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ARCHEOLOGICAL TEST EXCAVATIONS AT SITE 41WM21 IN GRANGER RESERV--ETC(U)
MAY 78 G L MOORE, H J SHAFER, E P BAXTER DACW63-76-C-0176

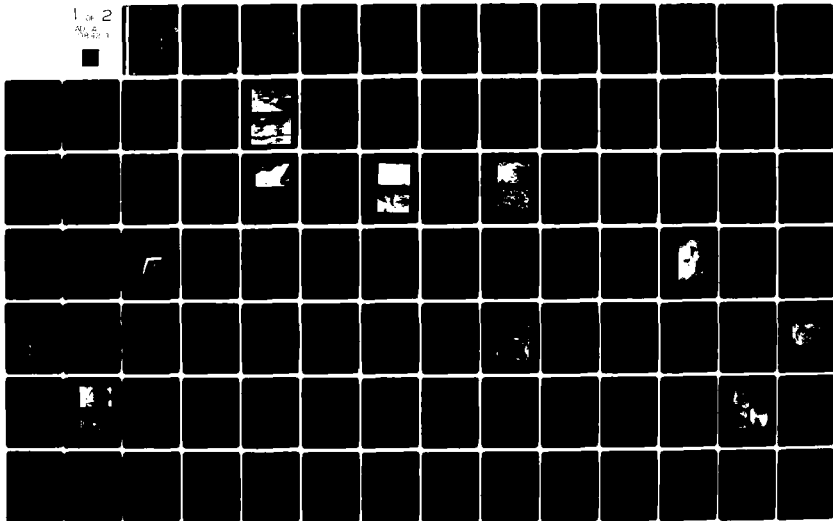
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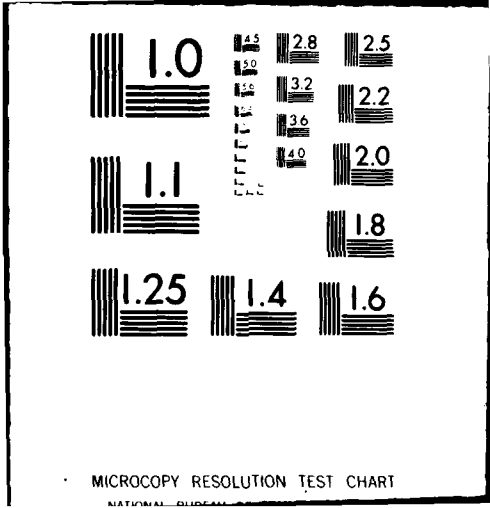
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Archeological Test Excavations
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
	AD-A089213	
4. TITLE (and Subtitle) Archeological Test Excavations at Site 41WM21, Williamson County, Texas		5. TYPE OF REPORT & PERIOD COVERED Archeological Test Excavations Oct - Dec 1976
		6. PERFORMING ORG. REPORT NUMBER 37
7. AUTHOR(s) Gary L. Moore Revised by Harry J. Shafer, Edward P. Baxter, John Ippolito, & Clell L. Bond, Appendix by		8. CONTRACT OR GRANT NUMBER(s) DACW63-76-0176
9. PERFORMING ORGANIZATION NAME AND ADDRESS Texas A&M Research Foundation College Station, Texas		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NA
11. CONTROLLING OFFICE NAME AND ADDRESS Ft Worth District, Corps of Engineers Engineering Division, Plng Br, SWFED-P POB 17300, Ft. Worth, TX 76102		12. REPORT DATE May 1978
		13. NUMBER OF PAGES 104
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) NA		15. SECURITY CLASS. (of this report) Unclas
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE NA
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Archeological Test Excavations Granger Reservoir Site 41WM21 Williamson County, Texas		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report documents the attempts to salvage archeologically significant data by test excavations in areas of the site selected on the basis of least disturbance by construction activities. Three cultural occupation periods, correlated with separate geomorphic features, were identified during the course of test excava- tions. The artifactual assemblages indicate an intermittent occupation of the site during the Early, Middle, and Late Archaic Periods.		

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at

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in

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Williamson County, Texas

13

by

10 Gary L. Moore

~~Subject~~

Harry J. Shafer & Edward P. Baxter
John Ippolito & Clell L. Bond

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15 DA 1163-75-3-0176 Appendix by
Vaughn M. Bryant

9 Final Rept. at-D. 76 14 17

Report submitted to the U.S. Army Corps of
Engineers, Ft. Worth District, in fulfillment
of the terms of Contract No. DACW63-76-0176.

Texas A&M Research Foundation Project
No. 3446

Report No. 37 (Revised)
Anthropology Department
Texas A&M University

May 1978

Submitted by

Vaughn M. Bryant (for)

Harry J. Shafer
Principal Investigator

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ABSTRACT

Test excavations at 41WM21 (Centerline Site) were conducted from October through December 1976 by the staff members of the Texas A&M Anthropology Research Laboratory. The site was originally surveyed in 1973 by the Texas Archeological Survey and re-evaluated in 1976 by Texas A&M University. Following the re-evaluation, the site was extensively disturbed by dam construction activities which prevented access to deposits previously deemed scientifically important. This report documents the attempts to salvage archeologically significant data by test excavations in areas of the site selected on the basis of least disturbance by construction activities. Three cultural occupation periods, correlated with separate geomorphic features, were identified during the course of test excavations reported herein. The artifactual assemblages indicate an intermittent occupation of the site during the Early, Middle and Late Archaic Periods.

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ACKNOWLEDGEMENTS

The completion of this study was made possible by the cooperation of a number of individuals and agencies. Their assistance is acknowledged here and we wish to point out that this is but a token of our appreciation of their aid.

The assistance and cooperation provided by the National Park Service Inter-agency Archeological Services, Denver, deserves special mention -- specifically, Roy Reeves III and Judy Shafer of the Denver Office who aided directly in our field work.

We wish to acknowledge the cooperation of Curtis Tunnell and Alton Briggs of the Texas Historical Commission.

Additionally, members of the Anthropology Society of the University of Texas and the Travis County Archeological Society donated their weekend time to assist in the excavations.

Students, staff and faculty also provided invaluable aid in both the field and laboratory phases. Personnel who conducted the actual field excavations were: Steve Kotter, Laura Hillier, Melissa Seminara, John Ippolito, Sarah Walker and Gary L. Moore.

Dr. Harry Shafer and Dr. Vaughn M. Bryant, Co-Principal Investigators and Edward Baxter, Staff Archeologist, provided excellent advice in all phases of the study.

Edie Schaffer aided in the drafting chores, photographic work was done by Paul Ragsdale and the typist was Pat Dering. Editorial assistance was provided by Carol S. Weed.

Thanks should go to Mr. Ken Howell, Lake Ranger, and to Mr. George Reude, Geologist, U.S. Army Corps of Engineers, for their help and support during the project.

Last, but not least we wish to thank Dave Peterson and his staff of the Clearwater Construction Company for their cooperation.

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PREFACE

The following report is a revised version of a manuscript submitted earlier to the U.S. Army Corps of Engineers, Ft. Worth District. Compilation of the final report of the archeological research conducted at 41WM21 was complicated by several inhibiting factors: the frustration of coordinating field research in the midst of ongoing construction activity, and the turn-over of personnel involved in the field work.

Statement of Work. The Contractor shall furnish all services, plant labor, equipment, supplies, travel and transportation required to accomplish the work described herein. The work to be accomplished under the contract consists of excavating, using both mechanical and hand work, an area approximately 20 meters square in or near the center of archeological site 41WM21 to a depth terminating at either water level or deepest artifact deposition but shall be a minimum of 25 feet deep. The work area shall be mapped using standard surveying instruments and procedures to establish horizontal and vertical control. Laboratory preparation and analysis of excavated archeological testing methods shall include but not be limited to (a) soil analysis, (b) pollen analysis, (c) radiometric dating (C-14), (d) analysis of faunal and plant remains. Excavated areas shall not be refilled. Bi-weekly progress reports shall be submitted to the Contracting Officer.

Funds were provided by the U.S. Army Corps of Engineers, Fort Worth District, for the fulfillment of the archeological contract.

Field work commenced and was finished on schedule. However the area of the test excavation was not near the approximate center of 41WM21, but rather on the periphery. The density and complexity of artifactual materials exposed in the dam core trench and the river diversion channel were lacking in the main test excavation unit. Unfortunately, this was the only area the archeologists could test due to construction activities and impounded water. Therefore, all the investigative effort was expended trying to understand a marginal area of the site and project this information to the site proper.

The Texas A&M Anthropology Laboratory feels that its archeological performance in the above undertaking was severely hampered by the circumstances surrounding our research efforts. An ordered plan of investigation was not possible (see Methods) and the resulting site report falls short of our anticipated contribution. It is recommended that future archeological projects be planned and executed well in advance of the letting of any land modification contracts.

Harry J. Shafer
Principal Investigator

Ed Baxter
Project Coordinator

INTRODUCTION

Test excavations were conducted at site 41WM21, the Centerline Site (Fig. 1), in the fall of 1976 by members of the Texas A&M University Anthropology Laboratory and operating under the auspices of Contract No. DACW-63-C-0716 between the U.S. Army Corps of Engineers, Fort Worth District, and the Texas A&M Research Foundation. This work was undertaken on the basis of the information provided by tests conducted during the course of Texas A&M University Anthropology Laboratory's archeological survey of the Granger Lake area (Moore ms. in prep.), and consultations with the State Historical Officer representative Alton Briggs, National Park Service archeologists Roy Reeves and Judy Shafer, and personnel from the U.S. Army Corps of Engineers, namely Bud Horseman and Larry Banks.

Assessment of the site's resources was based on the observations and limited test findings along a recent river diversion channel cut that bisected the main portion of the site and a core trench for the dam excavated during the course of dam construction. These two promising areas (Fig. 2), however, were not available for further exploitation due to construction activities as explained in the Preface and the dangers these imposed to archeological personnel (Fig. 3,A,B). One small segment of the site was set aside for archeological test excavations on the basis of the assumption that an adequate sample of prehistoric deposits would be represented. There was no way to verify this assumption without excavation, however, since the surface had been modified and mechanically compacted to a depth of approximately one meter.

This report documents the findings of both the test excavation and previous tests at 41WM21 and discusses their contribution to the archeology of the Granger Lake area.

Figure 1. Map showing location of 41WM21 relative to the Granger Lake and Dam area.

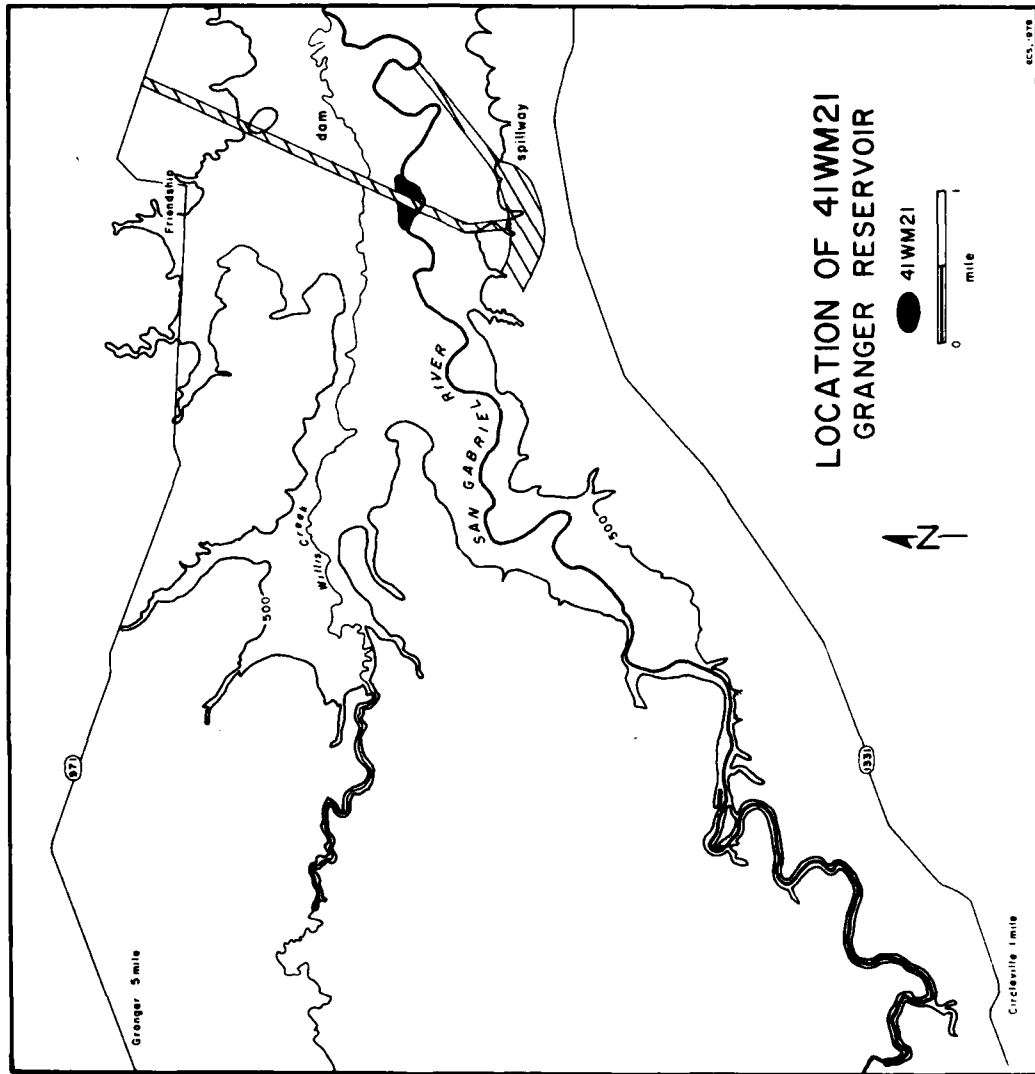





Figure 2. Plan of 41WM21 showing relative locations of core trench, diversion channel, and test excavation units.

TEST EXCAVATIONS AT 41WM21

-  Test Units flooded following construction of haul road
-  Test Units covered by construction of haul road
-  Test Units destroyed following collapse of haul road after heavy rains

All Test Units plotted according to location of SE corners

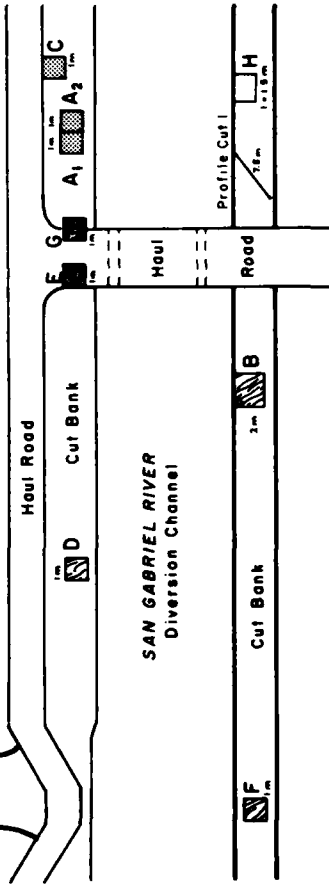
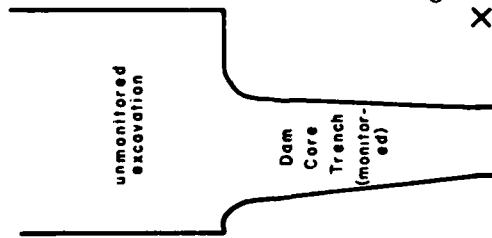
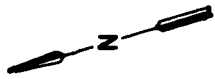
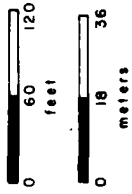
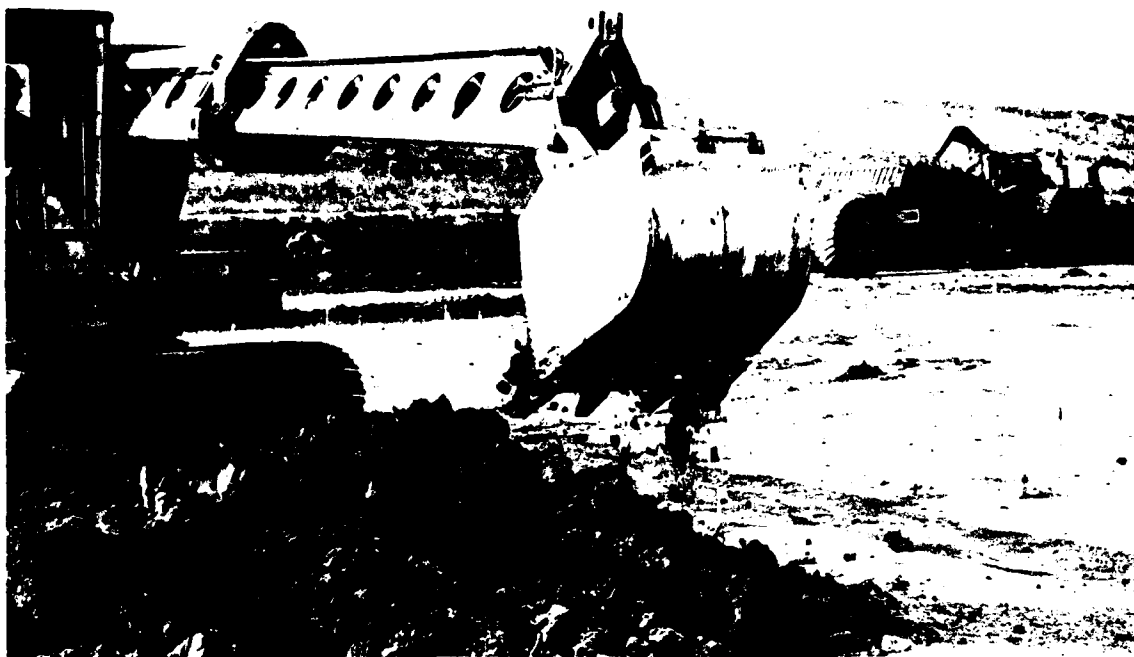


Figure 3. Dam construction activities in progress. A, machinery using haul road in background. Stakes are control points for the main test excavation unit and machinery in foreground is removing impervious material in the main test excavation unit; B, heavy machinery passing main test excavation work.



A



B

Archeological Background

A history of the previous archeological research and a conceptual model of the prehistoric lifeways of the San Gabriel valley are discussed here in order that the findings from 41WM21 test excavations can be viewed in the perspective of the area's prehistory. An analysis of the findings in light of the lifeways model will be presented in the Discussion section.

Professional archeological work in the Granger Lake area began in 1963 with reconnaissance of the North Fork and Granger (formerly Laneport) reservoir areas (Shafer and Corbin 1965). Following the recommendations provided by these surveys, several sites in the North Fork area (Sorrow 1969; 1971; Jackson 1974) were investigated. Eddy (1973) tested three sites in the Granger Lake area and Prewitt (1974) reported the findings of test excavations at Loeve-Fox and the results of additional survey work in the same area. Recently, intensive surveys have been conducted at both Granger and North Fork reservoirs (Patterson ms. in prep., Moore ms. in prep.). Downstream near San Gabriel, Gilmore (1969) reported on the field work at the San Xavier Mission complex.

An important objective of archeology today is to investigate the paleoecology and adaptive modes of prehistoric cultures in order to identify and explain the stability or changes observed in the culture history. In order to achieve this goal, it is necessary to have control on both the time and space parameters of the cultural assemblages undergoing study.

One notable result of the San Gabriel research efforts together with other work in central Texas (e.g. Shafer 1963; Johnson, Suhm and Tunnel 1962; Sorrow, Shafer and Ross 1967; Wesolowsky, Hester and Brown 1976) is the demonstrated 10-11,000 year long culture history of this portion of

the state. An excellent model of the chronology of central Texas is presently available on the basis of the works listed above. This chronology is based primarily on changes in projectile point form and less so on the shifting of tool assemblages. Using these chronological guides, it is possible to detect changes through time in the location and distribution of certain kinds of sites.

The spatial parameters are more difficult to define, or at least have not been given nearly as much attention as has the temporal models. Undoubtedly part of the difficulty lies in the conceptual approach to viewing the prehistory. Archeologists working in central Texas in the past have relied on the application of the Midwestern Taxonomic system of Kelley (1947) and Suhm, Krieger and Jelks (1954) and to their definition of spatial boundaries. While this approach served the purpose of placing attention on similarities and differences from one geographic area to the next, it was limited in that it served purely descriptive ends. Also, the rigid application of the concept in Texas tended to obscure possible intra-areal differences. For example, there are subtle differences in the Archaic materials along the Leon River when compared to those along the Colorado. These differences are erased, however, as emphasis is placed on the similarities and both areas are included in the Edwards Plateau Aspect (Suhm, Krieger and Jelks 1954:Fig. 4). Such a classificatory scheme lacks the flexibility of detecting the kinds of differences that could mark sensitive boundaries between prehistoric ethnic groups.

Previous archeological studies in central Texas have indicated that the aboriginal populations inhabiting the San Gabriel valley were exclusively hunters and gatherers. There is no evidence that agriculture was practiced along the San Gabriel valley until protohistoric (Spanish Colonial) times at

the San Xavier Mission complex (Gilmore 1969). Evidences for the foraging adaptation occur all along the San Gabriel and its major tributaries from its headwaters in the limestone plateau country and in the prairies to its confluence with the Little River. The archeological sites appear in several different forms and in nearly every topographic setting. There is a notable relationship between certain kinds of sites and environmental settings. For example, accumulations of angular fragments of burned rocks (burned rock middens) occur in the limestone plateau country of western Williamson County. This type of site which indicates repeated utilization of one locality for processing specific resources is related either to the limestone outcrops or possibly to plateau plant resources. Rockshelters sometimes occur in the plateau cliffs also (Shafer and Corbin 1965). In the prairie setting, different topographic situations and environmental zones are encountered. It has been assumed that the location and character of the archeological sites in the prairie area are the result of patterned subsistence and resource utilization strategies (Eddy 1974; Prewitt 1976).

The hunting and gathering lifeway, by its very definition, usually implies a degree of mobility in the annual movement of the human populations as they exploit the plant and animal resources. The degree of mobility or length of time spent in any one location depends upon the resources available and the peoples' ability to exploit those resources -- that is, their technology. Other factors may lead to changes in the way a group of people will utilize a particular area. These factors include increased knowledge in available resources leading to improved technology, increase or decrease in population, ecological change, immigrants encroaching upon the resident territory of a group, or a shift in the territorial range that would incorporate access to new or more abundant resources.

The ability for a hunter-gatherer population to maintain an existence in one area depends upon the necessary resource diversity in the area that could sustain the population throughout the year and their knowledge to exploit these resources. One of the essentials to the survival of a hunter-gatherer is the necessity of that group to remain in the territory where they know the resources, as a move to a new unknown area would place a high risk on the group's ability to survive. For that reason, territorial behavior can be expected and, we assume, was operative in the San Gabriel valley. This is not to say that such boundaries were not contested and Prewitt's (1974) data at the Loeve-Fox Site suggests that intergroup warfare was practiced.

Shafer and Bryant (1976) in presenting an adaptive model for the San Gabriel valley, have suggested that no single resource zone (such as the Edwards Plateau margin, Taylor Prairie or Blackland Prairie) and the riverine environments transecting these zones contained sufficient resources to provide the year around sustenance for groups of hunters and gatherers. These zones taken together however, could have provided the necessary resources to sustain such populations indefinitely (cf. Campbell 1975; Shafer 1975). In order to exploit the necessary diversity and because no one resource was sufficient to provide year round subsistence, it was suggested that successful adaptation required individual groups to be composed of bands which followed semi-nomadic movements within recognized territorial ranges.

Eddy (1974) and Prewitt (1975) have discussed views on the settlement strategies of the prehistoric groups who utilized the Granger Lake area. Eddy (1974:105,106), in his study of three sites in the Granger Lake area concluded that:

... Archaic State sites along the San Gabriel River of central Texas were located according to vegetational habitats containing a few desirable resources. These key resources were the principal determinants of the locational choice. Thus the close proximity of the site to the selected and highly valued resources was a decision to reduce the exploitative effort. A corollary statement is: that the increased distance to other habitats progressively and systematically reduced their resource use. To paraphrase, the aboriginal peoples of central Texas were efficiently lazy in their everyday, routine work.

Prewitt (1976) offers a model to explain the exploitative system for Late Prehistoric periods in the area. The model is presented as a series of hypotheses based on several propositions. In essence, Prewitt is saying that the prehistoric strategy for selecting or moving a campsite was based on the following criteria.

1. the proximity to the most desirable of unequally valued resources;
2. surface topography;
3. knowledge of previous campsites or the circumstances determining the choice of campsite remained constant;
4. when energy expenditure became too costly, campsites were moved knowing that a suitable alternate site was available;
5. seasonal variation of resources may have dictated the need to move from one place to another;
6. each site was repeatedly occupied through time.

In order to confirm Prewitt's model, campsites would (1) need to show a pattern in terms of their location on topographic features and (2) exhibit stratification or other evidence for repeated utilization.

While both models imply a minimax strategy of energy expenditure, Prewitt takes a more flexible and reasonable approach. However, both archeologists do not take into consideration the potential exploitation sphere for

any site in the area (or the site catchment areas as defined by Vita-Finzi and Higgs 1970). Furthermore, the application of both models needs to be expanded to a diversity of resource zones (not just to the prairie-riverine environment) to be adequately tested. We suggest, for example, that the choices of campsites were based on the proximity to water; to the availability of an adequate supply for firewood (which would be an important criterion in a prairie environment); to food resources; and, on a low level of priority, to mineral resources. Indeed, the occupation of any location in the Granger Lake basin would allow access to all food resources within an hour's walk. In other words, we reject Eddy's model in that it is inconsistent with the exploitative strategies of known hunters and gatherers. Prewitt's model has a limited application both in time and space. It was intended to apply to the Late Prehistoric Period in the Granger Lake area. It seems doubtful that the people who occupied the Granger Lake sites limited their settlement exclusively to that area. Prewitt's model needs to be expanded both temporally and spatially.

That the test excavations at 41WM21 will not serve as a complete test for any of the three discussed exploitative models is acknowledged. However, the findings may be relevant to examining critical portions of Prewitt's model if the model is applied to the earlier Archaic occupation. Further the recovered data from 41WM21, in part, tests the model presented here. This model suggests that the choice of site locations represents a decision of convenience, that decision being based on the presence of a variety of criteria (such as the availability of water, firewood, isolation, proximity to other groups, etc.), rather than a decision based on the presence of only one or two exploited resources.

Physical and Geologic Setting and Site Description

The first published data on 41WM21 (Centerline Site) is included in the Loeve-Fox site report (Prewitt 1974:136 and 139). It is as follows:

Location: Left (here north) bank of the San Gabriel River about 1.5 miles south of Friendship. Situated on the centerline of the Laneport Dam. The diversion channel excavated during initial phases of dam construction bisected the site.

Description: Site is contained within alluvial terrace deposits on the inside meander of the river. Scattered midden debris (including mussel shells, animal bones, burned rock, and flint flakes) and several intact stone hearths were observed in the exposed sides of the diversion channel. The top of the midden debris is covered by about five feet of sterile alluvium. The bottom of the deposits are about twenty feet below ground surface. No diagnostic artifacts were recovered; however, reported artifacts indicate an Archaic and possibly Post-Archaic affiliation.

Recommendations: Site is being destroyed by construction of Laneport Dam and controlled excavations are consequently impractical; thus no further work is recommended.

Although a considerable portion of the 41WM21 site area had been destroyed by dam construction activities prior to the time the TAMU investigations had begun, a sufficient portion of the area remained to allow some archeological and geomorphic observations to be made.

After an initial examination of the site area it appeared that Prewitt's (1974: 136, 139) assessment of 41WM21 did not fully consider the site's potential for providing archeological information. The dam construction, at the time of the Prewitt survey, had not reached the point that the archeological resource was beyond recovery.

During the course of the final archeological survey of the Granger Reservoir District, members of the Texas A&M Anthropology Laboratory revisited 41WM21 and made the following observations:

1. The horizontal extent of the site was much greater than is suggested in the Prewitt report. It extended over 300 meters on an east/west axis. It was apparent that 41WM21 was one of the larger sites documented during the Texas A&M University survey of the Granger Reservoir District.

2. The vertical distribution of the site extended from the then present ground surface to more than seven meters in depth. Thirty-one burned rock hearths were noted in the diversion channel sides and seventeen distinct cultural levels were located.

3. The cultural lenses (living surfaces?) were thin deposits of snail and mussel shell, burned and unburned bone, charcoal and lithic debris separated by alluvium accumulations of varying thicknesses. The burned rock hearths were located in these cultural levels. Each level appeared to be separated by sterile alluvial deposits.

Both the location and configuration of the site strongly reflects the depositional history of the San Gabriel River. The site area is located on a portion of the San Gabriel that the U.S. Army Corps of Engineers (Department of the Army 1972:II:15) terms Reach 3. Reach 3 extends roughly from Circleville (approximately 10 miles above 41WM21) to the confluence of the Brazos and San Gabriel Rivers. The Corps characterizes the river in Reach 3 as having a meandering flattened gradient, as having alluvial stream banks and beds which contain noticeable deposits of sand, gravel and shell fragments, and as entering an area of generally increased rainfall. The Corps of Engineers (1972:II-20) also note that the San Gabriel River has in modern times experienced frequent flooding, a gauging station at the dam site recording 31 major floods between the years of 1924 and 1959.

Viewed as a whole, this portion of the San Gabriel River valley could probably be termed mature, the river itself having a rather moderate gradient

of approximately 10 feet per mile. The meandering dendritic drainage pattern expresses no evidence of structural control and the underlying named formations, the Taylor and Navarro groups, consist of poorly consolidated clays, clay shales, clay sands and clay marls, and are usually found buried under 10-90 feet of recent alluvium (George Reude, Corps of Engineers Geologist: personal communication 1977).

Complicating the archeological interpretation of 41WM21 as well as the interpretation of most of the other sites in the San Gabriel valley, is the lack of definity on the rate of alluvial sedimentation. George Reude (personal communication 1977) suggests that deposition since the Pleistocene has been at a relatively constant rate until the recent introduction of mechanized agriculture, and that some alluvium covering archeological sites might be interpreted as a short distance rearrangement of sediments during the natural meandering of the San Gabriel. Prewitt (1974:22) believes that data at the Loeve-Fox sites indicates the valley as continually aggraded, although the rate has slowed consistantly from four feet or more per 1000 years in the Middle Archaic times to 1.5 to 2 feet per 1000 years in post-Archaic and modern times. Eddy (1974:290-300) also believes that the floodplain has generally tended to aggrade since 7000 B.P., but acknowledges that some sites such as 41WM135 may indicate that aggradation in some stretches of the river may have ceased by A.D. 1.

The investigations at 41WM21 clearly indicate that the aboriginal occupations occurred on a natural levee and a point bar deposit associated with the alluvial development on the inside of a meander loop. Point bar and levee development such as that at 41WM21 is a relatively well-understood geologic phenomena (Gilluly, Waters and Woodford 1959:203-204; Leopold and

Wolman 1957), and is illustrated in the generalized schematic of Figure 15. As a stream's flow curves around the outside of a meander bend centrifugal force and an increase in velocity undermines the outside bank while concomitantly a decrease in velocity on the inside of the meander (the point bar) reduces carrying capacity and deposition is made. The levee is not necessarily a meander loop phenomenon but does frequently develop behind or to the lee of the point bar. The levee deposits usually form only during larger floods when the stream overflows its channel, the loss of velocity as it spills on the floodplain causing a rapid deposition of some of the suspended load. Approximate elevations of the site, including both the levee and the point bar, range between 450-750 feet above mean sea level and interpolated from the U.S.G.S. Friendship Quadrangle (1963).

Surface collections and stratigraphic examination suggest that at least some cultural components of the site were found on a portion of the natural levee and over the entirety of the point bar deposit. Geologically much of the natural levee build-up predates the point bar development; however, both features are in the active floodplain of the San Gabriel River and the stratigraphic evidence suggests that alluvial sediment was actively and frequently being deposited on both of these geologic features during the period they were occupied. Recent deposition has, however, been unquestionably disproportionately large on the point bar; however the absence of radiocarbon dates and/or diagnostic artifacts prevents an accurate assessment of the rate of deposition.

Research Design

One of the most important considerations in the investigation of 41WM21, or any other site in the Granger Reservoir, was the development of a research design which could be incorporated into existing and future archeological programs. Aside from the obvious need for standard and well-documented archeological techniques, close attention was needed to interpret the presence of numerous occupation lenses present in the site. The recovery of charred plant materials from these lenses, combined with tests for fossil pollen, were expected to provide the opportunity for the first study of the economic use of plants for the Middle Archaic in the central Texas sequence. Also, charred plant materials were expected to be sufficiently abundant to securely date the cultural and alluvial deposits by the carbon-14 dating technique.

The research design was therefore oriented toward the recovery of data useful to the reconstruction of the local environment setting at the time of the prehistoric utilization. The temporally diagnostic lithic artifacts recovered during the initial testing of 41WM21 suggested a central Texas Archaic affiliation. The near absence of environmental data pertaining to that time period, and the suspected availability of the resources to address that problem, isolated 41WM21 as a singularly significant site. Other cultural data was to be sought, and was expected during recovery excavations, but the environmental aspect remained as the area of prime investigative importance.

Initial Testing

A series of test excavations were undertaken along the diversion channel banks guided by refuse concentrations observed eroding from the banks. Units

A-1 and A-2 (Fig. 2) revealed in situ cultural deposits which consisted of distinct zones separated by sterile alluvial strata. Test Unit B (Fig. 4A), which was located in the lower portion of the site, near the water level resulted in the documentation of five cultural deposits within 47 vertical centimeters (Fig. 4B). Those deposits were characterized by thin surfaces of snail shell, animal bone, charcoal, burned rock and lithic debris. It appeared that each lens was spread over a large horizontal area, dipped slightly downstream, and that the site was composed of a number of activity areas occurring at various vertical levels.

It was at this time that ongoing construction activities in the area of the proposed dam centerline forced a halt in the examination of the north side of the diversion channel. At the same time a core trench was being excavated along the dam axis and archeological monitoring activities were centered on that location.

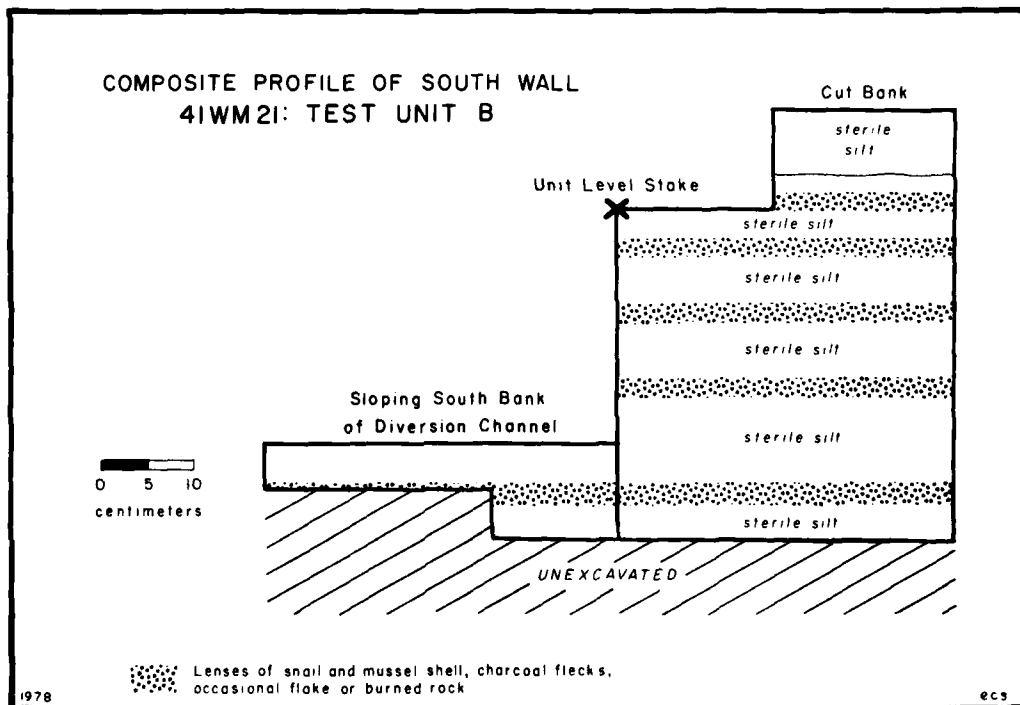
A large "paddle wheel" scraper was being used to remove the dirt from the dam core trench, and each time the machine would pass through, the monitoring crew would rush to inspect the cut and document any cultural deposits which had been exposed (Fig. 5,A,B). It was impossible to determine the exact configuration of most cultural features as the "dragging" effect of the scraper resulted in an unknown degree of horizontal displacement (Fig. 5). Furthermore, the archeologists, rushing between cuts to inspect and record what was observed, had to compromise the opportunity to fully document (e.g. expose, map, photograph and profile) the features that were recognized.

Twenty-four hearths were located in this manner, and it was evident that the site extended about 92 meters to the north of the diversion channel (Fig. 7). These hearths were recorded at depths from 140 cm. to 268 cm.

Figure 4. A, view looking north of Test Unit B; B, composite profile of south wall of Test Unit B.



a



b

Figure 5. A and B, crew members investigating archeological feature (Hearth 22) exposed by heavy machinery cutting core trench for the Granger Lake dam.



A



B

Figure 6. A, burned limestone rock concentration in Test Unit H (looking east downstream); B, scattered limestone rocks (displaced hearths?) looking east along north bank of diversion channel.

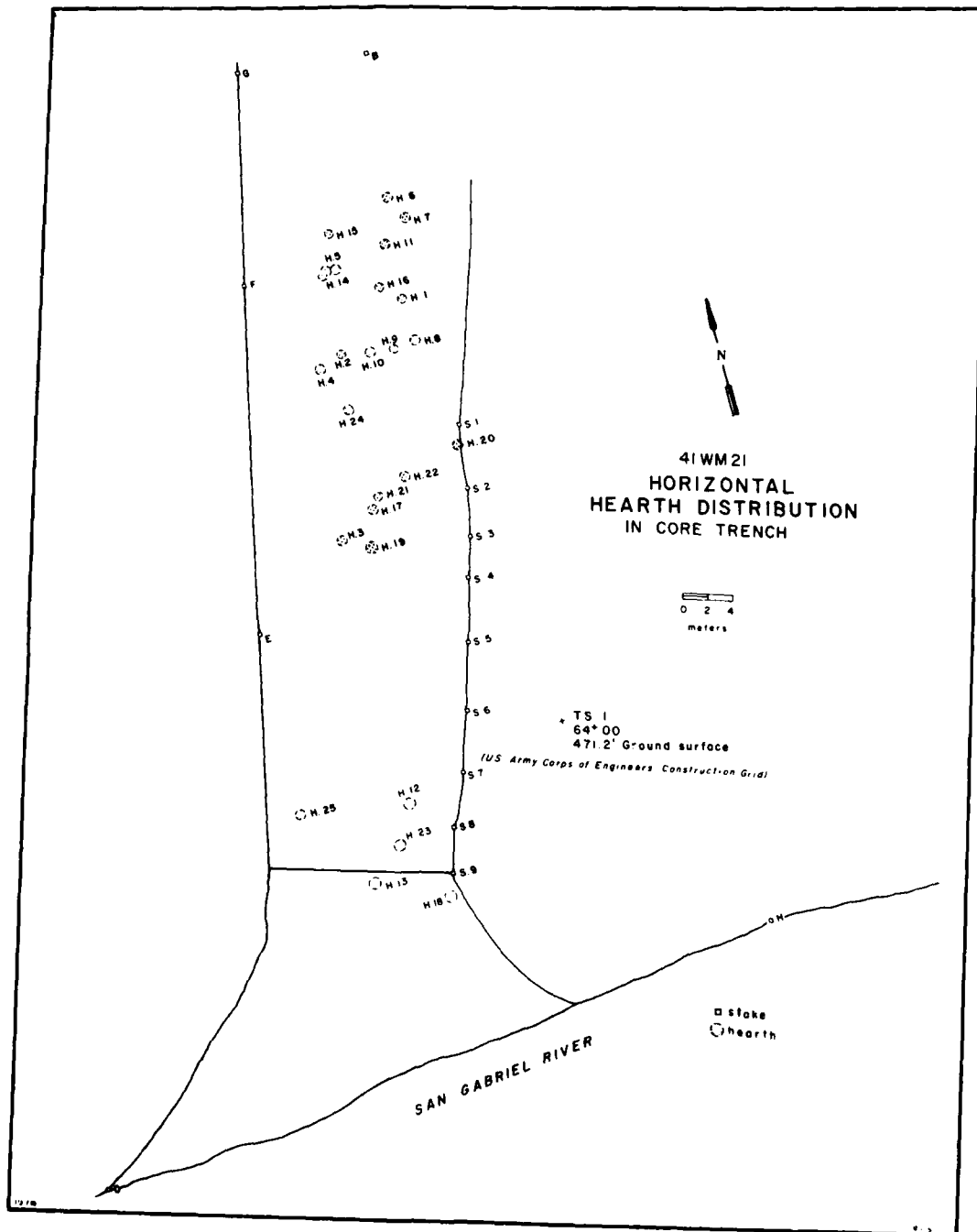


A



B

Figure 7. Horizontal distribution of hearths, core trench at 41WM21.



below the then present ground surface (Fig. 8). Core trench excavations did not extend beyond this depth (268 cm.) and it was impossible to determine the vertical extent of the site in that location. However, an examination of a topographic map of the area, the dipping cultural strata observed in the diversion channel banks, and the results of core testing along the center-line suggested that the point bar rises in elevation as it moves to the north and away from the diversion channel.

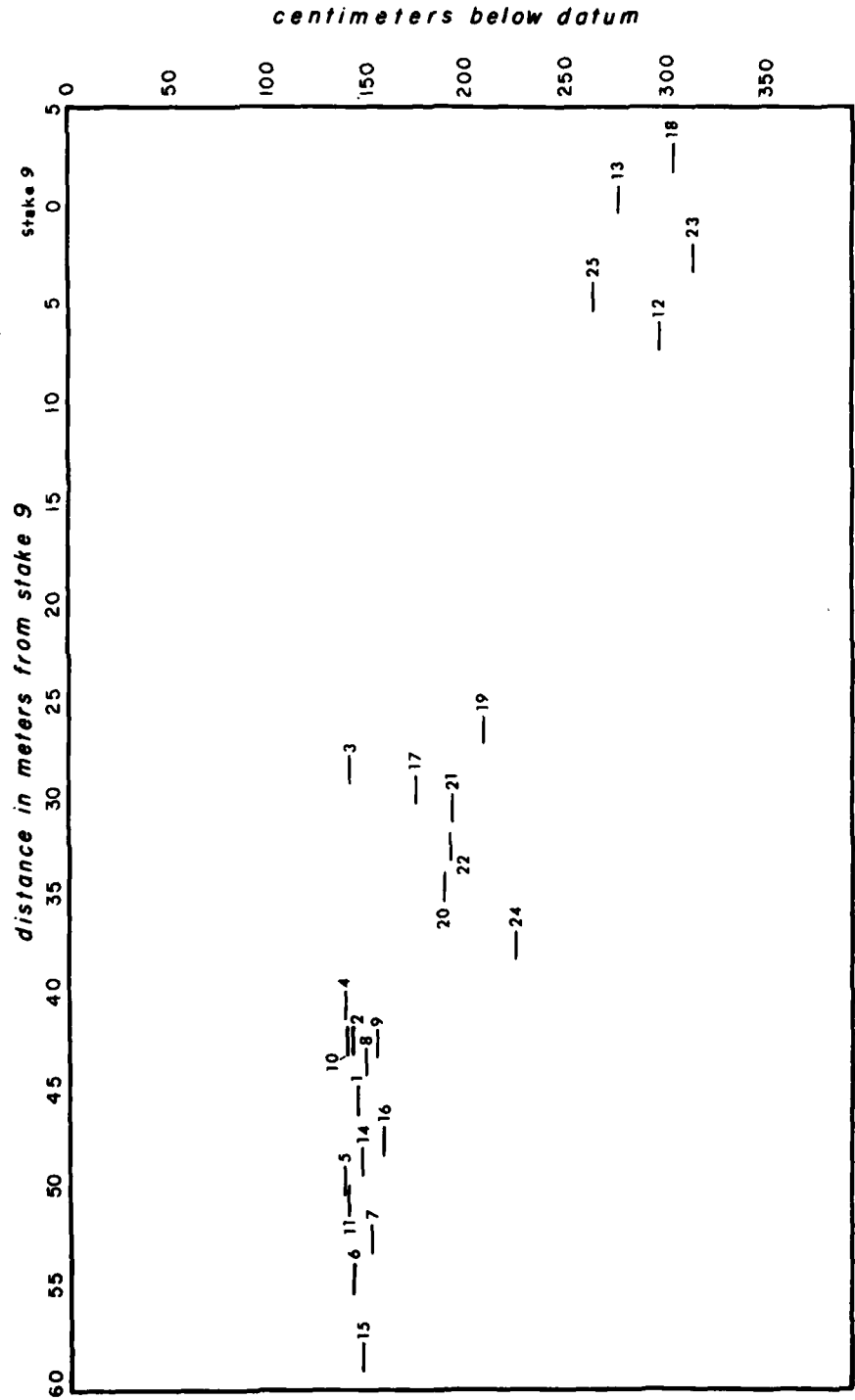
Subsequent to the core trench monitoring activities, Test Unit D (Fig. 2) was excavated to expose a portion of bone which had been noted during an earlier inspection. The excavation revealed a part of a deer skull with one "4 point" antler still intact. The skull (Fig. 9) was located in a thin layer of snail shell. On excavation the lens was also found to contain lithic debris and burned rocks.

All other efforts to expand the test excavations along the walls of the diversion channel at 41WM21 were foiled by the construction of a haul road and an earthen bridge. Two five feet diameter pipes installed as drains failed to allow sufficient water to pass under the road and water was backed up over all existing units. As a result, the most promising portion of the site was no longer available for further investigation. Although controlled excavation was halted, general monitoring was continued on the dam core trench excavations.

The sampling of a site such as 41WM21 was complicated by many factors not usually encountered in archeological testing. Ongoing construction activities had destroyed a major portion of the site and continued to alter much of the remaining area. Consequently, future research designs were directed toward the segment of the site which had suffered the least amount

Figure 8. Vertical distribution of burned rock concentrations (hearths) in dam core trench at 41WM21.

41WM21
 VERTICAL DISTRIBUTION OF CORE TRENCH HEARTHS



—N—

of destruction and which would be preserved for the duration of salvage archeological investigations. Therefore, the choice of test excavation areas was not determined on surface archeological evidence, but was balanced against the findings of the diversion channel, core trench, and the practicalities of investigating a site in the midst of an intensive construction project.

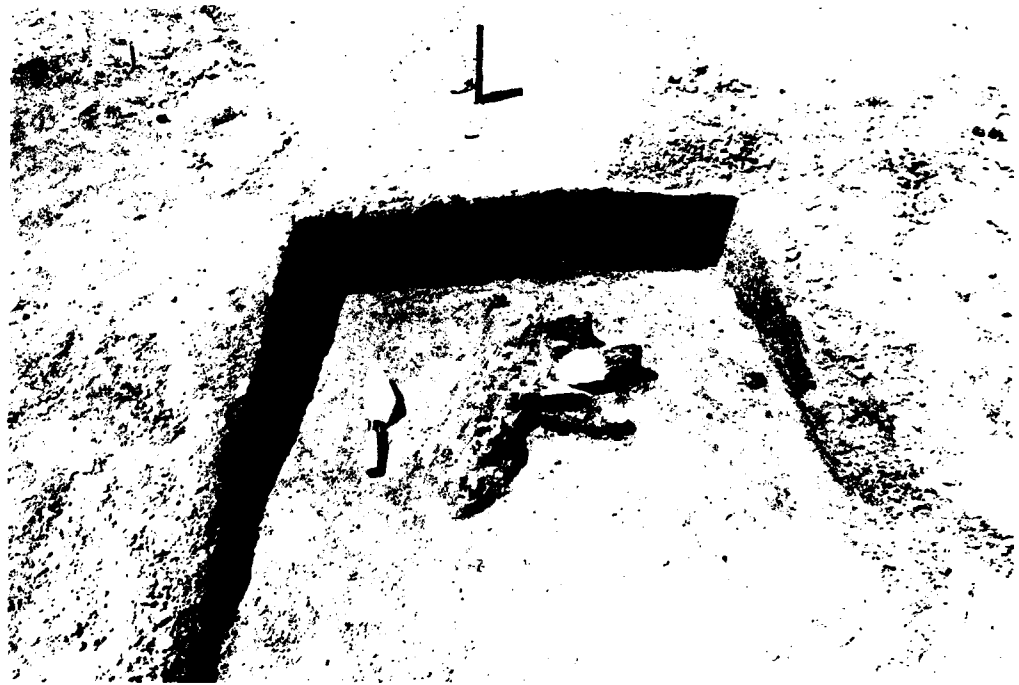
It should be stressed that such a localized excavation was expected to yield limited data in regard to the overall character of the site. The distribution of cultural materials of 41WM21 was most certainly not uniform throughout the site area, and it was possible that important archeological components would be missed even utilizing the most careful sampling techniques. This is not to say that localized excavation should be considered in a negative vein. In some cases it is better to explore a small segment thoroughly enough to establish its structure confidently than to expend the same time and resources drawing from a large segment when the principal result can only be average, nonstructural parameters of the segment.

Proposal for Additional Investigations

Texas A&M University entered into contract negotiations with the U.S. Army Corps of Engineers, Fort Worth District, for additional testing at 41WM21. The proposal statement as submitted by the Texas A&M University Anthropology Laboratory reads as follows:

Members of the Texas A&M University Anthropology Laboratory propose to conduct archeological test excavations at Site 41WM21 in the Granger Lake Reservoir District in order to explore (as many as are feasible) ancient, buried refuse lenses present at the site. The test excavations will be conducted by using both mechanical earth moving equipment accompanied by precision hand work, to examine deposits buried to a depth of approximately 20 feet beneath the original ground surface. The lenses of cultural refuse represent the remnants of prehistoric encampments

Figure 9. Deer skull exposed in Test Unit D, looking north.
The base of the skull is near the trowel; one
antler is at a right angle to the trowel.



on a sequence of surfaces of a flood plain deposit developed on a point bar feature of the San Gabriel River. The dates of these cultural deposits are estimated to be from the Middle to Late Archaic Periods (ca. 2000 B.C. - A.D. 500).

The scope-of-work includes opening an area of approximately 20 meters square with mechanical equipment in order to create stepped profiles or benches which then can be selectively excavated by hand. The objective is to explore designated refuse lenses in order to determine what kinds of activity areas and other cultural features might be represented in this kind of cultural resource. The work area will be mapped using standard surveying instruments and procedures, and horizontal and vertical controls will be maintained.

The lenses are composed of thin deposits of snail, mussel, burned rock, bone, charcoal and chipped stone flakes and artifacts. We anticipate, from the results of survey testing at the site carried out by Texas A&M, distinct activity areas will be isolated. Perhaps more importantly, technological data for one specific Middle or Late Archaic period will be recovered which will allow, through detailed stone technological analysis, for a thorough understanding of the manufacturing and consumption behavior. Furthermore, the presence of charred plant materials indicated in the tests, combined with tests for fossil pollen, may provide the opportunity for the first study of the economic use of plants for the Middle Archaic in the central Texas sequence. Also, charred plant material should be sufficiently abundant to securely date the cultural deposits by the carbon-14 dating technique.

The research design is oriented toward the recovery of data useful to the reconstruction of the local environmental setting at the time of the prehistoric utilization. Toward this end, samples of soils, pollen, carbon, faunal remains and floral (charred plant) remains will be collected for analysis.

Contract Agreements

Subsequent to the submission of the Texas A&M University proposal, the U.S. Army Corps of Engineers responded with an archeological contract which included the following objectives:

1. To excavate an area approximately 20 meters square utilizing both mechanical and hand equipment to a depth terminating at either water level or deepest artifact deposition.
2. To map the work area using standard surveying instruments and procedures for the purpose of establishing horizontal and vertical control.

3. To conduct laboratory preparation and analysis activities of excavated archeological materials concurrently with field testing.
4. To include within the analysis and testing methodology: (a) soil analysis, (b) pollen analysis, (c) radiometric dating (C-14), and (d) analysis of faunal and floral remains.

Following the signing of this contract, the Texas A&M University field party made preparations for a more intensive investigation at 41WM21.

INVESTIGATIVE METHODOLOGY

The determination of the manner and method of investigating any archeological resource is based upon the integration of a multitude of variables. The researcher's general archeological knowledge and experience, information gained from similar archeological sites, data recovered from surface investigations, limited testing, and excavation, observations of geomorphic features and exploitable resources, the present physical condition of the site and the objectives of the work in relation to the overall problem orientation, time and crew and funding available are but a few of the items of consideration from which the archeologist must choose a plan of action. The individual's own variation of "standard professional archeological techniques" are employed with this plan of action to exert a degree of control over vertical and horizontal references, quality and consistency of sampling, accuracy of reporting techniques, etc.

In investigating an average hypothetical aboriginal site the archeologist takes into consideration all the facts, suppositions, and intuitions at his disposal. From these he devises a preliminary plan for the execution of the work, or, in other words, the methods to be employed in accomplishing the task. The calculations upon which these methods are based are in a

continual state of change due to the input of additional information derived from the continuation of the field work.

The ultimate success of an archeologist in the field is the retrieval of 100% of the information contained within a site backed up with the credibility of having established perfect control on all phases of the investigation. In reality only degrees of the ultimate goal are achieved since variables as mentioned above often play an inhibiting role.

The "Methodology" section of an archeological report usually encompasses one to two pages expanding upon themes such as the usage of trowels and shovels, the size of the screen mesh, the fact that photographs are taken, and an explanation of the standard trinomial site recording system. The actual methods of investigation and interplay of variable factors which resulted in any particular course of action are seldom mentioned.

41WM21

Texas A&M University's first involvement with 41WM21 was in the context of its being one part of an overall assessment of all the archeological sites within the proposed reservoir. The following conditions directly related in the choice of methods needed to perform this assessment:

1. The original physiography of the site had been almost totally modified. The river had been re-channelled through the site. Geomorphic features had been cut, filled, and compacted leaving the surface totally altered.

2. Ongoing construction activities utilizing large earth moving machinery were further altering the resource thereby adding a critical time and safety limit on the possibility of further investigation.

3. Artifactual materials and features were observed in situ at varying depths in the rapidly eroding river channel diversion cut.

4. A past report (Prewitt 1974) had also noted the artifactual materials but had assessed the site as having no archeological potential due to ongoing construction activities.

Faced with the contractual objective of assessing the site, the existing physical condition of the resource, the tenuous future of the site and a past assessment based on non-archeological criteria, the archeologist developed an immediate plan of action.

The archeological materials exposed in the eroding diversion channel bank were quickly examined. Control procedures employed during this examination were limited due to the urgency created by the plight of the resource. The objective of the examination was to determine the types of archeological indicators present, not to facilitate the development of a statistically significant comparison of inter-type variation.

Techniques used during this brief field examination included:

1. observations,
2. counting the number of exposed burned rock clusters,
3. troweling the eroded bank back in localities to determine the presence of any definable in situ cultural lenses, and
4. photography.

Texas A&M deviated from the standard of reporting the results of the examination in a final comprehensive report. Instead a verbal report was immediately transmitted by phone and personal communication to the federal agency responsible for the construction activities, the state agency charged

with managing the cultural resources in Texas, and the federal cultural resources managers for the Texas area (also the archeological project sponsor).

The body of the verbal report stated that "ongoing construction activities at 41WM21 were adversely affecting an archeological site where intact cultural remains were present at varying depths. The same construction activities prohibited an accurate controlled assessment of the site's archeological potential" (Edward P. Baxter, personal communication).

Obviously the methods chosen to examine the site and report the results in this emergency situation could hardly conform to any ideas of properly controlled archeological investigations in the classical sense. However, the methods were successful in that although faced with several inhibiting factors the objectives of the actions were fulfilled.

The Texas A&M University's second phase of investigations directly resulted from the verbal report. A meeting was held at 41WM21. The meeting resolved some of the factors inhibiting investigation but added others.

1. Texas A&M was given additional funds and increased time to assess the site.

2. Construction activities on the site were supposed to cease until the assessment was completed.

Before the meeting was finished a large earth moving machine began cutting a wide path through the site in preparation of a core trench for the dam.

The reality of the situation was that point 1 above was implemented. Point 2, however, was disregarded due to the construction schedule. The

state and federal agency responsible for the construction project changed the nature of the archeological work from a controlled assessment study to a monitoring of construction activities.

The choices of location of investigations at the site, the methods of investigation, and the time element were dictated again by the priorities of non-archeological schedules.

The majority of the investigation time was spent in monitoring activities. The construction contractor's interpretation of archeological monitoring was "anything the archeologists wanted to do as long as the paddle wheel scraper was not slowed down." The average time between scrapes was approximately 15 minutes.

Techniques employed in the monitoring phase were:

1. Part of the crew would follow behind the scraper searching for artifactual materials or in situ features.
2. Artifacts (usually redeposited by the machine) were collected.
3. Features, in this case hearths, were located both horizontally and vertically by means of a transit, troweled, and photographed.

The rest of the assessment field time was spent in controlled testing of the eroding banks of the channel diversion cut. However, prior to the completion of this work an earth fill haul road bridge was constructed on the eastern most part of the area of investigation. A thundershower and insufficient drainage under the newly constructed bridge caused inundation and erosion of the test units prior to completion.

The assessment revealed the type of archeological materials present in two parts of the site but the lack of proper control procedures and archeological techniques precluded any sound comparative analysis.

Further cultural management negotiations resulted in a third phase of archeological investigations to be performed by Texas A&M.

Factors influencing investigative methodology were:

1. The choice of location was chosen by the negotiators. Criteria used in location selection were not archeologically based but conformed to the ongoing construction schedule.

2. The chosen site had about a meter of impervious packed soil over it which precluded hand excavation.

3. In the two previous archeological investigations artifactual material was noted at depths of up to six meters below present ground surface.

4. The Corps of Engineers safety regulations prohibited any deep excavations unless a 1:3 slope of all walls was also excavated to prevent the danger of slumpage. Therefore the horizontal and vertical extent of the excavations was of such magnitude that without a machine-aided excavation, it would be impossible to complete the excavation within the allotted time.

5. The data and reference points of the earlier assessment had been removed by the daily change in the topography of the site area and the destruction by inundation and erosion.

6. Monies and time were sufficient to accomplish a successful test excavation.

7. Due to the massive change of the surface of the site geomorphic features were unidentifiable. Therefore any preconceived ideas of the internal structure of the site were based solely upon the information gained from the two areas of the earlier assessment attempts.

In order to conform to the above conditions a plan of investigation was implemented which combined a dualism of machine and hand excavation procedures. A large square (20 m x 20 m horizontally and 4.65 m deep) was excavated by machine. The internal structure of this large unit was planned in a series of step down benches and wheelbarrow ramps (Figs. 10 and 11). This provided for controlled hand excavation on different vertical areas of the site, straight instead of sloping walls for profiles, and a way to remove fill for screening.

A rough estimation of 100 meters was used to place the southeast corner of the main test excavation units in relation to the eastern edge of the core trench. A control stake, labeled N500/W500 was then placed as the southwest corner stake, and an arbitrary elevation of 100 meters above mean sea level was given to this point. Grid control was provided by placement of stakes at two meter intervals along the north/south and east/west axes.

All measurements were taken from the N500/W500 datum stake. All depths, then, are meters below ground surface (bgs). The depths of the excavations were as follows:

Ramp A: Ground surface to surface of Bench 1 (1.64 meters) (Fig. 11).

Ramp B: From slope (.50 meters, bgs) to surface of Bench 2 (3.41 meters, bgs).

Test Unit 1: 1.00 meters, bgs.

Bench 1: 1.64 meters, bgs (Fig. 11).

Bench 2: 3.41 meters, bgs.

Bench 3: 3.90 meters, bgs.

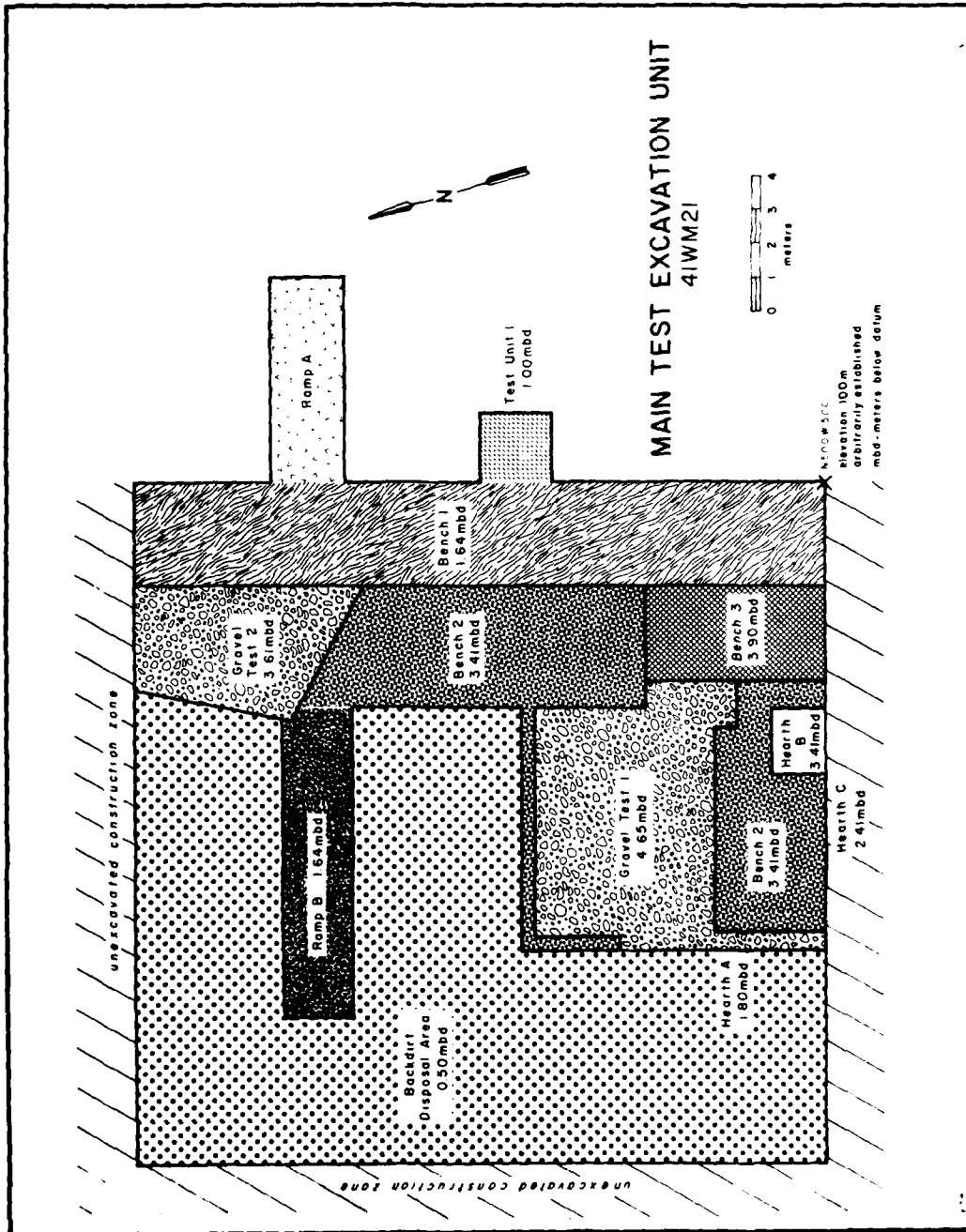
Gravel Test 1: 4.65 meters, bgs (basal gravels reached at that point).

Gravel Test 2: 3.61 meters, bgs (basal gravels reached at that point).



Figure 10. Crew cleaning Bench 1 in the main test excavation unit of 41WM21.

Figure 11. Plan of main test excavation unit, 41WM21.



The initial excavation was begun with the assistance of a grade-all. Upon completion of the grade-all work, it was apparent that the cultural indicators which had been well-defined in the cut bank, could not be defined in the main test unit. The excavation strategy was then modified to facilitate gathering as much information about the unit as possible. This strategy involved the cutting of profiles, in order to attempt to define stratigraphic layers indicative of cultural occurrences. The fill was removed by wheelbarrow, utilizing Ramps A and B, and screening was limited to five percent of the hand excavation. Screening produced no artifacts, however the few in situ artifacts were left in place and tagged to allow for quick identification. Instead of lens after lens of cultural occupation zones, only clusterings of cultural refuse were observed (Figs. 12, 13, and 14,A,B). One two meter square, Test Unit 1, was partially excavated above Bench 1, producing no evidence of cultural occupation in the first half-meter of fill. Two other areas of concern were gravel test units. These were hand excavated with pick and shovel in an effort to determine the existence of any cultural materials in these levels. The tests proved negative and the units were then used for screening and depositing backfill.

Rains, a rising water table, and freezing hastened the closure of the main test unit. One frost late in the excavation season caused the collapse of two of the larger profile units and the destruction of one burned rock feature. As the site was changing from day to day, it was impossible or at least an exercise in futility, to attempt a detailed contour map of the site. However, an effort was made to schematically represent a profile of the area as it might have appeared previous to the construction-related modifications (Fig. 15).

INTERNAL STRUCTURE OF MAIN TEST EXCAVATION UNIT

The internal structure of the main excavation unit can be described as considerably different from the other areas observed and tested at 41WM21. The upper portion of the site had been totally removed and replaced prior to the Texas A&M University investigations. The top meter of soil had been hauled to the site, deposited, and packed to form a mantle of impervious material which contained no cultural debris. The second meter of depth was dark gray soil (humus stained) which contained scattered cultural debris (Fig. 12). The evidence of massive root disturbance precluded the chance of in situ materials. The next five meters of deposition contained various cultural indicators such as snail shell, mussel shell, burned rock and chipped stone materials (Figs. 12, 13 and 14,A,B). Unlike the diversion channel and core trench where discrete refuse lenses were observed, the depositional sequences were not definable as continuous lenses. Rather, the soil profile appeared homogeneous although it contained scattered cultural indicators. The absence of obvious lensing can be attributed to two factors: scarcity of cultural materials which would mark a fossil surface and soil behavior such as leaching and vertisol activity. Soil samples were taken and chemical tests run in attempts to detect evidence for living surfaces but the results were negative (Appendix 1).

River gravels and sand lenses were encountered at the base of the excavations. These alluvial deposits were explored to a depth of over one meter and were found to be culturally sterile. Water accumulation at the bottom of the test unit resulting from heavy rains prevented excavation to bedrock shale.

OCCUPATIONAL FEATURES

A total of 59 phenomena described as occupational features were either documented or observed during the course of investigations at 41WM21. Fifty-

Figure 12. South wall profile of the main test excavation unit, 41WM21.

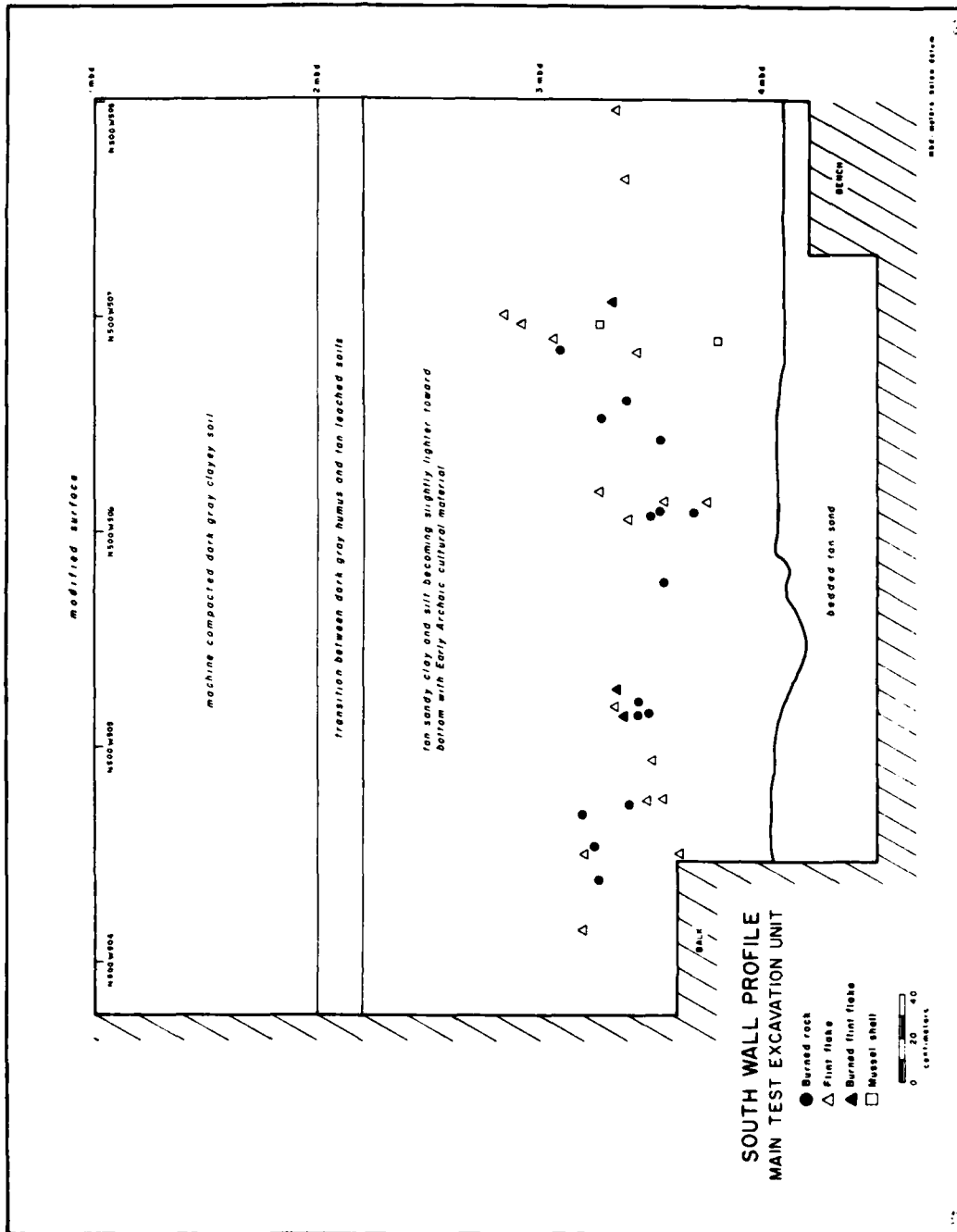


Figure 13. East wall profile of the main excavation unit, 41WM21.

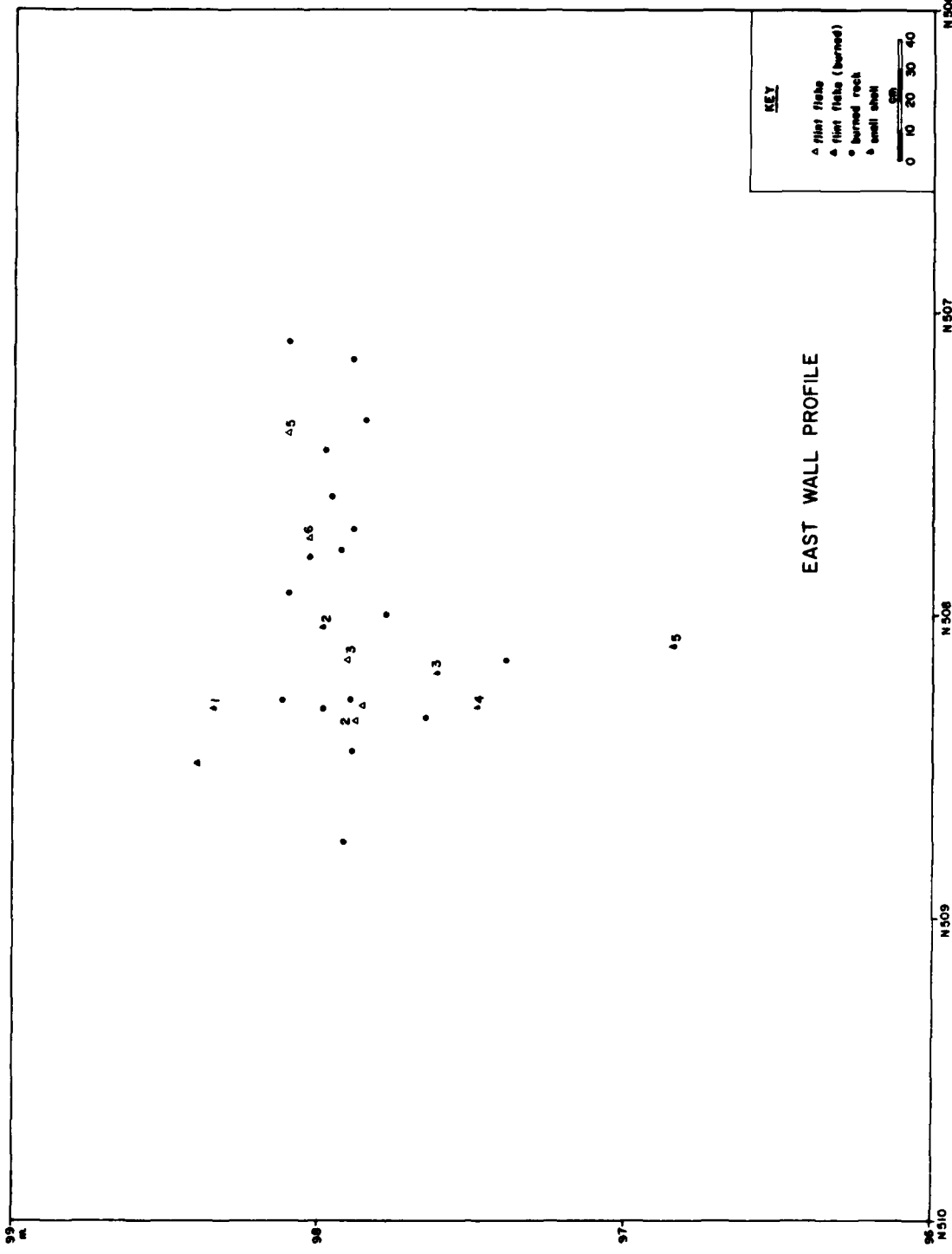


Figure 14: A, view of south profile and clearing activity exposing Hearth B, main test excavation unit, 41WM21; B, view of east profile in main test excavation unit at 41WM21. Color tones seen in profile are due to differential drying of freshly exposed soils.



A



B

seven of these features consisted of circular pavements or evident concentrations of burned, river-worn limestone (or rarely, chert) cobbles. Twenty-four of these features were documented in the dam core trench monitoring operation (Figs. 5,A,B, and 16); thirty were observed in the banks of the diversion channel (Fig. 6B), and three were found in the main test excavation unit (Figs. 14A, 17A). In addition, two other features were recorded: one was a deer skull found in Test Unit D (Fig. 9) and the other was a chipping debitage concentration discovered in Test Unit H. The features are discussed below by area.

Diversion Channel Banks

The most obvious features seen in the banks of the diversion channel were exposed concentrations of burned limestone cobbles. One (Fig. 6B) was explored to record the structural characteristics. However, this feature was found to consist of an apparent burned rock scatter rather than an intact structural feature; because much of the feature had been removed by channel excavation, its full limits and outline are unknown. Other burned rock features observed in the channel banks appeared to represent small, circular or oval pavement of burned rock on seemingly flat surfaces.

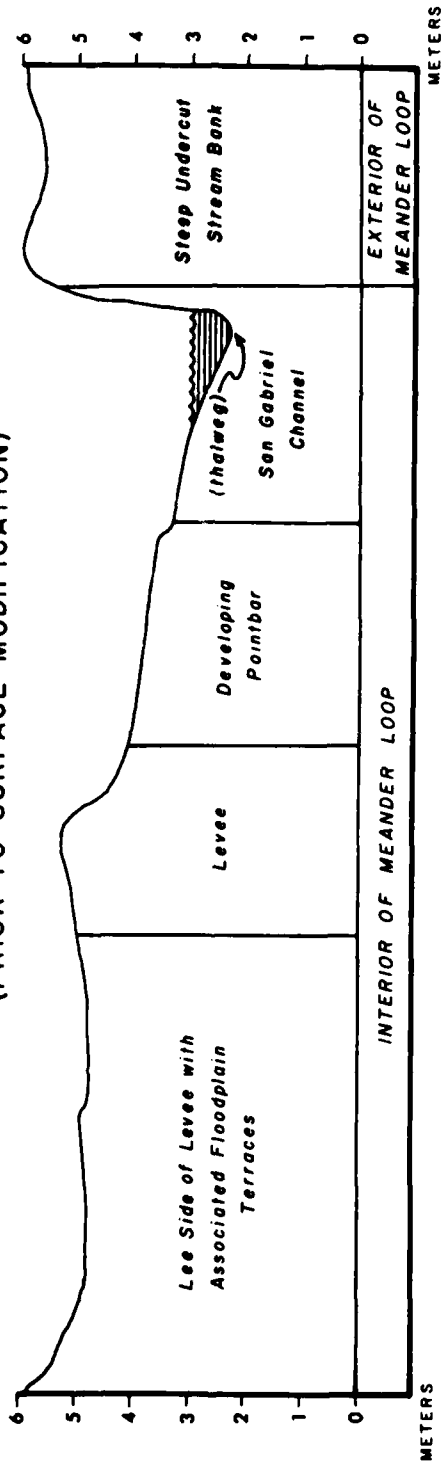
The two non-burned rock features consist of a white tail deer skull (Odocoileus virginianus) with one attached "4-point" antler (Fig. 9) and a concentration of interior flakes derived from the same core. This discovery was made in the laboratory after the materials had been cleaned and processed; the chipping feature could not be explored further once the discovery was made since the Test Unit H area had been removed from further archeological study by dam construction activities.

Dam Core Trench

Twenty-five burned rock features were recorded in the core trench

Figure 15. Generalized schematic cross section of the San Gabriel floodplain at 41WM21.

GENERALIZED SCHEMATIC CROSS SECTION OF THE
 SAN GABRIEL FLOODPLAIN AT 41WM 21
 (PRIOR TO SURFACE MODIFICATION)



Approximate Horizontal Scale



Figure 16. Burned rock concentration (Hearth 1) exposed in core trench during monitoring activities, 41WM21 (see Fig. 5A,B).



Figure 17. A, view of Hearth A in the main test excavation unit at 41WM21; B, excavation of Hearth B in the main test excavation unit.



A



B

monitoring phase. None could be thoroughly explored due to the conditions as explained earlier; however, a brief description, elevation and horizontal placement was recorded for each feature. The horizontal placement of 25 features is shown in Figure 7; the vertical placement is illustrated in Figure 8.

Without exception, these features were small, probably circular pavements, of burned limestone cobbles. The largest concentration measured 40 centimeters in maximum diameter. The cobbles showed varying degrees of burning, ranging from slightly discolored gray hues to intensively burned and crumbly reddish orange hues.

The horizontal and vertical position of these features follow interesting patterns and may be noted in Figures 7 and 8. The oldest features stratigraphically are also the southernmost; as one moves up the stratigraphic profile, the placement of the hearths trend northward; Hearth 3 is a notable exception. Also, there is stratigraphic clustering when the vertical distribution shown in Figure 8 is examined; Hearths 12,13,18,23 and 25 are deeper than the other features; Hearths 17, 19-22, and 24 cluster at the midpoint of the distribution while Hearths 1,2,4-11, and 14-16 represent the most recent clustering stratigraphically. It is not possible to explore the meaning of this apparent stratigraphic clustering relative to the geomorphic features identified as being part of the depositional history of this locality. One is tempted to suggest, however, that the hearth placements are marking the buried surfaces of a developing alluvial feature whose river bordering crest is trending northward as it gradually increases in elevation through time.

Main Test Excavation Unit

Three small burned rock concentrations were encountered in the main test excavation unit (Figs. 14A and 17,A,B). All represent small concentrations or

scatters of burned limestone cobbles; none were tightly arranged as were most encountered in the dam core trench (cf. Fig. 16).

Discussion

Critical toward determining the range of cultural behaviors carried out at 41WM21 is an understanding of the functions served by the burned rock concentrations. They are classed here under the rubric of "hearths" but this is meant to imply a general function only. Hearths can range in form from tiny fires built using only wood for construction, to elaborate devices designed to encourage air flow and to direct or concentrate the radiation of the heat via construction materials and manner of arrangement. Hearths may be used for warming, baking, smoking, cooking in an open fire, or a combination of any of these; certain foodstuffs may require certain kinds of fireplaces to process and prepare. The point is that a rock pavement hearth may have functioned as a specialized tool for processing certain foodstuffs.

The hearths at 41WM21 may have been constructed in several ways but only the circular pavement features were documented with certainty. These features were apparently more than temporary fireplaces since the limestone cobbles sometimes evidenced intense exposure to heat (perhaps from repeated fires) as indicated in the degrees of discoloration. The color hues resulting from burning ranged from light gray to a bright orange; the reddish tones resulting from the oxidizing of ferric minerals absorbed by the limestone during water transport from the Edwards Plateau, the parent source west of Georgetown in western Williamson County.

Further evidence of the specific nature of the feature is the construction process indicated: the builders selected stones of desired size from the river

gravels, transported them to the locus of use, prepared a surface and placed the stones in a desired pattern. Fires may have either been built on the stones or the stones placed on a bed of coals; however, there is no record of a charcoal lens lying beneath any of the stones.

It is possible that the circular pavement features are central fireplaces for structures since similar features have recently been found by the Texas Department of Public Transportation archeologists at an apparently late prehistoric site near Lake Buchanan (Milton Bell, personal communication). These "hearths" are enclosed by circular alignments of stones possibly representing house outlines. No stone circles were observed or documented at 41WM21. This is not to say that a structure could not have been present, however, since frame structures could have been built without anchoring the bottom with stones.

The apparent extensive use of the features at 41WM21 would suggest a specific function, perhaps as a quasi-specialized cooking, parching, or heating device. Indeed, the features may have had more than one function. In any event, their use spans a considerable period of time as shown in the dam core trench examples.

In sum, the function of the circular burned rock pavements remains unknown other than their being some form of cooking or heating structure. In future excavations it might be profitable to explore the hypothesis suggested by Dr. Dee Ann Story (personal communication) and based on the Lake Buchanan data that they are central hearths to temporary structures. Utilizing the heat radiation from the hot stones to warm a structure and its occupants would seem plausible. In testing this hypothesis, one should also note the distribution of the hearths relative to the riparian forests along the stream which would supply the source of firewood.

ARTIFACT SAMPLE

A total of 439 lithic artifacts were collected during the course of the survey, initial testing and test excavation at 41WM21. This small sample is described and discussed in order to examine its temporal, technological, and functional implications. The inherent problem of interpreting such a small sample drawn from many different contexts is realized, and certainly no claim is being made that these represent isolated activity sets or a representative sample of all activities carried out at 41WM21. The importance of the collection lies in its use as an indicator of time span, technology, and perhaps general function represented in the chipped stone sample. A listing by provenience of the artifacts are presented in Table 1.

Examples of most artifact classes, including all diagnostic specimens, are illustrated to scale and provide the reader with a relative perspective of size. Measurements are included with those artifacts not illustrated to scale.

Raw Materials

Lithic raw materials used by the prehistoric inhabitants of 41WM21 include limestone, nodular chert and fine grained quartzite. The limestone items are stream-worn cobbles gathered from the San Gabriel gravels. They are usually flat-oval in shape although many have been broken by thermal fracturing, the implications being that they may have been used for heat conduction purposes in cooking.

The cherts range in texture from relatively coarse to a fine, almost glassy-like texture. Colors range considerably and include grays, tans, browns, and reddish-brown banded cherts. The chert comes from cobble and pebble nodules from the San Gabriel River gravels and on Pleistocene terrace deposits outcropping

Table 1. Provenience of Lithics, 41WM21. (Survey and initial test.)

Table 1. Provenience of Lithic Artifacts from 41W21.

Provenience	Modified Flakes	Biface Fragments	Core Fragments	Cores	Cortex Flakes	Secondary Cortex Flakes	Interior Flakes	Biface Thinning Flakes	Flakes	Flake Fragments	Chert Nodule	Hammerstone: abraded	Burnt	Initial Series Biface	Intermediate Biface	Final Series Biface	Misc. Bifaces	Bulverde	Lange	Ensor	Bell	Distal Frags.	Totals
General Surface ϕ																							2
Surface North Side				1						1													2
Surface Near Trench Cut						1	4			1													6
Test Pit B (Southside River)				2	2	2	3	4	2														15
Test Pit D ϕ			1				2																3
Test Pit D ϕ -15 cm.										1	8												9
Test Pit E (all levels)	1	2				4	10	1	25				1										44
Test Pit F (all levels)	2				1	1		6	2								1					1	14
Test Pit F (S.E. corner)						1		8	33													1	43
Test Pit H (Step 1 and Step 2)				8	8		5	1	22														36
West end of site, S. side of river																					1		1
South wall of main test excavation unit, 1.78 m. below surface																					1		1
Dam Core Trench																							
Hearth #1 (10-20 cm)						1				2	7												10
Hearth #2 (10-20 cm)							2			2													4
Level 1 (0-10 cm) A11 Features			1			1	1				3												6
Level 2 (10-20 cm) A11 Features		1	1			1		1	15					1									21
Level 3 (20-30 cm) A11 Features			3	1	1	1		2	5				1	1		2							16
Level 4 (30-40 cm) A11 Features			1	1	1	1	1	8															11
Level 5 (40-50 cm) A11 Features		1	1	1	1	2	5	10						1	2							1	25
Level 6 (50-60 cm) A11 Features	1														1						1		3
Level 7 (60-70 cm) A11 Features				1				1	5	1													10
Level 8 (70-80 cm) A11 Features			3	2	3	3								1									12
Level 9 (80-90 cm) A11 Features			1	2	2	2		2															5
Level 10 (90-100 cm) A11 Features			2	2	1	4		9									1						19
Level 11 (100-110 cm) A11 Features			3	1	2		2							1									9
TOTAL	4	4	9	11	18	21	39	34	160	1	1	1	2	3	2	6	3	1	2	1	1	4	327

throughout the valley. The cherts were used principally for the manufacture of chipped stone tools although some of the nodules which exhibit extensive burning may have been used much the same way as the limestone.

Quartzite rarely occurs but does naturally outcrop on the surfaces of the Blackland Prairie beyond the north and south valley walls. The quartzite occurs in very ancient lithic deposits (Geological Age may predate the Pleistocene) in the form of well rounded pebbles and cobbles. One quartzite artifact was a milling stone converted to a hammerstone and abrading stone.

Chipped Stone Artifacts

The chipped stone sample is described under two major headings, debitage (waste material resulting in the manufacture of stone tools) and tools. The majority of the chipped stone sample falls into the first category.

DEBITAGE

Flakes

The flake sample was sorted on the basis of the relative position from which they were removed from the core. For example, the chert nodules are angular to subrounded cobbles possessing a crusted outer surface called cortex. The flake is described as a cortex flake; if only a portion of the outer surface is cortex, then the term secondary cortex is used. Flakes that exhibit no cortex are referred to as interior flakes. All flakes classified under these headings also exhibit prominent bulbs of force and were presumably (although not necessarily) removed using a hard, probably stone, hammer.

Another flake category used in the analysis is the thinning flake (Muto 1971: Fig. 15). It is classified separately from those above because of the functional implications these flakes provide. *Thinning* flakes are the residue from the reduction and thinning processes in the manufacture of thin biface tools.

Thinning flakes have a series of attributes that set them apart from the previously defined categories.

Flakes which are too fragmentary (either through scattering or detachment or burning) for classification into the above groups are classified under the heading flake fragments.

Discussion: Frequency statistics would be meaningless in view of the sample size and lack of systematic collecting procedures. The sample does suggest that the entire sequence of core reduction is indicated in the sample, from removing initial flakes to final thinning of biface cores. This finding could indicate two things: either the knappers gathered their cobbles from gravel deposits in the immediate proximity of the site or that virtually no core reduction was done at lithic resource procurement locations. It must be kept in mind, however, that occasional partial reduction could take place at the procurement station and our sample would never show an indication of this.

Biface Failures

The manufacturing sequence of a biface tool requires varying degrees of reduction from a nodule or large flake blank. Since the manufacturing principal is based on a complex series of guided failures, inadvertant fracturing of the artifact can occur at any point in the sequence. These failures can be due to several causes (see Muto 1971 for an excellent discussion of biface failures), but the result is the fossilization of the sequence at the time of the fracture. Several examples of biface failures are represented in the sample and occur as thick bifacially chipped artifacts.

The biface failure sample was divided into four categories, three of which are assumed to represent relative points in the manufacturing continuum of thin biface tools. The categories are: initial series, intermediate series, final series and miscellaneous.

Initial Series

These three artifacts presumably represent initial attempts to biface a chert cobble. All exhibit flake scars that have deep negative bulbs of percussion, presumably from hard-hammer flaking. Two possess traces of the nodular cortex of the parent cobble on both surfaces. The third specimen was broken and attempts to flake the broken edges are in evidence. None exhibit signs of soft hammer or advanced thinning.

Length: 8.2, 10.4, and 13.6 cm; Width: 5.5, 5.7, and 5.9 cm; Thickness: 2.4, 2.6 and 3.6 cm.

Intermediate Series

Two biface fragments show initial attempts at thinning. Both appear to have fractured across the section during the course of being thinned.

Length: both fragmentary; Width: 4.5 and 7.9 cm; Thickness: 1.8 and 2.8 cm.

Final Series

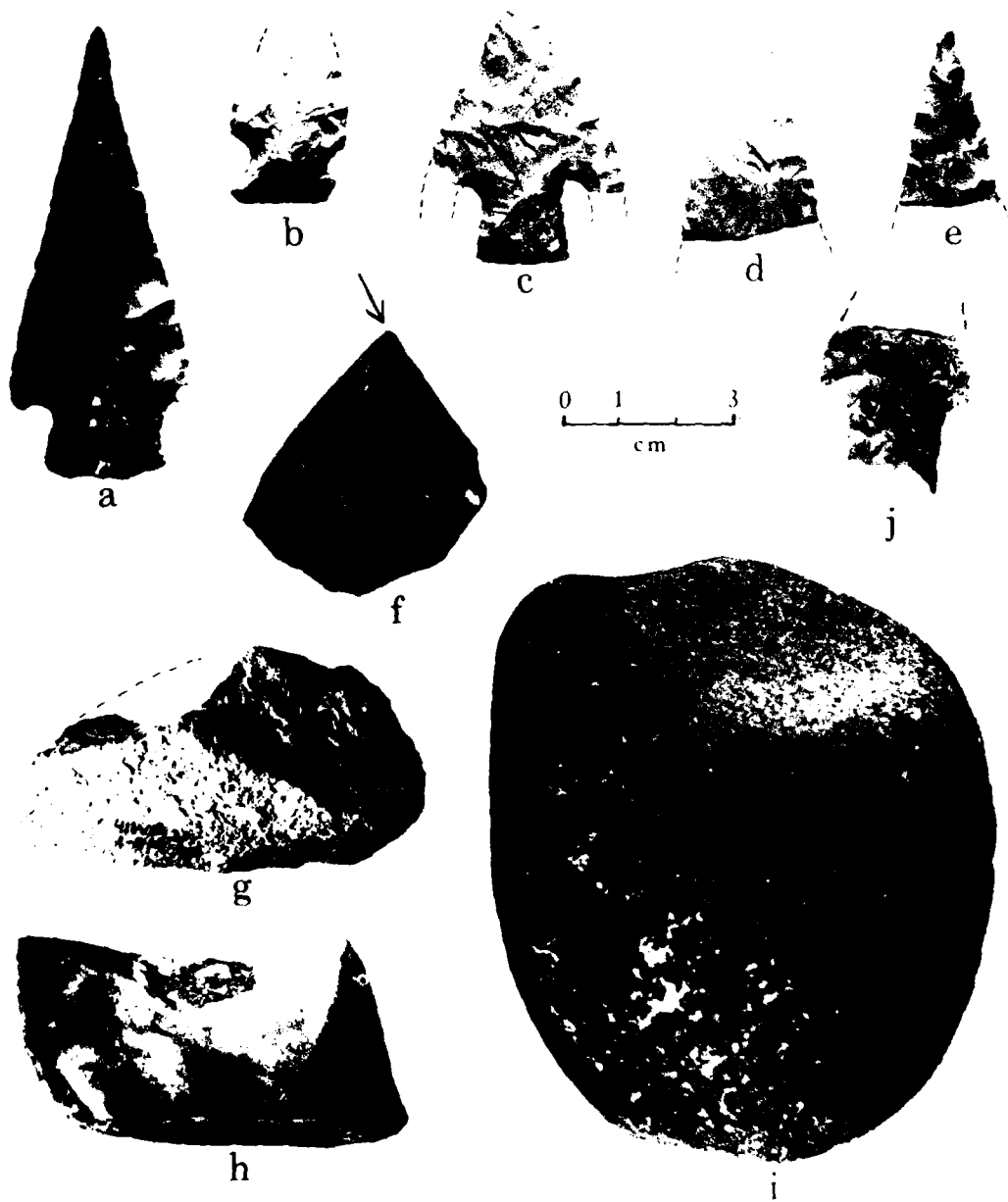
Six biface fragments (2 proximal, 2 medial, and 2 distal) exhibit advanced, nearly final thinning (Fig.18,D,E). All appear to have broken during the final stages of thinning and four are broken across the mid-section. Platform preparation for thinning (light edge beveling on one and dulling on the other) was observed on two examples.

Length: (none complete); Width: (range) 3.5-4.7 cm; Thicknesses: (range): 0.6-0.9 cm.

Miscellaneous Bifaces

Three specimens fall into this group. Two are thick percussion flaked bifaces. One of these failed due to an inadvertant fracture of one edge

Figure 18. Lithic artifacts: A, Lange point; B, Ensor point; C, Bell point; D,E, distal fragments of projectile points; F, burin; G, uniface; H, modified flake, I, hammerstone-abrader; J, Bulverde point.



and the other appears to have been discarded due to the knapper's inability to work off the faceted edge of the cobble. The third example is a burned biface medial fragment.

Length: 6.2 and 8.8 cm (2 specimens); Width: 5.0 and 8.2 cm; Thickness: 2.1 and 4.3 cm.

TOOLS

Thirteen artifacts are described under this heading. Six are projectile points, three are modified flakes, two are burins, and two are biface (chopping) tools.

Projectile Points (6 specimens) (Fig. 18,A-E,J).

One specimen (Fig. 18C) is classified as a Bell point (Sorrow, Shafer and Ross 1967:12-14; Wesolowsky, Hester and Brown (1976). It is a barbed point with a slightly expanding stem and a straight, thinned base. Although neither barb is complete, they extended approximately even with the base. The blade is triangular and the specimen is made on a well-thinned triangular preform. The material is patinated blue-gray flint.

A second specimen, also of patinate, blue-gray flint (Fig. 18J) is a slightly contracting stem point which was broken in the medial section. This specimen is classified as a Bulverde (Suhm and Jelks 1962:169). The base is slightly concave and the shoulders are moderate but not barbed. The blade was triangular and when complete, may have represented three-fourths of the total length.

One complete specimen (Fig. 18A) made of tan flint is classified as a Lange (Suhm and Jelks 1962:203). The corner notched specimen has a slightly expanding stem with mildly concave stem edges and a weakly convex base.

Shoulders are strong. The blade is long and triangular with approximately straight lateral edges. Flaking pattern indicates that the Lange was made from a large, thinned biface preform.

A small side-notched dart point made of blue-gray flint is classified as an Ensor (Suhm and Jelks 1962:189). The base is straight and the lateral edge remnants are mildly convex. This specimen appears to have been mostly pressure flaked and the preform may have been heat-treated judging from the slightly waxey appearance of the flint. Also, the specimen may have been broken by impact.

The remaining two specimens (Fig. 18,D,E) are distal fragments of finely made biface fitting the class of projectile points. Both are made of thinned biface preforms and are pressure thinned.

Bifaces

Two bifaces were recovered during the testing of 41WM21. One is a flat oval chert cobble that has been carefully bifaced at the narrower end. The cortex surface remains over approximately two-thirds of the specimen. The other is a thin tool which seems to have been broken subsequent to completion.

Burin (2 specimens) (Fig. 18F).

One is questionable and is a biface fragment (probably an intermediate series failure) exhibiting one burin facet originating from a roll snap fracture (i.e. a fracture originating from a bending stress failure resulting in a matching concave - convex surface on the two pieces). Although no apparent use marks are evident nor can we be certain that the specimen was ever used as a tool, the deliberate removal of the burin spall suggests

intentional recycling of this broken biface. The other is a secondary flake, with removal of the burin spall at the distal end of the flake.

Modified Flakes (3 specimens) (Fig. 18,G,H).

These flakes, representing two secondary cortex and one interior flake, exhibit edge modifications. Edge retouch on these appears to have been the result of use.

Hammerstone Abrader (1 specimen) (Fig. 18I).

This quartzite cobble may have once served as a milling stone but its most obvious use was as a hammerstone and as an abrader. Abrasion wear is clearly evident diagonally across one surface and again across one end. Both ends exhibit battering but one much more than the other. The function of the abrasion was evidently to dull the edges of biface preforms for platform preparation during the course of thinning.

Artifact Discussion

If any date range of the projectile point styles is reasonably accurate, then the occupation span for 41WM21 extends over several thousand years of the central Texas Archaic sequence including Early, Middle, and Late Archaic periods. The projectile points are the only temporally diagnostic lithic artifacts in the sample (Fig. 18). Few tools can be identified among the lithic artifacts recovered (this does not include burned rocks). The majority of the sample is composed of debitage resulting from the manufacture of biface tools and if this small sample is a reliable indication, a sufficiently large sample of debitage is present in the more concentrated areas of occupation along the banks of the diversion channel. Therefore, it is doubtful

that expansion of investigation here would provide a sufficient sample to address specific questions regarding chert procurement and reduction methods. Debitage analysis other than Eddy's (1973) contribution is regrettably lacking for the Granger Reservoir District archeological studies. Such analyses would be rewarding regardless of whether or not the findings are positive. Defining the lithic manufacturing technology, however, was but one objective that could have been reached with the cultural resources at 41WM21. We anticipated the possibility of defining lithic tool sets or activity sets incorporating stone tools. Determining tool function through morphological, wear pattern and experimental studies is a central objective of any technological analysis. The debitage, while certainly important in terms of providing data on a group's adaptation to local resources, is secondary when a higher level of technological study is approached. This higher level focuses on patterned procurement and processing activities that went to sustain the population. Determining the tool function allows the archeologist to reach this higher level of technological study. Since the most common tools are of stone, it stands to reason that an intensive functional study of artifacts will be necessary in the future if archeologists ever hope to obtain answers to questions pertaining to why the site was occupied and what the people were doing at that location. Purely morphological studies of artifacts which has been the customary approach of researchers in the area will not provide the appropriate data to fulfill functional and behavioral objectives.

Projectile Point Chronology

The chronological interpretations of the occupation(s) of 41WM21 are based on projectile point typology and the placement of those types within

the temporal framework of the central Texas prehistoric sequence. The sequence is based on the efforts of Johnson, Suhm and Tunnell (1962); Shafer (1963); Sorrow, Shafer and Ross (1967); Wesolowsky, Hester and Brown (1976) and Weir (1977).

The earliest known specimen is the barbed Bell point (Fig. 18c). The Bell type was first described by Shafer from the Landslide Site in Stillhouse Hollow Reservoir (Sorrow, Shafer and Ross 1967:12-14). Bell points have been found at the Jetta Court Site in Austin (Wesolowsky, Hester and Brown 1976). The estimated range for this style is 5000-6000 years B.P. and falls in the Early Archaic Period in the Central Texas chronology.

Bulverde points are a common Middle Archaic period style dating approximately 3500-5000 years B.P. (Sorrow, Shafer and Ross 1967). Lange points are a Middle to Late Archaic style dating approximately 2000-3000 years B.P.

The latest point in the collection is the Ensor point. These point styles date in the Late to Terminal Archaic periods in the central Texas chronology, or about 500-1800 years B.P. (Sorrow, Shafer and Ross 1967).

Local collectors reported finding a number of Pedernales projectile points in the diversion channel during the first stages of dam construction. This type point has been assigned to the Middle Archaic period.

Based on the recovered diagnostic artifacts and their estimated age, it is possible that 41WM21 was the subject of prehistoric utilization for over 7000 years.

FAUNAL REMAINS

As noted on Table 2, only a limited amount of faunal material was recovered during excavation. What was recovered was extremely fragmentary and/or was retrieved from non-indicative contexts. The predominant species

Table 2. Faunal remains from 41WM21.

Table 2. Faunal Remains from 41WM21. Numbers Indicate Bones or Items Present.

Provenience	Species or Type of Faunal Remains										Totals	
	Bison sp. or Bos sp.	Deer or Antler	Pocket Gopher	Cottontail Rabbit	Skunk	Snake	Fragments or Unid. Teeth					
Diversion channel, Southside River, 6.6 m. below surface	1*											1
Surface: next to N. side of diversion channel											1	1
Surface: River Bank Collection		4*									7	11
Centerline Test Pit #2		3			1						8	12
Test Pit #D		35 (1 skull 7 IDs ??)									18	53
Test Pit D#: 0 to 15 cm.		2									22	24
Test Pit #F					6		1				4	11
Test Pit #F: S.E. Corner										6 vert.	5	11
Trench Cut: Level 10 (90-100 cm.)		1 (antler burned)										1
West End of Site	2	1										3
TOTALS	3	46	6	1	1	6	65					128

identifiable was deer (Odocoileus virginianus), and the majority of pieces appeared to be antler fragments. Only two pieces, one deer and one Bison or Bos appeared to be modified, but the identification was tenuous because of the fragmentary nature of the specimens. Although several fragments were burned, their contexts disallowed any conclusions as to cultural modifications.

One provenience note relevant to the site's geomorphology is that all faunal remains came from the point bar formation. The fragmentary nature of the material recovered points up the high alkaline content of the matrix.

POLLEN ANALYSIS

Ten soil samples were taken in an attempt to extract a fossil pollen sequence from the alluvial deposits at 41WM21. Two were obtained from Test Unit A-1, one from Test Unit A-2 and seven from the main test excavation unit. The results of this analysis are presented in Appendix 1 but in essence, the soils at 41WM21 are devoid of fossil pollen.

CHARCOAL IDENTIFICATION

A small quantity of charcoal was recovered from the test units and the main excavation. Although there was not enough present to obtain radio-carbon dates, an attempt was made to identify the charcoal in an effort to add further data on the economic use of plants. The samples selected were both from Test Unit H in the diversion channel. Identification was made using a dichotomous wood key based upon the transverse (cross-section) face of the sample. The samples were small, probably portions of limbs. It was possible to identify two specimens: one is elm (Ulmus sp.) and the other is Carya sp. Neither specimen could be identified to species.

DISCUSSION

Archeological investigations at 41WM21 have yielded evidence for intermittent use of a developing point bar and possibly an associated levee feature over an extended (possibly several thousand year) period of time. The entire occupation sequence at the site is buried in floodplain deposits of the San Gabriel River.

The evidence for the point bar formation and the intermittent use of its surface is amply confirmed. Archeological evidence occurs in the form of small, thin lenses of cultural refuse and in situ features, particularly rock pavement hearths and, in one instance, a chipping locus, the locus being found in Test Unit H and identified by several flakes originating from the same core. Utilization of the point bar formation as a camping area took place very early in its development, as the lowest occupation lenses occur below the present day river level. These lenses can be traced through approximately three meters of alluvial deposits.

In the area of the main test excavation and the core trench monitoring, the findings suggest that an ancient river levee, a somewhat different geomorphic form, was also utilized for occupation. This land form was identified in the south wall of the main test excavation by Corps of Engineers geologist George Reude using both sediment analysis and stratigraphic observations. The relationship between the two land forms was not fully worked out because of the massive amount of earth moving that would be necessary to cross-section the site, a project beyond the scope of the test excavations. However, by using diagnostic cultural indicators, we can hypothesize the following cultural history for 41WM21.

The earliest utilization of the site area was during the early Archaic when surfaces of the levee feature were first occupied. Cultural indicators here include Bell and Bulverde dart point forms and deeply patinated chipping debris. Unfortunately, charcoal was not recovered in sufficient quantities to provide radiocarbon dating of these activity areas.

The second major period of occupation took place during the Middle Archaic Period and occurred on the front of a developing point bar feature next to the river. Intermittent use of the point bar feature over an extended period of time represents the most abundant aboriginal utilization of the site. Again, the collected charcoal was not of sufficient quantity to provide radiocarbon dates. However, identification did show that elm and Carya sp. (either walnut or pecan), major bottomland hardwoods, were used as fuels. The cultural activities best represented by archeological refuse emphasize campfire-cooking chores in which limestone rocks were used as heat conductors.

The third major period of utilization occurred in the Late Archaic Period, evidence of which was principally recovered on the surface and in the core trench monitoring. These cultural materials were recovered from dark humus stained clays probably representing floodplain deposition which blanketed the fossil levee and point bar feature. The archeological evidence of this period was meager at the time of the Texas A&M University inspection but an artifact collection made by a previous landowner indicates a rather extensive use of the site during the Late Archaic Period.

Previous archeological investigations in the Granger Lake area have revealed other evidence for utilizing developing point bar features by the aborigines. Eddy (1973:328) noted ancient hearths in a point bar formation

at 41WM133. Three features at 41WM133 date in the Early Archaic (8500-7000 B.P.) Period.

The utilization of levee formations for prehistoric campsite settlements was noted by Prewitt (1974:20-22) at the Loeve-Fox site and by Clell Bond (personal communication) at the Hoxie Bridge site. Occupation on this feature at the Loeve-Fox site may date from the Middle Archaic into the Post Archaic periods. At the Hoxie Bridge site, the materials associated with the levee surface occupations date in the Terminal Archaic and Post-Archaic periods (Clell Bond, personal communication).

The findings, when considered in light of the settlement models discussed in the Archeological Background section, provide some interesting data on the choice of campsite location. All activity areas observed at 41WM21 are interpreted as being the result of campsite (base camp, home base, or whatever) behaviors. Assuming this interpretation to be correct, the most favorable model for interpreting the campsite choice for the Middle Archaic campsites is one emphasizing convenience. As noted earlier, considering the "site catchment area" all major resource zones in the prairie-riverine area are within five kilometers of this site and are readily available for exploitation. The tentative interpretation that the early Archaic campsites were on a river levee feature and Middle and Late Archaic settlements on the floodplain point bar could suggest that a criterion of Prewitt's settlement model, namely selection on the basis of topographic positions, was operative. We would like to point out, however, that knowledge of the location of previous campsites by the aboriginal groups does not seem to be a viable criterion as the masking of previous deposits by sediments indicates a

considerable time lapse between occupations. We do not argue against such a criterion for resource utilization determining campsite selection at certain times or seasons such as when an excellent pecan harvest is imminent.

Appendix I
Analysis of Soils and Fossil Pollen from 41WM21
by
Vaughn M. Bryant, Jr.

Introduction

In an attempt to try and understand the paleoenvironmental record of the region near site 41WM21 I conducted a limited soil and pollen testing of the sediments. Ten soil samples were selected from excavations at 41WM21 and sent to the Texas A&M University Soil Testing Laboratory for analysis.

The soil analyses revealed that the range of soil pH of these samples varied from a low of 7.8 to a high of 8.4, thus indicating that these soils are all alkaline in nature. Calcium, magnesium, and potassium levels of these samples varied from high to very high levels, while the predicted nitrogen level was relatively low. The organic matter contents of each of these samples was less than 1% and ranged from a low of 0.2% to a high of 0.4% (Table 1).

Since the soil analyses (only intended as support data for the pollen studies) indicated a low probability of finding preserved fossil pollen in quantities large enough for statistical use, I decided to select three samples collected from different areas of the site for the pollen extraction phase. In this way, I felt that valuable time and expense would be saved if the tests proved negative. However, I was prepared to process the other seven samples and would have conducted further pollen and soil testing

Table 1. Test Conducted by Dr. Welch of the Texas A&M University
Soil Testing Laboratory on Pollen Samples from Site
41WM21.

Table 1

41WM21

Test conducted by Dr. Welch of the Texas A&M University Soil Testing Laboratory

<u>POLLEN SAMPLE NUMBER</u>	<u>PROVENIENCE</u>	<u>pH</u>	<u>MAGNESIUM*</u>	<u>PHOSPHORUS*</u>	<u>POTASSIUM</u>	<u>ORGANIC MATTER</u>
A	Test Unit A1 - Lowest Snail Strata	8.0	125	3.52	137.61	0.3%
B	Test Unit A1 - Middle Snail Strata	7.9	125	5.95	154.39	0.2%
F	Test Unit A2 - Snail Strata	8.3	125	1.98	154.29	0.3%
1	Main Test Excavation - West Wall, 3.3 mbd	8.1	125	2.67	138.61	0.2%
2	Main Test Excavation - West Wall, 3.1 mbd	7.8	125	4.84	144.04	0.3%
3	Main Test Excavation - West Wall, 2.9 mbd	8.4	125	3.99	145.56	0.3%
4	Main Test Excavation - West Wall, 2.7 mbd	8.5	125	4.00	149.98	0.2%
5	Main Test Excavation - West Wall, 2.5 mbd	8.0	125	5.56	152.11	0.4%
6	Main Test Excavation - West Wall, 2.3 mbd	8.2	125	5.26	151.77	0.3%
7	Main Test Excavation - West Wall, 3.1 mbd	7.9	125	3.88	137.66	0.3%

*parts per million

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TEXAS A AND M UNIV COLLEGE STATION DEPT OF ANTHROPOLOGY F/G 5/6
ARCHEOLOGICAL TEST EXCAVATIONS AT SITE 41WM21 IN GRANGER RESERV--ETC(U)
MAY 78 G L MOORE, H J SHAFER, E P BAXTER DACW63-76-C-0176

UNCLASSIFIED

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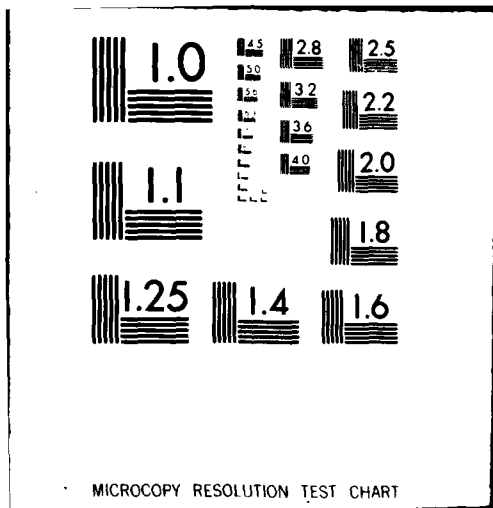
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of the site had any of the initial three samples contained more than a few fossil pollen grains.

The soil samples used for these analyses were collected using techniques designed to prevent contamination from other soils or atmospheric sources. The sampling technique is easy to conduct and does not require the use of expensive equipment. The principle objective was to secure soil samples free from atmospheric contamination of modern pollen. To achieve this, a one-foot wide section of exposed excavation wall surface was thoroughly cleaned from top to bottom by scraping away at least six inches of sediment with a clean trowel. Each soil sample was placed in a sterile polyethylene bag and quickly sealed to avoid atmospheric contamination from modern pollen. Between samplings, the trowel was thoroughly cleaned with distilled water and clean paper towels to avoid contamination of the succeeding samples with dirt from earlier samples. Sampling was begun with the lowest stratum and then continued up the column. In that way, there is a lower probability that pollen and dirt from the upper strata will fall into the sample and thus contaminate the specimens below. The amounts of sediment collected from each sample varied from a little under one pound to a little more than one pound per sample. Past experiments have shown that this amount of material is sufficient for conducting both a soil analysis and conducting fossil pollen extraction.

The extraction procedure used on these three samples was a process which has been designed for pollen removal from alkaline soils. This procedure consisted of the following steps:

- 1) Fifty grams of soil were removed from each sediment sample and were placed in a clean beaker.
- 2) The material in each beaker was then screened through a one-half millimeter brass screen to remove small rocks and

other large detritus. 3) A pellet containing approximately 12,500 Lycopodium spores was dissolved in diluted hydrochloric acid and then added to each sample so that an absolute pollen frequency could be calculated later during the analysis. 4) Each sample was mixed with distilled water and decanted in order to remove some of the larger grained silicates such as sand. 5) Each sample was then placed in a 15% aqueous solution of hydrochloric acid until all reaction ceased. 6) Each sample was then thoroughly washed with distilled water until a neutral pH was achieved. 7) Each sample was then placed in an aqueous solution of concentrated hydrofluoric acid (52%) for 24 hours and was stirred repeatedly during that time period. 8) The liquid fraction was then removed and decanted. The resulting residue was next treated with boiling hydrochloric acid (10%) and then washed with boiling distilled water until a neutral pH was obtained. 9) Each sample was then mixed with an acidic solution of zinc chloride (specific gravity 1.90) and centrifuged for 20 minutes at 2,000 RPM's. 10) The material was then removed from the zinc chloride heavy density treatment and diluted with distilled water in order to recover the fossil pollen and other organic detritus. The heavy residue was checked for pollen and since none was found, it was discarded. 11) Each sample was then placed in a warm solution of 10% potassium hydroxide for ten minutes and washed ten times in boiling distilled water. 12) Each sample was then stained and added to 2000 cks silicon oil and mounted on microscopic slides.

During the laboratory extraction process repeated wet mounts were made of the material at each stage in order to determine whether or not any pollen was being lost during the excavation process. The wet mount examinations

revealed that no pollen was being lost and that fossil pollen preservation was very poor.

In addition to the extraction procedure outlined above, several additional modifications of that procedure were attempted for two of the samples (Sample B and Sample F). The modified extraction technique did not improve the pollen yield from either of those two samples, thereby confirming my assumption that the fossil pollen in the soil samples from 41WM21 was not being lost through the use of a harsh chemical treatment during the laboratory extraction process.

Standard 200 grain pollen counts were attempted for each sample as suggested by Barkley (1934). Regrettably, this was not possible for any of the samples since none contained the minimum of 200 fossil pollen grains needed for a statistically valid count (Table 2).

Exotic pollen (Lycopodium spores) was added to each sample so that an absolute pollen frequency could be calculated for each stratigraphic zone tested at this site. The percentage of exotic pollen in each sample was noted and compared to the percentage of fossil pollen recovered in each sediment sample. Using this comparison I was able to calculate the absolute pollen frequency (APF) for each sediment sample obtained (Table 2). Since the exotic pollen chosen for use in this study (Lycopodium) came from Denmark and was from a cryptogram native to that region, there was no problem in being able to easily identify the modern exotic pollen from the fossil pollen native to the central Texas region.

Table 2. Absolute Pollen Frequency Results, Site No. 41WM21.

Table 2

<u>TAMU Sample #</u>	<u>Archeological Site</u>	<u>Provenience</u>	<u>Comments</u>
A	41WM21	Lowest snail strata, Test Unit A	Absolute pollen frequency (APF) determined to be less than 1,000 fossil pollen grains per gram of dried sediment. No recognizable pollen present, some fungal spores present.
B	41WM21	Lower strata, Test Unit A	APF equals less than 1,000 fossil grains per gram of dried sediment. No pollen or fungal spores encountered.
F	41WM21	Excavation unit, strata 2; approximately 1 m. below natural level.	APF equals less than 1,000 fossil grains per gram of dried sediment. One fragment of <u>Quercus</u> pollen grain, charcoal present and some fungal spores.

Discussion

Pollen preservation was the major problem encountered in the attempt to recover fossil pollen from the soils at 41WM21. Although it is difficult to determine the exact causes for pollen loss in these sediment samples, I can offer some hypotheses. In most cases, the major causes of pollen destruction in sediments result from four primary categories: (1) mechanical breakdown of the pollen grains; (2) chemical breakdown of the pollen wall; (3) pollen wall composition and structure; and (4) biological degradation.

The majority of the pollen encountered in any fossil sediment is most often of the wind-borne type (anemophilous). Wind-borne pollination is a very inefficient method, and therefore anemophilous plants tend to produce large quantities of pollen in an effort to achieve adequate pollination. In this type of plant each anther will generally contain between 10,000-70,000 (or more) pollen grains, which will be dispersed and carried by the wind. The vast majority never reach their intended destination and are instead deposited on the ground as "pollen rain". Sometimes the pollen contents of the air in some regions is so laden with pollen that a visible yellow film of pollen is deposited on the surface of the ground. An idea of the enormity of potential pollen productivity is exemplified by the spruce forests of middle and southern Sweden, which are estimated to produce approximately 75,000 tons of pollen annually (Faegri and Iversen, 1975).

Depending upon the regional vegetation of an area and the types of plants represented in that vegetation, the pollen rain can deposit anywhere from several hundred to many thousands of pollen grains per square centimeter of ground

surface. Under ideal environments of deposition, the vast majority of these pollen grains will become fossilized and can later be recovered through laboratory procedures and used to conduct pollen analytical studies. In less favorable environments of deposition, large numbers of these pollen grains become destroyed or badly damaged and thus are not available for later use in paleoenvironmental reconstruction.

One of the first factors which tends to destroy pollen grains, either before or during the fossilization process, is mechanical breakdown. Many pollen types tend to be very fragile and during their transportation on air currents, they can become abraded when they strike each other or other objects. Once deposited on the ground, they can become further abraded by the effects of water, wind and soil movement. Abrasion of pollen in loess deposits, for example, is generally more severe than in water or in other types of sediments. This is particularly true in areas where loess deposits are deep and subject to continual shifting through wind deflation. Pollen studies which I have conducted of loess deposits in the Pacific Northwest region of the United States have shown that in most cases, pollen recovery is minimal. Although pollen loss in these loess deposits could result partly from other factors, I suspect that a large percentage of the cause is attributable to the mechanical breakdown process itself.

In most sediments, an even more important degradation factor is the chemical destruction of the pollen wall itself. Dimbleby (1957) has shown that soil pH appears to be an important factor in pollen preservation. He found that in soils with a pH greater than 6.0 the preservation of fossil pollen was not sufficient to warrant subsequent analysis. In studies which

he conducted of soils from Guiana and regions of England, he found that soils containing a highly acidic pH of 3.0 contained as many as 436,000 pollen grains per gram of dried sediment. On the other hand, he noted that in soils with a less acidic pH of 5.5, fossil pollen recovery was only 2,400 pollen grains per gram of dried sediment. Furthermore, his study demonstrated that in soils with a pH greater than 6.5, fossil pollen recovery was impossible. Dimbleby's study was an important contribution to the field of palynology, yet later studies conducted by Martin (1963) have shown that fossil pollen could be recovered from southwestern United States soils containing a pH greater than 6.5. In related studies of soils from West Texas, I have also noted that pollen recovery is possible in highly alkaline soils with a pH as high as 8.9 (Bryant, 1969). However, I did find that when the soil pH is alkaline, the fossil pollen grains tended to be highly corroded, making identification very difficult, but not impossible.

Another factor which seems to play an important role in the preservation of fossil pollen is the oxidation-reduction potential (Eh) of sediment. Tschudy (1969) has noted that sediments containing a low Eh indicate a reducing environment and are better for the preservation of fossil pollen than high Eh indicating an oxidizing environment.

The chemical composition of pollen walls and the pollen wall structural morphology also play important roles in determining whether or not pollen grains will remain effectively preserved in various types of sediments. Havinga (1964) reported that he found that the relationship between the percentage of sporopollenin in the pollen wall of a grain very much affects its susceptibility to destruction through oxidation. He found that the differences

in oxidation rates of pollen walls closely paralleled the ratio of sporopollenin to nonsporopollenin material in a pollen wall itself. The lower the percentage of sporopollenin in the pollen wall, the greater the susceptibility to oxidation. The actual morphological structure of the pollen wall also partly determines the ability of that grain to remain preserved in certain sediments. Pollen grains having protruding structures from the sides, such as bladders or spines, can very often lose these appendages through a variety of degradation processes, such as abrasion, and/or chemical destruction. In some cases, the actual appearance of a pollen grain can become so altered due to the loss of the appended structures that identification is impossible; or it causes severe structural weaknesses which hasten the destruction of the remainder of the grain through normal processes.

Certain types of biological agents such as fungi and bacteria have been shown to play a role in the degradation of pollen grains. Some of these micro-organisms feed on the internal cytoplasm of pollen grains and thus aid in the destruction of the pollen grain by weakening the outer wall when they attempt to enter the pollen grain itself. Species of fungi such as the Phycomycetes, were investigated by Goldstein (1960) and found to be a causative factor in the destruction of certain pollen types. His data show that Phycomycetes tend to infect certain pollen types at a faster rate than others. For example, the pollen grains from coniferous trees tend to be more susceptible to destruction from Phycomycete activity than do the pollen grains from certain types of deciduous trees and herbaceous plants. Elsik (1971) has also noted that bacterial degradation occurs in pollen. He found that some bacteria, especially the Actinomycetes, tend to degrade pollen walls in a

definite pattern and that this activity can occur not only in fresh pollen still containing cytoplasm, but can also occur even after the pollen grain has become fossilized.

Based upon the above data, some palynologists have attempted to assess the pollen preservation potential of certain types of environments of deposition. In the early 1960's, Sangster and Dale (1961, 1964) attempted to determine the rate of pollen preservation in three types of environments: a weakly acidic peat bog, a more acidic peat bog, and a small alkaline pond. They found that the greatest amount of pollen destruction occurred in the pond deposit, while lesser amounts of destruction occurred in both types of peat sediments. In a later study by Havinga (1971), mixtures of 19 different types of fresh pollen and spores were placed in porous nylon containers that were then buried in five different environments of deposition: a river clay soil, a sphagnum peat, podsolized sand soil, a carex peat, and in a deposit of leaf mould. Based on his study, Havinga concluded that the ratio of pollen destruction varied in each of the five sediment types. The least destructive sediment to fossil pollen was the sphagnum peat and the most destructive was the deposit containing leaf mould. The other three sediment types were intermediate, and ranked from least to most destructive were: carex peat, podsolized sand soil, and river clay soil.

Any one or any combination of the above mentioned factors could have caused the destruction of fossil pollen in the sediments at 41WM21. One indication of the harsh environment of deposition found at this site is the low percentage of organic matter present in the soils (Table 1). When the percentage of organic matter in soils is very low, the cause is often a high Eh

potential, indicating a rapid rate of oxidation. Since many of the factors that tend to oxidize most types of organic matter also tend to act as an oxidizing agent of pollen, low soil organic content generally reflects low percentages of preserved pollen. From a number of pollen analyses conducted on soils from many different environments of deposition I now feel that as a general rule soils containing less than 1% organic matter do not generally contain sufficient fossil pollen for conducting a statistically valid analysis (Bryant 1978).

It is generally recognized by most palynologists that when fossil soil sediments fail to yield at least 1,000 fossil pollen grains per gram of dried sample, then analysis is a futile effort. Recovery and analysis of fossil pollen grains from low-yielding sediments requires the processing of large volumes of sediments (between 250-1,000 grams) and the analysis of many microscopic slides. It is not at all unusual to spend between 30-60 hours of microscopic analysis time per sample when dealing with these types of low-yielding sediments where the recovery of fossil pollen grains is less than 1,000 per gram of dried material. Based upon today's costs for processing and analysis of sediment samples for fossil pollen content, low-yielding samples would each generally cost at least ten times (or more) what other samples require. In addition, most palynology laboratories would not be willing to devote the large segments of time that would be required to properly process and analyze low-yielding sediment samples since many palynologists feel that the data derived from low-yielding samples are questionable at best.

The preliminary analysis of these three samples suggests that the environment of deposition at 41WM21 may not be conducive to fossil pollen preservation. We could have attempted additional pollen tests at 41WM21 but

in light of the soil analyses we felt that further tests would be futile.

In 1972 other fossil pollen tests at nearby sites 41WM124 (Bryant 1976) and 41WM133 (Eddy 1973) were attempted and showed that those sediments did not contain sufficient quantities of fossil pollen to warrant further study. These data now lead me to believe that fossil pollen preservation in the soils throughout this reservoir area is probably not sufficient for analytical purposes.

Although sufficient amounts of fossil pollen were not recovered from this site (41WM21), the reader can obtain a reasonably accurate description of the regional paleoenvironmental conditions for the past 30,000 years in a soon-to-be-published article by Bryant and Shafer (1978). A description of the vegetational record of central Texas during the past 16,000 years is already available (Bryant 1977) and can provide a useful overview even though it is based upon data recovered from several peat bogs in nearby Lee and Milam Counties.

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