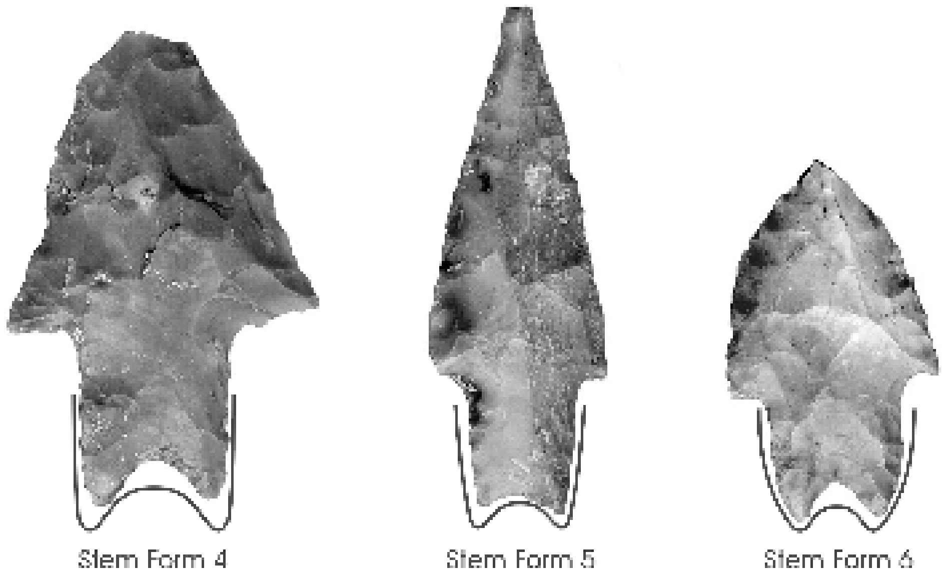
Data Recovery Excavations at 41MM340

A Late Archaic Site along Little River in Milam County, Texas



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Texas Antiquities Committee Permit No. 2654

Raymond P. Mauldin
Principal Investigator

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Abstract:

From August 2001 through January 2002, the Center for Archaeological Research of The University of Texas at San Antonio conducted Phase III Data Recovery excavations at archeological site 41MM340, under contract with the Texas Department of Transportation. The investigations were conducted under Texas Antiquities Permit No. 2654, with Raymond Mauldin serving as Principal Investigator. The mitigation fieldwork consisted of the excavation of 56 m^2 within the densest portion of the site to investigate cultural deposits encountered during the previous testing phase. Fifteen stratigraphic zones were identified and later grouped into seven analytical units, spanning from 3050–2060 BP of the Late Archaic period of Central Texas. The analytical units consisted of varying frequencies of burned rock, lithic debris, mussel shell, snail shell, and rock-lined and unlined thermal features. In concert with the archeological field investigations, the following special analyses and studies were performed to aid site interpretation: lithic, vertebrate faunal, mollusk, gastropod, lipid residue, macrobotanical, geomorphology, and magnetic sediment susceptibility. The analyses deal with the reconstruction of floodplain dynamics and paleoenvironmental conditions spanning the 1,000 years of site use. Subsistence strategies, site structural issues, and the organization of lithic technology as well as a study of regional variability in Pedernales projectile points constitute the body of the report.

Table of Contents:

Figures:

Tables:

Acknowledgments:

The 2001-2002 data recovery investigations at 41MM340 by the staff of the Center for Archaeological Research (CAR) were sponsored by the Texas Department of Transportation, Environmental Division. The fieldwork and subsequent analyses and write-up were facilitated by the hard work, dedication, and contributions of many individuals and organizations.

We want to extend our sincere thanks to the personnel of the Environmental Affairs Division of the Texas Department of Transportation (TxDOT). Dr. Nancy Kenmotsu, Dr. James Abbott, Cynthia Tennis, Tim Meade, and Al McGraw worked closely with CAR personnel providing useful and constructive comments during the development of the scope of work and research design. They were also extremely helpful in scheduling several field visits and allowing the rescheduling of deliverables due to bad weather. We extend a special thank you to Dr. Abbott for assisting with the coring of the floodplain to allow for the timely completion of the geomorphic research. We offer our thanks to the University of Texas Bureau of Economic Geology for providing the equipment and crew to drill the numerous sediment cores used in the geomorphic study.

John W. Parsons and Blane Laywell, TxDOT staff at the Cameron, Milam County, Bryan District office, are thanked for their cooperation and help throughout this lengthy project. Similarly, Jim Carter, of Carter Backhoe, is praised for his deft operation of heavy machinery in often inclement weather.

Several Milam County business owners and managers should here be acknowledged for having accommodated such a motley crew as us. They include: Staci Hanel of The Apple Tree; Dan and Joan Ratliff of Rainbow Courts Motel and Apartments; Phil Van Cleave of Cameron Seed Co.; Roger and Stella Booker of Kountry Inn Motel; and Gary Vrazel of Coufal Equipment Co.

Last, but not least, we extend appreciation to all of the crewmembers who were instrumental in the successful completion of this project; most notably: Michael Aiuvalasit, Cory Broehm, Rebecca Galdeano, Jennifer Henley, Floyd Jones, Bruce Moses, Sylvia Reyna, Rick Robinson, Amy Rose, Bryant Saner, Matt Senn, Juliana Vivona, and Jason Weston. The crewmembers endured the full spectrum of Central Texas weather and performed well even when having to walk through six inches of mud just to get from the excavation block to the water screening stations.

Similarly, our thanks also are extended to the laboratory staff who endured the resultant conditions of materials returned from the field; they include Toni Figueroa, Rebecca Galdeano, Jennifer Neel-Hartman, Jennifer Henley, Daniel Kruetzer, Carol Leezer, Jennifer Logan, Cindy Munoz, Rick Robinson, Amy Rose, Bryant Saner, Matt Senn, Kristi Ulrich, Carol Villalobos, Stacy Wagner, Jason Weston, José Zapata, and Marybeth Tomka who oversaw this large group.

Special analysts who contributed to this project include: Phil Dering, macrobotanical; Richard Fullington, gastropod; Rusty Greaves, stream dynamics; Ethan Grossman, isotopes; Bob Howells, mollusks; Mary Malainey, lipid residue; Raymond Mauldin, magnetic sediment susceptibility; Barbara Meissner, vertebrate faunal; Lee Nordt, geomorphology; Harry Shafer, Steve Tomka, and Jason Weston, lithics.

Bruce Moses and Rick Young of the CAR graphics department drafted the illustrations and CAR editor Johanna Hunziker formatted the report.

Chapter 1: Introduction

Richard B. Mahoney, Steve A. Tomka, and Raymond P. Mauldin

The Center for Archaeological Research (CAR) of The University of Texas at San Antonio was contracted by The Texas Department of Transportation, Austin (TxDOT; Work Authorization No. 57006PD004 to Contract No. 570XXPD004), to conduct data recovery excavations for a previously recorded prehistoric archeological site (41MM340) in Milam County. The investigations were conducted under Texas Antiquities Permit Number 2654, with Dr. Raymond Mauldin, CAR Assistant Director, serving as Principal Investigator. The work described in this report was conducted in the context of planned improvements to State Highway 36 by TxDOT and the Federal Highway Administration. The planned improvements have the potential to affect properties listed as eligible for the National Register of Historic Places (NRHP), and compliance with the regulations (Section 106) that implemented the National Historic Preservation Act of 1966 was required. TxDOT completed an inventory of the project area and site 41MM340 was identified during that inventory. In 2000, CAR, under contract with TxDOT, conducted testing to determine eligibility at 41MM340 and a nearby site, 41MM341 (Mahoney and Tomka 2001). As a result of that testing, CAR recommended that site 41MM340 be considered eligible for listing on the NRHP under criterion 'd' in that the site possessed temporal and physical integrity and contained information important in prehistory. The Texas Historical Commission (THC) concurred with that recommendation. Site 41MM340 is located within the present and proposed highway rights-of-way: land owned by TxDOT. TxDOT contracted with CAR to undertake excavations designed to recover data prior to the planned highway improvements since the site location could not be avoided, and the proposed highway construction would have an adverse effect on the significant data contained within the site.

Project History

Site 41MM340 is located on the left descending bankline of Little River in the central portion of Milam County, Texas (Figure 1-1). The site is along State Highway 36. The construction along State Highway 36 is part of a more extensive TxDOT effort related to highway improvements in Milam County (TxDOT CSJ: 0185-04-033 & 034). The bridge replacement aspect of the project will extend the western right-of-way (ROW) 21 m (70 ft) and maintain the current eastern ROW, with the western extension the focus of the cultural resources investigations. The first phase of development will involve construction of a new bridge west of the existing bridge ultimately providing a southbound corridor. The second phase of development involves the demolition and subsequent reconstruction of the current bridge providing the accompanying northbound corridor. The resultant twin bridges will each measure 14.9 m (49 ft) in width and will be separated by a distance of 22.8 m (75 ft).

1998-1999 Cultural Resources Investigations

Archeological site 41MM340 was discovered and recorded in 1998 by TxDOT archeologists Steve Ahr and Jim Abbott (1999) during a survey of approximately 2.52 ha (6.23 ac) of the Little River floodplain. The survey phase consisted of excavation of 28 backhoe trenches placed at roughly 50 m (164 ft) intervals across the approximately 1.2 km (0.75 mi)-wide floodplain. Radiocarbon dating of samples extracted from various features during the survey phase suggests a date of roughly 2800 BP (Late Archaic) for one component of 41MM340.

2000 Cultural Resources Investigations

From January through March of 2000, CAR archeologists conducted NRHP eligibility assessment testing for site 41MM340. Testing efforts consisted of manual excavation of 12 1-m^2 test units within the previously delimited site boundary. Geoarcheological interpretations were assisted with the mechanical excavation of an additional 14 backhoe trenches. The investigations demonstrated that the site contained several zones of cultural material, primarily consisting of chipped stone, burned rock, and mussel shell, with good temporal integrity. In addition, features were present, along with a variety of faunal and floral material. Radiocarbon dates indicated that the deposits spanned less than 1,100 years in the Late Archaic, with dates ranging between about 1450 and 350 B.C. As a result of these investigations, CAR recommended that site 41MM340 was eligible for inclusion in the NRHP under criterion 'd' (Mahoney and Tomka 2001). Specifically, CAR suggested that the degree of fine-grained temporal resolution of the deposits provided the potential to investigate changes in

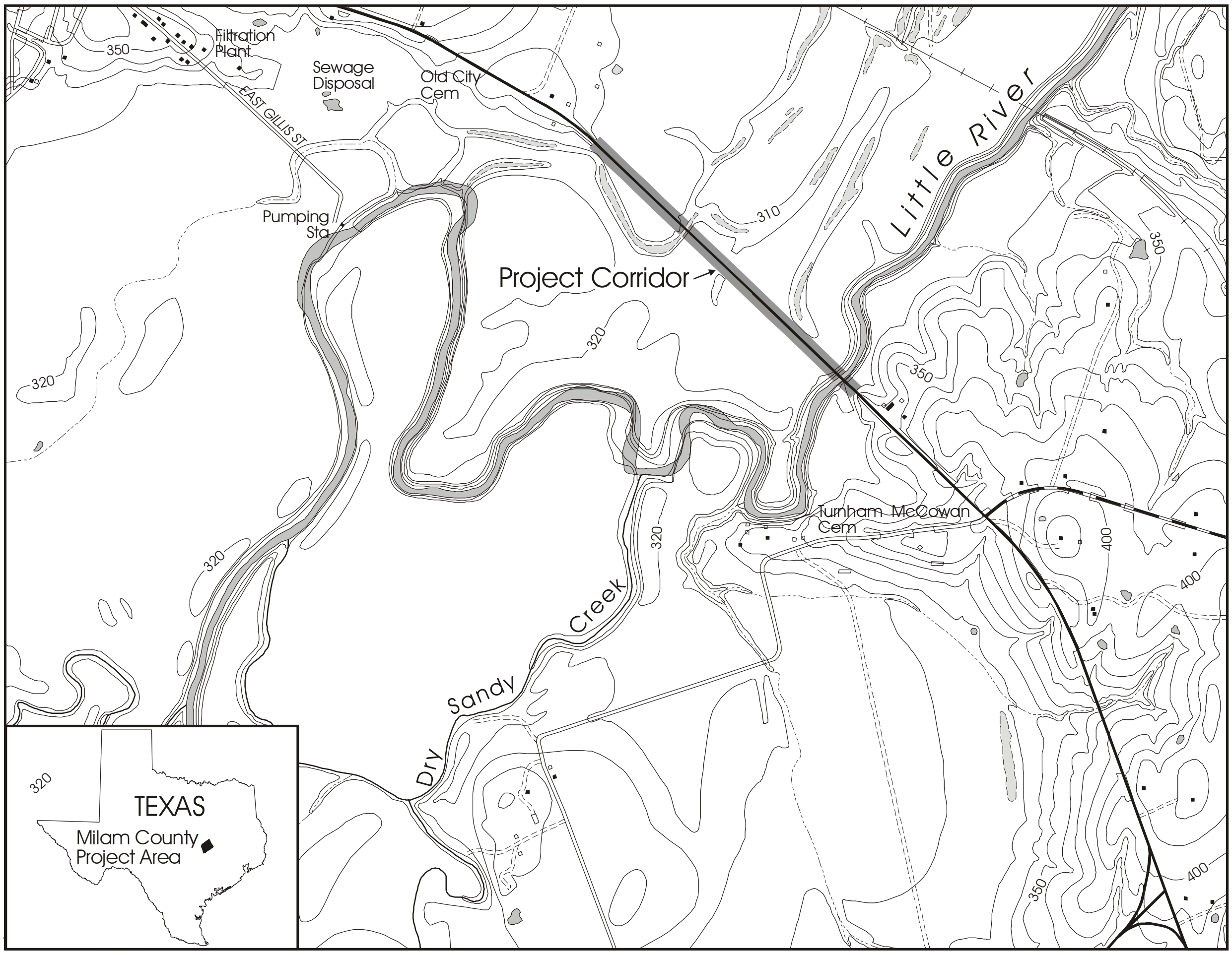

Figure 1-1. *Project area location.* Cameron, TX USGS topographic quadrangle (7.5′ series) 1961 (photo revised 1982).

human adaptation over short time periods. Mahoney and Tomka (2001:60) also suggested that the deposits had the potential for detailed paleoenvironmental reconstruction. THC concurred with these recommendations.

2001-2002 Cultural Resources Investigations

As the planned construction cannot avoid the site location, TxDOT contracted with CAR to design and implement a plan for data recovery prior to the construction. That plan formed the basis of an Antiquities Permit (no. 2654) issued to Dr. Raymond Mauldin and CAR in August of 2001 to conduct data recovery work at 41MM340. Personnel from CAR returned to the site in August of 2001 to conduct work outlined in the data recovery plan. Work involved the manual excavation of 56 1-m^2 units within the densest portion of stratified cultural deposits identified in previous testing. A total volume of 64.6 m^3 was removed and screened. Fieldwork was completed in January of 2002. An interim report was prepared and submitted to TxDOT in May of 2002 (Mahoney et al. 2002). That document was followed by a formal research design submitted to TxDOT and THC (Tomka et al. 2002). With minor modifications, both documents were approved. The research design (Tomka et al. 2002) outlined five research domains, including investigations of floodplain and meander dynamics, paleoenvironmental reconstruction, reconstruction of subsistence strategies, technological organization, and activity area organization. In addition, the research design also outlined specific topics, data needs, and analytical methods that guided the analysis of the material recovered from 41MM340. A draft report of that analysis was submitted to both TxDOT and THC in April of 2003. Comments on that draft were incorporated into this document.

Report Layout

This report consists of 13 chapters and 11 appendices of supporting data. The initial six chapters, including this one, provide background to the project, summarize the research perspective, outline the field and laboratory methods, and provide a summary of the data recovered. Specifically, Chapter 2 provides an overview of the environmental setting of the project area. Included in this chapter are discussions of the climate, hydrology, geology and soils, along with some information on floral and faunal resources. The second section relies primarily on pollen sequences from a series of nearby bogs to explore paleoenvironmental conditions at 41MM340. As the occupation dates to the Late Holocene, the paleoenvironmental review focuses on that period. Chapter 3 presents an overview of previous archeological work conducted in and around Milam County, as well as a short review of the cultural history of the region. Chapter 4 discusses the research issues that guided the project. Included in that chapter is a more detailed discussion of each of the five research domains, associated data needs, and analytical methods. The fifth chapter outlines the laboratory and field methods used. Chapter 6 provides a summary of several different artifact classes and feature types at 41MM340.

Following the initial six background chapters are six chapters that deal more explicitly with research issues. Chapter 7 outlines the development of analytical units that will serve to summarize aspects of artifacts and features recovered during the data recovery work.

Chapter 8 is the first of five chapters that investigates the specific research domains. Chapter 8 deals explicitly with floodplain and meander dynamics of Little River in the vicinity of 41MM340. Three major data types are considered. These are 1) stratigraphic profiles from sediment cores, backhoe trenches and cutbanks, 2) gravel analysis, and 3) mussel shell species identifications. These data are combined with radiocarbon dates from archeological deposits and geomorphic localities to reconstruct the relationships between repeated human occupations of the floodplain, flood frequency and intensity, and channel migration. The analyses reveal that periods of intensive flooding and sedimentation of the floodplain tended to be followed by intensive human occupation and that occupation and abandonment of site 41MM340 may have been conditioned by the proximity of the active channel to the site.

Chapter 9 combines the results of various special analyses including vertebrate and invertebrate faunal analysis, macrobotanical identifications, streamflow regimes, and patterns in ^{18}O isotope values collected from samples of prehistoric and modern mussel and snail shells to investigate paleoenvironmental conditions at the site. We conclude that flooding seems to have been more intensive during the period encompassed by the four deepest stratigraphic zones and that these events may have been driven by regional-scale processes. The intensity of flooding seems to decline during the later half of the archeological sequence.

Chapter 10 focuses on three data types, vertebrate faunal remains, gastropod samples, and macrobotanical identifications, to investigate subsistence. These data suggest that the diet of the occupants of the site was highly diverse and included a broad range of terrestrial and aquatic taxa as well as some degree of reliance on nut mast. Bison may have been present on the Blackland Prairie in low numbers and may have been pursued during the entire range of site occupation.

Chapter 11 focuses on site structural aspects. Using the analytical units identified in Chapter 7, we focus on several aspects of site use at 41MM340, including changes in feature types. A more detailed study of Analytical Unit 6 is undertaken as an example of the overall utility of the 41MM340 data set.

Chapter 12 addresses three main research issues related to lithic technology. These include the regional variability in Pedernales stem and blade forms, technological organization as reflected by the mix of formal and expedient tools, raw material acquisition and reduction through an investigation of debitage, and tool manufacture strategies. It concludes that there is considerable yet patterned regional variation in Pedernales stem and blade forms, and this variability has some interesting repercussions in terms of projectile point manufacture strategies, effectiveness, use-life, and rejuvenation strategies. The majority of the tools recovered from the various analytical units of the site are expediently manufactured forms. This suggests that labor and task requirements were relatively low during the occupation of the site. Debitage characteristics are consistent with local acquisition of raw materials. Finally, the proportion of manufacture-failed projectile points and miscellaneous bifaces suggests that tool kit refurbishing may have been one of the principal activities while this site was occupied.

Chapter 13 provides a summary of the overall project. Included is an evaluation of both the overall field and analytical methods used on the project.

The 11 appendices provide supporting data. Appendix A, by Dr. Lee Nordt, provides detailed soil and stratigraphic descriptions for sediment cores, cutbanks, and backhoe trenches. Appendix B presents the vertebrate faunal data collected at the site. Appendix C contains the results of the magnetic sediment susceptibility testing. Appendix D presents detailed results of stem and blade form variety classifications of Pedernales projectile points from ten sites. Dr. J. Philip Dering presents a discussion of the macro-botanical assemblage from the site in Appendix E. Dr. Mary Malainey presents a discussion of lipid residues on selected samples in Appendix F. Appendix G, by Robert Howells, Jennifer Neel-Hartman and Stacy Wagner, discusses mussel shell collected at the site. Richard Fullington presents an analysis of gastropods in Appendix H. Data on oxygen and carbon isotopes in samples of snail and mussel shells are listed in Appendix I. Features recorded on the site are described in Appendix J. Finally, Appendix K presents details on the radiocarbon dates associated with the project.

Chapter 2: Environmental Background

Raymond P. Mauldin and Richard B. Mahoney

This chapter provides an overview of the physical setting of the project area. This chapter has two principal sections. The first section provides an introduction to the environment of the project area. Included are discussions of the climate, hydrology, and geology and soils, along with some information on floral and faunal resources. The second section relies on pollen sequences from a series of nearby bogs to explore paleoenvironmental conditions at 41MM340. As the occupation dates to the Late Holocene, our paleoenvironmental review focuses on that period.

Environment

As noted in Chapter 1, 41MM340 is in the central portion of Milam County, about 1.2 km (0.75 miles) from the town of Cameron. The site is located within a floodplain along the left descending bankline of Little River (see Figure 1-1). The site sits at the border of two natural regions, the Blackland Prairie and the Oak Woods and Prairies, with the Little River essentially serving as a dividing line between these two regions at this location. The Edwards Plateau region is roughly 35 miles to the west, with the Piney Woods region about 70 to 80 miles to the east (Figure 2-1).

The Oak Woods and Prairies Region is a rolling to hilly area, with vegetation primarily consistent with the Post Oak Savannah, with oak-hickory or deciduous forests present and an understory of grasses. The Blackland Prairie is a gently rolling terrain characterized by grasses, scattered mesquite, and arboreal hardwoods in the river floodplains. Currently, much of this natural region is under cultivation (Diamond et al. 1987; Gould 1975).

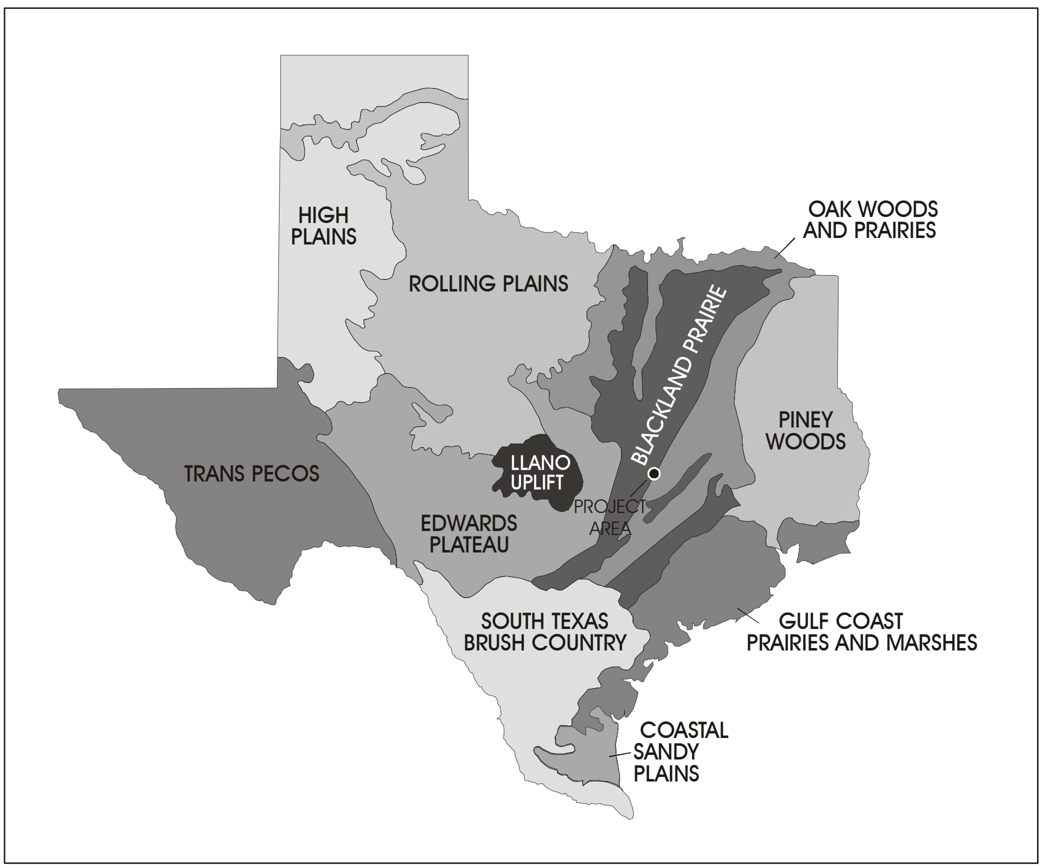

Figure 2-1. *Project area in relationship to Natural Regions of Texas.*

Climate

The climate of Milam County is semi-subtropical, with hot summers and relatively cool to cold winters. The average monthly minimum (Southern Regional Climate Center [SRCC] 2003a) and maximum (SRCC 2003b) temperatures for the city of Cameron between 1971 and 2000 are depicted in Figure 2-2. The patterning in these data demonstrate that temperatures peak during the months of July (95.7°F) and August (95.9°F), with lowest average mean temperatures occurring in January (39.2°F). Carter et al. (1925:4) provide information on the length of the growing season. Using data from Temple in Bell County, just to the west of Milam, they suggest that the last killing freeze in Milam County probably occurs in early March, with the first freeze averaging mid November. The growing season, then, averages roughly 248 days a year (Carter et al. 1925:4).

Precipitation at Cameron averages 34.17 inches per year (Bomar 1999:229). Precipitation amounts from 1971 to 2000 (SRCC 2003c) demonstrate that rainfall is bimodal (Figure 2-3) with a major peak in May (5.01 inches) and a secondary peak in the months of September (3.54 inches) and October (3.72 inches). The driest period of the year is in the months of July and August, when precipitation averages roughly 1.9 and 1.68 inches, respectively. These average precipitation totals mask considerable variability. For example, in 1957 Cameron recorded over 52.3 inches of precipitation, and 7.9 inches of rain fell within a single day in late July of 1979 (Bomar 1999:227), a month that averages only 1.9 inches.

Hydrology

Site 41MM340 is located on the Little River floodplain (Figure 2-4). Above its juncture with the San Gabriel River, the Little River runs approximately 36 miles from the confluence of the Leon and Lampasas rivers in Bell County. A variety of smaller creeks are also present and contribute to the overall river flow. The Little River eventually drains into the Brazos in eastern Milam County. Throughout much of its course, the Little River maintains an exceptionally wide floodplain, extending to over 5 km (3 miles) at certain points.

A USGS gage station is located near Cameron, and provides data on streamflow from late 1916 though 2002. The contributing drainage area for this station is roughly 7,065 square miles. Using this data to estimate water levels and flood periods is complicated, however, as the US Army Corps of Engineers has constructed a series of dams in this area to control flooding. Of immediate concern for the current discussion is the construction of three low capacity reservoirs. Lake Belton on the Leon River began impounding water in January of 1955, Lake Granger on the San Gabriel began operation in 1980, and Stillhouse Hollow Lake at the confluence of the Leon and Lampasas rivers began impounding water in 1968 (USGS 2003a). As these reservoirs would certainly have an impact on the magnitude and character of river flow, only data from 1917 through 1955 will be considered in this discussion.

All data used here are taken from the USGS gage station on Little River at Cameron, Texas (USGS 2003b). Stream flow data, recorded in ft^3/second at the Cameron Gage Station, were available for all days between January of 1917 and December of 1955, a period of 14,244 days. The median daily flow for this period was 392 ft^3/second, with a minimum flow of 0.3 ft^3/second recorded for several days in October of 1952, and a maximum flow of 420,000 ft^3/second recorded on the 10th of September in 1921. Flows under 1 ft^3/second were uncommon in the records used here: only 57 days (0.6%) had these low flows. All 57 days were in the early 1950s, a period of substantial drought in much of Texas (see Bomar 1999:155–157). Data on the annual mean streamflow suggest high variability, probably as a result of annual rainfall differences. Annual mean flow varied between a low of 101 ft^3/second in 1954 to a high of 4,532 ft^3/second in 1941.

The average monthly streamflow from 1917 through 1955 is a bimodal pattern, with a substantial flow reflected in May, a much smaller secondary peak in September, and minimal flows in August (Figure 2-5). These average figures belie some variability. In 12 of the 39 years between 1917 and 1955, the minimum flow occurred in August (Figure 2-6), the month with the lowest average flow. In 16 of the 39 years, the maximum flow occurred in May, the month with the highest average flow (Figure 2-7). Note, however, that minimum flows occurred in all months except February and May (Figure 2-6), and maximum flows in a given year occurred in all months with the exception of July and August (Figure 2-7).

These data suggest that low flows may have occurred during the late summer, high flows occurred during most other periods of the year, and extreme flows probably occurred during April and May. Comparison of Figure 2-5 with the rainfall data presented previously in Figure 2-3 clearly suggests that streamflow is driven by rainfall. To the degree

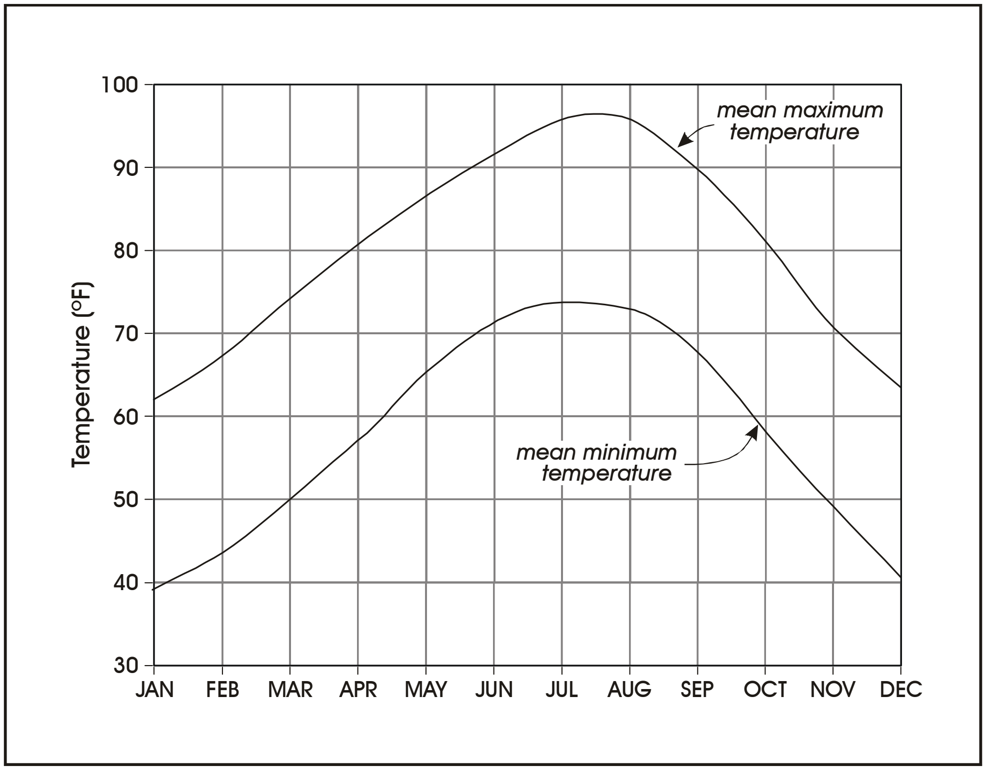

Figure 2-2. *Average monthly minimum and maximum temperatures for the city of Cameron between 1971 and 2000.*

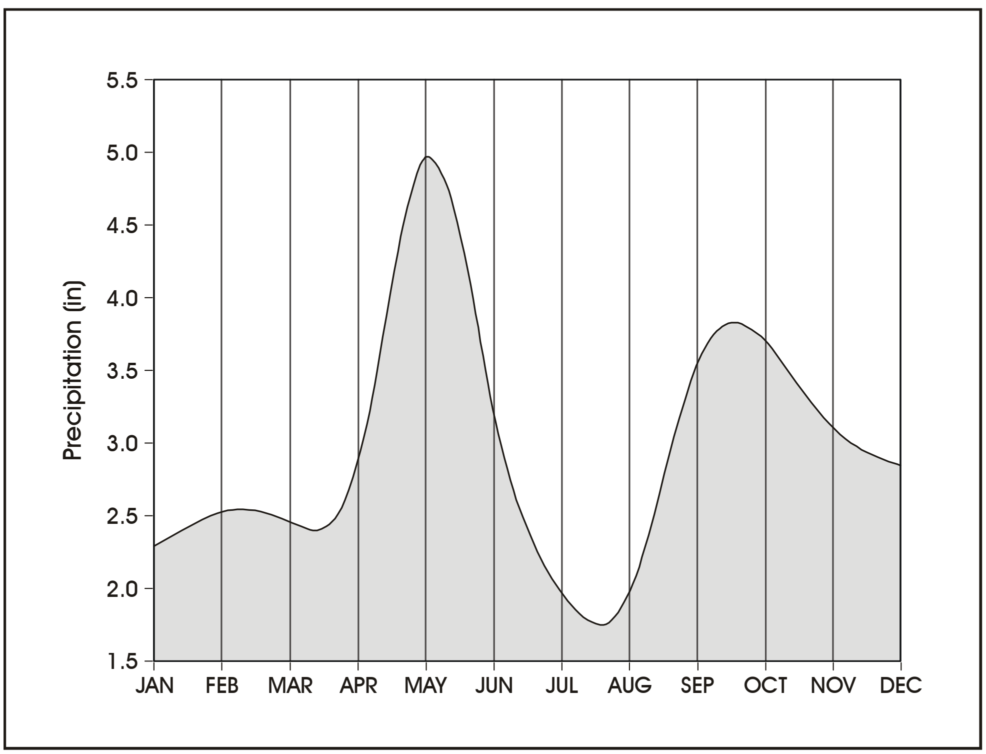

Figure 2-3. *Average monthly precipitation for the city of Cameron between 1971 and 2000.*

Figure 2-4. *Aerial photograph of the project area and the Little River floodplain.*

that this seasonal pattern of rainfall was present prior to 1917, we can suggest that these patterns in river flow were evidenced. It is, however, unclear if the current seasonal rainfall pattern was present during the Late Archaic occupation of 41MM340. Any comparison of these modern patterns with earlier periods is, of course, also complicated by changes to the drainage system, as well as modifications associated with water use for agriculture and ranching. Nevertheless, these seasonal variations in flow rates may have implications for the timing of site occupation, acquisition of riverine resources, and the deposition of sediments at 41MM340.

Flooding of the Little River was experienced during the course of the mitigation efforts at 41MM340. Rain was frequent during our work at the site in late 2001, and two major flooding events occurred. The first was on the 17th of November and the second was on the 17th of December. These events submerged much of the floodplain, and resulted in substantial water damage to the excavation, as well as the deposition of sediment at the site. We lack river height data for the 1917 through 1955 period, but a consideration of modern flow rates for these two flooding events can provide some measure of the streamflow in relationship to flooding. A consideration of daily flow rates for the months of October, November, and December of 2001 clearly shows these two flooding events (Figure 2-8). The relationship between flow rate and flooding is complicated. Certainly, flooding is dependent on a variety of factors (e.g., channel characteristics, vegetation characteristics) other than simply streamflow. Nevertheless, these streamflow data suggest that minimally a flow rate of 20,000 ft^3/second is associated with flooding in this particular portion of the Little River at the present time.

Using the 20,000 ft^3/second rate as a gross indicator of possible flooding, we can then consider the 1917 through 1955 data to begin to assess the timing and frequency of flooding. For the period considered, which consists of 14,244 days, the 20,000 ft^3/second flow rate threshold was exceeded 112 times (about 0.79%). The daily groupings of these events suggest that these 112 days probably reflect 44 distinct flooding events during this 39-year period, or roughly 1.13 floods per year. Figure 2-9 presents the primary months in which an event occurred. Floods are most likely during April and May, with 21 of the 44 (47.7%) events occurring during that period. Conversely, flooding in late summer is rare, with only five events (11.4%) occurring during the months of July, August, and September.

Geology and Soils

While additional information on the geology and soils of the immediate site area can be found in Chapter 7 of this report, here we provide a short overview of these topics at a regional level. The major geological features of the region are identified in Figure 2-10 (adapted from Barnes 1981). The Little River floodplain is a Quaternary deposit (Qal) consisting primarily of clay, silt, sand, and gravel. Raw materials potentially present in this deposit include chert, quartzite, limestone, and petrified wood. Older fluvial terrace deposits (Qt, Qhg) are indicated in this area, with gravels, sand, silt, and clay present. In addition to chert and limestone, igneous and metamorphic rock may be present in these deposits. Older Tertiary deposits are represented by the Wilcox Group (Ecb, Ewi, Eh, Esb) and the Midway Group (Emi). These deposits consist primarily of mudstone, sand, and clay. Marl and chalky marl Cretaceous deposits (Knt, Kknm) are found primarily to the west and north of 41MM340.

Clearly, the geological formations identified in Figure 2-10 suggest that tool stone should be present in this region in good quantity and, in fact, a variety of lithic raw materials are available in the immediate area of the site. During our work at 41MM340, S. Tomka collected samples and made observations on material exposed on a gravel bar within the Little River drainage. Tomka suggests that angular chert nodules in the size range of three to six inches were common to abundant at several locations. The chert cobbles were mixed in with a limestone cobble matrix. A variety of cherts

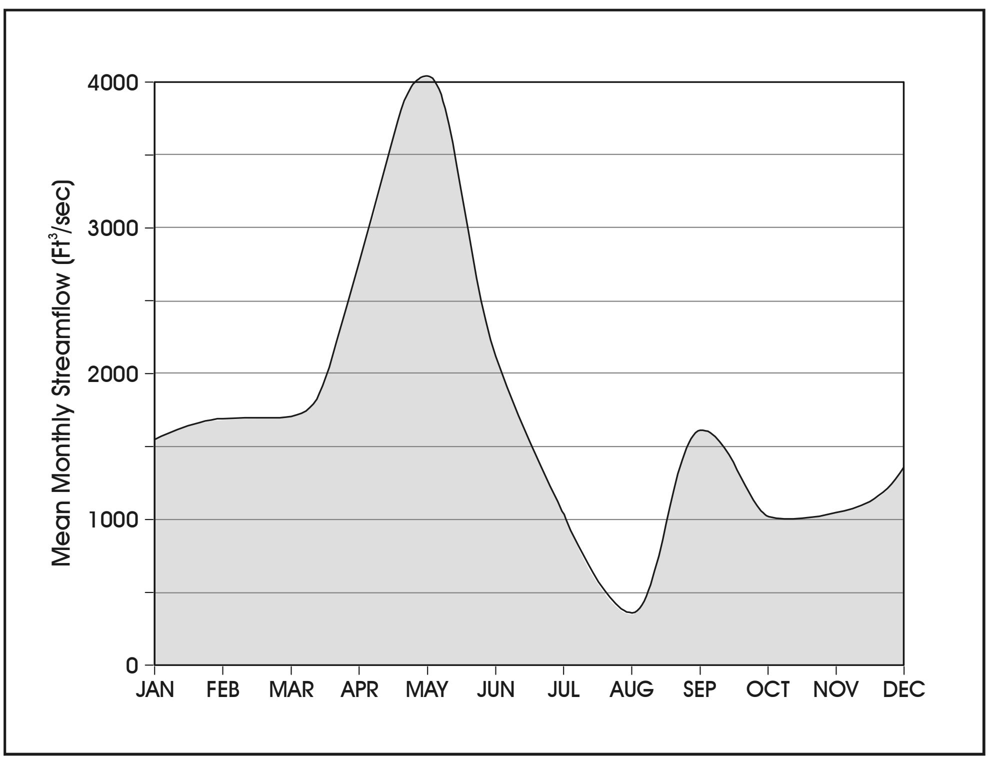

Figure 2-5. *Average monthly streamflow for Little River from 1917 through 1955.*

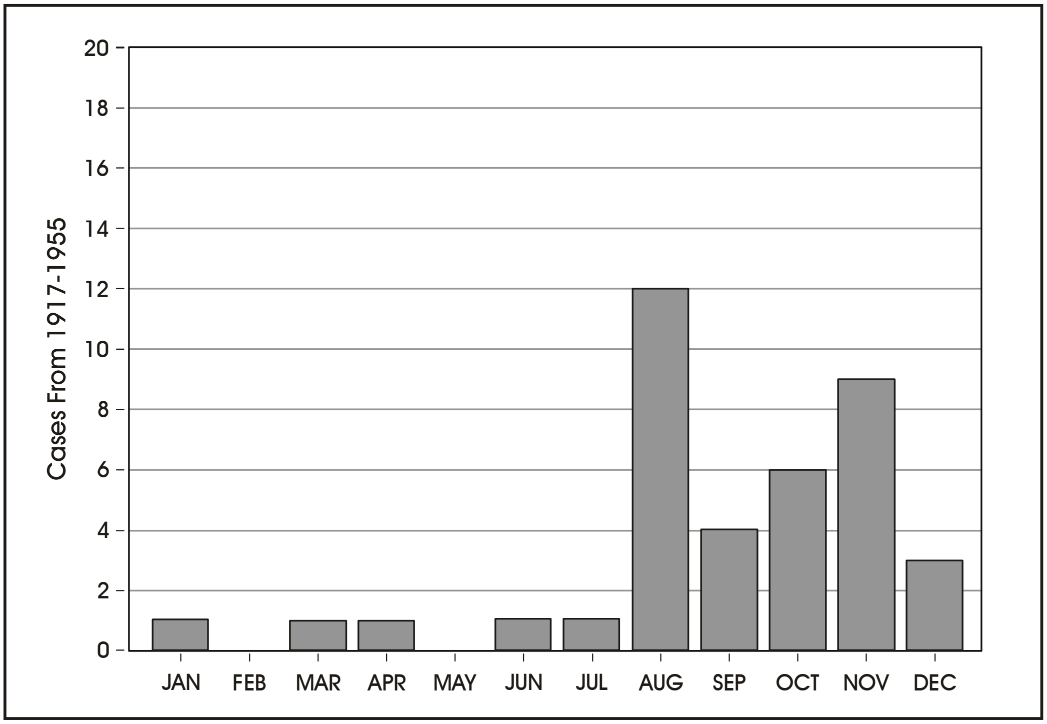

Figure 2-6. *Frequency of minimum streamflow by month in a year (1917 to 1955).*

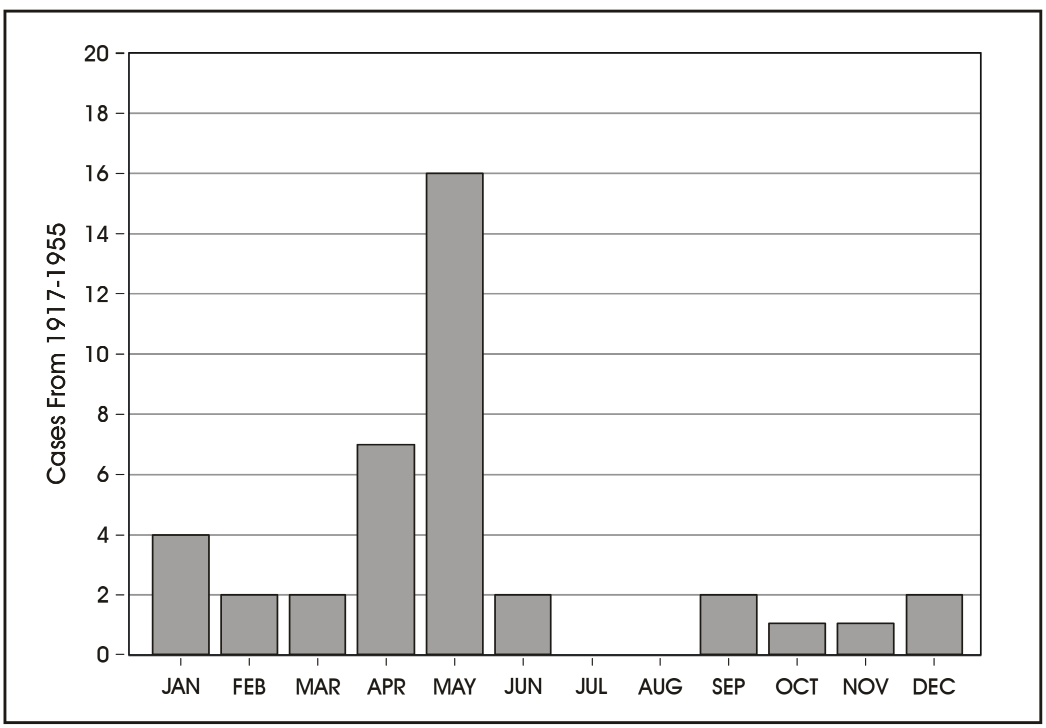

Figure 2-7. *Frequency of maximum streamflow by month in a year (1917 to 1955).*

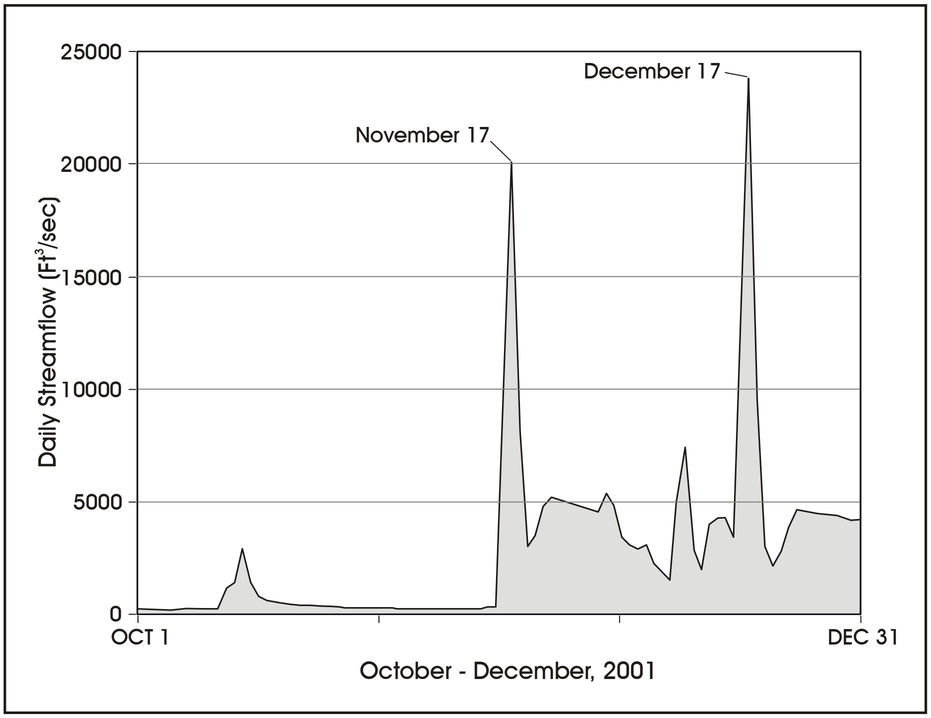

Figure 2-8. *Streamflow data for Little River for the months of October, November, and December of 2001.*

were present, with colors in the range of yellow, tan, light brown, and light gray. Also observed, though in much smaller quantities, were pieces of petrified wood and several quartzite nodules. The size and color range of the cherts observed by Tomka along this gravel bar are consistent with the vast majority of cherts recovered from our excavation at 41MM340.

According to recent, unpublished Soil Conservation Service (SCS) soil survey maps of the project area, 41MM340 is located within the Tinn series of very deep, moderately well-drained, very slowly permeable soils that formed in calcareous clayey alluvium. Sedimentation along the floodplain consists of dark soils eroded from limy uplands (Carter et al. 1925:16), adding to the calcareous nature of the floodplain sediments. The site sits on an apparent point bar formed by a former meander of Little River. This meander is still visible in the vicinity of the site and is part of a discontinuous line of sloughs and backwater ponds (see Figure 2-4). A slight escarpment (~50 cm high) located along the probable former terrace is only 100 m (328 ft) south of the site.

Faunal and Floral Resources

The current project falls within the Post Oak Savannah and Blackland Prairie vegetation regions. These regions tend to have a low diversity of plants and animals relative to some other regions of the state. For example, Davis and Schmidly (1994) demonstrate that the number of faunal species present in these settings is among the lowest of the 10 vegetation regions identified for the state. Faunal resources currently in the area include a variety of mammals, birds, reptiles, and mussels. Of specific interest is the presence of white-tailed deer. A variety of other smaller mammals, including gophers, rabbits, and coyotes were observed during the excavations at 41MM340. Previous testing at site 41MM340, as well as site 41MM341 located just to the southeast of 41MM340, produced evidence of a variety of animals, including deer, jackrabbit, cottontail rabbit, and raccoon. In addition, several different turtles and catfish were recovered (Meissner 2001:90–91). A variety of mussel shell was also recovered during our previous work at 41MM340 (Howells 2001a:94–98), and presently sections of the Little River support thriving populations of mussels (TPWD 2003).

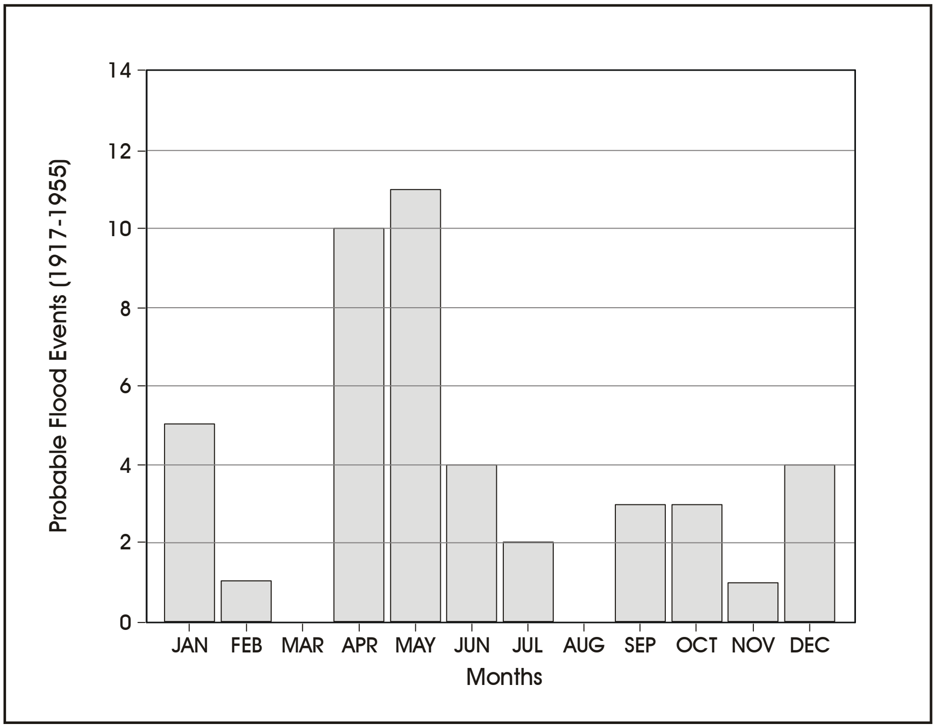

Figure 2-9. *Number of flood events (flow rate exceeded 20,000 ft³/sec) by month for Little River between 1917 and 1955.*

Figure 2-11, centered on Milam County, presents the project location relative to current vegetation zones. Clearly, the area has a low diversity of vegetation. Small areas of oak woods, forests, and grasslands are interspersed with cropland. The low vegetation diversity of the Blackland Prairie and the Post Oak Savannah settings is in clear contrast to the variety present on the Edwards Plateau, to the west of the current project setting (see Figure 2-11).

At present, the project area is used as pasture land. The predominant vegetation on the site is ground-cover grasses and dense giant ragweed (*Ambrosia trifida*) thickets, colloquially referred to as "bloodweed." A riparian zone exists along the bankline of Little River consisting of various hardwoods, primarily pecan (*Carya illinioensis*). Cattle are maintained along the western section of the proposed right-of-way. They are seasonally introduced into the remainder of the right-of-way.

Paleoenvironmental Conditions

This reconstruction of the paleoenvironmental conditions characterizing the vicinity of 41MM340 is based primarily on pollen records. Our previous work at the site (Mahoney and Tomka 2001) suggests that it was occupied during the Late Holocene. Using the uncalibrated radiocarbon dates, occupation was probably during a roughly 800-year period between about 3100 and 2300 BP. As such, our paleoenvironmental review will focus primarily on the last 4,000 years, with special attention to this 800-year period. Although a number of bog locations are present within the general vicinity of the Little River project, many of them (e.g., Boriack Bog, Gause Bog) either lack pollen records from the Late Holocene or are not well dated (see Bryant 1977:146). However, two bogs, Patschke located in Lee County, and Weakly located in Leon County, do contain appropriate deposits with radiocarbon dates. Since these bogs are located along the western edge of the Post Oak Savannah, these sequences should reflect the long-term westward movement and retreat of this vegetation boundary as climatic conditions oscillate between moister and drier conditions, respectively. Given that the Little River project area is in this same ecotonal setting, the paleoenvironmental reconstructions from these localities are relevant to modeling changes in resource structure and base in the vicinity of the site in question.

Weakly Bog contains a record of approximately 3,000 years of the Late Holocene. A date of 2375 radiocarbon years BP

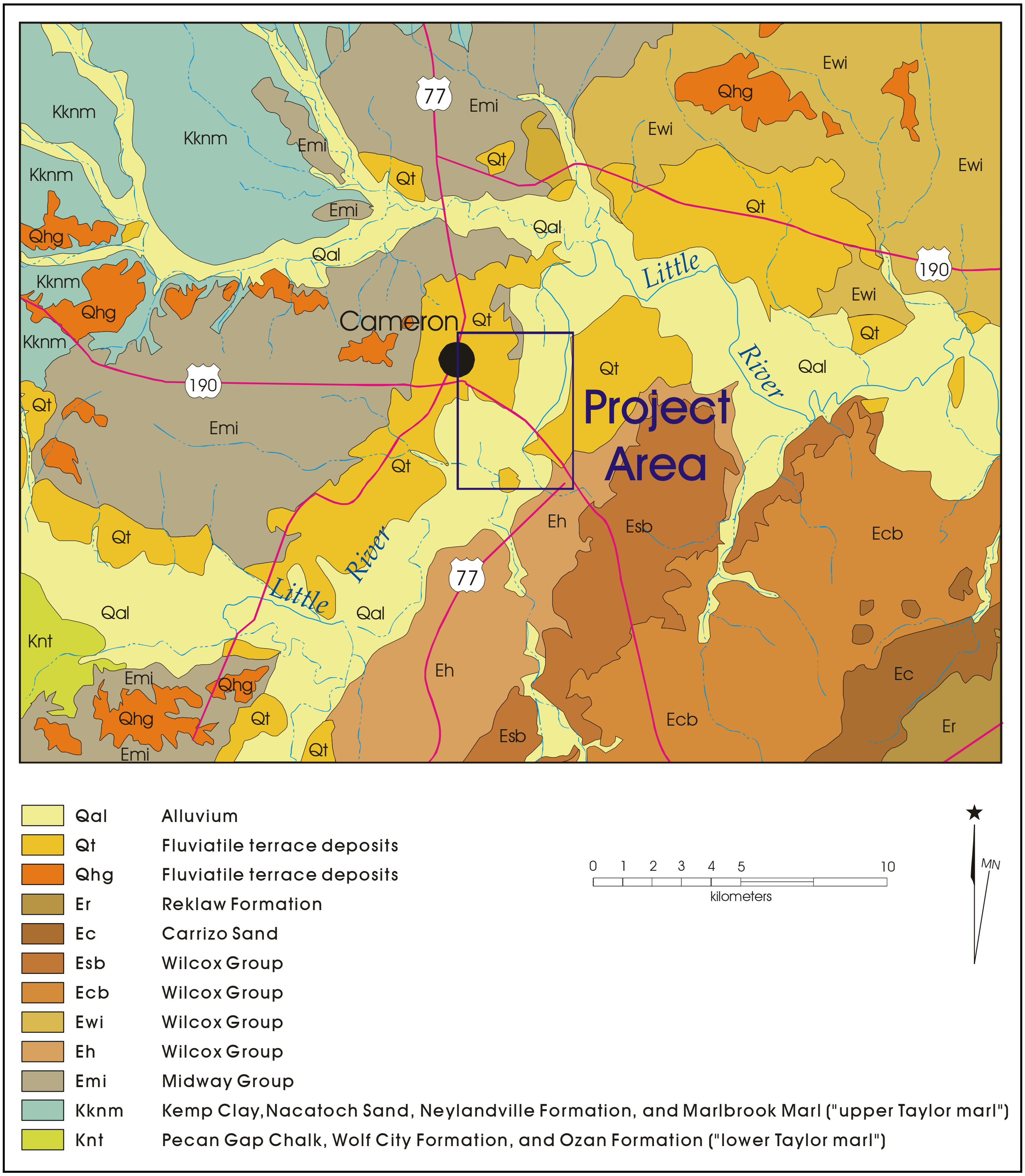

Figure 2-10. *Major geological features of the project area and surrounding region. Adapted from Barnes (1981).*

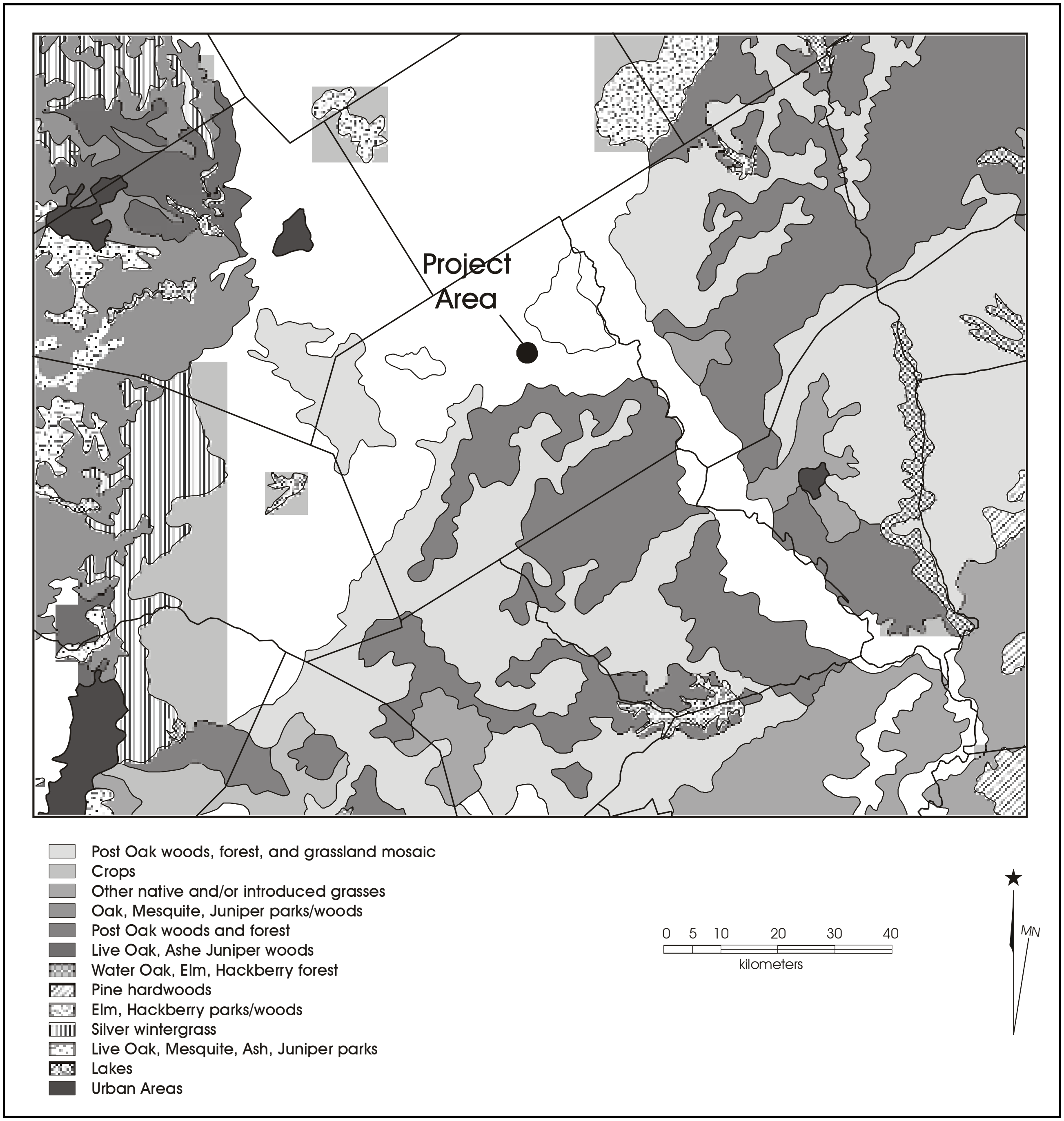

Figure 2-11. *Project location relative to current vegetation zones.*

was obtained for a sample from 120–129 cm below surface (bs), and a date of 2125 BP was obtained for a zone between 58–65 cmbs. A date of 1550 BP obtained from 50–58 cmbs indicates a 500–600-year hiatus in sedimentation in the core at a depth of about 55 cmbs. The upper 20–30 cmbs represent essentially modern deposits (Holloway et al. 1987:Table 1). Using a linear regression formula between radiocarbon sample depth and age, Bousman (1998:207) suggests that the upper 16 cm of deposits should date after circa 400–500 BP.

Holloway et al. (1987:75–77) interpret the lower section of the pollen spectra (58–124 cmbs) as representing a woodland plant community that appears to have been denser than that covering the vicinity of the bog today. In part, this interpretation is based on the extremely high pollen influx values for all taxa including grasses, in conjunction with the rapid sedimentation rates characterizing these deposits. Arboreal pollen peaks between 75 and 104 cmbs, starting immediately below a 2–3-cm-thick grass mat layer that coincides with a decrease in both Poaceae and Cyperaceae pollen. The high influx values for grasses suggest that patches of open prairie may have been quite common within these woodlands.

Pollen influx values decrease significantly in the upper 52 cm of the core although the upper pollen assemblages do not appear to change significantly in composition. Holloway et al. (1987:76) interpret this pattern as representing a significant change in the structure of the vegetation community in the vicinity of the bog. Specifically, the lower influx values seem to suggest a more open savannah woodland setting with a greater herbaceous understory and a more prevalent grassland component. According to Holloway et al. (1987:76–77), this change appears to reflect a shift from more mesic to drier conditions and may represent the establishment of the Post Oak Savannah along this portion of the deciduous forest. This change appears to have occurred sometime between 2125 and 1550 BP (but see Bryant 1977).

Bousman (1998:207), however, argues that the relative frequencies of grass and compositeae pollen does not increase as would be expected throughout the upper portion of the column if the reconstruction by Holloway is correct. Rather, only two well-defined and isolated peaks in grass and compositeae pollen are evident. One occurs sometime around 1150 BP at a depth of about 43–53 cmbs, while the other, based on Bousman's (1998:206–207) regression formula, is estimated to have occurred sometime around 400–500 BP at a depth of between 10–20 cmbs. These spikes in grass pollen coincide with decreases in oak pollen and might reflect short periods of perhaps warmer and drier conditions resulting in the expansion of the prairie patches or the wholesale eastward retreat of the oak savannah. Bousman (1998:207) also suggests that the presence of pecan/hickory throughout the upper 75-cm portion of the column, and the appearance of pine pollen in the upper 30 cm, in conjunction with the overall steady increase in arboreal pollen—with the exception of the two grass spikes—may actually be interpreted as indicative of increased moisture levels though the Late Holocene, contrary to Holloway et al. (1987).

Using Bousman's (1998) reconstruction of estimated arboreal canopy cover extrapolating from the upper portion of Boriack Bog and using the data from Weakly Bog, the 1,000-year period represented in the deposits at 41MM340 has been characterized by decreasing arboreal cover between 3200 BP and 3000 BP reaching a relatively open grassland community between 3000 BP and 2000 BP. The increase in arboreal canopy cover between 2000 BP and 1600 BP signals the return of woodlands and a more substantial woody vegetation component. A vegetation community dominated by grasses may have been present between 1600 BP and 1000 BP.

Recently, Camper (1991) has reanalyzed Patschke Bog, a Central Texas bog in Lee County that was originally investigated by Potzger and Tharp (1943, 1947). The samples presented by Camper appear to represent a continuous, and relatively well-dated sequence stretching back to 17,000 BP. However, as Bousman (1998:207–208) notes, the Patschke data have significant frequencies of local marsh taxa, such as alder *(Alnus)* and Cyperaceae. These local taxa make the identification of regional vegetation shifts difficult. In an attempt to clarify the pattern of regional change indicated at Patschke Bog, Nickels and Mauldin (2001) reviewed the raw pollen grain counts from Patschke (Camper 1991). While Bousman (1998) is correct in noting the high level of marsh taxa throughout the deposits, Nickels and Mauldin (2001) note that Camper's grain counts, unavailable to Bousman in 1998, are extremely high, with an average of just over 370 grains per level, and a minimum count of 270 grains for any single level. They reworked the original data, eliminating the potential contaminants from the Patschke Bog pollen sequence (Nickels and Mauldin 2001:34–35).

These revised percentages for grass (Poaceae) taxa for Patschke Bog (Nickels and Mauldin 2001), as well as the grass percentages for the better known Boriack Bog (Bousman 1998), are presented in Figure 2-12. Major contaminants have been removed from this Boriack sequence (see Bousman 1998). There is a good correlation between the Patschke data and Bousman's (1998) summary (Figure 2-12), especially in light of the fact that the dating of the sediment core analyzed from Boriack Bog (Core 1) is based on four radiocarbon dates from an adjacent core (Bousman, personal communication 1999). The Patschke Core 4 samples are better dated, being supported by four radiocarbon dates from the core itself, as well as additional dates from Core 2, located less than two yards away from Core 4 (Camper 1991:31).

Focusing on the last 4,000 years of the Patschke pollen sequence (Figure 2-12), a fluctuating but generally dry period is present in the initial Late Holocene, between roughly 4000 BP and 1000 BP, with accelerated mesic conditions occurring in the last 1,000 years. Drier intervals are indicated at about 3500 BP, 2500 BP, and about 1000 BP. Slightly more mesic intervals are present at around 3000 BP and about 1800 BP, as well as after roughly 1000 BP.

Figure 2-13 is an overlay of the arboreal pollen sequences derived from Weakly and Boriack bogs (Bousman 1998) with the grass pollen sequence derived from Patschke (Nickels and Mauldin 2001) for the last 7,000 years. Ideally, these two sequences should approximate mirror images, with increases in grass at Patschke reflected by decreases in arboreal pollen at Weakly, and decreases in grass reflected by increases in arboreal pollen. While some of the sequence works as anticipated, there are also clearly sections were the curves are similar. One likely source of error may be related to the detailed dating of these sequences. In addition, note that the probable occupational span of 41MM340 is also highlighted in the figure. While this represents only a short period within the overall sequence, grass pollen appears to be increasing while arboreal pollen is decreasing. The patterning in these data suggests that, at least at a regional level, climate may have become increasingly xeric during this 800-year span.

Summary

Overall, a fluctuating climatic pattern is suggested during much of the Late Holocene, with accelerated mesic conditions after about 1000 BP. There are a number of other indicators from throughout the state that seem to support climate fluctuations in the Late Holocene (see Brown 1998; Johnson and Goode 1994; Nordt et al. 1994; Robinson 1979; Toomey 1993; Toomey and Stafford 1994). During the relatively brief period of occupation at 41MM340, climate seems to have become more xeric. Note, however, that the location of site 41MM340 within the floodplain of the Little River is a setting with high water tables and therefore higher effective moisture levels relative to the adjacent upland. Such a setting would have always favored the development of more mesic woodland and forest communities. It is likely that shifts between vegetation communities dominated by woodlands and grasslands would have occurred primarily under relatively severe and long-term drought conditions. Perhaps a more accurate picture of the effects of these paleo-environmental conditions on the immediate surroundings of the site is to view them as resulting in oscillations between more closed to more open woodlands characterized by heavy woody plant components in high moisture periods and a mosaic of grasslands and woodlands during periods of lowered water tables. The surrounding uplands, where drops in effective moisture would have affected vegetation communities more drastically, are expected to have oscillated between relatively closed woodlands, more open woodland communities with patches of grasslands or prairies, and finally grasslands as effective moisture levels decreased and water tables dropped.

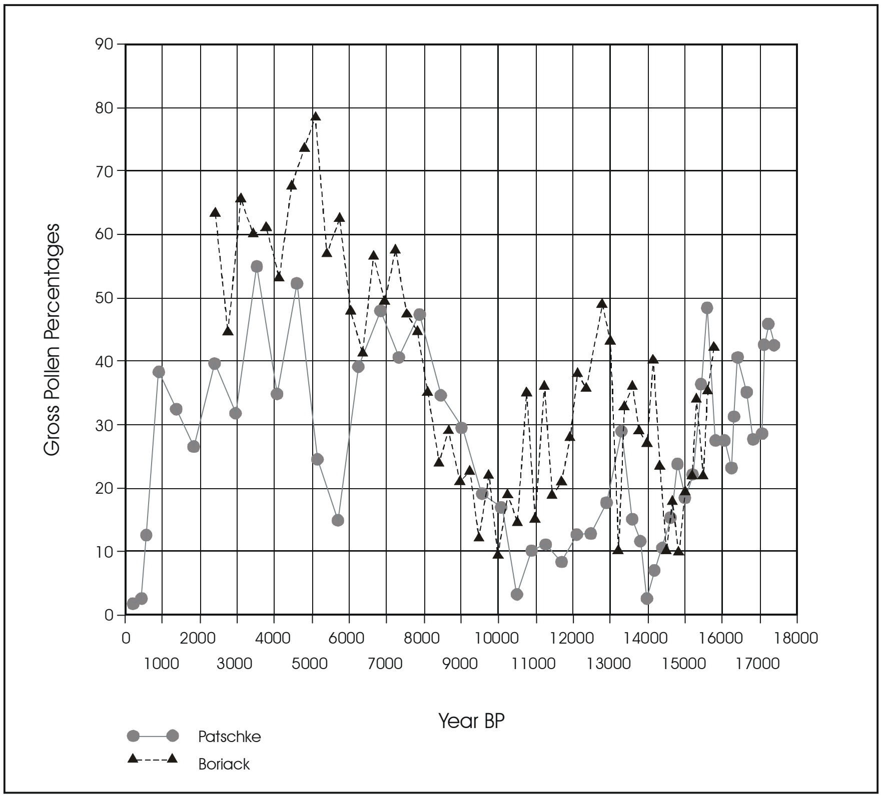

Figure 2-12. *Poaceae pollen percentages for Patschke and Boriack bogs.*

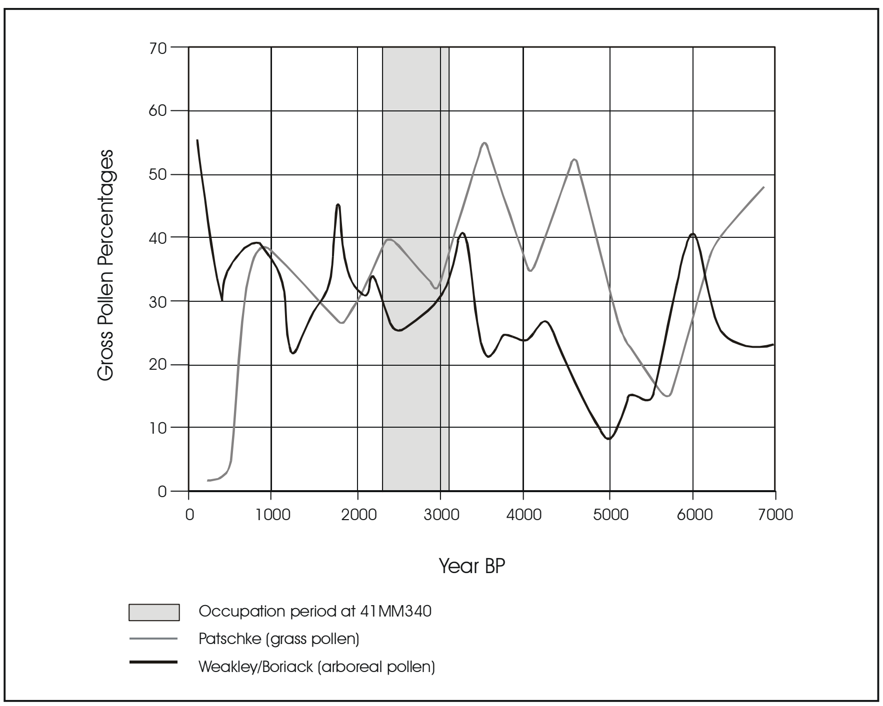

Figure 2-13. *Arboreal pollen sequences derived from Weakly and Boriack bogs and grass pollen sequence derived from Patschke Bog for the last 7,000 years. The transparency indicates the period of occupation of 41MM340.*

Chapter 3: Archeological Background and Cultural Setting

Richard B. Mahoney, Steve A. Tomka, and Raymond P. Mauldin

This chapter consists of two sections. The initial section presents an overview of previous archeological work conducted in and around Milam County. This overview is followed by a short review of the culture history of the region. Based on our previous testing at 41MM340 (Mahoney and Tomka 2001), site occupation occurred during the Late Archaic. Consequently, this culture history review focuses on the Late Archaic time frame.

A Review of Previous Investigations in and around Milam County

Early archeological work in Milam County is not well documented. The earliest published account of archeological sites in the county dates to the latter part of the 1930s (White 1937). No professional archeological surveys and/or excavations are reported in Milam County in the gray literature over the following two decades. In 1969, however, the Archeological Program of the State Building Commission sponsored a systematic survey and excavations at Mission San Francisco Xavier established in 1748 near the confluence of Brushy Creek and the San Gabriel River. The survey resulted in the description and recording of six archeological sites, with five of the six, 41MM10, 41MM11, 41MM16, 41MM17, and 41MM18, being part of the San Xavier Mission Complex (Gilmore 1969). By 1976, only 33 archeological sites were recorded within the files of the Texas Archeological Research Laboratory (Betancourt 1977:Table 2).

A number of major archeological surveys and excavation projects had occurred by the mid-1970s in surrounding counties and a broad picture of regional culture history was emerging (Laneport Reservoir, Shafer and Corbin 1965; Stillhouse Hollow, Sorrow et al. 1967; Upper Navasota Reservoir [Lake Limestone], Prewitt 1974; Millican Reservoir, Sorrow and Cox 1973; Somerville Reservoir, Honea 1961). The pace of archeological investigations in Milam County proper did not pick up until the mid-1970s as the mining of shallowly buried lignite became economically viable.

Even within the past few years, much of the archeological work conducted in the region has been driven and sponsored by impacts associated with lignite mining operations. Shell Oil Company, Northwestern Resources Co., and Alcoa were and continue to be the principal companies involved in lignite mining in Milam and the surrounding counties. Archeological investigations, including survey, testing and data recovery, are primarily spurred by developments within two principal lignite mining operations, the Sandow and Jewett Mines. The Sandow Mine consists of numerous leases situated in the vicinity of Rockdale, in southeastern Milam County. Jewett Mine is located to the east in nearby Leon and Freestone counties.

Professional archeological research associated with Sandow Mine was initiated by the Office of the State Archeologist during the latter part of 1976 (Betancourt 1977). This, like many of the subsequent cultural resource management projects within the mine, consisted of a survey of selected portions of the mine. The project resulted in the documentation of 72 previously unrecorded sites (41MM34 through 41MM105) and provided a reasonable sample of the landforms that were prehistorically and historically occupied within the survey area. Numerous subsequent surveys were carried out in the late 1970s and early 1980s within the mine primarily under the auspices of Texas A&M University (Carlson et al. 1983; Rushmore et al. 1980; Weed 1977; Weed and Ippolito 1977). These surveys, coupled with those conducted by Espey, Huston, and Associates (EH&A; James 1986; James and Moore 1987; Rogers and Cruse 1998) and North American Consultants, Inc. (Keller and LaVardera 1989) have resulted in the completion of inventories of historic and prehistoric properties across thousands of acres within the mine.

Although these surveys have resulted in the recording and basic documentation of hundreds of archeological sites, Phase II testing and Phase III data recovery efforts have been conducted only at a small number of these sites (Ippolito and Childs 1978; Ricklis 2001; Rogers and Kotter 1995; Weed and Whittaker 1980).

Comparative regional-scale archeological data derived from large-scale or intensive surveys useful for understanding settlement patterns and land-use strategies is not available from within Milam County. The nearest comparative data comes from the upper Navasota River basin and the site of Lake Limestone (formerly the Upper Navasota Reservoir). Although in scale this area provides a comparable regional data base, this project area is located within the Oak Woodlands. Therefore, in terms of ecological setting it is not directly comparable to the Sandow Mine area that is found in an ecotonal setting between the Oak Woodlands and the Blackland Prairie.

Prior to damming of the Navasota River, the Texas Archeological Survey (TAS) was charged with development of an inventory of the cultural resources to be affected by construction activities (Prewitt 1974). This initial survey resulted in the recording of 52 new prehistoric sites. Subsequent to this survey, TAS tested the NRHP eligibility of a total of 28 prehistoric sites over the course of several projects (Prewitt 1975; Prewitt and Mallouf 1977) prior to the impoundment of the nearly 14,000-acre reservoir in 1978.

Survey efforts carried out by EH&A associated with the construction of the Limestone Electric Generating Station followed the lake impoundment and resulted in the survey of some 3,500 acres and the recording of 38 sites, 16 of which were prehistoric (EH&A 1980). Additional survey fieldwork conducted for various utility easements located eight sites, six of which were prehistoric (EH&A 1981). Based on these survey results, seven sites were subject to NRHP eligibility testing (EH&A 1981). Two of the tested sites, Doyle Martin (41LN178) and P.I. Ridge (41FT52), were deemed eligible for NRHP inclusion and were subject to the only mitigation to occur on plant property.

Archeological investigations within the Jewett Mine proper began in 1979 (EH&A 1980) and continued through 1996 (Gadus et al. 1997). A total of 34 individual projects was conducted in the mine boundaries during this period. The interested researcher is referred to Gadus et al. (1997) for a synopsis of each of these projects. Eight surveys, covering 28,575 acres, 15 testing, and 11 mitigation projects have documented the 465 archeological sites encountered in Jewett Mine.

With few exceptions, the archeological investigations within Milam and surrounding counties have tended to concentrate on upland and upland margin settings. It is not surprising that the small site sizes and low density of cultural materials in many of the Sandow Mine sites prompted Betancourt (1977:38) to suggest that the scarcity of resources may have limited the use of the region.

Most of the sites recorded in Sandow Mine and the Lake Limestone area tend to be found on inter-basin ridges or valley walls in the vicinity of the confluences of drainages. Few sites were recorded in the floodplains of major drainages (see also Betancourt 1977:Table 3). It is worth noting, however, that these sites represent a sample of the prehistoric land-use system that is biased in at least two ways. First, these sites represent prehistoric occupation loci that produced sufficient cultural debris to be archeologically visible during a pedestrian survey. That is, other loci were no doubt utilized for various procurement and processing activities in varied settings across the uplands. However, due to their low archeological visibility, such locations were not identified during traditional pedestrian surveys. Second, in large part the surveys targeted upland settings that were to be impacted by strip mining rather than the valley bottoms. Therefore, sites that may be located in valley bottoms in floodplain settings would be dramatically under-represented in land-use reconstructions.

Another interesting aspect of these large databases is that reconstructions of lithic procurement practices tend to emphasize the localized sources of Uvalde gravels because this is the manner in which lithic resources occur in upland settings. Given this context, prehistoric lithic procurement activities tend to be viewed as spatially segregated from residential camping activities and imbedded into other foraging activities.

The general impression derived from studying site locations within Sandow Mine, Lake Limestone, and Jewett Mine is that prehistoric peoples preferred to locate their campsites at the confluence of drainages, on terraces overlooking floodplains along major streams, and in the vicinity of local outcroppings of workable gravels (Betancourt 1977: Figure 1).

The closer inspection of those archeological sites that have been tested and/or have been subject of data recovery efforts indicates that sites containing components predating the Late Archaic are scarce in both the Sandow and the Jewett mine regions (see also Fields and Tomka 1993; Fields 1995). Few of the sites that have been excavated within the region contain Paleoindian, Early Archaic, and Middle Archaic components and when they are present, they appear to occur in isolated pockets within sites (41LN106, 41LE59, 41LE177). The more numerous Late Archaic, Woodland, and Late Prehistoric components identified in the region tend to have low densities of archeological materials, few definable features, scattered burned rock, poor faunal and macrobotanical preservation, and a scarcity of datable materials.

Little River Sites

Limited professional research has occurred in the Little River basin in Milam County. With the exception of a single project (Fickel 1993), investigations along portions of Little River have all dealt with roadway, utility, or pipeline easements at the stream crossing (Ahr and Abbott 1999; THC 2003; TSDHPT 1990; Turpin et al. 1991).

At the time of the current investigations, there were 20 previously recorded archeological sites along Little River in Milam County (THC 2003). Of these sites, two contain only historic components (41MM273 and 41MM289; TSDHPT 1990; Turpin et. al. 1991). An inventory of the prehistoric sites along Little River is presented in Table 3-1.

Eight of the sites appear to be located on terraces bordering the floodplain. Four of the sites occur in the uplands. These upland sites may have been used, in part, for exploiting the gravel deposits common in these locations along Little River in Milam County. The remaining six sites, including 41MM341 previously tested by CAR (Mahoney and Tomka 2001), occur within the floodplain and may represent the occupation of former terraces or small rises that are no longer visible in the modern floodplain. The average distance of recorded sites from the extant meander of Little River is approximately 936 m (0.6 mi). Given this distance estimate, and the dynamic nature of Little River, it is almost certain that prehistoric occupations occurred much closer to water resources than the figure suggests. As such, the probable location relative to the associated relict meander has been measured from aerial photographs and USGS maps. Table 3-1 shows the results of this likely reconstruction, with an average, corrected distance of sites to relict meanders of Little River of roughly 37 m (121 ft). This corrected distance indicates a more feasible proximity of prehistoric sites to the former meander of the stream.

Table 3-1. Previously Recorded Prehistoric Archeological Sites along Little River in Milam County

				Meander of Little River				
Site	**Component**	**Soil**	**Landform**	**Relict (m)**	**Extant (m)**	**Site Size**	**USGS Quad**	**Project**
41MM8	unknown	?	terrace	20	740	?	Hanover	Freeman Site
41MM12	unknown	sandy loam	gravel pit	60	2020	10 acres	Hanover	C.K. Chandler
41MM13	unknown	sandy loam	terrace	70	1500	800x200 m	Hanover	C.K. Chandler, Espey, & SMU
41MM14	unknown	sandy loam	floodplain	40	1420	20 acres	Hanover	C.K. Chandler; SMU
41MM36	?	gravel	terrace	*	<20	?	Little River	Frank Bryan's #136 (1930s)
41MM128	unknown	sandy loam	upland	#	1560	?	Gause	Bill Moore (Texas A&M)
41MM129	unknown	sandy	upland	#	1860	?	Gause	Bill Moore (Texas A&M)
41MM130	LP	sandy	terrace	*	1380	?	Gause	Bill Moore (Texas A&M)
41MM131	unknown	sandy	terrace	*	820	?	Gause	Bill Moore (Texas A&M)
41MM136	unknown	sandy loam	floodplain	*	140	12.5 acres	Hanover	EHA, Brazos Electric
41MM142	unknown	?	terrace	*	<20	?	Sharp	D. Crawford
41MM253	?	?	upland	#	610	?	Gause	?
41MM264	?	?	floodplain	20	1400	?	Pettibone	?
41MM292	LP	?	floodplain	*	<20	50x100 ft	Hanover	Texas A&M
41MM302	unknown	sandy loam	upland	#	250	100x200 m	Gause	Bill Moore (BVRA)
41MM340	LA	silty clay	floodplain	30	500	40x20m	Cameron	UTSA-CAR
41MM341	LA/LP	silty clay	floodplain	*	500	50x25m	Cameron	UTSA-CAR
41MM344	LA	gravel	terrace	20	280	?	Pettibone	TxDOT FM 1600
			Average Distance	**37**	**936.25**			

* - position relative to floodplain suggests adjacency with relict meander (<20m)
\# - located atop upland bordering floodplain
? - data not contained in report or site form
LA - Late Archaic / LP - Late Prehistoric

The Late Archaic of East-Central Texas

Here, we briefly review the culture history of east-central Texas focusing on the Late Archaic period that seems to encompass the occupations identified during data recovery at 41MM340. Specifically, the oldest components at 41MM340 fall within what Johnson and Goode (1994) have termed the Late Archaic I period, with continued occupation into the early portion of the Late Archaic II period. A more detailed account of the various prehistoric periods discussed here, as well as an overview of other periods in the Central Texas region, can be found in Collins (1995), Johnson (1995), and Prewitt (1981, 1985). The reader is also urged to consult the relevant archeological literature of the Eastern Planning Region (see Kenmotsu and Perttula 1993) given that Milan County falls just west of this area and the archeological record of this region shares characteristics of both Central and East Texas.

The Late Archaic period, from approximately 4200 BP to 1200 BP (Johnson and Goode 1994:29), roughly coincides with the commencement of the Late Holocene geologic epoch. The terminus for this period is generally marked by the introduction of the bow and arrow or ceramics. As outlined in the previous chapter (see Figure 2-13), the climate seems to have fluctuated significantly during this period.

Within the state, some researchers believe populations increased throughout the Late Archaic (Prewitt 1985), while others feel that populations remained the same or even declined (Black 1989). Within the current region, investigations conducted at the Chesser Site (41LE59), a multicomponent site spanning the Paleoindian through Late Prehistoric, suggest a substantial growth in population with the onset of the Late Archaic period. This assertion is based on increases of stone tools and lithic debitage (Rogers and Kotter 1995:134).

Johnson and Goode (1994) suggest that the commencement of the Late Archaic I is characterized by a generally xeric environment. This drying trend is not supported by all climatic models (Collins 1995) but seems consistent with the extant pollen data. Johnson and Goode (1994:34–35) propose that, due to the xeric conditions experienced by the peoples of the Late Archaic I period, burned rock middens proliferate for the processing of semi-succulents. The temporally diagnostic projectile point types present during the Late Archaic I include Bulverde, Pedernales, Marshall, Montell, and Castroville (Johnson and Goode 1994:Figure 2).

When it comes to the Late Archaic II period, Johnson and Goode (1994:37) suggest that Eastern (United States) religious influences, manifested in the form of various burial practices, represent one of the primary indicators of the period. During this period, environmental conditions tend to ameliorate and more mesic conditions tend to dominate. While a definitive date cannot be placed upon the abandonment of burned rock middens, Johnson and Goode (1994) note that these feature types are generally associated with the Late Archaic I, and their absence denotes the beginning of the Late Archaic II. A variety of recent research on this issue, however, clearly questions this timing for burned rock midden use (see Black et al. 1997; Mauldin et al. 2003). Typical projectile point styles of this phase include, in progressive order, Marcos, Ensor, Frio, Darl, and Figueroa (Johnson and Goode 1994:Figure 2).

As evidenced in recovered artifact assemblages in the region, processing of plant resources appears to increase during this period (Story 1990). Of particular note is the Cottonwood Springs site (41LN107) in Leon County where the artifact assemblage is suggestive of a heavy emphasis on plant processing (Fields and Klement 1995). The authors base their interpretations on the low ratio of projectile points (n=40) compared to the number of tabular grinding stones (n=26) and grinding cobbles (n=27).

At a regional scale, it is likely that the procurement of animal protein through the trapping and killing of small game and the hunting of medium- and large-bodied ungulates probably played a significant role in the economic life of Late Archaic groups. The ecotonal setting of the project area between the plains of the Blackland Prairie coupled with the forested riverine corridors that descended across it from the Edwards Plateau, and the Post Oak Woodlands to the east would have offered a diversity of game species. The Post Oak Woodlands would have provided habitats for white-tailed deer while the open uplands away from the stream bottoms and the prairie to the west would have been prime habitat for pronghorn antelope. Both game species are known to have been present and hunted during the Late Archaic and in the absence of larger-bodied species such as bison, medium-bodied ungulates were the prey of choice for Late Archaic hunters (Yates 1982:15-57–15-227).

Reconstructions of prehistoric bison population dynamics within Texas suggest that bison were present in moderate numbers during the Late Archaic (Collins 1995; Dillehay 1974). The radiocarbon dates obtained from 41MM340 (Mahoney and Tomka 2001:Table 7-1) suggest that the entire span of recurrent site use took place during a lengthy period of bison "abundance" within the region. Nonetheless, although climatic conditions may have favored their southern migration from the Central Plains into the region, the overall population densities and whether they were present year round or on a seasonal basis is not known. When present in the region, they may have been a highly valued (ranked) resource, but Late Archaic hunting strategies as well as hunting logistics may have varied season by season and year by year. These short and long-term oscillations in the resource base on the Blackland Prairie would have likely impacted the exploitation of the prairie and adjacent regions. Moore et al. (1978) propose two alternative models for prehistoric exploitation of the prairie zone. Unfortunately, the authors lacked the sets of archeological data to allow the systematic investigation of whether exploitation of the prairie resembled a "prairie centered adaptation" or a "prairie ecotonal adaptation." The archeological investigations conducted on the eastern margins of the Blackland Prairie in the intervening years may now provide a more solid foundation for considering these two alternatives. This and other aspects of the research perspectives that guided the work conducted at 41MM340 and the analyses of the material remains are presented in the following chapter.

Chapter 4: Research Perspective

Steve A. Tomka and Raymond P. Mauldin

In this chapter we describe the specific research domains that guided the fieldwork and data collection at 41MM340, and influenced the analyses carried out on the data classes recovered from the site. The initial research domains proposed in the research design (Tomka et al. 2002) concerned floodplain and meander dynamics, paleo-environmental reconstructions, subsistence strategies, technological organization, and aspects of site structure. The completion of the proposed research goals associated with each of these domains depended, in part, on data already at hand at the time of the writing of the research design and data derived from a variety of special studies. As the results of special studies were becoming available, it became evident that some of the analyses proposed in the research design were unlikely to yield significant information. In addition, it became apparent that decisions related to excavation methods further compromised some research directions. Consequently, as often happens in archeological research, only some of the proposed research goals were completed. During the analysis new research directions emerge and become relevant to the interpretation of the site. In the following section, then, we provide a summary of the research domains, both old and new. For each domain, we also briefly outline what was accomplished. Additional details on the research topics, as well as alterations in the specific topic details, are presented in subsequent chapters that deal specifically with each domain.

Research Domains

In the research design associated with the Data Recovery Plan for site 41MM340 (Mauldin et al. 2001), the CAR Interim Report summarizing our data recovery efforts (Mahoney et al. 2002), and in the Research Design following our Interim Report (Tomka et al. 2002), CAR proposed to investigate five general research domains. These domains concerned floodplain and meander dynamics, paleo-environmental reconstructions, subsistence strategies, technological organization, and aspects of site structure. Table 4-1, taken from the research design (Tomka et al. 2002), summarizes the research domains, associated research topics, data needs, and the analytical methods. In addition to the five original domains, a sixth domain, centered on the definition and assessment of analytical units at the site, was added. Each of these is discussed in the following sections.

Floodplain and Meander Dynamics and Site Preservation

To prehistoric hunter-gatherers, rivers likely represented corridors characterized by high resource richness and diversity. Groups seeking to take advantage of these resource rich areas probably frequently revisited these localities. The daily need for water, combined with the relatively limited capacity to store large quantities of water, all but ensured that most campsites were situated in close proximity to a water source such as on a floodplain, near a spring, or on a nearby terrace.

In low-energy stream settings, seasonal flooding and stochastic flood events could cap and isolate debris from repeated human occupations creating isolated, behaviorally associated artifact assemblages (i.e., *gisements* of Collins 1995). However, it has been generally assumed that the chances of finding intact archeological deposits within active floodplains were low since meandering streams likely would have destroyed the archeological evidence. The existence of sites such as 41MM340 in an active floodplain suggest that much remains to be known about the floodplain dynamics of major streams. If we can increase our understanding of floodplain and meander dynamics, we can better define the relationships between streamflow, floodplain morphology, prehistoric occupation, and site preservation potential. Consequently, CAR suggested that one research domain focus on developing an understanding of floodplain and meander dynamics in the context of site preservation for 41MM340.

As outlined in Table 4-1, five related research topics focused on questions related to the timing and patterning of stream channel migration relative to patterns of human occupation of the floodplain. In addition, a variety of data types needed to begin exploration of these research areas are presented (Table 4-1). These include the identification and dating of paleosols and sloughs, dating human occupation across the floodplain, quantification of gravel deposits from the site to establish the process(es) that led to their deposition, and documentation of changes in mussel shell populations since they may reflect changes in preferred habitats and by implication flow regime. These data were recovered during our data recovery work at 41MM340. Finally, a series of analytical approaches and methods, designed to increase

Table 4-1. Summary of Research Domains, Topics, Data Needs, and Analytical Methods and Approaches Proposed for the Archeological Material Recovered from 41MM340

Research Domains	**Research Topics**	**Data Needs**	**Analytical Methods and Approaches**
Floodplain and Meander Dynamics	– channel migration patterns; – relationship between human occupation and landform stability; – relationship between extant sloughs and site occupation – relationship between gravels high-energy, over-bank deposits and site occupation; – relationship between Little River flow regime changes and episodes of site occupation and abandonment	– identification of paleosols and ages; – identification of sloughs and ages; – dating of human occupations across floodplain; – quantification of gravel deposits; –identification of changes in mussel shell populations over time	– inspection and description of soil sediment cores; – inspection and description of backhoe trench stratigraphy; – description of cutbank stratigraphy; – size-grading analysis of gravels; – radiocarbon samples; – mussel shell species identification
Paleoenvironmental Reconstructions	– shifts in Blackland Prairie/Oak Woodlands ecotone; – relationships between flow regimes and wet/dry periods; – relationships between floodplain stability and vegetation communities	– mammalian, avian, reptilian and osteichthyes assemblages; – ^{18}O isotope values from archeological and modern control mussel shell of the genus *Quadrula*; – gastropod assemblages; – pelecypod assemblages; – macrobotanical collections	– faunal analysis with emphasis on taxon and genus taxonomic level identification; – extraction of ^{18}O isotope values; – gastropod analysis; – pelecypod analysis; – macrobotanical analysis of charred non-food plant remains
Reconstruction of Subsistence Strategies	– mammalian, reptilian, avian, and osteichthyes species consumed; – species of pelecypods consumed; – principal plant foods consumed; – changes in overall diet breadth; – presence/absence of subsistence stress	– mammalian, avian, reptilian and osteichthyes assemblages; – pelecypod assemblages; – macrobotanical collections of nuts and seeds; – degree of bone processing	– faunal analysis with emphasis on taxon and genus taxonomic level identification; – rank order analysis of prey species by body size; – analysis of species richness over time; – quantification of average maximum green bone size; – macrobotanical analysis of charred nuts and seeds
Activity Area	– relationship between thermal feature morphology and food processing technology as reflected by lipid residues; – relationship between thermal feature morphology and food processing technology as reflected by feature use and artifact distribution patterns; – relationship between feature use and land-use strategies and site function; – relationship between peaks in magnetic sediment susceptibility and analysis units	– fatty acid residues from burned rock samples from rock-lined hearths; – fatty acid residues from burned clay samples from unlined hearths; – feature-centered artifact distribution patterns around rock-lined hearths, identification of contemporaneous surface is critical; – feature-centered artifact distribution patterns around unlined hearths, identification of contemporaneous surface is critical; – 5-cm thick soil column samples	– systematic lipid residue analysis of burned rock and burned clay samples; – analysis of artifact densities and types from excavation units at 1-3 m from features; – magnetic sediment susceptibility analysis to define patterns through the soil column
Technological Organization	– regional, temporal, and technological variability in Pedernales varieties and their relationship to cultural ecotones, and/or idiosyncratic manufacture; – changes in mobility and resource processing requirements through time; – evidence of "gearing up" and production for nonlocal use versus production for immediate tool replacement	– comparative collections of Pedernales points from southern and eastern edges of the Edwards Plateau and the Blackland Prairie; – identification and quantification of formal and expedient tool forms; – identification and quantification of bifaces by stage of reduction; – quantification of ratios of corticate and decorticate debitage; – quantification of ratios of manufacture-failed and use-broken tools	– analysis of Pedernales stem attributes and cluster analysis of data to define varieties; – categorization of tools into functional groups using low power use-wear analysis; – systematic analysis of debitage samples to identify expedient tools; – categorization of bifacial tools into stages of reduction; – sorting of debitage samples into decorticate and corticate groups; – categorization of bifacial tool forms into manufacture and use-broken forms

our understanding of the particular research topics within this research domain are outlined in the table.

The results of our investigation of this particular research domain are discussed in Chapter 8. There we use a variety of data types including sediment cores from across the floodplain, radiocarbon dates from paleosols and cutbanks, and data on gravel densities and size sorting to reconstruct the geomorphic history of the Little River floodplain in the vicinity of 41MM340. These data are combined with radiocarbon dates on the archeological components at the site and at nearby site 41MM341, descriptions of on- and off-site backhoe trench profiles, and changes in freshwater mussel shell species to identify relationships between floodplain dynamics, occupation history, and site preservation.

Paleoenvironmental Reconstruction

The second research domain proposed in the research design (Tomka et al. 2002) focused on paleoenvironmental reconstruction (see Table 4-1). The paleoenvironmental overview presented in Chapter 2 suggested that the roughly 1,000-year period of site occupation was characterized by relatively xeric conditions with an increase in the proportion of grasslands and open grassy patches within woodlands. Decreased ground cover may have, in turn, increased soil loss through erosion and may have led to increased flash flooding as a larger proportion of the precipitation become surface run-off and fed into drainage basins. Although this broad description may fit general trends, it is not known how regional climatic trends may have influenced the Little River drainage and how it may have manifested at the local level on the floodplain adjacent the site. Nonetheless, independent measures of paleoenvironmental conditions at different scales of analysis can provide information regarding on-site conditions (i.e., snails) as well as site proximate settings (i.e., vegetation communities exploited for firewood), and perhaps regional climatic conditions (i.e., mussel shells within Little River; faunal remains).

As outlined in Table 4-1, the research domain focused on reconstruction of paleoenvironmental conditions at both the site and regional levels involves three broad research topics. Specifically, these are related to the investigation of possible shifts in dominance of the Blackland Prairie and Oak Woodlands vegetation, relationships between flow regimes of the Little River and broad wet/dry conditions, and relationships between floodplain stability and vegetation communities. The types of data needed to investigate these research topics include samples of faunal remains, selected samples of mussel shells and snail shells, and feature-specific macrobotanical samples from throughout the deposits (see Table 4-1). These data were consistently recovered from our data recovery work. Analytical methods, also outlined in Table 4-1, were implemented to address this research issue.

In Chapter 9, we use patterns in the species composition of snail and mussel shell samples and faunal remains to reconstruct paleoenvironmental conditions at the time of site occupation. This data is combined with patterns in ^{18}O isotopic values obtained from prehistoric mussel shells of the genus *Quadrula* to infer trends in paleotemperature and/or changes in rainfall seasonality. Note also that, given the initial success with the ^{18}O isotopic results, we added a sample of snail from the genus *Rabdotus* to our analysis. This addition was not specified in the research design, though the results add important information on this research domain.

Reconstruction of Subsistence Strategies

The third research domain outlined in the research design (Tomka et al. 2002) focused on the reconstruction of subsistence strategies at 41MM340. This research domain investigates what floral and faunal resources the inhabitants of 41MM340 exploited over the roughly 1,000-year period of occupation, and how those patterns changed through time.

As outlined in Table 4-1, our research topics involved documenting what plant and animal species were consumed at the site, searching for evidence of subsistence stress, and documenting changes in the overall diet breadth through time. The types of data needed to answer to these questions overlap with those identified for the previous research domain. They include samples of vertebrate faunal remains from throughout the deposit, samples of mussel shells, macrobotanical samples containing charred fragments of nutshells and nuts from throughout the deposits, and information on the degree of bone processing reflected in the deposits. These data were consistently recovered from our work at 41MM340. A series of analytical methods were also outlined in the research design (Table 4-1).

The results of our investigation into this particular research design are outlined in Chapter 10. We use the results of the analysis of animal bone, mussel shells, and macrobotanical samples containing charred fragments of nutshells and nuts from throughout the deposits to reconstruct Late Archaic subsistence strategies. While any such discussion is complicated by factors of differential preservation of both plant and animal remains, and while we lack well-defined middle-range research connecting quantities of recovery to overall importance within the diet, our results do suggest several interesting trends in the recovered subsistence data from 41MM340.

Activity Area Organization

The fourth research domain involved documenting and investigating activity areas in the context of the structure of the site. Analyses of site structure are usually concerned with the use of space and how aspects of site use such as traffic patterns, use intensity, length of occupation, range of activities, maintenance requirements, and the distribution of discard areas conditions the distribution of features, facilities, and artifacts (e.g., Stevenson 1991). The testing and data recovery at 41MM340 resulted in the identification of a number of features, including a large number of burned rock concentrations, as well as cases of charcoal stained areas that had little or no burned rock. We suggested that these two different feature groups should reflect different capacities to dissipate heat (Tomka et al. 2002). These differences in thermal characteristics suggest that the two forms of hearths may have been used to process distinct food items with different cooking requirements (see Ellis 1997; Wandsnider 1997). This observation also implies that the associated activities and activity area maintenance requirements accompanying these two hearth types may have been different. When this information on features is combined with indications, both from testing (Mahoney and Tomka 2001) and data recovery (Mahoney et al. 2002), that a number of different zones of cultural deposits with fine-grained temporal resolution were present at 41MM340, Tomka et al. (2002) argued that several research topics grouped under the activity area research domain could be profitably investigated.

Under the activity area research domain, then, Tomka et al. (2002) outlined four overlapping research topics (Table 4-1). These involved investigating relationships between thermal feature morphology and food processing technology as reflected by lipid residues, the investigation of relationships between feature morphology and food processing technology as reflected by associated artifacts, relationships between feature use, land-use strategies, and site function, and relationships between peaks in magnetic sediment susceptibility values and the definition of analytical units. The types of data needed to answer these questions included samples of burned rock and burned clay from the two principal thermal feature types, the preservation of lipids and interpretable lipid analysis results from these samples, hearth-centered artifact distribution patterns, and several columns of sediment for magnetic susceptibility samples in order to help refine and isolate contemporaneous surfaces identified during the excavation (see Table 4-1).

After reviewing the feature data, the preliminary results from the lipid residue analysis (see Appendix F), the definition of the 15 stratigraphic zones that were identified in the field, and the vertical distribution of cultural material across the site in preparation for this report, it became apparent that the investigation of this research domain would require significant alterations. Foremost among these were changes related to the use of lipid residues. We had hoped that lipid residue, extracted from samples of burned rock and burned clay, would allow us to classify hearths into distinct groups based on the food items processed. Unfortunately, due to a number of possible factors including poor residue preservation, washing of burned rock samples, and low and incomplete residue signatures from burned clay, the residue analysis returned discouraging results. Therefore, residue analysis could not be used to provide an independent gauge of the food items processed in the thermal features identified at 41MM340.

A second set of problems was related to the documentation of contemporaneous surfaces across the site at various depths, as well as the definition of features. As discussed in greater detail at a later point in this chapter, as well as in Chapter 7, we had hoped that the 15 stratigraphic zones defined in the field would serve as analytical zones and, coupled with the magnetic sediment susceptibility results, allow us to identify a series of contemporary surfaces for artifact and feature comparison. It soon became apparent, however, that this hope was misplaced. As outlined in Chapter 7, we were able to identify seven broad zones within the deposits that we can trace across a significant portion of the site. However, these zones were commonly between 10 to 25 cm in thickness, and clearly did not reflect a single occupation surface. In part, this failure to more clearly define surfaces is related to the decision to excavate the site as a series of independent 1-x-1-m units, rather than to strip several of these units as large blocks. The flooding and heavy rains that caused frequent wall collapses further compromised the utility of this “phone booth” strategy for tracing surfaces, as well as for defining features that spanned several units. Given our failure to define potentially contemporary surfaces, comparisons of cultural material from around features across a given analytical zone within the site would be unlikely, in most cases, to accurately reflect relationships between artifacts and features.

Consequently, in Chapter 11, we shift the research topics slightly. First, we focus on changes in the proportions of rock-lined and unlined thermal features and their respective thermal properties to discuss changes in aspects of food processing technology through time as reflected by these changing feature forms. Second, we focus on a single analytical unit (Analytical Unit 6) which appears to have the best potential for spatial comparison. This analytical unit contains the largest number of features identified in a single zone (n=15), and the zone is clearly expressed in most areas of the site. Finally, a single projectile point type, Pedernales, dominates the point assemblage. Spatial comparisons, then, along the lines that we had anticipated to be able to conduct on several of the analytical zones are limited to Zone 6. The results of these analyses, which focused on different artifact, vertebrate fauna, and mussel shell densities for burned rock dominated features, burned clay and charcoal features, and non-feature contexts, suggests differences between feature types and associated material that may be related to feature function.

Technological Organization

The fifth research domain suggested in the research design by Tomka et al. (2002) involved aspects of chipped stone technological organization. Three general research topics were proposed under this domain (Table 4-1). These were an investigation of variability in Pedernales projectile point varieties, an investigation of changes in mobility as reflected in raw material and tool characteristics, and evidence of "gearing up" behavior.

As noted in our discussion of the previous research domain, the temporally diagnostic projectile points recovered from the lower levels of the site (Analytical Unit 6) are almost exclusively Pedernales points, one of the most common projectile types recovered from the Late Archaic I sub-period. A number of Pedernales morphological variants, based primarily on variation in stem morphology, have been defined over the years (Goode 2002; Johnson 2000; Sorrow 1969; Sorrow et al. 1967). Unfortunately, little regional-scale research has followed the definition of these variants and their distribution is poorly documented and understood. The variability in Pedernales points may be indicative of a variety of different processes, the most intriguing of which is that some varieties of Pedernales points, specifically the more straight to slightly contracting stem forms, represent a cultural variant more characteristic of East Texas (Harry Shafer, personal communication 2002). As part of this research topic, we compare collections of Pedernales points from 10 archeological sites from two regional clusters to investigate regional patterns in Pedernales varieties. The two clusters of sites include six sites from the southern Edwards Plateau and four sites from Central Texas.

The second and third research topics focus on how mobility may be monitored by variation in the lithic assemblage and by evidence of "gearing up" at 41MM340 (see Table 4-1). High quality and abundant quantity of raw materials within the Little River gravel bars in the vicinity of the site suggest that raw material was plentiful for the site's craftsmen. However, it is likely that throughout the Late Archaic period, hunter-gatherers were relatively mobile and this mobility would have drawn groups into many areas where either the raw material was not available, or availability was unknown or unpredictable. The high mobility of prehistoric groups, coupled with unpredictable raw material resources, may have conditioned lithic procurement practices (Andrefsky 1994a, 1994b; Bamforth 1990; Newman 1994), tool manufacture strategies (i.e., gearing up, Binford 1979), and tool design (Parry and Kelly 1987; Tomka 2001).

Both formally retouched (i.e., heavily flaked), as well as expedient (i.e., use-retouched) tool forms are present in the collection. While formal unifacial tool forms are uncommon in the collection, the bulk of the expedient tools are scrapers. Parry and Kelly (1987:285) have previously suggested that the manufacture of heavily retouched or formal tools is conditioned by raw material availability, but once raw material availability is not a constraining factor, the more mobile a group is the more likely it will be equipped with formal tool forms; and the less mobile, the more likely that expedient tool forms will dominate its tool assemblages. Tomka (2001), on the other hand, suggests that the tool forms utilized by hunter-gatherers are conditioned not by mobility, per say, but the processing requirements needed to be accomplished with the tools. Either theoretical approach has some interesting implications for interpreting the composition of tool assemblages when considered in terms of ratios of formal versus expedient forms. In the first instance, high proportions of expedient tool forms should suggest a high degree of sedentism, while a high proportion of formal tools would indicate high rates of mobility (i.e., distance and number of moves). In the second instance, high proportions of expedient tools would suggest low scales of processing requirements, while high numbers of formal tool forms would indicate increased processing stress.

While raw materials within the Little River gravel bars are plentiful, it is likely that throughout the Archaic period hunter-gatherers were relatively mobile and the occupants of the site would have resided at 41MM340 only on a seasonal basis. Such mobility would have drawn these groups into many areas where either the raw material was not available, or availability was unknown or unpredictable. The expected high mobility of prehistoric groups, coupled with unpredictable raw material resources, should encourage the manufacture and use of formal tool forms (Parry and Kelly 1987). Based on this scenario and theoretical expectation, we should encounter a high proportion of formal tool forms at the site throughout the various Archaic occupations.

If, on the other hand, the hunter-gatherer groups that occupied the site during the Archaic were highly mobile foragers who relied on daily foraging trips to provision themselves, resource processing activities would have been relatively minimal throughout the entire duration of occupation. Therefore, we should expect that resource processing tool kits should be dominated by informal/ expedient forms given low processing stress and requirements. If the same groups were involved in seasonal bulk resource procurement activities away from 41MM340, gearing up, or the manufacture of replacement tools used off-site in procurement and/or processing activities, would generate some manufacture and repair debris but most finished and formal tools that would be involved in such bulk processing activities would be curated and/or transported to other sites (i.e., kill sites, procurement sites, processing localities).

These theoretical implications are interesting because they provide an opportunity to perhaps relate the tool assemblages recovered from the site to broader off-site phenomena such as overall land-use strategies and the organization of resource procurement. Given these theoretical implications, Tomka et al. (2002) proposed to quantify two related aspects of technological organization in the analysis units of the site: 1) the ratio of functionally equivalent formal versus expedient resource processing tool forms (e.g., knives and scrapers); and 2) the degree of gearing up, if any, represented by tool manufacture activities. Formal tools are those specimens for which either the functional requirements or hafting needs of the tool cause a significant portion of the parent material to be modified or retouched. Expedient tools are those that require very little or no modification prior to hafting and/or use.

Specific data needs for investigating these concerns are outlined in Table 4-1. The results of these analyses are discussed in Chapter 12. In that chapter, we incorporate the analysis results of a 10% sample of the unmodified lithic debitage with the analysis of tool design characteristics to reconstruct lithic procurement and raw material reduction and tool manufacture strategies. To address the issue of Pedernales projectile point varieties, we present the results of analyses of 632 Pedernales projectile points from 10 sites representing a wide geographical range.

New Research Domain

As noted previously in our discussion of the problems encountered with the proposed activity area domain, we added a sixth research domain, the definition of analysis units, to our original list of research topics. This section summarizes the proposed research goals and the data types that were used to address those goals.

Definition of Analytical Units

Test excavations at 41MM340 identified a total of nine principal zones (Mahoney and Tomka 2001:27–35). The zones were identified based on variation in the densities of materials, including burned rock and ecofact assemblages. During the data recovery efforts at the site, Zones 1 and 3 were further subdivided resulting in the identification of a total of 15 stratigraphic zones employed throughout the excavation. These zones varied in thickness and volume and in most cases all zones were not present throughout the entire excavation block. Although the deposits within these 15 zones were excavated in 10-cm thick (or thinner) layers, the identification of contacts between adjacent zones was often difficult and would occur only as the excavators began digging into these zones. In addition, noting and keeping track of differences in artifact densities and types within and between zones was a subjective matter and often depended on communication between the excavator and the person water screening the deposits. All of these logistical concerns were further complicated by the difficult field conditions as a result of extensive rainfall and flooding—profiles often collapsed, material from flooding was frequently redeposited into active units, and deposits were frequently saturated. These factors made clear distinctions between zones difficult. As outlined in the subsequent chapter, the field excavations were designed to follow natural stratigraphic zones. Given the complicating factors listed above, field crews were generally liberal in defining stratigraphic breaks between units, with the rational that should those breaks turn out to be spurious, the material could be combined subsequently.

Following the fieldwork, these field-identified stratigraphic zones were systematically reviewed to create analytical units. This review, presented in Chapter 7, considers the distributions of major artifact categories by zone. This information is combined with patterns in magnetic sediment susceptibility derived from three soil columns from the excavation block. Finally, the distribution of temporally diagnostic artifacts is combined with the radiocarbon dates obtained during testing to define the analysis units and provide age estimates where possible. Ultimately, we define seven analytical units (AUs) from the 15 field identified stratigraphic zones.

Summary

This chapter provided a review of five research domains identified in the research design (Tomka et al. 2002) for the analysis of material collected at 41MM340. These five domains involved investigations into floodplain and meander dynamics, paleoenvironmental reconstructions, subsistence strategies, technological organization, and aspects of site structure. Associated with each domain were a series of research topics, data needs, and analytical methods (see Tomka et al. 2002; Table 4-1). As with most archeological investigations, only some of the proposed research topics were successfully investigated, the focus of several of the research topics were slightly altered, and there were changes in the analytical methods. Details regarding these changes are discussed in the appropriate chapters. In addition, during our analysis of the 41MM340 material it became apparent that the stratigraphic zones identified during excavation were not useful as analytical zones. Consequently, a sixth research domain, centered on the definition of analytical units at the site, was added after the research design was prepared.

Chapter 5: Methodology

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This chapter details the field and laboratory techniques and methods used during the data recovery investigations at 41MM340. The field methods section presents the manner in which data were recovered at the site, while the laboratory methods section describes how those data were processed once they left the field. Aspects of the preparation of the cultural material for the various analysts through final curation are also detailed in the laboratory section.

Field Methodology

As prescribed in the contract between TxDOT and CAR, 56 1-m^2 units were excavated at 41MM340. The fieldwork was conducted between August of 2001 and January of 2002. The field crew varied in size from two to ten individuals throughout the six months of operations, with an average crew size of roughly seven people. The crew worked ten-day sessions throughout the field effort. Both mechanical and manual excavations were used for the current phase of investigations at 41MM340, and their respective methods are described in this chapter.

Figure 5-1 presents an overall layout of the mitigation efforts, along with several elements of the initial testing (see Mahoney and Tomka 2001). The mitigation effort was positioned in the approximate center of the site based on our initial testing at 41MM340. On the southern portion of the site, CAR had previously excavated a single backhoe trench (Trench A) and a 2-x-2-m excavation block (Block 3). On the northwestern edge of the State Highway 36 ROW, CAR excavated backhoe Trench B, and a 2-x-2-m block designated Block 2. Test units within these blocks encountered stratified cultural components apparently related across this portion of the site (see Mahoney and Tomka 2001). Our current mitigation efforts focused in this central area (Figure 5-1).

Mechanical Excavation

The initial mitigation work at 41MM340 consisted of the mechanical re-excavation of backhoe Trenches A and B. These trenches were expanded and extended to intersect (Trenches C and D in Figure 5-1). The trenches were excavated with a Case® 580K backhoe equipped with an Extend-A-Hoe® arm attachment. Each trench was excavated to approximately 1.6 m (5.25 ft), the terminal excavation depth as prescribed by TxDOT.

Consistent with the testing methodology (see Mahoney and Tomka 2001), the upper 40 cm of sediments were scraped away with a backhoe prior to manual excavations (Figure 5-1). Based on our previous testing, these upper sediments lacked prehistoric cultural material. While historic and modern material was certainly present in low quantities in the upper few levels of the manual excavation below 40 cm, the majority of intrusive historic materials and bridge construction-related disturbances were contained within these upper 40 cm. Note, however, that in the southwestern section of the excavation, a low-grade concrete dump was present at 40 cmbs (see Figure 5-1). The concrete mass, which was a maximum of 33 cm in thickness, appeared to have been dumped into a shallow pit. It may be associated with the construction of the bridge.

A settling pond was excavated adjacent to the water screening stations to prevent particulate-laden water from entering nearby wetlands or Little River. In conformance with environmental concerns, silt fencing was erected around the perimeter of the settling pond in order to capture particulate matter suspended in the water in the event of an overflow of the pond due to rainfall. The settling pond measured approximately 10 m wide, 20 m long, and 2 m deep. The pond was excavated off-site immediately south of the site boundary (Figure 5-2).

Occasional maintenance of the pond was necessary to evenly distribute the resultant screened matrix that accumulated below each station. Maintenance consisted of dredging the congested areas and relocating the screened matrix across the pond floor. In consultation with Carla Kartman, TxDOT Environmental Specialist, none of the dredged material was relocated outside of the pond. This practice was deemed necessary to further maintain particulate-laden waters from leaving the worksite. In order to conform to Occupational Safety and Health Administration (OSHA) standards for protection of employees in excavations (29 CFR 1926.652), safety benches were mechanically excavated around the perimeter of the settling pond, backhoe trenches, and excavation block. Each safety bench was excavated to

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Figure 5-1. *Extent of data recovery excavations at 41MM340 (previous testing excavations and backhoe trenches are also shown).*

Figure 5-2. *Water screening stations and settling pond.*

adequate depths to maintain proper slope angles required under these provisions. No significant deposits or features were encountered during excavation of the safety benches.

To address the research domain of floodplain dynamics, ten additional core borings were excavated along the centerline of the current bridge (see Chapter 8). A portable truck-mounted drill rig provided by the Bureau of Economic Geology, The University of Texas at Austin, was used to excavate the cores across the floodplain. Following their excavation, the cores were individually boxed and transported to the Geology Department at Baylor University for analysis.

Manual Excavation

A contiguous 56-m^2 excavation block was established to investigate the stratified cultural deposits. The excavation block extended 9 m grid north and a variable 5–9 m grid east (Figure 5-1). A wall profile for each of the backhoe trenches adjacent to the excavation block was mapped, and the individual strata were outlined with colored string to aid the excavators. Previous work at 41MM340 had shown cultural material to extend to approximately 160 cmbs (see Mahoney and Tomka 2001). With the removal of the upper 40 cm, each unit was excavated about 120 cm. The total volume of sediment removed from the block was roughly 64.6 m^3.

The complex, stratified cultural deposits encountered during NRHP testing of 41MM340 (see Mahoney and Tomka 2001) prescribed careful, stratigraphic excavation efforts. The 56 units contained within the grid block were excavated stratigraphically, according to the zones encountered. Vertical provenience for the excavation was maintained by reference to a series of sub-datums established in active excavation areas. Horizontal provenience was maintained at a 1-m^2 level, though some items were point provenienced.

During our earlier testing efforts at the site, nine zones were identified in each of the two excavation blocks in this portion of the site (see Figure 5-1). These zones had roughly similar radiocarbon dates and artifact content within the two excavation blocks. The mitigation effort was begun with the expectation that these zones were contiguous throughout the central area of Figure 5-1. However, our current efforts at 41MM340 revealed a more complex pattern for the correlation of these original zones. Figures 5-3 and 5-4 present profiles of the east wall of backhoe Trench C (Figure 5-3) and the north wall of backhoe Trench D (Figure 5-4). These were drawn prior to any manual excavation. Note that in Figure 5-3, only seven undulating zones were identified, while in Figure 5-4, nine zones were defined. Furthermore, Zone 2 is not continuous in Figure 5-3, and Zones 1 and 3 merge together in the center of the profile. The delineation of these zones during manual excavation was difficult, a difficulty compounded by rain and, as noted in Chapter 2, floods. Ultimately, excavators identified 15 different zones within the block shown in Figure 5-1. Each zone was defined as a unique provenience, and further delineated by 10-cm arbitrary levels. In a number of cases, the bottom arbitrary level within a zone was less than 10 cm in thickness. Criteria for zone designations were based, in part, on artifact and ecofact densities and content. Communication among the crew was critical in maintaining consistent excavation of the various analysis units across the block. Crew, along with the project archeologist, conferred on the designation of zones and lenses encountered throughout the block. These zones were originally designed to serve as analytical units. However, as outlined in Chapter 7, we ultimately collapsed several of these zones for analysis.

All of the manually excavated soils and sediments were water screened through ¼-inch hardware cloth. Due to the cohesive properties of the clays within this region, it was necessary to use a deflocculating agent to expedite processing of the soils. The addition of various compounds to accelerate processing of clayey soils is common in archeology. Laundry detergents, Calgon®, and other forms of cleaning detergents have all been used with variable results (e.g., Mahoney and Moore 1998). Each of these compounds is classified as a polyelectrolyte that, under certain conditions, acts as an expedient method of deflocculation. However, as the overall process of ion replacement with clays is not completely understood (Grim 1968:212), site-specific trial-by-error approaches are required to determine the most efficient means by which to deflocculate soils for processing. Van Horn and colleagues (1993) successfully employed sodium bicarbonate ($NaHCO_3$) as a catalyst for dissolution of clay in coastal southern California. The compound has also been used with success on dense silty clay in Texas coastal sites (Mahoney and Moore 1998). Chemically, the addition of sodium bicarbonate causes an ion exchange reaction where sodium ions from the additive replace existing ions within the clay. This reaction causes the aggregate bond of the clay to fail and thereby disperses the clay into individual particles. These deflocculated particles remain separated due to their resultant charge. Aside from contributing an additional sodium component to the resultant processed matrix, the use of sodium bicarbonate should have no adverse effect upon the ecology of the surrounding environment (Dennis Neilsen, TxDOT Environmental Quality Specialist, personal communication 2000). Given our previous results at this site, as well as site 41MM341 (Mahoney and Tomka 2001), sodium bicarbonate was again used to deflocculate the soils for water screening at 41MM340.

The excavated matrix from each provenience was placed in five-gallon buckets to roughly three-quarters full. A standard 1-m^2, 10-cm level of blocky clayey soils typically yields 11 five-gallon buckets filled three-quarters full of sediments. Previous experience suggested that roughly 1 lb (454 g) of sodium bicarbonate was required per five-gallon bucket. Adequate water to cover the mixture was added, and the material was allowed to soak in the five-gallon bucket for at least 45 minutes prior to water screening. During the soaking process, the mixture was stirred once or twice to expose a greater surface area to the aqueous mixture. The resultant deflocculated material flowed through the ¼-inch screens much more easily than otherwise would have been possible. We estimate that roughly 7,400 pounds of baking soda were used to deflocculate the excavated sediments.

Water was supplied for the processing stations by a 2,000-gallon tanker truck. On average, approximately 1,500 gallons of water was used per day of excavation. Water was removed from the tanker via a 5-hp engine with a water pump attachment and a 2½-inch inlet hose. Water was then diverted to each individual station by means of a ¾-inch typical garden hose with a cut-off spray nozzle attached.

Due to the abundant rains encountered throughout the course of the field efforts, ingress and egress of the large tanker was not always possible. As such, it became necessary to seek alternate means of a water source for screening activities. Pumping water from the Little River was not feasible due to its distance of approximately 500 m from the screening stations. Nearby sloughs proved an unreliable source of water, as they quickly dried following even a brief cessation of the rains. However, we were able to circulate water from the sediment pond with the addition of fine-screen intake filters on the water pumps.

All cultural material recovered from a given provenience was assigned a single field sack number. These materials were generally recovered during screening and consist of the categories of burned rock, mussel shell, snail shell, debitage, and gravel. A variety of more specific samples

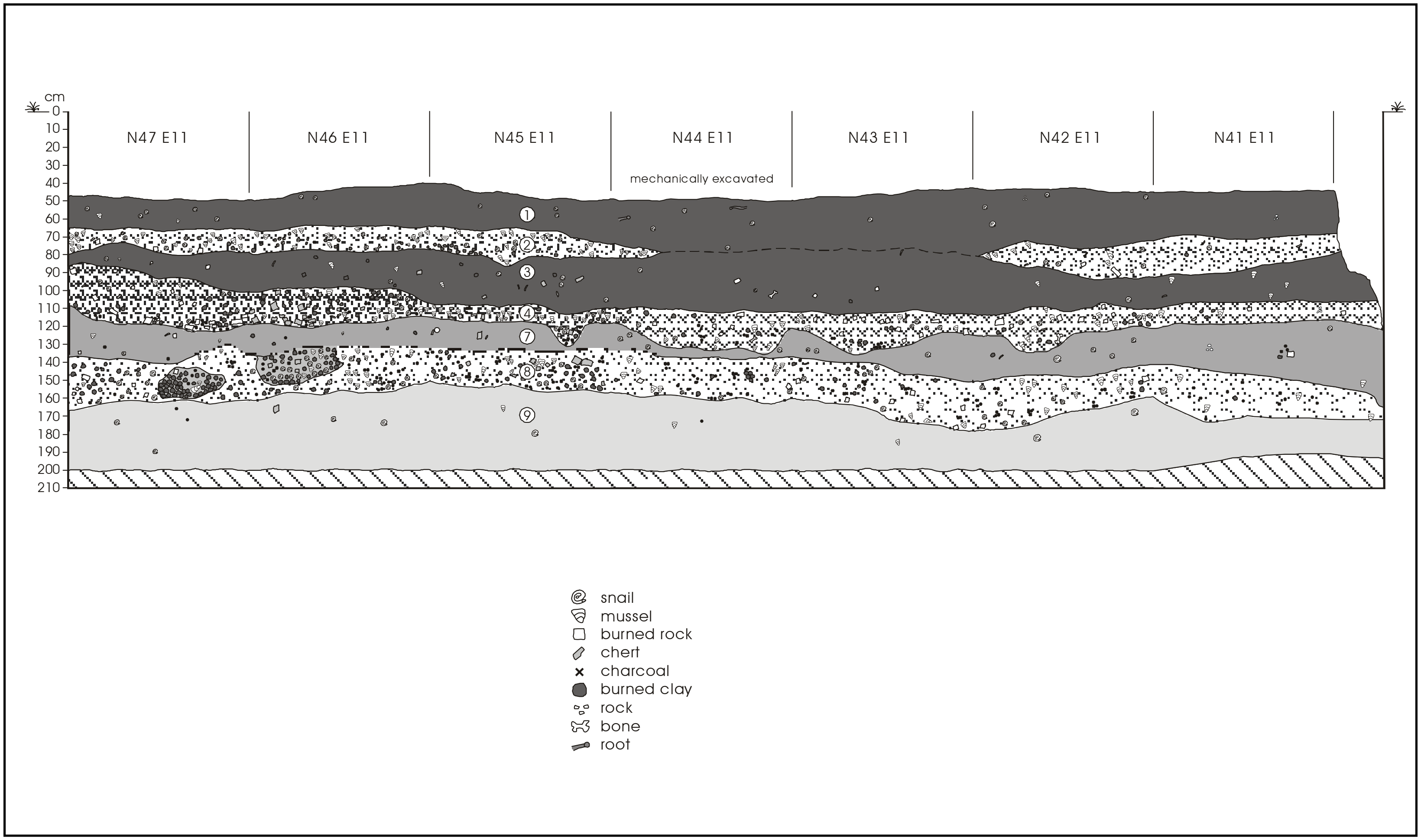


Figure 5-3. *Profile of east wall of BHT C, 41MM340.*

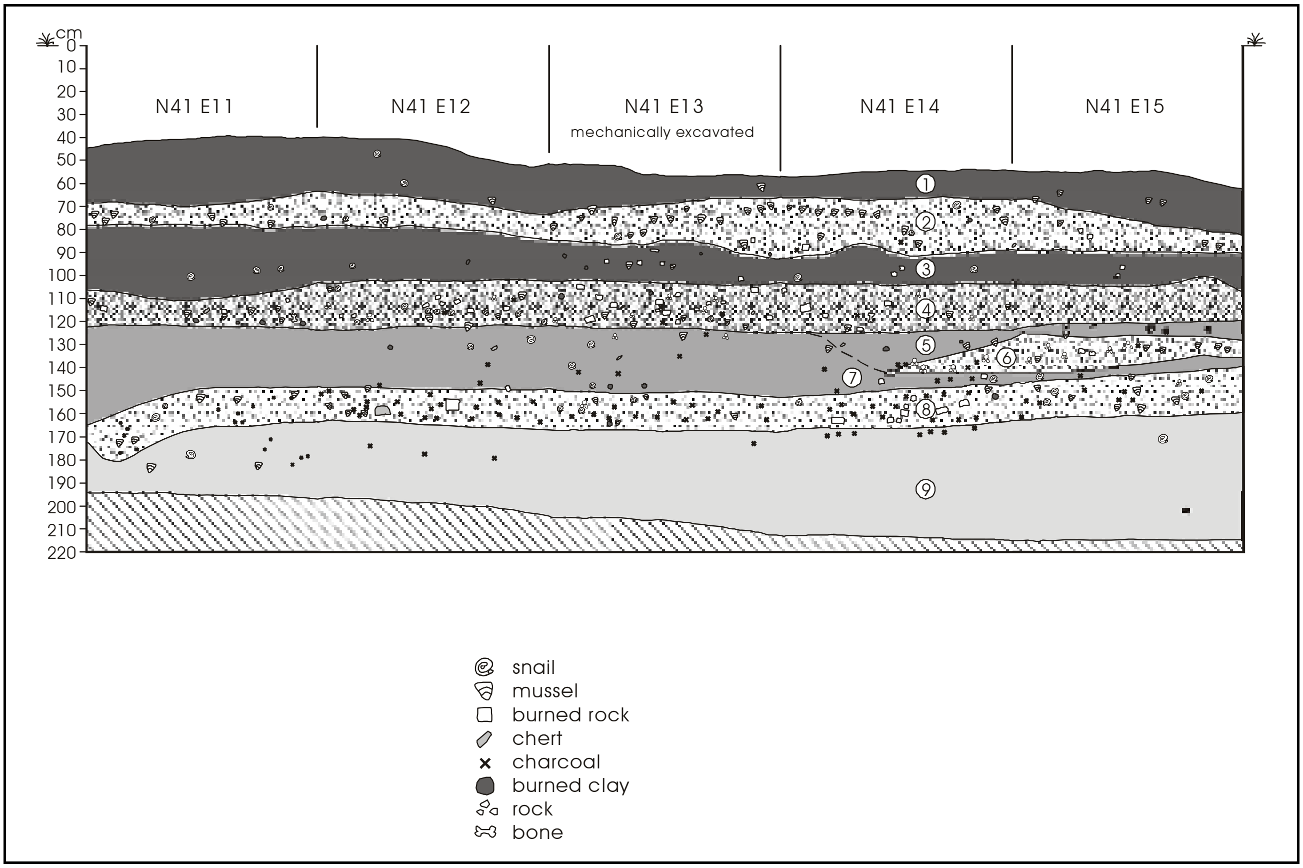


Figure 5-4. *Profile of north wall of BHT D, 41MM340.*

(e.g., soil samples, radiocarbon samples) were collected and assigned numbers for tracking purposes. Results and observations on all excavations were recorded on unique forms. Manual excavations resulted in the production of a number of different forms, including unit/level forms, feature forms, field sack logs, feature logs, wall profile maps, and plan view maps.

As discussed in Chapter 2, two major flooding events occurred during our work at 41MM340. In addition to the flooding, rainfall was frequent during most 10-day sessions often resulting in standing water and saturated sediments. While every effort was made to protect the excavation area with tarps, earthen berms, drainage cuts, and wood shoring of profiles, these events often resulted in significant damage to the site. The damage included the collapse of several profiles, losses of individual sub-datums, and the deposition of sediment onto active excavation areas. A significant component of field time was devoted to developing protective measures for the excavation, as well as cleaning up after significant floods or heavy rains (Figure 5-5).

The collapse of profiles, in combination with the fluctuating nature of the zones, made estimates of the volume of earth removed from a given unit difficult. Volumetric estimates were, therefore, based on the number of buckets of sediment removed from a given excavation level. While the number of buckets of sediment removed from a 100-liter (10 cm x 1 m x 1 m) level varied, in part, as a function of moisture content in the soil, a 10-cm level of blocky clayey soils typically yielded 11 five-gallon buckets filled three-quarters full of sediments. For purposes of determining sediment volume, then, each three-quarters full bucket was estimated to contain 9.09 liters of sediment in this setting.

Laboratory Methodology

Cultural materials recovered from the excavations at site 41MM340 were submitted to the CAR laboratory following each 10-day session for processing that included washing, sorting, and cataloging. All artifact field sacks were cross-checked against the field log and sorted by provenience.

Figure 5-5. *Excavation block at 41MM340 after a heavy rainfall.*

Photocopies of all original field forms including the feature log, the field sack log, and unit excavation forms were made after each session and kept in a secure location in the CAR laboratory.

Washing

Two methods of cleaning the artifacts were utilized, hand washing and machine washing. Hand washing was used on all diagnostic lithic and bone tools. The remaining artifacts were washed using a standard electric dishwasher. Charcoal, burned clay and special sample materials were not washed. The hand-washed artifacts were washed in tap water, and a soft bristle toothbrush was used when necessary. The artifacts were then placed on drying racks and left to air-dry. Artifacts that were to be cleaned in the dishwasher were first placed into mesh bags and soaked in a solution of tap water and sodium bicarbonate for half an hour to an hour. Some artifacts remained in this solution overnight, depending on how much soil had adhered to the artifacts. After soaking, the artifact mesh bags were gently agitated in the soaking mixture to loosen any adhering dirt and then placed into the dishwasher. Some of the artifacts washed in the dishwasher went through two or more washing cycles based on how much dirt remained after each wash. Sodium bicarbonate was also added to the washing cycles of the dishwasher when deemed necessary.

Initially, mussel and snail shell were removed from the general collection bags of artifacts to avoid being damaged from heavier materials in the bags. However, it was later determined that neither the weight of the artifacts nor the dishwasher cycle would damage them. Consequently, mussel and snail shell were not separated out of the bags prior to washing for the remainder of the project. Note also that burned rock was included in the above cleaning procedure. Subsequently, Malainey (personal communication 2002) suggests that the exposure of burned rock to sodium bicarbonate may act as a detergent and remove lipid residues from the burned rock. However, comparison of residue results from washed burned rock with those from unwashed burned rock, the latter collected from sediment samples, do not support this suggestion (see Appendix F).

Sorting and Initial Processing

After the artifacts were washed they were sorted according to their analytical classes and separated by their corresponding unit and level in preparation for cataloging. During the sorting process, lithic debitage and burned rock were counted, but not weighed. Organic materials such as charcoal and burned nutshell were weighed and faunal material such as mussel umbos and bone were counted and weighed. Samples of burned clay, mussel shell fragments and snail shell were only weighed. The gravel assemblages from selected proveniences were weighed, counted, and sorted by size. The size categories used during the sorting process were ¼, ½, 1, and 2-inch metal screens.

All flotation was done at CAR. Each flotation sample was carefully measured to the maximum volume of matrix and poured into a five-gallon bucket that was three-quarters full of water. A wooden stake was used to help stir the matrix for about 30 seconds. The mixture was then allowed to sit for a minute. This process was repeated several times to completely break up all the sediments. Once this was done, most of the water was poured onto a metal geologic sieve covered with a piece of cheesecloth. This light fraction was then dried. The remaining sediments were poured onto a ¼-inch geologic metal sieve to produce a heavy fraction. After each sample was processed, the bucket and wooden stake were washed to avoid contamination of other samples. Soil samples from features received the same lot number as the general collection of artifacts, but a different catalog number was assigned. Not all soil samples collected were floated. Soil samples that were floated were taken from the deepest level of a feature. A maximum of 1.5 liters of matrix was floated and separated by light and heavy fractions. All feature flotation samples were re-bagged and tagged with their proper provenience and sent to Phil Dering at Texas A&M University for further analysis (see Appendix E).

The Artifact Catalog, Catalog Database, and Analytical Protocol

After the artifacts were sorted, counted, and/or weighed, an artifact catalog was generated. The artifact catalog included provenience data along with the count and/or weight for each entry. As each provenience was entered into the catalog it was assigned a lot number. Each artifact class, as well as each unique item, such as a projectile point or bone tool within a particular unit and level, received a unique three-digit number in addition to the lot number—forming a catalog number. Mussel umbos and mussel shell fragments were given separate catalog numbers to facilitate data retrieval. All point-provenienced artifacts received their own lot numbers.

The artifact catalog was initially entered into a Microsoft® Excel spreadsheet and later imported into Microsoft® Access. A quality control check was preformed on the entries to catch and correct all inconsistencies with data entry and typographical errors. Provenience errors were caught by manually checking each entry against the unit level form, the field sack log, and the feature forms.

After cataloging and error checking, analysis was performed. For several data types (e.g., projectile points, bifaces) all items were analyzed. Because of the quantities present in other data sets (e.g., lithic debitage, mussel shell, snail shell) some form of sampling was employed dependent on the analytical goals. The analysis of chipped stone debitage, lithic tools, faunal material, and the magnetic susceptibility testing was conducted at CAR. All other analyses were either conducted exclusively by consultants or were conducted by CAR in conjunction with consultants. Details of these analyses can be found in the various appendices of this document or in the appropriate chapters.

Overall, 802 separate levels were excavated at 41MM340 and transported to the laboratory for processing. Note that 18 individual level samples were lost either during the field or lab efforts or had significant data missing. Overall, then, 2.2% of the excavated levels were compromised. The remaining 784 levels produced a variety of data types with known proveniences. These included the recovery of 47,928 pieces of unmodified debitage, 233,837 pieces of burned rock, 261.33 kg of mussel shell, 25.36 kg of snail shell, 5.58 kg of bone, and numerous sediment, charcoal, and burned clay samples.

Curation Preparation

Once the fieldwork was completed, all original field forms were returned to the laboratory for curation. All unit/level and feature forms, and any additional field forms, were placed in archivally stable folders. Lab-generated forms were housed in six three-ring binders until transfer to archival folders for final curation. All photos, slides, and negatives were also placed in plastic archival sheet protectors with the corresponding provenience written on the back of each photo and slide. Labeling of the artifacts for final curation consisted of writing the site trinomial and catalog number on a base 25% solution of B-72 in acetone. All labeling was done with a pigma ink pen and a top coat of B-72 was applied. All lithic and bone tools as well as unique items were labeled. Due to the large assemblage of debitage, only a 25% sample of the larger items (greater than approximately 2.5 cm in size) was labeled.

Subsequent to proper analyses and/or quantification and in consultation with THC and TxDOT, artifacts possessing little scientific value were discarded pursuant to Chapter 26.27(g)(2) of the Texas Administrative Code. Artifact classes discarded specific to this project include burned rock, snail shell, mussel shell fragments, unidentifiable metal, soil samples, and recent (post-1950) materials. In the case of prehistoric materials (i.e., burned rock), items recovered from *in situ* feature contexts were sub-sampled prior to disposal. Prior to discard, however, consultation was sought with THC and TxDOT archeologists regarding the specific discard and sampling strategies proposed. Once a proposed strategy was agreed upon by all parties involved, materials were discarded in a manner consistent with suitable disposal procedures. In all instances, however, discarded materials were documented and their counts included in this report and curation documentation.

In conclusion, all laboratory and curation procedures followed for processing, washing, sorting and cataloging artifacts and records meet CAR's curatorial standards. Each artifact was bagged in a 4-mil polyethylene re-closeable bag along with an acid-free final curation tag that provides all specific provenience as to location, depth, count, analytical class, and in some instances, artifact descriptions. In some cases, such as organic samples or materials that will continue to degrade, the specimen was double-bagged with the curation tag placed between the bags. In addition to the original lab tag, a final curation tag was placed into all bags. All records were placed in archivally stable, acid-free folders and sorted accordingly to type and unit. All original field forms with adhering dirt or staining were placed in sheet protectors. Each class of artifacts was boxed together. Every box was labeled with standard accession information including intra-site provenience, class of material, collection ownership, and permanent location within the CAR repository. The electronic database has been placed on a CD-ROM and is curated with the records. All records and artifacts will have permanent housing at CAR.

Chapter 6: Recovered Data

Richard B. Mahoney, Steve A. Tomka, and Raymond P. Mauldin

The methodology and excavation strategy outlined in the previous chapter resulted in the collection of a variety of different types of data, including several different artifact classes and feature types at 41MM340. The principal artifact data types obtained from the site include chipped and ground/battered stone artifacts, burned rock, and burned clay. Other artifact classes recovered include vertebrate faunal remains, mussel shells, and nut/seed samples. Additionally, snail shells, charcoal, soil samples and sediment cores were collected. Forty-nine features—45 of which were recorded during data recovery—were identified in this central area of the site. The data recovery features include two principal types. The most commonly defined feature type (n=26) consisted of clusters of burned rock. Sometimes these were associated with charcoal, stained soil, and burned clay, and in several cases a pit outline could be identified. The other common feature type (n=18) was characterized by staining with charcoal and, frequently, burned clay. While in some cases fire-cracked rock was also present in these features, the amount of rock was minimal. The final feature type identified was a single bone concentration. The following sections provide summaries of the quantities of the various artifactual and ecofactual data recovered at 41MM340. These are followed by a summary of the feature types. More detailed descriptions of individual features can be found in Appendix J.

Chipped Stone Artifacts

Over 58,000 chipped stone artifacts were recovered from the testing and data recovery investigations conducted at 41MM340, unmodified debitage comprises over 99% of the assemblage. One hundred and eleven cores, 109 projectile points, and 383 non-projectile point chipped stone tools were also recovered. A range of functional tool categories have been identified within these chipped stone artifacts, including 196 expedient scrapers, 19 minimally retouched scrapers, 120 miscellaneous bifaces, eight miscellaneous unifaces, nine artifacts classified as choppers, two wedges, 24 celts (Erath bifaces), a Perkin Pike, a knife, an adze, and two awls.

Projectile Points

The projectile point assemblage (n=109) recovered during the two phases of work at 41MM340 consists exclusively of dart points. Ninety-eight points (90%) came from data recovery and eleven (10%) were collected during testing. Typological descriptions are based on guides provided by Turner and Hester (1999) and Suhm et al. (1954), and Drs. Shafer and Tomka made the typological assignments. Note that several of the points recovered during testing (see Mahoney and Tomka 2001) have been retyped for the present report. Overall, 61 (56%) of the points recovered from CAR's work at 41MM340 could be assigned to an established type, 31 (28.4%) are untypable fragments, and 17 (15.6%) are untyped specimens.

Darl (n=1; Figure 6-1a)

The single complete Darl point (cat. no. 692) has an expanding stem, straight base, and alternately right beveled blade edges. The specimen is proportionally wider than the archetype form (Suhm et al. 1954:414, 415), but otherwise falls into the marginal ranges for the type.

Edgewood (n=1; Figure 6-1b)

This complete specimen (cat. no. 1872) has an expanding stem and straight base. The short, thick triangular blade is extensively reworked and the shoulders are weakly barbed.

Ensor (n=1; not shown)

One proximal fragment (cat. no. 2592-8) has deep side notches and loosely falls into the Ensor type. The blade was broken by impact.

Gary (n=6; Figure 6-1c through 6-1e)

Points with contracting stems with rounded bases characterize this group. Of the six Gary points, four are from data recovery. The stem on specimen 567-001 (Figure 6-1e) is slightly smoothed, an unusual feature for Gary points. Two of the points are complete and two are proximal fragments. The blade of one of the specimens has been substantially reworked and its stem exhibits specks of dark brown residue that may represent traces of mastic, possibly asphaltum (Figure 6-1c).

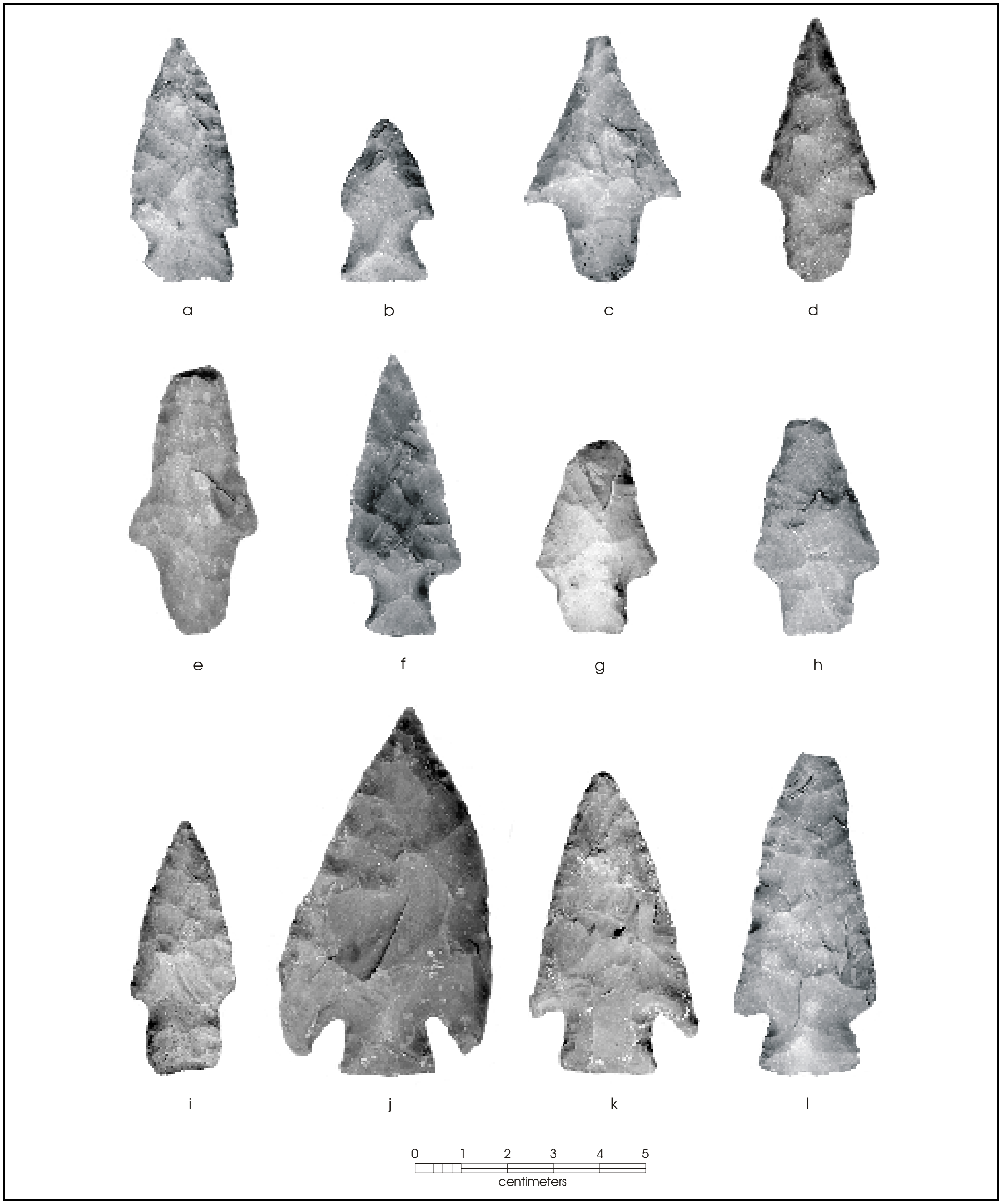


Figure 6-1. *Typed projectile points recovered from 41MM340.* a) Darl; b) Edgewood; c-e) Gary; f) Godley; g-i) Kent; j-l) Marcos.

Godley (n=1; Figure 6-1f)

Broad, shallow corner notches, an expanding stem and convex base identify this point (cat. no. 2289) as Godley. The specimen is complete.

Kent (n=7; Figure 6-1g through 6-1i)

Two of the Kent points are from testing while the others are from data recovery excavations. Kent points have approximately parallel stems and straight, or slightly concave or convex bases, squared shoulders, and triangular blades. They are generally short, with narrow stems and thick blades. Kent points are part of a series of Late Archaic-Early Woodland dart points that occur across southeast Texas and beyond. The five Kent points from data recovery are made of locally available fine-grained chert. Three of the specimens are proximal fragments (Figures 6-1g and 6-1h), while the other two are complete specimens (Figure 6-1i).

Marcos (n=15; Figure 6-1j through 6-1l)

One of the Marcos specimens is from testing while the others are from data recovery. Of the 14 specimens obtained during data recovery, seven are complete, six are proximal fragments, and one is a stem fragment. One specimen (cat. no. 937; Figure 6-1j) is a late reduction stage manufacture failure that was aborted due to a deep hinge fracture during final thinning. Specimens 1756 and 1461-002 exhibit impact fractures, while three others display reworked blades.

Marshall (n=7; Figure 6-2a and 6-2b)

Six of the seven Marshall points are from data recovery. Five of these six specimens are complete. The remaining specimen from data recovery is a proximal fragment. The blade on one specimen (cat. no. 577) has been resharpened.

Pedernales (n=20; Figure 6-2c through 6-2h)

Pedernales constitutes the largest single type group in the sample, and is one of the more interesting in terms of stylistic variability. The morphological consistency within the sample varies but one characteristic holds the group together; contracting stems and broad blades often with barbed shoulders (cat. no. 428; Figure 6-2d) characterize the variant of Pedernales present at 41MM340. Nonetheless, some specimens have narrow blades (e.g., cat. nos. 556 and 2520) that are sometimes recurved (e.g., cat. nos. 1860 [Figure 6-2e], 1894 [Figure 6-2f], and 1859). Three of the specimens are late stage preforms (cat. nos. 1859, 1861, and 2014); two have reworked blades suggestive of field maintenance (cat. nos. 1894 and 2520 [Figure 6-2g]); two exhibit impact fractures (cat. nos. 2506 [Figure 6-2h] and 2281-007); and three are stem fragments that have either end-shock or snapped fractures suggesting breaks within the haft element. Attributes observed on the Pedernales sample indicate the point type was made at the site (as shown by the presence of late stage preforms) and used there (as evidenced by in-field resharpening and maintenance and impact fractures).

Woden (n=1; Figure 6-2i)

This complete point (cat. no. 414) has a narrow, parallel stem and a faceted, unworked base; a feature that distinguishes the type (Jelks 1965). The thick point is of silicified wood, a material that occurs in small quantities in Little River gravels as well as in some upland gravel deposits.

Yarbrough (n=1; Figure 6-2j)

This point (cat. no. 721) has a parallel stem and straight base, and weak shoulders. The thick blade has been considerably reworked. Black mastic, probably asphaltum, adheres to the stem.

Untyped (n=17; Figure 6-3a through 6-3j)

Seventeen projectile points are sufficiently complete for typological assignment but could not be classified to any of the existing point types due to lack of morphological similarity. Fourteen of the specimens are from data recovery.

Two are so extensively retooled that the original form cannot be determined (cat. nos. 993 and 2511 [Figure 6-3i]). Two have parallel-sided stems, moderate shoulders, and triangular blades (cat. nos. 1278 [Figure 6-3d] and 294-001). One stem edge is beveled on each, giving them an appearance of Nolan, but clearly neither fit that type. They probably belong to the Kent series. Specimens 2435 and 1696 are late stage preforms with unfinished bases. Specimen 625 (Figure 6-3f) has a Darl-like stem, but the blade lacks the fine pressure retouch characteristic of the type. Black mastic, probably asphaltum, adheres to the stem of 2511 (Figure 6-3i). The material of 2188 (Figure 6-3a) is blue-gray Georgetown chert, a material that is non-local to the lower Little River valley. While some of the chert in the local gravels is derived from the Georgetown and similar outcrops, it loses the gray hues through chemical changes during stream transport (McGinley 1978) and takes on pinkish, tan, and brown hues. The material of specimen 2148, which possibly belongs to the Pedernales group, is silicified wood (Figure 6-3e). What is interesting about this point is that the blade and stem morphology is similar to the local variant of Pedernales, but because of the cleavage planes, the base could not be indented.

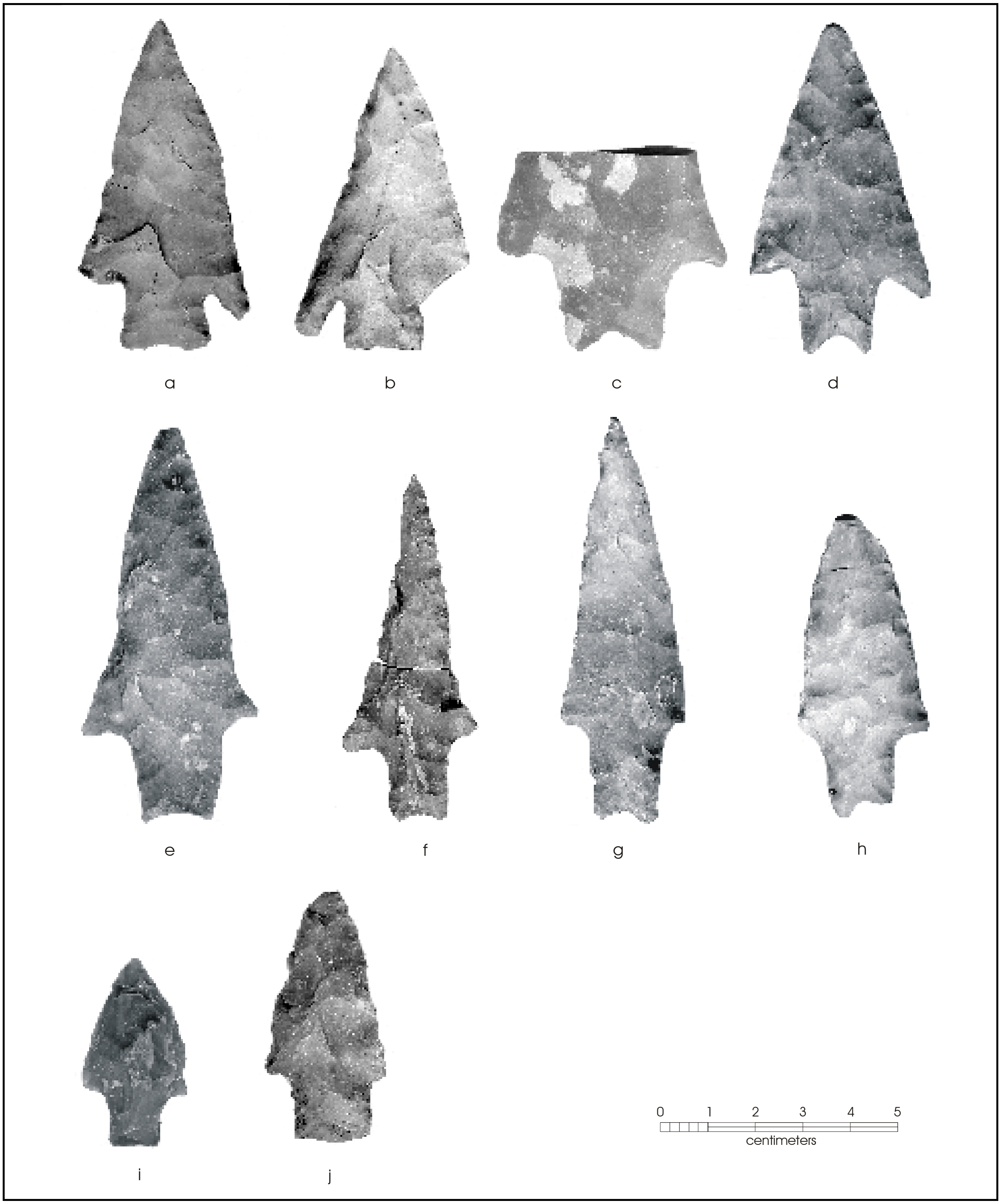


Figure 6-2. *Additional typed projectile points recovered from 41MM340.* a-b) Marshall; c-h) Pedernales; i) Woden; j) Yarbrough.

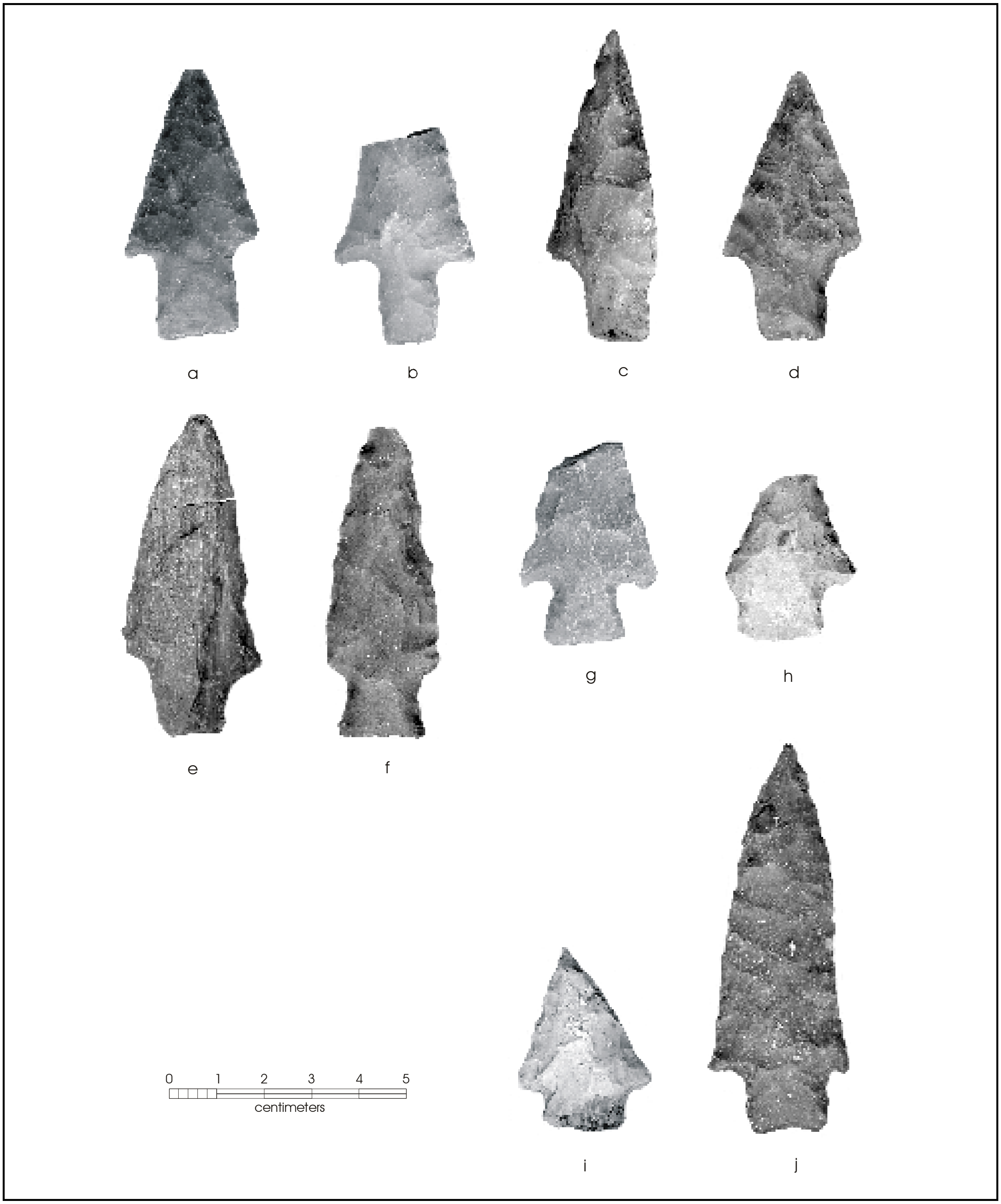


Figure 6-3. *Untyped projectile points recovered from 41MM340.*

Untypable (n=31)

These artifacts are dart point fragments that lack attributes that would allow for more confident classification. They include fragments of barbs, small stem fragments, and blades that retain only a hint of having been notched.

Other Chipped Stone Tools, Cores, and Debitage

Celts (n=24; Figure 6-4a through 6-4c)

Twenty-four bifacially flaked artifacts are classified as celts and celt fragments. Twenty of these are from data recovery. These 24 specimens fit the morphology of Erath bifaces first described by Story and Shafer (1965). These artifacts are sporadically reported across the Blackland Prairie (Bond 1978) and in the central Brazos valley (Roemer and Carlson 1987).

Erath bifaces range from small to relatively large teardrop-shaped bifacially flaked celts. The distal end is the broad end and the bit edges are characteristically convex and bifacially trimmed to an angle of approximately 70 degrees. The bifacial treatment of the bit is more consistent with axe use rather than adze use. The working edge is designed to be in the center of the longitudinal cross-section rather than favoring one face as is common among adzes. The working edges retain minute crushing and smoothing along the edge, consistent with axe wear. The lateral edges are often deliberately dulled by edge grinding, while the proximal end shows little or no alteration. Hafting is indicated by grinding on the lateral edges and rare traces of surface polish on flake scar ridges of the body in the vicinity of the proximal end. Breakage patterns also indicate hafting, as breaks occur in predominately three places: at the proximal one-third at the haft, at about mid point in the blade, and at about the distal one-third (Shafer 1994). Microscopic use-wear suggests use against material sufficiently soft to allow some bit penetration, but hard enough to create some micro-chipping along the bit edge. In terms of general function, use-wear suggests woodworking.

Following projectile points, celts were the most common formal tool recovered at 41MM340. The small collection contains both manufacture-failed and use-failed specimens indicating that at least some of the tools made or brought to the site were also used on site. Of the 20 specimens from data recovery, only four are complete. Three of the four are thick bifaces that retain stacked areas that could not be thinned during manufacture. Lacking use wear, these specimens do not appear to have reached the finished tool form. The fourth complete celt may represent an exhausted specimen. Two additional distal fragments and a proximal fragment appear to have been broken in manufacture, judging from their irregular thick shapes, ill-formed working edges, and perverse break morphologies. In total, then, six specimens represent manufacture-failed discards. Three additional specimens were broken during excavation and their original state at the time of discard cannot be determined. The remaining ten specimens, consisting of six distal fragments and four proximal ends, were broken in use. At least in one case (cat. no. 1354-001), use failure was precipitated by an embedded fracture line near the distal end of the tool. Use failures appear to have been caused by a combination of impact on the tool and transverse torque placed on the distal end of the tool. Use of the tools must have required considerable force as several exhibited impact breaks either on the unhafted portion of the blade or in the haft itself.

Adze (n=1; Figure 6-4d)

A single distal fragment appears to represent an adze (cat. no. 2070). While the working edge is somewhat convex, beveling has resulted in the edge being located much closer to the ventral face of the tool than its center, as in the case of the celts. The break morphology suggests that the tool failed in use. Although it represents a single specimen, the adze indicates that in addition to the felling of woody vegetation, some degree of woodworking may have occurred while the inhabitants occupied the site.

Awls (n=2; Figure 6-4e)

Two specimens are classified as awls since neither shows evidence of a rotating type of wear consistent with drills. One is a blade fragment (cat. no. 2351-007) and the other is complete, and represents a recycled projectile point (cat. no. 1465). The stem of the point has been extensively reflaked making it impossible to determine the original type.

Choppers (n=9; Figure 6-5a and 6-5b)

These tools are small cobbles that exhibit bifacially chipped and battered edges or ends. They are classified as choppers because heavy step fracturing, and in some instances rounding, suggests they were systematically and repeatedly struck against something relatively hard. There is a substantial range in the weights (112.7 to 473.5 g) of these specimens, and several have more than one heavily step-fractured/rounded edge. Interestingly, some rejuvenation of these heavily step-fractured and rounded edges appears to

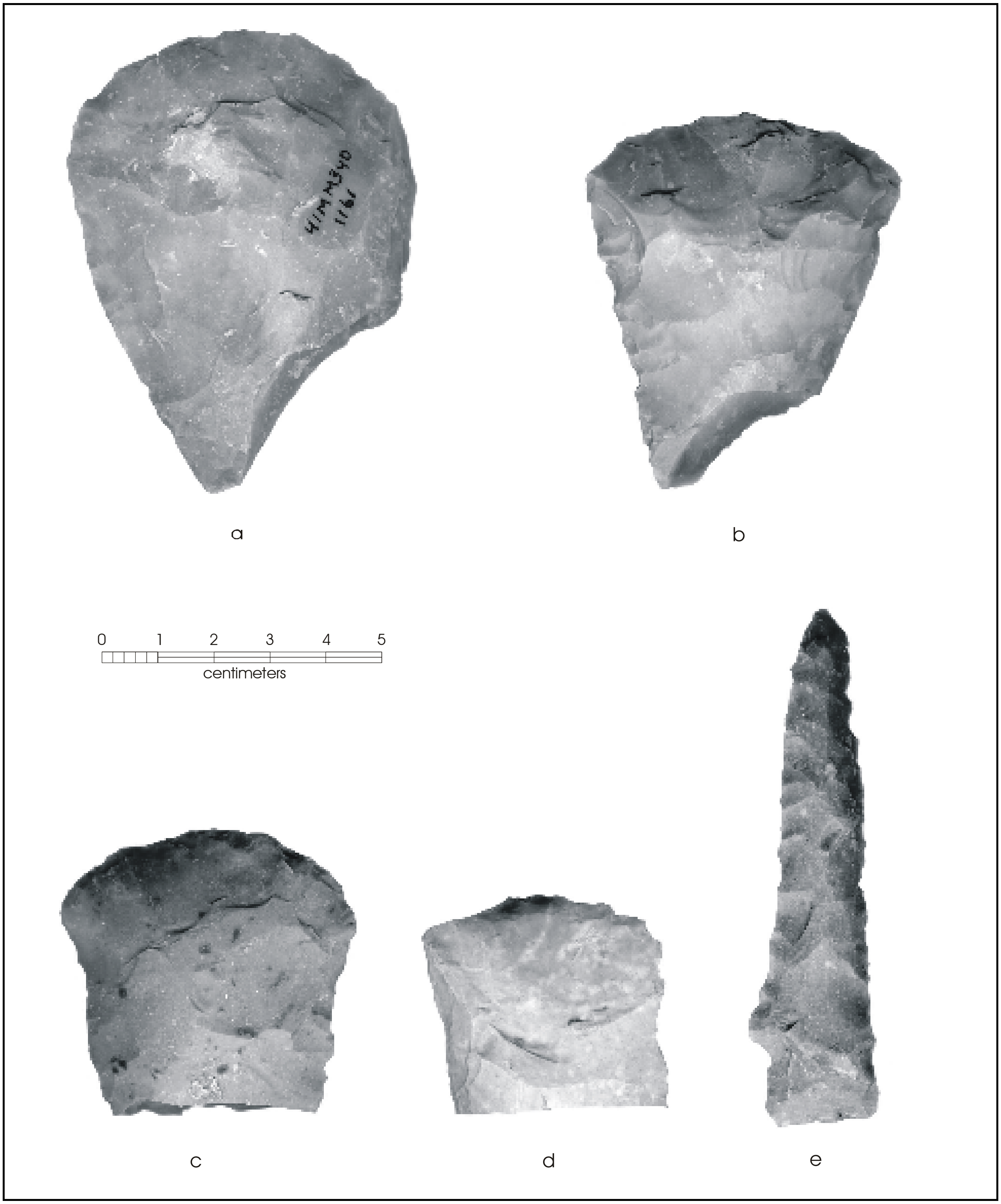


Figure 6-4. *Chipped stone tools recovered from 41MM340.* a-c) Erath celts; d) adze; e) awl.

have been necessary judging from the encounter of quite a number of unmodified flakes containing remnants of these crushed working edges on their dorsal faces.

Wedges (n=2; Figure 6-5c and 6-5d)

Two wedges, one recovered during testing (cat. no. 206-2) and the other during data recovery (cat. no. 1346) have been identified. The smaller of the two is missing a portion of its working edge while its proximal end is cortex-backed. The larger of the specimens (cat. no. 1346) is also cortex backed but its working edge is unifacially manufactured and it is straight rather than pointed. The larger specimen weighs 240.1 g, more than twice as much as the smaller specimen, although weight may not be critical to the proper functioning of wedges.

Perkin Pike (n=1; Figure 6-5e)

This unusual tool (cat. no. 1363) is a pointed, early reduction stage biface made from a thick elongated cobble. The specimen is similar in form to other specimens identified as Perkin Pikes in east Texas lithic assemblages (Jelks 1965: 175, 176). One end is retouched to a point, while the other has two flake scars that removed the cortex backing that is normally found on these specimens. Distal polish is noted at the tip and about 2 mm from the tip along one edge, and no obvious signs of battering are noted on the proximal end.

Knife (n=1; Figure 6-5f)

The single knife specimen (cat. no. 2592-4) has substantial shaping and resharpening. This knife is a long, narrow biface with evidence of retouch and some high gloss polish along both lateral edges. Technology and edge-wear is comparable to that seen on corner-tang or base-tang knives of the Late Archaic in the central Brazos basin in Texas, and unstemmed knives in the upper Brazos River valley (Gallagher and Bearden 1976).

Scrapers (n=215)

Two hundred and fifteen tools and tool fragments were categorized as scrapers. They can be divided into two classes, expedient specimens consisting of unmodified flake blanks, and minimally retouched tools, a group that consists of flakes that have been marginally retouched to create or shape the working edge. One hundred and eighty-one scrapers represent expedient tools with one or more working edge. Nineteen specimens fall into the minimally retouched scraper group. The 15 remaining specimens have at least one expedient and one minimally retouched working edge.

Miscellaneous Bifaces (n=120)

A total of 120 miscellaneous bifacially flaked artifacts in various stages of reduction was recovered during the excavations at 41MM340. The majority (n=101) of these specimens were found during data recovery investigations, with only 19 derived from testing. Most of the miscellaneous bifaces consist of specimens that failed before their manufacture reached a functional form. In addition, a small number of bifaces most likely represent the distal fragments of projectile points broken either in manufacture or during use. Because these specimens cannot be identified as fragments of projectile points, they are classified as miscellaneous bifaces.

Miscellaneous Unifaces (n=8)

Eight unifacially flaked artifacts are included in this category. These specimens are fragments that are simply too small to categorize into functional groups with any degree of certainty. Six of the eight have only small sections of unifacial retouch along their edges and may represent specimens discarded prior to the final stages of the manufacture process. The final two specimens represent fragments of unifacial tools with systematically flaked working edges. Unfortunately, the working edges are too small to allow the confident classification of these specimens as either scrapers or knives, or other functional categories.

Cores (n=111)

All of the cores identified in the collection are from data recovery. Multi-directional cores represent the highest number (n=64; 58%), followed by uni-directional (n=27; 24%), and bi-directional (n=17; 15%) specimens. Opposed bi-directional (n=2) and blade cores (n=1) are rare in the collection. The cores range from a minimum of 32.6 mm to a maximum of 102.6 mm in maximum dimension. Raw material size does not appear to be a limiting factor to most of the chipped lithic artifacts manufactured at 41MM340. The mean size of the maximum dimension of the cores is 61.5 mm (s.d.=13.7). The number of scars present on the cores ranges from a minimum of one to a maximum of 24, with a mean of 7.1 scars (s.d.=4.4).

Unmodified Debitage (n=57,599)

A large quantity of lithic debitage was recovered during the two phases of work at the site. The bulk of this material (n=48,072; 83%) comes from data recovery, while the remaining portion (n=9,527; 17%) is from the testing efforts conducted at the site. As noted in the previous chapter, some

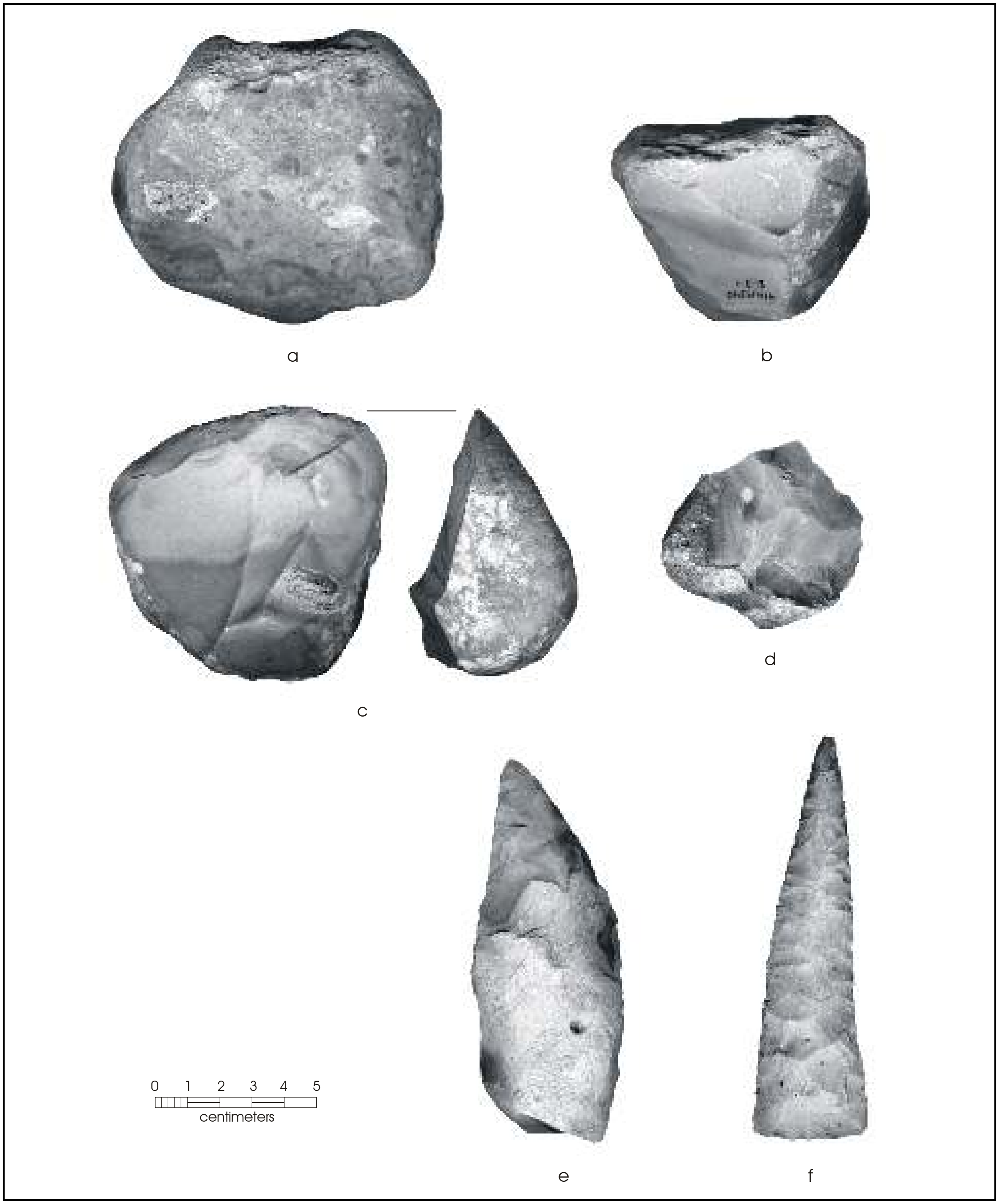


Figure 6-5. *Additional chipped stone tools recovered from 41MM340.* a-b) choppers; c-d) wedges; e) Perkin Pike; f) knife.

provenience information for some portion of the debitage was lost during either laboratory processing or fieldwork. The data recovery sample available for analysis, then, is 47,928 items.

Ground and Battered Stone Artifacts

Sixteen artifacts were recovered that were produced either by grinding or battering. These include 12 hammerstones, a mano, a combination mano/hammerstone, and two metates.

Hammerstones (n=12)

Artifacts classified as hammerstones are cobbles that display evidence of multiple impacts against hard materials. Ten of the 12 hammerstones are complete, and all are made of quartzite. The weights of the complete specimens range from 72.8 g to 484.7 g. The smallest complete specimen fits the size of hammerstones that would be employed during the late stages of lithic reduction. The other nine specimens range in weight between 172.7 g and 484.7 g, a range that is consistent with the notion that these hammerstones were probably used in early to middle reduction stage flaking. Late reduction stage flaking either occurs with lighter hammerstones or pressure flaking tools rather than percussors.

Mano/hammerstone (n=1)

One specimen is classified as a mano/hammerstone (cat. no. 1945-002). The item appears to have been used in a combination of tasks or a single task that consisted of grinding, crushing, and hammering.

Mano (n=1)

A single sandstone specimen appears to have been shaped and used as a mano (cat. no. 2114-006). The mano fragment has an oval shape and in its complete form it may have been a two-handed specimen.

Metates (n=2)

A complete metate and a metate fragment were recovered from the site. The complete specimen (cat. no. 2004) is a large 50-x-30-cm Catahoula sandstone slab with grinding in its center. It was recovered near Feature 41, a burned rock cluster (Figure 6-6). Specimen 2172 is a fragment of sandstone metate made of locally available sandstone.

Figure 6-6. *Complete Catahoula sandstone metate recovered from 41MM340.*

Vertebrate Faunal Remains

Vertebrate faunal remains were common at the site, though the sample was highly fragmentary. A total of 12,739 items was recovered from the combined data recovery and testing work at the site, with 1,600 items (1.12 kg) of bone recovered during testing and 11,139 items recovered during data recovery. The data recovery sample, which weighed 5.7 kg, included 10 bone beads and 42 other bone tools. While some loss of provenience information has reduced the sample slightly, the fragmented assemblage is well preserved. The majority of the bone could be assigned to the class taxonomic level only. Twelve mammalian, three bird, and three reptilian genera were identified in the collection. Barbara Meissner performed the analysis of this sample, and the results are presented in Appendix B. All faunal remains recovered from the site were curated.

Charcoal and Burned Nuts and Seeds

Data recovery investigations at 41MM340 recovered 7.32 kg of charred plant remains, including just over 12.2 g of nut shells. These plant remains represent almost 900 charcoal and burned nut and seed samples. The majority of the samples are from non-feature contexts. These samples were collected as encountered either during excavation or while water screening. No charcoal samples from the excavation block were submitted for radiocarbon dating; however, 33 screen-collected charred seed and nut fragment samples, 166 screen-collected charcoal samples, and 46 heavy and light fraction samples from flotation were submitted for macro-botanical identification and analysis.

The nut and flotation samples contained a total of 160 hickory nut fragments while nine woody taxa were represented in the botanical assemblage including oak and *Ilex* sp. (possibly *Ilex decidua* or possum haw), gum bumelia, honey locust, walnut, willow/cottonwood, and elm. These plants are typical of a deciduous hardwood forest dominated by oak with an understory of yaupon, possum haw, gum bumelia, and honey locust. Dr. Phil Dering at Texas A&M University conducted this analysis, and the results are presented in Appendix E.

While no assays were run on charcoal from the excavation block, nine charcoal samples were extracted and submitted for radiocarbon dating from portions of the Little River floodplain for geomorphological interpretations. Three of these samples were from sediment cores (N-4, N-5, and N-10), and the remaining six were from cutbank localities. The Beta Analytic radiocarbon assay forms are provided in Appendix K. These nine samples, in combination with the 16 previous radiocarbon samples from 41MM340 and the three samples from 41MM341 (Mahoney and Tomka 2001), bring the number of radiocarbon dates associated with the Little River floodplain to 28.

All charcoal, charred nut, and charred seed samples were curated given their potential analytical value.

Mussel Shells

A large quantity of mussel shell umbos and fragments was obtained during the testing and data recovery efforts at 41MM340. During data recovery, CAR recovered 262.01 kg of mussel shell. Two sets of mussel umbo samples were selected for special analysis. The goals of this analysis, as per the research design (Chapter 4), were to provide information related to prehistoric diet, and potentially floodplain dynamics and paleoenvironmental conditions at the time of site occupation.

Nine species of freshwater mussels were identified in the two samples including threeridge (*Amblema plicata*), Tampico pearlymussel (*Cyrtonaias tampicoensis*), Louisiana fatmucket (*Lampsilis hydiana*), washboard (*Megalonaias nervosa*), bleufer (*Potamilus purpuratus*), southern mapleleaf (*Quadrula apiculata*), smooth pimpleback (*Quadrula houstonensis*), false spike (*Quincuncina mitchelli*), and pistolgrip (*Tritogonia verrucosa*). Robert Howells, of Texas Parks and Wildlife, conducted this analysis and the results are presented in Appendix G.

Finally, twelve samples obtained from four individual mussel shells from the genus *Quadrula* were selected and submitted to Texas A&M for isotopic analyses of oxygen (^{18}O). These results are summarized in Appendix I.

All of the mussel shell umbos were curated; shell fragments were discarded.

Snail Shells

Over 35 kg of complete and fragmented snail shells were recovered during testing and data recovery at 41MM340. Our data recovery efforts resulted in the collection of 25.41 kg of snail shell. One controlled volume sample of matrix was extracted from unit N43/E17 of the excavation block. Among other things, this sample was to serve as the controlled volume sample from which to extract a column sample for snail analysis. The goals of this analysis, as per the research design (Chapter 4), were to provide information potentially related to floodplain dynamics and vegetation structure, and broader paleoenvironmental conditions at the time of site occupation. Eleven gastropod species were identified representing eight families. All gastropod shells were in excellent condition. Following the analysis of this column sample, laboratory staff identified two marine specimens (Common Atlantic Marginella [*Prunum apicina*]) in the snail collections. The specimens were separated horizontally by over eight meters and vertically by nearly one full meter (~90 cm). One of the two specimens was from Zone 2, Level 1 of unit N43/E16 while the other was from Zone 8, Level 4 of N47/E11. Dr. Richard Fullington identified the specimens and conducted the snail column analysis. The results are presented in Appendix H.

In addition, all snail shells derived from the ¼-inch water screening of matrix from 12 units (N41/E11, N41/E13, N41/E15, N42/E11, N42/E15, N43/E12, N43/E13, N45/E12, N45/E13, N45/E17, N49/E13, and N49/E15) were classified by species using the comparative collection provided by Dr. Fullington. Five species were identified in these collections: *Helicina orbiculata tropica; Polygyra mooreana; Praticolella berlandieriana; Rabdotus dealbatus; Mesodon* sp., and *Helisoma* sp. Dr. Tomka performed this analysis and the results are incorporated into Chapter 9, Paleoenvironmental Reconstructions.

Thirty samples of the genus *Rabdotus* from 28 archeological proveniences representing each stratigraphic zone, and two modern specimens, were submitted to Texas A&M for isotopic analyses of oxygen (^{18}O). These results are summarized in Appendix I.

The column samples of snails analyzed by Fullington, as well as the samples analyzed from the 12 units, were curated.

Burned Rock

Over 250,000 individual specimens of burned rock were collected from 41MM340 during testing and data recovery. Of these, 234,674 individual specimens of burned rock were collected during data recovery excavations. Four burned rocks, two washed and two unwashed, were submitted for residue extraction and the analysis of the fatty acid compositions of those residues. Dr. Mary Malainey conducted the analysis. The results are presented in Appendix F.

Because of poor residue preservation, only a small sample of the rock was curated.

Burned Clay

Burned clay was not systematically collected during the testing of 41MM340. Therefore, the 864 separate collections, representing over 31,725 individual pieces of burned clay, were all collected during data recovery. Most of these samples (n=750; 86.8%) were recovered during water screening and, therefore, could not be directly associated with a feature. Nonetheless, it is clear that the burned clay would have resulted from the use of a thermal facility. In addition to these water screening samples, 114 collections represent piece-plotted burned clay samples from features. It was hoped that these samples could be used for lipid residue analysis. Two unwashed burned clay specimens were submitted for residue extraction and the analysis of the fatty acid compositions of these residues. As in the case of the burned rock samples, Dr. Mary Malainey conducted the analysis, and the results are presented in Appendix F.

All piece-plotted burned clay was curated from the site. Other specimens were discarded.

Soil Samples

Eighty-seven flotation samples were collected during data recovery. Most of these were from distinct features, though several matrix samples from general excavation were also collected. In addition, three vertical columns of sediment were collected for magnetic sediment susceptibility analysis. These column samples came from three excavation units (N43.90/E17.90, N49.5/E16, and N46.5/E16) along the eastern side of the block and were collected in 5-cm increments. The first column consisted of 22 samples, and the second and third columns each contained 24 individual samples. Finally, a controlled constant-volume sample (10-x-10-cm) was removed from N43.90/E17.90, in arbitrary 10-cm levels, for micro- and macro-fauna distribution studies. This column consisted of 11 individual samples from 15 cm to 125 cm below datum (bd).

All soil samples have been floated. The light and heavy fractions from these samples were curated.

Gravels

To provide an additional avenue through which to investigate floodplain dynamics, all natural gravels found in the ¼-inch screens of selected units were collected and returned to the CAR laboratory for processing. In addition, the gravels recovered from 12 selected units (N41/E11, N41/E13, N41/E15, N42/E11, N42/E15, N43/E12, N43/E13, N45/E12, N45/E13, N45/E17, N49/E13, and N49/E15) were size sorted into four classes (1/4", 1/2", 1", and 2") and the specimens found in each size class were counted and weighed. Observations related to floodplain dynamics were based on this sample.

Because of the purely geoarcheological nature of these samples, the natural gravels recovered from the site were discarded after analysis.

Sediment Cores

Finally, to complement the geomorphic data gathered during testing of 41MM340 and 41MM341 (Mahoney and Tomka 2001), a total of 10 new sediment cores (N-1 through N-10) was obtained from along the floodplain beginning about 60 m north of the site and continuing to near the Little River channel (see Chapter 8). In addition, six cutbank locations, both upstream and downstream of the site, also were examined, profiled and sampled for charred materials for radiocarbon dating. Overall, during the testing and data recovery phases of work at 41MM340 and its vicinity (41MM341), a total of 30 sediment cores (C-1 through C-20 and N-1 through N-10) was examined in conjunction with profiles from 14 backhoe trenches excavated on and off the two sites. The results of the geomorphic investigations of these localities are discussed in Chapter 8.

Features

Fifty-one prehistoric features have been identified and excavated at 41MM340. Two of the features were recorded during the testing phase in Block 1, which is not comparable to the remainder of the site. As such, these two features will not be included in the current discussion. Of the remaining 49 features, four were recorded during testing and 45 were recorded during data recovery. More detailed information on the 45 newly recorded features can be found in Appendix J, while Mahoney and Tomka (2001) provide additional description of the previously recorded features. Table 6-1 provides summary data on the data recovery features. While features were noted from near the top of the manual excavation into stratigraphic Zone 9, most of the features (n=17) were recorded within Zone 8.

As noted previously, two primary feature types, those dominated by burned rock and those with few burned rocks but characterized by charcoal, staining and, frequently, burned clay, can be defined at the site. Of the 45 features uncovered during data recovery, the majority (n=26; 57.8%) consists of burned rock clusters (Figures 6-7, 6-8, and 6-9). Probable hearths or displaced hearths, these rock features were comprised primarily of burned sandstone. Several of these had underlying charcoal stains, and small amounts of burned clay were frequently present in the fill. These features tended to be large and amorphous (Table 6-1). Using only features with complete data, this feature type had an average length of 99.4 cm (n=20; minimum=30 cm, maximum=200 cm), an average width of 67.8 cm (n=20; minimum=25 cm; maximum=130 cm), and an average depth of 14.3 cm (n=26; minimum=3 cm, maximum=43 cm). Fifty percent of these features are described as irregular in shape.

The second most common feature type consists of 18 features characterized by staining with charcoal and, frequently, burned clay (Figure 6-10). While in some cases small amounts of fire-cracked rock were also present in these features, the amount of rock was minimal suggesting that the inclusion of this stone may have been incidental. One feature, Feature 7, appeared to lack burned clay, but did have charcoal and staining similar to the other 17 cases in this group. Also interpreted as hearths, these charcoal/burned clay features tended to reflect circular and elliptical shapes, with only three of the 18 characterized as irregular in outline (Table 6-1). As a group, these features were also smaller than the burned rock clusters, with an average length of 52.5 cm (n=13; minimum=25 cm, maximum=100 cm), an average width of only 40 cm (n=15; minimum=20 cm, maximum=55 cm), and an average depth of 11.7 cm (n=17; minimum=2 cm, maximum=30 cm).

In addition to the 44 features in the two primary groups, a bone concentration (Feature 10) was also identified (Table 6-1) at 41MM340. Unfortunately, the contents of the feature, described as a small concentration of three large pieces of animal bone and numerous smaller bone fragments, appears to have been lost in the field. No additional information is available on this bone concentration.

Table 6-1. Attributes of Features Recorded during Data Recovery at 41MM340

Feature Number	Stratigraphic Zone	Depth Below Datum (cm)	Primary Excavation Unit	Feature Type	Plan Shape	Maximum Length (cm)	Maximum Width (cm)	Depth of Feature (cm)	Comments
1	2	29	N41/E15	Charcoal/Burned Clay	Irregular	55	50	7	Some burned rock present
2	4	57	N41/E11	Charcoal/Burned Clay	Elliptical	25	20	5	Some burned rock present
3	4	57	N41/E13	Burned Rock Cluster	Irregular	110	70+	5	Continues outside of block
4	4	57	N41/E15	Charcoal/Burned Clay	Circular	30	30	7	
5	4	69	N43/E11	Burned Rock Cluster	Elliptical	60	50	11	
6	8	107	N41/E12	Charcoal/Burned Clay	Elliptical	45	30	3	
7	8	99	N41/E13	Charcoal Stain	Elliptical	55	45	9	Burned clay not present
8	4	78	N43/E11	Charcoal/Burned Clay	Elliptical	45	35+	17	Western edge lost in trench
9	8	106	N41/E12	Charcoal/Burned Clay	Elliptical	60+	30+	2+	Feature washed away
10	2	24	N42/E12	Bone Concentration	Irregular	20	10	3	Bone Lost
11	2	30	N42/E13	Burned Rock Cluster	Circular	120	80+	8	Burned Clay also present
12	2	23	N43/E14	Burned Rock Cluster	Irregular	160	120	19	Burned Clay also present
13	2	20	N49/E11	Burned Rock Cluster	Elliptical	95	75	21	Burned Clay also present
14	3b	32	N46/E11	Burned Rock Cluster	Elliptical	45	40	3	Burned Clay also present
15	3b	32	N47/E11	Burned Rock Cluster	Elliptical	60	30	17	
16	4	56	N44/E11	Burned Rock Cluster	Elliptical	100	60	18	Charcoal/Stain underneath
17	8	99	N42/E13	Charcoal/Burned Clay	Elliptical	100	50	30	
18	4	57	N47/E11	Burned Rock Cluster	Irregular	150	100+	43	Continues outside of block
19	8	85	N42/E13	Charcoal/Burned Clay	Circular	65	55	10	
20	8	104	N44/E11	Charcoal/Burned Clay	Elliptical	30+	30	5	Not defined in N45/E11
21	8	109	N46/E11	Charcoal/Burned Clay	Elliptical	65	55	17.5	
22	3b	50	N49/E11	Charcoal/Burned Clay	Irregular	63	34+	2	Not defined in N49/E12
23	4	65	N42/E14	Burned Rock Cluster	Irregular	160+	90	43	Southern end lost to slump
24	8	81	N47/E11	Burned Rock Cluster	Circular	30	25	11	
25	8	111	N47/E11	Charcoal/Burned Clay	Irregular	40+	40	26	Not defined in N47/E12
26	2	25	N43/E13	Burned Rock Cluster	Irregular	80	70	10	

Table 6-1. continued…

Feature Number	Stratigraphic Zone	Depth Below Datum (cm)	Primary Excavation Unit	Feature Type	Plan Shape	Maximum Length (cm)	Maximum Width (cm)	Depth of Feature (cm)	Comments
27	6	70	N43/E13	Burned Rock Cluster	Circular	48	45	3	Burned Clay also present
28	8	96	N44/E12	Charcoal/Burned Clay	Elliptical	35+	55	10	Not defined in N43/E12
29	8	103	N44/E12	Charcoal/Burned Clay	Circular	30	30	7	
30	8	103	N43/E13	Charcoal/Burned Clay	Elliptical	65	55	12	
31	2	27	N47/E13	Burned Rock Cluster	Irregular	120	90	8	
32	9	114	N49/E13	Charcoal/Burned Clay	Circular	25+	25	21	Continues outside of block
33	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Not Assigned in Field
34	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Not Assigned in Field
35	1b	16	N44/E16	Burned Rock Cluster	Elliptical	35+	65	10	Not defined in N45/E16
36	8	98	N48/E14	Burned Rock Cluster	Irregular	200	100	12	Mussel shell common
37	3d	42	N47/E14	Burned Rock Cluster	Irregular	65	45	12	
38	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Determined not to be a Feature
39	8	107	N46/E13	Burned Rock Cluster	Irregular	70+	60	5	Not defined in N46/E14
40	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Determined not to be a Feature
41	4	71	N46/E14	Burned Rock Cluster	Elliptical	80	75	22	Metate associated?
42	3b	38	N46/E14	Burned Rock Cluster	Irregular	70+	50+	31	Not identified in other units
43	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Determined not to be a Feature
44	6	78	N45/E16	Burned Rock Cluster	Circular	45	40	8	
45	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Determined not to be a Feature
46	2	35	N45/E14	Burned Rock Cluster	Irregular	50+	20+	7	Not identified in other units
47	9	116	N47/E14	Burned Rock Cluster	Circular	130	100	9	
48	2	26	N44/E18	Burned Rock Cluster	Elliptical	170	130	14	
49	6	77	N45/E15	Burned Rock Cluster	Irregular	120	45	11	
50	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Determined not to be a Feature
51	8	114	N43/E16	Charcoal/Burned Clay	Elliptical	40	30	10	
52	8	99	N43/E18	Burned Rock Cluster	Irregular	50+	50+	10	Continues outside of block

Figure 6-7. *Burned rock cluster (Feature 31), 41MM340.*

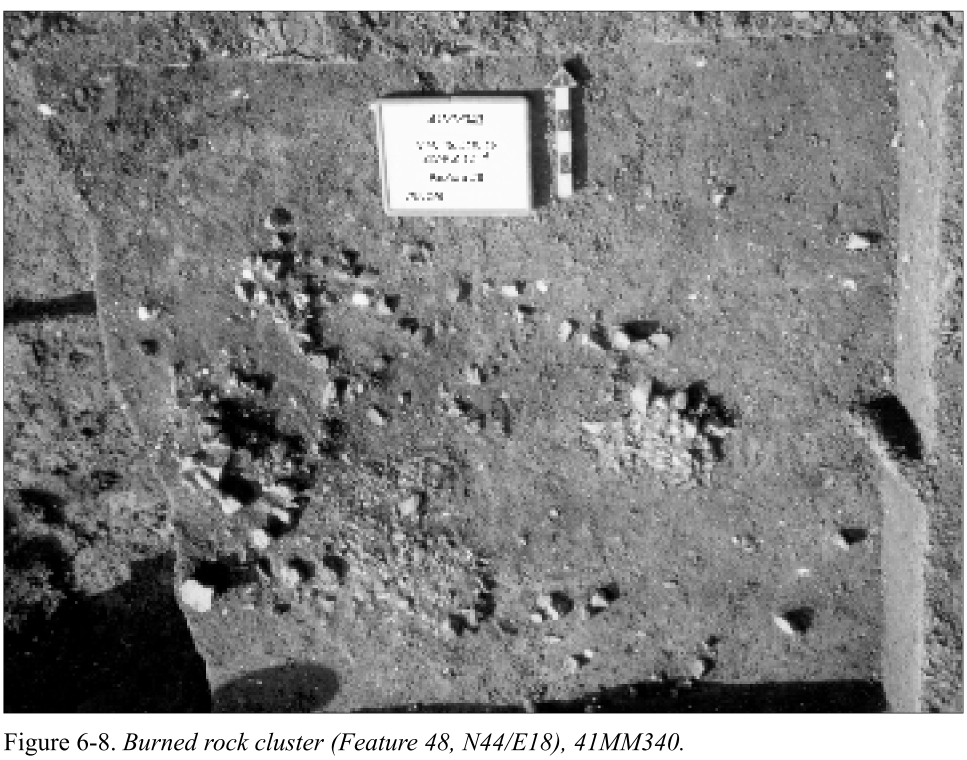


Figure 6-8. *Burned rock cluster (Feature 48, N44/E18), 41MM340.*

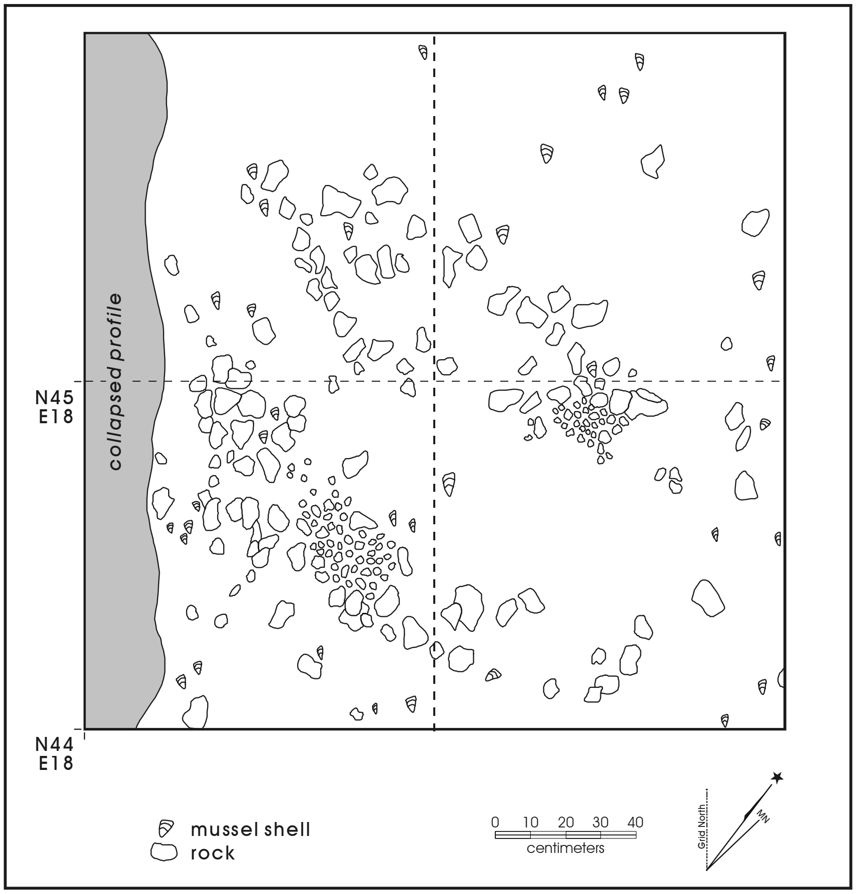


Figure 6-9. *Plan view of Feature 48, 41MM340.*

Figure 6-10. *Charcoal and burned clay feature (Feature 29), 41MM340.*

Chapter 7: Defining Analytical Units at 41MM340

Raymond P. Mauldin, Steve A. Tomka, and Richard B. Mahoney

The current chapter is the first of several that deal more directly with research issues. Specifically, this chapter develops analytical units that will serve to summarize aspects of artifacts and features recovered during the data recovery work. These analytical units, which are based on the 15 stratigraphic zones identified during excavation, will be used in subsequent chapters that focus on subsistence (Chapter 10), site structure (Chapter 11), and lithic technology (Chapter 12). This chapter consists of three primary sections. The initial section provides a brief review of the excavation strategy used at the site. Included in that section is a summary of the stratigraphic zones and an assessment of their potential utility for analytical units. The second section uses variation in debitage frequencies, along with burned rock and burned clay, to define seven zones for analysis. These seven analytical units are then assessed relative to the distribution of several point types that have good temporal control. In addition, patterns in magnetic sediment susceptibility provide an additional consideration of the potential utility of these analytical units. The third section provides a summary of the characteristics of these analytical units.

The Excavation Strategy at 41MM340

As outlined in Chapter 5, the excavation methodology used during the data recovery work at 41MM340 was a modification of that employed during testing at the site. Mahoney et al. (2001:27–35) identified nine zones, present in both Block 2 and Block 3, during the initial testing. Each of the zones contained somewhat different densities of artifacts and ecofacts (see Mahoney et al. 2001:Tables 7-8 and 7-9). In addition, several of the zones were correlated with subtle differences in sediment color and texture. Fourteen radiocarbon dates from several of the zones in Blocks 2 and 3 clearly demonstrate that the zones were roughly similar in age and in good stratigraphic order. The lowest dated zone, Zone 8, had radiocarbon assays that placed this zone at roughly 1400 to 1260 B.C. The middle zones in the blocks dated to between about 1210 and 510 B.C. The highest dated zone, Zone 2, had dates of roughly 760 to 390 B.C. (Mahoney et al. 2001:Table 7-1). Assuming that the dated material was in context, the sediments between Zone 8 and Zone 2 formed in a relatively short period of time, perhaps no more than 1,100 years, during the Late Archaic period.

The data recovery work was initiated, then, with the expectation that a similar pattern of zones would be identified in the sediments between Blocks 2 and 3 at the site. Furthermore, we expected to be able to use these zones as analytical units (AUs). That is, we specifically excavated these deposits following these apparent stratigraphic units in an effort to isolate artifacts and features that had a higher probability of being associated behaviorally. However, as shown in the initial profile drawings of Trenches C and D at the site, presented previously in Chapter 5 (see Figures 5-3 and 5-4), our mitigation efforts revealed a more complex pattern. Not all zones were clearly visible in both profiles. In addition, several of the zones with higher densities of cultural material merge together. Ultimately, excavators identified 15 different zones within the mitigation block.

Field Definitions and Assessment of the Stratigraphic Zones

The 15 stratigraphic zones identified during data recovery were based on identification criteria developed during our previous testing work at the site. The primary criterion for the identification of zones was apparent density and content changes in artifacts and ecofacts. These observations were supplemented by changes in sediment color, texture, and inclusions within the matrix of the excavation block. Table 7-1 summarizes several of the characteristics of the 15 zones, along with an estimate of the volume of screened matrix in the zone, the spatial extent of the zone, and the approximate maximum thickness of the deposit.

Using the criteria in Table 7-1, however, the identification of the individual units was not an easy task in many situations. Due to significant contrasts in artifact densities, as well as differences in sediment color, we are reasonably confident that the definition of some breaks, such as between Zones 8 and 9, were made with a high degree of consistency. On the other hand, other distinctions were much more difficult to make in the field, especially under conditions of excessive rainfall and flooding as were experienced at the site during our mitigation efforts. As a consequence of the probability that, at least in several cases, zonal assignment was inconsistent, we began a systematic review of the stratigraphic zones to assess their utility as analytical units.

Table 7-1. Characteristics of Stratigraphic Units Defined during Data Recovery at 41MM340

Stratigraphic Zones	Munsell Color	Color Name	Texture & Inclusions	Volume Excavated (m^3)	Spatial Extent (m^2 recorded in block)	Additional Characteristics/observations	Approximate Max. Thickness (cm)
1a	10 YR 3/1	Very Dark Gray	Silty Clay	5.85	42	Disturbed layer - removed primarily by scraping. Construction material.	25
1b	10 YR 3/1	Very Dark Gray	Silty Clay	2.34	23	Higher density of artifacts relative to Zone 1a.	20
1c	10 YR 3/1	Very Dark Gray	Silty Clay	0.527	7	Lower artifact densities.	10
2	10 YR 3/1	Very Dark Gray	Silty Clay	9.05	56	Much higher density of cultural material.	30
3a	10 YR 3/1	Very Dark Gray	Silty Clay	4.24	47	Lower frequency of artifactual material.	30
3b	10 YR 3/1	Very Dark Gray	Silty Clay	4.24	25	Higher density of artifacts relative to Zone 3a.	34
3c	10 YR 3/1	Very Dark Gray	Silty Clay	1.77	22	Lower density of artifacts.	21
3d	10 YR 3/4	Very Dark Yellowish Brown	Silty Clay	0.414	5	Higher volumetrically adjusted counts.	12
3e	10 YR 3/4	Very Dark Yellowish Brown	Silty Clay	0.345	5	Lower artifact density.	10
4	10 YR 5/4	Yellowish Brown	Silty Clay	9.4	53	Dramatic increase in artifacts relative to upper units.	30
5	10 YR 5/4	Yellowish Brown	Silty Clay	2.38	31	Decreased artifact density.	15
6	10 YR 5/4	Yellowish Brown	Silty Clay	3.37	36	Increasing calcium carbonate filaments. Higher artifact densities.	21
7	10 YR 5/4	Yellowish Brown	Silty Clay	5.2	56	Increasing calcium carbonate filaments. Nodules present. Lower artifact densities.	22
8	10 YR 5/4	Yellowish Brown	Silty Clay	13.94	56	Increasing calcium carbonate filaments. Nodules present. Charcoal very common. Artifact densities increase.	35
9	Not Recorded		Clay; Low silt content	2.26	56	Low artifact occurrence. Possibly represents a point bar formation.	unknown

The review began with a consideration of the overall size and spatial extent of the zones. Table 7-1 shows that several of the zones, such as Zones 1c, 3d, and 3e, are extremely limited both in spatial extent and in overall volume of sediment. These three zones account for less than two percent of all the screened volume removed from the site. In addition, these zones cover only a few square meters in spatial extent. If these zones were consistently defined and reflect useful distinctions, then the small size and limited volume of these units would be of considerable interest as they may represent extremely limited temporal packages of artifacts.

Two of these zones are closely related. Zone 3d overlies Zone 3e, and as shown in Figure 7-1, the two zones have identical spatial distributions. Table 7-1 suggests that Zone 3d is virtually identical to the underlying Zone 3e material in terms of sediment color and texture. The primary distinction between these zones is related to the differences in the quantity of material, with Zone 3d having higher adjusted counts and Zone 3e having lower densities. Table 7-2, which contrasts recovered material for Zones 3d and 3e, shows that this is indeed the case. In each of the four categories considered (burned clay, burned rock, debitage, and mussel shell) the number or weight of material in Zone 3d is greater than that in Zone 3e. These differences are also apparent when the numbers or weights are adjusted for screened volume of sediment. However, note that field distinctions were not made at the level of the entire zone. Rather, they were made on the basis of differences in individual levels within units. As shown in Figure 7-1, Zone 3d contains a single burned rock feature (#37) not present in the underlying 3e zone. Not surprisingly, the counts on burned rock and burned clay for Zone 3d in that single unit are high. In fact, the 150 liters of sediment assigned to Zone 3d in that unit contained 2,000 pieces of burned rock, 246 grams of burned clay, 84 pieces of debitage, and 785.9 grams of mussel shell. Comparison of these figures with the Zone 3d totals in Table 7-2 will suggest that this single unit accounts for a significant component of the differences between zones. When we remove this unit, differences between the two zones are greatly reduced. In fact, Zone 3e has slightly higher debitage densities than 3d. We suggest that these minor differences, especially when compounded by different excavators and less than ideal field conditions, are unlikely to have been consistently recognized in the field.

Figures 7-2 and 7-3 show a series of profiles from eight individual units that further casts doubt on the utility of many of our finer zone distinctions. Review of these profiles, which come from all areas of the site, suggests that while considerable variability is clearly present in several of the units, most have three zones of primary artifact clusters. In addition, note that several of these clusters are associated with features that appear to be excavated from these surfaces potentially defined by these zones. Given these patterns, we suggest that at least some portion of the 15 stratigraphic zonal distinctions may not be useful for the definition of analytical units.

Defining Analytical Units at 41MM340

Given the previous considerations, we developed analytical units (AUs) based on changes in artifact content in the stratigraphic zones. A systematic review of all 56 1-x-1-m excavation units was conducted, and three different classes of artifacts—debitage, burned rock, and burned clay—were used in the development of the AUs. These artifact classes were present in most of the levels within the 56 1-x-1-m units. Our goal was to isolate density changes in these artifact sets that could form the basis for the AUs.

The procedure involved three steps. First, within a unit, the number of debitage and burned rock, and the weight of burned clay, was corrected for different volumes of excavated sediment. These corrected figures were then standardized such that the mean values for each class was 0. This standardization allowed us to plot the volumetrically adjusted values on the same scale. For each unit, these values were then plotted and examined visually. Break points for the definition of AUs were placed where several of the different data sets seemed to have major alterations in density values. In all, seven different analytical units were defined based on the 15 original stratigraphic zones. These were identified as AU 1 through AU 7 with number assignments beginning at the top of the excavation block.

Figures 7-4 and 7-5 present two examples of this procedure. These cases were selected from the central portion of the block. Note that the levels that formed the Y-axis in the figures were assigned based on relative stratigraphic order. Levels do not represent a similar volume of sediment, nor are they comparable across units. The figures, then, should not be interpreted as necessarily reflecting the absolute depth or thickness of a given AU in these two units. Rather, they are presented only as examples of how the AUs were defined.

Figure 7-4 presents the standardized values for N44/E12. In this particular case, there were relatively consistent

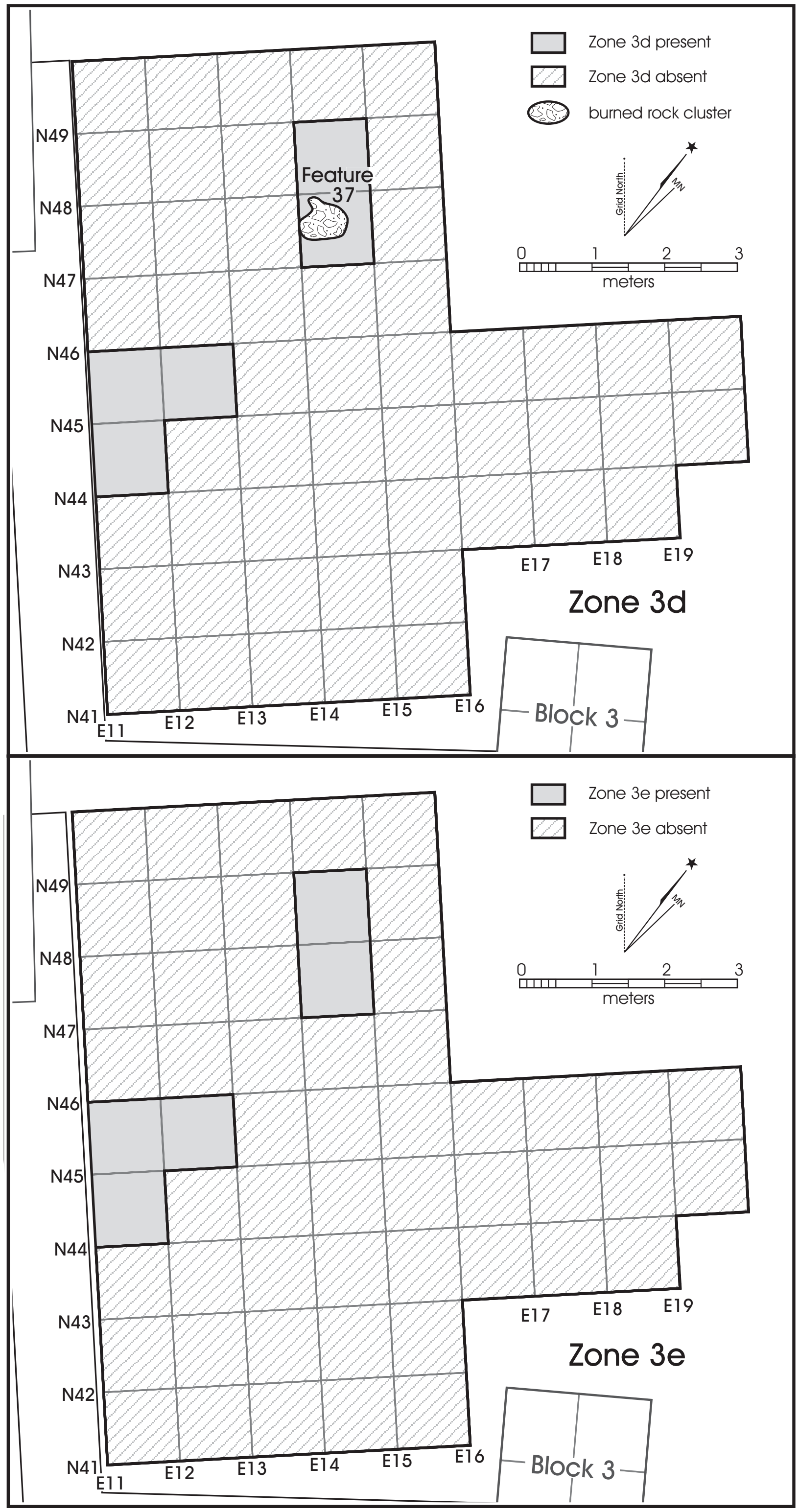


Figure 7-1. *Spatial extent of Zone 3d (top) and Zone 3e (bottom) identified at 41MM340.*

Table 7-2. Comparisons of Zones 3d and 3e
(adjusted values per 100 liters of soil in parentheses)

Zone	Volume (liters)	Burned Clay Weight (g)	Number of Burned Rock	Number of Debitage	Mussell Shell Weight (g)
3d	413.8	281.6 (68.1)	3067 (741.2)	191 (46.2)	1741.4 (420.8)
3e	345	26.7 (7.7)	601 (174.2)	140 (40.6)	209.2 (60.6)

changes in the densities in all three data sets making the distinction of AUs relatively straightforward. Figure 7-5 presents a more common case. Here, density changes were more variable, and a number of different distinctions could reasonably be made. In spite of this ambiguity, however, the distinctions in this particular case do serve to isolate density peaks in the deposits.

Table 7-3 shows the relationship between the original 15 stratigraphic zones and the seven analytical units for each of the 784 levels where sufficient data existed for an assignment. Note that there is clearly a strong relationship between these two descriptive units. In general, AU 1 is associated with Zones 1a and 1b, AU 2 with Zones 2, 3a and 3b, AU 3 with Zones 2, 3a, 3b, and 3c, AU 4 with Zones 3b, 4, 5, and 6, AU 5 with Zones 5, 6, and 7, AU 6 with Zone 8, and AU 7 with Zones 8 and 9. Note that AU 1, consisting of the upper portion of the deposits, was not defined in all excavation units within the block. Similarly, AU 7, the lowest analytical zone, was not defined in all units. The remaining five analytical units (AUs 2–6) were identified in each excavation unit in the block.

Assessing the Analytical Units

Given the way that the analytical units were created, it is likely that the density differences seen in the profiles presented in Figures 7-2 and 7-3 are encapsulated by the AUs. That is, reference to Figures 7-4 and 7-5 shows that AUs 2, 4, and 6 are likely to contain higher densities of artifacts, with AUs 1, 3, and 7 reflecting lower artifact densities. While the content of the analytical zones is documented in the latter part of this chapter, the reflection of the actual density patterns seen in the profiles is an advantage relative to the stratigraphic zones. It is unclear, however, if these AUs form coherent blocks of artifacts that have some utility in considering behavior. Here, we use two different data sets, the distribution of temporally diagnostic projectile points and patterns in sediment susceptibility to further assess the coherence of the analytical units.

As discussed in Chapter 6, a variety of projectile point types were recovered during the data recovery work at 41MM340. While many of these were either untyped or untypable, several forms with known temporal ranges were identified. Table 7-4 considers these forms relative to the analytical units. Diagnostic points were only present in AUs 2, 3, 4, 5, and 6. As noted in Chapter 6, Edgewood, Darl, Godley, Kent, and Gary forms are generally placed in the later portion of the Late Archaic, with Marcos and Marshall types falling in the middle portion of the Late Archaic. Pedernales forms reflect the early portion of the Late Archaic. Consideration of the distribution of these forms relative to the AUs suggests reasonable coherence, especially for AUs 3, 4, 5, and 6. The distribution of points in these AUs is also consistent with the radiocarbon dates for Blocks 2 and 3 obtained during testing (see Mahoney et al. 2001). These data suggest, then, that the procedure used to create the analytical units was consistent with the overall depositional sequence at 41MM340.

A final data set, patterning in sediment susceptibility, also has implications for considering the potential utility of the analytical units. We collected three sets of susceptibility samples from the 41MM340 block. Details of sample collection and processing, along with the raw data, can be found in Appendix C. As discussed in that appendix, interpreting magnetic sediment susceptibility results is complicated. While several processes can increase the susceptibility values in a sediment sample, sediments with higher organic content tend to have higher magnetic susceptibility (MS) values. Unfortunately, several cultural and non-cultural processes can result in the concentration of organic material. Certainly, the concentration of ash, charcoal, and refuse at a location as a result of human occupation will result in high MS readings. In addition,

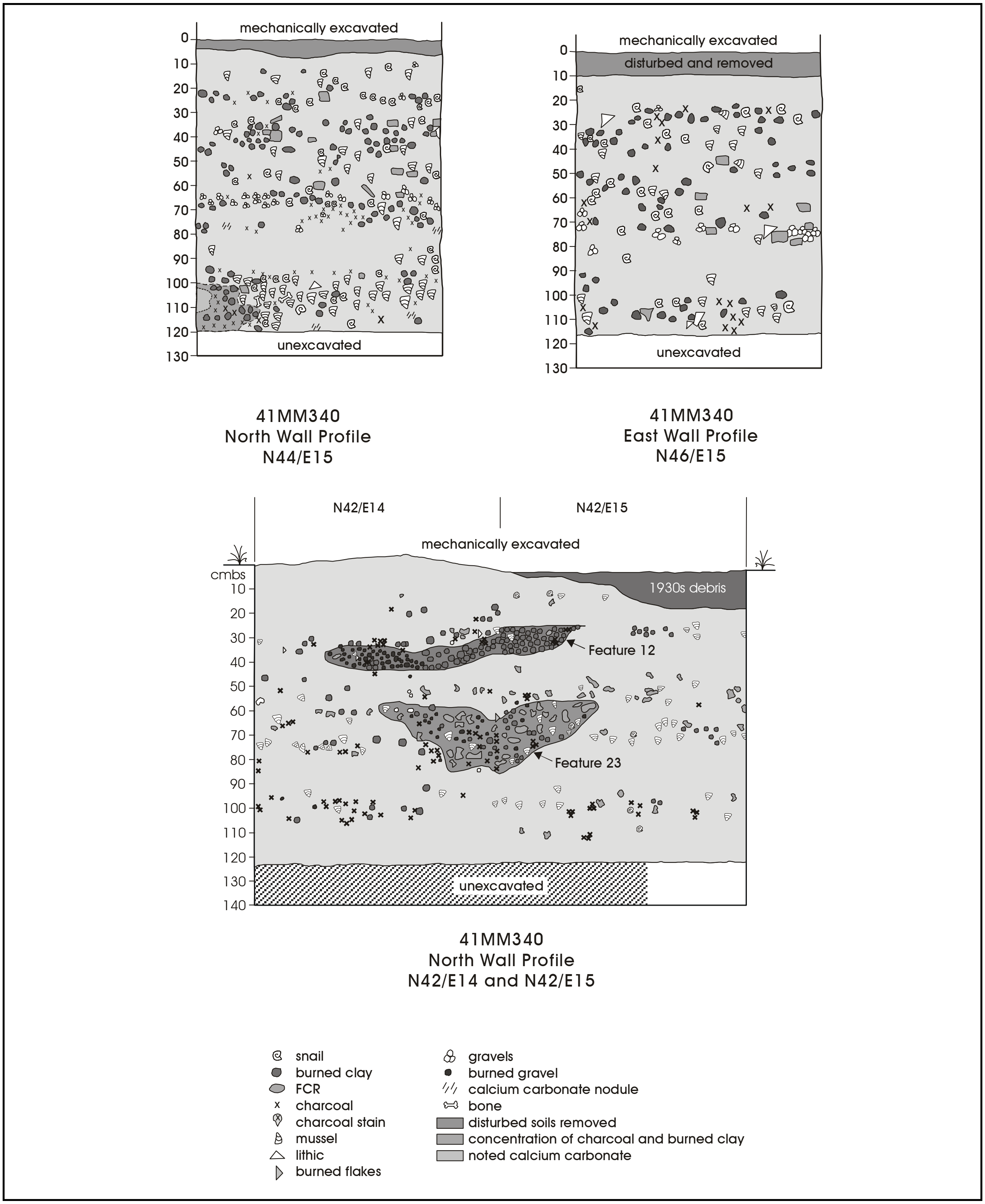


Figure 7-2. *Wall profiles of N44/E15, N46/E15, and N42/E14-15, showing three zones of primary artifact clusters.*

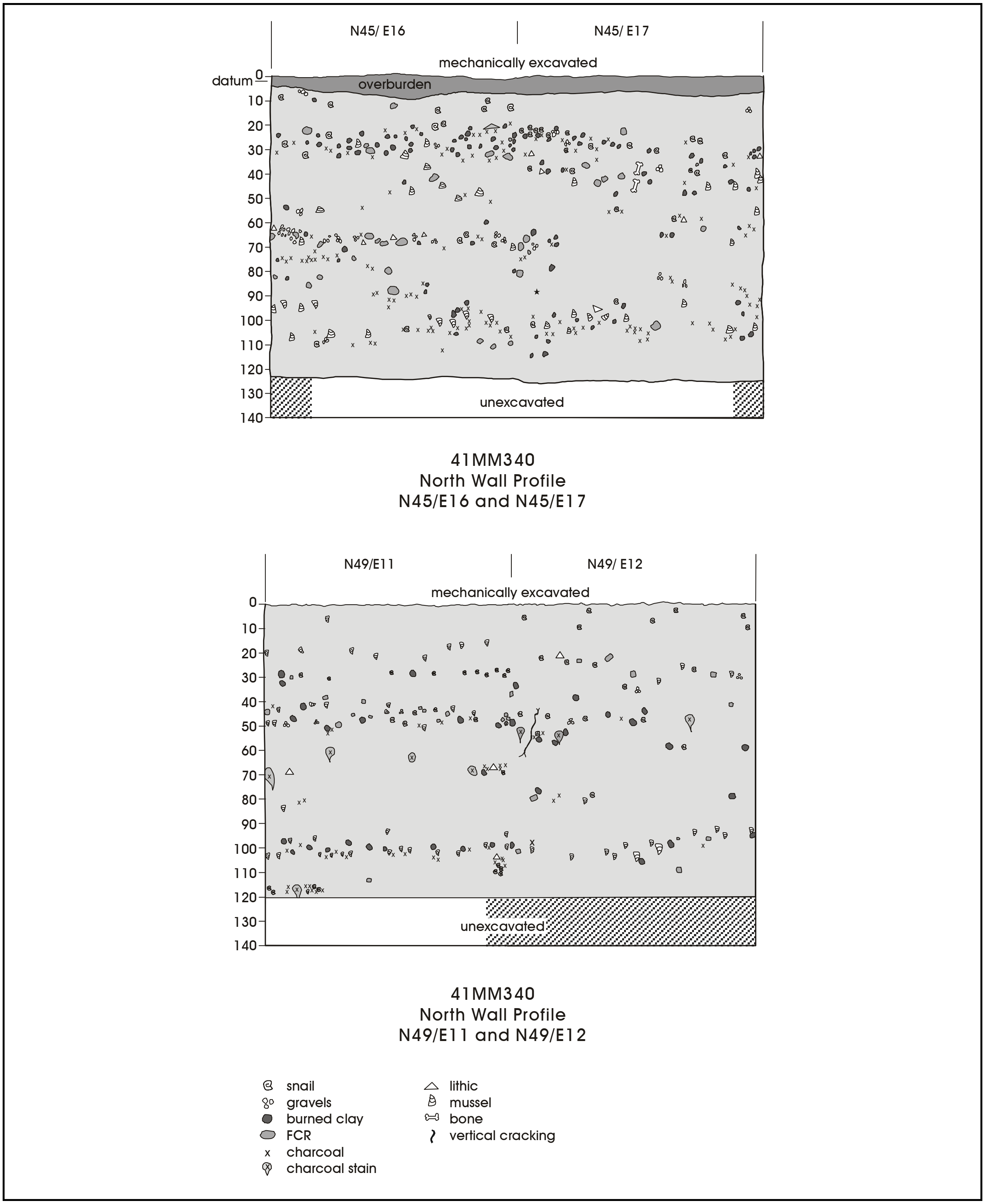


Figure 7-3. *North wall profiles of N45/E16-17 and N49/E11-12 showing three zones of primary artifact clusters.*

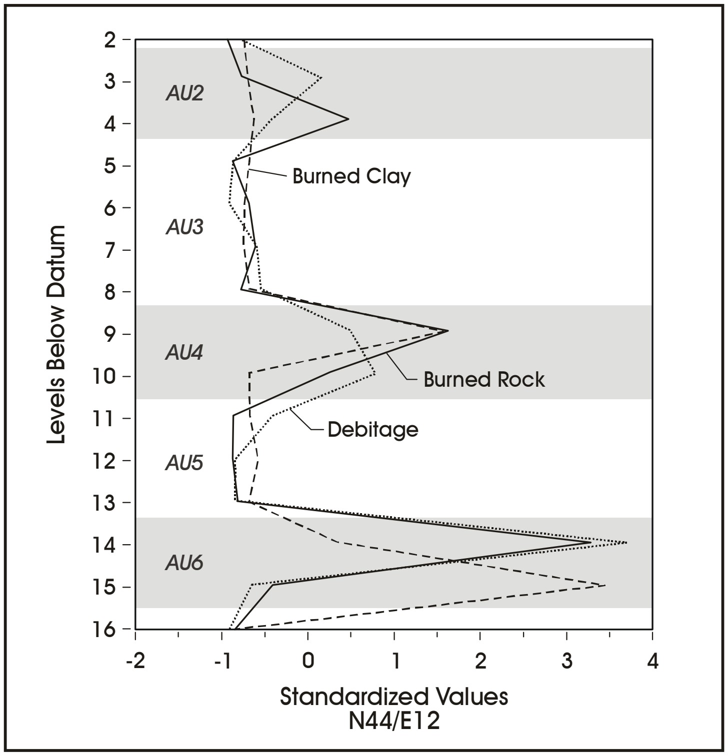


Figure 7-4. *Standardized values of three artifact classes with analytical units identified in N44/E12.*

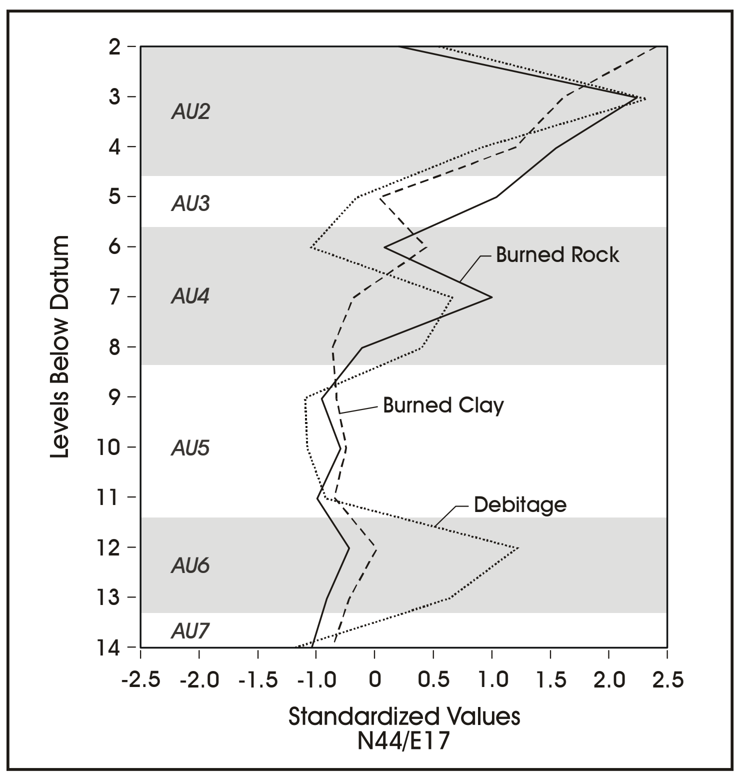


Figure 7-5. *Standardized values of three artifact classes with analytical units identified in N47/E17.*

Table 7-3. Relationship Between Stratigraphic Zones and Analytical Units Using 784 Individual Levels

	Analytical Units						
Stratigraphic Zones	1	2	3	4	5	6	7
1a	65	0	0	0	0	0	0
1b	15	12	0	0	0	0	0
1c	5	2	0	0	0	0	0
2	6	87	12	0	0	0	0
3a	0	13	38	11	0	0	0
3b	0	26	15	14	0	0	0
3c	0	3	14	8	1	0	0
3d	0	2	3	1	0	0	0
3e	0	0	3	1	0	0	0
4	0	1	6	95	3	0	0
5	0	0	1	18	14	2	0
6	0	0	0	21	28	0	0
7	0	0	0	6	62	7	0
8	0	0	0	0	9	102	26
9	0	0	0	0	0	3	23
Total	91	146	92	175	117	114	49

Table 7-4. Temporally Known Point Types by Analytical Units

Temporal Point Types	Analytical Units				
	AU 2	AU 3	AU 4	AU 5	AU 6
Darl	1				
Edgewood	1				
Godley	2				
Kent	1	2	1		
Gary	2	1			1
Marcos	4		5	3	1
Marshall			4	2	
Pedernales					18
Woden					1

stable surfaces should also have higher MS values relative to aggrading surfaces as organic material will have less time to build up at any given point in the sequence. The long-term occupation of a stable surface should result in a significant and consistent pattern.

While the number of cases for comparison is unfortunately few (n=3), a consideration of Figures 7-6 through 7-8 suggests several interesting patterns. Focusing first on the patterns in the susceptibility, Figure 7-6, taken from the east wall of N49/E15, shows three minor spikes and with one major spike in susceptibility values located in the upper portion of the plot. Figure 7-7 shows the pattern revealed three meters to the south of the Figure 7-6 samples. Here, two of these same spikes, including the large spike near the top and an underlying secondary spike are present. In addition, a large spike near the bottom of the profile is present. Finally, Figure 7-8, taken from N43/E17, presents a slightly different pattern. While the upper spike is once again present, the pattern in the lower deposits is more variable. Considered as a group, then, only the top spike in the sequence is consistently present across this area. One interpretation of this pattern is that the upper spike is reflecting a stable surface, occurring somewhere between 30 and 50 cm, across this area. The bottom portions of the profiles reveal a more active, aggrading pattern, with the secondary spikes simply reflecting small-scale concentrations of organics, possibly associated with human occupation.

Note that on all three figures we have identified the approximate locations of the AUs derived independently through our artifact analysis. In all three cases, the "stable" spike is clearly associated with AU 2. To the degree that this spike reflects a stable surface, this pattern suggests that AU 2 may have been used over a significantly longer period, potentially for a wider variety of activities. We anticipate, then, that AU 2 may have less integrity relative to the lower zones. Interestingly, this observation is consistent with the pattern in projectile points shown previously in Table 7-4. No other AU is consistently associated with a peak in the susceptibility values. The most parsimonious interpretation of this lack of association is that the individual spikes in the susceptibility values are reflecting small-scale concentrations of cultural material deposited on a rapidly aggrading surface. This pattern suggests that these lower AUs probably contain a series of discrete occupations. Note that we are not suggesting that each of these lower AU reflects a discrete occupation. Rather, they probably reflect periods of varying temporal length during which occupation of this particular area was either more or less intensive.

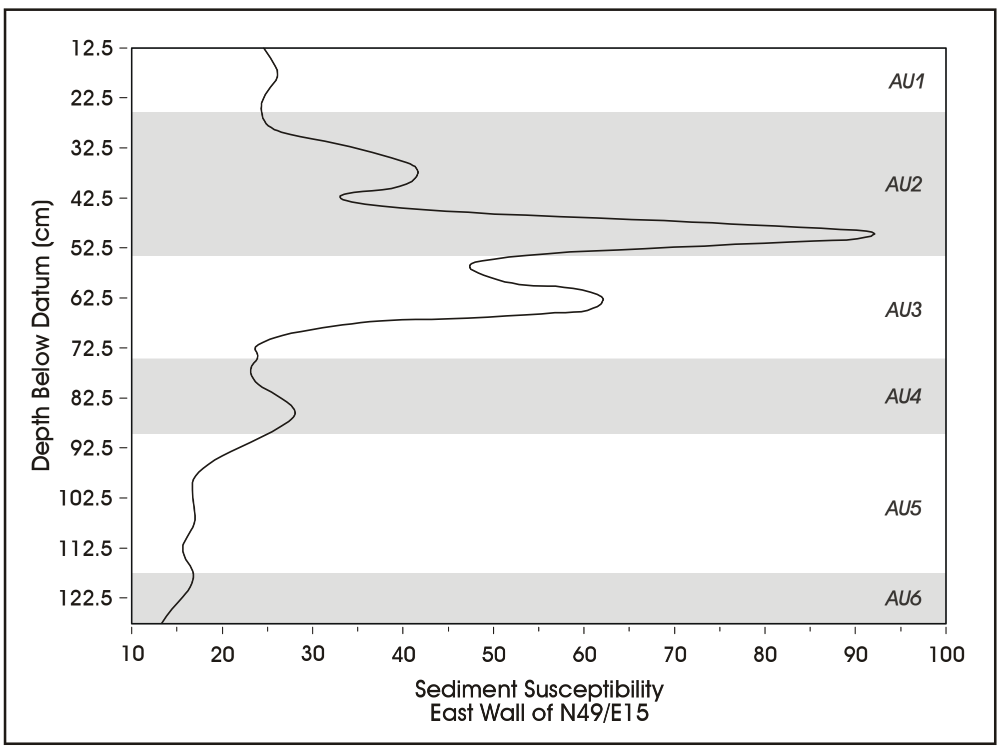


Figure 7-6. *Magnetic sediment susceptibility values with analytical zones identified for N49/E15.*

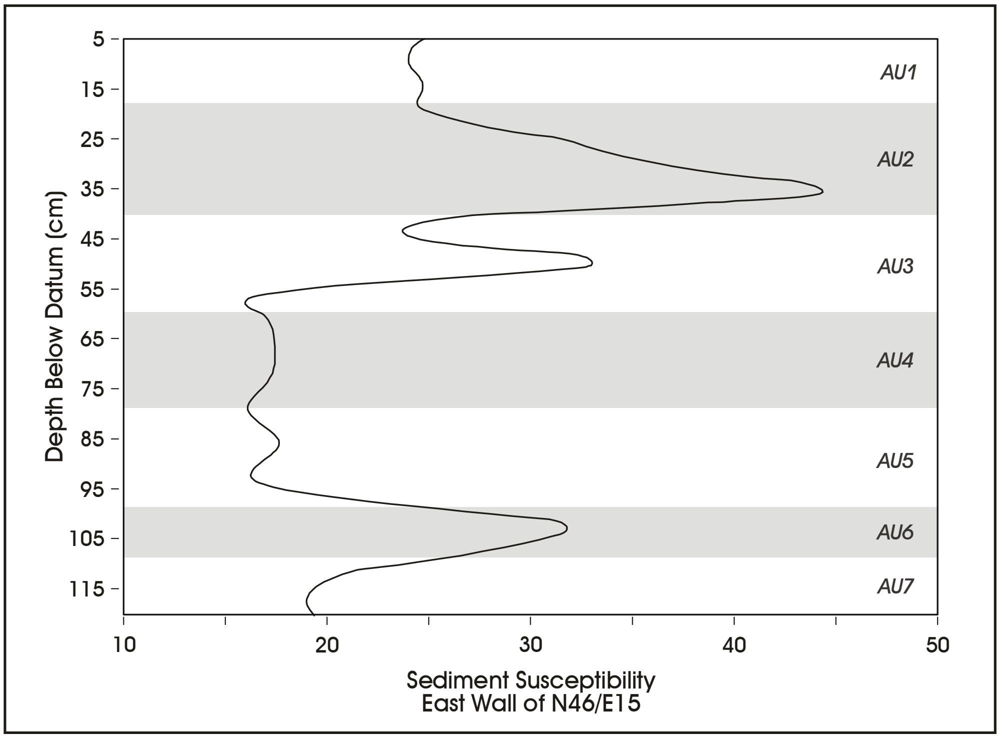


Figure 7-7. *Magnetic sediment susceptibility values with analytical zones identified for N46/E15.*

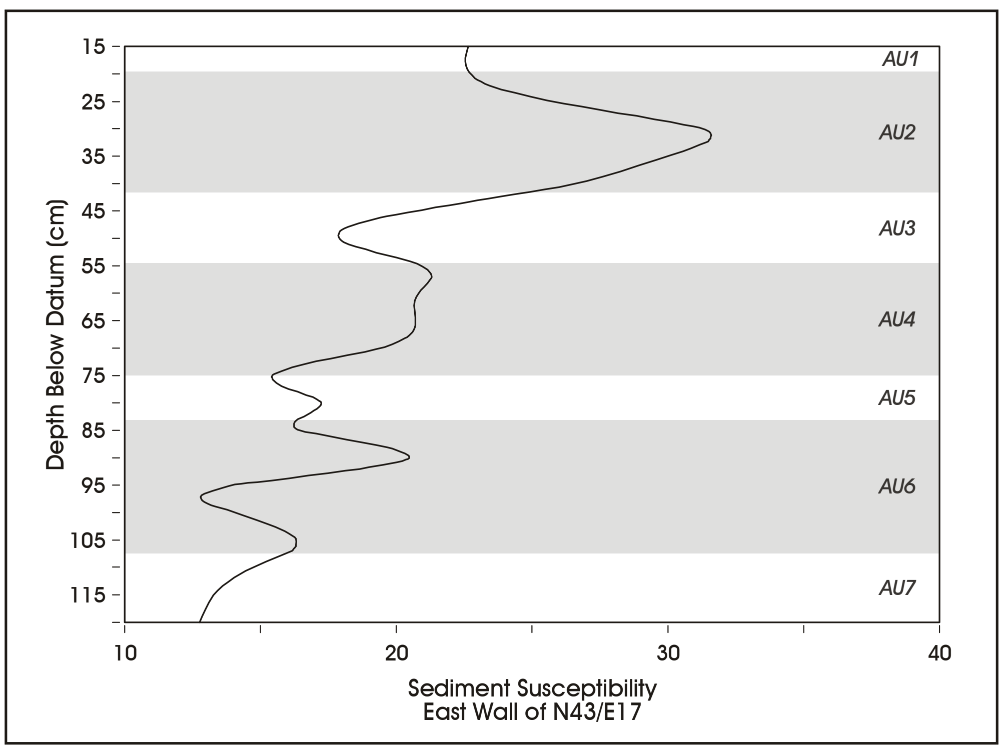


Figure 7-8. *Magnetic sediment susceptibility values with analytical zones identified for N43/E17.*

Characteristics of the 41MM340 Analytical Units

The various data sets discussed previously suggest that the analytical units created at 41MM340 have reasonable temporal coherence, are consistent with observable differences in profiles at the site, and, in most cases, probably reflect a series of occupations in an aggrading environmental setting. In this section, we provide summary information on the characteristics of these various AUs.

Table 7-5 provides summary data for each of the seven analytical units, along with the volume of sediment that could be clearly associated with that AU. Figures 7-9 through 7-11 present box plots of the number of burned rock, weight of burned clay, and the number of debitage by AU. Note that these figures plot volumetrically standardized numbers or weights for individual levels associated with a particular analytical unit, and that extreme outliers have been eliminated from these plots. Examination of the plots clearly suggest that levels assigned to AUs 2, 4, and 6 are characterized by higher frequencies of all three classes, and that these three AUs generally have higher overall densities. Conversely, AUs 1, 3, 5, and 7 all have lower densities. Certainly, this density pattern is not surprising, given the way that the AUs were defined. However, note that there do seem to be differences in the individual levels that are not explained by their definitional criteria.

Table 7-5. Recovered Material and Associated Volume by Analytical Unit

Analytical Unit	Total Volume Recovered (liters)	Bone Weight (grams)	Burned Clay Weight (grams)	Burned Rock Number	Debitage Number	Mussel Shell Weight (grams)	Snail Shell Weight (grams)
1	7762.4	142.34	286.9	3375	1502	13425.72	878.42
2	11792.5	1263.15	11447.68	58166	14107	48286.44	2275.9
3	6978.9	287.35	1195.2	16423	2401	11347.58	1214.21
4	13785	1662.79	11627.41	115469	17728	53766.83	4925.06
5	8033	562.89	767.9	7745	2554	18846.03	1208.11
6	10555.7	1500.27	13588.12	29423	8183	106537.54	13100.24
7	4506.3	158.37	706	3236	1453	9103.28	1757.33
Totals	63413.8	5577.16	39619.21	233837	47928	261313.42	25359.27

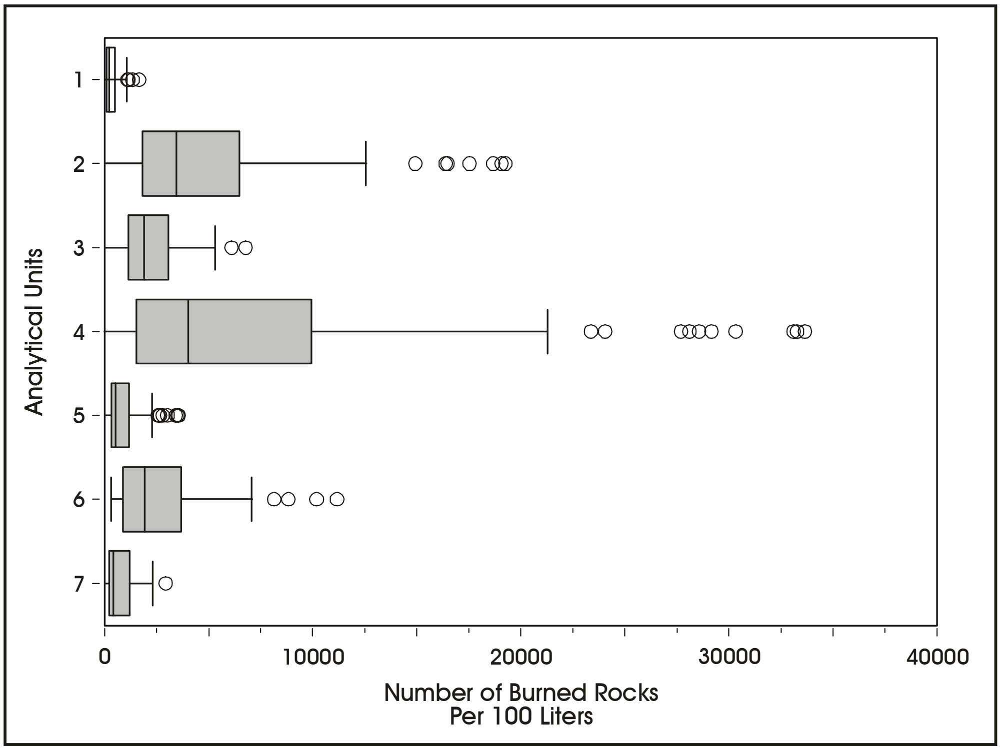


Figure 7-9. *Box plot of number of burned rock per 100 liters of sediment by analytical unit.*

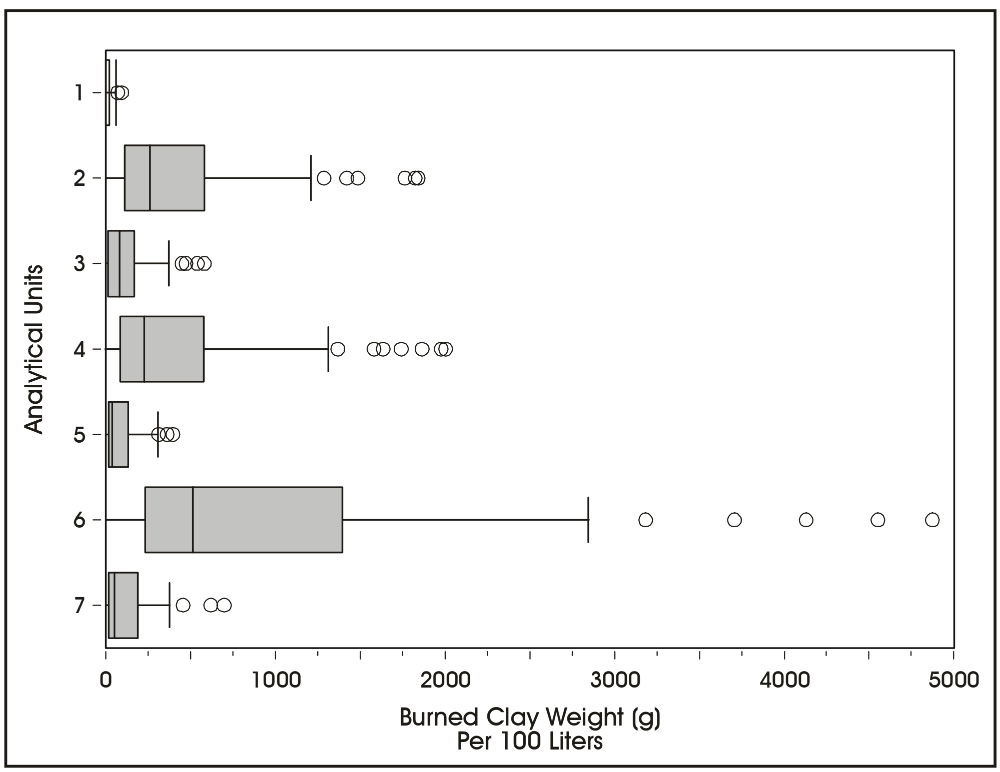


Figure 7-10. *Box plot of weight of burned clay per 100 liters of sediment by analytical unit.*

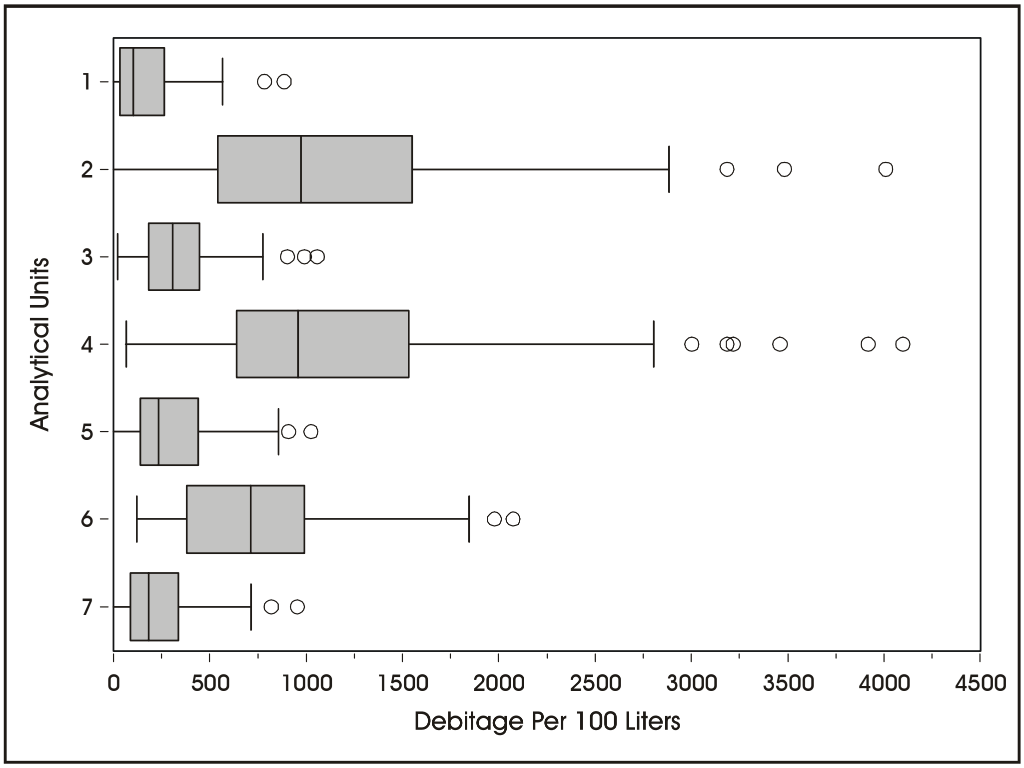


Figure 7-11. *Box plot of debitage per 100 liters of sediment by analytical unit.*

Chapter 8: Floodplain Dynamics

Lee C. Nordt, Russell D. Greaves, and Steve A. Tomka

This chapter details those aspects of the research design concerning floodplain dynamics. As defined in the data recovery research design (Tomka et al. 2002), the goal of this research domain was to document the relationship between short- and long-term changes in streamflow and floodplain dynamics and human occupation of the floodplain. For instance, the relatively large quantity of gravels recovered in the various analytical units of the site may be indicators of rapid and frequent high-energy overbank flooding. On the other hand, the migration of the stream channel from the northern to the southern side of the floodplain, as suggested by extant sloughs in the vicinity of sites 41MM340 and 41MM341, suggests long-term changes in streamflow and floodplain dynamics. In addition to documenting these short- and long-term phenomena, we are also concerned with defining how these phenomena influenced human use of site 41MM340 as well as the Little River floodplain. Did human occupation of the floodplain coincide with long periods of landform stability as revealed by buried paleosols? Were episodes of use and abandonment of the Little River floodplain related to long-term changes in the flow regime of the Little River and regional-scale climatic changes? Finally, do the extant sloughs found in the vicinity of the two sites represent channels of the Little River at the time of site occupation? Is site abandonment related to the movement of the channel?

The greater part of the field and analytical efforts went into gathering data and making observations of a geomorphic nature. Next, a sample of the large quantity of gravels recovered from 41MM340 was analyzed. Finally, the results obtained from the analysis of mussel shells were reviewed to solicit information of species composition and habitat preferences. This chapter discusses each of these analytical approaches in detail and closes with a summary of floodplain dynamics and their relationships to human occupation of 41MM340 and 41MM341.

Geomorphology

by Lee C. Nordt

For the testing phase of sites 41MM340 and 41MM341, archeological block units, backhoe trenches, and interpretations of sediment cores were used to reconstruct the alluvial stratigraphic framework of the Little River in the project area, and to make geoarcheological inferences (Mahoney and Tomka 2001). For the mitigation phase of site 41MM340, the alluvial history of the project area is modified with the addition of ten new deep sediment cores, descriptions of two cutbanks of the Little River near the site, and nine additional radiocarbon dates. After reconstruction of the alluvial stratigraphic framework, inferences about settlement patterns and preservation potentials will be assessed. Soil-stratigraphic descriptions from the sediment cores, cutbanks, and backhoe trenches are given in Appendix A.

Setting

The Little River begins at the confluence of the Leon and Lampasas rivers approximately 50 km upstream from the project area (Figure 8-1). The Little River then confluences with the San Gabriel River, and ultimately with the Brazos River downstream from the project area. Most of the drainage basin covers upper Cretaceous limestones and calcareous marls and muds. In the project area, the Little River flows along the strike separating the Tertiary Midway Group to the north and the Tertiary Wilcox Formation to the south. Tertiary formations are comprised mainly of interbedded sandstones and mudstones.

Pleistocene alluvial terraces border both sides of the Little River floodplain throughout much of the drainage basin (see Figure 8-1). Unpublished soil survey maps delineate these terraces principally as Alfisols with decalcified A–Bt profiles (Minwells series), consistent with a late Pleistocene age (Nordt 1993). The floodplain soils are mapped mainly as occasionally flooded, clayey Mollisols (Frio series) with weakly developed A–C or A–Bw profiles.

Methods

Ten sediment cores (N-1 through N-10) were extracted along the Highway 36 bridge crossing by a truck-mounted drill rig provided by the Bureau of Economic Geology. General descriptions were written in the field, with more detailed assessments performed in the Baylor University stratigraphy laboratory (Folk 1980; Soil Survey Division Staff 1993). An alluvial valley cross-section was constructed from a

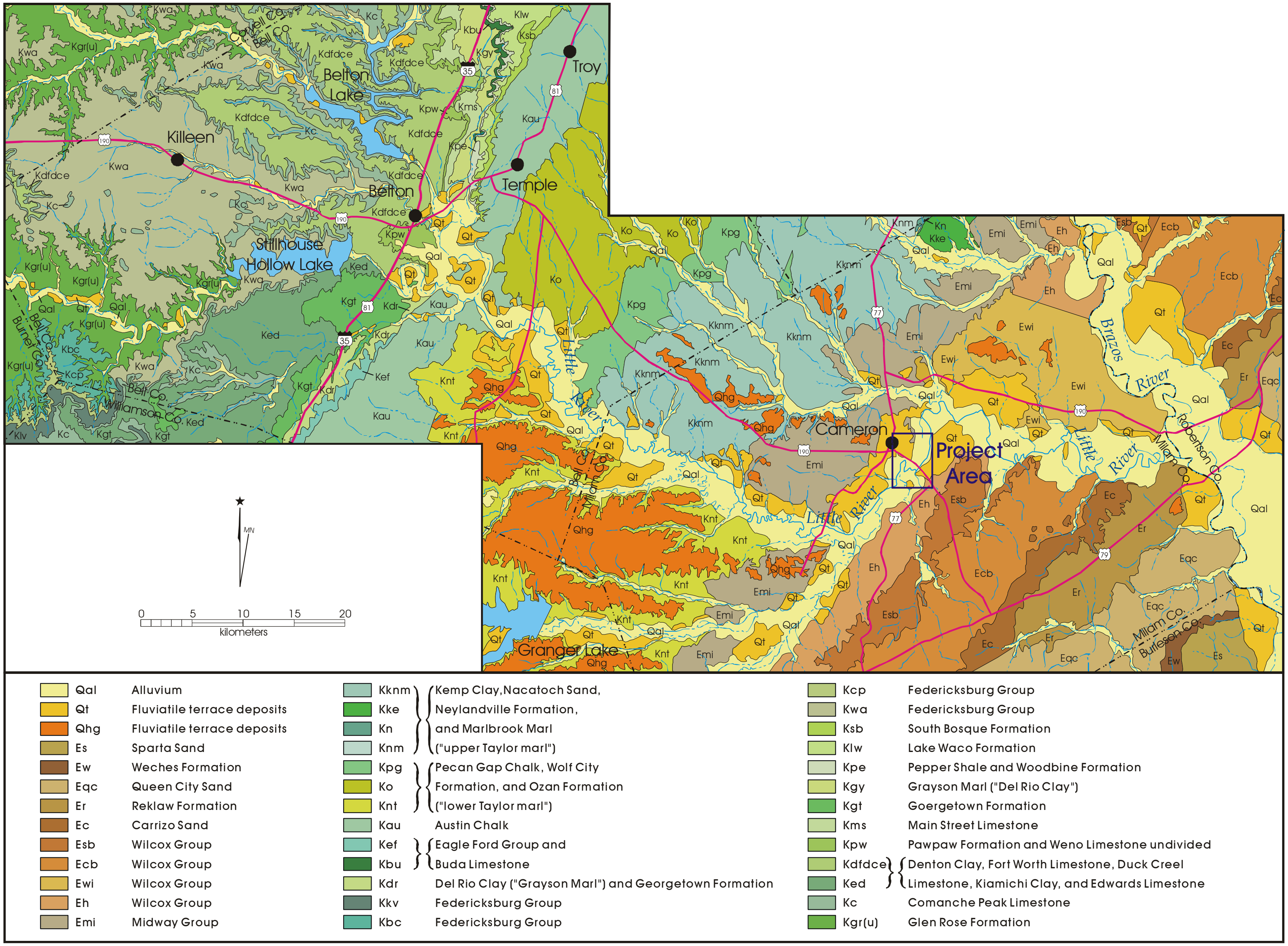


Figure 8-1. *Regional geology map of the project area (Bureau of Economic Geology, Austin Sheet:1981, Waco Sheet:1979). The Leon River and Lampasas River confluence to form the Little River just south of Stillhouse Hollow and Belton reservoirs. Below the project area the Little River empties into the Brazos River.*

combination of the ten sediment cores and generalized bridge cores given in the testing report (Mahoney and Tomka 2001). Backhoe and archeological block units containing radiocarbon ages from the testing phase were incorporated with the sediment cores where appropriate. A cutbank cross-section was constructed from descriptions of seven vertical profiles from two cutbank locations (CB1a–c and CB2a–d). Three radiocarbon ages were obtained from charcoal samples taken from the sediment cores and six radiocarbon samples from charcoal in the cutbank. Radiocarbon analysis was performed by Beta Analytic, Inc., and results reported in radiocarbon years before present (yr BP; Table 8-1).

Floodplain Geomorphology

The Little River is a meandering, mixed load stream flowing within a Holocene valley approximately 2 to 5 km wide (Figure 8-1). The modern channel is entrenched 6 to 7 m below the modern floodplain surface and hydrological analysis from the local water-discharge gauging station indicates that the floodplain is inundated with floodwaters approximately once every two years. Above the confluence with the San Gabriel River, the Little River channel is highly sinuous with a narrow meander belt and flows within a wide bedrock-confined valley (Figure 8-1). Below the confluence

Table 8-1. Results of Radiocarbon Assays from 41MM340

Sample No. [1]	Alluvial Unit, Paleosol	Location	Depth (cm)	^{14}C age[2] (yr BP)	Calendar Years[3] (one sigma BP)	Material	Interpretation
Beta-128738[5]	1	BHT-12/C-15	290	4720±70	5600-5305	sediment humate	maximum for deposition
Beta-167965[4]	1	CB2b	930	4390±40	5034-4868	hearth charcoal	time of deposition
Beta-167964[4]	1	CB2b	620	3090±50	3361-3214	hearth charcoal	time of deposition
Beta-141840	1	BHT-A/N-3	135	3050±40	3340-3210	hearth charcoal	time of deposition
Beta-141826	1	BHT-26/C-4	120-130	2880±40	3080-2940	hearth charcoal	time of deposition
Beta-141838	1	BHT-A/N-3	94-104	2800±40	2950-2850	hearth charcoal	time of deposition
Beta-141825	1	BHT-26/C4	100-110	2770±50	2920-2786	hearth charcoal	time of deposition
Beta-167961[4]	1	CB1a	724	2770±40	2920-2786	dispersed charcoal	time of deposition
Beta-167960[4]	1	CB1a	278	2460±40	2710-2360	hearth charcoal	time of deposition
Beta-141834	1	BHT-A/N-3	60-70	2440±40	2710-2350	hearth charcoal	time of deposition
Beta-141835	1	BHT-A/N-3	70-80	2420±50	2350-2710	hearth charcoal	time of deposition
Beta-128739[5]	1	BHT-16	220	2130±60	2320-1955	sediment humate	maximum for deposition
Beta-128735	1	BHT-13/N-8	180	2030±60	2105-1890	hearth charcoal	time of deposition
Beta-167962[4]	2	CB1c	779	1640±40	1564-1519	dispersed charcoal	time of deposition
Beta-128737[5]	1	BHT-12/C-15	100	1500±70	1535-1285	sediment humate	time of soil formation
Beta-141842	1	BHT-24/N-7	70-80	1270±40	1265-1170	hearth charcoal	time of deposition
Beta-167958[4]	2	N-5	841	1160±40	1168-991	dispersed charcoal	time of deposition
Beta-128740	2	BHT-17/N7	40	1050±50	1060-910	hearth charcoal	time of deposition
Beta-141843	2	BHT-15/N-7	60-70	940±50	930-790	hearth charcoal	time of deposition
Beta-167957[4]	2	N-4	609	860±40	790-729	dispersed charcoal	time of deposition
Beta-167963[4]	2	CB2a	679	710±40	672-652	hearth charcoal	time of deposition
Beta-141841	2	BHT-24/N-7	40-50	500±40	543-510	hearth charcoal	time of deposition
Beta-128742	2	BHT-13/N-8	100	420±40	360-330	dispersed charcoal	time of deposition
Beta-167959[4]	3	N-10	961	280±40	425-294	dispersed charcoal	time of deposition

[1]Beta Analytic, Inc.
[2]Reported in radiocarbon years before present (yr BP) and corrected for variations in $\delta^{13}C$.
[3]Calibrated to calendar years from Stuiver and Reimer (1993).
[4]Radiocarbon samples from this report .
[5]Radiocarbon samples from the TxDOT survey phase; all other samples taken from the testing report of Mahoney and Tomka (2001).

with the San Gabriel River, the Little River meander belt pattern widens considerably and reaches from valley wall to valley wall. Small channel meanders similar to those upstream from the project area have formed within the broader meander loops. The change in channel pattern could be from a significant increase in discharge below the San Gabriel River confluence, or in response to late Holocene downcutting in the Brazos River valley downstream (Waters and Nordt 1995).

In the southwestern part of the project area the floodplain is 3.5 km wide, then narrows to 1.2 km at the Highway 36 bridge crossing, and widens again just downstream to about 2.3 km (see Figure 8-1). Pleistocene terraces form the valley constriction at the bridge crossing, a phenomenon that occurs repeatedly in the Little River valley south of the San Gabriel River confluence. The valley constrictions act as funnels that discharge large quantities of high velocity floodwaters downstream into a broad valley reach. Sloughs cutting across the inside of these large meander loops carry excess flood waters that spill out of the trunk channel during flood stage. The sloughs merge and diverge and eventually re-enter the trunk channel before or at the next large meander bend (Figure 8-2). Sites 41MM340 and 41MM341 reside within the inside of one of these large meander loops. More specifically, site 41MM340 is situated on the inside of a meander loop of a slough near the northern valley wall of the Little River floodplain. Site 41MM341 is situated between this large slough and the modern channel in the middle of the floodplain.

Alluvial Stratigraphy Interpreted from Deep Sediment Cores

Figure 8-3 shows the geoarcheological localities examined for this project in the immediate vicinity of 41MM340 and 41MM341 (the cutbank localities are shown in Figure 8-2).

Figure 8-4 displays an alluvial stratigraphic cross-section of the Little River at the bridge crossing constructed from sediment cores, and from shallow backhoe trenches investigated during the testing phase (Mahoney and Tomka

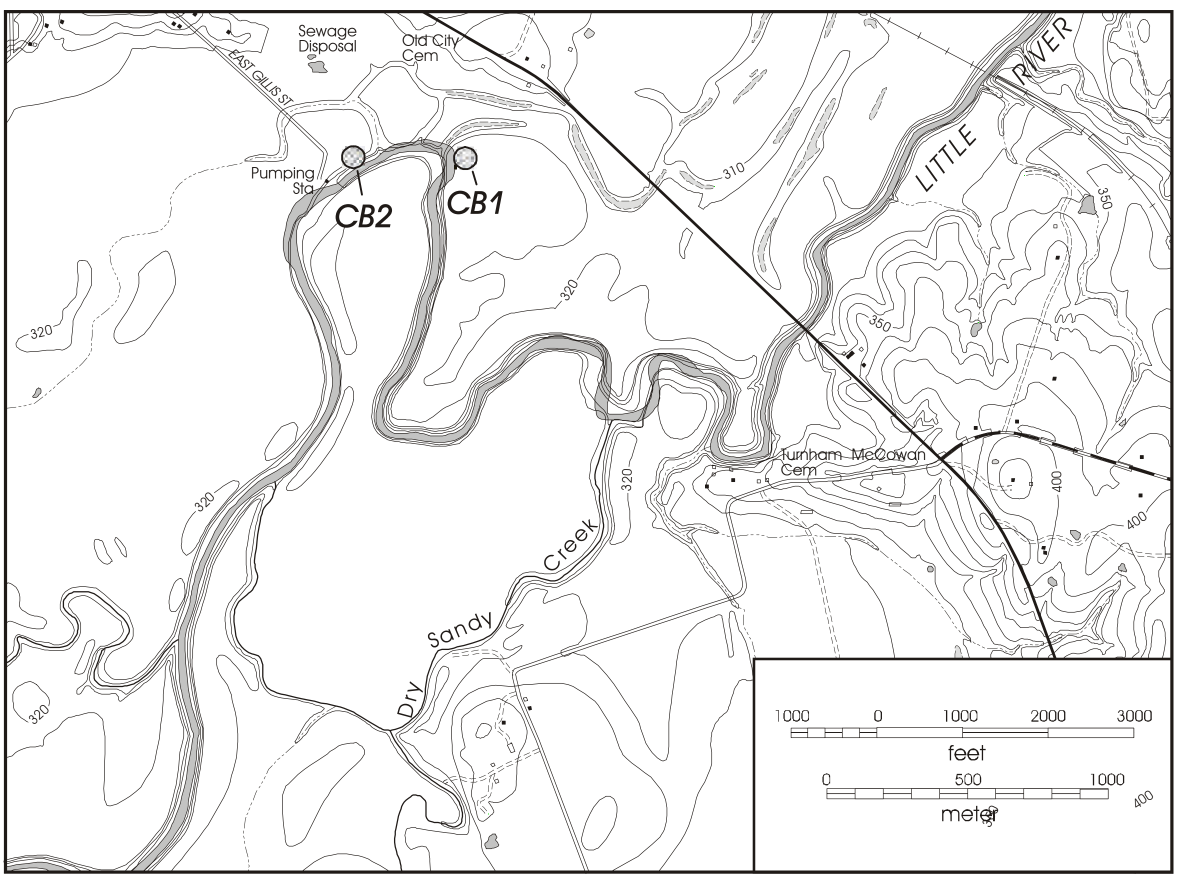


Figure 8-2. *Topographic map of the Little River project area showing cutbank localities 1 and 2.*

Image Redacted

Figure 8-3. *Topographic map of the project area showing backhoe trench (BHT), new sediment core (N), and 1930s bridge core localities in relation to sites 41MM340 and 41MM341 at the bridge crossing.*

2001). Four bridge cores (C-4, C-15, C-19, and C-20) were incorporated to complete the cross-section. Sediment stratigraphy, coupled with radiocarbon dating, reveals three unconformably bound alluvial units: Units 1, 2, and 3.

The bedrock valley floor contacts the Tertiary Midway Group, which consists of bedded and laminated black, very dark gray, gray, and greenish gray shale (noncalcareous) with few to common iron oxide redoximorphic features.

Unit 1

Unit 1 is displayed in N-1 through N-3 and C-4 in the northern part of the cross-section and in N-6 through N-8 and C-15 in the southern part of the cross-section (Figure 8-4). Unit 1 to the north rests on a bedrock strath 2 to 2.5 m higher than the bedrock strath beginning at N-3 and extending to the south. Thus, the alluvial thickness ranges from approximately 7 to 11 m. Unit 1 consists of three alluvial facies: lower channel, middle point bar, and upper floodbasin. Basal channel gravels are typically 40–70% in abundance, 0.2 to 6 cm in diameter, moderately well-sorted, siliceous and carbonatic, and grain supported in a light grayish brown to pale brown, medium to coarse sand matrix. The point bar facies consists of yellowish brown, brownish yellow and gray, fine to medium sands. Redoximorphic features in the form of light gray iron depletions and brownish yellow iron concentrations indicate a fluctuating water table. The upper floodbasin facies is clayey and pedogenically altered. The associated soil typically contains a very dark gray and clayey A horizon grading into a mottled olive yellow and grayish brown Bk horizon with up to 5% carbonate nodules and occasional redoximorphic features. The depth to carbonate nodules in the northern part of the cross-section ranges from about 70 to 130 cm, consistent with observations for similar soils along streams at Fort Hood for a humid to subhumid climate (Nordt 1992). Sedimentological relationships indicate that during deposition of Unit 1 the Little River was a mixed load stream similar to today and characterized by relatively thin channel gravel facies and thicker point bar and floodbasin facies.

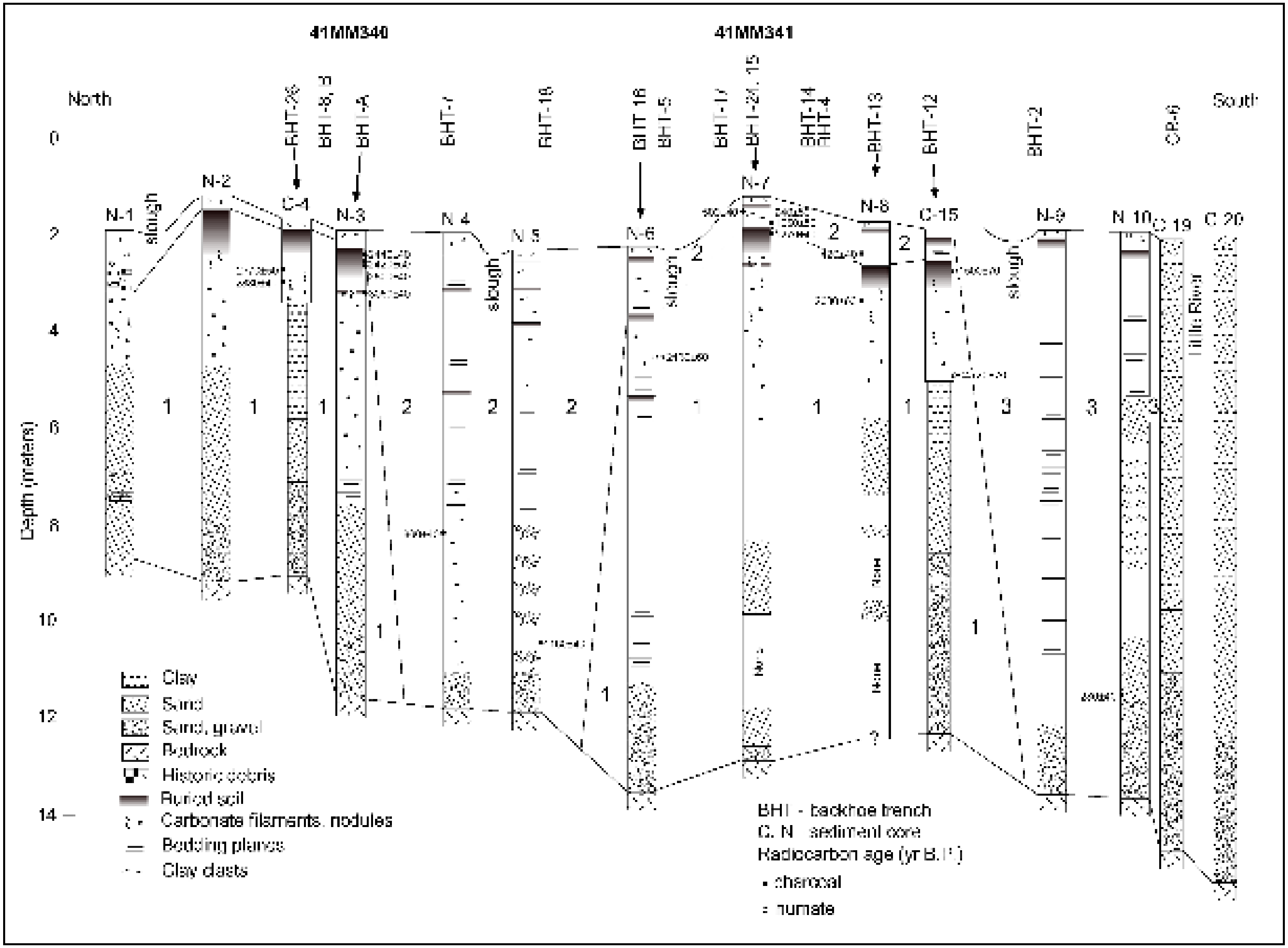
Radiocarbon dating of Unit 1 demonstrates that deposition began prior to 3050 yr BP based on a charcoal age (BHT-A/N3), or after 4720 yr BP based on a bulk sediment humate age (BHT-12/C-15; Table 8-1). The latter is probably sampling to older than the time of deposition based on comparisons of charcoal and humate dating along Fort Hood streams (Nordt 1993). Deposition slowed towards the top of Unit 1 in the floodbasin facies. For example, in the lower part of BHT-A/N3 (Figure 8-4; and Mahoney and Tomka 2001:Table 7-1), about 36 cm of sediment accumulated in 250 years (3050 versus 2800 yr BP), whereas it took 360 years to accumulate the next 24 cm of sediment (2800 versus 2420 yr BP). The radiocarbon ages are all from cultural features within the thick surface soil formed in the floodbasin facies. These features, and the sediments between them, accumulated rapidly relative to rates of pedogenesis, and they also impart a darker color to the sediments. These observations suggest that whereas there may have been brief periods of decreased rates of deposition, insufficient time was available to appreciably alter the sediments pedogenically during these episodes. Furthermore, dark zones related to occupation layers terminate at the margins of sites 41MM340 and 41MM341 indicating that they are anthropogenic rather than pedogenic.

In the southern part of the cross-section in Unit 1, fewer radiocarbon ages are available to assess rates of deposition. However, the ages are somewhat younger and indicate that the Unit 1 surface did not become stable until between 2030 and 1270 yr BP (N-8 and N-7, respectively). This, in turn, indicates that as much as a 1,000-year span of time may be compressed in the upper part of Unit 1 in the northern part of the cross-section. Apparently the Little River channel was migrating to the south, yielding slightly older and more compressed flood sediment away from the channel source in the northern part of the valley.

Unit 2

Unit 2 fills a slough exhibited in N-4 and N-5, with associated over-bank deposits in adjacent localities (see Figure 8-4). The slough consists of two facies: channel gravel and fine-grained channel fill. The basal channel gravels are up to 70% in abundance, 0.5 to 6 cm in diameter, moderately well-sorted, grain supported and in a pale brown fine to coarse sand matrix. In N-4, the channel gravels are overlain by thick and unweathered gray clays with numerous redoximorphic features, broken periodically by loamy beds. At least several very dark gray to black clayey beds occur throughout the column and may represent periods of depositional slow-down as reflected in redoximorphic features associated with hydrophytic plants. In N-5, a few fine detrital carbonate nodules occur within the weakly developed buried soil matrices. The surface soil is weakly developed and stratified, but classification is difficult because of surface disturbance.

A radiocarbon age from near the base of the slough is 1160 yr BP with an age of 860 yr BP from approximately 3 m above. This demonstrates that the slough began filling


41MM340
41MM341
North
South
Depth (meters)
slough
Little River
Clay
Sand
Sand, gravel
Bedrock
Historic debris
Buried soil
Carbonate filaments, nodules
Bedding planes
Clay clasts
BHT - backhoe trench
C, N - sediment core
Radiocarbon age (yr B.P.)
charcoal
humate

around 1200 yr BP. Deposition most likely terminated shortly after 400 to 500 yr BP when the modern Little River downcut to its current position in the southern part of the floodplain. Whereas it is possible that the slough was actually the location of the Little River trunk channel between 1200 and 500 yr BP, it seems unlikely in that an avulsion would have been necessary to shift the channel to its modern position without eroding the intervening Unit 1 sediments. Avulsions typically do not occur in upland streams with relatively low sediment supply and a paucity of levees and crevasse splays.

Unit 2 and the large slough could represent one of many channels emanating from the large Little River meander loop in the western part of the project area created by frequent, high magnitude flooding beginning around 1200 yr BP. It is also possible that the slough shown in Figure 8-4 was the channel of the unnamed tributary entering the floodplain from the west, which was pirated by the large Little River meander loop as it migrated into the area (see Figure 8-2).

Unit 3

Unit 3 primarily borders the modern Little River channel in the southern part of the project area as revealed in N-9, N-10, C-19, and C-20 (see Figure 8-4). Unit 3 is comprised of a channel gravel facies, thick point bar sequence, and thin floodbasin facies. The gravel facies contains up to 70% gravels 0.5 to 3 cm in diameter that are moderately well-sorted and grain supported in a grayish brown medium to coarse sand matrix. The point bar facies consists of dark gray to dark yellowish brown silty clay and silty clay loam with common silt laminations grading up into a weakly developed surface soil with an A–Bw or A–C profile sequence. The A horizon is typically very dark grayish brown clay to clay loam and the Bw horizon a dark gray to gray clay to clay loam.

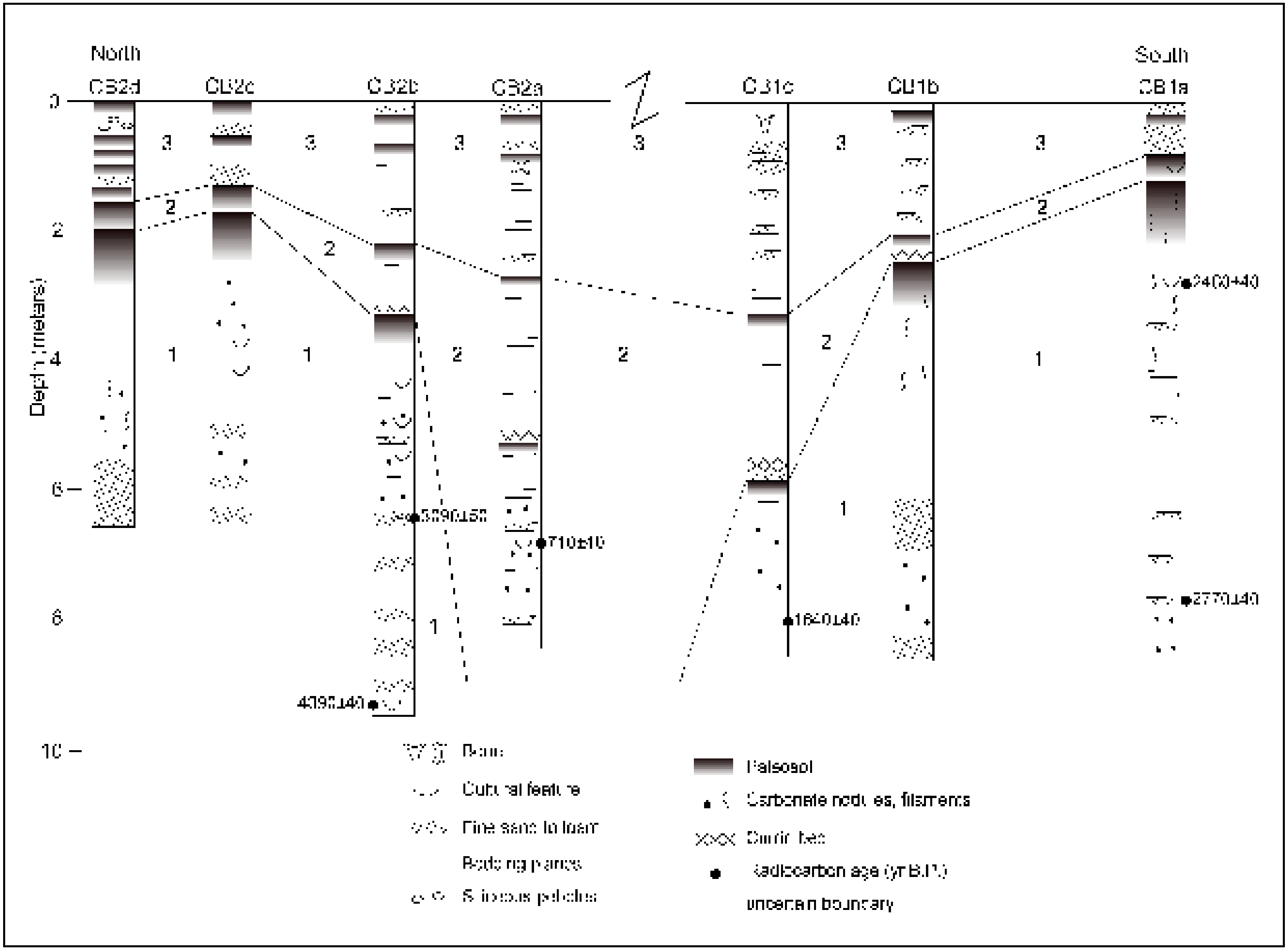
A radiocarbon age of 280 yr BP was obtained from the upper part of the channel gravels in N-10 indicating that incision occurred shortly after 500 to 420 yr BP (see N-7 and N-8). Floodbasin deposition has undoubtedly occurred during historic times, but is difficult to discern given the surface disturbance across the broader floodplain in the vicinity of the bridge. The Little River may well have been located near its modern position for the last 1,200 years, and simply downcut and backfilled with sediments after 500 yr BP.

Alluvial Stratigraphy Interpreted from Cutbanks

Three alluvial stratigraphic units were identified in the two cutbanks (CB1 and CB2) described west of sites 41MM340 and 41MM341, which are correlated to the stratigraphic framework established from the sediment cores near the bridge crossing (Figures 8-2, 8-4, and 8-5). Unit 1 is identified in CB1a, CB1b, CB1c, CB2b, CB2c, and CB2d (Figure 8-5). A point bar and floodbasin facies were identified. The lower point bar consists of bedded very pale brown, very fine sandy loams and dark grayish brown to brown silty clay and silty clay loams with groundwater carbonate nodules along bedding planes near the base of the section in some areas. The floodbasin facies is pedogenically modified to an A–Bk profile with filaments of carbonate on the south side and with both carbonate filaments and nodules on the north side. The A horizons are very dark gray to black clays and the Bk horizons are dark grayish brown clays. The beds in the lower point bar deposit dip away from the slough deposit on the south end (CB1a and CB1b), but towards the slough deposit on the north end (CB2b). The tentative correlation based on these observations is that the slough cut through Unit 1 deposits and is not facies-related to Unit 1. Based on depth to bedrock from the sediment cores, the bedrock and lower gravel channel facies of Unit 1 in the cutbank probably occur within a depth of an additional 1 to 2 m.

One chronological interpretation is that Unit 1 deposition was ongoing by 4390 yr BP (CB2b) and terminated between 2460 yr BP (CB1a) and 1640 yr BP (CB1c) as pedogenesis began (Figure 8-5). The other is that the lower exposure of CB1c is a remnant channel fill of Unit 1 truncated by Unit 2 as shown in CB2a. This suggests that the trunk channel of the Little River was flowing in the vicinity of the cutbank 1640 yr BP. This uncertainty is brought about because the 1640 yr BP age was obtained from dispersed charcoal not associated with a confining stratigraphic bed, rather than from a cultural feature. Regardless, the timing of pedogenesis is similar to that in Unit 1 (~1000 yr BP) described in the sediment cores at the bridge crossing.

Unit 2 fills the slough channel in the middle of the cutbank section in CB2a and CB1c and in the over-bank position in the remaining cutbank localities (Figure 8-5). The base of the slough deposit consists of massive to bedded dark gray clays with occasional slickensides grading up into a weakly developed A horizon with redoximorphic features indicative


North
South
CB2d
CB2c
CB2b
CB2a
CB1c
CB1b
CB1a
Depth (meters)
0
2
4
6
8
10
710±10
Paleosol
Cultural feature
Fine sand to loam
Carbonate nodules, filaments
Radiocarbon age (yr B.P.)
uncertain boundary

of a hydric soil. Carbonate nodules are smaller than those at the base of Unit 1 and are either detrital or of groundwater origin. Immediately above the deepest paleosol is the Currin bed, a light grayish brown to yellowish brown clay loam to silty clay loam flood deposit traceable throughout the cutbank. The upper part of Unit 2 in the slough deposit consists of massive to faintly bedded and mottled clays and silty clays grading up into very dark gray clays and silty clays of another weakly developed buried hydric soil. This upper buried soil can be traced laterally across Unit 1 to both the north and south, and is always above the Currin marker bed. A radiocarbon age of 710 yr BP from near the bottom of CB2a marks the timing of deposition of the slough. However, if the radiocarbon age of 1640 yr BP from the lower slough deposit in CB1c is part of Unit 2 rather than Unit 1, then the slough was carrying water and accumulating sediment at the same time the buried soil was forming at the top of Unit 1.

The slough deposit in CB1 and CB2 is split by an intervening deposit, partially covered in the cutbank, interpreted to be Unit 1 (the break shown in Figure 8-5). Although it is possible that the two sloughs exposed in the cutbank represent different episodes of channel filling, they may represent a single meander channel cross-cut in two locations by the modern Little River. Note that the cutbank sloughs appear to be related to either the surface channel that terminates approximately 300 m away from the cutbank as it heads towards site 41MM340, or to surface channels related to the unnamed tributary where it now enters the Little River (see Figure 8-2). In either case, and accompanied by the radiocarbon chronology, the cutbank slough may be related to the slough identified in the sediment cores near site 41MM340.

Unit 3 buries Unit 1 and Unit 2 in the cutbank and forms the modern floodplain surface of the Little River (Figure 8-5). Unit 3 consists of laminated and bedded gray to olive brown silty clay loams to fine sandy loams with little to no pedogenic alteration. Very weakly developed buried A horizons represent only brief periods of depositional slow-down. Multiple buried weakly developed A horizons in CB2d may reflect flood events emanating from the unnamed tributary where it now enters the Little River. Domestic cattle bones, and a radiocarbon age from the deep sediment cores at the bridge crossing, point to deposition of Unit 3 within the last 500 years. Unit 3 apparently fills the upper part of the sloughs cutting across the Little River floodplain towards sites 41MM340 and 41MM341, but thins appreciably in that direction. This indicates that Unit 3 was deposited after the Little River channel attained its modern position in the vicinity of the cutbanks. Again, Unit 2 slough deposits may have formed in response to high magnitude flooding spilling out of the banks of the Little River beginning sometime after 2000 yr BP, or perhaps closer to 1200 yr BP.

Summary of Alluvial Stratigraphic Interpretations

Three unconformably bound alluvial stratigraphic units were identified in the project area that correlate from cutbanks to sediment cores/backhoe trench localities at the bridge crossing (Figures 8-4 and 8-5). Deposition of Unit 1 began prior to 4390 yr BP and continued until near 1270 yr BP when deposition slowed considerably resulting in a buried A–Bk soil profile sequence in the upper floodbasin facies. During this time, the Little River channel was a mixed load meander belt slowly migrating from the northern to the southern part of the valley near the bridge crossing.

As the channel migrated to the south near the bridge crossing and to the north in the vicinity of the cutbank localities, high magnitude floods began to spill onto the floodplain and into a series of sloughs through the sites and downstream on the inside of the large meander loop. This event apparently was erosive initially and followed by acquiescent deposition of clays that eventually filled the sloughs with Unit 2 deposits. The largest and most surficially observable slough in the project area can be traced from CB1 and CB2 towards the bridge crossing where it meanders between sites 41MM340 and 41MM341. This particular slough was active between about 1600 and 500 yr BP, after which trenching of the modern Little River channel reduced flood frequency and slough sedimentation, confining deposition of Unit 3 to the margins of the river channel. It is possible that the unnamed tributary formed the primary slough before it was pirated by the modern meander loop at CB1 and CB2. At CB3 (not described) similar stratigraphic relations were observed as in CB1 and CB2: Unit 1 deposits with an inset Unit 2 slough, buried by sandy Unit 3 deposits. This lends further credence to the hypothesis that the slough network formed at about the same time.

Regional Correlation of the Alluvial Stratigraphic Framework

Alluvial stratigraphic work applicable to the study area has been conducted along the Leon River at Fort Hood (Nordt 1992), along the Lampasas River (Pearl 1997), and along the Brazos River to the south of the project area (Waters and Nordt 1995:Figure 6). In all areas, deposition was ongoing in the late Holocene between 4000 and 5000 yr BP. A period of paleosol formation/channel erosion occurred in the Brazos River basin around 2500 yr BP, which is not evident along the Leon and Lampasas rivers. The top of the well-structured Bk horizon in the upper part of Unit 1 in the Little River project area dates to near 2500 yr BP and may represent a truncated paleosol related to the paleosol in the Brazos River basin dating to the same time period. However, the number of cultural occupation zones rich in organics in the Little River project area render unequivocal correlation to the Brazos River basin problematic.

A period of landscape stability and soil formation ensued near 1000 yr BP in all localities with formation of this paleosol extending to as late as 600 yr BP in the Brazos River basin (Figure 8-6). After an erosional episode, a brief period of renewed deposition ensued that then buried the 1000 yr BP paleosol in the Lampasas and Little River localities (Units 3 and 2, respectively). Deposition terminated prior to 500 yr BP in both areas, and was followed by a brief period of pedogenesis. Channel erosion occurred again around 400 to 500 yr BP in the Lampasas, Little River, and Brazos River basins, and was followed by deposition creating the modern floodplain surfaces. The Leon River exhibits a slightly different history in that no additional erosional or soil formation events occurred after abandonment of the 1000 yr BP paleosol. The lack of correlation with parts of the Brazos River valley may be because episodes of channel erosion in the late Holocene were avulsion driven.

These data indicate partial linking among the different drainage basins in terms of periods of deposition, erosion, and soil formation. Long-term deposition was ensuing in the valleys during the middle to late Holocene when climate conditions were relatively mesic. However, between 1600 and 1300 yr BP pollen data suggests a warming trend (Bousman 1998) coinciding with formation of the 1000 yr BP paleosol when flooding may have been less frequent. High magnitude flooding, as documented in the broader North American Southwest near 1000 yr BP (Ely et al. 1993), appears to coincide with formation of the channel sloughs and truncation and burial of the 1000 yr BP paleosol in the project area. Flood magnitudes subsequently decreased and then increased again at 500 yr BP (Ely et al. 1993), precisely at the time that the stream network in the project area downcut for the last time.

Perhaps high magnitude flooding within the last 2,000 years began destabilizing the Little River floodplain network, as manifested by numerous sloughs cutting across broad meander loops in many parts of the valley. It is unclear why a paleosol and erosional event were identified in the Brazos River valley at 2500 yr BP and not in the other valleys, but the episode was much shorter than the paleosol/erosional couplet that formed near 1000 yr BP. It also appears that moving in a downstream direction from the Fort Hood area to the Brazos River, corresponding alluvial units and associated paleosols become more deeply buried.

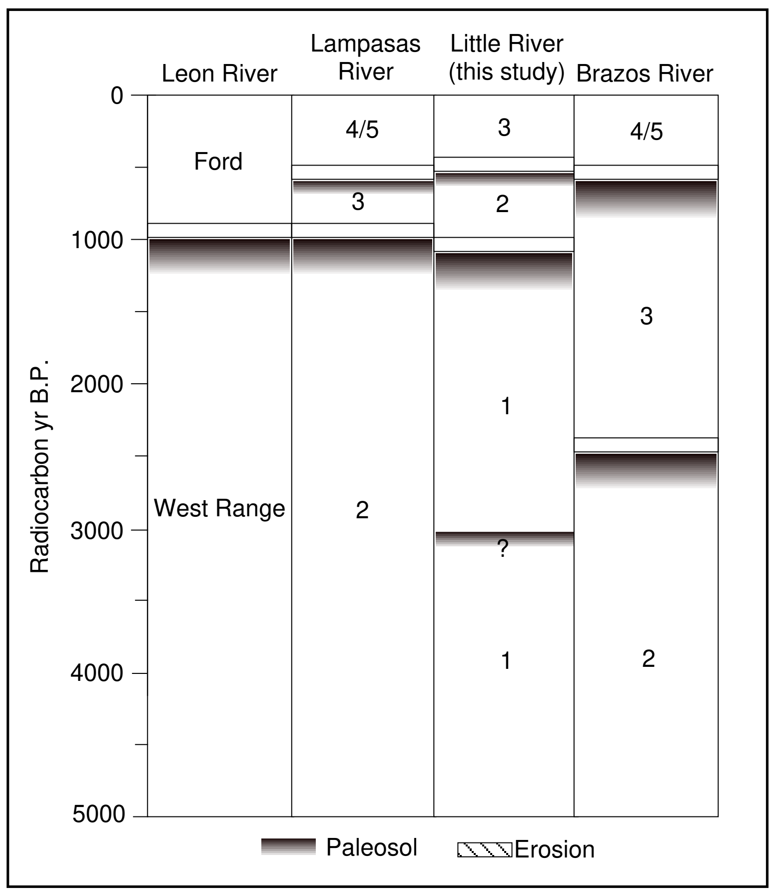


Figure 8-6. *Alluvial stratigraphic correlation chart of data from the Little River project area in comparison to surrounding drainage basins.*

Geoarcheological Implications for Sites 41MM340 and 41MM341

The dynamic fluvial history of the Little River during the late Holocene undoubtedly influenced settlement patterns and preservation potential in the project area. The earliest occupation identified occurred in Unit 1, dated to 4390 yr BP at a depth of 9.3 m (see Figure 8-5). Given the depth to bedrock observed in the sediment cores, perhaps only one to two more meters of alluvium occurs below this site. This suggests few, if any, early Holocene deposits are preserved in the project area because the meander belt spans from valley wall to valley wall. The earliest cultural components preserved at site 41MM340 date to around 3000 yr BP in Unit 1 at a depth of between 1.5 and 2 m. Accumulation of multiple occupation zones separated by quasi-sterile zones occurred up until about 2000 yr BP. The Little River channel at this time flowed in one of two areas. First, the channel was in the vicinity of site 41MM341 as it was migrating towards its modern position along the southern valley wall. This would account for compressed sediment/cultural stratigraphy in the vicinity of site 41MM340 because the river was located some distance away from the site. By the time site 41MM341 formed, the river was located near its modern position, but still depositing a veneer of sediment across site 41MM340. In both cases, the Little River would have been in the area of the sites, but not immediately adjacent to them during occupation.

The second possible location of the Little River during formation of sites 41MM340 and 41MM341 was in the slough that is now filled with sediments that post-date occupation of the sites. If so, the Little River avulsed from this location to near its modern position around 1200 yr BP, after which the slough filled with flood sediment emanating from the distal location of the new channel. Following this model, site 41MM340 would have formed immediately adjacent to the Little River on the inside of a meander loop and site 41MM341 would have been located on the outside of this meander loop. Regardless, the bulk of the sediment contained within the slough was deposited after site occupation. Yet a third possibility is that the Little River was near site 41MM341 (as proposed in the first possibility above) with the slough carrying waters from the unnamed tributary. This would have provided an even better resource base for the sites with two water bodies within the immediate area.

Regardless, sites 41MM340 and 41MM341 both formed in floodbasin settings receiving low energy flood waters and the deposition of clays settling from suspension. Preservation potential in primary contexts would be greatest where deposition was most rapid, as in Unit 1 in the subsoil horizons of the 1000 yr BP paleosol. In the surface horizon of the paleosol, preservation potentials would be less optimal because of potential compression of multicomponents and because of bioturbation associated with the formation of A horizons. These processes would have been more severe at site 41MM340 than 41MM341 because the former contains more time within a thinner package of sediment.

Similar observations can be made for occupation zones above the 1000 yr BP paleosol in Unit 2. In addition, these features formed in relation to an active slough (or tributary stream) in the middle of the project area and with the Little River most likely flowing along the southern valley wall. During this time, clayey floodbasin deposition from low energy floodwaters continued, but periods of landscape stability and soil formation were shorter. One feature at CB2 was actually preserved within a slough deposit dating to 710 yr BP. Any features preserved in Unit 3 would be no older than 400 to 500 yr BP and buried in point bar deposits along the channel or on the surface (or near surface) across the broader floodplain.

Stream Suspension Loads and Gravels from 41MM340

by Russell D. Greaves and Steve A. Tomka

Abundant gravels were encountered in several of the stratigraphic zones identified at 41MM340, while others were relatively free of gravels. Differences in gravel frequencies may reflect dynamic changes in the alluvial setting along Little River. In this section, we investigate more closely the patterns of gravel occurrence in the 41MM340 deposits to define broad patterns of alluvial deposition on the Little River floodplain in the vicinity of the site.

Nature of the Gravel Sample

The observations made here are solely in relation to the quantified frequencies of gravels within the excavation levels. This discussion uses information on clast sizes, frequencies and weights, and relies on the results of the geoarcheological investigations conducted by Nordt (Mahoney and Tomka 2001:Chapter 5) on the Little River floodplain. No corollary observations about these gravels were made at the time of fieldwork. All clasts were collected from water screening in the field and returned to the laboratory for quantification. Information regarding these gravels consists of the assigned archeological zone of provenience, numbers of clasts recovered from each excavation level, and some additional characteristics for specific units. Size sorting (≥ 2 in; <2 but ≥ 1 in; <1 but ≥ ½ in; and <½ but ≥¼ in) was performed on gravels from 12 (21%) of the 56 excavation units. The counts of the gravels in each of these size categories is available for all excavation levels. The weights (grams) of each fraction were recorded for each of the size sorted clast classes. A comparison of gravels from these 12 excavation units is presented by the defined stratigraphic zones in Table 8-2.

An initial archeological stratigraphy was identified during excavation (Mahoney and Tomka 2001:27–31). These zones were subdivided during the current project into additional subzones that later became equivalent to zones (see Chapter 7). Their identification is partially based on gross sediment characteristics and decisions regarding their content of archeological, molluscan, and vertebrate remains. Because we are concerned with tracking floodplain dynamics, and these dynamics are best expressed in the depositional zones identified during excavation rather than the analytical units, our discussion is structured around stratigraphic zones. This analytical strategy is also desirable because the radiocarbon assays obtained on the site date most directly the stratigraphic zones rather than the analytical units.

Clast frequency is presented in Table 8-2 for a sample of 12 excavation units (1-x-1-m) that have complete information on the recovered gravels from all identified zones. These units provide a sample of variability in gravel frequency across the excavation area. The southern units (N41/E11, N41/E13, N41/E15, N42/E11, N42/E15, N43/E12, and N43/E13) tended to have the largest samples, and several of these units were contiguous. The three units in the middle of the excavation block (N45/E12, N45/E13, and N45/E17) had moderate sample sizes, while the two northernmost units (N49/E13 and N49/E15) had relatively small samples.

The total sample contains 37,370 individual gravels weighing 82.2 kg. In general, gravel counts and weights were highest in the southern units and increased from grid west to east. The highest gravel densities were in N42/E15, N43/E13, and N41/E15. The lowest densities were in N41/E11 and N49/E15. As evident in Table 8-2, the zones varied in volume, and in general this variability strongly influences the raw number and weight of gravels recovered from each zone. That is, zones represented by high volumes of deposits also had higher counts and weights of gravels.

Observations

Based on raw counts, gravels were most common in the lower portion of the soil profile, from Zone 4 downward. Four of the six highest counts occur in Zone 4 or below. The highest densities of gravels in the upper soils were in Zones 2 and 3a.

Zone 4 had the highest number and weight of gravels recovered from any stratigraphic unit within the excavations. The sample from the 12 units indicates that 59% (n=21,955) of the gravels and 60% of the recovered weight (48 kg) came from this horizon. Zone 4 contained poorly sorted gravels with approximately equal weight contributions from the ¼–1-inch clast sizes. Deposits with lower gravel content occur below and above Zone 4. The units above Zone 4 (Zones 3c–3e) have very few gravels, and gravels also are sparse in Zone 5 compared with Zones 6–8. The Zone 4 deposits appear to correlate with the transition from Unit 1 to Unit 2 deposits as defined by Nordt (2001:16–20). This is based primarily on dated charcoal (Mahoney and Tomka 2001:31–35) and comparisons between Nordt's identified stratigraphy and the stratigraphically defined divisions (Zones). High gravel frequencies in the lower portion of the profile are present in Zones 8 and 6. Zone 8 contains the second highest clast frequency among the 12 units, with 4,527 gravels (12% of the total) weighing 9.9 kg (12.5% of the total sample weight). The decrease in recovered gravel from Zone 9 is probably due to the smaller volume excavated (327 liters).

The weight contributions from the different size gravels may be useful in identifying the maximum grain size transported, in combination with the statistically largest sample, to avoid overestimates based on small numbers of the largest transported bed load clasts. Zones 1a and 9 represent truncated depositional units. Table 8-2 indicates that two general patterns are present among the stratigraphic zones with gravel counts of 300 specimens or more. Given the small number of 1-inch clasts, in Zones 1b, 3b, 3c, 3d, 3e, 5, and 7, the ½-inch size range (approximately 12,700 microns) appears to represent the upper range consistently present in those deposits. In contrast, within Zones 2, 3a, 4, 6, and 8, the 1-inch size class (approximately 25,400 microns) represents the upper range consistently present in those deposits. These patterns in size class bed load contribution may suggest that higher energy levels may have been present within Zones 2, 3a, 4, 6, and 8. This conclusion is supported not only by the relatively large number of specimens in the 1-inch size class, but also by the fact that

Table 8-2. Breakdown of Gravel Counts and Weights by Clast Size and Individual Stratigraphic Zones

Zone & Liters of Matrix	Size Class	Count	Weight (g)	Percent Weight of 1" Class	Mean gravels/ liter of matrix
Zone 1a 1182	1/4"	333	271.1		
	1/2"	51	321.0		
	1"	1	29.8	4.79	
	2"				
	Total	385	621.9		0.33
Zone 1b 336.4	1/4"	138	139.1		
	1/2"	21	91.6		
	1"	1	73.3	24.11	
	2"				
	Total	160	304.0		0.48
Zone 1c 90.9	1/4"	4	1.3		
	1/2"				
	1"			0.00	
	2"				
	Total	4	1.3		0.04
Zone 2 1721.3	1/4"	1905	925.8		
	1/2"	213	1222.0		
	1"	21	1025.2	32.31	
	2"				
	Total	2139	3172.9		1.24
Zone 3a 1488.8	1/4"	840	794.2		
	1/2"	180	1045.0		
	1"	19	516.9	21.94	
	2"				
	Total	1039	2356.2		0.70
Zone 3b 300.1	1/4"	221	227.5		
	1/2"	37	247.9		
	1"	3	76.9	13.92	
	2"				
	Total	261	552.3		0.87
Zone 3c 127.4	1/4"	55	53.6		
	1/2"	16	85.1		
	1"	1	25.7	15.63	
	2"				
	Total	72	164.4		0.57
Zone 3d 72.7	1/4"	46	57.6		
	1/2"	9	48.9		
	1"			0.00	
	2"				
	Total	55	106.5		0.76

Table 8-2. continued…

Zone & Liters of Matrix	Size Class	Count	Weight (g)	Percent Weight of 1" Class	Mean gravels/ liter of matrix
Zone 3e 72.7	1/4"	237	225.4		
	1/2"	39	213.0		
	1"	5	119.0	21.35	
	2"				
	Total	281	557.4		3.87
Zone 4 2318.7	1/4"	18520	17965.4		
	1/2"	3053	17479.1		
	1"	376	11796.3	24.56	
	2"	6	795.3		
	Total	21955	48036.1		9.47
Zone 5 441	1/4"	696	691.5		
	1/2"	110	677.6		
	1"	11	382.1	16.16	
	2"	1	612.9		
	Total	818	2364.1		1.85
Zone 6 809	1/4"	3070	2947.6		
	1/2"	543	3577.4		
	1"	61	2974.3	29.68	
	2"	3	522.5		
	Total	3677	10021.8		4.55
Zone 7 1066.5	1/4"	1559	1390.2		
	1/2"	217	1123.1		
	1"	14	487.9	16.26	
	2"				
	Total	1790	3001.2		1.68
Zone 8 2236.3	1/4"	3896	3519.0		
	1/2"	565	3433.1		
	1"	64	2771.6	27.81	
	2"	2	242.6		
	Total	4527	9966.3		2.02
Zone 9 327.3	1/4"	163	157.5		
	1/2"	37	316.9		
	1"	7	502.0	51.41	
	2"				
	Total	207	976.4		0.63

by weight, this size class constitutes between 21.9% and 32.3% of the gravels within these zones. Lower energy levels may have been responsible for the deposits in Zones 1b, 3b, 3c, 3d, 3e, 5, and 7. Nonetheless, these conclusions are made with caution because the sample sizes are insufficient (Brown 1997:327–333). In addition, information about the paleochannel dimensions are critical to estimating past flow velocities. Even under ideal sampling conditions, such reconstructions can have significant variation (Brown 1997:88; Church 1978) that may exceed 100% of estimated flow calculations.

Five of the top six mean gravel densities by liter of matrix are in the lower stratigraphic zones (i.e., Zones 4, 5, 6, 7, and 8; Table 8-2). Only Zone 3e, which contains the third highest gravel density, is found in the upper portion of the stratigraphic column. Eliminating Zones 1a and 9, both of which are truncated, the five zones at the bottom of the profile (Zones 4–8) contained an overall average of 4.3 gravels per liter of deposit (32,767 gravels/6,871.5 liters). Within the upper portion of the profile (Zones 1b–3e), the overall average is only 0.95 gravels per liter of deposit (4,011 gravels/4,210.3 liters).

Because a number of the stratigraphic zones are represented by relatively small volumes of matrix, and relatively small gravel frequencies, they could not be included in the preceding interpretations. However, to obtain a general pattern of depositional processes throughout the profile, we combined the subzones (identified by letters) into broader zones equivalent to stratigraphic zones identified during testing. This strategy resulted in only one zone (Zone 9) having a small sample size (<300). Table 8-3 shows the gravel recovery patterns within these zones. Two patterns are evident when we consider the weight contribution of the 1-inch size clasts to the total weight of gravels, and mean gravel densities by zone. In Zones 2, 4, 6, and 8, the 1-inch size clasts constitute between 24.5% and 32.3% of the samples and the mean density of gravels ranges between 1.2 and 9.5 (mean=4.3) gravels per liter of deposits. On the other hand, in Zones 1, 3, 5, and 7, the 1-inch size clasts constitute only between 11.1% and 19.7% of the samples and the mean density of gravels ranges between 0.34 and 1.9 (mean=1.2) gravels per liter of deposits.

Archeological Implications

The alternation between deposits with high gravel content (Zones 2, 4, 6, and 8) and small to modest frequencies of clasts (especially Zones 1b, 3b, 3c, 3d, 3e, 5, and 7) is not directional. This most likely suggests that differences in streamflow reflected in deposits may indicate different hydrological regimes, or stochastic flood variation across the time period represented in the deposits at 41MM340. Nordt (2001:13) notes that modern streamflow data suggest floodplain inundation once every 24 months. Although subsurface investigations to determine the position of the old stream channel were not undertaken, this lack of directional variation in the deposits suggests that the different occupations at this site may have been placed in approximately similar relative positions at particular distances from the main channel.

Although the occupations of 41MM340 may have been regularly flooded by the Little River, the fact that five of the seven low-energy depositional contexts are above Zone 4 does suggest that perhaps flooding of the river was more common prior to around 2800 BP, the approximate age of the Zone 4 deposits. Over-bank deposition, due to flooding, may have slowed considerably after 2800 BP, with only two stratigraphic zones (Zones 2 and 3a; Zone 2 dates to about 2300 BP) indicative of depositional contexts similar to those predating Zone 4.

Freshwater Mussel Habitats and Streamflow

by Steve A. Tomka

Although the main contribution of the mussel shell analysis conducted on a sample from 41MM340 is related to subsistence practices, at least a small observation related to floodplain dynamics and streamflow characteristics can be made using the mussel data. Howells et al. analyzed a total of 22 samples, some 2,964 specimens, representative of a vertical sample through the deposits from 41MM340 (Appendix G). Although nine different species were identified in these samples, unionid taxa that prefer habitats characteristic of ponds, backwater settings and sloughs were entirely absent from the Little River samples. This is especially interesting in that sloughs are present in the vicinity of the site and taxa preferring standing or only slow flowing water and soft, sandy bottoms are common in nearby Brazos River samples.

Although the absence of these species may reflect dietary preference, it is unlikely that some of these species which are the largest among the unionid species would have been entirely ignored. In addition, their absence may also be due to their differential preservation since their thin shells may not preserve well. Nonetheless, if these species had occurred in the immediate vicinity and had been harvested, it is likely that fragments would have survived in the deposits.

If these factors do not account for their absence, the patterns may be interpreted as reflective of a lack of suitable habitats for the reproduction of these species. Again, while this is somewhat surprising in light of the number of sloughs on the floodplain, it may indicate either that sloughs usually contained only fast moving water or that they may not have contained slow moving water for sufficiently long periods to allow the establishment of viable populations of adapted

Table 8-3. Breakdown of Gravel Counts and Weights by Clast Size and Combined Stratigraphic Zones

Zone & Liters of Matrix	Size Class	Count	Weight (g)	Percent Weight of 1" Class	Mean gravels/ liter of matrix
Zone 1 1609.3	1/4"	475	411.56		
	1/2"	72	412.56		
	1"	2	103.1	11.12	
	2"	0	0		
	Total	549	927.22		0.34
Zone 2 1721.3	1/4"	1905	925.84		
	1/2"	213	1221.95		
	1"	21	1025.15	32.31	
	2"	0	0		
	Total	2139	3172.94		1.24
Zone 3 2061.7	1/4"	1399	1358.37		
	1/2"	281	1639.88		
	1"	28	738.5	19.76	
	2"	0	0		
	Total	1708	3736.75		0.83
Zone 4 2318.7	1/4"	18520	17965.35		
	1/2"	3053	17,479.15		
	1"	376	11796.29	24.56	
	2"	6	795.27		
	Total	21955	48036.06		9.47
Zone 5 441	1/4"	696	691.5		
	1/2"	110	677.6		
	1"	11	382.14	16.16	
	2"	1	612.9		
	Total	818	2364.14		1.85
Zone 6 809	1/4"	3070	2947.6		
	1/2"	543	3577.4		
	1"	61	2974.3	29.68	
	2"	3	522.5		
	Total	3677	10021.8		4.55
Zone 7 1066.5	1/4"	1559	1390.2		
	1/2"	217	1123.1		
	1"	14	487.9	16.26	
	2"				
	Total	1790	3001.2		1.68
Zone 8 2236.3	1/4"	3896	3519		
	1/2"	565	3433.1		
	1"	64	2,771.60	27.81	
	2"	2	242.6		
	Total	4527	9966.3		2.02
Zone 9 327.3	1/4"	163	157.5		
	1/2"	37	316.9		
	1"	7	502	51.41	
	2"				
	Total	207	976.4		0.63

species. Similarly, the absence of species adapted to soft sedimentary stream bottoms may also indicate that the stream discharge within the Little River was sufficiently rapid to maintain only a rocky channel bottom habitat unsuitable for other species. Finally, the mussel species pattern may also indicate that human populations simply did not visit the Little River floodplain during times when sloughs carried slower moving water and mussels preferring these habitats would have been available. Given the frequent reoccupation of the site, it is doubtful that all occupation episodes would have occurred well after flood deposits receded from all sloughs. Rather, it is more likely that the flow regimes within the Little River were sufficiently swift that they did not favor the establishment of abundant soft-bottom sand habitats and, therefore, species preferring these habitats did not become established in the stream channel in the vicinity of 41MM340.

Summary and Conclusions

by Steve A. Tomka

The geomorphic work conducted on the Little River floodplain in the vicinity of 41MM340 and 41MM341 and at cutbanks in the vicinity of the sites identified three alluvial units. The deposition of Unit 1 began sometime after 4720 BP and prior to 3050 BP and continued until about 1270 BP. Unit 2 represents slough fill deposits derived from overbank flooding and is encountered in sloughs found in the vicinity of the two sites. Radiocarbon assays from the fill deposits of the slough found near 41MM340 suggest that it began filling in around 1200 BP and had nearly entirely filled by around 400–500 BP. In its thickest form, Unit 3 is found near the present course of the Little River and thins significantly to the north. Radiocarbon dates on sediments from this unit suggest that the modern channel incised its present location around 500 BP.

Based on presently available dates, the earliest occupation of the floodplain occurred around 4390 BP, and it is found at a depth of about 9 m below surface in Unit 1. The earliest occupation of 41MM340 occurred around 3050 BP during the deposition of Unit 1. While deposition rates were relatively rapid during the early portion of human occupation of the unit (from 124–160 cmbs; Zone 8) rates of deposition seem to have slowed between 100–120 cmbs (Zone 7). The results of the gravel data analysis seem to agree with these shifts in deposition rates between Zones 8 and 7. In addition, the gravel data also suggest that shifts between high- and low-energy deposition contexts seemed to have occurred throughout the occupation of 41MM340. In general, however, deposition rates seemed to have been greater during the formation of Zones 4–8 than at later times. The only period that seems to have deposition rates similar to those preceding 2880 BP is during the formation of Zone 2 between about 2380 ± 50 BP and 2510 ± 40 BP (Mahoney and Tomka 2001:Table 7-1).

This general pattern seems to agree with deposition rate estimates derived from radiocarbon interval estimates and zone thickness information presented in Mahoney and Tomka (2001:Table 7-2). For instance, in Block 2 the 56 cm separating the bottom of Zone 4 and the top of Zone 8 may have accumulated at an estimated rate of 28.7 cm/100 yrs. In contrast, in the same block, the 14 cm separating the bottom of Zone 2 and the upper portion of Zone 4 may have accumulated at an estimated rate of only 7.8 cm/100 yrs. The fact that sediment deposition on the Little River floodplain in the vicinity of the two sites seems to have oscillated between high- and low-energy regimes, at least between Zones 2 through 8, seems to suggest that site 41MM340 occupied the same position compared to the active stream channel between approximately 2380 ± 50 BP (date from Block 2, Mahoney and Tomka 2001:Table 7-1) or 2440 ± 40 BP (Block 3) and 3050 BP.

The abandonment of 41MM340 around 1200–1300 BP and the early stages of occupation of 41MM341 some 400 m to the south suggests that the relationship of the Little River stream channel to 41MM340 changed dramatically around this time. The geomorphic work conducted in the Little River floodplain suggests that at the time of the occupation of 41MM340, the active river channel may have been in one of three locations: 1) near site 41MM341; 2) in the slough that is in the vicinity of 41MM340 and that began infilling after about 1200 BP; or, 3) near 41MM341 while site 41MM340 was located near the confluence of a tributary with Little River. The first scenario may explain the lack of sterile deposits capping the occupations of site 41MM340, since this scenario would place the stream at some distance from the site. This scenario would, however, not account for the gravel loads present on site and would also contrast with common hunter-gatherer tendencies to locate habitation sites near running water to reduce transportation costs. The second scenario would be consistent with both of these concerns but would necessitate the avulsion of the river from near 41MM340 to near its present channel sometime around 1200 BP. The problem with this scenario is that channel avulsions are not typical of upland streams. The advantage of the third scenario is that it places site 41MM340 in the vicinity of a watercourse, a tributary stream, and it therefore reduces transportation costs associated with water. Unfortunately, at this time we do not have the data to establish which of these scenarios transpired on the Little River floodplain. Nor do we have the data to allow us to establish whether the slough adjacent to 41MM340 is a remnant of a tributary stream or a former main channel of Little River itself.

Overall, in reviewing the information presented in this chapter in light of the specific research questions outlined in the Floodplain Dynamics research theme, it is clear that the results represent a mix of answers, new questions, and inadequate or insufficient data availability. For instance, the analysis of the gravels from the 12 units clearly indicates that the gravels are the product of relatively frequent flooding episodes. In addition, it appears that the intensity of the floods, and perhaps also their frequency, was greater prior to 2800 BP than following this period. Unfortunately, we do not know what factors are responsible for this change. It is possible that the pattern correlates with regional changes in climatic conditions or perhaps a shift in the location of the stream channel in relation to site 41MM340.

The latter possibility relates to one of the questions raised in the research domain, and is concerned with the relationship between floodplain dynamics and the human occupation and abandonment of the site. A radiocarbon date from sediments found (sediment core N-5) above the bottom of the slough in the vicinity of 41MM340 indicates that it began infilling sometime before 1200 BP. Unfortunately, we cannot be certain exactly when the slough began infilling and whether the slough is the former location of an old channel of the Little River itself or the channel of a tributary stream. Answering these questions would have required additional radiocarbon samples from the bottom of the slough and geomorphic research to trace the former channel of a tributary to Little River.

Similarly, because of the uncertainty as to what the slough adjacent to 41MM340 represents, we cannot be certain how the abandonment of 41MM340 and the occupation of 41MM341 relate to changes in floodplain dynamics and channel locations specifically. Regardless of what stream channel the slough adjacent to 41MM340 represents, we do know that this stream abandoned its channel not long before 1200 BP. However, since we lack a date for the uppermost portion of Zone 1 (see Mahoney and Tomka 2001:Tables 7-6 and 7-7) that contained small quantities of cultural material, we cannot directly link the abandonment of 41MM340 with the possible shift in the location of the stream channel. Furthermore, an investigation of this relationship would also necessitate the dating of the deepest cultural components found at 41MM341 to discern whether the abandonment of 41MM340 was followed immediately by the occupation of 41MM341.

If the slough adjacent 41MM340 is a former channel of the Little River, we can conclude that the geomorphological fieldwork and analyses were successful in documenting the systematic southward migration of the Little River channel across its floodplain. Dates derived from two extant slough scars suggest that the Little River may have occupied two previous locations prior to downcutting into its present channel sometime between 500 and 400 yrs BP. Because of its relationship to site preservation potential this is a significant conclusion. That is, slow migration of the stream channel through avulsion can skip over broad sections of the floodplain leading potentially to the preservation of archeological sites within these deposits. How common this process is and how broadly it can be applied to other portions of the Little River floodplain and to other streams is not known at the present time. Additional research along other portions of the Little River floodplain, as well as within the floodplains of other streams, may help define whether stream avulsion is a common process, either within certain drainages or during certain times.

A perspective on the relationship between long-term landform stability and human use of the floodplain can be obtained from the co-occurrence of paleosols and cultural materials across the Little River floodplain. If landform stability is defined as how much soil is deposited on or eroded from a surface during a given time, it is clear from 41MM340 and 41MM341 that between 3000–2000 yrs BP the Little River floodplain represented a relatively stabile land surface. Only about 110–120 cm of sediment were deposited on the floodplain at 41MM340 during this period. This measure of landform stability can be misleading though, since as indicated by the gravel data, this 1000-year period witnessed numerous over-bank floods. However, these flood deposits were so thin that they did not cap any of the recurrent occupation surfaces with a layer of sterile matrix. Therefore, while the Little River floodplain appears to have been a relatively stable landform during the occupation of 41MM340, it also represented quite a dynamic setting that was characterized not only by frequent and sometimes intense flooding but also channel avulsion episodes that slowly migrated the active channel from the north edge of the floodplain to its current southerly setting. Regardless, with the exception of the possible avulsion of the stream from the vicinity of 41MM340, these dynamic episodes were of sufficiently short duration that they never prevented the reoccupation of the site for periods sufficiently long to be measured by radiocarbon assays.

Finally, while long-term changes in the flow regime of the Little River may be signaled by the decreased intensity of flood events following 2800 BP, we are unable to establish with certainty whether this change is due to regional climatic changes. The gravel data suggests that a change in flow regimes may have occurred sometime around 2800 BP. The infilling of the slough in proximity to 41MM340 did not begin until about 1200 BP. These dates suggest that the change in flow regimes signaled by the gravels was not caused by a shift in the location of the channel with respect to the site. An increase in flooding intensity may occur during periods of drought as rainfall events can more severely erode barren surfaces. Such erosion can decrease in intensity as vegetation communities reoccupy landforms. These processes can generate the patterns in gravel occurrences noted in the 12 units discussed here and would likely be generated by regional-scale climatic oscillations between dry and moist periods. However, the downcutting of the Little River within its channel, as may have happened in the slough adjacent 41MM340, may result in similar changes in the amount and size of the gravels deposited during flood events. Therefore, lacking independent evidence, it is not possible to identify with certainty whether the changes in flow regimes identified at 41MM340 represent changes within the drainage of the Little River unrelated to climatic phenomena or are the result of regional climatic changes.

Chapter 9: Paleoenvironmental Reconstruction

Steve A. Tomka and Raymond P. Mauldin

This chapter brings together information relevant to the reconstruction of paleoenvironmental conditions during the time of occupation of 41MM340. In the research design accompanying the data analysis plan, Tomka et al. (2002) argued that the reconstruction of paleoenvironmental conditions may provide independent evidence for the reconstruction of floodplain dynamics. In addition, changes in climatic conditions also may impact the composition and structure of economically important species and such changes may in turn impact land-use strategies (i.e., frequency of moves, duration of occupation episodes) and subsistence practices. Therefore, it is useful to define variability in paleoenvironmental conditions because some changes in hunter-gatherer adaptations may be reflective of changes in this paleoenvironmental backdrop.

One of the research questions developed within this research domain relates to the potential effect of paleoenvironmental conditions on the composition of riverine resources. It seeks to define whether there were any changes in the flow regime of the Little River that would have impacted the riverine resource base (i.e., mussel shells and turtle remains). A second question focuses on the possibility that changes in paleoenvironmental conditions may have impacted the structure of resources on the Little River floodplain, and this may have in turn led to and conditioned the episodic occupation of the floodplain. It asks whether the shifts in snail populations and gravel deposits throughout the archeological sequence reflect changes in the immediate vicinity of the site and do these changes relate to the episodic occupation of the floodplain by hunter-gatherers. Finally, the third question seeks to clarify the scale of the paleoenvironmental changes. Were there any regional-scale paleoenvironmental changes during the occupation sequence of 41MM340 that would have shifted the vegetation boundary of the Blackland Prairie/Oak Woodlands?

To address these research questions, we compiled information from a diverse set of data including the composition of the vertebrate and invertebrate (both gastropod and pelecypod) faunal assemblages, the macrobotanical analysis of charred plant remains, variation in streamflow regimes as indicated by gravels, and changes in ^{18}O isotope values over time. These data types provide measures of paleoenvironmental conditions at different scales of analysis. For instance, snail species identification and composition provide information regarding on-site conditions, while macrobotanical species identification aids in the reconstruction of floodplain vegetation in the proximity of the site, and changes in isotope values (^{18}O and ^{13}C) may be reflective of regional climatic conditions.

As in the case of the investigation of floodplain dynamics in the previous chapter, in this chapter we rely on stratigraphic/depositional zones as the units of analysis. This strategy is adopted because these zones should reflect climatic and paleoenvironmental processes more directly than the analytical units that are based on changes in artifact densities. In addition, the radiocarbon dates from the site (Mahoney and Tomka 2001) date specifically the beginnings and ends of these depositional events.

Vertebrate Faunal Remains

Over 12,140 animal bones were recovered during the testing and data recovery excavations at 41MM340. The focus of this section is the materials from data recovery (n=11,139), although when possible, references are made to the smaller sample obtained during testing. Of the 11,139 pieces, provenience information was lost on 338 (3%) specimens during processing, cataloging, analysis, and data entry, leaving 10,801 specimens available for analysis. Although only a relatively small proportion of the data recovery sample could be identified to the order taxonomic level (n=779; 7.2 %;) and only 3.9% (n=424) could be identified to the genus taxonomic level, some interesting patterns are apparent within this sample (see Table B-2 in Appendix B). This discussion focuses on the distribution of vertebrate remains by stratigraphic zone. The discussion of subsistence patterns in the next chapter relies on bone distributions by analytical unit. The small discrepancies in the counts of bone by stratigraphic zone and analytical unit presented in tables in Appendix B occurs because not all specimens in the analyzed sample could be assigned to zones and/or analytical units.

In general, the species identified in the 41MM340 collection are consistent with the floodplain setting of the site. Mammalian species that prefer riverine habitats or deciduous woodlands are common (i.e., beaver, opossum, raccoon), as are reptiles such as turtles (including softshell turtles) and birds such as ducks. A minor grassland component is also present in the faunal remains as indicated by jackrabbits and cotton rats. Grassland communities may have bordered the wooded stream courses or open grassy patches may have been scattered throughout the deciduous riverine forest.

Patterns in a number of taxa are worth mentioning since they may provide some indication of paleoenvironmental conditions or habitat structure in the vicinity of the site. One of the more clear patterns is the abundance of rabbits, both cottontail (*Sylvilagus* sp.) and jackrabbits (*Lepus californicus*), in the deeper zones of the site. For instance, of the 346 mammalian elements recovered from Zones 4–8, 25% (n=88) are rabbit elements (see Table B-2). Among the upper levels, rabbit bones constitute 23% (n=53) of the mammalian bone (n=238), but a large percentage (62%) of these are clustered in Zone 2 (see Table B-2).

While jackrabbits are denizens of open habitats, cottontails prefer more wooded settings that offer greater cover. The percentages of jackrabbit remains are roughly equal in the deeper zones (Zones 4–8; n=35; 52%) and the upper zones (above Zone 4; n=32; 48%; see Table B-2). In contrast, cottontail skeletal elements are more common in the deeper zones (Zones 4–8; n=53; 72%) compared to the upper zones (above Zone 4; n=21; 28%). These differences imply that the floodplain in the vicinity of the site may have offered a mix of relatively open and more protected sparsely wooded habitats throughout the site's occupation but, unlike the other environmental indicators, it may suggest that canopy cover and the woody vegetation thinned rather than becoming more dense over time.

The final aspect of the faunal remains that may be revealing in terms of paleoenvironmental conditions is the relatively high frequency of turtle remains in two of the deeper stratigraphic zones (Zones 4 and 8) and one of the upper zones (Zone 2). Of the 180 turtle bones found at 41MM340, 116 (64%) were found in Zone 8. An additional 15 (8%) were from Zone 4, and 27 specimens (15%) were from Zone 2 (see Table B-2). Softshell turtle specimens were most common in Zone 8, with 39 (61%) of the elements. Softshell turtles prefer soft, sandy bottom conditions (Kirkpatrick 1996:34). These stream bottom conditions may have been quite common during the first occupation of 41MM340, since the site was established on what was likely a point bar. The sediments in portions of Zones 8 and 9 consist of coarse gray sands suggesting that sandy stream bottom conditions may have dominated over coarse gravel channel fill. Coarse sandy fill does not occur at any other time in the sediments exposed during data recovery suggesting that deposition conditions were changing over time.

Invertebrate Faunal Remains

The invertebrate faunal remains collected during data recovery at 41MM340 include large numbers of both mussel and snail shells. The mussel shells do not exhibit abrasions and wear derived from water transport, although, on average they appear to be smaller-sized individuals than their contemporary relatives. Relatively few of the mussels examined in detail appeared to be burned (see Appendix F) although mussels can be easily opened by placement on a bed of coals for a short period without leaving recognizable burn marks. Nonetheless, because mussels were often recovered in concentrations forming lenses or domed piles, and because they were not found as articulated complete valves, it is assumed that they are the result of human deposition rather than natural flood deposits or natural die-off populations. Although the mussels likely represent the products of human gathering and selection, because mussels are a relatively low ranked resource, it is likely that humans would have collected mussels roughly in the proportions in which they occurred in their natural habitat. Nonetheless, in interpreting the patterns in the mussel data, it is important to keep in mind that the samples are the result of human selection.

Although *Rabdotus dealbatus dealbatus* may have been gathered for food, there is no direct evidence that either *Rabdotus* sp., *Helicina* sp., or any of the other macroscopic species of snails represent samples biased by human selection. Therefore, it is expected that changes in species composition do not reflect human selection.

Mussel Shell

Almost 3,000 mussel shell umbos were analyzed by Howells as part of this special study. Of this sample, 2,939 (98.3%) were classified according to species. This sample includes specimens from stratigraphic Zones 1a, 1b, 2, 3, 3b, 4, 5, 6, 7, and 8. Because some of the sub-samples are quite small and do not allow for the definition of statistically valid patterning, they are combined into overall zone samples. That is, Zones 1a and 1b and Zones 3 and 3b are combined into Zones 1 and 3, respectively.

The densities of mussels by volume of the stratigraphic units indicate that the highest densities of mussels are found in Zones 6, 8, 2, and 4, respectively (Table 9-1). A total of nine species is represented within this sample but five of these (Tampico pearlymussel, Louisiana fatmucket, pistolgrip, washboard, and bluefer) occur in low numbers (<40 specimens). Of the four remaining species, two (threeridge and smooth pimpleback) are the most numerous. Threeridge appears to be a highly flexible species occurring in a variety of habitat conditions (Fullington and Fullington 1982:15-39). Smooth pimpleback appears to be a species that is less tolerant of arid conditions (Howells 2001b).

Figure 9-1 is a plot of the percentages of the four species that are represented by at least 100 specimens in the study sample. Threeridge and smooth pimpleback have the two largest sample sizes. In general, threeridge percentages are low in the deeper zones of the site and increase over time. In contrast, the percentages of smooth pimpleback are high in the deeper zones and decrease steadily over time. The higher percentages of smooth pimpleback in Zones 5-8 suggest moisture conditions and streamflow regimes that were relatively well suited to the habitat preferences of the species. The steady decrease of the smooth pimpleback species in the upper zones (1–4) suggests that conditions may have become more arid over time. It is possible that the increase of threeridge over time is a reflection of the fluctuating habitat conditions created by decreasing moisture regimes and the fact that this species could more readily adapt to such conditions.

Some support for this hypothesis may be found in the mussel shell sample from 41DW270, the Smith Creek Bridge Site (Hudler et al. 2002). At this site, Howells (2002:Table 68) shows that threeridge frequencies tend to increase from Level 10 to Level 4, although the trend is not a steady increase. Level 10 dates to around 2860 ± 40 BP while Level 4 dates to between 910 ± 40 BP (date for Level 3) and 2130 ± 40 BP (date for Level 4). Therefore, this trend is roughly contemporaneous with the steady increase in the same species at 41MM340. The common trend noted in these two sites separated by a large distance may suggest that the condition that appears to favor the increase in threeridge species may be a regional phenomena rather than one that is drainage- or stream-specific. Unfortunately, comparably large samples of mussel shells are not available from the same Blackland Prairie-Oak Woodlands area so that additional investigation of this trend is not possible.

Snail Shell

The snail analysis, utilizing a standard volume (10 cm^3) column sample, performed by Dr. Fullington, indicates that species richness ranges from 6 to 10 species throughout the column. The upper 65 cm of deposits have an average of 8 species, while the bottom 60 cm (65–125 cmbs) have a mean of 7.8 species. Based on habitat preference, the species identified by Fullington can be roughly divided into two principal groups open/sparsely wooded and densely wooded species. Five of the species are classified in the first group while four are classified in the densely wooded habitat type. Climax vegetation communities tend to have a more homogeneous, less diverse plant composition and structure, while transitional communities tend to be more patchy and heterogeneous both in structure and species composition. Therefore, if species richness can be used as a proxy for vegetation community diversity or patchiness, the pattern identified above suggests that the plant community and vegetation structure of the floodplain in the vicinity of 41MM340 was relatively homogeneous during the early

Table 9-1. Breakdown of Mussel Species and Densities by Stratigraphic Zone

Zone	Volume	Threeridge	Tampico pearlymussel	Louisiana fatmucket	Southern mapleleaf	Smooth pimpleback	False spike	Pistolgrip	Washboard	Bluefer	Total	Mussel/ volume
1	190.9	51	0	0	0	8	1	0	0	0	60	0.31
2	272.7	339	6	1	20	146	15	0	3	0	530	1.95
3	299.9	106	5	0	4	66	7	2	0	0	190	0.63
4	390.9	335	8	1	24	172	24	6	1	0	571	1.46
5	109.1	11	0	0	1	9	2	0	0	0	23	0.21
6	172.7	231	1	1	28	215	28	5	1	0	510	2.80
7	118.2	5	0	0	0	11	0	0	0	0	16	0.14
8	518.2	522	13	6	40	399	43	15	0	1	1039	2.01
Total		1600	33	9	117	1026	120	28	5	1	2939	

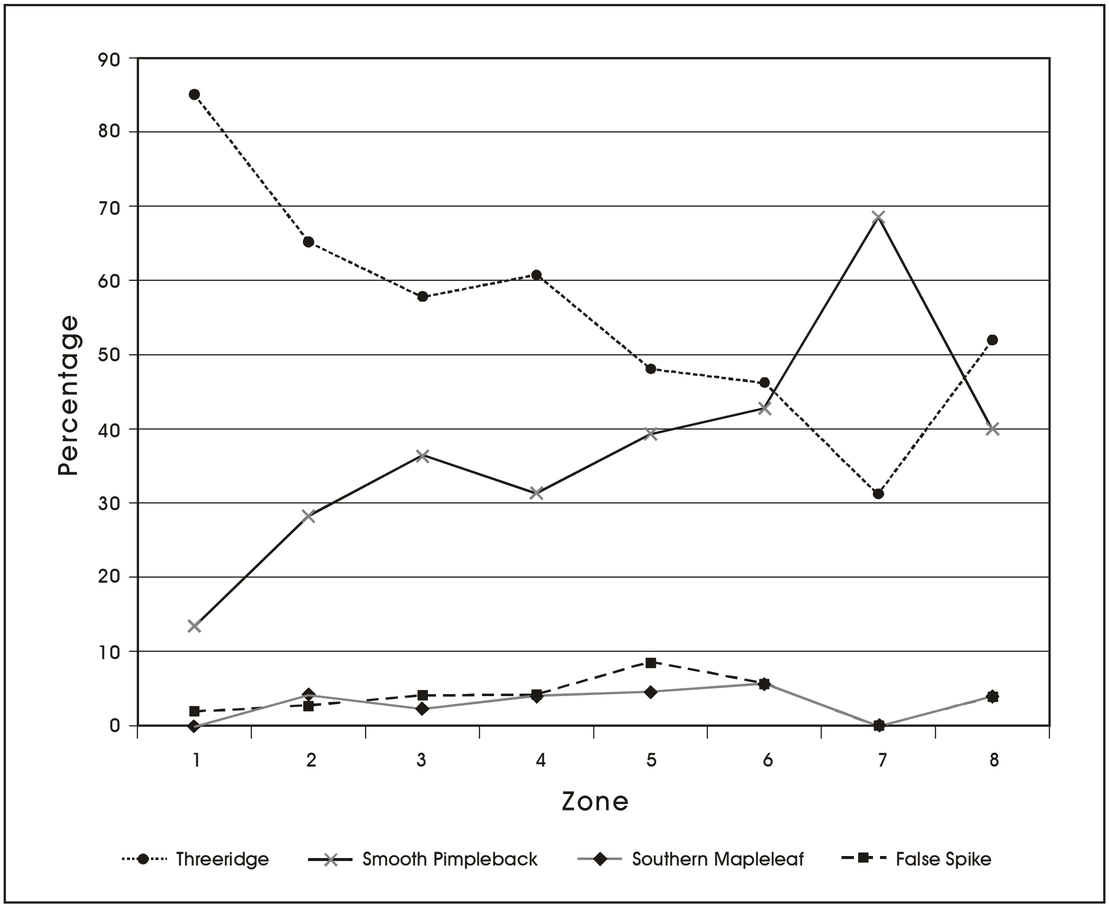


Figure 9-1. *Distribution of the four most common mussel shell species by stratigraphic zone.*

occupations of the site. Vegetation community structure may have become more complex and heterogeneous with time.

The controlled volume sample does not appear to show a significant shift in species composition through time. Part of the reason may be that the 10-cm^3 volume is too small to adequately sample the snail population. In addition, a single 10-cm^3 sample may not be representative of snail populations across a larger area of the site, especially since snails have relatively small home ranges.

While the controlled volume sample was not very productive, the testing phase analysis performed on a total of 1,638 specimens derived from samples from Zones 2, 4, 5, 6, and 8 showed a dramatic shift in wooded habitat compared to open habitat preferring species through time. The samples were derived from a combination of flotation samples (Zones 4, 6, and 8) and ¼-inch screen samples (Zones 2, 5, and 8). A total of seven species preferring woodland habitats was identified (*Helicina orbiculata tropica*, *Carychium mexicanum, Strobilops texasiana, Gastrocopta contracta, Gastrocopta pellucida hordeacella, Hawaiia minuscula,* and *Helicodiscus parallelus*). Of these seven species, only *Helicina orbiculata tropica* would typically be recovered in a ¼-inch screen. Only four species preferring open habitats (*Zonitoides arboeus, Rabdotus dealbatus dealbatus, Polygyra mooreana,* and *Praticolella berlandieriana*) were identified within the testing phase sample. Only one of these species, *Zonitoides arboeus*, would not be consistently recovered in a ¼-inch screen. Because of the nature of these samples, one would expect that open habitat preferring species would be dominant throughout the five zones sampled. However, as Figure 9-2 indicates, open habitat preferring species were most common in Zone 8 and declined steadily thereafter with the exception of a small increase in Zone 5. In contrast, wooded habitat preferring species represent the bulk of the samples from Zone 6 through Zone 2.

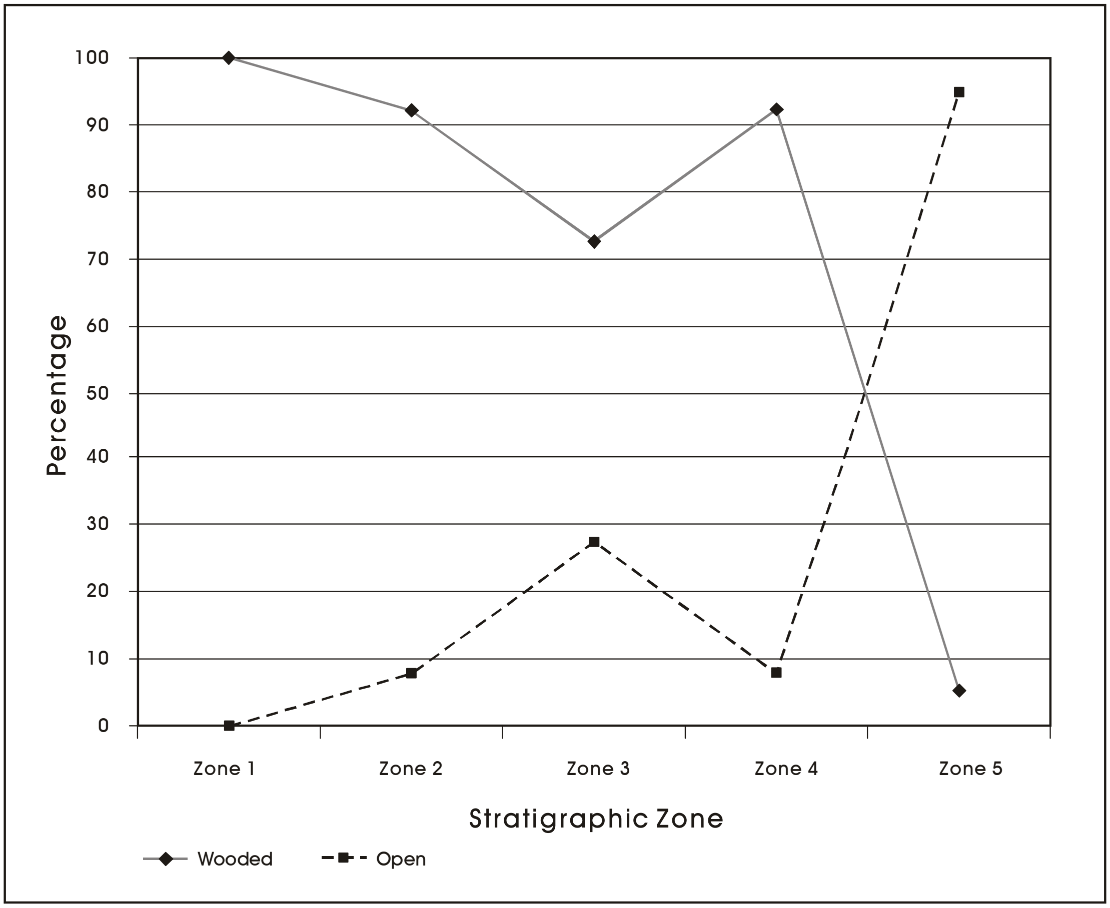


Figure 9-2. *Distribution of wooded habitat and open habitat snail species by stratigraphic zone (n=1,638).*

To further investigate whether these apparent patterns continue to hold true for the snail samples derived from data recovery, we analyzed the species composition of snail samples derived from 12 1-x-1-m excavation units (N41/E11, N41/E13, N41/E15, N42/E11, N42/E15, N43/E12, N43/E13, N45/E12, N45/E13, N45/E17, N49/E13, and N49/E15). These units are the same 12 that also had gravel samples analyzed in some detail in the previous chapter. As is the case for some of the testing phase samples, these samples derive from the ¼-inch water screening of deposits from Zones 1a, 1b, 1c, 2, 3, 3a, 3b, 3c, 3d, 3e, 4, 5, 6, 7, 8, and 9. All zones are not present within each of the four excavation units. Because of the nature of the samples, only macroscopic species were present within the samples. Four species (*Rabdotus dealbatus dealbatus, Polygyra mooreana, Praticolella berlandieriana,* and *Helicina orbiculata tropica*) were consistently present in large numbers throughout the deposits of the four units. Of these species, *Helicina orbiculata tropica* is identified as a snail that can occur in both open sparsely wooded and heavily wooded habitats but because it is a gill-breather it necessitates moisture and will choose wooded settings with ample leaf litter when available. The other three species are identified with open grassy or brushy habitats.

Table 9-2 presents the combined distribution and density of snail species by stratigraphic zone. The zone with the highest density of snails per liter of matrix is Zone 4 followed by Zone 8. Zones 3, 5, and 7 have the lowest snail densities in the site. *Helicina orbiculata*, *Rabdotus dealbatus*, and *Polygyra mooreana* have the largest samples while *Mesodon* sp. and *Helisoma* sp. occur in very low numbers. The distribution of the three most common species by depositional zone (Figure 9-3) indicates that *Rabdotus dealbatus dealbatus* tends to dominate in Zones 8 and 9 and thereafter shows a steady decline in numbers. Conversely, *Helicina orbiculata tropica* increases through the profile from Zone 7 through Zone 1. Although unit-by-unit variability is present

Table 9-2. Breakdown of Snail Species and Densities by Stratigraphic Zone

Zone	*Helicina orbiculata*	*Polygyra mooreana*	*Praticolella berlandieriana*	*Rabdotus dealbatus*	*Mesodon* sp.	*Helisoma* sp.	Total	Snail/Liter of Matrix
Zone 1	1651	20	2	32	0	0	1705	1.06
Zone 2	1691	35	4	101	0	0	1831	1.06
Zone 3	1703	84	12	60	0	0	1859	0.80
Zone 4	2340	143	22	505	0	6	3016	6.84
Zone 5	257	30	1	69	1	0	358	0.81
Zone 6	588	87	7	217	3	0	902	1.11
Zone 7	560	62	4	114	0	0	740	0.69
Zone 8	1445	257	34	3763	9	4	5512	2.46
Zone 9	116	18	0	284	1	0	419	1.28
Grand Totals	10351	736	86	5145	14	10	16342	

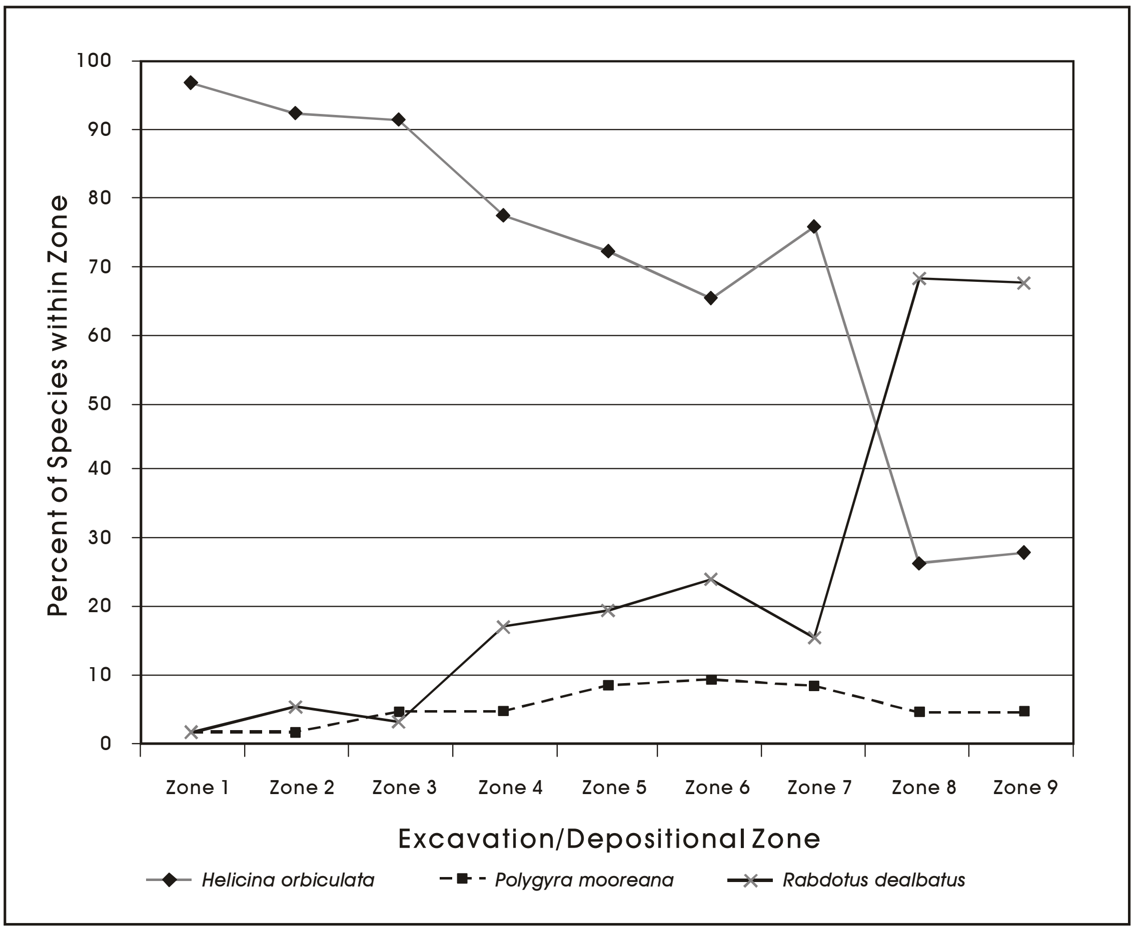


Figure 9-3. *Distribution of the three most common macroscopic snail species by stratigraphic zone.*

in the samples, the one clear trend that emerges is that open habitat species (i.e., *Rabdotus dealbatus dealbatus*) tend to dominate deeper zones while the single wooded habitat species (*Helicina orbiculata tropica*) is most common in the upper zones. Furthermore, it is likely that the predominance of wooded habitat species would be even greater if the samples included species recovered in flotation, since most of the "microscopic" species tend to be wooded habitat species. In addition, because juveniles of *Helicina orbiculata tropica* will not be recovered in the ¼-inch hardware cloth, it is likely that *Helicina* is under-represented in the collection.

To obtain an additional perspective on what these distributional trends may mean in terms of habitats and paleoclimatic conditions, we calculated the percentages of each individual snail species by zone. The results are presented in Figure 9-4. It is evident that the bulk of all of the *Rabdotus* specimens recovered from the site are from Zone 8. With the exception of a small peak in Zone 4, the percentages of *Rabdotus* remain low through the upper zones. A tri-modal pattern is evident in two species, *Praticolella* sp. and *Polygyra* sp., as large peaks occur in Zones 8 and 4 and a smaller peak is present in Zone 6. *Helicina* sp. exhibit two peaks and the percentage of *Helicina* remains high rather than declining in Zones 1–3.

These patterns suggest that snail micro-habitat conditions at the time of its earliest occupation (Zone 8) were sufficiently variable to allow for the existence of a variety of snail species but the conditions were best suited to *Rabdotus* (open grassland vegetation with few shrubs and

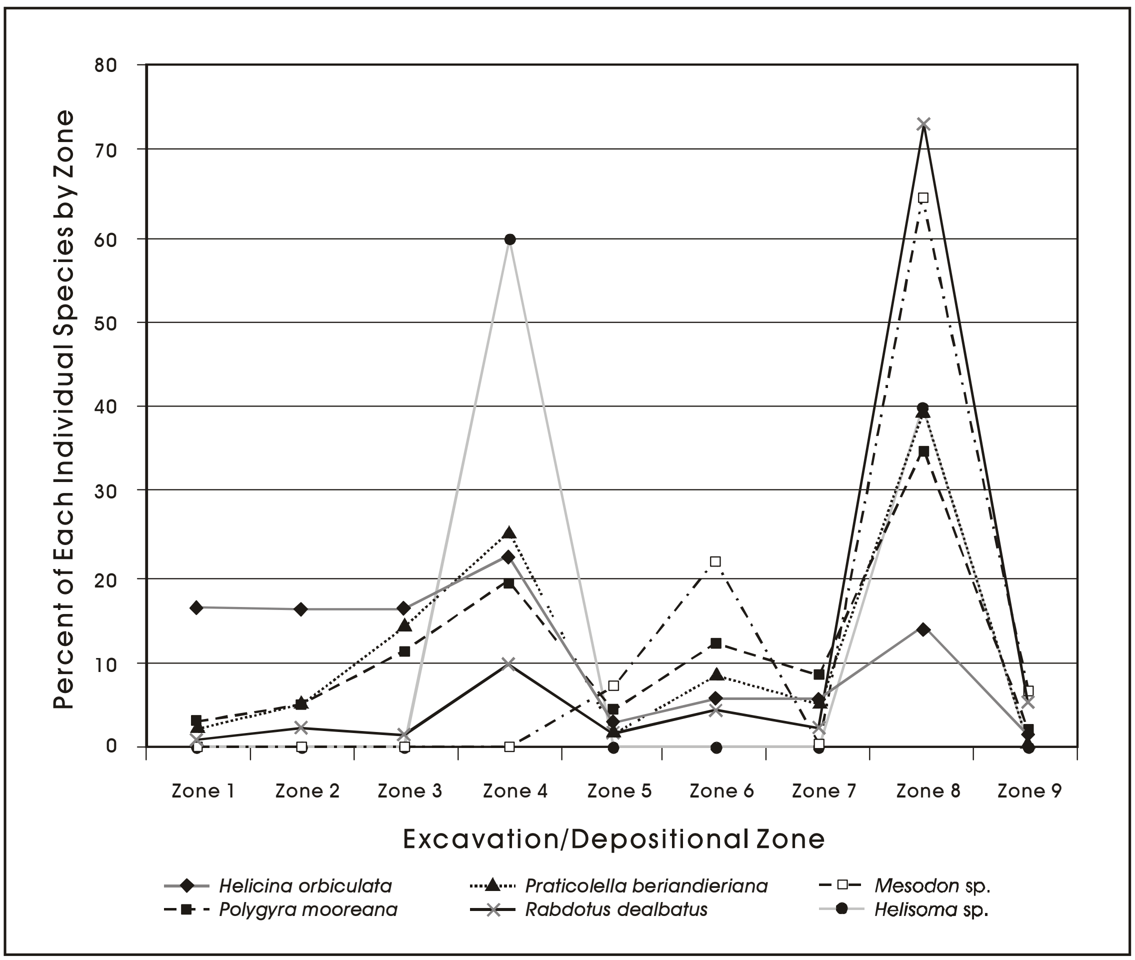


Figure 9-4. *Percentages of each snail species by zone.*

trees). Over time, however, the locality appears to have experienced a shrinkage in Rabdotus habitat perhaps as a result of an increase in woody invaders creating more shaded habitats. The multiple peaks in some species (in Zones 4, 6, and 8) suggest that the availability of habitat for these species oscillated through time. However, the fact that woodland *Helicina* species dominates the upper three zones suggests that by this time (i.e., around 2000 BP) the floodplain had become so heavily wooded that the habitat was best suited mainly for *Helicina* to the almost entire exclusion of other macroscopic species.

Macrobotanical Analysis and Changes in Floodplain Vegetation Structure

Previous macrobotanical analysis of samples from 41MM340 (Dering 2001) indicated that the charcoal samples were very reduced in size. Given that during testing many of the charred wood fragments were retained for radiocarbon analysis, it was thought that samples collected for radiocarbon dating may offer a better potential to identify taxa due to their larger size. This strategy was further encouraged by the fact that the site components were well-dated and the retention of additional charcoal samples for radiometric analyses was not a high priority. To ensure that the macrobotanical analysis was successful in identifying many samples of wood and indicators of the plant food component of the diet, we submitted 162 charcoal samples originally retained for radiocarbon dating, 41 flotation samples from features and other contexts with high densities of cultural material, and 32 nut and nutshell samples collected during water screening (Appendix E).

Table 9-3 presents the distribution of features with identified wood species by stratigraphic zone. The largest number of features with identified wood charcoal occurs in Zones 2 and 4, each with five features containing identified woody taxa. It is no surprise that the zones with fewer features have fewer woody taxa identified. A total of nine woody taxa was identified and all nine are representatives of a deciduous hardwood vegetation community. Oaks are the likely dominants in the deciduous hardwood forests while species such as willow-cottonwood, pecan, hickory, and walnut are common in riparian woodland settings.

Although the number of features sampled has an impact on the number of identified taxa by zone, several trends are notable in the data. Oak occurs throughout the four zones sampled and hickory and maple/boxelder are present in three of the four zones. Elm samples are present only in Zones 2 and 4, while walnut is present only in Zone 2, despite the rich samples from Zone 4, and pecan is present only in Zone 8, despite the large number of samples from Zones 2 and 4.

At the time of the writing of the research design, it was hoped that there would be some notable changes in the species of wood utilized for fuel at 41MM340 as the floodplain vegetation structure and composition changed. The analysis of the charcoal samples could not identify changes in the composition of the woody vegetation on the floodplain in proximity to 41MM340. The presence of pecan only in the deeper Zone 8 and of walnut only in Zone 2 is interesting but may simply be due to sampling biases. Other species found in the samples are consistent with a deciduous hardwood forest with a significant component of the samples derived from riparian species. The presence of some understory species (i.e., honey locust and gum bumelia) imply that the canopy was sufficiently open to permit the growth of these species or that flooding or other factors created openings within the deciduous riparian forest.

Streamflow Regimes

Observations related to floodplain dynamics and the depositional context of the large quantities of gravels recovered from 41MM340 also are relevant to the discussion of streamflow regimes. Patterns in streamflow regimes may in turn be used as potential proxy measures of overall oscillations between moist and dry climatic cycles. Since the

Table 9-3. Distribution of Features with Identified Wood Samples by Stratigraphic Zone

Stratigraphic Zone	Feature Numbers	Common Name of Wood Species
2	1, 11, 12, 13, 48	Hickory; Oak; Willow-cottonwood; Maple/boxelder; Walnut; Elm
3b	14, 15	Oak; Maple/boxelder
4	4, 5, 16, 18, 23,	Hickory; Oak; Willow-cottonwood; Maple/boxelder; Gum Bumelia; Elm
8	7, 17, 51	Hickory; Oak; Pecan; Honey Locust

results of the analyses of floodplain dynamics and gravel deposition were presented in the previous chapter, only a brief summary is provided here to emphasize those aspects that are particularly relevant from a paleoenvironmental perspective. Gravels from 12 1-x-1-m excavation units were analyzed to discern patterns in deposition dynamics and periodicity. Two aspects of the gravel collections were investigated. These were the density of gravels within the stratigraphic zones and the size composition of the samples.

The analysis of the gravel densities by individual stratigraphic zones (i.e., 1a, 1b, 1c, 2, 3a–e, 4, etc.; Table 8-2) indicated that gravel densities per liter of sediment were highest in Zones 4, 6, 3e, and 8, in that order, and were considerably less in other zones, particularly above Zone 4. The percentage weight contribution of the 1-inch clasts to the overall weight of gravels from each zone also suggests that higher energy flooding in Zones 2, 6, 4, and 8 than in the other zones may have been responsible for the gravels deposited. In general, the gravel data seem to suggest a change in the streamflow regimes over time characterized by relatively frequent high-energy flooding early on shifting to a lower energy, less frequent pattern over time. The gravel data from Zones 2 and 3e may reflect repeated high-energy flooding episodes within an otherwise long stable period (Zones 1a–3d) characterized by less flooding.

The analysis of the gravel densities and clast sizes by combined stratigraphic zones (Table 8-3) shows a systematic oscillation between zones characterized by extended periods of frequent and regular high-energy flooding and extended periods of lower energy flooding.

Variability in ^{18}O Isotope Values

Because there appears to be a strong correlation between ^{18}O values in water and temperature (e.g., Coplan and Kendall 2000; GNIP 2001), several researchers have been successful in monitoring aspects of paleotemperature and/or changes in rainfall seasonality by monitoring changes in ^{18}O values in mussel shell (e.g., Abell and Hoelzmann 2000; Goodfriend 1991). Freshwater mussels incorporate the isotopic makeup of water into their shell during the growth cycle. Although the relationship is anything but simple (see Claassen 1998), in general, decreasing ambient temperatures result in decreasing water temperatures and a depletion of ^{18}O. Therefore, the more negative the ^{18}O values the cooler the water and ambient temperatures, the less negative the ^{18}O values the warmer the water and ambient temperatures.

One of several complications of this link between temperature and ^{18}O patterns is related to differences in the source of rainfall. Water vapor traveling greater distances will be depleted in ^{18}O. In the context of the current site location, storms originating in the Gulf of Mexico should have more positive values relative to storms originating in the Pacific.

To investigate changes in paleotemperatures during the time of site use, we used two different approaches, the first focused on mussel shell and the second focused on snail shell. First, we selected one specimen of the genus *Quadrula* from each of the following zones: 2, 4, 6, and 8. We extracted three individual shell samples, measuring approximately 1/8-inch in diameter, from each shell. These samples were to gauge the degree of variability in ^{18}O values within each individual shell. As a comparative baseline, we selected a single modern specimen of the genus *Quadrula* collected from the Little River gravel bar found in the vicinity of the site. This specimen was sampled in the previously discussed manner to obtain nine additional samples. Twenty-one samples were submitted for analysis from four individual shells. The ^{18}O values obtained from these mussels are presented in Appendix I.

A second set of samples was focused on snails from the genus *Rabdotus*. Thirty individual snails were submitted, with 28 of these coming from N49/E15 in Zones 2 (n=5), 3b (n=2), 3c (n=2), 4 (n=5), 6 (n=5), 7 (n=4), and 8 (n=5). The two remaining specimens were modern and were collected near the site in the early summer of 2003. The ^{18}O values obtained from these snails are presented in Appendix I.

Figure 9-5 shows the box plots for each of the four mussel samples from Zones 2 (17 cmbs), 4 (63 cmbs), 6 (73 cmbs), and 8 (102 cmbs) and the modern sample. The Zone 8 sample dates to roughly 3050 BP, Zone 6 to about 2800 BP, Zone 4 to approximately 2600 BP, while the Zone 2 sample dates to about 2380 BP. Although a larger sample would be preferable from the modern context to reduce variability, the median value from the modern shell is used as a baseline ^{18}O value, and is thought to reflect modern temperatures. The three individual samples from each of the four prehistoric specimens have a narrower range of variability than the modern samples. This could be a product of sample size differences between the modern and prehistoric samples, with the single modern specimen being more heavily sampled. The greatest variability in prehistoric ^{18}O values is in the oldest sample followed by the one in Zone 6. The least amount of variability in ^{18}O values is in the specimen

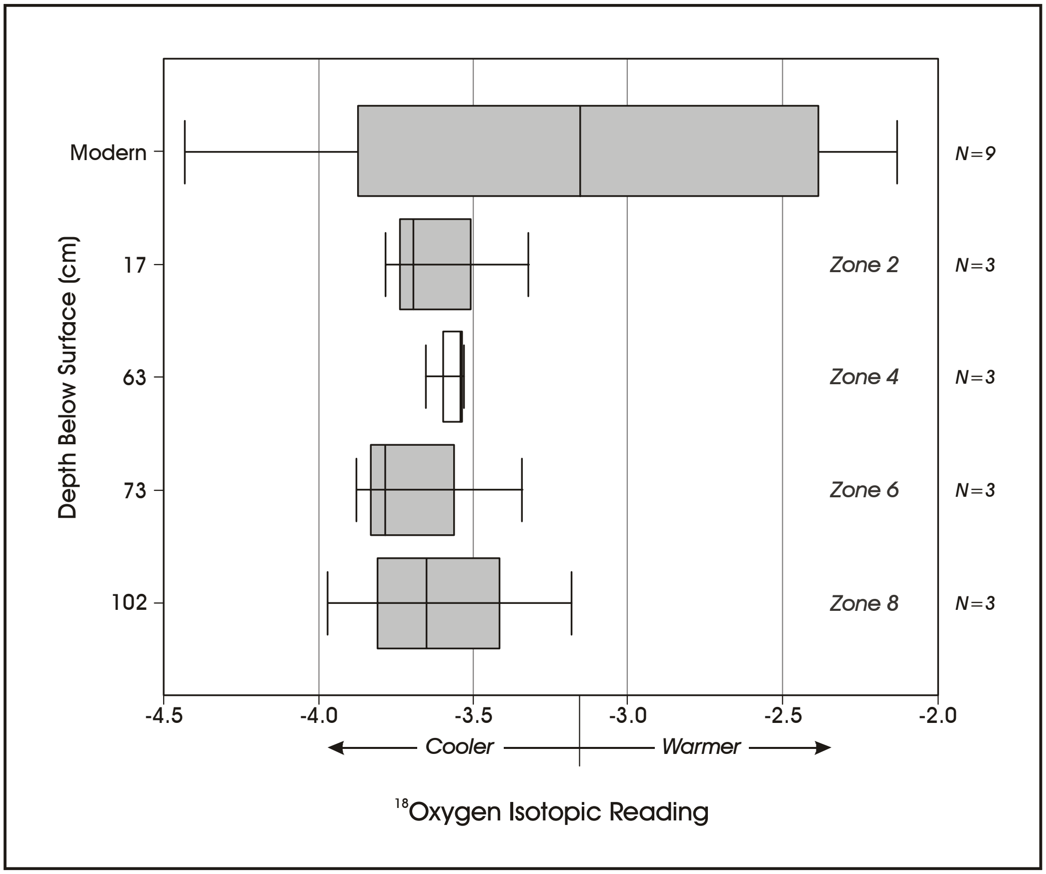


Figure 9-5. ^{18}O *values for 21 samples from one modern and four prehistoric mussel shells from 41MM340.*

from Zone 4. If the range in values is any indication, mean annual temperatures or the source of rainfall may have fluctuated more widely during the early occupations of the site compared to later times. Mean annual temperatures may have changed very little around 2600 BP during the time Zone 4 was being deposited.

Although the range in values is not dramatically different between the four prehistoric samples, there are some differences in the medians of the three values obtained from each sample. The differences in these median values may signal changes in mean annual temperatures during the periods sampled by the four prehistoric shells. Temperatures appeared to have become cooler between Zones 8 and 6 but a warming trend appears to characterize the shift from Zone 6 to Zone 4. Temperatures appear to have cooled again by the time Zone 2 was deposited only to climb to higher temperatures than at any other time during the occupation of 41MM340 reflected by these data.

Figure 9-6 presents a box plot of the snail samples by depth. As with Figure 9-5, the Zone 8 sample (112 cmbs) dates to roughly 3050 BP, Zone 6 (100 cmbs) to 2800 BP, Zone 4 (78 cmbs) to roughly 2600 BP, and Zone 2 (35 cmbs) to about 2380 BP. Interestingly, the overall pattern suggested by the snail data is considerably different than that suggested by the mussels. To the degree that the snail ^{18}O readings are indicative of temperature differences, the pattern in the median values suggests a gradual warming trend that culminates in Zone 4. Temperatures then oscillate through the remainder of the sequence. There is also considerable variability reflected in several of the earlier zones, with a wide range of values in Zones 8 and 7, and especially in Zone 4. Reduced variability is reflected in Zone 6 and Zone 2. If the range in values is any indication, then, like the mussel data, mean annual temperatures or the source of rainfall may have fluctuated more widely during the early portions of the occupation of 41MM340. Finally, note that in both the snail as well as the mussel

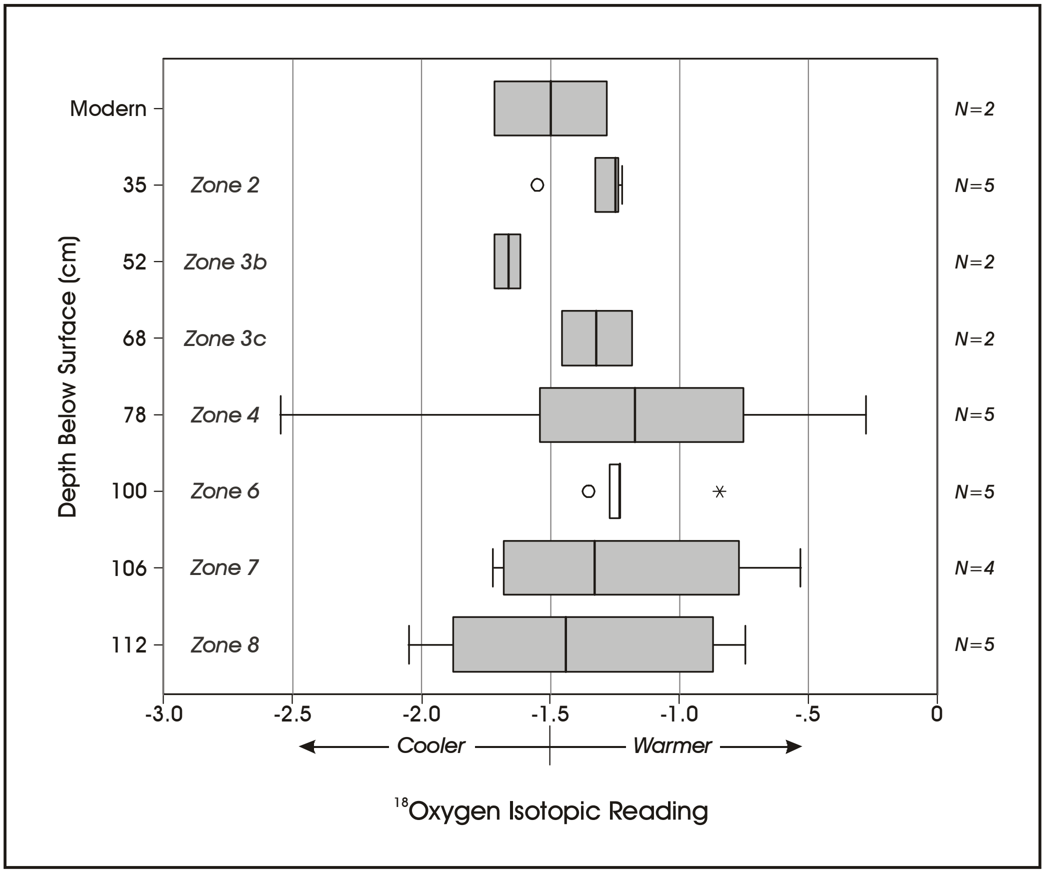


Figure 9-6. *^{18}O values for 30 samples from two modern and 28 prehistoric snail shells from 41MM340.*

values, it is not known whether these small changes in median ^{18}O values actually signal significant changes in temperature or rainfall. Given that the two patterns are quite different, it may be more useful to focus on the variability within a zone, and the oscillations through time reflected in both snail and mussel values.

Summary and Conclusions

One of the important aspects of these analyses is that some data types and analyses are more likely reflective of site-specific paleoenvironmental conditions (e.g., snails), while others are more likely responsive to broad regional changes in climatic conditions (e.g., gravel size classes and frequencies). For instance, the proximate driving forces behind changes in snail species over time may be changes in the vegetation structure of the plant communities found on the floodplain in the vicinity of the site. However, these changes may be ultimately caused by and reflective of regional-scale changes in climatic conditions such as oscillations between moisture-abundant and moisture-deficient periods. Therefore, when interpreting trends in paleoenvironmental conditions, it is important to differentiate between proximate causal factors that affect change at the local level and ultimate causal factors that place in motion changes at the regional scale.

At the beginning of this chapter we asked three questions that focused on the relationship between paleoenviromental conditions and site use. The first focused on the impact of paleoenvironmental conditions on riverine resources. The second question sought to define whether there were any changes in the floodplain resource structure that may be correlated to the seemingly episodic occupation of the floodplain. Finally, the third question sought to ascertain whether there were any regional-scale environmental changes that may have affected the location of the boundary of the Blackland Prairie/Oak Woodlands during the period of site occupation.

Answers to the first question derive from two data types, the mussel shells and the vertebrate faunal remains, and more specifically turtle remains recovered from the site. The mussel shell analysis identified dramatic changes in the relative abundances of two species—threeridge and smooth pimpleback. Threeridge percentages were low in the deeper zones of the site and increased over time, while the percentages of smooth pimpleback were high in the deeper zones and decreased through time. The changes in the percentages of smooth pimpleback suggest relatively elevated moisture regimes during the deposition of Zones 5–8 followed by more arid conditions over time. Turtle skeletal elements appear to be rather common in Zone 8 and are more common in Zones 4–8 than in the upper four zones, with the possible exception of Zone 2. Coupled with the abundance of softshell turtles—preferring soft, sandy bottom conditions (Kirkpatrick 1996:34)—in Zone 8, these data suggest that stream bottom habitat conditions may have been characterized by sandy deposits potentially related to the point bar deposits on which the first occupation of the site occurred.

These two data types and their analysis, then, indicates that whatever changes took place in Little River streamflow dynamics during the repeated reoccupations of 41MM340, they did impact the riverine resources harvested from the stream. We do not assume that the changes in the dominant species of mussel shell and the decrease in turtle remains over time is due to changes in consumption practices but rather that they reflect changes in the prey availability within the Little River.

Data types from which we can derive information related to changes in resource structure on the Little River floodplain include selected vertebrate (i.e., rabbits) and invertebrate (i.e., snails) faunal collections, and macrobotanical remains. The faunal analysis revealed relatively high frequencies of rabbit bones of both cottontails and jackrabbits within the 41MM340 deposits. Changes in the frequencies of skeletal elements of the two species offer some potential to reconstruct paleoenvironmental conditions. Jackrabbits usually prefer open prairie setting where they can outrun and outmaneuver their pursuers. Cottontail rabbits prefer more closed settings that offer greater cover from potential predators. Both species occurred throughout the column but cottontails were much more common in the deeper zones while jackrabbits were evenly spit between deeper and shallower zones. These patterns suggest that the floodplain in the vicinity of the site may have offered a mix of relatively open and more protected sparsely wooded habitats throughout site occupation. Contrary to other environmental indicators, however, the decrease in cottontail skeletal elements over time may suggest that canopy cover and woody vegetation thinned.

In the case of the snail analyses, changes in snail species are used as a proxy of changes in floodplain vegetation structure and composition. The results of the snail analyses also seem to support changing trends in floodplain vegetation structure. In the case of the snail species present at the site, open habitat preferring species seem to dominate the deeper deposits (Zones 6–8), while wooded habitat preferring species dominate snail populations in the upper zones. If the changes in snail populations do reflect changes in vegetation density and structure, the observed patterns may be a reflection of two distinct although related factors. On the one hand, the increase in wooded habitat species may simply be indicating that the floodplain had entered a period of relative stability that allowed for the establishment of a woody vegetation community that began replacing the more open or patchy, grassland dominated communities. On the other hand, the increase in woody vegetation on the floodplain may also have been encouraged by higher water tables brought on by increased effective moisture derived from extended periods of increased rainfall characterizing the entire region. In other words, two factors may be operating at distinct scales to produce the patterns in snail populations identified at 41MM340.

Finally, the macrobotanical analysis indicates that the deciduous woodland and riparian forest present at the site was well established and whatever changes may have impacted the floodplain had little effect on species composition. Changes in vegetation structure, but perhaps not the composition of the vegetation communities, may have been precipitated on the floodplain by proximate factors such as the migration of the stream channel, or ultimate factors such as regional changes in rainfall regimes.

The vertebrate and invertebrate remains appear to signal a change in floodplain resource structure during the occupations of the site. Whether these changes may have led to and conditioned the episodic occupation of the floodplain by hunter-gatherers may have depended on the factors that were behind these changes. That is, changes in streamflow patterns through time seem to suggest regular oscillations between extended periods characterized by greater flood intensity and/or greater flood frequency and intensity and periods of reduced flood intensity or frequency. Flood frequency or intensity may have declined over time given that only one stratigraphic zone, Zone 2, contains abundant evidence of intensive flooding above Zone 4. Although more frequent floods and more intense flooding may have discouraged the repeated and systematic reoccupation of the floodplain by hunter-gatherers, newly deposited alluvial soils could have contributed to the maintenance of a highly productive and diverse early successional vegetation community that may have been targeted by mobile groups (see Smith 1992).

We have obtained little direct data to address whether the changes in riverine resources or floodplain vegetation communities identified in the 41MM340 data are the result of regional-scale changes in paleoenvironmental conditions. The single most direct indicator of regional-scale paleoclimatic dynamics comes from the analysis of ^{18}O isotope values. Unfortunately, patterns derived from the analysis of ^{18}O isotope values in mussels and snails produced very different results. If the median ^{18}O isotope values of the modern samples can be taken as the ambient temperature for modern conditions, all prehistoric mussel samples seem to indicate slightly cooler temperature conditions during the Late Archaic compared to those of today (Figure 9-5). However, snail ^{18}O isotopic values (Figure 9-6) suggest that slightly warmer conditions may have been present during this same period. Clearly, snail and mussel values are responding to a variety of environmental factors that interact in complex ways to produce variable isotopic signatures.

Finally, proxy information related to the scale of changes in paleoenvironmental conditions comes from a number of snail analyses. For instance, Fullington and Fullington (1982:15-41, 15-53) noted a decrease in time of *Rabdotus dealbatus dealbatus* in Late Archaic deposits in a number of sites (i.e., 41WM53 and 4WM230) from the North Fork Reservoir. Corresponding with this decrease in *Rabdotus* there was an increase in the proportion of *Helicina orbiculata tropica* in the deposits suggesting a shift to more woodland settings at these sites over time. Similar trends in open versus woodland species over time were noted at the Adamek (41WM135) and Dobias-Vitek (41WM118) sites by Amaral and Witter (1973). Similarly, the upper levels (4–7) of the Smith Creek Bridge Site (41DW270) also appear to exhibit a similar trend of decreasing *Rabdotus* numbers compared to *Helicina orbiculata* (see Brown 2002:Table 70). Finally, paleoenvironmental data presented by Henry (1995) derived from a series of sites along Hog Creek in north-central Texas also indicates a generalized trend towards the replacement of the more open vegetation *Rabdotus* sp. with the more woodland *Helicina* sp. over time.

Many of the sites mentioned were located on floodplains and adjacent terraces. Therefore, it is likely that the shift in species composition reflects the same types of vegetation succession dynamics noted at 41MM340. Nonetheless, given that similar dynamics were occurring in a widely spaced area at roughly the same time during the Late Archaic would suggest that these processes were fueled by regional-scale changes in paleoclimate. Therefore, based on the available information collected during the data recovery efforts at 41MM340, we cannot determine with certainty whether the site-proximate changes reflect regional-scale or floodplain-specific changes and dynamics. Nonetheless, the similarity in snail species changes over time documented at several widely dispersed sites across the state suggests that even if the changes are the results of floodplain-specific changes and dynamics, it is likely that these changes are responses to broad regional-scale paleoclimatic patterns.

Having summarized these varied data types related to the reconstruction of paleoenvironmental conditions at the time of site occupation, it is worth remembering that our reconstruction of climatic conditions during the 800–1,000-year sequence of site occupation (see Chapter 2) indicated that grass pollen appeared to be increasing while arboreal pollen was decreasing over time. These trends suggest that, at least at a regional level, climate may have become increasingly xeric during the period of site occupation. How do the conclusions derived from the various data sets discussed and summarized above compare with this broad trend?

The geomorphological analysis of floodplain dynamics suggests that the earliest occupants of the site camped on a former point bar deposit. The snail species present at the time (*Rabdotus dealbatus dealbatus*) and the wood species identified in charcoal samples suggest a relatively open landform with the neighboring floodplain covered by a riparian deciduous forest. By the formation of stratigraphic Zone 6, the vegetation community on the former point bar was beginning to take on a more wooded look and open patches were becoming more restricted. Throughout roughly the first 400 years of occupation (Zones 4–8), intensive flooding tended to occur on a regular basis followed by extended periods of less intense floods. Human occupation of the site tended to occur during or immediately after these extended periods of flooding. Whether these periods of extended flooding contributed to highly disturbed floodplains that became rich with plant resources, or they represent periods when the stream was teaming with mussels, is not known.

It is also uncertain whether the periods of flooding necessarily represent periods of greater regional rainfall, contrary to our earlier reconstruction, or lesser rainfall occurring on devegetated surfaces. Runoff from bare surfaces may contribute to higher bed loads and may account for the zones with increased gravels and large clast sizes. Increased erosion may also contribute to some downcutting of the active stream channel which could result in the reduction of flooding of the former point bar deposit allowing it to stabilize as grasses or early successional species are replaced by woody species. Since the channel of the Little River remained relatively close to the site, perhaps even in the notable meander scar just some 100–120 m to the south of the site, flash flooding may have continued to impact the slowly stabilizing point bar landform and the surrounding floodplain. After about 2600 BP, flooding of the floodplain became less intense and does not seem to have impacted the vegetation composition and structure on the floodplain. The last intensive occupation of the site seems to have occurred around 2400 BP when intensive flooding again deposited large quantities of gravels across the floodplain. Subsequent occupations tended to be less intensive resulting in lesser quantities of cultural materials. We did not date the uppermost component at 41MM340 so no date is available for its abandonment. Regardless, sometime before 1260 BP, and perhaps as early as 1300 BP, the Little River channel avulsed from its previous channel and was re-established at some distance to the south of 41MM340.

In broad terms, this reconstruction fits the currently available data but it is still only a best estimate of the sequence of events and climatic conditions that may have influenced occupation and reoccupation, and finally abandonment, of site 41MM340. It also accounts for both site-specific trends in data as well as regional-scale climatic trends. Nonetheless, it remains simply one possible explanation among many until some of the assumptions holding the narrative together can be independently tested and data from other intensively explored sites can be incorporated into the reconstructive framework.

Chapter 10: Subsistence Strategies

Steve A. Tomka and Raymond P. Mauldin

In the two previous chapters we were concerned with defining the characteristics of the immediate environs of the site and the climatic conditions that prevailed during the long history of occupation of site 41MM340. In this and the following two chapters, we reconstruct the subsistence practices of the site's inhabitants, we examine the use of space and the food processing technologies employed (Chapter 11), and we examine the organization of activities associated with stone tool manufacture as well as tool design (Chapter 12).

In this chapter, we focus on the reconstruction of prehistoric subsistence practices at 41MM340. Recognizing that the nomadic lifeways of hunter-gatherers are in large part dedicated to resource procurement, we are also interested in identifying overall subsistence and land-use strategies to the degree possible. That is, we are interested in identifying how resource procurement activities (i.e., hunting, gathering) were organized to exploit the different parts of the economically useful landscape. Furthermore, because the site was repeatedly reoccupied over some 800–1,000 years, and during that time both the makeup and the structure of the resources changed, we are interested in identifying how subsistence and land-use strategies may have changed in response to changes in the resource base.

Several research topics, defined in the data recovery research design (Tomka et al. 2002), were identified to guide and focus this research. In addition to identifying the vertebrate remains that served as food sources for the inhabitants, we also needed to identify what were the species of pelecypods and the principal plant foods consumed by the site's inhabitants. Once this background information was obtained, we could begin reconstructing subsistence and land-use strategies and diachronic changes in subsistence. We were particularly interested in documenting if there were any changes in the overall diet breadth of the inhabitants over time. We also sought to identify if there were any indications of subsistence stress during the 800–1,000-year occupation of the site.

To elicit answers to these questions we relied on the analysis of data from three principal sources: 1) vertebrate faunal remains; 2) freshwater mussel shell samples; and 3) macrobotanical identifications of charred nut and seed fragments. The detailed results of these specialized analyses are presented in Appendices B, G and E, respectively. Because our analysis is concerned with the identification of hunter-gatherer subsistence practices, the units of analysis are not the stratigraphic/depositional zones used in the two previous chapters but rather the analytical units (AUs) defined in Chapter 7. These AUs are based on changes in artifact types and densities, and are supported by patterns in feature densities, diagnostic projectile points, and radiocarbon dates.

Vertebrate Faunal Remains

Faunal remains recovered during excavation, and which could be assigned to one of the seven AUs at the site, numbered 10,734 items. Table 10-1 shows the distribution of the vertebrate faunal remains by taxon and analytical unit. AU 4 followed by AUs 6 and 2 have the highest numbers of bones, while AUs 1, 3, 5, and 7 consistently have lower counts. The highest bone weight per liter of sediment (Figure 10-1) is found in AU 6 followed by AUs 4 and 2. Although these analytical units have high bone weights, the weight of bone per liter of sediment steadily decreases from the oldest to the youngest analytical unit. This trend also occurs within the low bone frequency units (i.e., 1, 3, 5, and 7). While the up and down oscillations in the weights are a product, to some degree, of analysis unit definition, there appears to be a decrease in bone weight from the oldest to the youngest AU. Note that this pattern suggests that bone preservation at the site probably was not dramatically affected by the age of the deposits for if that were the case, and all other things being equal, the pattern should be the reverse of the one evident in Figure 10-1.

Although only one bone fragment could be unequivocally identified as bison (*Bison bison*), many of the mammalian bones could be categorized in terms of size into very small, small, medium, large, and very large mammal groups. The very small group (n=2) contains bones likely derived from mice and rats. The small group (n=125) contains rabbit-sized animals, while the medium-sized group (n=22) consists of dog-sized specimens. The large mammalian bone group (n=2,435) contains deer-sized animal bones. Finally, the very large group (n=315) contains bison-sized animal bones.

Table 10-1. Distribution of all Bone by Taxon and Analytical Unit*

Taxon	**AU 1**	**AU 2**	**AU 3**	**AU 4**	**AU 5**	**AU 6**	**AU 7**	**Total**
Anas sp.		1		1				2
Anatidae				1				1
Ardeidae					1			1
Artiodactyla	10	76	15	38	23	49	6	217
Aves	4	78	12	84	34	79	20	311
Aves--medium		5			4	3		12
Aves--large	7	30	1	63	22	46	10	179
Aves--very large				1	3	1		5
Bison bison					1			1
Bovinae					2			2
Buteo sp.				2				2
Canis sp.		2	1	20	1	4	1	29
Carnivora				1		2		3
Castor canadensis		11		6				17
Colubridae				1				1
Conepatus mesoleucus		1		1		3		5
Crotalidae				3				3
Didelphis virginiana				3				3
Emydidae		1		1		4		6
Lepus californicus	1	26	3	17		17	3	67
Mammal	260	1477	302	1946	610	1933	170	6698
Mammal--large	70	546	178	670	228	518	76	2286
Mammal--medium		1	3	9	3	5	1	22
Mammal--small		14	1	40	31	37	2	125
Mammal--very large	10	68	20	102	28	82	2	312
Mammal--very small	1					1		2
Meleagris gallopavo				1				1
Mephitis mephitis						1		1
Odocoileus virginianus	5	39	4	63	7	26	5	149
Osteichthyes	1			2				3
Phasianidae						1		1
Procyon lotor				1	1	1		3
Rodentia		3		1	4	1	1	10
Sigmodon hispidus		1		1				2
Strigiformes						1		1
Sylvilagus sp.	1	17	3	27	4	20	1	73
Testudines		11	1	12	1	60	23	108
Trachemys sp.						1		1
Trionyx sp.	3	19	2		1	37	2	64
Urocyon cinereoargenteus				1				1
Vertebrata						2	2	4
Grand Total	373	2427	546	3119	1009	2935	325	10734

*Includes only bones that could be assigned to an AU.

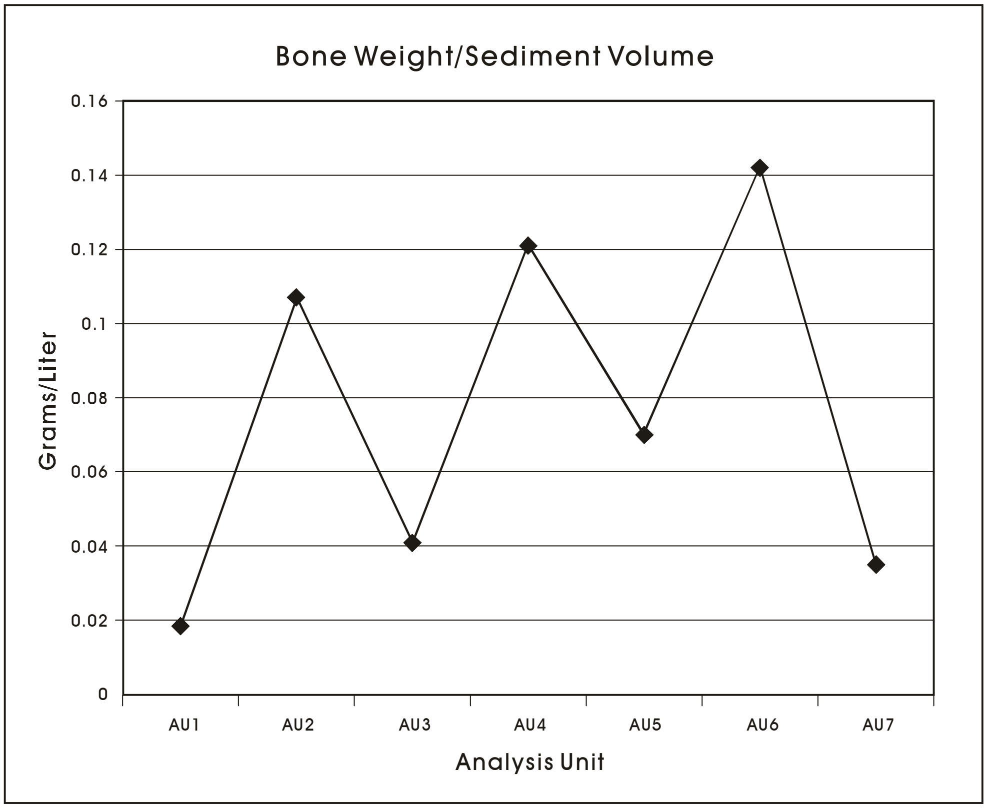


Figure 10-1. *Plot of bone weight (g) per liter of sediment by analytical unit.*

The breakdown of the small sample of specimens in the very large mammal category by analytical unit indicates that bison-sized remains occur at a low frequency in AU 7 (2.4%) and at moderate frequencies in the remaining AUs (Table 10-2). The highest frequencies and percentages of bison remains occur in AUs 4 and 6 where bison frequencies hover around 12–13% of all large to very large mammal bones. To test whether there are any statistically significant differences in these patterns, we calculated the adjusted standardized residuals for each cell of Table 10-2.

As discussed by several authors (e.g., Everitt 1977; Haberman 1973), adjusted residuals provide information on the individual cell contribution to a chi-square test. Adjusted residuals are analogous to Z scores such that an adjusted residual value exceeding an absolute value of 1.96 suggests that the cell frequency is significantly different from the expected frequency at a probability beyond the .05 level.

The adjusted residuals, then, indicate that in AUs 1–6 there are no statistically significant differences in the relative

Table 10-2. Distribution of Large and Very Large Mammalian Bone and Adjusted Residuals by Analytical Unit

Mammal Bone	AU 1	AU 2	AU 3	AU 4	AU 5	AU 6	AU 7	Total
Large (deer/antelope)								
Count	75	585	182	733	235	544	81	2435
Adjusted Residual	-0.09	0.96	0.72	-0.83	-0.11	-1.47	**2.63**	
Very Large (bison)								
Count	10	68	20	102	31	82	2	315
Adjusted Residual	0.09	0.96	-0.72	0.83	0.11	1.47	**-2.63**	
Total	85	653	202	835	266	626	83	2750

frequencies of large and very large mammal bones. Very large mammal bones tend to be over-represented in AU 6, although the pattern is not statistically significant. In contrast, very large mammal bones are under-represented in AU 7 where deer/antelope-sized bones dominate the two size categories.

Although in small frequencies, the presence of bison throughout the period from 3050 to about 2080 BP (AU 1–AU 7) supports the previously held notion that bison were present in Central Texas and on the Blackland Prairie during the Late Archaic (Collins 1995; Dillehay 1974). Interestingly, however, the adjusted residual patterns suggest the possibility that bison availability may have fluctuated, at least between the two oldest analytical units at the site (AU 6 and AU 7). The possibility also exists, however, that the changes in bison bone frequencies represents changes in hunting strategies, field dressing practices, or on-site butchering and food preparation techniques.

In Chapter 9 we discussed the distribution of rabbits by depositional zone. Here we look at the distribution of cottontail rabbits (*Sylvilagus* sp.) and jackrabbits (*Lepus californicus*) by analytical unit. In general, rabbits are most common in AUs 2, 4, and 6, the three units with the highest overall bone sample sizes (Table 10-1). The pattern is likely to be heavily influenced by sample size. Table 10-3 shows the distribution of cottontail and jackrabbits by analytical unit. Four analytical units (AUs 1, 3, 5, and 7) have small sample sizes. The sample sizes are moderate and reasonably similar in the remaining three AUs. The two deepest of these AUs (4 and 6) have higher percentages of cottontail rabbits compared to jackrabbits. In AU 2 the trend is reversed with jackrabbits representing a higher percentage of the rabbit bones compared to cottontail elements. To check whether these trends are statistically significant, we calculated adjusted residuals on all AUs except AU 1 since it has only two skeletal elements present. The results of the analysis, presented in Table 10-4, indicate that cottontail rabbits tend to be over-represented in AUs 4 and 5, although not to a statistically significant degree (.05 level). Jackrabbits are over-represented in AU 2.

Although cottontail and jackrabbits both were being hunted or snared by the inhabitants of 41MM340, there were some changes in the proportions in which they entered the archeological record. We are assuming that differential preservation would not have created the patterns observed since the skeletal elements of the two species are likely to be relatively similar in cortical thickness and hardness. If this assumption is correct, the variability noted above may reflect potential changes in the availability of the two species in the vicinity of the site as the vegetation structure changed on the Little River floodplain. The patterns may also be indicative of changes in the environmental niches exploited by the site's inhabitants. That is, since the two species tend to prefer different habitats, the changes in their proportions over time may reflect changes in the patterns of exploitation of different habitats within the economic environment of the site rather than changes in vegetation communities on the Little River floodplain.

The case of the heavier reliance on turtles during the time period encompassed by AU 6 (Table 10-5) is intriguing since bison skeletal elements also occur in higher than expected frequencies during this period (Table 10-2). The pattern may signal the fact that bison and other highly ranked species (i.e., deer and antelope) did not provide a consistent source of protein and that some exploitation of lower-ranked prey species had to occur to supplement the diet. The patterns may also reflect the occupation of the site during different times and/or seasons, some occurring when meat protein from large and very large animals was adequate and the other occupations taking place during seasons when such meat protein was in short supply and the diet had to be supplemented by riverine resources. Because we lack the appropriate temporal resolution within the archeological record, we cannot investigate this latter hypothesis.

Table 10-3. Distribution of Cottontail Rabbit and Jackrabbit Remains by Analytical Unit

Taxon	AU 1	AU 2	AU 3	AU 4	AU 5	AU 6	AU 7	Total
***Sylvilagus* sp.**								
Count	1	17	3	27	4	20	1	73
Column Percent	50.0	39.5	50.0	61.4	100.0	54.1	25.0	
Lepus californicus								
Count	1	26	3	17		17	3	67
Column Percent	50.0	60.5	50.0	38.6	0.0	45.9	75.0	
Total	2	43	6	44	4	37	4	140

Table 10-4. Distribution of Cottontail Rabbits and Jackrabbits and Adjusted Residuals by Analytical Unit

Taxon	AU 2	AU 3	AU 4	AU 5	AU 6	AU 7	Total
***Sylvilagus* sp.**							
Count	17	3	27	4	20	1	72
Adjusted Residual	**-2**	-0.11	1.48	1.94	0.27	-1.1	
Lepus californicus							
Count	26	3	17		17	3	66
Adjusted Residual	**2**	0.11	-1.48	-1.94	-0.27	1.1	
Total	43	6	44	4	37	4	138

Table 10-5. Distribution of Turtle Remains by Analytical Unit

Taxon	AU 1	AU 2	AU 3	AU 4	AU 5	AU 6	AU 7	Total
Testudines								
Counts		11	1	12	1	60	23	108
Column Percent		36.7	33.3	100.0	50.0	61.9	92.0	
***Trionyx* sp.**								
Counts	3	19	2		1	37	2	64
Column Percent	100.0	63.3	66.7		50.0	38.1	8.0	
Total	3	30	3	12	2	97	25	172

The pattern in mussel shell distributions by AU indicates that the highest weight of mussel shell per liter of sediment is found in AU 6 and shell weight per volume of sediment decreases significantly in the upper AUs (Figure 10-2). Although some differences are present in the species composition of the mussel shell samples (see Chapter 9), the more critical aspect of the mussel shell data is the apparent decreased reliance of the site's occupants upon mussels in AU 5 and above.

The apparent high reliance on mussel consumption during the period encompassed by AU 6 is especially interesting because it parallels the one noted in other riverine resources, namely turtles. In addition, the reliance on riverine resources seems to increase in the same analytical unit that contains higher than expected numbers of bison remains. This pattern may be additional support for the earlier observation that meat protein from more highly ranked prey may have been relatively scarce at times during the occupation of AU 6.

As a potential gauge of changes in subsistence and diet breadth through time, we compared the genus richness of the faunal collections from AUs 1–7. Only 17 taxa could be classified to the genus level from the total faunal collection from 41MM340. These genera and their breakdowns by analytical unit are shown in Table 10-6. The genus richness values range from 4 in AU 1 to 13 in AU 4. The three AUs with the three smallest sample sizes (AUs 7, 1, and 3, respectively) have the lowest richness values. The three AUs with the largest samples sizes (AUs 4, 6, and 2, respectively) have the highest richness values. Regression analysis between sample size and genus richness produced a correlation coefficient of .940 (R^2= .883) indicating that sample size has a significant impact on genus richness. Therefore, it is possible that the observed variability in genus richness, and therefore diet breadth, is strongly influenced by sample size rather than being reflective of changes in hunter-gatherer subsistence practices.

To further investigate any changes in subsistence strategies and diet breadth through time, we compared the genus richness of the upper five analytical units (AUs 1–5) with that of the bottom two AUs. These two groups roughly date to the San Marcos/Uvalde Phase and Round Rock Phase, respectively, identified by Prewitt (1985) for Central Texas. The San Marcos and Uvalde Phase materials cannot be confidently separated in the 41MM340 materials. The genus comparisons are presented in Table 10-7. The combined faunal collection from AUs 1–5 has a genus richness of 15, while the collection from AUs 6–7 has a richness of 9. Given that the overall sample size for the Round Rock Phase collections is only

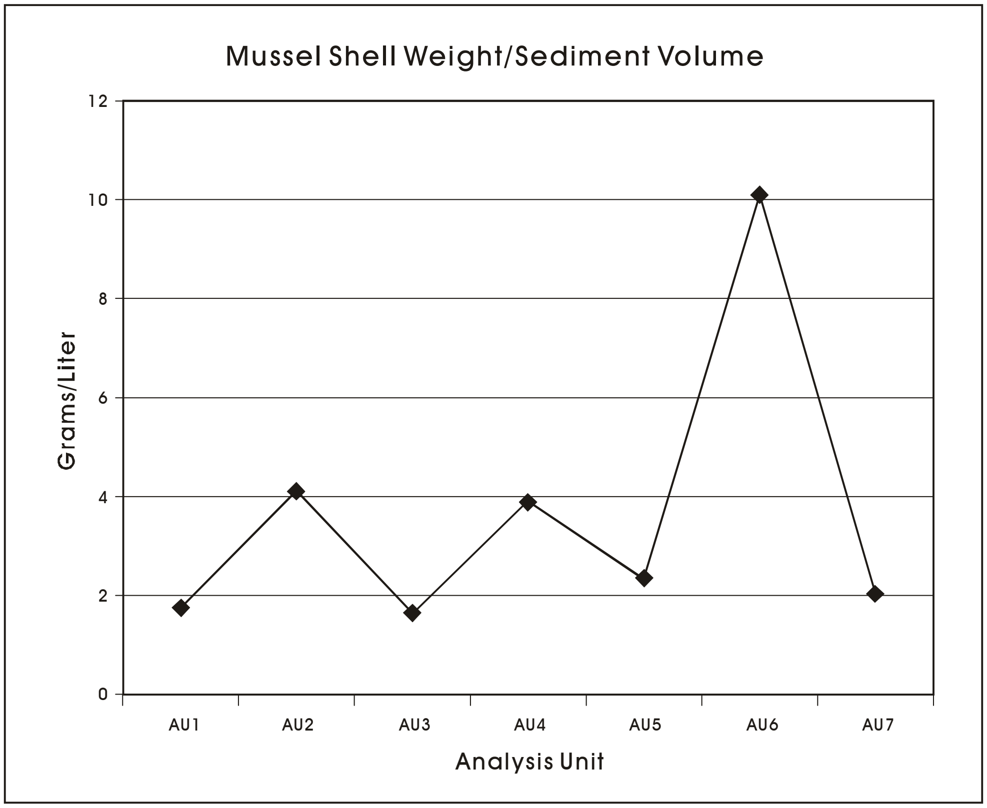


Figure 10-2. *Plot of mussel shell weight (g) per liter of sediment by analytical unit.*

Table 10-6. Genus Richness of Faunal Collections from 41MM340 by Analytical Unit

Taxa Classified to Genus	Common Name	AU 1	AU 2	AU 3	AU 4	AU 5	AU 6	AU 7
Anas sp.	Ducks		1		1			
Bison bison	American bison					1		
Buteo sp.	Hawks				1			
Canis sp.	Dogs, coyotes, wolves		1	1	1	1	1	1
Castor canadensis	Beaver		1		1			
Conepatus mesoleucus	Hog-nosed skunk		1		1		1	
Didelphis virginiana	Opossum				1			
Lepus californicus	Blacktailed Jackrabbit	1	1	1	1		1	1
Meleagris gallopavo	Turkey				1			
Mephitis mephitis	Striped skunk						1	
Odocoileus virginianus	White-tailed deer	1	1	1	1	1	1	1
Procyon lotor	Raccoon				1	1	1	
Sigmodon hispidus	Cotton rat		1		1			
Sylvilagus sp.	Cottontail rabbits	1	1	1	1	1	1	1
Trachemys sp.	Pond slider						1	
Trionyx sp.	Softshelled turtles	1	1	1		1	1	1
Urocyon cinereoargenteus	Gray fox				1			
Genus richness		4	9	5	13	6	9	5
Total faunal sample size		373	2427	546	3119	1009	2935	325

Table 10-7. Comparison of Genus Richness between San Marcos/Uvalde and Round Rock Phases, 41MM340

Taxa Classified to Genus Common Name	San Marcos/Uvalde Phases (AU 1-AU 5)	Round Rock Phase (AU 6-AU 7)
Ducks	1	
American bison	1	
Hawks	1	
Dogs, coyotes, wolves	1	1
Beaver	1	
Hog-nosed skunk	1	1
Opossum	1	
Blacktailed Jackrabbit	1	1
Turkey	1	
Striped skunk		1
White-tailed deer	1	1
Raccoon	1	1
Cotton rat	1	
Cottontail rabbits	1	1
Pond slider		1
Softshelled turtles	1	1
Gray fox	1	
Genus richness	15	9
Total faunal sample size	7474	3260

44% of the preceding phase, while the richness value is 60% of the preceding phase, it is possible that when sample size is taken into account, the combined Round Rock Phase collections have a higher richness compared to the combined San Marcos/Uvalde Phase collections. Therefore, although the combined San Marcos/Uvalde sample exhibits a wider absolute diet breadth, the Round Rock sample may have a wider diet breadth relative to sample size.

Finally, we compare the genus richness of selected components from the Granger Reservoir and North Fork Reservoir archeological projects (Yates 1982) with the patterns noted at 41MM340. The genus richness information for two San Marcos and two Round Rock components from these projects is presented in Table 10-8. The comparison shows that at least in the case of the faunal assemblage from 41WM267 and the collections from 41WM73 and 41WM56, genus richness is either higher (41WM267) or similar to (41WM73 and 41WM56) the corresponding collection from 41MM340 although the sample sizes are significantly smaller than in the case of the Little River collection. In the case of the San Marcos assemblage from 41WM267, the primary difference seems to lie in the presence of a number of mice, rat, and squirrel species present in the collection. At least in part, and assuming analytical consistency in species identification, these differences may be indicative of greater emphasis on the exploitation of arboreal species at 41WM267, a strategy potentially induced by habitat differences between 41MM340 and 41WM267. The greater proportion of mice and rats in the assemblage from 41WM267 compared to 41MM340 may be indicative of habitat differences between the sites, differences in length of site occupation, or perhaps real differences in subsistence strategies. The greater proportion of these small mammals may be indicative of some subsistence stress suffered by the inhabitants of 41WM267 during the San Marcos Phase.

There is little difference in the identified genera at 41MM340 and the two other Round Rock components in Table 10-8. Given the smaller samples sizes from 41WM56 and 41WM73, the relatively high genus richness in these assemblages compared to the 41MM340 Round Rock collections may be due to differential preservation or perhaps differential food processing techniques that may have contributed to a greater number of identifiable specimens.

Table 10-8. Comparison of Faunal Assemblage Genus Richness between Selected North Fork and Granger Reservoir Sites and 41MM340 San Marcos and Round Rock Phases

Taxa Classified to Genus Common Name	San Marcos/Uvalde Phases 41MM340 (AU 1-AU 5)	San Marcos 41WM124	San Marcos 41WM267	Round Rock Phase 41MM340 (AU 6-AU 7)	Round Rock 41WM73	Round Rock 41WM56
Ducks	1					
American bison	1					
Hawks	1		1			
Dogs, coyotes, wolves	1			1		
Fox squirrel			1		1	1
Ground squirrel			1			
Beaver	1		1		1	
Badger			1			
Hog-nosed skunk	1			1		
Opossum	1					
Blacktailed Jackrabbit	1		1	1	1	1
Turkey	1					
Prairie chicken			1			
Bobwhite			1			
Striped skunk				1		
White-tailed deer	1	1	1	1	1	1
Pronghorn antelope			1		1	1
Pocket gopher		1	1		1	1
Deer mouse		1	1			
Pocket mouse			1		1	
Pygmy mouse			1			
Harvest mouse			1			
Least shrew						1
Raccoon	1		1	1		
Cotton rat	1	1	1		1	1
Woodrat			1		1	1
Vole			1			
Cottontail rabbits	1		1	1	1	1
Pond slider			1	1	1	1
Softshelled turtles	1			1		1
Box turtle			1			
Gar						1
Catfish					1	1
Gray fox	1					
Genus richness	15	4	22	9	12	13
Total faunal sample size	7474	100	1455	3260	523	390

In general, an increase in diet breadth suggests that a greater number of species have to be included in the diet to meet protein needs. Conversely, a narrow diet indicates that much of the necessary protein requirements are being met through the exploitation of a few, higher-ranked species. Broad diets tend to include a variety of very small to small body sized species, while narrow diets tend to be dominated by medium to large and very large body sized species. Finally, a broadening of the diet may be indicative of some degree of subsistence stress.

To investigate potential changes in subsistence stress, we divided the faunal remains into two groups small to very small and medium to very large. Rat, mice, and rabbit-sized prey, as well as fish, beaver, skunk, opossum, all birds, and reptiles were grouped in the very small to small size category. Dog-sized prey as well as deer, bison, and bison-sized prey were grouped into the medium to very large prey group. The distribution of these two groups by analytical unit is shown in Table 10-9. The data indicate that medium to very large body sized prey species are over-represented in AUs 1, 3 and 4. They also tend to be over-represented in AU 2, although the adjusted residual value is not statistically significant at the .05 level (adjusted residual= ±1.71; p= .087). Very small to small prey species are over-represented in the two deepest AUs (6 and 7).

If the body size/subsistence stress relationship proposed earlier reflects prehistoric phenomena, the patterns noted in Table 10-9 suggest that a greater degree of subsistence stress characterized the two earliest analytical units compared to the upper four analytical units. That is, there appears to have been a heavier reliance on smaller prey species in AUs 6 and 7, with subsistence shifting to a heavier reliance on medium-sized and large species during the later four AUs (1–4). The over-representation of small to very small species in the deeper analytical units suggests that the pattern is not conditioned by differential preservation.

The size of the mammalian bone recovered from the different analytical units of 41MM340 suggests that some degree of subsistence stress may have been experienced by the site's occupants. Table 10-10 provides data on the average weight of individual bone fragments by AU. It is clear that the bone recovered from the site is heavily reduced, with an overall average of 0.49. The lowest mean bone weight occurs in AU 1 (0.37 g). Average bone weight increases steadily from AU 1 through AU 5 and decreases thereafter through the two deepest AUs. The average bone weight pattern does not appear to be the result of differential preservation since bone weight increases with depth at least in the upper five AUs.

To make sure that the reduced size of the bone is not simply a result of excavation methods, we sorted the bone from one unit (N48/E11; n=195) into those with fresh, excavation-related breaks and old breaks. We then measured the maximum dimension of the bone fragments in the old break group. The analysis indicated that the average maximum bone length in AU 1 ranged from 16.0–20.7 mm. These two aspects of bone size clearly indicate that the animal bone from the site has been heavily processed. We cannot determine with certainty what the reasons may have been for this degree of processing but it is feasible that maximum processing would have been the norm when meat protein was in short supply.

Macrobotanical Remains

Finally, the analysis of the large number of macrobotanical samples recovered from 41MM340 yielded a total of 158 pieces of hickory and pecan nut fragments. According to Dering (Appendix E), the quantity of nut fragments is a strong indication that mast exploitation was a significant aspect of the occupations of the site. Although mast yields are periodic (Hall 1998), their nutritional composition would have complemented lean meat protein resources quite well (Gardner 1997). As such, nuts could have played an important complementary if not a primary role in the diet of the inhabitants of the site, particularly if other indicators of subsistence stress are accurate.

Table 10-9. Counts and Adjusted Residuals Calculated for Two Groups of Faunal Remains from 41MM340, by Analytical Unit

Prey Body Size	AU 1	AU 2	AU 3	AU 4	AU 5	AU 6	AU 7	Total
Very Small-Small								
Count	18	218	23	269	106	314	62	1010
Adjusted Residual	-2.27	-1.71	-5.81	-1.99	0.74	5.34	4.5	
Medium-Very Large								
Count	95	732	221	904	293	686	91	3022
Adjusted Residual	2.27	1.71	5.81	1.99	-0.74	-5.34	-4.5	
Total	113	950	244	1173	399	1000	153	4032

Table 10-10. Mean Bone Weight
(per individual specimen) by Analytical Unit

Analytical Unit	Mean bone weight (g)
1	0.37
2	0.5
3	0.51
4	0.52
5	0.56
6	0.5
7	0.46
Total	0.49

Summary and Conclusions

The analyses of the three main data types (i.e., vertebrate and invertebrate fauna and macrobotanical remains) related to prehistoric hunter-gatherer subsistence strategies indicates that the overall diet of the inhabitants of the site contained a rich variety of terrestrial and aquatic animals and also included mast resources consisting of hickory and pecan. This generalized subsistence strategy is characteristic of many hunter-gatherer societies and it reflects either the year-round makeup of the diet or seasonal components when other higher ranked resources are not available.

The reliance on food items such as mussels, turtles, and rabbits, particularly in AU 6, suggests that the main source of protein, deer meat, had to be supplemented with lower-ranked resources. On the other hand, it is actually possible that the main components of the diet consisted of this diverse list of mammals, reptiles and birds, and deer meat was an intermittent contribution to a diet composed of smaller more diverse meat packages. Even so, the energy expended in procuring these resources may have been minimal since some of these animals could have been captured in snares and the use of such untended facilities requires very little energy input.

Although we have identified changes in genus richness over time, the patterns may be more strongly related to sample size rather than actual changes in diet breadth. The over-representation of small body sized prey species in AUs 6 and 7 suggests that some subsistence stress may have been experienced by the inhabitants of the site. The low mean bone weight of specimens in these same analytical units seems to support this observation.

Looking at the list of mammalian taxa present on site, it is certainly logical to interpret the diet of the inhabitants as generalized. However, the presence of low numbers of very large mammalian elements that were likely bison does raise the possibility that bison may have contributed a greater percentage to the diet than indicated by the scarcity of elements. At least theoretically, this could be a possibility since hunting would have certainly taken place some distance from the site and transportation constraints would have limited the archeological visibility of bison elements on site (Metcalfe and Barlow 1992). Although this scenario is a theoretical possibility, the varied faunal assemblage found at the site suggests that meat protein was in short supply.

The higher than statistically expected frequency of bison-sized bone fragments in AU 6 and their under-representation in AU 7 is intriguing. The differences may indicate major oscillations in bison availability during the first two periods of site occupation. On the other hand, the patterns may be reflective of differences in hunting strategies through time. Changes in hunting territories, field butchering practices, transportation constraints, and food processing techniques may all contribute to the oscillations noted in the collections.

Overall, although no clear-cut seasonality information is available on the occupations at the site, the reliance on mast resources, mussel shell, and the overall species richness suggest a fall or early winter occupation and reoccupation period. Although evidence of bison hunting is sparse, the presence of low quantities of bison bone throughout the analytical units supports previous notions of bison availability during the Late Archaic. At the same time, the small number of bison bone may mean that the site reflects an off-season camp occupied by folks otherwise involved in bison procurement on a seasonal basis. The exploitation of mast resources may have represented a significant aspect of the prehistoric diet. A heavy reliance on this resource may have been a response to some degree of subsistence stress. In addition, a reliance on mast exploitation would also be consistent with a fall site occupation and reoccupation period.

Chapter 11: Site Structural Issues

Raymond P. Mauldin and Steve A. Tomka

As outlined in Chapter 4, the fourth research domain proposed in the research design (Tomka et al. 2002) involved documenting and investigating activity areas in the context of the structure of the site. Research grouped under the "site structure" label usually is concerned with the use of space within a site, and the investigation of how aspects of site use (e.g., traffic patterns, feature locations, maintenance requirements, discard locations) interact with factors such as use intensity and activities conducted at the site (e.g., Stevenson 1991). This chapter investigates aspects of site structure at 41MM340. As noted in Chapter 4, there were a number of alterations to the topics proposed in the research design (Tomka et al. 2002), and the issues investigated in this chapter are different from those originally outlined. Consequently, the initial section of this chapter provides an overview of the research design for this domain, notes changes in the focus of the research topics, and outlines why these alterations were necessary. Following that section, we use the analytical units (AUs) developed in Chapter 7 to focus on the two common feature types present at 41MM340, those dominated by burned rock and those consisting of charcoal stains, often with burned clay present. We use these feature types in two ways. First, we look at changing frequencies of these types through time. Both feature types are represented in AUs 7, 6, 4, 3, and 2, a distribution that spans the majority of the occupation at 41MM340. The analysis suggests that the there is a change through time. Discounting Feature 10, the bone concentration, burned rock features account for almost 92% of the features in AUs 2 and 3 (n=13). That percentage drops to only 45% of the features in AUs 4, 6, and 7 (n=31). Second, we explore aspects of the distribution of these features in more detail relative to AU 6, an AU that contains 15 features with both types being well represented. The investigation of patterns in artifact and ecofact data relative to the two different feature types in AU 6 demonstrate several intriguing patterns both in the spatial clustering of these feature types, as well as the associations of these features with other aspects of material culture.

Research Design Changes

Focusing primarily on features, the original research design suggested that the two different feature types identified at 41MM340 should reflect different capacities to dissipate heat (Tomka et al. 2002), and, as such, the two forms of hearths may have been used to process distinct food types with different cooking requirements (see Ellis 1997; Wandsnider 1997). These observations also imply that the associated activities and activity area maintenance requirements accompanying these two hearth types may have been different. When this information on features was combined with indications that several different zones of cultural deposits with fine-grained temporal resolution were present at 41MM340, Tomka et al. (2002) argued that several research topics grouped under the activity area research domain could be profitably investigated. Specifically, four research questions were identified under this domain (see Tomka et al. 2002:28-29). First, were the different thermal features used to process similar or different foods? Second, did the different thermal features have similar spatial use patterns (i.e., drop zones, toss zones, maintained or unmaintained activity areas)? Third, were there any differences or similarities in the activity patterns associated with similar features through time? Finally, do the breaks in analytical units identified during the excavation correlate with peaks in magnetic sediment susceptibility peaks and, more importantly, buried occupation surfaces? Coupling these questions with data needs, the topics essentially involved investigating relationships between thermal feature morphology and food processing technology as reflected by lipid residues and by food processing technology as reflected by associated artifacts, relationships between feature use, land-use strategies, and site function, and relationships between peaks in magnetic sediment susceptibility values and the definition of analytical units.

Unfortunately, a major data type necessary for several aspects of this analysis, lipid residue signatures, was not present in significant quantities in burned rock and burned clay at the site. This conclusion is based on the analysis of six samples of burned sandstone and burned clay submitted from the site. This small sample was originally submitted to assess the potential impact of the sodium bicarbonate, used to break down the clay during water screening, on the recovery of residues. Samples of burned rock and burned clay that had been soaked in sodium bicarbonate (n=2), as well as samples not exposed to the deflocculant (n=4), were submitted for lipid analysis. As discussed in Appendix F, both groups of samples exhibited poor residue preservation resulting in weak or incomplete residue signatures. Given these results, it was clear that residue analysis could not be used to provide an independent gauge of the food items processed in the thermal features identified at 41MM340.

A second set of problems that caused alterations in the research topics was related to our failure to document contemporaneous surfaces across the site. As discussed in Chapter 7, we had hoped that the 15 stratigraphic zones defined in the field would serve as analytical zones and, coupled with the magnetic sediment susceptibility results, would allow us to identify a series of contemporary surfaces for artifact and feature comparison. The identification of roughly contemporaneous surfaces is critical for the investigation of zones of deposition around features, as well as maintenance activities associated with activity areas. Many of the 15 stratigraphic zones identified during excavation could not be traced over a significant portion of the block, and those that could (e.g., Zones 2, 3a, 4, 7, and 8) commonly ranged between 30 and 35 cm in thickness. As discussed in Chapter 7, given the results of the magnetic susceptibility values (see also Appendix C), the distribution of projectile point types, and the patterning of artifacts and features in profile drawings, it was clear that the stratigraphic zones probably did not represent contemporaneous surfaces necessary for the detailed investigations proposed in the research design.

Given our failure to define contemporary surfaces and the lack of interpretable residues for investigating the range of foods potentially processed in features, we shift the focus of the research topics under this domain. First, we focus on changes in the proportions of rock-lined and unlined thermal features through time. If, as several researchers have suggested (see Ellis 1997; Wandsnider 1997), the addition of rock to features is commonly associated with a need to maintain long-term heat in the context of the preparation of certain food types, then changes in feature forms may reflect broad changes in technology and subsistence. Second, we focus on a single analytical unit (AU 6) that contains a large number of both feature types, and appears to have the best potential for spatial comparison.

Features at 41MM340

As noted in Chapter 6, 45 features were identified at 41MM340 during data recovery (see Appendix J). With the exception of Feature 10, a concentration of bone, the features fall into two broad types. The first group, consisting of 26 features, was identified as burned rock clusters. While charcoal stains and shallow pits were sometimes associated with these features, and while burned clay was noted in many instances, large quantities of burned sandstone was the primary distinguishing characteristic for inclusion in this group. As summarized in Chapter 6, as a group these features are relatively large, averaging 99.4 cm in length and 67.8 cm in width. Eighteen features were placed in the second feature type, identified as charcoal stains, often with burned clay present. While small quantities of burned rock were sometimes noted in the features placed in this class, the quantities were minimal relative to the burned rock clusters. This group of features is smaller than the burned rock clusters, averaging 52.5 cm in length and 40.0 cm in width. We suggest that both of these feature types probably represent hearths. Both have evidence of burning, and in the case of the burned rock clusters, charcoal stains and associated pits were present in many, though not all, cases. Note also that both feature types frequently have burned clay present, probably an incidental by-product of heating. This presence further supports the notion that both feature types represent hearths.

The primary distinction between the feature types is the dominance of burned rock, primarily sandstone, in the burned rock clusters. The use of rocks, probably as thermal storage elements, suggests that these features had different heating properties relative to the thermal properties of the charcoal stains. As several researchers (e.g., Ellis 1997; Wandsnider 1997) have suggested, the capacity to dissipate heat slowly over longer periods of time is probably enhanced by the use of rock. While direct experimental data on temperature differences in hearths using sandstone and hearths lacking sandstone could not be located, experimental data presented by Mauldin et al. (1998) does show dramatic temperature differences in the ash of open hearths with Stage IV caliche cobbles when compared to a hearth lacking any cobbles. After six hours, hearths with caliche had, on average, a temperature 54°C higher than the hearth without caliche. After nine hours, the temperature differences were approaching 200°C, as the temperature of the hearth without caliche dropped rapidly, while those with caliche declined much more slowly. While not directly relevant to sandstone, these experimental data do support the assertion that long-term differences in thermal storage can be achieved by the addition of rock to features. Ethnographic data (see Wandsnider 1997) suggest that rock is often added in the context of specialized processing requirements associated with plant foods high in certain starches (see also Thoms 1989). Thermal features without rock, then, probably represent more generalized activities (e.g., general cooking, light production) relative to those with rock.

At 41MM340, Features were present in AUs 2, 3, 4, 6, and 7. Figures 11-1 through 11-4 present the distribution of all features types for AUs 2 (Figure 11-1), 4 (Figure 11-2), 6 (Figure 11-3), and 7 (Figure 11-4). The single burned rock feature in AU 3, Feature 14, is not shown. An examination of the figures clearly confirms the observations regarding feature size presented above. While precise size estimates are difficult in several cases as features were not identified in all excavated units (e.g., Features 35 and 42 in Figure 11-1), and while portions of some features were lost as a result of the collapse of profiles during excavation, the larger size of the burned rock clusters relative to the charcoal dominated features is readily apparent in these figures.

Table 11-1 presents data on the number of different features by type for those AUs with features. Overall, burned rock concentrations account for 59% of the 44 features. As shown in the table, however, the percentage of this feature type is higher in the upper AUs at the site. Over 92% of the features considered in AUs 2 and 3 (n=13) are burned rock concentrations. For AUs 4, 6, and 7, conversely, burned rock features make up only 45% of the features present. Note also that these three lower AUs contain over 94% of all features classified as charcoal stains. These data suggest, then, that there is probably a change through time reflected in features at 41MM340. A chi-square test of the data in Table 11-1, with AU 3 eliminated because of the small sample size (n=1), demonstrates that there is a statistically significant difference in the distribution ($\mathcal{X}^2$=10.695; df=3; p=.013). The standardized adjusted residuals for the individual cells suggest that the principal difference in the table is in AU 2, as these cells had absolute values of 2.8. Differences exceeding an absolute value of 1.96 suggest that the cell is significantly different at a probability beyond the .05 level (see Everitt 1977; Haberman 1973). No other individual cell adjusted residual scores exceeded an absolute value of 1.96. The more recent AUs are dominated by features that may reflect more specialized processing, with the possibility that they are focused on high starch plant foods, or other foods with specific processing characteristics. More generalized features, those not characterized by the addition of rock, are more common in the lower AUs. While we lack lipid residues or other independent support for the suggestion of different functions for these two broad feature classes, the changing feature frequencies probably reflect differences in site use, especially between the lower and upper AUs.

Patterns in Features and Artifacts

In order to further investigate the patterns in changing feature use, as well as to explore in more detail spatial patterns within 41MM340, we focused on AU 6. This AU was selected for more detailed consideration as it contained a high number of features (n=15) and had both of the feature types represented. Figure 11-3 suggests an additional advantage to this selection; the feature types have little spatial overlap. In fact, the charcoal stain features have a fairly restricted distribution concentrated in the southern and western portions of the AU. Finally, note that while this AU is relatively thick (about 15 to 35 cm) and while it certainly reflects a number of different occupations probably over several decades, the AU is dominated by Pedernales projectile points. In fact, of the 21 typed points recovered from this AU, 18 are Pedernales, and all Pedernales points with proveniences are from this analytical unit. This AU, then, seems to provide the best opportunity to isolate differences in these two feature types relative to other classes of artifacts such as density of bone, debitage, and mussel shell.

Figures 11-5 and 11-6 present two examples of our preliminary assessment of the potential of these data sets in this AU to reflect patterns of different feature and/or site use. Figure 11-5 presents an overlay of volumetrically corrected densities of debitage, grouped into three categories, onto the feature map presented previously (Figure 11-3). Figure 11-6 is a similar plot for mussels, again grouped into three ordinal categories. Consideration of the distribution of debitage density groups in Figure 11-5 suggests that debitage is generally higher on the southern end of this AU within 41MM340, an area dominated by charcoal stained features. In contrast, reference to Figure 11-6 suggests that mussel shell density is lowest in this area, and high in the northern section of the AU, a section dominated by burned rock clusters. Clearly, the mere association of high debitage densities with an area of the site dominated by charcoal stained features, and high mussel shell densities with areas of the site dominated by burned rock features, does not necessarily demonstrate a link between these data sets and these feature types. There are certainly areas of the site with low debitage counts that lack charcoal features, and areas of the site with high mussel weights that lack burned rock features. Nevertheless, the patterns are suggestive.

Given these preliminary results, we conducted a more detailed analysis to highlight these potential patterns. The spatial separation between the charcoal/burned clay features and the burned rock features allowed us to assign each

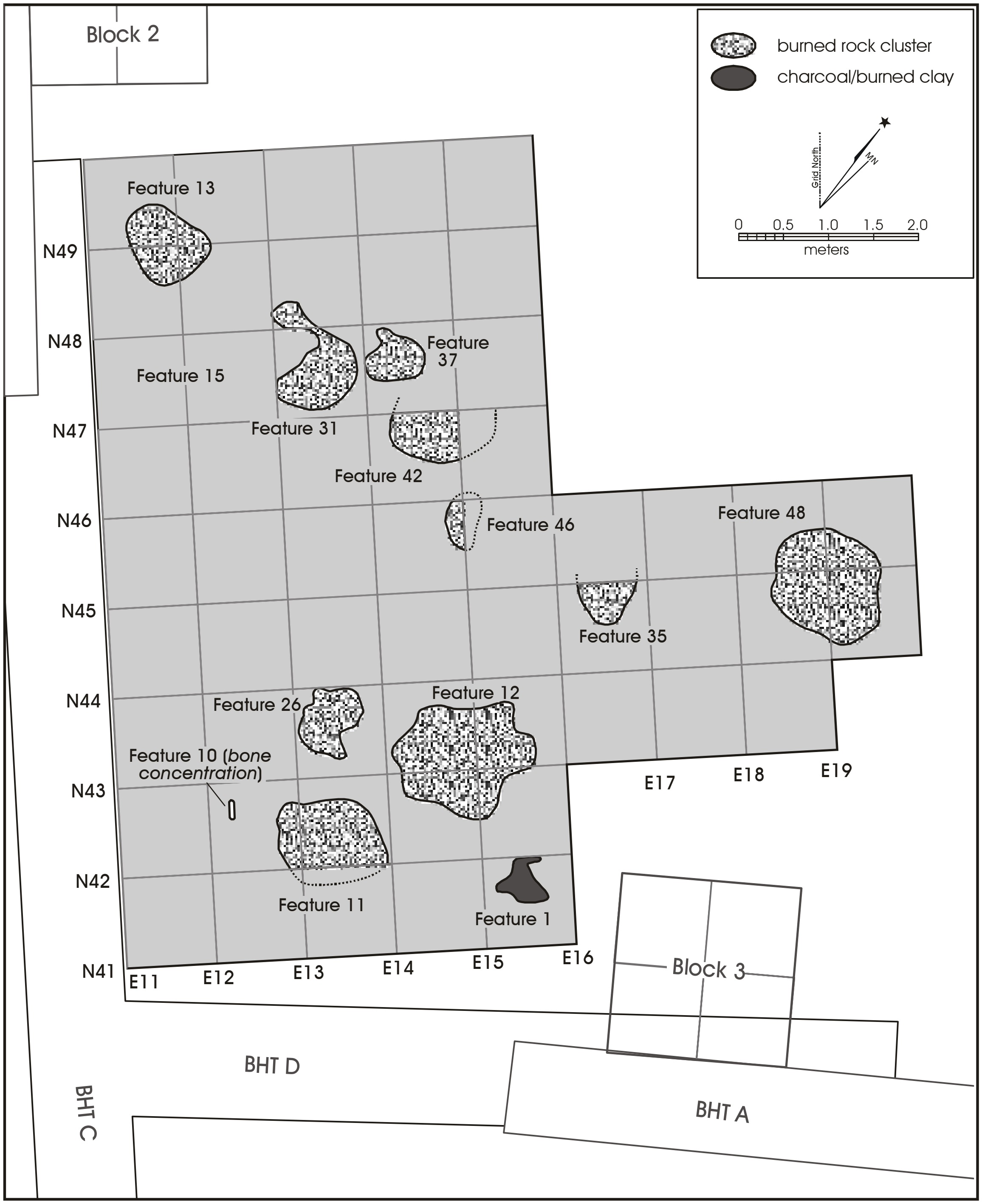


Figure 11-1. *Feature distributions in Analytical Unit 2.*

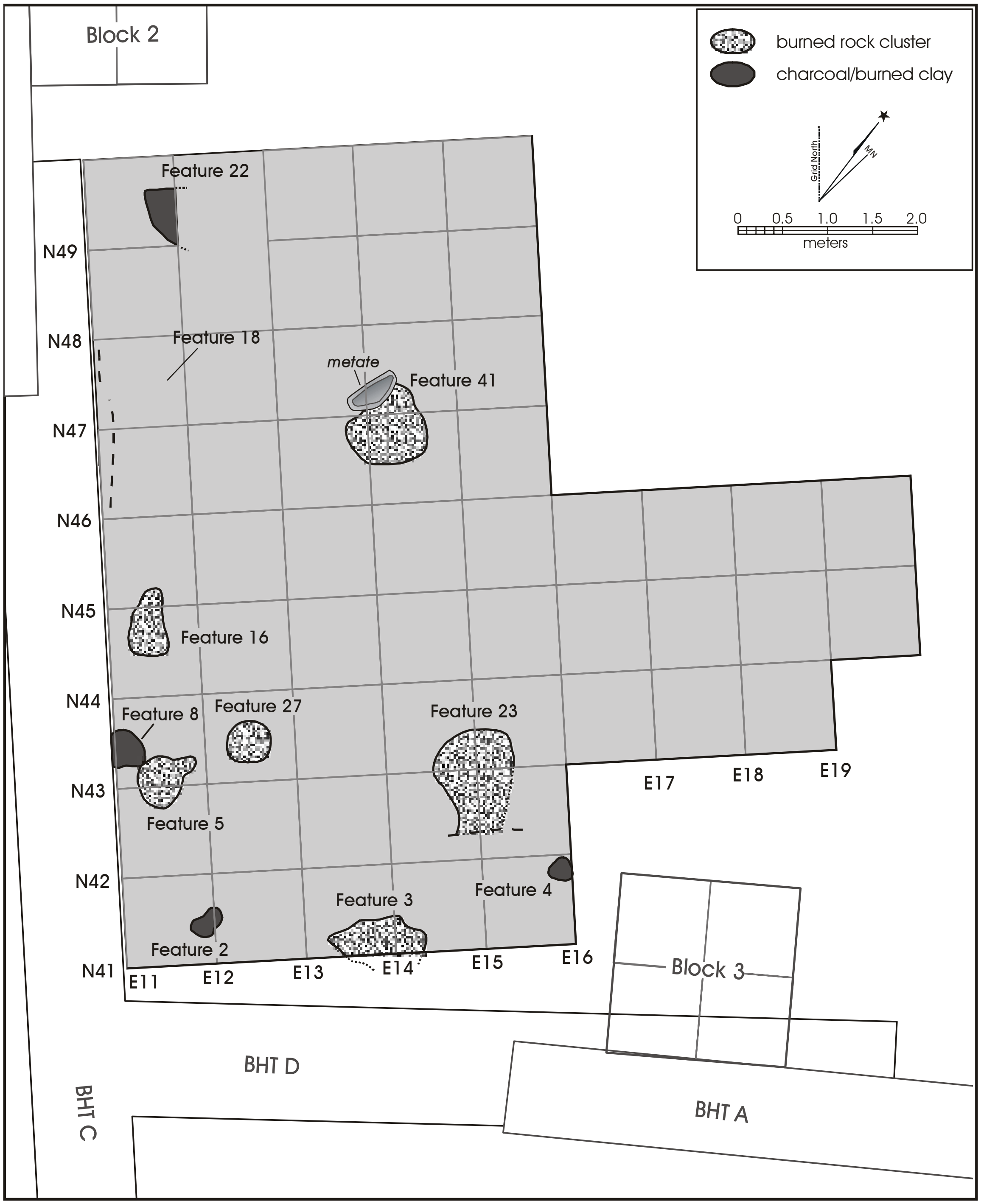


Figure 11-2. *Feature distributions in Analytical Unit 4.*

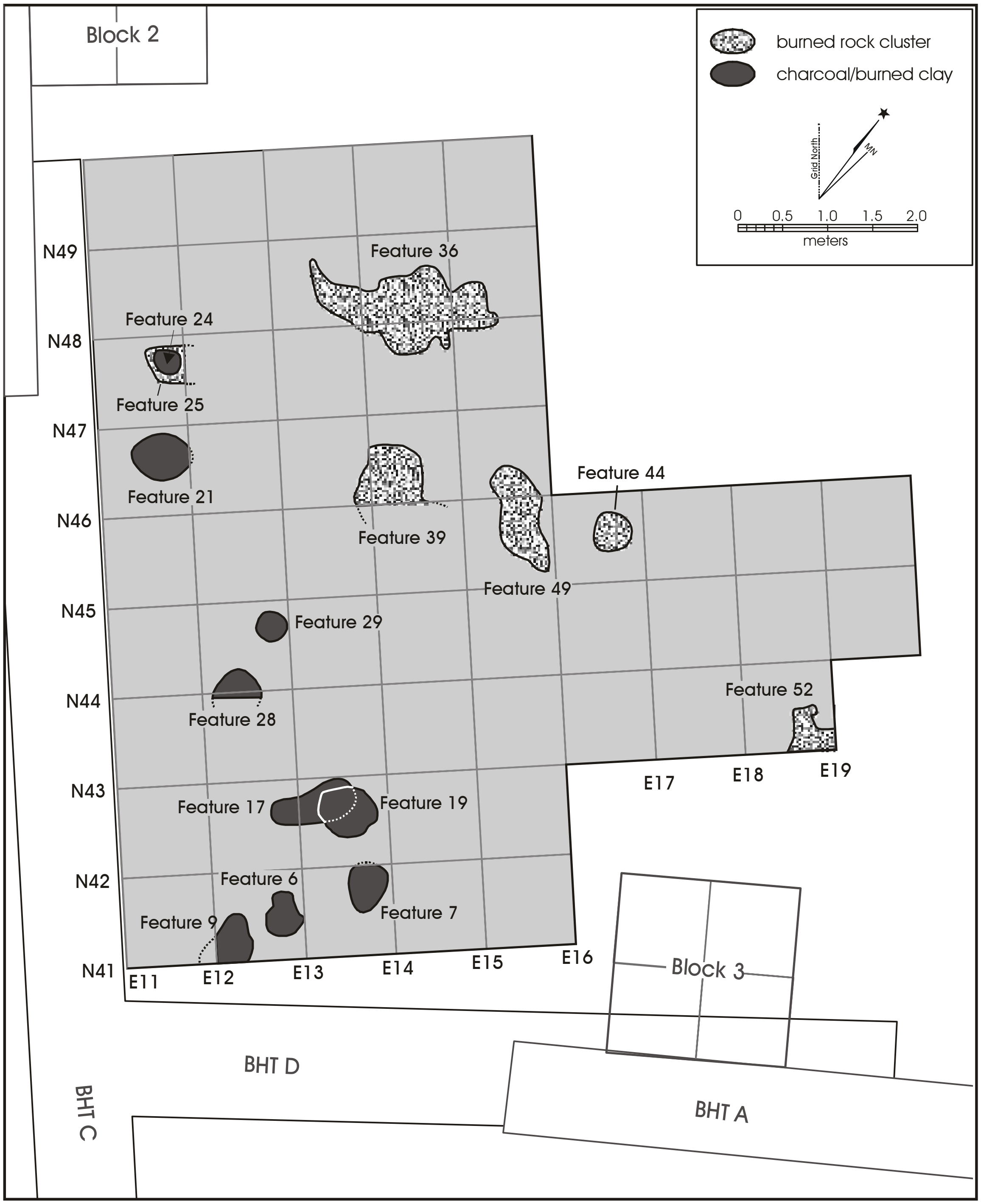


Figure 11-3. *Feature distributions in Analytical Unit 6.*

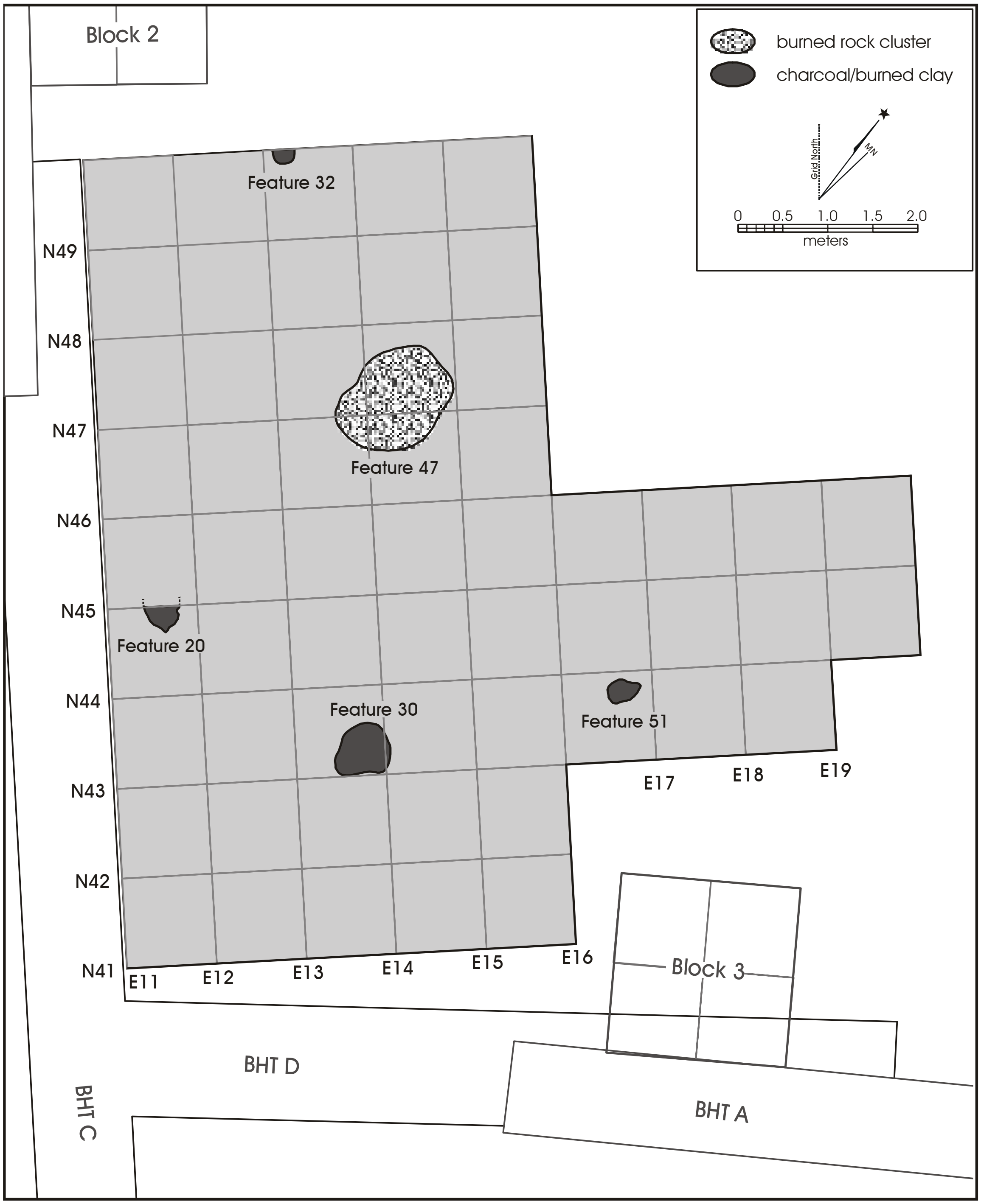


Figure 11-4. *Feature distributions in Analytical Unit 7.*

Table 11-1. Distribution of Feature Types by Analytical Unit

Analytical Unit	Number of Rock Clusters	Number of Charcoal Stained Features	Total Number of Features	Percentage of Burned Rock Features
2	11	1	12	0.92
3	1	0	1	1.00
4	7	4	11	0.64
5	6	9	15	0.40
6	1	4	5	0.20
Totals	26	18	44	0.59

individual excavation unit to one of three groups. The first group consisted of 15 squares that had, or potentially had (e.g., N47/E12), burned rock features present in some portion of the units. The second group, consisting of eight squares, had, or potentially had, charcoal/burned clay features present. The third group, consisting of 32 excavation units, had neither of these two feature types present. Finally, note that unit N47/E11 contained both a burned rock feature and a charcoal feature. This square was eliminated from consideration. While we are primarily interested in differences between squares with burned rock features and those with charcoal stains, we include the third group, squares with neither feature type, simply to provide some context for assessing the overall patterns.

For each of these three groups, two analytical steps were performed. First, box plots were constructed for the volumetrically corrected densities of the weight of bone (Figure 11-7), the weight of mussel shell (Figure 11-8), and the number of debitage (Figure 11-9) for these three groups. In a box plot, also known as a "box and whisker" plot, the heavy line within the rectangle depicts the location of the median value of a distribution, while the upper (Q .75) and lower (Q .25) quartiles define the right and left edge of the box. The length of the box, then, covers 50% of the cases. The length of the whiskers, the lines extending from the ends of the box, represent the location of adjacent values. The high adjacent value is the largest observation that is less than, or equal to, the upper quartile plus 1.5 times the interquartile (Q .75–Q .25) range. The lower adjacent value is the smallest observation that is greater than or equal to the lower quartile minus 1.5 times the interquartile range. Values to the right or left of the adjacent values are outliers (see Chambers et al. 1983; Tukey 1977). An examination of the box plots (Figures 11-7, 11-8, and 11-9) clearly suggests that the distributions are not normal. Consequently, the second analytical step involved the use of several nonparametric statistical tests to assess the strengths of the associations depicted in the box plots.

Reference to Figure 11-7, bone weights, suggests that the density of bone is slightly higher in those squares with burned clay/charcoal features present relative to either those squares with burned rock concentrations or those squares that lack features. Squares with burned rock clusters have an average bone weight of 16.07 grams per 100 liters, an average weight slightly higher than those squares with no features present (mean=11.73 g). Bone weight in squares with charcoal stains, in contrast, averaged 28.37 grams. Note, however, there is considerable variability in the bone weights within any one group. Reference to Figure 11-7 will show that differences in the median values are negligible. Despite differences in the average bone weights that hint at an association between charcoal stains and bone weights, a Wilcoxon two-sample test, a nonparametric equivalent of a "t" test (see Conover 1980:215-228), shows no statistical difference between these three groups (Z= -.645; p=.52).

Figure 11-8 presents patterns in mussel shell weights that are more clear-cut. There are clear differences between those squares with burned rock features, which have an average mussel shell weight of 1,406.4 grams per 100 liters, and those squares with charcoal stain features, which have an average weight of 632.6 grams. As the medians in the plots between these two groups do not overlap, it is probable that the differences between these two groups are statistically significant. A Wilcoxon two-sample test confirms this significance (Z= -2.32; p=.020). Note also that, while there is certainly some overlap, squares with burned rock features also tend to have higher values for mussel weights than

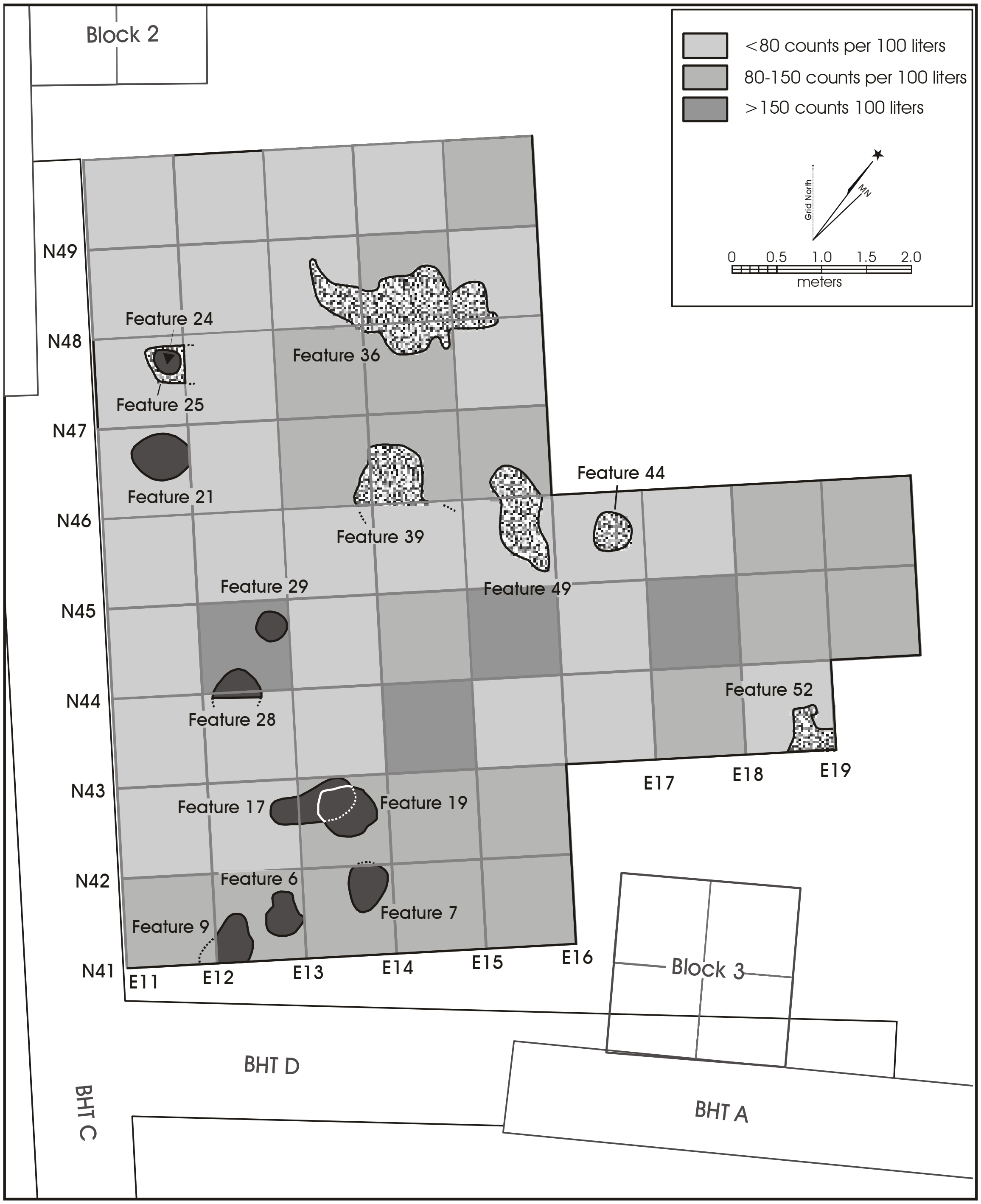


Figure 11-5. *Ordinal grouping of debitage densities within Analytical Unit 6.*

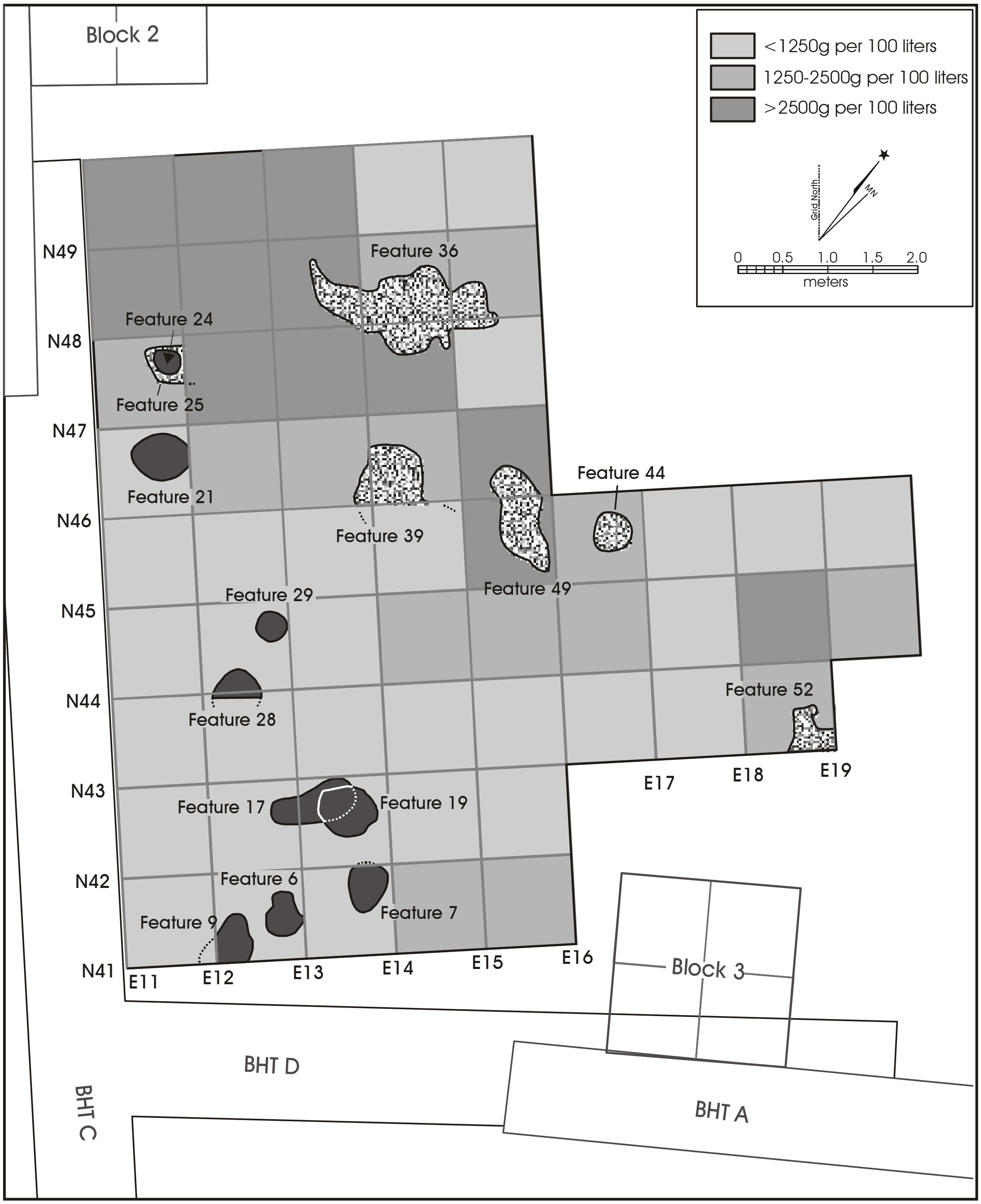


Figure 11-6. *Ordinal grouping of mussel shell weights within Analytical Unit 6.*

squares that lack either feature type, though the differences are not extreme. These patterns, hinted at in Figure 11-6, suggest that there may well be a meaningful association between mussel shell density and burned rock features.

Differences in debitage per 100 liters of sediment (Figure 11-9) suggest that squares with burned rock clusters may have lower densities than squares with charcoal features, though there is considerable overlap. Considering the mean values, squares with burned rock features have an average of 72.1 pieces of debitage per 100 liters of sediment, while squares with charcoal stains average 90.3 items per 100 liters. A Wilcoxon two-sample test, however, shows that the differences are not significant ($Z= -1.16$; $p=.245$).

While only differences in mussel shell are statistically significant, squares with burned rock features present have lower counts of debitage, lower bone weights, and higher weights of mussel shell relative to squares with charcoal stained features. These differences are consistent with the notion that burned rock clusters and charcoal stained features may, in fact, represent different activities.

Summary

In this chapter we have investigated several research topics that have been grouped under the rubric of "site structure." These topics have been altered from those proposed in the original research design (Tomka et al. 2002), alterations that were required by a lack of necessary data (e.g., lipid residues). The redesigned analysis has focused on changes in the relative frequencies of two primary feature types though time. We have demonstrated that the frequencies of two common types of features at 41MM340 change through time. Burned rock features are more common later in time, while features consisting of charcoal staining and burned clay are more common earlier in the sequence. Given the potential that these two types of features have radically different thermal properties, and as different groups of foods require different thermal ranges for effective processing, it is probable that this shift, which seems to have occurred between AU 4 and AU 2, reflects changes in the types of foods processed. A more detailed examination of these feature types relative to other classes of artifacts, conducted with data from Analytical Unit 6, further highlights possible

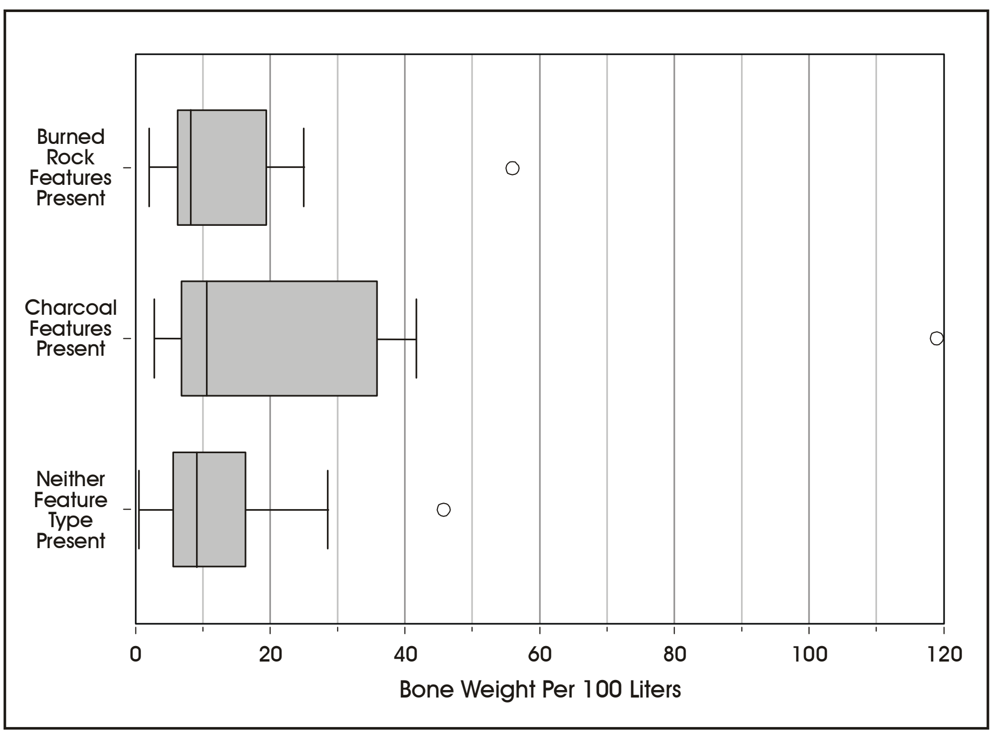


Figure 11-7. *Bone weights for squares with burned rock features present, charcoal/burned clay features present, and squares with neither feature type present.*

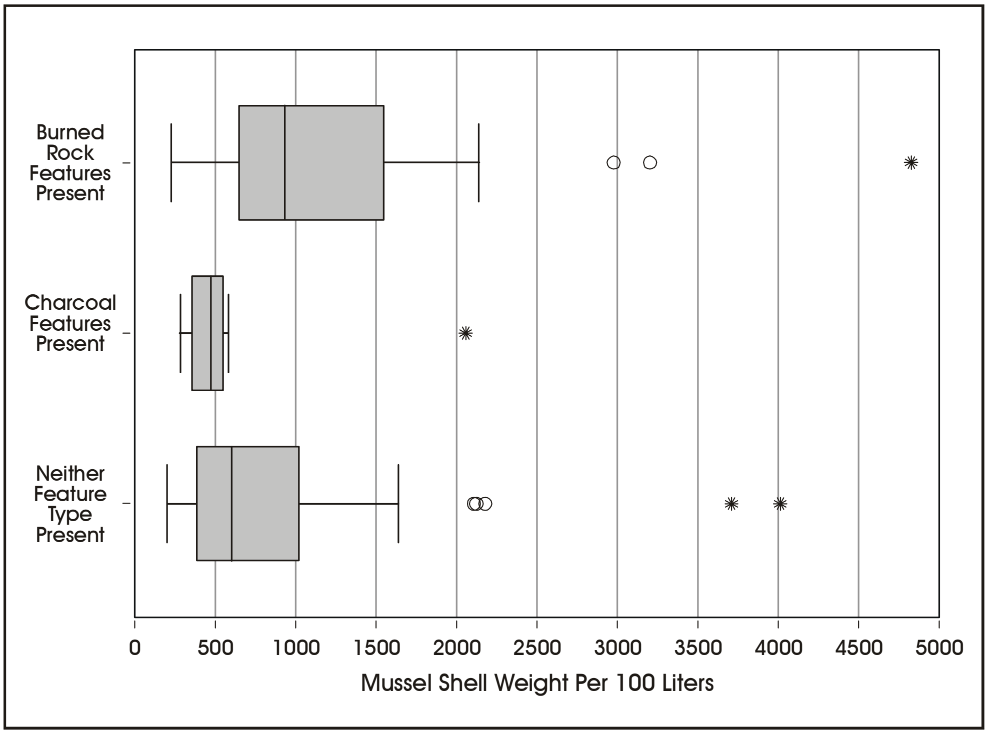


Figure 11-8. *Mussel shell weights for squares with burned rock features present, charcoal/burned clay features present, and squares with neither feature type present.*

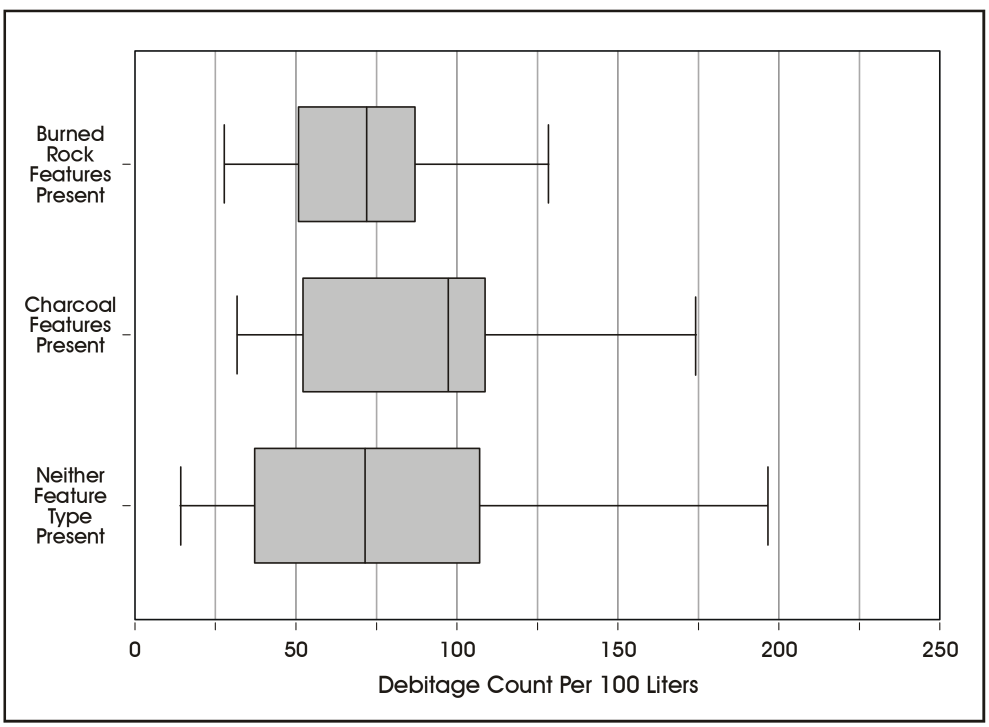


Figure 11-9. *Debitage counts for squares with burned rock features present, charcoal/burned clay features present, and squares with neither feature type present.*

differences in these two feature groups. Squares with burned rock features present tend to have low counts of debitage, lower bone weights, and higher weights of mussel shell when compared to squares with charcoal stained features, though only differences in mussel shell are statistically significant. While it is tempting to suggest that burned rock features at this location may be associated with the processing of mussel shell, we lack any independent verification for this suggestion, and the spatial association may reflect more general site maintenance activities rather than any direct link between features and processing of mussels. Features characterized primarily by charcoal staining, conversely, may reflect more generalized subsistence activities as indicated by a slightly elevated association with bone and debitage. In light of these suggestions, the patterning explored in AU 6 is of some interest. Recall that the distribution of these two feature types was spatially distinct, especially in the case of the potentially more general-purpose charcoal stain features. While it is possible that repeated uses of the general AU 6 surface would result in such a pattern, the clustering may also reflect fairly restricted groups of temporally related features.

Chapter 12: Lithic Technology at 41MM340

Steve A. Tomka, Harry J. Shafer, and Raymond P. Mauldin

This chapter addresses three principal research issues proposed in the research design and related to lithic technology at 41MM340. The three principal research foci consist of: 1) the relationship of Pedernales points recovered from 41MM340 to Pedernales points from other parts of the state; 2) variability in formal versus expedient tools through time; and 3) the role of the occupations at 41MM340 in the regional land use as manifested by evidence of gearing up. Each of these topics will be discussed in detail.

The initial section deals with variability in Pedernales projectile points. Before proceeding with the in-depth discussion of this topic, it is worth providing some general background to the early uses of the type-variety classification system in Texas.

A Brief History of the Type-Variety System in Texas

The splitting of large ceramic type samples into varieties began in the late 1950s and 1960s and was consistent with the cultural-historical paradigm in vogue at the time. The typological system was employed in the 1930s as a standard for collections analysis, especially in constructing time-space systematics. Krieger (1944, 1946; Newell and Krieger 1949) established the typological concept for Texas ceramics and lithics. The system was popularized by the publication of *An Introductory Handbook of Texas Archaeology: Type Descriptions* (Suhm et al. 1954). This system worked well for moderate-sized collections at a general level. A trend in typological studies at the time, however, was to go beyond the general level and seek more precise classificatory units to help better define archeological assemblages (Johnson 1962:149). Large-scale projects that yielded hundreds of specimens required a more systematic method of splitting to facilitate description and comparison. While the typological concept worked well as a basic building block for chronological studies, its uses were limited for large samples of ceramics collected from many sites during regional studies. The type-variety system proposed by Wheat et al. (1958) was a more encompassing taxonomic system for sorting and classifying Southwestern ceramics. Phillips (1958) and Aten (1983) applied the system to Southeastern ceramics. Uses of the type-variety system for ceramics have essentially been abandoned in the Southwest and Southeast, however, but are still very much in use in Mesoamerica.

Johnson (1962) and Jelks (1962), bowing to the trends of the time, were the first to apply the type-variety concept in Texas, but to lithics rather than ceramics. Johnson argued that chipped stone collections could be classified using the same type-variety system established for ceramics. He used the type-variety system to describe the large sample of dart points (n=1,342) from the Yarbrough site and smaller collections from the Miller site (Johnson 1962:148–155). He then compared the results to other Archaic assemblages across east Texas as part of his task to define the Archaic La Harpe Aspect. Jelks (1962) used the type-variety system to classify Perdiz and Scallorn points and Granbury bifaces from the Kyle site. Others soon followed Johnson's and Jelk's lead. Duffield (1963) applied the type-variety to his analysis of San Patrice points from the Wolfshead site. Story (1965) used Johnson's Gary point varieties in her analysis of the projectile points from Cedar Creek Reservoir. Johnson (1964:30) justified the use of naming varieties by his claims that "in the area of the La Harpe Aspect it was possible to do more or less detailed studies of the distribution of the projectile point varieties as well as the types." Johnson (1964) later changed his approach in his Devil's Mouth site study by assigning numbers rather than names to the varieties. His justification for not using formal names for varieties was the lack of comparative information from the lower Pecos River area at that time.

Following the lead of Johnson, Story, Jelks, and Duffield, other archeologists began to systematically apply the variety concept to projectile point analysis, albeit not in such a formal fashion as did their mentors (Nunley et al. 1965; Sorrow 1969; Sorrow et al. 1967). Varieties were given such tags as "groups" rather than formal names (Sorrow 1969; Sorrow et al. 1967). Shafer and Sorrow were the first to apply variety tags to Pedernales projectile points at the Landslide and Evoe Terrace sites (Sorrow et al. 1967). Shafer used stem morphology to sort the 14 Pedernales points into four descriptive varieties. Sorrow used shoulder morphology to sort the Evoe Terrace sample of 36 specimens into his four descriptive groups. Sorrow followed this lead in his analysis of the large collection of dart points from the John Ischy site (Sorrow 1969). His criteria for dividing the Pedernales sample (n=84) into five descriptive varieties were based on "morphological differences," and, again, his groupings were independent of those used for either the Landslide or Evoe Terrace collections (Sorrow 1969:17).

While Johnson's initial intent in applying the type-variety system was to detect regional variations beyond the type scale, neither he, nor anyone else, was able to do so.

Regional Patterning in Pedernales Varieties

The earliest projectile points recovered from 41MM340 are Pedernales dart points. The 18 points recovered from Analytical Unit 6 form a homogenous group characterized by narrow and parallel to slightly contracting stems, sharply pointed base corners or ears, and broad blades with slightly downward pointed ears. These points are most similar to the Pedernales varieties 3 and 4 from the John Ischy site (see Sorrow 1969:Figure 15 G-M and N-Q), Pedernales variety 2 from the Evoe Terrace site (Sorrow et al. 1967:Figure 42a-d), and Pedernales variety 3 from the Anthon site (Goode 2002:Figure 23c-f). The more classic Pedernales points with the somewhat barrel-shaped stems are entirely missing from the 41MM340 collection. The fact that none of the other Pedernales varieties found at other sites were present at 41MM340 was rather unusual and raised the possibility that the small collection represents a regional variant of the Pedernales type.

In order to investigate the possible regional variant, we compiled comparative Pedernales assemblages from 10 sites to quantify Pedernales varieties by site and region. The list of sites included the J. W. Edwards Site (41BN1), Kincaid shelter (41UV2), the La Jita site (41UV21), Woodrow Heard (41UV88), Panther Springs Creek (41BX228), the Bessie Kruze site (41WM13), the Anthon site (41UV60), the John Ischy site (41WM49), and the collection from the Evoe Terrace site (41BL104). The tenth collection consists of the 18 specimens from 41MM340. Over 600 specimens were considered.

Stem and Blade Forms among Pedernales Projectile Points

Because significant differences were noted in the nature of the preforms used in Pedernales projectile point manufacture, in addition to the previously documented variability in stem shapes, it was decided that variation in both stem form and blade form would be gauged during this comparative analysis.

Although we initially hoped to define the stem and blade forms using an SPSS cluster analysis routine, in the end we employed a less formal analytical scheme. We scanned the comparative collections and identified the distinct stem and blade forms present. Then, we drew their outlines and scanned the specimens to create a comparative baseline. Next, we categorized each projectile point within the comparative collections into one of the comparative baseline categories.

Stem Forms

Prior to the definition of stem categories several publications were consulted that divided Pedernales collections into varieties. Subsequently, the comparative collections compiled by CAR for the purposes of this analysis were also scanned for additional forms not present in the literature. Following these preliminary steps, and based primarily on outline shape, six stems form categories (Forms 1–6) were defined (Figure 12-1). The distinguishing features among stem forms include stem edge morphology, basal corner morphology, and relative degree of basal concavity or notching. Attention was paid to the attribute of fluting, a feature commonly observed on Pedernales points throughout central Texas. Fluting on one or both faces was observed on all stem varieties, but was a feature absent in the 41MM340 sample. Fluting was a method of thinning the base and was accomplished early in the manufacture process. A related and common characteristic of Pedernales points evident on preforms is that the stem was finished first, and the blade was thinned and finished last. The six stem categories are characterized by the following features:

Stem Form 1: Straight stem with indented base; stem corners are sharp.

Stem Form 2: Barrel-shaped stem with convex stem edges, rounded stem corners, and indented base.

Stem Form 3: Slightly expanding stem, straight stem edges, sharp stem corners, and weakly indented base.

Stem Form 4: Straight stem edges, rounded stem corners, moderate to deeply indented base.

Stem Form 5: Contracting stem with straight stem edges, sharp or rounded stem corners, and weakly to moderately indented base.

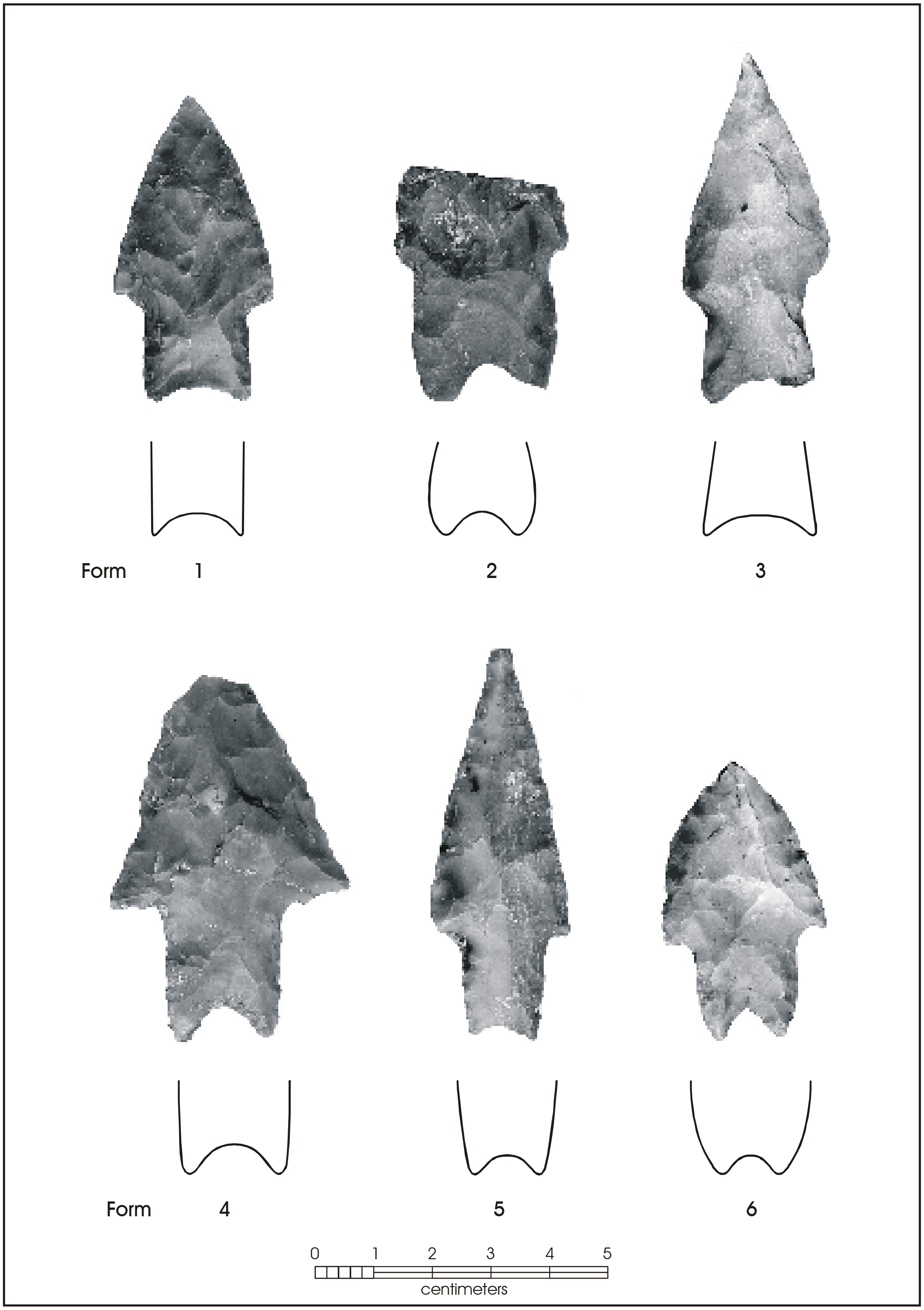


Figure 12-1. *Pedernales stem forms defined in the comparative collection.*

Stem Form 6: Contracting stem with convex stem edges and moderately indented base.

Overall, Stem Forms 1 and 4 are parallel sided, Stem Forms 2 and 6 are barrel-shaped; while Stem Form 3 is expanding and Form 5 is contracting in outline.

Blade Forms

During the systematic analysis of the Pedernales specimens in the comparative collections examined here, we noticed that some variants of Pedernales points (here defined as Blade Form 1; Figure 12-2) are characterized by narrow but relatively thick blades and subtle weak shoulders (c.f. Variety 2 specimens from the Anthon site; see Goode 2002:Figure 23a-b). Conversely, some Pedernales points (here defined as Blade Form 2; Figure 12-3) have very broad blades with large downward pointing barbs and bodies that are well thinned (Variety 5 from the Anthon site; see Goode 2002:Figure 24d-e). Finally, a third group of Pedernales points (here defined as Blade Form 3; Figure 12-4) are characterized by well-thinned body cross-sections, similar to those in the second group, and moderate to strong shoulders that may possess short downward pointing barbs or may be shouldered (Varieties 3 and 4 from the Anthon site; see Goode 2002:Figures 23c-f and 24a-c). The principal differences between these three forms are not only morphological but more importantly they may also reflect distinct preform manufacture strategies. Based on these differences in blade characteristics and preform morphology, three broad groups of blade technologies were identified.

The manufacture of Blade Form 1 specimens begin from relatively narrow, thick, and strongly biconvex triangular blanks with straight to slightly concave bases. The Class II, Stages 3 and 4 bifaces in Goode (2002:Figure 42), and the specimens in Figure 108:b-c (Goode 2002) are examples of the blanks. The key aspect of this blade type is its narrow and thick blade and slight shoulders that are made by simply narrowing the bottom third of the preform by lateral thinning to define the slightly shouldered blade from the stem.

In contrast, the manufacture of Bade Form 2 specimens begin from broad secondary and/or tertiary flake blanks oriented with their bulbs of percussion toward the proximal end of the desired projectile point. One of the first manufacture activities focuses on the thinning of the bulb of percussion and the shaping of the stem through basal or corner notching of the blank and the removal of the characteristic stem thinning flake (or flute). Once the stem is successfully executed, and if the barbs have not failed during notching, the blade of the projectile point is roughed out on the distal end of the flake blank. The manufacture of this blade form begins with the stem probably because the thinning and shaping of the blade is more time and energy intensive than the making of the stem. Therefore, making the stem first prevents wasted effort in blade thinning and shaping in case of failures that may occur during the notching of the barbs or the "fluting" of the stem. The final stages of manufacture of the Blade Form 2 specimens tend to focus on the refinement of this preform. The stem edges of these specimens retain the overlapping semicircular notching flake scars that are characteristic of deeply notched points (i.e., Andice and Bell).

Broad expanding and sometimes slightly downward pointing shoulders or barbs characterize the Blade Form 3 Pedernales points. This variant also begins by shaping of the stem of a broad well-thinned flake blank. However, rather than creating large barbs, the finished blade has broad shoulders. The examination of the blanks used in the manufacture of these specimens indicates that the only "notching" flake scars that are present on the stem appear immediately at the neck of the specimen, where they seem to have helped create the broad shoulders. The lower part of the stem appears to contain short lateral thinning flakes. It is possible that these variants may represent specimens that failed during notching yet were finished into broadly shouldered specimens. Given the possibility that the Blade Form 2 specimens may be reworked into the Form 3 specimens if their barbs fail, it may not always be possible to accurately differentiate between these two forms. The key characteristic of the Blade Form 3 specimens is the broad well-thinned blank, the early manufacture of the stem, and the shouldered blade.

Patterns in Pedernales Stem and Blade Forms

As part of this analysis, 632 Pedernales projectile points from 10 site collections were categorized according to stem form and blade form. The results of these classifications are presented in Appendix D. Not every point originally classified as a Pedernales was confirmed to be a Pedernales upon further review. Therefore, the number of Pedernales specimens from each of the respective sites may not agree with the number discussed in the original report. Finally, as evident in Appendix D, some specimens could not be classified according to both stem and blade form due to ambiguous characteristics. Therefore, in the case of some

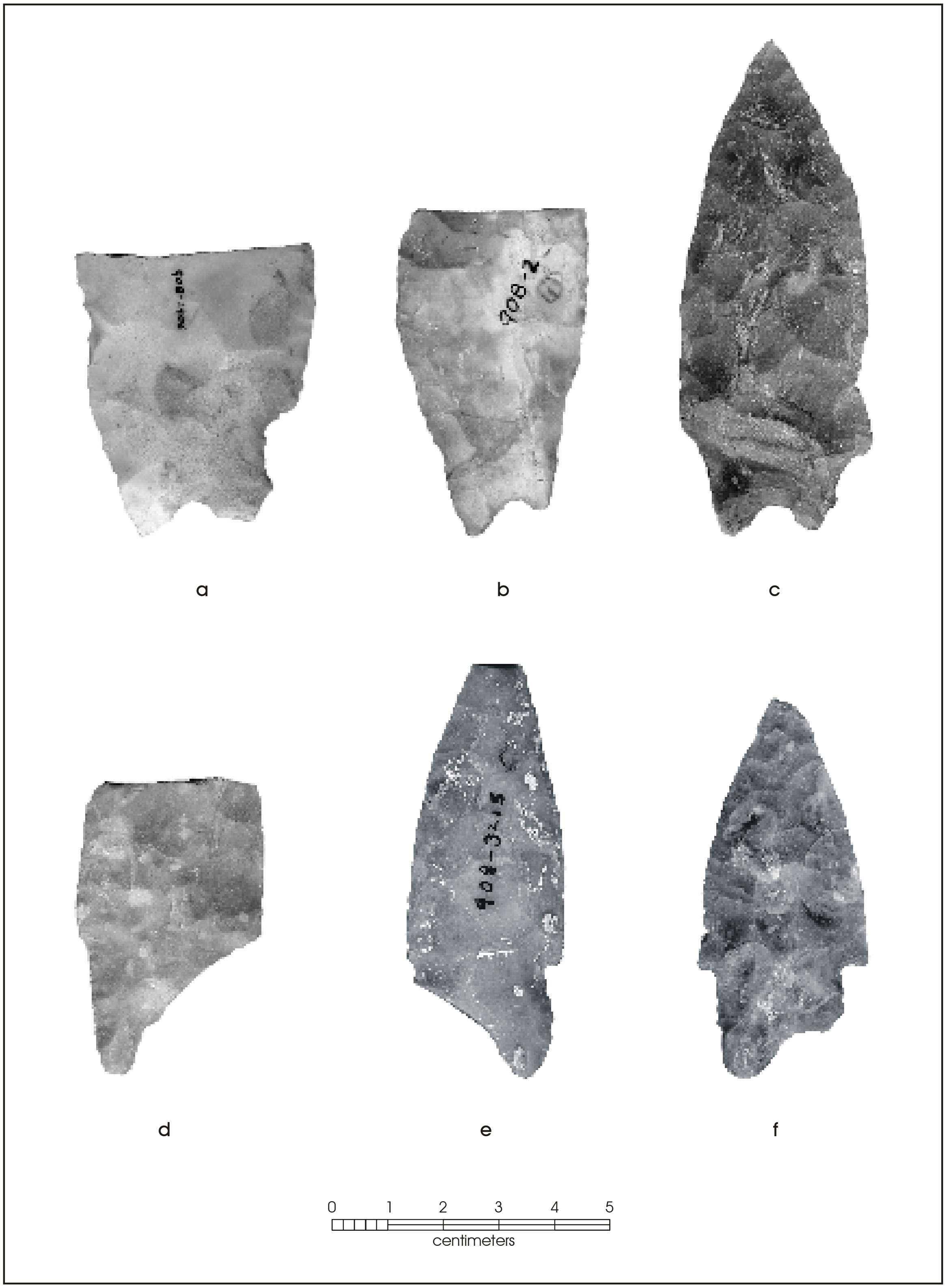


Figure 12-2. *Blade Form 1 specimens in various stages of manufacture.*

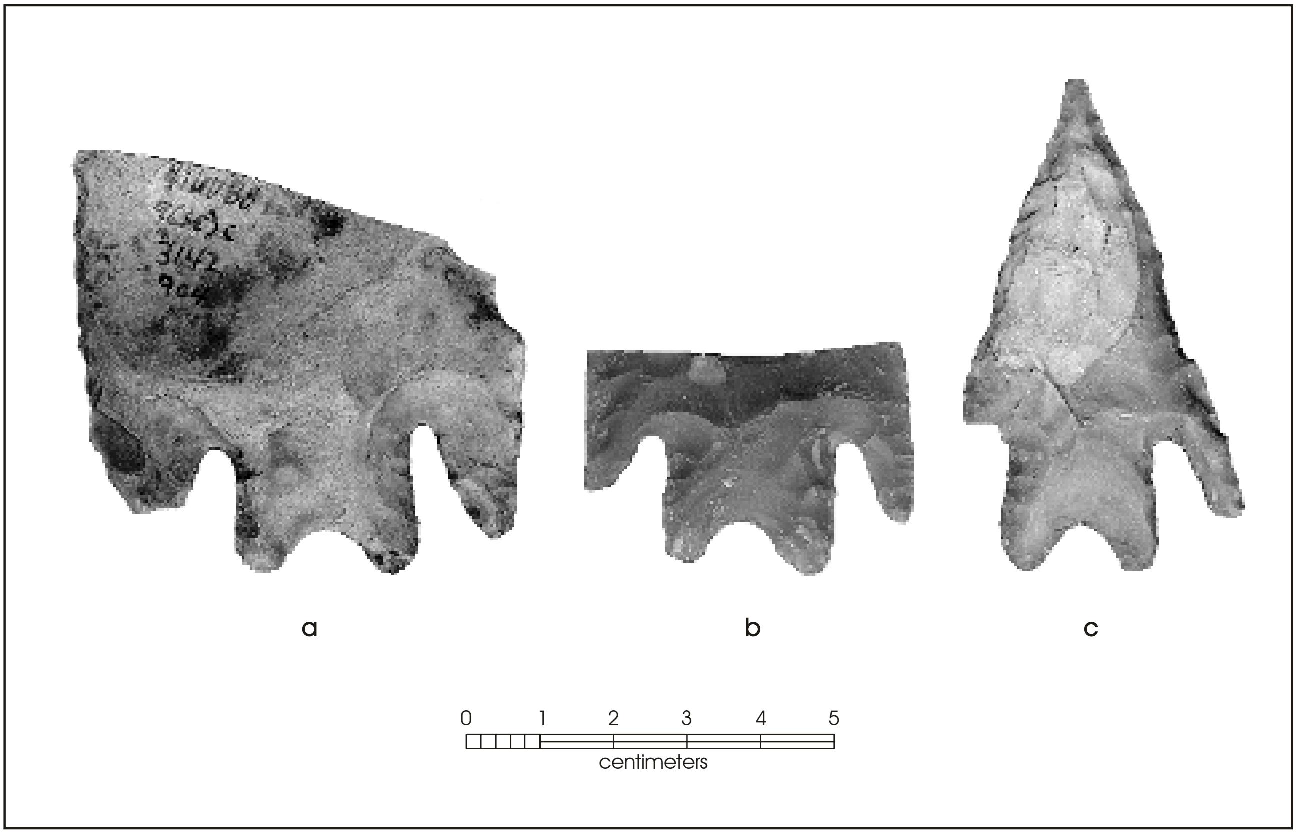


Figure 12-3. *Blade Form 2 (heavily barbed variety) specimens.*

sites, the samples classified for stem and blade forms may differ slightly. The classifications (carried out by H. Shafer and S. Tomka) are presented in Appendix D.

Figure 12-5 allows a visual comparison of the spatial patterning of stem and blade forms within the 10 Pedernales point assemblages used in this comparative study. Table 12-1 present the frequencies of stem forms within the combined projectile point collection by site. Of the 628 specimens classified, Stem Form 4, the parallel-sided deeply notched form, contains the largest number of specimens (n=273; 43.5%), followed by Stem Form 2, the barrel-shaped variety (n=189; 30.1%). The fewest specimens are found in Stem Form 6, the barrel-shaped but shallowly notched form (n=3; 0.5%).

To investigate whether there are any statistically significant differences between sites, we calculated adjusted standardized residuals for each cell of Table 12-1. Due to the small sample size in Form 6, the three specimens were combined into Stem Form 2, a morphologically similar form. The adjusted residuals are presented in Table 12-2. Recall that adjusted residual values equal to or greater than an absolute value of 1.96 suggests that the number of items in the cell is statistically different from the expected number at a probability beyond the .05 level (see Everitt 1977). Only statistically significant values are discussed here.

For Stem Form 1, three cells are significant. Stem Form 1 is under-represented in the Panther Springs Creek (41BX228) collection but over-represented in the Woodrow Heard (41UV88) and Evoe Terrace (41BL104) collections. Stem Form 2, the barrel-shaped form, is over-represented at three sites (41BN1, 41UV2, and 41UV60) and under-represented at three others (41UV88, 41MM340, and 41BL104). Stem Form 3, the slightly expanding form, is over-represented only at site 41BN1. Stem Form 4, the parallel stem with a deep basal notch or flute, is over-represented only at 41BX228, and under-represented at 41MM340. Finally, Stem Form 5, the contracting stem form, is under-represented at three sites (41BN1, 41BX228, and 41UV2), while being over-represented at 41MM340 and 41WM49. Note that the adjusted residual for Stem Form 5 at 41MM340 is 15.4, a value that far exceeds a probability level of .0001. This site

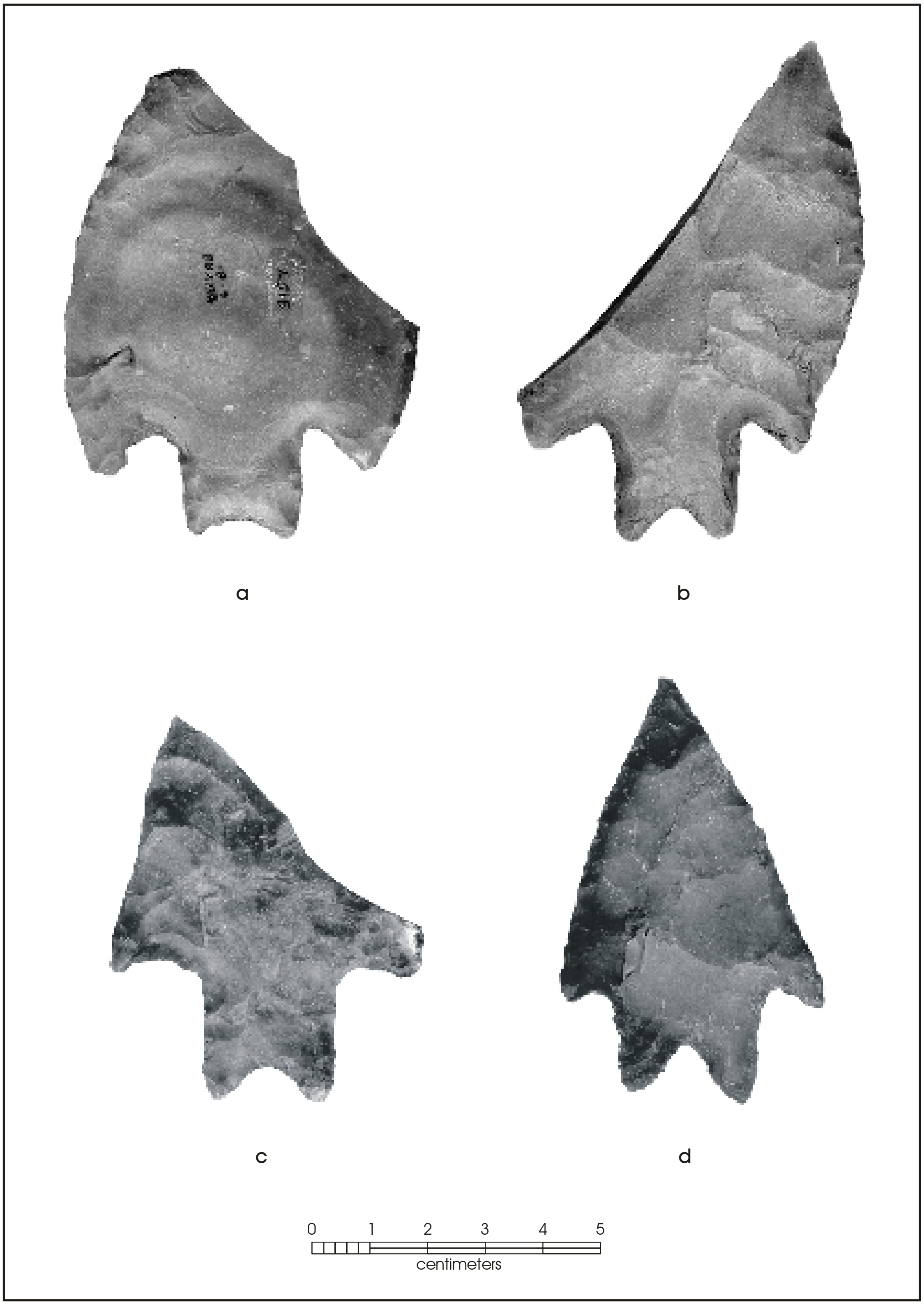


Figure 12-4. *Blade Form 3, broadly shouldered and slightly barbed specimens.*

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Figure 12-5. *Distribution of stem and blade forms at the 10 sites in the comparative collections (black represents stem forms; gray represents blade forms).*

Table 12-1. Breakdown of the Comparative Collection by Stem Form

Site	Stem Form						Total
	1	2	3	4	5	6	
41BN1	9	39	13	38	0	0	99
41BX228	4	32	14	64	0	1	115
41UV2	7	35	2	33	0	0	77
41UV21	13	22	6	43	1	0	85
41UV60	2	15	2	8	1	0	28
41UV88	15	12	7	38	1	1	74
41BL104	13	1	2	9	4	0	29
41MM340	1	0	1	0	16	0	18
41WM13	2	10	0	11	1	1	25
41WM49	12	23	2	29	12	0	78
Total	78	189	49	273	36	3	628

contains 44% of the examples of this stem form (16 of 36), but contains only 2.9% (18 of 628) of the points considered in this study. No other site in Table 12-2 has such a strong association with a particular stem form and 41MM340 is one of only two sites (41WM49 is the other) to have significant positive adjusted residuals in Stem Form 5 (see Table 12-2). The unique character of the Pedernales points at this site is clearly shown in Figure 12-6. The figure is a bivariate plot of the percentage of Stem Form 5 within a site against the percentage of occurrence of the most common stem form, Form 4. Clearly, the 41MM340 assemblage is unlike any of the other nine assemblages in terms of these two attributes.

Because we were also interested in discerning regional patterns in stem form, we combined the 10 sites into a Southern Edwards Plateau group (41BN1, 41BX228, 41UV2, 41UV21, 41UV60, 41UV88) and a Central and East-Central Texas group (41BL104, 41MM340, 41WM13, and 41WM49). Table 12-3 presents the raw counts, as well as the adjusted residuals, for this new grouping. As in the previous case, Stem Form 6 was combined with Stem Form 2 for this analysis. Note that all cells in the table have significant adjusted residuals. While the adjusted residuals are mirror images of each other given the two choices for any given stem form, the Southern Edwards Plateau has significantly higher occurrences of Stem Forms 2, 3, and 4, while the Central and East-Central Texas group has significantly higher frequencies of Stem Forms 1 and 5. That is, the barrel-shaped and deeply notched parallel stemmed Pedernales are common on the southern edge of the Edwards Plateau but scarce in central and east-central Texas where the contracting stemmed (Form 5), and shallowly concave based forms (Form 1) are most common.

Table 12-4 presents the frequencies of the blade forms within the combined projectile point collection by site. Blade Form 3, the thin-bladed, broadly shouldered or slightly barbed form, contains the largest number of specimens (n=326; 57.9%), with Blade Form 2, the form with large barbs and a broad blade, being the least common type (n=50; 8.9%). Table 12-5 presents the adjusted standardized residuals for each cell of Table 12-4. Blade Form 1, the thick-bladed and narrow-shouldered form, is statistically under-represented at four sites (41UV21, 41UV88, 41BL104 and 41MM340), while being over-represented at four other sites (41BN1, 41UV2, 41UV60, and 41WM49). Blade Form 2, the broad and heavily barbed form, is more frequent than expected at 41UV88. Finally, Form 3 is significantly over-represented at four sites (41UV21, 41UV88, 41BL104, and 41MM340), and under-represented at three others (41UV2, 41UV60, and 41WM49).

As we did with the stem forms, we again combined the sites into a Southern Edwards Plateau group (41BN1, 41BX228, 41UV2, 41UV21, 41UV60, 41UV88) and a Central and East-Central Texas group (41BL104, 41MM340, 41WM13, and 41WM49) and considered regional patterning in the Table 12-4 data. Table 12-6 presents the results of standardized adjusted residuals on the two regional groups. Surprisingly, none of the blade forms have a statistically significant deviation from expected at the .05 probability level. While Blade Form 2 shows a strong tendency to be under-represented in the Central and East-Central Texas sites, the probability associated with an adjusted residual of ±1.91 is .0548.

Table 12-2. Breakdown of Adjusted Residuals by Site and Stem Form within the Comparative Collection

Site	Stem Form 1	Stem Form 2	Stem Form 3	Stem Form 4	Stem Form 5	Total
41BN1						
Count	9	39	13	38	0	99
Adjusted Residual	-1.1	**2.1**	**2.2**	-1.1	**-2.7**	
41BX228						
Count	4	33	14	64	0	115
Adjusted Residual	**-3.2**	-0.5	1.9	**2.9**	**-2.9**	
41UV2						
Count	7	35	2	33	0	77
Adjusted Residual	-0.9	**3**	-1.8	-0.1	**-2.3**	
41UV21						
Count	13	22	6	43	1	85
Adjusted Residual	0.9	-1	-0.3	1.4	-1.9	
41UV60						
Count	2	15	2	8	1	28
Adjusted Residual	-0.9	**2.7**	-0.1	-1.6	-0.5	
41UV88						
Count	15	13	7	38	1	74
Adjusted Residual	**2.2**	**-2.6**	0.6	1.5	-1.7	
41BL104						
Count	13	1	2	9	4	29
Adjusted Residual	**5.4**	**-3.2**	-0.2	-1.4	1.9	
41MM340						
Count	1	0	1	0	16	18
Adjusted Residual	-0.9	**-2.9**	-0.4	**-3.8**	**15.4**	
41WM13						
Count	2	11	0	11	1	25
Adjusted Residual	-0.7	1.5	-1.5	0.1	-0.4	
41WM49						
Count	12	23	2	29	12	78
Adjusted Residual	0.8	-0.2	-1.8	-1.2	**3.9**	
Total	78	192	49	273	36	628

In summary, there do appear to be significant differences at a regional level in stem forms, with Stem Forms 1 and 5 being more common in the Central and East-Central Texas sites, and Stem Forms 2, 3, and 4 being more common in the Southern Edwards Plateau. However, no significant differences were noted in blade forms in the regional comparisons. It is unclear what these regional differences in stem forms mean. Interestingly, Stem Form 1 can be easily mistaken for a Bulverde type and its co-occurrence with Pedernales points would not be unexpected given their close temporal relationship. Stem Forms 3 and 5 are rather unique forms as reflected by the fact that they only constitute 8% and 6%, respectively, of the total number of specimens examined. The expanding stem form (Form 3) tends to be more often identified as a Pedernales in the Southern Edwards Plateau collections since concave based Pedernales points are more expected in this region. The contracting stem form (Form 5) is infrequent in the Southern Edwards Plateau collections perhaps because this form is dramatically different from the more classic Stem Forms 2 and 4 found

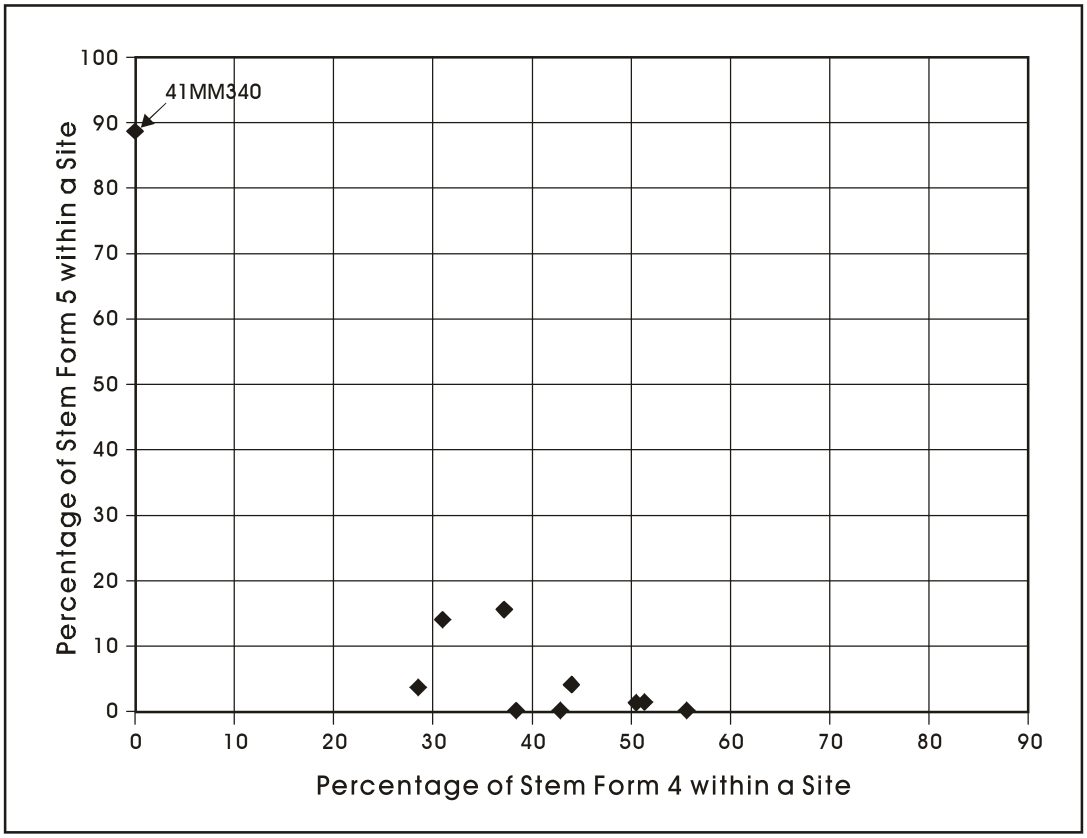

Figure 12-6. *Bivariate plot of the percentage of Stem Form 5 within a site against the percentage of occurrence of the most common stem form, Form 4.*

Table 12-3. Breakdown of Adjusted Residuals by Stem Forms and Regional Site Groups

Regional Site Group	Stem Form 1	2	3	4	5	Total
Southern Edwards Plateau						
Count	50	157	44	224	3	478
Adjusted Residual	**-2.7**	**2.2**	**2.3**	**3.1**	**-9.8**	
Central and East-Central Texas						
Count	28	35	5	49	33	150
Adjusted Residual	**2.7**	**-2.2**	**-2.3**	**-3.1**	**9.8**	
Total	78	192	49	273	36	628

Table 12-4. Breakdown of the Comparative Collection by Blade Form

	Blade Form			
Site	1	2	3	Total
41BN1	44	4	48	96
41BX228	30	14	57	101
41UV2	32	3	27	62
41UV21	15	8	57	80
41UV60	15	2	9	26
41UV88	4	13	52	69
41BL104	4	2	23	29
41MM340	0	0	15	15
41WM13	5	0	12	17
41WM49	38	4	26	68
Total	187	50	326	563

in this region. Therefore, although it is possible that the regional differences in stem forms may be reflective of broad, more or less homogenous Pedernales manufacture strategies, they may also be the product of regional variability in classifying Pedernales projectile points.

Technological Organization: Formal and Expedient Tools and Projectile Technology

Parry and Kelly (1987) have previously suggested that the manufacture of heavily retouched or formal tools is conditioned by raw material availability, but once raw material availability is not a constraining factor, the more mobile a group is the more likely that it will be equipped with formal tool forms and the less mobile, the more likely that expedient tool forms will dominate tool assemblages. Tomka (2001) on the other hand, suggests that the tool forms utilized by hunter-gatherers are conditioned not by mobility per say but the processing requirements needed to be accomplished with the tools. Either theoretical approach has some interesting implications for interpreting the composition of tool assemblages when considered in terms of ratios of formal versus expedient forms. In the first instance, high proportions of expedient tool forms should suggest a high degree of sedentism, while a high proportion of formal tools would indicate high rates of mobility (i.e., distance and number of moves). In the second instance, high proportions of expedient tools would suggest low scales of processing requirements while high numbers of formal tool forms would indicate increased processing stress.

To investigate the different aspects of technological organization, we turn to the distribution of selected chipped lithic artifacts by analytical unit shown in Table 12-7. The table presents only those artifacts could be assigned to a known analytical unit (i.e., surface and back dirt artifacts are not included). That is, those artifacts that derive from units and/or zones that could not clearly be assigned to an analytical unit are not included in the table. Therefore, the number of artifacts included in this table is less than the number of artifacts discussed in Chapter 6.

A number of general patterns are worth noting. Although the volume of matrix recovered from AU 7 is not large (4,506.3 m^3), the scarcity of artifacts suggests that this analytical unit represents the early stages of occupation of the landform. The oscillations in a number of data types examined in earlier chapters (i.e., 8 and 9) is clearly repeated in the distribution of a number of chipped lithic artifacts from the site. For instance, AUs 2, 4, and 6 have nearly identical high numbers of projectile points while the intervening AUs have much fewer but comparable numbers.

The diversity of formal tools is relatively low and with the exception of the awls it is suggestive of heavy involvement in woodworking activities. Choppers with heavily battered, step-fractured, and rounded working edges are almost entirely restricted to the upper AUs, while Erath celts are almost evenly distributed between the AUs. In addition to the numerous projectile points, Erath celts are the only other relatively common formally manufactured tool form. As indicated in the detailed discussion of lithic tools in Chapter 6, both use-broken and manufacture-failed specimens are

Table 12-5. Breakdown of Adjusted Residuals by Site and Blade Form within the Comparative Collection

Site	Blade Form 1	Blade Form 2	Blade Form 3	Total
41BN1				
Count	44	4	48	96
Adjusted Residual	**2.9**	-1.78	-1.72	
41BX228				
Count	30	14	57	101
Adjusted Residual	-0.8	1.94	-0.33	
41UV2				
Count	32	3	27	62
Adjusted Residual	**3.3**	-1.19	**-2.43**	
41UV21				
Count	15	8	57	80
Adjusted Residual	**-3**	0.38	**2.61**	
41UV60				
Count	15	2	9	26
Adjusted Residual	**2.7**	-0.22	**-2.46**	
41UV88				
Count	4	13	52	69
Adjusted Residual	**-5.2**	**3.1**	**3.14**	
41BL104				
Count	4	2	23	29
Adjusted Residual	**-2.3**	-0.39	**2.4**	
41MM340				
Count	0	0	15	15
Adjusted Residual	**-2.8**	-1.23	**3.35**	
41WM13				
Count	5	0	12	17
Adjusted Residual	-0.3	-1.31	1.08	
41WM49				
Count	38	4	26	68
Adjusted Residual	**4.2**	-0.93	**-3.5**	
Total	187	50	326	563

Table 12-6. Breakdown of Adjusted Residuals by Blade Forms and Regional Site Groups

Regional Site Group	Blade Form 1	Blade Form 2	Blade Form 3	Total
Southern Edwards Plateau				
Count	140	44	250	434
Adjusted Residual	-0.9	1.92	-0.26	
Central and East-Central Texas				
Count	47	6	76	129
Adjusted Residual	0.9	-1.92	0.26	
Total	187	50	326	563

Table 12-7. Breakdown of Chipped and Ground/battered Stone Artifacts by Analytical Unit

Description	AU 1	AU 2	AU 3	AU 4	AU 5	AU 6	AU 7	Total
Darl		1						1
Edgewood		1						1
Gary		1	1			1		3
Godley		1						1
Kent		2	2	1				5
Marcos		4		4	2			10
Marshall				4	2			6
Pedernales						19		19
Woden						1		1
Yarbrough				1				1
Untypable	1	10	2	13		2		28
Untyped	1	4	2	4	1	1		13
Projectile Points Total	**2**	**24**	**7**	**27**	**5**	**24**	**0**	**89**
Adze				1				1
Awl		2						2
Chopper	1	5	1		1	1		9
Erath Celt	2	3		5	2	4		16
Perkin Pike					1			1
Wedge		1						1
Formal Uniface Fragments		1			1			2
Formal Tools Total	**3**	**12**	**1**	**6**	**5**	**5**	**0**	**32**
Expedient Scraper	4	29	10	85	18	27	7	180
Expedient Scraper/Expedient Graver (2 working edges)				1				1
Expedient Scraper/Expedient Saw (2 working edges)			1	1				2
Expedient Scraper/Expedient Scraper/Expedient Knife (3 working edges)		1				1		2
Expedient Scraper/polisher (2 working edges)				1				1
Expedient Tools Total	**4**	**30**	**11**	**88**	**18**	**28**	**7**	**186**
Minimally Retouched Scraper		6	1	12	2	3	1	25
Expedient Scraper/Minimally Retouched Scraper			1	8		1		10
Minimally Retouched Tools Total	**0**	**6**	**2**	**20**	**2**	**4**	**1**	**35**
Miscellaneous Bifaces	**6**	**20**	**4**	**41**	**6**	**18**	**4**	**99**
Multidirectional Cores	2	11	8	21	1	18	2	63
Opposed bidirectional Cores				1		1		2
Bidirectional Cores	2	4		7		3	1	17
Blade							1	1
Unidirectional Cores	2	7	1	4	2	10		26
Cores Total	**6**	**22**	**9**	**33**	**3**	**32**	**4**	**109**
Hammerstone	1	1		4		2	1	9
Mano		1						1
Mano/Hammerstone				1				1
Metate		1						1
Ground/Battered Stone Tools Total	**1**	**3**	**0**	**5**	**0**	**2**	**1**	**12**
Grand Total	**22**	**117**	**34**	**220**	**39**	**113**	**17**	**562**

present within the group. It is clear that these tools were used and broken on site, and replaced with new tools manufactured on site.

Tools with minimally retouched working edges are infrequent (n=35). Twenty-five artifacts can be recognized and classified as minimally retouched scrapers. The remaining 10 tools possess multiple working edges, and consist of specimens with minimally retouched and expedient working edges.

The ratio of expedient to formal tools, not including projectile points, ranges from a low of 1.3:1 in AU 1 to a high of 14.7:1 in AU 4 (Table 12-8). Within the three AUs with the highest artifact densities, AUs 2, 4, and 6, expedient to formal tool ratios are 2.5:1, 14.7:1 and 5.6:1, respectively. Three of the top four expedient to formal tool ratios are in AUs 4–6. In the upper analytical units, only AU 3 has higher expedient to formal tool ratios. Only a small number of minimally retouched tools have been identified. Therefore, expedient tools also are more numerous than minimally retouched tools in all AUs except AU 1. The predominance of expedient tools suggests that with the exception of activities accomplished with formally manufactured hafted tools (Erath celts), most other activities conducted on site could be accomplished using expediently manufactured tools. The fact that expedient to formal tool ratios seem to be higher in the deeper AUs compared to the upper AUs may indicate that the assemblages derive from various short-term reoccupation episodes since shorter occupations would result in decreased rates of discard of formal tools with long use lives.

The examination of the ratios of projectile points to formal tools shows that while in AUs 1 and 5 the ratios are nearly identical or equal, in other AUs projectile points are more common than other formal tools. Two of the top three highest ratios are found in the deeper AUs (4 and 6), and projectile point to formal tool ratios are higher in the deeper AUs than in the upper two AUs. The fact that these patterns parallel the patterns in expedient and formal tool ratios is interesting. If we are correct in interpreting the shorter individual occupation spans for the earlier AUs, the projectile point to formal tool ratios may indicate that the primary focus of these early occupations was hunting and perhaps the refurbishing of projectile weaponry.

Artifacts classified as cores are nodular chert pieces with flakes removed to serve as blanks for expedient tools or the manufacture of formal tools. All bifacially flaked cores are classified as miscellaneous bifaces rather than cores. The ratio of cores to miscellaneous bifaces is very similar in Analytical Units 1, 2, 4, and 7. Cores, however, tend to out-number miscellaneous bifaces in AUs 3 and 6, suggesting perhaps that the production of flake banks for expedient tools may have been a significant part of the lithic reduction activities at the site.

Even more interesting is the pattern in the projectile point and miscellaneous biface ratios. Two of the three analysis units with large artifact collections (AUs 2 and 6) have similar ratios of points to bifaces. In Analytical Units 1, 4, and 5 bifaces outnumber projectile points. All bifaces that represent preforms of bifacially flaked Erath celts have been classified as Erath celts. In addition, only one bifacial knife was recovered from the site. Therefore, it is likely that the majority of the remaining bifaces represent projectile point manufacture failures. If this assumption is correct, and if we can further assume that for each projectile point discarded on site a replacement point was manufactured on site, the ratios of projectile points to miscellaneous bifaces would suggest that one failed biface was generated in the production of each point being replaced at 41MM340.

Table 12-8. Selected Artifact Ratios by Analytical Units

Artifact/Tool Category	AU 1	AU 2	AU 3	AU 4	AU 5	AU 6	AU 7
expedient:formal tool	1.33:1	2.5:1	11:1	14.7:1	3.6:1	5.6:1	-
expedient:minimally retouched	-	5:1	5.5:1	4.4:1	9:1	7:1	7:1
projectile point:formal tool	.67:1	2:1	7:1	4.5:1	1:1	4.8:1	-
cores:miscellaneous bifaces	1:1	1.1:1	2.2:1	.8:1	.5:1	1.8:1	1:1
projectile point:miscellaneous bifaces	.33:1	1.2:1	1.7:1	.6:1	.8:1	1.3:1	-

This calculation assumes that for each manufacture event, one of the events failed, resulting in a discarded biface while the second one was successful resulting in a functional point. However, this scenario would assume a 50% failure rate, a rather high figure for prehistoric knappers. While it is unlikely that prehistoric manufacture failure rates were as high as 50%, in reality we do not know what actual failure rates may have been. If we can assume, however, that prehistoric manufacture failure rates remained relatively even during the occupation of 41MM340, and if we can take the combined site-level projectile point to miscellaneous biface ratio (.90:1) as a starting baseline, then ratios dominated by miscellaneous bifaces may be reflective of higher levels of "gearing up" compared to collections in which projectile points outnumber miscellaneous bifaces.

With this context in mind, the data in Table 12-8 suggest that AUs 1 and 4 may be the product of greater levels of gearing up, while AUs 3 and 6 may represent lower levels of gearing up. The small size of the chipped lithic assemblage from AU 1 makes it unlikely that the assemblage is a product of intensive tool manufacture for future use. The larger sample sizes for the other AUs allow us to place more confidence in the interpretation.

If these assumptions and arguments are acceptable, it casts lithic manufacture at 41MM340 in a very different light and suggests that the production of large numbers of projectile points for use away from the site may have been one of the main reasons for visiting and revisiting the locality particularly during the periods encompassed by AUs 1 and 4. That is, the refurbishing of lithic tool kits and gearing up for intensive hunting activities in other parts of the annual range may have been one of the principal reasons for visiting the site.

A closer look at the projectile point technology of the three most common typed forms recovered from 41MM340 may cast additional light on differences between occupations of the site. The three most common projectile point types from the site are Pedernales (n=20), Marcos (n=15), and Marshall (n=7). All typed specimens of these three points are included in this discussion.

The 20 Pedernales points consist of nine (45%) manufacture-failed points, three stem fragments and two proximal fragments broken in use, four complete specimens that can be considered exhausted due to their narrow blades (see Figure 6-2 f and g), and two complete or nearly complete points (see Figure 6-2 d and e) that appear to be still functional. Five of the nine manufacture-failed specimens exhibit blade breaks (see Figure 6-2c), while the other four have been abandoned during manufacture due to failure to thin the blades. The presence of four exhausted yet complete points in combination with the nine manufacture-failed specimens suggests that some specimens may have been replaced before use failure. This aspect of the hunting technology also seems to support the earlier impression that some of the tool-making activities were designed to produce specimens for future use at other localities.

The 15 Marcos points consist of only two manufacture-failed specimens (see Figure 6-1j), one of these two is a proximal fragment. Of the six remaining proximal fragments, four appear to be use broken and break cause cannot be established on a heat spalled fragment. The sixth proximal fragment could easily have been refurbished into a functional specimen with little work. None of the seven complete specimens appear to be exhausted and all could have been further utilized before discard.

Although manufacture-failed specimens among the Marcos points are scarce, it does not mean that the remaining points were not made on site. As a matter of fact, only one specimen, made of Georgetown flint, does not match the characteristics of the cherts recovered from Little River gravel bars. The discard of still functional Marcos points is similar to the discard of functional Pedernales points. The Marcos points seem to have been discarded even more prematurely than the Pedernales specimens.

Six of the seven Marshall points are complete. The remaining specimen is a manufacture-broken proximal fragment. One of the complete specimens may be considered exhausted since it has a blade that equals its stem in length. Two other complete specimens are missing one barb each, and this may account for their discard. Raw material for each of the seven specimens matches the locally available materials. The discard strategy followed by the makers of the Marshall points also seems to mimic that of Marcos and Pedernales craftsmen and hunters. That is, projectile point replacement takes place before points reach an exhausted state.

Raw Material Acquisition

The final aspect of technological organization investigated in this chapter is raw material acquisition. Because key components of most prehistoric tool kits are made of lithic materials, access to and procurement of tool stone is an aspect of hunter-gatherer behavior that should have commanded significant attention.

Although the site is located in the Blackland Prairie, raw materials are available in quantity within the Little River drainage as it contains bed loads of stone that probably originated in the Edwards Plateau. The presence of these Plateau cherts in close proximity to the site makes the identification of "non-local" material, material probably procured from the Plateau, problematic. As noted in Chapter 2, during our work at 41MM340, S. Tomka made observations on material exposed on a gravel bar within the Little River drainage. Angular chert nodules mixed within a limestone cobble matrix were common to abundant at several locations, and pieces of petrified wood and quartzite nodules were also observed, though at much lower densities relative to the chert nodules.

Tomka also collected a variety of chert nodules from the Little River drainage near 41MM340. Two hundred and eighty-five nodules, primarily of chert, were gathered to provide data on raw material availability. Nodules ranged in size up to 16 cm in length, though most were in the 8–12 cm size range. A variety of chert colors were present in this collection, including a variety of yellows, tans, and light browns. Figure 12-7 presents a series of flakes struck from these nodules that reflect much of the range of this collection. The bottom portions of flakes 12-7h and 12-7i have been heated as a guide for the identification of thermally altered specimens in the current collection from 41MM340. The vast majority of the cherts recovered from data recovery at 41MM340 are consistent with the material ranges documented by Tomka in the Little River drainage suggesting that little non-local material may be present.

In order to explore the issue of raw material acquisition in more detail, we chose a 10% random sample from each analytical unit for more detailed analysis. This resulted in a sample size of 6,021 individual pieces of debitage. Following initial inspections of the 6,021 pieces, we subdivided the sample into 15 chert types based primarily on color. The descriptions of 14 of these types, and some of their defining characteristics, are provided in Table 12-9. Material Type 15, which is not described in the table, consisted of smaller groups of two or three items that could not be incorporated into the 14 other classes. Once the 15 groups were established and the sample was divided into the groups, we divided the samples into corticate and decorticate subgroups. In addition, the weight of each item was recorded as a measure of raw material size.

As our principal interest was in identifying local and non-local raw materials, we initially compared the raw material groups to the samples collected from the Little River drainage. Material Types 1, 2, 3, 4, 5, 6, 9, and 10 are clearly consistent in terms of color and inclusions with the samples collected from the drainage. In addition, Material Type 8, which contained a variety of cherts in the brown and reddish brown ranges, is consistent with collected samples that had experienced some heat alterations (see Figure 12-7 h and i). Material Type 12 is also classified as a local material. While no direct match between this material and the collection could be made, the material is within the color range and has similar inclusion patterns as the drainage samples. Based on this comparison, debitage in these samples are classified as representing local raw materials. Material in Groups 7, 11, 13, and 14 were not consistent with the drainage samples. These materials are classified as non-local, although it is entirely possible that materials with these color and inclusion patterns are present in the drainage at such a low frequency that they were not collected in our sample. Finally, note that Material Type 15 has been eliminated from the analysis. This group lacked coherence, being represented by those samples that did not fit into any of the other groups. It is probably that much of this group is non-local, but local materials are also present.

With the elimination of Type 15, 5,800 pieces of debitage remain. Of this total, 5,594 are in groups classified as local, with the remaining 206 (3.6%) being classified as non-local. Table 12-10 presents the chert types, their designation as local or non-local in origin based on comparison with the drainage samples, the number of items assigned to a group, the percentage of non-cortical debitage, the average weight, and the maximum weight for each raw material group. We have grouped all local samples at the top of the table. While there are exceptions in some categories (e.g., Material Type 9), comparison of the local and non-local groups suggests that local raw materials have larger samples sizes, tend to have lower non-cortical percentages, higher mean weights, and higher maximum weights relative to non-local designations.

Several of the differences shown in Table 12-10 are probably related to different reduction sequences for these different local and non-local material classes. We suggest that locally available materials would tend to be used primarily to produce new tool kits. Local materials would, then, be subject to long manufacture sequences involving decortication of nodules, thinning, and shaping of a variety of different tools. As such, debitage from local materials

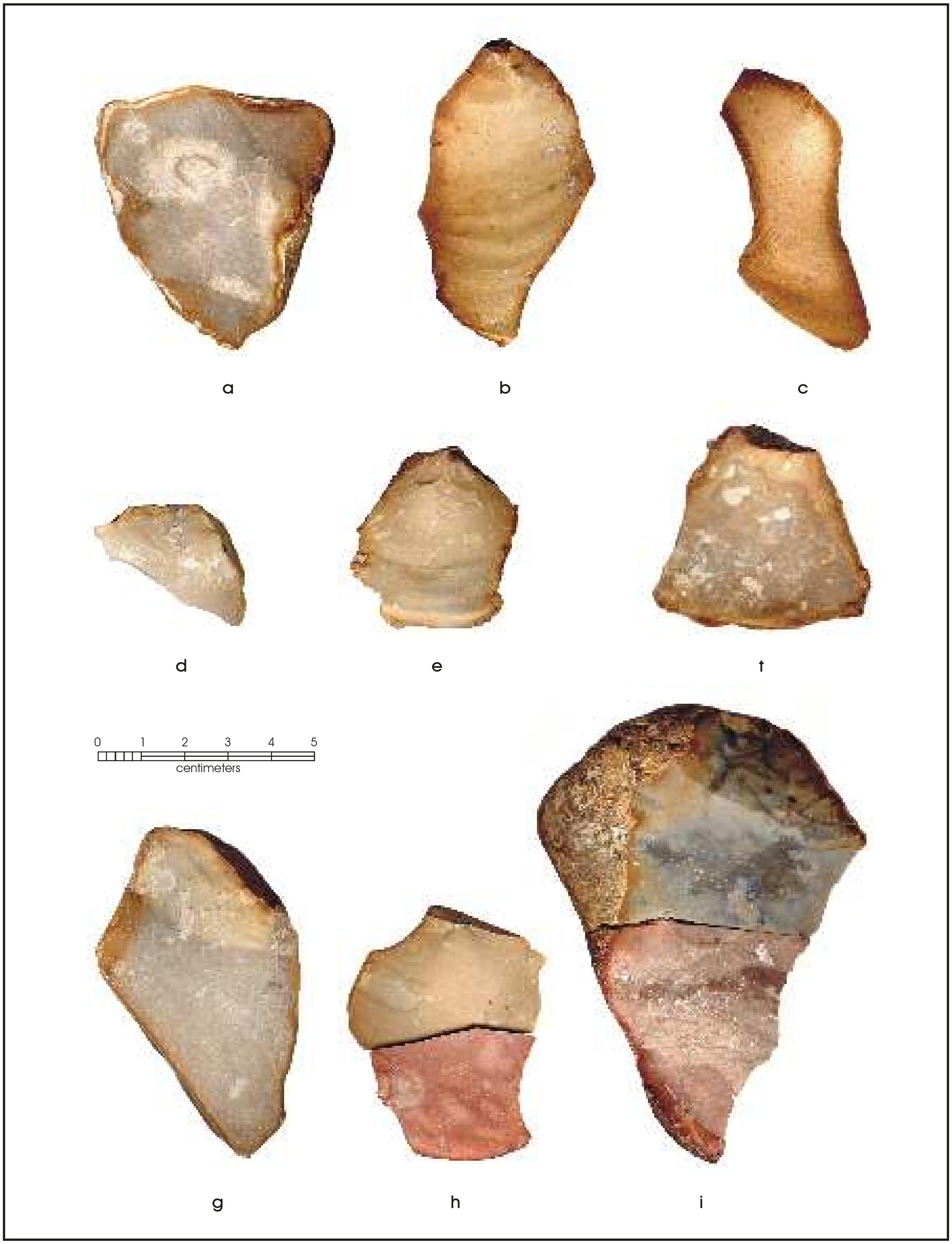

Figure 12-7. *Examples of local raw materials collected from the Little River drainage.*

Table 12-9. Material Types Identified in the 41MM340 Debitage Sample

Material Type 1: Chert. Material is within the very pale brown, yellow, and brownish yellow color ranges. Inclusions are frequently present. Munsell color ranges noted on selected specimens include 10YR 7/3, 7/4, 7/6, 6/3, 6/4, and 6/6. Generally opaque.

Material Type 2: Chert. Material is within the light gray, gray, and light brownish gray color ranges. Inclusions are common. Munsell color ranges noted on selected samples include 10YR 7/1, 7/2, 6/1, and 6/2, as well as 2.5Y 7/1 and 6/1. Generally opaque.

Material Type 3: Chert. Material is within the brown, dark grayish brown, and grayish brown color ranges. Inclusions are common, and some of the material tends to be translucent. Munsell color ranges noted on selected samples include 10YR 4/2, 4/3, 5/2, and 5/3.

Material Type 4: Chert. Material is within the gray, dark gray, grayish brown, and dark grayish brown color ranges. Inclusions are common. Some of the material tends to be translucent. Munsell color ranges noted on selected samples include 10YR 5/1, 4/1, 4/2 and 5/2. Material may overlap with Material type 3, though as a group, this material is darker in value.

Material Type 5: Chert. Material is within the gray, light gray, and light brownish gray color ranges. Inclusions are common. Some material tends to be translucent, but most is opaque. Munsell color ranges noted on selected samples are 2.5Y 6/1, 6/2, and 10YR 7/1.

Material Type 6: Chert. Material is within the very pale brown, pale brown, light brownish gray, and grayish brown color ranges. Inclusions are uncommon. Some of the material tends to be translucent. Munsell color ranges noted on selected samples include 10YR 6/2, 5/2, 7/3, and 6/3.

Material Type 7: Chert. Material is within the white, light gray, and very pale brown color ranges. Inclusions are common. Generally opaque. Munsell color ranges noted on selected samples are 10YR 8/1, 7/2, and 7/3.

Material Type 8: Chert. Material is within the brown and dark brown color ranges. Inclusions are common. Some material tends to be translucent. Munsell color ranges noted on selected samples are 7.5YR 5/3, 4/2, and 3/2.

Material Type 9: Chert. Material is within the gray, dark gray, very dark gray, grayish brown, and dark grayish brown color ranges. Inclusions are common. Some material tends to be translucent, but most is opaque. Munsell color ranges noted on selected samples include 10YR 3/1, 4/1, 5/1, 6/1, 4/2, and 5/2.

Material Type 10: Chert. Material is within the gray, dark gray, light grayish brown, grayish brown, and dark grayish brown color ranges. Inclusions are common. Some material tends to be translucent, but most is opaque. Munsell color ranges noted on selected samples include 10YR 6/1, 5/1, 4/1, 6/2, 5/2, and 4/2.

Material Type 11: Chert. Material is within the dark gray and very dark gray color ranges. Inclusions are common. Material is opaque. Munsell color ranges are 2.5Y 4/1, 3/1, and 2/1.

Material Type 12: Chert. Material is within the gray, light brownish gray, dark grayish brown, and brown color ranges. Inclusions are common in some of the material. Material tends to be translucent. Munsell color ranges are 10YR 6/1, 5/1, 6/2, 4/2, and 4/3.

Material Type 13: Chert. Material is within the gray, dark gray, pinkish gray, reddish gray, and dark reddish gray color ranges. Inclusions frequently occur. Generally opaque. Munsell color ranges are 5YR 6/1, 5/1, 4/1, 6/2, 5/2, and 4/2.

Material Type 14: Chert. Material is within the white, light gray, gray, and light brownish gray color ranges. Inclusions are common. Generally opaque. Munsell color ranges are 10YR 8/1, 7/1, 6/1, 5/1, 7/2, and 6/2.

Table 12-10. Characteristics of Local and Non-local Raw Material Groups in Debitage Sample

Material Group	Origin	Number of Items	% Non-Cortical Debitage	Mean Weight (g)	Maximum Weight (g)
1	local	1421	0.445	2.331	87
2	local	618	0.741	2.565	97.6
3	local	396	0.828	0.805	15.2
4	local	564	0.791	1.563	52.6
5	local	867	0.706	1.593	48.6
6	local	447	0.770	0.896	32.1
8	local	756	0.742	1.14	55
9	local	296	0.868	0.494	7.7
10	local	127	0.795	0.984	31.5
12	local	102	0.794	0.828	8
Total	**local**	**5594**	**0.683**	**1.626**	**97.6**
7	non-local	100	0.800	1.45	16.4
11	non-local	37	0.865	0.762	3.9
13	non-local	38	0.842	0.647	2.8
14	non-local	31	0.935	0.574	3.1
Total	**non-local**	**206**	**0.84**	**1.046**	**16.4**

should be characterized by large numbers of items, high variability in debitage size, and variable cortex percentages. Conversely, the rejuvenation of tools made of non-local materials, and transported to the site in a more finished form, would represent much shorter reduction sequences. These sequences should produce fewer debitage, debitage with a limited size range, and debitage with high percentages of non-cortical flakes. In general, these characterizations are consistent with the patterns of local and non-local tool stone use seen in Table 12-10.

If, in fact, non-local materials are correctly identified in Table 12-10, and if they reflect the importation of finished tools into 41MM340, then changes in the relative contribution of non-local raw materials in analytical units may provide a rough measure of changes in the way that raw material acquisition is organized. Figure 12-8 presents the relative contribution of non-local materials by analytical units. Roughly 5.4% of the tool stone in AU 6, an analytical unit characterized primarily by Pedernales points and probably dating to around 3000 BP, is derived from non-local sources. This percentage declines slightly through AU 4, where it begins a steady climb culminated in an over 11% non-local contribution in AU 1. These differences in non-local material contributions could reflect changes in a variety of different areas, including changes in the level of mobility, changes in the nature of the mobility system, or changes in the nature of the site use. While we currently lack methods to identify which of these areas should be pursued in future research, the patterning in Figure 12-8 clearly hints that material acquisition patterns varied significantly during the Late Archaic occupation of 41MM340.

Summary and Conclusions

This chapter focused on three principal research issues: 1) identifying regional variability in Pedernales projectile point stem forms and manufacture strategies as manifested in blade forms; 2) defining prehistoric technological organization as evidenced in the composition of tool assemblages from distinct analytical units; and 3) investigating raw material procurement practices as they are reflected in the chert types present in the debitage collections from 41MM340.

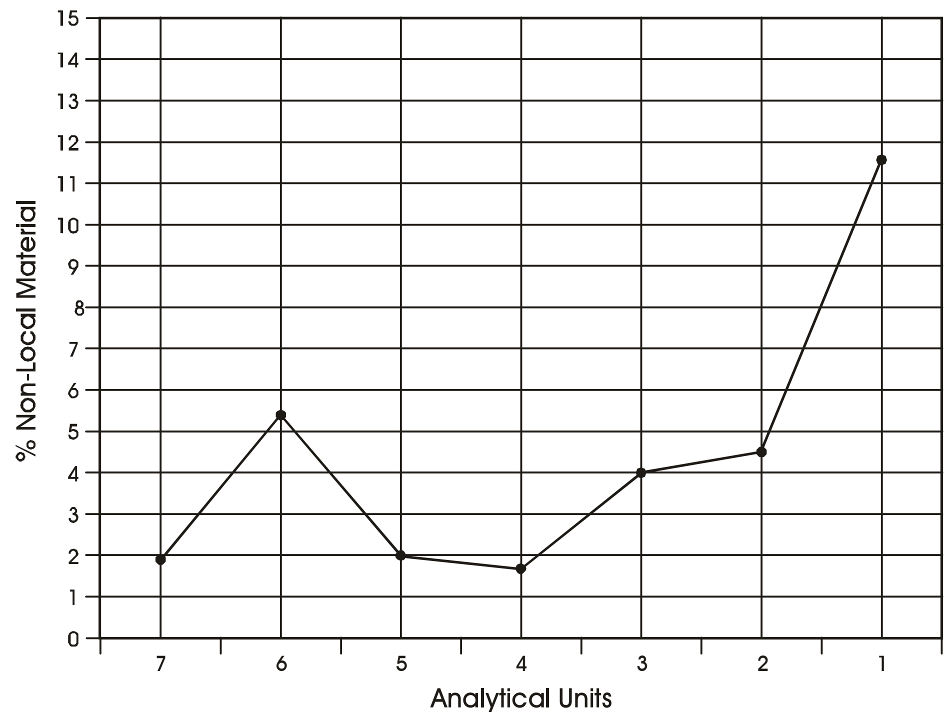

Figure 12-8. *Relative contribution of non-local raw materials by analytical unit.*

As far as we are aware, this study is one of the first to analyze a large comparative sample of Pedernales projectile points to investigate spatial patterning in varieties. It is not possible to determine whether the six stem form varieties represent the products of idiosyncratic behavior or some form of individual or group identifier (i.e., Weissner 1983). In addition, the data may also be interpreted as indicative of regional biases and tendencies in classifying projectile points into distinct types. Perhaps, however, these are not the questions or issues to pursue. The first analytical step is to identify patterning in the data. We are in the early stages of pattern recognition, and we clearly do not understand what the patterns represent. Nonetheless, as often happens, some interesting patterns have emerged during the analysis. Regardless of the "meaning" of the attribute, each stem and blade form has implications related to tool efficiency, survivability, etc. It is perhaps in this area of investigation where patterns may be more easily investigated.

The analysis of blade forms may be one such example. The three manufacture trajectories identified in this analysis have been discussed by several other authors (Ensor and Mueller-Wille 1988; Goode 2002; Decker et al. 2000). One of the interesting aspects of these blade forms is that they represent one of the few times when we can document two and perhaps three very different ways of manufacturing the same point type. The manufacture strategies of the blanks themselves may be viewed as representing more or less homogenous groupings representative of a shared technological repertoire. This aspect of Pedernales manufacture technology may be a more appropriate gauge of inter-regional variability than the variability in stem forms that may correlate more with the idiosyncratic behavior of individual craftsmen. The second, and perhaps more interesting, aspect of the blade form variability is that both the thickness of the blades and the size of the shoulders and barbs potentially have some important repercussions related to point failure characteristics and, potentially, hunting success. Narrow, thick and strongly biconvex blade cross-sections may be more resistant to bending fractures than broad, thin and flat blades. If this speculation is correct, it may imply that Blade Form 1 has a higher survival rate than Blade Forms 2 and 3. On the other hand, Blade Forms 2 and 3 may be more effective killing weapons since they create larger openings in an animal and the broad shoulders and/or barbs reduce specimen loss. The broader blade form (Form 2) may also have a longer effective use life when it comes to blade resharpening. As this scenario indicates, designing a particular tool or artifact is often a matter of choosing between competing design alternatives. Tool design often becomes an exercise in having to choose between design alternatives that may provide solutions to some aspects of tool use but may fail to address other aspects due to functional constraints, or other factors. Often, systematic experimental studies are necessary to identify and quantify the costs and benefits of distinct design alternatives. This stage of research in the analysis of lithic technologies is just beginning.

The analysis of the composition of lithic assemblages from different analytical units indicates that expedient tools dominated the various assemblages. The higher ratios of expedient to formal tools in the deeper analytical units may indicate that occupation spans may have been shorter during this period. This reconstruction is consistent with the assumption that the floodplain proper and the immediate site vicinity did not stabilize until sometime after the formation of Analytical Unit 4. The nearly equal presence of miscellaneous bifaces and projectile points, coupled with the predominance of manufacture-failed projectile points in AUs 4–6, suggests that manufacture of numerous replacement forms for future use (i.e., gearing up) may have been one of the principal activities performed during site visits. The discard of numerous points that are seemingly complete and retain use life suggests that projectile point replacement strategies favored replacement before failure, rather than having the projectile point break in use away from readily available raw material sources.

We did not expect to identify significant patterning in raw material use because we assumed that the homogenous good-quality gravels all derived from the Edwards Formation. Nonetheless, the breakdown of the debitage into local and non-local materials based on comparisons to collected samples from the Little River drainage allows us to suggest several patterns that implicate raw material acquisition. Locally available materials are represented by large sample sizes, small percentages of decorticate debitage, and larger and more variable flake size. Conversely, non-local raw materials are represented either by moderate or small sample sizes, tend to have a high relative frequency of decorticate specimens, and tend to be smaller overall and more uniform in size. Finally, changes in the relative contribution of non-local material through time suggest that acquisition of tool stone was variable, with non-local materials contributing an increasing component of the assemblage from AU 4 through AU 1. These changing acquisition patterns may be related to changes in the levels of mobility, with high mobility reflected in AU 6, lower mobility levels in AUs 7, 5, and 4, and a consistent increase in mobility levels from AU 4 through AU 1. However, other changes unrelated to mobility levels, including change in the nature of the use of 41MM340, could also account for these changing levels of non-local tool stone in the assemblages.

Chapter 13: Conclusions

Raymond P. Mauldin and Steve A. Tomka

This document has outlined the results of work conducted at site 41MM340 located in Milam County, Texas. The work was conducted by the Center for Archaeological Research (CAR) of The University of Texas at San Antonio under contract with the Texas Department of Transportation (TxDOT; Work Authorization No. 57006PD004 to Contract No. 570XXPD004). CAR had originally conducted testing at this site, along with site 41MM341, from January through March in 2000. Based on the results of that testing effort (Mahoney and Tomka 2001), data recovery was recommended for site 41MM340. CAR returned to the site in 2001 to conduct data recovery excavations.

The initial six chapters of this document provided background to the project, summarized the research perspective, outlined the field and laboratory methods, and provided a summary of the data recovered. Chapters 7 through 12 addressed a variety of research issues using data from the site, including investigation of floodplain dynamics, paleoenvironmental reconstruction, investigation of changing subsistence patterns, changes in the use of the site area though time, and changes in a variety of elements within the lithic technology. Rather than repeat detailed summaries of each of these avenues of research and their conclusions here, we choose to focus on two general aspects of these data sets. The first aspect has to do with possible diachronic trends in the environmental conditions at 41MM340, as well as changes in the adaptations that are probably related, in part, to those environmental trends. The second aspect is more synchronic, and is focused specifically on regional-scale investigations of stem and blade form variability in Pedernales projectile points.

A variety of different analyses have demonstrated that 41MM340 was probably a very different place at the time of its initial occupation, at roughly 1400 B.C., relative to its terminal occupation, which appears to have been around 400 B.C. While many of the individual data sets can be interpreted in a variety of different ways, there may well have been changes in rainfall, frequency and intensity of flooding, temperature, and the floral and faunal resources available for exploitation at 41MM340. These changes appear to be regional in scale, rather than simply reflecting the specific environment of 41MM340.

Not surprisingly, several aspects of the adaptations reflected at the site, which were probably developed in response to those different environmental conditions, also changed. While the overall diet of the occupants at 41MM340 during most periods of occupation was clearly diverse, changes in both the quantities of mussel shell and some directional changes in faunal remains, including a greater reliance on riverine resources early in the sequence, have been documented. There also appears to be a reduction in the quantities of mussel shell in the upper deposits relative to AU 6, a reduction that is consistent with a decreased focus on riverine resources. Other trends in the archeological data recovered from 41MM340, trends that probably reflect adaptive change, have also been documented though they cannot specifically be tied to environmental shifts. These include the increasing frequencies of burned rock clusters in the upper analytical units relative to features dominated by charcoal and burned clay. These may reflect shifts in the importance of high starch plants in the overall adaptations, or simply reflect changes in the specific activities at 41MM340.

The study of Pedernales projectile point collections from 10 sites located across the Edwards Plateau and into the Blackland Prairie concludes that there is considerable yet patterned regional variation in Pedernales stem forms. While no statistically significant differences were seen in regional comparisons of blade forms, the Pedernales points from site 41MM340 clearly have differences in stem form that set it apart from the other nine sites considered. Part of the variability within all 10 sites may have interesting implications in terms of projectile point manufacture strategies, effectiveness, use-life, and rejuvenation strategies. Some caution in the morphological variability included into the type may also be warranted.

The majority of the tools recovered from the various analytical units of the site are expediently manufactured forms. This suggests that labor and task requirements were relatively low during the occupations of the site. The proportion of manufacture-failed projectile points and miscellaneous bifaces suggests that tool kit refurbishing may have been one of the principal activities of the site's occupants.

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Appendix A

Soil-Stratigraphic Descriptions

Lee. C. Nordt

Appendix A-1: Core and Cutbank Descriptions

N1: 3084280N, 9695603S; between pylons 3 and 4 near bridge boring C1; calcareous and moist throughout.

Fill 0–119 cm; very dark gray (10YR 3/1.5) clay; hard; 3% pebbles, 0.3 to 1 cm, subrounded; lower 40 cm is broken asphalt; clear.

Bk1 119–162 cm; **(Unit 1)**; olive yellow (2.5Y 6/6) clay; common fine distinct gray (10YR 5/1) iron depletions; few medium distinct brownish yellow (10YR 6/6, 6/8) soft iron masses; 5% carbonate nodules, 0.5 to 1 cm diameter, white, pitted; very firm; gradual.

Bk2 162–219 cm; mottled gray (2.5Y 6/1), yellowish brown (10YR 6/6) and brownish yellow (10YR 6/8) clay; few medium distinct dark yellowish brown (10YR 4/6) soft iron masses; very firm; 1% carbonate filaments and 1% carbonate nodules, 0.5 to 2 cm, white, pitted; gradual.

Bk3 219–265 cm; light brownish gray (2.5Y 6/2) silty clay loam; common medium distinct brownish yellow (10YR 6/8) and few medium distinct strong brown (7.5YR 5/6) soft iron masses; few fine distinct iron manganese stains; 5% carbonate nodules, 0.5 to 1 cm diameter, white, pitted; abrupt.

C1 265–401 cm; mottled yellowish brown (10YR 6/8), brownish yellow (10YR 5/8) and light gray (2.5Y 7/1) sandy loam; friable; (saturated); clear.

C2 401–493 cm; light yellowish brown (10YR 6/4) loam; (saturated); gradual.

C3 493–569 cm; mottled olive yellow (2.5Y 6/6) and light gray (2.5Y 7/1) loam; (saturated); 1% carbonate nodules, white, pitted, in pockets; gradual.

C4 569–673 cm; light yellowish brown (10YR 6/4) fine and medium sand; very friable; (moist); abrupt.

Bedrock 673–722 cm; black (2.5Y 2.5/1) bedded shale; common fine distinct olive yellow (2.5Y 6/6) silt to very fine sand laminations in upper 12 cm; noncalcareous.

N2: between pylons 7 and 8 and bridge borings C2 and C3 on geomorphic ridge; calcareous and moist throughout.

Fill 0–27 cm; dark grayish brown (10YR 4/2) clay; hard; firm; 5% detrital carbonate clasts, 0.2 to 0.5 cm diameter, white; clear.

AB 27–113 cm; **(Unit 1)**; very dark gray (10YR 3.5/1) clay; very firm; few medium distinct dark grayish brown (10YR 4/2) biocasts; gradual.

Bk1 113–157 cm; dark gray (10YR 4/1) clay; very firm; many medium and coarse olive yellow (2.5Y 6/6) biocasts; 2% carbonate filaments; common snail fragments; gradual.

Bk2 157–251 cm; olive yellow (2.5Y 6/5) clay; very firm; common medium distinct light gray (2.5Y 7/1) iron depletions; 3% carbonate nodules, 0.2 to 0.5 cm diameter; gradual.

Bkg 251–343 cm; light gray (2.5Y 7/1) clay; firm; many medium distinct olive yellow (2.5Y 6/6) soft iron masses; common fine and medium iron manganese concretions; 5% carbonate nodules, 0.2 to 0.8 cm diameter; clear.

C1 343–417 cm; brownish yellow (10YR 6/8) fine sandy loam; friable; many fine and medium distinct light gray (2.5Y 7/1) iron depletions; few medium distinct yellowish brown (10YR 5/6) soft iron masses; clear.

C2 417–496 cm; mottled light gray (2.5Y 7/1) and olive yellow (2.5Y 6/6) medium fine sandy loam; very friable; few medium distinct yellowish brown (10YR 5/6) soft iron masses; (saturated); clear.

C3 496–671 cm; mottled light gray (2.5Y 7/1) and olive yellow (2.5Y 6/6) sandy loam, upper 35 cm loamy fine sand; one carbonate nodule bed, 0.5 cm thick, white; very friable; abrupt.

C4 671–803 cm; 70% pebbles, 0.2 to 3 cm diameter, siliceous and limestone, subrounded, moderately well sorted, grain supported, in yellowish brown (10YR 6/8) medium sand; abrupt.

Bedrock 803–873; black (2.5Y 2.5/1) bedded shale; common fine distinct olive yellow (2.5Y 6/6) silt to very fine sand laminations in upper 12 cm; noncalcareous.

N3: between pylons 16 and 17 near bridge boring C5; calcareous and moist throughout.

Fill 0–19 cm; very dark gray (10YR 3/1) clay; very firm; 3% pebbles, 0.2 to 0.4 cm diameter; few fine faint strong brown (7.5YR 4/4) iron pore linings; clear.

A 19–49 cm; **(Unit 2, 3)**; very dark gray (10YR 3/1) clay; very firm; ; few fine faint strong brown (7.5YR 4/4) iron pore linings; common snail fragments; clear.

Ab 49–110 cm; **(Unit 1)**; black (2.5Y 2.5/1) clay; very firm; common snail fragments; gradual.

Bk1 110–186 cm; dark gray (2.5Y 3.5/1) clay; very firm; common medium distinct light olive brown (2.5Y 5/4) soft iron masses; few faint slickensides; 4% carbonate nodules, 0.2 to 0.5 cm diameter, white; gradual.

Bk2 186–250 cm; gray (2.5Y 5/1) clay; very firm; many medium distinct olive brown (2.5Y 5/3, 5/4) soft iron masses; 2% carbonate nodules, 0.2 to 0.5 cm diameter, white; few fine iron manganese concretions; gradual.

Bk3 250–368 cm; gray (2.5Y 5/1) clay; firm; many medium distinct olive brown (2.5Y 5/3, 5/4) soft iron masses; 4% carbonate nodules, 0.2 to 0.8 cm diameter; few fine iron manganese concretions; clear.

Bkg 368–517 cm; gray (2.5Y 4.5/1) clay; firm; many medium distinct olive brown (2.5Y 5/3, 5/4) soft iron masses; 4% carbonate nodules, 0.2 to 0.8 cm diameter; 1% carbonate filaments; few fine iron manganese concretions; clear.

BC 517–566 cm; faintly bedded light gray (2.5Y 7/1) clay loam; firm; many medium and coarse yellowish brown (10YR 5/6, 5/8) soft iron masses; few medium distinct dark gray (2.5Y 4/1) biocast-iron depletions; saturated in lower half; gradual.

C1 566–630 cm; light gray (2.5Y 7/1) sandy clay loam; many medium and coarse yellowish brown (10YR 5/6, 5/8) soft iron masses; few medium distinct dark gray (2.5Y 4/1) biocast-iron depletions; gradual.

C2 630–801 cm; brownish yellow (10YR 6/6) medium sand; single grained; few coarse distinct light gray (2.5Y 7/1) iron depletions; saturated; gradual.

C3 801–870 cm; olive yellow (2.5Y 6/5) medium sand; single grained; 3% pebbles, 0.5 to 2 cm diameter, subrounded, siliceous-limestone; gradual.

C4 870–976 cm; olive yellow (2.5Y 6/6) medium sand; single grained; 30% pebbles, 0.5 to 2 cm diameter, subrounded siliceous-limestone; abrupt.

Bedrock 976–1022 cm; very dark gray (10Y 3/1) shale; common fine distinct gray (10Y 6/1) silt to very fine sand laminations; noncalcareous.

N4: N3413515, E695787; near pylon 23 and bridge boring C7; near slough; calcareous and moist throughout.

Fill 0–36 cm; dark gray (10YR 3.5/1) clay; very firm; 1% pebbles, 0.2 to 0.6 cm diameter, siliceous; common clay clasts, 0.2 to 0.5 cm diameter; clear.

Bw 36–56 cm; **(Unit 2, 3)**; dark gray (10YR 4/1) clay; very firm; common medium distinct brown (7.5YR 4/4) iron pore linings; few snail fragments; few shale clasts, 0.2 to 0.5 cm diameter; gradual.

Ab 56–147 cm; **(Unit 2)**; dark gray (2.5Y 3.5/1) clay; very firm; few fine distinct brown (7.5YR 4/4) iron pore linings; common medium distinct yellowish brown (10YR 5/4) soft iron masses; few snail fragments; gradual.

Bg 147–217 cm; dark gray (2.5Y 4/1) clay; very firm; few coarse distinct very dark gray (2.5Y 3/1) biocasts; common fine distinct dark yellowish brown (10YR 5/6) and yellowish brown (10YR 5/6) soft iron masses; few snail fragments; gradual.

Cg 217–327 cm; gray (2.5Y 5/1) clay; very firm; many medium distinct dark yellowish brown (10YR 4/6) soft iron masses; few dark gray (2.5Y 4/1) patches; few clay clasts; 0.2 to 0.5 cm diameter; few snail fragments; two, white (2.5Y 8/1) silt beds, 0.3 to 0.5 cm in diameter in middle of horizon; gradual.

Ab 327–401 cm; very dark gray (2.5Y 3.5/1) clay; very firm; common medium faint yellowish brown (10YR 5/4) soft iron masses; few fine distinct brown (7.5YR 4/4) iron pore linings; few snail fragments; gradual.

Bg 401–488 cm; dark gray (2.5Y 4.5/1) clay; very firm; common medium distinct light olive brown (2.5Y 5/4) soft iron masses; few fine distinct brown (7.5YR 4/4) soft iron masses; common clay clasts, 0.2 to 0.5 cm diameter; 1% carbonate nodules, 0.2 to 0.5 cm diameter, white; gradual.

Bssg 488–549 cm; dark gray (2.5Y 3.5/1) clay; very firm; common fine distinct brown (7.5YR 4/4) iron pore linings; few distinct slickensides; common clay clasts, 0.2 to 0.5 cm diameter; few distorted white (2.5Y 8/1) silt laminations; gradual.

C 549–564 cm; very dark gray (2.5Y 3/1) clay; very firm; few fine distinct brown (7.5YR 4/4) iron pore linings; many clay clasts, 0.2 to 1 cm diameter; few distinct white (2.5Y 8/1) silt laminations; gradual.

Bg1 564–619 cm; gray (2.5Y 5/1) clay; very firm; few fine distinct brown (7.5YR 4/4) iron pore linings; few medium distinct light olive brown (2.5Y 5/4) soft iron masses; few clay clasts, 0.2 to 0.5 cm diameter; gradual.

Bg2 619–716 cm; gray (2.5Y 4/1) clay; very firm; many fine distinct dark yellowish brown (10YR 3/4) soft iron masses; few fine distinct strong brown (7.5YR 5/6) iron pore linings; few clay clasts, 0.2 to 0.5 cm diameter; gradual.

Bg3 716–882 cm; gray (2.5Y 5/1) clay; common medium distinct light olive brown (2.5Y 5/4) soft iron masses; few clay clasts, 0.2 to 0.5 cm diameter; few snail fragments; clear.

C1 882–902 cm; gray (2.5Y 5/1) clay; very firm; few medium distinct light olive brown (2.5Y 5/4) soft iron masses; common clay clasts, 0.2 to 1 cm diameter; few sand stringers; gradual.

C2 902–990 cm; light gray (2.5Y 5/5.1) sandy clay loam, increasing to light olive brown (2.5Y 5/4) in lower half; common medium distinct yellowish brown (10YR 5/8) and brownish yellow (10YR 6/8) soft iron masses; 30% pebbles, 0.2 to 3 cm diameter, siliceous and limestone; abrupt.

Bedrock 990–1020 cm; very dark gray (10Y 3/1) shale; common fine distinct gray (10Y 6/1) silt to very fine sand laminations; noncalcareous.

N5: N3413473, E695836; between pylons 27 and 28 at bridge boring C8 near slough; calcareous and moist throughout.

Fill 0–24 cm; dark grayish brown (2.5Y 3.5/2) clay; very firm; 2% pebbles, 0.2 to 0.4 cm diameter, siliceous and limestone, angular, subangular; common clay clasts, 0.2 to 0.5 cm diameter; gradual.

Bw 24–76 cm; **(Unit 2, 3)**; dark grayish brown (2.5Y 4/2) clay; very firm; few medium distinct light olive brown (2.5Y 5/3) patches; clear.

Ab 76–113 cm; **(Unit 2)**; very dark grayish brown (2.5Y 3/2) clay; very firm; gradual.

Bw 113–153 cm; dark grayish brown (2.5Y 3.5/2) clay; very firm; few medium and coarse distinct very dark gray (2.5Y 3/1) biocasts; 1% carbonate nodules, 0.2 to 0.4 cm diameter; clear.

Ab 153–174 cm; very dark gray (2.5Y 3/1) clay; firm; common medium distinct light olive brown (2.5Y 5/3) patches; 1% carbonate nodules, 0.2 to 0.4 cm diameter, white; clear.

Bw1 174–265 cm; dark grayish brown (2.5Y 4/2) clay; firm; few fine and medium distinct light olive brown (2.5Y 5/3) patches; few fine and medium very dark gray (2.5Y 3/1) iron depletions; 1% carbonate nodules, 0.2 to 0.4 cm diameter; gradual.

Bw2 265–311 cm; light olive brown (2.5Y 4.5/3) clay; very firm; common fine and medium distinct dark gray (2.5Y 4/1) biocasts; 1% carbonate nodules, 0.2 to 0.4 cm diameter; few snail fragments; gradual.

BC1 311–384 cm; light olive brown (2.5Y 5/3) silty clay loam; firm; few medium distinct gray (2.5Y 5/1) iron depletions/biocasts; few pale yellow (2.5Y 7/3) silt laminations; few snail fragments; gradual.

BC2 384–456 cm; light olive brown (2.5Y 5/3) silty clay loam; firm; few medium distinct gray (2.5Y 4/1) iron depletions; few nail fragments; gradual.

Bg 456–569 cm; light olive brown (2.5Y 5/4) clay loam; firm; many medium and coarse distinct gray (2.5Y 6/1) iron depletions; few faint light yellowish brown (2.5Y 6/3) silt laminations; clear.

C1 569–873 cm; multiple 10 cm thick beds of mottled gray (2.5Y 6/1) and light olive brown (2.5Y 5/4) loamy fine sand; firm; few snail fragments and medium to coarse sand, 1–20 % pebbles, 0.2 to 0.4 cm diameter; light olive brown (2.5Y 5/4) sandy clay loam bed at base, 18 cm thick; abrupt.

C2 873–961 cm; 75% pebbles, 0.3 to 4 cm diameter, subrounded, moderately well sorted, grain supported in a fine to coarse sand matrix; abrupt.

Bedrock 961–1025; very dark gray (10Y 3/1) shale; common fine distinct distorted light gray (2.5Y 6/1) silt to very fine sand laminae; weakly calcareous.

N6: N341340, E695925; near pylon 33 and bridge boring C10 near slough; calcareous and moist throughout.

Fill 0–13 cm; dark gray (2.5Y 3/1.5) clay; very firm; 1% pebbles, 0.2 to 0.5 cm diameter, limestone and siliceous, subrounded to subangular; clear.

A/C 13–51 cm; **(Unit 2, 3)**; very dark grayish brown (2.5Y 3/2) clay; very firm; few light gray (2.5Y 7/2) silt laminations; gradual.

Bw 51–112 cm; dark grayish brown (2.5Y 4/2) clay; very firm; clear.

Ab1 112–152 cm; **(Unit 1)**; dark gray (2.5Y 3.5/1) and light olive brown (2.5Y 5/3) clay; very firm; clear.

Bw 152–190 cm; dark gray (2.5Y 4/1) clay; very firm; many medium and coarse distinct light olive brown (2.5Y 5/3) patches; gradual.

Bk 190–246 cm; light olive brown (2.5Y 5/3) clay; very firm; common medium distinct gray (2.5Y 5/1) iron depletions; 1% carbonate nodules, 0.2 to 0.5 cm diameter, white; gradual.

C 246–313 cm; faint beds of dark gray (2.5Y 4/1) and dark grayish brown (2.5Y 4/2) clay with few fine light gray (2.5Y 7/2) silt laminations; very firm to firm; clear.

Ab2 313–340 cm; very dark gray (2.5Y 3/1) clay; many fine and medium distinct light brownish gray (2.5Y 6/2) biocasts; common fine distinct dark yellowish brown (10YR 3/4) iron pore linings; gradual.

Bw/C 340–386 cm; gray (2.5Y 5/1) clay; very firm; common fine and medium distinct dark yellowish brown (10YR 4/4) iron pore linings; common fine and medium distinct light yellowish brown (2.5Y 6/3) biocasts; few white (2.5Y 8/1) silt laminations; gradual.

Bg1 386–547 cm; gray (2.5Y 5/1) clay; very firm; common fine and medium distinct dark yellowish brown (10YR 4/4) iron pore linings; common fine distinct light yellowish brown (2.5Y 6/3) biocasts; few fine distinct black (2.5Y 2/1) iron manganese stains; gradual.

Bg2 547–642 cm; light olive brown (2.5Y 5/3) clay; very firm; few fine and medium distinct gray (2.5Y 6/1) iron depletions; common fine and medium distinct dark yellowish brown (10YR 4/4) iron pore linings; gradual.

Bg3 642–778 cm; gray (2.5Y 6/1) clay; very firm; common fine and medium light olive brown (2.5Y 5/3) and dark yellowish brown (10YR 4/4) iron soft masses; clear.

C1 778–872 cm; bedded gray (2.5Y 5/1, 6/1) silty clay loam and light olive brown (2.5Y 5/3) sandy clay loam; firm; abrupt.

C2 872–923 cm; bedded yellowish brown (10YR 5/6) medium sand to very coarse sand; very friable; abrupt.

C3 923–1024 cm; 60% pebbles, 0.5 to 6 cm diameter in a light grayish brown (2.5Y 6/2) and light olive brown (2.5Y 5/3) muddy matrix, limestone, subrounded; abrupt.

C 1024–1133 cm; pale brown (10YR 6/3) medium to very coarse sands, with pebble beds 1 to 10 cm thick, 0.2 to 1.5 cm diameter, subrounded, siliceous and limestone; abrupt.

Bedrock 1133–1176 cm; very dark gray (5Y 3/1) shale; common fine distorted light gray (5Y 6/1) silt to very fine sand laminations; noncalcareous.

N7: 413306N, 696002E; near pylon 40 and bridge boring C12; calcareous and moist throughout.

A 0–45 cm; **(Unit 2)**; dark gray (10YR 3.5/1) clay; very firm; gradual.

Bw 45–86 cm; dark grayish brown (2.5Y 4/2) clay; very firm; few snail fragments; gradual.

Bk 86–144 cm; dark grayish brown (2.5Y 4/2) clay; very firm; 2% carbonate filaments; clear.

Akb 144–178 cm; **(Unit 1)**; very dark gray (2.5Y 3/1) clay; common medium distinct light olive brown (2.5Y 5/3) biocasts; 2% carbonate filaments; gradual.

Bk1 178–235 cm; dark grayish brown (2.5Y 3.5/2) clay; very firm; 2% carbonate filaments; gradual.

Bk2 235–325 cm; dark grayish brown (2.5Y 4/2) and light olive brown (2.5Y 5/3) clay; very firm; 3% carbonate filaments; 2% carbonate nodules/calcans; 0.5 to 1 cm diameter, white; gradual.

Bk3 325–377 cm; gray (2.5Y 4.5/1) clay loam; firm; many medium distinct light olive brown (2.5Y 5/4) soft iron masses; few fine faint iron manganese concretions, 0.2 cm diameter; 2% carbonate filaments; 4% carbonate nodules, 0.5 to 1 cm diameter, white; clear.

Bk4 377–532 cm; light olive brown (2.5Y 5/4) clay; very firm; common medium and coarse distinct gray (2.5Y 4/1) iron depletions; few distinct slickensides; few fine faint iron manganese concretions, 0.2 cm diameter; 3% carbonate nodules, 1 cm diameter, white; gradual.

BC1 532–620 cm; yellowish brown (10YR 5/6) clay loam; firm; few medium distinct brown (10YR 4.5/3) biocasts; few medium distinct gray (2.5Y 6/1) iron depletions; gradual.

BC2 620–707 cm; olive yellow (2.5Y 6/6) clay loam; firm; few medium distinct gray (2.5Y 6/1) iron depletions; clear.

BCg 707–866 cm; light gray (2.5Y 7/1) and brownish yellow (10YR 5/8) fine sandy loam; few fine distinct brown (7.5YR 4/4) iron pore linings; (saturated); abrupt.

? 866–1018 cm; No Recovery.

C 1018–1176 cm; medium to very coarse sand; 30% pebbles, 0.2 to 0.4 cm diameter, subrounded, siliceous and limestone; one 4 cm diameter chert fragment at base; abrupt.

Bedrock 1176–1178 cm; very dark gray (5Y 3/1) shale; weakly calcareous.

N8: 3413244N, 696100E; between pylon 46 and 47 near bridge boring C14; calcareous and moist throughout.

Fill 0–12 cm; dark gray (10YR 3.5/1) clay; very firm; 4% pebbles, 0.2 to 1 cm diameter, subrounded, siliceous and limestone, (glass); clear.

A 12–52 cm; very dark grayish brown (2.5Y 3/2) clay; very firm; gradual.

Bw 52–91 cm; **(Unit 2)**; dark grayish brown (2.5Y 4/2) clay; very firm; many medium and coarse faint light olive brown (2.5Y 5/3) soft iron masses; few snail fragments; clear.

Ab 91–161 cm; **(Unit 1)**; very dark gray (2.5Y 3.5/1) clay; very firm; common medium distinct light olive brown (2.5Y 5/3) biocasts; few snail fragments; gradual.

Bw 161–209 cm; mottled light olive brown (2.5Y 5/3) and gray (2.5Y 4.5/1) clay; very firm; 1% carbonate filaments; few snail fragments; gradual.

Bk1 209–343 cm; mottled light olive brown (2.5Y 5/3) and gray (2.5Y 4./51) clay; very firm; few fine distinct, 0.2 cm diameter, iron manganese concretions; 3% carbonate nodules, 0.5 to 1 cm diameter; gradual.

Bk2 343–407 cm; light olive brown (2.5Y 5/3.5) clay; firm; few medium distinct gray (2.5Y 5/1) iron depletions; few fine faint brown (7.5YR 4/4) and yellowish brown (10YR 5/8) soft iron masses; 3% carbonate nodules, 0.5 to 1 cm diameter and 2% carbonate filaments; few snail fragments; gradual.

BC1 407–469 cm; yellowish brown (10YR 5/4.5) sandy clay loam; firm; common fine distinct dark grayish brown (10YR 4/2) biocasts; gradual.

BC2 469–571 cm; light olive brown (2.5Y 5/4.5) fine sandy loam; few fine distinct grayish brown (2.5Y 5/2) iron depletions; abrupt.

C1 571–723 cm; muddy fine to coarse yellowish brown (10YR 5.5/4) sand; saturated; (only 9 cm recovery); abrupt.

C2 723–876 cm; well sorted medium to very coarse light yellowish brown (10YR 6/4) sand, 30% pebbles, 0.2 to 2 cm, poor to moderately sorted, subrounded, siliceous and limestone; saturated; only 18 cm recovery.

N9: 3413106N, 696218E; between pylon 56 and 57 near bridge boring C17; calcareous and moist throughout.

Fill 0–17 cm; very dark grayish brown (2.5Y 3/2) clay; very firm; 2% pebbles, 0.2 to 1 cm diameter, subrounded, carbonatic and siliceous; few light gray (2.5Y 7/1) contorted silt laminations, 0.3 cm diameter; gradual.

A 12–63 cm; **(Unit 3)**; very dark grayish brown (2.5Y 3/2) clay; very firm; common fine and medium distinct light olive brown (2.5Y 5/3) biocasts; 2% pebbles, 0.2 to 1 cm diameter, subrounded, limestone and siliceous; gradual.

Bw 63–122 cm; dark grayish brown (2.5Y 4/2) clay; very firm; few fine distinct brown (7.5YR 4/4) iron pore linings; few light gray (2.5Y 7/2) silt laminations, 0.5 cm diameter; clear.

B/C1 122–277 cm; 1 to 3 cm thick beds of dark gray (2.5Y 4/1.5) clay, very firm, common fine distinct brown (7.5YR 4/4) iron pore linings (60%) and pale yellow (2.5Y 7/3, 7/4) silt loam, firm, finely laminated (40%); gradual.

B/C2 277–435 cm; bedded dark gray (10YR 4/1) clay, very firm, few distinct clay clasts, 0.5 cm diameter (90%) and light yellowish brown (2.5Y 6/3) silt loam, firm, finely laminated (10%); gradual.

C 435–569 cm; bedded dark grayish brown (2.5Y 4.5/2) silty clay loam, firm, few fine distinct gray (2.5Y 5/1) iron depletions and light yellowish brown (2.5Y 6/3, 6/4) very fine sand to medium sand, 0.2 to 0.4 cm diameter, finely laminated; gradual.

Bg1 569–717 cm; gray (2.5Y 5/1) silty clay loam; firm; common fine distinct dark yellowish brown (10YR 3/4) and brown (7.5YR 4/4) iron pore linings; firm; few light yellowish brown (2.5Y 6/4) silt laminations, 0.5 cm thick; gradual.

Bg2 717–762 cm; dark gray (2.5Y 4/1) silty clay loam; firm; many fine distinct brown (7.5YR 4/4) iron pore linings; few light olive brown (2.5Y 5/3) silt loam laminations, 0.5 cm thick; gradual.

Bg3 762–873 cm; dark gray (2.5Y 4/1) silty clay; very firm; many fine distinct brown (7.5YR 4/4) iron pore linings; few light brownish gray (2.5Y 6/2) silt loam laminations, 0.5 cm thick; (saturated); gradual.

BCg 873–1025 cm; dark gray (N 4.5/0) clay loam; very firm; abrupt.

C1 1025–1150 cm; medium to very coarse sand; 20% pebbles, 0.2 to 0.3 cm diameter; abrupt.

C2 1150–1174 cm; 75% pebbles, 0.5 to 3 cm diameter, subrounded, moderately well sorted, grain supported, siliceous and limestone; abrupt.

Bedrock 1174–1177 cm; dark greenish gray (10Y 3/1) shale; weakly calcareous.

N10: 3413043N, 696289E; between pylon 61 and 62 and bridge boring C18 and C19; calcareous and moist throughout.

Fill 0–7 cm; very dark grayish brown (2.5Y 3/2) clay loam; firm; light olive brown (2.5Y 5.5/3) sandy pockets; 1% pebbles, 0.2 to 0.5 cm diameter, subrounded, limestone and siliceous; abrupt.

Ap 7–34 cm; **(Unit 3)**; very dark grayish brown (2.5Y 3/2) clay; very firm; few fine and medium distinct light olive (2.5Y 5/3) pockets; 1% pebbles, 0.2 to 0.5 cm diameter, subrounded, limestone and siliceous; 3% carbonate clasts, 0.3 to 0.4 cm diameter, white, in upper 1/3 horizon; clear.

Ab 34–51 cm; black (2.5Y 2.5/1) clay; very firm; common fine and medium distinct grayish brown (2.5Y 5/2) biocasts; gradual.

Bw 51–96 cm; gray (2.5Y 4.5/1) clay; very firm; few snail fragments; clear.

C1 96–106 cm; black (2.5Y 2.5/1) clay; very firm; few fine and medium distinct light olive brown (2.5Y 5/3) biocasts; gradual.

C2 106–161 cm; dark grayish brown (2.5Y 4/2) clay; very firm; few fine distinct light grayish brown (2.5Y 6/2) pockets; common clay clasts, 0.5 cm diameter; gradual.

C3 161–258 cm; silty clay – light olive brown (2.5Y 5/3), few fine distinct brown (7.5YR 4/4) iron pore linings, few medium and coarse distinct very dark gray (2.5Y 3.5/1) biocasts; silt to very fine sand – light brownish gray (2.5Y 7/2) laminations (5%), few fine faint brownish yellow (10YR 6/8) iron stains; friable; clear.

C4 258–313 cm; bedded brown (2.5Y 4/3) silty clay and light grayish brown (2.5Y 5/2) silty clay loam, 1 cm thick, common fine distinct dark yellowish brown (10YR 3/4) and brown (7.5YR 4/4) iron pore linings; 5% light brownish gray (2.5Y 7/2) silt to very fine sand laminations, 0.2 to 0.4 cm diameter; clear.

C5 313–352 cm; dark grayish brown (2.5Y 4/2) silty clay; few fine faint brown (7.5YR 4/4) iron pore linings; common clay clasts, 0.5 cm diameter; 3% light brownish gray (2.5Y 6/2) silt laminations, 0.2 cm diameter; abrupt.

C6 352–425 cm; silt to very fine sand – light yellowish brown (2.5Y 6/3), friable; silty clay loam (30%) - grayish brown (2.5Y 5/2), few fine faint dark gray (2.5Y 4/1) firm; few medium distinct brown (7.5YR 4/4) iron pore linings; clear.

C7 425–569 cm; very faintly laminated; silty clay and silty clay loam - gray (2.5Y 5/1), firm, few fine distinct black (2.5Y 2/1) iron manganese concretions, few fine distinct yellowish brown (10YR 5/6 and brown (7.5YR 4/4) iron stains on lamination planes; very fine sand (40%) – light yellowish brown (2.5Y 6/3), very friable; clear.

C8 569–690 cm; silty clay and silty clay loam (50%), gray (2.5Y 5/1), common fine distinct brown (7.5YR 4/4) iron stains on planes; firm; very fine sand – light yellowish brown (2.5Y 6/3), few beds, olive yellow (2.5Y 6/6), 1 to 5 cm thick; clear.

C9 690–842 cm; silty clay loam (30%) - dark gray (5Y 4/1), 3% gray (2.5Y 5/1) pockets; firm; few medium distinct dark yellowish brown (10YR 3/8) and brown (7.5YR 4/4) iron pore linings; sandy clay loam – gray (2.5Y 5/1, 6/1), firm, few snail fragments, faintly bedded; iron sulfide odor; common fine plant remains; clear.

C10 842–973 cm; light yellowish brown (2.5Y 6/3) medium fine sandy loam; very friable; common fine and medium distinct gray (2.5Y 5/1) iron depletions; few snail fragments; many fine plant fragments; abrupt.

C11 973–1176 cm; dark gray (2.5Y 4/1) medium to coarse sand; 40% pebbles, siliceous and limestone, 0.3 to 2 cm diameter, mostly matrix supported, subrounded, bedded; abrupt.

Bedrock 1176–1179 cm; dark gray (2.5Y 4/1) and gray (2.5Y 5/1) bedded shale; common fine yellowish brown (10YR 5/6) and brownish yellow (10YR 6/8) iron stains on bedding planes; calcareous.

CB1a; calcareous throughout.

A/C 0–11 cm; **(Unit 3)**; dark grayish brown (10YR 4/1.5) clay loam; weak to moderate subangular blocky; hard; abrupt smooth.

Ab1 11–32 cm; very dark grayish brown (10YR 3.5/1.5) clay loam; weak coarse subangular blocky; hard; common fine worm casts; few fine and medium light olive brown (2.5Y 5/4) biocasts; clear smooth.

C 32–66 cm; light olive brown (2.5Y 5/4) fine sandy loam; massive; firm; common fine and medium dark grayish brown (10YR 4/1.5) biocasts; abrupt smooth.

Ab2 66–101 cm; **(Unit 2)**; very dark grayish brown (10YR 3/1.5) clay; moderate coarse prismatic; very hard; few medium and coarse light olive brown (2.5Y 5/4) root casts; few small snails, 0.5 cm; dispersed FCR, flakes; clear smooth.

Bw 101–116 cm; dark grayish brown (10YR 4/2) clay; moderate medium prismatic; very hard; 2% carbonate filaments; common snails, 0.5 to 1.5 cm; abrupt smooth.

Ab3 116–136 cm; very dark grayish brown (10YR 3/1.5) clay; moderate to strong medium prismatic; very hard; 3% carbonate filaments; few medium yellowish brown (10YR 5/4) biocasts; common snails, 0.5 to 1 cm; gradual smooth.

Bk1 136–168 cm; very dark grayish brown (10YR 3/1.5) clay; moderate to strong medium prismatic; very hard; 7% carbonate filaments; few medium yellowish brown (10YR 5/4) biocasts; common snails, 0.5 to 1 cm; gradual smooth.

Bk2 168–205 cm; dark grayish brown (10YR 4/2) clay; moderate coarse prismatic; very hard; 5% carbonate filaments; common snails, 0.5 cm; clear smooth.

Bk3 205–253 cm; dark grayish brown (10YR 3.5/2) clay; weak coarse prismatic; very hard; 5% carbonate filaments; few snails, 0.5 cm; gradual smooth.

Bk4 253–290 cm; dark grayish brown (10YR 4/2) clay; weak coarse prismatic; very firm; 2% carbonate filaments; few clay clasts, 0.2 to 0.5 cm; shell lens, 278 cm, few siliceous pebbles, 0.5 cm, subrounded; gradual smooth.

BC 290–500 cm; 30 cm thick beds: silty clay loam-brown (10YR 5/3) and yellowish brown (10YR 5/4); silty clay-dark grayish brown (10YR 4/2), 1% carbonate filaments; weak coarse prismatic to massive; very firm and firm; few clay clasts, 0.2 to 0.5 cm; few snails, 0.5 cm; clear smooth.

C1 500–632 cm; faint beds: silt loam and silty clay loam; few medium and coarse gray (2.5Y 6/1) iron depletions (roots); few fine distinct dark yellowish brown (10YR 4/4) and strong brown (7.5YR 4/6) pore linings; clear smooth.

C2 632–772 cm; laminated to bedded: 70% - dark grayish brown (10YR 4/2) and brown (10YR 5/3) silty clay to silty clay loam; 20% - very pale brown (10YR 7/3) very fine sandy loam; 10% - very dark grayish brown (10YR 3.5/1); few medium distinct gray (2.5Y 6/1) iron depletions; few fine distinct dark yellowish brown (10YR 4/4) and strong brown (7.5YR 4/6) pore linings; beds dipping downstream; clear smooth.

C3 772–946 cm; grayish brown (10YR 5/2) clay loam; common fine and medium distinct gray (10YR 5/1) iron depletions (roots); few fine distinct brownish yellow (10YR 6/6) and strong brown (7.5YR 4/6) iron pore linings and stains; 5% carbonate nodules, 0.5 to 1.5 cm, white, pitted; faint beds dipping downstream.

CB1b; calcareous throughout.

A/C 0–13 cm; **(Unit 3)**; dark gray (10YR 3.5/1) clay loam; moderate medium subangular blocky; hard; few snails, 0.5 cm; many worm casts; abrupt wavy.

Ab1 13–28 cm; very dark grayish brown (10YR 3/2) clay loam; weak medium and coarse prismatic; hard; common fine and medium distinct brown (10YR 5/3) biocasts; many worm casts; few snails, 0.5 cm; gradual smooth.

C1 28–61 cm; faintly laminated; brown (10YR 5.5/3) very fine sandy loam; common fine and medium pale brown (10YR 7/3) very dark gray (10YR 3/1) biocasts; common worm casts; few snails, 0.5 cm; gradual smooth.

C2 61–76 cm; faintly laminated; pale brown (10YR 7/3) sandy loam; 10% dark grayish brown (10YR 4/2.5) laminae; few dark grayish brown (10YR 4/2.5) worm casts; few snail, 0.5 cm; abrupt smooth.

A/C 76–121 cm; dark grayish brown (10YR 4/2.5) sandy clay loam;; 5% pale brown (10YR 7/3) very sandy loam laminations; few snails, 0.5 cm; clear smooth.

C 121–205 cm; 15 cm thick beds, dark gray (10YR 3.5/1) and dark grayish brown (10YR 4/2); few pale brown (10YR 7/3) very fine sandy loam laminations; 10% brown (10YR 5/3) sand pockets; 1% carbonate filaments; abrupt wavy.

Ab2 205–222 cm; **(Unit 2)**; very dark gray (2.5Y 3/1) clay; weak coarse angular blocky; very hard; common fine and medium light olive brown (2.5Y 5/3) biocasts; few broken snails; 15% clay clasts, 0.2 to 0.5 cm; clear smooth.

C 222–242 cm; dark grayish brown (2.5Y 4/2) silty clay loam; massive; firm; few fine and medium distinct dark gray (2.5Y 4/1) iron depletions; 20% brown (10YR 5.5/3) patches; few snail fragments; clear smooth. (Currin bed).

Ab 242–256 cm; (transition); very dark brown (2.5Y 3.5/2) clay; massive; firm; 10% light olive brown (2.5Y 5/3) patches; 5% clay clasts, 0.2 to 0.5 cm; few snail fragments; clear smooth.

Ab3 256–290 cm; **(Unit 1)**; dark grayish brown (2.5Y 3.5/2) silty clay; weak coarse subangular blocky; firm; few fine faint dark yellowish brown (10YR 3/4) soft iron masses; few fine and medium dark gray (2.5Y 4/1) iron depletions; few clay clasts, 0.2 cm; gradual smooth.

BA 290–328 cm; dark grayish brown (10YR 4/2) silty clay; weak coarse angular blocky; firm; few fine and medium distinct dark gray (2.5Y 4/1) iron depletions; few clay clasts (0.2 cm); gradual smooth.

Bw1 328–366 cm; dark grayish brown (10YR 4/2) silty clay; weak coarse subangular blocky; firm; few fine and medium dark gray (2.5Y 4/1) iron depletions; 1% carbonate filaments; few clay clasts, 0.2 cm; gradual smooth.

Bw2 366–428 cm; dark grayish brown (10YR 4/2) silty clay; weak coarse subangular blocky; firm; few medium distinct gray (2.5Y 5/1) iron depletions; 1% carbonate filaments; few clay clasts, 0.2 cm; gradual smooth.

BC1 428–488 cm; dark grayish brown (10YR 4/2.5) clay; weak coarse subangular blocky; firm; few medium distinct dark brown (2.5Y 4/1) iron depletions; 1% carbonate filaments; few clay clasts, 0.2 cm; gradual smooth.

BC2 488–528 cm; brown (10YR 5/3) silty clay loam; massive; firm; 3% dark brown (2.5Y 4/1) iron depletions; few clay clasts, 0.2 cm; gradual smooth.

BC3 528–608 cm; brown (10YR 5/3) clay loam; massive; firm; few medium and coarse distinct gray (2.5Y 5/1) iron depletions; few fine distinct strong brown (7.5YR 5/6) iron concentrations around depletions.

BC4 608–698 cm; brown (10YR 5/3) clay loam; massive; firm; common fine distinct strong brown (7.5YR 4/6) iron pore linings; few medium and coarse distinct gray (2.5Y 5/1) iron depletions; 5% light brownish yellow (2.5Y 7/3) pockets.

Cg1 698–808 cm; dark gray (2.5Y 4/1) clay; massive; firm; common fine distinct strong brown (7.5YR 4/6) iron pore linings and soft masses; 1% carbonate nodules, 0.5 cm, white, pitted.

Cg2 808–840 cm; gray (2.5Y 5/1) clay; massive; very firm; common medium distinct yellowish brown (10YR 5/6) iron soft masses; 1% carbonate nodules, 0.5 cm, white, pitted.

Cg3 840–870 cm; gray (2.5Y 5/1) loam; massive; firm.

CB1c: calcareous throughout.

A 0–28 cm; **(Unit 3)**; dark grayish brown (10YR 4/2) clay loam; moderate fine and medium subangular blocky; hard; 10% brown (10YR 5/3) pockets; many worm casts; gradual smooth.

Bw 28–69 cm; light olive brown (2.5Y 5/3) clay loam; moderate medium and coarse prismatic; hard; common fine and medium dark grayish brown (2.5Y 4/1.5) worm casts; gradual smooth.

C/Bw1 69–107 cm; light olive brown (2.5Y 5.5/3) very fine sandy loam; massive with faint laminations; slightly hard; common fine and medium dark grayish brown (10YR 4/2) worm casts; clear smooth.

C/Bw2 107–146 cm; faintly bedded light olive brown (2.5Y 5.5/3) and dark grayish brown (2.5Y 4/2) silt loam with internal laminations; few fine and medium dark grayish brown (10YR 4/2) worm casts; few strong brown (7.5YR 5/8) iron stains on lamination planes; abrupt wavy.

C1 146–241 cm; two to eight cm thick beds; firm to very firm; silt loam – light olive brown (2.5Y 5/3), few fine distinct strong brown iron pore linings, faintly laminated; silty clay – dark gray (2.5Y 4/1) silty clay loam, few fine distinct strong brown (7.5YR 4/4) iron pore linings; concoidal fracture; eight cm thick silty clay loam bed at base, light olive brown (2.5Y 5/3); abrupt wavy.

C2 241–316 cm; 80% dark gray (2.5Y 3.5/1) silty clay; very firm; common clay clasts, 0.5 cm; 20% light olive brown (2.5Y 5/3) silty clay loam, laminated; lower 15 cm, light olive brown (2.5Y 5/3) and gray (2.5Y 5/1) silty clay loam; abrupt wavy.

Ab1 316–353 cm; **(Unit 2)**; very dark gray (2.5Y 3/1.5) silty clay; weak coarse subangular blocky; firm; 30% clay clasts, 0.5 cm; gradual smooth.

Bss 353–431 cm; dark gray (2.5Y 4/1) iron depletions and light olive brown (2.5Y 5/4) soft iron masses; clay; few fine distinct strong brown (7.5YR 4/6) iron pore linings; weak coarse angular blocky and parallelepipeds; very firm; common distinct slickensides; lower 10 cm faintly bedded, 1 cm; clear wavy.

C/Bw 431–470 cm; dark gray (2.5Y 3.5/1) clay; very firm; 30% concoidal fracture; few fine distinct strong brown (7.5YR 4/6) iron pore linings; few faint slickensides; clear smooth.

C1 470–511 cm; very dark gray (2.5Y 3/1) silty clay; very firm; 70% concoidal fracture; few fine distinct strong brown (7.5YR 4/6) iron pore linings; clear smooth.

C2 511–535 cm; very dark gray (2.5Y 3/1) silty clay; very firm; 80% concoidal fracture; few fine distinct strong brown (7.5YR 4/6) iron pore linings; few snails, broken and whole; clear smooth.

C3 535–560 cm; 1 to 2 cm beds of light yellowish brown (2.5Y 6/3), dark grayish brown (2.5Y 4/2) and gray (2.5Y 5/1) silty clay loam; common fine distinct strong brown (7.5YR 4/6) iron pore linings; abrupt smooth. (Currin bed).

C4 560–580 cm; 80% beds of very dark gray (2.5Y 3.5/1) clay, concoidal fracture; 20% light brownish gray (2.5Y 6/2) very fine sandy loam laminations; very firm; few fine distinct strong brown (7.5YR 4/6) iron pore linings; abrupt smooth.

Ab2 580–621 cm; **(Unit 1, 2)**; dark gray (2.5Y 3.5/1) clay; weak coarse angular blocky; very firm; 10% clay clasts, 0.5 cm; very firm; few fine distinct strong brown (7.5YR 4/6) iron pore linings; one faint 6 cm thick bed in middle, dark grayish brown (2.5Y 4/2); few broken snails; abrupt smooth.

Bssk1 621–673 cm; dark gray (2.5Y 3.5/1) clay; weak coarse angular blocky; very firm; few fine distinct strong brown (7.5YR 4/4) iron pore linings; few broken snails; few faint slickensides; 1% carbonate nodules, 0.5 cm, white, pitted; 5% clay clasts, 0.2 to 0.5 cm; clear smooth.

Bssk2 673–719 cm; dark gray (2.5Y 4/1) clay; moderate coarse angular blocky to parallelepipeds; very firm; many prominent slickensides; 10% clay clasts, 0.2 to 0.5 cm; few fine distinct strong brown (7.5YR 4/4) iron pore linings; few broken snails; 1% carbonate nodules, 0.5 cm, white, pitted; gradual wavy.

Bk 719–749 cm; dark gray (2.Y 4/1) clay; moderate coarse angular blocky; very hard; few fine faint strong brown (7.5YR 4;/4) iron pore linings; 2% carbonate nodules, 0.5 cm, white, pitted; few broken snails; few faint slickensides.

BCk 749–779 cm; gray (2.5Y 5/1); clay; 20% faintly bedded gray (2.5Y 6/2), 0.5 to 1 cm; 1% carbonate nodules, 0.5 cm, white, pitted; common fine distinct strong brown (7.5YR 4/6) iron pore linings; common distinct slickensides.

C1 779–814 cm; dark gray (2.5Y 3.5/1); massive; very firm; common fine distinct strong brown (7.5YR 4/4) iron pore linings; 1% carbonate nodules, 0.5 cm, white, pitted; 30% clay clasts, 0.5 to 1 cm; common distinct slickensides; abrupt.

C2 814–865 cm; gray (2.5Y 4.5/1); massive; very firm; common fine distinct strong brown (7.5YR 4/4) iron pore linings; 1% carbonate nodules, 0.5 cm, white, pitted; 30% clay clasts, 0.5 to 1 cm; common distinct slickensides; abrupt. (water line at base).

CB2a; calcareous throughout.

C/A 0–11 cm; **(Unit 3)**; brown (10YR 5/3) sandy clay loam; weak medium and coarse subangular blocky; hard; common fine and medium very dark gray (10YR 3/1) worm casts; common fine snail fragments; faint laminae in lower part; abrupt wavy.

Ab1 11–28 cm; very dark grayish brown (10YR 3.5/2) silty clay loam; few fine and medium brown (10YR 5/3) pockets; moderate fine and medium subangular blocky; many fine and medium worm casts; gradual smooth.

Bw 28–68 cm; dark grayish brown (10YR 4.5/2) silt loam; few fine and medium pale brown (10YR 6/3) pockets; weak coarse prismatic; very hard; common fine and medium dark gray (10YR 3.5/1) worm casts; clear smooth.

Ab2 68–117 cm; dark grayish brown (10YR 4/2) silty clay loam; few fine and medium pale brown (10YR 6/3) pockets; weak coarse prismatic; very hard; many fine and medium worm casts; few snails, 0.5 to 1.5 cm; gradual smooth. (bone fragments).

C/Bw 117–147 cm; 1 to 3 cm thick faint beds; pale brown (10YR 6/3) silt loam and dark gray (10YR 4/1.5) silty clay loam; few fine and medium very dark gray (10YR 3/1.5) worm casts; abrupt smooth.

C 147–267 cm; 1 to 8 cm thick beds of dark gray (2.5Y 4/1) silty clay and light olive brown (2.5Y 5/3) silty clay loam; few fine distinct strong brown (7.5YR 4/4) iron pore linings; few fine faint light gray (2.5Y 7/2) laminae; very hard and hard; clear smooth.

Ab3 267–299 cm; **(Unit 2)**; dark gray (2.5Y 3.5/1) silty clay; weak medium and coarse angular blocky; very hard; 20% clay clasts, 0.5 cm; one 0.2 cm thick light grayish brown (2.5Y 7/2) laminae; few fine distinct yellowish red (5YR 4/6) iron pore linings; clear smooth.

Bw/A 299–335 cm; 10 cm thick faint beds of dark gray (2.5Y 3.5/1) and dark grayish brown (2.5Y 4/2) silty clay; weak coarse angular blocky; very firm; few fine distinct strong brown (7.5YR 3/4) iron pore linings; 10% clay clasts, 0.5 cm; few fine snail fragments; gradual smooth.

Bw 335–371 cm; mottled light olive brown (2.5Y 5/3) and gray (2.5Y 4.5/1) clay; massive; firm; few fine snail fragments; clear smooth.

BC/C 371–433 cm; massive to faintly bedded dark gray (2.5Y 3.5/1) and dark grayish brown (2.5Y 4/2) clay; very firm; 30% clay clasts, 0.5 cm; few fine snail fragments; clear smooth.

C1 433–470 cm; dark gray (2.5Y 4/1) silty clay; very firm; common fine light olive brown (2.5Y 5/3) pockets; few fine distinct strong brown (7.5YR 4/4) iron pore linings; 50% clay clasts, 0.5 cm; clear smooth.

C2 470–498 cm; very dark gray (2.5Y 3/1) silty clay; 70% concoidal fracture; very firm; many fine and medium strong brown (7.5YR 4/6) iron pore linings and stains; abrupt wavy.

C3 498–513 cm; grayish brown (2.5Y 5/2.5) clay loam; massive; very hard; few fine distinct strong brown (7.5YR 6/6) iron pore linings; few fine and medium dark gray (2.5Y 3.5/1) biocasts; abrupt wavy. (Currin bed)

Ab4 513–528 cm; very dark gray (2.5Y 3/1) clay; moderate medium and coarse prismatic; very hard; few fine distinct strong brown (7.5YR 4/6) iron pore linings; many fine and medium snail fragments; gradual smooth.

Bw1 528–554 cm; gray (2.5Y 4.5/1) clay; weak coarse prismatic; very firm; few fine distinct strong brown (7.5YR 4/6) iron pore linings; common fine snail fragments; clear smooth.

Bw2 554–599 cm; dark gray (2.5Y 4/1) clay; weak coarse angular blocky; very firm; few faint slickensides; few fine snail fragments; few fine distinct strong brown (7.5YR 4/6) iron pore linings; gradual smooth.

Bg 599–679 cm; gray (2.5Y 5/1) clay; weak coarse angular blocky; very firm; few medium distinct strong brown (7.5YR 4/4) soft iron masses; few fine snail fragments; few faint slickensides; (no boundary).

C 679–814 cm; 10 to 15 cm thick beds; mottled 60% light olive brown (2.5Y 5/4) and 40% gray (2.5Y 6/1) clay and mottled light olive brown (2.5Y 5/4) and gray (2.5Y 6/1) clay loam with few very light olive brown (2.5Y 7/3) laminae; few fine and medium snail fragments; few carbonate nodules, 0.5 cm, white, pitted; hearth in uppermost bed.

CB2b; calcareous throughout; 13 m upstream from CB2a; first six horizons correlate with CB2a.

C/A 0–6 cm; **(Unit 3)**
Ab1 6–32 cm
Bw 32–62 cm
Ab2 62–92 cm
C/Bw 92–110 cm
C1 110–155 cm

C2 155–183 cm; dark gray (2.5Y 3.5/1) clay; very firm; 40% clay clasts, 0.5 cm; laminated light olive brown (2.5Y 5/3) silt loam, 10%; clear smooth.

C3 183–219 cm; very dark gray (2.5Y 3/1) clay; few faint light olive brown (2.5Y 5/3) beds, 1 to 2 cm thick; 20% clay clasts, 0.5 cm diameter; abrupt smooth.

Ab3 219–256 cm; **(Unit 2)**; very dark gray (2.5Y 2.5/1) clay; weak coarse angular blocky; very hard; few fine light olive brown (2.5Y 5/3) biocasts; 2% clay clasts, 0.5 cm; few fine snail fragments; gradual smooth.

Bw 256–297 cm; dark grayish brown (2.5Y 4/2) clay; weak medium and coarse angular blocky; very firm; common fine and distinct gray (2.5Y 5/1); few fine snail fragments; clear smooth.

C/A 297–308 cm; very dark gray (2.5Y 3/1) clay; 10% light olive brown (2.5Y 5/3) pockets; weak coarse angular blocky to concoidal (10%); very firm; few fine snails; abrupt smooth.

C 308–323 cm; dark gray (2.5Y 4/1) and grayish brown (2.5Y 5/2) clay/clay loam; massive; very firm; few fine clay clasts; few fine snail fragments; abrupt smooth. (Currin bed)

Ab4 323–351 cm; **(Unit 1)**; very dark gray (2.5Y 3/1) clay; 2% light olive brown (2.5Y 5/3) biocasts; moderate medium angular blocky; very firm; common fine snail fragments; gradual smooth.

Bw1 351–390 cm; light olive brown (2.5Y 5/3) clay; weak coarse prismatic; firm; common fine and medium gray (2.5Y 5/1) iron depletions; common fine snail fragments; clear smooth.

Bw2 390–408 cm; grayish brown (2.5Y 5/2.5) clay; common fine and medium gray (2.5Y 5/1) iron depletions; weak coarse prismatic; firm; common fine snails; gradual smooth.

Bw3 408–443 cm; light olive brown (2.5Y 5/3) clay; weak coarse prismatic; very firm; few fine and medium distinct gray (2.5Y 5/1) iron depletions; common fine and medium snail fragments, 3% carbonate nodules, 0.5 cm; one, 2 cm thick, light olive brown (2.5Y 5/3) bed in middle; gradual smooth.

C1 443–598 cm; multiple beds 10 to 20 cm thick, light olive brown (2.5Y 5/3) and dark grayish brown (2.5Y 4/2) clays; few fine distinct dark yellowish brown (10YR 4/4) iron pore linings; few fine and medium distinct gray (2.5Y 5/1) iron depletions; common fine and medium snail fragments.

C2 598–610 cm; light olive brown (2.5Y 5/3) silty clay loam; massive; firm; common fine distinct dark yellowish brown (10YR 3/6, 4/6) soft iron masses); few medium and coarse distinct gray (2.5Y 5/1) iron depletions; 2% carbonate nodules, white, pitted, 0.5 to 1 cm in iron depletions; clear smooth.

C3 610–650 cm; (water line); 5 to 15 cm thick faint beds of brown (10YR 5/3) and pale brown (10YR 6/3) clay loam; common fine distinct dark yellowish brown (10YR 3/6, 4/6) soft iron masses); few medium and coarse distinct gray (2.5Y 5/1) iron depletions; 2% carbonate nodules, white, pitted, 0.5 to 1 cm in iron depletions. (feature at water line).

C4 650–930 cm; same as above to water line.

CB2c; 20 m upstream from CB2b; calcareous throughout.

A/C 0–27 cm; **(Unit 3)**; very dark gray (10YR 3/1) clay loam; strong fine and medium subangular blocky; very hard; clear wavy.

C 27–50 cm; grayish brown (10YR 5/2.5) silt loam; weak coarse angular blocky; hard; few fine distinct very dark gray (10YR 3/1) biocasts; abrupt smooth.

Ab1 50–74 cm; dark grayish brown (10YR 4/2) silty clay loam; moderate fine and medium subangular blocky; very hard; few medium snails; 5% clay clasts, 0.5 cm; few fine distinct very dark brown (10YR 3/1); gradual smooth.

C 74–132 cm; yellowish brown (10YR 5/4) silt loam; massive; friable; few fine distinct dark gray (10YR 4/1) clay; abrupt smooth.

Ab2 132–147 cm; **(Unit 2)**; dark gray (10YR 3.5/1) clay; weak coarse angular blocky; very firm; gradual smooth.

Bw 147–167 cm; dark gray (10YR 4/1) clay; weak coarse angular blocky to massive; very firm; abrupt smooth.

Ab3 167–199 cm; **(Unit 1)**; black (10YR 2.5/1) silty clay loam; weak coarse angular blocky; very firm; many fine snail fragments; gradual smooth.

Bw1 199–244 cm; gray (10YR 4.5/1) clay; weak coarse angular blocky; very firm; few distinct slickensides; common fine snail fragments; gradual smooth.

Bw2 244–294 cm; grayish brown (10YR 4.5/2) clay; weak coarse angular blocky; very firm; few fine slickensides; common fine snail fragments; gradual smooth.

Bw3 294–352 cm; dark gray (10YR 4/1.5) and brown (10YR 5/3) clay; weak coarse angular blocky; very firm; few distinct slickensides; 5% carbonate nodules, white, 0.5 cm; common fine snail fragments; gradual smooth.

Bss 352–428 cm; dark grayish brown (10YR 4/2) grayish brown (10YR 5/2); weak coarse angular blocky; very firm; common distinct slickensides; gradual smooth.

BC1 428–460 cm; dark grayish brown (10YR 4/2.5) clay; weak coarse angular blocky; very firm; few fine faint gray (10YR 5/1) iron depletions and few fine distinct dark yellowish brown (10YR 3/4) soft iron masses; few distinct slickensides; gradual smooth.

BC2 460–495 cm; yellowish brown (10YR 5/4) silty clay loam; massive; very firm; few fine distinct gray (10YR 5/1) iron depletions; few fine distinct strong brown (7.5YR 4/6) soft iron masses.

C1 495–586 cm; (slope cover); brown (10YR 5/3) silt loam; massive; firm; few fine distinct strong brown (7.5YR 4/6) soft iron masses; few medium distinct gray (10YR 5/1) iron depletions; few medium black (10YR 2.5/1) organic traces.

C2 586–626 cm; brown (10YR 5/3) and yellowish brown (10YR 5/4) sandy clay loam; massive; friable; few medium and coarse distinct gray (10YR 6/1) iron depletions; 2% carbonate nodules, white, pitted, 0.5 to 1 cm in iron depletions; clear dipping.

C3 626–675 cm; brown (10YR 5/3) and yellowish brown (10YR 5/4) silt loam; massive; friable; few medium and coarse distinct gray (10YR 6/1) iron depletions.

CB2d; 25 m upstream from CB2c, 20 m downstream from tributary; calcareous throughout.

A/C 0–25 cm; **(Unit 3)**; brown (10YR 5/3) and yellowish brown (10YR 4/4) clay loam strong fine and medium subangular blocky; very hard; many fine very dark gray (10YR 3/1) biocasts; clear wavy.

C 25–42 cm; mixed brown (10YR 5/3) and very dark gray (10YR 3/1) clay; moderate medium angular blocky; very hard; 4% pebbles, 0.3 to 1 cm, siliceous, subrounded; clear wavy.

Ab/Bw1 42–75 cm; A – very dark grayish brown (10YR 3/2.5) clay; moderate fine and medium subangular block; very hard; 20% yellowish brown (10YR 5/4); B – strong brown (7.5YR 5/4) clay; moderate medium angular blocky; very hard; 30% very dark gray (10YR 3/1); clear wavy.

Ab/Bw2 75–95 cm; A – very dark grayish brown (10YR 3/2.5) silty clay loam; moderate medium and coarse subangular block; very hard; 20% yellowish brown (10YR 5/4); B – grayish brown (10YR 5.5/2) silty clay loam; weak coarse angular blocky; very hard; 30% very dark gray (10YR 3/1); clear smooth.

Ab/Bw3 95–129 cm; A – dark brown (10YR 3/3) clay loam; weak coarse angular block; hard; 10% yellowish brown (10YR 5/4); B – yellowish brown (10YR 5/4) loam; massive; friable; 10% dark brown (10YR 3/3); clear smooth.

Ab1 129–147 cm; dark gray (10YR 4/1) clay loam; weak coarse angular blocky to massive; very hard; few medium distinct light olive brown (2.5Y 5/3) pockets; clear smooth.

Ab2 147–170 cm; **(Unit 2)**; very dark gray (10YR 3/1) clay; weak coarse angular blocky; very hard; 2% clay clasts, 0.5 cm; gradual smooth.

Bw 170–200 cm; dark gray (10YR 4/1.5); 2% clay clasts, 0.5 cm; weak coarse angular blocky; very hard; common fine snail fragments; clear smooth.

Ab3 200–237 cm; **(Unit 1)**; very dark gray (10YR 3.5/1) clay; weak coarse angular blocky; very hard; common fine snail fragments; gradual smooth.

Bss1 237–272 cm; grayish brown (10YR 4/2) clay; moderate coarse angular blocky; very hard; common distinct slickensides; gradual smooth.

Bss2 272–328 cm; brown (10YR 5/3) and grayish brown (10YR 4/2) clay; moderate coarse angular blocky; very firm; common distinct slickensides; few medium distinct very dark gray (10YR 3/1) biocasts; common fine snail fragments; gradual smooth.

Bss3 328–381 cm; yellowish brown (10YR 4.5/4) clay; moderate coarse angular blocky; very hard; many prominent slickensides; few fine distinct dark gray (10YR 4/1) iron depletions; few fine snail fragments; gradual smooth.

Bss4 381–462 cm; yellowish brown (10YR 5/4) clay; moderate coarse angular blocky; very hard; common prominent slickensides; common fine distinct strong brown (7.5YR 4/6); few medium distinct gray (2.5Y 5/1) iron depletions; gradual wavy.

Bssk 462–537 cm; brown (10YR 4.5/3) clay; moderate coarse angular blocky to weak coarse prismatic; very hard; common distinct slickensides; 2% carbonate nodules, 0.3 to 0.6 cm, white, coalescing; 2% calcans; few distinct brown (10YR 4/3) coats; few medium distinct dark gray (2.5Y 4/1) iron depletions; gradual smooth.

BC 537–587 cm; yellowish brown (10YR 4.5/4) sandy clay loam; few distinct dark yellowish brown (10YR 4/4) coats; massive; friable; gradual smooth.

C 587–657 cm; yellowish brown (10YR 5/6) medium sandy loam; massive; friable; one meter to water line.

Appendix A-2: Backhoe Trench Descriptions

BHT-24 (Block 1); elevation 85.7 to 86.1 m; floodplain; calcareous throughout; A/C–Bk2 horizons from middle south wall, Ab2–Bk3 horizons from north wall on west end.

Fill 0–15 cm; gray (10YR 3.5/1) clay; moderate fine and medium angular blocky; very hard; few clay clasts, 0.5 cm; clear smooth.

A1 15–36 cm; **(Unit 2)**; gray (10YR 3.5/1) clay; moderate medium angular blocky; firm; common clay clasts, 0.5 cm; gradual smooth.

Ab 36–87 cm; **(Unit 1)**; dark gray (10YR 3/1) clay; few brown (10YR 5/3) pockets; moderate coarse angular blocky; firm; few clay clasts, 0.5 cm; gradual smooth.

Bk1 87–113 cm; (Unit 2); dark grayish brown (10YR 4/2) clay; few brown (10YR 5/3) pockets; weak coarse prismatic; firm; 3% calcium carbonate filaments; gradual smooth.

Bk2 113–137 cm; dark grayish brown (10YR 4/2) clay; weak coarse prismatic; firm; 3% calcium carbonate filaments, 1% carbonate nodules, 0.5 cm; clear smooth.

Bk3 (Ab?) 137–177 cm; dark gray (10YR 3/2) clay; few dark grayish brown (10YR 3.5/2) pockets; few fine faint yellowish brown (10YR 3/4) soft iron masses; weak coarse subangular blocky; firm; 1% calcium carbonate filaments; 1% calcium carbonate nodules, 0.5 cm; gradual smooth.

Bk4 177–219 cm; dark grayish brown (10YR 4/2) clay; common fine very dark grayish brown (10YR 3/2) pockets; weak coarse angular blocky; firm; few faint slickensides; 2% calcium carbonate nodules, 0.5 to 1 cm; 1% calcium carbonate filaments; gradual smooth.

Bk5 219–258 cm; dark grayish brown (10YR 4/2) clay; few very dark grayish brown (10YR 3/2) pockets; weak coarse prismatic; very firm; 3% calcium carbonate filaments; 2% calcium carbonate nodules, 0.5 to 1 cm; gradual smooth.

Bk6 258–284 cm; light olive brown (2.5Y 5/3) clay; 20% fine faint gray (10YR 5/1) iron depletions; few fine distinct yellowish brown (10YR 5/4) soft iron masses; weak coarse prismatic; very firm; 2% calcium carbonate filaments; 2% calcium carbonate nodules, 0.5 to 1 cm.

BHT-15 (Block 2); elevation 86.1 to 86.2 m; floodplain; calcareous throughout; A/C–Bk2 horizons from middle east wall, Akb2–Bk3 horizons from east wall below test unit.

Fill 0–24 cm; dark gray (10YR 3.5/1) clay; moderate medium angular blocky and platy; very hard; clear smooth.

A 24–53 cm; **(Unit 2)**; dark gray (10YR 3.5/1) clay; few brown (10YR 5/3) pockets; weak coarse angular blocky; firm; common clay clasts, 0.5 cm; clear smooth.

Ab 53–79 cm; **(Unit 1)** very dark gray (10YR 3/1) clay; few brown (10YR 5/3) pockets; moderate medium and coarse angular blocky; firm; few clay clasts, 0.5 cm; gradual smooth.

Bk1 79–113 cm; dark grayish brown (10YR 3.5/2) clay; 10% brown (10YR 5/3) pockets; weak coarse prismatic; hard; 2% calcium carbonate filaments; gradual smooth.

Bk2 113–140 cm; dark grayish brown (10YR 4/2) clay; weak medium and coarse prismatic; firm; 3% calcium carbonate filaments; clear smooth

Bk3 (Ab?) 140–159 cm; (Unit 1); dark gray (10YR 3/1) clay; 10% dark grayish brown (10YR 4/2) pockets; weak coarse angular blocky; very firm; gradual smooth.

Bk4 159–188 cm; dark gray (10YR 3.5/1) clay; 5% fine distinct gray (10YR 5/1) iron depletions along ped faces; few fine distinct dark yellowish brown (10YR 3/4) soft iron masses; moderate coarse prismatic; very firm; 2% calcium carbonate filaments; 2% calcium carbonate nodules, 0.5 to 1 cm; gradual smooth.

Bk5 188–223 cm; dark grayish brown (10YR 3.5/2) clay; 5% fine distinct gray (10YR 5/1) iron depletions along ped faces; moderate coarse prismatic; very firm; 3% calcium carbonate nodules; 1% calcium carbonate filaments; gradual smooth.

Bk6 223–280 cm; light olive brown (2.5Y 5/3) clay; few fine distinct dark yellowish brown (10YR 4/4) soft iron masses; 5% fine distinct gray (10YR 5/1) iron depletions along ped faces; weak coarse prismatic; extremely firm; 3% calcium carbonate nodules; 1% calcium carbonate filaments.

BHT-5; elevation ~85.5 m; slough; calcareous throughout; east wall.

Fill 0–18 cm; light olive brown (2.5Y 5/3), grayish brown (2.5Y 5/2), and very dark gray (2.5Y 3/1) clay; massive; extremely firm; few siliceous pebbles, 0.3 to 0.5 cm; abrupt smooth.

A 18–47 cm; **(Unit 2)**; dark gray (10YR 3.5/1) clay loam; weak coarse angular blocky; firm; common clay clasts, 0.5 cm; few siliceous pebbles, 0.3 to 0.5 cm; gradual smooth.

Bw 47–96 cm; dark gray (10YR 3.5/1) clay loam; weak coarse angular blocky; firm; two faint yellowish brown (10YR 5/4) beds, 1 cm; common clay clasts, 0.5 cm; clear smooth.

Ab 96–120 cm; **(Unit 1)**; very dark gray (10YR 3/1) clay; few yellowish brown (10YR 5/4) pockets; weak coarse angular blocky; very hard; common clay clasts, 0.5 cm; gradual smooth.

Bw 120–156 cm; dark gray (10YR 3.5/1) clay; few yellowish brown (10YR 5/4) pockets; weak coarse angular blocky; very hard; common clay clasts, 0.5 cm; 1% carbonate nodules 0.5 cm; gradual smooth.

C 156–240 cm; bedded clays and loams; clays-very dark and dark gray (10YR 3/1, 4/1), many clay clasts, 3 to 10 cm; loams-light brownish gray (10YR 6/2) and light gray (10YR 7/2) very fine sandy loam and silt loam, 0.2 to 0.5 cm.

BHT-16; elevation 85.4 m; slough; calcareous throughout; east wall.

Fill 0–9 cm; very dark gray (10YR 3/1) clay; distinct bedding planes; hard; abrupt smooth.

Fill 9–38 cm; dark gray (10YR 3.5/1) clay; massive; plastic; 5% siliceous pebbles, 0.5 to 2 cm; abrupt wavy.

A/Cb 38–87 cm; **(Unit 2)**; dark grayish brown (10YR 4/2) clay; faint brown (10YR 5/3) bed in middle; weak coarse angular blocky; very firm; common clay clasts, 0.5 cm; gradual smooth.

A 87–109 cm; dark grayish brown (10YR 4/2) clay; weak coarse angular blocky; very firm; common clay clasts, 0.5 cm; gradual smooth.

Bss 109–131 cm; dark grayish brown (10YR 4/2) clay; moderate medium angular blocky; very firm; common distinct slickensides; abrupt smooth.

C 131–165 cm; (Unit 2); dark grayish brown (2.5Y 4/2) clay; 30% brown (10YR 5/3) pockets; light brownish gray (10YR 6/2) silt loam lamination at top and bottom, 3 mm; faint light brownish gray (10YR 6/2) silt loam bed in middle, 2 cm; weak coarse angular blocky; very firm; few distinct slickensides; clear smooth.

Ab2 165–210 cm; **(Unit 1)**; dark gray (10YR 3.5/1) clay; few brown (10YR 5/3) pockets; weak coarse angular blocky; extremely firm; few distinct slickensides; 1% calcium carbonate nodules, 0.5 cm; gradual smooth.

Bk 210–245 cm; grayish brown (2.5Y 4.5/2) clay; weak coarse angular blocky; extremely firm; 5% fine faint dark gray (2.5Y 4/1) iron depletions along ped faces; few fine distinct dark yellowish brown (10YR 4/4) soft iron masses.

BHT-18; elevation 85.5 m; slough; calcareous throughout; east wall.

A/C 0–17 cm; **(Unit 2, 3)**; dark grayish brown (2.5Y 4/2) clay; very dark gray (2.5Y 3/1) bed in middle, 2 cm; weak coarse angular blocky; very firm; clear smooth.

A 17–53 cm; dark grayish brown (10YR 4/2) clay; moderate coarse angular blocky; firm; common clay clasts, 0.5 cm; clear smooth.

Ab1 53–72 cm; **(Unit 2)**; dark grayish brown (10YR 3.5/2) clay; weak coarse angular blocky; firm; common clay clasts, 0.5 cm; gradual smooth.

Bw 72–120 cm; dark grayish brown (2.5Y 4/2) clay; 3% brown (10YR 5/3) pockets; weak coarse prismatic; very firm; few faint slickensides; few clay clasts, 0.5 cm; clear smooth.

C 120–143 cm; dark grayish brown (10YR 3.5/2) clay; 5% brown (10YR 5/3) pockets; weak coarse prismatic; very hard; few clay clasts, 0.5 cm; gradual smooth.

Ab2 143–180 cm; very dark grayish brown (10YR 3/2) clay; 3% dark grayish brown (10YR 4/2) pockets; weak coarse angular blocky; very hard; gradual smooth.

Bk 180–211 cm; dark grayish brown (2.5Y 4/2) and light olive brown (2.5Y 5/3) clay; few fine faint dark yellowish brown (10YR 4/4) soft iron masses; weak coarse prismatic; very hard; 1% calcium carbonate nodules, 0.5 cm; abrupt smooth.

Bg 211–235 cm; very dark gray (10YR 3/1) clay; 15% brown (10YR 4.5/3) and dark grayish brown (10YR 4/2) pockets; few fine faint gray (2.5Y 5/1) iron depletions; weak coarse angular blocky; extremely firm; many clay clasts, 0.5 cm; gradual smooth.

BC 235–288 cm; dark gray (10YR 4/1) clay; weak coarse angular blocky to massive; extremely firm.

BHT-7; elevation 85.5 m; slough; calcareous throughout; east wall.

A1	0–33 cm; **(Unit 2, 3)**; dark gray (2.5Y 3.5/1) clay; weak medium and coarse subangular blocky; firm; few medium distinct dark yellowish brown (10YR 4/4) soft iron masses; 5% fine faint gray (2.5Y 5/1) iron depletions along ped faces; clear smooth.
A2	33–51 cm; very dark gray (2.5Y 3/1) clay; moderate medium and coarse angular blocky; very firm; common medium distinct dark yellowish brown (10YR 4/4) soft iron masses; few faint gray (2.6Y 6/1) laminations; gradual smooth.
Bw	51–64 cm; dark gray (2.5Y 4/1) and light brownish gray (2.5Y 6/2) clay loam; weak coarse angular blocky; very hard; clear smooth.
Ab1	64–85 cm; **(Unit 2)**; very dark gray (10YR 3/1) clay; few light brownish gray (2.5Y 6/2) pockets; weak coarse angular blocky; hard; few siliceous pebbles, 0.2 to 0.5 cm; gradual smooth.
Bw	85–104 cm; dark grayish brown (2.5Y 4/2) clay loam; 10% light brownish gray (2.5Y 6/2) pockets; weak coarse angular blocky; hard; few siliceous pebbles, 0.2 to 0.5 cm; gradual smooth.
C	104–114 cm; dark gray (10YR 3.5/1) clay loam; 2% faint light brownish gray (2.5 6/2) laminations; hard; clear smooth.
Ab2	114–133 cm; (Unit 2); dark gray (10YR 3.5/1) clay; 10% light brownish gray (2.5Y 6/2) pockets; weak coarse angular blocky; hard; few fine distinct dark brown (7.5YR 3/4) soft iron masses; gradual smooth.
C	133–141 cm; dark gray (10YR 4/1) clay; common medium distinct dark yellowish brown (10YR 3/4) soft iron masses; hard; clear smooth.
Ab3	141–166 cm; very dark gray (10YR 3/1) clay; weak coarse angular blocky; very firm; common medium distinct dark yellowish brown (10YR 4/4) soft iron masses; gradual smooth.
Bg	166–218 cm; dark gray (10YR 4/1) clay; common medium distinct dark yellowish brown (10YR 4/6) soft iron masses; 5% faint light brownish gray (2.5Y 6.2) laminations; weak coarse angular blocky; firm; gradual smooth.
Cg1	218–247 cm; laminated very dark gray and dark gray (2.5Y 3/1, 4/1) clay; common medium distinct dark yellowish brown (10YR 4/4) soft iron masses; firm; clear smooth.
Cg2	247–280 cm; dark gray (2.5Y 4/1) clay; massive; very firm; many medium distinct dark yellowish brown (10YR 4/4) soft iron masses.

BHT-8; elevation 85.7–85.9 m; floodplain; calcareous throughout; south wall.

A/C	0–22 cm; **(Unit 2, 3)**; massive gray (10YR 5/1) with faint yellowish brown (10YR 5/4) laminations; friable; abrupt wavy.
Ab1	22–39 cm; **(Unit 1)**; very dark gray (10YR 3.5/1) clay; weak coarse angular blocky; very firm; gradual smooth.
Bw1	39–75 cm; dark gray (10YR 4/1) clay; weak coarse angular blocky; extremely firm; few medium faint brown (10YR 4/3) soft iron masses; clear smooth.

Bw2 75–88 cm; (Unit 1); very dark gray (2.5Y 3/1) clay; few light olive brown (2.5Y 5/3) pockets; weak coarse angular blocky; extremely firm; gradual smooth.

Bk1 88–119 cm; brown (10YR 4/3) clay; 5% very dark gray (10YR 3/1) pockets; weak coarse prismatic; very hard; 2% calcium carbonate filaments; gradual smooth.

Bk2 119–143 cm; dark grayish brown (10YR 4/2) clay; 5% very dark gray (10YR 3/1) pockets; weak coarse prismatic; very hard; 5% calcium carbonate filaments; gradual smooth.

Bk3 143–200 cm; gray (10YR 4/1) clay; weak medium prismatic; very hard; moderate medium distinct dark yellowish brown (10YR 4/4/) soft iron masses; 5% calcium carbonate filaments; gradual smooth.

Bk4 200–281 cm; gray (10YR 4/1) clay; weak medium prismatic; very hard; moderate medium distinct dark yellowish brown (10YR 4/4) soft iron masses; 2% calcium carbonate filaments; gradual smooth.

Bk5 281–300 cm; light olive brown (2.5Y 5/4) clay; many medium distinct dark gray (2.5Y 4/1) pockets; weak coarse prismatic; very hard; 3% calcium carbonate filaments.

BHT-13; elevation 85.9 m; floodplain; calcareous throughout; east wall.

Fill 0–14 cm; backhoe trench backfill, variegated colors; massive; gradual smooth.

Ab1 14–29 cm; **(Unit 2)**; dark grayish brown (10YR 3.5/2) clay; weak medium angular blocky; firm; gradual smooth.

Bw1 29–62 cm; dark grayish brown (10YR 4/2) clay; weak medium and coarse angular blocky; firm; gradual smooth.

Bw2 62–117 cm; grayish brown (2.5Y 5/2) clay; weak medium and coarse angular blocky; firm; gradual smooth.

Ab2 117–161 cm; **(Unit 1)**; dark grayish brown (2.5Y 4/2) clay; weak coarse prismatic to moderate medium angular blocky; firm; few faint slickensides; gradual smooth.

Bk1 161–191 cm; dark grayish brown (10YR 4/2) clay; moderate medium prismatic; very firm; 2% calcium carbonate filaments; gradual smooth.

Bk2 191–230 cm; grayish brown (10YR 4.5/2) clay; weak coarse prismatic; very firm; 2% calcium carbonate nodules, 0.5 to 1 cm.

BHT-12; elevation 85.6 m; floodplain; calcareous throughout; east wall.

A/C 0–13 cm; **(Unit 2, 3)**; dark grayish brown (10YR 3.5/2) clay; weak medium subangular blocky; very firm; clear smooth.

Ab1 13–35 cm; **(Unit 2)**; very dark grayish brown (10YR 3/2) clay; weak medium subangular blocky; very firm; gradual smooth.

C 35–61 cm; grayish brown (10YR 4/2.5) clay; massive; firm; faint beds; clear smooth.

Ab2 61–95 cm; **(Unit 1)**; very dark grayish brown (10YR 3/2) clay; weak coarse angular blocky; very hard; 5% light yellowish brown (10YR 5/4) pockets; gradual smooth.

Bk1 95–141 cm; grayish brown (10YR 4.5/2) clay; weak coarse angular blocky; very hard; 5% light yellowish brown (10YR 5/4) pockets; 1% calcium carbonate filaments; 1% calcium carbonate filaments; gradual smooth.

Bk2 141–200 cm; gray (10YR 5/1) clay; weak coarse angular blocky; very hard; 1% calcium carbonate filaments; 1% calcium carbonate filaments; few faint slickensides; gradual smooth.

BHT-2; elevation 85.5–85.6 m; slough; calcareous throughout; south wall.

Fill 0–19 cm; very dark grayish brown (2.5Y 3/2) clay; strong medium subangular; firm; common siliceous pebbles, 0.5 cm; gradual smooth.

A2 19–36 cm; dark grayish brown (2.5Y 3/2) clay; moderate coarse subangular; firm; few siliceous pebbles, 0.5 cm; few clay clasts, 0.5 cm; gradual smooth.

Bw1 36–75 cm; **(Unit 3)**; dark grayish brown (2.5Y 4/2) clay; weak coarse subangular blocky; firm; few siliceous pebbles, 0.5 cm; faint light brownish yellow (2.5Y 6/4) laminations in lower 5 cm; abrupt smooth.

Bw2 75–92 cm; dark grayish brown (2.5Y 3.5/2) clay; weak medium angular blocky; very firm; 5% light yellowish brown (2.5Y 6/3) pockets; clear smooth.

Bw/C 92–129 cm; dark grayish brown (2.5Y 4/2) clay loam; common distinct pale brown (10YR 6/3) laminations; many clay clasts, 0.5 to 1.5 cm; abrupt smooth.

C1 129–143 cm; faintly laminated pale brown (10YR 6/3) and very dark grayish brown (10YR 3/2) silty clay loam; hard; abrupt smooth.

C2 143–153 cm; few faint pale brown (10YR 6/3) and very dark grayish brown (10YR 3/2) laminated clays; very hard; many clay clasts, 0.5 to 2 cm; few fine distinct brown (7.5YR 4/4) soft iron masses; abrupt smooth.

C3 153–202 cm; laminated pale brown (10YR 6/3) and dark grayish brown (10YR 4/2) silt loam; hard; 5% very dark grayish brown (10YR 3/2) pockets; abrupt smooth.

C4 202–217 cm; few distinct pale brown (10YR 6/3) and very dark grayish brown (10YR 3/2) laminated silt loams; slightly hard.

BHT-11; elevation 85.3 m; north slough; calcareous throughout; north wall.

Fill 0–33 cm; very dark gray (10YR 3.5/1) clay; weak coarse angular blocky; very firm; common siliceous pebbles, 0.5 to 2 cm; abrupt wavy.

Fill 33–72 cm; very dark gray and black (2.5Y 3/1, 2/1) and brownish yellow (10YR 6/6) clay; massive; firm; many siliceous pebbles, 0.5 to 2 cm; 2% detrital calcium carbonate nodules, 1 cm; abrupt wavy.

Bw 72–99 cm; **(Unit 3)**; dark gray (2.5Y 3.5/1) clay; common fine distinct brown (7.5YR 4/4) soft iron masses; weak coarse angular blocky; firm; few clay clasts, 0.5 cm; clear smooth.

Assgb1 99–132 cm; (Unit 2); very dark gray (2.5Y 3/1) clay; few fine distinct brown (7.5YR 4/4) soft iron masses; weak coarse angular blocky; very firm; common distinct slickensides; gradual smooth.

Bg1 132–161 cm; gray (2.5Y 5/1) clay; common fine distinct dark yellowish brown (10YR 4/4); weak coarse angular blocky; firm; clear smooth.

Bg2 161–186 cm; dark gray (2.5Y 4/1) clay; weak coarse angular blocky; very firm; common fine distinct yellowish brown (10YR 5/4) soft iron masses; gradual smooth.

Bg3 186–208 cm; gray (2.5Y 5/1) clay; moderate medium distinct brown (7.5YR 5/4) soft iron masses; weak coarse angular blocky; very firm; 1% calcium carbonate nodules; gradual smooth.

Bg4 208–230 cm; gray (2.5Y 5/1) clay; few fine distinct yellowish brown (10YR 4/4) soft iron masses; weak coarse angular blocky; very firm.

BHT-26 (Block 1); elevation 85.5 to 85.9 m; floodplain; calcareous throughout; south wall.

Fill 0–18 cm; dark gray (10YR 3/1.5) clay; moderate coarse platy; very hard; common siliceous pebbles, 0.5 cm; clear smooth.

Ab1 18–43 cm; **(Unit 1)**; dark gray (10YR 3.5/1) clay; weak coarse angular blocky; very hard; gradual smooth.

Bw1 43–71 cm; dark grayish brown (2.5Y 3.5/2) clay; weak coarse angular blocky; firm; few siliceous pebbles, 0.5 cm; clear smooth.

Bw2 71–94 cm; dark gray (2.5Y 3.5/1) clay; weak coarse angular blocky; very firm; 3% light olive brown (2.5Y 5/3) pockets; 1% calcium carbonate filaments; gradual smooth.

Bk1 94–115 cm; grayish brown (2.5Y 3.5/2) clay; 3% light olive brown (2.5Y 5/3) pockets and 1% very dark gray (2.5Y 3/1) pockets; weak coarse angular blocky; firm; 2% calcium carbonate filaments; gradual smooth.

Bk2 115–140 cm; gray (2.5Y 4/1) clay; weak coarse angular blocky; very firm; 1% very dark gray (2.5Y 3/1) pockets; moderate medium distinct brown (10YR 4/3) soft iron masses; 4% calcium carbonate filaments; gradual smooth.

Bk3 140–177 cm; gray (2.5Y 4/1) clay; common medium distinct dark yellowish brown (10YR 4/4) soft iron masses; weak coarse angular blocky; firm; 3% calcium carbonate nodules, 0.5 to 1 cm.

BHT-B (Block 2); elevation 85.9 m; floodplain; calcareous throughout; late Holocene over early Holocene alluvium; east wall.

A1 0–8 cm; **(Unit 2)**; dark gray (2.5Y 3.5/1) clay; weak coarse angular blocky; very firm; clear smooth.

Ab 8–31 cm; **(Unit 1)**; very dark gray (2.5Y 3.5/1) clay; weak coarse angular blocky; very firm; clear wavy.

Bw1 31–60 cm; very dark gray (10YR 3/1) clay; weak coarse angular blocky; very firm; clear wavy.

Bw2 60–74 cm; very dark gray (10YR 3/1) clay; weak coarse angular blocky; very firm; clear smooth.

Bk1 74–90 cm; black (2.5Y 2.5/1) clay; moderate medium prismatic to moderate medium angular blocky; very hard; 2% dark grayish brown pockets; 2% calcium carbonate filaments; gradual smooth.

Bk2 90–116 cm; very dark gray (10YR 3/1) clay; moderate medium prismatic to moderate medium angular blocky; very hard; 8% calcium carbonate filaments; gradual smooth.

Bk3 116–139 cm; dark gray (2.5Y 3.5/1) clay; few black (2.5Y 2.5/1) pockets; 30% brown (10YR 5/3) pockets; moderate medium prismatic to moderate medium angular blocky; very hard; 10% calcium carbonate filaments; gradual smooth.

Bk4 139–157 cm; very dark gray (2.5Y 3/1) clay; 30% brown (10YR 5/3) pockets; moderate medium prismatic to moderate medium angular blocky; very hard; 10% calcium carbonate filaments; gradual smooth.

Bk5 157–180 cm; yellowish brown (10YR 5/4) clay; few fine distinct dark yellowish brown (10YR 4/6) soft iron masses; common medium distinct dark gray (2.5Y 4/1) iron depletions along ped faces; weak coarse prismatic; very hard; 10% calcium carbonate filaments.

BHT-A (Block 3); elevation 85.4 to 85.7 m; floodplain; calcareous throughout; north wall; (missing upper 30 cm).

Bw 0–31 cm; **(Unit 2)**; dark gray (10YR 3/1.5) clay; weak coarse angular blocky; very firm; clear smooth.

Ab1 31–58 cm; **(Unit 1)**; very dark gray (10YR 3/1) clay; moderate medium prismatic to moderate medium angular blocky; very hard; 1% dark grayish brown (10YR 4/2) pockets; 1% calcium carbonate filaments; gradual smooth.

Akb2 58–79 cm; very dark gray (10YR 3/1) clay; 2% dark grayish brown (10YR 4/2) pockets; weak coarse prismatic; very hard; 5% calcium carbonate filaments; gradual smooth.

Bk2 79–117 cm; dark gray (10YR 4/1) clay; 5% dark yellowish brown (10YR 4/4) pockets; weak coarse prismatic; very hard; 5% calcium carbonate filaments; gradual smooth.

Bk3 117–134 cm; dark gray (10YR 4/1) clay; weak coarse prismatic; very hard; moderate medium distinct yellowish brown (10YR 5/4) soft iron masses; 5% calcium carbonate filaments.

CB-6; modern levee; calcareous throughout.

C 0–2 cm; (Unit 3); pale brown (10YR 6/3) fine sandy loam; single grain; abrupt wavy.

A 2–29 cm; very dark gray (10YR 3/1) clay; moderate fine and medium subangular blocky; very hard; clear smooth.

Bw1 29–49 cm; dark gray (10YR 3.5/1) clay; moderate medium and coarse subangular blocky; very hard; faint bed in lower part, 2 cm; clear smooth.

Bw2 49–71 cm; dark gray (10YR 3.5/1) clay; 30% brown (10YR 5/3) pockets; moderate medium and coarse subangular blocky; hard; few faint laminations; brown clay bed at base, 2 cm; clear smooth.

Bw3 71–87 cm; dark gray (10YR 3.5/1) and brown (10YR 5/3) laminated clay loam and loam; weak coarse angular blocky; hard; common faint laminations; abrupt smooth.

C1 87–123 cm; brown (10YR 5/3) loam; 30% dark gray (10YR 4/1) pockets; massive; hard; common faint laminations; abrupt smooth.

C2 123–140 cm; dark gray (10YR 4/1) clay loam; weak coarse prismatic; very hard; 30% brown (10YR 5/3) pockets; common fine distinct strong brown (7.5YR 4/6) iron pore linings; clear smooth.

C3 140–159 cm; brown (10YR 5/3) loam; 20% dark gray (10YR 4/1) pockets; massive; hard; few faint laminations; 2 cm clay bed at base with common fine distinct strong brown (7.5YR 4/6) iron pore linings; abrupt smooth.

C4 159–194 cm; dark gray (10YR 4/1.5) clay loam; 10% brown (10YR 5/3) pockets; weak coarse prismatic; very hard; common fine distinct strong brown (7.5YR 4/6) iron pore linings; clear smooth.

C5 194–220+ cm; pale brown (10YR 6/3) silt loam; 20% dark gray (10YR 4/1) pockets; few distinct beds and laminations of clay and silt loam; massive; hard; common fine distinct strong brown (7.5YR 4/6) iron pore linings.

Appendix B

Vertebrate Remains

Barbara A. Meissner and Richard B. Mahoney

Appendix B: Vertebrate Remains

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This appendix discusses the vertebrate faunal remains recovered from 41MM340, as well as detailed descriptions of the worked bone specimens identified in the collection. Also included is a brief discussion of the single deciduous human tooth recovered during excavations.

Vertebrate Faunal Remains

Methods

In the field, most bone was recovered by water screening through ¼-inch (.64 cm) screens. Bones were bagged with other artifacts by unit, zone, and level. A few bones were removed by excavating a block of soil around them, and returned to the lab where the soil was carefully removed. In the laboratory, all bone was washed in tap water to which sodium bicarbonate had been added to aid in removal of silt and clay. Bone was then rinsed, dried, and bagged by unit, zone, and level.

The bone was identified to the most specific taxon possible using the comparative collection at CAR, as well as several reference texts (Balkwill and Cumbaa 1992; Boessneck 1970; Cohen and Serjeantson 1996; Gilbert 1990; Gilbert et al. 1981; Hildebrand 1955; Hillson 1986; Olsen 1960, 1964, 1968; Schmid 1972; Sobolik and Steele 1996). Identifications were conservative, i.e., bone that appeared to be bison-sized was not identified as *Bison bison* unless it could be differentiated from *Bos* and *Equus* species. Bones with breaks that were clearly recent and that could be reassembled were counted as a single bone. For instance, a nearly complete turtle carapace found *in situ* broke into about 20 pieces during transportation and washing, but was counted as a single bone, since it was found unbroken.

All bone was weighed and any evidence of exposure to heat was noted. Element, portion of element, side, evidence of immaturity, butcher marks, and pathologies were noted on bone identified to the order taxonomic level. When bone could be identified only to class (e.g., mammal, bird, etc.) an estimate of the size of the animal was made when possible. After the analysis, the bone was bagged by unit, zone, and level. Bone identified to at least the order taxonomic level was bagged separately and included with bags of unidentified bone in the unit/zone/level bags. Bone tools were given separate catalog numbers and were bagged separately from the unit/level bags.

Results

A total of 10,844 vertebrate faunal remains, weighing 5,549.89 grams, was recovered during the data recovery project. A list of taxa identified for all bone is shown in Table B-1.

The bone was in good to excellent condition. Although the excavation methods did result in bone breakage, the majority of the bone had already been reduced to small pieces while it was still fresh. As a result, only 7.2% of the bone was identified to the order taxonomic level, and only 3.9% could be identified to the genus taxonomic level. This fragmentation of the bone was particularly true of the long bones of large mammals such as deer (*Odocoileus virginianus*) making identification difficult. In fact, the majority of identifiable deer bones, excluding teeth, were carpals, tarsals, and phalanges. The only exception were metatarsal fragments, which are distinctive even in small fragments if they include the anterior diaphysis.

Twelve mammalian genera were identified, as well as three bird genera and three reptilian genera. All genera are still present in the area today, with the exception of bison (*Bison bison*), which has been extirpated from Central Texas (Davis and Schmidly 1994:289).

In general, the meat diet of the inhabitants of 41MM340 consisted of deer, bison (*Bison bison*), jackrabbit (*Lepus californicus*), and cottontail rabbit (*Sylvilagus* sp.). Any of the other animals identified may or may not have been part of the diet as well.

All bone identified to at least the order taxonomic level was separated by excavation zone, as defined in the field, and is presented in Table B-2. The table includes the total bone, average bone weight and the percent of bone identified to the order taxonomic level for each zone. Zones 2, 4, and 8 are the zones with the highest counts of bone. Two items of interest in Table B-2 are the increasing numbers of cottontail

Table B-1. Taxa Identified from 41MM340

Taxa	Common Name	Count	Weight (g)
Mammalia	Mammals		
Bison bison	American bison	1	39.47
Canis sp.	Dogs, coyotes, wolves	29	25.70
Castor canadensis	Beaver	17	13.50
Conepatus mesoleucus	Hog-nosed skunk	5	1.55
Didelphis virginiana	Opossum	3	2.02
Lepus californicus	Blacktailed jackrabbit	67	26.26
Mephitis mephitis	Striped skunk	1	1.46
Odocoileus virginianus	White-tailed deer	151	587.63
Procyon lotor	Raccoon	3	2.74
Sigmodon hispidus	Cotton rat	2	0.20
Sylvilagus sp.	Cottontail rabbit	74	15.49
Urocyon cinereoargenteus	Gray fox	1	0.40
Artiodactyla	Deer, sheep, goats	220	447.08
Bovinae	Cattle or bison	2	7.35
Carnivora	Carnivores	3	1.66
Rodentia	Rodents	10	0.70
Mammal--very small	Rats, mice-sized	2	0.02
Mammal--small	Rabbit-sized	126	20.51
Mammal--medium	Dog-sized	22	8.33
Mammal--large	Deer, sheep-sized	2,312	2203.35
Mammal--very large	Cattle, bison, horse-sized	317	676.48
Mammal	Size indeterminate	6,769	1304.38
	Total Mammals	**10,137**	**5386.28**
Aves	Birds		
Anas sp.	Ducks	2	1.01
Buteo sp.	Hawks	2	0.34
Meleagris gallopavo	Turkey	1	0.89
Anatidae	Swans, ducks, geese	1	0.20
Ardeidae	Herons & bitterns	1	3.06
Phasianidae	Quails and pheasants	1	0.31
Strigiformes	Owls	1	0.19
Aves--medium	Pidgeon-sized	12	1.78
Aves--large	Chicken-sized	179	47.58
Aves--very large	Turkey, hawk-sized	5	1.23
Aves	Size indeterminate	311	42.51
	Total Birds	**516**	**99.10**
Reptilia	Reptiles		
Trachemys sp.	Pond slider	1	22.62
Trionyx sp.	Softshelled turtles	64	17.19
Colubridae	Non-poisonous snakes	1	0.08
Crotalidae	Pit vipers	3	0.57
Emydidae	Pond Sliders and cooters	6	1.81
Testudines	Turtles	109	20.55
	Total Reptiles	**184**	**62.82**
Osteichthyes	Boney Fishes		
Osteichthyes	Unidentified fish	3	1.03
	Total Fishes	**3**	**1.03**
Vertebrata	Unidentified bone	4	0.66
	Overall Totals	**10,844**	**5549.89**

Table B-2. Bone Identified to the Order Taxonomic Level, by Excavation Zones

	Zones																	
	1	**1a**	**1b**	**1c**	**2**	**3**	**3a**	**3b**	**3c**	**3d**	**3e**	**4**	**5**	**6**	**7**	**8**	**9**	**Totals**
Total bone	**46**	**111**	**330**	**10**	**1,751**	**67**	**268**	**846**	**165**	**52**	**23**	**2,280**	**285**	**583**	**658**	**3,230**	**96**	**10,801**
Average bone wgt. (g)	**0.36**	**0.45**	**3.45**	**1.38**	**0.53**	**0.55**	**0.58**	**0.48**	**0.52**	**0.35**	**0.42**	**0.57**	**0.32**	**0.60**	**0.44**	**0.51**	**0.59**	**0.51**
% ID'ed to Order	**6.5%**	**5.4%**	**4.5%**	**20.0%**	**9.7%**	**0.0%**	**6.7%**	**5.7%**	**9.1%**	**3.8%**	**8.7%**	**6.6%**	**7.7%**	**5.3%**	**5.6%**	**7.8%**	**7.3%**	**7.2%**
Identified to Order																		
Mammalia																		
Bison bison												1						**1**
Canis sp.					2			3				7	10	1	1	5		**29**
Castor canadensis					11									2	4			**17**
Conepatus mesoleucus					1							1				3		**5**
Didelphis virginiana												1		2				**3**
Lepus californicus	1				22		4	2	1		2	14		1		20		**67**
Mephitis mephitis																1		**1**
Odocoileus virginianus		4			34		6	7	2			53	1	6	8	28	2	**151**
Procyon lotor													1		1	1		**3**
Sigmodon hispidus			1									1						**2**
Sylvilagus sp.		1	3		11			5	1			13	4	13	4	19		**74**
Urocyon cinereoargenteus												1						**1**
Artiodactyla	2		9	1	59		6	25	9	2		34	3	2	12	52	2	**218**
Bovinae												1			1			**2**
Carnivora								1								2		**3**
Rodentia			1		2							2			3	2		**10**
Total Mammals	**3**	**5**	**14**	**1**	**142**	**0**	**16**	**43**	**13**	**2**	**2**	**129**	**19**	**27**	**34**	**133**	**4**	**587**
Aves																		
Anas sp.					1								1					**2**
Buteo sp.												1		1				**2**
Meleagris gallopavo												1						**1**
Anatidae												1						**1**
Ardeidae													1					**1**
Phasianidae																1		**1**
Strigiformes																1		**1**
Total Birds	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**2**	**1**	**0**	**2**	**0**	**9**
Reptilia																		
Trachemys sp.																1		**1**
Trionyx sp.			1	1	19		2	1							1	39		**64**
Colubridae												1						**1**
Crotalidae												2	1					**3**
Emydidae								2								4		**6**
Testudines		1			8			2	2			15		3	2	72	3	**108**
Total Reptiles	**0**	**1**	**1**	**1**	**27**	**0**	**2**	**5**	**2**	**0**	**0**	**18**	**1**	**3**	**3**	**116**	**3**	**183**
Grand Totals	**3**	**6**	**15**	**2**	**170**	**0**	**18**	**48**	**15**	**2**	**2**	**150**	**22**	**31**	**37**	**251**	**7**	**779**

Note: 43 bone fragments were recovered from backhoe trench fill and are not included in this table.

rabbits in the deeper zones, and the sharp increase in turtle in Zone 8.

Worked Bone

Perhaps the most distinctive attribute of this bone collection is the number of worked bone pieces identified. Twenty-one bone tools and tool fragments as well as nine possible tool fragments were identified during this project, presumably as a result of the excellent condition of most of the bone, making identification of such tools easier. In addition, 11 bone beads and bead fragments were identified. Table B-3 is a list and description of each specimen of worked bone. Figure B-1 shows a selection of tools and beads identified.

There are three examples of bone split from the proximal end of a deer-sized artiodactyl metatarsal (Figure B-1a through c). Each specimen has been partially smoothed, and the distal end removed by the groove-and-snap method. Two of these samples (Figure B-1a and b) show no further sign of use and were probably discarded during the manufacture of the tool. One bone (Figure B-1c) has a series of slight grooves in the distal end, but is too eroded to confirm if these grooves were deliberately cut or the result of use wear. These specimens are similar to those Harrell (1983:40–41) defines as "metatarsal tool platforms." She describes the process that creates them as follows:

> Platforms are defined as remnants of blanks which have been ground on one end to form uniform, smoothed surfaces. Typically the shaped end terminates with the remains of a transverse or circumscribed groove. It is presumed that these represent grips, or hand-held platforms, to facilitate shaping of tools. Once the appropriate form was achieved, the platforms were detached and discarded, and the tool bases ground smooth as a final step. (Harrell 1983:30).

Figure B-1d and Figure B-1e show specimens that may be the other end of such a manufacturing process. The distal ends have been broken by the groove-and-snap method, but then these ends have been smoothed and polished as described by Harrell (1983:30). These tools appear similar in size and cross-section to some of the other tools described here. Figure B-1f shows the cross-section of a fragment of a tool similar to those sown in Figure B-1d and B-1e.

In a group of very similarly worked bones, the proximal ends remain and have been extensively shaped and smoothed. Most were heat-altered and then polished (Figure B-1g through j). Most of these bones have been broken near the proximal end, but Figure B-1j appears to be nearly complete. The distal end of this tool is a flattened oval in cross-section, very similar to several other worked bones in the collection. Figure B-1k shows an example of a long, thin tool, similar to the distal end of Figure B-1i, and roughly similar in size and cross-section to Figure B-1d through f. Both Figure B-1l and B-1m appear to be tips of similar tools. Figure B-1m includes an enlarged view of this tool tip, showing the wedge-shaped end. There is slight use-polish visible on the end of this tip under 10x magnification.

Over all, the tools so far described are very similar. All appear to have been made on deer-sized metapodials, and all have flattened oval cross-sections between roughly 3.5 mm and 6 mm in diameter. Longer specimens have been shaped to a point. Some appear to have had their proximal ends removed after initial shaping, while at least one (and possibly others) has retained its proximal end. Most show at least some heat alteration, and for the most part, this heating has been done with remarkable evenness, suggesting that it was done deliberately and carefully. The result of such heating is a hardened surface that is less likely to break easily and will take a deep polish.

The purpose of these tools is unknown. Most of them are too thin to have been capable of heavy work. They are unlikely, for instance, to have been used as awls. Some may have been needles or needle blanks, with the section containing the eye broken off. Some may have been hairpins, used to keep long hair out of the face.

A few other tools, not resembling those described previously, were also identified. One unusual tool was made on a spiral fracture of a deer-sized long bone (Figure B-1n). It has been carefully shaped and shows some polish on the distal end. The proximal end is notched, but is too broken to be sure if this was done on purpose. The pointed end has some use-polish along the edges. It may have been a flesher, used to remove fat from the inside of hides, but it does not appear to have been heavily used, as there is only a small amount of polish on the tool.

Figure B-1o shows an antler tine that exhibits some use-polish, and has been badly charred on its blunted tip.

Table B-3. Descriptions and Proveniences of Worked Bone from 41MM340

Prov.	Zone	Lv.	Catalog #	Length	Description
Bone Tools and Bone Tool Fragments					
N43/E18	4	2	380-010	55.3 mm	Bone tool (see Figure B-1a). Fragment of artiodactyl metatarsal that has been split longitudinally and smoothed before the distal end of the tool was snapped off. On the exterior two preliminary grooves were cut, and the bone was snapped at the third groove. One the interior only the groove that snapped is noted. This section of tool shows no usewear on the snapped end and appears to be an unneeded part of the tool, removed during manufacture. There is no evidence of heat alteration.
N46/E15	4	2	2496	48.7 mm	Bone tool (Figure B-1b). This is a fragment of artiodactyl metatarsal that has been split longitudinally and smoothed before the distal end of the tool was snapped off. There are numerous shallow scratches near the distal end on both exterior and interior sides.
N46/E14	5	1	2268-009	57.5 mm	Bone tool (Figure B-1c). This is a fragment of artiodactyl metatarsal that has been split longitudinally and smoothed before the distal end of the tool was snapped off. Small grooves may have been cut in the distal end, although the bone is too deteriorated to be certain.
N47/E14	3d	1	2023-002	26.1 mm	Bone tool fragment (Figure B-1d), shaped into slightly flattened oval about 6.3 mm by 3.8 mm in cross-section.There is slight sign of heat alteration and the base of the tool is smoothed and polished.
N42/E14	4	1	948	30.5 mm	Bone tool fragment (Figure B-1e), shaped into an oval cross-section. The proximal end has been smoothed and shows some polish. There is no sign of heat alteration.
N44/E18	4	1	2564-010	7.4 mm	Bone tool fragment. Figure B-1f shows the cross-section, which is typical of the oval shape of the thin bone tools in this collection.
N45/E15	1c	1	2190-010	57.7 mm	Bone tool fragment (Figure B-1g) in 6 pieces. The fragment is probably split from proximal end of the metatarsal of an artiodactyl. It is burned, and carefully smoothed and polished.
N44/E19	2	1	2411-009	36.6 mm	Bone tool fragment in 2 pieces. Figure B-1h shows the interior, with smoothing, polishing, and a deep scratch. The entire tool fragment is charred, and highly polished.
N48/E12	2	1	1376-011	20.2 mm	Bone tool fragment (Figure B-1i). This piece is the proximal end of a tool, shaped, smoothed and very polished over all surfaces except the break. There is evidence of heat alteration.
N44/E17	8	2	1893-013	60.0 mm	Bone tool fragment in 3 pieces (Figure B-1j). Rounded and smoothed. The shape of the cross-section at the broken end of this tool is a much flatter oval than most of the other thin tools. There is a series of slight grooves near the proximal end, which may or may not have been intentional.
N46/E11	3c	3	1217	70.4 mm	Bone tool fragment (Figure B-1k) in 3 pieces. The tool is long and thin, with a slightly flattened oval cross-section. Striations from manufacture run parallel to the long axis of the tool, which shows some polish near the tip.
N46/E15	3b	1	2512-008	16.3 mm	Bone tool tip. This tip is burned, smoothed and polished (Figure B-1l)
N49/E12	3b	2	1494-011	16.6 mm	Tip of bone tool (Figure B-1m). The tip is intact, showing the wedge-shaped tip, which has a small amount of polish on the distal end when viewed thoguh 10x microscope. The cross-section is nearly round and 3.7 mm in diameter at the broken end.
N44/E11	8	3	1103-010	56.4 mm	Bone tool fragment (Figure B-1n), made on a spiral fractured long bone of a deer-sized animal. The tip has been carefully shaped and shows some use-polish. The broken end was also carefully shaped and shows many fine scratches under 10x magnification.
N45/E14	3b	1	2173-010	15.3 mm	Tip of an antler tine (Figure B-1o), probably used as a tool. The tip shows slight polishing and the blunted tip is heavily charred.
N45/E14	4	2	2419-015	22.5 mm	Bone tool fragment. The fragment is burned, but clearly shows shaping and smoothing, and is highly polished.
N45/E12	3e	1	1144-009	14.7 mm	Bone tool fragment. This fragment is small and burned, but it clearly shows smoothing, with numerous parallel striations.
N43/E14	4	2	1558-010	27.7 mm	Bone tool fragment, probably made on an artiodactyl metapodial. Smoothed and charred. No obvious usewear.

Table B-3. continued…

Prov.	Zone	Lv.	Catalog #	Length	Description
Bone Tools and Bone Tool Fragments					
N48/E14	4	2	2319-009	40.6 mm	Bone tool fragment. The bone is very eroded but appears to have been shaped into a long, flat shape about 4 mm thick.
N45/E11	4	2	1123-012	11.2 mm	Bone tool fragment. This fragment is small and burned, but it clearly shows smoothing, with numerous parallel striations.
N44/E17	8	1	1888-011	17.0 mm	Bone tool tip. This tip is burned, smoothed and polished, and the diameter is 3.5 mm at the broken proximal end and about 0.8 mm at the tip.
Bone Beads					
N43/E17	4	2	2001-009	8.2 mm	Bird bone bead (Figure A-1p). This bead was made by the groove-and-snap method. It shows some wear along the edge, presumably due to rubbing of the bead against other beads.
N44/E11	4	1	1047-001	23.1 mm	Bird bone bead (Figure A-1q). This bead was made by the groove-and-snap method. There is only slight polish on snapped edges.
N46/E12	8	2	1718-009	18.0 mm	Fragment of bird bone bead (Figure A-1r), made by the groove-and-snap method. The bead fragment is burned and polished.
N47/E13	8	2	1985-009		Seven fragments of at least two highly fragmented burned bird bone beads. The edges that were grooved-and-snapped are highly polished, presumably due to rubbing of the bead against other beads.
N46/E11	8	3	1183	25.6 mm	Fragment of bird bone bead, made by the groove-and-snap method. There is slight polish on the snapped edge.
Possible Bone Tool Fragments					
N45/E18	1b	1	2486-008	13.3 mm	Small fragment of an antler tine tip, possibly used as tool . It appears to have been shaped somewhat, but there is no visible polish on the tip.
N45/E19	4	1	1064-010	23.0 mm	Possible tool tip. This fragment has been heavily burned, but shows evidence of having been shaped.
N43/E18	4	1	907-010	12.0 mm	Possible tool fragment. The fragment is very small and is charred, but it appears to have been smoothed, and shows parallel oblique scratches under 10x microscope.
N45/E19	4	1	1064-012	10.2 mm	Tiny bone fragment that appears to have been smoothed and polished. It may be part of a bone tool.
N41/E15	4	2	543-009	13.0 mm	Possible tool fragment. The fragment is very small and is charred, but appears to have been smoothed, and fine striations are visible on the exterior.
N44/E11	4	2	1073-002	28.3 mm	Worked bone. This is a fragment of a long bone of a deer-sized animal. It has been smoothed and shows distinct striations on interior of bone.
N44/E16	4	2	1382	35.7 mm	Worked bone. Cut marks are evident on one end. The other end was broken while the bone was fresh, but shows some evidence of having been smoothed. There is no evidence of use wear, and the smoothing may not have been deliberate.
N45/E14	4	2	2419-014	18.3 mm	Possible tool fragment. The piece is very small, but appears to have been shaped. However, there is no evidence of polish.
N45/E19	4	2	1057-010	26.3 mm	Possible bone tool fragment that appears to have been shaped and smoothed. There is no sign of polish.

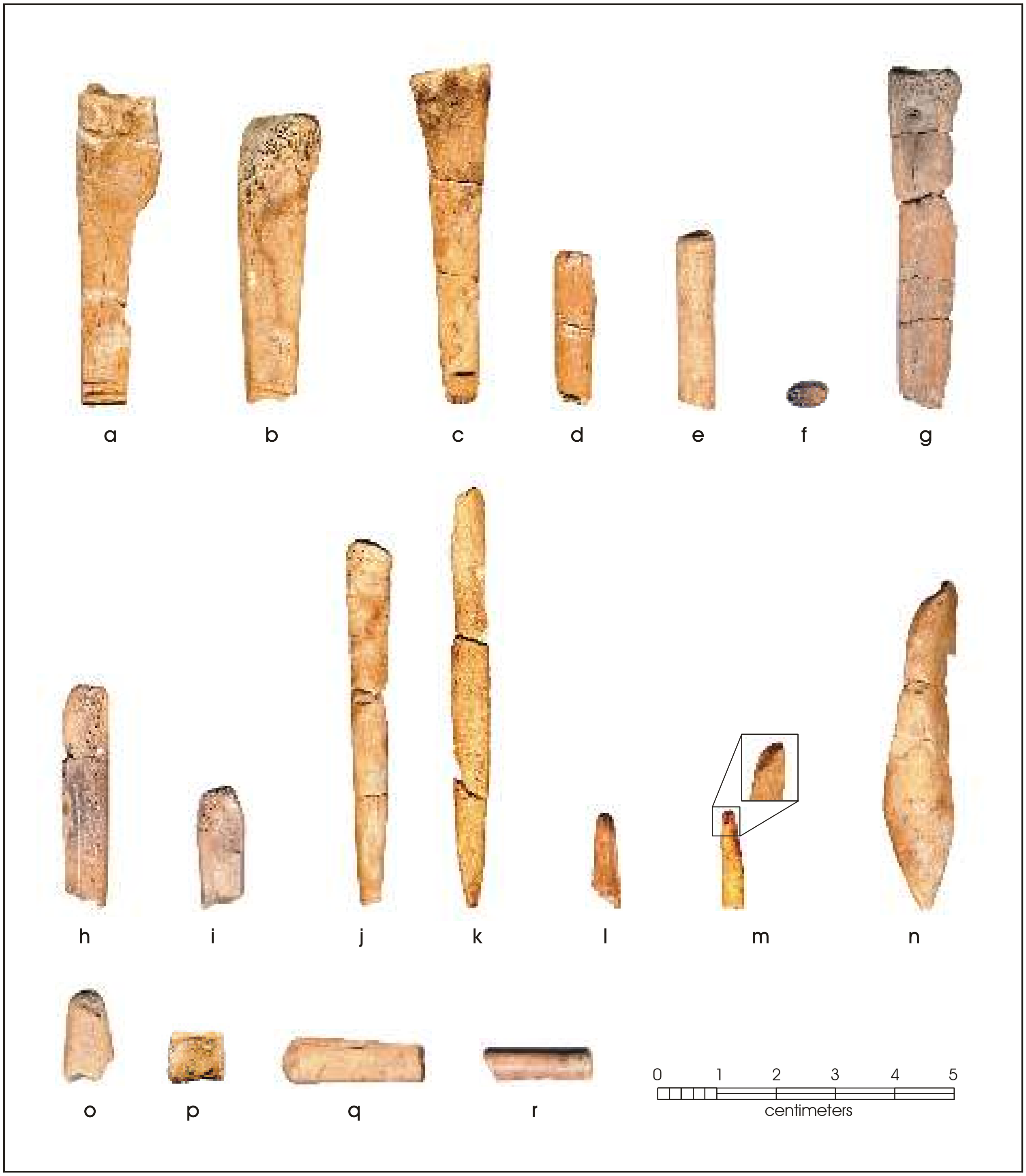

Figure B-1. *Selected worked bone from 41MM340.* a–b) Metatarsal platform tool fragments from Zone 4; c) Metatarsal platform tool from Zone 5; d) Bone tool shaft fragment from Zone 3d; e) Bone tool shaft fragment from Zone 4; f) Cross-section of bone tool fragment, from Zone 4, showing typical shaping; g) Proximal end of bone tool from Zone 1c; h–i) Proximal ends of bone tools from Zone 2; j) Nearly complete bone tool from Zone 8; k) Distal end of bone tool from Zone 3c; l–m) Distal tips of bone tools from Zone 3b; n) Bone tool made on spiral fractured long bone from Zone 8; o) Tool made from an antler tine from Zone 3b; p) Fragment of bird bone bead from Zone 4; q) Bird bone bead from Zone 4; r) Fragment of bird bone bead from Zone 8.

Four bird bone beads, and fragments of at least two more beads were recovered during the project (see Figure B-1p through r for examples). Each was made by the groove-and-snap method, and most show considerable polish on the sides that would have been rubbing against other beads on a string.

More than half of the worked bone (n=18, 56.3%) is from Zone 4. Most of the rest of the bone comes from Zone 8, Zone 3b, and Zone 2 (see Table B-3). These are the zones with the highest bone counts, making it likely that the distribution of tools across the zones is a reflection of overall bone sample size rather than definable changes in bone tool manufacture and usage.

Other Remains

A single human tooth was recovered from site 41MM340 in Unit N43/E15 within Zone 6. This is an undulating, cultural stratigraphic zone that occurs at 98–112 cm below ground surface in this excavation unit. Radiometric dating of this zone conducted during the 2000 testing phase (Mahoney and Tomka 2001) produced a date of roughly 3000 BP (3210–2920 at 2 sigma [Beta No. 142623]). This stratum consists of very compact, light grayish brown silty clay. The artifact assemblage recovered from this unit level consists of lithic debitage, burned rock, freshwater mussel shell, faunal remains, utilized lithic flakes, a lithic biface fragment, and a core. No other human remains were recovered from the site.

The tooth is a deciduous molar (“baby tooth”; dm^2 or #60) of the upper left arcade. Root resorption is near complete, and there is marked concave wear on the occlusal surface. These features indicate that the tooth was shed naturally as a process of permanent tooth development and subsequent eruption. At this stage of development, the individual is estimated to be 11 ± 2.5 years old (Ubelaker 1978). The deciduous molars are the last lot of teeth to be shed naturally. As few supernumerary posterior teeth are encountered, the development and subsequent shedding of these teeth are relatively accurate indicators of age.

As the deciduous tooth was the only element of human skeletal remains recovered, very little can be said in regard to the individual from whom it originated. No aspect of sex can be ascribed due to lack of sexual dimorphism in deciduous molars. Similarly, stature cannot be determined with this sole element. While ancestry can sometimes be discerned from morphological characteristics of certain teeth (i.e., shovel-shaped incisors of Native Americans and Asians), the deciduous molar does not lend itself to such interpretation.

The tooth is in poor condition. Due to the fragmented nature of the tooth when recovered, a solution of B-72® and acetone was applied in order to reconstruct the tooth for observation of morphological, non-metric traits and actual measurement of metric traits. Despite the fragmentary nature of the tooth, once reconstructed it was apparent that no carious lesions had affected the tooth. The molar has a mesiodistal diameter of 7.34 mm, a buccolingual diameter of 10.47 mm, and a crown height of 5.87 mm. The tooth was transferred to TxDOT in March 2002.

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Appendix C

Magnetic Sediment Susceptibility Testing

Raymond P. Mauldin

Appendix C: Magnetic Sediment Susceptibility Testing

Raymond P. Mauldin

The magnetic susceptibility (MS) of a given sediment sample can be thought of as a measure of how easily that sample can be magnetized (Dearing 1999; Gose and Nickels 2001). At low magnetic field strengths, this measure is primarily related to the concentration and grain size of ferro- and ferromagnetic minerals in the sample (Gose and Nickels 2001). A number of processes can result in an increase in MS values in a sediment sample. Of these processes, those that are of concern here are related to an increase in the organic constitutes or changes in the mineralogy of sediments in a given sample (see Collins et al. 1994; McClean and Kean 1993; Singer and Fine 1989). Sediments with higher organic content tend to have higher magnetic susceptibility values, probably as a result of the production of maghemite, an iron oxide, during organic decay (Reynolds and King 1995). Pedogenic processes, such as soil formation and weathering, can result in the concentration of organic material, as well as alterations in the mineralogy of a given zone. These processes can significantly impact susceptibility readings. Cultural processes, such as the concentration of ash, charcoal, and refuse would also produce higher MS readings. A measure of the magnetic susceptibility of a sediment sample, then, may provide information on both the presence of surfaces, as well as a measure of the concentration of cultural activity upon those surfaces.

Collection Procedures and Laboratory Methods

Seventy samples from three different units were analyzed for magnetic sediment susceptibility from 41MM340. Two sets of samples were collected at 5-cm intervals from the center of the eastern profiles of excavation units N46/E15 and N49/E15. A third set of samples was collected adjacent to the 10-x-10-cm block collected for detailed snail analysis in unit N43/E17. These samples were placed in plastic bags, and stored in the laboratory at CAR until analysis.

Sediment samples were air dried on a non-metal surface. After drying, the samples were then ground into a uniform grain size using a ceramic mortar and pestle. This was done to standardize particle size and make the material both easier to handle and pack into sample containers. After each sample was ground, the mortar and pestle were washed with tap water and wiped dry with a paper towel to avoid cross-sample contamination. The ground sample was then poured into a sample container consisting of a plastic cube with external dimensions of 2.54 x 2.54 x 1.94 cm. The cubes have an average weight of 4.85 grams. The sediment filled cube was then weighed, and the weight of the sample calculated by subtracting the empty cube weight. This was done to correct for differences in mass. Assuming that sample volume and material is constant, larger samples should have higher susceptibility values simply as a function of greater mass.

The cube was then placed into a MS2B Dual Frequency Sensor that, in conjunction with a MS2 Magnetic Susceptibility Meter, provided a measure of the magnetic susceptibility of the sample (see Dearing 1999). For each cube, two readings were taken using the SI (standard international) scale. The value, referred to as volume specific susceptibility and noted with the symbol κ (Kappa), is recorded on a scale of 10^{-5}, though there are no units associated with the value. That is, the value is dimensionless (Dearing 1999).

In order to correct for differences in sample weight, and provide units to the value κ, the mass specific susceptibility value (χ) was calculated using the formula

$$\chi = (\kappa / p)$$

where p is the sample bulk density expressed in kg m^{-3}. The bulk density is determined by dividing the sample mass by volume. However, as all samples were measured in identical cubes, and all cubes were full, the sample volume is assumed to be constant. Only the mass of the sample varied. Mass specific susceptibility can be determined by

$$\chi = \kappa * \text{calibrated mass/sample mass}$$

where sample mass is determined by subtracting the cube weight from the total sample weight (Dearing 1999). Calibrated mass is assumed to be 10 grams.

While the resulting values now have both a scale and associated units, the critical element for the current discussion is related to relative differences between χ sample values within a given profile or site, rather than absolute differences. That is, the principal interest is in rapid changes in the mass specific susceptibility values along a profile. This change may signal either a buried surface and/or cultural activity at that location. Comparisons of absolute values between samples from different areas, especially when the parent material of the soils is different, are of limited utility given our current goals.

This can be seen in Table C-1, which lists a variety of examples of mass specific susceptibility values for several different materials. In all cases, the analysis was performed following the procedures outlined previously. Note that the values differ widely, from a low of -1.47 for tap water, to a high of 97.62 for sediments collected from a burned rock midden. Samples 5 and 6 are on two different clays from the same general setting, far northern Lamar County in north Texas. The mass specific susceptibility is different for these samples, probably as a function of different frequencies of trace elements that, though small in absolute quantity, can dramatically impact the susceptibility values.

The potential impacts of cultural processes on susceptibility values can be seen by considering a data set collected from an archeological site located in Brown County, 41BR473. A total of 279 sediment susceptibility samples was collected from each level of over 50 shovel tests placed at this site. In all cases, the analytical procedures followed those outlined previously. Table C-2 presents summary data on all 279 cases, along with susceptibility scores for those settings that had fire-cracked rock (FCR) or chipped stone present. If cultural inputs result in higher susceptibility values, then it should be the case that significantly higher susceptibility values will be present in levels that have cultural material.

An examination of Table C-2 will demonstrate that this is indeed the case. Levels that have FCR present do have higher scores relative to those that lack FCR. Similarly, those levels that have chipped stone present have a higher average mass specific susceptibility score relative to those that lack chipped stone. As the distribution is approximately normal, a t-test was used to test the overall significance of these differences. In both the FCR and chipped stone comparisons, the test confirms that those levels with cultural material have significantly higher scores than those without cultural material (FCR t-statistic= 5.804, df=277, $p < .001$; chipped stone t-statistic=2.674, df=277, $p = .008$). Our preliminary investigations, then, coupled with the previous work, clearly suggest that an analysis of the magnetic susceptibility of sediment can provide additional information on both the presence of buried surfaces, as well as the impact of cultural material on those surfaces.

Table C-1. Magnetic Sediment Susceptibility Data for a Variety of Substances

Sample Type	Total Wt. (gr.)	Sample Wt. (gr.)	Reading 1 (k)	Reading 2 (k)	Reading 3 (k)	Average K	Corrected Mass (X)
1) Sandy sediment with organics	13.7	8.85	27.9	28	28.1	28	31.64
2) Modern mesquite charcoal and sediment	9.4	4.55	10.7	10.8	10.7	10.73	23.59
3) Modern oak wood ash	7.5	2.65	16.1	16.2	16.2	16.17	61.01
4) Sediment from burned rock midden	11.3	6.45	62.9	63	63	62.97	97.62
5) Grey clay - no human occupation	12.6	7.75	10.4	10.3	10.4	10.37	13.38
6) Red clay - no human occupation	10.8	5.95	11.9	12	12	11.97	20.11
7) Sandstone	14.7	9.85	6.9	7	7.1	7	7.11
8) Limestone	12.7	7.85	-0.5	-0.5	-0.5	-0.5	-0.64
9) Tap water	10.5	5.65	-0.8	-0.8	-0.9	-0.83	-1.47

Table C-2. Presence/absence of Cultural Material and Mass Specific Sediment Susceptibility Scores for Shovel Tests at 41BR473

	All Cases	FCR Present	FCR Absent	Cipped Stone Present	Chipped Stone Absent
Number of Samples	279	84	195	38	241
Mean Value	48.3	56.9	44.6	55.2	47.2
Standard Deviation	17.2	17.7	15.6	16.1	17.1

Results

Table C-3 presents the results of the susceptibility analysis of the 70 samples. An examination of the data for each of the 1-x-1-m units will demonstrate that most MS values range between around 15 and 40, though there are several cases where clear spikes are present. As discussed in Chapter 7 of this report, these spikes probably reflect either stable surfaces or intensive occupation.

Table C-3. Soil Susceptibility Results for 41MM340

Location	Sample #	Total Weight (gr.)	Average Reading	MSS Value
N46.5/E16	1	12.3	18.1	24.2
N46.5/E16	2	11.3	15.25	23.6
N46.5/E16	3	11.3	15.8	24.4
N46.5/E16	4	12.1	17.95	24.7
N46.5/E16	5	12	22.65	31.6
N46.5/E16	6	12.4	27.05	35.7
N46.5/E16	7	12.1	31.9	43.9
N46.5/E16	8	11.6	19.05	28.1
N46.5/E16	9	12	17.75	24.8
N46.5/E16	10	12.4	24.85	32.8
N46.5/E16	11	12.1	12.95	17.8
N46.5/E16	12	12.1	12.05	16.6
N46.5/E16	13	13.4	14.55	17.0
N46.5/E16	14	12.4	12.95	17.1
N46.5/E16	15	11.6	11.1	16.4
N46.5/E16	16	12.2	11.65	15.8
N46.5/E16	17	12.3	12.9	17.3
N46.5/E16	18	11.3	10.8	16.7
N46.5/E16	19	12.4	13.2	17.4
N46.5/E16	20	11.8	20.05	28.8
N46.5/E16	21	11.5	20.45	30.7
N46.5/E16	22	12	16.15	22.5
N46.5/E16	23	12	13.55	18.9
N46.5/E16	24	12.5	14.65	19.1

Table C-3. continued…

Location	Sample #	Total Weight (gr.)	Average Reading	MSS Value
N49.5/E16	1	12.2	18.4	25.0
N49.5/E16	2	12.5	19.9	25.9
N49.5/E16	3	11.5	16.1	24.1
N49.5/E16	4	11.9	18.6	26.3
N49.5/E16	5	11.8	26.3	37.7
N49.5/E16	6	11.9	28.4	40.2
N49.5/E16	7	11.8	27.7	39.7
N49.5/E16	8	12	67.2	93.7
N49.5/E16	9	12.3	40.3	53.9
N49.5/E16	10	12.1	39.6	54.5
N49.5/E16	11	11.3	39.5	61.1
N49.5/E16	12	12	21.7	30.3
N49.5/E16	13	12.2	17.5	23.7
N49.5/E16	14	12.2	16.9	22.9
N49.5/E16	15	11.7	19.1	27.8
N49.5/E16	16	11.3	16.9	26.1
N49.5/E16	17	11.8	14.3	20.5
N49.5/E16	18	11.8	11.7	16.8
N49.5/E16	19	11.5	11.5	17.2
N49.5/E16	20	12.4	12.6	16.6
N49.5/E16	21	11.8	10.8	15.5
N49.5/E16	22	12.7	13.5	17.2
N49.5/E16	23	11.9	10.5	14.9
N49.5/E16	24	12	9.6	13.4
N43/E17	1	11.8	15.8	22.7
N43/E17	2	11.6	15.4	22.7
N43/E17	3	11.9	18.1	25.6
N43/E17	4	11.6	21.2	31.4
N43/E17	5	11.9	21.2	30.0
N43/E17	6	11.9	18.7	26.5
N43/E17	7	11.6	13.9	20.5
N43/E17	8	11.9	12.6	17.8
N43/E17	9	11.7	14.4	21.0
N43/E17	10	11.7	14.2	20.7
N43/E17	11	11.7	14.2	20.7
N43/E17	12	11.8	13.4	19.3
N43/E17	13	11.7	10.5	15.3
N43/E17	14	11.9	12.2	17.3
N43/E17	15	11.9	11.6	16.4
N43/E17	16	11.7	14.1	20.5
N43/E17	17	11.8	9.6	13.7
N43/E17	18	11.9	9.9	14.0
N43/E17	19	11.8	11.4	16.3
N43/E17	20	11.9	10.3	14.6
N43/E17	21	11.7	9.1	13.3
N43/E17	22	11.7	8.8	12.8

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Appendix D

Pedernales Database

Compiled by Harry J. Shafer and Steve A. Tomka

Table D-1. Pedernales Points from 41MM340

Spec. No.	Stem form	Blade form
1860	5	3
1859	5	3
1894	5	3
1895	1	3
1861	5	3
1089	5	3
1778-001	5	3
2014	5	3
2520	5	3
428	5	3
2506	5	3
2281-007	5	3
422	5	indeterminate
2396	5	indeterminate
2476	5	3
941-012	5	indeterminate
1935	3	3
1050	5	3

Table D-2. Pedernales Points from 41BL104

Spec. No.	Stem form	Blade form
B4-F13-7	4	3
0-1	2	1
A	5	2
B5-6-1	1	3
0-2	1	2
C1-6	3	3
B3-6	4	1
B5-6-2	1	3
B4-7-1	1	3
B3-7	1	3
B	1	3
B2-7-1	4	3
C-2	4	3
C-1	4	3
C1-10-1	1	3
B8-8	1	3
C2-4	4	3
C1-10-2	5	1
C2-9	4	3
B5-5	5	3
B8-5	1	3
B2-7-2	1	3
B5-6	1	3
C2-1	4	3
B4-7-2	1	3
B1-7	4	3
0-3	1	3
C1-10-3	5	3
B2-5	3	1

Table D-3. Pedernales Points from 41BN1

Spec. No.	Stem form	Blade form
716	3	3
71	2	3
508	1	3
338	2	1
469	4	3
682	4	3
202	2	3
392	4	3
566	4	3
465	2	1
589	4	3
580	2	1
420	2	3
651	4	3
399	2	1
403	2	1
466	2	1
227	3	3
680	2	1
728	1	3
341	4	3
640	4	3
126	4	3
513	4	3
287	2	1
305	2	1
510	4	3
512	2	1
679	4	1
360	4	3
674	2	1
576	4	1
115	3	2
505	4	2
400	3	2
279	4	3
572	2	1
639	4	1
717	2	1
538	4	1
72	2	1
504	2	1
715	4	3
518	4	1
97	2	1
CAR-30	4	3
CAR-34	4	3
CAR-11	2	1
CAR-25	4	1
CAR-26	2	1
CAR-43	2	3
CAR-37	3	3
CAR-29	4	3
CAR-23	3	3
CAR-32	3	3
CAR-41	4	3
CAR-38	2	1
CAR-27	4	1
CAR-12	1	3
CAR-14	3	3
CAR-31	4	1
CAR-17	3	3
CAR-19	2	1
CAR-15	2	1
CAR-28	2	1
CAR-13	4	1
CAR-33	3	3
CAR-24	4	3
CAR-36	2	1
CAR-18	1	1
CAR-40	2	1
CAR-21	4	3
CAR-22	4	3
CAR-44	1	1
CAR-20	4	3
CAR-39	4	3
CAR-35	4	3
CAR-42	4	3
CAR-99	2	indeterminate
CAR-3	2	1
CAR-4	2	1
CAR-5	2	1
CAR-6	2	1
CAR-7	1	3
CAR-8	4	3
CAR-9	4	3
CAR-10	3	3
CAR-1	2	1
CAR-2	2	1
CAR-45	2	indeterminate
CAR-46	3	indeterminate
293	1	3
411	3	2
228	2	1
688	1	3
678	1	3
632	2	3
210	4	1
158	2	1

Table D-4. Pedernales Points from 41BX228

Spec. No.	Stem form	Blade form
443	4	indeterminate
169	4	indeterminate
387	2	indeterminate
151	4	indeterminate
244	3	indeterminate
53	4	1
386-1976	2	indeterminate
398	2	indeterminate
331	3	3
180	4	indeterminate
445-1-1979	3	indeterminate
396-1979	4	2
143	3	indeterminate
395-1979	4	3
446-1979	4	2
386-1979	4	indeterminate
77	4	3
D-2-1979	4	indeterminate
127	2	indeterminate
279	2	3
302	2	1
57	4	3
52	2	3
166	2	3
435	1	3
396-1979	2	2
15	4	2
395-2-1979	4	3
289	4	3
C-5	2	3
445-2-1979	4	2
D-2-1979	4	3
391-1	2	1
391-2	2	1
223	4	2
P-2	indeterminate	3
149	indeterminate	indeterminate
389-6-0124	2	3
396-143	2	1
391-3-074	4	2
115-1-077	2	1
142-134	4	2
391-4-0121	2	1
467-0127	4	3
446-0141	2	1
131-111	4	3
118-118	4	3

Spec. No.	Stem form	Blade form
115-2-0131	4	3
464-7-0138	2	3
145-0109	2	1
396-0107	4	3
292-117	4	1
289-2-112	2	1
461-114	4	3
104-115	2	1
63-0130	4	3
79-0132	4	3
177-116	2	1
396-0129	4	1
464-25-145	3	3
477-553	4	2
394-0123	4	3
175-080	2	1
D-5-104	4	3
453-085	2	1
C-5--0133	2	1
396-101	2	3
02-0126	4	3
464-21	4	1
81-098	4	2
10-0140	3	3
399-0128	4	3
53-086	4	3
391-088	3	3
391-142	4	3
395-096	4	2
395-0135	4	3
116-0122	4	3
235-113	4	3
397-0125	4	3
396-0119	2	1
C5-0110	3	3
396-093	4	3
386-0120	2	1
309-301-0137	4	3
397-0139	3	3
C-2-144	2	3
U-1-094	4	3
464-4-090	1	3
8-082	4	1
396-102	4	1
386-100	4	3
E-6-075	3	1
189-081	6	1

Spec. No.	Stem form	Blade form
390-076	4	indeterminate
388-095	2	1
214-0106	4	3
212-084	1	1
172-079	4	1
98-099	4	2
386-097	4	3
191-092	3	3
192-083	4	indeterminate
389-4-0103	3	3
D-5-089	3	3
P-11-5-1974	4	1
8-0136-1977	3	2
P-10-10-1974	4	2
P-32-10-1974	2	1
P-33-10-1974	4	1
P-39-10-1974	1	3
P-34-10-1974	4	3
T262SA	4	3
T194SA	4	3
T116SA	2	3
T153SA	4	3
T126SA	4	3

Table D-5. Pedernales Points from 41UV2

Spec. No.	Stem form	Blade form
908-522-1900	2	1
908-2-797	4	3
908-879	2	1
908-1920	4	3
908-2-1	4	1
908-2-2	2	1
908-1712	2	3
908-876	1	2
908-110	2	3
908-2-3	2	1
908-2-4	1	indeterminate
908-2-5	2	1
908-2238	4	1
908-2-6	2	1
908-1761	4	1
908-2-7	2	3
908-2540	4	indeterminate
908-233	1	3
908-2994	3	1
908-2926	2	1
908-2871	1	3
908-167	4	3
908-2548	4	indeterminate
908-1902	4	1
908-2-8	4	1
908-219	4	3
908-529	2	1
908-2-9	2	1
908-2-11	2	1
908-1637	4	3
908-2906	2	1
908-1012	1	3
908-450	4	3
908-2-10	4	3
908-2931	4	3
908-2-12	2	1
908-2-13	2	1
908-2-14	2	1
908-2-15	2	1
908-2-16	2	1
908-2-17	4	3
908-2-18	4	1
908-2-19	2	indeterminate
908-2-20	2	indeterminate
908-943	4	3
908-2675	4	3
908-803	4	3
908-504	4	3
908-975	4	3
908-2561	2	1

Spec. No.	Stem form	Blade form
908-47	2	1
908-598-693	4	3
908-684	2	indeterminate
908-1374	4	3
908-2179	4	indeterminate
908-3196	4	2
908-1740	4	2
908-1721	4	3
908-2573	4	3
908-1818	2	1
908-2746	1	1
908-3215	2	1
908-1906	3	3
908-2196	indeterminate	indeterminate
908-315	2	1
908-1854	1	3
908-100	4	indeterminate
908-5	2	1
908-368	4	3
908-1595	2	1
908-226	2	1
908-2119	4	indeterminate
908-82	2	indeterminate
908-323	2	indeterminate
908-2514	2	indeterminate
908-2555	4	indeterminate
908-160	2	indeterminate
908-2634	2	indeterminate

Table D-6. Pedernales Points from 41UV21

Spec. No.	Stem form	Blade form
14-1	2	1
175-1	2	1
14-3	4	3
164-1	4	3
110-2	4	3
97	4	3
175-3	2	1
110-1	2	3
163-1	2	3
175-4	1	3
184-1	2	1
14-2	1	2
174-1	4	3
175-5	4	3
184-1	4	3
163-2	1	3
146-1	4	3
105-1	2	1
163-2A	1	2
55	1	3
32	3	3
182-2	4	3
182-1	5	3
203-1	4	3
110-2	4	3
175-2	2	1
14-2	2	1
117	4	3
107-2	4	2
150	1	3
107-1	1	3
100	2	indeterminate
33	4	3
65	2	1
115-2	1	3
102-1	2	1
187	4	3
115-1	2	3
30	4	indeterminate
176-2	4	indeterminate
102-2	3	3
176-1	4	3
140	4	3
193	4	3
92	4	3
94	2	3
53	2	3
72-1	4	3
154-2	2	1
192-1	4	2
154-1	4	3
173-3	2	1
81-1	4	3
165-1	4	3
173-2	4	3
173-4	4	3
173-1	4	3
189-1	4	2
127-1	4	3
201-1	4	3
189-2	1	3
74-1	2	3
107-1	3	3
9	4	3
165-2	1	indeterminate
201-2	4	3
165-3	4	3
73-1	4	3
154-3	4	3
50-1	2	1
96-1	2	1
98-1	2	1
123-1	2	indeterminate
123-2	3	3
142-1	1	3
101-1	4	2
128-2	4	2
50-2	4	2
76-1	4	3
142-2	1	3
108-1	3	3
128-1	4	3
76-2	3	3
125	1	3
28-1	4	1

Table D-7. Pedernales Points from 41UV60

Spec. No.	Stem form	Blade form
35F1	2	1
35F2	2	1
45C2-2	2	1
19G2	2	1
45C2-1	2	1
16F	2	1
35F	2	1
16E	2	1
18F	2	1
54G	4	3
7E1	4	3
6E	4	indeterminate
9G	3	3
45H1	1	3
52G	4	indeterminate
7G2	3	3
52G	2	1
18F	2	1
47E	1	3
16D	4	3
3F1	4	3
52G	4	3
63	4	2
46G1	5	2
7F2	2	1
45G2	2	1
19F1	2	1
16F	2	1

Table D-8. Pedernales Points from 41UV88

Spec. No.	Stem form	Blade form
3142	4	2
3141	4	3
3157	1	3
3144	4	2
3118	2	3
3116	1	3
3134	4	indeterminate
3122	4	3
3104	2	2
3096	4	3
3155	1	3
3091	4	3
3119	3	3
3109	2	1
3097	4	3
3149	4	2
3148	1	3
3089	1	3
3154	1	3
3123	4	indeterminate
3114	1	3
3133	3	1
3108	4	3
3102	5	3
3115	2	3
3125	2	3
3085	4	3
3094	4	3
3107	4	3
3152	2	indeterminate
3100	1	3
3121	4	3
3128	2	3
3126	3	3
3117	4	3
3138	4	2
3112	4	3
3137	4	indeterminate
3111	4	3
3124	1	indeterminate
3101	1	3
3139	4	2
3092	4	3
3098	2	3
3086	3	3
3145	4	3
3136	4	3
3106	4	3
3093	2	1
3090	4	3

Spec. No.	Stem form	Blade form
3135	1	3
3150	3	2
3127	4	2
3113	4	3
3099	2	1
3110	2	2
3095	6	3
3120	4	3
3088	4	3
3143	1	3
3083	3	3
3105	1	3
3131	indeterminate	2
3147	1	3
3130	4	3
3103	2	3
3153	4	2
3084	4	3
3129	3	2
3151	4	3
3140	4	2
3087	4	3
3146	4	3
3156	1	indeterminate
3132	4	3

Table D-9. Pedernales Points from 41WM13

Spec. No.	Stem form	Blade form
18-I	5	indeterminate
22-I	4	3
13-H	4	indeterminate
25-I	2	1
28-J	2	3
36-J	2	3
23-I	1	3
33-I	2	1
30-J	2	indeterminate
17-H	1	3
37-I	4	3
18-N	2	1
15-J	4	3
2-K	4	3
37-A	4	3
4-G	4	1
38-F	4	3
26-J	4	3
3-G	6	indeterminate
23-G	2	indeterminate
15-N	4	indeterminate
32-I	2	indeterminate
26-I	2	indeterminate
2-I	4	3
25-I	2	1

Table D-10. Pedernales Points from 41WM49

Spec. No.	Stem form	Blade form
2-9-87	2	1
2-9-19	4	1
2-9-44	2	1
2-9-32-2	2	indeterminate
2-9-85	4	1
2-9-196	4	3
2-9-181	4	1
2-9-45	2	1
2-9-18	4	3
2-9-36	2	indeterminate
2-9-32-1	2	1
2-9-39	2	indeterminate
2-12-5	2	1
2-12-69	2	1
2-12-3	2	indeterminate
2-11-3	1	2
2-11-36	1	3
2-11-17-1	2	2
2-11-2	1	2
2-11-72	2	1
2-11-80	4	3
2-11-17-2	3	2
2-11-74	5	indeterminate
2-11-57	4	3
2-10-35	4	3
2-10-19-1	4	3
2-10-67	5	3
2-10-95	2	3
2-10-159	4	3
2-10-3	4	3
2-10-160	1	3
2-10-19-2	4	3
2-10-2	4	3
2-10-82	5	3
2-8-57	2	1
2-8-206	4	3
2-8-112	5	3
2-8-45	2	1
2-8-57-1	2	1
2-8-86	4	1
2-8-171	5	3
2-8-2-1	4	1
2-8-48	2	1
2-8-72	4	indeterminate
2-8-120	1	1
2-8-105	2	1
2-8-2-2	5	indeterminate
2-8-4	4	1
2-8-83	1	1
2-8-199	4	1
2-8-35	2	1
2-8-118	2	indeterminate
2-8-5-1	5	1
2-8-120	3	3
2-8-5-2	1	1
2-8-208	2	1
2-8-3	4	1
2-8-82	4	1
2-8-57-2	2	1
2-8-20	4	1
2-8-83	5	1
2-8-19-1	4	1
2-8-103	1	1
2-8-34	4	1
2-8-19-2	4	3
2-8-55	4	indeterminate
2-8-109	4	3
2-8-188	1	1
2-8-18	5	3
2-8-54	1	1
2-8-17	4	3
2-8-142	1	3
2-8-37	5	3
2-8-53	4	1
2-8-19-3	2	1
2-8-43	1	indeterminate
2-8-136	5	1
2-8-170	5	3

Appendix E

Macrobotanical Analysis

J. Philip Dering

Appendix E: Macrobotanical Assemblage from 41MM340

J. Philip Dering

Introduction

A total of 162 charcoal samples, 32 nut samples, and 41 flotation samples from 41MM340 were examined. The samples were recovered from 40 features and other contexts. The goal of the analysis was to describe the botanical assemblage and utilize the data to illuminate prehistoric land-use practices in the Little River area.

Laboratory Methods

Flotation samples are samples of archeological sediment that have been floated in water to separate lighter charred plant remains from heavy material such as rock or caliche, and to rinse out of the sample lighter material such as clays/silts that can be suspended in water. The light plant material is usually caught on fine-mesh material such as cheesecloth, or on very fine-mesh screen smaller than .450 mm. The sediment samples were floated by personnel from the Center for Archaeological Research.

Samples labeled "charcoal samples" and "nut samples" were also submitted. Because these sample types almost always contain material other than charcoal or nut, I refer to them as screen/point-collected samples to distinguish them from flotation samples.

Standard archeobotanical laboratory procedures were followed during analysis. The samples were first opened and dried in an herbarium dryer. Then each sample was sorted through a series of four nested geological screens with mesh sizes of 4-mm, 2-mm, 1-mm, and 0.450-mm. The material caught on all of the sieve levels, including the pan was scanned for floral parts, fruits, and seeds. Usually only the wood fragments caught on the 4-mm and 2-mm screens are separated and identified, because it is extremely difficult and time consuming to identify wood fragments smaller than 2 mm. Many times the diagnostic characteristics are not present in fragments smaller than 2–4 mm.

Due to the poor preservation encountered at most open sites, only carbonized plant remains were considered for inclusion in the archeological assemblage. Identification of all carbonized wood is accomplished by using the snap technique, examining them at 8 to 45 magnifications with a hand lens or a binocular dissecting microscope, and comparing them to samples in the herbarium at Texas A&M University. Identifications are made using reference collections at Texas A&M University.

Results

Archeobotanical Assemblage

During the testing phase analysis of five flotation samples had yielded a reduced plant assemblage consisting of three plant taxa—oak wood, *Ilex* sp. (holly or haw) wood, and a possible pecan nut fragment. Although analysis of materials from the data recovery phase also produced a relatively small plant assemblage, considerably more information was gleaned from this effort.

The charcoal samples contained a total of 431 wood fragments weighing approximately 11.5 g and three pecan nut fragments (Table E-1). The nut samples contained 84 hickory nut fragments weighing 7.6 g and six oak wood fragments weighing 0.4 g (Table E-2). The flotation samples yielded 76 hickory nut fragments weighing 1.5 g and 120 wood fragments weighing 1.7 g (Table E-3).

Wood Charcoal

The nine woody taxa represented in the botanical assemblage are oak and *Ilex* sp. (possibly *Ilex decidua* or possum haw), gum bumelia, honey locust, walnut, willow/cottonwood, hickory, maple/boxelder, and elm (Table E-4). These plants are typical of a deciduous hardwood forest dominated by oak with an understory of yaupon, possum haw, gum bumelia, and honey locust. Willow/cottonwood, pecan, hickory, and walnut trees are common trees in the riparian woodlands of the region.

The reduced nature of the assemblage is demonstrated by the large number of charcoal and flotation samples that did not contain identifiable plant material; 109 screen/point-collected charcoal samples contained carbonized wood fragments too small to manipulate (flecks), and 24 contained material that could not be identified due to a lack of diagnostic anatomical characters. Indeterminate wood was common for two reasons. First, most of the fragments were

Table E-1. Results of Screen-collected Charcoal Samples

Cat. No.	Feature	Taxon	Common	Part	Count	Weight
2266	41	Flecks			--	--
2265	41	Flecks			--	--
2257	41	Flecks			--	--
2256-003	41	Indeterminate	Wood	Wood	3	0.1
2257-002	41	*Juglans* sp.	Walnut	Wood	5	0.1
883	19	Flecks			--	--
884	19	Flecks			--	--
892	19	Flecks			--	--
895	19	Flecks			--	--
471	7	*Carya illinoiensis*	Pecan	Nut	3	0.2
1212-002	18	Indeterminate		Wood	9	0.1
1243	18	Flecks		Wood	--	--
1242	18	Flecks			--	--
1240	18	Flecks			--	--
1215-001	18	Flecks			--	--
1239	18	Flecks			--	--
1208	18	Flecks			--	--
1205	18	Flecks			--	--
1204	18	Flecks			--	--
1241	18	*Acer* sp.	Maple/boxelder	Wood	4	0.1
1298	18	Flecks			--	--
1274	15	*Acer* sp.	Maple/boxelder	Wood	2	0.1
1580	15	Flecks			--	--
1273	15	Flecks			--	--
1277	15	Flecks			--	--
1281	15	Flecks			--	--
1280	15	Flecks			--	--
1098	20	Flecks			--	--
1785-002	32	Flecks			--	--
1053-002	16	*Carya* sp.	Hickory	Wood	7	0.2
1053-001	16	Flecks			--	--
1045	16	Flecks			--	--
1537-001	12	Flecks			--	--
1531	12	Flecks			--	--
1020	12	Flecks			--	--
1018	12	Salicaceae	Willow-cottonwood	Wood	10	0.8
1530	12	Salicaceae	Willow-cottonwood	Wood	3	0.1
1541	12	Indeterminate		Wood	9	0.1
2408	48	Flecks			--	--
2484	48	Salicaceae	Willow-cottonwood	Wood	3	0.1
956	12	Flecks			--	--
957	12	Flecks			--	--
535-003	4	Ulmus sp.	Elm	Wood	7	0.1
535-001	4	Flecks			--	--

Table E-1. continued…

Cat. No.	Feature	Taxon	Common	Part	Count	Weight
535-002	4	Flecks			--	--
2440	49	Indeterminate		Wood	4	0.1
2501	49	Flecks			--	--
2502	49	Flecks			--	--
2399	51	Indeterminate	(no structure)	Wood	2	0.1
1647	29	Flecks			--	--
1646-001	29	Indeterminate	(no structure)	Wood	9	0.6
1712-002	14	*Quercus* sp.	Oak	Wood	5	0.2
1268	14	Flecks			--	--
1196	14	Flecks			--	--
1599	23	Flecks			--	--
955	23	Flecks			--	--
1549-001	23	Flecks			--	--
1588	23	Flecks			--	--
2000-1	41	Flecks			--	--
2254	41	Flecks			--	--
2002	41	Flecks			--	--
2260	41	Indeterminate		Wood	6	0.1
2264	41	Flecks			--	--
1328	13	Flecks			--	--
1323-001	13	Flecks			--	--
1426	13	Flecks			--	--
1469	13	Salicaceae	Willow-cottonwood	Wood	7	0.1
1433	13	Flecks			--	--
1390	13	Indeterminate		Wood	4	0.1
1481-04	13	Indeterminate		Wood	5	0.1
1384	13	Indeterminate		Wood	4	0.1
1435	13	*Ulmus* sp.	Elm	Wood	9	0.2
1476	13	Flecks			--	--
1385	13	Flecks			--	--
1329	13	Flecks			--	--
1480-002	13	Acer sp.	Maple/boxelder	Wood	7	0.4
660	11	*Quercus* sp.	Oak	Wood	8	0.6
639	11	Flecks			--	--
641-001	11	*Carya* sp.	Hickory	Wood	3	0.1
659	11	Flecks			--	--
1033	16	Indeterminate		Wood	4	0.1
1053-003	16	Indeterminate		Wood	7	0.1
590	5	Flecks			--	--
731	5	Indeterminate		Wood	2	0.2
734	5	*Ulmus* sp.	Elm	Wood	4	0.2
585	5	Flecks			--	--
730	5	Flecks			--	--
722	5	Flecks			--	--

Table E-1. continued…

Cat. No.	Feature	Taxon	Common	Part	Count	Weight
601	5	Flecks			--	--
743	5	Flecks			--	--
728	5	Flecks			--	--
749	5	Indeterminate		Wood	2	0.1
602	5	Flecks			--	--
587	5	Flecks			--	--
578-002	5	Flecks			--	--
582-002	5	Flecks			--	--
593-002	5	Flecks			--	--
739	5	Flecks			--	--
600	5	Flecks			--	--
601	5	Flecks			--	--
597	5	Flecks			--	--
906-001	17	Indeterminate		Wood	4	0.1
906-002	17	*Quercus* sp.	Oak	Wood	1	0.1
825	17	*Gleditsia tricanthos*	Honey Locust	Wood	4	0.5
899	17	Flecks			--	--
824	17	Flecks			--	--
836	17	Flecks			--	--
837	17	Flecks			--	--
905	17	Flecks			--	--
383	2	Flecks			--	--
387	2	Flecks			--	--
389	2	Flecks			--	--
343-001	2	Flecks			--	--
343-002	2	Flecks			--	--
388	2	Flecks			--	--
494	3	Indeterminate		Wood	2	0.2
436	3	Indeterminate		Wood	3	0.1
576	5	Flecks			--	--
693	5	Flecks			--	--
804	5	Flecks			--	--
578-001	5	Flecks			--	--
716	5	Flecks			--	--
581	5	*Ulmus* sp.	Elm	Wood	5	0.2
2412	5	*Bumelia lanuginosa*	Gum Bumelia	Wood	123	1.8
605	5	Flecks			--	--
591	5	Flecks			--	--
588-001	5	Flecks			--	--
588-002	5	Flecks			--	--
582-001	5	Flecks			--	--
584	5	Salicaceae	Willow-cottonwood	Wood	1	0.1
596	5	Salicaceae	Willow-cottonwood	Wood	5	0.1
599	5	Flecks			--	--

Table E-1. continued…

Cat. No.	Feature	Taxon	Common	Part	Count	Weight
690	5	Flecks			--	--
691-001	5	Salicaceae	Willow-cottonwood	Wood	1	0.1
691-002	5	Salicaceae	Willow-cottonwood	Wood	6	0.1
713	5	Flecks			--	--
2292	42	*Acer* sp.		Wood	4	0.1
2247	42	Indeterminate		Wood	11	0.1
2248	42	Indeterminate		Wood	5	0.1
494	3	Flecks			--	--
1554-002	23	Indeterminate		Wood	6	0.1
2581	23	*Ulmus* sp.		Wood	8	0.1
1563-002	23	Indeterminate		Wood	3	0.1
1589	23	Indeterminate		Wood	5	0.1
527	1	*Carya* sp.	Hickory	Nut	1	0.1
527	1	*Quercus* sp.	Oak	Wood	21	0.4
2132	1	*Carya* sp.	Hickory	Wood	9	0.2
524	1	*Carya* sp.	Hickory	Wood	8	0.3
526-001	1	*Carya* sp.	Hickory	Wood	23	0.6
425	1	Indeterminate		Wood	5	0.1
1534	12	*Juglans* sp.	Walnut	Wood	11	0.2
2339	36	Indeterminate		Wood	2	0.1
2338	36	Flecks			--	--
2333	36	Flecks			--	--
2299	36	Flecks			--	--
2249	36	Flecks			--	--
2246	36	Flecks			--	--
2291	36	Flecks			--	--
950	23	Flecks			--	--
1567	23	Flecks			--	--
1572	23	Flecks			--	--
1590	23	Flecks			--	--
924	23	Flecks			--	--
1568	23	Flecks			--	--
946	23	Flecks			--	--

smaller than 4 mm in length, reducing the opportunity for finding diagnostic characteristics. Second, much of the charred material was somewhat deteriorated, rendering identification impossible. Flotation samples produced similar results, and 17 of the samples did not contain carbonized plant material.

Considering the assemblage as a whole, willow/cottonwood was the most frequently occurring identifiable charcoal type (n=10), followed by hickory, elm, oak, and maple/boxelder, all of which occurred in a total of five flotation or charcoal samples. By comparison, the Indeterminate Hardwood type was noted in 109 of the screen/point-collected charcoal samples and in 17 flotation samples.

Nut Fragments

Nut fragments of both hickory and pecan were recovered from the samples. Hickory was relatively abundant, occurring in six flotation samples and 37 screen or point-collected samples. Both of these taxa may have been extremely important resources in regional prehistoric subsistence. No other taxa were represented by seed, nut, or root remains

Table E-2. Results of Screen-collected Nut Samples

Cat. No.	Taxon	Common	Part	Count	Weight
2076-008	*Carya* sp.	Hickory	Nut	1	0.2
2190-004	*Carya* sp.	Hickory	Nut	4	0.6
2189-005	*Carya* sp.	Hickory	Nut	1	0.2
2182-004	*Carya* sp.	Hickory	Nut	3	0.6
2192-003	*Carya* sp.	Hickory	Nut	1	0.1
1993-011	*Carya* sp.	Hickory	Nut	1	0.2
622-005	*Carya* sp.	Hickory	Nut	1	0.1
2485	Not botanical				
2127-007	*Carya* sp.	Hickory	Nut	1	0.2
2367-007	*Carya* sp.	Hickory	Nut	1	0.2
1783-001	*Carya* sp.	Hickory	Nut	16	1.9
1783-001	*Quercus* sp.	Oak	Wood	6	0.4
1786-008	*Carya* sp.	Hickory	Nut	4	0.3
1778-011	*Carya* sp.	Hickory	Nut	7	0.5
1736-002	*Carya* sp.	Hickory	Nut	1	0.1
1736-009	*Carya* sp.	Hickory	Nut	1	0.1
523-006	*Carya* sp.	Hickory	Nut	2	0.1
529-007	*Carya* sp.	Hickory	Nut	1	0.05
959-006	*Carya* sp.	Hickory	Nut	4	0.3
1676-005	*Carya* sp.	Hickory	Nut	2	0.2
1870-004	*Carya* sp.	Hickory	Nut	1	0.1
1898-009	*Carya* sp.	Hickory	Nut	3	0.7
1351-004	*Carya* sp.	Hickory	Nut	1	0.1
1347-001	*Carya* sp.	Hickory	Nut	12	0.3
2048-008	*Carya* sp.	Hickory	Nut	5	0.4
1747-009	*Carya* sp.	Hickory	Nut	2	0.1
1938-009	*Carya* sp.	Hickory	Nut	1	0.1
2241-002	*Carya* sp.	Hickory	Nut	3	0.1
2487-007	*Carya* sp.	Hickory	Nut	1	0.1
1377-004	*Carya* sp.	Hickory	Nut	1	0.1
1402-008	*Carya* sp.	Hickory	Nut	5	0.6
1961-005	*Carya* sp.	Hickory	Nut	1	0.1
1942-008	*Carya* sp.	Hickory	Nut	2	0.4

Table E-3. Results of Flotation Samples

Cat. No.	Feature	Taxon	Common	Part	Count	Weight
1212-001	23	*Acer* sp.	Maple/boxelder	Wood	11	0.1
529-1	1	*Carya* sp.	Hickory	Nut	3	0.1
1023-001	12	*Carya* sp.	Hickory	Nut	57	1
1711-001	14	*Carya* sp.	Hickory	Nut	6	0.1
1869-002	35	*Carya* sp.		Nut	2	0.1
2045-009	36	*Carya* sp.		Nut	1	0.1
2403-001	51	*Carya* sp.	Hickory	Nut	7	0.1
529-1	1	Indeterminate		Wood	7	0.1
538-001	4	Indeterminate		Wood	4	0.1
607-001	5	Indeterminate		Wood	2	0.1
477-001	7	Indeterminate		Wood	6	0.1
699-001	8	Indeterminate		Wood	8	0.1
1023-001	12	Indeterminate		Wood	2	0.1
1330-001	13	Indeterminate		Wood	8	0.1
1711-001	14	Indeterminate		Wood	26	0.4
1191-002	21	Indeterminate		Wood	3	0.1
1455-001	22	Indeterminate		Wood	1	0.1
1648-001	29	Indeterminate		Wood	5	0.1
1737-001	31	Indeterminate		Wood	5	0.1
1787-001	32	Indeterminate		Wood	11	0.1
2005-002	41	Indeterminate		Wood	19	0.1
2340-001	36	Indeterminate		Wood	7	0.1
2441-001	49	Indeterminate		Wood	3	0.1
1049-009	52	Indeterminate		Wood	8	0.1
392-001	2	No Identfiable Plant Remains				
1285-001	15	No Identfiable Plant Remains				
1068-001	16	No Identfiable Plant Remains				
911-001	17	No Identfiable Plant Remains				
901-001	19	No Identfiable Plant Remains				
1316-001	24	No Identfiable Plant Remains				
1260-010	25	No Identfiable Plant Remains				
1008-002	26	No Identfiable Plant Remains				
1516-001	27	No Identfiable Plant Remains				
1525-001	30	No Identfiable Plant Remains				
1958-001	39	No Identfiable Plant Remains				
2269-001	41	No Identfiable Plant Remains				
2218-001	44	No Identfiable Plant Remains				
2169-001	46	No Identfiable Plant Remains				
2287-001	47	No Identfiable Plant Remains				
2562-002	48	No Identfiable Plant Remains				
2454-001	36	No Identfiable Plant Remains				
607-001	5	*Quercus* sp.	Oak	Wood	8	0.1
1247-009	18	Salicaceae	Willow/Cottonwood	Wood	6	0.1
2251-001	42	Salicaceae		Wood	7	0.1

Summary

The botanical assemblage includes a total of 161 (9.2 g) hickory nut fragments and three pecan nut fragments that were noted in the data recovery samples. This is in addition to the seven thin nut fragments that were noted in the testing phase samples. The thin nut fragments resembled pecan, but were too small for an absolutely positive identification. It is clear now that pecan was harvested at the site.

The abundance of hickory nut fragments at 41MM340 suggests that the site was visited during the fall for the purpose of collecting and processing hickory nuts. Occupation may have continued through winter months and into the spring, but the minimal interpretation of the data suggest a fall occupation.

The charred hickory nut material is a by-product of processing this resource both for storage and consumption. The relatively abundant hickory nutshell remains reflect an intense use of forest mast for the rendering of vegetable oil and carbohydrates. Hickory nuts were processed by pounding into fragments and boiling to dissolve the meat into an oily mass which could then be strained from the shell (Talalay et al. 1984:352). Nut fragments are well-preserved at most archeological sites because so much of the processing involves fire, which results in accidental charring. After processing the nuts by boiling the nut fragments, which do not disintegrate, the nutshell fragments were often recycled as a fuel, for charred nut fragments are quite abundant at archeological sites located within the oak-hickory forests (Munson et al. 1971:417; Talalay et al. 1984:352).

Gardner (1997:174) has also emphasized the importance of parching hickory nuts prior to storage. He maintains that the nuts may have been stored for several weeks or months prior to being processed for oil. Parching the nuts on hot rocks or coals killed fungal growth and insects as well as the embryos. The process kept pest damage to a minimum and prevented the nuts from germinating during storage. Parching the nuts also has a higher potential to generate charred plant fragments as an incidental outcome of heat processing.

The relative abundance and ubiquity of hickory wood also poses an intriguing issue. Relatively high charcoal counts, especially of forest mast trees, has been considered an indication of clearing fields for cultivation (Johannessen 1984). However, this is surely not the case at 41MM340. Instead, Gardner (1997) has suggested that a certain level of forest management was practiced by Native Americans, and that unproductive nut-bearing trees were being girdled and utilized as firewood. Southeastern groups may have been managing oak and hickory stands in this manner by eliminating sick or unproductive trees. This opens the tree canopy to more sunlight, increasing mast production (Gardner 1997:177).

The presence of pecan shell in comparatively small quantities is also good evidence for the utilization of this resource. While hickory nut is typically over-represented, pecan is most likely under-represented in the archeological record. This is probably due to formation processes at the site, because pecan is processed differently than hickory. Unlike hickory nut, there is no direct archeological or ethnohistorical evidence for processing pecan into oil (Hall

Table E-4. Plant Taxa Identified in the Samples

Taxon	Common Name	Part
Acer sp.	Cf. maple/boxelder	Wood
Bumelia lanuginosa	Gum bumelia	Wood
Carya illinoiensis	Pecan	Nut fragment
Carya sp.	Hickory	Wood
Gleditsia tricanthos	Honey Locust	Wood
Ilex sp.	Holly, possum haw	Wood[1]
Juglans sp.	Walnut	Wood
Quercus sp.	Oak	Wood
Salicaceae	Willow/cottonwood	Wood
Thin nutshell		Nut fragment
Ulmus sp.	Elm	Wood

[1] From testing phase samples only

2000). Pecans may be stored for at least a year in an adequate setting, and the Payaya Indians of southern Texas stored pecans in pits, possibly to compensate for the reduced pecan productivity encountered after years of bounty (Hall 2000). Because pecans are not exposed to fire like hickory nuts, the chances for charring are greatly reduced, and the occurrence of pecan at archeological sites is comparatively rare. The pecan shell at 41MM340 is noteworthy and adds to our understanding of this important resource in the region.

Conclusions

The widespread and abundant occurrence of nutshell at sites in the eastern half of Texas suggests the importance of hickory nut processing in the region (Dering 2002, 2003). The hickory nut harvest is a predictable resource that becomes available in the fall, and is both concentrated in extensive stands and is storable for a few weeks to several months. Vegetable fat and protein rendered from the nuts can provide an excellent complement not only to venison or bison, which are very low fat resources, but also to wild roots, fruits, and any crops produced in gardens or fields (Talalay et al. 1984). Most plant resources are high in carbohydrates and low in fats and nuts are a notable exception. Rendering oil from hickory nuts produces a substance that is quite similar to a buttery vegetable oil.

Likewise, pecan is a predictable and in some areas a densely occurring resource that contains needed fat and carbohydrate resources that are easily harvested and stored. Because pecan is under-represented and seldom recorded from sites, its recovery from the Little River area is significant. These forest mast resources played an important role in the subsistence strategy of the region’s inhabitants.

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Appendix F

Analysis of the Fatty Acid Compositions of Archeological Residues from 41MM340

Mary E. Malainey

Appendix F: Analysis of the Fatty Acid Compositions of Archeological Residues from 41MM340

Mary E. Malainey

Introduction

Six samples, including two pieces of fired clay and four burned rocks, were submitted for fatty acid analysis. Sample size ranged between about 12 and 50 grams. Where necessary, subsamples were taken from large rocks. Exterior surfaces were ground off to remove any contaminants and samples were powdered and absorbed lipid residues were extracted with organic solvents. Fatty acid components of the lipid extracts were analyzed using gas chromatography. Residues were identified using criteria developed from the decomposition patterns of experimental residues. The first section of this appendix outlines the development of the identification criteria. Following this, analytical procedures and results are presented.

Fatty Acids and Development of the Identification Criteria

Introduction and Previous Research

Fatty acids are the major constituents of fats and oils (lipids) and occur in nature as triglycerides, consisting of three fatty acids attached to a glycerol molecule by ester-linkages. The shorthand convention for designating fatty acids, Cx:yωz, contains three components. The "Cx" refers to a fatty acid with a carbon chain length of x number of atoms. The "y" represents the number of double bonds or points of unsaturation, and the "ωz" indicates the location of the most distal double bond on the carbon chain, i.e., closest to the methyl end. Thus, the fatty acid expressed as C18:1ω9 refers to a mono-unsaturated isomer with a chain length of 18 carbon atoms with a single double bond located nine carbons from the methyl end of the chain. Similarly, the shorthand designation C16:0 refers to a saturated fatty acid with a chain length of 16 carbons.

Their insolubility in water and relative abundance compared to other classes of lipids, such as sterols and waxes, make fatty acids suitable for residue analysis. Since employed by Condamin et al. (1976), gas chromatography has been used extensively to analyze the fatty acid component of absorbed archeological residues. The composition of uncooked plants and animals provides important baseline information, but it is not possible to directly compare modern uncooked plants and animals with highly degraded archeological residues. Unsaturated fatty acids, which are found widely in fish and plants, decompose more readily than saturated fatty acids, sterols, or waxes. In the course of decomposition, simple addition reactions might occur at points of unsaturation (Solomons 1980) or peroxidation might lead to the formation of a variety of volatile and non-volatile products which continue to degrade (Frankel 1991). Peroxidation occurs most readily in fatty acids with more than one point of unsaturation.

Attempts have been made to identify archeological residues using criteria that discriminate uncooked foods (Loy 1994; Marchbanks 1989; Skibo 1992). Marchbanks' (1989) percent of saturated fatty acids (%S) criteria has been applied to residues from a variety of materials including pottery, stone tools, and burned rocks (Collins et al. 1990; Marchbanks 1989; Marchbanks and Quigg 1990). Skibo (1992:89) could not apply the %S technique and instead used two ratios of fatty acids, C18:0/C16:0 and C18:1/C16:0. Skibo reported that it was possible to link the uncooked foods with residues extracted from modern cooking pots actively used to prepare one type of food; however, the ratios could not identify food mixtures. The utility of these ratios did not extend to residues extracted from archeological potsherds because the ratios of the major fatty acids in the residue changed with decomposition (Skibo 1992:97). Loy (1994) proposed the use of a Saturation Index (SI), determined by the ratio: SI = 1- [(C18:1+C18:2)/ C12:0+C14:0+C16:0+C18:0)]. He admitted, however, that poorly understood decompositional changes to the original suite of fatty acids make it difficult to develop criteria for distinguishing animal and plant fatty acid profiles in archeological residues.

The major drawback of the distinguishing ratios proposed by Marchbanks (1989), Skibo (1992), and Loy (1994) is that they have never been empirically tested. The proposed ratios are based on criteria that discriminate food classes on the basis of their original fatty acid composition. The resistance of these criteria to the effects of decompositional changes has not been demonstrated. In fact, Skibo (1992) found his fatty acid ratio criteria could not be used to identify highly decomposed archeological samples.

In order to identify a fatty acid ratio unaffected by degradation processes, Patrick et al. (1985) simulated the long-term decomposition of one sample and monitored the resulting changes. An experimental cooking residue of seal was prepared and degraded in order to identify a stable fatty acid ratio. Patrick et al. (1985) found that the ratio of two C18:1 isomers, oleic and vaccenic, did not change with decomposition; this fatty acid ratio was then used to identify an archeological vessel residue as seal. While the fatty acid composition of uncooked foods must be known, Patrick et al. (1985) have shown that the effects of cooking and decomposition over long periods of time on the fatty acids must also be understood.

Development of the Identification Criteria

As the first stage in developing the identification criteria used herein, the fatty acid compositions of more than 130 uncooked Native food plants and animals from Western Canada were determined using gas chromatography (Malainey 1997; Malainey et al. 1999a). When the fatty acid compositions of modern food plants and animals were subject to cluster and principal component analyses, the resultant groupings generally corresponded to divisions that exist in nature (Table F-1). Clear differences in the fatty acid composition of large mammal fat, large herbivore meat, fish, plant roots, greens, and berries/seeds/nuts were detected, but the fatty acid composition of meat from medium-sized mammals resembles berries/seeds/nuts.

Samples in cluster A, the large mammal and fish cluster, had elevated levels of C16:0 and C18:1 (Table F-1). Divisions within this cluster stemmed from the very high level of C18:1 isomers in fat, high levels of C18:0 in bison and deer meat and high levels of very long chain unsaturated fatty acids (VLCU) in fish. Differences in the fatty acid composition of plant roots, greens, and berries/seeds/nuts reflect the amounts of C18:2 and C18:3ω3 present. The berry, seed, nut, and small mammal meat samples appearing in cluster B have very high levels of C18:2, ranging from 35% to 64% (Table F-1). Samples in subclusters V, VI, and VII have levels of C18:1 isomers from 29% to 51%, as well. Plant roots, plant greens and some berries appear in cluster C. All cluster C samples have moderately high levels of C18:2; except for the berries in subcluster XII, levels of C16:0 are also elevated. Higher levels of C18:3ω3 and/or very long chain saturated fatty acids (VLCS) are also common except in the roots which form subcluster XV.

Second, the effects of cooking and degradation over time on fatty acid compositions were examined. Originally, 19 modern residues of plants and animals from the plains, parkland and forests of Western Canada were prepared by cooking samples of meats, fish, and plants, alone or combined, in replica vessels over an open fire (Malainey 1997; Malainey et al. 1999b). After four days at room temperature, the vessels were broken and a set of sherds analyzed to determine changes after a short term of decomposition. A second set of sherds remained at room temperature for 80 days, then placed in an oven at 75°C for a period of 30 days in order to simulate the processes of long-term decomposition. The relative percentages were calculated on the basis of the ten fatty acids (C12:0, C14:0, C15:0, C16:0, C16:1, C17:0, C18:0, C18:1ω9, C18:1ω11, and C18:2) that regularly appeared in Precontact Period vessel residues from Western Canada. Observed changes in fatty acid composition of the experimental cooking residues enabled the development of a method for identifying the archeological residues (Table F-2).

It was determined that levels of medium chain fatty acids (C12:0, C14:0, and C15:0), C18:0, and C18:1 isomers in the sample could be used to distinguish degraded experimental cooking residues (Malainey 1997; Malainey et al. 1999b). These fatty acids are suitable for the identification criteria because saturated fatty acids are stable and the mono-unsaturated fatty acids degrade very slowly, as compared to polyunsaturated fatty acids (deMan 1992). Higher levels of medium chain fatty acids, combined with low levels of C18:0 and C18:1 isomers, were detected in the decomposed experimental residues of plants, such as roots, greens and most berries. High levels of C18:0 indicated the presence of large herbivores. Moderate levels of C18:1 isomers, with low levels of C18:0, indicated the presence of either fish or foods similar in composition to corn. High levels of C18:1 isomers, with low levels of C18:0, were found in residues of beaver or foods of similar fatty acid composition. The criteria for identifying six types of residues were established experimentally; the seventh type, plant with large herbivore, was inferred (Table F-2). These criteria were applied to residues extracted from more than 200 pottery cooking vessels from 18 Western Canadian sites (Malainey 1997; Malainey et al. 1999c, 2001b). The identifications were found to be consistent with the evidence from faunal and tool assemblages for each site.

Work has continued toward understanding the decomposition patterns of various foods and food combinations (Malainey et al. 2000a, 2000b, 2000c, 2001a; Quigg et al.

Table F-1. Summary of Average Fatty Acid Compositions of Modern Food Groups Generated by Hierarchical Cluster Analysis

Cluster	**A**				**B**						**C**				
Subcluster	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**XIII**	**XIV**	**XV**
Type	Mammal Fat and Marrow	Large Herbivore Meat	Fish	Fish	Berries and Nuts	Mixed	Seeds and Berries	Roots	Seeds	Mixed	Greens	Berries	Roots	Greens	Roots
C16:0	19.90	19.39	16.07	14.10	3.75	12.06	7.48	19.98	7.52	10.33	18.71	3.47	22.68	24.19	18.71
C18:0	7.06	20.35	3.87	2.78	1.47	2.36	2.58	2.59	3.55	2.43	2.48	1.34	3.15	3.66	5.94
C18:1	56.77	35.79	18.28	31.96	51.14	35.29	29.12	6.55	10.02	15.62	5.03	14.95	12.12	4.05	3.34
C18:2	7.01	8.93	2.91	4.04	41.44	35.83	54.69	48.74	64.14	39.24	18.82	29.08	26.24	16.15	15.61
C18:3	0.68	2.61	4.39	3.83	1.05	3.66	1.51	7.24	5.49	19.77	35.08	39.75	9.64	17.88	3.42
VLCS	0.16	0.32	0.23	0.15	0.76	4.46	2.98	8.50	5.19	3.73	6.77	9.10	15.32	18.68	43.36
VLCU	0.77	4.29	39.92	24.11	0.25	2.70	1.00	2.23	0.99	2.65	1.13	0.95	2.06	0.72	1.10

VLCS - Very Long Chain (C20, C22, and C24) Saturated Fatty Acids
VLCU - Very Long Chain (C20, C22, and C24) Unsaturated Fatty Acids

Table F-2. Criteria for the Identification of Archeological Residues Based On the Decomposition Patterns of Experimental Cooking Residues Prepared in Pottery Vessels

Identification	**Medium Chain**	**C18:0**	**C18:1 isomers**
Large herbivore	≤ 15%	≥ 27.5%	≤ 15%
Large herbivore with plant OR Bone marrow	low	≥ 25%	15% ≤ *X* ≤ 25%
Plant with large herbivore	≥15%	≥ 25%	no data
Beaver	low	low	≥ 25%
Fish or Corn	low	≤ 25%	15%≤ *X* ≤ 27.5%
Fish or Corn with Plant	≥ 15%	≤ 25%	15%≤ *X* ≤ 27.5%
Plant (except corn)	≥ 10%	≤27.5%	≤ 15%

2001). The collection of modern foods has expanded to include plants from the Southern Plains. The fatty acid compositions of mesquite beans (*Prosopis glandulosa*), Texas ebony seeds (*Pithecellobium ebano Berlandier*), tasajillo berry (*Opuntia leptocaulis*), prickly pear fruit and pads (*Opuntia engelmannii*), Spanish dagger pods (*Yucca treculeana*), cooked sotol (*Dasylirion wheeler*), agave (*Agave lechuguilla*), cholla (*Opuntia imbricata*), piñon (*Pinus edulis*), and Texas mountain laurel (or mescal) seed (*Sophora secundiflora*) have been determined. Experimental residues of many of these plants, alone or in combination with deer meat, have been prepared by boiling foods in clay cylinders or using sandstone for either stone boiling (Quigg 1999) or as a griddle. In order to accelerate the processes of oxidative degradation that naturally occur at a slow rate with the passage of time, the rock or clay tile containing the experimental residue was placed in an oven at 75°C. After either 30 or 68 days, residues were extracted and analyzed using gas chromatography. The results of these decomposition studies enabled refinement of the identification criteria.

Methodology

Descriptions of the samples are presented in Table F-3. Possible contaminants were removed by grinding off exterior surfaces with a Dremel® tool fitted with a silicon carbide bit. Immediately thereafter, each sample was crushed with a hammer mortar and pestle and the powder transferred to an Erlenmeyer flask. Lipids were extracted using a variation of the method developed by Folch et al. (1957). The powdered sample was mixed with a 2:1 mixture, by volume, of chloroform and methanol (2 X 30 mL) using ultrasonication (2 X 10 min). Solids were removed by filtering the solvent mixture into a separatory funnel. The lipid/solvent filtrate was washed with 16 mL of double distilled water. Once separation into two phases was complete, the lower chloroform-lipid phase was transferred to a round-bottomed flask and the chloroform removed by rotary evaporation. Any remaining water was removed by evaporation with benzene (1.5 mL); 1.5 mL of chloroform-methanol (2:1, v/v) was used to transfer the dry total lipid extract to a screw-top glass vial with a Teflon®-lined cap. The sample was flushed with nitrogen and stored in a -20°C freezer.

A 450 µL sample of the total lipid extract solution was placed in a screw-top test tube and dried in a heating block under nitrogen. Fatty acid methyl esters (FAMES) were prepared by treating the dry lipid with 6 mL of 0.5 N anhydrous hydrochloric acid in methanol (65–70°C; 60 min). Fatty acids that occur in the sample as di- or triglycerides are detached from the glycerol molecule and converted to methyl esters. After cooling to room temperature, 4 mL of double distilled water was added. FAMES were recovered with petroleum ether (3 mL) and transferred to a vial. The solvent was removed by heat under a gentle stream of nitrogen; the FAMES were dissolved in 75 µL of *iso*-octane transferred to a gas chromatography (GC) vial with a conical glass insert.

Solvents and chemicals were checked for purity by running a sample blank. The entire lipid extraction and methyl esterification process was performed and FAMES were

Table F-3. List of Samples Analyzed from Site 41MM340

Lab No.	FS. No.	Cat. No.	Feat. No.	Class	Status	Sample Size (g)
UTT 1	1850	2041	36	Burned Clay	Unwashed	50.076
UTT 2	1851	2029	36	Burned Clay	Unwashed	11.865
UTT 3	1816	2045-9a	36	Burned Rock	Unwashed	19.024
UTT 4	1881	2045-6a	36	Burned Rock	Washed	29.100
UTT 5	2090	2252-1a	41	Burned Rock	Washed	35.930
UTT 6	2004	1999	41	Burned Rock	Unwashed	42.333

dissolved in 75 µL of *iso*-octane. Traces of contamination were subtracted from the sample chromatogram. The relative percentage composition was calculated by dividing the integrated peak area of each fatty acid by the total area of fatty acids present in the sample.

The step in the extraction procedure where the chloroform, methanol and lipid mixture is washed with water is standard procedure for the extraction of lipids from modern samples. Following Evershed et al. (1990), who reported that this step was unnecessary for the analysis of archeological residues, previously the solvent-lipid mixture was not washed. This step was recently adopted to remove impurities so that a clearer chromatogram could be obtained in the region where very long chain fatty acids (C20:0, C20:1, C22:0, and C24:0) occur. It was anticipated that the detection and accurate assessment of these fatty acids could be instrumental in separating residues of animal origin from those of plant (Malainey et al. 2000a, 2000b, 2000c, 2001a).

In order to identify the residue, the relative percentage composition was determined first with respect to all fatty acids present in the sample (including very long chain fatty acids; see Table F-4) and second with respect to the ten fatty acids utilized in the development of the identification criteria (C12:0, C14:0, C15:0, C16:0, C16:1, C17:0, C18:0, C18:1ω9, C18:1ω11, and C18:2; not shown). The second step is necessary for the application of the identification criteria presented in Table F-2.

It must be understood that the identifications given do not necessarily mean that those particular foods were actually prepared, because different foods of similar fatty acid composition and lipid content would produce similar residues. It is possible only to say that the material of origin for the residue was similar in composition to the food(s) indicated.

Gas Chromatography Analysis Parameters

The GC analysis was performed on a Hewlett-Packard 5890 gas chromatograph fitted with a flame ionization detector connected to a personal computer. Samples were separated using a DB-23 fused silica capillary column (30 m X 0.25 mm I.D.; J&W Scientific, Folsom, CA). An autosampler injected a 3 µL sample using a split injection system with the ratio set at 1:20. Hydrogen was used as the carrier gas at a linear velocity of approximately 40 cm/sec. Column temperature was programmed from 155 to 215°C at 2°C per minute. The lower temperature was held for four minutes; the upper temperature was held for 15 minutes. Chromatogram peaks were integrated using ChromPerfect® software and identified through comparisons with external qualitative standards (NuCheck Prep, Elysian, MN). Using this procedure, fatty acids are detectable to the nanogram (1×10^{-9} g) level.

Results of Archeological Data Analysis

The fatty acid compositions of residues extracted from the samples are presented in Table F-4. Sufficient fatty acids were recovered from all samples to attempt identification; although, in the case of UTT 3, a bare minimum of lipid residue was recovered. The term "Area" represents the area under the chromatographic peak of a given fatty acid, as calculated by the ChromPerfect® software minus solvent blanks. The term "Rel%" represents the relative percentage of the fatty acid with respect to the total fatty acids in the sample.

Two residues, UTT 4 and UTT 6, appear to result from the preparation of plant foods of medium fat content, such as mesquite or corn. Two other residues, UTT 1 and UTT 2, also appear to result from the preparation of foods of medium fat content, but they may be of either plant or animal origin. Elevated levels of C14:0 and C16:1 in residues UTT 1 and UTT 2 may reflect the preparation of fish or another aquatic food, such as snail. Elevated levels of both C12:0 and C14:0 and very long chain fatty acids favor a plant origin for both UTT 1 and UTT 2 or the presence of low fat plant greens and roots.

It is important to note that residues UTT 1 and UTT 2 were both extracted from fired clay samples and contained material other than fatty acids. Several of these unidentified contaminants emerged from the column just before, between, and just after the medium chain fatty acids C12:0 and C14:0. It is possible that contaminants also emerged at exactly the same time as C12:0 and C14:0 and increased the sizes of their peaks. If so, the relative fatty acid composition of residues UTT 1 and UTT 2 may be distorted; levels of medium chain fatty acids may be artificially high and amounts of other fatty acids artificially low. If this is the case, the actual fatty acid compositions of residues UTT 1 and UTT 2 are similar to that of residues UTT 6 and UTT 4, respectively.

The composition of residue UTT 3 is consistent with a combination of large herbivore meat and low fat content plants. Using only the ten fatty acids used to establish the original identification criteria, the residue falls in the category of Large Herbivore; however, elevated levels of very long chain saturated fatty acids suggests the presence of low fat content plant greens or roots as well.

The composition of one residue, UTT 5, is characteristic of moderate-high fat content foods. These residues have relatively high levels of C18:1 isomers and levels of C18:0 below 25%. Examples of moderate-high fat content foods include Texas ebony seeds and the fatty meat of medium-sized mammals, such as beaver.

Table F-4. Fatty Acid Composition and Identification of Archeological Residues from Site 41MM340

Fatty acid	UTT 1		UTT 2		UTT 3		UTT 4		UTT 5		UTT 6	
	Area	**Rel%**	**Area**	**Rel%**	**Area**	**Rel%**	**Area**	**Rel%**	**Area**	**Rel%**	**Area**	**Rel%**
C12:0	8648	8.73	4736	9.05	990	2.94	0	0	1683	2.35	4755	5.66
C14:0	7580	7.65	2232	4.26	934	2.77	1782	3.09	1507	2.11	1642	1.95
C14:1	2741	2.77	0	0	0	0	0	0	0	0	0	0
C15:0	1877	1.89	0	0	0	0	966	1.67	0	0	1213	1.44
C16:0	24233	24.46	6848	13.08	10374	30.8	16192	28.07	14807	20.7	22244	26.47
C16:1	4280	4.32	7209	13.77	594	1.76	868	1.5	0	0	2401	2.86
C17:0	0	0	0	0	1527	4.53	0	0	0	0	0	0
C18:0	7696	7.77	6562	12.53	8495	25.22	10139	17.58	15923	22.26	10947	13.03
C18:1s	19078	19.26	7396	14.13	2109	6.26	8875	15.39	21731	30.38	17126	20.38
C18:2	8080	8.16	7178	13.71	2997	8.9	8046	13.95	3256	4.55	7588	9.03
C18:3w3	1258	1.27	5396	10.31	1957	5.81	4299	7.45	7971	11.14	9096	10.83
C20:0	3057	3.09	814	1.55	1643	4.88	772	1.34	1083	1.51	935	1.11
C20:1	5411	5.46	2352	4.49	0	0	3544	6.14	1875	2.62	4235	5.04
C24:0	5138	5.19	1628	3.11	2066	6.13	2198	3.81	1692	2.37	1837	2.19
Total	105649	100	54310	100	37237	100	58357	100	73028	100	85116	100
Identification	**Medium fat content food (mesquite/corn/fish), possibly with low fat content plant**		**Medium fat content food (mesquite/corn/fish), possibly with low fat content plant**		**Large Herbivore and low fat content plants**		**Medium fat content food (mesquite/corn)**		**Moderate-high fat content food (Texas ebony/beaver)**		**Medium fat content food (mesquite/corn)**	

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Appendix G

Freshwater Mussel Shell from 41MM340

Robert G. Howells, Jennifer Neel-Hartman, and Stacy A. Wagner

Appendix G: Freshwater Mussel Shell from 41MM340

Robert G. Howells, Jennifer Neel-Hartman, and Stacy A. Wagner

Introduction

Freshwater mussels (Family Unionidae) are frequently associated with Native American archeological sites where they were used as food, tools, and decoration (Howells et al. 1996; Neck 1982; Parmalee and Bogan 1998). Unionid mussel remains can provide clues to environmental conditions and habitat types present, as well as other elements relevant to archeological studies. Sites 41MM340 and 41MM341, located along the Little River, Milam County, Texas, were preliminarily examined by personnel from the Center for Archaeological Research (CAR) in early 2000 (Mahoney and Tomka 2001). Mussel shell material initially recovered form these sites was discussed by Howells (2001a). This appendix presents the results and discussion of additional unionid remains found during data recovery efforts at 41MM340.

Materials and Methods

Unionid material recovered from site 41MM340 was initially examined and sorted by CAR personnel. Shell disk sections and other fragments that did not include diagnostic features necessary for identification were separated from potentially identifiable materials. Following preliminary identification by the CAR staff, specimens were grouped, labeled, and bagged for subsequent re-examination and confirmation by the senior author. Specimens were identified using Howells et al. (1996) and by comparisons to reference collection shells taken by the senior author in the Brazos River drainage of Central Texas. Additionally, specimens of false spike (*Quincuncina mitchelli*) from the collection of J.A.M. Bergmann, Boerne, Texas, were borrowed for comparison to shell remains from 41MM340. Taxonomic terminology follows Howells et al. (1996).

Identifiable valves and fragments typically included beaks, pseudocardinal teeth, beak sculpture, lateral teeth, and occasionally disk portions when distinctive sculpturing was present. No attempt was made to match right and left valves or valve fragments. Therefore, because freshwater mussels have two valves, numbers given may not represent the true number of individual animals. For example, 100 specimens counted could have come from as many as 100 individual animals (if none of the specimens formed matched pairs) or as few as 50 individuals (if all materials represented matched pairs). Numbers and weights presented here do not include unidentifiable fragments initially removed by the CAR staff. Numbers of specimens that appeared to have been burned (gray or black in color rather than chalky white) were also noted. Valves and fragments that could not be identified to species include both unidentifiable materials (too worn or poorly preserved to allow confident identification), as well as others that remained unidentified (potentially identifiable valves or fragments that could not assigned to a specific species).

Examples of unionids from the site 41MM340 samples are presented in Plates 1 through 4. Morphological traits used in identifications are discussed and illustrated in Addendum I and Plates 5 through 12.

Samples summarized in Table G-1 actually represent two distinct sets of samples: one group of five proveniences from Zones 2, 3b, 4, 6, and 8 and a second group consisting of a 1-m^2 column sample from unit N44/E14.

Results and Discussion

A total of 22 sample sets (catalog numbers) from eight zones (depths) was examined and included 2,991 specimens weighing 11,213 grams (Table G-1). Nine species of freshwater mussels were identified including threeridge (*Amblema plicata*), Tampico pearlymussel (*Cyrtonaias tampicoensis*), Louisiana fatmucket (*Lampsilis hydiana*), washboard (*Megalonaias nervosa*), bleufer (*Potamilus purpuratus*), southern mapleleaf (*Quadrula apiculata*), smooth pimpleback (*Quadrula houstonensis*), false spike (*Quincuncina mitchelli*), and pistolgrip (*Tritogonia verrucosa*), as well as several unidentified valves and fragments (Table G-1, Figures G-1 through G-16).

Species Accounts

Threeridge (*Amblema plicata;* Figures G-1 through G-4)

Threeridge valves and fragments were first in abundance (54.0%) and occurred in all samples containing unionid remains (Table G-1). This species ranges throughout most of the Mississippi River drainage and in Texas systems except the Canadian, Rio Grande, and uppermost river

Table G-1. Freshwater Mussel Shell Remains Recovered from Site 41MM340
(numbers of specimens represent valves and valve fragments, not matched pairs of valves of individual animals)

		Unit			Number of each species[a]											
Cat. No.	**Zone**	**N**	**E**	**Level**	**Threeridge**	**Tampico pearlymussel**	**Louisiana fatmucket**	**Southern mapleleaf**	**Smooth pimpleback**	**False spike**	**Pistolgrip**	**Washboard**	**Bleufer**	**Unident.**	**Total N**	**Total Wt (g)**
1834-004	1a	44	14	1	1										1	4.6
1835-005	1b	44	14	1	50				8	1					59	295
487-003	2	41	14	1	241	3		13	90	8				14	369	1818.5
489-002	2	41	14	2	13	1	1	2	8			3		9	37	70.2
1836-009	2	44	14	1	59	2		4	33	7					105	288.7
1839-006	2	44	14	2	26			1	15					2	44	104.1
1841-006	3	44	14	1	9				2					2	13	33.7
2315-008	3b	47	15	1	32				7	3	2				44	171.2
2522-009	3b	47	15	2	65	5		4	57	4					135	365.2
539-007	4	41	15	1	114	1	1		15	7	3			21	162	426.5
2138-003	4	44	14	1	13				10	2	1				26	59.8
2142-006	4	44	14	2	83	6		15	67	4	1				176	519.6
543-006	4	41	15	2	125	1		9	80	11	1	1		1	229	735.1
2143-006	5	44	14	1	11			1	9	2					23	96.9
975-006	6	42	15	1	197	1	1	26	186	19	5			1	436	2172.9
2145-006	6	44	14	1	34			2	29	9		1			75	365.4
2147-006	7	44	14	1	5				11						16	23.4
2152-008	8	44	14	1	158	3	2	7	103	9	2		1		285	961.7
1074-005	8	44	18	1	209	3	3	15	182	20	9				441	1619.2
1076-002	8	44	18	2	47		1	4	50	6	1			2	111	324.5
2154-007	8	44	14	2	92	5		13	54	6	3				173	648.4
2157-007	8	44	14	3	16	2		1	10	2					31	108.6
Number of samples with species					22	12	6	15	21	17	10	2	1	8	22	22
Mean per sample with species					72.7	2.8	1.5	7.8	49	7.1	2.8	2.5	1	5.8	135.9	509.7
Mean per all samples with mussels					72.7	1.5	0.4	5.3	46.7	5.5	1.3	0.2	>0.1	2.4	135.9	509.7
Minimum per sample					1	0	0	0	0	0	0	0	0	0	1	4.6
Maximum per sample					241	6	3	26	186	20	9	3	1	21	441	2172.9
Grand total					1600	33	9	117	1026	120	28	5	1	52	1991	11213
Percent of total by species					54	1.1	0.3	3.9	34	4	0.9	0.1	>0.1	1.9		

[a] Scientific names are: Threeridge (*Amblema plicata*), Tampico pearlymussel (*Cyrtonaias tampicoensis*), Louisiana fatmucket (*Lampsilis hydiana*), southern mapleleaf (*Quadrula apiculata*), Smooth pimpleback (*Quadrula houstonensis*), False spike (*Quincuncina mitchelli*), Pistolgrip (*Tritogonia verrucosa*), Washboard (*Megalonaias nervosa*), and Bleufer (*Potamilus purpuratus*).

reaches (Howells et al. 1996). It is currently one of the more abundant unionid species in Texas and its thick, hard shells often survive long periods after the animal has died. This species can reach over 150 mm in shell length (Howells et al. 1996).

Washboard
(*Megalonaias nervosa;* Figure G-5)

Washboard remains included only five specimens in three samples (Table G-1). This species is typical of larger water bodies, both rivers and lakes, and is more common in the lower reaches of rivers than in headwater stretches. In Texas, it ranges into the central Brazos River drainage and along the coastal plain in the Guadalupe and Nueces-Frio systems (Howells et al. 1996). It is the largest North American unionid and can exceed 250 mm in shell length (Howells et al. 1996).

Smooth pimpleback
(*Quadrula houstonensis;* Figures G-6 and G-7)

Smooth pimpleback was second in abundance (34%) and was present in all but one collection sample from Level 1 (Table G-1). This species is endemic to the Colorado and Brazos drainages of Central Texas (Howells 2002a; Howells et al. 1996). It is currently rather rare and appears to have declined dramatically in both abundance and distribution in recent decades (Howells et al. 1997). Preliminary analysis of the 41MM340 materials (Howells 2001a) indicated smooth pimpleback was more abundant in deeper, older zones than during more recent periods. The present study data further support this with far more found in Zone 8 than in any of the more-recent zones. This species may have begun to decline naturally as environmental conditions in the region became more arid (see discussion in Howells 2001b), with pollution, habitat alteration, and other anthropogenic factors accelerating losses relatively recently. Although this species can slightly exceed 60 mm in shell length (Howells et al. 1996), most modern specimens are usually smaller (R. G. Howells, unpublished data).

Southern mapleleaf
(*Quadrula apiculata;* Figure G-8)

Southern mapleleaf was forth in abundance (3.9%) and was present in 15 of 22 samples with mussel remains (Table G-1). In recent years, this species has often been common to abundant statewide, except in far western and northwestern regions that are more arid and often lack permanent surface waters. Southern mapleleaf specimens have been documented to reach at least 118 mm in shell length, with unconfirmed reports to at least 150 mm. Size and shell thickness vary geographically in Texas and those from the Brazos and Colorado systems are among the most robust (R. G. Howells, unpublished data).

Pistolgrip
(*Tritogonia verrucosa;* Figure G-9)

Pistolgrip was sixth in abundance (0.9%), with remains in 10 samples (Table G-1). Pistolgrip ranges as far west as the Abilene area in the Brazos drainage and southwest into the lower Guadalupe River system (Howells et al. 1996). Shell length can exceed 170 mm (Howells et al. 1996). Recent biochemical genetic analysis has resulted in relocation of this species into *Quadrula* (Serb et al., In Press).

False spike
(*Quincuncina mitchelli;*
Figures G-10 through G-12)

False spike was third in abundance (4%) and occurred in 17 of 22 samples with mussel remains (Table G-1). Historically, it occurred in two disjunct areas including one population in Central Texas and another in the Rio Grande drainage (Howells 2001b; Howells et al. 1996). None have been documented in the Rio Grande in recent decades and the Central Texas population has declined to near extinction since the late 1970s (Howells et al. 1997). Subsequently, few biologists have extensive experience with it. Although the species had been found in preliminary studies at site 41MM340 (Howells 2001a), the large number found in the present study was unusual and suggests the species was probably much more abundant in the distant past than in recent years. Although some "subfossil" material from sediments in the Rio Grande drainage has been known to exceed 130 mm shell length (Howells et al. 1996), specimens in the J.A.M. Bergmann collection from Central Texas locations, primarily from the 1970s, are typically less than 50 mm in shell length. Recent biochemical genetic analysis has resulted in moving another species of *Quincuncina* into *Fusconaia* and a second into *Quadrula* (Serb et al., In Press). Absence of tissue from false spike for analysis leaves its taxonomic status uncertain; however, relocation into *Quadrula* is likely to occur in the near future.

Tampico pearlymussel
(*Cyrtonaias tampicoensis;* Figure G-13)

Tampico pearlymussel was fifth in abundance (1.1%) and was found in 12 of the 22 samples with mussel remains (Table G-1). This species ranges from the Brazos River drainage in Central Texas south and west into systems in northeastern Mexico (Howells 2001b; Howells et al. 1996). Maximum size can exceed 150 mm in shell length (R. G. Howells, unpublished data).

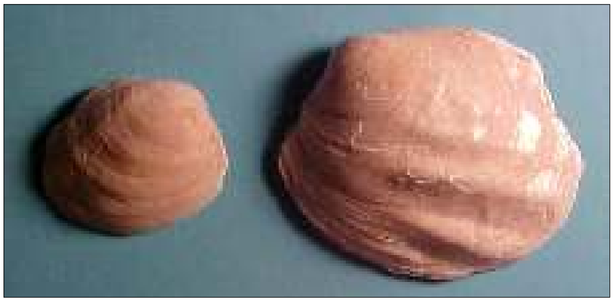

Figure G-1. Threeridge *(Amblema plicata)*. Cat. no. 1074-005. Specimen on the right shows typical pattern of external ridges. The juvenile on the left has minimal suggestion of ridges (often seen in some Central Texas populations). Poorly sculptured juveniles might be confused with smooth pimpleback *(Quadrula houstonensis)* externally, but internal shell features differ.

Figure G-2. Threeridge *(Amblema plicata)*. Cat. no. 1076-002. This specimen has a cross-hatch pattern on the central disk region, but lacks the sculpturing in the anterior field as seen in washboards *(Megalonaias nervosa)*.

Figure G-3. Threeridge (*Amblema plicata*) – left pseudocardinal teeth. Cat. no. 487-003. Posterior tooth is often larger than the anterior tooth, the anterior tooth is not flattened and chisel-like, and the beak cavity is deep.

Figure G-4. Threeridge *(Amblema plicata)* – right pseudocardinal tooth. Cat. no. 1076-002. Tooth is relatively triangular and angled posterio-ventrally rather than nearly vertically.

Figure G-5. Washboard *(Megalonaias nervosa)* – left pseudo-cardinal teeth. Cat. no. 543-006. Teeth are similar to threeridge *(Amblema plicata)*, but posterior tooth is often broader and lower, and the anterior tooth is often larger. Beaks are usually lower and beak cavities shallower in washboards.

Plate 1. Threeridge *(Amblema plicata)* and washboard *(Megalonaias nervosa)* specimens recovered from site 41MM340.

Figure G-6. Smooth pimpleback *(Quadrula houstonensis)* – right and left pseudocardinal teeth. Cat. no. 2522-09. The right pseudocardinal tooth is often nearly flat on its anterior surface with its long axis angled nearly straight downward. The left anterior pseudocardinal tooth is usually flat and chisel-shaped. Beaks are high and beak cavities deep. The interdentum is very short and broad.

Figure G-7. Smooth pimpleback *(Quadrula houstonensis)*. Cat. no. 2522-009. Externally the disk is usually smooth and completely unsculptured (though specimens with pustules have been reported), the beak is nearly centrally located, and the general shape is rather rounded or quadrate, but not elongate.

Figure G-8. Southern mapleleaf *(Quadrula apiculata)*. Cat. no. 487-003. Internal morphology is similar to smooth pimpleback, but less heavy. Left anterior pseudocardinal tooth is less chisel-like and the right pseudocardinal tooth without a flat anterior edge. Many small pimples cover the disk exterior (less so in larger specimens). The posterior ridge is usually obscure or only moderately developed (the specimen on the far left has a particularly bold ridge for the species).

Figure G-9. Pistolgrip *(Tritogonia verrucosa)*. Cat. no. 2152-008. The disk is heavily sculptured exteriorly and more rectangular than in southern mapleleaf *(Quadrula apiculata)*. Mature females are more elongate than males. Posterior ridge is bold.

Plate 2. Smooth pimpleback *(Quadrula houstonensis)*, southern mapleleaf *(Q. apiculata)*, and pistolgrip *(Tritogonia verrucosa)* specimens recovered from site 41MM340.

Louisiana fatmucket (*Lampsilis hydiana;* Figure G-14)

Louisiana fatmucket was seventh in abundance (0.3%), with nine specimens found in six samples (Table G-1). This species ranges west to the Brazos drainage of Central Texas, then along the coastal plain in the Guadalupe River and lower Nueces River (it is replaced in the Texas Hill Country by Texas fatmucket, *L. bracteata;* Howells et al. 1996). Large Louisiana fatmuckets can slightly exceed 100 mm in shell length (Howells et al. 1996).

Bleufer (*Potamilus purpuratus;* not shown)

A single fragment of bleufer in one sample was the only confirmation of this species (Table G-1). Bleufer ranges into the upper reaches of the Brazos and Colorado systems in west-central Texas. It can exceed 200 mm in shell length (Howells et al. 1996).

Unidentified Material (Figures G-15 and G-16)

Some specimens in this category had been broken, eroded and exfoliated, or were fragments that lacked diagnostic features. However, several should have been identifiable, but had traits that did not correspond to local unionid taxa. Unionids often display deformities and abnormal growth patterns (Howells et al. 1996; Parmalee and Bogan 1998) and this can confound identification of archeological specimens. Some unionid species were declining for natural reasons prior to European contact and many others have been eliminated since (Howells 2001b; Howells et al. 1996). In some cases, species have been found in archeological sites that had slipped into extinction prior to being documented by modern biologists and archeologists (e.g., Williams and Fradkin 1999). One specimen in the current study (Figure G-15) was particularly problematic. It resembled some of the lampsiliid pocketbooks, none of which are present in the Brazos drainage; it had certain affinities to Tampico pearlymussel, but pseudocardinal teeth were atypical. Regardless of the ultimate disposition of several of the "unidentifiable" specimens among the 41MM340 samples, all were too infrequent to be statistically meaningful to archeological interpretations of the faunal assemblage.

Species Not Found

Other unionid taxa documented from the Brazos River basin were presented in Howells (2001a). Among these, species typical of pond, backwater, and slough environments with little or no flow and soft bottoms were lacking from the 41MM340 samples. Such species that are known to occur in the central Brazos River drainage include giant floater (*Pyganodon grandis*), paper pondshell (*Utterbackia imbecillis*), pond mussel (*Ligumia subrostrata*), pondhorn (*Uniomerus tetralasmus*), tapered pondhorn (*U. declivis*), lilliput (*Toxolasma parvus*), and Texas lilliput (*T. texasiensis*). Giant floater and paper pondshell have thin shells that often crack when they become dry. Murray (1982a, 1982b) also noted the absence of these species in other archeological samples and suggested they may have been selected against due to poor taste. Although this is certainly possible, the fragile nature of their shells suggests they would be far less likely to be preserved than heavier-shelled forms. Failure to find them may only reflect poor survivability of their remains. Pond mussel and both pondhorn species have only slightly thicker shells that are not especially solid and may also tend to disintegrate over time. Both lilliput species are small, but often fairly solid. Lilliputs have been found at other archeological sites in Texas (Howells 1998, 2002b, 2002c).

Pink papershell (*Potamilus ohiensis*) and fragile papershell (*Leptodea fragilis*) are presently common at some locations in the Brazos River drainage, but were absent from the 41MM340 archeological assemblage. Both may occur on a variety of substrates, including soft and sandy bottoms. But again, both species usually have thin shells that would be less likely to remain intact long after the animals had died.

A number of other taxa have been documented from the Brazos River system, but they are often uncommon and generally have thinner or less-solid shells that would not be expected to preserve well (e.g., rock-pocketbook, *Arcidens confragosus*).

The absence of yellow sandshell (*Lampsilis teres*) from the 41MM340 site is particularly interesting. This species occurs from the Rio Grande north to southern Canada, and is often common to abundant when present, including at sites in the Brazos River basin (Howells et al. 1996). It is an active species, even as large adults, and is frequently encountered in both shallow and deeper waters. Yellow sandshell has been documented at other archeological sites in Texas, in some cases found in abundance (Howells 1998, 2002b, 2002c). Some specimens would have been expected to occur in the same habitats frequented by Louisiana fatmuckets. Considering that among the nearly 3,000 specimens examined from 41MM340, Louisiana fatmucket only accounted for 0.3% (six specimens) of the material recovered, if yellow sandshell was equally as abundant, sample size may have simply been insufficient to detect it.

Figure G-10. False spike *(Quincuncina mitchelli)*. Cat. no. 487-003. Right pseudocardinal tooth and beak. Beak cavity is shallower than in Tampico pearlymussel *(Cyrtonaias Tampicoensis)*.

Figure G-11. False spike *(Quincuncina mitchelli)*. Cat. no. 543-006. Beaks are lower, more narrow, and flatter than in Tampico pearlymussel *(Cyrtonaias tampicoensis)*.

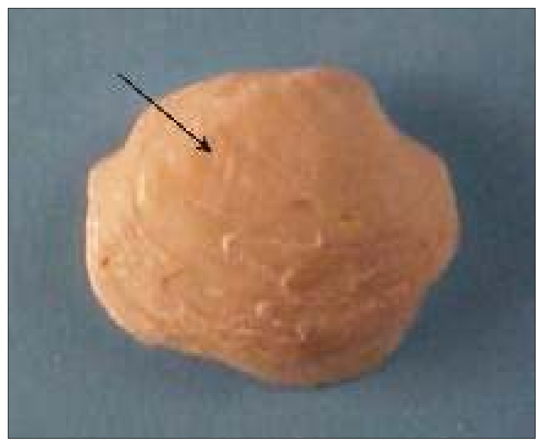

Figure G-12. False spike *(Quincuncina mitchelli)*. Cat. no. 487-003. Vertical grooves on the exterior of the disk below and posterior to the beak are diagnostic traits on many specimens. Other sculpturing may be present on the disk as well. This species is usually more elongate (often much more elongate) than Tampico pearlymussel *(Cyrtonaias tampicoensis)*.

Figure G-13. Tampico pearlymussel *(Cyrtonaias tampicoensis)* – interior and exterior views. Cat. no. 487-003. Interior has deeper beak cavities than false spike *(Quincuncina mitchelli)* and a broader interdentum. The exterior lacks sculpturing and the beak is high, inflated, and broad.

Plate 3. False spike *(Quincuncina mitchelli)* and Tampico pearlymussel *(Cyrtonaias tampicoensis)* specimens recovered from site 41MM340.

Figure G-14. Louisiana fatmucket *(Lampsilis hydiana)* – interior and exterior of left valve. Cat. no. 2152-008. This species typically has a rather shallow beak cavity, moderately long pseudocardinal teeth, and lateral teeth that are somewhat more peg-like than the strongly compressed teeth in yellow sandshell *(L. teres)*.

Figure G-15. Unidentified unionid valve – right valve. Cat. no. 1076-002. This specimen is similar to Tampico pearlymussel *(Cyrtonaias tampicoensis)*, but pseudocardinal teeth and other features differ. It also resembles some of the pocketbook mussels *(Lampsilis* spp.*)*, none of which occur in the Brazos basin.

Figure G-16. Broken valve fragments. Fracturing along growth-rest lines may result from heating of the shell, or may occur naturally.

Plate 4. Louisiana fatmucket *(Lampsilis hydiana)* specimen, unidentified unionid valve, and valve fragments recovered from site 41MM340.

Habitat and Species Associations

Among the species found, Louisiana fatmucket is generally associated with shallower waters and washboards typically prefer larger, deeper environments (rivers or lakes), but have been found in smaller streams in the Brazos River drainage, Texas (Howells et al. 1996). However, in some places, like the Guadalupe River, Louisiana fatmuckets have been found along river banks within a few meters of washboards in deeper waters adjacent to the main river channel. Relatively little is known about the habitat preferences of false spike (Howells et al. 1996), beyond comments by Wurtz (1950) who found it at a depth of 61 cm on cobble and mud in the Guadalupe River. False spike, however, probably occupied similar habitats as smooth pimpleback and southern mapleleaf. Otherwise, the remaining species might all be found together, or at least in close proximity, in similar environments ranging from moderately shallow to deeper water, on most substrates (except deep soft silt, deep shifting sand, and scoured bedrock and cobble), and from lotic to moderately swift flow rates (see summaries in Howells et al. 1996). However, none are typical of backwater oxbows, ponds, or sloughs. All require permanent water and are generally intolerant of long-term dewatering.

Most species typical of backwater oxbows, ponds, and sloughs usually have thin shells that are easily damaged and not well suited to preservation. However, some species such as lilliputs (*Toxolasma* spp.) have been documented at other archeological sites in Texas (Howells 1998). Still, the current study did not produce species that suggest unionid harvest had occurred in these habitats. Thus, it remains unclear if thin-shelled species were not present when the site 41MM340 materials were deposited, were selected against and not harvested, or were harvested but remains failed to survive into the present.

Specimen Sizes

Most of the unionid remains discovered were relatively small individuals (based on nearly intact valves and comparing fragment sizes to whole reference specimens). Most specimens were probably less than 30–35 mm in shell length. Threeridge fragments from some of the deeper zones (e.g., 2145-006 from Zone 6 and 1074-005 from Zone 8) may have come from specimens 58–60 mm in shell length (still only moderate size considering the maximum length for the species). One of the washboard fragments likely came from a specimen over 100 mm in shell length, but only three washboard specimens were identified. Recent smooth pimplebacks and false spikes are rarely large and are often found at sizes less than 50 mm. Other species have the potential of growing substantially longer, regularly do so today, and likely did so in the past.

Harvest may have been biased towards smaller specimens that may have been more abundant, more easily collected (e.g., in shallower waters than larger, older animals), or have had soft tissues that were more tender (a consideration in consumption of certain bivalve mollusks at the present). Similarly, high-energy flood conditions may have sorted both unionids and gravels by size and weight, also biasing availability.

Zone (Depth) Associations

When samples were grouped by zone (Table G-2), the uppermost zone produced 60 specimens and Zones 5 and 7 yielded very little unionid material (23 and 26 specimens, respectively). Zones 2, 4, and 6 contained substantially more mussel shell remains (553, 593, and 511, respectively), but Zone 8 exceeded all others with 1,041 total specimens. Among the most abundant taxa (threeridge, smooth pimpleback, false spike, and southern mapleleaf), numbers recovered by zone generally reflected the same pattern as total specimens. Tampico pearlymussel and pistolgrip were most abundant in Zone 8 and absent from Zones 1, 5, and 7. Too few specimens of other species were obtained to allow confident conclusions about their occurrences.

More specimens were taken from the five provenience samples from Zones 2, 3b, 4, 6, and 8 (n = 2,877) than in the 1-m^2 column samples (89; Table G-1). Most species were absent or taken in very small numbers in the column samples, except for threeridge and smooth pimpleback. The distribution pattern of smooth pimpleback among both groups of samples appeared similar with greater abundance in deeper, older layers. In threeridge, a group of 50 specimens recovered from Zone 1b in the column set of samples obscured similar comparisons for that species.

Mussel Reproductive Seasons

Freshwater mussels reproduction (see summary in Howells et al. 1996) involves release of sperm by the male into the water near a female (most species have separate sexes). The female draws the sperm into her mantle cavity with water during breathing and feeding activities. Eggs are fertilized,

Table G-2. Number of Samples Containing Freshwater Mussels (Unionidae) and Number of Specimens by species Recovered from Site 41MM340
(numbers of specimens represent individual valves or valve fragments, not matched pairs of valves of individual animals)

			Species[a]										
	Zone	Mussel samples per zone	Threeridge	Tampico pearlymussel	Louisiana fatmucket	Southern mapleleaf	Smooth pimpleback	False spike	Pistolgrip	Washboard	Bluefer	Unident.	Total
N samples	1	2	2	0	0	0	1	1	0	0	0	0	2
Total			51	0	0	0	8	1	0	0	0	0	60
N samples	2	4	4	3	1	4	4	2	0	1	0	3	4
Total			339	6	1		146	15	0	3	0	25	553
						20							
N samples	3	3	3	1	0	1	3	2	1	0	0	1	3
Total			106	5	0	4	66	7	2	0	0	2	192
N samples	4	4	4	3	1	2	4	4	4	1	0	2	4
Total			335	8	1	24	172	24	6	1	0	22	593
N samples	5	1	1	0	0	1	1	1	0	0	0	0	1
Total			11	0	0	1	9	2	0	0	0	0	23
N samples	6	2	2	1	1	2	21	2	2	1	0	1	2
Total			231	1	1	28	215	28	5	1	0	1	511
N samples	7	1	1	0	0	0	1	0	0	0	0	0	1
Total			5	0	0	0	11	0	0	0	0	0	26
N samples	8	5	5	4	3	5	5	5	4	0	1	1	5
Total			522	13	6	40	399	43	15	0	1	2	1041

[a] Scientific names are: Threeridge (*Amblema plicata*), Tampico pearlymussel (*Cyrtonaias tampicoensis*), Louisiana fatmucket (*Lampsilis hydiana*), southern mapleleaf (*Quadrula apiculata*), Smooth pimpleback (*Quadrula houstonensis*), False spike (*Quincuncina mitchelli*), Pistolgrip (*Tritogonia verrucosa*), Washboard (*Megalonaias nervosa*), and Bleufer (*Potamilus purpuratus*).

then held in pouches, called marsupia, on the female's gills where incubating eggs and hatched larvae, called glochidia, are held until ultimately released. The seasons during which females incubate eggs and young may vary with species. Some have rather short, specific brooding periods and other species may do so throughout the year. Unionid remains in the 41MM340 collection that were most abundant were generally those species with short brooding periods in late spring and early summer. Those that were less abundant either had year-round incubation or brooded during the colder winter months.

Threeridge, smooth pimpleback, and southern mapleleaf in Texas waters are typically gravid in late May, June, and early July (Howells 2000). Further, any individual appears to retain glochidia for relatively short periods. Additionally, these three species are rather sensitive to disturbance and readily abort their marsupial contents when disturbed. Brooding period for false spike is unknown, but likely similar because of its close relationship to spring-spawning quadrulids. As a result, there is a dramatically reduced chance that any given animal will actually be brooding eggs or young when collected, even during their reproductive period.

Tampico pearlymussel, Louisiana fatmucket, and bleufer can apparently carry eggs or young throughout the year locally, while washboard does so in winter (Howells 2000). Females of the first three species may also retain glochidia for extended periods before releasing them and are comparatively resistant to disturbances, often aborting only under extreme stress. Thus, among these taxa, there is an increased likelihood of any given specimen being an incubating female when collected.

Biologists dissecting unionids, shellers removing soft tissue, and pearlers searching for pearls have noted that full marsupia often rupture and release glochidia into the mantle cavity and other soft tissues during cleaning. Glochidial shells form even before hatching. So, when advanced eggs and hatched glochidia are released during dissection, they result in a "sandy" or "gritty" feel when the soft tissues are touched. This could result in an undesirable "gritty" nature to mussel flesh when consumed. Whether eggs and glochidia also impart an unpleasant taste is unknown.

Whether the abundant species were selected over other mussels to avoid consumption of incubating females is uncertain and open entirely to speculation. Still, harvesting the threeridges, smooth pimplebacks, and southern mapleleafs other than in late spring and early summer would have avoided potentially gritty meat.

Occurrence of Burned Materials and Other Indications of Human Manipulation

Mussel valves and valve fragments that appeared to have been burned were also examined by species and zone. Generally, a greater percentage of burned material was present in central and upper layers than in deeper zones (excluding Zone 1 with only a single specimen; Table G-3). No burned material was found in Zones 5 or 7 where there was also a reduced number of specimens. Despite having the greatest number of specimens, Zone 8 had some of the lowest percentages of burned material; however, some burned shell remains were still present.

It should be noted that it is not entirely clear that blackened material was actually burned or whether burning was deliberate (as in cooked specimens) or accidental (a campfire happened to have been constructed on a site that contained shell deposits). However, similarity to burned rock at archeological sites suggests grayed or blackened specimens may indeed have been burned. Additionally, biologists have subjected unionid shells to high temperatures in ovens to cause valves to fracture along growth-rest lines in efforts to age mussels (Neves and Moyer 1988; Sterrett and Saville 1975). Logically, then, shells exposed to high temperatures in campfires might also be expected to break along growth lines as opposed to random fracturing resulting from natural weathering and erosion. Several shell fragments from 41MM340 showed C-shaped breakage patterns consistent with having been heated (Figure G-16). Additionally, some freshwater mussels can close their valves so tightly that it is difficult to insert a steel knife blade. Attempts to pry valves apart with stone tool would have been even more difficult. Smashing mussel shells rarely produces C-pattern fragments. However, living mussels readily gape open when exposed to elevated temperatures. Certainly such C-shaped fragments can and do occur naturally as well and relatively few specimens from the present study demonstrated this pattern. Nonetheless, there is some suggestion a few of the specimens may have been heated.

Beyond a few C-shaped shell fragments, there was little confirmation that any of the material had been manipulated by humans (i.e., whether the specimens had been harvested

Table G-3. Percentage of Burned Freshwater Mussel (Unionidae) Shell Specimens Recovered from Site 41MM340
(blank cells indicate no specimens and 0.0% indicates mussel shell remains were collected but none were burned)

		Unit			Percentage burned by species[a]										
Cat. No.	**Zone**	**N**	**E**	**Level**	**Threeridge**	**Tampico pearlymussel**	**Louisiana fatmucket**	**Southern mapleleaf**	**Smooth pimpleback**	**False spike**	**Pistolgrip**	**Washboard**	**Bleufer**	**Unident.**	**Total % burned**
1834-004	1a	44	14	1	0.0										0.0
1835-005	1b	44	14	1	14.0				0.0	0.0					11.9
487-003	2	41	14	1	7.1	33.3		0.0	14.4	0.0				14.3	8.9
489-002	2	41	14	2	15.4	0.0	0.0	0.0	12.5			33.3		55.6	24.3
1836-009	2	44	14	2	13.6	0.0		25.0	9.1	14.3					12.4
1839-006	2	44	14	3	65.4			0.0	60.0					0.0	59.1
1841-006	3	44	14	1	11.1				50.0					0.0	15.4
2315-008	3b	47	15	1	40.6				0.0	0.0	0.0				29.5
2522-009	3b	47	15	2	15.4	0.0		0.0	5.3	0.0					9.6
539-007	4	41	15	1	13.2	0.0	0.0		33.3	0.0	0.0			42.9	17.9
2138-003	4	44	14	1	30.8				20.0	0.0	0.0				23.1
2142-006	4	44	14	2	12.0	0.0		0.0	4.5	0.0	0.0				7.4
543-006	4	41	15	2	3.2	0.0		0.0	3.8	0.0	0.0	0.0		0.0	3.1
2143-006	5	44	14	1	0.0			0.0	0.0	0.0					0.0
975-006	6	42	15	1	0.5	0.0	0.0	0.0	0.0	15.8	0.0			100.0	1.4
2145-006	6	44	14	1	0.0			0.0	0.0	0.0	0.0				0.0
2147-006	7	44	14	1	0.0				0.0						0.0
2152-008	8	44	14	1	0.0	0.0	0.0	0.0	1.0	0.0	0.0		0.0		0.3
1074-005	8	44	18	1	3.8	0.0	0.0	0.0	2.7	5.0	0.0				3.2
1076-002	8	44	18	2	2.1		0.0	0.0	8.0	0.0	0.0			0.0	4.5
2154-007	8	44	14	2	1.1	0.0		0.0	0.0	0.0	0.0				0.6
2157-007	8	44	14	3	6.3	0.0		0.0	0.0	0.0					3.2

[a] Scientific names are: Threeridge (*Amblema plicata*), Tampico pearlymussel (*Cyrtonaias tampicoensis*), Louisiana fatmucket (*Lampsilis hydiana*), southern mapleleaf (*Quadrula apiculata*), Smooth pimpleback (*Quadrula houstonensis*), False spike (*Quincuncina mitchelli*), Pistolgrip (*Tritogonia verrucosa*), Washboard (*Megalonaias nervosa*), and Bleufer (*Potamilus purpuratus*).

or naturally deposited at the site). All of the specimens recovered were consistent with the morphological forms that now occur in the Brazos and Colorado River basins (forms in both systems are usually morphologically similar). Thus, there was no indication mussels had been brought to the site from other drainage basins like the Guadalupe or Trinity.

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Addendum I
Notes on Mussel Shell Identification

Figures G-17 through G-41 on Plates 5 through 12 are photographs of shells (valves) and beak sculpture of modern unionid specimens. In conjunction with descriptions in Howells et al. (1996), these can assist in identification of mussel valves and fragments from archeological sites. Additional comments are provided with each photograph.

Plates 5 and 6 illustrate beak sculpture patterns among the unionid taxa recovered from 41MM340 as well as yellow sandshell that likely occurred there as well. Like fingerprints, mussel beak sculpture can be an important diagnostic feature in identification. However, the unionid beak is the oldest portion of the shell and hence, often the most worn region. Critical features are frequently exfoliated. Note that sculpture on threeridge beaks is more coarse than on washboard beaks (adults of both species rarely retain any beak sculpture; Figures G-17 and G-18). Smooth pimpleback beak sculpture is also extremely coarse (Figure G-19). Southern mapleleaf has well-defined nodules and ridges, but these are often fewer, and more coarse in pistolgrips (Figures G-20 and G-21). False spike displays a V-shaped, almost double-looped pattern (Figure G-22). Bleufer beaks rarely retain sculpture, but when present, are often in two rows of small nodules, rarely with the nodules connected by slight ridges (Figure G-23). Louisiana fatmucket beaks have a series of wavy ridges resembling very wide V-patterns (Texas fatmucket is very similar; Figure G-24). Yellow sandshell beak sculpture is similar to Louisiana fatmucket, but with finer lines that are more elongate (Figure G-25). The larger beaks in Tampico pearlymussel are largely free from diagnostic sculpturing, aside from the fine growth lines usually present in all unionids (Figure G-26).

Plate 7 illustrates how threeridges and washboards can be similar in appearance. Juvenile and especially heavily sculptured washboards usually display cross-hatch sculpturing on the disk dorsally and below and behind the beak (Figures G-27 and G-28). Threeridges never have cross-hatch sculpturing in the anterior or dorsal fields, though some occasionally have main ridges that may be broken on the central or posterio-ventral disk. Extremely large washboards (Texas and most other regions) usually loose most of their external sculpturing with age, except for the major ridges.

Plate 8 shows smooth pimpleback shells that are rounded and rather strongly inflated, with elevated and inflated beaks (typical of the species; Figures G-29 and G-30). In some areas, juvenile threeridges (and adults in other areas) may either lack major ridges entirely or develop them late in life. Such poorly sculptured threeridges can be confused with pimplebacks. However, threeridges have beaks that are less inflated, right pseudocardinal teeth that are angled posterio-ventrally (not downward) and lack a flat anterior surface, and are purple on the posterio nacre in recent specimens. Golden orb (Figure G-31) has historically been reported from the central Brazos drainage, but such specimens are likely misidentified smooth pimplebacks. Golden orb is more laterally compressed than smooth pimpleback, has a lower beak, and somewhat less massive pseudocardinal teeth.

Plate 9 illustrates how southern mapleleafs can be readily distinguished from pimplebacks by their sculpturing of numerous fine pimples (Figure G-32). These often cover the shell in juveniles, but may be restricted to the dorsal surface in large adults. Pistolgrips are also sculptured with small pimples, but also have other bold lines and ridges, as well as a well-defined posterior ridge (Figure G-33). Pistolgrip is sexually dimorphic with females being very elongate. Males are shorter than females, but still more elongate (more rectangular) than southern mapleleafs. Pseudocardinal teeth are somewhat less massive in pistolgrips.

False spike (Plate 10) is now very rare and nearly extinct. As a result, few specimens have been available for study. External sculpturing suggests it might be confused with a particularly rectangular southern mapleleaf. However, false spike often has vertical grooves on the mid-disk area that distinguish it from most other local unionids (Figure G-34). It became apparent during processing of the 41MM340 material that false spike could be confused with Tampico pearlymussel when viewed from the valve interior (Figures G-35 and G-36). However, false spike has a much smaller, more-pointed and flattened beak, with a relatively shallow beak cavity (high inflated beaks with deep beak cavities in Tampico pearlymussel). The interdentum is more narrow and thinner in false spike.

Plate 11 shows examples of bleufers and Tampico pearlymussels, which can also be similarly confused. Indeed, modern specimens from some sites in the central Brazos drainage are morphologically more alike than elsewhere in their respective ranges (Figure G-37). Tampico pearlymussel has much higher and fuller beaks and deeper beak cavities (Figure G-38). Bleufer has smaller beaks and less deep beak cavities. Lateral teeth in Tampico pearlymussel usually angle downward, but are typically positioned horizontally or even upward in bleufers. Bleufers are also sexually dimorphic with males elongate and round-pointed posteriorly and females more inflated, deeper bodied, and truncate posteriorly. There is little apparent sexual dimorphism in Tampico pearlymussels.

Louisiana fatmucket is also sexually dimorphic with males being more elongate and round-pointed posteriorly and females more inflated and truncate posteriorly. Most Texas populations have fairly heavy, inflated shells (Figure G-39). Some from the upper Trinity River and other areas may be so inflated that they have been confused with pocketbook-type lampsiliids. However, in the Guadalupe-San Antonio and Nueces-Frio systems, Louisiana fatmuckets are thinner shelled and more laterally compressed. Related Texas fatmuckets from the Texas Hill Country and Edwards Plateau are similar, but also have thinner shells than do many Louisiana fatmuckets. Yellow sandshell occurs over the range of both fatmuckets, but is always more elongate (Figures G-40 and G-41).

Figure G-17. Threeridge *(Amblema plicata)*.

Figure G-18. Washboard *(Megalonaias nervosa)*.

Figure G-19. Smooth pimpleback *(Quadrula houstonensis)*.

Figure G-20. Southern mapleleaf *(Quadrula apiculata)*.

Figure G-21. Pistolgrip *(Tritogonia verrucosa)*.

Figure G-22. False spike *(Quincuncina mitchelli)*.

Plate 5. Beak sculpture on selected freshwater mussels (Unionidae).

Figure G-23. Bleufer *(Potamilus purpuratus)*.

Figure G-24. Louisiana fatmucket *(Lampsilis hydiana)*.

Figure G-25. Yellow sandshell *(Lampsilis teres)*.

Figure G-26. Tampico pearlymussel *(Cyrtonaias tampicoensis)*.

Plate 6. Beak sculpture from selected unionid mussels.

Figure G-27. Threeridge (*Amblema plicata;* left) and washboard (*Megalonaias nervosa;* right). The number of ridges in both species may vary. Small washboards often have thinner, more compressed shells than equal-sized threeridges as well as cross-hatch sculpturing in the anterior and dorsal-central regions of the disk that is absent in threeridges. Larger adult washboards may not display this cross-hatch sculpturing. Also at equal shell sizes, threeridges often have more massive pseudocardinal teeth than washboards. Both species may be oval, quadrate, rectangular, or nearly circular.

Figure G-28. Threeridge (*Amblema plicata;* left) and washboard (*Megalonaias nervosa;* right). Among the left pseudocardinal teeth in threeridges, the posterior tooth is often the largest and highest. In washboards, the posterior tooth is often lower and stretched out laterally and the anterior tooth is proportionally larger. Beaks are often somewhat higher in threeridges and beak cavities deeper.

Plate 7. Threeridge *(Amblema plicata)* and washboard *(Megalonaias nervosa)*.

Figure G-29. Smooth pimpleback (*Quadrula houstonensis*) – right and left interior views. The right pseudocardinal tooth (top left) often has its main axis angled downward (not posterio-ventrally) and often displays a nearly flat anterior surface to the tooth. The left pseudocardinal teeth (bottom right) are moderately massive and the anterior tooth is often quadrate and almost-chisel like. Beaks are high and turned forward over a lunule, with deep beak cavities.

Figure G-30. Smooth pimpleback (*Quadrula houstonensis;* left) and juvenile threeridge (*Amblema plicata;* right). Small threeridges with poorly developed ridges can be confused with pimplebacks. In threeridges, the right pseudocardinal tooth angles more posteriorly, beaks are smaller, and the nacre is purple posteriorly (not apparent in the above specimen).

Figure G-31. Golden orb (*Quadrula aurea;* left) and smooth pimpleback (*Q. houstonensis;* right). Historical reports of golden orb from the Brazos drainage are likely incorrect. Golden orb is much less inflated and has a smaller beak and less massive pseudocardinal teeth than smooth pimpleback

Plate 8. Smooth pimpleback (*Quadrula houstonensis*), threeridge (*Amblema plicata*), and golden orb (*Q. aurea*).

Figure G-32. Southern mapleleaf (*Quadrula apiculata;* top) and pistolgrip (*Tritogonia verrucosa;* bottom). Southern mapleleaf may be round, quadrate, oval, or even rectangular, but pistolgrip is far more elongate (rectangular), especially pistolgrip females. Southern mapleleaf beaks are somewhat higher and pseudocardinal teeth heavier.

Figure G-33. Southern mapleleaf (*Quadrula apiculata;* top) and pistolgrip (*Tritogonia verrucosa;* bottom). Pistolgrips heavily sculptured and has a strongly angular posterior ridge in most specimens. Disk sculpturing often decreases with increasing size in southern mapleleafs and the posterior ridge is less pronounced (the specimen above has an exceptionally well-defined posterior ridge).

Plate 9. Southern mapleleaf (*Quadrula apiculata*) and pistolgrip (*Tritogonia verrucosa*).

Figure G-34. False spike (*Quincuncina mitchelli*). This example is typical of most Central Texas specimens. Externally the disk is often sculptured vertical grooves on the mid-disk below and posterior to the beak.

Figure G-35. False spike (*Quincuncina mitchelli*). When viewed externally, sculpture patterns are clearly different from Tampico pearlymussel (*Cyrtonaias* t*ampicoensis*); internally false spike has a interdentum that is narrow to absent and less massive pseudocardinal teeth, with the right tooth angled differently. Beaks are also more narrow, less inflated, and flattened in false spike.

Figure G-36. False spike (*Quincuncina mitchelli*). This species, and some other Central Texas mussels, often have atypically elongate forms called "gravel bar morphs."

Plate 10. False spike (*Quincuncina mitchelli*).

Figure G-37. Bleufer (*Potamilus purpuratus;* top) and Tampico pearlymussel (*Cyrtonaias tampicoensis;* bottom). In equal-sized specimens, pseudocardinal teeth are more massive in Tampico pearlymussel. Beaks are higher and more inflated in Tampico pearlymussel and lateral teeth angle downward. Bleufers have smaller beaks and lateral teeth that are nearly horizontal or angle upward.

Figure G-38. Tampico pearlymussel (*Cyrtonaias tampicoensis;* left) and bleufer (*Potamilus purpuratus;* right). Beak cavities are typically deeper in Tampico pearlymussel and secondary posterior ridges much less apparent.

Plate 11. Tampico pearlymussel (*Cyrtonaias tampicoensis*) and bleufer (*Potamilus purpuratus*).

Figure G-39. Louisiana fatmucket (*Lampsilis hydiana;* left) and Texas fatmucket (*L. bracteata;* right). Although an old historic record lists Texas fatmucket from the central Brazos drainage, its presence in the system is doubtful. Louisiana fatmucket usually has a much heavier and more inflated shell (except in some populations in the lower Guadalupe-San Antonio and Nueces-Frio systems). Texas fatmucket is thinner shelled. Ray patterns in Texas fatmucket are much wider near the margin and do not reach the tip of the beak. In Louisiana fatmucket, rays are more nearly equal in width throughout and often extend on to the beak.

Figure G-40. Yellow sandshell (*Lampsilis teres;* left) and Louisiana fatmucket (*L. hydiana;* right).

Figure G-41. Louisiana fatmucket (*Lampsilis hydiana;* left) and yellow sandshell (*L. teres;* right).

Yellow sandshell is more elongate than Louisiana fatmucket, with more elongate lateral teeth and pseudocardinal teeth more compressed and leaflike. Louisiana fatmucket is more oval than elongate-elliptical and often has pseudocardinal teeth that are thicker and more erect.

Plate 12. Louisiana fatmucket (*Lampsilis hydiana*), Texas fatmucket (*L. bracteata*), and yellow sandshell (*L. teres*).

Appendix H

Gastropod Analysis

Richard W. Fullington

Appendix H: Gastropod Analysis

Richard W. Fullington

Summary

A total of 310 gastropod and bivalve shells was identified from one vertical column (11 levels). Eleven gastropod and two bivalve species representing nine families were identified (Table H-1). All gastropod shells were in excellent condition. The bivalve species, however, were represented only by umbonal fragments and highly broken-up valve fragments. Literature records indicate that a number of the identified species can be found today in the immediate area, with the exception of *Carychium mexicanum* (Cheatum and Fullington 1971, 1973; Fullington and Pratt 1974).

Climatically and environmentally, there appears to have been little change through the time span covered by the examined levels (15–125 cmbs; Table H-2). The site area was heavily forested with a deep leaf litter floor—six of the site species prefer this type of habitat. There were open, grassy areas adjacent to these woods—six of the site species prefer this type of habitat. In summary, The area was a benched terrace with a riparian woodland adjacent to a relatively slow moving stream. *Carychium mexicanum* occurs in deep, constantly moist leaf litter and in moss alongside streams. The two bivalve species are more stream oriented in habitat preference. Individual valve fragments were not counted. Identifiable umbos were found only at depths of 15–35 cmbs. Many valve fragments occurred in the samples from depths 15–55 cmbs. From depths of 55–125 cmbs, very few to no fragments were found in the samples.

There are no clear environmental or climatic trends evident from the individual species or changes in population numbers downward through the recovered column, other than indications of a drying trend. The bivalve valve fragment numbers and total number of gastropods per level decline downward, particularly from 105–125 cmbs (Table H-2).

Methodology

Samples were recovered from flotation processing and fine screening. The shells were examined through a standard field microscope (20x).

Table H-1. Mollusca Species Identified from 41MM340

	Sample #s										
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Helicina orbiculata tropica	5	11	8	7	6	4	5	5	8	2	1
Rabdotus dealbatus dealbatus	4	3	4	3	5	8	6	9	5	3	2
Polygyra mooreana	3	2	1	1	2	1	3				1
Carychium mexicanum		2	1	2	2	4		2			
Strobilops texasiana	6	5	7	4	7	6	8	8	5	3	
Gastrocopta contracta		3	2	1	3	5	3	7	6		4
Gastrocopta pellucida hordeacella		2			1			2			
Zonitoides arboreus		1			2	2	1	2	1	2	
Hawaiia minuscula		3	3	1	4	3	4	4	5	4	3
Helicodiscus parallelus		2	1	1	2	1	4	3	2	2	1
Glyphyalinia sp.									1	2	
Llampsilis teres	1	1									
Quadrula sp.	1					1					
Unionid fragments	many	many	many	many	few	some	few		very few		

Table H-2. Species and Number of Specimens by Level

Depth (cmbs)	H. o.t.	R. d.d.	P. m.	C. mex.	S. tex.	G. con.	G. p.h.	Z. a.	H. m	H. p.	G. I.p.	L. t.	Q. sp.	Unionid frags.	Total Specimens	Total Species/Level
15-25	5	4	3		6							1	1	many	20	6
25-35	11	3	2	2	5	3	2	1	3	2		1		many	35	11
35-45	8	4	1	1	7	2	1		3	1				many	28	8
45-55	7	3	1	1	4	1			1	1				many	19	8
55-65	6	5	2	2	7	3	1	2	4	2				few	34	10
65-75	4	8	1	4	6	5		2	3	1				few	34	9
75-85	5	6	3		8	3		1	4	4				few	34	8
85-95	5	9		2	8	7	2	2	4	3					42	9
95-105	8	5			5	6		1	5	2	1			few	33	8
105-115	2	3			3			2	4	2	2		1		19	8
115-125	1	2	1			4			3	1					12	6
Totals	**62**	**52**	**14**	**12**	**59**	**34**	**6**	**11**	**34**	**19**	**3**	**2**	**2**		**310**	

Site Mollusca

GASTROPODA

Family Carychiidae
Carychium mexicanum Pilsbry

Family Pupillidae
Gastrocopta contracta (Say)
Gastrocopta pellucida hordeacella (Pilsbry)

Family Zonitidae
Zonitoides arboreus (Say)
Hawaiia minuscula (Binney)
Glyphyalinia sp.

Family Helicinidae
Helicina orbiculata tropica (Say)

Family Endodontidae
Helicodiscus parallelus (Say)

Family Polygyridae
Polygyra mooreana (Binney)

Family Bulimulidae
Rabdotus dealbatus dealbatus (Say)

Family Strobilopsidae
Strobilops texasiana (Pilsbry & Ferriss)

BIVALVIA

Family Unionidae
Lampsilis teres (Rafinesque)
Quadrula sp.

Data Analysis

The gastropod shells examined from the site appear to have been primarily deposited *in situ* and not from flood deposition.

Habitat Preferences

Densely wooded forest with deep, moist leaf litter and fallen logs:
Strobilops texasiana
Helicodiscus parallelus
Hawaiia minuscula
Gastrocopta contracta

Open grassy areas to sparsely wooded areas:
Rabdotus dealbatus dealbatus
Polygyra mooreana
Helicina orbiculata tropica
Gastrocopta pellucida hordeacella
Zonitoides arboreus

Moss adjacent to flowing water to very moist forest floor:
Carychium mexicanum

Relatively shallow riffle streams with intermittent silt bottom pools:
Lampsilis teres

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1974 Bulletin 1 The Aquatic and Land Mollusca of Texas. Part Three: The Helicinidae, Carychiidae, Achatinidae, Bradybaenidae, Bulimulidae, Cionellidae, Haplotrematidae, Helicidae, Oreohelicidae, Spiraxidae, Streptaxidae, Strobilopsidae, Thysanophoridae, Valloniidae (Gastropoda) in Texas. DMNH, Dallas.

Appendix I

^{18}O and ^{13}C Isotopes

Raymond P. Mauldin

Appendix I: ^{18}O and ^{13}C Isotopes

Raymond P. Mauldin

Table I-1 presents the ^{18}O and ^{13}C delta values for 21 samples taken from five different individual mussel shells. All samples are from the genus *Quadrula*. The modern shell, with nine individual readings, was collected from the Little River drainage in 2001. The three prehistoric specimens, with 12 readings, were collected during data recovery at 41MM340. Table I-2 presents the ^{18}O and ^{13}C delta values for 30 individual samples from the genus *Rabdotus*. Two of these samples are modern and were collected from the Little River drainage in 2003. The remaining 28 samples come from individual snails collected during data recovery at 41MM340.

All samples were processed in the CAR laboratory. For the mussels, the shell was drilled and the resulting shavings were ground. For the snails, individual shells were crushed and then more finely ground. All samples were sent for analysis to Dr. Ethan Grossman, Department of Geology at Texas A&M University. Based on the reruns of the same sample identified in Table I-1, Dr. Grossman reports that the precision on standards for the delta ^{18}O readings is ± 0.07 per mill. For the purposes of analysis reported in Chapter 9, mussel samples with multiple runs on a given sample were averaged to provide a single value. For example, specimen nos. 25583 and 25593, both taken from a single drill location

Table I-1. Oxygen 18 and Carbon 13 Isotopic Values for 41MM340 Mussel Shell (*Quadrula*)

Sample	Spec. #	Sample Identification #	δ ^{13}C vs. PDB	δ ^{18}O vs. PDB	Context	Depth
1	25580	LR-1	-6.41	-2.13	Modern	-
1	25581	LR-2	-7.44	-3.15	Modern	-
1	25582	LR-3	-9.54	-4.43	Modern	-
1	25583	LR-4	-7.73	-2.65	Modern	-
1	25593	LR-4 (DUP)	-7.75	-2.57	Modern	-
1	25584	LR-5	-8.26	-4.00	Modern	-
1	25591	LR-6	-8.75	-2.15	Modern	-
1	25586	LR-7	-8.72	-2.38	Modern	-
1	25589	LR-8	-8.24	-3.77	Modern	-
1	25594	LR-8 (DUP)	-8.27	-3.74	Modern	-
1	25592	LR-9	-9.21	-3.87	Modern	-
2	28872	LR 487-003-2A	-7	-3.69	Prehistoric	15-20 cmbd
2	28873	LR 487-003-2B	-7.91	-3.32	Prehistoric	15-20 cmbd
2	28965	LR 487-003-2C (RERUN)	-7.56	-3.7	Prehistoric	15-20 cmbd
2	28874	LR 487-003-2C	-7.69	-3.99	Prehistoric	15-20 cmbd
2	28886	LR 487-003-2C/(DUP)	-7.52	-3.66	Prehistoric	15-20 cmbd
3	28875	LR 2142-006-4A	-8.51	-3.53	Prehistoric	58-68 cmbd
3	28876	LR 2142-006-4B	-7.81	-3.65	Prehistoric	58-68 cmbd
3	28877	LR 2142-006-4C	-7.95	-3.57	Prehistoric	58-68 cmbd
3	28889	LR 2142-006-4C (DUP)	-7.96	-3.52	Prehistoric	58-68 cmbd
4	28878	LR 2143-006-5A	-8.69	-3.88	Prehistoric	68-78 cmbd
4	28881	LR 2143-006-5B	-3.34	-8.34	Prehistoric	68-78 cmbd
4	28882	LR 2143-006-5C	-7.69	-3.72	Prehistoric	68-78 cmbd
4	28890	LR 2143-006-5C (DUP)	-7.8	-3.85	Prehistoric	68-78 cmbd
5	28966	LR 2154-007-8A (RERUN)	-7.67	-3.19	Prehistoric	91-112 cmbd
5	28883	LR 2154-007-8A	-7.67	-3.17	Prehistoric	91-112 cmbd
5	28884	LR 2154-007-8B	-7.71	-3.97	Prehistoric	91-112 cmbd
5	28967	LR 2154-007-8C (RERUN)	-7.73	-3.64	Prehistoric	91-112 cmbd
5	28885	LR 2154-007-8C	-7.75	-3.53	Prehistoric	91-112 cmbd
5	28891	LR 2154-007-8C (DUP)	-7.8	-3.78	Prehistoric	91-112 cmbd

on a single specimen (LR-4), were averaged to arrive at a value for that particular drill hole on shell LR-4. The resulting 21 readings, then, represent averages derived from the 30 samples listed in Table I-1.

Table I-2. Oxygen 18 and Carbon 13 Isotopic Values for 41MM340 Snail Shell (*Rabdotus*)

Spec. #	Sample Identification #	13/12-C	18/16-O	Sample Type	Zone
31290	00-00-0-0-A/MAULDIN	-12.73	-1.28	Modern	na
31339	00-00-0-0-B/RERUN	-12.90	-1.72	Modern	na
31292	49-15-2-1-C	-9.81	-1.23	Prehistoric	2
31293	49-15-2-1-E	-9.48	-1.24	Prehistoric	2
31294	49-15-2-2-A	-9.91	-1.56	Prehistoric	2
31295	49-15-2-2-B	-9.32	-1.33	Prehistoric	2
31296	49-15-2-2-D	-9.51	-1.25	Prehistoric	2
31299	49-15-3B-1-A	-9.55	-1.72	Prehistoric	3b
31300	49-15-3B-1-B	-9.72	-1.62	Prehistoric	3b
31301	49-15-3C-1-A	-9.64	-1.46	Prehistoric	3c
31302	49-15-3C-1-B	-10.55	-1.19	Prehistoric	3c
31315	49-15-4-1-A	-9.40	-0.75	Prehistoric	4
31340	49-15-4-1-B/RERUN	-9.43	-1.55	Prehistoric	4
31305	49-15-4-1-C	-10.02	-0.28	Prehistoric	4
31306	49-15-4-1-D	-10.05	-1.18	Prehistoric	4
31309	49-15-4-1-E	-9.03	-2.56	Prehistoric	4
31342	49-15-6-1-A/RERUN	-8.59	-1.24	Prehistoric	6
31311	49-15-6-1-B	-9.25	-1.36	Prehistoric	6
31312	49-15-6-1-C	-9.36	-1.24	Prehistoric	6
31323	49-15-6-1-D/MAULDIN	-7.93	-0.85	Prehistoric	6
31324	49-15-6-1-E	-6.94	-1.28	Prehistoric	6
31325	49-15-7-1-A	-6.74	-1.01	Prehistoric	7
31326	49-15-7-1-B	-8.15	-1.66	Prehistoric	7
31327	49-15-7-1-C	-9.56	-0.53	Prehistoric	7
31328	49-15-7-1-D	-8.32	-1.73	Prehistoric	7
31329	49-15-8-1-A	-9.63	-1.89	Prehistoric	8
31332	49-15-8-1-B	-9.61	-0.87	Prehistoric	8
31333	49-15-8-1-C	-8.45	-0.74	Prehistoric	8
31334	49-15-8-1-D	-9.07	-1.44	Prehistoric	8
31335	49-15-8-1-E	-8.44	-2.06	Prehistoric	8

Appendix J

Feature Descriptions

Bruce K. Moses and Matthew J. Senn

Appendix J: Feature Descriptions

Bruce K. Moses and Matthew J. Senn

Feature 1

Feature 1 was encountered between 29 and 36 cmbd in Unit N41/E15, stratigraphic Zone 2. Charcoal flecks and small nodules of burned clay were concentrated in the soil matrix and delimited this feature. This feature had an irregular, asymmetrical shape approximately 55 cm wide and 50 cm long. The northern boundary of the concentration appeared to merge with the north edge of the excavation unit, but the feature's presence was negligible in adjacent units. Within the feature, charcoal, burned clay, burned rock, and burned mussel shells were recovered. There were no discernible differences between the color and texture of the soil matrix within the bounds of the feature and that of the rest of stratigraphic Zone 2. This feature was determined to be within Analytical Unit 2.

Feature 2

Burned clay nodules within an area of discolored soil served to delimit this thermal feature in Unit N41/E11, stratigraphic Zone 4. The feature had an irregular shape and ranged from 20 to 25 cm in diameter. Although a top elevation was not provided, the feature was described as shallow, its base being noted at 62 cmbd. The eastern edge of the feature intrudes approximately 5 cm into Unit N41/E12. Fire-cracked rock and charcoal samples were recovered from within the feature fill. This feature was determined to be within Analytical Unit 4.

Feature 3

This was an irregularly shaped burned rock cluster encountered in Units N41/E13-14, stratigraphic Zone 4. The feature measured 110 by 70 cm and extended partially into the balk of a mechanical trench. The cluster of burned rock was found exclusively in stratigraphic Zone 4, Level 1, between 57 and 62 cmbd. Fragments of bone, charcoal, debitage, and mussel shells were present within the feature matrix. This feature was determined to be within Analytical Unit 4.

Feature 4

This was a small circular thermal feature encountered in the northeastern corner of Unit N41/E15, stratigraphic Zone 4. It was delimited by a concentration of charcoal and burned earth. The feature was approximately 30 cm in diameter and was found exclusively in stratigraphic Zone 4, Level 1. Multiple carbon samples were collected between 57 and 64 cmbd. Mussel shell specimens also were noted and recovered from the feature fill. This feature was determined to be within Analytical Unit 4.

Feature 5

This burned rock feature, encountered in Units N42-43/E11, stratigraphic Zone 4, consisted of a concentration of burned rock and small (<1 cm) burned clay fragments present in two adjoining units. The feature was semi-elliptical, approximately 50 cm by 60 cm in size and rested between 69–80 cmbd. A few small (<2 cm) fire-cracked rocks and mussel shell fragments were recovered from the upper portions of this feature while rocks greater in size, along with a complete mano, were found in lower portions of the feature. This feature was determined to be within Analytical Unit 4.

Feature 6

Feature 6 was a thermal feature encountered in Unit N41/E12, stratigraphic Zone 8. The feature's bounds were delimited by a concentration of burned mussel shell and charcoal. The feature ranged from 30 to 45 cm in maximum dimension. A cluster of burned clay and a fragment of bone were visible near where the feature's edge contacted the east wall of the unit. The concentration ranged between 107 and 110 cmbd. This feature was determined to be within Analytical Unit 6.

Feature 7

Within Unit N41/E13, stratigraphic Zone 8, a particularly concentrated area of burned material was isolated as a thermal feature. The feature ranged from 45 to 55 cm in maximum dimension. The charred materials were isolated between 99 and 108 cmbd, but no burned clay or fire-cracked rocks were observed. A single bone specimen was recovered *in situ* at 104 cmbd and was associated with some burned shell. This feature was determined to be within Analytical Unit 6.

Feature 8

Feature 8 was a thermal feature delimited by a perimeter of dark, stained soil in the western half of Unit N43/E11, stratigraphic Zone 4. The western edge of the feature was lost in a mechanical trench, but the remainder was roughly elliptical in shape. The area of the stain varied between 35 and 45 cm in diameter and terminated at 95 cmbd. Charcoal, bone fragments, debitage, and burned clay were recovered from this feature. This feature was determined to be within Analytical Unit 4.

Feature 9

In the southwest corner of Unit N41/E12, stratigraphic Zone 8, a thin concentration of burned material was identified at 106 cmbd. The feature consisted of a thin layer of burned clay and scattered charcoal in association with mussel shells and a single bone fragment. The roughly elliptical feature measured approximately 30 by 60 cm and appeared to extend into Unit N41/E11. Much of the feature was lost when the edge of the unit collapsed during heavy rains. This feature was determined to be within Analytical Unit 6.

Feature 10

Feature 10 consisted of the bones of a large mammal concentrated in the west wall of Unit N42/E12, stratigraphic Zone 2. The feature was isolated between 24 and 27 cmbd and was approximately 20 cm long and 10 cm wide. Three large bones associated with this feature were identified in the field as bison based on the cortical thickness and overall size. The contents of the feature were lost in the field. This feature was determined to be within Analytical Unit 2.

Feature 11

This was a thermal feature that occupied the majority of Unit N42/E13, stratigraphic Zone 2. Fully 60% percent of the southwestern portion of this unit contained assorted burned debris between 30 and 38 cmbd. The feature may have extended into adjacent units but its presence was too ephemeral to distinguish it from the surrounding matrix. The feature contained large concentrations of burned rock, burned clay, lithic debris, and burned as well as unburned mussel shells. This feature was determined to be within Analytical Unit 2.

Feature 12

This burned rock cluster was present in four Units: N42-43/E14-15, stratigraphic Zone 2. Charcoal flecking and burned clay was associated with and surrounded the burned rock cluster. The feature had an irregular shape and measured roughly 160 by 120 cm in maximum dimensions. Within this general area of thermal activity there were two identifiable clusters of burned rock. In the westernmost portion of the feature was a dense gravel lens approximately 20 cm wide, 40 cm long, and no more than 7 cm thick. The upper half of the gravel lens was burned while the lower half remained unaltered, but in close association to burned clay. A second cluster of burned rock was noted in the southeastern portion of the feature. This concentration was composed of several large (4–6 cm) burned rocks. Like the burned gravel lens, this cluster of burned rock was associated with burned material characteristic of the feature fill. The feature material was predominantly charcoal and burned clay with some burned mussel shells. There were no discernible differences in the texture of the fill compared to the rest of stratigraphic Zone 2. It is possible that the feature was associated with the super-positioned strata (stratigraphic Zone 1b) and was intrusive into stratigraphic Zone 2. This feature was determined to be within Analytical Unit 2.

Feature 13

This burned rock cluster encompassed four excavation units (N48-49/E11-12) in stratigraphic Zone 2. The feature was delimited by the perimeter of a dark stain and a burned rock cluster. The feature was roughly elliptical and varied between 75 and 95 cm in diameter. The feature's uppermost extent occurred at 20 cmbd and the burned rock cluster descended 21 cm (to 41 cmbd) at its deepest extremity. The discolored soil persisted into Level 3 and terminated at 44 cmbd. There was a dense cluster of large (5 cm or less) burned rocks in the center of the feature associated with a charcoal concentration. There were also large amounts of burned clay, complete *Rabdotus* snail shells, and some lithic debris in the burned rock cluster. Unburned bone was collected from the deeper portions of the feature, but burned mussel shell was prevalent throughout. This feature was determined to be within Analytical Unit 2.

Feature 14

Feature 14 was a sparse burned rock cluster found in two adjacent excavation units: N46-47/E11, stratigraphic Zone 3b. The cluster was roughly elliptical and measured approximately 40 by 45 cm. The feature was located between 32 and 35 cmbd. The materials recovered from this feature included fire-cracked rocks, lithic debris, mussel shells, burned clay, and charcoal. This feature was determined to be within Analytical Unit 3.

Feature 15

Feature 15, identified within stratigraphic Zone 3b of Unit N47/E11, consisted of an area of burned rock in association with burned clay and charcoal. This feature was roughly elliptical and measured approximately 60 by 30 cm, ranging in depth between 32 and 49 cmbd. The feature contained large quantities of charcoal, fire-cracked rock, and burned clay. Lithic debris and mussel shells were also present in low densities.

A smaller area within Feature 15 was dominated by burned clay and just below this concentration, at 43 cmbd, a projectile point was found in a horizontal position in close contact with a vertical crack running through the entire feature. This feature was determined to be within Analytical Unit 2.

Feature 16

This feature was an area of concentrated fire-cracked rock that was present in two excavation units: N44-45/E11, stratigraphic Zone 4. The cluster was approximately 100 cm long by 60 cm wide, and was excavated between 56 and 67 cmbd. Mussel shells and small amounts of lithic debris were observed during excavation. An elliptical charcoal stain was also noted approximately 2 cm beneath the southern half of the burned rock cluster. The stain measured about 35 by 40 cm, and continued to a depth of 74 cmbd. This feature was determined to be within Analytical Unit 4.

Feature 17

This was a burned clay concentration in stratigraphic Zone 8 located in the northeast center of excavation Unit N42/E13 and extended westward into N42/E12. Feature 17 was elliptical, measuring approximately 100 by 50 cm, ranging between 99 and 120 cmbd. Charcoal and snail specimens were noted during excavation of this feature. This feature was determined to be within Analytical Unit 6.

Feature 18

Feature 18 was a large burned rock cluster identified in at least three excavation units—N46-47/E11, and a small portion of Unit N47/E12. The feature included an intrusive pit associated with stratigraphic Zone 4 that persisted through a total of four arbitrary 10-cm levels. The dimensions of the feature were irregular, measuring approximately 150 cm by 100 cm. Dense clusters of burned clay nodules of varying size from less than 1 cm to 10 cm delimited the perimeter of the feature. An unknown fraction of the western part of the feature was lost during mechanical trenching.

The shallowest extent of the feature was in the central portion of Unit N46/E11 where it persisted between 57 and 68 cmbd. At the southern edge of Unit N47/E11, the feature descended to 75 cmbd, reaching a maximum depth of 100 cmbd in the central portion of that unit. The contents of the feature fill were characteristic of intense thermal activity—burned rock, burned gravel, and charcoal. The feature also contained material consistent with that found in stratigraphic Zones 3d and 4—lithic debris and mussel shell. The thermal material was particularly intense in a 20 cm by 30 cm area in the northeast corner of N46/E11, exhibiting dense charcoal concentrations and bright orange burned clay. A bone awl fragment was found in close proximity to the southeast extremity of the feature between 62 and 71 cmbd. The context of the tool is uncertain; the awl was oriented almost vertically and displayed no definite signs of burning which would associate it with the intense thermal activity of this feature. This feature was determined to be within Analytical Unit 4.

Feature 19

Dominating most of Unit N42/E13, stratigraphic Zone 8, was a charcoal concentration within a dark stained area of soil. The stained soil was roughly circular, varying between 55 and 65 cm in diameter. The feature was defined between 85 and 95 cmbd. In addition to the charcoal, burned clay was also prevalent throughout the feature fill, as well as river-worn gravels. Some mussel shell was observed on the periphery of the stain, but was not typical of the feature fill. This feature was determined to be within Analytical Unit 6.

Feature 20

In the north-central portion of Unit N44/E11, stratigraphic Zone 8, a charcoal and burned clay concentration was identified. The feature was delineated as an irregular ellipse between 18 and 19 cm in diameter, and isolated between 104 and 109 cmbd. The feature fill was devoid of material except some isolated burned rocks and a mussel shell. The feature appeared to extend into Unit N45/E11 but was not defined in that unit. This feature was determined to be within Analytical Unit 7.

Feature 21

Feature 21 was an intrusive pit feature containing charcoal and burned clay. The feature was identified between 109 and 126.5 cmbd within the northeastern portion of Unit N46/E11, stratigraphic Zone 8. The feature had an elliptical shape and measured between 50 cm and 65 cm in diameter. The bulk of the pit descended no further than 115 cmbd, but a single isolated circular depression, approximately 20 cm in diameter, was identified in the western portion of the feature and descended another 11.5 cm. The feature fill was consistent with that of the matrix in the rest of stratigraphic Zone 8. This feature was determined to be within Analytical Unit 6.

Feature 22

A high concentration of burned clay along with some burned rock were the primary materials present in Feature 22. It was delimited by a dark charcoal stain in the southern half of the east wall of Unit N49/E11. The feature was associated with stratigraphic Zone 3b at a depth of 50–52 cmbd. The plan view of the unit shows a concentration of charcoal within the feature. Feature 22 appeared to extend into Unit N49/E12 but was not defined in that unit. This feature was determined to be within Analytical Unit 4.

Feature 23

This sizable pit feature was identified in three units—N42-43/E14 and N43/E15, stratigraphic Zone 4. The feature was likely present in a fourth unit located to the southeast, but its presence was not evident enough to be distinguished from the general matrix in stratigraphic Zone 4. The feature was delimited by a dense concentration of burned materials including burned rock, charcoal, and burned clay. The pit measured approximately 90 by 160 cm in maximum dimension. The feature was first encountered at 65 cmbd and continued down to 108 cmbd. In addition to the burned materials characteristic of the pit feature, there were mussel shells, bone fragments, lithic debris, *Rabdotus* shells, and a bone tool recovered from the feature fill. The southern portion of the feature was lost in a wall collapse following heavy rains. This feature was determined to be within Analytical Unit 4.

Feature 24

Feature 24 consisted of a burned rock cluster in association with a loose a matrix of river-worn pebbles in Unit N47/E11. Encountered between 81 and 92 cmbd and included in stratigraphic Zone 8, this feature was roughly circular, ranging between 25 and 30 cm in diameter. The stones comprising the feature varied between 2 and 5 cm in size. The feature fill was otherwise similar to the matrix of the associated stratigraphic zone. The associated concentrations of gravel suggest alluvial processes heavily impacted this feature. This feature was determined to be within Analytical Unit 6.

Feature 25

This thermal pit feature, comprised largely of charcoal and burned clay, was identified in stratigraphic Zone 8 between 111 and 137 cmbd. Identified in the northeast corner of Unit N47/E11, Feature 25 was irregularly shaped and measured approximately 45 by 60 cm in maximum dimension. The upper portion of the feature contained high concentrations of burned clay, otherwise, the feature fill consisted of material typical of stratigraphic Zone 8: burned rock, charcoal, and mussel shell. The feature's eastern edge appeared to extend into Unit N47/E12, but was not defined in that unit. This feature was determined to be within Analytical Unit 6.

Feature 26

Feature 26 was a burned rock cluster encompassing the greater part of Unit N43/E13, stratigraphic Zone 2. While the feature was dispersed across an irregular area approximately 70 cm by 80 cm, it was not identified in any of the adjacent excavation units. Burned rock and other materials characteristic of stratigraphic Zone 2 were recovered from the feature between 25 and 35 cmbd. The feature lacked any discernible morphology, and extensive vertical cracks through the main body of the feature suggest that some of the material may be out of context. This feature was determined to be within Analytical Unit 2.

Feature 27

This was a circular burned rock cluster located in the center of Unit N43/E13, situated between 70 and 73 cmbd in stratigraphic Zone 6. The cluster was roughly circular and varied in size between 45 and 48 cm in diameter. Also associated with the burned rock were mussel shells, burned clay, charcoal, and a linear concentration of gravel originating inside the cluster and fanning out toward the east. This feature was determined to be within Analytical Unit 4.

Feature 28

Feature 28 was an elliptical concentration of burned clay, charcoal and few burned rocks identified in the southern portion of Unit N44/E12, stratigraphic Zone 8. The feature measured approximately 35 by 55 cm. It was identified between 96 and 106 cmbd and intruded into stratigraphic Zone 9. The feature's southern edge appeared to extend into Unit N44/E11, but was not defined in that unit. This feature was determined to be within Analytical Unit 6.

Feature 29

This feature was a charcoal and burned clay concentration in the northeast quadrant of Unit N44/E12, stratigraphic Zone 8. The feature was circular, being approximately 30 cm in diameter. In comparison to other features of this type, Feature 29 contained relatively high concentrations of charcoal and conversely low quantities of burned clay. This feature was recorded between 103 cmbd and 110 cmbd. The cross-section of the feature indicated the deepest point of the feature was at its center, becoming shallower at its periphery. This feature was determined to be within Analytical Unit 6.

Feature 30

Feature 30 was an area of concentrated charcoal and burned clay in the southeast quadrant of Unit N43/E13, stratigraphic Zone 8. A small fraction (<8%) of this feature crossed into the adjacent eastern excavation unit. The concentration formed an irregular ellipse and varied between 55 and 65 cm in diameter. The feature was first identified at 103 cmbd and extended to a depth of 115 cmbd. The predominant materials within the feature were charcoal and burned clay, but other materials including burned rocks and burned mussel shells were also present. This feature was determined to be within Analytical Unit 7.

Feature 31

Feature 31 consisted of two irregular concentrations of burned rock in close proximity to one another. Initially encountered during excavation in Unit N47/E13, stratigraphic Zone 2, the feature was later found to extend northward into Unit N48/E13. The larger of the two concentrations measured approximately 80 by 55 cm wide and included mussel shells, burned clay and charcoal. The second concentration, located in Unit N48/E13, consisted of a loose assemblage of burned rocks approximately 30 cm in diameter. The overall size of Feature 31 was 90 cm by 120 cm. This feature was isolated between 27 and 35 cmbd. The material observed within the feature was consistent with that typical of stratigraphic Zone 2. Increased quantities of *Rabdotus* snail shells were observed within the larger concentration of this feature, but were not noted in association with the secondary smaller concentration. This feature was determined to be within Analytical Unit 2.

Feature 32

This was a small circular concentration of burned clay, charcoal, and snail shell associated with a river-worn cobble in the northwestern corner of Unit N49/E13, stratigraphic Zone 9. The burned clay concentration appeared to be delimited to 25 cm in diameter. The feature was identified between 114 and 135 cmbd. It is likely that Feature 32 extends toward the north, outside of the excavated area. This feature was determined to be within Analytical Unit 7.

Feature numbers 33 and 34 were not assigned.

Feature 35

Feature 35, a burned rock cluster, dominated the northern half of Unit N44/E16, stratigraphic Zone 1b. The feature measured 35 by 65 cm and appeared to extend into Unit N45/E16. Feature material was recovered between 16 and 26 cmbd and included burned clay, charcoal and shell. This feature was determined to be within Analytical Unit 2.

Feature 36

This burned rock cluster was initially encountered during excavations in Unit N48/E13, stratigraphic Zone 8, between 98 and 110 cmbd. Feature 36 extended to the east through Units N47-48/E14 and into N48/E15, stretching to a maximum length of almost 200 cm. The widest point in the cluster measured approximately 100 cm and covered portions of Units N48/E14 and N47/E14. In addition to burned rock, mussel shells and burned clay were common and lithic debitage was also recovered. This feature was determined to be within Analytical Unit 6.

Feature 37

Feature 37 was an irregularly shaped burned rock cluster identified in the western and central portions of Unit N47/E14, stratigraphic Zone 3d. The assemblage was concentrated in a 65-cm-long by 30-cm-wide area. The feature was identified between 42 and 54 cmbd, and the mean size of burned rocks was between 4 and 5 cm. Mussel shell, characteristic of stratigraphic Zone 3b, was noticeably absent from the feature fill. Burned rocks in the center of the loose scatter were noted as being significantly smaller (<3 cm) than those in the rest of the cluster. This feature was determined to be within Analytical Unit 2.

Feature 38

Determined not to be a separate feature upon analysis in the laboratory.

Feature 39

Excavated between 107 and 112 cmbd (stratigraphic Zone 8) in Units N46/E14 and N46/E13, material recovered from Feature 39 included burned rocks, burned clay, charcoal, lithic debris, and unburned mussel shell. The feature measured approximately 60 cm by 70 cm and appeared to extend southward into Unit N45/E14. The matrix within the feature was heavily mottled in color and significant amounts of *Rabdotus* snail shell were observed at the feature's periphery. Portions of the feature appeared to extend into Unit N44/E11, but the feature was not defined in that unit. This feature was determined to be within Analytical Unit 6.

Feature 40

Determined not to be a feature upon analysis in the laboratory.

Feature 41

This burned rock cluster was present in four adjoining units—N46-47/E13 and N46-47/E14, stratigraphic Zone 4. A large (50 cm by 30 cm) flat metate was also identified at the edge of Feature 41 at 76 cmbd and appeared to be associated with the feature. Feature 41 measured approximately 75 by 80 cm. The burned rock cluster was distributed evenly across a relatively horizontal plane between 71 and 93 cmbd. An ovoid area of mottled soil, 42 cm in diameter and 12 cm thick, was observed in association with the cluster. Very few artifacts were observed in association with the burned rock cluster, but within the mottled soil lens, burned clay, charcoal, some burned rock fragments, and *Rabdotus* shells were present. A single flake was recovered from this feature. This feature was determined to be within Analytical Unit 4.

Feature 42

Feature 42 was an irregularly shaped burned rock cluster located in the northern half of Unit N46/E14, stratigraphic Zone 3b. The feature measured 55 by 70 cm and appeared to cross into adjacent Units N46/E15 and N47/E14, although it was not defined in those units. The feature was isolated between 38 and 69 cmbd, intruding into stratigraphic Zone 4. The soil within the feature was distinctly darker than that of the matrix in the associated stratigraphic zone. Burned clay was the prominent material observed in the fill and the bottom of the feature was rounded. This feature was determined to be within Analytical Unit 2.

Feature 43

Determined not to be a feature upon analysis in the laboratory.

Feature 44

This feature was a cluster of burned rock and charcoal varying between 40 and 45 cm in diameter located in the east-central portion of Unit N45/E16, stratigraphic Zone 6. The upper dimensions of the feature began at 78 cmbd and persisted to 86 cmbd. There were mussel shells and burned clay found in association with the feature. This feature was determined to be within Analytical Unit 6.

Feature 45

Determined not to be a separate feature upon analysis in the laboratory.

Feature 46

This was a burned rock feature in the northeast quadrant of Unit N45/E14, stratigraphic Zone 2. The cluster had an irregular, elongated shape, approximately 50 cm long and 20 cm wide, oriented north-south. The feature material was isolated between 35 and 42 cmbd. The material associated with the feature fill included mussel shells, burned clay, charcoal, and lithic debris. Portions of Feature 46 appeared to extend into Unit N45/E15, but were not defined in that unit. This feature was determined to be within Analytical Unit 2.

Feature 47

This was a somewhat circular burned rock cluster identified in four adjoining units: N46-47/E13-14, stratigraphic Zone 9. The diameter of the cluster varied between 100 and 130 cm and ranged in depth from 116 to 125 cmbd. The perimeter of the cluster was indistinct and there was evidence of bioturbation. Mussel shells and lithic debris identified in the northeastern portion of the feature may indicate the intrusion of stratigraphic Zone 8 into the feature. This feature was determined to be within Analytical Unit 7.

Feature 48

This feature was a burned rock cluster identified in four adjoining units: N44-45/E18-19, stratigraphic Zone 2. The feature had an elliptical shape and measured approximately 130 cm by 170 cm. It was defined between 26 and 40 cmbd. Burned gravel and fire-cracked rock (sandstone) were the predominant materials recovered from the feature. Burned lithic debris was also found in association with the feature, as well as unburned mussel shell, heat spalls, and burned clay. This feature was determined to be within Analytical Unit 2.

Feature 49

Feature 49 was an irregularly shaped burned rock cluster identified within two heavily eroded units, N45-46/E15, in stratigraphic Zone 6. The cluster was approximately 120 cm long and 45 cm wide. The feature was recorded between 77 and 88 cmbd. Two bone specimens as well as charcoal and burned clay were recovered from the feature fill. This feature was determined to be within Analytical Unit 6.

Feature 50

Determined not to be a separate feature upon analysis in the laboratory.

Feature 51

This was a deep concentration of charcoal and burned clay in the northeast quadrant of Unit N43/E16, stratigraphic Zone 8. The concentration had an elliptical shape and measured roughly 40 by 30 cm. The feature abutted the east wall of the unit. The concentration was defined at 114 cmbd and extended down to a maximum depth of 124 cmbd. A single piece of burned rock was recorded within the feature. This feature was determined to be within Analytical Unit 7.

Feature 52

This was a burned rock cluster in the southeast corner of Unit N43/E18, stratigraphic Zone 8. The feature had an irregular shape and appeared to extend outside of the excavation grid. Feature 52 was initially encountered 99 cmbd and extended down an additional 10 cm to 109 cmbd. The length and width of the feature are greater than 50 cm. This feature was determined to be within Analytical Unit 6.

Appendix K

Radiocarbon Results

Dr. James Abbott Report Date: 7/9/02

Texas Department of Transportation Material Received: 6/5/02

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 167957	910 +/- 40 BP	-28.2 o/oo	860 +/- 40 BP

SAMPLE : 4850-06-01
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1040 to 1260 (Cal BP 910 to 690)

Beta - 167958	1140 +/- 40 BP	-23.9 o/oo	1160 +/- 40 BP

SAMPLE : 4850-06-02
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 780 to 980 (Cal BP 1170 to 970)

Beta - 167959	290 +/- 40 BP	-25.9 o/oo	280 +/- 40 BP

SAMPLE : 4850-06-03
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1500 to 1670 (Cal BP 450 to 280)

Beta - 167960	2460 +/- 40 BP	-24.7 o/oo	2460 +/- 40 BP

SAMPLE : 4850-06-04
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 780 to 410 (Cal BP 2730 to 2360)

Beta - 167961	2790 +/- 40 BP	-26.0 o/oo	2770 +/- 40 BP

SAMPLE : 4850-06-05
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 1000 to 820 (Cal BP 2950 to 2780)

Dr. James Abbott

Report Date: 7/9/02

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 167962	1640 +/- 40 BP	-25.1 o/oo	1640 +/- 40 BP

SAMPLE : 4850-06-06
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 340 to 530 (Cal BP 1610 to 1420)

Beta - 167963	720 +/- 40 BP	-25.9 o/oo	710 +/- 40 BP

SAMPLE : 4850-06-07
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1260 to 1310 (Cal BP 690 to 640) AND Cal AD 1370 to 1380 (Cal BP 580 to 570)

Beta - 167964	3090 +/- 50 BP	-25.1 o/oo	3090 +/- 50 BP

SAMPLE : 4850-06-08
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 1440 to 1250 (Cal BP 3390 to 3200)

Beta - 167965	4370 +/- 40 BP	-23.8 o/oo	4390 +/- 40 BP

SAMPLE : 4850-06-09
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 3100 to 2900 (Cal BP 5050 to 4860)

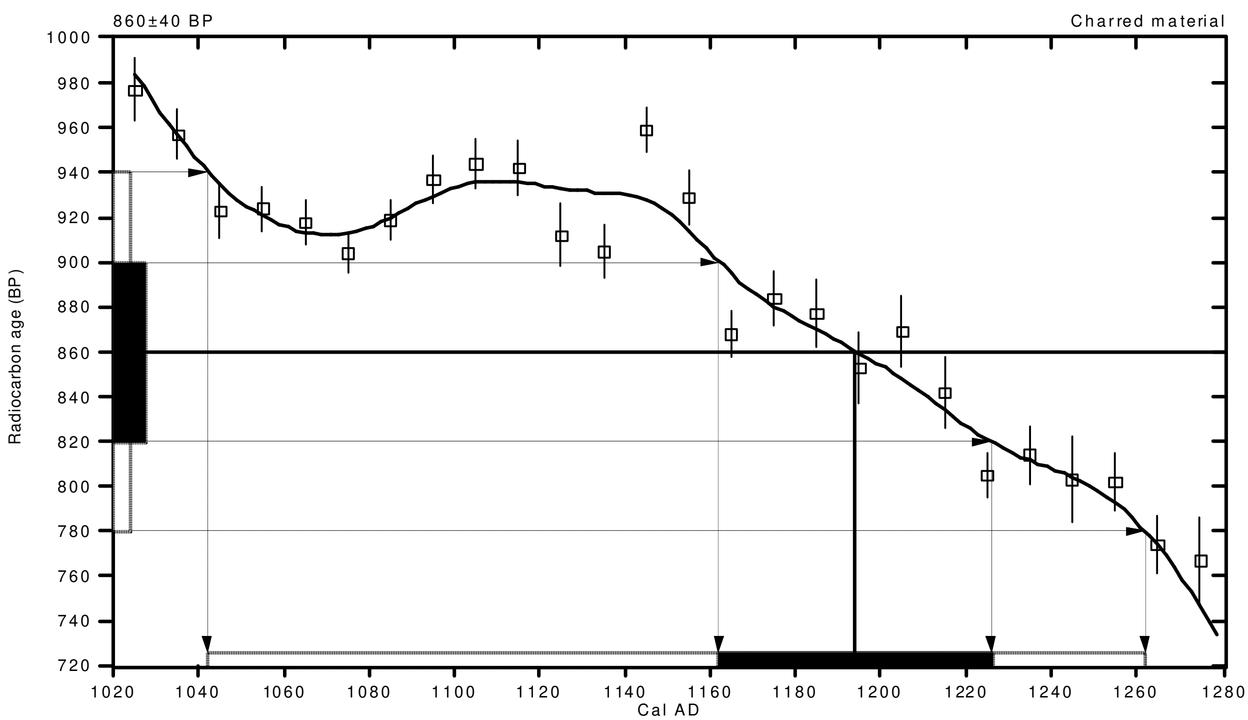
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-28.2:lab. mult=1)

Laboratory number:	**Beta-167957**
Conventional radiocarbon age:	**860±40 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 1040 to 1260 (Cal BP 910 to 690)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 1190 (Cal BP 760)
1 Sigma calibrated result: (68% probability)	Cal AD 1160 to 1230 (Cal BP 790 to 720)



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Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.9:lab. mult=1)

Laboratory number: **Beta-167958**

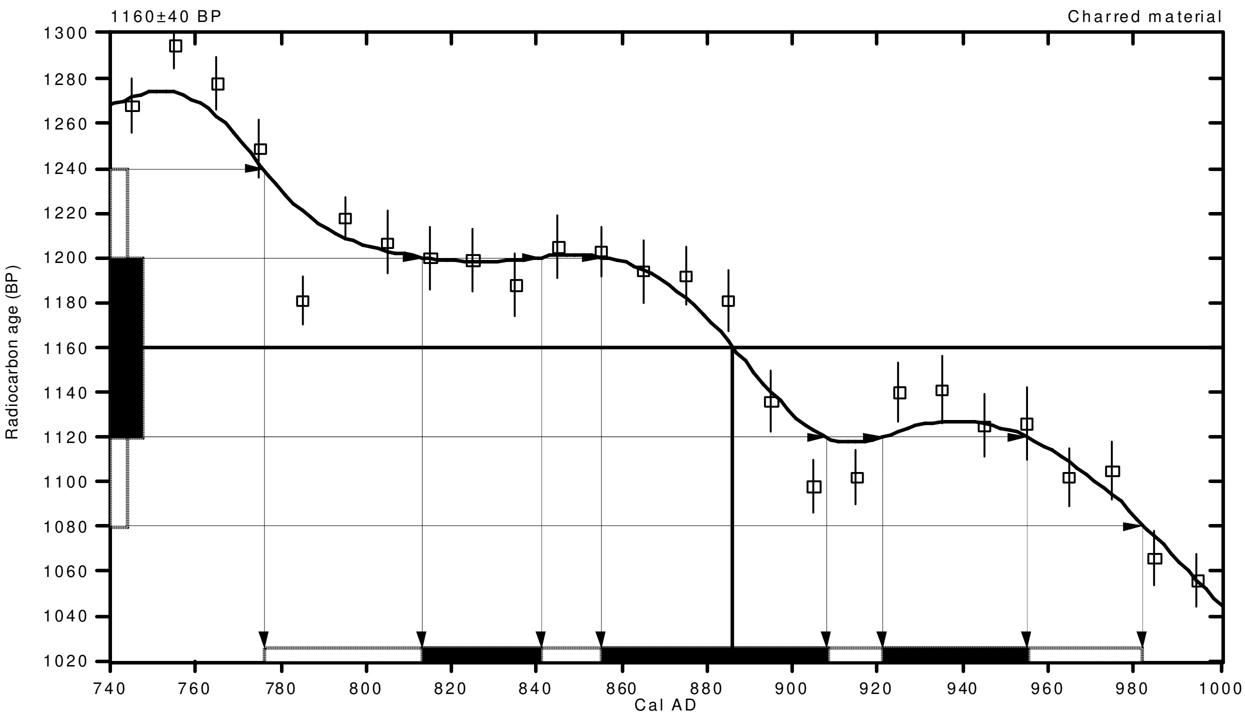
Conventional radiocarbon age: **1160±40 BP**

2 Sigma calibrated result: **Cal AD 780 to 980 (Cal BP 1170 to 970)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 890 (Cal BP 1060)

1 Sigma calibrated results: Cal AD 810 to 840 (Cal BP 1140 to 1110) and
(68% probability) Cal AD 860 to 910 (Cal BP 1100 to 1040) and
Cal AD 920 to 960 (Cal BP 1030 to 1000)



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INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
Mathematics
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.9:lab. mult=1)

Laboratory number: **Beta-167959**

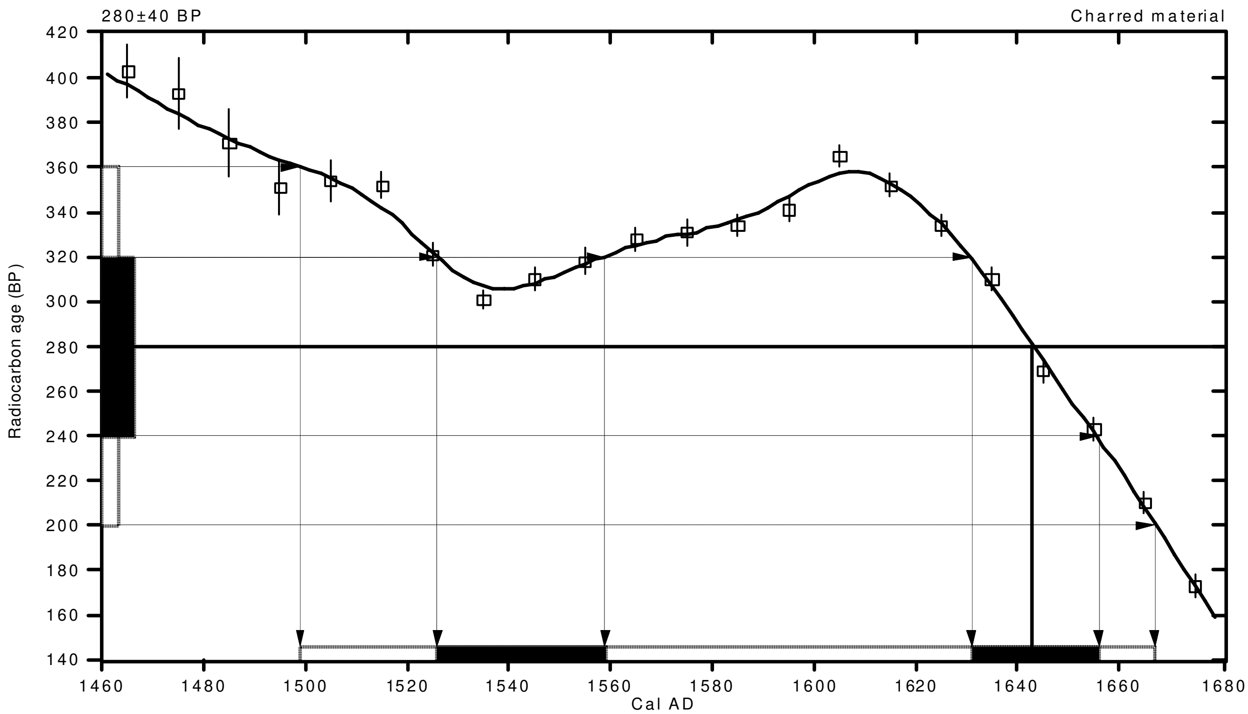
Conventional radiocarbon age: **280±40 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 1500 to 1670 (Cal BP 450 to 280)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1640 (Cal BP 310)

1 Sigma calibrated results: (68% probability) Cal AD 1530 to 1560 (Cal BP 420 to 390) and Cal AD 1630 to 1660 (Cal BP 320 to 290)



References:

Database used
INTCAL98

Calibration Database

Editorial Comment
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INTCAL98 Radiocarbon Age Calibration
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Mathematics

A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.7:lab. mult=1)

Laboratory number: **Beta-167960**

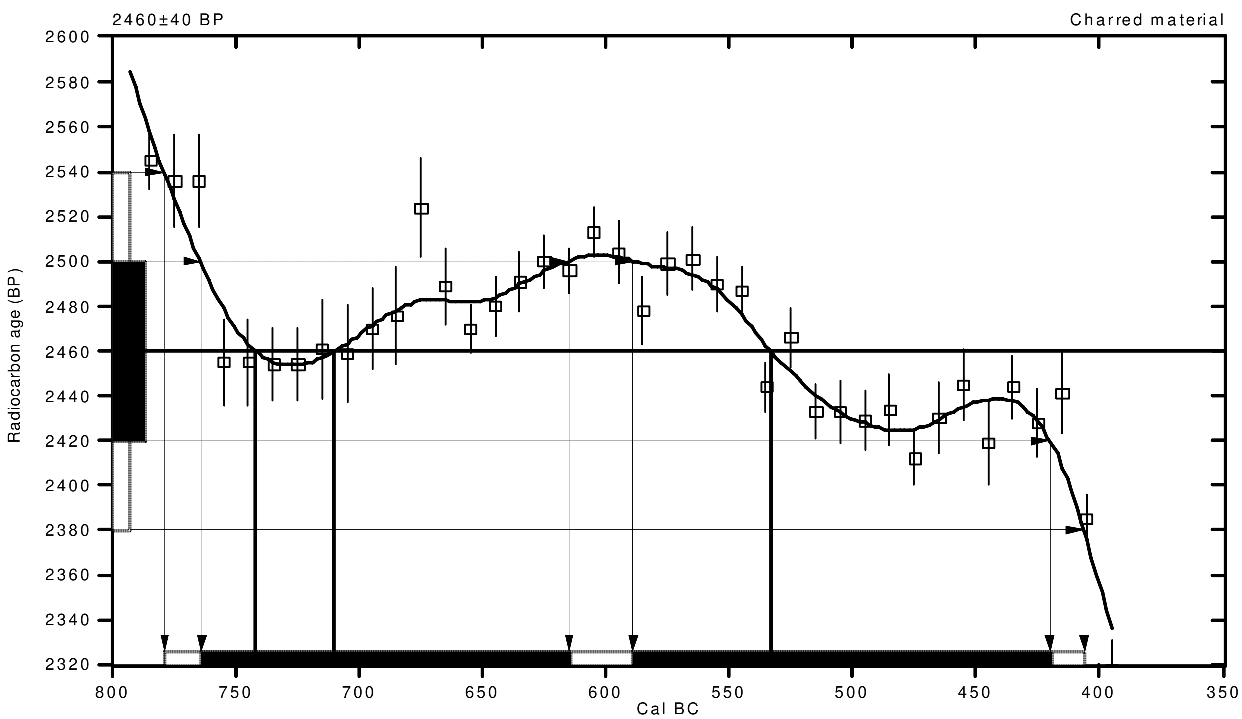
Conventional radiocarbon age: **2460±40 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 780 to 410 (Cal BP 2730 to 2360)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal BC 740 (Cal BP 2690) and Cal BC 710 (Cal BP 2660) and Cal BC 530 (Cal BP 2480)

1 Sigma calibrated results: (68% probability) Cal BC 760 to 620 (Cal BP 2710 to 2560) and Cal BC 590 to 420 (Cal BP 2540 to 2370)



References:

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Calibration Database

Editorial Comment
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INTCAL98 Radiocarbon Age Calibration
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Mathematics

A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-26:lab. mult=1)

Laboratory number: **Beta-167961**

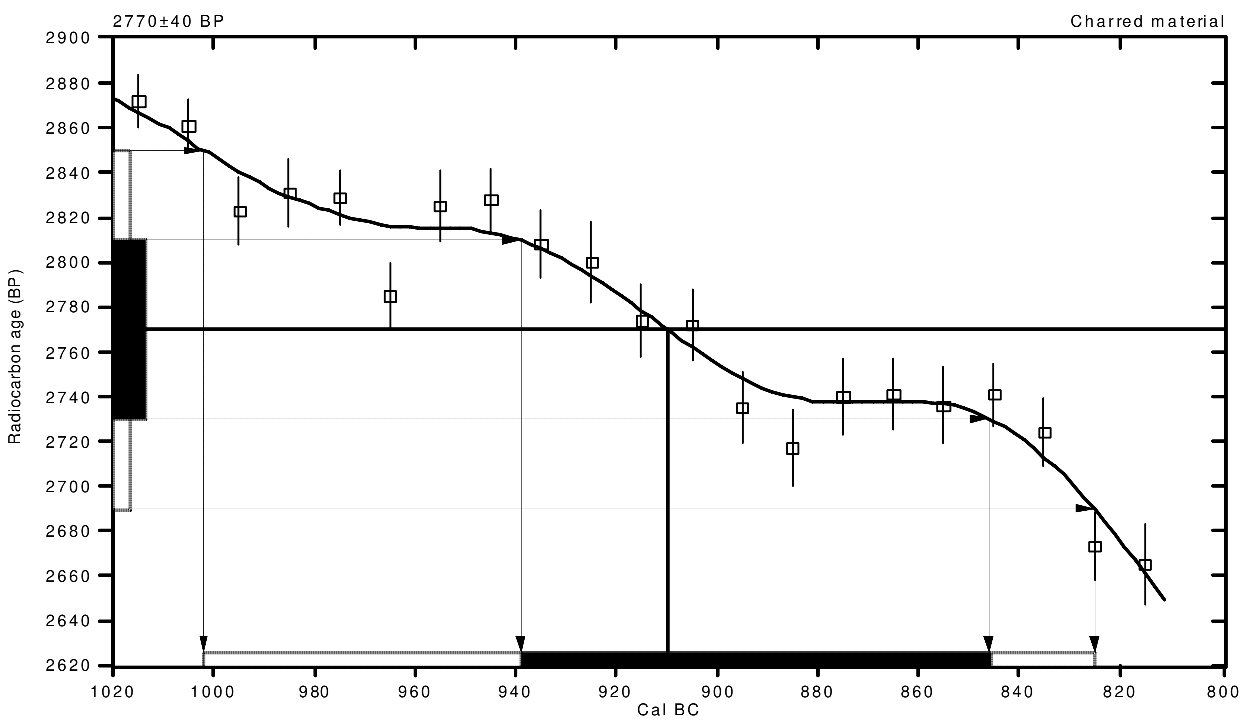
Conventional radiocarbon age: **2770±40 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 1000 to 820 (Cal BP 2950 to 2780)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 910 (Cal BP 2860)

1 Sigma calibrated result: (68% probability) Cal BC 940 to 850 (Cal BP 2890 to 2800)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.1:lab. mult=1)

Laboratory number: **Beta-167962**

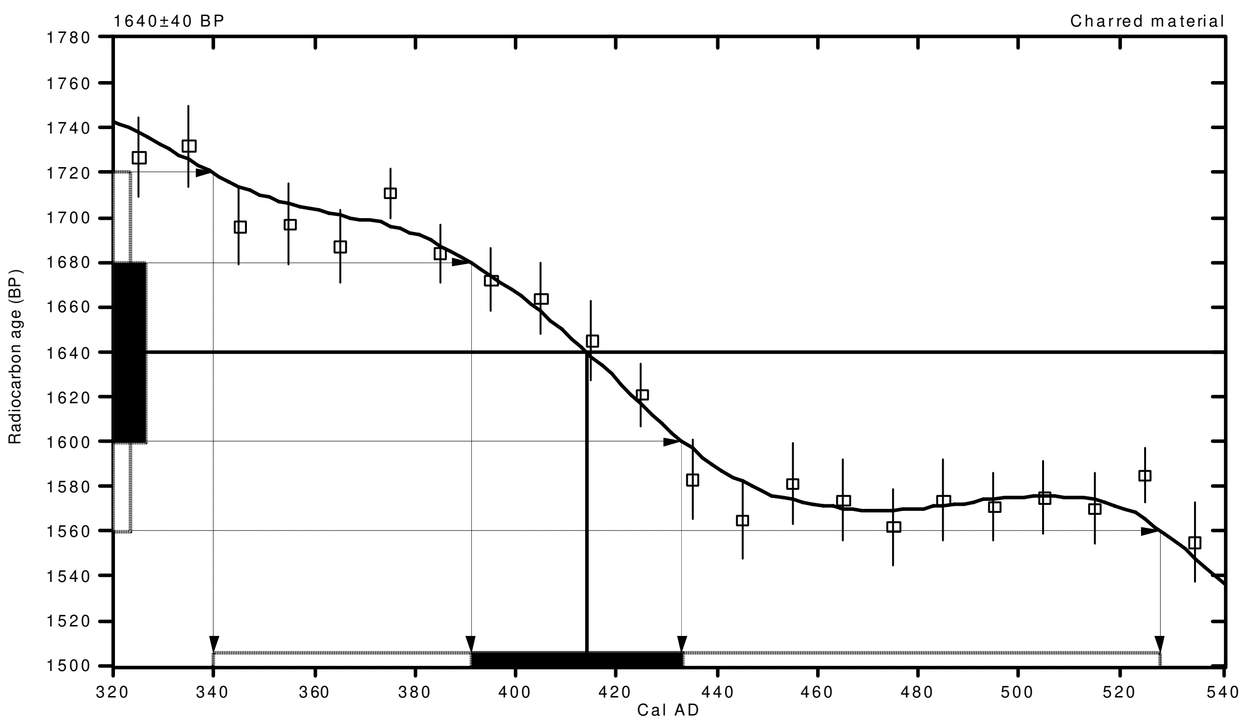
Conventional radiocarbon age: **1640±40 BP**

2 Sigma calibrated result: **Cal AD 340 to 530 (Cal BP 1610 to 1420)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 410 (Cal BP 1540)

1 Sigma calibrated result: Cal AD 390 to 430 (Cal BP 1560 to 1520)
(68% probability)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.9:lab. mult=1)

Laboratory number: **Beta-167963**

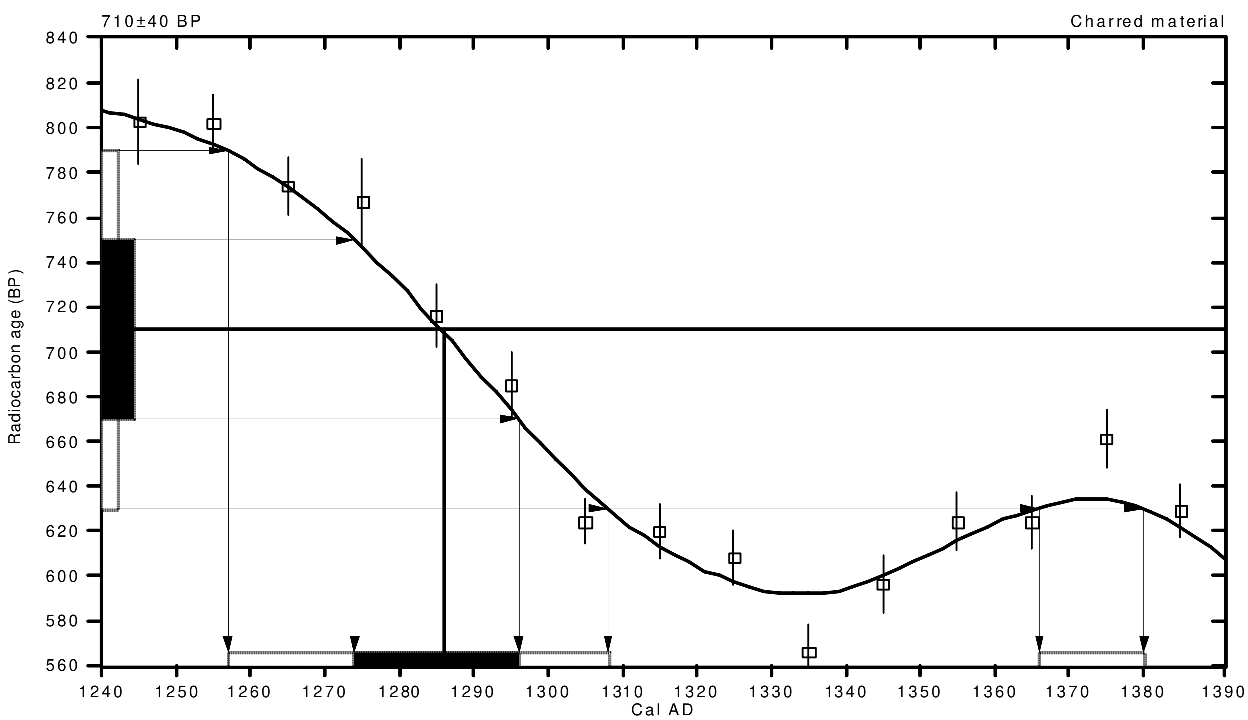
Conventional radiocarbon age: **710±40 BP**

2 Sigma calibrated results: **Cal AD 1260 to 1310 (Cal BP 690 to 640) and**
(95% probability) **Cal AD 1370 to 1380 (Cal BP 580 to 570)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1290 (Cal BP 660)

1 Sigma calibrated result: (68% probability) Cal AD 1270 to 1300 (Cal BP 680 to 650)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-25.1:lab. mult=1)

Laboratory number: **Beta-167964**

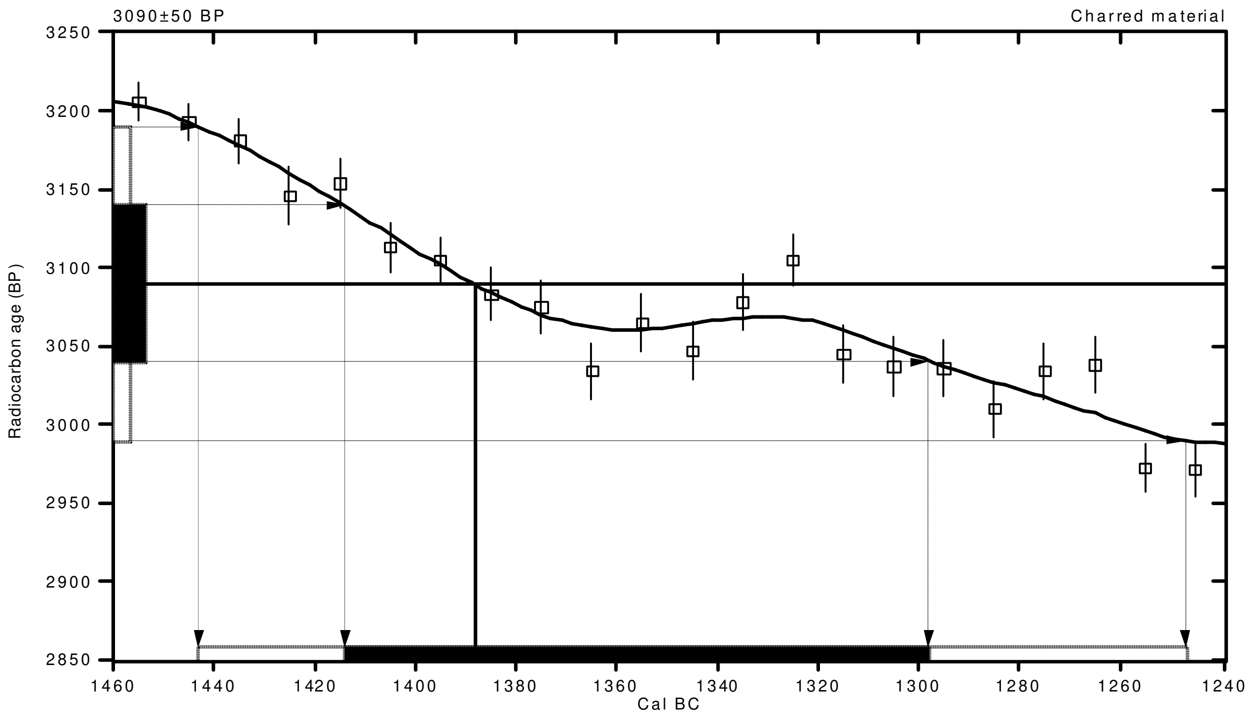
Conventional radiocarbon age: **3090±50 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 1440 to 1250 (Cal BP 3390 to 3200)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 1390 (Cal BP 3340)

1 Sigma calibrated result: (68% probability) Cal BC 1410 to 1300 (Cal BP 3360 to 3250)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.8:lab. mult=1)

Laboratory number: **Beta-167965**

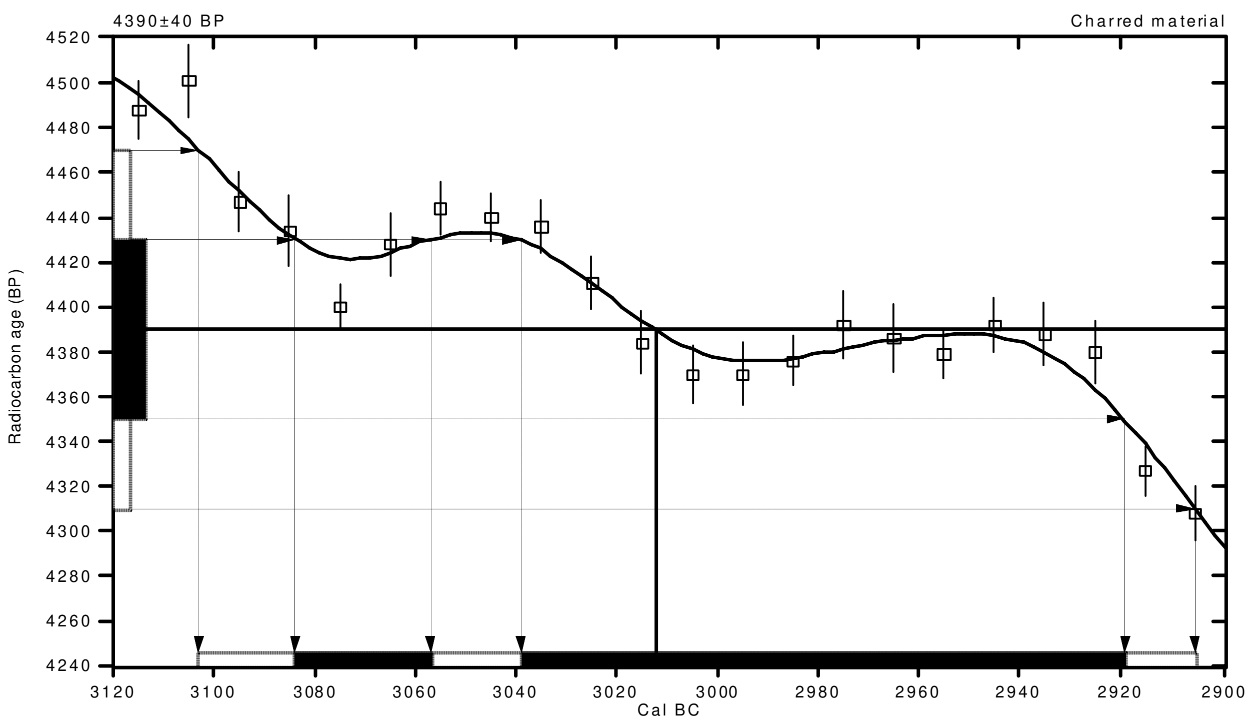
Conventional radiocarbon age: **4390±40 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 3100 to 2900 (Cal BP 5050 to 4860)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 3010 (Cal BP 4960)

1 Sigma calibrated results: (68% probability) Cal BC 3080 to 3060 (Cal BP 5030 to 5010) and Cal BC 3040 to 2920 (Cal BP 4990 to 4870)



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