DOLORES ARCHAEOLOGICAL PROGRAM TECHNICAL REPORTS

Report Number
DAP-061

Environmental Studies Report

Report Number: DAP-061

compiled by

Bruce F. Benz and Vickie L. Clay

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PREFACE

The Environmental Studies Group of the DAP (Dolores Archaeological Program) began operation informally during the initial field season at Dolores in 1978. From the beginning of its operation, the DAP staff recognized the need for a wide range of modern environmental data so that the prehistoric environments of the Dolores area could be derived and their role in cultural adaptation explained. Understanding the relationship between local environments and prehistoric communities is a major research emphasis as set forth in the project's general research design. The Environmental Studies Group was formally constituted after the 1978 field season to provide such data.

As originally conceived, the Environmental Studies Group was to continue the necessary studies throughout the life of the DAP in complement to analysis of botanical, faunal, and geological materials recovered from archaeological contexts. In April 1981, however, the contractor was directed by the Bureau of Reclamation to terminate the environmental studies program and to prepare a final report by 30 September 1981; after that time, only analysis and reporting of archaeological materials were to continue. Given this abrupt change in emphasis, and the continuing analytical responsibilities of the Environmental Studies Group, the production of the requested final report was, by necessity, an ad hoc effort.

In comparison with other project reports, the final Environmental Studies Report received less thorough treatment by the report production staff. This was primarily a consequence of the short period available for production of the report; also a contributing factor was a coterminous

reorganization within the report production department, which affected labor allocations. Despite the lack of writing and editorial time, a draft of the final report was submitted to the Bureau of Reclamation shortly after their specified deadline.

After submission of the draft, the complete report was circulated to the compilers and authors and to members of the DAP senior staff for review. This process, which is standard DAP procedure, identified a number of problems with the report. Most of the authors, who were unable to review their manuscripts prior to the draft submission, suggested extensive revisions in their sections, and it was recognized by the senior staff that the draft report probably did not meet DAP standards. However, the report was accepted without comment by the Bureau of Reclamation.

Presently, the DAP staff is in agreement on the need for ultimate revision of this report; however, through continuing discussions and correspondences with the Bureau of Reclamation, it has been requested that the report be submitted in final form without the implementation of the internally generated DAP comments and revisions. To comply with this request, the DAP is submitting the unmodified report to the Bureau of Reclamation as the final.

This report is essentially unedited and unrevised. There has not been the opportunity to implement the numerous suggestions and revisions provided by the authors and reviewers. We think that it is important that the reader be aware that the DAP staff does not consider this report adequate for circulation in its present form and that the condition of this report should in no way be taken as a reflection of the abilities of the authors, compilers, editors, or internal reviewers of the DAP.

One further caution and recommendation for the reader of this report: The data contained herein is the best that could be compiled under a very tight schedule. Much of it was not verified, and there are probably some errors. The DAP will produce a report entitled "Studies in Environmental Archaeology" in 1984 or early 1985. That report will contain updated verified data along with revised discussions and conclusions. The DAP recommends that the reader refer to this future report for the best information on the results of the DAP Environmental Studies Group.

ACKNOWLEDGEMENTS

For their assistance in compilation of this report we would like to thank Meredith Matthews and Beth Griffitts for compiling the faunal, pollen and vegetal tables and supporting us through many hours of less than normal behavior. We would also like to thank Jim Lowrie, Forest Service Biologist, Adrian Fisher, San Juan Basin Researcher at the Arriola Experiment Station, Donald Larue, Bureau of Reclamation Great Cut Laboratory Supervisor, and Dave Simrak Bureau of Reclamation Geologist for graciously consulting with us on this report. Ken Petersen and Allen Kane are also greatly appreciated for reviewing portions of this chapter.

Further thanks is extended to all of those persons who participated in the Dolores Archaeological Program's Environmental Studies Group (E.S.G.). These people included over the years; Richard Glaser, James Hampson, Vance Holliday, and Lucy Piety in geology; Steven Emslie, Paul Schneider, Beth King, and Meg Van Ness in fauna; and Ann Cooper, Mary Floyd, Brent Graham, Karen Laitner, William Litzinger, Shelli Nelson, Linda Scott, Rita Shuster, Lynne Sikkink, Lynn Udick, William A. Weber, and Ann Lucy Wiener in botany.

These people gave extensively of their time in both field and laboratory situations to provide the basis of this report. We thank them all.

ABSTRACT

The Environmental Studies Group has completed laboratory and field studies that serve as a comparisons for projections back in time. These include maps that inventory the present day bedrock geology, landforms, soils stream orders, and present and potential-natural vegetation. Two experimental gardens provide case studies of the potential of subsistence agriculture in the Dolores Archaeological Project area under present day conditions.

Analysis to date of geological, faunal, and floral (including pollen and tree-ring) matrials recovered from archaeological sites gives indications that the resources used prehistorically are similar to those available today. Further, the C-14 dated studies of plants collected by packrats and accumulated in their middens and the stratigraphy of Sagehen Marsh suggest that the plants and environment during Pueblo occupation may have been similar to that of today. Estimates of annual precipitation (Based on transformations of southwestern Colorado tree-ring indices) have been extended back to AD 909 and will be extended even earlier.

Sedimentary fill in prehistoric pitstructures provide depositional records that bridges the gap between pueblo occupation and the present. A study is proposed to analyze some of these in the Project area. Finally, the evaluation of sampling designs used dictates that caution and experience be used in interpreting archaeological materials recovered in the Project area. Poor preservation of organic material has been a major obstacle.

SECTION 1

INTRODUCTION

by

Bruce F. Benz and Vickie L. Clay

OBJECTIVES AND MODELS

The objectives of the Dolores Archaeological Program (D.A.P.) Environmental Studies Group (E.S.G.) can be described only after defining the term environment. In defining environment it should be recognized that many parts of our surroundings can be isolated to further describe the area of interest (e.g., cultural environment, terrestrial environment, social environment, to mention only a few). By isolating the human organism as the focal point, environment might be defined as the sum total of physical and biological factors that impinge upon the survival and reproduction of human populations through time and in space. This definition recognizes a dynamic system that can be broken down further, if necessary, to isolate the dynamics of particular factors.

The Dolores Archaeological Program's Research Design (Kane et al [1]) recognizes the processual interaction of humans, biota, and abiota in stating the importance of understanding human-ecosystem interaction (Problem Domain 1). More specifically, the E.S.G. realizes that humans extract energy and materials from their surroundings as a means of survival. The various forms of materials and energy, as well as the hypothesized means of extraction, are subsumed under the multifaceted concepts of economy and adaptation. Objectives of the E.S.G. relate specifically to describing, understanding, and explaining the reciprocal interaction of humans and environment through examining the materials and forms of energy that were and are extracted and extractable from the environments of the D.A.P.Area. These materials and energy are here considered as resources.

Not all materials and energy which are extractable from a human population's immediate surroundings are utilized. Furthermore, not all resources which are exploited necessarily originate in a human population's immediate surroundings. Both of these statements recognize the need to identify resource use versus availability, while considering cultural component of resource availability and use, social interaction. Realizing that resources may be available but go unused, and that some used resources maybe of nonlocal origin suggests the need to identify the entire realm of potential resources within the area of interest. We also recognize that as Twentyth century investigators, our bias, or ethnocentrism, limits our objective identification of resources. In general, describing resource availability and use requires documenting what extractable resources are available, how availability and extractability might have changed over some 900 + years, and what materials and related energy sources are present as a part of the prehistoric human resource base. To answer these questions, tasks undertaken by various E.S.G. personnel involved investigations of contemporary and prehistoric environments, of ethnographic literature, and of archaeological materials and contexts. Needless to say, the majority of tasks undertaken by E.S.G personnel have focused on the Dolores area.

The initial step in determining whether a resource was available to prehistoric inhabitants necessitates an assessment of that resource's availability today. While the present-day distribution of certain resources probably does not directly reflect prehistoric distribution of those resources, describing the environment of today allows a coherent dialogue for further investigations concerning the interaction of environmental materials and energy. Mapping of present-day bedrock,

landforms, soils, drainage, and vegetation has been the first step toward understanding resource distribution. Concurrent with general Project area mapping, collection of abiotic and biotic specimens has allowed D.A.P. personnel to recognize the variability in potential and real resources. The material source specimens (as these are called for abiotic resources) are used as comparative samples in identifying the type of material that was used prehistorically (Travis [2], Phagan and Maloney [3]). Biotic materials collected in the Dolores area are used primarily for identifying the specimens found in archaeological contexts. The differential vagaries of preservation, factors of bioturbation, as well as historic and recent introduction limit the use of these specimens for directly identifying the materials from archaeological contexts as local and/or as utilized resources. The condition of biotic remains (e.g., burned or possessing cut marks) provide a more substantive basis for making the determination that biotic remains represent utilized resouces (cf. Minnis [4], Keepax [5]).

Additional investigations concerning resource availability have been undertaken in an attempt to document resource use through ethnographic analogy. These investigations are considered linkage studies in that they are potentially useful for relating modern and historic resource use to prehistoric resource use. Ethnobiologic literature has been reviewed in an attempt to describe the range of botanical and zoological organisms considered as resources by Native Americans of the greater Southwest. Other linkage studies undertaken by the E.S.G. specifically discuss the implications of today's environment for understanding the prehistoric cultural manifestations in the Dolores area. These linkage studies

examine the erosion and deposition of sediments and the soil formation characteristics at archaeological sites in an attempt to understand the processes of archaeological site formation. Comparative studies of crop plants have been undertaken to examine the potential for subsistence agriculture in the Dolores area (Shuster [6, 7]). Two additional studies have been undertaken to reconstruct past climatic and environmental conditions in the Dolores area over the past 1000 years as evidenced by depositional histories in pitstructures by rates and packrat midden accumulations.

Analysis of archaeological materials which are representative of the biotic environment has been undertaken to directly address questions from Problem Domain 1 in the D.A.P. Research Design. Much progress has been made toward determining what might have been considered a resource by the prehistoric inhabitants of the Dolores area. In addition, methodological progress has been made for determining what remains might actually be associated directly versus indirectly with cultural occupation.

Certain investigations attempted by the E.S.G. are hybrid studies that combine aspects of archaeological materials analysis and linkage studies. These studies seek to determine what environmental conditions might have existed prehistorically, how human occupation was affected by these conditions and how these conditions were affected by human occupation. Unfortunately, most available material (e.g., pollen samples and dendrochronological specimens)is derived from cultural contexts and very little is from nonarchaeological contexts. The desire for materials from non-cultural contexts can be understood by realizing that natural environments can be reconstructed using archaeological materials only if the nature of the cultural screen is recognized. The cultural screen

might be defined as the bias in the artifactual and ecofactual assemblages which exists because of group perception in resource collection and of location of occupation. This concept might be equated with the cognized versus realized environments mentioned by Vayda and Rappaport [8]. The need to collect environmental materials from noncultural contexts has been recognized. In addition to one study, attempted in the Project area by Petersen [9], dendrochronological climatic reconstruction and packrat midden studies have been carried out and reported in this chapter.

One Problem Domain 4 in the D.A.P. Research Design is devoted specifically to identifying the movement of goods and information between the prehistoric occupants of Dolores and of surrounding areas. The Reductive and Additive Task groups have been more involved with this question than has the E.S.G. The E.S.G. has not yet had a chance to examine the archaeological remains specifically for exotic biological materials although it is recognized that most domesticates are not indigenous (e.g., maize, beans, squash). The question of interregional movement of domesticates has been addressed by recent studies of maize (Doebly and Bohrer [10], Galinat et al. [11]), and intensive analysis of the D.A.P. maize remains is recommended.

The theoretical framework within which the E.S.G. operates integrates a number of models which are used to describe and explain resource availability and use. The E.S.G. Midlevel Research Design identifies the research focus as one of understanding the "types and intensities of interaction between the environment and humans" (Bye [12:2]). This focus can be further subdivided into component models which facilitate examination of two classes of archaeological cultural material--bone and

plant. The models which direct investigations about prehistoric plant and animal exploitation recognized at the outset that the most intensive period of D.A.P. area occupation is characterized by the presence of subsistence agriculturalists. It must be recognized that agricultural activities can be equated with the highest level on a continuum of plant-human interaction; the lowest level on this continuum could be associated with hunting and gathering societies. In investigating an agricultural society (at least in part) it is emphasized that the various plants and animals used as resources respond to human activities. That is, harvested plants and animals might be classified as wild, tolerated, encouraged, or domesticated. The model of organismic response to human activities might then be characterized as levels of organism-human interaction. The "levels of interaction model" has been promoted and examined by various investigators (Bye [12], Harlan and De Wet [14], Harlan [15]).

Multiple cropping theory is another means by which we can examine the agricultural activities of the D.A.P. area's prehistoric inhabitants. Multiple cropping refers to an agricultural practice in which plants are cultivated at the same time and in the same space even though individual plant's growth requirements may overlap to the extent that interspecific competition will adversely affect productivity (cf. Papendick et al. [16]). Further, a multiple cropping system allows a diversity of harvestable yields and provides a more stable ecosystem than does a monoculture system. The basis for applying this principle to the Puebloan occupation of the Dolores area is the observation that the Tarahumara of Chihuahua, Mexico, practice this cultivation system (Bye [13]). The Tarahumara provide a suitable analog in that this group has been

characterized as subsistence agriculturalists.

A third model which seems suited to understanding the hunting practices of the D.A.P. area Anasazi is garden hunting (Linares [17]). This model refers to the characteristic assemblage of faunal species which commonly occupies ecotonal or early sereal communities of an ecosystem. Since the Anasazi were disturbing and modifying the Dolores area through their agricultural practices, ecotones and anthropogenic communities (early secondary seres initiated and maintained by man (Bye [13:123]) would be expected to occur. Consequently, it is expected that animals were procured in agricultural fields.

The three models which structure the E.S.G.'s examination of biotic archaeological remains can all be subsumed under a more general model. This general model is the ecosystem development model (Odum [18]). The description of the developmental stages of ecosystem development aptly characterize biotic resource availability of plants and animals affected by agricultural practices. That is, agricultural practices set the ecosystem back to the developmental stages which are beneficial to human subsistence. In addition to the productivity harvested in the form of domesticated plants, weedy plants and grazing animals are present and may be tolerated and/or encouraged. Exploitation of tolerated and encouraged weeds by prehistoric inhabitants may be subsumed under the multiple cropping theory. The possibility that weeds were considered resources, and thus were tolerated or even encouraged, and then exploited, suggests that various levels of plant-human interaction existed. Further, the herbivores (or grazing animals) were likely to take advantage of annual herbs which were found in these developmental ecosystems.

Leonhardy [19] has described the basic abiotic attributes of the D.A.P. area. Inherent in his description of the soils in the area is a realization that soils of today are dynamic entities undergoing development in much the same way as plant communities. (The term "ecosystem" used here and by Odum [18] includes soils, since soils are a combination of abiotic and biotic components.) Although it is difficult to consider the characteristics of present-day soils as being the same as in prehistory, there are few opportunities to examine the process of soil development. As a result it is necessary to assume soil attribute continuity through time. As described by Leonhardy, certain aspects of the abiotic environment, such as bedrock geology and gross topography, have probably not changed dramatically in the past 1000 years. As is discussed later in this chapter (Section 5a), however, the description of modern drainage patterns is probably not the same today as it was in the past. Basically, the description of earth resources by Leonhardy was a base line from which the E.S.G. has elucidated the parameters of environmental change that have taken place in the D.A.P. area. Bye [12] has contributed to this description in his discussion of present-day plant communities in the D.A.P. area.

A proposed study for mapping "agricultural potential" (Darsie [20] represents one use of E.S.G. assembled information that contributes to the modeling efforts of the D.A.P. This study proposes to elucidate environmental variability through examination of soils, landforms, hydrology, and topography in the D.A.P. area and, to eventually, to define agricultural potential spatially. Consideration of limiting factors on agriculture through time will come from information derived from the

D.A.P. Experimental Gardens, linkage studies dealing with environmental change, and the models of resource use and ecosystem development.

THE ORAGANIZATION OF THIS REPORT

The section immediately following is administrative. Sections 3-6 are summaries or final reports of studies accomplished to date. Section 3 describes the status of analysis of biotic and abiotic archaeological materials. As will be evident in Section 2, disparity exists between the progress of geologic, pollen, faunal, and macrobotanical analyses. Consequently, substantive information presented in Section 3 will vary. Section 4 describes or reviews reconnaissance of contemporary environments of the Dolores area. Information on contemporary environments is derived from earlier project contributions (e.g., Bye [12], Emslie [21]) and from investigations carried out by other Federal and State organizations (e.g., Siemer [22]). The contents of Section 5 describe studies carried out under the auspices of the D.A.P. The investigations reviewed and described in Section 5 represent proposals for future work, tasks accomplished through fieldwork, and information obtained through library research. Section 5 presents information which attempts to tie together the results of reconnaissance of contemporary environments in the Project area with archaeologically derived data obtained through fieldwork. Section 6 summarizes the contributions of the E.S.G. to the Dolores Project. This section also summarizes the data pertinent to resolving questions regarding prehistoric resource availability and use. Finally, two appendices are included to list pertinent off-project reports and papers which are based on E.S.G. activities, and to discuss the evolution of bulk soil and pollen sampling design.

SECTION 2

NATURE AND STATUS OF ENVIRONMENTAL STUDIES GROUP ACTIVITIES, 1978-1981: ADMINISTRATIVE REPORT

contributing authors

Bruce F. Benz and Vickie L. Clay

SECTION 2a: STATUS OF PERSONNEL AND MACROBOTANICAL ANALYSIS

by Bruce F. Benz

The inception of the E.S.G. was based in part on the D.A.P.'s need for personnel to direct sampling and to analyze prehistoric botanical remains. At the beginning of field operations, during the summer of 1978, W. Litzinger was hired to oversee the collection, processing, and later analysis of archaeobotanical materials. Over the course of this summer, Litzinger sought to extend the scope of his work by sugggesting that contemporary reconnaissance of floral environments would augment the information derived from archaeobotanical materials. The scope of work he proposed had two major concerns: 1) to assess contemporary floristics in relation to research design development for undertaking site catchment analysis and to begin a modern botanical voucher collection comprising herbarium and comparative specimens for use in identification of archaeobotanical materials; and 2) to develop and implement guidelines and procedures for collecting, processing and analyzing archaeobotanical materials from D.A.P. area sites (Litzinger [23]). The objectives outlined by Litzinger eventually gave rise to the Botanical Section of the E.S.G. During the latter half of 1978, three additional persons were hired (B. Benz, M. Mathews, and S. Nelson) by the E.S.G. to initiate analysis of archaebotanical materials and to compile the Comparative Ethnobotanical Data File (cf. Bye [12]).

In February of 1979, R.A. Bye was commissioned to oversee all E.S.G. activities. Bye continued as a Co-Principal Investigator in charge of the E.S.G. until June 1981. During the 1979 field season four additional

persons were hired, M.E. Floyd, M. Van Ness, R. Shuster, and L. Udick; Floyd engaged in botanical reconniassance and mapping, Van Ness undertook comparative ethnobotanical specimen collection, and Shuster managed the D.A.P. experimental gardens (Shuster [6]). Benz, Matthews, Nelson, and Udick participated in and supervised the collection of bulk soil and pollen samples from archaeological sites. Benz, Matthews, and Nelson analyzed archaeobotanical specimens following the field season.

During the 1980 field season, Litzinger, Benz, Matthews, and Shuster continued in their respective roles. Litzinger terminated his association with the D.A.P. in September 1980. Benz supervised field operations during the 1980 field season. E. Griffitts and A. Wiener were hired during the field season to analyze archaeobotanical material and to consult in field bulk soil and pollen sample collection respectively. Analysis of archaeobotanical materials continued during the September to December 1980 period. Three additional part-time analysts were hired for this period (A. Wiener, K. Laitner, and L. Sikkink). In January of 1981 the Botany Section of the E.S.G. was moved to the Laboratory Facility at Lebanon, Colorado, with Benz as Task Specialist and Matthews and Griffitts as analysts.

During the three year tenure of the E.S.G. (1978-1980), the Botany Section has participated in the collection of 7012 bulk soil samples and 1895 vegetal material specimens from archaeological sites (Table 1.2.1).

Table 1.2.1. Archaeobotanical Specimens Collected During 1978, 1979, 1980 Field Seasons

	1978	1979	1980	Total
Bulk Soil Samples	982	3390	2640	7012
Vegetal Material Specimens	250	961	684	1895

At the time of this writing, all vegetal material specimens have been processed through preliminary identification. Approximately 700, or 10 percent, of the bulk soil samples have been subjected to preliminary analysis. Needless to say, future archaeobotanical analysis should emphasize preliminary analysis of bulk soil samples.

At present, no macrobotanical (bulk soil and vegetal) data have been computerized. The data for those specimens processed through preliminary analysis exist on 5 by 8 inch cards. Computer input of macrobotanical data is currently in progress.

During the three years of botanical field reconnaissance, approximately 3000 botanical voucher specimens and 2000 ethnobotanical comparative specimens have been collected. Nearly all of the voucher specimens are currently on file at the Laboratory of Ethnobotany, University of Colorado. It is anticipated that one voucher specimen from each set of duplicate voucher specimens will be deposited at the University of Colorado herbarium. All ethnobotanical comparative specimens are present at the D.A.P. Laboratory Facility in Lebanon, Colorado. The latter specimens are currently being used to aid in the identification of macrobotanical material collected during excavation.

SECTION 2b: STATUS OF FAUNAL ANALYSIS

by Bruce F. Benz

Since the inception of the D.A.P., analysis of all animal remains has been done on a consultant basis by S. Emslie, currently co-director of the Center for Western Studies. In addition, investigations of present-day fauna in the D.A.P. area were carried out by Emslie and P. Schneider, an E.S.G. member during the summer of 1979 (Emslie [21]). Emslie's tenure as full-time consultant with the D.A.P. terminated in June of 1981.

Analysis of faunal material has been completed for all sites excavated through 1980 with the exceptions of Site 5MT2182 and Site 5MT0023. All information derived from this analysis is available through the D.A.P. Data Processing Group (D.P.G.). One problem which currently affects the use of computerized faunal data is the determination of minumum number of individuals. Since the size of certain sites' faunal assemblages is very large (e.g., Site 5MT4475, Site 5MT0023) the analysis of these remains has been carried out at the level of Field Provenience (F.S.). In many cases, this unit cannot be directly associated with any specific cultural unit.

SECTION 2c: STATUS OF POLLEN ANALYSIS

by Bruce F. Benz

Pollen samples obtained from excavation of cultural occupations in the D.A.P. area have been processed and analyzed by L. Scott (currently of Palynological Analysts), acting as a project consultant. Results of certain analyses are available in Scott [24]. From 1978 through the present, L. Scott has analyzed some 300 pollen samples. These samples constitutes approximately 7 percent of the total 3890 pollen samples collected to date (Table 1.2.2)

Table 1.2.2 Total Pollen Samples Collected from Archaeological Contexts during 1978, 1979, and 1980 Field Seasons

	1978	1979	1980	Total
Pollen Samples	314	772	2640	3890

Currently some 2809 lines of pollen data from these 300 samples are contained in the D.P.G. computer files.

SECTION 2d: STATUS OF DENDROCHRONOLOGICAL ANALYSIS

by Bruce F. Benz

Since the D.A.P.'s inception, the Laboratory of Tree-Ring Research, Tuscon, has consulted for the analysis of archaeological specimens for dating and paleoclimatic reconstruction (Robinson and Petersen, Section 3, this chapter). During the past three D.A.P. field seasons, 1608 dendrochronological specimens have been collected (Table 1.2.3).

Table 1.2.3 Dendrochronological Specimens Collected During 1978, 1979, and 1980 Field Seasons

	1978	1979	1980	Total
Number of Specimens	344	607	657	1608

Of these 1608 specimens 161 or 10 percent have retained sufficient integrity and are of a sufficient age to be datable. At present no information concerning the dating of these specimens has been computerized. Most of this information is included in D.A.P. site reports.

SECTION 2e: STATUS OF EARTH RESOURCE ANALYSIS

by Vickie L. Clay

Geoarchaeology, as defined by Hassan [25:267], is the "integration of earth sciences and the human past." At least nine different geoarchaeological topics have appeared in contemporary archaeological literature. These include studies of site locational analysis, regional and onsite stratigraphy, site geomorphological analysis, sedimentological analysis of site deposits, paleoevironmental analysis, raw material source analysis, modeling of man-landscape interactions, and dating techniques. The D.A.P. Earth Resource personnel have been actively collecting and collaborating with project archaeologists on many of the preceding topics. A brief summary of the contribututions of the Earth Resource program, as a history of its development, follows.

The D.A.P. did not undertake geological analysis of any nature during the 1978 field season. Not until the winter staff meeting of 1979 was a need recognized for geological analysis and field work to address Problem Domains 1 and 4 of the D.A.P. Research Design. To facilitate the development of a cohesive working environment, geological studies were put under the auspices of the Environmental Studies Group. Direction of a three member crew (V. Clay, R. Glaser, and J. Hampson) was provided by F. Leonhardy, acting as consultant to the project. The crew expended 2040 hours in field reconnaissance and map preparation. The consultant provided 160 hours of direction and soils mapping. Results of these 1979 time expenditures include:

1. Geology for the Dolores Archaeological Project Area: A Summary of Information, compiled by F. Leonhardy [19].
2. Soil reconnaissance map for the D.A.P., by F. Leonhardy.
3. Preliminary bedrock geology map of the D.A.P., by V. Clay, R. Glaser, and J. Hampson.
4. Preliminary general landforms map of the D.A.P., by V. Clay, R. Glaser, and J. Hampson.
5. Drainage areas and stream order map of the D.A.P., by R. Glaser, and J. Hampson.
6. Geological bibliography and available map resources for D.A.P., by V. Clay [26].
7. Dolores Archaeological Program Stratigraphic Description Manual and Site Stratigraphy Form, by F. Leonhardy [27].
8. Numerous geological reports and memorandum describing excavated archaeological sites, localities, and resource potentials.
9. Collection from 17 sites of 228 bulk soil-sediment samples, seven soil monoliths, and six soil peels.

The 1979 geological field season may be summarized as a descriptive phase wherein the modern abiotic environment was mapped and archaeological site geology was described.

Employment of geologists to evaluate project-wide Earth Resources was continued in the 1980 field season. R. Glaser and J. Hampson made up a two-person field team which was directed by the objectives set forth by

Leonhardy [19] in 1979. In addition to this crew, V. Holliday and L. Piety were employed as consultants to continue work outlined by Leonhardy and to aid in micro-geomorphological descriptions of archaeological sites. Expenditures of 1652 crew hours and approximately 160 consultant hours resulted in the following contributions:

1. Geological investigations of the Dolores Archaeological Program 1980, by V. Holliday and L. Piety (Section 4d, this chapter).
2. Surficial geology map of the D.A.P., by V. Holliday and L. Piety (Section 4d, this chapter).
3. A model for stratigraphy in pitstructure fills at the D.A.P., by R. Glaser (including in Section 5b, this chapter).
4. Numerous geological reports describing excavated archaeological sites.
5. Collection from 13 sites of 457 bulk soil-sediment samples and 22 monoliths.

The 1980 field season witnessed the completion of preliminary mapping of the modern abiotic environments in the Project area with the Surficial Geology Map. A model of pitstructure fill was presented to explain site stratigraphy seen in numerous pitstructures, thus turning a corner in earth resource studies from base line data gathering toward interpretative studies.

During the 1981 field season, V. Clay was employed as Earth Resource Crew Chief; one part-time crew chief, R. Glaser, preceded the employment of Clay. A total of 978 hours were expended, resulting in the following contributions:

1. Stratigraphy of Sagehen Marsh, by V. Clay (Section 5a, this Chapter).
2. Proposal for the analysis of soil monoliths, by V. Clay (Section 5b, this chapter).
3. Participation in the D.A.P. modeling effort of prehistoric agriculture potential (Darsie [20]).
4. Collection of eight bulk soil-sediment samples and eight C-14 samples from Sagehen Marsh.
5. Refinement and editing of 1979 and 1980 reports and maps concerning project earth resources and site formation processes.

The 1981 earth resource effort has been directed at specific interpretative reporting, analysis, and refinement of existing geological maps. Pace and emphasis of excavation allowed no geological sampling during the season.

A detailed account of geological samples currently stored by the D.A.P. Laboratory appears in Table 1.2.4. Additional information about stratigraphic description forms and geological site reports also appears in this table.

At present, 59 project photographs have been coded as being of geological interest. These include numerous soil, bedrock, landform, and hydrology photographs. Potential exists to code additional D.A.P. photographs of geological interest and to form a geological study package, as outlined by Nylander [28].

In summary, the D.A.P. Earth Resource section of the Environmental Studies Group has described the present abiotic environment of the Project area in some detail during two extensive field seasons. Sediment samples

Table 1.2.4. Tally of Earth Resource Samples 1978-1981.

SITE #	TOTAL # OF BS-SS (by year)	TOTAL # OF MONOLITHS (by year)	# OF SOIL PEELS	# OF STRATUM DESCRIPTIONS	# OF GEOLOGICAL SITE REPORTS
5MT0023	32 (79)	3 (79)	1 (79)	30 (79)	1
	83 (80)	4 (80)		32 (80)	1
5MT2151	8 (79)	1 (79)	1 (79)	3 (79)	
5MT2161	3 (79)	1 (79)			
	24 (80)	1 (80)			
5MT2182	46 (80)	2 (80)		5	
5MT2192				3 (79)	1 (79)
5MT2193	10 (79)			1 (79)	
5MT2194	10 (79)				
5MT2199	13 (79)			1 (79)	1 (79)
5MT2203	7 (79)				1 (79)
5MT2215	23 (80)	1 (80)		1 (80)	
5MT2235	1 (78)				
5MT2242				4 (79)	1 (79)
5MT2320	12 (79)			2 (79)	1 (79)
5MT2854	9 (79)	1 (80)	2 (79)	1 (79)	1 (79)
5MT2858	15 (79)	1 (79)		1 (79)	1 (79)
5MT4475	2 (78-79)	5 (78)			
	30 (80)	1 (80)		1 (80)	1 (80)
5MT4477	21 (80)	1 (80)		1 (80)	
5MT4479	47 (80)	2 (80)		2 (80)	1 (80)
5MT4480	50 (80)	2 (80)		4 (80)	
5MT4512	20 (79)		2 (79)	4 (79)	1 (79)
5MT4545	8 (79)				1 (79)
5MT4614	13 (79)			3 (79)	1 (79)
5MT4644	11 (79)	1 (79)		1 (79)	1 (79)
5MT4650	20 (80)	1 (80)		3 (80)	
5MT4654	40 (79)				
5MT4671	73 (80)	2 (80)		5 (80)	1 (80)
				1 (79)	
5MT4684	23 (80)	2 (80)		2 (80)	
5MT4797	14 (80)			1 (80)	
5MT5361	3 (80)	2 (80)		1 (80)	1 (80)?
G 1*	15 (79)				
	IC-14				
G 2**	IC-14				
G 3***				2 (79)	
G 4****				1 (79)	
G 5*****	8 (81)			2 (81)	1 (81)
	8 C-14 (81)				

G 1* - strata under Grass Mesa Site 5MT0023
G 2** - near Site 5MT2242
G 3*** - upper experimental garden
G 4**** - lower experimental garden
G 5***** - Sagehen Marsh

have been collected from archaeological contexts and await analysis. Based on these analyses and interpretations and on future modeling efforts, the Earth Resource personnel will have contributed to the D.A.P. effort to assess prehistoric economy and adaptation, foreign interactions, and interaction of culture with the physical environment.

SECTION 2f: BUDGETARY SUMMARY

by Bruce F. Benz

During the three plus years the D.A.P. has been in existence, $240,857 has been budgeted for the E.S.G. and consultants (Table 1.2.5). These funds have been spent on material collection, data collection, data analysis, and report preparation. Appendix A lists the reports, theses, and papers contributed which use, to some extent, data collected by the E.S.G.

Table 1.2.5. Budgetary Summary of the DAPESG for FY 1979, 1980, 1981.

FY 1979 (June 1978 - September 1979):

DAP Personnel:	Botany Section	18,527.00
	Geology Section	10,326.00
Consultants:	Faunal	3,000.00
	Laboratory of Tree-Ring Research	2,500.00
	Geology	4,338.00
	TOTAL =	38.691.00

FY 1980 (October 1979 - September 1980):

DAP Personnel:	Botany Section	52,647.00
	Geology Section	9,424.00
Consultants:	Faunal	20,880.00
	Laboratory of Tree-ring Research	7,640.00
	Geology	6,518.00
	Palynology	12,004.00
	TOTAL =	102,595.00

BY 1981 (October 1980 - September 1981):

DAP Personnel:	Botany Section	45,435.00
	Geology Section	11.621.00
Consultants:	Faunal	18,665.00
	Laboratory of Tree-ring Research	6,150.00
	Palynology	17,700.00
	TOTAL =	99,571.00
	GRAND TOTAL =	240,857.38

Note: At this time not all of the budgeted funds have been spent.

SECTION 3

ANALYSIS OF ARCHAEOLOGICAL MATERIAL

contributing authors

Bruce F. Benz, Kenneth L. Petersen,
and William J. Robinson

INTRODUCTION

by Bruce F. Benz

Reconstructing the prehistoric resource base can be very difficult. At the outset, the E.S.G. has sought to characterize the contemporary environment of the D.A.P. area (Section 4) in order to discern the range of organisms and materials present. In assessing contemporary resources, it is necessary to recognize the biases in ones perception of the definition of resource. Having recognized, the potential of materials and organisms which exist in the Project area today, it is possible to establish the first base line from which to begin the reconstruction of the prehistoric resource base. It must not be assumed, however, that all materials and organisms that exist in the Project area today were necessarily present prehistorically, expecially in the same quantity or quanlity. Conversely, if an organism or material is not present in the Project area today, one cannot assume it did not occur in the area prehistorically. Certainly the present-day distribution of an organism or material can be related to its prehistoric distribution. The critical point to recognize is that the distribution (and presence or absence) of a material or organism is affected by the dynamics of its surroundings. Consequently, it is believed that an understanding of the dynamics of the environment will elucidate processes that can be related to resource distribution.

Once the relationship between the effects of environmental dynamics and the resource distribution and availability is understood, it is necessary to address the presence of materials from prehistoric cultural contexts. First, do certain archaeological materials directly reflect the

activities of man (i.e., is the material nonlocal, or is a certain plant fragment commonly associated with the occurrence of certain features)? Second, is there any possibility that nonhuman agents have placed that object into an otherwise strictly cultural context? Finally, does an appropriate analog (cultural or environmental) exist that will explain the presence of nonlocal materials or plant parts associated with a feature?

This section specifically deals with documenting the occurrence in archaeological contexts of materials that are potential resources. Since we cannot assume that biotic remains occurring in archaeological contexts are necessarily directly associated with the prehistoric occupation, Section 3d will describe the sampling design (and some tentative results) implemented at Site 5MT4644, Pitstructure 1. This sampling design is envisioned as one means by which the E.S.G. is better able to relate biotic remains directly to resource availability and use. The three preceding parts describe the status of analyses of fauna, pollen, and macrobotanical materials or samples. Section 3e presents a regional climatic reconstruction based on tree-ring samples.

SECTION 3a: STATUS OF FAUNAL ANALYSIS

by Bruce F. Benz

The analysis methodlogy of excavation-recovered faunal material is outlined in Emslie [21]. Many of the attributes recorded for each species element are examined in relation to specific studies (e.g., butchering patterns) that are beyond the scope of this review. Instead, the emphasis of this discussion is on the species (or genre) that occur on or in loci of suspected prehistoric cultural activity.

During the past three field seasons, 6360 bags (each containing a minimum of one element or element fragment) have been received by the D.A.P. Laboratory Facility. At the present time, preliminary analysis on all but two sites (Site 5MT0023 and Site 5MT2182) has been completed. As a result of this analysis, approximately 15,500 lines of data are at present computerized. The information in this file indicates that 44 mammals, representing eight orders; 35 birds, representing eight orders; one amphibian; two reptiles; and one fish are represented in the archaeological record in the D.A.P. area (Table 1.3.1). Nearly all present-day habitats recognizable in the D.A.P. area are represented by appropriate faunal species. The fauna recognized in archaeological contexts is amazingly similar to that recorded for the contemporary environments of the D.A.P. area (Table 1.3.1). Notably absent from the archaeological record are many of the shrews and bats, as well as red squirrels, antelope and kit fox, grizzly bear, and raccoon. In contrast, antelope seem to have been more readily available prehistorically than today. The absence of smaller mammals in archaeological contexts should be considered lightly because preservation and sampling error probably

Table 1.3.1. Fauna Represented in the D.A.P. Area Sites, Survey, and Excavation (Page 1 of 3).

MAMMALS

- Insectivora:
  - Pigmy shrew (*Microsorex hoyi*)
- Chiroptera:
  - Bat family (*Vespertilionidae*)
- Lagomorpha:
  - Hare sp. (*Lepus* sp.)
  - Snowshoe rabbit (*Lepus americana*)
  - White-tailed jackrabbit (*Lepus townsendii*)
  - Black-tailed jackrabbit (*Lepus californicus*)
  - Cottontail rabbit (*Silvilagus* sp.)
  - Pika (*Ochotona princeps*)
- Rodentia:
  - Yellow-bellied marmot (*Marmota flaviventris*)
  - Gunnison prairie dog (*Cynomys gunnisoni*)
  - Spotted ground squirrel (*Spermophilus spilosoma*)
  - Rock ground squirrel (*Spermophilus variegatus*)
  - Golden mantled ground squirrel (*Spermophilus lateralis*)
  - Chipmunk sp. (*Eutamias* sp.)
  - Gopher sp. (*Thomomys* sp.)
  - Kangaroo rat (*Dipodomys* sp.)
  - Beaver (*Castor canadensis*)
  - Mouse sp. (*Peromyscus* sp.)
  - Wood rat sp. (*Neotoma* sp.)
  - Bushy tail wood rat (*Neotoma cinerea*)
  - Mexican wood rat (*Neotoma mexicana*)
  - Vole (*Microtus* sp.)
  - Mountain vole (*Microtus montanus*)
  - Long-tailed vole (*Microtus longicaudus*)
  - Muskrat (*Ondatra zibethicus*)
  - Porcupine (*Erethizon dorsatum*)
- Carnivora:
  - Coyote (*Canis latrans*)
  - Wolf (*Canis lupus*)
  - Dog (*Canis familiaris*)
  - Red fox (*Vulpes vulpes*)
  - Gray fox (*Urocyon cinereoargenteus*)
  - Bear (*Ursus* sp.)
  - Black Bear (*Ursus americanus*)
  - Ring-tailed cat (*Bassariscus astutus*)
  - Marten (*Martes americana*)
  - Long-tailed Weasel (*Mustela frenata*)
  - Wolverine (*Gulo gulo*)
  - Badger (*Taxidea taxus*)
  - Spotted skunk (*Spilogale putorius*)
  - Striped skunk (*Mephitis mephitis*)
- Artiodactyla:
  - Elk (*Cervus canadensis*)
  - Mule deer (*Odocoileus hemionus*)
  - Pronghorn Antelope (*Antilocarpa americana*)

Table 1.3.1. Fauna Represented in the D.A.P. Area Sites, Survey, and Excavation (Page 2 of 3).

MAMMALS

Artiodactyla: (cont.)

- Bighorn sheep (*Ovis canadensis*)
- Domestic cow (*Bos taurus*)
- Sheep (*Ovis* sp.)
- Horse (*Equis* sp.)

BIRDS

Anseriformes:

- Goose sp. (*Branta* sp.)
- Canadian goose (*Branta canadensis*)
- Duck sp. (*Anas* sp.)
- Mallard (*Anas platyrhynchos*)
- Ruddy Duck (*Oxyura jamaicensis*)

Falconiformes:

- Goshawk (*Accipiter gentilus*)
- Sharp shinned hawk (*Accipiter striatus*)
- Buzzard hawk sp. (*Buteo* sp.)
- Red tailed hawk (*Buteo jamaicensis*)
- Golden eagle (*Aquila chrysaetos*)

Galliformes:

- Sagehen (*Centrocercus urophasianus*)
- Turkey (*Meleagris gallopavo*)

Carviformes:

- Sandhill crane (*Grus canadensis*)
- Lesser sandhill crane (*Grus canadensis canadensis*)
- Greater sandhill crane (*Grus canadensis tabida*)

Columbiformes:

- Morning dove (*Zenaida macroura*)

Strigiformes:

- Screech owl (*Otus asio*)
- Great horned owl (*Bubo virginianus*)
- Pygmy owl (*Glaucidum gnoma*)
- Owl sp. (*Asio* sp.)
- Long ear owl (*Asio otus*)

Piciformes:

- Golden winged woodpecker (*Colaptes auratus auratus*)
- Woodpecker (*Colaptes auratus*)

Passeriformes:

- Western kingbird (*Tyrannus verticalis*)
- Stellars jay (*Cyanocitta stelleri*)
- Scrub jay (*Aphelocouma coerulescens*)
- Magpie (*Pica pica*)
- Raven (*Corvus corax*)
- Common crow (*Corvus brachyrhynchos*)
- Pinyon jay (*Gymnorhinus cyanaocephaluo*)
- Robin (*Turdus migratorius*)
- Northern shrikes (*Lanius excubitor*)
- Meadowlark sp. (*Sturnella* sp.)
- Yellow-headed blackbird (*Xanthocephalus xanthocephalus*)
- Green-tailed tohee (*Pipilo chlorura*)

Table 1.3.1. Fauna Represented in the D.A.P. Area Sites, Survey, and Excavation (Page 3 of 3).

AMPHIBIANS
- Amphibia:
  - Frog-toad order NFS (*Anura*)

REPTILES
- Squamata:
  - Eastern fence lizard (*Scelopurus undulatus*)
- Colubridae:
  - Gopher snake (*Pituophis melanoleucus*)

FISH
- Osteichthyes NFS
  - Fish bones

affected the recovery of small bones. The prehistoric absence of red and antelope squirrels might also be due to sampling bias or to other factors; their present occurrence may be due to recent logging practices. The archaeological absence of grizzly bear and kit fox remains might be attributed to ritual avoidance or ceremonial curation.

At present, a set of tables listing faunal resources by temporal and spatial divisions is not possible (although cf. Benz [29]). However, the short discussion that follows is an attempt examine the range of faunal species that have been analyzed from ten sites representing seven subphases of the Anasazi Tradition (Kane [30]).

Table 1.3.2 depicts the diversity indices (Wilson and Bossert [31]) of faunal assemblages from sites associated with particular subphase in the Escalante Sector. While significant differences may exist between McPhee and Sagehen phase sites, no statistical tests have been applied. There may also be a greater diversity of species in sites adjacent to the Dolores river. If this is the case, water-loving animals should also occur more frequently in sites to the river. Higher diversity, if significant, might suggest that 1) the hunting patterns revolved around a greater variety of habitats, 2) fewer habitats were very intensively hunted (as compared to those sites exhibiting a low diversity), or 3) faunal remains are today recovered from areas where preservation is better.

Table 1.3.2. Faunal Diversity Indices by Subphase.

Site No.	Phase	Subphase	Faunal Diversity Index*
5MT4545	Sagehen	Tres Bobos	1.7535
5MT4684	Sagehen	Tres Bobos	2.3996
5MT2198	Sagehen	Sagehill	1.8174
5MT4614	Sagehen	Sagehill	1.8126
5MT4644	Sagehen	Dos Casas	1.8145
5MT2193	Sagehen	Dos Casas	1.9545
5MT4477	McPhee	Periman	1.7997
5MT4475	McPhee	Periman, Cline	2.4250
5MT0023	McPhee	Grass Mesa	2.2885

* - This index was calculated on the basis of species present. When only the genius could be identified it was included in the percentage calculation if no species of that genus were also identified (Wilson and Bossert [31]).

Following the discussion of temporal differences, and the garden hunting model (Linares [17], Benz [29]), the McPhee Phase is expected to show a greater diversity of fauna than the Sagehen Phase. That is, assuming that population increased and aggregation occurred during the Sagehen Phase, need to farm a greater variety of environmental zones (ecosystems) might be expected (cf. Lipe [32]). This could lead to 1) access to and hunting of a wider range of habitats, and 2) more intensive exploitation of a narrower range of commensal (cf. Benz [29]) animals. Either case could lead to a higher diversity index during the McPhee Phase.

This discussion has remained cursory because of limitations in the data base. A more complete discussion using a more general perspective can be found in Benz [29]. Prehistoric faunal resource availability remains somewhat speculative. That is, although many mammals and birds are recovered from archaeological contexts, the actual association between some faunal remains and prehistoric behavior cannot be made. Certain animals characteristically find suitable residence in the soft, disturbed

earth of prehistoric puebloan sites. These remains can not, as yet, be isolated from the total number in the computer file.

Temporal association of faunal materials also remains tentative. In particular, multiple element and/or multiple component sites may overlap temporal boundaries of phases. Table 1.3.1 depicts the characteristic fauna of the Puebloan and of the minimal Archaic occupations of the D.A.P. area. The comparative ethnographic faunal file (Table 1.5.4, Section 5c) needs to be augmented to completely illustrate the range of behaviors associated with the presence, use, procurement, etc., of animal species. Until then, the absence of certain species and/or the spatial-temporal dynamics of faunal procurement can ony be marginally interpreted.

SECTION 3b: STATUS OF POLLEN ANALYSIS

by Bruce F. Benz

Methods employed in the extraction and analysis of pollen have been outlined by Scott [24]. At present, 300 pollen samples have been processed and analyzed.

Reconstructing prehistoric plant resource potential on the basis of pollen alone is tenuous. The analysis of pollen from archaeological sites requires that biases in the pollen record be recognized (cf. Hevly [33]). Reconstructing vegetational environments from pollen evidence has a long history in the Southwest (Bohrer [34], Martin [35], Martin and Byers [36], Schoenwetter and Eddy [37], Euler et al. [38]). Further, studies have examined resource use and tool, room, and feature function, as well as prehistoric diet based on pollen evidence (Scott [39, 40], Halbirt [41], Kelso [42, 43] .

The analysis of D.A.P. pollen samples by Scott has focused on plant resource use and feature function. Results of Scott's analysis lead to the suggestion that certain domesticated plants (corn and squash) and weedy plants (Cleome sp., Portulaca sp., and various Crucifers) were present in the D.A.P. area and possibly contributed to the Puebloan resource base. Other native wild plants, represented by a variety of pollen types in D.A.P. pollen samples, were undoubtedly present prehistorically in what is now the D.A.P. area.

Based on pollen evidence alone, it is difficult to be specific about which plants were actually utilized, as opposed to those which were locally available. Further, distinguishing plants which were locally available from those that were regionally available is difficult when dealing

with plants whose pollen is wind disseminated. Such problems must be taken into account when determining plant resource use versus plant availability on the basis of pollen. Acknowledging these problems, the following is a discussion of vegetal resource use and availability based on pollen.

Some 47 pollen types have been isolated from D.A.P. pollen samples. Thirty-two of the pollen types are generic identifications. The remaining 15 types are family or infra-family-level identifications; these provide less information because of the generality of the identification (see Table 1.3.3). Five genera (Alnus, Shepherdia, Salix, Typha, and Celtis) are suggestive of riparian habitats. Since all are wind-pollinated types, it is not clear whether the pollen of these plants represents actual use. If pollen of these five genera can be isolated in high frequency, the association of their occurrence with use would be strengthened.

The pollen of two high altitude genera (Abies and Picea) is represented in low frequency in D.A.P. pollen samples. These genera are also wind pollinated; consequently, the pollen documents only these genera as being located in the general region.

Grains of Lyciaum, Nicotiana, Physalis, Portulaca, Sphaeralcea, Lepidium, Arabis and Cleome are present in low frequencies from D.A.P. sites. These genera are weedy, colonizing plants. Many of these would be expected to shed their pollen on and around the site during, or immediately following occupation. Since many of these plants have an ethnographic utilization analog, their use by prehistoric people of the D.A.P. area is possible. However, inferred use of some of these weedy annuals must be substantiated by considering other pertinent biological and ecological factors. For example, when Cleome flowers during mid to

Table 1.3.3. Taxa and/or Pollen Types Represented in D.A.P. Archaeological Contexts.

Allium	Abies
Alnus	Picea
Cactaceae	Pinus
Opuntia	Collema
Cleome	Eriogonum
Sarcobatus	Eriogonum alatum
Compositae	Polygonum
Compositae Liguliflorae type	Polygonum sawatchense
Achillea	Portulaca
Artemisia	Ranunculaceae
Cruciferae	Rosaceae
Arabis	Amelanchier
Lepidium	Salix
Cucurbita	Lycium
Juniperus	Nicotiana
Shepherdia	Physalis
Quercus	Typha
Gramineae	Celtis
Zea mays	Umbelliferae
Liliaceae	Ephedra
Linum	Ephedra nevadensis type
Sphaeralcea	Ephedra torreyana type
Onagraceae	Cheno-am
Circaea	

Note: Those underlined represent generic identifications.

late summer the plant usually contains some bitter elements, resulting in reduced palatability. As a result, the presence of pollen in a localized area should not be immediately attributed to processing for consumption. Some other use, such as paint processing, could also be logically inferred (cf. Whiting [44]). Following this line of reasoning, the mere presence of pollen from the aforementioned weedy genera does not necessarily imply direct human use or consumption, although it does suggest that they may have been available to the Anasazi population. Instead, we should attribute weedy pollen to the presence of weedy species on or near the site and the accidental transportation by humans.

The remaining genera found by Scott in the D.A.P. Project area are represented in varied frequencies in the archaeological record. All but two genera (Sarcobatus and Ephedra) occur in the D.A.P. Project area today and are expected components of prehistoric vegetation communities (cf. Bye [12]).

Both Ephedra spp. and Sarcobatus vermiculatus are present today in the southern part of Montezuma County. These two plants are prolific pollen producers and have wind-disseminated pollen. A small percentage of Ephedra pollen has been isolated from otherwise alpine pollen assemblages which attests to its long-distance transport (Petersen, personal communication). As a result, questions concerning the presence of small percentages of Ephedra pollen relate more to its availability than to its use. That is, was Ephedra actually present in the prehistoric D.A.P. area or was it nonlocal? Until we have a chance to examine additional pollen samples and other sources of botanical evidence, the answer to this question must remain speculative.

At this time, no recognizable temporal patterns are evident in the

pollen record. Spatial patterns seem to be evident though, based on occurrence of Artemisia pollen (cf. Benz [29]). Artemisia pollen is relatively common from sites in the Sagehen Flats Locality, and absent from sites in the Grass Mesa Locality. This difference resembles, to some degree, the distribution of sagebrush shrublands in the D.A.P. area today. Additional investigations in this area are warranted.

SECTION 3c: STATUS OF MACROBOTANICAL ANALSIS

by Bruce F. Benz

Analysis Methodology

Analysis methods for macrobotanical materials have not yet been presented. Initial preliminary processing, sorting, and identification procedures have been presented in Litzinger [45]. Since the initial processing and sorting procedures have undergone revision during the past three years, the revised methods will be presented here. Following this discussion is an inventory presentation of taxa represented from D.A.P. archaeological sites.

Macrobotanical materials are recovered from archaeological contexts in two forms, vegetal material specimens and bulk soil (B.S.) samples. Justification for distinguishing these two specimen types lies in the size and visibility of botanical items during field collection.

Vegetal material is collected during excavation as large (i.e., greater than one quarter-inch or 0.6 cm) fragments of wood, basketry fragments, composite structural material, and fruit, stem and seed fragments. In some cases, the excavator does not separate various kinds of botanical material (wood versus cultigen fragments) while in the field. As a result, certain vegetal specimens contain a wide variety of plant parts and taxa. In other cases, the excavator may submit specimens comprising of a single plant part of a single taxon (e.g. *Pinus* sp. wood). After the material has been collected in the field, the specimen is brought to the D.A.P. Processing Laboratory. The vegetal material is subsequently air dried and packaged.

Analysis methods employed by E.S.G. personnel are dependent on the

condition and quantity of the vegetal material specimen. If, for example, a single item has been submitted, the item is immediately identified as to taxon and plant part. If a worked vegetal specimen is submitted, its components are identified and the specimen is repackaged and cataloged. When a large quantity of vegetal material is submitted, more elaborate methods are necessary. The contents of a large vegetal material sample are first screened through standard sieves (mesh sizes 5.6 mm, 2.0 mm, and 0.5 mm). Following screening, the two largest size grades (5.6 mm and 2.0 mm) are then sorted to extract macroscopically identifiable reproductive plant parts. Twenty wood fragments are also selected from each of the two largest size grades for microscopic identification. After the reproductive parts and wood fragments have been removed, the contents of all size grades are microscopically scanned under low power to remove additional identifiable botanical items.

Following removal and identification, botanical remains representing the same plant part and taxon are combined and assigned catalog item numbers. These catalog numbers serve to identify stored botanical items for easy access and for further more intensive analysis.

Bulk soil samples are collected by field personnel according to the design outlined by Litzinger [23]. This design standardizes the location and quantity of B.S. samples on cultural surfaces and in and around features.

Bulk Soil samples are returned to the Laboratory Facility for processing. Each sample receives a processing code that indicates how a B.S. sample is to be treated. Bulk Soil samples have been subjected to two processing modes: flotation, or water-separation, and water-screening. The water screening process entails placing the B.S.

sample on 30-mesh hardware cloth and washing the less than 1/30 inch soil/sediment matrix through. Flotation, or water-separation, is a technique that separates organic materials from inorganic materials in an aerated water medium (Bohrer and Adams [46]; Davis and Wesolowsky [47]; Jarman et al. [48]; Limp [49]; Minnis and Leblanc [50]; Schock [51]; Struever [52]; Wagner [53]). The water-separation apparatus originally used by the D.A.P. is described in Litzinger [23]. During the summer of 1980, Litzinger designed a new water separation system (Figure 1.3.1). This system requires less water and separates the light and heavy fractions more effectively than the previously employed apparatus. The new apparatus is constructed of a three foot long section of 4-inch diameter PVC pipe. At the base a water hose is fit through an air chamber. This hose feeds water into the three foot length of pipe. The air chamber is connected to a small vacuum pump. Air from this pump is forced through a rubber hose into the tube's air chamber. This air chamber feeds air into the upper water-filled section of the apparatus through a set of brass gasoline filters imbedded in a sheet of plastic which separates the air and water chambers.

Flotation of a B.S. sample begins by placing 1 L of matrix into the half-filled water chamber. The water and soil mixture is then agitated by forcing air into the water by means of the vacuum pump. This agitation forces the organic materials out of the soil/sediment matrix onto the surface of the air bubbles. These bubbles rise to the surface of the water, with the organic material. The agitation process lasts for approximately two minutes, after which the vacuum pump is turned nearly off and the heavy materials are allowed to settle out. Following settling, the uppermost level of water in the tube is poured off onto finely woven double

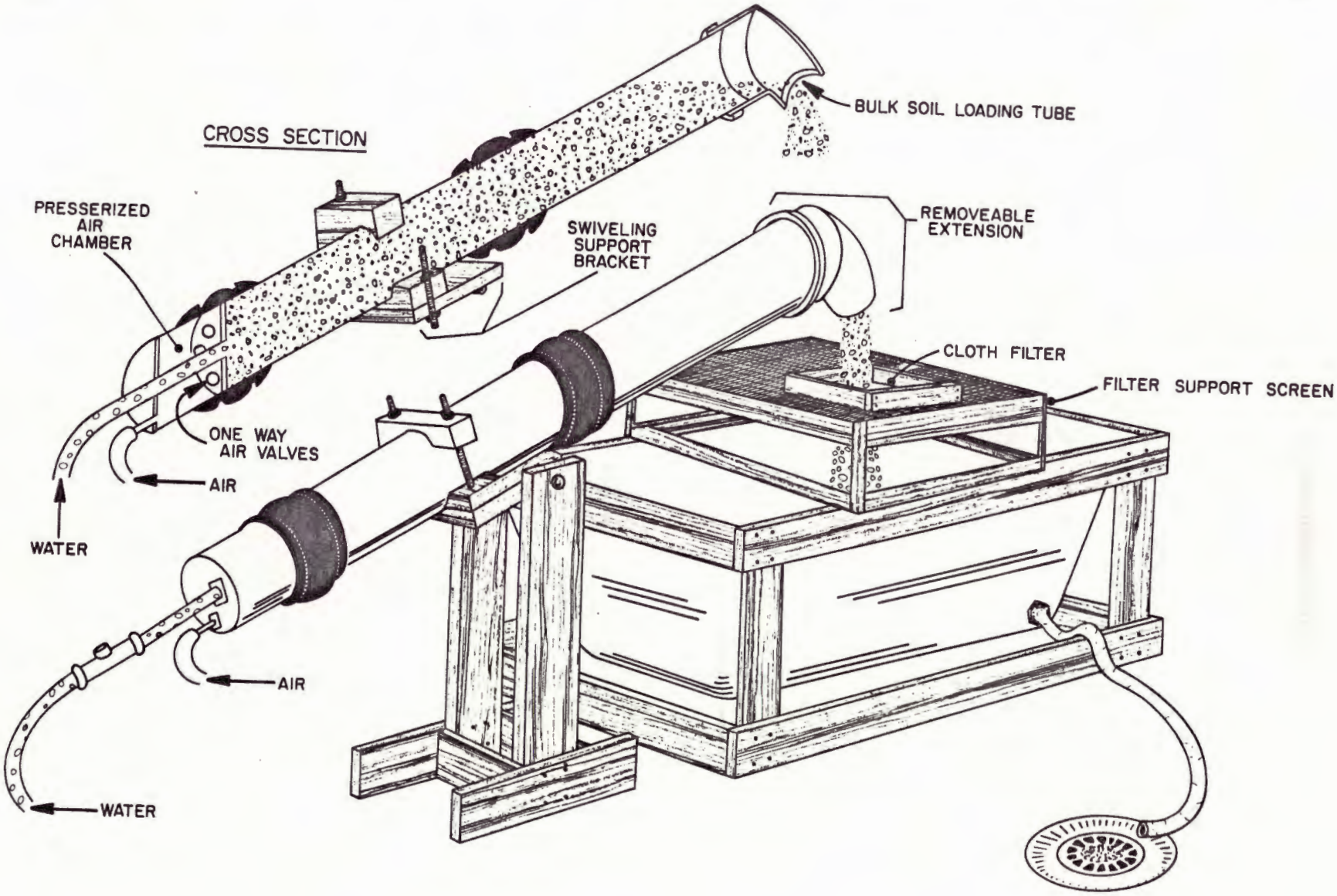

Figure 1.3.1. Bulk soil floatation aparatus.

knit cloth. This cloth then contains what s commonly referred to as the light fraction. The cloth is folded into quarters and stapled closed. The cloth is subsequently air dried. The remainder of the tube contents is composed of the heavy inorganic materials and some organic materials left in suspension. This water is poured through 30-mesh hardware cloth screen and then placed on a newspaper-covered cardboard flat. This material is commonly referrred to as the heavy fraction. The heavy fraction is taken indoors to dry. Subsequent to drying, the heavy fraction is examined, by laboratory personnel, for nonvegetal materials (bone, stone, and ceramics). These materials are removed and submitted to the appropriate task groups for analysis. Later the light and heavy fractions are put into the same plastic bag, although kept separate, and passed along to E.S.G. personnel for inventory and analysis.

The analysis process for both heavy and light fractions is the same. However, in consideration of the time factor, only about one-half of the 711 B.S. samples analyzed to date have had their heavy fractions examined. This inconsistency must be recognized later in the discussion of the presence and absence of parts of certain plants. It is likely that some plant parts are under-represented as a result of not examining the botanical contents of the heavy fraction (Appendix B).

The analysis of the floated B.S. sample proceeds by removing the contents of the light fraction from the cloth. The contents are poured into standard sieves (5.6 mm, 2.0 mm, and 0.5 mm) and are lightly shaken. Each size grade is sorted under a dissecting microscope (7x to 70x) to separate the identifiable botanical items. All identified materials are subsequently combined into taxonomic categories by plant part. Each plant part (e.g., fruit, seed, leaf) of each taxon is then cataloged and packaged.

following sorting, identification, and cataloging, the occurrence of each plant part by taxon is coded on the macrobotanical coding form (Figure 1.3.2). This coding form records the taxon, plant part, condition, quantity, and provenience unit from which a particular botanical object is derived. Information about vegetal material specimens is also recorded on this form. Consequently, all botanical material can eventually be inventoried by the D.P.G.

Status of Macrobotanical Analysis

Remains of at least 28 botanical genera have been recovered from D.A.P. archaeological contexts (Table 1.3.4). Three of these 28 taxa are cultivated plants: *Zea mays*, *Phaseolus* sp., and *Cucurbita* sp. Corn (*Zea mays*) occurs with regularity and in large quantity, which may attest to its importance to the prehistoric subsistence regime of the D.A.P. occupants, while also suggesting that maize has a high potential for being preserved archaeologically. Corn is present as kernels, cobs, cupule fragments, whole and partial ears, and stalk and peduncle fragments. These remains are commonly recovered from midden deposits, feature deposits containing primary and secondary refuse and hearths. Although most of these remains are composed of a relatively dense tissue which can withstand decomposition, their archaeological abundance argues for the importance of this domesticate during the D.A.P. Puebloan occupation. Beans (*Phaseolus* sp.)-and squash or pumpkin (*Cucurbita* sp.) occur in much lower frequencies than does maize. This may be a result of cultural use and/or preservation; that is, the parts of these plants recovered are always at least partially charred and represent the consumable part of the plant (Minnis [4]; Munson et al. [54]) for discussion of preservation

Table 1.3.4. Taxa Recovered from Archaeological Sites as Macrobotanical Material (Bulk Soil and Vegetal).

Taxon	Plant Part Represented
Yucca sp.	Fruit, seed, leaf
Amaranthus sp.	Fruit, seed
Alnus sp.	Bark
Chenopodium sp.	Fruit
Artemisia sp.	Fruit, leaf, bast, wood
Helianthus sp.	Fruit
Descurania sp.	Seed
Curcurbita sp.	Fruit, seed, peduncle
Juniperus sp.	Seed, bast, wood
Quercus sp.	Fruit, seed, wood
Phragmites sp.	Culm
Zea mays	Fruit, inflorescence, Peduncle, cuticle
Phaseolus sp.	Seed
Ribes sp.	Seed
Sphaeralcea sp.	Seed
Abies sp.	Wood
Pinus edulis	Needle, cone, seed, wood
Pinus ponderosa	Needle, wood, cone
Psuedotsuga cf. *menzeisii*	Needles, wood
Polygonum sp.	Fruit
Portulaca sp.	Seed
Cercocarpus sp.	Wood
Prunus sp.	Wood, fruit
Populus sp.	Wood
Salix sp.	Wood
Nicotiana sp.	Seed
Physalis sp.	Seed
Typha sp.	Leaf

Date

Prepared by

Site Number

DOLORES ARCHAEOLOGICAL PROJECT
U S Bureau of Reclamation

MACROBOTANICAL MATERIALS ANALYSIS
DATA CODING FORM

F.S. Number

through

Field Specimen Number	Catalog Item Number	Point Location	Process Stage	TAXON				Confidence	Plant Parts	Charredness	Completeness	Damage	Quantity	Coded Comments	Coded Comments	Special Specimens	
				Class	Family	Genus	Species									Type	Number
Text																	
Text																	
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versus use with regard to archaeological representation of certain plant parts.

Ruderal plant genera are represented by their disseminules in D.A.P. archaeological contexts. The taxa represented are Amaranthus sp., Chenopodium sp., Helianthus sp., Descurania sp., Portulaca sp., Nicotiana sp., and Physalis sp. These commensal plants produce prodigious amounts of seeds and/or fruits. Their fleshy parts are not usually preserved in archaeological contexts; therefore, the recovery of only disseminules is to be expected. At the present time no temporally relative patterns are evident in the occurence of weedy plant disseminules. However, an increase in the relative number of these seeds and fruits through time is expected if the Puebloan occupation increased in size and intensity (cf. Lipe [32]; Orcutt [55]). With greater population size and greater social control, it is expected that (1) either a greater amount of tillable land was brought under cultivation, (2) a greater variety of consumable resources were considered useful, (3) a single crop was more intensively cultivated, or (4) any combination of 1, 2, and 3. In all cases except 3 (which represents the current Western World perspective as "monoculture"), weedy plants (and consequently their seeds/fruits) would be expected to increase in frequency diachronically. This is to say, that with more land brought under cultivation and a greater diversity of perceived resources, weedy plants would occur more frequently in the archaeological record due to their greater and more realized abundance. Needless to say, more data must be gathered through the examination of B.S. samples to address these hypotheses adequately.

Undoubtedly, some of the most common artifacts found in Puebloan sites are wood charcoal. Much of the wood in sites of Puebloan age is not

collected in the field because of its ambiguous cultural context. Most wood charcoal exposed in unambiguous cultural contexts and not collected for dendrochronological specimens is submitted to the E.S.G. for analysis. The most common woody taxa recovered thus far are of Pinus spp., Juniperus spp., Populus spp., and Artemisia sp. Less frequently occurring are Quercus sp., Cercocarpus sp., Prunus sp., Salix sp., Abies sp., and Pseudotsuga cf. menzeisii. A large amount of analysis time has been spent working intensively on wood identification. Much further work is necessary to deal effectively with the ubiquitous wood charcoal.

This discussion of macrobotanical materials is cursory. A more thorough discussion is presented in Benz [29]. Additional analysis is necessary to understand and interpret the archaeobotanical record. As yet an adequate definition of a botanical resource has not been developed. Since its presence in the archaeological record does not necessarily indicate a plant's exploitation, it must be determined through sampling (cf. Benz et al. [56], 1979 Conference Paper) which plants are represented as a result of use, which are present as a result of human occcupation (anthropogenic plant communities), and which plant remains are nonculturally intrusive. This topic will be further discussed in the next section.

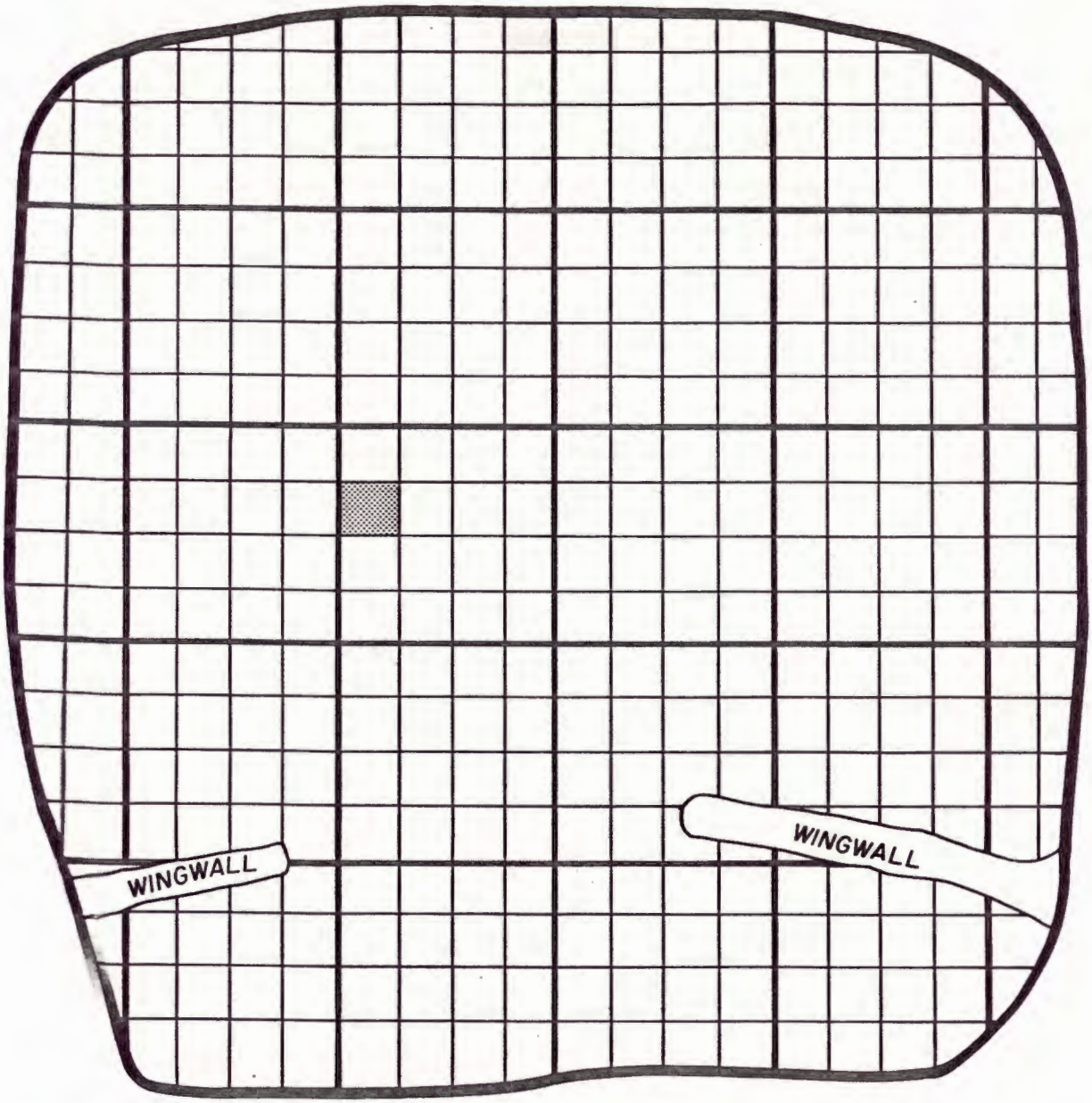
SECTION 3d: INTENSIVE BOTANICAL INVESTIGATIONS AT SITE 5MT4644

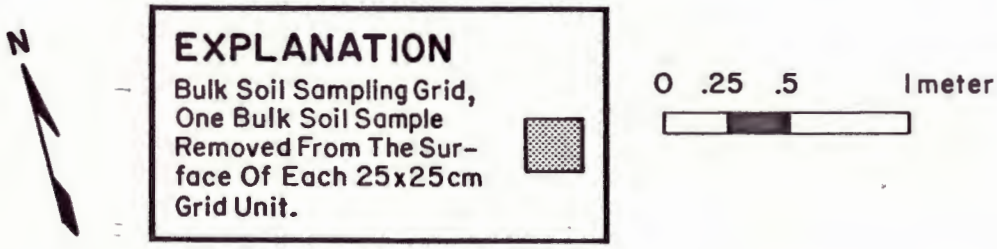
By Bruce F. Benz

During the 1979 field season, excavation at Windy Wheat Hamlet (Site 5MT4644) revealed an extensively burned pitstructure. This structure, subsequently designated Pitstructure 1, was chosen for implementation of an intensive bulk soil and pollen sampling program. The goals of this program were to collect as much of the pitstructure's use-compacted surface as possible as a means of reconstructing the prehistoric activities carried out in this structure. Inventory analysis of macrobotanical materials recovered in B.S. samples and of microbotanical materials recovered from pollen samples has been completed. However, the macrobotanical data have not been input into the D.P.G. files. Necessarily then, substantive results presented here deal primarily with data derived from the pollen sampling program and previous analyses of this data (Scott [39, 57]; Benz [29]).

Since the structure had burned during occupation, its mode of abandonment has been designated catastrophic (Kane and Robinson [58]). That is, at the time of the structure's burning, the occupants' daily activities were still being performed on its living surface. It is believed that while the superstructure burned, portions of the support lattice and roof collapsed onto the floor, sealing off the floor and bench surface from natural and cultural depositional processes. The task undertaken, then, was an attempted reconstruction of cultural activities based in part on the density and distribution of biotic materials recovered through bulk soil (Figure 1.3.3) and pollen sampling (Figure 1.3.4).

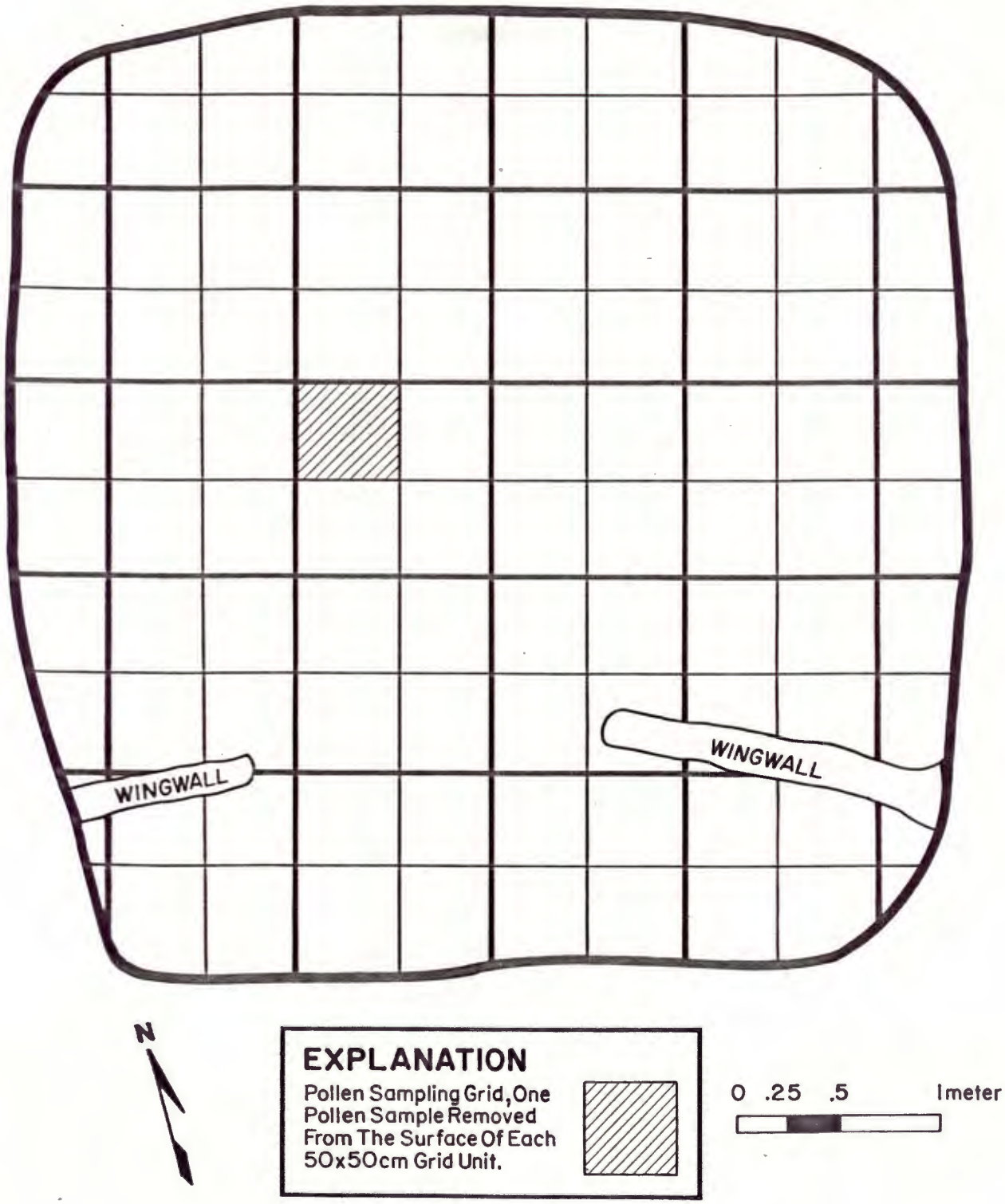
Methods employed for pollen sampling followed, in a general way, the





05MT04644 Pit Structure I

Figure 1.3.3. Bulk soil sampling grid, Site 5MT4644.



05MT04644 Pit Structure I

Figure 3.3.4. Pollen sampling grid, Site 5MT4644.

guidelines outlined by Litzinger [23] for surface transect sampling. However, the sampling design implemented for the floor of Pitstructure 1 was elaborated or intensified for B.S. sampling. As standard procedure, excavation of a cultural surface proceeds by gridding off a bounded area into 1 sq m loci (cf. Kane et al. [59]) approximately 10 cm above the cultural surface. Excavation of the strata that overlie the surface and of the surface proper are concentrated in these 1 sq m loci as a means of spatially proveniencing floor artifacts. Bulk soil and pollen samples were obtained following removal of the strata (floor fill) overlying the floor proper. These samples were procured from 25 by 25 sq cm horizontal surface units for B.S. and 50 by 50 sq cm horizontal units for pollen within each locus (Figures 1.3.3, 1.3.4, 1.3.5, and 1.3.6). Whenever possible, each sampling unit was scraped for a pollen sample and a B.S. sample immediately following exposure of the surface, in order to minimize contamination from the wind and from nearby excavation. The majority of the use-compacted surface of Pitstructure 1 was removed in this manner. Certain areas, for example the corners of the main chamber, were not sampled because of the small size of the excavation loci in these areas.

Following sample procurement, the B.S. and pollen samples were processed and analyzed according to program procedures outlined by Scott [24] for pollen and those outlined in Section 3c of this chapter for B.S. The analysis of pollen samples from the floor of this pitstructure recovered grains of 27 taxa (Table 1.3.5). The analysis of B.S. samples has recovered various plant parts of 19 taxa (Table 1.3.6).

The occurrence of 17 taxa in pollen and B.S. samples suggests that these plants were present in the site's immediate environment prehistorically. Whether many of these taxa were perceived as resources

Table 1.3.5. Botanical Taxa (or Pollen Types) Represented in Pollen Samples from Pitstructure 1, Site 5MT4644.

*Cactaceae	Opuntia sp.
*Capparidaceae	Cleome sp.
Chenopodiaceae	Sarcobatus sp.
**"Cheno-Am"	
Compositae	
Compositae	*Achillea sp.
	Artemisia sp.
Compositae	*liquliflorеae
Cruciferae	
Curcurbitaceae	Cucurbita sp.
Cupressaceae	Juniperus sp.
*Eleagnaceae	Shepherdia sp.
*Ephedraceae	Ephedra torreyana type
Fagaceae	Quercus sp.
Gramineae	
Gramineae	Zea mays
*Liliaceae	Allium sp.
Malvaceae	Sphaeralcea
Pinaceae	Pinus sp.
Polygonaceae	*Eriogonum sp.
	Polygonum sp.
	*Polygonum sawatchensis type
Portulacaceae	Portulaca sp.
Rosaceae	
Solanaceae	Lycium sp.
*Typhaceae	Typha sp.(?)
*Umbelliferae	

*Those taxonomic categories not represented in the material from B.S. samples.

**This category is largely artificial in that pollen from plants within the Amaranthaceae and Chenopodiaceae cannot be distinguished. In some instances, for example disseminule fragments, the appropriate genus or family cannot be distinguished. However, in the case of B.S. macro-botanical material, both Amaranthus sp. and Chenopodium sp. have been recovered and identified. As a result, those disseminules recovered in B.S and identified as "Cheno-Am" have been disregarded since both families are already represented by disseminules identifiable to genera.

Table 1.3.6. Botanical Taxa Represented in Bulk Soil Samples from Pitstructure 1, Site 5MT4644.

*Aqavaceae	*Yucca* sp.
Amaranthaceae	*Amaranthus* sp.
Chenopodiaceae	*Chenopodium* sp.
Compositae	*Artemisia* sp.
Cruciferae	*Descurania* sp.
Cucurbitaceae	*Cucurbita* sp.
Cupressaceae	*Juniperus* sp.
Fagaceae	*Quercus* sp.
Gramineae	*Phragmites* sp.
	Zea mays
*Leguminosae	*Phaseolus* sp.
Malvaceae	*Sphaeralcea* sp.
Pinaceae	*Pinus* sp.
Polygonaceae	*Polygonum* sp.
Portulaceae	*Portulaca* sp.
Rosaceae	cf. *Cercocarpus* sp.
Salicaceae	*Populus* sp.
Solanaceae	cf. *Physalis* sp.
	Nicotiana sp.

*Those taxonomic categories (families) not represented in the pollen samples.

Figure 1.3.5. Transect sampling design at Site 5MT4614, Pitstructure 1. Areas enclosed by string are 1 meter loci (Photo ~~018812~~).
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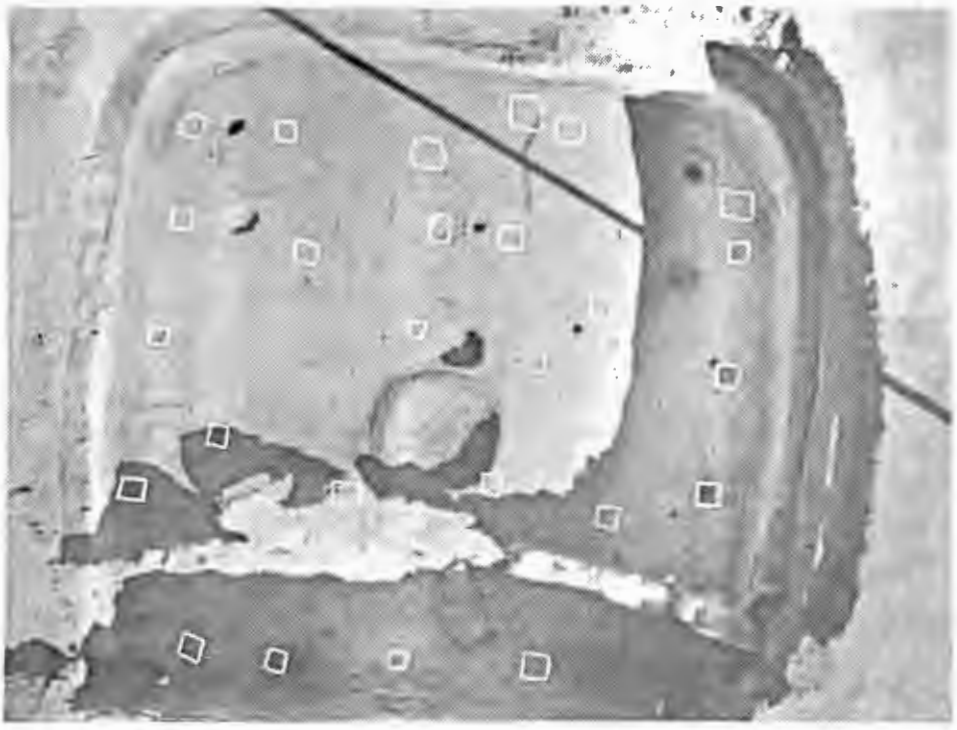

Figure 1.3.6. Transect sampling of Site 5MT4644, Pitstructure 1. Used to produce SYMAP representations (Photo ~~032513~~).
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and/or used by the prehistoric inhabitants can be more meaningfully discussed by grouping the plants according to their ecological response to human interaction with the environment.

Three cultigens are represented in B.S. samples: corn (Zea mays), squash (Cucurbita sp.), and beans (Phaseolus sp.). Squash and corn are also represented in the pollen record. Since these domesticated plants depend on man for survival, it is likely that these taxa were resources used by the prehistoric inhabitants of Windy Wheat Hamlet.

Many of the plant genera represented in the pollen and macrobotanical records can be characterized as ruderal, or weedy, plants. This category refers to the colonizing habit of herbaceous plants in areas of periodic disturbance. Some of these genera are responsive to human environmental manipulation and consequently are frequent in anthropogenic habitats, whereas other genera are simply pioneer species that colonize open habitats. Taxa represented by pollen or by plant remains from B.S. herein considered ruderal are as follows: Amaranthus sp., Chenopodium sp., Descurania sp., Sphaeralcea sp., Portulaca sp., cf. Physalis sp., and Nicotiana sp. The mere presence of these taxa in B.S. and pollen samples from the pitstructure's surface does not necessarily indicate that these plants were perceived as resources or that they were used by the inhabitants. Although ethnographic evidence supports inferences that these taxa were potential resources, the strongest support for making utilization inferences about these taxa comes from the distribution of their remains on the pitstructure's surface; that is, their presence on the surface may be fortuitous in the sense that the plants were present in the immediate environment but not consciously collected. For example, the pollen and fruits/seeds of chenopods and amaranths might have been

carried in on the clothing of the inhabitants. On the other hand, if pollen and seeds of certain taxa are spatially concentrated in some area of the pitstructure where other artifacts or features are present, inferences made with respect to use of a plant are strengthened. However, the spatial concentrations must be well understood in terms of preservation (see below) to substantiate the inference and to evaluate assumptions.

The occurrence of pollen and various other plant parts of certain taxa are here believed to represent prehistoric presence and use of the prehistoric natural environment. Remains of Artemisia sp., Juniperus sp., Quercus sp., and Pinus spp. are present in pollen and B.S. samples. Charred wood fragments of these taxa are common in B.S. samples. Their ubiquitous occurrence on the floor of this structure, as well as in the fill of features (e.g., the central hearth), suggest that these plants provided material for structural purposes and for fuel. The presence and distribution of pollen from these taxa neither support or refute this inference; rather, they suggest that the distribution of pollen on the floor is related to preservational factors.

As indicated, only the results of the pollen analysis are presently available for computerized manipulation. Therefore, the discussion of pollen distributional studies which follows is presented as a framework for examining the distribution of macrobotanical remains in the future.

Scott [39] presents distributional maps of various pollen types based on percentage data. On the basis of these maps, Scott states that, "...areas of the pithouse containing the largest variety of economic pollen and also the largest frequencies of the individual economic pollen types ... are all areas which appear to be logical areas to have been used

for the preparation, cooking and storage of plants." This interpretation is certainly acceptable, although other interpretations are equally tenable. The maps depicted in Figures 1.3.7, 1.3.8, 1.3.9, and 1.3.10 were constructed by the SYMAP Program (Dougnik and Sheehan [60]) using the same data employed by Scott [39]. Contour maps were constructed using this data by selecting for various taxa or groups of taxa through SPSS programs (Nie et al. [61]). These maps are based on the actual count of pollen types by taxa, not on percentages. Although this makes intersample comparison somewhat difficult, the results generally speak for themselves. Two mapping procedures were used to construct Figures 1.3.7, 1.3.8, 1.3.9, and 1.3.10. In the case of Figure 1.3.10, the value range assigned to each contour was calculated by the SYMAP mapping procedure. This procedure divides the total value range (frequency of a taxon or of a group of taxa) by the number of contours chosen--five in this case. The three remaining maps have been constructed by examining a frequency distribution of the value range of a taxon or of a group of taxa and specifying the contour intervals so that a nearly equal number of data points are included within each contour.

Figure 1.3.7 depicts the distribution of cultural pollen types. This group was constructed by summing the frequency of each of the following pollen types for each data point: Opuntia sp., Cleome sp., Achillea sp., Cruciferae, Cucurbita sp., Zea mays, Sphaeralcea sp., Eriogonum sp., Polygonum sp., Polygonum sawatchense type, Portulaca sp., Rosaceae, Nicotiana sp., and Umbelliferae. This map indicates that the greatest quantity of economic pollen types cluster to the north, east, and south of the central hearth, and on the north and south of the eastern wingwall.

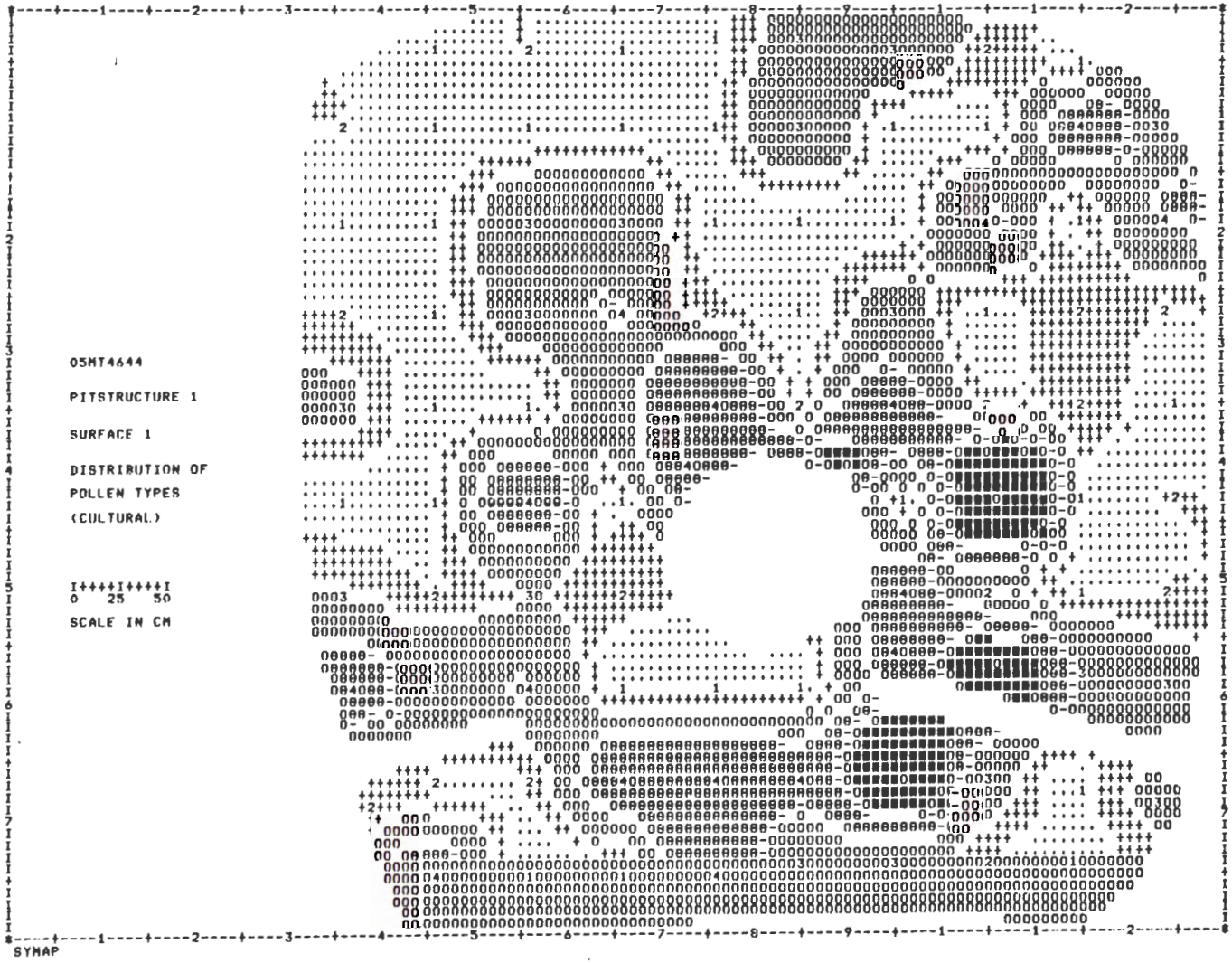

Figure 1.3./. SYMAP representation of cultural pollen distribution, Site 5MT4644.

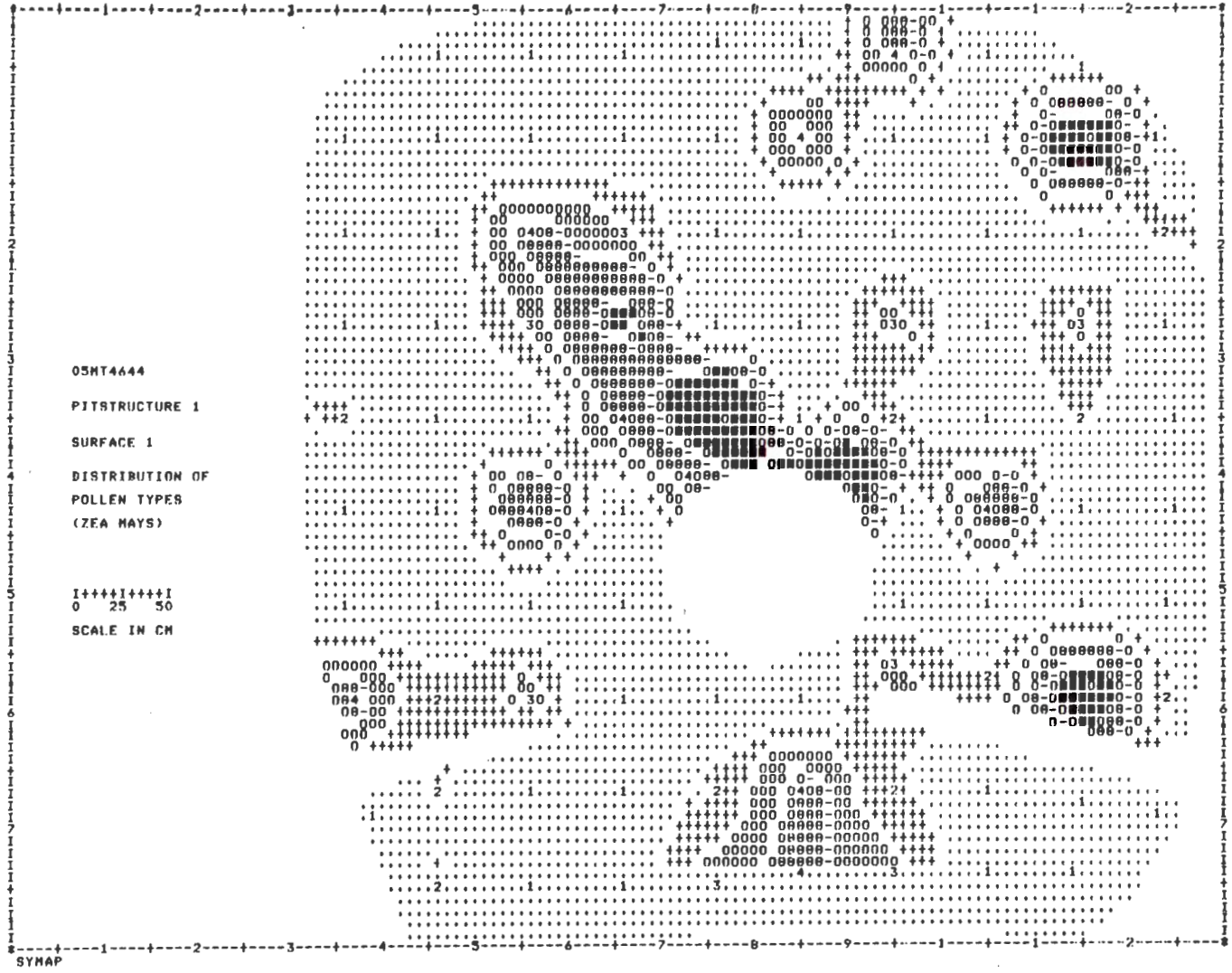

Figure 1.3.8. SYMAP representation of Zea mays pollen distribution, Site 5MT4644.

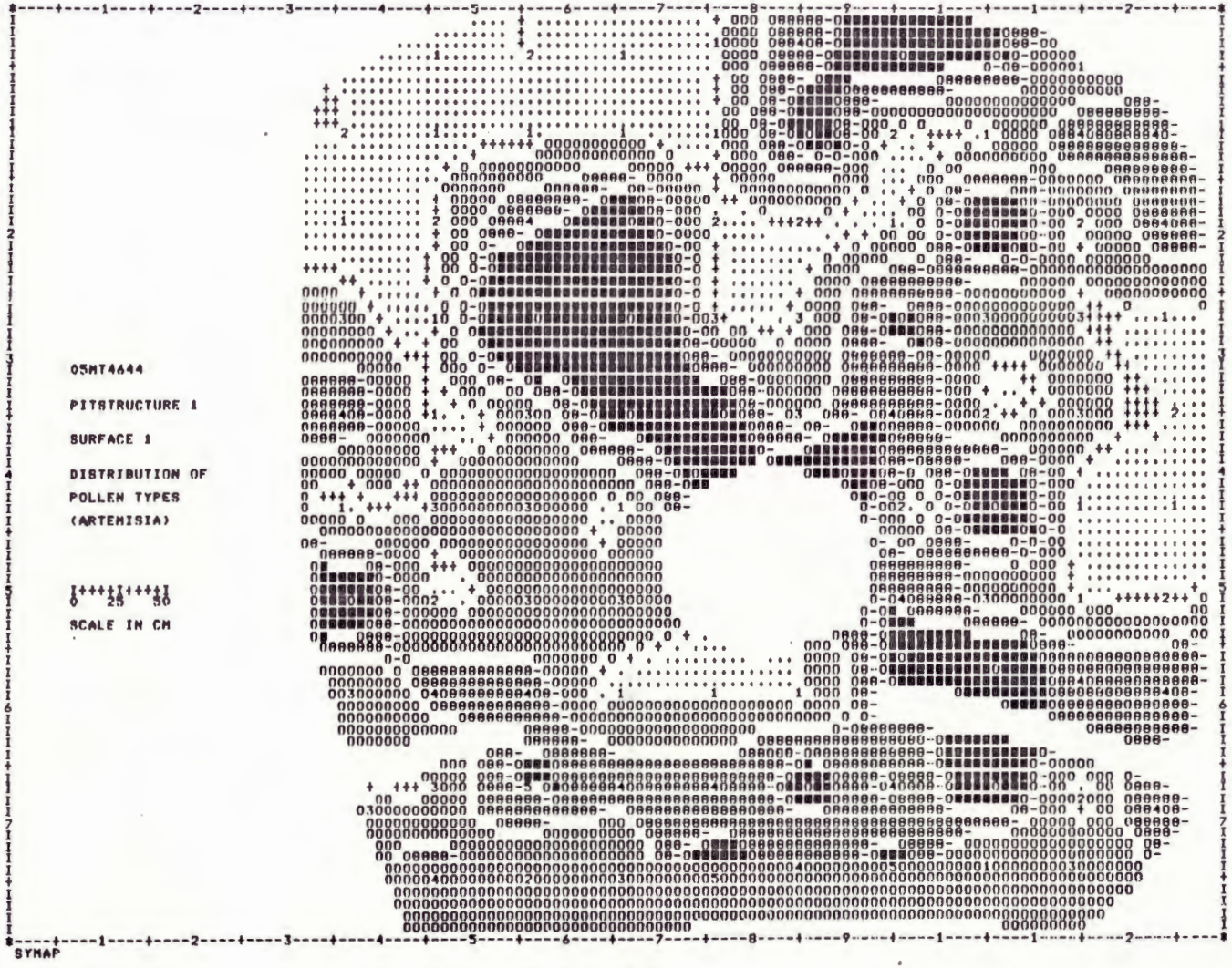

Figure 1.3.9. SYMAP representation of Artemisia pollen distribution, Site 5MT4644.

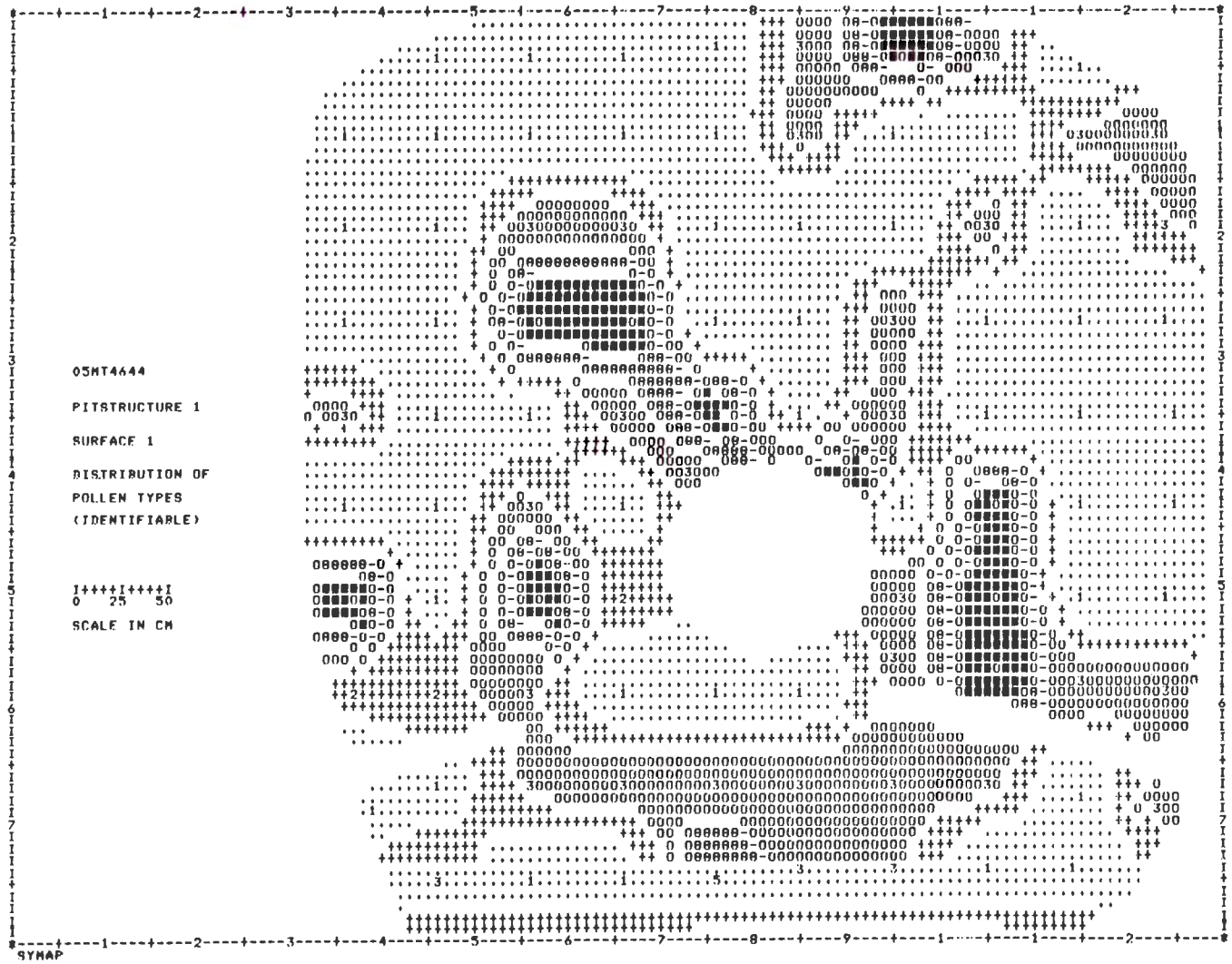

Figure 1.3.10. SYMAP representation of all identifiable pollen, Site 5MT4644.

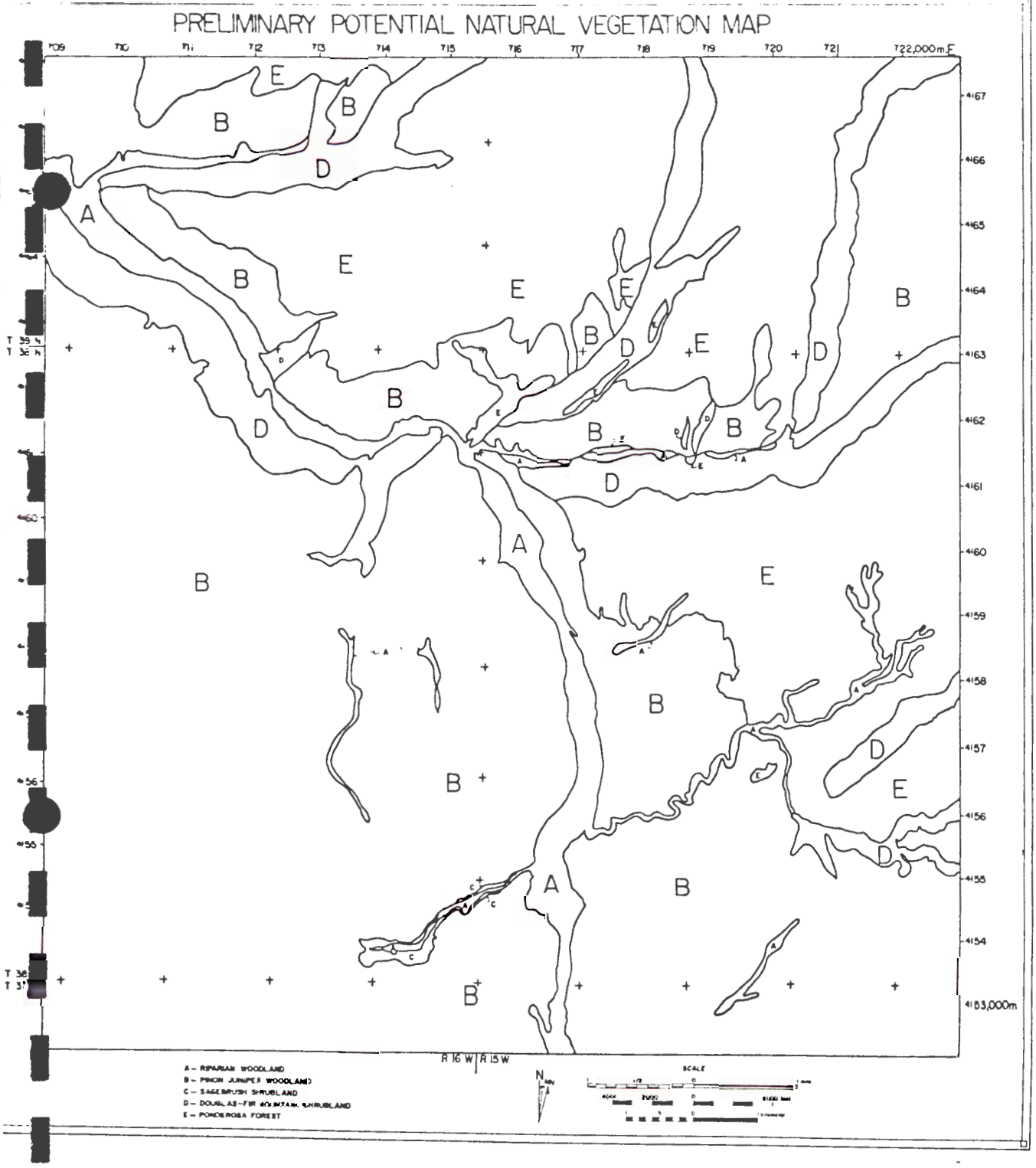

Figure 1.4.1. Potential natural vegetation map.

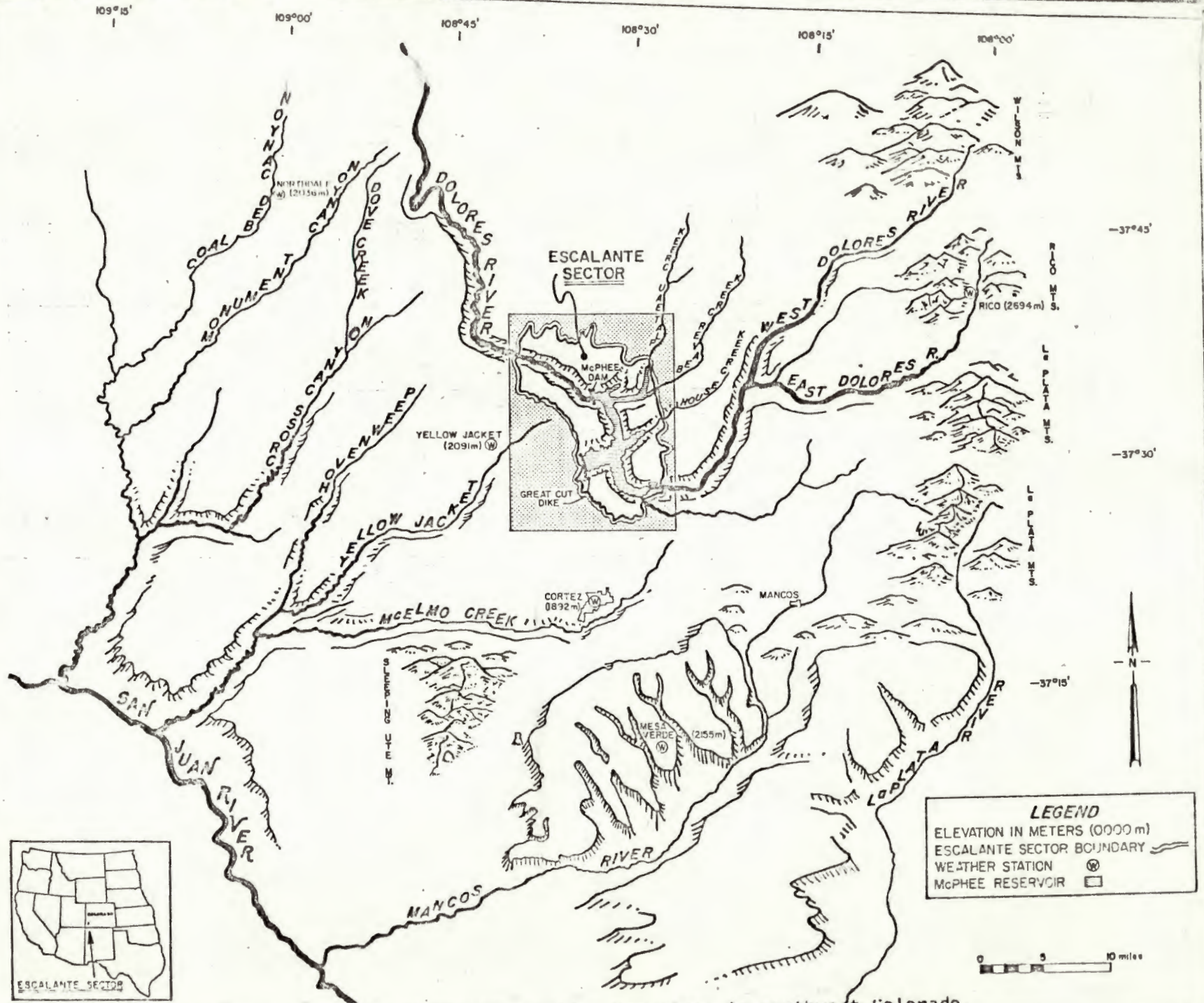

Figure 1.4.2. Map of weather station locations in southwest Colorado.

Turning to Figure 1.3.8, it seems that the greatest frequency of Zea mays pollen, definitely an economic pollen type, is to the north of the central hearth and along the north side of the eastern wingwall. This pollen type also occurs in somewhat lesser quantity in the northeast corner of the structure and to the south of the central hearth.

Figure 1.3.9 depicts the distribution of Artemisia sp. pollen. D. Steele (personal communication) has indicated that this taxon constitutes about 50 percent of the total pollen in all samples from this structure. The greatest frequency of this taxon again occurs to the north and northwest of the central hearth, in the northeast corner of the structure, and along the north and south sides of the eastern wingwall.

The last figure (Figure 1.3.10) illustrates the distribution of all identifiable pollen types present in samples from this structure's surface. Thus, this map is a composite map of the three previous maps, with some additional data added. The map illustrates the high frequency of pollen to the northwest, north, and northeast of the central hearth, in the northeast corner of the structure; and to the north of the eastern wingwall.

These distributional maps all indicate that there are relatively few locations on the surface of this structure that contain pollen of any type, economic or otherwise. Pollen is consistently present along the northern and eastern margins of the central hearth, along the eastern wingwall, and in the northeastern corner of the structure. If only economic pollen types were distributed in the fashion already described, the interpretation that these "high spots" reflect prehistoric activity would seem justified. However, the noneconomic pollen types (e.g., Artemisia sp.) follow this same distribution. Further, a comparison of

these maps to Figure 1 of Scott [39] suggests that the distribution of pollen on this surface is pretty well conditioned by whether there was "sufficient pollen for analysis." This suggests then that the distribution of pollen on this surface is of a reflection of where pollen was preserved--not necessarily where prehistoric activities were carried out. The fact remains that pollen preservation may be reflective of the areas where pollen was deposited (i.e., where plants were placed, processed, or stored) or may reflect how the surface was occupied (i.e., where people sat, worked, or slept), or indicates that the pollen on the structure's surface was differentially preserved due to catastrophic burning. Whatever the case, this sampling program has provided substantive results which indicate that the mere presence of certain pollen types in relation to each other and to other cultural manifestations does not necessarily mean that the plants represented were actually utilized by the inhabitants. Rather these results suggest that further examination of the botanical remains is necessary to associate their presence with prehistoric utilization.

In sum, the results of the intensive sampling program at Windy Wheat Hamlet indicate that three cultivated plants were utilized (corn, beans, and squash) and that four genera of woody plants provided material for fuel and for structural purposes (*Artemisia* sp., *Juniperus* sp., *Quercus* sp., and *Pinus* spp.). The remains of ruderal species present on the floor of this structure suggests that these plants were accessible to the inhabitants of Windy Wheat Hamlet. Until distributional studies of macrobotanical materials can be undertaken, however, the context of these plants in relation to prehistoric occupation can only be suspected.

SECTION 3e: CLIMATIC RECONSTRUCTION: TREE-RING EVIDENCE

by William J. Robinson and Kenneth L. Petersen

Precipitation amounts for southwestern Colorado from AD 909 to 1969 have been reconstructed by using tree-ring samples recovered from archaeological excavations in the region. The tree-ring samples were subjected to standard tree-ring dating procedures (Stokes and Smiley [62]), and a large number of pinyon pine, ponderosa pine, and Douglas-fir samples were absolutely dated. The rings of a number of these dated tree-ring samples were measured to provide ring-width data. A master chronology was produced by selection, standardization, and merging procedures described by Stokes and Smiley ([62:55-61), Fritts [63], and Fritts et al. [64].

Climate is the primary limiting factor to growth in the arid southwest, and the sequence of narrow and wide rings is a partial record of the year-to-year fluctuations. Recent efforts have produced analytical techiques for determining the quantitative effects of various factors and the growth of trees. A model of the relationships between tree growth and climate (Fritts [63:231-238) has been devised that shows that stored food reserves are the link between the previous year's climate and current growth. Narrow rings form during the current year when conditions of the previous year were not conducive for food production and the storage of an adequate reserve.

A mathematical relationship was established between current weather records for Southwest Colorado and the tree-ring chronology using the method outlined in Rose et al. [64]. This relationship was then used as a basis for converting tree-ring width into an estimate of precipitation for a portion of the weather records that have been held back as a test. The

results were calibrated and then the transformation was performed on the rest of the tree-ring series. In this case, the annual precipitation is an estimate of a "water year," or previous October through current September. The reconstruction is regional, rather than purely local. The justification is that in the regional study the variance explained rises to 0.72, whereas using only one local station (Cortez) a lower variance was explained (0.63).

The present mean precipitation for southwestern Colorado is 16.3 inches per "water year," with a mean standard deviation of 3.88. Table 1.3.7 is the year by year estimation of annual precipitation for southwestern Colorado.

These dates only extend back to AD 909, but estimates will be forthcoming that will extend this back to about the AD 600s and will be useful in evaluating the climate during the major period of occupation in the D.A.P. area.

Table 1.3.7. Reconstructed Annual Inches of Precipitation for Southwestern Colorado, AD 909-1969 (Page 1 of 3).

DATE	0	1	2	3	4	5	6	7	8	9
900	0	0	0	0	0	0	0	0	0	178
910	192	209	213	194	194	148	148	195	200	204
920	153	150	108	87	143	153	148	152	175	172
930	125	154	160	148	114	154	145	116	150	153
940	165	157	174	183	184	167	185	188	200	170
950	155	139	160	127	119	150	180	96	152	165
960	200	194	197	169	158	208	224	187	135	145
970	168	156	101	223	185	129	130	181	151	136
980	74	92	166	111	139	169	185	225	253	253
990	165	89	128	146	163	168	165	161	142	145
1000	151	126	119	151	126	83	195	183	171	101
1010	152	161	158	126	140	170	178	187	113	115
1020	195	161	145	203	215	180	126	169	159	159
1030	137	122	103	107	125	111	107	160	144	154
1040	123	131	175	135	140	162	120	141	106	179
1050	162	142	173	128	159	112	160	156	193	178
1060	163	170	138	219	219	237	158	107	127	176
1070	164	145	166	165	154	180	185	182	169	225
1080	230	148	109	133	166	121	149	228	223	137
1090	91	132	168	123	166	166	140	121	123	131
1100	163	158	192	206	129	180	114	159	162	165
1110	178	153	182	146	203	215	254	235	207	188
1120	157	154	211	149	212	172	133	205	229	210
1130	149	111	168	94	145	142	128	130	156	128
1140	117	171	164	143	145	113	102	112	116	105
1150	67	123	173	137	120	150	86	126	126	190
1160	147	135	167	175	122	141	133	119	86	109
1170	144	148	167	150	130	97	121	116	141	124
1180	146	187	144	177	237	165	120	202	170	183
1190	181	89	143	185	207	218	232	238	156	162
1200	226	209	176	195	165	134	168	157	171	220
1210	190	172	172	146	134	81	84	98	166	165
1220	137	140	165	164	172	176	137	112	156	166
1230	150	158	149	151	156	141	131	164	186	186
1240	161	157	176	153	160	131	129	152	228	197
1250	131	136	179	152	104	176	181	141	148	175
1260	131	189	165	137	167	185	157	187	157	193
1270	157	210	150	128	155	165	138	115	131	126
1280	124	135	145	98	127	97	150	83	112	152

Table 1.3.7. Reconstructed Annual Inches of Precipitation for Southwestern Colorado, AD 909-1969 (Page 2 of 3).

DATE	0	1	2	3	4	5	6	7	8	9
1290	139	175	147	129	157	74	162	142	148	92
1300	114	166	182	209	204	226	162	107	147	224
1310	219	198	259	244	153	172	118	161	172	191
1320	202	208	184	167	166	215	206	173	158	149
1330	213	222	227	239	225	160	261	226	126	167
1340	121	139	149	144	133	149	98	127	144	140
1350	113	78	160	178	170	143	171	205	208	207
1360	163	128	121	119	116	124	170	600	135	154
1370	177	155	146	162	166	104	125	144	136	141
1380	226	160	254	220	198	176	194	168	176	112
1390	110	155	159	157	173	138	125	137	82	107
1400	104	104	103	110	119	131	129	143	154	205
1410	144	125	148	89	131	125	150	142	128	155
1420	169	89	147	119	184	165	211	192	182	183
1430	177	166	217	198	146	136	146	141	119	143
1440	164	178	110	114	144	144	102	114	99	97
1450	116	169	146	170	142	83	126	103	188	153
1460	158	169	214	141	93	126	178	198	150	176
1470	140	116	120	99	132	117	143	190	155	87
1480	109	147	167	179	224	190	170	141	199	191
1490	190	251	168	186	137	84	149	160	196	116
1500	78	128	173	156	178	102	91	141	153	169
1510	115	191	194	177	176	129	111	132	108	177
1520	166	105	87	116	129	143	170	163	141	134
1530	154	130	95	135	126	158	176	164	132	161
1540	155	117	116	150	136	154	152	115	151	157
1550	162	148	150	169	119	151	226	188	168	154
1560	170	103	136	182	186	188	132	129	177	151
1570	177	184	147	119	122	123	135	122	116	99
1580	121	108	85	85	59	77	129	102	149	90
1590	96	139	91	141	163	154	131	105	140	147
1600	106	170	146	145	150	181	156	147	196	204
1610	200	156	151	153	156	186	205	226	208	153
1620	220	215	163	102	121	136	122	164	162	169
1630	157	134	109	184	168	190	97	112	154	141
1640	167	188	165	155	154	168	180	148	128	151
1650	187	185	137	176	110	183	175	121	117	163
1660	169	121	128	112	126	175	122	98	103	126
1670	115	151	165	183	183	174	133	148	181	151

Table 1.3.7. Reconstructed Annual Inches of Precipitation for Southwestern Colorado, AD 909-1969 (Page 3 of 3).

DATE	0	1	2	3	4	5	6	7	8	9
1680	175	190	199	187	106	102	149	153	190	179
1690	192	185	212	183	162	153	143	174	198	227
1700	211	212	256	155	146	220	217	133	150	197
1710	196	196	187	126	157	160	142	141	179	218
1720	259	152	149	174	117	239	203	178	122	94
1730	154	148	158	138	170	116	146	149	160	145
1740	138	152	152	186	179	223	233	188	125	208
1750	165	143	134	139	130	99	124	140	153	161
1760	145	138	129	171	156	131	184	134	167	176
1770	162	192	147	112	155	149	147	132	120	131
1780	106	141	109	203	176	157	162	162	120	134
1790	132	200	204	207	150	135	145	162	146	165
1800	144	150	169	134	160	99	138	161	130	160
1810	146	162	155	119	183	220	259	205	95	103
1820	97	153	121	101	117	138	138	135	163	138
1830	162	154	186	183	153	177	204	179	220	228
1840	234	177	144	184	184	128	159	89	199	181
1850	175	138	204	187	168	174	157	133	164	145
1860	150	96	177	130	103	161	176	208	211	181
1870	111	97	90	119	140	125	117	189	149	110
1880	132	134	120	131	158	166	150	125	186	164
1890	199	190	132	124	103	127	114	161	131	82
1900	117	144	86	131	97	196	214	225	207	222
1910	212	246	207	177	240	260	251	244	175	227
1920	142	200	198	164	184	176	223	200	183	176
1930	162	164	185	138	124	171	153	173	168	158
1940	175	230	178	154	164	152	116	184	193	185
1950	127	100	190	139	129	136	127	186	160	104
1960	159	139	153	135	168	195	162	150	147	148

SECTION 4

STUDIES OF CONTEMPORARY BIOTIC AND ABIOTIC ENVIRONMENTS

contributing authors

Bruce F. Benz, Vickie L. Clay,
Vance T. Holliday, and Lucy A. Piety

SECTION 4a: A CONTEMPORARY VEGETATION STUDIES - A REVIEW

The discussions in this section describe the results of Project area environmental investigations. Studies concerned with the distribution and documentation of both abiotic and biotic resources are described and cited.

According to Bye [12], the preliminary actual vegetation of the D.A.P. area comprises 11 vegetation zones. Bye stated that these 11 vegetation zones were determined on the basis of a few dominant species and upon the physiognyomy of these dominant species. This method of determination allows inexperienced persons to easily recognize these zones. The Survey Task Group should be able to recognize the vegetation zones on the basis of these few dominants.

Bye emphasized that the community concept cannot be applied to the D.A.P. area at this time. Defining a plant community requires that determinations of species composition in both space and time be made. Since vegetation reconnaissance and mapping took place only during three months of 1979, the dynamics of plant assemblages in their habitat could not be ascertained. The term zone applied to recognized vegetational differences of Bye, however, is assumed to represent assemblages that undergo change in a predictable manner. This pattern of change is the basis for recognizing what is considered below as Potential Natural Vegetation.

A floristic inventory of the Project area was conducted concurrently with mapping. Although it has been possible to determine the vegetation zone from which a plant species was collected, no determinations have been

made with regard to population structure, percent of ground cover, importance, species compositition, etc. Pinyon pine (Pinus edulis) is the only species on which quantitative data are available (Floyd [66]).

The floristic inventory which follows is arranged by D.A.P. locality (Table 1.4.1). Within each locality, plants noted and/or collected within each vegetation zone are listed by growth form. Only vascular plants are reported. Not all vegetation zones are represented in every locality. This floristic inventory was conducted in order to gather a sample of the Project area flora and to collect a variety of plant parts to aid in the identification of archaeological botanical remains.

Present-Day Vegetation Studies

Bailey [67] in his synthesis of U.S. ecoregions, places the D.A.P. area on the border between two highland ecoregion provinces: Rocky Mountain Forest and Colorado Plateau. According to Bailey [67], a province is a "subdivision that corresponds to a broad vegetation region having a uniform regional climate and the same type or types of zonal soils." The D.A.P. area is also proximal to the sectional boundary which separates the Colorado Plateau Province into the Juniper-Pinyon Woodland Sagebrush-Saltbush mosaic to the west and the Grama-Galleta Steppe and Juniper-Pinyon Woodland Mosaic to the South. The Ponderosa Pine-Douglas fir Forest is the section of the Rocky Mountian Forest lying to the northeast. Bailey [67] follows Kuchler [68] in defining a section as "climate climax at the level of Kuchlers potential vegetation types." The vegetation in the Rocky Mountain Province is characteristically zonal (or in belts (Meuller-Dombois and Ellenberg [69]) (Bailey [10:51]). Three of five belts recognized by Bailey occur within the Project area. These

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 1 of 25).

LOCALITY: TRIMBLE POINT
VEGETATION ZONE: PINYON JUNIPER OAK WOODLAND

TREES

Fagaceae
Quercus gambelii
Pinaceae
Pinus ponderosa

SHRUBS

Grossulariaceae
Ribes leptanthum
Rosaceae
Amelanchier sp.

HERBS

Compositae
Artemisia dracunculus
Artemisia frigida
Crepis acuminata
Erigeron divergens
Heterotheca villosa
Solidago sparsiflora
Leguminosae
Lupinus sp.
Linaceae
Linum lewisii
Onagraceae
Oenothera coronopifolia
Polemoniaceae
Collomia linearis
Scrophulariaceae
Castilleja linearifolia
Orthocarpus lutea
Orthocarpus purpureo-alba
Penstemon strictus

LOCALITY: TRIMBLE POINT
VEGETATION ZONE: ECOTONE DOUGLAS-FIR/OAK

SHRUBS

Berberidaceae
Mahonia repens

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 2 of 25).

VINES

Ranunculaceae
- *Clematis occidentalis*

HERBS

Asclepiadaceae
- *Asclepias subverticillata*

Chenopodiaceae
- *Salsola iberica*

Compositae
- *Ambrosia elatior*
- *Brickellia grandiflora*
- *Senecio eremophilus* ssp. *kingii*
- *Solidago nana*

Geraniaceae
- *Erodium cicutarium*

Polygonaceae
- *Polygonum douglasii*

Ranunculaceae
- *Thalictrum fendleri*

Scrophulariaceae
- *Penstemon bridgesii*

LOCALITY: TRIMBLE POINT
VEGETATION ZONE: ECOTONE PONDEROSA/OAK FOREST

TREES

Cupressaceae
- *Juniperus osteosperma*

Fagaceae
- *Quercus gambelii*

Pinaceae
- *Pinus edulis*
- *Pinus ponderosa*

Salicaceae
- *Populus angustifolia*
- *Populus tremuloides*
- *Salix* sp.

SHRUBS

Anacardiaceae
- *Rhus aromatica*

Caprifoliaceae
- *Symphoricarpus* sp.

Grossulariaceae
- *Ribes aureum*

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 3 of 25).

SHRUBS (cont.)

Rhamnaceae
- *Ceanothus fendleri*

Roseaceae
- *Amelanchier*
- *Amelanchier utahensis*
- *Holodiscus*
- *Pentaphylloides floribunda*
- *Potentilla gracilis*
- *Prunus virginiana*
- *Purshia tridenta*
- *Rose woodsii*

VINES

Ranunculaceae
- *Clematis* sp.
- *Clematis hirsuitissima*

HERBS

Alliaceae
- *Allium* sp.

Caryophyllaceae
- *Arenaria congesta*

Chenopodiaceae
- *Chenopodium* sp.

Compositae
- *Achillea lanulosa*
- *Artemisia dracunculus* spp. *glauca*
- *Artemisia ludoviciana*
- *Erigeron flagillaris*
- *Heliomeris multiflora*
- *Heterothera villosa*
- *Hymenopappus filifolius*
- *Madia glomerata*
- *Solidago nana*
- *Wyethia arizonica*

Gentianaceae
- *Frasera speciosa*

Hydrophyllaceae
- *Phacelia heterophylla*

Iridaceae
- *Iris missouriensis*

Leguminosae
- *Glycyrrhiza lepidota*
- *Lathyrus* sp.
- *Lotus* sp.
- *Lupinus caudatus argophyllus*
- *Thermopsis montana*

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 4 of 25).

HERBS

Linaceae
- *Linum lewisii*

Onagraceae
- *Epilobium paniculatum*
- *Gayophytum diffusum*

Polemoniaceae
- *Collomia linearis*
- *Ipomopsis* sp.
- *Ipomopsis aggregata*

Polygonaceae
- *Eriogonum racemosum*

Ranunculaceae
- *Thalictrum fendleri*
- *Ranunculus aquatilis*

Rubiaceae
- *Galium boreale*

Santalaceae
- *Comandra umbellara*

Scrophulariaceae
- *Castilleja* sp.
- *Castilleja linariaefolia*
- *Orthocarpus luteus*
- *Penstemon* sp.

GRASSES AND GRASSLIKE PLANTS

Cyperaceae
- *Eleocharis* sp.

Gramineae
- *Agropyron trachycaulum*
- *Blepharoneuron tricholepsis*
- *Bromus anomalous*
- *Elymus canadensis*
- *Poa* sp.

LOCALITY: CLINES CREST
VEGETATION ZONE: DISTURBED AND CULTIVATED LAND

TREES

Cupressaceae
- *Juniperus osteosperma*
- *Juniperus scopulorum*

Fagaceae
- *Quercus gambelii*

Pinaceae
- *Pinus edulis*
- *Pinus ponderosa*

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 5 of 25).

SHRUBS

Compositae
- *Artemisia* sp.
- *Artemisia tridentata*
- *Chrysothamnus* sp.

Rosaceae
- *Rosa woodsii*

HERBS

Amaranthaceae
- *Amaranthus graciezens*

Asclepiadaceae
- *Asdepias subverticillata*

Boraginaceae
- *Lappula redowski*

Chenopodiaceae
- *Chenopodium* sp.
- *Salsola iberica*

Compositae
- *Achillea millefolium lanulosa*
- *Artemisia frigida*
- *Carduus nutans*
- *Erigeron divergens*
- *Gutierreza* sp.
- *Helianthus annuus*
- *Heterotheca villosa*
- *Iva xanthifolia*
- *Madia glomerata*
- *Senecio* sp.
- *Tragopogon dubius*

Convolvulaceae
- *Convolvulus arvensis*

Cruciferae
- *Brassica* sp.
- *Lepidium* sp.

Cucurbitaceae
- *Cucurbita mixta*
- *Cucurbita pepo*

Geraniaceae
- *Erodium cicutarium*

Leguminosae
- *Lotus* sp.
- *Lotus wrightii*
- *Lupinus* sp.
- *Lupinus kingii*
- *Melilotus officinalis*

Malvaceae
- *Sphaeralcea* sp.
- *Sphaeralcea coccinea*

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 6 of 25).

HERBS (cont.)

Onagraceae
- *Epilobium paniculatum*
- *Oenothera* sp.
- *Oenothera coronopifolia*

Plantaginaceae
- *Plantago patagonica*

Polygonaceae
- *Eriogonum* sp.
- *Eriogonum racemosum*
- *Polygonum* sp.

Ranunculaceae
- *Ceratocephala testiculata*

Scrophulariaceae
- *Cordylanthus* sp.
- *Orthocarpus luteus*
- *Orthocarpus pupureo-albus*

Verbenaceae
- *Verbena bracteata*

GRASSES

- *Agropyron desertorum*
- *Bromopsis inermis*
- *Bromus tectorum*
- *Koeleria cristata*

LOCALITY: PERIMAN
VEGTATION ZONE: RIPARIAN WOODLAND

TREES

Salicaceae
- *Populus* sp.
- *Populus angustifolia*

Rosaceae
- *Crataegus* sp.

SHRUBS

Anacardiaceae
- *Rhus aromatica*

Eleagnaceae
- *Sheperdia* sp.

Salicaceae
- *Salix* sp.

Tamaricaceae
- *Tamarix pentandra*

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 7 of 25).

VINES

Ranunculaceae
Clematis ligusticifolia

HERBS

Asclepiadaceae
Asclepias sp.
Asclepias speciosa
Compositae
Erigeron subtrinervis
Leucanthemum vulgare
Tragopogon dubius
Cruciferae
Camelina microcarpa
Scrophulariaceae
Castilleja sp.

GRASSES AND GRASSLIKE PLANTS

Cyperaceae
Eleocharis machrostachya
Scirpus lacustris ssp. *validus*
Juncaceae
Juncus sp.

LOCALITY: PERIMAN
VEGETATION ZONE: RIPARIAN GRASSLAND - SHRUBLAND

TREES

Aceraceae
Acer negundo
Salicaceae
Populus angustifolia

SHRUBS

Anacardiaceae
Rhus aromatica
Compositae
Chrysothamnus nauseosus
Grossulariaceae
Ribes sp.
Oleaceae
Syringa vulgaris
Rosaceae
Prunus virginiana

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 8 of 25).

SHRUBS (cont.)

Rosaceae (cont.)
- Rosa sp.
- Rosa woodsii

Salicaceae
- Salix sp.

VINES

Ranunculaceae
- Clematis ligusticifolia

Vitaceae
- Vitis riparia

HERBS

Alliaceae
- Allium sp.

Amaranthaceae
- Amaranthus retroflexus

Apocyanaceae
- Apocynum cannabinum var glaberrimum
- Apocynum cannabinum var suksdorfii

Chenopodiaceae
- Chenopodium sp.

Compositae
- Achillea milleflorum
- Aster adscendens
- Aster commutatus
- Aster falcatus
- Aster rubrotinctus
- Carduus nutans
- Cirsium sp.
- Cirsium arvense
- Erigeron sp.
- Erigeron divergens
- Helianthus nuttallii
- Lactuca tartarica puchella

Convolvulaceae
- Convolvulus sp.

Cruciferae
- Descurainia pinnata
- Physaria sp.

Equisitaceae
- Equisitum laevigatum

Labiatae
- Mentha arvensis

Leguminosae
- Astragalus sp.
- Glycyrrhiza lepidota

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 9 of 25).

HERBS (cont.)

Legumi[illegible]ae (cont.)
- Lu[illegible]us sp.
- Me[illegible]ago lupulina
- Me[illegible]ptus officinalis
- Tr[illegible]ium sp.
- Tr[illegible]ium pratense
- Vi[illegible] americana

Malvaceae
- Ma[illegible] neglecta
- Sp[illegible]alcea coccinea

Martyniaceae
- Pro[illegible]coidia parviflora

Onagraceae
- Oe[illegible]era sp.

Plantaginaceae
- Plantago lanceolata

Polygonaceae
- Rumex crispus

Rubiaceae
- Galium boreale

Scrophulariaceae
- Penstemon barbatus

Solanaceae
- Nicotiana rustica
- Physalis sp.
- Solanum sp.

Typhaceae
- Typha latifolia

Umbelliferae
- Cicuta douglasii

GRASSES AND GRASSLIKE PLANTS

Cyperaceae
- Carex sp.
- Scirpus sp.

Gramineae
- Agrostis alba
- Dactylis glomerata
- Phleum pratense
- Sitanion hystrix

Juncaceae
- Juncus sp.

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 10 of 25).

LOCALITY: PERIMAN
VEGETATION ZONE: ECOTONE RABBITBRUSH - SWEET CLOVER SHRUBLAND

HERBS

Chenopodiaceae
- *Chenopodium* sp.
- Kochia sp.

Leguminosae
- *Medicago sativa*

Plantaginaceae
- *Plantago major*

LOCALITY: PERIMAN
VEGETATION ZONE: SAGEBRUSH SHRUBLAND

TREES

Cupressaceae
- *Juniperus osteosperma*
- *Juniperus scopulorum*

Fagaceae
- *Quercus gambelii*

Pinaceae
- *Pinus edulis*

SHRUBS

Anacardiaceae
- *Rhus aromatica*

Berberidaceae
- *Mahonia repens*

Compositae
- *Artemisia tridentata*
- *Chrysothamnus nauseosus*
- *Chrysothamnus viscidiflorus*

Grossulariaceae
- *Ribes* sp.

Hydrangeaceae
- *Fendlera rupricola*

Rosaceae
- *Amelanchier utahensis*
- *Cercocarpus montanus*
- *Peraphyllum ramossisimum*
- *Prunus virginiana*
- *Rosa woodsii*

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 11 of 25).

HERBS

Chenopodiaceae
- Chenopodium sp.

Compositae
- Achillea sp.
- Achillea millefolium
- Cirsium sp.
- Chrysopsis villosum
- Erigeron sp.
- Xanthocephalum sanothrae
- Hymenopappus filifolius
- Leucelene ericoides
- Petradovia pumila
- Senecic multilobatus
- Sonchus sp.
- Taraxicum sp.
- Tragopogon dubius

Convolvulaceae
- Convolvulus arvensis

Cruciferae
- Descurainia
- Descurainia pinnata

Geraniaceae
- Erodium cicutarium

Labiatae
- Nepata cataria

Leguminosae
- Lupinus sp.
- Melilotus officinalis
- Trifolium sp.

Liliaceae
- Yucca baccata

Onagraceae
- Oenothera coronopifolia

Polygonaceae
- Eriogonum sp.
- Eriogonum microthecum foliosum
- Eriogonum lonchophyllum

Rananculaceae
- Ceratocephala testiculata

Scrophulariaceae
- Penstemon barbatus

GRASSES

Gramineae
- Agropyron sp.
- Bromus sp.
- Elymus sp.
- Oryzopsis hymenoides

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 12 of 25).

LOCALITY: PERIMAN
VEGETATION ZONE: PINYON-JUNIPER WOODLAND

HERBS

Boraginaceae
- *Lappula redowski*

Compositae
- *Achillea* sp.
- *Carduus* sp.
- *Solidago* sp.
- *Sonchus* sp.
- *Tragopogon dubius*

Cruciferae
- *Sisymbrium altissimum*

Leguminosae
- *Lumpinus caudatus argophyllus*
- *Medicago sativa*

Malvaceae
- *Sphaeralcea coccinea*

Onagraceae
- *Oenothera coronopifolia*

Polygonaceae
- *Eriogonum racemosum*
- *Rumex* sp.

GRASSES

- *Aegilops cylindrica*
- *Agropyron desertorum*
- *Agropyron smithii*
- *Bromus inermis*

LOCALITY: PERIMAN
VEGETATION ZONE: PINYON JUNIPER OAK WOODLAND

TREES

Cupressaceae
- *Juniperus osteosperma*
- *Juniperus scopulorum*

Fagaceae
- *Quercus gambelii*

Pinaceae
- *Pinus edulis*

SHRUBS

Anacardiaceae
- *Rhus aromatica*

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 13 of 25).

SHRUBS (cont.)

Berberidaceae
- *Mahonia repens*

Compositae
- *Artemisia tridentata*
- *Chrysothamnus nauseosus*

Grossulariaceae
- *Ribes* sp.

Hydrangeaceae
- *Fendlera rupricola*

Rosaceae
- *Amelanchier utahensis*
- *Cercocarpus montanus*
- *Peraphyllum ramossisimum*

HERBS

Alliaceae
- *Allium* sp.
- *Allium accuminatum*

Boraginaceae
- *Cryptantha* sp.
- *Lappula* sp.
- *Lappula redowski*

Cactaceae
- *Opuntia* sp.
- *Corypantha* sp.

Chenopodiaceae
- *Chenopodium* sp.

Compositae
- *Achillea millefolium*
- *Aster* sp.
- *Carduus nutans*
- *Chysopsis* sp.
- *Erigeron* sp.
- *Erigeron speciosus*
- *Xanthocephalum sarothrae*
- *Heterotheca villosa*
- *Machraeranthera pinnatifida*

Cruciferae
- *Hedysarum boreale*
- *Physaria* sp.
- *Sisymbrium altissimum*

Leguminosae
- *Lupinus* sp.
- *Vicia* sp.
- *Trifolium* sp.

Liliaceae
- *Calochortus* sp.
- *Yucca baccata*

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 14 of 25).

HERBS (cont.)

Malvaceae
- *Sphaeralcea coccinea*

Polemoniaceae
- *Ipomopsis* sp.
- *Phlox* sp.

Polygonaceae
- *Eriogonum lonchophyllum*
- *Eriogonum umbellatum*

Scrophulariaceae
- *Castilleja* sp.
- *Orthocarpus* sp.
- *Penstemon* sp.
- *Penstemon barbatus*
- *Penstemon bridgesii*

GRASSES AND GRASSLIKE PLANTS

Cyperaceae
- *Scirpus* sp.

Gramineae
- *Bromus* sp.
- *Elymus cinereus*
- *Oryzopsis hymenoides*
- *Stipa* sp.

LOCALITY: PERIMAN
VEGETATION ZONE: DISTURBED AND CULTIVATED LAND

TREES

Cupressaceae
- *Juniperus osteosperma*

Pinaceae
- *Picea* sp.
- *Pinus* sp.

SHRUBS

Anacardiaceae
- *Rhus aromatica*

Grossulariaceae
- *Ribes* sp.

HERBS

Compositae
- Grindelia squarrosa
- *Lactuca* sp.

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 15 of 25).

HERBS (cont.)

Compositae (cont.)
- *Heterotheca villosa*

Convolvulaceae
- *Convolvulus arvensis*

Cruciferae
- *Chorispora tenella*
- *Sisymbrium altissimum*

Leguminosae
- *Medicago* sp.
- *Melilotus* sp.

Ranunculaceae
- *Aquilegia caerulia* - planted by house

LOCALITY: HOPPE POINT
VEGETATION ZONE: PONDEROSA/OAK FOREST

TREES

Cupressaceae
- *Juniperus osteosperma*
- *Juniperus scopulorum*

Fagaceae
- *Quercus gambelii*

Pinaceae
- *Pinus edulis*
- *Pinus ponderosa*

SHRUBS

Berberidaceae
- *Mahonia* sp.

Caprifoliaceae
- *Symphoricarpos* sp.

Compositae
- *Artemisia tridentata*

Rosaceae
- *Amelanchier* sp.
- *Amelanchier pumila*
- *Cercocarpos montanus*
- *Purshia tridentata*

VINES

Ranunculaceae
- *Clematis hirsutissima*

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 16 of 25).

HERBS

Alliaceae
- Allium sp.
- Allium acuminatum

Caryophyllaceae
- Arenaria sp.

Compositae
- Achillea lanulosa
- Artemisia dracunculus
- Artemisia ludoviciana
- Balsamorhiza sp.
- Erigeron)sp.
- Erigeron speciosus
- Heliomeris multiflora
- Heterotheca multiflora
- Heterotheca villosa
- Petradoria pumila
- Pyrrocoma crocea
- Solidago missouriensis
- Wyethia arizonica

Leguminosae
- Lotus wrightii
- Lupinus sp.
- Lupinus caudatus

Liliaceae
- Calochortus sp.

Onagraceae
- Epilobrium paniculatum
- Gayophytum diffusum ssp. parviflorum

Polemoniaceae
- Ipomopsis sp.
- Ipomopsis aggregata

Polygonaceae
- Eriogonum alatum
- Eriogonum racemosum
- Eriogonum umbellatum
- Polygonum douglasii

Ranuculaceae
- Ranunculus testiculatus

Rubiaceae
- Galium sp.

Scrophulariaceae
- Castilleja lineariordes
- Orthocarpus luteus
- Penstemon sp.

Umbelliferae
- Psuedocymopteris sp.

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 17 of 25).

GRASS

Gramineae
Oryzopsis hymenoides

LOCALITY: BEAVER POINT
VEGETATION ZONE: SAGEBRUSH SHRUBLAND

HERB

Amaranthaceae
Amaranthus retroflexus

LOCALITY: BEAVER POINT
VEGETATION ZONE: PINYON, JUNIPER, OAK WOODLAND

TREES

Cupressaceae
Juniperus sp.
Fagaceae
Quercus gambelii
Pinaceae
Pinus edulis

SHRUBS

Compositae
Artemisia tridentata

HERBS

Alliaceae
Allium acuminatum
Asclepiadaceae
Asclepias subverticillata
Compositae
Achillea millefolium lanulosa
Artemisia frigida
Erigeron speciousus machranthus
Tragopogon sp.
Leguminosae
Lupinus sp.
Liliaceae
Calochortus sp.
Linaceae
Linum lewisii
Polygonaceae
Eriogonum racemosum

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 18 of 25).

HERBS (cont.)

Polygonaceae (cont.)
Polygonum sawatchensis
Scrophulariaceae
Castilleja sp.

LOCALITY: GRASS MESA
VEGETATION ZONE: ECOTONE RIPARIAN GRASSLAND

TREES

Aceraceae
Acer negundo
Salicaceae
Populus angustifolia

HERBS

Boraginaceae
Lappula redowski
Leguminosae
Medicago sativa
Malvacee
Sphaeralcea coccinea

LOCALITY: GRASS MESA
VEGETATION ZONE: PINYON JUNIPER WOODLAND

TREES

Aceraceae
Acer glabrum
Cupressaceae
Juniperus sp.
Fagaceae
Quercus gambelii
Pinaceae
Pinus edulis
Pinus ponderosa
Saliaceae
Populus angustifolia

SHRUBS

Compositae
Artemisia tridentata
Chrysothamnus nauseosus
Chrysothamnus viscidiflorus

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 19 of 25).

SHRUBS (cont.)

Hydrangeaceae
- *Fendlera rupricola*

Rhamnaceae
- *Rhamnus* sp.

Rosaceae
- *Amelanchier alnifolia*
- *Amelanchier utahensis*
- *Cercocarpus montanus*
- *Peraphyllum ramossisimum*
- *Purshia tridentata*

VINES

Ranunculaceae
- *Clematis ligusticifolia*

HERBS

Boraginaceae
- *Crypantha* sp.
- *Lappula* sp.
- *Lappula redowskii*
- *Lithospermum multiflorum*

Caryophyllaceae
- *Stellaria* sp.

Chenopodiaceae
- *Chenopodium* sp.

Compositae
- *Cirsium* sp.
- *Helianthus nuttallii*
- *Heterotheca villosa*
- *Sonchus* or *Lactuca* sp.
- *Sonchus* sp.
- *Rudbeckia lacinata*
- *Tetradymia canescens*

Crassulaceae
- *Sedum* sp.

Cruciferae
- *Arabis* sp.
- *Sisymbrium* sp.
- *Sisymbrium altissimum*

Geraniaceae
- *Geranium* sp.

Leguminosae
- *Lotus wrightii*
- *Medicago sativa*
- *Melilotus alba*
- *Melilotus officionalis*

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 20 of 25).

HERBS (cont.)

Liliaceae
- *Calochortus nuttallii*
- *Yucca baccata*

Malvaceae
- *Malva neglecta*
- *Sphaeralcea coccinea*

Onagraceae
- *Gayophytum ramosissimum*
- *Oenothera caespitosa*

Polygonaceae
- *Eriogonum umbellatum*

Rubiaceae
- *Galium* sp.

Scrophulariaceae
- *Castilleja linearifolia*

GRASSES

Gramineae
- *Bromus tectorum*
- *Elymus* sp.
- *Oryzopsis hymenoides*
- *Stipa* sp.

LOCALITY: GRASS MESA
VEGETATION ZONE: PINYON-JUNIPER OAK WOODLAND

TREES

Aceraceae
- *Acer negundo*

Cupressaceae
- *Juniperus osteosperma*
- *Juniperus scopulorum*

Fagaceae
- *Quercus* sp.

Pinaceae
- *Pinus edulis*
- *Pinus ponderosa*

Salicaceae
- *Populus angustifolia*

SHRUBS

Anacardiaceae
- *Rhus aromatica*
- *Toxicodendron rydbergii*

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 21 of 25).

SHRUBS (cont.)

Berberidaceae
- *Mahonia repens*

Caprifoliaceae
- *Symphoricarpos* sp.

Celastraceae
- *Pachistema myrsinites*

Compositae
- *Chrypothamnus nauseosus*
- *Chrysothamnus viscidiflorus*

Cornaceae
- *Cornus stolenifera*

Eleagnaceae
- *Eleagnus* sp.

Hydrangeaceae
- *Fendlera rupricola*

Saliaceae
- *Salix* sp.

HERBS

Apocynaceae
- *Apocynum* sp.

Boraginaceae
- *Cryptantha* sp.

Chenopodiaceae
- *Chenopodium* sp.

Compositae
- *Chrysopsis* sp.
- *Heterotheca villosa*

Cruciferae
- *Lepidium* sp.
- *Sisymbrium* sp.

Geraniaceae
- *Geranium* sp.

Leguminosae
- *Lotus wrightii*
- *Melilotus alba*
- *Melilotus officinalis*

Liliaceae
- *Yucca baccata*

Malvaceae
- *Sphaeralcea coccinea*

Polemoniaceae
- *Ipomopsis* sp.

Santalaceae
- *Comandra umbellata*

Scrophulariaceae
- *Penstemon* sp.
- *Penstemon barbatus*

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 22 of 25).

GRASSES

Gramineae
- *Bromus tectorum*
- *Oryzopsis hymenoides*

LOCALITY: GRASS MESA
VEGETATION ZONE: DOUGLAS FIR-OAK MOUNTAIN SHRUBLAND

TREES

Acerceae
- *Acer glabrum*

Betulaceae
- *Betula gracilis*

Cupressaceae
- *Juniperus scopulorum*

Fagaceae
- *Quercus gambelii*

Pinaceae
- *Pinus ponderosa*
- *Pseudotsuga menziesii*

Saliaceae
- *Populus angustifolia*
- *Populus tremuloides*

SHRUBS

Anacardiaceae
- *Toxicodendron rydbergii*

Caprifoliaceae
- *Symphoricarpos* sp.

Celestraceae
- *Pachistema myrsinites*

Cornaceae
- *Cornus stolanifera*

Rosaceae
- *Amelanchier utahensis*
- *Prunus virginiana*

Salicaceae
- *Salix* sp.

HERBS

Campanulaceae
- *Campanula* sp.

Compositae
- *Achillea* sp.
- *Solidago* sp.

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 23 of 25).

HERBS

Geraniaceae
Geranium sp.
Labiatae
Monarda sp.
Polypodiaceae
Polypodiaceae
Ranunculaceae
Thalictrum sp.
Umbelliferae
Umbelliferae

LOCALITY: GRASS MESA
VEGETATION ZONE: PONDEROSA OAK FOREST ECOTONE

TREES

Cupressaceae
Juniperus scopulorum
Fagaceae
Quercus gambelii
Pinaceae
Pinus ponderosa
Salicaceae
Populus angustifolia

SHRUBS

Anacardiaceae
Rhus aromatica
Celestraceae
Pachystima myrsinites
Rosaceae
Amelanchier utahensis
Cercocarpus montanus

HERBS

Apocynaceae
Apocynum sp.
Compositae
Erigeron sp.
Cruciferae
Alyssum minus
Polygonaceae
Eriogonum sp.
Santalaceae
Commandra sp.

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 24 of 25).

LOCALITY: GRASS MESA
VEGETATION ZONE: DISTURBED AND CULTIVATED LAND

TREES

Aceraceae
- *Acer negundo*

Salicaceae
- *Populus angustifolia*

SHRUBS

Anacardiaceae
- *Rhus aromatica*

Compositae
- *Artemisia tridentata*
- *Chrysothamnus nauseosus*

HERBS

Amaranthaceae
- *Amaranthus graecizans*
- *Amaranthus hypochondriacus*
- *Amaranthus retroflexus*

Capparidaceae
- *Cleome serrulata*

Chenopodium
- *Chenopodium* sp.
- *Chenopodium album*
- *Kochia* sp.

Compositae
- *Artemisia ludoviciana*
- *Carduus nutans*
- *Cirsium* sp.
- *Cirsium arvense*
- *Cirsium* sp.
- *Grindelia* sp.
- *Iva xanthifolia*
- *Sonchus* sp.
- *Taraxicum* sp.

Cruciferae
- *Descurainia* sp.
- *Descurainia sophia*

Labiatae
- *Mentha arvensis*
- *Moldavica parviflora*

Leguminosae
- *Phaseolus acutifolius*
- *Phaseolus vulgaris*

Malvaceae
- *Gossypium* sp.

Table 1.4.1. Floristic Inventory of Selected D.A.P. Localities (Page 25 of 25).

HERBS (cont.)

Malvaceae
- *Malva* sp.

Polygonaceae
- *Rumex* sp.

Ranunculaceae
- *Ceratocephala testiculata*

Solanaceae
- *Solanum americanum*
- *Solanum sarachoides*

belts and characteristic dominants are the Sagebrush belt at low elevations, the foothills or Woodland belt dominated by pinyon pine; juniper, mountain mahagony (Cercocapus mountanus), and oak (Quercus gambelli); and the Montane belt where ponderosa pine (Pinus ponderosa) and Douglas-fir (Pseudotseuga menziesii) alternate in dominance with respect to slope, exposure and consequent moisture regimes. The two higher belts (Subalpine and Alpine) are found within some 20 km of the Project area where subalpine fir (Abies lasiocarpa) and Englemann spruce (Picea engelmannii) exist.

The elevational zonation of vegetation is not nearly as distinct in the Colorado Plateau Province (Bailey [70:55]). Particularly at low elevations, areas are covered by grasslands interspersed with a variety of xeric shrubs. Open stands of pinyon pine and various species of juniper are found at slightly higher elevations. The three higher belts are very reminiscent of the Rocky Mountain Province, although aspen (Populus tremuloides) and lodgepole pine (Pinus contorta) may be very frequent in the montane belt.

As a first step toward recreating the prehistoric vegetation, a Potential Natural Vegetation Map has been drawn (Figure 1.4.1) Tuxin [71] conceptualized potential natural vegetation of today as the vegetation structure that would become established if the interference of man were removed and all successional sequences were completed under present climatic and edaphic conditions. The climax vegetation associations depicted in Figure 1.4.1 are hypothesized as developing from natural successional stages following the prehistoric and historic occupations in the D.A.P. area. The vegetation associations are considered here as representing a stable ecosystem following the

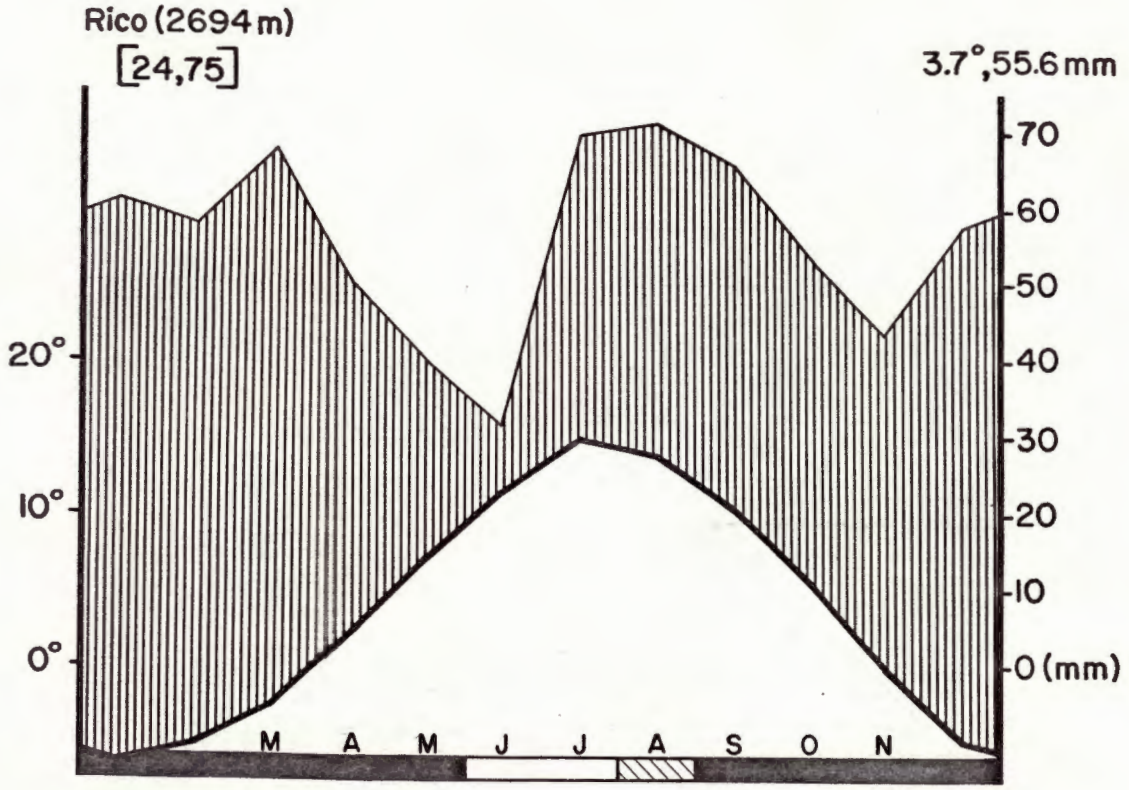

Figure 1.4.3. Ecological climate diagram for the Rico Weather Station.

*numbers in brackets [ ] refer to the length of record (number of years) for temperature and precipitation, respectively. The numbers in the upper right refer to mean annual temperature and precipitation.

polyclimax hypothesis. This hypothesis recognizes that there may be a number of different climax vegetation zones (a mosaic) within a climatic region that reflect local topographic and edaphic factors. That is to say, a climax landscape consists of a mosaic of edaphic and topographic climax vegetation types (Mueller-Dombois and Ellenberg [69:400ff]). Baileys [67, 70]) ecoregion sections illustrate this concept by naming the sections after the geographically dominant community within a mosaic. The five associations on the D.A.P. area Potential Natural Vegetation Map reflect this polyclimax perspective in, for example, limiting the Douglas-fir-Mountain shrubland to cool, mesic, north facing slopes.

Whether the Potential Natural Vegetation map accurately reflects the actual original vegetation (i.e., the vegetation that existed prior to human occupation) remains speculative. Prior to human occupation of the D.A.P. area, about 5000 BC (Kane [30]), the San Juan Basin and surrounding areas experienced periodic climatic fluctations (Euler et al. [38]; Petersen [72]). Following these periodic fluctuations we should expect distributional changes in the vegetation zones (cf. Kuchler [68, 73]; Meuller-Dombois and Ellenberg [69]).

Persons employing the PNV map should be aware that this reconstruction is based on the topography, soils, and climate of today. We emphasize that these three factors have probably been affected by the activities of man in the recent past. Consequently, the distribution of some vegetation zones may, in part, reflect the potential climax zone developed from anthropogenic plant associations, and therefore do not relect the actual original vegetation. Since this map is envisioned as providing input toward prehistoric environmental reconstruction, we might suggest that anthropogenic environments would be expected to differ

following the D.A.P. area Puebloan occupation. Consequently, the reconstruction of potential natural vegetation might also be different. For evaluating resource availability and agricultural potential this vegetation reconstruction is critical.

A short note concerning onsite vegetation is pertinent here. During the 1979 Field Season, one task which affected every E.S.G. Botany Section person was to document the flora on archaeological sites in their respective geographic areas of investigation. Only marginal amounts of time were expended to this end. The onsite vegetation listing of archaeological site reports is usually the end product. It was originally anticipated that onsite vegetation may be reflective of geographical areas of cultural activity (i.e., archaeological sites, cf. Yarnell [74]). Examination of many sites in the D.A.P. area, however, resulted in discontinuing this aspect of vegetation reconnaissance. That is, many of the sites excavated during the 1979 field season were located in areas of historic and present-day fields. The disturbance due to these historical and present-day agricultural activities removed or masked the effects of prehistoric cultural activity.

DAP-061

SECTION 4b: PRESENT-DAY FAUNAL INVESTIGATIONS

Zoological reconnaissance in the D.A.P. area has been undertaken by Emslie [21] and the Department of Natural Resources for the U.S. Fish and Wildlife Service (Burkhard et al. [75]). Three trap grids were monitored by Emslie during June through September 1979. Formal observations of birds and terrestrial animals were carried out (Emslie [21]). The investigations carried out for the U.S. Fish and Wildlife during 1980 included bird census, monitoring trap lines, helicopter range transects and big game counts.

Table 1.4.2 lists the animal species observed in the Project area (Emslie [21], Burkhard et al. [75]) and/or those species whose range includes Dolores and Montezuma counties (Armstrong [76]). Information supplied by Bailey [77] for adjacent areas of New Mexico was also extrapolated to southwest Colorado. Armstrong [76] lists 82 mammals whose range includes Dolores and Montezuma counties, and of these, Burkhard et al. [75] and Emslie [21] together observed only 32 in the D.A.P. Project area.

Regional faunas, such as Armstrong [76], have provided valuable information about species' habitat preferencee, general biology, historic range changes, and regional extinctions. Lechleitner [78] supplements Armstrong [76].

Bailey's [77] volume on the mammals of New Mexico, originally published in the early part of this century, emphasizes the affects of humans on animal distribution. With many species descriptions, he relates interesting accounts of historic hunting and of Native American faunal

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Tabel 1.4.2. Animal Species Observed in the D.A.P. Project Area Area and Animal Species Reported to Range in Dolores and Montezuma Counties (page 1 of 6).

MAMMALS		1	2	3	4
	INSECTIVERA				
Desert shrew	Notoisorex crawfordi		x		
Water shrew	Sorex palustris		x		
Dwarf shrew	S. nanus		x		
Vagrant shrew	S. vagrans	x	x		
Merriam's shrew	S. merriami	x	x		
Masked shrew	S. cinereus		x		
	CHIROPTERA				
Big eared bat	Plecotus townsendii	x	x		
Pallid's bat	Antrozous pallidus		x		
Hoary bat	Lasiurus cinereus		x		x
Silver haired bat	Lasionycteris noctivagans		x		
Big brown bat	Eptesicus fuscus	x	x		
Western bat	Pipistrellas hesperus		x		x
Long legged bat	Myotis volan	x	x		
California bat	M. californicus	x	x		
Small-footed bat	M. subulatus	x			
Fringed bat	M. thysanodes	x	x		
Long eared bat	M. evotis	x	x		x
Little brown bat	M. lucifugus		x	x	x
	M. leibii	x			
Free tailed bat	Tadarida brasilensia	x	x		
	LAGOMORPHA				
Snowshoe hare	Lepus americanus		x		
White-tailed jackrabbit	L. townsendii		x		
Black-tailed jackrabbit	L. californicus	x	x	x	x
Desert cottontail	Sylvilagus audubonii	x	x	x	x
Nuttall's cottontail	S. nuttallii	x	x		x
Pika	Ochotona princeps		x		
	RODENTIA				
Yellow-bellied marmot	Marmota flaviventris	x	x	x	x
Gunnison's praire dog	Cynomys gunnisoni	x	x	x	
Spotted ground squirrel	Spermophilus spilosoma		x		
Rock ground squirrel	S. variegatus	x	x	x	x
Golden mantled groundsquirrel	S. lateralis	x	x	x	x
Antelope squirrel	Ammospermophilus leucurus		x		
Least chipmunk	Eutamias minimus	x	x	x	x
Colorado chipmunk	E. quadrivattatus	x	x	x	x
Red squirel	Tamiasciurus hudsonicus	x	x	x	
Albert's squirrel	Sciurus alberti	x	x		x
Northern valley pocket gopher	Thomomys talpoides		x		
Bottae's pocket gopher	T. bottae	x	x	x	x
Kangaroo rat	Dipodomys ondii	x	x		
Silky pocket mouse	Perognathus flavus		x		
Apache pocket mouse	P. apache		x	x	

Tabel 1.4.2. Animal Species Observed in the D.A.P. Project Area Area and Animal Species Reported to Range in Dolores and Montezuma Counties (page 2 of 6).

		1	2	3	4
	RODENTIA (cont.)				
Beaver	Castor canadensis	x	x	x	
Western harvest mouse	Reithrodontomys megalotis	x	x		
Canyon mouse	Peromyscus crinitus	x	x		
Deer mouse	P. maniculatus	x	x	x	x
Brush mouse	P. boylii	x	x	x	x
Rock mouse	P. difficilis	x			
Pinon mouse	P. truei	x	x	x	x
Grasshopper mouse	Onychomys leucogaster		x		
Bushy tailed wood rat	Neotoma cinerea	x	x	x	x
Mexican wood rat	N. mexicana	x	x	x	x
White throated wood rat	N. albigula		x		
Red-backed mouse	Clethrionomys gapperi		x		
Heather vole	Phenacomys intermedius		x		
Mountain vole	Microtus montanus	x	x	x	
Long tailed vole	M. longicaudus	x	x	x	x
Mexican vole	M. mexicana	x	x		
Muskrat	Ondatra zibethicus	x	x	x	
Meadow jumping mouse	Zapus hudsonius		x		
Porcupine	Erethizon dorsatum	x	x		
	CARNIVORA				
Coyote	Canus latrans	x	x	x	x
Wolf	C. lupu		x		
Red Fox	Vulpes vulpes	x	x		
Kit Fox	V. macrotis		x		
Gray Fox	Urocyon cineroargenteus	x	x		
Black bear	Ursus americanus	x	x		x
Grizzly bear	U. arctos		x		
Ringtail	Bassariscus astutus	x	x		
Raccoon	Procyon lotor	x	x	x	x
Marten	Martes americana		x		
Ermine	Mustela erminea		x		
Long tailed weasel	M. frenata	x	x	x	x
Black footed ferret	M. nigripes		x		
Mink	M. vison	x	x		
Wolverine	Gualo gulo		x		
Badger	Taxidea taxus	x	x		
Spotted skunk	Spilogale putorius	x	x		x
Striped skunk	Mephitis mephitis	x	x		x
River otter	Lutra canadensis		x		
Cougar	Felix concolor	x	x		x
Lynx	Lynx canadensis		x		
Bobcat	Lynx rufus	x	x		
	ARTIODACTYLA				
Elk	Cervus canadensis	x	x	x	x
Mule deer	Odocoileus hemionus	x	x	x	x
Big horn sheep	Ovis canadensis	x	x		

Tabel 1.4.2. Animal Species Observed in the D.A.P. Project Area Area and Animal Species Reported to Range in Dolores and Montezuma Counties (page 3 of 6).

BIRDS		1	2	3	4
	CICONIIFORMES				
Great blue heron	Ardea herodias			x	
Black crowned night heron	Nycticorax nycticorax			x	
	ANSERIFORMES				
Canadian goose	Branta canadensis			x	x
Mallard	Anas platyrhynchos			x	x
Green winged teal	Anas crecca carolinensis			x	x
Blue winged teal	A. discors				x
Cinnamon teal	A. cyanoptera			x	x
American widgeon	A. americana				
Ruddy duck	Oxyura jamaicensis			x	
Common (American) merganser	Mergus merganser				x
	FALCONIFORMES				
Turkey vulture	Cathartes aura			x	
Goshawk	Accipiter gentilis			x	x
Sharp shinned hawk	A. striatus			x	x
Cooper's hawk	A. cooperii			x	
Red-tailed hawk	Buteo jamaicensis			x	x
Rough-legged hawk	B. lagopus				x
Golden eagle	Aquila chrysaetos			x	x
Bald eagle	Haliaeetus leucocephalus				x
Marsh hawk	Circus cyaneas				x
Prairie falcon	Falco mexicanus				x
Perrgrine falcon	F. peregrinus				x
Merlin or pigeon Hawk	F. columbarius				x
American kestrel/sparrow hawk	F. sparverius				x
	GALLIFORMIS				
Blue grouse	Dendragupus obscurus				x
Sharp-tailed grouse	Pedioecetes phasianellus				x
Sage grouse (hen)	Centrocercus urophasianus				x
Gambel's quail	Lophortyx gambelii				x
Ring-necked pheasant	Phasianus colchicus			x	x
Turkey	Meleagris gallopavo				x
	GRUIFORMES				
Sora	Porzana carolina				x
American coot	Fulica americana			x	x
	CHARADRIIFORMS				
Killdeer	Charadrius vociferus			x	x
Common snipe	Capella gallinago			x	x
Spotted sandpiper	Actitis macularia			x	x
American avocet	Recurvirostra americana				x

Tabel 1.4.2. Animal Species Observed in the D.A.P. Project Area Area and Animal Species Reported to Range in Dolores and Montezuma Counties (page 4 of 6).

		1	2	3	4
	COLUMBIFORMES				
Band tailed pigeon	Columba fasciata				x
Mourning Dove	Zenaida macroura			x	x
	STRIGIFORMES				
Screech owl	Otus asio				x
Great horned owl	Bubo virginianus				x
Pygmy owl	Glaucidum gnoma				x
	CAPRIMULGIFORMES				
Poor-will	Phalaenoptilus nuttalii				x
Common nighthawk	Chordeiles minor			x	x
	APODIFORMES				
White throated swift	Aeronautes saxatalis			x	x
Ruby throated hummingbird	Archilochus colubris				x
Black chinned hummingbird	A. alexandri				x
Broad tailed hummingbird	Selasphorus platycercus			x	x
	CORACIIFORMES				
Belted king fisher	Megaceryle alcyon			x	x
	PICIFORMES				
Common or Red Shafted Flicker	Colaptes auratus cafer			x	x
Lewis woodpecker	Asyndesmus lewis			x	x
Yellowbellied sapsucker	Sphyrapicus varius			x	x
Hairy woodpecker	Dendrocopos villosus			x	x
Downy woodpecker	D. pubescens				x
	PASSERIFORMES				
Western kingbird	Tyrannus verticulis				x
Cassin's kingbird	T. vociferans				x
Ash throated kingbird	Myiarchus cinerascens			x	x
Says phaebes	Sayornis saya				x
Flycatcher	Empidonax sp.				x
Hammond's flycatcher	E. hammondii			x	
Dusky flycatcher	E. oberholseri			x	
Western wood pewee	Contopus sordidulus			x	x
	Contopus mesoleucus			x	
Horned lurk	Eremophilia apestris			x	
Violet green swallow	Tachycineta thalassina			x	x
Olive-sided flycatcher	Nuttallornis boreais			x	
Tree swallow	Iridoprocne bicolor			x	
Rough winged swallow	Stelgidopteryx ruficollis			x	x
Barn swallow	Hirundo rustica			x	x
	Hirundo pyrrhanota			x	
Cliff swallow	Petrochelicken pyrrhonta			x	x

Tabel 1.4.2. Animal Species Observed in the D.A.P. Project Area Area and Animal Species Reported to Range in Dolores and Montezuma Counties (page 5 of 6).

		1	2	3	4
	PASSERIFORMES (cont.)				
Purple martin	Progne subis				x
Steller's jay	Cyanocitta stelleri			x	x
Scrub jay	Aphelocoma coerulescens			x	x
Black billed magpie	Pica pica			x	x
Common raven	Corvus brachyrhynchos				x
Common crow	C. brachyrhynchos				x
Pinon jay	Gymnorhines cyanocephalus			x	x
Black capped chickadee	Parus atricapillus			x	x
Mountain chickadee	P. gambeli			x	
Plains titmouse	P. inornatus				x
Common bushtit	Psaltriparus minimum				x
White breasted nutbatch	Sitta carolensis			x	x
Pygmy nutbbatch	S. pygmaea or S. pusilla			x	x
Brown creeper	Certhia familiaris				x
Wrentit	Chamaea fasciata				x
Dipper or water ouzel	Cinclus mexicanis				x
House wren	Troglodytes aedon			x	x
Bewick's wren	Thryomanes bewickii			x	x
Longbilled marshwren	Cistothorus palustris			x	
Canyon wren	Salpinctes mexicanus				x
Rock wren	S. obsoletus			x	x
Catbird	Dumetella carolinensis			x	x
Sage thrasher	Oreoscoptes montanus				x
American robin	Turdus migratorius			x	x
Hermit thrush	Catharus guttatus			x	
Western bluebird	Sialia mexicana			x	x
Mountain bluebird	S. currocoides			x	x
Townsend's solitaire	Myadestes townsendi				x
Ruby crowned kinglet	Regulus calendula			x	x
Blue-grey gnatcatcher	Polioptila caerulea			x	x
Northern shirke	Lanius excubitor				x
Starling	Sturnus vulgaris			x	x
Hutton's vireo	Vireo huttoni			x	x
Solitary vireo	V. solitarius			x	x
Warbling vireo	V. gilvus			x	x
Black and white warbler	Mniotilta varia				x
Orange crowned warbler	Vermivora celata				x
Nashville warbler	V. ruficapilla				x
Virginia's warbler	V. virginiae			x	x
Yellow warbler	Dendroica petechia			x	x
Audubon's warbler	D. coronata			x	
Yellow rumped warbler					x
Black throated grey warbler	D. nigrescens				x
Grace's warbler	D. graciae			x	
MacEillivray's warbler	Oporornis tolmiei			x	x
Yellowthroated warbler	Geothlypis trichas			x	
Yellowbreasted chat	Icteria virens			x	x

Tabel 1.4.2. Animal Species Observed in the D.A.P. Project Area Area and Animal Species Reported to Range in Dolores and Montezuma Counties (page 6 of 6).

		1	2	3	4
	PASSERIFORMES (cont.)				
Wilson's warbler	Wilsonia peursilla				x
House sparrow	Passer domesticus				x
Western meadowlark	Sturnella neglecta			x	x
Yellow-headed blackbird	Xanthocephalus xanthocephalus			x	
Red-winged blackbird	Agelaius phoeniceus			x	x
Northern oriole	Icterus galbula			x	x
Hooded oriole	I. cucullatus			x	
Brewer's blackbird	Euphagus cyanocephalus			x	x
Common or purple grackle	Quiscalus quiscula				x
Brown-headed cowbird	Molothrus ater			x	x
	P. ludovicianus			x	
Western tanager	Piranga ludoviciana			x	x
Black-headed grosbeak	Pheuticus melanocephalus			x	x
Blue grosbeak	Guiraca caeculea			x	
Indigo bunting	Passerina cyanea			x	x
Lazuli bunting	P. amoena			x	x
Evening grosbeak	Hesperiphona vespertina				x
House finch	Carpodacus mexicanus				x
Brown-capped rosy finch	Leucosticte australis				x
Pine siskin	Spinus pinus pinus			x	x
American gold finch	S. tristis			x	x
Lesser gold finch	S. psaltra			x	x
Green-tailed towhee	Pipilo chlorura			x	x
Rough-sided towhee				x	x
Rufous-sided towhee	P. erythrophthalmus				x
Lark bunting	Calamospiza melanocorys				x
Rufous-crowned sparrow	Aimophila ruficeps				x
Sage sparrow	Amphispiza belli				x
Grey-headed junco	Junco caniceps				x
Chipping sparrow	Spizella passerina			x	x
Brewer's sparrow	S. breweri			x	
White-crowned sparrow	Zonotrichia leucophrys				x
Song sparrow	Melospiza melodia			x	x

1 - Anderson, S., Mesa Verde Mammals, 1961.
2 - Armstrong, Mammals of Colorado, 1972.
3 - Emslie S., D.A.P., 1979.
4 - Burkhard, Fish and Wildlife Service.

exploitation. The discussions of habitat preferences of D.A.P. area mammals have proven useful.

Findely et al. [79] provides complete descriptions of species' habitat preferences. This monograph is useful for supplemental information on species whose range crosses the Colorado and New Mexico border.

Faunal information for the D.A.P. area is presently limited by the fact that it is only an inventory. Although the presence of species presence is useful information, until it can be linked with frequency of occurrence in D.A.P. area habitats, it is limited in its contribution to an understanding of biotic environments.

At present, no information concerning aquatic animals is available. Aquatic vertebrate research has been carried out by the U.S. Fish and Wildlife Service, but the E.S.G. has been unable to obtain any literature. Presuming that aquatic resources benefited the prehistoric D.A.P. inhabitants (Benz [29]), obtaining data on modern fish census is critical.

SECTION 4c: PRESENT-DAY CLIMATE: A REVIEW

Koppen [80] characterizes the climate of the D.A.P. as a Steppe Climate reflective of the mid-latitudes. One characteristic of the mid-latitude steppes is the unpredictable nature of precipitation over long periods of time. According to Thornwaite (in Trewartha [81]), the D.A.P. area is characterized as semiarid, microthermal, and deficient in rainfall during all seasons.

Employing temperature and precipitation information from five weather stations surrrounding the D.A.P. area (Figure 1.4.2), one of the most obvious characteristics of the weather in the D.A.P. area is the relative early summer drought and the variability in diurnal temperature fluctuations based on topography.

Figures 1.4.3 - 1.4.7 are ecological climate diagrams (Schneider [82]) based on data available from the Office of Colorado State Climatologist. The diagrams depict the periods of relative humidity (vertical shading), periods of relative drought (stippled), the months with mean daily minumum below 0° C (black) and the months with absolute minimum below 0° C, i.e., early and late frosts (diagonally shaded). The inclusions of the Rico weather station provides contrast due to its high elevation (i.e., averaging 600 m above all other stations). Of these five stations, Yellowjacket is the most similar to the D.A.P. area with respect to elevation. No station is very similar to the D.A.P. area in respect to topography, although Mesa Verde station and the Sagehen and Cline Crest localities are similar in terms of slope and aspect. Excluding the Rico station, the remaining four stations seem to reflect very similar temperature regimes (i.e., annual range of -5° to 20° C),

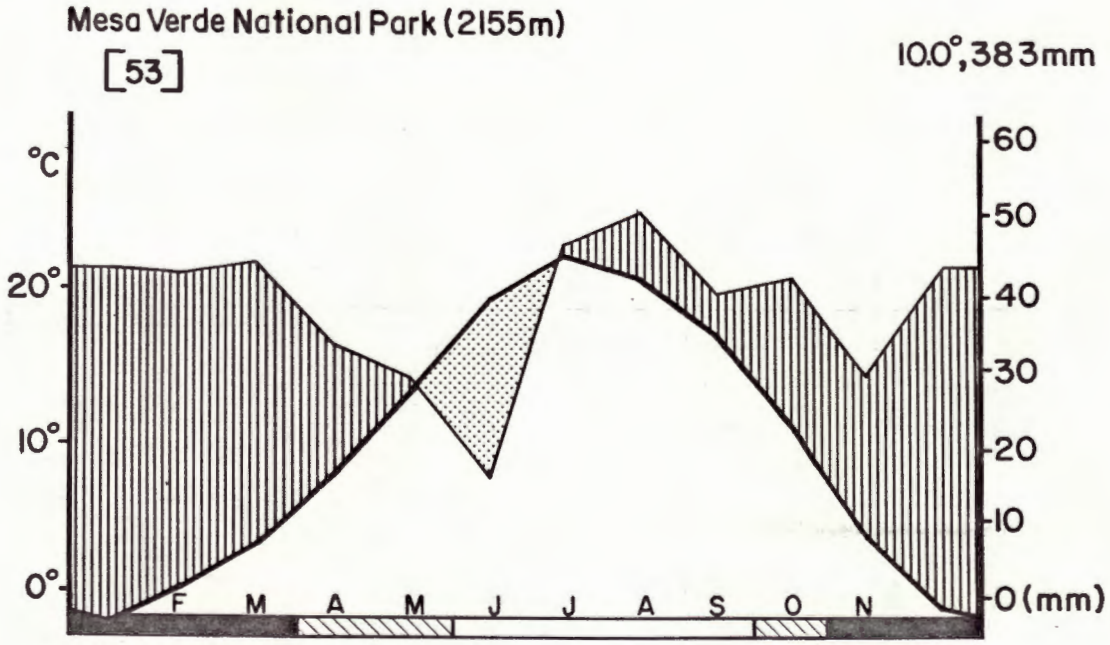

Figure 1.4.4. Ecological climate diagram for the Mesa Verde National Park Weather Station.

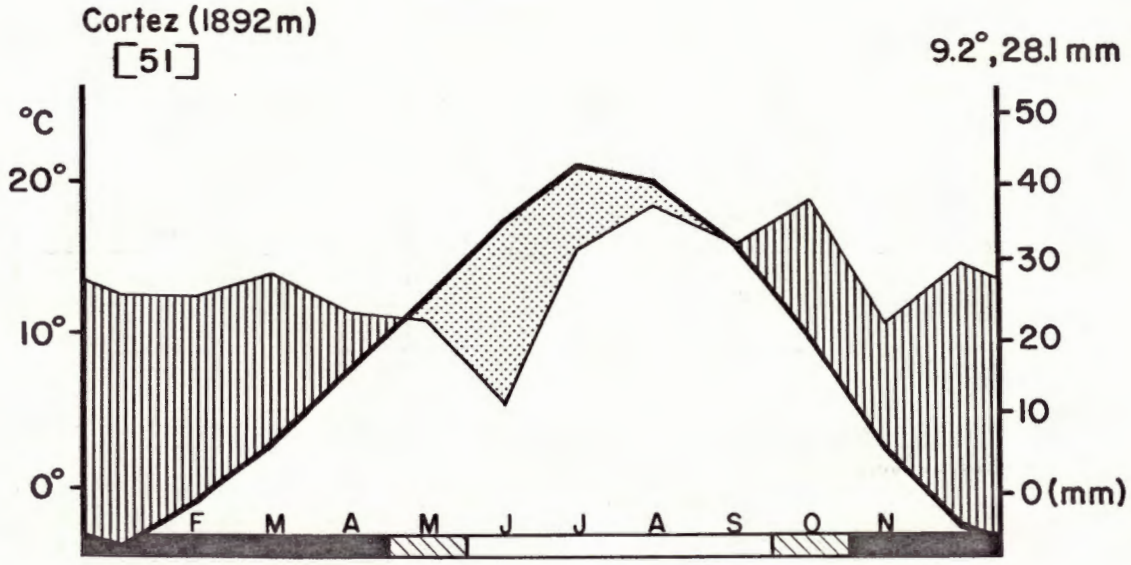

Figure 1.4.5. Ecological climate diagram for the Cortez Weather Station.

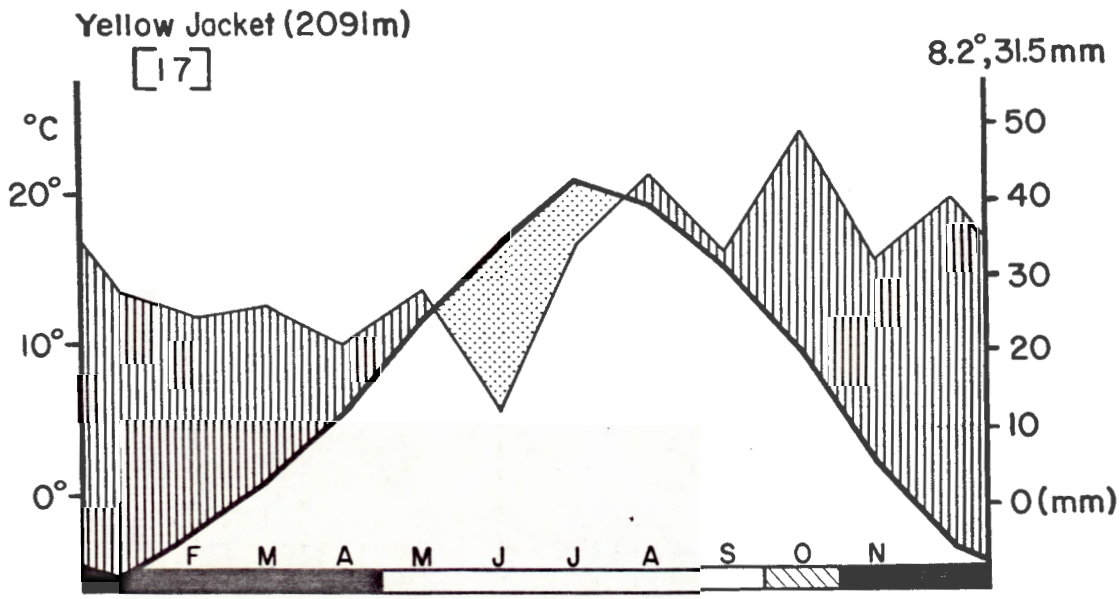

Figure 1.4.6. Ecological climate diagram for the Yellowjacket Weather Station.

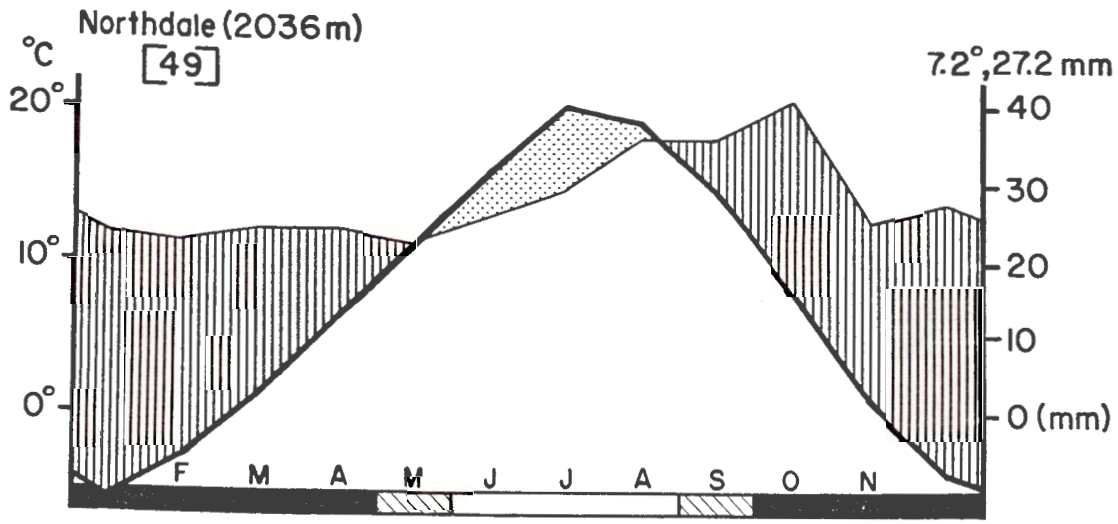

Figure 1.4.7. Ecological climate diagram for the Northdale Weather Station.

with the highest temperature in July and the lowest in January. Generally, all stations experience a relative drought beginning in the month of May although there is variation in duration of this drought. Precipitation also seems consistent over these four stations with the minimum in early summer (May or June) and the maximum during early winter (October or November). The length of the growing season is quite variable across these four stations. Northdale experiences the shortest growing season and Yellowjacket, the longest.

The length of the growing season has always been an important consideration with agriculture in the American Southwest (Carter [83]). The length of the growing season, calculated in days from the last frost in the spring to the first frost in the fall, is critical in determining whether a crop will mature and bear fruit. But this emphasizes growing season length and ignores the temperature requirements of a crop plant during the growing season. Most assume that this period of time is all that is necessary for the plant to mature. However, what if the average day/nighttime temperature of a 200 day growing season is never above 50° F. Given this extreme case, it seems unlikely that any but the hardy northern European domesticates would grow at all. A tropical cultigen such as corn might be expected to grow vegetatively, but it is unlikely that it would bear any fruit under these extreme conditions. Generally speaking, most of the corn grown today in the Southwest can mature in the 100-120 day growing season. Three of five weather stations previously mentioned average at least a 120 day growing season (Mesa Verde, Cortez, and Yellowjacket). However, one of the critical (or limiting) climatic factors that is experienced today by area farmers is the cold nights (A. Fisher CSU, Agricultural Extension Station, personal communication).

This was also a critical factor experienced by Shuster [7] in the D.A.P. experimental gardens. The concept of growing degree days (G.D.D.) is one means of understanding how low night temperatures might offset plant growth (Siemer [22]).

Growing Degree Days are calculated according to the needs of the plant. A tropical cultigen thus requires a higher average daily temperature than a temperate cultigen. On the basis of the required average daily temperature (base temperature) we can calculate the Growing Degree Days of a specific locale for a particular type of plant (e.g., warm versus cool season). Table 1.4.3 illustrates estimates of G.D.D. for the five weather stations surrounding the D.A.P. area. If Siemer [22:20] is correct in stating that most corn varieties (probably based on Iowa hybrid corn, see Shuster and Bye [84]) require 2500 G.D.D. 50 to mature seed, it would seem that only Mesa Verde National Park would be suitable for corn farming. All of the remaining four weather stations show lower G.D.D. and would be too risky. Actually, Native American varieties of corn require somewhat less than 2500 G.D.D. 50 to bear fruit (cf. Shuster [7]). In addition, just meeting the G.D.D. requirement for maturation necessitates an explicit definition of maturation be given. Maturation could mean that ears form, that the kernels become hard although not completely filled, or that the kernels on the ear fill and harden. In order to adequately use climatic data, it is necessary to define the relationships between climatic factors and the growth and maturation of the plants humans depend on.

Drought stress is a second commonly discussed topic of people working with southwestern agriculturalists (e.g., Euler et al. [38], Petersen [72]). However, moisture stress can be defined in as many ways as

Table 1.4.3. Estimates of Growing Degree Days for Five Stations Surrounding the D.A.P. Area.

Station	Elevation ft.	GDD*
Rico	8840 (2194 m)	533
Mesa Verde National Park	7070 (2155 m)	2527
Cortez	6210 (1893 m)	2237
Yellowjacket	6860 (2091 m)	2007
Northdale	6680 (2036 m)	1698

GDD* - Growing Degree days calculated form a 50°F base. This temperature assessment is estimated by subtracting 50°F from the average monthly temperature for months in which the average temperature is greater than 50° and multilying this by the number of days in each of these months (Siemer [22:20).

moisture affects the environment. Certain cultivated plants may require amounts of moisture at various points in their life cycle. According to Shuster [6] moisture is most critical for corn from germination through seedling establishment in the D.A.P. area (also see Shuster and Bye [84]). One obvious similarity of four of the five weather stations is the apparent drought during the early summer. At first glance it would seem that dry land agriculture is impossible in the D.A.P. and surrounding area. This apparent incongruity (when examined in light of agricultural practices today) is understandable when one recognizes that much of the area's moisture is received as early winter rains or as snow. If this moisture is retained by the soil until late spring, early planting would be beneficial. In periods where less winter moisture was retained in the upper reaches of the soil, deeper planting practices would be beneficial (Shuster [7], Shuster and Bye [85], Collins [86]).

The effects of topography on weather patterns have been examined recently by Barry and Bradely [87]. Siemer [22] suggests that topography profoundly influences weather patterns. The two aspects of weather already discussed are intensely affected by the topographic relief noted in the D.A.P. area (i.e., the "canyon effect and cold air drainage"). The canyon effect refers to increases precipitation at low elevations that are in close proximity to mountains (Siemer [22:4]). It is hypothesized that the precipitation which falls in the Dolores River valley reflects what Siemer refers to as the canyon effect.

Cold air drainage has been recognized in the canyons on Mesa Verde (Erdman et al. [88]) and in the D.A.P. area (Shuster [7]). The effects of cold air drainage were realized most amply by the early frost on 21 August 1980 which killed plants in the lower D.A.P. experimental garden. This

considerably shortened the length of the growing season (Shuster and Bye [85]). Drainage of cold air follows topographic lows. Topographically closed basins or steep sided canyons act as cold air lakes and streams. The effects of cold air drainage also influence the average daily temperature. In the D.A.P. area, these effects in the Sagehen Basin and along the Dolores River and large tributary canyons decrease the length of the growing season and the average daily temperature, and would have undoubtedly affected prehistoric agricultural practices.

SECTION 4d: SURFICIAL GEOLOGICAL INVESTIGATIONS - 1980[1]

by Vance T. Holliday and Lucy A. Piety

Introduction

Geologic consultation was provided to the Environmental Studies Program, Earth Resource Section of the Dolores Archaeological Program, for the periods May 27 and 28, June, July 1 through 17, and August 27 through 29, 1980. The work was oriented toward continuing the geologic investigations started in 1979 by Leonhardy and providing a base for future work[2].

There were several specific goals of the 1980 geologic work. The most important aspect was assisting crew chiefs and locality chiefs in interpretation of site microstratigraphy and local and areal geomorphic

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[1]This is an abridged version of the consultants' report submitted to the Dolores Archaeological Program by V. Holliday and L. Piety.

[2]We joined the D.A.P. rather suddenly under what could be considered emergency conditions. As we were newcomers to the D.A.P. and to the area, David Breternitz, Paul Farley, and Robert Bye aided immensely in helping us get organized, in outlining some of the geological problems to be tackled, and in answering innumerable questions about the program. Once we got started, Frank Leonhardy shared with us much of his considerable knowledge of the geology of the D.A.P. and surrounding area. Richard Glaser and James Hampson were invaluable as our guides to the area geology and to the D.A.P. in general. Their assistance in attacking some of the geologic problems and their companionship in the field were greatly appreciated. Bruce Benz and John Montgomery were a constant source of information and assistance concerning the archaeological, environmental, and business aspects of the program; Al Kane, Judi Burke, and Lora VanRenselaar were of considerable aid in dealing with additional archaeological and operational problems. We had several profitable discussions with Carl Phagan and Bill Lucius concerning lithic and ceramic resources respectively. Tom King, Bureau of Reclamation archaeologist in Cortez, provided maps and other valuable data dealing with Dolores project borrow pits.

setting and providing day-to-day consultation and direction concerning geological problems. Another important area of geologic interpretation was assessing the agricultural potential of the Dolores River flood plain, associated low terraces, fans and the uplands surrounding the river. Other areas of geologic investigations included observations of available material suitable for lithic tool manufacture, a review of previous geologic work, and when possible, a field check of various maps prepared by the Geology Crew in 1979.

The geologic investigations were accomplished primarily by field work in the Project area. Daily visits were made to active excavation areas. Numerous trips were also made in and around general areas of current and previous excavations, especially the Dolores River flood plain and Sagehen Flats. A general reconnaissance of most areas accessible by vehicle within the D.A.P. area were also made. Air photos and large- and small-scale topographic and geologic maps were utilized extensively. Limited laboratory analysis was carried out on samples from several soil profiles in order to solve several specific problems related to area soils and Quaternary stratigraphy. Publications pertinent to the local and regional geology were consulted. The geologic investigations were considerably aided by various geologic site reports, overviews, and maps resulting from earlier geologic work of the D.A.P.

In the following report the results of the 1980 geologic investigations are discussed from specific to general levels. Reports on the geologic aspects of individual sites are presented first. This is followed by a discussion of the Dolores River flood plain from the aspect of human occupation and agricultural potential. Some comments on the types and availability of resources for stone tools is presented, followed

by comments on several D.A.P. reports. An overview of the Quaternary geology and soils of the D.A.P. area is then offered. This includes a discussion of a map of the surficial geology of the area prepared as part of the 1980 geologic work. Throughout these discussions, where necessary, commentary is given concerning previous investigations into these various aspects of the geology and recommendations are presented for future geologic work.

The bedrock geology and major geomorphic aspects of the Project area have been reviewed by Leonhardy [19] and will not be covered in this report beyond comments on specific points raised by Leonhardy.

Site-specific Geology

Considerable time and effort was devoted to geologic investigations and interpretations of the sites being excavated during the periods of the writers' work in the D.A.P. area. These sites included the Periman community, Rio Vista Village (Site 5MT2182), McPhee Community, and Grass Mesa Village (Site 5MT0023). The time spent in and degree of interpretive detail possible for each area was due in large measure to the complexity of the geologic setting, and to the number and location of excavation areas, backhoe trenches, and natural exposures. As a result, the McPhee and Periman communities received considerably more attention than did the other sites or site areas.

Periman Community

Field observations at the Periman site (Site 5MT4671) during the 1980 season allow a preliminary interpretation of the stratigraphic and geomorphic history of the area. The interpretations are based on general observations of the local landscape, on more detailed studies of several

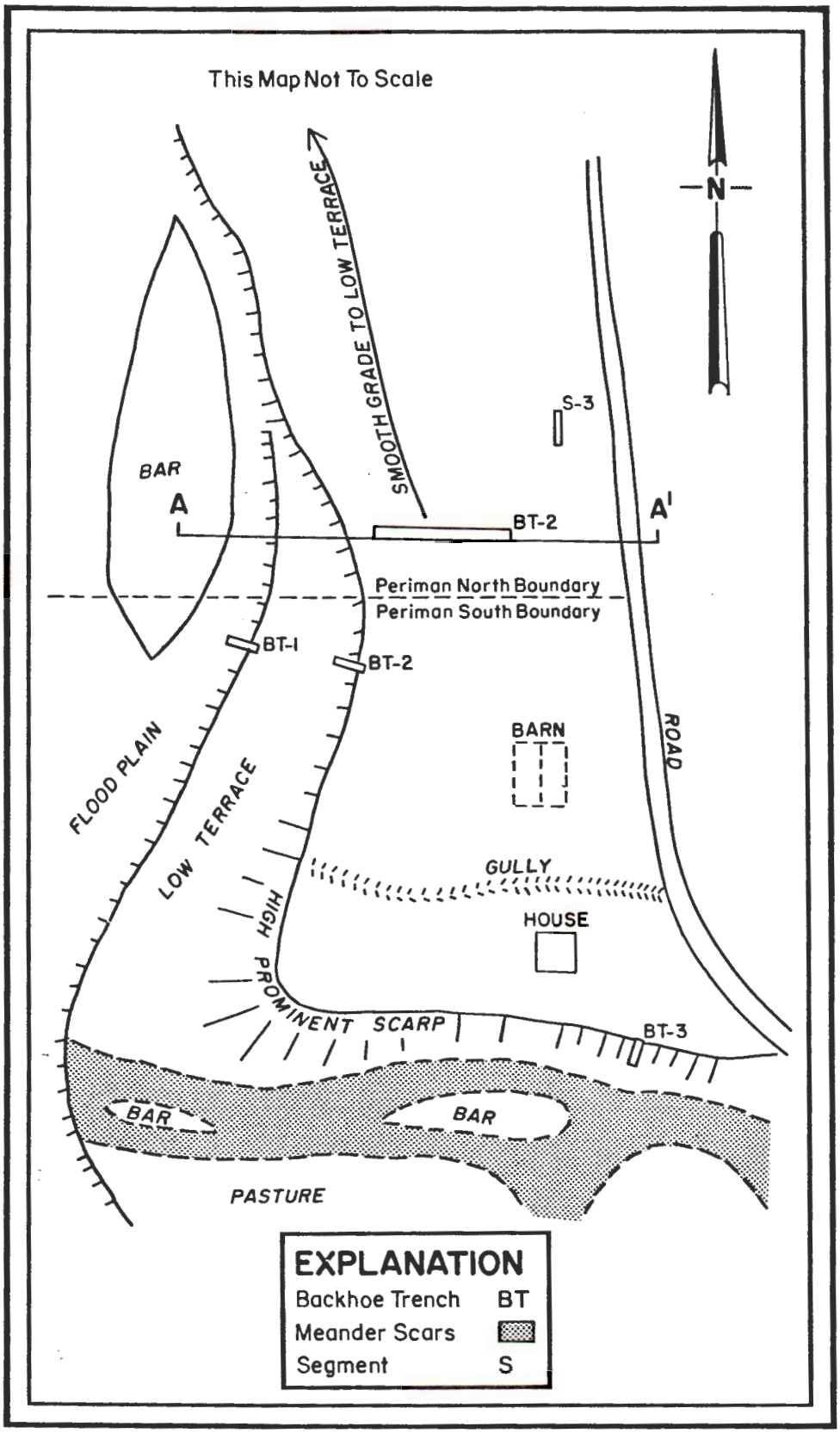
mechanically excavated trenches (Backhoe trenches 1, 2, 3, at south Periman; Backhoe Trench 2 and "Segment 3" at north Periman), on the deep pithouse excavations, and on notes from Bureau of Reclamation borrow materials Test Pits 118, 120, 121, 125, 130 (Figure 1.4.8).

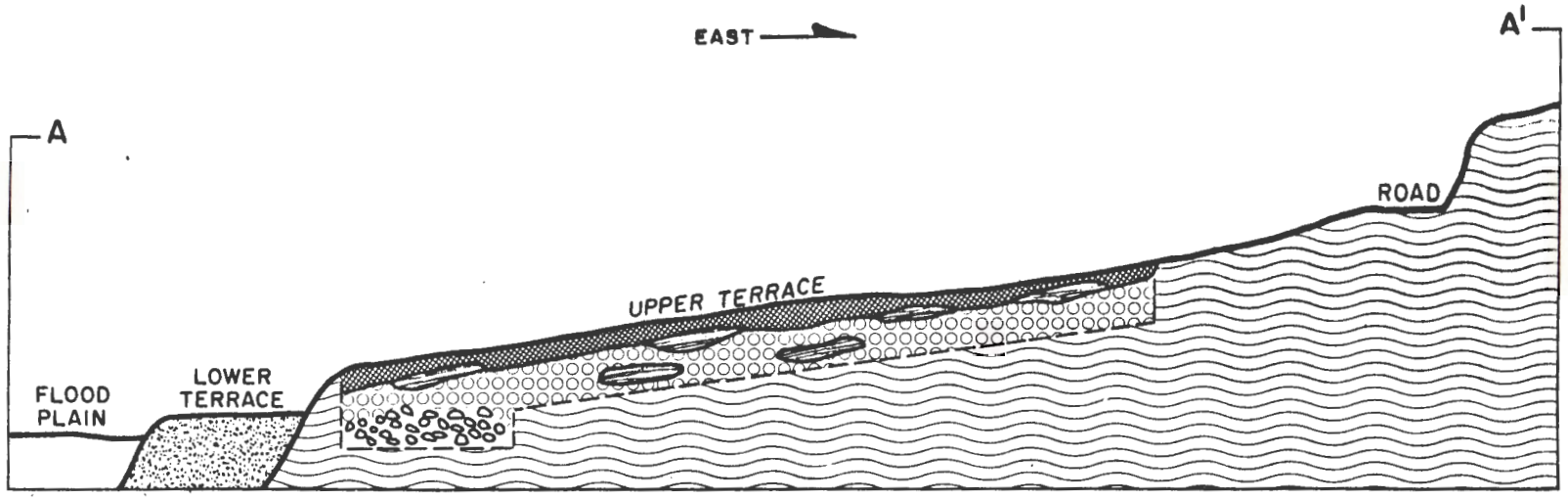
The area is a complex constructional feature with mainstream overbank deposits of the Dolores River and fan sediments derived from a side canyon cut into the bedrock walls of the Dolores valley immediately east of Periman (Glaser and Hampson [89]). These deposits have been sculpted on the south and west by the Dolores River, essentially leaving the site as a terrace.

The core of the site and bulk of the deposits throughout are primarily fan sediments. Many very large angular boulders can be seen in and on the scarp around the site, especially on the south side. This was probably a factor in the preservation of the area as it built up. On aerial photos, a meander scar can be seen to the south of the site abutting the south scarp and causing a nearly right-angle turn of the river--not a typical meander pattern (Figure 1.4.8). As well, no other low terraces have been noted along the Dolores in areas where there are no fans.

Alluvial deposition within the site is apparent in Backhoe Trench 2 (north Periman; Figure 1.4.9). A unit approximately 1 m thick fining upward from sandy loam to silt loam was observed all along the trench. Within this unit were thin discontinuous lenses of alluvial gravels. A few small pockets of angular stones were also noted which are presumably fan deposits. At the west end of the trench in a deep (3 m) cut were thick (1 m) lenses of large stream gravels and bedded sands. A correlative gravel deposit was also noted near the top of Backhoe Trench 2

Figure 1.4.8. Surficial geology map of Periman site area, locating backhoe trenches.





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EXPLANATION

- Possible Overbank Deposit (Dark, Clayey)
- Fan Deposit
- Soil Formed In Alluvium
- Fluvial Gravels
- Alluvial Sand
- Possible Fan Deposits
- Backhoe Trench

Figure 1.4.9. Backhoe Trench 2, north Periman looking south.

(south Periman), overlying a well-sorted silt-loam over 1 m thick. The fine-grained alluvium of Backhoe Trench 2 (north Periman) was also apparent in "Segment 3" of a series of trenches excavated just north of the north Periman roomblock.

The alluvium in the north Periman trenches is overlain by pockets and lenses of angular fan gravels (ca. 20-50 cm below the present landsurface). Above this, constituting the modern surficial deposits in the north Periman area, is recent slope wash.

The surface represented by the above described alluvium may well have been the aboriginal occupation surface. A moderately well-developed soil (A/cambic B/C horizonation) has formed in the alluvium indicating landscape stability for some time. The slope wash above the alluvium appears to be quite recent.

Below the prominent scarp on the west and south sides of the sites is a low terrace approximately 1-2 meters above the modern flood plain. The terrace is rather narrow on the east side but quite wide and long to the south, forming the large pasture in this area. This terrace consists of recent alluvium inset against the older, higher scarp (Figure 1.4.9). This alluvium is a dark gray silt to silt loam. That this deposit is quite young is indicated by lack of significant soil development. The deposition of this material and formation of the lower terrace most likely post-date the aboriginal occupation of the site. Hence, the river was probably at the elevation of this terrace, or perhaps a bit higher, during occuaption of the site.

One somewhat unusual geomorphic feature of the site warrants discussion. On the north side of the site, the surface of the fan is graded to the level of the lower terrace by a gradual slope starting at

the north Periman excavation area, whereas to the west and south the surface ends abruptly at the prominent scarp described earlier. The lower terrace and fan surface merge just northwest of the excavation area (Figure 1.4.10). The interpretation is that during the time the river was depositing material at the lower terrace level the fan had built out to the west and north and perhaps south (the river being well to the west). The Dolores River then moved to the east and cut the scarp on the west and possibly the one on the south; however, the latter may have already been in existence. The river then migrated back to the west, depositing the material that forms the lower terrace on the west and south, the surface of this terrace remaining at the same level as the north end of the undisturbed fan coming off of the site. The river remained at the same level throughout the process, with the downcutting to its present level occurring later.

Rio Vista Village (Site 5MT2182)

Rio Vista Village (Site 5MT2182) is located on a deposit which includes large angular boulders of Dakota Sandstone and Burro Canyon formations in a finer grained matrix. There, large boulders, which are rotated in various orientations relative to the general low angle southwestern bedrock dip, seem to be concentrated toward the west edge of the deposit, away from the bedrock slope. The general shape of the deposit is one that is steepest toward the bedrock slope and flattens slightly toward the valley. All of these features, especially the concentration of boulders at the toe of the the deposit (Figure 1.4.11), suggest that the deposit may be the result of a debris flow or perhaps a combination of a slide and a debris flow. In addition, the bedrock slope above the deposit seems to lack a well developed drainage that would be

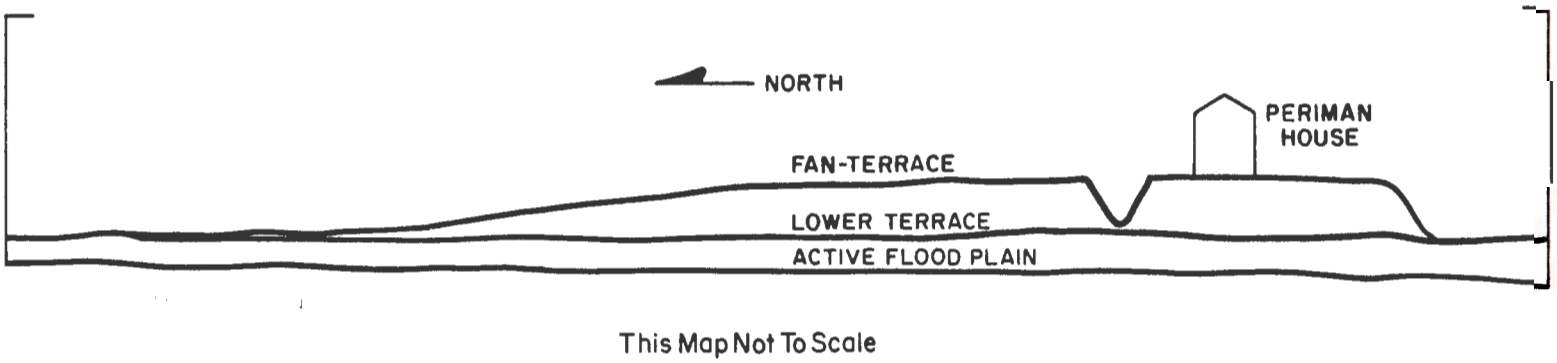
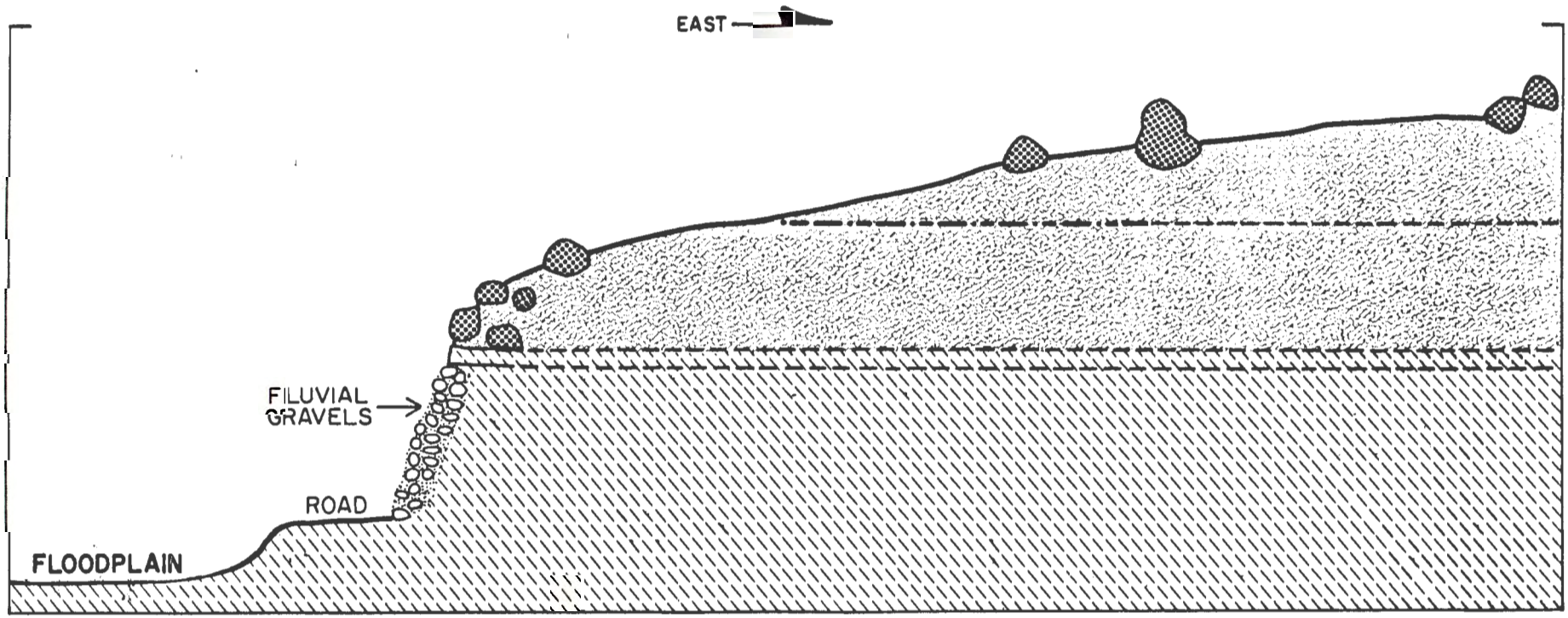


Figure 1.4.10. Schematic diagram of Periman site, Site 5MT4671 illustrates topographic relationship of Upper fan-terrace, lower terrace, and active floodplain.



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EXPLANATION

- Dakota Sandstone (Burro Canyon Formation)
- Loess Deposit (Well Developed Soil)
- Morris on Formation
- Uninvestigated Deposit
- Questionable Boundary
- Buried Soil(s) Below This Line

Figure 1.4.11. Schematic cross section of the Rio Vista Site, Site 5MT2182.

expected to have produced an alluvial/colluvial fan of this size. However, no good scar is observed upslope of the deposit either, but perhaps this is a function of the old age of the slide. Another possibility is that a debris fan from the drainage directly opposite Rio Vista Village on the west side of the Dolores River valley crossed the valley leaving large boulders of Dakota Sandstone and Burro Canyon formations at the location of Rio Vista Village. Any additional debris fan material deposited in the middle of the valley could have been removed through later erosion by the Dolores River.

Only a guess can be made as to whether bedrock underlies this deposit. On the south side of the deposit one exposure of possible Dakota or Burro Canyon sandstone bedrock can be seen in the bottom of a small drainage. However, this exposure might be the upper part of a large block of Dakota Sandstone. Unless some previously undetected faulting has occurred here, the elevation of an outcrop of Dakota Sandstone underneath this deposit seems too low by approximately 60 meters to be a part of the Dakota ridge forming the top of the valley. Unfortunately, only the surface of this Dakota Sandstone is exposed so that it is not possible to determine if the bedding in the block has a dip that conforms to the general dip for the area. Furthermore, purplish red and green shale/siltstone, of the Morrison Formation, can be seen at the northwest edge of the deposit at approximately the same elevation as the concentration of large angular Dakota Sandstone and Burro Canyon Formation boulders (Figure 1.4.11). This shale may be in place and could suggest that, if this deposit has bedrock underneath it, it is the Morrison Formation and not the Dakota Sandstone. Morrison Formation cropping out at this elevation would fit with the stratigraphy of the area (Leonhardy

[19]). Furthermore, this underlying unity of softer shale and siltstone may have been a contributing factor in the occurrence of the debris flow or slide. This slide produced movement of large amounts of resistant material that has been preserved here in the valley because the river could not move these large boulders of Dakota Sandstone.

The presence of Dolores River gravels underneath the deposit is also a matter of speculation. Well-rounded fluvial gravels can be seen in the road cut at the northwest side of the site (Figure 1.4.11). Whether these fluvial gravels extend under the possible slide deposit or are simply plastered on the riverside edge of the deposit can only be determined by more extensive digging. The Dolores River must have been at a higher elevation than present when the slide occurred since a steep scarp exists above the present flood plain. In other words, at the time of the slide the Dolores River was probably near the elevation of the top of the slide deposit or just slightly lower since this deposit is graded to a higher level that the present elevation of the Dolores River. This slide may have extended onto the contemporaneous flood plain, overriding the fluvial gravels at its toe. Subsequently, the river would not have been able to transport these large Dakota Sandstone or Burro Canyon boulders; so the Dolores River would have cut down next to them leaving the deposit as a topographic high.

Over this possible slide deposit, loess or finer grained slope wash has been deposited (Figure 1.4.11). Cultural features have been dug into this finer material. The soil is fairly well developed, but not as well developed as the typical soil found in the loess. The B horizon has moderate, medium prismatic to moderate, coarse, subangular blocky structure, continuous, moderate to thick clay films, a silty clay loam to

silty clay texture and a color of 5YR 5/4 (dry). Because this well-developed soil is seen in excavations at several elevations, a series of buried soils may exist, or one soil may slope as the ground surface does today.

Relatively old age for this slide deposit is indicated by the amount of downcutting of the Dolores River since its depostiion, by the amount of dissection on the surface of the deposit, and by the degree of soil development. The Dolores River has cut down about 14 meters since the slide was deposited. Relative to the terraces and fan at the Periman site, which are at a maximum height of 3 to 5 m above the present river level, the deposit on which Rio Vista Village is located is older, probably by several tens of thousands of years. Large blocks of Dakota and Burro Canyon sandstones seem to have influenced the drainage patterns by diverting small drainages or by collecting sediment behind them. Later these high areas were chosen as locations for rooms. These roomblocks, in turn, have helped to enhance the topography by further stablizing these high areas and by collecting more sediment. In addition, the indications that blocking of some of these surface drainages was attempted at the same time imply that this drainage system was established before occupation of the site. The degree of soil development in the overlying loess or reworked loess also indicates stability of this surface for some time. An alternative hypothesis for geological origin of Rio Vista Village area using a resistant bench as the trap for colluvium is presented by V. Clay (Section 4e, this chapter).

McPhee Community Cluster

The McPhee Community area is situated on a series of coalesced fans

with some mainstream alluvial material mixed in. The fans are composed of debris eroded off of the Dakota Sandstone and loess that forms the prominent high ground to the west, northwest, and north of the area. The alluvial material has been deposited by Sagehen Creek (an informal term for the west to east trending drainage in south Sagehen Flats), which cuts across the locality, and by the Dolores River.

Field examinations of exposures in the excavation areas, backhoe trenches along the terrace cutbanks, and observations of the local geomorphology combined with studies of air photos and a detailed topographic map of the locality allow for some interpretation of the sequence and relative age of fan and terrace formation. Until more exposures are available, however, particularly on the east side of the locality, more detailed interpretations cannot be attempted.

There appear to be at least three relatively older fans in the immediate area. Two of the fans are east of Site 5MT4479 and the other is under the McPhee site proper (Site 5MT4475 and Site 5MT4477). That these fans are relatively old is indicated by fairly extensive dissection and their large size relative to smaller younger fans. The fan immediately east of Site 5MT4479 appears to be stratigraphcally over and therefore younger than the easternmost fan. It is not yet possible to determine the age of the McPhee site fan beyond saying that it is older than the small fan underlying Site 5MT4479. It is probably contemporaneous with one or the other of the large fans. A fairly well-developed soil (A/cambic [argillic] B/C horizonation) at the McPhee site indicates that it has probably been in place since latest Pleistocene times (10,000 years BP). As exposures on the other two older fans become available the age

relationships of these and the McPhee site fan may be more precisely defined.

The next youngest fan is the one underlying Site 5MT4479. This fan appears to have been fed by two drainages. It has been inset between the McPhee site fan and the fan to the east. The walls of a pithouse dug into the fan and a shallow test trench (stratigraphic trench 1) reveal much of the stratigraphy of the upper sediments in the fan. On the floor of the pithouse is a dark brown silt loam very similar to the material found to the east on the McPhee terrace (and at about the same location as the top of the terrace). Above the basal silt loam is a unit almost 1 m thick consisting of a series of beds of dark brown loams and dark gray silty clays, each bed averaging 15-20 cm thick. The sharp contacts between each bed indicate that these are depositional rather than pedogenic features. The cyclic nature of the bedding further suggest alternating fan and alluvial deposition. Perhaps the dark brown loams are Sagehen Creek or Dolores River sedimentation and the dark gray fines represent slope-wash. Near the surface of the fan, above the bedded zone, is a thick (about 1 meter) dark brown silty clay to silty clay loam, probably representing a slowly aggrading A horizon. Scattered charcoal flecks and stones across the top of this unit indicates that it was the aboriginal occupation surface. Burying this surface is a thin zone of platy dark brown sandy clay loam to silt loam representing recent slope wash.

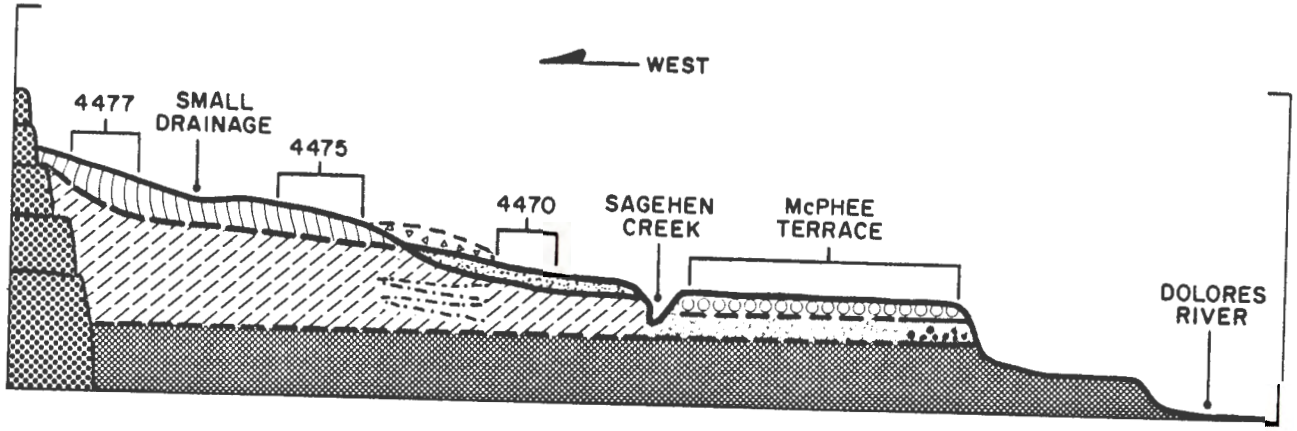
Lack of good soil development indicates that the Site 5MT4479 fan is relatively young. This is probably due to continual agradation of the fan not allowing pedogenesis to significantly alter the material. It certainly seems likely that the fan has formed within the Holocene, perhaps even middle to late Holocene. This is further suggested by the

relative age of the McPhee terrace. A trench was cut in the terrace north of the Washington State University field camp. Within the terrace is a weakly to moderately developed B horizon (cambic). In sediments burying this soil is the modern land surface soil which is also weakly to moderately developed. Together the two soils probably represent pedogenesis during the entire Holocene. Since the indications are that the Site 5MT4479 fan was built out over the McPhee terrace, the fan is probably quite young (Figure 1.4.12).

There are possibly two very young fans in the area. Both are small, well-shaped, and located immediately in front of drainages cut into the sandstone cliffs (drainages that also fed the older fans) (Figure 1.4.12). These are also locations of archaeological sites; however, the topographic highs that suggest fans may simply be aboriginal structures. Excavations in these areas should solve the problem.

Grass Mesa Village (Site 5MT0023)

Grass Mesa consists of two bedrock benches that were probably cut by the Dolores River, Beaver Creek, or a combination of these two streams (Figure 1.4.13 and 1.4.14). Alluvial deposits on the top of both benches indicate that these benches were probably cut by fluvial processes when the Dolores River was at a higher elevation than at present. Because the lower bench does not seem to extend across the full width of the Grass Mesa surface, Beaver Creek probably had little part in the cutting of the lower bench. The upper bench (Area 1, most of Area 2, and Area 3 on Figure 1.4.13) gradually slopes downward to the northwest and joins the lower bench at that end of the mesa. The age difference between the two benches is hard to determine, but may be fairly short since the Junction Creek Sandstone seems to be poorly cemented and thus easily erodable.



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EXPLANATION

- Dakota Sandstone
- Old Fan Surface
- Old Fan
- Young Fan
- Soil
- Buried Soil
- Gravels
- Possible Facies Changes (Fan & Stream Alluvium)
- Uninvestigated Deposit
- Bedrock
- Questionable Boundary

Figure 1.4.12. Schematic illustration of stratigraphy relationships in the McPhee area.

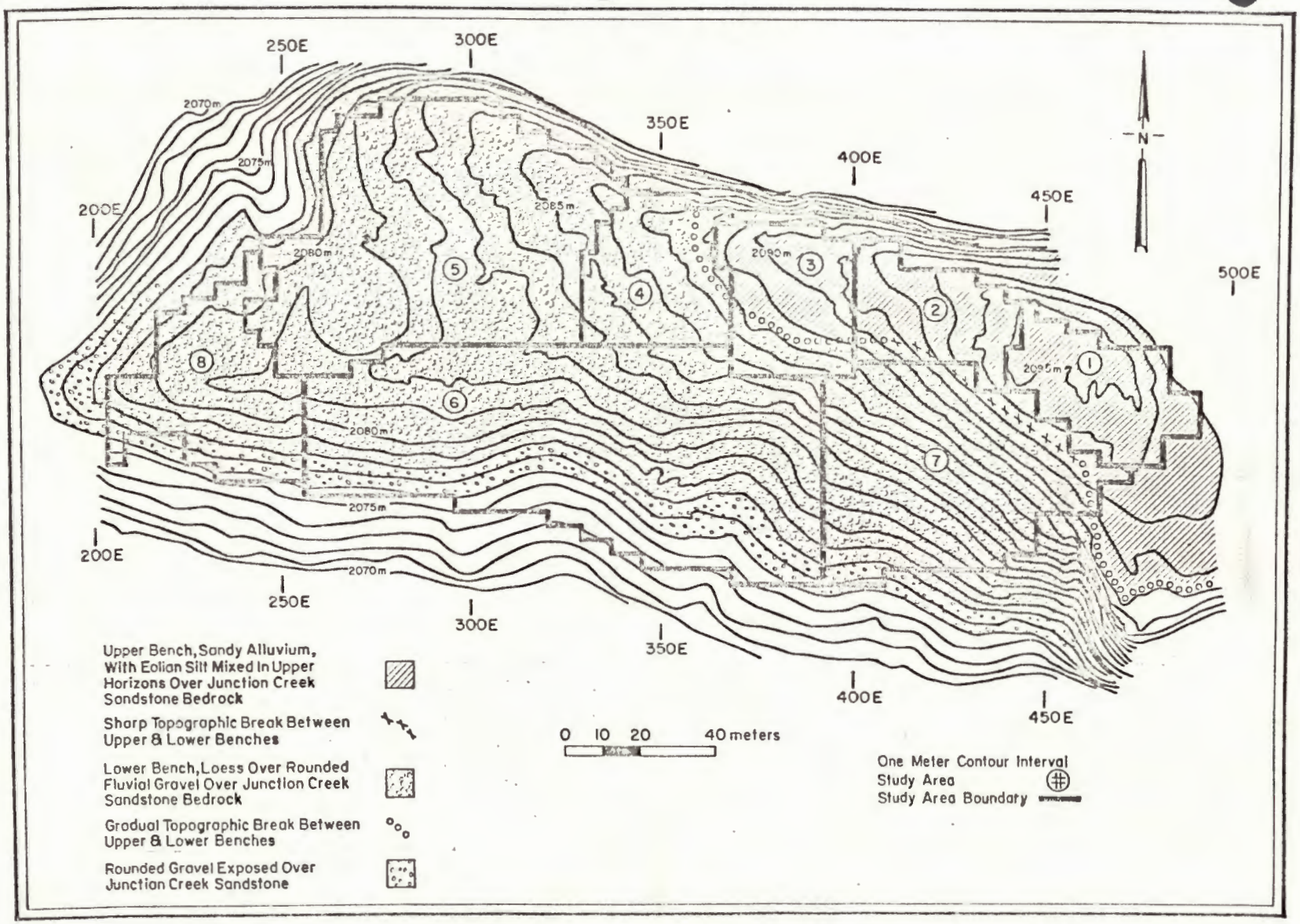
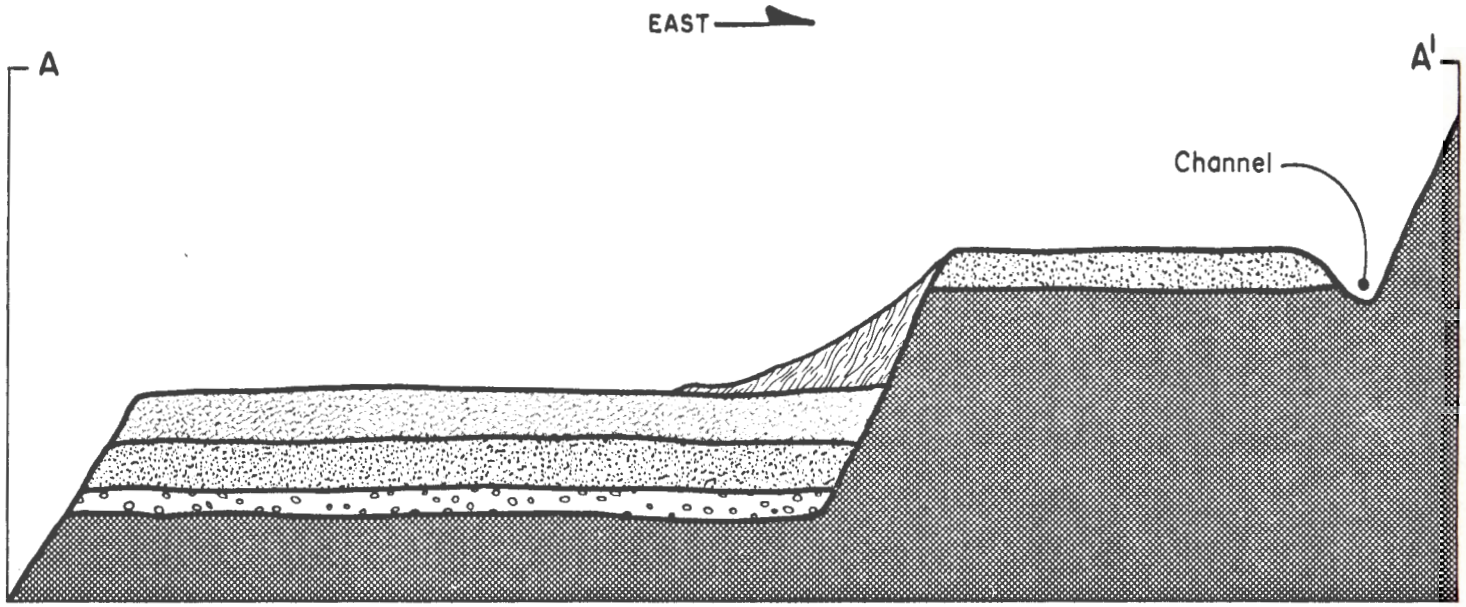


Figure 1.4.13. Topographic map of Grass Mesa Locality showing pertinent geological information.



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EXPLANATION

- Bedded Sandy Alluvium
- Slopewash
- Loess
- Fluvial Gravels
- Junction Creek Sandstone

Figure 1.4.14. Schematic cross section of Grass Mesa.

Perhaps the main flood plain level at the time the benches were cut was at the elevation of the lower bench and the upper bench represents a low terrace above the flood plain. Fluvial gravels and sands might have been deposited on the lower bench whereas only the finer grained sandy alluvium could have been deposited on the upper bench, probably during times of flooding. No rounded gravels have been observed in place on the upper bench.

The lower bench of Junction Creek Sandstone is covered by 2 to 3 m of well-rounded and rounded, chiefly cobble- and pebble-size gravels of fluvial origin. Bedded sandy loam alluvium seems to overlie these gravels. Some 1 to 2 m of loess then overlies this sandy alluvium. In a trench cutting the large depression located on lower Grass Mesa in Area 5, a well-developed soil with a textural B horizon and a silty clay loam to silty clay texture was noted in this loess above an abrupt contact with the alluvial sands. F. Leonhardy interprets the loess to be redeposited by stream action and does not think it actually represents an eolian deposit. However, possibly there are actually two distinct deposits, the bedded sandy alluvium underneath nonbedded in situ loess. no evidence of bedding within the loess unit has ben detected. Consequently, the loess may have not been redeposited by stream processes (see Quaterary Stratigraphy, this report).

From an auger hole in apparently culturally sterile material located on the highest part of the surface, the upper bench seems to be covered with at least 1 to 2 m of bedded sandy alluvium consisting of bands of white to tan sand or loamy sand alternating with layers of slightly darker brown sandy loam to loam. Locally this alluvium is probably mixed with some slopewash or residuum from the Junction Creek Sandstone. Even though

this alluvium on the upper bench does not seem to be covered by a distinct layer of loess, some silty material may be mixed with the upper part of this deposit. Perhaps the small areal extent of the upper bench prevented deposition of a loess layer, or perhaps erosion has removed any loess that was deposited. However, no evidence of redeposited loess has been noted on the lower bench. The soil on this upper bench is moderately well developed. The A horizon is generally thicker and the B horizon is generally less red and slightly less well developed than are these properties for the lower bench soil. The redder color and the finer grain size intially found in the loess when compared to the sandy alluvium may account for these differences rather than any long time break between the two bench surfaces. In addition, downslope movement of water may speed up soil formation processes on the lower bench. This same trend is seen in soils on the slopes of the upper bench. In the probability squares on the western slope of the upper of the upper bench (in Area 7), the soils in the natural deposits appears thicker and the B horizons more developed that of the soils on the top of the upper bench.

One particular phenomenon related to pedogenic development in the loess bears discussion. It has been noted that there are well-developed calcic horizons exposed in excavations along the northern edge of Area 5 which extend at least into Area 4. Downslope from the northern edge (to the south and west) the concentration of calcium carbonate decreases markedly until it appears only as occasional precipitates on ped faces (Blinman [90]. This may be a function of more through-flow of water nearer the edge which would tend to remove carbonate and inhibit calcic horizon development. This lack of a calcic horizon could have a bearing on pitstructure locations. At Rio Vista Village and on Mesa Verde the

tops of well-developed calcic horizons were used as the tops of benches around pitstructure walls. Once the structure was dug and roofed-over, the wall was essentially self-plastered.

The Dolores River

The Dolores River undoubtedly played an important role in the history of aboriginal occupation of the D.A.P. area. An important aspect of the 1980 geologic studies was assessing the potential of the Dolores River flood plain and low terraces for supporting agriculture. From a geologic standpoint the agricultural potential would be affected primarily by the physical and chemical nature of soils and sediments on the flood plain and low terraces and by the physical influence of the Dolores River. The following comments were based on field observations and aerial photograph and map interpretation. Chemical analyses were not carried out as part of the 1980 work.

Low terraces

A series of terraces are in evidence along the valley of the Dolores River (Leonhardy [19]); see Quaternary Stratigraphy, this section). Of concern here are the lowest terraces, grouped as t1 (less than 20 m above the flood plain), since they are nearest the river and would be most affected by the actions of the river. The t1 group is not particularly extensive however. Along the valley the only preseved terraces of this group are found where fans are located; coarse deposits of the latter apparently helped to preserve the terraces by covering them (see Periman Community Geology, this section). Terraces are also preserved where larger tributaries enter the river, such as Sagehen Creek and the associated McPhee terrace (see McPhee Community Geology, this report).

As discussed, the fan debris is extremely coarse. The terraces, exemplified by those on the west and north sides of the Periman community, are generally fine-grained, with silt to silt loam textures, and are well drained.

The presence of terraces in the Periman community area and associated other fans suggests that the terraces were, at one time, more extensive. Absence of such extensive surfaces is evidence for active migration of the Dolores River across the valley floor after formation of the surfaces and so consequent destruction of them. This is further suggested by rapidity of changes in the modern Dolores River channel, shown by the large number of meander scars in the valley, many recent enough to lack vegetation, and by the differences in the modern channel location on the U.S. Geological Survey 7.5 minute topographic maps made in 1965 (based on air photos taken in 1964) and the Colorado State Survey 7.5 minute aerial photographs flown between 1971 and 1976. Undoubtedly then, considerable areas with evidence of occupation and agricultural activity have been destroyed. Only extant fans and remnant terraces are likely to contain any such evidence today.

Dolores River Floodplain

The following is based on Bureau of Reclamation descriptions of deposits found in backhoe excavated test pits located along a section of the Dolores River valley (Bureau of Reclamation McPhee Dam Map sheets 71-D-234, 235, and 236; Figures 1.4.15a,b,c). The test pits are usually located on the present flood plain but some are situated on the low terraces or alluvial fans. Although silt and clay textures are listed in the descriptions, percentages are given for gravel and sand fractions only. Thickness is reported to the nearest half foot. For this report

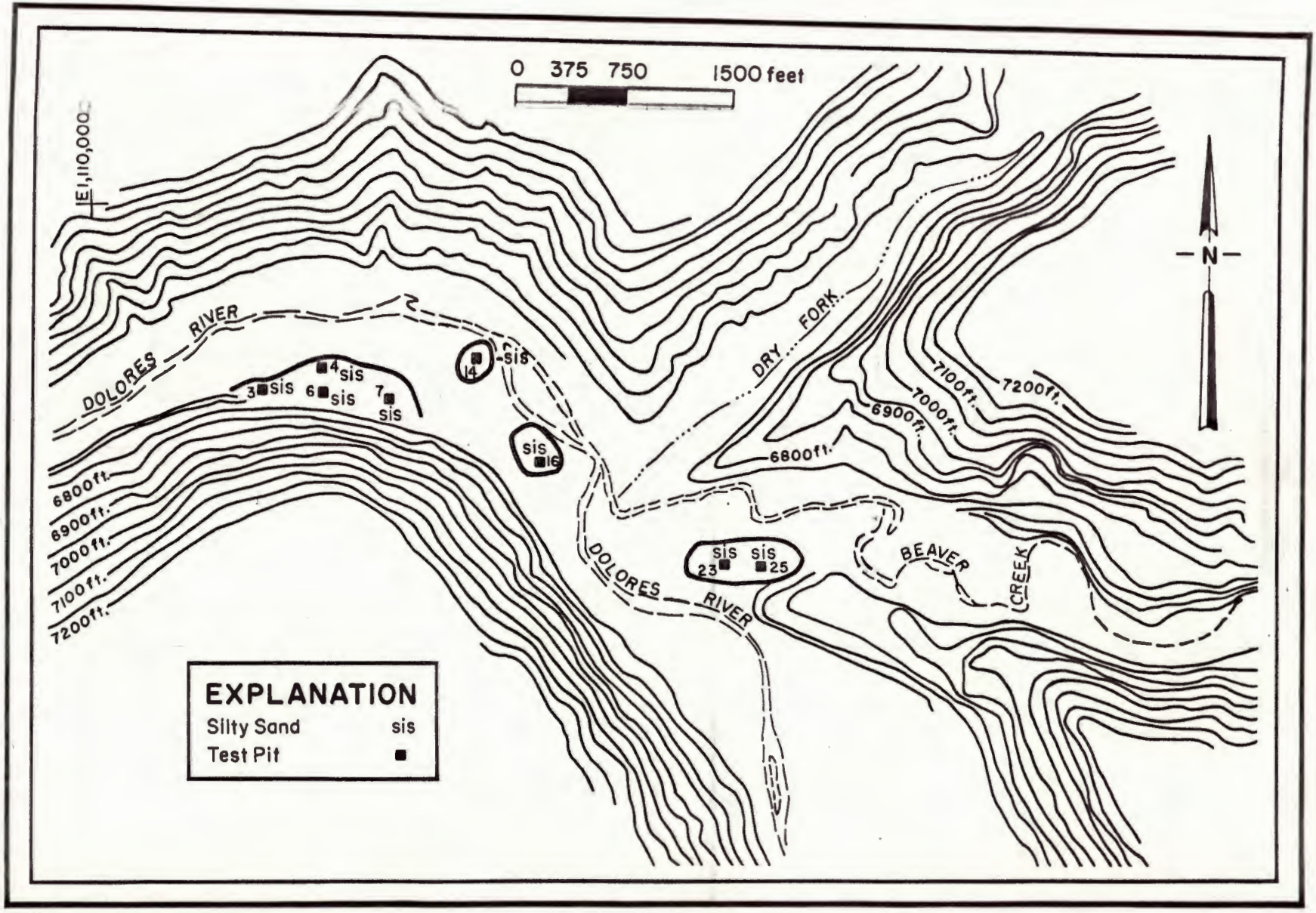

Figure 1.4.15a. Topographic map of portions of the Dolores River illustrating distributions of gravelly and nongravelly stream allumium.

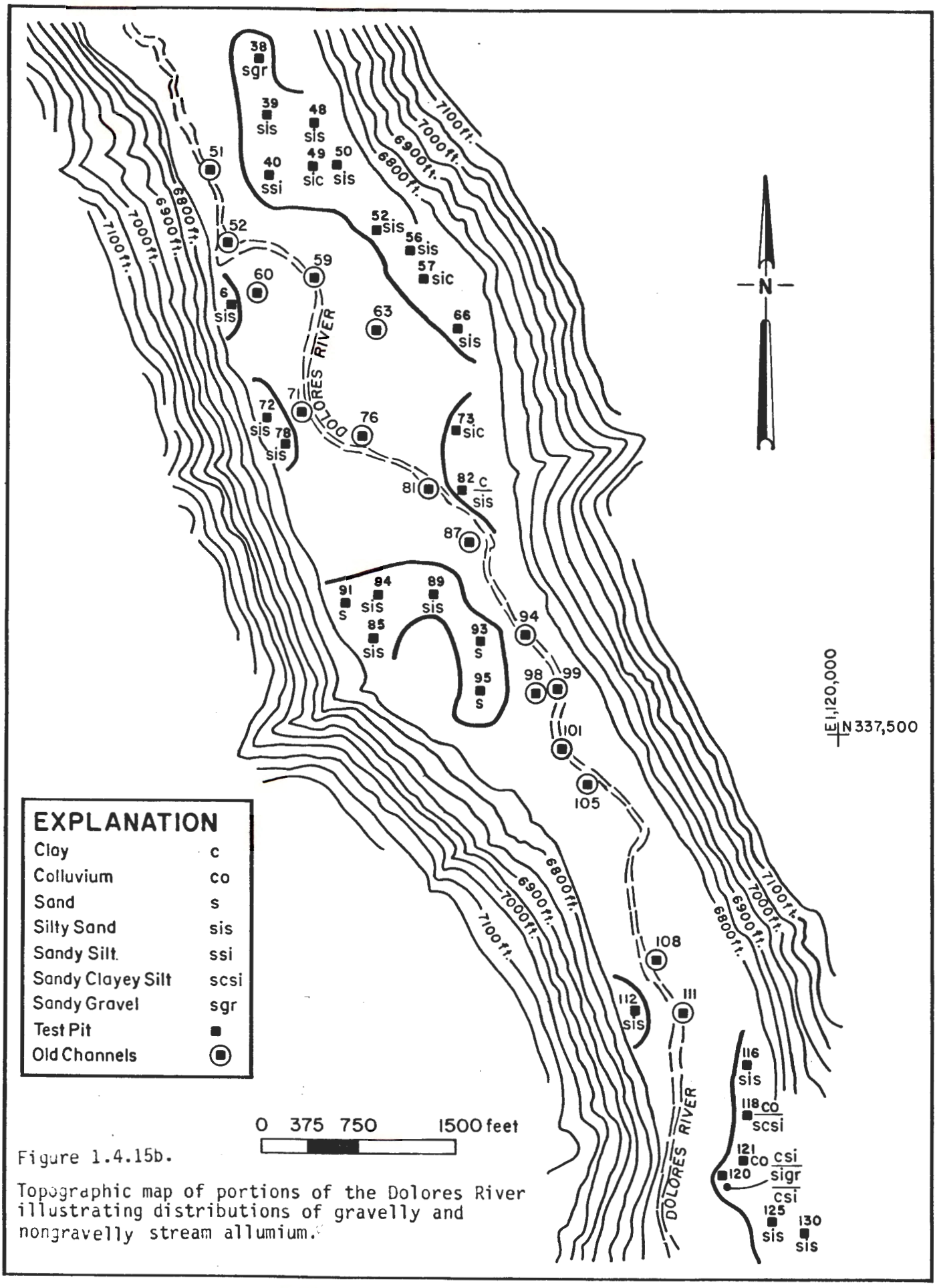

Figure 1.4.15b.

Topographic map of portions of the Dolores River illustrating distributions of gravelly and nongravelly stream allumium.

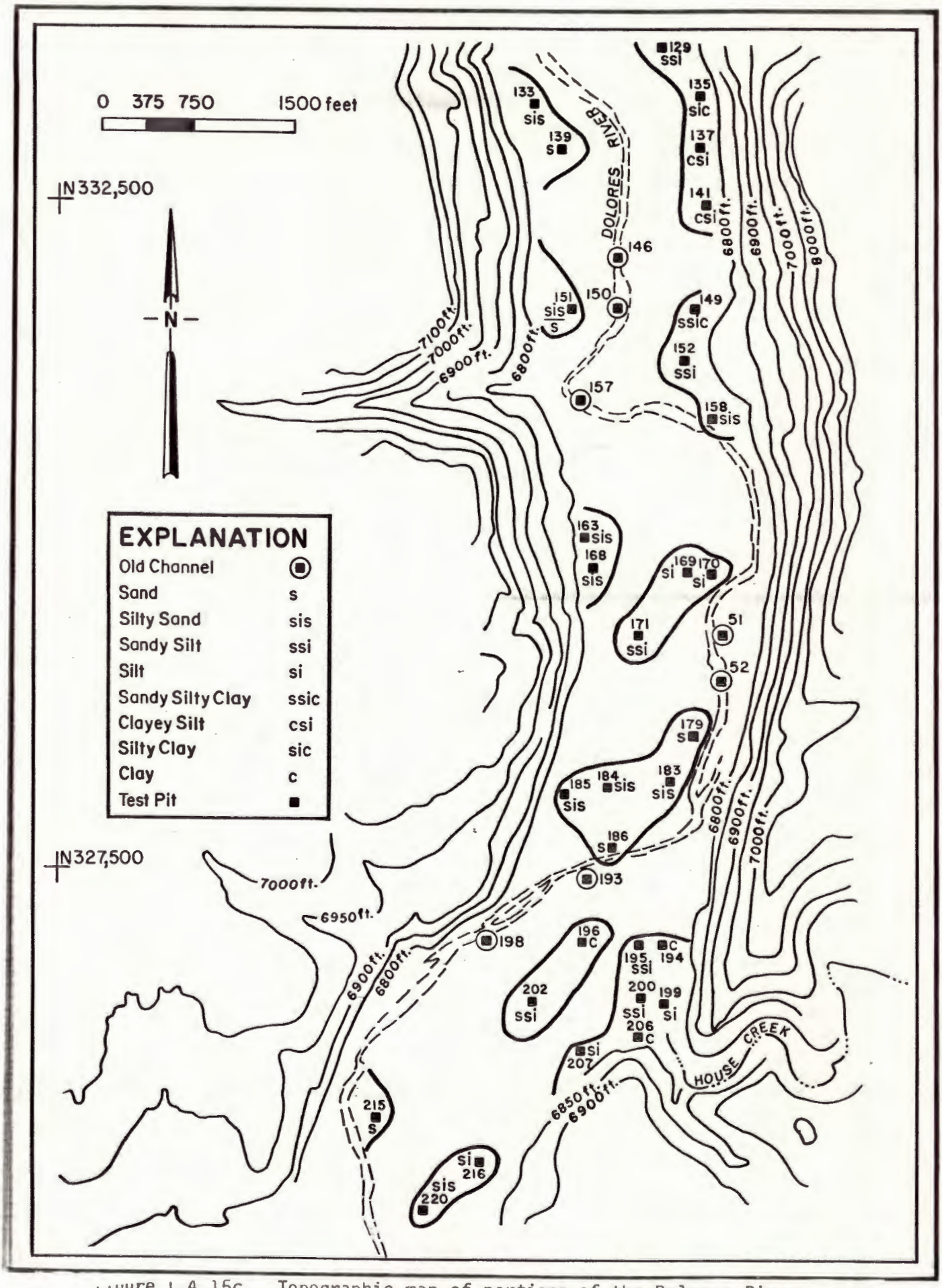

Figure 1.4.15c. Topographic map of portions of the Dolores River illustrating distributions of gravelly and nongravelly stream allumium.

thicknesses are given in meters with conversion to feet provided. For more detailed treatment of the test pit descriptions see Bureau of Reclamation [91].

Based on a comparison of modern flood plain deposits with deposits in the lowest terraces, the hydrology (e.g., discharge, gradient, velocity) and channel size and shape of the present Dolores River does not appear to be appreciably different from that of the river 1200 to 1000 years ago (Figure 1.4.17). The Principal differences between the modern flood plain and that of 1000 years or so ago is that the modern flood plain may be about 1 m lower (see Periman Community geology, this report). Of course, the positions of the terraces, flood plain deposits, and stream channel of 1000 years ago were undoubtedly different from those of today; but by characterizing the present flood plain, it may be possible to approximate the sedimentological nature of the flood plain of 1200 to 1000 years ago.

Flood Plain Deposits

The modern Dolores River flood plain is a complex deposit of fine- and coarse-grained sediments emplaced in the river valley as a result of meandering across the valley. Locally, deposits of fan debris are intermixed with the alluvium. The gravely alluvium is quite uniform, with chiefly subrounded and rounded gravel mixed with some subangular gravel (small boulder- to granule-size clasts) and fine- to coarse-size sand. It usually contains 60 to 65 or 70 percent (range is 60 to 80 percent) gravel and 31 to 36 percent (range is 28 to 38 percent) sand, along with 10 percent or less silt plus clay. The thickness of the gravelly alluvium as measured to the underlying bedrock is fairly constant, usually between 3 and 4 m (10 and 15 feet) but ranging from 2.5 to 7 m (8 to 21 feet).

The nongravelly material, however, has variable texture and thickness. It is often sandy silt (25 to 30 percent) sand, silt (2 to 20 percent), or silty sand (70 to 75 percent sand), but can range from sand (95 percent sand) to clay (15 to 20 percent sand) (map sheets 234, 235, and 236). Silt plus clay makes up anywhere from 5 to 95 percent of the material. Within the sand fraction, fine sand usually dominates, with lesser amounts of medium sand present. In general, all material is finer than gravel-size except at the mouth of Beaver Creek where the silty sand is mixed with 5 percent subrounded gravel in test pit TPB-25. Thickness of the nongravelly material ranges from 1 to 8 m (3.5 to 25 feet), but is usually between 1.5 to 2 or 3 m (5 to 7 or 9 feet) (Figure 1.4.15a, b, c).

Distribution of Floodplain Deposits

Nongravelly deposits greater than 1 m (3.5 feet) in thickness cover only 30 to 40 percent of the surface of the present valley floor (Figures 1.4.15a,b,c). This visual estimation of the amount of nongravelly material does not include areas of the flood plain which may contain a thin veneer 15 cm (less than 0.5 feet) of nongravelly material not reported by the Bureau of Reclamation. Where the greater 1 m (3.5 feet) thick nongravelly material is present, it is generally exposed at the flood plain surface and overlies gravelly alluvium. At the Periman Site, however, nongravelly material is covered by (test pit TPB-118), or mixed with (test pit TPB-121), angular sandstone blocks of colluvium. Furthermore, in test pit TPB-120 in the same area, nongravelly alluvium (clayey silt) interfingers with, and so is found both above and below, gravelly alluvium (silty gravel).

The nongravelly deposits are probably a combination of fan and colluvial material derived from weathered sandstone and shale bedrock of the valley walls and alluvial material deposited by the Dolores River during the waning stages of flooding. Consequently, the thickest deposits (usually 3 m, or greater than 10 feet) have a spotty distribution and are usually located near the edges of the valley on alluvial fans or low terraces. Thicker deposits can accumulate near the valley walls because of their closeness to the source of colluvial or fan material and because of the decrease in erodability as the fans increase in size and thickness.

Agricultual Potential of the Low Terraces and Flood Plain

The texture and permeability of sediments are two important factors influencing the suitability of an area for agriculture. There are many other physical, chemical, and environmental factors (e.g., water holding capactity, nutrient content, pH, length of growing season) important to agriculture but the investigation of these was beyond the scope of this study. The 1980 geologic investigations do allow for some general observations on the matter, however.

The nongravelly material overlying the gravelly alluvium generally has a silty sand texture which would probably be permeable enough to be well drained and thus suitable for agriculture. The lack of gravel-size clasts in the silty sand deposits also makes the nongravelly material attractive for farming. Less than half of the present flood plain, low terraces and alluvial fans, however, is covered with deposits of nongravelly material greater than 1 m in thickness. If the amount of nongravelly material present now is assumed to be similar to the amount of comparable material present during the time of aboriginal occupation, then

a major portion of these areas could not have been utilized for agriculture because of the presence of gravel at the surface. The thick deposits of nongravelly material concentrated near the valley walls are probably the best potential agricultural areas because of their thickness and position in the valley. They are less prone to erosion than similar thinner deposits in the center of the valley, and because of their slightly elevated position above the valley floor they are fairly well drained.

Comments on Availability of Lithic Resources

Availability in the local bedrock of materials suitable for manufacture of stone tools has been reviewed in brief by Leonhardy [19]. Generally, the Morrison Formation and Burro Canyon Formation, and, to a degree, the Dakota Sandstone, contain various orthoquartzites, cherts, and opals that are quite suitable for working into tools. However, the most varied, abundant, widespread, and easily available material is found in the cobbles that constitute the various gravel deposits on terraces in the area. These may have been as important as the bedrock units, if not more so. The gravels contain cobbles that are easily worked and transported, possessing a wide variety of suitable to excellent raw materials. These are primarily fine-grained igneous and metamorphic rocks from upstream areas of igneous intrusions and exposed metamorphic rocks. The possible significance of the deposits as sources for tool manufacture cannot be overemphasized. The variety of materials available in the gravels poses serious problems for using rock types as indicators of trade.

Review of Geomorphology, Quaternary, Geology, and Soils in the D.A.P. Area

Included in this discussion are various aspects of the geomorphology, Quaternary stratigraphy, and soils in the D.A.P. area providing information necessary for understanding the regional setting and environment of the area. The Quaternary stratigraphy and geomorphic history provide information concerning the development of the physical environment of the area through time. Study of landforms is also important for understanding site location, human activities within a given area, and microenvironments. An undersanding of soils is necessary for local and regional geomorphic and stratigraphic interpretations. The nature of soils is also a key component of prehistoric agricultural activities.

A map of the surficial geology of the Project area has been prepared (Figure 1.4.16). The map is to the same scale as maps prepared by the Geology Crew in 1979 (1:24,000). The surficial geology map illustrates the general nature of the geology at or immediately below the surface, which is what had the most immediate effect on aboriginal occupation. The map, essentially summarizes pertinent data from the 1979 maps with modifications resulting from the 1980 work. The map also includes contour lines to facilitate use in the field. Soils are described as part of the geologic description of given deposits. The soils will be, in large part, determined by the nature of the parent material in which they are formed. Geomorphology and drainage patterns can be interpreted from the contour lines.

As noted by Leonhardy [19] the geomorphology of the Project area is controlled primarily by gently south-dipping, Mesozoic sedimentary rocks,

EXPLAINATION FOR FIGURE 1.4.16

Surficial Geology Map of a Portion of the Dolores River Valley

a,t_1 Alluvium and Low Terraces

Gray to brownish gray gravelly sand with subrounded and rounded small boulder- to granule-size gravel of mixed lithology. May be bedded and may contain sand- or silt-rich lenses and layers. Composes the flood plain of the Dolores River and its tributaries. Thickness commonly 3 to 4.5 m (10 to 15 feet), but locally may be up to 6.5 m (21 feet) thick.

Gravelly alluvium may be covered by or be interfingered with dark gray silt mixed with variable amounts of sand and clay. Silt-rich material commonly near sides of the valley on t_1 terraces and alluvial fans, where it may interfinger with coarser fan material. Thickness usually 1.5 to 2.5 m (5 to 9 feet) locally up to 7.5 m (25 feet).

The t_1 terraces are 1 m (60 feet) above the Dolores River. Upper part has weak to nonexistent soil development, generally an A/C horizonation or some slight oxidation of the gravel. Soil on t_1 deposits may have an A/cambic B/C horizonation. Soil series included are Fluvents (A1B), Cheyenne sandy loam (J1), and Hesperus loam (V1) near the McPhee Site.

f Alluvial Fan

Dark gray to light brown variable textured material. Generally contains angular to subangular cobble- and pebble-size gravel of sandstone (Dakota Formation) with varying amounts of sand and silt. May locally be chiefly composed of sand with lesser amounts of silt and clay and little or no gravel (Entrada, Morrison, and Burro Canyon formations). Forms fan-shaped deposits, usually overlying Dolores River alluvium of the flood plain or terraces, at the mouths of drainages of varying sizes that may be graded to the present level of the Dolores River or a higher level. May interfinger with alluvium. Thickness is variable.

Upper part commonly has weakly developed soil with A/C horizonation, but soil may be more strongly developed on fans overlying terraces, rather than flood plain alluvium. Soil series is commonly Otero fine sandy loam (VO), but may also include areas mapped as Fluvents (A1B), and Cheyenne sandy loam (J1).

af Alluvial Fill

Reddish-brown to brown silt with variable, but lesser amounts of sand and clay. May show some stratification. Alluvium in upland swales and arroyos. Generally consists of reworked loess, locally mixed with colluvium. Thickness is variable.

Soil series is usually Ackmen loam (WO) but may also include areas of Gladel stony fine sandy loam (M2-D) and Batterson-Gladel-Rock outcrop complex (M2CE).

cs Sandstone and Shale Colluvium

Variable-colored sand mixed with lesser amounts of silt and clay. Locally contains boulder- to pebble-size angular and subangular blocky clasts of sandstone and/or cobble- to granular-size angular to subangular platy clasts of gray to black shale. Forms mantle over the steeper slopes and includes areas of bedrock. Thickness commonly 1 to 3 m (3 to 10 feet) but may be thicker locally.

Soil development weak and thin. Soil series is commonly Batterson-Gladel-Rock outcrop complex (M2CE), but may also include areas of Gladel stony fine sandy loam (M2-D) in drainages.

css Sandstone Colluvium

Areas of cs large enough to map separately where colluvium consists of boulder- to pebble-size angular blocky clasts of sandstone (Dakota Formation) in a chiefly sand matrix with lesser amounts of silt and clay. Soil series included are the same as those for cs.

csh Shale Colluvium

Areas of cs large enough to map separately where colluvium consists of cobble- to granule-size angular platy clasts of dark shale in a matrix of silt and clay (generally Mancos Formation). Soil series include Midway clay loam (c2) and Renohill (C4).

ls Landslide

Large mass of locally derived debris that has moved downslope (chiefly by gravity) of fairly recent age where upslope scarp is still visible. Smaller deposits of similar origin are not mapped separately but are included with the colluvial units. Older deposits that may have been emplaced mainly by gravity but show no upslope scarp are also included within the colluvial units. Soil series included same as the colluvial units.

l Loess

Reddish-brown nonstratified silt with lesser amounts of clay and fine and very fine sand. Forms mantle over bedrock and older terraces (t_2 through t_4). Not present on younger terraces (t_1) or alluvium (a), nor on the higher terraces (t_5 through t_7). Thickness commonly 0.5 to 4.5 m (2 to 15 feet) with an average thickness between 1 to 1.2 m (3 to 4 feet), locally up to 7.5 m (25 feet) thick.

Upper part commonly has strongly developed soil with a well-developed argillic B horizon and a well-developed calcic horizon. Commonly shows evidence of at least two well-developed soils. Soil series included are Pulpit (ROH), Sharps (ROL), Granath (R1), Bowdish-Pulpit (R7), Witt loam (RO), and combination units UH (Witt, Pulpit, Sharps) and M2/UH (Witt/Sharps and Gladel).

Includes areas of colluvium (cs), alluvial fill (af), and bedrock outcrop in arroyos and swales which are not large enough to be mapped separately.

t Gravelly Alluvium on Terraces (t_2 through t_x7)

Gray to brown gravelly sand with rounded to subrounded small boulder- to granule-size gravel of variable lithology. Locally contains lenses and layers of sand to sandy gravel. Thickness ranges from 3 to 9 m (10 to 30 feet). Gravel is locally covered by sand and is commonly covered by 1 to 8 m (3 to 25 feet) of loess. Loess absent on higher eroded terraces (t_5 through t_7) and on one Sagehen Flats terrace (t_2). Forms flat benches chiefly along the Dolores River but also along Beaver and House creeks. Terraces are at several heights above the present elevation of the Dolores River; t_2 is 20 to 25 m (60 to 80 feet), t_3 is 40 to 50 m (140-180 feet), t_4 is 90 to 105 m (300 to 350 feet), t_5 is 135 to 140 m (450 to 460 feet), t_6 is 180 to 185 m (600 feet), and t_7 is greater than 300 m (1000 feet). Terrace gradients are approximately parallel to the present gradient of the Dolores River valley. Stones in the lower parts are weathered to various degrees ranging from nearly unweathered to highly weathered.

Soil development is the same as described for the loess because most of the terraces are mantled by the loess. Below the loess, stones may have carbonate coatings and carbonate may compose part of the surrounding matrix. Soil series include the same ones listed for the loess (1) plus areas mapped as Granath Loam (R-1), Midway clay loam (C2), and Pulpit Loam (ROH).

Symbols

-------.... Contacts, dashed where approximate, dotted between two terraces of the same group that have slightly different heights above the Dolores River.

$^1/t3$ (?) Benches that may or may not include alluvium. May have formed through the erosion of bedrock to a resistant unit or may have been cut by the Dolores River indicating periods of stability in the river downcutting history.

---- Trace of the valley longitudinal profile. Numbers are miles downstream from the east edge of the mapping area and match those on the longitudinal valley profile.

D Trace of House Creek Fault; shows the downthrown side.

Meander scars. Where two ages could be distinguished on aerial photographs based on the amount of vegetation present, y=younger and o=older.

t Terraces of varying heights not related to the Dolores River.

.G.P.-1 Gravel pit localities.

Note: The part of the map including the Trimble Point Quadrangle (108° 30' to 108° 37'30" and 37° 30' to 37° 37' 30") was made using aerial photographs generally at a scale of 1:20,000; so units are mapped in a fair amount of detail. The remainder of the area was mapped from topographic maps and orthophoto quadrangles at scales of 1:24,000; so units are mapped in much less detail.

the east-west trending House Creek fault, and the Dolores River and its tributaries. The dominant geomorphic features are the canyon and flood plain of the Dolores River and Sagehen Flats.

The major landforms of the D.A.P. area have been mapped and described by Leonhardy [19]. The Landform Map may have some applications for large-scale studies of settlement patterns but it seems that the standard U.S.G.S. 7.5' topographic maps would be more useful in the field because landforms are shown in more detail on these maps and roads and other landmarks are provided, aiding in orientation on the ground. Additionally, most of the landforms of primary importance to archaeological site location are either too small or subtle to show up well or at all on 1:24,000 scale maps (e.g., the Periman and McPhee fans or the gently rolling topography of Sagehen Flats).

One notable problem on the 1979 Landform Map is the identification of the south Sagehen area, essentially between Road X and the House Creek fault scarp, as a pediment. The precise definition of a pediment has been the subject of debate for over a century, but several of the agreed-upon qualifications for a surface to be considered a pediment are that it is an erosional feature that cross-cuts bedrock and structural features, sometimes having a thin veneer of alluvium, and is usually along a mountain front (Press and Siever, [92:200, 290]). There is no evidence that a significant portion of Sagehen Flats is a pediment. The slopes on the north side of the Mancos Shale hillocks to the south of South Sagehen may be considered pediments. The surface of South Sagehen, rather, appears to be a constructional feature formed by accumulation of loess alluvium, and slopewash, burying, at different thicknesses, Mancos

Shale and Dakota Sandstone. The area can be considered to be a valley floor. The hillocks on the north side of the area identified as a pediment are nothing more than remnants of the loess deposits capping the Dakota Sandstone, cut up by arroyos.

As part of the 1979 geologic investigations a Stream Order-Drainage Basin Map of the Project area was prepared. As with the Landform Map, this map may have some uses for regional analysis of site location and agriculture. However, considerable revisions are recommended. Field examination and studies of topographic maps and aerial photos show that the drainages are considerably more complex (Holiday et al. [93]). The drainages mapped as first order (unbranched tributaries), have, in most cases, numerous smaller tributaries which are properly first, and in some cases second and third order drainages. This changes the ordering (to higher numbers) of most drainages on the map. These smaller, unmapped drainages may have been of considerable importance to aboriginal occupants, because they are more numerous and would influence local drainage and soil moisture; on the other hand, these small drainages may have been altered by historic logging and farming.

Quaternary stratigraphy, the principal Quaternary deposits of the area, are alluvial sediments of the Dolores River and tributaries and fine-grained eolian sediments (loess) that mantle most surfaces in the area.

Four general alluvial deposits of the Dolores River and associated surfaces are identified by Leonhardy [19]) and mapped on the Landform Map [19]. As part of the 1980 geologic investigations, terrace profiles of the Dolores River in the Project area were constructed in an effort to

refine the terrace sequence (Figure 1.4.17). This was only partially successful. The terraces of the Dolores River are generally present only as scattered remnants along the valley. Therefore identification of discrete, individual terraces was not possible based on the work done to date. Rather, grouping of terrace levels was done, essentially refining the groupings of Leonhardy.

Seven principal terrace levels were identified along the Dolores River between the town of Dolores and the area of the dam, t1-t7. The lower case t denotes terraces identified during 1980 work as opposed to those of Leonhardy with upper case T [19]. Because available topography maps are in feet the stream terrace profiles (Figure 1.4.17) and heights for each terrace are given in feet with conversion to meters.

The youngest terraces (t1) are less than 60 feet above the flood plain. In many cases these terraces are buried by or interfinger with fans (e.g., Periman site) (see Periman Community Geology and the Dolores River, this report).

The other six terraces (t2-t7) are generally cut on bedrock and have alluvial deposits of varying thickness, usually a thick, basal, cobbly gravel overlain by sandy gravel, sands and finally silts. In some areas, at varying levels bedrock benches without alluvial covers are apparent (Figure 1.4.16). Some of these may be terraces but, in the absence of alluvial mantles they are considered to be localized resistant outcrops of bedrock.

Most of the alluvial deposits of the different terraces are exposed in excavation areas or in local gravel pits (Figure 1.4.18). Deposits of the second terrace (t2), at 60 to 80 feet (20 to 25 m) above the flood plain are apparent as gravel caps on the hillocks on south Sagehen

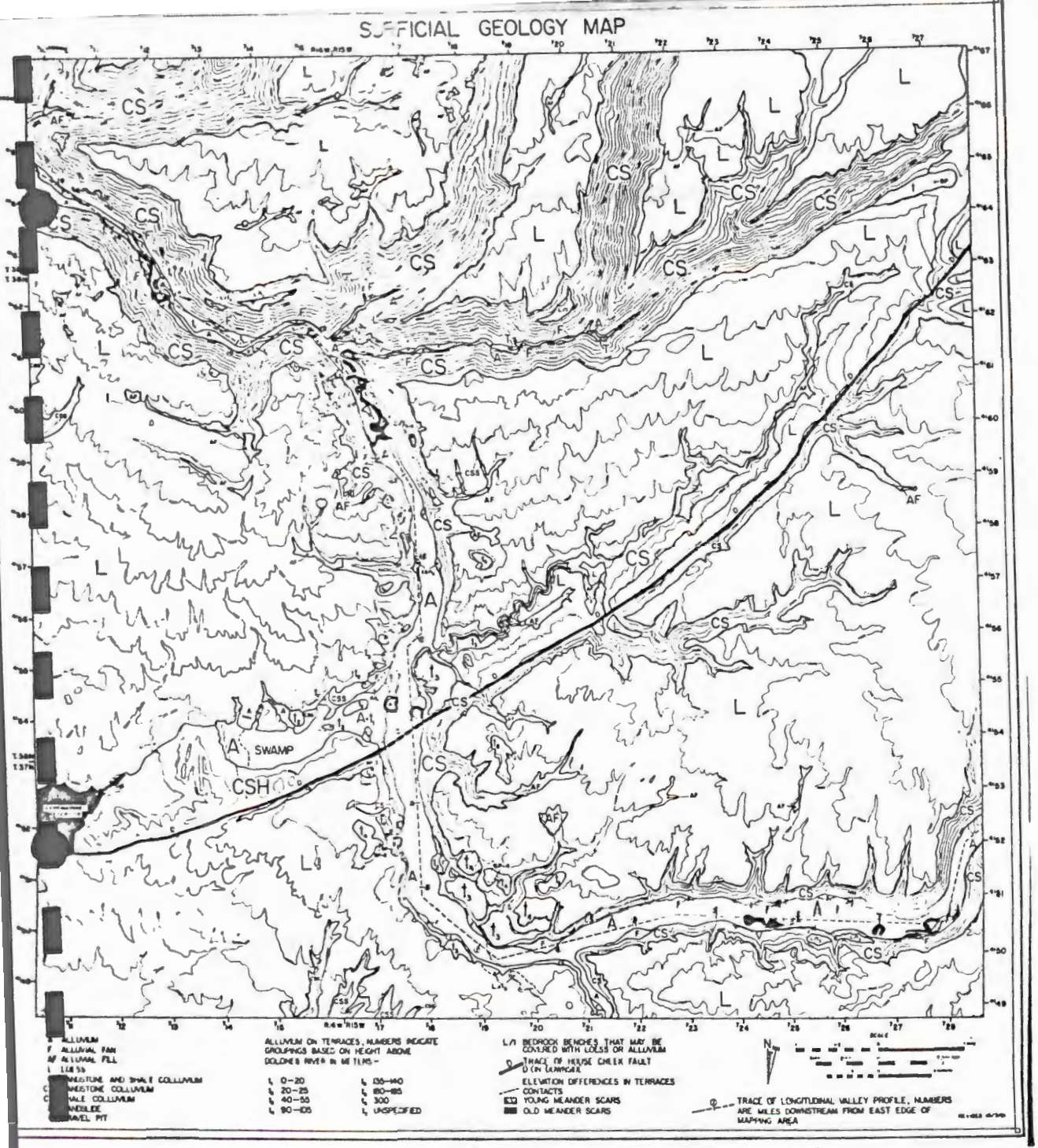

Figure 1.4.16. Surficial geology map.

and at Rio Vista Village. Several hillocks have no fine-grained sediments over the cobbles. Other hillocks and Rio Vista Village have gravel capped by silts (Figure 1.4.16). Cobbles of the third terrace (t3), at 140 to 180 feet (40 to 55 m) are capped by sands and silts and are well-exposed at Grass Mesa. The fourth terrace (t4), at 300 to 340 feet (90 to 105 m) above the river, have cobbles capped by silt and are exposed in gravel pits 1,2, and 4 (Figure 1.4.19 and Figure 1.4.20). Deposits of the fifth terrace (t5) consist of cobbles with no overlying silt at 450 to 460 feet (135 to 140 m) above the flood plain. The sixth terrace (t6), at 500 feet above the river has no overlying fines. The highest gravels in the Project are (t7) at 1080 feet above the river and are found downstream from the area of the dam on the far northwest corner of North Sagehen Flats.

The t2 gravels are significant features in reconstructing the history of the Dolores River drainage. Leonhardy [19] points out that "The valley system along the House Creek fault through South Sagehen Flats would seem to have been a part of the Dolores Canyon system and a former channel of the Dolores River. If so there is no direct evidence that a major river ever had a main channel west or southwest of the canyon." The t2 gravels on the south Sagehen hillock could be interpreted as evidence of mainstream flow through the area. Some of these gravel deposits are over one mile west of the present Dolores Canyon. It would seem difficult to have channels of the present river course swing one mile up South Sagehen. Additionally all higher gravels except at Grass Mesa, and House Creek, and t7 are found only upstream from the House Creek fault area. The Grass Mesa and House Creek fault gravels (t3) may be the result of deposition by Beaver Creek and House Creek respectively. Gravels higher than the t3 level were noted along both creeks some distance upstream from their

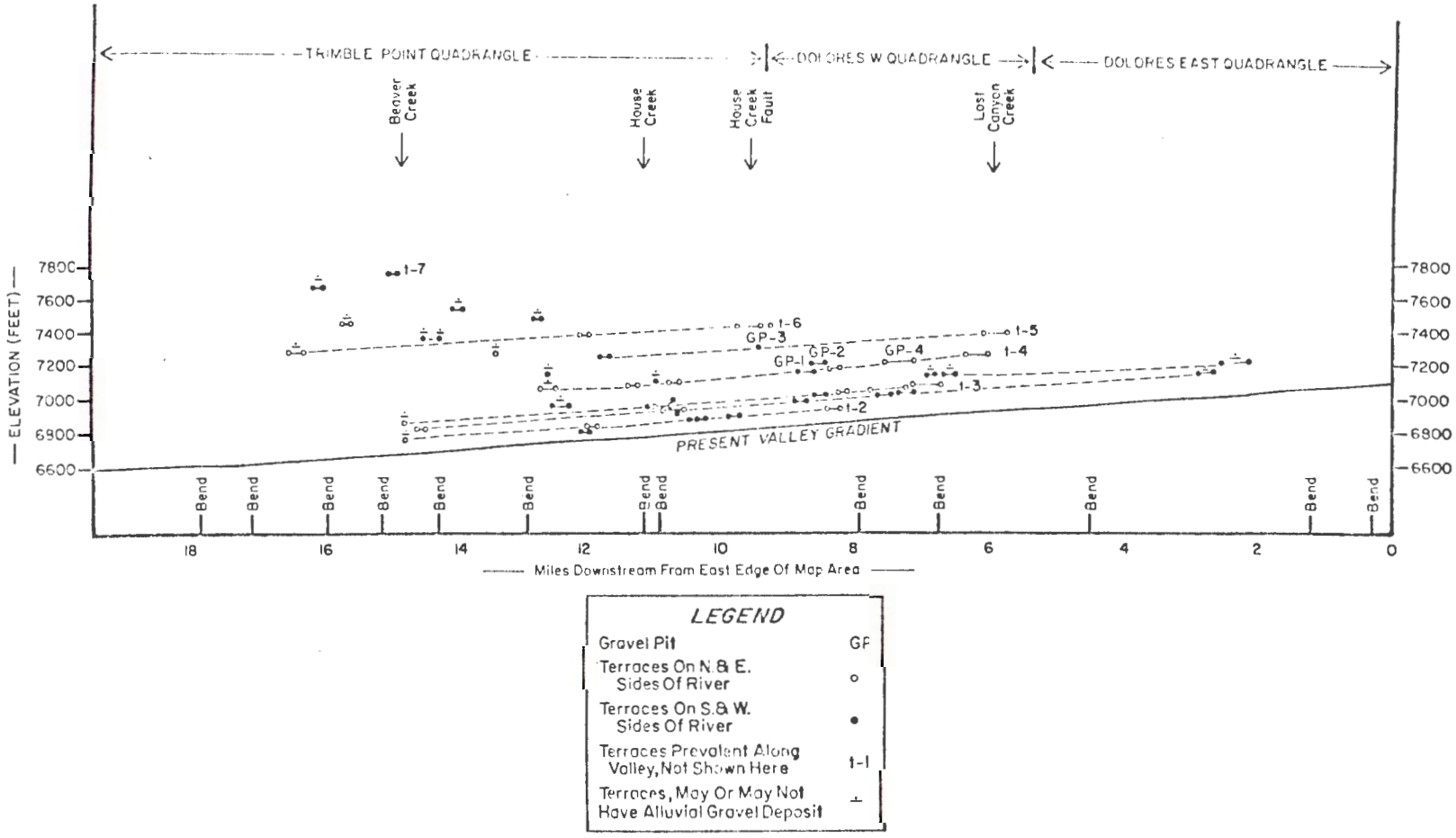

Figure 1.4.1/. Longitudinal profile of terraces along a section of the Dolores River.

respective confluences with the Dolores River (Figure 1.4.16). The t7 gravels to the northwest of Sagehen could have been emplaced by a stream running west across South Sagehen. The t2 gravels at Rio Vista Village suggest that piracy of the Dolores River and development of the present drainage system occurred during t2 times.

The t2 gravels on South Sagehen also provide some suggestion of movement along House Creek fault during the Quaternary. Gravels on the hillock with the small McPhee cemetery, just west of McPhee Road and just north of the fault scarp, are considerably different than the gravels on the other South Sagehen hillocks. The gravels on most of the hillocks are quite fresh (not grussified or otherwise weathered). The cemetery gravels are considerably more weathered, with the granitic clasts turned to grus, quite similar to the gravels in gravel pit 3, just 600 m south of the cemetery, but 120 m higher, on the upthrown side of the House Creek fault. This suggests, but by no means proves, considerable displacement along the fault within the history of the Dolores River.

The age of the various terraces could not be determined. Soils on various terrace levels can be a key to ages of the surfaces. However, soils on most of the terraces observed were formed in the silts which, as discussed below, are considered to be eolian deposits not related to alluvial deposition. No other criteria could be found for differentiating the ages of the terraces.

The silty deposits capping most of the terraces (Figure 1.4.19) have been the subject of some debate among D.A.P. personnel. Leonhardy considers much of this material to be reworked loess, deposited by the Dolores River in the final stages of deposition of each alluvial unit (essentially representing a fining-upward sequence of gravels-sands-

silts). From the 1980 geologic investigations it seems more likely that the silts are primary loess deposits, rather than reworked loess that caps the coarser alluvium. It seems unlikely that a large river system would consistently deposit a meter of silt at the end of each depositional cycle with no coarser material included. With the available, easily erodible sandstone throughout the area, such a major alluvial deposit would be expected to have more coarse-grained clastics. The silt always overlies either sand or gravel. The boundary between the silt and underlying alluvial material is quite abrupt (Figure 1.4.19 and 1.4.20), rather than grading upward as an alluvial deposit would. Finally, if each silt deposit was a function of alluvial deposition then soils formed in the silts should be progressively better developed with each older terrace. However, the soils formed in the silts are remarkably uniform on all terraces, exhibiting well developed, argillic B horizons (Table 1.4.4, Gravel pits 1,2,4). A well developed calcic horizon is also present at the base of the B horizon if permeability of underlying units is not high. The uniformity of soil development indicates that the deposits are of about the same age. This combined with the silty-clay to silt-loam texture and homogeneity of the unit suggests that the material is a loess deposit that mantled the terraces. This material is considered to be primary loess rather than loess redeposited by the Dolores River. Again, considerably more coarser material would be expected to have been mixed in. As well, redeposition of loess necessitates a source area with loess, older and higher than the oldest terrace, which is considerably higher, and therefore, older than Sagehen Flats. No such older loess deposits were located or are reported for the area.

Table 1.4.4. Field data sheets for selected soil profiles.
Data for localities G.P.-1, and G.P.-3 are incomplete because the descriptions were done to make a general comparison of the soil development at these localities.
Table 1.4.4 is on the following pages.

FIELD DATA SHEET (page 1 of 6).

Date Sampled: 4 July 1980

Elevation: 7060 ft. (2152 m)

Location: Backhoe trench at site #2847, NE 1/4, SW 1/4, Section 25, T 38 N, R 16 W

Vegetation: Grasses, thistles, wheat; has been cleared

Parent Material: Loess over loess mixed with weathered Dakota Sandstone (II) over Dakota Sandstone bedrock

Slope: Slight dip to the south

Aspect: North-facing wall of trench

Stoniness: No material greater than 2 mm

Classification: Argid

Horizon	Depth (cm)	Color	Boundary	Structure	Texture	Moist Consist.	Clay Films	Appearance of Carbonate
B21t	0-24	5YR 4/6(d) 5YR 4/4(m)	cl sm	str med sbk	SiCL	hard(d)	ma mk pf	none
B22t	24-72	5YR 5/6(d) 5YR 4/4(m)	abr wv	mod c pr-str med sbk	SiCL	hard(d)	cont k pf	none
B2tbl	72-124	clay films: 5YR 4/4-4/6(d) 5YR 3/4-4/4(m) inner ped: 5YR 4/6(d) 5YR 4/4(m) carbonate: 7.5YR 7/4(d) 7.5YR 6/6(m)	abr wv	mod c pr-str c sbk	SiCL	friable	cont k pf	40% carb. films on ped faces; none in matrix
B31tcabl	124-156	clay films: 5YR 4/4(d) 5YR 4/6(m) general: 5YR 6/4(d) 5YR 5/6(m)	cl wv	wk c sbk	SiCL	friable	few mk pf	80% finely divided carb., str. effer.; com. threads & coats of carb. mod. effer.
R (Dakota Sandstone)	190+							

FIELD DATA SHEET (page 2 of 6).

Date Sampled:	8 July 1980	Elevation:	6900 ft. (2104 m)
Location:	Arroyo at site 5MT4512; NW 1/4, NW 1/4, 38 N, R 16 W	Vegetation:	sagebrush, thistles, grasses
Parent Material:	Loess mixed with slope wash	Slope:	none
		Aspect:	W-facing arroyo wall
Stoniness:	No material greater than 2 mm	Classification:	Argid

Horizon	Depth (cm)	Color	Boundary	Structure	Texture	Moist Consist.	Clay Films	Appearance of Carbonate
Recent bed orgs. & sand	0-43							none
Reworked Material	43-57							none
A3b	57-72	5YR 3/3(m)		wk med pr-mod f sbk	L-CL	hard(d)	com n pf	none
B21tb	72-104	5YR 3/3(m)		mod med pr-str c sbk	L-CL	hard(d)	com mk pf	none
B22tb	104-153	5YR 4/4(d) 5YR 3/4(m)		mod med pr-str f sbk-abk	CL	friable	ma k pf	none
B23tbca	153-209	7.5YR 4/4(m)		mod med pr-str c sbk-abk	CL	firm	cont k pf	40% carb films & threads, str effer.;matrix-sl. effer.
IIB24tbca	209-240	7.5YR 4/4(m)		mod med pr-str f sbk-abk	SiC	firm	cont k pf	35% carb films & threads, str effer.; matrix sl. effer.
IIIB25tbca	240-266+	7.5YR 4/6-4/4(m)		mod c sbk	SiCL	firm	com mk pf	20% carb films & threads, str effer; in places carb, dissem; matrix sl. effer.

FIELD DATA SHEET (page 3 of 6).

Date Sampled:	15 July 1980	Elevation:	6820 ft. (2079 m)
Location:	Trench 1 in McPhee terrace, west side of McPhee Road, near site 5MT4684 NE 1/4, NW 1/4, Section 31,T 38 N, R 15 W	Vegetation:	bladed
Parent Material:	Loess and alluvium	Slope:	none
		Aspect:	South-facing wall of trench
Stoniness:	In the B horizon-about 2% pebble-size clasts of weathered dark shale	Classification:	Argid

Horizon	Depth (cm)	Color	Boundary	Structure	Texture	Moist Consist.	Clay Films	Appearance of Carbonate
Ap	0-8							
B21t	8-46			mod med pr-str c			ma k pf	
B22tca	46-60	5YR 4/6(d) 5YR 3/4(m)		mod med pr-str c sbk	SiCL		cont k pf	
B23tca	60-85		abr irr	wk med pr-mod med sbk			com mk pf	
IICb*	85-150+	greenish gray		massive	C			

* - Mancos Shale, probably reworked (alluvium; material of the B23tca horizon intertongues with the IICb.

FIELD DATA SHEET (page 4 of 6).

Date Sampled: 5 July 1980

Elevation: 7140 ft. (2177 m)

Location: Gravel pit G.P.-1, west of the Dolores River SE 1/4, SW 1/4, Section 6, T 37 N, R 15 W

Vegetation: bladed

Parent Material: Loess over gravelly alluvium

Slope: none

Aspect: west-facing

Stoniness: No material greater than 2 mm in the loess; about 80% of material is greater than 2 mm in the gravelly alluvium

Classification: Argid

Horizon	Depth (cm)	Color	Boundary	Structure	Texture	Moist Consist.	Clay Films	Appearance of Carbonate
B1				pr-c sbk			ma mk	
B2ca		5YR 4/4(d) 5YR 3/4(m)		pr-c sbk	SiCL		cont k pf	in films & coatings on ped faces
C1ca								stage II+; finely dissem. carb.; white but not hard
C2ca								
IIc3ca								stage II, as coating on on gravel and matrix

Textures are field textures.

FIELD DATA SHEET (page 5 of 6).

Date Sampled:	5 July 1980	Elevation:	7170 ft. (2186 m)
Location:	Gravel pit G.P.-2, west of the Dolores River SE 1/4, SW 1/4, Section 6, T 37 N, R 15 W	Vegetation:	pinyon and juniper
Parent Material:	Loess over gravelly alluvium	Slope:	none
		Aspect:	
Stoniness:	No material greater than 2 mm in the loess; about 80% of material greater than 2 mm in the gravelly alluvium	Classification:	Argid

Horizon	Depth (cm)	Color	Boundary	Structure	Texture	Moist Consist.	Clay Films	Appearance of Carbonate
B1								
B2		5YR 4/4(d) 5YR 3/4(m)		pr-c sbk	SiCL		cont k pf	80% thin carb films on ped faces
C1		5YR 4/6(d) 5YR 4/4-3/4(m)			SiL			
IIC2								stage II; as coatings on gravel and in matrix

FIELD DATA SHEET (page 6 of 6).

Date Sampled:	5 July 1980	Elevation:	7200 ft. (2195 m)
Location:	Gravel pit G.P.-2, northeast of the Dolores River; SW 1/4, NE 1/4, Section 8, T 37 N, R 15 W	Vegetation:	-----(cleared)
Parent Material:	Loess over gravelly alluvium (II) over weathered Dakota Sandstone bedrock (III)	Slope:	none
Stoniness:	No material greater than 2 mm in the loess; about 80% of material is greater than 2 mm in the gravelly alluvium	Aspect:	south-facing
		Classification:	

Horizon	Depth (cm)	Color	Boundary	Structure	Texture	Moist Consist.	Clay Films	Appearance of Carbonate
Loess I								
AB*		(dark)		str c sbk				
B2t								
Cca								laminar
Loess II								
B2tb1								
B2tcab2	to 4 m	5YR 4/4(d) 5YR 4/4-3/4(m)		pr-c sbk	SiCL		cont k pf	in films and threads and coatings on ped faces
Loess II or III								
C1b (2/3)								
IIC2ab (2/3)								
IIC3b(2/3	to 8 m							
R (Dakota Sandstone)								

Loess deposits throughout the D.A.P. area appear to be considerably more extensive and thicker than indicated by Haynes et al. [94] or the D.A.P. soils map. The material is a reddish-brown (5YR 4/3-4/4) silty-clay to silty-clay-loam, exhibiting at least one well developed soil profile, essentially identical to the loess and associated soils on the terraces (Table 1.4.4). Throughout Sagehen Flats the material averages 1 m thick and is found almost everywhere except immediately adjacent to drainages where it has been eroded to bedrock or the level of the drainage. The same deposits and soils were found far up House Creek, mantling hills and the floor of the valley to the southeast of the creek itself. The loess was equally common on the uplands of the east, northeast, and north of the Dolores River for some miles, although it appeared to thin starting about 5 miles to the northeast.

In a number of exposures, particularly on Sagehen Flats, there are indications of a buried soil formed in an older loess deposit. At gravel pit 2 (t4) there is evidence of two buried soils formed in loess, overlying the t4 gravels.

The buried soils are indicated by subtle but abrupt changes in color and structure down the profile and by coatings of calcium carbonate ($CaCO_3$) over clay films in the lower profle, in addition to an accumulation of $CaCO_3$ at the base of the upper profile (Table 1.4.4 and Table 1.4.5). The sequence of deposition and pedogenesis is interpreted as:

1. Deposition of loess, covering existing topography including Sagehen dipslope and terraces.
2. Soil formation in the loess, with movement of $CaCO_3$ down the profile followed by a build-up of clay and formation of clay films in the B horizon.

Table 1.4.5. Laboratory data sheets for selected soil profiles. Table is on the following pages.

LABORATORY DATA SHEET (page 1 of 3).

Location: Backhoe trench at site 5MT2847

		Percent of Total <2 mm Sample			Percent of Total Sand Sample					
Horizon	Depth (cm)	sand	silt	clay	Very Coarse >1000u	Coarse 1000-500u	Medium 500-250u	Fine 250-125u	Very Fine 125-50u	% $CaCO_3$
B21t	0-24	15.98	52.21	31.81	---	----	9.71	14.87	75.42	---
B22t	24-72	14.83	56.57	28.60	---	0.74	9.03	12.60	77.63	---
B2tb1	72-124	16.24	48.99	34.77	0.34	0.47	10.32	8.47	80.40	5.3
B31tcab1	124-156	17.42	51.19	31.39	0.51	0.79	20.73	14.83	63.13	39.4
IIB32tcab1	156-190	32.51	43.97	23.52	0.09	1.08	27.33	17.83	53.66	7.9

LABORATORY DATA SHEET (page 1 of 3).

Location: Backhoe trench at site 5MT2847

		Percent of Total <2 mm Sample			Percent of Total Sand Sample					
Horizon	Depth (cm)	sand	silt	clay	Very Coarse >1000u	Coarse 1000-500u	Medium 500-250u	Fine 250-125u	Very Fine 125-50u	% $CaCO_3$
B21t	0-24	15.98	52.21	31.81	---	----	9.71	14.87	75.42	---
B22t	24-72	14.83	56.57	28.60	---	0.74	9.03	12.60	77.63	---
B2tbl	72-124	16.24	48.99	34.77	0.34	0.47	10.32	8.47	80.40	5.3
B3ltcabl	124-156	17.42	51.19	31.39	0.51	0.79	20.73	14.83	63.13	39.4
IIB32tcabl	156-190	32.51	43.97	23.52	0.09	1.08	27.33	17.83	53.66	7.9

LABORATORY DATA SHEET (page 2 of 3).

Location: Arroyo at site 5MT4512

		Percent of Total <2 mm Sample			Percent of Total Sand Sample					
Horizon	Depth (cm)	sand	silt	clay	Very Coarse >1000u	Coarse 1000-500u	Medium 500-250u	Fine 250-125u	Very Fine 125-50u	% $CaCO_3$
A3b	57-72	36.98	38.42	24.60	---	1.57	22.58	35.25	40.60	---
B21tb	72-104	31.30	41.21	27.49	---	1.70	21.35	34.61	42.34	---
B22tb	104-153	38.25	34.35	27.40	0.89	1.44	17.11	27.94	52.63	0.9
B23tbca	153-209	38.38	30.45	31.17	2.85	2.46	34.54	29.25	30.89	1.9
IIB24tbca	109-240	4.08	50.30	45.62	0.58	1.91	11.69	13.18	72.64	5.0
IIIB25tbca	240-266+	6.54	55.12	38.34	0.23	0.24	3.71	5.24	90.58	1.9

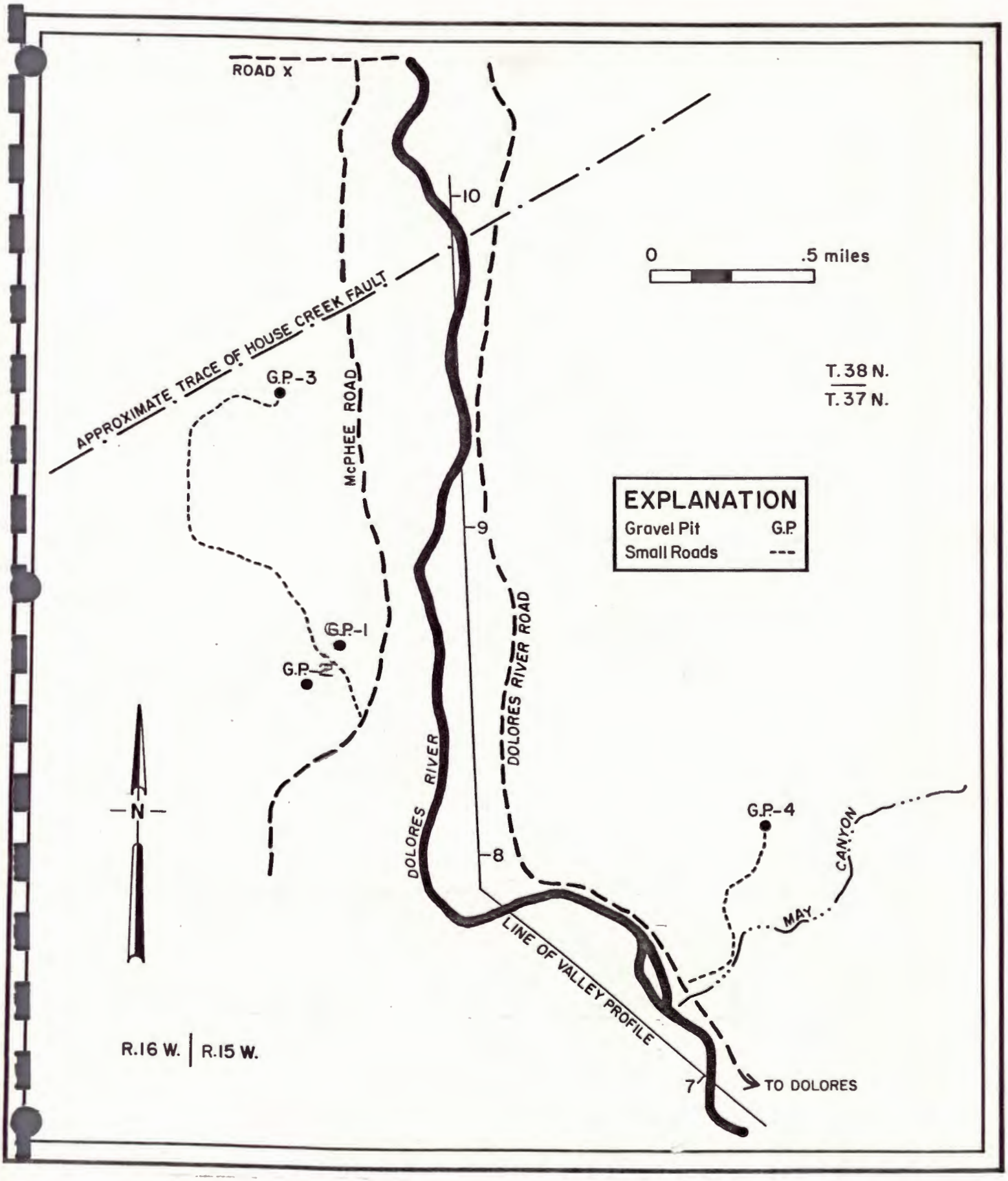

Figure 1.4.18. Location map of gravel pits mentoned in this section.

Abbreviations and Notes for Tables 1.4.4 and 1.4.5.

Soils described according to Soil Survey Staff [196] and Birkeland [97]. Abbreviations are as follows:

Color
- according to Munsell notation
- d - dry
- m - moist

Boundary
- abr - abrubt
- cl - clear
- irr - irregular
- sm - smooth
- wv - wavy

Structure

grade	wk - weak	size	f - fine	type	pr - prismatic
	mod - moderate		med - medium		sbk - subangualar blocky
	str - strong		c - coarse		abk - angular

Texture
- SiCL - silty clay loam
- C - clay
- L - loam
- CL - clay loam
- SiC - silty clay

Moist Consistence
- Moist unless otherwise indicated by (d)=dry consistence.

Clay films

Frequency	com - common, 25-50%	Thickness	n - thin
	ma - many, 50-90%		mk - moderately thick
	cont - continuous,>90%		k - thick
morphology	pf - clay films occur on faces of peds		

Appearance of Carbonate
- carb - carbonate
- dissem - dissemanated
- mod - moderate
- effer - effervescence
- sl - slight
- str - strong

Laboratory Data
- sand - 2000-50u
- silt - 50-2u
- clay - <2u

Sand, silt, and clay percentages determined using pipette method for carbonate-free and organic matter-free samples.
Sand fraction percentages determined by dry sieving.
% $CaCO_3$ determined using the Chittick method.

3. Deposition of loess, burying earlier loess/soil.
4. Translocation of $CaCO_3$ from new loess into buried soil, coating of clay films.
5. Build-up of clay and formation of clay films in soil in new loess.

This process would repeat in situations where three loess deposits (two buried soils) were observed.

Two cycles of loess deposition, indicated in part by a buried soil, are reported on Mesa Verde (Arrhenius and Bonatti [95]). A cursory examination of pithouse walls exposed on Chapin Mesa revealed that the soil development in the Mesa Verde loess is quiet similar to soil development in the Dolores area loess. These loess deposits are considered to be the same general unit. Correlations of specific buried soils/deposits and surficial soils/deposits was not possible.

Soils in the D.A.P. area reflect, to a large degree, the Quaternary sediments and geomorphic development. As noted, one of the striking pedologic aspects of the area is the widespread loess and associated soils (including the Witt, Pulpit, Sharps, and Bowdish series). These soils are considerably more widespread than indicated on the D.A.P. soils map. Large areas were mapped as Gladel (M2D) soils (soils with A/C horizons formed in Dakota Sandstone). On field inspection, however, these areas were invariably found to be covered by loess, which exhibited the characteristic soils formed in loess. In no instance were large areas of Dakota Sandstone exposed at the surface with a soil formed in the weathered sandstone. Dakota Sandstone was usually only exposed in narrow bands along drainages or in canyon walls.

The areas mapped as loess on the surficial geology map (Figure 1.4.16) approximate the areas of Witt, Pulpit, and Sharps-Bowdish soils. Mapping of individual soil series or localized bedrock outcrops was not within the scope of the 1980 geologic investigations. Identification of individual series within this group of soils is not considered critical, however, since the series are differentiated primarily on thickness of the B horizon. As well, there seemed to be considerable variation in soils formed in the loess beyond that suggested by the soil series. Most of the series identified for the area were defined in other areas of southwest Colorado and it may well be that these series are not suited to the Project area.

A case in point is the Granath loam (R1). This soil is classified as an Argiboroll, developed in loess. All other soils in the area formed in loess are Ustollic Haplargids. It would be highly unlikely to find Borolls mixed with Argids since the former are classified on the basis of temperature regime (cryic, pergelic, or frigid, associated with mean annual air temperature of 4.6°-6.7°C', Soil Survey Staff, [96]) and the latter on moisture regime. The mean annual temperature of the Dolores area is somewhat higher than that associated with Borolls but the area is dry enough to have Argids.

The area mapped as the Sagehen Paleosol on South Sagehen also appears to be a variant of the soils formed in loess. Leonhardy considers the soil to be developed in alluvium and redeposited loess, and equivalent to the buried soils on North Sagehen. Similar morphology and particle-size distribution of a soil from North Sagehen (Site 5MT2847, Table 1.4.5) and a Sagehen Paleosol profile (Site 5MT4512, Table 1.4.4) suggests that the Sagehen Paleosol and North Sagehen buried soil may be equivalent.

Evidence also suggests that the upper portion of the Sagehen Paleosol was formed in primary loess deposits. It exhibits morphological similarities to all other soils in the area formed in loess (Table 1.4.4 Site 5MT4512). The Sagehen Paleosol appears to have slightly higher sand content than the usual loess soils, but this may be a function of this soils position at the downslope end of Sagehen Flats, where it could accumulate some colluvim and slopewash as the loess was being deposited. Alluvium is obvious in many exposures on South Sagehen, but it is usually mantled by a homogeneous silty clay (the loess) with an abrubt contact between the two deposits. There was no evidence in any observed profiles to suggest that the silty clay was an alluvial deposit. The interpretation of the south Sagehen deposits follows that for the silty deposits on the river terraces: loess buried alluvium in arroyos which had developed on Sagehen Flats prior to loess deposition.

The topography of Sagehen Flats also suggests uniform eolian deposition throughout the area. Were South Sagehen to be an accumulation of alluvium, colluvium, and slopewash, it would be expected to have a more nearly horizontal surface as opposed to North Sagehen where loess caps the south-dipping Dakota Sandstone; and the surface of the loess reflects the dip. However, field observations and an examination of topographic maps shows no break in slope between North and South Sagehen Flats. There is an even north to south grade of 45 feet/1000 feet both north and south of Road X, the approximate north boundary of the Sagehen Paleosol.

Finally, the implication that the South Sagehen soil is significantly older than other soils in the area appears unwarranted. Features indicative of soil age include amount of translocated clay in the B horizon and development of clay films, color, and structure of the B

horizon (given similar parent material), and accumulation of secondary $CaCO_3$ (calcic horizon development). The calcic horizon development in soils formed in loess in the D.A.P. area varies considerably from area to area, with relatively low accumulations in soils formed in thicker eolian deposits or capping deep alluvium, and higher accumulations in soils with thinner parent material over bedrock. The calcic horizon development, then, is probably a function of permeability as well as of time. All other time-diagnostic properties are, as mentioned, quite similar, regardless of whether the soil is on South Sagehen, buried, or at the surface on North Sagehen, or formed in loess deposits on terraces. The only notable difference is that the buried soil on North Sagehen has slightly lower color value and the Sagehen Paleosol has lower value and chroma. These color differences are apparently a function of landscape position and drainage.

The age of the loess and associated soils is unknown, but by comparing the development of the loess soils in the Dolores area with the development of soils in similar parent material of known age in other areas, an approximate age for the Dolores valley loess can be suggested. The loess soils in the Dolores valley bear a striking similarity in color, structure, and B horizon clay content to the "Sangamon Soil"; a prominent stratigraphic marker in the midcontinent U.S. The age of the Sangamon Soil parent material is as old as 300,000 years (Birkeland; [94]). Based on the degree of development of both surficial and buried soils in the loess it seems reasonable to conclude that even the youngest loess soils in the D.A.P. area are at least of Wisconsin age and the buried soils older yet, perhaps of Sangamon age (greater than 100,000 years old). All of the loess soils, then, could be considered paleosols. If the South Sagehen

soil is equivalent to the buried soil on North Sagehen, it may represent the sum of soil development of the North Sagehen buried and surficial soils.

The most important aspect of soils in the D.A.P. area, from an archaeological perspective, is their agricultural potential. Although no laboratory analysis of this aspect of the local soils was undertaken it seems obvious that the loess derived soils were excellent for aboriginal agricultural purposes. Indentification of specific fields may be difficult since modern agricultural practices, grazing, and logging, may have masked or destroyed evidence. A simple means of investigation is detailing location of archaeological sites in an area of loess and determining if the areas between sites or site clusters would have been appropriate for farming. Otherwise such areas may have been randomly scattered between sites.

Since the Sagehen area has a noticeable slope to the south, some form of damming and irrigation may have been practiced. Some of the deeper drainages in the area have been backfilled and should have textures similar to the loess. These drainages may have been purposely dammed to take advantage of springs and accumulations of organic matter typical of such areas. It is also possible that such damming was a natural phenomenon. Throughout the rest of Sagehen, where shallow drainage have developed in loess, simple impoundment or restriction of drainage could have been accomplished by construction of earth dams throughout the area. Evidence for such structures would probably be very difficult to find however, owing to their simple construction and ease of erodability after abandonment.

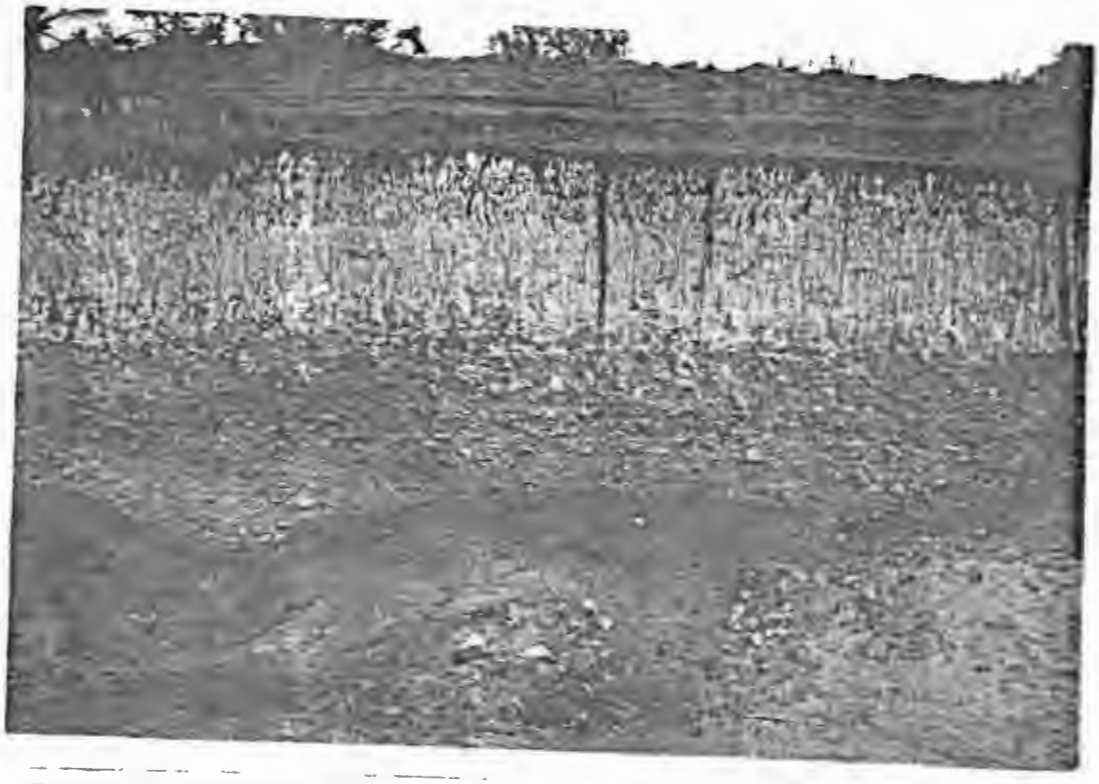

Figure 1.4.19. Cross section of Gravel Pit 4, loess above Gravel.

081901

Figure 1.4.20. Imbricated gravel and sand lens in Gravel Pit 4.

081902

SECTION 4e: A REVIEW OF 1979 AND 1980 GEOLOGICAL CONSULTANT REPORTS

The method of multiple working hypotheses (Chamberlain, [98]), although slightly more complex to envision than a single ruling theory, has inadvertently invaded the Dolores Archaeological Program's Earth Resource documentation. This may be due in part to the short time of employment granted various consultants and Leonhardy's informal Theory of Pronouncement wherein one consultant conducts two weeks of field work and makes a pronouncement of what he saw, followed the next field season by another consultant doing two additional weeks of field work and making a pronouncement of what he saw. These pronouncements do not usually coincide with one another. The preceeding section by Holliday and Piety contains working hypothesees for explanation of the modern and prehistoric abiotic environment that do not necessarily concur with those working hypotheses developed by Leonhardy in 1979. It is the purpose of this section to review the various geological viewpoints and suggest ways in which the D.A.P. may use the amassed data base without conflicting results.

A major concern of the Holliday and Piety report is that a red loess deposit formed a somewhat continuous deposit over the Project area during Wisconsin time, thus providing the parent material for most upland soils that are seen today. Leonhardy [19] on the other hand, maps a majority of the Project area soils as having derived from local sandstone bedrock residuum or colluvium derived from bedrock and loess deposits. A comparison of the Surficial Geology Map (Figure 1.4.16) with the Reconnaissance soils map (Figure 1.4.21) quickly illustrates this difference. In actualilty the true explanation lies somewhere in between

these two maps (V. Holliday and F. Leonhardy, personal communication, 1981). Loess was deposited in the Project area (Kottlowski et al. [99]), while bedrock was and is still being mechanically and geochemically weathered. Affecting the top of both deposits are factors of soil formation (e.g., climate, organisms, parent material, topography, and time (Jenny, [100]) and the ongoing geomorphic processes of erosion and deposition are aggrading and degrading the profiles available for examination. Assessing whether a soil developed on the Project area has a loess, a sandstone residuum, or a reworked alluvium parent material is a difficult task. The ultimate source of all these deposits is sandstone. Primary and reworked loess deposits should be of similar grain size, and sorting or bedding, as expected in most water-worked sediments, may not be evident. It should be pointed out that the project soils map has arbitrarily divided the landscape into similar soil series as seen by the Soil Conservaton Service (S.C.S.) who partially mapped the House Creek Drainage and Sagehen Flats; it is based on both aerial photo and field checking, by D.A.P. and S.C.S personnel; and it does map evident differences in factors that influence soil formation (specifically drainage, topography, and vegetation). The surficial geology map, on the other hand, generalizes the assumed primary loess deposit as being fairly continuous (except where it has been eroded by drainages) with the idea that these areas were reasonably similar and productive for prehistoric agriculturalists. With these different viewpoints in mind it should be simple to choose the map or reference which most aptly describes the archaeological problem in question. Both maps and interpretations may be used when necessary if it is realized that they are both working hypotheses and neither constitutes a ruling theory.

LABORATORY DATA SHEET (page 3 of 3).

Location: Trench 1 in McPhee terrace, west side of McPhee Road; near site 5MT4684.

		Percent of Total <2 mm Sample			Percent of Total Sand Sample					
Horizon	Depth (cm)	sand	silt	clay	Very Coarse >1000u	Coarse 1000-500u	Medium 500-250u	Fine 250-125u	Very Fine 125-50u	% $CaCO_3$
B22tca	46-60	16.96	57.22	25.82	0.28	0.32	1.91	5.36	92.13	3.2

Terrace divisions pose another area illustrating views from different geo-observational platforms. A quick glance at the 1979 General Landforms Map (Figure 1.4.22) and another glance at the 1980 Surficial Geology Map (Figure 1.4.16) shows two divisions of terraces within the Project area. In this instance, the 1980 divisions just further subdivide those made in 1979; however, the extent of the 1980 terraces is reduced. Again the more accurate terrace configuration probably lies somewhere in the middle, and even further subdivisions of terraces would probably be possible with additional interest in the topic and availability of field time and personnel. At this time finer subdivision of the terraces seems unwarranted. The 1980 map clearly illustrates that there are at least seven elevationally separate terraces above the Dolores River, although their complete extent is hard to determine due to loess and colluvium deposits that bury the cut bedrock and alluvial gravels which characterize these terraces. The gradients of all the terraces seem to conform to the gradient of the modern Dolores River as shown by Figure 1.4.17 in the previous report.

Other working hypotheses concerning the terrace gravels may also be examined. Due to the indeterminate dating of the House Creek fault, a number of the terraces on the north side of the fault may be contemporaneous with the higher terraces seen in gravel pits on the south side of the fault. Differential weathering of feldspars has been witnessed in higher terraces on the south and immediate north sides of the fault; however no detailed analysis has been made. During reconnaissance for material source samples for both lithics and ceramics, Travis [2] and Maloney (Phagan and Maloney [3]) have been concerned with the age and weathering characteristics as well as

compositional variability of the different terrace gravels. To this end Maloney and Clay have collected a statistical sample (Krumbein and Sloss [102]) of terrace gravel from each terrace designated in the 1980 Surficial Geology Map. Further hand specimen analysis of these gravel samples should clear up some of the confusion, although the interaction of alluvial and structural deformation in the Project area may never be completely understood. It is herein recommended that the terrace subdivisions of the 1980 Surficial geology map be used in determining site landform when it is dictated by survey or excavation reports. This entails a shift from the 1979 General Landforms Map when the site of concern is located on a terrace of any sort. In essence the terraces mapped on the 1979 map are outdated and obsolete.

Again, considering the General Landforms Map (1979) and the Surficial Geology Map (1980) the designation of alluvial fans is much more precise in the more recent map. It is suggested that the alluvial fan designations of 1980 be used if a site is situated in an area mapped as such on the Surficial Geology Map. A geologist's training, perception, and internal prioritizing nature continually biases his/her work, thus different observations of the abiotic environment should be expected and encouraged. Thus, the Surficial Geology Map and General Landform Map need to be used simultaneously when determining site landform.

The pediment mapped on the 1979 General Landforms Map has also been updated, in the previous report by Holliday and Piety, to a valley bottom due to the controversial definition of pediment in the geological literature. Moreover, this valley bottom designation is now updated to a possible graben or structural basin in Section 5a of this chapter. With

increasing geological exposures becoming available through Bureau of Reclamation construction activities, the geological interpretations of the Project area are subject to revision. This is a necessary scientific process which should not harm archaelogical interpretation if it, too, is flexible and capable of handling new geoenvironmental interpretations as they arise.

Additional hypotheses for the formation of deposits where archaeological sites are located exemplify yet another area in which geologists tend to have numerous observational interpretations, not always similar. The deposits which underlie the Rio Vista Village (Site 5MT2182) have been suggested by Holliday and Piety in the previous report as being a slide from the same canyon wall or from a debris flow from the opposite canyon drainage. After brief field observation in 1981, the present author suggests that the site is perched on a resistant sandstone unit in the upper Morrison Formation which forms a resistant bench. This bench tends to follow the regional bedrock dip downstream in the Dolores River Canyon, and catch large colluvium that is transported by gravity down the canyon wall. These three working hypotheses all need further exposures, and possibly lab work, to determine their feasibility. As many ideas about site location geology as possible should be initially considered until these can be further substantiated or discarded.

Grass Mesa (Site 5MT0023) deposits of noncultural origin invoke two hypotheses at present. Leonhardy [19] maintains that the deposit is alluvial in origin, while Holliday and Piety observe a definite break between alluvial deposits and eolian deposited loess which they believe caps the lower terrace. The exposures available in 1980 were no doubt

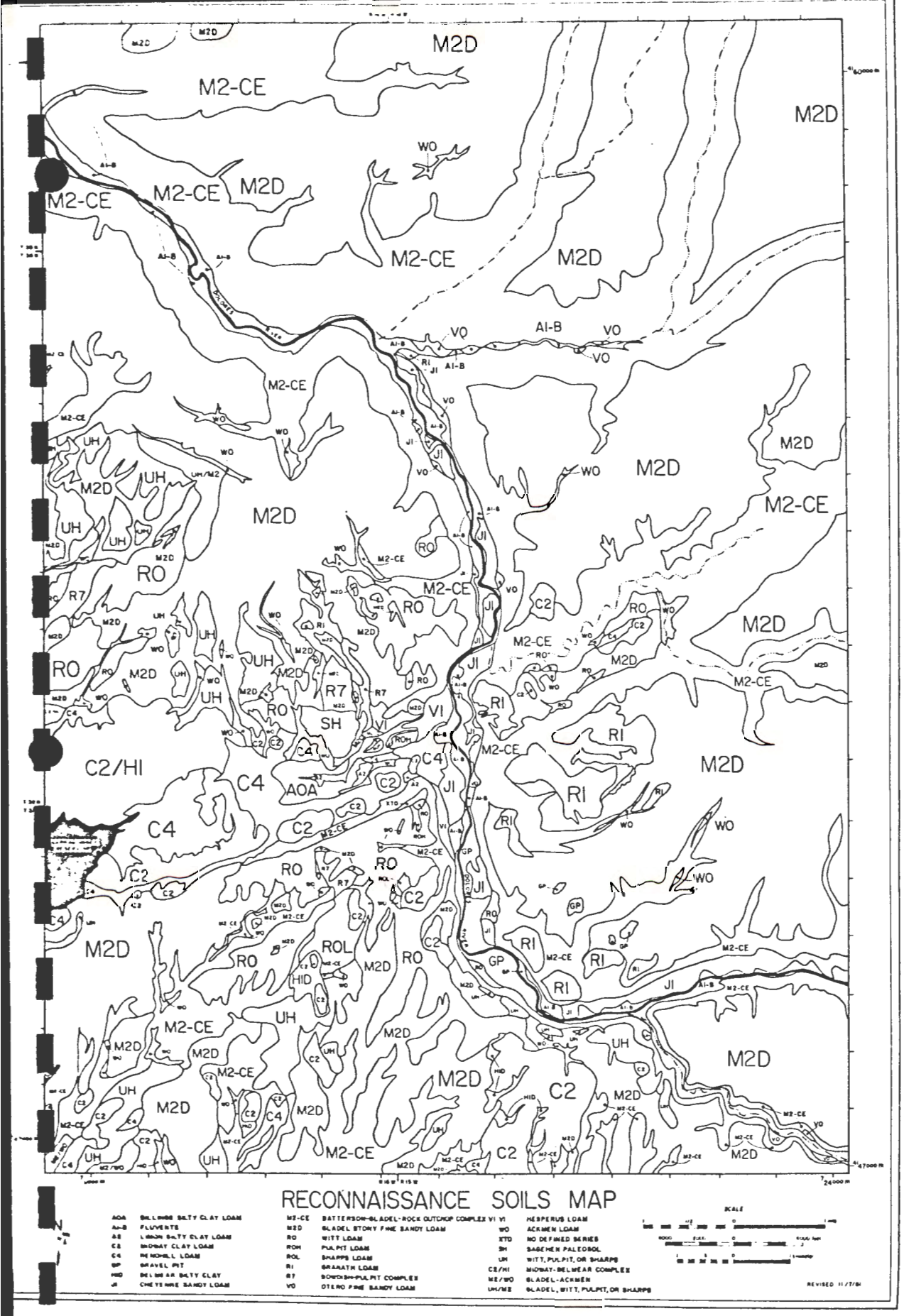

Figure 1.4.21. Reconnaissance soils map.

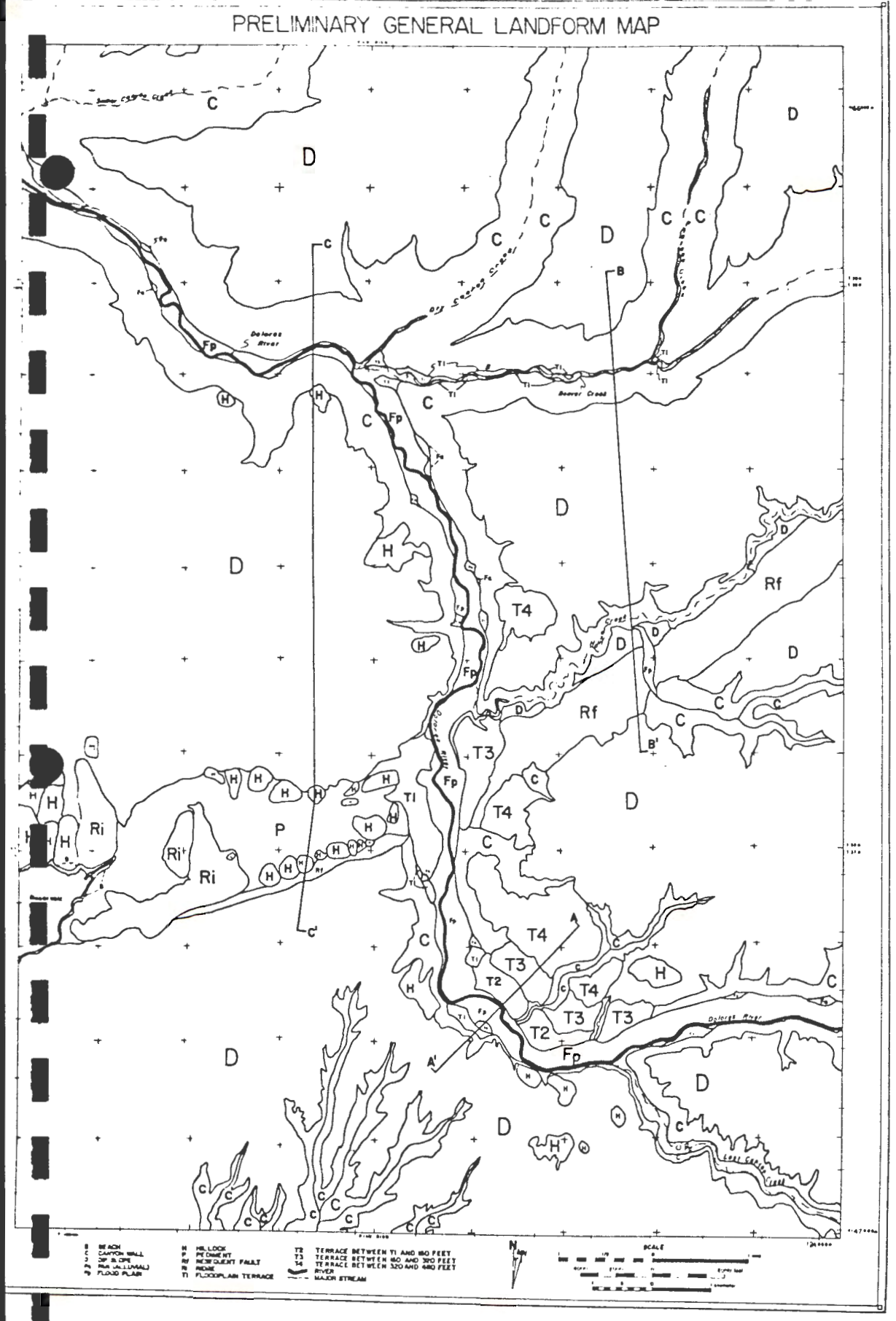

Figure 1.4.22. General landforms map.

more conducive to the latter interpretation than those available to Leonhardy in 1979. The later interpretation may be more valid; however, no substantive laboratory analysis has been done to conclusively substantiate either viewpoint. Numerous geological interpretations of a single site need not cause a chaotic situation; instead these should give rise to a number of cultural/landscape interactive explanations which may have ensued in prehistory.

Discrepencies in the D.A.P. geological interpretations do exist. A number of these reflect an increase in stratigraphic exposure and documentation, while others reflect only different geologists' biases and lack of adequate exposures and laboratory analysis to eliminate unrealistic working hypotheses. At present it seems critical to consider as many plausible working hypotheses about the geological environment, both past and present, in the Dolores Project area as possible when asking and explaining the area's prehistory and environment. D.A.P. archaeologists should utilize the geological maps (Figures 1.4.16, 1.4.21, 1.4.22, 1.4.23) with the realization that this is the present configuration of geology as perceived by various geologists who were trained to delineate various complexly interrelated continuums on paper, emphasizing perceived similarities. How these mapped relationships compare with the abiotic environment perceived by the prehistoric peoples of the area is left to the archaeologist.

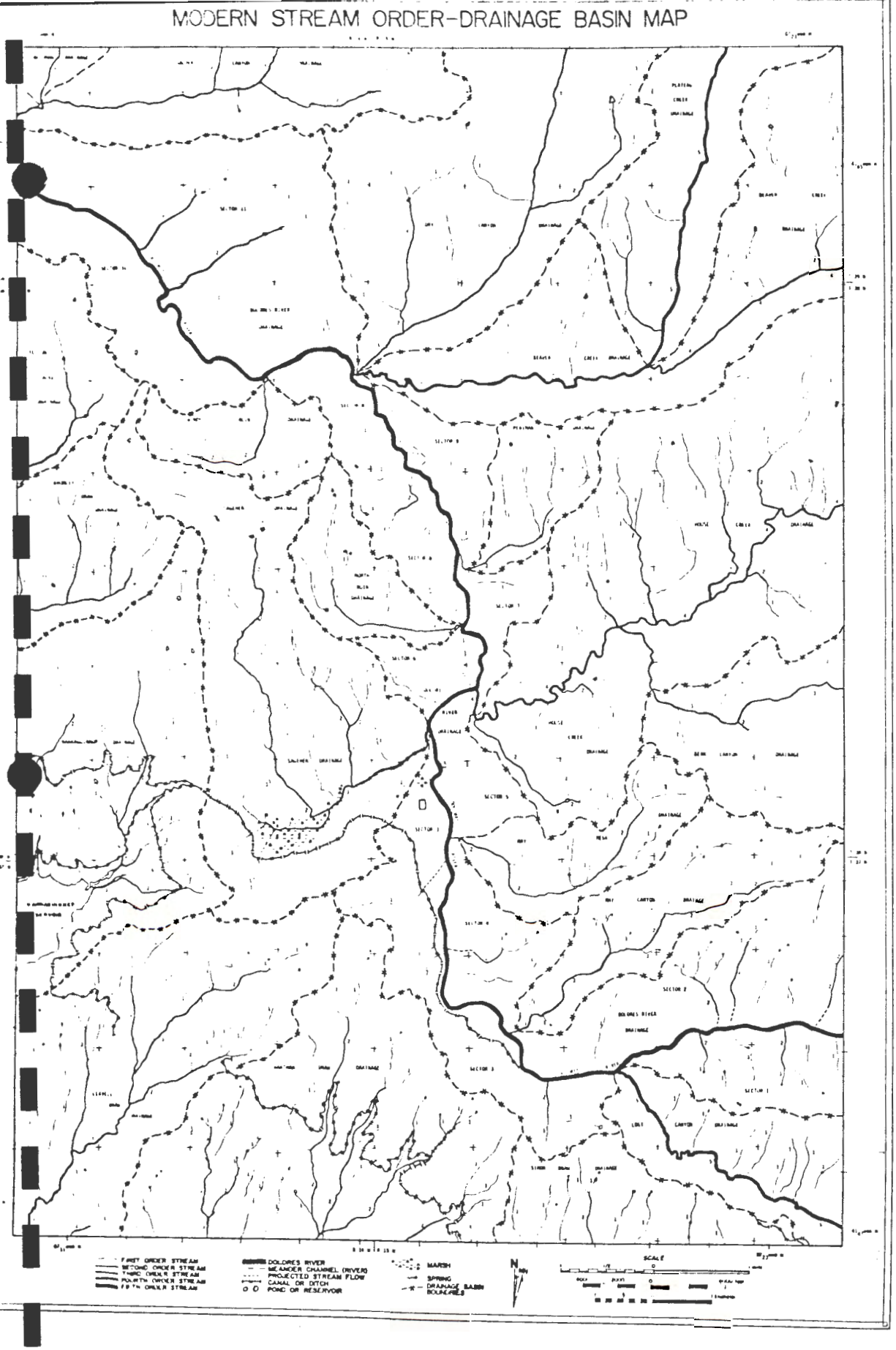

Figure 1.4.23. Stream order and drainage area map.

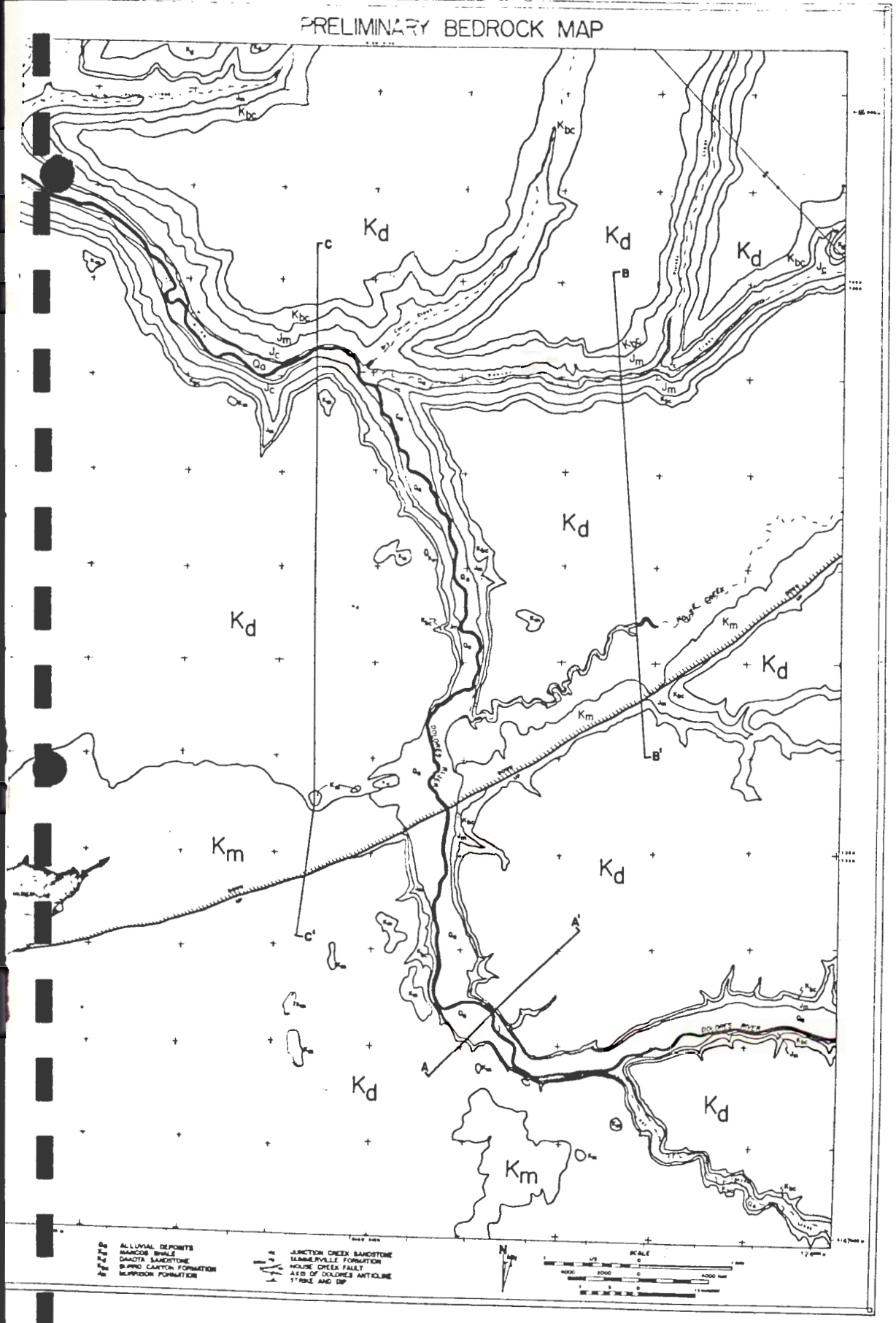

Figure 1.4.24. Bedrock geology map.

Figure 1.4.25. North facing canyon wall with characteristic Douglas fir, oak mountain shrubland near McPhee Dam Site. Also note the Riparian Grassland in the lower right. 105201

Figure 1.4.26. Northeast view of Dolores River canyon with a Riparian Woodland Zone in the foreground, and a Pinyon-Juniper Woodland zone in the center on a Southwest facing slope.

105201

Figure 1.4.27. Looking east across Sagehen Flats, a Sagebrush Shrubland Vegetation Zone lies in the foreground with a cultivated-disturbed zone in the center. 105401

Figure 1.4.28. Sagehen Flats Marshland Vegetation zone within the sagebrush shrubland, viewing west. 105401

SECTION 4f: SUMMARY OF CONTEMPORARY ENVIRONMENTAL INVESTIGATIONS

To date, the E.S.G. has characterized the Dolores Project area's modern environment through various mapping and descriptive maneuvers. The E.S.G. maps comprise a compilation of pertinent data which may be used advantageously by the informed environmental archaeologist. An attempt to describe the underlying map making procedures, and assumptions, and the general content will be discussed below.

Eleven vegetation zones (Figures 1.4.25, 1.4.26, 1.4.27, 1.4.28, 1.4.29, 1.4.30, and 1.4.31), appear on the Preliminary Actual Vegetation of the D.A.P. Map [12]. These zones reflect the class and species of plants in the D.A.P. area at the time of mapping. Thus the differences are evident and easily recognized by the untrained observer. As with all of the E.S.G. maps, the scale is 1:24,000 and the region covered involves all of the U.S.G.S. Trimble Point Quadrangle and parts of the Boggy Draw, Dolores West, and Dolores East Quadrangles. Also, consistent with all E.S.G. maps, is a detailed description of the mapping units, either on the map itself or, more commonly, in a report associated with the map. The descriptions are critical when utilizing these maps.

The Potential Natural Vegetation Map (Section 4a, this chapter) (Figure 1.4.1) is a map of concepts. If the Preliminary Actual Vegetation Map were inserted into a climax formation machine and the contemporary factors of climate, physiography, and man's past environmental (both historic and prehistoric) impact held at today's levels, the result would be the P.N.V. map. In essence, vegetation succession is the only factor allowed to continue to an equilibrium state with present environmental conditions held constant.

Figure 1.4.29. Looking east at the confluence of Plateau Creek, Beaver Creek, and the Dolores River. The north facing slope in the center right illustrates the Douglas Fir, Oak Mountain Shrubland Zone, the center and lower left illustrate a Ponderosa Oak Forest. Riparian Woodland and Grassland Zones extend from the lower right center to the left, following the valley floor. Shrubs in the immediate foreground are Gambel's Oak.

The Preliminary Bedrock Map of the D.A.P. (Figure 1.4.24) delineates the consolidated rock units as well as river alluvium forming the basic foundation of the Project area. The formation and member designations follow regional and Bureau of Reclamation (revised) standards. Most of the mapping was done from photos (Figure 1.4.32) with limited field checking, thus the preliminary designation.

The General Landforms Map of the D.A.P. (Figure 1.4.22) delineates gross landforms that are obvious on topographic maps. These divisions are of a morphogenetic nature in that they describe the landforms and allude to the processes that formed them.

Stream Order and Draniage Areas of the D.A.P. (Figure 1.4.23) is a map that illustrates the present drainage patterns existing on the project. The drainages are designated by any channel with perennial or intermittent stream symbols on the U.S.G.S. topographic quadrangles. Stream order designations follow Strahler [103] and allow quantitative geomorphological analysis. Drainage area boundaries follow topographic highs between adjacent areas.

The Reconnaissance Soils Map (Figure 1.4.21) represents a generalized Soil Conservation Service approach (Soil Survey Staff [96]) to assessing the upper regolith. Topography, vegetation zones, slope, and aspect combined with limited field checking, aided in the aerial photo mapping of this contemporary environmental element.

Surficial Geology of the D.A.P. (Figure 1.4.16) is a combination of all Quaternary and Recent deposits at or very near the modern ground surface. This map views soils and landforms from a sedimentary perspective and uses both a morphogenetic and a lithogenetic approach.

A number of landforms including terraces and fans are more precisely mapped on this map than on the gerneralized landform map.

With the above review of major E.S.G. maps and their premises, it is believed that archaeologists will be able to obtain valuable and beneficial information from this data base.

Recognition of relationships among and between the contemporary abiotic environment and the abioticenvironment, as mapped on the Project area and described in the regional literature, is also important when assessing the contemporary environment. If the recognizable modern patterns and relationships persisted in prehistory, modern analog situations may be developed for the more stable relationships. Thus, a modern example of a fauna-floral relationship is the association of marsh hawks with marshland and riparian vegetation zones. Another example is the association of hillock landforms with Mancos Shale bedrock, the underlying relationship being erodability of shale.

Whether the foregoing relationships, or the maps of contemporary environmental elements, recognizable on the ground or from the air are explicitly representative of the modern natural environment is open to question. Man in his modern industrial state has interacted with the Project area intensively for over a century. Logging, farming, coal mining, gold dredging, irrigation reservoir and pond construction, and river modification, as well as historic constructions and destructions have all had an effect on vegetation zone distribution and associated faunal distribution, sedimentary degradation and aggradation, drainage area configuration, and numerous other modern environmental factors and relationships. Realizing that the contemporary abiota and biota are a result of a number of additive and interactive factors initiated on the

interactive factors initiated in the past and greatly influenced by modern, historic, and prehistoric inhabitants precautionary meausres are necessary when using contemporary environmental data to reconstruct the prehistoric environment. Therefore, an evaluation of the prehistoric environmental record as well as the contemporary environmental record must be combined into complementary studies such as the linkage studies in the following section.

SECTION 5

LINKAGE STUDIES

contributing authors

Bruce F. Benz, Vickie L. Clay
Richard H. Glaser, and Thomas R. Van Devender

INTRODUCTION

Linkage studies undertake to discern similarities and differences between modern and prehistoric environments and between historic and prehistoric cultural practices. The first two papers in this section describe E.S.G. research activities that seek to understand the geological processes that have given rise to the Sagehen Flats marsh over the course of the last Mesozoic to Recent millenia and the geological processes that affect the filling of pitstructures and the site formation processes in the D.A.P. area. Following these two contributions are summaries of two literature searches, a short critique of the D.A.P. Experimental Garden and a discussion of environmental reconstruction based on packrat-porcupine midden studies. The literature searches describe the role played by plants and animals in the subsistence strategies of Native Americans in the Greater Southwest during the historic period. Although it is difficult to justify the assumption of cultural continuity, ethnographic documentation of plant and animal use provides analogs from which we can examine the archaeological record for patterning or nonassociations. The ultimate test of the utility of these analogs is examination of the archaelogical record for suspected relationships.

Figure 1.4.30. Southwest view of Marshland Vegetation Zone within Ponderosa Forest at Hoppe Point (Photo ~~008531~~).
105501.

Figure 1.4.31. Pinyon-Juniper-Oak Woodland Zone at center, looking north within the Sagehen Flats Locality (Photo ~~012009~~).
105501

SECTION 5a: STATIGRAPHY AND GEOLOGIC HISTORY OF THE SAGEHEN MARSHLAND

by Vickie L. Clay

Introduction

A marsh can be defined in a number of ways. The American Geological Institute [104:269-270] offers three common usages:

1. ... shallow lakes, the waters of which are either stagnant or actuated by a very feeble current; they are filled with rushes, reeds and sedge and are often bordered by trees...

2. A tract of low, wet ground, usually miry and covered with rank vegetation. It may, at times, be sufficiently dry to permit tillage..., but requires drainage to make it permanently arable.

3. In biological usage: A herbaceous plant dominated ecosystem in which the rooting medium is inundated for long periods if not continually." (cf. Bye [12])

Hydrologically a marsh is a place where the water table is at or near the ground surface due to underlying geological phenomena (Press and Siever [92]). In the arid and semiarid regions of the Southwest evaporative loss may exceed water income, creating temporary eutrophic (highly productive) ponds in some instances and grassland vegetation in other instances (Whittaker, [105]. These ponds may be seasonally astatic (fluctuating, wet to completely dry) or perennially astatic (fluctuating pond levels, but always wet) (Cole, [106]).

The modern Sagehen Marsh (Figure 1.5.1) meets most of these definitional criteria; however it has never been observed in a completely dry state during the archaeological investigations of the D.A.P. The western periphery of the marsh partially dried during the 1978 and 1979 excavation seasons, leaving alkali at the ground surface.

This report is the first in a series of linkage studies which begin with an evaluation of present resource availability. Assessment of prehistoric resource availability is complex. In the case of an abiotic environmental resource (e.g. a marsh) sedimentary deposits and stratigraphic relationships represent earlier depositional and erosional events (e.g. unconformities) that may provide evidence for a historical view of the modern resource. The resource to be studied is the Sagehen marsh. The primary line of inference concerns relationships of sedimentary deposits to their depositional environment. By careful examination and interpretation of these deposits, coupled with dating of statigraphically available vegetal and organic material, a reasonable model of the past Sagehen marsh environment will be developed. Specifically, this study addresses question 1 in Problem Domain 1 of the D.A.P. Research Design [1]. The consideration of the entire modern marsh area as one resource is done due to the abiotic emphasis of the study and to the lack of extensive biotic investigations of this feature. A lack of conclusive evidence for marsh persistence from macrobotanical, pollen, and faunal analyses of archaeological remains (S. Emslie, B. Benz personal communications) precludes any attempt at answering question 2 in Problem Domain 1 of the D.A.P. Research Design [1] at this time. When this question is pursued with regard to a marshland resource, problems may arise in trying to identify archaeological biota specifically characteristic of riverine versus marshland environments.

Prior to this study, three informal models to explain the prehistoric existence of Sagehen Marsh were popular on the D.A.P. These models included:

1. The marsh existed prehistorically as it does today.

Figure 1.4.32. Junction Creek, Morrison, Burro Canyon, and Dakota Formations exposed from valley floor to canyon rim in the Dolores River Canyon at the McPhee Dam Site (Photo 088905).

Figure 1.5.1. Marshland at Sagehen Flats; June 1981. 10640

2. The marsh resulted from seepage of water out of Montezuma Canal System Main Canal #2 (Site 5MT5181) after it was completed in 1889. The marsh did not exist prehistorically.
3. Cores taken from the Sagehen Marsh in 1978 by K.L. Petersen revealed sediments that had apparently resulted from alternately wet and dry episodes in the marsh (K. Petersen, 1981 personal communication). Suggesting that the marsh may have existed intermittantly in the past.

These models afford a starting point from which to describe previous studies in the marsh area.

Previous Studies

The Dolores Archaeological Program Survey Group has actively recorded all recognizable prehistoric and historic sites within the takeline as it occurs on the Sagehen Flats Locality. The takeline is a Dolores Project administrative unit which includes the McPhee Reservoir and lands surrounding the reservoir purchased by the Federal Government as part of the Dolores Project. Figures 1.5.2 and 1.5.3 illustrate the location of prehistoric and historic sites respectively that occur within a 1 km radius of the modern marsh perimeter. It is assumed that the sites appearing on these two figures would have had the resources of a marshland readily available if the marsh existed historically (Figure 1.5.2), or prehistorically (Figure 1.5.3).

One historic site (Site 5MT5181) is of particular interest when considering the present extent of the marsh. This site comprises the Montezuma Valley Tunnel and Canal System and includes Main Canal # 2 and associated Features (Figure 1.5.3). This canal contours Mancos Shale

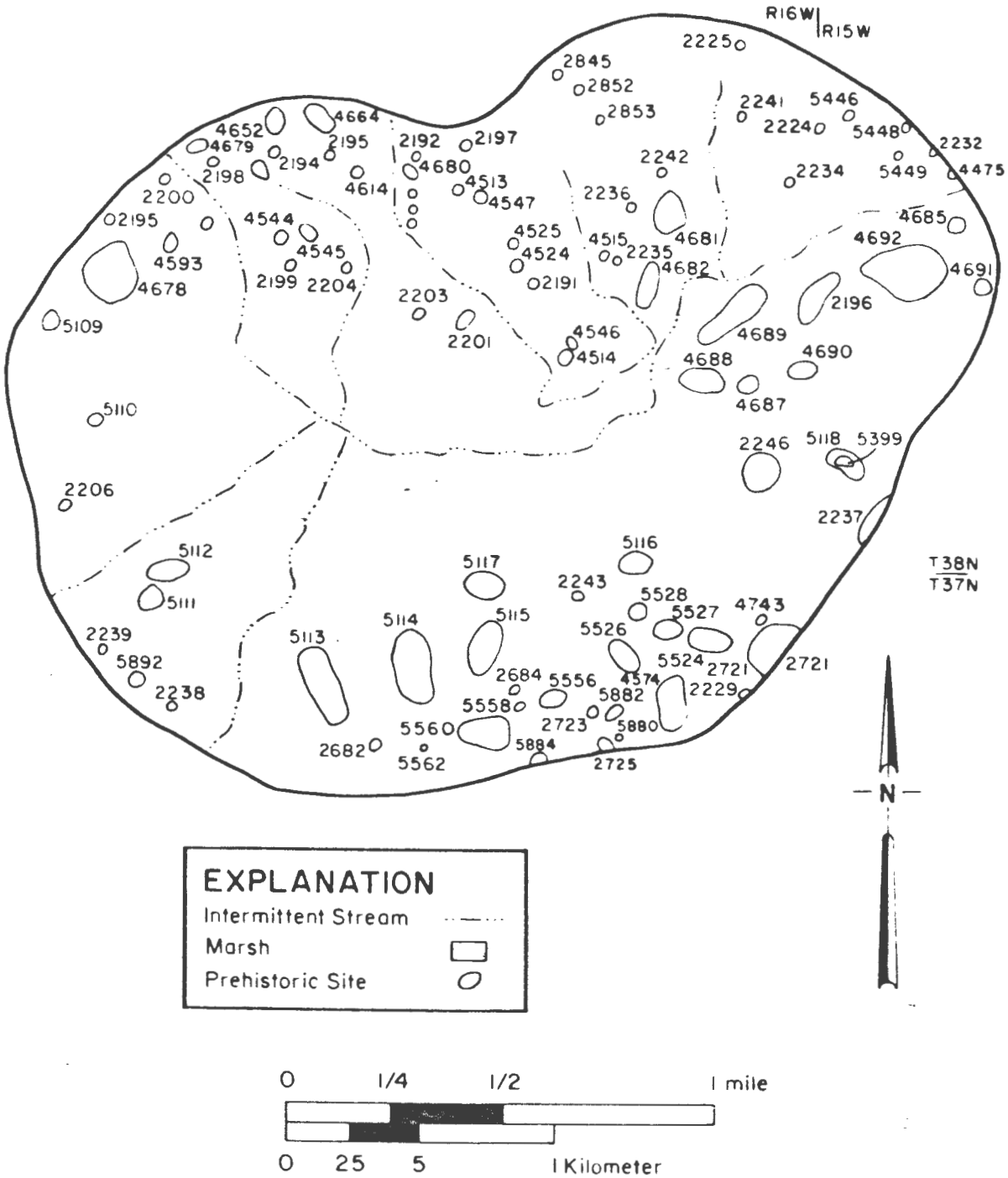

Figure 1.5.2. Prehistoric sites located within 1 kilometer of the marsh perimeter.

features (Figure 1.5.3). This canal contours Mancos Shale/hillocks to the south of the marsh, approximately 6 to 12 m above the marsh center (Figure 1.5.4), and may be responsible for the modern extent of the marsh as mentioned in the second model of marsh formation. Historical records on file in the Montezuma Valley Irrigation Company Office in Cortez, Colorado, reveal that Main Canal # 2 was completed in 1889 and first carried water on April 25 of that year. The D.A.P. historical survey form for Site 5MT5181 contained the following information concerning Main Canal # 2.

> "A large number of farms and ranches in the Project area, specifically Sagehen Flats and those in the adjoining communities of Lebanon, Arriola, etc., receive water from Main Canal # 2. ...Maintenance of wooden flumes became a major problem for the irrigation company due to their high cost. All but a few wooden flumes were replaced over the years." (D. Duranceau et al. 7-16-79 [107] Historical Survey Form Site 5MT5181).

A wooden flume was located during this study and will be discussed in a later stratigraphic description. Another historical account by Freeman [108:96] indicates the nature of water resources in Montezuma Valley prior to the irrigation system:

> "Water was scarce in the valley before water was brought in, or was obtainable only at widely scattered springs, some of the springs were very weak and some of the water was not usable, being strong with alkali. Much water had to be hauled from the better springs and even from the Dolores River."

It is apparent from these historic records that water was limited for drinking and agricultual purposes, necessitating a canal system to supply the farms in Sagehen Flats. Main Canal # 2, its associated irrigation valves, and at least one wooden flume served this need. If the marsh was at its present (e.g., May, 1981) capacity, it is strange that a canal would be necessary to service the Sagehen Flats farms. This may indicate

that marsh water was exceedingly alkaline or only seasonally accessible during historic times.

The modern marshland has been mapped on a number of E.S.G. maps which partially characterize its biotic and abiotic nature. Mapped characteristics of the marsh include the following:

1. Mancos Shale (km) including gray siltstone, mudstone, and bentonitic clay beds underlie the area. (Bedrock Geology Map - Leonhardy [19]).
2. Pediment (P) Valley floor, structural basin from the general landform designation. (General Landform Map - Leonhardy [19]).
3. Sagehen Drainage Area, including first, second, and third order streams. (Modern Stream Order-Drainage Basin Map - Leonhardy [19]).
4. Billings Silty Clay Loam (AOA), Limon Silty Clay Loam (A2), and Ackmen Loam (WO) are the designated soil series in the area. (Reconnaissance Soils Map - Leonhardy [19]).
5. The marsh is designated as a swamp with three terraces of T2 designation near the eastern periphery. (Surficial Geology Map - Holliday and Piety, Section 4d, this chapter).
6. Marshland vegetation zone. (Preliminary Actual Vegetation Map, Bye [12]).
7. Pinyon-Juniper woodland vegetation zone skirted by sagebrush shrubland. (Potential Natural Vegetation Map, Bye, Section 4a, this chapter).

These descriptive mapping projects provide a general summary of the existing environmental information available for the modern Sagehen marsh.

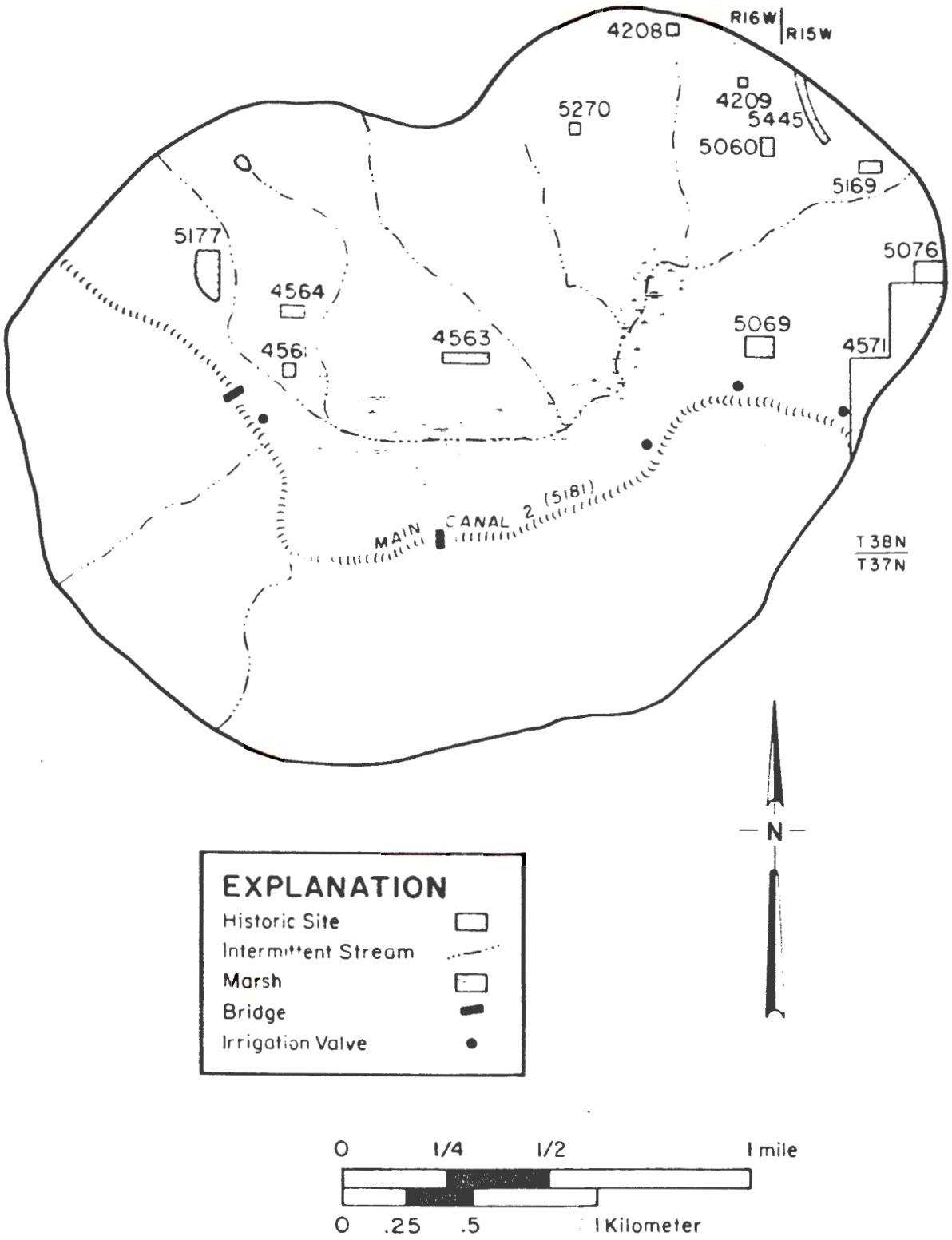

Figure 1.5.3. Historic sites located within 1 kilometer of the marsh perimeter.

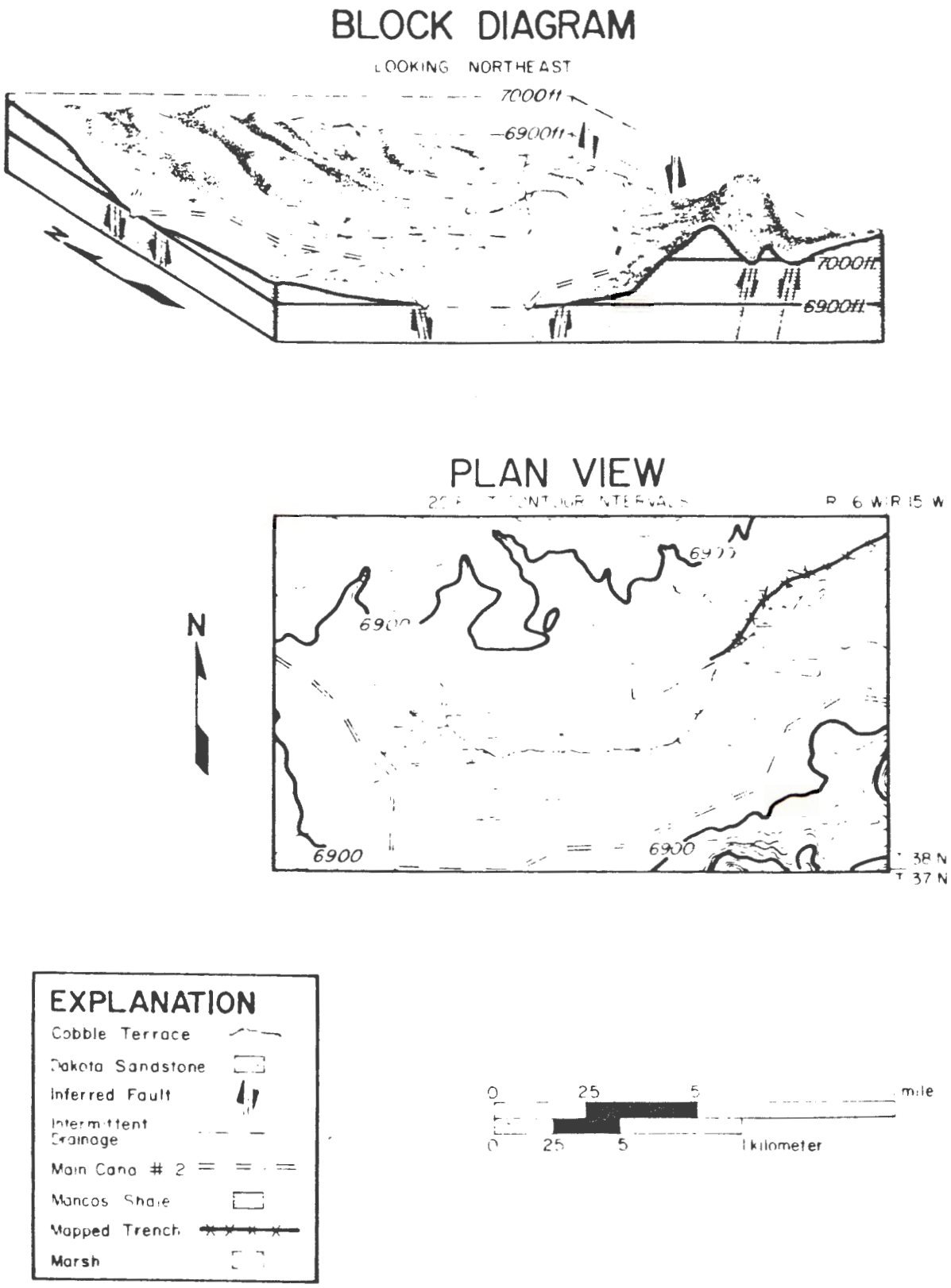

Figure 1.5.4. Block diagram and planar map of the present topography and mapped trench within the Sagehen Marsh.

During the 1978 field season two cores were taken by Petersen from the Sagehen marsh to evaluate pollen and paleoenvironmental reconstruction potential. This analysis is presently in progress (K. Petersen, personal communication).

This section has attempted to summarize the archaeological survey data and environmental studies that have taken place in or in proximity to the Sagehen marsh. Base line studies reviewed provide a foundation for the stratigraphic study now presented.

Present Study

The Bureau of Reclamation completed the excavation of a trench (in 1981) which follows the major intermittent stream course through the Sagehen marsh. With the completion of this trench, the most extensive stratigraphic profile of soils and sediments existing within the Project area was exposed (Figure 1.5.4). The purpose of the trench was to lower the water table and facilitate further excavation of canal and outlet works at the Great Cut Dike (D. Simrak, USBOR Geologist, personal communication).

An opportunity to clarify the history of the Sagehen marsh was recognized by the E.S.G. The earth resource crew chief was assigned the mapping and reporting responsibilities.

The marsh trench is oriented along an intermittent stream (Figure 1.5.5) and has been mapped primarily near its eastern margin, due to construction activity in the western half. The eastern part of the trench contained a diversity of soils and sediments. An extensive profile description was drawn every 60 m as determined by pacing (Figure 1.5.6). This description included a general soils characterization, but was

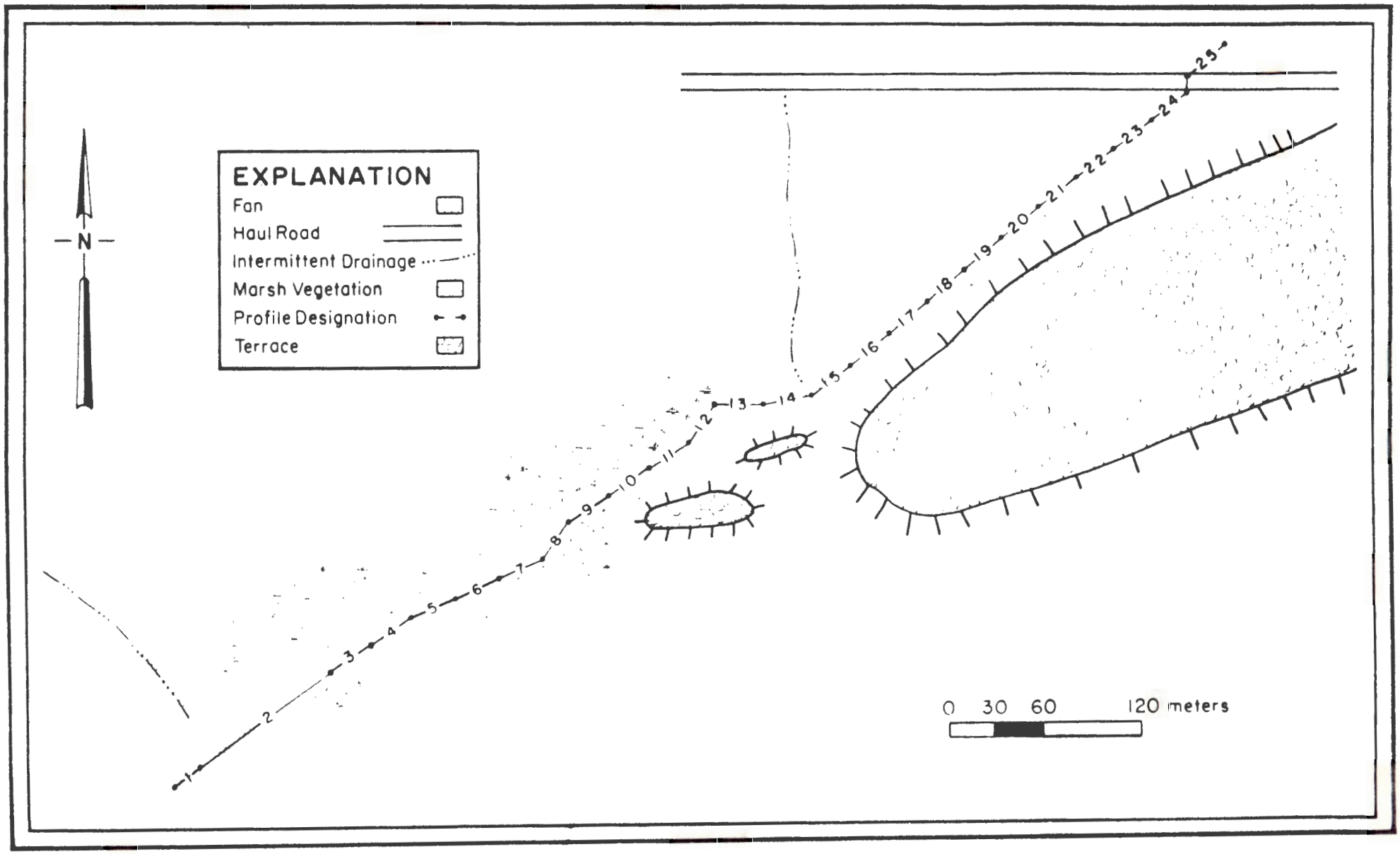

Figure 1.5.5. Mapped trench location in Sagehen Marsh.

considerably modified when sediments with little or no recognizable soil formation properties were encountered. Lithology and bedding characteristics were then described following Reineck and Singh [109]. Vegetation cover was also noted for each profile. In addition to these descriptive activities, a number of samples were collected for radiocarbon dating and eight sediment samples were extracted from Profile A (Figure 1.5.7) for analysis. Time constraints, however, prevented analysis of the sediment samples.

Three samples were submitted to laboratories for radiocarbon analysis (Table 1.5.2).

Results

Figure 1.5.6 represents a continuous profile through 930 m of mapped trench area. Starting at the western edge of the trench and proceeding in a northeast direction a generalized profile description is as follows.

Profile 1 is characterized by alluvial fan deposits aproximately 1 m thick, alternating with marshland sediments. These deposits include well-sorted clean sand lenses alternating with dark gray, organic rich silty sand deposits of 10-20 cm thickness. Angular sandstone gravels occur at the base of the sand lenses. Below this is a buried A horizon a 1 m depth with in situ Artemisia tridentata (B. Benz, personal communication) in a growth position. If this sagebrush is of similar age to that dated from other marsh profiles, the A horizon surface was an open ground surface prior to AD 1650-1750 (Table 1.5.2). This buried A horizon is a dark gray silt loam. The water table prevented further analysis below 1.3 m. An interesting structure of historic nature was also revealed in this profile. This structure is a wooden water flume, an ancillary feature of

Site 5MT5181, the Montezuma Valley Irrigation System. The stratigraphy exposed in this profile suggests that the surface of this structure, at 0.78 m below the modern ground surface was near the 1889 ground surface and has subsequently been buried. The aforementioned buried A horizon was utilized or excavated into, to provide a somewhat impermeable base for the structure (Figure 1.5.8). Historically this structure was constructed in a fan channel, with sand at the ground surface.

Profiles 2 through 5 represent a relatively stable and continuous profile illustrating soil development. An A horizon persists for the entire 300 m section and is characterized by a root zone composed of small Typha sp. and marsh grasses with an inorganic fraction composed of silty clay. The B horizon is a fine-grained silty clay with prismatic structure and minimal root fragments. In the lower B horizon the texture is clay loam, and the structure is subangular blocky with discontinuous clay skins apparent on the peds. The darker color of this lower B may indicate that it was an earlier A horizon. Lower in this unit, nodules of alkaline salt precipitates are apparent, but discontinuous. This lower unit is prismatic in structure and retains a clay loam texture. No buried macrofossils were located in this section of the trench; however, an earlier ground surface and a minimum of two separate soil development sequences appear to be present here. The A and upper B horizons may have been deposited and developed since historic times in colluvium derived from loess parent material. The buried soil profile may have developed in and prior to earlier historic times (AD 1650-1750) if this surface corresponds to the sagebrush date of Profile B. Rates of soil formation may have been accelerated by erosion and redeposition of well-developed

soils from the Sagehen Uplands, and by fluctuating levels of the water table in the marshland during historic times.

Profiles 6 through 9, including Profile A, again typify alluvial fan sediments (as described in Profile 1) stratigraphically overlying an older soil profile. A thick (20-25 cm) root mat of Typha sp. exists at the profile surface. Below this is a complex of loamy sands and organic rich silty clay loam deposits of 10-25 cm in thickness. Artemisia tridentata occurs in the various sand deposits in both horizontal and upright positions. Below the alluvial deposits is a dark gray clay deposit which has decomposed Artemisia tridentata remnants in the upper part and continuous clay skins on the peds. The clay is strongly subangular blocky and has abundant limonite stains throughout. This material may be very near the bedrock contact and appears to be residual Mancos Shale at a depth of 1.5 m below the modern marsh surface.

Profiles 10 and 11 illustrate deposits of an alluvial fan channel overlying what appears to be residual Mancos Shale. Sagebrush remains were common approximately 0.75 to 1 m below the modern ground surface.

The next two profiles, 12 and 13, represent sandy fan alluvium above a residual clay which has a number of well-rounded nonlocal pebbles (e.g., igneous and metamorphic origin) lying conformably on a well-scoured surface of Mancos Shale. The depth of this profile to bedrock contact is 2 m. Profile 13 has a channel deposit superimposed into the pebbly deposit above the residual Mancos Shale. Vegetal remains occur from 0.5 to 0.75 m below the modern marsh surface in this profile. The depth to bedrock in a number of the mapped profiles may indicate that the observed stratigraphy records only a relatively short span in the history of the Sagehen Basin.

The profile sequence of 14 through 18 records the largest alluvial fan channel deposit (aproximately 100 m) in the mapped trench. This profile essentially bisects the channel as it topographically proceeds from the North Sagehen dip slope. This section also contains Profile 14 (Figure 1.5.9) from which a sagebrush sample was taken for radiocarbon analysis. An organic soil sample from a Profile 15 stratum was also taken for radiocarbon dating (Table 1.5.2). The Artemisia tridentata was taken from 1.5 to 2 meters below the modern ground surface in a sandy loam deposit. The organic sediment samle was removed from a dark gray silty clay loam deposit (e.g., marsh sediment) directly under the stratum containing sagebrush. The extent of the channel deposits described may also include the deposits in profiles 12 and 13 previously described. Scirpus sp. is the dominant vegetation over this set of profiles. Topographically this channel deposit appears to form a sediment dam which contains alternating sand and organic rich loamy sediments. This deposit also appears to abut the t2 terrace mapped approximately 10 m south of the mapped trench (Surficial Geology Map, Figure 1.4.16). This fan deposit may have been an active damming agent instrumental in the formation of the Sagehen marsh at certain times in the past. Fan alluviation was active historically and deposited 1 m of sediment above the dated sagebrush growing at or near the 1889 ground surface 1.75 to 2 m below the modern ground surface. The organic sediment date also indicates that a marsh environment probably existed before the sagebush entered the marsh and during a time when Anasazi people were immigrating to the Project area. During this earlier period, fan alluviation may also have been actively damming the east edge of the marsh area.

Profiles 19 through 25 do not have marsh sediments; however, they do present an apparent transitional sequence from marsh and fan sediments to well-developed soils with underlying fan deposits (note Profiles 22 and 25 Figure 1.5.6). The dominant vegetation above these profiles consists of weedy species, rabbitbrush (Chrysothamnus sp.), and sagebrush (Artemisia sp.). The A and B soil horizons appear to be developed in loess parent material which has been emplaced in the basin after upland erosional processes transported this material to the lower basin. One charcoal lens is apparent in profiles 20 and 21 (Figure 1.5.6). No date was attempted from this unit as it is stratigraphically outside the modern marshland perimeter. The A horizon is characterized by sandy loam with abundant roots. In some instances this zone appears to have been plowed, based on the friability and massive crumb structure. Silty clay loam with weak subangular blocky structure characterizes the B horizon. An alkaline deposit of precipitates formed a white, abrupt contact on the soils as the water table lowered in the trench. This indicates the abundance of basic alkaline salts present in the B and C horizons. Below this horizon in the C horizon a sandy loam with occasional angular sandstone pebbles and cobbles occurs. No macrobotanical samples were located in these profiles.

The profiles constitute the raw data of this study. These descriptions were somewhat limited by the extent of the water table and the nature of the exposure. Topographic continuity of an otherwise cross-sectional view allows for establishing sources for the fan deposits as being in the north and south Sagehen uplands (Figure 1.5.4), specifically the Sagehen drainage area (Figure 1.5.10). This area contains 18.84 sq km dissected by 35.44 km of intermittent stream courses. This yields a

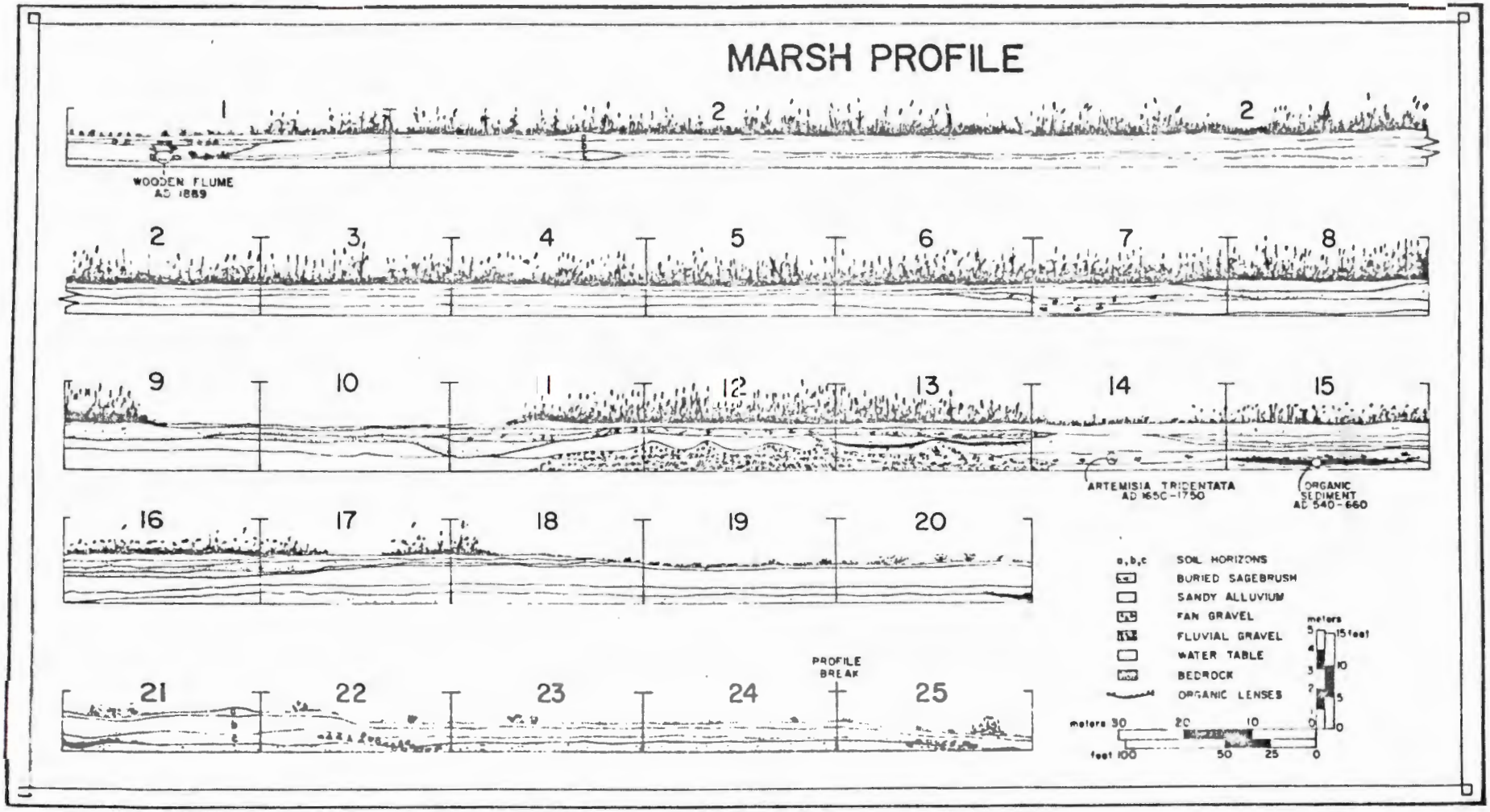

Figure 1.5.6. Stratigraphic profiles of the Sagehen Marsh Trench.

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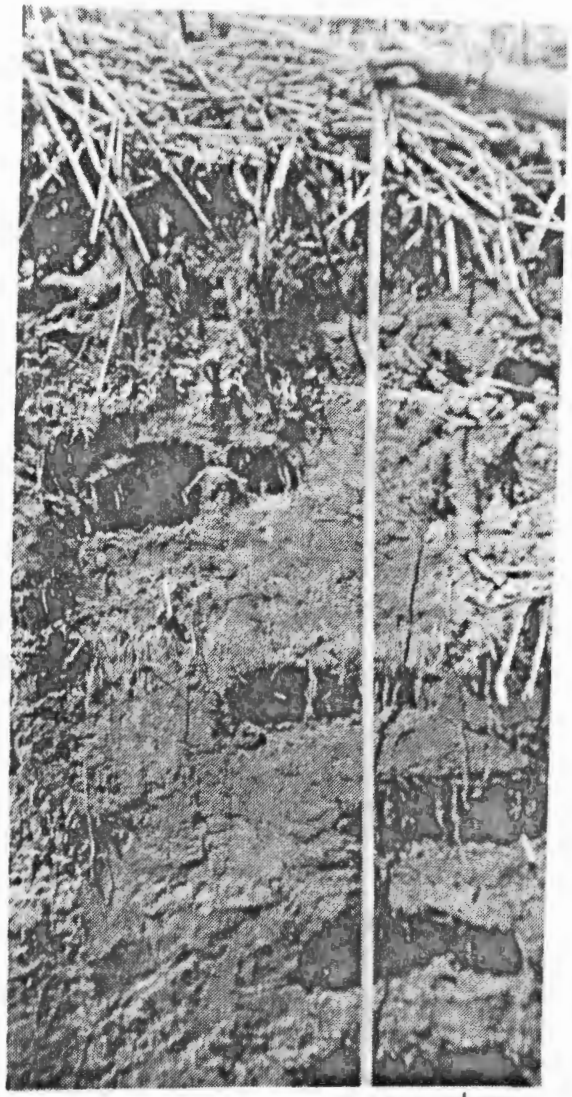

Figure 1.5.7. 101701

Profile A in the Sagehen Marsh showing sediment sample locations (Photo ~~101701~~). 105701

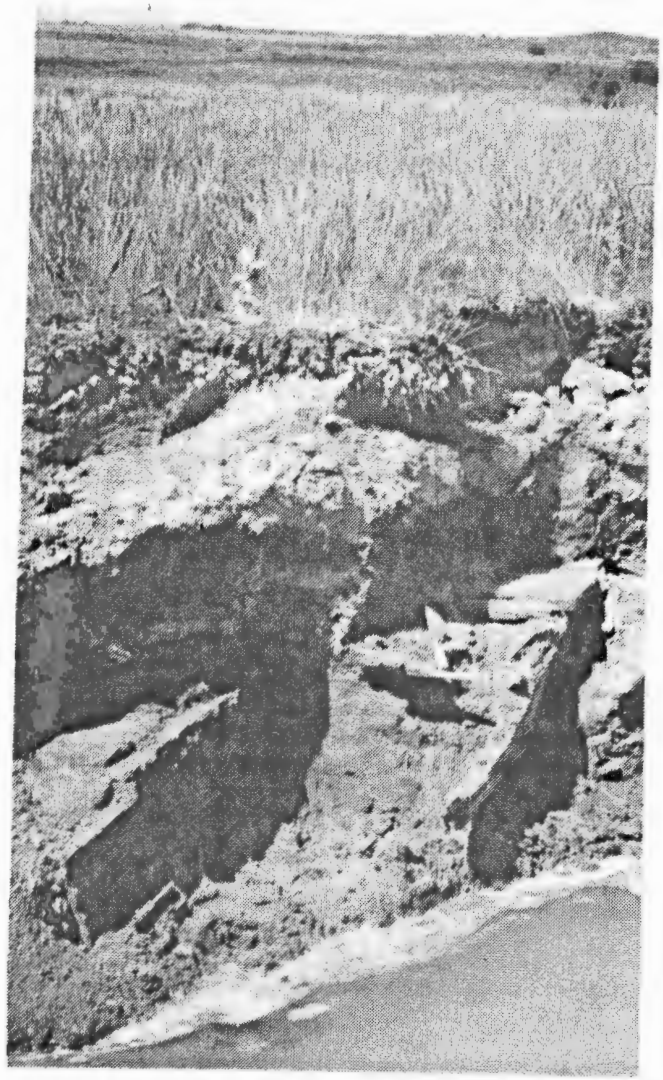

Figure 1.5.8. Historic water flume (Site 5MT5181) buried by fan alluvuum in Profile 1 (Photo ~~018193~~). 105701

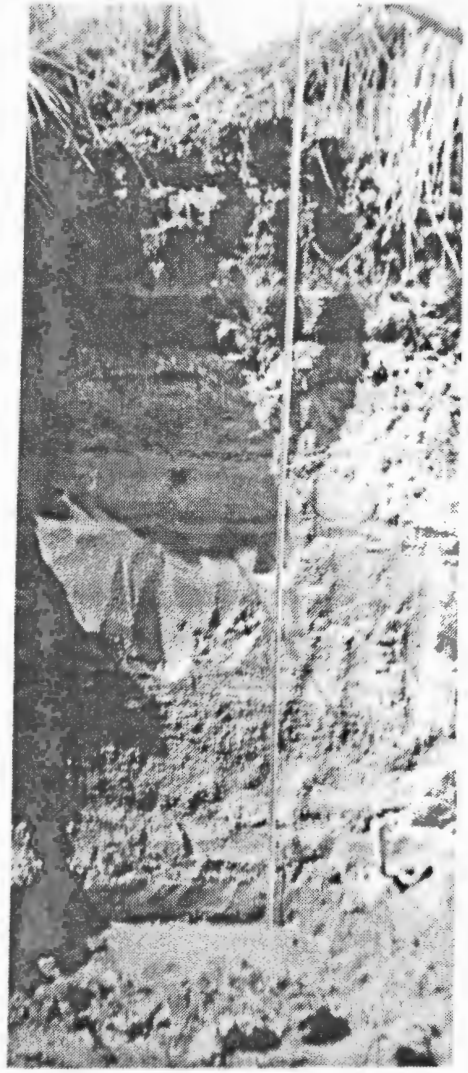

Figure 1.5.9. Profile 14 illustrating fan alluvuum and location of sagebrush used in radiocarbon dating near base of profile (Photo ~~101702~~). 105701

drainage density of 1.88 and represents a relatively mature drainage stage for this drainage area (Strahler [103]). Other drainage basin data appear in Table 1.5.1.

Table 1.5.1. Drainage Basin Data Summary.

Sagehen Marsh Drainage Area		18.84 sq km
Marsh Area Only		0.72 sq km
Total Stream Lengths		35.44 sq km
Overall Drainage Density		1.88
Stream order	Stream Length	Drainage Density
1	24.80 km	1.32
2	8.94 km	0.47
3	1.70 km	0.09

Dated material from the marsh appears in Table 1.5.2. Figures 1.5.8, 1.5.9, 1.5.10, and 1.5.11 illustrate the nature of dated material in the Sagehen marsh stratigraphy. The dated materials indicate two historic dates for vegetal material and one prehistoric date for organic rich seiment. The sagebrush dates reveal the dry nature of the marsh historically, and the sediment date indicates the wet nature of the marsh prehistorically. Combining the work done previously on the Sagehen Marsh with the present research a geological history for the area where the existing marsh lies is now reviewed. It should be recognized that this geological history is a model.

Table 1.5.2. Dates from Sagehen Marsh.

Material and Location	Laboratory	Date (AD)
Wooden Flume, Profile 1, 0.78 m.b.m.g.s.*	Historical Records	1889
Artemisia tridentata, Profile 14, 0.50-0.75 m.b.m.g.s.*	Beta Analytic (2937)	250 ±50: 1650-1750
Artemosia tridentata, Profile 14, 0.50-0.75 m.b.m.g.s.*	Dicarb Radioisotope	Not yet available
organic rich marsh sediment, Profile 11, 2.00 m.b.m.g.s.*	Beta Analytic (3058)	1350 ±60: 540-660

As with traditional stratigraphic superposition and uniformitarianistic theory in geology, this history will start at the base of the sedimentary units exposed in the Project area. A description of the sedimentary unit will be given first, followed by a processual discussion of erosion, transportation, and depostion.

Within the Mesozoic era (65-225 m.y. BP) and during the Jurassic period (190-136 m.y.BP) three formations were deposited in the D.A.P. Project area. The first was the Summerville Formation (30 m thick) consisting of red-brown and green siltstone, sandstone, and claystone (Shawe et al. [110]). This formation represents the preservation of an intertidal environment with abundant fine-grained (low energy transport) sediments.

Statigraphically above the Summerville is the Junction Creek Sandstone Formation (60-150 m thick) consisting of a weakly cemented white quartz sandstone. The large crossbeds observed in this formation indicate a terrestrial environment consisting of large dune fields.

The next Jurassic deposit to occur in the Project area is the Morrison Formation (76 to 91 m thick). This deposit consists of a lower red member (Salt Wash) and an upper green member (Brushy Basin) in the

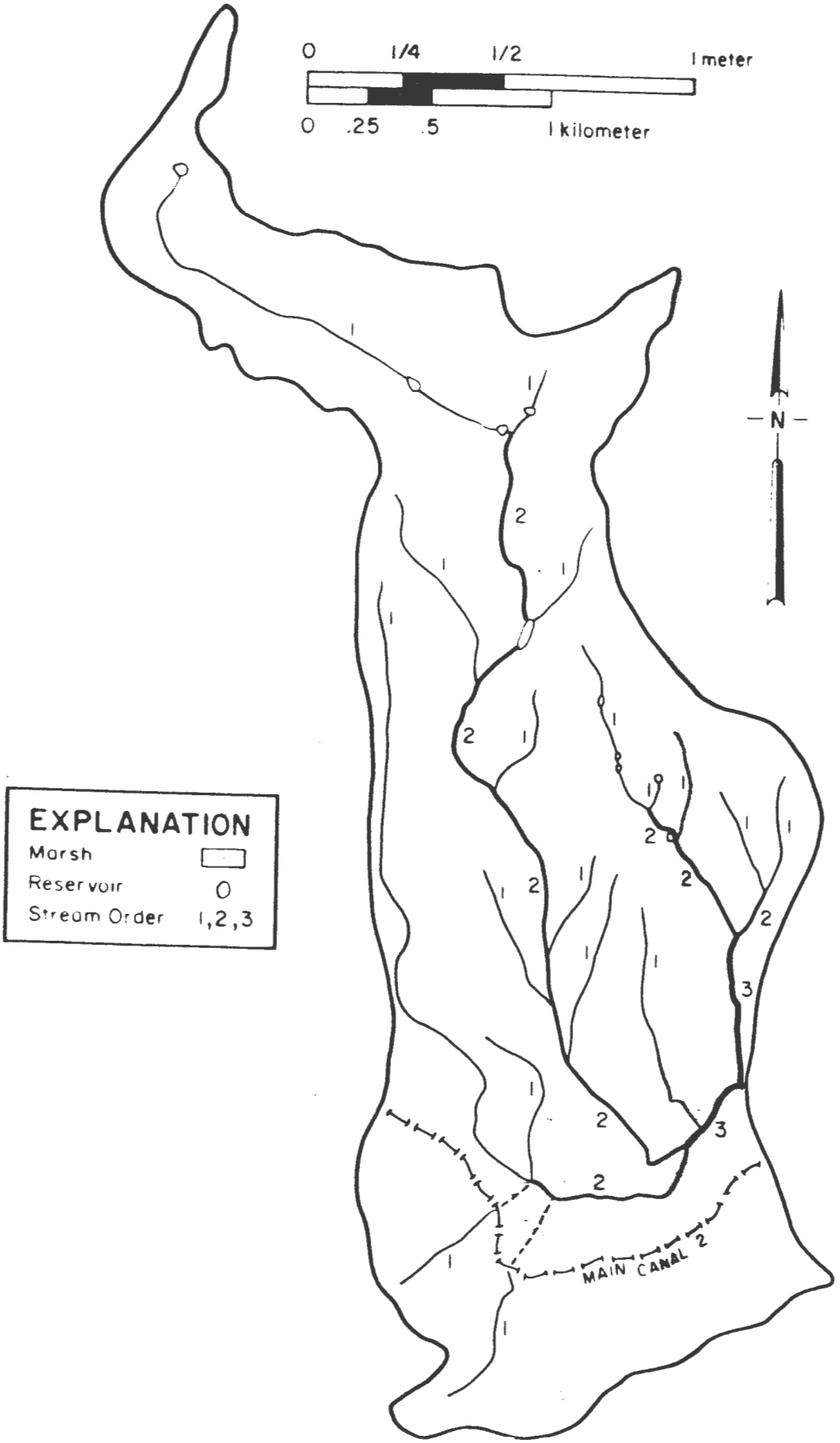

Figure 1.5.10. Drainage area of Sagehen Marsh.

D.A.P. area. The deposits are similar in diversity to the Summerville Formation but suggest a fluvial and flood plain environment of deposition. The three Jurassic formations of sedimentary rock measure approximately 210 m and represent a number of different depositional environments.

Cretaceous (136 to 65 BP) deposits that overlie the Jurassic sediments are the Burro Canyon, Dakota, and Mancos formations. The Burro Canyon (0 to 20 m thick) appears as a discontinuous white to gray sandstone, mudstone, chert, and conglomerate unit again representing fluviatile terrestrial environments (Shawe [110]). The Dakota Sandstone (38 to 61 m thick) is predominantly an orange to buff sandstone unit with minimal conglomeritic sandstone. A coaly shaly siltstone bed exists near the center of the unit. This deposit reflects alluvial beach, stream, and backwater swamp deposits in a near coastline environment of the ensuing Cretaceous Sea. The Mancos Shale (305 m thick) near Mancos, County is a thick deposit of siltstones and mudstone with some clay beds. This shale represents a shallow sea depositional environment. Sedimentary deposits lying above the Mancos Shale have not been preserved in the D.A.P. Project area. Instead of a continuous sequence, there is a major unconformity between Cretaceous and Quaternary sediments which removed approximately 63 million years of the depositional record.

After the sediments were deposited and much of the younger Cretaceous sediment was removed by erosion, major tectonic events took place. These events are schematically represented in Figure 1.5.12. The development of Sagehen Flats as a structural basin is at present a working model. Faulting to the extent shown on the figure has not been completely documented. However, excavations in the Great Cut area have exposed small 2 to 3 m displacements in clay beds within the Mancos Shale (D. Simrak,

personal communication). Phagan and Maloney ([3] research proposal) also believe there is more faulting than previously mapped. Faulting associated with the House Creek fault is believed to have occurred due to the presumed distributions of fault-related lithic resource material. The dating of the post-folding events or faulting episode, is a controversial issue. A Bureau of Reclamation memorandum [102] recognizes the similarities of gravels on the immediate north and south side of the fault, as do Holliday and Piety (Section 4d, this chapter). If the gravels are assumed to be Quaternary deposits related to outwash from glacial activity upstream, the faulting could be relatively young. Unfortunately the gravel relationships have not been examined in great enough detail to accurately address the age of faulting.

After the Sagehen Basin was developed through structural warping and faulting, a number of events may have occurred simultaneously. Drainage development probably continued with a readjustment to a topographically lower (downdropped) base level, then a new drainage pattern was developed (along the fault scarp). This new drainage configuration allowed material to be transported into the basin.

A shift to climatically influenced sedimentary deposits is hypothesized after structural formation, physiographic stability, and drainage establishment is made. In the D.A.P. case, either late Tertiary or early Quaternary times witnessed the completion of these events. After this climatically induced glacial onslaughts in the surrounding mountains are recognized as the Florida, Durango, and Wisconsin moraines and outwash (Atwood and Mather [111]). The Pinedale and Bull Lake glacial episodes were correlated with the Durango and Wisconsin glaciations by Richmond [112]) in the Animas River drainage to the east. The seven terraces

delineated by Holliday and Piety (Section 4d, this chapter) may correspond to outwash and continued uplift and downcutting of the Dolores River during these times. Four terraces have been recognized by Shawe et al. [110] in the Slick Rock District downstream from the D.A.P. areas. Two t_2 terraces exist near the outlet of Sagehen Marsh today (Figure 1.5.5). These may have been formed in Wisconsin times.

Another event that greatly affected the D.A.P. Project area and apparently occurred in pre-Wisconsin time was the deposition of red brown loess and simultaneous soil formation (Kottlowski, et al. [99]). This loess came in at least two waves (Arrhenius and Bonatti [95]) and soils were formed in both deposits. This loess is visible in profiles 2-5 and 17-25 in the marsh trench (Figure 1.5.6). This loess deposit is predicted to have blanketed the entire Sagehen basin and surrounding areas. Differential erosion, especially of the Mancos Shale, has obliterated any eolian evidence on this bedrock type; however, remnants of the loess deposit appear to preserve well above the Dakota Sandstone which forms the major upland ground surface in the area. Remnants of fan alluvium are sometimes trapped under this redeposited loess. From channel deposits appeared in Profiles 23 and 25 (Figure 1.5.6). It is herein hypothesized that the initial loess deposits were deeper than 2 m and subsequent erosion, transportation, and redeposition of these deposits has occurred. Evidence near Site 5MT4512 on Sagehen Flats has also documented fan channels below loess deposits on what presently is a ridgetop. This evidence may suggest reversed topography taking place during the Quaternary on the Sagehen Flats upland. Reversed topography results when previous ridges become drainages and previous drainages become ridges as the pattern of drainages on the landscape changes and cuts downward

through time. The dynamic nature of deposits resulting during the last two million years is complex. One factor which greatly influences these unconsolidated deposits is climate (Kottlowski et al. [99]). Climatic reconstructions by K. Petersen [9] in the La Platas and the organic sediment date from Profile 14 offer a reasonable framework from which to predict Sagehen marsh sedimentary reactions previous to and during Anasazi occupation.

The modern climate, as reviewed in Section 4c of this chapter, is characterized as a steppe climate with unpredictable precipitation over long periods of time. It is also considered semiarid with a rainfall deficit during all seasons. Although the Project area is generally characterized as being fairly dry, the marsh is presently wet.

K. Petersen's work revealed the following climate during and since Anasazi occupation:

> "The AD 800-1050 period was about as wet, but the AD 800-1000 period was cooler than the present century. The AD 1050-1100 period was as wet and the AD 1100-1200 period was as warm as the 1920's. By AD 1250 the climate of southwestern Colorado was too cold and dry to successfully grow corn and remained so until the recent change in the climate to warmer and wetter conditions during the past 100 years or so." ([9] abstract).

This concurs with other historical reports by Newberry [113] concerning the extent of a great sage plain as well as early precanal statements made by (Freeman [108]). As shown by the historic date of sagebrush (AD 1650-1750) which stratigraphically lies below fan alluvium and most organic marsh sediments, there apparently was a drier period previous to the modern marsh existence. Prior to this historic sagebrush date is the date an organic rich sediment (AD 540-660) which may indicate that a marsh did exist during this time frame. If the AD 800-1100 period was almost as wet as and cooler than present, it is possible, assuming the present

drainage situation is similar in the Sagehen Drainage Area that a marsh environment of similar nature (although probably less perenial and more seasonally astatic than the one existing today) may have existed then.

Summary

There is stratigraphiic evidence to support parts of this working hypothesis; however, an evaluation of the modern and historic deposits indicates that given a climate similar to today's and also realizing man's impact as an erosive agent (Strahler [103]), deposits of approximately 1 m of fan alluvium in the existing Sagehen Basin are possible. If these alluvial deposits act as a natural dam across the relatively impermeable Mancos Shale Formation it would again be possible to create a surface water table. This water table would then be subject to drying and wetting, or fluctuating levels depending on rates of evaporation. It is thus possible that the Anasazi may have had a marshland resource readily accessible to their sites. This area may also have provided an area of potentially arable land, if the alkaline nature of the deposits was less than those of today.

In summary, the Sagehen Basin development can be outlined as follows:

1. Deposition of Mesozoic and Cenozoic sedimentary units and induration (e.g., Summerville, Junction Creek, Morrision, Dakota, Mancos, Point Lookout formations).

2. Structural Deformation in the Tertiary (Laramide Orogeny) and erosion of several hundreds of meters of sedimentary deposits down into the lower Mancos over the Project area. Faulting and development of the Sagehen Structural Basin. Initial incising of the Dolores River with associated terrace development.
3. Continual uplift and incising of the Dolores River and tributaries, in the early Quaternary, and development of additional terraces. Glacial advance and retreat in the San Juans Mountains aid in sedimentary contributions to the Dolores River terraces. Conformable blanketing of the area by 2 cm or more of red loess and simultaneous soil development, in at least two separate episodes.
4. Differential erosion and redeposition of the loess on various bedrock types, dependent on climatic, runoff, and other hydrological conditions.
5. During Anasazi occupation it is possible that a marshland did exist as a seasonal astatic pool. An organic sediment date of 1350 $\pm$ 60 years supports this.
6. Historic dating of what seems to be a sagebrush shrubland developed on a buried soil horizon indicates a drier climate during the period AD 1650-1750. Since this time, rapid deposition of alluvial fan sediments has covered the marsh area alternating with wet marshland vegetation. This deposition appears to correspond to a wetter and warmer climatic situation ensuing in the last 100 years.

This study has attempted to assess the prehistoric resource possibilities for an existing resource. Using available climatic

reconstructions and dated stratigraphic events as modern analogs it seems reasonable to hypothesize the existance of a seasonal astatic pool for the Anasazi Period.

Alternative hypotheses must be considered as well when discussing Sagehen marsh existence. The underlying tectonic forces which typified the area during Tertiary and early Quaternary times may have rumbled at many times in the more recent past. Any faulting in the Sagehen Basin would change stream base levels and accelerate upland erosion and basin deposition. Thus the formation of a marsh at irregular times in the past is possible with a slight tectonic shift, necessitating absolutely no climatic influence.

The influence of modern man on Sagehen Flats through agricultural activities and deforestation has no doubt accelerated erosion processes and depositional rates and activities in the lowlands (Strahler [103]). These factors may be more influential upon the sedimentary environment than climate. Thus basing an Anasazi Period sedimentary reconstruction on modern stratigraphy and related climate may involve a faulty assumption, (i.e., climate has a stronger affect on sedimentary environments than does modern man).

Climatic data also has its drawbacks. Primarily, the climate of modern and historical times is not an exact analog of that represented during Anasazi occupation. Climatic and tree-ring curves have similar peaks and troughs; however the magnitude of these peaks and troughs fail to exactly duplicate each other.

Conclusions

Stratigraphy exposed within the Sagehen marshland reveals a complex depositional and erosional sequence. Alluvial fan deposits, reworked loess deposits, and residual bedrock deposits have filled the Sagehen basin since its structual formation. Sagebrush (Artemisia tridentata) and organic sediments, as well as historical structures, offered datable material within the profile. From these dates a resonable, but not continuous, history for the marsh was presented.

The existence of the Sagehen marshland as an available resource for Anasazi use was recognized with the organic sediment date of AD 540-660. From this time period, until the early historic date of AD 1650-1750 on sagebrush, a marshland environment may have existed periodically, but not to the extent (as revealed by strata thickness) as the early prehistoric marsh or the modern marsh. During the AD 1650-1750 period sagebrush existed throughout the entire modern marshland. In AD 1889, when the wooden flume was constructed for the Montezuma Valley Canal System, a marshland did not exist and Sagebrush still covered the modern marsh area.

Apparently the extent of the modern marsh started developing after the construction of the Montezuma Valley Canal System and also during a shift in climate to wetter conditions.

Addressing the previously described models for the formation of the Sagehen marshland, it does not appear that the marshland has existed in its present state in the prehistoric past. The marsh area has been covered by sagebrush during part of its history. The second and third models seem to provide better explanations. The Montezuma Valley Canal System probably as contributed water to the modern marshland since its

construction in 1889. Wetter climatic conditons, as outlined by Petersen [9], have also contributed to the modern marshland. Early prehistoric marshland environments probably resulted from wetter climatic conditions as outlined in Petersen [9]. Thus, a combination of cultural and natrual environmental changes may be responsible for the modern Sagehen marshland. The early prehistoric (AD 540-660) marshland was probably caused by wetter climatic conditions. During the interim, both prehistoric man and climate probably contributed to the erosional and depositional regime in the Sagehen Locality and facilitated a few limited marshland environments alternating with dry sagebrush communities.

SECTION 5b. A PROPOSAL FOR THE ANALYSIS OF SOIL MONOLITHS

by Vickie L. Clay [1]

Introduction

Impetus for the recognition of site formation and site disturbance processes has been recently emphasized by contemporary archaeologists (Schiffer, [114], and Wood and Johnson, [115]). The D.A.P. has also been concerned with these processes and has instigated the collection and mapping of stratigraphic profiles, and the inclusion in site reports of statements about site formation and disturbance. Schiffer's four types of cultural formation processes involve the transformation of materials in various contexts. The S-A (systemic-to-archaeological context), the A-S, (archaeological-to-systemic context), the A-A (within-systemic context transformations from state to state), and the S-S (within-systemic context transformations from state to state) all outline the various processes involved in producing the archaeological record. Stratigraphic studies of D.A.P. pitstructure fills specifically address the S-A and A-A transformations. Wood and Johnson [115] emphasize the importance of the relationships of cultural features to one another - and to the natural features of a site as being the basis for archaeology. Therefore, recognizing the need for studing archaeological context necessitates an understanding of the matrix in which remains are embedded and abandonment modes, as

[1]One segment of this Section (stratigraphy in Pitstructure Fills) was contributed by Richard H. Glaser.

outlined in Kane and Robinson [58] also provide a framework from which to evaluate certain stratigraphic sequences (e.g., soil monoliths). An understanding of how physical disturbance processes affect the archaeological record is also critical.

To this end the Dolores Archaeological Project's Earth Resource section of the E.S.G. has collected sediment samples in the form of bulk soil sediment and soil monoliths and provided stratigraphic assistance to excavating archaeologists since the 1979 excavation season began. A proposal follows which integrates the analysis of these geological samples, using this yet unanalyzed data base, with questions inherent to the D.A.P. Research Design. This proposal may also contribute to the modeling efforts being undertaken at present on the Project (Lipe [116]).

Thirty-four soil monoliths (vertical columns of 15 to 50 cm in crosssection), predominately from the center of pitstructure fills, and 685 associated strata bulk soil-sediment samples currently exist (Figure 1.2.4 Section 2, this chapter). The collection location of these samples provides a convenient data source for an intensive study of site formation processes. Processes addressed in this proposal include the nature of the pitstructure site prior to occupation; the prehistoric construction of the pitstructure, the use of the pitstructure; the abandonment of the structure and the filling of the pitstructure, with possible reuse as a midden or later constructed pitstructure, kiva, room, etc.; the effects of historic and modern man on the site surface; and the effects of the archaeologist while excavating. This study can potentially involve all questions outlined in Problem Domain 1, Economy and Adaptations (D.A.P. Research Design [1]). Addressing question 1 on resource availability an examination of the naturally sterile stratigraphy just outside the

pitstructure wall could be made for each of the 34 monolith samples. An in-depth historic, ethnographic, and archaeological literature review is proposed to evaluate cultural soil/sediment preferences for kiva and/or subsurface structure constructions in the Southwest and elsewhere. Assuming that the local soils were of a similar nature prehistorically especially below the plow zone, evaluation of the resources (e.g., soil, landform, surficial geology) at each site where a monolith was retrieved could enhance the temporal understanding of site location as it relates to pitstructure construction. Using mapped soils (Leonhardy [19]) to locate absolute abundances of soil types that were used for pitstructure construction, temporally distinct patterns of preference may also be detected.

In addressing question 2 of Problem Domain 1, it is apparent that prehistoric people selected ccertain soil types for prehistoric excavation. Other locally available abiotic pitstructure construction materials, including plaster, sand, and rock, are often present in pitstructure fills. An evaluation of how these resources were used ethnographically is also suggested. Quantity and source of abiotic construction materials could be evaluated from existing E.S.G. maps. A study to determine which of the available construction materials were not utilized could also be addressed through analysis of pitstructure sediments.

In question 3 of Problem Domain 1 an evaluation of how the resource was utilized could also be evaluated by considering the pitstructure location as a recycable resource (i.e., used for timber scavaging, windbreak, later excavation and occupation, midden, storage). The tasks involved in site formation could then be evaluated by looking at the

adaptive strategy of prehistoric man to his subsurface environment. What limitations did this subsurface environment pose to prehistoric man and how did he adapt to these perturbations (e.g., rodents, wall and roof collapse, flood, snowstorm, pestilence, fire)? Again, with the range of available monoliths and stratigraphic sections, it might be possible to evaluate temporal similarities and differences in pitstructure adaptive strategies.

In summary, a study of soil monoliths and associated bulk-soil-sediment samples coupled with an evaluation of the E.S.G. abiotic maps and additional field soil sampling outside excavated pitstructure walls will address all major topics in Problem Domain 1. Defining the location of a pitstructure as a resource and delineating the site formation processes that occur will describe one facet of the cultural interactive strategies with the natural abiotic environment, and provide contextual data that would enhance the description needed in all of the other problem domains. Already in existence are four models of pitstructure fill which emphasize various aspects sedimentary, environmental, and cultural relationships possible in the archaeological record.

Models of Pitstructure Fill

William Litzinger, the first E.S.G. coordinator, 1978-1979, removed a number of extremely large monoliths for environmental sampling from Site 5MT4475 (McPhee Village) during the 1978 field season. His goal was to conduct both biotic (e.g., pollen, macrofossil, and faunal) as well as abiotic (e.g., grain size, structure, and microstratigraphy) analysis on a single 0.5 by 0.5 by 2 m profile (W. Litzinger, personnal communication). An evaluation of postdepositional deposits, bioturbation, and climatic

reconstruction possibilities could thus be obtained from a sample of this size.

Leonhardy [19] envisions a recognizable relationship between sedimentary deposits and climatic conditions. He argues that pitstructure fills can be used as climatic indicators in the Project area for the duration of time after abandonment until the pitstructure was completely filled. Leonhardy predicts that a project-wide stratigraphic column could be developed which would reflect certain climatic events through evaluation of grain size and bedding changes in the profiles. Leonhardy assumes that climatic events would occur on a project-wide scale and would therefore, be visible in all fills from similar temporal units. Thus, with fine scale sedimentary analysis of pitstructure fills a local climatic reconstruction is predicted. Acknowledgement of culturally derived deposits and culturally enhanced natural deposits is seen as possibly causing some misinterpretation of sediments, if only the climatic model is used. Another problem which may limit this model is the lack of concern for the local physiography of the site, where most of the fill would originate. Although a number of difficulties are foreseen with this model, it is worthwhile to consider this model as well as the other models presented.

The next model model entails the conceptual organization of natural stratigraphic filling of pitstructures based on observing and collecting many of the unanalyzed geological samples that exist at present.

Stratigraphy in Pitstructure Fills[1]

Introduction

The focus of the geology section of the D.A.P. during the 1980 field season was to describe and to sample pitstructure fill; 20 pitstructures were described and sampled. Emphasis of this study was on natural stratigraphy.

A composite stratigraphic model has been synthesized from these pitstructures from profile drawings and profile field descriptions. This model should be regarded as a preliminary formulation until analyses of the stratigraphic monoliths, sediment samples, and pollen samples are complete.

Two theories concerning pitstructure fill were proposed by the geology section. Both theories deal with stratigraphic chronology and stratigraphic correlation and how they are reflected in the fill.

The hypothesis is that a stratigraphic column can be constructed by correlating the stratigraphy among pitstructures. This theory assumes that there is a series of temporally diagnostic events reflected in the fill of pitstructures. In order to correlate them, these events have to be broad enough to affect at least two or more pitstructures at one time. A series of events that can be correlated is needed to place pitstructure fills in chronological order. A stratigraphic column could then be constructed to include all major events represented in the pitstructure fills. Pitstructures could then be relatively dated by comparing their stratigraphy with the master stratigraphic column.

[1]This is the text of a report submitted to the D.A.P. by Richard H. Glaser in March 1981.

The second theory suggests that pitstructure fills are dependent on the local depositional environment and does not reflect Project-wide events. Consequently, stratigraphy could not be correlated temporally and a master stratigraphic column could not be constructed. Instead, a predictable sequence of strata will be visible representing a series of events common to filling a pitstructure.

In either theory, texture and geologic primary structure are the variables to be examined in order to determine depositional environment. Both texture and geologic structure are dependent on source areas, mode of transportation, and shape of depositional environment.

Based on an examination of a number of pitstructure fills during the 1980 field season, certain stratigraphic similarities among pitstructures are evident. This stratigraphic sequence seems to represent a series of common events resulting in pitstructure fill rather than a series of temporally diagnostic events. This projection supports the second theory proposed. It may be that a combination of ideas from both theories represents the actual processes that occur; both theories are still being explored. The validity of either theory, however, depends upon complete analysis of all bone samples collected; the results of this analysis are not available at this time.

Transportation Processes

There are four major processes that transport material into pitstructures: slumping, deposition of sediment by water, aeolian sediment deposition, and deposition of secondary refuse.

Slump is anything that has fallen into a pitstructure that was once part of the structure itself. This includes wall slump and roof fall. A strata resulting from slump should be mixed, reflecting the way it is

deposited; in the process of slumping, material is not sorted but deposited as a whole. Inclusions may be sandstone, pieces of wall and roof, beams, adobe, charred material (if the pitstructure burned), and chunks of surrounding soil.

Deposition of sediment by water occurs in numerous ways. One is by overbank flooding by the Dolores River. Such flooding results in very well-sorted, inclusion-free, homogenous deposits. Most sites in the Project area, however, are not affected by overbank flooding except for the few that are close enough to the river. Sediment can also be washed into a pitstructure during large rainstorms or spring runoff. Runoff from large rainstorms moves a minimum of sediment, does not last long, and is very sporadic. Runoff from spring melt probably accounts for more sediment being deposited than does runoff from rainstorms or flooding. Spring runoff lasts longer than rainstorms and affects more sites in the Project area than does overbank flooding.

Eolian sediment seems to contribute only a minimal amount of pitstructure fill. There is no evidence for substantial windblown deposits in the geologic record (i.e., pitstructure fill). A study of recent depostion in pitstructures excavated in previous years indicates that a minimal amount of wind-blown material has collected; subsequently, it can easily be disguised in the geological record or easily destroyed by events following its deposition. Wind-blown deposits tend to be silt to very fine sand and homogenous. If an eolian deposit is fairly thick (i.e., 10 cm) it is likely to affect more than one pitstructure.

Deliberate deposition of materials from later prehistoric occupations can also add material to the fill of pitstructures. Secondary refuse is refuse that has been taken by humans from one place and deliberately

deposited elsewhere (e.g., pitstructures). Secondary refuse does not include artifacts that have washed in from the surface of the site or materials that are in their original places (e.g., ash in a hearth). Most pitstructures have little or no trash fill at all. Only two pitstructures examined in the Project area, at Site 5MT4480 and Site 5MT2182, were almost completely filled with secondary trash. Some of the other pitstructures had small lenses or pockets of trash.

There is a bias in the discussion of transportation processes. An assumption is made that what is known about the present is the key to understanding the past. The processes discussed are based on modern observations. These processes probably occurred during Anasazi times, although there may be variation in the intensity of each process.

Source Areas

All pitstructures examined in 1980 were either on slopes or at the bases of slopes. These slopes provide source areas from which detritus is transported and subsequently deposited in pitstructures. Textures of fill will be dependent on the varied source areas in the Project.

The canyon walls, which consist of sandy colluvium and bedrock outcrops (mostly sandstone, siltstone, and shale), are detrital source areas for all the sites in the Dolores River Valley. Fill in these areas tends to be very sandy (e.g., Site 5MT4650, Site 5MT2151, and Site 5MT2161) and may contain fine to medium gravels (e.g., Site 5MT4671).

The Dolores River is not an important source for fill in pitstructures. Most sites are high enough above the river level that they would not be affected by flooding. The only exception is Site 5MT4671, Periman Hamlet. Stratum 6 in Pitstructure 2 at this site was pure silt to silt loam (80-90 percent silt), containing few to no inclusions and no

primary structures. This stratum was probably deposited by overbank flooding of the Dolores River, and it was the only stratum found in any pitstructure that represented a flood deposit.

The sites at the McPhee complex are all situated on the McPhee terrace, which is buried by a series of fans. The source area for this series of fans is the cliff and dip slope to the north and west of the terrace (Holiday and Piety [ ]). The fans, cliffs, and dip slope are detrital source areas for the fill in the pitstructures in the McPhee area. Because of the variety of sources involved in the McPhee area, texture varies from structure to structure.

Loess as a source of fill is evident in the House Creek Locality.

The t2 terrace in this locality is capped with river cobbles which are overlaid by loess. Site 5MT2215 is on the edge of the terrace and the loess provides the only source of detritus for fill at that site. This results in very silty to fine sandy loam textures. Loess also provides a source area for numerous other sites in the Project area (e.g., North Sagehen area).

Refuse is another source for fill. Pitstructure 1, at Site 5MT2182, and Pitstructure 5, at Site 5MT4480, were mostly filled with secondary trash. Although cases such as these are few in the Project area, they are generally detected readily in profile or during excavation.

Shape of the Depositional Environment

There are two factors to consider when discussing the shape of the depositional environment. One is the shape of the pitstructure and how it changes as it fills; the other is the position of a site in its physical environment.

The position of the site in its physical environment (e.g., on top of a hill, base of a slope, on a floodplain, on a fan) has an effect on the type of sediment available, amount of sediment available, and the potential energy for transportation of sediment. In general, more slope above a site indicates a potential for more sediment in greater variety and force being deposited than at sites on gentler slopes; less slope means less potential energy for transportation of sediment from a source area to a pitstructure. The higher the energy of transportation, the coarser the fill texture will be.

The shape of the pitstructure determines how it fills, and the fill in turn determines the depositional environment, i.e., how the sediment will be distributed. Therefore, the stratigraphy of the fill will reflect the changes in the depositional environment.

Average length and width of a pitstructure is 3-5 m and the average depth is 1 to 3 m. Most pitstructures have steep walls and are square in profile. The steep walls are unstable when not protected from weathering and have a tendency to slump. As the pitstructure fills with initial deposits (e.g., roof fall, wall slump). The walls become protected and will eventually become stable.

With few exceptions, most of the pitstructures studied by the geology section exhibited roof fall/wall slump at the base of pitstructure fill.

After slumping has stopped, a relatively deep, rounded basin is usually left. Over time, more deposit will collected forming a shallower basin. This shallow basin is very stable and provides an environment for sediment to deposit with a low amount of energy.

In general, the shape of the depositional environment changes from an initially steep, unstable, and high-energy environment to shallow, stable,

low-energy environment. Any initial wall slump/roof fall deposits will show up differently in profile from the later water and aeolian deposits, reflecting the conditions under which they were deposited.

Cumulative Stratigraphic Descriptions

The model for pitstructure fill stratigraphy in the Project area is based on observations during the 1980 field season by geology section personnel. This model is based on stratigraphic profiles and personal interpretation. Only when analyses of sediment samples and stratigraphic monoliths are complete can a more dependable model be constructed. Nevertheless, this model presents a common series of events that may account for post-abandonment pitstructure fill. The series is represented by four major stratigraphic units. These units, however, are not necessarily present in all pitstructures.

The strata in this model are numbered 1 through 4. Stratum 1 is the top stratum and therefore the youngest deposit; Stratum 4 is the bottom stratum, and therefore the oldest deposit. Cumulative descriptions were made for each stratum showing its typical or most common properties. Colors were given according to values on the Munsell Color Chart. Textures were assigned in the field.

Stratum 1

Stratum 1 is homogeneous in color, texture, and pedogenic structure. Its color is typically 10YR4/2, according to the Munsell Color Chart, due to its high organic content. Its texture ranges from silt loam to loamy sand and is dependent on variations in source area. The pedogenic structure of Stratum 1 is usually massive but may have a fine to medium, moderately developed platy or crumb structure in the upper 20 centimeters. The thickness of the stratum ranges from 20-60 cm in the center and thins

toward the edges where it usually coalesces with the A horizon of the soil surrounding the pitstructure.

Stratum 1 does not show any geologic structures such as bedding, graded bedding, cross bedding, etc. Inclusions, e.g., charcoal, artifacts, and sandstone are minimal. The stratum is usually set into a shallow basin that may extend past the walls of the pitstructure. The lower boundary ranges from abrupt (1 mm-1 cm) to diffuse (> 12.5 cm).

Stratum 2. Stratum 2 contains beds ranging from 2-10 cm thick, these beds show as alternating layers of light and dark material. This color differentiation is sometimes associated with alternating coarse and fine sediments, the lighter beds being coarse materials (gravels and sands) and the darker beds being finer materials (silts and clays). The lighter material is typically 7.5YR-10YR 4-5/4, 5/6, and the darker material is 10YR 3/2-3, 4/2, 4/4, 4/6. Texture varies with source and ranges from sand and silt loams to loam.

The boundaries between beds within Stratum 2 are sharp (1-2.5 cm) to gradual (7.5-12.5 cm). The boundary at the base of the stratum is very abrupt (< 1 mm) to clear (2.5-7.5 cm).

Stratum 2 is not consistent as is Stratum 1 above it, and it lacks the fine laminations of Stratum 3 below it. The basin in which Stratum 2 is set is shallow, but is deeper than that of Stratum 1.

Stratum 3. Stratum 3 averages 20-120 cm thick and is laminated with alternating layers of coarse and fine materials. This stratum is situated in a deep basin and therfore is thickest in the middle and thinner toward the edges of the pitstructure. It has a smooth and very abrupt boundary at its base where it contacts Stratum 4.

The laminations that distinguish this stratum are often graded, having the coarsest material at the bottom and the finer material toward the top. Each lamination represents one depositional event. The boundaries between graded beds are very abrupt due to new depositional events laying down coarse sediment on top of fine sediment. The laminations may be as thin as 1 mm and as thick as 2 cm. The grading is often subtle although they are usually visible upon close examination.

Texture and color vary according to the source area and the grading. The coarser material tends to be a lighter color than the finer material. The texture, in general, has a tendency to be clayey, but there is quite a bit of variation.

Pedogenic structure is usually moderate to strong, medium to coarse, and subangular to angular blocky. The structure is controlled by the horizontal bedding and may be due to expanding and contracting clays.

Stratum 4. Stratum 4 is a nonbedded stratum, usually mottled with bright orange chunks of soil (either native soil or adobe). It may include sandstone, charcoal, burned, or charred material associated with burned roof fall, wall slump, trash, and natural deposits. The matrix varies in color and texture but generally reflects the native soil surrounding the site. Thickness varies from 10-60 cm in the center of the pitstructure and thickens (up to 1.5 m) toward the walls. The variation in thickness of Stratum 4 forms a basin in which Stratum 3 sits. Some Stratum 4 material may tend to dip toward the center of the pitstructure although this tendency is not always indicative of bedding.

Stratum 4 is quite varied in structure and appears in different forms in different pitstructures. It is generally mixed and may contain many substrata of varying descriptions.

Model for Stratigraphic Fill in the D.A.P.

The stratigraphic model presented in this discussion is based on data collected in the Project area. There are no known references in the geologic literature to which this model may be compared and tested. Some analogies may be drawn from varving in glacial lakes or turbidity deposits in deep ocean basins. Both glacial and turbidity deposits are processes of a much larger scale than pitstructure sedimentation, although some concepts may be applicable.

Fill Deposition. Pitstructure fill deposition varies due to circumstances at the time of abandonment. If a pitstructure were abandoned due to fire, its roof might have collapsed immediately; depending upon the intensity of burning, the roof might have totally or only partially collapsed. If a pitstruc- ture were not abandoned due to fire, and the unburned roof beams removed by inhabitants of the area for re-use, the pitstructure then would have been partially or totally exposed to weathering. If its beams were left in place, a roof could have remained intact until weathering caused its partial or total collapse. Any krotoina or eolian sediment that might have been deposited before the roof collapsed is considered negligible for the purpose of this report; even though the weathering processes may have occurred over long periods of time, the roof will be considered to be the first thing to have been deposited in the pitstructure. Only when the roof has partially or totally collapsed can the walls be exposed to weathering processes or can sediment be transported into the pitstructure. Stratum 4 represents the initial roof collapse and the weathering that takes place afterwards.

Stratum 4 is mixed and may consist of roof beams, burned material, wall slump, and often large sandstone inclusions. Stratum 4 is generally

the result of slumping, a process in which material is not sorted as it is in alluvial and aeolian processes. Stratum 4 may be deposited relatively soon after abandonment or over a period of several years.

Slumping of the main structural features is the first step in the natural stabilization of a pitstructure and the readjustment of the pitstructure to the natural slope of the land. The vertical walls of a pitstructure are unstable when not protected from weathering by a roof and they tend to slump once exposed; however, a number of pitstructures in the Project area demonstrate little or no wall slump at all.

The boundary between Strata 3 and 4 is smooth and very abrupt. This is probably due to water collecting in open pitstructures during late winter and early spring.

Stratum 3 represents depositional events after initial slumping. The graded laminations characteristic of Stratum 3 are rhythmic deposits that represent a series of cylcic depositional events. The graded laminations are similar to varves that are deposited in glacial lakes where single graded varve is laid down each year. When material is washed into a lake from upstream during the warm season the heaviest material is deposited and the lighter material stays suspended. Not until the lake freezes and the water is no longer agitated will the fine material be allowed to settle out (E. Leonard, personal communication). When this happens the same type deposit is laid down over and over again. The laminations in Stratum 3 represent a similar depositional cycle, probably associated with standing water in a pitstructure. This cycle may be related to the freezing and thawing of snow. When snow melts and a pitstructure fills with water, sediment is deposited, with the heaviest settling out first. If a freeze occurs, the runoff stops and sediment is no longer trans-

ported. Any material suspended in the water in the pitstructure will settle out. A thaw allows snow to melt and new runoff transports more sediment to the pitstructures. This process repeats itself as the temperature rises and falls, depositing graded laminations over and over. The cycle's fluctuations vary in time and intensity; the longer the runoff period, the thicker the deposit and the less chance of it being graded. This process would produce a number of laminations per year.

Summer deluges may also contribute to Stratum 3 often water collects in pitstructures from large summer rainstorms. These rainstorms are short term and sporadic and would not create thick cycle deposits.

The graded laminations also are a result of the shape of the depositional environment as well as climatic factors. Stratum 3 is set in a deep basin that allows water to collect and allows settling sediment to grade. A basin of a different shape (e.g., shallower) would form a stratum with different characteristics.

Assuming this theory of cyclic deposition is correct, Stratum 3 may take very few years (< 20 years) to be deposited, depending on the amount of precipitation over a given amount of time and the amount of detritus available.

By the time Stratum 3 is deposited the original pitstructure depression has filled in quite a bit, resulting in a relatively shallow depression. Any wall is exposed during Stratum 3 time will generally be rounded and modified by erosion at the end of Stratum 3 time.

Stratum 2 is transitional and reflects modified characteristics of both Strata 1 and 3. It is bedded, as is Stratum 3, although the bedding is thicker and not graded. Stratum 2 has interbeds of highly organic and

nonorganic units. The organic units are very similar to those in Stratum 1.

The characteristics of Stratum 2 are probably a result of the change in depositional environment between Stratum 3 and Stratum 1, with neither environment being dominant. Stratum 2 is set in a shallow basin that often extends beyond the walls of the pitstructure. This basin is not deep enough for water to collect to a depth to let graded deposits develop.

Stratum 1 is deposited in the shallow basin formed by Stratum 2. Stratum 1 is massive and homogeneous in color, has no primary structures, and has is very highly organic content. It is quite different from the other 3 strata.

The depositional environment changes as a pitstructure fills with sediment. Stratum 3 is deposited in a deep basin with relatively steep walls, while Stratum 1 is deposited in a shallow basin with gentle slopes. The different depositional environments affect the formation of the particular strata. The gentle slopes of the basin in which Stratum 1 is set are also fairly stable, which may allow a high amount of organic matter to collect. The high organic content indicates slow sedimentation and probable low energy during transportation. Wind and soil creep deposit material slowly and may be the major processes in depositing Stratum 1 material, but probably are not as involved in deposition of Strata 2, 3, or 4. The high silt content found in Stratum 1 may also reflect these processes, although this texture may be due to the leaching of clays downward to lower strata. The shallow basin does not allow the formation of graded beds, possibly because it does not allow enough water to accumulate.

Conclusions

The model defined in this discussion of pitstructure fill is based on field data from the Project area. Among pitstructures, the fills will no doubt vary and some pitstructures may better fit the model than do

others. Differences in the physical characteristics of Stata 4, 3, 2, and 1 are reflective of changes in depositional environment. Shape varies from steep, deep, and unstable in Stratum 4 to shallow, gentle, and stable in Stratum 1; finally the surface realigns with the present ground surface. Modes of transportation vary from coarse slumping to deposition to standing water to eolian deposition and soil creep. Texture varies from pitstructure to pitstructure depending on source area for detritus and the mode and energy of transportation.

The two theories proposed in this paper have yet to be validated. The basic concepts of each theory, and how these are reflected in pitstructure fill, must be composed. As stated before, a complete composition can not be done without a complete analysis of collected geologic and botanical samples.

The first theory is based in major geologic events that would affect large portions of the Project area. The second theory is based on local environmental factors creating a fill sequence common to all pitstructures regardless of time period. Both theories are directly related to the slope of the depositional environment, to source areas for detritus, and to modes and energy of transportation.

After investigating approximately 20 pitstructure fill sequences in 1980 it appears that the fills are reflective of local factors and not of major geological events. Evidence for deposits by major geological events could not be obtained without comparable geometric data. A combination of

Figure 1.5.11. Buried sagebrush in Sagehen Marsh Trench (Photo 081907).

both theories may represent the actual processes filling in pitstructures in the Dolores Archaeological Project area. Until more data are generated a more complete picture can not be constructed.

The model for stratigraphy is pitstructure fill may be used as a basis for describing and interpreting Program-specific pitstructure fill, as well as a framework upon which to build a more complete model of pitstructure fill in general.

Evaluation of the Models

The Glaser model specifically defines four strata apparent in most D.A.P. pitstructures, again emphasizing the natural depositional sequence and the continually changing environment of deposition. This model is less dependent on climate and more concerned with local pitstructure catchment of colevium, snowmelt, and sheetwash than the Leonhardy Model. The four strata sequence is a recurrent visual phenomena which needs specific laboratory verification. The pilot study in this report sheds some light on this sequence.

An additional model concerning pit structure fill has been informally considered by R. Lightfoot (personal communication). In dealing with excavations in the Grass Mesa Locality, Lightfoot suggests that pitstructure fill is related in part to the different modes of abandonment (Kane and Robinson [58]). Lightfoot believes that an evaluation of a number of pitstructure fill sequences from structures with different abandonment modes, would illustrate differences in the fill. If there are significant differences with fill sequences from structures with different modes of abandonment, this fill stratigraphy or parts of it could be used to predict mode of abandonment without complete excavation of the

structure. Thus a predictive model could be generated if differences do exist in pitstructure fills with different abandonment modes.

Obviously, there are a number of working hypotheses on the D.A.P. which consider both natural and cultural factors that are involved in the formation of pitstructure fill sequences. A combination of these various models into one multidimensional model is considered necessary at this time. One model with a number of testable implications which supports a detailed sedimentological, chemical, and possibly biological analysis of the collected samples is outlined.

A minimum of five site formation processes were responsible for the sedimentary deposits inside and immediately outside of a pit structure. These are illustrated in Figure 1.5.13. They include: 1) pre-occupation abiotic processes of sediment deposition and soil formation; 2) prehistoric adaptive strategies involved in pitstructure location, construction, habitation, and abandonment; 3) fill processes of a cultural, natural, and combined origin; 4) pedological processes acting upon each new filling phase; and finally 5) recent human intervention processes of agriculture, grazing, pothunting, and, most recently, site excavation. These five site formation processes influence the nature of the archaeological matrix (e.g., monolith, Bulk Soil-sediment samples), although each process is concurrently influenced by a more theoretical level of determinants. These include for the pre-occupation processes the pedological determinants of climate, parent material, topography, time, and organisms; and the sedimentological determinant agent of transport, amount of energy, source and nature of transportable material; and topography. For prehistoric adaptive strategy and historic to modern land alteration processes, the ultimate influence is from culture and environment. Fill

process is again ultimately tied to the sedimentological factors of agent, energy, source, and slope configuration. Pedological process is essentially determined by climate, parent material, time, topography, and organisms.

Working within a framework such as that outlined in Figure 1.5.13, there are a number of testable hypotheses which relate to Problem Domain 1 in the project research design. An asssessment of pre-occupation abiotic process may be made by analysis of sediments just outside the pit structure wall. This stratigraphy was established prior to prehistoric construction of the pitstructure. A few questions which may be addressed here are:

1. What are the physical characteristics of the culturally sterile soil?
2. How deep is the unconsolidated sediment/soil deposit?
3. What was the topography of the prehistoric ground surface?
4. Is the parent material residuum or loess? Is it reworked or in situ? How old (relatively) is the deposit?
5. What are the chemical characteristics of the soil? Where are the carbonates, phosphate levels, calcium carbonate ($CaCO_3$), and alkalis in the profile?

The next factor discussed, that of prehistoric adaptive strategies, generates a number of questions for the analysis of internal and external sedimentary deposits.

1. Were there temporal differences in the preference of certain soil characteristics for pitstructure construction?
2. How hard was the soil to excavate, necessitating what types of tools, how large of a work force?

3. Were pitstructure all constructed during certain seasons, e.g., during wet springs to avoid hot dry summer and fall or frosty winters?
4. Where and how was the excavated material used or disposed of?
5. Were certain constructional features in pithouses (i.e., rock walls, plaster walls) a responsive strategy to erodability of surrounding soils, rodent disturbance, or structural stability if built in earlier fill?
6. What is the ethnographic literature dealing with subterranean excavation methods and living or adaptive habits?
7. What is the evidence for mode of abandonment as reflected in the stratigraphic record?
8. Is there any evidence for season of abandonment in the stratigraphy record?

The filling processes as already outlined by the models of Leonhardy, Glaser, and Lighfoot could address the following questions:

1. Do pitstructure fill sequences reflect climatic events, mode of abandonment, or immediate sedimentary depositional environments?
2. How do cultural activities, both prehistoric and historic, coupled with natural processes fill a pitstructure in the D.A.P. area? This question necessitates some local experimental work.

Pedological processes acting upon the fill sequence also pose a number of analytically testable questions. These include:

1. How distinct and to what degree have pedological processes acted upon the fill sequence?
2. What types of turbation have been active in the soil profile?

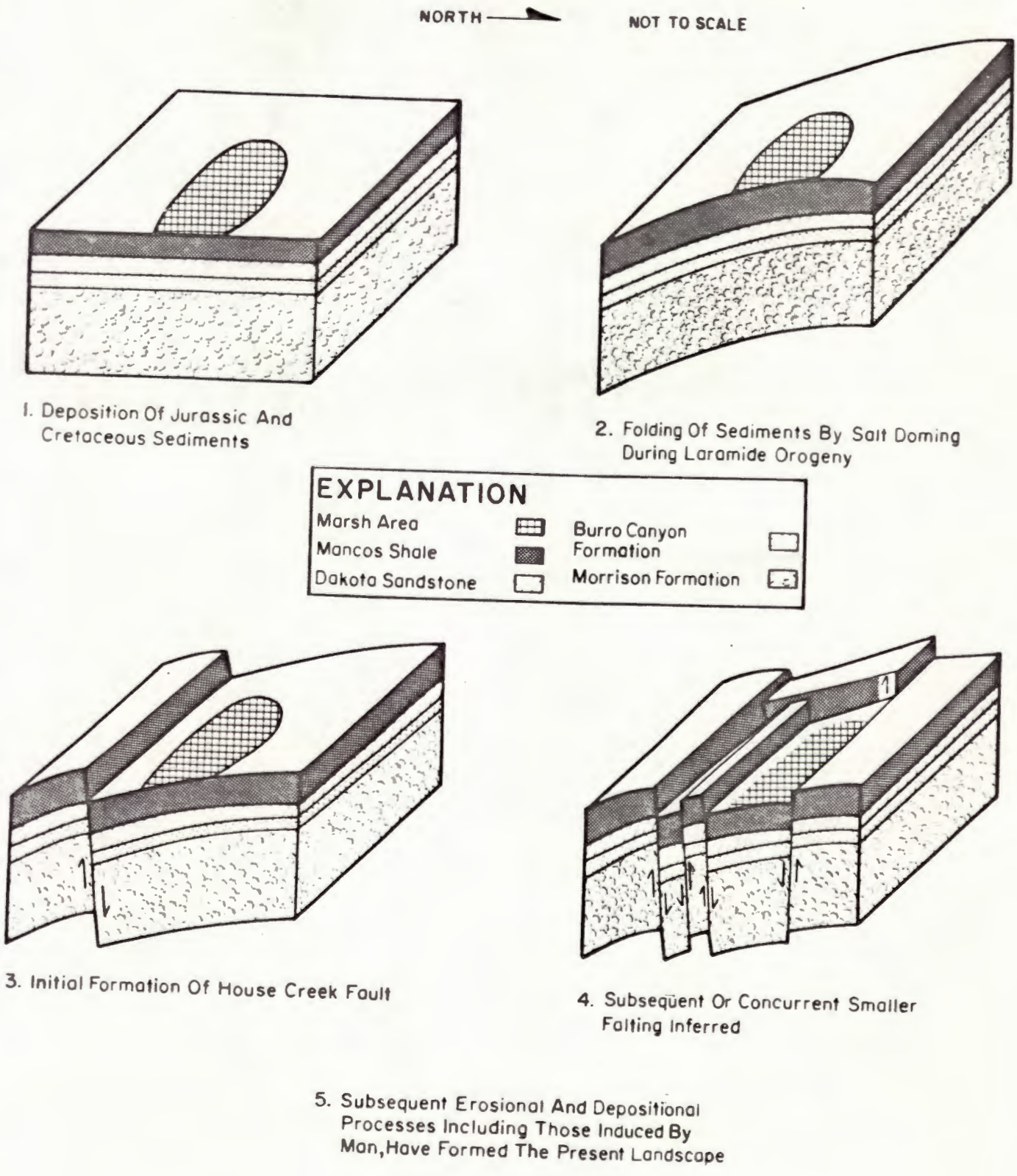

Figure 1.5.12. Block diagrams modeling the origin of the Sagehen Structural Basin.

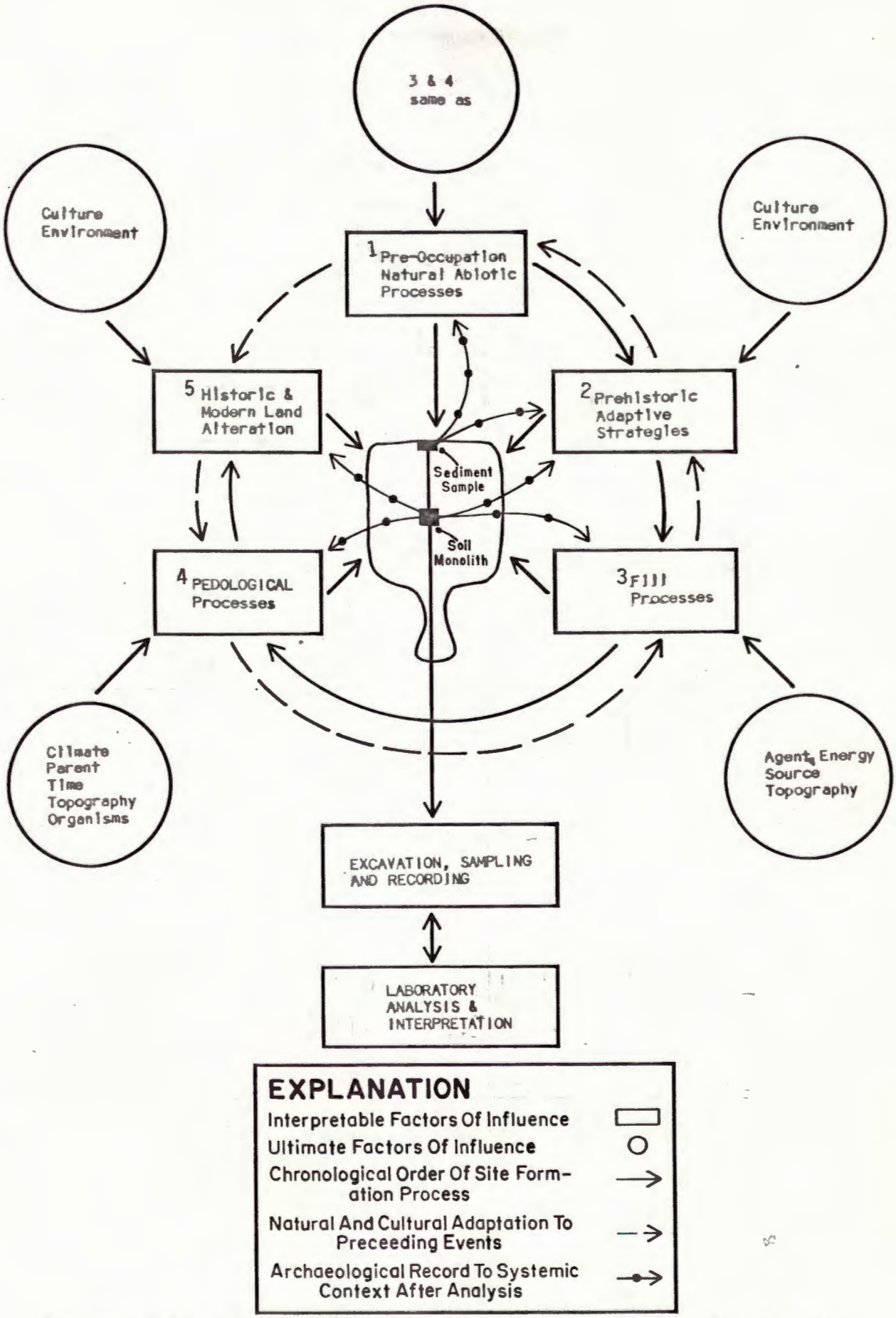

Figure 1.5.13. Factors influencing pitstructure fill and site formation processes.

3. What do turbation factors imply about the archaeological record?

4. What does the pedolological influence imply about site preservation (e.g., reducing soil conditions tend to preserve perishables, oxidation, and rodents reduce the potential for preservation)?

The last item in the fifth order of site formation processes as modeled here includes the historic to modern land alteration procedures that have influenced the soil profiles and samples collected. Questions that may be addressed when working on this factor include:

1. How deep do the affects of modern man go in agriculture fields and in grazing areas?

2. How do these effects alter the archaeological record?

In total the assessment of sediment samples from inside and outside a pitstructure may allow for the interpretation of a relatively complex system for site formation process. Most of the samples necessary for this study have already been collected and it would be productive to conduct the analysis of the samples and ascertain as much information as possible while the interest and analytical facilities are available. It is advised that the unused portion of the sample be returned to permanent storage to aid future archaeological researchers. Research questions as well as technique refinement will be forthcomming and therefore, materials should be curated for future studies.

To aid in the formation of the suggested model concerning factors influential in pitstructure fill processes as well as to test and refine techniques of geological analysis on soil samples, a pilot study was conducted. A review of this study is now presented to further

substantiate the immediate need for analysis of collected sediment samples.

Pilot Study

Introduction

This pilot study was designed to assess the present status of plaster-shrouded soil samples that had suffered during transportation, drying, and exposure since their initial excavation. In addition, a number of facilities and techniques of analysis were secured and utilized to determine best and most efficient methods, as well as time estimates for sediment analysis. Finally, an assessment of how much information pertaining to economy and adaptation could be extracted from a soil monolith and associated soil samples, was made by attempting to answer questions set forth in the composite site formation model presented earlier. New refinements on analytical techniques, and an experimental approach to developing a seasonally sensitive local modern analog from which to assess the climatic and topographic contributions to the sediment profile in a pitstructure, are then outlined.

Procedures

A monolith was chosen for preliminary analysis with the assistance of A. Kane, J. Kleidon, and M. Morris. A monolith from Site 5MT4479 Pitstructure 1 was chosen because it was excavated in the 1980 field season (Figure 1.5.14) and clearly exhibited a fill sequence similar to the one modeled by Glaser (Figure 1.5.15). The excavators had recognized and described a number of statigraphic units in Figure 1.5.16 that were seen in the continuous north-south trending profile through the pitstructure. The position of the monolith with the profile as well as the approximate depth

to the floor was well documented. This sample provided a well recorded, testable unit of stratigraphy that was also located within the McPhee Community where a number of other monoliths had been collected.

Analytical procedures that were undertaken on the soil monolith included:

1. Opening of monolith plaster casting with a hand saw
2. Scraping down one surface with knife to remove excess plaster casting material and provide a fresh working surface.
3. Physical description of the sample which includes depth of beds, laminations, color, texture, consistency, structure, bedding, amount of pore space, worm casts, and charcoal.
4. Chemical description of the monolith, at 5 cm arbitrary levels, including: 1) carbonate search with HCL; 2) rapid phosphate analysis (Eidt and Woods [117]); 3) estimate of soil organic matter by loss on ignition for one hour at 1000°C, comparing weight and color before and after. (Walkley [118])
5. Granulometric analysis (at 5 cm arbitrary levels) using the Earth Manual [119] analysis, emphasis on sand versus fines (silt and clay). Cummulative curves of the results were constructed.

Results and Interpretations

Results of these types of analyses appear in Figure 1.5.17 and Table 1.5.3. The table represents a detailed physical description of the opened monolith. The figure illustrates sample location, field strata identified, lab strata recognized, grain size analysis results, median grain size, relative phophate levels, and loss on ignition results.

A closer examination of Figure 1.5.17 allows for comparison of laborataory versus field perceptions of strata as well as a fitting of the

Table 1.5.3. Physical Description of Pilot Study Monolith 5MT4479, Pit Structure 1 (page 1 of 7).

Sample # & Arb. Depth	Natural Strata Depths	Descriptions
1 0-5 cm	0-2 cm	7.5YR3/2 dark brown, sandy loam, nonsticky and non plastic, platey, abrupt boundary.
	2-5 cm	7.5YR3/2 dark brown, sand, nonsticky and nonplastic, massive, friable moist, dry slightly hard, 5% sand stone pebbles (subangular).
2 5-10 cm	5-10 cm	10YR3/2 very dark gray brown, silt loam, slightly sticky and slightly plastic, massive, friable moist dry slightly hard, visible organics 1-5%, annelid trails approximately 5%.
3 10-15 cm	10-15 cm	10YR3/2.5 very dark gray brown, silt loam, slightly sticky and slightly plastic, massive, friable moist dry slightly hard, annelid trails 5% rootlet present
4 15-20 cm	15-20 cm	10YR3/2 very dark gray brown, silt loam, slightly sticky and slightly plastic, massive, friable moist dry slightly hard, 10-20% pore space from annelid and rootlet disturbance, one gray sherd at 30° angle from horizontal.
5 20-25 cm	20-25 cm	10YR3/2 very dark gray brown, silt loam, slightly sticky and slightly plastic, massive, friable moist and dry slighly hard, 10% pore space from annelid and rootlet disturbance.
6 25-30	25-30 cm	10YR3/2 very dark gray brown, silt loam, slightly sticky and slightly plastic, massive, friable moist and dry slightly hard, 10% pore space from annelid annelid and rootlet disturbance, 1-3% sandstone fragments to 2 cm diameter.
7 30-35 cm	30-35 cm	10YR3/2 very dark gray brown, silt loam, slightly sticky and slightly plastic, massive, friable moist and dry slightly hard, 10% pore space from annelid and rootlet disturbance, 1-3% sandstone fragments.
8 35-40 cm	35-40 cm	10YR3/2 very dark gray brown, silt lowam, slightly sticky and slightly plastic, massive, friable moist and dry slightly hard, 8-10% pore space from annelid and rootlet disturbance, abrubt boundary.
9 40-45 cm	40-45 cm	10YR3/2 very dark brown, sandy silt loam, slightly sticky and slightly plastic, massive, friable moist and dry slightly hard, 10% pore space from annelid and rootlet disturbance, 1% sandstone fragments to 1 cm in diameter, 3% charcoal fragments.

Table 1.5.3. Physical Description of Pilot Study Monolith 5MT4479, Pit Structure 1 (page 2 of 7).

Sample # & Arb. Depth	Natural Strata Depths	Descriptions
10 45-50 cm	45-47 cm	10YR3/2 very dark brown, silty loam, slightly sticky slightly plastic, massive, friable moist and dry slightly hard, 10% pore space from annelid disturbance, abrupt boundary.
11 50-55 cm	50-55 cm	10YR3/2 very dark gray brown,sandy silt loam slightly sticky and slightly plastic, massive with drying cracks prominent, moist slightly hard and dry hard, 10% pore space from annelid and rootlet disturbance, few sandstone fragments, abrupt boundary.
12 55-60 cm	55-57 cm	10YR2/1 black, silt loam, slightly sticky and slight plastic, massive, friable moist, dry slightly hard, few sandstone frags. 10% pore space from annelid and rootlet disturbance, abundant charcoal fragments abrupt boundary.
	58-60 cm	10YR3/2 very dark gray brown sandy silt loam, slightly sticky and slightly plastic, friable moist dry slightly hard, massive.
13 60-65 cm	60-63 cm	10YR3/2 very dark gray brown, silt loam, slightly sticky and slightly plastic, massive 5% pore space worm and rootlet distrubance, 3% charcoal flecks, few sandstone fragments, abrupt boundary.
	64-65 cm	10YR2/1 black, sandy silt loam, slightly sticky and slightly plastic, massive, moist slightly hard and dry hard, massive with drying cracks, abrupt boundary
14 65-70	65-70 cm	10YR3/2 very dark gray brown, silt loam, slightly sticky and slightly plastic, moist slightly hard and dry hard, massive 8% pore space from annelid and rootlet disturvance, 1-3% charcoal flecks.
15 70-75 cm	70-75 cm	10YR3/2 very dark gray brown, silt loam, slightly sticky and slightly plastic, moist slightly hard and dry hard, massive, 8% pore space from annelid and rootlet disturbance, 1-3% charcoal flecks, gradual boundary.
16 75-80 cm	75-76 cm	10YR3/2 very dark gray brown, silt loam, slightly sticky and slightly plastic, moist slightly hard and dry hard massive, 3% rootlets, abrupt boundary.
	77-80 cm	10YR2/1 black, silt loam, slightly sticky and slight plastic, moist slightly hard and dry hard, massive 5-10% charcoal flecks, 3-5% pore space from annelid and rootlet disturbance.

Table 1.5.3. Physical Description of Pilot Study Monolith 5MT4479, Pit Structure 1 (page 3 of 7).

Sample # & Arb. Depth	Natural Strata Depths	Descriptions
17 80-85 cm	80-81 cm	10YR2/1 black, silt loam, slightly sticky and slight plastic, moist slightly hard and dry hard massive, 5-10% charcoal flecks, 3-5% pore space, abrupt bndry
	82-85 cm	10YR3/2 very dark gray brown, silt loam slightly sticky and slightly plastic, moist slightly hard and dry hard, few sandstone fragments, 3-5 % pore space massive
18	85-89 cm	10YR3/2 very dark gray brown, silt loam, slightly sticky ans slightly plastic, moist slightly hard and dry hard, massive with drying cracks 3-5% pore space
	89-90 cm	10YR3/2 very dark gray brown sandy silt loam, slightly sticky and slightly plastic, moist slightly hard and dry hard, massive.
19 90-95 cm	90-92 cm	10YR2/1 black, silt loam, slightly sticky and slight plastic, moist slightly har and dry hard, massive 5% charcoal fleks, 3-5% pore space, abrupt boundary
	93-94 cm	10YR3/2 very dark gray brown, sandy silt loam, slight sticky and slightly plastic, moist slightly hard and dry hard, massive, 1% charcoal flecks, 3-5% pore space, abrupt boundary.
	94-95 cm	10YR2/1 black, silt loam, slightly sticky and slightly plastic, moist slightly hard, and dry hard, massive, 5-10% charcoal flecks to 3 mm in diameter, 3-5% pore space.
20 95-100cm	95-97 cm	10YR3/2 very dark gray brown, silt loam, slightly sticky and slightly plastic, moist slightly hard and dry hard, massive, 8% pore space from annelid and rootlet disturbance, 1-3% charcoal flecks, gradual boundary.
	98-100cm	10YR3/2 very dark gray brown, sandy silty loam sligh sticky and slightly plastic, moist slightly hard and dry hard massive, gradual boundary
21	100-102cm	10YR3/3 dark brown, sandy silt loam, slightly sticky slightly plastic, moist slightly hard, dry hard, massive, 3-5% oire soace frin riit and annelid dist abrupt boundary
	103-104cm	10YR3/2 very dark gray brown, clay loam, sticky and plastic, moist hard, and dry very hard, blocky strct 5% charcoal fragments, 3-5% pore space abrupt contact
	104-105cm	10YR3/3 dark brown, sandy silt loam, sticky and plastic, moist hard, and dry very hard, massive, 3-5% pore space, gradual boundary

Table 1.5.3. Physical Description of Pilot Study Monolith 5MT4479, Pit Structure 1 (page 4 of 7).

Sample # & Arb. Depth	Natural Strata Depths	Descriptions
22 105-110cm	105-109cm	10YR3/2 very dark gray brown, medium sandy silt loam sticky and plastic, moist hard and dry very hard, massive, 3-5% pore space from rootlet disturbance, no no worm disturbance below this bed, 3% charcoal flecks, abrupt boundary.
23 110-115cm	109-111cm	10YR3/3 dark brown, medium to coarse sandy silty loam, sticky and plastic, moist hard and dry very hard, massive, 5% pore space, abrupt boundary
	111-112cm	10YR3/2 very dark gray brown, fine sandy silt loam, sticky and plastic, moist hard and dry very hard, massive, 5% posr space 5% charcoal flecks abrupt bnd
	112-114cm	10YR3/4 dark yellowish brown, fine sand, nonsticky and nonplastic moist friable and dry slightly hard 0% pore space or charcoal flecks, abrupt boundary.
	114-115cm	10YR3/4 dark yellowish brown, fine sand, nonsticky and nonplastic, moist friable and dry slightly hard 0% pore space or charcoal flecks, abrupt boundary
24 115-120cm	115-116cm	10YR2/2 very dark brown, medium sandy silt loam, sticky and plastic, moist hard and dry very hard, massive, 3% pore space, 20% charcoal flecks abr. bnd
	116-118cm	10YR3/2 very dark gray brown, fine sandy silt loam, sticky and plastic, moist hard and dry very hard, massive, 3% pore space, 1-2% charcoal flecks gradual boundary
	118-120cm	10YR3/3 dark brown, coarse sand, slightly sticky slightly plastic, moist hard and dry very hard, massive, 3% pore space, 1-2% charcoal flecks, ab. bnd
25 120-125cm	120-122cm	10YR3/4 dark yellowish brown, coarse sand, nonsticky and nonplastic, moist friable, and dry slightly hard massive, 5% pore space, 1-2% charcoal flecks, abrupt boundary.
	122-124cm	10YR3/3 dark brown, fine sandy silt loam, slightly sticky and slightly plastic, moist friable, dry slightly hard, blocky, 5% pore space, 1-3% charcoal flecks, abrupt boundary.
	124-125cm	10YR3/2 very dary gray brown, medium sandy silt loam slightly sticky and slightly plastic, moist friable, dry slightly hard, massive, 3% pore space, 5% charco flecks, gradual boundary.
26 125-130	125-126cm	10YR3/2 very dark gray brown, motled, medium sand nonsticky and nonplastic, moist friable and dry slightly hard, massive, 3% pore space, 1% charcoal flecks, abrupt boundary.

Table 1.5.3. Physical Description of Pilot Study Monolith 5MT4479, Pit Structure 1 (page 5 of 7).

Sample # & Arb. Depth	Natural Strata Depths	Descriptions
26cont	125-128cm	10YR3/3 dark brown, mottled, fine sandy silt loam slightly sticky and slightly plastic, moist friable and dry slightly hard, no pore space, 5% charcoal flecks massive, abrupt boundary.
	128-129cm	10YR3/2 very dark gray brown, mottled, very fine sandy silt loam, slightly sticky and slightly plastic moist friable and dry slightly hard, massive, no pore space, 3% charcoal flecks, gradual boundary
	129-131cm	10YR3/2 very dark gray brown, very fine sandy silt loam, slightly sticky and slightly plastic, moist friable, and dry slightly hard, massive, no pore space, 2% charcoal flecks, abrupt boundary
27 130-135cm	131-132cm	10YR3/4 dark yellowish brown, med. sand, nonsticky and nonplastic moist friable and dry slightly hard no pore space or charcoal flecks, abrupt boundary.
	132-134cm	10YR2/1 black, fine sandy silt loam, slightly sticky and sl.plastic, moist friable and dry slightly hard massive, 5% pore space, 8-10% charcaol flecks, abrupt boundary.
	134-135cm	10YR3/2 very dark brown, fine sandy silt loam,slightl sticky sl. plastic, moist friable, dry slightly hard massive, 2% pore space, 3% charcoal flecks abr. bndy
28 135-140cm	135-138cm	10YR3/3 dark brown, medium sandy silt loam, slightly sticky sl. plastic, moist friable, dry slightly hard massive, 2% pore space, 2% charcoal flecks abr. bndy
	138-139cm	10YR3/2 very dark gray brown, very fine sandy loam slightly sand, and slightly plastic moist friable dry slightly hard, massive, no pore space, 3% charc. flecks, abrupt boundary.
	139-140cm	10YR3/3 dark brown, medium sandy silt loam, slightly sticky and slightly plastic, moist friable and dry slightly hard, massive, 1% charcoal flecks, abr. bnd
29 140-145cm	140-145cm	10YR3/3 dark brown, mottled, medium sandy clay loam sticky and plastic, moist slightly hard and dry very hard, blocky, 3-5% charcoal fragments, abrupt bndry
30 145-150cm	145-148cm	10YR3/4 dark yellowish brown, medium sandy silt loam slightly sticky and slightly plastic, moist friable, dry slightly hard, massive, 3% charcoal flecks, abrupt boundary.
	148-151cm	10YR3/3 dark brown, medium silty clay loam, sticky and plastic, moist slightl;y hard, and dry very hard massive, 2% charcoal flecks, abrupt boundary,graded bedding.

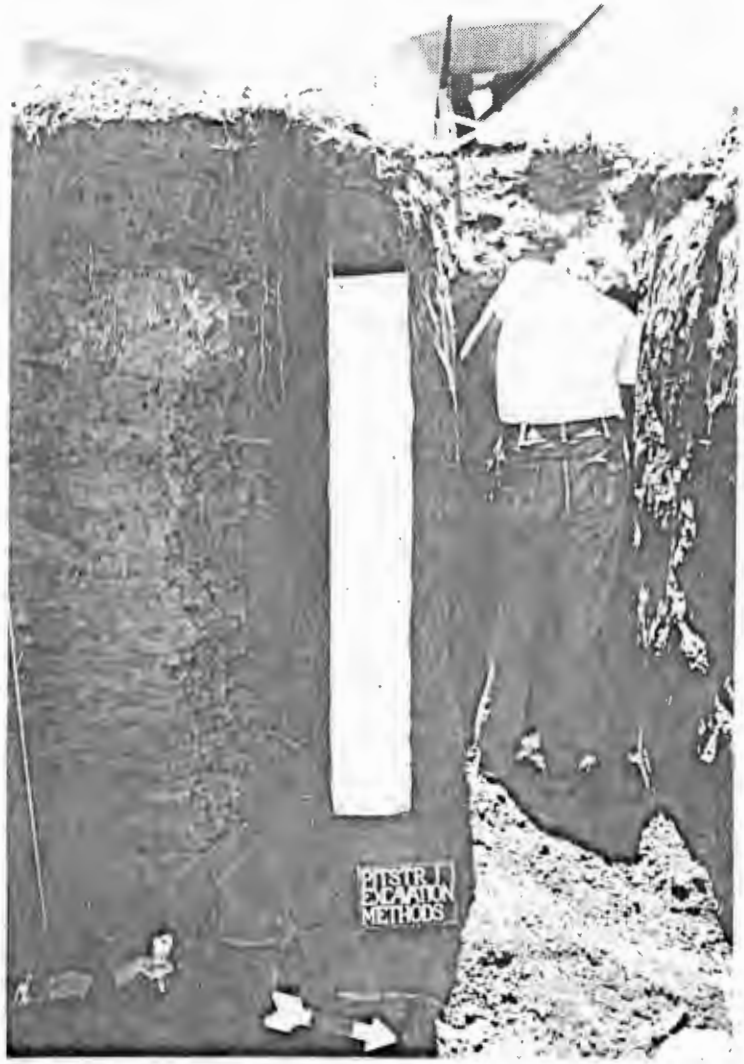

Figure 1.5.14. Monolith partially encased in casting material Site 5MT4479, Pitstructure 1.

Figure 1.5.15. Stratigraphy of Pitstructure 1, Site 5MT4479 and location of monolith within stratigraphic trench.

Table 1.5.3. Physical Description of Pilot Study Monolith 5MT4479, Pit Structure 1 (page 6 of 7).

Sample # & Arb. Depth	Natural Strata Depths	Descriptions
31 150-155cm	151-154cm	10YR3/3 dark brown, medium sandy silt loam, sticky plastic, moist slightly hard, and dry very hard, massive, 2% charcoal flecks, abrupt boundary.
	154-158cm	10YR2/2 very dark brown, coarse sandy silt loam, slightly sticky and slightly plastic, moist slightly hard and dry very hard, massive, 5% charcoal flecks abrupt boundary.
32 155-160cm	158-159cm	10YR3/3 dark brown, medium sandy silt loam, slightly sticky and slightly plastic, moist slightly hard and dry very hard, massive, 5% charcoal flecks, abrupt boundary.
	159-160cm	10YR3/2 very dark gray brown, clay loam, sticky and plastic, moist slightly hard, dry very hard, massive 5-10% charcoal flecks, abrupt boundary.
33 160-165cm	160-161cm	10YR3o4 dark yellowish brown, fine sandy silt loam, sticky and plastic, moist slightly hard and dry very hard, massive, 2% charcoal flecks, abrupt boundary.
	161-162cm	10YR3/2 very dark gray brown, clay loam, sticky and plastic, moist slightly hard and dry very hard, mass 5% charcoal flecks, abrupt boundary.
	162-165cm	10YR2/2 very dark brown, clay loam, sticky and plastic, moist slightly hard and dry very hard blocky5% charcoal flecks, abrupt boundary.
34 165-170cm	165-166cm	10YR3/3 dark brown, medium sandy silt loam, slightly sticky sl. plastic, moist slightly hard, dry very hard, massive, 3% charcoal flecks, abrupt boundary
	166-167cm	10YR4/3 brown, clay laom, sticky and plastic, moist slightly hard and dry very hard, massive, 5% charcoal flecks, abrupt boundary.
	167-168cm	10YR3/3 dark brown, medium sandy silt loam, slightly sticky ans slightly plastic, moist slighty hard, dry very hard, massive, 3% charcoal flecks, abt boundary
	168-171cm	10YRT3/3 dark brown, clay loam, sticky and plastic moist slightly hard and dry very hard, massive, 5%
35 170-175cm	171-173cm	10YR4/3 brown, medium sandy silt loam, slightly sticky and slightly plastic moist slightly hard, dry very hard, massive, 3% charcoal flecks, abrupt bndry
	173-174cm	10YR3/3 dark brown, clay laom, sticky and plastic, moist slightly hard and dry very hard,massive, 3% charcoal flecks, abrupt boundary.
36 175-180cm	174-180cm	10YR3/3 dark brown, clay loam, sticky and plastic moist slightly hard and dry very hard, massive, 5% charcoal flecks, abrupt boundary.

Table 1.5.3. Physical Description of Pilot Study Monolith 5MT4479, Pit Structure 1 (page 7 of 7).

Sample # & Arb. Depth	Natural Strata Depths	Descriptions
37 180-185cm	180-182cm	10YR3/3 dark brown, coarse sandy silt loam, sticky plastic, moist slightly hard, and dry very hard, massive, 5-10% charcoal flecks, abrupt boundary.
	182-183cm	10YR3/3 dark brown, fine silt loam, sticky and plastic, moist slightly hard and dry very hard, massive, 2% charcoal flecks, abrupt boundary.
	183-185cm	10YR4/3 brown, medium sandy silt loam, sticky and plastic, moist slightly hard, and dry very hard massive, 2% charcoal flecks.
38 185-190	185-189cm	10YR4/3 brown, medium sandy silt loam, sticky and plastic moist slightly hard, and dry very hard, massive, 2% charcoal flecks, gradual boundary
39 190-195cm	189-191cm	10YR4/3 brown medium sandy silt loam, sticky and plastic, moist slightly hard and dry very hard, mass 3-5% charcoal flecks.
	191-193cm	10YR3/3 dark brown, medium sandy silt loam, sticky and plastic, moist slightly hard, and dry very hard massive, 5-10% charcoal fragments, abrupt boundary
	193-195cm	10YR4/3 brown, coarse sandy silt loam, slightly sticky and slightly plastic, moist slightly hard dry very hard, massive, 2% charcoal fragments.

Note: all Munsell's moist; no carbonate reaction in entire monolith

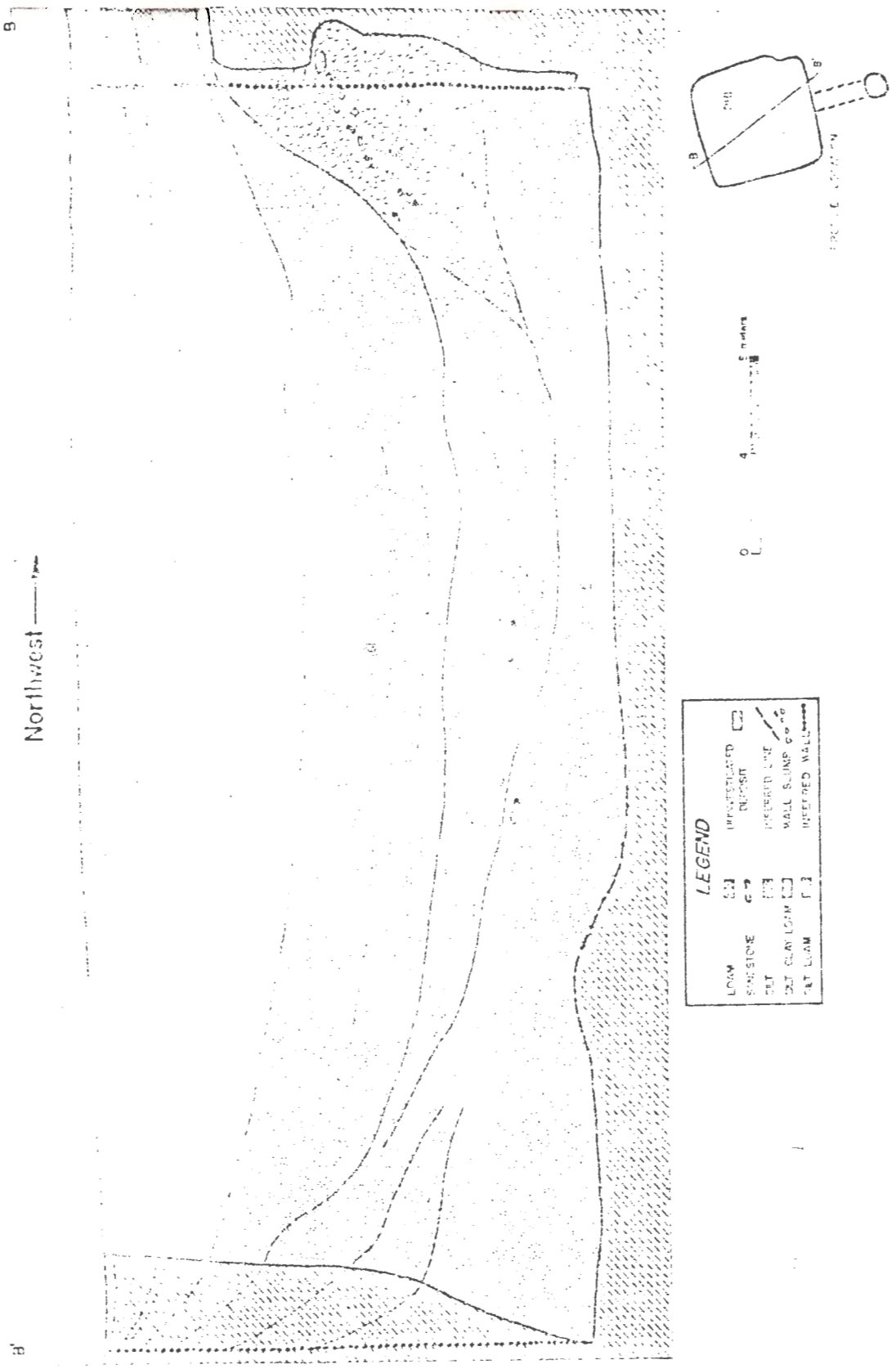

Figure 1.5.16. Stratigraphy of Pitstructure 1 (Site 5MT4479) as described by excavation crew.

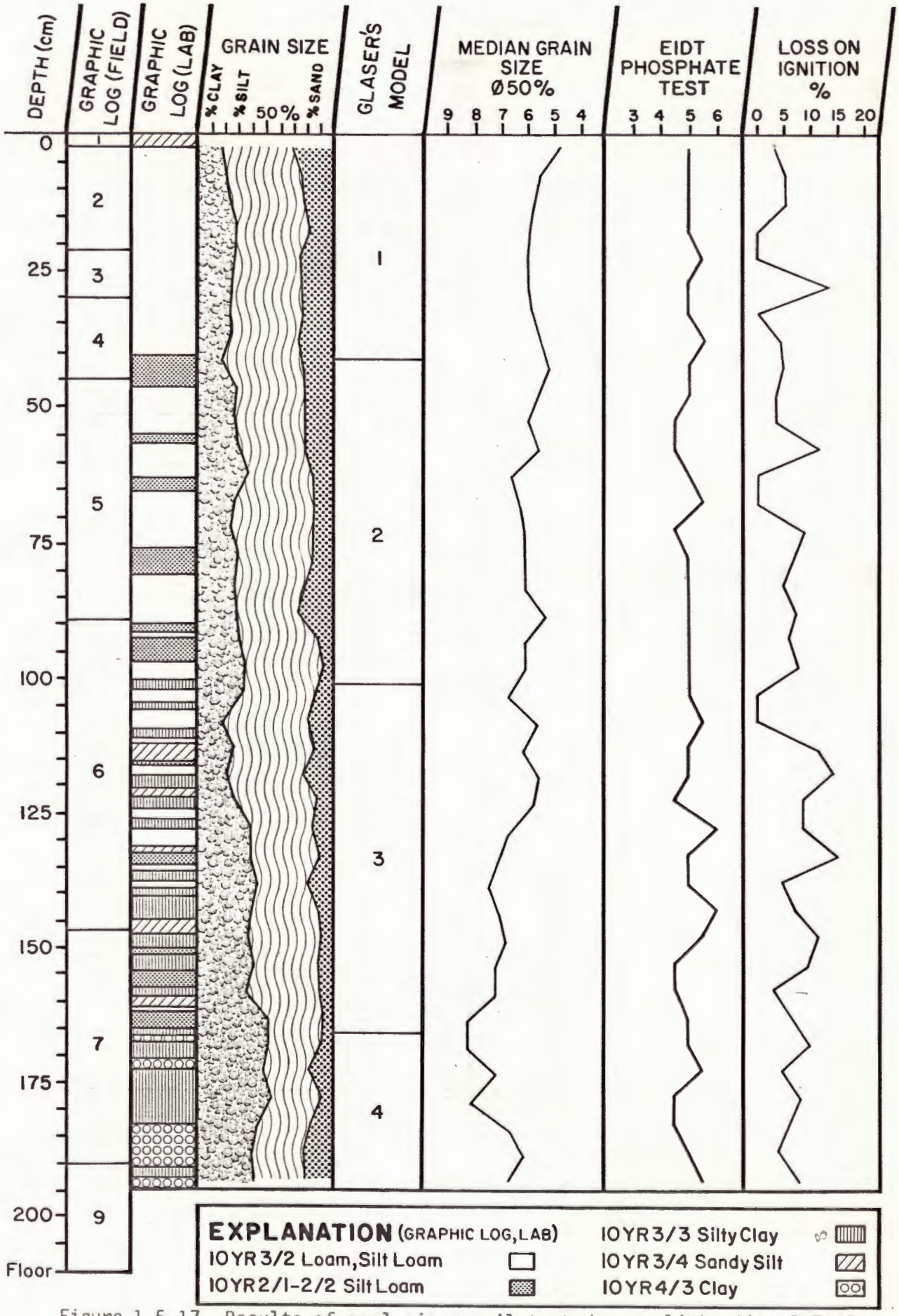

Figure 1.5.17. Results of analysis on pilot study monolith, Site 5MT4479, Pitstructure 1.

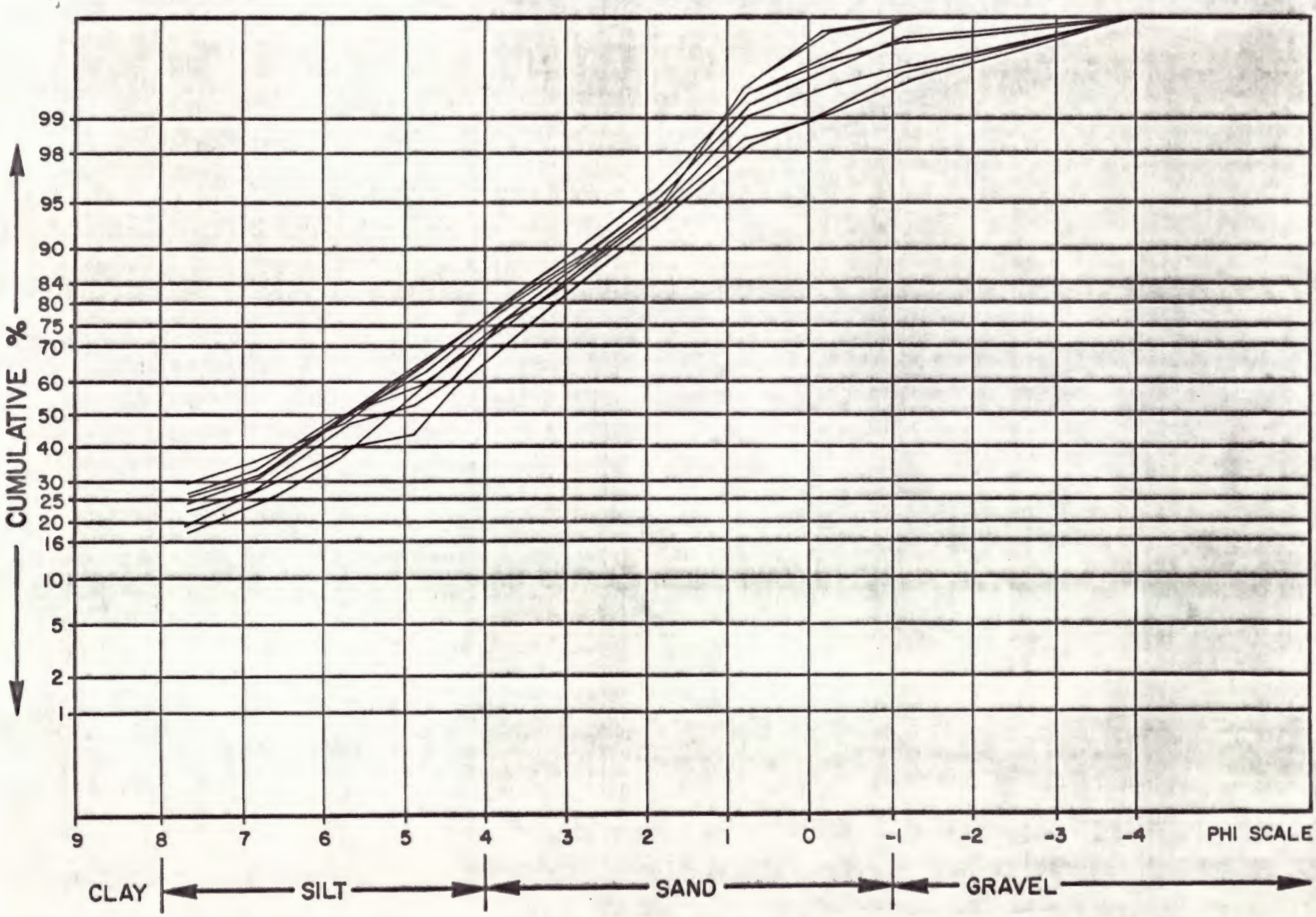

Figure 1.5.18. Cummalitive grain size curves for Samples 1-8 (Glaser's Stratum 1).

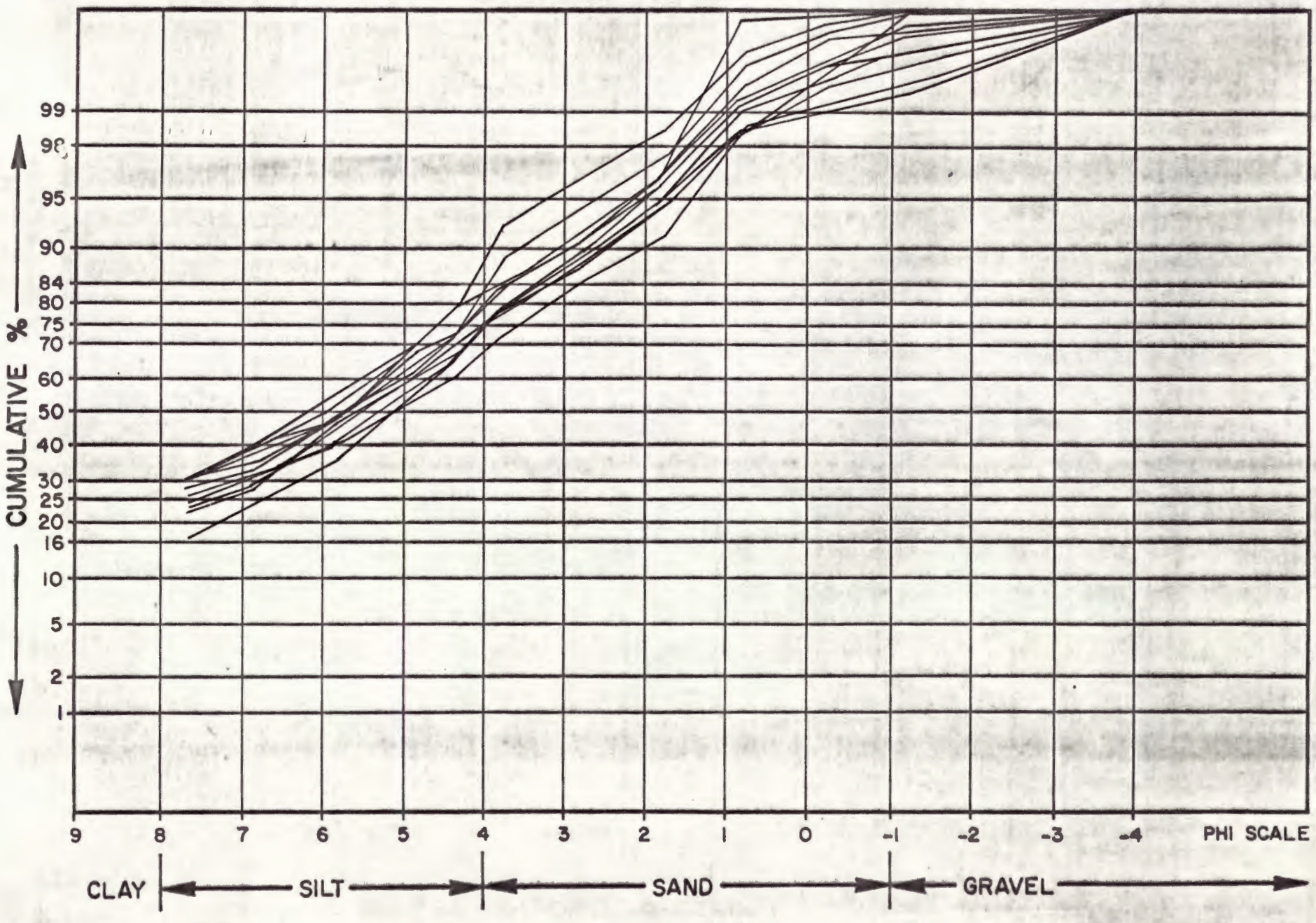

Figure 1.5.19. Cumulative grain size curves for Samples 9-20 (Glaser's Stratum 2).

Glaser model to the graphic log observed in the laboratory. Strata 1, 2, 3, and 4 as recognized in the field may reflect pedogenic structure differences, or they may represent lenses of fill material not represented in the monolith. In general the material from 0 to 40 cm below modern ground surface complies with Glaser's stratum 1. It is characterized in this monolith as having very dark gray brown color, somewhat homogeneous structure (except 0-5 cm platey, the rest massive), silt loam to loam texture, median grain size ranging from 5 to 6 in the medium silt range of Folk [120], an Eidt Spot test averaging 5 which is relatively high on the 1 to 6 scale, and 0 to 15 percent loss on ignition. The loss on ignition figures for the entire monolith are considered questionable due to the coarsness (0.1 g) of the scale used. This matter will be corrected by using the Great Cut Facilities of Bureau of Reclamation in future analysis.

If Glaser's Model is again used we can corelate his Stratum 2 with the excavation field crew's Stratum 5 and the results of this author's examination of similar beds between 40 and 100 cm below modern ground surface. Stratum 2 may then be characterized as a unit with alternating fairly thick (2-5 cm) beds of very dark gray brown and black material with essentially a silt loam texture, massive structure, a median grain size from 5.5 to 6.5 in the medium to fine silt range, an Eidt spot test for phosphates is still relatively high ranging from 4.5 to 5.5, and the loss on ignition data is still erratic. In general this stratum has alternatiang bed colors and is composed more of silt loam than loam as in Stratum 1.

Continuing with the Glaser Model Stratum 3 can be seen to roughly correspond with field recognized Stratum 6 and part of Stratum 7 as well

as the multiple laminations recorded by laboratory observation between 100 cm and 165 cm. The laminations range from 0.5 cm to 4 cm in thickness and appear to be discontinuous. The predominant lamination colors are very dark gray brown, dark brown, and dark yellowish brown. The amount of clay sized particles increase in this stratum and the amount of any size particles decrease thus forming a silty clay to clay textural designation (Soil Survey Staff [96]). The median grain size of this stratum ranges from 5 to 8 phi, or medium through very fine silt. The relative phosphate test ranges from 4.5 to 6 in this stratum and tends to fluctuate a lot, as does the loss on ignition graph; both graphs tend to represent slightly higher occurrences of phosphate and estimatable organic matter than those occurring in earlier strata. This is probably due in part to the finer grained nature of the matrix material.

The last Glaser stratum which may be utilized with this data base is 4. Corresponding well with the lower 7 and 9 strata designations from the field record and also with the lower beds observed in the laboratory, this stratum may well represent structural collapse. Beds, of 8-10 cm thickness occur in alternating colors of brown and dark brown. Increases in sand as well as clay occur with a slight decrease in silt size particles to form a clay texture (Soil Survey Staff [96]). Median or average grain size is 6 to 8 phi again in the medium to very fine silt designations of Folk [120]. Relative phosphate testing indicates an increase from 5 to 6 from top to bottom of this stratum and loss on ignition is from 5 to 10 percent.

A more detailed array of cumulative grain size curves is presented in Figures 1.5.18-1.5.21 with a phi scale and Folk's [120] designation of sand, silt, and clay size parameters appearing on the lower scale. Each

of the cumulative curves represent the range of variation reflected within the Glaser Model's four statigraphic designations. As a result of 60 minute maximum hydrometer readings, the cumulative curves are not susceptable to statistical parameter descriptions as outlined in Folk [120], except to discribe median grain size. In future analysis hydrometer tests will be taken for a longer interval to allow further statistical evaluation of mean, sorting, skewness, and kurtosis parameters.

A comparison of the numerous curves from each of the four modeled strata, aludes to the similarities and differences within individual samples. Stratum 1 sample curves appear to be the most homogeneous while strata 2, 3, and 4 have sample curves that tend to have the same internal shape, but seem to have a great variation in cumulative percents of certain grain size classes. Thus, wide spreads of similarly shaped curves are observed. Figure 1.5.20 (stratum 3) exhibits the widest spread at the silt clay boundary indicating a wide range in silt and clay size particles in each sample. If this is compared to the Figure 1.5.17 graphic laboratory log and grain size log the variability of the multiple laminations is evident.

More than cursory examination of the cumulative curves for similarities and patterns is not possible at this time. Longer hydrometer runs, experimental curves from a number of control samples in the culturally sterile soil around the pitstructure, and an experimental understanding of how, with what material and rate open pitstructures fill would enable greater interpretative value to be gained from these samples. Conducting statistical tests on the various sample results and attempting

to find clusters may offer a way to further test the suitability of the Glaser Model.

Using the amassed data just presented to explain Leonhardy's climatic change hypothesis is tenuous at best with the present lack of knowledge about how pitstructures fill under different climatic or weather conditions. An experimental approach is again seen as a necessity and will be given further consideration momentarily with a design to obtain this information.

The mode of abandonment ideas held by Lightfoot cannot be further studied without analysis of numerous pit structure fills from different abandonment modes. Pitstructure 1 at Site 5MT4479 was assigned a leisurely mode of abandonment (M. Morris, personal communication) with two of the main supports possibly being removed for reuse. It seems fair to hypothesize that the lower stratigraphic units would be the most affected by different abandonment modes. Again statistical comparisons need to be made to determine the nature and significance of relationships.

With the present pilot study information, addressing the questions set forth in the composite site formation process/pitstructure fill model is now attempted. No assessment of pre-occuptaion abiotic process can be accurately made since no samples have been taken from the culturally sterile soil. However, the site is situated on the McPhee terrace with underlying alluvial fan sediments (Section 4d, this chapter) and on the Hesperus loam as mapped by Leonhardy [19]. Characteristics of this soil series include fine-loamy textures developed on alluvial fans, valleys, and valley filling sideslopes. Typical horizons include A_1 a dark gray loam, B_1 dark gray heavy loam, B21t dark brown light clay loam, B22t grayish brown light clay loam, B_3 brown light clay loam, and C brown

loam (Leonhardy [19] after S.C.S. descriptions). This natural profile contains some similarities with the pitstructure fill and the Hesperus loam may have been the parent material for much of the fill sequence. Its well drained loamy character and friability may have facilitated pitstructure construction at this site as well as elsewhere in the McPhee Community.

The nature of the original prehistoric Hesperus loam may have afforded friable soils which drained well and were economically feasible for construction. Prehistoric adaptive stratiegies then may be addressed based on the attributes of the natural soil profile. No attempt was made to ascertain if reactive architectural features existed within the pitstructure to essentially prevent friable soils from entering the subterranean room. Evidence for prehistoric adaptive strategy within the soil monolith was limited. However, in stratum 4 there were large charcoal fragments of conifers which may have been part of the roof fall. The nature of roof fall may also yield information about roof construction and man/environment adaptation. The absence of roof fall would allude to abandonment mode, and the preservation of the roof may be related to the preservation within the room as well as artifact contextual disassociation if roofs are partially scavenged versus left alone to natural degradation processes.

The nature of the filling process at Site 5MT4479 tended to fit the Glaser model. Four strata could be delineated based on subtle differences in color, bed and lamination thickness, and texture. More testing using statistics would be useful to determine if the differences are significant.

Pedological processes were acting on the monolith profile but not to a great degree. The soil structure in Table 1.5.3 changes from platey (top 5 cm) to massive (strata 1 and 2) to alternating massive and blocky (strata 3 and 4) depending on texture. Worm casts and root disturbance was evident in strata 1 and 2. Carbonates were not present anywhere in the monolith. It does not appear that ongoing soil forming processes extend below stratum 2.

No affects of historic or modern man were noted by the excavation crew (J. Kleidon, personal communication). Grazing as well as other surface land-altering activities have probably occurred in the area. The nature of stratum 1 may be partially the result of man-altering activities giving rise to a high sand component in the upper samples.

From this attempt to address questions raised by the composite model of site formation, the magnitude of answerable questions is realized. Although many questions remain unanswered, the range of inquiry is sufficiently broad to make a proposal of this nature essential to environmental archaeological endeavors at the D.A.P.

Future Monolith Studies

Suggestions for additional monolith and bulk soil-sediment sample analyses are now presented. A logical sequential investigation of monoliths and sediments from all sites with such samples in the McPhee Community is proposed first, followed by a similar intensive study and report on samples from the Grass Mesa Locality. Lastly all other samples from isolated site areas with distinct physiographies could be analysed. Approximately four weeks per site monolith and related samples is predicted for one or two analysts. Three progress reports and one final

report incorporating all results and interpretations are predicted. It is proposed that the first progress report of the McPhee Community findings would be available in six months, the second progress report of the Grass Mesa Locality due in 12 months, and a third progress report due in 18 months on the remainder of the samples. A final report is predicted in 24 months. Permission to use the USBOR Great Cut Laboratory Facilities is requested for the entire study period. Expenses will be minimal including distilled water (approximately $10.00 per monolith 40 crucibles for loss on ignition, and filter paper for rapid phosphate analysis at approximately $5.00 per monolith).

In addition to the analyses of already collected samples, two experiments are proposed. Using two archaeologically excavated pitstructures, one at McPhee Community and one at Grass Mesa Locality, a weekly recording of sediment accumulation, type of sediment accumulating, and weather conditions is suggested. Placing gridded rebar at three locations from near the wall to the center of the excavated pitstructure to measure seasonal fluctuations in sediment type and accumulation is necessary. Weather stations with minimum-maximum thermometers and rain gauges at each site are also necessary. This experiment will establish a modern seasonal sediment-accumulation weather analog and provide necessary comparative samples for the existing monolith samples. Since no data of this type is available in the existing Southwest archaeological literature an experiment of this type is unique to the D.A.P. and essential to understanding the collected samples. One weather station exists at McPhee; another one with similar equipment needs to be procured for the Grass Mesa area.

Procedural changes arising after the pilot study include using a sensitive scale (not on project at D.A.P. but at Great Cut) for loss on ignition to estimate percent organic matter, and determination of pH or alkalinity in all samples (if a pH meter can be located). In addition to these changes, the hydrometer analysis will be conducted for longer time intervals to derive information necessary for determination of standardized grain size statistical parameters (Folk [120]). Finally, nominal data obtained from analysis of monoliths and associated sediment samples will be input to the A.D.P. system to facilitate stratigraphic identification and statistical comparision and testing necessary to pitstructure modeling refinement.

The importance of this study is twofold. Linkage of the modern experimentally derived stimulants for pitstructure filling with the collected soil column and determining the major influencing factors to refine the existing models for pitstructure fill is one goal. The other is to model the prehistoric adaptive strategies involved in pitstructure construction, habitation, and abandonment, or reuse.

Summary

Archaeological context, as revealed by surrounding matrix remains and important factor in contemporary archaeological investigations (Schiffer [114]). The Earth Resource personnel as well as archaeological crew chiefs at D.A.P. have recognized the importance of this matrix especially after excavating through 1 to 3 m of the matter to expose structural floors and walls.

The characteristics of this fill have promoted at least four models that explain the relationships of this deposit to the surrounding

environment. Leonhardy's climatic model, Glaser's four strata basin filling model, Lightfoot's abandonment mode model, and Clay's composite site formation process/pitstructure fill model. All models are based on individual visual experiences with numerous D.A.P. stratigraphic profiles.

Following a pilot study examining a monolith column form Site 5MT4479 Pitstructure 1, evidence for the Glaser and Clay models was presented. Multiple analyses and an experimental design for developing modern sedimentary analogs was found necessary to test the Leonhardy and Lightfoot models. A sequence for monolith analysis and a designed experiment for developing modern sedimentary-weather analogs was presented.

A study of this nature will enhance the D.A.P. assessment of prehistoric economy and adaptation through an experimental, analytical, and explanatory presentation of pitstructure formation and filling processes.

SECTION 5c: ETHNOZOOLOGICAL LITERATURE SEARCH

The ethnozoological literature search was carried out by S. Emslie during his period of employment with the D.A.P. Emslie reviewed some 26+ articles, monographs, and books which deal with ethnographic and archaeological reference on mammals and birds. This number of references has provided evidence for human use of some 45 mammal species and 29 birds whose ranges extend into southwestern Colorado. The list presented in Table 1.5.4 is a condensed presentation of those mammals and birds occurring in the D.A.P. area today, (based on Emslie [21]; Burkhard et al. [75]; Armstrong [76]) today, and which have been recovered from archaeological contexts in the surrounding area and/or have been referred to in southwestern ethnography. The literature reference, either archaeological or ethnographic, which follows the animals name is numbered according to the alphabetized references which follow immediately. This literature search is by no means complete. The importance of this file necessitates its being continuously updated. The long term contribution of this file is as a reference for analogs and for examination of temporal and geographic distribution of animal species.

Table 1.5.4. Ethnographic and Archaeologically Documented Fauna which Occur in Dolores and Montezuma Counties (page 1 of 3).

		REFERENCES
	MAMMALS	
	CHIROPTERA	
Big eared bat	Plecotus townsendii	14
Little brown bat	Myotis lucifugus	14
	LAGOMORPHA	9, 20
Jackrabbit	Lepus sp.	5, 26
Snowshoe hare	Lepus americanus	14
White-tailed jackrabbit	L. townsendii	10, 14
Black-tailed jackrabbit	L. californicus	14, 18
Cottontail	Sylvilagus sp.	3, 26
Desert cottontail	Sylvilagus audubonii	14, 18
Nuttall's cottontail	S. Nuttallii	14
	RODENTIA	
Marmot	Marmota sp.	12, 15
Yellow-bellied marmot	Marmota flaviventris	14, 18, 25
Rock ground squirrel	Spermophilus variegatus	14
Golden mantle ground squirrel	S. lateralis	14
Antelope squirrel	Ammospermophilus leucurus	18
Colorado chipmunk	Eutamias quadrivattatus	14
Red squirrel	Tamiasciurus hudsonicus	14
Albert's squirrel	Sciurus alberti	14
Pocket gopher	Thomomys sp.	26
Bottae's pocket gopher	T. bottae	14, 18
Kangaroo rat	Dipodomys ondii	18
Silky pocket mouse	Perognathus flavus	14
Apache pocket mouse	P. apache	14
Beaver	Castor canadensis	14, 18
mouse	Peromyscus sp.	13, 26
Deer mouse	P. maniculatus	14, 18
Pinyon mouse	P. truei	14
Grasshopper mouse	Onychomys leucogaster	18
Bushy-tailed wood rat	Neotoma cinerea	14
Mexican wood rat	N. mexicana	14
White-throated wood rat	N. albigula	14, 18
Long-tailed vole	M. longicaudus	14
Muskrat	Ondatra zibethicus	14
Porcupine	Erethizon dorsatum	14, 18
	CARNIVORA	
Coyote	Canus latrans	14, 18, 23
Wolf	C. lupus	14
Red Fox	Vulpes vulpes	14
Gray Fox	Urocyon cineroargenteus	14
Black bear	Ursus americanus	9, 13, 14
Grizzly bear	U. arctos	14

Table 1.5.4. Ethnographic and Archaeologically Documented Fauna which Occur in Dolores and Montezuma Counties (page 2 of 3).

		REFERENCES
	CARNIVORA (cont.)	
Raccoon	Procyon lotor	14, 20
Marten	Martes americana	14
Weasel/ferret	Mustela sp.	9
Mink	M. vison	14
Badger	Taxidea taxus	13, 14, 18, 20, 23
Striped skunk	Mephitis mephitis	14
River otter	Lutra canadensis	14
Cougar	Felix concolor	13, 14, 18, 20, 23
Bobcat	Lynx rufus	18
	ARTIODACTYLA	
Elk	Cervus canadensis	9, 14, 23
Mule deer	Odocoileus hemionus	6, 18, 20
Deer	Odocoilieus sp.	11, 23, 26
Big horn sheep	Ovis canadensis	18, 20, 21, 22
	CICONIIFORMES	
Great blue heron	Ardea heriodias	7, 18
	ANSERIFORMES	
Canadian goose	Branta canadensis	14, 18
Cinnamon teal	Anas cyanaptera	18
	FALCONIFORMES	
American kestrel/ sparrow hawk	Falco sparverius	2, 18
Golden eagle	Aquila chrysaetos	2, 7, 18, 24
Marsh hawk/ Northern harrier	Circus cyaneas	18
Sharp shinned hawk	Accipiter striatus	7
Turkey vulture	Cathartes aura	7, 8, 14
	CHARADRIIFORMS	
Killdeer	Charadrius vociferus	7
	COLUMBIFORMES	
Mourning Dove	Zenaida macroura	18
	CAPRIMULGIFORMES	
Common nighthawk	Chordeiles minor	14
Poor-will	Phalaenoptilus nuttalii	14
	APODIFORMES	
White-throated swift	Aeronautes saxatalis	14

Table 1.5.4. Ethnographic and Archaeologically Documented Fauna which Occur in Dolores and Montezuma Counties (page 3 of 3).

		REFERENCES
	PICIFORMES	
Common/red shafted flicker	Colaptes cuiratus cafer	2, 7, 16
	PASSERIFORMES	
Pinyon jay	Gymnorhines cyanocephalus	14, 16
Scrub jay	Aphelocama coeruluscens	14
Steller's jay	Cyanocitta stelleri	2, 14, 16
Warbler	Hirundo sp.	2, 4
Common raven	Corvus brachyrhynchos	7, 18
House wren	Troglodytes aedon	14
Rock wren	Salpinctes obsoletus	14
Western bluebird	Sialia mexicana	19
Yellowthroated warbler	Geothlypis trichas	14
Western meadowlark	Sturnella neglecta	7
Yellow-headed blackbird	Xanthocephalus xanthocephalus	14
Red-winged blackbird	Agelarus phoeniceus	7
Black-billed magpie	Pica pica	14
Song sparrow	Melospiza melodia	14

SECTION 5d: ETHNOBOTANICAL LITERATURE SEARCH

Bye [21] describes plant family as plants which were represented in archaeological contexts excavated by the D.A.P. in 1978. Included in his discussion is the plant part represented, the ecology of the plant, the plants relationship to human activities and what the plant has been used for by the people in the Greater Southwest. Absent in his discussion though, is any citation of the document where use is referenced.

The table that follows (Table 1.5.5) is a compilation of plants which occur in Dolores and Monezuma counties that have documented use by or association with Native Americans of the Greater Southwest. The table is arranged alphabetically by plant family following Weber [121] and Harrington [122] and the Plant Information Network. Common names have been omitted for the sake of brevity. The numbers which follow the plant name refer to the literature citation in the references cited section that follows immediately. We envision that this table will complement the discussion of Bye [12].

This literature search has documented human use of about 200 genera in approximately 65 families on the basis of 34 literature citations. In some cases the plant name is preceded by an asterisk (*). The asterisk indicates this plant as a recent, post Columbian introduction. Although it may be possible that remains of such a plant occur in archaeological contexts, consideration of contamination <u>must</u> be made prior to assoicating it with the prehistoric cultural manifestation. This literature file is not complete. In order for this document to be useful it must be continually updated. At any point in time this document can be used to describe and illustrate the geographical extent of particular plants and

Table 1.5.5. Ethnographic and Archaeologically Documented Plants which Occur in Dolores and Montezuma Counties (Page 1 of 9).

	REFERENCES
ACERACEAE	
Acer glabrum	31
Negundo intenius (Acer negundo)	28
ALLIACEAE	
Allium sp.	9, 17, 27
Allium acuminatum	11
Allium geyerii	31
AMARANTHACEAE	
Amaranthus sp.	2, 6, 7
Amaranthus blitoides	28
*Amaranthus retroflexus	2, 28, 31
ANACARDIACEAE	
Rhus sp.	31
Rhus trilobata (Rhus aromatica)	4, 11, 31, 32
Rhus radicans (Toxicodendron rydbergii)	31
APOCYNACEAE	
Apocynum sp.	31
Apocynum androsaemifolium	11
ASCLEPADACEAE	
Asclepias sp.	14, 28, 31
BERBERIDACEAE	
Berberis sp. (Mahonia sp.)	9
Berberis repens (Mahonia repens)	31
BETULACEAE	
Alnus sp.	9, 27, 28
Alnus tenuifolia	28
BORANGINACEAE	
Lithospermum multiflorum	11
CACTACEAE	
Corypantha - see Mammillaria (old name)	
Echinocereus sp.	23, 13
Echinocereus engelmannii (Echinocereus fendleri)	6
Opuntia sp.	2, 6, 7, 9, 13, 14, 17, 23, 25, 26, 27, 31, 32
Opuntia polyacantha	11
Opuntia whipplei	31
Mammillaria sp.	9, 27, 28
Neomammillaria wrightii	31

Table 1.5.5. Ethnographic and Archaeologically Documented Plants which Occur in Dolores and Montezuma Counties (Page 2 of 9).

	REFERENCES
CAPPARIDACEAE	
Cleome sp.	25, 26, 31
Cleome lutea	11, 31
Peritoma serrulata (Cleome serrulata)	28, 31, 38
CAPRIFOLIACEAE	
Sambucus ramenosa	11
CARYOPHYLLACEAE	
Arenaria congesta	11
Arenaria fendleri	31
Arenaria laguinosa (Arenaria confusa)	31
Cerastium berringianum	31
Silene sp.	31
Silene acaulis	11
Silene menziesii	11
*Silene noctiflora	31
CELESTRACEAE	
Pachystima myrsinites	31
CHENOPODIACEAE	
Atriplex sp.	26, 28
Atriplex argentia	31
Atriplex canescens	2, 11, 28, 31
Atriplex confertifolia	11
Atriplex rosea	31
Chenopodium sp.	2, 6, 9, 23, 26, 31, 32
*Chenopodium album	31
Chenopodium leptophyllum	11, 31
Monolepsis nuttalliana	31
*Salsola pestifer (Salsola iberica)	31
Sarcobatus sp.	25
Sarcobatus vermiculatus	31
COMPOSITAE	27
Achillea millefolium	11
Ambrosia psilostachya	11
Artemisia sp.	25, 28
Artemisia dracunculoides (Artemisia dracunculus)	11
Artemisia frigida	28
Balsamorhza sagittata	11
Brickelia grandiflora	11
Chaenactis douglasii	11
Chrysothamnus sp.	26, 32
Chrysothamnus nauseosus	28
Cirsium sp.	23
Grindelia squarrosa	11

Table 1.5.5. Ethnographic and Archaeologically Documented Plants which Occur in Dolores and Montezuma Counties (Page 3 of 9).

	REFERENCES
COMPOSITAE (cont.)	
Gutierrezia sp.	26, 32
Guiettezia longifolia (Guierrezia sarothae)	28
Helianthus sp.	23
Helianthus annuus	11, 28
Lygodesmia grandiflora	11
Senecio sp.	11
*Taraxacum taraxacum (Taraxicum officinale)	28
CONVOLVULACEAE	
*Convolvulus arvensis	31
CORRACEAE	
Cornus stolonifera	11, 31
CRUCIFERAE	
Arabis fendleri	31
Arabis perennans	31
Descurainia sp.	6, 8, 31
Descurainia pinnata	31
*Descurainia sophia	2, 31
Lepidium montanum	31
Lesquerella sp.	31
Lesquerella rectipes	31
Rorippa sp.	31
*Sisymbrium altissimum	31
Stanleyella wrightii (Thelypodium wrightii)	28
CURCUBITACEAE	
Cucurbita foetidissima	13, 27, 28
CUPRESSACEAE	
Juniperus sp.	2, 6, 7, 9, 14, 23, 25, 26, 27, 31
Juniperus communis	31
Juniperus monosperma	23, 28, 31, 32
Juniperus osteosperma	23
Juniperus scopulorum	31, 32
CYPERACEAE	6, 9
Carex sp.	11
Carex festivella	31
Eleocharis sp.	31
ELAEAGNACEAE	
Shepherdia argebtea	31

Table 1.5.5. Ethnographic and Archaeologically Documented Plants which Occur in Dolores and Montezuma Counties (Page 4 of 9).

	REFERENCES
EPHEDRACEAE	
Ephedra sp.	9, 27
Ephedra torreyana	25, 31
EQUISITACEAE	
Equisitum sp.	14, 31
Equisitum hymale	11
Equisitium laevigatum	31
ERICACEAE	9
Arctostaphylos sp.	31, 32
Arctostaphylos uva-ursi	31
EUPHORBIACEAE	
Euphorbia sp.	25, 27, 31
Euphorbia fendleri	31
FAGACEAE	
Quercus sp.	2, 7, 9, 14, 17, 23, 25, 27
Quercus gambelii	3
FUMARIACEAE	
Corydalis aurea	31
GENTIANACEAE	
Frasera speciosa	31
GERANIACEAE	
**Erodium cicutarium*	31
Geranium sp.	31
Geranium atrupupureum	31
Geranium fremontii	11
Geranium richardsonii	31
GRAMINEAE	
**Agropyron trachycaulum*	31
Bouteloa sp.	23
Bouteloa curtipedula	28
Bouteloa gracilis	31
Bromus tectorum	31
Festuca idahoensis	31
Festuca ovina	11
Glyceria nervata (*Glyceria stricta*)	11
Hilaria jamesii	31
Hordeum jubatum	31
Hordeum pusillum	6

Table 1.5.5. Ethnographic and Archaeologically Documented Plants which Occur in Dolores and Montezuma Counties (Page 5 of 9).

	REFERENCES
GRAMINEAE (cont.)	
Koeleria cristata	23, 31
Muhlenbergia sp.	31
Muhlenbergia andina	31
Oryzopsis hymenoides	2, 31
*Phleum pratense	31
Phragmites sp.	6
Phragmites phragmites (Phragmites australis, Phragmites communis)	7, 14, 17, 23, 28
Poa fendleriana	23
Sitanion hystrix	31
Stipa sp.	31
*Triticum sp.	28
GROSSULARIACEAE	
Ribes aureum	11
Ribes leptanthum var brachyanthum	11
HYDROPHYLLACEAE	
Phacelia sp.	27
IRIDACEAE	
Iris missouriensis	31
JUNCACEAE	
Juncus saximontanus	31
JUNCAGINACEAE	
Triglochin maritimum	11
LABIATAE	
Dracocephalum parviflorum (Moldavica parviflora)	11
Monarda menthaefolia	28
LEGUMINOSAE	
Astragalus sp.	32
Astragalus haydenianus (Astragalus bisulcatus var haydenianus)	31
Astragalus praelongus	31
Lathyrus ecosmus	31
Lotus wrightii	31
Lupinus sp.	31
Lupinus kingii	31
*Medicago sativa	31
Melilotus sp.	31
*Melilotus alba	31
*Melilotus officionales	31
Parryella filifolia	31

Table 1.5.5. Ethnographic and Archaeologically Documented Plants which Occur in Dolores and Montezuma Counties (Page 6 of 9).

	REFERENCES
LEGUMINOSAE (cont.)	
Petena scoparium	31
Robinea neomexicana	23
LINACEAE	
Linum lewisii	11, 31
Linum puberlum	31
LOASACEAE	
Mentzelia sp.	7, 8, 23, 31
Mentzelia albicaulis	31
Mentzelia lanciniata	31
Mentzelia multiflora	11
LORANTHACEAE	
Phoradendron juniperinum	31
MALVACEAE	
Malvaceae	9, 27, 28
*Malva neglecta	31
Malvastrum coccineum (Sphaeralcea coccinea)	31
Sidalcea neomexicana	31
Sphaeralcea sp.	25, 31
Sphaeralcea fendleri	31
NYCTAGINACEAE	9, 27
Ambronia fragrans	31
Mirabilis sp.	31
Mirabilis multiflora	31
Mirabilis oxybaphoides	31
Oxybaphus sp.	31
Oxybaphus linearis	31
Tripterocalyx wootonii	
OLEACEAE	
Forestiera neomexicana	31
Fraxinus sp.	6, 9, 27
ONAGRACEAE	
Onagraceae	9, 25, 27, 31
Gaura sp.	31
Gayophytum ramossimum	31
Oenothera sp.	31
Oenothera albicaulis	31
Oenothera caespitosa	11, 31
Oenothera coronopifolia	31
Oenothera flava	31
Oenothera hookeri	31

Table 1.5.5. Ethnographic and Archaeologically Documented Plants which Occur in Dolores and Montezuma Counties (Page 7 of 9).

	REFERENCES
OROBANACEAE	2
PINACEAE	
Abies concolor	28
Picea/Abies	25
Picea engelmannii	31
Pinus sp.	7, 9, 25, 27, 31
Pinus edulis	2, 11, 18, 23, 26, 28, 31, 32
Pinus flexilis	31
Pinus ponderosa	2, 17, 23, 26, 31
Pseudotsuga sp.	6, 26
Pseudotsuga mucronata (*Pseudotsuga taxifolia*, *Pseudotsuga menziesii*)	28, 31, 32
POLYGONACEAE	
Eriogonum sp.	24, 31
Eriogonum alatum	31
Eriogonum cernum	31
Eriogonum jamesii	31
Eriogonum leptophyllum	31
Eriogonum ovalifolium	11
Eriogonum racemosum	31
Polygonum sp.	31
Polygonum aviculare	31
Polygonum sawatchense	31
Rumex sp.	31
Rumex crispus	31
Rumex hymenosepalus	31
PORTULACACEAE	
Portulaca sp.	26
Portulaca oleraceae	28, 31
PRIMULACEAE	
Androsace sp.	31
Androsace septentrionalis	31
RANUNCULACEAE	
Clematis sp.	31
Clematis ligusticifolia	31, 11
Delphinium sp.	31
Delphinium nelsonii	31
Delphinium sacposum	31
Ranunculus sp.	31
Ranunculus aquatilis	11
Ranunculus cymbalaria	31
Ranunculus inamoenus	31

Table 1.5.5. Ethnographic and Archaeologically Documented Plants which Occur in Dolores and Montezuma Counties (Page 8 of 9).

	REFERENCES
RANUNCULACEAE (cont.)	
Thalictrum fendleri	31
RHAMNACEAE	
Ceanothus fendleri	31
ROSACEAE	
Amelanchier mormanica (Amelanchier utahensis)	31
Cowania stansburiana (Cowania mexicana)	11
Frageria vesca	11
Geum macrophyllum	11
Potentilla sp.	31
Potentilla hippiana	31
Prunus sp.	31
*Prunus armeniaca	11, 28, 32
Prunus melanocarpa (Prunus virginiana)	2, 26, 31
Purshia tridentata	31
Rosa sp.	31, 28
Rosa neomexicana (Rosa woodsii)	31
RUBIACEAE	
Galium sp.	28
Ptelea sp.	9
SALICACEAE	
Populus sp.	6, 31
Populus acuminata	31
Populus angustifolia	11
Populus tremuloides	28, 31
Populus wislizeni (Populus fremontii wislizenii)	25
Salix sp.	25, 28, 31, 32
Salix amydaloides	11
Salix exigua	31
Salix lasiandra	11, 31
SAXIFRAGACEAE	
Heuchera sp.	31
Heuchera parviflora	31
SCROPHULARIACEAE	
Castilleja einariaefolia	28
SOLANACEAE	
Datura sp.	17
Nicotiana attenuata	28
Solanum jamesii	28

Table 1.5.5. Ethnographic and Archaeologically Documented Plants which Occur in Dolores and Montezuma Counties (Page 9 of 9).

	REFERENCES
TYPHACEAE	
Typha sp.	9
Typha latifolia	11, 31, 32
ULMACEAE	
Celtis sp.	9, 27
Celtis reticulata	28
UMBELLIFERAE	
Pseudocymopterus montanus	31
VALARIANACEAE	
Valariana edulis	11
VIOLACEAE	
Viola nephrophylla	31
VISCACEAE	
Arceuthobium vaginatum	31
Arceuthobium campylopodum	31
VITACEAE	
Parthenocissus vitaceae	31
Vitis sp.	9, 27

* - Introduced

New names are in parenthesis, these are not found in older references

in some cases the geographic exploitation of these plants (cf. Nabhan et al. [123]).

SECTION 5e: REVIEW OF THE COMPARATIVE/EXPERIMENT GARDEN PROGRAM-A SHORT REVIEW

For two summers (1979, 1980) the E.S.G. investigated the potential of primitive Southwestern agricultural practices in the D.A.P. area. The efforts of R. Shuster illustrated that corn, bean, and squash horticulture is a productive undertaking in the D.A.P. area today. More specific summaries of the D.A.P. Experimental Garden are presented in the second chapter of this volume. Additional summaries are available in Shuster [7]; Shuster and Bye [84, 85]; and Bye and Shuster [85].

At the beginning of the experimental garden program, Bye and Shuster reviewed the literature on past experimental garden undertakings and realized that few, if any, meet the standards for documenting the factors which affect productivity under subsistence agriculture. Few previous experimental gardens sought to throughly document the sources of seed, the resulting yield, or the amount of effort necessary to obtain harvestable biomass in the form of edible fruits etc. Neither did any of the previous undertakings seek to examine the effects of intra- and interspecific competition or climatic factors which affect obtaining a yield.

Realizing the need to document some of the aforementioned paramenters Shuster cultivated two gardens for two years. This contribution cannot be underestimated. Data are provided on the factors which affect subsistence agriculture while also providing substance which supports models that direct many E.S.G. activities (e.g., Multiple Cropping theory, Garden Hunting Ecosystem development). Shuster and Bye [84] have also described the variation of five "exotic races of maize cultivated in the D.A.P. gardens. This study is of critical importance for archaelogists working with the colonization of new areas by prehistoric peoples.

The contribution of the D.A.P. Experimental Gardens will continue to be realized. As a linkage study the E.S.G. experimental gardens provide data on the processes of component interaction under agriculture today (e.g., planting system, soil nutrient depletion or fertilization, intra- and interspecific competition) which will be useful for understanding the past directly. That is, although crop varieties used today in the D.A.P. Experimental Garden are probably different from those used by the prehistoric groups in this area, the processes of cropping, (e.g., intraspecific competition, predation) have continuity with the past. On the basis of this assumption and the information presented by Shuster [7] and Bye (personal communication) it appears to be wrong to assume that: (1) the process of agriculture is based on the desire to produce only one type of product, (e.g., only corn is worth cultivating, field weeds are of no use); (2) the best system for maximizing yield is planting only one crop in one place at one time; (3) intraspecific competition is detrimental to attaining the highest yield; (4) frost free season is the major limiting factor affecting productivity; and (5) the maximum yield can only be maintained through greater input of energy and materials.

SECTION 5f: LATE HOLOCENE PLANT RECORDS FROM THE DOLORES RIVER AREA, MONTEZUMA COUNTY, COLORADO[1]

by T.R. VanDevender

Plant remains preserved in packrat (Neotoma sp.) middens have proven to be a very powerful tool for reconstructing the local vegetation of rocky habitats for the past 40,000 years (VanDevender and Spaulding [124]). Most packrat midden research has focused on late Wisconsin and early Holocene woodland communities in areas that presently support desertscrub prior to 8000 BP (radiocarbon years before present). Subtle changes in vegetation and climate recorded in packrat middens of younger ages which are of more archaeological interest have received little study. The only middle and late Holocene midden studies from the Colorado Plateaus are those of Schmutz et al. [125] for Wide Rock Butte in Canyon de Chelly, Arizona, and Betancourt and VanDevender [126] for Chaco Canyon, New Mexico. The analyses of late Holocene middens contemporaneous with the Anasazi occupation of the Dolores River area, Montezuma County, Colorado, are reported here.

Methods

Packrats, or woodrats, are medium-sized cricetid rodents that live

[1]Steve Emslie, Center for Western Studies, Inc., Flagstaff, collected the midden samples and initiated the project. Robert A. Bye, Jr., University of Colorado, provided the information on the local distributions of plants and useful comments on nomenclature and identifications. Gene Hall helped sort the midden samples. The Dolores Archaeological Project provided financial support for the analysis and radiocarbon dates through the University of Texas at Austin Radiocarbon Laboratory. Carol Plenkers typed the manuscript.

in a wide variety of habitats in North America. All species collect and bring into their houses or dens a variety of materials for food or construction (Finley [127]). Eventually, representative samples of the local flora accumulate in waste areas in the houses termed middens. Most of the forage activities of packrats are within 30-50 m of the nests.

Yarrow [128] first described the hardened dark deposits that are known to be indurated packrat middens. Yarrow thought that the deposits were the work of Euphryne (=Sauromalus) obesa (chuckwalla), but was countered in a footnote by E.D. Cope, the famous paleontologist and herpetologist, who correctly ascribed them to Neotoma. In dry, protected rock shelters, packrat houses may be reduced to where living areas occur in rock cracks and only a midden and debris pile are visible. The midden often becomes cemented with packrat urine into dark, shiny masses. These deposits will be preserved in shelters as long as they are dry. Middens have been dated at more than 50,000 BP (VanDevender and Spaulding [124]).

The plant remains in middens are usually well preserved and can be identified to the species level. Each assemblage may have 15-35 kinds of plants in them. The organic remains in the sample are ideal for radiocarbon dating because they have been dry and are free of many contamination problems. Ideally, radiocarbon dates are preferred on a single plant that has ecological significance (a community dominant or an extralocal plant) (VanDevender [129]). In samples from carefully controlled stratigraphic contexts, the resulting dates can be extended to associated plants allowing the entire assemblage to be placed in a time framework.

The plant remains in the samples were identified using the reference collections in the Laboratory of Paleoenvironmental Studies, University of

Arizona, and several seed manuals: Delorit [130]; Knight [131]; Martin and Barkley [132]; and Montgomery [133]. Plant nomenclature follows Weber [134] although Martin and Hutchins [135] was also consulted.

Results

A series of hardened midden samples from a single site at about 2100 m elevation in sandstone above the Dolores River area, Montezuma County, Colorado (37°31'N, 108°33'W), were collected by Steve Emslie [21]. Five of these were washed, sorted, analyzed and radiocarbon dated. One sample (Dolores #5) was built by porcupine (*Erethizon dorsatum*), the others by packrats (*Neotoma* sp.). Two duplicate samples from Dolores #4 were analyzed and dated.

Radiocarbon dates in this study were obtained on the wood of *Quercus* sp. (oak) and *Pinus edulis* (Colorado pinyon), twigs of *Juniperus* cf. *osteosperma* (Utah juniper), and miscellaneous twigs. The dates yield ages ranging from 1450 ± 160 BP (Dolores #2) to 580 ± 90 BP (Dolores #3, Table 1.5.6). The two dates from Dolores #4 are statistically the same. This late Holocene time series nicely spans the peak of Anasazi populations in the Four Corners area.

The five middens contained 25-34 plants per sample for a total of 54 (Table 1.5.7). At least 19 (35 percent) were woody perennials. Other growth forms recorded include: three perennial grasses (5.5 percent), four succulents (7.5 percent), nine herbaceous perennials (at least 16.7 percent), and herbaceous annuals (at least 16.7 percent). Forty-three (78.9 percent) of these plants still occur fairly close to the site. Only twelve (22.2 percent) of them occur within packrat forage distance (about 50 m) of the site. Four (7.3 percent) plants still occur in the Dolores

Table 1.5.6. Radiocarbon Dates from Packrat and Porcupine Middens from the Dolores River Area, Montezuma County, Colorado.

Sample	D.A.P. Provenience	Date (BP)	UT Lab No.	Material Dated
Dolores #3	5MT4654-000002-06-02-0003	580 ± 90 BP	X-3887	*Quercus* sp. wood
Dolores #5	5MT4654-000010-06-02-0005	670 ± 40 BP	X-3888	*Pinus edulis* wood
Dolores #4 (1)	5MT4654-000014-06-02-0004	900 ± 210 BP	X-3889	*Juniperus* sp. twigs
Dolores #4 (2)	5MT4654-000014-06-02-0001	990 ± 190 BP	X-3885	miscellaneous twigs
Dolores #2	5MT4654-000002-06-02-0001	1450 ± 160 BP	X-3886	miscellaneous twigs

Table 1.5.7. Plant remains from packrat and porcupine middens from the Dolores River area, Montezuma County, Colorado. (page 1 of 3).

Species	Common Name	Growth Form	Distri-Bution	Material	D#3	D#5*	D#4(1)	D#4(2)	D#2
Amelanchier sp.	Service berry	WP	O	Seeds, twig	2	2	2	2	2
Artemisia frigida	Estafiata	HP-WP	N	Leaves	2			2	2
A. ludoviciana	White sage	HP	N	Leaves	2		2	2	2
A. tridentata-type	Big sagebrush	WP	O	Leaves, wood	3		2	2	3
Astragalus sp.	Loco weed	HA-HP	N	Pods		2	2		
Atriplex canescens	Fourwing saltbush	WP	E	Fruits, leaves	2		2	2	3
Avena/Festuca-type	Oats/fescue	GP	N	Seeds	2	2		2	2
Berberis fendleri	Fendler barberry	WP	E	Leaves, spines					2
Cercocarpus montanus	Mountain mahogany	WP	N	Seed, leaves	1				2
Chenopodium sp. A	Goosefoot	HA	O/N	Seeds	2	2		2	2
Chenopodium sp. B	Goosefoot	HA	O/N	Seeds	2				1
Chenopodium sp. C	Goosefoot	HA	O/N	Seeds	2				
Chroysothamus sp.	Rabbitbrush	WP	O	Achene			1		
cf. Dalea	Indigo bush	HP	N	Pod		2			
Echinocereus sp.	Hedgehog cactus	SP	?D	Seed			1		
Gutierrezia sp.	Snake weed	WP	N	Involucres	2		1	2	2
Helenium-type	Sneeze weed	HA-HP	D	Achenes		1			1
Helianthus sp.	Sunflower	HA	N	Achenes	2	4	3	3	2
Heterotheca sp.	Golden aster	HA-HP	N	Achenes involucre	2	2	3	3	2
Iva sp.	Poverty weed	HA-HP	N	Achene		1			
Kochia sp.	Summer-cypress	HA-HP	N	Seed		1			
Juniperus cf. osteosperma	Utah juniper	WP	N	Seeds, twigs	5	5	5	5	4

Table 1.5.7. Plant Remains from Packrat and Porcupine Middens from the Dolores River area, Montezuma County, Colorado. (page 2 of 3).

Species	Common Name	Growth Form	Distri-Bution	Material	D#3	D#5*	D#4(1)	D#4(2)	D#2
Juniperus scopulorum	Rocky Mnt. Juniper	WP	O	Seeds, twigs	4	3	2	3	2
Lactuca cf. serriola	Wild lettuce	HA	N	Achene		1			
Lappula redowskii	Stickweed	HA	O	Nutlets	1			1	
Lesquerella sp.	Bladderpod	HP	O	Pods, leaves	1				2
Mahonia repens	Creeping barberry	WP	O	Leaves	2		2		2
Mirabilis multiflora	Colorado 4 o'clock	HP	D	Seeds	1				
M. oxybaphoides	Spreading 4 o'clock	HP	N	Seeds				2	
Opuntia polyacantha	Plains prickly pear	SP	N	Seeds, spines	3		3	4	5
Oryzopsis hymenoides	Indian rice grass	GP	O	Seeds	1	1	1		
Pediocactus mesae-verde	Mesa Verde cactus	SP	E	Areole			1		
Penstemon sp.	Beardtongue	HP	N	Pods				1	2
Phacelia sp.	Caterpillar weed	HA	N	Seed	1				
Physalis sp.	Ground cherry	HA	N	Seeds	1	1	2	2	2
Pinus edulis	Colorado pinyon	WP	N	Nuts,needles,wood	5	5	3	3	3
Pinus ponderosa	Ponderosa pine	WP	N	Needles			2		
Polygonum sp. A	Knotweed	HA-HP	N	Seeds(triangular)	1	2	3	3	
Polygonum sp. B	Smartweed	HA-HP	N	Seeds (flat)	1	1	1		
Prunus nr. virginiana	Chokecherry	WP	O	Seeds					1
Psoralea sp.	Scurf pea	HP	E	Pods, seeds	2	1	2	2	
Purshia tridentata	Antelope brush	WP	N	Leaves	1				2
Quercus gambelii	Gambel oak	WP	O	Acorns, leaves	2	5	3	2	2
Rhus aromatica	Skunkbush	WP	O	Seeds	2	2	3	2	2

Table 1.5.7. Plant Remains from Packrat and Porcupine Middens from the Dolores River area, Montezuma County, Colorado. (page 3 of 3).

Species	Common Name	Growth Form	Distri-Bution	Material	D#3	D#5*	D#4(1)	D#4(2)	D#2
cf. Robinia neomexicana	New Mexican locust	WP	E	Spines					1
Rosa sp.	Wild rose	WP	N	Seeds	2		2		2
Rudbeckia sp.	Coneflower	HA-HP	D	Achene					1
Salvia sp.	Sage	HA-HP	E	Seeds	1	1	1	2	1
Shepherdia argentea	Buffaloberry	WP	E	Seeds	2		2	2	1
Sphaeralcea sp.	Globe mallow	HP	O	Carpel,seed,leaves		1	2	2	2
Stipa cf. neomexicana	New Mexican feathergrass	GP	N	Seeds					1
Trifolium sp.	Clover	HA-HP	N	Seeds		2			
Verbesina enceliodes	Crownbeard	HA	N	Achenes		2			
Yucca cf.baccata	Banana yucca	SP	N	Seeds, leaves	3		4	3	3
N = 54				Total:	33	25	29	25	34

* - porcupine midden; 1 = rare; 2 = uncommon; 3 = common; 4 = very common; 5 = abundant; HA = herbaceous annual; HP = herbaceous perennial; WP = woody perennial; SP = succulent perennial; GP = perennial grass; O = onsite, within 50 m; N = near site, but not with 50 m, D =observed in area but more than 2 km away; E = extralocal, not observed in area.

River area but are more distant. Another seven plants (12.9 percent) no longer occur in the Dolores River area at all.

Discussion

These radiocarbon dated midden assemblages provide a good reflection of the local vegetation near this site for the 1070 radiocarbon year period betwen 1450-580 BP. The differences between the plants in the assemblages and the modern vegetation are very interesting, especially those that no longer occur in the area. Berberis fendleri (Fendler barberry) and cf. Robinia neomeicana (New Mexican locust), found in Dolores #2 dated at 1450 ± 160 BP, may have been heavily impacted by the local Anasazi. The other extralocal plants, including Atriplex canescens (fourwing saltbush), Pediocactus mesae-verdae (Mesa Verde cactus), Psoralea sp. (scurf pea), and Shepherdia argentea (buffaloberry) were present in younger samples and probably disappeared due to the land use activities of later inhabitants, especially the Europeans of the past two centuries.

Most of the other plants that no longer grow within 50 m of the site were probably similarly affected. Important woodland plants in this group include Pinus edulis (pinyon), P. ponderosa (Ponderosa pine), Juniperus cf. osteosperman, Cercocarpus montanus (mountain mahogany), Rosa sp. (wild rose), Artemisia frigida (estafiata), A. ludoviciana (white sage), Opuntia polycantha (plains prickly pear), and Yucca cf. baccata (banana yucca). Kochia sp. (summer-cypress) is interesting because the annual K. scoparia is supposed to be an introduced European weed while the uncommon perennial K. scoparia is supposed to be an introduced European weed while the

uncommon perennial K. americana is native (Martin and Hutchins [135]). The seeds could be either plant.

Acer negundo (box elder) and Ribes sp. (currant) important woody perennials found near the site at the present time, were also found in the midden samples.

Although there are important differences between the prehistoric and modern flora at this site, most of the changes are most easily explained by man's impact on the landscape. Plants were used for food, fuel, fiber, and construction materials by both prehistoric and historic inhabitants. A recent packrat midden study in Chaco Canyon, New Mexico, has demonstrated that these activities have locally had profound influences on the structure and composition of the modern vegetation (Betancourt and VanDevender [126]). In Chaco Canyon a pinyon-juniper woodland was replaced by the modern Great Basin desertscrub as the Anasazi population reached its maximum. Similar prehistoric and historic imprints on the modern landscape should be considered for other areas on the Colorado Plateau that previously supported sizeable populations.

SUMMARY AND CONCLUSIONS

by Bruce F. Benz and Vickie L. Clay

The magnitude of this report necessitates a brief summary of each section followed by a few concluding statements.

The Environmental Studies Group has directed studies on the relationship of the prehistoric human organism with the surrounding prehistoric biological and physical environment. Models which have been used to guide these studies include: the ecosystem development model (Odum [18]), the garden hunting model (Linares [17]), the levels of interaction model (Bye [13]), and multiple crop theory (Papendick et al. [16]), all of which describe the stages of ecosystem development and aid in characterization of the modern and prehistoric biotic resource supply. The law of superposition and the principle of uniformitarianism guide the geological studies; however, uniformitarianism applies here only to processes. The specific studies contained in this chapter principally addressed the Economy and Adaptation Problem Domain in the D.A.P. Research Design [Kane et al. [1]].

At present, the number of analysis of vegetal, faunal, palynological, dendrochronological, and geological samples from archaeological contexts is limited. All macrobotanical remains have been analyzed; however, only 10 percent of the Bulk Soils samples have been subjected to preliminary analysis. Faunal remains have been identified for all but two sites through the 1980 excavation season. Seven percent of the pollen samples collected have been analyzed. Ten percent of the dendrochronological samples sent to the Arizona Tree-ring Laboratory were datable. One of 34 soil monoliths and no Bulk Soil-sediment samples have been analyzed.

From these analyses of archaeological materials, potential prehistoric resource availability may be described. The faunal remains occurring in the D.A.P. archaeological record include 44 mammals, representing eight orders; 35 birds representing eight orders; one amphibian; two reptiles; and one fish. Forty-seven pollen types have been found in archaeological pollen samples (primarily in features) and represent cultigens, weedy species, riparian, shrubland, and alpine vegetation zones. Macrobotanical analysis has identified the remains of 28 botanical genera, including three cultigens (corn, beans, squash) from archaeological contexts. Intensive botanical investigations of materials from the floor of Pitstructure 1, Site 5MT4644 revealed 27 plant taxa from pollen and 19 taxa from macrobotanical remains. Seventeen taxa were present in both pollen and macrobotanical samples, including three cultigens (corn, beans and squash), four woody taxa, and seven weedy taxa. Using dendrochronological samples from the D.A.P., W. Robinson was able to reconstruct a precipitation curve for the project area covering the period from AD 909-1969. Archaeological vegetal material has provided the best data base for assessing prehistoric climate.

Studies of the contemporary biological and physical environments have provided necessary comparative collections and observations of ecological relationships to facilitate archaeological analyses of biotic and abiotic materials. The configuration of vegetation, fauna, climate, and surficial geology on the modern project area are reviewed in detail in Section 4.

Section 5 contains studies that link the contemporary environments to the prehistoric ones. These include historical accounts of Sagehen Marsh and pitstructure fills as seen in their respective stratigraphies, reviews of ethnozoological literature, and the comparative gardens, and a study of

packrat/porcupine middens. Sagehen Marsh dates indicate that it probably existed when Anasazi entered the area, was sporadically wet and dry during Anasazi occupation, was a sagebrush plain during early historic time, and was re-established as a marshland environment after canal construction in the vicinity in 1889. The analysis of pitstructure fill sediments has the potential to answer prehistoric adaptive strategy questions and provide a separate climatic reconstruction based on stratigraphic sequences. The ethnographic literature search provides information about uses of animals by historic Native Americans. A review of the comparative gardens emphasizes the importance of an ecological approach when evaluating prehistoric agriculturalists. This study provided quantitative weather, soil fertility, cropping, and productivity data that form a unique framework for modeling prehistoric agriculture. Analysis of vegetal remains by VanDevender (Section 5e, this chapter) in packrat middens adjacent to the McPhee area provides a vegetation reconstruction for this part of the Project area through time. These linking studies indicate that climate, flora, fauna, and sedimentary deposits have changed appreciably through time.

The modern D.A.P. Project area environments are not equivalent to their prehistoric counterparts. An understanding of the ways factors in the modern environments interact with each other, coupled with glimpses of the past as recovered from the archaeological record, provides the data base from which the environmental archaeologist may reconstruct the prehistoric available and utilized resources. Environmental data have numerous limitations; however, these should not preclude its use in modeling or explaining of prehistoric economy and adaptation, foreign interaction, or cultural process.

APPENDIX A

PUBLISHED REPORTS AND REPORTS IN PREPARATION DEALING WITH D.A.P. ENVIRONMENTAL STUDIES DATA

by

Meredith H. Matthews

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1979 A sampling strategy for the recovery of small-scale archeaological remains. Paper presented at the 37th Annual Plains Conference, Kansas City, Missouri.

n.d. Analysis of *Zea mays* variability in prehistoric and contemporary populations, M.A. Thesis, University of Colorado, Boulder.

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Bye, Robert A., Jr.
1979 Environmental Studies, Chapter 6, *In* Analysis 1979, Volume IV, Dolores Archaeological Program Technical Reports, David A. Breternitz, Senior Principal Investigator. Reports from the Dolores Archaeological Project, Cultural Resources Series. Bureau of Reclamation, Upper Colorado Region: Salt Lake City.

1980 Portulaca seed ecology and human disturbance. Paper presented at the 3rd Ethnobiology Conference, Tucson, Arizona.

1981 The development and application of ethnobotanical principles. Paper to be presented at the XIII International Botanical Congress, Sydney, Australia.

Bye, R.A. and R. Shuster
1981 Developing an integrated model for contemporary and archaeological subistence systems. Paper presented at the 46th Annual Meeting of the Society for American Archaeology, San Diego, California.

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APPENDIX B

EVALUATION OF ENVIRONMENTAL STUDIES GROUP SAMPLING DESIGN FOR BULK SOIL AND POLLEN

by

Bruce F. Benz

INTRODUCTION

Intrasite sampling for bulk soil (B.S.) and pollen has prompted a great deal of discussion over the past three years. The initial approach to B.S. and pollen sampling was nonsystematic and nonrepresentative. Recognizing the need to redirect sampling efforts toward systematically obtaining biotic--primarily botanical--materials for specifically addressing D.A.P. Research Design Problem Domains, the present sampling program was devised by Litzinger [23, 45] in collaboration with Bye. The resulting sampling program seeks to obtain samples that generally represent the wide range of feature and surface types that will in turn represent a variety of resource procurement, processing, consumption and discard activities. In addition, this sampling strategy focuses on determining what types of botanical remains can be directly related to the cultural occupation and defining what can be related to the occupation as a resource.

The sampling design as described by Litzinger ([23, 45]; cf. Benz et al. [56]), distinguishes two separate control systems that reflect different research design objectives. First, it is necessary to define what constitutes a botanical resource. Second, it is necessary to identify and describe how, where, and when a botanical resource was procured, processed, consumed, and/or discarded. In the case of determining what botantical resources consisted of, a set of vertical control samples has been established to determine what plant remains occur only in a cultural context. This system of controls assumes that: (1) the excavator can distinguish between the cultural stratum and the noncultural strata above and below this stratum and (2) tht these strata

reflect differences and similarities that exist because of prehistoric cultural activities. To determine where and how these botanical resources were utilized necessitated a somewhat different sampling scheme. That is, differential density and distribution of botanical materials across a prehistoric surface or in relation to a feature reflect prehistoric activities. This sampling strategy recognizes that differential density and distribution is undoubtedly dependent on the intensity and duration of the activity (Litzinger [23:21]). Consequently, even though activity intensity and duration vary independently on many surfaces, some activity patterns exist, and that can be keyed into this patterning. At the present time only one study has beeen attempted which examined the spatial relationships of surface botanical debris and features. Matthews [136] presents results of investigations which indicate that there is no discernible relationship between the central fire hearth and the surface distribution of charred botanical items as one moves progressively further from the hearth. Although the sample size was small (only two pithouses) this suggests that the distribution of remains on a surface adjacent to a hearth may not be related to the activities that were carried out in that hearth. It is difficult to anticipate what the surface distribution of botanical materials indicates, but there are numerous possibilities. Examination of B.S. and pollen data from Pitstructure 1, Surface 1, Site 5MT4644, should provide clues to the nature and meaning of other surface distributions (cf. Section 3d, this chapter). If surface distributions of pollen in this pitstructure are any indication, then preservation of the structure is a key to understanding how closely one can reconstruct prehistoric activities on the basis of botanical evidence.

Determining what botanical items are directly related to the cultural occupation is somewhat easier than relating resource use to activity. The system of vertical control samples provides contextual evidence for describing those materials that can be associated with prehistoric cultural activity and those materials that are indirectly or not associated with the prehistoric occupation. That is to say, B.S. samples recovered from features and surfaces contain botanical materials that can be linked to human use, to human occupation of space, or to postabandonment site formation processes. One of the first steps attempted by the Environmental Studies Group is to determine what kinds of materials might have been introduced into an archaeological context that are totally unrelated to the sites' human occupations. In this case, botanical items which are present in the sites' soil horizons or sediment layers prior to occupation have no direct bearing on the subsequent human occupation. Seeds, fruits, and various other plant parts might be carried into the site by various animals. One possible reason for the animals' presence relates to the fact that softer, disturbed soil/sediments would be present on or in archaeological sites and that these could be easily colonized by burrowing animals. Nelson's [137] work with harvester ants indicates that extraordinarily high percentages of Polygonum sp. fruits in B.S. samples may reflect insect disturbance rather than cultural use. Botanical items reflecting indirect evidence of prehistoric human occupation are seeds and fruits of weedy annual plants. Since these items are very common in B.S. samples, it is necessary to factor out any noise (e.g., postoccupational seed rain) prior to associating these plants with human consumption. That anthropogenic plant associations are present on archaeological sites is indicated by Yarnell's vegetation study on the

Pajarito Plateau (Yarnell [74]). Assuming distinctive flora on prehistoric ruins to be the case, we should expect this anthropogenic environment to be also reflected in a site's seed bank (cf. Harper [138]). Further, following abandonment of the site, the initiation of secondary succession should be visible in postoccupational fill as a stratum that contains the the disseminules of weedy colonizing species characteristic of secondary seres and also the remains of species common to Puebloan ruins.

Bulk Soil sampling employing vertical controls has supported this sequence of events and made it possible to "factor-out" those plants which probably represent postoccupational invasion of the immediate onsite environment. Data from a single feature at Site 5MT4512 (Feature 20) will serve as an example. Feature 20 contained 2 strata (Table 1.B.1). Single upper and lower control B.S. samples were obtained directly above and beneath this feature. The lower control sample contained no botanical material. As a result, any botanical material that might have been contained within the sites preoccupational deposits were either nonexistent or not introduced into the cultural strata. The cultural strata contained disseminules of four genera. All but one of these genera were also present within the stratum which overlaid the feature (upper control sample context). The seeds of Portulaca sp. occurred only in the two cultural strata. Following the reasoning previously outlined, only on the presence (and potential use) of Portulaca sp. can be related to cultural occupation. The stratum that overlaid the feature, although containing other indications of prehistoric occupation, was not associated directly with the cultural feature below by the excavator. As a result, the presence of Polygonum sp., Chenopodium sp., and Amaranthus

Table 1.B.1. Archaeological Example for Site 5MT4512.

Field Specimen Number	Bulk Soil Number	Sample Type	Sample Contents
337	130	Upper Control	*Amaranthus* sp.
			Chenopodium sp.
			Polygonum sp.
337	128	Feature Fill	*Amaranthus* sp.
338	129	Stratum 1	*Chenopodium* sp.
		Stratum 2	*Polygonum* sp.
			Portulaca sp.
338	131	Lower Control	Nothing Recovered

Benz et al. [56]

sp. can not be directly associated with the cultural context of the feature. Rather the presence of these generas disseminules can be indirectly associated with the cultural occupation. It is uncertain whether these genera were utilized by the prehistoric inhabitants. However, the plants were present on the site following occupation and perhaps during occupation.

The examples presented in the cursory evaluation seem to provide the most reasonable data set for examining the usefulness of the D.A.P. B.S. pollen sampling strategy. For a discussion of pollen sampling the reader should refer to two papers written by Scott [24, 40]. These studies were based on two sets of pollen samples. The first set was collected from the floor of Pitstructure 1, Site 5MT4644, and the second set is derived from the rooffall stratum that immediately overlaid the floor. The similarities between the 2 data sets suggests that close scrutiny of the data is warranted. The presence and absence of pollen types from floor and roof fall can probably be related to preservational factors. At this time some 700 $\pm$ B.S. samples (approximately nine percent of all samples collected) have been anlayzed. At the present time, the vertical control aspect of B.S. pollen sampling is acting as control on interpretation. That is, the Environmental Studies Group is not attempting to associate anything ambiguous directly with human activities. The horizontal or spatial system of controls has not yet proved itself. Additional analysis will provide data necessary to investigate this further.

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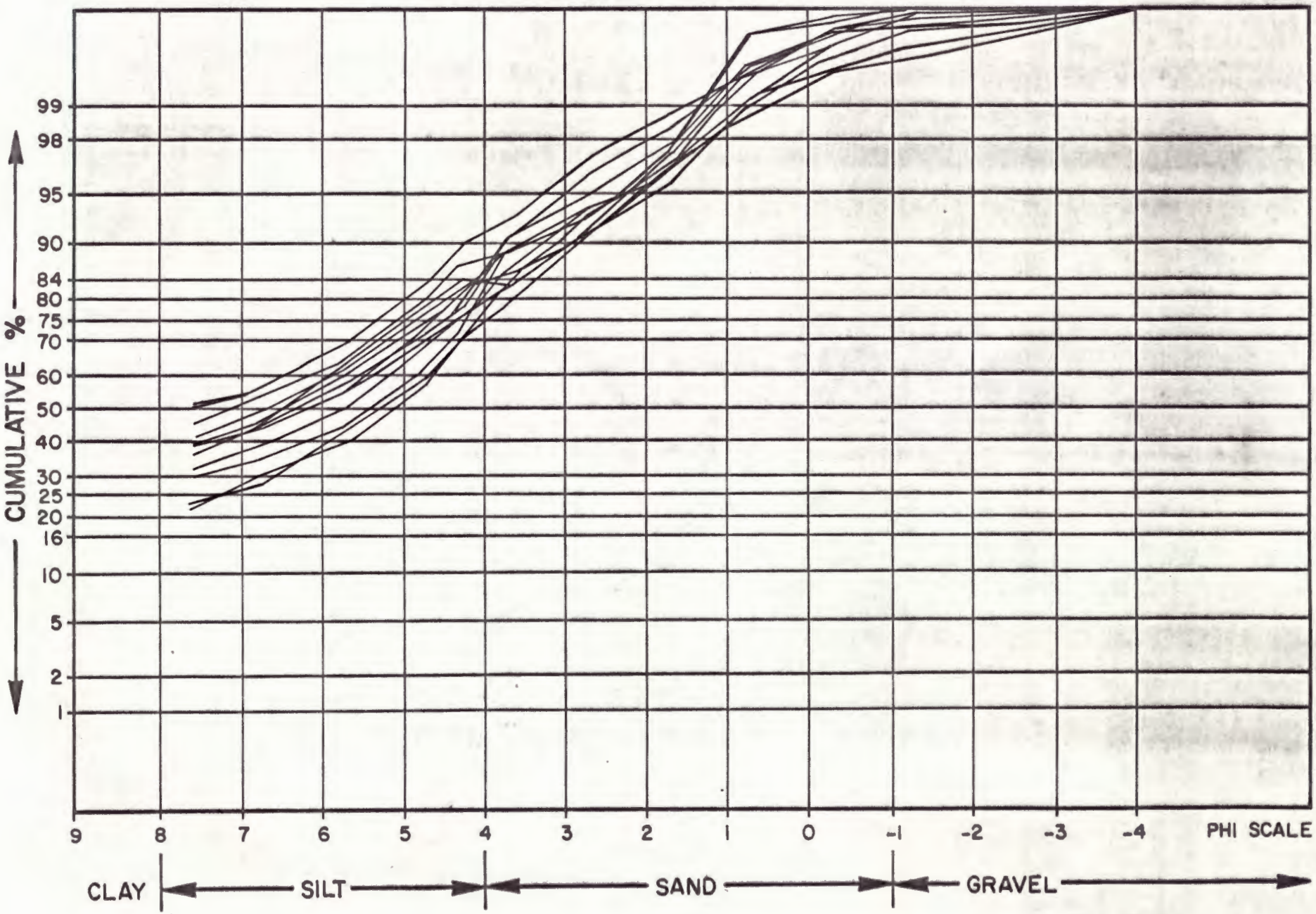

Figure 1.5.20. Cumulative grain size curves for Samples 21-33 (Glaser's Stratum 3).

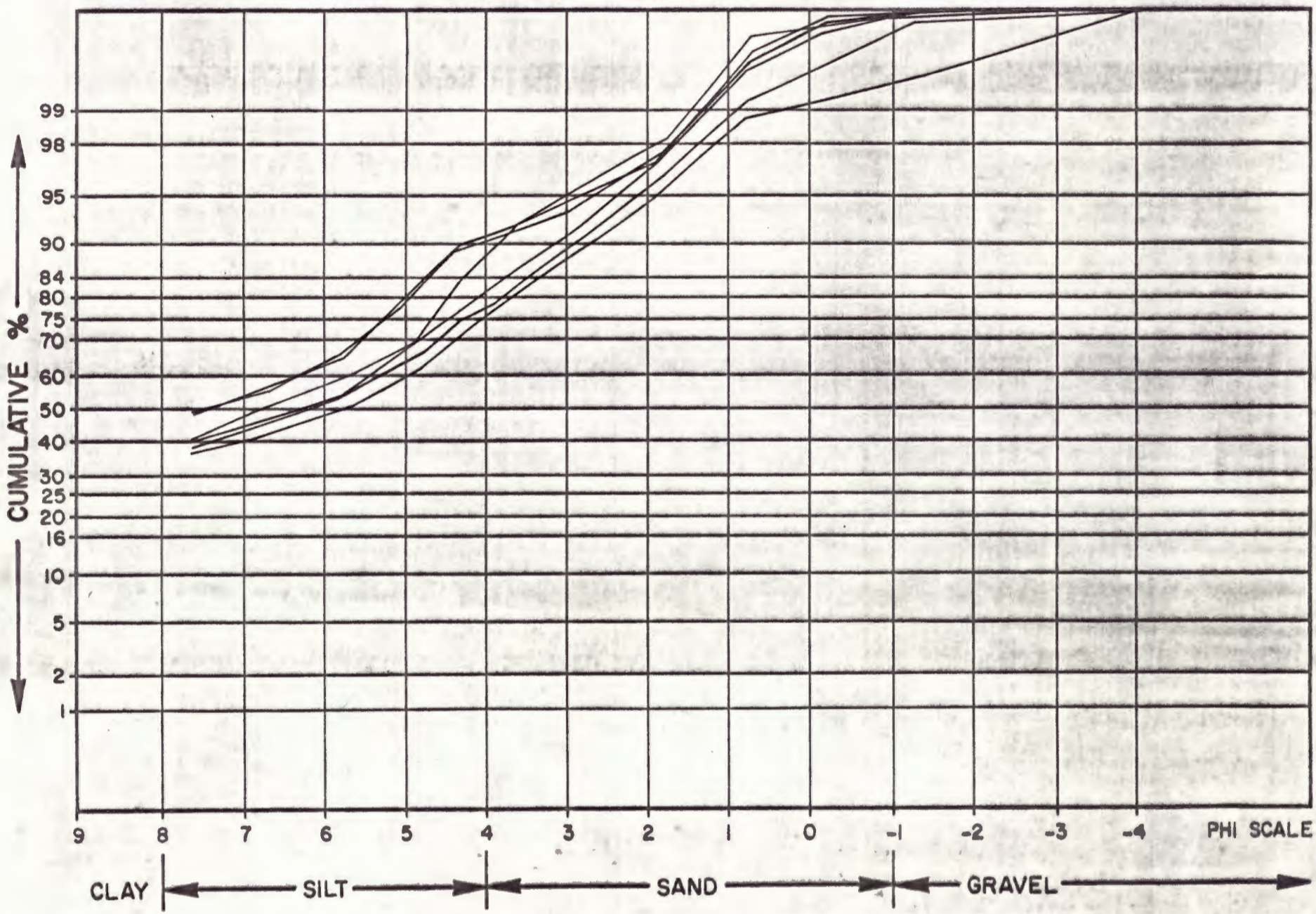

Figure 1.5.21. Cumulative grain size curves for Samples 34-39 (Glaser's Stratum 4).

Table 2 (cont.). Levels of interaction defined by spatial-cultural units.

Interactive Level (Crow Canyon)	Value	Economic Interaction	Social Interaction	Integrative Mechanisms	Archeological Manifestation/ Other
Component	-5	Use during an occupation period of a site that may be preceded or succeeded by other uses of the site. Interactions and integrations are the same as for room. A microcomponent (-5.5) would define each use change within a room, although all uses may be from a single component.			
Activity Area	-6	Specific use of an area identifiable archeologically. Occurs within a room or extramural.	A kin based activity, such as initiation into a society.	The focal area within a room where it was used for economic or social activity.	A grouping of artifacts or features within or outside a room associate with a specific use or set of uses that are identifiable.