

**ARCHEOLOGICAL PROSPECTION INVESTIGATIONS
OF THE YARBOROUGH OPEN SITE #4 (3NW303) AT THE
STEEL CREEK HORSE CAMP IN BUFFALO NATIONAL
RIVER, NEWTON COUNTY, ARKANSAS**

By

Steven L. De Vore, Caven Clark, Chuck Bitting, and Jay Sturdevant

Midwest Archeological Center
Technical Report No. 115



NATIONAL PARK SERVICE
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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

Between June 5 and 15, 2007, the Yarborough Open Site #4, 3NW303, at the Steel Creek Horse Camp located within the Buffalo National River in Newton County, Arkansas, was investigated with archeological prospection techniques including archeogeophysics and geoarcheology. The archeogeophysical techniques included a magnetic survey, a vertical electrical (resistivity) sounding, and a magnetic susceptibility profile in order to evaluate the eastern portion of the site for potential campground modernization. Based on the results of the magnetic survey data, geoarcheological trenches were excavated in a selected portion of the project area. The survey was conducted by the Midwest Archeological Center at the request of the park archeologist. Archeogeophysical anomalies with a potential of being prehistoric features were identified and ground-truthed during the investigations. The archeogeophysical survey results indicated the eastern portion of the site had been highly impacted by the construction of buildings and livestock pens associated with the ranch and by subsequent National Park Service demolition of several of the ranch buildings. A total of 9,200 m² or 2.27 acres were surveyed during the archeological prospection investigations at the site. Based on both the results of the archeological prospection investigations and geoarcheological backhoe trenching, this site, or this portion of 3NW303 does not meet requirements of criterion D for listing the site on the National Register of Historic Places.

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In Memory Of

The report is dedicated to the memory of Carla Jean Lash who left us while I was conducting the field portion of this project. Although we had our disagreements over the years, she has always been a close friend. She will be missed by her family and friends.

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1. INTRODUCTION

The National Park Service's (NPS) Midwest Archeological Center (MWAC) and Buffalo Nation River (BUFF) staffs and volunteers conducted archeological prospection investigations at the Yarborough Open Site #4 (3NW303) in the Steel Creek Horse Camp within the boundary of Buffalo National River in Newton County, Arkansas (Figure 1). The archeological prospection survey of the site was conducted between June 5 and 15, 2007 (De Vore 2007). The archeological investigations, including archaeo-geophysics, geoarcheological, and traditional archeological techniques, were requested by the park archeologist Dr. Caven Clark for the non-destructive and non-invasive investigations of Site 3NW303 in response to a proposed plan to develop a new horsecamp at Steel Creek in the Upper Ranger District of Buffalo National River. The existing campground has promoted accelerated resource degradation and concern for sanitary conditions with existing camping units located too close together, creating heavy impacts on the campgrounds and the horse tethering areas (Clark 2007). The proposed new campground will consist of 17 new horse camp units with water and electrical hook-ups for recreational vehicles, as well as horse tethering poles. In addition, the proposed campground location will also contain a horse washing station. The cadastral location of the project is within the former Valley Y horse ranch in T16 N, R22W, Section 17 of Newton County, Arkansas (Figure 2). Two areas within the project area were identified as the Preferred Alternative and Alternative 1 (Clark and De Vore 2007). The Preferred Alternative area contains Site 3NW303 and measures 10,000 m² or 2.5 acres. The Alternative 1 area contains the remaining 4.5 acres of the identified six acres in the archeological prospection project area. Much of the project area is included in the recorded polygon of site 3NW303 (Archeological Sites Management Information System [ASMIS] #BUFF00219).

Archeological fieldwork activities proposed for the archeological prospection investigations included 1) the archeogeophysical investigations of the six acre project area with a complete magnetic survey of the project area and additional limited survey of archeological areas of interest identified by the magnetic survey with resistance, conductivity, and ground penetrating radar techniques as time permitted; 2) geoarcheological investigations to examine the subsurface geomorphology and stratigraphy along the spine of the knoll, the old drainage channel, and other specified areas; 3) archeological testing or ground truthing of significant geophysical anomalies identified as potential cultural features; and 4) report preparation (Clark and De Vore 2007). A phased approach was recommended for the project with the archaeo-geophysics and the geoarcheological investigations conducted first with a short review period and then the more traditional archeological excavations and ground-truthing of geophysical anomalies as necessary. The archeogeophysical survey techniques included a magnetic survey with a fluxgate gradiometer, a resistance survey with a resistance meter and twin probe array, a vertical electrical sounding with a resistivity meter and Wenner probe array, and a magnetic susceptibility profile with a magnetic susceptibility meter. These techniques offer inexpensive, rapid, and relatively non-destructive and non-invasive methods of identifying buried archeological resources and site patterns that are detectable and that also provide

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means for sampling relatively large areas in an efficient manner (Roosevelt 2007:444-445; Von Der Osten-Woldenburg 2005:621-626).

The Yarborough Open Site # 4, 3NW303, coincides with the Preferred Alternative project area. Site 3NW303 was originally documented during an archeological survey of 17 tracks of land during 1977 (Panowski 1977). Within the site, the knoll, a prominent landscape feature of the site, in the northwest corner of the project area has surface artifacts within the Preferred Alternative footprint (4,400 m² or 1.09 acres). Previous archeological investigations in 1987 found buried Mississippian cultural deposits on the knoll (Coleman 1987). Artifacts were recovered to a depth of 0.3 to 0.65 cm bs; however, no features were identified. Debitage has been found throughout the Preferred Alternative project area. Debitage is extant throughout the knoll in small rodent and horse disturbances. A piece of concrete with creek gravel exposed on the south side of the knoll suggests that the area has been previously disturbed. Historic photographs of the project area show no major disturbances on the knoll.

The purpose of the archaeogeophysical survey of the site was to provide an evaluation of the buried archeological resources in the eastern part of the Yarborough Open Site #4 for compliance with Section 106 of the National Historic Act of 1966, as amended through 1992, that would be in the primary area of potential effect (APE) of the proposed horsecamp. The project was also to identify and evaluate buried prehistoric and historic archeological resources. In conjunction with the National Park Service, Midwest Archeological Center, Lincoln, Nebraska, a work plan was developed to use a combination of geoarcheological testing and backhoe trenching to investigate the nature and extent of archeological deposits at this site (Clark and De Vore 2007). During the course of the archaeogeophysical survey several people assisted in the field project including Buffalo National River staff consisting of Dr. Caven Clark, Ray Wiggs, Chuck Bitting, Mike Jenks, Brian Woods, Sam Holman, and Bill Willard; two Youth Conservation Corps (YCC) participants, Jessica Nance and Billy Sanatanna; and a Volunteer-In-Park (VIP) participant, Doug Whitman.

2. ENVIRONMENTAL SETTING

The archeological prospection project area of the proposed horse camp lies within the mutual floodplains of the Buffalo River and Steel Creek (Figure 3). It is located in the Boston Mountains section of the Ozarks Plateaus Province of the Interior Highlands (Fenneman 1938:655-659; Fowlkes et al. 1988:3-5). The project area is also located within the Boston Mountains of the East and Central Farming and Forest Land Resource Region (USDA 2006:379-380). The region consists of a submature to mature, deeply dissected plateau with narrow, rolling ridgetops and entrenched streams. The valley walls are typically steep. The Boston Mountains mark the southern most extent of the Ozarks. The north side of the project area lies on a knoll (Figure 4). A broad swale runs through the middle of the project area. From the topography, it appears this swale may have been an overflow channel of the Buffalo River. The knoll may have been developed on a gravel bar separating the overflow channel from the primary channel of the river. If this is the case, the swale should have fairly fine sediments deposited in backwater situations, while the knoll should have coarser sediments, possibly with quite a bit of gravel as water velocities would have been higher when deposition was taking place.

The project area also lies within the Carolinian biotic province (Dice 1943:16-18). The province consists of the great temperate deciduous forest, which dominated by a mixture of hardwoods and pines (Dice 1943:17-18; Shelford 1963:56-88,89-119; USDA 2006:380). The Oak-Hickory overstory of the Ozarks plateaus consists of red oak, white oak, and hickory with shortleaf pine and eastern redcedar (Kricher 1998:81-85; Shelford 1963:57-59; Sutton and Sutton 1985:71-80). Understory vegetation in open areas and under medium forest canopy includes big bluestem, switchgrass, Indiangrass, and little bluestem while broadleaf uniola, longleaf uniola, wildrye, and low panicums occur under heavy canopy (USDA 2006:380). Several different types of canes, vines, and briars may be found along draws and valleys. Strips of deciduous trees, including eastern cottonwood, maples, elms, sycamore, black walnut, oak, hickory, and willows, are most commonly found on the bottomlands along stream channels (Fowlkes et al. 1988:109; Kricher 1998:85-90; Shelford 1963:89-119).

During the prehistoric and historic periods, white-tailed deer were present in the timbered areas along streams and slopes. Cottontail rabbits are common along with coyotes, red and gray foxes, black bear, bobcats, beavers, raccoons, opossums, skunks, muskrats, and fox and gray squirrels (Brady 1988:76; Shelford 1963:59-60; Sutton and Sutton 1985:77; USDA 2006:380). Numerous other mammals and rodents also inhabit the region (Kricher 1998:81,84; Shelford 1963:60; Sutton and Sutton 1985:77-80). Numerous species of birds inhabit the grasslands, the shrublands, and wooded areas of the region (Kricher 1998:81,85; Shelford 1963:59; Sutton and Sutton 1985:78-80). Turkey, ruffed grouse represented some of the regional game birds, as well as migratory waterfowl, in both prehistoric and historic times. A variety of raptors and numerous grassland and forest species of songbirds are present (Brady 1988:77; Kricher 1998:81,85; Sutton and Sutton 1985:78-80). Reptiles include several species of lizards, turtles, and snakes (Shelford 1963:59-60; Sutton and

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Sutton 1985:78-80). Amphibians are found in the prairies, forests, and wetlands (Sutton and Sutton 1985:80). Fish, including smallmouth bass, Kentucky bass, rock bass, longear and green sunfish, white suckers, and sculpins along with a variety of minnows, shiners, and darters are found in the cool-water streams throughout the region (Brady 1988:76). Insects and other invertebrates abound throughout the region with the grasshopper being one of the most abundant insect groups (Shelford 1963:60-61).

The region has a semitropical humid climate characterized by hot summers and relatively mild winters (Trewartha and Horn 1980:273-282). The annual average temperature ranges between 13 and 16°C (National Climatic Data Center 1988:125; USDA 2006:380). Annual January temperatures average 0.9° C (Hickmon 1941:774; National Climatic Data Center 1988:125). The lowest recorded winter temperature is -21° C (National Climatic Data Center 1988:5,125). Annual July temperatures average 25.8° C (Hickmon 1941:774; National Climatic Data Center 1988:125). The highest recorded summer temperature is 40° C (National Climatic Data Center 1988:5,125). Annual precipitation averages between 106.5 to 139.5 centimeters (Hickmon 1941:774; National Climatic Data Center 1988:5,125; USDA 2006:380) with the majority falling from April through September. Snowfall while uncommon does occur nearly every winter but the snow cover seldom lasts more than a couple of days (National Climatic Data Center 1988:5,125-126; USDA 2006:380). Annual snowfall averages 38.1 cm per year (National Climatic Data Center 1988:5,125). The growing season averages 225 days with killing frosts occurring as late as April 25th in the spring and as early as October 10th in the fall (Hickmon 1941:774; National Climatic Data Center 1988:126; USDA 2006:380). The sun shines approximately 65% of the time in the summer and 50% of the time in the winter (National Climatic Data Center 1988:5). The prevailing winds are from the northeast (National Climatic Data Center 1988:5). The annual relative humidity averages 55 percent (National Climatic Data Center 1988:5).

The bedrock geology (Figure 5) in the immediate project vicinity consists of Ordovician aged sandstones and limestones of the Everton formation at river level of an elevation of 297 m above mean sea level (amsl), overlain unconformably by the Mississippian limestones of the Boone formation at an elevation of approximately 378 m amsl (McFarland 1979,2001,2004). Lying on top of the bedrock in the valley is a deposit of unknown thickness of Quaternary alluvium. Source materials for the alluvium range from the Ordovician sediments in the Everton Formation, through the Pennsylvanian age Atoka formation of the tops of the highest hills in the headwaters of the river. The formations are all sedimentary in origin and contain shales, limestones, dolomite, breccias, sandstones, and conglomerates (McFarland 1979,2001,2004).

The Buffalo River in the Steel Creek location has a gradient of 2.9 m/km. Steel Creek has a gradient of 11.5 m/km in the immediate project vicinity. The drainage area of the Buffalo River above the site is approximately 330 square kilometers. The Steel Creek drainage is approximately 8.5 square kilometers. The relatively high gradients of the streams allow them to move large bed sediments during bank full discharge events. The river and creek channels contain gravel, cobble, and boulders in their bed load. Overbank

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deposits on this part of the Buffalo typically consist of sands, silts, and clayey sands and silts. The sands, silts, and clays are derived from the sandstone, limestone, dolomite, and shale units of Ordovician, Mississippian, and Pennsylvanian age.

Soils within the Rolling Soft Shale Plain are dominated by Ultisols and Inceptisols (Foth and Schafer 1980:63-84,177-201; USDA 2006:380). The shallow to very deep, well drained, loamy soils have udic soil moisture and thermic soil temperature regimes with mixed or siliceous mineralogy (USDA 2006:380). Parent materials in Newton County consist of materials weathered from consolidated bedrock of the Ordovician through Pennsylvanian Periods of the Paleozoic Era (Croneis 1930; Fowlkes et al. 1988:107; Haley et al. 1993). The soils formed under hardwood forests or mixed hardwood and pine forests (Fowlkes et al. 1988:109). Depth to bedrock ranges from shallow to very deep. The project area lies within the Nella-Enders-Steprock soil association of *deep and moderately deep, strongly sloping to very steep, well drained, stony and very stony soils that formed in residuum or in colluvium of acid sandstone or shale* (Fowlkes et al. 1988:11-12). The soil within the project area consists of the occasionally flooded Razort loam (48) soil mapping unit (Fowlkes et al. 1988:63-64,102-103). The Razort loam soil in the project area consists of a deep, well drained, level to nearly level soil located on the flood plains paralleling the streams (Fowlkes et al. 1988:63). Formed in loamy alluvium (Fowlkes et al. 1988:102), the soil has a moderate permeability, slow to medium surface runoff, low shrink-swell potential, high available water capacity, moderate natural fertility and a moderate organic matter content (Fowlkes et al. 1988:63). Occasional flooding occurs during the winter and early spring (Fowlkes et al. 1988:64). The soil pH ranges from neutral to medium acid (Fowlkes et al.1988:63). The native vegetation in the project area consists of mixed bottomland hardwoods (Fowlkes et al. 1988:102,109). These resources provided the basis of the aboriginal subsistence of prehistoric times and the historic and modern Euroamerican farming economy.

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3. CULTURAL HISTORY OF BUFFALO NATIONAL RIVER

The cultural sequence for the Buffalo National River spans the entire range of North American prehistory and history from the earliest Native American occupation to the Euro-American settlement and development in the Eastern Woodlands Archeological Culture Area (Willey 1966). The sequence is divided into two periods based on the availability of written records: 1) the Prehistoric Period and 2) the Historic Period. The Prehistoric Period is further subdivided into the Paleoindian, Dalton, Archaic, Woodland, and Mississippian (Table 1). The Historic Period in Arkansas began very early with the A.D. 1541-1543 expedition of Hernando de Soto. The subsequent four hundred-sixty years of human experience in the Ozark Plateau region includes a complex set of historic records with intertwined cultural groups and historical perspectives. The Historic Period is further subdivided into the Protohistoric/ Contact, European Encounters, Early American Migration and Settlement, Civil War, Homesteading and Industry, and Modern Development. Current knowledge regarding the cultural history of the region comes from research conducted in the northwestern park of the state, as well as the southern part of Missouri. Summaries of current knowledge regarding the prehistoric cultural history of the Ozark Plateaus include Davis (1991), Harrington (1924,1960), Lafferty et al. (1988), Pitcaithley (1978), Sabo et al. (1990a,1990b), Schambach and Newell (1990), and Wolfman (1979). For more detailed discussions of the Historic Period in the Ozarks region, one is referred to the following sources: Arnold (1991) Chapman (1959), Pitcaithley (1978), Rogers (1987a, 1987b), Sabo (1992), Sabo et al (1990a), Smith (2003) and Steel and Cottrell (1993).

Paleoindian (10,000 B.C to 8500 B.C.)

The Paleoindian Period is the earliest confirmed period of human occupation in the Ozarks. Distinctive artifacts included fluted and unfluted lanceolate points and a diverse toolkit of drills, gravers, burins, knives, and scrapers, most of which continue with little modification into subsequent cultural periods. Most Paleoindian finds reported in Arkansas have been isolated surface discoveries with no intact features. No sites dating to this period have been excavated. The diagnostic artifacts have been found in bluff shelters and open sites, especially along river terraces and older upland surfaces.

Dalton (8500 B.C to 7500 B.C.)

The Dalton Period is, in comparison with the Paleoindian Period, well known throughout the region. The distinctive Dalton point is the primary diagnostic artifact of this archeological culture, but other tool types are known. Dalton sites have been found in a wide variety of topographic settings from terraces along major rivers to uplands. There is continuity that places Dalton comfortably between Paleoindian and Early Archaic Periods, and its tool kit is sufficiently diagnostic to warrant considering it a discrete archeological culture, irrespective of period.

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Archaic (7500 B.C. to 500 B.C.)

The Archaic Period is defined by increasing diversity of material culture technology and a concomitant change in subsistence behaviors. A wide diversity in stone tools, both chipped and ground, is a hallmark of the Archaic Period. The mode of hafting of bifaces includes both stemmed and notched points. Grooved axes and celts appear for the first time archeologically. There are increasing quantities of tools associated with plant processing, such as grinding stones and pitted cobbles. Bluff shelters have been found to contain preserved organics in the form of twined fiber bags and sandals. The first domesticates, squash and gourd, appear near the end of the Archaic as part of the increasing role of food production. Population increase may be inferred from the large number of sites with Archaic materials, and from the evidence of larger individual site size and duration of occupation.

Woodland (500 B.C to A.D. 850)

The Woodland Period is defined by the appearance of pottery in the archeological record, but otherwise is largely a continuation of trends already seen during the Archaic. Woodland people in the Ozarks do not appear to have participated in the construction and use of elaborate burial mounds with accompanying burial ceremonialism, nor is there much evidence of long-distance trade or exchange. Settlement does not appear to have changed much from the earlier Archaic times.

Mississippian (A.D. 850 to A.D. 1541)

The Mississippian Period had an identifiable yet indeterminate presence in the Ozarks region. To the east and west, Mississippian people built large fortified villages, temple mounds, and cemeteries. Mississippian people developed an elaborate material culture assemblage with distinctive shell-tempered and decorated pottery and small arrow points. The evidence of Mississippian culture present in the Ozarks may represent seasonal visits for the acquisition of specific resources. It is entirely possible that, in the Ozarks, the basic cultural pattern remained essentially “Woodland” while in the large river basin areas to the west and east, the more classic Mississippian Culture took hold.

Protohistoric/Contact (A.D. 1500 to A.D. 1700)

The Protohistoric or Contact Period marks the transition from a strictly archeological record to one augmented by ethnographic, ethnohistoric, and historic records. The archeology of this period is very poorly known in the Ozarks. Until the advent of Euro-American culture was felt here, there would be little to distinguish a protohistoric site from an earlier one. Typically, observations made by the first visitors are used to establish a baseline and to project back in time the locations and characteristics of native societies. At contact, which begins with the Spanish forays in the sixteenth and seventeenth centuries and continues with the early French and American records of the eighteenth

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and nineteenth centuries, the Osage appear to have been the dominant Native American group in northern Arkansas and southern Missouri. Later and well into the Historic period, the Cherokee, Delaware, and Shawnee begin to enter the Ozarks as pressure for relocation mounts in the eastern United States. In terms of material culture, items associated with this period include metal objects, glass trade beads, and other items of Euro-American manufacture.

European Encounters (A.D. 1541 to A.D. 1803)

There is very little information regarding the interface between prehistory and history for the Buffalo River region. The expedition led by the Spaniard Hernando de Soto in 1541 to 1543 passed near the confluence of the Buffalo and White Rivers. Similarly, the French Jesuits followed the arteries of transportation and communication along the major rivers including the Mississippi and the Arkansas, but not the Buffalo and White Rivers. Although surrounding area had gradually become known during the prior century, it was not really until the early nineteenth century that the Buffalo River region entered the historic record to any significant extent.

Early American Migration and Settlement (1803 to 1860)

Included as part of the 1803 Louisiana Purchase, Arkansas became part of the territory controlled by the fledgling United States of America. Settlement along the Buffalo River watershed began in the late 1820s. Legal ownership of the land was not possible until after the federal survey had been completed. Surveys in the Buffalo River watershed began in 1829 and continued through the subdivision surveys of 1845. The first settlers to the Buffalo River chose land situated on fertile bottomland fields. Small fields were cultivated to provide basic necessities for family and livestock. Usually a nearby water source was a prerequisite to settlement.

Mills were established fairly early in the settlement history of the Buffalo River region. In most cases, where the mills were established, town centers later grew. One of the earliest mills was at Marble Falls. Another mill at Peter Beller's, near present Dogpatch, is where the Parkers of the Parker-Hickman farm probably took their grains. David Williams established a mill at what became to be called Mt. Hersey. Williams Mill appeared on the federal surveyor's map for 1843. Undoubtedly, these mills had been there for several years before the surveyor's visit.

Civil War (1860-1865)

The period of the Civil War along the Buffalo River can be characterized by three activities: 1) officially-sanctioned skirmishes resulting from Union or Confederate patrols through the area; 2) irregular activities of guerrilla groups on both sides; and 3) the saltpeter cave nitre production. Regarding the conflict, opinions varied as much along the Buffalo River as they did throughout the nation. Newton County (upper river) represents

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the strong division of the inhabitants between North and South, even of family member against family member. The middle portion of the river, although showing both Union and Confederate sympathizers, appears to have been more sympathetic to the Confederate cause; this may have been due to the influence and activities of James Harrison Love, a Confederate captain from Searcy County who was involved in several engagements along the Buffalo River. Middle river inhabitants also became part of the so-called Peace Society, and extension of similar activities from other mid-south areas. The lower river had fewer wartime encounters, partially because it was a more sparsely-settled area. After 1864, Yellville became a garrison for Union troops.

One of the main activities of the Confederate supporters in the area was to use the caves rich in bat guano, from which they extracted nitrate for gunpowder. Destroying the “saltpeter works” remained a mission of the Union troops. Several caves along the Buffalo River, including Saltpeter Cave and Bat Cave, were utilized for their deposits of bat guano.

Homesteading and Industry (1865-1930)

After the Civil War, community centers began to establish themselves along Buffalo River. Many centers arose because a mill or store was established; later, particularly in the late nineteenth and early twentieth centuries, post offices were established in many of these stores and the name selected for the post office station would become the name of the wider community area. Around the early businesses, other enterprises and some residences began to gather.

Most community center served a local population. But some became known area-wide. During the mining days of the late nineteenth century, towns like Rush and Ponca saw the influx of workers and businesses from other areas. Probably the most outstanding example was Gilbert, created in the early twentieth century with the arrival of the Missouri and North Arkansas Railroad to the region and the establishment of a railhead on Buffalo River. Gilbert became the hub for Buffalo River traffic, as cotton, logs, and ore were taken to the center from both up and down the river.

The majority of entries in the public land books date from the 1880-1915 period, as the remaining public land was entered by both prospective homesteaders and logging companies taking advantage of the timber resources of the Buffalo River watershed. At times, the two came into conflict, as “squatter land” was legally entered by outside interests. The homesteads of this period in many cases were trying on a wilderness life style for the first time and needed help in even constructing a simple one-room log shelter. Descendents of older settlers reused log structures, incorporating many into farm outbuildings or reusing the logs for new structures.

Most of these homestead entries were located on less desirable land, away from the river valley and main tributaries. However, new road systems and travel made the ridge-top

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dweller more accessible to the rest of the world than the earlier settlers would have been. In addition, the increase in schools, churches, and community centers aided in decreasing the isolation of these later settlers.

Beginning in the 1880s, timber contracts were purchased along the overlooked ridgetop lands of the Buffalo River watershed. Trees were cut and slid down to the river for floating to the sawmill or railhead. Other loads went out by wagon. Stave mills were another timber use. At the stave mill, the timber was sliced into staves for barrels and then transported to manufactures. Logging became a big commercial venture along the Buffalo River from the 1880s to the 1930s and continues to today in some areas. It is appropriate that historic sites related to the logging industry be recognized in Buffalo National River.

The mining days along the Buffalo River began in the early 1880s and eventually attracted national attention to the area. Rush was the site of the initial discovery of zinc ore and from the development at Rush, mining ventures stretched out across the northwestern Arkansas area. The White River steamboats, the stage lines, and later the new railroad lines shared in bringing the outside world to the mineral “belt.” During the mining period (1880 to 1940), Buffalo River residents experienced some economic improvement by providing supplies necessary for the mining enterprise, in wages paid to local workers who participated in the mining, and in the construction and transportation facilities necessary for the mining process. Mining revivals were attempted in the 1950s at Ponca and at Rush, but had little success.

Modern Development and Recreation (1930 to present)

The development of the state highway system in the 1920s and the building of bridges across Buffalo River and other tributaries linked the Buffalo River communities with larger trade centers and with each other. With this new transportation link came the development of a leisure industry utilizing the Buffalo River.

In the 1930s, recreational cabins began to be erected at various places along the river for city dwellers who wanted to get away for a day of fishing or recreational activity. Many of these early structures were constructed of native stone and wood as small, square, functional structures.

In the 1950s, the Army Corps of Engineers began to look at Buffalo River as a source of energy and recreational development. A plan dating back to 1897 had focused on ways to utilize the river’s physical energy. Now the Corps began to activity plan it harnessing of Buffalo River, and placed markers and gauges along the length of the river. Also in the 1950s, the first thoughts began with a group of river admirers that the Buffalo River had the quality to be an area of national significance. Throughout the 1960s, groups mustered on side for and against preservation of the free-flowing river until on March 1, 1972, Public Law 92-237 was signed by President Nixon to establishment of the Buffalo National River “for the purposes of conserving and interpreting an area containing

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unique scenic and scientific features, and preserving as a free-flowing stream an important segment of the Buffalo River in Arkansas for the benefit and enjoyment of present and future generations.”

4. PREVIOUS ARCHEOLOGICAL INVESTIGATIONS WITHIN BUFFALO NATIONAL RIVER

Buffalo National River lies within the boundary of the Arkansas Ozarks Research Study Unit (Raab et al. 1982:NW1-NW24). Archeological information for this region consists of published reports and articles, as well as Master's theses and Ph.D. dissertations. Historically, much of the archeological investigations in the region have focused on the bluff shelter sites where exception preservation of perishable materials occurred. These sites were also the focus of rampant relic hunting, which has destroyed the archeological and scientific potential in many of the bluff shelters. More recent projects have been response to public agencies undertakings in a variety of environmental settings. The investigation of historical archeological sites has also increased (Stewart-Abernathy and Watkins 1982:HA1-HA97).

Pre-National Park Service Investigations in the Buffalo River National River

Prior to the establishment of the Buffalo National River, several thousand acres were incorporated into Buffalo River and Lost Valley State Parks, which were administered by the State of Arkansas. Scientific excavations within the park boundaries were first undertaken in the 1920s and 1930 by Winslow M. Walker, M. R. Harrington, and S. C. Dellinger (Dillinger 1932,1936; Dillinger and Dickinson 1942; Harrision 1924,1960; and Walker 1932). Their research interests defined the occupants of the bluff shelters as the "Ozark Bluff-Dweller Culture." The dry shelters preserved organic material to the point of species identification. It was this dry organic material that first interested the archeologists, and very little material was analyzed except for the items associated with the shelter burials. Much has happened since those early days of expeditions, pith helmets, and horseback. Nothing was recorded or documented until the 1960s. The 1960s also saw the beginning of site recording by local enthusiasts. Most of these first site records describe sites as "undisturbed." Major investigations during the 1960s focused on excavations at Indian Rockhouse (new part of the interpretive trail at Buffalo Point), Peccary Cave, and Saltpeter Cave.

Investigations within the Buffalo National River

The "undisturbed" character of archeological resources changed dramatically after the Buffalo National River was established in 1972. By 1975, when there was another influx of site recording by local amateur archeologists, the majority of the site descriptions mentioned "looter pits and screens" at almost every bluff shelter or cave site. The 1970s witnessed scientific testing and surveying of selected areas, as well as the first and only archeological overview and assessment of the Buffalo River valley (Wolfman 1979). According to Wolfman, an intensive field survey is most critical so that we can "evaluate the impact of the park on archeological resources." Wolfman designed a survey program that would require three years with a survey crew of three, surveying 160 acres

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per day. The intense survey has not yet been done, but many selected areas have been surveyed and tested—as documented throughout the 1970s, 1980s, and 1990s (Bradford 1979a,1979b,1979c; Campbell 1975; Coleman 1986, 1987a, 1989; Earth Search, Inc. 1988; Keller 1988, 1989; Panowski 1977; Sierzchula 1984; Spears and Lafferty 1985; Spears and Turk 1990; and Spears et al. 1986).

Three sites within the park were excavated between 1988 and 1990. Two were open sites on river terraces (Lafferty et al. 1988; Sabo et al. 1990b), and the third was a bluff-top site (Spears 1989; and Spears and Taylor 1988). These reports brought new information about the prehistoric settlement patterns along the Buffalo River. They verified the multi-component nature of the terrace sites along the Buffalo River and reaffirmed the notion of extensive Dalton/Early Archaic deposits first noted by Hester Davis in the 1960s. The open terrace sites and the ridge-top sites have been previously overlooked in favor of the fantastic resources contained in the dry bluff shelters. The multiple components at terrace site 3MR80 and 3NW205 suggest early Dalton age occupations and a greater Mississippian presence in the region.

At 3NW205, the Elk Track Site, three questions arose from the artifact assemblages and house design: 1) Why is there such diversity in projectile points (nine point types), 2) The flaring rim sherds were still being used, while further east “the flaring rims were almost passé by this time.” Was the flaring rim maintained because of inferior materials?, and 3) House design appears to be unique to the Ozarks with characteristics similar to house structures in the Mississippi River valley, the Loftin Site along the White River, and the Shell Lake Site in Missouri. Because of the atypical house design, the large variety of projectile points, and the ceramic rim sherds, Lafferty designated an Erbie Phase sometime between A.D.1000 and A.D. 1600. The Erbie Phase is contemporaneous with the War Eagle Phase in the Upper White River valley and the Spiro Phase in the Arkansas River valley.

At the Fred Dirst Site, 3MR80, two conclusions shed new light on the previous “moribund backwater portrayal of the Ozarks.” The first was that “grog-tempered pottery found in the organically enriched midden...is the earliest documentation of the use in the Ozarks” (Sabo et al. 1990b:329). The associated carbon date for the pottery is much earlier than previously thought for grog-tempered pottery in the Woodland/Mississippian transition with the Emergent Mississippian developments revealed that the prehistoric inhabitants participated in the broad pattern of cultural development that their neighbors participated in” (Sabo et al. 1990b:330). The prehistoric Ozark inhabitants were not “behind the time,” only conservative.

The 1990s were witness to a reduction in major developments along the river. During this time, most archeological surveys were generated by trail developments or excavations from previous preliminary reports. Analysis and reporting was completed for the large mitigation excavations conducted at the Dry Ford Site, 3NW507 (Klinger et al. 1993). The Klinger report incorporated an extensive study and analysis of lithic material

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distribution, site activity percentages per archeological period, along with intersite and regional comparisons. Klinger made several noteworthy conclusions: 1) nearly all the cherts used at Dry Ford originated from the bluff outcrops, talus slopes, or in stream deposits...cortex was not present on any specimens from the southern Missouri varieties; 2) throughout every occupation period, the site was utilized as a hunting camp site; 3) flake size does not increase with depth; and 4) an absence of n suggests the use of domesticated plant foods was not occurring at the site.

At the present time, there are 675 recorded sites within the BUFF boundary. Since 2000, BUFF staff archeologists have continued working with a variety of compliance related issues in the park, particularly the effect of fire on the park's historic and prehistoric archeological components (Cande and Pebworth 2004; Redmond and Lindsey 2004; Sturdevant 2006; Sturdevant et al. 2005; and Sturdevant and McKee 2007). Other threats facing the archeological resources at BUFF include ongoing site looting in bluff shelters and open sites, as well as erosion along the banks of the Buffalo River. BUFF and MWAC staffs are actively trying to address these issues of site preservation in order to maintain a satisfactory level of condition for the BUFF archeological resources. During the past couple of year, the BUFF and MWAC archeological staffs have also been conducting site condition assessments on sites lacking such assessments since their original recordation (Green 2003).

Previous Archeological Investigations at the Yarborough Open Site #4, 3NW303

The first site record for Site 3NW303 dates from June 17, 1970 as an Arkansas Archeological Survey (AAS) site form filed by Steve Erwin. Typical of the time, it contains little information but notes that in spite of limited surface visibility debitage was noted and that "several good mortars have come from the Yarborough land." Since then several archeological investigations have occurred at the present project location (Figure 6).

Although not part of the archeological investigations of Site 3NW303, a major impact to the Valley Y Ranch was conducted after the property was transferred to the National Park Service. Several of the ranch's outlying buildings, including the large show barn, and corral fences were removed from the field where Site 3NW303 is located. Two large pits were opened and the demolition debris was pushed into the pits. Once the pits were filled, the area was covered with backdirt from the excavations, smoothed, and landscaped leaving little surface evidence for the location of the pits except some concrete fragments on the surface of the field.

A second site form was completed March 16, 1977 by Bruce Panowski (1977). He states that the: *Lithic scatter is spread over several hundred meters on valley floor much under existing modern ranch houses. Lithics most evident in eroded corrals, road cuts, etc.* Two nondiagnostic biface fragments were collected at this time. Although he notes that surface visibility was poor, his plotting of the site boundaries is very general.

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An archeological survey of selected areas within the Buffalo National River was conducted by James Bradford (1979b,1979c) during 1979, including the Steel Creek development area. The project concentrated on proposed development areas within each proposed campground location. According to Bradford, two archeological sites had been documented at the Steel Creek development area including 3NW305 in the vicinity of the Steel Creek primitive campground and 3NW303 in the vicinity of the ranch residence and the canoe launch. Both sites were identified as extensive lithic scatters. In the primitive campground area, he indicated that the facility was *essentially complete and was accomplished without archeological clearance* (Bradford 1979b:7) and that monitoring was in order to assess public use impacts to the archeological resources. Although he indicated that much of the Steel Creek area had been developed to some degree due to the presence of the Valley Y Ranch activities and recommended archeological clearance for the proposed development project, he added that *if during development any previous unknown cultural material is encountered, operations should cease immediately and a qualified archeologist consulted to determine the significance of the material* (Bradford 1979c:14).

There is an Assessment of Effect or XXX form (1986-16) relating to the construction of the existing horse camp for 1986. It contains no information indicating the presence of cultural materials in this area.

In October 1987, Roger Coleman and Myra Foster (Coleman 1987b,1987c) filed a site form based on their profiling of post holes for the horse corral. Among their observations is the presence of *buried stone concentrations* and an *intact undisturbed buried cultural horizon from 36 to 61 cm below surface*. *Artifacts recovered include flakes from bifacial reduction, grog and shell tempered sherds, calcined bone, charcoal, and quantities of fire-cracked rock*. All of these materials were collected from the backdirt piles from post holes. The horizontal extent of the artifact distribution *seems to be coterminus with floodplain elevation*, (i.e., confined to the terrace feature). However, it was in the northwest corner of the corral (Area 2) that the buried deposits were located. Their accompanying site map has 3NW303 divided into two parts separated by the swale between.

September 19, 1996 David Hayes monitored the installation of the waterline at the horse camp. He noted the presence of *fire-cracked rock throughout the site and extending to the site boundary north and west*. *Lithics were also present along with one projectile point base (Rowen [type] 8500 – 9500 bp) that was collected*. Cultural material was located between 5 – 30 cm below surface; one “chopper” was found but not collected. He also noted that the density of artifacts was greater at the southern end of the project area.

David Hayes conducted limited shovel testing prior to the construction of the existing toilet facility. In his report dated November 22, 1999 (Hayes 1999:4) he states:

The toilet by the put-in was located within archeological site 3NW303, a [sic] Archaic/Mississippian prehistoric lithic scatter. Four of the five shovel tests were

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positive for cultural material which consisted of fire-cracked rock, charcoal, 22 flakes, and one utilized flake.

David Hayes monitored the perc test of the septic drainfield at the site on December 6, 1999. Cultural material was found in half of the ten test sites in all areas of the drainfield. Maximum test depths were recorded, ranging from 14 cm to 56 cm below surface. No diagnostic materials were observed.

On January 7, 2000 Hayes and Stuart West used a mechanical posthole digger to excavate holes for a new horse fence (Hayes 2000). Two flakes and one piece of FCR were found at the northeastern end of the field, across the road from where comparable discoveries were made in 1987. A projectile point was found on the surface this same year on the north side of the stables.

In 2002, BUFF Archeologist Charlotte Hunter (2002) examined the ground preparation for a fee collection station at Steel Creek, located southwest of the current horse camp. No artifacts were observed in this area.

A brief surface survey for cultural materials was made by Tony Collins and Noel Mays on August 8, 2001 close to the Buffalo River where a project to construct rock vanes to control bank erosion was anticipated (Collins and Mays 2001). No materials were noted.

Archeological interest in 3NW303 may be characterized as sporadic, determined almost exclusively by compliance obligations. The site is, at the very least, an extensive lithic scatter producing very little in the way of diagnostic artifacts, nor can it be said to be a very rich site in terms of artifact density. However, there is also a documented presence of buried artifacts and possibly a buried living surface in the vicinity of the existing septic drainfield and toilet facility. This subtle knoll feature may have the highest potential for prehistoric occupation.

Among the unknowns is the physical relationship between the discharge of Steel Creek and the Buffalo River which in prehistoric times may have been a prime determinate for site location preference. Also unknown is the extent of site disturbance from the Yarborough Ranch structures. A combination of these may conspire to greatly limit the extent of surviving deposits on the site. These latter questions were central to the investigation undertaken in June 2007.

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5. ARCHEOGEOPHYSICAL 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 late 1940s and early 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.

Archeogeophysical prospection techniques available for archeological investigations consist of a number of geophysical 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 Archeogeophysical Prospection Techniques

The passive archeogeophysical 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

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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 archeogeophysical 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. Ferrous or 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 a 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 53,800 nT with an inclination of approximately 65.8° (Peddie 1992; Peddie and Zunde 1988; Sharama 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 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 1973,1992:313-381; Burger 1992:389-452; Clark 2000:92-98,174-175; David 1995:17-20; Dorin and Savit 1988:633-749; 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 2001:357-358,2003:441,205:434-436,2006a:205-233,2006b:235-250; Lowrie 1997:229-306; Milson 2003:51-70; Mussett and Khan 2000:139-180; Nishimura 2001:546-547; Robinson and Çoruh 1988:333-444; Scollar et al. 1990:375-519; Telford et al. 1990:62-135; 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

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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 Archeogeophysical Prospection Techniques

The active archeogeophysical 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 archeogeophysical 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-

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28; Dobrin and Savit 1988:750-773; Gaffney and Gater 2003:26-36,56-61; Gaffney et al. 1991:2;2002:7; Hallof 1992:39-176; Heimmer and DeVore 1995:29-35,2000:59-60; Kvamme 2001:358-362,2003:441-442;2005:434-436; Lowrie 1997:206-219; Milson 2003:83-116; Mussett and Khan 2000:181-201; Nishimura 2001:544-546; Robinson and Çoruh 1988:445-478; Scollar et al. 1990:307-374; Sharma 1997:207-264; Somers 2006:109-129; Tagg 1964: Telford et al. 1990:522-577; Van Nostrand and Cook 1966; Weymouth 1986:318-341; Witten 2006:299-317; and Zonge et al. 2005:265-300 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 Milson 2003:99 for common configurations). The typical archeological horizontal 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 completes the electrical circuit. The measurements are stored in the resistance meter's memory until downloaded to a lap-top 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 and

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Tagg 1964 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 $\rho_a = 2\pi ar$, where ρ_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 ohm-meters (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 (Milson 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 1993; Iris Instruments 1999; Milson 1996:71). Combining the resistance meter, probes, and a multiplexer unit, several probe configurations can be measured at a single location (Geoscan Research 1995). 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

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sets of probes to comparable apparent resistivity measurements the following formula is used (Geoscan Research 1995: B-1): $\rho_a = 2\pi r / \mathbf{G.F.}$, where ρ_a is the apparent resistivity, r is the measured resistance at each electrode separation, and $\mathbf{G.F.}$ 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 ($\mathbf{G.F.} = 1/C2P2 + 1/C1P1 - 1/C2P1 - 1/C2P1$ 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 ($\mathbf{R} = \mathbf{V/I} = (1/2\pi) (\rho_1/a_m + \rho_2/a_r)$ where ρ_1 is the resistivity of the soil beneath the mobile probes, a_m is the mobile probe separation distance, ρ_2 is the resistivity of the soil beneath the remote probes, and a_r 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 $\rho_1 = 2\pi a_m R - \rho_2(a_m/a_r)$. By combining all the resistivity data, a three dimensional display can be generated of the soil resistivity.

Magnetic Susceptibility Survey. The magnetic susceptibility survey is an active archeogeophysical technique, which induces an electromagnetic field into the ground (see Alexander 1977:368-379; Banerjee 1981:25-99; Burger 1992:394-397,412-414; Challands 1992:33-41; Clark 2000:171; 99-117,175-182; Dalan 1995; Dalan and Banerjee 1998:3-36; David 1995:20-22; Dearing 1994; Dunlop and Özdemir 1997:633-675; Ellwood et al. 1998:55-71; Gaffney and Gater 2003:44-46; Gaffney et al. 1991:3,2002:9; Mussett and Khan 2000:139-161; Robinson and Çoruh 1988:333-374; Scollar et al. 1990:375-421; Sharma 1997:65-75; Tarling 1983; Thompson and Oldfield 1986; and Yates 1989 for more details of magnetic susceptibility surveys). Magnetic susceptibility measures the degree to which a material may be magnetized (Sheriff 1973:135). It is defined as the ratio of the induced magnetic field in a material to the applied magnetic field.

An electromagnetic field is induced into the ground through the transmitting coil. The induced primary field causes an electric current flow in the earth. 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 magnetic susceptibility within the influence area of the instrument. The receiving coil detects the response alteration (secondary electromagnetic field) in the primary electromagnetic field. The in-phase component of the secondary signal is used to measure the magnetic susceptibility of the subsurface soil matrix. It can be expressed as volume susceptibility (K) where the measurement is normalized by volume or as mass susceptibility (X) where the measurement is normalized

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by mass. Volume susceptibility (K) is equal to the volume magnetization induced in a material of susceptibility (M) divided by an applied field (H). Volume susceptibility is a dimensionless quality (Thompson and Oldfield 1986:25). Volume susceptibility is generally used in field surveys where readings are taken with the various field sensors but no samples are collected for further processing in the laboratory setting. The low field mass susceptibility (X) is equal to the volume susceptibility (K) divided by the bulk density of the sample (ρ in units of kg cm^{-3}). This yields X values in the International System's (SI) units of $\text{m}^3 \text{kg}^{-1}$. Mass susceptibility is commonly used on collected field samples in a laboratory setting.

Magnetic susceptibility may be one of the most important but least utilized geophysical investigative techniques in archeological landscape studies. Both areal prospection of the surface and the study of the magnetostratigraphy can be employed during a project (Clark 2000:99-117). In general, the technique is extremely sensitive to environmental change and is widely used in environmental studies (Thompson and Oldfield 1986). The techniques for the measurement and interpretation of magnetic susceptibility are derived from the fields of rock magnetism and paleomagnetism (Banerjee 1981; Dearing 1994; Nagata 1961; Tarling 1983). Iron oxides are present in most of the earth's soils. The iron is present and magnetically detectable in grains of magnetite, maghaemite, and hematite. The process of weakly magnetic oxides and hydroxides that are converted to more strongly magnetic forms within the subsurface layers is referred to as "magnetic enhancement." These iron minerals in the soil are "susceptible" to becoming magnetized in the presence of a magnetic field (Ellwood et al. 1998). Enhancement occurs as a function of soil formation and is commonly seen to have higher susceptibility values within the surface layers. The magnetic grains that are produced are typically fine-grained and thus an increase in frequency dependence in conjunction with an increase in susceptibility is potentially indicative of a developed soil (Dalan et al. 2003). This fundamental property can be quickly and easily measured on small samples.

The magnetic susceptibility of soils has a high correlation with the mineralogy of the parent material and local geology. Soils developed in strongly magnetic basalts have higher X values than soils developed in limestone or sandstone. Soils generally have higher $X\rho$ values in the topsoils as compared with the subsoils. Magnetic enhancement of the topsoil results from accumulation of primary minerals that are resistant to weathering found in the parent material (Dearing 1994:48-51) and the formation of secondary minerals by burning of soil in the presence of organic matter, by the addition of dust from industrial combustion processes or volcanic eruptions, and/or by organic and inorganic chemical processes in the soil (Dearing 1994:51-52). The degree of the magnetic enhancement in the topsoil is controlled by the local geology, the climatic conditions, vegetation and organic matter, soil organisms (i.e., bacteria), and time (Alexander 1977:368-379; Dearing 1994:55-61). Human activity also has an effect on the susceptibility through heating effects from fires and chemical and bacterial effects on garbage decomposition (Dearing 1994:88-91). Magnetic enhancement also allows the identification of buried soils, characterization of sediments, and identification of source locations.

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The application of magnetic susceptibility to archeological prospection centers around two factors: 1) typically, greater susceptibility is found in the topsoil than in underlying subsoil, and 2) human activities associated with site occupation enhance the susceptibility of the topsoil (Clark 2000:99-17; Gaffney and Gater 2003:44-46). The method has been developed to detect evidence of human occupation and define site limits in the topsoil even when no distinctive features have survived. It can be applied to research questions concerning the following topics: 1) site limits, activity areas, or features; 2) morphology or function of sites, activity areas, and features and their formation processes; 3) the effects of sedimentation and erosion upon the archeological record; 4) establishing and expanding stratigraphic sequences; and 5) climatic regimes and other information on soil-forming factors (Dalan and Banerjee 1998:13). Magnetic susceptibility studies have been used to study accumulated cultural and natural deposits (Challands 1992; Yates 1989). These techniques can also be used to correlate stratigraphy across a site, as well as, identify buried soils or paleosols (Dalan and Banerjee 1998).

6. ARCHEOGEOPHYSICAL SURVEY METHODOLOGY

The June 2007 project sought to determine the nature and extent of subsurface features and disturbance within the area of potential effect (APE) of the proposed horsecamp. The condition of the site at the time of the survey was stable. Minimal ground disturbance has been caused by use as a pasture. Surface visibility in February and March of 2007 was fair, but sufficient to note the extensive, light, and diffuse presence of debitage on the knoll surface and the absence of same in the swale to the southeast. Large pieces of concrete were also noted as likely remnants of the Valley Y (Yarborough) Ranch buildings.

The work plan for the 2007 archeogeophysical survey of horse pasture located at the Steel Creek Horse Camp, including a portion of Site 3NW303, called for the use of magnetic survey techniques with a fluxgate gradiometer and the evaluation of resistivity, conductivity, and ground-penetrating radar survey techniques if time permitted the additional survey activities (Clark and De Vore 2007). The survey was to cover the knoll area of the horse pasture between the canoe access and the ranch buildings. Initially, two reference points for the north south baseline were set three meters inside the fenceline along the gravel road separating the pasture from the neighboring hay field. The geophysical grid units were established at the project location with a portable Ushikata S-25 Tracon surveying compass (Ushikata 2005) and 100 meter tape. The surveying compass was used to sight in the two perpendicular base lines and grid corners. Wooden hub stakes were placed at the 20-meter grid corners. Twenty-six complete 20-meter by 20-meter grid units were established in the horse pasture and the neighboring hay field and the area surrounding the comfort station near the canoe access for a total project area of 10,400 m² or 2.57 acres; however, due to time constraints, only 23 grid units were surveyed with the fluxgate gradiometer for a total survey area of 9,200 m² or 2.27 acres. The 2007 datum was established in the southwest corner of the project area relocated in the southwest corner of the 2002 project area at N500/E500 and used for the present magnetic survey. The geophysical grid was oriented 40° east of magnetic north.

Global positioning system (gps) coordinates were collected on the geophysical grid corners with a Trimble GeoExplorer 3 gps unit (Trimble Navigation 1999). The positional data was collected as Universal Transverse Mercator (UTM) coordinates in Zone 15 North using the North American Datum of 1983 (NAD-83) as the horizontal reference. Once the coordinates were collected, the rover files were downloaded to a field laptop computer for differentially correcting the data in the Trimble Patherfinder Office software (Trimble Navigation 2000). The National Geodetic Survey continuously operating reference station (CORS) at Harrison, Arkansas was selected as the provider for the base station gps data. The field gps data was differential corrected using the CORS Harrison base station data. The corrected data files were then exported to an EXCEL spreadsheet (Table 2) and a point map was generated (Figure 7). The corrected data was added to the park's geographic information system (gis) as a layer illustrating the location of the archaeo-geophysics project grid.

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A site map of the project area was also made with a Nikon field station (Nikon 1993). The mapping station for the instrument was selected in the southwestern corner of the horse pasture. The arbitrary coordinates of North 5020 and East 5020 with an elevation of 304 meters were used for the mapping station location with the zero degree backsight reference point located at N5060/E5020. The grid unit corner hub stakes, the hay field and horse pasture fence lines, the gravel roads, the NPS comfort station, ranch buildings, utility meters, backhoe trenches, and trees were mapped with the field station. During the mapping, two rebar were set as site reference points at N4980/E5008 and at N5084/E5065. The topographic data collected with the field station were downloaded to the field laptop computer with the Nikon TransIt download software (Nikon 1996). Both the coordinate data and the raw field measurement data files were downloaded into the TransIt folder. The data files were then transferred and processed in the WordStar (MicroPro 1989) software program package. Extraneous data fields were striped from the coordinate data file leaving the North coordinate, the East coordinate, and the elevation data field measurements. This processed data file was saved as a SURFER dat file and transferred to the project folder in the SURFER 8 folder for processing. The grid file was constructed from the topographic data. The contour map and data point plot map were constructed in SURFER 8 (Golden Software 2002). A project field map was constructed in SURFER 8 for the final presentation (Figure 8). During the magnetic survey while the survey ropes were in place in each grid unit, a sketch map was also made of relevant surface features. Elements from the completed project map and the sketch map were combined to form the site map of the project area (Figure 9).

Before the start of the geophysical survey, yellow nylon ropes were laid out on the grids (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. The survey 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. The ropes serve as guides during the data acquisition and in the development of the sketch map of the surface features. The 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 provides a simple way to maintain one's position within the geophysical survey grid unit as data are being 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 the grid(s) until the survey was completed for each technique.

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Magnetic Survey Methodology

The magnetic survey was conducted with a Geoscan Research FM36 fluxgate gradiometer with a ST1 sample trigger (Figure 11). The instrument is a vector magnetometer, which measures the strength of the magnetic field in a particular direction (Geoscan Research 1987). The two fluxgate magnetic 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 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 field strength. With a built-in data logger, the gradiometer provides fast and efficient survey data collection.

The gradiometer sensors must be accurately balanced and aligned along the direction of the field component to be measured. The zero reference point was established at in a quiet area where there were no noticeable localized magnetic variation located at N5010/E5054. The readings should vary less than 2 to 3 nT. The balancing and alignment procedures were oriented to magnetic north. The balance control on the instrument was adjusted first. The balancing the instrument was conducted in the 1 nT resolution range to within a range of ± 1 nT. The magnetic sensors were then aligned to within a range of ± 1 nT. 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 survey of each traverse was conducted in a zigzag or bidirectional mode beginning in the southwest corner or lower left-hand corner of each grid unit (Table 2). During the survey, data were collected at 8 samples per meter (0.125 m) along each traverse and at half-meter traverses across each individual grid unit resulting in 16 samples per square meter. A total of 6,400 measurements were recorded during the magnetic survey for each complete 20 m by 20m grid unit. With eight samples per meter and one-half meter traverses in the zigzag mode, it took approximately 30 minutes to complete a 20m by 20 m grid unit. At the end of the data acquisition of two grid units, the instrument's memory was full and the magnetic data from the survey were downloaded into the Geoscan Research GEOPLOT software (Geoscan Research) on a field laptop computer. It took approximately 26 minutes to download the data from memory of the gradiometer when it was full. The

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grid files were downloaded into the GEOPLOT software and a composite file created in GEOPLOT was reviewed in the field prior to the clearing of the gradiometer's memory.

Soil Resistance Survey Methodology

The Geoscan Research RM15 advanced resistance meter and PA5 multiprobe array in a twin probe configuration (Geoscan Research 1996) is used to collect the horizontal resistance data during the archeogeophysical survey of the project area (Figure 12). 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 1.0 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 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 be beyond acceptable survey levels.

During the resistance survey, data were collected at 2 samples per meter (0.5 m) along 0.5 meter traverse across the survey area in a zigzag or bidirectional mode resulting in 4 samples per square meter (Table 4). For each traverse, a total of 40 resistance measurements were recorded in the memory of the Geoscan Research RM15 resistance meter. A total of 1,600 measurements were recorded for each complete 20-m by 20-m grid unit during the soil resistance survey. At the end of the day, the resistance data from the survey were downloaded into the Geoscan Research GEOPLOT software (Geoscan

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Research 2003) on a laptop computer. It took approximately fifteen 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.

Vertical Electrical Sounding Methodology

The vertical electrical sounding (VES) is conducted with the Gossen Geohm 40D earth tester with a Wenner probe array (Gossen 1995). The VES was centered at N5040/E5070 with the offset line oriented east-west (Figure 13). 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, 0.7, 1.0, 1.5, 2.0, 3.0, 4.0, 5.0, 7.0, and 10.0 meters in both directions from the center probe to obtain data for the offset sounding (Table 5). 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. A total of 30 measurements were recorded along the VES offset line. It took approximately 1.5 hours to set up the array and conduct the vertical electrical sounding at the project area.

Magnetic Susceptibility Profile Methodology

A magnetic susceptibility profile was recorded along the vertical face of the northern trench wall in the second trench approximately four meters from the west end of the trench. The magnetic susceptibility profile was collected with a hand held Geolograzvedka Model PIMV-1M magnetic susceptibility meter (Figure 14). The instrument was first calibrated by holding it in the air and depressing the reading button. Within 10 seconds of calibrating the instrument, it was placed against the vertical wall of the trench and a measurement was taken. The instrument was recalibrated in the air and the process continued until measurements had been taken all along the vertical exposure. Eleven measurements were taken along the vertical wall exposure of the backhoe trench from 3 cm bs to 1.0 m bs and hand recorded in the field notebook (Table 6).

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7. DATA PROCESSING

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. 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.

Processing Magnetic Data

Due to the limited memory capacity and changes in the instrument setup of the FM36 fluxgate gradiometer, the data were downloaded into a laptop computer after the completion of two grid units at the site. On the laptop computer, the GEOPLOT software was initialized and the data from the instrument was downloaded as grid data files on the laptop computer (Geoscan Research 2003:4/1-29). Each grid file contained the magnetic raw data obtained during the survey of the individual grids. The grid files were reviewed as a shade plot display (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

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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.

In order to process the magnetic data, the grid files from the survey must be combined into a composite file. The first step in creating a composite file is to create a mesh template with the grid files oriented in the correct position in the overall survey of the site (Geoscan Research 2003:3/15-21). Once the grid files have been placed in the correct position in the mesh template, the composite file is generated. The master grid or mesh template is saved as a file for later modification as necessary.

After the creation of the composite file for the magnetic 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 2003:5/2-3). The shade plot represents the data in a raster format with the data values assigned 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. 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.

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 ferrous anomalies, which 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 geomorphologic changes in the landscape. 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).

DATA PROCESSING

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. No periodic defects were noted in the data set.

The magnetic 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 2002:16). 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 statistics function (Geoscan Research 2003:6/101-102) was then applied to the entire magnetic data composite file for the southern portion of the site. The mean, standard deviation, and variance were used to determine appropriate parameters for the subsequent processing steps. The magnetic data ranged from -258.5 to 125.0 nT with a mean of -1.46 and a standard deviation of 41.661 after the application of the zero mean traverse algorithm. 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 2 matrix. The interpolate function requires three parameters: direction, interpolation mode and interpolation method. In the Y direction, the number of data measurements is expanded to yield an 8 x 4 data matrix. In the X direction, the number of data measurements are shrunk yielding a 4 x 4 matrix. 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 composite data files were then exported to xyz data files for use in the SURFER 8 contouring and 3d surface mapping program (Geoscan Research 2003:5/4-7; Golden Software 2002).

In SURFER 8 (Golden Software 2002), the initial step is to view the xyz data file. Adjustments to the x and y coordinates were made to the data file. The x or Easting and the y or Northing coordinates was divided by four to yield the sample interval position at every 0.25 meters across the magnetic data set. The value 5000 was added to the Northing coordinate and the value 5000 was added to Easting 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. 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

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methods produce a rectangular matrix of data values from regularly spaced or irregularly spaced XYZ data. The grid geometry is defined for the project area. 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 number of lines should correlate with the number of traverses and samples per traverse. 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 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 round shapes on the displays. Due to the presence of unsurveyed areas along the edges of the rectangular survey area, a blanking file was 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.

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 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 data are also clipped to a range between -20 and 20 nT for better visual presentation of the image. 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 magnetic value data. The distance or spacing between the lines represents the relative slope of the geophysical data surface. The contour map may be modified by changing the mapping level values in the levels page of the contour map properties dialog controls. 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 data (Figure 15).

Processing Soil Resistivity Data

The soil resistance data were downloaded into a laptop computer after the completion of survey at the end of the day. On the laptop computer, the grid files were oriented in a mesh file for the correct location of each set of grid data collected during the survey. A composite file was generated for the resistance data for further processing of the resistance data (Geoscan Research 2003). The composite data file was reviewed for data transfer or survey errors. It was observed that the resistance data contained numerous errors including streaks in the data. Although attempts were made to correct the problem, it became apparent that there was a major instrument malfunction. The resistance data were exported into SURFER 8 mapping software where image and contour maps of the data were generated in SURFER 8 (Golden Software 2002). Although attempts were made to correct the instrument malfunction, it was apparent that the resistance survey would not yield any useful information. The resistance survey was discontinued and the erroneous data was discarded (Figure 16).

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: $\rho_a = 2\pi ar$, where ρ_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 RESIX modeling software package (Butler 1999). The first step in the RESIX program was to create a new sounding file for the offset Wenner array data from the site. The probe spacing value and the apparent resistivity value were entered from the processed data in the field notebook to the spreadsheet in the program software (Table 5). The resulting apparent resistivity values in ohm-meters (Sheriff 1973:156) were plotted by electrode spacing. The forward model of the data was carried out using a 283 point adaptive linear filter (Anderson 1979; Davis et al. 1980). The model used the probe spacings data and the apparent resistivity to generate a synthetic response. A three layer model was created for the approximate subsurface electrical layering (Table 7). The graphic file and the data were saved as a binary file (Figure 17). The calculated model values were then hand-transferred to the GRAPHER 7 worksheet for the display of the electrical stratification plot (Golden Software 2007). In GRAPHER 7, the model data was entered into a new worksheet (Golden Software 2007:23). A 2D line graph was illustrating the model was created in GRAPHER 7 (Golden Software 2007:23-24).

Processing Magnetic Susceptibility Profile Data

The hand written measurements from the field notebook (Table 6) were entered into a new worksheet in GRAPHER 7 (Golden Software 2007). A 2D line graph was created in GRAPHER 7 (Golden Software 2007:23-24) for subsequent analysis (Figure 18).

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8. DATA INTERPRETATION

Andrew David (1995:30) defines interpretation as a “holistic process and its outcome should represent the combined influence of several factors, being arrived at through consultation with others where necessary.” Interpretation may be divided into two different types consisting of the geophysical interpretation of the data and the archaeological interpretation of the data. At a simplistic level, geophysical interpretation involves the identification of the factors causing changes in the geophysical data. Archeological interpretation takes the geophysical results and tries to apply cultural attributes or causes. In both cases, interpretation requires both experience with the operation of geophysical equipment, data processing, and archeological methodology; and knowledge of the geophysical techniques and properties, as well as known and expected archeology. Although there is variation between sites, several factors should be considered in the interpretation of the geophysical data. These may be divided between natural factors, such as geology, soil type, geomorphology, climate, surface conditions, topography, soil magnetic susceptibility, seasonality, and cultural factors including known and inferred archeology, landscape history, survey methodology, data treatment, modern interference, etc. (David 1995:30). It should also be pointed out that refinements in the geophysical interpretations are dependent on the feedback from subsequent archeological investigations. The use of multiple instrument surveys provides the archeologist with very different sources of data that may provide complementary information for comparison of the nature and cause (i.e., natural or cultural) of a geophysical anomaly (Clay 2001). Each instrument responds primarily to a single physical property: magnetometry to soil magnetism, electromagnetic induction to soil conductivity, resistivity to soil resistance, and ground penetrating radar to dielectric properties of the soil to (Weymouth 1986b:371). Although the survey of Site 3NW303 did involve the use of a fluxgate gradiometer and a resistance meter with a twin probe array, the resistance meter malfunction resulted in the use of only the gradiometer data for interpretation.

Interpretation of Magnetic 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 contrast 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

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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 is made of magnetic poles (North or positive and South or negative). A simple dipole anomaly contains the pair of opposite poles that relatively close together. A monopole anomaly is simply one end of a dipole anomaly and may be either positive or negative depending on the orientation of the object. The other end is too far away to have an affect on the magnetic field.

Magnetic anomalies of archeological objects tend to be approximately circular in contour outline. The circular contours are caused by the small size of the objects. The shape of the object is seldom revealed in the contoured data. The depth of the archaeological object can be estimated by half-width rule procedure (Bevan 1998:23-24; Breiner 1973:31; Milsom 2003:67-70). The approximations are based on a model of a steel sphere with a mass of 1 kg buried at a depth of 1.0 m below the surface with the magnetic measurements made at an elevation of 0.3 m above the ground. The depth of a magnetic object is determined by the location of the contour value at half the distance between the peak positive value of the anomaly and the background value. With the fluxgate gradiometer, the contour value is half the peak value since the background value is approximately zero. The diameter of this contour (Bevan 1998:Fig. B26) is measured and used in the depth formula where depth = diameter – 0.3 m (Note: The constant of 0.3 m is the height of the bottom fluxgate sensor above the ground in the Geoscan Research FM36 were I carry the instrument during data acquisition. This value needs to be adjusted for each individual that carries the instrument.). The mass in kilograms of the object (Bevan 1998:24, Fig. B26) is estimated by the following formula: mass = (peak value - background value) * (diameter)³/60. It is likely that the depth and mass estimates are too large rather than too small, since they are based on a compact spherical object made of iron. Archeological features are seldom compact but spread out in a line or lens. Both mass and depth estimates will be too large. The archaeological material may be composed of something other than iron such as fired earth or volcanic rock. Such materials are not usually distinguishable from the magnetic data collected during the survey (Bevan 1998:24). The depth and mass of features comprised of fired earth, like that found in kilns, fireplaces, or furnaces could be off by 100 times the mass of iron. If the archeological feature were comprised of bricks (e.g., brick wall, foundation, or chimney), estimates could be off by more than a 1000 times that of iron. The location of the center of the object can also be determined by drawing a line connecting the peak positive and peak negative values. The rule of thumb is that the center of the object is located approximately one third to one half of the way along the line from the peak positive value for the anomaly. One should also be cautious of geophysical anomalies that extend in the direction of the traverses since these may represent operator-induced errors. The magnetic anomalies may be classified as three different types: 1) dipole, 2) monopole, and 3) linear.

DATA INTERPRETATION

There are numerous dipole and monopole magnetic anomalies in the data set from the magnetic survey of Site 3NW303 (Figure 19). The magnitude, orientation of the dipole, and shape and size of the anomalies suggest that the vast majority of the anomalies are caused by modern ferrous materials related to the ranching and more recent park activities at the site. One strong dipole anomaly located near N5030/E5035 may indicate a well used to water the livestock in the corral. Fifteen anomalies were identified as potential prehistoric features (Table 8). The selection of these anomalies for ground truthing was also based on their magnitude, range in positive and negative values, orientation, and shape of the anomalies. The orientation of the north and south poles of the magnetic anomalies in line with magnetic north or close to that alignment suggested the possibility of a fire related feature such as a hearth, roasting pit, or burned structure. Several linear alignments of magnetic anomalies correlate to the location of modern park fence lines, historic ranch fence lines and corrals, and buried park and ranch utility lines. Large cluster of magnetic anomalies indicate the locations of demolished ranch buildings as noted on the 1965 aerial photograph of the area (Figure 20). The locations of the magnetic anomaly clusters represent the locations of the large show barn or arena, a small building or shed in one on the corral pens, and a portion of a long rectangular horse stable. In the area of the park service road to the canoe access, there are numerous strong magnetic anomalies. The road fill appears to have been removed from its sides, which now form the drainage ditch. It appears that these anomalies relate to material from the demolished show barn or arena. Two large anomaly clusters in the southern portion of the survey area have been identified as the disposal pits associated with the demolition and burial of ranch building by a National Park Service contractor shortly after the purchase of the land by the government for incorporation into Buffalo National River. However, without additional archeological investigations of these anomalous areas, their true nature may go undetected.

Interpretation of Vertical Electrical Sounding Data

The results of the modeling of the vertical electrical sounding data from the site suggest a three-layer curve for the electrical stratification of the soil. Using the 2D line graph as the background, an electrical stratigraphic block diagram is created by inserting rectangles in the data ranges (Figure 21). The rectangles are subsequently filled and labeled with the appropriate ohm-meter value from the model for the final presentation (Golden Software 2007:24-38). The model indicates that the upper 0.23 meters have an apparent resistivity of 77.96 ohm-meters, the second 1.24 m thick layer measures 22.44 ohm-meters, and the bottom layer measures 574.5 ohm-meters. The upper layer corresponds to the loamy plowzone (Fowlkes et al. 1988:102). The second layer corresponds to the Bt horizon of the Razort loam soil. The bottom layer corresponds to the gravelly sandy loam C horizon of the Razort soil mapping unit. This model suggests a slightly conductive loamy soil to a very conductivity loamy soil in the upper 1.47 m (Bevan 1998:8; McNiel 1980:16; Telford et al. 1990:289-291). This is underlain with a highly resistivity gravelly sandy loam layer extending to the bottom of the sounding.

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Interpretation of the Magnetic Susceptibility Profile Data

The results of the magnetic susceptibility profile on the north wall of Trench #2 illustrate a typical enhancement of the topsoil (Figure 22). The magnetic susceptibility then decreases to a depth of approximately 35 cm bs where there is an increase in the magnetic susceptibility. There may be a mineralogical change in materials deposited on flood plain or there may be a period where there stable period of time of soil development with no accumulation of flood deposits resulting in the increases susceptibility between 35 and 55 cm bs. The magnetic susceptibility then drops off at a fairly consistent rate generally found in the subsoil. This also corresponds to the gravelly sandy loam layer noted in the soil description of the Razort loam soil (Fowlkes 1988:102).

9. GROUND TRUTHING MAGNETIC ANOMALIES

Ground truthing archeogeophysical anomalies provide an important method to verify and enhance survey results using independent evidence. Although many archeogeophysical maps do not lend themselves to easy interpretations, ground truthing the anomaly helps improve the interpretation of the data. Similarly shaped anomalies can have diverse causes (e.g., a circular weak anomaly may be a refuse or storage pit or small pieces of metal, magnetic rocks, undulating dips in topsoil or midden deposits, or tap roots). The goals in ground truthing archeogeophysical survey data provide better detection of anomalies associated with archeological features and the classification of anomalies related to archeological features from survey clutter. Survey clutter includes non-random responses or signals that are not of interest to the survey identification of archeological features. Ideally, the ground truthing results will provide a mechanism by which one can assign various types of anomalies to archeological feature categories. When considering ground truthing archeogeophysical anomalies, five factors should be considered in the selection of the ground truthing method. These include information return on the identification of the anomaly, cost of identifying the anomaly, invasiveness of the technique, social and political issues associated with the project, and the type of risks involved in conducting the ground truthing investigations. The idea in ground truthing archeogeophysical anomalies is to provide the identification of archeological features in order to target funds and resources to the excavation of most promising archeological features.

At Site 3NW303, fifteen magnetic anomalies (Table 8) were identified for ground truthing based on the anomaly's dimensions (size and shape), amplitude of the signal (i.e., magnitude of the measured magnetic variation of the anomaly from the background levels), discreteness of the anomaly, sign (positive or negative) and the orientation of the dipole or monopole anomaly, and its location on the landscape (e.g., relationship to other anomalies, to the topographic setting, to artifact distributions, etc.). The anomalies were first tested with a Schonstedt magnetic locator or pipe detector. The Schonstedt magnetic locator detects the magnetic field of iron or steel objects and provides an audio detection signal (Schonstedt 1992). The peak frequency occurs when the instrument's tip is held directly over the magnetic target. If the ground truthing resulted in an audio response from the instrument, the target was identified as a ferrous metal object. The target anomaly was eliminated from further consideration as a possible archeological target of interest for further investigation. Fourteen anomalies tested positive as ferrous materials. In the present site setting, these objects were interpreted as modern ferrous metal objects and further investigations were not warranted. If no audio response was indicated over the location of the magnetic anomaly, an Oakfield soil sampling coring tool was inserted into the ground in the center of the anomaly and at four points outside the anomaly. The soil core extracted with the coring tool was examined for disturbance related indicators (e.g., discoloration of the soil in the core that might indicate anthropogenic modification of the natural soil in the profile, pieces of charcoal, bone, or wood, the presence of ash, or artifacts) that would suggest the anomaly represented an archeological feature. One anomaly was cored

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with the Oakfield coring tool. The soil core appeared to represent a truncated natural soil profile. Visual investigation of the area indicated the presence of a leveled square area. Examination of the aerial photograph from 1965 suggested that the identified surface feature was a corral pen. The area had been leveled by removing the upper portion of the slope and filling in the down slope side. The truncated profile noticed in the soil cores in and around the anomaly was caused by the mechanical leveling of the corral area. None of the potential anomalies were identified as prehistoric archeological features.

10. GEOARCHEOLOGICAL INVESTIGATIONS AT SITE 3NW303

Geoarcheological investigations are used to place a site and its contents in a relative and absolute temporal setting (Waters 1992:7-12). In order to accomplish this objective, stratigraphic principles and absolute dating techniques are used. In addition to dating cultural and natural levels, geoarcheology is also used to understand the site formation processes including both cultural and natural transformations that occur to create a site and its associated contexts. The reconstruction of the landscape that existed at the time of the occupation of the site by its human inhabitants provides the basis for understanding the past human behavior, which was affected by the surrounding natural environment (Waters 1992:11). Geoarcheology represents the combined study of archeological and the geomorphological record in order to understand the effects of natural and cultural processes that impact the landscape (see Birkeland 1984; Butzer 1982; Davidson and Shackley 1976; French 2003; Goldberg and Macphail 2006; Herz and Garrison 1998; Holliday 2004; Pollard 1999; Rapp and Gifford 1985; Rapp and Hill 1998; Retallack 2001; Schiffer 1987; Shackley 1975; Stein and Farrand 2001; and Waters 1992 for more information on the application of geoarcheological investigations to archeological research).

Backhoe Trenches

Three trenches were placed by backhoe in the project area where the magnetometer survey indicated the area was relatively undisturbed. The trenches were excavated with the park's Caterpillar Model 416D backhoe loader (Figure 24). Trenches 1 and 2 are on the same line, running at an azimuth of 157 degrees (Figure 25). Trench 3 is nearly perpendicular to Trenches 1 and 2. Its azimuth is 250 degrees. Trenches 1 and two run along the axis of the high ground, Trench 3 runs across the swale (Figures 26-27).

Trench 1. Trench 1 is 13 m long with a maximum depth of 1.5 m (Figures 28-32). It starts as gravel in the bottom 0.1 m, turns to sand in the next 0.2 m, then gets progressively finer toward the top of the profile. The color of the profile is fairly uniform, getting slightly redder near the top of the profile in the plow zone. There were some coarser clastics near the 10 m mark within the plow zone. They appear to indicate prehistoric human occupation for a short time in that area.

Trench 2. Trench 2 (Figures 33-34) is 10 m in length with a maximum depth of 1.5 m. The bottom of the trench starts in gravel for the first 0.1 m and grades to finer materials as it goes up in elevation. Generally, the color of the sediment is less uniform than Trench 1. There is an anomalous cobble embedded in sand and silt at the 0.9 m depth at the 8 m point on the profile. The plow zone is approximately 0.3 m in depth and contains mostly silt and clay with some sand. It is redder than most of the subsoil. There were two fire cracked cobbles found in the plow zone.

Trench 3. Trench 3 (Figures 35-37) is 11 m in length with a maximum depth of 1.9 m. It is a much less uniform trench than either Trench 1 or 2. There is gravel below

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the 1.5 m depth at the 3 m point, but none was found to a depth of 1.9 m at the 7 m point. This indicates a change in depositional environment. It appears the hill is underlain by a gravel bar, while the swale may be an old channel filled with overbank deposits. There is a higher clay content at depth in this profile, indicating a slow settling basin rather than a high energy deposition environment. There is a distinct transition from clayey silt to sandy silt between 0.9 m and 0.6 m depth. A post hole at the 8.5 m point goes down to the transition line and stops abruptly. This hole is filled with yellowish sand. It would appear it was simply filled with clean sand from somewhere as there is no indication of a substantial sand layer in the overlying sediments as would be expected from a large flood event. Of course the sediments above the post hole are disturbed by plowing, so any indication of a flood could have been removed mechanically.

Geomorphological Interpretation

The general lack of sharp changes in colors and textures indicate this site has a stable depositional history. The lack of gravel at the 1.9 m depth in Trench 3 indicates this is an old overflow channel, whereas the knoll is underlain by an old gravel bar. The gravel and sands may allow lateral migration of water through the soil to the river. This could pose some concern for river water quality if septic leach fields are placed in such a way where the liquid effluent is in these coarse sediments. The site appears geologically stable, and probably poses no geo-hazards. There is no indication of karst deposits buried under the sediments, but that is always a possibility in a rich karst terrain such as this. It is not too uncommon to find sinkholes within the floodplain of the river and larger tributaries in a similar geologic setting. The limited geophysical prospecting which was done cannot discern this potential. This project provided a good opportunity to analyze soil profiles when ground disturbing activity is taking place to get a better understanding of the geomorphology of the Buffalo River.

11. ARTIFACT ANALYSIS

Artifacts recovered from this project are described below. In conjunction with the backhoe excavations, all prehistoric materials observed in backdirt and trench profiles was collected and bagged by trench number. Soil associations in all cases indicated origin in the uppermost layer of soil, that is, from the disturbed area of the site. Most of the artifacts were associated with Trench 1 which was located near the top of the knoll. Only one flake was found in Trench 3, located near the base of the knoll and edge of the swale.

Types of artifacts were limited to a single grit-tempered sherd of limited diagnostic value, and lithic artifacts (Tables 9-11). Typical of this area, all stages of lithic reduction are represented in approximately equal amounts. Raw materials are exclusively local in origin. A single projectile point (Figure 38) was recovered from Trench 1. It is broadly similar to points from Late Archaic through Late Woodland periods and is of limited diagnostic value.

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12. SUMMARY AND CONCLUSIONS

Between June 5 and 15, 2007, the Midwest Archeological Center and Buffalo National River staff and volunteers conducted archeological prospection investigations at the Yarborough Open Site #4 (3NW303) in the Steel Creek Horse Camp within the boundary of Buffalo National River in Newton County, Arkansas. The 2007 archeological prospection project consisted of archeogeophysical and geoarcheological investigations of the horse pasture and adjacent hay field as part of the Section 106 compliance activities associated with the construction of a proposed horse camp at Steel Creek in the Upper Ranger District of Buffalo National River. The proposed new campground will consist of 17 new horse camp units with water and electrical hook-ups for recreational vehicles, as well as horse tethering poles. In addition, the proposed campground location will also contain a horse washing station. During the investigations, 9,200 square meters or 2.27 acres were surveyed with a Geoscan Research FM36 fluxgate gradiometer.

Findings suggest that there is a remnant prehistoric archeological site within the project area. The project area itself is heavily disturbed by the construction, then demolition of a horse ranch here in the 1970s. Few undisturbed areas of the site remain. Archeogeophysical investigations identified a large number of anomalies that relate to the horse camp, but the few anomalies that were potentially prehistoric proved negative when ground truthed. Artifacts recovered from the site are typical of lithic assemblages all along the Buffalo River: raw materials are locally derived and all stages of lithic reduction are present. Artifact densities are very low and the site is best described as an extensive and diffuse lithic scatter broadly dating to somewhere between the Late Archaic and Late Woodland periods. Earlier finds suggest an even broader span of use of this location throughout prehistory. No buried horizons were detected in backhoe trenching and all prehistoric material appears to be concentrated within the historic plowzone of the uppermost 20-30 cm. The site integrity of the prehistoric component has been severely impacted by the 20th century ranching activities and the subsequent demolition of the ranch buildings, structures, and fences by the National Park Service, as well as more recent modifications to the terrain, including the construction of the public restroom facility and the gravel access roads to the canoe access point on the river, the installation of the buried utility lines, and the building of new pasture and hay field fences. The potential for providing information that would contribute to our understanding of human history and prehistory is extremely limited. Based on both the results of the archeological prospection investigations and the geoarcheological backhoe trenching, this site, or this portion of 3NW303 does not meet requirements for Criterion D of the National Register of Historic Places (National Park Service 1990:21-24).

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TABLES

Table 1. Prehistoric cultural chronology of Northwest Arkansas.

Cultural Period <i>Sub-Period</i>	Adaptation Type from Sabo et al. (1990)	Chronology (In Years Before Present)	Environmental Context from Sabo et al. (1990)
Protohistoric		500 - 300 B.P.	
<i>Mississippian</i>		<i>900 - 500 B.P.</i>	
<i>Emergent Mississippian</i>		<i>1,100 - 900 B.P.</i>	
Mississippian	Late Holocene Sedentary (Dispersed)	1,100 - 500 B.P.	<i>(Various Small Scale Climatic Fluctuations)</i>
<i>Late Woodland</i>		<i>1,500 - 1,100 B.P.</i>	
<i>Middle Woodland (Hopewellian)</i>		<i>2,000 - 1,500 B.P.</i>	
<i>Early Woodland</i>		<i>2,500 - 1,800 B.P.</i>	
Woodland	Late Holocene Semi-Sedentary	2,500 - 1,100 B.P.	Establishment of Modern Oak-Hickory, and Oak-Pine Forests
<i>Late Archaic</i>		<i>5,000 - 1,800 B.P.</i>	
<i>Middle Archaic</i>		<i>8,000 - 5,000 B.P.</i>	
<i>Early Archaic</i>		<i>9,500 - 8,000 B.P.</i>	
Archaic		9,500 - 1,100 B.P.	Onset of Hypsithermal Warmer and Drier Conditions Oak-Hickory Forest
Dalton	Early to Middle Holocene Mobile Hunter-Gatherer	10,500 - 9,500 B.P.	Early Holocene Increasing Deciduous Forest
<i>Late Paleoindian</i>		<i>11,000 - 10,500 B.P.</i>	
<i>Early Paleoindian</i>		<i>12,000 - 11,000 B.P.</i>	
Paleoindian	Pleistocene Holocene Transition Mobile Hunter-Gatherer	12,000 - 10,500 B.P.	Terminal Pleistocene Boreal Forest

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Table 2. Global positioning system coordinates for archeological prospection project (Zone 15 North).

Northing (m)	Eastng (m)	Elevation (m)
3988326.397	469574.232	304.734
3988324.14	469674.538	304.190
3988320.269	469693.887	304.633
3988240.534	469671.799	304.312
3988231.144	469675.842	304.380
3988219.391	469643.612	302.503
3988219.363	469578.624	304.054

Table 3. Acquisition and instrumentation information for the gradiometer survey used in the grid input template.

GENERAL	value	Instrumentation	value
Acquisition		Survey Type	Gradiometer
Sitename	3NW303	Instrument	FM36
Map Reference		Units	nT
Dir. 1 st Traverse	N	Range	AUTO
Grid Length (x)	20 m	Log Zero Drift	Off
Sample Interval (x)	0.125 m	Baud Rate	2400
Grid Width (y)	20 m	Averaging	Off
Traverse Interval (y)	0.5 m	Averaging Period	16
Traverse Mode	ZigZag		

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Table 5. Offset Wenner array resistivity data centered at N5040/E5070.

Probe spacing (m)	East (left) offset resistance reading (ohms)	West (right) offset resistance reading (ohms)	average resistance reading (ohms)	$\rho_a = 2 \pi R d$ apparent resistivity (ohm-meters)
0.1	114.90	114.90	114.900	72.194
0.15	79.80	79.60	79.700	75.115
0.2	58.20	57.90	58.050	72.948
0.3	31.00	30.70	30.850	58.151
0.4	18.17	18.30	18.235	45.830
0.5	11.50	11.60	11.550	36.285
0.7	6.25	6.30	6.275	27.599
1.0	4.46	4.50	4.480	28.149
1.5	3.67	3.70	3.685	34.730
2.0	3.39	3.50	3.445	43.291
3.0	3.23	3.30	3.265	61.544
4.0	3.19	3.30	3.245	81.556
5.0	3.09	3.10	3.095	97.232
7.0	2.82	2.69	2.755	121.171
10.0	2.64	2.43	2.535	159.278

Table 6. Magnetic susceptibility profile (N5025.7/E5084.8) down the wall of Trench 2.

Depth below ground surface (cm)	Volume susceptibility (K) measurement (SI--International System of Units)
3	1.5×10^{-3}
14	2.0×10^{-3}
22	1.4×10^{-3}
34	1.7×10^{-3}
43	1.6×10^{-3}
50	1.6×10^{-3}
60	1.1×10^{-3}
70	1.2×10^{-3}
80	1.2×10^{-3}
90	9.3×10^{-4}
100	9.2×10^{-4}

Table 7. Vertical electrical sounding model centered at N5040/E5050.

Number of layer	Apparent resistivity (ohm-meters)	Thickness of layer (m)	Elevation at top of layer (m amsl)
1	77.96	0.229	304.0
2	22.44	1.24	303.7
3	574.50		302.5

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Table 8. Ground-truthed magnetic anomalies.

Anomaly ID	Location	Type	Shape	Measurement Range (nT)	Description
A1	N5044.8/E5020.5	dipole	circular	-6.0 to 10.5	Metal
A2	N5045.2/E5025.5	monopole	circular	8.9	Soil disturbance associated with corral
A3	N5047/E5029	dipole	circular	-17.0 to 32.8	Metal
A4	N5043.5/E5067.5	dipole	circular	-10.0 to 19.1	Metal
A5	N5036.4/E5071.5	monopole	circular	17.3	Metal
A6	N5037.9/E5076	dipole	circular	-12.0 to 15.9	Metal
A7	N5036.8/E5081	dipole	oval	18.4 to 13.5	Metal
A8	N5035.8/E5084	dipole	oval	-18.9 to 31.0	Metal
A9	N5038.4/E5087.5	dipole	oval	-4.5 to 14.2	Metal
A10	N5036.3/E5089.5	monopole	oval	41.5	Metal
A11	N5033.2/E5094	dipole	oval	-31.7 to 25.5	Metal
A12	N5026.5/E5100.5	dipole	broad oval	-39.5 to 15.5	Metal
A13	N5043.5/E5108.6	dipole	oval	-22.4 to 22.0	Metal
A14	N5058.8/E5121.5	dipole	oval	-26.4 to 49.0	Metal
A15	N5036.3/E5125.5	dipole	oval	-6.9 to 14.9	Metal

Table 9. Lithic artifacts from Trench 1.

Description	Quantity	Heat Treated	Burned
Proj Pt	1	0	0
Biface	1	0	0
Biface frag	1	0	1
Decort flake	1	0	0
Secondary flake	3	0	1
Bifacial thinning flake	4	1	0
Shatter/frags	3	0	0

Table 10. Lithic artifacts from Trench 2.

Description	Quantity	Heat Treated	Burned
Decort flake	4	1	0
Secondary flake	4	1	1
Bifacial thinning flake	7	0	0
Core	1	0	0
Grit-temp sherd	1	n/a	n/a

Table 11. Lithic artifacts from Trench 3.

Description	Quantity	Heat Treated	Burned
Secondary flake	1	1	0
Bifacial thinning flake	3	0	0

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FIGURES

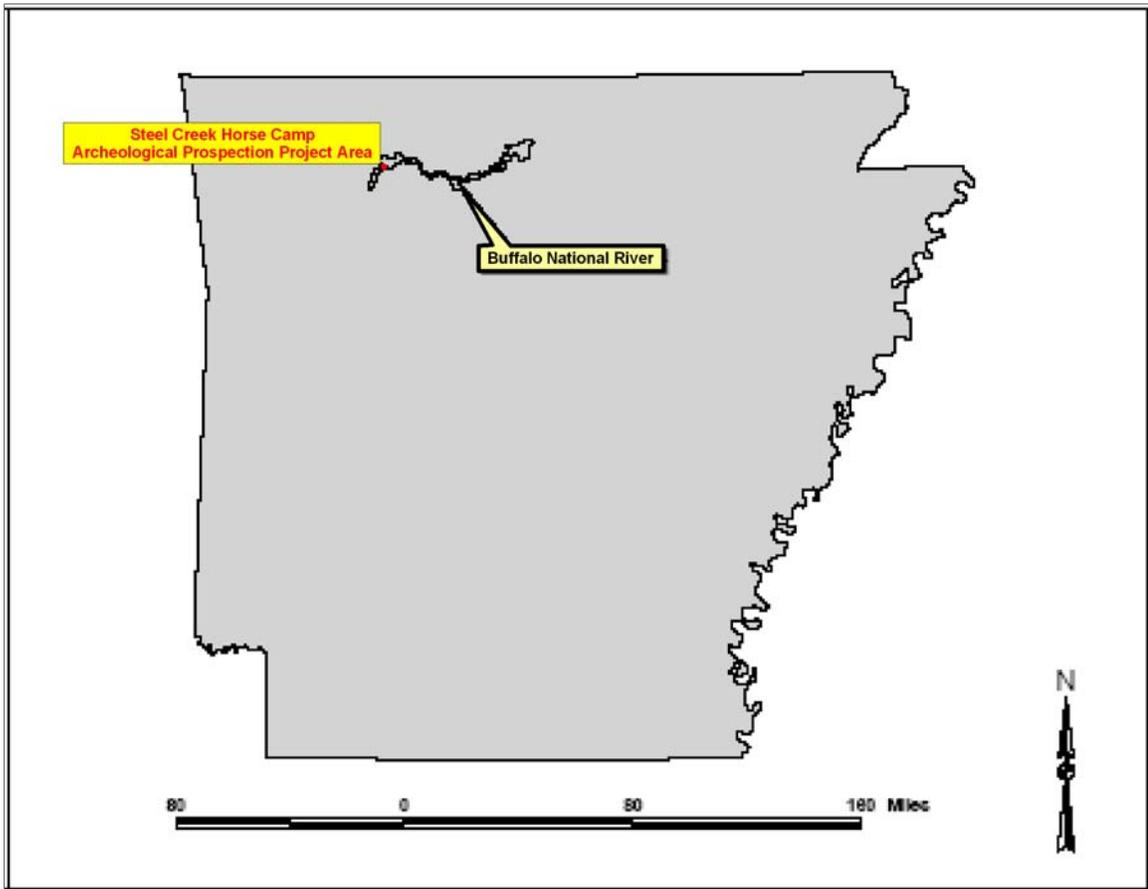


Figure 1. Location of the Steel Creek Archeological Prospection Project Area in Buffalo National River, Arkansas.

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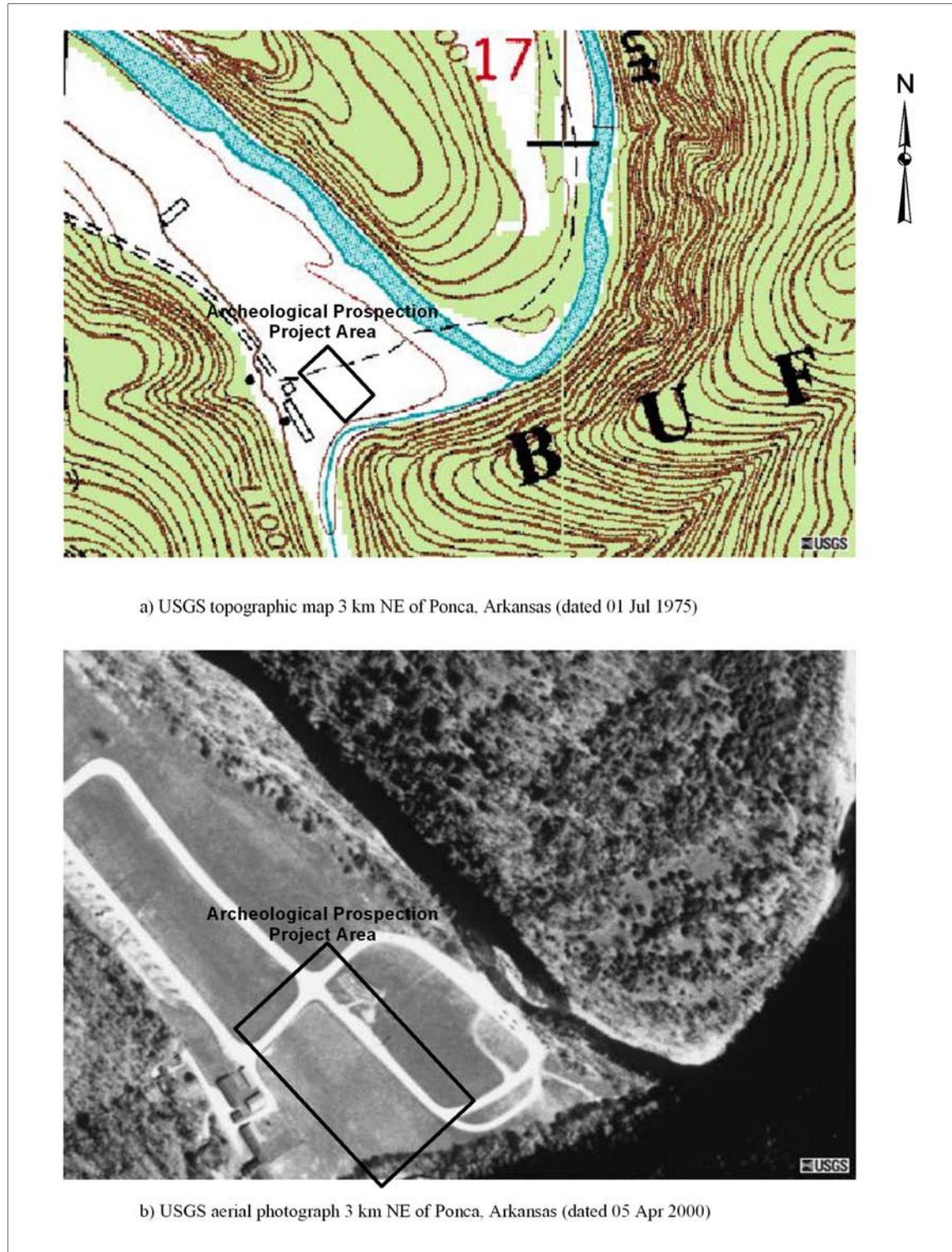


Figure 2. Archeological prospection project area at the Steel Creek Horse Camp in Newton County, Arkansas.



Figure 3. General view of the archeological prospection project area from the bluffs to the southeast (view to the west).



Figure 4. General view of the archeological prospection project area from the south side of Site 3NW303 (view to the northeast).

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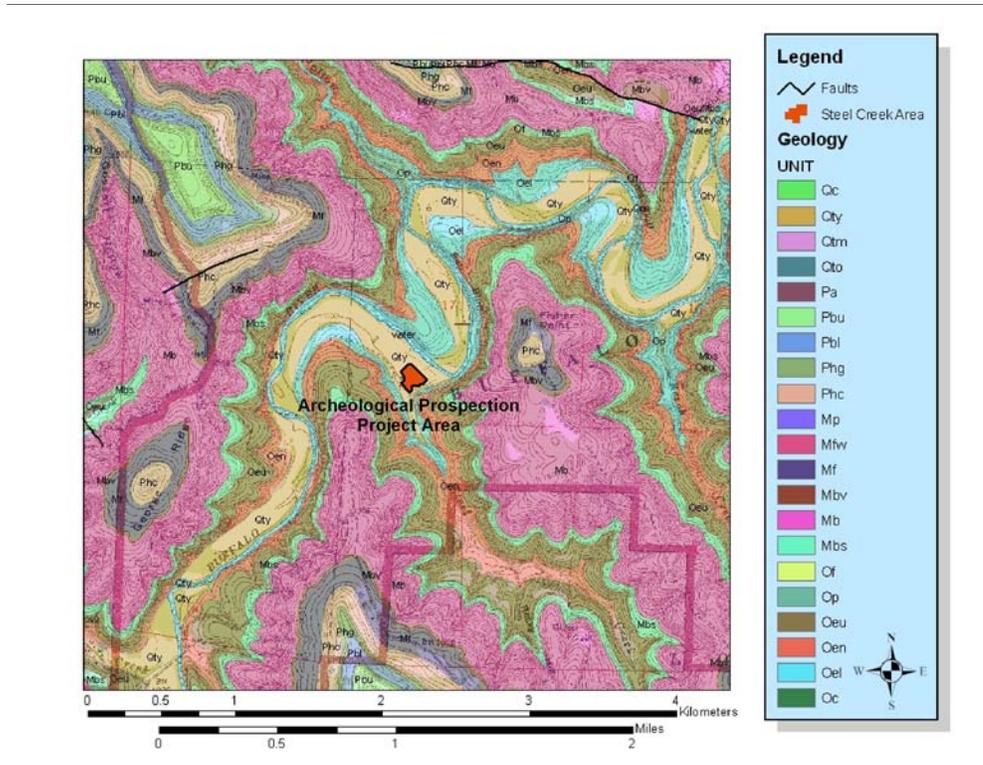


Figure 5. Geologic map of Steel Creek vicinity.

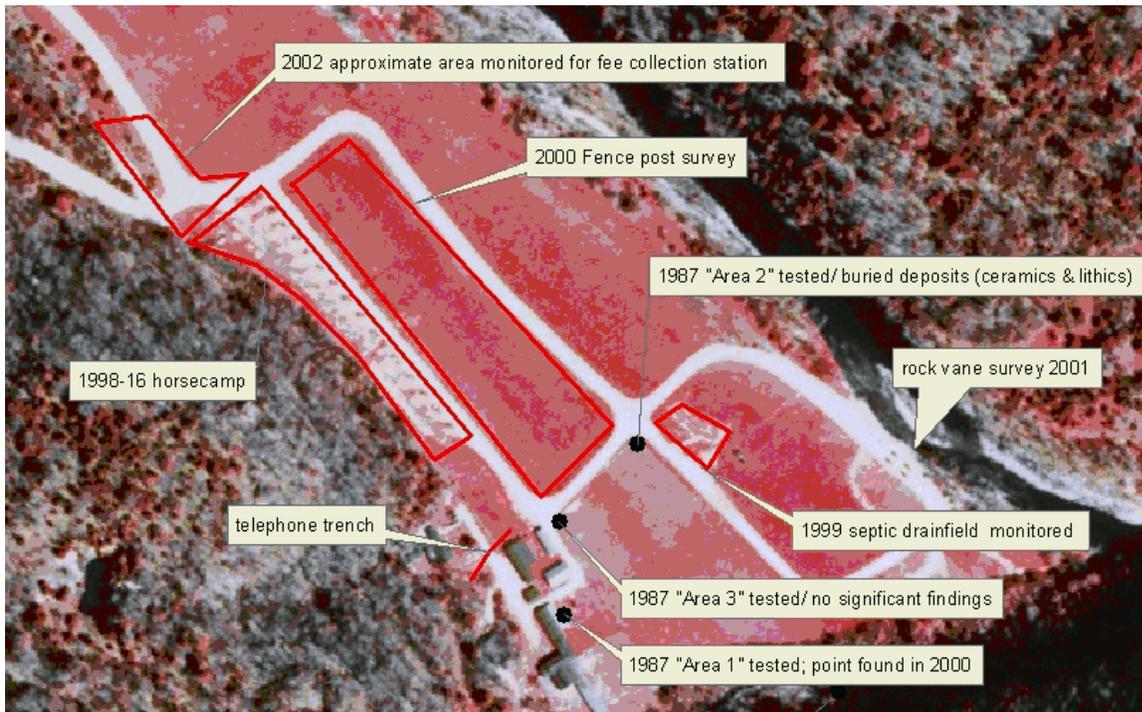


Figure 6. 2000 aerial showing locations of previous work in and near the project area.

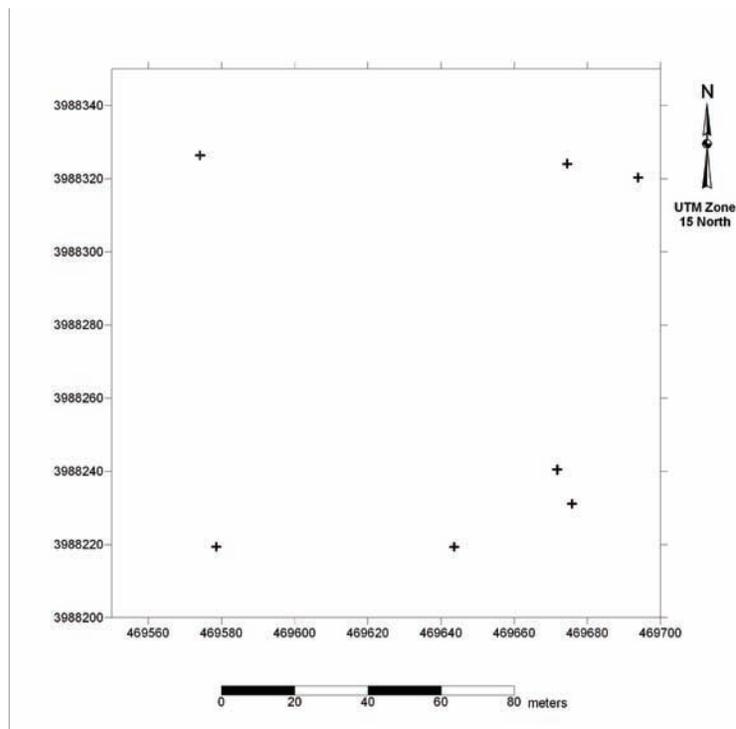


Figure 7. Global positioning system archeological prospection grid corner coordinates.

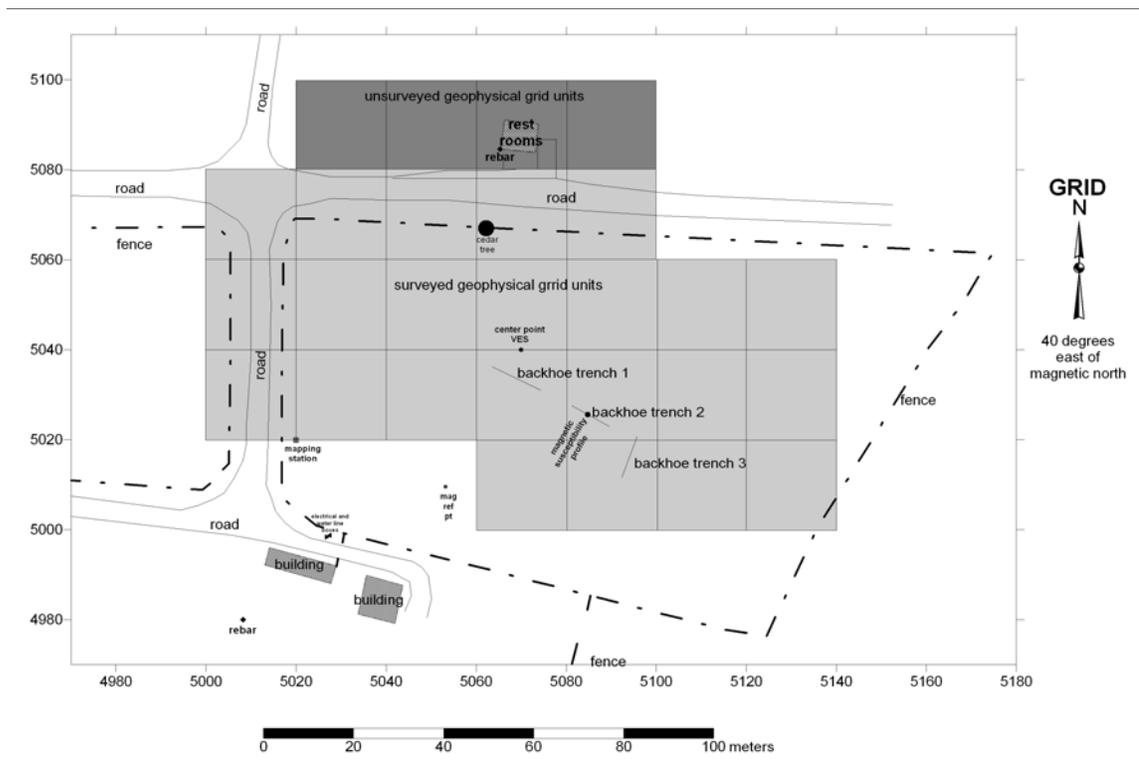


Figure 8. Site map of the archeological prospection project area at Site 3NW303.



Figure 11. Conducting the magnetic survey with a Geoscan Research FM36 fluxgate gradiometer (view to the west).



Figure 12. Conducting the resistance survey with a Geoscan Research RM15 resistance meter and PA-5 multi-probe array in the twin probe array configuration (view to the southeast).

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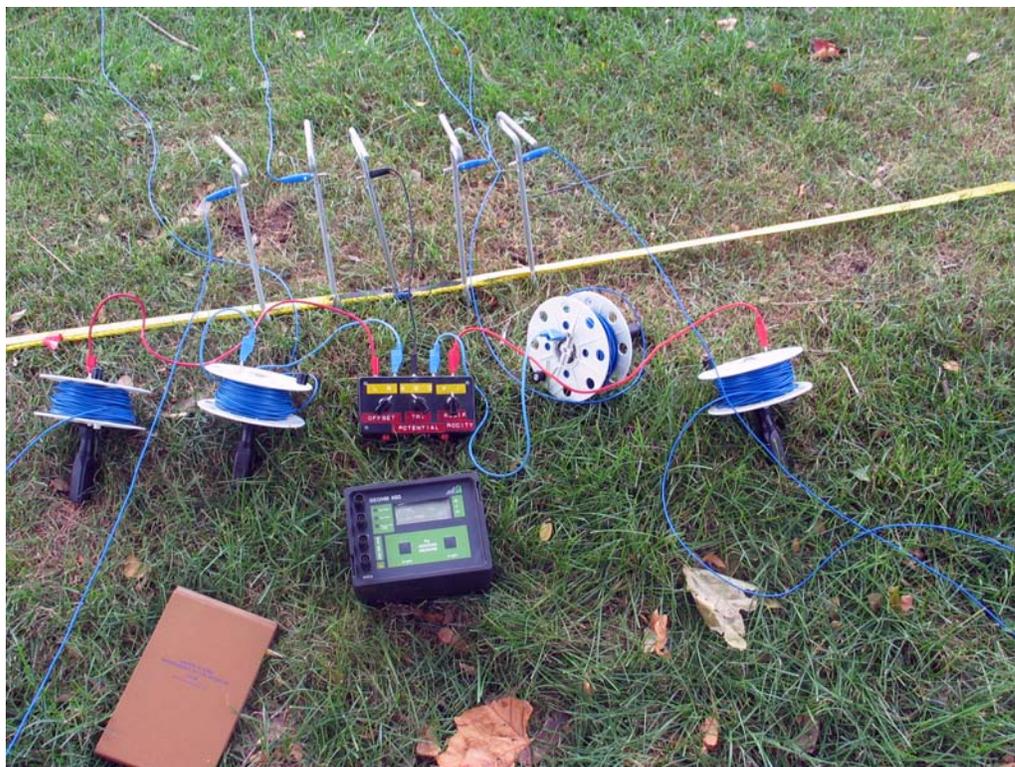


Figure 13. Conducting a vertical electrical sounding with a Gossen Geohm 40D earth tester or resistivity meter and offset Wenner probe array.



Figure 14. Geologorazvedka model PIMV-1M hand held magnetic susceptibility meter.

FIGURES

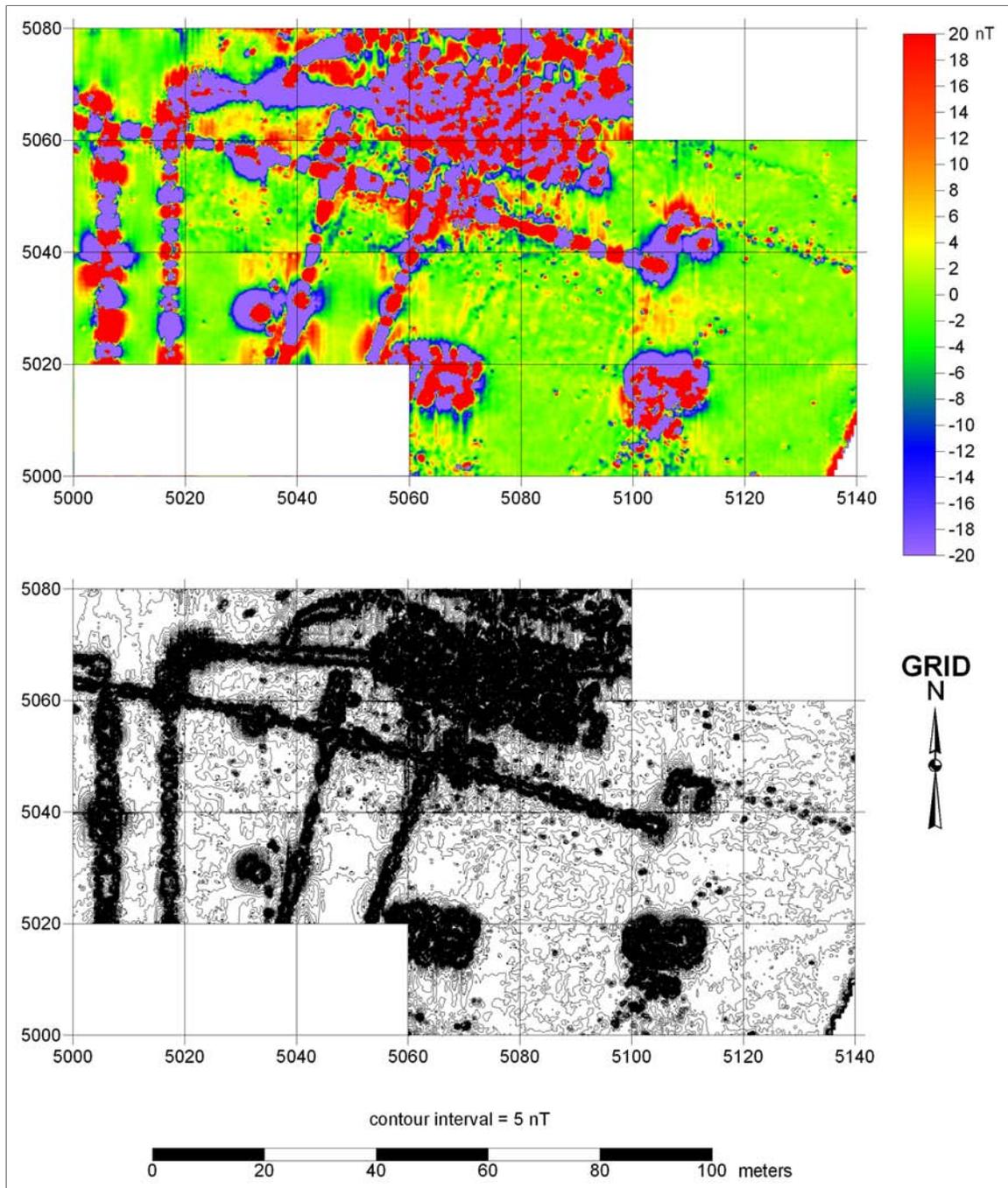


Figure 15. Magnetic image and contour data plots.

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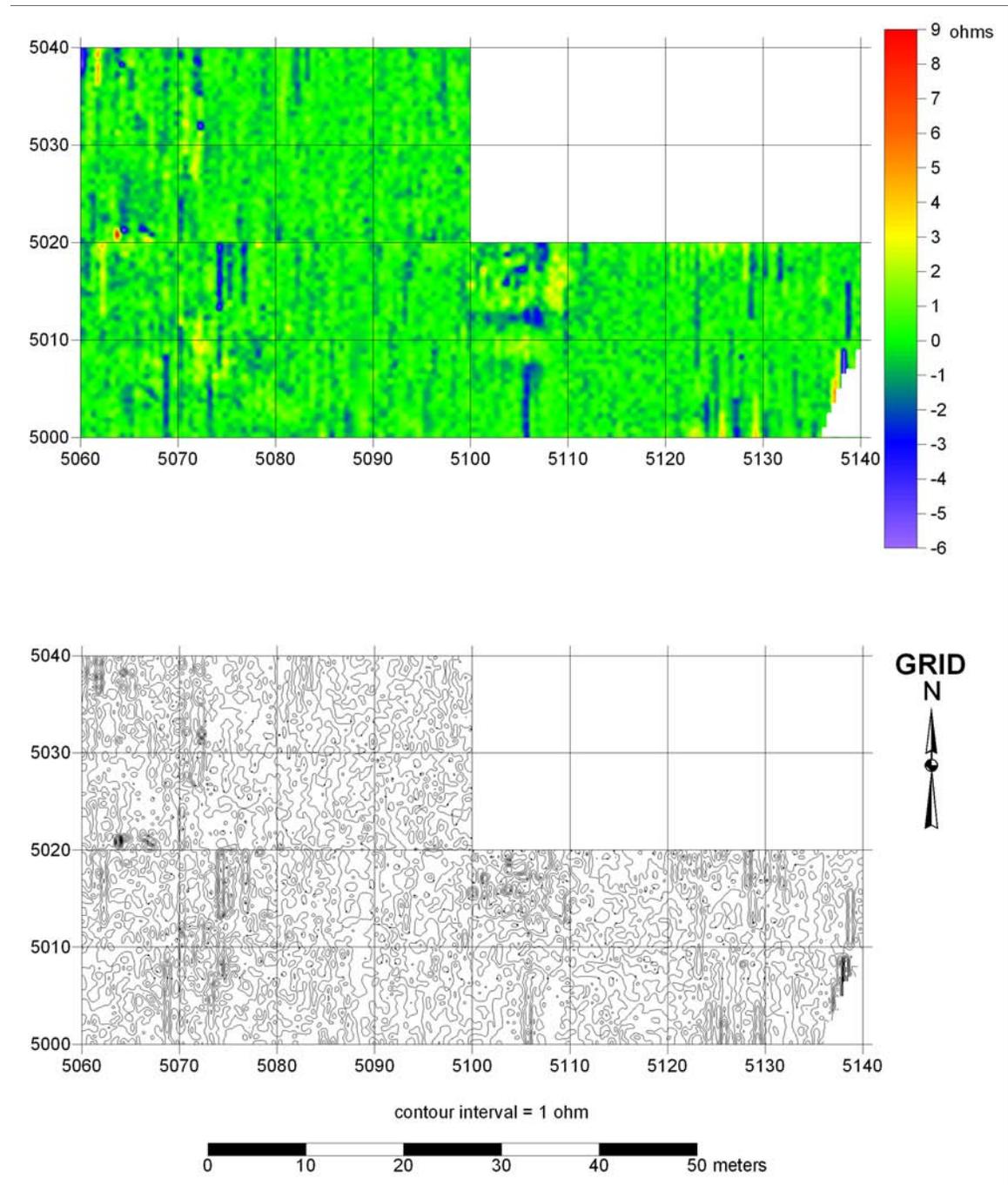


Figure 16. Resistance image and contour data plots of erroneous data from malfunctioning instrument.

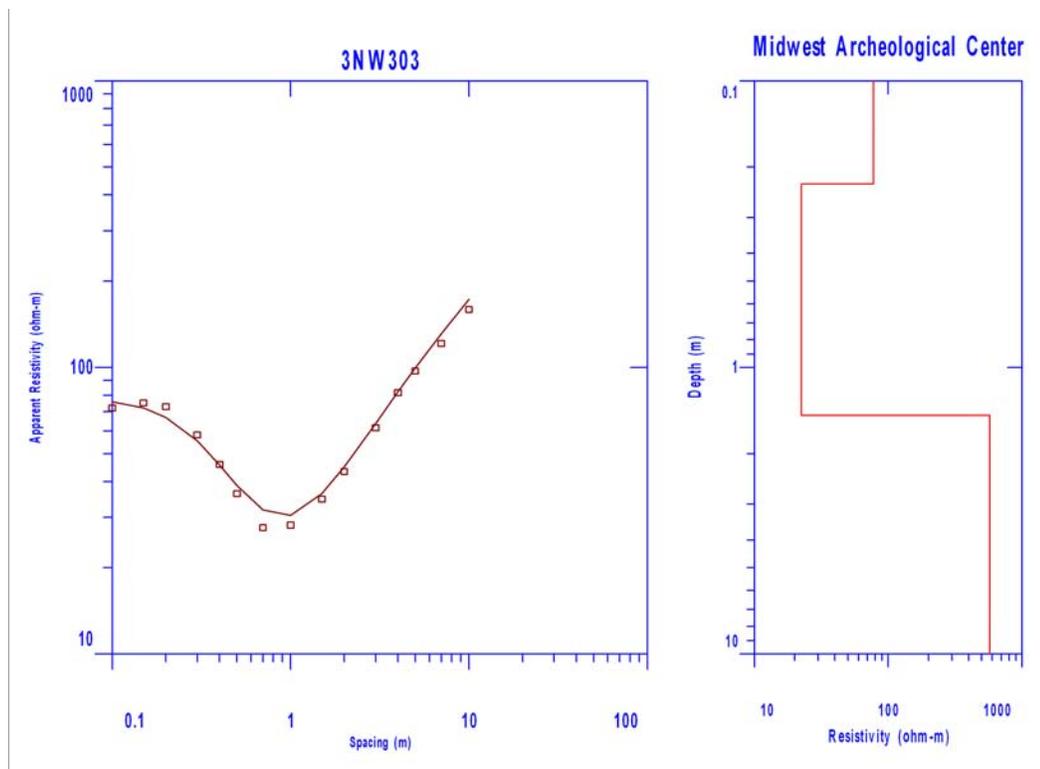


Figure 17. Resistivity data and model for vertical electrical sounding centered at N5040/E5050.

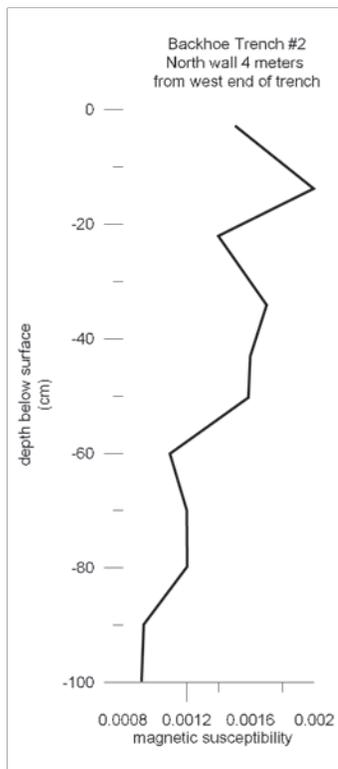


Figure 18. Volume magnetic susceptibility profile data from Backhoe Trench #2.

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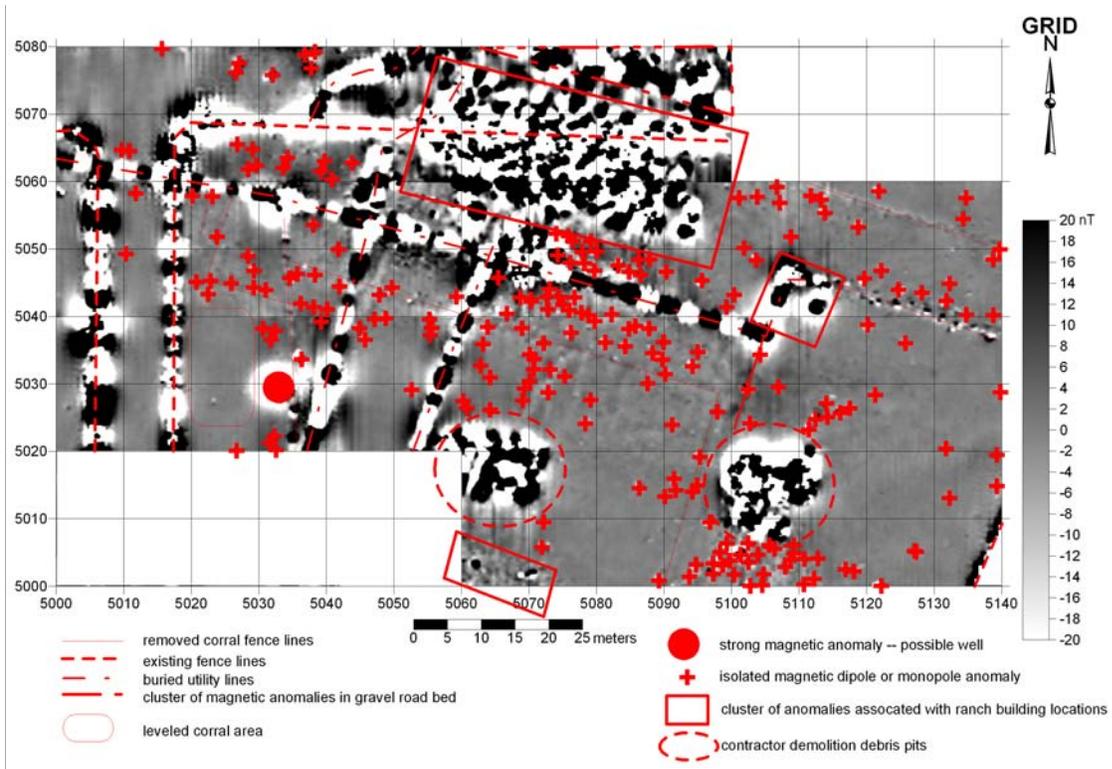


Figure 19. Interpretation of the magnetic data from Site 3NW303.

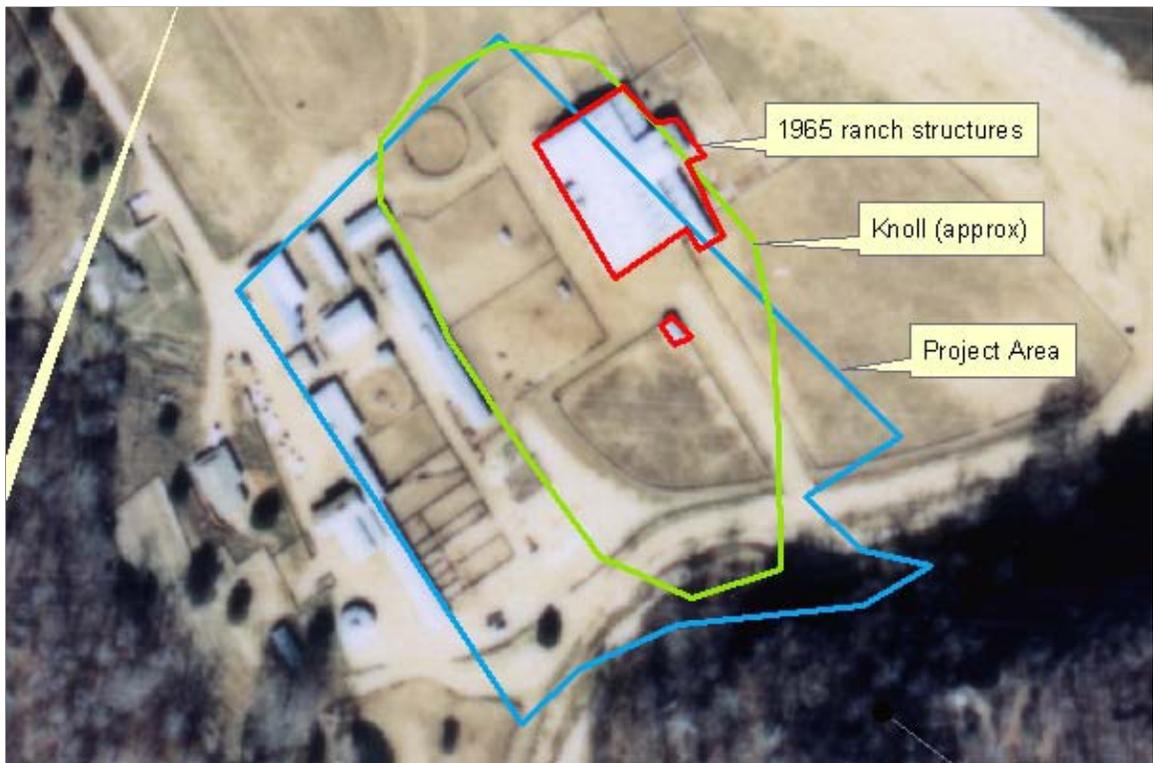


Figure 20. 1965 aerial photograph of Valley K Ranch.

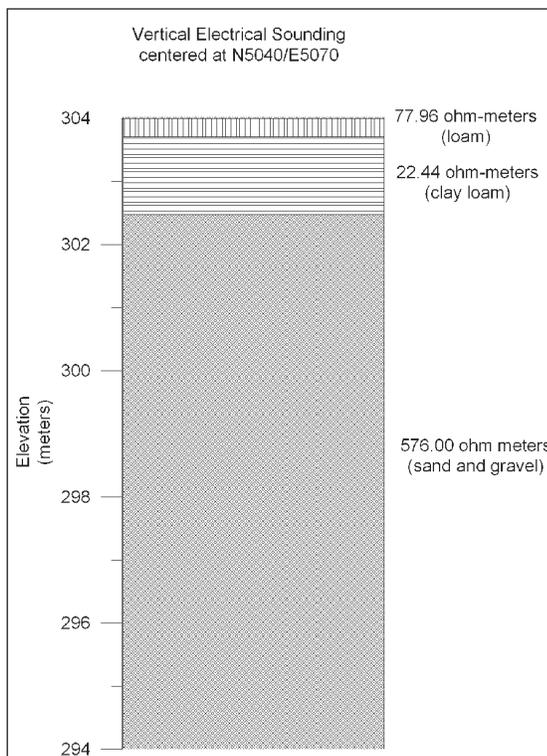


Figure 21. Electrical stratification of vertical electrical sounding data.

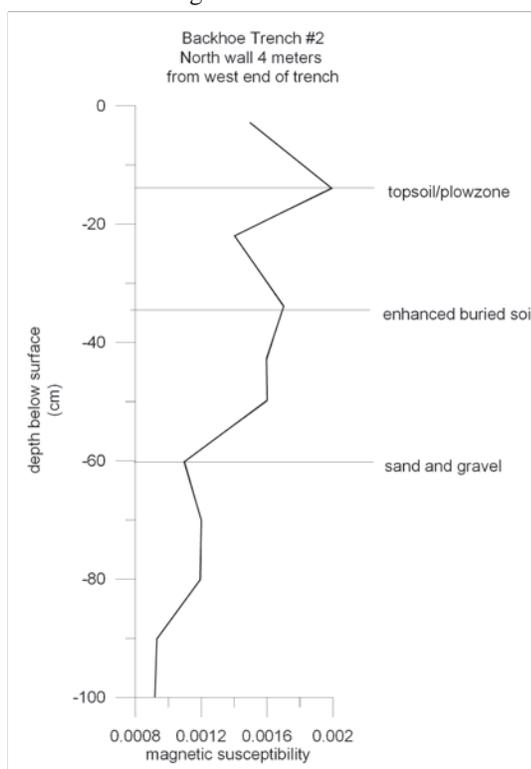


Figure 22. Interpretation of the volume magnetic susceptibility data from north wall of Backhoe Trench 32.

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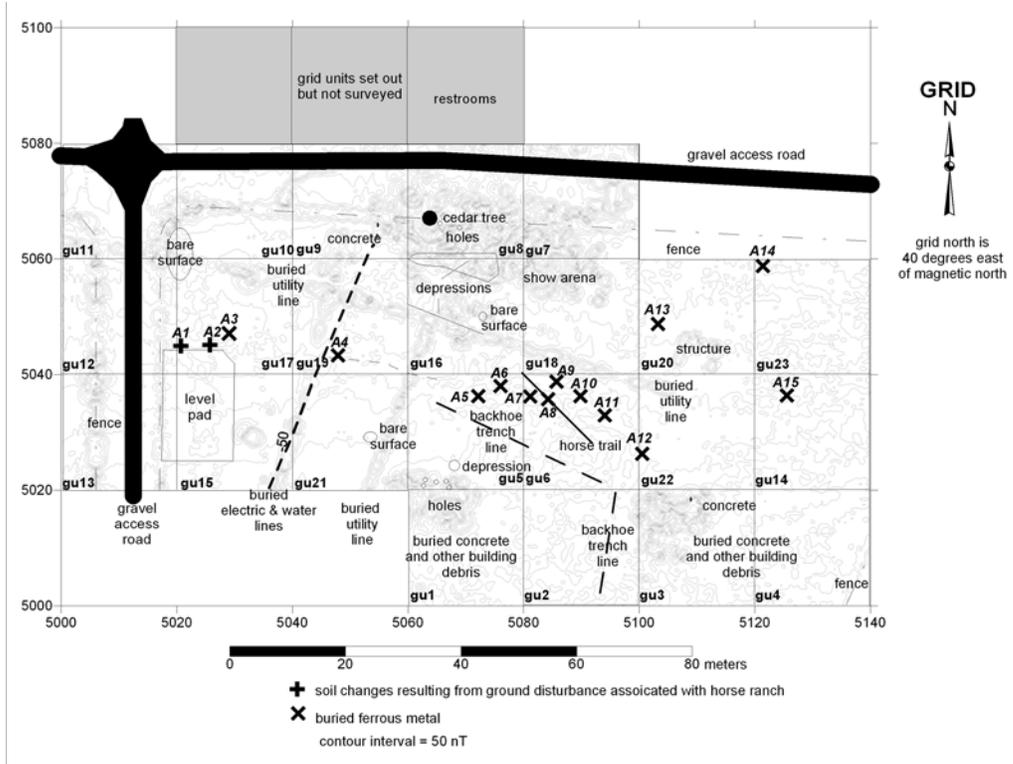


Figure 23. Location of ground-truthed magnetic anomalies.



Figure 24. Excavation of backhoe trenches with a CAT 416D backhoe (view to northeast).

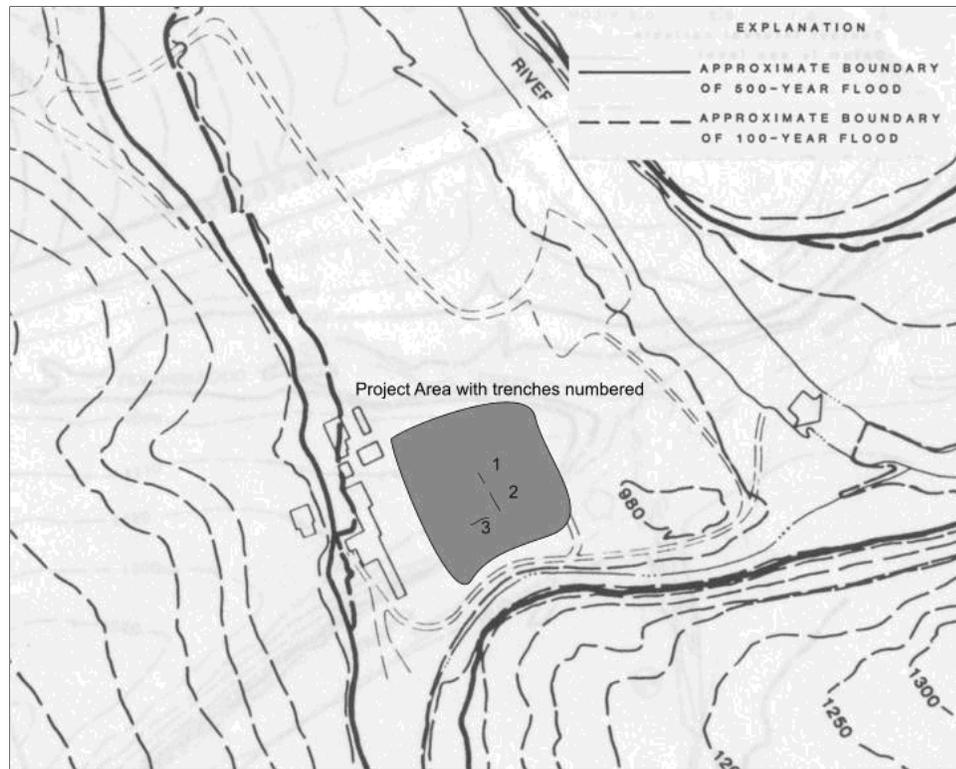


Figure 25. Location of project area and trenches



Figure 26. Backhoe is completing backfilling of Trench 1 with field staff concentrated around Trench 2 and Trench 3 is visible on the right. (view of to the east).

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Figure 27. Backhoe is standing to the left of Trench 1 and Trench 2 is visible to the left of the backhoe (view to the southwest).

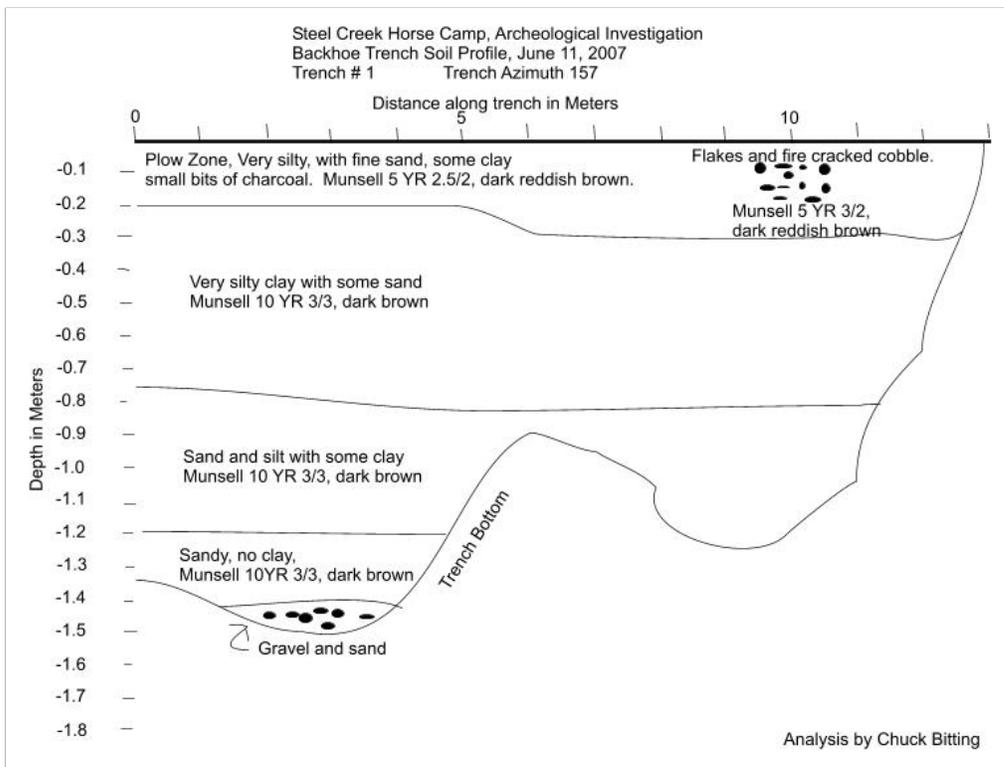


Figure 28. Profile of Trench #1.



Figure 29. Trench 1 with area of wall collapse visible on left profile of trench (view to the northwest).



Figure 30. Trench 1 profile showing darker “A” horizon and uniform subsoil (view to southwest)

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Figure 31. Trench 1 with Trench 2 in background (view to southeast).



Figure 32. Area of wall collapse visible on right side of Trench 1 (view to south).

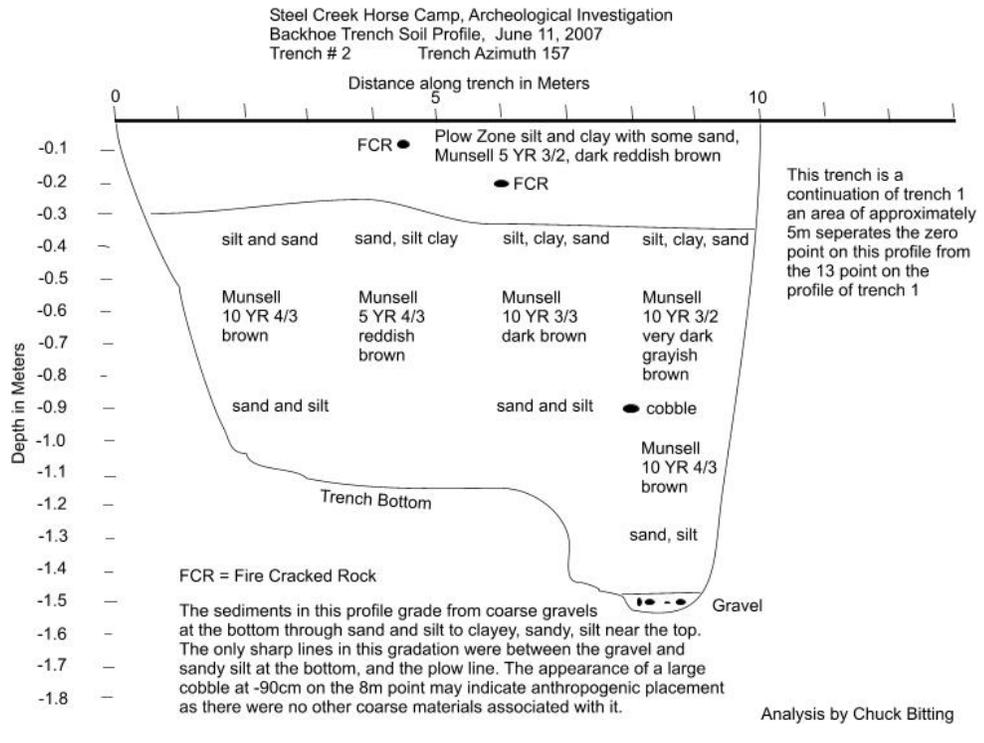


Figure 33. Profile of Trench #2



Figure 34. Mapping soil profile in Trench #2 (view to the northwest).

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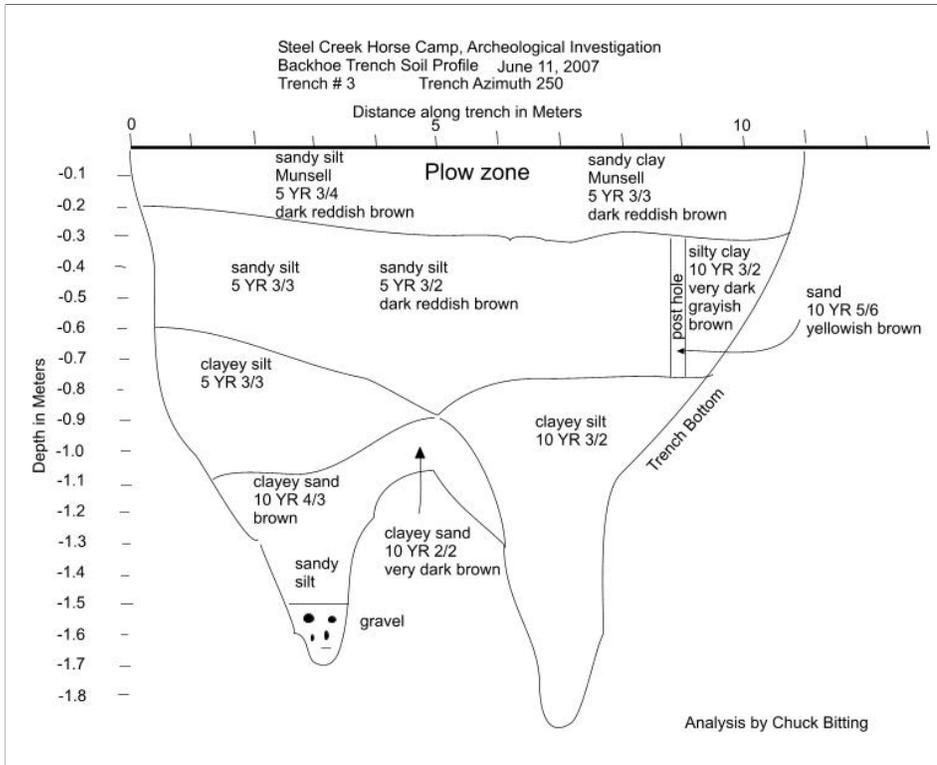


Figure 35. Profile of Trench #3.



Figure 36. Slope dropping down into a natural swale in Trench 3 (view to the southwest).



Figure 37. Inspecting profile in Trench 3 (view to the northeast).



Figure 38. Nondiagnostic biface and expanding stemmed point from Trench 1.