4.0 DEEP TEST METHODS AND TECHNIQUES

4.1 INTRODUCTION

Three subsurface testing methods were independently applied to the six test locales to assess their utility for buried site discovery. These methods include, in order of increasing subsurface impact, geophysical survey (remote sensing), coring and augering, and backhoe trenching. Because ground disturbances affect the results of these surveys, the order in which the methods were applied to each test locale followed their relative amount of subsurface disturbance (i.e., remote sensing, followed by coring and augering, and then trenching).

Each of the methods used during this study was applied to a predetermined area whose generalized boundaries were established through consultation between the principal geoarchaeologists and archaeologists in the field prior to initiation of the field investigations. The generalized outline of the test locale was initially selected to meet the archaeological and geomorphological testing criteria established for that locale and then marked using a hand-held Global Positioning System (GPS) instrument (WAAS corrected to achieve <3 m [<9.8 ft] accuracy).

The test areas chosen were at least 0.4 ha (1 ac) in size, and the rationale for test locale sizes, shapes, and layouts was discussed previously (Chapter 3.0). Test areas were identical for each of the methods under investigation (geophysical survey, coring, and trenching) at each locale. A 40 m × 100 m (131 ft × 328 ft) grid was surveyed at the Clement, Hoff Deep, Fritsche Creek II, and Root River test locales; a 60 m × 80 m (197 ft × 263 ft) grid was surveyed at the City Property test locale; and a 30 m × 140 m (98 ft × 459 ft) grid was surveyed at the Anderson test locale. Prior to geophysical survey the test locales were cleared of agricultural crops as needed, and the surface was prepared (i.e., plowed, disked). Next, a datum was established and the test locale was gridded into 20 m × 20 m (66 ft × 66 ft) sampling units. The baselines and interior nodes of the grid were marked using PVC stakes. These staked points allowed the geophysical surveys, cores, augers, backhoe trenches, and archaeological test units to be more easily measured, interrelated, and plotted. Relative elevations were measured using a transit at each staked grid node and baseline to create a generalized topographic map of each test locale.

4.2 GEOPHYSICAL SURVEY METHOD AND TECHNIQUES

4.2.1 Introduction

The geophysical remote sensing surveys were conducted by sampling at regular intervals along consistently spaced parallel transects. These transects were located using the survey grid established at each test locale prior to initiation of all fieldwork. The sampling intensity employed determines the resolution of the survey, as well as the speed at which the survey can be completed. Usually, a small transect interval will result in more readings and data collected than a larger transect interval and, consequently, the subsurface may be reconstructed more accurately. Accuracy, however, comes at a price, as smaller intervals require more transects, increasing the amount of time and cost to complete the survey. As a result, effective and efficient geophysical survey designs aim to balance the intensity of the survey coverage with completion time. In practice, appropriate sampling intervals differ from instrument to instrument. Additionally, sampling intervals must also be appropriate to the scale and geophysical contrast in subsurface features (Somers and Hargrave 2004:6). Thus, the relationship between soil composition, soil moisture, and feature geometry must be considered (Weymouth 1986:386-7). The intervals employed in this study were selected based on the operators' professional opinion as to the most cost effective means of maximizing information.

The surveys were conducted using a Geoscan FM36 magnetic gradiometer (Figure 4.2.1-1:A, B), a Geoscan RM15 and MPX15 multiplexed earth resistance meter (Figure 4.2.1-1:C), and a Sensors and Software Noggin SmartCart 250mHz GPR unit (Figure 4.2.1-1:D).

4.2.2 Magnetics

The Geoscan FM-36 magnetic gradiometer (Figure 4.2.1-1:A, B) was used to map changes in the magnetic gradient of the test locales. The survey was conducted by dividing the test area into a set of grid areas and then collecting grid-wise magnetic reading from transects within the survey area. Eight magnetic gradient readings were taken per meter along each of the survey transects. The transects were spaced 0.5 m (1.6 ft) apart, which yielded a data density of 6400 readings for each 20 m × 20 m (66 ft × 66 ft) area of the survey grid, at a spatial resolution of 0.0625 m^2 (0.67 m^2). The instrument sensors on the FM-36 are 0.5 m (1.6 ft) apart vertically, and their sensitivity was set at 0.1 nanotesla. Survey data collection times and personnel hours were recorded for each survey test locale.

The data were analyzed using Geoplot 3.0 image processing software (Geoscan Research 1987) and ArcGIS 8.3. The processed magnetic gradient data are shown for each survey area in Appendix A, while selective, representative data plots and interpretations are presented in the discussions of results for each test locale in Chapters 5.0 through 10.0. In the data plots, areas of low magnetism are shown as white and high magnetism are black.

4.2.3 Resistivity

In this study, a series of electrical potential difference maps was acquired by passing induced current through progressively deeper layers using five successively greater electrode spacings (Figure 4.2.2-1C), while maintaining a fixed central reference point. The maps show the electrical paths taken and depths penetrated for each resistivity reading so that a three-dimensional, multiplexed resistivity model of the subsurface can be created. The potential difference measurements are directly proportional to the changes in the deeper subsurface. Apparent resistivity values calculated from measured potential differences can be interpreted in terms of overburden thickness, water table depth, and the depths and thicknesses of subsurface strata. In practice, the depth of penetration for any individual probe pair is variable across space, as currents induced by the instrument refract at layer boundaries causing distortion. However, post-processing can reduce some of these effects. Thus, the multi-probe array returns a series of resistivity images of increasing depth penetration, permitting three-dimensional approximations of the subsurface. Because the relationship between electrode separation and depth sensitivity is complex, the vertical scale quoted for the pseudo-sections displayed are approximate. Furthermore, as the depth of investigation increases, the size of the smallest anomaly that can be

Figure 4.2.1-1. Geophysical Survey Field Methods

resolved also increases. The precision of resistivity profiles diminishes as the inverse square of the electrode spacing (DOE 2000:25). Consequently, only larger features can be resolved within deeper profiles, while near-surface, small-scale features can be resolved using three-dimensional, multiplexed resistivity instrumentation.

The resistivity surveys conducted for this project consisted of one resistivity reading taken at 1 m (3.3 ft) intervals along transects that were spaced 1 m (3.3 ft) apart. This resulted in a data density of 400 readings for each 20 m × 20 m (66 ft × 66 ft) area of the survey grid and yielded a spatial resolution of 1 m^2 (11 ft^2). The zigzag traverse method was used, with traverses spaced 1 m (3.3 ft) apart. Instrument settings were typically 40v; 1ma; 10× gain; 137Hz, but occasionally were altered to fit site-specific conditions in the field. To address change in earth resistivity with depth, resistivity surveys at all test locales were conducted in vertical profiling mode. The physics of this process are well documented (Aspinall and Crummett 1997; Bozzo et al. 1994; Clark:1990:61-63). The mobile probes were configured for five simultaneous twin array surveys, with interprobe spacings of 1 m (3.3 ft), 2 m (6.6 ft), 3 m (9.8 ft), 4 m (13.1 ft) and 5 m (16.4 ft). The multiple twin array survey was designed to record resistivity at depths roughly corresponding to the interprobe spacings used in the survey and is well suited to archaeological targets. With this array setup, the earth resistivity was measured for a hemispheric volume of ground directly below the mobile survey probes (Figure 4.2.1-1:C) (Clark 1990:29; Kvamme 2001:361). The resulting depth slices can be computed along any axis to investigate change in three dimensions in a process known as resistivity tomography. Images created in this manner are known as resistivity pseudosections.

Because, as discussed in Chapter 3.0, the subsurface resistivity distribution is controlled by hydrology, soil and/or bedrock geology, some understanding of the composition and resistive properties of the subsurface materials is needed understand the meaning of the survey. At the areas surveyed during this study, the local bedrock geology is considerably deeper than the detection limits of the instrument and setup used (i.e. <3 m to 5 m [<9.8 ft to 16.4 ft] deep), which makes the geological and pedological properties of the unconsolidated deposits the main concern for this study. The test locales consist mainly of relatively fine-grained, alluvial soils. The main exceptions to this are the Fritsche Creek II and Anderson test locales, which are generally coarse-grained colluvial and alluvial fan (Fritsche Creek II) and eolian sand (Anderson) deposits. During this study all surveys occurred during a period of normal precipitation.

Survey data collection times and personnel hours were recorded for each survey test locale. The raw resistivity data collected in the field generally ranged from about 1 ohm to 220 ohms. Like the magnetic survey, data processing was performed through Geoplot and ArcGIS software and included data filtering and interpolation algorithms. These included de-spiking to remove the effects of ferric debris and to reduce noise; low and high pass filtering to remove or enhance regional gradients; and interpolation of grid cells. The processed resistivity data are shown for each survey in Appendix A (five resistivity plots, one for each depth slice), while important interpretations are shown as figures accompanying discussions of the results for each test locale.

4.2.4 Ground Penetrating Radar

The GPR surveys undertaken during this project used a Sensors and Software Noggin 250 SmartCart (Figure 4.2.1-1:D). Survey times and personnel hours were recorded for each survey test locale. The survey proceeded in a similar manner to the other geophysical techniques and used the same grid. Typically, 20 GPR readings were taken per meter along each transect. These transects were spaced 0.5 m (1.6 ft) apart, and the survey was performed using a zigzag recording method. Data were collected in the field and analyzed using Sensors and Software (2000) EKKO_Mapper and EKKO_3D software. Data were edited using Win_EKKO_Pro. Signal saturation corrections and root mean square amplitude averaging were applied to improve raw data, which are presented as vertical profiles and time/depth slices in two dimensions at 0.5 m (1.6 ft) intervals. ArcGIS 8.3 was used to overlay the data with other geophysical information. In general, the GPR data were processed and plotted to provide pseudo cross-sections (40 per grid or about 240 per test locale) and two-dimensional maps at ca. 0.5 m (1.6 ft) depth slices (about 30 maps). Examples of representative maps and sections are depicted for the discussions of individual testing locations (Chapter 5.0-10.0), while complete maps and sections are shown in Appendix A.

4.3 CORING/AUGERING METHODS AND TECHNIQUES

The coring/augering field investigations for this project focused on defining the distribution of anthropogenic features at known archaeological sites and identifying and assessing the potential for buried archaeological sites at the test locales where archaeological materials previously have not been identified. We also evaluated the usefulness of coring for reconstructing the depositional framework and subsurface stratigraphy and/or detecting the presence of buried landscape components and paleo-surfaces. The coring and augering process used actually is a two-step procedure. It was selected for this study because it has relatively low impact on buried archaeological resources, but can still be used to construct maps and cross sections and provide three dimensional survey coverages. It also has a generally unlimited depth range for most geomorphic settings. For the coring step of the process, 18 to 20 continuous, solid-earth cores were collected per acre from each of the test locales (Figure 4.3-1:A). A truck-mounted Geoprobe® was used to extract 4.5-cm (1.75-in) diameter cores. Core samples were described in the field using standard systems for describing soils (Soil Survey Staff 1975; Schoeneberger et al. 1998) and geological features (Collinson and Thompson 1982; Folk 1974) and then were discarded. The times for the start and finish of each core were recorded in a log.

The subsurface information gleaned from the cores (Figure 4.3-1:B) was then used to identify “target” horizons that were believed to have a high-potential for buried archaeological material (i.e., soil horizons or other zones suggesting buried, stable ground surfaces). Because the probability of actually finding archaeological material in a 4.5-cm (1.75-in) core is small, these target horizons were then sampled using 10-cm to 13-cm (4-in to 5-in) diameter flight-augers. Augering was accomplished by advancing 10-cm or 13-cm (4-in or 5-in) diameter continuous flight augers with the truck-mounted Geoprobe. The use of different auger sizes was necessary to accommodate equipment malfunction. When the 10-cm (4-in) diameter auger was used, six auger holes were excavated at each locus; when the 13-cm (5-in) diameter auger was used, four

Figure 4.3-1. Coring Survey Field Methods

auger holes were excavated at each locus. Multiple holes were necessary at each locus to simulate consistent volume shovel probes. For each auger location (1) the auger is advanced to the top of the target stratum; (2) the hole is cleaned out; (3) the auger is advanced into the target deposit; and (4) the target deposit is brought to the surface and screened through one-quarter inch mesh hardware cloth. The start and finish times at each locus were then recorded in a log. Sediment was collected from the target horizon and screened through one-quarter inch mesh for archaeological material (Figure 4.3-1C).

The cores were placed every 20 m (66 ft) in a grid-wise pattern and included placement of cores along the test locale boundaries. Sedimentological and stratigraphical cross sections were prepared for each of the test locales to show the subsurface relationships of stratigraphic horizons revealed in the cores. These served as a basis for constructing the depositional history of the deep test area. Detailed descriptions of the cores are included in Appendix B. Specific results and conclusions, as well as how they fit within the Holocene geological and geoarchaeological context for the six test locales in Minnesota, are discussed in Chapters 5.0-10.0.

4.4 TRENCHING METHODS AND TECHNIQUES

Backhoe trenching for this project focused on defining the distribution of anthropogenic deposits at known archaeological sites and identifying and assessing the potential for buried archaeological sites at test locales where archaeological materials previously have not been identified. This work focused on developing a three dimensional picture of buried landscapes and associated depositional horizons and paleosols using a multidisplinary approach that involved collaboration of earth scientists and archaeologists in field decisions and interpretations (Figure 4.4-1). The geoarchaeological analyses and conclusions were based on the examination of backhoe trench profiles that were described, sampled, and analyzed to identify characteristics pertinent to the depositional environments and histories at each test locale. The content and context of each archaeological occupation discovered were placed into the stratigraphic framework of the landform (Figure 4.4-1). The backhoe trenches were supplemented by archaeological test excavations placed adjacent to the trenches. Consequently information pertaining to landform development prior to human occupation (stratigraphy and geological history), use of the landform during occupation (anthropogenic effects), and history of archaeological site formation and abandonment (site taphonomy) was obtained.

Five to seven trenches per acre were placed within the test locales to study specific sedimentary or geomorphological aspects of the landform. The trenches were typically 4 m to 6 m (13 ft to 20 ft) long by about 1 m to 1.5 m (3 ft to 5 ft) wide and usually 3 m to 4 m (9 ft to 12 ft) deep (Figure 4.4-1). Trenches were generally placed within the test locales under study to test general spacing parameters for site discovery, to reveal the most complete stratigraphy, and to investigate specific testing criteria established for the various test locales. The specific rationale and factors that were used to locate trenches during this study are discussed in Chapters 5.0-10.0. Because two of the test locales were part of previously recorded National Register-eligible archaeological sites, some discretion was used in trench placement to minimize the impact to the archaeological resources (i.e., a minimum number of trenches were used, and we avoided placing additional excavations near trenches that clearly indicated significant cultural resources).

Figure 4.4-1. Trenching Survey Field Methods

Archaeological material was discovered through two means. First, the trench walls and profiles were visually inspected and then troweled to identify artifacts and possible cultural features. Second, sediments from promising or high-potential horizons were screened to recover artifacts from 50 cm × 50 cm (20 in × 20 in) test units placed off the sides of the backhoe trenches (Figure 4.4-2). Details of the methods employed for these archaeological test units are discussed below.

Sediment and soil characteristics within the test locales were recorded for the backhoe trenches (Figure 4.4-1), as well as for profiles of any auxiliary 50-cm × 50-cm (20-in × 20-in) archaeological test excavation units placed alongside the trenches (Figure 4.4-2). Standard field recording procedures were used to document details of the geological and pedological formation environments of sediments observed in the trenches. These characteristics included observations of the lithology (texture) of each distinct stratum, as well as bedding, sorting, and the contacts (boundaries) between strata. Elevation differences were measured as depths below the ground surface at each individual exposure. Each exposure was also measured in relation to a site datum. Post-depositional weathering and soil formation characteristics were recorded following standard soil descriptive terminology developed by the United States Department of Agriculture, Soil Conservation Service (USDA-SCS 1974). These characteristics include descriptions of texture, color, mottling, structure, consistency, inclusions, intrusions, and transferals. Soil horizon nomenclature follows Birkeland (1984:7), and the USDA-SCS Soil Survey Manual (USDA-SCS 1993). Soil-horizon designations represent modern conditions. In addition, trenches were photographed and mapped in relation to other features and trenches at the site. Finally, trench locations were recorded using GPS equipment. Field hours and equipment hours were recorded for testing at each of the test locales and were used in the cost benefit analysis. Detailed descriptions of these trenches are presented in Appendix C.

The subsurface of the testing locale was mapped based on soils and sedimentary horizons observed in trench profiles. To aid in understanding their subsurface relationships, as well as in reconstructing the depositional history (sedimentological and stratigraphical), the trenches were linked to create cross section(s) that were drawn across various axes of each test locale. The locations of the cross sections were selected to show either atypical or more complete aspects of the stratigraphic and depositional relationships of the subsurface deposits. Detailed descriptions of each trench excavated during this research are included in Appendix C. Specific results and conclusions for the deep test trenching, as well as how they fit within the Holocene geological and geoarchaeological context for the six test locales, are presented in Chapters 5.0-10.0.

4.5 ARCHAEOLOGICAL FIELD METHODS

Traditional archaeological field methods were a key component of both the coring/augering and backhoe trenching deep testing procedures to demonstrate the presence or absence of archaeological deposits. Archaeological methods were not part of the remote sensing surveys because no subsurface soils are exposed.

The goal of the archaeological contribution to the coring/augering survey was to identify and sample target horizons that had a high potential for containing buried archaeological material. These horizons were sampled for artifacts using 10-cm or 13-cm (4-in or 5-in) diameter continuous flight augers. Four 13-cm or six 10-cm diameter closely-spaced auger holes were

Figure 4.4-2. Trenching Survey Field Methods

placed at each location determined to include one or more target horizons. These numbers of auger holes were the maximum that could be drilled without moving the coring rig and, hence, were the most cost efficient method of sampling. The resulting area sampled is approximately 75 in^2 (484 cm^2), which approximates a 25-cm (10-in) diameter shovel test. The exact grid coordinates of the sets of auger test-holes were measured and recorded. Archaeologists then screened the soils from the target surface. This process is consistent with the methods used in standard shovel test survey in Minnesota (Anfinson 2001:34). Consequently, the archaeological testing during the coring/augering process can be considered shovel tests and are, therefore, subject to the same constraints and statistical treatments as shovel testing (see Kintigh 1988; Nance 1983; Nance and Ball 1986; Shott 1985, 1989; Krakker et al. 1983).

Artifacts and evidence of archaeological deposits were sought in two ways within the backhoe trenches (Figure 4.4-2). First, trench profile walls were scraped clean with trowels and shovels to expose any possible features and prepare the trench walls for photography. The walls were examined in detailed for the presence of cultural features or artifacts during this process. Special attention was paid to buried land surfaces (i.e., paleosol sequences) to ensure that artifacts were exposed if discovered as a result of wall preparation. These artifacts or features were mapped and their location recorded on the profile. In addition to visual inspection of the walls by earth scientists and archaeologists, identified land surfaces stable enough to have allowed human occupation, typically marked by variably developed paleosol sequences, were sampled for the presence of buried cultural material using at least one 50 cm × 50 cm (20 in × 20 in) excavation unit. These units were placed off the side of each trench and used the trench profile to guide their placement and excavation. Once the location was decided and fixed, the exact grid coordinates of the test unit were measured and recorded, and a 1 m (3.3 ft) profile segment was mapped and photographed by the archaeologists. When no artifacts or other evidence of an archaeological site were observed along the trench profile, these test units provided supporting evidence whether archaeological material was present in the subsurface.

Intervening horizons not of archaeological interest were removed either by hand using shovels and trowels or, more typically, with the assistance of the backhoe to expose an area approximately 1 m × 1 m (3.3 ft × 3.3 ft) in size. A buffer was maintained above the beginning of each horizon to be sampled so that the target horizon was not compromised or disturbed in any way. Once the 1 m × 1 m (3.3 ft × 3.3 ft) area was cleaned to the desired depth, a 50 cm × 50 cm (20 in × 20 in) unit was laid out. Excavation and recordation proceeded in 10 cm (4 in) levels to a depth of at least 10 cm (4 in) below the base of the target horizon. Sediments from each level were screened, and artifacts were provenienced by level.

Stable surfaces of an age compatible with human occupation, identified in the cores and trenches based on their stratigraphic, pedological, and sedimentological characteristics, were tested for archaeological content mainly by passing samples of soil and sediment from the horizon through one-quarter inch screen. While the recovery of microdebitage using various recovery methods has been suggested to be a potentially useful technique for site discovery (Dunnell and Stein 1990; Fladmark 1982) that is potentially both cost effective and minimally destructive to archaeological deposits (also see Hull 1987; Vance 1987), little actual application or rigorous testing of its usefulness, cost-effectiveness, and reliability has taken place. Difficulties in using microdebitage include the accurate recognition and classification of microdebitage as opposed to other sediment particles, the possibility of transport of microdebitage from its original location and movement through sediments that actually do not contain archaeological sites, and the demonstrated failure to identify sites based on the presence/absence of microdebitage (Michlovic 1994).

Several studies consider these issues in detail. First, because of its small size, microdebitage is prone to the same movement processes as naturally occurring sedimentary particles or pedological clasts. Given the ease that sand-sized and smaller particles can be moved up or down the soil profile (Johnson 1990, 1992; Johnson and Watson-Stegner 1990), microdebitage may be more prone to biomantle displacements than any other artifacts. Moreover, because microdebitage has the same size range as sand particles, such artifacts can be transported just as readily as sand grains in most depositional settings (alluvial, colluvial, and eolian). Yet, such settings are precisely the primary contexts within which buried archaeological sites are usually found and preserved. Shackley (1978), for example, points out the possibility and ease with which small scale debris can be transported in an alluvial setting. Colluvial settings can also easily duplicate many of the same depositional processes present in alluvial environments; microdebitage as well as other sand-size particles can and probably do become entrained and remobilized in mass-flow deposits. Additionally, Fladmark (1982) notes the potential for eolian transport of sub-sand sized particles (i.e., less than 2 mm), an aspect that is particularly relevant in dune settings. In such settings, medium- to fine-grained sand particles are preferentially eroded and transported, leaving coarse- to very coarse-grained sand and larger particles behind as lags. In such settings, while the larger microdebitage may not be actually transported, it can become redeposited as an erosional lag, often losing the original cultural context of the artifacts. Clearly, the presence of microdebitage does not necessarily indicate the occurrence of in situ archaeological deposits. In fact, their presence alone (i.e., without other cultural artifacts and/or features) should probably raise a red flag concerning the possible undisturbed nature of the deposits. As is true with any cultural artifact, the significance of microdebitage can only be assessed through its larger depositional, pedological, and archaeological contexts.

In another study, Michlovic et al. (1988) obtained positive results with regard to the co-occurrence of micro- and macrodebitage ($\geq$0.25 in) in plow zone and stratified contexts at previously known sites; however, they did not identify any microdebitage at any locations they tested where a prehistoric site was not already known to exist. Fladmark (1982:214), who failed to recover any microdebitage from a number of his column samples that contained macroartifacts, also observed the unpredictable nature of the occurrence of microdebitage . An even more dramatic example of this unpredictability occurred at the Mooney site (12NR0029) in Norman County, Minnesota (Michlovic 1994). In this instance microdebitage occurred in only two of 305 core samples that were taken from the site. Finally, Nicholson (1983) in his comparative study of sampling techniques that evaluated the reliability of microdebitage as an indicator of sites in regional surveys, concluded that microdebitage was not a very useful indicator of occupation.

Finally, although no systematic time studies have been conducted, evidence presented by Metcalfe and Heath (1990:793) from the Heartbreak Hotel excavations in Utah indicates that the processing and analysis of microdebitage is extremely time-consuming. Further, the numerous logistical issues associated with screening sediments through small mesh screen or undertaking flotation recovery suggest that the use of microdebitage for site discovery is not cost effective for Phase I site identification.

Soils at the Hoff Deep test locale were particularly difficult to screen, and it was not always possible to screen the entirety of the auger sample. In this one instance, flotation samples were collected from auger target horizons. Following preliminary analysis of the artifacts from the augering, ten flotation samples (ca. 10 liters each) from auger holes that produced archaeological materials in comparable target horizons were floted as a blind test for the presence of archaeological materials that may have been missed. None produced archaeological materials.

4.6 ARCHAEOLOGICAL LABORATORY METHODS

4.6.1 Prehistoric Period Artifacts

Standard analytic procedures were employed in the analysis of the prehistoric artifacts recovered from the sites investigated. This analysis was designed to classify and describe the recovered materials in terms of the types of artifacts represented, their typological affiliation where appropriate, and their functional, temporal, and cultural affiliation where possible. The major artifact classes associated with the prehistoric components at these sites include ceramics, lithic tools and debitage, and fire-cracked rock. The artifacts are described and discussed for each test locale (i.e., Chapters 5.0-10.0) and are listed in Appendix E. Artifacts were prepared for curation in accordance with 36 CFR § 79, *Curation of Federally-Owned and Administered Archaeological Collections*. The recovered faunal remains from each site were analyzed separately and the results are presented in discussion of each test locale. These are listed in Appendix F.

Ceramic Assemblage

The prehistoric ceramic sherds were initially sorted by vessel segment (i.e., rim, neck, body, base) and then by paste and temper characteristics, surface treatments, and decoration. Exterior surface treatments include cordmarked, smoothed over cordmarked, net impressed, brushed, striated or wiped, and smoothed surfaces, while interior treatments, which were mainly uniformly smoothed, range from incomplete smoothing that left temper protruding to well smoothed. Exfoliated/eroded sherds represent a residual class of ceramics. Paste characteristics include texture (i.e., silty or sandy), structure (massive, blocky, and laminar in sherd cross section), and hardness (i.e., friable [crumbly and easily disintegrated] or compact [well-consolidated and tightly knit]). Temper characteristics include size (i.e., fine [<1 mm], medium [1-2 mm], coarse [2-3 mm], very coarse [>3 mm), and poorly sorted [mix of particle sizes]), relative amount (i.e., low, moderate, or high), and types. Temper types are mainly shell or grit, which include felsic grit (light-colored, such as quartzite and granites), mafic grit (dark-colored, such as darker-colored granites, hornblendes, diabase), and mixed felsic and mafic grit. The number, weight and sizes of sherds were recorded for each of these categories. Sherd sizes are based on their estimated surface area (Size Grade [SG] 1=1 cm^2 or less; SG 2=1-4 cm^2; SG 3=4-9 cm^2; SG 4=9-16 cm^2).

Lithic Assemblage

The lithic artifacts recovered from the prehistoric sites are subdivided into chipped and ground stone tools, debitage or debris from the manufacture and maintenance of chipped stone tools, and fire-cracked rock. The chipped stone tools are classified according to standard morpho-functional types (e.g., projectile points, bifaces, end scrapers, and retouched and edge damaged flakes). Pertinent descriptive attributes such as shape, cross-section shape, and raw material type were recorded for each tool along with metric dimensions (e.g., length, width, and thickness).

The debitage is classified by flake type, flake size, flake treatment (i.e., heat-treated) and raw material. Flake types include shatter, decortication flakes, blocky secondary flakes, and three subtypes of flat secondary flakes subdivided by the type of striking platform. These include 1) no striking platform, 2) simple (unfaceted) platforms, and 3) complex (faceted) platforms. Simple striking platforms are typically flat, lack faceting, are seldom ground, and are often oriented at right or slightly acute angles to the axis of the flake. Complex striking platforms are usually diminutive, multifaceted, frequently ground, and often exhibit lipping of the bulb of percussion. They are also usually oriented at sharply acute angles to the axis of the flake. Flakes are measured and grouped into 10-mm size intervals. The lithic raw materials include chert, quartz (milky or colorless), quartzites, orthoquartzites, and silicified sandstone and are identified based on both published and unpublished references (e.g., Bakken 1985, 1997; Bozhardt 1998; Morrow and Behm 1986) and a comparative collection at CCRG's laboratory facility. For example, chert types include Prairie du Chein, Grand Meadow, Burlington, and Knife River, which can be distinguished based on color and fossil inclusions (i.e., oolitic, etc.). Quartzite, Orthoquartzites and silicified sandstone can be identified based on color, luster, cementation, and grain type, texture, size and shape. Most of these can be distinguished from one another to varying degrees, although Bozhardt (1998) has noted that considerable overlap can occur both within and between sources in texture and/or color.

4.6.2 Historic Period Artifacts

Historic period artifacts were collected from surface and subsurface contexts and used mainly to monitor the nature and extent of historic disturbances. These artifacts are categorized according to material of manufacture (i.e., ceramic, glass, metal, bone, rubber, plastic, and mineral-composite-miscellaneous) and their observable physical properties (e.g.,. Cleland 1983). These properties include function, form, color or type of decoration, and method of manufacture. Besides providing the basis on which to identify specific types of artifacts or objects (e.g., tablewares, utilitarian kitchenwares, bricks, bottles/jars, various types of metal artifacts, etc.) and their context of use, these attributes also provide important information pertaining to age. The classification scheme focuses on aspects of late nineteenth and early twentieth century material and associated aspects of technological change. Specific details of the composition and age of the recovered historic period artifacts is detailed under the individual site assemblage descriptions.

4.6.3 Faunal Remains

Zooarchaeological remains from each site were examined individually, with the following information recorded for each specimen: element, section or portion of the element, side of the body (when applicable), taxonomic classification, and relative age (adult or juvenile/sub-adult). Determination of age was based on the degree of epiphyseal fusion, tooth eruption, and occlusal wear. Refitting of bone fragments was restricted to specimens recovered from the same provenience. An osteological comparative collection and various reference manuals were used in the identification of certain specimens.

Evidence of butchering and carcass processing, in the form of cut, saw, and chop marks was recorded when observed. Each specimen was examined for evidence of exposure to heat, in the form of burned (partially smoked or burned black) and calcined (gray to bluish white in color, chalky texture) bone, as well as other cultural modification(s). Due to specimen fragmentation, otherwise unidentifiable pieces of mammal bone are categorized as being from large, medium, or small mammals, based on the relative size and thickness of each specimen. The approximate live weight of large mammals is considered to be greater than 23 kg (50 lbs), 5 kg to 23 kg (11 lbs to 50 lbs) for medium mammals, and less than 5 kg (11 lbs) for small mammals. When it was not possible to reliably categorize a specimen based on size, it is simply classified as mammal or mammal of indeterminate size. A detailed inventory of the faunal assemblage is included at the end of this analysis as Appendix F.