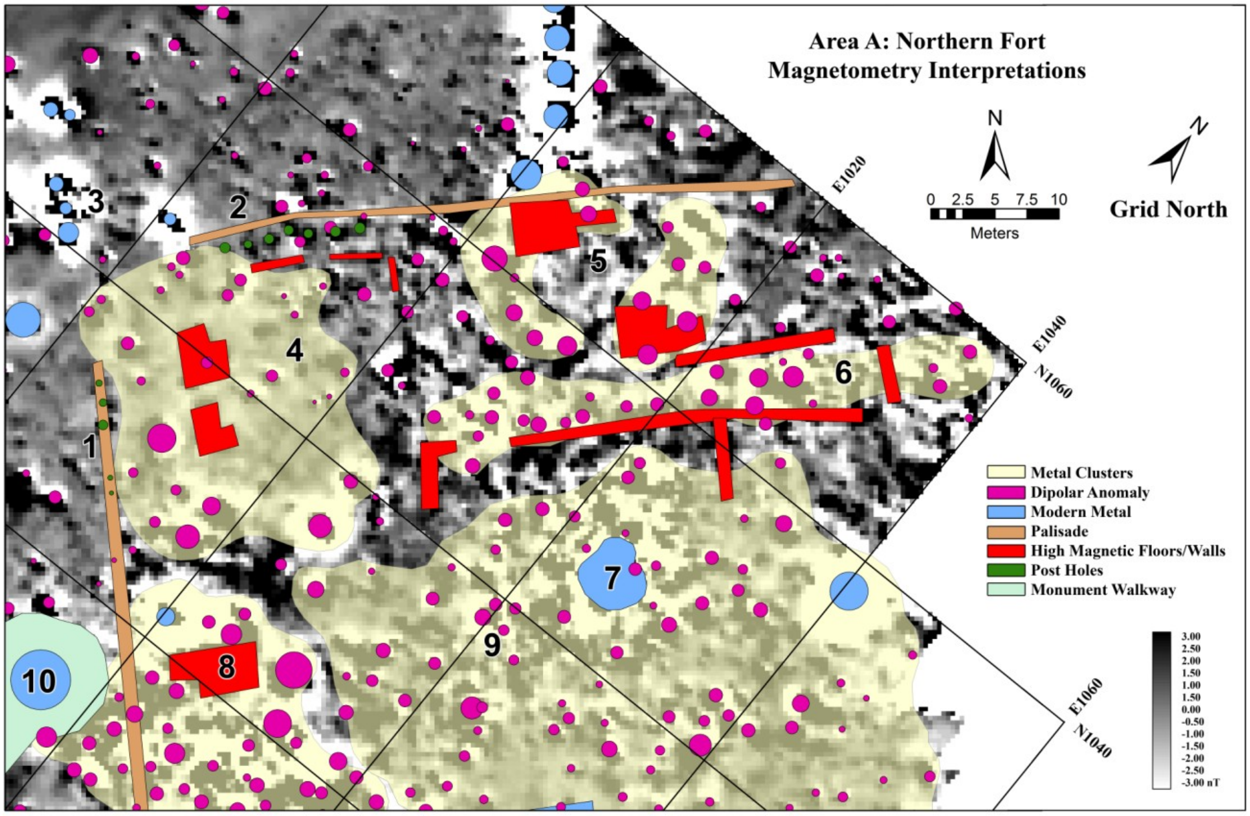

Figure 31: Area A-Northern Fort Magnetometry Interpretations. Anomaly Groups: 1 – West Palisade, 2 – North Palisade, 3 – Northwest Blockhouse, 4 – Structures, 5 – Structures and Metal Cluster, 6 – Structure and Metal Cluster, 7 – Metal Cluster and Tree, 8 – Structures and Metal Cluster, 9 – Open Area (Center of Fort), 10 – Monument and Walkway.

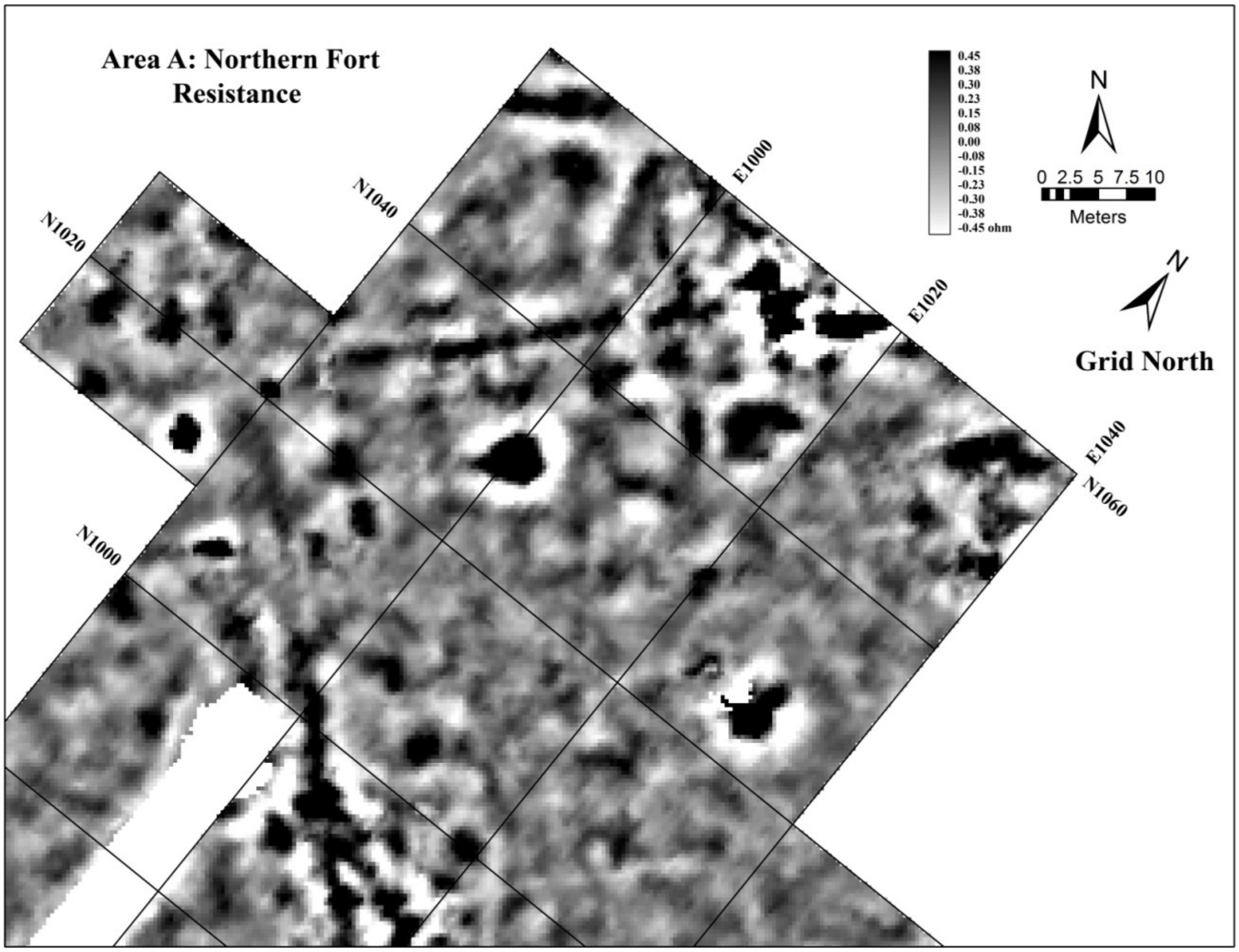

Figure 32: Area A-Northern Fort Electrical Resistance

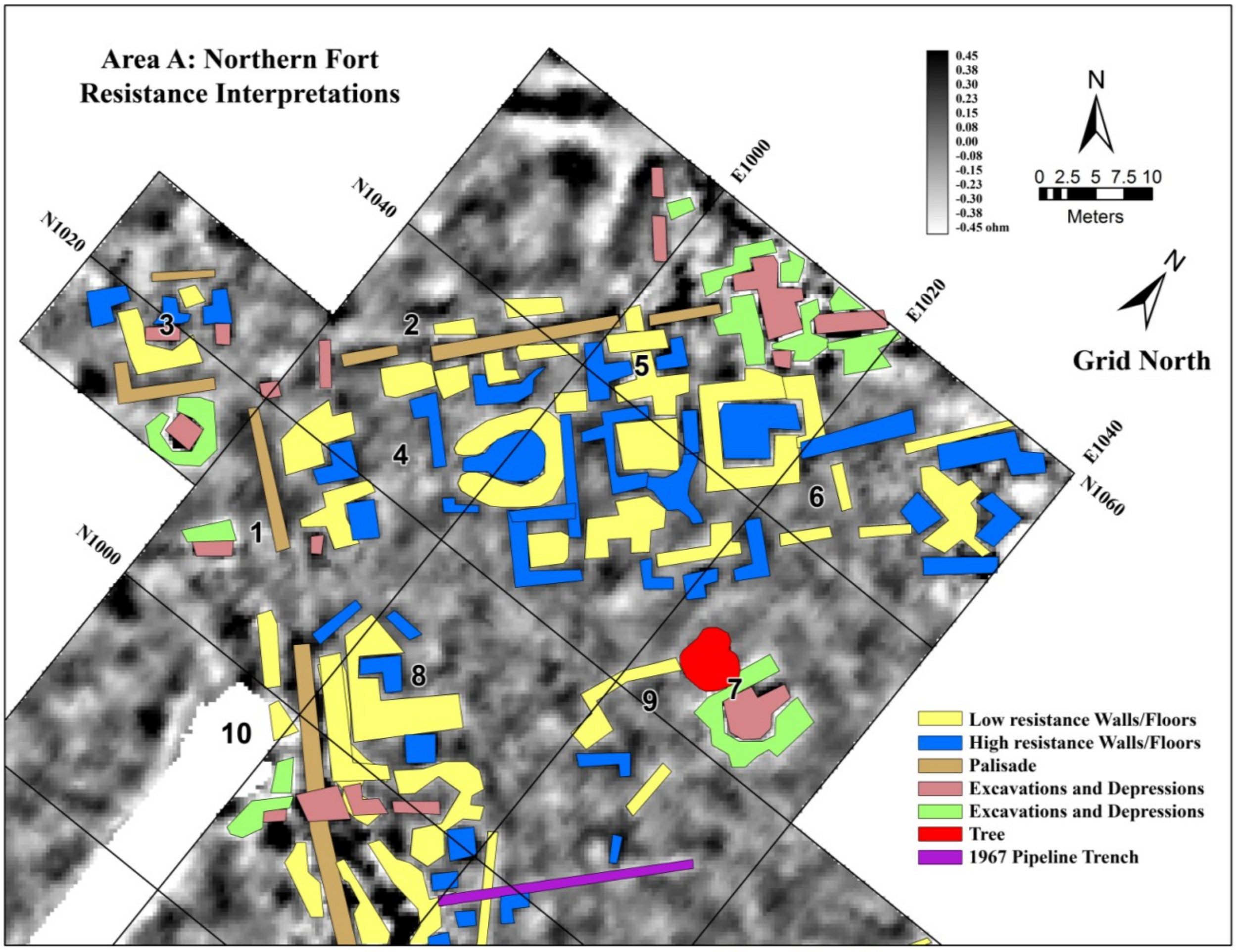

Figure 33: Area A-Northern Fort Electrical resistance Interpretations. Anomaly Groups: 1 – West Palisade, 2 – North Palisade, 3 – Northwest Blockhouse, 4 – Structures, 5 – Structures and Metal Cluster, 6 – Structure and Metal Cluster, 7 – Metal Cluster and Tree, 8 – Structures and Metal Cluster, 9 – Open Area (Center of Fort), 10 – Monument and Walkway.

Table 2: Area A Anomaly Interpretations – Northern Fort					
Anomaly Group	**Survey**	**Types**		**Interpretation**	**Notes**
1: West Palisade					
	Magnetometry	Negative magnetic band		Palisade line	Possibly caused by windblown soil against palisade
	Magnetometry	High magnetic circular anomalies		Post holes	Likely located within palisade builder's trench
	Magnetometry	Dipole cluster edge		Activity area	
	Electrical resistance	High resistant linear anomaly		Palisade builder's trench	Less water and/or more soil compaction than surrounding soil. Parallels circular magnetic anomalies
2: North Palisade					
	Magnetometry	Negative magnetic band		Palisade line	Possibly caused by windblown soil against palisade
	Magnetometry	High magnetic circular anomalies		Post holes	First identified by Kvamme (2008).
	Magnetometry	Dipolar anomaly		Excavation trench	Likely due to metal left in the units
	Magnetometry	Line of dipolar anomalies		Excavation trench	Likely due to metal left in the units
	Electrical resistance	High resistant linear anomaly		Palisade builder's trench	Less water and/or more soil compaction than surrounding soil. Parallels circular magnetic anomalies
3: Northwest Blockhouse					
	Magnetometry	Dipolar anomalies		Excavation units	Likely due to metal left in the units
	Magnetometry	Gap between north and west linear negative anomalies		Location of Northwest blockhouse	Indicates the location of the blockhouse as the palisade lines do not directly meet

	Electrical resistance	Low resistant anomaly		Northwest blockhouse interior/floor	
	Electrical resistance	High resistant line		Northwest blockhouse wall	
	Electrical resistance	High resistant anomalies inside blockhouse		Blockhouse supports and/or excavation units	Supports for the second story or excavation units. Units here do not express the same pattern as excavations elsewhere on the site.
	Electrical resistance	High resistant area surrounded by low resistant area		Excavation units	Similar pattern to excavation units elsewhere on the site
4: Structures					
	Magnetometry	High magnetic anomaly		Unknown structure	Possible packed earth floor or roofing remains. Corresponds to high resistant anomaly.
	Magnetometry	High magnetic anomaly		Unknown structure	Possible packed earth floor or roofing remains. Corresponds to high resistant anomaly.
	Electrical resistance	High resistant anomaly		Unknown structure	Corresponds to high magnetic areas. Possible packed earth floor.
	Electrical resistance	High resistant anomaly		Unknown structure	Corresponds to high magnetic areas. Possible packed earth floor.
	Electrical resistance	Low resistant anomaly		Unknown structure	Northwest of high resistant area
	Electrical resistance	Low resistant anomaly		Unknown structure	Northwest of high resistant area
	Magnetometry	Linear higher magnetic anomaly		Small storehouse	Corresponds with low resistant anomaly
	Magnetometry	Linear higher magnetic anomaly		Powder magazine	Corresponds with low resistant anomaly
	Electrical resistance	Low resistant anomaly		Small storehouse	Corresponds with linear high magnetic anomaly

	Electrical resistance	Low resistant anomaly		Powder magazine	Corresponds with linear high magnetic anomaly
	Electrical resistance	Linear high resistant anomaly		Powder magazine	Corresponds with linear high magnetic anomaly and low resistant area
	Electrical resistance	Oval high resistant anomaly		Root cellar	Surrounded by low resistant area. Entrance visible to the west. Packed earth floor within cellar results in higher resistance due to more compact soil and less moisture. Depression visible on site.
	Electrical resistance	Low resistant anomaly		Root cellar	Soil excavated from the cellar less compact resulting in lower resistance. Also may be retaining moisture.
5: Structures and Metal Cluster					
	Magnetometry	High magnetic anomaly close to north palisade		Sawmill shed floor	Correspond to high resistant linear anomalies
	Magnetometry	High magnetic anomaly		Unknown structure	Corresponds to high resistant anomaly
	Magnetometry	Area clear of dipolar anomalies		Horse work shed floor	Corresponds to low resistant anomaly – horse work shed floor.
	Magnetometry	Dipole cluster			Area surrounding horse work shed
	Magnetometry	Dipole cluster			Area surrounding horse work shed
	Electrical resistance	Low resistant anomaly		Horse work shed floor	Floor. Corresponds to area clear of dipolar anomalies
	Electrical resistance	High resistant linear anomalies		Horse work shed walls	
	Electrical resistance	Rectangular high resistant anomaly		Unknown structure	Corresponds to high magnetic anomaly. Small depression visible on site.
	Electrical resistance	North-south linear high resistant anomaly		Fence line	Possible constructed using a builder's trench.
6: Structure and Metal Cluster					
	Magnetometry	Linear dipole cluster		Storehouses	Debris field around storehouse.

	Magnetometry	Linear high magnetic anomaly		Storehouse walls	Corresponds with linear high and low resistant anomalies. Decomposition of wood left in the ground could cause higher magnetism.
	Electrical resistance	East-west linear low resistant anomalies		Storehouse walls	Corresponds with linear high magnetic anomalies
	Electrical resistance	East –west linear high resistant anomalies		Storehouse walls	Builder's trench with differential drainage or soil compaction compared to surrounding soil. Corresponds with linear high magnetic anomalies.
	Electrical resistance	Rectangular low resistant anomalies		Storehouse floors	Wood floors used in storehouse so soil here likely to be less compact and/or retaining more water than an earth floor
	Electrical resistance	Angled linear high resistant anomaly		Unknown structure walls	Different orientation than east-west storehouse
	Electrical resistance	Angled low resistant anomaly		Unknown structure floor	Different orientation than east-west storehouse
7: Metal Cluster and Tree					
	Magnetometry	Large dipole anomaly		Modern metal post	
	Magnetometry	Gap in survey		Tree	
	Electrical resistance	High resistant anomaly		Tree	Tree drawing moisture from the soil
	Electrical resistance	High resistant anomaly		Depression	Similar pattern to excavations and depressions elsewhere on the site. Tree roots likely also contributing to the high resistance.
	Electrical resistance	Low resistant anomaly		Depression	Similar pattern to excavations and depressions elsewhere on the site.
8: Structures and Metal Cluster (North half of this area discussed in Table 3, Area B)					
	Magnetometry	Dipole cluster			Two dipole clusters combined to better reflect group of buildings at this location. Debris field.
	Magnetometry	Rectangular high magnetic anomaly		Quarters floor	

	Electrical resistance	Rectangular low resistant anomaly near palisade		Kitchens floor	
	Electrical resistance	Rectangular low resistant anomaly		Quarters floor	
	Electrical resistance	Rectangular high resistant anomalies		Quarters walls	
	Electrical resistance	High resistant anomaly intersecting palisade		Excavation trench	Similar pattern to excavations and depressions elsewhere on the site.
	Electrical resistance	Low resistant anomaly intersecting palisade		Excavation trench	Similar pattern to excavations and depressions elsewhere on the site.
	Magnetic susceptibility	North-south linear higher susceptible anomaly		Palisade builder's trench	Enhanced magnetism due to decomposing palisade post bases.
	Magnetic susceptibility	Dipolar anomaly		Metal	
	Magnetic susceptibility	High susceptible area near palisade		Quarters	
	Magnetic susceptibility	Low susceptible area		Quarters	
	Magnetic susceptibility	Linear high susceptible anomaly intersecting palisade		Excavation trench	
	Conductivity	Circular low conductive anomalies		Metal	
	Conductivity	Circular high conductive anomalies		Metal	
	Conductivity	Low conductive area		Open area behind quarters	

	Conductivity	High conductive area		Quarters floor	Corresponds with high-low electrical resistance patterning indicating quarter's location. A high conductive area should correspond with a low resistant floor.
	Conductivity	High conductive area on west edge of survey		Monument walkway	
9: Open Area					
	Magnetometry	Dipole cluster		Open area	Two dipole clusters combined to better reflect open activity area in center of the Fort.
	Electrical resistance	Linear low resistant anomalies		Unknown structure walls	Corresponds with area of higher magnetic susceptibility.
	Magnetic susceptibility	High susceptible area		Unknown structure	Corresponds with linear low resistant anomalies
10: Monument and Walkway					
	Magnetometry	Large dipole anomaly		Monument plaque	
	Electrical resistance	Survey gap		Monument Walkway	Electrical resistance data not collected over monument walkway.

Table 2: Area A Anomaly Interpretations – Northern Fort. Low and high measurements are compared to the average background reading. The average magnetism in the entire magnetometry survey is -5.89 nT. The average resistance for the 2007 survey is 0.0002 ohms, while the average resistance of the 2012 survey is 0.019 ohms.

Many of the geophysical anomalies correspond to the known positions of structures on historic maps and images, in addition to exhibiting characteristics that appear to indicate the building and construction types described in historic documents. Other anomalies point to evidence of structures not marked on maps. The presence of these unknown structures points to construction and remodeling during the Fort's occupation in order to fit the needs of the residents. Using the historic maps as a reference, potentially unknown structures can be identified based on anomalies that do not appear to correspond to the known locations of structures. Two unknown structures are discussed here, followed by a discussion of anomalies likely relating to the sawmill and horse work shed. Appendix E contains both Maximilian's 1833 map and the 1855 military inventory map distorted to approximately fit the final anomaly interpretations.

Unknown Structures

Two unknown structures are located within Anomaly Group 4 (Figure 31), near the west palisade. Anomalies are present at this location in both the magnetometry and electrical resistance. The higher magnetic anomalies correspond to the locations of higher resistant anomalies in the electrical resistance data (Figure 33:4). To the northwest of each higher resistant anomaly is an area of lower resistance. A pattern of a higher resistant anomaly surrounding a low resistant anomaly is common for structures within the Fort. These anomalies do not directly correspond to structures on the 1855 maps. Maximilian's 1832 map (Figure 5) indicates a long north-south structure extending closer to the blockhouse, although the 1832 map is much less detailed than later maps. It is possible that additional structures were present at this location early in the Fort's occupation and were dismantled during later Fort renovations. These structures may have had packed earth floors which would cause similar anomalies between the two structures in the

geophysics. A second possibility is that these structures are in fact marked on the historic maps and actually relate to the Manager's house. Turnely's 1855 map (Figure 7) and Behman's 1854 painting (Figure 6) places the manager's house much closer to the western quarters.

Sawmill and Horse Work Shed

Two areas of higher magnetism are visible near the north palisade (Figure 31:5). The northern anomaly is set right up against the palisade, while the southern anomaly is located near a long linear cluster of dipolar anomalies. Both of these anomalies correspond to higher resistant anomalies in the electrical resistance. According to the 1854 and 1855 maps, a long low shed containing the sawmill was set against the palisade at this location, with a non-rectangular shed directly to the south of the west end of the long shed. The 1855 military inventory describes this shed as an "irregular shed house covered with old shingles, conical roof, supported on seven posts in the ground, used for sheltering horses working in the mill," (De Land 1902:349). Two clusters of dipolar anomalies surround the areas of higher magnetism, likely associated with the sheds at this location. A small open area in the center of the two clusters of metal between the two sheds is possibly an open use area kept clear of tools and debris. If the northern anomaly is the west end of the sawmill shed, then either the southern shed is incorrectly located on the maps or an additional structure was present at this location at some point in the Fort's occupation.

It is also possible that the higher magnetic anomaly along the palisade is not the location of the west end of the long shed, but an activity area west of the long shed. Identifying the fence line to the west visible in both maps (if present) would resolve this issue. The fence line is not visible in the magnetometry surveys. Linear anomalies to the south are likely foundation lines of a building which outline a cluster of dipolar anomalies. According to the 1855 maps, this structure was a

storage building and the center of trade for the fort during the fur trading period.

Higher resistant anomalies are present in the same location as the higher magnetic anomalies discussed above (Figure 33:5). The southern anomaly corresponds with a depression visible on the surface at the site. While it might be expected that moisture would collect in the depression resulting in lower electrical resistance, this appears not to be the case. The depression may be draining better than the surrounding soil, causing higher resistance as in the palisade builder's trench. An additional low resistant anomaly surrounded by higher resistant linear features is located to the west corresponding to the area clear of dipolar anomalies in the magnetometry. This second anomaly group does not match the electrical resistance pattern of structures elsewhere in the Fort, possibly indicating a different method of construction for this structure. Based on the 1854 and 1855 maps, the second anomaly group is likely to be the non-rectangular shed that lines up with the west end of the sawmill shed. A line of higher resistance separates the non-rectangular shed from the root cellar, possibly indicating the fence line visible on the maps. If the fence was constructed using a builder's trench to set the posts, it is possible that the trench will drain moisture more easily than the surrounding soil resulting in higher resistance. Additional high areas of resistance are present against the palisade to the east and are the result of excavation units. The excavation units display high and low electrical resistance values (typically in the 1.0 to 3.0 ohm and the -0.5 to -1.0 ohm ranges) which is different from the electrical resistance of archaeologically caused anomalies.

Area B-Southern Fort

Area B encompasses anomalies within and near the southern area of the Fort that represent the palisade, structure walls and floors, metal clusters, and post holes (Figure 35 and Figure 37). The 2007 survey covered the main area of the Fort with both magnetometry and electrical

resistance. The area immediately south of the Fort was covered only with magnetometry in 2007. A limited area of Area B was covered with magnetic susceptibility (Figure 28) and conductivity (Figure 29). A close-up of Area B magnetometry is presented in Figure 34, with interpretations in Figure 35. Electrical resistance is presented in Figure 36 with interpretations in Figure 37. Groups of anomalies are identified by numbers in the above mentioned figures. Table 3 provides a summary list of anomalies within anomaly groups and their interpretations. Specific anomalies of interest are discussed following the table.

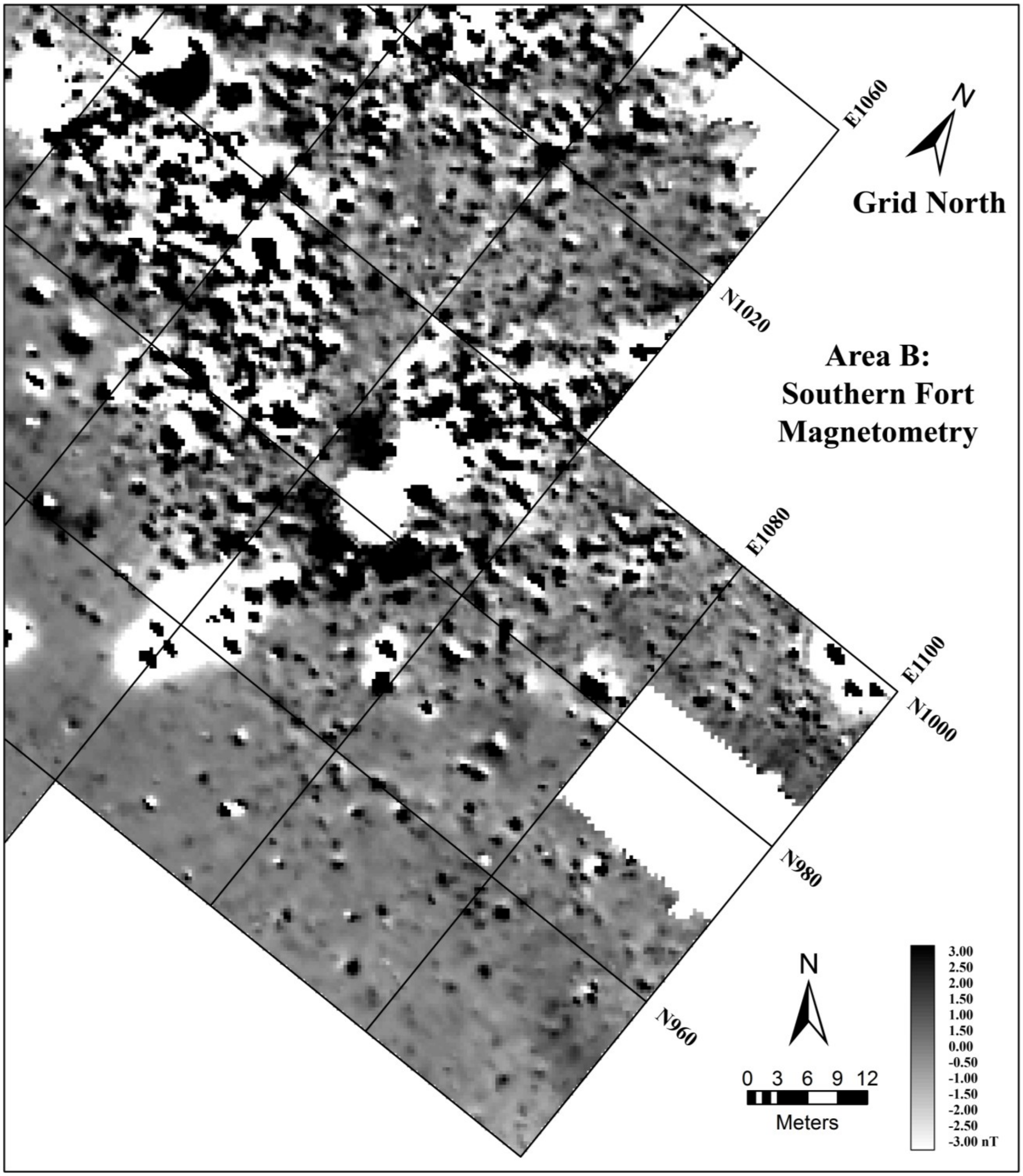

Figure 34: Area B-Southern Fort Magnetometry

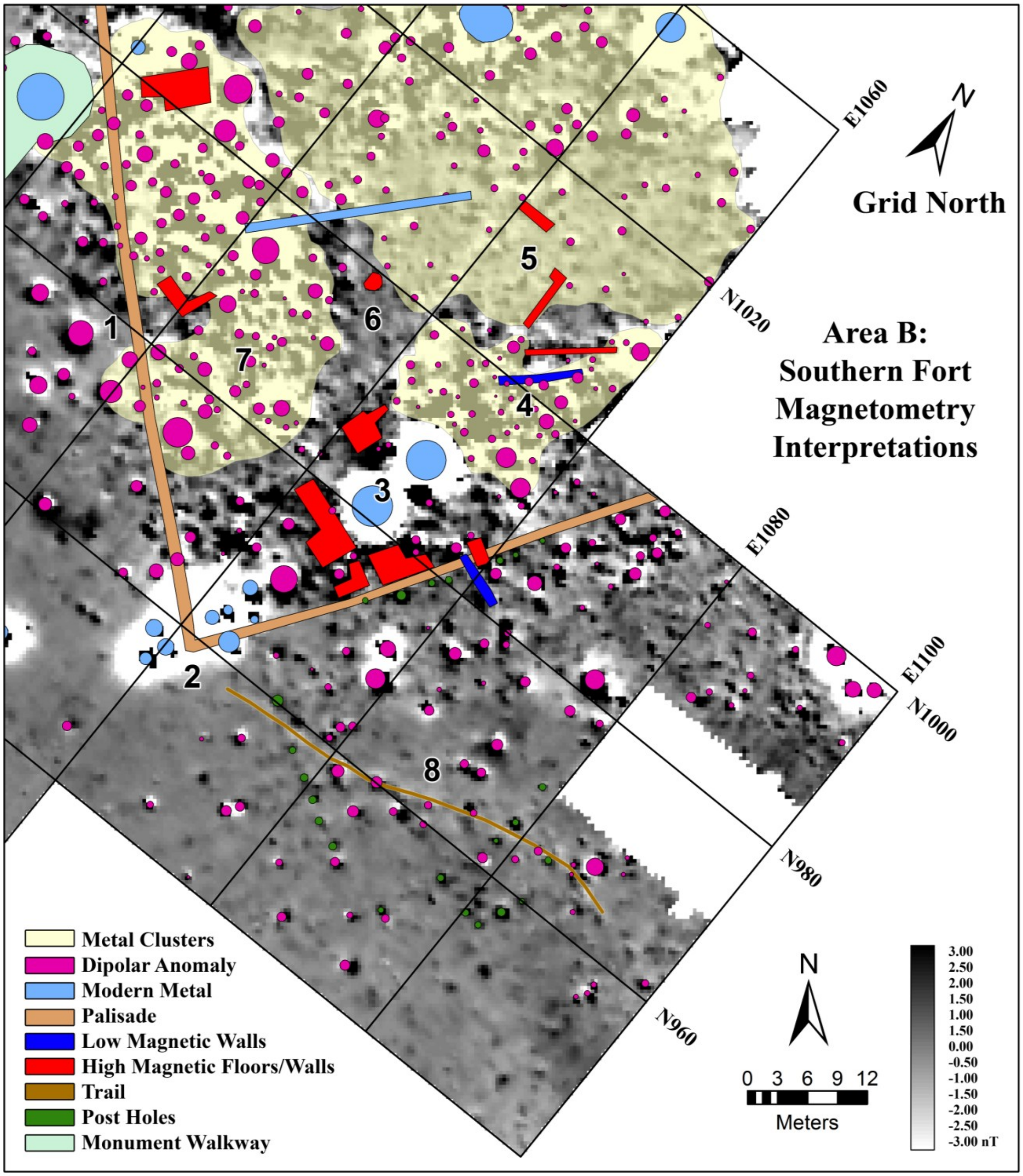

Figure 35: Area B-Southern Fort Magnetometry Interpretations. 1 – West Palisade, 2 – Southwest Palisade Corner and South Palisade, 3 – Structures, 4 – Structure and Metal Cluster, 5 – Structure, 6 – Open Area, 7 – Structures and Metal Cluster, 8 – Garden Fence and Trail.

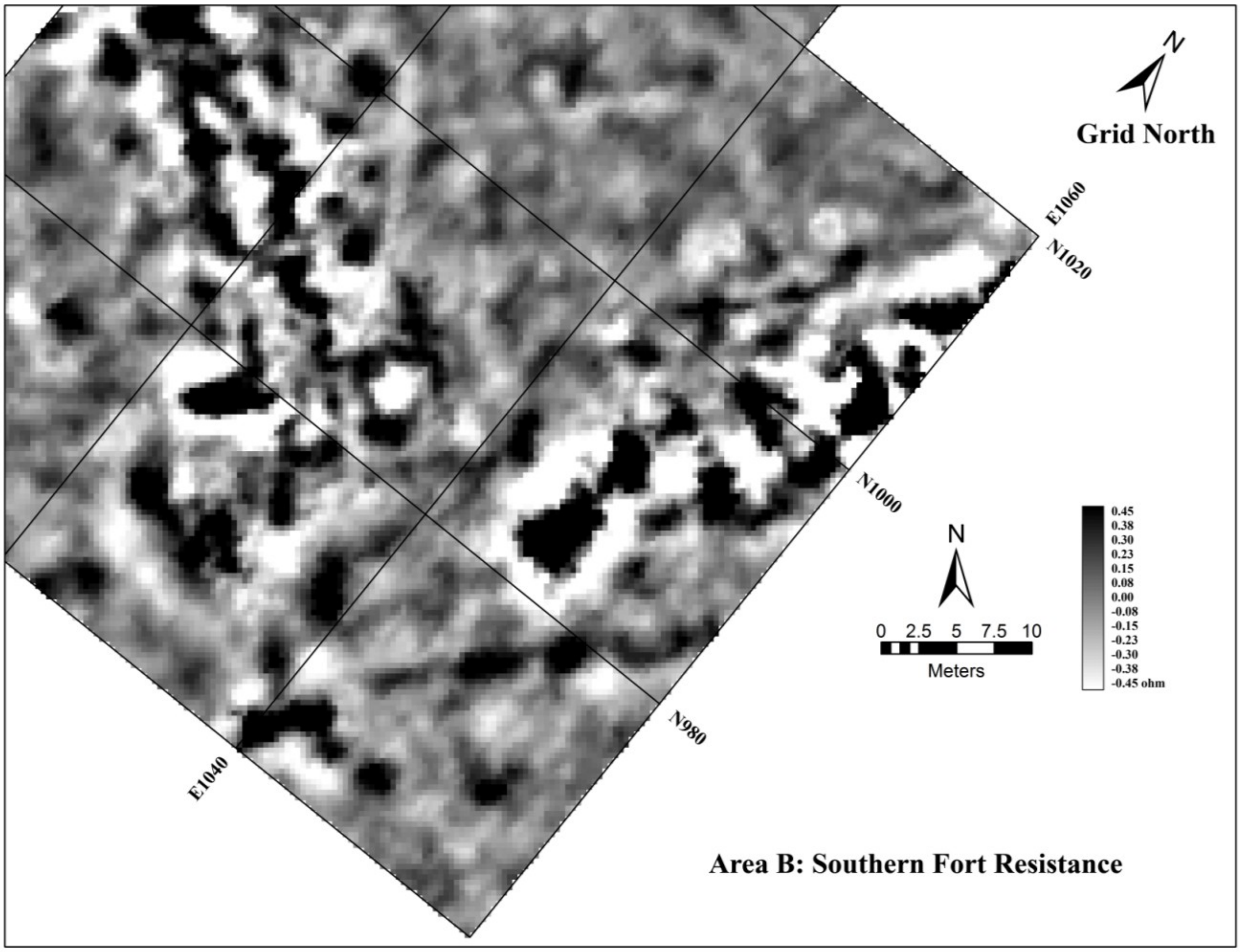

Figure 36: Area B-Southern Fort Electrical resistance

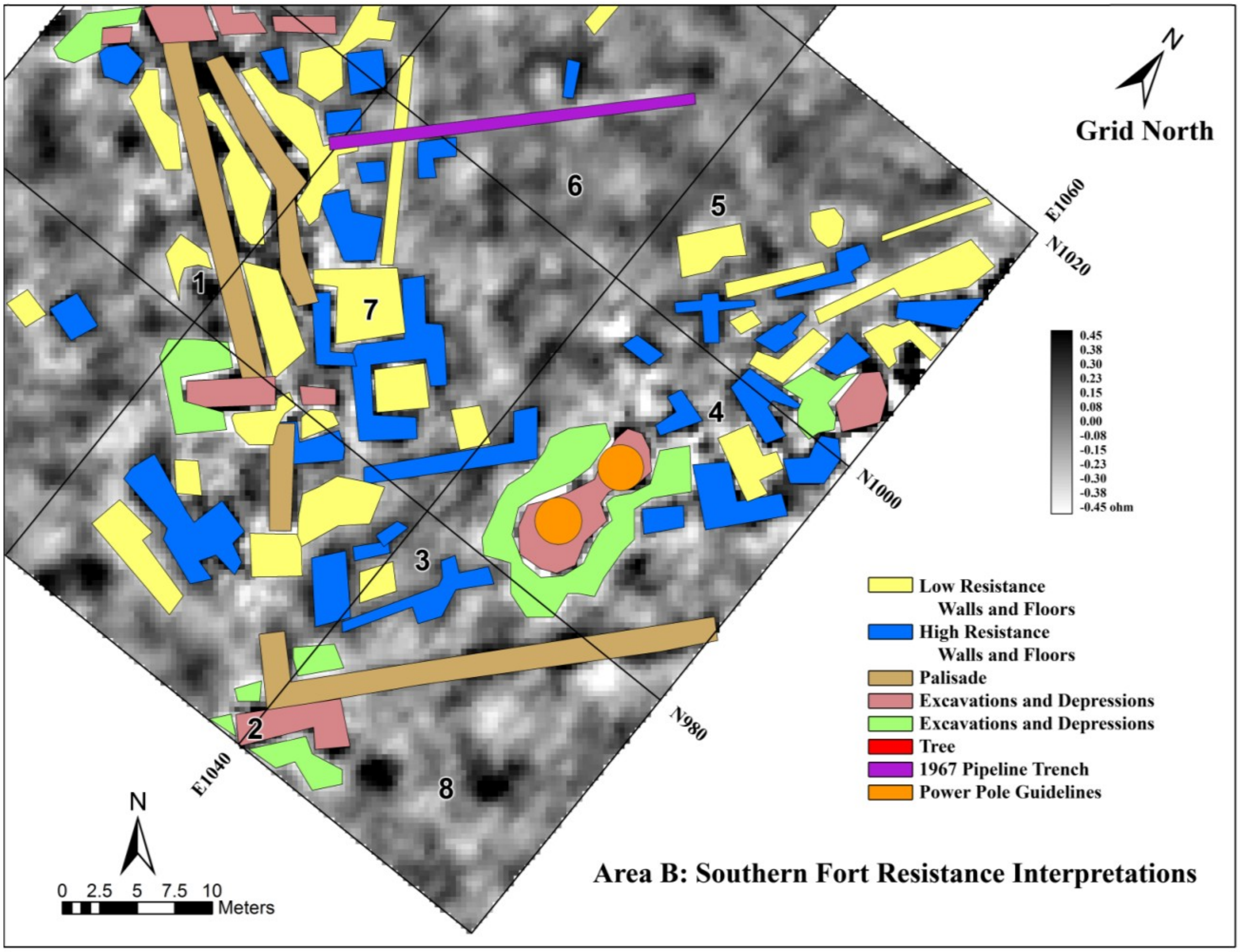

Figure 37: Area B – Southern Fort Electrical resistance Interpretations. 1 – West Palisade, 2 – Southwest Palisade Corner and South Palisade, 3 – Structures, 4 – Structure and Metal Cluster, 5 – Structure; 6 – Open Area, 7 – Structures and Metal Cluster, 8 – Garden Fence and Trail.

Table 3: Area B Anomaly Interpretations – Southern Fort					
Anomaly Group	**Survey**	**Types**		**Interpretation**	**Notes**
1: West Palisade					
	Magnetometry	Dipolar anomaly cluster			Obscures palisade line
	Electrical resistance	High resistant linear anomalies		Palisade builder's trench	Less water and/or more soil compaction than surrounding soil. Multiple linear anomalies may indicate multiple constructions of the palisade.
	Electrical resistance	High resistant anomaly intersecting palisade		Excavation trench	Similar pattern to excavations and depressions elsewhere on the site.
	Electrical resistance	Low resistant anomaly intersecting palisade		Excavation trench	Similar pattern to excavations and depressions elsewhere on the site.
	Electrical resistance	Low resistant linear anomalies			Parallels the palisade builder's trench.
2: Southwest Palisade Corner and South Palisade					
	Magnetometry	Dipolar anomalies		Excavation units	Metal left behind in excavation units
	Magnetometry	High magnetic circular anomalies		Post holes	Likely located within palisade builder's trench
	Magnetometry	Lower magnetic linear anomaly		Gate/ Doorway?	Break in palisade line. Low magnetism could be cause by removal of topsoil from use
	Electrical resistance	High resistant anomaly intersecting palisade		Excavation units	Similar pattern to excavations and depressions elsewhere on the site.
	Electrical resistance	Low resistant anomaly intersecting palisade		Excavation units	Similar pattern to excavations and depressions elsewhere on the site.
	Electrical resistance	East-west high resistant linear anomaly		Palisade builder's trench	Parallels circular magnetic anomalies
3: Structures					
	Magnetometry	Dipolar anomaly Pair		Power pole anchors	

	Magnetometry	High magnetic anomaly		Storage building?	In same location as storehouse on 1855 map. May also be processing effects due to power pole anchors.
	Magnetometry	High magnetic anomaly		Storage building?	In same location as storehouse on 1855 map. May also be processing effects due to power pole anchors.
	Magnetometry	High magnetic anomaly		South quarters building	
	Electrical resistance	High resistant anomaly		Power pole anchors	Removal of soil to install power pole anchors. Similar pattern to excavations elsewhere on the site.
	Electrical resistance	Low resistant anomaly		Power pole anchors	Removal of soil to install power pole anchors. Similar pattern to excavations elsewhere on the site.
	Electrical resistance	Low resistant anomaly		Storage building floor	Paired with linear high resistant anomaly.
	Electrical resistance	Linear high resistant anomalies		Storage building walls	Paired with low resistant anomaly.
4: Structure and Metal Cluster					
	Magnetometry	Cluster of dipolar anomalies		South quarters	
	Magnetometry	Linear high magnetic anomaly		South quarters	
	Electrical resistance	Linear high resistant anomalies and high resistant areas		South quarters walls	High-low-high pattern may indicate different rooms with earth floors. The complex pattern may be due to the dismantling of the building.
	Electrical resistance	Linear low resistant anomalies and low resistant area		South quarters floors	High-low-high pattern may indicate different rooms with earth floors. The complex pattern may be due to the dismantling of the building.
	Electrical resistance	High resistant anomaly		Excavation units	Similar pattern to excavations and depressions elsewhere on the site.

	Electrical resistance	Low resistant anomaly		Excavation units	Similar pattern to excavations and depressions elsewhere on the site.
5: Structures					
	Magnetometry	Linear high magnetic anomalies		Unknown structure	Set at an angle to the south quarters to not likely to be associated with that structure.
6: Open Area					
	Magnetometry	Dipolar anomaly cluster		Fort open area	Fewer dipolar anomalies than near structures
	Magnetometry	Circular high magnetic anomaly		Burned area?	Similar to Anomaly 2 in Area C. May be a burned area but there are no confirmed burned areas visible in the magnetometry
	Electrical resistance	East-west linear low resistant anomaly		1967 pipeline trench	First identified by Kvamme (2008)
	Electrical resistance	North-south linear low resistant anomaly		West quarters	Intersects pipeline trench. Likely related to west quarters as it has lower resistance than the pipeline trench.
	Conductivity	East-west linear low conductive anomaly		1967 pipeline trench	First identified by Kvamme (2008). Located slightly north of east-west linear low resistant anomaly. May be evidence of heaped earth from the trench during excavation.
7: Structures and Metal Cluster (North half of this area discussed in Table 2, Area A)					
	Magnetometry	Dipolar anomaly cluster		West quarters	Odd cluster shape may be due to the combination of debris fields of the three connected buildings indicated at this location on the 1855 map.
	Magnetometry	High magnetic anomaly		West quarters wall	Forms a 90 degree angle. Likely the southwest corner of the main quarters building.
	Electrical resistance	Linear high resistant anomalies		Quarters and office walls	
	Electrical resistance	Low resistant anomalies		Quarters and office floors	
	Magnetic susceptibility	Linear high magnetic susceptibility anomaly		Unknown structure	Does not appear to correspond to west quarters and office buildings

	Magnetic susceptibility	Dipolar anomalies		Metal	Debris field from buildings
	Conductivity	Large area of low conductivity		Offices	
8: Garden Fence and Trail					
	Magnetometry	Circular high magnetic anomalies		Post holes	Post holes may form part of a fenced enclosure for either a garden or animal corral.
	Magnetometry	Linear low magnetic anomaly		Trail	Trail use can erode magnetically enriched topsoil leaving a linear low magnetic signature.

Table 3: Area B Anomaly Interpretations – Southern Fort. Low and high measurements are compared to the average background reading. The average magnetism in the entire magnetometry survey is -5.89 nT. The average resistance for the 2007 survey is 0.0002 ohms, while the average resistance of the 2012 survey is 0.019 ohms.

Anomalies in the Southern Fort area correspond to buildings marked on maps from the military period of the Fort.

South Quarters

Dipolar anomalies in this area form a cluster identified in the cluster analysis. The metal cluster, along with a linear anomaly of higher magnetism, defines the area of a structure at this location (Figure 35:4). Maximilian's 1832 map indicates the presence of a long building serving as employee quarters along the south palisade. Later maps and images also show the employee quarters, and Culbertson describes this building as a seven room building covered with a dirt roof (1952:76). The dirt roof could cause increased magnetism at the edges of the building due to the erosion of magnetically enriched topsoil off of the roof. A higher magnetic anomaly to the west could be the end of the building. The metal cluster is likely caused by debris from the dismantling of the building in 1856 or possibly metal artifacts lost during the Fort's occupation.

Electrical resistance indicates multiple high and low resistant anomalies in this area (Figure 37:4). While the anomaly pattern is complex, linear anomalies to the north define the extent of the north wall line of the building. Generally, anomalies here display a high-low-high pattern, possibly indicating the presence of specific rooms. Low resistant areas would indicate the presence of floors, with high resistant areas indicating walls.

Electrical resistance is also higher and lower in this location than in other areas of the Fort, ranging from ~0.6 to 2.6 ohms and ~ -0.3 to -1.0 ohms. One specific pair of high and low resistance fits the extreme end of these ranges. Using the electrical resistance pattern of excavations elsewhere in the Fort, it is likely that digging occurred here at some point. The 1997-2001 excavations did not have units at this location. While the 1980-1981 excavation map is not able to be georectified due to the lack of ground control points, the units shown on this map appear to

intersect the palisade at this approximate location. Extending the electrical resistance survey to the east would cover the east end of the building and help provide a more complete picture of this area, including the identification of additional excavation units.

West Quarters

The West Quarters, Clerk's Office, and Clerk's Quarters was divided in half by the division between Area A and Area B. Anomalies relating to the north end of the West Quarters building are described in Table 2 above, while anomalies relating to the south end of the building and the additional buildings are described in Table 3. A full discussion of all the anomalies relating to these buildings is included here.

According to 1832 and 1855 maps, a long building with an attic served as living quarters at this location. In 1850, Culbertson (1952:76) indicates that this building is where the kitchen and mess hall is located in addition to personal quarters, although the 1855 military inventory indicates the kitchens as a separate structure behind the quarters (De Land 1902:348-349). The details of the living quarters are not clear as Behman's 1854 Fort image and Sully's 1856 image each depict this building differently. In Figure 6, Behman shows a long white building with five red doors above a boardwalk. Each door has an adjacent window, and five dormer windows are present in the roof. A small red building is attached to the south end, again with a short boardwalk and a small shed to the west. Sully (Figure 9), while showing a white building with five red doors, only places three dormer windows in the roof, and shows two additional buildings at the south end. One of these buildings matches the red building depicted by Behman, but it does not appear to be attached to the main building. Sully depicts a small white building attached to the south end of the quarters. While the building may have been repainted or an additional construction completed, a window on the red building matches in both images. Turnley's 1855 map indicates two small structures at the

south end of the quarters building (Figure 7). The reported use of these two buildings varies depending on the year, and likely was changed throughout the Fort's occupation to reflect the needs of the American Fur Company and/or military. Culbertson describes the building to the south closest to the palisade as the clerk's house, with the building attached to the end of the quarters as an office (1952:76). Turnley's 1855 map labels both smaller buildings as quarters, with the kitchens located at the north end of the building next to the palisade (De Land 1902:348-349).

Two clusters of dipolar anomalies were identified by cluster analysis near the west palisade (Figure 31:8). There is not a clear visual distinction between the two clusters. The two clusters were combined into a single metal cluster due to a lack of a clear separation along with the Fort maps indicating a single long building at this location. A higher magnetic anomaly, partially obscured by dipolar anomalies, is present at the north end of the cluster, while a second higher magnetic anomaly that forms a 90 degree angle is located near the south end of the metal cluster.

The higher magnetic corner may form the southwest corner of the main long building. Subdividing the full metal cluster in this area into one larger cluster and two additional smaller clusters to the south would fit the pattern indicated on the 1885 map and 1856 image. There may be other areas of higher magnetism present which are covered up by the multiple dipolar anomalies. The high concentration of metal may indicate debris from when the Fort was in use or from dismantling the structures at the end of the military period, although the increased metal near the palisade in the south corner of the cluster is likely metal left behind from the excavation trench that intersected the palisade wall.

High resistant anomalies clearly outline areas of low resistance at the south end of this anomaly group (Figure 37:7), while low resistant areas to the north (Figure 33) do not clearly define rectangular rooms. However, the pattern of low-high-low-high follows with the idea of a

structure with multiple rooms, each with an outside entry, matching the description of the long building marked at this location on the Fort maps. The end of the long building, along with the two additional smaller buildings, is visible in the electrical resistance. The larger block of low resistance surrounded by higher resistant linear anomalies is likely the end of the long building containing the living quarters. The smaller two areas of low resistance are likely the office and clerk's quarters in the fur trading period and living quarters in the military period. An excavation trench intersects the palisade wall and is visible in the electrical resistance as higher and lower resistance areas, although not as distinct from the anomaly signature of the palisade wall at this location.

Magnetic Susceptibility of this area reveals several dipolar anomalies, and a linear anomaly of slightly high magnetic susceptibility (Figure 28:7). The palisade line is visible as a higher susceptible linear anomaly. Enhancement of magnetism can be caused by decomposition of organic material, and in this case may be caused by the breaking down of post bases within the trench. Several prominent dipolar anomalies visible in the magnetometry are also visible in the magnetic susceptibility. An area of higher magnetic susceptibility is located east of the palisade, possibly reflecting the higher magnetic area visible underneath the dipolar anomalies in the magnetometry. Linear anomalies of higher magnetic susceptibility are perpendicular to the palisade line. A linear anomaly that crosses the palisade is likely the result of an excavation trench. Conductivity at the south end of the structure shows a large area of lower conductivity beneath the approximate locations of the two south buildings (Figure 29:7).

Area C-Northwest Blockhouse and Ephemeral Stream

Area C encompasses anomalies that represent the northwest blockhouse, a possible structure and burned area, and the ephemeral stream channel north of the Fort (Figure 39). This

area was surveyed only using magnetometry in 2007. A close-up of Area C magnetometry is presented in Figure 38, with interpretations in Figure 39. Table 4 provides a summary list of anomalies within anomaly groups and their interpretations. Specific anomalies of interest are discussed following the table.

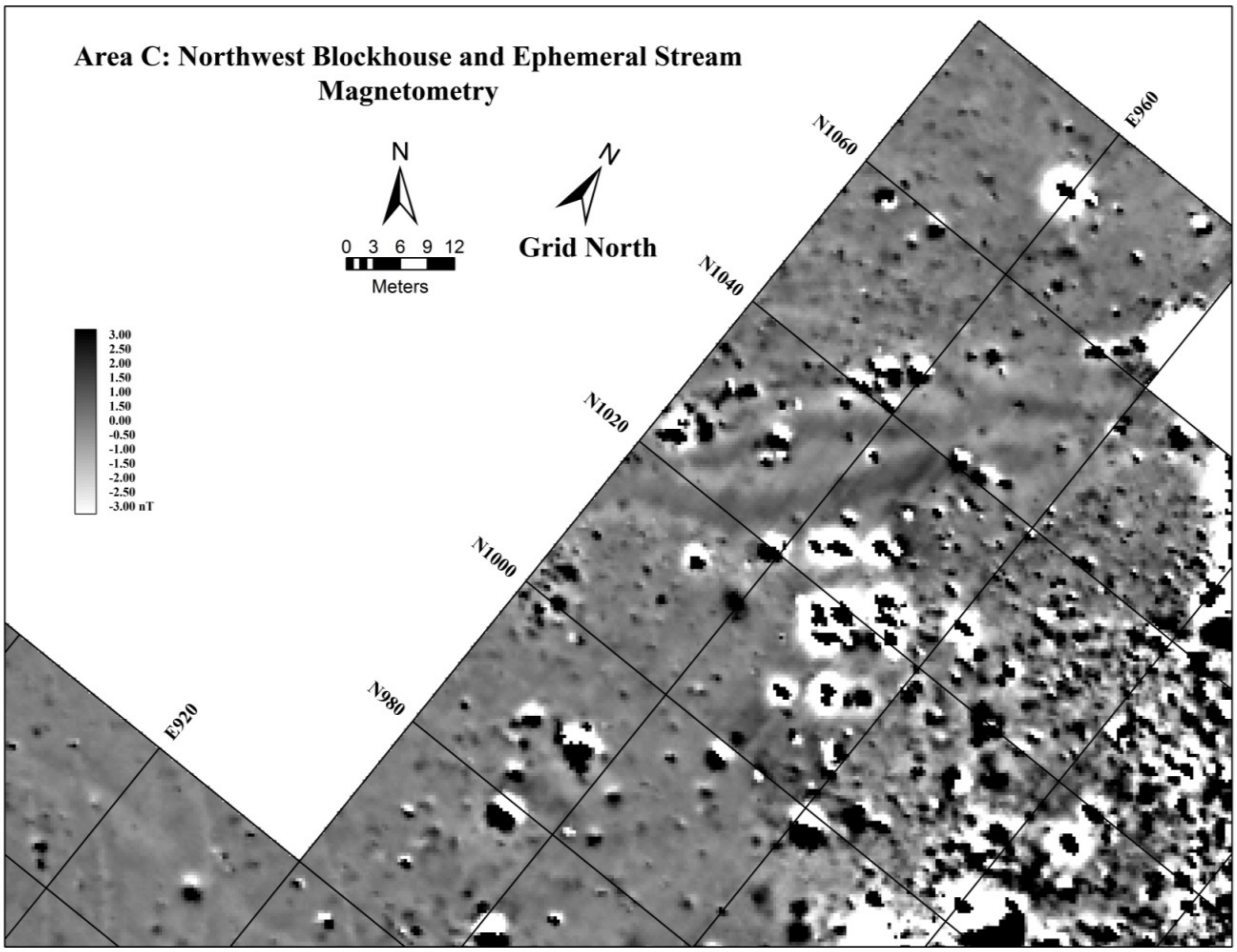

Figure 38: Area C-Northwest Blockhouse and Ephemeral Stream Magnetometry

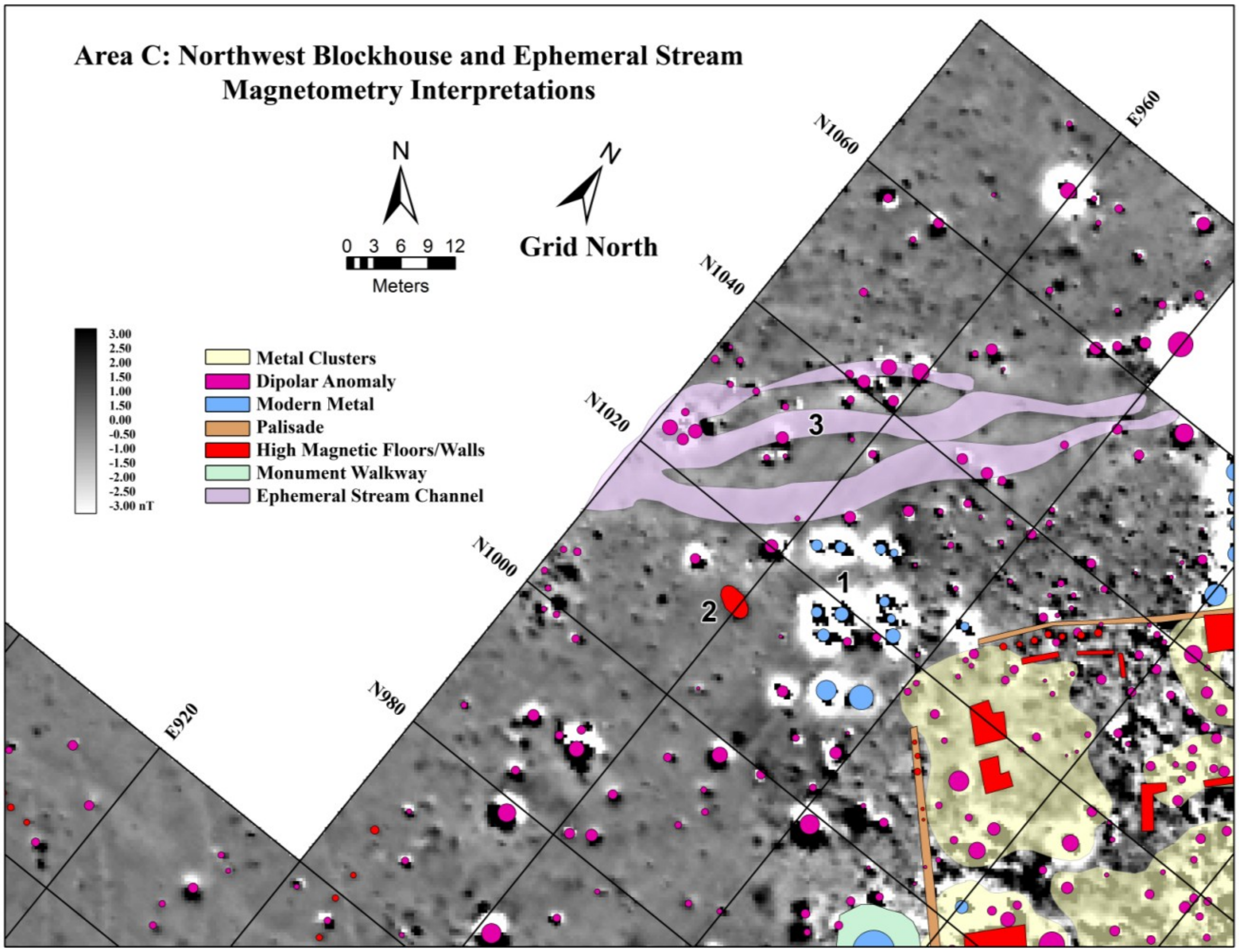

Figure 39: Area C-Northwest Blockhouse Magnetometry Interpretations. 1 – Northwest Blockhouse, 2 – Burned Area, 3 – Ephemeral Stream.

Table 4: Area C Anomaly Interpretations – Northwest Blockhouse and Ephemeral Stream					
Anomaly Group	**Survey**	**Types**		**Interpretation**	**Notes**
1: Northwest Blockhouse					
	Discussed in Area A – Northern Fort. See Table 2.				
2: Burned Area					
	Magnetometry	Oval shaped high magnetic anomaly		Burned area?	Similar to Anomaly 6 in Area B. May be a burned area but there are no confirmed burned areas visible in the magnetometry.
3: Ephemeral Stream					
	Magnetometry	High magnetic anomaly		Ephemeral stream	Not visible in aerial imagery, but visible at the site as a shallow stream bed. Stream bed was dry in August 2012.

Table 4: Area C Anomaly Interpretations – Northwest Blockhouse and Ephemeral Stream. Low and high measurements are compared to the average background reading. The average magnetism in the entire magnetometry survey is -5.89 nT.

Outside of the Fort in Area C, the most visible anomaly is the streambed channel (Figure 38:3). Dipolar anomalies present in this area outside the Fort and are likely related to activities during the Fort's occupation. A potential burned area is located close to the location of the northwest blockhouse.

Burned Area

An oval-shaped anomaly with higher magnetism (~3.0 to 6.2 nT) does not appear to be associated with any Fort structures or activities marked on historic maps (Figure 39:2). However, in Sully's 1856 watercolors (Figure 9 and Figure 10), there appear to be buildings located close to the palisade just outside the Fort that are not the military portable cottages. Sully's "Inside Fort Pierre" (Figure 9) does depict a red wall with an apparent window outside the Fort at this location. While this structure is not marked on any maps, it is possible that it was the location of the sutler's store present during the military period due to its proximity to the Fort and the portable cottages. This anomaly may be a burned area from a hearth or campfire external to the Fort and related to the building in Sully's images.

Area D-Fort Main Field

Area D encompasses anomalies that represent one of the military barracks, north/south lines, possible trails, and the monument walkway (Figure 41). Combination of the 2007 and 2012 magnetometry surveys completely covered this area of the site. The 2012 electrical resistance survey covered a small portion of this area as detailed in Figure 16. A close-up of Area D magnetometry is presented in Figure 40, with interpretations in Figure 41. Electrical resistance is presented in Figure 42 with interpretations in Figure 43. Groups of anomalies are identified by numbers in the above mentioned figures. Table 5 provides a summary list of anomalies within anomaly groups and their interpretations. Specific anomalies of interest are discussed following the table.

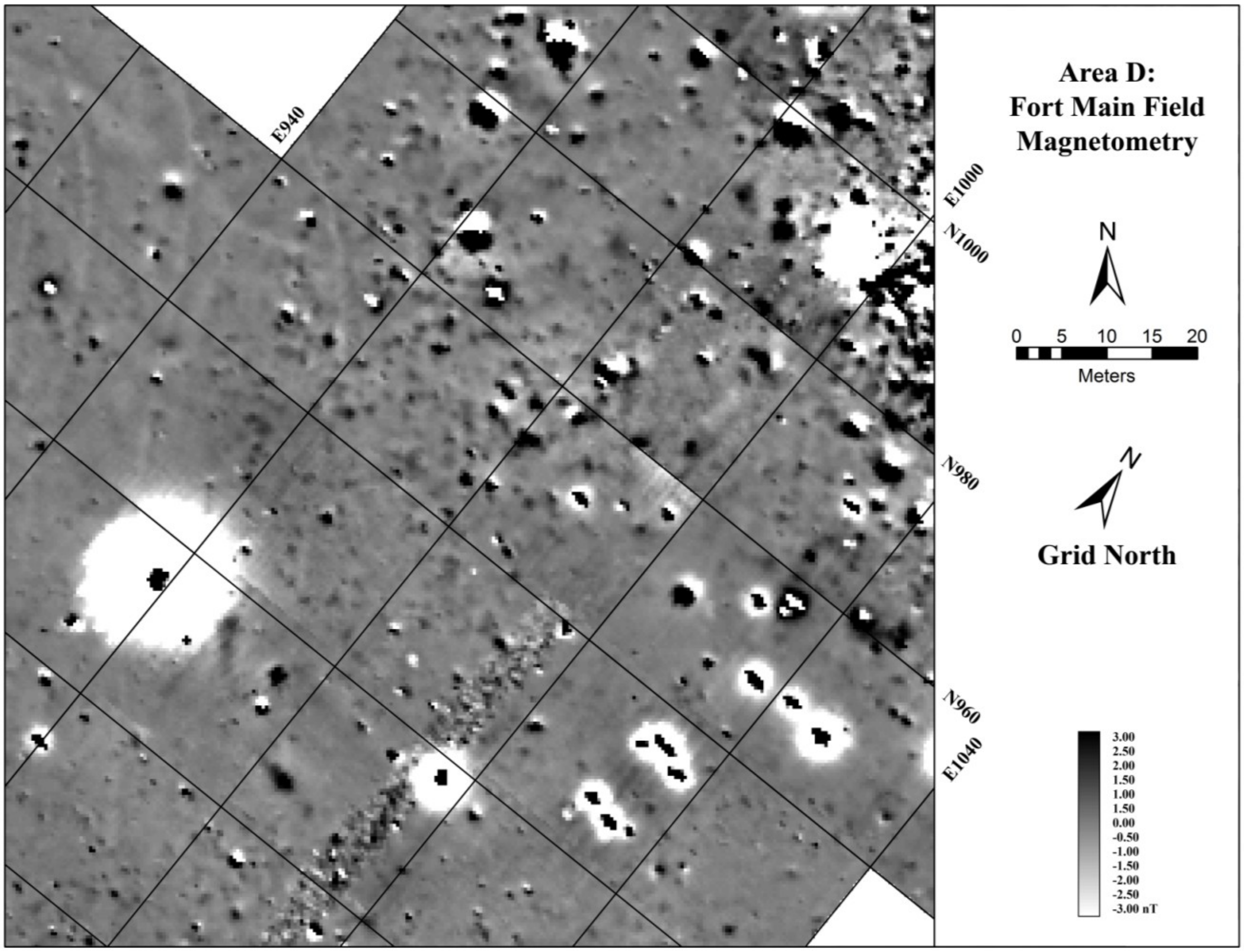

Figure 40: Area D-Fort Main Field Magnetometry

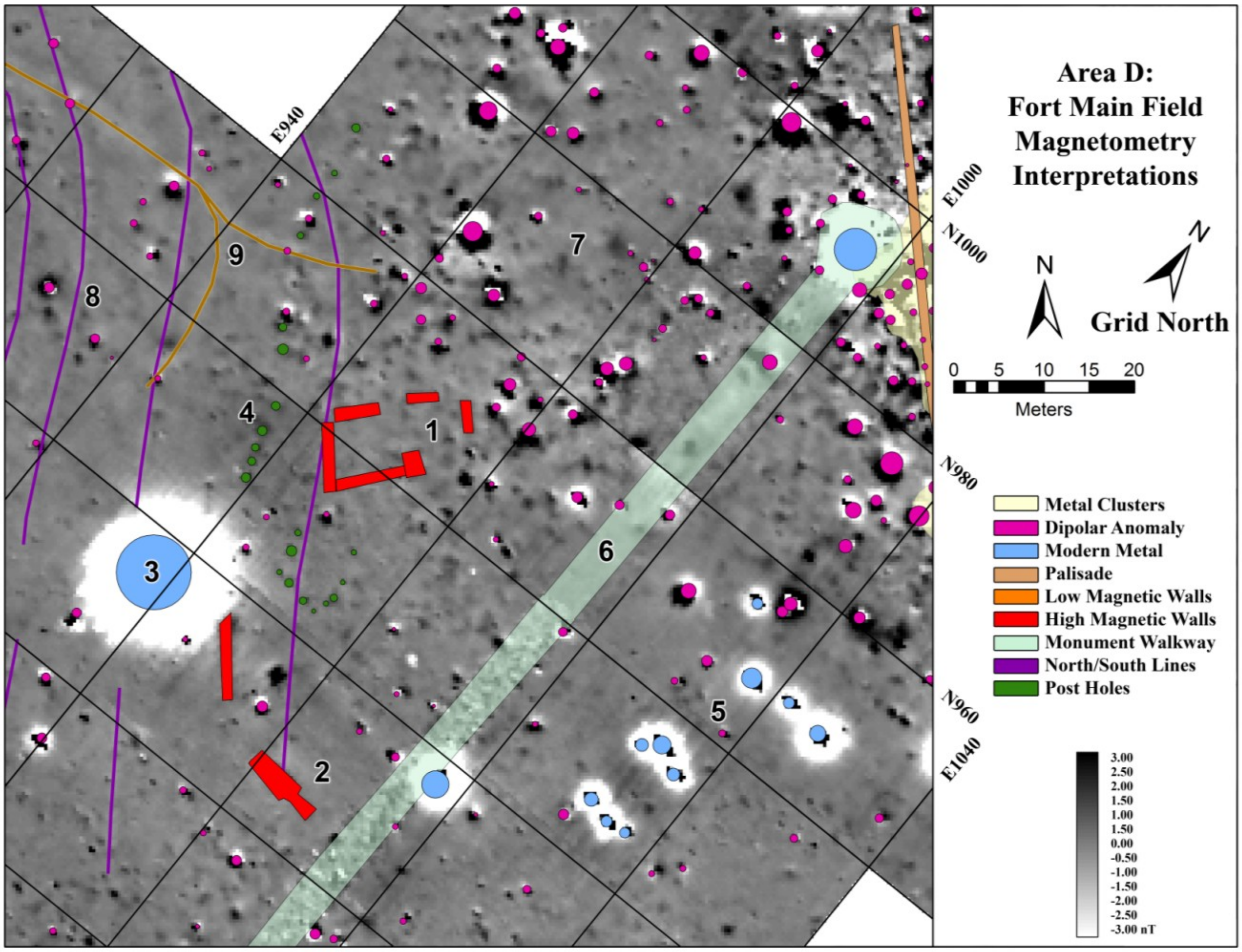

Figure 41: Area D-Fort Main Field Magnetometry Interpretations. 1 – Military Barracks, 2 – Possible Windbreak, 3 – Modern Power Pole and Electric Box, 4-Post Holes, 5 – Modern Agricultural Debris, 6 – Monument Walkway, 7 – Fort Field, 8 –North/South Lines, 9 – Trail.

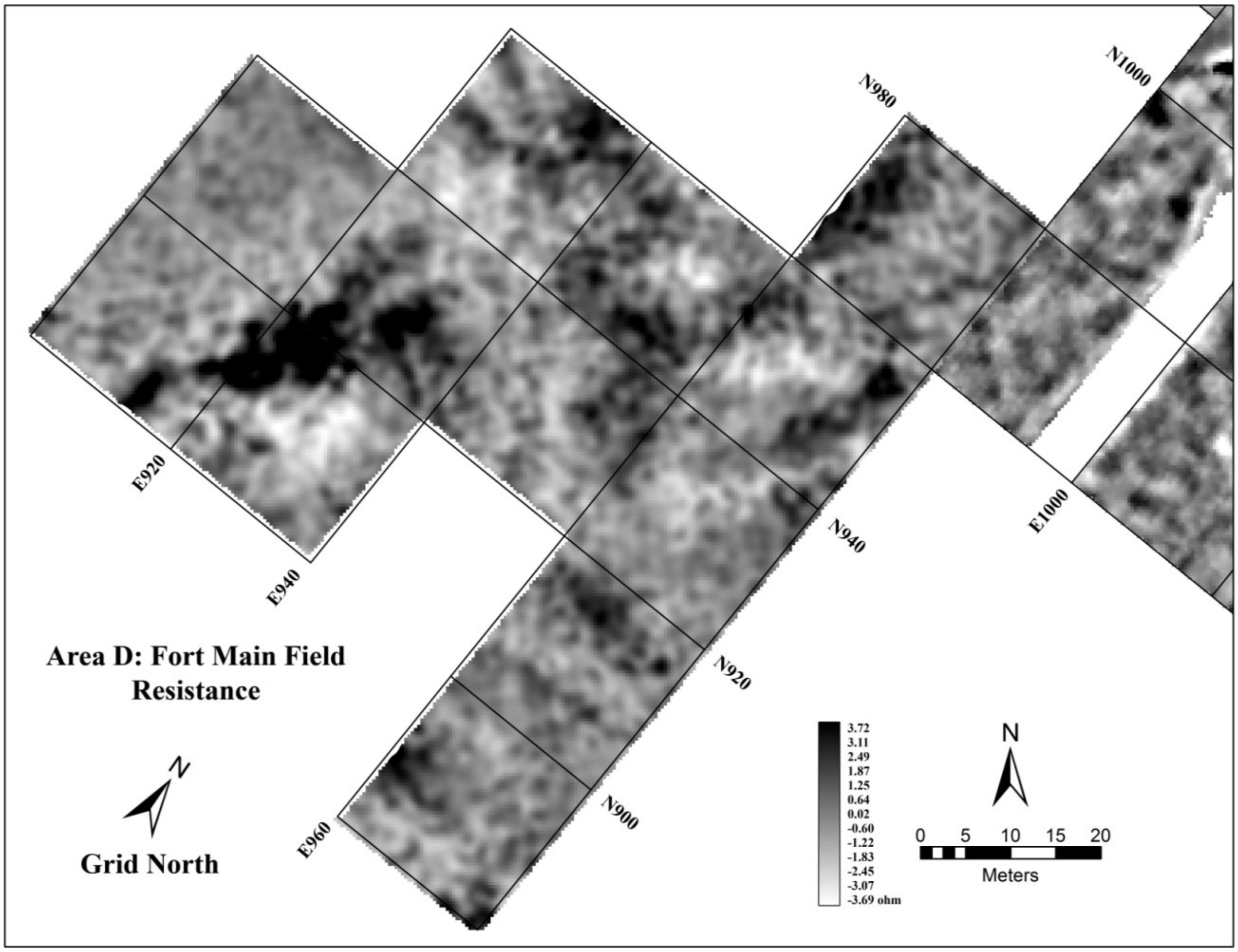

Figure 42: Area D Fort Main Field Electrical Resistance

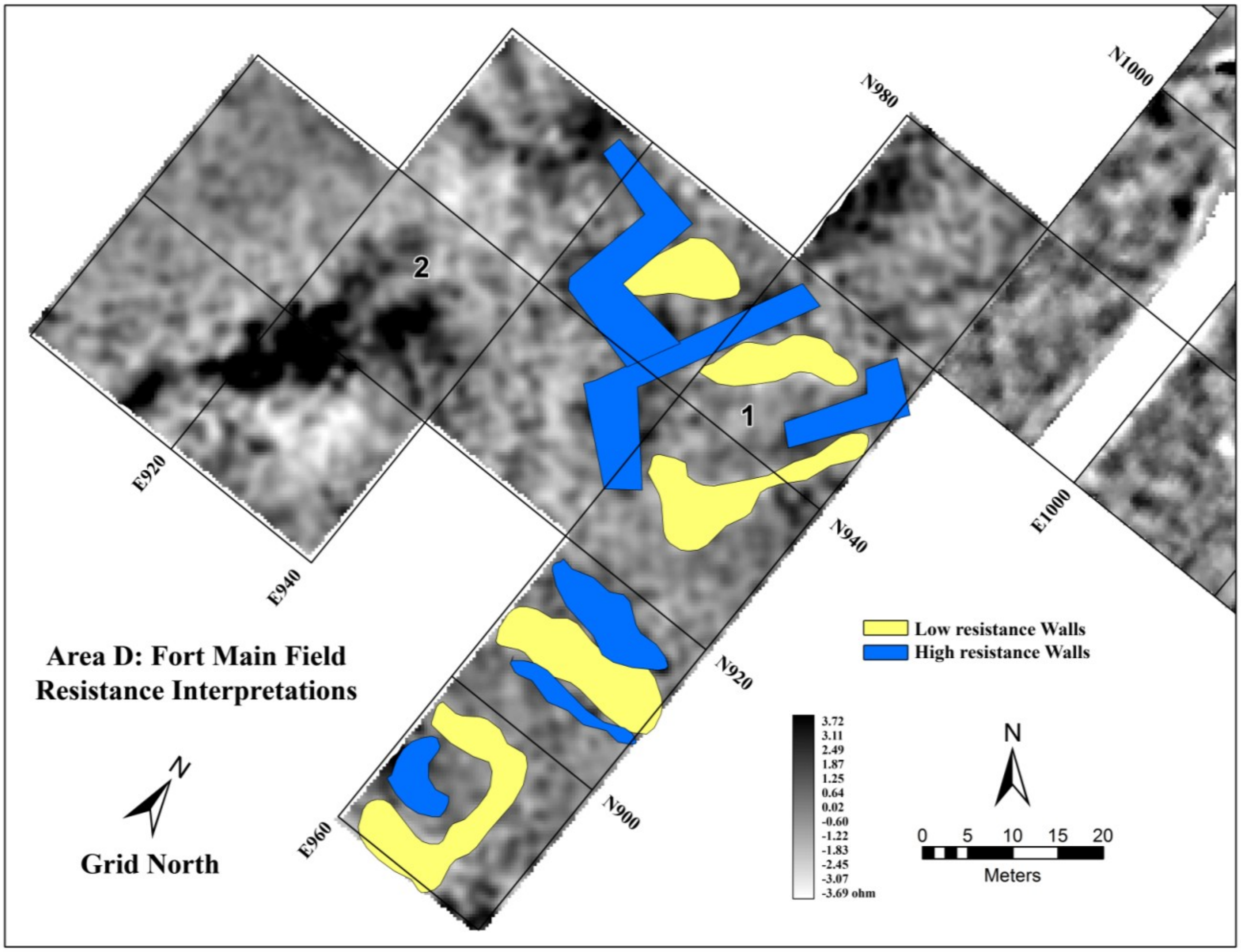

Figure 43: Area D-Fort Main Field Electrical Resistance Interpretations. 1 – Military Barracks, 2 – Unknown Structure.

Table 5: Area D Anomaly Interpretations – Fort Main Field					
Anomaly Group	**Survey**	**Types**		**Interpretation**	**Notes**
1: Military Barracks					
	Magnetometry	Linear high magnetic anomalies		Military Barracks supports	Corresponds to high and low electrical resistance anomalies. Approximate dimensions match the dimensions of the soldiers barracks in historic documents
	Magnetometry	Dipolar anomalies		Metal	Possible debris field from barracks or items from usage of the Fort field
	Electrical resistance	High linear anomaly		Earth berm	Earth heaped against the walls of the barracks to provide insulation
	Electrical resistance	Low linear anomaly		Earth berm	Earth heaped against the walls of the barracks to provide insulation
2: Unknown Structure					
	Magnetometry	Linear high magnetic anomaly		Unknown	May be related to military structures
3: Modern Power Pole and Electric Box					
	Magnetometry	Large dipolar anomaly		Power pole and electric box	Obstructs up to 20 meter radius around power pole and box due to extremely high readings
4: Post Holes					
	Magnetometry	Circular high magnetic anomalies		Post Holes	Post holes – may be related to military structures and the linear high magnetic anomaly above.
5: Modern Agricultural Debris					
	Magnetometry	Dipolar anomalies		Modern metal	Metal left during ranching period of the site, or metal related to the excavations of the southwest corner of the Fort.

6: Monument Walkway					
	Magnetometry	Mix of dipolar anomalies		Monument path	Gravel layer laid down after the 2007 survey making the path magnetically visible in the 2012 survey. The path is visible in the 2012 survey but not the 2007 survey.
	Magnetometry	Dipolar anomaly		Interpretive sign	Multiple interpretive signs have been installed along the path to the stone monument. Additional signs are located closer to the stone monument but were installed after 2007 and do not interfere with the 2007 magnetometry survey.
7: Fort Field					
	Magnetometry	Dipolar anomalies			Dipolar anomalies are scattered throughout the Fort field, although not as high of concentrations as in the vicinity of the Fort.
8: North-South Lines					
	Magnetometry	Linear low magnetic anomalies		Geologic origin? Cattle trails?	These roughly parallel north-south lines are also visible in the aerial photography.
9: Trail					
	Magnetometry	Linear low magnetic anomaly		Trail	Trails may be caused by the wearing away of magnetically enriched topsoil. Not visible in the aerial imagery like the roughly parallel north-south lines.

Table 5: Area D Anomaly Interpretations – Fort Main Field. Low and high measurements are compared to the average background reading. The average magnetism in the entire magnetometry survey is -5.89 nT. The average resistance of the 2012 electrical resistance survey is 0.019 ohms.

Military Barracks

Higher magnetic linear anomalies form a rectangle in the field west of the Fort. This anomaly is subtle, but the interior dimensions match the dimensions of one of the military barracks constructed during the military period. Turnley gives dimensions of the enlisted barracks as 40 feet by 18 feet which is approximately 12.2 meters by 5.5 meters (1892:128). Measuring the interior using the ruler tool in ArcMap gives approximate dimensions of 14.5 meters by 6 meters, making this likely the location of one of the enlisted men's barracks. The high magnetism may be due to the presence of posts that supported the structure above the ground. Dipolar anomalies scattered around the anomaly may be a debris field from the dismantling of the cottage for transport to Fort Lookout and Fort Randall. According to Sully's 1856 images, multiple barracks were assembled in a line facing the Fort's west palisade (Figure 9). Evidence of other cottages is not visible in the magnetometry survey, except for a potential group of circular anomalies to the south of the identified cottage. It would be expected that cottages constructed at similar times would show similar signatures in the geophysics, so the identification of the circular anomalies as a possible portable cottage is not definitive.

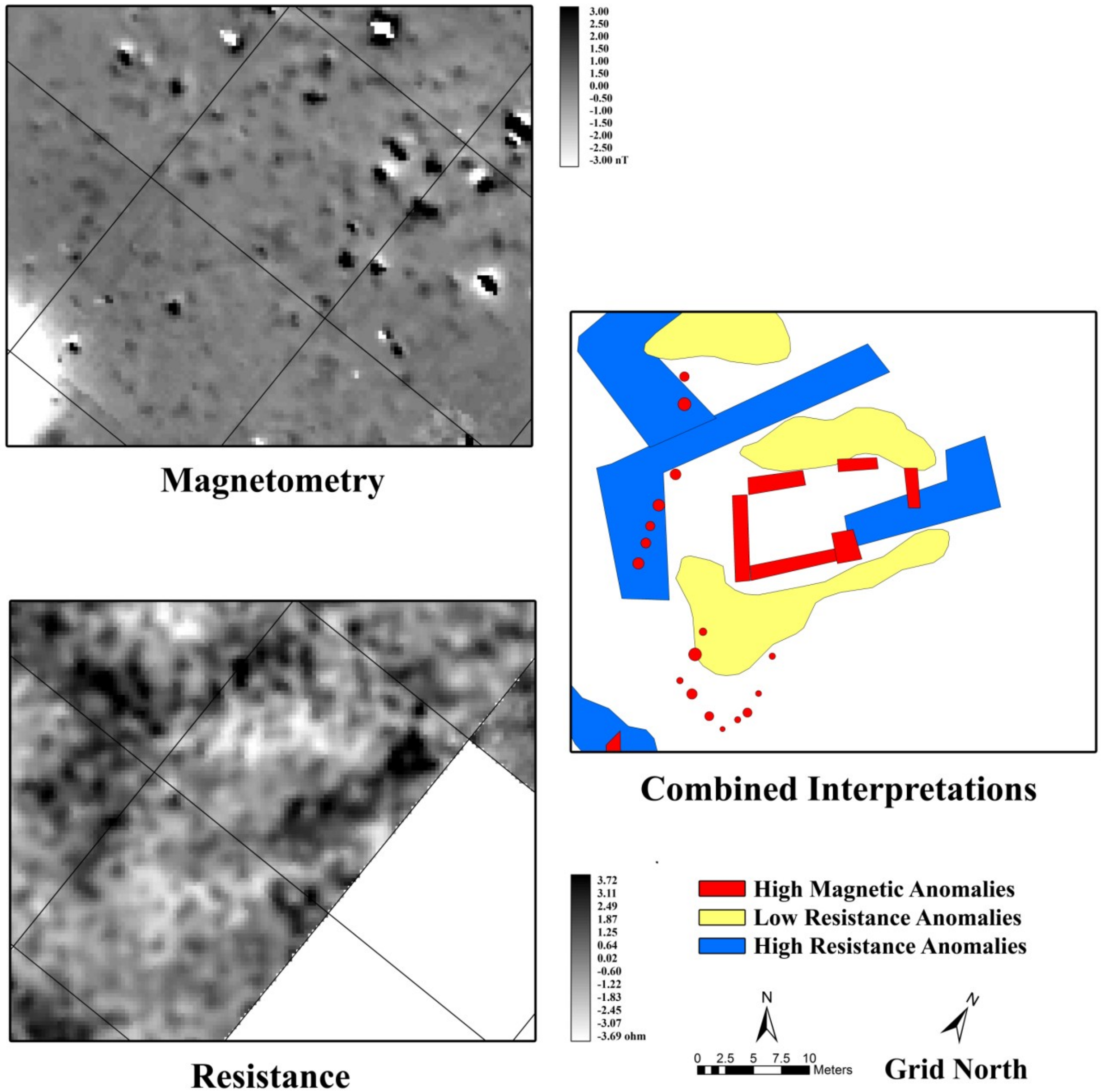

Figure 44: Close-up of magnetometry and resistance at military barracks.

Areas of high resistance form linear features in the same location as the cottage identified in the magnetometry, and areas of low resistance roughly outline the location (Figure 44). Historic records indicate that earth was heaped against the walls of the barracks for insulation, which could cause a difference in resistance due to soil compaction. The lower resistant anomalies cover a

larger area than the anomalies in the magnetometry due a combination of the heaping of the earth and the low resolution of the electrical resistance survey.

To the west and to the south, additional areas of high and low resistance are loosely defined, possibly indicating additional barracks locations. However, these are difficult to fully interpret as evidence of archeology due to the limited area and low resolution of the survey. This area of the site would benefit from more complete coverage with a higher resolution electrical resistance survey to define these potential anomalies.

Post Holes

Two higher magnetic anomalies appear to form a curve around the area of the military barracks (Figure 41:2). The northern end of this curve resolves into circular anomalies near the identified barracks. It is not clear if these circular anomalies relate to the other anomalies to the south or if they are a separate entity. Because similar circular anomalies elsewhere on the site are known to be post holes, it is likely that these anomalies are also post holes as they exhibit the same shape and magnetism (~1.5-2.0 nT). These anomalies may be related to the portable cottages, but their exact association is unknown. A section of these anomalies are obscured by the large dipolar anomaly formed by the modern power pole and electric box discussed below. A possibility for this pattern is a corral built for horses or cattle in the Fort field prior to the military occupation. No evidence of this line of anomalies can be seen in the electrical resistance data (Figure 43:2). The low resolution of the survey does not provide enough detail to resolve small anomalies.

Fort Field

The field west of the Fort has multiple dipolar anomalies, but these dipoles are not as

concentrated as within the Fort itself and cluster analysis did not identify any distinctive clusters of metal (Figure 41:7). The metal may be left from the occupation of the Fort, or related to the ranching period similar to the dipolar anomalies visible in Anomaly Area 5: Modern Agricultural Debris. Much human activity took place outside of the Fort during its active period. Native Americans camped nearby when they came to trade and Euroamerican traders went to the Fort to deliver their furs, get supplies, and hear news. Culbertson describes “Indian lodges” around the Fort, and other visitors mentioned the Indian presence in the field. Many of the dipolar anomalies may be related to lost or discarded trade goods during the Fort’s occupation as people lived and worked outside the Fort palisade.

Trail

A line of low magnetism is visible cutting across the north edge of the survey it splits into two just north of the military barracks (Figure 41:9). This anomaly is interpreted as a trail due to its difference from the other low magnetic linear anomalies the field. As mentioned earlier, trails could cause a lower magnetism signature due to the removal of magnetic topsoil exposing lesser magnetic soils. While the trail appears to branch around the location of the military barracks (Figure 41:1) with the eastern branch heading toward the Fort’s west gate, this trail could also be a cattle trail from the ranching period. This anomaly is not visible in the aerial imagery (while the roughly parallel north-south lines are visible in the aerial imagery), supporting the interpretation as a trail rather than a geologic feature.

Area E-Fort Western Field

Area E encompasses anomalies that represent evidence of structures, either enclosures or

possible tipi rings (Figure 46). Dipolar anomalies are also scattered throughout the field but do not form any recognizable clusters or patterns. This area of the Fort field was covered only by the magnetometry survey. A close-up of Area E magnetometry is presented in Figure 45, with interpretations in Figure 46. Groups of anomalies are identified by numbers in the above mentioned figures. Table 6 provides a summary list of anomalies within anomaly groups and their interpretations. Specific anomalies of interest are discussed following the table.

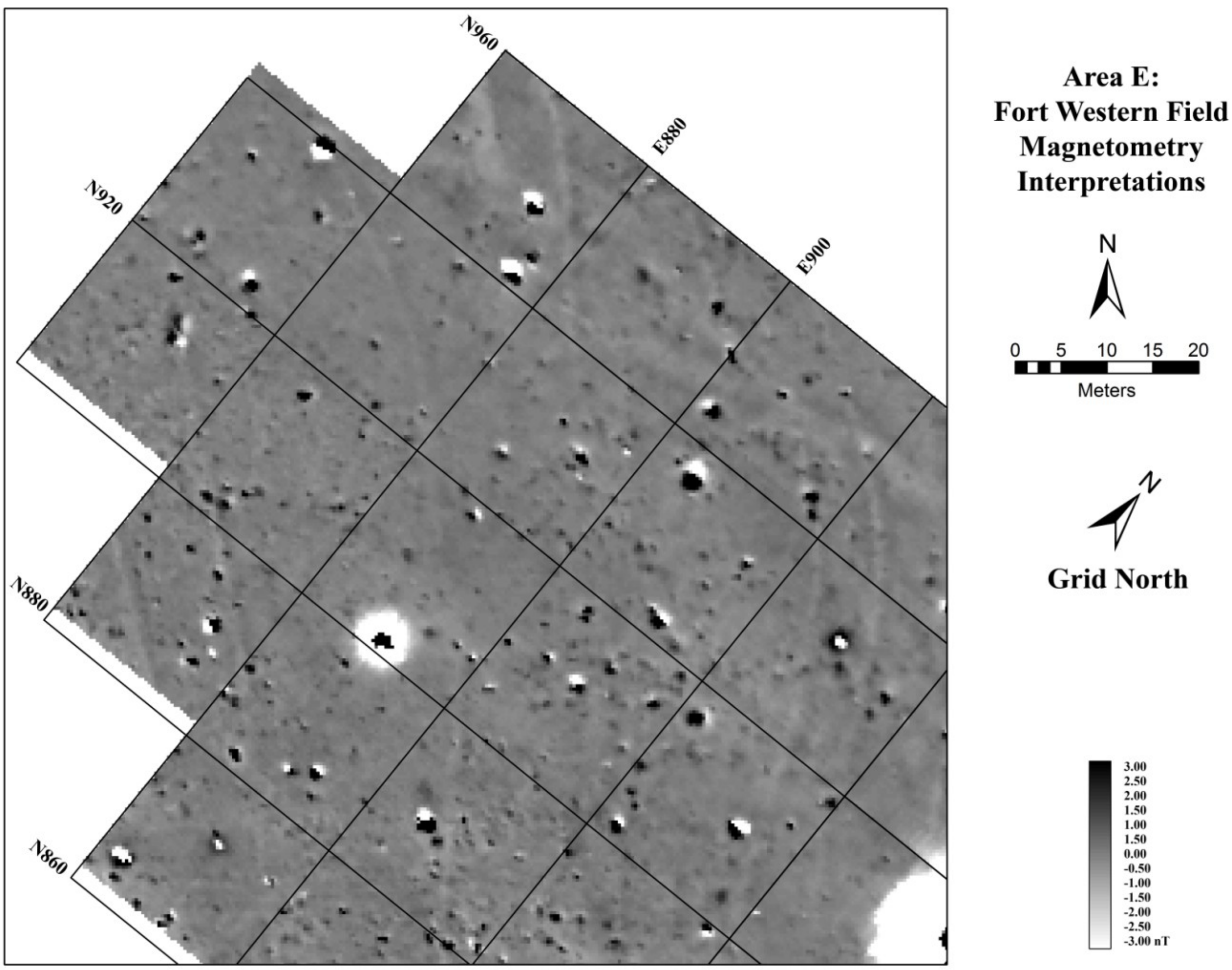

Figure 45: Area E-Fort Western Field Magnetometry

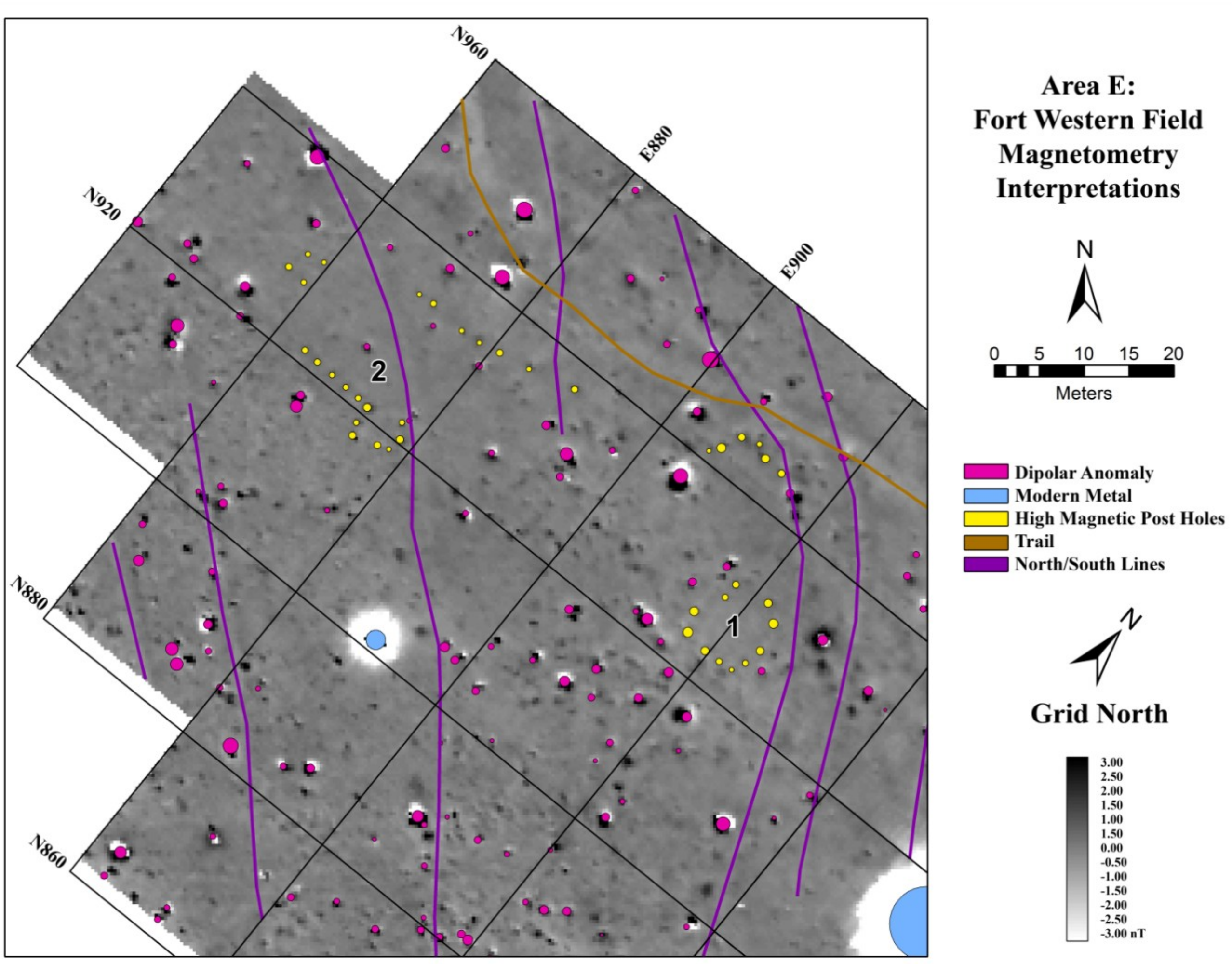

Figure 46: Area E-Fort Western Field Magnetometry Interpretations.

Table 5: Area E Anomaly Interpretations – Fort Western Field					
Anomaly Group	**Survey**	**Types**		**Interpretation**	**Notes**
1: Stone Circle or Post Holes					
	Magnetometry	Ring of circular high magnetic anomalies		Stone circle or post holes	Similar to post holes identified elsewhere on the site
	Magnetometry	Partial ring of circular high magnetic anomalies		Stone circle or post holes	Similar to post holes identified elsewhere on the site
2: Unknown Structure					
	Magnetometry	Lines of post holes		Post holes forming animal enclosure	Similar to post holes identified elsewhere on the site. Layout of post holes is also similar to layout of post holes south of the Fort (Area B:8)

Table 6: Area E Anomaly Interpretations – Fort Western Field. Low and high measurements are compared to the average background reading. The average magnetism in the entire magnetometry survey is -5.89 nT.

Stone Circle or Post Holes

Multiple circular high magnetic anomalies form a ring in the west half of the Fort field, along with a partial ring just to the north (Figure 46:1). These circular anomalies match the magnetism of post holes elsewhere on the site. Other rings may be present in the field, but are not easily identifiable due to the number of dipolar anomalies. The ring may be a stone circle left from a Native American encampment either prior to or during the Fort's occupation. Stones or wooden pegs may be used to weigh down the edges of tipi coverings. Stone that was magnetically different from the surrounding soil would create anomalies in the magnetometry. No stones were visible on the surface of the site during the 2012 survey. The lack of apparent hearths within the rings does not eliminate the possibility of these stones being used for habitation structures. Stone rings have been identified that do not contain interior hearths, with external hearths often located a distance away from the tipi (Kehoe 1983:334-335). Augustus Meyers described heaths in use both inside and outside of tipis in 1855-56. Meyers states that the Dakota Sioux cooked on hearths outside of the tipis until winter (Meyers 1914:86).

Post Holes

Multiple circular anomalies form lines in the extreme west of the field (Figure 46:2). These anomalies do not form a complete shape, and the size of the anomaly group is too large for a building. The circular anomalies could be post holes that form an enclosure for cattle or horses. Sully's 1856 watercolors do not depict any enclosures this far west of the Fort, nor do Bodmer or Catlin's earlier images. However, Bodmer and Catlin depict multiple Sioux encampments surrounding the Fort and it is possible that these anomalies are related to Native American activities.

V. CHAPTER 5: ANALYSIS OF ANOMALIES WITH EXCAVATION DATA

A. Excavation Features and Geophysical Anomalies

Excavation data from the 1980-1981 and the 1997-2001 projects provides an opportunity to more fully interpret the geophysical results. Specific anomalies can be tied to specific features visible within the excavations, allowing positive identification of certain anomalies inside the Fort. Locations of the 1997-2001 excavation units are detailed in Figure 1. The 1980-1981 units are not easily georeferenced, but some indications of these units can be seen in the geophysics, and interpretations can be made based on approximate locations. Discussion will refer to the 1997-2001 excavations unless specifically noted. The locations of the 1997-2001 excavations are shown in Figure 1. Excavation areas are referenced using Fosha's (2010) naming system and structures and use areas within the Fort will be discussed based on excavation data from all units. Table 7 provides a summary of excavation areas and interpreted features from Fosha's excavation report (2010a). A final map of interpretations, combining the excavation information and the geophysical anomalies is included at the end of the chapter as Figure 51. The final map adjusts the earlier interpretations and creates a better picture of the types of anomalies visible in the geophysics at this site. Maximilian's 1833 map and Turnley's 1885 map have been distorted to fit the final interpretations and are included in Appendix E.

Summary of Excavation Areas and Interpreted Features		
Excavation Area	**Field Number**	**Selected Interpreted features**
Southwest Corner	Area 1 1997, 1998 & 2000-4	Palisade builder's trench Adobe block Post molds Possible wagon ruts
West Palisade Trench 1	Area 2000-2	Puddled adobe Palisade builder's trench Adobe block Builder's trench Post mold
West Palisade Trench 2	Area 2000-3	Puddled adobe Palisade builder's trench Adobe block Adobe block pavement Builder's trench Plaster concentration with paint Post molds
West Palisade Trench 3	Area 2	Adobe block pavement Builder's trench Possible builder's trenches Post molds
Northwest Bastion and North Wall	Area 6 1998	Rectangular and circular post molds Puddled adobe (possible floor) Puddled adobe Palisade Builder's trench Builder's trench
North Palisade Wall	Area 3	Palisade builder's trench Rectangular depression Post molds
Northeast Corner of Palisade	Area 8	Palisade builder's trench Post mold Builder's trenches
East Palisade Wall 1	Area 3-1997, Area 4-1998	Palisade builder's trench Puddled adobe Rectangular and circular post molds Square cut timbers Rectangular fire reddened area
East Palisade Wall 2	Area 9	Rectangular and circular post molds Fire reddened area Puddled adobe Post molds
Southeast Bastion	Area 2001-2	Palisade builder's trench Post molds Builder's trench Hearth

Table 7: Summary of excavation areas and interpreted features. Summary compiled from excavation report. For full list of features and comments see Fosha 2010a.

Palisade

The palisade line is identified as builder's trenches and post molds with intact post bases in several excavation areas. Specifically, the Southwest Corner and West Palisade Trench 3 provide details about the palisade location and construction, while other areas give indications of different associated features and different construction and removal of the palisade during the Fort abandonment. The western palisade in particular has undergone changes through time which are visible in the electrical resistance survey.

West Palisade

The western palisade is well defined in both the excavations and in the geophysical surveys. Features within Western Palisade Trench 3 include post molds, builder's trenches, and an adobe brick pavement (Fosha 2010a:55). The palisade line identified in the magnetometry and the electrical resistance aligns with the center trench of the three identified builder's trenches, making the adobe brick pavement external to the palisade (Figure 47). Post holes identified in the magnetometry also fall within the builder's trench. While there is no evidence of baked bricks at Fort Pierre Chouteau, several historical documents indicate that adobe was used in the Fort construction, although it is not specified whether the adobe was used as bricks or plastered over the wood construction of the palisade. Elsewhere in the Fort, historic documents refer to the construction of adobe chimneys. Individual adobe bricks are clearly visible in the excavations interpreted as an adobe pavement by Fosha (Fosha 2010a:44,55).

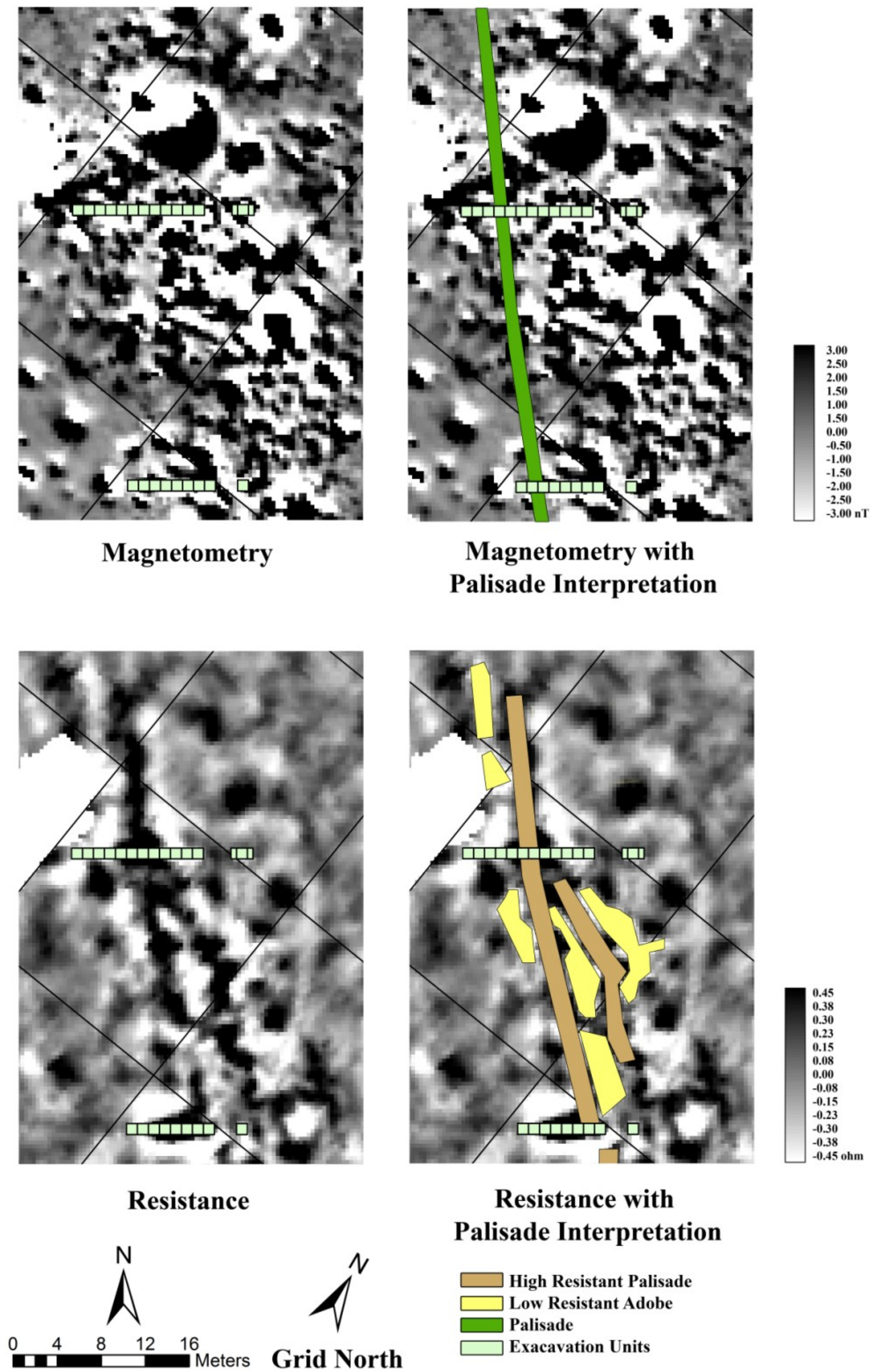

Figure 47: West palisade excavation units in relation to magnetometry and resistance, with interpretations. Northern excavation trench is West Palisade Trench 2. Southern trench is West Palisade Trench 1.

Based on the location of the palisade line in both the magnetometry and the electrical resistance in relation to the excavation trench, the line of higher magnetism is in fact the palisade trench with some intact post bases, while the line of slightly negative magnetism detects the adobe pavement or remains of the adobe pavement. In Figure 47, the electrical resistance survey is much clearer in defining the palisade line with an external adobe pavement. The low-high electrical resistance banding on the west palisade is likely picking up the adobe pavement as less resistant due to moisture retention and the builder's trench as more resistant due to better drainage. Because adobe is composed of a clay base mixed with plant material, the clay in the adobe may trap moisture on top of the pavement resulting in lower resistance. Generally, adobe creates high resistant anomalies due to the density and resistance to moisture (Kvamme, personal communication, April 19, 2013).

Using the low-high pattern as an indication of the adobe pavement and palisade, a break in this low-high pattern on the west palisade may indicate the location of a gate late in the fur trading period of the Fort. Later images and maps of the Fort do not indicate the presence of a gate in the west palisade. Excavations also identified multiple parallel builder's trenches in the location of the palisade, which is visible as multiple low-high bands in the electrical resistance. These anomalies and features indicate successive repair and extension of the palisade during the Fort's occupation. The multiple builder's trenches identified in Western Palisade Trench 3 may also indicate the successive building and repair of the west palisade.

North Palisade

Excavation trenches across the north palisade line (Excavation Areas: Northwest Bastion and North Wall, North Palisade Wall, depicted in Figure 48) did not encounter an adobe brick

pavement, although in places the electrical resistance signature still exhibits the low-high banding in places, indicating the likelihood of an adobe brick pavement at unexcavated areas outside the palisade. A low resistant break in the north palisade line likely indicates the location of a gate and adobe pavement. Sully's 1856 image, Fort Pierre Looking South (Figure 10), indicates a doorway in the north palisade near the blockhouse, making it possible that an adobe pavement did continue outside the northern palisade. Fosha indicates the presence of "fine sandy silt with a density and soil consistency identical to adobe brick" north of the palisade builder's trench in the North Bastion and North Wall excavation area which may be indications of decomposing adobe (Fosha 2010a:62).

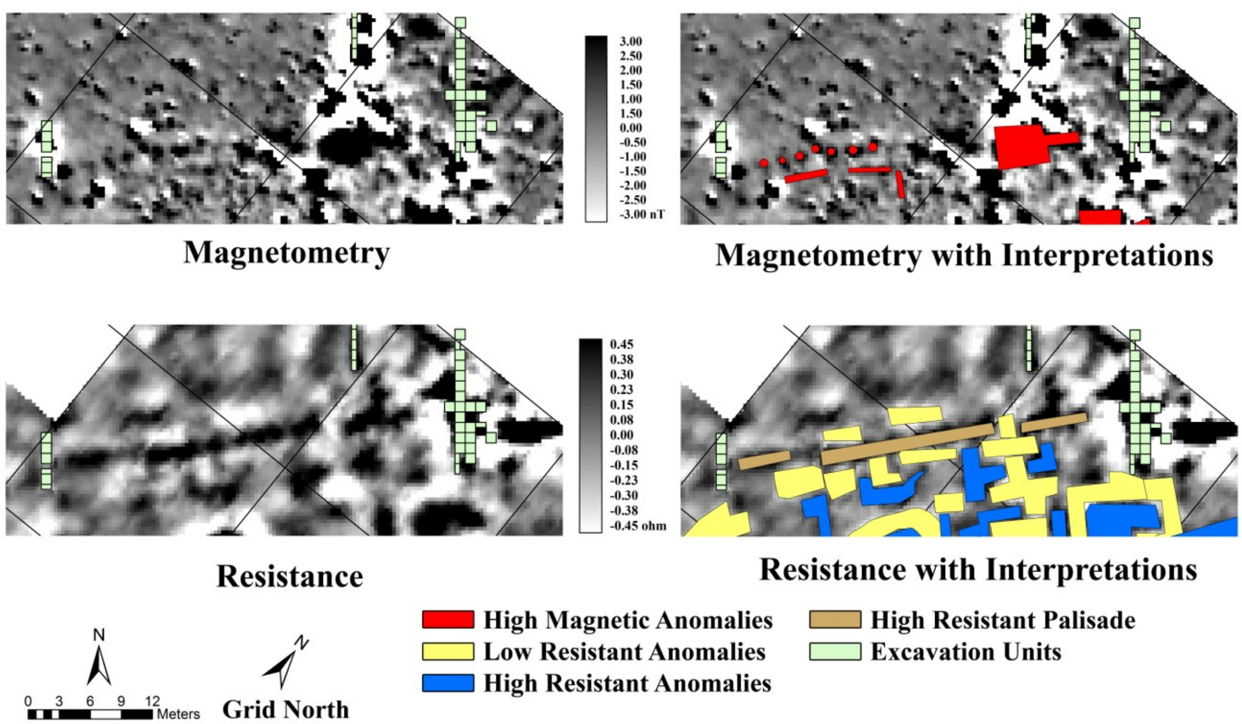

Figure 48: Close up of northern palisade excavation units in relation to magnetometry and resistance, with interpretations. The eastern trench is part of the Northwest Bastion and North Wall excavations. The western trench is the North Palisade Wall excavations.

Another possibility is that the adobe brick pavement was only used in areas of the palisade where gates were located. The adobe-like soils along the north and south palisades either indicate a

partial pavement or are the result of adobe eroding off of the palisade wall while the Fort was in use. No adobe soils were found in the North Palisade Wall trench or the Northeast Corner of Palisade excavations to the east.

Excavations at the northwest corner of the palisade encountered the palisade builder's trench, but did not contain any intact posts in the units. Posts at this location were likely removed during the dismantling of the Fort for transportation to Fort Lookout and Fort Randall. Intact post bases were identified in the southwest corner of the Fort, indicating that not all palisade material was removed during abandonment. East of the northwest excavations, circular anomalies are visible in the magnetometry indicating the presence of intact post bases.

Geophysical surveys do not extend to the northeast corner of the Fort. However, based on the palisade anomalies elsewhere in the Fort, the builder's trench will be visible in electrical resistance in this area, along with any adobe present either internal or external to the palisade line. Magnetometry will not provide any indications of missing posts but may detect intact post bases or the edge of the palisade line by the distribution of dipolar anomaly clusters.

South Palisade

Excavations at the southwest corner of the Fort clearly identified the location of the palisade builder's trench, along with intact bases of posts. The palisade posts are visible as circular anomalies in the magnetometry to the east of the excavations. Puddled adobe was present exterior to the palisade, while an adobe pavement and puddle adobe was found inside the palisade. Evidence of adobe is again visible in the electrical resistance as low resistant areas, with the palisade builder's trench as a high resistant anomaly. Adobe pavement was not only used exterior to the palisade, and therefore some areas of low resistance within the Fort may be remains of adobe

pavement in addition to any adobe used in the building of structures.

East Palisade

The east palisade is likely to be similar to the other palisade walls, particularly the west palisade, due to the presence of gates. The main entrance to the Fort was located in the east palisade plus a secondary stable entrance was added late in the Fort's history. Both east gates are visible in the 1854 Behman watercolor (Figure 6). Puddled adobe was again identified near the palisade builder's trench, but no evidence of an adobe pavement was found in the excavations (Fosha 2010a:78). Geophysical surveys did not cover the eastern palisade area, so these excavations cannot be directly compared to anomalies.

Northwest Blockhouse

Adobe was present in multiple units located in the vicinity of the northwest blockhouse. The blockhouse was not clearly defined by the excavations as they were terminated before full excavation of possible features, but excavations did indicate that features relating to the blockhouse were present (Fosha 2010a:58). Dipolar anomalies in the area of the blockhouse were visible in the magnetometry, but no other anomalies in the magnetometry indicated the presence of the blockhouse walls. Slight indications of the blockhouse were present in the electrical resistance. Further excavation of the blockhouse and features would aid in identifying the construction method of the blockhouse and the corresponding geophysical anomalies.

Southeast Blockhouse

The southeast corner of the palisade was not identified in either the 1980-1981 or

1997-2001 excavations. The 1980-1981 excavations followed two sets of north/south post lines (including intact post bases) along with an east/west line of posts which dropped off the terrace edge (Ruple 1990:18). The east/west line was interpreted as the south palisade, but the location of the southeast blockhouse was not identified. The location of the blockhouse was also not locatable in 2001, although most units in this area were not excavated deeper than 20 cm (Fosha 2010a:88). The geophysical survey does not extend to the edge of the terrace, but if completed, would assist in identifying the location of the blockhouse or its absence due to erosion by using palisade anomaly patterns visible elsewhere in the Fort.

Fort Structures

While the 1997-2001 excavations focused on determining the boundaries of the Fort and did not directly sample any internal Fort structures, the East Palisade Wall area did encounter cut timbers which were interpreted as sills for structures. In other areas of the Fort, builder's trenches near the identified palisade trench are evidence of buildings and other structures located near the palisade walls. Combining the excavation information with the interpreted geophysical anomalies allows identification of specific structures in the geophysics relating to the late fur trading period and the military period of the Fort. Evidence of earlier Fort construction, particularly buildings located directly against the palisade walls as is detailed in Maximilian's map (Figure 5), is less clear.

Sawmill Shed and Horse Work Shed

The North Palisade Wall excavation area identified a rectangular depression bounded by the palisade builder's trench to the north (Fosha 2010a:66). The depression was filled with clay

and silty clay, with walls sloping to the floor, and was interpreted as the likely location of the sawmill during the late fur trading period and military period of the Fort based on 1854 and 1855 maps (Fosha 2010a:68).

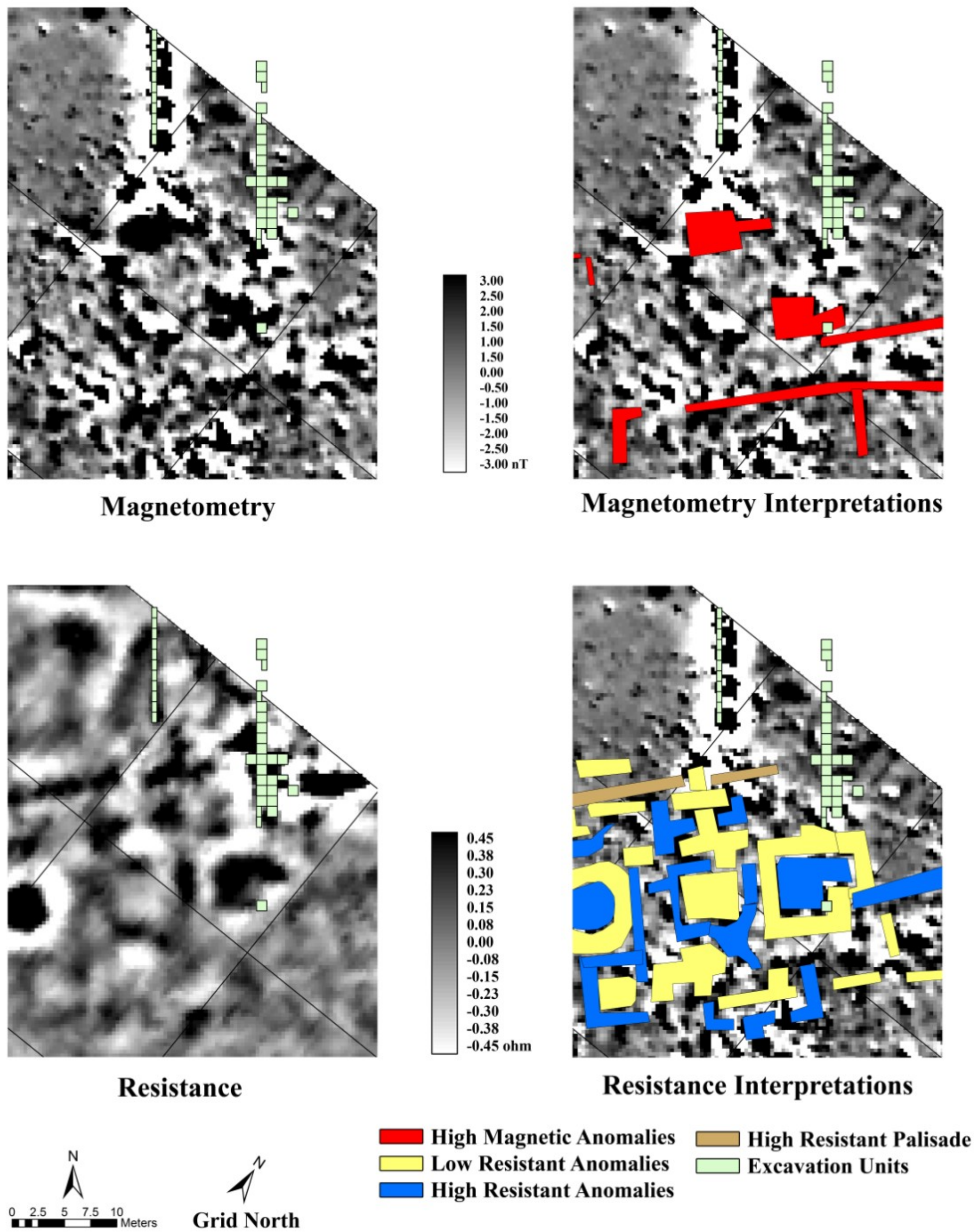

Figure 49: North Palisade Wall excavations in relation to magnetometry.

Anomalies in the magnetometry and electrical resistance (Figure 49) to the west of these excavation units indicate the west end of the sawmill shed, along with additional sheds in this area including the shed for sheltering the sawmill horses. The area clear of dipolar anomalies corresponds to a low resistance area, which is the likely location of the horse work shed. The large higher magnetic anomaly just to the north of the open area is the end of the sawmill shed, while the large higher magnetic anomaly to the south of the open area corresponds with a higher resistant anomaly surrounded by lines of lower resistance, indicating a difference in construction. This grouping of anomalies indicates the presence of a shed earlier in the fur trading period, which used a different method of construction than the other structures.

Western Quarters

West Palisade Trench 1 identified three parallel builder's trenches, the center of which contained multiple post molds and the intact bases of two posts (Fosha 2010a:48). Accepting the center trench as the west palisade line, the eastern trench likely relates to the nearest building due to the presence of a single post mold within the trench. This building is marked as living quarters on the 1855 map. Electrical resistance in this area reveals multiple high and low anomalies. Based on evidence of builder's trenches elsewhere at the site, a builder's trench should exhibit a high resistant anomaly, indicating the presence of wall construction. The south end of the quarters building, where two small additional buildings were attached (See Chapter 4 discussion – Area B:7), do have linear high resistant anomalies. These anomalies frame the south end of the quarters and the two smaller buildings. Adobe derived soil was also found covering the eastern builder's trench in these excavation units. The 1855 military inventory indicates the clerk's house (Building

15 on Turnley's inventory map, Figure 7) was of adobe construction. As adobe elsewhere in the Fort exhibits a strongly lower resistant signature, large low resistant anomalies in this area indicate the remains of this building as an adobe building would not have been easily moved to the new military Fort.

North Storehouse

The storehouse identified in the geophysical results (Figure 33, Area A:8) does not have any corresponding excavation units directly associated with this area. However, linear high resistant anomalies again indicate the presence of builder's trenches in the construction of this building. Posts are not able to be identified in the magnetometry due to the abundance of dipolar anomalies obscuring the interior of the Fort.

East Workshops

Excavation units to the east (East Palisade Wall 1) of the north storehouse found post molds and rectangular cut wood timbers indicating the location of the workshops at the east end of the Fort (Fosha 2010a:80). These buildings were supported by wood sills and according to the 1855 inventory had mud roofs, while the storehouse had a shingled roof and wooden floors. The geophysical surveys do not cover the full eastern end of the Fort, but it is likely that these structures will exhibit different anomalies as the construction method is different than the west quarters or the north storehouse. Of note is an adobe feature identified as a possible adobe floor of a building (Fosha 2010a:77). Adobe used as a floor will create anomalies similar to the adobe pavement near the palisade wall, but in a large block versus a line

South Quarters

One of the north/south post lines identified by Ruple takes a sharp turn toward the southwest corner of the Fort, forming an angle greater than 90 degrees (Ruple 1990:18). This angled feature does not appear on the 1855 military inventory map, but the 1855 military planning map indicates a line matching that approximate angle attaching to the southeast corner of the living quarters and extending southeast to the closest corner of the blockhouse (Figure 8). If this line is the feature discovered in the excavations, then the two north-south lines of posts are part of the living quarters building. This building is described as a log construction with a mud roof in the military inventory, yet it must have had similar construction to the palisade, with builder's trenches and inset posts. This would create the same patterns as the palisade in the magnetometry and electrical resistance, at least for the eastern end of the quarter's building.

Trails

The trail identified south of the Fort in Figure 50 as a lower magnetic linear anomaly angles toward the southwest corner excavations. Excavation units located outside the palisade found alternating clay silt and clay lines which were interpreted as wagon ruts. The trail south of the Fort appears to connect up to this feature identified in the Southwest Corner excavations, confirming the presence of a trail leading around the south side of the Fort. Trails identified elsewhere in the field may also have indications of wheel ruts as they exhibit the same signature as the south trail in the magnetometry. However, cattle trails have been known to cause similar anomalies (Kvamme 2006). As the field was used as pasture, the trails may not be connected to the period of occupation at the Fort. The presence of the feature outside the southwest corner of the Fort strengthens the interpretation of the trail closest to the Fort as being one created by humans.

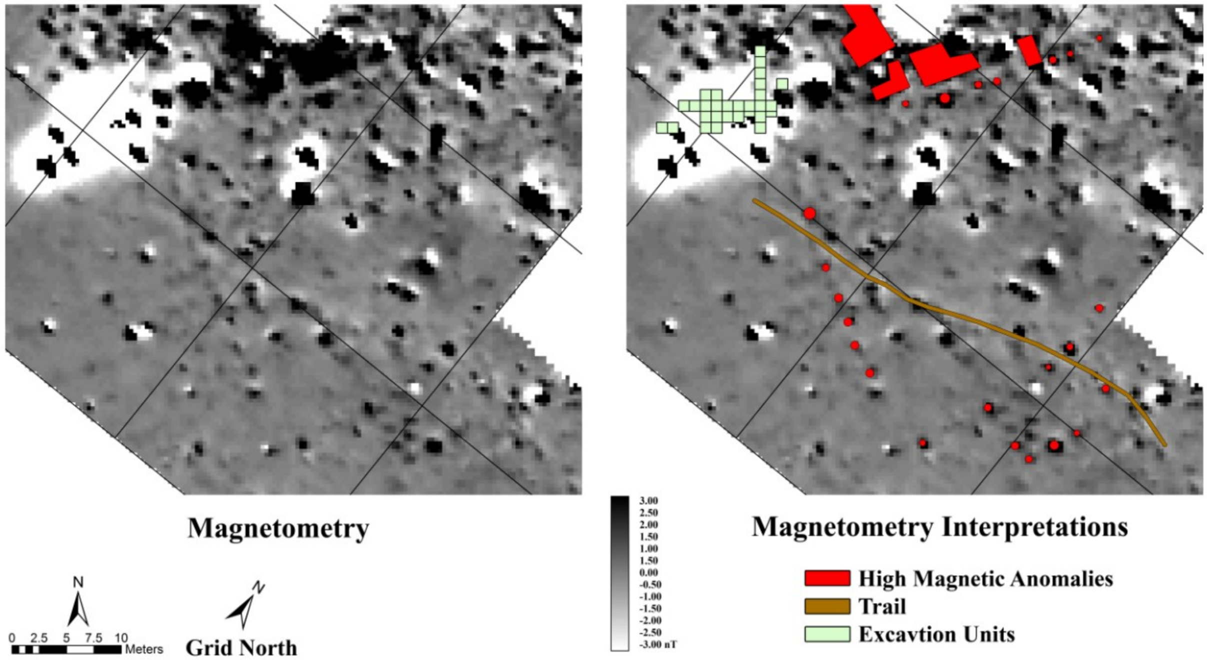

Figure 50: Southwest Corner excavations in relation to magnetometry.

Military Barracks and Fort Field

There are no excavation units placed outside the Fort in the main field. Therefore, interpretation of the military barracks and other anomalies is restricted to the geophysical surveys. The construction of the barracks utilized earth as insulation which should cause similar patterns in the electrical resistance as moved earth inside the Fort. However, due to the noise present in the 2012 electrical resistance survey, only general, large scale anomalies can be identified and not connected to any of the excavation data.

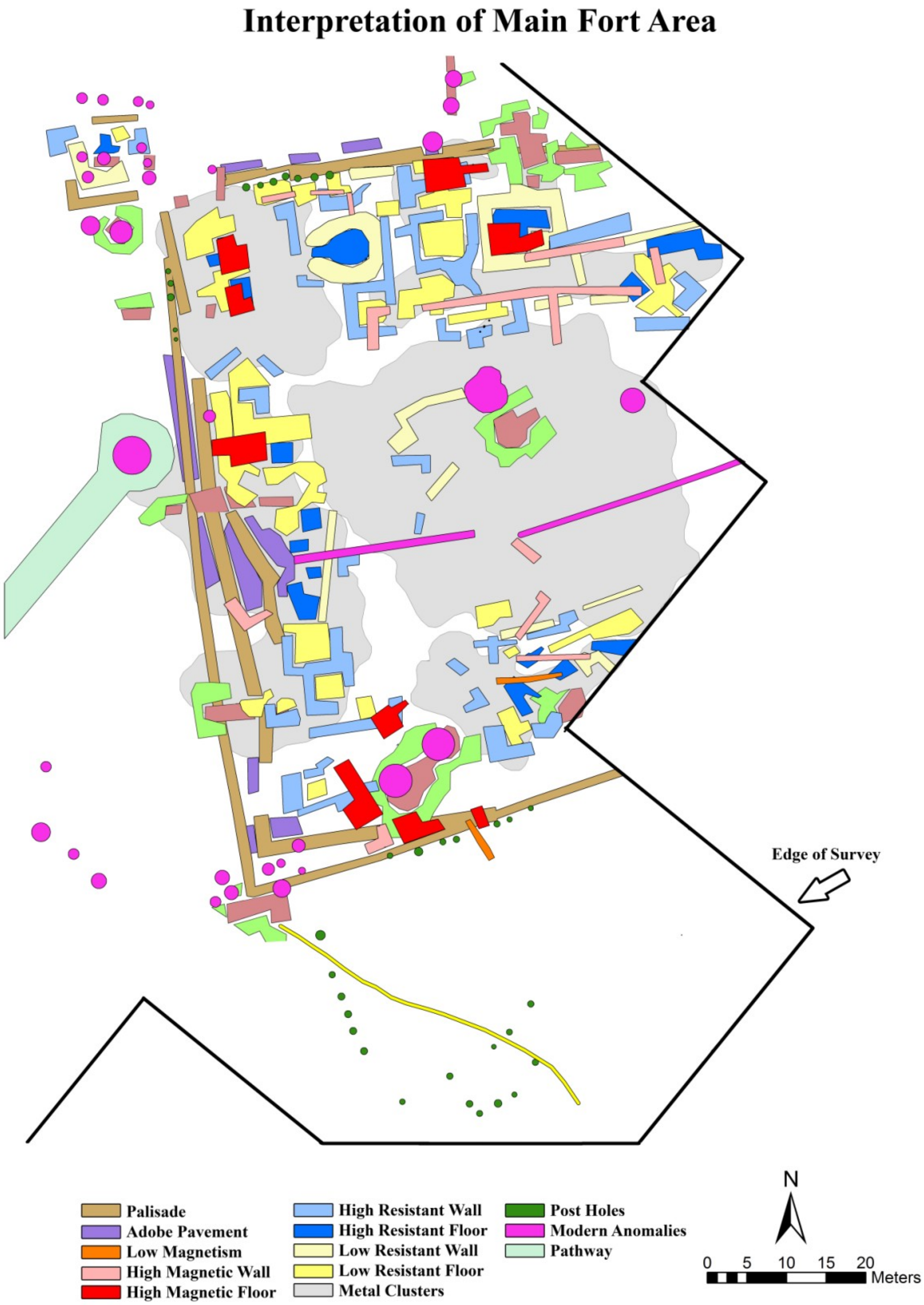

Figure 51: Final Interpretations of Fort Area

VI. CHAPTER 6: CONCLUSION

Fort Pierre Chouteau, while one of many fur trading sites and military posts on the frontier, is the result of a unique combination of Native American, fur trader, and military experiences on the Missouri River. Understanding the site layout along with the context of different structures and buildings allows a better understanding of the Fort as well as the changes in layout through its occupation. The analysis of geophysical surveys and excavation data at Fort Pierre Chouteau provides an important first step as to the connections between archaeological features and geophysical anomalies. The combination of excavation information and geophysical anomalies allows a more detailed interpretation of the layout of the Fort along with the identification of structures that correspond to historic maps.

To address the three research questions, this paper examined multiple sources of information including historic documents, excavation reports, and geophysical surveys. Ideally, excavations will follow geophysical surveys in order to validate anomaly interpretations. At Fort Pierre Chouteau excavations were completed prior to the geophysical surveys. This study utilized the excavation reports in order to interpret anomalies and provide a better understanding of the extent and layout of the Fort. A detailed history was presented placing the Fort in its historic context followed by discussion regarding geophysical anomalies and excavation features.

Geophysical surveys were completed in two phases: initial surveys were completed over the main area of the Fort in 2007, with additional surveys in 2012 to extend the magnetometry and electrical resistance surveys into the field to the west. The two-phase nature of the surveys allowed a much larger area of the site to be covered. Magnetometry, electrical resistance, magnetic susceptibility, and conductivity surveys revealed anomalies relating to multiple periods of the

Fort's occupation. Magnetometry and resistance provided the most geophysical information due to surveys covering much larger areas of the site than the magnetic susceptibility and conductivity surveys.

The 2007 and 2012 magnetometry surveys were combined into a single dataset which contained multiple dipolar anomalies in the immediate vicinity of the Fort. Cluster analysis using Kintigh and Ammerman's (1982) K-means procedure indicated slight clustering between dipolar anomalies over the entire survey area, with no apparent clustering of dipolar anomalies inside the Fort palisade. Visually, there appears to be clustering of dipolar anomalies inside the Fort when compared to the rest of the survey. Final determination of dipolar anomaly clusters was made using a combination of the computer calculated clusters and cluster association with anomalies interpreted as relating to structures. Due to the large number of dipolar anomalies inside the Fort palisade, few areas of high and low magnetism were identified inside the palisade. However, at least two areas of high magnetism were identified indicating the presence of structures inside the Fort not recorded on any of the historic maps. Palisade post holes were also visible as high magnetic circular anomalies in the magnetometry survey.

Resistance provided the clearest image of anomalies and archaeology within the Fort. As the 2007 and 2012 resistance surveys were completed at different spatial resolutions, they were processed separately and combined in GIS software. The 2007 resistance survey provided the most detail of anomalies inside the Fort palisade, including areas of high and low resistance relating to the palisade and other buildings and structures. The palisade builder's trench was extremely prominent as well as areas of earth movement (including historic cellars and excavation units). The anomalies do not form clear building footprints, likely due to the continual renovation of buildings inside the Fort. In addition, the dismantling of buildings during the Fort abandonment also would

cause more complex geophysical signatures.

Magnetic susceptibility and conductivity surveys covered a limited area over the western palisade line. Both techniques indicated anomalies relating to the building used as the western quarters as well as the western palisade line. Areas of high and low magnetic susceptibility indicated the location of the quarters, as well as the presence of a structure in the center of the Fort which corresponded to anomalies visible in the resistance data. Anomalies in the conductivity data more generally indicated the quarters, but an anomaly relating to the 1967 pipeline trench was definitely visible.

Examining the excavation data in conjunction with the geophysical data allowed characterization of typical geophysical anomalies for specific structures within the Fort. The palisade is visible as a high resistance anomaly indicating the presence of a builder’s trench. Adobe pavement visible in the excavations creates a low resistant anomaly parallel to the palisade builder’s trench. Intact post bases were present in the southwest corner excavations, supporting the interpretation of the high magnetic circular anomalies present along the palisade line as post holes. Other structures inside the Fort are not as clearly defined due to the excavations focusing on the palisade.

Outside of the palisade, evidence of the military barracks is visible as anomalies in both the magnetometry and resistivity surveys. Subtle high magnetic anomalies in the Fort field form a rectangle that matches the approximate size and expected orientation of the soldier’s barracks assembled at the site in 1855. A large anomaly in the resistance corresponds to the location of those magnetic anomalies. Additional anomalies of interest outside the Fort include a circle of magnetic anomalies further west in the field, possibly indicating the Native American presence at the site.

Anomalies seen in the geophysical surveys are related to different occupations of the Fort, yet only reveal part of what is present archaeologically. Different stages in construction and abandonment are identifiable in the geophysics, creating a complex mix of anomalies. The interpreted results of this project reveal a history of construction and renovation within the Fort, as well as evidence of its dismantling during abandonment. In particular, changes to the western palisade are strongly evident in the electrical resistance survey. Anomalies representing walls and floors are visible, but they do not always form clear outlines of structures due to the periodic renovation of the Fort through the addition of new structures and changes to existing structures. Additional disruption of the anomaly pattern for building footprints is likely due to the dismantling of the Fort's structures. In addition, archaeological evidence of the military period is present outside the palisade, visible in the magnetometry and electrical resistance. While the portable cottages were intentionally dismantled for use at other military posts, the location of one of these structures is visible in the geophysics, implying that identification of the location of other military structures is possible. The limited usage of the portable cottages used by the U.S. Military is an important aspect of military fort archaeology on the frontier.

Adobe was identified in many excavation units and can be directly connected to low resistance anomalies paralleling the palisade. Historic documents describe the use of adobe for chimneys and wall construction, but do not mention the use of adobe for pavement and floors. Magnetometry and the excavations reveal the presence of intact palisade post bases, indicating that posts may have been cut off at the ground surface or left in place. Other palisade posts may have been completely removed for transportation to the new Fort leaving only the builder's trench.

While this project provides important information as to the locations of anomalies and therefore potential archaeological features, further work is necessary to fully connect the two data

sets, and to explore the specific geophysical characteristics of features. Ideally, understanding the characteristics of anomalies at Fort Pierre Chouteau would allow better interpretation of similar sites on the Missouri. Ground-truthing is necessary to validate interpretations of many of the anomalies, and would also provide an opportunity to closely examine soil composition. A clearer understanding of the geology and soils of the site should allow a more direct connection between specific feature types and anomalies, particularly when examining how adobe appears in the geophysical results. This understanding would aid the identification of adobe-caused anomalies at other sites. Excavations at the military barracks location are necessary to determine what features are present in the ground that relate to the military occupation outside of the palisade.

Additional work is needed to extend the magnetometry and electrical resistance surveys to cover the entire field, along with expanding the number of techniques used. Magnetic susceptibility and conductivity both appear to have potential and could reveal more characteristics of anomalies in relation to archaeological features inside and outside of the palisade. Ground penetrating radar, while not examined in this project, could also provide additional information about the site and future studies of the site would benefit from its use. The military barracks area would also benefit from a electrical resistance survey with higher spatial resolution (and arguably less dry conditions) to better resolve the anomalies at that location. A more detailed examination of the field surrounding the Fort using geophysics may also allow the identification of nearby Native American encampments. The Native American component is important in order to better understand the complex interactions that took place between Native Americans, Europeans, Euroamericans, and the U.S. Military at Fort Pierre Chouteau. The geophysical surveys should also be extended to the edge of the terrace to try and capture as much of the remaining Fort as possible. As the palisade is clearly identifiable in the electrical resistance data, the severity of

damage by erosion to the Fort's eastern wall could therefore be determined. In addition, the location of the southwest blockhouse (if still present) could be identified.

The unique combination of events and people at Fort Pierre Chouteau are an important aspect of the fur trade and the frontier experience on the Missouri River. Utilizing archaeological geophysics as a tool to examine a site is important in order to create a clearer picture of site layout and activity areas, along with determining the connections between anomalies visible in the data and features visible in the excavations. The application of multiple archaeological tools to a site will contribute to a better picture of the site as a whole, and to the understanding of what is located within the ground before (and after) excavation.

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VIII. APPENDICES

A. Appendix A: Condition of Fort Pierre Chouteau Buildings in 1855

U.S. Military Property Inventory Map

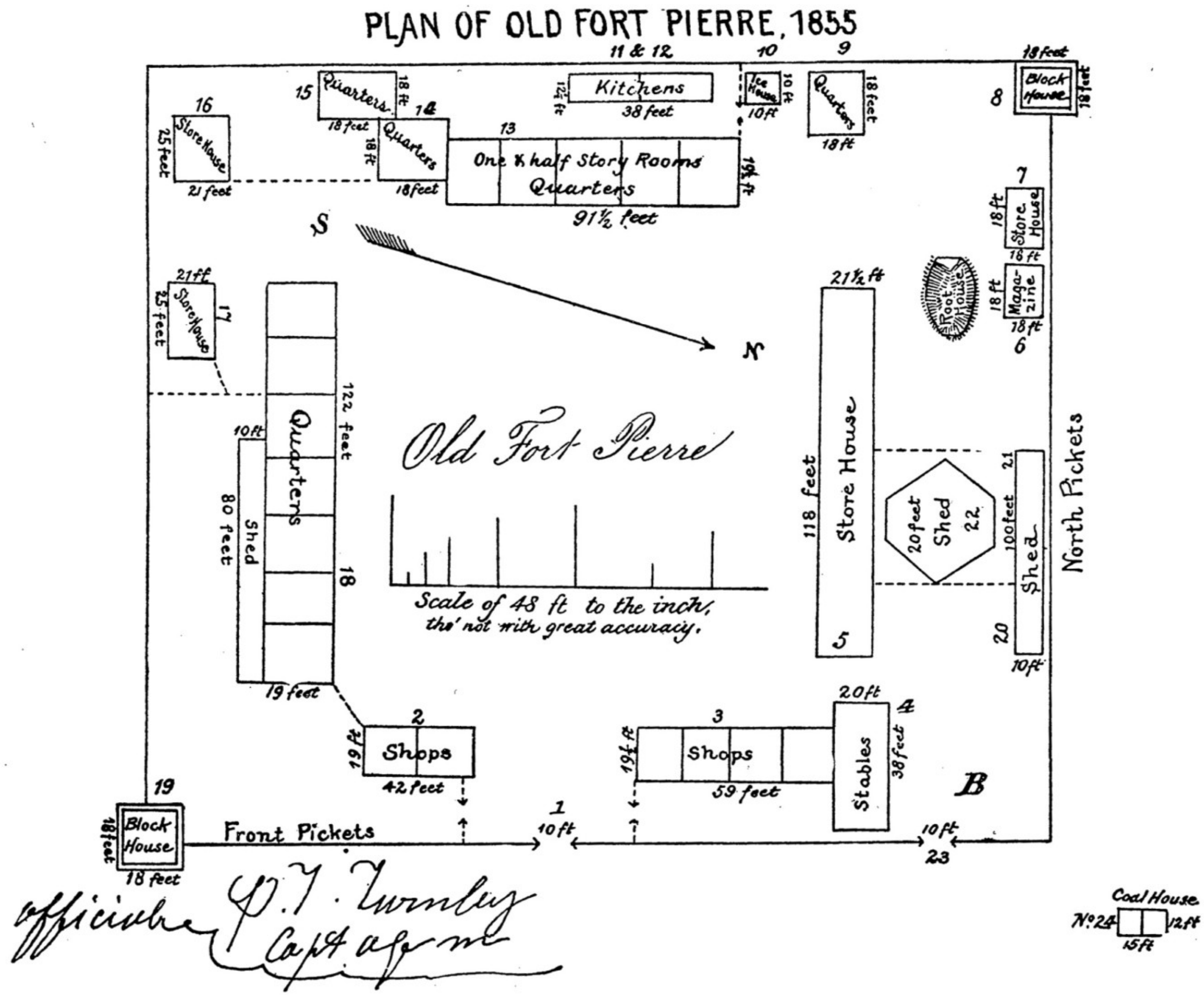


Figure 52: 1855 Military Inventory Map by Captain Parmenus T. Turnley (from Wilson 1902)

1855 Property Inventory Referenced to Turnley's 1855 Inventory Map

Number	Structure	Description/Notes
1	Gate	10 feet wide by 16 feet high
2	Carpenter Shop	One Story mud roof building of hewed logs. Logs dropped horizontally between posts.
3	Blacksmith, Tin & Saddler Shop	One Story mud roof building of hewed logs. Logs dropped horizontally between posts.
4	Stables	One Story mud roof building of hewed logs. Logs dropped horizontally between posts. Attic hay loft.
5	Store House	One Story shingled roof building of hewed logs. Logs dropped horizontally between posts. Roof attic space but no joists. Rough wood floor with up to 4 inch gaps between planks.
6	Magazine	One story, made of adobe and covered with metal
7	Log House	Similar to shop construction with a mud roof
8	Block House	Two story, shingle roof
9	Log House	Story and a half
10	Ice House	Covered with shingles
11	Kitchens	Log hut, shingle roof
12	Kitchens	Log hut, shingle roof
13	Log House	Five rooms, one and half story. Cottonwood floors.
14	Log House	One and a half story, shingle roof, wood floor
15	House	Constructed of adobe, one and a half story, mud roof
16	Store House	Log construction, covered in shingles
17	Store House	Log construction, covered in shingles
18	Huts	Log construction, mud roof
19	Block House	Two story, shingle roof
20	Shed	Open shed supported with cottonwood poles, covered with slabs
21	Shed	Open shed supported with cottonwood poles, covered with slabs
22	Horse Shed	Irregular shed, shingled conical roof supported on seven posts.
23	Horse Lot Gate	10 feet wide by 16 feet high
B	Horse Lot	

Table 8: 1855 Military Property Inventory. Summarized from De Land 1902. For the full detailed inventory with estimated costs of repair, see Deland 1902:348-349.

Appendix B: Calculated values for Cluster Analysis

All Metal, n = 893

	Actual Points			Random Points 1			Random Points 2			Random Points 3		
Number of Clusters	**SS**	**%SSE**	**log10(SS)**	**SS**	**%SSE**	**log10(SS)**	**SS**	**%SSE**	**log10(SS)**	**SS**	**%SSE**	**log10(SS)**
1	5906716	100	2	5906716	100	2	5906716	100	2	5906716	100	2
2	2234920	37.8369	1.5779	2382006	40.3271	1.6056	2378658	40.2704	1.6050	2377525	40.2512	1.6048
3	1570592	26.5899	1.4247	1594440	26.9937	1.4313	1595614	27.0136	1.4316	1603311	27.1439	1.4337
4	1205796	20.4140	1.3099	1285472	21.7629	1.3377	1276773	21.6156	1.3348	1271451	21.5255	1.3330
5	928136	15.7132	1.1963	1050786	17.7897	1.2502	1044394	17.6815	1.2475	1043083	17.6593	1.2470
6	768187.2	13.0053	1.1141	834059	14.1205	1.1499	824536.2	13.9593	1.1449	839626.4	14.2148	1.1527
7	643615.5	10.8963	1.0373	731815.5	12.3895	1.0931	730255.1	12.3631	1.0921	746920.3	12.6453	1.1019
8	553340.3	9.3680	0.9716	653003.5	11.0553	1.0436	655585.9	11.0990	1.0453	664529.6	11.2504	1.0512
9	482330.1	8.1658	0.9120	584628	9.8977	0.9955	581603	9.8465	0.9933	591295.9	10.0106	1.0005
10	432082.5	7.3151	0.8642	523556.8	8.8638	0.9476	523210	8.8579	0.9473	531604.3	9.0000	0.9542
11	389552.8	6.5951	0.8192	474389.5	8.0314	0.9048	476997.9	8.0755	0.9072	488820.8	8.2757	0.9178
12	356805	6.0407	0.7811	432708.7	7.3257	0.8648	434644	7.3585	0.8668	452487.5	7.6606	0.8843

Table 9: Calculated values for Sum Square Error for both actual data and three randomized datasets (all points in survey).

Only Metal Located Inside the Palisade, n = 368

	Actual Points			Random Points 1			Random Points 2			Random Points 3		
Number of Clusters	SS	%SSE	log10 (SS)	SS	%SSE	log10 (SS)	SS	%SSE	log10 (SS)	SS	%SSE	log10 (SS)
1	309764.4	100	2.0000	309764.4	100	2	309764.4	100	2	309764.4	100	2
2	163551.6	52.7987	1.7226	165429.2	53.4048	1.7276	166292.3	53.6835	1.7298	166170.3	53.6441	1.7295
3	108795.7	35.1221	1.5456	112092	36.1862	1.5585	114760.5	37.0477	1.5688	110781.3	35.7631	1.5534
4	79251.84	25.5846	1.4080	79943.23	25.8078	1.4118	80475.4	25.9796	1.4146	79139.75	25.5484	1.4074
5	61549.58	19.8698	1.2982	59361.89	19.1636	1.2825	60302.19	19.4671	1.2893	60981.9	19.6865	1.2942
6	47715.59	15.4038	1.1876	48292.06	15.5899	1.1928	48571.74	15.6802	1.1954	48201.88	15.5608	1.1920
7	40469.2	13.0645	1.1161	41386.83	13.3607	1.1258	42019.47	13.5650	1.1324	41343.57	13.3468	1.1254
8	34606.12	11.1718	1.0481	37014.06	11.9491	1.0773	37178.47	12.0022	1.0793	36649.98	11.8316	1.0730
9	31011.34	10.0113	1.0005	33060.22	10.6727	1.0283	32903.71	10.6222	1.0262	32778.7	10.5818	1.0246
10	27998.27	9.0386	0.9561	29251.9	9.4433	0.9751	29427.6	9.5000	0.9777	29316.19	9.4640	0.9761
11	25522.16	8.2392	0.9159	26894.62	8.6823	0.9386	26537.39	8.5670	0.9328	26713.42	8.6238	0.9357
12	23561.82	7.6064	0.8812	24685.29	7.9691	0.9014	24853.2	8.0233	0.9044	24308.43	7.8474	0.8947

Table 10: Calculated values for Sum Square Error for both actual data and three randomized datasets (only points inside palisade).

Appendix C: Cluster Analysis Defined Clusters

Calculated Clusters-All points in Survey Area

Five Cluster Solution
R Generated Plot

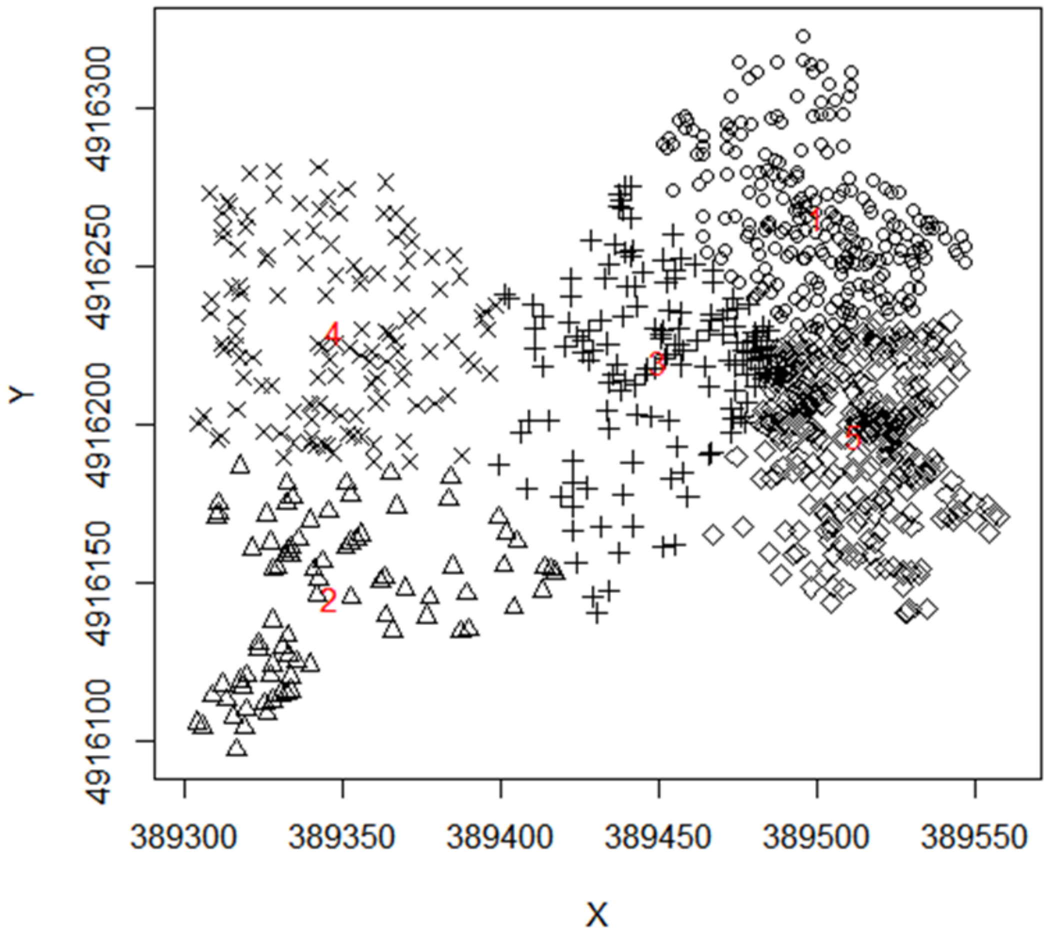


Figure 53: Calculated clusters from all points in survey area, five cluster solution.

Calculated Clusters-All points in Survey Area

Five Cluster Solution
Clusters Overlaid on Magnetometry Survey

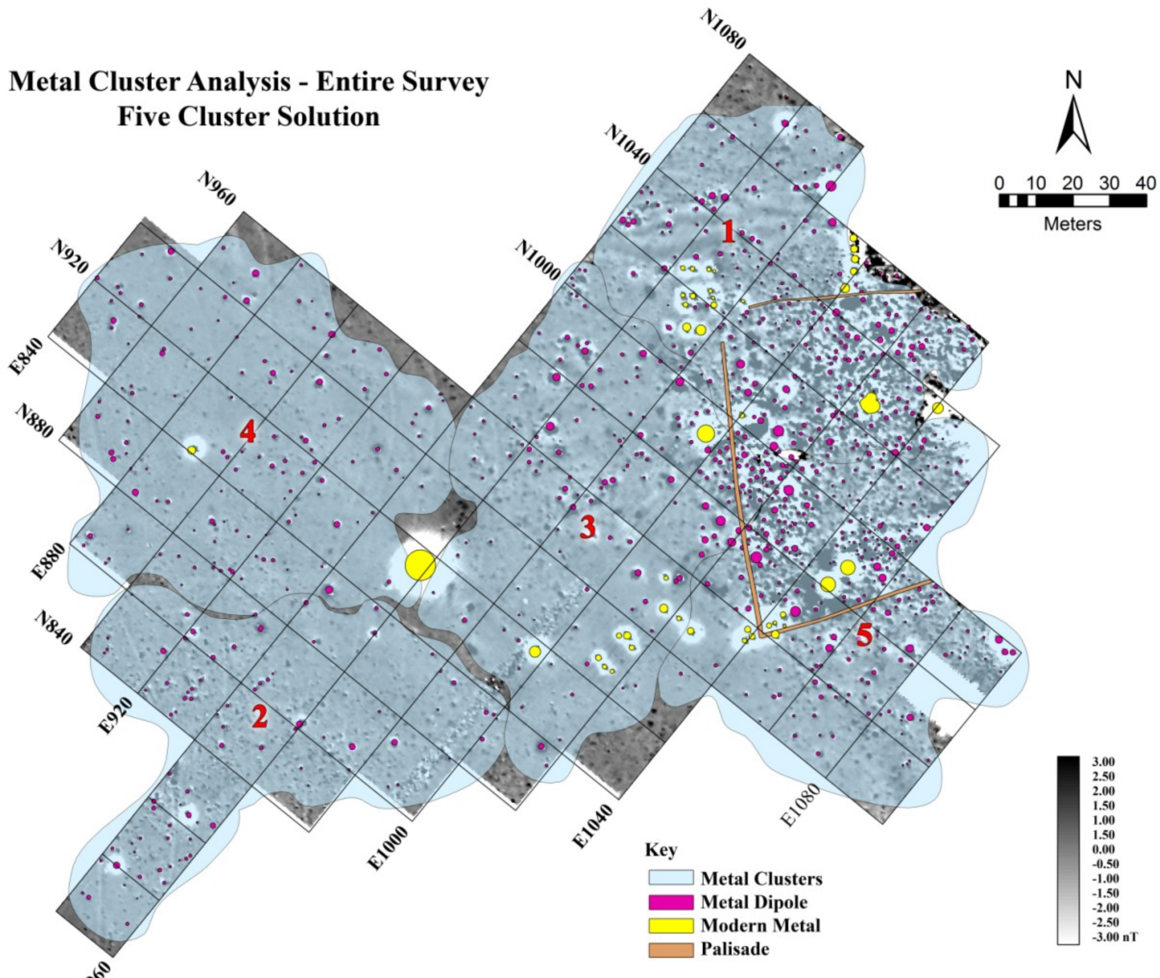


Figure 54: All survey points, five cluster solution overlaid on magnetometry data.

Calculated Clusters-All points in Survey Area

Eight Cluster Solution
R Generated Plot

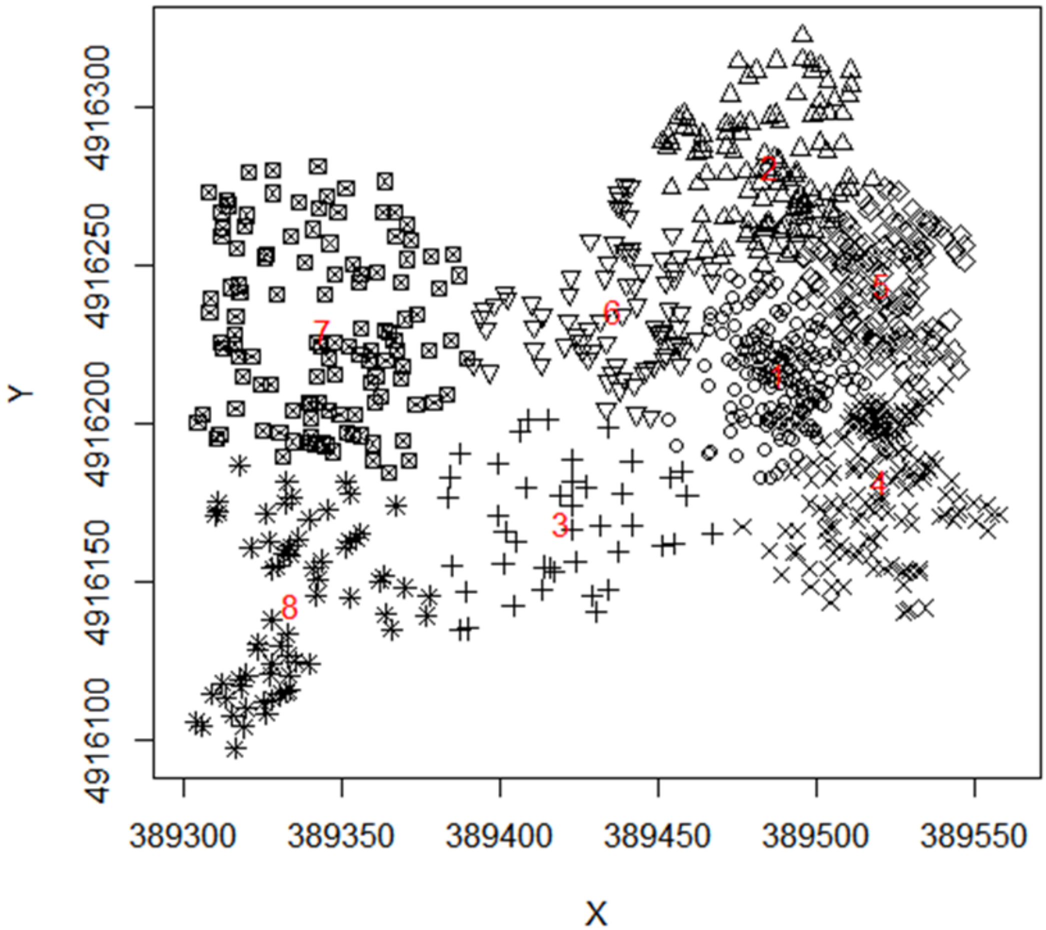


Figure 55: Calculated clusters for all points in survey area, eight cluster solution.

Calculated Clusters-All points in Survey Area

Eight Cluster Solution
Clusters Overlaid on Magnetometry Survey

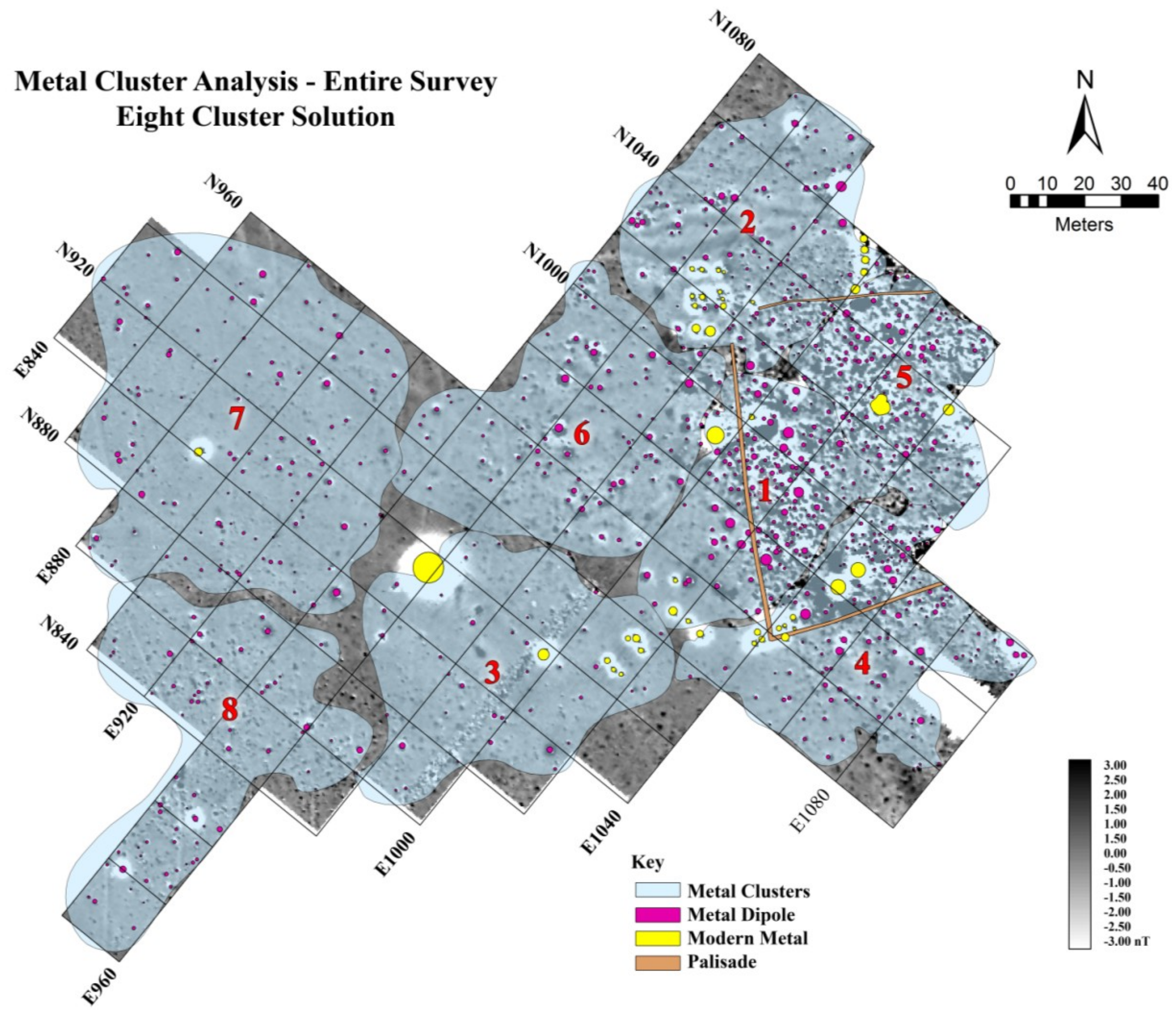


Figure 56: All survey points, eight cluster solution overlaid on magnetometry data.

Calculated Clusters-Only Points Inside Palisade

Nine Cluster Solution
R Generated Plot

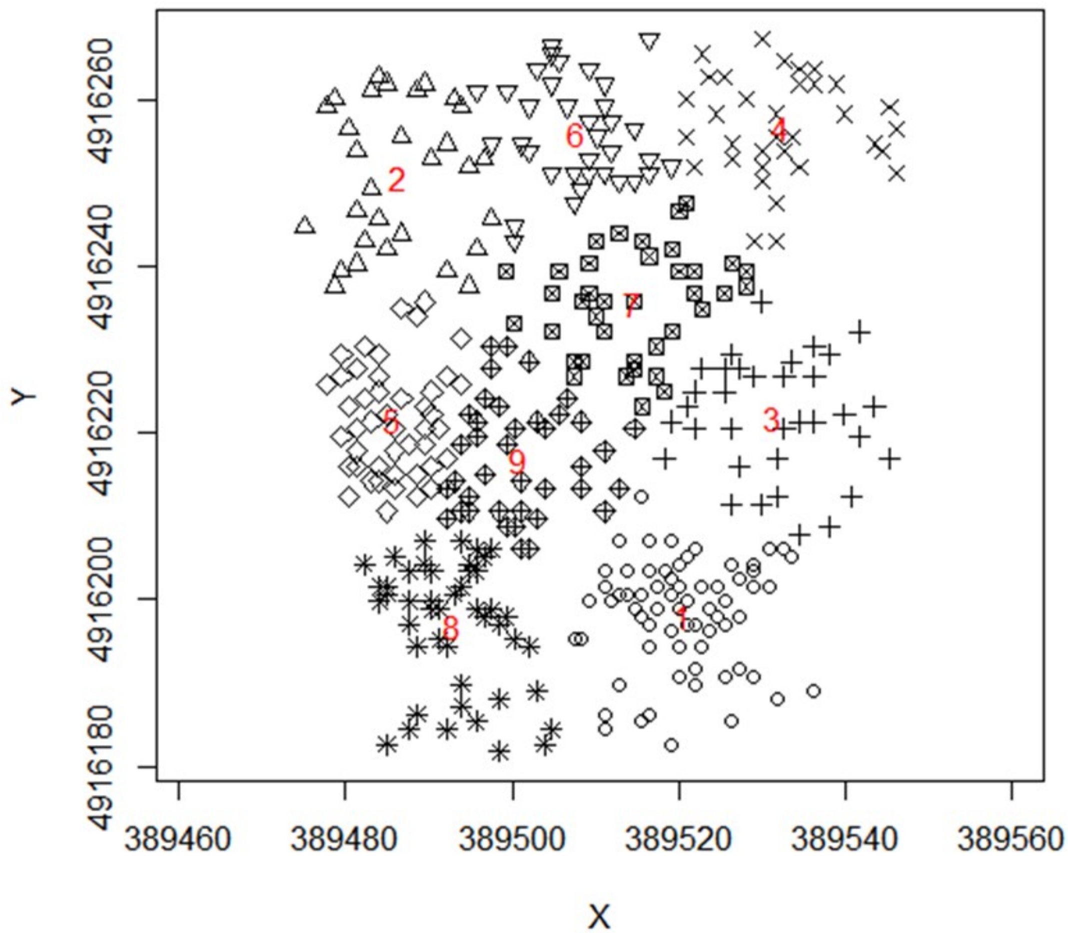


Figure 57: Calculated clusters from only points inside palisade, nine cluster solution.

Calculated Clusters-Only points located inside palisade

Nine Cluster Solution
Overlaid on Magnetometry Survey

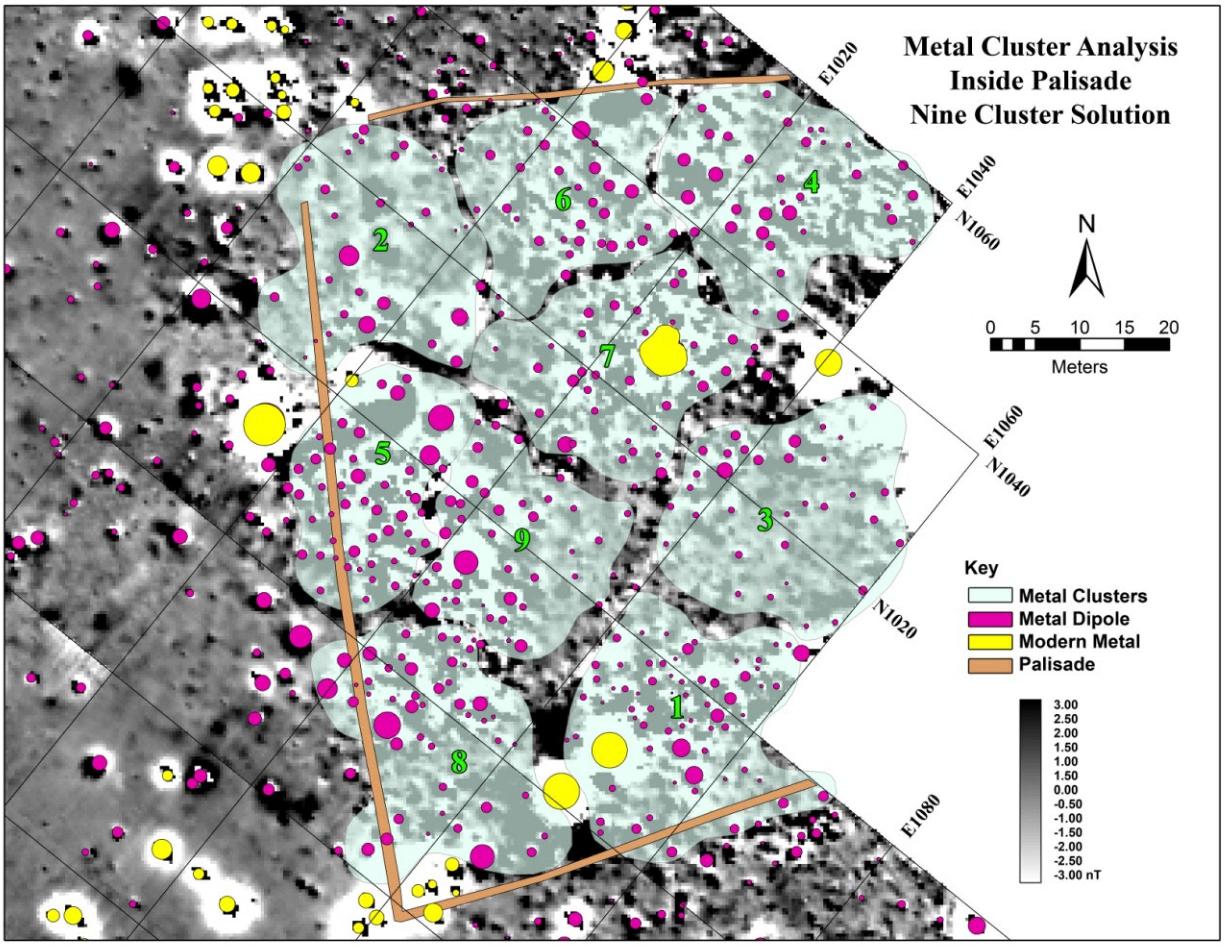


Figure 58: Only points inside palisade, nine cluster solution overlaid on magnetometry data.

Final Defined Clusters

Combination of Cluster Analysis and Geophysical Anomaly Interpretations

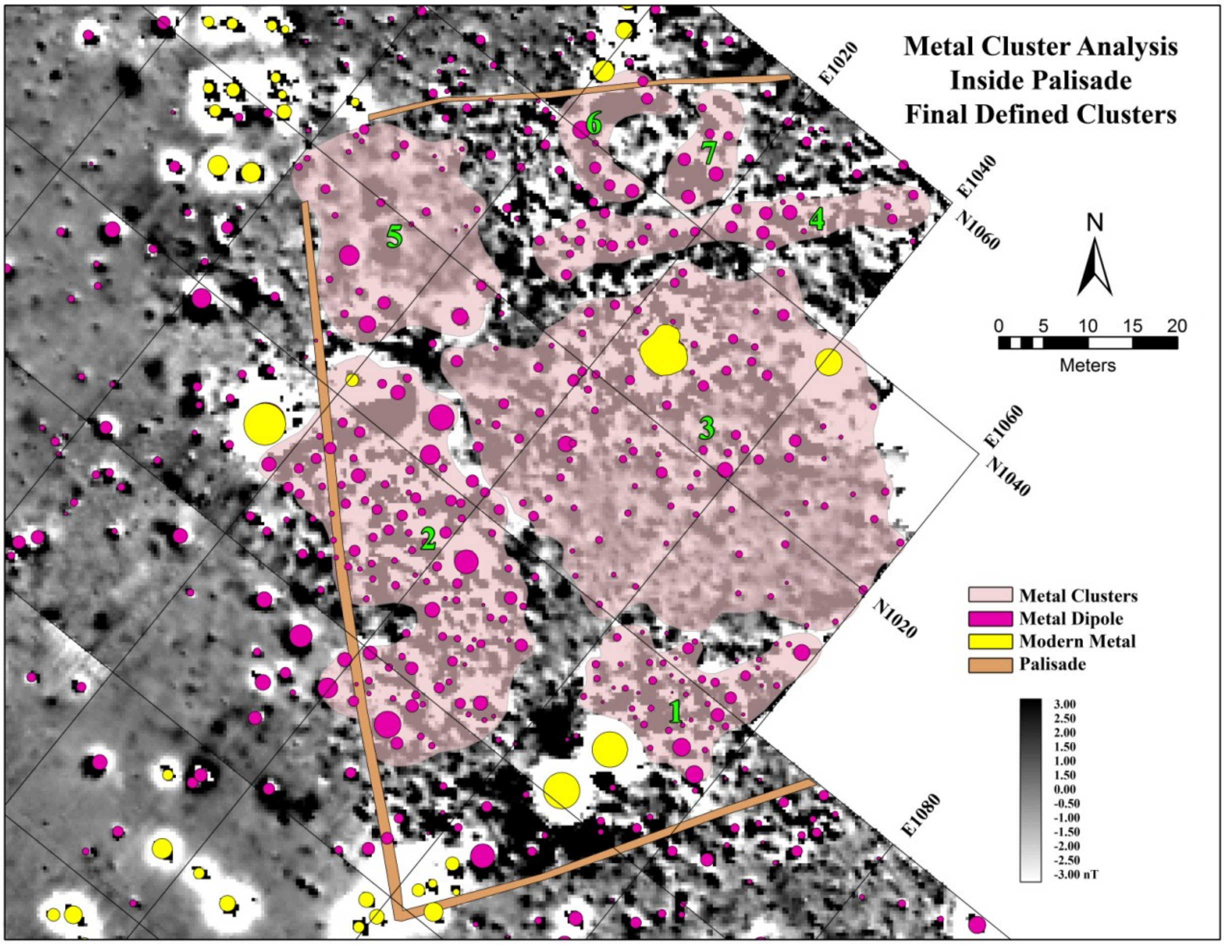


Figure 59: Final defined clusters combining cluster calculations and association with structure anomalies. Seven clusters overlaid on magnetometry data.

Appendix D: Aerial Photography and High Resolution Orthoimagery

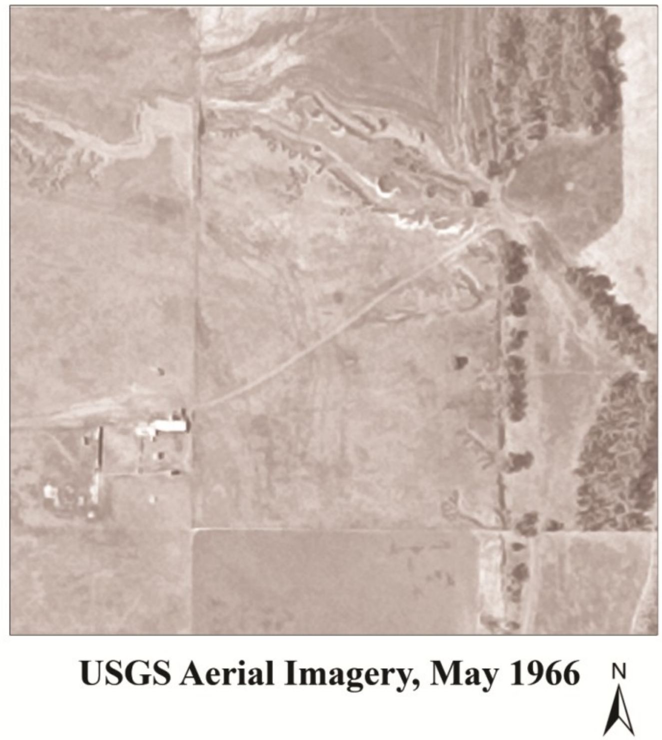


Figure 60: USGS Aerial Imagery, May 1966

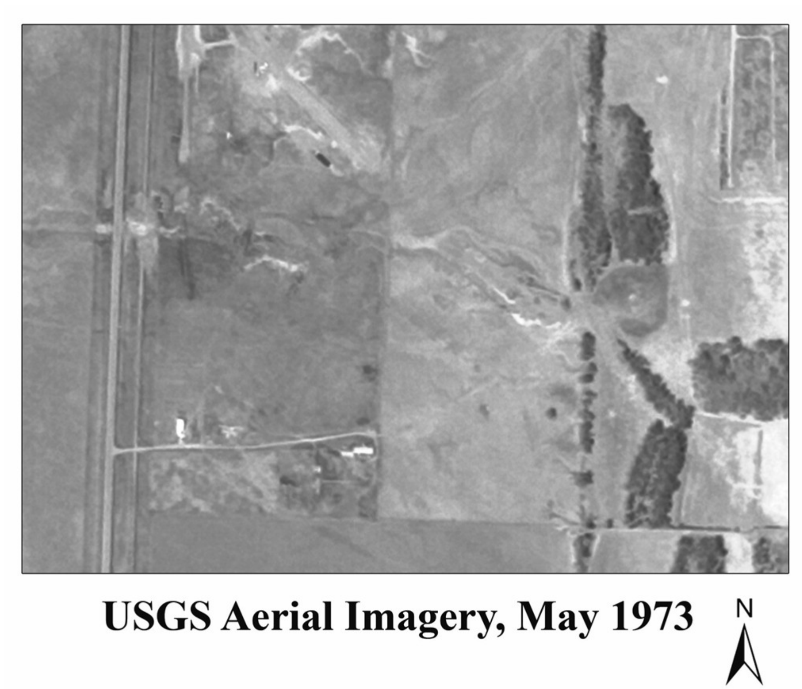


Figure 61: USGS Aerial Imagery, May 1973

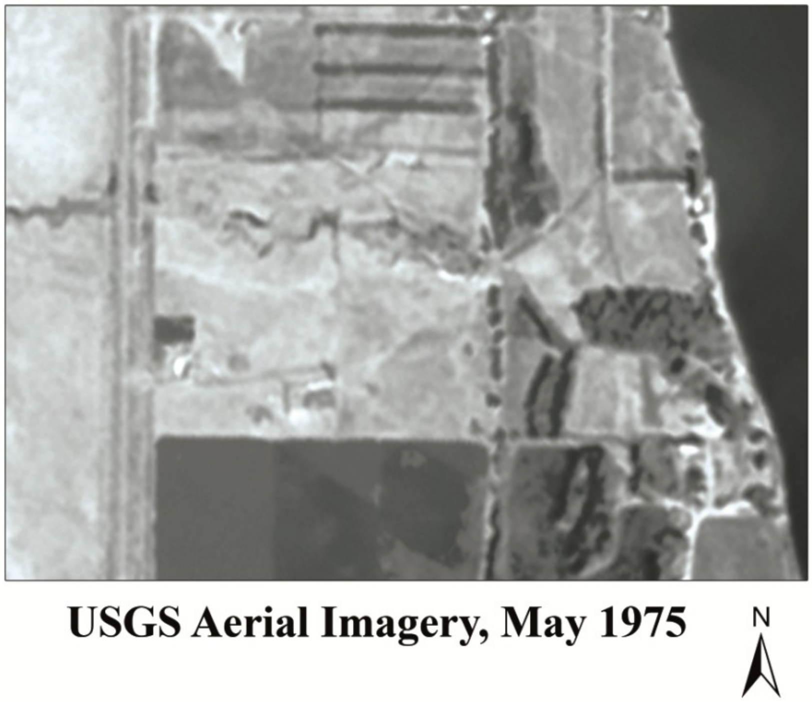


Figure 62: USGS Aerial Imagery, May 1975

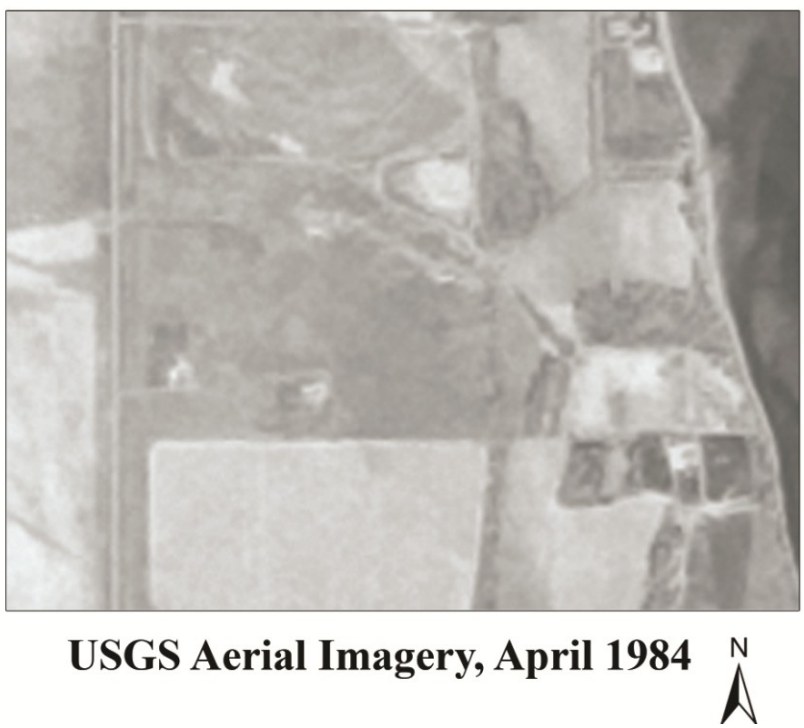


Figure 63: USGS Aerial Imagery, April 1984

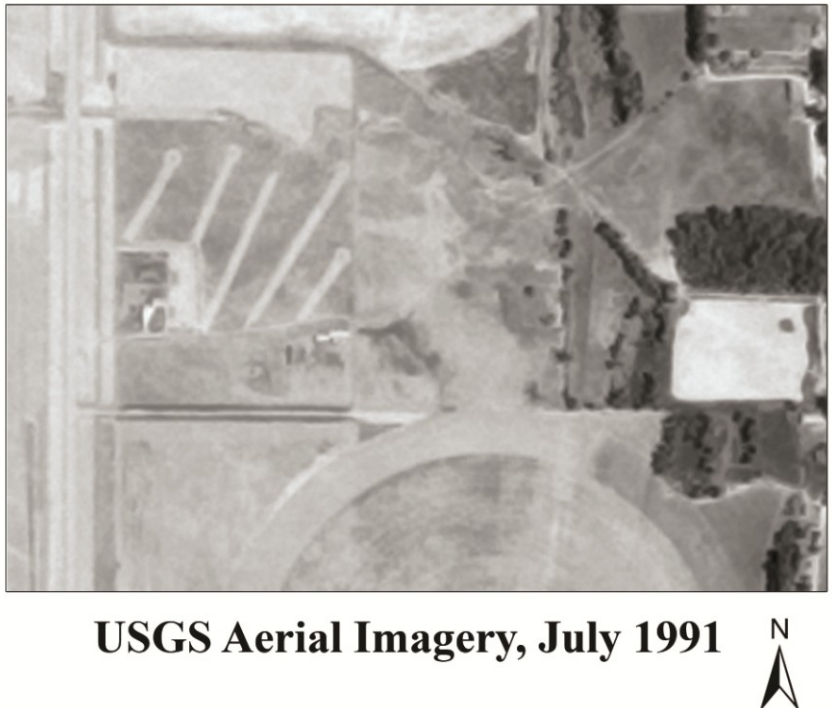


Figure 64: USGS Aerial Imagery, July 1991

Figure 65: USGS Aerial Imagery, October 1997

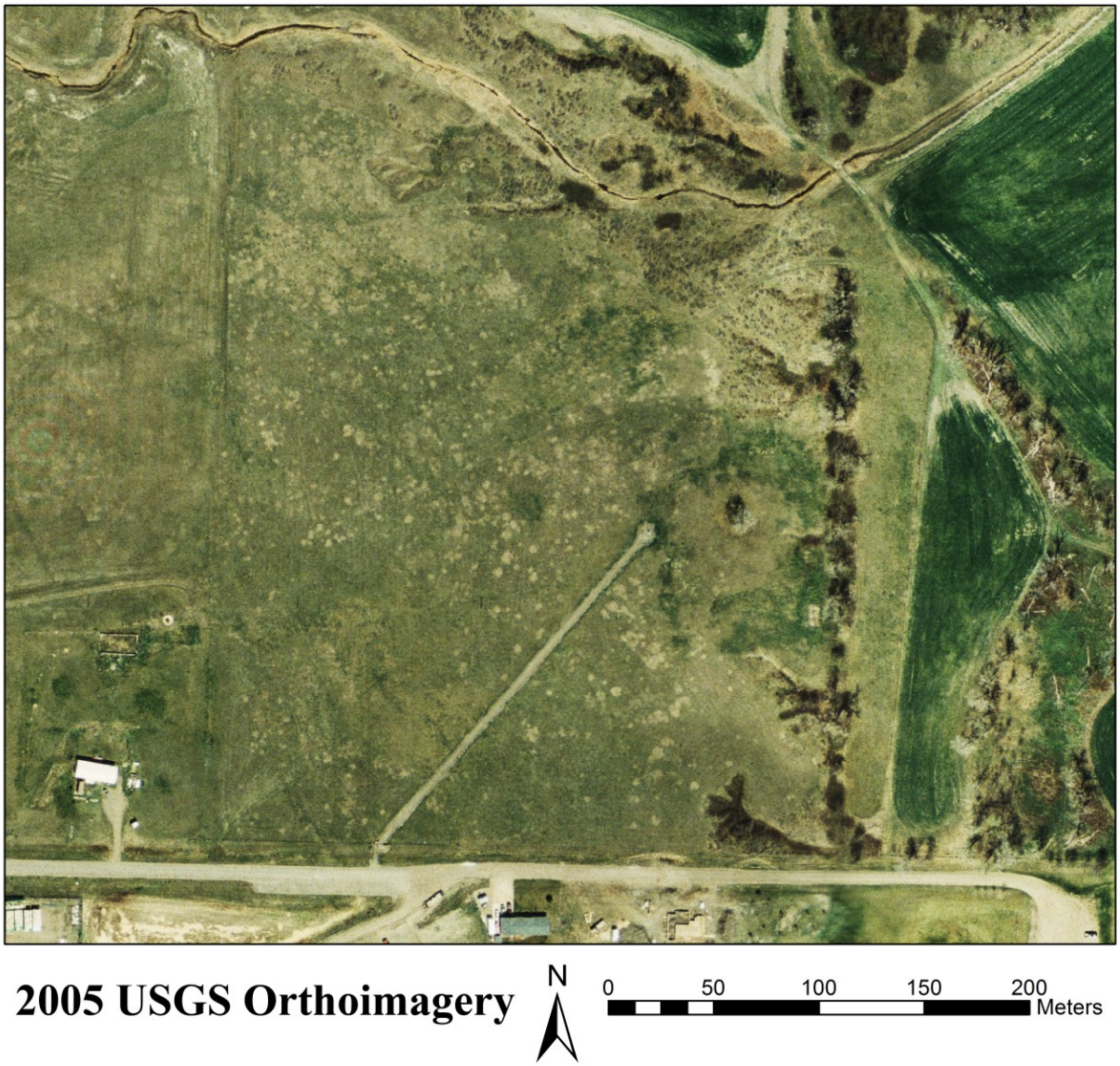


Figure 66: 2005 USGS High Resolution Orthoimagery

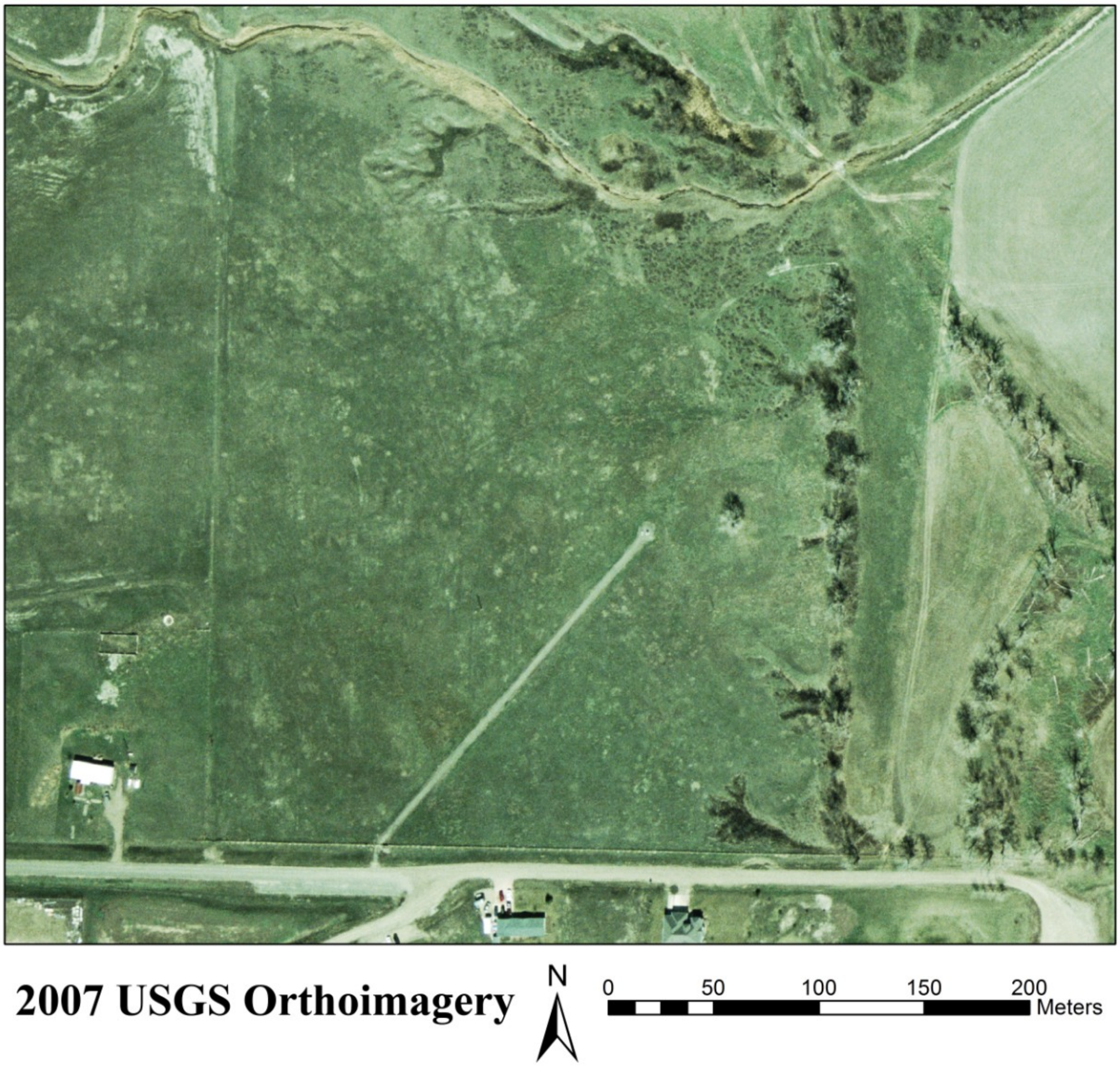


Figure 67: 2007 USGS High Resolution Orthoimagery

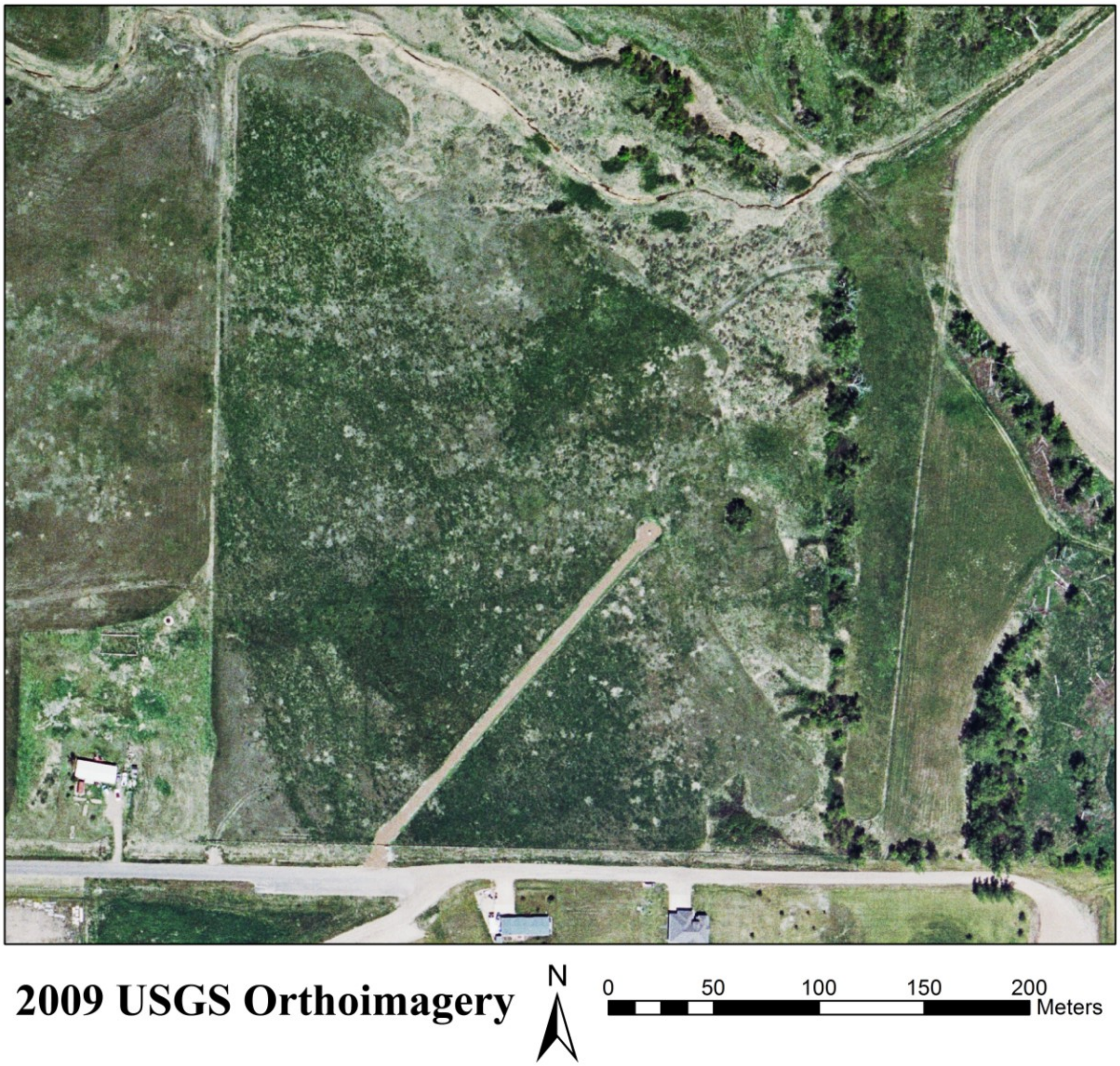


Figure 68: 2009 USGS High Resolution Orthoimagery

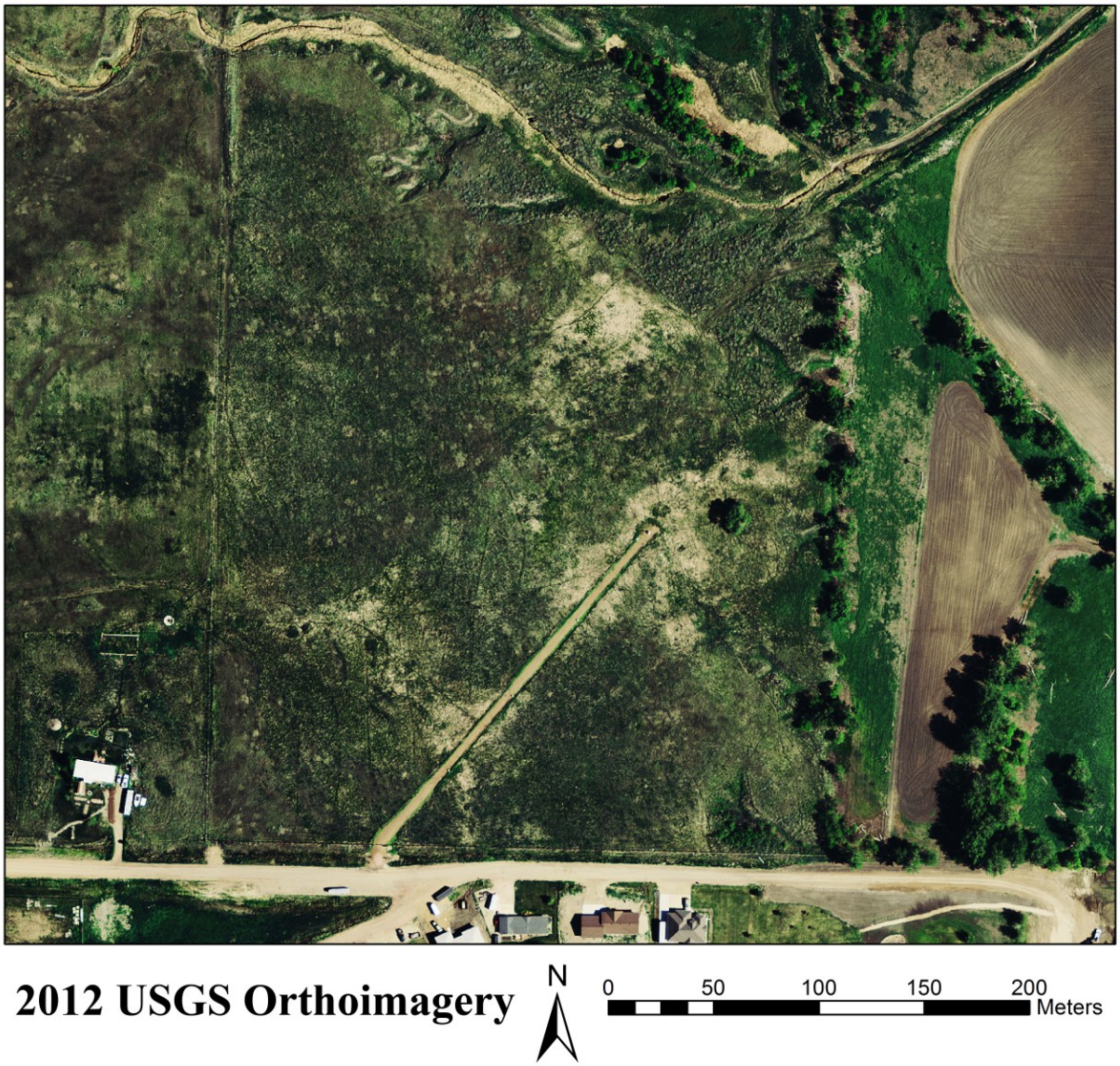
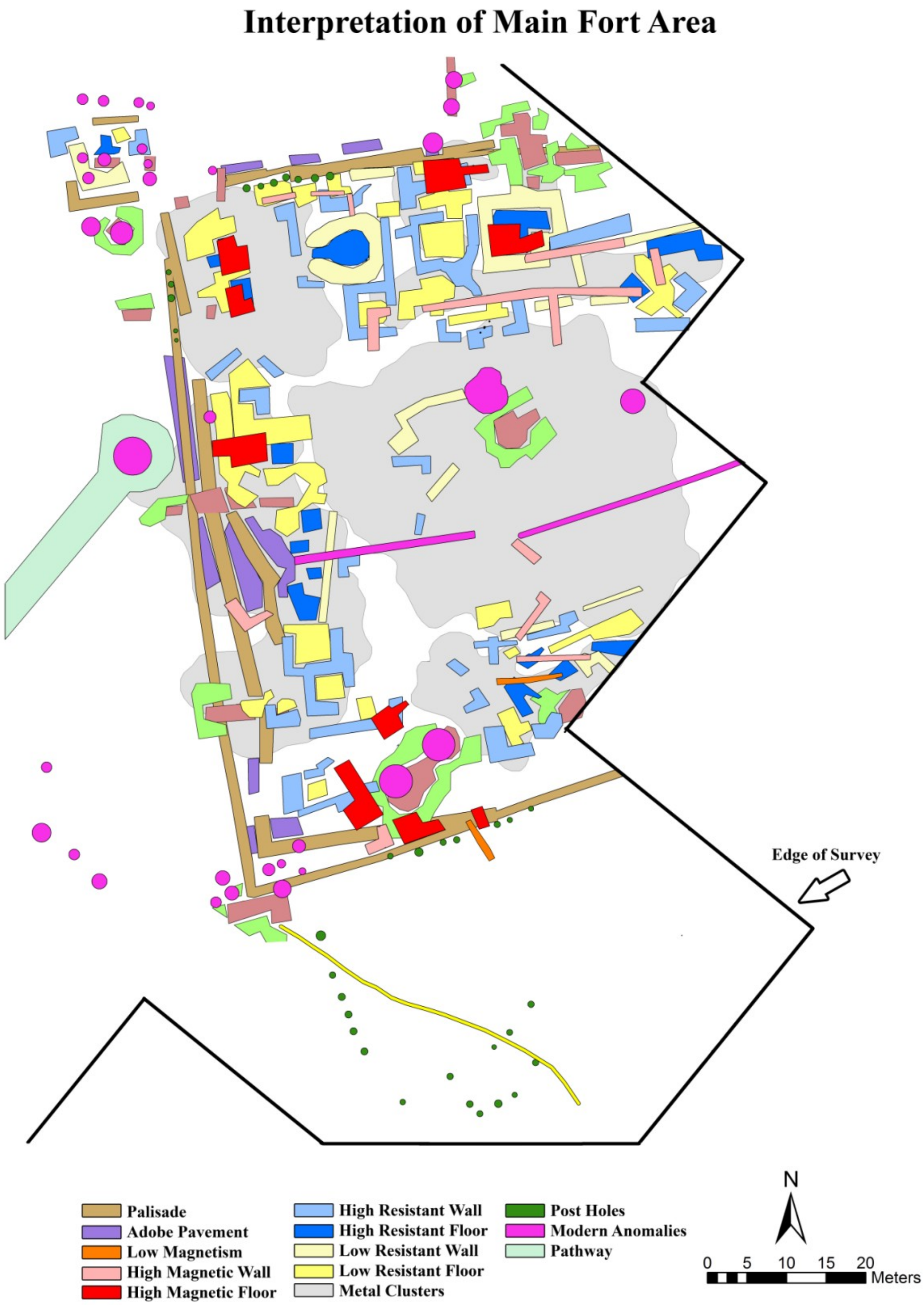
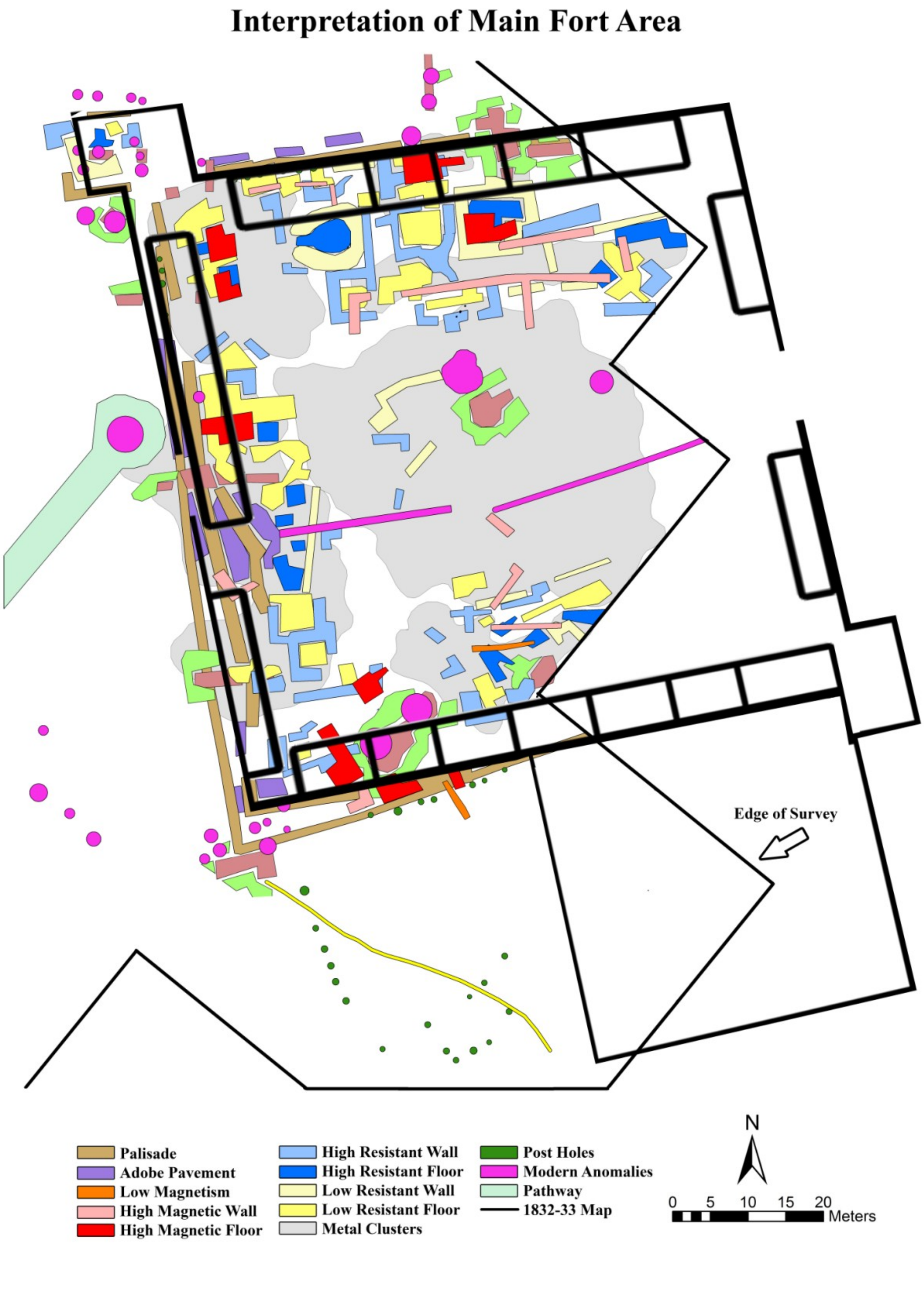


Figure 69: 2012 USGS High Resolution Orthoimagery

Appendix E: Final Interpretive Map – Combined Geophysics and Excavations



Final Interpretive map overlaid with 1832-33 Map, Distorted to Fit Anomalies



Final Interpretive map overlaid with 1855 Map, Distorted to Fit Anomalies

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