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Archeological Testing Of The Fivemile Crossing Site, 41MN55: A Toyah Site On The San Saba River, Menard County, Texas

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ARCHEOLOGICAL TESTING OF THE FIVEMILE CROSSING SITE, 41MN55: A TOYAH SITE ON THE SAN SABA RIVER, MENARD COUNTY, TEXAS

by
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ABSTRACT

Archeological testing of the Fivemile Crossing site, 41MN55, was conducted by Prewitt and Associates, Inc., for the Texas Department of Transportation in November 2006. Located on an alluvial terrace along the San Saba River about 4.3 miles west of Menard, Texas, the site consists of a shallowly buried Late Prehistoric or Protohistoric occupation. Eighteen hand-excavated test units sampled 13.5 m^2 from two very narrow strips of intact deposits within the right of way on both sides of FM 2092. The excavations recovered chipped stone artifacts and bone-tempered pottery from a single occupation zone attributed to the Toyah culture. What remains of the site inside the right of way is minimal and is considered not eligible for listing in the National Register of Historic Places or designation as a State Antiquities Landmark. The road improvements were allowed to proceed without further archeological investigations.

CURATION

The recovered cultural materials and all project records will be submitted to the Texas Archeological Research Laboratory at the University of Texas at Austin for permanent curation.

ACKNOWLEDGMENTS

Archeological testing of the Fivemile Crossing site was conducted in conjunction with the FM 2092 road project undertaken by the Texas Department of Transportation (TxDOT). At TxDOT's San Angelo District, environmental coordinator Nancy Fisher and assistant environmental coordinator Ann Maxwell were extremely helpful. They coordinated the archeological work schedule and arranged for mechanical equipment to backfill the excavations. Jim Abbott and John Arnn, with the Archeological Studies Program of TxDOT's Environmental Affairs Division, oversaw the cultural resources work. Special thanks to Arnn for the many engaging conversations on Toyah culture and social identity in the archeological record. Jason Barrett, also with TxDOT's Archeological Studies Program, provided review comments on the January 2012 draft version of this report.

The Prewitt and Associates team for the field investigations included myself as principal investigator, Jenny McWilliams and Gemma Mehalchick as project archeologists, and Karl Kibler as project geoarcheologist. Matt Carter, Jim Gillentine, and Beth Sain served as archeological field technicians. In the laboratory, Tim Griffith analyzed the lithic debitage, and John Dockall provided insights into some of the chert tools. Karen Gardner identified the freshwater mussel shells. As a consultant for Prewitt and Associates, James Feather conducted the luminescence dating of two ceramic sherds.

Finally, I would like to thank Ms. Laura Austin, who gave us permission to inspect the portion of 41MN55 on her land, south of FM 2092. We are grateful for this opportunity, which allowed us to better understand the site as a whole and the cultural materials recovered from within the state-owned right of way.

Douglas K. Boyd

Principal Investigator

INTRODUCTION

This report describes archeological testing of 41MN55, a Late Prehistoric site containing a Toyah phase occupation zone at the top of a Pleistocene alluvial terrace of the San Saba River in Menard County, Texas (Figure 1). Prewitt and Associates, Inc. (PAI), conducted the archeological investigations for the Texas Department of Transportation, Environmental Affairs Division (TxDOT-ENV), under Work Authorization Nos. 57536SA006, 57540SA006, 57548SA006, 57720SA001, and 57901SA002 to address the requirements of Section 106 of the National Historic Preservation Act (16 USC 470 et seq.; 36 CFR 800) and the Antiquities Code of Texas (Texas Natural Resources Code*,* Title 9, Chapter 191; 13 TAC 26).

The road improvement project (CSJ No. 2008-01-091), performed by TxDOT's San Angelo District, was undertaken to restore, resurface, and widen a 4.9-mile-long segment of FM 2092, beginning 0.4 miles east of U.S. Highway 83 in Menard and extending eastward just past Fivemile Crossing of the San Saba River. The road improvements were in the planning stage when the archeological survey and testing of 41MN55 were conducted. Because project-related construction impacts could occur anywhere within TxDOT's 100-ft-wide right of way, the Area of Potential Effects (APE) for the archeological resources was considered to be the entire right of way. All of the archeological investigations were conducted within the right of way except for examining the area south of FM 2092 with landowner permission.

PAI conducted archeological investigations in two phases. The archeological survey of the FM 2092 roadway was conducted in June 2006. A preliminary report submitted to TxDOT-ENV and the Texas Historical Commission (Boyd and McWilliams 2006) recommended archeological testing of 41MN55 to obtain sufficient information for a complete National Register and State Antiquities Landmark assessment. The final report on the FM 2092 survey (McWilliams and Boyd 2008) was completed in January 2008.

Field investigations for testing of 41MN55 were conducted in November 2006. An interim report (Boyd and Mehalchick 2007) was submitted in August 2007. The final report on the cultural resources survey of the FM 2092 corridor from Menard to Fivemile Crossing provided the first published description of 41MN55 (see McWilliams and Boyd 2008:Tables 4 and 5, Figure 7c, 37). The current report incorporates findings from the survey and testing phases of work.

ENVIRONMENTAL BACKGROUND

The environmental background for Menard County below is derived from the following sources: Blair (1950:Figure 1), Brune (1975:11–12, 55), Bureau of Economic Geology (1981), Dallas Morning News (1999:98, 231), Estaville and Earl (2008:5–9, 20–21, 26, 29–30), Natural Fibers Information Center (1987:349), Smyrl (2010), Stephens and Holmes (1984:Maps 3–6), Texas Parks and Wildlife Department (2017), and the U.S. Department of Agriculture (1967).

Menard County encompasses 902 square miles near the geographic center of Texas. It lies along the northeastern edge of the Edwards Plateau physiographic

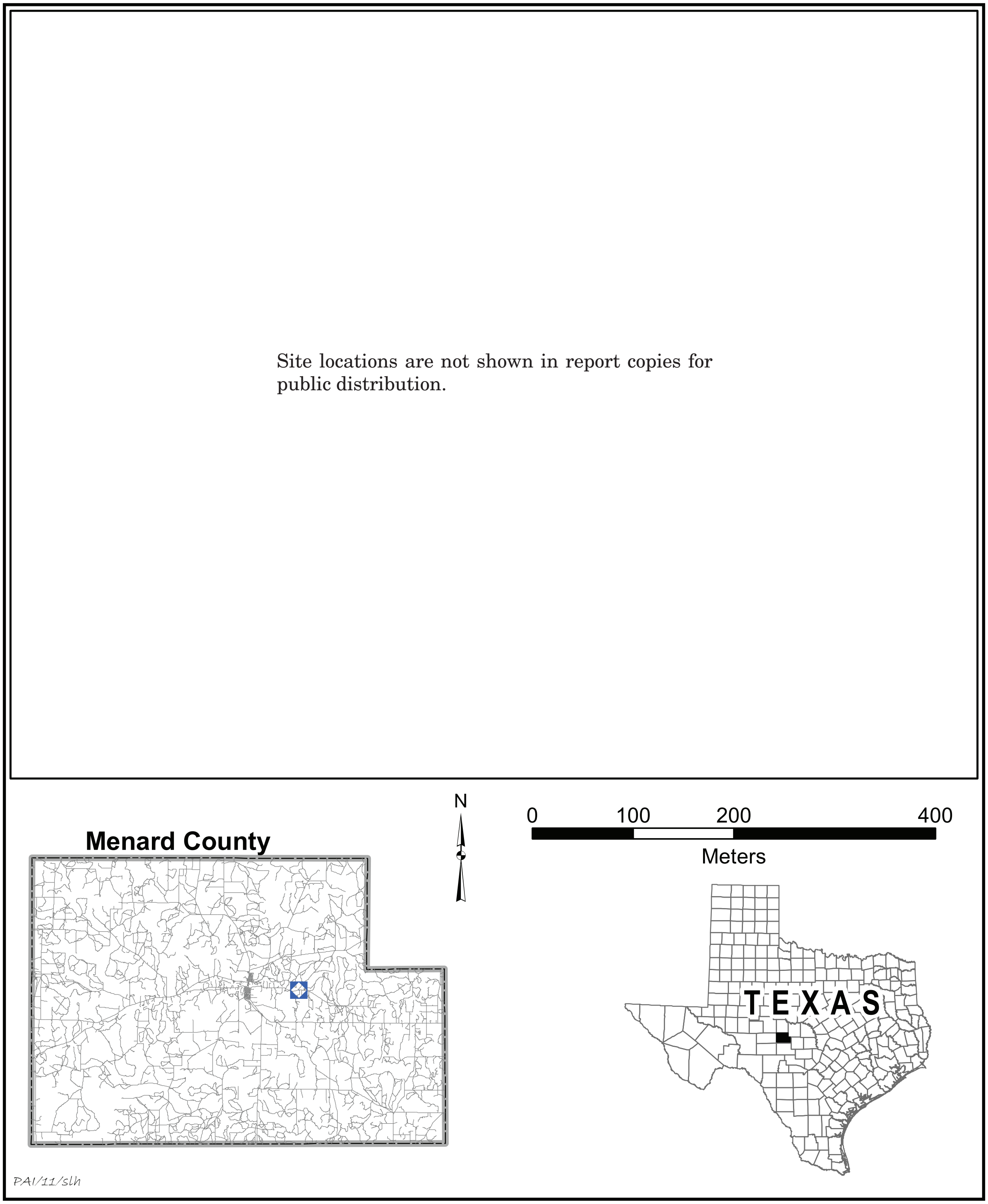

Figure 1. Map showing the location of 41MN55 within the FM 2092 right of way just east of Fivemile Crossing at the San Saba River and the location of an off-site backhoe trench. The site extends north and south of the road right of way, but the boundaries are not known. Base map is the 2004 aerial photograph from the U.S. Department of Agriculture, National Agricultural Imagery Program, obtained from the Texas Natural Resources Information System.

region where it abuts the Llano Uplift physiographic region. Menard County is dominated by outcrops of Lower Cretaceous-age limestones and dolomites, with veneers of alkaline soils derived from weathering of these Cretaceous layers. Topographic elevations range from 2,400 to 1,700 ft above sea level, and the dominant geological formations represented in the county are, from highest to lowest on the landscape, Segovia, Fort Terrett, and Hensell Sand. Almost all of Menard County is drained by the San Saba River, which is deeply incised and flows from west to east through the center of the county and converges with the Colorado River 60 miles downstream in San Saba County. Pleistocene- and Holocene-age alluvial deposits are found all along the San Saba River and its tributaries. Freshwater springs emerge in many places, fed primarily by the Edwards-Trinity Aquifer and to a lesser extent by minor aquifers such as the Hickory. The San Saba River flows year-round, with most of the springs that feed into the river being upstream and west of Menard County.

Menard County has a humid subtropical climate, with hot humid summers and cold dry winters. The average rainfall is about 24 inches a year, with most of it falling between April and September. In normal years, some rainfall is distributed throughout the year, but seasonal dry spells and droughts are common. Moderate droughts were recorded between 1910 and 1936, and severe droughts were recorded from 1950 to 1957. The average temperature fluctuates between a mean of 30ºF in January and a mean of 95ºF degrees in July, but temperature extremes of –2ºF and 109ºF have been recorded. The county has a long growing season of approximately 222 days, generally extending from late March through early November.

Most of the county (83 percent) is uplands where thin, stony, alkaline soils support prairie grasses and stands of various trees, predominantly live oak, juniper, and mesquite. The Menard County Soil Survey (USDA 1967:49) reports that "about 94% of the county has always been in grass."

Menard County is in the center of the Balconian Biotic Province, which is the heart of the physiographically distinctive Edwards Plateau region (Blair 1950:112). The province is characterized by a broad range of flora and fauna, with many species that are typically found in one or more of the biotic provinces that surround it. The uplands are characterized as a scrub forest dominated by four types of trees—mesquite, Mexican cedar, Texas oak, and live oak— while the riparian environment along rivers and streams support species such as pecan, hackberry, elm, and bald cypress. Many Chihuahuan Desert plants are present in the western part of the Balconian. Fauna documented in the province include 57 species of mammals, but none of them are exclusive to the province. Bison, once native to the region, are conspicuously absent from the list (acknowledging that some ranchers are reintroducing bison in many parts of Texas). The Balconian Province also hosts numerous species of lizards, snakes, frogs, toads, and amphibians, and one species of land turtle.

The ecology of the Edwards Plateau changed dramatically in historical times, and the current flora and fauna are quite different than what was there in Late Prehistoric times. The Texas Parks and Wildlife Department (2017) provides an excellent summary of the most significant ecological changes:

> "When the Edward Plateau region was settled by European man in the mid-1800s, it was maintained as a grassland savannah largely by grazing habits of bison and antelope as well as by frequent natural and man-made fires. The land supported a rich diversity of forbs and grasses. Cedar was restricted to overgrazed areas along rivers and streams, and in areas of shallow soils and steep canyons where fires did not occur frequently. White-tailed deer were rarely found in the grasslands. With European settlement came fences, cows, sheep, goats and the control of fire. Livestock were continuously grazed in fenced pastures which disrupted the natural movement patterns of grazing animals. Plants were not allowed to rest and recover from grazing. By 1900, continuous overgrazing and control of fire had taken its toll. The land began to change from a grassland to a brushland. Many of the woody brush species were readily grazed by sheep, goats, cattle, and an increasing deer herd. These animals have selective eating habits and eat the more desirable plants first and leave the less desirable plants for last. By the 1940's, many of the good quality plant species were highly depleted and not readily found on most ranges. The Edwards Plateau is now dominated by many poor quality browse, forb, and grass plants. Ashe juniper and red berry juniper (commonly called cedar) are highly undesirable forage plants for domestic livestock and deer. In much of the Edwards Plateau, cedar has become the dominant plant species causing a once diverse and healthy landscape to become a "cedar break" in many areas with very little plant diversity on the landscape."

CULTURAL BACKGROUND

Occupation of the Fivemile Crossing site occurred during the Late Prehistoric and possibly Protohistoric periods, and the material remains are specifically attributed to the Toyah phase. Consequently, the background information presented in this section focuses on the Late Prehistoric Toyah phase of central Texas. The ideas presented here are derived from a number of publications—Arnn (2012a, 2012b), Arnn et al. (2010), Carpenter (2017), Collins (1995), Dillahey (1974), Johnson (1994), Kenmotsu and Arnn (2012), and Kenmotsu and Boyd (2012), Mauldin et al. (2012), Prewitt (2012), and Ricklis (1994).

The Toyah phase appeared around A.D. 1200–1300 and survived as a recognizable cultural manifestation until at least A.D. 1700. It disappearance in the archeological record may be attributed to dramatic changes in Native American societies during the period of European contact. Sites assigned to the Toyah phase are found across a vast region of the state that includes all of central Texas and extends west to the Pecos River, south to the Rio Grande, and southeast almost to the Gulf Coast. The material remains that are considered diagnostic are a hunting tool composed of three tools—the Perdiz arrow point, the beveled knife, and end scrapers used for killing, skinning, and hide scraping—along with plainware pottery tempered with tiny fragments of crushed bone.

Many Toyah research topics have been proposed and debated in the literature, but this brief review mentions only three of the broadest ones—social identity, Toyah pottery, and lifeways/subsistence strategies.

Toyah was first recognized as a distinctive cultural manifestation in Texas by J. Charles Kelley (1947), and it has been studied and debated intensively since then. Many sites have been assigned to Toyah over the years, and its geographic range has been broadened to cover a large portion of Texas. It been called the Toyah horizon, the Toyah phenomenon, the Perdiz interval of the Late Prehistoric period, and most commonly today, the Toyah phase. In his study of the Buckhollow site, Johnson's (1994) proposed a Classic Toyah region where the Toyah culture was pure and unadulterated, bordered by a large Shared Area where Toyah peoples interacted with other groups and took on extra trappings not found in the Classic Toyah region. This study was an important step toward recognizing the existence of different social identities within Toyah, and the fact that Toyah peoples in the shared areas were involved in complex exchange systems.

More recently, Arnn (2012a, 2012b) described Toyah as an even broader construct called a social field. He looked more closely and critically at social identity across the vast Toyah area, examining both ethnographic and archeological evidence to argue for the existence of a large and complex Toyah social field composed of many distinct sociocultural groups. The social field concept reflects the likelihood that the archeological sites we assign to the Toyah phase are not the remains of a single group but were generated by many different groups of people. These groups may have shared some common material culture items and similar lifestyles, but each group would have recognized themselves as being distinct and separate from the others. One of the unfortunate truths in archeology is that many of the things that were most important in defining social identity—things like clothing, hairstyles, and body tattoos—do not survive in the archeological record. For the Toyah phase, we are left with relatively mundane things like Perdiz arrow points, utilitarian cooking pottery, and stone tools for hide skinning and scraping.

Pottery associated with the Toyah phase is typically a relatively homogeneous and sparsely decorated plainware with small fragments of crushed bone added as temper. Pottery has been found at many Toyah sites, but assemblages are usually limited to few sherds, and the sherds are generally small. Occasionally, rim and body sherds are large enough to reconstruct partial or whole vessel forms (Arnn 2012b:Figure 3.3), but our understanding of Toyah pottery is still limited. This pottery is usually referred to Leon Plain or Doss Redware (a variant that has a distinctive red slip), and the bone-tempered plainwares found at Spanish colonial mission and presidio sites are usually called Goliad Plain. These formal ceramic type names remain ill-defined, however, and their use sometimes adds confusion rather than providing clarification. Consequently, many archeologists choose to call Toyah pottery by a simpler descriptive name such as bone-tempered plainware. Along the margins of the Toyah region, Toyah sites may contain plain bone-tempered pottery along with pottery imported from other regions. This is especially true along the eastern margin of the Toyah region where Caddo-made pottery is often found in Toyah sites.

Some bone-tempered wares found in Toyah sites have Caddo-style decorations, and there is uncertainty regarding where some of these vessels were manufactured (i.e., locally vs. east Texas). Ceramic sourcing studies using petrographic and geochemical (neutron activation analysis) data have proven useful in addressing this question, however (e.g., Pertulla et al. 2003). Systematic studies of large samples of central Texas pottery—examining composition, technological attributes, and decorative styles—are needed to unravel the complexity of Toyah pottery and the interactions between Toyah hunter-gatherers and their neighbors. The Central Texas Ceramic Project, initiated by the Texas Archeological Research Laboratory in 2002 and funded in part by TxDOT, was an attempt to push statewide research in this direction by compiling a large body of neutron activation analysis data (Creel 2002; Texas Archeological Research Laboratory 2006). A comprehensive analysis of the central Texas data by Creel et al. (2013) demonstrates the utility of this type of geochemical sourcing and is an important first step in understanding the complexities of Toyah phase ceramics.

How we view Toyah lifeways is another area open for debate, and the ideas involve perceptions of subsistence strategies (e.g., generalized foragers vs. specialized hunters) and residential mobility (e.g., localized vs. broad regional territories). In a recent study, Carpenter (2017:150) outlines two opposing models for understanding the Toyah phenomenon. He describes the current and most popular model as "kin-based groups of generalized foragers operating within limited territorial boundaries." Carpenter proposes and favors a model of Toyah as "a manifestation of a dual economy of agriculturalists and maritime-adapted groups engaging in long-range hunting on a seasonal basis." In this model, Toyah people were "highly mobile people who traveled far to hunt and process bison." However, Mauldin et al. (2012) and other researchers have questioned the idea that most Toyah peoples were predominantly focused on bison hunting. Their reanalysis of Toyah faunal evidence led them to question the idea that Toyah culture emerged and spread during a time of increasing bison abundance on the Southern Plains. While the idea of fluctuating bison populations over time has found widespread acceptance, the concept of how abundant or scarce bison were at various times has remained a topic of discussion since it was proposed more than 40 years ago by Dillahey (1974).

The Fivemile Crossing site is assigned to the Toyah phase based on the recovery of bone-tempered pottery and an end scraper from the narrow strip of State-owned right of way. Although no Perdiz arrow points were found, there is no doubt of the site's Toyah affiliation, and it is centrally located in the Classic Toyah region. The site has a low density of cultural materials (within the State-owned right of way at least), and this probably reflects the short-term nature of the occupations. These types of low-density sites constitute an important part of the Toyah archeological record, and they have the potential to yield information pertinent to the research topics mentioned above.

SITE SETTING

Site 41MN55 is a prehistoric artifact scatter on a Pleistocene-age alluvial terrace overlooking the San Saba River. Quaternary alluvium fills the entire San

Saba River valley for more than 10 miles on either side of the town of Menard, Texas (Bureau of Economic Geology 1981). The river valley is inset into an eroded landscape of Lower Cretaceous formations that form the undulating limestone uplands. These formations consist of (from oldest to youngest): Hensell Sand, Fort Terrell Member, Segovia Member, and Fort Terrell/Segovia undivided. The Fort Terrell and Segovia Members are particularly noteworthy because they are chert-bearing deposits that crop out across vast areas north and south of the river. The soil survey for Menard County indicates that the portion of the site within the State-owned right of way is on Uvalde silty clay loam soils that are found "on broad terraces along the San Saba River and larger creeks in the county" (U.S. Department of Agriculture 1967:15–16, Sheets 26 and 34).

The Pleistocene terrace is on the north side of FM 2092 and immediately east of the San Saba River overlooking the floodplain. Its western edge is about 80 to 100 m east of the river at Fivemile Crossing. The terrace surface, which is 4 to 5 m above the floodplain, is bisected by the road cut at the point where FM 2092 rises up from the floodplain onto the higher terrace. The right of way consists of grass-covered borrow ditches on either side of the paved roadway. A fallow agricultural field is to the south, and a currently occupied home, garden, and small pecan orchard are to the north. The home is a rock house about 20 m north of the FM 2092 right of way and only 10 to 15 m east of the edge of the terrace. The edge of the terrace and the active San Saba River floodplain are covered by pecan and elm trees. Prickly pears and mesquites grow along the edge of the right of way, particularly along the southern fence line.

The age of the landform is interpreted as Pleistocene based on the stratigraphic profile of a backhoe trench excavated just beyond the east end of the site (Table 1; see Figure 1). The trench exposed a A-B-Bk soil profile, with the lower zone from 102 to 125+ cm being a well-developed calcic horizon with up to 50 percent carbonate nodules (McWilliams and Boyd 2008:Figure 7c and Appendix B).

The area of the site south of FM 2092 and beyond the State-owned right of way rests primarily on the Pleistocene terrace (i.e., Uvalde silty clay soils), but it also extends into an area mapped and described as Terrace Escarpment in the Menard County soil survey (U.S. Department of Agriculture 1967:14, Sheets 26 and 34). The Terrace Escarpment is a long narrow strip of gravelly deposits that "border the bottom lands of the San Saba River and larger creeks in the county." These are

Table 1. Description of profile of Backhoe Trench 11, excavated just east of 41MN55 (from McWilliams and Boyd [2008:92–93]).

Location	In Mechanical Search Area No. 6, south of FM 2092, at Fivemile Crossing. On higher Pleistocene terrace 225 m east of San Saba River, just east of 41MN55.
0–34 cm	Brown (7.5YR 4/2) silty clay loam, moderate medium blocky angular structure, A horizon.
34–102 cm	Brown (7.5YR 5/4) silty clay loam, moderate medium prismatic structure breaks to moderate medium blocky angular structure, B horizon.
102–125+ cm	Light brown (7.5YR 6/4) silt loam, weak medium prismatic structure breaks to moderate fine blocky angular structure, common soft nodules and masses (ca. 5 mm) of carbonate that increase to 50% with depth, Bk horizon.

a series of gravel lenses deposited along the edge of the Pleistocene terrace. Gravels and stones make up as much as 50 percent of the deposit in some places, and the gravel lenses may be exposed at the surface or buried within a foot of the surface. The gravel exposures along the edge of the terrace most likely served as a source of chert nodules for people inhabiting the site.

SITE DISCOVERY

Site 41MN55 was discovered and recorded in June 2006 during the Phase I survey of FM 2092 (Figure 2). PAI archeologists conducted a pedestrian survey of 4.9 miles of FM 2092 from Menard to Fivemile Crossing; the investigations also included geoarcheological mapping, historic research, backhoe and gradall trenching, mechanical auger testing, and shovel testing. The results of this survey, including the initial site description of 41MN55, were presented in an interim report (Boyd and McWilliams 2006) and in the survey report (McWilliams and Boyd 2008:37–38).

PAI archeologists observed scattered burned rocks, chert flakes (primary, secondary, and tertiary), chipped stone tools (including a Plains-style end scraper), a possible limestone mano, three bone-tempered pottery sherds, and mussel shell umbos and fragments. All artifacts were observed in the upper portion of the Pleistocene terrace where the road cuts down into the landform (see Figure 2 profile). Cultural materials appeared to be eroding down the terrace cuts exposed in the ditches. Artifacts were most concentrated on the north side of FM 2092 but were also present south of the road. The deep section of the ditches extended about 50 m to the east from the edge of the terrace, providing good subsurface and erosional exposures. Very few artifacts were observed in the road right of way farther east where the ditches were shallower. Based on the extent of surface evidence, it was estimated that the site extends 190 m east-west by 30 m north-south (the width of the right of way).

The bone-tempered pottery and the Plains-style end scraper were collected from the area where most surface artifacts were observed (see Figure 2). These diagnostic artifacts suggested that the cultural remains represented a Toyah phase occupation. It appeared that the deposits immediately adjacent to the north and south property fences, marking the edges of the right of way, had not been disturbed. Based on these findings, further testing was recommended to assess the site more fully. A preliminary summary report on the survey (Boyd and Mehalchick 2007) was submitted and reviewed by TxDOT and the Texas Historical Commission. Both agencies agreed with the recommendation, and 41MN55 was slated for archeological testing and National Register assessment.

During the planning for the testing, no detailed road construction plans were available, so the area of potential effects (APE) could not be fully defined. While the normal depth of impacts for similar road improvement projects is typically about 3 ft below the road surface, TxDOT and PAI agreed that the APE for this project was different. When it was originally constructed, the FM 2092 roadway was cut deep into the alluvial terrace, and the right of way nearest the river has steep cut

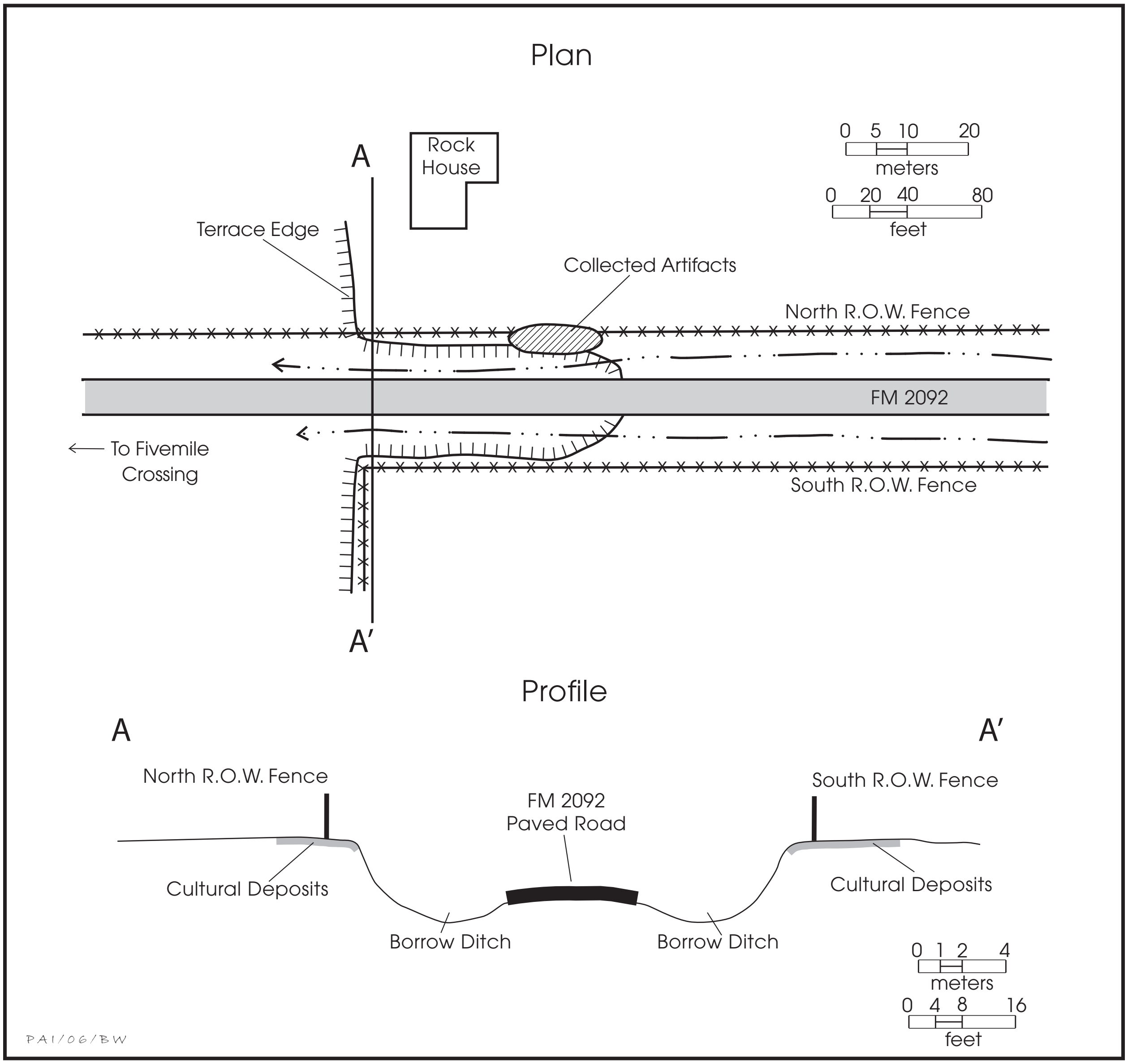

Figure 2. Plan and profile of 41MN55 (from McWilliams and Boyd [2008:Figure 8]).

banks on the north and south sides of the road (see Figure 2). Because of the steep banks and the narrow width of the right of way, there was the potential for the road improvements to involve lateral cutting into the intact alluvial terrace surface. Consequently, TxDOT and PAI agreed that the horizontal APE for this project would include the entire State-owned right of way and that the vertical APE would include: (1) all of the buried alluvial deposits from 0 to 3 ft deep within the FM 2092 right of way in all locations where the ground surface was at or close to the level of the road; and (2) all of the alluvial deposits exposed in the north and south road cuts, varying from about 3 to 12 ft thick, in areas where the terrace surface was 3 ft or more above the level of the road.

METHODS OF INVESTIGATIONS AND WORK ACCOMPLISHED

Testing was conducted in November 2006. Eighteen hand-excavated units sampled the cultural deposits at the top of the terrace in the two areas where the cultural materials were most concentrated and the deposits were most intact. All of the test units were adjacent to the northern or southern property fences that marked the edges of the right of way (Figure 3). The test units were concentrated in the western end of the site in proximity to the edge of the alluvial terrace (Figure 4). The absence of cultural material in Backhoe Trench 11, excavated during the FM 2092 survey, helped establish the eastern boundary of the site (see Figure 1).

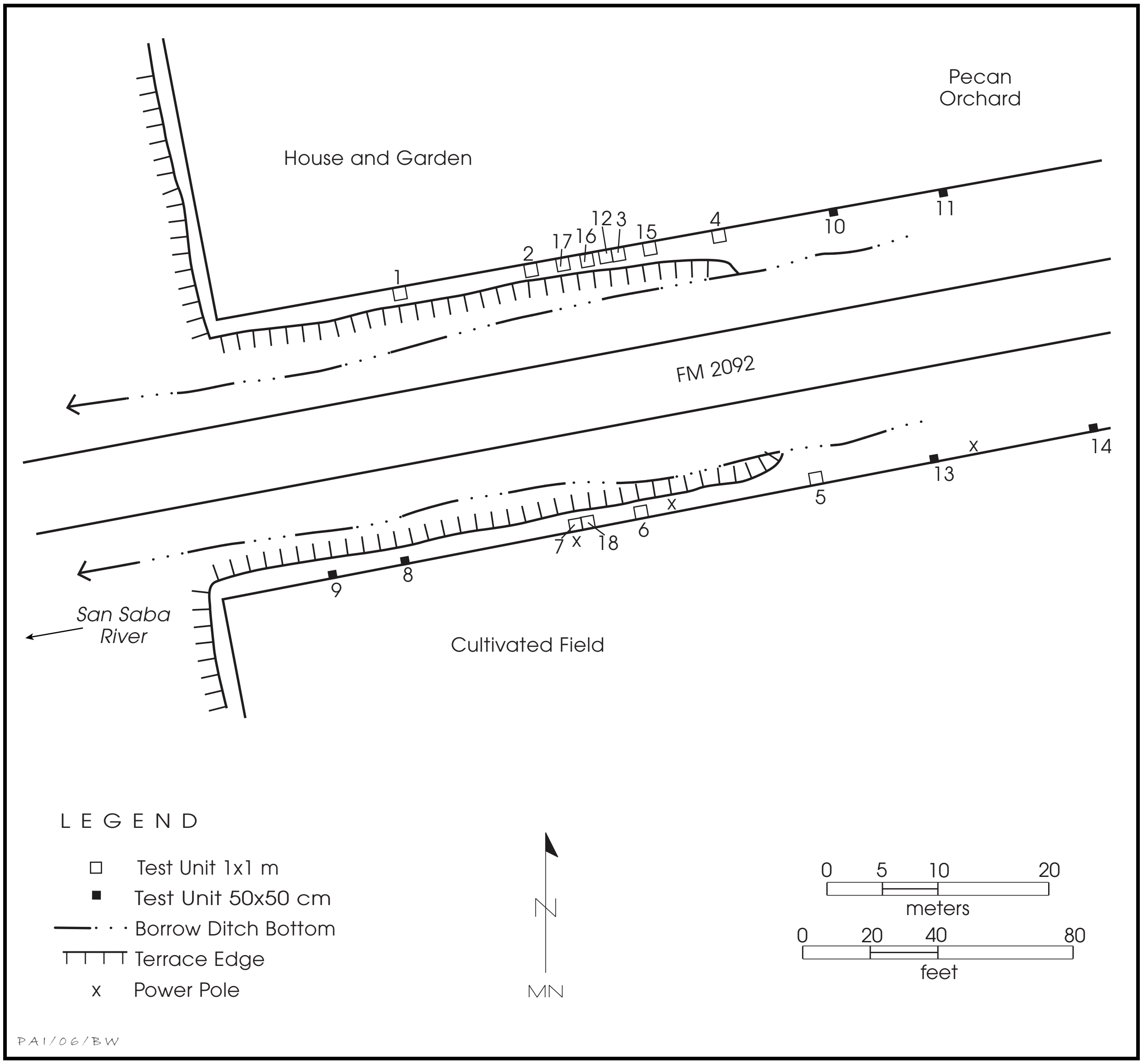

Figure 3. Map of 41MN55 showing test unit locations in the FM 2092 right of way.

Figure 4. Photographs of the 2006 test excavations. Upper photograph shows excavations along the northern right-of-way fence, facing west, with Fivemile Crossing in the background. Lower photograph shows Test Unit 8 at the top of the road cut along the southern right-of-way fence, facing southwest.

Of the 18 test units, 12 were 1x1 m and 6 were 0.5x0.5 m. The test units were numbered sequentially as they were excavated. Unit depths ranged from 25 to 57 cm. The total volume of hand-excavated sediment is 5.28 m^3, and the total area sampled was 13.5 m^2 (Table 2). A permanent datum point for elevation control was established on the metal base of the TxDOT "San Saba River" sign pole. It was assigned an arbitrary elevation of 99.30 m. The first level for each unit varied in thickness due to the natural slope of the landform, but all first levels ended at an even 10-cm elevation (i.e., the first 10-cm interval as measured from the ground surface). All subsequent excavations were in 10-cm levels. Excavation of each unit was terminated when the B horizon was encountered.

The hand-excavated sediment was dry screened through 1/4-inch hardware mesh. All prehistoric cultural materials (excluding small mussel shell fragments that lacked umbos) and any charred materials were collected. A few samples of snail shells and historic and modern items were saved. Diagnostic artifacts were retrieved from the site's surface. Excavation record forms were completed for each

Table 2. Summary of test units

Test Unit No.	Size (m)	Starting Elevation (m)	Ending Elevation (m)	Thickness of Excavated Sediment (cm)	Volume of Excavated Sediment (m^3)*	Area of Excavated Sediment (m^2)
1	1x1	99.05	98.60	45	0.45	1.00
2	1x1*	99.17	98.60	57	0.57	1.00
3	1x1	99.15	98.80	35	0.35	1.00
4	1x1	99.23	98.90	33	0.33	1.00
5	1x1	99.11	98.80	31	0.31	1.00
6	1x1**	99.17	98.70	47	0.40	1.00
7	1x1	99.09	98.70	39	0.39	1.00
8	0.5x0.5	99.04	98.60	44	0.11	0.25
9	0.5x0.5	99.00	98.60	40	0.10	0.25
10	0.5x0.5	99.18	98.90	28	0.07	0.25
11	0.5x0.5	99.17	98.90	27	0.07	0.25
12	1x1	99.15	98.80	35	0.35	1.00
13	0.5x0.5	99.15	98.80	35	0.09	0.25
14	0.5x0.5	99.15	98.90	25	0.06	0.25
15	1x1	99.19	98.80	39	0.39	1.00
16	1x1	99.19	98.80	39	0.39	1.00
17	1x1	99.15	98.70	45	0.45	1.00
18	1x1	99.13	98.80	33	0.33	1.00
Total					5.28	13.50

* Note that volume estimates for some units may be slightly higher than the actual volumes because the calculations are not adjusted for the ground surface slope.

** The last excavated level in this 1x1-m unit was 0.5x0.5 m.

level of each test unit. The project archeologist maintained a daily field journal, and the investigations were documented with digital photographs keyed to a field photo log. The site and the excavations were mapped with a Sokkia electronic total station. After completion of the work, TxDOT personnel mechanically backfilled all excavations. All collected cultural materials were processed in the laboratory in November and December 2006.

Immediately following the testing, an interim report was prepared. Boyd and Mehalchik (2007) recommended that the portion of 41MN55 in the right of way was not eligible for listing in the National Register or for designation as a State Antiquities Landmark. TxDOT and the Texas Historical Commission concurred with this recommendation, and the road work for FM 2092 was allowed to proceed.

RESULTS

Cultural Materials

Collected prehistoric cultural materials consist of 16 chipped stone tools, 2 cores, 472 unmodified flakes, 11 spalls, 63 ceramic sherds, 1 possible modified mussel shell, 53 burned rocks (1,563.3 g), 9 unmodified bones, and 41 mussel shell fragments with and without umbos (Tables 3 and 4). In addition, 10 unmodified flakes and charcoal fragments were recovered from two sediment flotation samples (Table 5).

The excavations also recovered sparse snail shells, and many historic artifacts and modern items were observed. The snail shells are considered to be natural, and the historic and modern items were discarded as trash that either accumulated along the public roadway or were deposited by people living in the nearby house.

Chipped Stone Artifacts

The chipped stone artifacts include bifacial tools classified as a projectile point fragment (either distal tip or arrow point base), 2 middle-stage bifaces, and 1 indeterminate biface fragment (Table 6). Edge-modified flakes (n = 6) are the most common expedient tools. Other tools consist of 2 gravers/edge-modified flakes, 2 unifacial scrapers, 1 scraper fragment, and 1 core tool. All the chipped stone tools are chert, and 7 specimens exhibit smooth or roughened abraded dorsal cortex characteristic of stream-rolled gravels. Evidence of thermal alteration was observed on 12 of the 16 chipped stone tools, and 8 of these may have been intentionally heat treated. The other 4 are intensively burned, either by accident or because they were discarded into a fire.

One unifacial end scraper (Figure 5), which was surface collected from the area between Test Units 2 and 3, is a classic Plains-style tool common on Toyah sites (Johnson 1994:117–138). It was made on a large blade flake, and its dorsal side retains about 30 percent cortex. It has a steep distal working edge with evidence of use wear (e.g., step fractures and edge rounding). The ventral surface has ridges on the proximal half of the tool, and they exhibit clear edge-rounding haft wear under low-power (10x) magnification. The cortex-covered ridge edges on the dorsal side

Table 3. Cultural materials by test unit

Test Unit	Artifacts																Other Cultural Materials	
	Point fragment	Middle-stage biface	Biface fragment	End scraper	Scraper fragment	Edge-modified flake	Graver/edge-modified flake	Core tool	Core	Unmodfied chert debitage	Unmodified quartzite debitage	Chert spall	Ceramic sherd	Possible modified mussel shell	Total artifacts	Burned rocks (g)	Bones	Mussel shells (with umbo)
Surface				1														
1			1							16		2	4		23	206.7		8
2	1					1	1			56		4			63	298.4	1	2
3		1				2				66		2	23		94	10.5	6	2
4						1				11					12		1	
5						1	1			9		1			12			
6										33			2		35	129.4		1
7					1					42	1		1		45	104.4		4
8										4					4	111.2		
9						1				13					14	60.9		4
10															0	11.8		
11															0			
12									1	75		1	23		100	275.9	1	3
13										11	1				12			
14															0			
15										14					14	70.4		
16		1							1	33			3	1	39	256.8		1
17										21		1	4		26	26.9		1
18				1				1		65	1		3		71			1
Total	1	2	1	2	1	6	2	1	2	469	3	11	63	1	564	1,563.3	9	27

Note: Excludes materials recovered from flotation (see Table 5).

Table 4. Collected and observed cultural materials by provenience

Test Unit	Level	Elevation (m)	Lot No.	Point fragment	Middle-stage biface	Indeterminate biface fragment	End scraper	Scraper fragment	Edge-modified flake	Graver/edge-modified flake	Core tool	Core	Unmodified chert debitage	Unmodified quartzite debitage	Chert spall	Ceramic sherd	Possible modified mussel shell	Burned rock	Burned rocks (g)	Bone	Mussel shell fragment (with umbo)	Mussel shell fragment (no umbo)	Snail shell	Charcoal	Historic or modern items observed or collected
–	surface	–	1				1									4									
1	1	99.05–98.90	2										4		1			2	30.6		4	2	18		X
1	2	98.90–98.80	3			1							6		1			2	117.5		2		7		
1	3	98.80–98.70	4										5					4	58.6		2		2		
1	4	98.70–98.60	5										1												
2	1	99.17–99.10	6										2					1	298.4					X	X
2	2	99.10–99.00	7							1			18		1										X
2	3	99.00–98.90	8	1					1				26		2					1	2				
2	4	98.90–98.80	9										7		1										
2	5	98.80–98.70	10										3									1			
2	6	98.70–98.60	–																						
2	–	99.12–99.09	11																					X	
3	1	99.15–99.05	12		1								13		1	2					1				X
3	2	99.05–98.95	13						2				43		1	17				6					
3	3	98.95–98.90	14										6			1		1	10.5		1				
3	4	98.90–98.80	15										4			3									
4	1	99.23–99.10	16						1				2												X
4	2	99.10–99.00	17										9												
4	3	99.00–98.90	18																	1					
5	1	99.11–99.00	19						1	1			8		1										X
5	2	99.00–98.90	20										1												
5	3	98.90–98.80	–																						X

Table 4, continued

Test Unit	Level	Elevation (m)	Lot No.	Point fragment	Middle-stage biface	Indeterminate biface fragment	End scraper	Scraper fragment	Edge-modified flake	Graver/edge-modified flake	Core tool	Core	Unmodified chert debitage	Unmodified quartzite debitage	Chert spall	Ceramic sherd	Possible modified mussel shell	Burned rock	Burned rocks (g)	Bone	Mussel shell fragment (with umbo)	Mussel shell fragment (no umbo)	Snail shell	Charcoal	Historic or modern items observed or collected
6	1	99.17–99.00	21										7					1	129.4						X
6	2	99.00–98.90	22										21			2					1				
6	3	98.90–98.80	23										5												
6	4	98.80–98.70	–																						
7	1	99.09–98.90	24					1					20					9	93.3		3	2			
7	2	99.90–98.80	25										17	1		1		1	11.1		1				
7	3	98.80–98.70	26										5												
8	1	99.04–98.80	27										4					2	70.2			5	5		
8	2	98.80–98.70	28															1	41.0			1	1		
8	3	98.70–98.60	–																						
9	1	99.00–98.80	29						1				9					2	60.9		3	3			
9	2	98.80–98.70	30										4								1				
9	3	98.70–98.60	–																						
10	1	99.18–99.10	31															1	11.8						
10	2	99.10–99.00	–																						
10	3	99.00–98.90	–																						
11	1	99.17–99.10	–																						
11	2	99.10–99.00	–																						X
11	3	99.00–98.90	–																						
12	1	99.15–99.00	32									1	54		1	19		11	254.2	1	3				X
12	2	99.00–98.90	33										14			4		1	13.1						
12	3	98.90–98.80	34										7					1	8.6						
13	1	99.15–99.00	47										8												X

Table 4, continued

Test Unit	Level	Elevation (m)	Lot No.	Point fragment	Middle-stage biface	Indeterminate biface fragment	End scraper	Scraper fragment	Edge-modified flake	Graver/edge-modified flake	Core tool	Core	Unmodified chert debitage	Unmodified quartzite debitage	Chert spall	Ceramic sherd	Possible modified mussel shell	Burned rock	Burned rocks (g)	Bone	Mussel shell fragment (with umbo)	Mussel shell fragment (no umbo)	Snail shell	Charcoal	Historic or modern items observed or collected
13	2	99.00–98.90	48										1												
13	3	98.90–98.80	49										2	1											
14	1	99.13–99.00	–																						X
14	2	99.00–98.90	–																						
15	1	99.19–99.00	35										9					2	70.4						X
15	2	99.00–98.90	36										5												X
15	3	98.90–98.80	–																						X
16	1	99.19–99.00	37		1							1	22			1	1	7	193.0						X
16	2	99.00–98.90	38										6			2		3	63.8		1				
16	3	98.90–98.80	39										5												
17	1	99.15–99.00	40										3		1										X
17	2	99.00–98.90	41										12			4		1	26.9		1				X
17	3	98.90–98.80	42										3												
17	4	98.80–98.70	43										3												
18	1	99.13–99.00	44				1						26	1		2									
18	2	99.00–98.90	45								1		31			1									
18	3	98.90–98.80	46										8								1		1	X	
Total				1	2	1	2	1	6	2	1	2	469	3	11	63	1	53	1,563.3	9	27	14	34		

Notes: All excavated proveniences are shown even if no cultural materials were recovered.
All chipped stone tools and cores are chert.
All burned rocks are limestone.
Charcoal in lot 11 is probable burned root.

Table 5. Cultural materials from flotation samples

Test Unit	Level	Elevation (m)	Lot No.	Unmodified Debitage	Charcoal	Historic or Modern Items Observed
15	1	99.10–99.00	50	5	X	3 glass fragments
16	2	99.00–98.90	51	5	X	–

of the proximal end are smoothed from haft wear as well. The specimen is nearly complete, but its proximal end has damage in the form of lateral flake scars. Two large flake scars came from one direction and a smaller flake scar came from the opposite direction. These flakes clearly removed some of the worn proximal ridges, and the scars are not the type of damage that would occur to a scraper still in the haft. Consequently, it appears that the flake scars occurred after the tool was removed from the haft, and they could represent an attempt to rework the proximal end. One of these flake scars has some retouch or use scars along its edge, indicating that the proximal end of this tool was used in some sort of expedient task before the scraper was finally discarded or lost.

One of two chert cores retains less than 25 percent stream-rolled cortex. The core has a crushed edge, but differences in patina and the presence of later flake scars indicate that the battering occurred prior to its final use as a core. The second core is decorticate and displays several hinge terminations on the flake removals. Both of the cores may have been heat treated.

The debitage assemblage consists of 472 specimens, of which 469 are chert and 3 are quartzite. The quartzite specimens are small to very small tertiary flakes that are white to clear and slightly translucent. The source of the quartzite is unknown and could be nonlocal.

The attributes of the chert flakes are summarized in Tables 7, 8, and 9. The cortex attributes, material quality types (i.e., graininess of the chert), and flake sizes all suggest intensive use of local stream gravels. Almost all the flakes are fine-grained chert (98.3 percent), with only eight specimens being lower quality medium- or coarse-grained chert. Notably, 99.1 percent of the primary and secondary flakes exhibit smooth abraded cortex characteristic of stream-rolled cobbles in alluvial gravels. A single small secondary flake has worn chalky cortex that could represent chert from a weathered upland source. In terms of size, none of the recovered flakes is over 2 inches (51 mm) in maximum length, and more than 85 percent of the flakes are under 1 inch (25 mm). Small and very small tertiary flakes dominate the assemblage, suggesting that much of the flint knapping at 41MN55 was late-stage tool production or maintenance. Many of the small tertiary flakes appear to be unifacial thinning flakes that could result from resharpening scraping tools.

Only 12.4 percent of the chert flakes exhibit obvious evidence of thermal alteration: crazing, n = 12; glossy surface, n = 21; potlids, n = 2; crazing and glossy surface, n = 13; crazing and potlids, n = 8; glossy surface and potlids, n = 2. The specimens with crazing and potlids have been intensively heated, probably after

Table 6. Chipped stone tools and cores

Test Unit	Level	Elevation (m)	Lot and Specimen No.	Artifact Type and Description	Measurements (mm)	Cortex	Chert Color	Heating Evidence
CHIPPED STONE TOOLS								
–	surface	–	1-1	Uniface, Plains-style end scraper with steep-angle distal working edge; made on secondary blade. Scraper is nearly complete, with damage on its proximal end.	Length 66.2 Width 47.1 Thickness 19.4	Stream-rolled, smooth	Light gray	Slightly glossy; possibly heat treated
1	2	98.90–98.80	3-1	Biface, indeterminate edge fragment	Length (37.6) Width (18.2) Thickness (11.7)	Stream-rolled, smooth	Reddish brown with mottles and dark brown banded	Glossy; probably heat treated
2	2	99.10–99.00	7-1	Graver/edge-modified flake	Length 3.0 Width 22.4 Thickness 5.4	None	Brown	None
2	3	99.00–98.90	8-1	Projectile point, distal tip or base	Length (12.0) Width (6.6) Thickness (2.7)	None	White and brown	Glossy; probably heat treated
2	3	99.00–98.90	8-2	Edge-modified flake	Length 49.0 Width 33.1 Thickness 15.1	Stream-rolled, smooth	Banded gray and white	None
3	1	99.15–99.05	12-1	Biface, middle-stage fragment	Length 80.0 Width 58.0 Thickness 19.5	Stream-rolled, smooth	Red with white mottles	Glossy and color alteration; probably heat treated
3	2	99.05–98.95	13-1	Edge-modified flake	Length 81.8 Width 32.6 Thickness 28.2	Stream-rolled, smooth	Dark gray with white and brown bands near cortex	None
3	2	99.05–98.95	13-2	Edge-modified flake; retouched edge on very thin biface-thinning flake	Length (33.2) Width (25.1) Thickness 3.3	None	Light brown (no mottles)	Glossy; possibly heat treated
4	1	99.23–99.10	16-1	Edge-modified flake	Length 26.3 Width 22.4 Thickness 9.8	None	Brownish gray	Crazed; intensively heated

Table 6, continued

Test Unit	Level	Elevation (m)	Lot and Specimen No.	Artifact Type and Description	Measurements (mm)	Cortex	Chert Color	Heating Evidence
5	1	99.11–99.00	19-1	Edge-modified flake	Length 30.0 Width 25.2 Thickness 5.7	Stream-rolled, smooth	Dark gray with mottles	Slightly glossy; possibly heat treated
5	1	99.11–99.00	19-2	Graver/edge-modified flake	Length 27.9 Width 26.8 Thickness 3.5	None	Dark brown with gray mottles	Crazed; intensively heated
7	1	99.09–98.90	24-1	Uniface, scaper fragment	Length 42.2 Width 25.2 Thickness 6.3	Stream-rolled, rough	White with red flecks	Glossy; probably heat treated
9	1	99.00–98.80	29-1	Edge-modified flake	Length 22.1 Width 21.1 Thickness 7.4	None	Gray with red flecks	Glossy and color alteration; probably heat treated
16	1	99.19–99.00	37-2	Biface, middle-stage fragment	Length 73.9 Width 44.8 Thickness 22.2	Stream-rolled, rough	Gray with white mottles	None
18	1	99.13–99.00	44-1	Uniface, end scraper	Length 50.8 Width 42.1 Thickness 23.7	None	Dark brown with gray mottles	Crazed and glossy; intensively heated
18	2	99.00–98.90	45-1	Core tool; fragment of heavy chopping tool	Length 80.4 Width 57.4 Thickness 34.9	Stream-rolled, smooth	Gray chert, mottled	Crazed with potlids; intensively heated
CORES								
12	1	99.15–99.00	32-1	Core	Length 43.3 Width 41.9 Thickness 34.9	Stream-rolled, rough	Dark gray with white inclusions and pink banded	Slightly glossy; possibly heat treated
16	1	99.19–99.00	37-1	Core	Length 65.3 Width 58.7 Thickness 33.3	None	Dark gray chert, few inclusions	Glossy; possibly heat treated

Note: Measurements in parentheses are partial measurements on broken tools.

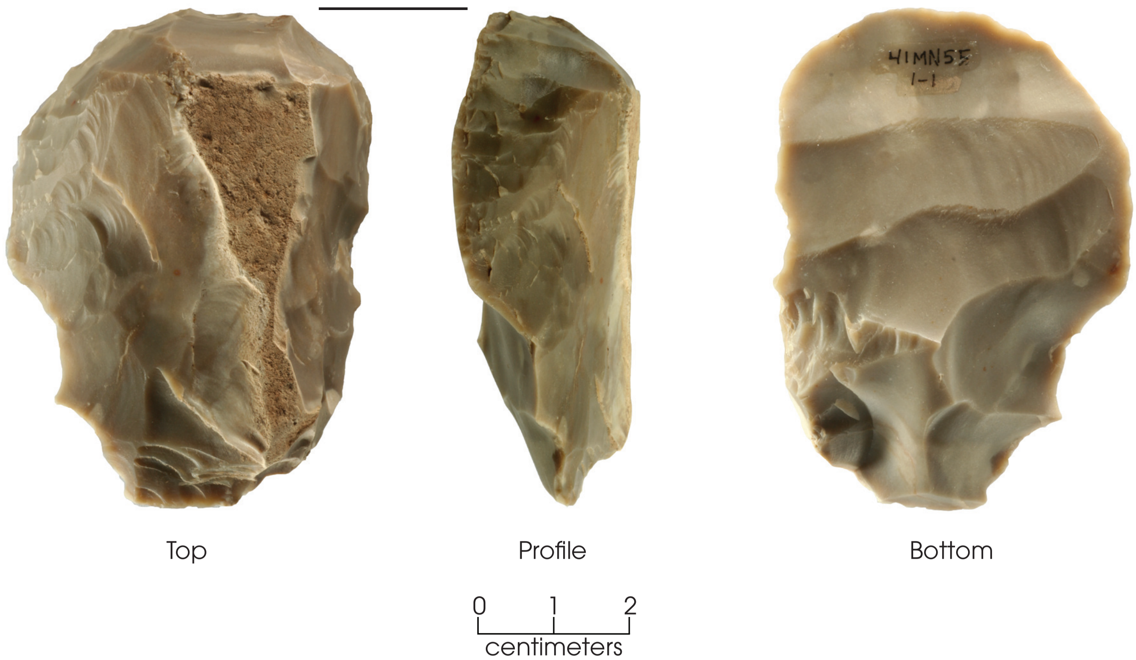

Figure 5. Plains-style end scraper.

Table 7. Unmodified chert debitage by amount of dorsal cortex and material type

Doral Cortex	Fine-Grained Chert	Medium-Grained Chert	Coarse-Grained Chert	Total	Percent
Primary	7	2	0	9	1.9%
Secondary	103	5	0	108	23.0%
Tertiary	351	0	1	352	75.1%
Total	461	7	1	469	100.0%
Percent	98.3%	1.5%	0.2%	100.0%	

Note: Excludes the three quartzite tertiary flakes.

Table 8. Unmodified chert debitage by amount of dorsal cortex and flake size

	Large	Medium	Small	Very Small	Total	Percent
Dorsal Cortex	1.5 to 2.0 inches (38 to 51 mm)	1.0 to 1.5 inches (25 to 38 mm)	0.5 to 1.0 inches (13 to 25 mm)	< 0.5 inches (< 13 mm)		
Primary	1	2	5	1	9	1.9%
Secondary	17	26	33	32	108	23.0%
Tertiary	4	18	128	202	352	75.1%
Total	22	46	166	235	469	100.0%
Percent	4.7%	9.8%	35.4%	50.1%	100.0%	

Note: Excludes the three quartzite tertiary flakes.

Table 9. Unmodified debitage by chert color

Color	No.	Variations
Banded colors	9	Tan, gray, and brown
Black	1	–
Brown	228	47 specimens have some degree of mottling or inclusions
Dark brown	41	5 specimens have inclusions
Dark gray	2	–
Gray	68	7 specimens have inclusions
Gray and brown	31	5 specimens have inclusions
Light brown	7	4 specimens have inclusions or mottles; 1 specimen is translucent
Light gray	1	–
Mottled brown	1	–
Red, brown, and gray	1	–
Reddish brown	34	2 specimens have inclusions
Tan	32	3 specimens have inclusions or mottling
Tan and brown	9	5 specimens have inclusions
Tan and gray	2	1 specimen has inclusions
White to light gray	1	–
White and tan	1	–
Total	469	

Note: Excludes the three quartzite specimens.

being discarded into fires. Only the 21 specimens that exhibit a glossy appearance are candidates for intentionally heat treatment.

A subjective analysis of chert colors was conducted to augment the interpretation of other flake attributes (see Table 9). Most of the flakes are various shades of brown, gray, or both. The banded specimens, also dominated by tan, gray, and brown colors, probably represent materials that have been altered by being buried in moist stream gravel bars for hundreds of years. The few specimens (n = 35) that exhibit red or reddish brown colors do not appear to represent discoloration from heat treating, and they all lack any definitive heating attributes. It is more likely that the reddish color in these specimens is natural, possibly due to iron content in the cherts and prolonged exposure to moisture.

The debitage attributes indicate that almost all of the chert flakes are from locally available stream gravels. Similarly, most of the chert tools exhibit the colors brown and gray and cortex characteristics typical of the chert debitage, also suggesting use of local stream gravels (see Table 6). Chert tools and debitage observed at other sites nearby in the San Saba River valley during the FM 2092 survey (McWilliams and Boyd 2008) exhibited the same common chert colors (primarily browns and grays) and stream-rolled cortex.

Ceramic Sherds

The ceramic assemblage consists of 63 plain bone-tempered body sherds. Several are burnished, some exhibit polish, and brush marks are visible on 2 specimens. The largest sherd is 25.0x21.7x4.4 mm and displays a break along a coil line. None of the fragments are more than 5 mm thick. All of the sherds are similar in appearance and could have come from a single vessel or multiple vessels.

Sherds were found on both sides of FM 2092. North-side proveniences with sherds are as follows: surface, n = 4; Test Unit 3, n= 23; Test Unit 12, n= 23; Test Unit 16, n = 3; and Test Unit 17, n = 4. South-side proveniences with sherds are: Test

Unit 6, n = 2; Test Unit 7, n = 1; and Test Unit 18, n = 3. The fact that the sherds were found as much as 30 m apart (i.e., on opposite sides of the 100-ft-wide right of way) suggests that they represent more than one pot.

Five sherds were subjected to neutron activation analysis (NAA) and mineralogical analysis through petrographic study of thin sections (Table 10). The NAA study is reported in Ferguson and Glascock (2012), and the petrographic analysis is reported in Robinson (2012). Two other sherds were submitted for luminesence dating, but it appears that the dating results are erroneous (see Appendix and Dating of the Component below).

Table 10. Bone-tempered sherds submitted for ceramic sourcing

Lot	Test Unit	Level	Elevation (m)	NAA and Petrographic Sample No.
1	none	surface	–	PAI-117
13	3	2	99.05–98.95	PAI-113
32	12	1	99.15–99.00	PAI-114
12	3	1	99.15–99.05	PAI-115
14	3	3	98.95–98.90	PAI-116

The petrographic analysis indicates that the five sherds are all very similar in ceramic paste composition, including the types and amounts of bone tempering added to the clay (Robinson 2012). But these sherds are distinctively different than the bone-tempered pottery recovered from Mission San Sabá and Presidio San Sabá, located 1.6 and 5.7 miles west of 41MN55, respectively. This is not surprising, since the presidio and mission plainwares are visually similar to Goliad Plain ceramics found at other Spanish colonial sites in Texas.

The NAA study by Ferguson and Glascock (2012) generally supports Robinson's interpretation that the 41MN55 sherds are different than the other sample sherds. Although the NAA sample is small, it is notable that four of the five 41MN55 sherds fall into their own geochemical group, and the fifth sherd falls into an unassigned category. The chemical composition of the 41MN55 sherds is unique, and it does not match the chemical compositions of any of the native-made plainwares from any of the Spanish Colonial sites in the sample (Ferguson and Glascock 2012:Table 12.4). This means that the 41MN55 sherds were manufactured from clay sources that were different than the clay sources used to make any of the native-made plainwares at nearby Mission San Sabá and other Spanish colonial sites in Texas. This suggests that the people who lived at the Fivemile Crossing site represent a Late Prehistoric Toyah phase group that had no connections with Mission San Sabá or any other Spanish colonial settlements.

The petrographic analysis by Robinson (2012) was intended as a stand-alone study to compare bone-tempered plainware sherds from a small number of sites.

In contrast, that NAA analysis of plainware sherds from 41MN55, Mission San Sabá, and other Spanish colonial sites in Texas was part of a larger study called the Central Texas Ceramic Project (CTCP). Sponsored by the Texas Archeological Research Laboratory at the University of Texas at Austin, the CTCP was initiated by Darrell Creel to gather and interpret NAA elemental chemistry data for a large sample of central Texas ceramics (Creel 2002; Texas Archeological Research Laboratory 2006). Ceramic sourcing through NAA has proven to be an excellent tool for addressing a broad range of research topics pertaining to social identity, exchange systems, and movements of people across time and space (e,g., Glowacki and Neff 2002; Perttula et al. 2003). The status of the CTCP was reported by Creel in 2002 and TARL in 2006 (Creel 2002; Texas Archeological Research Laboratory 2006), followed by Jeffrey Taff's (2006, 2007) reporting on preliminary analyses of the NAA data. More recently, Creel et al. (2013) presented the results of a much more rigorous analysis of the NAA data, along with many important interpretations and useful insights into the ceramics manufactured, used, and traded by central Texas hunter-gatherers. Much of the CTCP data pertains directly to bone-tempered wares associated with Toyah phase occupations, so the 41MN55 sherds have been added to the growing chemical composition database that now includes NAA data on 602 ceramic sherds and 40 clay samples in the greater central Texas area. The CTCP geochemical sourcing project has compiled a great deal of data that are available for future research, and the addition of new NAA samples will continue to improve the NAA database. TxDOT contributed a significant amount of funding to this project for NAA analyses on pottery from many central Texas sites and for the comprehensive data analysis and reporting by Creel et al. (2013).

Possible Modified Shell

One possible modified mussel shell was recovered from Test Unit 16, Level 1. It is a small trapezoidal valve edge fragment without an umbo that measures approximately 33x27 mm and 5.2 mm thick. The specimen has three broken edges with sharp breaks, while the distal edge is sinuous and appears to be smoothed, perhaps from use as a scraping tool.

Unmodified Faunal Remains

Nine unmodified animal bones were recovered. Seven of the bones are small nondescript fragments, and one is a small mammal vertebra. The ninth specimen, from Level 1 of Test Unit 12, is the proximal end of an armadillo radius. All of the bones are unburned, and several are weathered from surface exposure before being buried. The attributes and contexts of these bones make their associations with the Late Prehistoric occupations dubious at best. Notably, the armadillo bone is an obvious intrusion because this species expanded northward into Texas in historic times (Davis 1974:267).

Twenty-seven freshwater mussel shell umbos and 14 fragments were recovered. Most of these specimens are fragmentary, and even with the umbo fragments, it is not possible to determine the minimum number of valves accurately. Only 11 of the umbo fragments are large enough to be confidently identified to species. They represent a minimum of three species, all in the Unionidae family, which are found across the eastern half of Texas and into west-central Texas (Table 11; Howells et al. 1996: 35, 71, 107).

Table 11. Species identification of mussel shells

Test Unit, Level, and Elevation (m)	Lot	*Amblema* sp.	*Lampsilis teres* (Yellow Sandshell)	*Lampsilis* sp.	*Quadrula apiculata* (Southern Mapleleaf)	*Quadrula* sp.
TU 1, Level 1, 99.05–98.90	2	2		1		
TU 2, Level 3, 99.00–98.90	8					2
TU 7, Level 1, 99.09–98.90	24		1			2
TU 9, Level 1, 99.00–98.80	29				1	2
Total		2	1	1	1	6

Burned Rocks

Fifty-three burned rocks weighing 1,563.3 g were collected. All are angular limestone fragments. The largest is a fist-sized piece that weighs 298.4 g. The average recovery of 11.5 kg (25.4 lbs) per square meter is low, and no concentrations of rocks were found that would suggest the presence of features. Rather, the evidence seems to indicate a more or less continuous light scatter of burned rocks dispersed on a stable living surface. The presence of scattered burned rocks indicates that burned rock features are likely to be (or have been) present at the site, likely beyond the road right of way.

Historic Artifacts and Modern Debris

Historic and modern items were observed during the excavations, and these were recorded on level records but not collected. Only one historic artifact, a glass bottle base with an embossed marking, was collected. The historic and modern items are listed in Table 12.

The collected specimen is cobalt blue glass inscribed with the words "Genuine Phillips" and "Made in U.S.A." Phillips brand milk of magnesia (magnesium hydroxide) was sold in these blue glass bottles during the late nineteenth century and well into the twentieth century. As such, this specimen is probably historic in age (i.e., over 50 years old) but not particularly diagnostic. The other observed items include glass fragments (some burned), metal and wire fragments, iron fence staples, pieces of aluminum foil, and .22-caliber brass cartridge cases. A modern wooden fence post remnant also was found. These items provide evidence of historic and modern disturbances and are not associated with the Native American occupations. More than 61 historic and modern items were found in Level 1, while far fewer specimens were found in Level 2 (n = 12) and Level 3 (n = 2). Glass fragments and fence staples account for the majority of intrusive items found. Historic and modern items were

Table 12. Historic and modern items by test unit and level

Test Unit	Level	Elevation (m)	Lot	No.	Observed	Collected	Other
UNITS NORTH OF FM 2092							
1	1	99.05–98.90	2	2	1 oxidized glass fragment, 1 piece of aluminum foil		
2	1	99.17–99.10	6	3+	1 iron fragment and several glass fragments		
2	2	99.10–99.00	7	2	2 glass fragments		
3	1	99.15–99.05	12	6	4 metal fragments, 1 fence staple, 1 burned glass fragment		
3	2	99.05–98.95	13	1	1 glass fragment (blue)		
4	1	99.23–99.10	16	3	1 iron fragment, 1 glass fragment, 1 piece of aluminum foil		
11	2	99.10–99.00	–	3	3 metal fragments		
12	1	99.15–99.00	32	10	8 metal fragments, 1 burned glass fragment, 1 metal wire fragment		
15	1	99.19–99.00	35	18	4 fence staples, 12 glass fragments, 1 metal fragment, 1 bottle base	cobalt blue bottle base with embossed markings: “Genuine Phillips” and “Made In U.S.A.”	
15	2	99.00–98.90	36	3	2 glass fragments (blue)		wooden fence post
15	3	98.90–98.80	–	1	none		wooden fence post
16	1	99.19–99.00	37	4	2 glass fragments, 2 metal fragments		
17	1	99.15–99.00	40	5+	several glass fragments, several metal fragments, 1 metal wire fragment		
17	2	99.00–98.90	41	3+	several burned glass fragments, 1 metal wire fragment		
UNITS SOUTH OF FM 2092							
5	1	99.11–99.00	19	4+	several fence staples, 2 cartridge cases (.22 caliber)		
5	3	98.90–98.80	–	1	1 fence staple		
13	1	99.15–99.00	47	2	2 fence staples		
14	1	99.13–99.00	–	4+	several burned glass fragments, several fence staples		

observed both north (n > 64) and south (n > 11) of FM 2092, but there was a greater diversity of artifact types north of the road in closer proximity to the farmhouse.

Other Materials

Charcoal was recovered from the upper two levels of Test Unit 2, and from Level 3 of Test Unit 18 (see Table 4). The charcoal sample from 99.12–99.09 in Test Unit 2 (at the interface of Levels 1 and 2) probably represents a modern root burn caused by a brush fire along the road right of way.

Dating of the Component

PAI archeologists were careful to look for evidence of cultural features, organic-rich dark sediment that might yield charred plant remains, and potentially datable charcoal samples and animal bones. No cultural features or dark-stained sediments were found, and the excavations produced only three piece-plotted charcoal fragments (see Table 4). Two of the three charcoal samples, from the upper levels of Test Unit 2, were in a dubious context thought likely to represent modern burned wood. One sample from Test Unit 18, Level 3, was initially considered to be possibly associated with the Toyah occupation, but after the distribution of historic artifacts was considered, it was decided the sample context was not reliable. Two sediment samples (from Unit 15, Level 1, and Unit 16, Level 2) were processed for flotation and yielded tiny flecks of charcoal (see Table 5), but their contexts are considered questionable as well. Although nine bones were recovered from test unit excavations, and one was recovered from flotation (see Table 4), none of these specimens were considered to be definitely associated with the Toyah occupation, and they could easily be instrusive bones from modern road kills. Consequently, no charred remains or bone specimens from 41MN55 were submitted for radiocarbon dating.

In an attempt to gain chronological information on the 41MN55 occupations, two ceramic sherds were submitted to Dr. James Feathers at the Luminescence Dating Laboratory, University of Washington, for dating using optically stimulated luminescence (OSL) and thermoluminescence (TL) techniques (Table 13; Appendix[1]). The two resulting dates, 2090±470 B.C. and A.D. 850±160, are both much older than expected, since the Toyah phase in central Texas is generally thought to begin around A.D. 1300 (Arnn 2007, 2012a; Johnson 1994; Kenmotsu and Boyd 2012). As discussed in detail in the Appendix, the OSL date of 2090 B.C. may be inaccurate because of “insufficient firing,” and may reflect the last time that some of the sediments were exposed to sunlight long before being procured to make the pottery. The second sample was assayed using both the OSL and TL techniques. Since the OSL and TL dates for the second sample are in agreement, it is less likely that insufficient firing skewed this date. Although it is possible that the OSL/TL date could be correct, and that this sherd is from a bone-tempered pot made between A.D. 690 and 1010, there is no reliable evidence that bone-tempered pottery was made in central Texas this early. A more plausible interpretation is that the OSL/TL date is incorrect, but we do not fully understand the

[1] For a detailed explanation of luminescence dating, including field sampling methods for OSL and TL, see Nelson et al. (2015).

source of the error. Based on the current body of chronological evidence for the Toyah phase and bone-tempered pottery in central Texas, both of these luminescence dates should be considered erroneous.

Table 13. Optically stimulated luminescence and thermoluminescence dates on two bone-tempered ceramic sherds by the Luminescent Dating Laboratory at the University of Washington

Sample No.	UW2460	UW2461
Date based on OSL data	2090±470 B.C.	n/a
Date based on OSL and TL data	n/a	A.D. 850±160
Lot No.	1	32
General Location	North side of FM 2092	North side of FM 2092
Provenience	Surface collection between Test Units 2 and 3	Test Unit 12, Level 1, Elevation 99.15–99.00 m (0–15 cm below surface)
Weight (grains)	1.9	1.3
Length x width (mm)	19x14	21x12
Thickness (mm)	5.5–6.0	4.5–5.0

The use of multiple dating methods was considered desirable because they could provide complementary and potentially corroborating results. During the analysis phase, PAI archeologists evaluated the potential for several other absolute dating techniques, including the following:

1. Direct AMS radiocarbon dating of terrestrial snail shells, including the use of an ancient carbon correction factor. See discussions by Boyd and Kleinbach (1999), Quigg (1999:4-3 to 4-5), and Quigg and Cordova (1999:9-2 to 9-5, 2000:29–30, 136–144).

2. AMS radiocarbon dating of organic residue extracted from ceramic sherds. See discussions by Berstan et al. (2008), Hart and Lovis (2007), Hedges et al. (1992), and Loy (1991, 1993).

3. AMS radiocarbon dating of organic residue extracted from burned rocks. See discussions by Quigg and Cordova (1999:4-3 to 4-5, 2000:48–49, 136–144, 230, 250), and Quigg et al. (2002:321–327).

4. Amino acid epimerization dating (A/I Ratio) of terrestrial snail shell. See discussions by Boyd (1999), Ellis et al. (1996), Quigg (1999:4-3 to 4-5), and Quigg and Cordova (1999:9-2 to 9-5, 2000:143–144).

5. OSL of alluvial sediments from the cultural zone. See discussion by Rittenour (2008).

Each of these techniques was carefully considered in light of the high degree of bioturbation and dubious sample contexts. The analytical and interpretive problems associated with some of these techniques were also considered. After these assessments were made and reviewed with TxDOT archeologists, these techniques were ruled out as methods for obtaining reliable chronological dates for the 41MN55 occupations. Lacking any definitive absolute dates, the chronology of the Native American occupation at the Fivemile Crossing site remains uncertain. The geomorphic setting and the ceramics indicate the occupation dates to the Late Prehistoric period and possibly into Protohistoric times (i.e., early European contact).

Distribution of Cultural Materials

The vertical and horizontal distributions of cultural materials were analyzed, but only a few general patterns are apparent. The cultural materials are concentrated mostly in the upper 30 cm of deposits, between 99.20 and 98.90 m, in the upper A horizon. Historic artifacts and modern debris are present throughout this zone and occasionally to greater depths.

Cultural materials were most concentrated in five units in a cluster on the north side of FM 2092 (see Table 3 and Figure 3). The units with the highest frequencies are, from west to east, Test Units 2, 17, 16, 12, and 3. These units are within a 9-m-long area where the observed density of surface artifacts was highest. Test Unit 15 was one of the least productive units in terms of artifacts and burned rocks, although it was only 2–3 m east of two of the most productive units (Test Units 3 and 12). The variability in the frequencies of artifacts and burned rocks between units suggests that discrete activity areas may be represented by concentrations of cultural materials.

Test Units 11 and 14, at the eastern end of the project area, were the only units devoid of cultural materials. Test Units 6–9 and 18, which are clustered mostly along the southwest margin of the right of way, lack modern/historic items. Chipped stone tools and cores were found in 10 of 18 units, but none yielded more than 3 artifacts. Test Units 2, 3, and 12 along the north-central fence line and Test Unit 18 near the south-central fence line generated more than half (n = 264) of the 472 pieces of unmodified debitage. Almost three-quarters (n = 46) of the 63 ceramic sherds were found in contiguous Test Units 3 and 12. Greater burned rock weights (more than 200 g) were found in units along the north margin of the right of way. Only Test Units 1 and 3 contained more than five bones or mussel shell umbos.

Site 41MN55 Outside the FM 2092 Right of Way

During the testing phase, PAI archeologists made a quick reconnaissance survey of the cultivated field on private land south of FM 2092 with permission from the landowner, Laura Austin. The field had been plowed some weeks or months prior, and at the time of the investigation, it was sparsely vegetated. Ground surface visibility was excellent, and artifacts were easy to see on the flat surface over a large area. No artifacts were collected, and the investigation consisted only of a visual inspection. PAI archeologists observed bifacial cores, tested cobbles, utilized flakes, unmodified debitage, and burned rocks. A cluster of flakes (possibly indicating the presence of a chipping station) and one cluster of burned rocks were observed. The artifacts were most concentrated in the western portion of the terrace, within 50 m of the terrace edge. Some historic or modern domestic artifacts were observed along the fence line on the west edge of the terrace.

Site 41MN55 extends 190 m east-west in the FM 2092 right of way, and observations in the field indicate that it extends southward at least 75 m. No investigations were done north of the highway, but the site probably extends that direction as well, perhaps occupying much of the high terrace overlooking the prominent bend in the San Saba River (see Figure 1).

Summary of the Toyah Phase Occupation at the Fivemile Crossing Site

The testing at 41MN55 found no cultural features and yielded a small artifact assemblage, and the interpretability of the investigated portion of the site is limited. There are few research issues that can be addressed, even at a cursory level, using such data. However, it is worth considering some of the more important aspects of the site.

Establishing the age and duration of the Toyah occupation at 41MN55 was an important goal of the archeological investigations. From a general perspective, any archeological site data becomes much more meaningful if its chronology can be precisely defined, and good dating of site components and individual occupation episodes is critical to reconstructing meaningful regional prehistories. Based solely on the recovered cultural materials, the occupation at 41MN55 most likely dates within the classic Toyah period of central Texas, between ca. A.D. 1300 and 1700 (Arnn 2012a; Johnson 1994; Kenmotsu and Boyd 2012). Unfortunately, more-precise dating is not possible.

Site 41MN55 is a location where a variety of activities occurred. Pottery vessels were used and broken, chert cores were brought on site and worked, lithic tools were manufactured and maintained, chipping debris was discarded, and unifacial hide scrapers were used, resharpened, and discarded. The thermally altered limestone rocks also indicate that people made fires, presumably for cooking and/or warming. The diversity of activities seems to represent a residential base camp, but the tested portion of the site and the material culture sample are small, and the occupation is not dated precisely. Consequently, it is impossible to infer the number and duration of occupation episodes.

The proximity of 41MN55 to Mission San Sabá, which was occupied only briefly by the Spanish in 1757–1758, and Presidio San Sabá, which was occupied for more than a decade from 1757 to 1771, is notable. A nearly complete Perdiz arrow point and a historic strike-a-light flint were found at the mission in association with a Spanish colonial bone cluster that may have been discarded in a small pit. The animal bones included cow, deer, large and medium mammal, and fish, and some exhibited butchering marks made by metal tools (McWilliams et al. 2012:Figures 5.13 and 5.14; Table 11.5). The bone cluster represents a Spanish colonial discard event, but the associations between the Perdiz arrow point, the strike-a-light flint, and the bones are not clear, and the edges of the pit were poorly defined. However, circumstantial evidence suggests that someone carrying a Perdiz arrow point was at the mission for a short time in 1757 or 1758, and that Toyah peoples may have been living in the area while the Spaniards occupied the mission and presidio. Because of the findings at Mission San Sabá, one of the questions going into the 41MN55 investigations was whether Toyah peoples might have lived at Fivemile Crossing while the Spaniards were at the mission and presidio. This question cannot be answered due to the paucity of archeological data, however.

The setting makes the site an ideal location for a Late Prehistoric or Protohistoric campsite or small hamlet. The site sits on a high alluvial terrace 4 to 5 m above the San Saba River, just 100 m away. It is one of the few locations in this stretch of the valley where the river has meandered into a position so close to the terrace. Thus, the inhabitants could camp safely out of reach of the large floods that occur often yet be close enough to overlook the riparian habitat from their camp. The topographic and geomorphic evidence suggests that this location would not have been as attractive several thousand years ago, in Late Archaic times, for example, because the San Saba River was much farther west. As a consequence, this location would have had limited water availability and reduced ectotone diversity, substantially decreasing access to critical food resources. The eastward migration of the river in this area, which occurred over the past 500 to 1,000 years, is what made the 41MN55 locality increasingly attractive as a campsite in Late Prehistoric times.

The soil survey for Menard County (U.S. Department of Agriculture 1967:Sheets 26 and 34) maps the presence of another feature that may have been attractive to the prehistoric inhabitants. Just south of FM 2092, a linear patch mapped as "Terrace Escarpments" runs parallel to the river along the edge of the terrace. These are described as "long, narrow areas of gravelly breaks between the bottom lands and uplands. These areas border the bottom lands of the San Saba River and larger creeks in the county" (U.S. Department of Agriculture 1967:14). No gravelly deposits were observed in the FM 2092 right of way, but this gravelly terrace area immediately to the south could have been an easily accessible source of limestone rocks and chert nodules.

ASSESSMENT AND RECOMMENDATIONS

The Fivemile Crossing site, 41MN55, which lies on an alluvial terrace overlooking the San Saba River, consists of a shallowly buried Late Prehistoric occupation. Testing revealed evidence of a single component that produced diagnostic artifacts (i.e., pottery and end scrapers) attributed to the Toyah culture. The bone-tempered ceramic sherds recovered are typical of the pottery found at Toyah sites in this area, such as at the Buckhollow site reported by Johnson (1994) and the Janee site (41MN33) reported by Arnn (2007, 2012a).

Most of the site is outside the FM 2092 right of way. Although this uninvestigated area has been disturbed by cultivation and other activities, it likely retains sufficient horizontal spatial patterning of artifacts to infer cultural activities across a large area. There also is the potential for intact features, such as rock-lined hearths and other intrusive pits. The artifact density is likely to be low, reflecting short duration of occupations there and perhaps a limited range of activities. Although not tested, it is likely that this part of 41MN55 contains important archeological data.

In contrast, the part of the site in the FM 2092 right of way does not contain important information and thus is not eligible for listing in the National Register of Historic Places under Criterion D or designation as a State Antiquities Landmark. Following the evaluation process defined by the National Park Service (U.S. Department of the Interior 1997), the key issues for 41MN55 are the low integrity of the archeological deposits and the limited areal extent of the archeological remains within the road right of way. In regard to the former, no cultural features were found, despite an intensive level of testing, and intrusive historic and modern items are intermixed with the prehistoric cultural materials in almost all units. This mixing is almost certainly due to bioturbation (plant root activity and animal and insect burrowing) and natural geological processes (clay shrink-swell). The part of 41MN55 within the right of way lacks sufficient integrity of association to be able to address important questions of prehistory or history (36 CFR 60.4).

In regard to the latter issue, the road cut has removed most of the terrace surface over the western portion of the site, and cultural deposits are present only in thin strips 1–2 m wide along the north and south edges of the right of way. The potential for undiscovered features in these strips is low, and the potential to discern meaningful horizontal patterns of cultural materials is lower still. Even if additional excavation was done here, it is unlikely that work would provide useful archeological data relevant to research topics such as subsistence, technology, and social identity.

REFERENCES CITED

Arnn, John W.

2007 Transformation and Persistence of Indigenous Cultural Identity During the Early Colonial and Prehistoric Periods in Texas. Ph.D. dissertation, Department of Anthropology, University of Kentucky, Lexington.

2012a *Land of the Tejas: Native American Identity and Interaction in Texas, A.D. 1300–1700*. University of Texas Press, Austin.

2012b Defining Hunter-Gatherer Sociocultural Identity and Interaction at a Regional Scale: The Toyah/Tejas Social Field. In *The Toyah Phase of Central Texas, Late Prehistoric Economic and Social Processes*, edited by Nancy A. Kenmotsu, and Douglas K. Boyd, pp. 44–75. Texas A&M University Press, College Station.

Arnn, John, Rebecca Shelton, and Linda W. Ellis

2010 Prehistoric Ceramics in the North Central Texas, Prairie Savanna, and Central Texas Archeological Regions. In *Regional Summaries of Prehistoric and Early Historic Ceramics in Texas for the Council of Texas Archeologists*, edited by Linda W. Ellis and Timothy K. Perttula, pp. 61–77. Prepared for the Ceramics Protocol Committee, Council of Texas Archeologists, Austin, Texas. Electronic document, http://counciloftexasarcheologists.org/wordpress/wp-content/uploads/Regional-Summaries-Ceramics.pdf, accessed July 25, 2017.

Berstan, R., A. W. Stott, S. Minnitt, C. Bronk Ramsey, R. E. M. Hedges, and R. P. Evershed

2008 Direct Dating of Pottery from Its Organic Residues: New Precision Using Compound-Specific Carbon Isotopes. *Antiquity* 82 (317):702–713.

Blair, W. F.

1950 The Biotic Provinces of Texas. *Texas Journal of Science* 2: 93–117.

Boyd, Douglas K.

1999 Summary and Evaluation of Radiocarbon Dates and Amino Acid Epimerization Analysis of Snail Shells. In *National Register Testing of 42 Prehistoric Archeological Sites on Fort Hood, Texas: The 1996 Season*, by Karl Kleinbach, Gemma Mehalchick, Douglas K. Boyd, and Karl W. Kibler, pp. 439–445. Archeological Resource Management Series, Research Report No. 38. United States Army, Fort Hood.

Boyd, Douglas K., and Karl Kleinbach

1999 Summary and Evaluation of Radiocarbon Dates. In *National Register Testing of 19 Prehistoric Archeological Sites at Fort Hood, Texas: The 1995 Season*, by Gemma Mehalchick, Karl Kleinbach, Douglas K. Boyd, Steve A. Tomka, and Karl W. Kibler, pp. 265–272. Archeological Resource Management Series, Research Report No. 37. United States Army, Fort Hood.

Boyd, Douglas K., and Jennifer K. McWilliams

2006 Preliminary Report on Archeological Survey of FM 2092 from Menard to Fivemile Crossing, Menard County, Texas. Submitted to the Texas Department of Transportation, Environmental Affairs Division, by Prewitt and Associates, Inc. Austin.

Boyd, Douglas K., and Gemma Mehalchick

2007 Interim Report on Archeological Testing of 41MN55, A Toyah Phase Site in the FM 2092 Right of Way, Menard County, Texas. Submitted to the Texas Department of Transportation, Environmental Affairs Division, by Prewitt and Associates, Inc., Austin.

Brune, Gunnar

1975 *Major and Historical Springs of Texas*. Report No. 189. Texas Water Development Board, Austin.

Bureau of Economic Geology
1981 *Geologic Atlas of Texas, Llano Sheet*. Bureau of Economic Geology, The University of Texas at Austin.

Carpenter, Stephen M.
2017 The Toyah Complex of South and Central Texas: Long-range Mobility and the Emergence of Dual Economies. *Plains Anthropologist* 62(242):133–156.

Collins, Michael B.
1995 Forty Years of Archeology in Central Texas. *Bulletin of the Texas Archeological Society* 66:361–400.

Creel, Darrell
2002 Central Texas Ceramics Project. *Newsletter of the Friends of the Texas Archeological Research Labora*tory, July 2002, p. 10.

Creel, Darrell, Jeffrey R. Ferguson, and Nancy A. Kenmotsu
2013 A Compositional Analysis of Central Texas Hunter-Gatherer Ceramics and Its Implications for Mobility, Ethnic Group Territory, and Interaction. *Bulletin of the Texas Archeological Society* 84:29–83.

Dallas Morning News
1999 *2000–2001 Texas Almanac, Millennium Edition*. Dallas Morning News, L.P., and Texas A&M University Press Consortium, College Station.

Davis, William B.
1974 *The Mammals of Texas* (1978 reprint edition). Bulletin 41. Texas Parks and Wildlife Department, Austin.

Dillahey, Thomas D.
1974 Late Quaternary Bison Population Changes on the Southern Plains. *Plains Anthropologist* 19(65):180–196.

Ellis, G. Lain, Glenn A. Goodfriend, James T. Abbott, P. E. Hare, and David W. Von Endt
1996 Assessment of Integrity and Geochronology of Archaeological Sites Using Amino Acid Racemization in Land Snail Shells: Examples from Central Texas. *Geoarchaeology: An International Journal* 11(3):189–213.

Estaville, Lawrence E., and Richard A. Earl
2008 *Texas Water Atlas*. Texas A&M University Press, College Station.

Ferguson, Jeffrey R., and Michael D. Glascock
2012 Neutron Activation Analysis of Ceramics from Mission San Sabá and other Spanish Colonial Sites in Texas. Appendix F in *A Slice of Mission Santa Cruz de San Sabá: Historic Archeological Investigations of a Portion of an Apache Mission in the Spanish Northern Frontier*, by Jennifer K. McWilliams, Douglas K. Boyd, John E. Dockall, Mark R. Wolf, Steven Schooler, Brian Sawyer Shaffer, and Leslie L. Bush, Reports of Investigations No. 182. Prewitt and Associates, Inc., Austin. Draft report 2012; anticipated publication 2018.

Glowacki, Donna M., and Hector Neff (editors)
2002 *Ceramic Production and Circulation in the Greater Southwest: Source Determination by INAA and Complementary Mineralogical Investigations.* Cotsen Institute of Archaeology at the University of California, Los Angeles.

Hart, John P., and William A. Lovis
2007 A Multi-Regional Analysis of AMS and Radiometric Dates from Carbonized Food Residues. *Midcontinental Journal of Archaeology* 32(2):201–261.

Hedges, R. E. M., Chen Tiemei, and R. A. Housley
1992 Results and Methods in the Radiocarbon Dating of Pottery. *Radiocarbon* 34(3):906–915.

Howells, Robert G., Raymond W. Neck, and Harold D. Murray
1996 *Freshwater Mussels of Texas.* Texas Parks and Wildlife Department, Austin.

Johnson, Leroy
1994 *The Life and Times of Toyah-Culture Folk: The Buckhollow Encampment, Site 41KM16, Kimble County, Texas.* Office of the State Archeologist Report 38. Texas Department of Transportation and Texas Historical Commission, Austin.

Kelley, J. Charles
1947 The Lehmann Rock Shelter: A Stratified Site of the Toyah, Uvalde, and Round Rock Foci. *Bulletin of the Texas Archeological and Paleontological Society* 18:115–28.

Kenmotsu, Nancy Adele, and John W. Arnn
2012 The Toyah Phase and the Ethnohistorical Record: A Case for Population Aggregation. In *The Toyah Phase of Central Texas, Late Prehistoric Economic and Social Processes*, edited by Nancy A. Kenmotsu, and Douglas K. Boyd, pp. 19–43. Texas A&M University Press, College Station.

Kenmotsu, Nancy Adele, and Douglas K. Boyd
2012 The Toyah Phase in Texas: An Introduction and Retrospective. In *The Toyah Phase of Central Texas, Late Prehistoric Economic and Social Processes*, edited by Nancy A. Kenmotsu, and Douglas K. Boyd, pp. 1–18. Texas A&M University Press, College Station.

Loy, Thomas
1991 Prehistoric Organic Residues: Recent Advances in Identification, Dating and Their Antiquity. In *Archaeometry'90: Proceedings of the 27th International Symposium on Archaeometry*, edited by E. Pernicka and G. A. Wagner, pp. 645–656. Birkhauser Verlag, Boston.

1993 On the Dating of Prehistoric Organic Residues. *The Artefact* 16:46–49.

Mauldin, Raymond, Jennifer Thompson, and Leonard Kemp
2012 Reconsidering the Role of Bison in the Terminal Late Prehistoric Period in Texas. In *The Toyah Phase of Central Texas, Late Prehistoric Economic and Social Processes*, edited by Nancy A. Kenmotsu, and Douglas K. Boyd, pp. 90–110. Texas A&M University Press, College Station.

McWilliams, Jennifer K., and Douglas K. Boyd
2008 *Historical Assessment and Geoarcheological Survey of 4.9 Miles of FM 2092 from Menard to Fivemile Crossing, Menard County, Texas.* Reports of Investigation No. 155. Prewitt and Associates, Inc., Austin.

McWilliams, Jennifer K., Douglas K. Boyd, John E. Dockall, Mark R. Wolf, Steven Schooler, Brian Sawyer Shaffer, and Leslie L. Bush
2012 *A Slice of Mission Santa Cruz de San Sabá: Historic Archeological Investigations of a Portion of an Apache Mission in the Spanish Northern Frontier*. Reports of Investigations No. 182. Prewitt and Associates, Inc., Austin. Draft report 2012; anticipated publication 2018.

Natural Fibers Information Center
1987 *The Climates of Texas Counties.* Natural Fibers Information Center, University of Texas at Austin, in cooperation with the Office of the State Climatologist, Texas A&M University.

Nelson, Michelle S., Harrison J. Gray, Jack A. Johnson, Tammy M. Rittenour, James K. Feathers, and Shannon A. Mahan
2015 User Guide for Luminescence Sampling in Archaeological and Geological Contexts. *Advances in Archaeological Practice* 3(2):166–177. Electronic document, https://www.cambridge.org/core/journals/advances-in-archaeological-practice/article/user-guide-for-luminescence-sampling-in-archaeological-and-geological-contexts/2281D4CA64A1407D925ADCCDC0D64448, accessed August 1, 2017.

Perttula, Timothy K., Sergio A. Iruegas, and Hector Neff
2003 *Caddoan Pottery in Central Texas.* Archeological Resource Management Series, Research Report No. 51. United States Army, Fort Hood.

Prewitt, Elton R.
2012 Toyah: Reflections on Evolving Perceptions. In *The Toyah Phase of Central Texas, Late Prehistoric Economic and Social Processes*, edited by Nancy A. Kenmotsu, and Douglas K. Boyd, pp. 181–204. Texas A&M University Press, College Station.

Quigg, J. Michael
1999 *Archeological Monitoring at Upland Sites 41ZP39 and 41ZP176 for TransTexas Gas Well Site USA #3, Falcon Reservoir, Zapata County, Texas.* Technical Report No. 23224. TRC Mariah Associates, Inc., Austin.

Quigg, J. Michael, and Carlos Cordova
1999 *Archeological Investigations at Upland Sites 41ZP39 and 41ZP176 for TransTexas Gas Well Site USA #3, Falcon Reservoir, Zapata County, Texas.* Technical Report No. 22347. TRC Mariah Associates, Inc., Austin.

2000 *Data Recovery at 41ZP364: An Upland Campsite at Falcon Reservoir, Zapata County, Texas.* TRC Technical Report No. 22317. TRC Mariah Associates, Inc., Austin.

Quigg, Michael J., Shane Pritchard, and Grant Smith
2002 *The Boiler Site (41WB557) Utilization of an Upland Setting over the Last 4200 Years, Webb County, Texas.* TRC Technical Report No. 27277. TRC Mariah Associates, Inc., Austin. Archeological Studies Program Report No. 45. Environmental Affairs Division, Texas Department of Transportation, Austin.

Ricklis, Robert A.
1994 Toyah Components: Evidence for Occupations in the Project Area during the Latter Part of the Late Prehistoric Period. In *Archaic and Late Prehistoric Human Ecology in the Middle Onion Creek Valley, Hays County, Texas,* by Robert A. Ricklis and Michael B. Collins, pp. 207–316. Studies in Archeology 19. Texas Archeological Research Laboratory, The University of Texas at Austin.

Rittenour, Tammy M.
2008 Luminescence Dating of Fluvial Deposits: Applications to Geomorphic, Palaeoseismic and Archaeological Research. *Boreas* 37:613–635. Electronic document, http://www.geomorph.uni-bayreuth.de/de/ressourcen/Lumineszenz/Rittenour_08.pdf, accessed December 6, 2011.

Robinson, David G.
2012 Neutron Activation Analysis of Ceramics from Mission San Sabá and other Spanish Colonial Sites in Texas. Appendix G in *A Slice of Mission Santa Cruz de San Sabá: Historic Archeological Investigations of a Portion of an Apache Mission in the Spanish Northern Frontier*, by Jennifer K. McWilliams, Douglas K. Boyd, John E. Dockall, Mark R. Wolf, Steven Schooler, Brian Sawyer Shaffer, and Leslie L. Bush, Reports of Investigations No. 182. Prewitt and Associates, Inc., Austin. Draft report 2012; anticipated publication 2018.

Smyrl, Vivian Elizabeth
2010 "Menard County." Handbook of Texas Online. Texas State Historical Association. Electronic document, http://www.tshaonline.org/handbook/online/articles/hcm11, accessed July 25, 2017.

Stephens, A. Ray, and William M. Holmes
1984 *Historical Atlas of Texas*. University of Oklahoma Press, Norman.

Taff, Jeffrey A.
2006 Chemical Analysis of Ceramics from the Toyah Archaeological Area. M.A. thesis, Department of Anthropology, The University of Texas at Austin.

2007 Chemical Compositional Analysis of Ceramics from Central Texas: Implications for Residential Mobility and Exchange. Paper presented in the Toyah symposium ("The Toyah Phase: Revisiting the Late Prehistoric in Central Texas") at the 72nd Annual Meeting of the Society for American Archaeology, Austin, Texas, April 25–29, 2007.

Texas Archeological Research Laboratory
2006 Central Texas Ceramic Project. Internet status report, electronic document, http://www.utexas.edu/research/tarl/research/current.php#Central, accessed August 1, 2007.

Texas Parks and Wildlife Department
2017 Edwards Plateau Ecological Region. Electronic document, https://tpwd.texas.gov/landwater/land/habitats/cross_timbers/ecoregions/edwards_plateau.phtml, accessed August 2, 2017.

U.S. Department of Agriculture
1967 *Soil Survey of Menard County, Texas.* U.S. Department of Agriculture, Soil Conservation Service, in cooperation with the Texas Agricultural Experiment Station, College Station.

U.S. Department of the Interior
1997 *How to Apply the National Register Criteria for Evaluation.* U.S. Department of the Interior, National Park Service, Cultural Resources, Washington, D.C.

APPENDIX: Luminescence Analysis of Two Ceramic Sherds from 41MN55

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Two ceramic samples from site 41MN55 in Menard County, west-central Texas, were submitted by Prewitt and Associates, Inc., for luminescence dating and analyzed using optically stimulated luminescence (OSL), infrared stimulated luminescence (IRSL), and thermoluminescence (TL) techniques. These techniques can date materials by determining when the silica grains were last exposed to sunlight or intensive heating. Both samples are bone-tempered plainware believed to date to the Late Prehistoric or early European contact period, and probably associated with the Toyah phase in central Texas from ca. A.D. 1300 to 1700. The sherds were found in deposits at the top of a Pleistocene-age alluvial terrace of the San Saba River. The first specimen, from Lot 1, was recovered from the surface and given the laboratory number UW2460. The second, from Lot 32, was recovered 0–15 cm below the surface and given the laboratory number UW2461.

The results are described below. For the Luminescence Dating Laboratory's standard laboratory procedures, see Laboratory Procedures below (Feathers 2003).

RESULTS

The two ceramic sherds were submitted for luminescence dating of the buried cultural component at 41MN55. The fine-grain method using 1–8 µm grains was used for both samples, and age estimates were derived using the OSL and TL techniques.

Dose Rate

Dose rate measurements were made for each sample and also for an associated alluvial sediment sample, the latter providing the external dose rate. Dose rates on the samples were mainly determined using alpha counting and flame photometry. The beta dose rate calculated from these measurements was compared with the beta dose rate measured directly by beta counting. These were in agreement for UW2460 but slightly different for UW2461, possibly reflecting some disequilibrium in the U decay chain. For this sample, beta counting was used for the beta dose rate. Moisture content was estimated as 40±20 percent of saturated value for the samples, and 6±3 percent for the sandy sediments, reflecting the semiarid environment. Table A.1 gives relevant data, including the total dose rate for each sample. The concentrations of radionuclides for the ceramics were similar to that of the sediment, suggesting that the pottery was probably made from local materials.

Table A.1. Dose rate, luminescence analysis

Sample	^{238}U (ppm)	^{233}Th (ppm)	K (%)	Beta Dose Rate (Gy/ka) ß-counting	Beta Dose Rate (Gy/ka) α-counting/flame photometry	Total Dose Rate* (Gy/ka)
UW2460	2.94±0.21	8.20±1.09	1.50±0.07	1.85±0.15	1.86±0.07	3.00±0.19
UW2461	3.98±0.26	8.39±1.25	1.45±0.16	1.67±0.14	1.97±0.14	3.49±0.26
Sediment	2.90±0.21	9.16±1.19	1.50±0.11			

*Dose rate calculated for OSL. It will generally be somewhat higher for TL because of higher alpha efficiency.

Equivalent Dose

Equivalent dose was determined by TL, IRSL, and OSL, as described in the Laboratory Procedures section below. Both samples were very small, and only limited material was available for analysis. For UW2460, there was only enough material for 5 fine-grained aliquots. No TL was attempted on this sample, and only IRSL and OSL measurements were made. For UW2461, there was enough material for 40 aliquots. Although all but 5 of the aliquots were used for TL, there was considerable scatter in the TL signal from aliquot to aliquot, so that several aliquots had to be removed as outliers. The resulting precision was not high, and it was also not possible to measure a reliable anomalous fading rate. The plateau was also fairly narrow, 270–310°C. The best data came from OSL.

OSL/IRSL was measured on five aliquots for each sample. There was no measurable IRSL signal on either sample, so most of the OSL signal probably stemmed from quartz. The scatter among aliquots for UW2460 was not high, but equivalent dose estimates required extrapolation of the growth curve because administered regeneration doses were not high enough. Given the expected age of the sample, such a high equivalent dose was not expected and in fact produced an unreasonably old age. The decay curves were rather gradual, so it is possible the OSL was dominated by slow-bleaching components. Firing in antiquity thus may not have been sufficient to reset the signal. The OSL equivalent dose for UW2461 was lower, but there was high scatter. Two aliquots produced relatively low equivalent dose values, and two produced relatively high values (the fifth had no usable signal). The two low values were judged most reasonable, although both aliquots also suffered from some recuperation (significant signal after a zero dose). Dose recovery could only be assessed on UW2460, and the recovered dose did not differ from the administered dose.

Equivalent dose values are given in Table A.2, which also includes b-values (which reflect the lower efficiency of alpha irradiation in producing luminescence). The low b-values for OSL for both samples also suggest the OSL is mainly stemming from quartz.

Age Estimates

Table A.3 indicates the best estimated ages for the samples. For UW2640, the only estimate is from OSL, and as mentioned earlier, the age is much older than reasonable. Insufficient firing coupled with lack of a fast bleaching component would appear to account best for the age overestimation. For UW2461, although neither

Table A.2. Equivalent dose, luminescence analysis

	Equivalent Dose (Gy)			b-Value (Gy µm^2)		
Sample No.	*TL*	*IRSL*	*OSL*	*TL*	*IRSL*	*OSL*
UW2460	–	–	12.27±1.10	–	–	0.46±0.17
UW2461	4.19±1.04	–	4.53±0.60	1.68±0.52	–	0.68±0.06

TL nor OSL produced very good data, the ages were in agreement. This age is still over-estimated in terms of the believed fourteenth-century date. One might be able to argue for insufficient firing for this one as well, but it is an argument much less easily made because the TL and OSL are in agreement, and residual signals in either are not likely to be the same. The expectations of a later date might need reconsidering.

Table A.3. Age estimates, luminescence analysis

Sample No.	Age (ka)	% Error	Basis For Age	Date (years A.D./B.C.)
UW2460	4.10±0.47	11.4	OSL	B.C. 2090±470
UW2461	1.16±0.16	13.8	OSL and TL	A.D. 850±160

LABORATORY PROCEDURES

Sample Preparation, Fine-Grain Method

The sherd is broken to expose a fresh profile. Material is drilled from the center of the cross section, more than 2 mm from either surface, using a tungsten carbide drill tip. The material retrieved is ground gently by a corundum mortar and pestle, treated with HCl, and then settled in acetone for 2–20 minutes to separate the 1–8 μm fraction. This is settled onto a maximum of 72 stainless steel discs.

Glow-Outs

Thermoluminescence is measured with a Daybreak reader using a 9635Q photomultiplier with a Corning 7-59 blue filter, in N_2 atmosphere at 1–450°C. A preheat of 240°C with no hold time precedes each measurement. Artificial irradiation is given with a ^{241}Am alpha source and a ^{90}Sr beta source, the latter calibrated against a ^{137}Cs gamma source. Discs are stored at room temperature for at least one week after irradiation before glow out. Data are processed using Daybreak TLApplic software.

Fading Test

Several discs are used to test for anomalous fading. The natural luminescence is first measured by heating to 450°C. The discs are then given an equal alpha irradiation and stored at room temperature for varied times: 10 min, 2 hours, 1 day, 1 week, and 8 weeks. The irradiations are staggered in time so that all of the second glows are performed on the same day. The second glows are normalized by the natural signal and then compared to determine any loss of signal with time (on a log scale). If the sample shows fading and the signal versus time values can be reasonably fit to a logarithmic function, an attempt is made to correct the age following procedures recommended by Huntley and Lamothe (2001). The fading rate is calculated as the g-value, which is given in percent per decade, where decade represents a power of 10.

Equivalent Dose

The equivalent dose is determined by a combination additive dose and regeneration (Aitken 1985). Additive dose involves administering incremental doses to natural material. A growth curve plotting dose against luminescence can be extrapolated to the dose axis to estimate an equivalent dose, but for pottery this estimate is usually inaccurate because of errors in extrapolation due to nonlinearity. Regeneration involves zeroing natural material by heating to 450°C and then rebuilding a growth curve with incremental doses. The problem here is sensitivity change caused by the heating. By constructing both curves, the regeneration curve can be used to define the extrapolated area and can be corrected for sensitivity change by comparing it with the additive dose curve. This works in cases in which the shapes of the curves differ only in scale (i.e., the sensitivity change is independent of dose). The curves are combined using the "Australian slide" method in a program developed by David Huntley of Simon Fraser University (Prescott et al. 1993). The equivalent dose is taken as the horizontal distance between the two curves after a scale adjustment for sensitivity change. Where the growth curves are not linear, they are fit to quadratic functions. Dose increments (usually five) are determined so that the maximum additive dose results in a signal about three times that of the natural and the maximum regeneration dose is about five times the natural. If the regeneration curve has a significant negative intercept, which is not expected given current understanding, the additive dose intercept is taken as the best, if not fully reliable, approximation.

A plateau region is determined by calculating the equivalent dose at temperature increments between 240° and 450°C and determining over which temperature range the values do not differ significantly. This plateau region is compared with a similar one constructed for the b-value (alpha efficiency), and the overlap defines the integrated range for final analysis.

Alpha Effectiveness

Alpha efficiency is determined by comparing additive dose curves using alpha and beta irradiations. The slide program is also used in this regard, taking the scale factor (which is the ratio of the two slopes) as the b-value (Aitken 1985).

Radioactivity

Radioactivity is measured by alpha counting in conjunction with atomic emission for ^{40}K. Samples for alpha counting are crushed in a mill to flour consistency, packed into plexiglass containers with ZnS:Ag screens, and sealed for one month before counting. The pairs technique is used to separate the U and Th decay series. For atomic emission measurements, samples are dissolved in HF and other acids and analyzed by a Jenway flame photometer. K concentrations for each sample are determined by bracketing between standards of known concentration. Conversion to ^{40}K is by natural atomic abundance. Radioactivity is also measured, as a check, by beta counting, using a Risø low level beta GM multicounter system. About 0.5 g of crushed sample is placed on each of four plastic sample holders. All are counted for 24 hours. The average is converted to dose rate following Bøtter-Jensen and Mejdahl (1988) and compared with the beta dose rate calculated from the alpha counting and flame photometer results.

Both the sherd and an associated soil sample are measured for radioactivity. Additional soil samples are analyzed where the environment is complex, and gamma contributions determined by gradients (after Aitken 1985:Appendix H). Cosmic radiation is determined after Prescott and Hutton (1988). Radioactivity concentrations are translated into dose rates following Adamiec and Aitken (1998).

Moisture Contents

Water absorption values for the sherds are determined by comparing the saturated and dried weights. For temperate climates, moisture in the pottery is taken to be 80±20 percent of total absorption, unless otherwise indicated by the archaeologist. Again for temperate climates, soil moisture contents are taken from typical moisture retention quantities for different textured soils (Brady 1974:196), unless otherwise measured. For drier climates, moisture values are determined in consultation with the archaeologist.

PROCEDURES FOR OSL OR IRSL FINE-GRAINED POTTERY

OSL and IRSL on fine-grain (1–8 μm) pottery samples are carried out on single aliquots following procedures adapted from Banerjee et al. (2001) and Roberts and Wintle (2001). Equivalent dose is determined by the single-aliquot regenerative dose (SAR) method (Murray and Wintle 2000).

The SAR method measures the natural signal and the signal from a series of regeneration doses on a single aliquot. The method uses a small test dose to monitor and correct for sensitivity changes brought about by preheating, irradiation, or light stimulation. SAR consists of the following steps: (1) preheat; (2) measurement of natural signal (OSL or IRSL), L(1); (3) test dose; (4) cut heat; (5) measurement of test dose signal, T(1); (6) regeneration dose; (7) preheat; (8) measurement of signal from regeneration, L(2); (9) test dose; (10) cut heat; (11) measurement of test dose signal, T(2); and (12) repeat of steps 6 through 11 for various regeneration doses. A growth curve is constructed from the L(i)/T(i) ratios, and the equivalent dose is found by interpolation of L(1)/T(1). Usually a zero regeneration dose and a repeated regeneration dose are employed to ensure the procedure is working properly. For fine-grained ceramics, a preheat of 240°C for 10 s, a test dose of 3.1 Gy, and a cut heat of 200°C are used, although these parameters may be modified from sample to sample.

The luminescence, L(i) and T(i), is measured on a Risø TL-DA-15 automated reader by a succession of two stimulations: first 100 s at 60°C of IRSL (880 nm diodes), and then 100 s at 125°C of OSL (470nm diodes). Detection is through 7.5 mm of Hoya U340 (ultraviolet) filters. The two stimulations are used to construct IRSL and OSL growth curves, so that two estimations of equivalent dose are available. Anomalous fading usually involves feldspars, and only feldspars are sensitive to IRSL stimulation. The rationale for the IRSL stimulation is to remove most of the feldspar signal, so that the subsequent OSL (post IR blue) signal is free from anomalous fading. However, feldspar is also sensitive to blue light (470 nm), and it is possible that IRSL does not remove all the feldspar signal. Some preliminary tests in our laboratory have suggested that the OSL signal does not suffer from fading, but this may be sample specific. The procedure is still undergoing study.

A dose recovery test is performed by first zeroing the sample by exposure to light and then administering a known dose. The SAR protocol is then applied to see if the known dose can be obtained.

The laboratory is currently investigating using pulsed OSL to measure equivalent dose on ceramics. In pulsed mode, the stimulating light is turned off and on in a series of pulses with the luminescence only measured during the off-time. Because the time between stimulation and emission is much longer for quartz than feldspar, an appropriate pulse width can be chosen to eliminate any feldspar signal. Previous work has suggested that a 10 µs on-time and 240 µs off-time for each pulse, and also using an initial infrared exposure (as in double SAR), will minimize the feldspar signal during the off-time, so that the signal stems mainly from quartz. Pulsed OSL is measured on a Risø DA-20 using similar parameters as in the double SAR. Detection is for 100 s total (both on- and off-time) which includes 400,000 pulses for a total on-time of 4 seconds. This procedure is currently undergoing study because it is not certain 4 seconds is sufficient exposure to deplete the signal.

Alpha efficiency will surely differ among IRSL, OSL, and TL on fine-grained materials. It does differ between coarse-grained feldspar and quartz (Aitken 1985). Research is currently underway in the laboratory to determine how much b-value varies according to stimulation method. Results from several samples from different geographic locations show that OSL b-value is less variable and centers around 0.5. IRSL b-value is more variable and is higher than that for OSL. TL b-value tends to fall between the OSL and IRSL values. We currently are measuring the b-value for IRSL and OSL by giving an alpha dose to aliquots whose luminescence have been drained by exposure to light. An equivalent dose is determined by SAR using beta irradiation, and the beta/alpha equivalent dose ratio is taken as the b-value.

Age and Error Terms

The age and error for both OSL and TL are calculated by a laboratory-constructed spreadsheet, based on Aitken (1985). All error terms are reported at one sigma (see Table A.3).

REFERENCES CITED

Adamiec, G., and Aitken, M. J.
1998 Dose Rate Conversion Factors: Update. *Ancient TL* 16:37–50.

Aitken, M. J.
1985 *Thermoluminescence Dating.* Academic Press, London.

Banerjee, D., A. S. Murray, L. Bøtter-Jensen, and A. Lang.
2001 Equivalent Dose Estimation Using a Single Aliquot of Polymineral Fine Grains. *Radiation Measurements* 33:73–93.

Bøtter-Jensen, L, and V. Mejdahl
1988 Assessment of Beta Dose-Rate Using a GM Multi-Counter System. *Nuclear Tracks and Radiation Measurements* 14:187–191.

Brady, N. C.
1974 *The Nature and Properties of Soils.* Macmillan, New York.

Feathers, J. K.
2003 Use of Luminescence Dating in Archaeology. *Measurement Science and Technology* 14:1493–1509.

Huntley, D. J., and M. Lamothe
2001 Ubiquity of Anomalous Fading in K-feldspars, and Measurement and Correction for it in Optical Dating. *Canadian Journal of Earth Sciences* 38:1093–1106.

Murray, A. S., and A. G. Wintle
2000 Luminescence Dating of Quartz Using an Improved Single-Aliquot Regenerative-Dose Protocol. *Radiation Measurements* 32:57–73.

Prescott, J. R., D. J. Huntley, and J. T. Hutton
1993 Estimation of Equivalent Dose in Thermoluminescence Dating: The *Australian Slide* Method. *Ancient TL* 11:1–5.

Prescott, J. R., and J. T. Hutton
1988 Cosmic Ray and Gamma Ray Dose Dosimetry for TL and ESR. *Nuclear Tracks and Radiation Measurements* 14:223–235.

Roberts, H. M., and A. G. Wintle
2001 Equivalent Dose Determinations for Polymineralic Fine-Grains Using the SAR Protocol: Application to a Holocene Sequence of the Chinese Loess Plateau. *Quaternary Science Reviews* 20:859–863.