Archaeological Investigations and Interdisciplinary Studies at the Water Canyon Paleoindian Site (LA 134764)

Report for the 2015 and 2016 Field Seasons

Robert D. Dello-Russo

with contributions by:

Patricia Dello-Russo, Linda Scott Cummings,
Vance T. Holliday, Susan Mentzer & Paul Goldberg,
Barbara Winsborough, and Chad Yost

University of New Mexico / Maxwell Museum of Anthropology
Office of Contract Archeology Report No. 185-1318

April 2021

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IN COLLABORATION WITH:

Office of Contract Archeology/University of New Mexico;
School of Anthropology and Department of Geosciences/University of Arizona; and
Energetic Materials Research and Testing Center/New Mexico Institute of Mining and Technology

APPENDICES' DATA SOURCES INCLUDE:

Beta Analytic, Inc.; NSF-Arizona AMS Laboratory and Laboratory of Archaeological Sciences;
UNM Center for Stable Isotopes; and Penn State EESL Accelerator Mass Spectrometry Laboratory

SUBMITTED TO:

New Mexico Historic Preservation Division
Department of Cultural Affairs
Santa Fe, NM

Office of Contract Archeology Report No. 185-1318
Submitted under
State of New Mexico/CPRC Archaeological Project Specific Permit No. SE-346
NMCRIS Activity No. 145965

COVER ART:

"Bison Hunters at Water Canyon, 8000 BC"

April 10, 2021

NMCRIS No.: 145965

NMCRIS INVESTIGATION ABSTRACT FORM (NIAF)

1. NMCRIS Activity No.: 145965	**2a. Lead Agency:** New Mexico Department of Cultural Affairs, Historic Preservation Division	**2b. Other Agency(ies):** New Mexico Institute of Mining and Technology	**3. Lead Agency Report No.:**

4. Title of Report:

Archaeological Investigations and Interdisciplinary Studies at the Water Canyon Paleoindian Site (LA134764) - Report for the 2015 and 2016 Field Seasons

Author(s) Robert Dello-Russo, PhD - With Contributions by Patricia Dello-Russo, Chad Yost, Barbara Winsborough, Linda Scott Cummings & R. A. Varney, Susan Mentzer & Paul Goldberg, Vance Holliday, Tim Wester and Jed Frechette

5. Type of Report

☐ Negative

☑ Positive

6. Investigation Type

☐ Research Design ☑ Archaeological Survey/Inventory ☐ Architectural Survey/Inventory ☐ Test Excavation ☒ Excavation
☐ Collections/Non-Field Study ☐ Compliance Decision Based on Previous Inventory ☐ Overview/Lit Review ☐ Monitoring
☐ Ethnographic Study ☐ Site/Property Specific Visit ☐ Historic Structures Report ☐ Other

7. Description of Undertaking (what does the project entail?):

This research (not true undertaking) consists of the final archaeological and interdisciplinary research efforts completed at the Water Canyon Paleoindian site (LA 134764) under the direction of Robert Dello-Russo as the Principal Investigator. These efforts occurred during the 2015 and 2016 field seasons, and included manual and mechanical excavations in the field, some pedestrian survey, and the recovery of a broad range of physical samples. The details of the field work and post-field studies are provided in the technical report.

[ ] Continuation

8. Dates of Investigation: from: 27-May-2015 to: 10-Oct-2016 | **9. Report Date:** March-2021

10. Performing Agency/Consultant: UNM Office of Contract Archeology and UNM Dept. of Anthroplogy (Archaeology sub-field

Principal Investigator: Robert Dello-Russo

Field Supervisor: Patrice Dello-Russo (then Walker); Christian Solfisburg, Vance Holliday

Field Personnel Names: Beth Parisi, Cyler Conrad (UNM TA), Caitlin Ainsworth (UNM TA), Andrew Richard (U of AZ TA), (others listed in report)

11. Performing Agency/Consultant Report No.: OCA Report #185-1318

12. Applicable Cultural Resource Permit No(s): NM HPD Project Specific Permit SE-346 (issued April 27, 2015)

NMCRIS No.: 145965

13. Client/Customer (project proponent): N/A

Contact:

Address: **Phone:**

14. Client/Customer Project No.: N/A

15. Land Ownership Status (must be indicated on project map): Land Owner (By Agency) New Mexico Institute of Mining & Technology (NMIMT)

	Acres Surveyed	Acres in APE
TOTALS	ca. 7	ca. 22

16. Records Search(es):

Date(s) of HPD/ARMS File Review: N/A	Name of Reviewer(s): N/A	
Date(s) of Other Agency File Review: N/A	Name of Reviewer(s): N/A	Agency: N/A

17. Survey Data:

a. Source Graphics [ ] **NAD 27** [X] **NAD 83** **Note: NAD 83 is the NMCRIS standard.**

☑ **USGS 7.5' (1:24,000) topo map** ☐ **Other topo map, Scale:**

☑ **GPS Unit Accuracy** ☑ **<1.0m** ☐ **1-10m** ☐ **10-100m** ☐ **>100m** ☑ **Aerial Photo(s)**

Other Source Graphic(s):

b. USGS 7.5' Topographic Map Name	**USGS Quad Code**
Water Canyon 1985	34107-A1-TF-024

c. County(ies): Socorro

d. Nearest City or Town: Socorro

e. Legal Description:

f. Township (N/S)	**Range (E/W)**	**Section**
3 South	2 West	3 (NE of SE and SE of NE)

Projected legal description? [ ] **Yes** [X] **No** [ ] **Unplatted**

f. Other Description (e.g. well pad footages, mile markers, plats, land grant name, etc.):

[ ] **Continuation**

18. Survey Field Methods:

Intensity: ☑ 100% coverage ☐ <100% coverage

Configuration: ☑ block survey units ☐ linear survey units (l x w):

NMCRIS No.: 145965

[ ] other survey units (specify):

Scope: [✓] non-selective (all sites/properties recorded) [ ] selective/thematic (selected sites/properties recorded)

Coverage Method: [✓] systematic pedestrian coverage

[ ] other method (describe):

Survey Interval (m): 15 **Crew Size:** varied **Fieldwork Dates:** from: to:

Survey Person Hours: **Recording Person Hours:** 0.00 **Total Hours:**

Additional Narrative:

Pedestrian surveys were conducted in Locus 1 North, Locus 2, and Locus 6

[ ] Continuation

19. Environmental Setting (NRCS soil designation; vegetative community; elevation; etc.):

The Water Canyon site is located in a juniper savannah setting at approximately 5780 ft elevation.

[ ] Continuation

20.a. Percent Ground Visibility:

45-85% visibility

b. Condition of Survey Area (grazed, bladed, undistributed, etc.):

heavily grazed; no explosive testing in or in near vicinity of site

[ ] Continuation

21. CULTURAL RESOURCE FINDINGS [X] **Yes, see next report section** [ ] **No, discuss why:**

[ ] Continuation

22. Attachments (check all appropriate boxes):

[x] USGS 7.5 Topographic Map with sites, isolates, and survey area clearly drawn (required)

[X] Copy of NMCRIS Map Check (required / N/A)

[ ] LA Site Forms - new sites (with sketch map & topographic map) if applicable

[ ] LA Site Forms (update) - previously recorded & un-relocated sites (first 2 pages minimum)

[ ] Historic Cultural Property Inventory Forms, if applicable

[ ] List and Description of Isolates, if applicable

[ ] List and Description of Collections, if applicable

23. Other Attachments:

[ ] Photographs and Log **[ ] Other Attachments (Describe):**

NMCRIS No.: 145965

24. I certify the information provided above is correct and accurate and meets all applicable agency standards.

Principal Investigator/Qualified Supervisor: **Printed Name:** Robert Dello-Russo

Signature: **Date:** June 15, 2020 **Title:** Principal Investigator / Director OCA

25. Reviewing Agency	**26. SHPO**
Reviewer's Name/Date:	**Reviewer's Name/Date:**
Accepted [ ] **Rejected [ ]**	**HPD Log #:**
	Date sent to ARMS:

CULTURAL RESOURCE FINDINGS

[fill in appropriate section(s)]

SURVEY RESULTS: SEE Technical Report for details.

Archaeological Sites discovered and registered: 0
Archaeological Sites discovered and NOT registered: 0
Previously recorded archaeological sites revisited (site update form required): 0
Previously recorded archaeological sites not relocated (site update form required): 0
TOTAL ARCHAEOLOGICAL SITES (visited & recorded): 0
Total isolates recorded: 0
HCPI properties discovered and registered: 0
HCPI properties discovered and NOT registered: 0
Previously recorded HCPI properties revisited: 0
Previously recorded HCPI properties not relocated: 0
TOTAL HCPI PROPERTIES (visited & recorded, including acequias): 0

☑ **Non-selective isolate recording?**

MANAGEMENT SUMMARY: SEE Technical report for details.

[ ] Continuation

IF REPORT IS NEGATIVE, YOU ARE DONE AT THIS POINT.

SURVEY LA/HCPI NUMBER LOG

Sites/Properties Discovered:

LA/HCPI No. **Field/Agency No.** **Eligible? (Y, Criterion "d")**

NMCRIS No.: 145965

Previously recorded revisited sites/HCPI properties:

LA/HCPI No. **Field/Agency No.** **Eligible? (Y, Criterion "d")**

MONITORING LA NUMBER LOG (site form required)

Sites Discovered (site form required):

LA No. **Field/Agency No.**

Previously recorded sites (site update form required):

LA No. **Field/Agency No.**

Areas outside known nearby site boundaries monitored? **[ ] Yes** **[ ] No, Explain why:**

TESTING & EXCAVATION LA NUMBER LOG (site form required)

Tested LA number(s)

Excavated LA number(s) LA 134764

ABSTRACT

This report describes the final archaeological and interdisciplinary research efforts completed at the Water Canyon Paleoindian site (LA 134764) under the direction of Dr. Robert Dello-Russo as the Principal Investigator. These efforts occurred during the 2015 and 2016 field seasons, and included manual and mechanical excavations in the field and the recovery of a broad range of physical samples. The report discusses these and provides the results of some analytical studies (such as the development of an age-depth model using both previously and newly acquired radiocarbon dates). The results of laboratory-based analyses are also discussed in the body of the report; the detailed analytical reports by individual specialists are provided in the report appendices. These analyses included a phytolith study (Appendix C), a diatom study (Appendix D), a ground stone residue analysis (Appendix E), and a soil micromorphological study (Appendix F). Additional appendices include the Field Sample Log (Appendix A) for all work done during the 2015 and 2016 seasons, locations and descriptions for all mechanical sediment cores (Appendix B), and reports from radiocarbon dating laboratories for all chronometric samples submitted after the 2015–2016 seasons (Appendix G). Appendix H comprises a listing of all publications (peer reviewed and otherwise), presentations, papers, and posters that derived from work at the Water Canyon Paleoindian site.

Further, within the report, there is a summary of recently acquired chronometric dates for the site and a summary of temporally diagnostic projectile points. The report closes with a brief discussion of potential future directions for research at the site, conclusions, and a references section.

Finally, as summarized in Holliday et al. (2019:23):

> The Water Canyon site is notable in the Southwest for its multiple Paleoindian occupations in an intact, stratified context (the only such documented Paleoindian site in New Mexico west of the Pecos River), its multiple *Bison* sp. bone beds, and its extensive paleo-wetland with abundant paleoclimatic and paleoenvironmental proxy data. The Water Canyon site is also unusual in being one of the few Paleoindian sites preserved in an alluvial fan. The site formed at the mouths of several swales cut into the distal toe of the old bajada flanking the Magdalena Mountains and emptying into the Water Canyon drainage. Archaeological materials are found at the surface on older, stable coalesced fan surfaces and on stable surfaces formed on Late Pleistocene sediments inset against those older fan surfaces. Buried, in situ cultural deposits are found in a paludal deposit that formed in the fans of intermittent drainages…identified as No Name Arroyo and Big Wash.

Holliday et al. (2019:26) also note that

> [t]he Water Canyon [site]…contains three late Paleoindian occupation features in ancient paludal deposits on and beneath coarser, higher energy deposits more typical of an alluvial fan. The oldest, well-dated occupation zone, at ~9240 ^{14}C yr BP (~10,390 cal yr BP), is a bed of *Bison* sp. bones on the margin of the ancient wetland, interpreted as an open-air processing station. A nearby *Bison* sp. bone bed, farther out in the paleo-wetland and downslope from the processing station, and a probable kill site with an in situ Eden projectile point, currently dates to ~8955 ^{14}C yr BP (~10,070 cal yr), but it may be older. It may be functionally related to the older processing area. The youngest, well-dated occupation level, at ~8321 ^{14}C yr BP (~9365 cal yr BP), is also along the margins of the paleo-wetland and may also contain processed *Bison* sp. bone and a hearth. Both Clovis and Folsom artifacts have been found on the surface of the site, and remnants of both Clovis- and Folsom-aged paludal strata are preserved in the site but may be of limited extent. Nevertheless, the data show that the palustrine en-

vironment that interrupted fan construction attracted ancient foragers since at least ~11,000 ^{14}C yr BP (late Clovis time) through the early Holocene."

The entirety of research efforts at Water Canyon, from 2000 to 2020, has revealed a complex Paleoindian site in a complex geological setting. Much work remains to be done at this site and future researchers will confront interesting archaeological, paleo-ecological, and geomorphological challenges as they endeavor to unravel the remaining mysteries that assuredly await them.

ACKNOWLEDGMENTS

Research endeavors at the Water Canyon site during 2015 and 2016, and during the ensuing analytical phase from 2016 until 2020, have been generously underwritten with financial and/or in-kind donations, by the following institutions, organizations, and individuals:

- Office of Contract Archeology (OCA) and the OCA Archaeological Research Fund, University of New Mexico
- Argonaut Archaeological Research Fund (under the direction of Vance T. Holliday), University of Arizona
- School of Anthropology & Department of Geosciences, University of Arizona
- Energetic Materials Research and Testing Center, New Mexico Institute of Mining & Technology
- Recent Water Canyon Research Donors (2015–2020): Roland and Martha Mace, Art and Susan Hurley; Dennis Zeunert, Mike Abernathy and Carolyn Galceran, Laurence and Sherye Boylan, Dr. Sally Davis and Dr. Richard Kozoll, John R. Guth, Marilyn Guida, Maryann and Allen Sanborn, Lois Lockwood, George and Carol Price, Gary Grief and Dorothy Wells, Gerald McElvy, and William Doleman

Report editing and proofreading were generously undertaken by Patrice Dello-Russo and InDesign formatting and layout were expertly completed by Lynne Arany. The original oil painting *Bison Hunters at Water Canyon, 8000 BC,* used as cover art for this report, was created by Patrice Dello-Russo and beautifully represents how the site may have looked in prehistory. Jed Frechette, of the Lidar Guys, and Tim Wester, of A Line of Flight Video, graciously donated their time, effort, and unique data sets to the Water Canyon project, for which I am extremely grateful

The tremendous research results that have emerged thus far from the Water Canyon Paleoindian site are the product of the collaborative efforts of the many highly skilled and talented professionals who dedicated themselves to this project, both in this and prior seasons. Their names and affiliations may be found throughout the body of this report. It has been my distinct and humble pleasure and honor to have worked with all of them over the years.

— Robert Dello-Russo

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ONE

Introduction

Paleoindian archaeological research in North America has been significantly influenced by work in the greater Southwest and neighboring areas. Well-known sites in the Southwest include the Folsom site, the Blackwater Draw site (Figgins 1927; Meltzer 2006; Hester 1972; Howard 1933, 1935), the Lubbock Lake site (Johnson 1987), Bonfire Shelter (Kilby et al. 2020), the Murray Springs site (Haynes and Huckell 2007), Stewart's Cattle Guard site (Jodry 1999) and, more recently, El Fin del Mundo (Sanchez et al. 2014) (Fig. 1.1). Yet, examples of in situ Paleoindian occupations in well-stratified contexts are still quite rare. As a result, the chronologies for artifacts and occupations and the nature of subsistence activities must often be inferred from neighboring regions, usually the Great Plains to the east. In addition, complementary terminal Pleistocene and early Holocene paleoenvironmental data from continuous stratigraphic records are also rare across the Southwest.

> Preserved in the complex cut-and-fill stratigraphy of an alluvial fan, the Water Canyon site represents one of the most notable and rare Paleoindian sites in the American Southwest west of the Pecos River for having an in situ, stratified multi-component Paleoindian record. Paleoindian cultures currently represented at the site include Clovis, Folsom, Cody-Eden, probable Allen-Frederick, and an unnamed Late Paleoindian. In addition, the preservation at the site of an extensive buried wetland deposit provides a robust proxy archive for the reconstruction of the paleoenvironment over the terminal Pleistocene-to-early-Holocene transition (~13,100–~8300 cal yr BP). Archaeological remains within this deposit currently include, at a minimum, two Cody-Eden *Bison* sp. bone-beds—one the remnants of a kill with an associated in situ Eden point and the second an open-air processing locale—and an Allen-Frederick era *Bison* sp. bone bed (processing area) with associated flaked and ground stone artifacts and an ephemeral hearth. Future research avenues include excavation of the latest Pleistocene to earliest Holocene sediments in Locus 1; clarification of the bone bed palimpsest in Locus 1 North; accurate determination of age for the Eden bone bed in Locus 5; and determination of the nature and extent of the possible Clovis processing area and Folsom locality in Locus 6 (Dello-Russo and Holliday 2019:1).

Within this context, the Water Canyon site in west-central New Mexico (Dello-Russo et al. 2010) represents a rare research laboratory. The site has yielded evidence for multiple Paleoindian activity areas spanning the period from ~13,000 to ~8300 calendar years before present (cal yrs BP). Archaeological bone, stone artifacts, plant remains, paleo-wetland sediments, and other classes of paleoenvironmental proxy data—such as pollen, phytoliths, diatoms, stable carbon isotopes and land snails—have been recovered from stratified, dateable deposits (Fig. 1.2).

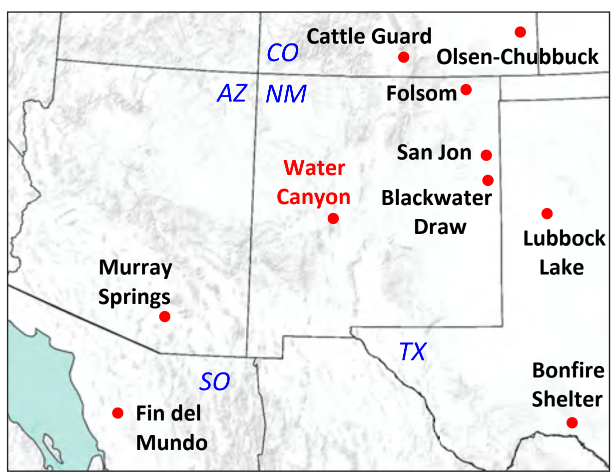


Figure 1.1. Water Canyon site in regional context of Paleoindian sites.

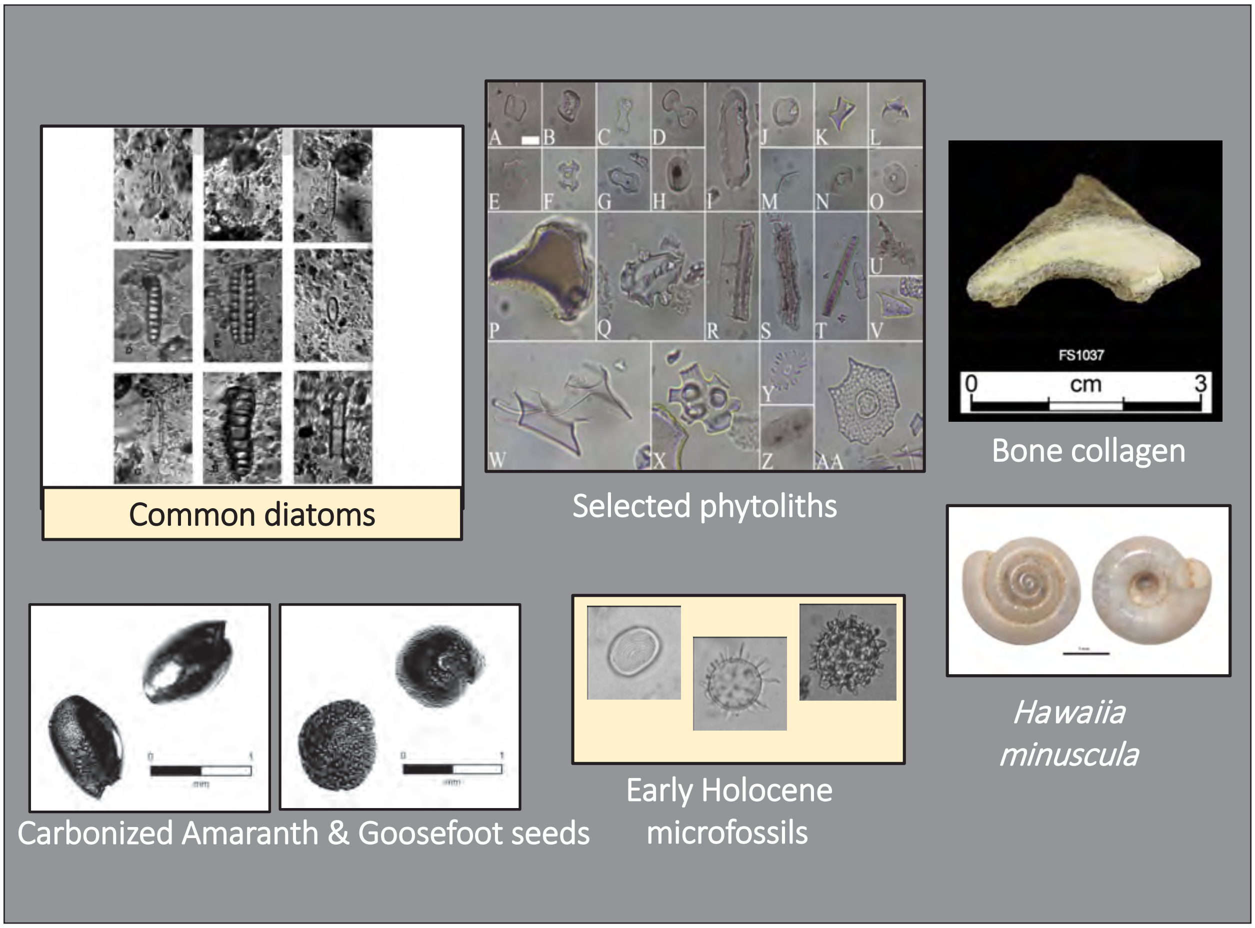


Figure 1.2. Sources of paleo-environmental proxy data from the Water Canyon site.

The site currently encompasses five different surface loci and at least two subsurface loci (Figs. 1.3, 1.4, 1.5). The subsurface cultural deposits consist of intact, buried Paleoindian materials in a stratified context, including a bed of poorly preserved Bison sp. bone (Locus 5), and, in Locus 1 North, a palimpsest of three additional—but very well-preserved—Bison sp. bone deposits consisting of butchered bones, flaked and ground stone artifacts, and the remains of an ephemeral hearth. A subsurface temporally diagnostic artifact is represented by a resharpened Eden point associated with the bone bed in Locus 5. Surface diagnostics included two conjoining fragments of a possible point or hafted knife with parallel, diagonal flake scars in Locus 1, and two probable late Paleoindian parallel-sided, shallow-concave base points recovered in Locus 3. An additional base of an Eden point was recovered on the surface in Locus 4, and Clovis and Folsom occupations at the site are evidenced by diagnostic projectile point fragments documented on the surface in Loci 3 and 6. Subsurface cultural deposits associated with the Folsom and Clovis age components have not yet been identified at the site, although sediments dated to these respective time periods have been identified along arroyo profiles in Locus 1 North.

Curation of Collections and Records

The research field seasons at the Water Canyon site (LA 134764)—which began in 2000 and then spanned the years from 2008 through 2016—together with the related analyses during that same span and also extending well into the year 2020, have generated

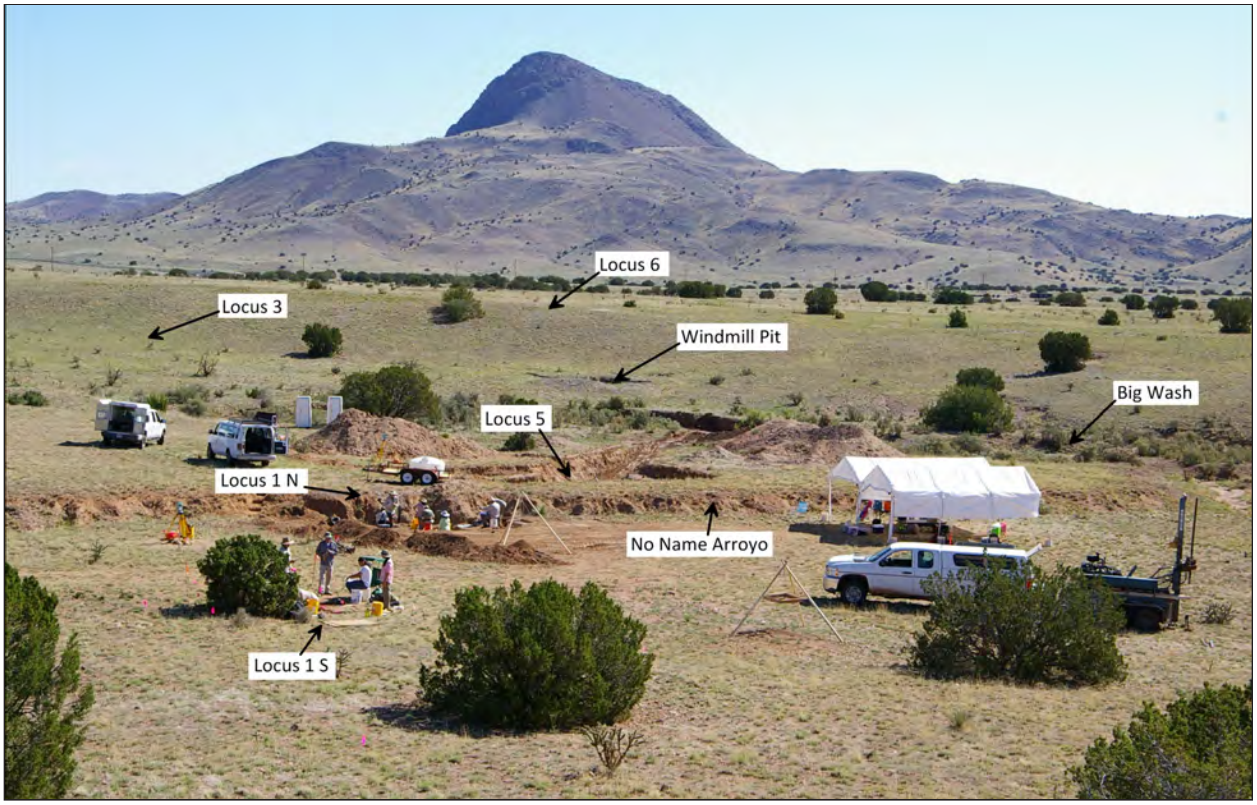


Figure 1.3. Water Canyon site, overview to north, Strawberry Peak in background (2015).

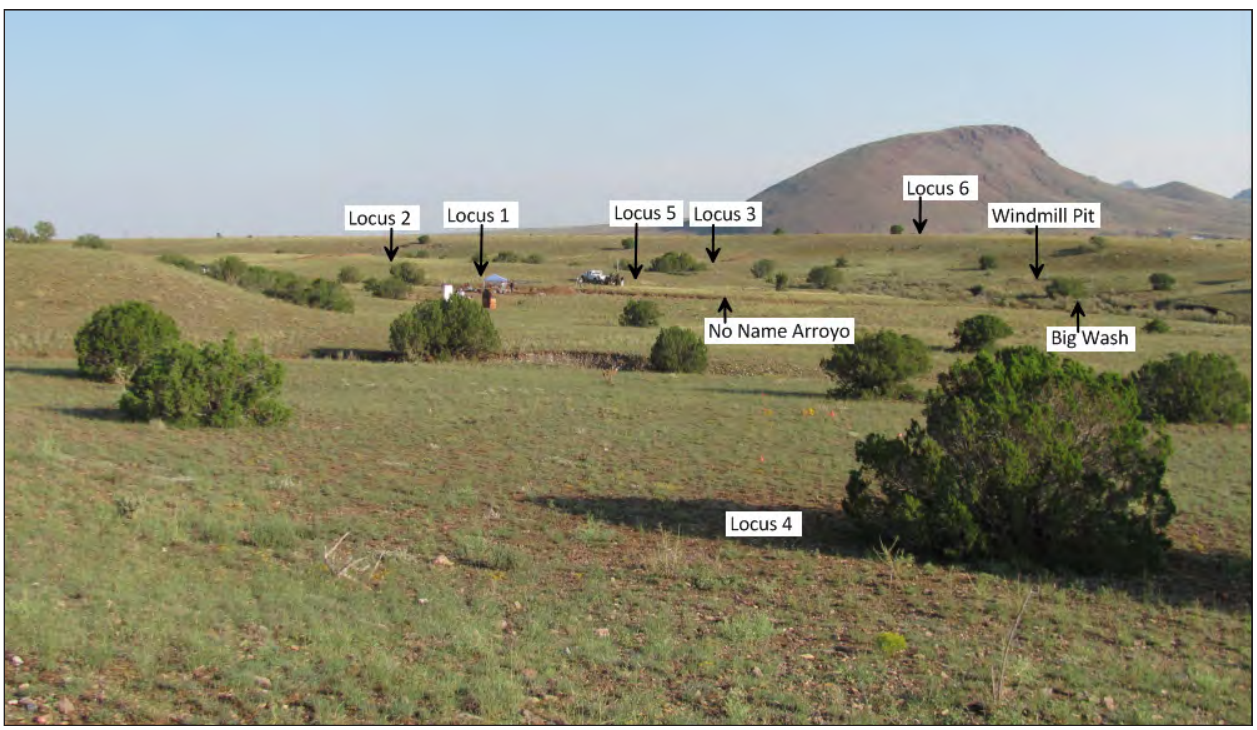


Figure 1.4. Water Canyon site, overview to northwest (2012).

collections of artifacts and samples from the archaeological surveys and excavations, and from the associated interdisciplinary studies, and have also produced concomitant field records, notes, photographs, and logs. Those samples that still remain in existence (that is, were not destroyed by processing for analysis—such as the flotation processing of sediment samples for macrobotanical analysis), together with the entire archive of paper and digital records, have been accessioned at the Museum of Indian Arts and Culture (MIAC) in Santa Fe, NM, for study by future researchers.

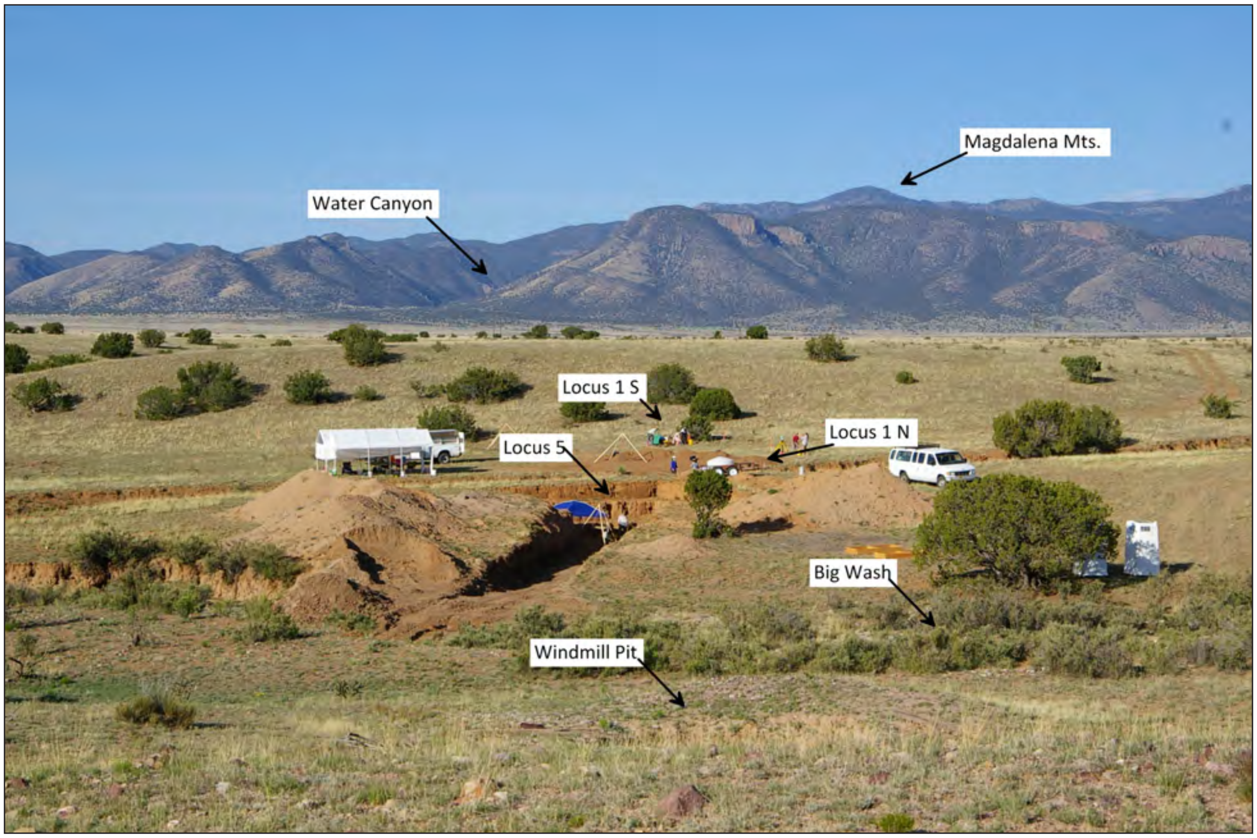


Figure 1.5. Water Canyon site, overview to south, Magdalena Mts. in background (2015).

TWO

Research Background

The efforts undertaken during the 2012 and 2013 field seasons are described in detail in *Archaeological Excavations at the Water Canyon Paleoindian Site (LA 134764), Socorro County, New Mexico—Interim Report for the 2012 and 2013 Field Seasons* (Dello-Russo 2015a). The following sections provide brief summaries of that work as a background to the work completed in 2015 and 2016.

Brief Summary of the 2012 Fieldwork

During the 2012 field effort (9/5 to 9/16/12) directed by Principal Investigator Dr. Robert Dello-Russo, work was conducted in Locus 1 North, in BHT-4, BHT-5, and BHT-6, in various mechanical cores, and in a few sampling locations in the Big Wash. A total of 242 new field samples were collected; these included: 42 flaked stone artifacts (lithics; none diagnostic); 56 bison bone elements, fragments, or tooth enamel; nine "ochre" samples; 54 bulk sediment flotation samples; 11 pollen samples; 14 bulk sediment ^{14}C samples; 39 charcoal ^{14}C samples; 10 optically stimulated luminescence (OSL) samples; and seven possible fire-cracked rock (FCR) elements. These samples were recovered from five hand-excavated units in Locus 1, including Study Units 1-6, 1-10, 1-14, 1-15, and 1-17. Pollen and ^{14}C samples were collected from the north wall of Study Unit 1-9 (coincides with the south wall of Study Unit 1-6). Previously excavated backhoe trenches BHT-4, BHT-5, and BHT-6 were re-opened for the collection of the OSL samples, and an additional eight mechanical sediment cores (12-1 through 12-8) were completed, sampled, and described.

During the late afternoon of 9/10/2012, three pollen samples and three companion ^{14}C bulk sediment samples (FS 1278, FS 1279, and FS 1280) were recovered from a freshly exposed section (Section 12-9) along the south wall of the Big Wash. The elevations of the FS 1278 and FS 1279—at 44.994 m and 45.197 m respectively—coincided with the elevations of the bones recovered in the Locus 5 soil cores. The bulk sediment samples were submitted to the NSF-Arizona AMS laboratory at the University of Arizona (U of A) for dating.

All hand-excavated study units in Locus 1 along with three previously excavated backhoe trenches (BHTs 4, 5, and 6) were backfilled on the final day of fieldwork (09/16/12). At the completion of the study unit excavations, all of the units were lined with black plastic and backfilled by hand. Once the five study units were backfilled, the entire excavation grid block was covered with a large sheet of black plastic and mechanically buried to the level of the adjacent ground surface. The three backhoe trenches were mechanically re-buried without black plastic linings. A "sea wall" was bermed along the northern edge of the excavation grid block along the southern edge of No Name Arroyo, to help direct sheetwash and arroyo flow away from the excavation area.

Brief Summary of the 2013 Fieldwork

In 2013 (4/29 to 5/13/2013), again under the direction of Principal Investigator Dr. Robert Dello-Russo, efforts were focused in Locus 5, primarily to expose the deeply buried bison bone bed discovered by mechanical coring in previous field seasons. A stepped excavation area measuring 12 by 12 m and an access "driveway" in the northeast corner of the excavation were laid out with a total station and were largely completed with a mechanical trackhoe and backhoe. Additional refinement and clean-up were completed with the mechanical backhoe and hand excavations. The stepped configuration followed OSHA guidelines, stopped at about 3.7 m below the surface when "black mat" sediments (remnant fossil wetland; *see* Dello-Russo et al. 2016) were encountered, and resulted—at the base of the mechanical excavation—in a surface where a 6 by 6 m hand-excavation grid could be established (although the actual surface measured closer to 7 by 7 m). *Bison* sp.[1] bones were immediately encountered in the southwest corner of the grid. Within the grid, six study units (Study Units 5-1 through 5-6) were excavated.

Hand excavations in Locus 5 recovered a suite of 10 dateable charcoal samples, six of which came from Study Unit 5-5 in an area approximately 5 cm deep (FS 5112–5117). Additional charcoal samples came from different levels in Study Unit 5-3 (FS 5007, 5071, 5088) and adjacent to bone in Study Unit 5-1 (FS 5035). Sixteen bulk sediment samples were recovered from the Locus 5 hand excavations for AMS radiocarbon dating, including samples from Study Unit 5-1 (FS 5030, 5035), Study Unit 5-2 (FS 5031), Study Unit 5-3 (FS 5007, 5059, 5060, 5076, 5077, 5096, 5105, 5124), Study Unit 5-4 (FS 5039, 5045, 5054, 5075), and Study Unit 5-5 (FS 5086, 5093, 5101, 5108, 5110).

In all, 23 bulk sediment flotation samples were recovered from the Locus 5 excavations. These included a combined sediment sample, for both flotation and ^{14}C analyses, that was collected from the upper south wall tier of the excavation pit, in the southwest corner at a grid elevation of 49.582 m (FS 5025), along with samples collected from the five individual study units in Locus 5, including Study Unit 5-1 (FS 5010, 5021, 5028), Study Unit 5-2 (FS 5006, 5016, 5020, 5032), Study Unit 5-3 (FS 5005, 5059, 5076, 5095, 5104, 5123), Study Unit 5-4 (FS 5038, 5044, 5053, 5074), and Study Unit 5-5 (FS 5085, 5092, 5100, 5107, 5109). Sub-samples—to serve as samples for phytolith analysis by Chad Yost—were split off from each of the samples listed above. Portions of bulk sediment samples FS 5005, 5059, 5076, 5095, 5104, and 5123 (from Study Unit 5-3) were split off and delivered to Susie Smith for pollen analysis and to Barbara Winsborough for diatom analysis (FS 5005, 5059, 5095, and 5123). Winsborough also analyzed samples from Locus 1 that had been collected in previous field seasons (FS 1195, 1197, 1202, 1203, 1211, 1217, 1219, 1229, 1249, 1632, 1633, and 1634).

An OSL sample (FS 5027) was collected by Robert Dello-Russo and Vance T. Holliday on 5/6/2013 from the southwest corner of the excavation pit, in the south wall profile on the top stepped tier at 48.675 m grid elevation. An additional four OSL samples (FS 5136–5139) were collected by Robert Dello-Russo and Stephen A. Hall on 7/12/2013. These were also recovered in the southwest corner of the excavation pit, at 48.802, 47.932, 46.761, and 46.116 m grid elevation, respectively.

These five OSL samples, together with an additional six collected in 2012 from BHT-5, were sent to Ron Goble at the University of Nebraska for dating. The six OSL date samples collected in 2012 were: FS 1285 (from BHT-5), 1286 (BHT-5), 1288 (BHT-6), 1289 (BHT-4), 1290 (BHT-4), and 1291 (BHT-4).

Abundant bones, bone fragments, teeth, and pieces of tooth enamel were recovered during the 2013 excavations in Locus 5. All of the excavated study units (Study Units 5-1 through 5-6) yielded bone fragments in the dry screen recovery. Most of the identifiable and intact bone was recovered from Study Units 5-1 and 5-6 in the southwest corner of the excavation block. Study Units 5-2 and 5-4 also yielded intact bone, and a single molar was recovered from Study Unit 5-3. No portions of the intact bone bed were encountered in Study Unit 5-5 (located in the northeast corner of the excavation block), and it is likely that excavations needed to continue for at least another 20 cm depth to do so. Based on excavations from several of the units, the bone bed appeared to slope downward from the southwest to the northeast. In addition to the bison faunal remains found in Locus 5 and noted above, small land snails and land snail eggs were recovered from Locus 1 and from Locus 3 (recovered in 2010) and from Locus 5 (recovered in 2013). These were sent to Dr. Stephen A. Hall at Red Rock Geological Enterprises in Santa Fe, NM, for analysis and interpretation (Hall 2015).

Finally, 15 flaked stone artifacts and one possibly modified cobble were recovered from the hand excavations in Locus 5 during the spring 2013 field season. The majority of the flaked stone artifacts were pieces of debitage, but also included a single diagnostic pro-

[1] The individuals represented in the Locus 1 North faunal assemblage tend to fall somewhere between *B. antiquus* and *B. bison* in size and, as such, they could represent smaller individuals of a southern clade, or a mountain-foothill population, of *B. antiquus;* or, due to their early Holocene age, they could represent some of the first *B. bison* in the region. Given these issues, we have chosen to refer to these animals as *Bison* sp. Further discussion of this issue is provided in Chapter 6 (*see* "Bison Analysis" section).

jectile point. Ten of these lithic artifacts were found during 1/8-inch dry screen recovery, including lithics from Study Unit 5-1 (FS 5068), Study Unit 5-2 (FS 5012), Study Unit 5-3 (FS 5066, 5078, 5106), Study Unit 5-4 (FS 5036), and Study Unit 5-6 (FS 5099). Five of the lithics artifacts were found in situ, including a Late Paleoindian Eden point of dark gray, fossiliferous chert from Study Unit 5-1 (FS 5081) and a potentially modified cobble (FS 5065), a rhyolite flake from Study Unit 5-3 (FS 5009), and both a rhyolite flake and a McDaniel Tank obsidian pressure flake from Study Unit 5-5 (FS 5072 and 5111, respectively). The discovery of the Eden point (by George Crawford) in association with the *Bison* sp. bone bed was significant.

All hand-excavated study units in Locus 5 were backfilled on the final day of fieldwork (05/13/13) by R. Dello-Russo, J. Dello-Russo, B. Parisi, and P. Walker. At the completion of the study unit excavations, all exposed bones left in situ were carefully covered with screened, overburden brown sands, for protection and to reduce the chance of moisture buildup, and then covered with small squares of black plastic. Each of the hand-excavated units was then lined with black plastic sheets and hand-filled with screened sediment. Once the six study units were backfilled, the entire excavation grid block was covered with a large sheet of black plastic, and mechanically buried with roughly 0.6 m (2 ft) of overburden and or screened sediment. The fill was gently contoured and sloped by hand from south to north, to allow for drainage out of the excavation pit and into the trenched driveway to the northeast. In addition, the corners of the two-level tiers, or stepped benches, of the pit were bermed with sediment to trap and/or slow water that might enter the excavation block along the sides of the pit.

As noted previously, all archaeological efforts completed in 2012 and 2013 were fully reported in the Interim Report for the 2012 and 2013 field seasons, *Archaeological Excavations at the Water Canyon Paleoindian Site (LA 134764), Socorro County, New Mexico* (Dello-Russo 2015a).

THREE

Data Recovery Efforts and Results for the 2015 and 2016 Seasons

2015 Spring Field Season and the University of New Mexico Field School

The 2015 field season ran from May 27 through June 21 of that year. In accordance with the project's revised research design (Dello-Russo 2015b), several research goals guided the 2015 investigations. The data recovery plan (with some modifications) was presented to, and approved by, the New Mexico Historic Preservation Division (NMHPD) and the Cultural Properties Review Committee (CPRC) in March 2015. Research objectives included: 1) additional hand excavations in Locus 1; 2) additional hand and mechanical excavations in Locus 5; 3) additional mechanical soil coring between Locus 1 and Locus 4; 4) continued recovery and dating of OSL samples; 5) continued recovery and analysis of paleoenvironmental proxy samples; and 6) a contingency plan to deal with discovery situations. Soil micromorphology samples (FS 1557–1560) were to be recovered from Study Unit 1-6 in Locus 1 North for analysis by Susan Mentzer at the Institute for Archaeological Sciences in Tübingen, Germany.

Introduction, Crew Roster, and Site Visitors

For 2015, our efforts focused in both Locus 1 and Locus 5, to further examine the potential for buried cultural, chronometric, and paleoenvironmental data in direct association with the *Bison sp.* bone beds and potential activity areas. Adult and juvenile *Bison* sp. bones had been discovered in the bison bone bed in Locus 5 during the 2013 field session and adult (and possibly juvenile) *Bison* sp. bones had been excavated in the Locus 1 bone bed during the 2010 and 2012 field sessions. In 2015, bones were encountered in both loci in various states of preservation and required different approaches for removal. Many of the bones in Locus 1 were removed intact but the most fragile bones (primarily in Locus 5) were treated with Elmer's wood glue and/or Elmer's Glue-All and then plaster jacketed, while others (primarily in Locus 1) were plaster jacketed without prior treatment. Overall, bone preservation was far better within Locus 1 than within Locus 5.

Dr. Robert Dello-Russo continued in his role as the Principal Investigator for the Water Canyon Research Project for the 2015 field season, which included a University of New Mexico (UNM) archaeological field school (Fig. 3.1a), and for the short 2016 session (discussed later in this chapter). He was assisted in the field by colleagues, Office of Contract Archeology (OCA) staff, and volunteers. Field assistants included: Dr. Vance T. Holliday and Andy Richard (both of U of A) conducting mechanical and hand soil coring; Susie Smith (independent consulting palynologist) recovering pollen samples; Patrice Walker (Escondida Research Group) serving as Field Director; Art Hurley (volunteer excavator); Alice Lesbats (volunteer excavator); Beth Parisi (volunteer

Figure 3.1a. 2015 field school crew at Water Canyon. Front row (left to right): Patrice Walker Dello-Russo, Caitlin Holland, Amber Greak, Beth Parisi, Karina Rogers, Caitlin Ainsworth; middle row: Jeff Thomas, Cyler Conrad, Alice Lesbats; back row: Dr. Robert Dello-Russo, Jason Liddell, Christian Solfisburg, Christopher Griffin, Art Hurley.

Field Sample Log assistant); and Christian Solfisburg (OCA, as Locus 5 supervisor). The 2015 UNM archaeological field school (a collaborative effort between the UNM Office of Contract Archeology and the UNM Department of Anthropology) was directed by Dr. Dello-Russo and included UNM students Christopher Griffin, Amber Greak, Caitlyn Holland, Jason Liddell, Karina Rogers, and Jeff Thomas. Two UNM anthropology graduate students, Caitlin Ainsworth and Cyler Conrad, served as teaching assistants and excavators. Several workshops were conducted during the course of the field school: faunal analysis and mock excavation, directed by Robin Cordero (OCA); lithic analysis, by Banks Leonard (OCA); field presentations on geomorphology and soils analysis, by Dr. Les McFadden (UNM); and the contexts of Paleoindian sites, by Dr.

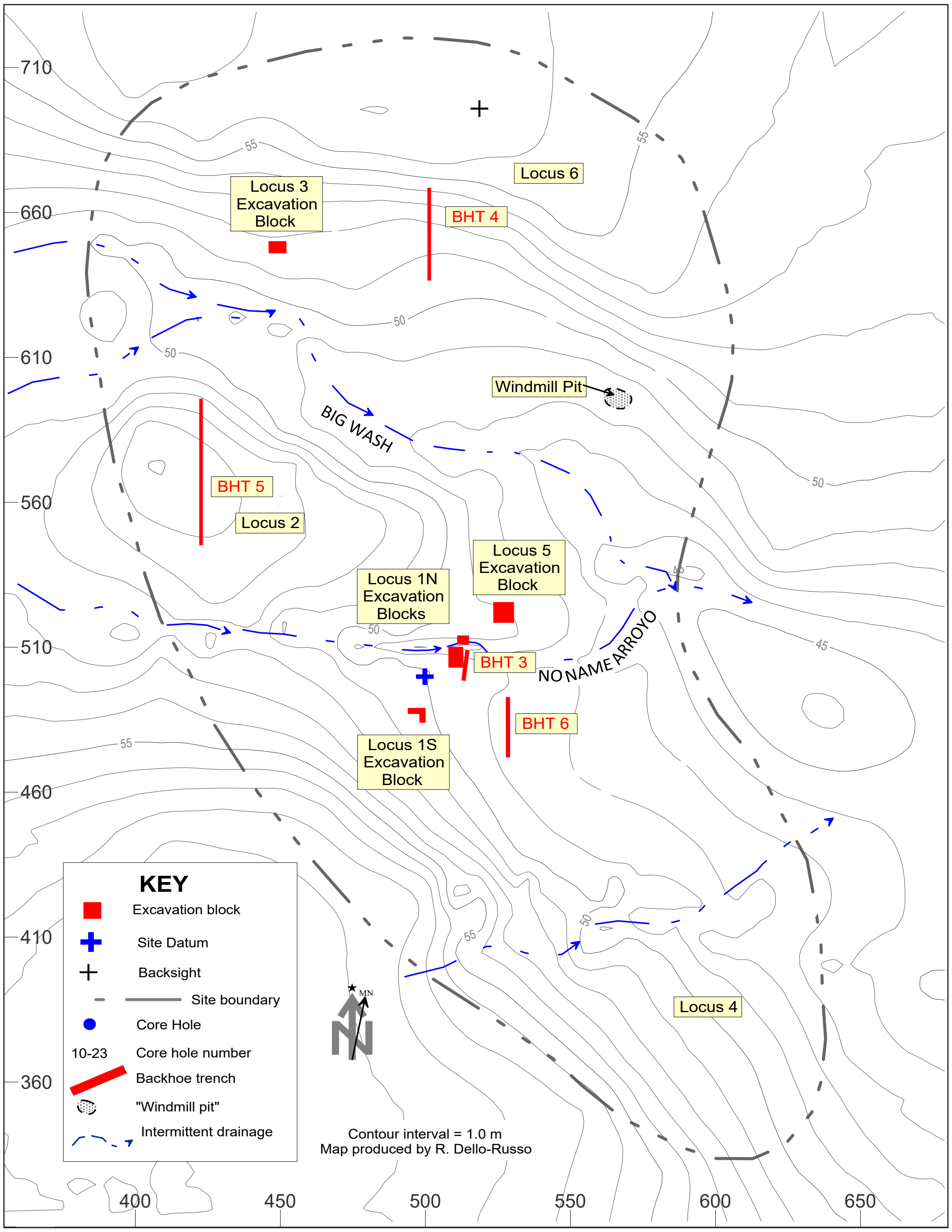


Figure 3.1b. Plan map of Water Canyon site with excavation loci.

Michael Collins of Texas State University (TXST). Excavations were undertaken in Locus 1 North, in Locus 1 South, and in Locus 5 (Fig. 3.1b).

An evening lecture series was also part of the 2015 season's field school, with guest speakers presenting on a variety of topics related to the overall research efforts. Lecturers included: Dr. Michael Collins (TXST), Cyler Conrad (anthropology graduate teaching assistant, UNM), Dr. Patricia Crawford (Harvard University, retired), Dr. Stephen A. Hall (independent geomorphologist, Red Rock Geological Enterprises), Dr. John Shea (Stony Brook University), and Susie Smith (independent consulting palynologist).

Logistical efforts were undertaken by numerous individuals and entities. OCA staff assisted with pre-field equipment organization and administration efforts, including, in particular, Donna Lasusky, Caitlin Holland, and Danielle Schneider. The in-field mock excavation units were constructed and filled by Caitlyn Holland and Danielle Schneider. Post-fieldwork efforts at the OCA laboratory were assisted by Evan Kay (OCA lab coordinator), Caitlyn Holland, Danielle Schneider, and several UNM students, including Jeff Thomas, Jason Liddell, and Christopher Griffith. The UNM Environmental Archaeology Laboratory, directed by Dr. Keith Prufer and assisted by Clayton Meredith, processed bone and tooth collagen for numerous radiocarbon dates. Field support was provided by EMRTC and included an on-site water truck, portable toilets, an on-site equipment storage container, and mechanical excavation equipment (backhoe and trackhoe). Our EMRTC liaison was Robert Vega (assistant operations director); the EMRTC backhoe/trackhoe operator was George Cline.

Two separate tours of the site were conducted and each included numerous visitors. The first was a UNM Maxwell Museum of Anthropology–sponsored tour led by its then-director, Dr. James Dixon. An OCA-led tour followed, and included Dr. Jan Biella (NM State Archaeologist), Dave Brewer (Archaeological Society of NM), Dr. Richard Chapman (OCA Director Emeritus, retired), Robin Cordero, Alex Kurota, Donna Lasusky, Banks Leonard, and Danielle Schneider (all of OCA), and Dr. Ariane Pinson (US Army Corps of Engineers). Subsequent visitors included Larry and Sheri Boylan, Robert Vega, Dr. Michael Collins (TXST), and Dr. Les McFadden (UNM), with his soils class.

Hand Excavations, 2015

Patrice Dello-Russo

Excavations were conducted during the 2015 field season in Locus 1 and Locus 5, with hand excavations at two separate locations within Locus 1 (Locus 1 North and Locus 1 South) and within the "big pit" at Locus 5. A total of 32 study units were excavated. Excavations were mostly 1 by 1 m square study units, with several 1 by 0.50 m units in Locus 5 and one partial 0.20 by 0.50 m study unit in Locus 1, the latter of which was excavated for the purpose of removing a bone that spanned two study units. Descriptive results of the Locus 1 and Locus 5 excavations are detailed below. In addition to artifacts collected from subsurface contexts, surface artifact collections were completed in Locus 1, Locus 3, and Locus 6. All collected samples were provided with Field Sample (FS) numbers and these FS numbers were catalogued in an FS Log. This log is provided in Appendix A.

Locus 1 Methodology

Within Locus 1, 27 study units were opened for excavation during the 2015 field school. Ten of these were focused in the area of the known and previously excavated bone bed adjacent to No Name Arroyo. This area was designated as the Locus 1 Bone Bed, or Locus 1 North (*see* Fig. 3.1b). The remaining 17 study units were positioned over an artifact concentration on a remnant Pleistocene terrace (Paleo-Stratum 4 terrace) southwest of the bone bed, and designated as Locus 1 South (*see* Fig. 3.1b).

As described in the revised research design (Dello-Russo 2015b), the 2015 field session activities within Locus 1 focused on these two separate areas due to: 1) the high likelihood for additional *Bison* sp. remains in Locus 1 North, particularly in the area east of the previously excavated units, and 2) the likelihood that the artifact scatter located uphill and south of the bone bed (Locus 1 South) represented the remains of a late Paleoindian camp or processing area associated with the bone bed. This belief was based, in part, on the morphology of a late Paleoindian diagnostic artifact that was discovered just to the southwest of Locus 1 South (with parallel diagonal flaking pattern) and the concordance between the cross-dates for this type of artifact (similar to Allen-Frederick types) and the radiocarbon dates previously obtained from the bison bone bed.

All study units in Locus 1 were hand excavated and documented in 10 cm levels, separated into two arbitrary 5 cm vertical sub-levels designated A and B, and systematically tied to the main site datum. Point-located field samples were mapped with a Nikon total station and artifacts measuring 2 cm or larger in maximum dimension had two provenience points, or "pro-points," taken with the total station, in order to map artifacts and faunal materials in three-dimensional space (McPherron 2005) and to continue our appraisal of site formation processes. All hand-excavated sediments were dry screened with 1/8-inch hardware cloth. Collected samples included artifacts and bone, along with chronometric, micro-biological, and sediment samples (pollen, phytolith, diatom, ^{14}C, and OSL). Collections and documentation followed procedures previously utilized at the site (4.10.16.12 NMAC).

Description of Hand Excavations in Locus 1 North—Bone Bed(s)

This area of the site has been the focus of previous testing or data recovery efforts during five separate field sessions beginning in 2008 and continuing through 2012. In 2010, a grid block of 35 study units was laid out on the south side of No Name Arroyo and, within that block, 10 study units were initially excavated (Study Units 1-5, 1-6, 1-7, 1-9, 1-10, 1-11, 1-12, 1-14, 1-15, 1-17). After mechanically removing over 1 m of overburden, hand excavations revealed the presence of a bison bone bed and stratigraphy illustrating the presence of at least six separate strata (horizons tentatively described as the following: an A, a Bt, Btwk, a C, an Ak [black mat], and a Bgk). Bison bone fragments were found at grid depths beginning at 48.57 m and continuing down through 48.13 m. Subsequent analyses revealed that the bone bed in Locus 1 was a palimpsest of three different depositional events over time (Dello-Russo et al. 2021; Holliday et al. 2019).

Due to the high degree of faunal preservation in this part of the site, the 2015 field efforts focused on recovering additional elements from within the bone bed to enable further analysis of the late Paleoindian processing of Bison sp. in Locus 1. Thus, in 2015, three previously excavated study units were reopened and expanded in depth (Study Units 1-6, 1-14, 1-15). Six new 1 by 1 m study units were excavated (Study Units 1-19, 1-20, 1-21, 1-31, 1-34, 1-45), along with one partial unit (Study Unit 1-46), which was opened for the purpose of retrieving a bone element that spanned two study units. The south half of Study Unit 1-47, on the north side of No Name Arroyo, was excavated (from 512.00 to 512.50 m grid north) to expose a south-facing profile. This was accomplished by facing the cut-bank wall. A map of these study units is provided in Figure 3.2a; data on the Locus 1 North study units excavated in 2015 are provided in Table 3.1.

The block of previously excavated study units in the Locus 1 bone bed had been lined with black plastic and backfilled with screened sediments after each prior excavation [specifically, field seasons 2009 (spring and fall), 2010, and 2012]. Thus, the previously screened overburden deposits across the grid block were mechanically removed for the 2015 excavations. These mechanical excavations terminated upon reaching the black plastic, or just above the black plastic. Following the mechanical excavation of overburden sediments from the Locus 1 bone bed, hand excavations commenced. The six new 1 by 1 m study units were hand excavated to grid depths ranging from 48.405 m to 47.085 m. The three previously excavated study units were re-opened to depths ranging from 48.00 m to 47.004 m, and the partial study units (Study Units 1-46 and 1-47) reached depths of 48.166 m and 47.20 m grid elevation, respectively. Figure 3.2b provides a photograph showing 2015 field school students excavating in Locus 1 North.

Study Unit 1-6 (509E / 509N) (stratigraphic study unit)

This study unit, located at the southern bank of No Name Arroyo, was reopened for the purposes of exposing the general stratigraphy within Locus 1, and for collecting micromorphology samples from within the Stratum 6 (black mat) sediments and along the transition between the gleyed sediments at the base of the unit and the black mat sediments above. Following both the 2010 and 2012 field sessions, the study unit had been lined with black plastic and mechanically backfilled. These backfilled overburden deposits were removed for the 2015 field session to just above the level of the previous study unit termination near the base of Level 17 (47.100 m). The initial study unit excavations from 2010 began within Level 3 (48.559 m) and terminated at the base of Level 8 (48.000 m); the 2012 excavations began at the top

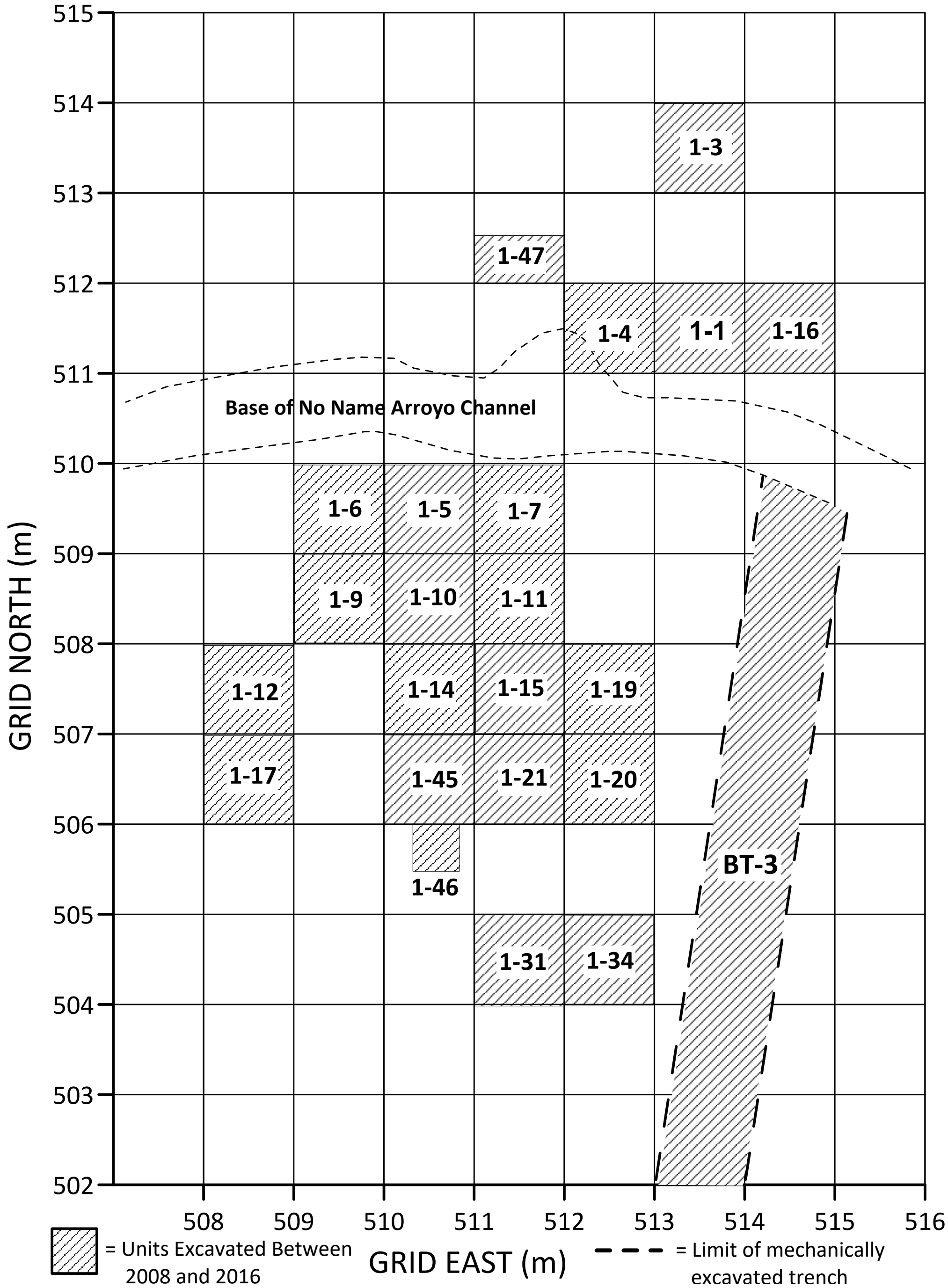


Figure 3.2a. Map of 2015 excavation units in Locus 1 North.

Table 3.1. 2015 excavated study units in Locus 1 North.

1-by-1m study unit (SU) no.	SW corner grid provenience coordinates (m)	Beginning grid elevation (m)	Ending grid elevation (m)	Levels excavated	Comments
SU 1-6	509E / 509N	47.233	47.004	17 – 18	-----
SU 1-14	510E / 507N	48.277	48.000	6 – 8	-----
SU 1-15	511E / 507N	48.031	47.900	8 – 9	Charcoal samples are continuation of thermal feature (Feat. 1) in SU 1-11; abundant bones
SU 1-19	512E / 507N	48.557	47.848	3 – 10	Possible groundstone/anvil (FS 1343)
SU 1-20	512E / 506N	48.351	47.834	5 – 10	Abundant bones
SU 1-21	511E / 506N	48.581	47.903	3 – 9	Abundant bones
SU 1-31	511E / 504N	48.685	48.405	2 – 4	Some bison tooth enamel
SU 1-34	512E / 504N	48.740	48.123	1 – 7	-----
SU 1-45	510E / 506N	48.379	47.085	5 – 18	Deep into gley; last 5 levels w/ auger
SU 1-46	510E / 505N	48.350	48.166	5 – 7	Small excavation to assist removal of bone element in south end SU 1-45 to north.
SU 1-47	511E / 512N	47.80	47.20	10 – 16	Bulk sediment ^{14}C samples (FS 22, 31, 32); phytolith samples (FS 1632–1634); diatom samples (FS 1632–1634)

of Level 9 (48.000 m) and terminated at the base of Level 17 (47.100 m); and the 2015 excavations encompassed a single level, Level 18 (47.100–47.000 m), terminating close to the base of Level 18 at 47.004 m.

The previous excavations in this study unit revealed that the black mat (Stratum 6) began at a depth of 48.255 m within Level 6, and continued to at least 47.004 m in Level 18.

The following section is a general paraphrase of the 2012 excavation notes for Study Unit 1-6, as evidenced in the 2015 excavations:

As noted during the 2010 excavation of the study unit, the black mat deposits became noticeably darker and, apparently, more organically enriched with depth. Cultural materials were recovered exclusively within the black mat between elevations of 48.200–48.000 m (Levels 7 and 8). The objective, stated in 2012, for further excavations in the study unit was to facilitate exposure of a fresh profile wall from which a pollen column and companion ^{14}C samples could be extracted. Thus, the 2012 excavation in this unit began with Level 9 (48.00–47.90 m) at 48.04 m grid elevation and terminated at 47.10 m at the base of Level 17 (47.20–47.10 m). Each of the levels in this study unit was excavated as a 10 cm level without the 5 cm A and B level subdivisions. The study unit excavations began with Level 9, in consolidated, compact soils at the contact between the basal sediment of the current active channel in No Name Arroyo and the black mat, which was exposed in the southern margins of the unit. A cobble line was present along the edge of the black mat, with cobbles ranging in size from 1.5 to 6.0 cm. By Level 12 (47.70–47.60 m), the black mat extended across the entire study unit with very hard, compact, and consolidated sediments. At the base of this level, fine, compact grey gleyed clay sediments were evidenced. Levels 13 through 15 were within this gleyed clay stratum, which became increasingly grey-brown with depth. At Level 16 (47.30–47.20 m), gravels and elongated charcoal smears were encountered within the gleyed clays. Several in situ charcoal flecks and/or smears were collected (FS 1230, 1231, 1232, 1240) between 47.293–47.217 m. Nodules of ferrous oxide (redoximorphic features) were scattered throughout the level along with rock fragments ranging from 5-20 cm in size. Both Levels 16 and 17 were in sandier sediments with numerous gravels. Since Level 9 (48.00–47.90 m) was the last level that held cultural/biological materials, Level 17 (47.20–47.10 m) was excavated with a pick in order to more quickly reach a greater depth for evaluating this study unit's deposits. Seven pollen samples were collected from the vertical south wall of the study unit (FS 1256–1262). Paired with these pollen samples was a column of six collected samples for ^{14}C analyses (FS 1269–1274). Elevations for these paired samples ranged from 48.030–47.280 m. Additional field samples collected from this study unit included bulk sediment for flotation and/or black mat analysis from Levels 9–17 (FS 1190, 1195, 1197, 1202, 1203, 1211, 1217, 1219, 1229, 1249, respectively), a red ochre (hematite) sample from Level 9 (FS 1177), bone fragments recovered from 1/8-inch dry screen from Level 9 (FS 1183) and bone recovered in situ from Level 9 (FS 1173). The study unit was terminated at 47.10 m at the base of Level 17 during the 2012 field session.

Figure 3.2b. Students excavating Bison sp. bone bed in Locus 1 North (photo courtesy Michael Wester).

The 2015 excavations began in the very compact, grey mat sediments (Stratum 6) at 47.233 m (near the top of Level 17) and were hand excavated and cleaned out to the base of Level 17 (47.100 m). Then, only a single 10 cm level was excavated, Level 18 (47.100–47.000 m). Sediments within Level 18 increased in sand content with clay also present in the silts. Cobbles were present in the western half of the study unit (10–15 cm in maximum dimension) and up to 10% subangular to rounded gravels. The study unit excavation was terminated at the base of Level 18, at approximately 47.004 m where dense alluvial gravels were encountered. No artifacts were recovered in the 2015 excavations within this unit. A single sediment sample (FS 1398) was collected near the top of Level 18. The south wall of the study unit was cleaned and faced to reveal a fresh profile, and a series of four micromorphological samples (FS 1557–1560) were collected, extending from just above the contact of the black mat with the grey-green gleyed sediment and down across the transition and into the gleyed sediment (Levels 12, 13, 14; 47.690–47.481 m). Due to the hardness and compact nature of the sediment, these samples were recovered by driving metal electric junction boxes into the sediment profile. The locations of the micromorphological sediment samples in the south wall of Study Unit 1-6 are illustrated and further discussed in the "Soil Micromorphological Samples" section, later in this chapter.

Study Unit 1-14 (510E / 507N)

Originally excavated in 2012, this study unit was reopened in 2015 for the purposes of increasing the depth of the unit to locate any potential bone and to assess its spatial relationship to bone found in adjacent Study Unit 1-15 to the east and Study Unit 1-45 to the south.

Notes from the 2012 excavation indicate that:

This 1 by 1 m study unit, located 3 m south of the south wall of No Name Arroyo, was newly excavated with the 2012 field session. Due to the mechanical scraping of overburden, the 2012 excavation in this unit began in Level 3, with a grid elevation of 48.60 m, and terminated at 48.23 m within Level 6 (48.30–48.20 m). Level 3A (48.60–48.55 m) began in the brownish-tan soils of the Bk Horizon, just above the sediments of the gray mat. The Bk Horizon continued partly into Level 3B (48.55–48.50 m) and possibly into Level 4A (48.50–48.45 m), where soils became darker and likely comprised the upper portion of the gray mat. A few gravels were present, most of which were smaller than 0.5 cm, with some in the 1–4 cm range. No cultural materials were present in the upper margins of Level 3, and a single flaked lithic (FS 1223) was recovered in the dry screen from Level 3B. The southwest quadrant of Level 4A contained intact gray mat soils, while the northwest quadrant may represent the base of the Bk overlying the gray mat. Reddish soil was apparent in the northeast quadrant, but appeared distinctly unstructured. Extensive parallel runs of bioturbation were present in the eastern half of Level 4A and either represented krotovinas or bucket tooth marks from the backhoe. Level 4B (48.45–48.40 m) had evidence of a krotovina in the northeast corner, but the disturbance only extended 2–3 cm into the level. Although two other krotovinas were present in the west and south walls at the floor margins, the majority of the level was within the gray mat soil. Some reddish-brown soil was present in the level and either represented the lower portion of the Bk Horizon or was the result of possible disturbance. From Level 4A, two flaked lithics (FS 1228), one of which was obsidian, were recovered in the dry screen, and a charcoal fleck was found in situ (FS 1233, 48.453 m); bone fragments (FS 1242) were recovered from the screen from Level 4B. Level 5A (48.40–48.35 m) was entirely within the gray mat and the only indication of disturbance was in the south wall, where a krotovina extended west-northwest toward the krotovina in the west wall of the upper excavation levels. Level 5B (48.35–48.30 m) had a minor disturbance, also in the south wall and from a krotovina, although it was smaller than in the previous level; a few gravels were present, 2–5 cm in size, with several less than 1 cm in size. Two unidentified flat bones (FS 1246 and 1250) were found in situ in Level 5A, and one small bone was encountered in the eastern margin of the study unit, near the base of Level 5B and extending into the next level (Level 6). Dry screen recovery from Level 5 included bone and a single obsidian flake (FS 1245) from the upper portion of the level and bone fragments (FS 1276) from the lower 5 cm of the level. One in situ charcoal fragment (FS 1267, 48.298 m) was collected from Level 5B, but was actually part of the next level (Level 6A). The final level excavated within this unit, Level 6A (48.30–48.23 m), exhibited an increase in clasts in the southwest quadrant, especially right along the west wall. A krotovina extended through the central portion of the unit from south to east. Darker soils were apparent in areas within the northeast quadrant and north half of the unit. Two unidentified flat bones were found in situ and collected (FS 1281 and 1294) from Level 6. Bulk sediment samples were recovered from Levels 4A, 4B, 5A, 5B, and 6A (FS 1227, 1235, 1242, 1265, and 1277, respectively). This study unit was terminated near the base of Level 6 at 48.23 m.

Due to the charcoal collected in 2010 from a suspected thermal feature in adjacent Study Unit 1-11 (to NE), attention was given to the potential in Study Unit 1-14 for similar occurrences (Study Unit 1-11 charcoal collected between elevations 48.36–48.15 [Levels 5–7]). Two charcoal flecks (FS 1233, 48.453 m, Level 4 and FS 1267, 48.298 m, Level 6) were collected from Study Unit 1-14; one was above the bracketed elevation for anticipated charcoal and one within. However, within the elevations where the most abundant charcoal was found in Study Unit 1-11 (mid-Level 6 to upper-Level 7, between 48.25–48.19 m), the soils in Study Unit 1-14 contained no observed charcoal, although darker soils were noted in the northeast quadrant and in the northern portion of this study unit in Level 6, and might possibly be inferred as sediments enriched from the adjacent feature deposits. This study unit was also terminated for the 2012 field session before excavations reached the base of the charcoal recovered in adjacent Study Unit 1-11.

For the 2015 field session, Study Unit 1-14 was re-opened and the backfilled overburden sediments and the plastic that lined the unit were removed. Excavations from the 2012 season had terminated at 48.23 m in Level 6, and excavations for 2015 began within the same level designation but just above this elevation, at 48.277 m. This minor elevational discrepancy was likely due to the accretion of sediments from wall disturbance during prior backfilling or possible sediment movement from burrowing rodents and amphibians (frogs were often encountered during the 2015 field session). Level 6 (48.300–48.200 m) was thus a partial level within Study Unit 1-14 and extended from 48.277 m to 48.200 m. Sediments were hard and compact, with moderate gravels and several cobbles (7–10 cm). A bulk sediment sample was collected (FS 1481). Within this partial level, two unidentifiable bone fragments were collected from dry screen recovery (FS 1466) along with a burned bone fragment found at 48.244 m (FS 1472), adjacent to a rodent krotovina in the southeast quadrant of the unit, and a single lithic flake recovered from the screen (FS 1480). Of note were numerous krotovinas throughout the level. Level 7 (48.200–48.100 m) consisted of similarly compact grey sediments with abundant small gravels (2–6 cm); a number of base elevations were mapped to assess whether the sediment comprised a gravel lens that had been apparent in adjacent Study Unit 1-45 to the south. The adjacent Study Unit 1-45 gravel lens occurred a few centimeters higher, between Levels 6 and 7. A large krotovina was mapped in the southeast quadrant of Study Unit 1-14 and was a continuation of the krotovina mapped initially in upper 5 cm of Level 6. The krotovina extended eastward into Study Unit 1-21. A humerus shaft fragment and two other long bone fragments were plaster jacketed (FS 1574, FS 1575, FS 1576, respectively). Additional collections from Level 7 included screen bone (FS 1536), an upright cobble (FS 1511), and a bulk sediment sample (FS 1540). The final excavated level for Study Unit 1-14 was Level 8 (48.100–48.000 m). Similar to the two preceding levels, sediments were hard and compact, light brownish-tan, with abundant gravels and an increase in cobbles (10–14 cm). The krotovina on the east edge of the unit was present throughout this level, with several bone fragments recovered from the screened krotovina fill (FS 1599) and two point-located long bone fragments recovered from within the krotovina (FS 1595, FS 1597). Also collected in situ from Level 8 were a long bone shaft fragment (FS 1606) and a lithic flake (FS 1591), along with a possible FCR fragment from dry screen recovery (FS 1599) and a bulk sediment sample (FS 1610). The study unit was terminated at 48.000 m at the base of Level 8.

Study Unit 1-15 (511E / 507N)

This study unit was originally excavated in 2012 and re-opened in 2015 for the purposes of further examining the depth of the bone bed deposits within the unit and to assess the occurrence of charcoal found near the base of some study units excavated in 2012. The backfilled overburden deposits from 2012 were manually surface stripped to expose the black plastic laid down at the completion of the 2012 excavations, which had terminated at 48.000 m, at the base of Level 8. The 2015 excavations encompassed one single level, Level 9 (48.000–47.893 m).

For context, a recapitulation of the findings of the 2012 excavation is as follows:

This 1 by 1 m study unit, located 3 m south of the south wall of No Name Arroyo, was newly excavated with the 2012 field session. This unit is immediately south of previously excavated Study Unit 1-11, which exhibited a concentration of charcoal thought to represent a thermal feature. Due to the mechanical scraping of overburden, the excavation in Study Unit 1-15 began within Level 3B, with a grid elevation of 48.53 m, and terminated at 48.00 m, at the base of Level 8B. This was the case over most of the unit, with the exceptions of several removed and collected bones. In those cases, the excavations penetrated down into Levels 9A and 9B, to a depth of 47.929 m. Levels 3B and 4A were levels with an uneven surface, resulting in partial excavation across the unit, while Level 4B was a complete level, and the level within which the gray mat was exposed at 48.45 m. Sediments in the partial levels above the gray mat were reddish-brown silty loams with 10% small gravels and several rock clasts, and sediments within the gray mat were dark brown, organic-rich silty loams with some rock (3–4 cm in size) and very few gravels. Disturbance from a rodent burrow and krotovinas was noted in northeast corner of the study unit, beginning in Level 4B (48.45–48.40 m) and continuing down through Level 7B (48.15–48.10 m), where it extended through much of the north half of the unit. Red-hued sediments were found within these disturbances and, for Levels 6 and 7, the rodent burrow sediments were screened separately. One small charcoal fleck was found in Level 5B (FS 1120, 48.311 m), but it was suspected that it may have been associated with disturbed sediments. In Level 6A (48.30–48.25 m), charcoal was fairly common, with only the largest fleck collected (FS 1142, 48.25 m). Charcoal flecks were also fairly abundant in Level 6B (48.25–48.20 m) and five samples were collected there (FS 1144, 1149, 1150, 1152, 1170). Charcoal content continued to be fairly abundant through the upper 3 cm of Level 7A (48.20–48.15 m), with four additional samples collected (FS 1174, 1175, 1176, 1186). By Level 7B (48.15–48.10 m) charcoal flecking was very sparse, but it increased again in low quantities in Level 8A (48.10–48.05 m), with nine collected samples from Level 8A (FS 1212, 1213, 1214, 1221, 1224, 1225, 1236, 1244, 1248). Three nodules of possible red ochre (hematite) were also collected from Levels 7A (FS 1181) and 8A (FS 1222 and 1234). Gravel content (<2 cm in size) increased in the gray mat by Level 7 (48.20–48.10) and extended into Level 8, then diminished by the base of Level 8B (48.05–48.00 m). A significant increase in bone was also noted beginning in Level 6B and again in Level 8A, and continuing through Level 8B, where single bone elements extended into Level 9A. A possible vertebra (FS 1200) was collected from Level 7B, a humerus (FS 1216) from Level 8A, and numerous bones (n = 14) were recovered from Level 8B, including carpals (FS 1277 and 1303), a possible rib fragment (FS 1301), a vertebral epiphysis (FS 1302), a 2nd phalanx (FS 1304), and a right metacarpal (FS 1305). Level 8B revealed a second humerus (FS 1306) and a possible rib fragment (FS 1309). In Levels 8B and 9A and 9B, it was noted that gravels (1–8 cm in size) were mixed in with the bones (excavations were continued down to 47.929 m as bones were defined). Other samples collected from the Study Unit 1-15 included bulk sediment flotation samples from Levels 4A, 4B, 5A, 6A, 6B, 7A, 7B, 8A, 8B (FS 1088f, 1102, 1116, 1134, 1166, 1189, 1204, 1220 and 1239, 1266, respectively), lithics from dry screen recovery in Levels 3B, 4A, 5B, 6A, 6B, 8A (FS 1088c, 1088f [which included one obsidian fragment], 1107, 1125, 1133 and 1140, 1158 and 1164, 1263, respectively), in situ lithics from Levels 4B and 5A (FS 1096 and 1097, 1117, respectively), bone from dry screen recovery in Levels 4A, 5B, 6B, 7A, 8A (FS 1088f [which included one burned bone], 1125, 1158 [which included one burned bone and two enamel fragments], 1192, 1218 and 1264, respectively), along with unidentified bone recovered in situ from Level 6A (FS 1131), Level 6B (FS 1148, 1153, 1168, 1169), Level 7A (FS 1185), Level 8A (FS 1208, 1209, 1210, 1238), and Level 8B (FS 1298, 1299, 1300, 1307, 1308, 1310). Excavation in Study Unit 1-15 was terminated at 48.00 m, at the base of Level 8B (although see above about defining bones down to 47.929 m).

Study Unit 1-15 was a highly productive unit in terms of bone recovery, with 26 bones found in situ in the lower levels of the unit (Levels 6–8, 48.25–48.00 m). When combined with dry screen recovery, bone was found in all levels except for Level 3, and lithics were found in all levels except for Level 7. Also notable is the abundance of charcoal, both observed and recovered, within the elevations bracketed (48.36–48.15 m) for anticipated charcoal based upon the previous excavations of adjacent Study Unit 1-11 (to the north), where a possible thermal feature was identified. From the Study Unit 1-11 feature, charcoal samples were collected mostly between 48.25–48.19 m (primarily mid-Level 6 and into upper Level 7). When comparing the charcoal recovered from Study Unit 1-15 to the Study Unit 1-11 thermal feature, Study Unit 1-15 had abundant charcoal at the same elevations as well as a second fluorescence of charcoal slightly deeper. Charcoal from Study Unit 1-15 was abundant in Level 6, with six samples collected in situ between 48.250–48.201 m, and was common in upper Level 7, with four collected samples from the upper 4 cm of level (between 48.200–48.162 m), but then became sparse in its lower 6 cm, only to pick up again, however in low quantities, in upper Level 8, with nine samples collected (between 48.085–48.046 m). As with Study Unit 1-11, charcoal from Study Unit 1-15 was most common between 48.25–48.17 m, with a second occurrence between 48.09 to 48.05 m, suggesting potential for an expanded area for the feature, or possibly an environmental derivation.

The 2015 excavations were to begin with Level 9 (48.000–47.900 m), however, the 2015 beginning elevations were a few cm higher than the terminal elevations from 2012 at the base of Level 8 (48.000 m) and thus, the 2015 excavations began near the base of Level 8B and simply constituted an initial, partial level (48.05–47.992 m) for clean-out and leveling, and was designated Level 8. This partial level revealed fragmented bone that was likely exposed at the base of Level 8 in 2012. The bone fragments were point provenienced and collected (FS 1385B, 1452, 1456), along with several from dry screen recovery (FS 1457A and 1457B), which included one burned bone (FS 1462). Excavations were to continue in 10 cm levels rather than breaking down the 10 cm level into two 5 cm A and B designations as was done in the previous (2012) field session within this study unit, however only one complete level was excavated in Study Unit 1-15 during the 2015 field session, Level 9 (47.993–47.893 m). Sediments were medium-grained sandy silts with 10% gravels and evidence of the Stratum 6 black mat. This level was productive in terms of bone recovery, with 15 fragments or elements collected (FS 1503-1509, 1513, 1516, 1520–1523, 1524, 1530) along with a single fragment of burned bone found within separately screened sediment from a rodent burrow (FS 1477) and several in dry screen recovery (FS 1487). Additional collections include screen lithics (FS 1469A, 1486), charcoal (FS 1478), pollen (FS 1494), and a bulk soil sample (FS 1482). Of note were two possible FCR fragments (FS 1469B), neither of which is definitive as FCR, however they are different than many of the other rocks found within the black mat.

The second appearance of charcoal noted in 2012 in Level 8, between 48.09 to 48.05 m, was considered during the current excavation, however no significant amounts of charcoal were noted in the initial, partial excavation level from 48.050–47.992 m, nor in Level 9 (down to 47.893), and only a few fragments were mapped and/or collected. The study unit was terminated at 47.893 m at the base of Level 9 (47.993–47.893). Twenty-two samples were recovered from this level, including 17 bone samples (one of which was burned), one soil sample, one charcoal sample, two lithic samples, and one pollen sample. A strong potential is thought to exist below Level 9 for additional bone recovery.

Numerous, variably sized fragments of identifiable bone elements were recovered from Level 8 (during 2012 fieldwork) and from Level 9 in 2015. Identified bone included a cuneiform, fragments of ribs, several humeri, two femurs, a metacarpal, lumbar vertebra, molars, pisiforms, two phalanges, several radii, several tibia and numerous long bones, along with a metatarsal that spanned both Study Unit 1-15 and Study Unit 1-21 to the south. Fragments of burned bone were found in both Levels 8 and 9, and charcoal was largely limited to the upper portions of Levels 6–8 (similar to elevations for the possible hearth feature in Study Unit 1-11 to the north). Two possible FCR fragments from Level 9 further bolster the potential for the thermal feature.

Study Unit 1-19 (512E / 507N)

This 1 by 1 m study unit, located 3 m south of the south wall of No Name Arroyo, was newly excavated during the 2015 field session. This unit is adjacent to previously excavated Study Units 1-15 (to the west) and 1-11 (to the northwest), both of which exhibited concentrations of charcoal thought to represent a thermal feature. Due to the mechanical scraping of overburden, the excavation in Study Unit 1-19 began within Level 4 (48.500–48.400 m; although the uppermost corner grid elevation was 48.557 m, or Level 3), and terminated at 47.839 m within Level 10 (at base of FS 1615 scapula). Only a portion of the southeast quadrant of Level 10 was excavated and this was solely for the purpose of retrieving a bison scapula that extended into the unit from Study Unit 1-20 to the south.

In the first excavated level of Study Unit 1-19, Level 4 (48.500–48.400 m), sediments were mostly within the gray mat, and consisted of a hard and compact, light brown sandy clay with 10% small pea-sized gravels along with discontinuous areas of reddish-orange sediment, likely from the percolation of sediments above the gray mat, with numerous 5–10 cm clasts. The black mat is exposed first in the northeast corner of this level and across the eastern portion of the study unit, along with a corresponding decrease in the larger clasts and the appearance of white carbonate streaks. A thin gravel lens of small gravels (<1 cm) occurred in this level across the northwestern portion of the study unit.

Level 5 (48.400–48.300 m) sediments continued to expose the black mat, with dark brown clay, minor amounts of small gravels, and $CaCO_3$ streaks. A rodent burrow extends across the southern half of the study unit in this level, and four charcoal flecks were noted and mapped but were too small to be collected, though numerous charcoal smears were encountered throughout the level. A single rhyolite flake was found within the dry screen recovery (FS 1328).

Level 6 (48.300–48.200 m) continued to be within the black-to-grey mat sediments. The rodent burrow that was exposed above, in Level 5, continued through Level 6 in a northwest to southeast direction across the center and southern half of the study unit. The krotovina is filled with tiny gravels and a loose, reddish-orange sediment that was screened separately. More charcoal flecks and smears were encountered in Level 6, and as with Level 5 above, these were mapped but not collected due to their small size and lack of structural integrity. Gravel was still most abundant in the northwest quadrant of the study unit. A yellow mineral—possibly some type of ochre—was noted by the excavator. Two small rodent bones and a single bison bone fragment were collected in Level 6 from the dry screen recovery (FS 1335).

Sediments within Level 7 (48.200–48.100 m) appeared to be lighter in color than in the preceding levels, and were a grayish-brown hue that contrasted sharply with the reddish-orange fill within the rodent burrow, which continued within this level and expanded with a new arm of the burrow extending into the north wall of the study unit. Gravels in the northwest quadrant of the level were slightly larger in size over the preceding levels, ranging in size up to 2 cm. Charcoal was again noted and several fragments were mapped throughout this level, with three collected samples (FS 1342, 1348, 1350). One of the charcoal fragments (FS 1348) was specifically collected due to its proximity to a flat clast (FS 1343) that was interpreted to be a groundstone fragment or possible anvil stone. In dry screen recovery from the northwest quadrant of Level 7, a lithic flake was also collected (FS 1340).

The sediments within Level 8 (48.100–48.000 m) appeared to be black mat sediments with dark red mottling, gray clays, 10% small gravels (1–5 cm) and 2% gravels (>5cm). Within the northwest quadrant of Level 8, light orange-red sediment with loose gravel (<3 cm) was noted, as were rootlets in the southwest quadrant of the level. The rodent burrow, which had been exposed in the preceding three levels, was no longer present within Level 8. Charcoal was again noted and mapped throughout Level 8 but no samples were collected. Three lithic flakes were collected, two from dry screen recovery (FS 1364) and one in situ (FS 1368). Bone was also collected within Level 8, with FS 1367 found in dry screen recovery and two fragments found in situ (FS 1374, 1375).

Within Level 9 (48.000–47.900 m) the sediments varied in hue from dark grey to black, with the western half of the study unit transitioning into the darker hue in the northwest quadrant and to a dark red and gray hue in the southwest quadrant. Sediments were coarse, sandy silt with 10% loose gravel (varying from <1 cm up to 2–3 cm in size) along with some larger clasts (5+ cm), several of which had $CaCO_3$ filaments on their bottom sides. A number of bones were exposed in the western half of Level 9, including several long bone fragments (FS 1499, 1500–1502), a possible astragalus (FS 1439), two fragments of burned bone (FS 1383B), and bone fragments from dry screen recovery (FS 1383A); in addition, a scapula was exposed in the southeast corner of the unit, extending into Study Unit 1-20 to the south. A possible lithic flake was collected from dry screen recovery (FS 1393). Several charcoal flecks were mapped and a single fragment of charcoal was collected (FS 1441).

The final level within Study Unit 1-19 was a partial level within Level 10 (47.900–47.800 m), which was excavated to a depth of 47.848 m in the southeast corner of the unit for the purpose of removing a complete scapula. The scapula had been exposed near the base of Level 9, and extended into Level 10, as well as laterally into the south wall of the unit and into Study Unit 1-20 to the south. The Level 10 sediments in this southeast corner of Study Unit 1-19 were a mottled black mat and reddish-orange sediment with moderate to abundant gravels. Three cobbles (<10 cm) were exposed in a location adjacent to the articular end of the bone and resting at the same surface as the bone (ca. 47.850 m). The scapula exhibited a notch along the lateral edge of the bone and the notch corresponded with a rodent krotovina that extended along the south wall of the unit, suggesting it may have been gnawed by the rodent. The scapula was collected as FS 1615 from Study Unit 1-20 (*see* Fig. 3.4). Samples recovered from Study Unit 1-19 within the partial Level 10 included dry screen recovery of bone (FS 1489) and lithic material (FS 1589). Bulk sediment flotation samples for Study Unit 1-19 were collected from Levels 4, 5, 6, 7, 8, and 9 (FS 1314, 1326, 1334, 1351, 1372, and 1392, respectively). Excavation of this study unit was terminated in this partial Level 10 at 47.848 m.

Study Unit 1-20 (512E / 506N)

This 1 by 1 m study unit, located 4 m south of the south wall of No Name Arroyo, was newly excavated during the 2015 field session. It was adjacent to previously excavated Study Unit 1-15 (to the northwest) and newly excavated units Study Unit 1-19 (to the north) and Study Unit 1-21 (to the west). Due to the mechanical scraping of overburden sediments, the excavation in Study Unit 1-20 began just above Level 6 (48.300–48.200 m), with a grid elevation of 48.351 m (in Level 5), and terminated at 47.834 m within Level 10, at the base of the most deeply collected bone (FS 1629).

Level 6 was the first complete level to be excavated in this study unit, and exhibited compact gray, sandy silt with moderate gravel (<2 cm) and streaks of $CaCO_3$ throughout. No collections were made within this level.

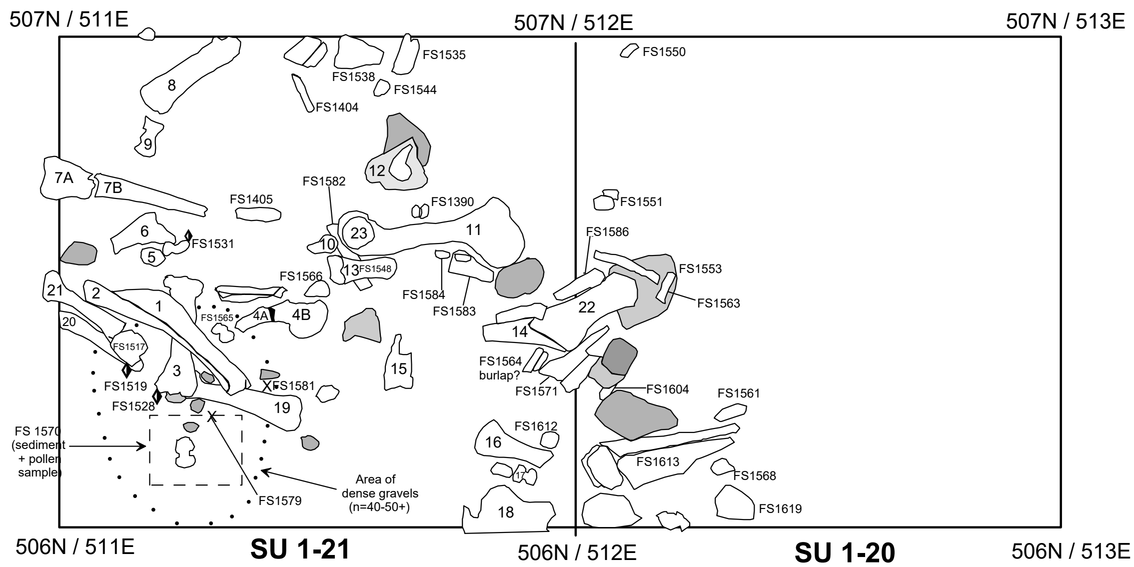
Level 7 (48.200–48.100 m) was within the black mat deposit and had several krotovinas present, primarily in the southern half of this study unit. These were excavated and their loose, reddish-hued sediments were screened separately, with one containing a rodent tooth and bone (FS 1448). Additional small bone fragments (FS 1467) and a single lithic flake, at an approximate elevation of 48.105 m, were collected from dry screen recovery (FS 1460). A small fleck of charcoal was noted and mapped but not collected, at an elevation of 48.105 m, and a small 2 cm area of charcoal smears was also noted at the base of the level, along with a nodule of iron oxide.

Level 8 (48.100–48.000 m) was free of krotovinas in the southern half of the study unit, although one appeared in the northwest quadrant. A number of rock clasts, 4–20 cm in diameter, were encountered and mapped in the southern half of the unit, where bone fragments were also exposed, several of which extended into Study Unit 1-21 to the west. A humerus, exposed in the southeast corner of the study unit, extended into the east wall of the unit and into the area outside of the grid block where excavations have not yet taken place. The humerus thus remained in situ and was carefully backfilled at the termination of the excavations. Three bones, including a rib fragment (originally field identified as a possible tarsal), were collected in Level 8 (FS 1488 [rib], 1496, 1497). Bone was also collected from dry screen recovery (FS 1471).

The final excavated level for Study Unit 1-20 was Level 9 (48.000–47.900 m), which was the most productive in terms of bone, lithics, and charcoal. A total of 35 bones or bone fragments were point located and collected from Level 9 (FS 1514, 1525, 1526, 1529, 1533, 1537, 1539, 1546, 1549–1551, 1553, 1561–1563, 1568, 1571, 1572, 1587, 1588, 1593, 1598, 1600A–C, 1603–1605, 1612–1614, 1618, 1619, 1622, 1624, 1627, 1631). Additional collections from Level 9 included lithics (FS 1577) and bone (FS 1518) from dry screen recovery, along with two charcoal fragments (FS 1527, 1616) located near the base of the level. Plan view drawings of the bone distributions in this study unit are provided in Figure 3.3 (Levels 8 and 9) and Figure 3.4 (Levels 9 and 10).

Level 10 was not formally excavated; instead, the excavations in this level consisted of bone removal for those bones that extended into Level 10 from Level 9 above. Several bones (FS 1611, 1615, 1617, 1620, 1623, 1625, 1626, 1629) and two lithics (FS 1621, 1628) were collected, the latter of which was a dark red, angular pebble that may have been utilized as a pecking or pounding tool based upon one or two possible flake scars on its more pointed end, however this type of impact damage could not be verified in the field.

Of note was a complete scapula (FS 1615) located in the northwest corner of the unit (*see* Fig. 3.4). As discussed in greater detail in the Study Unit 1-19 section above, the scapula extended into that unit (to the north of Study Unit 1-20) and was plaster jacketed for removal. The two lithic flakes (FS 1621, 1628) were point-located at elevations of 47.882 and 47.839 m, respectively. As noted above, Level 10 was terminated at the base of the deepest collected bone (FS 1629) at an elevation of 47.834 m.



Bone No.	Element	FS No.	Bone No.	Element	FS No.
1	Radius	1386	13	Calcaneus	1548
2	Ulna	1386	14	Undet. Frag.	n/a
3	Metacarpal	1528	15	Undet. Frag.	n/a
4	Humerus	1554	16	Metapodial	1556
5	Phalanx	1382	17	Phalanx	1555
6	Radius / Ulna	1532	18	Innominate	1607
7	Tibia	1490	19	Metapodial	1552
8	Metatarsal	1402	20	Undet. Frag.	1517
9	Tarsal	1390	21	Metapodial	1519
10	Tarsal	1567	22	Radius / Ulna	1593
11	Distal Femur	1585	23	Humerus	1573
12	Distal Humerus	1403			

Pollen Samples
FS1495
FS1496
FS1519
FS1528
FS1531

KEY:
= Bone
= Clast
X = FCR or Lithic Artifact
= Pollen Sample

Photos taken
6/18/2015
#7567 - 7571

Drawn by: Patricia Dello-Russo

Figure 3.3. Plan view, bone distribution, Study Units 1-20 and 1-21/Levels 8 and 9.

Study Unit 1-21 (511E / 506N)

Study Unit 1-21 is a newly excavated 1 by 1 m unit, located 4 m south of the south wall of No Name Arroyo. This unit, excavated during the 2015 field session, is adjacent to previously excavated Study Unit 1-15 (to north) and newly excavated units Study Unit 1-20 (to east) and Study Unit 1-45 (to west). Due to the mechanical scraping of overburden sediments, the excavation in Study Unit 1-21 began within Level 3 (48.600–48.500 m), with a grid elevation of 48.581 m, and terminated at 47.903 m at the base of Level 9.

The first excavated level, Level 3, was a partial level within this study unit, extending from 48.581 to 48.500 m. Sediments consisted of compact, light brown, sandy silt with 10% subangular gravels (≤2 cm) in the upper few centimeters of the level, with larger gravels (7% at 2–4 cm, 15% at 4–7 cm) in the lower 5 cm of the level. A sediment sample was collected (FS 1315). The black mat was encountered along the western edge of the unit near the base of Level 3 at 48.51 m.

The first complete 10 cm level was Level 4 (48.500–48.400 m), with similar sediment and gravel content as the lower portion of Level 3 although the larger (4–7 cm) gravels decreased in frequency with depth until none were encountered in the lower few centimeters of Level 4. A rock clast (11 cm) was encountered near the base of the level and two tiny flecks of charcoal were found and mapped (but were not collected) at elevations of 48.480 and 48.454 m. A bulk sediment sample was collected from Level 4 (FS 1324).

Sediments in Level 5 (48.40–48.300 m) were dark brownish-gray sandy silts with abundant gravels at <2 cm, 5% at 2–4 cm, and 2% at 4–7 cm. Streaks of $CaCO_3$ were noticed across the unit in the lower 3 cm of the level as well as adhering to the base of the larger (4–7 cm) sub-angular gravels. A sediment sample was collected (FS 1329).

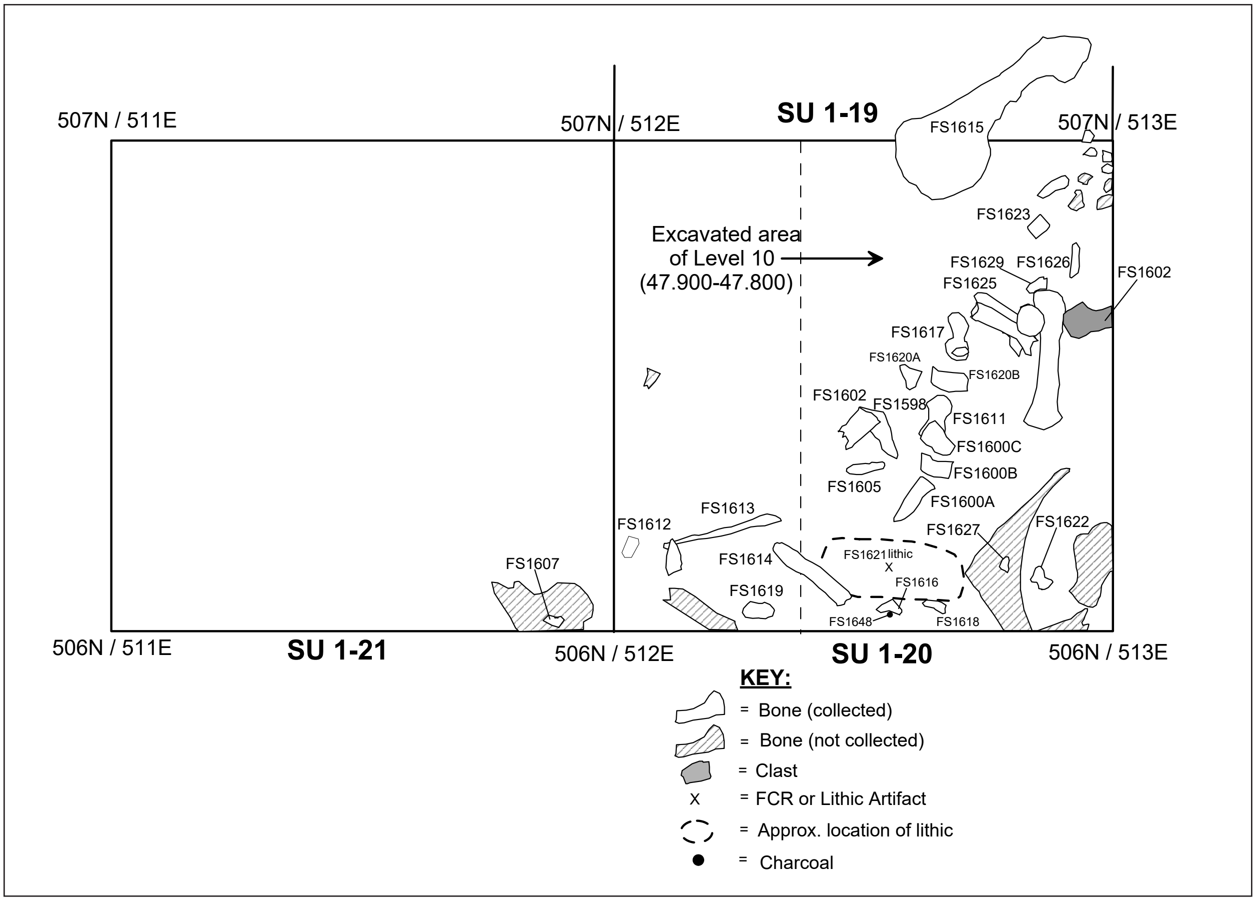


Figure 3.4. Plan view, bone distribution, Study Units 1-19, 1-20, and 1-21/Levels 9 and 10.

Increases in $CaCO_3$ were noted in Level 6 (48.300–48.200 m), initially only on the bottoms of gravels larger than 2 cm, then within the lower few centimeters of the level where $CaCO_3$ filaments infused the sediments across the unit and completely coated gravels. Finally, the sediments became darker and siltier as the black mat was exposed. The single collected sample from this level was bulk sediment (FS 1332).

Level 7 (48.200–48.100 m) was within the black mat, and a krotovina, exposed in the upper few centimeters in the southeastern side of the study unit, was filled with reddish-brown fine silts that contrasted with the black mat sediments. A gravel lens was exposed in the northwest quadrant of the unit, with dense gravels <1 cm coated with $CaCO_3$. Numerous small rodent bones were collected from the level (FS 1336, 1349) and three bison long bones (tibia, articulating radius/ulna) were initially exposed within the gravels in the western half of the unit. These gravels were subangular, coated with $CaCO_3$, and ranged in size from <2 cm (60%), 2–4 cm (25%), to 4–7 cm (5%). A bulk sediment sample (FS 1345) was collected.

The most productive level in Study Unit 1-21 in terms of bone was Level 8 (48.100–48.000 m), which was entirely within the black mat, with abundant gravels and $CaCO_3$ (sediment sample FS 1371). The gravel lens, observed in the level above, expanded eastward and southward across the study unit in Level 8. Abundant bison bone was found to be in fragile condition. Collected identifiable bones include: three humeri (FS 1403, 1554a-b, and 1573); two radii (FS 1386 and 1573, which included an articulating ulna; both were plaster jacketed); rib fragments (FS 1583 and 1594, which was plaster jacketed); an innominate (which was exposed at the base of the study unit in the southeast quadrant and extended into the unexcavated unit to the south; while the innominate was left in situ, several fragments were collected as FS 1607); a femur (FS 1585); a tibia (FS 1490a–b); a calcaneus that exhibited a cut mark (FS 1548); three metapodials (FS 1556, 1552, and 1519, the latter two of which were plaster jacketed); two tarsals (FS 1390 and 1567); a metatarsal (FS 1402); and a phalanx (FS 1555). Additional bones recovered here include: long bone fragments (FS 1385a, 1404, 1405, 1590); numerous unidentifiable fragments (FS 1535, 1538, 1542, 1544, 1565, 1582); and dry screen recovery fragments (FS 1356, 1377a–b). Six flaked lithics (FS 1362, 1384, 1579, 1580, 1581, 1619) were also collected within these bone contexts and include: a chalcedony flake (FS 1362), which was located near the articulated radius/ulna and was considered to be a candidate for residue analysis; a flaked lithic (FS 1581); two possible FCR fragments (FS 1579, 1580); and a single cobble (FS 1382), which was also located near the articulated radius/ulna. The distribution of bones in Levels 8 and 9 of Study Unit 1-21 is illustrated in Figure 3.3; the distribution of bones in Levels 9 and 10 is illustrated in Figure 3.4.

Study Unit 1-31 (511E / 504N)

This 1 by 1 m study unit was newly excavated in 2015 and was located near the southern end of the Locus 1 North excavation block. It is 2 m south of Study Unit 1-21 and immediately west of Study Unit 1-34 (described below). The unit was excavated to determine the southern extent of the bone bed. The start of excavations in this unit began in Level 2 (48.700–48.600 m), at 48.685 m grid elevation, and ended at 48.413 m (northeast corner) in Level 4 (48.500–48.400 m).

The sediments in Level 2 were fine, but hard-packed, brown-grey to light brown, and were dominated by 2–6 cm-sized gravels. About 10% of the gravels were 6–10 cm in size, and two were >10 cm in size. The initial excavation work was undertaken with a shovel until a lithic was encountered (FS 1347), and then trowel work began. A soil sample (FS 1354) was recovered from the southwest corner.

Level 3 sediments were light brown and sandy/clayey. They were also well-compacted but did not contain many inclusions or gravels (a few >5 cm sub-angular clasts), although an abundant amount of charcoal flecking was observed by the excavator. There was a relatively large amount of charcoal in the southeast and southwest quadrants and two charcoal chunks from the southwest quadrant were recovered for wood identification purposes (FS 1358 and FS 1360). A soil sample (FS 1361) was recovered from the southwest corner and a small flake—excavated near the base of the level—was recovered in the screen (FS 1370).

Mottling of the sediments was widespread in Level 4, and the gravels were dominated by 3–5 cm sub-angular clasts. $CaCO_3$ was observed on the bottoms of the larger clasts. Rocks >6 cm were not common. The sediment in the northwest corner of the study unit had a reddish-brown color, while that in the northeast corner had a grayish-brown color. The remainder of the unit was characterized by slightly compact, light brown, clayey sand. Numerous cicada burrows were encountered across the entire upper portion of the level. One charcoal fleck was mapped in the north-central portion of the unit and some bison tooth enamel was excavated from the bottom of the eastern half of the unit and recovered in the screen (FS 1378). Sand was encountered at 48.453 m and continued to 48.405 m. The results of excavations in this unit suggest that the bone bed in Locus 1 North does not extend this far to the south.

Study Unit 1-34 (512E / 504N)

This 1 by 1 m study unit, which was also newly excavated in 2015, is immediately east of Study Unit 1-31 and 2 m south of Study Unit 1-20. The excavation level began at 48.740 m grid elevation in the southeast corner of the unit, near the base of Level 1 (48.800–48.700 m). This study unit excavation terminated at 48.123 m in the southeast corner, within the lower portion of Level 7 (48.200–48.100 m).

Level 2 (48.700–48.600 m) sediments at Study Unit 1-34 were fine-grained, light brown silts with a yellowish tint that had 1–3 cm gravels. In the upper 6 to 9 cm, the sediment contained similar gravels and some cobbles >10 cm in diameter. The sediment became moister, darker, and more compact with depth. A soil sample (FS 1353) was taken in the northwest corner and a possible rhyolite flake was recovered in the screen (FS 1344).

Level 3 (48.600–48.500 m) included compact, light brown and grayish sediments in the upper 2 cm, after which the sediment became extremely compacted with cobbles approximately 10–12 cm in length. To soften the sediments and assist with excavation, the surface was soaked with water. Six charcoal fragments were mapped in the west-central portion of the study unit, with darker sediments surrounding them, and one fragment (FS 1365) was collected. Due to the observation of mottling in the sediment in the western half of the unit (and later in the eastern half of the unit), it was thought at this point that the excavation was approaching the level of the black mat. Larger gravels (10–20 cm in length) were concentrated in the northeast corner of the unit and a soil sample (FS 1363) was collected from the southwest corner of the unit.

Level 4 (48.500–48.400 m) began with light brown sediment with a yellowish tint, with darker mottling and a concentration of charcoal—predominantly in the western half, with some in the eastern half. A few medium sized (6–7 cm) and large (9–10 cm) cobbles were encountered in the northeast corner. The sediment changed to a red color by the north wall and this was thought to be bioturbation, perhaps a rodent tunnel. The sediment moisture content increased with depth, and the color changed to a darker brown and dark mottled gray. A cobble taken from the northwest corner had $CaCO_3$ on the underside. Screened sediment contained mostly 2–3 cm gravel and some 3–5 cm gravel, the latter occurring mostly in the northeast corner. A soil sample (FS 1376) was recovered from the southeast corner, as was a flake (FS 1373). A bone fragment (FS 1387) was collected in the south-central portion of the unit.

At the start of Level 5 (48.400–48.300 m), the sediment was still a light brown, silty sand with about 15% 4–7 cm gravels and one larger cobble in the center of the study unit. A few charcoal flecks were observed in the north-central and southwestern portions of the unit and some bioturbation was noted in the southeast and southwest corners. A soil sample (FS 1411) was recovered from the southeast corner from the zone of bioturbation. One fist-sized cobble was noted by the excavator near the base of the level protruding from the south wall of the unit. No artifacts, bones, or charcoal were recovered.

As with the previous levels at Study Unit 1-34, Level 6 (48.300–48.200 m) consisted of light brown sediment, although at this point it was characterized as sandy silt. The gravel content remained steady at about 15% and there was a moderate to high number in the 4–7 cm size range. Bioturbation was observed in the western half, with a distinct krotovina extending southward from the study unit's north wall. Larger cobbles had $CaCO_3$ on their undersides. As the excavation of the level progressed, the gravel frequency went up to about 50%, and small iron oxide nodules began to appear. The sediment changed to a greyish-brown color and began clumping as a result of an increasing clay content and increasing $CaCO_3$ filaments. Small smears of charcoal appeared in the western half of the unit and in the southeast corner as the gravel content dropped to about 10%. A soil sample (FS 1447) was collected from the southeast corner. Again, no artifacts, bones, or charcoal were collected.

The final level in Study Unit 1-34, Level 7 (48.200–48.100), started out as a grayish-brown sandy silt with a few 4–7 cm gravels and 10% smaller gravels. A long krotovina was mapped across the southern half of the unit and a small charcoal fleck (FS 1474) was collected from the east-central part of the unit. A few other charcoal flecks were observed in the western half of the unit, along with $CaCo_3$ on the underside of gravels and in the form of filaments throughout the sediment. A large rhyolite flake (FS 1485) was recovered from the southwest corner of the unit and a soil sample (FS 1479) was collected from the southeast corner. The level terminated about 1–2 cm above the formal base of the level, at 48.12 m.

Study Unit 1-45 (510E / 506N)

Newly excavated in 2015, this 1 by 1 m study unit is located 4 m south of the south wall of No Name Arroyo and adjacent to Study Unit 1-14 (to the north) and Study Unit 1-21 (to the east). Following mechanical and shovel scraping, the trowel excavations in this study unit started in Level 5 (48.400–48.300 m) at an actual grid elevation of 48.379 m in the northwest corner and ended in Level 13 (47.600–47.500 m) at an actual grid elevation of 47.476 m in the southwest corner of the unit. This study unit was dug deeply, in part, to allow for the stratigraphic exposure of the west wall of the unit. The west wall profile illustrates both Stratum 6A and Stratum 6B, the former being the gleyed olive unit and the latter being the black unit (black mat; *see* Holliday et al. 2019:19 for a fuller discussion of, and justification for, these strata; see also the "Soil Micromorphological Samples" section later in this chapter). Beyond the trowel work in this study unit, a bucket auger was employed—for one auger probe in each of the east and west halves of the unit—to examine the deeper parts of the Stratum 6A gleyed sediments. These auger tests are described following the study-unit level descriptions.

While removing overburden sediments with picks and shovels, a *spinus process* (FS 1395) was collected from outside the unit to the south (@ N505.833; E510.677; Z48.33). The sediments in Level 5 were a light gray-brown, fine, sandy clay with 40% >2 cm medium, rounded gravels. Most were concentrated in the southwest corner of the unit from which a soil sample (FS 1396) was recovered. No other artifacts, bones, or charcoal were collected in this level.

At the start of Level 6 (48.30–48.20 m) excavation, some overburden at the southern edge of the unit was removed to make it easier to excavate within Study Unit 1-45. During this effort, an obsidian flake fell into the southwest corner of the unit and was collected (FS 1412). A soil sample (FS 1406) was also collected there. The sediments in this level, which were extremely dry and compact, were light gray-brown, fine sandy clay with silt and >40% gravels. The majority of the gravels (3–6 cm) were in the southern half of the unit. These were sub-rounded with $CaCO_3$ on their undersides. At mid-level, a deposit of poorly preserved bone fragments was revealed at the center of the unit and some bone fragments were observed along the southern wall. The bones were entirely encrusted in rounded to sub-rounded, $CaCO_3$-coated gravels which ranged in size from 3 to 6 cm. Carbon-enriched sediment and charcoal were encountered to the north of, and around, the bone deposit. Both bone (FS 1400) and lithics (FS 1417) were recovered in the screen.

Level 7 (48.20–48.10 m) contained the same type of sediments as the previous level—light, gray-brown, fine sandy silts with clay. The same poorly preserved, spongy bone fragment deposits as were encountered above were also documented in this level, primarily at the center of the unit, with two small fragments protruding from the level surface at the northwest corner and some along the southern wall. A few elements were identified as ribs (FS 1449). Gravel in the southern half of the unit was 3–6 cm in size, while the gravels in the northern half were 1–3 cm in size but also increased to 5–8 cm in size and frequency with depth. Bones along the northern wall were encrusted with gravels. Dark, mottled sediment was observed along the eastern edge of the bone deposit and a cluster of charcoal was encountered along the northern edge of the bones. Several larger cobbles, measuring 10–11 cm in diameter were noted. Numerous $CaCO_3$ nodules were noted throughout the level as well. Bones were collected in the screen (FS 1440), as were lithics (FS 1444). A small, chalcedony scraper (FS 1445) was collected in the screen but was thought to have come from the southern half of the unit. Other recovered bone fragments included FS 1442, 1446, 1450, 1451, and 1459 (possible vertebra?). A red rhyolite lithic (FS 1455) was also recovered.

The upper portion of Level 8 (48.10–48.00 m) consisted of compact, brown-gray, very fine, sandy clay, with a rodent burrow extending across the northwest quadrant. The sediment included about 30% gravels measuring 1–3 cm in size. Red silicified rhyolite lithics (FS 1464) and bison tooth enamel (FS 1461) were collected from the screen. A possible bison rib (FS 1463) and a possible metapodial fragment (FS 1465), both thought to possibly be from an animal smaller than a bison, were point-located in the northwest and southeast corners of the unit, respectively. Sediment suggestive of the black mat, coupled with a decrease in the frequency of small gravel, were noted with an increase in depth. Gravels became larger (3–5 cm) and more rounded. A soil sample (FS 1468) was collected from the northeast corner of the unit and one bone fragment (FS 1470) was recovered in the central portion of the unit.

By Level 9 (48.00–47.90 m), the sediment was easily identifiable as the black mat (Stratum 6B). As in other Study Units, this is also where the bone deposits and associated lithic tools and artifacts increased in frequency. The sediments in this level were relatively moist, compacted, clayey sands with a dark brown color, and with 3–5 cm sized rounded gravels. Calcium carbonate was frequent, covered the base of much of the gravel, and was found as filaments primarily in the northern half of the unit. A soil sample (FS 1476) was collected in the northeast quadrant. A chert spurred end-scraper (FS 1475) was recovered from the southeast quadrant of the unit. The bones that were collected included two undetermined fragments (FS 1512, 1517), two distal phalanxes (FS 1515, 1534), a metapodial (FS 1519), and two bags of bone fragments recovered in the screen (FS 1518). A complete tibia (FS 1510) was exposed near the center of the unit and was pedestaled for plaster jacketing. Two cobble lithic tools (FS 1491 and 1492) were found encrusted around the tibia. FS 1492 was thought to be a possible hammerstone. One pollen sample (FS 1495) was recovered from beneath the lower articular end of the tibia at 48.141 m.

By Level 10 (47.90–47.80 m), all pedestaled bone had been removed and the level was excavated to determine if the bone deposit continued more deeply. The sediment consisted of a dark brown-black, sandy clay with ~60% well-rounded gravels <5 mm in size and ~20% angular gravels >2 cm in size. At the start of the level, a red, proximal rhyolite flake (FS 1596) was recovered in the northeast quadrant of the unit and a soil sample (FS 1592) was collected from the southwest corner of the unit. By 47.86 m, there were no additional artifacts or bones encountered and the sediment became a black and gray mottled matrix with <10% gravels of 3–5 cm size. There was an abundance of $CaCO_3$ that occurred as filaments throughout the matrix, as ~1 cm-size nodules and as coatings beneath the gravels. A cluster of cobbles occurred in the south-central part of the unit, and the excavator described many of them as "rotten." The sediment became very compact and it was decided to excavate the next level with a pick rather than a trowel.

Level 11 (47.80–47.70 m) was excavated almost exclusively with a pick, except for a small cluster of cobbles and gravels in the south-central portion of the unit, which was excavated with a trowel. The matrix consisted of a very compact, grayish-brown-black clayey-sand with silt, and was dominated by gravels <5 mm in size. There were also high amounts of $CaCO_3$, ferrous oxide, and "rotten rock." While the ferrous oxide was continuous throughout the level, the cobbles were mostly prevalent in the southwest quadrant and they were generally larger than 10 cm in size. A piece of angular debris (FS 1608) and a soil sample (FS 1609) were collected from the southwest corner of the unit. At the base of this level (46.70 m), the interface with a green-gray stratum (Stratum 6B) was exposed.

Excavation with a pick continued in Level 12 (47.70–47.60 m), as the matrix was extremely compact. Ferrous oxide and $CaCO_3$ were abundant and the entire south edge of the study unit was "webbed" with $CaCO_3$ filaments, according to the excavator. The western edge had the highest concentration of iron oxide, with the southwest corner of the unit stained orange from the high concentrations. The sediment was greenish-gray (gleyed) with >60% well-rounded gravels <2 mm in size and <10% rounded, angular clasts measuring <5 cm in size. By 47.60 m grid elevation, the entire level surface was coated with orange-yellow ferrous oxide, and ferrous oxide nodules were decaying in situ, and staining the surface. One soil sample (FS 1624) was taken in the southwest corner of the unit. No artifacts, bones, or charcoal were recovered.

The final fully excavated level in Study Unit 1-45 was Level 13 (47.60–47.50 m), which was composed of a very compacted, rusty orange-brown, very fine sandy clay with some silt, and dominated (at ca. 50%) by 2 mm, well-rounded gravels and <10% rounded and angular gravels measuring about 5 cm in size. To create a stratigraphic profile of the west wall of Study Unit 1-45, which is illustrated in Figure 3.5, the excavator took the level down with a pick. As with the preceding level, this gleyed "gray mat" was heavily mottled with ferrous oxide (also staining and nodules) and CaCO3 webbing, nodules (3–5 cm in size) and filaments. A soil sample (FS 1630) was collected in the southwest corner of the unit, but no artifacts, bones, or charcoal samples were recovered.

Below Level 13, the subsurface matrix was investigated with two bucket auger samples. One (Auger #1-1-2015) was placed in the eastern half of the study unit (N506.478 / E510.881) and the other (Auger #1-2-2015) was placed in the western half of the unit (N506.448 / E510.148). The east auger began at 47.485 m and ended at 47.085 m grid elevation, and the west auger began at 47.491 m and ended at 47.091 m grid elevation. According to the excavator's notes, there was a noticeable decrease in the amount of organic sediment from 20 to 30 cm depth in the auger samples and no organics after 30 cm. The results of the Study Unit 1-45 auger sampling are presented in Table 3.2.

Study Unit 1-46 (510E / 505N)

Trowel excavations were undertaken in a small portion of this study unit to recover a proximal ulna fragment (FS 1543) extending south from the south wall of adjacent Study Unit 1-45, located to the north. The small excavation area can be described as a segment 20 cm wide east–west by 50 cm long north–south. The southwest corner of this retrieved bone segment is located at 510.50E/505.50N. The upper grid elevations of the entire 1 by 1 m unit range from 48.350 m in the southwest corner to 48.333 m in the northeast corner. The sediment in the excavated area consisted of a light, gray-tan, sandy clay with ~60% gravels <5 mm in size, ~30% >5 cm in size, and 10% >15 cm in size. A cobble layer occurred at 48.238 m grid elevation. The proximal ulna fragment was recovered (with its north end @ N506.026/E510.586/Z48.209 [pro-point 1] and south end @ N505.857/E510.547/Z48.189 [pro-point 2]). The lowest point in the excavation was at 48.166 m. No other artifacts or charcoal were recovered.

Study Unit 1-47 (511E / 512N)

This entire study unit was not excavated; instead, the southern half of the unit, which extends along

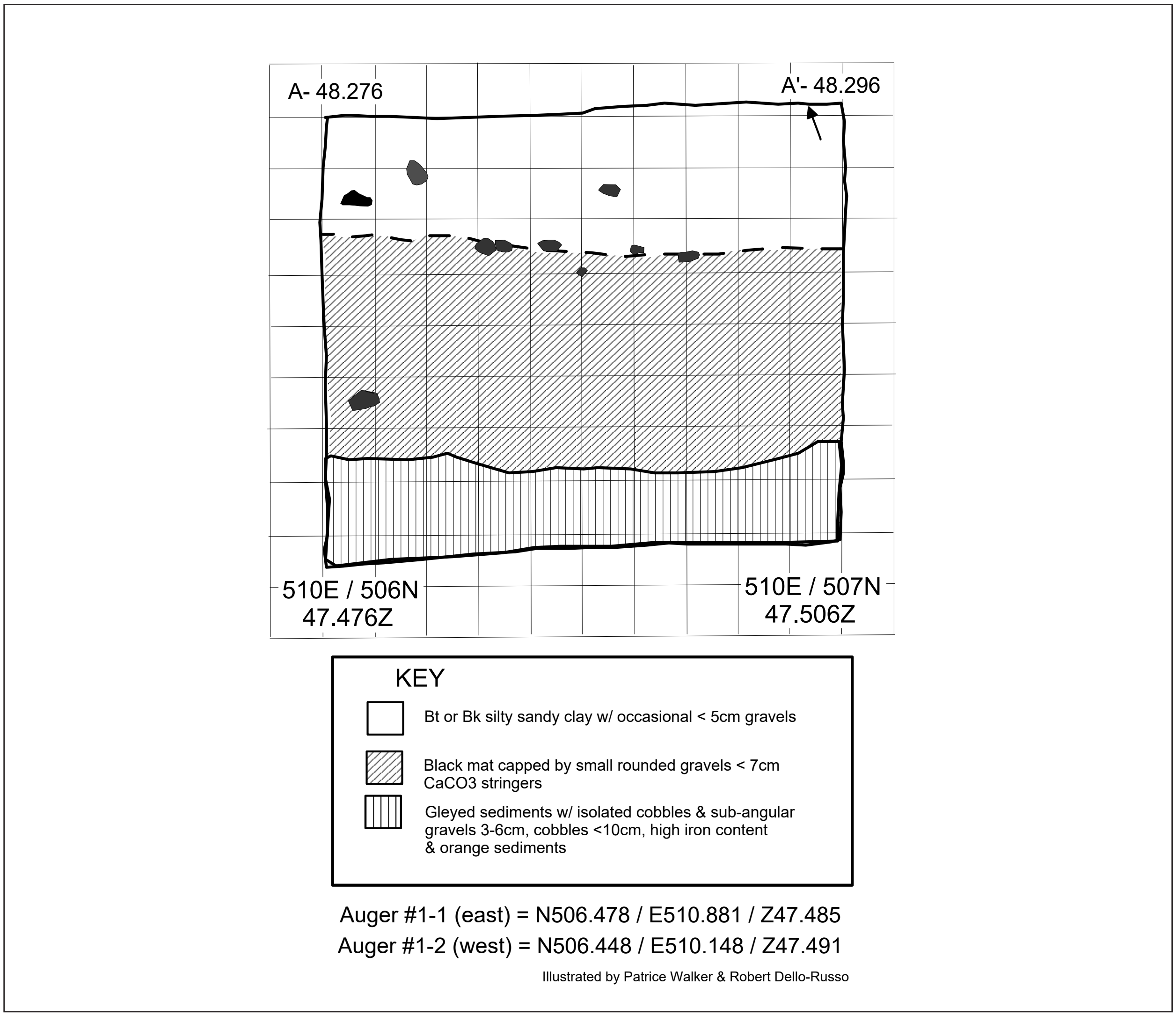


Figure 3.5. Stratigraphic profile of west wall of Study Unit 1-45.

the irregular north cut bank of No Name Arroyo, was faced for a clean profile from which several field specimens were collected (as discussed in the "Sampling for Chronometric..." section later in this chapter).

Descriptions of Hand Excavations in Locus 1 South

Prior to excavation in this area, the surface artifact scatter was re-mapped and collected for laboratory analysis. The rationale for excavation here was to establish whether artifacts and dateable thermal features were buried in the subsurface context, and to further clarify the true nature of the uphill artifact assemblage and its possible temporal and functional relationships with the bone bed. Accordingly, a new block of study units was laid out using the Nikon total station and tied, spatially, to the central site datum.

Seventeen 1 by 1 m study units were excavated on the gently sloping, remnant terrace (Stratum 4) of Locus 1 South, slightly uphill and to the southwest of the Locus 1 bone bed (Fig. 3.6). These 17 study units included Study Units 1-22 through 1-25, 1-27 through 1-30, 1-35 through 1-40, and 1-42 through 1-44. While it had been originally proposed (Dello-Russo 2015b) that Locus 1 South should consist of a maximum of six study units, due to the very shallow nature of the deposits, an additional nine study units were opened to expose a broader surface area within this suspected activity area. Data on these study units are provided in Table 3.3.

The study unit excavations over the suspected activity area (Locus 1 South) all began at the present surface. Further, due to the shallow nature of these study units and the homogeneity of the sediments, they are herein described as a single block. Each of these 1 by 1 m study units was similar in sediment content, beginning with unconsolidated silty loams of the A Horizon and terminating at, in or near the contact with the underlying AB Horizon. Sediments in the top 3–5 cm of the A Horizon were filled with juniper needles, rootlets, and loose, sandy to powdery duff.

Immediately below this duff layer were gravelly, light brownish-gray, moderately consolidated to heavily compacted sediments, with sub-rounded to sub-angular gravels measuring less than 1 cm in size and comprising roughly 30%–50% of the deposits, along with abundant gravels between 1-2 cm in size and occasional cobbles (6–18 cm in size). Most study units were terminated at the interface between the A Horizon and AB sediments. This was a fairly clear break between the lightly-to-moderately consolidated sediments of the A Horizon with the densely compacted and gravelly dark brown to reddish-brown AB sediments. Filaments and small nodules (2–5 mm) of $CaCO_3$ were dispersed across the study units after approximately 5 cm in depth. Excavation depths were shallow (less than 20 cm) for all 17 study units, with surface elevations ranging from 50.559 m to 50.216 m grid elevation, and base depths ranging from 50.544 m to 50.084 m, with most units terminating somewhere between 50.300 to 50.100 m.

Table 3.2. Hand-auger test results in Locus 1 North, Study Unit 1-45.

Auger No.	Grid Elevation (m)	Level No.	Sediment Description	Comments
1-1-2015	47.485 – 47.385	14	Fine sandy silt w/ trace amount of clay	Gravel w/ oxidation
	47.385 – 47.285	15	Silty medium sand / trace clay	Organically enriched, oxidation
	47.285 – 47.185	16	Medium sandy silt / appears to have moved out of organic deposit	Decrease in organic content, no clay
	47.185 – 47.085	17	Fine sandy silt / dark gray	$CaCO_3$ & oxidation, increase in gravels
	47.085	18	Terminated at interface at underlying gravel / sand deposit	
1-2-2015	47.491 – 47.391	14	Medium-coarse sandy silt w/ trace of clay / organically enriched	Noticeably organically enriched, $CaCO_3$ and oxidation (strong)
	47.391 – 47.291	15	Silty medium sand / decrease in organics	Increase gravel content, strong oxidation, carbonates
	47.291 – 47.191	16	Fine, sandy silt / greater than 5% gravel (rounded), dark gray	Noticeable decrease in organics
	47.191 – 47.091	17	Medium sandy silt / gravelly @ 5% rounded / gray	Oxidation (moderate), increase in sand, remaining silt matrix
	47.091	18	Terminated @ gravel interface with underlying sand / gravel deposit	

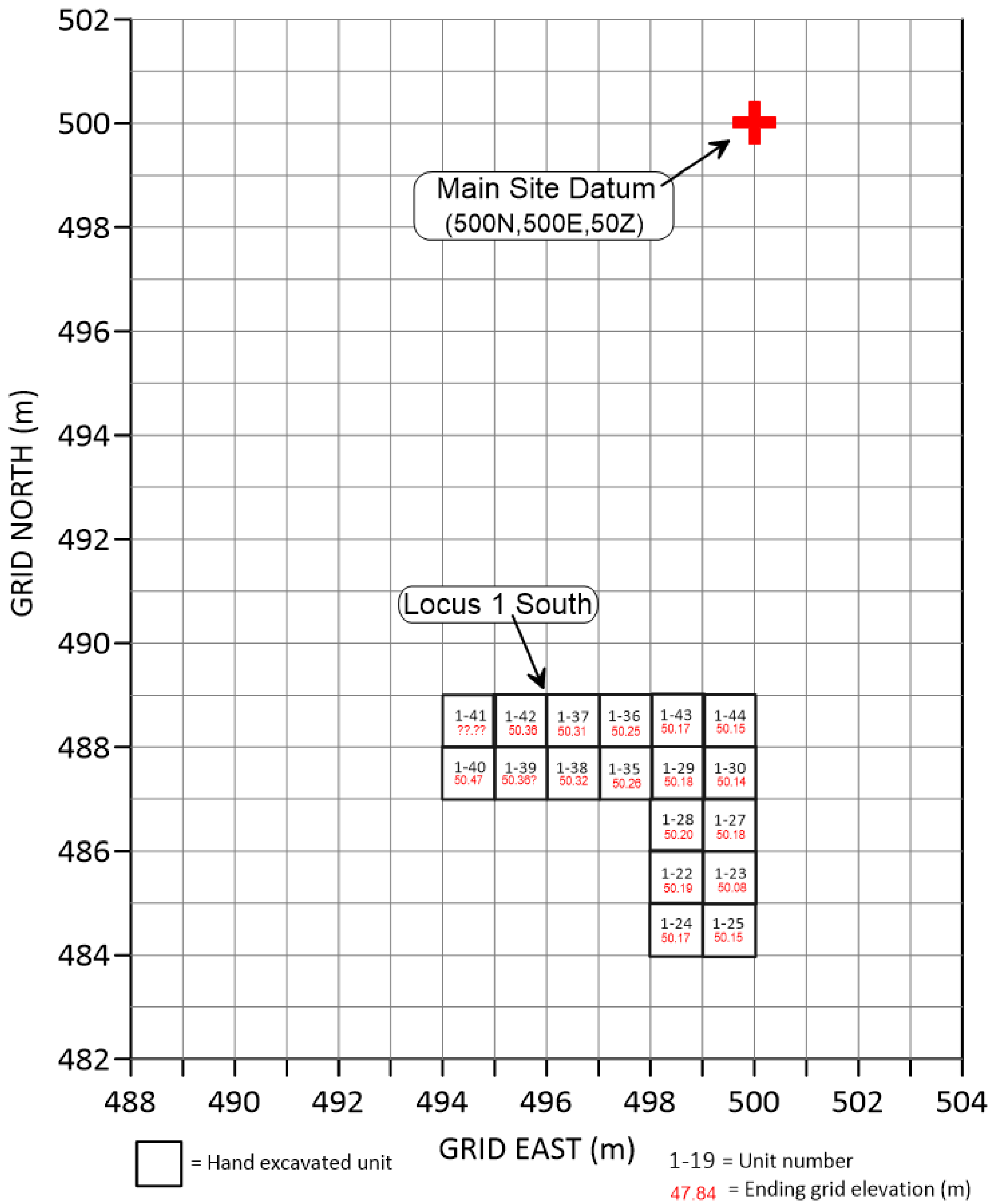


Figure 3.6. Map of 2015 hand-excavated units in Locus 1 South.

Table 3.3. 2015 excavated study units in Locus 1 South.

1-by-1-m study unit no.	Grid provenience coordinates (Easting / Northing)	Beginning grid elevation (m)	Ending grid elevation (m)	Levels excavated	Comments
SU 1-22	498E / 485N	50.401	50.193	1 – 4	FS 1325
SU 1-23	499E / 485N	50.336	50.084	2 – 5	FS 1313, 1327, 1339
SU 1-24	498E / 484N	50.456	50.171	1 – 4	FS 1316, 1322
SU 1-25	499E / 484N	50.370	50.150	2 – 4	No FS
SU 1-27	499E / 486N	50.286	50.180	3 – 4	FS 1333, 1338
SU 1-28	498E / 486N	50.349	50.195	2 – 4	FS 1352, 1355
SU 1-29	498E / 487N	50.327	50.184	2 – 4	FS 1337
SU 1-30	499E / 487N	50.275	50.139	3 – 4	FS 1341; *in situ* biface (Figure 3.7)
SU 1-35	497E / 487N	50.385	50.264	2 – 3	FS 1357, 1379
SU 1-36	497E / 488N	50.364	50.246	2 – 3	FS 1381
SU 1-37	496E / 488N	50.424	50.305	1 – 2	FS 1366, 1380
SU 1-38	496E / 487N	50.459	50.320	1 – 2	FS 1388, 1389, 1394
SU 1-39	495E / 487N	50.543	50.358?	0 – 2?	FS 1401
SU 1-40	494E / 487N	50.598	50.465	0 – 1	No FS
SU 1-42	495E / 488N	50.485	50.361	1 – 2	FS 1409
SU 1-43	498E / 488N	50.263	50.174	3 – 4	FS 1408, 1410, 1413a, 1413b, 1414, 1415 / Feature 2 (possible hearth)
SU 1-44	499E / 488N	50.256	50.145	3 – 4	FS 1397, 1407

Artifacts collected from the Locus 1 South activity area excavation covered seven study units and included 11 lithic flakes (FS 1313, 1322, 1325, 1333, 1352, 1366, 1389, 1397; and FS 1341, a complete biface [or uniface?] on a curved flake [Fig. 3.7]; FS 1357, a biface fragment; and FS 1388, a core). In addition, a small fragment of FCR was collected (FS 1410). The FS 1341 tool illustrated in Figure 3.7 was recovered from Study Unit 1-30. It is noteworthy in that it has a slightly thinned and concave base and appears to be a broken and re-sharpened, slightly-convex-to-parallel-sided projectile point, similar to Allen-Frederick or Angostura types (or under an umbrella adaptation known as Foothill-Mountain), but more suggestive of the regionally specific, late Paleoindian point type known as Belen. It may have functioned, in its repurposed state,

Figure 3.7. Biface (FS 1341) recovered from Study Unit 1-30.

as a knife (with the diagonal side of the artifact being the cutting edge). As mentioned previously, there are two other Belen-like projectile point fragments on the Water Canyon site (FS 6017, see Fig. 5.1i, and FS 6077, see Fig. 5.1h) that could be contemporary with the FS 1341 Belen-like tool at Locus 1 South. Rather than being seen as contemporary with the Plainview point type, which was manufactured between 12,100–11,300 cal yr BP (Holliday et al. 2017), we suggest that the FS 1341 Belen point, and the other Belen-like points at Water Canyon, date to the Belen range between 10,500–9000 cal yr BP (Judge 1973). Accordingly, the artifact scatter in Locus 1 South can be interpreted as a late Paleoindian activity area, perhaps contemporary with the Allen-Frederick-age or Angostura-age (ca. 10,400–9000 cal yr BP; Pitblado 2007) bone-processing area in Locus 1 North.

A single purported feature, Feature 2, was excavated in Locus 1 South. Feature 2 was found within Study Unit 1-43, which in turn was located near the northeast corner of the Locus 1 South excavation block (Fig. 3.8). The feature was shallowly buried, located about 8 cm below the current ground surface, and consisted of a small clast of FCR, three charcoal flecks, and two roughly tabular clasts greater than 10 cm in size that angled downward and south-southwestward. Two additional clasts (<10 cm) were located in proximity and, together, the four clasts formed a roughly circular alignment. Although fairly convincing but not definitive, the feature was cross-sectioned and the fill was removed separately from the southern half (FS 1413a) and the north half (FS 1413b). Two charcoal fragments were collected (FS 1414, FS 1415) from the northern half of the feature, where they were found nestled against one of the slanting clasts, at elevations of 50.190 m and 50.181 m respectively. The third charcoal fragment was more of a smear and was not collected but was point provenienced, with an elevation of 50.215 m. No carbon was noted in the feature fill, no artifacts were found in association with the feature, nor within the overall study unit. No oxidization was noted in the underlying sediments. The center point of the feature fill extended from ~50.22 m grid elevation to ~50.17 m, approximately 2 cm below the break of A Horizon sediments with AB sediments, which were

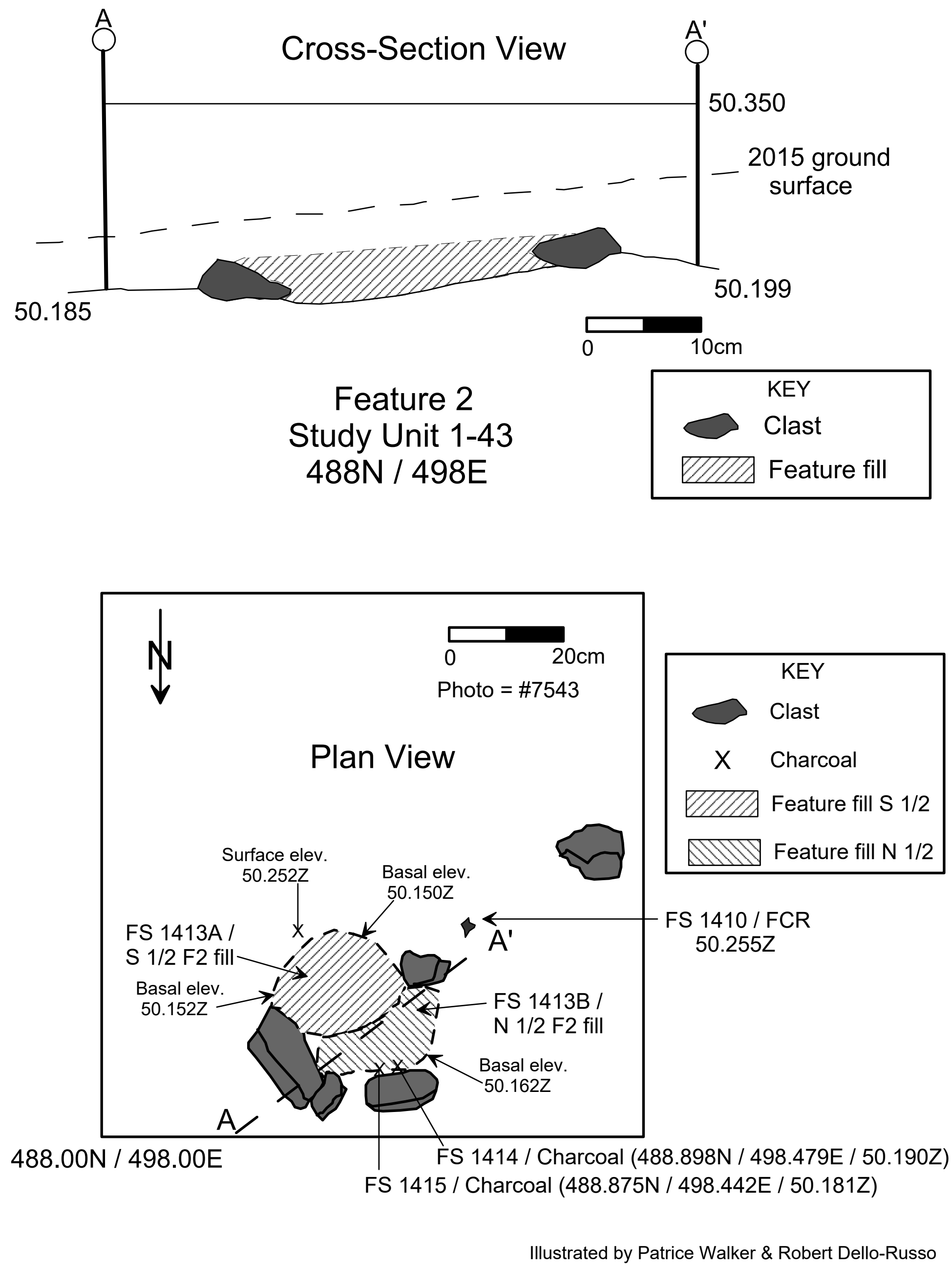


Figure 3.8. Plan and profile views of Feature 2 in Locus 1 South.

orange-brown silty clays. Most of the fill was grey-brown sandy silt. Rootlets extended throughout the feature. Gravels were abundant with 30% less than 3 mm in size and 2–5% between 3 mm up to 3 cm. Gravels consisted of water-rounded, sub-rounded to sub-angular clasts within the unit. A sediment sample was also collected (FS 1408) from the study unit. The deepest elevation of the feature fill was ~50.15 m. [Note: Feature 2 photos taken and archived in the OCA repository include: OCA 7543–7547 (surface of Feature 2 and Feature 2 with northern half of fill removed) and OCA 7548–7549 (excavated Feature 2).]

A roughly semi-circular alignment of cobbles was found near the west wall of Study Unit 1-23 and, while suggestive, was not convincing as a potential feature. Nonetheless, the fill from within the cobble area was removed as a sediment sample (FS 1327). A flake was also collected from Study Unit 1-23 about 40 cm to the east of these cobbles (FS 1313). In the adjacent unit to the west, Study Unit 1-22, no continuation of this cobble alignment was apparent, however, the only cobbles found within the unit were located in the southeast quadrant. A single lithic flake (FS 1325) was collected from Study Unit 1-22, adjacent to the cobbles and near the unit's east wall. No FCR nor charcoal were found in association and the cobble anomaly was not considered to be a feature. However, as with the sample from Study Unit 1-23, the fill from within this clast alignment was collected separately and will be available for any potential chronometric and subsistence analysis. Other than the lithics previously mentioned, no diagnostic artifacts nor bone, and no additional charcoal nor FCR, were noted within any of the other shallow study units excavated in this southern excavation block of Locus 1. Other collected samples included bulk soil flotation samples (FS 1316, 1327, 1337, 1338, 1339, 1355, 1379, 1380, 1381, 1394, 1401, 1407, 1408, 1409).

Overall, Locus 1 South appears to have been a locus of activity, with a potential hearth along with toolstone use, refurbishment, and discard. The association of the activity area with the Locus 1 bison bone bed has yet to be established. One charcoal sample from Feature 2, FS 1414, was submitted to International Chemical Analysis, Inc. (ICA) for a radiocarbon assay on June 16, 2016. The analysis (16C/0634) indicated that the sample was virtually all modern carbon and dated predominantly to AD 1955 ± 5 (72.4%) with a minor probability of dating to AD 1900 ± 10 (23.0%). If the charcoal is associated with Feature 2, then Feature 2 is clearly not associated with the activities in Locus 1 North.

Descriptions of Hand Excavations in Locus 5

Within the deep pit of Locus 5, originally excavated mechanically and by hand in 2013, five study units were opened or partially opened during the 2015 field school. To provide context for the current excavation in this locus, the prior work from the 2013 field season is summarized as follows:

Following the mechanical block excavation of deep overburden sediments from Locus 5, a 6 by 6 m grid was laid out at the base of the tiered pit. The purpose of this excavation block was to investigate the potential for buried bone as suggested by the bone fragments exposed in a series of previously drilled (2010 and 2012 field seasons) mechanical cores in the area of Locus 5. The mechanical cores contained bones at depths ranging from 45.45 to 45.20 m, which were roughly 3.5 m below the 2013 ground surface prior to excavation. Mechanical excavations terminated immediately upon encountering bones in the southwest corner of the 6 by 6 m excavation grid designated as Locus 5. The bones were encountered within the sediments of the wet meadow, or black mat, deposit. Thirty-six 1 by 1 m study units were laid out within the grid block. Of these, five 1 by 1 m study units (Study Unit 5-1 through 5-5) and one partial 1 by 0.50 m study unit (Study Unit 5-6) were hand excavated to depths ranging from 45.82 to 45.40 m. Four of these study units contained the previously drilled core holes. Excavations within three of the five study units reached the level of the anticipated bone, each revealing bone at or within 10–15cm of the level of the bone from the mechanical cores.

Study Unit 5-1 and partial Study Unit 5-6 did not contain a previously drilled core hole but were excavated because bone was exposed during the mechanical excavation of the grid block. The partial nature of Study Unit 5-6 was necessary due to the constraints of the tiered pit, the west wall of which formed the west edge of the partial study unit.

Study Units 5-1 through 5-6 were excavated in arbitrary 10 cm levels. To establish uniform elevations for each of the excavated study units, starting surface elevations for each unit were calculated across the grid, and the high point within each unit was then used to determine the elevation measurements for each level within the individual study units. In order to have levels beginning and ending with even 10 cm increments, (e.g., 10, 20, 30, etc.), the initial excavation level for each unit, Level 1, was generally slightly greater than 10 cm. Grid elevations within Locus 5 were referenced to Sub-Datum 13A with a control elevation at 49.005 m and grid coordinates of 520.006E / 529.017N. This sub-datum was located at the top of the northwest corner of the large excavation in Locus 5.

In situ bone, charcoal, and flaked stone artifacts, as well as bone, snail, and flaked stone artifacts collected from 1/8-inch screen along with bulk sediment samples (for flotation and radiocarbon studies) were recovered from the Locus 5 excavations. Bulk sediment samples were retrieved within each complete level, beginning with each designated Level 2 in the excavated study units. All excavated sediments were screened through 1/8-inch hardware cloth. All three-dimensional provenience data (north coordinates, east coordinates, and elevations) were controlled by the use of a Nikon total station. The proximal and distal ends of identifiable bones were mapped with the total station and mini-prism to determine provenience, orientation, and inclination.

The previously completed mechanical cores and study-unit hand excavations in Locus 5 demonstrated the presence of a probable Cody-age *Bison* sp. bone bed, although it is poorly preserved as a likely consequence of fluctuating water tables. This faunal assemblage slopes downward from the southwest to the northeast, dropping almost 45 cm over a horizontal distance of 7 m, or at a slope of about 3.7 degrees. Currently, the horizontal extent of the bone bed is unknown, although hand auger tests completed in 2015 (see discussion below) revealed that the bone bed extended across the full reach of the 6 by 6 m grid in Locus 5, and possibly beyond. In addition, the chronometric age of the bones in the deposit (as opposed to the sediment in and around the deposit, or charcoal associated with the deposit) is unknown. Previous mechanical cores east of the Locus 5 excavation pit did not contain bone, thus the limits of the bone bed are not thought to be extensive beyond the pit to the east. The bones do appear to extend westward beyond the pit, however.

For the 2015 field session, the revised Water Canyon research design (Dello-Russo 2015b) proposed that two trenches be mechanically excavated with a backhoe along the northern and eastern edges of the Locus 5 excavation block to explore for the horizontal and lower limits of the bone deposit and to expose the subsurface stratigraphy in that region of the site. Because the level of bison bone preservation was so low in Locus 5, the trenching was considered to constitute only a minimal impact to the poorly preserved assemblage and was to be closely monitored. Attempts were also to be made to reach, document, and sample Late Pleistocene (Pre-Clovis, Clovis, and Folsom age) sediments. The trenches were to be mapped using the total station; stratigraphic profiles were to be documented in each trench; and chronometric, microbiological, and sediment samples were to be recovered. However, after discussion with the NM Cultural Properties Review Committee, the mechanical trenching plan was abandoned in favor of continued hand excavation and auger testing. Thus, during the 2015 field school, one previously excavated 1 by 1 m study unit (Study Unit 5-1) was reopened, two new 1 by 1 m units were excavated (Study Units 5-7 and 5-8), and two 1 by 0.5 m units were excavated (Study Units 5-11 and 5-12). The data for the five study units excavated in 2015 are listed below in Table 3.4, with study unit summaries following. A map of the Locus 5 study units excavated in 2015 is provided in Figure 3.9.

Study Unit 5-1 (524E / 519N)

The hand excavations in this study unit during the 2015 field session began where excavations ended in 2013, at the top of Level 4 (45.70–45.60 m). The matrix of sediments consisted of sand, unsorted gravels, cobbles, and some small boulders within which the black mat (Stratum 6) had formed. The western two-thirds of the unit were made up of this matrix which represented an old channel deposit. Sorted sand and gravels under the cobbles indicate a fluvial bedding process. Bone elements and fragments appeared to overlay the cobbles. Initially, a metapodial and a femoral head were mapped and recovered (as much as possible, owing to the very poor degree of preservation) in the eastern half of the unit. The midpoint of the level excavation (~45.68–45.65 m) was where the bulk of the bones were encountered, mapped, and recovered. Faunal elements were recovered from the central and western portions of the unit and included a rib shaft (unknown side), a left mandible, a right vertebral end of a rib, an axial vertebra, a patella or vertebra fragment, a rib fragment, a tooth fragment, and a right tibia. While initially identifiable during excavation and mapping they unfortunately could

Table 3.4. 2015 excavated study units in Locus 5.

1-by-1m study unit no.	Grid provenience coordinates (Easting / Northing)	Beginning grid elevation (m)	Ending grid elevation (m)	Levels excavated	Comments
SU 5-1	524E / 519N	45.700	44.363	4 – 7	Level 7 is >1m stratigraphic level
SU 5-7	525E / 519N	45.780	45.600	3 – 4	----
SU 5-8	525E / 520N	45.830	45.290	3 – 7	----
SU 5-11	524E / 518.5N	46.027	44.363	1 – 17	Upper level includes laminated Stratum 8 sediment from paleo-channel; Bones at 45.51 m. Level 7 is >1m stratigraphic level
SU 5-12	525E / 518.5N	46.039	45.59	1 – 5	Upper level includes laminated Stratum 8 sediment from paleo-channel

not be recovered intact, and were thus recovered as fragments in two bags (FS 5142). One bulk sediment sample was collected as FS 5143. [Note: Study Unit 5-1/Level 4 photos OCA4502 and 4503 are archived in the OCA repository.]

Level 5 (45.60–45.50 m) began at 45.61 m. The matrix was essentially the same as the preceding Level 4, and consisted of cobbles with sand and gravel. The black mat (Stratum 6) had formed in the gravels. Two-thirds of Level 5 consisted of fine alluvium over the top of the cobbles and gravels, but this occurred only within the eastern one-third of the unit. Faunal elements were only found above the cobbles and gravel and were recovered as a group (FS 5144); they were relatively non-descript (again owing to poor preservation).

Following Level 5, Levels 6 and 7 (45.50–45.30 m) continued with cobbles, sand and gravels within which the Stratum 6 black mat had formed (Munsell 7.5YR 2.5/1 Black). At the base of Level 6, the excavator encountered a clayey, silt layer, with <5% clay, after which the sediment in the gravels took on a slightly grayer color. The matrix throughout represented unsorted channel sediments with no observable differences in bedding. No cultural materials were noted. Level 7 was a deep, stratigraphic level that remained relatively unchanged throughout, until the excavation was terminated at 44.36 m.

Study Unit 5-7 (525E / 519N)

Study Unit 5-7 was newly opened in 2015. This 1 by 1 m study unit is immediately east of Study Unit 5-1 and was truncated in prehistory along ~10 cm of its south edge by the actions of a west-to-east flowing paleo-channel (the ancestral No Name Arroyo). Accordingly, that portion of the unit consists of finely laminated Stratum 8 silty sands and gravels.

Initial excavation in this study unit consisted of mechanical work coupled with shovel efforts to remove overburden sediments down to the beginning level (Level 3; 45.80–45.70 m). The initial level was selected because it was thought to be about 20 cm above the bone bed. The sediments in Level 3 consisted of fine, sandy silt with a low clay content with black mat development throughout. Small chips of bone, 1–2 cm in size, were observed throughout and were collected in the 1/8-inch screen as FS 5146. The bone fragments were too small to map in place. A bulk sediment sample of 5 liters in volume (FS 5149) was collected from the southwest corner of the unit beginning immediately north of the paleo-channel. The level ended at 45.70 m.

The second level in this study unit (Level 4; 45.70–45.60 m) consisted of the same sediment as in Level 3 with 2–4 cm gravels also observed by the excavator. As with the preceding level, small fragments of bone were seen throughout the level, although most were below the 5 cm threshold for in situ mapping. Numerous fragments were recovered in the screen as FS 5155. An intact tooth was mapped in place in the northeast corner of the unit and collected as FS 5151, and a bulk sediment sample (FS 5149) was collected

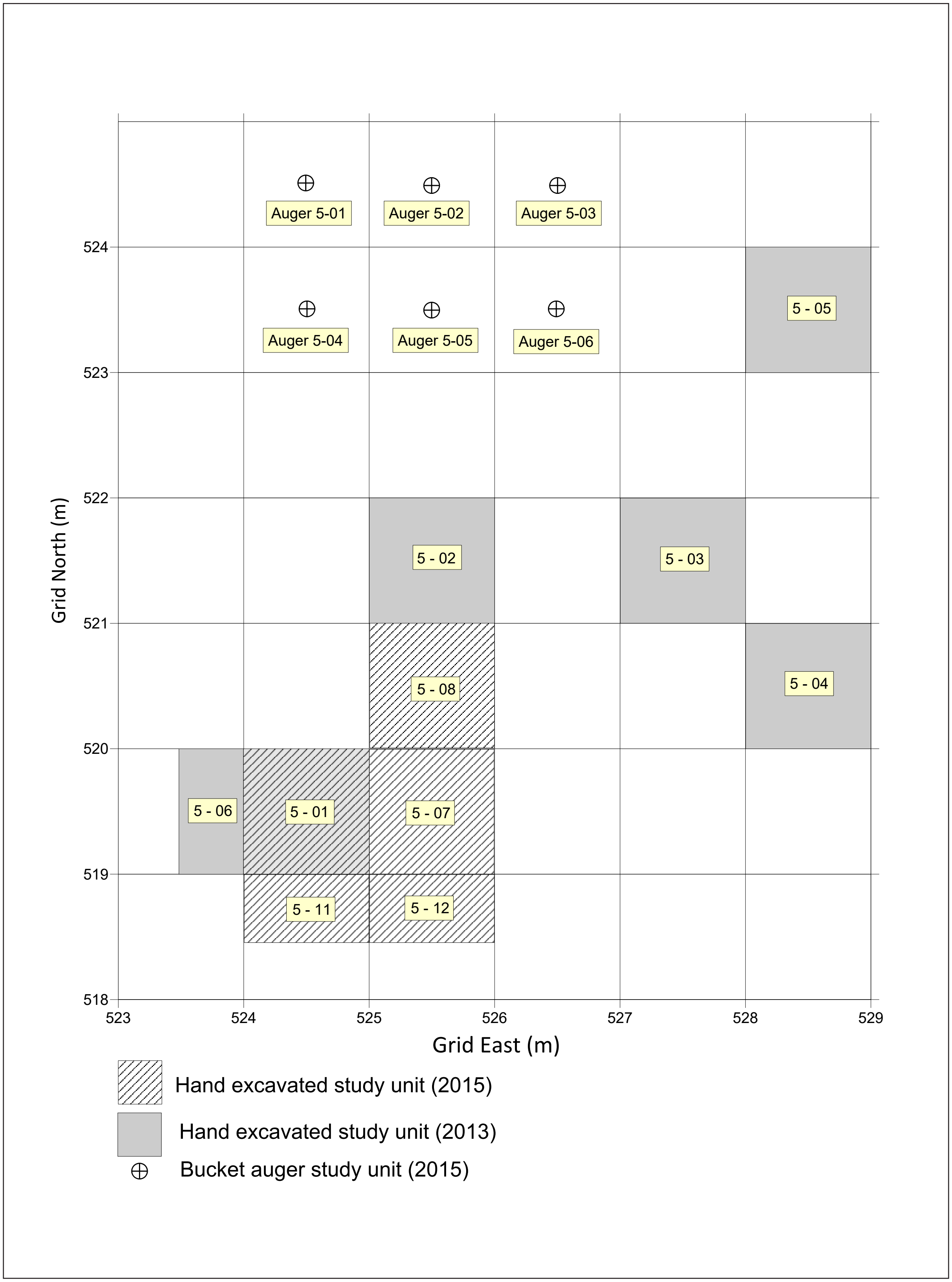


Figure 3.9. Plan map of 2015 Locus 5 excavation units.

from the same corner. By the lower half of the level (@ ~45.65–45.60 m) the matrix became increasingly sandier and the bone bed was encountered in the southwest corner of the unit at 45.61 m. Excavations were terminated at 45.60 m for this study unit.

Study Unit 5-8 (525E / 520N)

This newly excavated study unit was located immediately north of Study Unit 5-7. The matrix in the first level (Level 3; 45.80–45.70 m) was described by the excavator as moist black mat with cobbles but very few gravels. Bone "flakes" were encountered in the first 10 cm level and were collected from the 1/8-inch screen as FS 5147. A soil sample was collected from the northeast corner of the unit as FS 5150 and tooth enamel was mapped in situ near the center of the unit and collected as FS 5148. No other cultural materials were encountered in the Level 3, which ended between ~45.67 and ~45.63 m.

The second excavated level was labeled as Level 2 by the excavator but is actually assigned as Level 4 (45.70–45.60 m) based on the Locus 5 grid elevations (45.67–45.60 m) and level designations. The matrix continued to be moist, fine, silt and sand in which the black mat had formed, with 4–6 cm size gravels observed in the 1/8-inch screen. As the depth of the level increased, the color of the matrix lightened; this change was attributed to an increase in the sand content. A soil sample (FS 5153) was collected from the center of the unit and a bone sample collected from the screen was assigned FS 5152.

Level 5 (45.60–45.50 m) matrix continued as a moist, fine sandy silt with an apparent high organic content. The Munsell reading was 7.5YR 2.5/1 Black. Bone fragments, pea-sized gravel and $CaCO_3$ streaks were observed in the sediment at ~5–6 cm in depth, and bone fragments were collected in the screen as FS 5158. A sediment sample was collected from the northeast corner of the study unit as FS 5159. As bones were revealed in situ in the southwest portion of the unit, excavation tools changed from trowels to wooden tools. An *os coxae* and a metapodial were pedestalled in advance of their recovery.

Level 6 (45.50–45.40 m) was where the bone bed began to be fully revealed. The sediment matrix continued to consist primarily of moist, fine sandy silt, although the clay content began to increase slightly. The black mat (Stratum 6) continued to be evident within the level. While many bones were pedestalled prior to removal, others were only partially exposed in Level 6 and continued down into the lower level, so could not be completely pedestalled and removed in this level. Bone fragments were recovered in the 1/8-inch screen as FS 5160. A sediment sample (FS 5161) was collected from the east-center edge of the study unit, while three other bulk sediment samples were collected for radiocarbon (^{14}C) dating (FS 5163, 5164, 5165). Pollen "pinch" samples were collected in a composite (unit level) sample (FS 5162). The pinch samples, collected by Susie Smith, were recovered in the northeast and southwest corners of the study unit. Bones that were completely pedestalled and exposed were stabilized with a 50%-50% mixture of Elmer's wood glue and water prior to removal and then jacketed with plaster-impregnated bandages. Recovered bones included the metatarsal (FS 5167), a rib fragment (FS 5169), and a metacarpal (FS 5170). These bones were all recovered in the western half of the study unit (Figs. 3.10a, 3.10b).

The final level excavated in Study Unit 5-8 was Level 7 (45.40–45.293 m). Excavations in this level were undertaken only in the eastern half of the study unit, as the bone bed sloped downward from northwest to southeast and excavation work was terminated in the western half of the study unit after the completion of Level 6. The black mat sediment (Stratum 6) remained consistently the same as in the preceding level; fine sandy silt with increased clay content in the southeast corner of the study unit. A pair of maxillae were removed from the southeast quadrant as FS 5171 and bone fragments recovered in the 1/8-inch screen were collected as FS 5168. The density of 3–5 cm gravels increased toward the east and the density of poorly preserved bone fragments was very high in the southeast corner of the unit, which caused excavations to stop at 45.397 m in that area. The remaining northern two-thirds of the eastern half of the study unit were taken down to 45.408 m (north-central corner) and 45.293 m (northeast corner).

Study Unit 5-11 (524E / 518.5N)

The area excavated in this study unit is the northern half of a 1 by 1 m unit. It measured 1 m wide west-to-east and 0.5 m long from south-to-north. The reason for this configuration was due to the erosion—in prehistory—of the bone bed along the south edge of the study unit by an incising paleo-channel, and the subsequent laminar deposition of fine sedi-

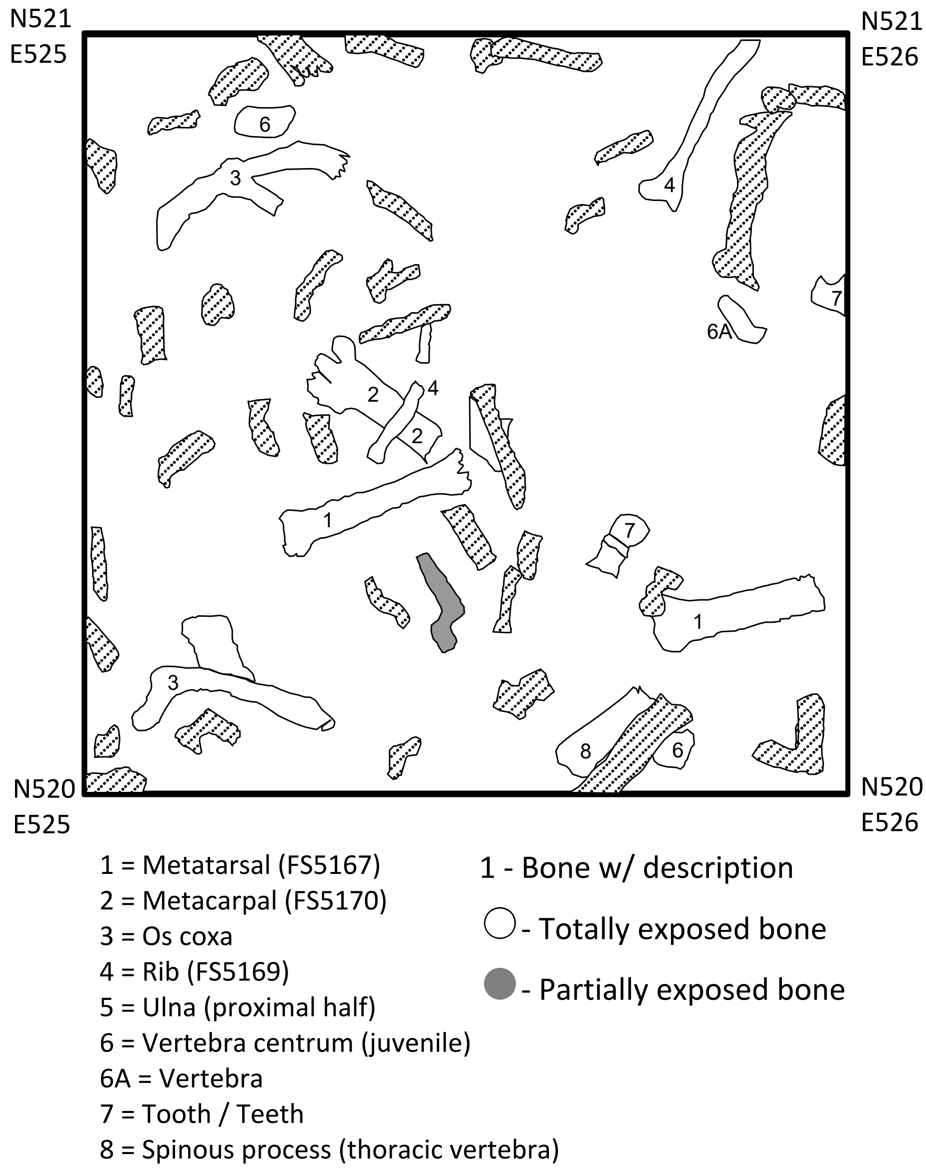


Figure 3.10a. Plan view of faunal elements in Levels 5 and 6 of Study Unit 5-8 (1 by 1 m). North is to the top of the illustration; the bone bed slopes downward from northwest to southeast.

ments as the paleo-channel re-filled with Stratum 8 sands, silts, and gravels. This is illustrated in Figure 3.11. These arroyo sediments took up approximately 20 cm, horizontally, of the southern portion of Study Unit 5-11.

The excavation in the study unit began in Level 1 (46.00–45.90 m). This study unit, actually encompassing four, 10 cm levels, was excavated down approximately 34 cm to an ending level of approximately 45.63 m, which was almost to the base of Level 4 (45.70–45.60 m). The excavated matrix consisted of sorted sand with small gravels until, at the base of the level, pebbles and cobbles were found to line the base of the paleo-channel where they were embedded in black mat sediments. Sediments were sifted through 1/8-inch screen and no cultural materials were encountered in this level.

The next "level" of excavations (45.63–45.51 m) which, according to grid elevations, encompassed portions of Levels 4 through 6 (45.70–45.50 m), pro-

Figure 3.10b. Study Unit 5-8 excavated to base of Level 5 showing faunal elements exposed in western half of unit.

ceeded down through the base of the paleo-channel, returning to black mat sediments. The matrix consisted primarily of gravels, sand, and cobbles. The faunal remains were encountered initially at 45.51 m, near the base of Level 5, where the excavation was terminated. All the faunal remains were mapped in the far northeast and southeast corners of the study unit, and included the partially excavated top of a femur, the top of a metapodial, and the top of a tooth. None of these elements could be collected as they were too poorly preserved and crumbled upon exposure to the air and upon any attempts to pedestal, glue, and plaster cast them. A sediment sample (FS 5166) was collected from the extreme western edge of the unit.

Level 6 (45.51–45.40 m) consisted of cobbles, sand, and gravel with the black mat formed within the deposit. The sediment within the black mat was a fine, sandy silt with <5% clay. It still retained a Munsell color of 7.5YR 2.5/1 Black. No cultural materials were encountered in this level.

Level 7 (45.40–44.30 m) represented the final level excavated in this study unit. It consisted of unsorted large alluvial cobbles, sand, and gravel, and was dug to the same depth as Level 7 in Study Unit 5-1 (44.36 m), in an attempt to reach the base of the black mat. The color of the sediment within which the large alluvial cobbles were embedded turned slightly grayer in places but, for the most part, the black mat continued throughout the channel deposits of Level 7.

Study Unit 5-12 (525E / 518.5N)

Study Unit 5-12 was configured the same as Study Unit 5-11 and consisted of the northern half of a 1 by 1 m unit. It was positioned to investigate the southernmost extent of the bone deposit, where the deposit had been truncated by the prehistoric incision and erosion of a paleo-channel. The subsequent infilling of the paleo-channel deposited Stratum 8 sediments in fine layers that were excavated in Level 1 (46.00–45.90 m) beginning at 46.03 m. The excavated sediments, which consisted of sorted sands with small gravels, were sifted through 1/8-inch screen until the base of the paleo-channel was encountered at 45.66 m, midway through Level 4. No cultural materials were encountered.

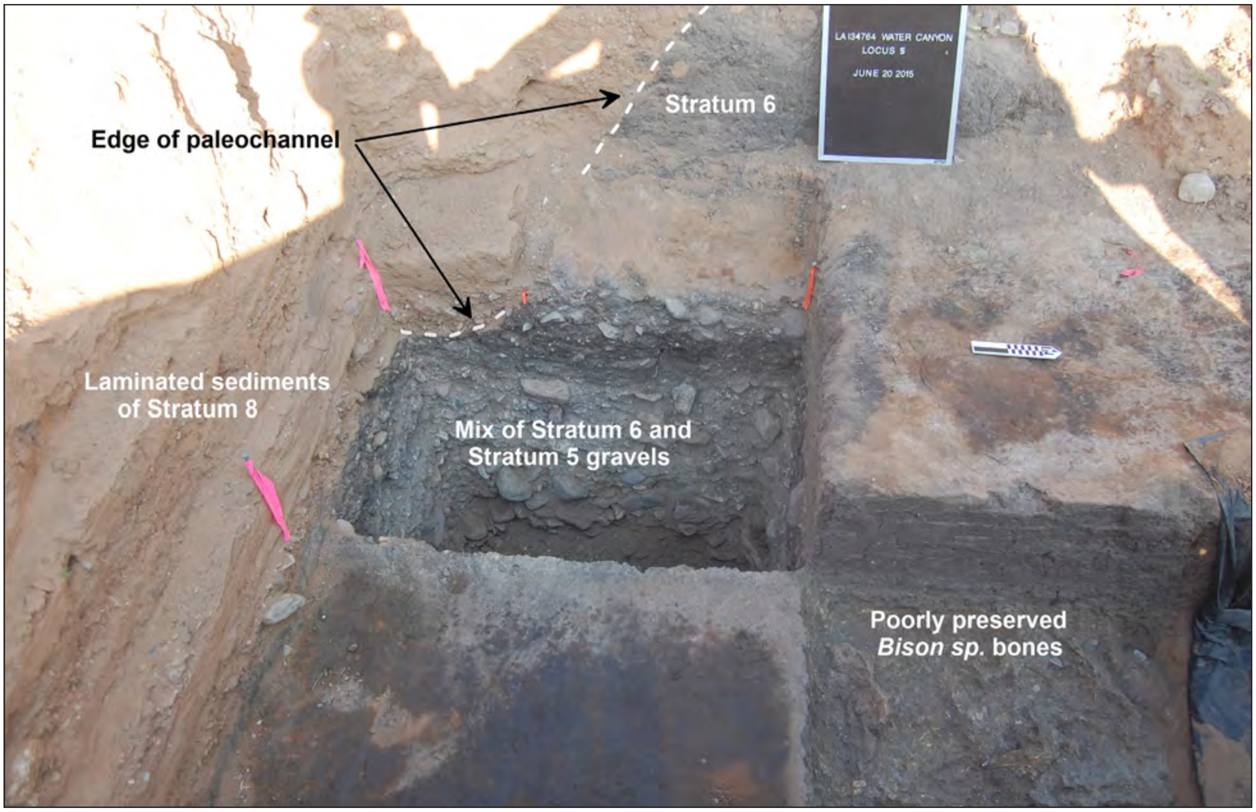


Figure 3.11. Close-up view of excavation units and paleo-channel in northwest corner of Locus 5.

The subsequent excavation, which began midway through Level 4 (45.70–45.60 m), penetrated through the base of the paleo-channel and into sandy, gravelly sediments in which the black mat had developed, with mottled patches of lighter, gray clay and higher sand content in the lower half of the level. Sediments were again sifted through 1/8-inch screen and bone fragments collected in the screen were designated as FS 5156. A rib fragment (FS 5157) was recovered in situ in the northwest corner of the unit at 45.714 m. The excavation of this study unit ended at the extreme upper end of Level 5 (at 45.59 m grid elevation).

Hand-Auger Tests in Locus 5

Six hand-auger tests were completed in Locus 5 during the 2015 field school, on June 6. Each of these auger tests were placed in the center of an unnumbered study unit at the north end of Locus 5 (*see* Fig. 3.9) and the results of these tests, presented in Table 3.5, indicate that the black mat (Stratum 6) extends across Locus 5 to the north. In addition, the *Bison* sp. bone bed extends across Locus 5 to the north as well, if the faunal remains and tooth recovered from hand-augers #5-4, #5-5 and #5-6 are indications of that same bone bed. The faunal remains and tooth in those hand-auger locations were recovered at 40–60 cm below the ground surface, or at 45.42–45.62 m grid elevations, which are roughly equivalent to Levels 5 and 6 in Locus 5. These are entirely consistent with the grid elevations of *Bison* sp. bones encountered in Study Unit 5-8, 3 m to the south-southwest. The *Bison* sp. tooth recovered in hand-auger #5-5 was collected as FS 5146.

Mechanical core 12-8, in the northeast quadrant of Locus 5 and completed in 2012, reached faunal material at 45.20 m (base of Level 8). Moreover, our excavation experience in 2013 revealed that the bone bed extended west beyond the limits of Locus 5. However, no mechanical soil cores to the west or east of Locus 5 produced any faunal remains, so the bone bed probably does not extend to any great degree in those directions. To the south of the bone bed, the paleo-arroyo truncated the feature and, to date, no other faunal remains have been observed in No Name Arroyo that could have been associated with the Locus 5 bone bed. These findings, taken together

Table 3.5. 2015 descriptive and locational data for hand-auger results in Locus 5.

Auger No. / N / E	Depth bgs (cm)	Grid elevation (m)	Recovery	Sediment description	Comments
5-1 / 524.5 / 524.5	0 – 10	46.039 – 45.930	Ø	7.5YR 2.5/1; Very fine sandy silt; < 1% poorly rounded gravels; black	High organic content, black mat
"	10 – 20	46.939 – 45.839	Ø	7.5YR 2.5/1Very fine sandy silt; < 1% angular gravels; Black	High organic content, black mat
"	20 – 30	45.839 – 45.739	Ø	7.5YR 2.5/1 ; Very fine sandy silt; trace clay; < 1% rounded & poorly rounded gravels; Black	High organic content, black mat
"	30 – 40	45.739 – 45.639	Ø	7.5YR 2.5/1; Very fine sandy silt; trace clay; < 1% rounded & poorly rounded gravels; Black	High organic content, black mat
"	40 – 50	45.639 – 45.539	Ø	7.5YR 2.5/1 ; Very fine sandy silt; 3-5% rounded & poorly rounded gravels; Black	Noticeable increase in gravel; gravel increasing in size & volume
"	50 – 60	45.539 – 45.439	Ø	7.5YR 2.5/1 ; Very fine sandy silt; 20-30% sub-angular gravels; Black	Gravel content increases in size & volume
"	60 – 70	45.439 – 45.339	Ø	Interface between maximum depth of black mat and underlying gravels	---
"	70 – 80	45.339 – 45.239	Ø	10YR 5/2; Terminal level; 10-20% angular gravel; greyish-brown	Size & volume of gravel increasing
5-2 / 524.5 / 525.5	0 - 10	46.065 – 45.965	Ø	7.5YR 2.5/1 Black; very fine sandy silt; 1% small angular gravel	Black mat; high organic content
"	10 – 20	45.965 – 45.865	Ø	7.5YR 2.5/1 Black; sandy silt; <1% gravel	Black mat; high organic content
"	20 – 30	45.865 – 45.765	Ø	7.5YR 2.5/1 Black; fine sandy silt; >1% gravel w/ a few sub-angular particles	Gravel increasing w/ depth; still in black mat; high organic
"	30 – 40	45.765 – 45-665	Ø	7.5YR 2.5/1 Black; fine sandy silt; 3-5% sub-angular gravel	Observable CaCO3; Black mat; high organic matter
"	40 – 50	45.665 – 45.565	Ø	7.5YR 2.5/1 Black; fine sandy silt; decrease in gravel	Black mat; high organic matter; sparse gravel
"	50 – 60	45.565 – 45.465	Ø	7.5YR 2.5/1 Black; fine sandy silt; decrease in gravel; CaCO3 in very small amount	Black mat; high organic; sparse gravel
"	60 – 70	45.465 – 45.365	Ø	7.5YR 2.5/1 Black; sand silt w/ increase in sand; 35% sub-rounded pebbles;	Black mat; high organic material
"	70 – 76	45.365 – 45.300	Ø	Due to rock @ 76 cm depth - Terminated	---
5-3 / 524.5 / 526.5	0 – 10	46.088 – 45.988	Ø	7.5YR 2.5/1; black; Fine, sandy silt; <1% gravels	Black mat; very little gravel, <1% total volume
"	10 – 20	45.988 – 45.888	Ø	7.5YR 2.5/1; black; Fine, sandy silt; <10% granular to pea size gravels; 2% pea size to 2 cm	Black mat; gravels have CaCO3
"	20 – 30	45.888 – 45.788	Ø	Fine, sandy silt; <1% total volume gravel	Black mat; gravel level 1% and decreasing

Table 3.5 *(continued)*

Auger No. / N / E	Depth bgs (cm)	Grid elevation (m)	Recovery	Sediment description	Comments
"	30 – 40	45.788 – 45.688	Ø	Fine, sandy silt; <1% total volume gravel	Black mat; gravel level 1% and decreasing
"	40 – 50	45.688 – 45.588	Ø	Fine, silty, sandy, moist; < 1% gravels; CaCO3	Black mat
"	50 – 60	45.588 – 45.488	Ø	Fine, silty, sandy, moist; 4% gravels pea size to 2 cm; CaCO3	Black mat
"	60 – 70	45.488 – 45.388	Ø	Fine, silty, sandy, moist; 4-5% pea size gravels; CaCO3	Black mat
"	70 – 80	45.388 – 45.288	Ø	Fine, silty, sandy, moist; 4-5% pea size gravels; CaCO3	Black mat
"	80 – 90	45.288 – 45.188	Ø	Terminated due to rock	Black mat
5-4 / 523.4 / 524.5	0 – 10	46.020 – 45.920	Ø	7.5YR 2.5/1 black; very fine sandy silt w/ 3-5% sub-angular gravels	Black mat; high organic content
"	10 – 20	45.920 – 45.820	Ø	7.5YR 2.5/1 black; fine sandy silt w/ 10% sub-angular gravels	Black mat; high organic content; increased silt
"	20 – 30	45.820 – 45.720	Ø	7.5YR 2.5/1 black; fine sandy silt w/ 5% sub-angular gravels	Black mat
"	30 – 40	45.720 – 45.620	Ø	7.5YR 2.5/1 black; medium sandy silt w/ 10% sub-angular gravels; a few pebbles	Black mat
"	40 – 50	45.620 – 45.520	Faunal	7.5YR 2.5/1 black; medium sandy silt w/ 15% sub-angular gravels; w/ more granular pebbles	Faunal sample not collected; Black mat
"	50 – 60	45.520 – 45.420	Faunal (bone)	Coarse, sandy silt w/ 15% sub-angular gravels with pebbles	Faunal sample not collected; Black mat
"	60 – 70	45.420 – 45.320	Ø	Coarse, sandy silt w/ 15% sub-angular gravels with gray gravels and cobbles	Black mat
5-5 / 523.5 / 525.5	0 – 10	46.52 – 46.42	Ø	Black mat	----
"	10 – 20	46.42 – 46.32	Ø	Black mat	----
"	20 – 30	46.32 – 46.22	Ø	Black mat	----
"	30 – 40	46.22 – 46.12	Ø	Black mat	----
"	40 – 50	46.12 – 46.02	Ø	Black mat	----
"	50 – 60	46.02 – 45.97	Faunal (teeth)	Terminated at faunal sample; Black mat	Faunal sample collected as FS 5146
5-6 / 523.5 / 526.5	0 – 10	45.90 – 45.80	Ø	Black mat	----
"	10 – 20	45.80 – 45.70	Ø	Black mat	----
"	20 – 30	45.70 – 45.60	Ø	Black mat	----
"	30 – 40	45.60 – 45.50	Ø	Black mat	----
"	40 – 50	45.50 – 45.40	Ø	Black mat	----
"	----	45.45	Faunal (unknown)	Terminated a grid level of faunal sample (45.45 m)	Faunal sample not collected

with the results of the six hand-auger tests, suggest that the size of the bone bed most likely approaches, or possibly exceeds, 50 sq m in area, but not by much.

Mapping and Collection of Surface Artifacts in Locus 2, Locus 6, and Areas In-between

Beginning on May 28, 2015, and continuing on June 4, 7, 10, 11, 14, 19, and 20, a total of 144 surface artifacts were mapped with the total station and collected during the field school. These were collected from Locus 2 (n = 54), Locus 3 (n = 3), Locus 4 (n = 6), Locus 6 (n = 71) and from some areas between the designated loci (n = 10). The artifacts from these latter locations were given "SA" (surface artifact) field sample numbers (and most were subsequently given FS numbers). For the most part, locational and descriptive data for these surface artifacts were documented, although the quality of these data was irregular and, as a consequence, those data for some of the artifacts are not represented evenly. The data for all the collected artifacts are presented in tables that are referenced below. The majority of surface artifacts were collected from Locus 2 and Locus 6. These two loci likely represent the remains of prehistoric activity areas and are discussed in greater detail below.

Additional Field Discoveries in Locus 2

The surface artifacts in Locus 2 were found on a relatively high elevation landform (interfluvial ridge) in the central portion of the site, between the Big Wash and No Name Arroyo. Among these artifacts was one gray dacite projectile point, discovered by Dr. Richard Chapman during the 2015 field school, which was assigned a Gypsum type designation (FS 2003), named by Harrington (1933). In west-central New Mexico, this point type is thought to have been utilized between 4000 and 2800 cal yr BP (late Middle Archaic to early Late Archaic period). This point type is similar in morphology to the Augustin point recovered and named by Dick (1965) at nearby Bat Cave (7000–5000 BP) and to the Manzano point recovered and named by Hibben (1941) from nearby Manzano Cave (4000–2800 BP). A more recent summary of Gypsum points in southwestern New Mexico and the Plains of San Agustin has been produced by Formby (1986), where the average lengths of Gypsum points recovered from those locations were 28 mm and 26 mm, respectively. The remaining Locus 2 assemblage consisted of 54 collected flake stone artifacts which consisted of a majority of red silicified rhyolite irregular cores and flakes, yellow silicified rhyolite irregular cores and flakes (a few cortical), two obsidian probable flakes, one quartz (quartzite?) irregular core, one chalcedony flake, and seven red silicified rhyolite biface fragments. Descriptions and locational data for these artifacts are presented in Table 3.6. The assemblage, as described, represents the remains of core reduction, biface manufacture, and probable tool production. As such, it suggests that weapon refurbishment was the activity that took place at this location, during the middle-to-late Holocene.

Of additional interest, in Locus 2, is the change that occurred in surface patterning over time (between surface mapping 2015 and surface mapping 2009) as can be seen when comparing Figure 3.12a and Figure 3.12b, respectively. The frequencies of artifacts in the main Locus 2 concentrations of each map are essentially the same (~50), and the constituents of each assemblage are similar (cores, bifaces, flakes). However, a significant number of artifacts appear to have moved from the northeast downhill to the southwest. This underscores the dynamic nature of the sediments at the Water Canyon site. After significant downpours at the site, we have generally sought to revisit the various surface loci in the hopes of finding newly exposed artifacts. At Locus 2, the dacite Gypsum point was found in 2015 and, while apparently visible and mapped in 2009 as a biface, was not identified as a temporally diagnostic projectile point.

Additional Field Discoveries in Locus 6 and Environs

During the 2015 field school, Patrice Walker supervised a student survey and mapping effort across Locus 6 and along the slope of the terrace landform on which Locus 6 is situated. This area of the site had never before been sufficiently inspected, but casual walk-overs, followed by a more intensive investigation by Dr. Michael Collins, had verified that the locale contained a noteworthy number of interesting artifacts. The results of the survey and field collection efforts produced an interesting artifact assemblage, the locational and descriptive data for which are pro-

Table 3.6. Descriptive and locational data for surface lithic artifacts in Locus 2.

Sample FS No.	Locational Data			Description / Comments
	Grid Easting (m)	Grid Northing (m)	Grid Depth (m)	
2001	482.110	538.426	51.831	Obsidian (flake?)
2002	480.483	543.306	52.119	Obsidian (flake?)
2003	450.387	559.317	53.473	Gypsum point / dacite
2004	456.529	562.042	53.058	Red rhyolite biface
2005	496.073	528.587	50.467	Red rhyolite flake in lithic scatter
2006	505.896	519.914	49.783	Yellow rhyolite flake in lithic scatter
2007	491.681	526.188	50.633	Grey transparent chalcedony flake
2008	492.555	543.438	51.564	Red rhyolite flake
2009	485.152	541.426	51.800	Orange rhyolite flake
2010	482.792	545.413	52.076	White quartz (quartzite?) core
2011	480.787	543.034	52.081	Red rhyolite flake
2012	484.849	556.178	52.092	Yellow rhyolite flake with cortex
2013	479.257	554.038	52.374	Red rhyolite flake
2014	481.181	556.503	52.258	NON-CULTURAL
2015	465.190	540.193	52.541	Yellow rhyolite core
2016	464.224	539.614	52.588	Yellow rhyolite core
2017	468.871	537.847	52.477	Red rhyolite flake
2018	469.126	539.659	52.432	Yellow rhyolite core
2019	478.000	528.785	52.134	Yellow rhyolite flake
2020	501.400	522.126	50.200	Yellow rhyolite flake
2021	471.941	539.714	52.286	Yellow rhyolite flake
2022	458.655	523.214	53.001	Red rhyolite flake
2023	459.303	526.841	52.826	Red rhyolite flake
2024	454.136	523.403	53.212	Yellow rhyolite flake
2025	456.697	513.421	52.580	Red rhyolite flake
2026	456.838	513.142	52.547	Red rhyolite flake
2027	454.155	537.072	52.828	Red rhyolite flake
2028	459.863	540.235	52.477	Red rhyolite flake
2029	455.456	539.728	52.692	Red rhyolite flake
2030	447.688	529.256	53.293	Red rhyolite flake
2031	449.625	536.633	52.941	Yellow rhyolite flake with cortex
2032	450.734	532.617	53.044	Yellow rhyolite flake
2033	450.237	534.159	53.001	Yellow rhyolite flake
2034	445.213	530.386	53.357	Rhyolite flakes (cluster of 3)

(Table 3.6 *continues*)

Table 3.6 *(continued)*

Sample FS No.	Locational Data			Description / Comments
	Grid Easting (m)	Grid Northing (m)	Grid Depth (m)	
2035	445.810	521.830	53.451	Rhyolite flakes (cluster of 2)
2036	444.329	522.758	53.493	Red rhyolite flake
2037	439.792	526.456	53.653	Rhyolite flakes (cluster of 2)
2038	461.804	531.698	52.681	Yellow rhyolite flake
2039	458.682	533.068	52.768	Red rhyolite flake
2040	457.870	533.634	52.786	Red rhyolite flake
2041	439.309	524.000	53.685	Red rhyolite flake
2042	436.389	517.552	53.677	Red rhyolite flake
2043	432.297	517.765	53.841	Red rhyolite flake
2044	429.265	521.942	54.037	Red rhyolite biface
2045	431.831	526.440	53.915	Red rhyolite flake
2046	430.601	527.231	53.958	Yellow rhyolite flake
2047	432.140	538.519	53.399	Rhyolite core
2048	435.582	537.118	53.442	Yellow rhyolite flake
2049	519.464	518.697	49.305	Red rhyolite biface
2050	462.642	560.994	52.885	Red rhyolite biface
2051	462.595	560.829	52.887	Red rhyolite biface
2052	462.708	559.554	52.892	Red rhyolite biface
2053	460.437	563.164	52.921	Yellow rhyolite flake
2054	459.710	563.174	52.935	Red rhyolite biface
2055	467.102	556.139	52.755	Red rhyolite biface

vided in Table 3.7. The spatial distribution of the assemblage, as mapped in 2015, is illustrated in Figure 3.13a.

The combined assemblage from Locus 6, and partly from Locus 3, includes 82 artifacts, of which only 67 are clearly identified. These are composed primarily of mahogany red or mustard yellow silicified rhyolite flakes (n = 28). Both of these raw materials are locally available. The former material is found at the Black Canyon Quarry (Dello-Russo 2004) about 20 km to the southwest of the site and the latter can be found lying on the surface of the nearby valleys of the Socorro Mountains. The remainder of the flakes are made of chert (n = 8), chalcedony (n = 5), and obsidian (n = 3). Perhaps more importantly, the assemblage includes a relatively high percentage of tools, including: projectile points or point fragments (n = 4); bifaces and unifaces (n = 8); end-scrapers, a spurred end-scraper, and side-scrapers (n = 9); one graver; and one small, possible ground stone mortar. Of additional interest concerning the scrapers is that at least six of them are refurbished broken blade fragments. This, according to Collins (1999) is a hallmark of the Clovis culture and suggests, therefore, that a portion of Locus 6 was utilized as a hide-processing location during Clovis times. This interpretation is supported, in part, by the nearby presence of two Clovis projectile points.

It is likely that the artifact distribution continues to the northeast, beyond the old boundary fence illustrated in Figure 3.13a. EMRTC restricted our access to the southwest side of the fence, so we were un-

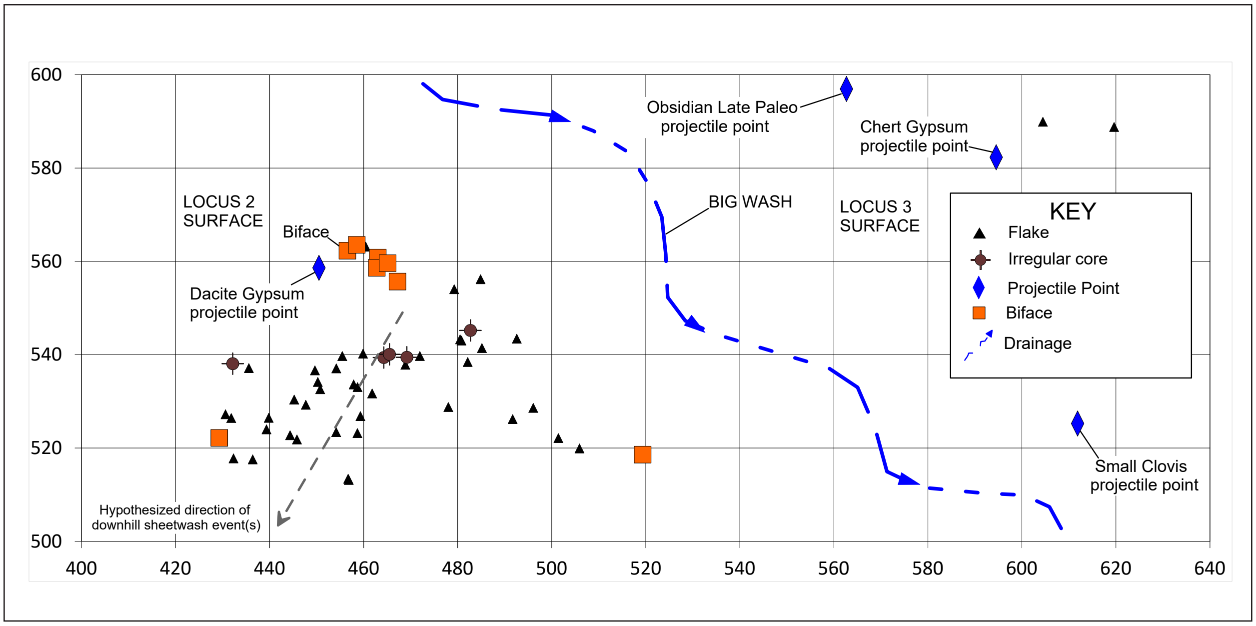


Figure 3.12a. Plan map of 2015 surface artifact distribution in Locus 2; north is to the top of the illustration.

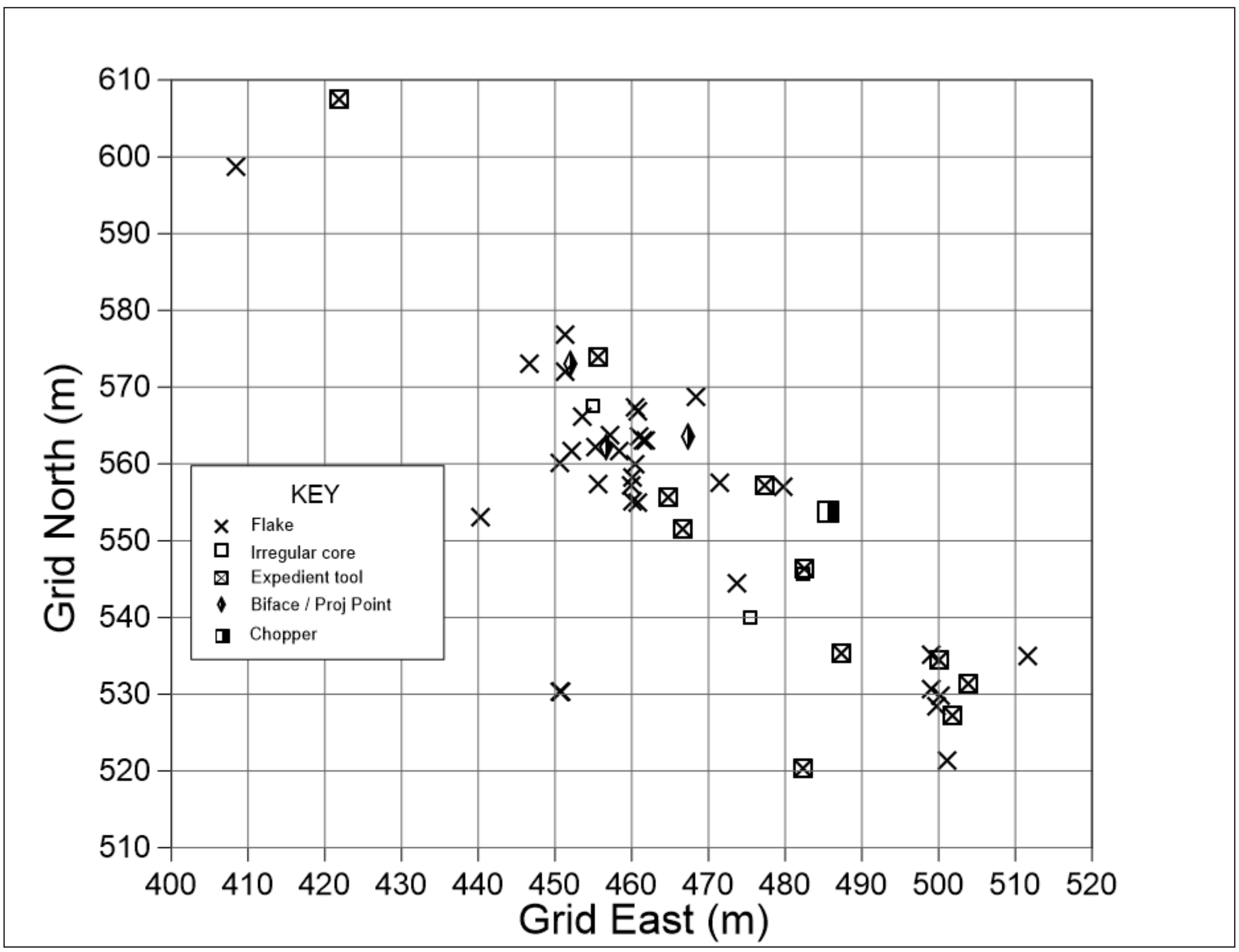


Figure 3.12b. Plan map of 2009 surface artifact distribution in Locus 2.

Table 3.7. Descriptive and locational data for surface lithic artifacts in Locus 6 and adjacent localities.

Sample FS No.	Locational Data			Description / Comments
	Grid Easting (m)	Grid Northing (m)	Grid Depth (m)	
6001	576.303	664.769	54.789	Folsom base fragment / Red rhyolite?
6002	538.139	685.910	56.116	Clovis blade – end-scraper / black & tan chert
6005	696.694	56.102	696.694	---
6006	695.815	56.093	695.815	---
6007	692.463	55.930	692.463	---
6008	705.250	55.643	705.250	---
6009	707.285	55.623	707.285	---
6010	---	---	---	Obsidian flake / surface
6011	688.752	55.366	688.752	Obsidian flake
6012	685.685	55.359	685.685	Yellow chert expedient flake
6013	679.496	54.825	679.496	Tan-orange chert uniface
6014	679.443	54.598	679.443	Chalcedony end-scraper
6015	691.304	54.981	691.304	Mustard chert scraper
6016	680.972	54.074	680.972	Red rhyolite biface - distal fragment
6017	671.028	53.912	671.028	Black basalt drill or biface tip
6018	665.478	53.802	665.478	Notched chert graver
6019	655.054	53.505	655.054	Tan chert flake
6020	603.817	626.62	52.328	Sparkling chalcedony
6021	579.851	645.483	53.666	Red-brown chert end-scraper
6022	570.275	644.602	53.892	Red rhyolite flake -heat treated?
6023	568.414	640.858	53.704	Red rhyolite flake
6024	569.061	636.314	53.478	Chalcedony flake with rind
6025	563.624	640.479	53.629	Orange-red rhyolite expedient flake
6026	568.084	649.839	54.115	Red rhyolite edge scraper
6027	570.43	649.122	54.03	Red rhyolite edge scraper
6028	570.455	649.128	54.021	Red rhyolite edge scraper
6029	566.488	655.302	54.305	Red rhyolite biface fragment
6030	563.985	653.556	54.365	Orange-red chert proximal flake
6031	556.794	665.185	54.715	Orange-tan chert flake
6032	546.261	661.425	54.802	----
6033	524.545	674.246	54.956	Tan spurred end-scraper
6034	514.114	676.816	55.411	Orange chalcedony flake
6035	502.259	681.185	55.885	Speckled red chert flake
6036	499.353	693.368	56.296	Black chert flake
6037	506.379	703.813	56.037	Large orange-tan chert flake
6038	516.658	716.577	55.67	Mortar?
6039	500.371	713.87	55.91	Yellow flake

Table 3.7 *(continued)*

Sample FS No.	Locational Data			Description / Comments
	Grid Easting (m)	Grid Northing (m)	Grid Depth (m)	
6040	499.664	713.111	55.941	Red flake
6041	499.128	713.984	55.936	Red flake
6042	499.424	715.215	55.886	Red flake
6043	500.634	717.403	55.806	Red flake
6044	498.377	718.205	55.805	Red flake
6045	498.229	717.466	55.83	Red flake X 2
6046	497.256	714.772	55.901	Red flake
6047	497.813	712.615	55.959	Chert flake (possible biface)
6048	497.609	712.517	55.974	Red flake
6049	496.768	712.805	55.954	Red flake
6050	495.804	713.353	55.941	Red flake
6051	495.343	714.361	55.919	Red flake
6052	494.493	718.384	55.829	Red flake (cortex present)
6053	494.456	720.066	55.779	Red flake (possible biface w. retouch present)
6054	494.097	718.111	55.832	Red flake (uniface)
6055	493.116	716.99	55.885	Red rhyolite biface flake
6056	491.467	718.612	55.838	Red rhyolite biface flake
6057	493.122	715.692	55.875	Red rhyolite uniface flake
6058	493.02	714.802	55.946	Red flake
6059	493.383	714.711	55.914	Red flake
6060	493.792	714.362	55.919	Red flake
6061	494.656	713.318	55.945	----
6062	495.776	713.289	55.945	----
6063	492.869	712.292	55.997	----
6064	492.182	712.759	55.968	----
6065	487.897	704.627	56.191	Red rhyolite spurred end-scraper
6066	485.588	707.594	56.108	Yellow rhyolite flake
6067	481.947	705.512	56.197	Red rhyolite flake
6068	457.13	705.547	56.327	Chalcedony flake
6069	453.161	710.697	56.269	Orange-tan chert biface
6070	430.906	733.209	56.396	Tan chert expedient tool on blade flake
6071	488.004	697.691	56.298	Yellow chert uniface
6072	476.240	681.360	56.162	1 red rhyolite flake / 1 yellow rhyolite flake
6075	594.667	582.810	48.960	Gypsum projectile point / red-white chert / SA-001
6076	611.763	525.995	45.758	Clovis projectile point / complete / small size / SA-003
6077	562.840	597.542	48.426	Obsidian Late Paleo point / SA-006
SA-007	639.894	463.275	45.616	Obsidian
SA-008	541.615	441.040	48.498	Chalcedony

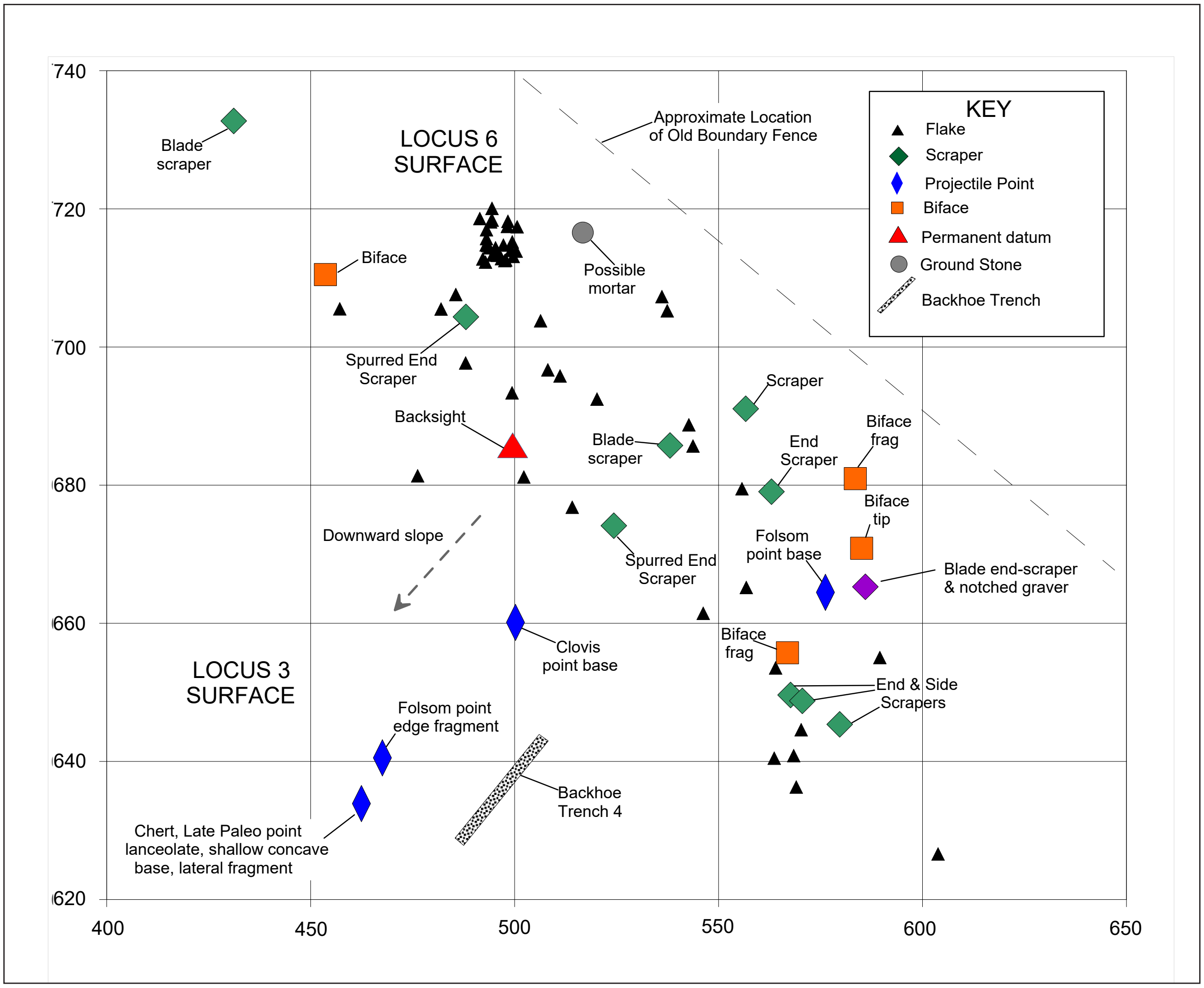


Figure 3.13a. Plan map of 2015 surface artifact distribution in Locus 6; north is to the top of the illustration.

able to continue surveying, mapping and collecting beyond to the northeast.

As is further apparent in Figure 3.13a, the surface artifacts are distributed across both Locus 6 (an upper, old and stable, Pleistocene-age surface) and on part of Locus 3 (a lower terrace related to the development of the Big Wash within the Magdalena Fan). Locus 3 is located between 4 and 7 m below Locus 6, and it is likely that the Clovis and Folsom artifacts on Locus 3 were originally part of Locus 6 and have washed down as the southwestern edge of the upper surface eroded back (to the northeast) over time.

Thus, when considering the dynamics of site formation processes between the upper Pleistocene fan terrace and the lower alluvial terrace, it is useful to examine the south-to-north stratigraphic profile from BHT-4 that is shown in Figure 3.13b. There it can be seen that sediments on Locus 3 contemporary with a potential Folsom occupation (ca. 12,300 cal yr BP; Surovell et al. 2016 suggest a range of 12,610 to 12,170 BP) are now buried 0.80 m below the current ground surface. Thus, it is much less likely that Folsom (or earlier Clovis) artifacts would have been deposited on the surface of Locus 3 during those respective periods and somehow worked their way to the surface by the present time, and more likely that the artifacts associated with those cultures would have washed down from the higher, adjacent surface of Locus 6, which has been stable since the Pleistocene.

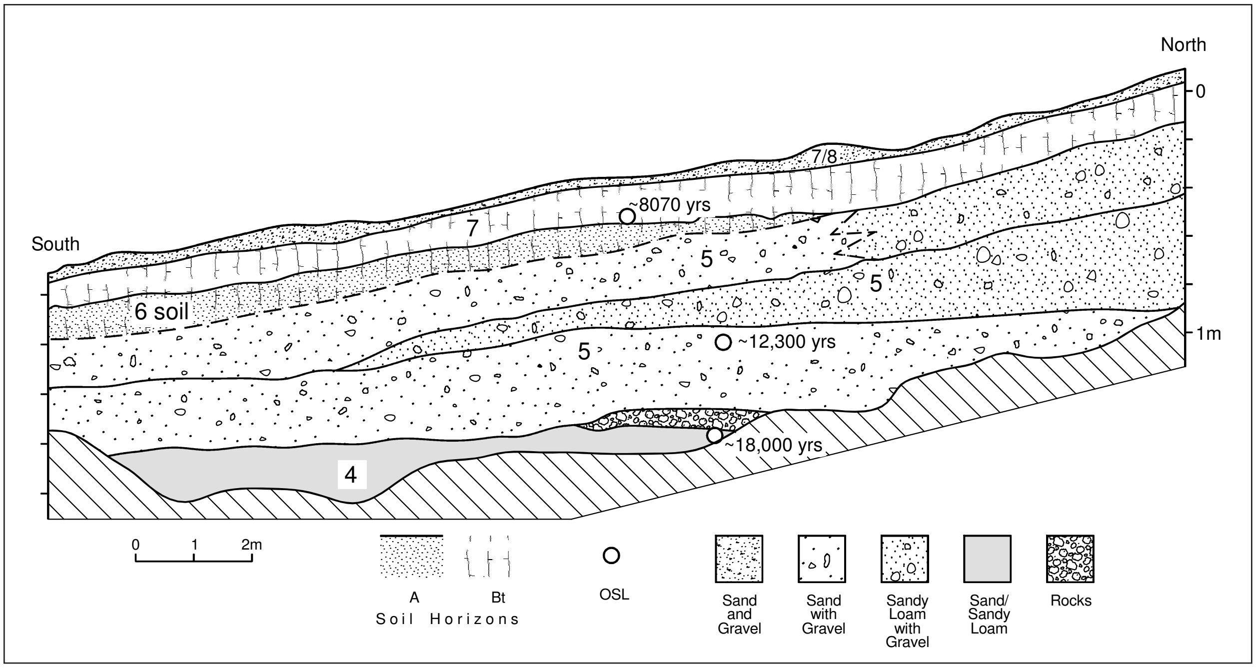


Figure 3.13b. BHT-4 west wall profile.

Continued Mechanical Coring and Hand Augering

During the previous 2013 field season, we observed possible fossil wet meadow (black mat) deposits in the cut bank of a small arroyo that courses from west-to-east across the north edge of Locus 4, suggesting that the artifact scatter documented in Locus 4 represents the remains of a late Paleoindian camp at the edge of the wet meadow. We also currently suspect that the bone deposit in Locus 5 rests in an ancient meander of the site's "Big Wash." This and the cut bank exposure of the black mat near Locus 4 (observed in 2013) suggest that the ancient meander may have continued over into the lower gradient area between Locus 1, Locus 5, and Locus 4, and may contain additional black mat deposits and, possibly, additional faunal or other cultural deposits.

Accordingly, in 2015, additional mechanical coring efforts were undertaken by Vance T. Holliday and Andy Richard, using the Giddings rig, in the relatively low-gradient area between Locus 1, Locus 5, and Locus 4. Sediments from the mechanical cores were examined for evidence of the black mat, cultural deposits and faunal remains, and sampled, when possible, for chronometric and micro-botanical data. The locations of the core holes were mapped using the total station.

Twenty-six new mechanical soil cores were completed for the 2015 field session and the locations of these cores are illustrated in Figure 3.14. The locational data for these cores are provided in Table 3.8. From these, sediment and soil horizons were described and these descriptions are provided in Appendix B. Cores 15-1 through 15-19 were drilled from Locus 1 southeast along a swale toward Locus 4; Cores 15-20 through 15-26 were drilled along the northwest bank of the small arroyo near Locus 4. In addition, on May 31, 2015, Vance T. Holliday and Robert Dello-Russo drilled two hand-augered sediment cores into the banks of the Big Wash well east of the site for the purposes of collecting Stratum 6 (black mat) sediments outside the site boundaries to provide additional data to refine our understanding of the paleo-wet meadow deposits (*see* Figs. 3.14, 3.15). Locational data for these were originally taken by GPS, then converted to grid coordinates and added to Table 3.8. Two bulk sediment samples (FS 1330, 1331) were collected from these hand-augers and sent for radiocarbon dating. No descriptions of these auger samples are available.

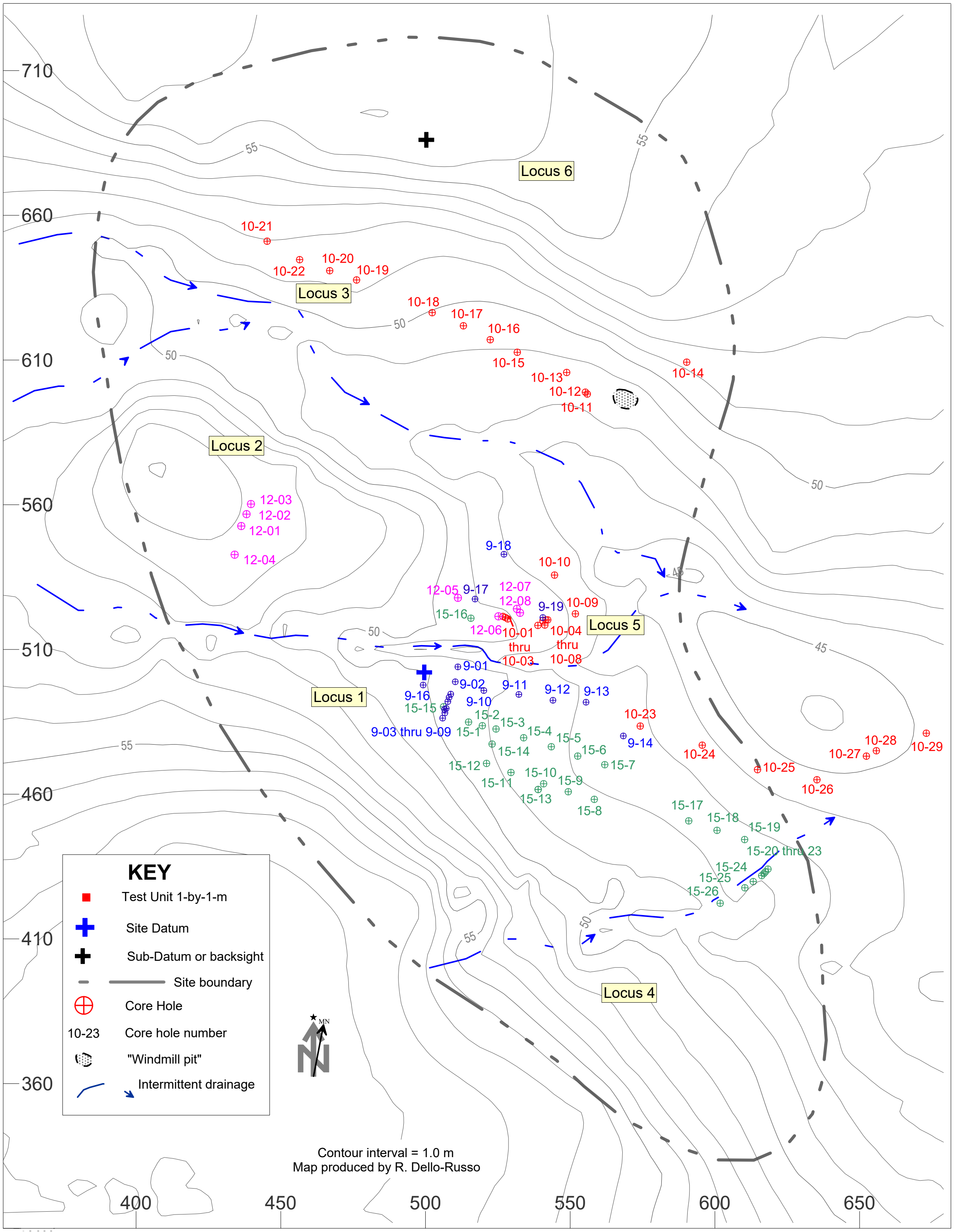


Figure 3.14. Locations of mechanical and hand-excavated sediment cores.

Table 3.8. Locational data for 2015 mechanical cores and hand-augers.

Core or Auger No.	Locational Coordinates		
	Grid Easting (m)	Grid Northing (m)	Grid Elevation (m)
Core 15-01	514.881	484.916	49.321
Core 15-02	519.638	483.655	49.126
Core 15-03	524.372	482.522	48.885
Core 15-04	533.918	479.492	48.485
Core 15-05	543.473	476.393	48.168
Core 15-06	552.596	473.160	47.841
Core 15-07	561.945	470.183	47.604
Core 15-08	558.333	458.213	48.103
Core 15-09	549.335	460.846	48.205
Core 15-10	540.820	463.598	48.415
Core 15-11	529.531	467.494	48.846
Core 15-12	521.091	470.626	49.223
Core 15-13	538.927	461.615	48.558
Core 15-14	523.017	477.320	48.975
Core 15-15	506.225	490.194	49.811
Core 15-16	515.691	520.792	49.305
Core 15-17	590.962	450.778	47.641
Core 15-18	600.735	447.501	47.229
Core 15-19	610.272	444.320	46.984
Core 15-20	618.341	434.110	47.037
Core 15-21	617.483	433.212	47.051
Core 15-22	616.935	432.593	47.110
Core 15-23	616.185	431.857	47.155
Core 15-24	613.245	429.794	47.392
Core 15-25	610.344	427.655	47.479
Core 15-26	601.825	422.312	47.768
Auger 15-1	829.612	370.332	38.360
Auger 15-2	951.120	439.867	40.800

Figure 3.15. Dello-Russo and Holliday hand-augering, with Andrew Richard assisting, for Stratum 6 samples in Big Wash.

Lidar Mapping of Locus 1 North during the 2015 Field School

By Level 9 (48.00–47.90 m) in Locus 1 North, the sediment was easily identifiable as the black mat (Stratum 6B). As in other study units for this project, this was also where the bone deposits and associated lithic tools and artifacts had been increasing in frequency. As a consequence, on Sunday, June 14, 2015, at a point when the field school students had taken a break from excavating in Locus 1 North, Dr. Dello-Russo brought Jed Frechette, a principal of the Lidar Guys, based in Albuquerque, NM, to the site to do some Lidar imaging of the Locus 1 North excavation block. The original idea for this experiment was to create a data point cloud of sufficient density to allow for the "printing" of a three-dimensional model of the excavation block itself. Sadly, it was later discovered that such a "3-D print" would be prohibitively expensive to produce. Nevertheless, this effort generated a very high-resolution point-cloud and a rotating, three-dimensional video of Locus 1 North, as it appeared at that point of excavation, with some excavation tools and pedestaled bones in place. This end product of our efforts included a short video of

Figure 3.16 (facing):
the full video is available for viewing at
https://oca.unm.edu/media/wc_lidar_locus_1.mp4

the excavation that rotates, enabling the viewer to see into the excavations in progress (Fig. 3.16).

Backfilling Excavated Areas during the 2015 Field School

All hand-excavated study units were backfilled on the final day of the 2015 field session (June 27, 2015), with the exception of Study Unit 1-6, which was backfilled with screened sediments and sandbags on June 18, 2015. Backfilling was a multi-step process: filled sandbags, measuring approximately 12" x 24" and weighing approximately 18 kgs (~40 lbs) each, were stacked in layers within the excavated study units in both Locus 5 and Locus 1 (Fig. 3.17) For those study units within which bison bone had been exposed but had not been recovered, the exposed bone was left in situ, covered with several centimeters (5–15 cm) of fine, re-screened gray back-dirt sediments to provide a contrast with the grey-brown sediments at the excavation base, and then covered with black plastic sheeting. The plastic sheeting was then weighted in place with large cobbles (15–25 cm). Sandbags were then stacked over this plastic and, as with all the excavation study units, these sandbags were layered until they reached nearly to the level of the current ground surface, at which point all of the sandbags within the excavation blocks were covered with large sheets of black plastic and then backfilled by hand with several centimeters (10–20 cm) of back dirt until the sediments reached a level which matched the current ground surface. The study units located in Locus 1 South, which were quite shallow, were simply backfilled with back-dirt sediments.

Sampling for Chronometric and Paleo-Environmental Proxy Aliquots

On October 1, 2015, a small crew including Dr. Dello-Russo, Christian Solfisburg, Evan Kay, and Evan Sternberg (all from OCA) returned to Locus 1 to clean the north wall profile of Study Unit 1-47 (on the north side of No Name Arroyo) for the purpose of collecting phytolith/diatom samples (FS 1633–1643) and bulk sediment radiocarbon samples (FS 1644–1647).

Figure 3.16. Stationary image from Lidar Guys video of Locus 1 North excavation block, 2015; view to west.

Figure 3.17. Staging and laying sandbags in Locus 1 North during the 2015 Field School.

These samples are all listed and described in Table 3.9. The cleaned profile on the north wall of Study Unit 1-47 is illustrated in Figure 3.18. In the north wall profile of Study Unit 1-47, the base of the gray-green stratum (Stratum 6) had coordinates on the west side of the unit (at N512.458m / E510.992m / Z47.273m) and on the east side of the unit (at N512.446m / E511.901m / Z47.214m).

To develop a more robust understanding of the evolution of the landforms upon and within which the Water Canyon site is located, and to aid in the reconstruction of past floral communities and the refinement of our understanding of localized climatic change over the Pleistocene-Holocene transition, sediment samples were systematically recovered from both hand-excavated and mechanically cored localities. Aliquots (sub-samples) were partitioned from these samples for chronometric data, and for proxy paleo-environmental materials, such as pollen, phytoliths, and diatoms. In addition, a series of micromorphological sediment samples were collected from the south wall profile of Study Unit 1-6 in Locus 1 along the south side of No Name Arroyo. The proxy paleo-environmental sediment samples (for the recovery of pollen, phytoliths, and diatoms) were pulled from both the south wall of Study Unit 1-6 and from the newly cleaned profile on the north wall of Study Unit 1-47 along the north side of No Name Arroyo. Phytolith and diatom samples were also previously recovered from Study Unit 5-3 in Locus 5. The bulk sediment chronometric samples, together with the proxy paleo-environmental and micromorphological samples are listed in Table 3.9.

Chronometric Samples

Twenty-seven samples were collected in 2015 for radiocarbon (^{14}C) dating, including bulk sediment (soil or-

Table 3.9. Descriptions and locational data for 2015 chronometric, paleoenvironmental, and micromorphological samples.

FS No.	Sample Type	Study Unit / Level	Locational Data			Comments
			Grid Easting (m)	Grid Northing (m)	Grid Depth (m)	
1195	Diatoms / Phytoliths	SU 1-6 / L9	509	509	48.00 – 47.90	Bulk sed
1197	Diatoms / Phytoliths	SU 1-6 / L10	509	509	47.90 – 47.80	Bulk sed
1202	Diatoms / Phytoliths	SU 1-6 / L11	509	509	47.80 – 47.70	Bulk sed
1203	Diatoms / Phytoliths	SU 1-6 / L12	509	509	47.70 – 47.60	Bulk sed
1211	Diatoms / Phytoliths	SU 1-6 / L13	509	509	47.60 – 47.50	Bulk sed
1217	Diatoms / Phytoliths	SU 1-6 / L14	509	509	47.50 – 47.40	Bulk sed
1219	Diatoms / Phytoliths	SU 1-6 / L15	509	509	47.40 – 47.30	Bulk sed
1229	Diatoms / Phytoliths	SU 1-6 / L16	509	509	47.30 – 47.20	Bulk sed
1249	Diatoms / Phytoliths	SU 1-6 / L17	509	509	47.20-47.10	Bulk sed
1317	Radiocarbon (^{14}C)	4 – 52 cm below surface	549.335	460.846	47.755 – 47.685	Core 15-9 middle / Giddings rig / bulk sed
1318	Radiocarbon (^{14}C)	65 – 73 cm below surface	549.335	460.846	47.555 – 47.475	Core 15-9 lower / bulk sed
1319	Radiocarbon (^{14}C)	40 – 45 cm below surface	549.335	460.846	47.805 – 47.755	Core 15-9 upper / bulk sed
1320	Pollen	56 – 62 cm below surface	549.335	460.846	48.205 (surf)	Core 15-9 / Giddings rig / bulk sed
1321	Pollen	73 – 78 cm below surface	549.335	460.846	48.205 (surf)	Core 15-9 / Giddings rig / bulk sed
1327	Radiocarbon (^{14}C)	SU 1-23 / L1	499.072	485.403	50.232	Locus 1S – Bulk sed from center west side in rock ring - check for charcoal
1330	Radiocarbon (^{14}C)	N/A	829.612	370.332	N/A	Core 15-1 / VTH Big Wash
1331	Radiocarbon (^{14}C)	N/A	951.120	439.867	N/A	Core 15-2 / VTH Big Wash
1342	Radiocarbon (^{14}C)	SU 1-19 / L4	512.487	507.690	48.182	-----
1348	Radiocarbon (^{14}C)	SU 1-19 / L4	512.387	507.447	48.171	-----
1350	Radiocarbon (^{14}C)	SU 1-19 / L4	512.837	507.855.	48.162	-----
1358	Radiocarbon (^{14}C)	SU 1-31 / L2	511.320	504.081	48.561	-----
1360	Radiocarbon (^{14}C)	SU 1-31 / L2	511.151	504.174	48.565	-----
1365	Radiocarbon (^{14}C)	SU 1-34 / L2	512.365	504.399	48.515	-----
1414	Radiocarbon (^{14}C)	SU 1-43 / L1	498.479	488.898	50.190	-----
1415	Radiocarbon (^{14}C)	SU 1-43 / L1	498.443	488.875	50.181	-----
1438	Radiocarbon (^{14}C)	SU 1-45 / L2	510.420	506.844	48.200	-----
1441	Radiocarbon (^{14}C)	SU 1-19 / L6	512.229	507.547	47.894	-----
1474	Radiocarbon (^{14}C)	SU 1-34 / L6	512.739	504.442	48.179	-----
1478	Radiocarbon (^{14}C)	SU 1-15 / L10	511.597	507.892	47.937	-----
1484	Radiocarbon (^{14}C)	SU 1-20 / L3	512.079	506.426	48.016	-----
1494	Pollen	SU 1-15 / L9	511.00	507.000	48.00 – 48.10	Bulk sed
1495	Pollen	SU 1-45 / L2	510.545	506.334	48.141	Pollen from under FS1510 (tibia)
1527	Radiocarbon (^{14}C)	SU 1-20 / L9	512.684	506.889	47.914	-----

(Table 3.6 *continues*)

Table 3.9 *(continued)*

FS No.	Sample Type	Study Unit / Level	Locational Data			Comments
			Grid Easting (m)	Grid Northing (m)	Grid Depth (m)	
1557	Micromorphology	SU 1-6 / L12	509.825	509.076	47.690	Elevation taken @ base of Electric Junction Box (EJB)
1558	Micromorphology	SU 1-6 / L12	509.767	509.052	47.606	Elevation taken @ base of EJB
1559	Micromorphology	SU 1-6 / L13	509.862	509.052	47.552	Elevation taken @ base of EJB
1560	Micromorphology	SU 1-6 / L14	509.773	509.047	47.481	Elevation taken @ base of EJB
1616	Radiocarbon (^{14}C)	SU 1-20 / L4	512.656	506.188	47.903	-----
1625	Radiocarbon (^{14}C)	SU 1-20 / L5	512.840	506.585	47.839	PL-1 & PL-2 represent one bone [1]
			512.729	506.656	47.878	
1632	Diatoms / Phytoliths	SU 1-47 [4] / L15	511.349	512.501	47.317	For phytolith, diatom analyses
1633	Diatoms / Phytoliths	SU 1-47 [4] / L15	511.319	512.506	47.368	For phytolith, diatom analyses
1634	Diatoms / Phytoliths	SU 1-47 [4] / L14	511.346	512.502	47.490	For phytolith, diatom analyses
1635	Diatoms / Phytoliths	SU 1-47 [4] / L13	511.345	512.513	47.557	For phytolith, diatom analyses
1636	Diatoms / Phytoliths	SU 1-47 [4] / L12	511.332	512.507	47.660	For phytolith, diatom analyses
1637	Diatoms / Phytoliths	SU 1-47 [4] / L11	511.353	512.506	47.744	For phytolith, diatom analyses
1638	Diatoms / Phytoliths	SU 1-47 [4] / L15	511.464	512.482	47.329	For phytolith, diatom analyses
1639	Diatoms / Phytoliths	SU 1-47 [4] / L15	511.454	512.504	47.363	For phytolith, diatom analyses
1640	Diatoms / Phytoliths	SU 1-47 [4] / L14	511.458	512.508	47.470	For phytolith, diatom analyses
1641	Diatoms / Phytoliths	SU 1-47 [4] / L13	511.485	512.537	47.543	For phytolith, diatom analyses
1642	Diatoms / Phytoliths	SU 1-47 [4] / L12	511.516	512.563	47.629	For phytolith, diatom analyses
1643	Diatoms / Phytoliths	SU 1-47 [4] / L11	511.445	512.551	47.709	For phytolith, diatom analyses
1644	SOM	SU 1-47 / L16	511.828	512.521	47.230	Collected for 14C dating
1645	SOM	SU 1-47 / L15	511.830	512.489	47.352	Collected for 14C dating
1646	SOM	SU 1-47 / L13	511.785	512.482	47.532	Collected for 14C dating
1647	SOM	SU 1-47 / L12	511.777	512.495	47.648	Collected for 14C dating
5005	Diatoms / Phytoliths	SU 5-3 / L1	521.93	527.91	45.980	Bulk sed
5059	Diatoms / Phytoliths	SU 5-3 / L2	521.903	527.843	45.871	Bulk sed
5095	Diatoms / Phytoliths	SU 5-3 / L4	527.838	521.778	45.696	Bulk sed
5123	Diatoms / Phytoliths	SU 5-3 / L6	527.841	521.9	45.479	Bulk sed
5162	Pollen	SU 5-8 / L6	525.000	520.000	45.495 – 45.404	Pollen "pinch" samples [2]
5171	Radiocarbon (^{14}C)	SU 5-8 / L1	525.679	520.398 (520.540? in total station record)	45.318	2 (maxillary?) molars [3]

[1] Sample cut into 3 pieces: Sent FS1625A to ICA (no collagen – no date); FS 1625B delivered to Prufer & UC Irvine (extremely small amount of collagen – no date); Largest fragment (1625C) sent to ICA (collagen extracted).

[2] From NE & SW corners of unit / grid elevations indicate Level 6. Level forms suggest Level 5.

[3] Un-erupted one sent for dating on 10-07-15 to K. Prufer (UNM) pre-treatment lab then to S. Newsome (UNM) isotope lab / then to Irvine AMS ^{14}C lab.

[4] These Study Units were incorrectly listed as SU1-46 in Yost/Appendix C: Table 1, p. 4; and in Winsborough/Appendix D: Table 1, p. 22.

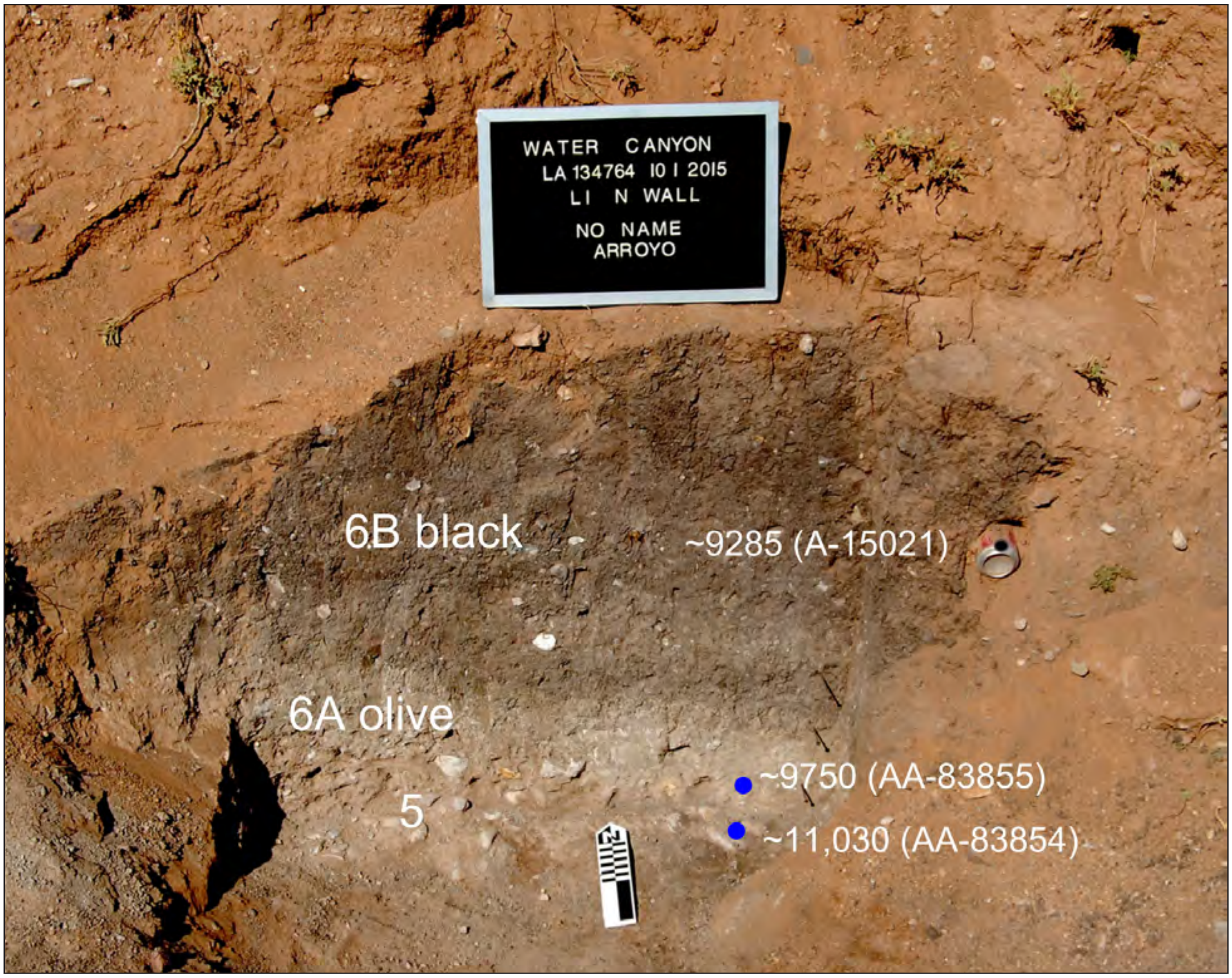


Figure 3.18. North wall profile of Study Unit 1-47.

ganic matter), charcoal, and bone and tooth (collagen) samples collected from Locus 1 North (*see* Fig. 3.18), Locus 1 South, and Locus 5. These are listed and briefly described in Table 3.9, and include FS 1317–1319, 1327, 1330, 1331, 1342, 1348, 1350, 1358, 1360, 1365, 1414, 1415, 1438, 1441, 1474, 1478, 1484, 1527, 1616, 1625, 1644–1647, and 5171. Not all of these samples returned dates, however. For example, some of the bone or tooth samples (e.g., FS 1625A, 1625B, 5171) contained insufficient collagen to provide a date. The radiocarbon dates for those samples that did return dates are presented and summarized, along with their calibrated dates, in Chapter 4 of this report (*see* the "Summary of New Chronometric Dates" section). A number of these dates were utilized together to develop an age-depth model, also discussed in Chapter 4 of this report (*see* the "Age-Depth Modeling" section), to assist in the interpretation of the proxy paleo-environmental samples. Finally, see Appendix G ("Chronometric Analyses") of this report for individual sample results from the analyzing laboratories.

Pollen Samples

Pollen samples were collected in 2015 from Core 15-9 (N460.846 / E549.335) at 56–62 cm below ground surface (bgs) (FS 1320) and at 73–78 cm bgs (FS 1321). Three additional pollen samples were recovered as "pinch" samples from the sediments immediately below the bison bones in both Locus 1 and Locus 5. One was taken in Study Unit 1-45 at

48.141 m (FS 1495) as a composite sample from directly beneath two point-located ends of a tibia (FS 1510). A second was taken in Study Unit 1-15, in culturally rich Level 9, as FS 1494, and the third was taken as a composite sample in Study Unit 5-8 from the southwest and northeast corners of the unit, between 45.495 and 45.400 m, as FS 5162. These samples were collected by Susie Smith but, to date, these have not yet been analyzed.

Phytolith Samples

Phytolith samples were collected from both Locus 1 and Locus 5 in a stratigraphic manner. The four samples from Locus 5 came from Study Unit 5-3 during the 2013 excavation and were recovered from Levels 1 (FS 5005), 2 (FS 5059), 4 (FS 5095), and 6 (FS 5123). Those from Locus 1 came from Study Unit 1-6 and were recovered in 2012 from Levels 9 through 17 (FS 1195, 1197, 1202, 1203, 1211, 1217, 1219, 1229, 1249). An additional three phytolith samples were collected in 2015 from Study Unit 1-47, Level 14 (FS 1634) and Level 15 (FS 1632 and 1633). The phytolith analysis and report on the analytical results were completed by Chad Yost; that full report is provided as Appendix C of this report.

Diatom Samples

Sixteen sediment samples were collected during field sessions in 2012, 2013, and 2015 from Locus 1 (south wall of Study Unit 1-6, Levels 9–17; and Study Unit 1-47, Levels 14–15; FS 1195, 1197, 1202, 1203, 1211, 1217, 1219, 1229, 1249, 1632, 1633, 1634) and from Locus 5 (Study Unit 5-3, Levels 1, 2, 4, 6; FS 5005, 5059, 5095, 5123) to investigate their diatom content and to determine the nature of the paleoenvironments the diatoms represent. A total of 1,368 diatom valves and fragments of valves were found and, of these, 22 different diatom species were recognized. The diatom analysis was completed and reported by Dr. Barbara Winsborough, and her report is provided as Appendix D of this report.

Soil Micromorphological Samples

On June 18, 2015, a series of four micromorphological samples (FS 1557–1560) were collected by Dr. Dello-Russo and Christian Solfisburg (OCA), and the collection locations ranged from just above the contact of the black mat with the grey-green gleyed sediment, down across the transition and into the gleyed sediment (Fig. 3.19; Levels 12, 13, 14; 47.690–47.481 m). Due to the hardness and compact nature of the sediment, these samples were recovered by driving metal electric junction boxes into the sediment profile. These sediment samples were collected with the hopes that a micromorphological analysis of thin-sections derived from these samples would shed light on the depositional and post-depositional history of Stratum 6. Stratum 6 was of primary interest because virtually all of the buried cultural materials (faunal and lithic) were recovered within the stratum. The thin sections showed subtle differences in the lithology of Stratum 6 in Locus 1, enabling us to subdivide the stratum in Locus 1 into Stratum 6A and Stratum 6B (Holliday et al. 2019:19; *see* Figure 3.18, above, for the visual distinction between the two). The junction box samples were sent to Spectrum Petrographics in Vancouver, WA, to be impregnated with resin and then sent to Drs. Susan Mentzer and Paul Goldberg at the University of Tübingen, Institute for Archaeological Sciences, in Tübingen, Germany, for thin-sectioning and analysis. Further discussion of their analytical results is presented in Chapter 4 of this report (*see* the "Micromorphological Analysis" section); their full analysis is provided as Appendix F in this report.

2016 Fall Field Session and the SUAV Mapping Effort

On October 10, 2016, Scott Gunn (Office of Contract Archeology), Patrice Walker (Escondida Research Group, LLC), Tim Wester (A Line of Flight Video, LLC), and Mike Abernathy and Carolyn Galceran (both of Rapid Imaging Software, Inc.) accompanied Dr. Dello-Russo to the site to utilize an Inspire 1 model small, unmanned, aerial vehicle ("SUAV"), or drone, for the production of digital maps of the site (Figs. 3.20a, 3.20b).

It was quite a gusty day, so the time required for the drone vehicle to cover the entire site was greater than originally anticipated and necessitated frequent battery recharging. Nevertheless, the day was a complete success and products included a high-resolution topographic map of the Water Canyon site—where topo points were taken at every 3 cm—and a series of short video flyovers of the site as well.

Figure 3.19. Micromorphology sample collection locations in south wall of Study Unit 1-6.

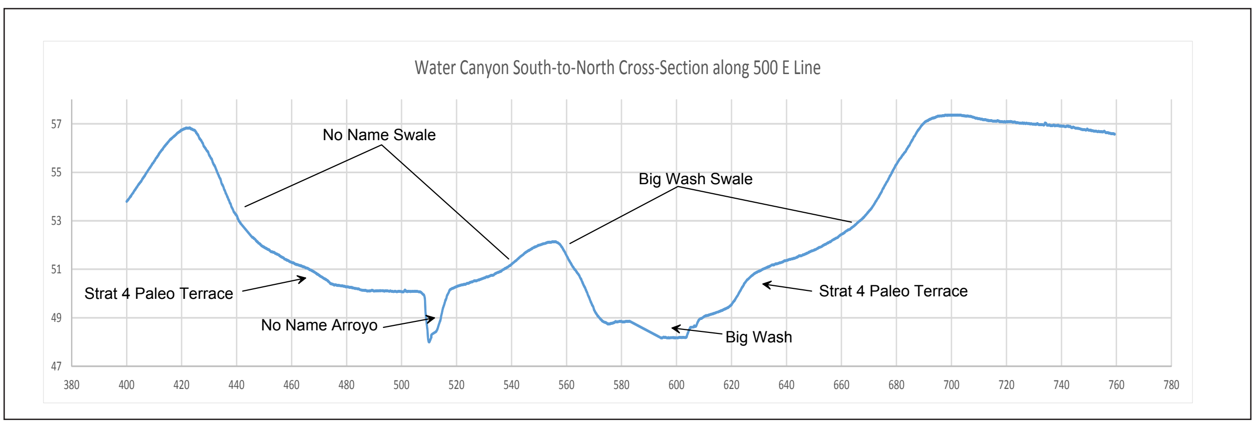
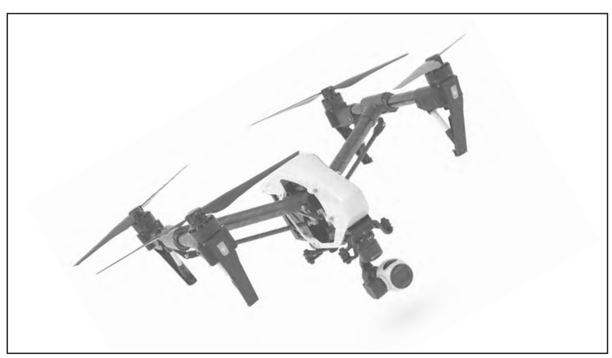


Figure 3.20a. Drone-data-generated site profile; vertically exaggerated south-to-north cross section of the Magdalena alluvial fan at the Water Canyon main site datum. Below, Figure 3.20b. Inspire 1 SUAV.

From the topographic map, it was possible to generate cross-section profiles at any position on the site landscape. The south-to-north cross-section illustrated in Figure 3.20a was taken across the 500 East line (thus cutting across the main site datum at 500 East / 500 N). Our original topographic map of the site was created in 2009 using a total station and a hand-held prism, the latter of which was moved across the site by a "rod-man" at approximate 1 m intervals. That work took approximately three days to complete. In



contrast, the 2016 drone mapping took about three hours to complete, and the drone cross-section enabled us to discern fine-grain topographic details, such as the Stratum 4 paleo-terrace (*see* Fig. 3.20a), that were not evident in the older topographic map, and barely evident on the ground to the naked eye, yet were important in understanding the landscape evolution of the site (Holliday et al. 2019).

FOUR

Laboratory Analyses—Brief Summaries and Interpretations of Results

Phytolith Analysis

The analysis of the phytolith samples—conducted by Chad L. Yost, PAST, LLC (*see* Appendix C)—also documented the occurrence of both platy evaporite crystals and microscopic charcoal particles in samples dated to the Bolling-Allerod (BA). The evaporites were probably transported by wind to Water Canyon from a dessicating basin, while the charcoal particles reflect increases in regionally and locally sourced fires during the late fall or spring due to fuel loading from dried-out summer grass populations and increased lightning activity from summer thunderstorms. Accordingly, the presence of both the evaporites and the microscopic charcoal in the Water Canyon sediment record reflect a dry regional climate at the time of the BA. Both the evaporites and charcoal were much reduced by the time of the Younger Dryas (YD).

Also observed in the Water Canyon samples were varying amounts of microscopic volcanic glass shards termed cryptotephra. Subtle cryptotephra peaks were noted in FS 1249 and FS 1217. Of particular interest here is the potential for detection of cryptotephra from the Mount St. Helens (Swift Creek) and Glacier Peak Cascade Range eruptions (13.74–13.45 cal ka BP). The cryptotephra observed in the Water Canyon samples could be potential isochrons for the dating of the BA-aged sediments if increased sampling resolution and tephra optimized separation techniques are utilized.

As summarized by Yost in Appendix C,

> The combined pollen and phytolith data indicates [sic] that the Water Canyon site during the BA consisted of a relatively narrow riparian zone lined with C3 grasses and sedges. The surrounding piedmont consisted of a juniper grassland ecotone comprised of a mix of C4 mesophytic Panicoideae and C4 xerophytic Chloridoideae grasses that were supported by higher than modern summer precipitation. Towards the termination of the BA, there may have been a substantial drop in summer precipitation as Panicoideae grass abundance (was) significantly reduced. The relatively high abundance of C3 grasses, sedges and tallgrass C4 Panicoideae may have made the Water Canyon drainage preferable to grazers over lower elevation C4 shortgrass habitats for much of the BA.

As for the YD, Yost goes on to observe that,

> there are numerous regional paleoenvironmental records, including the phytolith record (at Water Canyon), that indicate a switch from an initially cool and dry YD to a wetter period starting around 12,300 BP. The Scholle wet meadow, located ~100 km northeast of Water Canyon, was active between 12,300 and 11,100 BP (Hall et al. 2012). Polyak et al. (2004) using speleothem growth rates from the Guadalupe Mountains in southeastern New Mexico conclude that significantly increased precipitation was in place by at least 12,500 BP. The phytolith record from Water Canyon also is indicative of an initially cool and seasonally dry start to the YD, followed by an increase in precipitation sometime between 12,500 and 12,000 BP.

Finally, to summarize Yost in Appendix C, the grass and sedge taxa during the early Holocene represented a broad category of wetland complexes or alliances that varied seasonally as semi-permanently flooded wetlands along an elevation gradient. As precipitation and temperature changed over time, these paleo-wetlands are thought to have succeeded from one type of alliance to another. The presence of a dense graminoid community consisting of C3 grasses, sedges, and tallgrass C4 Panicoideae grasses in the Water Canyon drainage likely made this a preferable place for large mammals to graze, especially during the early Holocene. Despite apparent regional drying between

10,000 and 9500 cal yr BP [as seen in a soil organic matter δ13C record from central New Mexico (Hall and Penner 2013)], the Water Canyon site maintained its high-water table at least seasonally to support a very dense grassland community. This may have maintained the Water Canyon site as a regional refuge for grazing herbivores, and as a preferred prey location for big-game hunters, well into the early Holocene.

Diatom Analysis

According to Barbara Winsborough, Winsborough Consulting (*see* Appendix D), diatom assemblages similar to those from wet intervals at Water Canyon are reported from black mats at the Lubbock Lake and Blackwater Draw sites (Harris-Parks, 2014). The Water Canyon diatom data suggest that the Water Canyon wetland ecosystem was repeatedly re-established during the time interval of 12,327 cal yr BP through 9730 cal yr BP, but there was not a time when there was permanent standing water. This suggests a climate that was predominantly dry (cold and dry in the winter and warmer and wetter in the summer) with an aquifer that may have been sustained by snowmelt and where groundwater discharge may have been in the form of diffuse seeps. Such moisture would have supported mosses and some larger emergent plants, so the site was generally defined by damp, humid conditions at the time the diatoms were alive. Some of the diatom assemblage could also describe a spring-fed meadow, or cienega, with saturated soils supporting abundant macrophytes.

Tuber Starch and Bone Marrow Lipid Residues on the Oldest Slab Groundstone Anvil in New Mexico

The lithic artifact assemblage recovered in association with the bones from Locus 1 North included 141 unutilized debitage flakes, three retouched or utilized flakes, four bifaces, four multipurpose tools, five scrapers, and two projectile point or hafted knife fragments, as well as a small, modified slab grinding/anvil implement made of sandstone (FS 1343).

The modified slab's surfaces had both striations and planed high points, suggesting that it had been used for grinding activities. Numerous impact areas were also identified on the slab, suggesting that it had also been utilized as an anvil stone. This latter functional interpretation was reinforced by the recovery of a spatially associated hammerstone (FS 1382). The hammerstone impacts to the slab are thought to have been derived during bone breakage for marrow recovery. The hammerstone impacts, which occurred after the grinding wear, also eventually broke the slab. Analysis by Linda Scott Cummings (PaleoResearch Institute, Inc.) indicates that both starch and lipid residues were preserved on the slab (*see* Appendix E), suggesting that the slab had been used to process tubers and bone marrow, respectively. The slab and the hammerstone are illustrated in Figures 4.1a and 4.1b, respectively.

The groundstone/anvil slab, along with the other types of artifacts in the Locus 1 North assemblage, and together with hearth charcoal, burned/calcined bone, and a number of long bones that exhibited percussion marks, bone flakes, and green-bone fracture edges comprise what we infer to be the remains of two open-air activity areas utilized for bison processing during the Late Paleoindian (Allen-Frederick?) and the Cody (Eden) periods (Dello-Russo et al. 2021). The slab grinding/anvil artifact is most closely asso-

Figure 4.1a. Plan, oblique, and cross-section views of combination slab grinding/anvil implement (FS 1343; ca 9300 cal yrs BP = Allen-Frederick?) recovered in Locus 1 North.

Figure 4.1b. Hammerstone (FS 1382) recovered in Locus 1 North and found in association with the slab grinding/anvil tool shown in Fig. 4.1a; scale is in cm.

ciated with the stratigraphically uppermost activity area. The affiliation of the upper open-air activity area with a possible Allen-Frederick occupation and the stratigraphically lower activity area with a possible Cody (Eden) era occupation are based on the probable dates of the bone beds themselves, at ~8200 ^{14}C yr BP and ~9200 ^{14}C yr BP, respectively. The Locus 1 North Allen-Frederick–era date conforms well with the 9350–7900 ^{14}C yr BP (or 11,000–9400 cal yr BP) range suggested by Pitblado (2007:p. 112) for Allen-Frederick in the southern Rocky Mountains. Unfortunately, no temporally diagnostic artifacts were found in direct association with either of the Locus 1 North bone beds.

As of the date of this publication, the association of the slab grinding/anvil artifact with the ~8200 ^{14}C yr BP date makes it the *oldest such artifact* ever recovered in New Mexico!

Micromorphological Analysis of Stratum 6 (Black Mat)

The analytical results by Drs. Susan Mentzer and Paul Goldberg at the University of Tübingen, Institute for Archaeological Sciences, in Tübingen, Germany, are presented in Appendix F.

In their report, Mentzer and Goldberg stated (*see* pp. 7–8, Appendix F):

> In sum, the observations suggest a general timeline for the formation of (the Stratum 6) sequence:
>
> 1. Deposition of the lower unit by water, likely multiple events
> 2. Bioturbation and obliteration of much of the original laminated fabric in the lower unit
> 3. Deposition of the upper unit
> 4. Wetting and compaction of the lower unit
> 5. Complete gleying of the lower unit, with partial gleying of the base of the upper unit
> 6. Drying of the two units, with formation of secondary carbonates, illuvial clay coatings, and possible development of a weak angular blocky structure due to subsequent soil formation.
>
> It is possible that steps 3, 4, and 5 were related to a single event, and thus the deposition of the upper unit is contemporaneous with a rise in the water table that impacted both units.

Summary of New Chronometric Dates

During the 2015 field session, 27 samples were collected for AMS (Accelerator Mass Spectrometry) radiocarbon (^{14}C) dating. These samples included: bulk sediment, from which the soil organic matter (SOM) would be dated; charcoal; and bones and teeth, from which collagen would be dated. The samples were collected from Locus 1 North, Locus 1 South, and Locus 5 (FS 1317–1319, 1327, 1330, 1331, 1342, 1348, 1350, 1358, 1360, 1365, 1414, 1415, 1438, 1441, 1474, 1478, 1484, 1527, 1616, 1625, 1644–1647, 5171). Not all of the aforementioned samples were submitted for chronometric dating and not all of the submitted samples returned dates. For example, some of the bone or tooth samples (e.g., FS 1625A, 1625B, 5171) contained insufficient collagen to provide a date. As it turned out, many of the bones from Locus 1 North had dateable collagen, while none of the bones or teeth from Locus 5 had dateable collagen. This proved to be a great disappointment, as we were only able to chronometrically date Locus 5 with SOM and charcoal samples and optically stimulated luminescence (OSL) samples. However, we were also able to obtain a relative date for the Locus 5 bone bed with the associated Cody/Eden point recovered there.

The following table (Table 4.1) presents all the bulk sediment, charcoal, and faunal samples that returned AMS radiocarbon dates since the completion

Table 4.1. Chronometric dates returned after the 2015–2016 Water Canyon field sessions.

FS No.	Lab No.	Study Unit/ Auger No.	Grid Elevation (m)	Material Dated	^{14}C yr BP	Cal yr BP Range (2-sigma) [1, 2]	Mean Cal yr BP (2-sigma; highest probability)
1037	Beta-292053	SU 1-20	48.31	Bone collagen	8200 ± 40	10,234 – 10,500	9152 ± 125
1066	AA94467	SU 1-12	48.170	Charcoal	9454 ± 51	10560 – 10800	10,680 ± 120
1330	AA106878	Hand-auger 15-1	38.36	SOM	2671 ± 25	2745 – 2791	2768 ± 23
1331	AA106885	Hand-auger 15-2	40.80	SOM	6126 ± 28	6938 – 7157	7048 ± 110
1350	16C0714	SU 1-19	48.162	Charcoal	8170 ± 50	9010 – 9267	9139 ± 128
1414	16C0634	SU 1-43	50.190	Charcoal	100.11 ± 0.30	0 – 253	126 ± 126
1510	PSU-3565	SU 1-45	48.14	Bone collagen	9,240 ± 50	10,258 – 10,524	10,391 ± 133
1528	PSU-3566	SU 1-21	48.09	Bone collagen	9,185 ± 50	10,240 – 10,442	10,341 ± 101
1605	PSU-3567	SU 1-20	47.88	Bone collagen	8810 ± 70	9621 – 10,161	9891 ± 270
1613	PSU-3564	SU 1-20	48.00	Bone collagen	9180 ± 60	10,234 – 10,500	10,367 ± 133
1625C	16B0713	SU 1-20	47.860	Bone collagen	8640 ± 40	9535 – 9682	9609 ± 73
1644	16OS0636	SU 1-47	47.230	SOM	7030 ± 40	7786 – 7953	7870 ± 84
1645	16OS0637	SU 1-47	47.352	SOM	7830 ± 40	8538 – 8729	8634 ± 95
1646	16OS0638	SU 1-47	47.532	SOM	9090 ± 40	10,187 – 10,298	10,243 ± 55
1647	16OS0639	SU 1-47	47.648	SOM	9020 ± 40	10,153 – 10,248	10,201 ± 48
5007	AA103920	SU 5-3	46.017	Charcoal	8394 ± 45	9402 – 9482	9442 ± 40
5071	AA103921	SU 5-3	45.814	Charcoal	8776 ± 62	9910 – 9662	9786 ± 124
5088	Beta-512350	SU 5-3	45.721	Charcoal	8620 ± 30	9635 – 9530	9583 ± 53
5096	AA104050	SU 5-3	45.673	SOM	8955 ± 57	10,228 – 9912	10,070 ± 158
5105	AA104051	SU 5-3	45.574	SOM	8623 ± 89	9890 – 9472	9681 ± 209
5124	AA104111	SU 5-3	45.483	SOM	8997 ± 53	10,247 – 10,117	10,182 ± 65
5163	16OS0640	SU 5-1	45.540	SOM	9750 ± 40	11,122 – 11,241	11,182 ± 60
5164	16OS0641	SU 5-1	45.490	SOM	10,000 ± 40	11,274 – 11,629	11,452 ± 177
5165	16OS0642	SU 5-1	45.440	SOM	10,280 ± 40	11,826 – 12,180	12,003 ± 177
5166	16OS0643	SU 5-11	45.571	SOM	10,080 ± 40	11,396 – 11,824	11610 ± 214

[1] Reimer, Paula J., et al., 2013

[2] Stuiver, M., and P. J. Reimer, 1993

of the 2015–2016 field seasons, together with their respective lab numbers, FS numbers, standard radiocarbon dates (in radiocarbon years before present, or ^{14}C yrs BP), and their 2-sigma calibrated date ranges (in cal yrs BP). Copies of the laboratory reports for the dates reported in Table 4.1 are grouped together in Appendix G. A number of these dates—along with dates secured previously—were utilized together to develop age-depth models, as discussed in the "Age-Depth Modeling" section below, to assist in the interpretation of the proxy paleo-environmental samples.

Age-Depth Modeling for Sample Interpretation

"Age-depth relationships are used to study the evolution of climate/environmental proxies along sediment depth and therefore through time" (Blaauw and Cristen 2011:457). Past climates and environments can be reconstructed from sediment deposits, such as those found in wetlands or marshes. Within the vertical sediment profile of such a setting, the "proxies" for ecological conditions—such as diatoms, phytoliths, and pollen—occur at a range of depths, and together these constitute a geological archive. As such, it is important, when attempting to reconstruct paleo-ecological conditions, to establish reliable relationships between the depths at which the proxies are recovered and the ages of the sediments at their respective depths. It is common in paleoecology, in shifts from lake to marsh deposits, to find stratigraphic indications for abrupt changes or discontinuities in accumulated deposits. Such abrupt shifts create missing sections and are seen as jumps in the age-depth model.

Locus 1 North Age-Depth Model

In our initial approach to developing an age-depth model for Locus 1 North at Water Canyon, we assumed that there was little variation in the depositional history of sediments in this locality. We soon discovered, however, that this was not the case in reality (*see* Holliday et al. 2019). There are numerous unconformities in evidence in Stratum 6 (the stratum where the majority of buried cultural materials were recovered), particularly in Locus 1 North, and these unconformities were instrumental in creating the compressed, but multi-component, *Bison* sp. bone bed documented in Locus 1 North (Dello-Russo et al. 2021).

Accordingly, in developing the age-depth model discussed in this section, we utilized seven AMS radiocarbon dates returned primarily on SOM samples (but also on one bone collagen and one charcoal sample) recovered largely (although not exclusively) from a 1.02 m vertical profile in Locus 1 North (see Table 4.2), with the hopes that this density of dates would be able to capture some of the variation in rates of sediment deposition over time. These sample AMS dates were then calibrated [OxCal v 4.2.4. (C.B. Ramsey 2017); r:5 IntCal 13 atmospheric curve (Reimer et al. 2013)] and the 2-sigma calibrated dates (ranging from 13,171 to 9053 cal yr BP) were graphed against their respective grid elevations. The comparison generated a curve whose algebraic representation is a second-degree polynomial with an extremely robust "goodness of fit" (r^2) of 0.9408 (Fig. 4.2). This polynomial equation ($Y = 4120675.272 - 168081X + 1717.569876X^2$) represents the age-depth model for Locus 1 North. By replacing "X" in the equation with the grid elevation (in meters) of a given proxy sample, a calculated age of that sample can be determined.

Locus 5 Age-Depth Model

Some proxy paleo-environmental samples were also recovered from Stratum 6 in Locus 5. The tempo of stratigraphic deposition in Locus 5 was thought to have been less variable than that in Locus 1 North, and this was born out in the resulting curve generated by the age-depth model for four AMS radiocarbon dates produced in that deposit (Fig. 4.3). For this model, the samples were all soil organic matter (SOM) and their mean sample ages ranged from 9442 to 10,182 cal yr BP. Their range of variation was much smaller and their age-depth model curve had an even better "goodness of fit" ($r^2 = 0.9880$) than the age-depth model in Locus 1 North, despite the fact that the curve utilized fewer dates. The second-degree polynomial equation that describes the curve for the Locus 5 age-depth model is: $Y = -3257585.397 + 144270.1578X - 1592.330958X^2$. The radiocarbon dates used in this model, and the grid depths from which they were recovered in Locus 5, are provided in Table 4.3.

Modeled Chronometric Ages for Proxy Paleo-Environmental Samples

Twenty sediment samples were recovered from the Water Canyon site for phytolith analysis (Yost, Ap-

Table 4.2. Radiocarbon-dated samples used for Locus 1 North age-depth model.

Sample FS No.	Grid Elevation (m)	Laboratory No.	Material / Provenience (Study Unit)	Mean Age Cal Yr BP (2-sigma)
1037	48.31	Beta 292053	Bone / SU 1-12	9053
1059a	48.15	Beta 288067	Charcoal / SU 1-11	9279
1274	48.03	AA103849	Sediment / SU 1-6	10,516
1273	47.82	AA103848	Sediment / SU 1-6	10,727
1272	47.70	AA103847	Sediment / SU 1-6	11,199
1271	47.57	AA103815	Sediment / SU 1-6	11,242
1232	47.29	AA-373607	Sediment / SU 1-6	13,171

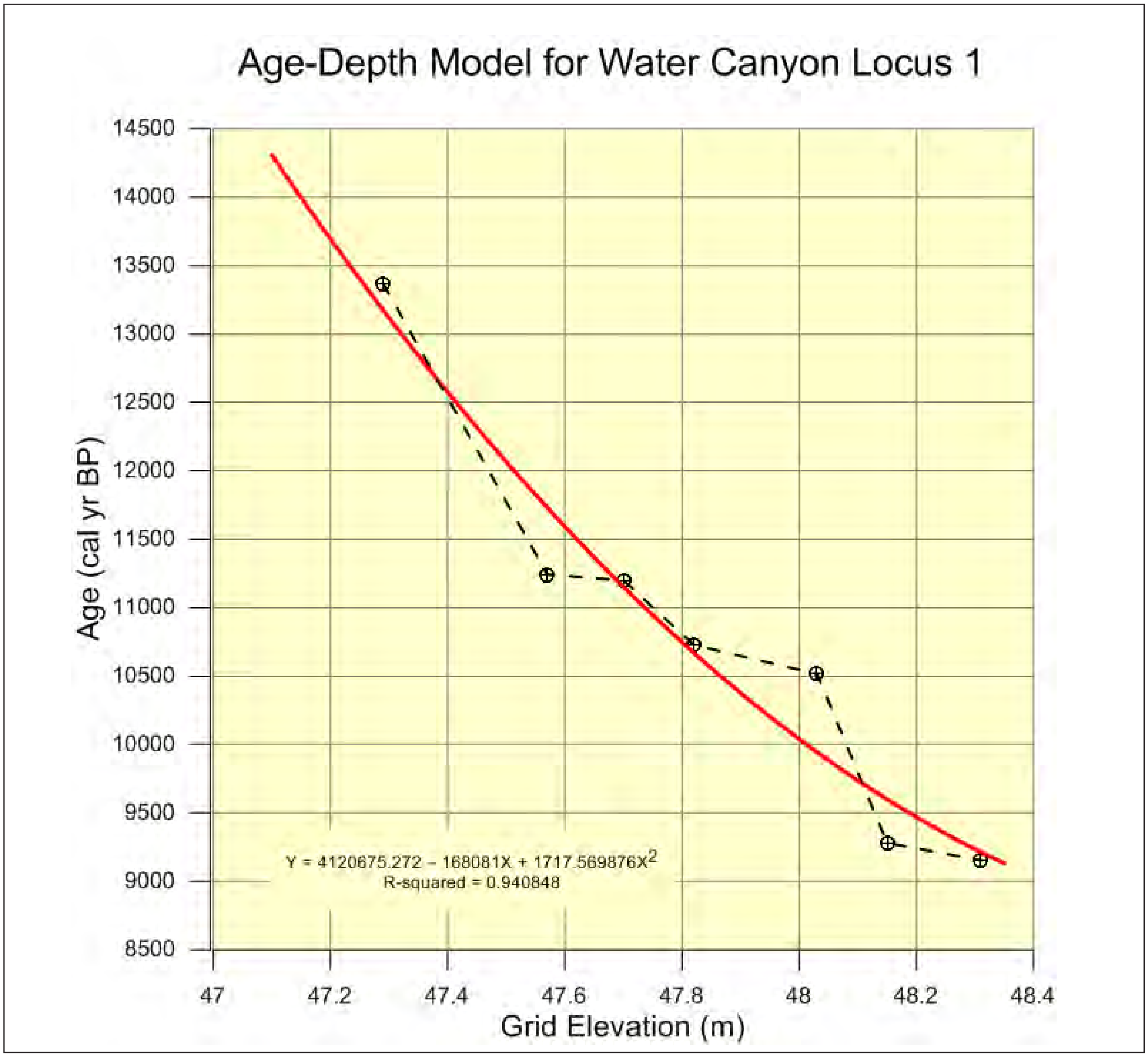


Figure 4.2. Locus 1 (North) age-depth model for Water Canyon proxy samples.

pendix C), diatom analysis (Winsborough, Appendix D) and micromorphology analysis (Mentzer and Goldberg, Appendix F; Holliday, Dello-Russo, and Mentzer 2019). Four of these samples were from Locus 5 (the four youngest) and the remainder were from Locus 1 North. The locational data for these samples are provided in Table 4.4, together with the modeled chronometric ages of each sample, based on the age-depth models presented in the previous discussions. These samples span a range of over four thousand years—from 14,006 to 9513 cal yr BP—which also represents a geological timespan from the terminal end of the Pleistocene (during the Bolling-Allerod epoch; 14,006–12,870 cal yr BP), through the Younger Dryas stadial (12,850–11,650 cal yr BP; Surovell et al. 2016:1) and into the earliest Holocene geological epoch.

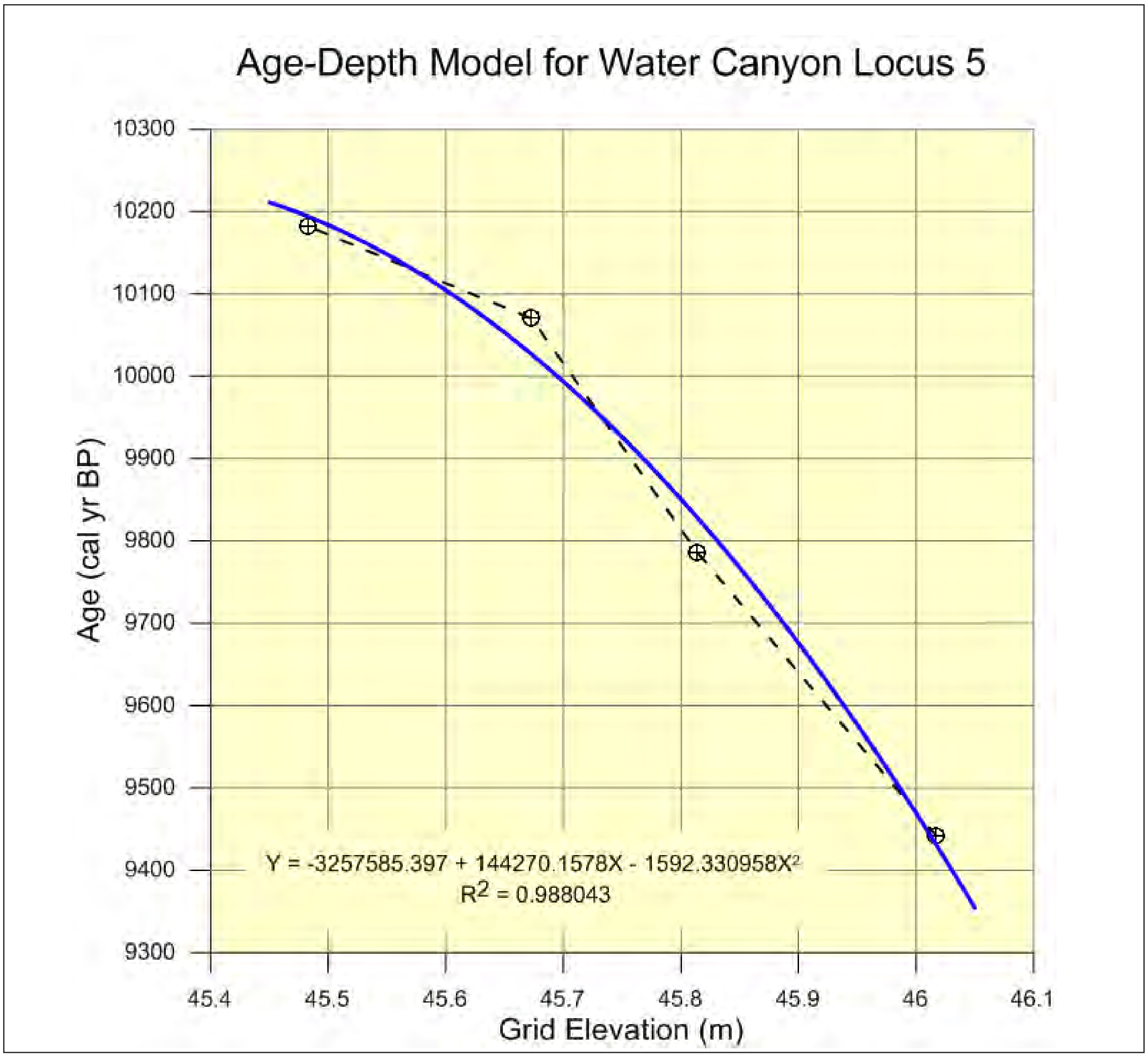


Figure 4.3. Locus 5 age-depth model for Water Canyon proxy samples.

Table 4.3. Radiocarbon-dated samples used for Locus 5 age-depth model.

Sample FS No.	Grid Elevation (m)	Laboratory No.	Material / Provenience (Study Unit/Level)	Mean Age Cal Yr BP (2-sigma)
1037	46.02	Beta 292053	Sediment / SU 5-3 / L1	9442
1059a	45.81	Beta 288067	Sediment / SU 5-3 / L2	9786
1274	45.67	AA103849	Sediment / SU 5-3 / L4	10,070
1273	45.48	AA103848	Sediment / SU 5-3 / L6	10,182

Table 4.4. Modeled chronometric ages for phytolith, diatom, pollen, and micromorphology samples.

FS No.	Sample Type(s)	Study Unit	Grid Elevation (m)	Level	Modeled Age (Cal yr BP)
5005	Phytolith, Diatom, Pollen	SU 5-3	45.980	1	9513
5059	Phytolith, Diatom, Pollen	SU 5-3	45.871	2	9730
5095	Phytolith, Diatom, Pollen	SU 5-3	45.696	4	9999
5123	Phytolith, Diatom, Pollen	SU 5-3	45.479	6	10,196
1195	Phytolith, Diatom	SU 1-6	47.950	9	10,214
1197	Phytolith, Diatom	SU 1-6	47.855	10	10,568
1202	Phytolith, Diatom	SU 1-6	47.755	11	10,956
1557	Micromorphology	SU 1-6	47.715 [2]	11	11,117
1203	Phytolith, Diatom	SU 1-6	47.654	12	11,379
1558	Micromorphology	SU 1-6	47.631 [2]	12	11,480
1559	Micromorphology	SU 1-6	47.577 [2]	13	11,726
1211	Phytolith, Diatom	SU 1-6	47.554	13	11,836
1560	Micromorphology	SU 1-6	47.506 [2]	13	12,064
1634	Phytolith, Diatom	SU 1-47 [1]	47.490	14	12,144
1217	Phytolith, Diatom	SU 1-6	47.454	14	12,327
1633	Phytolith, Diatom	SU 1-47 [1]	47.368	15	12,773
1219	Phytolith, Diatom	SU 1-6	47.350	15	12,870
1632	Phytolith, Diatom	SU 1-47 [1]	47.317	15	13,051
1229	Phytolith, Diatom	SU 1-6	47.253	16	13,412
1249	Phytolith, Diatom	SU 1-6	47.153	17	14,006

[1] These Study Units were incorrectly listed as SU 1-46 in Yost/Appendix C: Table 1, p. 4; and in Winsborough/ Appendix D: Table 1, p. 22.

[2] Original Grid Elevations for these samples taken at base of electric junction boxes; the grid elevations in this table were calculated for mid-points of electric junction boxes that were 5 cm wide.

FIVE

Summary Discussions

Paleoindian-Age Diagnostic Artifacts

Throughout the numerous field seasons at the Water Canyon site, a broad range of temporally diagnostic artifacts, both surface and subsurface, has been recovered. These were primarily projectile points and projectile point fragments (Fig. 5.1 [a–j]). Data about these artifacts are provided in Table 5.1. Among the earliest diagnostic projectile points found at the Water Canyon site are two Clovis points. The first is the basal portion of a large, rhyo-dacite point, originally found in 2009 by Dr. Robert Dello-Russo and recovered from the surface of Locus 3, at the toe of a slope leading northward up to Locus 6 (FS 001; Fig. 5.1 [a]). The second is a relatively small, complete, dark mahogany red, silicified rhyolite point collected from the southeasternmost edge of Locus 3, not far from Big Wash (FS 6076; Fig. 5.1 [b]).

On the surface of Locus 6, researchers also recovered several small lithic blade fragments that had been repurposed into end-scrapers, four of which are illustrated in Figure 5.2 [a (FS 6003), b (FS 6002), d (FS 6018), e (FS 6065)]. This refurbishment of blades is considered to be a hallmark of Clovis technology (Collins 1999) and the presence of these artifacts suggests that a portion of Locus 6 may represent the remains of some sort of fine-level hide-processing locale. Three other blade fragments repurposed into spurred end-scrapers were recovered in the Bison sp. bone bed of Locus 1 North. These are also illustrated in Figure 5.2 [c (FS 1444), f (FS 1480), g (FS 1475)].

Notably, several of the scrapers in Locus 6 are thought to have been made of Edwards Plateau chert, a lithic raw material sourced to central Texas (Table 5.1). We believe that it is possible that the blade-scrapers were curated from their original place of deposition in Locus 6 to be used again in Locus 1 North and, interestingly, this conforms well with the added presence in Locus 1 North of a rhyolite, early-stage biface fragment (FS 1033) that exhibited an overshot flake scar on one face (Dello-Russo 2012:28).

Such overshot technology was also typical of the Clovis culture and, as such, we considered it possible that the biface fragment had been curated from Locus 6. Thus, the Clovis points, the re-purposed blades, and perhaps the large, rhyolite biface fragment, represent an occupation(s) of the site during the Terminal Pleistocene geological epoch (Bolling-Allerod interstadial) or from 14,690 to 12,890 cal yr BP. The Clovis tradition itself is thought to have existed over the years 13,250 to 12,800 cal yr BP (Waters and Stafford 2007).

Two fragments of Folsom points—one a base fragment recovered at Locus 6 (FS 6001), and the second an edge fragment (FS 3035) recovered at Locus 3 (Figs. 5.1 [c] and 5.1 [d], respectively)—provide evidence of site occupation during the Younger Dryas climatic interval or transition from the terminal Pleistocene to the earliest Holocene (12,850–11,650 cal yr BP; Surovell et al. 2016:1). The Folsom tradition is thought to have extended across the years 12,610 to 12,170 cal yr BP (Surovell et al. 2016).

One largely complete, Late Paleoindian age, Eden-style projectile point was recovered in situ during the 2013 excavation field season at Locus 5 (FS 5081; Fig. 5.1 [e]). Another Eden style projectile point base-and-blade fragment was recovered on the surface of Locus 4 during the initial year 2001 survey documentation of the site (FS 063; Fig. 5.1 [f]; Dello-Russo 2002). Together, these points represent an occupation, or occupations, of the site during the years ~9800–8800 ^{14}C yr BP (Knell and Muñiz 2013:11). The very interesting observation about these two projectile points is that, metrically, they are similar, and morphologically (i.e., the shape of the base) they are identical. This suggests, perhaps, that one toolmaker made both points and, as such, there may have been a functional relationship between Locus 4 and Locus 5. Following this logic, the one lower, westernmost, bone bed in Locus 1 North that is radiocarbon

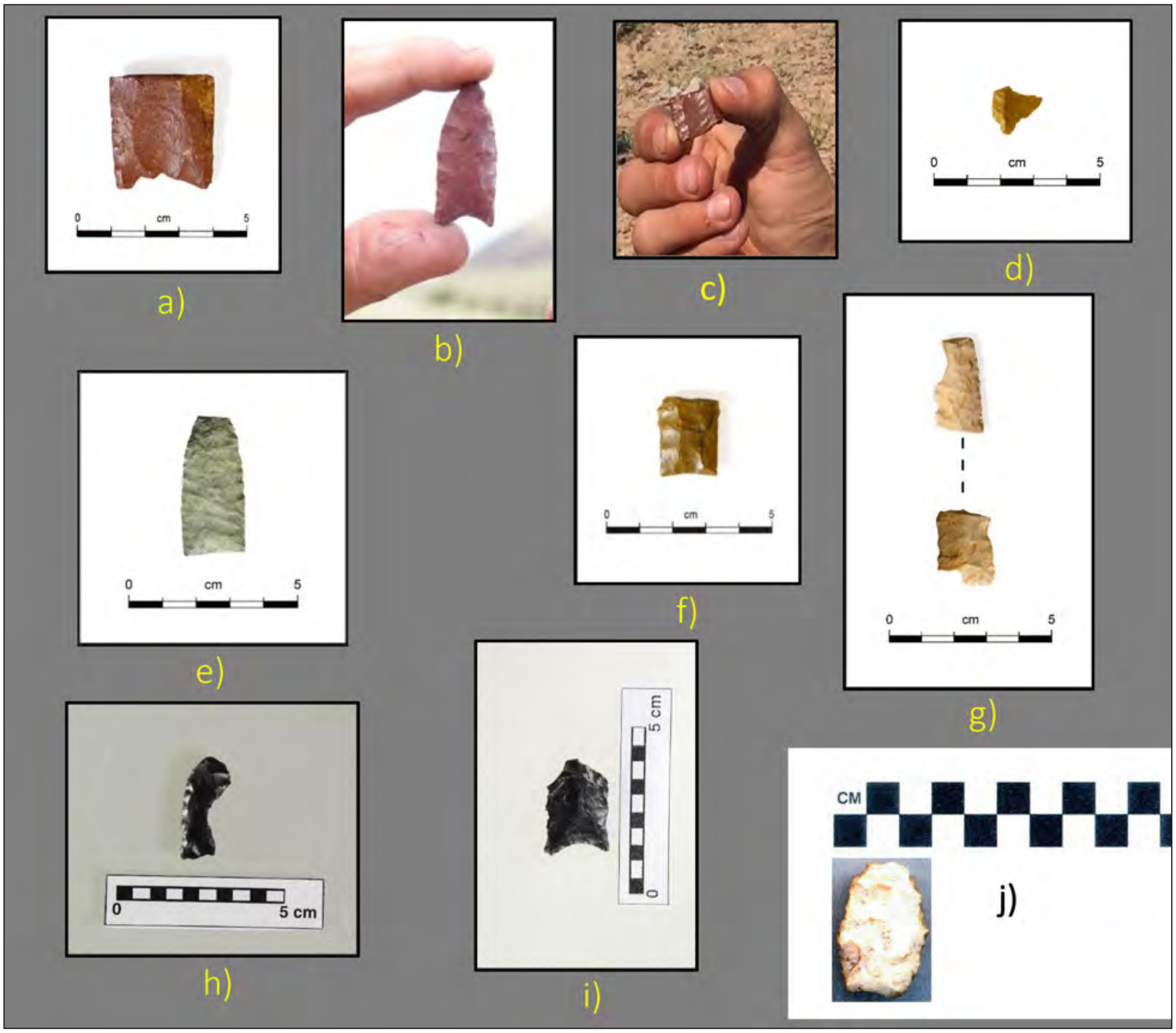


Figure 5.1 [a–j]. Paleoindian era projectile points and fragments from the Water Canyon site: a) Clovis point base (FS 001); b) Complete small Clovis point (FS 6076); c) Folsom point base (FS 6001); d) Folsom point edge fragment (FS 3035); e) Complete resharpened Eden point (FS 5081); f) Eden point base (FS 063); g) Allen-Frederick articulating point or knife base and mid-section fragments (FS 061 and FS 1296, respectively); h) Lateral fragment lanceolate late Paleoindian (Belen?) point (FS 6077); i) Resharpened lanceolate late Paleoindian (Belen?) point (FS 6017); j) Late Paleoindian (Belen?) preform (FS LA134764.1).

dated to a range from 9240 to 9180 ^{14}C yr BP, may also be functionally related to the Eden points recovered in Locus 5 and Locus 4.

Other lithic artifacts considered to be temporally diagnostic include two articulating fragments of a siltstone biface found 3.9 m apart on the surface just to the southwest of Locus 1 South (FS 061, FS 1296; Fig. 5.1 [g]). These fragments (interpreted as the remains of a hafted knife or perhaps a projectile point) exhibit flake scars in a parallel oblique configuration on one face; such scars are suggestive of a Late Paleoindian Allen-Frederick style, which has a date range of 9350–7900 ^{14}C yr BP (Pitblado 2003:112). In addition, the site also produced two small, lanceolate-shaped, Late Paleoindian points with shallow, concave bases. One of these was complete, although heavily resharpened, and was manufactured of black chert (FS 6017; Fig. 5.1 [i]). The other was a lateral fragment made of obsidian (FS 6077; Fig. 5.1 [h]). These points are arguably similar in style to types named Belen (for points

Table 5.1. Descriptive data for temporally diagnostic artifacts.

FS No.	Locus	Image No.	Dimensions			Material Type	Artifact Style / Cultural Affiliation	Artifact type, Comments	Locational Coordinates		
			L (mm)	W (mm)	Th (mm)				Grid Easting (m)	Grid Northing (m)	Grid Elevation (m)
001	3	5.1a	32.69	33.46	8.46	Rhyo-dacite	Clovis	Projectile point base, blade; found by R. Dello-Russo	500.193	661.549	52.701
6076	3	5.1b	42.42	19.38	6.03	Red silicified rhyolite	Clovis	Projectile point, small, complete, made on flake, ground on lateral and basal edges; found by C. Griffith	611.763	525.995	45.758
1475	1N	5.2g	27.58	26.21	7.11	Edwards Plateau chert	Clovis	End scraper on prismatic blade fragment, 3 edges exhibit use-wear; found by M. Collins	506.29	510.82	47.95
1480	1N	5.2f	31.81	21.41	8.67	Edwards Plateau chert	Clovis	End scraper on prismatic blade fragment, 2 edges exhibit use-wear; found by M. Collins	507.00	510.00	48.30 –48.20
1650	6	5.2b	24.33	18.59	5.14	Translucent chalcedony	Clovis	Refurbished blade fragment, end-scraper with micro-use-wear over retouch flaking	676.71	462.99	55.262
6002	6	5.2c	22.06	23.57	7.05	Dark gray, Edwards Plateau material (?)	Clovis	Prismatic blade fragment with unifacial retouch and scraper use-wear	685.91	538.14	56.116
6018	6	5.2d	28.09	28.59	6.62	Dark brown-purplish, Edwards Plateau material (?) with fossil inclusions	Clovis	Prismatic blade fragment tool; found by M. Collins	665.48	586.00	53.802
6033	6	5.2a	32.05	21.73	8.71	Butterscotch tan fossiliferous chert	Clovis	Hafted spurred end scraper / on blade fragment; found by P. Walker Dello-Russo	674.25	524.55	54.956
6065	6	5.2e	27.88	25.32	24.94 (?)	Dark red silicified rhyolite	Clovis	Spurred end-scraper made on prismatic blade flake	714.36	487.90	56.191

(Table 5.1 *continues*)

Table 5.1 *(continued)*

FS No.	Locus	Image No.	Dimensions			Material Type	Artifact Style / Cultural Affiliation	Artifact type, Comments	Locational Coordinates		
			L (mm)	W (mm)	Th (mm)				Grid Easting (m)	Grid Northing (m)	Grid Elevation (m)
6001	6	5.1c	17.7	22.53	4.62	Red silicified rhyolite	Folsom	Projectile point base, ground lateral and basal edges; found by J. Lidell	576.303	664.769	54.789
3035	3	5.1d	15	14	2.83	Yellow silicified rhyolite	Folsom	Projectile point edge fragment; found by P. Walker Dello-Russo	462.83	640.37	51.323
5081	5	5.1e	41.65	18.79	6.33	Dark gray oolitic chert	Eden	Projectile point, complete, resharpened; found by G. Crawford	524.341	519.089	45.698
63	4	5.1f	(22.8) [1]	20.9	5.5	Yellow silicified rhyolite	Eden	Base; found by R. Dello-Russo	~555 [2] 601.62	~371 [2] 368.62	~50.724 [2] 50.72
61	1N	5.1g	31.91	16.15	5.65	Orange-cream siltstone	Allen-Frederick (?) / Late Paleoindian	Point or knife mid-section blade, parallel-oblique flaking, articulates with FS 1296	483.12	478.65	51.67
1296	1N	5.1g	23.24	17.36	5.89	Orange-cream siltstone	Allen-Frederick (?) / Late Paleoindian	Point or knife base, parallel-oblique flaking, articulates with FS 61	486.874	479.904	51.377
6077	3	5.1h	29.12	(--)	5.4	Obsidian	Late Paleoindian	Broken lateral portion, ground lateral and basal edges, small lanceolate w/ shallow concave base; found by C. Holland	562.840	597.542	48.426
6017	3	5.1i	25.9	14.26	4.83	Black chert	Late Paleoindian	Resharpened, small parallel sided lanceolate w/ shallow concave base	585.16	671.03	53.912
LA134764.1 [3]	4	5.1j	42.1	29.0	9.7	White quartzite	Late Paleoindian (?)	Preform – shallow concave base; found by R. Dello-Russo	601 ~585 [2]	354 ~325 [2]	surface
2056 (2003?)	2	5.3a	34.47	19.19	5.53	Dark dacite	Gypsum / Middle Archaic-to-early Late Archaic	Made on flake, acute shoulders, missing tip; found by R. Chapman	450.387	559.317	53.473
6075	3	5.3b	28.92	16.72	5.93	Orange-red-white chert	Gypsum / Middle Archaic-to-early Late Archaic	Made on flake, rounded shoulders, contracting stem, slight concave base; found by C. Ainsworth	594.667	582.810	48.960

Table 5.1 *(continued)*

FS No.	Locus	Image No.	Dimensions L (mm)	W (mm)	Th (mm)	Material Type	Artifact Style / Cultural Affiliation	Artifact type, Comments	Locational Coordinates Grid Easting (m)	Grid Northing (m)	Grid Elevation (m)
LA134764.2 [3]	4	n/a	(16.7)	(16.4)	3.8	Red silicified rhyolite	Armijo / early Late Archaic	Projectile point base – broken ear and tip; found by R. Dello-Russo	~591 [2]	~322 [2]	surface
69	1N	n/a	(16.23)	15.21	5.22	Obsidian	Armijo / early Late Archaic	Projectile point base, expanding concave base, highly weathered	507.01	493.47	49.743
62	2	5.3c	(19.12)	16.43	5.71	Obsidian	Armijo / early Late Archaic	Projectile point – proximal, tip broken, reworked, expanding concave base	395.76	563.82	50.78
1063	1N	5.4	--	--	--	Fired clay, temper	Ancestral Puebloan / Formative era	Ceramic – 2 smeared, ind. grayware sherds recovered from flotation of bulk sediment sample; found by L. Etsitty	509.00	508.00	48.39

[1] Measurements in parentheses are incomplete; [2] Grid coordinates preceded by tildes (~) are approximate and calculated from GPS coord's; [3] Documented during original survey (Dello-Russo 2002).

found in the middle Rio Grande Valley), St. Mary's Hall (for points recovered from the Wilson-Leonard site in Texas), or the southern Rocky Mountain version of Angostura (embracing the previous Foothill-Mountain type or, preferably, adaptation), which have ages in the region ranging from 10,500–9000 cal yr BP (*see* Judge 1973), 10,400–9000 cal yr BP (Holliday 2000), and 10,400–9000 cal yr BP (Pitblado 2007), respectively. A white, quartzite pre-form (FS LA134764.1; Fig. 5.1 [j]) was also recovered from Locus 4 during the original site survey in 2001 (Dello-Russo 2002). Given its shape and size, we suggest it was a preform for a late Paleoindian point.

Archaic-Age and Formative-Age Diagnostic Artifacts

In Locus 2, a dark gray, dacite Gypsum-style, stemmed projectile point was recovered during the 2015 field school (FS 2003; Fig. 5.3 [a]). That same dacite artifact was apparently mapped as a biface in 2009 (Dello-Russo 2010:10) but not recognized or collected at the time as a temporally diagnostic artifact. This point, and the artifact assemblage at Locus 2, are more fully discussed in the "Additional Field Discoveries in Locus 2" section of Chapter 3 in this report**.** During the 2015 field school, Locus 2 was re-mapped, and the two mapped Locus 2 artifact scatters (2009 and 2015) are compared in the same Chapter 3 section referenced above. In that section, we also point out that the Gypsum projectile point type was named by Harrington (1933). In west-central New Mexico, this point type is thought to have been utilized between 4000 and 2800 cal yr BP (late Middle Archaic to early Late Archaic period). This point type is similar in morphology to the Augustin point recovered and named by Dick (1965) at nearby Bat Cave (7000–5000 BP) and to the Manzano point recovered and named by Hibben (1941) from nearby Manzano Cave (4000–2800 BP).

An additional Gypsum-style, stemmed projectile point (FS 6075; Fig. 5.3 [b]) was located and recovered in the vicinity of Locus 3 during the 2015 field school about 110 m east-northeast of the dacite Gypsum point (Fig. 5.3 [a]). This second Gypsum point was manufactured from a red and white chert. Together, the discovery of the two Gypsum points and, possibly, the 54 artifacts in the Locus 2 assemblage mapped

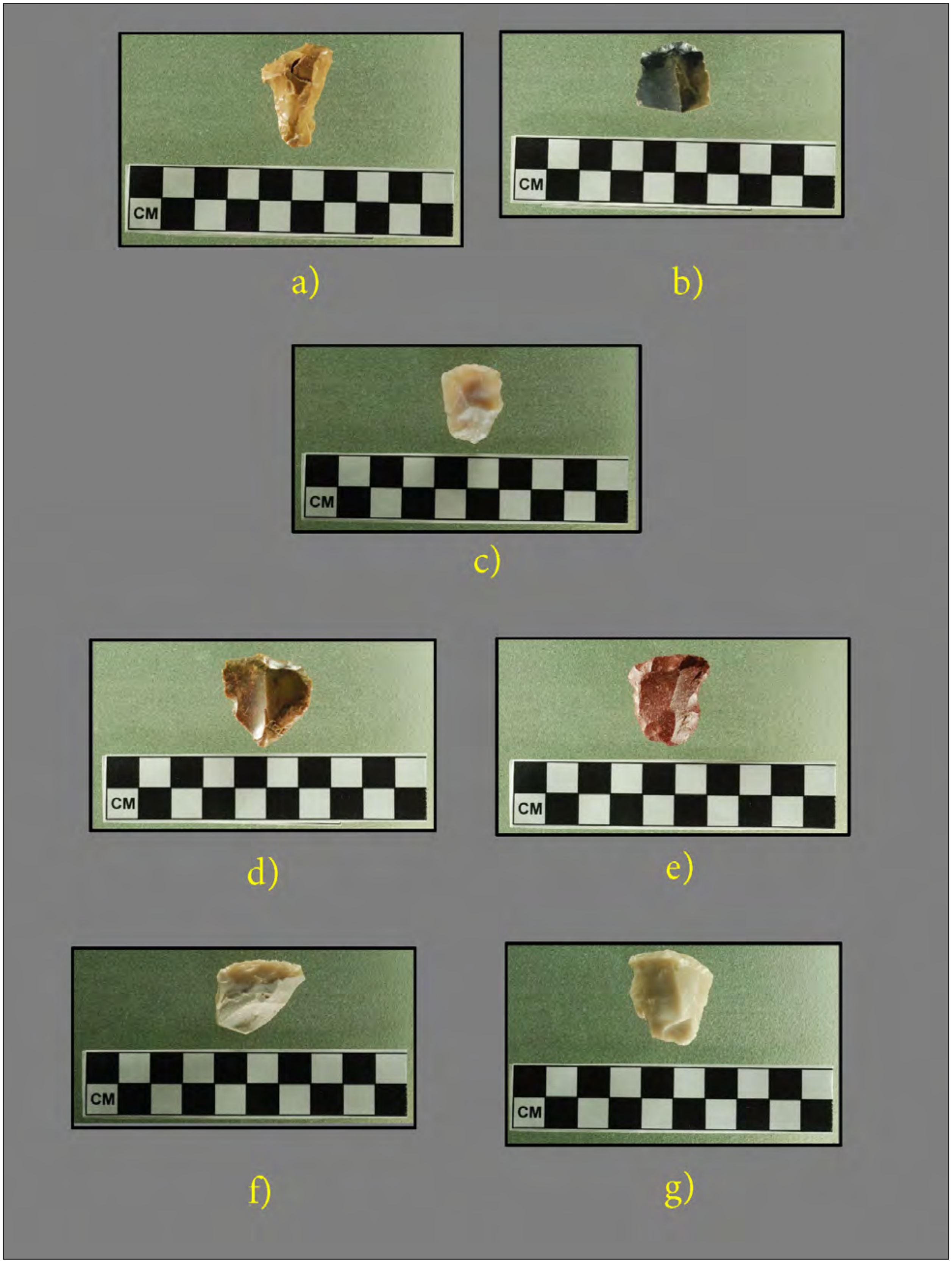


Figure 5.2 [a–g]. Probable Clovis era re-purposed blade fragments from the Water Canyon site: a) FS 6033; b) FS 1650; c) FS 6002; d) FS 6018; e) FS 6065; f) FS 1480; g) FS 1475.

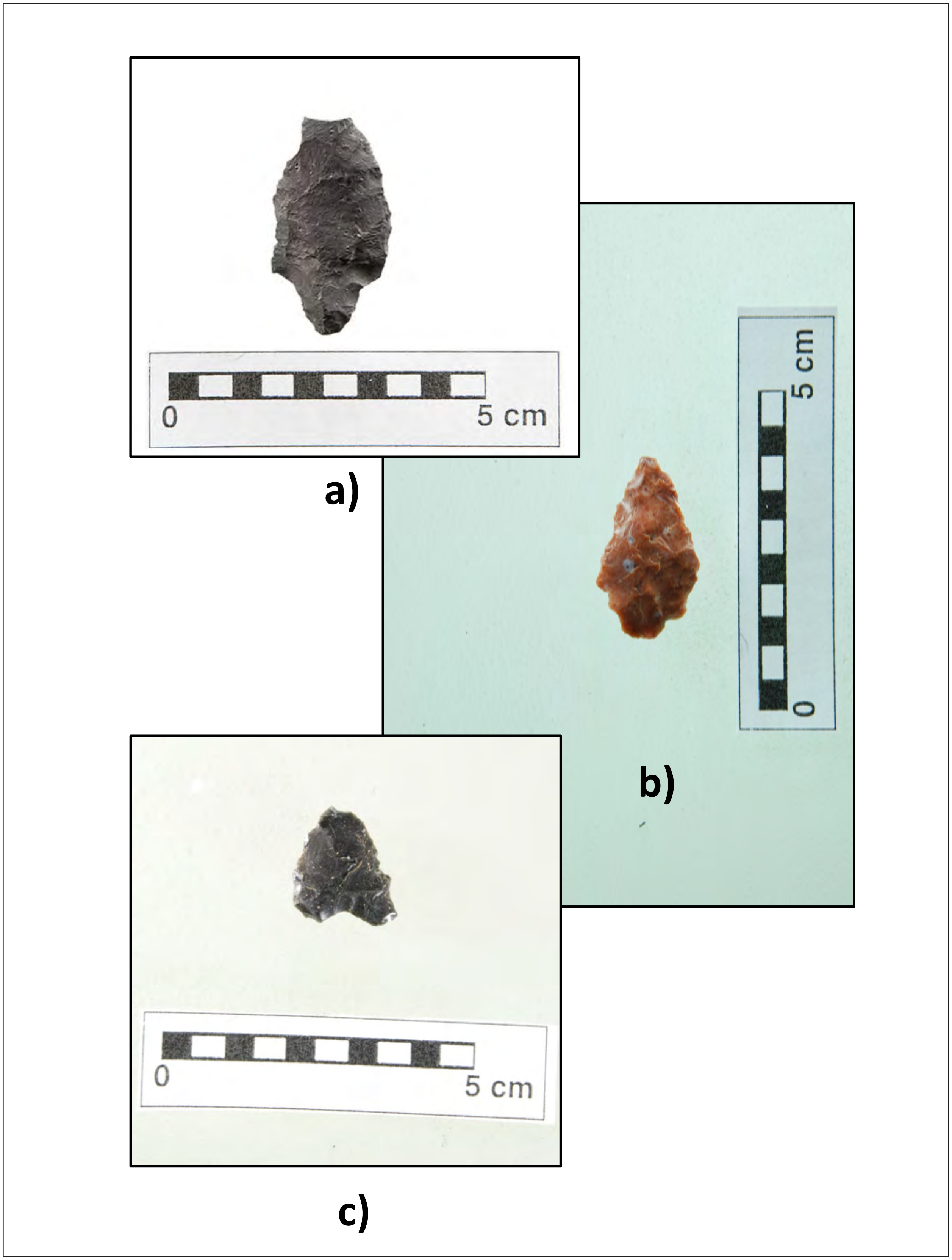


Figure 5.3 [a–c]. Archaic era Gypsum and Armijo points from the Water Canyon site: a) Dacite Gypsum point (FS 2056); b) Chert Gypsum point (FS 6075); c) Obsidian Armijo point (FS 062).

in 2009, and again in 2015, may have represented the remains of a late Middle Archaic to early-Late Archaic–era weapon refurbishment locale.

A third temporally diagnostic Late Archaic projectile point—this time a severely resharpened, obsidian Armijo style point (FS 062; Fig. 5.3 [c])—was recovered in 2009 on the surface of Locus 2. It is morphologically similar to two other Armijo-style points that were previously recovered from the Water Canyon site: an obsidian one from Locus 1 North (FS 069) and a red rhyolite one from Locus 4 (FS LA134764.2). The latter, red rhyolite, one was recorded during the original site documentation (Dello-Russo 2002). The Armijo point type was originally named by Irwin-Williams (1973) and is thought to have been made from approximately 3800 to 2800 BP. The small size of these points suggests a possible use with a bow and arrow and their presence at the Water Canyon site suggests a passing use of the area for hunting during the early part of the Late Archaic era, or even a short-term occupation during that same era. They are potentially contemporary with the two Gypsum-style points recovered at Locus 2 and Locus 3.

Finally, there are two smeared, indented, grayware ceramic sherds (FS 1063; Fig. 5.4) that were collected from Locus 1 North during excavations there in 2010 (Dello-Russo 2012:10–11). These artifacts were actually recovered during the flotation of FS 1063 (a bulk sediment sample from Study Unit 1-9 immediately north of, and at most 10 cm above, a bison vertebra). These two sherds were assigned the same FS number as the bulk sediment sample from which they were recovered. Based on the assessment made by Dean Wilson, then ceramic specialist at the Office of Archaeological Studies in Santa Fe, the sherds dated to approximately AD 1300 and thus seemed to be out of stratigraphic position. The process or processes that accounted for the presence of these artifacts in the location where they were recovered was unclear at the time of their discovery, but the existence of a stratigraphic unconformity at the top of the black mat (as suggested by the stratigraphy in BHT-6) was considered likely. The presence of such unconformities in Locus 1 North was confirmed in the study of the geoarchaeology of the Water Canyon site by Holliday et al. (2019).

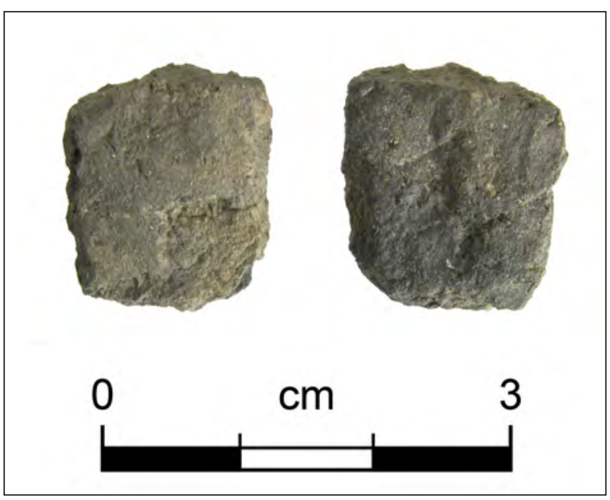


Figure 5.4. Formative era ceramic sherds (FS 1063), Locus 1 North from the Water Canyon site.

Spatial Distribution of Temporal/ Functional Components at the Water Canyon Site

The Water Canyon site is clearly a multi-component site in the classic sense. There is strong evidence—primarily in the forms of temporally diagnostic projectile points, other functional tools, and bone beds—for use of the site for a range of inferred purposes during distinct periods of time from the terminal Pleistocene geological epoch (Bolling-Allerod) through the Younger Dryas Climatic Interval to the earliest Holocene and then again during the mid-late Holocene epoch. Figure 5.5 provides a plan topographic view of the Water Canyon site with the various loci of the site labeled according to their temporal components and their inferred functions.

In some cases, the temporal and functional attributions are clear (based on radiocarbon dates and/or the presence of a temporally diagnostic artifacts, and the presence of well-defined tools and/or features). This is true for the "Eden *Bison* sp. bone bed (kill locale)" at Locus 5, where we have a virtually complete, in situ, Eden projectile point (FS 5081) and an extensive bone bed. Along the east side of the site, at the "Isolated Clovis, Belen, Gypsum points," there are no well-defined loci or activity areas, but there are some Belen/Angostura-type projectile point fragments (FS 6017 and FS 6077) present. These are highlighted to underscore the possibility at Water Canyon of a possible Foothill-Mountain adaptation during the late Paleoindian era, which may also be associated with the possible Belen- or Angostura-type artifact (FS 1341) in Locus 1 South, the preform observed in Locus 4, and the upper *Bison* sp. bone bed/processing area in Locus 1 North (*see* discussion in the "Bison Analysis" section of Chapter 6 in this report). The small, complete Clovis point (FS 6076) is located in this area, although it was assigned to Locus 6. A chert Gypsum point (FS 6075) was recovered in this general area as well.

The "Folsom processing locales" assignment for Locus 3 had tentatively been based on the recovery of the edge of a Folsom point in that location (FS 3035) and the Folsom-age OSL date of 12,300 years BP recovered from 0.8 m below the surface in the west wall of BHT-4 (Figure 3.13b) in that locus. The Folsom-age assignment to the east end of Locus 6 hinges primarily on the recovery of a Folsom point base (FS 6001) there. It is not clear, however, which surface artifacts in Locus 6 should be associated with a Folsom component or with a Clovis component. In light of these observations, it important to keep in mind that it is much less likely that Folsom (or earlier Clovis) artifacts were deposited on the surface of Locus 3 during the Folsom (or Clovis) period and worked their way to the surface by the present time, than it is that the artifacts associated with those cultures would have washed down over time from the higher, adjacent surface of Locus 6, which has been stable since the Pleistocene.

The added description of Locus 6 as a "Clovis processing area" is due to three significant recoveries there: a Clovis point base (FS 001) at the toe of the slope of Locus 6; the small, complete Clovis point (FS 6076) not far from the nearby Windmill Pit southeast of Locus 6 (noted above); and, numerous blade fragments that had been repurposed into end-scrapers on the Locus 6 surface. Beyond these blade fragments, and as noted previously, it is not yet clear which other Locus 6 artifacts could be associated with the Clovis

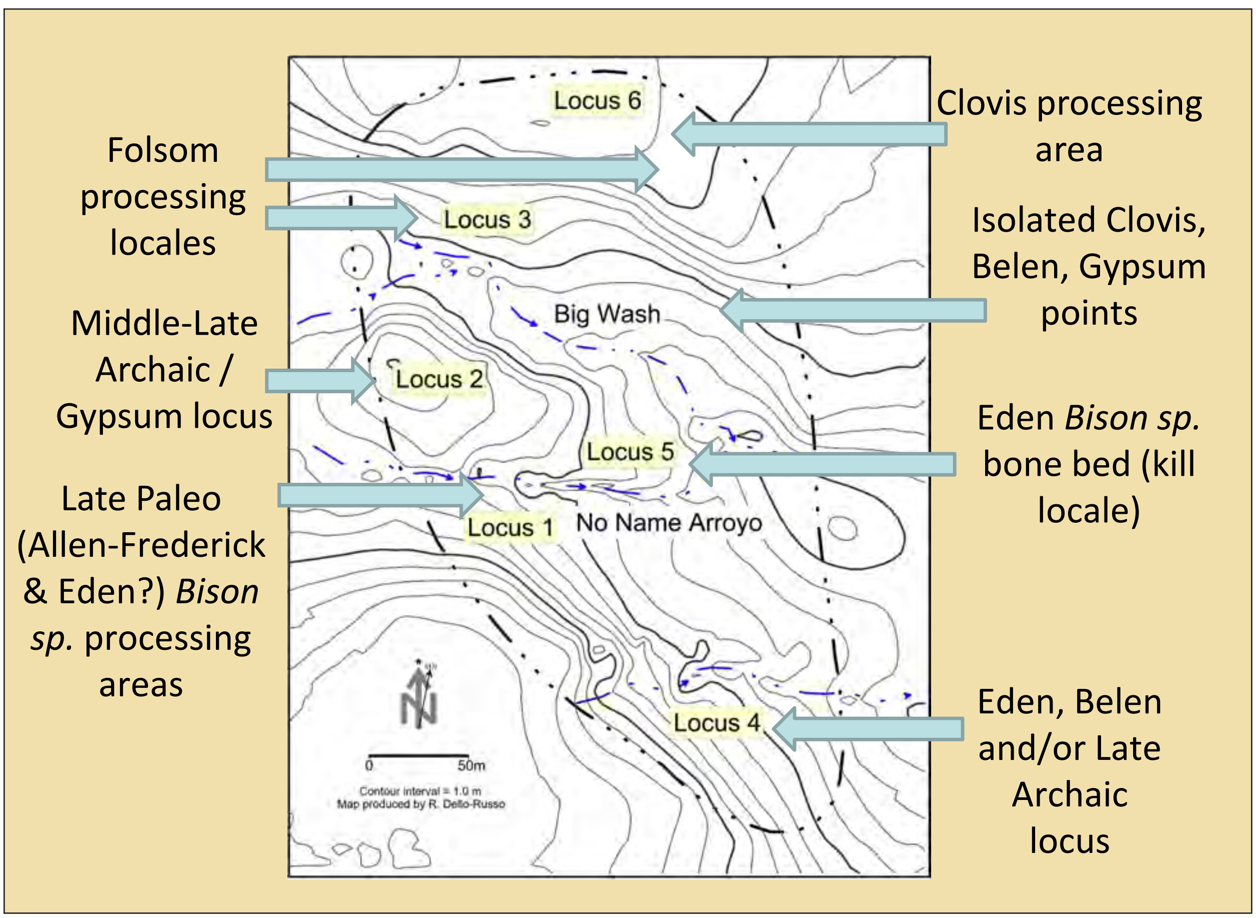


Figure 5.5. Map of proposed spatial distribution of temporal components at Water Canyon site.

component, and which might be associated with the Folsom component.

The "Late Paleo (Allen-Frederick & Eden?) *Bison* sp. processing areas" at Locus 1 North are labeled as such due to the presence of three compressed *Bison* sp. bone beds and numerous radiocarbon dates on both charcoal and bone collagen. The Allen-Frederick portion of that attribution is based on the dated bone in the upper bone bed of Locus 1 North of ~9152 cal yr BP (8200 ^{14}C yr BP). The Eden attribution is based on bone dates between ~10,391 to ~10,367 cal yrs BP (9240 to 9180 ^{14}C yr BP) for the lower, westernmost, bone bed in Locus 1 North.

The "Middle-Late Archaic/Gypsum Locus" assigned to Locus 2 is based on the presence of a dacite Gypsum-style point (FS 2003) recovered there along with an obsidian Armijo-style point (FS 062). These diagnostic points and the artifact assemblage documented in Locus 2 suggest weapon refurbishment activities occurred there in the Middle-to-Late Archaic period.

Finally, the "Eden, Belen, and/or Late Archaic locus" attribution provided for Locus 4 is based primarily on the discovery of a base-and-blade to an Eden point (FS 063) at that location. The strong morphological and metric similarities between that point and the Eden point in Locus 5 (FS 5081) suggest a possible functional tie between the two loci. A shallow, concave based preform (Belen-like; FS LA134764.2) is further suggestive of a Late Paleoindian occupation. The artifact assemblage (including a knife, four scrapers and 10 utilized flakes) at Locus 4 indicates a possible processing area function. In addition, two Armijo points were also documented at Locus 4, suggesting the possibility that the activities were tied to the Middle-to-Late Archaic occupation at Water Canyon.

A final point to reiterate about Water Canyon, as underscored by its multi-component nature illustrated in Figure 5.5 and discussed above, is that the Water Canyon site—because of its wetland resources, which drew grazing herbivores repeatedly over time—was a persistent and significant, regional resource for hunter-gatherers over a period of almost 5,000 years (~13,200–~8000 BP) and then again ~3000 BP.

SIX

Noteworthy Findings / Avenues of Future Research

Based on what is presently known about Water Canyon, there are at least three major areas of the site where we have made noteworthy findings that, in turn, can provide avenues of future research. These include: Locus 1 North, Locus 5, and the combined Loci 3 and 6. Some brief discussions of our discoveries in these areas will provide additional insights into the significance of the Water Canyon site and underscore the need for additional research.

Excavation Below and Beyond Locus 1 Bone Beds

The Water Canyon site, as we have noted previously, is characterized by a series of coalesced alluvial fan deposits or bajadas (Fig. 6.1). The in situ cultural materials at Water Canyon were laid down in a setting of low-energy paleo-wetland sediments that were buried between high-energy late Pleis-

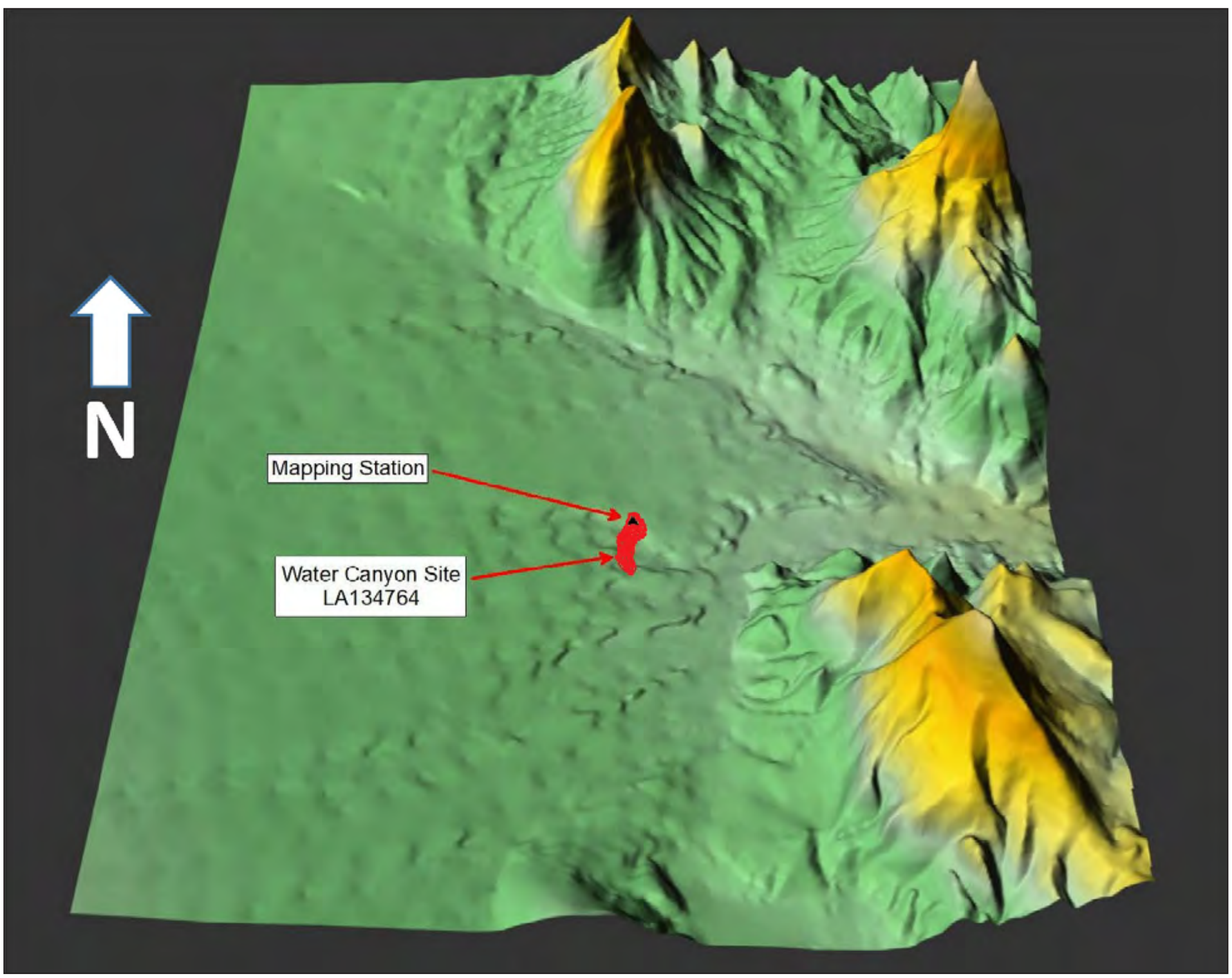


Figure 6.1. Magdalena alluvial fan topography surrounding the Water Canyon site.

tocene and both early and later Holocene fan deposits. Other cultural remains were found atop the stabilized surfaces of these deposits. It is important to reiterate, however, that there are wetland sediments below the bone beds in Locus 1 North that date to the latest-Pleistocene-to-earliest-Holocene transition, including the YD Chronozone, and there are sediments beyond those same bone beds, that, based on the results of dated samples from our sediment cores, come from that same transitional era (Figs. 6.2, 6.3). Because Eden, Folsom, and Clovis diagnostic artifacts have been recovered from other areas of the site, and the Eden point in Locus 5 (FS 5081) was the only one found in situ in a subsurface context, we believe it would be prudent to test in the following locations for the presence of intact, buried remains in the latest-Pleistocene-to-earliest-Holocene-age sediments:

1. East of the excavated study units in Locus 1 N and west of BHT-3;

2. East of BHT-3 and west of Locus 4 in the gently sloping area where mechanical core nos. 15-1 through 15-14 are located (*see* Fig.

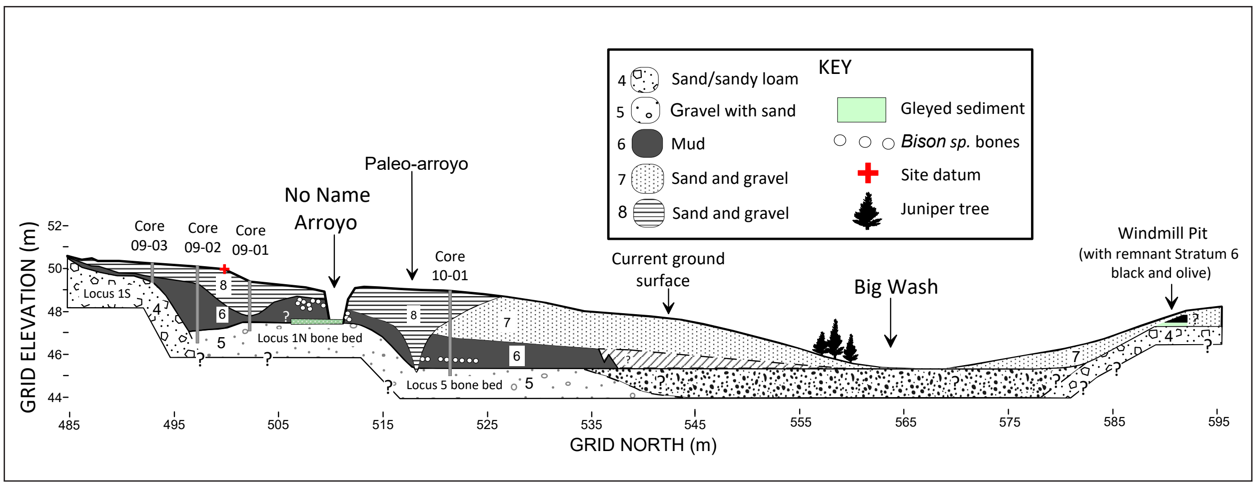


Figure 6.2. South-to-north soil stratigraphic cross-section of Water Canyon site.

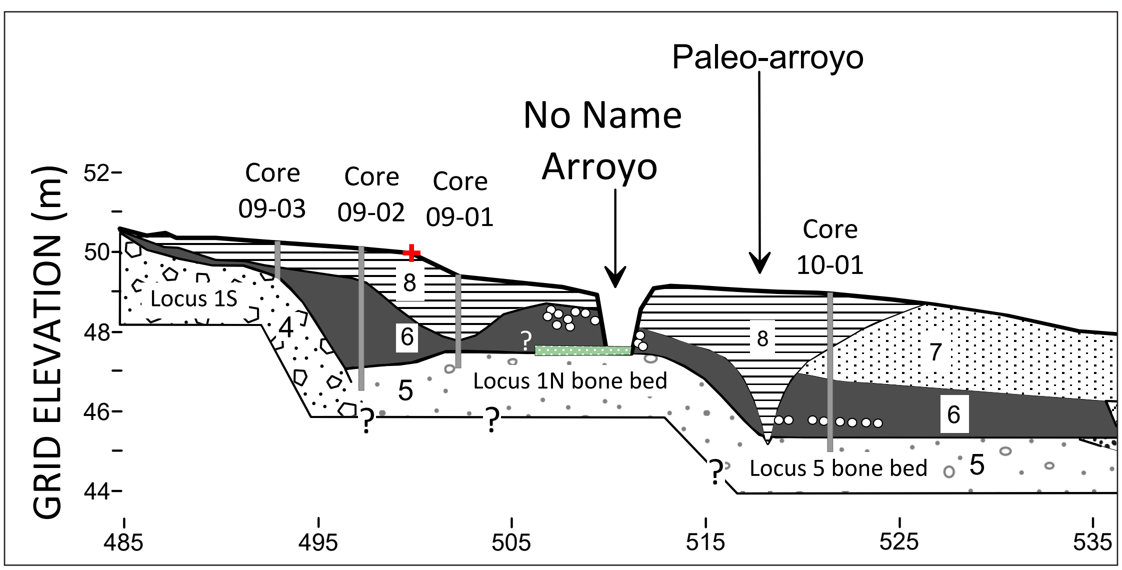


Figure 6.3. Locus 1 North detail of south-to-north stratigraphy; horizontal axis is Grid North (m).

3.14). The results of those coring efforts revealed gleyed sediments similar to those seen in Locus 1 North. Broad mechanical stripping of the overburden in this area might be warranted.

3. South of Locus 1 North from the North 502 line to the North 492 line. Based on the results of mechanical coring in 2009, this zone appears to have deep Stratum 6 deposits (*see* Fig. 6.3).

Aside from the profiles exposed on the two sides of No Name Arroyo, only a few bucket auger tests have been made in Locus 1 North (Study Units 1-5 and 1-45) to examine the deeper sediments, so further excavation work here is clearly warranted.

Clarifying the Palimpsest of Events at Locus 1 North

Returning to the very well-preserved *Bison* sp. bone bed in Locus 1 North (Fig. 6.4), collagen samples from six faunal elements in the recovered bone assemblages at Locus 1 have returned calibrated radiocarbon ages ranging from ~9150 to ~10,390 cal yrs BP, suggesting that the bone bed actually represents the remains of three chronologically distinct depositional events (Dello-Russo et al. 2017, 2021; Holliday et al. 2019).

Within the uppermost portion of the Locus 1 bone bed (Fig. 6.5), we mapped a relatively dense concentration of charcoal fragments, and, of these, 10 dated samples had a pooled mean of 9366 cal yrs BP. This is roughly contemporary with the unpretreated

Figure 6.4. Well-preserved Bison sp. bones in Locus 1 North.

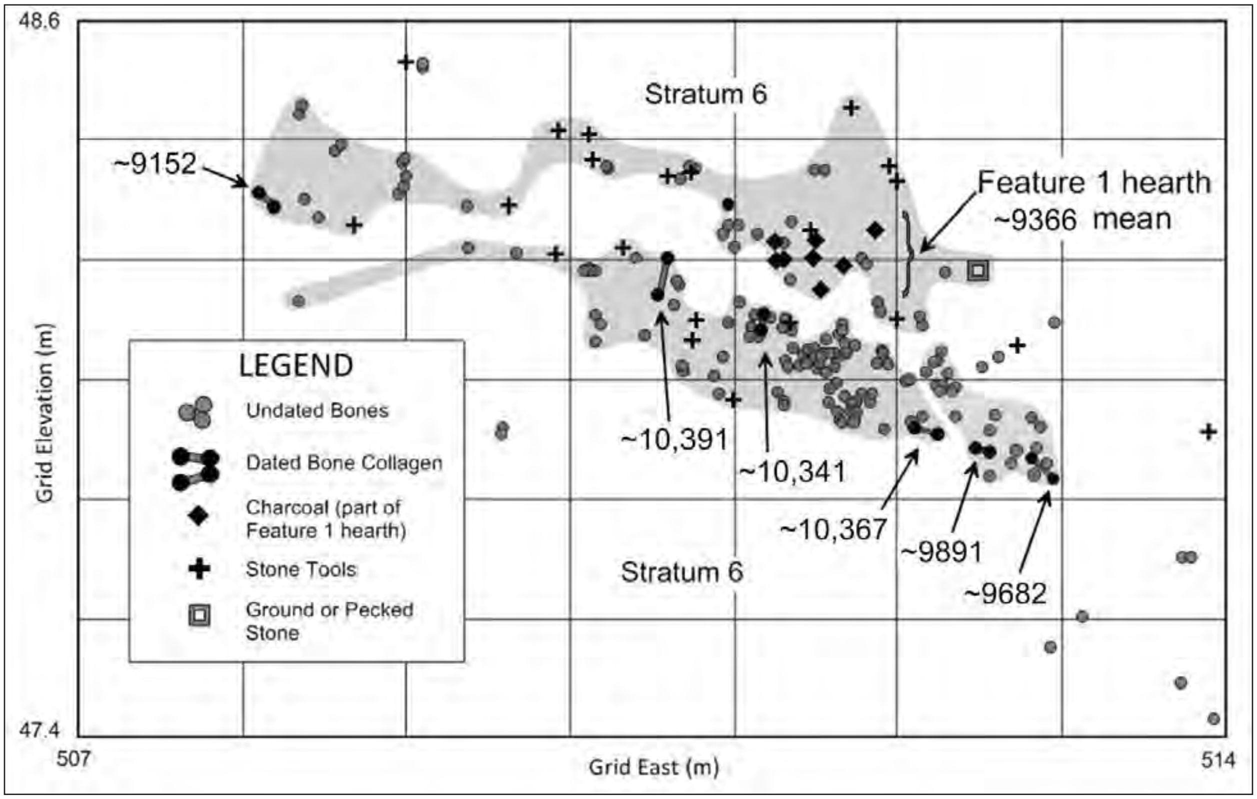


Figure 6.5. West-to-east back plot, Locus 1 North, with dated bone collagen and hearth charcoal (cal yr BP).

bone date in the upper portion of the bone bed, at ~9150 cal yr BP. The charcoal fragments were also directly associated with burned and calcined bone fragments, and carbonized amaranth and goosefoot seeds. From these data, we inferred the past presence of a small hearth (Buenger 2003; c.f. Surovell et al. 2016:83), designated as Feature 1 (Dello-Russo et al. 2017). Collagen samples in the lower, westernmost portion of the bone bed are dated to a range from ~10,390 to ~10,340 cal yrs BP, indicating that the upper and lower bone beds were deposited during two discrete events and are separated by an erosional disconformity.

As previously discussed in Chapters 3 and 4 of this report, the lithic assemblage recovered from Locus 1 North includes 141 unutilized debitage flakes, three retouched or utilized flakes, four bifaces, four multipurpose tools, five scrapers, and two projectile point or hafted knife fragments, as well as a small, slab grinding/anvil implement. The types of artifacts in the assemblage, together with hearth charcoal, burned/calcined bone and a number of long bones that exhibited percussion marks, bone flakes, and green-bone fracture edges comprise what we infer to be the remains of two open-air activity areas utilized for bison processing during Late Paleoindian periods contemporary with Allen-Frederick and Cody-Eden eras (Dello-Russo et al. 2021). The third cluster of bones with yet a third distinct set of dates—at ~9891 cal yr BP—represents the remains of another event inset into Locus 1 North and largely eroded by the actions of No Name Arroyo during the Holocene (Holliday et. al 2019). Thus, another avenue of future research in Locus 1 North should be a further determination of which bones and artifacts are associated with which depositional event through continued chronometric dating of bone collagen.

Ages of the Locus 5 Bone Bed and the Eden Point

Locus 5 is also an area of great interest at Water Canyon and one recommended as a locale for additional research. The poorly preserved bone bed in Locus 5 is located approximately 3.5 m below the surface (Figs. 6.6, 6.7) and, as noted previously, is associated with a resharpened Eden point (FS 5081; Fig. 6.7). Currently, there are no bones or teeth sufficiently well-preserved in Locus 5 to provide a reliable collagen date. Based on SOM dating, the age of the bone bed is between ~11,305 and ~11,000 cal yrs BP, although the point itself is more closely associated with an SOM date of ~10,070 cal yr BP (FS 5096, the dated SOM sample, was collected in Study Unit 5-3, at a location that was ca. 4.21 m northeast of the resharpened Eden point [FS 5081]).

Both Eden and Scottsbluff points are unfluted, stemmed lanceolate projectile point styles of the geographically broader Cody Tradition. In the Eden and Scottsbluff region of the northern Great Plains, Scottsbluff sites are dated between ~10,880 and ~8850 cal yrs BP, while Eden has a narrower range between ~11,160 and ~9525 cal yrs BP (Holliday 2000; Knell and Muñiz 2013:11). Knell and Muñiz (2013:7) speculate that Eden and Firstview are regional variants (following Wheat 1972), where Eden is more of a central Great Plains style and Firstview a southern Great Plains style (Knell and Muñiz 2013:11). Fogle-Hatch (2015) argues, however, that the Firstview type is metrically and morphologically similar enough to Scottsbluff and Eden types that it should no longer be considered a unique type. Nevertheless, the Firstview assemblages from the Olsen-Chubbuck site, the Blackwater Draw Locality 1, the San Jon site, and the Lubbock Lake site have age ranges between ~10,600 and ~9160 cal yrs BP (Holliday et al. 1999; Holliday 2000), similar to Eden. The evidence for Eden at the Water Canyon site is well within the general range of Cody across the Great Plains and in the southern Rocky Mountains (Pitblado 2003; Knell and Muñiz 2013) so, given what we know at present, the ~10,070 BP age

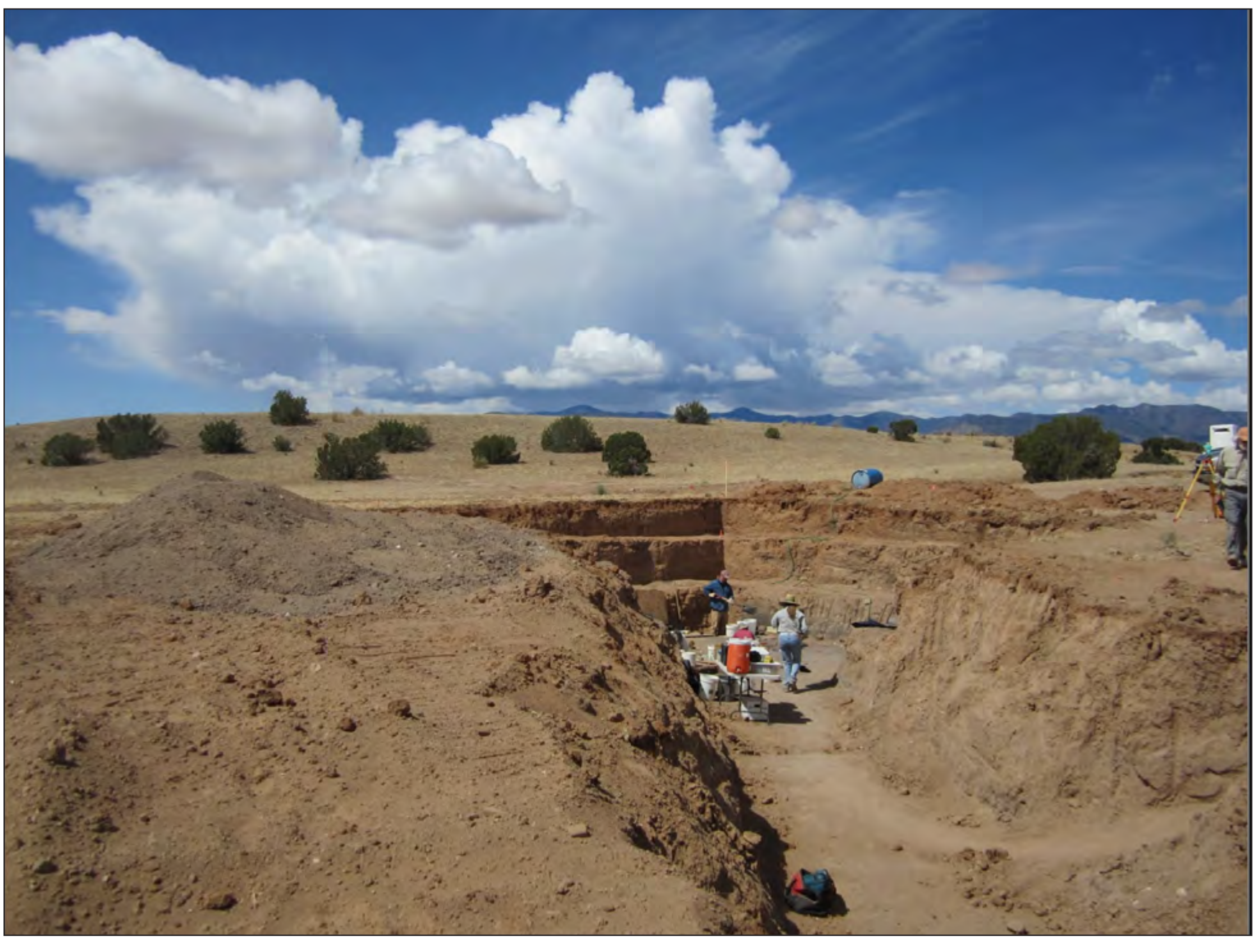


Figure 6.6. Locus 5, 2015, looking southwest.

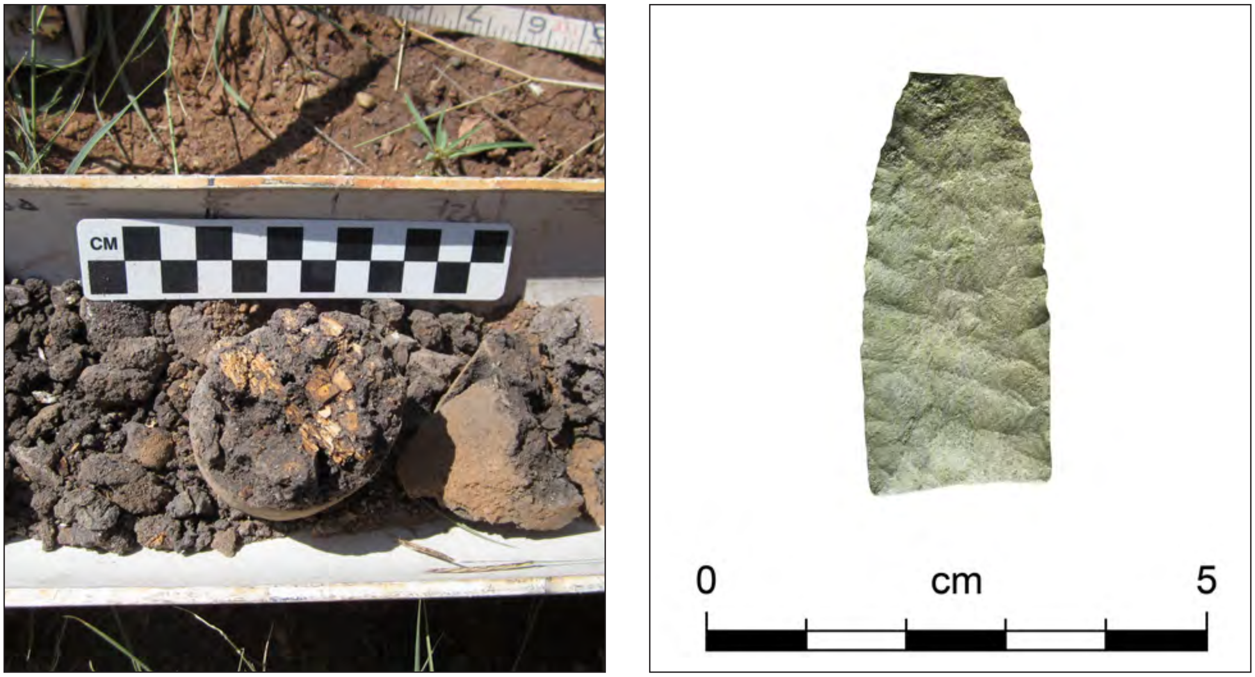


Figure 6.7. Locus 5 (*left*), poorly preserved *Bison* sp. bones in Giddings sediment core (with associated SOM date of 11,150 cal yr BP), and (*right*), resharpened Eden projectile point (with associated SOM date of 10,070 cal yr BP).

of the Locus 5 Eden point makes Water Canyon one of the earlier Cody sites in the south-central and Southwestern United States.

Since the Locus 5 bone bed arguably covers at least 50 sq m, additional excavation work to expose more *Bison* sp. bones with perhaps greater degrees of preservation, and to potentially recover additional associated projectile points, could be a possible solution to the chronometric issues in Locus 5. Lacking that, Locus 5 might be an arena for innovative approaches to chronometric dating, such as advances in the dating of tooth enamel.

Investigating Possible Clovis and Folsom Activity Areas

One additional avenue of research pertains to the Clovis occupation at the Water Canyon site. While the recoveries of one large Clovis point base in Locus 3 and one small, but complete, Clovis point in the vicinity of Locus 3 (*see* Fig. 5.1, [a] and [b], respectively) provide evidence of this occupation, the interesting discovery of a number of broken blade fragments reworked into end scrapers (*see* Fig. 5.2 [a–g]) also suggests a possible Clovis-aged processing area at the adjacent Locus 6 (Collins 1999).

Moreover, the area encompassing both Locus 3 and Locus 6 also contains evidence of use during the Folsom period. That period of time would have been significant at Water Canyon as it would have been demonstrably wetter (*see* the "Phytolith Analysis" section in Chapter 4, and Appendix C of this report) and most likely more attractive to grazing herbivores (*Bison* sp.) and the Folsom hunters that pursued them. Clearly, as evidenced in BHT-4 in Locus 3, below the Locus 6 landform, there are buried, Folsom-age sediments, and it is possible (likely) that some remains of buried features may exist in shallow contexts at Locus 6 as well.

Furthermore, it is currently unclear which surface artifacts are associated with the Folsom or Clovis components at Locus 6. Artifacts on this stable, Pleistocene-age surface have been mapped (*see* Fig. 3.13a) and recovered, but no excavations have yet taken place there. Thus, little is known about the potential for buried, intact cultural remains or dateable features in Locus 6 and future research there should be directed toward determining the nature and extent of any possible activity areas.

Bison Analysis, Biometrics, and Species Determination

The analysis of *Bison* sp. elements from Locus 1 North presents us with a final and provocative avenue of future research. The bulk of the *Bison* sp. elements in the Locus 1 North deposits were recovered from 1.57 to 2.18 m below the grid surface elevation of 50.00 m. Table 6.1 lists the 60 identifiable *Bison* sp. elements and fragments of the assemblage recovered to date, which represent at least one to two cows, three juveniles, and at least one bull. These same elements are illustrated in a bison skeleton in Figure 6.8. Several recovered long bones exhibited percussion marks, bone flakes, and green-bone fracture edges. Most of these fractures occurred at or near mid-shaft suggesting that they had been processed for the recovery of marrow. These data were derived from a faunal analysis completed by Robin Cordero, OCA faunal specialist (Dello-Russo et al. 2021).

Upon comparison of the *Bison* sp. remains in Locus 1 North with both modern and ancient forms (Table 6.2), it became apparent that we could not simply refer to the animals in the bone bed as *Bison antiquus* on the basis of their age. The following passage is quoted from Dello-Russo et al. (2021):

> The faunal remains identified in Locus 1 North are attributed to *Bison* sp. on the basis of measurements of metacarpals, radii, and femora recovered during excavations between 2009 and 2015 and comparisons of those measurements to published metrics for the same elements for both *Bison antiquus* and *Bison bison* recovered at other archaeological sites in the region (Lewis 2003; McCartney 1983; Todd 1987).… The individuals represented in the Locus 1 North faunal assemblage tend to fall somewhere between *B. antiquus* and *B. bison* in size and, as such, they could represent smaller individuals of a southern clade, or a mountain-foothill population, of *B. antiquus* or, due to their early Holocene age, they could represent some of the first *B. bison* in the region.

Table 6.1. *Bison* sp. elements, Locus 1 North.

Element	Total
Calcaneus	4
Cuneiform	2
Femur	7
Fused metacarpal	3
Fused metatarsal	8
Humerus	5
Long bone indeterm.	1
Middle phalange	3
Naviculo-cuboid	2
Pisiform	1
Proximal phalange	3
Radio-ulna	2
Radius	4
Rib indeterm.	3
Scaphoid	2
Tarsal indeterm.	1
Tibia	9
Ulna	4
Unciform	1
Total	**60**

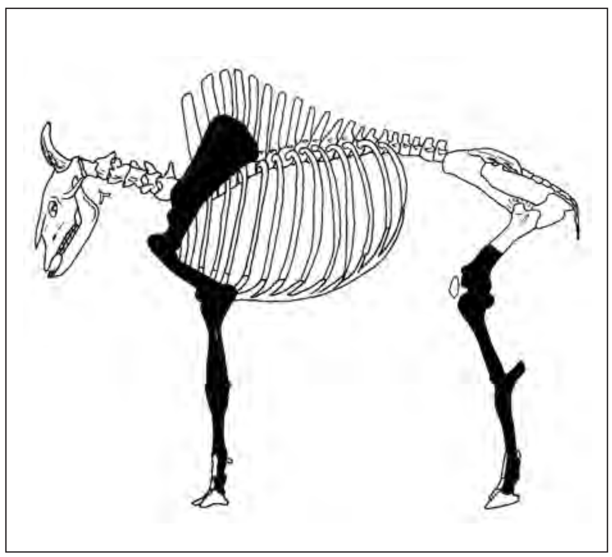


Figure 6.8. Bison skeletal representation of elements recovered in Locus 1 North.

Given these issues, we choose to refer to the animals in both Locus 1 North and—by extrapolation—in Locus 5 (since metric comparisons have yet to be made for that bone bed) as *Bison* sp. The questions raised by these findings might include:

Table 6.2. Comparative post-cranial measurements for Bison sp. from Locus 1 North.

Element Name	FS No.	Measurement Location on Element	Measurement (mm)	Comparative collection or site (reference)					
				Horner II (Todd, 1987)		Lamb Spring (McCartney, 1983)		Modern Bison (Lewis, 2003)	
				Male	Female	Male	Female	Male	Female
Metacarpal	FS 1305 FS 1528	Maximum Length (MC1)	215 214	---	---	220±8.1	216.1±5.3	210.6±7.3	202.6±11.1
	FS 1305 FS 1528	Proximal Breadth (MC2)	82.26 68.93	---	---	80.4±4.4	67.3±4.0	74.8±3.9	63.7±4.4
	FS 1305 FS 1528	Proximal Depth	51.04 43.21	---	---	43.5±1.9	39.0±1.8		36.8±3.3
	FS 1305 FS 1528	Mid-Shaft Width	53.54 37.73	---	---	53.0±3.2	41.4±1.9	48.2±3.2	37.5±3.2
	FS 1305 FS 1528	Mid-shaft Breadth	32.23 28.38	---	---	34.3±1.9	29.2±0.8	32.6±2.3	26.8±2.3
	FS 1305 FS 1528	Distal Breadth (MT4)	82.93 67.74	---	---	---	---	75.3±2.7	63.7±3.5
Radius	FS 1508 FS 1386 FS 1493	Greatest Breadth of Proximal End (RD3)	95 89 89	---	88.5±2.8	---	---	---	---
	FS 1508 FS 1386 FS 1493	Greatest Breadth of Proximal Articular Surface (RD4)	91.7 85.76 86.08	---	85±2.4	---	---	---	---
Femur	FS 1585	Greatest depth of Proximal End (RD9)	50.83	57±2.8	48.7±2.3	---	---	---	---
	FS 1585	Greatest Length of Lateral Condyle (FM6)	65.14	73.2±2.2	65.8±2.1	---	---	---	---
	FS 1585	Greatest Breadth of Distal End (FM12)	103	118.3±3.3	107.5±2.1	---	---	---	---

Table from Dello-Russo et al. 2020, Table 1.

• Did these bison represent the earliest forms of modern *Bison bison* in North America? or,

• Did these bison represent some transitional, or foothills-adapted form of the animal? or,

• Were these bison genetically *Bison antiquus*, but smaller, because C4 grasses (which are less robust nutritionally than the C3 grasses that thrived in cooler, wetter climates) had arrived earlier in the southern Great Plains as the Holocene climate warmed and dried?

The resolution of these issues is beyond the scope of this report, but these topics do represent provocative research questions and might best be resolved by a DNA study wherein the Locus 1 North assemblage could serve as an excellent comparative data set between *B. bison* and *B. antiquus* genetic data sets collected from other archaeological sites in other regions in western North America (cf. Wilson et al. 2008).

SEVEN

Conclusions

In conclusion, Water Canyon (LA 134764) is a partially buried, multi-component, stratified Paleoindian site in the Southwestern United States. The archaeological materials are within an alluvial fan at the toe of a large bajada. It contains numerous late Paleoindian features in ancient paludal deposits, which are themselves both on and beneath coarser, higher energy deposits more typical of an alluvial fan. The beds of *Bison* sp. bones on the margin of the ancient wetland, interpreted as the remains of open-air processing stations, date to ~9365, ~9890, and ~10,390 cal yrs BP. A nearby *Bison* sp. bone bed, farther out in the paleo-wetland and downslope from the processing stations, is interpreted as a probable kill site with an in situ Eden projectile point that currently dates to ~10,070 cal yrs BP, but may be as old as ~11,150 cal yrs BP. It may also be functionally related to one of the older processing area in Locus 1 North, and possibly to an open artifact scatter in Locus 4.

The Paleoindian bison bone beds at Locus 1 North of the Water Canyon site represent another rarity west of the southern Great Plains in New Mexico and Arizona. While bison kills are stereotypical features of Paleoindian sites in the surrounding region, the Water Canyon site is unique west of the Pecos River in New Mexico in large part because it contains these rare, open-air processing areas. The latest of these processing areas also contains a combination grinding stone/anvil implement that had both tuber starch and marrow lipids preserved on it. These findings are significant because they suggest that late Paleoindian hunter-gatherers had begun to broaden their diets with the inclusion of tubers, such as cattails, and had been intensifying their food-processing activities through the processing of *Bison* sp. bones for marrow. While similar tools have been recorded at late Paleoindian sites in Texas, Colorado, Wyoming, and Nevada, as of this writing, this groundstone/anvil artifact represents the oldest such tool ever documented in New Mexico.

These features, combined with the recovery of both Clovis and Folsom artifacts from the surface of the site, and remnants of both Clovis- and Folsom-aged wetland strata preserved in the site, show that the ancient wetlands environment at Water Canyon attracted foragers since at least late Clovis time, through the Younger Dryas and the early Holocene, and again during the middle-to-late Holocene epoch. As a consequence, the Water Canyon site can, for years to come, provide a wealth of data to augment our understanding of Paleoindian chronology, lifeways, paleoenvironment, and site formation processes in the American Southwest.

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Appendices

APPENDIX A. 2015 Field Sample Log

WATER CANYON 2015 FIELD SEASON
FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
LOCUS 1 NORTH & SOUTH							
1311	Lithic	N/A	505.215	508.303	48.530	5/28/2015	Arroyo - red rhyolite flake - found by crew 1st day
1312	Lithic	N/A	500.411	509.578	48.075	5/28/2015	Arroyo - red rhyolite biface frag - found by crew 1st day
1313	Lithic	1-23 / L1	499.674	485.569	50.281	5/29/2015	Locus 1 South - surface - red rhyolite flake, no cortex, no util.
1314	Bulk soil	1-19 / L4	512.864	507.118	48.485	5/29/2015	Locus 1 North - SE corner
1315	Bulk soil	1-21 / L3	511.259	506.754	48.527	5/29/2015	Locus 1 North - SE corner
1316	Bulk soil	1-24 / L1	498.124	484.898	50.327	5/29/2015	Locus 1 South - NW corner
1317	14C	45-52 cm below surface	549.335	460.846	48.205 (surf)	5/29/2015	Core 15-9 middle / Giddings rig / bulk sed
1318	14C	65 to 73 cm below surface	549.335	460.846	48.205 (surf)	5/29/2015	Core 15-9 lower / Giddings rig / bulk sed
1319	14C	40 to 45 cm below surface	549.335	460.846	48.205 (surf)	5/29/2015	Core 15-9 upper / Giddings rig / bulk sed
1320	Pollen	56 to 62 cm below surface	549.335	460.846	48.205 (surf)	5/29/2015	Core 15-9 / Giddings rig / bulk sed
1321	Pollen	73 to 78 cm below surface	549.335	460.846	48.205 (surf)	5/29/2015	Core 15-9 / Giddings rig / bulk sed
1322	Lithic	1-24 / L1	498.000	484.000	50.300	5/29/2015	Screen
1323	MISSING						
1324	Bulk soil	1-21 / L4	511.247	506.749	48.423	5/30/2015	Locus 1 North
1325	Lithic	1-22 / L1	498.892	485.292	50.315	5/30/2015	Locus 1 South - screen - red rhyolite flake
1326	Bulk soil	1-19 / L4	512.822	507.100	48.377	5/30/2015	Locus 1 North
1327	Bulk soil	1-23 / L1	499.072	485.403	50.232	5/31/2015	L 1 South - From center west side in rock ring - check for charcoal
1328	Lithic	1-19 / L4	512.000	507.000	48.330	5/31/2015	L 1 North - Screen / bottom of level @ 48.30
1329	Bulk soil	1-21 / L6	511.277	506.748	48.270	5/31/2015	Locus 1 North
1330	Bulk soil 14C	N/A	829.612	370.332		5/31/2015	Auger 15-1 / VTH hand auger / Big Wash / UTM E313239 m N3772794 m Elev 5720 ft
1331	Bulk soil 14C	N/A	951.120	439.867		5/31/2015	Auger 15-2 / VTH hand auger / Big Wash / UTM E313117 m N3772724 m Elev 5728 ft
1332	Bulk soil	1-21 / L6	511.260	506.693	48.225	6/3/2015	L 1 North - NW corner

WATER CANYON 2015 FIELD SEASON
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FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
1333	Lithic	1-27 / L1	499.550	486.419	50.264	6/3/2015	Locus 1 South - Surface
1334	Bulk soil	1-19 / L6	512.762	507.142	48.288	6/3/2015	Locus 1 North - SE corner
1335	Bone	1-19 / L6	512.000	507.000	48.200	6/3/2015	L 1 North - Screen
1336	Bone	1-21 / L7	511.000	506.000	48.20 - 48.10	6/3/2015	L 1 North - Screen
1337	Bulk soil	1-29 / L1	498.000	487.000	50.251 - 50.232	6/3/2015	L 1 South - NW corner
1338	Bulk soil	1-27 / L1	499.000	486.000	50.171	6/3/2015	L 1 South
1339	Bulk soil	1-23 / L2	499.000	485.000	50.151 - 50.121	6/3/2015	L 1 South - NW corner
1340	Lithic	1-19 / L7	512.000	507.000	48.100	6/3/2015	L 1 N - screen / 2 flakes from NW corner of unit
1341	Lithic	1-30 / L1	499.395	487.666	50.188	6/3/2015	L 1 South - Straight base triangular biface
1342	14C	1-19 / L7	512.487	507.690	48.182	6/4/2015	L 1 N - Charcoal
1343	Ground stone	1-19 / L7	512.519	507.275	48.183	6/4/2015	PL-1 / L 1 N / slab anvil groundstone
	Ground stone	1-19 / L7	512.471	507.408	48.181	6/4/2015	PL-2 / L 1 N / slab anvil groundstone
1344	Lithic	1-34 / L1	512.519	504.000	48.740 - 48.690	6/4/2015	L 1 N - Screen
1345	Bulk soil	1-21 / L7	511.721	506.752	48.180 - 48.140	6/4/2015	L 1 N
1346	Bone	1-19 / L7	512.299	507.432	48.180	6/4/2015	L 1 N - Screen
1347	Lithic	1-31 / L2	511.000	504.000	48.730 - 48.600	6/4/2015	L 1 N - screen
1348	14C	1-19 / L7	512.387	507.447	48.171	6/4/2015	L 1 N - Charcoal
1349	Bone	1-21 / L7	511.000	506.000	48.200 - 48.100	6/4/2015	L 1 N - screen
1350	14C	1-19 / L7	507.855	512.837	48.162	6/4/2015	L 1 N - Charcoal
1351	Bulk soil	1-19 / L7	507.143	512.760	48.126	6/4/2015	
1352	Lithic	1-28 / L1	498.000	486.000	50.349 - 50.200	6/4/2015	L 1 S - screen
1353	Bulk soil	1-34 / L3	512.243	504.693	48.600 - 48.550	6/4/2015	L 1 N - Partial level
1354	Bulk soil	1-31 / L2	511.121	504.092	48.598	6/4/2015	L 1 N - SW corner
1355	Bulk soil	1-28 / L1	498.870	486.873	50.264 -50.227	6/4/2015	L 1 S - NE corner
1356	Bone	1-21 / L8	511.000	506.000	48.100 - 48.000	6/4/2015	L 1 N - screen
1357	Lithic	1-35 / L1	497.788	487.535	50.309	6/4/2015	L 1 N / banded chert, possible biface
1358	14C	1-31 / L3	511.320	504.081	48.561	6/4/2015	L 1 N / large charcoal sample for wood ID
1359	Lithic	1-34 / overburden	512.000	504.000	...	6/4/2015	L 1 N / broken by pick-ax / found during cleanout of unit / unit provenience only
1360	14C	1-31 / L3	511.151	504.174	48.565	6/5/2015	L 1 N / charcoal sample for wood ID
1361	Bulk soil	1-31 / L3	511.111	504.086	48.508	6/5/2015	L 1 N

WATER CANYON 2015 FIELD SEASON
FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
1362-1	Lithic	1-21 / L8	511.341	506.482	48.094	6/5/2015	PL-1 / L 1 N / chalcedony flake found next to radius ulna / suitable for residue testing
1362-2	Lithic	1-21 / L7	511.316	506.341	48.124	6/5/2015	PL-2 / L 1 N / chalcedony flake found next to radius ulna / suitable for residue testing
1363	Bulk soil	1-34 / L3	512.192	504.124	48.517	6/5/2015	L 1 N
1364	Lithic	1-19 / L8	512.000	507.000	48.100 - 48.000	6/5/2015	L 1 N- screen
1365	14C	1-34 / L3	512.365	504.399	48.515	6/5/2015	L 1 N / charcoal
1366	Lithic	1-37 / L1	496.648	488.050	50.399	6/5/2015	L 1 S / red rhyolite, possible angular debris, surface
1367	Bone	1-19 / L8	512.000	507.000	48.100 - 48.000	6/5/2015	L 1 N - screen
1368	Lithic	1-19 / L8	512.738	507.278	48.055	6/5/2015	PL-1 / L 1 N
	Lithic	1-19 / L8	512.738	507.297	48.041	6/5/2015	PL-2 / L 1 N
1369	Bone	1-31 / L3	511.000	504.000	48.600 - 48.500	6/5/2015	L 1 N - screen
1370	Lithic	1-31 / L3	511.000	504.000	48.600 - 45.500	6/5/2015	L 1 N - screen
1371	Bulk soil	1-21 / L8	511.553	506.333	48.035	6/5/2015	L 1 N
1372	Bulk soil	1-19 / L8	512.774	507.150	48.020	6/5/2015	L 1 N - SE corner
1373	Lithic	1-34 / L4	512.770	504.285	48.448	6/5/2015	L 1 N - pinkish color similar to color found in 1-31 / L2 screen
1374	Bone	1-19 / L8	512.219	507.661	48.029	6/5/2015	L 1 N
1375	Bone	1-19 / L8	512.303	507.672	48.010	6/5/2015	L 1 N
1376	Bulk soil	1-34 / L4	512.879	504.126	48.452	6/5/2015	L 1 N
1377	Bone	1-21 / L8	511.000	506.000	48.100 - 48.000	6/5/2015	L 1 N - screen / 2 bags
1378	Bone	1-31 / L4	511.000	504.000	48.500 - 48.400	6/5/2015	L 1 N - screen
1379	Bulk soil	1-35 / L1	497.819	487.061	50.281	6/6/2015	L 1 S - SE corner
1380	Bulk soil	1-37 / L1	496.111	488.118	50.375	6/6/2015	L 1 S - NW corner
1381	Bulk soil	1-36 / L1	497.058	488.100	50.245	6/6/2015	L 1 S - SW corner
1382	Lithic	1-21 / L8	511.252	506.575	48.095	6/6/2015	L 1 N - cobble near radius-ulna
1383-A	Bone	1-19 / L9	512.000	507.000	48.000 - 47.900	6/6/2015	L 1 N - screen
1383-B	Bone	1-19 / L9	512.000	507.000	48.000 - 47.900	6/6/2015	L 1 N - screen / burned bone
1384	Lithic	1-21 / L8	511.000	506.000	48.100 - 48.000	6/6/2015	L 1 N - screen
1385-1	Bone	1-21 / L8	511.163	506.836	48.087	6/6/2015	PL-1 / L 1 N / metatarsal
1385-2	Bone	1-21 / L7	511.153	506.893	48.105	6/6/2015	PL-2 / L 1 N / distal end of metatarsal

WATER CANYON 2015 FIELD SEASON
FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
1385-3	Bone	1-15 / L8	511.330	507.083	48.068	6/12/2015	PL-3 /L 1 N / for metatarsal (bone extended into Units 1-15 and 1-21 / removed in 2 pieces
1386-1	Bone	1-21 / L7	511.140	506.547	48.105	6/6/2015	PL-1 / L 1 N
1386-2	Bone	1-21 / L8	511.350	506.367	48.083	6/6/2015	PL-2 / L 1 N
1386-3	Bone	1-21 / L7	511.033	506.533	48.128	6/6/2015	PL-3 / L 1 N
1386-4	Bone	1-21 / L7	511.318	506.356	48.100	6/6/2015	PL-4 / L 1 N
1387	Bone	1-34 / L4	512.000	504.000	48.500 - 48.400	6/6/2015	L 1 N - screen
1388	Lithic	1-38 / L1	496.467	487.946	50.350	6/6/2015	L 1 S - core
1389	Lithic	1-38 / L1	496.000	487.000	50.460 - 50.320	6/6/2015	L 1 S - screen
1390	Bone	1-21 / L8	511.686	506.686	48.046	6/6/2015	L 1 N - carpal?
1391	Lithic	N/A	509.932	507.366	48.415	6/6/2015	L 1 N - surface artifact found outside unit / approximate location
1392	Bulk soil	1-19 / L9	512.687	507.194	47.923	6/6/2015	L 1 N - SE corner
1393	Lithic	1-19 / L9	512.000	507.000	48.000 - 47.900	6/6/2015	L 1 N - screen
1394	Bulk soil	1-38 / L1	496.092	487.071	50.363	6/6/2015	L 1 S - SW corner
1395	Bone	South of Unit 1-45 = 1-46 / L1	510.677	505.833	48.333	6/7/2015	L 1 N - in overburden, approximate location
1396	Bulk soil	1-45 / L5	510.069	506.042	48.302	6/7/2015	L 1 N - SW corner
1397	Lithic	1-44 / L1	499.000	488.000	50.256 - 50.145	6/7/2015	L 1 S - Screen
1398	Bulk soil	1-6 / L18	509.947	509.115	47.073	6/7/2015	L 1 SE corner
1399	Lithic	1-43 / L1	498.000	488.000	50.284 - 50.174	6/7/2015	L 1 S - screen
1400	Bone	1-45 / L5	510.000	506.000	48.350 - 48.300	6/7/2015	L 1 N - start of level which ranges from 48.35 to 48.295
1401	Bulk soil	1-39 / L1	495.228	487.744	50.491 - 50.358	6/7/2015	L 1 S - NW corner
1402-1	Bone	1-15 / L8	511.297	507.063	48.087	6/7/2015	PL-1 / L 1 N / metapodial
1402-2	Bone	1-21 / L8	511.179	506.937	48.095	6/7/2015	PL-2 / L 1 N / metapodial
1403-1	Bone	1-21 / L8	511.676	506.749	48.041	6/7/2015	PL-1 / L 1 N / humerus
1403-2	Bone	1-21 / L8	511.617	506.807	48.044	6/7/2015	PL-2 / L 1 N / humerus
1404-1	Bone	1-21 / L8	511.874	506.457	48.025	6/7/2015	PL-1 / L 1 N / long bone fragment
1404-2	Bone	1-21 / L8	511.935	506.463	48.029	6/7/2015	PL-2 / L 1 N / long bone fragment
1405-1	Bone	1-21 / L8	511.664	506.305	48.081	6/7/2015	PL-1 / L 1 N / long bone fragment

WATER CANYON 2015 FIELD SEASON
FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
1405-2	Bone	1-21 / L8	511.653	506.398	48.075	6/7/2015	PL-2 / L 1 N / long bone fragment
1406	Bulk soil	1-45 / L6	510.055	506.110	48.233	6/7/2015	L 1 N
1407	Bulk soil	1-44 / L1	499.118	488.141	50.187	6/7/2015	L 1 S
1408	Bulk soil	1-43 / L1	498.793	488.689	50.198	6/7/2015	L 1 S
1409	Bulk soil	1-42 / L1	495.919	488.067	50.375	6/7/2015	L 1 S
1410	Lithic	1-43 / L1	498.328	488.622	50.255	6/7/2015	L 1 S / possible FCR
1411	Bulk soil	1-34 / L5	512.937	504.073	48.324	6/7/2015	L 1 N - SE corner
1412	Lithic	N/A	...	...	...	6/7/2015	L 1 N / obsidian flake / south of Unit 1-45? Found after pickaxing in soil sample hole
1413A	Bulk soil	1-43 / L1	498.000	488.000	...	6/10/2015	L 1 S / Feature 2 fill / north half (bag 1 of 2)
1413B	Bulk soil	1-43 / L1	498.000	488.000	...		L 1 S / Feature 2 fill / south half (bag 2 of 2)
1414	14C	1-43 / L1	498.479	488.898	50.190	6/10/2015	L 1 S / charcoal / Feature 2
1415	14C	1-43 / L1	498.443	488.875	50.181	6/10/2015	L 1 S / charcoal / Feature 2
1416	Lithic	N/A	...	...	...	6/4/2015	L 1 N / obsidian flake / found in Locus 1 N backfill pile
1417	Lithic	1-45 / L6	510.000	506.000	48.30 - 48.20	6/10/2015	L 1 N- screen
1418	Lithic	surface	503.617	485.283	50.024	6/10/2015	Yellow rhyolite
1419	Lithic	surface	501.152	485.723	50.168	6/10/2015	Chert
1420	Lithic	surface	502.244	479.573	50.378	6/10/2015	Red rhyolite flake
1421	Lithic	surface	502.483	473.915	50.575	6/10/2015	Red rhyolite
1422	Lithic	surface	499.254	483.571	50.389	6/10/2015	Red rhyolite flake
1423	Lithic	surface	495.008	481.879	50.748	6/10/2015	Red rhyolite flake
1424	Lithic	surface	493.973	484.366	50.647	6/10/2015	Red rhyolite flake
1425	Lithic	surface	490.395	467.502	52.506	6/10/2015	Red rhyolite flake
1426	Lithic	surface	491.161	463.375	52.269	6/10/2015	Red rhyolite flake
1427	Lithic	surface	489.190	461.285	52.600	6/10/2015	Red rhyolite
1428	Lithic	surface	487.319	464.541	52.515	6/10/2015	Red rhyolite
1429	Lithic	surface	481.651	465.855	52.937	6/10/2015	Yellow rhyolite
1430	Lithic	surface	480.307	481.656	51.778	6/10/2015	Red rhyolite
1431	Lithic	surface	482.548	480.694	51.650	6/10/2015	Yellow rhyolite
1432	Lithic	surface	483.850	483.511	51.408	6/10/2015	Red rhyolite
1433	Lithic	surface	484.094	483.733	51.384	6/10/2015	Quartz flake

WATER CANYON 2015 FIELD SEASON
FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
1434	Lithic	surface	483.401	486.723	51.303	6/10/2015	Chert flake
1435	Lithic	surface	487.094	487.513	50.989	6/10/2015	Red rhyolite
1436	Lithic	surface	491.624	490.587	50.613	6/10/2015	Obsidian flake
1437	Lithic	surface	494.617	511.470	50.055	6/10/2015	Red rhyolite / too close to TS-1 location to shoot - recorded on Locus 5 TS and Locus 5 TS log
1438	14C	1-45 / L6	510.420	506.844	48.200	6/11/2015	L 1 N
1439	Bone	1-19 / L9	512.193	507.513	47.944	6/11/2015	L 1 N
1440	Bone	1-45 / L6	510.000	506.000	48.30 - 48.20	6/11/2015	L 1 N - screen
1441	14C	1-19 / L10	512.229	507.547	47.894	6/11/2015	L 1 N - charcoal
1442-1	Bone	1-45 / L7	510.670	506.172	48.157	6/11/2015	PL-1 / L 1 N
1442-2	Bone	1-45 / L7	510.655	506.142	48.163	6/11/2015	PL-2 / L 1 N
1442-3	Bone	1-45 / L7	510.444	505.941	48.173	6/11/2015	PL-3 / L 1 N
1443	NO RECORD						
1444	Lithic	1-45 / L7	510.000	506.000	48.2 - 48.1	6/11/2015	L 1 N - screen / chalcedony uniface scraper
1445	Bulk soil	1-45 / L7	510.112	506.140	48.105	6/11/2015	L 1 N
1446	Bone	1-45 / L7	510.842	506.915	48.130	6/11/2015	L 1 N
1447	Bulk soil	1-34 / L6	512.950	504.040	48.259	6/12/2015	L 1 N
1448	Bone	1-20 / L8	512.843	506.320	48.069	6/12/2015	L 1 N - from rodent burrow
1449-1	Bone	1-45 / L7	510.412	506.087	48.191	6/12/2015	PL-1 / L 1 N
1449-2	Bone	1-46 / L6	510.403	505.981	48.203	6/12/2015	PL-2 / L 1 N
1450-1	Bone	1-45 / L7	510.085	506.732	48.180	6/12/2015	PL-1 / L 1 N / unknown type
1450-2	Bone	1-45 / L7	510.115	506.724	48.185	6/12/2015	PL-2 / L 1 N / unknown type
1451-1	Bone	1-45 / L7	510.128	506.929	48.181	6/12/2015	PL-1 / L 1 N / unknown type
1451-2	Bone	1-45 / L7	510.156	506.934	48.181	6/12/2015	PL-2 / L 1 N / unknown type
1452-1	Bone	1-15 / L8	511.417	507.049	48.042	6/12/2015	L 1 N - long bone fragment
1452-2	Bone	1-15 / L8	511.443	507.078	48.026	6/12/2015	L 1 N - long bone fragment
1453	Bone	n/a	507.000	509.000	...	6/12/2015	L 1 N - bone from south or west of Unit 1-13 / found while removing back dirt
1454	Bulk soil	1-20 / L7	512.912	506.763	48.150	6/12/2015	L 1 N
1455	Lithic	1-45 / L8	510.791	506.573	48.094	6/12/2015	L 1 N - approximate
1456	Bone	1-15 / L8-9	511.329	507.823	48.018	6/12/2015	L 1 N / initial cleanout and leveling of L9

WATER CANYON 2015 FIELD SEASON
FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
1457	Bone	1-15 / L8-9	511.000	507.000	48.050 - 48.000	6/12/2015	L 1 N (2 bags) / screen / 1457A = screen bone; 1457B = screen bone for special lab analysis
1458	Bone	1-45 / L8	510.965	506.121	48.094	6/12/2015	L 1 N
1459-1	Bone	1-45 / L7	510.641	506.606	48.124	6/12/2015	PL-1 / L 1 N / poss vertebrae
1459-2	Bone	1-45 / L7	510.665	506.621	48.105	6/12/2015	PL-2 / L 1 N / poss vertebrae
1460	Lithic	1-20 / L7	512.386	506.595	48.105	6/12/2015	L 1 N - approximate
1461	Bone	1-45 / L8	510.000	506.000	48.100 - 48.000	6/12/2015	L 1 N - screen
1462	Bone	1-15 / L7	511.000	507.000	48.160	6/12/2015	L 1 N - burnt
1463-1	Bone	1-45 / L7	510.158	506.843	48.106	6/12/2015	PL1 / L 1 N
1463-2	Bone	1-45 / L8	510.187	506.811	48.092	6/12/2015	PL-2 / L 1 N
1464	Lithic	1-45 / L8	510.000	506.000	48.100 - 48.000	6/12/2015	L 1 N - screen
1465	Bone	1-45 / L8	510.934	506.301	48.035	6/12/2015	L 1 N / metapodial
1466	Bone	1-14 / L6	510.000	507.000	48.260 - 48.200	6/12/2015	L 1 N - screen / partial level
1467	Bone	1-20 / L7	512.000	506.000	48.200 - 48.100	6/12/2015	L 1 N - screen
1468	Bulk soil	1-45 / L8	510.784	506.837	48.000	6/13/2015	L 1 N - NE corner
1469	Lithic	1-15 / L9	511.000	507.000	48.000 - 47.900	6/13/2015	L 1 N - screen / bags designated 1649A - screen lithic & 1469B - screen FCR - 2 frags
1470-1	Bone	1-45 / L8	510.688	506.519	48.021	6/13/2015	PL-1 / L 1 N / frag
1470-2	Bone	1-45 / L8	510.694	506.548	48.012	6/13/2015	PL-2 / L 1 N / frag
1471	Bone	1-20 / L8	512.000	506.000	48.100 - 48.000	6/13/2015	L 1 N / screen
1472	Bone	1-14 / L6	510.931	507.324	48.244	6/13/2015	L 1 N / burnt
1473	Bone	1-15 / L9	511.000	507.000	48.000 - 47.900	6/13/2015	L 1 N - screen
1474	14C	1-34 / L7	512.739	504.442	48.179	6/13/2015	L 1 N - charcoal
1475-1	Lithic	1-45 / L9	510.816	506.286	47.950	6/13/2015	PL-1 / L 1 N / top / chert spurred end scraper
1475-2	Lithic	1-45 / L9	510.819	506.293	47.949	6/13/2015	PL-2 / L 1 N / bottom / spurred end scraper
1476	Bulk soil	1-45 / L9	510.669	506.836	47.879	6/13/2015	L 1 N
1477	Bone	1-15 / L9	511.000	507.000	48.000 - 47.900	6/13/2015	L 1 N / Burnt /in separately screened sediment from rodent burrow
1478	14C	1-15 / L9	511.597	507.892	47.937	6/13/2015	L 1 N / Charcoal
1479	Bulk soil	1-34 / L7	512.907	504.072	48.135	6/13/2015	L 1 N

WATER CANYON 2015 FIELD SEASON
FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
1480	Lithic	1-14 / L6	510.000	507.000	48.300 - 48.200	6/13/2015	L 1 N - screen
1481	Bulk soil	1-14 / L6	510.113	507.920	48.196	6/13/2015	L 1 N
1482	Bulk soil	1-15 / L9	511.904	507.212	47.929	6/13/2015	L 1 N
1483	Bulk soil	1-20 / L8	512.934	506.813	47.996	6/13/2015	L 1 N
1484	14C	1-20 / L8	512.079	506.426	48.016	6/14/2015	L 1 N
1485-1	Lithic	1-34 / L6	512.271	504.081	48.211	6/14/2015	PL-1 / L 1 N / large rhyolite flake
1485-2	Lithic	1-34 / L6	512.241	504.057	48.204	6/14/2015	PL-2 / L 1 N / large rhyolite flake
1486	Lithic	1-19 / L7	512.000	507.000	48.120 - 48.110	6/14/2015	L 1 N - Screen
1487	Bone	1-19 / L7	512.000	507.000	48.110 - 48.000	6/14/2015	L 1 N - Screen
1488-1	Bone	1-20 / L8	512.151	506.101	48.091	6/14/2015	PL-1 / L 1 N / rib fragment sternal end
1488-2	Bone	1-20 / L7	512.139	506.071	48.105	6/14/2015	PL-2 / L 1 N / rib fragment sternal end
1489	Bone	1-19 / L10	512.000	507.000	47.900 - 47.800	6/14/2015	Screen
1490-1	Bone	1-45 / L7	510.978	506.780	48.114	6/15/2015	PL-1 / L 1 N / west piece of broken tibia
1490-2	Bone	1-21 / L8	511.232	506.742	48.060	6/15/2015	PL-2 / L 1 N / east piece of broken tibia
1490-3	Bone	1-21 / L8	511.198	506.728	48.061	6/15/2015	PL-3 / L 1 N / broken tibia (east half?)
1491	Lithic	1-45 / L7	510.404	506.385	48.119	6/15/2015	L 1 N / Cobble
1492	Lithic	1-45 / L7	510.583	506.373	48.153	6/15/2015	L 1 N / Cobble
1493	Bone	1-19 / L7	512.000	507.000	48.200 - 48.100	6/15/2015	L 1 N / Screen / separately sceened small bulk pedestal from unit corner nail which marked 4 units (1-15, 1-19, 1-20, 1-21)
1494	Bulk soil	1-15 / L9	511.000	507.000	48.000 - 47.900	6/17/2015	L 1 N / Pollen
1495	Bulk soil	1-45 / L7	510.000	506.000	48.200 - 48.100	6/17/2015	L 1 N / Pollen from under FS1510 (tibia)
1496	Bone	1-20 / L8	512.173	506.795	48.012	6/17/2015	L 1 N / indeterminate long fragment
1497	Bone	1-20 / L8	512.519	506.176	48.020	6/17/2015	L 1 N / indeterminate long fragment
1498-1	Bone	1-45 / L7	510.522	506.163	48.161	6/17/2015	PL-1 / L 1 N
1498-2	Bone	1-45 / L7	510.459	506.151	48.152	6/17/2015	PL-2 / L 1 N
1499-1	Bone	1-19 / L9	512.049	507.387	47.970	6/17/2015	PL-1 / L 1 N
1499-2	Bone	1-15 / L8	511.992	507.310	48.006	6/17/2015	PL-2 / L 1 N
1500-1	Bone	1-19 / L9	512.127	507.664	47.954	6/17/2015	L 1 N
1500	Bone	1-19 / L9	512.076	507.611	47.970	6/17/2015	L 1 N
1501-1	Bone	1-19 / L9	512.030	507.517	47.949	6/17/2015	PL-1 / L 1 N

WATER CANYON 2015 FIELD SEASON
FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
1501-2	Bone	1-19 / L9	512.074	507.557	47.957	6/17/2015	PL-2 / L 1 N
1502	Bone	1-19 / L9	512.153	507.768	47.937	6/17/2015	L 1 N
1503	Bone	1-15 / L9	511.784	507.394	47.974	6/17/2015	L 1 N
1504-1	Bone	1-15 / L9	511.952	507.885	47.941	6/17/2015	PL-1 / L 1 N / in between 1-15 & 1-19
1504-2	Bone	1-19 / L9	512.050	507.911	47.950	6/17/2015	PL-2 / L 1 N / in between 1-15 & 1-19
1505	Bone	1-15 / L9	511.843	507.735	47.975	6/17/2015	L 1 N
1506	Bone	1-15 / L9	511.752	507.181	47.945	6/17/2015	L 1 N
1507	Bone	1-15 / L9	511.743	507.208	47.934	6/17/2015	L 1 N
1508-1	Bone	1-15 / L9	511.401	507.370	47.944	6/17/2015	PL-1 / L 1 N
1508-2	Bone	1-15 / L9	511.389	507.494	47.998	6/17/2015	PL-2 / L 1 N
1509-1	Bone	1-15 / L9	511.119	507.216	47.990	6/17/2015	PL-1 / L 1 N
1509-2	Bone	1-15 / L8	511.096	507.159	48.063	6/17/2015	PL-2 / L 1 N
1510-1	Bone	1-45 / L7	510.545	506.334	48.141	6/17/2015	PL-1 / L 1 N / tibia & small bag w/ fragments
1510-2	Bone	1-45 / L6	510.604	506.562	48.203	6/17/2015	PL-2 / L 1 N / tibia & small bag w/ fragments
1511	Lithic	1-14 / L7	510.424	507.651	48.182	6/17/2015	L 1 N / Cobble
1512-1	Bone	1-45 / L8	510.954	506.377	48.022	6/17/2015	PL-1 / L 1 N
1512-2	Bone	1-45 / L8	510.853	506.436	48.017	6/17/2015	PL-2 / L 1 N
1513-1	Bone	1-15 / L9	511.876	507.544	47.928	6/17/2015	PL-1 / L 1 N
1513-2	Bone	1-15 / L9	511.825	507.582	47.959	6/17/2015	PL-2 / L 1 N
1514	Bone	1-20 / L8	512.621	506.493	48.037	6/17/2015	L 1 N
1515	Bone	1-45 / L8	510.877	506.545	48.005	6/17/2015	L 1 N
1516	Bone	1-15 / L9	511.834	507.675	47.959	6/17/2015	L 1 N
1517-1	Bone	1-45 / L7	510.953	506.512	48.106	6/17/2015	PL-1 / L 1 N / in 2 units
1517-2	Bone	1-21 / L7	511.025	506.485	48.120	6/17/2015	PL-2 / L 1 N
1518	Bone	1-20 / L9	512.000	506.000	48.000 - 47.900	6/17/2015	L 1 N / screen bags (2 bags)
1519-1	Bone	1-45 / L8	510.959	506.584	48.075	6/17/2015	PL-1 / L 1 N / in 2 units
1519-2	Bone	1-21 / L8	511.098	506.447	48.074	6/17/2015	PL-2 / L 1 N
1520-1	Bone	1-15 / L9	511.816	507.801	47.910	6/17/2015	PL-1 / L 1 N
1520-2	Bone	1-15 / L9	511.795	507.689	47.910	6/17/2015	PL-2 / L 1 N
1521-1	Bone	1-19 / L9	512.014	507.203	47.901	6/17/2015	PL-1 / L 1 N

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FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
1521-2	Bone	1-15 / L9	511.930	507.166	47.931	6/17/2015	PL-2 / L 1 N
1522-1	Bone	1-19 / L9	512.010	507.114	47.957	6/17/2015	PL-1 / L 1 N / in 2 units
1522-2	Bone	1-15 / L9	511.949	507.064	47.998	6/17/2015	PL-2 / L 1 N
1523-1	Bone	1-15 / L9	511.814	507.107	47.926	6/17/2015	PL-1 / L 1 N
1523-2	Bone	1-15 / L9	511.834	507.037	47.952	6/17/2015	PL-2 / L 1 N
1524	Bone	1-15 / L9	511.919	507.182	47.915	6/17/2015	L 1 N
1525-1	Bone	1-20 / L8	512.025	506.266	48.037	6/17/2015	PL-1 / L 1 N
1525-2	Bone	1-20 / L8	512.053	506.328	48.050	6/17/2015	PL-2 / L 1 N
1526	Bone	1-20 / L8	512.266	506.047	48.045	6/17/2015	L 1 N
1527	14C	1-20 / L9	512.684	506.889	47.914	6/17/2015	L 1 N
1528-1	Bone	1-21 / L7	511.186	506.420	48.109	6/17/2015	PL-1 / L 1 N
1528-2	Bone	1-21 / L8	511.166	506.599	48.081	6/17/2015	PL-2 / L 1 N
1529	Bone	1-20 / L8	512.251	506.086	48.031	6/17/2015	L 1 N
1530-1	Bone	1-15 / L10	511.797	507.256	47.894	6/17/2015	PL-1 / L 1 N
1530-2	Bone	1-15 / L9	511.820	507.233	47.930	6/17/2015	PL-2 / L 1 N
1531	Bone	1-21 / L8	511.152	506.599	48.083	6/17/2015	L 1 N
1532-1	Bone	1-21 / L8	511.080	506.662	48.099	6/17/2015	PL-1 / L 1 N
1532-2	Bone	1-21 / L8	511.146	506.681	48.068	6/17/2015	PL-2 / L 1 N
1533-1	Bone	1-20 / L8	512.244	506.101	48.000	6/17/2015	PL-1 / L 1 N
1533-2	Bone	1-20 / L8	512.219	506.072	48.011	6/17/2015	PL-2 / L 1 N
1534	Bone	1-45 / L9	510.909	506.560	47.974	6/17/2015	L 1 N
1535	Bone	1-21 / L9	511.680	506.962	47.971	6/17/2015	L 1 N
1536	Bone	1-14 / L7	510.000	507.000	48.200 - 48.100	6/17/2015	L 1 N
1537	Bone	1-20 / L9	512.242	506.335	47.990	6/17/2015	L 1 N
1538-1	Bone	1-21 / L7	511.551	506.985	47.951	6/17/2015	PL-1 / L 1 N
1538-2	Bone	1-21 / L7	511.640	506.969	47.973	6/17/2015	PL-2 / L 1 N
1539	Bone	1-20 / L7	512.350	506.522	47.985	6/17/2015	L 1 N
1540	Bulk soil	1-14 / L7	510.798	507.882	48.121	6/17/2015	L 1 N
1541	Lithic	1-21 / L9	511.000	506.000	48.000 - 47.900	6/17/2015	L 1 N / Screen
1542	Bone	1-21 / L9	511.000	506.000	48.000 - 47.900	6/17/2015	L 1 N / Screen
1543-1	Bone	1-45 / L6	510.586	506.026	48.209	6/17/2015	PL-1 / L 1 N / 2 units / proximal ulna frag

WATER CANYON 2015 FIELD SEASON
FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
1543-2	Bone	1-46 / L7	510.542	505.851	48.189	6/17/2015	PL-2 / L 1 N / 2 units / proximal ulna frag
1544	Bone	1-21 / L9	511.634	506.913	47.944	6/17/2015	L 1 N
1545	Bone	1-15 / L8	511.149	507.033	48.070	6/17/2015	L 1 N
1546-1	Bone	1-20 / L8	512.440	506.957	47.902	6/17/2015	PL-1 / L 1 N
1546-2	Bone	1-20 / L8	512.435	506.887	47.902	6//17/2015	PL-2 / L 1 N
1547	Bone	1-21 / L8	511.495	506.324	48.051	6/17/2015	L 1 N
1548-1	Bone	1-21 / L8	511.571	506.566	48.071	6/17/2015	PL-1 / L 1 N
1548-2	Bone	1-21 / L8	511.647	506.602	48.063	6/17/2015	PL-2 / L 1 N
1549	Bulk soil	1-20 / L9	512.900	506.851	47.951	6/18/2015	L 1 N
1550	Bone	1-20 / L9	512.109	506.967	47.917	6/18/2015	L 1 N
1551	Bone	1-20 / L9	512.075	506.674	47.997	6/18/2015	L 1 N
1552-1	Bone	1-21 / L8	511.404	506.358	48.020	6/18/2015	PL-1 / L 1 N
1552-2	Bone	1-21 / L8	511.294	506.420	48.063	6/18/2015	PL-2 / L 1 N
1553-1	Bone	1-20 / L9	512.176	506.532	47.999	6/18/2015	PL-1 / L 1 N
1553-2	Bone	1-20 / L8	512.068	506.543	48.020	6/18/2015	PL-2 / L 1 N
1554A	Bone	1-21 / L8	511.375	506.581	48.044	6/18/2015	L 1 N
1554B-1	Bone	1-21 / L8	511.358	506.517	48.051	6/18/2015	PL-1 / L 1 N
1554B-2	Bone	1-21 / L8	511.491	506.507	48.070	6/18/2015	PL-2 / L 1 N
1555	Bone	1-21 / L8	511.903	506.144	48.044	6/18/2015	L 1 N
1556-1	Bone	1-20 / L8	512.017	506.163	48.025	6/18/2015	PL-1 / L 1 N
1556-2	Bone	1-21 / L8	511.850	506.200	48.054	6/18/2015	PL-2 / L 1 N
1557	Micromorph	1-6 / L12	509.825	509.076	47.690	6/18/2015	L 1 N / elevation taken @ base of EJB
1558	Micromorph	1-6 / L12	509.767	509.052	47.606	6/18/2015	L 1 N / elevation taken @ base of EJB
1559	Micromorph	1-6 / L13	509.862	509.052	47.552	6/18/2015	L 1 N / elevation taken @ base of EJB
1560	Micromorph	1-6 / L14	509.773	509.047	47.481	6/18/2015	L 1 N / elevation taken @ base of EJB
1561-1	Bone	1-20 / L9	512.379	506.290	47.966	6/18/2015	PL-1 / L 1 N
1561-2	Bone	1-20 / L9	512.315	506.257	47.971	6/18/2015	PL-2 / L 1 N
1562	Bone	1-20 / L9	512.248	506.639	47.906	6/18/2015	L 1 N
1563	Bone	1-20 / L9	512.263	506.535	47.979	6/18/2015	L 1 N
1564	Burlap	1-21 / L9	511.921	506.343	47.973	6/18/2015	L 1 N
1565	Bone	1-21 / L9	511.266	506.451	47.977	6/18/2015	L 1 N

WATER CANYON 2015 FIELD SEASON
FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
1566	Bone	1-21 / L8	511.565	506.564	48.065	6/18/2015	L 1 N
1567	Bone	1-21 / L8	511.526	506.637	48.026	6/18/2015	L 1 N
1568	Bone	1-20 / L9	512.329	506.171	47.980	6/18/2015	L 1 N
1569	Lithic	1-21 / L8	511.597	506.601	48.011	6/18/2015	L 1 N
1570	Bulk soil	1-21 / L9	511.302	506.207	47.919	6/18/2015	L 1 N
1571-1	Bone	1-20 / L8	512.062	506.330	48.032	6/18/2015	PL-1 / L 1 N
1571-2	Bone	1-20 / L7	512.052	506.345	48.028	6/18/2015	PL-2 / L 1 N
1572	Bone	1-20 / L9	512.594	506.557	47.940	6/18/2015	L 1 N
1573	Bone	1-21 / L8	511.601	506.670	48.040	6/18/2015	L 1 N
1574-1	Bone	1-14 / L7	510.561	507.109	48.121	6/18/2015	PL-1 / L 1 N
1574-2	Bone	1-14 / L7	510.669	507.201	48.145	6/18/2015	PL-2 / L 1 N
1575-1	Bone	1-14 / L7	510.536	507.529	48.118	6/18/2015	PL-1 / L 1 N
1575-2	Bone	1-14 / L7	510.526	507.451	48.138	6/18/2015	PL-2 / L 1 N
1576-1	Bone	1-14 / L7	510.507	507.459	48.124	6/18/2015	PL-1 / L 1 N
1576-2	Bone	1-14 / L7	510.627	507.384	48.152	6/18/2015	PL-2 / L 1 N
1577	Lithic	1-20 / L9	512.000	506.000	48.000 - 47.900	6/18/2015	L 1 N / Screen
1578	Bone	1-21 / L9	511.311	506.464	47.956	6/18/2015	L 1 N
1579	Lithic	1-21 / L9	511.246	506.245	47.926	6/18/2015	L 1 N / FCR?
1580	Lithic	1-21 / L10	511.183	506.376	47.899	6/18/2015	L 1 N / FCR?
1581	Lithic	1-21 / L10	511.370	506.308	47.878	6/18/2015	L 1 N
1582-1	Bone	1-21 / L8	511.499	506.574	48.066	6/18/2015	PL-1 / L 1 N
1582-2	Bone	1-21 / L8	511.615	506.365	48.067	6/18/2015	PL-2 / L 1 N
1583-1	Bone	1-21 / L8	511.721	506.608	48.047	6/18/2015	PL-1 / L 1 N / Rib fragments
1583-2	Bone	1-21 / L8	511.776	506.625	48.073	6/18/2015	PL-2 / L 1 N / rib fragments
1584-1	Bone	1-21 / L8	511.828	506.585	48.025	6/18/2015	PL-1 / L 1 N
1584-2	Bone	1-21 / L8	511.751	506.594	48.048	6/18/2015	PL-2 / L 1 N
1585-1	Bone	1-21 / L8	511.883	506.640	48.008	6/18/2015	PL-1 / L 1 N
1585-2	Bone	1-21 / L8	511.678	506.631	48.047	6/18/2015	PL-2 / L 1 N
1586-1	Bone	1-20 / L8	512.047	506.379	48.027	6/18/2015	PL-1 / L 1 N
1586-2	Bone	1-21 / L8	511.946	506.288	48.025	6/18/2015	PL-2 / L 1 N
1587-1	Bone	1-20 / L9	512.659	506.729	47.903	6/18/2015	PL-1 / L 1 N

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FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
1587-2	Bone	1-20 / L9	512.759	506.789	47.909	6/18/2015	PL-2 / L 1 N
1588	Bone	1-20 / L9	512.353	506.366	47.937	6/18/2015	L 1 N
1589	Lithic	1-19 / L10	512.000	507.000	47.900 - 47.800	6/18/2015	L 1 N / Screen
1590-1	Bone	1-21 / L8	511.574	506.515	48.050	6/18/2015	PL-1 / L 1 N
1590-2	Bone	1-21 / L8	511.610	506.452	48.046	6/18/2015	PL-2 / L 1 N
1591-1	Lithic	1-14 / L8	510.772	507.138	48.098	6/18/2015	PL-1 / L 1 N
1591-2	Lithic	1-14 / L8	510.749	507.145	48.065	6/18/2015	PL-2 / L 1 N
1592	Bulk soil	1-45 / L11	510.191	506.114	47.785	6/18/2015	L 1 N
1593-1	Bone	1-20 / L9	512.100	506.502	47.981	6/18/2015	PL-1 / L 1 N / radius-ulna
1593-2	Bone	1-21 / L8	511.942	506.422	48.043	6/18/2015	PL-2 / L 1 N / radius-ulna
1594-1	Bone	1-21 / L8	511.624	506.388	48.049	6/18/2015	PL-1 / L 1 N
1594-2	Bone	1-21 / L8	511.562	506.504	48.060	6/18/2015	PL-2 / L 1 N
1595-1	Bone	1-14 / L8	510.913	507.457	48.087	6/19/2015	PL-1 / L 1 N
1595-2	Bone	1-14 / L8	510.981	507.508	48.089	6/19/2015	PL-2 / L 1 N
1596	Lithic	1-45 / L10	510.829	506.717	47.828	6/19/2015	L 1 N / Approximate
1597-1	Bone	1-14 / L8	510.881	507.456	48.073	6/19/2015	PL-1 / L 1 N
1597-2	Bone	1-14 / L8	510.956	507.515	48.082	6/19/2015	PL-2 / L 1 N
1598-1	Bone	1-20 / L9	512.501	506.461	47.922	6/19/2015	PL-1 / L 1 N / tibia posterior shaft
1598-2	Bone	1-20 / L9	512.550	506.359	47.943	6/19/2015	PL-2 / L 1 N / tibia posterior shaft
1599	Bone	1-14 / L8	510.000	507.000	48.100 - 48.000	6/19/2015	L 1 N / screen
1600A-1	Bone	1-20 / L9	512.593	506.224	47.943	6/19/2015	PL-1 / L 1 N
1600A-2	Bone	1-20 / L9	512.624	506.308	47.926	6/19/2015	PL-2 / L 1 N
1600B	Bone	1-20 / L9	512.622	506.343	47.903	6/19/2015	L 1 N
1600C	Bone	1-20 / L10	512.650	506.400	47.885	6/19/2015	L 1 N / Area of fragments
1601-1	Bone	1-20 / L9	512.003	506.434	47.907	6/19/2015	PL-1 / L 1 N
1601-2	Bone	1-21 / L9	511.995	506.530	47.933	6/19/2015	PL-2 / L 1 N
1602	Lithic	1-14 / L8	510.000	507.000	48.100 - 48.000	6/19/2015	Possible FCR in screen
1603-1	Bone	1-20 / L10	512.472	506.454	47.897	6/19/2015	PL-1 / L 1 N
1603-2	Bone	1-20 / L9	512.454	506.399	47.923	6/19/2015	PL-2 / L 1 N
1604	Bone	1-20 / L9	512.082	506.299	47.928	6/19/2015	L 1 N
1605-1	Bone	1-20 / L10	512.477	506.333	47.884	6/19/2015	PL-1 / L 1 N

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1605-2	Bone	1-20 / L10	512.567	506.364	47.877	6/19/2015	PL-2 / L 1 N
1606	Bone	1-14 / L8	510.162	507.264	48.062	6/19/2015	L 1 N
1607	Bone	1-21 / L8	511.894	506.025	48.114	6/19/2015	L 1 N / Frags from innominate / main bone not removed from unit
1608	Lithic	1-46 / L11	510.269	505.993	47.789	6/19/2015	L 1 N
1609	Bulk soil	1-45 / L11	510.151	506.195	47.761	6/19/2015	L 1 N
1610	Bulk soil	1-14 / L8	510.949	507.142	48.041	6/19/2015	L 1 N
1611-1	Bone	1-20 / L10	512.618	506.483	47.855	6/19/2015	PL-1 / L 1 N
1611-2	Bone	1-20 / L10	512.623	506.401	47.886	6/19/2015	PL-2 / L 1 N
1612	Bone	1-20 / L9	512.053	506.177	47.998	6/19/2015	L 1 N
1613-1	Bone	1-20 / L9	512.323	506.206	47.973	6/19/2015	PL-1 / L 1 N
1613-2	Bone	1-20 / L9	512.111	506.163	47.998	6/19/2015	PL-2 / L 1 N
1614-1	Bone	1-20 / L9	512.356	506.169	47.954	6/19/2015	PL-1 / L 1 N
1614-2	Bone	1-20 / L9	512.452	506.066	47.996	6/19/2015	PL-2 / L 1 N
1615-1	Bone	1-20 / L10	512.679	506.975	47.895	6/19/2015	PL-1 / L 1 N / Scapula / in units 1-19 and 1-20
1615-2	Bone	1-20 / L10	512.616	506.891	47.875	6/19/2015	PL-2 / L 1 N / Scapula
1615-3	Bone	1-19 / L10	512.891	507.188	47.839	6/19/2015	PL-3 / L 1 N / Scapula
1616	14C	1-20 / L9	512.656	506.188	47.903	6/19/2015	L 1 N / charcoal
1617	Bone	1-20 / L10	512.701	506.575	47.858	6/19/2015	L 1 N
1618	Bone	1-20 / L9	512.565	506.064	47.912	6/19/2015	L 1 N
1619	Bone	1-20 / L9	512.279	506.071	47.990	6/19/2015	L 1 N
1620	Bone	1-20 / L10	512.567	506.522	47.836	6/19/2015	L 1 N
1621	Lithic	1-20 / L10	512.530	506.148	47.882	6/19/2015	L 1 N / Approximate location
1622	Bone	1-20 / L9	512.875	506.110	47.920	6/19/2015	L 1 N
1623	Bone	1-20 / L10	512.852	506.864	47.883	6/19/2015	L 1 N
1624	Bulk soil	1-45 / L13	510.152	506.088	47.598	6/19/2015	L 1 N
1625-1	Bone	1-20 / L10	512.840	506.585	47.839	6/19/2015	PL-1 / L 1 N
1625-2	Bone	1-20 / L10	512.729	506.656	47.878	6/19/2015	PL-2 / L 1 N
1626	Bone	1-20 / L10	512.913	506.759	47.857	6/19/2015	L 1 N
1627	Bone	1-20 / L9	512.826	506.154	47.934	6/20/2015	L 1 N
1628	Lithic	1-20 / L10	512.910	506.502	47.839	6/20/2015	L 1 N

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1629-1	Bone	1-20 / L10	512.845	506.594	47.834	6/20/2015	PL-1 / L 1 N / Fragment of juvenile femur
1629-2	Bone	1-20 / L10	512.869	506.597	47.875	6/20/2015	PL-2 / L 1 N / Fragment of juvenile femur
1630	Bulk Soil	1-45 / L13	510.125	506.023	47.543	6/20/2015	L 1 N - gleyed sediment
1631	Bone	1-20 / L8	512.964	506.637	48.094	6/20/2015	L 1 N
1632	Sediment	1-47 / L15	511.349	512.501	47.317	10/1/2015	L 1 N / for phytolith, diatom analyses
1633	Sediment	1 - 47 / L15	511.319	512.506	47.368	10/1/2015	L 1 N / for phytolith, diatom analyses
1634	Sediment	1 - 47 / L14	511.346	512.502	47.490	10/1/2015	L 1 N / for phytolith, diatom analyses
1635	Sediment	1 - 47 / L13	511.345	512.513	47.557	10/1/2015	L 1 N / for phytolith, diatom analyses
1636	Sediment	1 - 47 / L12	511.332	512.507	47.660	10/1/2015	L 1 N / for phytolith, diatom analyses
1637	Sediment	1 - 47 / L11	511.353	512.506	47.744	10/1/2015	L 1 N / for phytolith, diatom analyses
1638	Sediment	1 - 47 / L15	511.464	512.482	47.329	10/1/2015	L 1 N / for phytolith, diatom analyses
1639	Sediment	1 - 47 / L15	511.454	512.504	47.363	10/1/2015	L 1 N / for phytolith, diatom analyses
1640	Sediment	1 - 47 / L14	511.458	512.508	47.470	10/1/2015	L 1 N / for phytolith, diatom analyses
1641	Sediment	1 - 47 / L13	511.485	512.537	47.543	10/1/2015	L 1 N / for phytolith, diatom analyses
1642	Sediment	1 - 47 / L12	511.516	512.563	47.629	10/1/2015	L 1 N / for phytolith, diatom analyses
1643	Sediment	1 - 47 / L11	511.445	512.551	47.709	10/1/2015	L 1 N / for phytolith, diatom analyses
1644	SOM	1 - 47 / L16	511.828	512.521	47.230	10/1/2015	soil organic matter collected for 14C dating
1645	SOM	1 - 47 / L15	511.830	512.489	47.352	10/1/2015	soil organic matter collected for 14C dating
1646	SOM	1 - 47 / L13	511.785	512.482	47.532	10/1/2015	soil organic matter collected for 14C dating
1647	SOM	1 - 47 / L12	511.777	512.495	47.648	10/1/2015	soil organic matter collected for 14C dating
LOCUS 2							
2001	Lithic	Surface	482.110	538.426	51.831	5/28/2015	Obsidian flk / 1st day crew find / XFR analysis
2002	Lithic	Surface	480.483	543.306	52.119	5/28/2015	Obsidian flk / 1st day crew find / XRF analysis
2003	Lithic	Surface	450.387	559.317	53.473	6/7/2015	Gypsum point / dacite / aka Surface Artifact #004 / found by D. Chapman
2004	Lithic	Surface	456.529	562.042	53.058	6/7/2015	Red rhyolite biface / aka Surface Artifact #005
2005	Lithic	Surface	496.073	528.587	50.467	6/10/2015	Red rhyolite flake in lithic scatter
2006	Lithic	Surface	505.896	519.914	49.783	6/10/2015	Yellow rhyolite flke in lithic scatter
2007	Lithic	Surface	491.681	526.188	50.633	6/10/2015	Grey transparent chalcedony flake

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2008	Lithic	Surface	492.555	543.438	51.564	6/10/2015	Red rhyolite flake
2009	Lithic	Surface	485.152	541.426	51.800	6/10/2015	Orange rhyolite flake
2010	Lithic	Surface	482.792	545.413	52.076	6/10/2015	White quartz core
2011	Lithic	Surface	480.787	543.034	52.081	6/10/2015	Red rhyolite flake
2012	Lithic	Surface	484.849	556.178	52.092	6/10/2015	Yellow rhyolite flake with cortex
2013	Lithic	Surface	479.257	554.038	52.374	6/10/2015	Red rhyolite flake
2014	Lithic	Surface	481.181	556.503	52.258	6/10/2015	NON-CULTURAL
2015	Lithic	Surface	465.190	540.193	52.541	6/10/2015	Yellow rhyolite core
2016	Lithic	Surface	464.224	539.614	52.588	6/10/2015	Yellow rhyolite core
2017	Lithic	Surface	468.871	537.847	52.477	6/10/2015	Red rhyolite flake
2018	Lithic	Surface	469.126	539.659	52.432	6/10/2015	Yellow rhyolite core
2019	Lithic	Surface	478.000	528.785	52.134	6/10/2015	Yellow rhyolite flake
2020	Lithic	Surface	501.400	522.126	50.200	6/10/2015	Yellow rhyolite flake
2021	Lithic	Surface	471.941	539.714	52.286	6/10/2015	Yellow rhyolite flake
2022	Lithic	Surface	458.655	523.214	53.001	6/10/2015	Red rhyolite flake
2023	Lithic	Surface	459.303	526.841	52.826	6/10/2015	Red rhyolite flake
2024	Lithic	Surface	454.136	523.403	53.212	6/10/2015	Yellow rhyolite flake
2025	Lithic	Surface	456.697	513.421	52.580	6/10/2015	Red rhyolite flake
2026	Lithic	Surface	456.838	513.142	52.547	6/10/2015	Red rhyolite flake
2027	Lithic	Surface	454.155	537.072	52.828	6/10/2015	Red rhyolite flake
2028	Lithic	Surface	459.863	540.235	52.477	6/10/2015	Red rhyolite flake
2029	Lithic	Surface	455.456	539.728	52.692	6/10/2015	Red rhyolite flake
2030	Lithic	Surface	447.688	529.256	53.293	6/10/2015	Red rhyolite flake
2031	Lithic	Surface	449.625	536.633	52.941	6/10/2015	Yellow rhyolite flake with cortex
2032	Lithic	Surface	450.734	532.617	53.044	6/10/2015	Yellow rhyolite flake
2033	Lithic	Surface	450.237	534.159	53.001	6/10/2015	Yellow rhyolite flake
2034	Lithic	Surface	445.213	530.386	53.357	6/10/2015	Rhyolite flakes (cluster of 3)
2035	Lithic	Surface	445.810	521.830	53.451	6/10/2015	Rhyolite flakes (cluster of 2)
2036	Lithic	Surface	444.329	522.758	53.493	6/10/2015	Red rhyolite flake
2037	Lithic	Surface	439.792	526.456	53.653	6/10/2015	Rhyolite flakes (cluster of 2)
2038	Lithic	Surface	461.804	531.698	52.681	6/10/2015	Yellow rhyolite flake

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2039	Lithic	Surface	458.682	533.068	52.768	6/10/2015	Red rhyolite flake
2040	Lithic	Surface	457.870	533.634	52.786	6/10/2015	Red rhyolite flake
2041	Lithic	Surface	439.309	524.000	53.685	6/10/2015	Red rhyolite flake
2042	Lithic	Surface	436.389	517.552	53.677	6/10/2015	Red rhyolite flake
2043	Lithic	Surface	432.297	517.765	53.841	6/10/2015	Red rhyolite flake
2044	Lithic	Surface	429.265	521.942	54.037	6/10/2015	Red rhyolite biface
2045	Lithic	Surface	431.831	526.440	53.915	6/10/2015	Red rhyolite flake
2046	Lithic	Surface	430.601	527.231	53.958	6/10/2015	Yellow rhyolite flake
2047	Lithic	Surface	432.140	538.519	53.399	6/10/2015	Rhyolite core
2048	Lithic	Surface	435.582	537.118	53.442	6/10/2015	Yellow rhyolite flake
2049	Lithic	Surface	519.464	518.697	49.305	6/10/2015	Red rhyolite biface
2050	Lithic	Surface	462.642	560.994	52.885	6/10/2015	Red rhyolite biface
2051	Lithic	Surface	462.595	560.829	52.887	6/10/2015	Red rhyolite biface
2052	Lithic	Surface	462.708	559.554	52.892	6/10/2015	Red rhyolite biface
2053	Lithic	Surface	460.437	563.164	52.921	6/10/2015	Yellow rhyolite flake
2054	Lithic	Surface	459.710	563.174	52.935	6/10/2015	Red rhyolite biface
2055	Lithic	Surface	467.102	556.139	52.755	6/10/2015	Red rhyolite biface
LOCUS 3							
3038	Lithic	Surface	455.255	655.355	52.206	6/20/2015	yellow rhyolite flake
3039	Lithic	Surface	457.431	655.276	52.165	6/20/2015	red rhyolite flake
3040	Lithic	Surface	462.369	650.006	51.799	6/20/2015	yellow rhyolite biface fragment
LOCUS 4							
4003	Lithic	Surface	622.590	449.644	46.536	6/19/2015	pinkish-tan rhyolite - Biface tip fragment
4004	Lithic	Surface	643.089	376.345	49.142	6/19/2015	yellow rhyolite - unifacial tool - spurred

WATER CANYON 2015 FIELD SEASON
FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
4005	Lithic	Surface	581.375	364.243	51.312	6/20/2015	red rhyolite - ang debris - HT incorrect when shot. Change from 2.50 to 1.479
4006	Lithic	Surface	610.619	362.665	50.621	6/20/2015	red rhyolite - biface frag - HT incorrect when shot. Change from 2.50 to 1.479
4007	Lithic	Surface	649.564	381.156	47.360	6/20/2015	red rhyolite - retouched flake - HT incorrect when shot. Change from 2.50 to 1.479
4008	Lithic	Surface	655.565	375.427	48.250	6/20/2015	red rhyolite - flake fragment - correct HT 1.479
4009	Lithic	Surface	N/A	N/A	N/A	6/20/2015	NO SHOT - NOT COLLECTED
LOCUS 5			**East**	**North**	**Elev.**		
5140	Bone	5-11 / L5	524.000	518.500	45.510	5/30/2015	Screen / 2 small bags from unit / 1 bag contains teeth and 1 femur head
5141	Lithic in screen	5-11 / L5	524.000	518.500	45.510	5/30/2015	
5142	Bone	5-01 / L4	524.000	519.000	45.600	6/3/2015	2 bags
5143	Bulk soil	5-01 / L4	524.860	519.850	45.610	6/4/2015	soil for wet screen (1/16")
5144	Bone	5-01 / L5	524.000	519.000	45.61-45.50	6/4/2015	
5145	Tooth enamel	Auger 5-5	525.500	523.500	45.970	6/7/2015	auger
5146	Bone	5-07 / L3	525.000	519.000	45.83-45.70	6/10/2015	Screen
5147	Bone	5-08 / L3	525.000	520.000	45.83-45.70	6/10/2015	Screen
5148	Tooth enamel	5-08 / L3	525.681	520.250	45.780	6/10/2015	
5149	Bulk soil	5-07 / L3	525.000	519.000	45.73-45.70	6/11/2015	
5150	Bulk soil	5-08 / L3	525.000	520.000	45.75-45.70	6/11/2015	
5151	Tooth	5-07 / L4	525.563	519.808	45.650	6/11/2015	
5152	Bone	5-08 / L4	525.000	520.000	45.70-45.60	6/11/2015	Screen
5153	Bulk soil	5-08 / L4	525.500	520.500	45.67-45.60	6/11/2015	20x20x5 cm = vol of collected bulk soil
5154	Bulk soil	5-07 / L4	525.500	519.500	45.70-45.65	6/11/2015	
5155	Bone	5-07 / L4	525.000	519.000	45.70-45.60	6/11/2015	Screen
5156	Bone	5-12 / L3-L4	525.000	518.500	45.76-45.60	6/12/2015	Screen
5157	Bone	5-12 / L3-L4	525.183	518.913	45.714	6/12/2015	Rib fragment
5158	Bone	5-08 / L5	525.000	520.000	45.60-45.50	6/12/2015	Screen
5159	Bulk soil	5-08 / L5	525.873	520.895	45.566-45.544	6/13/2015	
5160	Bone	5-08 / L6	525.000	520.000	45.500-45.400	6/13/2015	Screen
5161	Bulk soil	5-08 / L6	525.894	520.482	45.50-45.48	6/13/2015	not in separate Locus 5 box - went to OCA in Locus 1 box
5162	Pollen	5-08 / L6	525.000	520.000	45.495-45.404	6/14/2015	

WATER CANYON 2015 FIELD SEASON
FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
5163	14C bulk sediment	5-01 / L5	524.036	519.528	45.540	6/17/2015	Sent for date - 16OS/0640
5164	14C bulk sediment	5-01 / L6	524.050	519.541	45.490	6/17/2015	Sent for date - 16OS/0641
5165	14C bulk sediment	5-01 / L6	524.045	519.537	45.440	6/17/2015	Sent for date - 16OS/0642
5166	14C bulk sediment	5-11 / L5	524.017	518.785	45.571	6/17/2015	Sent for date - 16OS/0643
5167-1	Bone	5-08 / L6	525.268	520.351	45.443	6/17/2015	PL-1
5167-2	Bone	5-08 / L6	525.489	520.435	45.406	6/17/2015	PL-2
5168	Bone	5-08 / L7	525.000	520.000	45.40-45.30	6/18/2015	Screen
5169	Bone	5-08 / L6	525.425	520.540	45.440	6/18/2015	Rib fragment
5170-1	Bone	5-08 / L6	525.333	520.552	45.429	6/18/2015	PL-1 Metacarpal
5170-2	Bone	5-08 / L7	525.460	520.482	45.362	6/18/2015	PL-2 Metacarpal
5171	Tooth	5-08 / L7	525.679	520.398	45.318	6/18/2015	
LOCUS 6							
6001	Lithic	Surface	576.303	664.769	54.789	6/11/2015	Folsom base fragment / Red rhyolite? / found by J. Liddell
6002	Lithic	Surface	538.139	685.910	56.116	6/11/2015	Clovis blade - end scraper / black & tan chert
6003	NO RECORD						
6004	NO RECORD						
6005	Lithic	Surface	508.167	696.694	56.102	6/14/2015	
6006	Lithic	Surface	511.145	695.815	56.093	6/14/2015	
6007	Lithic	Surface	520.226	692.463	55.930	6/14/2015	
6008	Lithic	Surface	537.418	705.250	55.643	6/14/2015	
6009	Lithic	Surface	536.095	707.285	55.623	6/14/2015	
6010	Lithic	Surface				6/14/2015	Obsidian flake / surface / not recorded in total station
6011	Lithic	Surface	542.724	688.752	55.366	6/14/2015	Obsidian flake
6012	Lithic	Surface	543.711	685.685	55.359	6/14/2015	Yellow chert expedient flake
6013	Lithic	Surface	555.734	679.496	54.825	6/14/2015	Tan-orange chert uniface
6014	Lithic	Surface	563.262	679.443	54.598	6/14/2015	Chalcedony end-scraper
6015	Lithic	Surface	556.651	691.304	54.981	6/14/2015	Mustard chert scraper
6016	Lithic	Surface	583.491	680.972	54.074	6/14/2015	Red rhyolite biface - distal fragment
6017	Lithic	Surface	585.162	671.028	53.912	6/14/2015	Black basalt drill or biface tip
6018	Lithic	Surface	586.003	665.478	53.802	6/14/2015	Notched chert graver
6019	Lithic	Surface	589.563	655.054	53.505	6/14/2015	Tan chert flake
6020	Lithic	Surface	603.817	626.620	52.328	6/14/2015	Sparkling chalcedony
6021	Lithic	Surface	579.851	645.483	53.666	6/14/2015	Red-brown chert end-scraper

WATER CANYON 2015 FIELD SEASON
FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
6022	Lithic	Surface	570.275	644.602	53.892	6/14/2015	Red rhyolite flake -heat treated?
6023	Lithic	Surface	568.414	640.858	53.704	6/14/2015	Red rhyolite flake
6024	Lithic	Surface	569.061	636.314	53.478	6/14/2015	Chalcedony flake with rind
6025	Lithic	Surface	563.624	640.479	53.629	6/14/2015	Orange-red rhyolite expedient flake
6026	Lithic	Surface	568.084	649.839	54.115	6/14/2015	Red rhyolite edge scraper
6027	Lithic	Surface	570.430	649.122	54.030	6/14/2015	Red rhyolite edge scraper
6028	Lithic	Surface	570.455	649.128	54.021	6/14/2015	Red rhyolite edge scraper
6029	Lithic	Surface	566.488	655.302	54.305	6/14/2015	Red rhyolite biface fragment
6030	Lithic	Surface	563.985	653.556	54.365	6/14/2015	Orange-red chert proximal flake
6031	Lithic	Surface	556.794	665.185	54.715	6/14/2015	Orange-tan chert flake
6032	Lithic	Surface	546.261	661.425	54.802	6/14/2015	NO RECORD
6033	Lithic	Surface	524.545	674.246	54.956	6/14/2015	Tan spurred end-scraper
6034	Lithic	Surface	514.114	676.816	55.411	6/14/2015	Orange chalcedony flake
6035	Lithic	Surface	502.259	681.185	55.885	6/14/2015	Speckled red chert flake
6036	Lithic	Surface	499.353	693.368	56.296	6/14/2015	Black chert flake
6037	Lithic	Surface	506.379	703.813	56.037	6/14/2015	Large orange-tan chert flake
6038	Lithic	Surface	516.658	716.577	55.670	6/14/2015	Mortar?
6039	Lithic	Surface	500.371	713.870	55.910	6/14/2015	Yellow flake
6040	Lithic	Surface	499.664	713.111	55.941	6/14/2015	Red flake
6041	Lithic	Surface	499.128	713.984	55.936	6/14/2015	Red flake
6042	Lithic	Surface	499.424	715.215	55.886	6/14/2015	Red flake
6043	Lithic	Surface	500.634	717.403	55.806	6/14/2015	Red flake
6044	Lithic	Surface	498.377	718.205	55.805	6/14/2015	Red flake
6045	Lithic	Surface	498.229	717.466	55.830	6/14/2015	Red flake X 2
6046	Lithic	Surface	497.256	714.772	55.901	6/14/2015	Red flake
6047	Lithic	Surface	497.813	712.615	55.959	6/14/2015	Chert flake (possible biface)
6048	Lithic	Surface	497.609	712.517	55.974	6/14/2015	Red flake
6049	Lithic	Surface	496.768	712.805	55.954	6/14/2015	Red flake
6050	Lithic	Surface	495.804	713.353	55.941	6/14/2015	Red flake
6051	Lithic	Surface	495.343	714.361	55.919	6/14/2015	Red flake
6052	Lithic	Surface	494.493	718.384	55.829	6/14/2015	Red flake (cortex present)
6053	Lithic	Surface	494.456	720.066	55.779	6/14/2015	Red flake (possible biface with retouch present)
6054	Lithic	Surface	494.097	718.111	55.832	6/14/2015	Red flake (uniface)
6055	Lithic	Surface	493.116	716.990	55.885	6/14/2015	Red rhyolite biface flake
6056	Lithic	Surface	491.467	718.612	55.838	6/14/2015	Red rhyolite biface flake
6057	Lithic	Surface	493.122	715.692	55.875	6/14/2015	Red rhyolite uniface flake

WATER CANYON 2015 FIELD SEASON
FIELD SAMPLE LOG - All Samples

FS No.	Sample Description	Test Unit / Level	East Grid Coordinate (m)	North Grid Coordinate (m)	Grid Elevation (m)	Date	Comments
6058	Lithic	Surface	493.020	714.802	55.946	6/14/2015	Red flake
6059	Lithic	Surface	493.383	714.711	55.914	6/14/2015	Red flake
6060	Lithic	Surface	493.792	714.362	55.919	6/14/2015	Red flake
6061	Lithic	Surface	494.656	713.318	55.945	6/14/2015	NOT COLLECTED
6062	Lithic	Surface	495.776	713.289	55.945	6/14/2015	NOT COLLECTED
6063	Lithic	Surface	492.869	712.292	55.997	6/14/2015	NOT COLLECTED
6064	Lithic	Surface	492.182	712.759	55.968	6/14/2015	NOT COLLECTED
6065	Lithic	Surface	487.897	704.627	56.191	6/14/2015	Red rhyolite spurred end-scraper
6066	Lithic	Surface	485.588	707.594	56.108	6/14/2015	Yellow rhyolite flake
6067	Lithic	Surface	481.947	705.512	56.197	6/14/2015	Red rhyolite flake
6068	Lithic	Surface	457.130	705.547	56.327	6/14/2015	Chalcedony flake
6069	Lithic	Surface	453.161	710.697	56.269	6/14/2015	Orange-tan chert biface
6070	Lithic	Surface	430.906	733.209	56.396	6/14/2015	Tan chert expedient tool on blade flake
6071	Lithic	Surface	488.004	697.691	56.298	6/14/2015	Yellow chert uniface
6072	Lithic	Surface	476.240	681.360	56.162	6/20/2015	1 red rhyolite flake / 1 yellow rhyolite flake
NON-LOCI SURFACE ARTIFACTS							
SA-001	Lithic	Surface	594.667	582.810	48.960	5/28/2015	Gypsum projectile point / red-white chert / FS 6075
SA-002	Lithic	Surface	...	...	...	6/4/2015	Found in Locus 1 backfill
SA-003	Lithic	Surface	611.763	525.995	45.758	6/7/2015	Clovis project point / red rhyolite /complete / small size / found by C. Griffith / FS 6076
SA-004	Lithic	Surface	450.387	559.317	53.473	6/7/2015	Gypsum projectile point/ gray dacite / found by D. Chapman / Locus 2 / FS 2003
SA-005	Lithic	Surface	456.529	562.042	53.058	6/7/2015	Collected in Locus 2 as FS 2004
SA-006	Lithic	Surface	562.840	597.542	48.426	6/19/2015	Obsidian
SA-007	Lithic	Surface	639.894	463.275	45.616	6/20/2015	Obsidian
SA-008	Lithic	Surface	541.615	441.040	48.498	6/20/2015	Chalcedony - shot with wrong HT - change HT from 2.50 to 1.479
SA-009	Lithic	Surface	619.586	588.817	50.348	6/20/2015	
SA-010	Lithic	Surface	604.445	589.925	50.106	6/20/2015	
SA-011	Lithic	Surface	476.240	681.360	56.162	6/20/2015	

APPENDIX B. – SOIL CORE DESCRIPTIONS BY VANCE T. HOLLIDAY

WATER CANYON, Season III
Core and Section Descriptions, May, 2015
cores 15-1 to 15-7 is E–W line
cores 15-8 to 15-15 is E–W line ~13m S of above line (plus several off line)
15-16 is W of Loc 5 block
15-17 to 15-18 continues 15-8/12 line to the E
15-20 to 15-26 is along N face of South Arroyo, S of 15-19

Core 15-1

Strats	Depth, cm	Soil Horizon	Description
	0-8	A	
	8-18	AB	
	18-55	Bt	
	55-75	Bw	
	75+	C	coarse gravel

Core 15-2

Strats	Depth, cm	Soil Horizon	Description
	0-5	ABw	
	5-20	AB	
	20-60	Btw	
	60-80	Bw	
	80-202	A1b	Gray mat
	202-230	A2b	Black mat
	230-240+	Bgb	mottled olive green, olive gray, gray, Fe ox stains, cse gravel

Core 15-3

Strats	Depth, cm	Soil Horizon	Description
	0-12	AB	
	12-60	Bt	
	60-90	Bw	
	90-115	Bwb	
	115-205	C	loose sandy f gravel
	205-215	A1b	gray mat
	215-235	A2b	black mat
	235-280+	Bg	mottled clay w gravel

Core 15-4

Strats	Depth, cm	Soil Horizon	Description
	0-25	AB	
	25-65	Bt	
	65-115	Bw	loose, sandy
	115-185	C	sandy, gravelly
	185-205+	A1b	black mat

Core 15-5

Strats	Depth, cm	Soil Horizon	Description
	0-5	A	
	5-45	ABt	
	45-80	Btw	
	80-95	Bw	
	95-120	C	sandy gravel
	120-150	Bwb	sandy
	150-175	A1b2	black mat
	175-200	Cg	mottled lt olive gray SC w carb
	200-240	C	med gray s w gravel lense in lower 5cm

Core 15-6

Strats	Depth, cm	Soil Horizon	Description
	0-5	A	
	5-45	Abt	
	45-80	Bw	
	80-105	Bwb	
	105-120	A1b2	loose S gray mat
	120-180+	A2b2	black mat w dense gravel in lower 5cm

Core 15-7

Strats	Depth, cm	Soil Horizon	Description
	0-6	A	
	6-50	AB	
	50-70	Bt	
	70-108	Bw	
	108-135	A1b	loose S & gravelly gray mat
	135-150	A2b	dense gray mat w gravel &carb

Core 15-8

Strats	Depth, cm	Soil Horizon	Description
	0-20	C	dense gravel

Core 15-9

	Depth, cm	Soil Horizon	Description⁺
	0-35	A/ABt	
	35-40	ABb	black mat w weak soil superimposed
	40-80	A1b	black mat; C14 45-52, 65-73
	80-88	A2b	dk olive gray mat

Core 15-10

	Depth, cm	Soil Horizon	Description⁺
	0-17	AB	
	17-40	Bt	
	40-56	ABwb	Black mat with weak soil
	56-65	A1b	dense black mat
	65-70	A2b	dense black mat with fine pebbles
	70-75+	A3b	dense black mat with large rock frags

Core 15-11

	Depth, cm	Soil Horizon	Description⁺
	0-12	AB	
	12-36	Bt	fine pebble lenses 23-24, 33-36cm
	36-74	A1b	dense black mat with common rock frags
	74-85+	A2b	dense dark gray mat

Core 15-12

	Depth, cm	Soil Horizon	Description⁺
	0-35	Bt	common fine pebbles and rock frags
	35-61	Bw	pebbly and rocky sandy mud

Core 15-13 (2m S of 15-10)

	Depth, cm	Soil Horizon	Description⁺
	0-40		coarse rock frags

Core 15-14 (6m N or 15-12; ~half way betw 15-12 and 15-3)

	Depth, cm	Soil Horizon	Description+
	94-114	A1b	gray mat
	114-122	A2b	black mat with common rock frags
	122-144		lenses of sand, sandy clay and pebbles
	144-195	Btkb2	
	195-202+	Btgkb2	rocky, mottled

Core 15-15 (~2m NW of Tr 6)

	Depth, cm	Soil Horizon	Description+
	0-36	Bt	
	36-46	A1b	gray mat
	46-90	A2b	gray mat (likely the pinch out we see in arroyo cut just NW of Loc 1)
	90-142	Btkb2	

Core 15-16 (W of - upslope from - Loc 5 pit)

	Depth, cm	Soil Horizon	Description+
	0-5	A	49.305 – 49.255
	5-25	Bt	49.255 – 49.055
	25-65	Btw	49.055 – 48.655
	65-98	Bwb1	48.655 – 48.325
	98-118	Bkb1	Loose loamy f sand w common carb films 48.325 – 48.125
	118-130	A1b2	transition of loamy f sand to black mat 48.125 – 48.005
	130-170	A2b2	black mat 48.005 – 47.605
	170-183+		Dense gravel 47.605 – 47.475+

Core 15-17

	Depth, cm	Soil Horizon	Description+
	0-30	Bt1	
	30-40	Bt2	
	40-65	Bw	
	65-200		loose f sand & med-fine pebbles
	200-225	Ab1	black mat
	225-245	Bgb1	gleyed clay
	245-270	Btg1b2	
	270-360	Bt2gb2	

Core 15-18

	Depth, cm	Soil Horizon	Description+
	0-6	A	
	6-50	Bt	
	50-78	Btw	
	78-100	Bk	dense zone of f-med pebbles w carb coatings
	100-120		fine sand
	120-130		f pebble zone
	130-180		loose f sand w f-med pebbles
	180-235		gray mat?
	235-242	Ab	dense black mat w common rocks
	232-295+	Bgb	dense mottled clay

Core 15-19

	Depth, cm	Soil Horizon	Description+
	0-4	A	
	4-56	Bt	cobble lens 7-10, 50-53cm
	56-70	Bw	
	70-75+		v f sand w rocks and f-med pebbles

Core 15-20

	Depth, cm	Soil Horizon	Description+
	0-74	A-Bt	
	74-85	Bw	
	85-100+		black mat

Core 15-21

	Depth, cm	Soil Horizon	Description+
	0-70	A-Bt	f pebble lenses ~60 and ~70cm
	70-83	Bt	
	83-88	Bt/Ab	transition from Bt t black mat
	88-100+	Akb	black mat w carb films, common frock frags & few Fe–ox stains

Core 15-22

	Depth, cm	Soil Horizon	Description+
	0-73	A-Bt	coarse stone line at base; Btk in lower 15cm
	73-100	Agkb	dark olive gray mat w common carb films; few Fe-ox stains

Core 15-23

	Depth, cm	Soil Horizon	Description+
	0-75	A-Bt	Btk in lower 15cm
	75-94	Agb1	gray green clay w mass of rounded pebbles; wk stone line across top
	94-105+	Btgkb2	

Core 15-24

	Depth, cm	Soil Horizon	Description+
	0-83	A-Bt	Btk in lower 15cm
	83-90	Agb	darker olive gray clay; common small pebbles and rock frags
	90-110+	Agkb	olive green clay; common rocks & pebbles; common barb bodies & films

Core 15-25

	Depth, cm	Soil Horizon	Description+
	0-53	A-Bt	v thin red-brown transition to Agb at base
	53-68	Agk1b	dark gray mat w common carb threads; v common rock frags
	68-85+	Agk2b	mottled olive-green silty clay; common rock frags; common carb threads & coatings on rocks

Core 15-26

	Depth, cm	Soil Horizon	Description+
	0-20	Bt	
	20-40	Bwb?	Blocky sandy clay loam
	40-72	Agb2	Olive clay; very rocky
	72+	Btgkb3	

APPENDIX C. Phytolith Analysis

Phytolith analysis of late Pleistocene and early Holocene sediments from the Water Canyon Paleoindian site, LA134764, New Mexico

by

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Introduction

A total of 16 sediment samples were submitted for phytolith analysis from the Water Canyon Paleoindian site (LA134764), located west of Socorro, New Mexico. The site is located along the eastern edge of the Water Canyon basin, at an elevation of approximately 1760 m (5780 ft), and situated within a juniper savanna ecotone. The phytolith samples are stratigraphic and span a time interval from approximately 14,000 to 9,500 BP. The phytolith samples include sediments from buried wet meadow deposits sometimes referred to as black mats. The goal of this analysis was to determine the presence and abundance of specific types of plants growing at and in the general vicinity of the Water Canyon site based on the recovery of their microscopic silica plant remains called phytoliths. The phytolith extracts also included the silica remains of aquatic organisms, evaporitic minerals, microscopic charcoal and plant starch granules. Together with the phytolith record and other paleoclimate records from the region, this evidence was used to infer general aspects of the climate during the late Pleistocene and early Holocene at the Water Canyon site.

Phytolith Review

Phytoliths are biogenic silica ($SiO_2{-}nH_2O$) in-fillings and casts of cells that are formed in plant tissues such as leaves, stems, bark, fruit and seeds. Phytoliths range in size between 5 and 200 microns, and a single grass plant can produce 10^5 to 10^6 phytoliths (Yost and Blinnikov 2011). When plant matter decays, phytoliths are released and incorporated into soils and sediments. One gram of dry soil can contain 10^4 to 10^6 grass phytoliths (Yost, unpublished data) and one cm^3 of lake sediment can yield 10^4 to 10^5 grass phytoliths (Yost, et al. 2013). Because of their decay-in-place taphonomy, phytoliths tend to represent a very localized vegetation record, whereas pollen records are influenced by both local and regional vegetation. However, depending on the geomorphology of the study area, a proportion of the phytolith record may have been deposited some distance from its initial place of formation due to wind or water transport.

The strength of phytolith analysis lies in its ability to identify grasses (Poaceae) to subfamily and even lower taxonomic levels that require specific temperature and precipitation regimes. Also, grasses are annuals or short-lived perennials whose composition on the landscape can change relatively quickly in response to changes in annual temperature, moisture, light intensity, and land use practices. Because grasses and the phytoliths that they produce are found in virtually every plant community, tracking changes in grass phytolith abundance over time compliments other paleoenvironmental proxies such as pollen and stable isotopes.

The majority of grasses in North America are either members of the Pooideae, Panicoideae or Chloridoideae subfamilies, which produce distinctive and diagnostic phytoliths. Pooideae are cool season mesophytic C_3 grasses that respond favorably to winter precipitation and their abundance on the landscape is negatively correlated with increasing summer temperature (Paruelo and Lauenroth 1996). Panicoideae are warm season mesophytic C_4 grasses that are positively correlated with increasing amounts of summer precipitation. Chloridoideae are warm season xerophytic C_4 grasses that are positively correlated with increasing summer temperature and decreasing summer precipitation (Taub 2000). Since climate is the dominant control on the distribution of C_3 and C_4 grasses (Huang, et al. 2001), and in particular, the Pooideae, Chloridoideae and Panicoideae subfamilies, reconstructing their proportions on the landscape through the use of phytoliths can reveal changes in temperature and precipitation over time.

Additional Microfossils and Particles in Phytolith Extracts

Although phytolith extraction protocols are optimized for the recovery of biogenic silica from plant cells, other useful microremains and particles are often present in the phytolith fraction recovered from soils and sediments. Some of these microremains recovered in the Water Canyon samples are reviewed next.

Diatoms

Diatoms are single-celled algae with a biogenic silica cell wall. They grow in a wide range of habitats, including the surfaces of wet plants and rocks, damp soils, marshes, wetlands, mudflats, and all types of standing and flowing aquatic habitats (Spaulding, et al. 2010). Their silica cells, or frustules, often are preserved in sedimentary deposits. Because individual taxa have specific requirements and preferences with respect to water chemistry, hydrologic conditions, and substrate characteristics, the presence of diatoms in soils and sediments can provide information about the nature of the local environment or the sources of water used for cooking and food processing.

Freshwater sponges

Freshwater sponges (Porifera: Spongillidae) are primitive members of the animal kingdom. They use biogenic silica to form skeletons comprised of spicules and other structures such as spherasters for support and for reproduction. Freshwater sponges inhabit a wide variety of wet habitats that include ponds, lakes, streams, and rivers; however, they need a hard stratum for growth like submerged logs, aquatic plant stems and rocks. They typically thrive in water that is slightly alkaline (above pH 7), and their abundance is negatively correlated with increasing turbidity, sediment load and salinity. However, some taxa can overcome the negative effects of increasing salinity if calcium ion concentrations are also increasing (Barton and Addis 1997; Cohen 2003; Dröscher and Waringer 2007; Francis, et al. 1982; Harrison 1988).

Chrysophyte stomatocysts

Chrysophyte stomatocysts are biogenic silica structures produced by chrysophycean algae (classes Chrysophyceae and Synurophyceae) during the resting stage of their life cycle (Wilkinson, et al. 2001). Like diatoms, these organisms are often preserved in soils and sediments and can be used to reconstruct past environmental conditions. Chrysophytes are primarily unicellular or colonial organisms that are abundant in freshwater habitats throughout the world. Chrysophytes are related to diatoms, but are distinct organisms. Chrysophyte stomatocysts are most common in fluctuating freshwater habitats of low to moderate pH and that experience some winter freezing. Many stomatocyst types are found in specific habitats, such as montane lakes, wet meadows, ephemeral ponds, perched bogs, and the moist surfaces of rock and plant substrates. Chrysophyte stomatocysts can also be found in sites that are only wet during certain seasons, such as snowmelt ponds and low swales (Adam and Mahood 1981). In cool-cold temperate lakes, chrysophytes are most common in the spring, when acidic snowmelt dominates the water chemistry. Chrysophytes are intolerant of eutrophic lake conditions (Cohen 2003).

Starch granules

Starch is a plant energy storage substance composed of crystalline and non-crystalline regions made up of amylose and amylopectin. Some of this starch forms globular, spherical, or polyhedral bodies referred to as either grains or granules. Starch granules are found in many plant parts, but are often concentrated in seeds, fruits, roots, and tubers. Starch granules range in size between 1 and 100 microns, and can persist in soil, artifact surfaces, cooking residue and dental calculus for tens of thousands of years. A single plant species often produces a variety of starch granule shapes, sizes and forms. Some of these morphotypes overlap with those produced by other plants; however, there are often morphotypes that are diagnostic of specific plants at various taxonomic levels. When viewed using polarized light microscopy, starch granules appear bright white against a black background, a phenomenon termed birefringence. Chemical extraction, cooking, drying and environmental degradation can result in reduced or even the complete loss of birefringence (Gott, et al. 2006).

Methods

Approximately 6 to 15 grams of sediment from each sample was wet-sieved through a 250-µm mesh and placed in a 400 ml beaker (Table 1). After settling for two hours, the water was decanted. Next, 20 mL of 37% hydrochloric acid (HCl) was added to each sample to remove carbonates and any reaction with the HCl was noted (Table 1). Next, 100 ml of 70% nitric acid (HNO_3) was added to each sample and all samples were heated to 80° C for one hour to oxidize the acid soluble organic fraction. Samples were then rinsed five times with reverse osmosis deionized water (RODI) water. Next, 10 ml of 10% potassium hydroxide (KOH) was mixed into each sample, and after 10 minutes, the solution color was recorded as a qualitative measure of humic acid (humate) content (Table 1). This step was followed by five rinses with RODI water to remove the base soluble organics. Next, a 10% solution of sodium hexametaphosphate was mixed into each sample and the samples were allowed to settle by gravity for one hour, and then decanted to remove any clay-sized particles still in suspension. This step was repeated at least four more times or until the supernatant was clear after one hour of settling. The samples were then transferred to 50 ml centrifuge tubes and dried under vacuum in a desiccator. The dried samples were then mixed with 10 ml of sodium polytungstate (SPT, density 2.3 g/ml) and centrifuged for 10 min at 1,500 rpm to separate the biogenic silica (phytolith) fraction, which will float, from the heavier inorganic mineral and silica fraction. Each sample was then rinsed five times with RODI water to remove the SPT. Because a significant quantity of platy and low density minerals were extracted along with the phytolith fraction, the samples were re-dried and mixed with a heavy liquid (2.3 g/ml) comprised of cadmium iodide and potassium iodide (CdI_2/KI), which is particularly effective at removing these types of particles. The samples were rinsed five times with RODI and then spiked with polystyrene microspheres for phytolith concentration calculations. The samples were then rinsed twice in 99% ethanol and stored in 1.5 ml vials.

For microscopy, the samples were mounted in optical immersion oil and the cover glass was sealed with fingernail polish. Phytolith counting was conducted with a transmitted light microscope using a magnification of 500x. A minimum of count of 200 taxonomically significant phytoliths was first conducted. Additional phytoliths were counted for samples with high phytolith concentrations to increase the chances of rare phytolith type recovery. Phytolith identification and classification primarily follows Mulholland and Rapp (1992), Fredlund and Tieszen (1994), and Piperno (2006), with morphotype descriptors following the International Code for Phytolith Nomenclature 1.0 (Madella, et al. 2005). For analysis of the results, phytolith relative abundance was based on the phytolith sum. Non-phytolith relative abundances were calculated from the phytolith sum. Phytolith concentrations were calculated from the microsphere counts and normalized to sample sediment weight. Because of the interpretive value, percent relative abundance based only on phytoliths diagnostic of C_3, C_4 xerophytic and C_4 mesophytic grasses was calculated and graphed separately. The 1600 series samples were diagramed separately because they were not dated by the time of this report.

Table 1. Samples analyzed for phytoliths from the Water Canyon site (LA1347640)

FS No.	Test Unit	Level	Modeled Age	Weight started (g)	HCl Rx†	KOH Rx‡	Phytolith extract (g)	% Phyt.	Extract purity (%)*	Phyt conc. (per g)
5005	5-3	1	9,513	6.073	None	Black	0.071	1.169	~99	4,871,283
5059	5-3	2	9,730	6.999	None	Black	0.097	1.386	~99	4,174,439
5095	5-3	4	9,999	6.905	None	Black	0.084	1.217	~95	1,822,940
5123	5-3	6	10,196	7.300	None	Black	0.074	1.014	~98	1,795,518
1195	1-6	9	10,214	6.460	None	Black	0.020	0.310	~98	486,791
1197	1-6	10	10,568	6.505	None	Black	0.024	0.369	~95	991,791
1202	1-6	11	10,956	6.647	None	Black	0.011	0.165	~75	45,133
1203	1-6	12	11,379	6.632	None	Black	0.008	0.121	~50	32,311
1211	1-6	13	11,836	6.987	None	Dk brwn	0.005	0.072	~5	8,419
1217	1-6	14	12,327	6.745	None	Dk brwn	0.005	0.074	< 1	1,186
1219	1-6	15	12,870	14.75	None	Dk brwn	0.008	0.054	< 1	4,676
1229	1-6	16	13,412	7.376	None	Black	0.001	0.014	~5	595
1249	1-6	17	14,006	7.504	None	Black	0.001	0.013	~5	589
1634	1-46	14	TBD	6.294	None	Black	0.002	0.032	~90	6,441
1633	1-46	15	TBD	6.622	Mod	Black	0.002	0.030	~50	1,798
1632	1-46	15	TBD	7.767	None	Dk brwn	0.001	0.013	~25	588

† Qualitative observation of sediment reaction in 37% hydrochloric acid (HCl) to estimate $CaCO_3$ content.

‡ Qualitative observation of sediment reaction in 10% potassium hydroxide (KOH) to estimate humic acid (humate) content; black, brown, and clear correspond to high, moderate, and none.

* Extract purity estimated by microscopic examination. Low purity samples often have volcanic glass or low-density evaporites and authigenic minerals such as gypsum and hydrated sodium silicates that could not be removed without losing phytoliths.

Results

Phytoliths

Phytolith preservation varied from good to excellent, and exhibited no evidence for biogenic silica dissolution severe enough to dissolve small and lightly silicified morphotypes. This indicates that changes in the phytolith assemblage reflect coherent changes in the proportionality of C_3 grasses, C_4 grasses, and other plants throughout the entire record (Figures 1 and 2). Phytolith concentrations ranged from a low of 589 per gram (FS 1249) to a high of 4.87×10^6 per gram (FS 5005). Interestingly, phytolith concentrations increased at a near perfect exponential rate from the oldest to the youngest sample. This phenomenon is clearly visible when concentrations were plotted on a log scale (Figure 3 *H*). As is typical, grass and sedge phytoliths comprised nearly 100% of the phytolith record, as trees and shrubs are poor phytolith producers in most temperate biomes. One exception to this was the recovery of a single ponderosa pine (*Pinus ponderosa*) needle phytolith in sample FS 1211 (Figure 4 *U*). With a few exceptions, grass phytolith identifications were limited to the subfamily level, with phytoliths diagnostic of C_4 xerophytic Chloridoideae (Figure 4 *A*, *B*), cool season C_3 Pooideae (Figure 4 *H*, *I*), and C_4 mesophytic Panicoideae (Figure 4 *C*, *D*) generally observed, and listed here, in order of most common to least common. When just considering phytoliths diagnostic of C_3 and C_4 grasses (Figure 3, *A*), C_4 xerophytic (Chloridoideae) grasses dominate much of the record. Interestingly, cool season C_3 grasses are dominant in 3 out of 4 samples between ~11,500 and 10,200 cal BP. This is almost certainly reflective of the dominance of a common wetland C_3 grass such as *Glyceria borealis, G. striata or Deschampsia cespitosa* at the site, and not reflective of a switch to C_3 grass dominance in the surrounding uplands. This will be expanded on further in the discussion section.

Lower taxonomic levels of grass identification were made for three taxa. Stipa-type bilobates diagnostic of C_3 subfamily Pooideae, tribe Stipeae grasses were observed throughout the record (Figure 4 *G*). For this location, *Achnatherum* species are the most likely source for this phytolith type. It should ne noted that the genus *Achnatherum* now includes almost all North American grasses formerly included in the *Stipa* (needlegrass) and *Oryzopsis* (ricegrass) genera.

Plateau saddle phytoliths diagnostic of *Phragmites* (common reed, locally as carrizo) were first observed during the Younger Dryas chronozone (YD) in FS 1217 and peaked in abundance in FS 5123 (Figure 4 *J*-*L*) during the early Holocene. Based on biogeography and the age of these samples, plateau saddle phytoliths are diagnostic of the native *Phragmites australis* ssp. *americanus*, an obligate wetland grass. Today, the native subspecies of *Phragmites* is rare in NM but is listed as occurring in Lincoln, San Juan, and Los Alamos counties; the non-native genotype is listed as occurring throughout New Mexico, including Socorro County (USDA-NRCS 2016). Rondel phytoliths with distinctive angular keels diagnostic of canarygrass (*Phalaris* spp.), an obligate wetland grass, were observed in the early Holocene samples. *Phalaris* first appeared in the phytolith record in FS 1202, which has a modeled age of 10,956 cal BP, and peaks in abundance in FS 1195 (~10,214 cal BP). Both *Phalaris arundinacea* (reed canarygrass) and *Phalaris caroliniana* (Carolina canarygrass) are native to New Mexico, with the former restricted to northern counties and the latter with a more limited and southern distribution (USDA-NRCS 2016). Based on biogeography and known wetland plant associations, the *Phalaris* phytoliths recovered here are likely derived from *Phalaris arundinacea*. It is very fortuitous that both *Phragmites* and *Phalaris* grasses were identified through their phytolith remains, as these obligate wetland taxa can be used to identify specific wetland plant communities that may be used as modern analogs for the paleowetlands at the Water Canyon site. This approach is expanded in the Discussion section.

Phytoliths diagnostic of sedges (Cyperaceae) were observed in all of the Water Canyon samples and were dominant or codominant with grass phytoliths post-YD until approximately 10,000 cal BP. A phytolith morphotype termed "thin with ridges" derived from sedge leaf, sheath and culm epidermis was the most common sedge phytolith observed (Figure 4 *W*). This morphotype has been observed in a wide variety of genera, including *Scirpus*, *Schoenoplectus* and *Eleocharis* and is likely to be only diagnostic at the family level. The high abundance of this phytolith at times suggests the occurrence of dense stands of sedges. Irregular phytoliths with tubular projections diagnostic of sedge roots and rhizomes were present in low numbers throughout the record and confirm that sedges were rooted at the site (Figure 4 *X*). Three different types of sedge achene cone cells were observed, indicating the presence of at least three sedge taxa. The achene cone cell in Figure 4 *Y* is typical of *Scirpus* and the one in Figure 4 *AA* is typical of *Cyperus*, but similar morphotypes have been observed in other genera such as *Kyllinga* and *Eleocharis*. With some additional modern reference work, it is likely these achene cone cells could be attributed to specific taxa. And lastly, given the high abundance of diagnostic sedge phytoliths in FS 1203 and FS 1202, the highly abundant elongate psilate morphotypes (Figure 4 *T*) attributed to grasses and sedges (Figures 1 and 2) may be predominantly derived from a particular sedge with prolific long cell silicification. Again modern reference work with common New Mexico wetland graminoids may help to identify more taxa.

Evaporite minerals

Some phytolith extracts contained very high concentrations of platy evaporite crystals, particularly those that fall within the Bølling-Allerød chronozone (BA) (Figures 3 *D* and 5 *A*-*B*). By the middle of the YD, evaporite abundance rapidly diminishes. The application of strong acids during phytolith extraction should have removed most of the calcium-based evaporitic minerals such as calcite and gypsum; however, some gypsum may survive exposure to low pH if there has been sodium silicate replacement of the calcium sulfate matrix, which can occur in evaporitic settings with shallow burial depths and sulfate reducing bacteria (Warren 2006). Regardless, the presence of evaporites in the early part of the record is likely due to wind transport from a desiccating basin.

Microcharcoal

Microscopic charcoal was commonly observed in all of the Water Canyon phytolith extracts (Figure 5 *C*). Charcoal particles were counted in two maximum dimension size classes: < 50 µm and > 50 µm, which roughly reflect regionally and locally sourced fires, respectively. Both size classes peak in abundance during the BA and are much reduced during the YD, with the exception of the peak in regional charcoal during the middle of the YD (Figures 3 *C*).

Cryptotephra

Microscopic volcanic glass shards termed cryptotephra were observed in varying amounts in many of the Water Canyon samples (Figure 5 *D*). Subtle cryptotephra peaks were noted in FS 1249 and FS 1217 (Figure 1). Cryptotephra can travel hundreds to several thousands of km from the source eruption. With the advancement of chemical fingerprinting to specific volcanic eruptions, cryptotephra is increasingly being used as an isochron. Of particular interest here is the potential for detection of cryptotephra from the Mount St. Helens (Swift Creek) and Glacier Peak Cascade Range eruptions (13.74-13.45 cal ka BP) that have recently been detected as a cryptotephra couplet in lake sediments from New England (Pyne-O'Donnell, et al. 2016). The cryptotephra observed here should be noted as being a potential isochron if increased sampling resolution and tephra optimized separation techniques are utilized.

Diatoms

Although phytolith extraction techniques are not optimized for diatom recovery, diatoms were observed in every sample except FS 5095 and FS 5123 (Figures 1 and 2). Diatoms were likely in those extracts, but because of high phytolith concentrations, were not observed during the phytolith counts. Pennate diatoms (Figure 6 *C*-*E*) that are typical of shallow water and moist surfaces were rare in the phytolith samples, but most common in the uppermost samples FS 5005 and FS 5059. Centric diatoms such as the two *Aulacoseira* species (Figure 6 *A* and *B*) that are more typically found in rivers, ponds, and lakes were most abundant in the samples from the BA and YD chronozones. *Aulacoseira* abundance (Figure 1) is well correlated with evaporite abundance (Figure 3 *D*) and suggests wind deposition of these diatoms from a desiccating basin. Barbara Winsborough completed a detailed diatom analysis of samples from the same levels as the phytolith samples and presented the results in a separate report (Winsborough 2016).

Freshwater sponges

Microremains from freshwater sponges were present in low numbers and restricted to the late Pleistocene and early Holocene samples (Figure 1). Sponge spicules were highly fragmented (Figure 6 *F*), suggesting eolian transport to site. Sponge spherasters were the most common type of sponge microremain observed (Figure 6 *G*); they peak in abundance during the BA and the first half of the YD. Because of their small size and spherical shape, sponge spherasters may be easily transported along the ground and through the air from desiccating lake basins. Little is known about freshwater sponge ecology, and they are notoriously hard to identify because the reproduction structures needed for identification are rarely observed in sediments. Generally, freshwater sponges thrive in water that is slightly alkaline, and many taxa may be tolerant of some salinity, especially in the presence of calcium ions – conditions typical of some desiccating basins.

Chrysophytes

One chrysophyte stomatocyst was observed in sample FS 5059 (Figure 6 *H*). There were likely many more, however, extremely high phytolith concentrations likely diluted their numbers and reduced their probability of being observed. Chrysophyte algae are understudied, and as such, their stomatocysts (resting spores) are rarely used as paleoenvironmental indicators. The stomatocyst here corresponds nicely with #270 from the Atlas of Chrysophycean Cysts Vol. II (Wilkinson, et al. 2001), which was collected from a high latitude peat deposit. Progress has been slow in linking stomatocyst morphotypes to the species that produce them; however, finding the same stomatocyst in a modern wetland may help in identifying the type of wetland that existed at Water Canyon during the period of time represented by FS 5059.

Starch granules

Somewhat unexpectedly, 22 starch granules were recovered from FS 1634 and three were recovered from FS 1632 (Figure 2). Starch can survive the phytolith extraction procedure and they are routinely recovered from contexts related to starchy food processing and storage. However, disarticulated granules are not very common in paleoenvironmental contexts, as exposure to water can rapidly gelatinize the granules, making them unrecognizable. Two main types of starch granules were recovered, a faceted polyhedral morphotype with a centric to slightly eccentric hilum (Figure 7 *A*-*F*), and a lenticular morphotype with lamellae visible in plane-polarized light (Figure 7 *G*, *H*). Polyhedral starch granules are produced by a variety of plants, including grass seeds and sedge roots. This particular morphotype is more similar to sedge root types than to grass seed types. An examination of modern sedge roots from taxa commonly found at regional wetland habitats may significantly narrow down the possibilities. The lenticular granules are undoubtedly from C_3 Pooideae tribe Triticeae grass seeds. Based on the work of (Perry and Quigg 2011), their visible lamellae are suggestive of *Pseudoroegneria spicata* (western wheatgrass); however, *Pascopyrum smithii* (western wheatgrass) may also be a possibility for these starch grains if the potential effects of degradation on starch morphology are considered. Modern ambient starch granule contamination is always a possibility; however the recovery of two very different starch morphologies in relatively high abundance from taxa very likely to be growing at or near the Water Canyon site during the study period makes contamination an unlikely source for these granules. It is most likely that a fragment of sedge root and an intact tribe Triticeae grass seed were the source for these starch granules; however, an anthropogenic source is also possible, as grinding activities can easily spread starch granules across a site.

Discussion

Because of its geomorphic setting, the phytolith record from the Water Canyon site is derived from two primary sources, the plants growing in a niche habitat at the site, and plant fragments transported to the site from the surrounding piedmont. Untangling these two sometimes very strong but distinct signals can be a challenge. This is exemplified when viewing the summarized C_3 versus C_4 grass phytolith relative abundance values in Figure 3 *A*. In the southwestern and high plains regions of North America, cool season C_3 grasses are primarily restricted to habitats with high effective moisture such as high elevation sites, riparian zones and wetlands. The C_3 grass signal in Figure 3 *A* is specific to the site, whereas the C_4 mesophytic (Panicoideae) and C_4 xerophytic (Chloridoideae) signal is likely to be exclusively derived from uplands that surround the site and better reflects the dominant grass functional types on the greater landscape. In contrast, phytoliths derived from obligate wetland plants such as sedges

(Cyperaceae), *Phragmites australis*, and *Phalaris* spp. represent a site-specific signal at Water Canyon (Figure 3 *B*). For most of the phytolith record, the landscape signal appears to be dominant and suggests that C_3 grasses and sedges were restricted to the riparian zone along No-Name Arroyo and probably along other drainages in the basin. Between ~11,500 and 10,200 BP, the site-specific signal is dominant, with an expanded wetland comprised of dense grass and sedge vegetation overpowering the greater landscape phytolith signal. For the uppermost four samples with a modeled age range between 10,200 and 9,500 cal BP, it appears that more of a landscape level signal is dominant; however, these four samples are from Locus 5, which is situated on the north side of No-Name Arroyo and in a slightly different geomorphic setting. The high Chloridoideae phytolith abundance may reflect that these grasses were growing at or very close to this location. The shift from Locus 1 samples to Locus 5 samples in the composite phytolith record in part explains the high variability in phytolith abundance values at ~10,200 BP.

It is important to point out that the percent relative abundance of grass functional type phytoliths only approximates their actual proportions in biomass on the landscape. In fact, in modern samples, C_4 xerophytic Chloridoideae phytoliths are often overrepresented when compared to actual Chloridoideae abundance (Blinnikov, et al. 2013; Fredlund and Tieszen 1994). It is also important to point out that both C_4 Panicoideae and Chloridoideae grasses require summer precipitation for growth; however, Chloridoideae grasses decrease in abundance relative to Panicoideae grasses as summer precipitation values increase. For example, between 200 and 400 mm annual precipitation, Chloridoideae grass abundance varies between 60 and 75%, between 600 and 1000 mm this value decreases to around 50%, and above 1000 mm, Chloridoideae values can be as low as 25% (Taub 2000).

Bølling-Allerød Chronozone samples

Samples 1249 (14,006 cal BP) and 1229 (13,412 cal BP) fall securely within the BA. Sample 1219 with its modeled age of 12,870 cal BP and inherent chronological uncertainties is situated on the boundary with the YD (12.9-11.7 ka; Broecker, et al. 2010). The BA warm period spans from 14,700 to 12,900 BP and was interrupted at around 14,000 BP by a brief return to cooler conditions at some Northern Hemisphere locations for a few hundred years. Paleoenvironmental records for the BA are limited in the southwest; however, isotope and packrat midden records from northern Arizona (K. L. Cole and Arundel 2005), and a speleothem isotope record from Fort Stanton Cave in southeastern New Mexico (Asmerom, et al. 2010) indicate warm conditions with variable precipitation during the BA. Lake basin records are also mixed during the BA, with paleolakes Estancia in NM (Allen and Anderson 2000) and Cochise in AZ (Ballenger, et al. 2011) exhibiting evidence for highstands during the first half of the BA, and evidence of regression and desiccation during the second half of the BA. For paleolake San Agustin, the higher elevation C-N sub-basin remained palustrine throughout much of the late Pleistocene; however, the lower elevation Horse Spring sub-basin had regressed significantly and was alkaline by 13,200 BP (Ballenger, et al. 2011).

When considering the phytolith and evaporite records, FS 1219 has a greater affinity to what would be expected for a late BA sample than an early YD sample (Figure 3 *A*). In fact, the rise in C_4 xerophytic phytoliths corresponds with evidence for lake basin desiccation during the

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later stages of the BA. Proxies for summer monsoon and tropical cyclone precipitation suggest decreasing intensity as the BA progressed, although still at enhanced levels relative to modern (Antinao and McDonald 2013). Phytolith relative abundance for C_4 mesophytic (Panicoideae) grasses are at their highest levels for the entire record between ~14,000 and 13,500 BP. This is likely due to increased summer precipitation allowing some panicoid grasses to outcompete some C_4 xerophytic grasses. The high values in both local (>50 µm size) and regional (<50 µm size) charcoal (Figure 3 *C*) likely reflects increased fires in late fall or spring due to fuel loading from dried-out summer grass populations and increased lightning activity from summer thunderstorms.

Pollen analysis was conducted on FS 1249 (14,006 cal BP) but only a few grains were recovered (Dello-Russo 2015). The poor pollen preservation was likely due to seasonal wetting and drying. For what was recovered, grass pollen was codominant with Asteraceae, followed by Cheno-am types (Chenopodiaceae family–*Amaranthus* spp.), sage (*Artemisia* spp.) and juniper rounding out the balance of the pollen sum. With the exception of the sedge pollen, there is a paucity of obligate wetland taxa; in fact most of the pollen record is dominated by taxa adapted to seasonal drying. The combined pollen and phytolith data indicates that the Water Canyon site during the BA consisted of a relatively narrow riparian zone lined with C_3 grasses and sedges. The surrounding piedmont consisted of a juniper grassland ecotone comprised of a mix of C_4 mesophytic Panicoideae and C_4 xerophytic Chloridoideae grasses that were supported by higher than modern summer precipitation. Towards the termination of the BA, there may have been a substantial drop in summer precipitation as Panicoideae grass abundance is significantly reduced. The relatively high abundance of C_3 grasses, sedges and tallgrass C_4 Panicoideae may have made the Water Canyon drainage preferable to grazers over lower elevation C_4 shortgrass habitats for much of the BA.

The high evaporite mineral content in BA sediments (Figure 3 *D*), concomitant with the high abundance of both planktonic *Aulacoseira* spp. diatoms and freshwater sponge microremains (Figure 2), suggests that these particles may be an eolian assemblage from a desiccating lake basin. In their reanalysis of the San Agustin Basin cores, Markgraf et al. (1983) did not report the occurrence of *Aulacoseira* diatoms, and explicitly noted the absence of evaporitic minerals. However, the original cores they analyzed appear to have either been recovered from just outside of the lowest elevation sub-basin (Horse Spring Basin) or at the very margin of the sub-basin, and may not be fully representative of the playa conditions. Paleolake Estancia is another potential source for the evaporites and the biogenic silica remains, as there is evidence for a significant desiccation event between ~15,000 and 14,000 BP (Allen and Anderson 2000). Sourcing the origins of the evaporitic minerals at Water Canyon is somewhat tangential but may have relevancy in understanding wind patterns and storm tracts during this portion of the late Pleistocene. The apparent paradox between increased summer precipitation and overall lake basin desiccation during the BA is resolved when considering that winter precipitation is largely responsible for maintaining lake levels, as a significant proportion of summer precipitation can be lost due to evaporation.

Younger Dryas Chronozone samples

The YD spanned from 12,900 to 11,700, as recorded in Greenland ice core $\delta^{18}O$ records (Broecker, et al. 2010). The YD was an abrupt climate change event that affected much of the Northern Hemisphere. Europe experienced significantly cool and wetter conditions, and North America experienced changes in climate that varied by region in both the timing and the direction of change, with some areas experiencing cooler and wetter conditions, while other areas were cooler and dryer (Ballenger, et al. 2011; Carlson 2013; Holliday, et al. 2011). The highest resolution regional paleoclimate record that includes the YD is the Fort Stanton speleothem oxygen isotope record, which is located ~150 km southeast of Water Canyon (Asmerom, et al. 2010). The Fort Stanton speleothem records the YD as a well-defined drop in $\delta^{18}O$ values of 2 to 3‰ (Figure 3 *E*). Speleothem $\delta^{18}O$ values are determined by three variables: 1) precipitation source area, with Pacific Ocean $\delta^{18}O$ values averaging around -11‰, and Gulf of Mexico $\delta^{18}O$ values averaging around -3‰, 2) the amount effect – the more a cloud rains out, the more negative the rain water $\delta^{18}O$ values, and 3) cave and atmospheric air temperature, which equates to about a 0.33‰ speleothem calcite fractionation increase with each degree C increase in air temperature. Thus, the drop in Fort Stanton $\delta^{18}O$ values during the YD is a combination of all three variables; however, based on other paleoenvironmental records, a mostly Pacific (winter) precipitation source and cooler temperatures are the likely cause for the drop in YD $\delta^{18}O$ values at Fort Stanton Cave.

There are numerous regional paleoenvironmental records, including the phytolith record presented here, that indicate a switch from an initially cool and dry YD to a wetter period starting around 12,300 BP. The Scholle wet meadow, located ~100 km northeast of Water Canyon, was active between 12,300 and 11,100 BP (Hall, et al. 2012). Polyak et al. (2004) using speleothem growth rates from the Guadalupe Mountains in southeastern New Mexico conclude that significantly increased precipitation was in place by at least 12,500 BP.

The phytolith record from Water Canyon also is indicative of an initially cool and seasonally dry start to the YD, followed by an increase in precipitation sometime between 12,500 and 12,000 BP. For samples 1217 (~12,327 cal BP) and 1211 (~11,836 cal BP), C_4 mesophytic Panicoideae grass phytoliths rise to ~10% relative abundance, although still lower than during the BA, and C_4 xerophytic Chloridoideae grass phytoliths decrease from 70 to 56% relative abundance. The high relative abundance of C_4 grasses during the late Pleistocene, and in particular during the YD in the Water Canyon samples seems counterintuitive; however, isotopic studies of herbivore teeth from the southwestern US indicate C_4 plant dominance for at least the last 30.0 ka (Connin, et al. 1998). In a carbon isoscape model for North America derived from bison and mammoth tissue $\delta^{13}C$ values, Cotton et al. (2016) reconstruct C_4 grass values of ~40% for the period from 28,000 to 18,000 BP for this part of New Mexico. Interestingly, the boundary with C_4 grass abundance values of 20% or less was modeled to be approximately 100 km from the Water Canyon region. Cotton et al. (2016) also point out that when local changes in temperature do not exceed 8° C lower than modern during the late Pleistocene, C_4 grasses will still be favored over C_3 vegetation due to their greater efficiency with lower atmospheric CO_2 concentrations. Holmgren et al. (2007) using macrofossils from packrat middens propose that temperatures were no more than 5.5° C cooler than today in the Southwest during the late Pleistocene. They go on to speculate that south of 35° N, contiguous C_4 grasslands may have extended from central Texas to southern Arizona. The landscape level phytolith signal for both the BA and YD at Water Canyon supports this hypothesis.

One *Pinus ponderosa* needle phytolith (Figure 4 *U*) was recovered in sample 1211, indicating the presence of this fire adapted tree within the watershed. C_3 grass phytoliths rise dramatically from 20% to 34% relative abundance in sample 1211. It's important to note that the drop in C_4 xerophytic grass phytoliths is due to both increased C_4 mesophytic grasses at the landscape level (upland grassland) and the rise in C_3 grasses at the site level (wetland/riparian zone). Sedge phytolith abundance is consistent with values during the BA, but the obligate wetland grass *Phragmites australis* ssp. *americanus* (common reed, carrizo) appears for the first time in the record.

Phragmites is an important plant to have a record for because it is a wetland indicator species, and evidence for the presence of a few more indicator plants can be used to identify well-known wetland plant associations and the location of modern analogs. Cattail (*Typha latifolia*) and Baltic rush (*Juncus balticus*) are two such indicator taxa; however, these genera do not produce phytoliths and unfortunately there is no associated pollen record with these samples. However, if the absence of *Typha* pollen for the early Holocene at Water Canyon (Dello-Russo 2015) is extended back to the YD, then the Beaked Sedge Alliance (Muldavin, et al. 2000) (Appendix 1A) may be a potential modern wetland analog for at least the latter half of the YD. Regardless, the presence of *Phragmites* indicates a change from a wet but likely narrow riparian zone to an expanded seasonal wetland with increasingly diverse taxa around 12,300 BP. It's interesting to note the steady increase in the Fort Stanton speleothem $\delta^{18}O$ values throughout the YD, likely due to an increase in the ratio of summer to winter precipitation. It is also interesting to note the spike in the regional charcoal record and its approximate synchronicity with the multidecadal positive excursion in Fort Stanton speleothem $\delta^{18}O$ values just after 12,500 BP.

It appears that at the Water Canyon site, the YD was not expressed as a static climatic event but rather as a transgressive climatic phenomenon. At the onset of the YD, the hydrology was dominated by winter precipitation and summers were relatively dry. With overall cooler temperatures, this may have resulted in greater effective moisture relative to the BA. By the middle of the YD there was a switch to a greater proportion of summer precipitation, however winter precipitation may have been maintained at previous levels, resulting in a net increase in moisture. It's possible that the climatic effects of increasing summer insolation overprinted on the climatic effects of the YD. Numerous climate records have found evidence for a strong link between increasing insolation from changes in the earth's orbital parameters and increased monsoon strength in Africa, Asia, India, and South America, a phenomenon commonly referred to as the orbital monsoon hypothesis (Kutzbach 1981). There have been a limited number of studies that have specifically looked for this same relationship in North America, but evidence is mounting (Anderson 2012; J. E. Cole, et al. 2007; Lachniet, et al. 2013). For the Water Canyon samples, it is intriguing to see the relationship between increasing summer insolation and increasing phytolith concentrations, suggesting a link between grassland densities and summer monsoon intensity in southwestern North America.

Early Holocene samples

Locus 1

Early Holocene samples from Locus 1 have a modeled age range of 11,379 to 10,214 cal BP (FS 1203, 1202, 1197, 1195). This age range includes the period of a summer insolation maximum for July at 30° N, which reaches its peak at around 10,300 BP (Table 2). Use of a 30° N latitude insolation curve is common for investigations of summer monsoons on orbital time scales in Africa and elsewhere; however, the center of action for development of the North American monsoon may be closer to 20° N (Adams and Comrie 1997; Castro, et al. 2001) and perhaps a better fit for investigating a link between increased insolation and monsoon intensity.

Table 2. Peak insolation values and timing for 20° to 40° N Latitude[†]

Latitude for insolation calculation	Peak insolation year (100 year time steps; before year 2000)	Average insolation value for 21 June to 20 July (W/m^2)
20° N	10,500	490.9
25° N	10,400	501.9
30° N	10,300	509.8
35° N	10,200	514.8
40° N	10,100	517.0

[†] Insolation values from Laskar et al. (2004)

The phytolith samples are characterized by a dramatic change in the vegetation signal from the YD record; however, the trends appear to have been initiated during the latter part of the YD. In samples 1203 and 1202, Sedge and C_3 grass phytoliths are overwhelmingly dominant, indicating an expansion of a wetland habitat and an increase in plant densities. C_3 grasses reach their peak in relative abundance in sample 1203. At the landscape level, C_4 grass phytolith abundance values are reduced but this is likely due to the increase in the wetland signal and not reflective of a decrease in C_4 grasses on the surrounding piedmont. Phytoliths from common reed (*Phragmites australis*) reach their second highest value for the record in sample 1203, and reed canarygrass (*Phalaris* cf. *arundinacea*) appears for the first time in sample 1202. It should be noted that both *Phragmites* and *Phalaris* produce a variety of phytolith morphotypes that are not diagnostic; only one type of rondel morphology is diagnostic for these grasses. Thus, these low relative abundance values are significantly underestimating their actual abundance at the site. With several important wetland indicator taxa now identified, comparisons to modern wetland complexes can be made.

The grass and sedge taxa identified in the early Holocene Locus 1 samples key out to the broad category of wetland complexes or alliances termed Persistent Emergent Wetlands by the New Mexico Natural Heritage Program (Muldavin, et al. 2000). Within this broad category are 14 specific alliances that vary from temporarily, seasonally, and semipermanently flooded wetlands along an elevation gradient. With changes in precipitation and temperature over time, paleowetlands likely progressed along varying directions of succession from one type of alliance to another. Assigning the Water Canyon wetland deposits to the persistent emergent wetland

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category is fairly secure, but identifying a specific wetland alliance is much more speculative; however, it may be useful in trying to identify modern wetland locations that could be used as analogs for paleowetland deposits such as black mats.

Table 3. Possible modern wetland analogs for Water Canyon paleowetland sediments

Wetland Alliance[†]	Soil type	Redox mottles depth (cm)	Gleyed horizon depth (cm)	Flood recurrence interval (years)	1217	1211	1203	1202	1197	1195	5123	5095	5059	5005
Common Spikerush	Fluvaquent	9.1	20.6	2.6			X	X				X	X	X
Softstem bulrush	Fluvaquent	9.1	20.6	2.6							X			
Reed canarygrass	Mollic Fluvaquent	4.2	18.3	5.2					X	X				
Beaked sedge	Histosol	NP	NP	1.0	X	X	X	X						

[†] Muldavin et al. (2000)

For samples 1203 and 1203, the dominance of sedges and C_3 grasses is consistent with the Beaked Sedge Alliance (Appendix 1A), which may have originated during latter half of the YD. However, associated pollen samples for this period of time indicate the presence of several wetland plants and Asteraceae pollen that suggest an increase in plant diversity, which is consistent with the Common Spikerush Alliance (Muldavin, et al. 2000). Interestingly, birch pollen was recovered in sediments that date between 10,800 and 9,279 cal BP at Water Canyon (Dello-Russo 2015). The modern Scrub-Shrub Wetland complex contains the River Birch (*Betula*) Alliance that includes shrubby maple (*Acer*) and alder (*Alnus*). It seems most likely that that this pollen was transported to the site via wind or water from higher up in the watershed; however, as mentioned in (Dello-Russo 2015), bog birch (*Betula glandulosa*) could have been growing along the margins of the Water Canyon wetland. Although *Betula glandulosa* is not mentioned as being associated with modern emergent herbaceous wetlands (Muldavin, et al. 2000), the unique climatic influences during this period of time likely resulted in some unique plant combinations.

Samples 1197 and 1195 (~10,568-10,215 cal BP) mark the transition to a new dominant wetland plant association. Sedge phytoliths initially drop in relative abundance followed by a rebound, and the appearance of distinctive sedge achene phytoliths similar to those produce by *Scirpus* and *Cyperus* are consistently observed. *Phragmites* phytolith values are unchanged, but *Phalaris* phytoliths reach their highest value for the entire record and general C_3 grass phytoliths reach their second highest value. With values ranging between 500,000 and 1,000,000 phytoliths per gram of sediment, these samples mark the beginning of an explosive rise in phytolith concentrations that eventually peak at almost 5,000,000 in the uppermost sample (FS 5005). A possible modern wetland analog for these samples is the Reed Canarygrass Alliance (Appendix

1C), which can vary from a *Phalaris* monoculture to a rich complex with over 46 wetland graminoids and forbs (Muldavin, et al. 2000). This alliance has dark, anaerobic, mucky, saturated soils that are classified as mollic fluvaquents. Muldavin et al. (2000) note that surface water usually recedes later in the growing season but that the water table remains near the surface. They also note that redox mottles and gleyed horizons form at depths below surface of 4.2 and 18.3 cm, respectively.

Locus 5

The Locus 5 samples examined for phytoliths are FS 5123, 5095, 5059 and 5005. These samples span a modeled age range of ~10,196 to 9,513 cal BP, which includes the waning period of the 30° N summer insolation maximum of 10,300 BP. Despite falling nicely within the increasing phytolith concentration curve, sample 5123 is somewhat of a singularity in regards to its phytolith assemblage. In some respects, it has a strong affinity with the landscape level vegetation signal (C_3/C_4 grasses) for the other 5000 series samples; however, it breaks dramatically with the wetland signal for both the 1100 series samples from Locus 1 and the 5000 series samples. The modeled age for sample 5123 is 10,196 cal BP and the modeled age for sample 1195 is 10,214 cal BP. Based on the uncertainties inherent with an age model and the ^{14}C dates it was based on, these two samples could be contemporaneous or even inverted in relative age. Thus, the jagged shape of the trend line in Figure 3 is not too surprising, especially considering that these loci are on two different sides of No-Name Arroyo and are like recording a different mix of the wetland and landscape vegetation signals.

Regardless of the somewhat peculiar relationship with the samples from either Loci 1 or 5, sample 5123 is recording an interesting wetland signal. Both sedge and *Phragmites* phytolith values are at their highest levels of relative abundance for the record, and C_3 grass phytolith values are still relatively high. This sample may highlight the patchy distribution of wetland plants at the Water Canyon site. The dominance of sedge phytoliths, the relatively high abundance of *Phragmites* and low abundance of *Phalaris* phytoliths suggests an affinity with the Softstem Bulrush Alliance (Muldavin, et al. 2000)(Appendix 1D). This alliance is described as being widespread in New Mexico and characterized by high cover and dominance of softstem rush (*Scirpus tabernaemontani*). Muldavin et al. (2000) describe the soils for this alliance as being anaerobic, dark and poorly drained. They also state that a gleyed mineral horizon typically forms underneath the surface under thick organic accumulations at the surface.

For samples 5095, 5059 and the uppermost sample 5005, obligate wetland indicator grasses and sedges are much reduced, C_3 grasses decline, and C_4 mesophytic and xerophytic grass phytoliths increase in abundance. Despite the apparent reduction in the wetland signal, the phytolith concentration values reach their highest levels for the record. The phytolith assemblages for these three samples are almost a mirror image of the YD samples, yet their phytolith concentrations are over 800 times higher. Also, the humic acid content for these three samples is much higher than for the YD samples (Table 1). The speleothem record from Pink Panther Cave suggests decreasing winter precipitation and overall drying between 10,000 and 9,500 BP (Figure 3 *F*). Increased aridity during this period is also indicated from a soil organic matter $\delta^{13}C$ record from central New Mexico (Hall and Penner 2013). Despite the apparent drying in the region, the Water Canyon site maintained its high water table at least seasonally to support a very dense grassland community. Seasonal drying may have crossed a threshold where many perennial obligate wetland plants could not remain viable, but C_4 grasses and other herbaceous plants could colonize these areas later in the growing season.

As first discussed in the Results section, a chrysophyte stomatocyst was observed in sample 5059. This stomatocyst corresponds nicely with type #270 from the Atlas of Chrysophycean Cysts Vol. II (Wilkinson, et al. 2001), which was collected from a high latitude peat deposit. The presence of this stomatocyst provides further evidence for the highly organic and acidic conditions of the sediments that the wetland plants were rooted in. Phytoliths are best preserved under slightly acidic conditions, and the phytolith assemblage in this same sample was noted as being perfectly preserved.

The Water Canyon pollen records for this period indicate a high abundance of disturbance taxa such as Cheno-am pollen and a ragweed type pollen that may be derived from marshelder (*Iva* spp.)(Dello-Russo 2012, 2015). Taxa identified from the combined pollen and phytolith records suggest that the Common Spikerush Alliance wetland (Appendix 1B) may be a modern analog for the paleowetland that existed during this period of time. Potential key wetland taxa associated with this alliance type that may be indicated by the pollen and phytolith records include *Cyperus esculentus*, *Eleocharis palustris*, *Helianthus ciliaris*, *Malvella leprosa* and *Iva axillaris* (Muldavin, et al. 2000). This community occurs on sites subject to seasonal flooding, and generally develops as narrow stringers along stream banks with fluvaquent soil development.

1600 Series samples (Locus 1)

At the time of this report, samples 1632, 1633 and 1634 from Locus 1 did not have ages associated with them, so they were not diagrammed as part of the composite record in Figure 3, and instead were diagrammed separately in Figure 2. It was suspected that these samples would fall within the age range of the 1200 series samples (Robert Dello-Russo, personal communication). Comparison to the phytolith record in Figure 1 suggests that these samples may have a chronological affiliation with the 1217 to 1202 set of samples that span from ~12,300 to 10,900 BP.

The most significant finding from these samples was the recovery of 22 starch granules in sample 1634 and 3 starch granules in 1632. Details about these starch granules were discussed in the Results section above, and it was concluded that modern contamination is an unlikely source for these granules. It is most likely that a fragment of sedge root and an intact tribe Triticeae grass seed (for example *Elymus*, *Pascopyrum*, *Pseudoroegneri* or *Hordeum*) were the source for these starch granules; however, an anthropogenic source is also possible, as grinding activities can easily spread starch granules across a site. The probable sedge root starch morphology is consistent with what has been described for *Scirpus tabernaemontani* (syn. *Schoenoplectus tabernaemontani* and *Scirpus validus*) by others (Messner 2011). The previously discussed Softstem Bulrush Alliance, which is dominated by *Scirpus tabernaemontani*, may serve as a modern analog for one of the paleowetland phases at the Water Canyon site.

Conclusion

Phytolith analysis of 16 late Pleistocene and early Holocene samples from the Water Canyon Paleoindian site yielded a well-preserved record of grasses and sedges. The phytolith record consisted of a site level wetland signal comprised of C_3 grasses, obligate wetland grasses and sedges that sometimes overpowered the surrounding landscape signal comprised of C_4 mesophytic (Panicoideae) and C_4 xerophytic (Chloridoideae) grasses.

During the BA, the combined pollen and phytolith data indicates that the Water Canyon site was a relatively narrow riparian zone lined with C_3 grasses and sedges. The surrounding piedmont consisted of a juniper grassland ecotone comprised of a mix of C_4 mesophytic Panicoideae and C_4 xerophytic Chloridoideae grasses that were supported by higher than modern summer precipitation. Towards the termination of the BA, there may have been a substantial drop in summer precipitation as Panicoideae grass abundance was significantly reduced. The relatively high abundance of C_3 grasses, sedges and tallgrass C_4 Panicoideae may have made the Water Canyon drainage preferable to grazers over lower elevation C_4 shortgrass habitats for much of the BA.

The phytolith record suggests that the YD chronozone at the Water Canyon site was not expressed as a static climatic event but rather as a transgressive climatic phenomenon. During the onset of the YD at around 12,900 BP, the phytolith record is indicative of winter-dominated precipitation with low to moderate summer precipitation. By the middle of the YD (~12,300 BP) there was a switch to a greater proportion of summer precipitation, however winter precipitation may have been maintained at previous levels, resulting in a net increase in moisture. It is possible that increased summer insolation resulted in increased monsoon precipitation during the latter part of the YD. Thus, a climate forcing from the progression of the summer insolation maximum may have overprinted on the climatic effects of the waning YD.

For the early Holocene period from ~11,700 to ~10,000 BP, the phytolith record was overwhelming dominated by a sedge and C_3 grass wetland signal. Obligate wetland grasses that included *Phragmites australis* ssp. *americanus* and *Phalaris arundinacea* increased in abundance, and as discussed, may be useful in identifying modern wetland plant alliances that could serve as analogs for the paleowetlands observed at Water Canyon. This period also marked the point where phytolith concentrations increased exponentially, indicative of high grass and sedge densities at the site. This period also brackets the July insolation maximum at 30° N latitude that may have produced a peak in increased summer monsoon precipitation. The relationship between increasing summer insolation and increasing phytolith concentrations at Water Canyon is intriguing, and suggests a link between C_4 grassland densities and summer monsoon intensity in southwestern North America.

For the early Holocene period from ~10,000 to 9,500 BP, obligate wetland indicator grasses and sedges were much reduced, and C_3 grasses declined. The landscape level signal strengthened as C_4 mesophytic and xerophytic grass phytoliths increased in abundance, and phytolith concentration values reach their highest levels for the record, peaking at $\sim5\times10^6$ phytoliths per gram of sediment. This suggests that very dense grasslands dominated the surrounding landscape, possibly benefiting from enhanced summer monsoon precipitation. However, the reduction in obligate wetland taxa at Water Canyon suggests that winter precipitation was on the decline. The presence of a dense graminoid community consisting of C_3 grasses, sedges and tallgrass C_4 Panicoideae grasses in the Water Canyon drainage likely made this a preferable place for large mammals to graze, especially during the early Holocene.

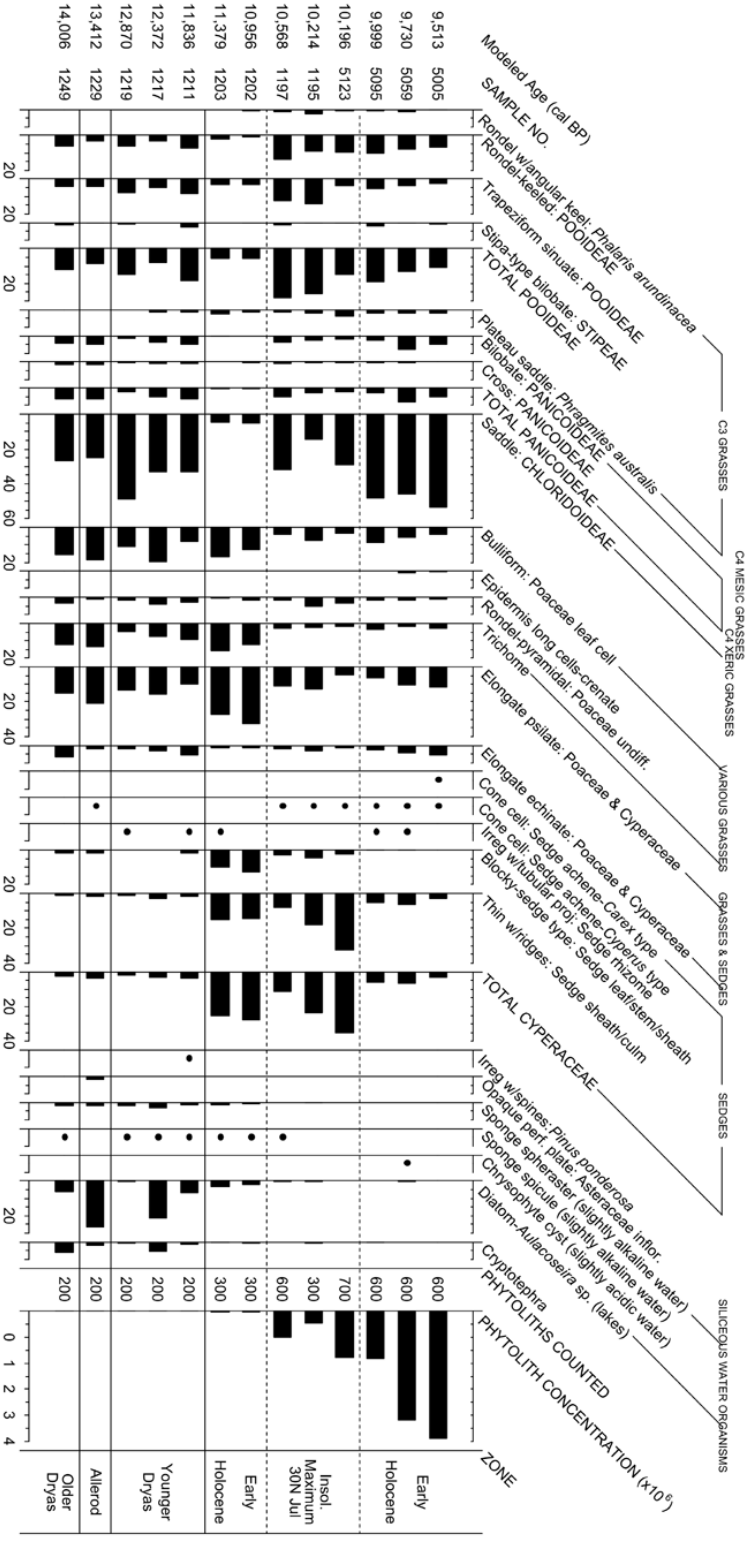

Figure 1. Composite percentage diagram for phytoliths and other siliceous microremains recovered from Loci 1 and 5. Non-phytolith percentages were based on the phytolith sum. Phytolith concentrations were calculated from sediment dry weight.

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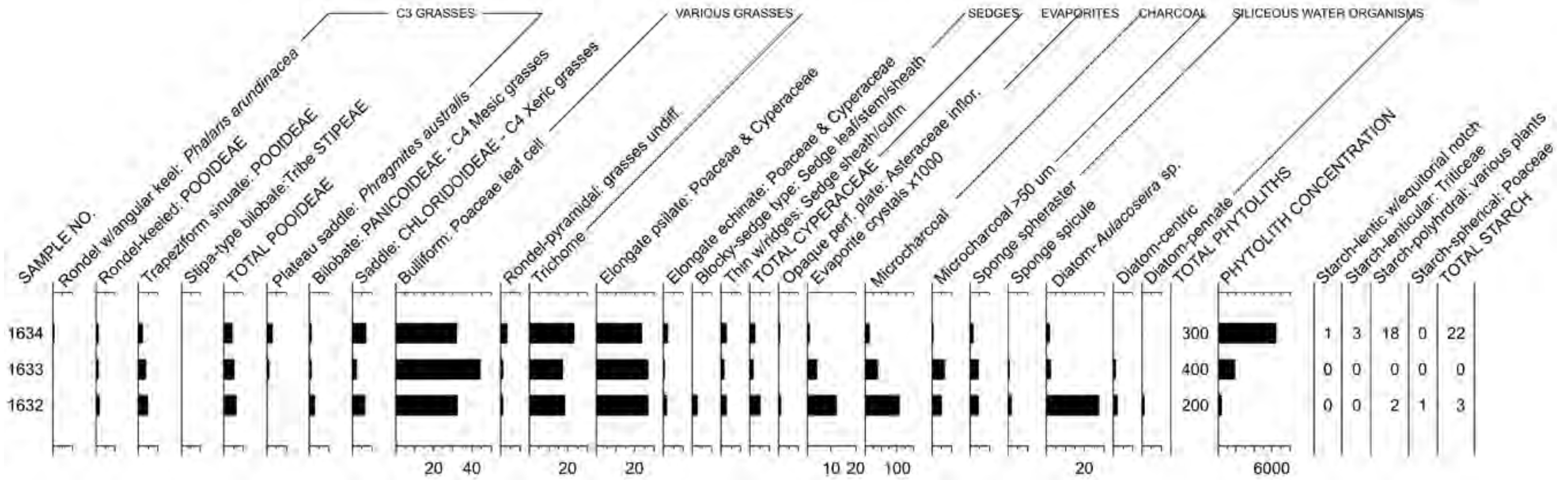

Figure 2. Composite percent relative abundance diagram for phytoliths, charcoal, evaporite crystals and other siliceous microremains recovered from Loci 1, Unit 1-46. Non-phytolith percentages were based on the phytolith sum. Phytolith concentrations were calculated from sediment dry weight. Starch granule values are raw counts.

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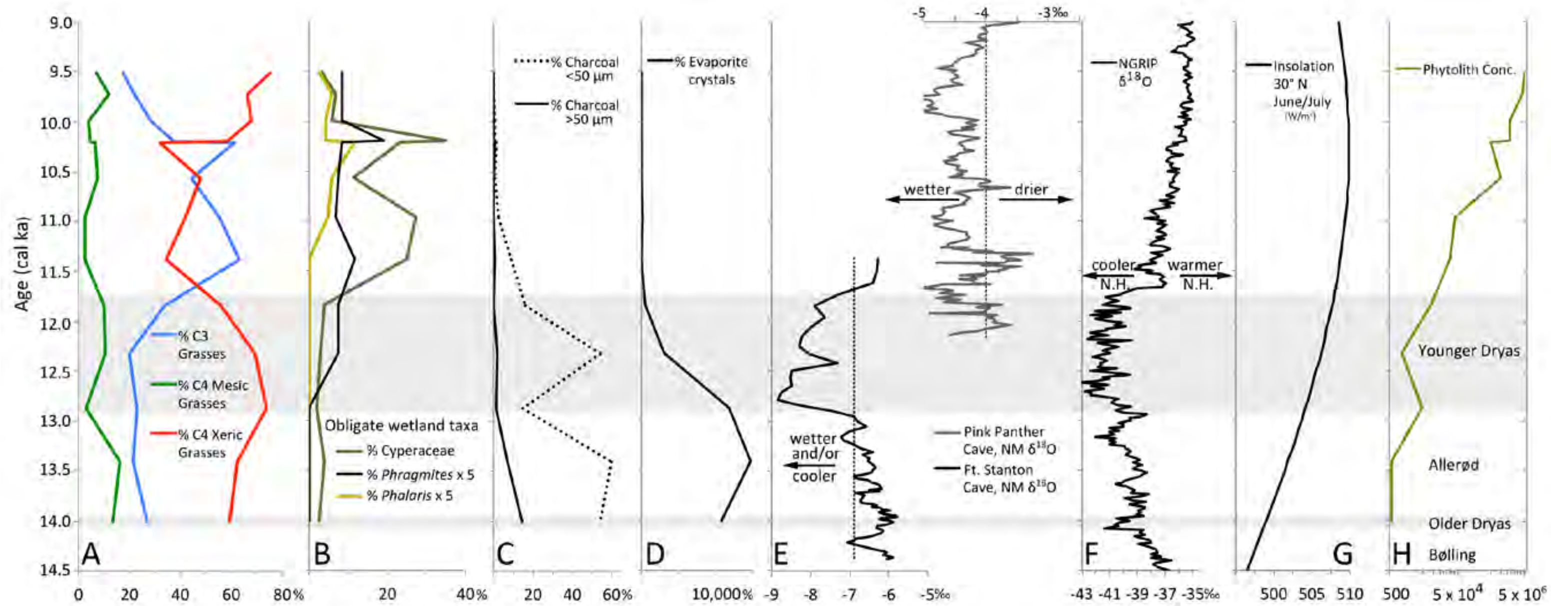

Figure 3. Comparison of select phytolith, microcharcoal and evaporite records from the Water Canyon site to regional and Northern Hemisphere climate records. **A)** Relative abundance values for phytoliths indicative of cool season C_3 grasses, warm season C_4 mesophytic grasses and warm season C_4 xerophytic grasses. The C_3 morphotypes are mostly from subfamily Pooideae taxa, C_4 mesic morphotypes mostly from subfamily Panicoideae taxa, and C_4 xeric morphotypes from subfamily Chloridoideae taxa. **B)** Relative abundance values for phytoliths diagnostic of select obligate wetland grasses (*Phragmites australis* ssp. *americanus*, *Phalaris arundinacea or P. caroliniana*) and sedges (Cyperaceae). **C)** Microcharcoal abundance relative to phytolith sum, with the <50 µm fraction sourced from local and regional fires, and the >50 µm fraction most likely sourced from local fires. **D)** Evaporite crystal abundance relative to phytolith sum, and possibly sourced from the San Agustin basin. **E)** Speleothem oxygen isotope values from Fort Stanton Cave, NM (Asmerom et al., 2007) and Pink Panther Cave, NM (Asmerom et al., 2010). **F)** Greenland oxygen isotope record from the NGRIP core using the GIC05 chronology (Andersen et al., 2007). **G)** Insolation values for June-July at 30° N from Laskar et al., (2004). **H)** Phytolith concentrations per gram dry sediment for grasses (Poaceae) and sedges (Cyperaceae).

Figure 4. Selected phytoliths recovered from Water Canyon site (LA134764) sediments.

All micrographs taken at 500x magnification; scale bar equals 10 µm. **A-B)** Saddle phytoliths derived from C_4 xerophytic grasses (Chloridoideae). **C-D)** Bilobate phytoliths derived from C_4 mesophytic grasses (Panicoideae). **E-F)** Cross phytoliths derived from C_4 mesophytic grasses (Panicoideae). **G)** Stipa-type bilobate phytolith derived from C_3 Pooideae tribe Stipeae grasses. **H)** Keeled rondel phytolith derived from C_3 Pooideae grasses. **I)** Trapeziform sinuate phytolith derive from C_3 Pooideae grasses. **J-L)** Plateau saddle phytolith derived from *Phragmites australis* (common reed), viewed in top, side and oblique positions. **M-O)** Three individual angular keel rondel phytoliths derived from *Phalaris* spp. (canarygrass). **P)** Bulliform cell phytolith derived from grass leaves. **Q)** Part of a silicified grass stomatal complex. **R)** Bulliform-type phytolith typical of grasses (Poaceae) and sedges (Cyperaceae). **S)** Silicified long cell phytolith typical of grasses and sedges. **T)** Elongate-psilate phytolith typical of grasses and sedges. **U)** Irregular with spiny projections phytolith derived from *Pinus ponderosa* needles. **V)** Trichome phytolith typical of grasses. **W)** Thin with ridges phytolith derived from sedge leaf or sheath epidermis. **X)** Irregular with tubular projections phytolith derived from sedge roots and rhizomes. **Y)** Cone cell phytolith derived from sedge achenes, possibly a species of *Scirpus*. **Z)** Sequence of cone cell phytoliths derived from sedge leaf or inflorescence epidermis. **AA)** Cone cell phytolith derived from sedge achenes, possibly from a species of *Cyperus*.

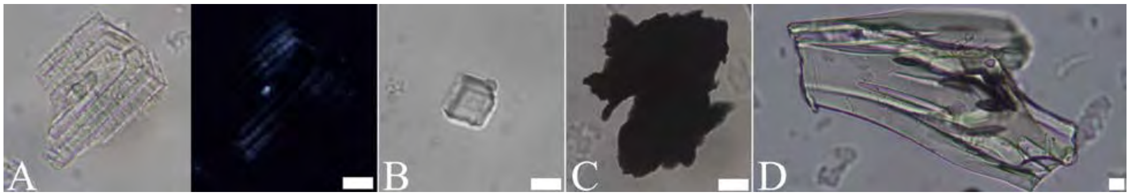

Figure 5. Selected micrographs of evaporite crystals, charcoal and volcanic glass observed in phytolith extracts from Water Canyon site (LA134764) sediments.

All micrographs taken at 500x magnification; scale bar equals 10 µm. **A)** Tabular evaporitic crystal viewed under plane-polarized (left) and cross-polarized light (right). **B)** Rhombic evaporitic crystal. **C)** Microcharcoal particle. **D)** Cryptotephra particle.

Figure 6. Selected micrographs of siliceous water organisms observed in phytolith extracts from Water Canyon site (LA134764) sediments.

All micrographs taken at 500x magnification; scale bar equals 10 µm. Diatom species level identifications were made by Barbara Winsborough. **A)** Two *Aulacoseira* sp. diatom frustules in girdle view. **B)** *Aulacoseira* cf. *italica* diatom in valve view (FS 1633). **C)** *Epithemia adnata* diatom in valve view (FS 5059). **D)** *Surirella* cf. *ovalis* diatom in valve view (FS 5059). **E)** *Stauroneis acuta* diatom in valve view (FS 1632). **F)** Freshwater sponge (Spongillidae) spicule fragment. **G)** Freshwater sponge spheraster. **H)** Chrysophyte (golden algae) stomatocyst (FS 5059).

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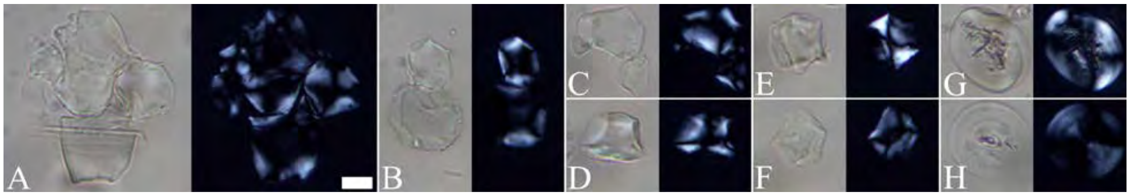

Figure 7. Selected micrographs of starch granules observed in the phytolith extract from Water Canyon site (LA134764) sediment sample FS 1634.

All micrographs taken at 500x magnification with plane-polarized (left) and cross-polarized (right) light; scale bar equals 10 µm. **A-C)** Clusters of faceted polyhedral starch granules. Although some grasses can produce similar morphotypes, these are consistent with those found in sedge (Cyperaceae) roots, in particular *Schoenoplectus*. **D-F)** Individual faceted polyhedral starch granules. **G-H)** Lenticular (in side view) C_3 Pooideae tribe Triticeae granules with visible lamellae under plane-polarized light, characteristics suggestive of *Pseudoroegneri spicata* (bluebunch wheatgrass) seed starch.

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Appendix 1

A. Beaked Sedge-Baltic Rush Community Type occurs here in thin bands on the banks of Little Costilla Creek in the upper Rio Grande watershed (from Muldavin et al., 2000).

B. Common Spikerush Alliance on the upper San Francisco River of the Gila River watershed (from Muldavin et al., 2000).

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C. Reed Canarygrass Alliance in a marsh along the Rio San Jose in the Rio Grande watershed (from Muldavin et al., 2000).

D. Softstem Bulrush-Broadleaf Cattail Community Type bordering the channel of Oak Creek in the Canadian watershed (from Muldavin et al., 2000).

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APPENDIX D. Diatom Analysis

DIATOM PALEOENVIRONMENTAL ANALYSIS OF SEDIMENTS FROM THE WATER CANYON PALEOINDIAN SITE (LA134764)

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INTRODUCTION

This investigation is part of an interdisciplinary research project of the Water Canyon Paleoindian site located in west-central New Mexico. The site, at about 1760 m elevation, is at the east edge of the Water Canyon basin, and is one of a series of early-to-middle Holocene age archaeological sites eroding out of sediments along the Water Canyon drainage at the toe end of a large alluvial fan that flanks the Magdalena Mountains (Dello-Russo, 2013). The goal of this part of the project is to investigate the diatom content of 16 samples (Table 1) submitted for diatom analysis and determine the nature of the paleoenvironments they represent.

Diatoms are unicellular, eukaryotic algae that are distinguished by the presence of a silica cell wall. They live in a wide variety of aquatic habitats, including rivers, streams, ponds, lakes, ditches, bogs, lagoons, marshes, swamps, mud flats, beaches, estuaries, bays and oceans. In addition to the aquatic forms, many species are aerial, capable of surviving and reproducing in a variety of non-aquatic (not submerged), moist, humid or dry habitats, such as soil, wet rocks, tree bark, moss, waterfall spray, springs, seeps, swales, fens, tundra, caves, wet meadows, cienegas and moors. These algae often derive their water from moisture in the air and rainfall. The availability of moisture, length of dry periods, substrate, pH, nutrient availability, conductivity, and available light all play a part in determining which of the aerial diatoms thrive in a particular habitat. The aerial environment is harsh in comparison to aquatic habitats and the number of taxa in an assemblage is often lower.

Many species are cosmopolitan, found in different parts of the world under similar environmental conditions, making it possible to predict their environmental requirements and tolerances. Diatoms can be identified to species level, and a large and growing body of information exists on the range and ecological tolerances of many of the common forms. Diatoms are good indicators of water chemistry, depth, pH, salinity, habitat, substrate, nutrient concentrations and pollution levels. Because of their silica cell walls they are often preserved in sedimentary deposits, making them well-suited for use in paleoenvironmental reconstruction.

METHODS

Approximately one cm^3 of sediment was oxidized with 35% H_2O_2 to remove organic material and decalcified with 31% HCl. After rinsing to a neutral pH, the material was dried onto cover slips and mounted on glass slides with Naphrax®. The slides were scanned at x1500 magnification, and the first 600 diatoms encountered were identified and recorded. When there were not sufficient diatoms to obtain this count, the entire 22 x 22 mm area of the coverslip was scanned and all diatom remains recorded.

RESULTS

The results of this analysis are variable, depending on the sample. The samples range from diatomaceous to barren of any diatom remains. All samples that have any diatoms are included on Table 2. A total of 1368 diatom valves and fragments of valves were found. Of these, 22 different diatom species could be recognized. Six other specimens were fragments that could only be identified with confidence to the genus level. In addition to diatoms, one specimen of Concentricystes, a distinctive microfossil of unknown affinity was found, and a few sponge spicules were recorded. Many of the diatoms are illustrated on Plates 1-3.

The most diatomaceous samples, FS1217, FS5059, and FS5095 provide the best information about the paleoenvironments represented by these samples. The 3 diatomaceous samples are very similar in diatom composition (Table 2), with the same taxa common in the three samples. These diatoms, in order of abundance, are *Diadesmis gallica* W. Smith, *Hantzschia amphioxys* (Ehrenberg) Grunow, *Denticula elegans* Kützing, *Luticola mutica* (Kützing) D.G. Mann, *Nitzschia amphibia* Grunow, *Pinnularia appendiculata* (Agardh) Cleve and *Pinnularia borealis* Ehrenberg. It is the association of these common diatom species and their ecological preferences that determines the interpretation of the paleoenvironment. The ecological preferences and tolerances of the rarer species, those diatoms that were recorded only a few times, or only in one or a few samples, are also taken into consideration to provide information about the entire range of conditions represented by the assemblage. Table 3 is a glossary defining the ecological terms used in this report.

DISCUSSION

<u>Ecological Characteristics of the Most Common Diatoms and their Significance to Paleoenvironmental Interpretation</u>

The autecological characteristics of each of the most abundant species are examined to produce a comprehensive description of the range of paleoenvironmental variability that is represented by the individual samples. Because the diatoms discussed are cosmopolitan there is a range of ecological characteristics reported by various authors working in somewhat different settings. Unless specified, ecological information comes from a collection of sources including: Round 1981, Vos and de Wolf 1993, Van Dam et al. 1994, Stoermer and Smol 1999, Johansen 1999, Lange-Bertalot and Genkal 1999, Winter and Duthie 2000, Van de Vijver et al. 2004, Potapova and Charles 2007, Porter, 2008, and others).

The most abundant diatom in these samples is a very small oval form called *Diadesmis gallica* (Plate 1 A, B). It is a typical aerial diatom (Johansen 1999). It dominates the assemblage on ice in caves of the northern Yukon Territory, Canada, where it is well-adapted to the aerial, humid, very low light intensity conditions near the entrance (Lauriol et al. 2006). In the Canadian High Arctic, *Diadesmis gallica* represented up to 1/4 of the diatom population living epiphytically on patches of moss surrounding and in shallow, mesotrophic, dilute, poorly buffered tundra ponds that evaporated seasonally (Antoniades et al. 2005). It forms a biofilm associated with moss in a cave in Spain (Hernández-Mariné and

Molina 2012), and It was found with other aerial diatoms in East Antarctica (Sabbe et al. 2003).

In Switzerland, *Diadesmis gallica* was found in an ephemeral, strongly shaded, low pH (3.95-5.3), low conductivity (46-61 μS cm^{-1}), low temperature (8.5-14.9^o C) sandstone stream 5-15 cm deep, that experienced long periods of episodic drying (Veselá 2009). *Diadesmis gallica* was also part of the aerophilic group of diatoms found in a very small, upland, shallow (25 cm), moderate conductivity, circumneutral oligotrophic to mesotrophic limestone stream in South Poland, whose flow is partly underground (Wojtal 2009).

Diadesmis gallica was very abundant in an east central Utah early-mid Holocene (10,000 to 8,000 cal yr. BP) fen that lacked standing water most of the year and had vegetation that kept the light levels low (Steve Nelson, personal communication 5/23/2016). *Diadesmis gallica* was uncommon but present in a Bolivian cloud forest, on rocks in an alpine, shallow (< 50 cm deep), fast flowing stream that was clear, cold, mesotrophic to eutrophic, with circumneutral pH, probably high concentrations of organically bound nitrogen, oxygen levels above saturation and low conductivity water (Morales et al. 2009).

From these records cited above, it appears that this diatom is a cold temperature form that thrives in dark, damp to wet shady environments, such as the underside of surface litter or moss, that may be occasionally, briefly submerged. It is reported at a pH range mostly from 6.4-7.2, in low to moderate conductivity (between 292 and 569 μS cm^{-1}), and well aerated conditions.

The second most abundant diatom, *Hantzschia amphioxys* (Plate 1 G), is one of the most common soil diatoms in the world. It is rare in acidic soils, and reaches high densities in neutral to slightly alkaline soils, and *Hantzschia amphioxys*, as well as *Luticola mutica* and *Pinnularia borealis*, two other diatoms common in these samples, are absent or rare on strictly aerial lithic substrates unless there are mosses present (Johansen 1999). The ecological characteristics for *Hantzschia amphioxys* include a tolerance of different nutrient levels, an indicator of high total phosphorous, α-mesosaprobous, tolerant of organically bound nitrogen (OBN), and >75% DO saturation, fresh-brackish water, low chloride optimum (<15 mg/L), is motile, found in dry soil, and survives prolonged dry periods.

The next most common taxon, *Denticula elegans* (Plate 1 D, E), is usually classified as aquatic but is found in both submerged and dry settings. It is typically found in oligotrophic, shallow, carbonate-rich, sometimes seasonally flowing spring water, such as travertine encrusted canals and waterfalls, where it can live in a film of flowing water and adapts to drying conditions by producing a large, firm, mucilaginous envelope that retains water (Winsborough 2000). It is alkaliphilous, prefers low total nitrate and phosphate, occurs in fresh and brackish water, including inland saline lakes that become reduced or dry out seasonally such as small, ephemeral pools, seeps, shallow springs, prairie potholes and mud flats.

Denticula elegans, a Great Basin thermophile found in water and soil, was numerically dominant in Devil's Hole, a flooded, groundwater fed cave system in southwestern Nevada, that receives very little direct insolation, has physiochemical characteristics of the water, provided here because they are remarkably stable, including a temperature of 32-33 C, pH 7.1-7.5, dissolved oxygen of 2.0-8.1 mg L^{-1}, total dissolved solids (TDS) of 410-870 mg L^{-1}, conductivity of 820 μS cm^{-1}, SiO_2 of 21-23.5 mg L^{-1}, very low nitrate and phosphorous, Ca of 46-51 mg L^{-1}, HCO_3 of 300-311 mg L^{-1} (Shepard et al. 2000). It was also the dominant species in Blue Lake Warm Spring, Utah, with a temperature of 25-26 C, pH 8.1, TDS 4831 mg L^{-1}, conductivity 8163 μS cm^{-1}, low nitrate and phosphorous, Ca 153 mg L^{-1} (Kaczmarska and Rushforth 1984). This diatom would have been abundant during warm, moist seasons.

Luticola mutica (Plate 1 F, Plate 2 A), the next most abundant diatom, is a very common aerial taxon found in dry and moist soil, on mosses, liverworts and lichens. It is eutrophic, α-mesosaprobous, tolerant to OBN, tolerates low amounts of organic enrichment and nearly 100% DO saturation, circumneutral pH, brackish-freshwater, chloride optimum low (<15 mg/L), benthic, motile, dry soil, cosmopolitan, wide range of tolerance

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to nutrients, indicator of high total phosphorous, α-mesosaprobous , survives prolonged dry periods.

The next most abundant diatom, *Nitzschia amphibia* (Plate 1 G, Plate 2 H), is aerial and aquatic, cosmopolitan, tolerates a wide range from oligotrophic to eutrophic water, springs, creeks, lakes and ponds, and aerial on moss, wet surfaces, mud and floating algal mats, epiphytic, epipelic, epilithic, prefers high conductivity, indicator of high total and organic nitrogen and total phosphorous, α –mesosaprobous to eurysaprobous, requires periodic elevated concentrations of OBN, tolerates highly degraded conditions, and >50% DO saturation, alkaliphilous to alkalibiontic, fresh-brackish water, benthic, non-motile, tolerates higher salt contents and slight fluctuations in osmotic pressure, eurythermal, oligohalobous (indifferent), warm to cool water.

Pinnularia appendiculata (Plate 3 B, C) is aerial and aquatic, cosmopolitan, prefers mineralized waters, salt-rich inland waters, salines, soda lakes, generally in waters with an average to high electrolyte content, oligo-mesotrophic, oligosaprobous, generally intolerant to OBN, tolerates nearly 100% DO saturation, acidophilous, freshwater, conductivity optimum low (<200 μS/cm), chloride optimum low (<15 mg/L), benthic, motile, soil. It is an inhabitant of soil crust communities in Arizona, that include rocks, lichens, mosses and algae in crusted hummocks (Johansen et al. 1981)

Pinnularia borealis (Plate 3 D) is a typical aerial diatom, often found in slightly brackish habitats (Johansen 1999). It lives on moss, is frequent on wet and nearly dry walls, oligo-mesotrophic, β-mesosaprobous, tolerant to OBN, tolerates nearly 100% DO saturation, circumneutral pH, fresh-brackish water, benthic, motile, cosmopolitan, on soils, dry moss, and other extremely dry environments. It is common in Antarctic terrestrial habitats (Sabbe et al. 2003).

One significant environmental characteristic of the abundant diatoms is that all of these are aerial forms or aquatic species that are also found in aerial settings. In addition to these commonly occurring diatoms there were several other taxa, found in smaller numbers, that straddle the environmental boundary between submerged and just damp, and are adapted to shallow, aquatic settings that dry out regularly. *Epithemia adnata* (Kützing) Brébisson (Plate 1 H)*, Epithemia turgida* (Ehrenberg) Kützing (Plate 3 E, F)*, Rhopalodia brebissonii* Krammer (Plate 3 G, H)*, Rhopalodia gibba* (Ehrenberg) Müller, and *Rhopalodia gibberula* (Ehrenberg) Müller are aquatic, benthic diatoms. They, like *Denticula elegans*, have internal siliceous supports that may aid in withstanding osmotic stress and elevated conductivity or salinity, from either carbonate or chloride. These species are sometimes included in lists of diatoms from dry settings as well as aquatic because they are often found in lacustrine settings that fluctuate in size seasonally, leaving the margins dry.

Aulacoseira italica (Ehrenberg) Simonsen (Plate 1 I, Plate 2 I) , *Brevisira arentii* (Kolbe) Krammer (Plate 2 E, F) and *Stephanodiscus* sp. (Plate 2 B) are the only aquatic, planktonic diatoms found in the samples. *Aulacoseira italica* is aquatic, mesotrophic to eutrophic, β-mesosaprobous, tolerant to organically bound nitrogen (OBN), tolerates >75% DO saturation, alkaliphilous, fresh-brackish water, planktonic and benthic, non-motile, cosmopolitan. It is found commonly in lakes and ponds. Many species of *Aulacoseira* are found in large lakes but *A. italica* also grows in small ponds, and in wetlands with submerged areas. *Brevisira arentii* is found with *Aulacoseira* spp. It was dominant in a moss-lined, humic rich, high dissolved organic carbon, slightly acidic, oligotrophic, low alkalinity pond in New England (Köster and Pienitz 2006). The *Stephanodiscus* specimens were fragments and could not be identified further but they are planktonic and represent a submerged setting during which they form short-lived, periodic blooms (Goldsborough and Robinson 1996).

The remaining diatom species are benthic, aquatic species found in circumneutral to alkaline, nutrient rich, shallow ponds or streams. These include *Encyonema silesiacum* (Bleisch) D.G. Mann (Plate 3 A), a common epiphytic and epilithic, shallow water species tolerant of high nutrient concentrations; *Caloneis bacillum* (Grunow) Cleve, a β-mesosaprobous, mud species tolerant of organic pollution; *Nitzschia perminuta* (Grunow) Peragallo (Plate 2 G), an oligosaprobous species also tolerant of high levels of organics; *Nitzschia* cf *vermicularis* (Kützing) Hantzsch, another

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mud species; *Placoneis elginensis* (Gregory) E.G. Cox (Plate 2 C), also β-mesosaprobous and nutrient tolerant; *Stauroneis kriegeri* Patrick and *Stauroneis pseudosmithii* Van de Vijver & Lange-Bertalot, both found in small pools of water, moss, and soil; and *Ulnaria ulna* (Nitzsch) Compère (Plate 2 D), a common, broadly tolerant species found in temporarily submerged ditches, ponds, streams and lakes.

<u>Temporal Variability in Paleoenvironment</u>

All of the diatoms discussed above (except the planktonic cells) could easily have been living in essentially the same place, at different times of the year and under slightly different moisture regimes. During dry periods when water levels were low, the exposed sediments would have favored the aerial, epipelic (mud) diatoms such as *Hantzschia amphioxys* and *Luticola mutica*. The surface was colonized by grasses, mosses and sedges as in a wet meadow. As organic litter accumulated, the environment became more nutrient-rich and algal mats and crusts could develop beneath the macrophytes. Macrophyte growth increases shading. The amount of incident light reaching the subsurface can be significantly reduced by an emergent macrophyte canopy such as *Phragmites* or *Typha* or a thick floating mat of duckweeds (*Lemna minor*). *Diadesmis gallica* is not a typical component of a well illuminated assemblage so it must have become common only after a thick cover developed.

During wet periods, epiphytic, epipelic and epilithic diatoms could grow on vegetation, mud and submerged pebbles, but the numbers of these diatoms in the samples was low. These diatoms may have been transported from a nearby flowing water environment and ended up in the samples as overbank deposits. If the water was deep enough, for long enough, and adequately nutrient-rich, a phytoplankton population could develop, but there is no evidence of significant phytoplankton development in the Water Canyon samples other than the small numbers of centric, planktonic diatoms found. Sponge spicules, an indication of very humid conditions, were also observed in two samples (Table 2).

A possible analog to the Water Canyon assemblages is a core from Stonehouse Meadow, a spring-fed sedge meadow in Spring Valley, eastern central Nevada, dated between 8000 and 1750 cal. Yr BP. A large component of the assemblage during relatively moist conditions was dominated by *Epithemia* spp., *Rhopalodia* spp., *Nitzschia amphibia* and *Denticula* spp., diatoms that can survive in environments with elevated levels of total dissolved solids, often in sodium carbonated systems; and an assemblage dominated by aerial taxa including *Hantzschia amphioxys*, *Luticola mutica*, and *Pinnularia borealis* during drier conditions (Mensing et al. 2013). A diatom assemblage similar to that from wet intervals in Water Canyon is reported from black mats at Lubbock Lake and Blackwater Draw sites (Harris-Parks, 2014).

<u>Reasons for Lack of Diatoms in Some Samples</u>

There were few to no diatoms in some samples and many in others. There are several reasons for this. The absence of diatoms may indicate an environment that was not conducive to diatom growth such as a dry or aeolian surface, or a setting in which diatoms were originally present but later removed by diagenetic and pedogenic processes. Poor diatom preservation may be explained by silica dissolution, frequent wind-induced resuspension cycles and grazing by benthic invertebrates that can cause breakage of diatom frustules (Bennion et al., 2010).

Silica dissolution affects all siliceous microfossils, including diatoms, phytoliths, and sponge spicules, but diatoms are the group that is most sensitive to dissolution by oxidation and bacterial decay. While the diatom is alive there is an organic casing consisting of polysaccharides, proteins and lipids around the silica wall that protects it against dissolution. Dissolution of the siliceous exoskeleton is slow except in alkaline conditions or in the interstitial water of peat bogs (Round et al. 1990). In a setting with alternating wet and dry environments, a lowering of the water table, increases biological activity and decomposition processes, with diatoms rare in unsaturated soil environments and frequent in saturated conditions (Bouma et al 1990).

Three major types of black mats, depending on morphological and geochemical characteristics, were identified in a micromorphology study of 25 Younger Dryas age sediments from Arizona, New Mexico, Texas and Nevada, and diatoms were reported only from the black mat deposits at Lubbock Lake and Blackwater Draw (Harris-Parks 2014) so diatoms may not be present in certain types of black mats.

Mechanical breakage can be caused by transport or by the effects of grazing. Grazing pressures include insect herbivory, particularly fly larvae, oligochaete worms, microcrustacea (cladocerans, copepods, and ostracods,), amphipods, snails, tadpoles and fish. Diatoms produce high-energy lipids and provide essential fatty acids making them a desirable food source (Julius and Theriot, 2010).

<u>Comparison of Locus 1 (1000 Series Samples) to Locus 5 (5000 Series Samples)</u>

To investigate the possibility that Locus 5 could have been a paleo channel and Locus 1 a wet meadow, the characteristics of each setting are considered and compared to the autecological characteristics of the diatoms in samples from both loci. All samples in Locus 1 are older black mat samples from below the paleochannel deposits and those in Locus 5 are younger black mat samples from above the channel deposits. What is being compared therefore are the diatom assemblages in two black mat accumulations, separated in time by an interval favorable for paleochannel development. These paleoenvironments have in common a water table that intersects the ground surface near the distal toe of alluvial fans or where faults force ground water to the surface as seeps or springs, and differ in their specific sedimentary facies.

A paleochannel is often filled with coarse, clastic sediments as the finer material was carried off by the current. Sand and gravel, however, can also find their way into a wet meadow in localized, lobate overbank deposits (Miller et al. 2011). A wet meadow is saturated ground along perennial streams where water from spring and groundwater discharge moves over the surface without ponding (Hall et al. 2012). Wet meadows are essentially large seeps, but do not have standing water except seasonally or for brief periods after heavy precipitation events, and the sediments are mostly silt with variable amounts of fine to medium sand that originates from both local and aeolian sources (Pigati et al 2014). Related to the wet meadow, and associated with perennial springs and headwater streams, is the ciénega, perpetuated by permanent, scarcely-fluctuating sources of water forming saturated soils (Hendrickson and Minckley 1985). This setting differs in lacking the fluctuating water levels of the wet meadow but has the typical shallow braided channels between pools and saturated ground that trap organic materials and nutrients.

If discharge from the distal end of an alluvial fan is localized at a point source that is higher than the water table downstream incision should create a distinct confined channel. If the channel bed fills up with coarse material, such as arroyo flood deposits, it will have a different porosity from the surrounding sediments and, at that time, would not have supported the same diatom community as a wetland. The transition to an unconfined wet meadow, (with channel stabilization leading to plant productivity, soil production and organic matter accumulation) could have been abrupt or gradual. Complicating this story is the fact that basins with low-gradient meadow complexes contain discontinuous gullies and stream channels on the valley floor as well as slope failures along banks, seepage erosion, and piping, a phenomenon associated with burrows, decaying roots or other openings created by plants and animals, that involves the enlargement of existing macropores and cavities by groundwater flow, and if prevalent can be the dominant mechanism of meadow degradation (Miller et al. 2011).

One possible scenario for the deposition of repeated generations of black mats at Water Canyon involves a history of repetitive wetland formation and drainage processes associated with multiple sequences of lake-wet meadow impounding followed by catastrophic failures possibly due to slope erosion or outburst flood deposits that extended downstream from the landslide dam. This happened at White Rock Canyon, New Mexico (Reneau and Dethier 1996) where sands and gravels are directly overlain by silt, sand and clay.

At Water Canyon there could have been a terminal Pleistocene landslide or other sediment influx downstream (possibly induced by long periods of heavy rain) that backed up the water forming a basin that eventually filled with wetland vegetation, creating the sediments in Locus 1. Subsequent drainage of the wetland, perhaps triggered by extreme precipitation, heavy snowmelt events or earthquakes, would allow for erosive, rapid channel incision, scour and deposition of coarse sediments. Seismic activity could also have contributed to abrupt landform adjustment in the absence of regional climate change. Reestablishment of the wetlands would have followed when another landslide blocked outflow and dammed up the water, repeating the cycle. Because of the low relief, the channels would have been capped with fine sediment and became part of a new wet meadow (Locus 5), with shallow, meandering, braided streams. In this case, if the climate and water table were the same during the deposition of Loci 1 and 5, the predominant diatoms in the black mats at each locus should be similar, allowing for differences due to allochthonous diatom material that was eroded, transported and added to the wet meadow as runoff, and overbank deposits.

The diatomaceous samples in each locus contain the same dominant species, but the proportions of each species are somewhat different. Locus 5 contains fewer aerial diatoms and greater numbers of aquatic species. This is based on comparison of 600 diatom cells from the most diatomaceous locus 1 sample and 600 diatoms from the best Locus 5 sample. These differences may indicate slightly wetter conditions in locus 5.

CONCLUSIONS

Although there were fluctuations in water level due to periods of drying and flooding, this wetland ecosystem appears to have been repeatedly reestablished during the time interval of 12,327 cal yr BP thru 9730 cal yr BP since the three diatomaceous samples FS1217 (Locus 1)with a modeled age of 12,327 cal yr BP, FS5059 (Locus 5) at 9,730 cal yr BP, and

FS5095 (Locus 5)at 9,999 cal yr BP, covering a time span of about 2600 years, all have very similar diatom assemblages. The samples in Locus 5 contain an assemblage that may represent slightly wetter conditions. These assemblages define the mosaic of micro-habitats that were available to the diatoms during the period covered by the samples. There is not enough diatom data to draw any conclusions about the post- 9730 cal yr BP and there is no data for pre-12,327 cal yr BP.

The diatoms are a combination of aerial species and aquatic forms, many adapted to temporarily submerged or wetted settings that dry out. The assemblage indicates that there was not permanent standing water. The lack of significant numbers of aquatic diatoms means that the climate was probably predominantly dry, with the aquifer sustained by snowmelt. Groundwater discharge may have been in the form of diffuse seeps where the water table intersected the ground surface. This moisture supported moss or similar cover, as well as larger emergent plants. The ground surface was probably very shallowly submerged, for brief intervals but not long enough for a typical aquatic flora to develop, other than taxa adapted to fluctuating moisture. Most likely, rather damp, humid conditions defined the site at the time these diatoms were alive.

The overall climate may have been cold and dry in the winter and warmer and wetter in the summer. The diatoms living on the sediment surface and in the detrital mat reflect an environment that was exposed to the entire seasonal temperature range, but the most abundant diatom, *Diadesmis gallica*, is an aerial species reported from cold or cool climates. Another abundant diatom, *Denticula elegans* is abundant in warm, shallow water, suggesting that the ground surface was warm or temperate and wet part of the year.

The conductivity of the groundwater-fed system was low to moderate, possibly increasing during evaporitic periods. The pH was never very acidic, probably circumneutral to somewhat alkaline in freshly submerged water bodies, but as these submerged meadows dried out or the water table dropped, mineral salts accumulated, making the pH more alkaline. This is reflected by the presence of alkaliphilous diatoms, such as

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Epithemia spp., Rhopalodia, and *Denticula elegans* that are adapted to aquatic settings that dry out. Mosses can create locally slightly more acidic habitats, even when growing on limestone or travertine, but these pH differences are localized.

Depending on the vegetation, particularly the grasses and emergent water plants, and the degree to which the water table fluctuated, this diatom assemblage could describe a spring-fed wet meadow, or cienega, with saturated soils supporting abundant macrophytes. The combination of canopy, vegetation, and accumulated organic matter would have limited substantially the amount of light available to the diatoms at the sediment surface.

There were low numbers of planktonic diatoms in these diatom samples. They are a combination of *Aulacoseira* spp., taxa found in somewhat permanent lakes with a slightly acidic to slightly alkaline pH, and fragments of *Stephanodiscus* sp. another planktonic diatom, that is alkalibiontic, meaning that it only occurs in alkaline water with a pH above 7. *Stephanodiscus niagare* Ehrenberg was abundant in core samples between 18,000 and 15,000 yr B.P. in the San Agustin Basin in western New Mexico, that was interpreted as a large, freshwater, alkaline lake with salinity levels of less than 3000 ppm, and possibly consisting of several short duration intervals of high and low lake stands (Markgraf et al. 1983, Markgraf et al. 1984).

Abundant planktonic diatoms, particularly sturdy, heavy-celled *Aulacoseira* spp. were found in the pollen samples, particularly in Locus 1 (Chad Yost, personal communication 5/24/2016). These planktonic diatoms represent a lake setting. This is a different environment than that indicated by the diatom assemblage. The planktonic diatoms either were transported from a nearby lake, or were reworked or eroded from an older paleolake. These diatoms would have accumulated on the surface when a lake dried out and resisted dissolution, much the same as *Denticula elegans, Epithemia* spp. and *Rhopalodia* spp. Transport mechanisms include wind, birds, turtles and mammals. The larger sample volume and different preparation used in pollen extraction may contribute to the difference in the quantity of *Aulacoseira* spp. recovered.

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— Appendix D, page 21, intentional blank [per Author's report file] —

TABLE 1

LIST OF DIATOM SAMPLES ANALYZED FROM THE WATER CANYON PALEOINDIAN SITE (LA134764)

FS No.	Test Unit/ Level	N. Grid Co. (m)	E. Grid Co. (m)	Grid Elev. (m)	Modeled Age (cal yr BP)	Diatom Summary
1195	Unit 1-6 Lev. 9	509	509	48.00-47.90	10,214	few diatoms
1197	Unit 1-6 Lev. 10	509	509	47.90-47.80	10,568	few diatoms
1202	Unit 1-6 Lev. 11	509	509	47.80-47.70	10,956	no diatoms
1203	Unit 1-6 Lev. 12	509	509	47.70-47.60	11,379	no diatoms
1211	Unit 1-6 Lev. 13	508	509	47.60-47.50	11,836	no diatoms
1217	Unit 1-6 Lev. 14	508	509	47.50-47.40	12,327	very many diatoms
1219	Feat. 1-6 Lev. 15	508	509	47.40-47.30		no diatoms
1229	Unit 1-6 Lev. 16	509	509	47.30-47.20	13,412	no diatoms
1249	Unit 1-6 Lev. 17	509	590?	47.30-47.10	14,006	no diatoms
1632	Unit 1-46 Lev. 15	512.501	511.349	47.317		few diatoms
1633	Unit 1-46 Lev. 15	512.506	511.319	47.368		no diatoms
1634	Unit 1-46 Lev. 14	512.502	511.346	47.490		no diatoms
5005	Unit 5-3 Lev. 1	521.93	527.91	45.980	9,513	few diatoms
5059	Unit 5-3 Lev. 2	521.903	527.843	45.871	9,730	very many diatoms
5095	Unit 5-3 Lev. 4	527.838	521.778	45.696	9,999	many diatoms
5123	Unit 5-3 Lev. 6	527.841	521.9	45.479	10,196	few diatoms

TABLE 2

DIATOM TAXA RECOVERED FROM THE WATER CANYON PALEOINDIAN SITE (LA134764)

FS Number	1195	1197	1217	1632	5005	5059	5095	5123
Aulacoseira italica (Ehrenberg) Simonsen				1			2	
Aulacoseira sp. fragments							4	
Brevisira arentii (Kolbe) Krammer			2					
Caloneis bacillum (Grunow) Cleve						2		
Cymbella sp.		1						
Denticula elegans Kützing			31			82	25	1
Denticula sp.		1						
Diadesmis gallica W. Smith			191			230	32	
Encyonema silesiacum (Bleisch) D.G. Mann				1	1			
Epithemia adnata (Kützing) Brébisson			7			12	7	
Epithemia turgida (Ehrenberg) Kützing	2		3				2	
Epithemia sp.		2						1
Hantzschia amphioxys (Ehrenberg) Grunow		2	181	4	1	151	45	1
Luticola mutica (Kützing) D.G. Mann			89	2		37	8	
Nitzschia amphibia Grunow			40			44	7	
Nitzschia perminuta (Grunow) Peragallo			12			2		
Nitzschia cf. *vermicularis* (Kützing) Hantzsch	1							
Placoneis elginensis (Gregory) E.J. Cox			2					
Pinnularia appendiculata (Agardh) Cleve			18			10		
Pinnularia borealis Ehrenberg			15			8	4	
Rhopalodia brebissonii Krammer			6			18	1	
Rhopalodia gibba (Ehrenberg) Müller						2	1	1
Rhopalodia gibberula (Ehrenberg) Müller							3	
Stephanodiscus sp.			2				1	
Stauroneis kriegerii Patrick						2		
Stauroneis pseudosmithii Van de Vijver & Lange-Bertalot			1					
Surirella sp.							1	
Ulnaria ulna (Nitzsch) Compère	1				1			
Total count	4	6	600	8	3	600	143	4
Concentricystes [unknown affinity]	1							
Sponge spicule		3		1				1

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TABLE 3

GLOSSARY OF DIATOM ATTRIBUTES AND WATER QUALITY TERMS

Definitions adapted primarily from Van Dam et al. 1994, Potapova and Charles 2007, Lange-Bertalot and Genkal 1999, Porter 2008, Winter and Duthie 2000.

pH

acidobiontic- optimal occurrence at pH <5.5, occurs below pH

acidophilous- mainly occurring at pH <7

circumneutral- mainly occurring at pH-values about 7

alkaliphilous- mainly occurring at pH >7

alkalibiontic- exclusively occurring at pH >7

indifferent- no apparent optimum, tolerates a wide pH range

Salinity (halobion or salt spectra) concentration of sodium chloride (related to conductivity in brackish and fresh water)

	Cl^- (mg/L)	Salinity (ppt)
fresh	<100	<0.2
fresh-brackish	<500	<0.9
brackish-fresh	500-1000	0.9-1.8
brackish	1000-5000	1.8-9.0
brackish-marine	5000-30,000	9.0-30

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marine	30,000-40,000	30-40
hypersaline	over 40,000	over 40

halophobous- occurs only in fresh water

halophilous- freshwater form stimulated by small amounts of salt

oligohalobous- freshwater, indifferent to small amounts of salt

mesohalobous- brackish water form 500-30,00 mg/l Cl, (mesosaline or mesohaline)

β-mesohalobous- 500-10,000 mg/l

α-mesohalobous- 10,000-30,000 mg/l

polyhalobous- can withstand salt concentrations greater than those of the sea and tolerate concentrations of 5-35 ppt

euryhalobous- occurring over a broad range of salt concentrations

stenohalobous- occurring within a narrow range of salinities

euhalobous- marine

pleio-euryhaline- tolerates a salinity range of 5-35 ppt

conductivity- the concentration of dissolved salts (electrolytes), made up of cations calcium, magnesium, sodium and potassium, and anions bicarbonate, sulfate and chloride (used primarily in inland, continental settings with variable anions.

Oxygen requirements

continuously high (about 100% saturation)

fairly high (above 75% saturation)

moderate (above 50% saturation)

low (above 30% saturation)

very low (about 10% saturation)

Saprobity (organic pollution, harmful substances)

	Oxygen saturation (%)	BOD_5^{20}(mg/L)	
saprophobous			clean, unpolluted water
oligosaprobous	>85	<2	low amounts of organic enrichment, clean water
mesosaprobous			occurring in moderate to highly polluted water
β-mesosaprobous	70-85	2-4	somewhat degraded conditions, rich in diatoms and green algae
α-mesosaprobous	25-70	4-13	degraded conditions, preponderance of cyanobacteria, tolerant diatoms and some green algae
α-meso-polysaprobous	10-25	13-22	highly degraded conditions, cyanobacteria and a few diatoms

polysaprobous	<1	>22	extremely degraded conditions, very polluted, few algae

Trophic state (growth promoting substances such as nitrate and phosphate, often from animals)

oligotrophic- nutrient poor

oligo-mesotrophic- low nutrient concentrations

mesotrophic-moderate nutrient concentrations

meso-eutrophic- rather high nutrient concentrations

eutrophic- high nutrient concentrations, nutrient rich

eurytrophic- indifferent to nutrients

Life form

planktonic- always suspended in the water column

euplanktonic- usually suspended in the water column

tychoplanktonic- facultatively planktonic but usually associated with benthic habitats

benthic- occurring on the bottom of a water body

sessile- directly attached to substrate

epiphytic- attached to aquatic plants or other algae

epilithic- attached to rocks and pebbles

epipelic- in or on mud

epipsammic- attached to sand grains

aerial (aerophilis, subaerial)- habitats that are not submerged, such as soil, moss, wet walls and mud

aquatic- submerged

edaphic- associated with sediments, particularly intertidal sand and silt

epontic- sessile, firmly attached to substratum, including macrophytes, rocks and sand

cosmopolitan- found in various parts of the world under similar environmental conditions

Water flow characteristics

limnobiontic- characteristic of non-flowing (standing) waters (lakes, ponds, lagoons)

limnophilous- optimum development in non-flowing waters

rheophilous- characteristic of flowing waters

PHOTOMICROGRAPHS OF THE COMMON OR ECOLOGICALLY SIGNIFICANT DIATOMS IN THE WATER CANYON SAMPLES

PLATE 1

All images at 1000x magnification. A, B. *Diadesmis gallica* W. Smith, different focal levels. C. *Nitzschia amphibia* Grunow. D, E. *Denticula elegans* Kützing, front and side views. F. *Luticola mutica* (Kützing) D.G. Mann. G. *Hantzschia amphioxys* (Ehrenberg) Grunow. H. *Epithemia adnat*a (Kützing) Brébisson . I. Two cells of *Aulacoseira italica* (Ehrenberg) Simonsen.

PLATE 2

Images A, B, C, E, F, G, H, I at 1000x, D at 400x. A. *Luticola mutica* (Kützing) D.G. Mann. B. *Stephanodiscus* sp. fragment. C. *Placoneis elginensis* (Gregory) E.G. Cox. D. *Ulnaria ulna* (Nitzsch) Compère. E, F. *Brevisira arentii* (Kolbe) Krammer, different focal levels. G. *Nitzschia perminuta* (Grunow) Peragallo. H. *Nitzschia amphibia* Grunow. I. *Aulacoseira italica* (Ehrenberg) Simonsen.

PLATE 3

Images A, B, C, D, F, G, H, I at 1000x, E at 400x. A. *Encyonema silesiacum* (Bleisch) D.G. Mann. B, C. *Pinnularia appendiculata* (Agardh) Cleve. D. *Pinnularia borealis* Ehrenberg. E, F. *Epithemia turgida* (Ehrenberg) Kützing. G, H. *Rhopalodia brebissonii* Krammer. I. broken sponge spicule.

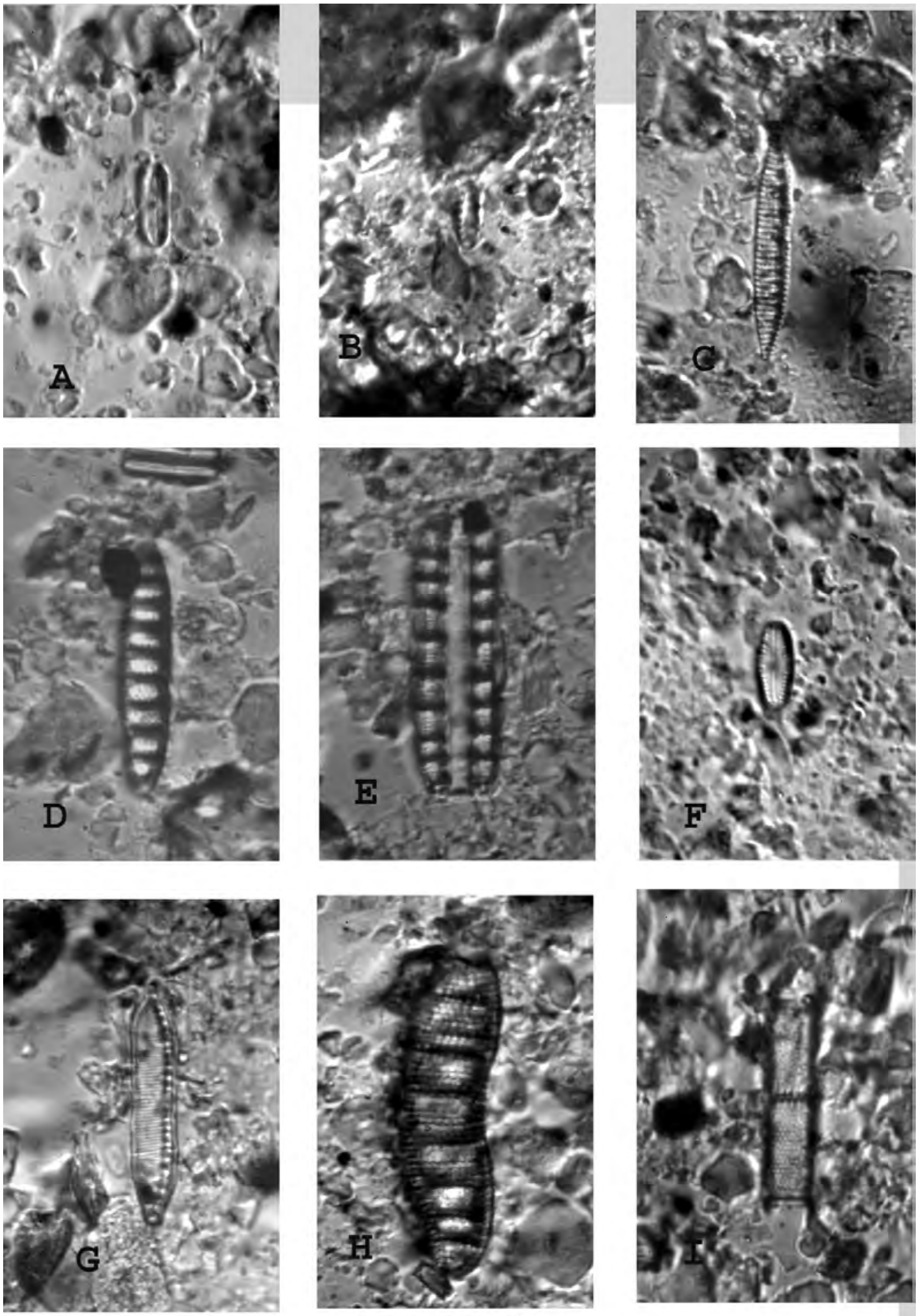

PLATE 1

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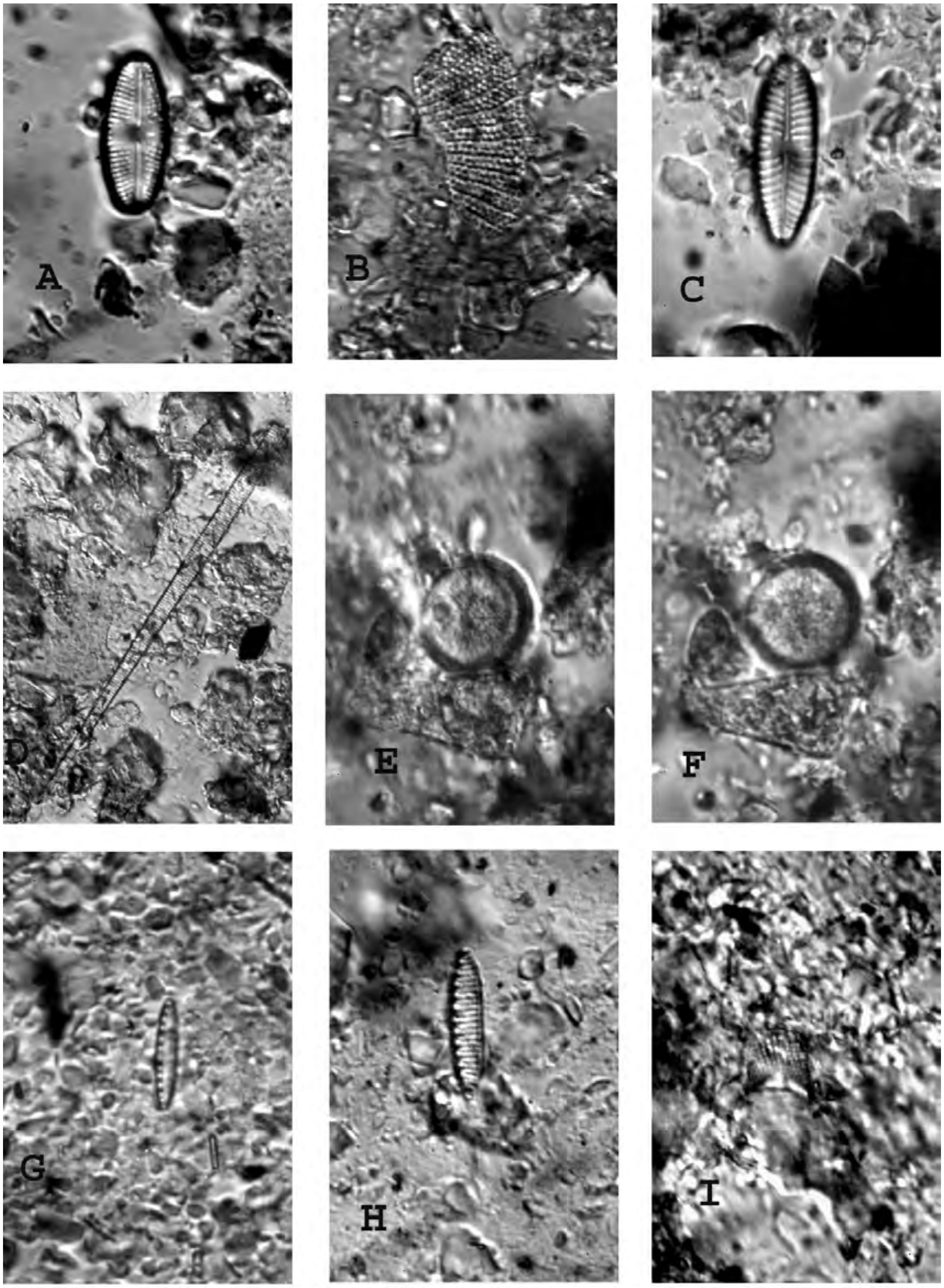

PLATE 2

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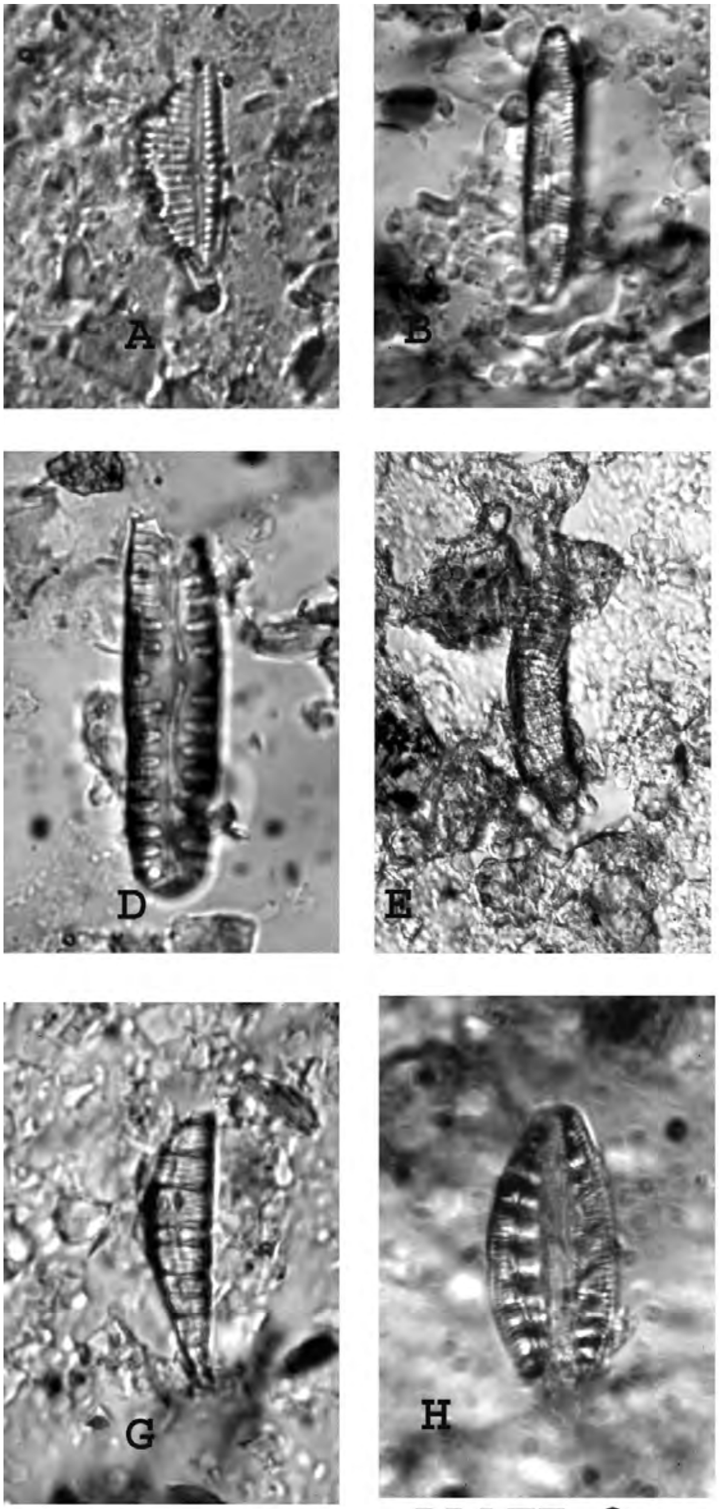

PLATE 3

32

ADDITIONAL NOTES ON DIATOM PALEOENVIRONMENTAL ANALYSIS OF SEDIMENTS FROM THE WATER CANYON PALEOINDIAN SITE (LA134764)

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INTRODUCTION

This note is an addition to the diatom paleoenvironmental report on sediments from the Water Canyon Paleoindian site located in west-central New Mexico. The site, at about 1760 m elevation, is at the east edge of the Water Canyon basin, and is one of a series of early-to-middle Holocene age archaeological sites eroding out of sediments along the Water Canyon drainage at the toe end of a large alluvial fan that flanks the Magdalena Mountains (Dello-Russo, 2013). Two samples from LA 134764 were submitted for diatom analysis to investigate the paleoenvironment associated with the bone bed between Locus 1 and Locus 5.

Sample 1: FS 5161, 520.482 N, 525.894 E, Level 4, Unit 5-08, Grid Elev. (m) 45.50 to 45.48, 6-3-15.

Sample 2: FS 1371.1, 506.333 N, 511.553 E, Level 6, Unit 1-21, Grid Elev. (m) 48.050 to 48.020, 6-5-15.

METHODS

Approximately one cm^3 of sediment was oxidized with 35% H_2O_2 to remove organic material and decalcified with 31% HCl. After rinsing to a neutral pH, the material was dried onto cover slips and mounted on glass slides with Naphrax®. Two slides of 22 x 22 mm area were scanned at x1500 magnification, and all diatoms encountered, including fragments, were identified and recorded.

RESULTS AND DISCUSSION

Sample 1: There were no diatoms at all and the few phytoliths observed were extensively pitted and fragmented.

Sample 2: One complete aquatic, benthic diatom was found. This is *Navicula reichardtiana* Lange-Bertalot. This small benthic diatom is found in eutrophic, moderately electrolyte rich water, particularly those rich in calcium carbonate and also rarely in brackish water. It is pollution tolerant to critical levels making it a good indicator of eutrophy, (high nutrient concentrations) and is β-mesosaprobous (tolerant of somewhat degraded conditions).

There were also 14 small fragments of *Hantzschia amphioxys* (Ehrenberg) Grunow. This one of the most common soil diatoms in the world. It is rare in acidic soils, and reaches high densities in neutral to slightly alkaline soils, The ecological characteristics for *Hantzschia amphioxys* include a tolerance of different nutrient levels and organically bound nitrogen. It is an indicator of high total phosphorous and α-mesosaprobous (degraded) conditions. It is found in dry soil, and survives prolonged dry periods, and also in fresh-brackish temporary water.

In addition to diatoms, 3 chrysophycean statospores were recorded in sample 2. These are green algal resting spores that are produced in water, often in settings that dry out.

CONCLUSIONS

Because there were few diatoms or other microfossils, it is hard to say much about the paleoenvironments that characterized the deposition of the samples. In sample 2 there is evidence from the presence of an aquatic diatom and the statospores that there was water present, at least temporarily but it may have been turbid flood water. One possible reason for the lack of diatoms may be due to an environment that was temporarily flooded, followed by muddy then dry conditions. The degree of dissolution reflected by the fragments of *Hantzschia amphioxys*, a sturdy diatom, and the phytoliths suggests a combination of mechanical breakage, grazing, and post depositional diagenesis. These processes are typically responsible for the dissolution of the delicate diatoms, leaving a depauperate assemblage.

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Appendix E. Ground Stone Residue Analysis

POLLEN, PHYTOLITH, STARCH, AND ORGANIC RESIDUE (FTIR) ANALYSIS OF
A SANDSTONE SLAB FROM THE WATER CANYON PALEO INDIAN SITE (LA 134764),
SOCORRO COUNTY, NEW MEXICO

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INTRODUCTION

The Water Canyon Paleo Indian Site (LA 134764) is one of a series of late Pleistocene/early Holocene sites observed eroding out of sediments along the first big bend in the Water Canyon drainage. Originally documented in 2001, this site covered an area of approximately 3250 sq m on a northeast-facing, gentle hillslope immediately above No Name Arroyo, an intermittent drainage. Continued work at the site has expanded the area to approximately 9 hectares (Robert Dello-Russo, personal communication September 8, 2016).

METHODS

Ground Stone Washes for Pollen, Phytoliths, and Starch

Use of ground stone tools in processing plants and animals can leave evidence on the artifact surface. Concentrations of pollen, phytoliths, and starches from the artifact surfaces may represent plants that were processed using the tools.

All visible dirt was removed, then the surface was cleaned using pressurized air to remove any modern contaminants. A small portion of the ground surface was tested with dilute (10%) hydrochloric acid (HCl). The strong reaction indicated presence of calcium carbonates, so the ground surface was washed first with dilute HCl to remove these carbonates prior to washing to recover pollen, phytoliths, and starch. The ground surface was washed with a 0.5% Triton X-100 solution to recover pollen, phytoliths, and starches. The surface was scrubbed with an ultrasonic toothbrush and rinsed thoroughly with reverse osmosis deionized (RODI) water to recover the sample, which was sieved through 250-micron mesh to eliminate any large particles released during the washing process. The wash sample was large enough to split into two aliquots to be processed separately for pollen and phytoliths/starch.

Ground Stone Washes for Pollen

The sample was split for pollen and phytolith/starch recovery after sieving. The pollen aliquot first received three 25 minute treatments in hot hydrofluoric acid to remove inorganic particles. The sample was acetylated for 10 minutes to remove extraneous organic matter. The sample was rinsed with RODI to neutral. Following this, a few drops of potassium hydroxide (KOH) were added to the sample, which was then stained lightly with safranin.

A light microscope was used to count the pollen at a magnification of 500x. Pollen preservation in these samples varied from good to poor. Comparative reference material collected at the Intermountain Herbarium at Utah State University and the University of Colorado Herbarium was used to identify the pollen to the family, genus, and species level, where possible.

“Indeterminate” pollen includes pollen grains that are folded, mutilated, or otherwise distorted beyond recognition. These grains were included in the total pollen count since they are part of the pollen record. The microscopic charcoal frequency registers the relationship between pollen and charcoal. The total number of microscopic charcoal fragments was divided by the pollen sum, resulting in a charcoal frequency that reflects the quantity of microscopic charcoal fragments observed, normalized per 100 pollen grains.

Pollen analysis also included observing and recording starch granules and, if they were present, their assignment to general categories. We did not, however, search for starches outside the pollen count, as starch analysis was conducted on the phytolith fraction. Starch granules are a plant's mechanism for storing carbohydrates. Starches are found in numerous seeds, as well as in starchy roots and tubers. The primary categories of starches include the following: with or without visible hila, hilum centric or eccentric, hila patterns (dot, cracked, elongated), and shape of starch (angular, ellipse, circular, or lenticular). Some of these starch categories are typical of specific plants, while others are more common and tend to occur in many different types of plants.

Phytolith

After sieving Sample FS 1343, the portion designated for phytolith/starch analysis was soaked in a 3% solution of sodium hypochlorite (bleach) to destroy the organic fraction. After sitting overnight, the sample was rinsed several times to remove the bleach. After several RODI water rinses that neutralized the sample, it was freeze dried. The dried material was mixed with sodium polytungstate (SPT) at a density of 2.1 g/ml and centrifuged to separate the phytoliths, which will float, from the other silica, which will not. After the phytolith-rich fraction was recovered, the sample was rinsed with RODI water, then alcohol to remove the water. After several alcohol rinses, the sample was mounted in immersion oil for counting with a light microscope at a magnification of 500x. Because starch analysis was requested, the phytolith slide also was scanned in search of starch. The phytolith diagram was produced using Tilia, a computer program developed by Dr. Eric Grimm of the Illinois State Museum for diagraming pollen.

FTIR (Fourier Transform Infrared Spectroscopy)

A mixture of chloroform and methanol (CHM) was used as a solvent to remove lipids and other organic substances that had soaked into the surface of the ground stone. The CHM solvent and sample were placed in a glass container, covered, and allowed to sit for several hours. After soaking the solvent was poured into a beaker to then decant small quantities into an aluminum evaporation dish, where the CHM evaporated, concentrating the organic residue in the aluminum dish. The aluminum dishes were tilted during the process of evaporation to separate the lighter fraction of the residue from the heavier fraction. The lighter and heavier fractions, often visible as bands in the dish, are designated upper (lighter fraction) and lower (heavier fraction), respectively, in the subsequent analysis. The residue remains in the aluminum dish for FTIR spectral analysis.

FTIR is performed using a Bruker Alpha optical bench with an ATR (attenuated total reflection) accessory and a diamond crystal. The dish containing the organic residue was placed on the FTIR crystal with the residue in contact with the crystal, and the spectra were collected by a specially encoded infrared beam, which passes through the sample producing a signal called an “interferogram.” The interferogram contains information about the frequencies of infrared light that are absorbed and the strength of the absorptions, which is determined by the sample's chemical make-up. A computer reads the interferogram, uses Fourier transformation to decode the intensity information for each frequency (wave numbers), and presents a spectrum.

PHYTOLITH REVIEW

Phytoliths are silica bodies produced by plants when soluble silica in the ground water absorbed by the roots is carried up the plant's vascular system. Evaporation and metabolism of this water result in precipitation of silica in and around cellular walls. Opal phytoliths, which are distinct and decay-resistant plant remains, are deposited in soil as the plant or plant parts die and break down. However, they are subject to mechanical breakage, erosion, and deterioration in high pH soils. Usually, phytoliths are introduced directly into the soils in which plants decay. Phytolith transportation occurs primarily through animal consumption, human plant gathering, or wind, water, or ice soil erosion or transportation. Phytoliths produced in roots/tubers deteriorate at the level of those roots/tubers and are not represented on the growing surface. Therefore, roots/tubers phytolith recovery from stratigraphic sediments does not necessarily represent vegetation coeval with that represented by phytoliths produced in leaves or other above ground vegetative parts.

Three major types of grass short-cell phytoliths include festucoid, chloridoid, and panicoid. Smooth elongate phytoliths provide no aid interpreting either paleoenvironmental conditions or the subsistence record, because all grasses, various other monocot plants, and several dicots produce them. Phytoliths tabulated to represent "total phytoliths" include the grass short-cells, bulliform, trichome, elongate, and dicot forms. All other silica and non-silica body recovery frequencies are calculated by dividing the number of each type recovered by the "total phytoliths."

The festucoid class of phytoliths is ascribed primarily to the subfamily Pooideae and occurs most abundantly in cool, moist climates. They grow well in shady areas and during cooler spring and fall months. They are the first grasses to "green up" in the spring, going dormant in the summer, then growing again in the fall. Brown (1984) notes that festucoid phytoliths are produced in small quantity by nearly all grasses (mostly rondel-type phytoliths, which exhibit an approximately circular shape). Therefore, while these typical phytolith forms are produced by the subfamily Pooideae, they are not exclusive to this subfamily. Trapeziform phytoliths are tabular and may be thin or thick. Their outer margins may be smooth, slightly spiny, or sinuate.

Warm season or summer grasses are divided into the group that thrives in dry conditions (chloridoid) and those that grow best in humid conditions (panicoid) or that grow along sources of water. Chloridoid saddle phytoliths are produced by the subfamily Chloridoideae, a warm-season grass that grows in arid to semi-arid areas and requires less available soil moisture (Gould and Shaw 1983:120). They thrive in hot, dry conditions of summer. Twiss (1987:181) notes that some members of the subfamily Chloridoideae also produce both bilobate (panicoid) and festucoid phytoliths. Also, saddles may be produced in non-chloridoid grasses. Bilobates and polylobates (lobates) are produced mainly by panicoid (tall) grasses, although a few festucoid grasses also produce these forms. Panicoid or tall grasses prefer the warmth of summer and thrive in humid conditions or grow next to water such as creeks, rivers, and lakes.

More than 97% of the native U.S. grass species (1,026 or 1,053) are divided equally among three subfamilies: Pooideae, Chloridoideae, and Panicoideae (Gould and Shaw 1983:110).

Bulliform phytoliths are produced in grass leaf cells that control leaf rolling in response to drought. These cells often silicify under wet or moist conditions and increase in abundance as grass leaves age. Trichomes represent silicified hairs, which may occur on the stems, leaves, and the glumes or bran surrounding grass seeds.

Conifers produce opal silica phytoliths in their inner bark and needles. Polyhedral phytoliths are reported to be observed in leaves (Bozarth 1993), and at PaleoResearch Institute we have observed the blocky forms in bark reference samples. Blocky and angular forms also are noted in many dicots.

Terms applied to phytoliths in this study use the International Code for Phytolith Nomenclature (ICPN) (Madella et al. 2005). Phytolith reference samples prepared and curated at PaleoResearch Institute were consulted when identifying phytoliths recovered in this study.

Other Siliceous Microfossils

Sponge spicules and spherasters represent fresh water sponges. Both diatoms, not evident here, and sponge spicules can be transported with sediment. As an illustration, recovery of sponge spicules in upland soils is noted to accompany loess deposits derived from Illinois floodplains (Jones and Beavers 1963).

ETHNOBOTANIC REVIEW

Archaeological studies reference ethnographically documented plant uses as indicators of possible, or even probable, plant uses in pre-Columbian times. The ethnobotanic literature provides evidence for both broad and specific historic exploitation of numerous plants. Multiple ethnographic sources evidencing a plant's exploitation suggest its widespread historic use and an increased likelihood of the same or a similar plant's use in the past. We consulted a broad range of ethnographic sources both inside and outside the study area to permit a more exhaustive review of potential plant uses. Ethnographic sources document historic use of some plants enduring from the past. Most likely medicinal plant use persisting into the historic period originated in pre-Columbian times. Unfortunately, due to changes in subsistence practices and European food introduction, a loss of plant knowledge likely occurred. The ethnobotanic literature serves only as a guide for potential uses in pre-Columbian times, not as conclusive proof of those uses. When compared with the material culture (artifacts and features) recovered by the archaeologists, pollen, phytoliths, starch, and macrofloral remains can become use indicators. We provide the following ethnobotanic background to discuss plants identified during pollen and starch analysis.

Native Plants

Amaranthaceae (Amaranth Family)

Recent revision to botanical taxonomy, using gene-based APG (The Angiosperm Phylogeny Group 1998) and APG II (The Angiosperm Phylogeny Group 2003) systems, subsumes Chenopodiaceae under Amaranthaceae and places *Sarcobatus* as the single genus in its own family (Sarcobataceae). Cheno-am is a term derived from pollen analysis, although we have replaced it with Amaranthaceae according to the revised botanical taxonomy. Cheno-am or Amaranthaceae refers to a group that includes the genus *Amaranthus* (amaranth, pigweed) and members of the Chenopodiaceae (goosefoot family) such as *Atriplex* (saltbush), *Chenopodium* (goosefoot), *Monolepis* (povertyweed), and *Suaeda* (seepweed). These plants, which produce large quantities of seeds, are weedy annuals or perennials, often growing in ecologically disturbed habitats such as cultivated fields and the vicinity of habitation sites (Castetter and Bell 1942:61; Curtin 1984:47-71; Kearney and Peebles 1960; Kirk 1975).

Weedy annuals or perennials, species of *Amaranthus* (amaranth, pigweed) and *Chenopodium* (goosefoot) grow in disturbed areas, including cultivated fields and near habitation sites. Amaranth and goosefoot greens and seeds provided food. Sometimes eaten raw, the nutritious seeds often were parched, ground into meal, and made into mushes and cakes (Harrington 1967:55-62, 69-71; Kirk 1975:57-65). While *Chenopodium* seeds contain calories roughly equivalent to corn, they provide significantly more protein and fat (Asch 1978:307 cited in Kindscher 1987:82). The leaves, which are most tender during young spring growth, were eaten fresh or cooked, but could be eaten throughout the growing season (Harrington 1967:55-62, 69-71; Kirk 1975:57-65). *Amaranthus* leaves provided iron and vitamin C, while young *Amaranthus* leaves contain significant amounts of protein, calcium, phosphorus, potassium, vitamin A, and vitamin C (Watt and Merrill 1963:6 cited in Kindscher 1987:22). Amaranthaceae were gathered from early spring through fall (Harrington 1967:55-62, 69-71; Kirk 1975:57-65). *Amaranthus* poultices were used to reduce swellings and to soothe aching teeth. Leaf tea was used to stop bleeding, as well as to treat dysentery, ulcers, diarrhea, mouth sores, sore throats, and hoarseness. *Chenopodium* leaves are rich in vitamin C and were eaten to treat stomach aches and to prevent scurvy. Leaf poultices were applied to burns, and tea made from the whole plant was used to treat diarrhea (Angier 1978:33-35; Foster and Duke 1990:216; Harris 1972:58; Krochmal and Krochmal 1973:34-35, 66-67; Moore 1990:12).

Poaceae (Grass Family)

A large, widely-distributed family, Poaceae (grass family) thrive in many different climates and biomes. The family includes many diverse, economically-important species. Grasses on the landscape provide fodder for game animals. Grass caryopses (seeds) have been used extensively for food. Often, parched grass seeds were ground into meal to make mushes and cakes. When present, grass awns (hairs) were singed off by exposing the seeds to flame. Depending on species, grass seeds ripen from spring to fall, providing a long-term available food source. In addition, roots, edible raw, roasted, or dried, were ground into flour. Grass leaves and stems provided raw materials for building, weaving, and making cordage. For example, bedding, baskets, mats, clothing, twine, thatch, clothing and sandals all were made from grasses. Grass functioned as a floor covering, tinder, and to make brushes and brooms (Chamberlin 1964:372; Cushing 1920:219, 253-254; Fowler 1986:76-77; Harrington 1967:322;

James 1901:72-85; Kindscher 1987:228-237; Kirk 1975:177-190; Liljeblad and Fowler 1986:416-417; Rogers 1980:32-40).

DISCUSSION AND CONCLUSIONS

Site LA 134764 is situated at an elevation of approximately 1760 m (5780 ft) in a juniper savannah vegetation community. Modern vegetation is typical of a semi-desert grassland, and a Great Basin Woodland is observed nearby in the Socorro Mountains (Brown 1994 in Robert Dello-Russo, personal communication June 15, 2016). Shrubby Apache plume (*Fallugia*), sumac (*Rhus*) and occasional juniper (*Juniperus*) trees grow in two dry arroyos, tributaries of Water Canyon that cut through the site. Water Canyon headwaters are to the southwest in the Magdalena Mountains. Concentrations of bison bones and scattered Paleo Indian artifacts are associated with exposures of “black mat” sediments dated to approximately 9300 to 13,000 calendar years at this site (Robert Dello-Russo, personal communication June 15, 2016).

One ground stone was recovered at this site and submitted for pollen, phytolith, and starch analysis (Table 1). When these analyses were nearly completed, organic residue analysis using FTIR was authorized. This draft report summarizes the pollen, phytolith, and starch results.

The pollen record is dominated by Amaranthaceae pollen (Figure 1, Table 2) representing plants in the goosefoot/amaranth family. Recovery of moderate quantities of *Artemisia* and High-spine Asteraceae pollen represent sagebrush and plants in the sunflower family growing locally. Poaceae pollen was observed as a moderate frequency which, when combined with recovery of a spherical starch, suggests grass seed processing. Small quantities of *Pinus* and *Quercus* pollen attest to local or regional growth of pine and oak trees. Finally, a small quantity of *Ephedra nevadensis*-type pollen was recorded, documenting regional growth of ephedra or Mormon tea. It was not recovered in sufficient quantity to suggest processing using this ground stone. Recovery of a large quantity of microscopic charcoal in the wash sample suggests either that this ground stone was recovered from the stain or that it was burned after its last use. Burning normally destroys the pollen record of use. If that is the case here, then the pollen record was acquired from the sediments in which this ground stone was burned, and it represents local vegetation. Total pollen concentration is calculated at approximately 66 pollen per cm^2 of washed ground surface, which is typical of ground stone washes.

The phytolith record is dominated by chloridoid saddles (Figure 2), typically produced in short grasses that thrive in hot, dry summers. Moderate quantities of rondels and elongates were observed. Rondels and keeled rondels represent festucoid or cool season grasses, as do trapeziform and trapeziform sinuate phytoliths. Together they indicate cool season grasses, which grow during cooler months of the year and often in shady places, and were moderately abundant on the landscape. A very small quantity of bilobates was noted, representing panicoid or tall grasses that live in more mesic settings and grow during the heat of summer. Bulliforms, whether cuneiform or rectangular, are produced in grass leaves, representing cells that control leaf rolling in response to drought. They were moderately abundant. Trichomes observed in this sample are typical of those produced in grasses. Dendriforms, representing cells of grass inflorescences, were noted as a small portion of the signature.

Dendriforms originate in the bract material (lemmas, paleas and glumes) that surrounds the seed (caryopsis) of some wild and domesticated grasses. They are very common in the bract material of Pooideae grasses native to North America (and also common in domesticated Old World cereals, which is irrelevant here). The presence of these dendriforms, particularly when they occur as sheet elements, might suggest that grass seeds were ground when recovered from ground stone washes. This is because the dendriform-bearing plant material that encapsulates the grass seed is never entirely removed from all of the grains during the parching and winnowing steps. These dendriforms can then be left on grinding equipment, cooked, digested, and incorporated into the archaeological records. Disarticulated dendriforms cannot be reliably ascribed to a particular grass (i.e., *Hordeum pusillum*) however, and are instead broadly representative of local growth of, and occasionally processing of, wild grasses. In the absence of a soil control sample with which to assess the environmental recovery level for these phytoliths (and an absence of sheet elements containing dendriform phytoliths), dendriforms recovered in this context are deemed to likely represent part of the local environmental signal. This is because we find an average of three dendriforms per 200 "grain" count of phytoliths in many sediments. A signature of grass processing should rise above this frequency. In this sample, a single dendriform was observed in a count of 302 phytoliths, which falls within the frequency expected as part of the background environmental signature.

Elongate smooth and spiny forms are typically produced in grasses. They are not considered to be diagnostic of any particular grass. Interstomatal cells are recorded, but are not considered to be diagnostic. They border stomata. Dicot bulky cells were rare and cannot be assigned even to a botanic family. A single spheraster was noted, which indicates the presence of freshwater sponges. They might have arrived on this surface along with grass seeds that are interpreted to have been ground as a result of recovery of a grass seed-type starch. Alternatively, it might indicate use of water while, or even after, grinding.

The pollen and starch record suggests grinding grass seeds using this prehistoric ground stone, while the phytolith record does not add information to the interpretation.

FTIR analysis of organic compounds yielded peaks in the 3000–2800 wave numbers (cm^{-1}) range (Table 3) indicating the presence of fats/lipids and/or plant waxes. Lipids, whether fats or oils, are always noted between 3000 and 2800 cm^{-1} on the FTIR spectrum. These peaks represent the general group of fats/lipids. Distinction between saturated and unsaturated esters is made in the fingerprint region (below 1500 cm^{-1}) of the spectrum. The presence of fats/lipids is supported in this sample by the presence of three required peaks for saturated esters at 1741, 1164, and 1100 cm^{-1}. Fatty acids, components of most lipids in humans, animals, and plants (Wardlaw and Insel 1996:108), are considered saturated if the carbons are connected by single bonds. Animal fats contain high proportions of saturated fatty acids. Triglycerides are indicated by a peak at 1741 cm^{-1}, while fats/lipids and/or humates are represented by a peak at 1377 cm^{-1}. Aromatic esters are suggested by recovery of all three required peaks at approximately 1711, 1250, and 1100 cm^{-1} and the additional peak at 721 cm^{-1}, the latter of which represents a methylene group on a benzene ring of aromatic esters. Aromatic esters, with their ability to produce distinctive odors, occur naturally in many plant foods. They are defined by the presence of a benzene ring as part of the alpha carbon (Smith 1999:108). In contrast, aliphatic or saturated esters do not contain a benzene ring. Some have defining odors, while others do not. Distinguishing between saturated/aliphatic and aromatic esters, or identifying the presence of both, is easy when all three bands are present, since they occupy different wave number regions.

Peaks representing proteins were observed as a sharp peak at 3356 cm^{-1} representing amide A (amide I). Proteins are large molecules comprising sequences of amino acids bonded together by peptide bonds. The amino acid arrangement is organized by the genetic code of the mRNA template copied from an organism's genetic code (Creighton 1993). Proteins degrade after a limited time, making their identification at a specific level difficult. Amide bands group proteins by molecular bonds to allow identification of proteins with FTIR. Jung (2000:329) identifies the amide I band as 1700–1600 cm^{-1} peaking around 1650 cm^{-1}, the amide II band as peaking at 1550 cm^{-1}, and the amide III band between 1330 and 1230 cm^{-1}. Stuart (2004:81), on the other hand, defines the amide I band between 1680–1660 cm^{-1} representing C=O (carbon double-bond oxygen) stretching and the amide II band between 1650–1620 cm^{-1} representing NH_2 bending, identifying these as primary amides. He notes two other primary amide bands at 3360–3340 and 3190–3170 cm^{-1} representing NH_2 asymmetric stretching. A peak at 3356 cm^{-1} in this sample suggests a nitrogen-hydrogen bond of amides. The other peak ranges are not represented in this sample. Proteins and amides peaks are common in archaeological records, perhaps as a result of deterioration of animal remains in sediments.

Other peaks representing proteins are noted between 1700–1350 cm^{-1}. The amino acids lysine, glutamate, and serine are suggested by peaks at 1628, 1610, 1541, 1413, and 1250 cm^{-1}. The ubiquity of glutamate in both plant and animal kingdoms makes this an inappropriate peak to use as a marker for the presence of individual plants or animals. Lysine and serine are amino acids commonly found in meat and some plants. The essential amino acid lysine is present in a wide variety of high protein foods including legumes, cereals, nuts, seeds, fruits, and animal products; as a result, ascribing a match with lysine alone is difficult (Young and Pellett 1994). Cultigens contributing high amounts of important dietary lysine include amaranth, beans, spinach (a Chenopodiaceae), gourds/squash, and pumpkin seeds (Wardlaw and Insel 1996:158; Young and Pellett 1994:1206S). Detailed nutritional information is rarely available for native plants; however, inclusion of spinach in this list suggests that other species in the goosefoot family contain lysine. A nonessential amino acid, serine, helps maintain metabolic function (Nelson and Cox 2005). It activates N-methyl-D-aspartate (NMDA) receptors in the brain, serving as a neuronal signal, as well as helping to build muscle tissue (Mothet et al. 2000). Bovids, eggs, nuts and seeds, legumes, and milk comprise common dietary serine sources. Peaks at 1579 and 1541 suggest the presence of calcium oleate, a calcium salt formed when calcium-containing alkaline materials, such as limestone or shell, are combined with oleic acid (common in many plant and animal fats) in the presence of heat (Hanumantha Rao and Forssberg 1991:885; Wang et al. 2008). The presence of this double peak in this ground stone sample is surprising, since it is usually recovered on fire-cracked rock or ceramics. These peaks are of low amplitude. It is possible they represent grinding fat or fatty meat cooked over a fire while still on the bone, as both fat and calcium must be heated to produce calcium oleate. Alternately, cooked bone marrow might have been ground, perhaps to make pemmican.

Carbohydrates and polysaccharides are represented by several peaks suggesting pectin, cellulose, arabinogalactan, glucomannan, and starch. Arabinogalactan is a sugar found in plant carbohydrate structures, particularly gums and hemicelluloses. Among other functions, arabinogalactan bonds with proteins to repair damage (Nothnagel 2000). Arabinogalactan II often is linked with glucomannan, a pectic compound. Wave numbers 1146, 1066vs, 1034, 896, 872, and 809 are observed when this hemicellulose and pectic compound are linked (Kacuráková et al. 2000). With the exception of the peak at 872 cm^{-1}, most of these peaks are not represented in this sample. Glucomannan is present in woody, fibrous cell walls of conifers and/or dicots (Vogel 2008; Willför et al. 2008). Peaks at 1150, 1092, 1064, 1034, 941, 898, 872, and 814 cm^{-1} are associated with this polysaccharide (Kacuráková, et al. 2000). Starch is the common energy storage mechanism for plants. Peaks at 1155, 1110, 1082, 1026vs, 931, and 850 cm^{-1} indicate starches (Kacuráková, et al. 2000). Cooking starches allows for easier digestion by making them more water soluble and available for breakdown by digestive enzymes (Wardlaw and Insel 1996:80). Recovery of a peak at 931 cm^{-1}, which is typical for starch, supports the interpretation from the pollen and starch records that grass seeds were ground. Pectin is a component of cell walls, as is cellulose, making both so abundant they cannot be used to interpret use of this ground stone.

Grinding grass seeds, suggested in the pollen and starch records, is supported by recovery of a peak representing starch and perhaps the peak representing lysine, which is common in cereals. Cereals, which are grass seeds, should have nutrients in common with wild grass seeds, which have been less studied for their nutritional content. Grinding fatty meats or animal fat, such as cooked bone marrow, is suggested by recovery of peaks representing fats and lipids in the functional group area of the spectrum (3000–2800 cm^{-1}) and the three required peaks indicating saturated esters.

TABLE 1
PROVENIENCE DATA FOR A SAMPLE FROM
THE WATER CANYON PALEO INDIAN SITE (LA 134764), SOCORRO COUNTY, NEW MEXICO

Sample No.	Unit	Level	North Grid Coordinate (m)	East Grid Coordinate (m)	Grid Elevation (m)	Provenience/ Description	Analysis
FS 1343	1-19	4	507.275	512.519	48.519	Sandstone slab, possible ground stone	Pollen Phytolith Starch FTIR

FTIR = Fourier Transform Infrared Spectroscopy

TABLE 2
POLLEN TYPES OBSERVED IN A SAMPLE FROM
THE WATER CANYON PALEO INDIAN SITE (LA 134764), SOCORRO COUNTY, NEW MEXICO

Scientific Name	Common Name
ARBOREAL POLLEN:	
Pinus	Pine
Quercus	Oak
NON-ARBOREAL POLLEN:	
Amaranthaceae	Amaranth family (now includes Chenopodiaceae, these two families were combined based on genetic testing and the pollen category "Cheno-ams")
Asteraceae:	Sunflower family
Artemisia	Sagebrush
High-spine	Includes Aster, Rabbitbrush, Snakeweed, Sunflower, etc.
Ephedra nevadensis-type (includes *E. clokeyi, E. coryi, E. funera, E. viridis, E. californica, E. nevadensis,* and *E. aspera*)	Ephedra, Jointfir, Mormon tea
Poaceae	Grass family
Indeterminate	Too badly deteriorated to identify
STARCHES:	
Spherical starch	Typical of starches produced by grass seeds
OTHER:	
Microscopic charcoal	Microscopic charcoal fragments
Total pollen concentration	Quantity of pollen per cubic centimeter (cc) of sediment

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TABLE 3
FTIR PEAK SUMMARY FOR A SAMPLE FROM
THE WATER CANYON PALEO INDIAN SITE (LA 134764), SOCORRO COUNTY, NEW MEXICO

Peak Range	Represents	Sample 1343
Fats, oils, lipids, waxes, humates:		
3000-2800	Aldehydes: fats, oils, lipids, waxes	2952, 2922/2921, 2852
2959, 2938, 2936, 2934, 2931, 2930, 2926, 2924, 2922	CH_2 Asymmetric stretch	2922
1750–1730 1210–1160 1100–1030 Rule of Three	Saturated esters (C=O Stretch)	1741 1164 1100
1742	Triglycerides (C=O Stretch)	1741
1377	Fats, oils, lipids, humates (CH_3 symmetric bend)	1377
1730–1705 1310–1250 1130–1100 750–700 Rule of Three + 1	Aromatic esters	1711? 1250/49 1100 721
Proteins, amides, amino acids:		
3500–3300 sharp	Amide A	3356
1700-1350	Protein	1628, 1610, 1580/79, 1541, 1464, 1459, 1413, 1377, 1366
1465-1455	Protein/lipids	1464, 1459
1640-1610, 1550-1485,	Lysine (amino acid) NH_3^+ bending	1628, 1610, 1541
1415	Glutamate CO_2^- symmetric stretching	1413
1394, 1379, 1366	Split CH3 umbrella mode, 1:2 intensity	1366
1350-1250	Serine O-H bending	1250/49

12

TABLE 3 (Continued)

Peak Range	Represents	Sample 1343
Carbohydrates, Polysaccharides:		
1680-1600, 1260, 1100**vs**, 955	Pectin	1628, 1610, 1100
1170-1150, 1050, 1030	Cellulose	1174
1028-1000	Cellulose Carbohydrates	1018
872	Arabinogalactan (Type II) + Glucomannan (9:1, w/w), Glucomannan, Galactoglucomannan	872
1019	Primary alcohol CH_2-O stretch	1018
941	Glucomannan	938
931	Starch	933
Minerals, etc.:		
1577, 1539	Calcium oleate	1579, 1541
872	$CaCO_3$	872
722-719	CH_2 Rock (methylene)	721

FCR = Fire-cracked Rock
vs = Very Strong band
s = Strong band – If the **vs** or **s** is next to a number it applies to that number. If it is left of two numbers it applies to both. If it is next to a compound it applies only to that compound at that specific wave number.

13

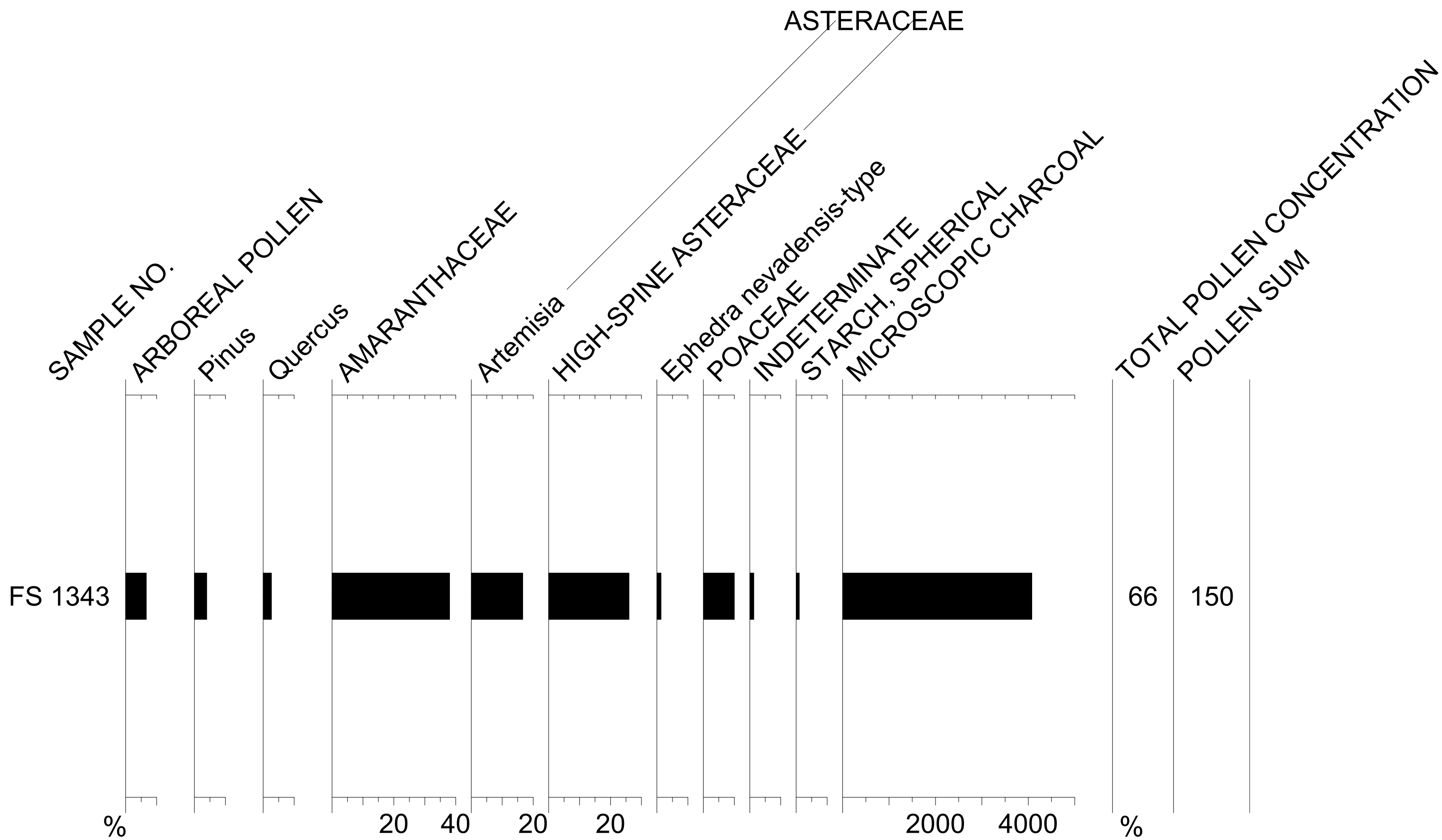

FIGURE 1. POLLEN DIAGRAM, LA 134764, NEW MEXICO.

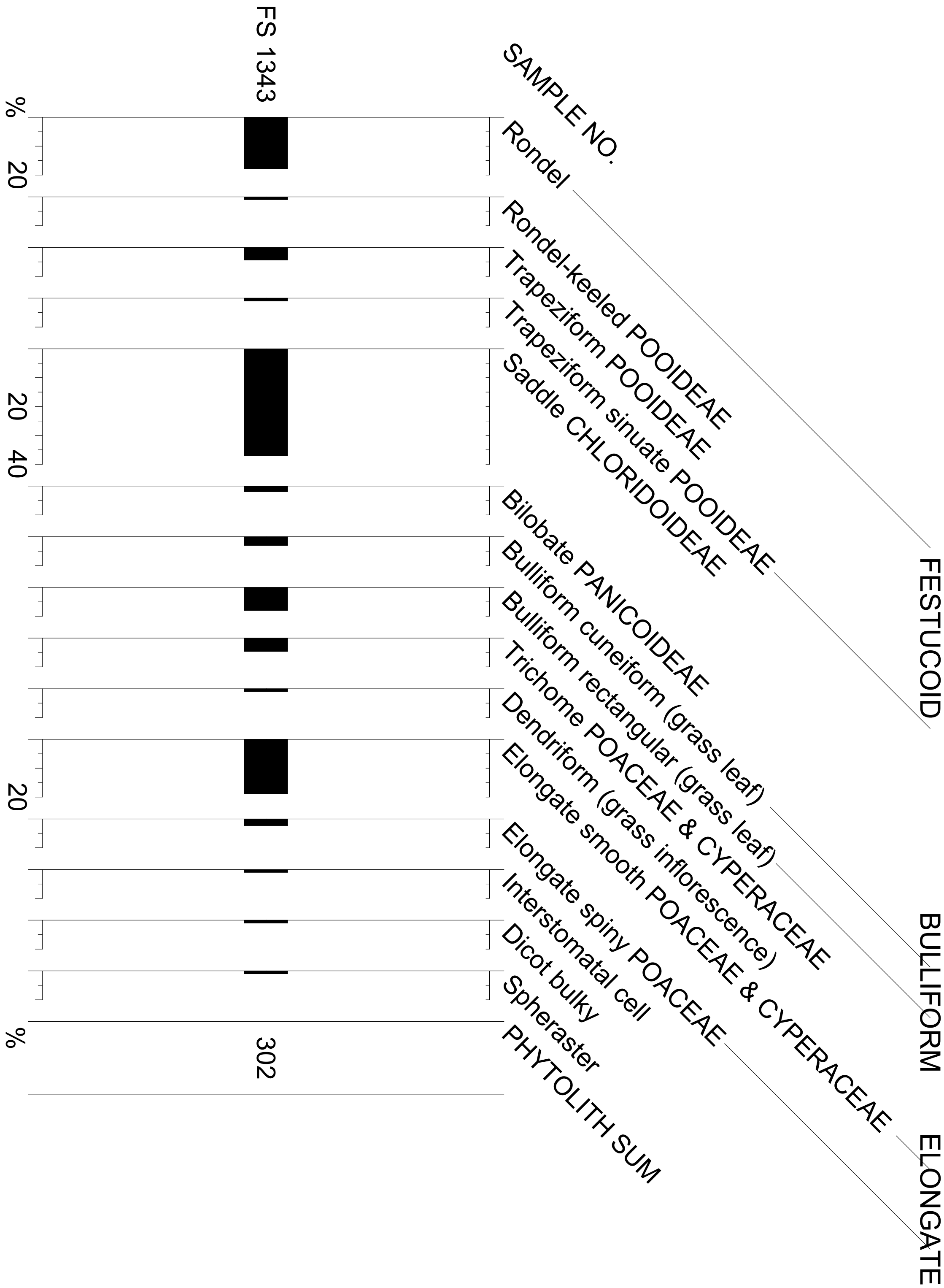

FIGURE 2. PHYTOLITH DIAGRAM, LA 134764, NEW MEXICO.

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Appendix F. Micromorphological Analysis

Report on the micromorphological analysis of thin sections from Water Canyon, New Mexico

S.M. Mentzer and P. Goldberg

In 2015, Dr. Robert Dello-Russo and Christian Solfisburg collected four micromorphological samples from Water Canyon Locus 1 using electrical boxes. As indicated in Figure 1, the four samples overlap to provide full coverage of the transition between a lower, greenish-grey gleyed (?) unit and a darker, upper unit that exhibits visual characteristics that are consistent with a black mat. The samples were dried, indurated with resin, and processed into standard petrographic thin sections by Spectrum Petrographics. The finished thin sections were shipped to the University of Tuebingen for analysis.

Figure 1: Profile photograph with locations of the four micromorphology samples.

The thin sections were scanned on a flatbed scanner to obtain incident light images (Figure 2). The samples were then analyzed under plane- (PPL) and cross-polarized (XPL) light, as well as oblique incident light using a stereomicroscope and standard petrographic microscope. All analyses were conducted at the University of Tübingen by S. Mentzer and P. Goldberg. The samples were described using criteria defined by Stoops (2003).

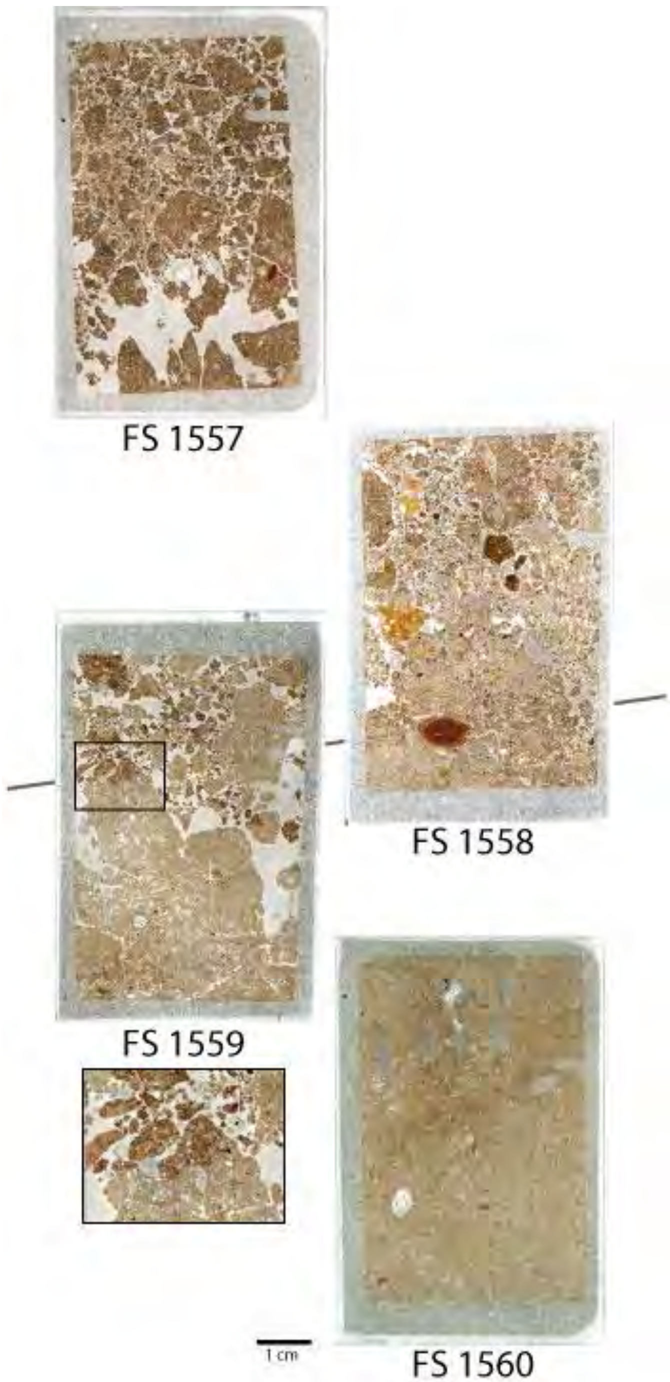

Figure 2: The four thin sections arranged in stratigraphic order, showing approximate overlap between samples. The contact between the two sedimentary units is present in the two middle thin sections, although the high porosity and granular structure indicates that there has been some disturbance of the samples, likely during removal from the profile or shipping to Spectrum Petrographics. A grey line indicates the approximate position of the contact. In sample FS1559, the contact between the units (black box and inset) is sharp and undulating. Incident light scans.

2

The lowest sample (FS 1560) exhibits very little soil structure. The sediment appears massive at meso-scale, but under the microscope is comprised of sand-sized aggregates of clay, silt and sand that have been compacted together, yielding a welded aggregate structure (Figure 3). This type of structure is indicative of compaction under wet conditions following insect bioturbation (Kooistra and Pulleman 2010, Kwaad and Mücher 1994, Wright 1983). Porosity is low, and the dominant void type is channels, which range in diameter from <1 mm up to 4 mm. Packing voids and vughs in the spaces between welded aggregates are also present. In general, the degree of microaggregation is higher at the base of the slide relative to the top, and conversely, the compaction of the sediment and abundance of channel voids increases upwards (see Figure 3).

Of the four thin sections, this sample contains the finest sediment. The texture varies slightly from the base of the thin sections to the top, with a weak coarsening upwards trend. Rare bands of finer sediment are present at the top of the sample. The channel voids, which are likely related to root or insect activity, are locally infilled with sediment that contains organic material, as well as calcium carbonate. The calcium carbonate crystals are fibrous or needle-shaped, which is consistent with fungal or insect activity (Verrecchia 1994). Obvious redoximorphic features are absent at microscale, although the color of the unit in the field is indicative of gleying as a result of post-depositional saturation.

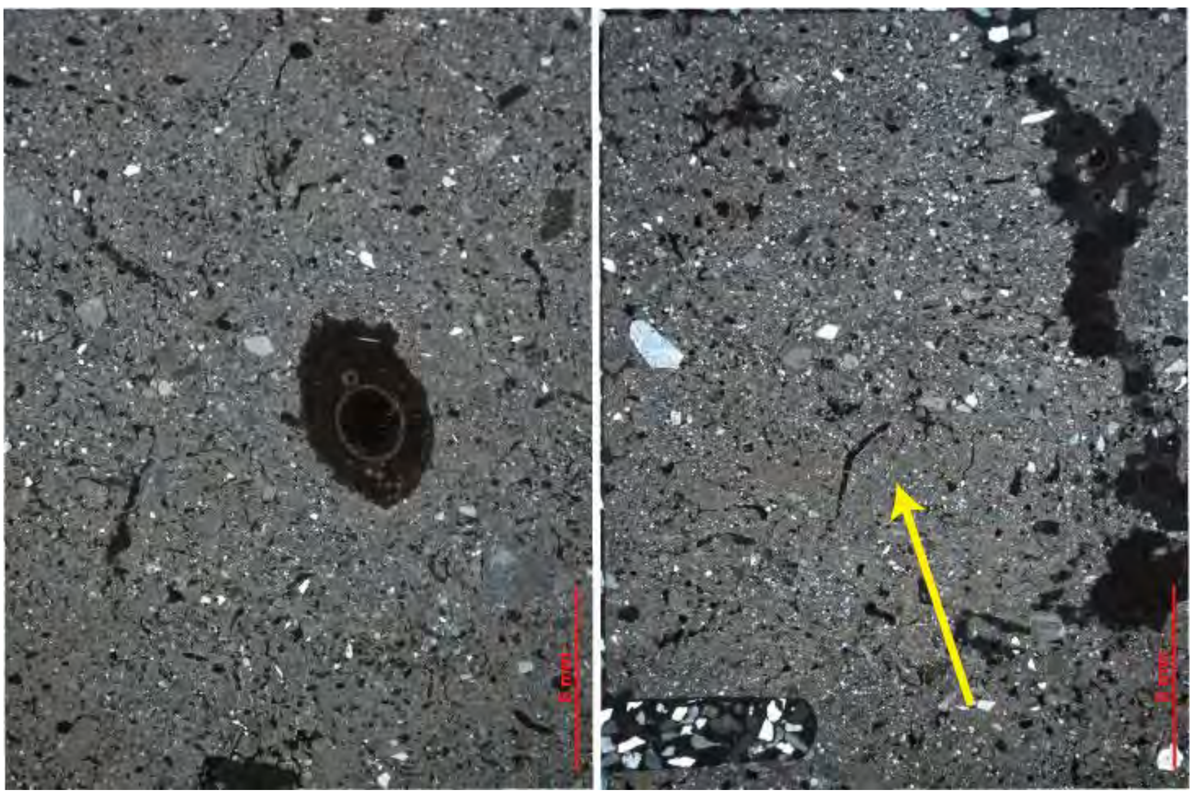

Figure 3. The sediment in the lower unit is composed of welded aggregates. The base of sample FS1560 (left) exhibits slightly higher porosity in the form of packing voids and vughs. The individual aggregates of sediment are more visible here relative to at the top of the sample (right), where channels are more abundant and occasional bands of clay (arrow) may be remnants of an original laminated fabric. XPL.

Sample FS1559 contains the lower unit, as well as the very base of the contact with the overlying black mat. The lower unit is comprised of light-colored, fine sediment and is consistent with the sediment in sample FS1560 in terms of mineralogical composition and texture. Welded microaggregates and channel voids are present; however, laminations of silt and clay are also locally present. The laminations suggest that the original depositional fabric of this unit was related to water, and was later obliterated by post-depositional insect activity and compaction. Relative to the underlying sample, the texture is finer, and the soil structure is slightly more developed, with fissures and crack voids delineating a weak angular blocky structure (Figure 4). As these voids cut across welded aggregates and channels, it is likely that structural development post-dates insect activity. Orientation of clays along the crack and fissure voids suggests some wetting and drying of the deposit.

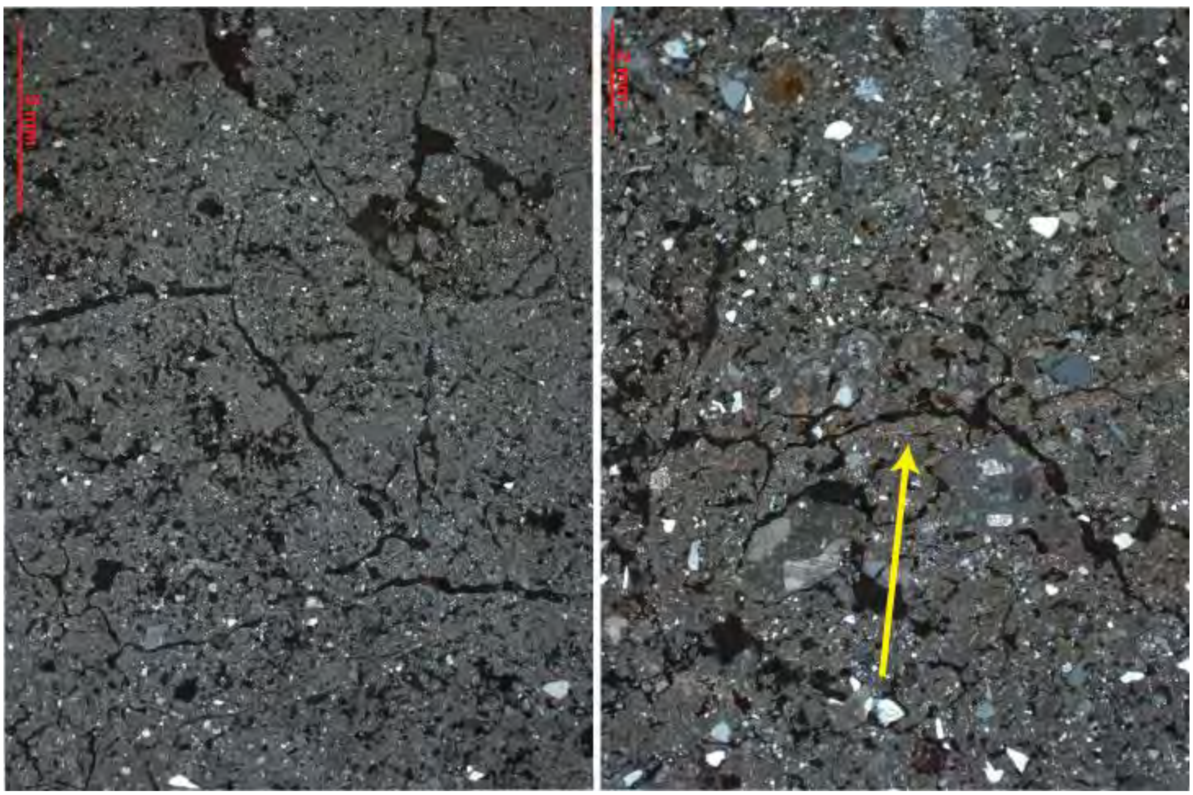

Figure 4. In sample FS1559, the top of the lower unit visible exhibits structural development and also contains remnants of laminations. Fissures separate angular blocky peds (left). At the contact with the upper unit (right), the sediment is markedly coarser, and a band of clay (arrow) is present in sample FS1558. XPL.

Due to disturbance of the sample during removal or processing, only ~1 cm of the original contact between the lower light-colored sediment, and the upper black mat is present in sample FS1559. This contact is sharp and undulating (see Figure 2, inset). Aggregates of the darker sediment at the top of the thin section likely derive from the black mat, although their original orientation is unknown due to disturbance of the sample. Relative to the underlying unit, the sediment in the black mat is coarser and contains more abundant sand-sized fragments of volcanic rock as well as microscopic fragments of organic material. The structure and fabric of this unit are difficult to discern in this sample, but some post-depositional features are visible including calcite infilling and coating the edges of channel voids.

4

Sample FS1558 also contains the contact between the two sedimentary units. The sample is not as disturbed as sample FS1559. Here the contact is not sharp and undulating, but instead seems to be comprised of domains of lighter and darker sediment directly above a band of oriented clay (see Figure 4). As in FS1559, the abundance of gravel-sized fragments of volcanic rock fragments – several exhibiting gleyed edges (Figure 5) – and silt-sized of organic materials increase markedly at or above the contact.

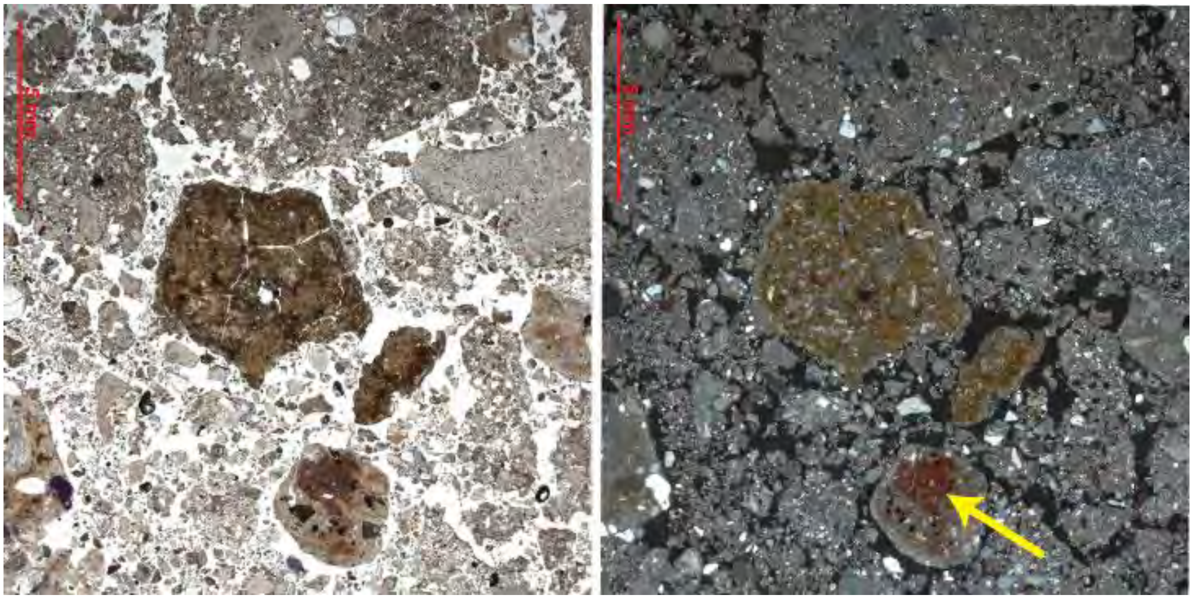

Figure 5. The sediment at the contact between the two units is disturbed. The upper sediment is coarser than the lower sediment, and contains sand- and gravel-sized fragments of volcanic rock. Here, three weathered volcanic rock fragments present at the contact between the two units exhibit post-depositional redoximorphic features. The edges of the rock fragments are lighter in color in PPL (right) and grey under XPL (left), while the centers are darker in color and contain reddish iron oxides. The iron oxides are especially prominent under XPL (yellow arrow). Bleaching of rock fragment edges, or gley, is indicative of reducing conditions within a water table. The similarity in color between the fragment edges and the surrounding sediment suggests that much of the sediment is fully gleyed.

The uppermost sample, FS1557 contains only sediment from the upper unit. Although the original structure of the deposit has been disturbed during processing, the mm- to cm-sized angular fragments of sediment with internal channels indicate that the structure may have been moderately-developed angular blocky structure, with channels and internal planar voids present (Figure 6). Within these ped fragments, aspects of the original depositional fabric are not preserved. However, some post-depositional features are visible. These include thin illuvial clay coatings, which increase in abundance towards the top of the slide. These features typically form within the subsurface horizons of soils (Kühn et al. 2010). Clays in the fine fraction are also weakly oriented around some voids and coarser components. In addition, the fragmented peds exhibit gley along their edges. Microscopic evidence for gley includes bleaching along fragment edges, with preservation of iron oxides within the ped centers (Figure 7). This distribution of iron oxides indicates that reducing conditions were present within water filling the macro-void system (fissures, cracks and channels) (Bouma et al. 1990, Tucker, Drees and Wilding 1993). As in lower samples, some channel voids are infilled with secondary carbonate (see Figure 6).

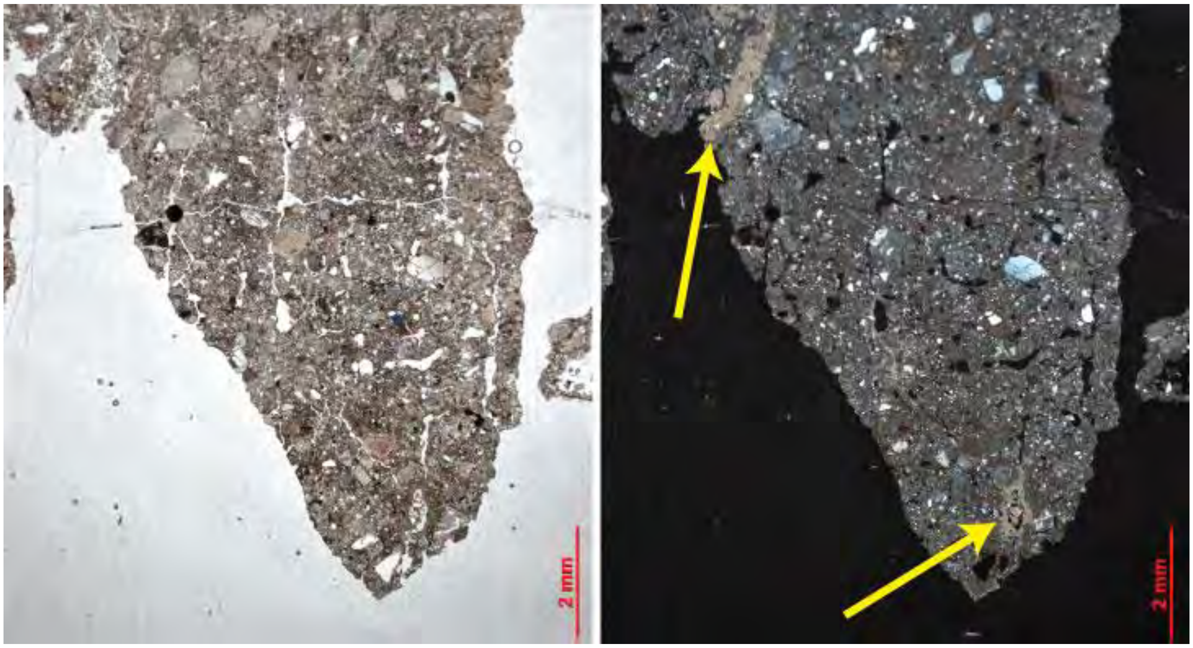

Figure 6. An angular fragment of disturbed sediment from the upper unit contains some pedofeatures and structural elements. Under PPL (right), planar fissures and channel voids are visible, which indicates that the unit likely exhibits an angular blocky structure. Under XPL (left), some of the larger channel voids (arrows) are infilled with secondary carbonate.

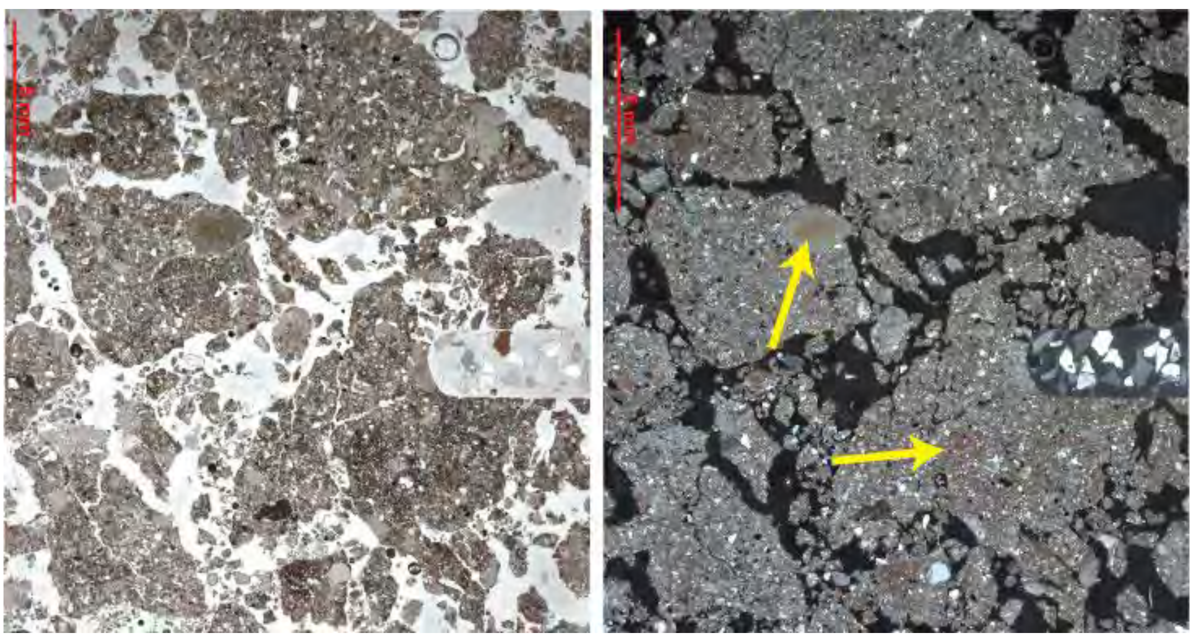

Figure 7. Fragments of sediment from the black mat contain redoximorphic features, including bleached ped edges, and iron oxides in ped centers. Under XPL (left), reddish concentrations of primary iron oxides are visible inside volcanic rock fragments (upper arrow) and ped centers (lower arrow).

6

To summarize, the microscopic characteristics of the sequence of samples indicate that the two units have distinctive compositions, which suggests that these are discrete depositional packages. The lower unit contains few gravel-sized fragments of volcanic rock, as well as low abundance of organic material incorporated into the fine fraction. The upper unit is coarser and contains abundant organic material (Figure 8). The mineralogy of the two units is similar, and therefore the sediment source was likely the same. The lower unit exhibits broad (cm-scale) alternations in texture, and also contains some (mm-scale) remnants of laminations, which are both consistent with deposition by water in a fluvial or alluvial setting.

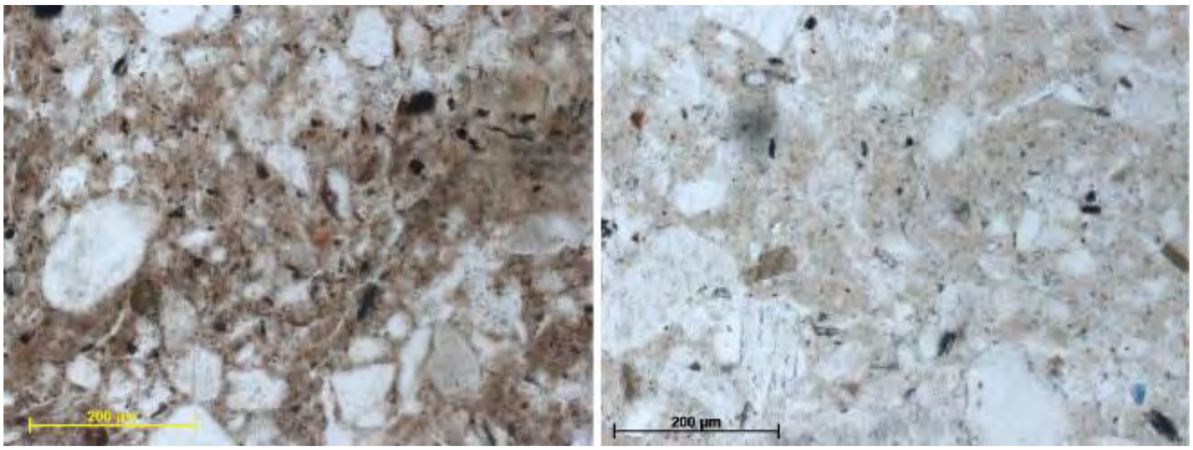

Figure 8. The fine fraction of the upper unit (left) is significantly darker and browner in color compared to the lower unit (right). Much of this difference in color is due to the presence of more abundant silt-and fine sand-sized fragments of organic material. When present, the majority of the organic material in the lower unit is concentrated in void infillings and thus likely postdates the deposition of the unit. PPL.

Furthermore, several of the post-depositional features in the lower unit (microaggregation, channel formation, and compaction/welding of aggregates) seem to predate the deposition of the overlying black mat sediment. Other stages, such as formation of secondary carbonates in voids and development of weak soil structure could either pre-date or post-date deposition of the black mat sediment. Secondary carbonates are present throughout the sequence, and unfortunately, disturbance of the upper sediment unit during sampling has prevented observation of soil structure. The angular shapes of the sediment seem to suggest that an angular blocky structure may have extended from the black mat downward into the top of the lower unit.

In sum, the observations suggest a general timeline for the formation of this sequence:

1) Deposition of the lower unit by water, likely multiple events

2) Bioturbation and obliteration of much of the original laminated fabric in the lower unit

3) Deposition of the upper unit

4) Wetting and compaction of the lower unit

5) Complete gleying of the lower unit, with partial gleying of the base of the upper unit

6) Drying of the two units, with formation of secondary carbonates, illuvial clay coatings, and possible development of a weak angular blocky structure due to subsequent soil formation.

It is possible that steps 3, 4 and 5 were related to a single event, and thus the deposition of the upper unit is contemporaneous with a rise in the water table that impacted both units.

Finally, the sediment in the upper unit was described in the field as a black mat. Harris-Parks (2016) has recently published a micromorphological comparison of 25 samples from black mats in four localities throughout the American Southwest. Relative to the samples described in her work, the sediment from Water Canyon is coarser in texture and apparently represents an increase in depositional energy relative to the underlying unit. It also lacks clear laminations, and contains significantly less organic material and humic staining visible in thin section. Diatoms, phytoliths and gastropods were also not present within the Water Canyon micromorphology samples. Although calcium carbonate is present at Water Canyon, it appears to be associated with a later phase of drying of the sequence, possibly related to plant activity (roots) and soil formation. In addition, much of the structure of the unit visible in thin section appears to be related to a later phase of soil formation following burial. Bioturbation features such as microaggregates and infilled burrows are not visible, although the presence of distinctive sedimentary domains along the contact may suggest that burrows were once present. Clay coatings are suggestive of soil forming processes occurring at depth.

Based on the micromorphological analyses the Water Canyon samples do not neatly fit into the classification system proposed by Harris-Parks (2016: Table 2). Although the unit exhibits characteristics indicative of a high water table (gley) and moisture fluctuations (slickensides), the remaining features are not consistent with those of other black mat samples indicative of permanent or intermittent standing water. At best, the Water Canyon samples are most similar to black mat samples derived from moist, productive soils.

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APPENDIX G. Chronometric Analyses

BETA

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Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

February 25, 2011

Dr. Robert Dello-Russo
Escondido Research Group, LLC
25 Alcalde Road
Santa Fe, NM 87508
USA

RE: Radiocarbon Dating Result For Sample LA134764 FS1037

Dear Dr. Dello-Russo:

Enclosed is the radiocarbon dating result for one sample recently sent to us. It provided plenty of carbon for an accurate measurement and the analysis proceeded normally. As usual, the method of analysis is listed on the report sheet and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analysis. It was analyzed with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

The cost of the analysis was charged to the VISA card provided. A receipt is enclosed. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA ANALYTIC INC.
DR. M.A. TAMERS and MR. D.G. HOOD
4985 S.W. 74 COURT
MIAMI, FLORIDA, USA 33155
PH: 305-667-5167 FAX:305-663-0964
beta@radiocarbon.com

REPORT OF RADIOCARBON DATING ANALYSES

Dr. Robert Dello-Russo — Report Date: 2/25/2011

Escondido Research Group, LLC — Material Received: 1/24/2011

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 292053	7990 +/- 40 BP	-12.3 o/oo 15N/14N= +10.2 o/oo	8200 +/- 40 BP

SAMPLE : LA134764 FS1037
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (bone collagen): collagen extraction: with alkali
2 SIGMA CALIBRATION : Cal BC 7340 to 7070 (Cal BP 9290 to 9020)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-12.3:lab. mult=1)

Laboratory number: **Beta-292053**

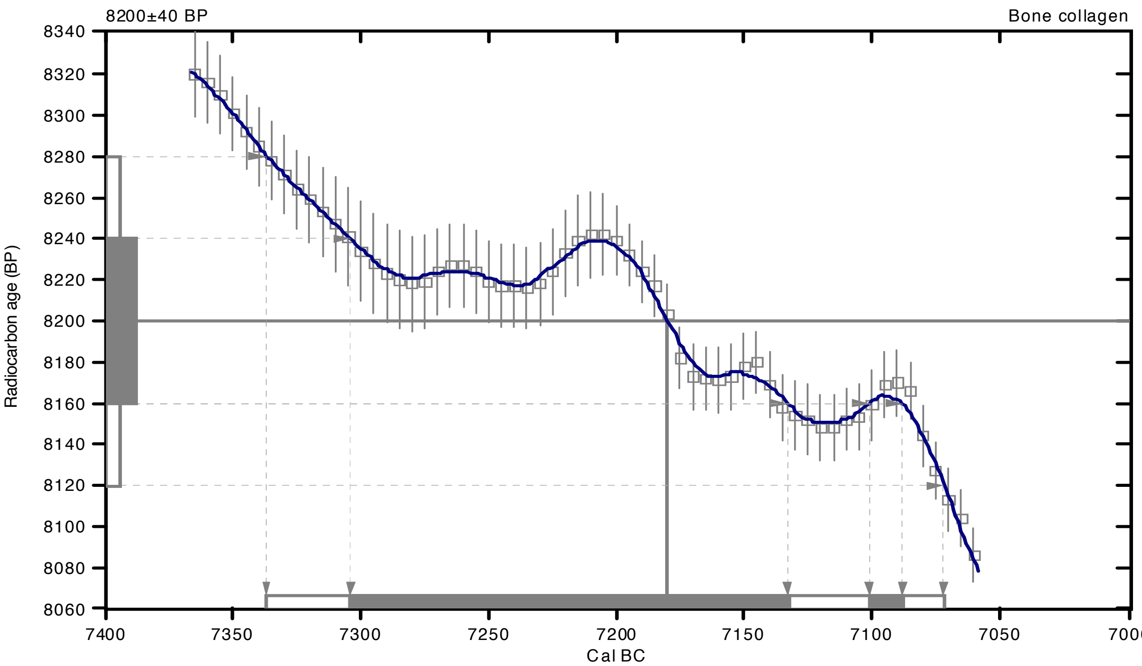
Conventional radiocarbon age: **8200±40 BP**

2 Sigma calibrated result: **Cal BC 7340 to 7070 (Cal BP 9290 to 9020)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 7180 (Cal BP 9130)

1 Sigma calibrated results: Cal BC 7300 to 7130 (Cal BP 9250 to 9080) and
(68% probability) Cal BC 7100 to 7090 (Cal BP 9050 to 9040)



References:
Database used
INTCAL04
Calibration Database
INTCAL04 Radiocarbon Age Calibration
IntCal04: Calibration Issue of Radiocarbon (Volume 46, nr 3, 2004).
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

Beta Analytic Radiocarbon Dating Laboratory

4985 S.W. 74th Court, Miami, Florida 33155 • Tel: (305)667-5167 • Fax: (305)663-0964 • E-Mail: beta@radiocarbon.com

Beta Analytic
TESTING LABORATORY

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info@betalabservices.c

ISO/IEC 17025:2005-Accredited Testing Laboratory

December 27, 2018

Dr. Robert Dello-Russo
University of New Mexico
1717 Lomas Blvd. NE
MSC07-4230
Albuquerque, NM 87131-0001
USA

RE: Radiocarbon Dating Results

Dear Dr. Dello-Russo,

Enclosed is the radiocarbon dating result for one sample recently sent to us. As usual, specifics of the analysis are listed on the report with the result and calibration data is provided where applicable. The Conventional Radiocarbon Age has been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

The reported result is accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all pretreatments and chemistry were performed here in our laboratories and counted in our own accelerators here in Miami. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 program participated in the analysis.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result. The reported d13C was measured separately in an IRMS (isotope ratio mass spectrometer). It is NOT the AMS d13C which would include fractionation effects from natural, chemistry and AMS induced sources.

When interpreting the result, please consider any communications you may have had with us regarding the sample. As always, your inquiries are most welcome. If you have any questions or would like further details of the analysis, please do not hesitate to contact us.

Our invoice will be emailed separately. Please forward it to the appropriate officer or send a credit card authorization. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact us.

Sincerely,

Chris Patrick

Digital signature on file

Chris Patrick Director

Beta Analytic Inc
4985 SW 74 Court
Miami, Florida 33155
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Fax: 305-663-0964
info@betalabservices.com

ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

Robert Dello-Russo	Report Date: December 27, 2018
University of New Mexico	Material Received: December 10, 2018

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 512350	**WC-5088**	**8620 +/- 30 BP**	IRMS δ13C: -12.6 o/oo

(91.5%)	**7686 - 7581 cal BC**	**(9635 - 9530 cal BP)**
(3.9%)	**7713 - 7692 cal BC**	**(9662 - 9641 cal BP)**

Submitter Material:	Charcoal
Pretreatment:	(charred material) acid/alkali/acid
Analyzed Material:	Charred material
Analysis Service:	AMS-Micro-sample Analysis; Standard delivery
Percent Modern Carbon:	34.20 +/- 0.13 pMC
Fraction Modern Carbon:	0.3420 +/- 0.0013
D14C:	-658.05 +/- 1.28 o/oo
Δ14C:	-660.85 +/- 1.28 o/oo(1950:2,018.00)
Measured Radiocarbon Age:	(without d13C correction): 8420 +/- 30 BP
Calibration:	BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -12.6 o/oo)

Laboratory number **Beta-512350**

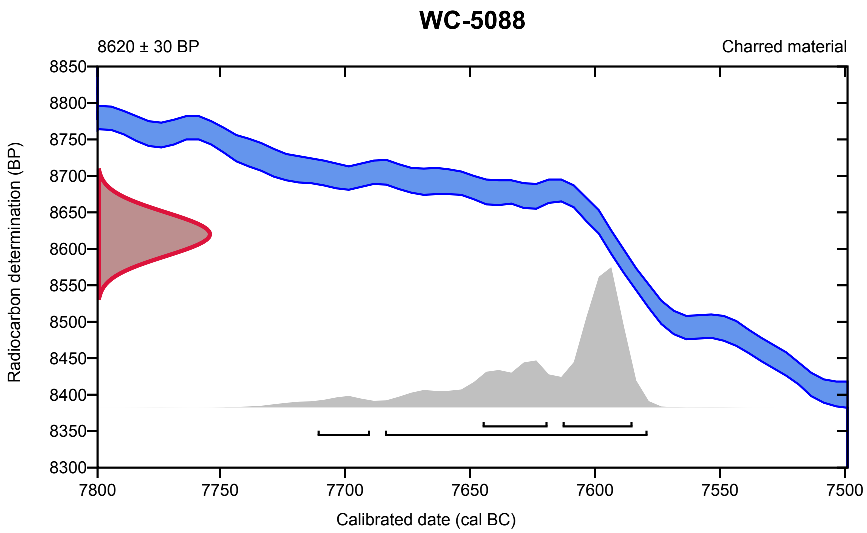
Conventional radiocarbon age **8620 ± 30 BP**

95.4% probability

(91.5%)	7686 - 7581 cal BC	(9635 - 9530 cal BP)
(3.9%)	7713 - 7692 cal BC	(9662 - 9641 cal BP)

68.2% probability

(48.5%)	7615 - 7587 cal BC	(9564 - 9536 cal BP)
(19.7%)	7647 - 7621 cal BC	(9596 - 9570 cal BP)



Database used
INTCAL13

References
References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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BETA Beta Analytic TESTING LABORATORY

ISO/IEC 17025:2005-Accredited Testing Laboratory

Quality Assurance Report

This report provides the results of reference materials used to validate radiocarbon analyses prior to reporting. Known-value reference materials were analyzed quasi-simultaneously with the unknowns. Results are reported as expected values vs measured values. Reported values are calculated relative to NIST SRM-4990B and corrected for isotopic fractionation. Results are reported using the direct analytical measure percent modern carbon (pMC) with one relative standard deviation. Agreement between expected and measured values is taken as being within 2 sigma agreement (error x 2) to account for total laboratory error.

Report Date: December 27, 2018
Submitter: Dr. Robert Dello-Russo

QA MEASUREMENTS

Reference 1

Expected Value: 96.69 +/- 0.50 pMC

Measured Value: 96.71 +/- 0.31 pMC

Agreement: Accepted

Reference 2

Expected Value: 0.51 +/-0.04

Measured Value: 0.50 +/- 0.04 pMC

Agreement: Accepted

Reference 3

Expected Value: 129.41 +/- 0.06 pMC

Measured Value: 129.40 +/- 0.35 pMC

Agreement: Accepted

COMMENT: All measurements passed acceptance tests.

Validation: Chris Patrick
Digital signature on file

Date: December 27, 2018

Wednesday, July 20, 2011 NSF-Arizona AMS Laboratory Page 1 of 1

Contact: Holliday, V.T.

AA #	Sample ID	Suite	Material	d13C	F	14C age BP
AA94457	S Diablo 266	1 of 11	charcoal	-24.7	0.6650 +- 0.0031	3,277 +- 38
AA94458	WaterCanyon 1036	2 of 11	charcoal	-20.6	0.3535 +- 0.0021	8,354 +- 48
AA94459	WaterCanyon 1049	3 of 11	charcoal	-10.2	0.3537 +- 0.0022	8,349 +- 49
AA94460	WaterCanyon 1051	4 of 11	charcoal	-23.4	0.3553 +- 0.0025	8,314 +- 56
AA94461	WaterCanyon 1052	5 of 11	charcoal	-21.7	0.3494 +- 0.0028	8,447 +- 64
AA94462	WaterCanyon 1053	6 of 11	charcoal	-19.5	0.3548 +- 0.0023	8,324 +- 52
AA94463	WaterCanyon 1054	7 of 11	charcoal	-21.5	0.3521 +- 0.0021	8,385 +- 48
AA94464	WaterCanyon 1055	8 of 11	charcoal	-24.1	0.3538 +- 0.0023	8,346 +- 51
AA94465	WaterCanyon 1058	9 of 11	charcoal	-21.4	0.3542 +- 0.0021	8,338 +- 48
AA94466	WaterCanyon 1059b	10 of 11	charcoal	-23.9	0.3609 +- 0.0021	8,186 +- 47
AA94467	WaterCanyon 1066	11 of 11	charcoal	-24.0	0.3082 +- 0.0020	9,454 +- 51

Reported by ________________________

NSF-Arizona AMS Laboratory

NSF-Arizona AMS Laboratory
(520) 621-6810 (phone)

Physics Building
(520) 621-9619 (fax)
1118 East Fourth St.
AMS@physics.arizona.edu
PO Box 210081
University of Arizona
Tucson, AZ 85721-

DATA REPORT

"radiocarbon age BP"

AA	lab #	sample ID:	Contact 1	MASS	d13C value	F (d13C)	dF (d13C)	14C age BP	d14C age
AA103920	X27646	FS-5007	Dello-Russo, R.	1.06mg	-24.2	0.3517	0.0020	8,394	45
AA103921	X27647	FS-5071	Dello-Russo, R.	0.31mg	-11.2	0.3354	0.0026	8,776	62

The University of Arizona
College of Science
Accelerator Mass Spectrometry Lab

DATA REPORT

"radiocarbon age BP"

1118 E. 4th St.
PO Box 210081
Tucson, AZ 85721-

(520) 621-6810 (phone)
(520) 621-9619 (fax)
AMS@physics.arizona.edu

AA	lab #	sample ID:	Contact 1	MASS	d13C value	F (d13C)	dF (d13C)	14C age BP	d14C age
AA104050	X27681A	Water Canyon FS-5096	Holliday, V.	2.86mg	-23.9	0.3280	0.0023	8,955	57
AA104051	X27682A	Water Canyon FS-5105	Holliday, V.	1.92mg	-23.7	0.3418	0.0038	8,623	89
AA104111	X27684A	Water Canyon FS-5124	Dello-Russo, R.	2.39mg	-24.0	0.3263	0.0021	8,997	53

UNIVERSITY OF ARIZONA AMS LABORATORY

Holliday, V. (AA106878 – AA106885) – Radiocarbon Analytical Report

Summary Page

The following analytical report contains 14C analysis from the University of Arizona for eight samples listed at the bottom of this page. This report contains:

- Summary page, includes data qualifiers, non-conformances, and data summary (page 1)

Data Qualifiers: Fraction Modern Carbon and Radiocarbon Age were calculated as weighted averages of combined machine runs to reduce overall error. A small sample correction is applied to samples with a carbon mass less than 0.50 mg.

Non-Conformances: None.

Report generated by: Richard Cruz

Report Generation Date: 1/21/2016

Reviewer: Greg Hodgins

Date: 1/21/2016

Signature:

Data Summary

AA	lab #	sample ID	MASS	d13C value	F (d13C)	dF (d13C)	14C age BP	d14C age
AA106878	X29549	W.C. Big Wash15-1 FS1330	1.92mg	-19.4	0.7171	0.0022	2,671	25
AA106879	X29550A	WHSA 207 15-11 105-110	1.87mg	-20.4	0.3047	0.0015	9,547	41
AA106880	X29551	JM-1 15-1 480-490	1.20mg	-10.7	0.2878	0.0013	10,004	35
AA106881	X29552	JM-1 15-2 475-485	0.98mg	-12.3	0.2996	0.0015	9,683	41
AA106882	X29553A	Boles Wells 15-2 60-70	2.66mg	-16.1	0.5921	0.0019	4,210	25
AA106883	X29554A	Blue Well Playa 15-1 250-260	1.36mg	-22.8	0.1217	0.0010	16,921	66
AA106884	X29555	Blue Well Playa 15-1 240-250	0.65mg	-22.6	0.2641	0.0015	10,696	46
AA106885	X29556	W.C. Big Wash 15-2 FS1331	1.42mg	-23.3	0.4664	0.0016	6,126	28

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and the Environment

EESL
ENERGY AND ENVIRONMENTAL
SUSTAINABILITY LABORATORIES

February 16, 2018 Prufer

PSUAMS#	Sample ID	Description	Material	fraction Modern	±	$D^{14}C$ (‰)	±	^{14}C age (BP)	±
3564	B1000	CSI-1000. FS1613. Water Canyon. bison. 0.28mg	XAD amino a	0.3190	0.0022	-681.0	2.2	9180	60
3565	B1004	CSI-1004. FS1510. Water Canyon. bison. 0.50mg	XAD amino a	0.3166	0.0019	-683.4	1.9	9240	50
3566	B1001	CSI-1001. FS1528. Water Canyon. bison. 0.53mg	XAD amino a	0.3186	0.0019	-681.4	1.9	9185	50
3567	B1002B	CSI-1002. FS1605. Water Canyon. bison. 0.15mg	XAD amino a	0.3339	0.0027	-666.1	2.7	8810	70

Radiocarbon concentrations are given as fractions of the Modern standard, $D^{14}C$, and conventional radiocarbon age, following the conventions of Stuiver and Polach (Radiocarbon, v. 19, p.355, 1977).

Sample preparation backgrounds have been subtracted based on measurements of ^{14}C-free bone.

All results have been corrected for isotopic fractionation according to the conventions of Stuiver and Polach (1977), with $\delta^{13}C$ values measured on prepared graphite using the AMS. These can differ from $\delta^{13}C$ of the original material, if fractionation occurred during sample graphitization or the AMS measurement, and are not shown.

Comments:
Larger errors are due to smaller sample sizes as estimated from $^{12}C^-$ currents. Optimal size is 0.7mg or ~100µA.

Accelerator Mass Spectrometry Laboratory

International Chemical Analysis Inc.
1951 NW 7th Ave
STE 300
Miami, FL U.S.A 33136

Summary of Ages

Submitter Name: Robert Dello-Russo
Company Name: Office of Contract Archeology
Address: 1717 Lomas Blvd. NE, MSC07-4230,
University of New Mexico, Albuquerque, NM 87131-0001

ICA ID	Submitter ID	Material Type	Pretreatment	Conventional Age	Calibrated Age
16C/0634	FS 1414	Charcoal	AAA	100.11 +/- 0.30 pMC	Cal 1890 - 1910 AD (23.0%) Cal 1950 - 1960 AD (72.4%)
16OS/0639	FS 1647	Organic Sediment	AO	7030 +/- 40 BP	Cal 6000 - 5840 BC (94.6%) Cal 5820 - 5810 BC (0.8%)
16OS/0638	FS 1646	Organic Sediment	AO	7830 +/- 40 BP	Cal 6810 - 6570 BC
16OS/0637	FS 1645	Organic Sediment	AO	9090 +/- 40 BP	Cal 8420 - 8400 BC (2.4%) Cal 8390 - 8370 BC (1.9%) Cal 8350 - 8240 BC (91.1%)
16OS/0636	FS 1644	Organic Sediment	AO	9020 +/- 40 BP	Cal 8300 - 8200 BC (93.9%) Cal 8040 - 8020 BC (1.5%)
16OS/0640	FS 5163	Organic Sediment	AO	9750 +/- 40 BP	Cal 9290 - 9170 BC
16OS/0641	FS 5164	Organic Sediment	AO	10000 +/- 40 BP	Cal 9750 -9720 BC (3.1%) Cal 9690 - 9320 BC (92.3%)
16OS/0642	FS 5165	Organic Sediment	AO	10280 +/- 40 BP	Cal 10420 - 10400 BC (1.7%) Cal 10290 -10250 BC (2.5%) Cal 10230 - 9880 BC (91.2%)
16OS/0643	FS 5166	Organic Sediment	AO	10080 +/- 40 BP	Cal 9990 - 9940 BC (2.6%) Cal 9880 - 9450 BC (92.8%)

- Calibrated ages are attained using INTCAL13: **IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0–50,000 Years cal BP.** *Paula J Reimer, Edouard Bard, Alex Bayliss, J Warren Beck, Paul G Blackwell, Christopher Bronk Ramsey, Caitlin E Buck, Hai Cheng, R Lawrence Edwards, Michael Friedrich, Pieter M Grootes, Thomas P Guilderson, Haflidi Haflidason, Irka Hajdas, Christine Hatté, Timothy J Heaton, Dirk L Hoffmann, Alan G Hogg, Konrad A Hughen, K Felix Kaiser, Bernd Kromer, Sturt W Manning, Mu Niu, Ron W Reimer, David A Richards, E Marian Scott, John R Southon, Richard A Staff, Christian S M Turney, Johannes van der Plich*t. **Radiocarbon 55(4), Pages 1869-1887**.
- Unless otherwise stated, 2 sigma calibration (95% probability) is used.
- Conventional ages are given in BP (BP=Before Present, 1950 AD), and have been corrected for fractionation using the delta C13.
- Calibrated age for sample FS 1414 was attained using BOMB 13 NH1

International Chemical Analysis Inc.
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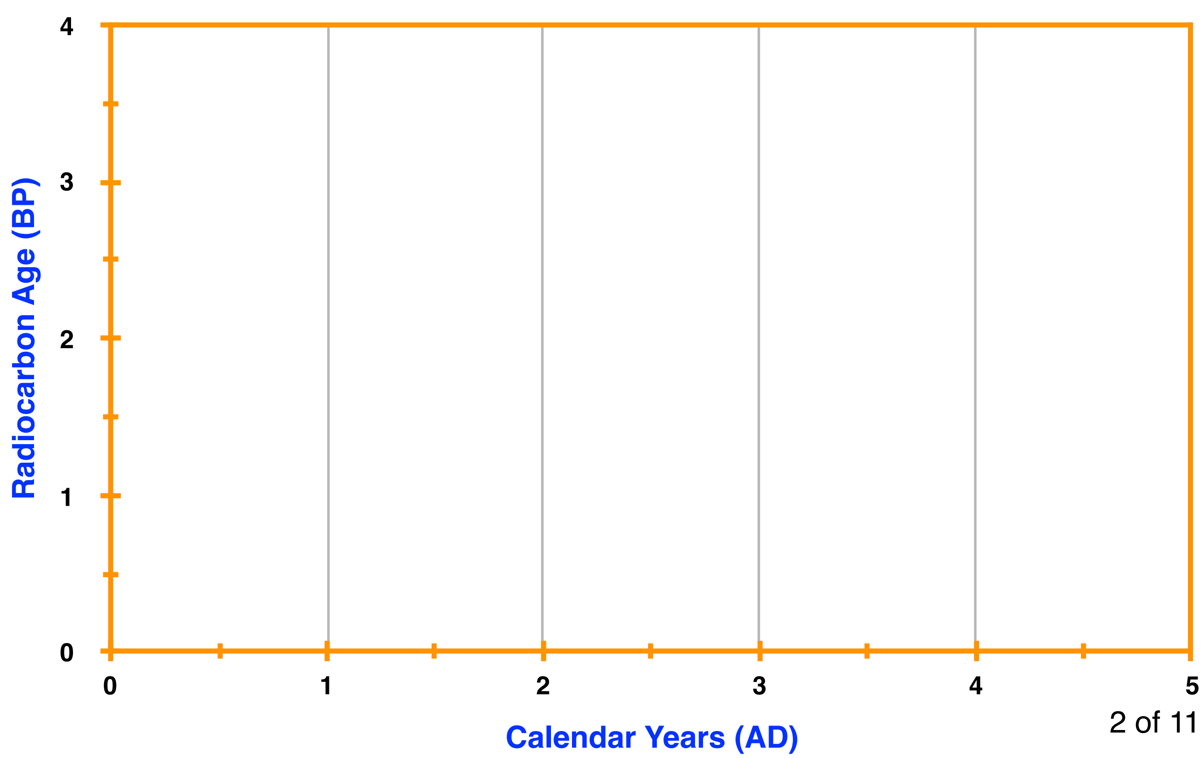
Sample Report

Submitter Name: Robert Dello-Russo
Company Name: Office of Contract Archeology
Address: 1717 Lomas Blvd. NE, MSC07-4230,
University of New Mexico, Albuquerque, NM 87131-0001

Date Received	June 16, 2016	**Material Type**	Charcoal
Date Reported	July 13, 2016	**Pre-treatment**	AAA
ICA ID	16C/0634	**C13/C12**	-25.0 o/oo
Submitter ID	FS 1414	**Conventional Age**	**100.11 +/- 0.30 pMC**

Calibrated Age	**Cal 1890 - 1910 AD (23.0%)** **Cal 1950 - 1960 AD (72.4%)**



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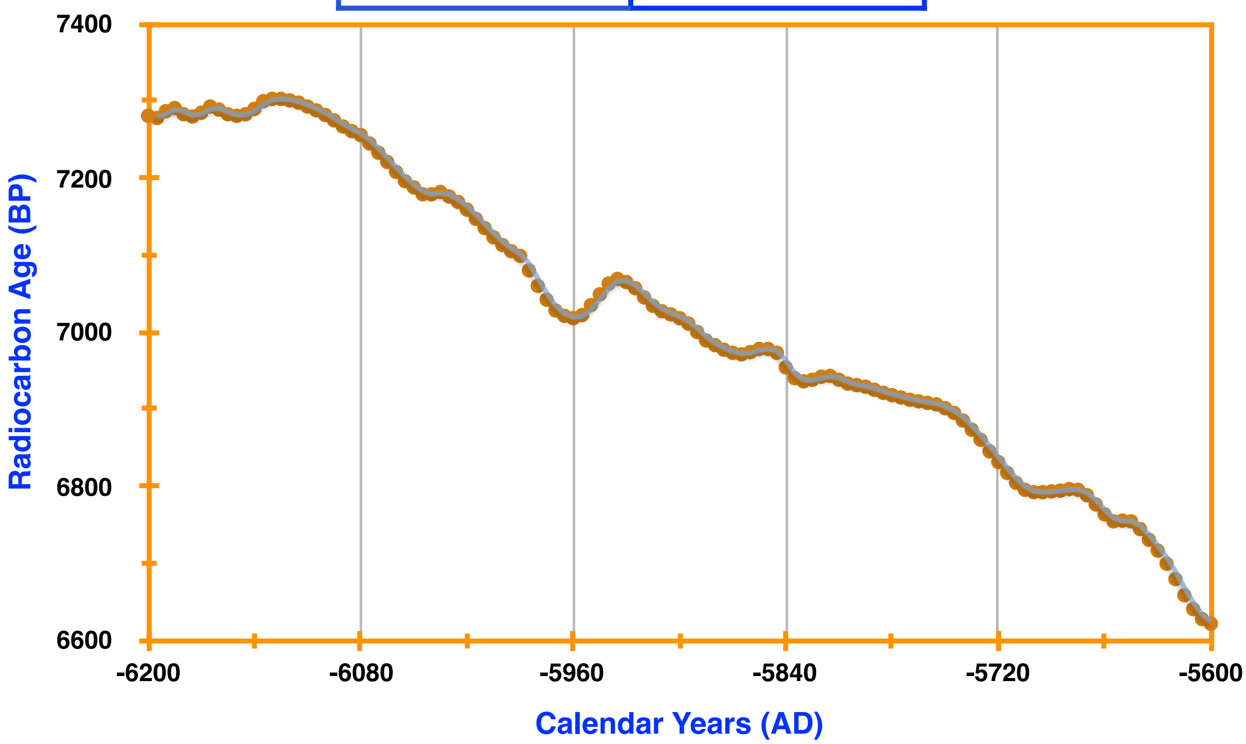
Sample Report

Submitter Name: Robert Dello-Russo
Company Name: Office of Contract Archeology
Address: 1717 Lomas Blvd. NE, MSC07-4230,
University of New Mexico, Albuquerque, NM 87131-0001

Date Received	June 16, 2016	Material Type	Organic Sediment
Date Reported	July 13, 2016	Pre-treatment	AO
ICA ID	16OS/0639	C13/C12	-25.0 o/oo
Submitter ID	FS 1647	Conventional Age	**7030 +/- 40 BP**

Calibrated Age	Cal 6000 - 5840 BC (94.6%) Cal 5820 - 5810 BC (0.8%)



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International Chemical Analysis Inc.
1951 NW 7th Ave
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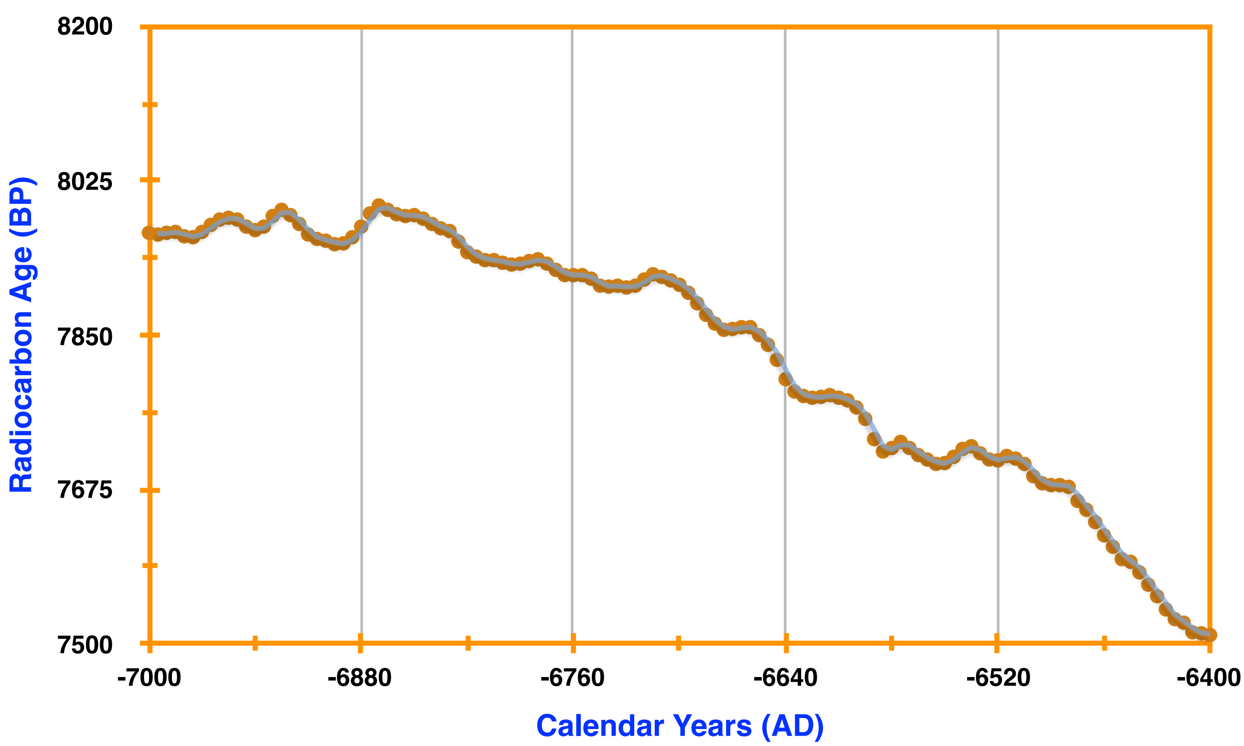
Sample Report

Submitter Name: Robert Dello-Russo
Company Name: Office of Contract Archeology
Address: 1717 Lomas Blvd. NE, MSC07-4230,
University of New Mexico, Albuquerque, NM 87131-0001

Date Received	June 16, 2016	**Material Type**	Organic Sediment
Date Reported	July 13, 2016	**Pre-treatment**	AO
ICA ID	16OS/0638	**C13/C12**	-33.0 o/oo
Submitter ID	FS 1646	**Conventional Age**	**7830 +/- 40 BP**

Calibrated Age	**Cal 6810 - 6570 BC**



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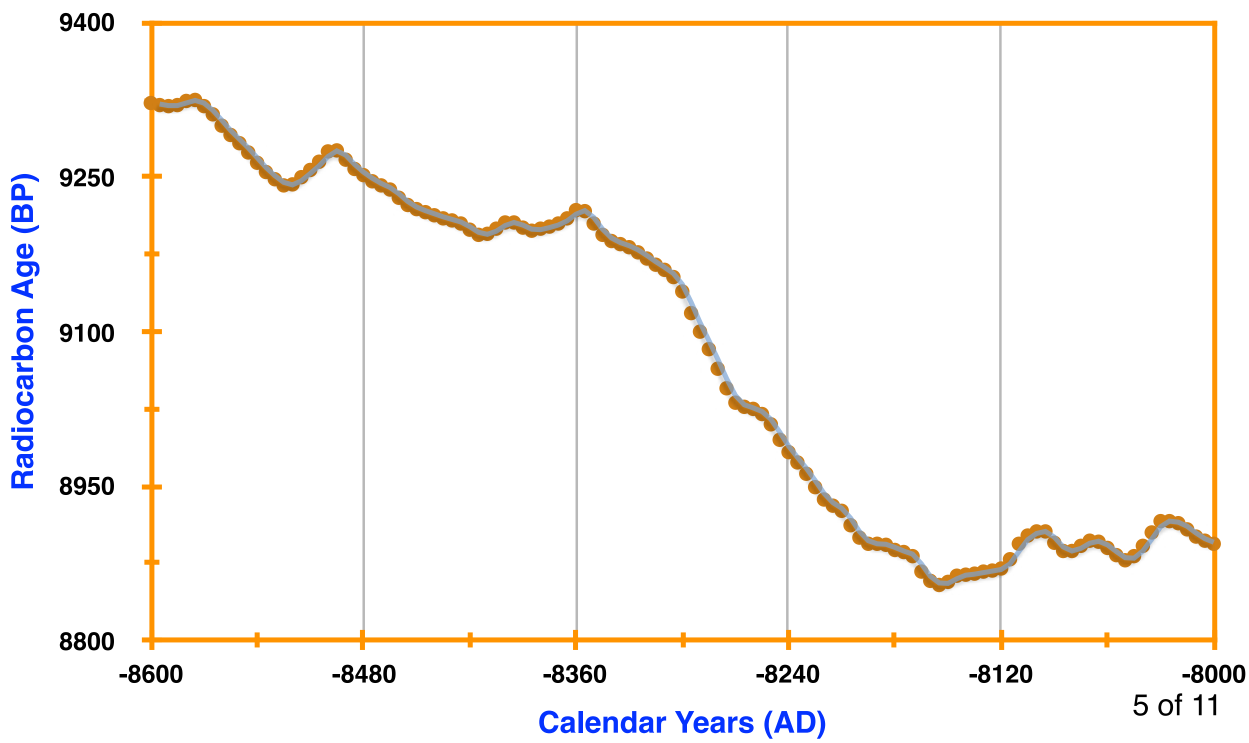
Sample Report

Submitter Name: Robert Dello-Russo
Company Name: Office of Contract Archeology
Address: 1717 Lomas Blvd. NE, MSC07-4230,
University of New Mexico, Albuquerque, NM 87131-0001

Date Received	June 16, 2016	Material Type	Organic Sediment
Date Reported	July 13, 2016	Pre-treatment	AO
ICA ID	16OS/0637	C13/C12	-33.8 o/oo
Submitter ID	FS 1645	Conventional Age	**9090 +/- 40 BP**

Calibrated Age	Cal 8420 - 8400 BC (2.4%) Cal 8390 - 8370 BC (1.9%) Cal 8350 - 8240 BC (91.1%)



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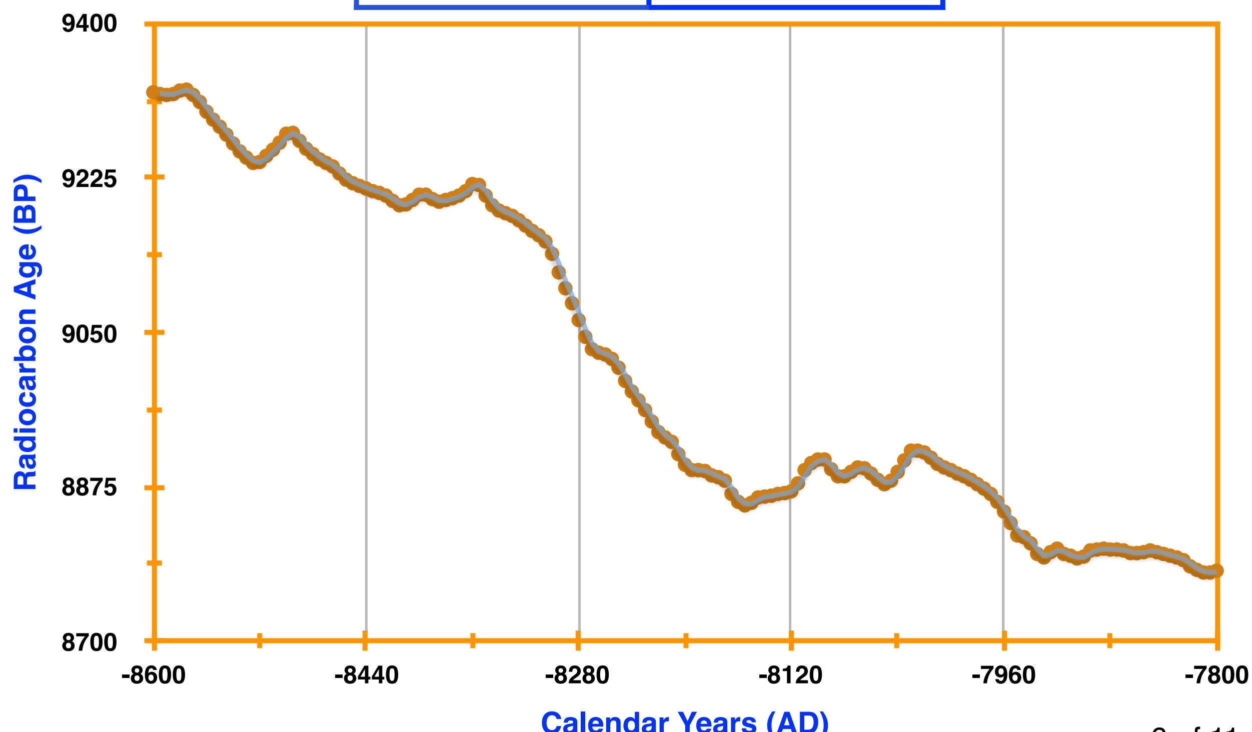
Sample Report

Submitter Name: Robert Dello-Russo
Company Name: Office of Contract Archeology
Address: 1717 Lomas Blvd. NE, MSC07-4230,
University of New Mexico, Albuquerque, NM 87131-0001

Date Received	June 16, 2016	Material Type	Organic Sediment
Date Reported	July 13, 2016	Pre-treatment	AO
ICA ID	16OS/0636	C13/C12	-26.1 o/oo
Submitter ID	FS 1644	Conventional Age	**9020 +/- 40 BP**

Calibrated Age	Cal 8300 - 8200 BC (93.9%) Cal 8040 - 8020 BC (1.5%)



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Sample Report

Submitter Name: Robert Dello-Russo
Company Name: Office of Contract Archeology
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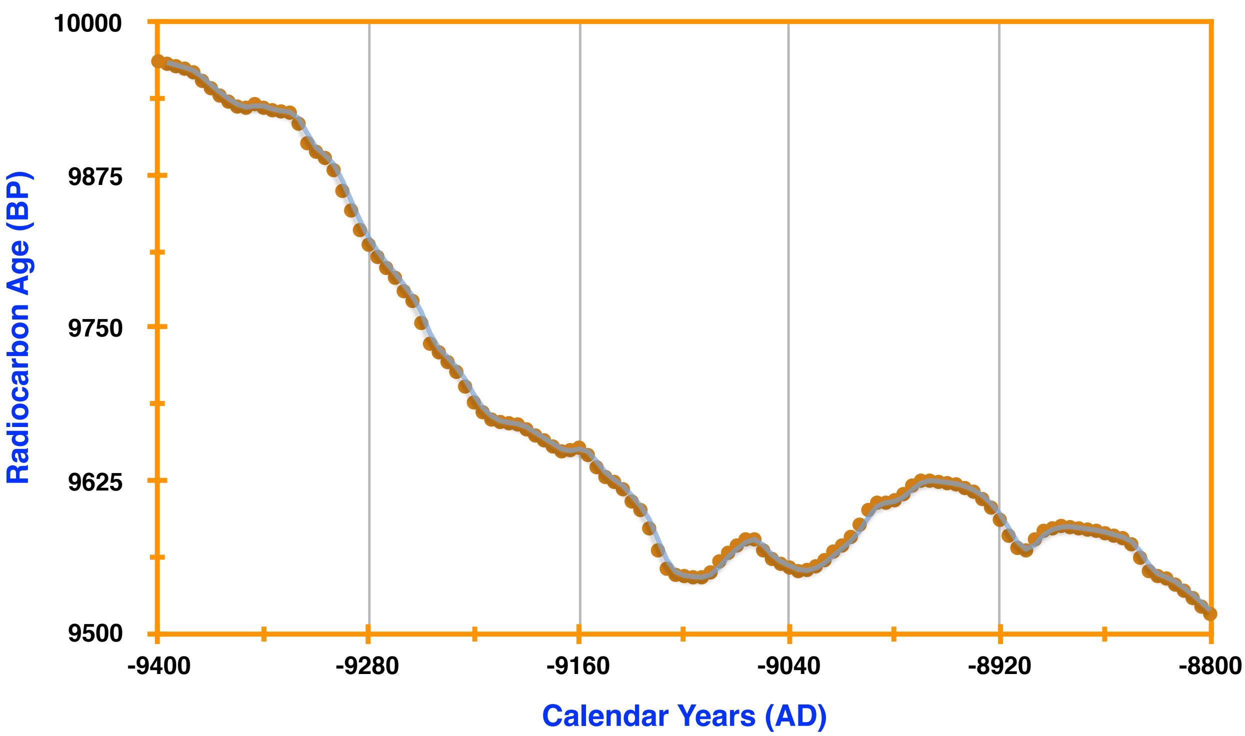
University of New Mexico, Albuquerque, NM 87131-0001

Date Received	June 16, 2016	Material Type	Organic Sediment
Date Reported	July 13, 2016	Pre-treatment	AO
ICA ID	16OS/0640	C13/C12	-22.5 o/oo
Submitter ID	FS 5163	Conventional Age	**9750 +/- 40 BP**

Calibrated Age	**Cal 9290 - 9170 BC**



7 of 11

International Chemical Analysis Inc.
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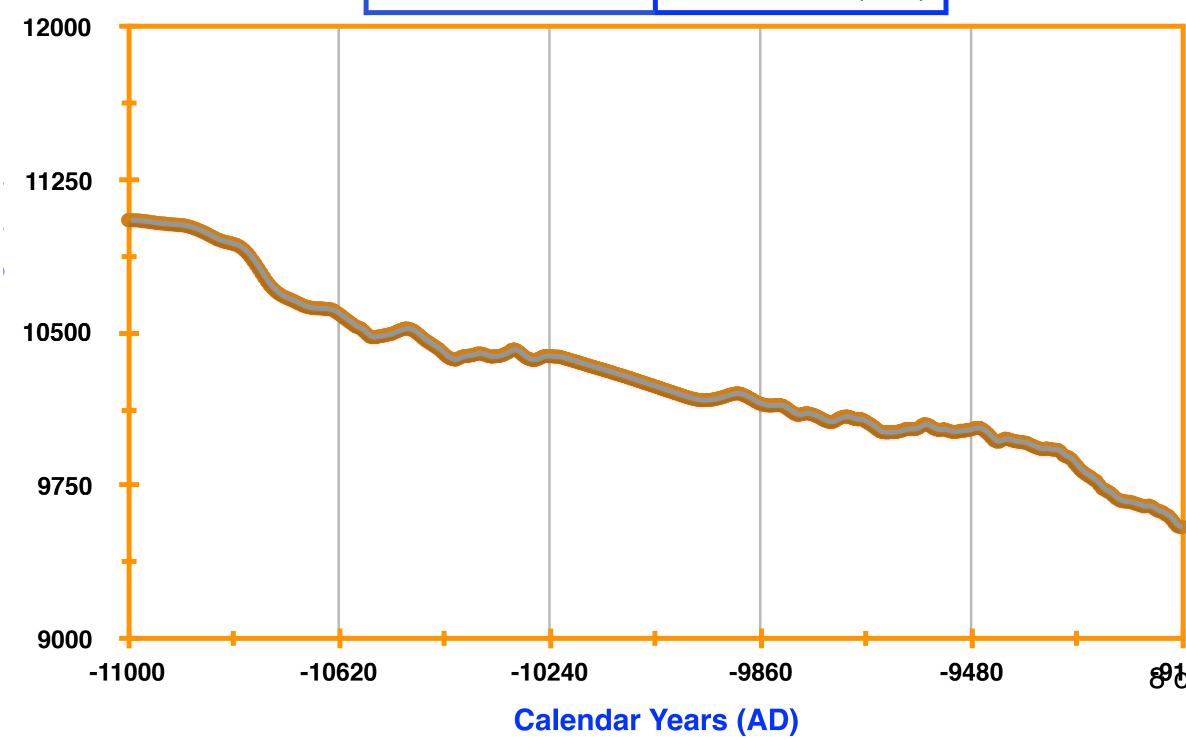
Sample Report

Submitter Name: Robert Dello-Russo
Company Name: Office of Contract Archeology
Address: 1717 Lomas Blvd. NE, MSC07-4230,
University of New Mexico, Albuquerque, NM 87131-0001

Date Received	June 16, 2016	Material Type	Organic Sediment
Date Reported	July 13, 2016	Pre-treatment	AO
ICA ID	16OS/0641	C13/C12	-24.2 o/oo
Submitter ID	FS 5164	Conventional Age	**10000 +/- 40 BP**

Calibrated Age	**Cal 9750 -9720 BC (3.1%)** **Cal 9690 - 9320 BC (92.3%)**



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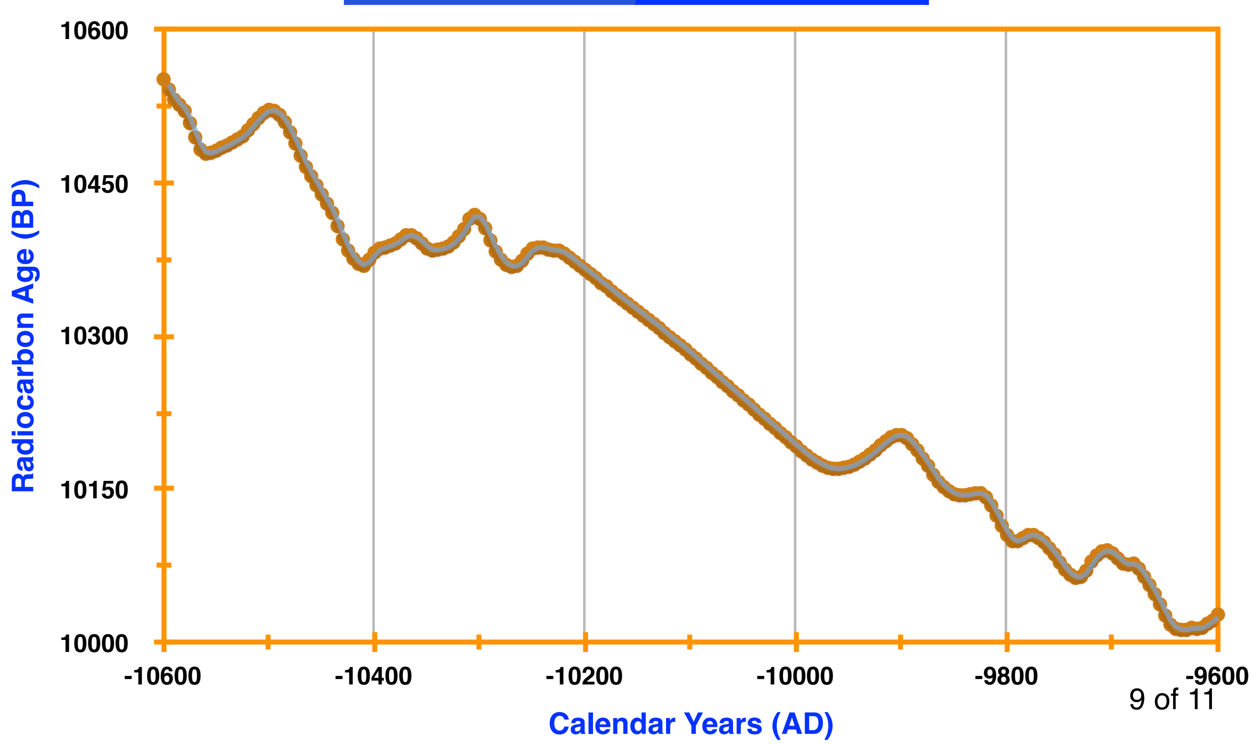
Sample Report

Submitter Name: Robert Dello-Russo
Company Name: Office of Contract Archeology
Address: 1717 Lomas Blvd. NE, MSC07-4230,
University of New Mexico, Albuquerque, NM 87131-0001

Date Received	June 16, 2016	Material Type	Organic Sediment
Date Reported	July 13, 2016	Pre-treatment	AO
ICA ID	16OS/0642	C13/C12	-25.0 o/oo
Submitter ID	FS 5165	Conventional Age	**10280 +/- 40 BP**

Calibrated Age	Cal 10420 - 10400 BC (1.7%) Cal 10290 -10250 BC (2.5%) Cal 10230 - 9880 BC (91.2%)



9 of 11

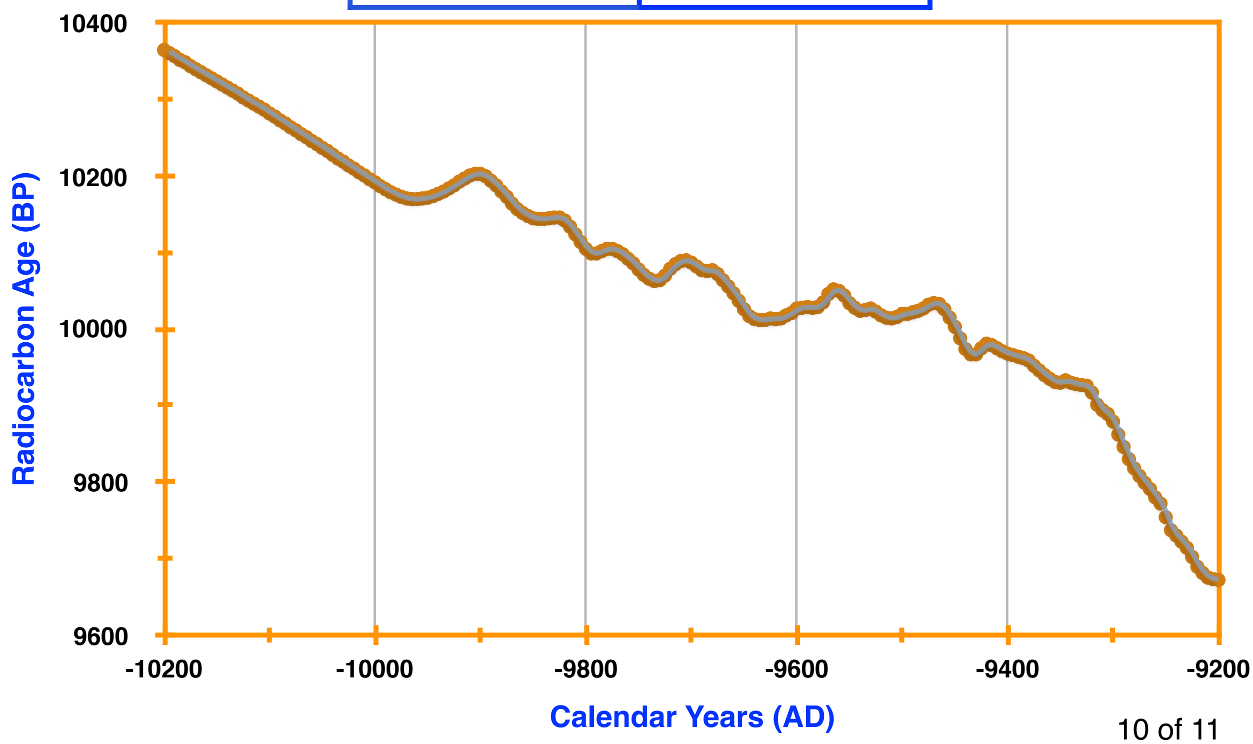
International Chemical Analysis Inc.
1951 NW 7th Ave
STE 300
Miami, FL U.S.A 33136

Sample Report

Submitter Name: Robert Dello-Russo
Company Name: Office of Contract Archeology
Address: 1717 Lomas Blvd. NE, MSC07-4230,
University of New Mexico, Albuquerque, NM 87131-0001

Date Received	June 16, 2016	Material Type	Organic Sediment
Date Reported	July 13, 2016	Pre-treatment	AO
ICA ID	16OS/0643	C13/C12	-25.0 o/oo
Submitter ID	FS 5166	Conventional Age	**10080 +/- 40 BP**

Calibrated Age	Cal 9990 - 9940 BC (2.6%) Cal 9880 - 9450 BC (92.8%)



10 of 11

International Chemical Analysis Inc.
1951 NW 7th Ave
STE 300
Miami, FL U.S.A 33136

QC Report

Submitter Name: Robert Dello-Russo
Company Name: Office of Contract Archeology
Address: 1717 Lomas Blvd. NE, MSC07-4230,
University of New Mexico, Albuquerque, NM 87131-0001

Date Submitted	June 16, 2016	Date Reported	July 13, 2016
QC 1 Sample ID	IAEA C7	QC 2 Sample ID	NIST OXII
QC Expected Value	49.35 +/- 0.50 pMC	QC Expected Value	134.09 +/- 0.70 pMC
QC Measured Value	49.79 +/- 0.20 pMC	QC Measured Value	134.29 +/- 0.50 pMC
Pass?	YES	Pass?	YES

- pMC = Percent Modern Carbon.
- IAEA = International Atomic Energy Agency.

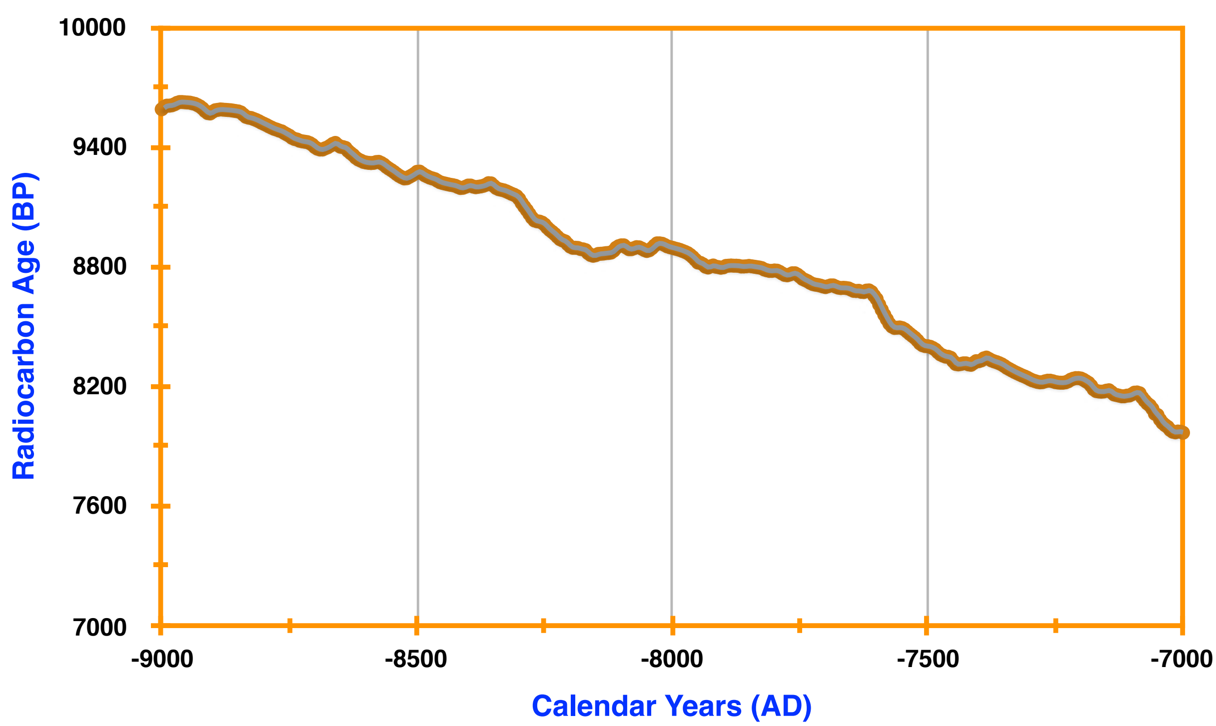
International Chemical Analysis Inc.
1951 NW 7th Ave
STE 300
Miami, FL U.S.A 33136

Sample Report

Submitter Name: Robert Dello-Russo
Company Name: Office of Contract Archeology
Address: 1717 Lomas Blvd. NE, MSC07-4230,
University of New Mexico, Albuquerque, NM 87131-0001

Date Received	July 01, 2016	Material Type	Bone
Date Reported	August 31, 2016	Pre-treatment	Col-AAA
ICA ID	16B/0713	C13/C12	-24.9 o/oo
Submitter ID	**FS 1625c**	Conventional Age	**8640 +/- 40 BP**

Calibrated Age	**Cal 7740 - 7580 BC**



1 of 2

International Chemical Analysis Inc.
1951 NW 7th Ave
STE 300
Miami, FL U.S.A 33136

QC Report

Submitter Name: Robert Dello-Russo
Company Name: Office of Contract Archeology
Address: 1717 Lomas Blvd. NE, MSC07-4230,
University of New Mexico, Albuquerque, NM 87131-0001

Date Submitted	July 01, 2016	Date Reported	August 31, 2016
QC 1 Sample ID	**IAEA C7**	QC 2 Sample ID	**NIST OXII**
QC Expected Value	49.53 +/- 0.50 pMC	QC Expected Value	134.09 +/- 0.70 pMC
QC Measured Value	49.86 +/- 0.20 pMC	QC Measured Value	134.36 +/- 0.20 pMC
Pass?	YES	Pass?	YES

- pMC = Percent Modern Carbon.
- IAEA = International Atomic Energy Agency.

- Calibrated ages are attained using INTCAL13: **IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0–50,000 Years cal BP.** *Paula J Reimer, Edouard Bard, Alex Bayliss, J Warren Beck, Paul G Blackwell, Christopher Bronk Ramsey, Caitlin E Buck, Hai Cheng, R Lawrence Edwards, Michael Friedrich, Pieter M Grootes, Thomas P Guilderson, Haflidi Haflidason, Irka Hajdas, Christine Hatté, Timothy J Heaton, Dirk L Hoffmann, Alan G Hogg, Konrad A Hughen, K Felix Kaiser, Bernd Kromer, Sturt W Manning, Mu Niu, Ron W Reimer, David A Richards, E Marian Scott, John R Southon, Richard A Staff, Christian S M Turney, Johannes van der Plich*t. **Radiocarbon 55(4), Pages 1869-1887**.
- Unless otherwise stated, 2 sigma calibration (95% probability) is used.
- Conventional ages are given in BP (BP=Before Present, 1950 AD), and have been corrected for fractionation using the delta C13.

Appendix H. Publications, Papers & Posters, and Presentations

The following list includes peer-reviewed publications (in bold text) and other publications (such as newspaper, newsletter and magazine articles) about the Water Canyon site. A subsequent section of the list includes professional conference papers and posters that have been presented about scientific research undertaken at the site between 2010 and 2019, and these are followed by a listing of public presentations about the site:

PEER-REVIEWED and OTHER PUBLICATIONS

Ballenger, Jesse

2012 "President's Message – The Water Canyon Site." *Glyphs*, Vol. 63, No. 4, pp. 2-3. Newsletter of the Arizona Archaeological and Historical Society, October, Tucson, AZ.

Curtis, Wayne

2016 "The Act That Changed Archaeology". In *American Archaeology*, a quarterly publication of the Archaeological Conservancy, Vol. 20, No.1, Santa Fe, NM. https://www.archaeologicalconservancy.org/american-archaeology-magazine/american-archaeology-magazine-back-issues/americanarch-2016-spring/. Description of Water Canyon site, and quotes from R. Dello-Russo in discussion about NRHP basis for discovery of site.

Dello-Russo, Robert D.

2015 A Revised Research Design for the 2015 Archaeological Field School at the Water Canyon Paleoindian Site (LA 134764), Socorro County, New Mexico. OCA Report No. 185-1175 submitted by UNM Office of Contract Archeology, Albuquerque, NM to the NM Historic Preservation Division, Santa Fe, NM.

2015 Archaeological Excavations at the Water Canyon Paleoindian Site (LA 134764), Socorro County, New Mexico: Interim Report for the 2012 and 2013 Field Seasons. OCA Report No. 185-1175, submitted to Historic Preservation Division of the New Mexico Department of Cultural Affairs, Santa Fe, by the UNM Office of Contract Archeology, Division of the Maxwell Museum of Anthropology, Albuquerque, NM.

2015 Water Canyon Paleoindian Fieldschool a Success! *Department of Anthropology Newsletter*, Winter 2015:7. University of New Mexico, Albuquerque.

2014 The Water Canyon Paleoindian Site: A Five-Year Plan for Interdisciplinary Research at the Energetic Materials Research and Testing Center, NMIMT, Socorro County, New Mexico. Research plan submitted to EMRTC by Office of Contract Archeology, a Division of the Maxwell Museum of Anthropology, University of New Mexico, Albuquerque, NM.

2014 "The Water Canyon Paleoindian Site – Interdisciplinary Research in West-Central New Mexico." *Maxwell Museum of Anthropology Newsletter* Vol. ??, No. ??. pp. ??.

2013 Another Bison Kill Discovered at Water Canyon: Implications for Southwestern Paleoindian Studies. *New Mexico Archaeology – The Newsletter of the Friends of Archaeology.* August 2013, pp. 8-11, Santa Fe.

2013 New Finds at the Water Canyon Paleoindian Site (LA 134764). *NewsMAC – Newsletter of the New Mexico Archeological Council,* Vol 2013-2.

2013 The Water Canyon Paleoindian Site – Preliminary Evidence of Site Formation Processes, Site Structure and Late Paleoindian Lifeways. In *From the Pueblos to the Southern Plains: Papers in Honor of Regge Wiseman*, edited by Emily J. Brown, Karen Armstrong, David M. Brugge and Carol J. Condie. Archaeological Society of New Mexico Volume No. 39, pp. 51-63.

2012 Continued Interdisciplinary Research at the Water Canyon Paleoindian Site (LA 134764), Socorro County, New Mexico: Interim Report for the 2010 Field Season and Data Recovery Plan for the 2012 Season. OAS Preliminary Report 42, Office of Archaeological Studies, Santa Fe, NM.

2012 The Water Canyon Paleoindian Site – A New Window into New Mexico's Distant Past. *El Palacio*, Volume 117, no. 3, pp. 54-59.

2011 Paleoindian Research at the Water Canyon Site (LA134764) *NewsMAC – Newsletter of the New Mexico Archeological Council*, Vol.2011-1, pp.2-12.

2011 Analysis of Soil and Radiocarbon Samples from the Caja del Rio & Water Canyon Paleoindian Sites. *New Mexico Archaeology – The Newsletter of the Friends of Archaeology.* May 2011, pp. 2-3, Santa Fe.

2010 *Archaeological Testing at the Water Canyon Site (LA134764), Socorro County, New Mexico: Interim Report for the 2008 and 2009 Field Seasons.* ERG Report No. 2009-09 submitted to the New Mexico Historic Preservation Division, Santa Fe, by Escondida Research Group, LLC, Santa Fe.

2002 *A Cultural Resources Inventory of 472 Acres in Socorro County, New Mexico: The Archaeology of the EMRTC / GLINT Project Area.* Report No. 2001-03 submitted by Escondida Research Group to Energetic Materials Research and Testing Center, New Mexico Institute of Mining and Technology, Socorro, NM.

Dello-Russo, Robert D., Robin Cordero and Banks Leonard

2021 Dello-Russo, Robert, Robin Cordero, and Banks Leonard. Chapter 6: Analytical and Interpretive Challenges Posed by Late Paleoindian Activity Areas at the Water Canyon Site, West-Central New Mexico. In *Diversity in Open Air Site Structure Across the*

Pleistocene/ Holocene Boundary. **Editors: Kristen Carlson and Leland Bement, University of Colorado Press, Boulder.**

Dello-Russo, Robert D, Susan J. Smith, Patricia A. Walker

2016 The black mat at the Water Canyon Paleoindian site near Socorro, New Mexico: A paleoenvironmental proxy data archive for the Pleistocene-Holocene transition, *in: The Geology of the Belen Area,* Frey, Bonnie A.; Karlstrom, Karl E.; Lucas, Spencer G.; Williams, Shannon; Zeigler, Kate; McLemore, Virginia; Ulmer-Scholle, Dana S., New Mexico Geological Society, Guidebook, 67th Field Conference, pp. 491-500.

Dello-Russo, Robert D., Patricia A. Walker and Vance T. Holliday.

2010 Recent Research Results from the Water Canyon Site, A Clovis and Late Paleoindian Locale in West-Central New Mexico. *Current Research in the Pleistocene*, Volume 27, pp: 30-31. Center for the Study of the First Americans, Texas A&M University, College Station, TX.

2009 *A Testing Plan for a Cienega Deposit at the Water Canyon Site (LA134764), Socorro County, New Mexico.* Research design submitted to the New Mexico Historic Preservation Division, Santa Fe by Escondida Research Group, LLC, Santa Fe.

Harden, Paul

2011 "Socorro – 10,000 B.C." Article published about recent discoveries at the Water Canyon site in *El Defensor Chieftain* newspaper, Saturday, June, 4, Socorro, NM.

Holliday, Vance, Robert Dello-Russo and Susan Mentzer

2019 Geoarchaeology of the Water Canyon Paleoindian Site, West-Central New Mexico. *Geoarchaeology, an International Journal, 1-29*.

Wentworth, Karen

2016 *Uncovering the Mystery of Very Early Humans in New Mexico*. University of New Mexico On-line Newsletter, March 16, https://news.unm.edu/news/uncovering-the-mystery-of-very-early-humans-in-new-mexico .

PROFESSIONAL CONFERENCE PAPERS or POSTERS

Robert D. Dello-Russo

2014 *Paleoindians in Socorro County: How the Cramers helped facilitate a decade of research collaboration in west-central New Mexico.* Paper presented at the 79th Society for American Archaeology Annual Meeting, Symposium 466: "The Cramer Endowments, Private Funding and the Search for the First Americans: A Session in Memory of Joseph L. Cramer." Austin, TX.

2013 *Five Exciting Years of Paleoindian Discoveries at Water Canyon.* Poster presented at the Paleo-American Odyssey Conference, Santa Fe, NM.

2011 *The Water Canyon Paleoindian Site: Paleoenvironmental Inferences for the Pleistocene-Holocene Transition*. Presentation at the New Mexico Archaeological Council Fall Conference: "Pre-Ceramic Hunters, Foragers, and Early Farmers in New Mexico", November 12, Hibben Center, University of New Mexico, Albuquerque, New Mexico.

2011 *Paleoindians at the Water Canyon Site. Recent Archaeological Discoveries in Socorro County, NM*. Taos Archaeological Society, 7-6-11, Fort Burgwin, Taos.

2011 *Paleoindians at the Water Canyon Site. Recent Archaeological Discoveries in Socorro County, NM*. Albuquerque Archaeological Society, 2-15-11, Albuquerque, NM.

2010 *Paleoindians and Persistent Places: Recent Discoveries at the Water Canyon Site, Socorro, NM*. Santa Fe Archaeological Society meeting, 10-18-10, Santa Fe, NM.

Dello-Russo, Robert D. and Vance T. Holliday
2019 *Paleoindians beyond the edge of the Great Plains: The Water Canyon site in western New Mexico.* Paper presented at the 84th meeting of the Society for American Archaeology, April 12th, Albuquerque, NM.

Robert Dello-Russo and Susan Smith
2013 *The Water Canyon Paleoindian Site: A Significant Archive of Paleoclimatic Data for the Early Holocene in West-Central New Mexico.* Paper presented at the 125th Anniversary Geological Society of America, Topical Session 24: "Climate Change in the Interior Western United States from the Last Glacial Maximum to the Holocene." Denver, CO.

2011 *A Paleoindian Sense of Place: Snapshots of the Early Holocene Environment in West-Central New Mexico.* "From Lubbock Lake to Lehner Ranch: Paleoindian Chronologies, Technologies, Paleoenvironments, and Land-Uses Across the Southern High Plains – Southwest Boundary" Symposium at the 69th Plains Anthropological Conference, Tucson, AZ.

Robert Dello-Russo and Patricia Walker
2010 *Thoughts about Paleoindians and Persistent Places on the Landscape: Recent Discoveries at the Water Canyon Site, Socorro County, NM.* Philmont Archaeological Conference, Cimarron, NM.

Dello-Russo, Robert, B. Leonard and R. Cordero
2017 *Analytical Challenges Posed by the Early Holocene / Late Paleoindian Activity Areas at the Water Canyon Site, West-Central New Mexico.* Paper presented at the 82nd Annual Meeting of the Society for American Archaeology, Vancouver, BC, Canada.

Robert Dello-Russo, Susan J. Smith, Chad Yost, Barbara Winsborough, Stephen Hall, Pamela McBride and Owen Davis

2016 *The Black Mat at the Water Canyon Paleoindian Site and a New Paleoenvironmental Record for the Pleistocene-Holocene Transition in West-Central New Mexico.* Poster presentation for American Quaternary Meeting 2016: Retooling the Quaternary to Manage the Anthropocene / Section III. Paleoecology: Tools, Models and Novel Approaches. Santa Fe, NM.

<u>REQUESTED PUBLIC PRESENTATIONS</u>

Dello-Russo, Robert D.

2019 *Geoarchaeology and Paleo-Environment of the Water Canyon Paleoindian Site.* Taos Archaeological Society, 11-12-19, Taos, NM.

2018 *The Water Canyon Paleoindian Site.* Oasis lecture – Albuquerque, NM. 9-20-18.

2018 *The Water Canyon Paleoindian Site*. Beer and Bones Lecture. Walk-in-the-Park Productions, Denver, CO. 10-6-1.

2018 *Moving Sediment and Mobile People: A Fascinating Paleoindian World Revealed at the Water Canyon Site.* Jornada Research Institute, 8-24-18, Tularosa, NM.

2018 *Buried for 10,000 Years: Startling New Discoveries at the Water Canyon Site.* 2018 Southwest Seminars – Voices from the Past 2018 Lecture Series, 6-11-18, Santa Fe, NM.

2018 *Ten Years of Interdisciplinary Research: The Significance of the Water Canyon Paleoindian Site in New Mexico.* Albuquerque Archaeological Society, 1-16-18, Albuquerque, NM.

2017 *Water Canyon: The Most Important Paleoindian Site in New Mexico Since the Discovery of Blackwater Draw? 10-28-17,* El Paso Museum of Archaeology, *El Paso, TX.*

2013 *Water Canyon 2013: The Discovery of the 2nd Paleoindian Bison Kill Component.* Presentation to the Cultural Resource Preservation Committee of the New Mexico State Historic Preservation Office, Santa Fe.

2012 *Paleo-Indian Ecology: The Early Holocene at the Water Canyon Site in West-Central New Mexico.* Southwest Seminars- Ancient Sites, Ancient Stories, 1-23-12, Santa Fe, NM.

2011 *Paleoindians at the Water Canyon Site: Recent Archaeological Discoveries in Socorro County, NM.* Presentation to the Albuquerque Archaeological Society, Albuquerque, NM. February 11.

2011 *Paleoindians at the Water Canyon Site. Recent Archaeological Discoveries in Socorro County, NM*. Sierra Club, 2-22-11, Sevilleta National Wildlife Refuge, Socorro County, NM.

2010 *A Paleoindian Oasis? Interdisciplinary Discoveries at the Water Canyon Site*. Presentation for Office of Archaeological Studies Brownbag Series, 2-23-2010, Santa Fe, NM.

2010 *Paleoindians and Persistent Places: Recent Discoveries at the Water Canyon Site, Socorro County, NM.* Presentation to the Archaeological Society of Santa Fe, NM. October 18.

OFFICE OF CONTRACT ARCHEOLOGY

REPORT NO. 185-1318

Maxwell Museum of Anthropology

University of New Mexico

2021