

GEOMORPHIC INVESTIGATION OF NORFORK RESERVOIR
ARKANSAS AND MISSOURI

by

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PREFACE

This investigation was authorized by the U.S. Army Engineer District, Little Rock, Corps of Engineers, on DA Form 2544, Order No. 88-138, "Geomorphic Investigation of Norfork Reservoir, Arkansas and Missouri," dated 29 August 1988. This investigation was begun and the report prepared during the period 1 October 1988 to 31 March 1989.

The report was written by Mr. Joseph B. Dunbar and Mr. Francis J. Coulters, Geological Environments and Analysis Section (GEAS), Engineering Geology Branch (EGB), Earthquake Engineering and Geosciences Division (GD), Geotechnical Laboratory (GL), U.S. Army Corps of Engineer, Waterways Experiment Station (WES), Vicksburg, MS. Mr. Dunbar was the project geologist and was responsible for organizing and supervising the study. Mr. Bennie Washington assisted with the report preparation and prepared the illustrations.

A field reconnaissance of the Bull Shoals project area was conducted during the week of 25 to 29 October 1988 by WES geologists and personnel from Archeological Assessments Inc. in Nashville Arkansas. Dr. Jack Bennett, Mrs. Mary Bennett, and Mr. John Northrip of Archeological Assessments Inc. assisted and provided valuable information to the WES field party.

This work was performed under the direct supervision of Mr. Robert J. Larson, Chief GEAS, and the general supervision of Dr. Lawson M. Smith, Chief EGB, Dr. Gus Franklin, Chief GD, and Dr. William F. Marcuson III, Chief GL.

COL Dwayne G. Lee, CE, is the Commander and Director of WES. Dr. Robert W. Whalin is the Technical Director.

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PART I: INTRODUCTION

Background

The following study identifies the different landforms in the Norfork Reservoir area and provides detailed information about these landforms. This study is intended to aid archaeologists in locating and evaluating cultural resources in the project area by establishing a geomorphic framework for subsequent cultural resource surveys. Previous studies have shown there are well defined landform site associations (Dunbar and Coulters, 1989; Dunbar and Coulters, 1988; and Smith, Dunbar, Britsch, 1987). Landforms are evaluated in this study to be areas of high, low, or no cultural site potential based on the distribution of recorded archaeological sites in the project area. Sites are defined by the presence of artifacts. In addition, this study will identify important characteristics about the landforms in order to evaluate the natural and human impacts to sites. A geomorphic approach to cultural resource surveys should enable archaeologists to better manage the cultural resources in their jurisdiction, obtain more information about these cultural resources, and hopefully, provide a better understanding of prehistoric man's relationship to his environment.

Purpose and Scope of Work

The purpose of this study is to define the geomorphology of the project area and in order to assist the archaeologist in identifying and evaluating the cultural resources in the Norfork Reservoir area. This report will

provide the archaeologist with a geomorphic framework that will identify and define the different geomorphic landforms in the study area, the geomorphic processes that are operating and are responsible for the present landscape, and relate the geomorphic features to the existing archaeological sites in order to predict the locations of undiscovered sites.

Major objectives of this study are as follows: a) map the geomorphic features or landforms in the study area on appropriate scale base maps, b) define the geomorphic processes that have been active in the project area, c) reconstruct to the extent possible, the geomorphic development of the study area and d) determine the archaeological significance of the geomorphic features, especially in terms of aiding in locating previously undiscovered archaeological sites. The following investigation was conducted in three stages: a) geomorphic mapping of the Norfork Reservoir project area, b) limited field investigations of the different landforms, and c) data analysis and report preparation.

Study Area

Norfork Reservoir is located on the North Fork River on the border between Southeast Missouri and Northeast Arkansas. The North Fork River is a major tributary to the White River and part of the main drainage in the Southern Ozarks. The reservoir is formed by Norfork Dam, located approximately 4.8 river miles above the junction of the North Fork and White Rivers. The reservoir area is contained on portions of nine 7-1/2 minute United States Geological Survey (USGS) topographic base maps as shown by Figure 1. Norfork Reservoir is located in portions of Izaard, Fulton, and Baxter Counties in Arkansas and Ozark County in Missouri.

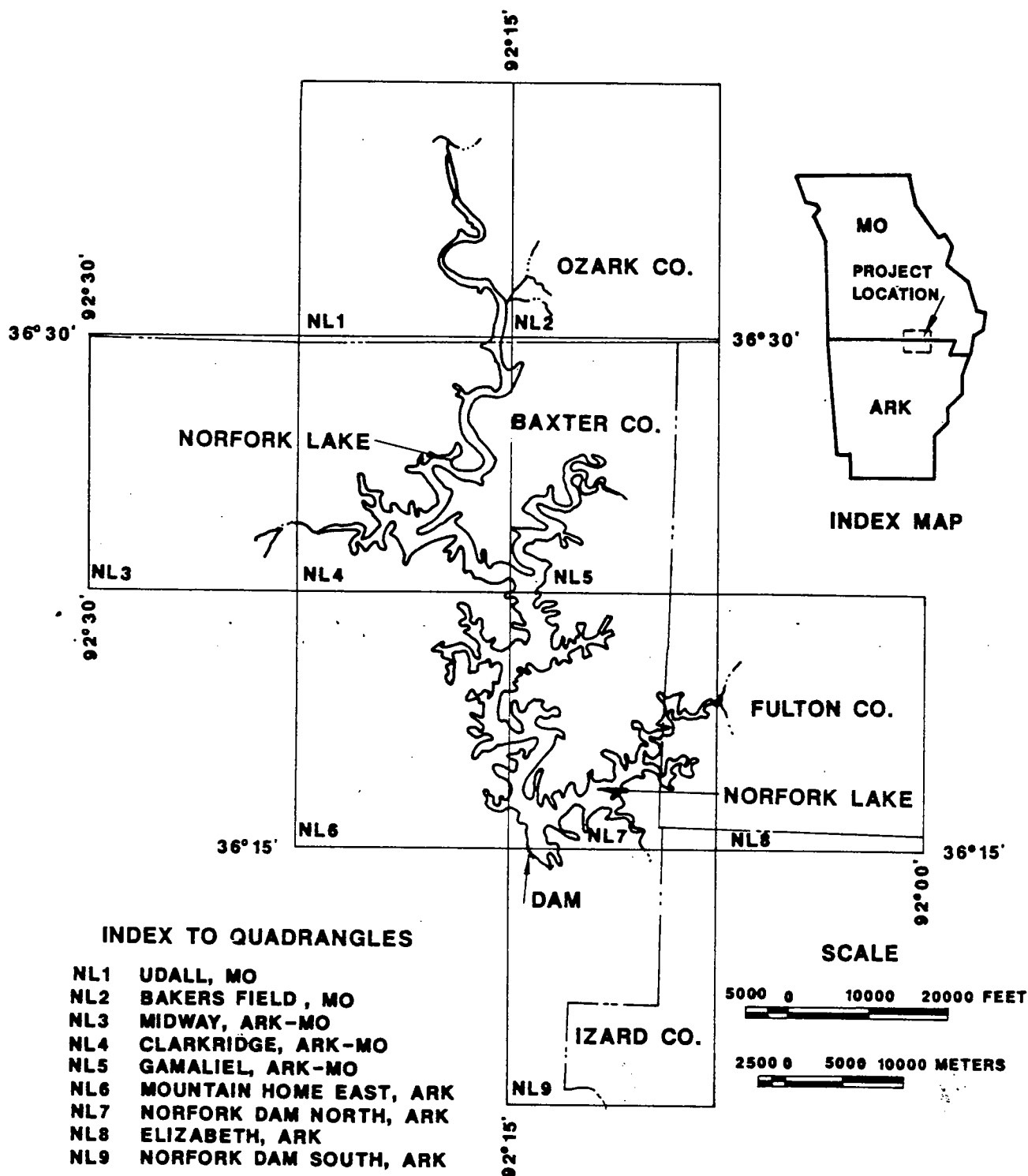


Figure 1. Location map and index to quadrangles

The project boundary used in this study is an inclusive area that borders the entire reservoir and extends from the reservoir surface, up the adjacent hill slope to the hill summit. The project boundary for the stream valleys that are tributary to the reservoir and which are located between adjacent summits is 20 ft (6.0 meters) above the maximum reservoir pool. Consequently, the project boundary is an irregular boundary that was selected in order to evaluate the entire hill slope and flood plain geomorphic systems, rather than a narrow elevation based boundary bordering the reservoir (i.e., 20 ft (6 meters) above maximum pool level). Selection of a narrow elevation based study boundary would ignore the various landscape components and the geomorphic processes that are acting above this boundary.

The Norfork Lake Dam measures 2,624 ft (799.8 meters) in length and 216 ft (65.8 meters) in height above the stream bed (U.S. Army Corps of Engineers, 1984). The surface area of the reservoir at low water (conservation pool at 550 ft (167.6 meters) Mean Sea Level (MSL)) is approximately 22,000 acres and at maximum pool (flood-control pool at 580 ft (176.8 meters) MSL) is approximately 30,700 acres. Construction of the dam began in 1941 and was completed in 1949. The Norfork Dam is a multipurpose dam, providing flood control, recreation, and hydroelectric power.

PART II: GEOLOGY AND GEOMORPHOLOGY

Physiography and Geology

The North Fork River and its tributaries are located within the Ozark Plateau physiographic province (see Figure 2). The Ozark Plateau occupies the greater part of Southern Missouri and Northern Arkansas and is a geologically stable area, composed primarily of Paleozoic (570 to 245 million years (my)) age and older rocks. The Ozark Plateau is subdivided into the St. Francis and the Boston Mountains and the Springfield and Salem Plateaus. The project area is contained within the Salem Plateau. The portion of the Salem Plateau containing Norfork Reservoir is composed primarily of Ordovician (400 to 500 my) age sedimentary rocks.

The North Fork River and its tributaries have incised and formed a well defined drainage basin in the Ordovician age sedimentary rocks in the project area. The sedimentary rocks are primarily cherty dolomites. These sediments dip gently due south at less than three degrees. The Cotter Dolomite and the Jefferson City Formations are the principal formations exposed throughout much of the project area (see Figure 2; from Haley and others, 1976).

The basal unit in the valley walls is the Jefferson City Formation, consisting of cherty, gray to brown silty dolomite. The Jefferson City Formation is approximately 200 ft (61 meters) thick (Thomson, 1982). Overlying the Jefferson City Formation is the Cotter Dolomite, consisting of silty gray to brown cherty dolomite with lenses of sand and locally persistent sandstone beds. Thomson (1982) has identified the Cotter Dolomite as ranging from 100 to 150 ft (30 to 46 meters) thick. Both formations contain cherts which are oolitic and white, gray or black.

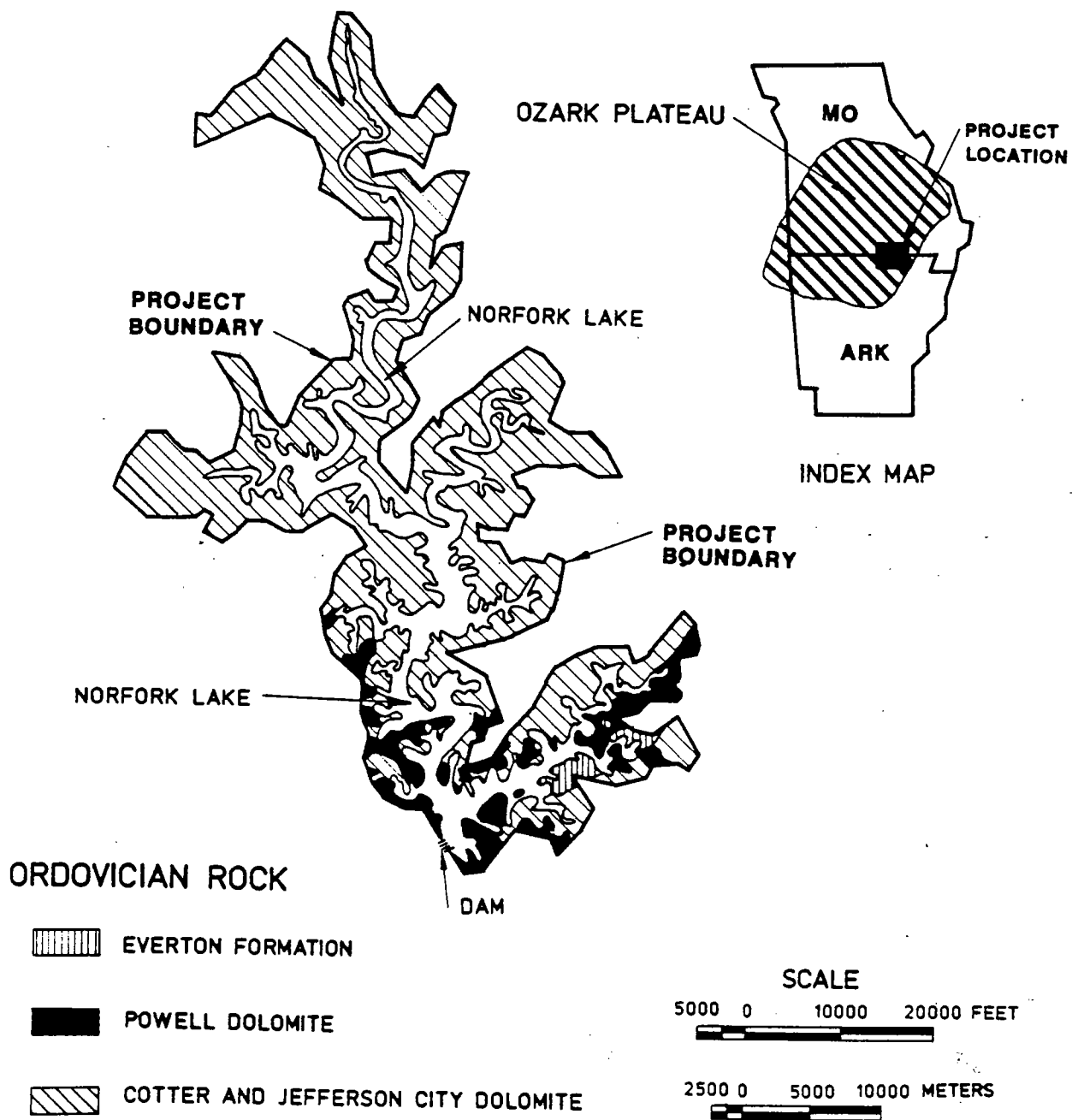


Figure 2. Geology of the project area (from Haley and others, 1976)

In addition to the Jefferson City and Cotter Dolomites, two other formations are exposed in the project area. The Powell and Everton Formations are exposed in the upper parts of the tributary valleys, near the central and southern margin of the project area (see Figure 2). The Powell Formation overlies the Cotter Dolomite and is composed primarily of cherty dolomite with thin sandstone beds. The Everton Formation which overlies the Powell Formation is composed primarily of uniform, fine-grained silica sandstone with occasional lenses and thin beds of limestone and conglomerate.

Geomorphic Setting

The drainage basin of the North Fork River has been evolving since at least the Tertiary (65 to 2 my) Period when the Ozark Plateau began uplifting in response to continental tectonism (uplift). The North Fork River and its tributaries have been downcutting into the underlying sediments and widening their valley walls since the time that a drainage basin began forming on the underlying Ordovician age sediments. The North Fork River system has evolved not only in response to the tectonism, but also changing environmental influences (primarily major climate changes) that have been operating during this time as well.

Changes in climate are short term occurrences when considering the long duration of geologic time that has elapsed between deposition of the Ordovician age sediments and the beginning of a North Fork River drainage basin. However, changes in climate have resulted in major changes to the North Fork River drainage basin when considering the shorter geologic record of Pleistocene (2 my to 10,000 years) glaciation in North America. Glaciation and glacial drainage were not directly connected to the North Fork River as there

are no recorded glacial sediments in the North Fork River Valley. Throughout the Pleistocene the North Fork River was situated near the southern limit of the glacial maxima. The geologic record indicates that the major effects of northern glaciation to the North Fork River system were indirect, primarily through climatic influences.

Climate changes in the North Fork River system are reflected by changes in precipitation and vegetation. Significant changes in precipitation govern the rate at which valley wide erosion occurs and the quantity of sediment being transported to the fluvial system. Vegetation changes occur in response to the different temperature and precipitation characteristics and new vegetation species become dominant shortly after these changes occur. Maximum erosion and downcutting will occur following a sudden climate change when vegetation stress is at a maximum and hill slopes are responding to the different precipitation and erosion levels. Eventually, as new species of vegetation become adapted to the landscape, the erosion rate decreases and the landscape attains equilibrium with the new climatic conditions.

During the Pleistocene there occurred numerous and sudden climate changes in the Ozark Plateau region as the continental glaciers repeatedly advanced and retreated across North America (Flint, 1971; Wright and Frey, 1965). One can only speculate on the specific changes that were brought about by the shifts in climate to a drainage basin such as the North Fork River. It is believed that each time there was a climate change, because of a major glacial advance or retreat, there may have began a new cycle of erosion and/or

deposition within the valley¹. The result of each new cycle was to create a new flood plain surface that reflected the existing climate and system characteristics. The new flood plain surface formed either above, below, or at the same level as the previous flood plain surface.

The net effect of both long and short term tectonic and climatic activity in the North Fork River drainage basin has been the creation of a well established flood plain that has downcut to its present level and formed a relatively narrow valley. There are preserved in the valley walls the erosional/depositional remnants of the North Fork River's path to its present position. These fluvial remnants are terraces, formed from alluvial sediments (depositional type terraces) or river cut, flat topped rock benches (erosional or strath type terraces), and they are situated above the present flood plain. Multiple terrace levels are preserved in the North Fork River drainage basin, both depositional and erosional type terraces.

Geomorphic Mapping and Field Studies

The first objective of the study was to identify and map the geomorphic features within the study area. Mapping was done at a scale of 1:24,000 on nine 7-1/2 minute USGS topographic base maps. Delineation and definition of the primary geomorphic features was accomplished primarily by analysis of topographic data, aerial photography (black and white stereographic coverage, 1:12,000 scale, flown December 1983), and a field reconnaissance survey of the project area. The results of the geomorphic mapping are presented on Plates 1

1. Cycles of erosion and deposition may also occur by mechanisms other than major climate shifts. Flood plain aggradation and degradation may occur from variability within specific climate as geomorphic thresholds in the system are exceeded or from man made impacts to the system.

through 9 (see Figure 1 for quadrangle index). The criteria that were used to define the various geomorphic features in the project area are explained in detail in the next section.

The field reconnaissance of the project area was conducted to verify the results of the geomorphic mapping and to identify general characteristics of the different landforms. The field reconnaissance was a joint effort between geologists from WES and archaeologists from Archeological Assessments Inc. of Nashville, Arkansas. Archeological Assessments Inc. was under contract by the Little Rock District to conduct a detailed evaluation of cultural resources in the headwaters in the Udall Quadrangle area (Plate NL-1) at the time of this investigation. Field activities consisted of site inspections of the various landforms by boat and automobile and limited soil sampling at selected sites. Soil sampling was confined primarily to the terraces in the headwaters of Norfork Lake. The purpose of the soil sampling was to further define terrace characteristics. Soil sampling was conducted with a truck-mounted, chain driven soil probe (3-in., 7.62 cm) belonging to Archeological Assessments Inc. Maximum depth of sampling by the soil probe was about 10 ft (3 meters).

Landform Classification

A literature review of the project area was conducted prior to adopting a landform classification. Data were obtained about the soils, the geology and the geomorphology, and the archaeological sites. In addition, U.S. Army Corps of Engineers construction and environmental impact reports for the dam and the reservoir area were evaluated.

The literature review was conducted to establish basic criteria for a

landform classification in the project area. The primary consideration of the landform classification was that it address both the fluvial and the hillslope geomorphic systems as the project area incorporates features from both. Second, it was important that the classification define the landscape prior to the dam construction (pre-1949) in order to compare different parts of the study area to each other and thereby determine the effects of reservoir flooding. Lastly, it was important that the classification be suited to the mapping scale, be relatively simple to use and still aid the archaeologist in evaluating cultural resources, and also allow for later expansion and definition of additional landforms if desired.

The general landform classification that was used in this study is presented in Table 1 and is shown in Figure 3. The classification contains five primary landforms or map units. The major characteristics of the landforms are included in Table 1. The individual landforms are differentiated according to various physical characteristics such as geomorphic system, slope, geology, composition of the underlying material, apparent age, and the types of processes active on each of the different surfaces. Several of the major landforms have been subdivided further to differentiate some of the more important physical characteristics or processes that are dominant. These additional subdivisions are described in more detail later in this report. Before examining the individual landforms, it is first necessary to examine and review various characteristics of the two geomorphic systems to which these landforms belong.

Table 1.
General landform classification for Norfolk Reservoir (see Figure 3)

Map Unit	Landform	Percent Slope	Slope Angle degrees	Geomorphic System	Slope Type	Type of Material*	Geomorphic Processes**	Landform Age†
1	Summit	<10	<6	Hill Slope	Convex	BR-TS	SFP-BT-SC-ER	?
2	Side Slope	>10	>6	Hill Slope	Convex- straight- concave	BR-TS	SFP-BT-MM-ER	?
3	Foot Slope	5-10	3-6	Hill Slope	Concave	COL-BR-ALUV	SFP-BT-DCOL-ER-VA	?
4	Terrace	<10	<6	Fluvial	Concave	ALUV-BR	SFP-BT-ER-VA-FS	P-H
5	Flood Plain	<5	<3	Fluvial	Horizontal	ALUV-BR	VA-LA-BT-FS-ER-SFP	H

* BR = Bedrock (primarily Ordovician dolomites), TS = Thin residual soil, COL = Coluvium, ALUV = Alluvium.

** SFP = Soil forming processes (pedogenesis), BT = Bioturbation, MM = Erosion by mass movements (SC = Soil creep, Rock falls, Rock slides, Debris flows, Soil falls), ER = Erosion by sheet wash, rill formation, and gully formation, DCOL = Deposition of erosion products from MM and ER, LA = Lateral accretion, VA = Vertical accretion, FS = Fluvial scouring.

† H = Holocene (<10,000 years), P = Pleistocene (2 million - 10,000 years), ? = Unknown-estimated to have begun during Tertiary period (66-2 MY BP).

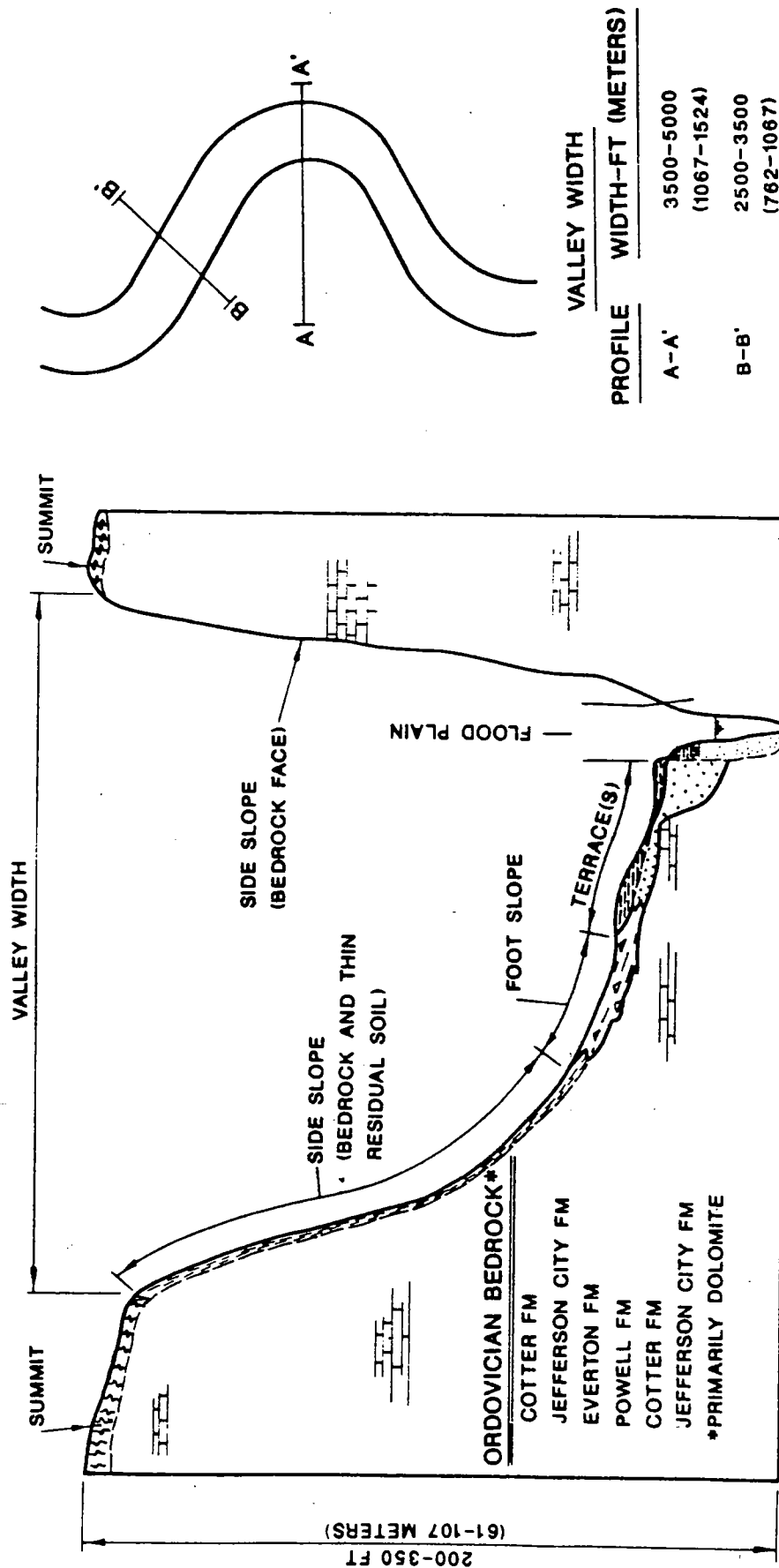


Figure 3. Idealized valley profile showing the major landform units and general range in valley widths (see Table 1 for general landform characteristics)

Hill Slope Geomorphic System

Introduction

It is not the purpose of this study to examine in detail the characteristics and processes of hill slope systems. It is necessary however to identify important concepts and processes of the hill slope system as it relates to the project area. A more detailed presentation of hill slope systems can be obtained in a number of good reference texts on the subject (see Fairbridge, 1968; Carson and Kirkby, 1972; or Leopold, Wolman, and Miller, 1964).

Many different geomorphic processes are responsible for the creation of a hill slope. The shape of a hill slope is determined by the relationships between the weathering of the underlying parent material and the transport of the weathering products down slope, usually to a fluvial system at the base of the slope. Weathering is the basic mechanism by which the underlying rock is decomposed and disintegrated. It encompasses both chemical and physical processes. The main transport agents of the weathering products are running water, ice, wind, mass movements, and biological disturbances. These different processes have been ongoing in the project area for millions of years, at least since the beginning of the Tertiary Period when the Ozark Plateau was uplifted.

Weathering

Physical weathering (disintegration) occurs by a wide variety of methods. The methods include impact and abrasion of particles from the action of running water and wind, ice and freeze-thaw relationships, differential mineral expansion from temperature variability, wetting and drying phenomena,

and organic activity. An important organic activity in physical weathering is bioturbation, biologically produced soil and rock disturbances. These disturbances include the movements of burrowing organisms and root growth.

Chemical weathering (decomposition) involves complex chemical reactions between earth materials and the earth's atmosphere and hydrosphere. These reactions result in the decomposition of the underlying rock and the formation and development of a soil profile. The final product of these various chemical reactions is the reduction of rock to clay minerals and the liberation of soluble ions. Vegetation is another major factor in the chemical weathering process by facilitating organic acids formation from the decayed vegetation and thereby affecting soil pH. The organic acids form weak solutions which contribute to rock decomposition. The rate at which chemical weathering occurs is a function of the composition of the parent material and the climate. Climate governs the available precipitation and controls the temperature of the earth's atmosphere and the earth materials in contact with the atmosphere. Other factors affecting chemical weathering rates, include the length of time during which weathering has occurred and topography (slope) of the area.

Sediment Transport

The main agents of sediment transport in the project area are running water and mass movements. Precipitation erodes the surface materials by forces produced from rain impact and by the movement of surface water. The movement of surface water will occur first by sheet wash, the down slope movement of surface water as a thin continuous layer. This water begins to erode tiny rills into the ground surface, which at a point downstream, merge into and form a permanent drainage gully. The gullies combine to form a larger-scale intermittent stream channel. These seasonal flowing channels in turn combine to join a permanent stream that is capable of forming a flood plain.

At some point down stream, the drainage collects into a major stream channel such as the North Fork River. The rills, gullies, various intermittent and permanent streams, and the major channel collectively form a drainage basin.

Sediment transport by mass movements is less frequent than precipitation events. However, mass movements as the name implies involves the transport of large volumes of earth materials rather than the movement of single particles during a precipitation event. Fairbridge (1968) identifies two basic classes of mass movements. The first class of movements are surface movements which simply transfer debris down slope in a layer over bedrock. The major type of movement in this class is soil creep, the imperceptible movement of materials down slope under the influence of gravity.

The second class of movements are deep-seated, involving the underlying parent material, and they occur generally at a much faster rate. A general classification of deep-seated mass movements is presented in Figure 4 (from Ritter, 1978; after Varnes, 1958). There are two general types of deep-seated mass movements, flows and slides. The type of mass movements is a function of slope angle, composition of the earth materials, moisture content of the earth material mass, and the vegetation characteristics of the hill slope. The main driving forces behind these movements are gravity and climate. Each of these different types of weathering and sediment transport mechanisms has occurred in the project area during the geologic past. These different processes are occurring presently and they will continue to occur.

Slope Form

There are three basic components to a hill slope (see Figure 5); a convex crest or summit, a straight or rectilinear side slope, and a concave foot slope (Fairbridge, 1968). The three components can combine to form complex slopes that reflect characteristics about the underlying geology and the

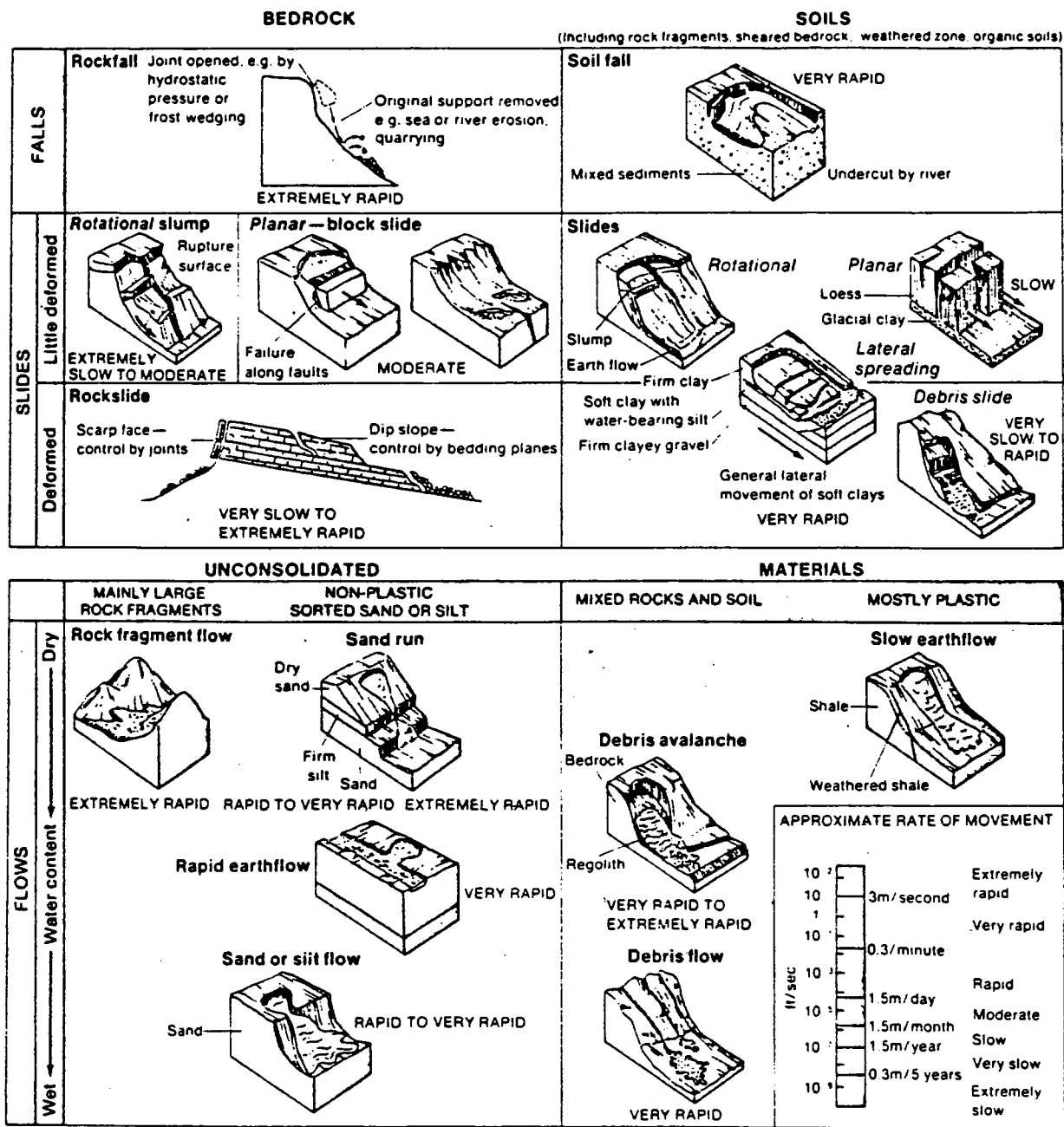


Figure 4. A general classification of deep-seated mass movements (from Ritter, 1978; after Varnes, 1958)

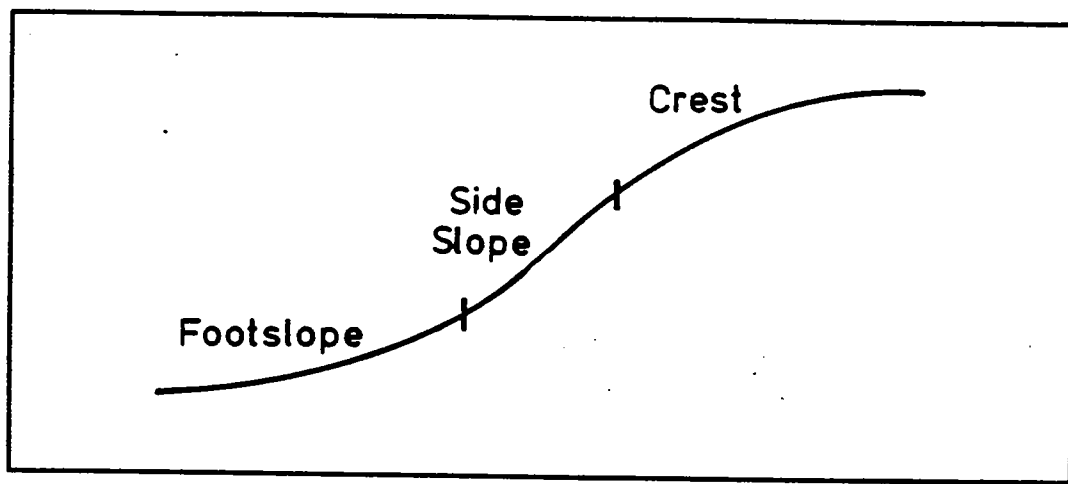


Figure 5. Hill slope components (Fairbridge, 1968)

geomorphic processes that are operating. The geomorphic classification that was used to map the project area is based on slope form (see Figure 5) as a function of slope angle or percent slope. The primary mapping units of the hill slope system are summits (Map Unit 1), side slopes (Map Unit 2), and foot slopes (Map Unit 3) as shown by Figure 3 and 5. Associated with each of these landforms are specific geomorphic processes which are identified in Table 1.

The shape of the hill slope system has been studied in great detail by geomorphologists for the past century. It is an area of geomorphic research where total agreement has yet to be reached between slope form and the specific types of processes that are responsible for these geomorphic shapes. For purposes of this study, it is important to understand that the basic processes described in this section and identified in Table 1 are interacting with each other and the hill slope system to produce a characteristic profile shape.

Fluvial Geomorphic System

Flood Plain Definition

A precise definition of a flood plain is important to this study because the terrace boundaries are partially determined by the limits of the pre-dam flood plain. A definition of a flood plain can have many meanings depending on the individual's perspective. Fairbridge (1968) identified the problem of defining a flood plain and described it as follows:

"To define a flood plain depends somewhat on the goals in mind. As a topographic category, it is quite flat and lies adjacent to a stream; geomorphologically, it is a landform composed primarily of unconsolidated depositional material derived from sediments being

transported by the related stream; hydrologically, it is perhaps best-defined as a landform subject to periodic flooding by the parent stream. A combination of these perhaps comprises the essential criteria for defining the flood plain."

The basic definition of a flood plain as defined by Fairbridge must contain three parts; it must contain elements of topography, geomorphology, and hydrology.

The hydrologic criteria for defining a flood plain must incorporate flood frequency as part of the definition and it becomes the area of the river valley that is subject to inundation by the annual flood or the highest discharge during the year. The question then becomes what is the average annual flood? To resolve this problem, average annual flood is expressed by flood frequency and a probability distribution or recurrence interval. Leopold, Wolman, and Miller (1964) suggest that a flood frequency of 1 to 2 years should be used as the basis for defining a river's flood plain.

The definition of a flood plain as used in this study is that area of the of the river valley that is subject to inundation by a flood with a recurrence interval of two years (see Figure 3), and it must meet the topographic and geomorphic criteria described above in the Fairbridge definition. Also implied by this definition is a stream channel that flows throughout the year.

Defining Flood Plain Limits

The procedure that was used to establish the limits of the flood plain area is based on flood frequency data from USGS stream gaging stations in and adjacent to the project area. At these gaging stations the USGS has defined the 2 year flood interval in addition to others (i.e., 5, 10, 25, 50, etc.). Flood frequency data for gaging stations at Tecumseh, Missouri and at Henderson, Arkansas, obtained from the individual state USGS offices for the general period 1921 to 1950, were plotted as a function of elevation and river mile

upstream from the mouth of the North Fork River (see Figure 6). The general flood plain limits for North Fork River locations in the project area were determined from these two gaging stations. By extrapolating between the two stream gages, the limits of the 2-year flood plain were estimated for all locations. The lateral extent of the flood plain was estimated from the elevation of the 2-year flood stage. In addition to flood frequency data, there is identified in Figure 6 the maximum and minimum pool levels, and the topographic river profile. The topographic river profile represents the point in the river's channel where the specified contour interval crosses the river.

Numerous topographic profiles were constructed for locations throughout the project area to determine the limits of the pre-dam flood plain and to evaluate the impacts of reservoir flooding on both the fluvial and hill slope systems. A representative number of these topographic profiles are located in Figure 7A (see also Figure 6 for profile locations) and the profiles are presented in Figures 7B through 7G (profiles NL-1 through NL-6, respectively). The profiles were mainly constructed in the river bendways. The topographic profiles clearly show the reservoir levels at selected locations in the project area. In addition, the profiles identify the approximate elevations and lateral limits of the pre-dam flood plain. The accuracy of the topographic data from which the sections are based is limited to the nearest 10 ft (3 m) contour interval and was obtained from 1941 preliminary 1:10,000 scale base maps of the reservoir area.

Reservoir flooding has impacted the entire project area. At the minimum pool level (see Figure 6), the reservoir has inundated the pre-dam flood plain to approximately river mile 45 (about the top of the Udall Quadrangle, Plate NL-1). The maximum pool level has completely inundated the flood plain in the project area and a significant portion of the hill slope system. The maximum

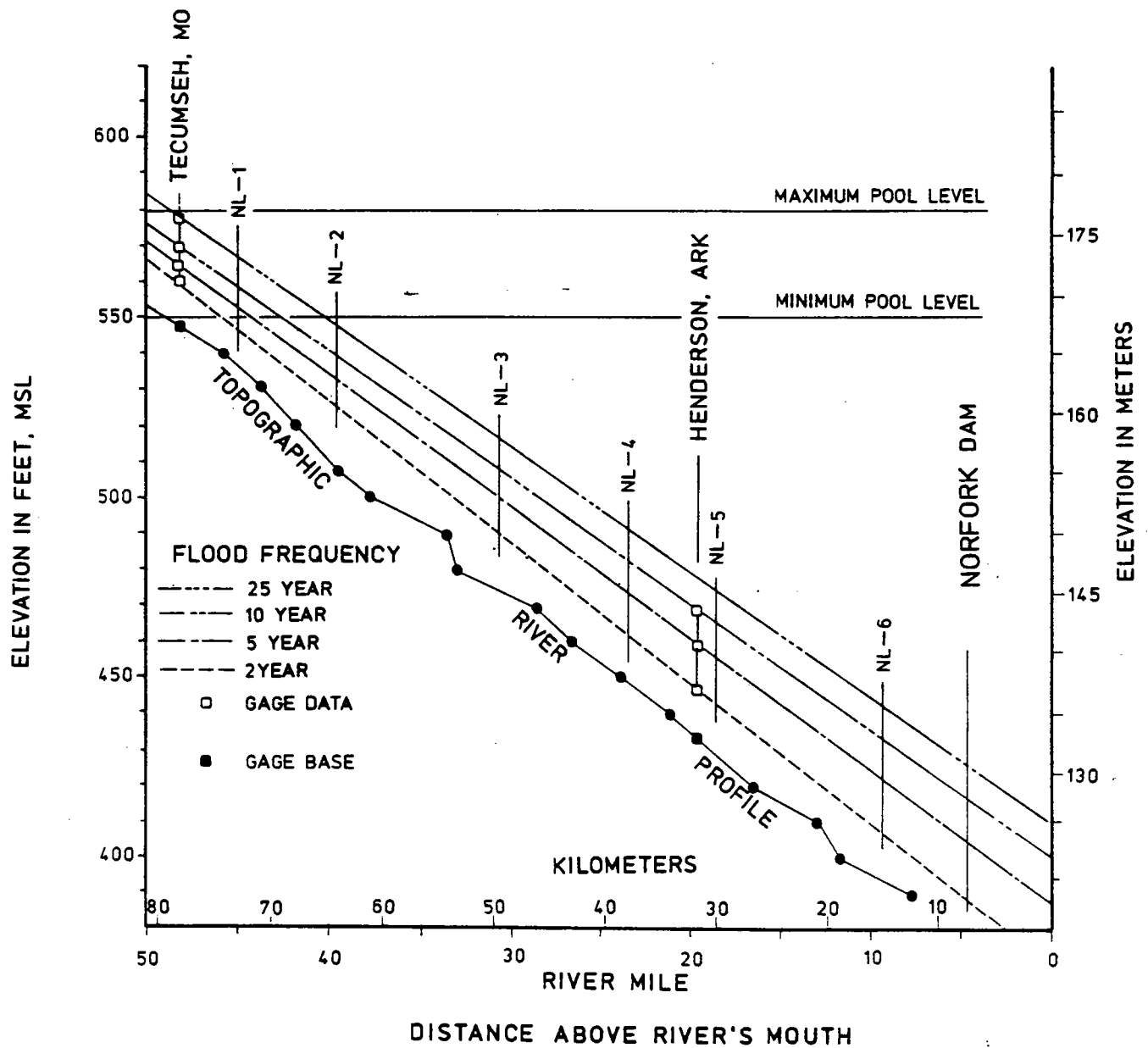


Figure 6. Flood frequency data for the North Fork River prior to construction of Norfork Dam. Gage data from the Missouri and Arkansas USGS state offices. Profiles identified and located above are presented in Figures 7A through 7F

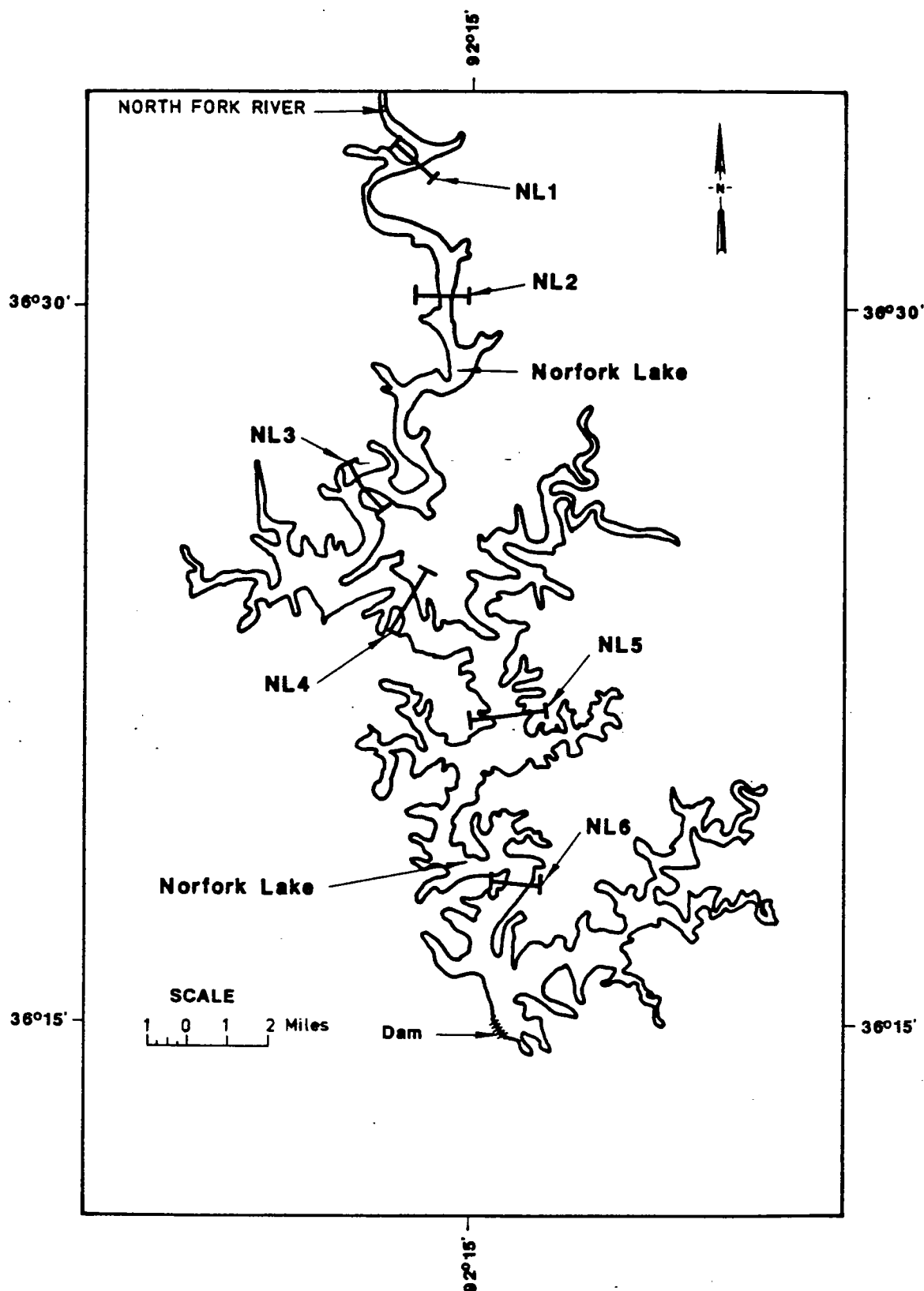


Figure 7A. Index map to topographic and flood frequency profiles

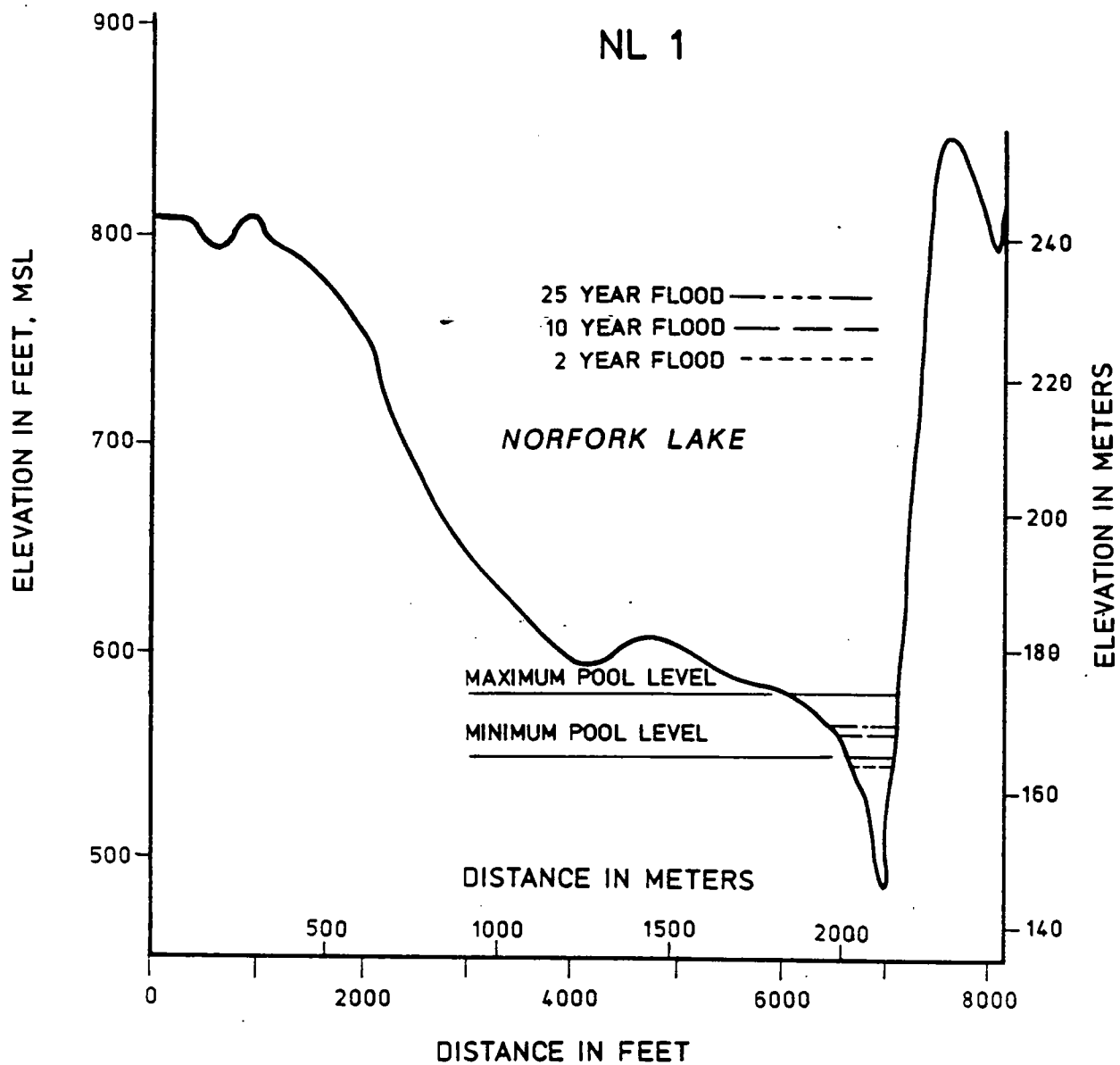


Figure 7B. Profile NL-1 (see Plate NL-1 for exact location)

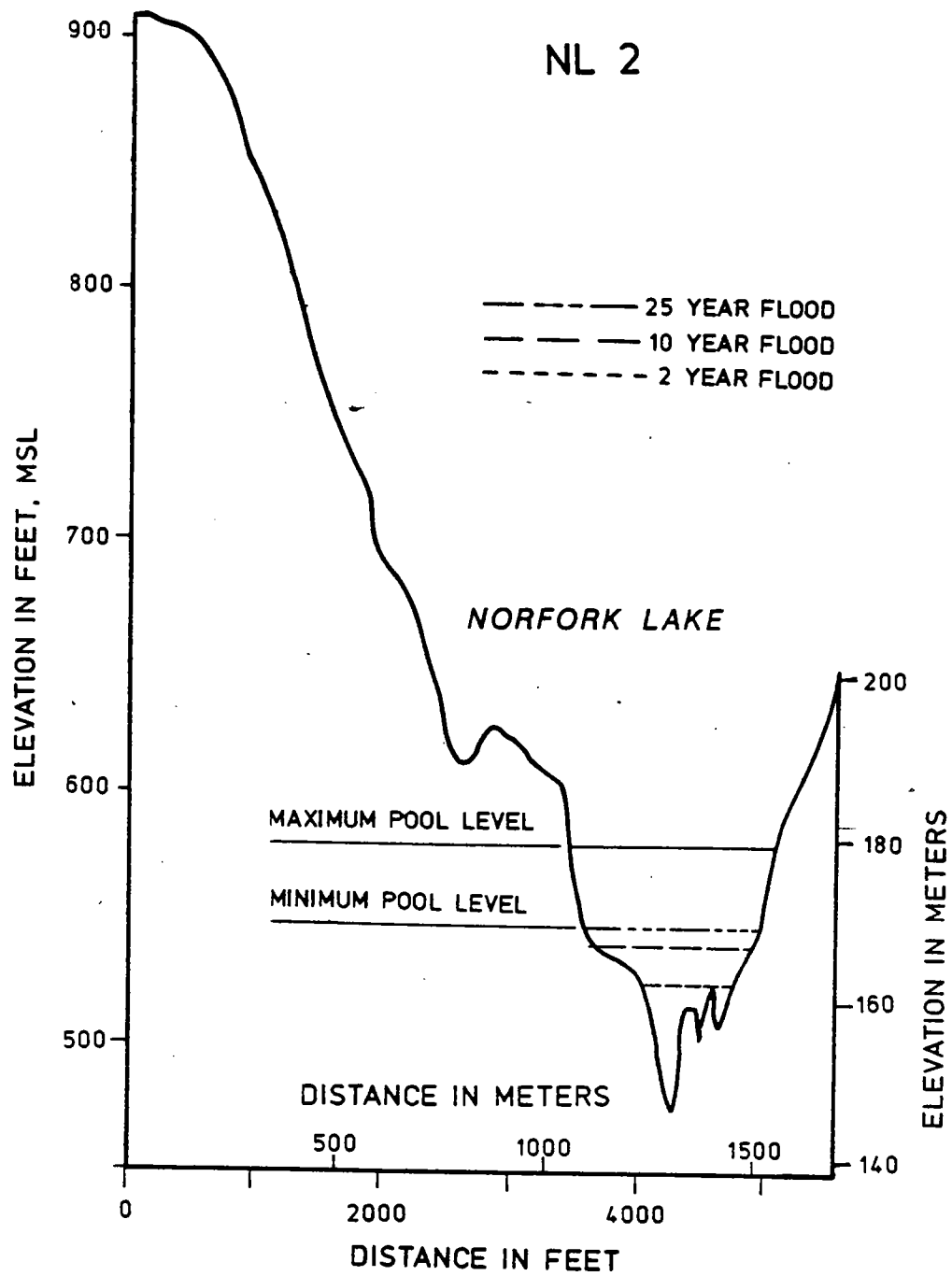


Figure 7C. Profile NL-2 (see Plate NL-1 for exact location)

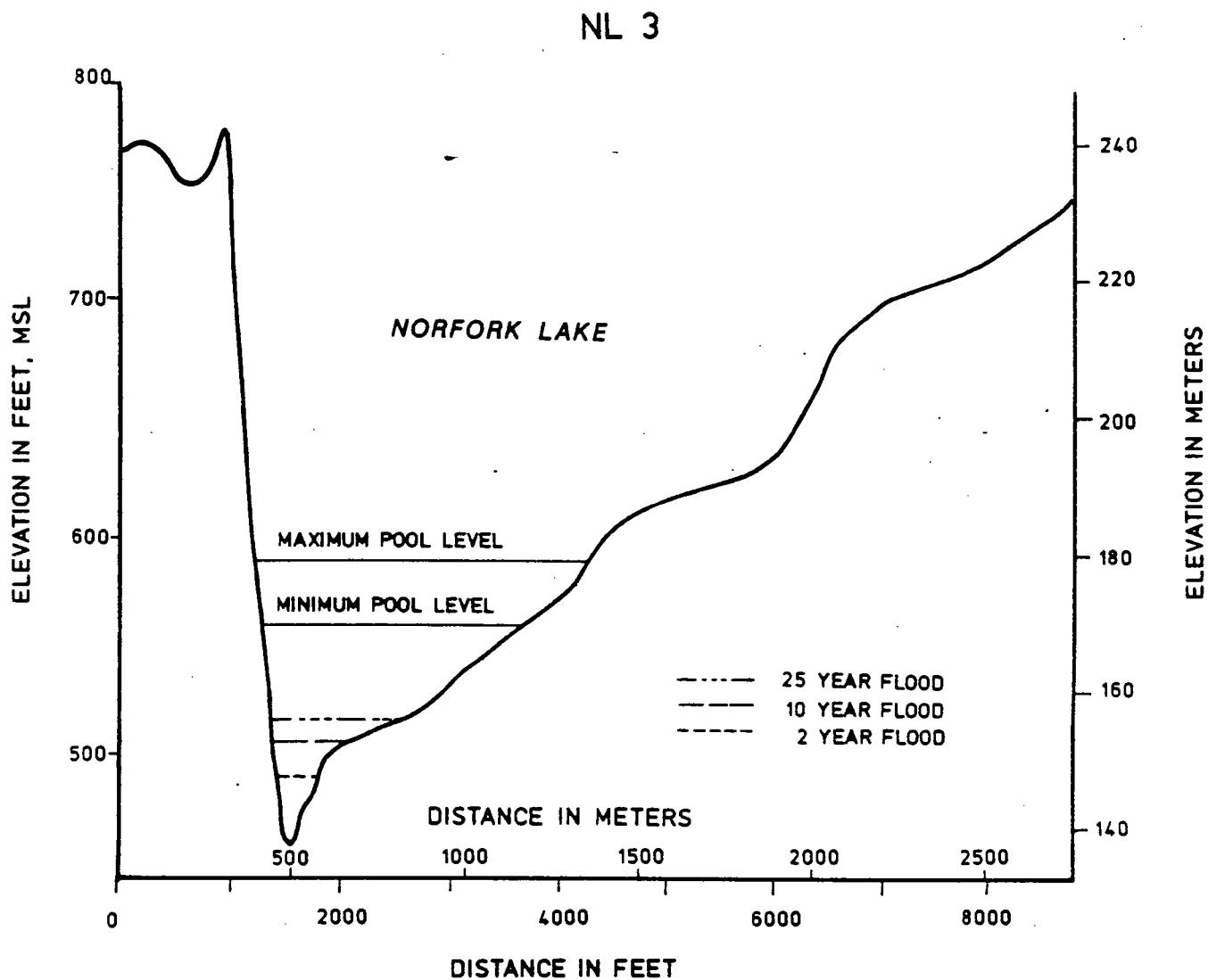


Figure 7D. Profile NL-3 (see Plate NL-4 for exact location)

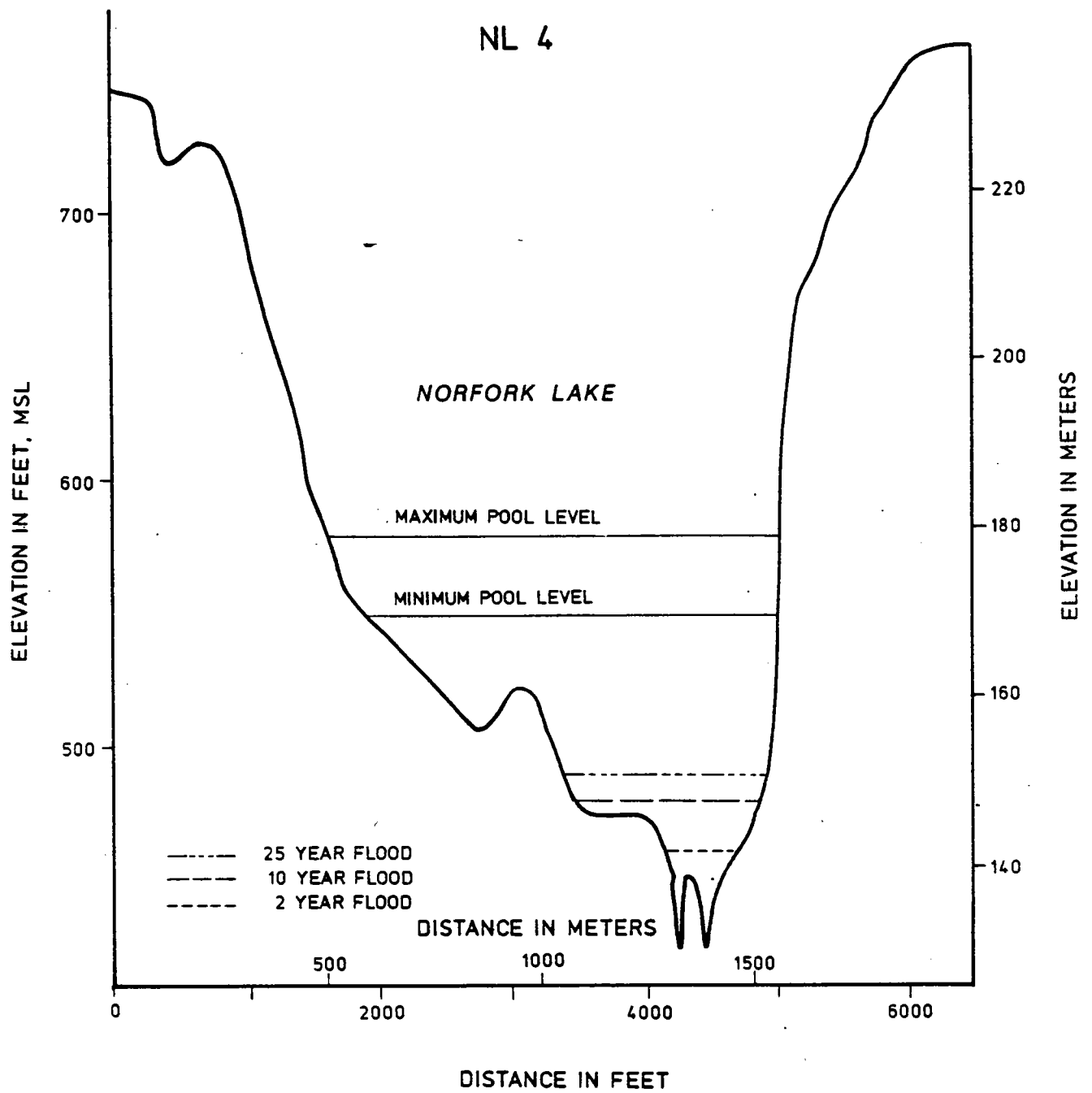


Figure 7E. Profile NL-4 (see Plate NL-4 for exact location)

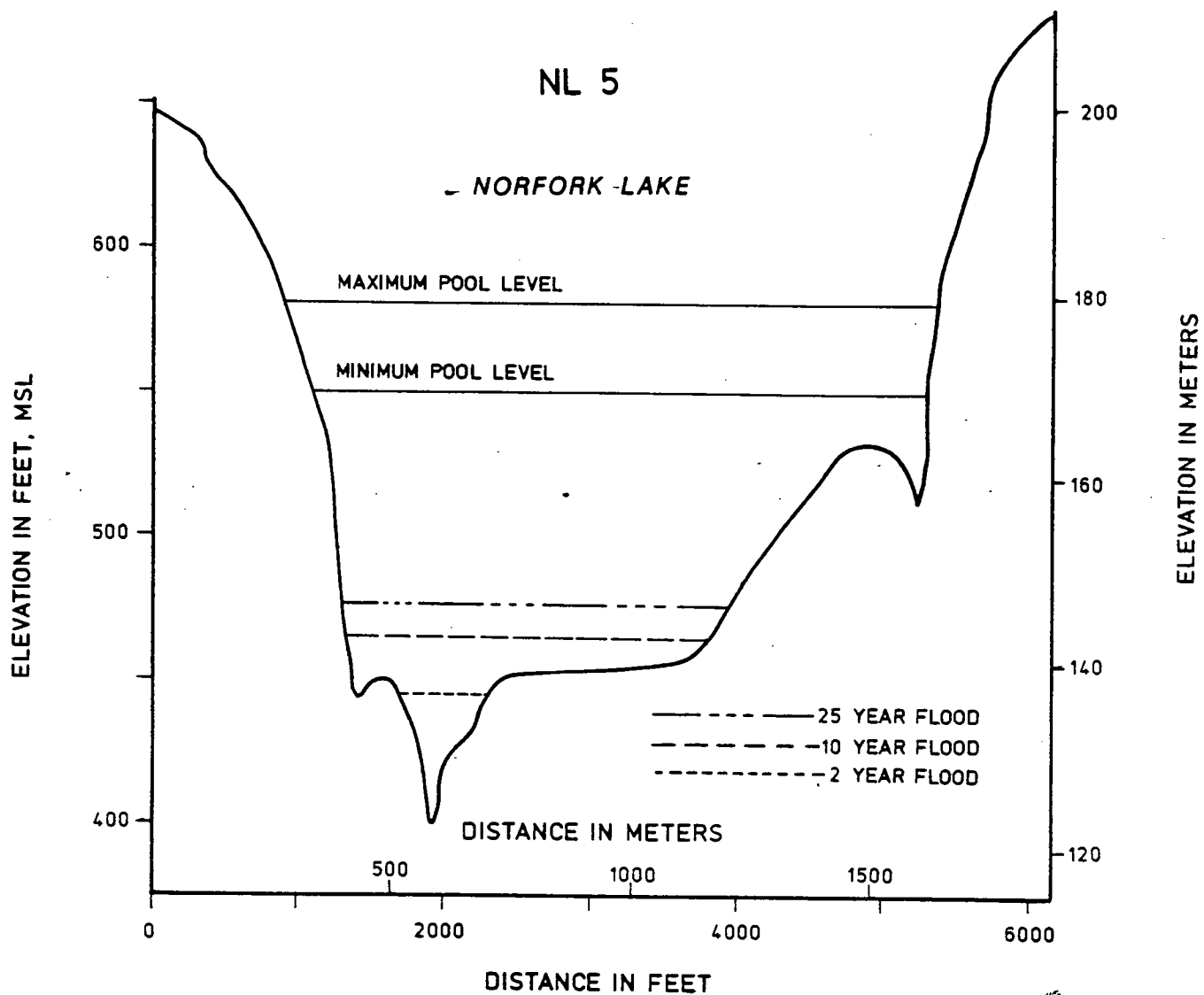


Figure 7F. Profile NL-5 (see Plate NL-7 for exact location)

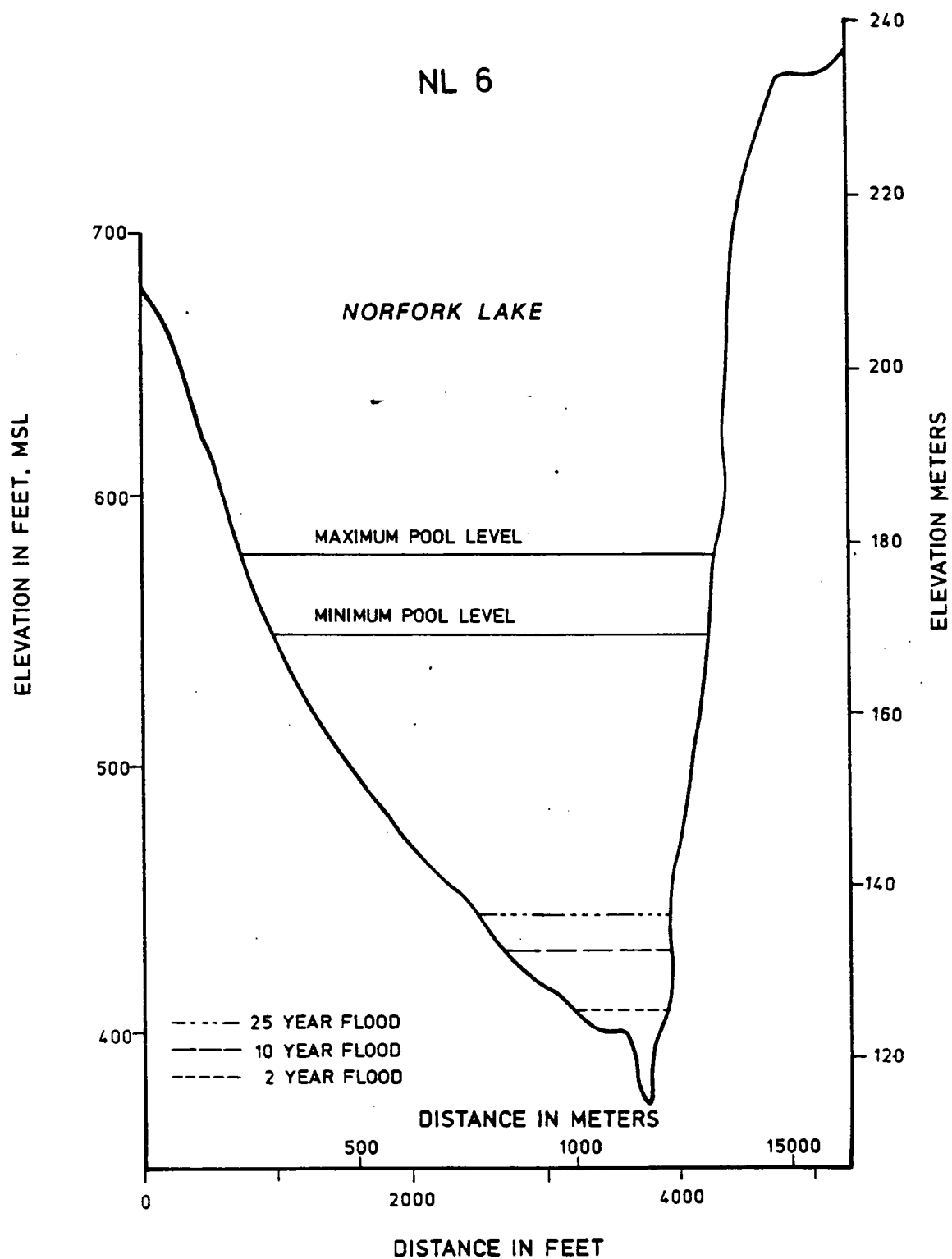


Figure 7G. Profile NL-6 (see Plate NL-7 for exact location)

and minimum reservoir levels for each year since Norfork Lake Dam was constructed are presented in Figure 8 (data from Norfork Project office). High water (elevation above 565 ft MSL) has occurred in 1945, 1957, 1961, 1973, 1979, and 1985.

Types of Flood Plain Sediments and Major Processes

Within the limits of the flood plain area are sediments deposited by the main stream and its tributaries. These sediments are identified as Map Unit 5 on the geomorphic maps (see Table 1 and Figure 3). Fluvial sediments are deposited by only two methods, either by vertical accretion or by lateral accretion.

Vertical accretion on the floodplain occurs during times of high water flow when the river's banks are crested and sediments are deposited on top of the river banks. Sediments deposited by vertical accretion become finer-grained with distance from the stream bank because the velocity of flood water flow decreases with distance away from the channel. The velocity of channel flow determines the maximum sediment grain-size that is transported. Further away from the channel, silts and clays are deposited; while closer to the channel, the more coarse-grained sediments such as fine sand are deposited.

In contrast, lateral accretion occurs within the confines of the river channel. Lateral accretion, as the name implies, is the deposition of sediment in the form of bars in response to channel migration. Deposits formed by lateral accretion are usually coarse-grained, consisting of fine to coarse sand and/or fine gravel because they are deposited in relatively high velocity flows in the channel.

The flood plain sediments formed by the two basic processes described above can be further differentiated according to the different depositional environments in which these sediments are deposited. The different kinds of

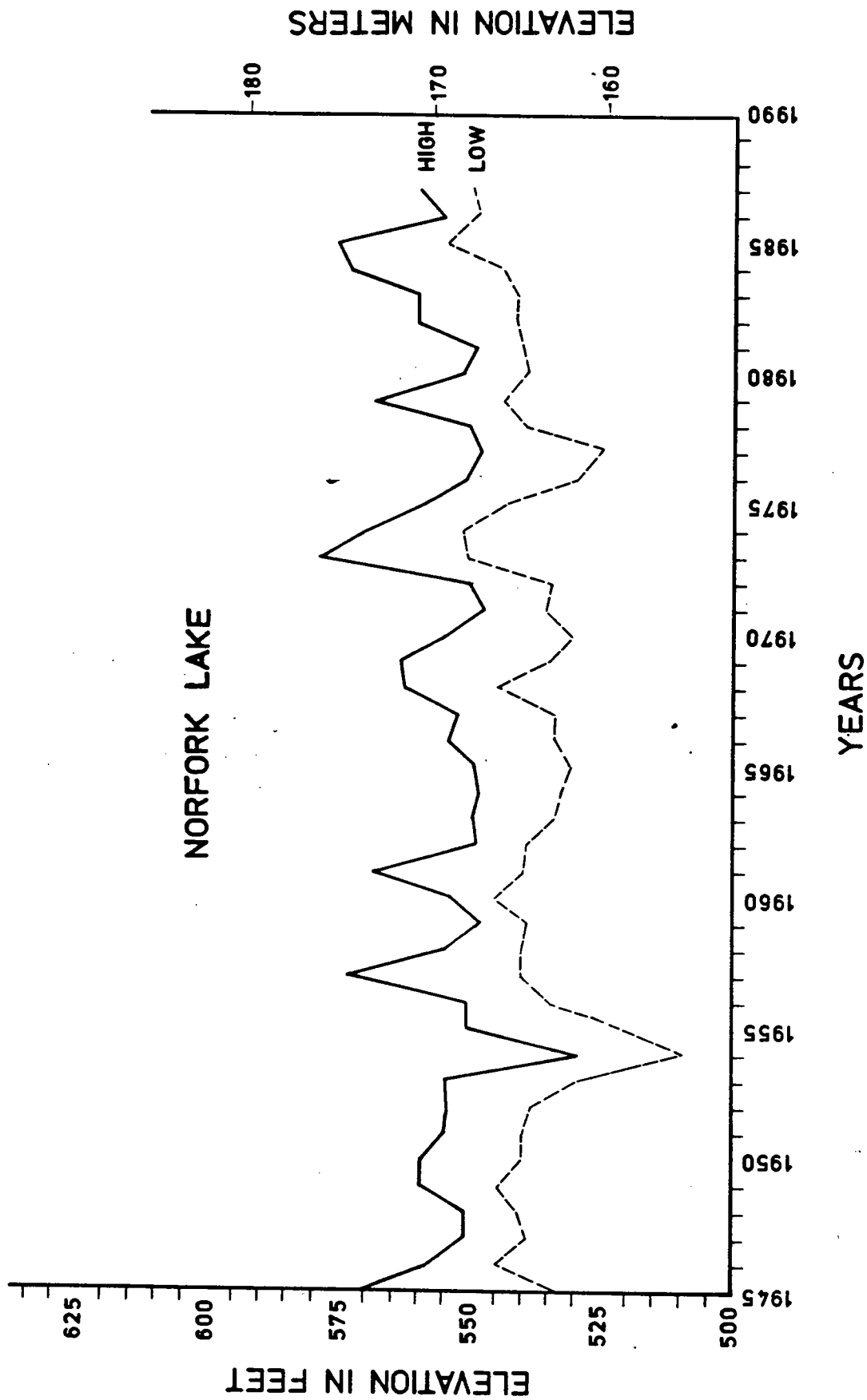


Figure 8. Annual maximum and minimum reservoir levels for Norfork Lake

flood plain environments present in the project area will be individually described in the following section.

Fluvial Erosion and Valley Migration

In addition to deposition, erosion by fluvial scouring occurs along the outside bendways or cutbanks of the North Fork River. In much of the project area the cutbanks are formed from bedrock. Fluvial scouring along the cutbank of the channel and associated deposition on the inside or convex side of the channel, permits a river to migrate across its flood plain. Associated with the valley wide lateral migration of the North Fork River during geologic time has been fluvial downcutting by stream entrenchment. The net migration of the North Fork River across its flood plain in both the horizontal and vertical dimensions has produced a characteristic valley width.

The valley width (width between summits) for the main channel is much different in the channel bendways as compared to the straight river reaches as shown by Figure 3. Valley width is at a maximum in the bendways, almost double the width of the straight river reaches. The net result of both horizontal and vertical migration is best displayed in the channel bendways (see Figures 7B through 7G), where a faint "stair step" character is sometimes displayed on the convex side of each river bendway. These eroded stair steps represent terraces and mark past elevations of the river's flood plain.

Abandoned Flood Plains - Terraces

A terrace is simply an abandoned flood plain surface that remains elevated above the present river's flood plain. Terraces are a transitional landform between the hill slope and the fluvial systems. Terraces will often display characteristics of and receive sediment from both systems. With the passage of time and an increased distance away from the flood plain, terraces may become so altered by hill slope geomorphic processes that the original

fluvial characteristics of the flood plain are destroyed. Terraces are mapped in the study area as Map Unit 4 (see Figure 3 and Table 1).

Bates and Jackson (1980) define a terrace as consisting of a relatively flat or gently inclined surface that is bounded on one edge by a steeper descending slope and on the other edge by a steeper ascending slope. Furthermore, they state that the term terrace is commonly but incorrectly applied to the deposit underlying the surface. The term is used correctly in the context of topographic form rather than identifying the material underlying the terrace surface. Terraces are composed of either fluvial sediments (depositional type terraces) or parent material (rock) that was scoured clean of soil by the actions of the stream (erosional type terrace).

There are other important characteristics that distinguish terrace surfaces from the flood plain in addition to topography and flood frequency. The major characteristic that distinguishes a terrace from a flood plain, in addition to flood frequency and topography, is the development of a soil profile within the fluviially deposited sediments. The presence or absence of a soil profile reflects the types of geomorphic processes that are active in the area and also indirectly identifies the relative time that has transpired for the profile to develop. Soil forming processes and the development of a soil profile are controlled by the composition and physical properties of the underlying terrace surface, the environmental influences (climate and geomorphic processes) to the terrace surface, the topography and slope of the surface, the types of vegetation which are growing on the surface and the land use characteristics of that area (i.e., crop land versus timber, etc.), and the length of time involved in which the soil has developed. These characteristics control the different types of geomorphic and pedogenic processes that are involved in soil formation and they govern the soil profile development.

The field investigation conducted in the Norfolk Reservoir area included examination of soil profiles in cut banks or obtaining soil samples from different terraces for analysis (see Appendix A). The mapping of terraces on the geomorphic maps is based in part on the examination and interpretation of soil samples and soil profiles. The recognition and understanding of the different physical and chemical characteristics of terrace soils is important in differentiating multiple terrace levels and is important in interpreting the geomorphic chronology of the Quaternary in the study area.

Hill Slope and Fluvial Landforms

Summits (Map Unit 1)

Summits are level to gently sloping hill crests characterized by convex slopes. The major processes operating on the convex summits are soil creep and the formation of soil from the decomposition of the underlying bedrock (see Table 2). Associated with these processes are bioturbation and general erosion by sheet wash, rill formation, and gully formation. In general, summits in the project area are tree covered and they are composed of thin, very cherty silt loam soils (Ward and McCright, 1983; and Harper, Fowlkes, and Howard, 1981). Bedrock is often exposed or is present on the surface as angular to subangular gravel and cobbles.

The study boundaries were based on the summit locations. Summits are identified for all the quadrangle maps. Summits may also occur at intermediate levels on the hill slope. Intermediate level summits (benches) are formed by differential erosion of rock of varying resistance or by a change of base level erosion. The main criteria for defining a summit was slope angle (see Table 2) and position relative to the pre-dam and reservoir flood plain.

Table 2.
Expanded landform classification for Norfolk Reservoir

Map Unit	Landform	Percent Slope	Slope Angle degrees	Geomorphic System	Slope Type	Type of Material*	Geomorphic Processes**	Landform Age†
1	Summit	<10	<6	Hill Slope	Convex	BR-TS	SFP-BT-SC-ER	?
2	Side Slope (Soil and Rock)	10-100	3-45	Hill Slope	Convex-straight-concave	BR-TS	SFP-BT-MM-ER	?
2A	Side Slope (Rock Face)	>100	>45	Hill Slope	Straight	BR	MM-ER-FS	?
3	Primary Foot Slope (Permanent Stream)	5-10	3-6	Hill Slope	Concave	COL-BR-ALUV	SFP-BT-DCOL-ER-VA	?
3A	Secondary Foot Slope (Intermittent Stream)	10-20	6-12	Hill Slope	Concave	COL-BR-ALUV	SFP-BT-DCOL-ER-FS	
4	Quaternary Terrace Undifferentiated	<10	<6	Fluvial	Concave	ALUV-BR	SFP-BT-ER-VA-FS	P-H
4A	Quaternary Terrace-Low Terrace	10	<6	Fluvial	Concave-Horizontal	ALUV-BR	SFP-BT-ER-VA-FS	P-H
4B	Quaternary Terrace-Intermediate Terrace	<10	<6	Fluvial	Concave-Horizontal	ALUV-BR	SFP-BT-ER-VA-FS	P-H
4C	Quaternary Terrace-High Terrace	<10	<6	Fluvial	Concave-Horizontal	ALUV-BR	SFP-BT-ER-VA-FS	P-H
5	Flood Plain Undifferentiated	<5	<3	Fluvial	Horizontal	ALUV-BR	VA-LA-BT-FS-ER-SFP	H
5A	Point Bar-Marginal Bar (Lateral Accretion)	<5	<3	Fluvial	Horizontal	ALUV-BR	LA-FS-ER-BT	H
5B	Swamp (Vertical Accretion)	<5	<3	Fluvial	Horizontal	ALUV-BR	VA-BT-ER-FS-SFP	H

* BR = Bedrock (primarily Ordovician dolomites), TS = Thin residual soil, COL = Colluvium, ALUV = Alluvium.

** SFP = Soil forming processes (pedogenesis), BT = Bioturbation, MM = Erosion by mass movements (SC = Soil creep, Rock falls, Rock slides, Debris flows, Soil falls), ER = Erosion by sheet wash, rill formation, and gully formation, DCOL = Deposition of erosion products from MM and ER, LA = Lateral accretion, VA = Vertical accretion, FS = Fluvial scouring.

† H = Holocene (<10,000 years), P = Pleistocene (2 million - 10,000 years), ? = Unknown-estimated to have begun during Tertiary period (66-2 MY BP).

Side Slopes (Map Units 2 and 2A)

Side slopes are the gently to steeply sloping portions of hill slopes. The major geomorphic process occurring on side slopes is sediment transport, mainly by surface erosion and by mass movements (see Table 2 and Figure 4). Slope angle is critical to the kinds of processes that are operating on side slopes and to the types of slopes that will be developed. Rock slopes begin to develop at some critical or threshold angle and the type of mass movement changes from soil to rock dominated movements (see Figure 4). The exact critical angle for the beginning of rock faces is unknown. The minimum angle is interpreted to be about 45 degrees (100 % slope) for the project area. Woody vegetation occurs on both soil and rock side slopes. Other types of geomorphic processes occur on side slopes in addition to sediment transport. These processes are usually minor in comparison and include soil formation, bioturbation, and surface erosion.

Side slopes were differentiated into soil and rock slopes (Map unit 2) and primarily rock slopes or faces (Map Unit 2A). An important aspect of rock faces (Map Unit 2A) in cultural resource surveys is the possible presence of rock shelters or caves.

Foot Slopes (Map Units 3 and 3A)

Foot slopes occur at the base of hill slopes. The major geomorphic process occurring on foot slopes is sediment accumulation. Sediment from surface wash and mass movements are deposited at the base of hill slopes. Because of sediment deposition, foot slopes are concave in profile (see Figure 5). Other geomorphic processes that occur on foot slopes include soil formation, bioturbation, erosion by sheet wash and mass movements, and occasional fluvial scouring and vertical accretion of fluvial sediment during high water periods, when flood flow covers the lower foot slopes.

Foot slopes were differentiated into two general types. The first category of foot slopes are primary foot slopes (Map Unit 3). Primary foot slopes are those associated with a permanent stream channel and a flood plain. Primary foot slopes are adjacent to the major tributaries and to the North Fork River. Primary foot slopes are the least mapped feature of the three components of the hill slope classification. In most of the project area primary foot slopes are underwater. In the headwaters where primary foot slopes are exposed (see Plate NL-1), either the mapping scale (1:24,000 scale and 20 ft contour interval) is too small to differentiate this map unit clearly or the energy of the North Fork River fluvial system has removed the sediment and debris from the base of slopes at a rate where large-scale accumulation of materials was prevented. The lack of primary foot slopes in the project area is interpreted to be from a combination of these two reasons. Primary foot slopes in the project area occur mainly in the bendways of the North Fork River (see Figure 3). This suggests that lateral migration of the stream channel away from the base of a hill slope allows sediment to accumulate because of the decrease in fluvial flooding and scouring (less energy for sediment removal).

The second category of foot slopes are secondary foot slopes (Map Unit 3A). Secondary foot slopes are associated with intermittent stream channels and they lack a true flood plain. Secondary foot slopes occur at a much smaller scale than primary foot slopes and they reflect both fluvial and hill slope processes and sediments. Secondary foot slopes occur throughout the project area.

Often associated with hill slope systems are alluvial fans which form at the base of hill slopes. Alluvial fans are stream deposited cone shaped masses of fluvial sediment formed at the base of steep upland slopes. Because

of the mapping scale or because the energy of the North Fork River fluvial system is able to remove the basal debris, there are no alluvial fans identified in the project area.

Terraces (Map Units 4, 4A, 4B, and 4C)

The terraces mapped on the geomorphic maps are flat or gently inclined surfaces which occur between the hill slopes and the flood plain. The boundary between the terrace and the flood plain was first identified by defining the limits of the flood plain. This boundary was then refined further by incorporating various different types of data into the location estimate. These data included topographic information, soils data from the available county soil survey bulletins, and present land use interpreted from aerial photography and from site investigations. The terraces mapped on the geomorphic maps are judged to be primarily depositional type terraces (i.e., composed of alluvium).

Terraces were identified on the geomorphic maps as Map Unit 4, undifferentiated Quaternary terrace. In the head waters of the project area (Udall Quadrangle; Plate NL-1), multiple terrace levels were identified and they were differentiated as 4A, 4B, and 4C to define low, intermediate, and high terrace levels, respectively (see Table 2). The classification of terraces as low, intermediate, or high implies only topographic position, it does not imply similar age for equivalent levels that are situated on adjacent meanders. A more detailed evaluation of terrace sediments (i.e., primarily definition of soils data) would be necessary to differentiate terrace ages and correlate the different surfaces laterally. Each terrace must be evaluated separately before specific details can be interpreted for the Holocene and Pleistocene chronology of the North Fork River.

As part of the field reconnaissance of the project area, limited soil

sampling was conducted on selected terrace surfaces. In addition, nine borings were drilled by Archaeological Assessments Inc. in early June, prior to the WES field reconnaissance, on a multiple terrace at Ford Cove (see Figures 9A; Figure 9B; and Plate NL-1, Udall Quadrangle). Borings were drilled on each terrace level that was mapped. The terrace levels were determined by topographic position in the field, from the use of 1:10,000 scale topographic maps, and boring data. The soils data from four selected borings are presented in Appendix A and summarized in Figure 9B. The cores were evaluated by a soil scientist contracted by Archeological Assessments.

The different terraces are formed from alluvial sediments which have had sufficient time to develop a soil profile. The soils data identifies buried soil horizons in each boring. The presence of buried horizons suggests a fluvial system that has aggraded and subsequently degraded its flood plain several times while the system was operating at that elevation. Alternatively, each different soil horizon may represent a single major flood event (period) while the river was flowing at that level.

The soil profiles at Ford Cove become more mature with distance up slope from the river. This indicates that the terrace surfaces, located on the convex side of a river meander, generally become older with an increase in elevation and distance from the main channel. It is judged that the lower terrace surface represents a Holocene and/or Pleistocene age surface, while the intermediate and upper level terraces at this location may possibly represent Late or perhaps Middle Pleistocene age surfaces.

Some terraces may have been classified in the geomorphic mapping as being part of the hill slope system. These terraces have downcut into the Ordovician age rocks and are primarily erosional or strath type terraces. This type of terrace occurs as a bench or intermediate level summit and is

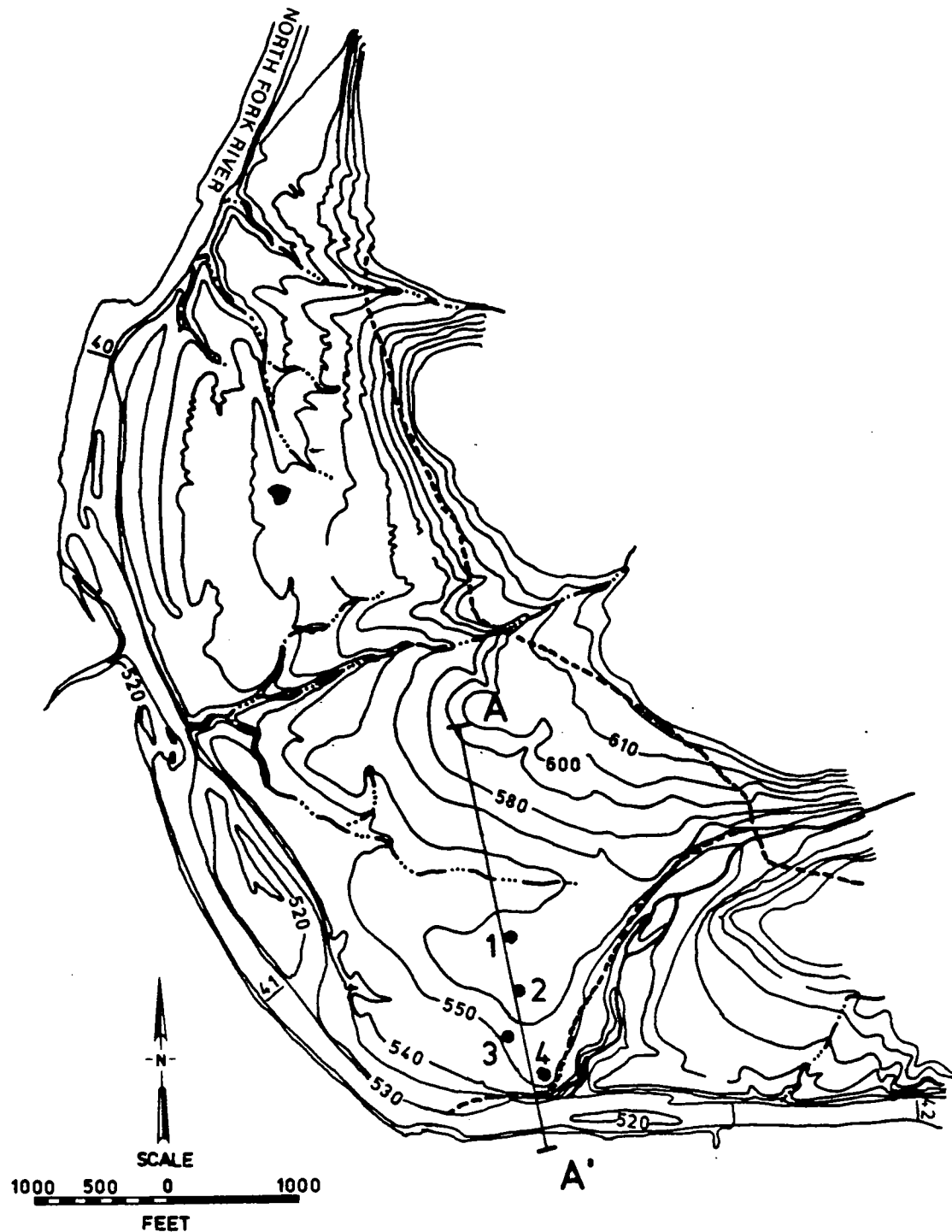


Figure 9A. Location map for Ford Cove borings, see Figure 9B for soil profiles and Plate NL-1 for general location of Ford Cove and geomorphic classification

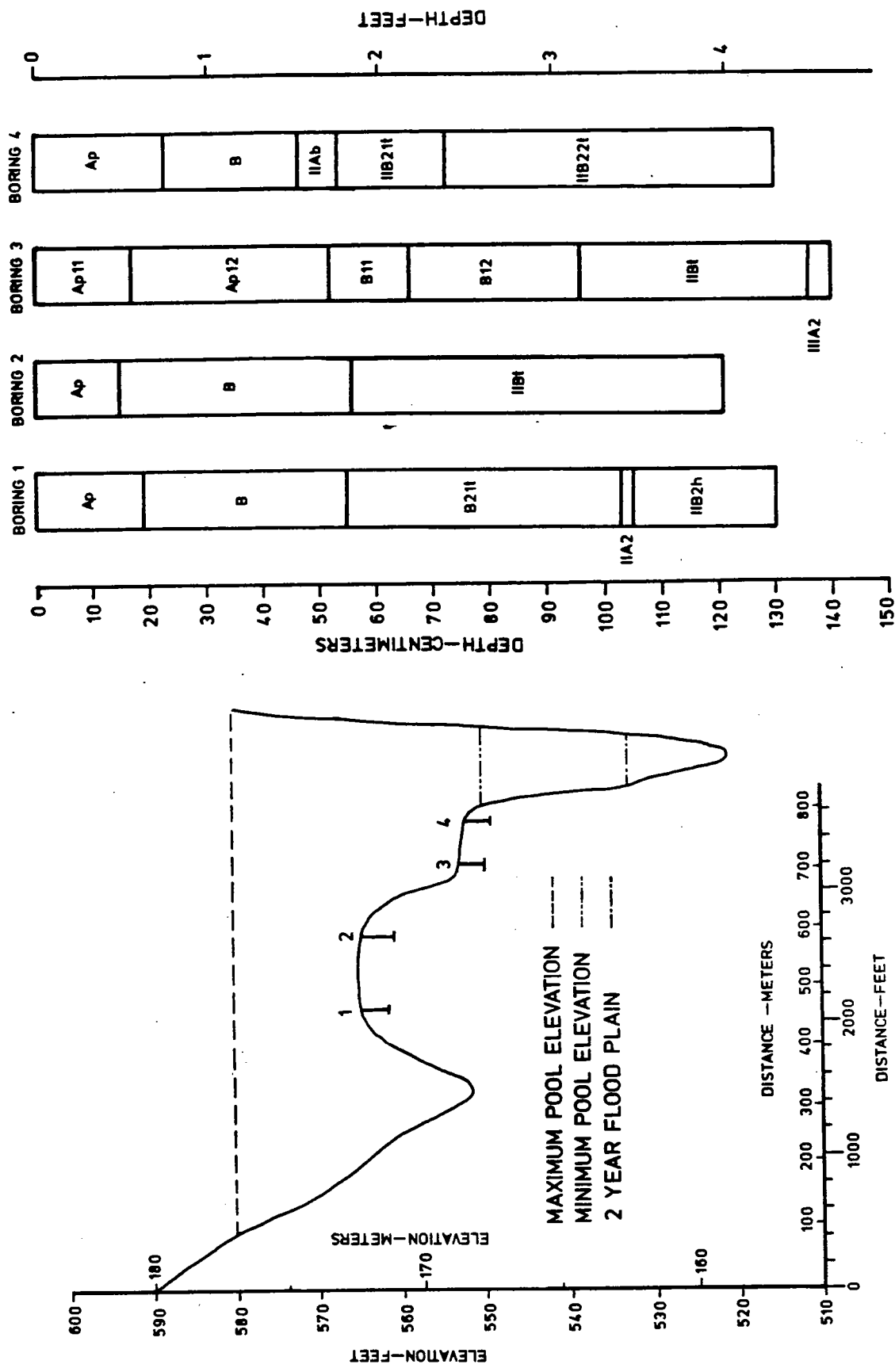


Figure 9B. General topographic profile showing core locations and general soil profiles of Ford Cove borings (see Appendix A for detailed boring logs and Plate NL-1, Udall Quadrangle, for general location).

identified only from field inspections to determine for the presence of alluvial sediments. Usually the fluvial sediments remaining on these terrace remnants are coarse grained, consisting of rounded stream gravels and cobbles. The fine-grained sediments have long been eroded or washed away during the time that has passed since abandonment of these surfaces by the fluvial system. It is estimated that these types of "terraces" were probably abandoned several million years ago. This type of feature is mapped and presently occurs as an intermediate and high level summit. This type of terrace is well above the limits of the pre-dam flood plain.

Flood Plain (Map Units 5, 5A, and 5B)

Undifferentiated flood plain deposits are identified on the geomorphic maps as Map Unit 5 (see Table 2). Flood plain deposits where lateral accretion is dominant were mapped as point bar and marginal bar deposits (Map Unit 5A) and vertical accretion deposits were mapped as swamp (Map Unit 5B).

The major depositional environment forming lateral accretion deposits is a point bar. Point bars are formed as a river channel migrates across its flood plain, depositing a sand bar along the inside or convex bank of the channel. With time, the convex sand bar grows in size and the point bar is developed. Associated with the point bar landform are a series of arcuate ridges and swales. The ridges are formed by lateral channel movement and represent relic sandy lateral bars separated by low lying swales. The swales are locations where fine grained sediments accumulate. Marginal bars form by the same process of lateral accretion, except they tend to develop in straight river reaches. Collectively these two types of sandy deposits form the point bar and marginal bar environment (Map Unit 5A). The principal geomorphic process in this environment is lateral accretion. Other processes that are active include minor vertical accretion, fluvial scouring, bioturbation, and

sheet wash erosion. The point bar deposit is the dominant and the most dynamic environment within the flood plain. Point bar limits were defined primarily from interpretation of the aerial photography and topographic information.

Point bar and marginal bar deposits are as thick as the total depth of the river that formed them. These deposits fine upward from the maximum size of the river's bedload (coarse sand and/or fine gravel) to fine-grained soils (usually silt or clay) at the surface. The basal or coarse grained portion of the point bar sequence is deposited by lateral accretion while the uppermost or fine-grained portion of the point bar sequence is deposited by over bank deposition or vertical accretion.

Swamp deposits (Map Unit 5B) are vertical accretion deposits that receive sediment during times of high water flow, when the river's banks are crested and suspended sediment in the flood waters is deposited in areas well removed from the main channel. Swamp deposits are generally well drained and are covered extensively by mature trees as compared to the active point bar and marginal bar deposits. The principal geomorphic processes are vertical accretion of new sediment from annual flooding of the North Fork River and its tributaries, pedogenesis, and bioturbation.

Swamp deposits were mapped primarily in the upper tributary valleys where streams are intermittent and valley width is relatively wide as compared to the scale of the stream channel. Consequently, swamp deposits are a minor environment in the project area.

PART III: SIGNIFICANCE OF GEOMORPHOLOGY TO CULTURAL RESOURCES

Introduction

Objectives

The last and most important objective of this study is to determine the archaeological significance of the geomorphic features, especially in terms of locating previously undiscovered sites. The major goals of this objective are as follows: a) identify and define the principal archaeological site-landform associations and classify the landforms according to their site potential; b) provide guidance for locating sites that are of specific ages or cultural components; and c) identify areas that have high potential for site destruction or preservation by natural geomorphic processes.

The approach that was used to define the relationships between known archaeological sites and geomorphic features involved identifying the known archaeological sites, evaluating the geomorphic site data from the recorded sites, and identify important characteristics that relate the archaeological sites to the geomorphic features. These characteristics were then evaluated to predict the locations of undiscovered sites according to their geomorphic context.

Procedure

The archaeological site data were obtained from Archeological Assessments Inc. in Nashville, Arkansas. The site data provided by Archeological Assessments Inc. consisted of maps (7-1/2 minute USGS topographic base maps) showing the locations of 82 recorded sites. The sites were examined in the field by Archeological Assessments Inc. in a cultural resource management survey for the Little Rock District. The recorded sites are all located in the

head waters in the Udall quadrangle. There are no sites in the data base for quadrangles south of the Udall quadrangle.

Important geomorphic characteristics from the site location and the geomorphic maps were compiled into a data base for later analyses of the site and landform associations. Important characteristics compiled for the data base include site number, river mile location, site drainage basin, and landform type. The data base is presented in Appendix B. Because of their cultural sensitivity, the known archaeological sites are not individually identified on the geomorphic maps in Plates NL-1 to NL-9.

Archaeological Site Definition

An archaeological site is defined by Willey and Phillips (1958) as the smallest unit of space that marks the location of a single unit of settlement and is usually covered with artifacts or components indicating former occupation. The physical limits of a site may vary from a few square meters to many square kilometers.

An archaeological site for purposes of this study is simply a location where artifacts have been found. The definition of a site as used in this study does not differentiate on whether settlement has occurred as in the definition by Willey and Phillips. There are no restrictions placed on the usage of the term "archaeological site" in this study. A site can be a location where settlement has occurred, or it can be a location that was occupied only once and artifacts were left. An example of such a site is a kill site, a location where an animal was killed and artifacts were left after processing the animal remains.

The primary objective of using the archaeological site data is to show the general relationships between the sites and the landforms. It will be

left to archaeologists to interpret information about the site beyond its geomorphic characteristics. The archaeological site data has been field verified by Archeological Assessments Inc. and should contain no erroneous site data as noted in the Bull Shoals geomorphic investigation (Dunbar and Coulters, 1989). The site locations in the Udall Quadrangle are both point and area locations. Illustrations have been prepared from the data base in Appendix B, specifically about site and landform associations. It is very important for the reader to understand, the actual number of sites that are distributed with respect to each landform are not as important as the general relationships defined by the illustrations that are presented in this section of the report.

Characteristics of an Archaeological Site

The artifacts that make up the archaeological site have by their distribution and position within the site certain temporal and spatial qualities. These qualities are defined by the geographic, stratigraphic, and the ethnographic characteristics of the artifacts (Gould, 1987).

The stratigraphic and geographic characteristics describe physical qualities about the site itself. The geographic characteristics describe the spatial context between the artifacts and their relationships to other artifacts and their environment. The stratigraphic characteristics define the temporal or chronological order of the artifacts and relate these characteristics to the site occupation. Defining the geomorphic setting of the site is an important step in evaluating the geographic and stratigraphic characteristics of the site.

This study describes mainly the geographic (environmental or geomorphic) characteristics of the known archaeological sites. The definition of the site geomorphology is important to understanding the overall site archaeology

as the different landforms are dominated by certain types of geomorphic processes. These different kinds of processes will affect or control the distribution of the archaeological sites and the associated artifacts.

The stratigraphic and chronological characteristics of an archaeological site are not fully addressed by this study. A detailed evaluation of these characteristics, will require the acquisition and analysis of further soil borings on the landforms upon which the individual sites are located. These soil borings will identify important sedimentological and soil forming characteristics and provide datable materials for determining chronologic boundaries.

The last major criteria of an archaeological site is the ethnographic characteristics. These characteristics are determined by the archaeologist. The ethnographic characteristics of the artifacts and the site are concerned with the human qualities of the site. Ethnographic characteristics relate the human occupation to their associated activities and to the different types of cultures. However, before the ethnographic characteristics can be fully understood, the geographic and stratigraphic characteristic need to be fully defined and evaluated.

Distribution of Known Archaeological Sites

Drainage Basin

The recorded archaeological sites (total of 82 sites) were evaluated according to stream valley as shown by Figure 10. Eighty percent of the sites are associated with the North Fork River and twenty percent are associated with the tributaries to the North Fork River. There are 66 sites adjacent to the main channel of the North Fork River and 16 sites adjacent to the North

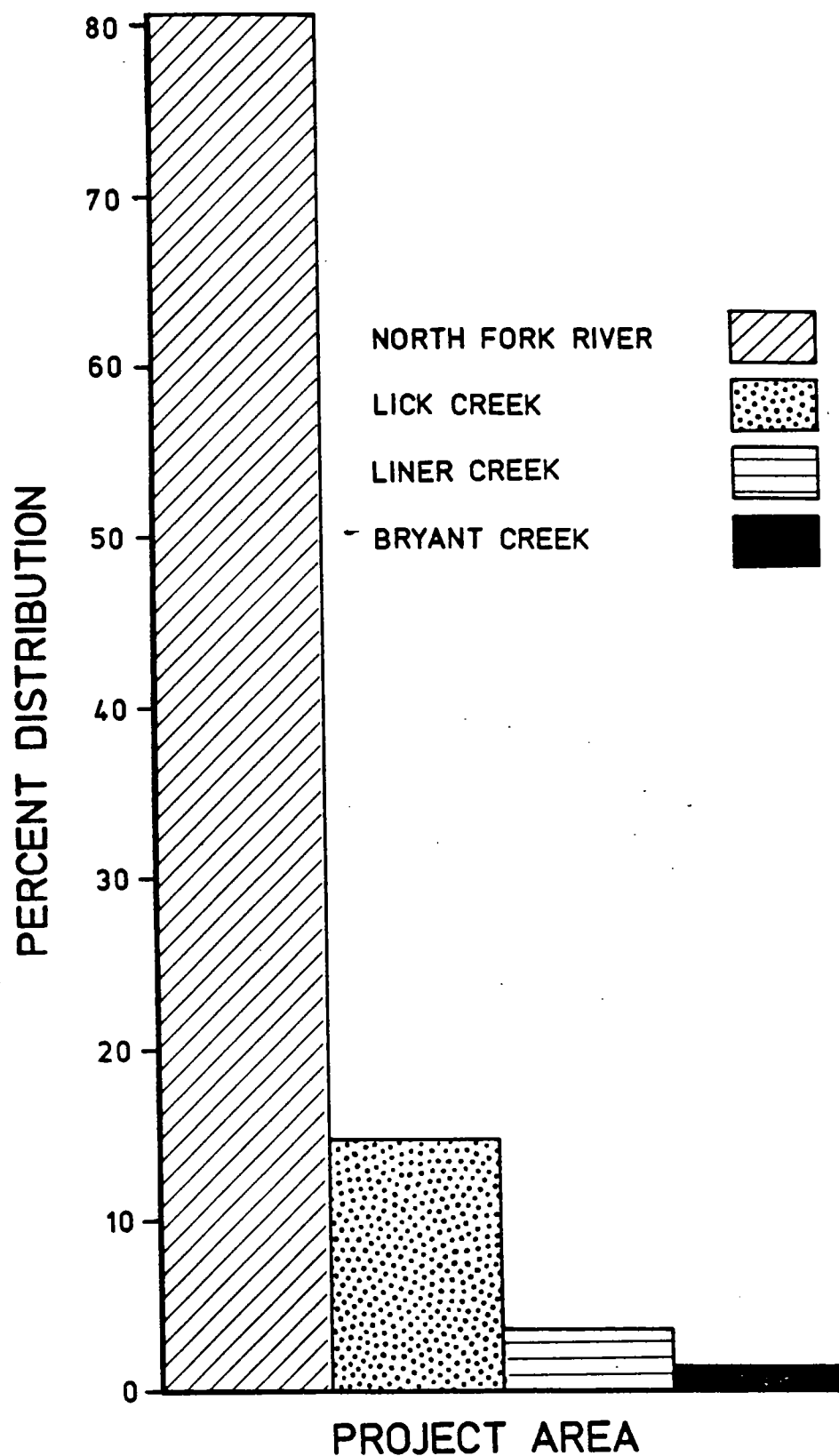


Figure 10. Distribution of archaeological sites by drainage basin for the project area and for North Fork River tributaries. Total number of sites evaluated is 82, 66 sites are located adjacent to the main channel and 16 sites are located adjacent to North Fork River tributaries.

Fork River tributaries. The largest concentration of tributary valley sites is at Lick Creek where there are nearly fifteen percent of the total North Fork River tributary sites. Other tributaries with known sites are Liner Creek, and Bryant Creek. These tributaries contain less than five percent of the known sites.

Landforms

The distribution of the recorded archaeological sites as a function of the different landforms that the sites are located on is presented in Figure 11A for all the sites in the project area and Figure 11B for only the North Fork River sites. The largest concentration of sites are on the Quaternary terraces (Map Unit 4), 56 percent of all the sites (see Figure 11A) and almost 58 percent of the North Fork River sites (see Figure 11B). The remaining sites are approximately distributed in order of occurrence to side slope (Map Unit 2), primary foot slope (Map Unit 3), flood plain (Map Unit 5), and summit (Map Unit 1).

It is estimated that the Udall Quadrangle site distribution is approximately representative of the entire project area. The Udall distribution is very similar to the site distribution at Bull Shoals (Dunbar and Coulters, 1989). A similar distribution is judged significant considering that the site data at Bull Shoals may contain some inaccurate data and also the site data is composed entirely of point locations. The Norfork data contains both point and area sites. The distribution is interpreted to be representative considering the geomorphology and geology at Bull Shoals and Norfork are so very similar.

Elevation, Flood Frequency, and Site Location

The distribution of the known archaeological sites as a function of elevation, flood frequency, and their approximate river mile location above

UDALL QUADRANGLE NORTH FORK RIVER AND TRIBUTARIES

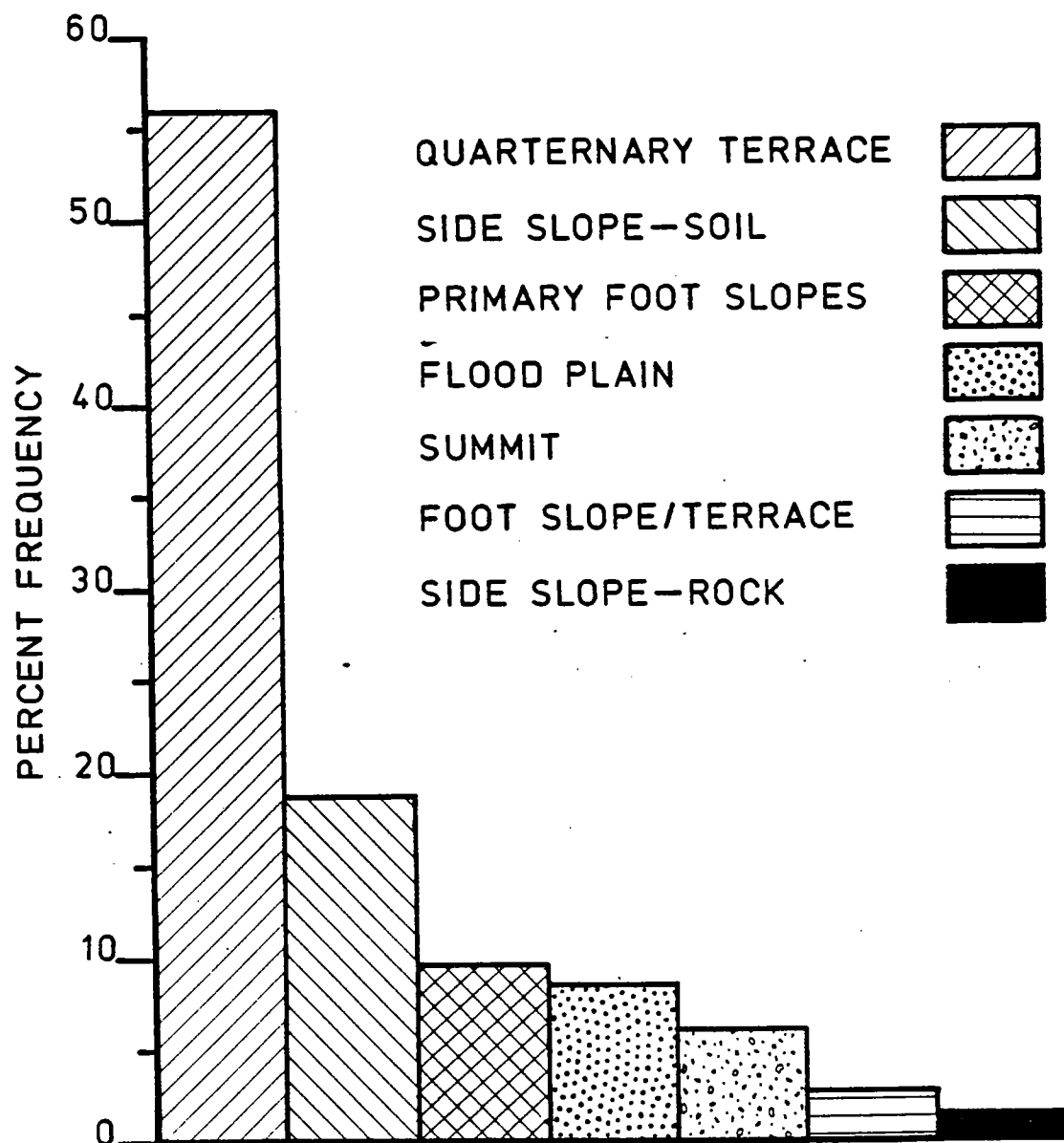


Figure 11A. Distribution of Udall archaeological sites by landform (see Table 2 for landform characteristics)

UDALL QUADRANGLE NORTH FORK RIVER

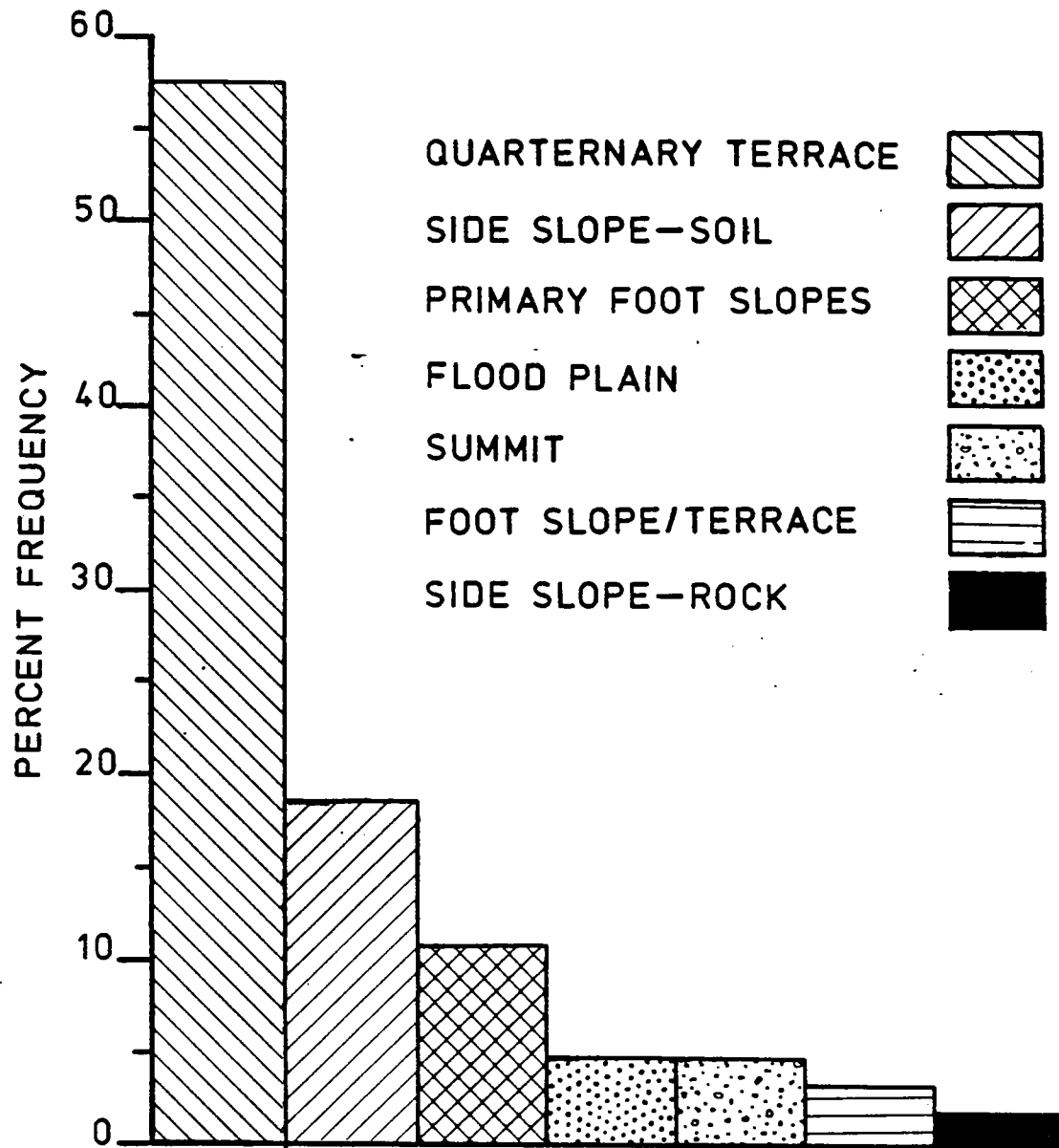


Figure 11B. Distribution of North Fork River, Udall archaeological sites by landform

the mouth of the North Fork River is shown in Figure 12A for the left bank North Fork River sites, and Figure 12B for the right bank North Fork River sites. The sites identified in these illustrations are point and area (landform) locations and the sites are associated only with the North Fork River. The landforms that the sites are located upon are identified in both illustrations except for the unlabeled sites which represent terraces (i.e., darkened polygons). The locations where rock faces occur are identified in Figures 12A and 12B as indicated. The Udall sites occur at or above the pre-dam flood plain. The majority of Udall sites occur between the minimum and maximum pool levels. The terraces are interpreted to be composed of alluvium. The site distributions show well defined relationships with the landforms.

Prediction of Site Occurrence

Introduction

The distribution of the known archaeological sites as identified in the preceding illustrations indicates that sites are not random, but are clearly associated with specific landforms in the project area². The geomorphic relationships identified for the known sites can be used to locate previously undiscovered sites and guide the subsequent archaeological analysis of the site. Hopefully, these relationships will help to improve the efficiency of later cultural resource investigations in the project area and maximize the results obtained. It is hoped that this geomorphic study, in addition to

2. It is assumed that the known site population is representative of the total site distribution for the portion of the drainage basin under study, even though the recorded sites are not uniformly distributed over the project area.

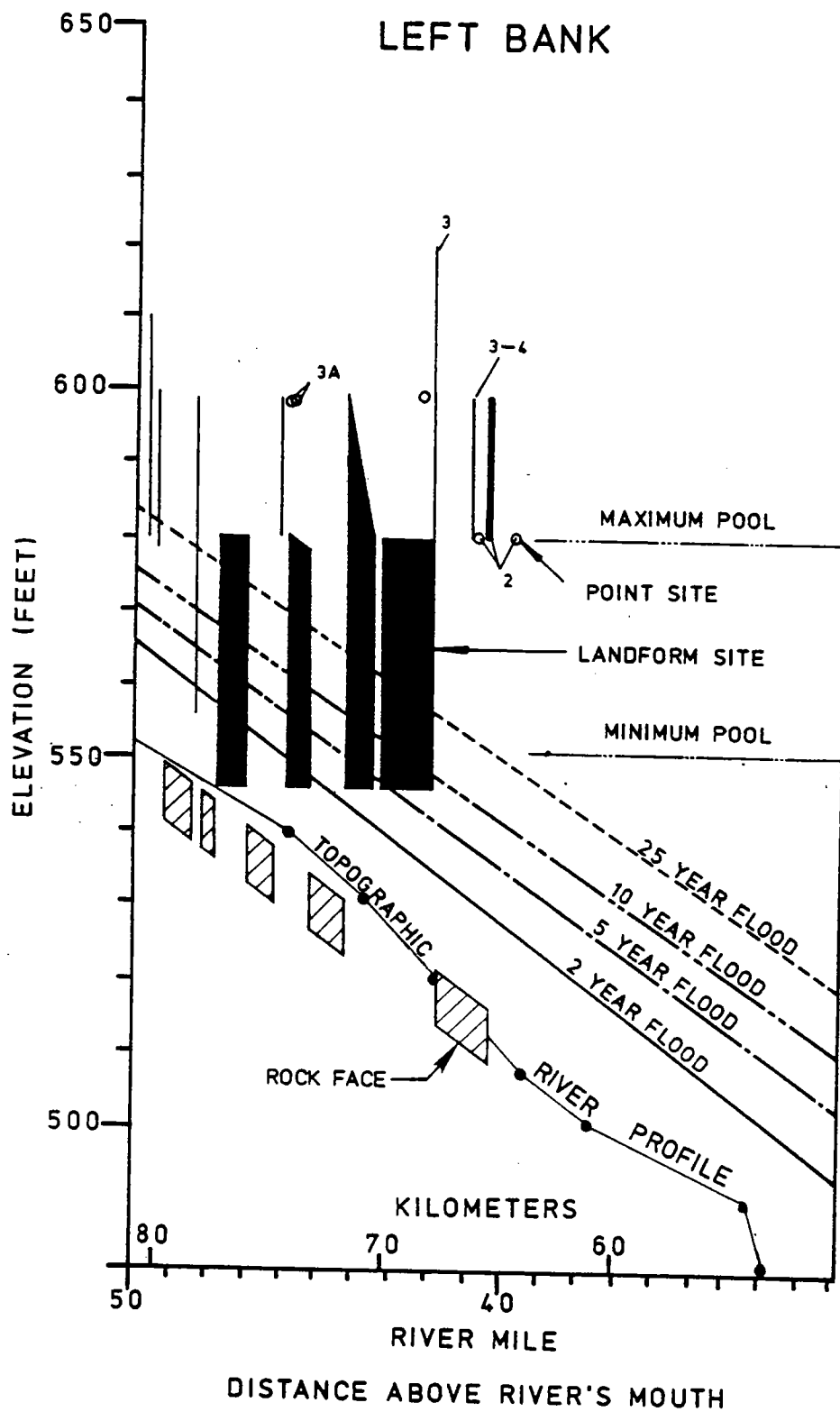


Figure 12A. Distribution of left bank North Fork River archaeological sites as a function of elevation, flood frequency, and distance above river's mouth

locating undiscovered sites, will aid the archaeologist in defining the ethnographic site characteristics. Several generalizations are presented below about the distribution of the known archaeological sites and the landforms which host these sites.

Site Occurrence

Terraces (Map Unit 4) appear to have the highest site potential of all the landforms identified by this study. It is estimated (based on the distribution of recorded sites) that 50 to 60 percent of all the sites in the study area are located on terraces that border the North Fork River and its tributaries. The remaining 40 to 50 percent of the sites in the project area are located in their order of occurrence on side slopes (Map Unit 2), foot slopes (Map Unit 3), flood plain (Map Unit 5), and summits (Map Unit 1).

Terraces identified on the geomorphic maps are primarily depositional type terraces, composed of fluviially deposited sediments. Erosional type terraces such as rock cut terraces do occur, but they are interpreted to occur mainly in the hillslope system. Rock cut terraces are identified by field reconnaissance surveys and subsurface boring data to determine for the presence of fluviially deposited gravels, cobbles and boulders at surface or at shallow depths. Rock cut terraces occur mainly as intermediate level summits and were mapped on the geomorphic maps as being part of summits (Map Unit 1).

Artifact Distribution

The locations where artifacts are most likely to be encountered is on the terraces. Artifacts may be located either on the terrace surface or as part of the fluvial sediments that compose the terrace. Of all the landforms defined by this study, terraces are best for determining the geomorphic chronology of the project area as they may be composed of datable materials and artifacts.

The stratigraphic provenience of datable materials and artifacts is important to reconstructing the Holocene and/or Late Pleistocene chronology of the site, the terrace, and also the project area as a whole. This study did not specifically address the chronological reconstruction of the project area. Conclusions made about landform age as identified in Tables 1 and 2 and in the text are judgmental and based primarily on field observations and laboratory analysis of the available data.

Artifacts that are located on the hill slope, either on summits or side slopes, are considered to be sites that are situated on top of residual soils or fluvial cut rock benches. These locations represent the oldest landforms in the project area. Sites located on foot slopes may represent an actual site or may represent sediment and artifact transport from up slope and colluvial build-up. Foot slope sites may contain artifacts in the subsurface. Artifact depths will depend on the rate of sediment transport for that particular location.

Site Preservation and Destruction

Introduction

In the North Fork River Valley a number of processes are or have been at work either preserving or destroying the evidence of prehistoric groups. Most evident are the processes of historic man such as cultivation of the soil; construction of roads, buildings, and earthen works; and "pot hunting." However, natural processes have also played a key role in the preservation or destruction of the archeological record. Some geomorphic processes, like fluvial sedimentation on flood plains, terraces, and the base of hillslopes, will serve to preserve the record through burial. Erosional processes may

destroy sites by redistribution or destruction of the artifacts. In the following paragraphs, the archaeological significance of several processes are discussed, including fluvial sedimentation, chemical weathering, fluvial scouring, and wave attack during fluctuating reservoir levels.

Fluvial Sedimentation and Site Preservation

An understanding of fluvial sedimentation rates is important to evaluating artifact decay and preservation characteristics. Knowledge about sedimentation rates is also important in understanding the stratigraphic or chronological significance of the archaeological record. Rapid sedimentation will promote the preservation and superposition of artifacts and features that result from serial occupation of sites (see Figure 13; from Ferring, 1986). In contrast, slow sedimentation rates will promote artifact decay and will result in the accumulation of archaeological debris as mixed assemblages.

It is therefore important to understand, at least in general terms, local sedimentation rates in order to address the potential for artifact preservation and the types of artifacts that will be preserved. Sedimentation rates in the project area were interpreted from geomorphic evidence and are based on field observations and laboratory analysis of the available data.

Geomorphic Evidence and Archaeological Significance of Sedimentation Rates

Geomorphic evidence was the principal means of determining sedimentation rates in the study area. The various types of evidence used to determine sedimentation rates are presented in Figure 14 (from Ferring, 1986). The evidence includes characteristics of sedimentary structure, soil profile development, bioturbation, and fossil preservation. The types of evidence shown by Figure 14 and a general knowledge of the different processes operating within and on each landform makes it possible to estimate sedimentation rates for each landform identified in Table 3.

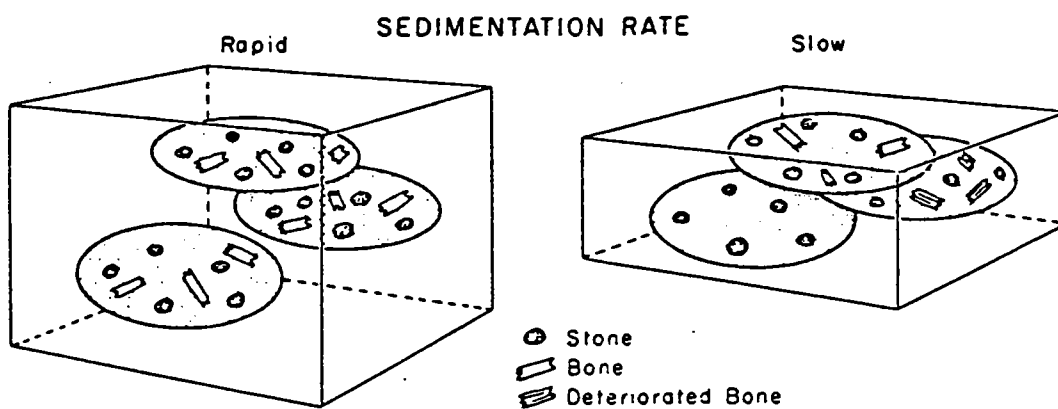


Figure 13. Sedimentation model contrasted between settings with rapid and slow accumulation rates. Better superposition and artifact preservation occurs with rapid sedimentation as compared to slow sedimentation (from Ferring, 1986)

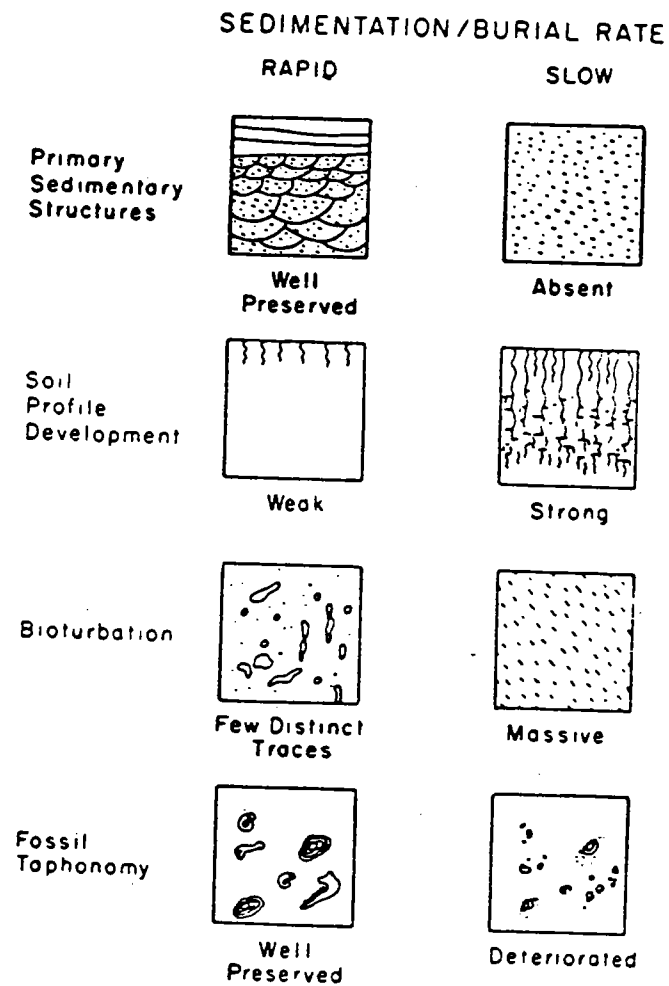


Figure 14. Geomorphic evidence of sedimentation rates (from Ferring, 1986)

Sedimentation rates in the study area must be considered in terms of the influence of post-reservoir impoundment sedimentation. The primary area of sediment transport in the project area occurs on the flood plain. Sedimentation rates on the flood plain are the highest that occur in the project area. In contrast, the lowest sedimentation rates occur on the side slopes and the summits. Side slopes and summits are mainly locations of weathering and erosional processes. Sedimentation rates on foot slopes and terraces are intermediate between the low rates on summits and hillslopes and the high rates on floodplains.

The site preservation and destruction characteristics of the different landforms, as a function of sedimentation, are evaluated for different types of archaeological artifacts in Table 3. The artifacts examined in Table 3 are animal bones, shell, charcoal, ceramics, crystalline lithics, and granular lithics. The different landforms were evaluated according to their ability to enhance preservation, accelerate decay, or are neutral and have no effect (adapted from Mathewson and Gonzales, 1988). The interpretations made in Table 3 are based on the deterioration of archaeological sites primarily by chemical weathering in a humid environment with the main preservation influence from burial by fluvial sedimentation as indicated by the model in Figure 13.

Discussion

Preservation and destruction qualities of landforms are site dependent and are based on a number of interdependent variables. These variables include soil pH, soil moisture, wet aerobic or anaerobic environments, types of micro-organisms and macro-organisms present, sediment movement, and soil loading. The relationships between these variables are very complex. They can vary slightly and result in different decay properties for the different

Table 3. Relationship between Geomorphology and Archaeological Site Components

MAP UNIT	LANDFORM TYPE	AGE ¹			PROCESSES ²								RATE ³			ARCHAEOLOGICAL ARTIFACT ⁴					
		H	P	T	LA	VA	BT	FS	ER	MM	SC	SF	L	M	R	AB	SH	CH	CE	CL	GL
1	Summit	?					X		X		X	X	X			A	A	A	A	N	N
2	Side Slope - Soil	?					X		X	X	X	X	X			A	A	A	A	N	N
2A	Side Slope - Rock	?						X	X	X			X			A	A	A	A	N	N
3	Primary Foot Slope	?					X	X	X	X		X	X	X		B	B	B	B	N	N
3A	Secondary Foot Slope	?					X	X	X	X	X	X	X	X		B	B	B	B	N	N
4	Terrace - Undiff.	X	X		X	X	X	X	X			X	X	X	X	E	E	E	E	N	N
4A	Terrace - Low	X	X		X	X	X	X	X			X	X	X	X	E	E	E	E	N	N
4B	Terrace - Intermed.	X			X	X	X	X	X			X	X	X	X	E	E	E	E	N	N
4C	Terrace - High	X			X	X	X	X	X			X	X			B	B	B	B	N	N
5	Flood Plain -Undiff.	X			X	X	X	X	X			X	X	X	X	B	B	B	B	N	N
5A	Point - Marginal Bar	X			X	X	X	X	X			X	X	X	X	A	A	A	A	N	N
5B	Swamp	X			X	X	X	X	X			X	X	X	X	E	E	E	E	N	N

-
1. Age: H = Holocene (< 10,000 YBP), P = Pleistocene (10,000 - 2,000,000 YBP), T = Tertiary (2,000,000 - 66,000,000) ? = unknown estimated to have begun during Tertiary
 2. Geomorphic Processes: LA = lateral accretion, VA = vertical accretion, BT = bioturbation, ER = erosion, by sheet wash, rill and gully formation, SF = soil formation, FS = fluvial scouring, MM = mass wasting processes, SC = soil creep
 3. Sediment Rate: L = low, M = moderate, R = rapid
 4. Archaeological Artifact: AB = animal bones, SH = shell, CH = charcoal, CE = ceramics, CL = crystalline lithics, GL = granular lithics, A = accelerates decay, E = enhances preservation, N = neutral or no effect, B = site dependent, may accelerate decay or enhance preservation

artifact types. Hamilton (1987), Steele (1987), and Vaughn (1987) describe the effects that each of these variables has on artifact deterioration in archaeological sites. Additional information about the various chemical processes and artifact deterioration is available from these sources. The majority of artifacts identified in the Udall quadrangle are lithics. These artifact are least affected by chemical and physical weathering as shown in Table 3.

Chemical weathering promotes the decay of bone, shell, charcoal, and pottery. Stone artifacts are not affected. With increasing sedimentation and burial, artifact preservation is greatly enhanced as burial reduces the rate at which chemical weathering occurs. Archaeological sites are most threatened on the summits and on the side slopes where sedimentation rates are very low or where erosion is the dominant process.

Archaeological sites are more likely to be protected adjacent to or near the main channel where maximum sedimentation and burial occurs. Archaeological sites that are near to the main channel are buried by vertical accretion of sediment. Vertical accretion is presently an important mechanism for sedimentation in the headwaters of the project area. Ordinarily sites on the flood plain and the terraces are considered to be areas of high to moderate sedimentation rates. These areas in general represent locations of artifact preservation.

Reservoir flooding has altered the natural physical and chemical processes of the hill slope and fluvial systems. Pool levels on Norfork Reservoir have fluctuated between wide limits as shown in Figure 8. The consequences of pool fluctuations are significant in terms of historic sediment transport to the landforms in the headwater area (see Figures 7 through 9). Sediment has been deposited by vertical accretion on landforms that are

situated above the normal flood plain limits. Boring data is available at Ford Cove (see Figure 9) to support evidence for sedimentation caused by reservoir flooding. A thin layer of very fine sandy loam soils has been deposited on the lower most terrace surface (borings 3 and 4), and silt loam soils on the upper terrace surface (borings 1 and 2). However, flooding is a fairly recent condition when considering the time that has elapsed since prehistoric man first began to inhabit the project area. Artifact preservation as a function of sedimentation in the headwaters on terraces in general will be enhanced by reservoir flooding.

There are several other factors to be considered in a discussion of artifact preservation and decay for geomorphic systems under conditions of reservoir flooding. Reservoir flooding can expose artifacts by fluvial scouring and accelerate artifact decay by chemical and physical processes. In addition artifacts are affected by ground-water movement and associated chemical reaction between the ground water and artifacts. The physical effects of fluvial scouring and ground-water movement on the different landforms were not considered in Table 3.

Flooding causes fluvial scouring along the main channel and at the mouth of the tributary streams as they discharge onto the main flood plain. Terraces are most affected by fluvial scouring because of reservoir flooding and from headward erosion by tributary streams that flow adjacent to and intersect terrace surfaces. In addition, terraces are considered to be areas of shallow ground water. Terraces are composed primarily of unconsolidated sediments and are hydraulically connected to the main channel. The consequences of reservoir flooding has been to increase the probability of fluvial scouring to areas above the normal flood plain and to increase the frequency and magnitude of ground-water level fluctuation in terrace soils. Other indirect and

potentially adverse effects of reservoir flooding on archaeological sites (artifacts) include wave wash (wind and boat traffic) and river bank caving following a rapid pool draw down.

There are no strict rules governing archaeological site preservation or destruction as a function of the respective landforms and associated geomorphic processes. Various trends or generalizations have been identified above which can be used as guidelines in evaluating the archaeological significance of the different landforms. Specific areas or individual archaeological sites should be examined and evaluated on the merits of each site.

PART IV: SUMMARY AND CONCLUSIONS

Geomorphology

Geomorphic mapping in the project area has identified five general categories of landforms that are associated with the hill slope and fluvial geomorphic systems. The major landforms are summits (Map Unit 1), side slopes (Map Unit 2), foot slopes (Map Unit 3), terraces (Map Unit 4), and flood plain (Map Unit 5). The landforms in these geomorphic systems were differentiated according to important physical characteristics such as slope, geology, approximate landform age, and by the types of geomorphic processes that are active within each landform. Several of the landforms were further subdivided to differentiate the more important geomorphic characteristics and processes unique to each landform. The geomorphic classification that was used in mapping is composed of a total of twelve different landform types.

The development of the North Fork River drainage basin is estimated to have begun sometime during the Early to Middle Tertiary Period. Fluvial downcutting and lateral planation have created a well defined valley and flood plain. Numerous terraces are located along the valley walls of the North Fork River drainage basin. Terraces represent abandoned flood plain surfaces. The mapped terraces are located midway between the pre-dam flood plain and the hill slope system. In the project area terraces are primarily composed of fluvial deposited sediment, estimated to have been deposited during the Holocene and Late Pleistocene. Rock cut terraces are located mainly in the hill slope system and represent flood plain surfaces that were abandoned several million years before the present. Rock cut terraces occur as intermediate level summits and are mapped on the geomorphic maps as summits.

Archaeological Significance

The majority of the recorded archaeological sites are located on terraces adjacent to the North Fork River and its tributaries. It is estimated, based on the distribution of the recorded sites, that between 50 to 60 of the archaeological sites in the project area are located on terraces. The remaining sites are located in their order of occurrence on side slopes, foot slopes, the flood plain, and summits. The terraces that have been mapped on the geomorphic maps are considered to be depositional type terraces and are composed of fluvial deposited sediments. The highest site potential for undiscovered sites is on terraces.

Geomorphic processes will govern the preservation and decay characteristics of archaeological artifacts within sites. Landforms which have high sedimentation rates will promote artifact preservation while those which have low sedimentation rates will promote artifact decay by chemical weathering. Archaeological sites are most threatened on the summits and side slopes by chemical weathering. Sites located on terraces and foot slopes, areas of higher sedimentation, are better protected. Buried sites are more likely to be located on terraces, than any other landform in the project area. In addition, foot slopes may also contain buried artifacts, either naturally or because of slope wash and colluvial build-up. Terraces and foot slopes are presently receiving above normal sedimentation because of historic reservoir flooding.

The historic actions of modern man in the project area have altered the landscape, affected the natural geomorphic balance, and has impacted the majority of archaeological sites, either directly or indirectly. Man's activities in the project area have included reservoir construction and

flooding, timbering, agricultural clearing, and recreation activities. Consequently, there are probably few locations in the project area that have not been either directly affected by these activities or indirectly affected because of high water fluvial scouring, sedimentation, chemical and physical effects of ground water movements, wave wash, and bank caving. All of these different activities have affected archaeological sites in the project area, but it is unknown to what degree or extent. Archaeological sites need to be individually examined to determine the positive and negative affects of man's actions and the natural hazards at each location.

PART VII: RECOMMENDATIONS

The following recommendations are made in regard to cultural resource investigations in the project area:

- a). Future cultural resource surveys should concentrate efforts on the terraces, especially in river bendways and at the mouth of large tributary streams.
- b). Investigations for buried sites should concentrate primarily on the terraces. Other favorable locations for buried sites include the foot slopes and/or the boundary areas between hill slopes and terraces.
- c). Use the geomorphic data contained in this report to analyze archaeological sites according to their geomorphology and geomorphic processes.
- d). Upon completion of a general archaeological field survey, conduct detailed site investigations of significant archaeological sites to include archaeology, geomorphology, and paleoenvironmental studies.
- e). Perform a regional basin paleoenvironmental study of the project area to more accurately define the geomorphic chronology and paleoclimate.
- f). Integrate this data into a reservoir management plan to address the affects of fluvial scouring, sediment supply, bank erosion, ground water contamination, and archaeological site destruction.
- g). Examine areas of high site potential and evaluate methods of preserving or protecting sites from natural and man induced hazards.

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GEOMORPHIC MAPS

<u>PLATE NO.</u>	<u>QUADRANGLE</u>	<u>PAGE</u>
PLATE NL1:	UDALL, MO	74
PLATE NL2:	BAKERS FIELD, MO	75
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PLATE NL9:	NORFORK DAM SOUTH, ARK	82

APPENDIX A:
SOIL BORING LOGS FROM FORD COVE

Boring No: 1

Location: Ford Cove

Quadrangle: Udall (Plate NL-1)

Date Cored: 6/6/88

Logged By: J. Hoelscher

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
Ap	0 - 19	Brown (10YR 5/3) very fine sandy loam; common medium distinct light brownish gray (10YR 6.2) mottles moderate medium granular and weak medium subangular blocky; friable; clear smooth boundary.
B	19 - 55	Yellowish brown (10YR 5/4) heavy very fine sandy loam; pressure flake at 20 cm.; moderate medium subangular blocky; friable; clear smooth boundary.
B21t	55 - 103	Yellowish red (5YR 5/8) sandy clay loam; common clay films on ped faces; few FeMn concretions; strong medium subangular blocky; firm; clear smooth boundary.
IIA2	103 - 105	Pale brown (10YR 6/3) very fine sandy loam; weak medium subangular blocky; friable; abrupt smooth boundary.
IIB21t	105 - 130	Red (2.5YR 4/8) sandy clay loam; common medium distinct pale brown (10YR 6/3) mottles; few FeMn concretions; common thick clay films on ped faces; strong medium subangular blocky.

Boring No: 2

Location: Ford Cove

Quadrangle: Udall (Plate NL-1)

Date Cored: 6/6/88

Logged By: J. Hoelscher

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
Ap	0 - 15	Brown (10YR 5/3) silt loam; common fine distinct gray 10YR 6/1) mottles; moderate medium granular structureless; friable; clear smooth boundary.
B	15 - 56	Yellowish brown (10YR 5/4) heavy silt loam; moderate medium subangular blocky; friable; abrupt smooth boundary.
IIBt	56 - 121	Yellowish brown (10YR 5/8) silty clay loam.

Comments: Chert by volume 15 - 20% throughout profile; colluvium.

Boring No: 3

Location: Ford Cove

Quadrangle: Udall (Plate NL-1)

Date Cored: 6/6/88

Logged By: J. Hoelscher

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
Ap11	0 - 17	Dark grayish brown (10YR 4/2) fine sandy loam; few fine distinct light brownish gray (10YR 6/2) mottles; moderate medium granular structureless; very friable; clear smooth boundary.
Ap12	17 - 52	Very dark grayish brown (10YR 3/2) very fine sandy loam; **midden**; moderate medium granular and weak medium subangular blocky; very friable; clear smooth boundary.
B11	52 - 66	Brown (10YR 5/3) heavy silt loam; weak medium subangular blocky; friable; gradual smooth boundary.
B12	66 - 96	Yellowish brown (10YR 5/4) heavy silt loam; few fine faint light brownish gray (10YR 6/2) mottles; weak medium subangular blocky; friable; abrupt smooth boundary.
IIBt	96 - 136	Yellowish brown (10YR 5/8) sandy clay loam; common distinct light brownish gray (10YR 6/2) and pale brown (10YR 6/3) mottles; clay films on ped faces; common FeMn concretions; moderate medium subangular blocky; firm; abrupt smooth boundary.
IIIA2	136 - 140	Pale brown (10YR 6/3) silt loam; weak fine granular and possibly weak medium subangular blocky.

Boring No: 4

Location: Ford Cove

Quadrangle: Udall (Plate NL-1)

Date Cored: 6/6/88

Logged By: J. Hoelscher

<u>Horizon</u>	<u>Depth (cm)</u>	<u>Description</u>
Ap	0 - 23	Brown (10YR 5/3) very fine sandy loam; common FeMn concretions; common light brownish gray (10YR 6/2) mottles; moderate medium granular and weak medium sub-angular blocky; very friable; clear smooth boundary.
B	23 - 47	Yellowish brown (10YR 5/4), dark grayish brown (10YR 4/2) loam; common light brownish gray (10YR 6/2) mottles; few FeMn concretions; friable clear smooth boundary.
IIAb	47 - 52	Yellowish brown (10YR 5/4), dark grayish brown (10YR 4/2) fine sandy loam.
IIB21t	52 - 73	Yellowish brown (10YR 5/6) silty clay loam; strong medium subangular blocky; clear smooth boundary.
IIB22t	73 - 130	Light brownish gray (10YR 6/2), pale brown (10YR 6/3), red (2.5YR 4/6) sandy clay loam; common FeMn concretions; common clay films on ped faces; strong medium subangular blocky; clear smooth boundary.

APPENDIX B:
CATALOGUE OF KNOWN ARCHAEOLOGICAL SITES

<u>SITE NO</u>	<u>MAP¹ UNIT</u>	<u>ELEVATION (FT MSL)</u>	<u>RIVER² MILE</u>	<u>DRAINAGE BASIN</u>
23OZ062	4	546-570	R40.1-40.5	NORTH FORK R
23OZ063	4	546-565	R44.7	NORTH FORK R
23OZ064	4	546-570	L42.0-42.9	NORTH FORK R
23OZ065	4	546-570	L45.2-45.9	NORTH FORK R
23OZ066	4	546-560	R40.5-40.7	NORTH FORK R
23OZ067	4	546-550	R40.7-41.0	NORTH FORK R
23OZ114	2	640	L45.2	NORTH FORK R
23OZ118	4	546-580	R44.1	NORTH FORK R
23OZ119	4	546-580	R44.5	LICK C
23OZ120	4	600-620	R44.5	LICK C
23OZ121	4	600-625	R44.4	NORTH FORK R
23OZ122	1	760	R44.1	NORTH FORK R
23OZ123	2A	600	R43.5	NORTH FORK R
23OZ124	2	800-840	R43.5	NORTH FORK R
23OZ125	2	546-560	R43.5	NORTH FORK R
23OZ126	4	560	R41.8	NORTH FORK R
23OZ127	4	546	R41.4	NORTH FORK R
23OZ128	4	600-620	R41.4	LINER C
23OZ129	3A-5C	580-600	R41.4	LINER C
23OZ130	4	546-560	R41.9	NORTH FORK R
23OZ131	4	546-565	R41.1-41.4	NORTH FORK R
23OZ132	4	560-580	R41.4	NORTH FORK R
23OZ133	4	605	R40.7	NORTH FORK R
23OZ134	4	600	R40.4	NORTH FORK R
23OZ135	2	620	R40.4	NORTH FORK R
23OZ137	2	600-620	R39.9	NORTH FORK R
23OZ138	4	600	R39.4	NORTH FORK R
23OZ139	4	546-600	R39.0-39.3	NORTH FORK R
23OZ140	3A-5C	565	R42.2	NORTH FORK R
23OZ141	3A-5C	600	R41.4	LINER C
23OZ142	4	546-620	R44.5-45.8	NORTH FORK R
23OZ143	3	620	R44.6	NORTH FORK R
23OZ144	2	680	R45.9	NORTH FORK R
23OZ145	3	600-640	R45.8	NORTH FORK R
23OZ146	4	600	R46.0	NORTH FORK R
23OZ147	2	660-680	R46.1	NORTH FORK R
23OZ148	4	580	R44.6	LICK C
23OZ149	4	580-600	R44.6	LICK C
23OZ150	1	600-640	R44.6	LICK C
23OZ151	1	680	R44.6	LICK C
23OZ152	5A	580-600	R44.6	LICK C
23OZ153	2	580-600	R44.6	LICK C
23OZ154	5A	580	R44.6	LICK C
23OZ155	3	600	R44.6	LICK C
23OZ156	4	560-580	R44.6	LICK C
23OZ157	4	560-600	R44.6	LICK C
23OZ158	4	580	R48.3	BRYANT C
23OZ159	3	546-640	R48.5	NORTH FORK R

<u>SITE NO</u>	<u>MAP¹ UNIT</u>	<u>ELEVATION (FT MSL)</u>	<u>RIVER² MILE</u>	<u>DRAINAGE BASIN</u>
23OZ160	3	670	R48.7	NORTH FORK R
23OZ161	3	640	R48.7	NORTH FORK R
23OZ162	5A	546-580	R48.7	NORTH FORK R
23OZ163	4	600-640	R49.0	NORTH FORK R
23OZ164	4	546-600	L48.2-48.4	NORTH FORK R
23OZ165	4	546-600	R49.6-49.9	NORTH FORK R
23OZ166	1	660-680	R48.1	NORTH FORK R
23OZ167	2	630	R48.1	NORTH FORK R
23OZ168	3	580-600	L49.6	NORTH FORK R
23OZ169	4	580-600	L49.4-49.6	NORTH FORK R
23OZ170	4	580	R46.8	NORTH FORK R
23OZ171	2	600	R46.8	NORTH FORK R
23OZ172	4	546-600	R46.4-47.2	NORTH FORK R
23OZ173	3	590-640	R47.1-47.2	NORTH FORK R
23OZ174	4	546-580	L47.1-47.6	NORTH FORK R
23OZ175	4	590-600	L46.2	NORTH FORK R
23OZ176	5C	600	L46.1	NORTH FORK R
23OZ177	4	600	L46.1	NORTH FORK R
23OZ178	1	580	L45.1	NORTH FORK R
23OZ179	4	580-590	L49.2	NORTH FORK R
23OZ180	4	580	L49.2	NORTH FORK R
23OZ181	4	580-600	L49.2	NORTH FORK R
23OZ182	4	600	L49.2	NORTH FORK R
23OZ183	4	580-600	L49.4	NORTH FORK R
23OZ184	2	620-640	L45.4	NORTH FORK R
23OZ185	4	546-580	L42.9-43.2	NORTH FORK R
23OZ186	4	546-600	L43.5-44.2	NORTH FORK R
23OZ187	4	580-630	L42.1	NORTH FORK R
23OZ188	4	580-600	L42.2	NORTH FORK R
23OZ189	2	630	L42.0	NORTH FORK R
23OZ190	2	580	L39.7	NORTH FORK R
23OZ191	4	580-600	L40.2-40.4	NORTH FORK R
23OZ192	3-4	580	L40.5	NORTH FORK R
23OZ193	3-4	580-600	L40.9	NORTH FORK R

1. Map Units; 1 = Summit, 2 = Side Slope (soil and rock), 2A = Side Slope (rock face), 3 = Primary Foot Slope, 3A = Secondary Foot Slope, 4 = Quaternary Terrace Undifferentiated, 5A = Point Bar and Marginal Bar, 5B = Swamp

2. River Mile for sites on the North Fork River and its tributaries; L = left bank, R = right bank