**Table 1**
**Geomorphology of the Big Cypress Drainage Basin Project Area**

| Surface | Landform-Formation | Age | Geomorphic Processes |
|---|---|---|---|
| Floodplain | Point Bar (PB) | H | LA |
| | Point Bar (PB2) | H-(P?) | LA-VA-BT-SF |
| | Lacustrine Delta (LD) | H | LA-VA |
| | Abandoned Course (ACO) | H | VA-LA |
| | Abandoned Channel (AC) | H | VA-LA |
| | Undiff. Tributary Alluvium (QAL) | H | VA-LA |
| Terrace | Abandoned Flood Plain (QTU and QTP) | H-P | E-SF |
| Valley Slopes | Claiborne Group | T | E-SF |
| | Sparta (ECS) | T | E-SF |
| | Weches (ECW) | T | E-SF |
| | Queen City (ECQ) | T | E-SF |
| | Reclaw (ECR) | T | E-SF |
| | Carrizo (ECC) | T | E-SF |
| | Wilcox Group (EWU) | T | E-SF |
| | Midway Group (PMU) | T | E-SF |

AGE: H – Holocene, P = Pleistocene, T= Tertiary
PROCESS: VA = Vertical Accretion, LA = Latetral Accretion, ET = Sioturbation, SF = Soil Forming Processes, E = Erosion

Geologic formations that make up the valley slopes are identified on the geomorphic maps and in Table 1. These Tertiary formations arefluvial-deltaic, near shore, and marine sedimentary sequences composed of unconsolidated sand, silt, and clay. Boundaries separating the different geologic units are based on the Tyler Sheet (scale: 1:250.000) by Flawn (1965) and from an engineering geology investigation of the Shreveport to Daingerfield project area by Albertson (1992).

The Weches Formation (ECW) caps many of the high hills and "mountains" in the upper reach of the study area (plates 1 and 2). The Weches is the source of iron ore which developed into the local iron and steel industry in Lone Star, Kellyville, and Jefferson, TX. Approximately 33 percent of the study area (Plates 1, 2, 3, 4, and 5) is covered by the Queen City Sand Formation (ECQ) Beneath the ECQ are the clays of the Reklaw Formation (ECR). Springs emerge where the ECQIECR contact is exposed (Plates 4 and 5) Underlying the ECR is the Undifferentiated Wilcox Group (EWU) which consists of interbedded deposits of sand, clays, lignitic silts, and lignite. The EWU makes up 27 percent of the study area and forms the hills and valley slopes in the lower reach of the Big Cypress Bayou and along

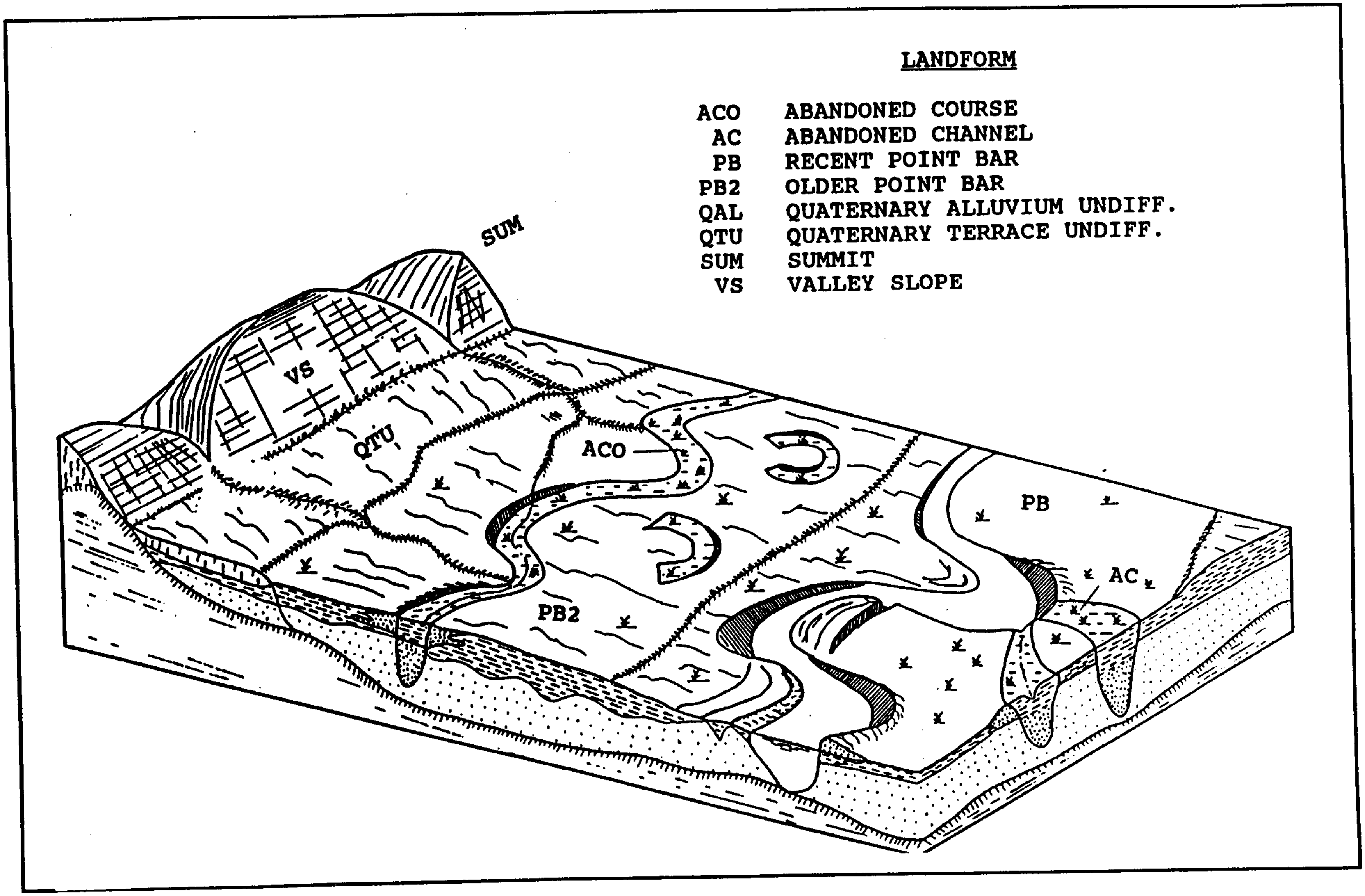


Figure 2. Generalized block diagram of Big Cypress Bayou drainage basin showing major geomorphic environments in study area



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Twelvemile Bayou in the Red River (Plates 5, 6, 8, 9, 10, 11, 12, and 13). The oldest unit outcropping in the study area is the Paleocene age Undifferentiated Midway Group (PMU). Black clays of the PMU form the slopes in the vicinity of Mooringsport, LA (Plates 9 and 10). Overlying the Tertiary units in the valleys are Pleistocene and Holocene fluvial sediments.

### Terrace (QTU, QTP, and QTD)

A terrace is an abandoned floodplain surface that is elevated above the present river's floodplain. A terrace consists 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 (Bates and Jackson 1980). Terraces generally border the present floodplain or may be preserved as topographic islands or remnants within the present floodplain. Terrace islands or remnants in tbe floodplain were not mapped because of the limited accuracy of the topographic data. Terraces are differentiated on the geomorphic maps according to their interpreted age. Terraces identified as QTD are Deweyville terraces along the main Red River Valley (Plates 10 through 11). Deweyville terraces contain oversized fluvial channels and courses as compared to the present system. Deweyville terraces in the Gulf Coast are estimated to have formed between 17,000 and 30,000 years BP (Kolb, Smith, and Silva 1975). Recently, Autin and others (1991) reported that the Deweyville may extend to as early as 10,000 years BP. Oversized meander scars found on the QTD represent the fluvial response of the respective drainage basin to higher rainfall conditions than the present. These terraces are not related to sediment transport by glacial melt water. Pleistocene terraces identified as QTP occur in the Red River Valley following the usage of Smith and Russ (1974). Terraces identified as QTU are undifferentiated Quatemary terraces. Pleistocene terraces in the Big Cypress Bayou drainage basin are mapped as QTU.

Terraces (QTU, QTP, and QTD) mapped in the study area are flat or gently inclined surfaces which occur between the valley slopes and the floodplains of the respective drainage basins. Mapped terraces on the geomorphic maps (Plates 4 through 8) are interpreted to be depositional terraces. In general, the boundary between the terrace and the floodplain was mapped by first defining the limits of the floodplain from hydrologic data. This boundary was then further refined by incorporating soils data from the available county soil survey builetins, land use interpreted from aerial photography, and from site investigations conducted in the field.

In addition to flood frequency, another important characteristic that distinguishes terrace surfaces from the floodplain and its associated landforms is the development of a mature soil profile(s) by pedogenic processes. The presence or absence of a soil profile reflects the types of geomorphic processes that are active in the area and the age of the soil sequence. Soil forming processes are governed by the physical properties of the soils, the environmental influences of the geomorphic system, and the duration of the geomorphic processes. The absence of a soil profile indicates a soil that has been recently deposited and has not had sufficient time to develop a profile.

Physical properties of the underlying soils and the soil profile are variable because of differences in (a) topography and slope, (b) the types of vegetation which are growing on the surface, (c) the land use characteristics of the area (i.e. crop land versus timber), (d) variations in climate, (e) composition of the underlying parent materials, and (f) the time involved in which the soil has formed. These variations control the different types of geomorphic and pedogenic processes that are involved in soil formation, and they govern the soil profile that will be developed.

Terraces bordering Big Cypress Bayou (Plates 4 through 8) are generally well drained in comparison to the floodplain. Flood frequency on terrace surfaces is between 100 to 500 years. Lack of flooding on the terrace surfaces, as compared to the floodplain, results in soil forming or pedogenic processes becoming dominant. In areas where flooding is more frequent, soil forming processes are less dominant as sedimentation rates increase.

## Floodplain

A working definition of a floodplain is important to this study as the terrace boundaries are determined by the limits of the present floodplain. The definition of a floodplain can have many meanings. Fairbridge (1968) identified the problem of defining a floodplain 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."

Based on this definition, a floodplain must contain three basic parts. It must contain elements of topography, geomorphology, and hydrology as part of the definition.

Flood frequency must be incorporated as part of any definition for a floodplain. Consequently, it is that area of the river valley which 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 has been expressed by flood frequency and a probability distribution or by a recurrence interval. The hydrologic part of the definition for a floodplain becomes a function of flood frequency. Leopold, Wolman, and Miller (1964) suggest that a flood frequency of I to 2 years should be used as the basis for defining the river's floodplain.

The definition of a floodplain as used in this study is that area of the floodplain that is subject to inundation by a flood with a recurrence interval of 2 years. Within this area are sediments deposited by the main stream and its tributaries. These sediments are differentiated according to the iandforms which they comprise. The primary landforms are identified in Table 1 and are illustrated in Figure 2. These landforms will be individually described as follows.

The procedure that was used to establish the general limits of the floodplain of the Big Cypress Basin and its tributaries is based on the interpretation of flood frequency data from stream gaging stations in the project area. Flood frequency data were provided by the Hydraulics Branch, LMK. The limits of the 2-year flood were determined for selected locations on the floodplain as shown by Figures 3 and 4. Topographic profiles containing the various flood stages are presented in Appendix D. The extent of the present floodplain in the project area was estimated from the lateral limits of the 2-year flood stage. The accuracy of the topographic data is limited to the nearest 5-ft (1.5-m) contour interval which was obtained from the USGS 7-l/2-min base maps of the project area. Additional criteria were evaluated before the final floodplain limits were established. These criteria are described in more detail in the next section.

## Floodplain Geomorphic Environments

### Point bar (PB and PB2)

Point bar deposits are lateral accretion deposits formed as a river migrates across its floodplain. River channels migrate across their floodplain by eroding the outside or concave bank and depositing a sand bar on the inside or convex bank (Figure 2). With time, the convex bar grows in size and the Point bar is developed. Associated with the point bar are a series of arcuate ridges and swales. The ridges are formed by lateral channel movement and are relic sandy lateral bars separated by low-lying swales. The swales are locations where fine-grained sediments accumulate.

Point 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 bed load (coarse sand and/or fine gravel) to fine-grained soils (clay) at the surface. The basal or coarse-grained portion of the point bar sequence (i.e. point bar substratum) is deposited primarily by lateral accretion, while the fine-grained or upper portion of the point bar sequence (i.e., point bar topstratum) is deposited by overbank vertical accretion.

Point bar deposits in the Red River Valley and the Big Cypress Bayou basin are the dominant and the most dynamic environment within the project area. Point bar limits were defined primarily from interpretation of the color IR photography and topographic data. The boundaries for the present meander belt are identified on the geomorphic maps as PB and define the active portion of the present floodplain. Older point bar deposits are identified as PB2 and were mapped only in the Big Cypress Bayou Basin (i.e. Plates 4 through 7). PB2 deposits are adjacent to the present meander belt and are well removed

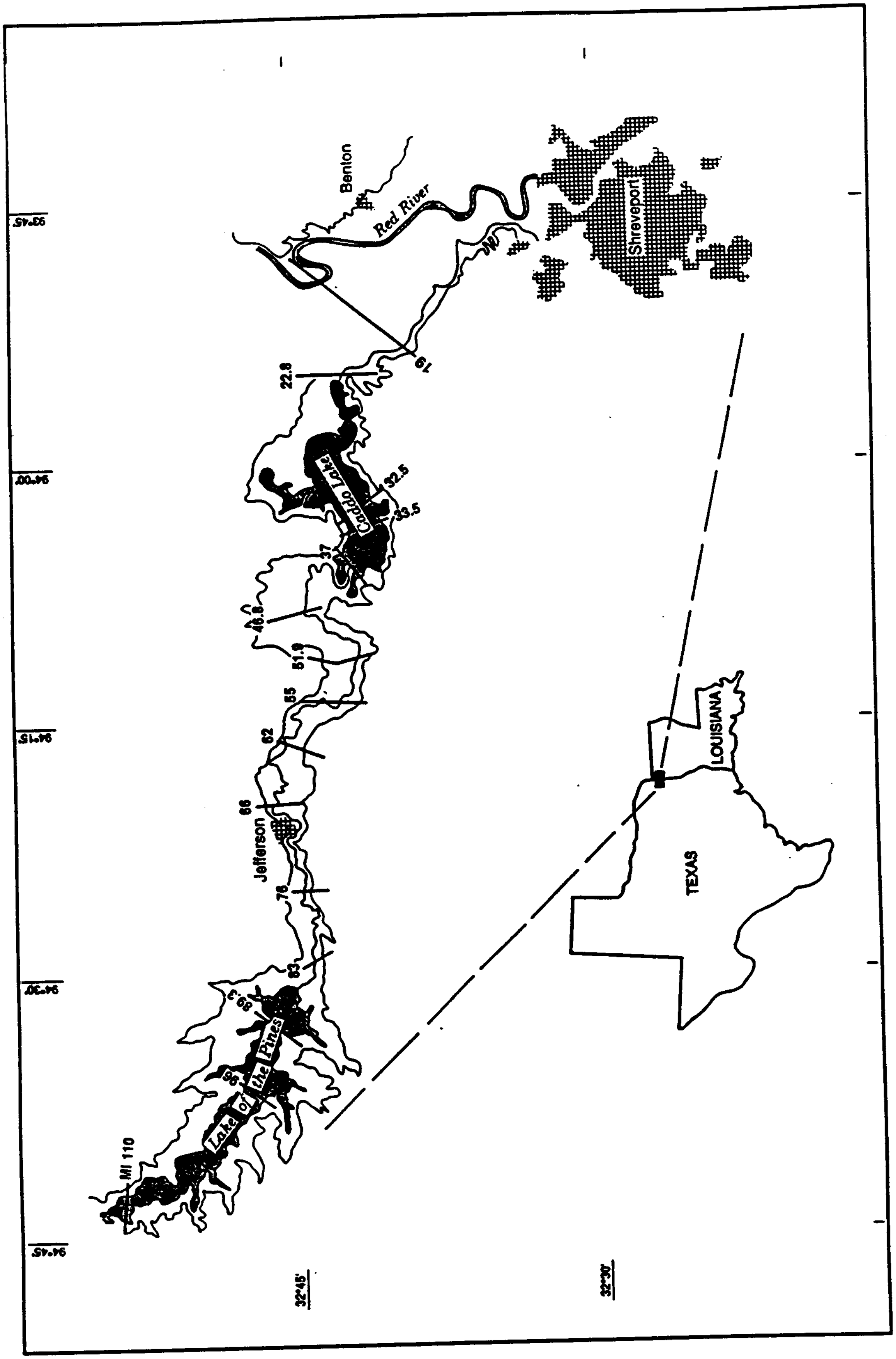


Figure 3. Locations of topographic profiles; see Figure 4 for flood frequency and elevation data and Appendix D for individual profiles

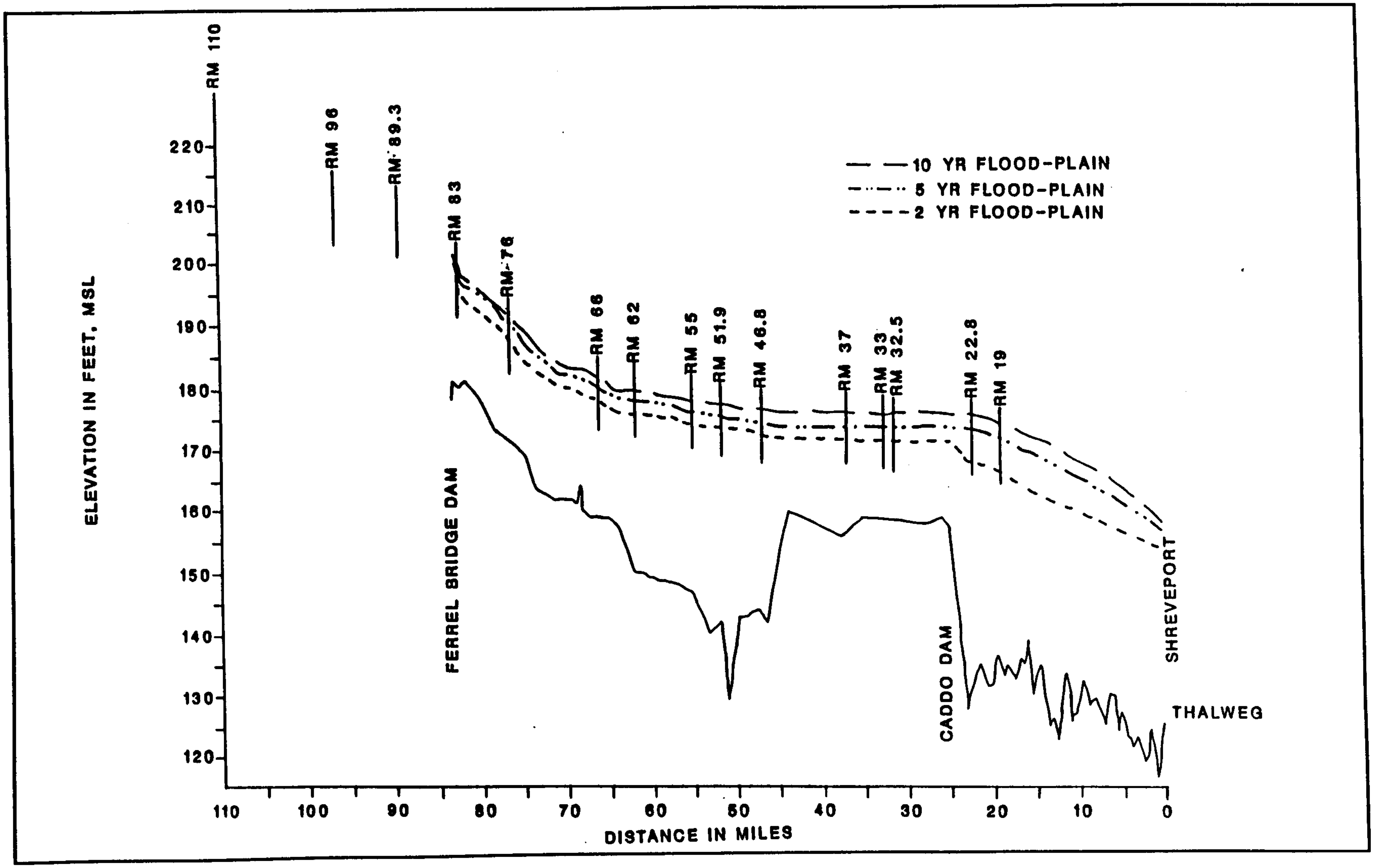


Figure 4. Flood frequency at selected locations in study area; see Figure 3 for locations of topographic profiles and Appendix D for individual profiles

QTU

from the zone of active lateral accretion. The PB2 surface is receiving sediment primarily by vertical accretion. This surface is covered by well developed pine forests.

Priiary characteristics of the PB or active point environment are the well developed ridge and swale topography and its proximity to the main channel. In the Red River Valley, ridge and swale topography is especially well developed. Major swales are identified on the geomorphic maps for both the upper and lower reaches of the study area. Another primary characteristic of the PB environment is the well developed sandy point bars along the main channel. Sandy point bars are easily recognized on aerial photography and on topographic maps.

PB2 deposits are generally well drained and covered by mature trees as compared to the active point bar. The principal geomorphic processes are vertical accretion of new sediment from annual flooding, pedogenesis (soil formation), and bioturbation. Bioturbation is the churning and stirring of the underlying sediment by vegetation and organisms (Bates and Jackson 1980). These processes combine to produce a characteristic soil profile and lithology which is different from the active point bar. In general, soil profiles are better developed in older point bar deposits than in the active point bar setting. Classification of soils by the SCS in the Big Cypress Basin indicates Inceptisols and Alfisols are the major soil groups for the PB2 surface, while Entisols are associated with the younger PB environment.

General relationships between landforms defined by this study and SCS soil series are presented in Appendix E. Each of these different soil series has a unique soil profile characterized by diagnostic physical or chemical properties, The diversity of the soil series for the different landforms reflects, in part, differences in mapping conventions between the various counties and differences in soil type due to geography and variations associated with the soil forming variables (i.e. time, parent material, climate, biological activity, etc.). Because of the great variety of soil series associated with the different landforms, specific or exact relationships between soil series and landform type are not possible. Rather, general soil properties and characteristics can be differentiated for the various landforms.

Point bar deposits in the Big Cypress Bayou basin are approximately 25 to 30 ft (7.5 to 9.0 m) thick. Soil types defined by borings drilled as part of this study and from boring data evaluated by Albertson (1992) identify a typical point bar sequence as grading upward from poorly graded, or uniform sands at the base, to silty sands, silts, and clays near ground surface. These deposits are usually variable horizontally, especially where ridge and swale topography is well developed or relic chutes (high water channel across the point bar neck) are present. In the Red River Valley, point bar thickness is generally two to three times greater than point bars along its tributaries (Smith and Russ 1974). Except for differences in thickness and areal extent, point bar deposits occurring in the Red River Valley are generally similar to those in the Big Cypress Bayou basin. The major difference is due to scale between the two respective fluvial systems and occurs in vertical accretion or top-stratum thickness. Red River point bar deposits contain a much thicker topstratum.

Boring data indicates that point bar deposits are separated into two distinct units based on soil types; a thin predominantly fine-grained upper unit or point bar tonstratum (silt and clay) deposited by vertical accretion, and a thick, coarse-grained lower unit or point bar substratum (silty sand and sand) deposited by lateral accretion. The thickness of the point bar topstratum in the Big Cypress Bayou Basin reach is variable, ranging from less than 3 ft (1 m) to approximately 10 ft (3 m). For the Red River Valley, topstratum thickness is approximately two times as great, averaging approximately 20 ft (7 m) in thickness (Smith and Russ 1974). (Knowledge about top-stratum thickness is helpful in understanding and evaluating buried archaeological sites.) The substratum, in comparison to the topstratum, is much thicker, forming almost the entire thickness for this environment. In the Big Cypress Bayou basin, topstratum thickness is much greater in the PB2 environment than in the PB unit.

### Natural levee

Natural levee deposits were not mapped as a separate environment on the geomorphic maps because this environment is present throughout the floodplain to some extent and mapping this environment would detract from the topographic information on the base maps. However, natural levee deposits are described in this report as a separate environment because it is an important geomorphic process in the study area, especially as it affects cultural resources.

Natural levee deposits form by vertical accretion when the river overtops its banks during flood stage and sediment suspended in the flood flow is deposited immediately adjacent to the channel. The resulting landform is a low, wedge-shaped ridge with the greatest thickness adjacent to the river. Natural levee thickness decreases away from the river until it eventually merges with other floodplain deposits.

Natural levee deposits in the upper project area are less than 5 ft thick and are about 100 to 200 ft (30.5 to 61 m) wide. These limits are below the contour accuracy of the 7-1/2 min map scale used in the geomorphic mapping. Natural levee limits are not readily identified on the available aerial photography except for the main Red River Valley where the scale of the fluvial landforms are much larger. In comparison, natural levees along the Red River may range several miles in width. A reconnaissance investigation in the upper Big Cypress basin identified silt and sand as the predominant soil types associated with natural levee deposits.

Natural levee deposits generally contain a low organic content because oxidation has reduced organic materials to a highly decomposed state. Soils are typically brown to reddish brown. Small calcareous nodules are frequently associated with these deposits as a result of groundwater movement through the permeable levee soils. Natural levee soils are generally well drained, have low water contents, and a stiff to very stiff consistency.'

**Abandoned course (ACO)**

An abandoned course is a river channel that is abandoned in favor of a more efficient course (Figure 2). A course must contain a minimum of two meander loops for the channel to be classified as an abandoned course on the geomorphic maps. Abandoned courses are abundant throughout the project area and are identified as AC0 on the geomorphic maps in Plates 1 through 13.

An abandoned course forms when the river's flow path is diverted to a new position on the river's floodplain. This event usually is a gradual process and begins by a break or a "crevasse" in the river's natural levee during flood stage. The crevasse forms a temporary or crevasse channel that may, over time, develop into a more permanent channel. Eventually, the new channel diverts the majority of flow and the old channel progressively fills. Final abandonment begins as coarse sediment fills the abandoned channel segment immediately down stream from the point of diversion. Complete filling of the abandoned course is a slow process that occurs first by lateral accretion and then later by overbank deposition and vertical accretion. The complete filling process may take several hundred to several thousand years to complete. In some instances, complete filling may not occur as relict and upland drainage preserves partial stream flow through the course.

Abandoned courses and associated abandoned channels collectively form a meander belt on the floodplain of the river. Meander belt deposits consist of a several mile wide, massive point bar sequence, divided by various abandoned channels and courses which collectively form the meander belt. The frequency and location of the meander belt segments are useful for determining the Holocene chronology of floodplain development.

Abandoned courses in the Red River Valley are identified on the geomorphic maps with a general meander belt classification developed by Saucier and Snead (1989) for the Red River (Figure 5, modified from Saucier 1974). This classification divides the Red River into five major meander belts. Meander belt 1 is the youngest, while belt 5 is the oldest. Abandoned courses in the Red River associated with the most recent meander belt are not numbered on the geomorphic maps to avoid symbol crowding. The oldest meander belt that is present in the Red River study area is meander belt 5, estimated to be 4,000 to 5,500 years BP. This meander belt corresponds to the Twelvemile Bayou abandoned course (Plates 10 and 12).

Meander belts are not identified above the headwaters of Caddo Lake, because abandoned course segments are too discontinuous to differentiate. Furthermore, the valley width does not readily permit the development of multiple meander belts.

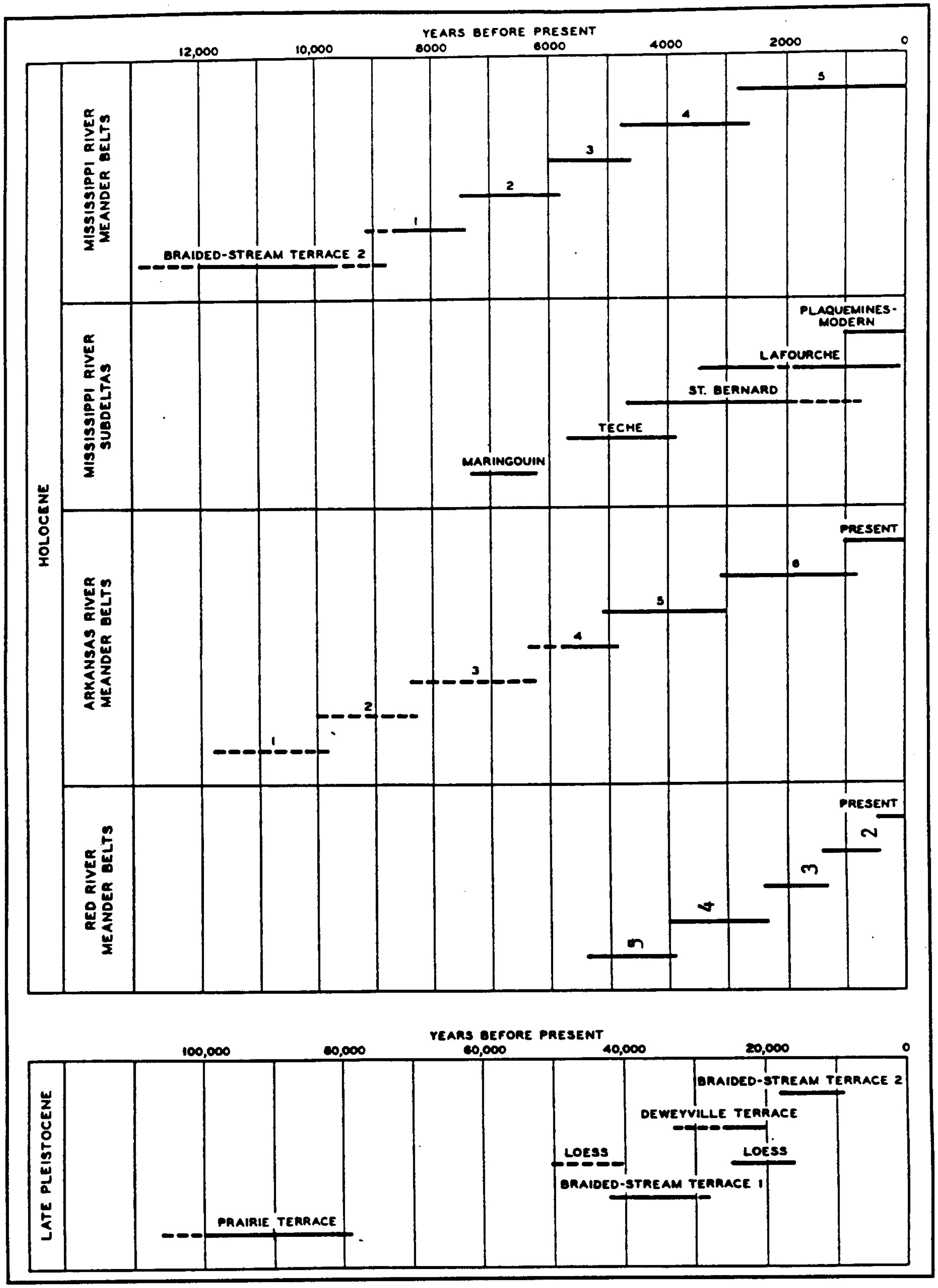


Figure 5. Chronology of late Pleistocene and Holocene landforms and deposits (modified from Saucier 1974)

### Abandoned channel (AC)

Abandoned channels are relict channel loops that are abandoned when the river cuts across its point bar (Figure 2). The cutoff produces an oxbow lake. The process by which the river abandons the loop occurs either gradually as a neck cutoff or during a single flood event as a chute cutoff. A chute is a high water channel across the point bar of the channel. Abandoned channels mapped by this study may be either well defined classic "oxbow" loops or loop segments. Abandoned channels are abundant throughout the project area. These features are mapped in the Red River Valley (Plates 10 through 13), in the Big Cypress Bayou reach (Plates 4 through 8), and in the main tributaries to these systems. Abandoned channels are not always individually labeled on the geomorphic maps because these features are so numerous.

Channel filling is a gradual process. It occurs initially by lateral accretion, when the channel is still connected to the main course. After the main channel has migrated away from the abandoned segment, then vertical accretion dominates. During times of high water flow, suspended sediment is transported to the abandoned channel. Above Caddo Lake, abandoned channels associated with the present meander belt (PB) are generally hydraulically connected to the main channel, are younger in age than abandoned channels in the mature point bar (PB2) environment, and are still in the process of filling. In contrast, abandoned channels in the PB2 environment are filled or almost completely filled. Abandoned channels that are not filled continue to receive sediment by overbank deposition during the peak flood season which may occur for only a brief time each year,

As part of this study, several abandoned channels were sampled to provide stratigraphic and chronologic information about the channel. The *major goal* of the field work during this study was to obtain samples to determine general stratigraphy and date selected abandoned channels. Field work was confined primarily to the Big Cypress Bayou reach between the headwaters of Caddo Lake and Jefferson, TX. Eight vibracores were drilled in five different abandoned channels (Plates 6 and 7).

It is important to understand that even with radiometric dating techniques, an exact age is still not possible, since radiocarbon dating provides only a chronology of the filling history, not when the channel was active and receiving full river flow. Furthermore, there are risks associated with dating channel fill deposits, because older, eroded materials (i.e. logs) may become incorporated into the younger channel fill sequence. Ideally, dating is best where only the vertical accretion component of the channel fill is sampled. The vertical accretion component incorporates the latter stages of the abandonment process when trees, roots, and other organic sediments are concentrated in the filling cycle. Dating of individual abandoned channels provides general data to estimate the age of the respective abandoned course (or meander belt) from its individual components. Additionally, age relationships may also be interpreted from the position and orientation of the abandoned channels on the floodplain with respect to other nearby abandoned channels and courses or other primary geomorphic surfaces.

Vibracore drilling was moderately successful as four cores penetrated well into the basal substratum sands. Boring data indicate abandoned channels are characterized by a thin clay topstratum which is underlain by a thick sandy substratum (Appendix A, borings Vl, V2, V3, and V4). Generally absent from abandoned channel sediments in the Big Cypress Bayou reach are organic rich horizons. Three samples submitted for testing contained insufficient carbon. Consequently, radiometric dating was limited by the available organic content of these sediments. Radiocarbon test results as previously noted are presented in Appendix B and are summarized in Table Bl.

The absence of datable carbon in floodplain sediments in the Big Cypress Bayou reach is an important geomorphic characteristic. An absence of carbon indicates that geomorphic processes active during the Holocene and Late Pleistocene were not favorable for the preservation of organic sediments. Rather, oxidation of organic sediments is typical for the study area above the headwaters of Caddo Lake. Pollen data from vibracore borings evaluated during this study supports degradation of organic sediments as pollen density is low in samples selected for analysis (Appendix C). Environmental conditions did not favor preservation of organics that were deposited in fluvial sediments. Climate and sedimentation rates promoted organic decay.

**Lacustrine (L)**

Lacustrine or lake deposits were mapped only within the main Red River Valley (Plates 10 through 13). Lacustrine deposits were formed by historic Soda Lake situated below Caddo Dam. This historic lake is presently drained. Lake limits are dashed on the geomorphic maps, as the exact boundaries for the historic lake are unknown. Lacustrine deposits were mapped on the geomorphic maps as overlying other floodplain environments (i.e. lacustrine overlying point bar (L/PB), lacustrine overlying backswamp (L/BS), etc.).

Lacustrine deposits are fine-grained sediments deposited from suspension on the shallow lake bottom. Lake deposition is generally well removed from the locus of active sediment discharge into the lake. During this phase, deposition is dominated by slow vertical subaqueous accretion of suspended sediment which drops out of suspension because of reduced energy conditions. Sediment transport in suspension is mainly by wave and currents away from the locus of active fluvial discharge. Lacustrine deposits are usually associated with and overlain by lacustrine delta deposits.

A major goal of this study was to separate and determine the thickness of lacustrine deposition in the former lake bed of Soda Lake. A shallow boring was drilled in a field that was once beneath Soda Lake to provide stratigraphic information about the former lacustrine deposits (Plates 12 and 13; Appendix -A, boring ST12).

Stratigraphically lacustrine deposits are distinguishable from backswamp (also point bar topstratum) deposits by the presence of sedimentary layering in x-rays in homogenous clay sequences. Because bioturbation from vegetation and burrowing organisms disturbs the sedimentary layering in backswamp deposits, these two environments are distinguishable by x-ray techniques. X-ray data from boring ST12 indicates that lake sediments at this location arc approximately 3.2 ft (1 m) thick (Appendix A, boring ST12). This value seems reasonable as it agrees with a report to the Chief of Engineers of 3 to 4 ft (0.91 to 1.22 m) of sediment being deposited because of the Red River Raft (USACE 1873). Depending on location and distance with respect to sediment source areas and preraft floodplain topography, lake deposits may occur at even much greater thickness, perhaps as much as 5 to 10 ft (1.52 to 3.05 m). With only one boring, it is not possible to provide a better range estimate.

**Lacustrine delta (LD) and lacustnne delta distributary channels (LDC)**

Lacustrine delta (LD) deposits occur primarily at the head waters of Caddo Lake and Lake O' the Pines from backwater flooding caused by the development of these lakes. Lacustrine delta deposits are mapped in the headwaters area of Lake O' the Pines and Caddo Lake as shown on Plates 1, 7, and 8. Lacustrine delta deposits mapped on the geomorphic maps represent the growth of both lacustrine delta and natural levees associated with an advancing fluvial system into a drowned river valley. For reasons already mentioned, natural levee deposits were not mapped as a separate environment.

Lake O' the Pines was formed by construction of Ferrels Bridge Dam during the 1950's. Caddo and Soda Lakes were formed by natural damming on the Red River. The exact mechanism by which these lakes formed is unclear. Historic, geomorphic, and archaeological data indicate these lakes probably developed because of a massive log jam in the lower Red River valley. Data evaluated during this study indicate these lakes may have formed during late prehistoric time, and possibly the lakes may be as much as 500 years old based on a radiocarbon date of 510 +/- 60 years in boring ST12. The formation and origin of Caddo and Soda Lakes will be described in more detail in the next section of this report.

Lacustrine delta distributary Channels (LDC) are formed at the river's mouth. Chanads advance into the lake by lateral accretion of coarse sandy sediments to the channel mouth and form bay mouth bars. The individual lacustrine delta channels form a complex network of diverging channels that distribute flow away from the main channel. These distributary channels are separated by coarse sand bars which collectively form the lacustrine delta. Evolution of the branching distributaries is short lived as the lateral constraints imposed by the lake boundaries promote rapid filling, abandonment of the numerous distributaries, and continued lakeward advancement of the trunk channel. Continued overbank deposition of new sediment along the trunk channel results in natural levee growth. These natural levees in turn merge and interfinger with smaller marginal interdistributary lakes and/or other older flood plain remnents.

Lacustrine delta deposits as mapped on the geomorphic maps consist of the entire vertical and lateral accretion sedimentary sequence. This environment is the result of lacustrine, distributary channel and delta mouth bar, and natural levee processes described previously. At the headwaters of Caddo Lake, a lacustrine delta complex has been mapped (Plates 7 and 8). Big Cypress Bayou upon entering the Clinton Lake area (Plate 7) extends due east to approximately the middle of the lake where it forms a delta complex. At this location, Government Ditch was dredged. The delta complex contains two lacustrine delta distributary channels. One distributary channel extends nearly due south where it again branches into another delta complex. The other distributary channel continues eastward where it meanders along the eastern boundary of Caddo Lake and merges with a submerged abandoned course.

Topographic and hydrographic data shown on the base map support classifying Big Cypress Bayou as a lacustrine delta complex. Channel widths of the lacustrine delta distributary channels are half as wide as the channel upstream and downstream of the complex. The downstream portion of the channel is interpreted to be the submerged abandoned course of the former floodplain.

The general thickness and composition of lacustrine delta deposits are illustrated by boring V4 (Plate 7 and Appendix A). At this location, vibracore sampling was in an abandoned channel partially filled by lacustrine delta deposits. Lacustrine delta deposits in boring V4 are sandy and approximately 9 ft (2.74 m) thick. Lacustrine delta thickness at this location represents the lateral accretion component of the filling cycle.

Development of lacustrine delta growth and lacustrine filling in the headwaters area (i.e. Clinton Lake, Carters Lake and Chute, Black Lake, etc.) have been dependent upon the lake level. Construction of Caddo Dam in the early 1900's established the lake level at approximately 169 ft (51.5 m) mean sea level (MSL). The lake level has been slightly higher before Caddo Dam, when the Red River Raft was in existence and drainage from Caddo Lake was controlled by changing base level (Kidder 1914, Leverett 1913, and Janes 1914). Leverett (1913) reports geologic evidence for the lake level reaching 180 ft (54.9 m) MSL. During prehistoric and early historic times, the headwaters area probably experienced both fluvial and fluvialdeltaic growth, depending upon lake level stages. From the geomorphic mapping, lacustrine delta development has not been widespread because the lake itself is considered to be relatively young. It is estimated that Caddo and Soda Lakes are less than 500 years old. Valley drowning in the headwaters area has submerged older floodplain deposits beneath Clinton Lake and flooded the nearby abandoned channels (i.e. Old Horse Slough and Carters Chute, Plate 7) associated with the PB2 surface.

### Raft distributary channels (RD)

Raft distributary channels are considered comparable to crevasse channels. These channels form as a break or crevasse in the natural levees and transport floodwaters to low lying areas bordering the floodplain. These channels are well developed on the Red River floodplain (Plates 10 through 13) and were formed because of the Red River Raft. The Raft is described in more detail in the next section of this study.

**Backswamp (BS)**

Backswamp (BS) deposits in the project area are located in poorly drained forested areas bordering the point bar environments. This environment is approximately 1 percent of the study area. Backswamps are common in the Red River valley and have been covered with lacustrine deposits. The dynamics of the Big Cypress Bayou with its narrow valley and high sand content are not conducive to backswamp formation.

Backswamp deposits form by periodic flooding and vertical accretion of new sediment. The primary geomorphic process occurring in this environment are vertical accretion of new sediment by annual flooding, pedogenisis, and bioturbation. These processes combine to form a characteristic soil profile and litbology. In general, soil types are predominantly gray to dark gray clay interbedded with silt and decayed roots and wood fragments.