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Technical Report No. 117



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**United States Department of the Interior**
**National Park Service**
**Midwest Archeological Center**
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This report has been reviewed against the criteria contained in 43CFR Part 7, Subpart A, Section 7.18 (a) (1) and, upon recommendation of the Midwest Regional Office and the Midwest Archeological Center, has been classified as

*Available*

Making the report available meets the criteria of 43CFR Part 7, Subpart A, Section 7.18 (a) (1).

## ABSTRACT

Geophysical and archeological investigations were conducted at four residences at the Harry S Truman National Historic Site in Independence, Missouri. The investigations were conducted as part of the park's rehabilitation projects for the replacement of basement foundations at the Noland House and the Frank Wallace House. The four property lots associated with the Noland House (23JA636), the Truman Home (23JA635), the George Wallace House (23JA634) and the Frank Wallace House (23JA637) were documented and recorded with the Archeological Survey of Missouri. The Truman Grandview Farm (23JA638) was also recorded with the Archaeological Survey of Missouri during the course of the project.

The geophysical investigations at the Noland property (23JA636) included magnetic, resistance, conductivity, and ground-penetrating radar surveys. Archeological investigations at the Noland property included 20 shovel tests and three controlled test excavations in the Noland yard. An additional two shovel tests were placed in the crawl space beneath the middle part of the house. Five hundred twenty-five square meters were surveyed with a fluxgate gradiometer, a resistance meter and twin probe array, a ground conductivity meter, and a ground penetrating radar cart system with a 400 mHz antenna. The geophysical data indicated the presence of buried archeological objects and features related to the Noland family, as well as more recent buried utility lines. Artifacts consisted of 19th and 20th century objects. The excavations indicated that the historic deposit averaged less than 20 cm deep.

The geophysical investigations of the Truman Home, the George Wallace House, and the Frank Wallace House property lots included magnetic, conductivity, and ground penetrating radar surveys. Three thousand fifty-eight square meters of the Truman property (23JA635), 890 square meters of the Frank Wallace property (23JA637), and 890 square meters of the George Wallace property (23JA634) were surveyed with a fluxgate gradiometer, a ground conductivity meter, and a ground penetrating radar cart system with a 400 mHz antenna. The geophysical data suggested the location of buried utilities and artifacts associated with the Truman and Wallace families.

Monitoring activities during the construction phase of the installation of the Noland House and the Frank Wallace House basement foundations identified artifacts and features associated with the occupation of the houses during the late 19th century and throughout the 20th century.

**ACKNOWLEDGEMENTS**

The authors would like to thank the former Superintendent James Sanders and Acting Superintendent Carol Dage and staff of the Harry S Truman National Historic Site (HSTR) for their support and knowledge of the Truman, Noland, Gates, and Wallace families during the geophysical investigation phase of the project. During the survey, several Midwest Archeological Center archeological technicians and University of Nebraska students assisted in the project at the Noland property. We would like to thank all of them for their time and effort in helping conducting the geophysical survey and excavating the shovel tests and excavation units during the project. These include Harold Roeker, Elizabeth Beavers, Mike Hammons, and Liz Spott. During the geophysical investigations of the Truman and the two Wallaces properties, Mike Hosking, Joe Cannon, and Joseph Gray assisted in the survey efforts. We would also like to extend our appreciation to Alan O’Bright, Midwest Regional Architect, for his insight and support during the investigations.

At the Midwest Archeological Center, a number of people deserve credit for helping complete this project. These include Dr. Mark Lynott, Dr. Ralph Hartley, and Thomas Thiessen. Dr. Douglas Scott and Dr. Vergil Noble provided information about the park including a historic overview and past archeological investigations. Bonnie Farkas, Darin Schlake, Allan Weber, Jeff Larson, Anna Loach, and Linda Clarke should also be commended for all of their hard work addressing the various fiscal, computer, and personnel issues related to the project.

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## 1. INTRODUCTION

Park Staff at Harry S Truman National Historic Site (HSTR) requested the archeological and geophysical evaluation of buried archeological resources in the property lots associated with the Noland House, the Truman Home, the George Wallace House, and the Frank Wallace House (Figure 1). The archeological evaluation phase was part of a rehabilitation project for the replacement of the basement foundations associated with the Noland House and the Frank Wallace House within the boundary of the Harry S Truman National Historic Site in Independence, Missouri. Archeologists from the Midwest Archeological Center (MWAC) conducted three separate site visits in relation to this project. During the week of March 14-18, 2005, Midwest Archeological Center staff conducted geophysical and archeological investigations of the Noland House property (Site 23JA636) at 216 North Delaware Street, Independence, Missouri (De Vore 2005a). During the period from April 8th to April 14th, geophysical investigations were conducted in the three lots associated with the Truman Home (Site 23JA635) at 219 North Delaware Street, the George Wallace House (Site 23JA634) at 605 Truman Road, and the Frank Wallace House (Site 23JA637) at 601 Truman Road (De Vore 2005b). The four residences were documented and recorded with the Archaeological Survey of Missouri. The Truman Grandview Farm site (23JA638) was also documented and recorded with the Archaeological Survey of Missouri at this time (Figure 2). During the period between December 9th and 16th, MWAC archeologists monitored construction activities associated with the raising of the Noland House for the removal of the existing foundation and soil matrix in the crawl space under the house, and the removal of the front porch at the Frank Wallace House (De Vore 2005c; Thiessen 2005). Prior to the arrival of MWAC archeologists for the final monitoring phase of the project, the excavation of the soil matrix surrounding the Noland and Frank Wallace Houses was monitored by qualified archeologists. An MWAC archeologist monitored excavations around the Noland House during the week of November 7-12 (Noble 2005) and a Jackson County Parks and Recreation archeologist (Peterson 2005) monitored work surrounding the Frank Wallace House through a cooperative arrangement with HSTR staff in the later part of November and early part of December.

Established on May 23, 1983 (Public Law 98-23), the Harry S Truman National Historic Site commemorates the life and accomplishments of Harry S Truman (1884-1972), the 33rd President of the United States. Prior to the establishment of the Park, the Truman Home and a surrounding eight-block area was designated a National Historic Landmark district in 1971. In 1985, the Truman farm in Grandview was designated a National Historic Landmark. The National Historic Site boundaries were expanded to include the Noland and Wallace Houses in 1989 (Public Law 101-105) and to include the Truman/Young farm in 1993 (Public Law 103-184). The Park contains the Independence unit near the historic downtown area of Independence and the Grandview unit one mile west of U.S. Highway 71 at 12301 Blue Ridge Boulevard in Grandview (National Park Service 1985, 1987, 1995, 1999). The 1.41-acre Independence unit contains the Truman Home and carriage house at 219 North Delaware Street, the George P. Wallace House and garage at 605 West Truman Road, the Frank G. Wallace House at 601 West Truman Road, the Joseph T. Noland House at 216 North Delaware Street, and the visitor center at 223 North Main Street. The 5.26-acre Grandview unit contains the farmhouse, outbuildings, and a portion of the 600-acre Truman/Young family farm.

Geophysical methods were used to survey the Noland House yard and the joint Truman and Wallace yards at Harry S Truman National Historic Site during the Spring of 2005 (Figure 3). The geophysical investigations were requested by the park staff as part of a rehabilitation project planned for the Noland and Frank Wallace Houses to identify buried archeological resources. The geophysical investigations were part of the archeological inventory and evaluation project of the four properties. The geophysical equipment used in the survey effort included a ground penetrating radar cart system with 400 MHz antenna, a resistance meter with twin probe array, a fluxgate gradiometer, a ground conductivity meter, and a resistivity meter with an offset Wenner probe array. Archeological investigations at the Noland House property included shovel tests and formal one by one meter excavation units.

The Noland House property (Site 23JA636) is located at 216 North Delaware Street (Figure 4) across from the Truman Home at 219 North Delaware. The park is planning a rehabilitation project, which will involve raising the entire structure to permit excavation of a full basement in lieu of the present partial basement and crawl space, as well as replacement of the foundation. To accomplish this, it will be necessary to excavate a 2.1-meter wide trench around the house for the shoring to support the raised house and a ramp in the yard west of the house so that mechanized equipment can remove the foundation and access the basement. Since no previous archeological investigations have taken place on the Noland House property, it is unknown whether any archeological resources or features associated with the construction or occupation of the house existed in the lot around the house or under the crawl space in the basement. The purpose of the Noland House geophysical and archeological inventory project is to evaluate the potential of the Noland House lot and crawl space to yield archeological resources associated with the Noland and Truman families. The project work order calls for the geophysical and archeological investigations of exterior property surrounding the house and the interior crawl space beneath the house. The areal extent of the project covers approximately 525 m2 or 0.13 acres.

The Truman Home property (Site 23JA635) is located at 219 North Delaware Street (Figure 5), the George Wallace House property (Site 23JA634) is located at 605 Truman Road (Figure 6), and the Frank Wallace House property (Site 23JA637) is located at 601 Truman Road (Figure 7) in Independence, Missouri. The park is planning a rehabilitation project that will involve raising the Frank Wallace House to permit the replacement of the basement foundation. Since no previous archeological investigations have taken place on the Frank Wallace property, it is unknown whether any archeological resources or features associated with the construction or occupation of the house existed in the lot around the house. The purpose of the present geophysical and archeological inventory project is also to evaluate the potential of the Frank Wallace House property lot to yield archeological resources associated with the Wallace and Truman families. Given the areal extent of the three adjacent properties, the project scope-of-work calls for the geophysical investigation of all three properties, totaling approximately 4,548 m2 or 1.22 acres.

The final phase of the geophysical and archeological investigations associated with the basement replacement project was to monitor the construction demolition of the basement at the Noland House (216 North Delaware Street; Site 23JA636) and the front porch at the Frank Wallace House (601 Truman Road; Site 23JA637) properties at Harry S Truman National Historic Site. The purpose of the archeological monitoring project was to identify and document any archeological resources associated with the original house construction activities and later modifications at the Noland House and the Frank Wallace House. The present monitoring project also included the identification and documentation of earlier historic or prehistoric resources uncovered during the construction of the 2.1 meter wide trench around the exterior of the foundations at both houses for the placement of the shoring used during the raising of the houses above the foundations. The project also called for the monitoring of the demolition of the basement and crawl space fill at the Noland House and the demolition of the front porch and associated fill at the Frank Wallace House.

# HARRY S. TRUMAN

## 2. ENVIRONMENTAL SETTING

The present project is located in the Osage Plains section (Fenneman 1938:605-630) of the Central Lowlands Province of the Interior Plains near its boundary with the Dissected Till Plains to the north (Fenneman 1938:588-605). Carl Chapman (1975:1-19) further divides the physical environment of Missouri based on his archaeological work in the state. The State of Missouri is divided into six general physiographic regions. The project area lies in the Lower Missouri Valley locality of the Northwest Prairie Region in the rolling loess mantled hills region of the state.

The project area consists of undulating or rolling topography formed by the erosion of the uplands by numerous drainages feeding into Mill Creek, a tributary of the Missouri River and other Missouri River tributaries. The ridge tops are narrow with moderate sloping to steep ridge slopes and narrow valley floors. Bedrock is comprised of Pennsylvanian aged limestones and shales (Branson 1944:282-284; McCourt 1917). The National Historic Site lies at an elevation of approximately 310 meters above mean sea level.

The project areas lie within the Iowa and Missouri Deep Loess Hills resource area of the Central Feed Grains and Livestock Region (USDA 1981:114-115). The soils in western Missouri are dominated by Hapludolls of the Udoll order (Foth and Schafer 1980:116-125), although the young alluvial soils of the floodplains are primarily Orthents (Foth and Schafer 1980:53-60). Alfisols are formed under forest vegetation (Foth and Schafer 1980:143). The soils are deep with medium to moderately fine textures with mixed mineralogy. The soils are well to poorly drained with udic soil moisture and mesic soil temperature regimes. Parent materials consist of loess, alluvium, and residual material or some combination of these materials (Preston 1984:85). The Iowa and Missouri Deep Loess Hills land resource area contains soils that formed under tall prairie grasses. Depth to bedrock ranges from shallow to very deep. The project areas lie within the Knox-Sibley-Urban land association of “Urban land and deep, gently sloping to steep, well drained soils that formed in loess; on uplands” (Preston 1984:8).

The soil within the majority of the Harry S Truman National Historic Site project area is identified as the Sibley-Urban land complex with 2 to 5 percent slopes (Preston 1984:35-36). A small portion of the project area around the sides and front of the George Wallace and Frank Wallace House property lots is identified as Higginsville-Urban land complex with 5 to 9 percent slopes (Preston 1984:37-38). Urban lands consist of areas covered by buildings and other structures, streets, parking lots, land leveling or excavation, and other man made features that obscure or alternate the native soils to the point where identification is not possible (Preston 1984:35,38). Urban lands tend to be impervious to water where the ground is covered. The Sibley-Urban land complex consists of the deep, well-drained, gently sloping Sibley silt loams (Preston 1984:35-36, 81) intermixed with Urban land. Developed in very thick silty loess, these soils are found on moderately wide complex ridges. The Sibley soils have a moderate permeability with a very high available water capacity. Surface runoff is medium. Natural fertility of the soil is high with moderate organic matter content. The soil pH ranges from neutral to medium acid. It also has a moderate shrink-swell potential. The soil complex is commonly found in yards, parks, gardens, and open areas between buildings. The Higginsville-Urban land complex consists of moderately sloping and somewhat poorly drained Higginsville silt loams (Preston 1984:37-38, 71-72) intermixed with Urban land. The Higginsville soils developed in very thick loess on the side slopes. The Higginsville soils are moderately permeable with a rapid surface runoff and high available water content (Preston 1984:38). The natural soil fertility is high with moderate organic matter content. The soil pH ranges from medium to slightly acid. It also has a moderate shrink-swell potential.

The project area also lies within the Illinoian biotic province (Dice 1943:21-23). Prairie and deciduous forest alternate across the landscape although the forests thin as the annual moisture levels decrease. The major native prairie grasses included big bluestem, indiangrass, and switchgrass. Little bluestem and sideoats grama preferred the steeper soils along the Missouri River. A mixed deciduous forest community grew along the bottomlands and side slopes adjacent to the streams (Shelford 1963:334-344; Steyermark 1963; Sutton and Sutton 1985:58-70). These forests consist of medium tall, multilayered broadleaf deciduous species. Dominate species include the linden, red oak, white oak and shagbark hickory on the protected upland slopes with bur oak and bitternut hickory on the steeper side slopes. Along the floodplains, the deciduous forests are dominated by eastern cottonwood, honey locust, sycamore, black walnut, and American elm (USDA 1981:115). Other minor forest species include dogwood, sycamore, box elder, mulberry, cedar, and prickly ash. Persimmon, chokeberry, wild plum, wild grapes, and mushrooms are some of the resources used by prehistoric inhabitants of the region, as well as, the historic Euroamerican settlers. These forests have well developed undergrowth vegetation communities of small trees, shrubs, and fords, including redbuds, hornbeam, pawpaw, hawthorn, gooseberry, sumac, sweet haw, blackberry, raspberry, jack-in-the-pulpit, bloodroot, mayapple, wild asters, goldenrods, chenopods, ragweeds, and smartweed (Phillips 1979; Steyermark 1963). They are often interrupted by freshwater marshes and prairie communities.

Bison, elk, pronghorn antelope, and wolves inhabited the plains during the prehistoric and early historic periods (Shelford 1963:334-335). Numerous other mammals and rodents also inhabited the region including prairie dogs, jackrabbits (Schwartz and Schwartz 1959; Shelford 1963:334-336). Numerous species of birds inhabited the grasslands, the shrublands, and wooded areas of the region (Shelford 1963:336). Reptiles included several species of lizards, turtles, and snakes (Shelford 1963:336). Fish, including catfish, carp, and bass, and fresh water mussels were found in the streams throughout the region (Buchanan 1980; Pfleiger 1971). Insects and other invertebrates abound throughout the region (Shelford 1963:336-339).

The region has a typical continental climate characterized by large daily and annual variations in temperature (Moxom 1941:945-954). The project area lies within the subhumid continental climatic zone (Thornthwaite 1948). Winters are fairly brisk and the summers are warm (Moxom 1941:953-954). Annual January temperatures average -1.78° C (Preston 1984:2, 98). The average daily minimum winter temperature is 0.56° C. The lowest recorded winter temperature is –23.3° C (Preston 1984:2). Annual July temperatures average 26.7° C (Preston 1984:98). The average daily maximum temperature in the summer is 25.6° C. The highest recorded summer temperature is 44.4° C (Preston 1984:2). Annual precipitation averages 90.8 centimeters (Preston 1984:2, 98) with the majority falling from April through September. The average seasonal snowfall is 55.9 centimeters per year (Preston 1984:2, 98). The growing season averages 220 days with killing frosts occurring as late as May 8 in the spring and as early as October 16 in the fall. Severe thunderstorms and tornadoes occur occasionally with hail and high winds. Although these are generally local in extend and of short duration, the resulting damage can be severe. Droughts may occur anytime throughout the year, but are most damaging during the crop-growing season (Moxom 1941:954). Flooding may occur along smaller streams on the average of one to two times in the spring and early summer months during most years. Occasional severe flooding of the Missouri River can produce heavy losses. The sun shines approximately 75% of the time in summer and 60% of the time in winter (Preston 1984:2). The prevailing winds are from the south with the highest average wind speed of 19.31 kilometers per hour occurring in the spring (Preston 1984:2).

## 3. HISTORICAL OVERVIEW

Since the inception of the Harry S Truman National Historic Site, the National Park Service has completed numerous historic resources, historic structures, and cultural landscape studies documenting the history of Park and its association with President Truman and his family. Using these documents (Bahr Vermeer Haecker Architects 2004; Cockrell 1984, 1985; Cockrell and Krueger 1989; Evans-Hatch and Evans-Hatch 2001; and Restoration Associates 1987), the following historic overview has been compiled illustrating the association of the Truman, Gates, and Wallace families to the National Park unit and to the Independence, Missouri, community.

In 1827, Independence was founded as the Jackson County seat of government following the establishment of Jackson County in December 1826 (Foerster 1978; Hickman 1990; Union History Company 1966). Initially, the 240-acre town site was surveyed by George C. Sibley of Fort Osage. Lying on the uplands between the Missouri River on the north, the Big Blue River on the west, and the Little Blue River on the east, the plat of the town was laid out according to the Shelbyville square plan (Ohman 1983:33-34). During the next sixty years, the town's prosperity was tied to local, regional, and national events. Independence served as a jumping off point for the Oregon, California, and Santa Fe trails, a mecca for the Mormons, a battleground during the Civil War, an agricultural center, and a suburb of Kansas City. In 1833, Jones Hoy Flournoy from the State of Missouri purchased the land on which sits the four houses that forms the core of the Independence unit of the Park. The 80-acre parcel was located adjacent to the northwest corner of the town. Cornelius and Sarah Davy bought the parcel from Jones and Clara Flournoy in 1836 along with lands totaling approximately 100 acres. The Davys sold 86 acres to James F. Moore and his wife, Sarah, in 1839. Although the Moore's gave the attorney, Benjamin F. Hickman, permission to sell the land, he was unable to find a buyer for six years. In 1846, the Moores had their attorney survey their parcel and divide it into three blocks with 18 lots. Mr. Hickman filed the plat map and legal description of the parcel with the City of Independence in 1847 as the Moore's Addition. The lots began to sell shortly after the plat and legal descriptions were filed. The future Gates/Wallace/Truman Home and the two Wallace Houses were built on portions of lots 3, 2, and 1. The future Noland House was built on the southern portions of lots 4 and 5.

The Truman Home was located at 219 North Delaware Street, Independence, Missouri. The property was located on the uplands in the center part of town. The property was acquired by George Porterfield Gates (the grandfather of Bess Truman) in 1867. Historical evidence suggests that a small house built sometime between 1848 and 1850 was located on the lots 2 and 3. He enlarged the house to a two-story house, rectangular structure with the small house at the rear. In 1868, Mr. Gates bought lot 1. In 1885, Mr. Gates constructed a sizable addition to the house. Atlases and maps of Independence during the 1800s, along with the existing Sanborn fire insurance maps from 1907, 1916, 1926, 1949, and 1962, provide a cursory review of the various changes made to the property by the Gates, Wallace, and Truman families (Gallup Map & Supply

Company 1931; Gallup Map & Supply Company 1940; Hickman and Thornton 1876; Hopkins 1886; Northwest Publishing Company 1904; Ruger 1868; Slavens 1976). The Gates, Wallaces, and Trumans continued to modify the house at 219 North Delaware throughout their respective ownerships. The property measures 175' wide by 225' long or 0.78 acres. The house has a footprint of 2,414 sq. ft. For a period of time after Margaret "Madge" Gates (George's eldest daughter) married David Wallace, the Wallaces lived at 219 North Delaware in the 1880s. Elizabeth Virginia "Bess" Wallace was born in 1885 while the family lived on West Ruby Street. Frank Gates Wallace was born in 1887 after the family moved in with Madge's parents. George Porterfield Wallace was born in 1892 after the Wallace family moved to a house two blocks from the Gates residence in 1890. An infant gril was born in 1898 but died a day later. David Frederick Wallace was born in 1900. In 1904, Madge moved her family back in with her parents after the death of her husband in 1903. After their marrage in 1919, Bess and Harry truman established their residence at 219 North Delaware. During his term as President, Mr. Truman continued to visit Independence using the residence as the Summer White House. The Trumans retired to their home at 219 Delaware Street. In 1972, the 219 North Delaware was designated as a contributing element to Harry S Truman Historic District National Historic Landmark. The property was designated the Harry S Truman National Historic Site under the care of the National Park Service in 1982.

The Noland House was the residence of President Truman's aunt and uncle, Margaret Ellen "Ella" Truman Noland and Joseph Tilford Noland where they lived with their daughters, Nellie and Ethel. Their eldest daughter, Ruth, had married Robert Ragland and moved out prior to the family move to the residence at 216 North Delaware. The Noland family occupied the house from August 1900 until August 1971 when Ethel passed away. During a stay at the Noland House across the street from the Gates/Wallace home in 1910, Harry Truman renewed his acquaintance with Bess Wallace. They had originally met at the Trinity Episcopal Church after the Truman family had moved back to Independence in 1890. The Noland House property was initially purchased in 1858 by Frederick F. Yeager and sold to Charles Sayre in 1865. The construction of the house took place sometime between 1858 and 1865 and resulted in a two-story, four-room structure. The house was then purchased and remodeled by the Slack family between 1868 and 1885, when multiple rooms were added to the first story of the house as well as the basement. In 1885, the Slack family moved out of the Noland House, but still kept it as a rental property. Around 1887, the Slack family again remodeled the Noland House, this time adding a front porch, stairwell and two second floor bedrooms. Atlases and maps of Independence during the 1800s, along with the existing Sanborn fire insurance maps from 1907, 1916, 1926, 1949, and 1962, provide a cursory review of the various changes made to the property by the Noland family (Gallup Map & Supply Company 1931; Gallup Map & Supply Company 1940; Hickman and Thornton 1876; Hopkins 1886; Northwest Publishing Company 1904; Ruger 1868; Slavens 1976). The Noland House property was originally listed as a contributing element to the Harry S Truman Historic District National Historic Landmark (listed November 11, 1971). The house was inherited by Ardis Haukenberry, the eldest daughter of Ruth Noland Ragland, who continued to live in the house until 1986. Between

1986 and the purchase of the property by the National Park Service in 1991, the Noland House served as a rental property. Since the acquisition of the property by the National Park Service, the house has sat vacant. Following a recent historic resource study, the Noland House property was nominated to the National Register of Historic Places on its own merits, and was listed on February 23, 2005. The property measures 50’ wide by 114’ long or 0.13 acres. The house has a footprint of 1,484 sq. ft.

The Frank Wallace House was located at 601 Truman Road, Independence, Missouri. The property was located on the uplands in the center part of town. Frank Wallace, brother of Bess Truman, and his wife, Natalie Ott Wallace, moved into the newly built bungalow in 1915 on the site of the former garden and grazing area of the Gates-Wallace house at 219 North Delaware Street. The house became an intimate part of the buildings and landscaping features associated with the Truman Home compound. The physical proximity of the house with the Truman Home and the George Wallace House and family interactions represents the Truman and the Wallace close family ties and their commitment to home, family and community. Existing Sanborn fire insurance maps from 1907, 1916, 1926, 1949, and 1962, provide a cursory review of the various changes made to the property by the Gates and Wallace families. The property measures 57.09’ wide by 165’ long or 0.22 acres. The house has a footprint of 1,552 sq. ft. In 1972, 601 Truman Road was designated as part of the National Historic Landmark district commemorating the life of Harry S Truman. The property was incorporated into the Harry S Truman National Historic Site under the care of the National Park Service in 1991.

The George Wallace House was located at 605 Truman Road, Independence, Missouri. The property was located on the uplands in the center part of town. George Wallace, brother to Bess Truman, and his wife, Mary Frances “May” Southern Wallace, moved into the newly built bungalow in 1916 on the site of the former garden and grazing area of the Gates-Wallace house at 219 North Delaware Street. Like the Frank Wallace House, the George Wallace House became an intimate part of the buildings and landscaping features associated with the Truman Home compound. In addition, the physical proximity of the house with the Truman Home and the Frank Wallace House and family interactions represents the Truman and the Wallace close family ties and their commitment to home, family and community. Existing Sanborn fire insurance maps from 1907, 1916, 1926, 1949, and 1962, provide a cursory review of the various changes made to the property by the Gates and Wallace families. The property measures 57.09’ wide by 165’ long or 0.22 acres. The house has a footprint of 1,418 sq. ft. In 1972, 605 Truman Road was designated as part of the National Historic Landmark district commemorating the life of Harry S Truman. The property was incorporated into the Harry S Truman National Historic Site under the care of the National Park Service in 1991.

## 4. FILE SEARCH AND PREVIOUS ARCHEOLOGICAL DOCUMENTATION

A file search of the Archaeological Survey of Missouri (University of Missouri-Columbia) records was requested in March 2005 for the Noland property (ASM Identification Number 04-5-70), the Truman/Wallace properties (ASM Identification Number 05-3-33), and the Truman Farm (ASM Identification Number 05-3-66). No archeological resources were identified during the Noland, Truman and Wallace properties file search of Sections 2 and 3, Township 49 North, Range 32 West of Jackson County or for the file search associated with the Truman farm in Sections 11, 12, 13, and 14, Township 47 North, Range 33 West of Jackson County. The immediate project area lies within the West Missouri archeological study unit (Wright 1987:B24/1-B24/14). The unit consists of two watersheds along the Missouri River valley.

Limited archeological investigations at the Truman Home property have been conducted. These investigations have been related to small restoration projects. In 1988, MWAC acheologist William Sudderth recovered wine bottles from two basement alcoves (68 bottles in the west alcove and 19 bottles in the south alcove) as part of a removal, stabilization, and curation project (Noble 1988; Sudderth 1988). The wine bottles were packed and removed for permanent storage. In 1992, MWAC archeologist Vergil Noble (1992) monitored excavations to improve the downspout drainage at the rear of the Truman Home. During the monitoring, four pieces of slate roofing were recovered. Limited ground disturbing activities resulted during the 1993 inspection of the coal room in the basement of the Truman Home (Given 1993). A small brick channel or trough was identified beneath the existing dirt floor. Given also noted that an old well or cistern may be present adjacent to the brick trough. Additional excavations in the dirt floor and inspection of several openings in the exterior wall by Masten indicated that the brick duct was a fresh air intake for the original coal furnace (Masten 1993). Masten also concluded that there were no known wells or cisterns located in the basement of the house. MWAC archeologist Scott Stadler (2001) conducted archeological investigations beneath the three porches and in the basement of the Truman Home as part of stablization project of the porches and basement. A small brick feature consisting of three courses of brick was identified under the front porch. Stadler identified the feature as a base for a former support post for the porch. Two features were identified under the kitchen porch including a cistern dating to ca. 1867 and a small brick retaining wall at the east end of the 1867 porch. Excavations in the basement suggested that the basement floor had been excavated into culturally sterile subsoil. Artifacts recovered from the porch excavations included cut and wire nails, slate roofing fragments, a glass marble, a wooden die, plastic beads, a ferrous wheel from a child's toy, a toy rail car, a golf club head, a child's leather shoe, a K. C. and I. Line (Kansas City Railways company) ticket, whiteware, and window glass. A few badly rusted pieces of ferrous metal were recovered from the basement excavations.

In order to determine the foundation depth for the proposed rehabilitation of the Noland House basement foundation, Archeologist John Peterson (2003) of the Jackson

County Parks and Recreation Department assisted the Harry S Truman staff in monitoring three exploratory holes in the Noland House basement. The purpose of the excavations was to determine the depth of the foundation beneath construction joints and collect data on the chronology of the house additions. Three small exploritory excavations were placed near the southeast corner of the south wall (Hole 1), near the intersection of the crawl space foundation and an addition to the south side of the house (Hole 2), and at the base of the western basement foundation wall (Hole 3). Hole 1 bisected a construction joint in the south brick wall. This area of the basement was partially excavated and contained a concrete cap over the subsoil. Peterson noted that a builder's trench may be present but the size of the excavation precluded any further examination. The excavation of Hole 2 in the crawl space revealed a 10 cm wide builder's trench along the south wall. Artifacts from the feature included cut nails, a redware rimsherd from an unglazed flower pot and a shoe heel fragment. Hole 3 was located along the west wall of the basement in the north room of the "root cellar" area. Three courses of brick were identified below the basement's concrete floor. A mixed layer of sand and coal clinkers below the concrete floor suggested that the room may have functioned as a dump for the coal furnace. Also in 2003, two soil cores were removed from the yard at the exterior northwest corner and the northeast corner of the Noland House to explore the engineering properties of the soil (Terracon 2003).

Additional coring was conducted at the Truman Farm House and at the Frank and George Wallace Houses in order to assess the engineering properties of the soils for proposed rehabilitation projects at the Frank Wallace House and the Truman Farm House (Peterson 2004). The stratigraphy of three pits excavated by Park staff at the Truman Farm House and the Carriage House at the Truman Home were also examined during this monitoring project. Cores at the Truman Farm House were located in the yard near the southwest corner of the house and near the northeast corner of the house. No artifacts were noted during the coring. The park excavations were located along the south side of the building next to the southwest corner and the north side of the northeast corner of the building. A small whiteware sherd was recovered from the southwestern excavation pit. The brick foundation in the southwest pit extended to 96 cm below the surface while the brick foundation on the northeast corner only extended to a depth of 67 cm below the surface where it was found resting on a concrete footing. Two cores were drilled at the Frank Wallace House: one in the yard outside the south wall of the house and one inside the basement. Three cores were drilled at the George Wallace House: one in the yard between the two houses near the southeast corner of the building, one in the front yard near the northwest corner of the building, and one in porch fill. Two blue transfer print earthenware and porcelain sherds and a plain white porcelain sherd were recovered from the two cores in the yards of the Frank and George Wallace Houses. A plain whiteware sherd was recovered from the core in the George Wallace porch. The excavation pit along the east side of the Truman Home Carriage House near the northeast corner revealed a feature that may have been a builder's trench. Four artifacts were recovered from the ash, coal, clinker, limestone-mixed fill, including a polychrome floral decorated whiteware plate rim sherd, a plain whiteware sherd, and two clear container glass fragments. Peterson suggested that the artifacts dated the fill to the late 19th or early 20th century. The foundation wall consisted of rough blocks of limestone with a sandy mortar that extended to a depth of 65 cm below the surface.

Archeological investigations at the Truman Farm near Grandview prior to the recent coring activities mentioned above included an archeological survey and testing project conducted at the farm grounds in 1983 (Bray 1983). The project was part of the restoration efforts by the Truman Farm Home Foundation (Evans-Hatch and Evans-Hatch 2001:97-108). Above ground structures, buildings, and features were mapped and described. Additional probing with a tile probe and limited exploratory excavation pits to examine the target revealed numerous features around the house and in the barnyard. In 1994, four small areas of ground disturbances related to the installation of outdoor security lamps were examined (Richner 1994). The backfill from the small installation pit southeast of the house contained several artifacts that were viewed as associated with the 19th century backyard midden. On the northeast side of the house, a shallow access trench for the new electrical line conduit contained a 10 cm thick fill zone over the natural soil matrix. A single whiteware ceramic sherd was observed in the backfill.

## 5. GEOPHYSICAL PROSPECTION TECHNIQUES

Various geophysical instruments have been used by archeologists to locate evidence of past human activity. Magnetometers and soil resistance meters began to be employed on Roman sites in England during the 1950s (Aitken 1961), and their use was the focus of considerable research in the 1960s and 1970s. During this period, the archeological applications of additional instruments were explored (Aitken 1974, Clark 2000, Scollar et al. 1990, Tite 1972). While many of the early studies in England and Europe were very successful, it was some time before improvements in detector sensitivity and data processing techniques allowed a wide range of New World sites to be mapped. Virtually all the instruments used in non-invasive mapping of historic sites originated as prospecting devices for geological exploration. In general, cultural resource applications using geophysical instruments focus on weaker anomalies or smaller anomalies. It is important to emphasize that instruments employed in archeological geophysical surveys do not respond only to the desired cultural targets, and consequently, feature detection depends greatly on the recognition of patterns that match the anticipated form of the cultural target. The challenge in archeological geophysics is to recognize the anomalies produced by the target features and sort them out from the "noise" produced by the responses from the surrounding matrix. The amount of data collected in any given area and the method of collection both affect one's ability to recognize the specific anomaly type or "signature" of the feature being sought.

Geophysical prospection techniques available for archeological investigations consist of a number of techniques that record various physical properties of earth, typically in the upper couple of meters; however, deeper prospection can be utilized if necessary. Geophysical techniques are divided between passive techniques and active techniques. Passive techniques are ones that measure inherently or naturally occurring local or planetary fields created by earth related processes under study (Heimmer and De Vore 1995:7, 2000:55; Kvamme 2001:356). The primary passive method utilized in archeology is magnetic surveying. Active techniques transmit an electrical, electromagnetic, or acoustic signal into the ground (Heimmer and De Vore 1995:9, 2000:58-59; Kvamme 2001:355-356). The interaction of these signals and buried materials produces alternated return signals that are measured by the appropriate geophysical instruments. Changes in the transmitted signal of amplitude, frequency, wavelength, and time delay properties may be observable. Active methods applicable to archeological investigations include electrical resistivity, electromagnetic conductivity (including ground conductivity and metal detectors), magnetic susceptibility, and ground-penetrating radar. Active acoustic techniques, including seismic, sonar, and acoustic sounding, have very limited or specific archeological applications.

### Passive Geophysical Prospection Techniques

The passive geophysical prospection technique used during the project is the magnetic survey. As indicated above, passive techniques measure existing physical properties of the earth. Other passive geophysical techniques include the measurement of earth's natural electrical fields, gravitational fields, radiometric measurement of radioactive elements, and thermal measurements of soil temperature changes. These passive methods with limited archeological applications include self-potential methods, gravity survey techniques, and differential thermal analysis.

### Magnetic Surveys

A magnetic survey is a passive geophysical prospection technique used to measure the earth's total magnetic field at a point location. Magnetometers depend upon sensing subtle variation in the strength of the earth's magnetic field in close proximity to the archeological features being sought. Variation in the magnetic properties of the soil or other buried material induces small variations in the strength of the earth's magnetic field. Its application to archeology results from the local effects of magnetic materials on the earth's magnetic field. These anomalous conditions result from magnetic materials and minerals buried in the soil matrix. Iron based materials have very strong effects on the local earth's magnetic field. Historic iron artifacts, modern iron trash, and construction material like metal pipes and fencing can produce such strong magnetic anomalies that nearby archeological features are not detectable. Other cultural features, which affect the earth's local magnetic field, include fire hearths, and soil disturbances (e.g., pits, mounds, wells, pithouses, and dugouts), as well as, geological strata.

Magnetic field strength is measured in nanoteslas (nT) (Sheriff 1973:148). In North America, the earth's magnetic field strength ranges from 40,000 to 60,000 nT with an inclination of approximately 60° to 70° (Burger 1992:400; Milsom 2003:55; Weymouth 1986:341). The project area has a magnetic field strength of approximately 55,490 nT with an inclination of approximately 68° 6' (Peddie 1992; Peddie and Zunde 1988; Sharma 1997:72-73). Magnetic anomalies of archeological interest are often in the ±5 nT range, especially on prehistoric sites. Target depth in magnetic surveys depends on the magnetic susceptibility of the soil and the magnetic mass associated with buried features and objects. For most archeological surveys, target depth is generally confined to the upper one to two meters below the ground surface with three meters representing the maximum limit (Clark 2000:78-80; Kvamme 2001:358). Magnetic surveying applications for archeological investigations have included the detection of architectural features, soil disturbances, and magnetic objects (see Bevan 1991,1998:29-43; Breiner 1973; Burger 1992:389-452; Clark 2000:92-98,174-175; David 1995:17-20; Gaffney and Gater 2003:36-42,61-72; Gaffney et al. 1991:6,2002:7-9; Heimmer and DeVore 1995:13,2000:55-56; Kvamme 2001:357-358,2003:441,2005:434-436,2006a:205-233,2006b:235-250; Lowrie 1997:229-306; Milsom 2003:51-70; Mussett and Khan 2000:139-180; Nishimura 2001:546-547; Scollar et al. 1990:375-519; Weymouth 1986:343; and Witten 2006:73-116 for more details on magnetic surveying).

Two modes of operation for magnetic surveys exist: 1) the total field survey and 2) the magnetic gradient survey. The instrument used to measure the magnetic field strength is the magnetometer (Bevan 1998:20). Three different types of magnetic sensors have been used in the magnetometer: 1) proton free precession sensors, 2) alkali vapor (cesium or rubidium) sensors, and 3) fluxgate sensors (for a detailed description of the types of magnetometers constructed from these sensors see Aitken 1974; Clark 2000:66-71; Milsom 2003:58-62; Scollar et al. 1990:450-469; Weymouth 1986:343-344).

The total field magnetometer is designed to measure the absolute intensity of the local magnetic field. This type of magnetometer utilizes a single sensor. Due to diurnal variation of the earth's magnetic field, the data collected with a single sensor magnetometer must be corrected to reflect these diurnal changes. One method is to return to a known point and take a reading that can be used to correct the diurnal variation. A second method is to use two magnetometers with one operated at a fixed base station collecting the diurnal variation in the magnetic field. The second roving magnetometer is used to collect the field data in the area of archeological interest. Common magnetometers of this types used in archaeological investigations include the proton precession magnetometer, the Overhauser effect magnetometer (a variation of the proton precession magnetometer), and the cesium magnetometer.

The magnetic gradient survey is conducted with a gradiometer or a magnetometer with two magnetic sensors separated by a fixed vertical distance. The instrument measures the magnetic field at two separate heights. The top sensor reading is subtracted from the bottom sensor reading. The resulting difference is recorded. This provides the vertical gradient or change in the magnetic field. Diurnal variations are automatically canceled. This setup also minimizes long-range trends. The gradiometer provides greater feature resolution and potentially provides better classification of the magnetic anomalies. Two commonly used gradiometers in archeological investigations are the cesium gradiometer and the fluxgate gradiometer. They are capable of yielding 5 to 10 measurements per second at an accuracy resolution of 0.1 nT (Kvamme 2001:358). Cesium gradiometers record the absolute total field values like the single sensor magnetometers. The fluxgate sensors are highly directional, measuring only the component of the field parallel to the sensor's axis (Clark 2000:69). They also require calibration (Milsom 2003:2003:61-62). Both cesium and fluxgate gradiometers are capable of high density sampling over substantial areas at a relatively rapid rate of acquisition (Clark 2000:69-71; Milsom 2003:60-62).

## Active Geophysical Prospection Techniques

The active geophysical prospection techniques used during the project included conductivity, resistivity, and ground-penetrating radar. As indicated above, active techniques transmit electrical, electromagnetic, or acoustic signals into the ground. The interaction of these signals and buried materials produces an altered return signal, which is measured by the appropriate geophysical instrument. The ground-penetrating radar and ground conductivity meter utilize electromagnetic signals. The resistivity meter injects an electric current into the ground.

## Soil Resistivity Surveys

The resistivity/soil resistance survey is an active geophysical technique, which injects a current into the ground (see Bevan 1991,1998:7-18; Burger 1992:241-318; Carr 1982; Clark 2000:27-63,171-174; David 1995:27-28; Gaffney and Gater 2003:26-36,56-61; Gaffney et al. 1991:2;2002:7; Heimmer and DeVore 1995:29-35,2000:59-60; Kvamme 2001:358-362,2003:441-442,2005:434-436; Lowrie 1997:206-219; Milsom 2003:83-116; Mussett and Khan 2000:181-201; Nishimura 2001:544-546; Scollar et al. 1990:307-374; Sharma 1997:207-264; Somers 2006:109-129; Telford et al. 1990:522-577; Van Nostrand and Cook 1966; Weymouth 1986:318-341; and Witten 2006:299-317 for more details on resistivity surveys). It measures the resistance to the flow of an introduced electrical current in the soil. The voltage is measured, and by Ohm's Law, one may compute the resistance at any given point (**R=V/I** where **R** is resistance, **V** is voltage, and **I** is current). Soil resistance is dependent on several factors, including the soil structure, soil texture, soil water solution conductivity, capillary conductance, the depth of the archeological targets (i.e. features or objects), and the material comprising the archeological target. The differential electrical resistance is primarily dependent on the moisture content in the subsurface matrix (Carr 1982:47-105; Clark 2000:27; Heimmer and De Vore 1995:9, 30). Since electricity is easily conducted through water and follows the path of least resistance, the resistivity anomalies are identified as contrasts between the resistance values of the buried features and objects and those of the surrounding soil matrix.

The two types of resistivity surveying techniques used in archeology are the lateral profiling (horizontal) and the vertical electrical sounding (VES). Lateral profiling is done with fixed electrode spacings. Resistance measurements in ohms (Sheriff 1973:156) are collected by moving the electrode array from point to point along fixed traverses. Due to the problem of contact resistance between two electrodes in the ground, a typical soil resistance survey makes use of four electrodes or probes. The current passes through two electrodes and the voltage is measured between the other two probes. The configuration of the electrodes also varies (see Gaffney and Gater 2003:29 and Milsom 2003:99 for common configurations). The present survey utilizes the twin probe array (Geoscan Research 1996). On the twin probe array, a current and voltage probe are located on a mobile frame that is moved around the site. Two additional probes are located away from the survey area and also consist of a current probe and voltage probe. The probes on the frame are located at a fixed distance apart. A general rule of thumb for the depth investigation of soil resistance survey is the depth is equal to the distance between the probes. This value is not a unique number but an average for the hemispheric volume of soil with a radius equal to the probe separation distance. The probes are connected to the resistance meter, which is also on the frame. The measurement is taken when the mobile probes make contact with the ground and complete the electrical circuit. The measurements are stored in the resistance meter's memory until downloaded to a laptop computer. The resulting data is integrated to provide areal coverage of the site under investigation.

The VES is done at a location by measuring several resistance values with increasing electrode separation (see Bevan 1998:17-18; Gaffney and Gater 2003:34-35; Lowrie 1997:215-217; Milsom 2003:108-112; and Mussett and Khan 2000:186-194 for additional information for conducting a vertical electrical sounding). As the separation between the electrodes increases, the same proportion of current is disturbed through an increasing depth of soil. This results in a proportionally larger effect of the deeper layers on the apparent resistivity. The Wenner array is most commonly used probe array for VES. In this configuration, the electrodes are evenly spaced with the current electrodes on the ends and the voltage electrodes in the middle (C1 P1 P2 C2). The near surface conditions differ at each electrode for each reading resulting in a relatively high noise level. To produce a smoother sounding curve, the VES is produced by using an offset array where the electrodes are expanded in opposite directions. The two readings for each offset separation are averaged together. This suppresses the local effects at each electrode. The difference between the two readings indicates the significance of these effects. The resistance values using the Wenner probe array obtained are converted to apparent resistivity by the formula $\boldsymbol{\rho_a = 2\pi ar}$, where $\boldsymbol{\rho_a}$ is the apparent resistivity, a is the electrode spacing, and r is the measured resistance at each electrode separation. The resulting apparent resistivity values in ohmmeters (Sheriff 1973:156) are plotted by electrode spacing. Variation of the apparent resistivities with each increasing electrode spacing are compared to sounding curves (Orellana and Mooney 1972) or modeled in a computer program (Butler 1999; Interpex 2002). This produces an estimate of the electrical stratification of the soil. This information provides the investigator with basis data that can be used to determine the applicability of the various techniques to the project area (i.e., if the resistivity is high, then ground-penetrating radar should work well on the site, or if the resistivity is extremely high, then a ground conductivity survey may not be practical).

By combining the two methods, one can obtain both lateral profiles at different vertical depths. This requires the use of multiple sets of probes. For this to be achieved, data must be gathered along multiple traverses at a number of different spacings, which are multiples of a fundamental distance. The probes are moved along the traverse at regularly spaced intervals to obtain the horizontal changes. With the different distance spacings between the probes, the vertical changes are also identified during the survey. By combining the two resistivity methods, the resulting data may be displayed as layers at the various depths based on the probe separation or as vertical pseudo-sections (Milsom 1996:91-93). The most common probe array used in archeology using this combination is the twin electrode probe array, although multiprobe switching resistivity systems are becoming more common (Geoscan Research 1996; Iris Instruments 1999; Milsom 1996:71). Combining the resistance meter, probes, and a multiplexer unit, several probe configurations can be measured at a single location (Geoscan Research 1996). By combining the multiple configurations, pseudo sections or depth information can be collected relatively rapidly over a large area. The conversion of the soil resistance measurements to resistivity is more complicated than in the Wenner probe array (Bevan 2000:2). Like the Wenner probe array, four probes are used to take the resistance measurement; however, instead of having the linear arrangement of potential, current, current, and potential probes set at equal distances apart, in the twin electrode array, one current and one potential set of probes are on the mobile frame and moved about the site collecting readings. The second set of remote probes is set away from the grid. To convert the resistance readings from the multiple sets of probes to comparable apparent resistivity measurements the following formula is used (Geoscan Research 1996: B-1): $\rho_a = 2\pi r/G.F$, where $\rho_a$ is the apparent resistivity, **r** is the measured resistance at each electrode separation, and **G.F.** is equal to the inverse of the distance between the remote probes plus the distance between the mobile probes minus inverse of the distance between the remote potential and mobile current probes minus the inverse of the remote current and mobile potential probes (**G.F. = 1/C2P2 + 1/C1P1 – 1/C2P1 – 1/C2P1** where C2P2 equals the probe separation distance between C2 and P2, etc.). The resistance measured by the twin electrode probe array is determined by the resistivity below both sets of probes ($R = V/I = (1/2\pi)\ (\rho_1/a_m + \rho_2/a_r$ ) where $\rho_1$ is the resistivity of the soil beneath the mobile probes, am is the mobile probe separation distance, $\rho_2$ is the resistivity of the soil beneath the remote probes, and ar is the remote probe separation distance). The apparent resistivity can be approximated by the formula $\rho_a = \pi ar$, where the electrode spacing a of both the mobile and remote electrodes are equal, or to $\rho_a = 2\pi ar$ (approximate), where the electrode spacing **a** is equal to the mobile probe separation when the remote probe spacing is much greater than the mobile probe spacing. A more accurate method (Bevan 2000) of determining the resistivity measurements from the soil resistance data is to determine the resistivity below the remote, fixed electrodes by taking measurements at two separate probe spacings where $\rho_2 = 2\pi\ ((R_1 – R_2)/(1/a_{r1} – 1/a_{r2}))$. The resistivity below the mobile probes can be computed as $\rho_1 = 2\pi amR - \rho_2(am/ar)$. By combining all the resistivity data, a three dimensional display can be generated of the soil resistivity.

Electromagnetic Conductivity Surveys

The capacity of soil to conduct electrical currents has led to the use of soil conductivity and soil resistivity meters in cultural resource management (Heimmer and De Vore 1995:29-41). Both resistivity and conductivity represent active geophysical techniques. Soil resistivity meters used in archeological surveys typically involve four metal probes placed in contact with the soil. A small alternating current is normally applied to two of the probes and the voltage difference between the other two probes is measured. Variations in soil moisture, chemistry, and structure affect the electrical resistance of the soil. Soil resistivity surveys are particularly well suited to locating high resistance material (e.g. stone or brick) in relatively conductive soil (e.g. clay). Soil conductivity meters provide another method of measuring the soil's ability to conduct electrical current. This survey technique measures the soil conductivity. Theoretically, conductivity represents the inverse of resistivity. High conductivity equates to low resistivity and vice versus. The electromagnetic ground conductivity meter induces an electromagnetic field into the ground through a transmitting coil (see Bevan 1983,1991,1998:29-43; Burger 1992:310; Clark 2000:34-37,171; Clay 2006:79-107; David 1995:20-23; Gaffney and Gater 2003:42-44; Gaffney et al. 1991:5,2002:10; Heimmer and DeVore 1995:35-41,2000:60-63; Kvamme 2001:362-363,2003:441-442,2005:434-436; Lowrie 1997:222-225; McNiel 1980a,1980b;

Milsom 2003:129-147; Mussett and Khan 2000:210-227; Nishimura 2001:551-552; Scollar et al. 1990:520-575; Weymouth 1986:317-318,326-327; and Witten 2006:147-198 for more details on conductivity surveys). The induced primary field causes an electromagnetic wave flow in the earth similar to the electrical current in a resistivity survey. The materials in the earth create secondary eddy current loops, which are picked up by the instrument's receiving coil. The interaction of the generated eddy loops or electromagnetic field with the earthen materials is directly proportional to terrain conductivity within the influence area of the instrument. The receiving coil detects the response alteration (secondary electromagnetic field) in the primary electromagnetic field. This secondary field is out of phase with the primary field (quadrature of conductivity phase). The in-phase component of the secondary signal is used to measure the magnetic susceptibility of the subsurface soil matrix. Only the quadrature or conductivity phase data were collected during the present project. Changes result from electrical and magnetic properties of the soil matrix. Changes are caused by materials buried in the soil, differences in soil formation processes, or soil disturbances from natural or cultural modifications to the soil. Electromagnetic conductivity instruments are also sensitive to surface and buried metals. Due to their high conductivity, metals show up as extreme values in the acquired data set. On occasion, these values may be expressed as negative values since the extremely high conductivity of the metals cause saturation of the secondary coil. The apparent conductivity data were recorded in units of millisiemens per meter (mS/m). The electrical conductivity unit or siemens represents the reciprocal of an ohmmeter or the unit for resistivity (Sheriff 1973:197). The relationship between conductivity and resistivity is represented by the following formula (Bevan 1983; McNiel 1980a): mS/m = 1000/ohm/m.

Its application to archeology results from the ability of the instrument to detect lateral changes on a rapid data acquisition, high-resolution basis, where observable contrasts exist. Lateral changes in anthropogenic features result from compaction, structural material changes, buried metallic objects, excavation, habitation sites, and other features affecting water saturation (Heimmer and De Vore 1995:37). Since the conductivity meter has no direct contact with the soil, this permits the conductivity meter to be moved more rapidly than a resistivity meter and a greater area can be surveyed in a shorter period of time. The instrument has been used to identify areas of impaction and excavation as well as buried metallic objects. It has the potential to identify cultural features that are affected by the water saturation in the soil (Clark 2000:36; Heimmer and De Vore 1995:36-37). In the present project, the investigations are looking for changes in the electromagnetic conductivity between the natural soil surrounding the grave and the disturbed soil within the grave. Conductivity meters are also susceptible to interference from metal including gas or water pipes and wires. Metallic trash in the topsoil can degrade conductivity signals.

### Ground-penetrating Radar Survey

Ground-penetrating radar (gpr) is an active method that has recently achieved popularity in cultural resource management applications (see Bevan 1991,1998:43-57; Clark 2000:118-120,183-186; Conyers 2004,2006:131-159; Conyers and Goodman 1997;

David 1995:23-27; Gaffney and Gater 2003:47-51,74-76; Gaffney et al. 1991:5-6,2002:9-10; Heimmer and DeVore 1995:42-47,2000:63-64; Kvamme 2001:363-365,2003:442-443;2005:436-438; Lowrie 1997:221-222; Milsom 2003:167-178; Mussett and Khan 2000:227-231; Nishimura 2001:547-551; Scollar et al. 1990:575-584; Weymouth 1986:370-383; and Witten 2006:214-258 for more details on ground-penetrating radar surveys). Although Bruce Bevan pioneered the archeological use of gpr a quarter-century ago (Bevan 1977; Bevan and Kenyon 1975), the cost of equipment and problems dealing with the massive amount of data produced by gpr surveys limited the number of archeological applications. Recently, Conyers and Goodman (1997) have published an introduction to gpr for archeologists, and Bevan (1998) has provided an excellent comparison of various radar antennae as applied to a consistent group of archeological features. Reductions in the cost of equipment and improvements in the software available for processing the voluminous data have helped to make gpr surveys more affordable and analysis more efficient.

Ground-penetrating radar uses pulses of radar energy (i.e., short electromagnetic waves) that are transmitted into the ground through the surface transmitting antenna. A short burst of radio energy is transmitted and then the strength of the signal received from reflectors a few nanoseconds after the pulse’s transmission is recorded by the receiving antenna. The combination of time after transmission and strength of reflected signal provides the data used to create plan maps and profiles. The radar wave is reflected off buried objects, features, or interfaces between soil layers. These reflections result from contrasts in electrical and magnetic properties of the buried materials or reflectors. The contrasts are a function of the dielectric constant of the materials (Sheriff 1973:51). The depth of the object or soil interface is estimated by the time it takes the radar energy to travel from the transmitting antenna and for its reflected wave to return to the receiving antenna. The depth of penetration of the wave is determined by the frequency of the radar wave. The lower the frequency, the deeper the radar energy can penetrate the subsurface; however, the resulting resolution, or the ability to distinguish objects, features, and soil changes, decreases. These low frequency antennas generate long wavelength radar energy that can penetrate several tens of meters under certain conditions, but can only resolve larger targets or reflectors. The higher the radar wave frequency, the higher the resulting resolution but the depth penetration decreases. High frequency antennas generate much shorter wavelength energy, which may only penetrate a meter into the ground. The generated reflections from these high frequency antennas are capable of resolving objects or features with maximum dimensions of a few centimeters. A resulting tradeoff exists between subsurface resolution and depth penetration: the deeper the penetration then the resulting resolution is less or the higher the resolution then the resulting depth penetration is much shallower.

As the radar antenna system (transmitting and receiving antennas) is moved along the survey line, a large number of subsurface reflections are collected along the line. The various subsurface materials affect the velocity of the radar waves as they travel through the ground (Conyers and Goodman 1997:31-40). The rate at which these waves move through the ground is affected by the changes in the physical and chemical properties of the buried materials through which they travel. The greater the contrast in electrical and magnetic properties between two materials at the interface results in a stronger reflected signal. As each radar pulse travels through the ground, changes in material composition or water saturation, the velocity of the pulse changes and a portion of the energy is reflected back to the surface where it is detected by the receiving antenna and recorded by the ground-penetrating radar unit. The remaining energy continues to pass into the subsurface materials where it can be reflected by deeper reflectors until the energy finally dissipates with depth. In a uniform soil, there would be little energy reflected (except at the air/soil interface), and the bulk of the energy would be absorbed within a short distance. Objects included in the soil or strata with contrasting electrical properties may result in reflection of enough energy to produce a signal that can be detected back at the antenna. The radar system measures the time it takes the radar pulse to travel to a buried reflector and return to the unit. If the velocity of the pulse is known, then the distance to the reflector or the depth of the reflector beneath the surface can be estimated (Conyers and Lucius 1996).

Actual maximum depth of detection also depends upon the electrical properties of the soil, the frequency of the antenna, and the contrast between the target and its matrix. Plan maps present the average signal strength across the grid during the selected time interval (e.g. 7.2 to 14.4 ns). Because these time intervals correspond with horizontal layers or slices of soil, they are called either time-slices or depth-slices. The analyst can set the span of the time-slice and consequently the thickness of the depth-slice. Ground-penetrating radar profiles illustrate a cross section through the soil with the ground's surface at the top of the image. The profile images are conceptually similar to what one would see when looking at the side of an excavated trench. The vertical scale used on the profiles can be marked in nanoseconds (ns) indicating the amount of time between the transmission of the radar pulse and the receipt of the reflected signal or in units indicating depth below the ground surface. The earlier reflections are received from targets nearer the surface and the later reflections are received from deeper levels or features. The velocity can be measured directly in the field in some cases, calculated from the form of strong hyperbolic reflections, or estimated by using values of similar soils.

The success of the survey is dependent on soil and sediment mineralogy, clay content, ground moisture, depth of burial and surface topography and vegetation. The ground-penetrating radar signal can be lost or attenuated (i.e., quickly dissipated) in soils that have high moisture content, high electrical conductivity, highly magnetic materials, or high clay contents. Dry soils and sediments, especially those with low clay content, represent the best conditions for energy propagation. The soils at the project sites contain relatively high clay contents and relatively high moisture levels during the survey. A ground-penetrating radar survey, with its capability for estimating the depth and shape of buried objects, may be an extremely valuable tool in the search of grave shafts. At times, however, radar cannot profile deep enough or the strata may be so complex as to render the graves indistinguishable from the surrounding soil profile. Selection of the appropriate antenna frequency is also important in providing a good compromise between the depth penetration and resolution.

## 6. GEOPHYSICAL FIELD SURVEY PROCEDURES

The survey scope-of-work for the Noland property (23JA636) project called for magnetic, resistance, conductivity, and ground-penetrating radar surveys of the property lot associated with the residence in order to identify the extent of the site and location of buried archeological resources (Figure 8). The geophysical survey covered an area of 525 $m^2$ (0.13 acres). The property lot measured approximately 35 meters east-west by 15 meters north-south. The house and front porch had a footprint of 154 square meters.

The scope-of-work for the Truman and the two Wallace properties also called for magnetic, resistance, conductivity, and ground-penetrating radar surveys in order to identify the extent of the site and location of buried archeological resources (Figure 9). However, because of an inadvertent setup error during the wiring of the probes on the twin array frame, a resistance survey of the three residences failed to acquire reliable resistance data. The geophysical survey of the three adjacent properties covered an area of approximately 5,459 $m^2$ (1.35 acres). The three joint property lots measured 103 meters east-west by 53 meters north-south. The Truman Home (both house and porches) had a footprint of 224 square meters while the George Wallace house including the porches had a footprint of 132 square meters and the Frank Wallace House including the porches had a footprint of 144 square meters.

The geophysical grid was established at the two project locations with a portable Ushikata S-25 Tracon surveying compass (Ushikata n.d.) and 100-meter tape. The surveying compass was used to sight-in two perpendicular base lines and the geophysical grid unit corners. Wooden hub stakes were placed at the 20-meter grid corners at both sites with additional stakes placed at the 20 meter points and the end points along the end of the properties. The geophysical grids for the Noland property and the three joint properties across the street including the Truman Home and the two Wallace Houses were aligned parallel to the property lot boundary lines and the street. Magnetic north was oriented 4 degrees east of Grid North.

At the Noland property, the initial geophysical grid corner stake (a wooden 2-inch by 2-inch hub stake) was set at one meter in from the north side of the property chain link boundary fence and one meter in from the west side of the of the property chain link fence. A second wooden hub stake was set 25 meters east of the first hub stake in the northwest corner of the yard and one meter in or south of the fence. Using the surveying compass, an east-west baseline along the north property fence was established for the geophysical survey of the Noland property. Grid corner stakes were set every 10 meters along this baseline to 40 meters east of the northwest corner stake. In order to set the north-south baseline, the surveying compass was moved to the stake 10 meters east of the northwest corner stake. A north-south baseline was laid out with grid stakes at 11 meters south and 13 meters south of the mapping station stake. At 13 meters south of the east-west baseline, the stake is approximately one meter north of the southern chain link property fence. The southern east-west baseline was established from this grid stake. The grid stakes for the southwest corner were inset parallel to the slightly angled fence corner. The geophysical grid at the Noland property measured 13 meters north-south by 40 meters east-west. Two geophysical grid units measuring 13 meters by 20 meters were finally established and used throughout the geophysical surveying efforts at the Noland property.

At the joint property containing the Truman House, the George Wallace House, and Frank Wallace House, the initial geophysical grid corner stake was set at one meter in from the south side and one meter in from the east side of the two chain link fences that meet at the southeast corner of the Frank Wallace property. A second stake was placed one meter in from the east chain link fence to form a north-south baseline for the project area near the gate from the Frank Wallace backyard to the driveway on the east side of the house. Grid unit stakes were then placed at 20 meters, 40 meters, and 47 meters north of the southeast corner stake. The surveying compass was rotated 90 degrees to the west and the east-west baseline along the southern boundary of the joint property was established. The edge of the Frank Wallace property measured 12 meters west of the southeast corner stake. The southwest corner of the George Wallace property was 23 meters west of the southeast corner grid point in the Frank Wallace backyard. The remaining grid unit corner stakes were placed at twenty-meter intervals where it was possible. Other grid stakes were placed at convenient locations near the edges of the houses and garages. Fifteen complete and partial 20-meter-by-20-meter grid units were established within the boundaries of the three joint property lots. The grid measured 96 meters east-west by 47 meters north-south. The north side of the grid was located approximately one meter south of the sidewalk along Truman Road.

Once the geophysical grid was established, a Nikon DTM-730 electronic field station (Nikon 1993) was positioned over the site datum or control point (N5000/E5000, elevation [elev.] 93.90 feet, measurements in feet) set by the architects during the architectural mapping of the Noland House and property for the rehabilitation project (Bahr Vermeer Haecker Architects 2004). The architects used magnetic nails in the concrete sidewalk, street, and asphalt parking lot for the control point locations. Two additional control points were also located at N5103.90/E4988.87 with an elev. of 93.15 feet and N5024.60/E4796.18 with an elev. of 98.40 feet. The backsight for the mapping station was located at the N5103.9/E4988.87 control point in the street. The field station was set to map in the English measurement of feet instead of metric due to the architects use of the English measurements in their documentation of the Noland House and property. The same grid coordinates and control points were used to map the Truman and Wallace joint project area.

The site features, geophysical grid points, and topography were mapped with the field station, prism, and prism pole. The data were stored on the memory card of the DTM-730 and subsequently downloaded into a laptop computer. Initially the coordinate data (i.e., survey codes, northing coordinates, easting coordinates, and elevation) and raw field data (i.e., survey codes, horizontal angle, vertical angle, and slope distance) files were transferred from the field station to the laptop computer with the Transit software package

(Nikon 1996). These data files for each site were then transferred to the WordStar 5.5 software package (MicroPro 1989). The extraneous information in the coordinate data files were removed leaving the northing (Y) coordinates, easting (X) coordinates, elevations (Z coordinates), and point descriptions. This locational information was then converted to an XYZ data (dat) file for processing in the SURFER 8 mapping software (Golden Software 2002). A file folder was created on the laptop computer to hold the mapping and geophysical data.

In SURFER 8, a grid file was created from the data file for the two separate project areas (Golden Software 2002:89-161). The data columns were identified for the appropriate coordinate and elevation data. Column B contained the X values or the East coordinates. Column A contained the Y values or East coordinates. Column C contained the Z or elevation values. Column D contained the description of the individual points. The grid line geometry was set for minimum and maximum values in both the X and Y directions. These values formed the corner points for the generated contour maps. The data were gridded using the Kriging algorithm (Golden Software 2002:17-121). The generated grid file was then smoothed (Golden Software 2002:383-387). The spline smoothing routine was selected to eliminate the angular contours by rounding the edges using a cubic spline interpolation over the gridded data. The grid file defined the XY locations of each grid node over the extent of the map and the interpolated Z value at each node. Finally, a blanking file was created and the blanking routine was run over the topographic data set (Golden Software 2002:403-405). The blanking routine removed grid mode data from portions of the project area that did not contain any original data (e.g., the house footprint) in order to eliminate false contour lines in those locations.

A contour map was then created from the grid file (Golden Software 2002:197-230). The contour map consisted of several components, which defined the appearance of the contour map. These included the contour level, which defined the interval between contour lines. The line component determined the appearance of the contour lines, including type, thickness, and color. The area between the contour lines could be filled with a gradually changing spectrum of colors. The labeling feature allowed for the placement of the contour value on the contour lines. This component controlled the text properties, numeric format, spacing, and interval of the labels. Hachures or small tick marks could also be placed along the contour lines to indicate the direction of slope. These were generally not used in the generation of the topographic or feature maps, but were used for indicating negative values in the geophysical data. The contour lines were drawn as a series of smoothed line segments between adjacent grid lines. A map posting the location of the individual feature points was also generated (Golden Software 2002:241-258) and overlain (Golden Software 2002:373-380) on the contour map. The points were used to draw natural and cultural features and objects including lines, polygons, and points; to label specific features; to change the appearance of the objects; and to assign unique symbols to classes of objects (Golden Software 2002:467-492). A scale bar and north arrow were added to the finished contour map. The project area's natural and cultural features were also labeled. Figure 8 illustrates the natural and cultural features at the Noland property geophysical project area. Figure 9 illustrates the natural and cultural features at the joint Truman and Wallace geophysical project area.

Before the start of the geophysical survey at both properties, yellow nylon ropes were laid out on the geophysical grid units (Figure 10). These ropes served as guide ropes during the actual data acquisition phases of the project. Twenty-meter ropes were placed along the top and bottom base lines connecting the grid corners. These ropes formed the boundaries of each grid during the data collection phase of the survey. Additional traverse ropes were placed a one-meter intervals across the grid at a perpendicular orientation to the base lines beginning with the line connecting the two wooden hubs on the left side of the grid unit. These ropes serve as guides during the data acquisition. These 20-meter lengths of ropes are divided into 0.5-meter increments by different colored tape. One color (blue) is placed every meter along the rope with a different colored (red) tape placed at half-meter intervals. The use of different colored tape on the ropes provided a simple way to maintain one's position within the geophysical survey grid unit as data were collected. The geophysical data were therefore recorded in a series of evenly spaced parallel lines with measurements taken at regular intervals along each line resulting in a matrix of recorded measurements (Kvamme 2001:356; Scollar et al. 1990:478-488). Beginning in the lower left-hand corner of the grid, data collection occurred in a parallel (unidirectional) or zigzag (bi-directional) mode across each grid unit until the survey was completed for each technique. Once the survey of the individual grid unit was completed, the ropes were moved to the next grid unit until completion of the survey for each instrument. During the gpr survey, only the two baseline end ropes were used as placement guides for plastic jugs with attached plastic pin flags. The jugs served as sighting reference points during the gpr survey rather than the traverse survey ropes. The use of the jugs avoided any entanglements at the end of the survey lines between the plastic tent pegs used to hold the ropes in place and the gpr survey cart and antenna. During the geophysical survey, a sketch map of above ground natural and cultural features located on the properties was complied using the survey ropes for guides.

## Magnetic Gradient Survey Methodology

The magnetic gradient survey is conducted with a Geoscan Research FM36 fluxgate gradiometer (Figure 11) with a ST1 sample trigger (Geoscan Research 1987). The instrument is a vector magnetometer, which measures the strength of the magnetic field in a particular direction. The gradiometer consists of a control unit that contains the electronics, menu keyboard pad, power source, operating program, on-off switch, connector for the charger/data output/external logger, analog output connector, LCD display screen, sounder outlet, balance control, and memory chips (Geoscan Research 1987:8-10). The tubular carrying handle connects the control unit to the vertical sensor housing tube that contains the two fluxgate sensors. N/S and E/W sensor alignment controls are located on the sensor tube. It has a resolution of 0.05 nT with a 0.1 nT absolute accuracy.

The sensors are set at 0.5 meters apart from one another. The instrument is carried so the two sensors are vertical to one another. Height of the bottom sensor above the ground is relative to the height of the surveyor. In the carrying mode at the side of the author's body, the bottom sensor is approximately 0.30 meters above the ground. Two readings are taken at each point along the survey traverse, one at the upper sensor and one at the lower sensor. The difference or gradient between the two sensors is calculated (bottom minus top) and recorded in the instrument's memory. Each sensor reads the magnetic field strength at its height above the ground. The gradient or change of the magnetic field strength between the two sensors is recorded in the instrument's memory. This gradient is not in absolute field values but rather voltage changes, which are calibrated in terms of the magnetic field. The fluxgate gradiometer does provide a continuous record of magnetic field strength. With a built-in data logger, the gradiometer provides fast and efficient survey data collection. Typically, data across a 20-meter-by- 20-meter grid unit with sampling parameters of eight samples per meter and 0.5-meter traverses in the zigzag mode of operation can be collected in 30 minutes. This amounts to 6,400 readings per survey grid unit.

Prior to the start of the survey, the memory of the gradiometer is cleared and the menu settings are checked for the appropriately planned survey. The operator must be free of any magnetic metal. If any clothing or objects carried by the operator are slightly magnetic, there is a high probability that the survey results will be degraded due to presence of magnetic materials in close proximity to the sensors in the instrument. As one walks along the traverse, the presence of magnetic materials on the operator will result in a shift in the readings of 1 to 2 nT or greater. This will cause a stripe effect to the data. The gradiometer is programmed for a resolution of 0.1nT, reading average off, log zero drift off, log interval at 0.25 m, baud rate of 2400, average period set to 16 readings, check offset off, and the encoder external trigger type. When the instrument is turned on, the initial LCD display indicates the current display resolution, the status of the log drift facility, and the battery status. The resolution display reading can be either positive or negative and with the instrument set to the 0.1 nT resolution mode, the maximum value recorded is 204.7 nT. Although some magnetic anomalies may be stronger in the positive and negative values, the instrument defaults to a program recognized value (2047.5) when these extremely strong values are observed. Generally such strong fields result from the close proximity of highly magnetic iron artifacts to the instrument. On the sample trigger, the samples/m knob is set to 8 samples/m and the rate knob is located at the 1 o'clock position. The toggle switch is set to the stop position. The grid size interval in the instrument and the traverse m knob on the sample trigger must be set to the same value. The value is set to 20 for the 20 meter grid unit size.

The sensors must be accurately balanced and aligned along the direction of the field component to be measured. The zero reference point at the Noland property was established at N5030.81/E4810.98 and the balancing and alignment procedures were oriented to magnetic north. The zero reference point at the Truman and Wallace joint properties was established at N5059.81/E5296.33 and the balancing and alignment procedures were oriented to magnetic north. These reference points were selected where there were no noticeable localized changes in the digital display or by raising the instrument above the ground with the use of a plastic step stool. The readings should vary less than 2 to 3 nT in the area surrounding the zero balance reference point. The balance control on the instrument was adjusted first. The balancing of the instrument was conducted in the 1 nT resolution range by first inverting the instrument and zeroing the instrument. The instrument was then rotated 180 degrees about the same horizontal plane of the axis of the handle. The trimming tool was inserted into the balance control slot on the side of the instrument and the reading in the digital display was reduced in half. The procedure was repeated until the reading in the upright and inverted positions was within a range of –1 to 1 nT. With the instrument held vertically at a height where the alignment controls were within easy reach, the two sensors were then aligned. At first, the bottom sensor was aligned. The instrument was pointed to magnetic north and the instrument was zeroed so that the display reading was zero. The instrument was then rotated around the sensor tube 180 degrees until it pointed south. The small aluminum wheel of the N-S alignment control at the bottom of the tube was used to adjust the sensor until the reading was half of the value first observed when it was rotated to the south. The instrument was rotated back 180 degrees until it pointed to magnetic north and rezeroed. The display reading was checked. If the north reading was within the range of –1 to 1 nT, the alignment was considered successful and the bottom sensor was aligned. If the north reading was not within the correct range, the procedure was repeated until the readings were within the correct display range. Once the bottom sensor was aligned, the top sensor was then aligned. The instrument was rotated 90 degrees until it faced east. The instrument was zeroed and then rotated 180 degrees until it faced west. The display reading was noted. The E-W alignment control wheel at the top of the sensor tube was adjusted until the reading was half of the observed reading. The instrument was then returned to its east facing position and rezeroed. If the east reading was within the range of –1 to 1 nT, the alignment was considered successful and the top sensor was aligned. If the east reading was not within the correct range, the procedure was repeated until the readings were within the correct display range. As a final check, the instrument was rotated 360 degrees about the vertical tube axis. If the display reading stayed within the –1 and 1 nT range, the sensor alignment procedures were considered successful. If the observed display readings went over the acceptable range, the balancing and alignment procedures were repeated until successful. The instrument was returned to the 0.1 nT resolution operating range and then zeroed at arms length over the operator's head. The operator's manual (Geoscan Research 1987:29-31) illustrates the steps involved in preparing the instrument for actual field data collection.

The magnetic gradient survey was conducted in a zigzag or bidirectional mode beginning in the southwest corner or lower left-hand corner of each grid unit. With the instrument on, the Enable Log button on the menu pad is pushed to initialize the logging display mode. The LCD screen displayed the starting Grid Number (G1), the Line Number (L1), and the Position Number (P1). The toggle switch on the sample trigger was moved to the start position and the operator began walking the traverse line. The instrument was carried along the traverse rope with the control box facing magnetic north. The sample trigger on the instrument provided a series of clicks for every sample reading and a beep on every eighth sample reading. As each measurement was recorded, the logging display was advanced one position until reaching the end of the line and then the line number advanced. The grid number advanced when the end of the grid was reached. The geophysical investigator maintained a pace along the traverse in accordance with the audio beeps from the fluxgate gradiometer. This placed the eighth sample reading at the meter tape mark. At the end of the first traverse, the instrument stopped collecting and recording the data. The toggle switch was moved to the stop position. At the end of each line, the operator moved over to the next traverse, revered his direction of travel, and proceeded back down the next traverse line towards the starting edge of the grid unit. The instrument was held in the same orientation with the control unit facing the same direction throughout the survey. The zigzag mode of data acquisition was repeated over and over until the end of the grid was reached. At the end of the grid, the instrument was turned off. The operator maintained a constant vigilance of the tilt of the instrument throughout the survey. The gradiometer was maintained in a vertical position during data acquisition. Any rotation or tilt in the instrument could cause errors of shifts in the readings of 1 to 2 nT or more.

During the Noland property magnetic survey, data were collected at eight samples per meter (0.125 m) along each traverse and at 0.5-meter traverses across each individual grid unit resulting in 16 samples per square meter (Table 1). The survey began in the lower left hand corner of the grid units. The traverses were covered in a zigzag mode with the first traverse headed west for the Noland property. The direction was reversed on the next traverse and the traverse was covered in the east direction. The traverses on the Truman, George Wallace, and Frank Wallace properties were collected along north and south directions oriented on Grid North beginning in the lower left hand corner facing north (Table 2). A total of 160 magnetic measurements were recorded for each 20 m long traverse in the memory of the Geoscan Research FM36 fluxgate gradiometer. The dummy space holder value of 2047.5 was added to the data string in areas where it was impossible to continue the survey where the house was located. Twelve thousand eight hundred measurements were recorded during the magnetic gradient survey of two 20-meter-by-20-meter grid units including dummy values and 96,000 measurements were recorded for the joint Truman and Wallace properties. Occasionally, the magnetic field strength of an object is extremely high. In these cases, the fluxgate sensors may not be able to recycle or record the high gradient change. In these cases, the dummy value of 2047.5 is inserted into the data string. This value is recognized in the GEOPLOT software as a value that will not be used in the processing algorithms. A total of 7,948 dummy values were recorded in the magnetic gradient data set for the two grid units in the magnetic survey of the Noland property and a total of 46,530 dummy values were recorded in the magnetic data from 15 grid units within the Truman and Wallace properties.

The instrument's memory can hold data acquired from the two grid units with the sample density of eight samples per meter and 0.5 meter traverses. At the end of the data acquisition of the two grid units, the magnetic gradient data from the survey were downloaded into the Geoscan Research GEOPLOT software (Geoscan Research 2003) on a laptop computer. It took approximately 25 minutes to collect the data for each grid unit.

It took approximately 26 minutes to download the data from the instrument's memory. The grid files created in GEOPLOT were reviewed in the field prior to the clearing of the gradiometer's memory and returning for further survey of the project area.

### Ground Conductivity Survey Methodology

The Geonics EM38 ground conductivity meter (Geonics 1992) was used to conduct the conductivity survey in the two project areas (Figure 12). The instrument is lightweight and approximately one meter in length. The apparent conductivity of the ground is in millisiemens per meter (mS/m) with a measurement precision of ±0.1% of full scale deflection. The meter consists of the transmitting and receiving coils embedded in the case of the instrument, a 9-volt battery, horizontal and vertical digital displays, recorder connector, and control panel. The control panel contains the conductivity range switch with two settings (1000 millisiemens/meter and 100 millisiemens/meter), on/off/battery test switch, a fine and course inphase (I.P) zero controls, a phase adjustment knob, the quadrature phase (Q/P) zero control, and a toggle switch for Q/P and I/P modes. The transmitting and receiving coils are located at opposite ends of the meter with an intercoil spacing of 1 meter. It has an operating frequency of 14.6 kHz in the 100 mS/m range and 40.4 kHz in the 1000 mS/m range. The conductivity meter can collect conductivity data in the quadrature phase operating mode or magnetic susceptibility data in the in-phase operating mode. The present ground conductivity survey is operated in the quadrature phase (Note: the in-phase operating mode measures magnetic susceptibility in parts per thousand or ppt). The EM38 ground conductivity meter has a depth of investigation of approximately 1.5 meters in the vertical dipole mode with optimum resolution at 0.6 meters. An adjustable tubular handle is attached to the meter for carrying during survey. The handle also contains the manual trigger button.

Prior to the start of data acquisition, the meter must be nulled and the battery checked for nominal operating voltage. The battery test is conducted at the beginning of the survey and start of each day or when the voltage is thought to be low. With the range switch in the 1000 mS/m position and the battery test switch to BATT, a good battery should have a display of over –720 units. The battery is replaced if the display is below -720. After the battery check, the instrument is nulled in the inphase mode and then zeroed in the quadrature phase mode. Nulling is conducted at the beginning of the survey at the same zero reference point used to balance and align the fluxgate gradiometer at the Noland and the Truman/Wallace properties. Since the EM38 measures ground conductivity by inducing very small electrical eddy currents into the ground and measuring the magnetic field that these currents generate, it is important to null the larger primary signal produced by the transmitting coil so that the electronic circuitry is not overloaded by the primary signal. All metal objects must be removed from the operator prior to beginning the initial inphase nulling operation. The range switch is set to the 1000 mS/m position. The instrument is positioned at a height of 1.5 meters above the reference point in the vertical dipole position (upright). The mode toggle switch is set to the I/P position. The meter is nulled by first adjusting the I/P course knob and then the fine I/P knob until the display reads zero. The range switch is then set to the 100 mS/m position and the procedures are repeated. The meter is successfully nulled when the meter reads approximately zero (±10 mS/m) on the 100 mS/m setting at 1.5 meters above the ground. The instrument is then zeroed. The instrument zeroing is conducted at the beginning of the survey and checked two to four times throughout the day at the magnetic reference point used for the Noland and the Truman/Wallace surveys. With the instrument at a height of 1.5 meters above the ground, the mode toggle switch is set to the normal Q/P position. With instrument in the horizontal dipole position (flat) and the range switch set to 100 mS/m, the Q/P Zero Control knob is adjusted until the meter reads 50 mS/m. This value is referred to as **H**. Without changing the instrument height, rotate the EM38 about its long axis to the vertical dipole position. The value in this position is referred to as **V**. Regardless of any layering in the earth at a height of 1.5 meters, **V** should equal twice **H** (**V=2H**). If it does not, then the Q/P Zero is not set correctly. To adjust the Q/P Zero, one needs to calculate the correlation **C** value that affects **V** and **H** equally (**C=V-2H**). With the meter in either the horizontal or vertical dipole position, adjust the Q/P Zero Control by the correlation value. Turn the control in the direction of higher conductivity if the value is positive and lower conductivity if the value is negative. The repeat the vertical and horizontal dipole measurements to insure that the instrument zero is set correctly. If not, repeat the procedures until it is correctly set. After the Q/P Zero is set, the instrument needs final inphase nulling before commencing the survey. The final inphase nulling is carried out as previously mentioned for the initial inphase nulling procedure, except the EM38 is placed on the ground in the vertical dipole position.

The meter is connected to the Omnidata DL720 Polycorder (Geonics 1998) for digital data acquisition after the nulling and zeroing procedures have been completed. Data were collected in the continuous mode and stored in the polycorder’s memory. The data stored in the Polycorder are downloaded into the laptop computer at the end of the day for processing in the Geonics DAT38 software (Geonics 1997). The polycorder contains the EM38 operating program along with BATTERY, CREATEDIR, FILE DIR, and DEMO programs. The EM38 program acquires and records the data from the EM38 ground conductivity meter. It also records field survey information (i.e., survey line number, starting station, survey increment, recorded phase component, survey comments, etc.). It is important to note that data files cannot be appended. If a mistake is made in the file setup or during the survey, or if the polycorder is turned off, one cannot use the same file. A new one, including file name, must be created. The BATTERY program is used to check the voltage status of the polycorder’s rechargeable battery pack. FILEDIR has to be present for the EM38 program to run. The CREATEDIR program creates a directory file FILEDIR if it is deleted by mistake or if the data files are erased manually. The DEMO program is used to examine the voltage output of any analog channel in the Polycorder. With the polycorder connected to the EM38 and the EM38 set to the Q/P mode, the polycorder is turned on. At the mode prompt, 0 (zero) is selected to initiate the polycorder program setup. The EM38 program is then selected and executed. The polycorder prompt requires confirmation of the Polycorder clock setting. The digital instrument type is selected. The operator is then requested to provide a file name. The file name can be up to eight alphanumeric characters in length. The Polycorder creates two files with this name, a header file and a data file. The operator is then prompted for the GPS option (global positioning system), which is answered with no. The operator then selects the survey phase type (Q for quadrature or conductivity; I for inphase or susceptibility; or B for both), the mode (V for vertical dipole; H for horizontal dipole; or B for both), and the number of orientations (1 or 2; can be in 0 and 90 degree rotation about the common axis or at two different heights about the ground). For the present survey, Q is selected for the survey phase type, V is selected for the vertical dipole position, and 1 is selected of the number of orientations. The operator can provide his or her name and additional comments in the operator and comment fields. The polycorder can be set to the automatic data collection mode or to the manual mode. The automatic collection mode is selected for the Hardscrabble project. The polycorder then prompts for the time interval in seconds between data readings which is set at 0.5 seconds. The polycorder then prompts the operator for the line number, line direction, start station, and increment in the positive or negative direction. After all the information requested for the file setup has been completed, EM38 program provides the ready prompt after which the operator presses the enter key to start the logging. From that point on, the data is automatically logged until the end of the line is reached. The enter key is pressed at the end of the line to stop further data collection. The line “L” key is pressed to end the collection of data along the traverse line. The EM38 program then prompts for the new survey line number, direction, start station, and increment. All prompts must be answered before the operator starts the next line. Upon completion of the grid, the file is closed with the end option, and the polycorder is returned to file setup routine.

The ground conductivity survey was designed to collect four samples per meter along 0.5-meter traverses or eight data values per square meter at the Noland (Table 3) and the Truman/Wallace (Table 4) projects. The data were collected in a parallel fashion with the surveyor returning to the starting side of the grid and maintaining the same direction of travel for each traverse across the grid. The conductivity survey on the Noland property began in the lower right hand corner of the grid units facing east while the conductivity survey in the Truman and Wallace properties began in the lower left hand corner of the grid units facing north. A total of 3,204 data values were collected in the conductivity survey of the Noland property and a total of 27,098 conductivity data values were recorded for the joint Truman and Wallace properties. With four samples per meter and 0.5-meter traverses in the parallel mode, it took approximately 45 minutes to complete a 20 m by 20 m grid unit. The data were downloaded to a laptop computer for processing in Geonics DAT38RT software. It took approximately 10 minutes to download the data from the five grid units. The header and data files from the polycorder were converted to a *.g38 file in the DAT38RT software program and then converted to SUFER file format for further processing on the laptop computer. The data should be viewed for any operational errors before the data is deleted from the polycorder. The data files were then placed in the hstr file folder in the surferprojects folder under the Surver8 folder on the laptop computer. The file folder names were maintained when the data were transferred to the desk personal computer at MWAC.

## Soil Resistance Survey Methodology

The Geoscan Research RM15 advanced resistance meter (Figure 13) and PA5 multiprobe array in a twin probe configuration (Geoscan Research 1996) is used at the Noland property but due to an operator error in wiring the mobile probes on the twin probe array, resistance data was not processed for the Truman and Wallace survey. The resistance meter has a resolution of 0.05 ohms with an absolute accuracy of 0.1 ohms. The resistance meter consists of a control unit that contains the electronics, menu pad, power source, operating program, and memory chips. It also contains the on/off switch, expansion ports for the potential and current mobile and remote probes, a LCD display screen, and charger connector. The mobile and remote probe cables are plugged into the back of the RM15 resistance meter. The control unit is attached to the multiprobe array frame by a mounting plate and short and long knoblet screws.

The soil resistance survey is designed with a twin electrode probe array. The stainless steel mobile probes on the frame consist of a set of current and potential probes. The remote probes also consist of a set of stainless steel current and potential probes. The mobile probes on the frame with the resistance meter are moved uniformly across the site. The mobile probes are at a set distance apart on the array frame, which for the present survey was 0.5 meters. The mobile probes are inserted into the ground so the center of the frame is over the center of the traverse point. For acceptable readings, the mobile probes need to be within ±7.5 cm of the center point of the 0.5-meter cell on the traverse line since the reading is of an average volume of a hemisphere with a radius equal to the mobile probe separation distance. This provides some freedom in the placement of the probes, which makes the system fast and easy to use. If an obstacle is in the way of the probes, the frame can simply be moved to one side or the other of the obstacle for the placement of the probes if the displacement will not greatly affect the location of the measurement. The insertion depth for the mobile probes is not critical. With reasonably moist soil, the downward momentum of the frame is enough force to push the probes into the ground to a depth of 3 to 5 cm. The remote probes are stationary, and are set at a distance that is 30 times the twin probe separation distance on the PA5 frame from the survey grid area. At this distance, the background resistance reading is essentially independent of the mobile probes' location. The remote probes were placed approximately 15 meters southeast of N0/E30). The separation distance between the remote probes is not critical since the probes are left in a fixed position throughout the survey. The remote probes were separated by a distance of approximately one-half meter. The remote probes are connected to the resistance meter by means of a 100-meter cable and drum. Although the insertion depth of the remote probes is not critical due to the high contact resistance tolerability of the RM15, it is best to insert the probes as far into the ground as possible to eliminate any offset in background resistance caused by remote probe contact resistance or capacitive coupling of the 100 m cable. This is not generally important in a twin electrode probe survey since one is only looking for changes in an arbitrary background level as the mobile probes are moved along the traverse lines in a grid survey. However, should the remote probe contact resistance change, as in the case of a rain shower, then the offset and background resistance could also change beyond acceptable survey levels.

Prior to the start of the survey, the memory of the resistance meter is cleared and the menu settings are checked for the appropriately planned survey. For the present project, the resistance is programmed for a mapping grid size of 20 m, a grid sample interval of 0.5 m, a grid traverse interval of 0.5 m, and the zigzag grid traverse mode. The range parameters include a gain of 10, a current of 1 mA, and a frequency of 137 Hz. The setup parameters include a medium auto-log speed, an output voltage of 40 v, a high pass filter value of 13 Hz, and a mains frequency equal to the United States standard of 60 Hz. In the array parameters, the PA5 is the selected hardware with the twin configuration. The probe separation was set to 0.5. The communications parameters for downloading the data are set to 9600 baud rate and with a data separator of no space. In the program menu, the meter can be programmed as a single twin array (the default setting), parallel arrays, and multiple arrays. As the word single implies, only one configuration is used during the survey. This is set by the placement of two probes on the array frame. The final menu category contains the battery voltage status.

In order to have an appropriate operating range for data acquisition, the soil resistance system is moved around the grid area to check the dynamic range of resistance values. The gain and current ranges are adjusted so that changes of approximately 1% in the background resistance are observed. Typically this means adjusting the current and/or gain ranges up or down to get a measurement display of three decimal places on the LCD screen. Once the gain and current ranges are set, they are not changed during the survey of the grid. If they require a change because of repeated over-range readings, the data must first be downloaded and the memory cleared. The grid may need to be re-surveyed at the new settings. Once the gain and current ranges are set (x10 for the gain and 1mA for the current) the operator is ready to begin the survey. The Enable Log button is pushed to enable the Logging Display. The LCD screen displays the ohm reading and the initial position location (G1, L1, P1). To take the first reading, the Start button is pushed. The averaged measurement is recorded into memory and the P position values will increment one position. At the end of the line, the L value is advanced one unit, and at the end of the grid, the G value is advanced one unit. An “A” is also displayed on the LCD screen, which indicated the meter, is in the Auto-Log mode and ready for the next measurement. The array frame and meter are picked up, moved to the next location, and the probes are inserted into the ground. At this point in the survey, the readings are automatically recorded. The RM15 detects the placement of the mobile probes in the ground in the automatic method of logging. The instrument provides both an audible warble for the recordation of the averaged resistance value in the instrument’s memory, and advances the position counter to the next point value. When the mobile probes are removed from the ground, the LCD screen indicates an open circuit (HCR / Open cct.). The survey continues to the end of the grid. At the end of the line, the instrument will provide one beep, and at the end of the grid, it makes two beeps. There are also times when the reading from one of the positions may be over the operating range of the RM15. In those cases, the Dummy Log button is depressed and the dummy value of 2047.5 is inserted into the data set.

During the Noland resistance survey, data were collected at two samples per meter (0.5 m) along 0.5-meter traverses across the grid resulting in four samples per square meter (Table 5). The survey began in the lower left hand corner of the grid units. The traverses were covered in a zigzag mode with the first traverse headed west for the Noland property from the lower left hand corner of each grid unit. The direction was reversed on the next traverse and the traverse was covered in the east direction. For each traverse, a total of 40 resistance measurements were recorded in the memory of the Geoscan Research RM15 resistance meter for a twenty-meter traverse line. A total of 3,200 measurements were recorded during the soil resistance survey with 1,614 dummy value readings. At the end of the data acquisition phase at the site (approximately 2 hours), the resistance data from the survey were downloaded into the Geoscan Research GEOPLOT software (Geoscan Research 2003) on a laptop computer. It took approximately five minutes to download the data from the survey. The grid files were reviewed in the field prior to the clearing of the resistance's memory. The site/file folder name for the resistance data from the Noland property was the same as the magnetic data site/file folder name of hstr. Each grid unit data file was assigned an alphanumeric identifier for the grid unit and the letter "r" to identify the grid file as a resistance data grid file.

## Vertical Electrical Sounding Methodology

The vertical electrical sounding (VES) is conducted with the Gossen Geohm 40D earth tester (Figure 14) with a Wenner probe array (see Bevan 1998:7-18; Carr 1982; Gaffney and Gater 2003:34-36; Gossen-Metrawatt GMBH 1995; Lowrie 1997:215-217; Milsom 1996:71-73; and Mussett and Khan 2000:186-194 for more details of vertical resistivity soundings). The resistivity meter has four measuring or operating ranges: 1) 0.01 Ω (ohms) to 19.99 Ω, 2) 0.1 Ω to 199.9 Ω 3) 1.0 to 1.999 kΩ, and 4) 10 Ω to 19.99 kΩ. It has an intrinsic error of ±2% of reading ±3 digits and a service error ±5% of reading ±3 digits.

The VES at the Noland property was centered at N5046.49/E4846.38 with the offset line oriented northeast-southwest. The offset Wenner array of five electrodes was used to take resistance readings at the following increments: 0.1, 0.15, 0.2, 0.3, 0.4, 0.5, 0.70, 1.0, 1.5, 2.0, 3.0, 4.0, and 5.0 meters in both directions from the center probe to obtain data for the offset sounding (Table 6). The distance between the probes also approximates the depth of investigation. The resistance measurements including the probe separations for both directions along the Wenner array offset were hand recorded in the field notebook for both directions of the offset. The average offset resistance values and the apparent resistivity were calculated. A total 26 measurements were recorded at the site. It took approximately 1.5 hours to set up the array and conduct the vertical electrical sounding at the Noland property.

## Ground-penetrating Radar Survey Methodology

The Geophysical Survey Systems, Inc. (GSSI), TerraSIRch SIR System-3000 ground-penetrating radar (gpr) system (Figure 15) is used for the Noland and Truman/ Wallace geophysical survey projects. The gpr system consists of the digital control unit (DC-3000), a 400 MHz ground coupled antenna (Model 5103), and the GSSI Model 623 survey cart with survey wheel for mounting the antenna and control unit (GSSI 2003a). System hardware contains a 512 MB compact flash memory card as its internal memory. The digital control unit also accepts an industry standard compact flash memory card up to 2 GB. The processor is a 32-bit Intel StrongArm PISC 206 MHz processor with enhanced 8.4" TFT display, 800 x 600 resolution, and 64k colors. The processor produces both linescan and O-scope displays. The gpr system uses one channel. The Model 5103 antenna operates at a nominal frequency of 400 MHz. The 400 MHz antenna has a depth of view of approximately 4 m assuming a ground dielectric constant of 5 with a range of 50 ns, 512 samples per scan, 16 bit resolution; 5 gain points, 100 MHz vertical high pass filter, 800 MHz vertical low pass filter, 64 scans per second, and 100 kHz transmit rate.

The S-3000 control unit was placed on the survey cart and connected to the antenna. The odometer survey wheel attached to the frame of the cart was also connected to the antenna by a small cable. As the cart was moved along on the ground, the cart's right rear wheel turned the odometer wheel and the revolutions were translated into distance along the traverse line.

The LCD display on the SIR 3000 control unit provides immediate visual display of the gpr profile data as it is collected. Once the battery is installed into the SIR 3000, the unit boots up (GSSI 2003a:6). The initial screen displays the words TerraSIRch SIR-3000 in the middle of the screen. At the bottom of the screen, there is a set of six buttons positioned over the function keys. The mark button on the right side of the unit allows one to change between English and Metric units of measurement. This is set to metric for the current projects at the Hardscrabble and Wish-ton-wish sites. Selection of the function key below the TerraSIRch button display initiates the gpr data collection program. A set of three screens is displayed with the left window containing the parameter selection tree, the middle window displaying the profile data in linescan format, and the right window showing a single scan in an oscilloscope trace depiction. The command bar at the bottom of the screen allows one to toggle between functions.

Initially, the System menu is opened on the parameter tree. The System menu contains the choices for the system setup. The System menu contains the submenus for Units, Setup, Path, Backlight, Date/Time, Battery, and Version (GSSI 2003a:9-10). Metric units are selected for depth and distance. Time is selected for Vscale (vertical scale) display. Setup contains factory setups for the various antenna configurations, which cannot be overwritten, and 16 user setups. The factory default for the 400 MHz antenna (400met) is selected and saved in one of the user setups. The Path submenu allows for the creation of separate folders for the gpr profile files. The Backlight submenu controls the LCD screen brightness. The Date/Time submenu allows one to set the system's internal clock to the correct date and time. The Battery selection provides a check on the remaining charge on the battery in percent of total charge. The Version informs one of the current version of TerraSIRch operating software.

The next step is to configure the SIR-3000 for data collection. The Collect menu is opened (GSSI 2003a:11-16). There are five submenus that need to be configured. The Radar submenu contains the information concerning the antenna frequency selection (400 MHz), the antenna transmit rate (100 kHz), the mode of data collection (distance for survey wheel with value of -1583 for survey cart system), and activation of gps capability (off). The Scan submenu allows for the selection of the number of individual data points or samples collected per scan (512 samples/scan), the data format (16-bit), the time window range (100 ns which is two-way travel time), the Diel or dielectric constant value of the material (generally left at the factory default of 8). The dielectric constant is a measure of the capability of a material to store and pass a charge when an electromagnetic field is applied to the material (Sheriff 1973:51). It reflects the velocity of the radar wave that can pass through a given material. The scan Rate is the number of scans that the SIR-3000 records in its RAM memory per second (100 with a T-RATE of 100 kHz and use of a survey wheel). The scans per unit of horizontal distance is set to 50 scans per meter. This equals 1 scan every 2 cm. The Gain submenu allows for the artificial enhancement of the radar signal in order to offset the natural effects of signal attenuation. During the survey, the Gain is set to the manual mode. The auto mode is used to re-initialize and adjust the antenna's gain values during the initial reconnaissance of the survey area in order to keep from clipping the data. Five separate values are available for the evenly spaced gain points ranging from 1 to 5 (3 is the factory default). The individual gain values can be manipulated are left at the factory default values. The Position submenu controls the position of the time zero setting. Time zero is defined as the location of the beginning of the transmit pulse. During a survey, the Position is set to the manual mode. The offset represents the time lag from the initiation of the radar pulse in the SIR-300 control unit to the transmission of the pulse from the antenna dipole. This is generally represented by the time value where the direct coupling of the signal between the transmitting and receiving antennas. The Surface submenu allows for the display option of setting time zero at the first reflected target or the ground surface. The gpr system was moved around the grid prior to the start of the survey to adjust the gain. If a location caused the trace wave to go off the screen, the gain was set to auto and then back to manual. The position was set to the manual mode with the offset value at the factory default and the surface display option set to zero. The final submenu allows for the manipulation of data collection filters to remove interference and smooth noise. These include low and high pass filters, stacking, and background noise removal filters. These are left at their factory defaults for the specific antenna in use.

The final step prior to the start of the data collection is to return to the System menu and select the path for the profile data. In the Path submenu, a new folder can be named. The folder will contain the radar profile collected in the grid. Once the new path is selected, it is saved in one of the user defined setups. With the setup completed, the run/

stop button at the bottom of the display screen is selected and the collect mode is initiated. The gpr unit is moved across the grid and at the end of the traverse, the collect button is selected and data acquisition is halted. The gpr unit is placed at the start of the next line before saving the profile. Once the profile line is saved, the gpr unit is ready to collect the next profile line. The gpr data are recorded on a 512 MB compact flash card and transferred to a laptop computer at the end of the survey.

The gpr profiles were collected along 0.5 meter traverses beginning in the southwest corner or lower right hand corner of each grid unit for the Noland property (Table 7) survey facing east and the southwest or lower left hand corner of each grid unit in the Truman/Wallace project area facing north (Table 8). The data were collected in the zigzag or bidirectional mode with the operator alternating the direction of travel for each traverse line. The gpr profiles were collected in the x direction during the Noland survey and in the y direction for the Truman/Wallace survey. At the Noland property, a total of 47 radar profiles were collected across the two grid units along the East or x traverse lines. The data folder containing the profile line data was transferred to the laptop computer via the 512 MB compact flash card used to record the data in the TerraSIRch SIR-3000. The profiles were consecutively labeled beginning with HSTR____001 to HSTR____047 with the dzt extension for the Noland gpr survey (Table 9). The files were placed in the HSTR file folder on the laptop computer before transfer to the HSTR file folder on the desk personal computer. At the Truman/Wallace properties, a total of 247 radar profiles were collected across the fifteen grid units along the North or y traverse lines. The profiles were consecutively labeled beginning with TRUMAN__001 to TRUMAN__064 and HSTRA___001 to HSTRA___183 with the dzt extension for the Truman/Wallace gpr survey (Table 10). The files were placed in the TRUMAN and HSTRA file folders on the laptop computer before transfer to the TRUMAN file folder on the desk personal computer. With one-half meter traverses in the parallel mode, it took approximately 25 minutes to complete a 20m by 20 m grid unit. The data folder containing the profile line data was transferred to the laptop computer via the 512 MB compact flash card used to record the data in the TerraSIRch SIR-3000.

Ground-penetrating surveys generally represent a trade-off between depth of detection and detail. Lower frequency antennae permit detection of features at greater depths but they cannot resolve objects or strata that are as small as those detectable by higher frequency antennas. Actual maximum depth of detection also depends upon the electrical properties of the soil. If one has an open excavation, one can place a steel rod in the excavation wall at a known depth and use the observed radar reflection to calibrate the radar charts. When it is not possible to place a target at a known depth, one can use values from comparable soils. Reasonable estimates of the velocity of the radar signal in the site's soil can be achieved by hyperbola matching. Using one of the hyperbolas on a radargram profile (Goodman 2006:82-86), the velocity was calculated to be approximately 3 cm per ns. For a time slice between 5 and 15 ns with the center at 10 ns (two way travel time), the approximate depth to the center of the gpr slice would be 15 cm. With a 100 ns window open, the total depth displayed was approximately 1.5 meters; however, due to noise and signal attenuation, the ability of the radar to detect buried cultural and natural features extended to less than one meter.

## 7. DATA PROCESSING AND INTERPRETATION

Processing of geophysical data requires care and understanding of the various strategies and alternatives (Kvamme 2001:365; Music 1995; Neubauer et al. 1996). Drs. Roger Walker and Lewis Somers (Geoscan Research 2003) provide strategies, alternatives, and case studies on the use of several processing routines commonly used with the Geoscan Research instruments in the GEOPLOT software manual. Dr. Dean Goodman (Goodman 2006) provides information on the processing of ground penetrating radar in the GPR-SLICE manual. Additional tips on processing and integrating geophysical data are provided in Heather Ambrose's (2006) master's thesis. Dr. Kenneth Kvamme (2001:365) provides a series of common steps used in computer processing of geophysical data:

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

It is also important to understand the reasons for data processing and display (Gaffney et al. 1991:11). They enhance the analyst's ability to interpret the relatively huge data sets collected during the geophysical survey. The type of display can help the geophysical investigator present his interpretation of the data to the archeologist who will ultimately use the information to plan excavations or determine the archeological significance of the site from the geophysical data. Integration of the various complementary geophysical data sets also provides additional insight into the identification of the geophysical anomaly and the relationship of the anomaly to the archeological or natural cause of the anomaly (Ambrose 2006; Clay 2001).

### Processing Magnetic Gradient Data

Due to the limited memory capacity and changes in the instrument setup of the Geoscan Research FM36 fluxgate gradiometer, the data were downloaded into a laptop computer after the surveying of two grid units at the Noland and Truman/Wallace properties. On the laptop computer, the GEOPLOT software was initialized and the download data routine was selected from the file menu (Geoscan Research 2003:4/1-29). The default input template was then selected. The selection of the gradiometer and FM36 was then made. The grid input template was displayed. For the gradiometer survey, the survey information was entered under the general category, which contained settings for the acquisition of the data and the instrumentation used to acquire the data. The next step required entering the grid name for downloading data from the FM36. In the grid name for downloading screen, the file name for the grid unit was entered into the laptop computer. The grid file contained the magnetic gradient raw data obtained during the survey. The download instructions screen was displayed after the file names were checked for duplicate names in the laptop computer and entered into the laptop computer. The instrument was connected to the laptop computer via the RS323 serial port and serial cable, switched on, and after waiting approximately one second, the next step was initialized for downloading the data. The display indicated that the laptop computer was waiting for the data from the instrument. The DUMP key on the FM36 keyboard was depressed and the download process was initiated. Downloading the magnetic gradient data from a typical 20 m by 40 m survey area at eight samples/m and 0.5 m traverses required approximately 26 minutes to complete the download process. The FM36 was then switched off and disconnected from the laptop computer. The grid files were reviewed in the shade plot display under the graphics menu in the Geoscan Research GEOPLOT processing software (Geoscan Research 2003) for data transfer or survey errors. If no data transfer errors were observed, a composite of the data file(s) was created for further data processing. Generally, while in the field, the composite file was processed with the zero mean traverse routine and viewed on the laptop computer before the memory in the gradiometer was cleared. From this preliminary review of the collected data, the geophysical investigator could analyze his survey design and methodology and make appropriate survey decisions or modifications while still in the field. Grids actually consist of three files or parts: 1) the grid data file (*.dat), 2) the grid information file (*.grd), and 3) the grid statistics and histogram file (*.grs). The grid data and grid statistics are stored in binary format (Table 1 for the Noland property data and Table 2 for the Truman/Wallace properties data). The grid information is stored in ASCII (text) format.

In order to process the magnetic gradient data, the grid files from the survey must be combined into a composite file. To construct a composite file containing all of the grid files collected at a site, the master grid routine is selected from the file menu in GEOPLOT (Geoscan Research 2003:3/15-21). The master grid file names screen is displayed and the grid files are entered into the mesh template by the grid position in the overall survey of the site. The mesh template defines how the grids fit adjacent to one another within the surveyed area. The grid files are entered into the mesh cells according to their position beginning in the upper left hand corner of the surveyed area (Table 1 for the Noland property data and Table 2 for the Truman/Wallace properties data). For grids that are in the line of travel or traverse direction (X direction on the template), the grid names are placed from left to right in the mesh cells on the screen display. Grids that are perpendicular to the traverse direction (Y direction on the template) are placed from the top cell to the bottom cell of the mesh template. The GEOPLOT survey directions have the display the line of travel along the traverse on the X-axis and the movement across the grid along the Y-axis. This format is also followed for the creation of the composite file. Once the grid files have been placed in the correct position in the mesh template, the composite file is generated by selecting the create composite button on the display screen. The master grid or mesh template is also saved as a file for later modifications as necessary. The composite file is also named. Generally, the same prefix is given to both the mesh and composite files (Table 1 for the Noland property data and Table 2 for the Truman/Wallace properties data). Like the grids, composites also consist of three files or parts: 1) the composite data file (*.cmp), 2) the composite information file (*.cmd), and 3) the composite statistics and histogram file (*.cms). The composite data and composite statistics are stored in binary format. The composite information is stored in ASCII (text) format. The mesh file (*.plm) contains a text file used to load several grids into memory at the same time.

After the creation of the composite file for the magnetic gradient data collected at the site, the data is viewed as the numeric data values or the graphic representation of the data (Geoscan Research 2003:5/2-3). In order to continue to analyze the data, the grid or composite files must be opened. The open grid/composite command is selected under the file menu. The appropriate grid or composite data file is selected from the correct sitename folder. The default screen display is the shade plot. The shade plot is useful in highlighting subtle changes in the data set. The shade plot represents the data in a raster format with the data values assigned a color intensity for the rectangular area at each measurement station. Data may be presented as absolute numbers, in units of standard deviation, or as a percentage of the mean. Several color and monochrome palettes provide different visual enhancements of the data. Plotting parameters, data histogram, data statistics, processing history, scale and north arrow are provided in sidebars adjacent to the display screen. For the initial shade plot display, the parameter mode is set in the shade plot window with clip between a minimum value of -3, maximum value of 3, contrast equal to 1, and units to standard deviation. Set to the normal position, the grey55.ptt shaded palette is selected to represent the changes in the data set. Trace plots of the data represent the data in a series of side-by-side line graphs, which are helpful in identifying extreme highs and lows in the data. The trace plots show location and magnitude. For the initial trace plot display, the parameter mode is set in the trace plot window to standard with a resolution of 0.5, units to standard deviation, view to front, 0% displacement in the X direction, and 0% expansion in the Y direction.

Up to this point, we have been collecting the data and preparing it for processing and analysis. Inspection of the background should show the data as bipolar and centered on zero. There should be a broad range in the archeological anomalies with weak anomalies less than 1 nT, typical 1 nT to 20 nT anomalies, strong anomalies greater than 20 nT. If the anomalies are weak then reset the clip plotting parameter to a minimum of –2, a maximum of 2, and units to absolute. Then one should identify weak and strong magnetic anomalies. The strong anomalies often represent modern intrusions into the site such as localized surface iron trash, wire fences, iron dumps, pipelines, and utility lines. Geological trends in the data set should also be identified. Since gradiometers provide inherent high pass filtering, broad scale geological trends are already removed from the data set. If such trends appear to exist, there may be changes in the topsoil thickness, natural depressions, igneous dikes or other geomorphological changes in the landscape. The final step prior to processing the data is to identify any defects in the data. These can range from periodic errors appearing as linear bands perpendicular to the traverse direction, slope errors appearing as shifts in the background between the first and last traverses, grid edge mismatches where discontinuities exist between grids, traverse striping consisting of alternating stripes in the traverse direction which most commonly occurs during zigzag or bi-directional surveys, and stager errors resulting in the displacement of a feature on alternate traverses (Geoscan Research 2003:Reference Card 3).

Initially, the spectrum function (Geoscan Research 2003:6/87-95) was applied to the data. The spectrum function provided analysis of the frequency spectrum of the data, splitting it into amplitude, phase, real, or imaginary components. The amplitude component was selected for the analysis to identify any periodic defects. These defects may have been the effects of cultivation (e.g., plow marks, ridge and furrow) or operator induced defects during data acquisition). It operated over the entire site data set. The spike tolerance was left in the default on position. This had the effect of reducing any broad spectral energy from noise spikes in the data set. No periodic defects were noted in the data sets from the two project areas at Harry S Truman National Historic Site.

The magnetic gradient data were “cleaned up” using the zero mean traverse algorithm (Geoscan Research 2003:6/107-115). This algorithm was used to set the background mean of each traverse within a grid to zero, which removed any stripping effects resulting from “scan to scan instrument and operator bias defects” (Jones and Maki 2003:16). It also was useful in removing grid edge discontinuities between multiple grids. The algorithm utilized the least mean square straight line fit and removal default setting on over the entire composite data set. The letter “z” was added to file name when the composite file was saved to indicate that the zero mean traverse routine had been applied to the data.

The statistics function (Geoscan Research 2003:6/101-102) was then applied to the entire magnetic gradient data set for each of the sites. The mean, standard deviation, and variance were used to determine appropriate parameters for the subsequent processing steps. The magnetic data for the Noland property ranged from –295.3 to 192.2 nT with a mean of 3.55 nT and a standard deviation of 64.05 nT. The magnetic data for the Truman/ Wallace property ranged from –283.9 to 790.1 nT with a mean of -0.89 nT and a standard deviation of 47.593 nT.

The data set is interpolated to produce a uniform and evenly spaced data matrix (Geoscan Research 2003:6/53-56). Increasing or decreasing the number of data measurements creates a smoother appearance to the data. The original matrix is an 8 x 1 matrix. The interpolate function requires three parameters: direction, interpolation mode and interpolation method. Method may be either sinx/x or linear and the mode is either expand or shrink. In the Y direction, the number of data measurements is first expanded using the sinx/x method and then using the linear method. This yields an 8 x 4 data matrix. In the X direction, the number of data measurements are shrunk using the sinx/x method. This yields a 4 x 4 matrix. The letter “i” was added to file name when the composite file was saved to indicate that the interpolation routine had been applied to the data.

The low pass filter was then used to remove high-frequency, small-scale spatial details over the entire data set (Geoscan Research 2003:6/57-60). It was also used to smooth the data and to enhance larger weak anomalies. The function scanned the data set with a gaussian weighted, rectangular window set to the default values for the X radius of 1 unit and the Y radius of 1 unit. The letter “l” was added to file name when the composite file was saved to indicate that the low pass filter routine had been applied to the data.

The composite data files were then exported to separate xyz files for use in the SURFER 8 contouring and 3d surface mapping program (Golden Software 2002). The export batch data routine was selected under the file menu in GEOPLOT (Geoscan Research 2003:5/4-7). The export parameters for exported files were set to XYZ-CommaSV (comma-separated variables) with the top-left reference corner identifying where the origin point of the X and Y coordinates was located. The X and Y reference coordinates identified the initial starting point in the export data set. The default values were 0,0. The X and Y increment entries identified the sample and traverse intervals of the loaded data set with default values of 1. The export file extension  “dat” was selected since it is the extension that SURFER 8 readily recognizes as a data file. The file names remained the same for all the files. The files were the exported to “expdata” folder in GEOPLOT. The files are then transferred to an appropriately named site folder in the SURFER 8 contouring and 3d surface mapping program’s project folder (Golden Software 2002).

In SURFER 8 (Golden Software 2002), the initial step is to view the *.dat file. The open file command is selected to open the zero mean traverse, interpolate, and low pass filter processed file found in the sitename folder under the SURFER 8 projects folder. The data is displayed in a worksheet format with the North (Y) coordinated listed in Column A, the East (X) coordinates in Column B, and the data in Column C. Since the X and Y coordinate data from the export function in GEOPLOT are listed in sequential integer values, the North and East coordinate values are corrected to the correct sample interval and traverse interval through the data transform routine. The North coordinate (Column A) is corrected by the formula **A=A/4** to provide the correct sample interval position for the data. The East coordinate (Column B) is corrected by the formula **B=B/4** to provide the correct traverse interval position for the data. The value 440 was added to the East coordinate values and 500 was added to the North coordinate values in order to express the results into the mapped site coordinate system. The data are sorted, using the data sort command, to check for GEOPLOT dummy values (i.e., 2047.5). The rows of data containing these values are deleted from the file. Due to the large ranges of values, the data are also clipped to 20 for data values greater than 20 nT and to –20 for data values less than –20 nT. The data is saved as a new file containing the corrections.

In order to present the data in the various display formats (e.g., contour maps, image maps, shaded relief maps, wireframes, or surfaces), a grid must be generated (Golden Software 2002). The grid represents a regular, rectangular array or matrix. Gridding methods produce a rectangular matrix of data values from regularly spaced or irregularly spaced XYZ data. The grid data command is used to set the parameters of the grid. The data columns are identified. Column A is identified as the Y coordinate and Column B is identified as the X coordinate. The data values (Z coordinate) are found in Column C. The gird geometry is then defined. The minimum and maximum values for the X and Y coordinates are defined. These values represent the beginning and ending coordinates of the surveyed geophysical grid. The sample interval and traverse spacing are defined in the distance between data units under spacing. The # of lines field provides the number of lines in the X and Y directions. The number of lines should correlate with the number of traverses and samples per traverse. For the Noland project, the data columns consist of 0 to13 in the North or Y direction, 0 to 40 in the East or X direction with the X-spacing of 0.25 and the Y-spacing of 0.25. For the Truman/Wallace project, the data columns consist of 0 to 47 in the North or Y direction, 0 to 96 in the East or X direction with the X-spacing of 0.25 and the Y-spacing of 0.25. The Kriging gridding method was selected for processing the data. The Kriging method is very flexible and provides visually appealing displays from irregularly spaced data. The Kriging variogram components are left in the default values. The default linear variogram produces a reasonable grid in most circumstances. The grid file (*.grd) is created and named with the same prefix as the data file (*.dat). The next step in the formation of the visual display of the data from the site is to apply the spline smoothing operation to the grid file. The operation produces grids that contain more rounded lines in the contour display. The default settings for the node method and the number of nodes to insert between the rows and columns of data points are used for this operation. The resulting grid is saved under the same name.

At this point in the process, maps of the data may finally be generated (Golden Software 2002). Typically for geophysical surveys, contour maps, image maps, shaded relief maps, and wireframes may be generated. The image map is a raster representation of the grid data. Each pixel or cell on the map represents a geophysical data value. Different color values are assigned to ranges of data values. The image map is created by selecting the image map operation from the map menu and opening the grid file. The image map is generated. The map may be edited. The color scale is set with the minimum value assigned the color white and the maximum value assigned the color black. The scale is a graduated scale flowing from white through several shades of gray to black. SURFER 8 has a several predefined color scales including the rainbow scale, which is often used for the presentation of geophysical data, or the investigator may create a color spectrum suitable for the project data. To complete the image map, descriptive text is added along with a direction arrow, a color scale bar, and map scale bar. Another way to represent geophysical data is with contour maps. Contour maps provide two-dimensional representations of three-dimensional data (XYZ). The North (Y) and East (X) coordinates represent the location of the data value (Z). Lines or contours represent the locations of equal value data. The distance or spacing between the lines represents the relative slope of the geophysical data surface. To create a contour map, the new contour map operation is opened under the contour map routine in the map menu. The grid file is selected and the contour map is generated. The contour map may be modified by changing the mapping level values in the levels page of the contour map properties dialog controls. Contour levels can be added or subtracted to the display. The line style, fill colors and hachure shape can be changed. Labeling may also be changed. As with the image maps, descriptive text, including information on the contour interval, is added along with a direction arrow and map scale bar. If color fill is used, a color bar is also added. Contour maps are useful in determining the strength of the magnetic anomalies as well as their shape and nature. The various types of maps can be overlain on one another and different types of data can be illustrated by stacking the displays within a single illustration. Both the image and contour maps were generated for the magnetic gradient data collected at the Noland property (Figure 16) and the Truman/Wallace properties (Figure 17).

## Processing Ground Conductivity Data

The ground conductivity data were downloaded into a laptop computer after the completion of survey at each site. On the laptop computer, the DAT38RT software was initialized and the copy files from Polycorder 720 routine was selected from the menu (Geonics 1997:19-25). The default fast mode was selected for copying or downloading the data from the Polycorder to the laptop computer. The fast mode permits the rapid transfer of all data files in the Polycorder’s dirfile directory. The dump program is selected on the Polycorder. The Polycorder parameters for communications with the laptop are set to a baud rate of 9600 with 8 data bits, no parity and the mating call equal to <CR>. At the ready prompt on the Polycorder, the Polycorder is driven by the laptop computer. Selecting the enter key on the laptop computer, the fast file copy from Polycorder 720 screen is displayed. The first prompt on the laptop computer asks for the Polycorder’s file names. All is entered or the enter key is selected. The second prompt asks for the disk files in the Polycorder format. Two files are created for each site data file (i.e., the header file with H prefix plus file name and the data file with the D prefix plus file name). The third prompt identified the created file in DAT38 format. The Polycorder header and data files (i.e., the DL files) are converted into the DAT38 format with the file name and “g38” extension identifier). The serial port is set to com1. The copy files routine is selected from the menu on the laptop computer. The header file is transferred first followed by the data from each site file from the Polycorder to the laptop computer. Once the files have been transferred to the laptop computer, the next step is to create the data files. The enter data files routine is opened in the DAT38RT program (Geonics 1997:35-37). A list of entered survey files is displayed in the window. The DAT38 (*.g38) file is selected. The screen then displays the profile lines within the file (with Component/Mode/Orientation). Information including the measured component (i.e., conductivity phase), mode (i.e., vertical), and orientation (i.e., 1) are listed next to the line numbers. All of the lines in the file are selected by pressing <ENTER>. The final stage in the preparation of the data files for processing is the creation of the surfer XYZ (*.dat) files in ASCII format. The write file for contour package subroutine is selected from the main DAT38RT menu (Geonics 1997:62-65). The surfer format is selected for the format of the created file. A file name is given to the finished file. The dipoles mode, instrument orientation, component, and survey geometry fields are left in the default values of vertical, 1, conductivity, and arbitrary respectively. The create file command is selected from the submenu. Messages and prompts are provided to enter the beginning and ending X and Y coordinates for each line in the survey grid file. All of the X and Y coordinates with the corresponding conductivity measurements are written to the *.dat file. At the end of the line setup procedure, a window displays the created data file. It can be examined without leaving the program. The file is saved in the DAT38RT folder in the laptop computer. The line setup procedure is required for each grid data file. The *.dat files from the survey are then transferred to SURFER 8.

In SURFER 8 (Golden Software 2002), the data file created in DAT38RT is opened through the open routine in the file menu. The data are presented in the worksheet display. The worksheet contains the East (X) coordinate in the A column, the North (Y) coordinate in the B column, and the data value (Z) in C column. In order to process the data in GEOPLOT (Geoscan Research 2003), the data values must be arranged in ascending order by sorting the X and Y values. All three columns are selected. The sort routine in the data menu is selected and the sort parameters are set with the Column B set for sorting first in ascending order and Column A set for sorting second in ascending order. The data are checked for the correct number of entries based on the number of traverses covered in the survey and by the number of sample intervals per traverses. The conductivity data collected from the Noland property contain 3,068 measurements and the conductivity data collected from the Truman/Wallace properties contain 26,043 measurements. In order to import the data into GEOPLOT, one must make certain that the total number of data values equals the number of measurements taken in the grid unit. For the present survey, a total of 3,200 readings is needed in each grid unit data file (Note: The dummy value of 2047.5 is added at the correct spacing interval to complete the data matrix if needed.). The file is sorted in ascending order in with the X values sorted first and then the Y values sorted next to arrange the data in its correct orientation within the columns of the file's worksheet. The X and Y values are deleted from the file leaving the Z or data values. The data file is saved in SURFER 8 and then copied to GEOPLOT's impdata folder.

To process the data in GEOPLOT, the data is imported into GEOPLOT using the import data routine under the file menu (Table 3 for the Noland property data and Table 4 for the Truman/Wallace properties data). The default grid template is selected in the import data screen. The electromagnetic survey type is selected and the user defined category is selected as the instrument. The grid input template screen is displayed on the laptop computer. The ground conductivity survey information is entered under the general category, which contains the settings for the acquisition of the data and the instrumentation used to acquire the data. The next step requires the entering of the grid name(s) for importing. The import data screen is displayed after the grid input template parameters are entered. In the import data screen, the import file format is set to Z. The import file parameters are set to top-left reference corner for the start of the grid data acquisition point and the import dummy value equals 2047.5. Unlike the X or East and Y or North directions in the original conductivity data for the Noland property survey, the X and Y directions for the Truman/Wallace properties survey in GEOPLOT are reversed with X representing the North direction and Y representing the East direction. Under the import file names, the drive is set to the d drive, the extension is set to the “dat” file extension type, and directory path is set to d:\geoplot\impdata. The correct data file is selected from the list of import file names. The imported grid file is saved to the correct sitename directory (Table 3 for the Noland property data and Table 4 for the Truman/ Wallace properties data). A notification window indicates the successful completion of the import routine. The grid data set actually consists of three files or parts: 1) the grid data file (*.dat), 2) the grid information file (*.grd), and 3) the grid statistics and histogram file (*.grs). The grid data and grid statistics are stored in binary format. The grid information is stored in ASCII (text) format.

In order to process the conductivity data, the grid files from the site must be combined into a composite file. To construct a composite file, the master grid routine is selected from the file menu in GEOPLOT (Geoscan Research 2003:5/2). The master grid file names screen is displayed and the grid file names are entered into the mesh template in the correct location and orientation (Table 3 for the Noland property data and Table 4 for the Truman/Wallace properties data). The grid files are converted into a single composite. The composite file is generated by selecting the create composite button on the display screen. The master grid or mesh template file is also saved for later modification if necessary. The composite file is also named. Generally, the same prefix is given to both the mesh and composite files (Table 3 for the Noland property data and Table 4 for the Truman/Wallace properties data). Like the grids, composites also consist of three files or parts: 1) the composite data file (*.cmp), 2) the composite information file (*.cmd), and 3) the composite statistics and histogram file (*.cms). The composite data and composite statistics are stored in binary format. The composite information is stored in ASCII (text) format. The mesh file (*.plm) contains a text file used to load several grids into memory at the same time.

After the creation of the composite file for the ground conductivity data, the data may be viewed either as the numeric data values or as a graphic representation of the data (Geoscan Research 2003:5/2-3). In order to continue to analyze the data, the grid or composite file must be opened. The open grid/composite command is selected under the file menu. The appropriate grid or composite data file is selected from the correct sitename folder. The default screen display is the shade plot. The shade plot is useful in highlighting subtle changes in the data set. The shade plot represents the data in a raster format with the data values assigned a color intensity for the rectangular area at each measurement station. Data may be presented as absolute numbers, in units of standard deviation, or as a percentage of the mean. Several color and monochrome palettes provide different visual enhancements of the data. Plotting parameters, data histogram, data statistics, processing history, scale and north arrow are provided in sidebars adjacent to the display screen. For the initial shade plot display, the parameter mode is set in the shade plot window to clip with minimum value of –3, maximum value or 3, contrast equal to 1, and units to standard deviation. Set to the normal position, the grey55.ptt shaded palette is selected to represent the changes in the data set. Trace plots of the data represent the data in a series of side-by-side line graphs, which are helpful in identifying extreme highs and lows in the data. The trace plots show location and magnitude. For the initial trace plot display, the parameter mode is set in the trace plot window to standard with a resolution of 0.5, units to standard deviation, view to front, 0% displacement in the X direction, and 0% expansion in the Y direction.

Up to this point, we have been collecting the data and preparing it for processing and analysis. Initially, the data is displayed in a shade plot or trace plot. The clip parameters are set to a minimum of –3 and a maximum of 3 with a contrast set to 1 and units in standard deviation (SD) for the shade plot. The trace plot is displayed utilizing the standard default parameters with a resolution of 0.1 SD and units set to SD. Processing conductivity data begins with the inspection of the data changes on the background signal. These data changes are superimposed on the local geology. There should be a broad range in the archeological anomalies with weak anomalies or archeological features having less than 5 % change, typical anomalies with 5% to 20% change, and strong anomalies with greater than 20% change in conductivity values. The data are checked for noise spikes including low-level spikes, which create a noisy appearance in the data displays, and extremely high anomalous readings, which may be as large as ±1000% about the mean. The large background, which underlies the archeology, may have a regional gradient that is dependent on the local geology, drainage, or topography. The regional gradient may change from virtually none to over 300% across large sites. Changes may also occur from differences in topsoil thickness, natural depressions, or other topographic conditions (Geoscan Research 2003: Reference Card 2).

The statistics function (Geoscan Research 2003:6/101-102) was then applied to the entire conductivity data set for each of the two project areas. The mean, standard deviation, and variance were used to determine appropriate parameters for the subsequent processing steps. The original data from the Noland property conductivity survey ranged from –172.7 to 101.2 mS/m with a mean of 33.24 mS/m and a standard deviation of 13.277 mS/m and the data from the Truman/Wallace properties ranged from -191.2 to 193.6 mS/m with a mean of 43.73 mS/m and a standard deviation of 34.520 mS/m.

The conductivity data were “cleaned up” using the zero mean traverse algorithm (Geoscan Research 2003:6/107-115). This algorithm was used to set the background mean of each traverse within a grid to zero, which was useful in removing grid edge discontinuities between multiple grids. The algorithm utilized the least mean square straight line fit and removal default setting on over the entire composite data set. The letter “z” was added to file name when the composite file was saved to indicate that the zero mean traverse routine had been applied to the data.

The data set is interpolated to produce a uniform and evenly spaced data matrix (Geoscan Research 2003:6/53-56). Increasing or decreasing the number of data measurements creates a smoother appearance to the data. The original matrix is a 4 x 2 matrix. The interpolate function requires three parameters: direction, interpolation mode and interpolation method. Method may be either sinX/X or linear and the mode is either expand or shrink. In the Y direction, the number of data measurements is expanded using the sinX/X method. This yields a 4 x 4 data matrix. The letter "i" was added to file name when the composite file was saved to indicate that the interpolation routine had been applied to the data.

A high pass filter (Geoscan Research 2003:6/49-52) was used to remove the low frequency, large-scale spatial detail (i.e., the slowly changing geological "background" response). This is generally used to increase small feature visibility; however, one must be careful since broad features could be removed. The parameters are left in their default settings of 10 for the X radius and Y radius. The weighting uses the default gaussian setting. The resulting data is bipolar with the mean centered on zero. The original mean may be restored by using the add function (Geoscan Research 2003:6/11-13). The letter "h" was added to file name when the composite file was saved to indicate that the high pass filter routine had been applied to the data.

The composite data were then exported to separate disk file in a data file format for use in the SURFER 8 contouring and 3d surface mapping program (Golden Software 2002). The export batch data routine was selected under the file menu in GEOPLOT (Geoscan Research 2003:5/4-7). The export parameters for exported files were set to XYZ-CommaSV (comma-separated variables) with the top-left reference corner identifying where the origin point of the X and Y coordinates was located. The X and Y reference coordinates identified the initial starting point in the export data set. The default values are 0, 0. The X and Y increment entries identified the sample and traverse intervals of the loaded data set with default values of 1. The export file extension "dat" was selected since it is the extension that SURFER 8 readily recognizes as a data file. The file names remained the same for all the files. The files were the exported to "expdata" folder in GEOPLOT. The files are then transferred to an appropriately named site folder in the SURFER 8 contouring and 3d surface mapping program's project folder (Golden Software 2002).

In SURFER 8 (Golden Software 2002), the initial step is to view the *.dat file. The Open File command is selected to open the zero mean traverse, edge match, interpolate, high pass filter processed file found in the sitename folder under the SURFER 8 projects folder. The data is displayed in a worksheet format with the North (Y) coordinated listed in Column A, the East (X) coordinates in Column B, and the data in Column C. Since the X and Y coordinate data from the export function in GEOPLOT are listed in sequential integer values, the North and East coordinate values are corrected to the correct sample interval and traverse interval through the data transform routine. The North coordinate (Column A) is corrected by the formula **A=A/4** to provide the correct sample interval position for the data. The East coordinate (Column B) is corrected by the formula **B=B/4** to provide the correct traverse interval position for the high pass filtered data. The data are sorted, using the data sort command, to check for GEOPLOT dummy values (i.e., 2047.5). The rows of data containing the dummy values are deleted from the file. The data is saved as a new file containing the corrections.

In order to present the data in the various display formats (e.g., contour maps, image maps, shaded relief maps, wireframes, or surfaces), a grid must be generated (Golden Software 2002). The grid represents a regular, rectangular array or matrix. Gridding methods produce a rectangular matrix of data values from regularly spaced or irregularly spaced XYZ data. The grid data command is used to set the parameters of the grid. The data columns are identified. Column A is identified as the Y coordinate and Column B is identified as the X coordinate. The data values (Z coordinate) are found in Column C. The gird geometry is then defined. The minimum and maximum values for the X and Y coordinates are defined. These values represent the beginning and ending coordinates of the surveyed geophysical grid. The sample interval and traverse spacing are defined in the distance between data units under spacing. The # of line field provides the number of lines in the X and Y directions. The number of lines should correlate with the number of traverses and samples per traverse. The data columns for the Noland data consist of 0 to 13 in the North or Y direction, 0 to 40 in the East or X direction with the X-spacing of 0.25 and the Y-spacing of 0.25. The data columns for the Truman/Wallace data consist of 0 to 47 in the North or Y direction, 0 to 96 in the East or X direction with the X-spacing of 0.25 and the Y-spacing of 0.25. The Kriging gridding method was selected for processing the data for the two sites. The Kriging method is very flexible and provides visually appealing displays from irregularly spaced data. The Kriging variogram components are left in the default values. The default linear variogram produces a reasonable grid in most circumstances. The grid file (*.grd) is created and named with the same prefix as the data file (*.dat). The next step in the formation of the visual display of the data from the site is to apply the spline smoothing operation to the grid file. The spline smoothing operation produces grids that contain more round shapes on the displays. The default settings for the node method and the number of nodes to insert between the rows and columns of data points are used for this operation. The resulting grid is saved under the same name. Due to the presence of unsurveyed areas in the conductivity surveys, blanking files were constructed and applied to the grid file. The blanking file contains the X and Y coordinates used to outline the blanked portion of the grid, as well as, the number of parameter points and whether the blanking operation is located on the interior of the parameter points or on the exterior of these points. The resulting grid is saved under the same name.

At this point in the process, maps of the data may finally be generated (Golden Software 2002). Typically, for geophysical surveys, contour maps, image maps, shaded relief maps, and wireframes may be generated. The image map is a raster representation of the grid data. Each pixel or cell on the map represents a geophysical data value. Different color values are assigned to ranges of data values. Selecting the image map operation from the map menu and opening the grid file creates the image map. The image map is generated. The map may be edited. The color scale is set with the minimum value assigned the color white and the maximum value assigned the color black. The scale is a graduated scale flowing from white through several shades of gray to black. SURFER 8 has a several predefined color scales including the rainbow scale which is often used for the presentation of geophysical data or the investigator may create a color spectrum suitable for the project data. To complete the image map, descriptive text is added along with a direction arrow, a color scale bar, and map scale bar. Another useful means of displaying the geophysical data is with contour maps. Contour maps provide two-dimensional representations of three-dimensional data (XYZ). The North (Y) and East (X) coordinates represent the location of the data value (Z). Lines or contours represent the locations of equal value data. The distance or spacing between the lines represents the relative slope of the geophysical data surface. To create a contour map, the new contour map operation is opened under the contour map routine in the map menu. The grid file is selected and the contour map is generated. The contour map may be modified by changing the mapping level values in the levels page of the contour map properties dialog controls. Contour levels can be added or subtracted to the display. The line style, fill colors and hachure shape can be changed. Labeling may also be changed. As with the image maps, descriptive text, including information on the contour interval is added along with a direction arrow and map scale bar. If color fill is used, a color bar is also added. Contour maps are useful in determining the equal strength of the resistance anomalies as well as their shape and nature. The various types of maps can be overlain on one another and different types of data can be illustrated by stacking the displays within a single illustration. Both the image and contour maps were generated for the ground conductivity data collected at the Noland property (Figure 18) and the Truman/Wallace properties (Figure 19).

## Processing Soil Resistivity Data

The soil resistance data were downloaded into a laptop computer after the completion of survey at each site. On the laptop computer, the GEOPLOT software was initialized and the download data routine was selected from the file menu (Geoscan Research 2003:4/1-4/27). The default input template was then selected. The selection of the resistance (instrument type) and RM15 (instrument) was made. The grid input template was displayed. For the resistance survey, the survey information was entered under the general category, which contained settings for the acquisition of the data and the instrumentation used to acquire the data (Table 5 for the Noland property data). The next step required entering the grid name(s) for downloading data from the RM15. In the grid names for downloading screen, the file name for the grid unit was entered into the laptop computer. The grid file contained the resistance raw data obtained during the survey. The file name for the grid unit included the grid unit number identifier followed by the letter “r” for the resistance survey type (i.e., 1r to 2r). The download instructions screen was displayed after the file name was checked for duplicate names in the laptop computer and entered into the laptop computer. The instrument was connected to the laptop computer via the RS323 serial port and serial cable, switched on, and after waiting approximately one second, the next step was initialized for downloading the data. The display indicated that the laptop computer was waiting for the data from the instrument. The DUMP key on the

RM15 keyboard was depressed and the download process was implemented. Downloading the resistance data from a typical 20-m by 20-m grid unit at 2 samples/m and 0.5-meter traverses required approximately 5 minutes to complete the download process. The RM15 was then switched off and disconnected from the laptop computer. The grid file was reviewed in the shade plot under the graphics menu in the Geoscan Research GEOPLOT processing software (Geoscan Research 2003) for data transfer or survey errors. If no data transfer errors were observed, the memory in the resistance meter was cleared. From this preliminary review of the collected data, the geophysical investigator could analyze his survey design and methodology and make appropriate survey decisions or modifications while still in the field (Table 5 for the Noland property data). The grid data set actually consists of three files or parts: 1) the grid data file (*.dat), 2) the grid information file (*.grd), and 3) the grid statistics and histogram file (*.grs). The grid data and grid statistics are stored in binary format. The grid information is stored in ASCII (text) format.

In order to process the resistance data, the grid file from the site must be combined into a composite file. To construct a composite file, the master grid routine is selected from the file menu in GEOPLOT (Geoscan Research 2003:3/15-18). The master grid file names screen is displayed and the grid file name is entered into the mesh template (Table 5 for the Noland property data). The grid data needs to be converted into a composite file. The composite file is generated by selecting the create composite button on the display screen. The master grid or mesh template is also saved as a file for later modification is necessary. The composite file is also named. Generally, the same prefix is given to both the mesh and composite files (Table 5 for the Noland property data). Like the grids, composites also consist of three files or parts: 1) the composite data file (*.cmp), 2) the composite information file (*.cmd), and 3) the composite statistics and histogram file (*.cms). The composite data and composite statistics are stored in binary format. The composite information is stored in ASCII (text) format. The mesh file (*.plm) contains a text file used to load several grids into memory at the same time.

After the creation of the composite file for the resistance data collected at the site, the data may be viewed either as the numeric data values or as a graphic representation of the data (Geoscan Research 2003:3/18-21). In order to continue to analyze the data, the grid or composite files must be opened. The open grid/composite command is selected under the file menu. The appropriate grid or composite data file is selected from the correct sitename folder. The default screen display is the shade plot. The shade plot is useful in highlighting subtle changes in the data set. The shade plot represents the data in a raster format with the data values assigned a color intensity for the rectangular area at each measurement station. Data may be presented as absolute numbers, in units of standard deviation, or as a percentage of the mean. Several color and monochrome palettes provide different visual enhancements of the data. Plotting parameters, data histogram, data statistics, processing history, scale and north arrow are provided in sidebars adjacent to the display screen. For the initial shade plot display, the parameter mode is set in the shade plot window to clip with minimum value of –3, maximum value or 3, contrast equal to 1, and units to standard deviation. Set to the normal position, the grey55.ptt shaded palette is selected to represent the changes in the data set. Trace plots of the data represent the data in a series of side-by-side line graphs, which are helpful in identifying extreme highs and lows in the data. The trace plots show location and magnitude. For the initial trace plot display, the parameter mode is set in the trace plot window to standard with a resolution of 0.5, units to standard deviation, view to front, 0% displacement in the X direction, and 0% expansion in the Y direction.

Up to this point, we have been collecting the data and preparing it for processing and analysis. Initially, the data are displayed in a shade plot or trace plot. The clip parameters are set to a minimum of –3 and a maximum of 3 with a contrast set to 1 and units in standard deviation (SD) for the shade plot. The trace plot is displayed utilizing the standard default parameters with a resolution of 0.1 SD and units set to SD. Processing resistance data from a single twin probe separation distance begins with the inspection of the data changes on the background signal. These data changes are superimposed on the local geology. There should be a broad range in the archeological anomalies with weak anomalies or archeological features having less than 5 % change, typical anomalies with 5% to 20% change, and strong anomalies with greater than 20% change in resistance values. The data are checked for noise spikes including low-level spikes which create a noisy appearance in the data displays, and extremely high anomalous readings which may be as large as ±1000% about the mean. The large background, which underlies the archeology, may have a regional gradient that is dependent on the local geology, drainage, or topography. The regional gradient may change from virtually none to over 300% across large sites. Changes may also occur from differences in topsoil thickness, natural depressions, or other topographic conditions (Geoscan Research 2003: Reference Card 2).

Due to a recording glitch in the original data, the search and replace function (Geoscan 2003:6/85-86) was used to remove the erroneously recorded value of 204.7. It was replaced by the dummy value of 2047.5. This removed the high data values in unsurveyed areas of the partial grid units and adjacent to the concrete well cover. The letters “sr” were added to file name when the composite file was saved to indicate that the search and replace routine had been applied to the data.

The statistics function (Geoscan Research 2003:6/101-102) was then applied to the entire resistance data set. The mean, standard deviation, and variance were used to determine appropriate parameters for the subsequent processing steps. A total of 3,200 measurement readings were recorded with 1,614 readings representing the dummy value of 2047.5. The large number of dummy values resulted from the filling of the empty portions of the partial grids with those values. The resistance data ranged from 17.4 to 103.0 ohms with a mean of 23.02 ohms and a standard deviation of 4.051 ohms.

The noise spikes are removed with the despike function (Geoscan Research 2003:6/35-39). The function locates and removes random, spurious measurements present in the resistance data. The despike parameters are left in the default settings with both the x radius and y radius set to 1, the threshold set to 3.0 standard deviations, and the spike replacement set to the mean. The mean indicates that the noise spike value will be replaced by the window mean value obtained from the surrounding values. The letter "d" was added to file name when the composite file was saved to indicate that the dispiking routine had been applied to the data.

The data set is interpolated to produce a uniform and evenly spaced data matrix (Geoscan Research 2003:6/53-56). Increasing or decreasing the number of data measurements creates a smoother appearance to the data. The original matrix is a 2 x 2 matrix. The interpolate function requires three parameters: direction, interpolation mode and interpolation method. Method may be either sinx/x or linear and the mode is either expand or shrink. In the Y direction, the number of data measurements is expanded using the sinx/x method. The data are also expanded in the X direction using the sinx/x method. The resulting data matrix is a 4 x 4 matrix. The letter "i" was added to file name when the composite file was saved to indicate that the interpolation routine had been applied to the data.

A high pass filter (Geoscan Research 2003:6/4952) was used to remove the low frequency, large-scale spatial detail (i.e., the slowly changing geological "background" response). This is generally used to increase small feature visibility; however, one must be careful since broad features could be removed. The parameters are left in their default settings of 10 for the x radius and y radius. The weighting uses the default gaussian setting. The resulting data is bipolar with the mean centered around zero. The original mean may be restored by using the add function (Geoscan Research 2003:6/11-13). The letter "h" was added to file name when the composite file was saved to indicate that the high pass filter routine had been applied to the data.

The composite data file was then exported to separate disk file in a different file format for use in the SURFER 8 contouring and 3d surface mapping program (Golden Software 2002). The export batch data routine was selected under the file menu in GEOPLOT (Geoscan Research 2003:5/4-5/7). The export parameters for exported files were set to XYZ-CommaSV (comma-separated variables) with the top-left reference corner identifying where the origin point of the X and Y coordinates was located. The X and Y reference coordinates identified the initial starting point in the export data set. The default values are 0, 0. The X and Y increment entries identified the sample and traverse intervals of the loaded data set with default values of 1. The export file extension "dat" was selected since it is the extension that SURFER 8 readily recognizes as a data file. The file name remained the same for the data file. The file was the exported to "expdata" folder in GEOPLOT. The file was then transferred to an appropriately named site folder in the SURFER 8 contouring and 3d surface mapping program's project folder (Golden Software 2002).

In SURFER 8 (Golden Software 2002), the initial step is to view the *.dat file. The open file command is selected to open the low pass filter and zero mean traverse processed file found in the sitename folder under the SURFER 8 projects folder. The data is displayed in a worksheet format with the North (Y) coordinated listed in Column A, the East (X) coordinates in Column B, and the data in Column C. Since the X and Y coordinate data from the export function in GEOPLOT are listed in sequential integer values, the North and East coordinate values are corrected to the correct sample interval and traverse interval through the data transform routine. The North coordinate (Column A) is corrected by the formula **A=A/4** to provide the correct sample interval position for the data. The East coordinate (Column B) is corrected by the formula **B=B/4** to provide the correct traverse interval position for the data. The data are sorted, using the DATA SORT command, to check for GEOPLOT dummy values (i.e., 2047.5). The rows of data containing these values are deleted from the file. The data is saved as a new file containing the corrections.

In order to present the data in the various display formats (e.g., contour maps, image maps, shaded relief maps, wireframes, or surfaces), a grid must be generated (Golden Software 2002). The grid represents a regular, rectangular array or matrix. Gridding methods produce a rectangular matrix of data values from regularly spaced or irregularly spaced XYZ data. The grid data command is used to set the parameters of the grid. The data columns are identified. Column A is identified as the Y coordinate and Column B is identified as the X coordinate. The data values (Z coordinate) are found in Column C. The gird geometry is then defined. The minimum and maximum values for the X and Y coordinates are defined. These values represent the beginning and ending coordinates of the surveyed geophysical grid. The sample interval and traverse spacing are defined in the distance between data units under spacing. The # of lines field provides the number of lines in the X and Y directions. The number of lines should correlate with the number of traverses and samples per traverse. For the Noland property, the data columns consist of 0 to 13 in the North or Y direction, 0 to 40 in the East or X direction with the X-spacing of 0.5 and the Y-spacing of 0.5. The Kriging gridding method was selected for processing the data for the two sites. The Kriging method is very flexible and provides visually appealing displays from irregularly spaced data. The Kriging variogram components are left in the default values. The default linear variogram produces a reasonable grid in most circumstances. The grid file (*.grd) is created and named with the same prefix as the data file (*.dat). The next step in the formation of the visual display of the data from the site is to apply the spline smoothing operation to the grid file. The spline smoothing operation produces grids that contain more round shapes on the displays. The default settings for the node method and the number of nodes to insert between the rows and columns of data points are used for this operation. The resulting grid is saved under the same name.

At this point in the process, maps of the data may finally be generated (Golden Software 2002). Typically, for geophysical surveys, contour maps, image maps, shaded relief maps, and wireframes may be generated. The image map is a raster representation of the grid data. Each pixel or cell on the map represents a geophysical data value. Different color values are assigned to ranges of data values. Selecting the image map operation from the map menu and opening the grid file creates the image map. The image map is generated. The map may be edited. The color scale is set with the minimum value assigned the color white and the maximum value assigned the color black. The scale is a graduated scale flowing from white through several shades of gray to black. SURFER 8 has several predefined color scales including the rainbow scale, which is often used for the presentation of geophysical data, or the investigator may create a color spectrum suitable for the project data. To complete the image map, descriptive text is added along with a direction arrow, a color scale bar, and map scale bar. Another useful means of displaying the geophysical data is with contour maps. Contour maps provide two-dimensional representations of three-dimensional data (XYZ). The North (Y) and East (X) coordinates represent the location of the data value (Z). Lines or contours represent the locations of equal value data. The distance or spacing between the lines represents the relative slope of the geophysical data surface. To create a contour map, the new contour map operation is opened under the contour map routine in the map menu. The grid file is selected and the contour map is generated. The contour map may be modified by changing the mapping level values in the levels page of the contour map properties dialog controls. Contour levels can be added or subtracted to the display. The line style, fill colors and hachure shape can be changed. Labeling may also be changed. As with the image maps, descriptive text, including information on the contour interval, is added along with a direction arrow and map scale bar. If color fill is used, a color bar is also added. The various types of maps can be overlain on one another and different types of data can be illustrated by stacking the displays within a single illustration. Both the image and contour maps were generated for the soil resistance data collected at the Noland property (Figure 20).

## Processing Vertical Electrical Sounding Data

The field measurements were then averaged for each probe spacing along the two offset directions. The resulting average resistance value was used to calculate the resulting apparent resistivity using the formula: $\boldsymbol{\rho_a = 2\pi ar}$, where $\boldsymbol{\rho_a}$ is the apparent resistivity, **a** is the electrode spacing, and **r** is the measured resistance at each electrode separation. The probe spacing and apparent resistivity values were entered into the spreadsheet in the IX1D modeling software package (Interpex 2002). The first step in the IX1D program was to create a new sounding file by selecting the dc resistivity sounding popup under sounding under new under file menu. The Wenner Array was selected under the array type in the new sounding parameters window with apparent resistivity data selected under the type of data. Clicking on the OK button at the bottom of the window opened the apparent resistivity entry/edit menu window. The entry window contained header information fields for the data set name, the Easting coordinate, the Northing coordinate, the elevation, and azimuth angle in degrees where zero is north. The spreadsheet beneath the header information fields contains the identification number for the probe spacing, the probe spacing value, and the apparent resistivity value. These values were entered form the processed data in the field notebook (Table 6). The OK button at the bottom of the screen was selected. The resulting apparent resistivity values in ohmmeters (Sheriff 1973:156) were plotted by electrode spacing. Under the calculate menu, the estimated layered model routine was selected. The forward model of the data was carried out using a 283 point adaptive linear filter (Anderson 1989; Davis et al. 1980). The model used the probe spacings data and the apparent resistivity to generate a synthetic response (Table 11). A three-layer model was created for the Noland property for the approximate subsurface electrical layering. The graphic file and the data were saved as an IX1D binary file under the file name "noland hstr.IXR" for the VES data collected at the Noland property (Figure 21). The calculated model values were then hand-transferred to the GRAPHER 5 worksheet for the display of the electrical stratification plot (Golden Software 2003).

In GRAPHER 5, the model data is entered into a new worksheet under the file menu (Golden Software 2003:35-71). The worksheet is saved as a dat file. The next step is to create a 2D line graph under the graph menu in GRAPHER 5 (Golden Software 2003:73-90). The line plot type is selected in the select plot type window under the graph wizard button. The data columns used for the X and Y axes are identified. The depth below the surface is on the Y-axis and the resistivity value is located on the X-axis. Using this ling graph, an electrical stratigraphic block diagram is created by inserting rectangles in the data ranges (Figure 22). The rectangles are subsequently filled and labeled with the appropriate ohmmeter value from the model for the final presentation (Golden Software 2003:127-224).

### Processing Ground-penetrating Radar Data

The gpr radargram profile line data is imported into GPR-SLICE (Goodman 2006) for processing. The first step in GPR-SLICE is to create a new project folder in the file menu for the gpr survey data (Goodman 2006:11). The 16-bit GSSI radargrams are then imported into the folder. The profile data for the Noland and Truman/Wallace properties are placed in the appropriate radargram profile folder (Tables 7 and 9 for the Noland property data and Tables 8 and 10 for the Truman/Wallace properties data). The next step is to create the new information file in the create info item under the file menu (Goodman 2006:12-14). The number of profiles are identified along with the file identifier or name, the file extension (.dzt), the name increment (1), and the profile name start identifier (1). The direction of the starting profile is identified (x for the Noland property gpr data and y for the Truman/Wallace properties gpr data), the beginning and ending points for the survey area in both the x and y directions, the unit marker value (1), the time window (100) in nanoseconds (ns), the number of samples per scan (512), and the scans per marker (50). The type of gpr data collected is identified as 16 bit data. The create info button is selected to produce the info.dat file. Two files are created for the Truman/Wallace gpr data and merged into one info.dat file through the append function. Information is reviewed and may be corrected in the edit function if the coordinate information needs correcting (Goodman 2006:15-16). The profile data is then transferred from the main folder to the raw subfolder for processing (Goodman 2006:17). After the transfer of the profile data files, the extraneous header information is removed (Goodman 2006:18-19). During the conversion process, the signal may be enhanced by applying gain to the radargrams. Once the conversion process is completed, the next step is to reverse the gpr data resulting from the zigzag survey (Goodman 2006:20-21). The profiles to be reversed are selected and the reversing routine is applied. The next step is to set the navigation markers for each profile (Goodman 2006:22-23). The GSSI SIR 3000 category is selected and the artificial navigation routine is applied. The gpr profile data is now ready for processing time slices. This is the main operation in the program that takes the 2D vertical profile data and generates a series of horizontal data time slices for the creation of a 3D model (Conyers and Goodman 1997; Goodman et al. 1995). The program resamples the radargrams to a constant number of scans between the markers and collects the time slice information from the individual radargrams (Goodman 2006:23-30). The number of slices is set to 20 slices. The slice thickness is set to 35 (6.84 ns) to allow for adequate overlap between the slices. The offset value on the radargram where the first ground reflection occurs is viewed in the search 0 ns subroutine. This value is used to identify the first radargram sample at the ground surface. The end sample is 512. The offset value in entered in the samples to 0 ns box. The cut parameter is set to square amplitude with the cuts per mark set to 2. The slice/resample button is selected for processing the radargrams. The final step in the slice menu is to create the XYZ data file. The grid menu is entered next in the processing step (Goodman 2006:30-33). The beginning and ending values for the x and y coordinates are entered. The grid cell size is set to 0.1 with an x search radius of 0.9 and a y search radius of 0.9. The blanking radius is set to 0.45, the data type is regular, the number of grids equal 20 for the number of slices, and the starting grid number is 1. The Kriging algorithm is utilized to estimate the interpolated data. The covariance and sill are set to 1.2 with the nugget set to 0.2 and a smoothing factor of 1.4. The start gridding button is selected and the gridded dataset is created. A low pass filter may be applied to the combined dataset to smooth noisy time slices in this menu. At this point, one may view the time sliced radar data in the pixel map menu (Goodman 2006:34). Figure 23 illustrates the time slices for the ground-penetrating radar data from the Noland property. Time slice 5 (18.2 to 22.1 ns) is selected to illustrate the significant buried archeological features identified during the gpr survey at the Noland property (Figure 24). Figure 25 illustrates the time slices for the ground-penetrating radar data from the Truman/Wallace properties. Time slice 7 (27.3 to 33.2 ns) is selected to illustrate the significant buried archeological features identified during the gpr survey at the Truman/Wallace property (Figure 26). The gain may be readjusted for any time slice. This is done in the transforms submenu. The interpolations value is set to 5 and the interpolate grids routine is selected. The new interpolated grids are all normalized. The next step is to create the 3D dataset in the grid menu (Goodman 2006:35-134). The number of grids is now equal to 95 ((20-1)*5). The 3D database is created under the create 3D file routine. The 3D data may be displayed as a series of z slices in the creation of a 3D cube with a bitmap output for animating the 3D cube.

The slice option provides the means to specify the number and type of plots either in time slices or depth slices. Times slices are generally used since gpr systems record the time for the radar or radio waves to travel to a target and return to the gpr unit. Depth has to be calculated before it can be used. Depth depends on the velocity of the wave to the target and back. Depth is determined by the following equation: $D = V \times T/2$ where D is depth (meters), V is velocity (meters/nanosecond), and T is the two-way travel time (nanoseconds). Velocity of the radar wave is determined by the dielectric permittivity of the material (Conyers and Goodman 1997:31-35; Sheriff 1973:51). Other physical parameters that affect the transmission of the radar wave include the magnetic permeability and electrical conductivity of the material. Increases or decreases in these parameters may increase the velocity, slow it down, or attenuate it so there is no reflected signal. In most heterogeneous soils, the various soil layers have differing affects on the velocity of the radar wave. The velocity may be estimated using velocity charts of common materials (GSSI 2003a:49-50) or by identifying reflections in gpr profiles caused by buried objects, artifacts, or stratigraphic soil/sediment layers (Conyers and Goodman 1997:107-135). The depth used in this report was calculated using a value of ca. 0.037 m/ns, which was determined by fitting a hyperbola to radargram reflections in the search submenu in the filtering menu in GPR-SLICE (Goodman 2006:81-92). The software determines the velocity and the relative dielectric constant for the hyperbola fit. With the time window set to 100 ns which represents two-way travel time, the maximum depth (i.e., indicated by 50 ns) recorded was 1.85 meters; however, the relative depth of archeological targets of interest was limited to the upper 0.75 m.

## Interpretation – Magnetic Gradient Data

Interpretation of the magnetic data (Bevan 1998:24) from the project requires a description of the buried archeological feature of object (e.g., its material, shape, depth, size, and orientation). The magnetic anomaly represents a local disturbance in the earth's magnetic field caused by a local change in the magnetic contract between buried archeological features, objects, and the surrounding soil matrix. Local increases or decreases over a very broad uniform magnetic surface would exhibit locally positive or negative anomalies (Breiner 1973:17). Magnetic anomalies tend to be highly variable in shape and amplitude. They are generally asymmetrical in nature due to the combined affects from several sources. To complicate matters further, a given anomaly may be produced from an infinite number of possible sources. Depth between the magnetometer and the magnetic source material also affect the shape of the apparent anomaly (Breiner 1973:18). As the distance between the magnetic sensor on the magnetometer and the source material increases, the expression of the anomaly becomes broader. Anomaly shape and amplitude are also affected by the relative amounts of permanent and induced magnetization, the direction of the magnetic field, and the amount of magnetic minerals (e.g., magnetite) present in the source compared to the adjacent soil matrix. The shape (e.g., narrow or broad) and orientation of the source material also affects the anomaly signature. Anomalies are often identified in terms of various arrays of dipoles or monopoles (Breiner 1973:18-19). A magnetic object in made of magnetic poles (North or positive and South or negative). A simple dipole anomaly contains the pair of opposite poles that relatively close together. A monopole anomaly is simply one end of a dipole anomaly and may be either positive or negative depending on the orientation of the object. A linear anomaly is a series of closely connected dipoles. The depth and mass of the archeological object can be estimated by the half-width rule procedure (Bevan 1998:23-24; Breiner 1973:31; Hinze 1990; Milsom 2003:67-70; Telford et al. 1990:87). These measurements represent an approximation of the object's size and depth. It is likely such measurements are too large rather than too small, since the model used in the analysis of the anomalies is based on a compact spherical object made of iron. Due to the large number of anomalies at the Noland and Truman/Wallace properties, no depth or mass values were calculated for the magnetic anomalies identified at the Harry S Truman National Historic Site geophysical project areas.

Concentrations of magnetic anomalies associated with the boundary fence lines and the house are the most noticeable features in the magnetic data set from the Noland property (Figure 27). There is also a concentration of magnetic anomalies in the location of the gravel parking pad near the southwest corner of the property next to the alley. A number of smaller dipole anomalies in the Noland backyard are probably associated with iron or steel based artifacts or building material such as bricks that have been deposited by the various owners of the property including the National Park Service. One concentration of anomalies near N4/E10 is identified as the wire mesh associated with the transplanted tree and its root ball. The buried water and gas lines show up as a linear series of magnetic anomalies in the southeastern part of the Noland property.

The magnetic data from the survey on the Truman/Wallace properties also contain concentrations of anomalies along the chain link and iron grill fences that surround the property and divide the George and Frank Wallace yards from the Truman yard (Figure 28). One linear concentration of magnetic anomalies on the west and north side of the Truman Home represents the location of a buried water line. A series of magnetic anomalies along the east side of the Frank Wallace House and in the backyard coincide with the location of a buried clay tile storm drain. A concentration of magnetic anomalies along the east side of the George Wallace garage may represent a trash dump in the garden area. There is also a large concentration of magnetic anomalies to the east and south of the brick porch on the east side of the Truman Home. These concentrations may also represent trash dumps. Other magnetic anomalies in the yards of the three properties may be isolated iron or steel based artifacts. The main sidewalk around the Truman Home and the front sidewalks at the George Wallace and Frank Wallace properties appear to contain iron rebar or mesh as indicated by the series of magnetic anomalies. The location of the Secret Service's security post near the southwest corner of the Truman Garage is indicated by a magnetic low anomaly.

## Interpretation – Ground Conductivity Data

Ground conductivity surveys are much faster to complete than the resistivity surveys but are also more complicated (Bevan 1998:29). Like the resistivity surveys, ground conductivity surveys detect changes in soil contracts. These soil contracts can result from natural conditions or from cultural activities (Bevan 1988:31-33). The conductivity anomalies represent the location and approximate shape of the features; however, different kinds of features can produce similar conductivity anomalies. They also detect metal objects. The resulting conductivity anomalies from buried metal (e.g., utility lines, pipes, and objects) may hide other features in immediate vicinity.

The conductivity data from the Noland property reveals the location of the buried water and gas lines (Figure 29). The linear anomalies consist of negative or low values surrounded by conductivity high values. The negative values are the results of the over saturation of the receiving coil on the conductivity meter. The magnitude of the signal did not allow for the receiving coil to obtain reset itself before taking the next measurement. This is a common occurrence in a setting where conductive metals are present such as the buried utility pipes used for water and natural gas lines. The front sidewalk is also visible in the conductivity data. The effect of the chain link fence along the west side of the property is also identified in the conductivity data. Some of the conductivity anomalies in the Noland backyard appear to be associated with magnetic anomalies. The location of the magnetic and conductivity anomalies in the two complementary data sets suggests that the objects causing the anomalies are buried iron or steel based artifacts. The wire from the tree root ball is highly noticeable in both data sets. A conductivity anomaly near the southwest corner of the house is in the approximate location of a cistern. Drain tile capturing the rainwater from the roof eave trough through the downspout at the southwest corner of the house is oriented in the direction of the buried cistern. The steel window well near the northwest corner of the house is also visible in the conductivity data.

The conductivity data from the Truman/Wallace properties also contain numerous linear conductivity anomalies associated with the chain link and iron grill fences surrounding the three properties and separating the Wallace properties from the Truman property (Figure 30). The rebar or mesh-reinforced sidewalks are identified in the conductivity data as well. The water line on the west side of the Truman Home and the storm drain on the east side of the Frank Wallace House are also present in the conductivity data. Several curved linear conductivity anomalies are present in the Truman yard. These low value anomalies appear to represent the location of the buried security light lines surrounding the Truman Homes. The light post, flagpole, and sign in the front yard of the Truman Home are also represented by a series of conductivity anomalies. The Secret Service security post is represented by a low conductivity anomaly. The location of the suspected trash dump next to the George Wallace garage is represented by a concentration of conductivity anomalies. Other isolated conductivity anomalies in the yards of the three residences may represent discarded or lost metallic objects. A cistern with its drainpipe may also be present near the northwest corner of the George Wallace House. Broad areas of low conductivity in the yards surrounding the houses appear to represent areas of disturbance from activities of the former occupants or the National Park Service.

## Interpretation – Soil Resistance Data

Interpretation of the resistivity data results in the identification of lateral changes in the soil. Since the array parameters are kept constant through out the survey, the depth of penetration varies with changes in the subsurface layers. For each probe separation, the depth penetration is approximately the same as the distance between the current and potential probe for each separation distance. The resistance reading for each separation distance represents the average value for the hemispheric volume of soil with the same radius. If the soil below the survey area was uniform, the resistivity would be constant throughout the area. Resistances of the increasing volumes reflected by the increasing probe separation distances will change, but the apparent resistivity which takes into account the changing depths remains approximately the same. Changes in soil characteristics (e.g., texture, structure, moisture, compactness, etc.) cause small and large areas to have different resistivities. Large general trends reflect changes in the site's geology whereas small changes may reflect archeological features.

The resistance data from the Noland property survey (Figure 31) contains a disturbed area associated with the gravel parking pad. The buried utility lines associated with the water and natural gas lines are present in the resistance data and are identified by the slightly lower resistance values. The trees, cistern, and bushes are identified by resistance highs. The sidewalks and house are identified in the data set as areas containing dummy values since no data were collected in these locations because of the inability to insert the probes in to the ground. The row of circular landscaping blocks is visible on the ground.

## Interpretation – Vertical Electrical Sounding

The results of the modeling of the vertical electrical sounding data from the Noland property suggest a three-layer curve for the electrical stratification of the soil in the backyard (Figure 22). The model indicates that the upper 0.107 meters have an apparent resistivity of 12.00 ohm-meters, the second 1.000 m thick layer measures 21.79 ohm-meters, and the bottom layer measures 4.42 ohm-meters (Table 11). This model suggests a highly conductive clayey soil is found throughout the profile (Bevan 1998:8; McNiel 1980a:16; Telford et al. 1990:289-291). The very conductive values in the clayey layers suggest that ground-penetrating radar may have problems with wave attenuation in this area due to the relatively high clay content of the soil. Using this as a basis for antenna selection, a 400 MHz antenna may provide adequate depth penetration from 1.0 to 1.5 meters and better resolution than antennas with low frequencies.

## Interpretation – Ground-penetrating Radar Data

Analysis and interpretation of the gpr data may be conducted in several different ways. The individual radargrams for each profile line may be analyzed for hyperbolic reflections. The radargrams may be combined and processed to provide planar time slices of the data. Constructing the time slices for the geophysical survey area provides another way of looking at the gpr profile data. The time slices may also be combined to form 3D cubes of the gpr data. In the 20 slices constructed in GPR-SLICE (Goodman 2006; Goodman et al. 1995), the slices provide a planar view of the data at 3.9 ns intervals with an overlap of 0.8 ns.

The gpr time slice data from the Noland property (Figure 32) identified a high amplitude strength anomaly in the approximate location of the cistern. Other high amplitude strength anomalies occur along the edges of the house near the location of drain tiles and downspouts. Other high amplitude strength gpr anomalies may represent buried metallic objects or cement landscaping blocks. Tree roots are also visible in the gpr profile data.

The gpr time slice data from the Truman/Wallace properties (Figure 33) identify the locations of the sidewalks, the gravel driveway, and asphalt drive, which are also visible on the surface of the ground. The buried storm drain line is indicated by a linear high amplitude strength anomaly along the east side of the Frank Wallace property. Isolated high amplitude strength gpr anomalies appear to represent buried objects. A slightly higher amplitude strength anomaly in the front of the Frank Wallace House may represent a difference in the soils in front of the house. This could be related to a yard modification activity.

## 8. ARCHEOLOGICAL INVESTIGATIONS AT THE NOLAND HOUSE

The second portion of the archeological investigations at the Noland property included the use of more traditional archeological excavation procedures including shovel tests and limited formal one-meter-by-one-meter excavation units (Figure 34). Shovel tests were placed at selected intervals across the Noland property to determine the depth and density of cultural deposits (Table 12). Three formal one-meter-by-one-meter excavation units were also placed in the backyard of the Noland property. One unit was placed along the west foundation wall of the house and two were placed in the backyard in anomalous areas identified during the geophysical survey (Table 13). The location and extent of the gravel parking pad in the southwest corner of the Noland property was also identified through the use of a steel tile probe.

Twenty-five shovel tests were excavated including 23 shovel test units in the Noland property yard (Figure 35) and two units in the crawl space (Figure 36) beneath the Noland House. The orifice diameter of the shovel test unit averaged between 40 and 50 cm. Depths ranged from 23 cm to 90 cm. A number of the units were further probed with an Oakfield soil coring tool once it became too difficult to excavate the unit any deeper with the shovel or trowel. Numerous historic artifacts related to the occupation of the Noland House by the original occupants and successors, including the activities associated with the National Park Service ownership, were recovered. Utilizing the classification scheme developed by Roderick Sprague (1980-81:255-259) for historic artifacts, the recovered artifacts from the shovel test units consist of personal items such as buttons for clothing; domestic items such as bottle glass, bone, and ceramic housewares for culinary and gustatory uses; architectural items such as nails, screws, brick, window glass for construction materials and hardware; commerce and industry items for heating such as coal and slag and commercial services such as a 1953 nickel for monetary use (Table 12). In addition to the historic artifacts recovered in the units, several pieces of lithic debitage suggest the occupation of the area by prehistoric Native Americans. The material indicated the presence of a light midden of cultural materials including personal, domestic, construction, and commercial items associated with the occupants of the house from the late 19$^{th}$ century and from the early to mid-20$^{th}$ century, as well as subsequent National Park Service activities.

The three formal excavation units were excavated in arbitrary 10 cm levels until sterile subsoil was encountered (Table 13). The units were shovel skimmed and the material screened through ¼-inch steel mesh screens (Figure 37). The levels were measured from the modern ground surface at the northwest corner of the excavation unit. The materials recovered in the screen were collected and bagged by excavation unit and level. Upon completion of the excavation, profiles of the east wall were drawn and described for all three excavation units (TU1 through TU 3). The north wall of TU1 was also drawn and described. TU1 was placed adjacent to the west all of the Noland House in order to determine the presence of a builder's trench for the basement foundation. The excavations of TU1 revealed the builder's trench in the north wall profile (Figures 38 and 39). It extended out from the west wall approximately 20 cm at the base of the excavation unit and 50 cm near its top at 25 cm below the surface. Although the present archeological excavations did not extend to the bottom of the foundation wall, it appeared that the builder's trench was first excavated during the construction of the west basement when that portion of the house was expanded. The depth of the brick foundation was approximately 1.5 meters below the ground surface. The east wall profile (Figures 40 and 41) provided a detailed view of the plastered over brick wall foundation in the upper 10 to 14 cm. The second layer contained brick and mortar debris from the construction of the foundation wall. Artifactual materials included domestic debris and construction related materials (Table 13). TU2 was placed in the southwest portion of the Noland backyard in the vicinity of a concentration of magnetic and resistance anomalies. Shovel test T1 ST2 indicated the presence of a thick band of gravel in the area. The excavation of TU2 also indicated a thick band of gravel (Figure 42). The gravel layer was approximately 6 to 9 cm thick throughout the excavation (Figure 43). Several tree roots were also present in the excavation unit. A steel tile probe was used to probe the area of the gravel parking pad (Figure 44). The results of the probing suggested that the gravel parking pad measured approximately 7 meters long (north-south) and 5.6 meters wide (east-west). Recovered artifacts and material suggested the dumping of domestic materials from the house (Table 13). TU3 was placed in the north part of the Noland backyard near a couple of magnetic anomalies. The excavations indicated the presence of a mottled or disturbed area at a depth of 22 cm (Figure 45). The basin shaped feature may have been the cause of the magnetic anomalies (Figure 46). Numerous domestic artifacts and construction materials were recovered. It would appear that the yard in the vicinity of TU3 contained discarded and broken materials and artifacts from the inhabitants of the house. This also included discarded construction debris such as brick, slate, and mortar. Coal fragments suggest the use of coal as a heating material and its discard from furnace or stove cleaning episodes (Table 13).

The soils in the vicinity of the Noland property consists of silt loams associated with the Sibley-Urban complex (Preston 1984:35). The shovel tests and excavations suggested that the Noland yard had been disturbed from previous construction-related activities associated with the initial construction of the Noland House and subsequent modifications and additions to the building. There also appeared to be filling and leveling episodes in the Noland yard associated with the construction and modifications to the house including the excavations of the full and partial basements in the west and east ends of the house, respectively.

## 9. MONITORING CONSTRUCTION ACTIVITIES

The present discussion is a compilation of three monitoring projects conducted by MWAC archeologists during November and December 2005 (De Vore 2005c, Noble 2005, Thiessen 2005). The monitoring projects were associated with the construction demolition and shoring activities associated with the foundation rehabilitation projects at the Noland and the Frank Wallace Houses at Harry S Truman National Historic Site in Independence, Missouri. Additional monitoring of the construction activities associated with the lifting of the two houses and the removal of the foundations was conducted by John Peterson, the historic sites curator of the Jackson County Parks and Recreation historic sites division (Peterson 2005) in November and December 2005. The structural and foundation work at the two NPS properties required the excavation of a 2.1-meter (7 feet) wide and 1.2-meter (4 feet) deep trench around the two buildings. A bobcat excavator was used to remove the soil from the trench.

During Noble's initial monitoring visit to the park, he monitored the excavation of the construction trench around the foundation of the Noland House (Noble 2005). A narrow trench with a chain trencher attachment of the bobcat excavator was used to make the initial depth cut to 1.2 meters. The preliminary narrow trench was located 2.1 meters from the west, south, and east walls and porches of the Noland House. The trench on the north side of the house was limited to 1.5 meters due to the proximity of the northern property line. During the removal of the concrete sidewalk on the south side of the house, the top of a 19th century brick cistern was exposed. The cistern was located approximately 2 meters from the south porch near the southwest corner of the building. Although the cistern was not originally noted in the field geophysical investigations (De Vore 2005a), subsequent review of the geophysical data did contain a gpr anomaly at the cistern location. Noble identified the cistern as a large domed shaped cylinder approximately 2.4 meters (8 feet) in diameter. It was filled with loose soil to almost the top of the dome. A few whiteware sherds were noted in the backdirt as the trencher cut through the cistern. A plastic container was also present on top of the fill. Noble (2005) suggested that the mixed assemblage of late 19th through very recent 20th century artifacts dated to a very late filling episode ca. 25 to 30 years ago when the cistern fell into disuse after city water was introduced into the neighborhood.

Prior to the arrival of MWAC archeologists, a 2.1-meter wide and 1.2-meter deep bobcat trench had been excavated around the Frank Wallace House and on the west side of the Noland House. The monitoring of the bobcat excavation of this construction trench was conducted by John Peterson (2005) during the months of November and December 2005. During the monitoring of the bobcat trench excavation on the west side of the Noland House, a ceramic sewer pipe was uncovered (Peterson 2005:3-6). A shallow brick and mortar rubble area was uncovered between the southeast corner of the house and the porch area. Two small pits were uncovered during the inspection of a construction joint near the southeast corner of the porch. The bottom of brick footings were exposed during the excavation of these pits. During monitoring of the Frank Wallace perimeter trench, historic deposits were exposed. The deposits appeared to be more dense near the north end of the house and were identified as general trash deposits or middens by Peterson (2005:6-8). A dense area of broken and unbroken bottle glass was identified on the east side of the house near the north end. A small can dump was on the east side of the main feature and extended into the bobcat trench wall. A ceramic storm drain and trench were also noted extending along the east edge of the house. The storm drain had been detected during the geophysical survey of the Truman/Wallace properties (De Vore 2005b). The midden on the north side of the house was identified in the geophysical data but was not recognized until the December monitoring activities. The artifacts appeared to pre-date the construction of the Wallace House and may have represented a filling episode in the lower end of the Gates and Wallace property during the late 19th century.

Additional MWAC monitoring of the construction demolition at the Frank Wallace House and the lifting of the Noland House occurred in December 2005 (De Vore 2005c, Thiessen 2005). The lifting and shoring of the Noland House was completed during the first part of the week of December 11-15, 2005 (Figure 47). The removal of the basement foundation and crawl space fill was planned for the latter part of the week. In the mean time, the contractor cut a bobcat trench on the north side of the Frank Wallace House for the planned removal of the front porch (Figure 48). During the construction of the access ramp, a historic midden deposit was noted approximately 42 to 63 cm below surface (De Vore 2005c). A cut nail and an ironstone plate base with a maker's mark were collected from the historic fill. Preliminary analysis of the two artifacts suggested a filling episode dating between the 1870s and the 1880s and may have been associated with the Gates occupation of the Truman Home. The contractor continued to demolish the front porch during the week (Figure 49). During the demolition, the fill within the porch foundation was removed (Figures 50 and 51). The foundation fill consisted of ashes, fired earth, and coal on top of a mottled yellowish and grayish colored soil (Thiessen 2005). Artifacts noted in the fill were collected by the MWAC archeologist and reported as consistent with the early 20th century construction and occupation of the Frank Wallace House (Thiessen 2005). Thiessen continued to monitor the removal of the crawl space deposit at the Noland House during the remainder of the week at the park (Figure 52 and 53). The soil in the crawl space underneath an addition to the original house ca. 1868 and 1886 appeared to be undisturbed. A few artifacts were collected during the removal of the foundation and floor in the full basement in the western portion of the house next to the crawl space. The artifacts were consistent with a very late 19th or early 20th century data.

## 10. ARTIFACT ANALYSIS

The historic artifact assemblage recovered from the Noland and Frank Wallace Houses can best be understood by applying a functional classification scheme along the lines of that developed for historic artifacts by Roderick Sprague (1980-81:255-259). For the purposes of this analysis, the artifacts recovered have been assigned to one of four functional categories: personal artifacts (such as clothing buttons), hardware and architectural artifacts (nails, brick fragments, window glass), kitchen and domestic artifacts (ceramics, bottle glass) and "mixed-use" artifacts (non-diagnostic glass sherds, etc.) (Tables 14 and 15). The artifacts recovered indicate the presence of a light midden of cultural materials including personal, domestic, hardware and architectural items associated with the occupation of the house from the late nineteenth century to the mid-twentieth century, as well as subsequent National Park Service activities.

### Noland House

The Noland House site produced by far the greater number of historic artifacts (n=462), due to the fact that, in contrast with the Frank Wallace House site, formal archaeological investigations (shovel tests and test units) were undertaken at the Noland House. Table 14 illustrates the artifact assemblage from the Noland House site broken down by functional category and arranged by provenience. The majority of the artifacts recovered can be classified as hardware/architectural (182 of 462, about 39%) or mixed-use (132 of 462, about 29%) in function. Overall, the Noland House assemblage is consistent with domestic activities associated with the late nineteenth and early twentieth century occupation of the house. In addition to largely nondescript nails (both cut and wire), glass sherds, and construction debris (brick fragments, etc.), a large number of ceramic sherds were recovered, largely whiteware and porcelain.

Significant/diagnostic artifacts

Four artifacts (or sets of artifacts) recovered from the Noland House site are of particular interest. Two have diagnostic markings that allow for greater precision of identification and dating. Two complete glass bottles were recovered from the floor of the west basement. One (HSTR 30726), a fully machined colorless bottle with a crown cap finish, is embossed "I. P. C. Co."; this is most likely a soda bottle produced by the Illinois Pacific Coast Company of San Francisco, California, between 1930 and 1932 (Society for Historical Archeology 2008; Toulouse 1971). The other bottle (HSTR 30727) is a colorless glass bottle with "straight brandy" style lipping tool finish (Figure 54). The body shape is reminiscent of bottles used for oils and salad dressings (Society for Historical Archeology 2008). It is embossed with the words "Ridenour-Baker Grocery Co." and "Kansas City, MO". The Ridenour-Baker Grocery Company was incorporated by two prominent Kansas merchants in 1887, and was aggressively promoted; by 1908 it was described as the "largest grocery business west of the Mississippi" (Horton 1908). This may have been a bottle of cooking sherry or something similar.

Two artifacts are not temporally diagnostic, but rather provide a glimpse of the lives of the inhabitants of the Noland House. One is a clear glass chandelier prism fragment (HSTR 30471), and the other consists of two porcelain doll's head fragments (HSTR 30681). Both are consistent with an upper-middle class household with female children, such as that of the Noland family (Bahr Vermeer Haecker Architects 2004).

## Frank Wallace House

In comparison with the Noland House, the Frank Wallace House site produced substantially fewer historic artifacts (n=41) and no prehistoric artifacts; this is largely due to the fact that formal archeological investigations were not conducted at the Frank Wallace site. The numbers of historic artifacts per functional category recovered from the Frank Wallace site are presented in Table 15. As can be seen, about 90% of the artifacts recovered (37 of 41) are kitchen or domestic items. Of these 37, 29 (about 78%) are ceramic artifacts, as detailed in Table 16.

Significant/diagnostic artifacts:

Archeological investigations at the Frank Wallace House produced four artifacts (or sets of artifacts) with significant or diagnostic features. One colorless cup-molded glass bottle base fragment (HSTR 30696) with the letters "P.S." embossed on the base was recovered from the porch fill; this is possibly a beer bottle produced by the Puget Sound Glass Company of Anacortes, Washington, between 1924 and 1929 (Society for Historical Archeology 2008; Toulouse 1971). A porcelain fragment (HSTR 30709) with a maker's mark (including the letters "J.P." and "L" and the word "France") was recovered from the porch fill. This suggests a piece of French Limoges porcelain produced by Jean Pouyat, possibly between 1891 and 1932 (DuBay 2007).

The porch fill also produced eight fragments (five of which articulate) from a small porcelain cup (HSTR 30707), perhaps a teacup (Figure 55). These fragments exhibit a blue transfer-print decoration reminiscent of (but not identical to) the classic "Willow pattern" (Thomas 1940). This seems likely to be a piece of English export porcelain produced with a Chinese style pattern. A 1940 Spode catalog, for example, contains descriptions of similar pieces; likewise, its descriptions of dining services, servants, etc., seem consistent with the use of this style of pottery by an upper-middle class family like the Wallace family (Bedford 1969; Hughes 1959; Spode 1940; Thomas 1940; Wills 1969).

Finally, a plain whiteware plate fragment (HSTR 30723) was recovered from the slump trench wall bearing a partial maker's mark ("Ironstone China", "J. & G. Meakin" and the British arms). This is a fragment of a Staffordshire ironstone china plate produced by J. & G. Meakin of Hanley for export; the presence of the British arms suggests a production date prior to 1890 (Hughes 1959; Jewitt 1878). Each of these artifact identifications is consistent with an upper-middle class occupation of the Frank Wallace House between the end of the nineteenth century and the middle decades of the twentieth (Bahr Vermeer Haecker Architects 2004).

## Prehistoric Artifacts

In addition to the historic artifacts recovered at both house sites, a number of possible lithic artifacts were recovered at the Noland House site (as noted above). In all, twenty-five pieces of possible non-diagnostic shatter, totaling 11 grams in weight, were recovered from ten proveniences. There is a great deal of similarity both in terms of artifact size as well as raw material among the lithic fragments recovered. The identification of these artifacts is not definitive; it is conceivable that they may be gravel fragments.

## 11. CONCLUSIONS AND RECOMMENDATIONS

The archeological and geophysical project at Harry S Truman National Historic Site (HSTR) was requested by the park staff for the archeological and geophysical evaluation of buried archeological resources in the property lots associated with the Noland House, the Truman Home, the George Wallace House, and the Frank Wallace House. The archeological evaluation phase was part of a rehabilitation project for the replacement of the basement foundations associated with the Noland House and the Frank Wallace House within the boundary of the Harry S Truman National Historic Site in Independence, Missouri. During the week of March 14-18, 2005, the Midwest Archeological Center staff conducted geophysical and archeological investigations of Noland House property (Site 23JA636) at 216 North Delaware Street, Independence, Missouri (De Vore 2005a). During the period from April 8$^{th}$ to April 14$^{th}$, geophysical investigations were conducted in the three lots associated with the Truman Home (Site 23JA635) at 219 North Delaware Street, the George Wallace House (Site 23JA634) at 605 Truman Road, and the Frank Wallace House (Site 23JA637) at 601 Truman Road (De Vore 2005b). During the period between December 9$^{th}$ and 16$^{th}$, MWAC archeologists monitored the construction activities associated with the raising of the Noland House for the removal of the existing foundation and soil matrix in the crawl space under the house, and the removal of the front porch at the Frank Wallace House (De Vore 2005c; Thiessen 2005). Prior to the arrival of the MWAC archeologists for the final monitoring phase of the project, the excavation of the soil matrix surrounding the Noland House and the Frank Wallace House had been monitored by a MWAC archeologist during the week of November 7-12 at the Noland House (Noble 2005) and by a Jackson County Parks and Recreation archeologist (Peterson 2005) in later part of November and early part of December at the Frank Wallace House through a cooperative arrangement with the HSTR staff.

Geophysical methods were used to survey the Noland House yard and the joint Truman and Wallace yards at Harry S Truman National Historic Site during the spring of 2005. The geophysical investigations were part of the archeological inventory and evaluation project of the four properties. The geophysical equipment used in the survey effort included a ground penetrating radar cart system with 400 MHz antenna, a resistance meter with twin probe array, a fluxgate gradiometer, a ground conductivity meter, and a resistivity meter with an offset Wenner probe array. Archeological investigations at the Noland House property included shovel tests and formal one by one meter excavation units. The areal extent of the project covered approximately 525 $m^2$ or 0.13 acres. The areal extent of the geophysical investigations of the three adjacent Truman/Wallace properties covered approximately 4,548 $m^2$ or 1.22 acres.

The final phase of the geophysical and archeological investigations associated with the basement replacement project was to monitor the construction demolition of the basement at the Noland House (216 North Delaware Street; Site 23JA636) and the front porch at the Frank Wallace House (601 Truman Road; Site 23JA637) properties at Harry S Truman National Historic Site. The purpose of the archeological monitoring project was to identify and document any archeological resources associated with the original house construction activities and later modifications at the Noland House and the Frank Wallace House.

The magnetic, ground conductivity, resistance, and ground-penetrating radar data collected at the Noland property provided information of the physical properties (i.e., magnetic gradient, and conductance, the resistance, and ground-penetrating radar reflections) of the subsurface materials. Numerous small-scale magnetic, conductivity, resistance, and ground-penetrating radar anomalies are identified in the four data sets. Buried utility lines to the house including the water and gas lines were identified. A concentration of magnetic, and resistance anomalies in the southwest corner was identified and confirmed with the shovel tests and excavation units as a gravel parking pad. Although not originally identified during the geophysical survey, a cistern off the southwest corner of the Noland House was uncovered during the monitoring of the construction trench surrounding the house. Further review and analysis of the geophysical data did identify an anomalous area that coincided with the cistern location. The cistern was initially missed in the preliminary review of the geophysical data during the initial phase of the project at the Harry S Truman National Historic Site. Other features identified during the construction of the demolition trench were missed in the geophysical data due to the close proximity of the survey grids to the house and resulting negative effects of the materials used to construct the house, such as brick, nails, steel pipe, air condition units, metal window wells, galvanized metal downspouts, and buried utility lines (both ceramic drain tile and steel/iron gas and water pipes). Excavations including shovel tests and formal excavation units indicated the presence of a light scatter of historic artifacts in the Noland yard associated with the late 19$^{th}$ century construction of the house and subsequent 19$^{th}$ and 20$^{th}$ century modifications and additions to the main house unit, as well as the National Park Service activities after the Noland property was incorporated into the Harry S Truman National Historic Site.

The magnetic, ground conductivity, and ground penetrating radar data collected at the Truman/Wallace properties also provided information of the physical properties (i.e., magnetic gradient, and conductance, the resistance, and ground-penetrating radar reflections) of the subsurface materials. Numerous small-scale magnetic, conductivity, resistance, and ground-penetrating radar anomalies are identified in the three data sets. Buried utility lines to the Truman Home including the water and gas lines were identified along with the security lighting system surrounding the Truman Home. A buried ceramic storm water drainage tile pipe was identified in the eastern portion of the Frank Wallace property. Although not originally identified during the geophysical survey, a midden deposit was present in the front yard of the Frank Wallace property. A midden deposit associated with a filling or multiple filling episodes in the lower part of the original Gates property (i.e., the location of the Frank Wallace property and house) was uncovered during the monitoring of the construction trench surrounding the Frank Wallace House. Further review and analysis of the geophysical data did identify an anomalous area that coincided with the front yard midden location. Other features identified during the construction of the demolition trench around the Frank Wallace House were missed in the geophysical data due to the close proximity of the survey grids to the house and resulting negative effects of the materials used to construct the house, such as brick, nails, steel pipe, air condition units, metal window wells, galvanized metal downspouts, and the buried storm drain line. The recovery of artifacts and the documentation of features in the demolition trench indicated the presence of a late 19$^{th}$ century midden deposit, which was probably used as a disposal area for refuse from the Gates occupation and to fill the low area in this portion of the property. Fill inside the front porch foundation of the Frank Wallace House appeared to be materials discarded from furnace and stove cleaning episodes, as well as other activities, to provide a base for the raised front porch.

While these techniques represent extremely valuable methodologies for the initial investigation of the Noland, Truman, and Wallace properties, an excavation strategy needs to be developed to verify the identified anomalies in the non-construction demolition zones surrounding the houses. The question could be raised that the use of traditional excavation methods would have been more productive. It is true that the excavations would have allowed a better view of the subsurface materials; however, the amount of time and costs in labor and analysis to conduct such excavations would be substantially higher to cover the same area investigated with the geophysical techniques. With an estimated cost of $3,000.00 per cubic meter of excavation, only six to ten excavation units (to a depth of 40 to 50 cm could have been placed on the two project areas. The chances of placing one excavation over the top of a significant archeological resource would be extremely low. The geophysical techniques provide virtually 100% coverage of the area under investigation with substantial information on the extent and integrity of the archeological resources. Using the baseline geophysical data, evaluative excavations can be better targeted than through traditional shovel testing and other excavation methods; however, it should be noted that the close proximity of the buildings and other above ground structures caused a negative effect in the geophysical data by saturating the data with high energy anomalies caused by the overpowering nature of the physical materials used in their construction. Monitoring the construction trenching along the foundations of the Noland and the Frank Wallace Houses provided an opportunity to assess the archeological deposits in the negatively affected geophysical zone adjacent to the buildings. Preliminary shovel testing and formal excavations at the Noland property provided information on the nature, extent, and significance of the artifact concentrations; however, given the wide spacings that were used and the limited area that was opened to investigation, it is highly possible that major archeological resources would be missed on the Truman and Wallace properties.

This report has provided an analysis of the geophysical data collected during the investigations of the Noland and Truman/Wallace properties, the excavations at the Noland property, and monitoring activities at the Noland House and the Frank Wallace House on the Harry S Truman National Historic Site in Independence, Missouri. Both project areas contained a high degree of integrity based on the analysis of the geophysical data, the excavation results and artifact analysis, and the monitoring activities.

Finally, refinement of the archeological and geophysical interpretation of the survey data is dependent on the feedback of the archeological investigations following geophysical survey (David 1995:30). Should additional archeological investigations occur at the sites investigated during this project, the project archeologist is encouraged to share additional survey and excavation data with the geophysical investigators for incorporation into the investigators' accumulated experiences with archeological and geophysical investigations. Throughout the entire geophysical and archeological investigations, communication between the geophysicist and the archeologist is essential for successful completion of the archeological investigations. It is also important for the investigators to disseminate the results of the geophysical survey and archeological investigations to the general public. It is through their support in funds and labor that we continue to make contributions to the application of geophysical techniques to the field of archeology.

## REFERENCES CITED


Aitken, M. J.
1961 *Physics and Archaeology*. Interscience Publishers, New York.

1974 *Physics and Archaeology*. 2nd Edition. Clarendon Press, Oxford.

Ambrose, Heather M.
2006 *Quantitative Integration and Three-dimensional Visualization of Multi-tool Archaeological Geophysical Survey*. ProQuest Information and Learning Company, Ann Arbor, Michigan.

Anderson, Walter L.
1989 A Hybrid Fast Hankel Transform Algorithm for Electrical Modeling. *Geophysics* 54(2):263-266.

Bahr Vermeer Haecker Architects
2004 *Noland House, Harry S Truman National Historic Site, Independence, Missouri, Historic Structure Report*. Bahr Vermeer Haecker Architects, Ltd., Lincoln, Nebraska.

Bedford, John
1969 *Old Spode China*. Walker and Company, New York.

Bevan, Bruce W.
1977 Ground-Penetrating Radar at Valley Forge. Ms. on file, Midwest Archeological Center, Lincoln.

1991 The Search for Graves. *Geophysics* 56(9):1310-1319.

1983 Electromagnetics for Mapping Buried Features. *Journal of Field Archaeology* 10(1):47-54.

1998 *Geophysical Exploration for Archaeology: An Introduction to Geophysical Exploration*. Special Report No. 1. Midwest Archeological Center, National Park Service, Lincoln, Nebraska.

2000 *The Pole-Pole Resistivity Array Compared to the Twin Electrode Array*. Technical Report No. 6. Geosight, Weems, Virginia.

Bevan, Bruce W., and J. Kenyon
1975 Ground-Penetrating Radar for Historical Archaeology. *MASCA Newsletter* 11(2): 2-7.

Branson, Edwin B.
1944 *The Geology of Missouri*. University of Missouri Studies, Volume 19, Number 3. University of Missouri, Columbia.

Braun, E. Lucy
1938 Deciduous Forest Climaxes. *Ecology* 19:515-522.

Bray, Robert T.
1983 Archaeological Survey and Testing at the Truman Farm Home and Grounds, Grandview, Missouri. Ms. on file, Harry S Truman National Historic Site, Independence, Missouri.

Breiner, Sheldon
1973 *Applications Manual for Portable Magnetometers*. GeoMetrics, Sunnyvale, California.

Buchanan, Alan C.
1980 *Mussels (Naiades) of the Meramec River Basin*. Aquatic Series No. 1. Missouri Department of Conservation, Jefferson City.

Burger, H. Robert
1992 *Exploration Geophysics of the Shallow Subsurface*. Prentice Hall PTR, Englewood Cliffs, New Jersey.

Butler, Mark S. (editor)
1999 *RESIX Plus v2 User's Manual: DC Resistivity Data Interpretation Software*. Third Edition. Interpex Limited, Golden, Colorado.

Carr, Christopher
1982 *Handbook on Soil Resistivity Surveying: Interpretation of Data from Earthen Archeological Sites*. Research Series, Volume 2. Center for American Archeology Press, Evanston, Illinois.

Chapman, Carl H.
1975 *The Archaeology of Missouri, I*. University of Missouri Press, Columbia.

1980 *The Archaeology of Missouri, II*. University of Missouri Press, Columbia.

Clark, Anthony
2000 *Seeing beneath the Soil: Prospecting Methods in Archaeology*. Reprinted. Routledge, London. Originally published in 1990 by B. T. Batsford Ltd., London.

Clay, R. Berle
2001 Complementary Geophysical Survey Techniques: Why Two Ways Are Always Better than One. *Southeastern Archaeology* 20:31-43.

2006 Conductivity Survey: A Survival Manual. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by Jay K. Johnson, pp. 79-107. University of Alabama Press, Tuscaloosa.

Cockrell, Ron
1984 *Harry S Truman National Historic Site, Independence, Missouri Historic Structures Report: History and Significance*. Midwest Regional Office, National Park Service, Omaha, Nebraska.

1985 *The Trumans of Independence: Historic Resource Study Harry S Truman National Historic Site, Independence, Missouri*. Midwest Regional Office, National Park Service, Omaha, Nebraska.

Cockrell, Ron, and Keith Krueger
1989 *Cultural Landscape Report Harry S Truman National Historic Site, Missouri*. Midwest Regional Office, National Park Service, Omaha, Nebraska.

Conyers, Lawrence B.
2004 *Ground-penetrating Radar for Archaeology*. AltaMira Press, Walnut Creek, California.

2006 Ground-Penetrating Radar. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by Jay K. Johnson, pp. 131-159. University of Alabama Press, Tuscaloosa.

Conyers, Lawrence B., and Dean Goodman
1997 *Ground-Penetrating Radar: An Introduction for Archaeologists*. AltaMira Press, Walnut Creek, California.

Conyers, Lawrence B., and Jeffrey E. Lucius
1996 Velocity Analysis in Archaeological Ground-penetrating Radar Studies. *Archaeological Prospection* 3(1):25-38.

David, Andrew
1995 *Geophysical Survey in Archaeological Field Evaluation*. Research & Professional Services Guidelines No. 1. Ancient Monuments Laboratory, English Heritage, London.

Davis, P. A., S. A. Greenhalgh, and N. P. Merrich
1980 Resistivity Sounding Computations with any Array Using a Single Digital Filter. *Bulletin of the Australian Society of Exploration Geophysicists* 11:54-62.

De Vore, Steven L.
2005a Trip Report – Geophysical and Archeological Evaluation of the Noland House Property – Harry S Truman National Historic Site, Independence, Missouri (March 14-18, 2005). On file, Midwest Archeological Center, Lincoln, Nebraska.

2005b Trip Report – Geophysical Evaluation of the Truman Home, the George Wallace House, and the Frank Wallace House Properties – Harry S Truman National Historic Site, Independence, Missouri (April 8-14, 2005). On file, Midwest Archeological Center, Lincoln, Nebraska.

2005c Trip Report – Construction Demolition Monitoring at the Noland House and the Frank Wallace House Porch Properties – Harry S Truman National Historic Site, Independence, Missouri (December 8-14, 2005). On file, Midwest Archeological Center, Lincoln, Nebraska.

Dice, Lee R.
1943 *The Biotic Provinces of North America*. University of Michigan Press, Ann Arbor.

DuBay, Debby
2007 *Antique Trader Limoges Price Guide*. K.P. Krause Publications, Iola, Wisconsin.

Evans-Hatch, Gail E. H., and Michael Evans-Hatch
2001 *Farm Roots and Family Ties: Historic Resource Study, the Harry S Truman Grandview Farm, the Wallace Houses, and the Noland House in Independence, Harry S Truman National Historic Site, Grandview and Independence, Missouri*. Evans-Hatch & Associates, Silverton, Oregon.

Fenneman, Nevin M.
1938 Physiography of Eastern United States. McGraw-Hill Book Company, New York.

Foerster, Bernd
1978 *Independence, Missouri*. Independence Press, Independence, Missouri.

Foth, Henry D., and John W. Schafer
1980 *Soil Geography and Land Use*. John Wiley & Sons, New York.

Gaffney, Chris, and John Gater
2003 *Revealing the Buried Past: Geophysics for Archaeologists*. Tempus Publishing, Stroud, Great Britain.

Gaffney, Chris, John Gater, and Sue Ovenden
1991 *The Use of Geophysical Techniques in Archaeological Evaluations*. Technical Paper Number 9. Institute of Field Archaeologists, University of Birmingham, Birmingham, England.

2002 *The Use of Geophysical Techniques in Archaeological Evaluations*. IFA Paper No. 6. Institute of Field Archaeologists, University of Birmingham, Birmingham, England.

Gallup Map & Supply Company
1931 *Atlas of Jackson County, Missouri*. Gallup Map & Supply Co., Kansas City, Missouri.

1940 *Gallup's Atlas of Independence, Missouri*. Gallup Map & Supply Co., Kansas City, Missouri.

Geonics
1992 *EM38 Ground Conductivity Meter Operating Manual for EM38 Models with Digital Readout*. Geonics Limited, Mississauga, Ontario, Canada.

1997 *Computer Program manual (Survey Data Reduction Manual) DAT38, Version 3.40*. Geonics Limited, Mississauga, Ontario, Canada.

1998 *DL720/38 Data Logging System Operating Instructions for EM38 Ground Conductivity Meter with Polycorder Series 720, Version 3.40*. Geonics Limited, Mississauga, Ontario, Canada.

Geoscan Research
1987 *Fluxgate Gradiometer FM9 FM18 FM36 Instruction Manual, Version 1.0*. Geoscan Research, Bradford, England.

1996 *Resistance Meter RM15 Instruction Manual, Version 2.4*. Geoscan Research, Bradford, England.

2003 *Geoplot Version 3.00 for Windows Instruction Manual, Version 1.95*. Geoscan Research, Bradford, England.

Given, David N.
1993 Trip Report, Truman Home, March 18-19. On file, Midwest Regional Office, Omaha, Nebraska.

Golden Software
2002 *Surfer 8 User's Guide: Contouring and 3D Surface Mapping for Scientists and Engineers*. Golden Software, Golden, Colorado.

2003 *Grapher 5 2D and 3D Graphing for Scientists and Engineers Getting Started Guide: Gain the Power behind Superior Graphing*. Golden Software, Golden, Colorado.

Goodman, Dean
2006 *GPR-SLICE – Ground Penetrating Radar Imaging Software Ver. 5.0 User's Manual*. Geophysical Archaeometry Laboratory, Woodland Hills, California.

Goodman, D., Y. Nishimura, and J. D. Rogers
1995 GPR Time Slices in Archaeological Prospection. *Archaeological Prospection* 2(2):85-89.

Gossen
1995 *Geohm 40D Earth Tester Operating Instructions*. Gossen-Metrawatt GMBH, Nurnberg, Germany.

GSSI
2003a *TerraSIRch SIR Sytem-3000 User's Manual*. Geophysical Survey Systems, Inc., North Salem, New Hampshire.

2003b *RADAN for Windows Version 5.0 User's Manual*. Geophysical Survey Systems, Inc., North Salem, New Hampshire.

2003c *3D QuickDraw for RADAN 5.0 User's Manual*. Geophysical Survey Systems, Inc., North Salem, New Hampshire.

Heimmer, Don H., and Steven L. De Vore
1995 *Near-Surface, High Resolution Geophysical Methods for Cultural Resource Management and Archeological Investigations*. Revised Edition. Interagency Archeological Services, National Park Service, Denver, Colorado.

2000 Near-Surface, High Resolution Geophysical Methods for Cultural Resource Management and Archaeological Investigations. In *Science and Technology in Historic Preservation*, edited by Ray A. Williamson and Paul R. Nickens, pp. 53-73. Advances in Archaeological and Museum Science, Volume 4. Kluwer Academic/Plenum Publishers, New York.

Hickman, E. A., and A. L. Thornton
1876 *Hickman's Property Atlas of Jackson County, Missouri*. E. A. Hickman and A. L. Thornton, Kansas City, Missouri.

Hickman, William Z.
1990 *History of Jackson County, Missouri*. Reprint. Southern Historical Press, Greenville, South Carolina. Originally published in 1920 by the Historical Publishing Company, Topeka, Kansas.

Hinze, William J.
1990 The Role of Gravity and Magnetic Methods in Engineering and Environmental Studies. In *Geotechnical and Environmental Geophysics, Volume 1: Review and Tutorial*, edited by Stanley H. Ward, pp. 75-126. Society of Exploration Geophysicists, Tulsa, Oklahoma.

Hopkins, G. M. (compiler)
1886 *Atlas of the Environs of Kansas City in Jackson County, Missouri*. G. M. Hopkins, Philadelphia, Pennsylvania.

Horton, James C.
1908 Peter D. Ridenour and Harlow W. Baker, Two Pioneer Kansas Merchants. *Transactions of the Kansas State Historical Society, 1907-1908* 10:589-619.

Hughes, G. Bernard
1959 *Victorian Pottery and Porcelain*. The MacMillan Company, New York.

Interpex
2002 *IX1D Version 2.05*. Interpex Limited, Golden, Colorado. <hppt://www.interpex.com/ix1d.htm>.

Iris Instruments
1999 *Syscal Kid – Switch 22 Compact Resistivity Meter Multi-Electrode Switching System Operating Manual*. Iris Instruments, Orleans, France.

Jewitt, Llewellynn
1878 *The Ceramic Art of Great Britain, from Pre-Historic Times Down to the Present Day*. Virtue and Co., London.

Jones, Geoffrey, and David L. Maki
2003 *Geophysical Investigation at the Garden Coulee Site (32W118): An Historic Native American Village at the Fort Union Trading Post National Historic Site.* Report of Investigation Number 46. Archaeo-Physics, Minneapolis, Minnesota.

King, Julia A., Bruce W. Bevan, and Robert J. Hurry
1993 The Reliability of Geophysical Surveys at Historic-Period Cemeteries: An Example from the Plains Cemetery, Mechanicsville, Maryland. *Historical Archaeology* 27(3): 4-16.

Kvamme, Kenneth L.
2001 Current Practices in Archaeogeophysics: Magnetics, Resistivity, Conductivity, and Ground-Penetrating Radar. In *Earth Sciences and Archaeology*, edited by Paul Goldberg, Vance T. Holliday, and C. Reid Ferring, pp. 353-384. Kluwer Academic/Plenum Publishers, New York.

2003 Geophysical Surveys as Landscape Archaeology. *American Antiquity* 68(3):435-457.

2005 Terrestrial Remote Sensing in Archaeology. In *Handbook of Archaeological Methods, Volume 1*, edited by Herbert D. G. Maschner and Christopher Chippindale, pp. 423-477. AltaMira Press, Lanham, Maryland.

2006a Magnetometry: Nature's Gift to Archaeology. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by Jay K. Johnson, pp. 205-233. University of Alabama Press, Tuscaloosa.

2006b Data Processing and Presentation. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by Jay K. Johnson, pp. 235-250. University of Alabama Press, Tuscaloosa.

Kvamme, Kenneth L., Jay K. Johnson, and Bryan S. Haley
2006 Multiple Methods Surveys: Case Studies. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by Jay K. Johnson, pp. 251-267. University of Alabama Press, Tuscaloosa.

Lowrie, William
1997 *Fundamentals of Geophysics*. Cambridge University Press, Cambridge, United Kingdom.

Masten, Charles H., Jr.
1993 Trip Report, Harry S Truman, May 4-5. On file, Midwest Regional Office, Omaha, Nebraska.

McCourt, Walter E.
1917 *The Geology of Jackson County*. Missouri Bureau of Geology and Mines Volume 14, Second Series. Missouri Bureau of Geology and Mines, Rolla.

McNiel, J. D.
1980a *Electrical Conductivity of Soils and Rocks*. Technical Notes TN-5. Geonics Limited, Mississauga, Ontario, Canada.

1980b *Electromagnetic Terrain Conductivity Measurement at Low Induction Numbers*. Technical Notes TN-6. Geonics Limited, Mississauga, Ontario, Canada.

MicroPro
1989 *WordStar 5.5*. MircoPro International Corporation, San Rafael, California.

Milsom, John
1996 *Field Geophysics*. Second Edition. John Wiley & Sons, Chichester, England.

2003 *Field Geophysics*. Third Edition. John Wiley & Sons, Chichester, England.

Moxom, Walter J.
1941 Climate of Missouri. In *Climate and Man: 1941Yearbook of Agriculture*, edited by Grove Hambridge, pp. 945-954. House Document No. 27, 77th Congress, 1st Session. U. S. Government Printing Office, Washington, D. C.

Music, B.
1995 On-Site Prospection in Slovenia: The Case of Rodik. *Archaeological Computing Newsletter* 43:6-15.

Mussett, Alan E., and M. Aftab Khan
2000 *Looking into the Earth: An Introduction to Geological Geophysics*. Cambridge University Press, Cambridge, United Kingdom.

National Park Service
1985 *Environmental Assessment for the General Management Plan Harry S Truman National Historic Site, Missouri*. Harry S Truman National Historic Site, Independence, Missouri.

1987 *Harry S Truman National Historic Site General Management Plan*. Harry S Truman National Historic Site, Independence, Missouri.

1995 *Statement for Management Harry S Truman National Historic Site, Independence, Missouri*. Harry S Truman National Historic Site, Independence, Missouri.

1999 *Resources Management Plan Harry S Truman National Historic Site*. Harry S Truman National Historic Site, Independence, Missouri.

Neubauer, W., P. Melichar, and A. Eder-Hinterleitner
1996 Collection, Visualization, and Simulation of Magnetic Prospection Data. In *Interfacing the Past: Computer Applications and Quantitative Methods in Archaeology, CAA95, Volume 1*, edited by H. Kamermans and K. Fennema, pp. 121-129. Analecta Praehistorica Leidensia No. 28. University of Leiden, Leiden, The Netherlands.

Nikon
1993 *Field Station DTM-700 Series DTM-750/DTM-730/DTM-720 Instruction Manual*. Nikon Corporation, Tokyo.

1996 *TransIt Version 2.1 User's Guide*. Nikon Inc. Instrument Software Department, Melville, New York.

Nishimura, Y.
2001 Geophysical prospection in Archaeology. In *Handbook of Archaeological Sciences*, edited by D. R. Brothwell and A. M. Pollard, pp. 543-553. John Wiley & Sons, Ltd., Chichester, England.

Noble, Vergil E.
1988 Trip Report - April 4-10, Independence, MO and Springfield, IL. On file, Midwest Archeological Center, Lincoln, Nebraska.

1992 Trip Report – Harry S Truman, November 8-10. On file, Midwest Archeological Center, Lincoln, Nebraska.

2005 Trip Report: November 7-12, 2005. On file, Midwest Archeological Center, Lincoln, Nebraska.

Northwest Publishing Company
1904 *Plat Book of Jackson County, Missouri: Compiled from County Records and Actual Surveys*. Northwest Publishing Company, Minneapolis, Minnesota.

Ohman, Marion M.
1983 *A History of Missouri's Counties, County Seats, and Courthouse Squares*. University of Missouri Extension Division, Columbia.

Orellana, Ernesto, and Harold M. Mooney
1972 *Two and Three Layer Master Curves and Auxiliary Point Diagrams for Vertical Electrical Sounding Using Wenner Arrangement*. Interciencia, Madrid, Spain.

Peddie, Norman W.
1992 *The Magnetic Field in the United States, 1990, Total Intensity Chart*. U.S. Geological Survey Geophysical Investigations Map GP-1002-F. U.S. Geological Survey, Reston, Virginia.

Peddie, Norman W., and Audronis K. Zundie
1988 *The Magnetic Field in the United States, 1985, Inclination Chart*. U.S. Geological Survey Geophysical Investigations Map GP-986-I. U.S. Geological Survey, Reston, Virginia.

Peterson, John K.
2003 *Exploration Hole Monitoring, Noland House Basement, Harry S Truman National Historic Site Independence, Missouri*. Jackson County Parks and Recreation, Blue Springs, Missouri.

2004 *Monitoring of Soil Coring and Foundation Exploration for the Harry S Truman National Historic Site, Independence, Missouri*. Jackson County Parks and Recreation, Blue Springs, Missouri.

2005 *Trench Excavation Monitoring Noland and Frank Wallace Houses Harry S Truman National Historic Site Independence, Missouri: November 14, 16, 29-30, and December 1, 2005*. Jackson County Parks and Recreation, Blue Springs, Missouri.

Pflieger, William L.
1971 *A Distributional Study of Missouri Fishes*. Museum of Natural History Publication 20. University of Kansas, Lawrence.

Phillips, Jan
1979 *Wild Edibles of Missouri*. Missouri Department of Conservation, Jefferson City.

Preston, George D.
1984 *Soil Survey of Jackson County, Missouri*. U.S. Government Printing Office, Washington, D.C.

Restoration Associates
1987 *Harry S Truman National Historic Site, Truman Home HS-01, Truman Carriage House HS-02 Historic Structures Report*. Solomon Claybaugh Young Architects Inc., Kansas City, Missouri.

Richner, Jeffrey J.
1994 Trip Report, Truman Farm, Grandview Missouri. On file, Midwest Archeological Center, Lincoln, Nebraska.

Ruger, A.
1868 *Bird's Eye View of the City of Independence, Jackson County, Missouri*. Jackson County Historical Society, Independence, Missouri.

Schwartz, Charles W., and Elizabeth R. Schwartz
1959 *The Wild Mammals of Missouri*. Missouri Department of Conservation, Jefferson City.

Scollar, I., A. Tabbagh, A. Hesse, and I Herzog
1990 *Archaeological Prospection and Remote Sensing*. Topics in Remote Sensing 2. Cambridge University Press, Cambridge, England.

Sharma, Prem V.
1997 *Environmental and Engineering Geophysics*. Cambridge University Press, Cambridge, United Kingdom.

Shelford, Victor E.
1963 *The Ecology of North America*. University of Illinois Press, Urbana.

Sheriff, R. E.
1973 *Encyclopedic Dictionary of Exploration Geophysics*. Society of Exploration Geophysicists, Tulsa, Oklahoma.

Slavens, J. W. L.
1976 *An Illustrated Historical Atlas Map, Jackson County, Mo*. Reprint. Jackson County Historical Society, Independence, Missouri. Originally published in 1877 by Brink, McDonough & Co., Philadelphia, Pennsylvania.

Society for Historical Archeology.
2008 *Historic Glass Bottle Identification & Information Website*. Electronic document, http://www.sha.org/bottle/, accessed October 22, 2008.

Somers, Lewis
2006 Resistivity Survey. In *Remote Sensing in Archaeology: An Explicitly North American Perspective*, edited by Jay K. Johnson, pp. 109-129. University of Alabama Press, Tuscaloosa.

Spode
1940 *Spode: The Fine English Dinnerware*. Copeland & Thompson, New York.

Sprague, Roderick
1980-81 A Functional Classification for Artifacts from $19^{th}$ and $20^{th}$ Century Historical Sites. *North American Archaeologist* 2(3):251-261.

Stadler, Scott
2001 Trip Report-Investigations under Front, South, and Kitchen Porches at the Truman Home, Harry S Truman National Historic Site. On file, Midwest Archeological Center, Lincoln, Nebraska.

Steyermark, Julian A,
1963 *Flora of Missouri*. Iowa State University Press, Ames.

Sudderth, Ed
1988 Trip Report, Harry S. Truman National Monument, June 15-17, 1988. On file, Midwest Archeological Center, Lincoln, Nebraska.

Sutton, Ann, and Myron Sutton
1985 *The Audubon Society Nature Guides: Eastern Forests*. Alfred A. Knopf, Inc., New York.

Telford, W. M., L. P. Geldart, and R. E. Sheriff
1990 *Applied Geophysics*. Second Edition. Cambridge University Press, Cambridge, United Kingdom.

Terracon
2003 *Geotechnical Report the Noland House 216 North Delaware Independence, Missouri*. Project No. 02035293. Terracon Consulting Engineers and Scientists, Lenexa, Kansas.

Thiessen, Thomas D.
2005 Trip Report: Construction Demolition Monitoring at the Noland House and the Frank Wallace House Porch Properties, Harry S Truman National Historic Site, December 13-16, 2005. On file, Midwest Archeological Center, Lincoln, Nebraska.

Thomas, Leslie
1940 *The Story on the Willow Plate*. Schocken Books, New York.

Thornthwaite, C. W.
1948 An Approach toward Rational Classification of Climate. *Geographical Review* 38:55-94.

Tite, M. S.
1972 *Methods of Physical Examination in Archaeology*. Seminar Press, New York.

Toulouse, Julian Harrison.
1971 *Bottle Makers and Their Marks*. Thomas Nelson Inc., New York.

Union History Company
1966 *The History of Jackson County, Missouri: Containing a History of the County, Its Cities, Towns, etc*. Reprint. Ramfre Press, Cape Girardeau, Missouri. Originally published in 1881 by the Union Historical Company, Kansas City, Missouri.

USDA
1981 *Land Resource Regions and Major Land Resource Areas of the United States*. Agriculture Handbook 296. U. S. Government Printing Office, Washington, D.C.

Unklesbay, A. G., and J. D. Vineyard
1992 *Missouri Geology: Three Billion Years of Seas, Sediments and Erosion*. University of Missouri Press, Columbia.

Ushikata
2005 *Tracon & Surveying Compasses*. Ushikata Manufacturing Company, Tokyo.

Van Nostrand, Robert G., and Kenneth L. Cook
1966 *Interpretation of Resistivity Data*. Geological Survey Professional Paper 499. U.S. Printing Office, Washington, D.C.

Weymouth, John W.
1986 Geophysical Methods of Archaeological Site Surveying. In *Advances in Archaeological Method and Theory, Volume 9*, edited by Michael B. Schiffer, pp. 311-395. Academic Press, Orlando, Florida.

Wills, Geoffrey
1969 *English Pottery and Porcelain*. Doubleday & Company, Garden City, New York.

Witten, Alan J.
2006 *Handbook of Geophysics and Archaeology*. Equinox Publishing Ltd., London.

Wright, Christopher A.
1987 Part B; Study Units. In *Master Plan for Archaeological Resource Protection in Missouri*, edited by Donald E. Weston and Michael S. Weichman, pp. Bi/1-B26/5. Archaeological Associates and Environmental Systems Analysis, Kansas City, Missouri. Prepared for Division of Parks, Recreation and Historic Preservation, Missouri Department of Natural Resources, Jefferson City, and the National Park Service, Washington, D.C. Survey and Planning Grant Number 29-85-9310-009-B.

# TABLES

Table 1. Acquisition and instrumentation information for the gradiometer survey used in the grid input template at the Noland House (Site 23JA636).

| **GENERAL** | | | |
|---|---|---|---|
| Acquisition | Value | Instrumentation | Value |
| Sitename | HSTR | Survey Type | Gradiometer |
| Map Reference | | Instrument | FM36 |
| Dir. 1st Traverse | W | Units | nT |
| Grid Length (x) | 20 m | Range | AUTO |
| Sample Interval (x) | 0.125 m | Log Zero Drift | Off |
| Grid Width (y) | 20 m | Baud Rate | 2400 |
| Traverse Interval (y) | 0.5 m | Averaging | Off |
| Traverse Mode | Zig-zag | Averaging Period | 16 |
| **FILE NOMINCLATURE** | Raw data | Processed data | Corrected |
| Grid | cg1,cg2 | | |
| Mesh | mg | | |
| Composite | cg | cgz,cgzi.cgzil,cgzilr | |

Table 2. Acquisition and instrumentation information for the gradiometer survey used in the grid input template at the Truman/Wallace properties (Sites 23JA634, 23JA635, and 23JA637).

| GENERAL | | | |
|---|---|---|---|
| Acquisition | Value | Instrumentation | Value |
| Sitename | HSTR | Survey Type | Gradiometer |
| Map Reference | | Instrument | FM36 |
| Dir. 1st Traverse | N | Units | nT |
| Grid Length (x) | 20 m | Range | AUTO |
| Sample Interval (x) | 0.125 m | Log Zero Drift | Off |
| Grid Width (y) | 20 m | Baud Rate | 2400 |
| Traverse Interval (y) | 0.5 m | Averaging | Off |
| Traverse Mode | Zig-zag | Averaging Period | 16 |
| FILE NOMINCLATURE | Raw data | Processed data | Corrected |
| Grid | htg1,htg2,htg3,gwg4 ,fwg5,htg6,htg7,htg8 ,gwg9,fwg10,htg11, htg12,htg13,gwg14, fwg15 | | htg7a |
| Mesh | twg | | twga |
| Composite | twcg | twcgz,twcgzi,twcgzil, twcgr | twga,twgaz,twgazi,tw gazil,twgazilr |

Table 3. Acquisition and instrumentation information for the ground conductivity survey used in the grid input template at the Noland House (Site 23JA636).

| | | | |
|---|---|---|---|
| GENERAL | | | |
| Acquisition | Value | Instrumentation | Value |
| Sitename | HSTR | Survey Type | EM |
| Map Reference | | Instrument | EM38 |
| Dir. 1st Traverse | W | Units | mS/m |
| Grid Length (x) | 20 m | | |
| Sample Interval (x) | 0.25 m | | |
| Grid Width (y) | 20 m | | |
| Traverse Interval (y) | 0.5 m | | |
| Traverse Mode | Parallel | | |
| FILE NOMINCLATURE | Raw data | Processed data | Corrected |
| Grid | 1qcc,2qcc | | |
| Mesh | mq | | |
| Composite | cq | cqi,cqih,cqihr | |

Table 4. Acquisition and instrumentation information for the ground conductivity survey used in the grid input template at the Truman/Wallace properties (Sites 23JA634, 23JA635, and 23JA637).

| | | | |
|---|---|---|---|
| GENERAL | | | |
| Acquisition | Value | Instrumentation | Value |
| Sitename | HSTR | Survey Type | EM |
| Map Reference | | Instrument | EM38 |
| Dir. 1st Traverse | N | Units | mS/m |
| Grid Length (x) | 20 m | | |
| Sample Interval (x) | 0.25 m | | |
| Grid Width (y) | 20 m | | |
| Traverse Interval (y) | 0.5 m | | |
| Traverse Mode | Parallel | | |
| FILE NOMINCLATURE | Raw data | Processed data | Corrected |
| Grid | 1qht,2qht,3qht,4qgw ,5qfw,6qht,7qht,8qh t,9qgw,10qfw,11qht, 12qht,13qht,14qgw, 15qfw | | |
| Mesh | twq | | |
| Composite | twcq | twcqc,twcqs. twcqi,twcqih, twcqihr | |

Table 5. Acquisition and instrumentation information for the resistance survey used in the grid input template at the Noland House (Site 23JA636).

| | | | |
|---|---|---|---|
| GENERAL | | | |
| Acquisition | Value | Instrumentation | Value |
| Sitename | HSTR | Survey Type | Resistance |
| Map Reference | | Instrument | RM15 |
| Dir. 1st Traverse | W | Units | Ohm |
| Grid Length (x) | 20 m | Current Range | AUTO |
| Sample Interval (x) | 0.5 m | Gain Range | AUTO |
| Grid Width (y) | 20 m | Baud Rate | 9600 |
| Traverse Interval (y) | 0.5 m | Frequency | 137 Hz |
| Traverse Mode | Zig-zag | High Pass Filter | 13 Hz |
| ACCESSORIES | | | |
| | Accessories | Value | |
| | Array Hardware | PA5 | |
| | Interface | AD1 | |
| | Log Mode | Single | |
| | Configuration | Twin | |
| | Probe Spacing | 0.5 | |
| FILE NOMINCLATURE | Raw data | Processed data | Corrected |
| Grid | r1,r2 | | |
| Mesh | mr | | |
| Composite | cr | crsr,crsri,crsrih, crsrihr | |

Table 6. Offset Wenner array resistivity data at the Noland House (Site 23JA636).

| Center at N5046.9/ E4846.4 | | | | $\rho a = 2 \pi R d$ |
|---|---|---|---|---|
| Probe spacing (m) | Left (Northeast) offset resistance reading (ohms) | Right (Southwest) offset resistance reading (ohms) | average resistance reading (ohms) | Apparent resistivity (ohm-meters) |
| 0.1 | 15.31 | 15.11 | 15.21 | 9.557 |
| 0.15 | 14.56 | 14.48 | 14.52 | 15.685 |
| 0.2 | 12.27 | 12.25 | 12.26 | 15.406 |
| 0.3 | 9.08 | 9.13 | 9.105 | 17.163 |
| 0.4 | 7.39 | 7.43 | 7.41 | 18.623 |
| 0.5 | 6.18 | 6.23 | 6.205 | 19.494 |
| 0.7 | 4.26 | 4.33 | 4.295 | 18.890 |
| 1.0 | 2.71 | 2.84 | 2.775 | 17.236 |
| 1.5 | 1.39 | 1.70 | 1.545 | 14.561 |
| 2.0 | 0.47 | 1.10 | 0.925 | 11.624 |
| 3.0 | 0.33 | 0.60 | 0.465 | 8.765 |
| 4.0 | 0.19 | 0.28 | 0.235 | 5.906 |

| Table 7. Acquisition and instrumentation information for the ground-penetrating radar survey at the Noland House (Site 23JA636). | | | |
|---|---|---|---|
| GENERAL | | | |
| Acquisition | Value | Instrumentation | Value |
| File Nam | HSTR | Survey Type | GPR |
| Number of Profile Lines | 41 | Instrument | GSSI TerraSIRch SIR 3000 |
| Dir. 1st Traverse | E | Samples/scan | 512 |
| Grid Length (x) | 20 m | Bits/sample | 16 |
| Scans/meter | 50 | Scans/second | 100 |
| Grid Width (y) | 20 m | Meters/mark | 2 |
| Traverse Interval (y) | 0.5 m | Diel Constant | 8 |
| Traverse Mode | zig-zag | Antenna | 400 MHz |
| Profile Names | HSTR____001 to HSTR____047 | | |
| ACCESSORIES | | | |
| | Channel(s) | 1 | |
| | Range Gain (dB) | -20.0 31.0 38.0 38.0 43.0 | |
| | Position Correction | 0 ns | |
| | Vertical IIR LP N = 1F | 800 MHz | |
| | Vertical IIR HP N = 1F | 100 MHz | |
| | Position (ns) | 0 | |
| | Range (ns) | 100 | |

Table 8. Acquisition and instrumentation information for the ground-penetrating radar survey at the Truman/Wallace properties (Sites 23JA634, 23JA635, and 23JA637).

| GENERAL | | | |
|---|---|---|---|
| Acquisition | Value | Instrumentation | Value |
| File Nam | HSTRA and TRUMAN | Survey Type | GPR |
| Number of Profile Lines | | Instrument | GSSI TerraSIRch SIR 3000 |
| Dir. 1st Traverse | N | Samples/scan | 512 |
| Grid Length (x) | 65 m | Bits/sample | 16 |
| Scans/meter | 50 | Scans/second | 100 |
| Grid Width (y) | 25 m | Meters/mark | 2 |
| Traverse Interval (y) | 0.5 m | Diel Constant | 8 |
| Traverse Mode | Zig-zag | Antenna | 400 MHz |
| Profile Names: Wallace properties | HSTRA___001 to HSTRA___183 | Profile Names: Truman property | TRUMAN__001 to TRUMAN__064 |
| ACCESSORIES | | | |
| | Channel(s) | 1 | |
| | Range Gain (dB) | -20.0 31.0 38.0 38.0 43.0 | |
| | Position Correction | 0 ns | |
| | Vertical IIR LP N = 1F | 800 MHz | |
| | Vertical IIR HP N = 1F | 100 MHz | |
| | Position (ns) | 0 | |
| | Range (ns) | 100 | |

Table 9. Ground-penetrating radar profiles for survey of Noland property (23JA636).

| HSTR Profile Name | Y line | X start coordinate | X end coordinate |
|---|---|---|---|
| HSTR____001 | 0 | 2 | 40 |
| HSTR____002 | 0.5 | 40 | 2 |
| HSTR____003 | 1 | 1 | 40 |
| HSTR____004 | 1.5 | 40 | 1 |
| HSTR____005 | 2 | 0 | 40 |
| HSTR____006 | 2.5 | 40 | 0 |
| HSTR____007 | 3 | 0 | 40 |
| HSTR____008 | 3.5 | 40 | 31 |
| HSTR____009 | 3.5 | 22 | 0 |

| Table 9. Concluded | | | |
|---|---|---|---|
| HSTR Profile Name | Y line | X start coordinate | X end coordinate |
| HSTR____010 | 4 | 0 | 22 |
| HSTR____011 | 4.5 | 15 | 0 |
| HSTR____012 | 5 | 0 | 14.5 |
| HSTR____013 | 5.5 | 15 | 0 |
| HSTR____014 | 6 | 0 | 15 |
| HSTR____015 | 6.5 | 15 | 0 |
| HSTR____016 | 7 | 0 | 15 |
| HSTR____017 | 7.5 | 15 | 0 |
| HSTR____018 | 8 | 0 | 15 |
| HSTR____019 | 8.5 | 15 | 0 |
| HSTR____020 | 9 | 0 | 15 |
| HSTR____021 | 9.5 | 15 | 0 |
| HSTR____022 | 10 | 0 | 15 |
| HSTR____023 | 10.5 | 15 | 0 |
| HSTR____024 | 11 | 0 | 24 |
| HSTR____025 | 11.5 | 24 | 0 |
| HSTR____026 | 12 | 0 | 40 |
| HSTR____027 | 12.5 | 40 | 11 |
| HSTR____028 | 12.5 | 9 | 0 |
| HSTR____029 | 13 | 0 | 40 |
| HSTR____030 | 12.5 | 40 | 34 |
| HSTR____031 | 12 | 34 | 40 |
| HSTR____032 | 11.5 | 40 | 36 |
| HSTR____033 | 11 | 36 | 40 |
| HSTR____034 | 10.5 | 40 | 36 |
| HSTR____035 | 10 | 36 | 40 |
| HSTR____036 | 9.5 | 40 | 37 |
| HSTR____037 | 9 | 37 | 40 |
| HSTR____038 | 8.5 | 40 | 37 |
| HSTR____039 | 8 | 36 | 40 |
| HSTR____040 | 7.5 | 40 | 36 |
| HSTR____041 | 7 | 36 | 40 |
| HSTR____042 | 6.5 | 40 | 36 |
| HSTR____043 | 6 | 36 | 40 |
| HSTR____044 | 5.5 | 40 | 34 |
| HSTR____045 | 5 | 33 | 40 |
| HSTR____046 | 4.5 | 40 | 33 |
| HSTR____047 | 4 | 31 | 40 |

Table 10. Ground-penetrating radar profiles for survey of Truman/Wallace properties (23JA634, 23JA635, and 23JA637).

| TRUMAN Profile Name | X line | Y start coordinate | Y end coordinate |
|---|---|---|---|
| TRUMAN__001 | 80 | 0 | 27 |
| TRUMAN__002 | 80.5 | 27 | 0 |
| TRUMAN__003 | 81 | 0 | 9 |
| TRUMAN__004 | 81 | 17 | 27 |
| TRUMAN__005 | 80 | 29 | 47 |
| TRUMAN__006 | 80.5 | 47 | 29 |
| TRUMAN__007 | 81 | 29 | 47 |
| TRUMAN__008 | 81.5 | 47 | 40 |
| TRUMAN__009 | 81.5 | 36 | 17 |
| TRUMAN__010 | 81.5 | 9 | 0 |
| TRUMAN__011 | 82 | 0 | 36 |
| TRUMAN__012 | 82 | 40 | 47 |
| TRUMAN__013 | 82.5 | 47 | 41 |
| TRUMAN__014 | 82.5 | 36 | 0 |
| TRUMAN__015 | 83 | 0 | 35 |
| TRUMAN__016 | 83 | 41 | 47 |
| TRUMAN__017 | 83.5 | 47 | 41 |
| TRUMAN__018 | 83.5 | 27 | 0 |
| TRUMAN__019 | 84 | 0 | 22 |
| TRUMAN__020 | 84.5 | 20 | 0 |
| TRUMAN__021 | 85 | 0 | 20 |
| TRUMAN__022 | 85.5 | 20 | 0 |
| TRUMAN__023 | 86 | 0 | 20 |
| TRUMAN__024 | 86.5 | 21 | 0 |
| TRUMAN__025 | 87 | 0 | 22 |
| TRUMAN__026 | 87.5 | 22 | 0 |
| TRUMAN__027 | 88 | 0 | 22 |
| TRUMAN__028 | 88.5 | 22 | 0 |
| TRUMAN__029 | 89 | 0 | 22 |
| TRUMAN__030 | 89.5 | 22 | 0 |
| TRUMAN__031 | 90 | 0 | 22 |
| TRUMAN__032 | 90.5 | 22 | 0 |
| TRUMAN__033 | 91 | 0 | 22 |
| TRUMAN__034 | 91.5 | 22 | 0 |
| TRUMAN__035 | 92 | 0 | 22 |
| TRUMAN__036 | 92.5 | 21 | 0 |
| TRUMAN__037 | 93 | 0 | 22 |

| Table 10. Continued | | | |
|---|---|---|---|
| TRUMAN Profile Name | X line | Y start coordinate | Y end coordinate |
| TRUMAN__038 | 93.5 | 21 | 0 |
| TRUMAN__039 | 94 | 0 | 22 |
| TRUMAN__040 | 94.5 | 22 | 0 |
| TRUMAN__041 | 95 | 0 | 47 |
| TRUMAN__042 | 95.5 | 47 | 0 |
| TRUMAN__043 | 94.5 | 24 | 47 |
| TRUMAN__044 | 94 | 47 | 24 |
| TRUMAN__045 | 93.5 | 24 | 47 |
| TRUMAN__046 | 93 | 47 | 24 |
| TRUMAN__047 | 92.5 | 24 | 47 |
| TRUMAN__048 | 92 | 47 | 42 |
| TRUMAN__049 | 91.5 | 42 | 47 |
| TRUMAN__050 | 91 | 47 | 41 |
| TRUMAN__051 | 90.5 | 41 | 47 |
| TRUMAN__052 | 90 | 47 | 41 |
| TRUMAN__053 | 89.5 | 41 | 47 |
| TRUMAN__054 | 89 | 47 | 41 |
| TRUMAN__055 | 88.5 | 42 | 47 |
| TRUMAN__056 | 88 | 47 | 41 |
| TRUMAN__057 | 87.5 | 42 | 47 |
| TRUMAN__058 | 87 | 47 | 41 |
| TRUMAN__059 | 86.5 | 42 | 47 |
| TRUMAN__060 | 86 | 47 | 41 |
| TRUMAN__061 | 85.5 | 42 | 47 |
| TRUMAN__062 | 85 | 47 | 41 |
| TRUMAN__063 | 84.5 | 42 | 47 |
| TRUMAN__064 | 84 | 47 | 41 |
| HSTRA Profile Name | X line | Y start coordinate | Y end coordinate |
| HSTRA___001 | 1 | 0 | 47 |
| HSTRA___002 | 1.5 | 47 | 0 |
| HSTRA___003 | 2 | 0 | 47 |
| HSTRA___004 | 2.5 | 47 | 0 |
| HSTRA___005 | 3 | 0 | 47 |
| HSTRA___006 | 3.5 | 47 | 0 |
| HSTRA___007 | 4 | 0 | 47 |
| HSTRA___008 | 4.5 | 47 | 0 |
| HSTRA___009 | 5 | 0 | 47 |
| HSTRA___010 | 5.5 | 47 | 0 |

| Table 10. Continued | | | |
|---|---|---|---|
| TRUMAN Profile Name | X line | Y start coordinate | Y end coordinate |
| HSTRA___011 | 6 | 0 | 47 |
| HSTRA___012 | 6.5 | 47 | 0 |
| HSTRA___013 | 7 | 0 | 47 |
| HSTRA___014 | 7.5 | 47 | 0 |
| HSTRA___015 | 8 | 0 | 47 |
| HSTRA___016 | 8.5 | 47 | 0 |
| HSTRA___017 | 9 | 0 | 47 |
| HSTRA___018 | 9.5 | 47 | 0 |
| HSTRA___019 | 10 | 0 | 47 |
| HSTRA___020 | 10.5 | 47 | 0 |
| HSTRA___021 | 11 | 0 | 47 |
| HSTRA___022 | 11.5 | 47 | 0 |
| HSTRA___023 | 12 | 0 | 47 |
| HSTRA___024 | 12.5 | 47 | 21 |
| HSTRA___025 | 13 | 25 | 47 |
| HSTRA___026 | 13.5 | 47 | 25 |
| HSTRA___027 | 14 | 26 | 47 |
| HSTRA___028 | 14.5 | 47 | 28 |
| HSTRA___029 | 15 | 28 | 47 |
| HSTRA___030 | 15.5 | 47 | 28 |
| HSTRA___031 | 16 | 30 | 47 |
| HSTRA___032 | 16.5 | 47 | 30 |
| HSTRA___033 | 17 | 30 | 47 |
| HSTRA___034 | 17.5 | 47 | 30 |
| HSTRA___035 | 18 | 31 | 47 |
| HSTRA___036 | 18.5 | 47 | 32 |
| HSTRA___037 | 19 | 32 | 47 |
| HSTRA___038 | 19.5 | 47 | 32 |
| HSTRA___039 | 20 | 32 | 47 |
| HSTRA___040 | 12.5 | 15 | 0 |
| HSTRA___041 | 13 | 0 | 14 |
| HSTRA___042 | 13.5 | 13 | 0 |
| HSTRA___043 | 14 | 1 | 12 |
| HSTRA___044 | 14.5 | 12 | 1 |
| HSTRA___045 | 15 | 1 | 12 |
| HSTRA___046 | 15.5 | 11 | 1 |
| HSTRA___047 | 16 | 1 | 11 |
| HSTRA___048 | 16.5 | 11 | 1 |

| Table 10. Continued | | | |
|---|---|---|---|
| TRUMAN Profile Name | X line | Y start coordinate | Y end coordinate |
| HSTRA___049 | 17 | 1 | 11 |
| HSTRA___050 | 17.5 | 11 | 9 |
| HSTRA___051 | 17.5 | 7 | 1 |
| HSTRA___052 | 18 | 2 | 11 |
| HSTRA___053 | 18.5 | 11 | 2 |
| HSTRA___054 | 19 | error | delete |
| HSTRA___055 | 19 | 2 | 11 |
| HSTRA___056 | 19.5 | 11 | 1 |
| HSTRA___057 | 20 | 1 | 11 |
| HSTRA___058 | 20.5 | 11 | 0 |
| HSTRA___059 | 21 | 0 | 11 |
| HSTRA___060 | 21.5 | 11 | 0 |
| HSTRA___061 | 22 | 0 | 11 |
| HSTRA___062 | 22.5 | 11 | 0 |
| HSTRA___063 | 23 | 0 | 11 |
| HSTRA___064 | 23.5 | 11 | 0 |
| HSTRA___065 | 24 | 0 | 11 |
| HSTRA___066 | 24.5 | 11 | 0 |
| HSTRA___067 | 25 | 0 | 11 |
| HSTRA___068 | 25.5 | 11 | 0 |
| HSTRA___069 | 26 | 0 | 11 |
| HSTRA___070 | 26.5 | 11 | 0 |
| HSTRA___071 | 27 | 0 | 11 |
| HSTRA___072 | 27.5 | 11 | 0 |
| HSTRA___073 | 28 | 0 | 4 |
| HSTRA___074 | 28 | 6 | 10 |
| HSTRA___075 | 28.5 | 10 | 7 |
| HSTRA___076 | 28.5 | 4 | 0 |
| HSTRA___077 | 29 | 0 | 4 |
| HSTRA___078 | 29 | 7 | 10 |
| HSTRA___079 | 29.5 | 10 | 7 |
| HSTRA___080 | 29.5 | 4 | 0 |
| HSTRA___081 | 30 | 0 | 10 |
| HSTRA___082 | 30.5 | 10 | 0 |
| HSTRA___083 | 31 | 0 | 10 |
| HSTRA___084 | 31.5 | 9 | 0 |
| HSTRA___085 | 32 | 0 | 9 |
| HSTRA___086 | 32.5 | 9 | 0 |

| Table 10. Continued | | | |
|---|---|---|---|
| TRUMAN Profile Name | X line | Y start coordinate | Y end coordinate |
| HSTRA___087 | 33 | 0 | 10 |
| HSTRA___088 | 33.5 | 10 | 0 |
| HSTRA___089 | 34 | 0 | 10 |
| HSTRA___090 | 34.5 | 10 | 0 |
| HSTRA___091 | 35 | 0 | 10 |
| HSTRA___092 | 35.5 | 10 | 0 |
| HSTRA___093 | 36 | 0 | 10 |
| HSTRA___094 | 36.5 | 10 | 0 |
| HSTRA___095 | 37 | 0 | 20 |
| HSTRA___096 | 37.5 | 20 | 0 |
| HSTRA___097 | 38 | 0 | 20 |
| HSTRA___098 | 38.5 | 20 | 0 |
| HSTRA___099 | 39 | 0 | 20 |
| HSTRA___100 | 39.5 | 17 | 0 |
| HSTRA___101 | 40 | 0 | 20 |
| HSTRA___102 | 40.5 | 20 | 0 |
| HSTRA___103 | 41 | 0 | 20 |
| HSTRA___104 | 41.5 | 20 | 0 |
| HSTRA___105 | 42 | 0 | 20 |
| HSTRA___106 | 42.5 | 20 | 0 |
| HSTRA___107 | 43 | 0 | 20 |
| HSTRA___108 | 43.5 | 20 | 0 |
| HSTRA___109 | 44 | 1 | 20 |
| HSTRA___110 | 44.5 | 20 | 1 |
| HSTRA___111 | 45 | 1 | 20 |
| HSTRA___112 | 45.5 | 20 | 1 |
| HSTRA___113 | 46 | 0 | 20 |
| HSTRA___114 | 46.5 | 20 | 0 |
| HSTRA___115 | 47 | 0 | 20 |
| HSTRA___116 | 47.5 | 20 | 0 |
| HSTRA___117 | 48 | 0 | 20 |
| HSTRA___118 | 48.5 | 20 | 0 |
| HSTRA___119 | 49 | 0 | 20 |
| HSTRA___120 | 49.5 | 20 | 9 |
| HSTRA___121 | 49.5 | 7 | 0 |
| HSTRA___122 | 50 | 0 | 17 |
| HSTRA___123 | 50.5 | 17 | 8 |
| HSTRA___124 | 51 | 8 | 17 |

| Table 10. Continued | | | |
|---|---|---|---|
| TRUMAN Profile Name | X line | Y start coordinate | Y end coordinate |
| HSTRA___125 | 51.5 | 17 | 10 |
| HSTRA___126 | 52 | 10 | 20 |
| HSTRA___127 | 52.5 | 20 | 10 |
| HSTRA___128 | 53 | 9 | 20 |
| HSTRA___129 | 53.5 | 20 | 9 |
| HSTRA___130 | 54 | 9 | 20 |
| HSTRA___131 | 54.5 | 20 | 9 |
| HSTRA___132 | 55 | 9 | 20 |
| HSTRA___133 | 55.5 | 20 | 9 |
| HSTRA___134 | 56 | 9 | 20 |
| HSTRA___135 | 56.5 | 20 | 9 |
| HSTRA___136 | 57 | 9 | 20 |
| HSTRA___137 | 57.5 | 20 | 9 |
| HSTRA___138 | 58 | 9 | 20 |
| HSTRA___139 | 58.5 | 20 | 9 |
| HSTRA___140 | 59 | 9 | 20 |
| HSTRA___141 | 59.5 | 20 | 8 |
| HSTRA___142 | 60 | 8 | 20 |
| HSTRA___143 | 60.5 | 20 | 8 |
| HSTRA___144 | 61 | 8 | 20 |
| HSTRA___145 | 61.5 | 20 | 10 |
| HSTRA___146 | 62 | 10 | 20 |
| HSTRA___147 | 62.5 | 20 | 10 |
| HSTRA___148 | 63 | 8 | 20 |
| HSTRA___149 | 63.5 | 20 | 0 |
| HSTRA___150 | 64 | 0 | 20 |
| HSTRA___151 | 64.5 | 20 | 0 |
| HSTRA___152 | 65 | 0 | 20 |
| HSTRA___153 | 65.5 | 20 | 0 |
| HSTRA___154 | 66 | 0 | 20 |
| HSTRA___155 | 66.5 | 20 | 6 |
| HSTRA___156 | 67 | 6 | 20 |
| HSTRA___157 | 67.5 | 20 | 6 |
| HSTRA___158 | 68 | 6 | 20 |
| HSTRA___159 | 68.5 | 20 | 6 |
| HSTRA___160 | 69 | 6 | 20 |
| HSTRA___161 | 69.5 | 20 | 6 |
| HSTRA___162 | 70 | 0 | 11 |

| Table 10. Concluded | | | |
|---|---|---|---|
| TRUMAN Profile Name | X line | Y start coordinate | Y end coordinate |
| HSTRA___163 | 70 | 15 | 20 |
| HSTRA___164 | 70.5 | 20 | 18 |
| HSTRA___165 | 71 | 18 | 20 |
| HSTRA___166 | 71.5 | 20 | 15 |
| HSTRA___167 | 72 | 0 | 20 |
| HSTRA___168 | 72.5 | 20 | 0 |
| HSTRA___169 | 73 | 0 | 20 |
| HSTRA___170 | 73.5 | 20 | 0 |
| HSTRA___171 | 74 | 0 | 20 |
| HSTRA___172 | 74.5 | 20 | 0 |
| HSTRA___173 | 75 | 0 | 20 |
| HSTRA___174 | 75.5 | 20 | 0 |
| HSTRA___175 | 76 | 0 | 20 |
| HSTRA___176 | 76.5 | 20 | 0 |
| HSTRA___177 | 77 | 0 | 20 |
| HSTRA___178 | 77.5 | 20 | 0 |
| HSTRA___179 | 78 | 0 | 20 |
| HSTRA___180 | 78.5 | 20 | 0 |
| HSTRA___181 | 79 | 0 | 20 |
| HSTRA___182 | 79.5 | 20 | 0 |
| HSTRA___183 | 80 | 0 | 20 |

| Table 11. Vertical electrical sounding model at the Noland House (Site 23JA636). | | |
|---|---|---|
| Number of layer | apparent resistivity (ohm-meters) | thickness of layer (m) |
| 1 | 12.00 | 0.107 |
| 2 | 21.79 | 1.000 |
| 3 | 4.42 | ------ |

| Table 12. Shovel test descriptions. | | | |
|---|---|---|---|
| Coordinates | Line and test number (T* ST*) | Depth (cm) | Description |
| N5029.9784/E4822.5923 | T1 ST1 | 84 | 0-32 cm brown silty loam, 20-30 concentration of charcoal, brick, cement, etc., subsoil at about 32 cmbs; 19 pc curved grass, brick, cement, slag, 6 nails, 2 bone, 1 whiteware sherd, 1 pc shell, 1 impressed glass, 1 glass, prism frag |
| N5029.9479/E4838.3572 | T1 ST2 | 64 | 0-15 cm limestone gravel, 15-25 medium brown/red silty loam, 25-34 cm yellow-brown silty clay, 34-64 cm mottled medium brown gray silty clay; slag, 2 yellowware sherds, 1 nail, 1 drain tile, 2 bone, 2 glass |
| N5030.2588/E4854.7557 | T1 ST3 | 64 | Thin layer of sandy soil at 65 cmbs, probed to 85 cm; 1953 nickel, coal, brick frag @ 20 cmbs, wire nail @18 cmbs |
| N5030.6846/E4871.5086 | T1 ST4 | 53 | 0-25 cm medium brown silty loam, 25-40 cm yellow-brown silty clay, 40-53 cm brown/gray silty clay; multiple roots throughout to a depth of 30 cmbs; probed to a depth of 74 cmbs, no change; drain tile runs through southwest portion of unit a 7 cmbs; brick, shell button, 1 bone, 1 shell, 3 whiteware sherds, 4 glass, 1 nail |
| N5030.6098/E4887.6566 | T1 ST5 | 23 | 0-23 cm medium brown silty loam; lots of roots; test adjacent to tree; stopped due to large root; 2 debitage; 3 glass, 1 porcelain sherd |
| N5030.7591/E4904.1220 | T1 ST6 | 58 | 0-18 cm medium brown silty loam, 18-34 cm yellow-brown silty clay, 34-58 cm brown/gray silty clay; probed to a depth of 83 cmbs, no change; many roots at 14-44 cmbs; 2 nails, 1 flat glass, 2 curved glass |
| N5030.9861/E4920.3873 | T1 ST7 | 76 | 0-17 cm brown silty loam, 17-46 cm mottled brown/yellow-brown silty loam clay; 46-76 cm brown silty clay; brick, 1 nail, 5 glass, 2 bone, 2 plastic, 1 porcelain sherd, 9 debitage |
| N5030.1938/E4936.6303 | T1 ST8 | 55 | 0-26 cm medium brown silty loam, 26-53 cm mottled medium brown silty clay w/ yellow-brown silty clay, 53-55 cm yellow-brown silty clay; probed to 80 cmbs; 1 metal tag, 1 possible flake, 1 cut nail, 2 glass |

| Table 12. Continued | | | |
|---|---|---|---|
| Coordinates | Line and test number (T* ST*) | Depth (cm) | Description |
| N5039.8785/E4926.6883 | T2 ST1 | 42 | Near south side of porch; 0-28 cm medium brown clay, 28-42 cm tan clay; glass, 1 nail, brick |
| N5039.9836/E4942.9591 | T2 ST2 | 36 | South side of tree in front yard; 0-18 cm brown silty loam, 18-36 cm yellow-brown loam; 1 chair foot (?) |
| N5046.0327/E4821.7306 | T3 ST1 | 67 | Brown/gray silty loam moving to medium brown silty clay at about 30 cmbs; soil probe to 82 cmbs; 5 nails, 1 bone, 1 coal, 5 curved glass |
| N5046.5673/4838.2219 | T3 ST2 | 52 | 0-52 cm gray-brown grading to gray-light brown; 1 debitage, 4 pc glass, 1 porcelain sherd, 1 pc bone, brick |
| N5046.7267/E4854.5896 | T3 ST3 | 41 | 0-24 cm gray brown silty loam, 24-41 cm tan brown clay subsoil; 1 whiteware sherd, 1 flake |
| N5059.6423/E4945.6934 | T3½ ST1 | 90 | Test near sidewalk steps in front of house; 0-24 medium brown/gray silty loam, 24-50 mottled brown-tan silty clay, 50-90 cm dark gray/brown silty loam; probed to 100 cmbs (same); brick, 2 debitage, 2 nails, 1 button (2 pieces) |
| N5065.8598/E4821.7258 | T4 ST1 | 52 | 0-25 cm medium brown/gray silty clay loam, 25-52 cm medium brown/gray silty clay; 4 nails, 2 glass, brick, 1 whiteware sherd |
| N5065.6753/E4837.9435 | T4 ST2 | 55 | 0-20 cm medium brown silty loam, 20-55 cm brown/gray silty clay; 2 whiteware sherds, glass, bone |
| N5066.1566/E4854.3317 | T4 ST3 | 53 | 0-14 cm gray brown silty loam, 14-53 cm medium brown silty clay; 3 glass, 1 brick, few bricks and charcoal frags from 15-25 cmbs |
| N5066.5699/E4870.5926 | T4 ST4 | 35 | 0-24 cm gray brown silty loam, 24-35 cm medium brown silty clay; 1 button, 1 flake, 7 nails, 1 glass, brick |
| N5066.3161/E4887.2676 | T4 ST5 | 80 | 0-23 cm brown silty loam, 23-43 mottled lt brown-medium brown silty loam-clay, 43-67 cm brown/gray clay loam, 67-80 cm brown silty clay; 1 whiteware sherd, 1 debitage, brick |

| Table 12. Concluded | | | |
|---|---|---|---|
| Coordinates | Line and test number (T* ST*) | Depth (cm) | Description |
| N5066.1708/E4903.5458 | T4 ST6 | 46 | 0-12 cm medium brown silty loam, 12-57 cm mottled gray brown/yellow tan silty clay, 57-72 cm gray brown silty clay; soil probe to 72 cmbs; 1994 penny, 4 nails; charcoal and brick frags at about 12 cmbs; many roots from 12 cmbs on down |
| N5066.4828/E4920.0491 | T4 ST7 | 45 | 0-45 cm brownish-gray silty soil; lots of tree roots; 2 glass, 1 nail, brick |
| N5066.2898/E4935.9211 | T4 ST8 | 90 | 0-23 cm brown silty loam, 23-66 mottled medium brown-lt brown silty clay, 66-90 brown silty loam clay; 1 whiteware sherd, 2 glass, 2 nails; mortar and brick |
| Crawl space under house | ST1 | 45 | Near chimney; 35 cm N and 35 cm E of NE corner of central brick support; 0-27 cm extremely dry medium brown silty loam, 27-45 extremely dry lt brown-tan silty loam; 1 glass, 2 brick, 1 wire, 1 twist tie |
| Crawl space under house | ST2 | 35 | SW corner of crawl space; 77 cm north of S wall and 71 cm east of W wall; on surface bricks, cardboard, pull top Falstaff beer cans, metal scrap, pipe joints, Birdgravel can |

Table 13. Test excavation unit descriptions.

| Excavation Unit | Excavation unit coordinates | Vertical level | Soil | Comments |
|---|---|---|---|---|
| TU1 – unit located near middle of and adjacent to the west side of the Noland House | NE: N5050.6631/E4868.9394 SE: N5047.3343/E4868.9034 SW: N5047.3515/E4865.9430 NW: N5050.6410/E4865.9083 | L1 (0-10 cmbs) | Medium brown silty loam | Brick and mortar concentrated near wall of house; small pieces found throughout unit but not collected; artifacts include 9 nails, 2 screws, 4 glass, 1 whiteware sherd, 1 rodent tooth; coal, slag noted but not collected |
| | | L2 (10-20 cmbs) | Medium brown silty loam transitioned to lighter brown silty soil near bottom of level | High artifact concentration in east side of unit (against house); artifacts consist of building debris (brick, mortar, etc.); most associated with building episode of house; 1 long nail, 1 rodent bone, 19 nails, 1 piece of green glass, 1 plastic, 1 bone frag, 5 pieces of debitage, 2 whiteware sherds, 1 large piece of glass, 9 pieces clear glass; lots of brick, mortar, slag, and coal noted but not collected |
| | | L3 (20-30 cmbs) | Mottled lt brown to medium brown loamy clay – fill material | 4 nails, 1 pc wire, 2 glass, 1 button |

Table 13. Continued

| Excavation Unit | Excavation unit coordinates | Vertical level | Soil | Comments |
|---|---|---|---|---|
| | | L4 (30-40 cmbs) | Medium brown silty loam gave way to dark brown silty (35-40 cmbs) clay soil; soil probes at each corner indicated the soil was consistent throughout the cores | 1 bullet, 6 nails, 2 metal pieces, melted glass, 1 plastic piece, 1 glass; brick, mortar, coal, and slag noted but not collected |
| TU2 | NE: N5038.2839/E4841.3611 SE: N5035.1114/E4841.7565 SW: N5035.0632/E4838.1223 NW: N5038.2222/E4838.0450 | L1 (0-10 cmbs) | Gravel layer; thick layer of crushed gravel; rock fill under thin layer of top soil | 1 glass, 1 screw, 1 nail, 1 pc plastic (all in top level of soil); below grass was all crushed limestone/ dolomite |
| | | L2 (10-20 cmbs) | Dark brown soil under gravel with brick and slate (possibly shingle) mixed in fill, screens easy | Slate, bone, porcelain, glass, nails, bone |
| | | L3 (20-30 cmbs) | Lighter brown sandy loam; soil a little more hard to screen | Black walnut root laying E-W in bottom of level; glass, ceramics, brick, nails |
| | | L4 (30-40 cmbs) | Moist dark brown silty clay | Rotting, large walnut roots; 5 ceramic sherds, 2 glass, 2 bone, 1 nail; uncollected coal fragments and very small brick pieces |

Table 13. Concluded

| Excavation Unit | Excavation unit coordinates | Vertical level | Soil | Comments |
|---|---|---|---|---|
| | | L5 (40-50 cmbs) | Dark brown silty clay to 50 cmbs; probed NW corner to 90 cmbs – soil continued to be the same until about 75 cmbs where it had a slight mottling with yellow/tan silty clay | 1 brick fragment at top of level but it was not collected |
| TU3 – North edge of yard | NE: N5058.1767/E4844.8683<br>SE: N5054.9384/E4844.9640<br>SW: N5054.8910/E4841.6855<br>NW: N5058.1982/E4841.6855 | L1 (0-10 cmbs) | Medium brown silty loam, dry | 1 terracotta pot rim, 2 whiteware sherds, 9 glass, 1 button, 3 plastic, 2 metal wrappers/foil; some mortar noted but not collected |
| | | L2 (10-20 cmbs) | Medium brown silty loam | 1 pop tab, 5 flat glass, 22 curved glass, 6 nails, 9 whiteware sherds, 2 pc terracotta, 1 stoneware sherd, 2 porcelain; brick, slate, coal, and mortar were noted but not collected |
| | | L3 (20-30 cmbs) | Medium brown silty loam turning to medium brown silty clay close to 20 cmbs; northeast quadrant has some mottling with yellow/tan silty clay | 12 glass frags, 1 metal chunk, 1 piece bone, 1 snap/button/rivet, 3 whiteware sherds |
| | | L4 (30-40 cmbs) | Medium brown silty clay with slight lt brown mottling | 1 pc curved glass |

| Table 14. Noland House Artifacts by Functional Category | | | | | |
|---|---|---|---|---|---|
| Provenience | Personal Artifacts | Kitchen/ Domestic Artifacts | Architectural Artifacts/ Hardware | Mixed-Use Artifacts | Total |
| West Basement Floor | 0 | 4 | 0 | 0 | 4 |
| Basement Crawl Space | 1 | 2 | 0 | 0 | 3 |
| TU1, Level 1 | 0 | 1 | 16 | 0 | 17 |
| TU1, Level 2 | 0 | 5 | 20 | 13 | 38 |
| TU1, Level 3 | 1 | 0 | 5 | 2 | 8 |
| TU1, Level 4 | 1 | 1 | 8 | 2 | 12 |
| TU2, Level 1 | 1 | 3 | 2 | 0 | 6 |
| TU2, Level 2 | 0 | 8 | 19 | 26 | 53 |
| TU2, Level 3 | 0 | 26 | 4 | 10 | 40 |
| TU2, Level 4 | 0 | 7 | 1 | 2 | 10 |
| TU3, Level 1 | 1 | 8 | 1 | 8 | 18 |
| TU3, Level 2 | 2 | 11 | 9 | 26 | 48 |
| TU3, Level 3 | 1 | 5 | 1 | 11 | 18 |
| Transect 1, ST1 | 0 | 5 | 13 | 20 | 38 |
| Transect 1, ST2 | 0 | 5 | 1 | 2 | 8 |
| Transect 1, ST3 | 1 | 0 | 1 | 0 | 2 |
| Transect 1, ST4 | 1 | 5 | 6 | 0 | 12 |
| Transect 1, ST5 | 0 | 1 | 0 | 3 | 4 |
| Transect 1, ST6 | 1 | 0 | 2 | 3 | 6 |
| Transect 1, ST7 | 2 | 4 | 7 | 0 | 13 |
| Transect 1, ST8 | 0 | 2 | 2 | 0 | 4 |
| Transect 2, ST1 | 0 | 0 | 4 | 2 | 6 |
| Transect 2, ST2 | 0 | 1 | 0 | 0 | 1 |
| Transect 3, ST1 | 0 | 7 | 4 | 0 | 11 |
| Transect 3, ST2 | 0 | 6 | 0 | 0 | 6 |
| Transect 3, ST3 | 0 | 1 | 0 | 0 | 1 |
| Transect 3.5, ST1 | 2 | 0 | 3 | 0 | 5 |
| Transect 4, ST1 | 1 | 2 | 7 | 0 | 10 |
| Transect 4, ST2 | 0 | 4 | 0 | 0 | 4 |
| Transect 4, ST3 | 0 | 0 | 4 | 0 | 4 |
| Transect 4, ST4 | 1 | 1 | 8 | 0 | 10 |
| Transect 4, ST5 | 0 | 1 | 15 | 0 | 16 |
| Transect 4, ST6 | 1 | 0 | 4 | 0 | 5 |
| Transect 4, ST7 | 0 | 2 | 2 | 0 | 4 |

Table 14. Concluded

| Provenience | Personal Artifacts | Kitchen/ Domestic Artifacts | Architectural Artifacts/ Hardware | Mixed-Use Artifacts | Total |
|---|---|---|---|---|---|
| Transect 4, ST8 | 0 | 1 | 7 | 2 | 10 |
| Under House, ST1 | 0 | 0 | 4 | 0 | 4 |
| Under House, ST2 | 0 | 1 | 2 | 0 | 3 |
| Total | 18 | 130 | 182 | 132 | 462 |

Table 15. Frank Wallace House Artifacts by Functional Category.

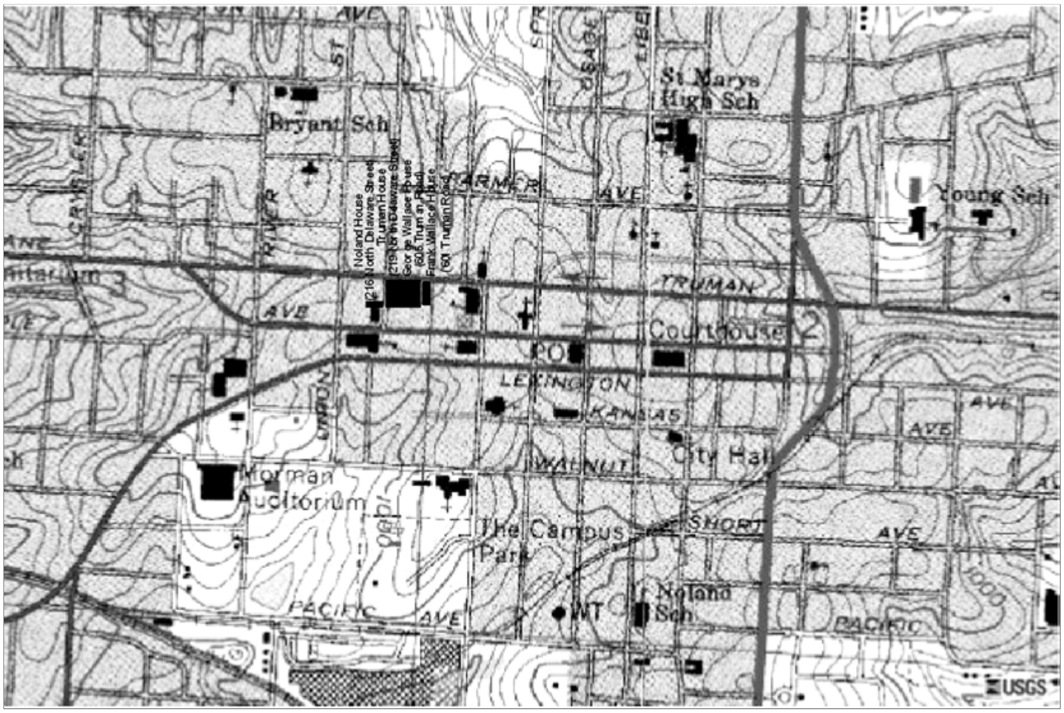
| Provenience | Personal Artifacts | Kitchen/Domestic Artifacts | Architectural Artifacts/ Hardware | Mixed-Use Artifacts | Total |
|---|---|---|---|---|---|
| West Trench Floor | 0 | 2 | 0 | 0 | 2 |
| Porch Fill | 0 | 33 | 3 | 0 | 36 |
| Slump Trench Wall | 0 | 1 | 1 | 0 | 2 |
| Under Porch | 0 | 1 | 0 | 0 | 1 |
| Total | 0 | 37 | 4 | 0 | 41 |

Table 16. Frank Wallace House Kitchen/Domestic Artifacts by Type.

| Artifact Description | Artifact Count | Material Type | Material Type Total | Provenience |
|---|---|---|---|---|
| Whiteware handle fragment | 1 | Whiteware | | West Trench Floor |
| Bone china fragment, decal decorated | 1 | Whiteware | | Porch Fill |
| Whiteware fragments, decal decorated | 3 | Whiteware | | Porch Fill |
| Whiteware fragment, annular decorated | 1 | Whiteware | | Porch Fill |
| Bone china rim fragment, decal decorated | 1 | Whiteware | | Porch Fill |
| Whiteware saucer fragment, decal decorated | 1 | Whiteware | | Porch Fill |
| Whiteware fragement, gray burned glaze | 1 | Whiteware | | Porch Fill |
| Bone china rim fragment, gilt edge decorated | 1 | Whiteware | | Porch Fill |
| Molded whiteware fragments, decorated | 3 | Whiteware | | Porch Fill |
| Plain whiteware plate fragment with maker’s mark | 1 | Whiteware | | Slump Trench Wall |
| Whiteware rim fragment, decal decorated | 1 | Whiteware | | Under Porch |
| | | Whiteware Total | 15 | |
| Undecorated porcelain body fragment | 1 | Porcelain | | West Trench Floor |
| Porcelain cup fragments, transfer print decorated | 8 | Porcelain | | Porch Fill |
| Porcelain rim fragment, transfer print decorated | 1 | Porcelain | | Porch Fill |

| Table 16. Concluded | | | | |
|---|---|---|---|---|
| Artifact Description | Artifact Count | Material Type | Material Type Total | Provenience |
| Limoges porcelain fragment with maker's mark | 1 | Porcelain | | Porch Fill |
| Porcelain rim fragment, decal decorated | 1 | Porcelain | | Porch Fill |
| Mug base fragment with gilt line decoration | 1 | Porcelain | | Porch Fill |
| | | Porcelain Total | 13 | |
| Stoneware fragment, lead-glazed | 1 | Stoneware | | Porch Fill |
| | | Stoneware Total | 1 | |
| Colorless glass bottle base | 1 | Glass | | Porch Fill |
| Screw top colorless bottle finish | 1 | Glass | | Porch Fill |
| Colorless square ink bottle, melted | 1 | Glass | | Porch Fill |
| Colorless glass bottle fragment | 1 | Glass | | Porch Fill |
| Milk glass canning jar cover inserts | 2 | Glass | | Porch Fill |
| Milk glass container fragment | 1 | Glass | | Porch Fill |
| | | Glass Total | 7 | |
| Zinc canning jar lid | 1 | Metal | | Porch Fill |
| | | Metal Total | 1 | |
| Total | 37 | | 37 | |

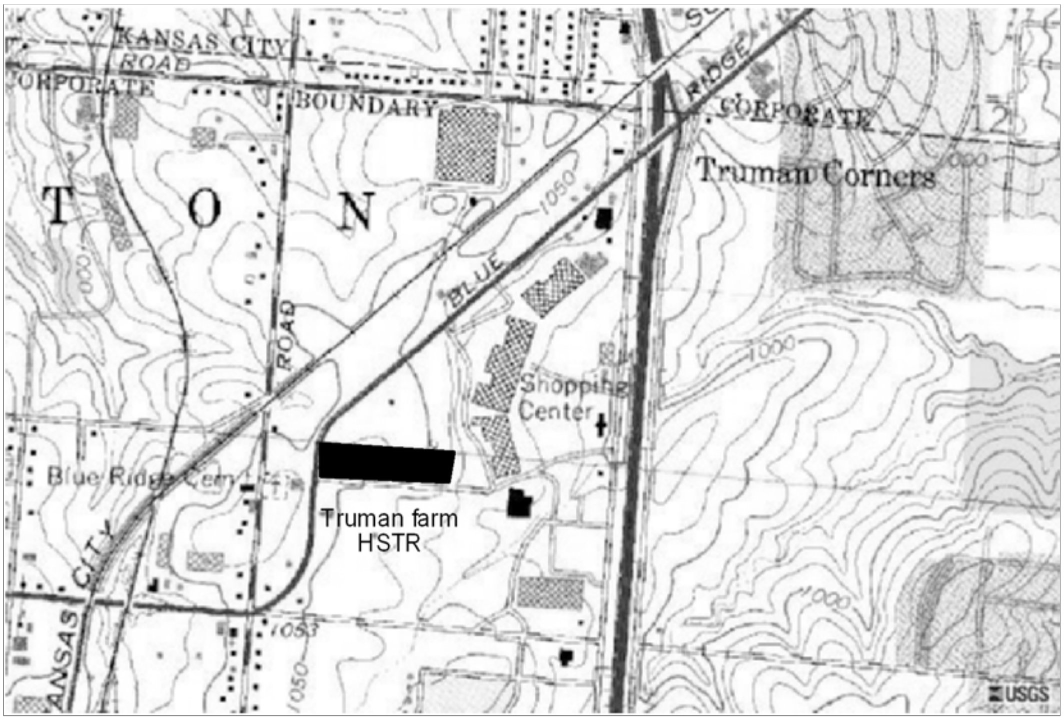
## FIGURES




a) Independence, Missouri quadrangle (USGS 7.5 minute topographic series 1990).


b) Independence, Missouri, United States (USGS aerial photograph 1996).

**Figure 1.** Location of the Noland, Truman, and Wallace properties in Independence, Missouri.




a) topographic map of Truman farm, Grandview, Missouri (USGS topo map dated 01 Jul 1995).


b) aerial photograph of the Truman farm (USGS aerial photo dated 22 March 1997).

**Figure 2.** Location of the Truman farm in Grandview, Missouri.

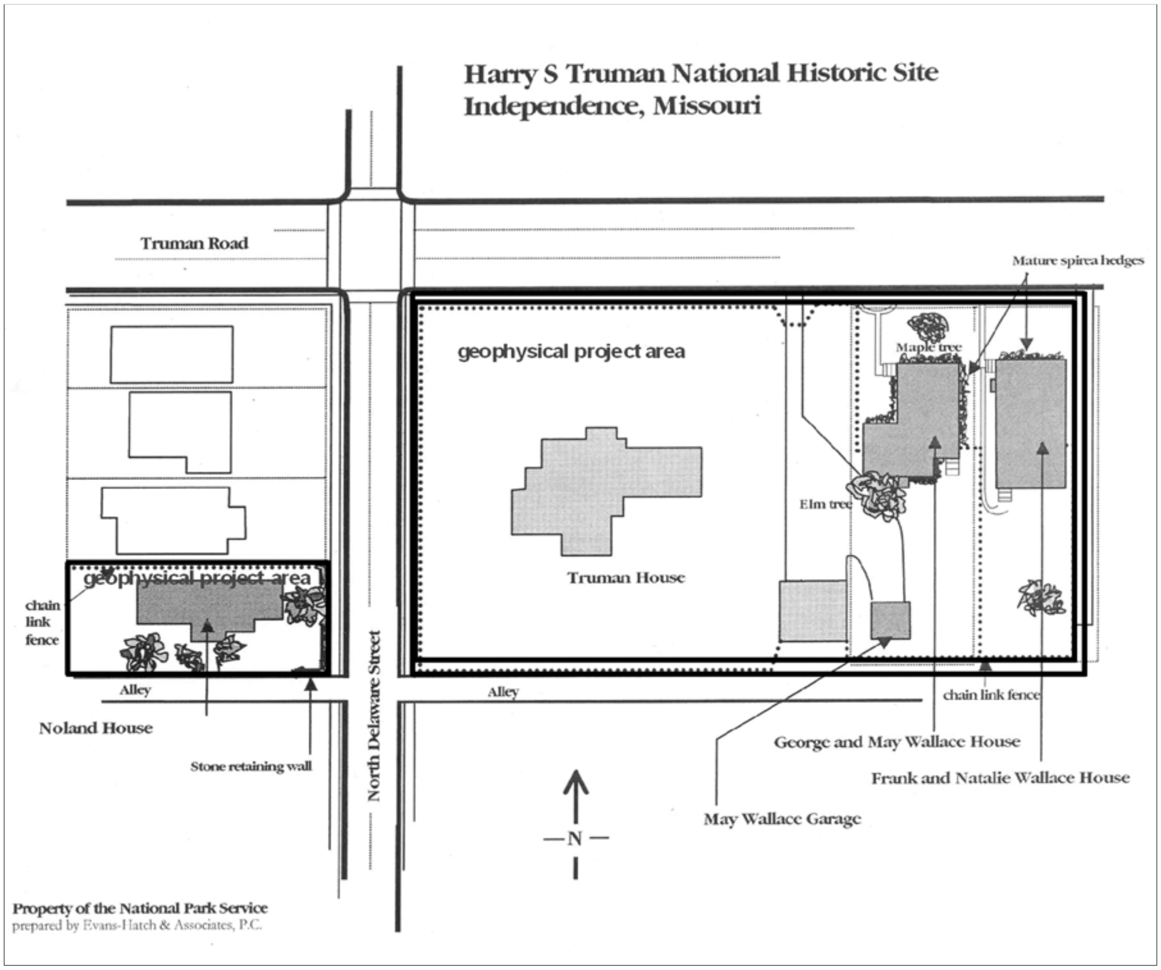
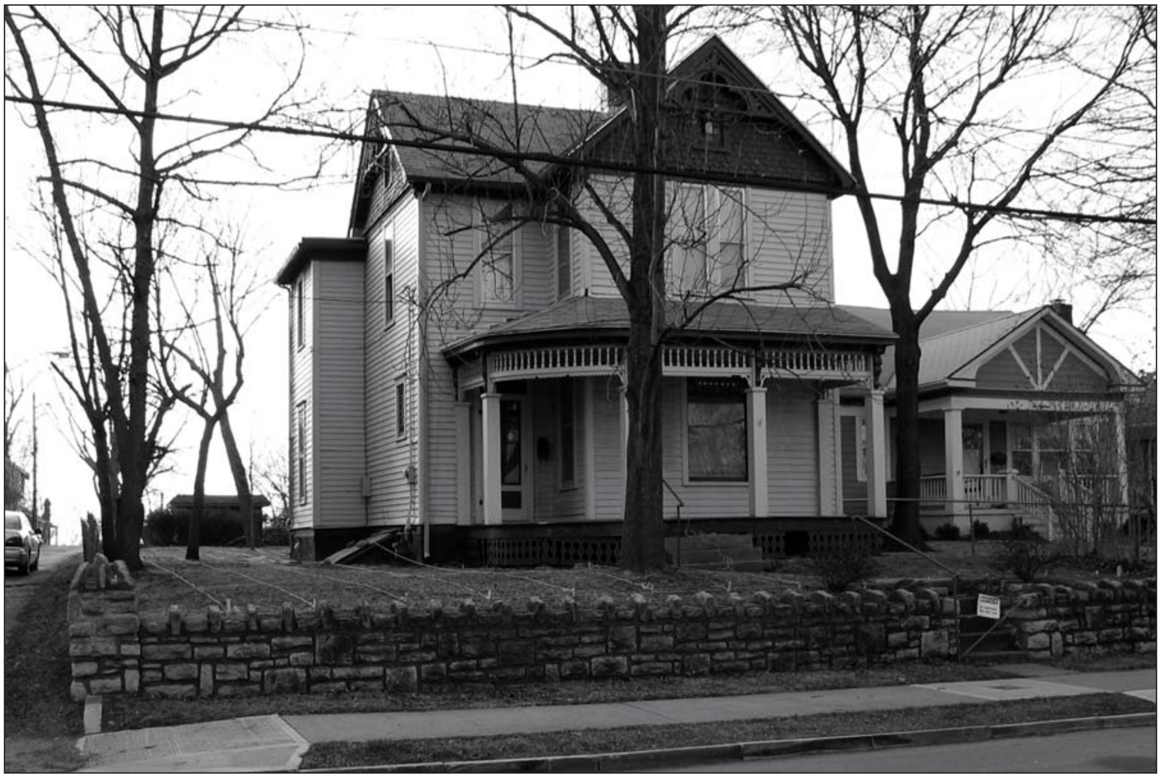



**Figure 3.** Geophysical project areas at the Harry S Truman National Historic Site.



a) Front side of the Noland House and property (view to the west).

b) Rear of the Noland House and Backyard (view to the east).

**Figure 4.** General views of the Noland House and property.

a) Front of the Truman Home and property (view to the east northeast).

b) Rear of the Noland House and Backyard (view to the east).

**Figure 5.** General views of the Truman Home and property.

a) Front side of the Noland House and property (view to the west).

b) Rear of the Noland House and Backyard (view to the east).

**Figure 6.** General views of the George Wallace House and property.


a) Front of Frank Wallace House and property (view to the south).

b) Rear of Frank Wallace Home and backyard (view to the north).

**Figure 7.** General views of the Frank Wallace House and property.

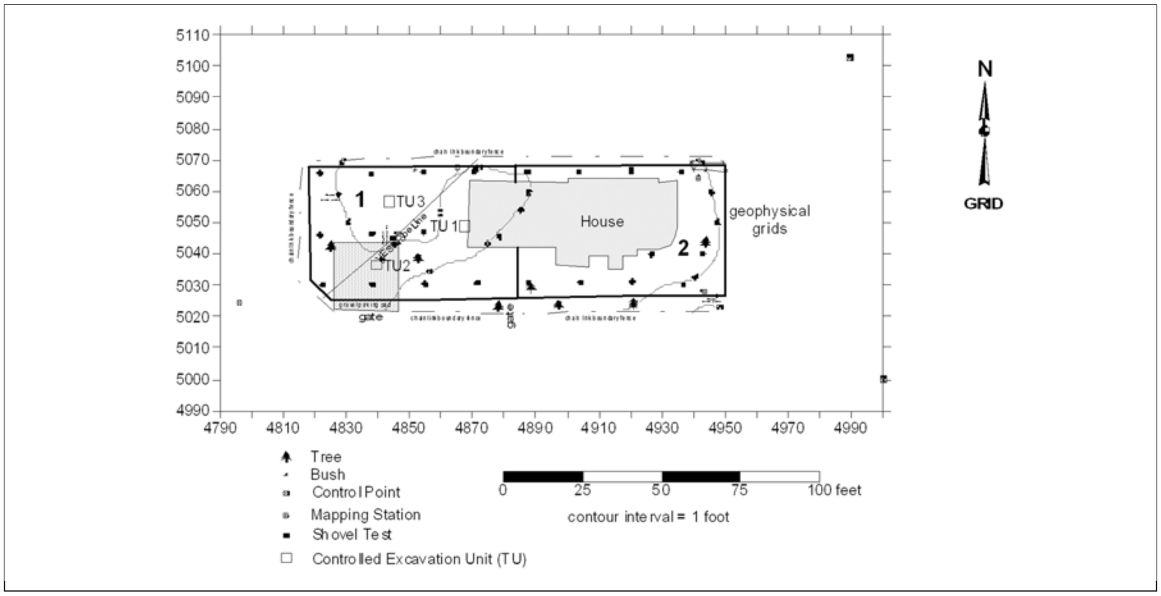



**Figure 8.** Geophysical and acheological project map of the Noland property (23JA636).


**Figure 9.** Geophysical project map of the Truman and Wallace properties (23JA634, 23JA635, and 23JA637).

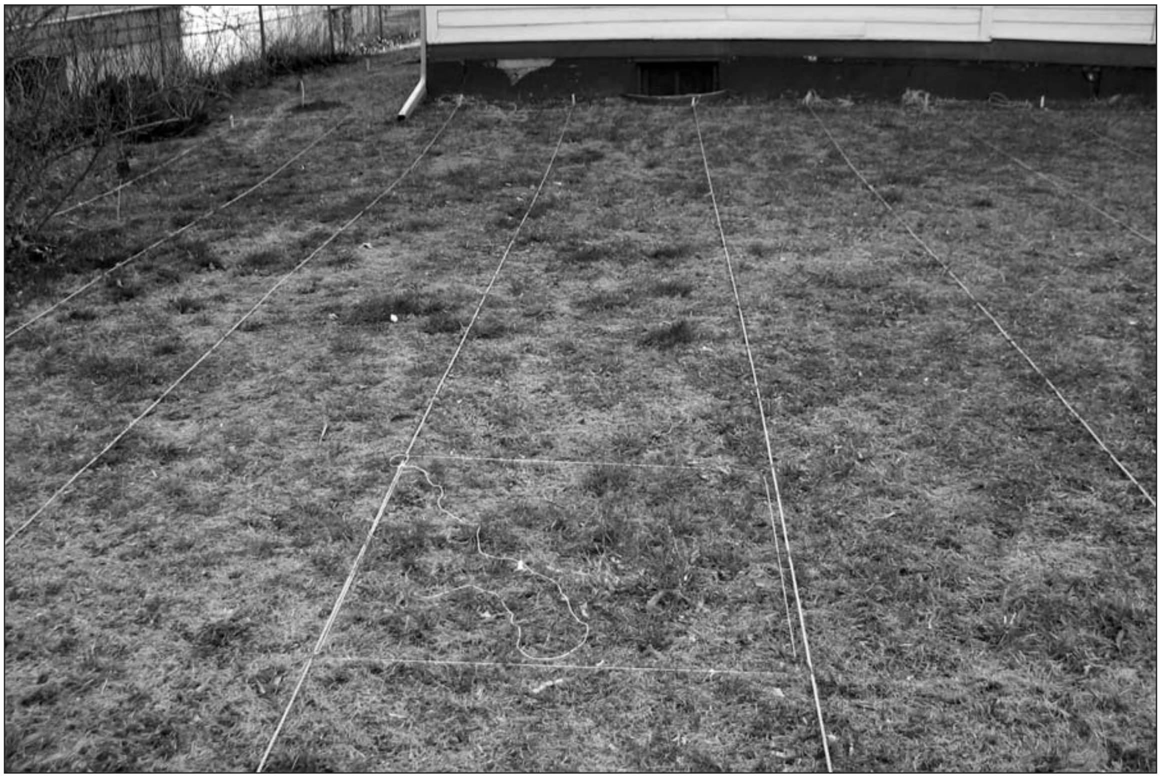


**Figure 10.** Survey ropes in the backyard of the Noland property (view to east).

**Figure 11.** Magnetic survey with the fluxgate gradiometer (view to the southwest).

**Figure 12.** Conductivity survey with the ground conductivity meter (view to the northwest).

**Figure 13.** Resistance survey with the resistance meter and twin probe array (view to the east).

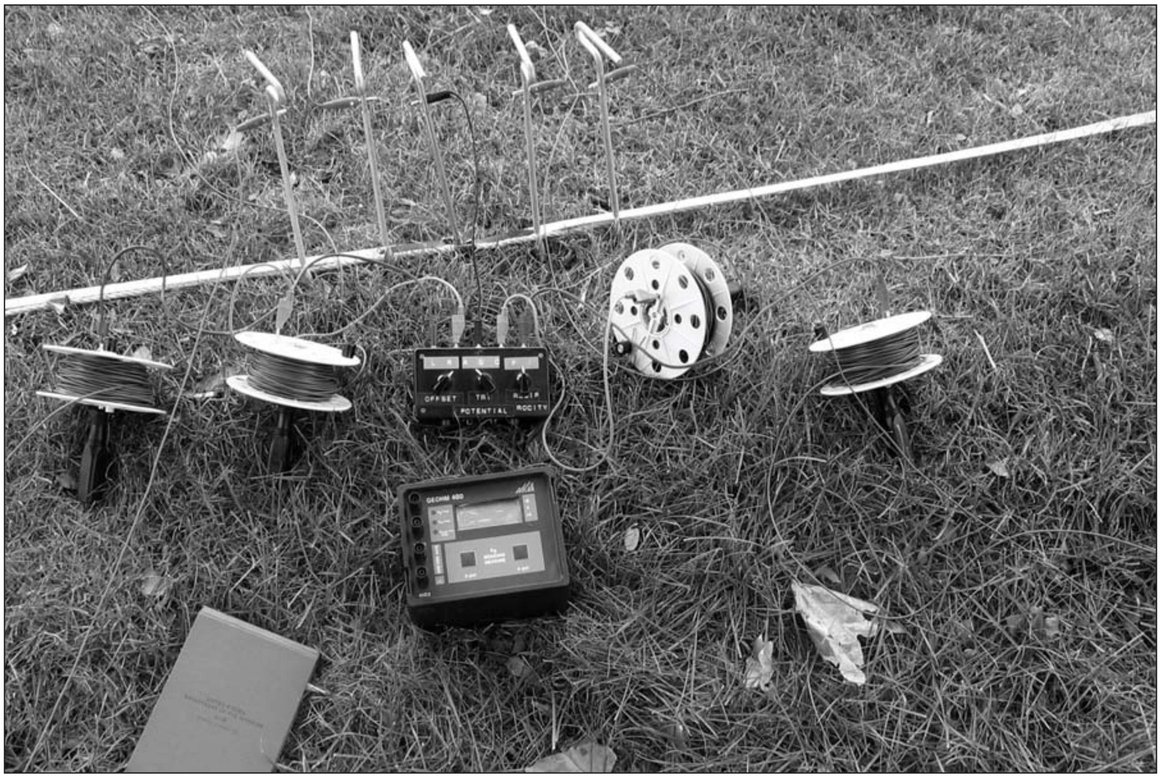


**Figure 14.** Vertical electrical sounding with resistivity meter and Wenner probe array.

**Figure 15.** Ground-penetrating radar survey with the gpr cart system and 400 MHz antenna (view to the south).

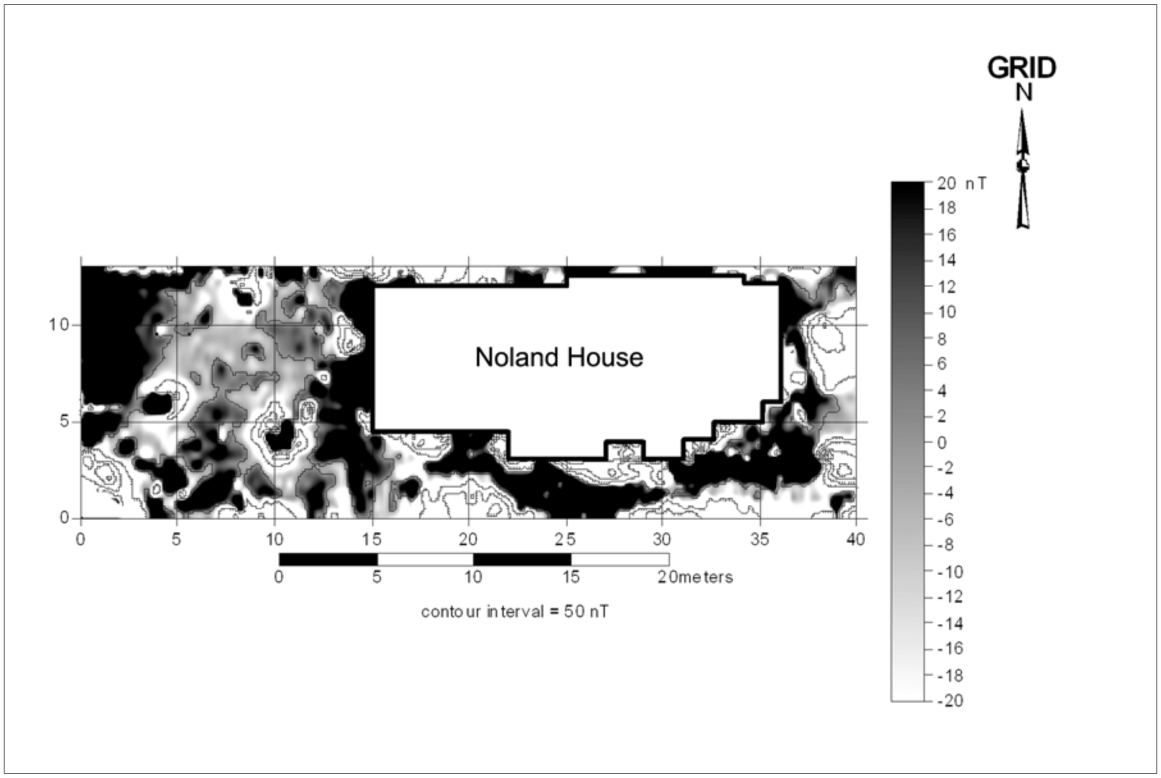



**Figure 16.** Image and contour plot of magnetic data from the Noland property.

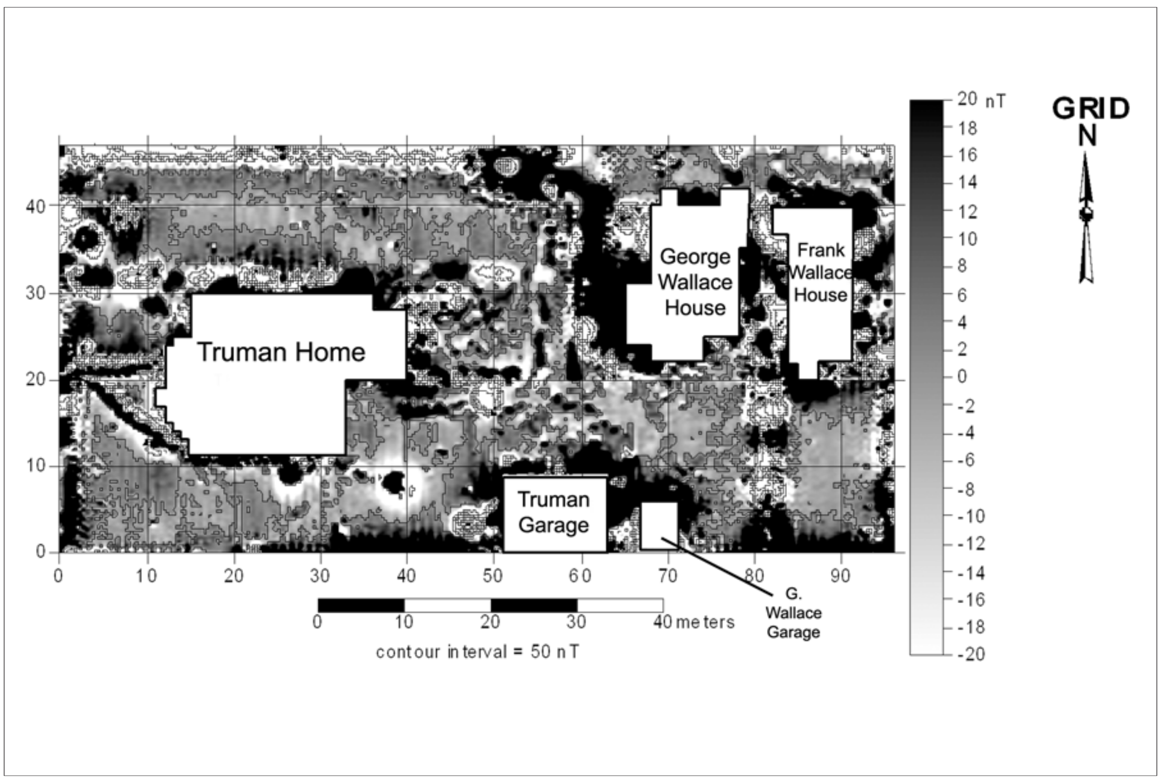



**Figure 17.** Image and contour plot of magnetic data from the Truman/Wallace properties.

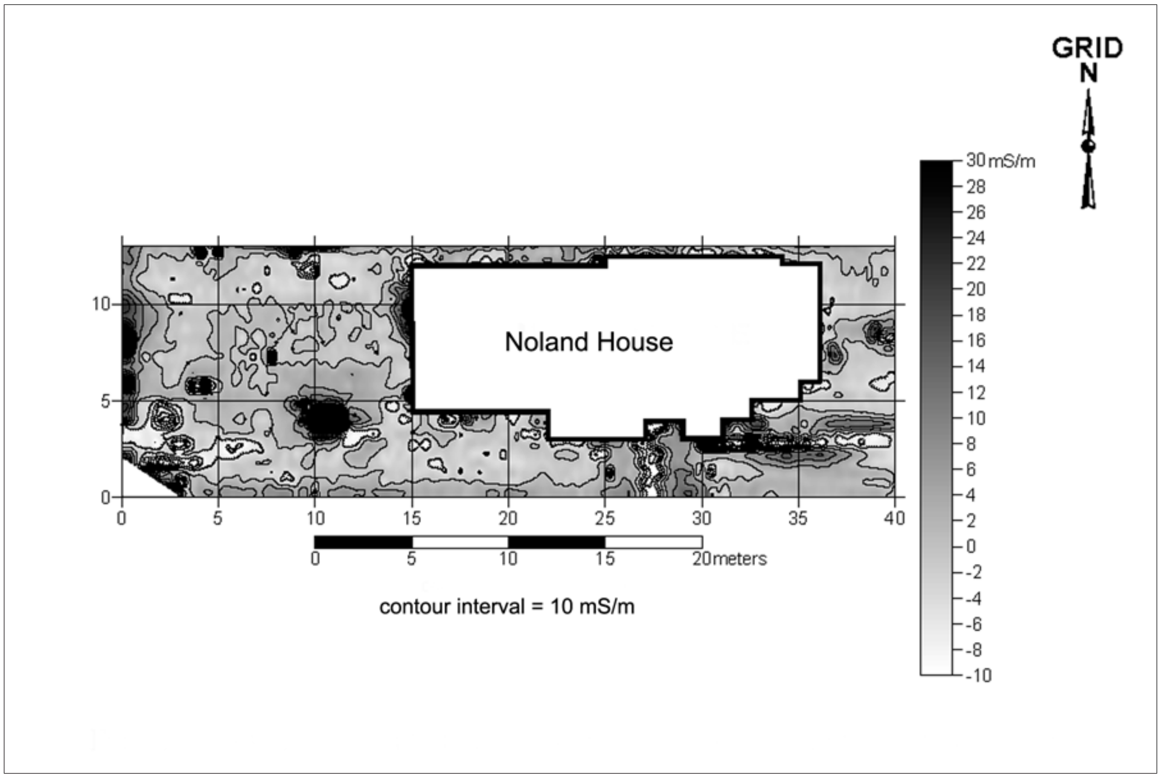



**Figure 18.** Image and contour plot of conductivity data from the Noland property.

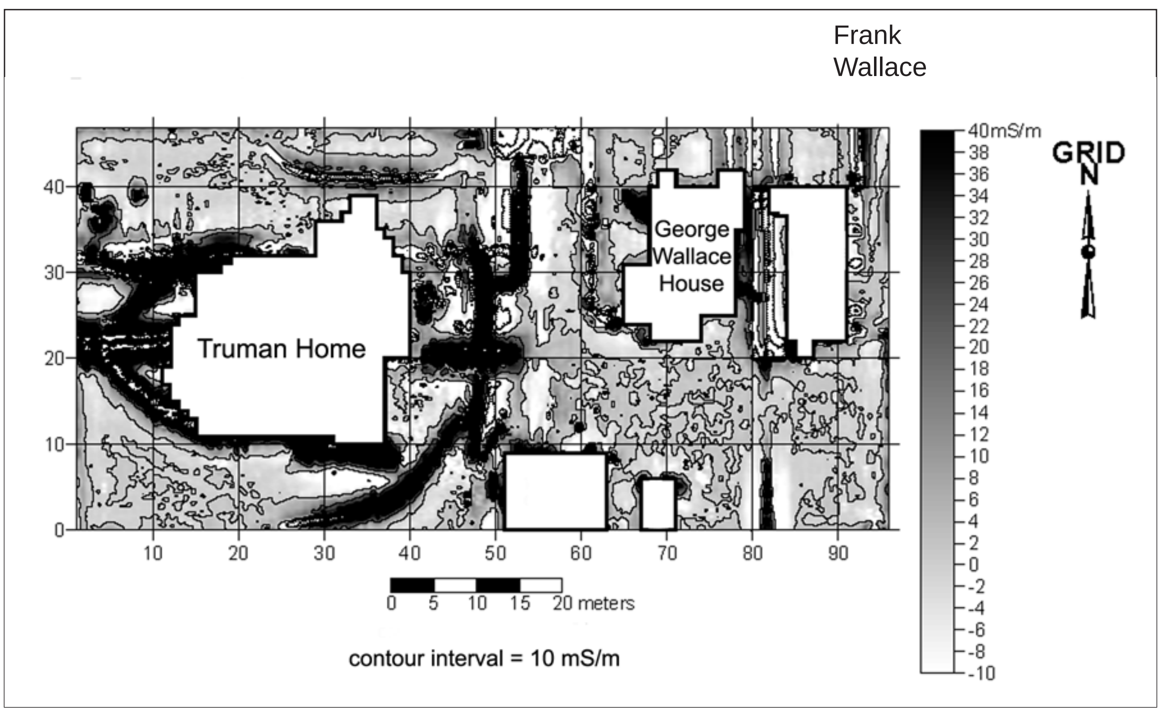



**Figure 19.** Image and contour plot of conductivity data from the Truman/Wallace properties.

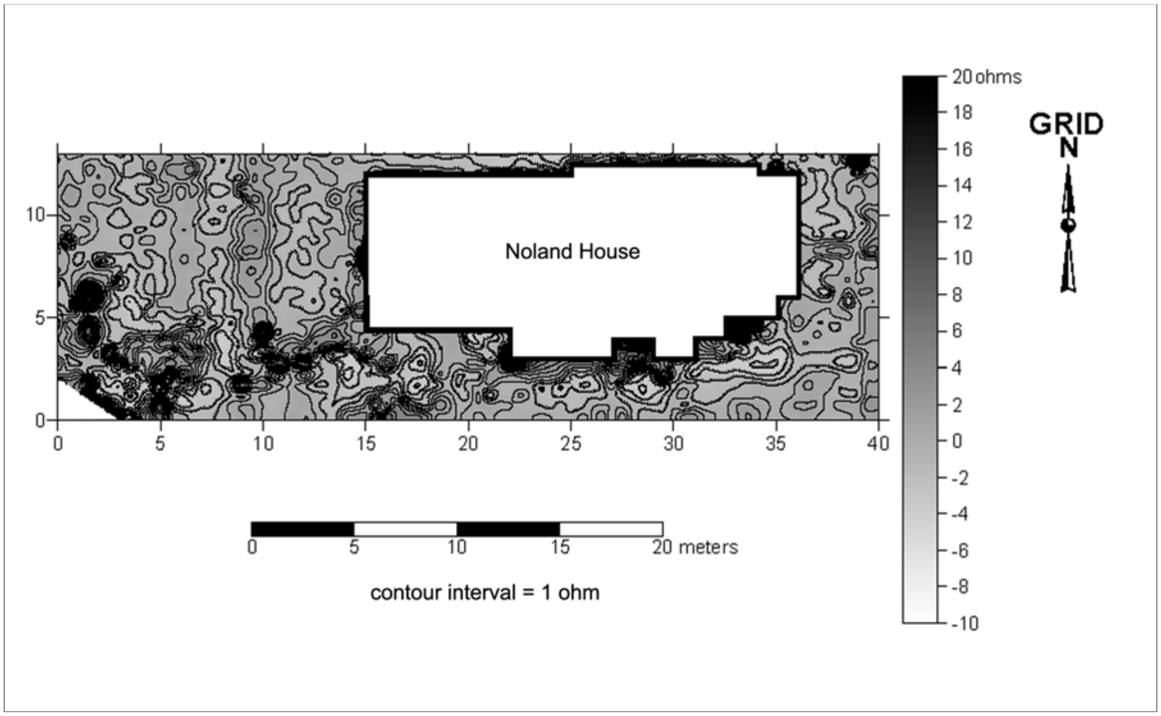



**Figure 20.** Image and contour plot for the resistance data from the Noland property.

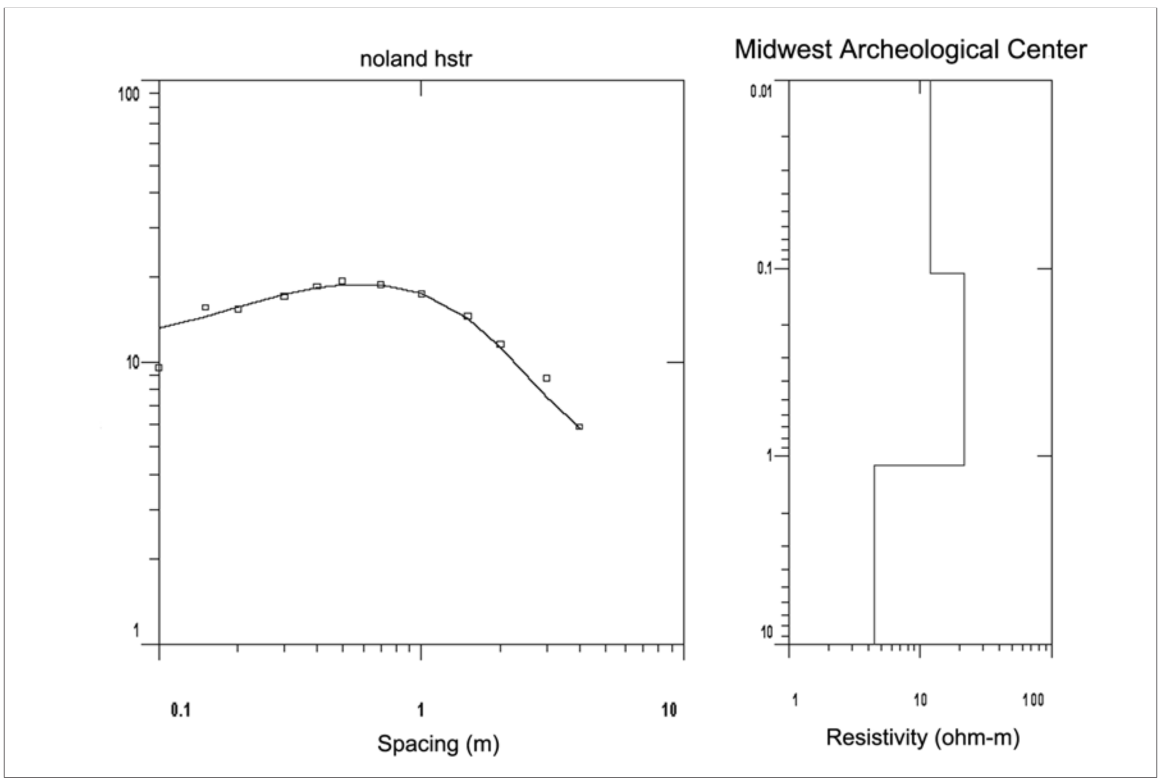



**Figure 21.** Data curve and three-layer model of vertical electrical sounding data from the Noland property.

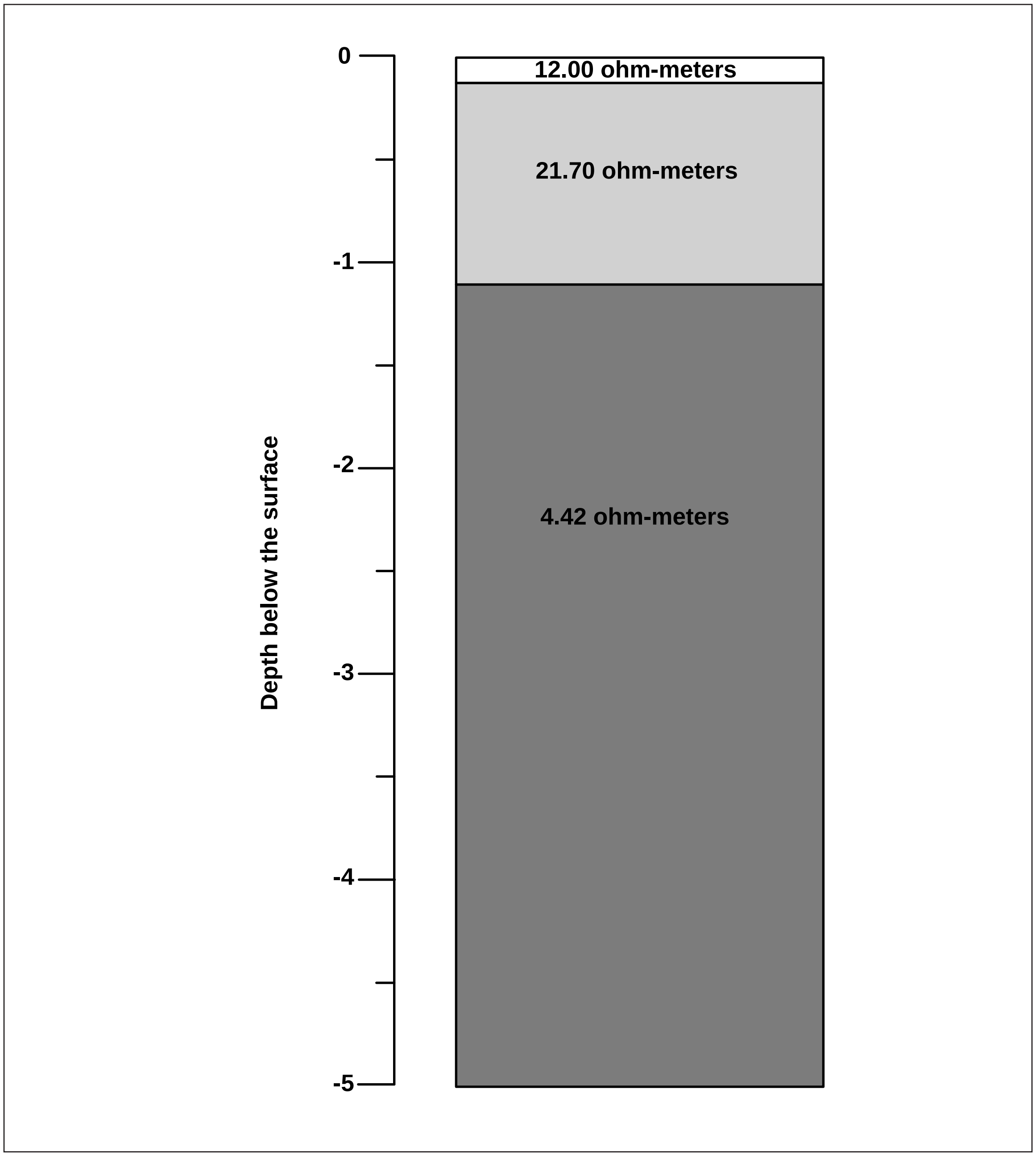



**Figure 22.** Electrical statification of the soil from the Noland property.


**Figure 23.** Time slices of ground-penetrating radar data from the Noland property.

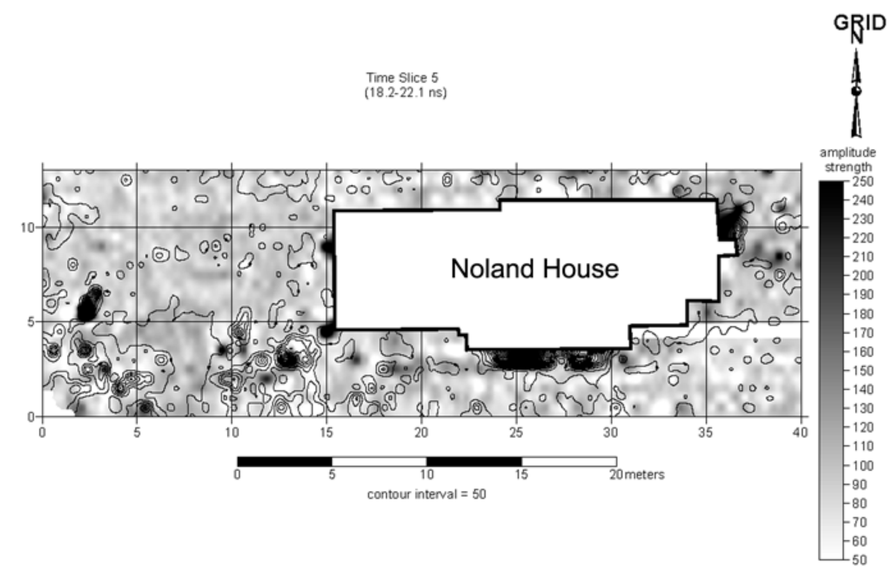



**Figure 24.** Image and contour plot of the time slice five layer data from the Noland property.

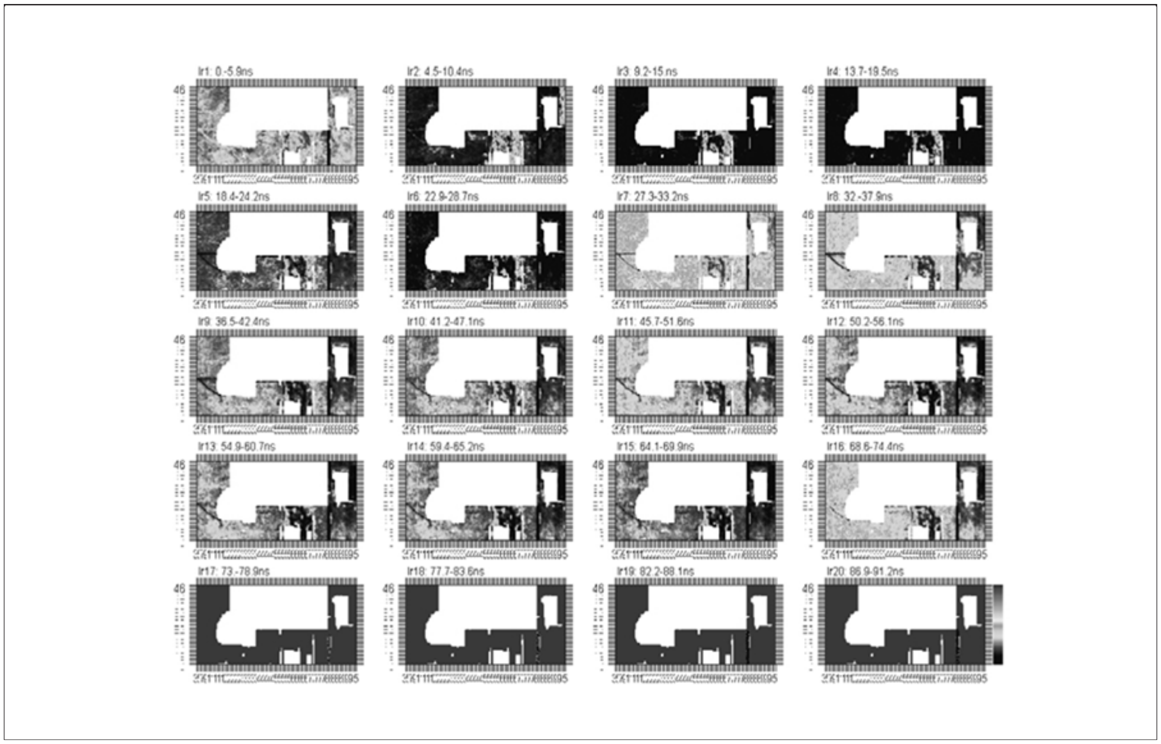


**Figure 25.** Time slices of ground-penetrating radar data from the Truman/Wallace properties.

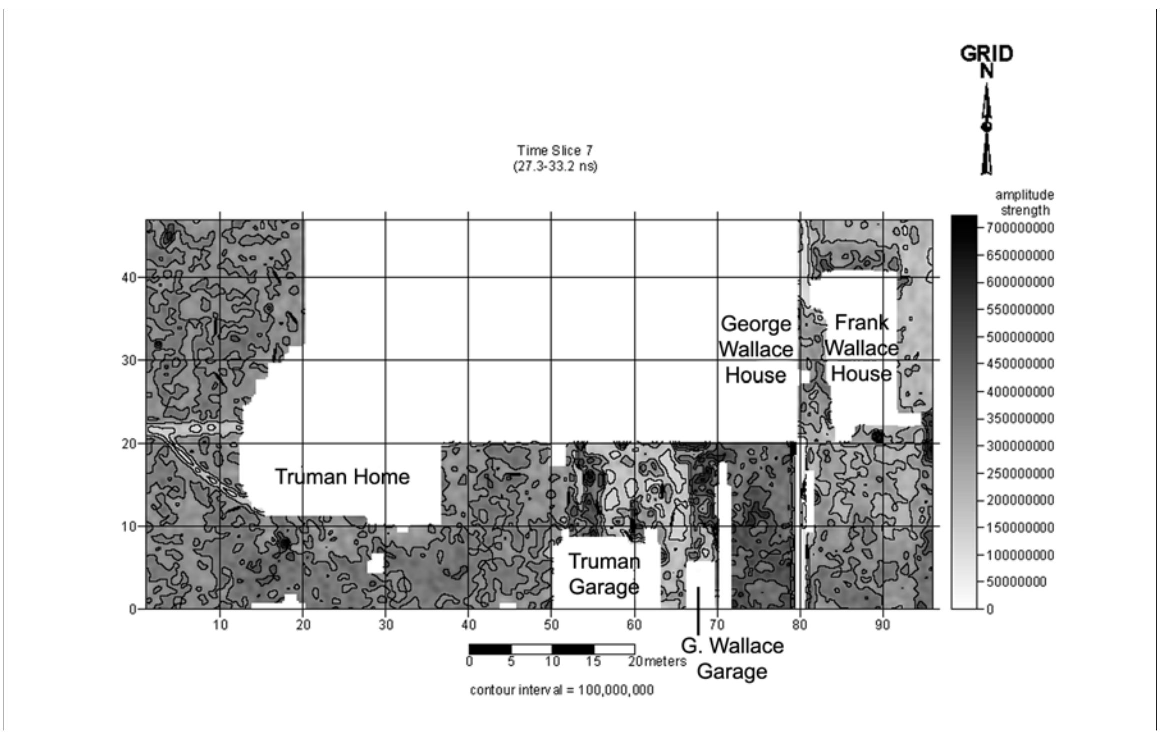



**Figure 26.** Image and contour plot of the time slice seven layer data from the Truman/Wallace properties.

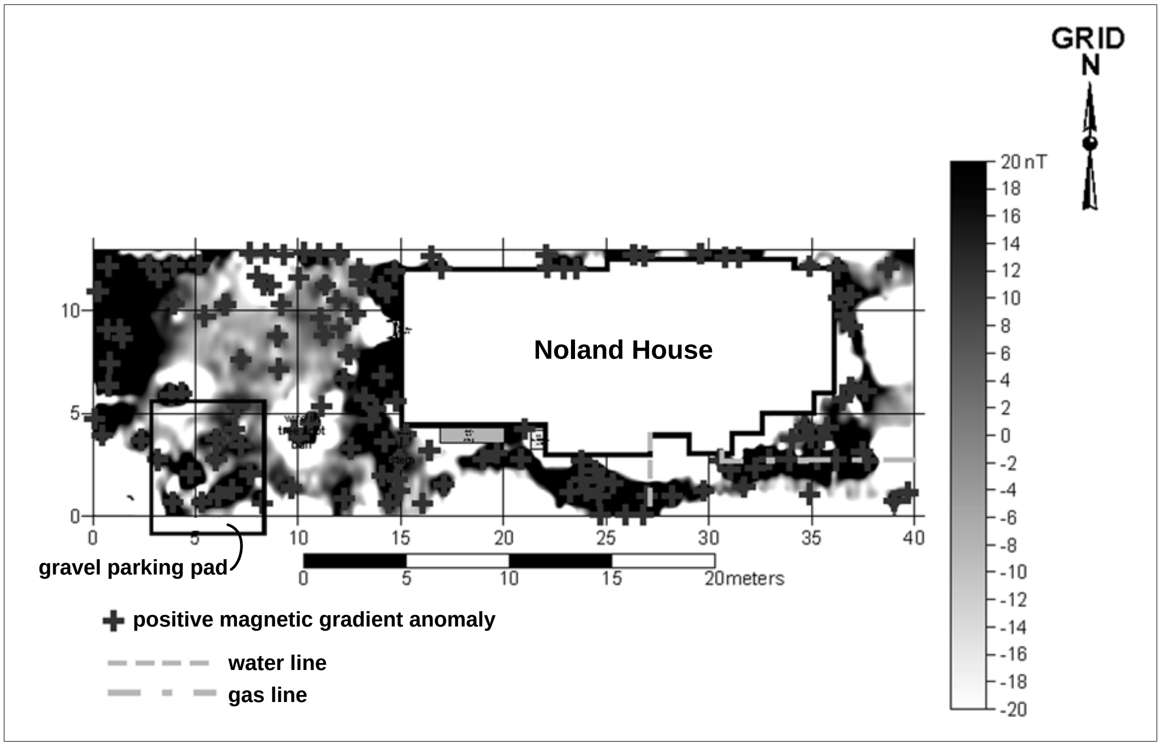



**Figure 27.** Interpretation of the magnetic data from the Noland property.

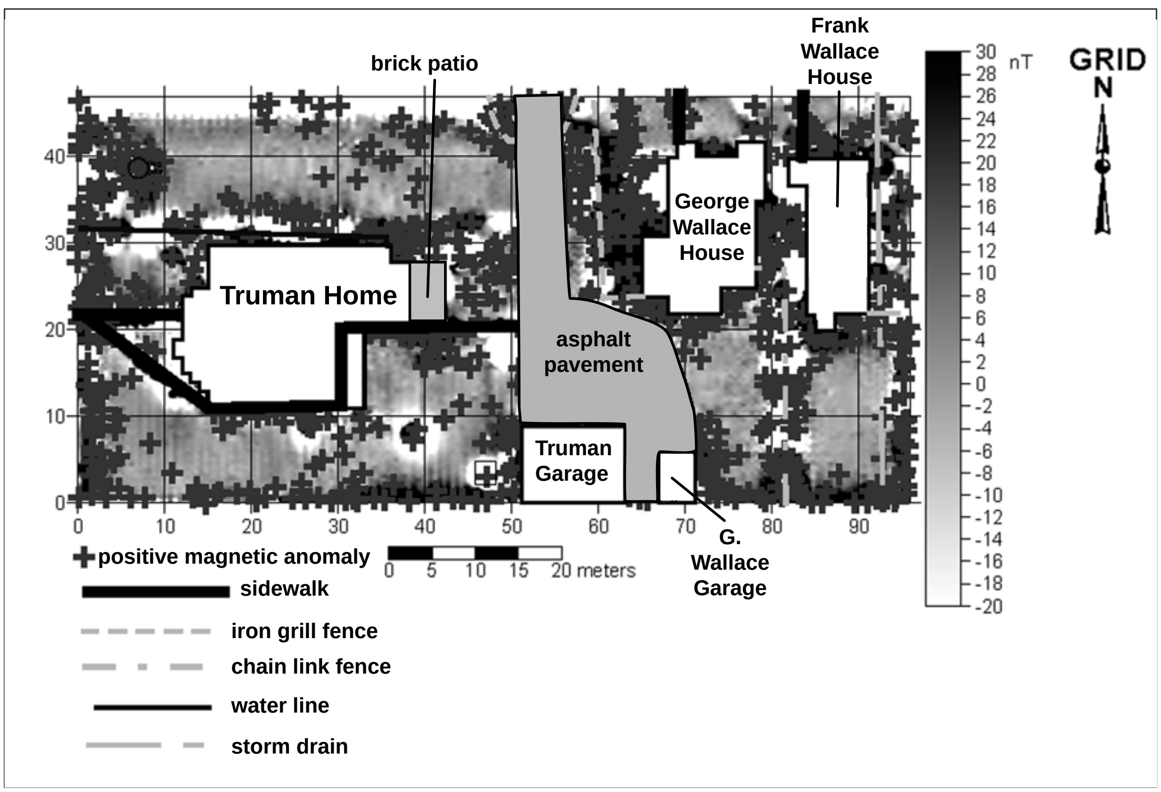



**Figure 28.** Interpretation of the magnetic data from the Truman/Wallace properties.

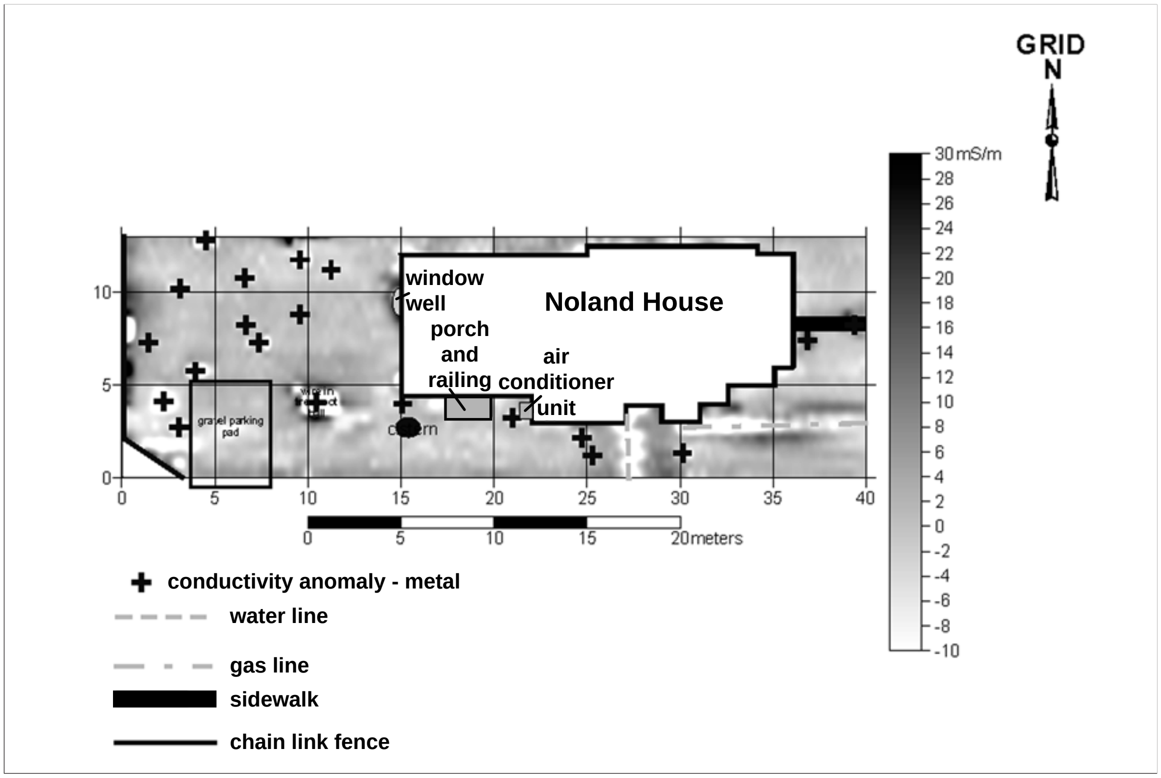



**Figure 29.** Interpretation of the conductivity data from the Noland property.

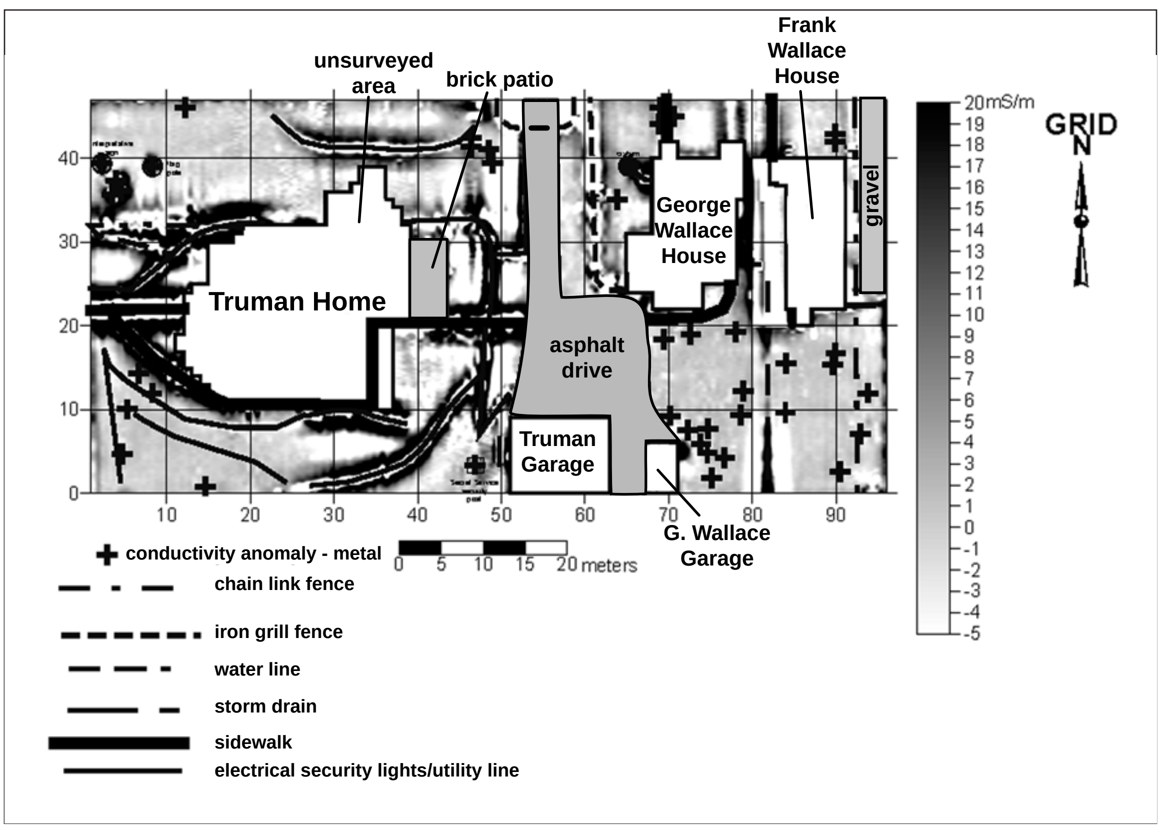



**Figure 30.** Interpretation of the conductivity data from the Truman/Wallace properties.

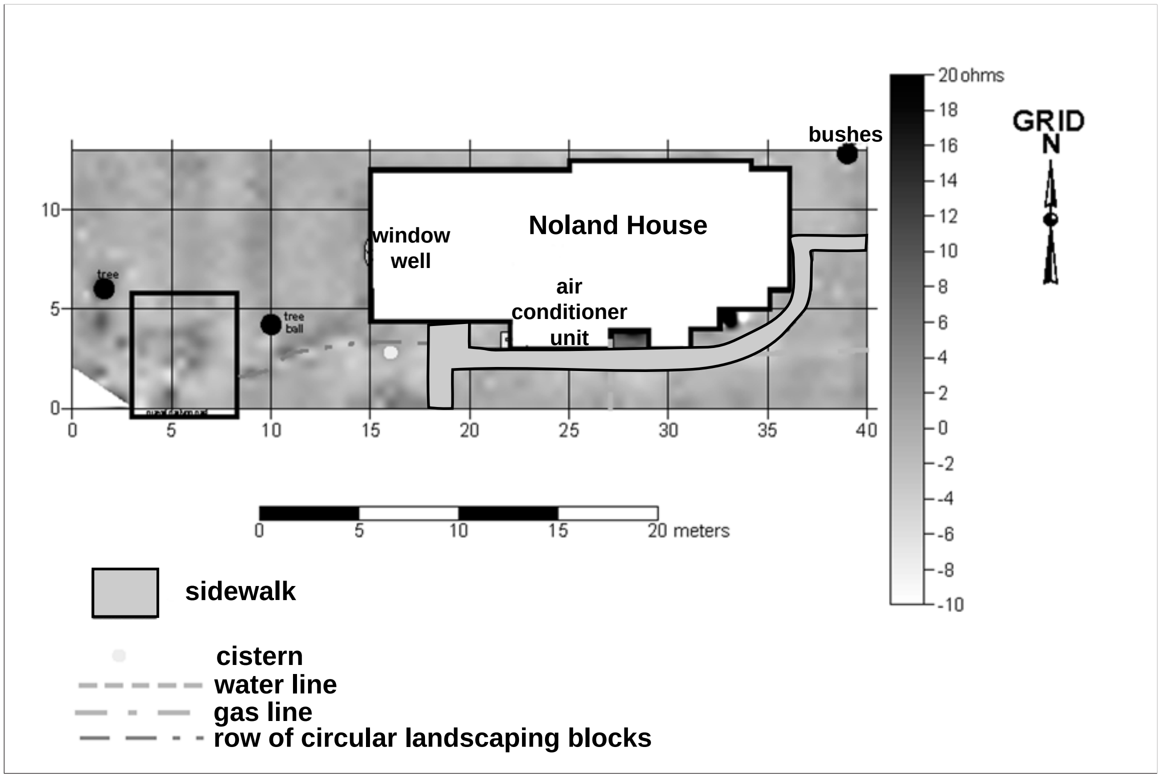



**Figure 31.** Interpretation of the resistance data from the Noland property.

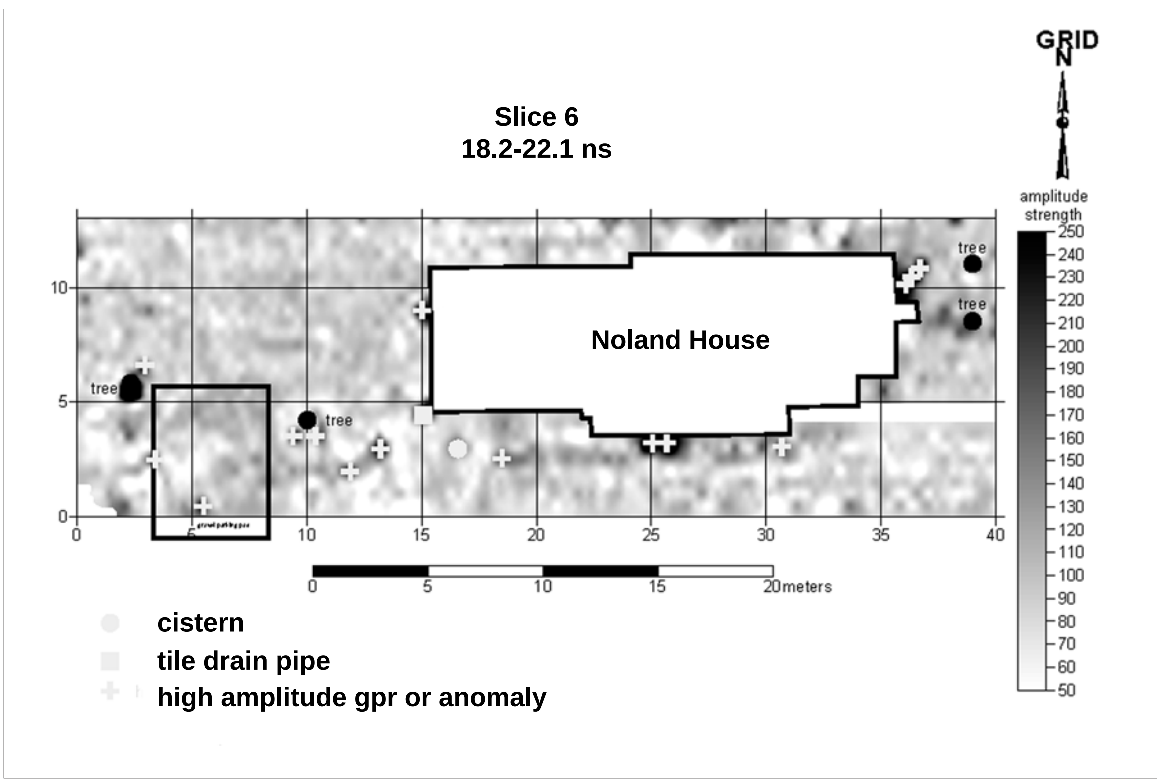



**Figure 32.** Interpretation of the time slice five layer gpr data from the Noland property.

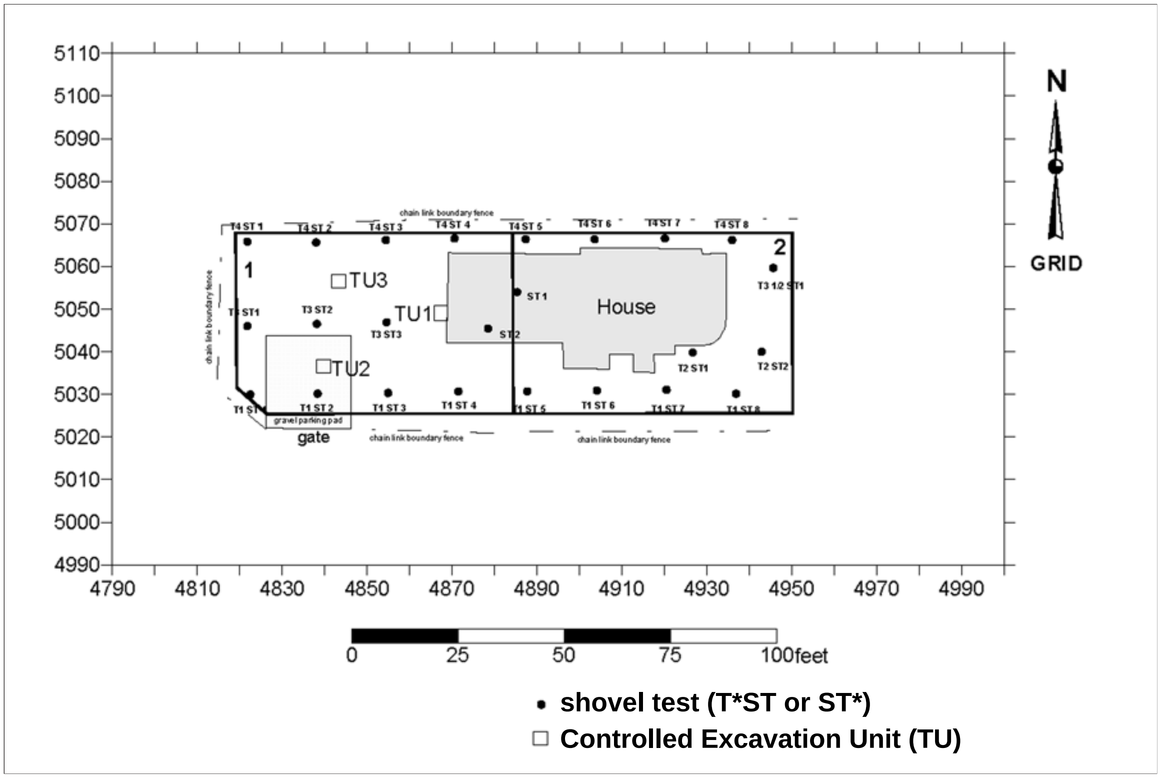



**Figure 33.** Interpretation of the time slice seven layer gpr data from the Truman/Wallace properties.

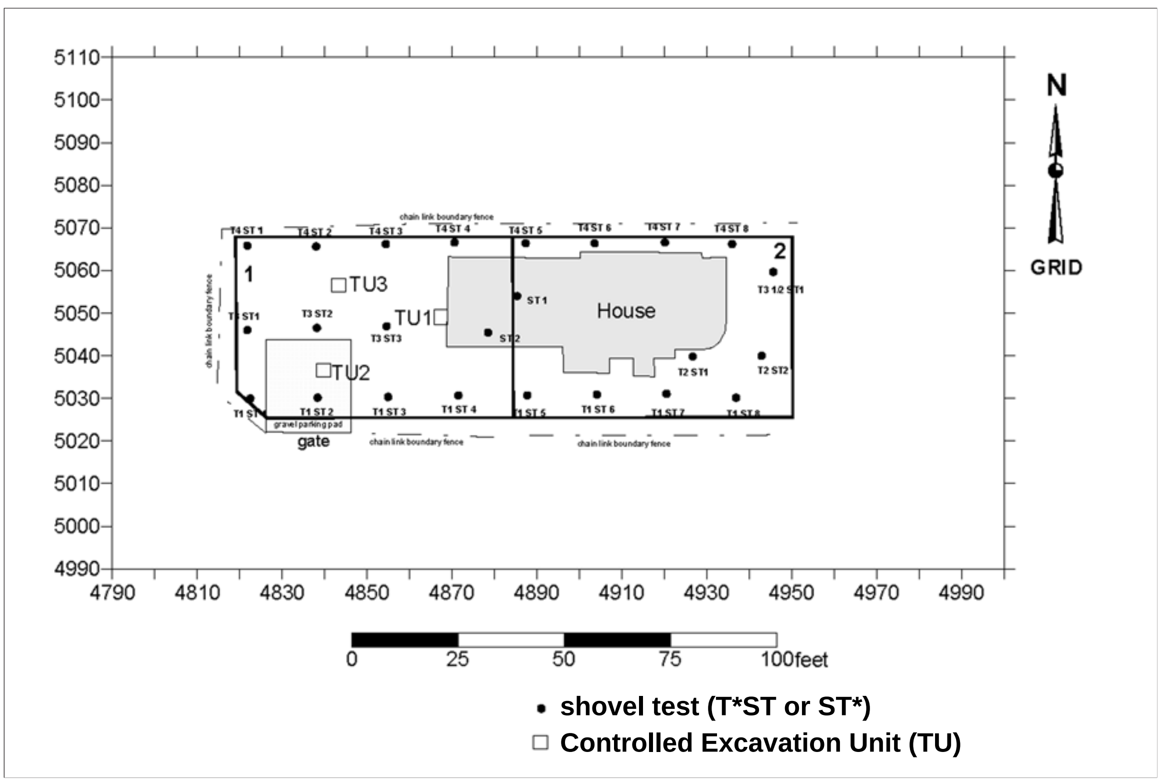



**Figure 34.** Location of shovel tests and excavation test units at the Noland property.

**Figure 35.** Excavating shovel test adjacent to front porch (view to the west northwest).

**Figure 36.** Excavating shovel test in crawl space under center part of the Noland House (view to the north).


**Figure 37.** Excavation of TU2 near southwest corner of the Noland Property (view to the west).


**Figure 38.** North wall profile of TU1 (view to the north).

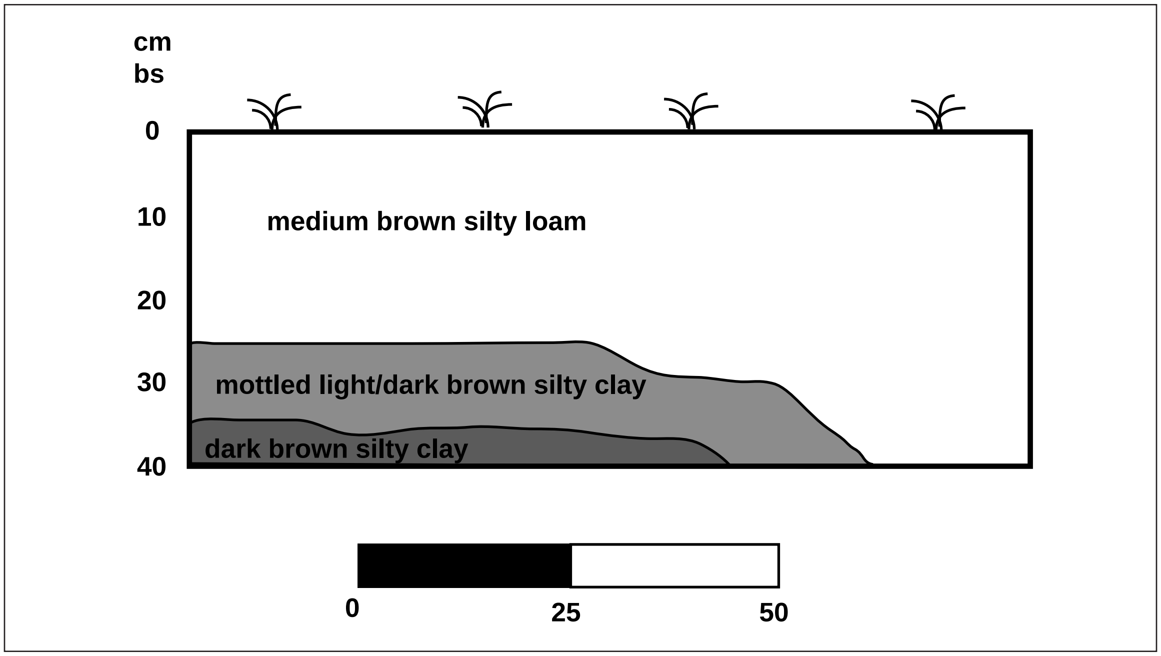



**Figure 39.** North wall profile drawing of TU1.


**Figure 40.** East wall profile fo TU1 along edge of the Noland House (view to the east).

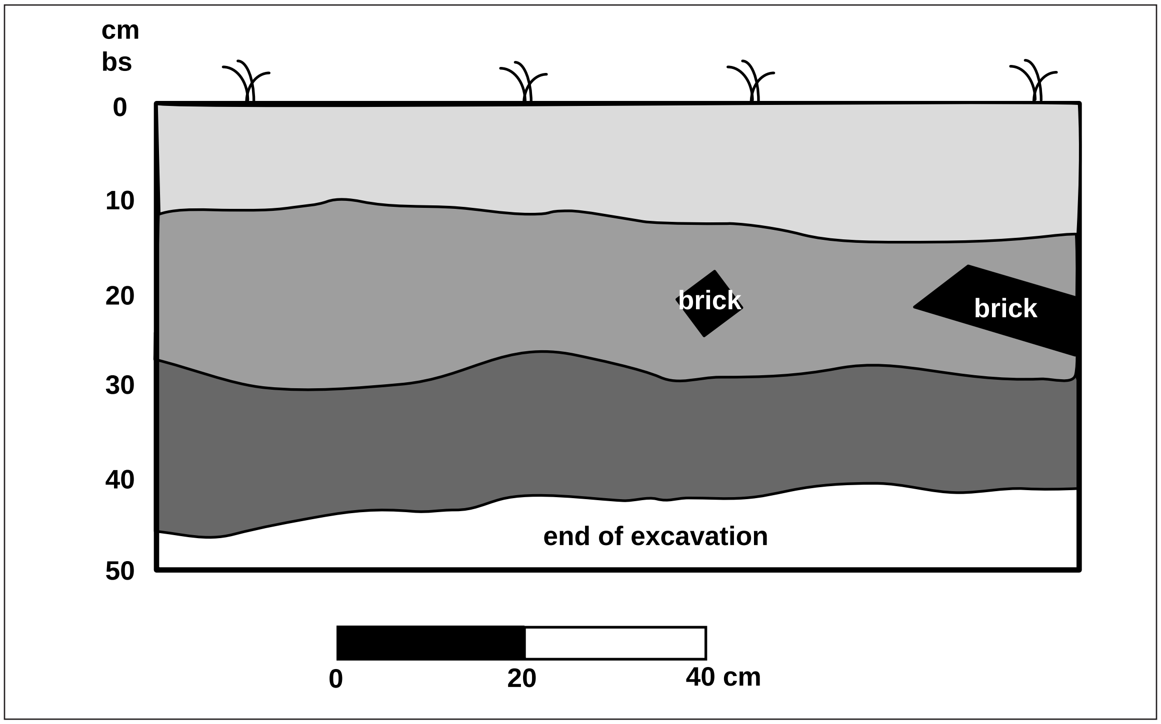



**Figure 41.** East wall profile drawing of TU1.


**Figure 42.** East wall profile of TU2 (view to the east).

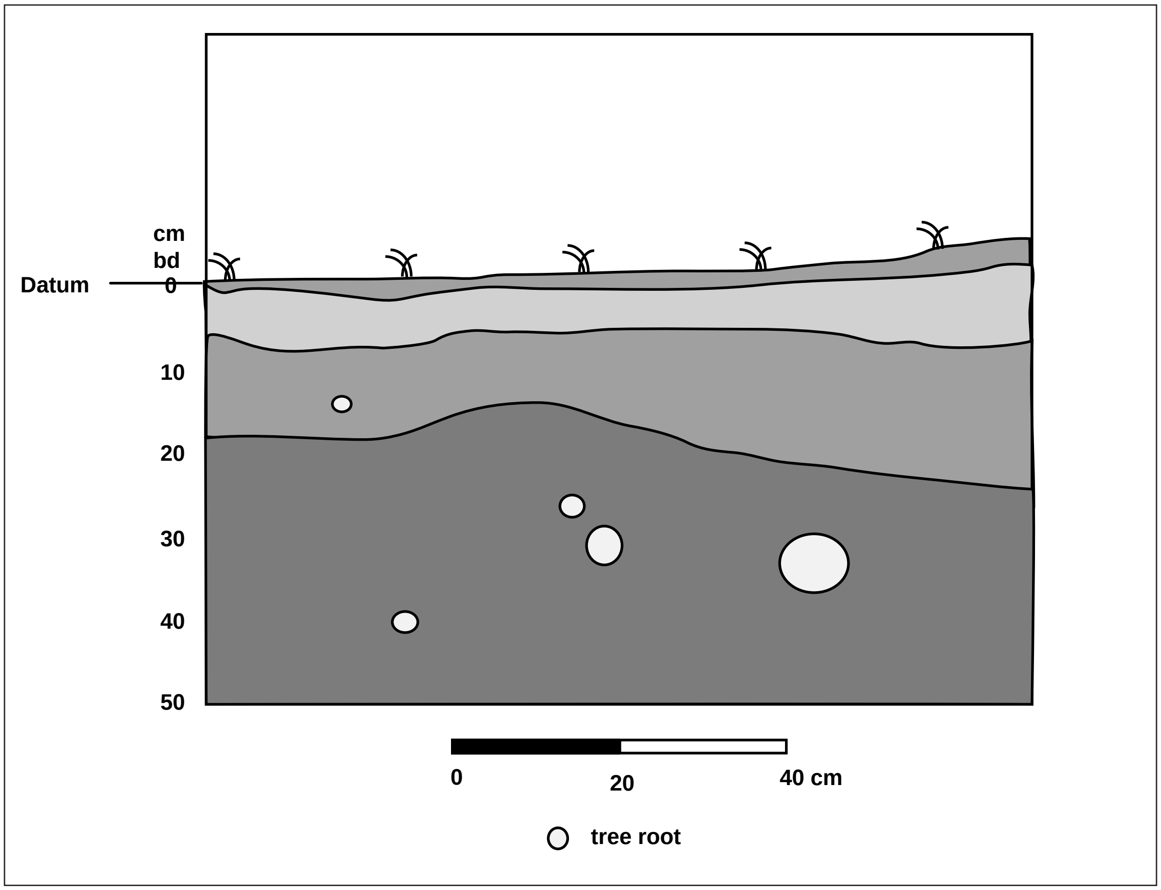



**Figure 43.** East wall profile drawing of TU2.

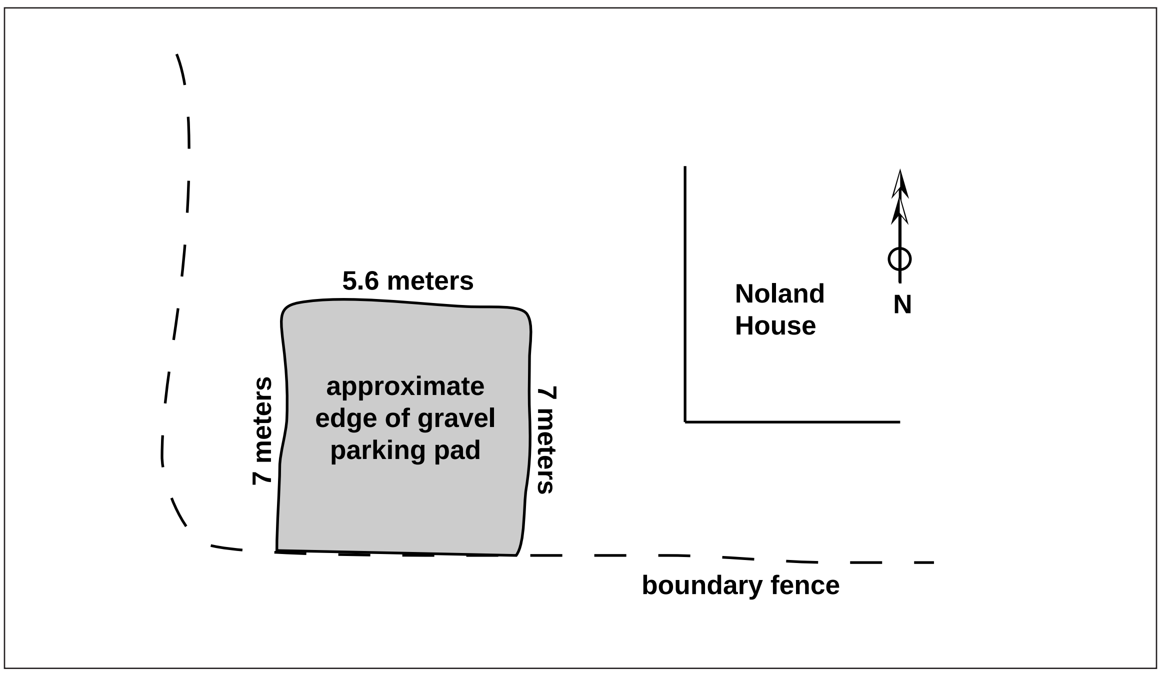



**Figure 44.** Sketch of the gravel parking pad after probing the area with a tile probe.


**Figure 45.** East wall profile of TU3 (view to the east).

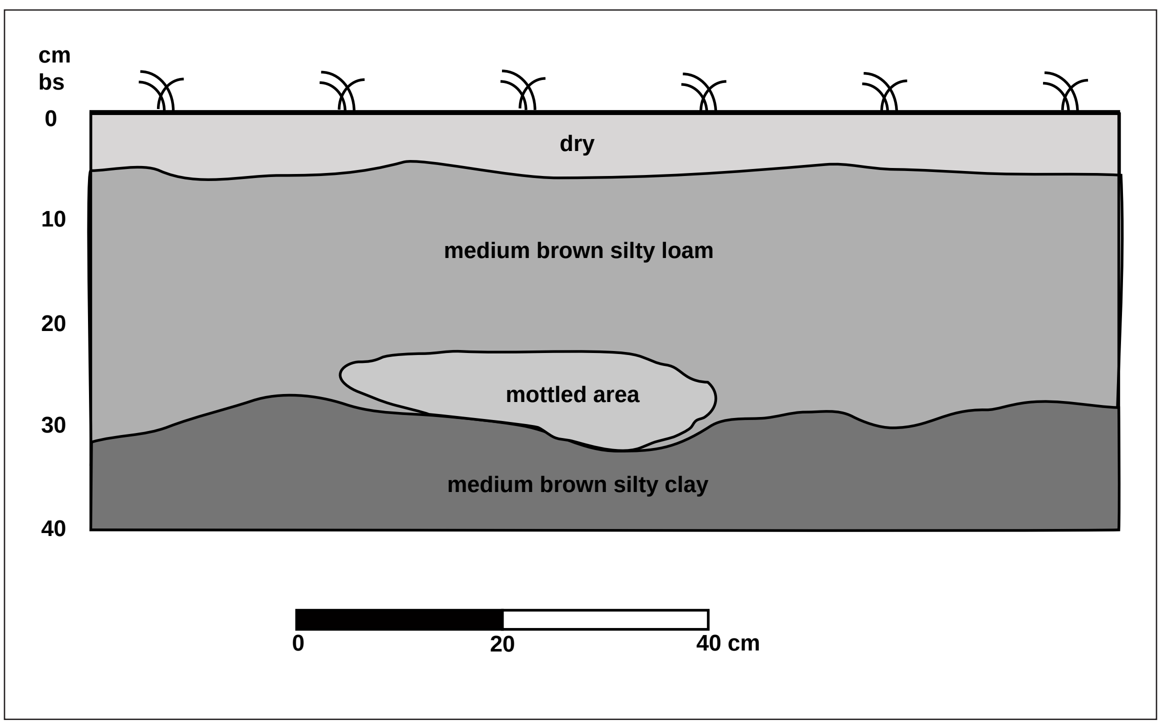



**Figure 46.** East wall profile drawing of TU3.

**Figure 47.** Noland House on shoring exposing basement and foundations (view to the northeast).


**Figure 48.** Excavation of access ramp to Frank Wallace front porch (view to the east southeast).

**Figure 49.** Removal of Frank Wallace front porch using jackhammer (view to the southeast).

**Figure 50.** Fill inside Frank Wallace front porch (view to the southwest).

**Figure 51.** Frank Wallace front porch after removal of porch foundation and fill (view to the southeast).

**Figure 52.** Exposed crawl space beneath the Noland House (view to the northeast).

**Figure 53.** Crawl space beneath the Noland House after removal of the soil (view to the northeast).


**Figure 54.** Glass bottle from Noland House (HSTR 30727).

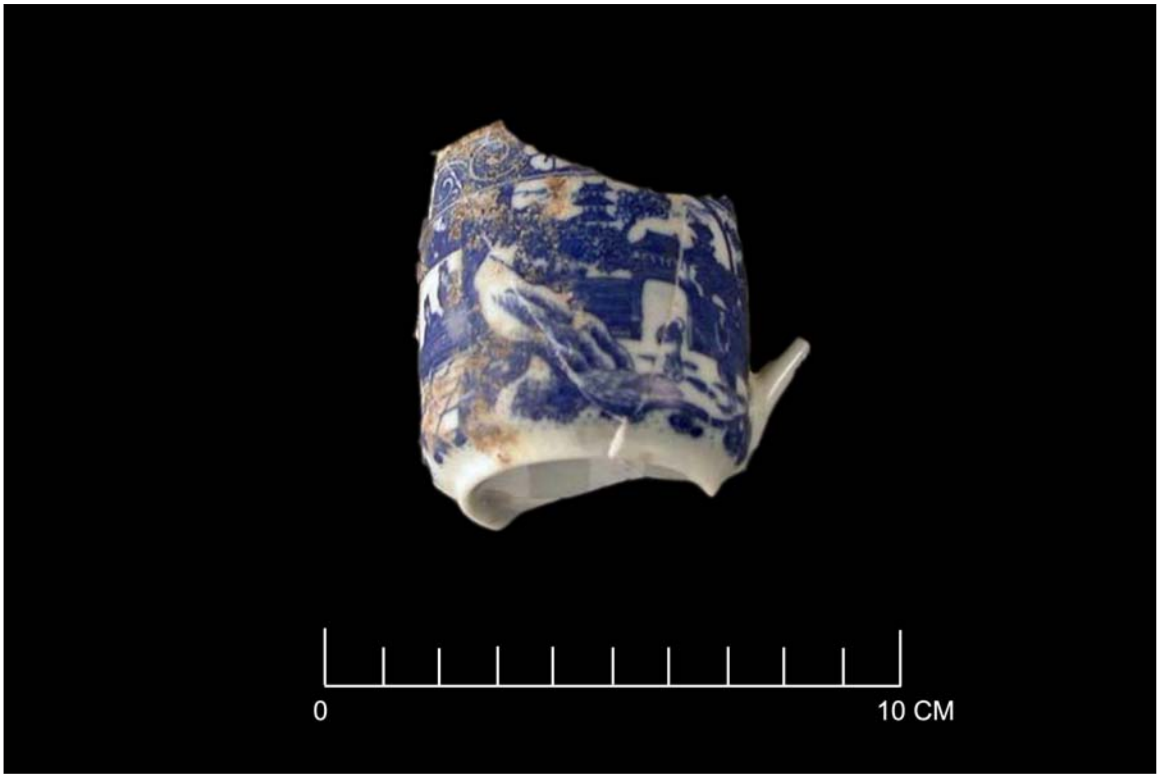



**Figure 55.** Porcelain teacup (partial) from Frank Wallace House (HSTR 30707).