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U.S. Army Corps of Engineers

Geomorphic Mapping Pool 7 - Upper Mississippi River Basin

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St. Paul District

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The purpose of the survey was to delineate geomorphic surfaces within the valley margins of Pool 7 on the Upper Mississippi River. These landforms have been mapped and their potential for prehistoric cultural resources has been addressed. Discussed in the report are areas of relatively high and relatively low archaeological potential and the potential for site burial by Holocene and historical alluvium. As a result of Lock and dam construction, the lower reaches of the Pool which contain the Mississippi River Holocene floodplain desposits are inundated. In fact, a large proporation of Holocene surfaces within the valley have been inundated due to locak and dam impoundment.

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GEOMORPHIC MAPPING
POOL 7 - UPPER MISSISSIPPI
RIVER BASIN

October 5, 1987

Donohue & Associates, Inc.
4738 North 40th Street
Sheboygan, Wisconsin 53083

ABSTRACT

Geomorphic investigation of Pool No. 7 was undertaken in response to St. Paul District Corps of Engineer's request, Contract No. DACW37-86-M-1723. The purpose of the contract is to delineate geomorphic surfaces within the valley margins of Pool No. 7. These landforms have been mapped and their potential for prehistoric cultural resources has been addressed. Discussed in the text are areas of relatively high and relatively low archaeological potential and the potential for site burial by Holocene and historical alluvium.

The landforms within the pool margins have been identified through the use of U.S. Army Corps of Engineers plane table maps, pre- and post-Lock and Dam aerial photographs, Mississippi River Commission maps, and the Brown Survey maps. The Brown Survey maps were used as a base map in the production of these landform surfaces. Some areas, particularly along the east valley, were not covered by any of the previously mentioned maps and had limited post-Lock and Dam aerial photograph coverage. These areas were mapped through the use of U.S.G.S. 7.5 minute Quadrangle maps. Additional in-house investigations included evaluation of Lock and Dam No. 7 borehole data, inclusion of concurrent Pool 21 investigations, and literature reviews of other work done in the Upper Mississippi Valley. Finally, field investigations were conducted in order to check mapping units that were delineated.

Glacial events occurring during the late Woodfordian have produced thick deposits in the Mississippi River Valley. Episodes of aggradation and degradation in response to glacial advances, retreats, and glacial lake discharge have produced outwash terrace surfaces seen particularly along the east valley margin. Since major valley entrenchment, which occurred approximately 9500 yr B.P. and continued into the early Holocene, alluviation of the valley floor has progressed. The area within the valley margins of Pool No. 7 is unusually wide compared to other pools in the Upper Mississippi Valley. Dramatic valley widening occurs just above Lock and Dam No. 7. As a result, remnants of very late glacial/early Holocene terrace remnants occur and cover much of the eastern portion of the pool. The evidence seen from these outliers such as Brice Prairie, Amsterdam Prairie, and Red Oak Ridge Island indicate that the Mississippi River has occupied its present position throughout most of the Holocene. Lateral reworking of valley floor sediments has been restricted to the west valley margin.

As a result of Lock and Dam construction, the lower reaches of the Pool which contain the Mississippi River Holocene floodplain deposits are inundated. In fact, a large proportion of Holocene surfaces within the valley have been inundated due to Lock and Dam impoundment.

The remaining topographically higher surfaces seen particularly on the east valley margin have been subjected to Holocene desiccation, drought, and subsequent deflation. Dunes and blowouts are common features observed in the terraces. However, it is unknown when stability resumed on these surfaces. The coarse textured (medium to coarse sand) terrace deposits have been unstable into the late Holocene. Evidence of this was seen at Red Oak Ridge Island. Furthermore, surfaces containing finer grained (silty sand) sediment found along the east valley margin were probably stable periodically for significant duration during the late Holocene.

In effect, based upon only a few site specific examples it is only possible to make broad generalizations. Local small scale spatial and temporal variability in; sediment characteristics, slope and drainage, site geographical aspect or position, subsurface permeabilities, fluctuations in local water table, dominant vegetation; and anthropogenic utilization and behavior all in response to Holocene climates precludes context prediction at individual sites. Hence, site specific geomorphological investigations should be considered since deflation of the terraces along the east valley of the pool has been a major Holocene process. It is expected that some locations on these terraces may have been stable throughout much of the late Holocene.

Along the east valley and to a lesser degree along the west valley margins of the pool, alluvial fans and colluvial slopes are observed. Holocene landforms (particularly alluvial fans) contain a high potential for buried archaeological context. These are identified primarily along the valley margins. Black River and Halfway Creek have produced prominent fans. The Halfway Creek fan was investigated and contains the entire Holocene alluvial sequence, with weak organic enrichment (perhaps a paleosol at considerable depth).

RP/STPAUL7/AB2

PREFACE

The study of Pool 7 was initiated in response to a proposal produced by the U.S. Army Corps of Engineer, St. Paul District. The study focuses attention upon geomorphic units or landforms which vary in their distribution, both temporarily and spatially, within the pool. The primary objective of the study was to construct a geomorphic map that would emphasize landscape development from the late glacial to contemporary times.

The investigation was performed during the period beginning October 1986, through September 1987, under the direction and supervision of Mr. David Berwick, COE Project Manager. Compilation of the geomorphic map, literature, and archival search, field investigations, and draft report write-up were conducted by Donohue & Associates' Project Manager, Mr. Jeff Anderson. The geomorphic mapping was conducted by Mr. David Richardson from Donohue & Associates and University of Wisconsin--Madison. Mr. Richardson also assisted the project manager during the field investigations. Additional help was provided by Ms. Chris Liechen from Donohue & Associates. Finally, there was discussion with Mr. Peter E. Church from the U.S. Geological Survey, and Mr. Robert F. Boszhardt, from Mississippi Valley Archaeology Center.

Following the rough compilation of the geomorphic map, areas were field verified. These areas, such as Dakota Creek, Halfway Creek, Rosebud and McIlvane Island, were investigated with a silt probe. The field investigations were used to help identify landscapes and to determine their relative chronology in the pool. Delineation of these geomorphic units and their ages can be used for archaeological site prediction in Pool 7.

RP/STPAUL7/AB6

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CHAPTER 1

INTRODUCTION

BACKGROUND

Previous and Concurrent Mississippi River Geomorphic Investigations

Fundamental geomorphic investigations were first conducted in Pool No. 10 in the Upper Mississippi Valley by Church (1984). This study addressed landforms which showed a high and low potential for containing archaeological sites. Like the study at Pool 10, the Pool 7 investigation focused interp ation from pre- and post-Lock and Dam aerial photographs, topor phic maps, borehole logs, and field investigation.

Concurrent with investigations conducted at Pool 7 are similar investigations in Mississippi River Pools 17 and 18 by Benn and Bettis and Pool 21 by Anderson. These efforts are being conducted in order to determine landscape evolution and to help predict archaeological site distribution and context.

Objectives of the Present Study

The primary objective of this study is to produce a map of Pool 7 that delineates late Wisconsinan and Holocene geomorphic surfaces. Use of indirect sources such as boring logs, Corps of Engineer plane table maps, aerial photographs, and previous literature have been the primary focus of this work effort. A limited amount of field work has been done in order to verify the distribution and identification of landforms mapped within the pool margins. The study also involves some use of archaeological data produced by the Upper Mississippi Valley Research Center and Great Lakes Archaeological Research Center. Additional sources located further south in Pools 10, 11, and 21 have been used to supplement this study.

Project Scope

The scope of the project focuses from the bluff line on the Minnesota side of the Mississippi River to the bluff line abutting the Onalaska terrace on the east side of the river. The project includes evaluation of tributary streams as they enter the main valley. The Pool begins near Trempealeau, Wisconsin at Mississippi river mile 714.3 and extends south to Lock and Dam No. 7 located at LaCrescent, Minnesota, and French Island, LaCrosse, Wisconsin (Figure 1, 2). The entire length of the pool is 11.8 miles (Figure 3). Valley width is unusually wide in this reach of the river at approximately 8 miles. This is most apparent along the northern end of the Pool.

Delineation of the geomorphic surfaces has been done through interpretation of existing information. The field investigations included soil profile descriptions at key landform locations through the use of an Oakfield silt probe. The profiles were described in the field and no samples were taken for particle size, radiocarbon, or organic carbon analysis.

Project Limitations

Throughout the project, the effort was made to extract as much information from indirect sources when preparing the geomorphic maps. The information was provided through maps which were procured from the St. Paul District Corps of Engineers. The Corps of Engineers' plane table maps had limited coverage and only included survey of government-owned land and did not include areas such as Amsterdam and Brice Prairie.

A series of aerial photographs from 1927 and 1942 were used. They were shot at different scales and the 1942 photos were after Pool impoundment. The 1927 aerial photographs only included that area adjacent to the main Mississippi river channel and did not

PROJECT AREA
POOL NO. 7

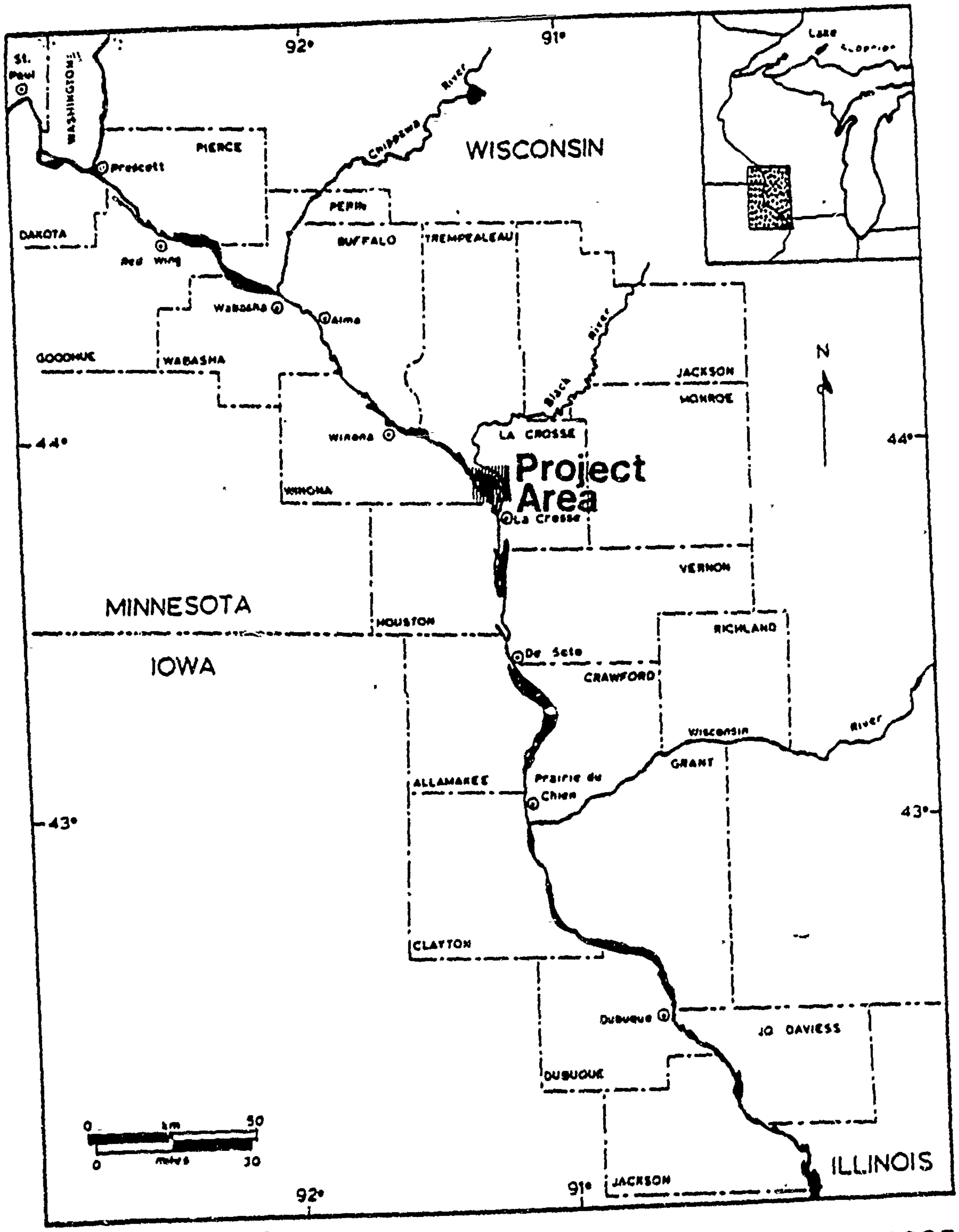
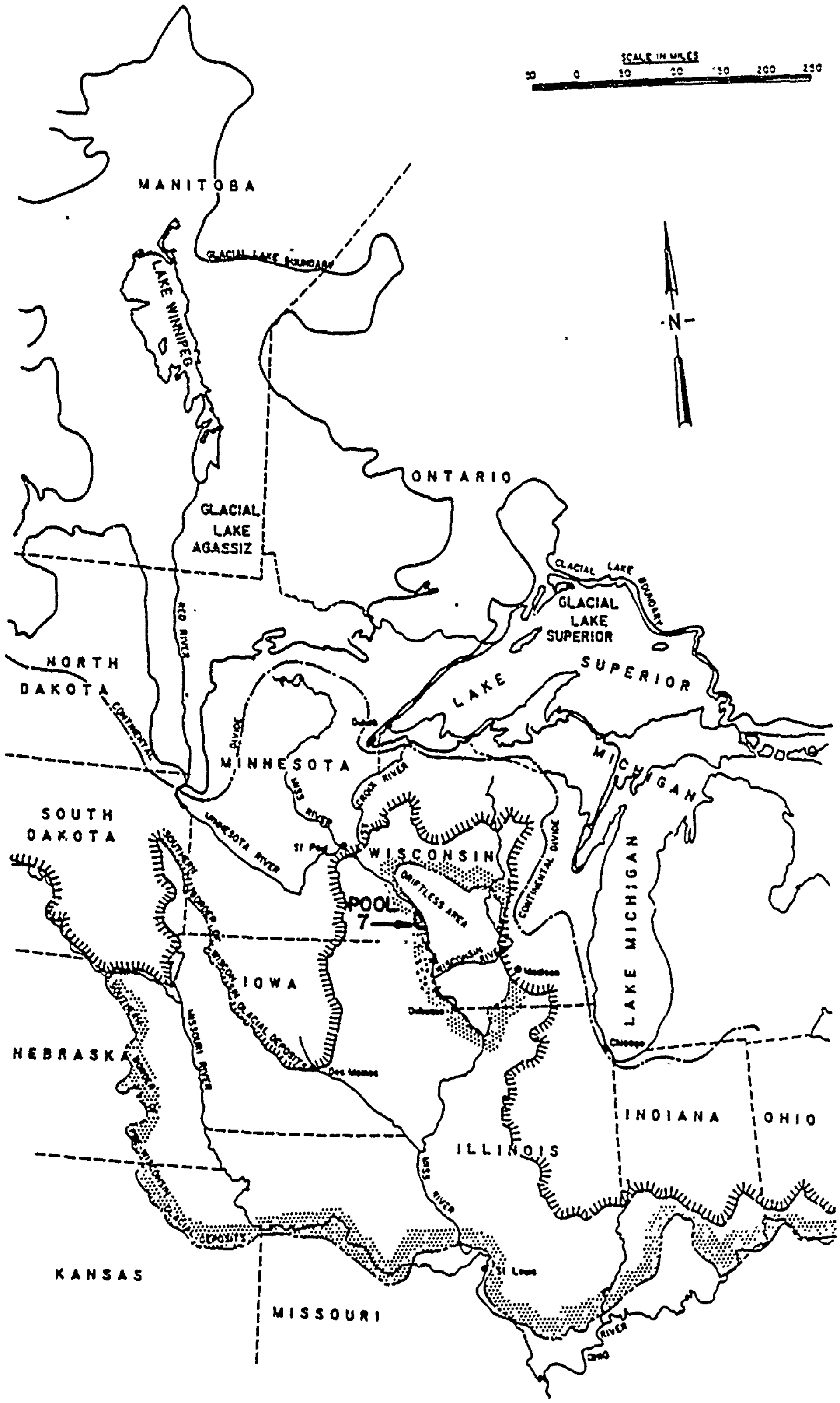


FIGURE 1 SOURCE: Adapted From Overstreet et al. 1985



GLACIAL MAP OF UPPER MIDWEST

FIGURE 2 Map displaying distribution of Pleistocene glacial deposits and maximum areal extent of glacial Lakes Agassiz and Superior (map adapted from Flint, et al., 1949, Church, 1984)

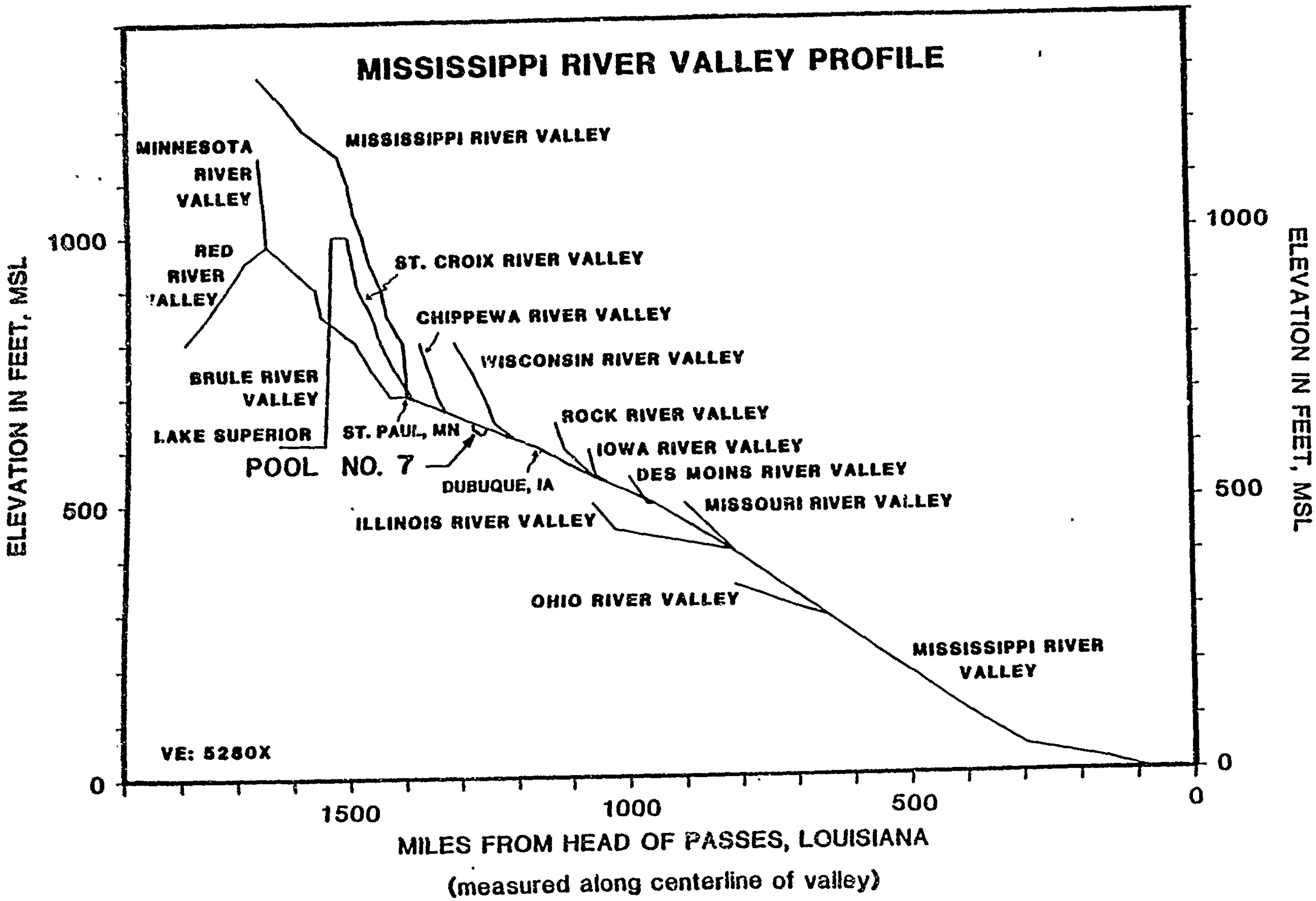


FIGURE 3 Longitudinal profile of Mississippi River valley from headwaters to mouth and valley profiles of lower reaches of major tributaries. The profiles of glacial lake outlets to the Mississippi River are also indicated (Adapted from

include the east valley margin. Consequently, post-Lock and Dam aerial photographs were used along the east valley margin in addition to U.S.G.S. 7.5 minute topographic quads. Interpretations, therefore, were biased toward government-controlled land closer to the main river channel. Those areas not covered by the Brown Survey, Mississippi River Commission, and USACE plane table maps occurred along the east valley margin, consequently, these areas were mapped using fewer resources.

The study was ι fined by a limited scope which did not provide for field analysis other than a brief visit to the Pool. The amount of time conducted for the field verification aspect of the study totalled four days. Generally, studies of this nature usually incorporate more detailed field analysis and include laboratory analyses. Additional research for landscape evolution documentation would include particle size analysis, radiometric dating, and organic carbon analysis. Funding necessary for more work of this nature was beyond the scope of the project.

Furthermore, borehole data available at Lock and Dam site No. 7 was general and showed some inconsistency. In some cases where boreholes were taken at the same location, different sedimentological descriptions were reported. Based on this borehole data, only a very generalized valley cross-section could be constructed.

Historical Floodplain Modifications

As a result of European settlement, the Upper Mississippi Valley has experienced considerable landscape modifications. As a result of clearcutting and agricultural land use, erosion of uplands and main valley deposition has occurred. Specific to Pool 7, post-settlement alluvium (PSA) constitutes a significant deposit of varying distribution across the valley. Topographically low areas such as backwater lakes and ponds are subject to thick PSA deposits. These lower areas where vertical accretion deposits predominate, thick PSA deposits should be encountered. Thick deposits are expected along the main Mississippi River channel. Here, overbank deposition occurs adjacent to the channel margin during high magnitude discharges when sediment concentrations are highest.

Another source of historical floodplain modification is through the maintenance of the 9-foot navigation channel. Dredge spoil deposits occur on islands located in the main channel. Furthermore, along the main channel margins, particularly the east channel margin, direct spoil deposits also occur.

A previous geomorphic study has been conducted by Simons and Chen (1979). Their report was concerned with historical geomorphic changes from Pools 5 through 8 from the Upper Mississippi River basin. The changes investigated were those that occurred as a result of European settlement and the impact of development on the Upper Mississippi River. The development was in reference to maintenance of the 6-foot, and 9-foot river channel and operation of the dams. Some of the conclusions which were reached in this study included that the Mississippi River in this reach during the last 150 years has remained essentially unchanged. Secondly, as a response to the construction of Lock and Dams, a number of islands in the main channel had increased in size, due to accelerated sedimentation. Inundation of Holocene age islands in the lower reaches of the pool has also increased as a result of higher impoundment levels. Filling of the non-main channel areas has mainly been caused by deposition of fine grain PSA.

Post Settlement Alluvium (PSA)

Historical Perspective:

The phenomenon of post-settlement alluvium in the Upper Mississippi Valley is the result of European settlement and subsequent land use. Destruction of the natural vegetal cover has accelerated surface runoff by stripping the highly mobile organic rich surface horizon and exposing less permeable subsurface horizons. The first major impact upon the landscape began with intensive exploitation of lead. Later, as lead reserves became exhausted, agriculture became a key factor in mobilizing sediment from the uplands.

The era of pioneer lead mining came to a close at the beginning of the American Civil War. Up until the war, zinc sulfide was discarded and considered useless. After 1860, zinc production became an important component and was produced by several new mining companies. Zinc production reached a peak during World War I. After World War I, zinc production gradually declined, but was revived again during World War II, and finally, by 1979, the last zinc mine in Wisconsin closed. Meanwhile, many of the earlier lead miners had changed their occupation to farming (Schafer, 1932).

The Big Platte watershed, a tributary to the Mississippi River in Pool 11, had undergone significant changes as a result of agricultural land use (Knox, 1977). By the 1850's, much of the watershed was put under wheat cultivation. As the organic rich surface horizon was stripped, reducing infiltration capacities of the soil, surface runoff and erosion increased and valley and stream alluviation became a locally significant problem. The mouths of the Grant and Platte Rivers in Pool 11 were experiencing rapid siltation by the 1850's affecting the navigation of steamboat traffic.

The introduction of corn to the highly dissected Driftless Area uplands initiated a period of maximum environmental degradation from the 1870's through the 1940's (Knox, 1977). The consequences of these land use practices has enlarged the channel cross-section in the headwater tributary reaches while the floodplains and downstream valleys have seen considerable vertical accretion of sediment (Knox, 1972). Soil conservation methods were introduced in the 1950's and have had a moderating effect on sediment loss in southwestern Wisconsin.

Distribution & Identification of Post-Settlement Alluvium (PSA)

Historical alluvial deposits are frequently found in stream valleys and tributary mouths, particularly where tributaries enter the main valley of the Mississippi River. They are often stored in low order valleys adjacent to cultivated uplands, but are apparent in the higher order stream valleys such as the Black and Mississippi Rivers.

These historical deposits are usually silty, although they may include both coarser and finer texture. They occupy the surface of the landscape creating a unit of variable thickness and distribution. These deposits are nearly always found at the mouths of tributaries as they enter a higher order valley.

Historic sediments often occur as laminated bands of variable thickness. Bands may be a centimeter thick of more if the surface is inundated for relatively long periods or if high sediment loads are being transported. Usually the laminations or laminae are thinner and represent deposition from lower sediment loads or shorter flood duration. At other times, these deposits are thick, massive, and homogeneous units. The massive units are usually composed of fine silt and clay and are typically found in backwater areas, which are frequently inundated for long periods. Many areas within Pool 7 contain historical deposits. Relatively thick PSA units occur where the Black River enters Pool 7. In addition, considerable PSA deposits are expected on the lower surfaces within the Mississippi River Valley margin that are categorized as vertical accretion deposit areas. Thick deposits were recorded in similar areas within Mississippi River Valley at Pool 11 (Overstreet, 1985), and at Pool 21 (Anderson, report in progress).

Historical sediment mobilized from upland areas is often calcareous. The calcareous nature of these sediments is a result of erosion of unleached loessal deposits. Another cause for the presence of unleached sediments is liming practices from agricultural operations.

Historical deposits mobilized within the main Mississippi River valley are usually not calcareous. Near the mouths of tributaries, it is possible to detect flood discharges from both the tributary and from the main Mississippi River channel. This was observed to the south in Pool 11 (Overstreet, 1985) where alternating bands of calcareous and noncalcareous units occurred in a profile. The interpretation was that calcareous deposits came from upstream in the Turkey River while the noncalcareous deposits which were usually composed of quartzitic well rounded sand grains and originated from the main Mississippi River Valley.

Historical sediments mobilized from within Pool 7 are much less likely to be calcareous. These are sediments which have been eroded from islands and along terrace margins or from the channel bed. These leached materials have been reworked from within the Pool and are generally composed of quartzitic sand. The exception will be where sediments mobilized from the Black River watershed enter the main valley.

Areas which have experienced slow historical vertical accretion have undergone pedogenic development. This is seen through the development of a surface A horizon. Very weak A horizons will develop over relatively short periods of time, especially when accumulation of sediment occurs at a slow rate. Surface horizons develop rapidly compared to the development of subsurface or Bt horizons. Cashell, (1980) Schafer (1979), and Leisman (1957) have demonstrated that rigorous organic matter buildup began on disturbed surfaces in less than 20 years. Parsons et. al., (1970) considered soil development on surfaces ranging in age from historical to at least 5,250 yr B.P. and discovered that soils on the youngest surface may contain as much organic matter as soils on older surfaces.

Another pedogenic process occurring on these slowly alluviating surfaces is turbation from soil animals and plants which incorporate the historical material into the prehistoric surface horizon. Slowly aggrading surfaces which occur in Pool 11 (Overstreet, 1985) have been stabilized by vegetation and show organic material being translocated down root channels and worm holes. Soil flora provide a mechanism for the downward movement or organic carbon which effects soil development over relatively short periods of time (Crocker, 1967). Hole (1981) and Thorp (1967) emphasized the role of soil animals in the conversion of raw organic material to humus, the mixing of organic and inorganic material, the creation of channels, and the vertical displacement of soil particles.

The nature and genesis of post-settlement alluvium found in Pool 7 reflect different intensities of competing geomorphic and pedogenic processes. At sites where slow vertical accretion exists from infrequent overbank flows, weak surface pedogenic horizons are emerging and in many cases are mixed with the underlying presettlement material. These surficial deposits, may or may not contain carbonates. These sites are generally located away from tributary mouths, and are likely to be found on the central portion of the islands and on lateral accretion ridges and mixed deposits toward the upper reach of the Pool.

Current research being conducted in Mississippi River Pool 21 (Anderson, report in progress) has shown that the center of the islands contain thinner veneers (about 50 cm) of historical sediment. The island margins, on the other hand, show a thicker PSA deposit (greater than 1 meter).

Anderson and Overstreet (1986) have shown that historical sediment in the Iowa River at Coralville reservoir constitutes a discontinuous unit capping Holocene surfaces. The historical deposits concentrated in low lying areas such as meander scars, chutes, and backwater ponds while other slightly higher areas contain only a thin unit of PSA.

Current research being conducted in the Des Moines River system, south of the City of Des Moines, has shown a similarity to the Iowa River system (Rogers et al. 1987). In the reach of the Des Moines River system, at Lake Red Rock, historical sediments are observed as a discontinuous unit concentrating in low lying areas within the main valley margins.

In Pool 7, deep historical deposits are expected where tributaries enter the main Mississippi River Valley. For example, two silt probe cores were taken where the Black River enters the Main Valley Park. These cores showed PSA thicknesses of 100 cm and 110 cm, respectively. Topographically lower areas mapped as vertical accretion are also suspected to contain thick deposits of PSA. In these areas, frequent long duration inundation occurs, greatly increasing the thickness of the historical deposit.

Furthermore, the raised base level caused by Pool impoundment has promoted sedimentation in the Pool and throughout the Mississippi River system. The Upper Mississippi River system has acted as a series of settling basins from upstream and tributary sources. An average accumulation of 2.5 cm./year of fine sediments has been estimated in backwater lakes from Pools 4 through 10 during the 11 year period from 1964-1975 (McHenry et al., 1976).

RI-/STPAUL7/AB5

CHAPTER 2

PHYSIOGRAPHY AND QUATERNARY LANDSCAPE EVOLUTION IN POOL 7

GEOLOGY, SOILS AND CLIMATE OF THE POOL 7 AREA

Pool 7 lies within the central lowlands physiographic region. The lowlands is composed of the Driftless Area of southwestern Wisconsin and portions of southeastern Minnesota, and the Paleozoic plateau of northeastern Iowa. In southwestern Wisconsin no evidence of direct glacial deposition exists and bedrock is exposed frequently near the surface under loess (Figure 1). The exception is near the mouth of the Wisconsin River, where pre-Illinoian till is identified on the Bridgeport surface (Knox et. al., 1982). Northeastern Iowa is known as the Paleozoic plateau (Hallberg et. al., 1984) and has undergone repeated glaciation during the pre-Illinoian period. To the north of the project area, the central lowlands includes an area of thick till and stratified deposits. These deposits range in age from pre-Illinoian to Wisconsinan.

The bedrock in the physiographic providence is relatively flat-lying sandstones, limestones and dolomite of Paleozoic age. Upland exposures are of the Prairie du Chien group of dolomite, while at lower elevation Upper Cambrian sandstone is observed. (Beatty, 1960, Heyl et. al. 1959; Figure 4). Weathering and erosion of the sandstone provide a local source of alluvial and eolian deposits in the valley. Additional sources come from upstream in the Mississippi and from the tributaries.

The structure of the bedrock in the Upper Mississippi Valley is largely determined by the Laurentian uplift of Pre-Cambrian rocks to the north. These bedrock units dip gently southward from the uplift (Simons and Chen, 1979, Simons et.al., 1976). The bedrock units of the Valley were intermittently deformed throughout the Paleozoic era, but apparently minor faulting is recognized during the Tertiary.

Soils in this portion of LaCrosse County have formed largely from three kinds of parent material. These materials include loess, weathered Cambrian sandstone and alluvial deposits. (Beatty, 1960). Native soil types in the area include Hapludalfs (hardwood forest soils) which are developed in loess capped uplands. Hapludolls (prairie soils) are developed in main valley terrace deposits, and Entisols and Inceptisols are developed in recent and late Holocene deposits, and on some severely deflated terrace surfaces. In most cases, surface A horizons are truncated especially in the relatively coarse textured terrace deposits.

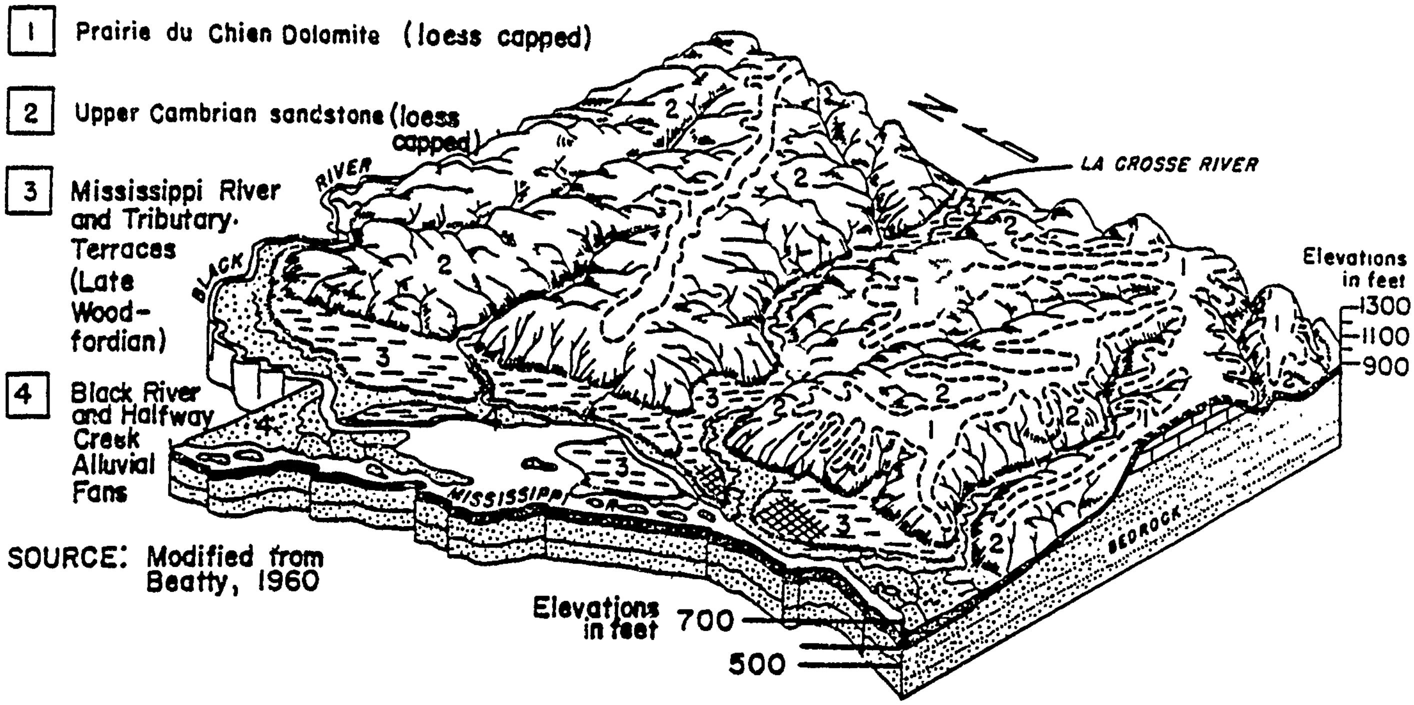


FIGURE 4 MAP SHOWING BEDROCK AND ALLUVIAL DEPOSITS IN LA CROSSE COUNTY

The present climate of the area is humid continental receiving approximately 32 inches of precipitation annually. The relatively evenly distributed rainfall supports a native deciduous oak/hickory forest in the loess capped uplands. The highly permeable more drought prone coarse textured Mississippi terraces support prairie vegetation.

PRE-WISCONSINAN SITE FORMATION EVENTS

The basal alluvial deposits found in the valley were likely deposited during pre-Illinoian age. Apparently, the last major episode of deep valley incision occurred during Illinoian glaciation. Isostatic downbending under glacial load accompanied by upwarping in the peripheral belt of the glacier could account for the major Mississippi Valley incision. Forebulge uplift in the Driftless Area of southwestern Wisconsin and northwestern Illinois steepened the valley gradient necessary for rapid and deep incision of the Upper Mississippi Valley (Willman and Frye, 1969, Knox and Johnson, 1974).

Upon glacial retreat during the Illinoian, the weight of the ice was significantly reduced on the recently glaciated landscape. The result tended to cause rebound while the forebulged Driftless Area began to subside. The steep valley gradient of the Mississippi was greatly reduced, thus promoting valley aggradation.

During the post-Illinoian, alluvial deposition probably continued; although, the magnitude and duration of valley aggradation is unknown.

A geologic cross-section taken across the Mississippi River near Prairie Du Chien, Wisconsin included a total of 27 borings. None of the holes penetrated the valley fill into bedrock (Church, 1984). Similarly, the Lock and Dam No. 7 borings did not penetrate the interpreted Wisconsinan and Holocene fill (Figure 5). Near Dubuque, Iowa, Whitlow and Brown (1963) estimate the depth of the valley fill in the Mississippi at approximately 400 feet. About 10 miles upstream from Dubuque, Whitlow and West (1966) estimate the depth of fill to be about 300 feet. Thus, in this reach of the Mississippi River Valley the amount of fill is for the most part unknown.

Just upstream from the mouth of the Wisconsin River near Pool 10, pre-Wisconsinan glacial events have been identified. The Bridgeport terrace is observed immediately upstream from the confluence of the Mississippi and Wisconsin Rivers. Evidence recovered indicates that the terrace overlies a dolomite and sandstone strath and represents at least two major pre-Wisconsinan depositional events (Knox et al. 1982).

The eastward dipping sediments that fine towards Central Wisconsin indicate that the Wisconsin River flowed in an eastwardly direction, probably through the Black Earth Creek Valley drainage and into the Rock River. The clay mineralogy of the till is similar to the Wolf Creek formation which is observed in Northeast Iowa and is considered pre-Illinoian in age. Beneath the Wisconsinan loess which caps the surface, a second pre-Wisconsin event is seen in the terrace. The apparent fluvial event includes deposits of clayey cherty sands with erratics which appear to represent a central and northern Wisconsin source. These deposits are best preserved near Blue River and Muscoda, which is east from the confluence of the Mississippi and Wisconsin Rivers.

WISCONSINAN FLOODPLAIN EVOLUTION

The events surrounding the late Woodfordian and early Holocene development of the valley is primarily based upon events occurring upstream in the Mississippi River system. Valley aggradation and degradation occurred throughout the Wisconsinan age. Apparently, much of the sand and gravelly sand units were deposited during the late Wisconsinan or Woodfordian substage. Rapid alluviation of the valley occurred during the late Woodfordian in both the Mississippi and Wisconsin River Valleys (Knox and Johnson, 1974). The Mississippi continued to aggrade until the Red River and Superior lobes retreated north approximately

12,200 yr B.P. (Clayton, 1982). As the lobes retreated, rapid incision occurred but by 11,500 yr B.P., both the Red River and Superior lobes readvanced causing renewed aggradation. This event was followed by subsequent valley incision until about 10,800 yr B.P. The final episodes of valley entrenchment occurred when glacial advances blocked eastward drainage of Lake Superior causing the discharge of meltwater through the Mississippi from 9,900 to 9,500 yr B.P.

During the stages of late Woodfordian glacial advances, retreats, and catastrophic glacial lake discharges, the Mississippi River Valley aggraded and degraded in response to the change in sediment load and discharge volumes of the meltwater. During periods of glacial advance, bedload was introduced into the drainage network which caused aggradation of coarse sediment. In contrast, when drainage was blocked, or when glacial lakes (such as Lake Agassiz) formed, episodes of high magnitude discharge would occur, in some cases catastrophically with relatively sediment free water. These episodes would initiate valley entrenchment.

Evidence of these catastrophic discharges occur near the mouths of tributaries entering the Mississippi Valley. These smaller tributary valley terrace deposits show crossbedded sand and gravelly sand dipping up valley. Deposits like this are observed at Mill Coulee which is just north of Prairie Du Chien along the east valley margin.

Other evidence of glacial lake drainage occurs further south near Dubuque. Apparently, glacial lake drainage would, at times, carry considerable quantities of fine grain sediment. This clay rich sediment found on high Mississippi terraces, absent of a loess cap, resulted from discharges associated with drainage from Lake Agassiz and Superior between 13,000 and 9,500 yr B.P. (Flock, 1983). Meltwater containing red clay from glacial lake Superior drained through the St. Croix River Valley and into the Mississippi Valley. To the west, Lake Agassiz containing gray clay discharged through the Minnesota River Valley and into the Mississippi. Apparently discharges and flood stage height were of sufficient magnitude to create slackwater conditions necessary for the deposition of fine grain sediment.

Near the mouth of Dakota Creek in Pool No. 7 evidence of main valley aggradation with subsequent discharge, is interpreted from silt probe cores on a late Woodfordian terrace. Red clay is interbedded with laminae of medium sand, red silt, gray silt, and brown silt. The sand, gray and red silt, and red clay are probably correlative to deposits associated with the Savanna Terrace (Flock, 1983). The texture and Muncell colors of the deposits closely match those described by Flock. These sediments are apparently main valley deposits, while the brown silt is interpreted as reworked loess from tributary drainage.

About 22 miles south of Dakota Creek, the Savanna Terrace at Crooked Creek has been identified by Flock (1983) at an elevation of about 700 feet (213 m). The terrace seen at Dakota Creek lies between the 700 to 720 feet contour.

Locally, Woodfordian aggradation of the Mississippi River flood plain is represented along both the east and west valley margins. The Onalaska Terrace and all terrace outliers are related to late glacial aggradation and are probably correlative to the Savanna Terrace (Knox, 1985). In addition, Red Oak Ridge and Rosebud Islands are terrace outliers which have been cut off from the main Onalaska Terrace. Both of the islands and the Onalaska Terrace lack loess caps indicating that the formation of this surface post-dated loessfall and consequently, developed after 14,000 years B.P. (Ruhe, 1969, Overstreet et. al., 1985).

HOLOCENE FLOODPLAIN EVOLUTION

Glacial events occurring during the late Woodfordian have produced deep deposits in the Mississippi River Valley. Episodes of aggradation and degradation in response to glacial advances, retreats, and glacial lake discharge have produced outwash terrace surfaces seen particularly along the east valley margin. Since major valley entrenchment, approximately 9500 yr B.P., incision apparently continued until alluviation of the valley floor progressed somewhat later. The area contained within the valley margin of Pool No. 7 is unusually wide compared to other margin of Pool No. 7 is unusually wide compared to other pools in the Upper Mississippi Valley. Dramatic valley widening occurs just above Lock and Dam No. 7. As a result, deposits of late glacial/early Holocene occur and cover much of the eastern portion of the pool. The evidence is seen from terrace outliers such as Brice Prairie, Amsterdam Prairie, Rosebud, and Red Oak Ridge Island. They indicate that the Mississippi River has occupied its present position during the postglacial.

As a result of Lock and Dam construction, the lower reaches of the Pool which contain the Mississippi River Holocene floodplain deposits are inundated by Lake Onalaska. In fact, a large portion of the surfaces within the valley developed during the Holocene, have been inundated due to Lock and Dam impoundment. The remaining topographically higher surfaces seen particularly on the east valley margin have been subjected to mid-Holocene desiccation and drought. Dunes and blowouts characterize the surface of the terraces. Along the east and west valley margins of the P alluvial fans and colluvial slopes are observed.

Apparently, at least four episodes of entrenchment occurred during the late glacial/early Holocene. The Onalaska Terrace and the 700 - 720 foot tributary terraces were established during the first downcutting episode. The second episode produced the terraces along the western margin of Amsterdam Prairie, and included Brice Prairie, and the Caledonia Terrace. These surfaces occur about 680 - 685 feet.

The third episode produced the Red Oak Ridge and French Island terraces which are observed at about 655 - 660 feet. The fourth event produced the Rosebud and Bell Island surfaces. They occur at about 645 - 650 feet.

Subsequent downcutting apparently continued during the early Holocene. Incision apparently continued to at least 580 feet, and is indicated by the borehole data (Figure 5). The relict main Mississippi River channel located between Brice and Amsterdam Prairies was abandoned probably during one of the last episodes of incision.

Textural composition of the terraces are somewhat different. For example, the terrace deposits in Amsterdam Prairie below the dunes are medium sand, however, the erosional eolian blowouts are coarser textured and occur as a lag. The sediments observed in Red Oak Ridge Island are primarily coarse sand, whereas, the lowest surface at Rosebud Island shows a relatively poorly sorted lag of coarse sand, gravels, and pebbles in the upper two meters. This lag is underlain by a better sorted coarse sand and granules observed to a depth of 2.75 meters.

The interpretation is that subsequent catastrophic discharges downcut into older Woodfordian alluvium and concentrated coarse sediment on lower terraces particularly Rosebud Island as a lag. Further valley incision into Woodfordian alluvium apparently continued during the early Holocene.

Valley alluviation renewed following the entrenchment episode, although it is not known when this occurred. The evidence supporting Holocene valley alluviation is seen in the borehole data where fine sand and clay are interpreted as Holocene main valley deposits. This also indicates that the main Mississippi channel has remained along the west valley margin probably throughout much of the Holocene. If the terraces seen to the east are of late Woodfordian to early Holocene age, then the river has remained in a relatively confined meander belt throughout most of the Holocene.

The alluvial fans of the Black and Halfway Creek drainages developed since the last episode of valley incision. The Black River fan is extensive and prior to its development, the Black may have occupied the relict channel between Brice and Amsterdam Prairie, although this is unknown. The fan deposits represent an alluvial sequence which probably covers most of Holocene.

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CHAPTER 3

INTERPRETATION OF LATE WISCONSINAN AND HOLOCENE DEPOSITS AND GEOMORPHIC MAPPING UNITS

METHOD OF MAP CONSTRUCTION

Sources

A number of sources were used in order to draft the mapping units seen within the valley margins of Pool 7. First, two sets of Corps of Engineers aerial photographs were used. The 1927 photos had a flight line along the current channel. The 1942 photos were flown at a higher altitude and covered most of the valley margins. Coverage of most of the pool could be seen from these photographs.

In addition to the aerial photographs, the Mississippi River Commission maps at a scale of 1:20,000 were compiled in 1894 and used as a source. These maps included vegetation and have a contour interval of 5 feet.

The Brown Survey maps were compiled in 1929 and 1930, and are at a scale of 1:12,000. They are another useful pre-Lock and Dam source with a contour interval of 5 feet.

The third set of maps were the Corps of Engineers plane table maps. These are at a scale of 1 inch to 400 feet and were compiled in 1933. The plane table maps were reduced to a scale 1 inch = 1,000 feet (1:12,000) to match the scale of the USGS base map. The contour interval is 1 foot.

The USGS base map is a composite of four 1:24,000 (1 inch = 2,000 feet) 7.5 minute quadrangles. The four quads were Holman, Onalaska, Pickwick, and LaCrescent. The 1:24,000 scale and 20-foot contour interval was insufficient to map geomorphic features so the four quads were enlarged and combined to form a single 1:12,000 (1 inch = 1,000 feet) base map.

A final source was the LaCrosse County soil survey compiled by Beatty in 1960. This was helpful to identify marshland deposits near the Halfway Creek alluvial fan.

Mapping Process

The plane table maps were used to map the pre-Lock and Dam geomorphic features. These maps were chosen because they have a 1 foot contour interval and they designate the pre-Lock and Dam vegetation and land use. In addition to the plane table maps, air photos and the Brown Survey maps were used to determine the pre-Lock and Dam geomorphology of the area.

The 1927 and 1942 air photos which show vegetation river channels, and lakes were examined to obtain the general distribution of the lateral accretion deposits and the mixed lateral and vertical accretion deposits. The air photos also show the location of lateral accretion ridges. The Brown Survey maps were used to help distinguish the Mississippi terraces found in Pool 7.

After the geomorphic data was compiled on the plane table maps, a scale and projection problem arose. The plane table maps at 1 inch to 1,000 feet were applied to the USGS base map at 1 inch to 1,000 feet. Although the scale is the same, the plane table maps were a straight line projection, whereas, the USGS map is a Lambert conformal conic projection. A direct transfer of information from the plane table maps to the USGS base map was impossible. This problem was solved by detailed mapping of the geomorphic units on the plane table map and then transferring this information to the 20 foot contour interval USGS base map.

The final map has the geomorphic features identified using shading, cross hatching, and symbols. The different shades are achieved using photography. The landforms assigned a common shade were placed on an amberlith overlay. The U.S.G.S. base map was placed beneath the amberlith sheets and the landforms of a common shade were traced from the base map and cut out on the amberlith. Five amberlith overlays were used for the four shades of gray and black presented on the final map. A final sheet of mylar is used for the symbols and lettering on the map and also areas marked with zip-o-tone. The photographic work was done by Aerometric Engineering, Inc. of Sheboygan, Wisconsin.

Mapping of Pool 7 was undertaken during May through August of 1987. After mapping of the pool was initially undertaken, one week field verification involved looking at key locations in the valley in order to confirm geomorphic mapping units and was conducted during June of 1987.

GEOMORPHIC UNITS

Valley Margin Deposits, Tributary and Mississippi River Terraces

Valley Wall

A dotted line indicates the valley wall location on both the east and west margin of Pool 7. The upland rises to over 1200 feet, but, for mapping purposes the 800 foot elevation was considered the valley wall. The mapping unit represented by a dotted line follows the 800 foot contour on both the east and west valley wall.

Colluvial Slopes

At the base of the main valley wall are deposits of very poorly sorted sediment, consisting of material varying in texture from boulders to clay. These colluvial deposits are a result of down-slope movement of material through gravitational mass wasting processes. It is suspected that the majority of footslopes developed primarily during the Woodfordian, particularly above the 720 foot terrace elevation. Similarly, other regions throughout the Upper Mississippi Valley have reported colluvial slope development during the Woodfordian (Knox, 1982, Anderson, 1986) and formed in response to periglacial climatic conditions which facilitated mass wasting. These deposits are seen along the east and west valley walls of Pool 7. It is unknown the degree of footslope development during the Holocene. Footslope deposits below the 720 foot terrace elevation are Holocene. These deposits occur along the valley walls on both the east and west margins of the Pool. In addition, at the base of terrace escarpments, colluvial depcsits are expected, particularly the downwind slopes.

Alluvial Fans

Abutting the valley wall, alluvial fans are observed entering the main valley. Numerous fans are identified along the west margin where low ordered tributaries enter the Mississippi Valley. Tributary channels entering the main channel have produced numerous fans. Major tributaries such as the Black River and Halfway Creek have produced fans of much greater aerial content. The alluvial fan produced by the Black River is in association with channel deposits of lateral and vertical accretion. Thus, this fan is mapped as a mixture of fan, vertical, and lateral accretion deposits. Alluvial deposits entering from the Black River system and from Halfway Creek have produced fill in the abandoned Mississippi River channel during the Holocene. These fans are of large areal extent.

Mississippi River Terraces

Apparent late glacial/early Holocene terrace remnants occur along the east valley margin of Pool 7. These terraces contain outwash material composed of medium to coarse grained sand, granules and pebbles. These terraces occupy a considerable area within the Pool and indicate that lateral stream erosion by the Mississippi River has been rather limited in this reach of the Valley. Investigations at one of these terrace outliers was conducted at Red Oak Ridge Island (Overstreet, et al., 1985). This work showed that Red Oak Ridge Island is probably a late glacial/early Holocene erosional remnant composed of coarse sandy outwash material. The island has been subjected to episodes of eolian scour and reworking at the locations studied during that project. Areas tested on the island by the project geomorphologist had been subjected to eolian scour and was determined that deflation had occurred at these areas. Although, depression areas were not tested, they may provide stratigraphic archaeological potential. Late Holocene surface stability through a time spatial context across the Pool cannot currently be established.

Four late glacial outwash terraces are identified in Pool 7, although the geomorphic map combines two terraces into one mapping unit. The highest of these terraces is Amsterdam Prairie which has an elevation from about 700 to 720 feet. This terrace occupies the extreme eastern margin of Pool 7 and abuts the valley wall. The second terrace has an elevation of about 680 to 685 feet and is found along the western margin of Amsterdam Prairie and the northern part of the Pool in Caledonia township. The third terrace has an elevation of about 655 to 660 feet encompassing most of Brice Prairie, Red Oak Ridge Island and French Island. Rosebud and Bell Island is the fourth terrace with an approximate elevation of 645 to 650 feet. This youngest terrace relates to one of the last stages of valley incision. The coarse poorly sorted lag observed in the upper 2 meters provides evidence to this interpretation.

Boszhardt (1987, personal communication) (1984) shows that Woodland encampments were found on stable terrace surfaces. Photographs showing refuse pits and stratified archaeological deposits were identified in the terraces. Profile descriptions provided by E.A. Bettis acknowledged archaeological context. Therefore, it is apparent that stability occurred on the Mississippi River terraces during the late Holocene.

Dunes

Different from Pools 10, (Church, 1984) 11 (Overstreet, 1985), and 21 (Anderson, report in progress), Pool 7 shows a considerable degree of dune development particularly on the outwash terraces along the valley margins. The late Woodfordian terraces, for example at Amsterdam Prairie, are undulating due to the abundance of dunes which have been active at various times when extended droughts occurred during the Holocene (Knox, 1985).

Weak paleosol development has been identified on the back side of the dunes (Knox, personal communication). Organic enriched horizons leach and oxidize rapidly in coarse textured soils. This suggests that episodes of eolian activity at some terrace locations occurred late during the Holocene.

Blowouts

In conjunction with dune development, areas on the Mississippi terraces have undergone significant eolian scour. Blowouts are observed as depressions on these late Woodfordian/early Holocene terraces. In Pool 11 on the Osceola terrace, eolian depressions were observed (Overstreet, 1984). Likewise, Red Oak Ridge Island in Pool 7 shows depression areas where eolian scour has been active (Overstreet, et.al., 1985). These outwash terraces located in the Pool are composed of relatively well sorted, highly permeable sand. Due to the high permeability and subsequent droughty nature of these coarse textured sediments, the stabilizing effects of vegetation were periodically attenuated during the Holocene.

Eolian activity, during the early and into the middle Holocene, was greatly affected by the change in atmospheric circulation patterns associated with the wasting of the Laurentide Ice sheet to the north of the U.S./Canadian border. A zonal circulation pattern which provided relatively dry Canadian air masses out of the northwest apparently persisted during the mid-Holocene. As a result, surfaces became unstable and dunes and blowouts began forming during this period. Provided the main channel was entrenched, the lower river stages and concomitant lower local water tables promoted further desiccation of vegetal species.

Tributary Terraces

Terrace remnants exist in the tributaries to Pool 7. These surfaces represent former floodplains which have been abandoned during the late Woodfordian/early Holocene period. These terraces are located close to the mouth of the tributary where it enters the main valley. The terrace continues upstream along the north tributary valley wall. Dakota Creek has a 700-720 foot tributary terrace correlative to the Savanna terrace. (Flock, 1983). The Dakota Creek terrace was investigated during the field program. Aggradation of the tributary valley was in response to main valley aggradation during the late Woodfordian. Isolated remnants of terraces such as this can be found throughout Pool 7 where tributaries enter the main valley from the west.

Tributary Floodplains

Tributary floodplains are those features topographically lower and are composed of Holocene surfaces. Several of the features are observed along the Minnesota side of the pool. Due to the project scope and mapping scale, differentiation of Holocene surfaces is not possible.

In addition to Holocene surfaces, these floodplains commonly contain large quantities of historical deposits. Investigation in Van Loon Public Hunting Grounds show that over one meter of

PSA occurs on the Black River Holocene surfaces. Geomorphic investigations at Pool 11 showed considerable quantities of PSA capping these lower terrace surfaces as tributaries enter the main valley (Overstreet, 1985). For example, where the Turkey River enters the main valley near Cassville, Wisconsin, depths exceeding 16 feet of historical sediment were recorded.

Mississippi River and Tributary Channel, Lakes, and Abandons

These features include areas which are presently inundated by active or in some cases inactive stream flow. These units include the main Mississippi River channel, minor channels, tributary channels, abandoned channels, and lakes.

Tributary Channels

These are channels located within tributary valleys that discharge directly into Pool 7. Discharges from these tributary channels are generally more variable since they often are more sensitive to convection storms which are frequent during the summer months. Since smaller tributaries are more responsive to small isolated convection storms compared to the main Mississippi Valley, flooding is often out of phase with the main valley. Major tributaries such as the Black River have produced extensive alluvial fans. The fan has produced a massive fill along the eastern valley margin.

Major Main Valley Channel

The major channel of the Mississippi abuts the west valley wall in this region of the Upper Mississippi Valley. The major channel is also where dredging operations occur in order to maintain a nine foot navigation channel necessary for barge traffic. The main Mississippi River channel during the late glacial/early Holocene, flowed between Brice and Amsterdam Prairie and was subsequently abandoned. Since then, the main channel has confined to a rather narrow meander belt along the west margin of the Pool.

Minor Channels

Several minor channels are near the major channel of the Mississippi River. These channels are positioned parallel to the main channel and are separated by recent sandbar deposits and late Holocene islands. These minor channels have significant discharge during times of floods but, during periods of baseflow their discharge contribution is greatly reduced.

Abandoned Channels and Lakes

Abandoned channels are relict channels which have been cut off from active stream flow. These channels are abundant particularly in the Black River alluvial fan. Abandoned channels are often occupied during period of high magnitude discharge. Some of the abandoned channels are periodically active as minor channels and apparently occur as feeder streams transporting sediment into the main valley alluvial fan.

Abandoned channels in conjunction with tributaries to the Black River are generally perpendicular to the longitudinal axis of the valley. In contrast, abandoned channels associated with minor channels and swales of the main Mississippi River are parallel to the valley axis. In some cases, abandoned channels have formed linear lakes which progressively are being filled with fine grain sediment. These areas are mapped as abandoned channels if the 1927 air photos and the plane table maps showed water. If the areas were vegetated, they were mapped as vertical accretion deposits.

Combined with this mapping unit are lakes. The lakes are, in many cases, a result of tributary meander cut-offs in the main valley and of swales located between ridge crests. In other cases these lakes may have resulted from scour into older main valley deposits, however, this is unknown. Some of the larger lakes probably result from the major channel abandonment. For example, Round Lake, located in the northern portion of Pool 7 may represent one of these main channel abandonment features.

Main Valley Deposits

These are deposits which occurred after late glacial stages of valley entrenchment. Apparently during the early Holocene, valley entrenchment continued and was followed by alluviation near the end of the early Holocene. This interpretation is considerably different from evidence in Pool 21 where reworking of valley floor deposits occurred late (Anderson, report in progress). Major tributaries such as the Black River have contributed to valley alluviation in Pool 7. The morphology of the valley in this reach of the Mississippi River is anomalously wide (approximately 8 miles). Anomalously wide valleys tend to promote aggradation and inhibit ridge and swale topography. Pools 10, 11, and 21 show prominent ridge and swale topography, whereas Pool 7 shows very little development of these features. This may be in part due to stream flow velocity changes which occur during flood stage. A relatively wide valley may attenuate variable discharge rates and thus may inhibit the construction of ridge and swale topography. Proportionately narrow valleys tend to respond to pulses of flood discharges with more variable streamflow velocities. This variability may promote rapid episodic lateral channel migration and bar deposition.

Similar observations were seen at Coralville and Lake Red Rock Reserviors. The Coralville reservoir is unusually wide at the Hawkeye Wildlife Area and shows very little ridge and swale topography, compared to the downstream Iowa River gorge (Anderson and Overstreet, 1986). The Des Moines River at Lake Red Rock shows a relatively narrow valley, and more evident ridge and swale topography is observed on the low late Holocene terrace (Rogers, et al. 1987).

Lateral Accretion Ridge

Ridge and swale topography is not the dominant main valley feature in Pool 7. Lateral accretion ridges are observed primarily along the upper end of the pool. For example, along the northern margin of the Pool near Lock and Dam No. 6, a series of ridges can be observed. These deposits are arcuate and have formed as a result of lateral stream migration of the minor channels within the main valley. The deposits found in the ridge are expected to be coarse textured and capped by a veneer of vertical accretion silt of Holocene and/or historical age. The ridge deposits are characteristically those of channel bars rather than overbank deposits, however, overbank finer grained deposits may cap the ridge. Capping of the ridges by vertical accretion deposits occur during flood stage as suspended load is trapped by the bar vegetation.

A couple of observations can be made regarding development and relative age of the ridge and swale topography. The first observation is that this topography tends to develop in valleys where bedrock control and/or constriction occurs. In the Upper Mississippi Valley, Pools 10, 11, and 21 show this form of main valley characteristics. Ridge and swale topography is also evident on the low late Holocene terrace in the Des Moines River Valley at Lake Red Rock.

In contrast, where anomalously wide valleys exist in a drainage hierarchy, this topography is less pronounced. Pool 7 and the Hawkeye Wildlife Area in the Iowa River System have anomalously wide valleys where this type of topography is either subdued or not evident. It is suspected that more variable flow velocities occur in confined reaches. The changes in the velocities may produce discrete episodes of instability and relatively rapid lateral stream migration. In the wide valleys, discharges and flow velocities may be attenuated, therefore, producing a more constant rate of lateral migration.

Another observation is that ridge and swale topography may indicate young age. Investigations at Lake Red Rock (Rogers et al. 1987) has shown that prominent ridge and swale topography exists on the low late Holocene terrace. The older intermediate terrace does not show this morphologic characteristic. It is believed that at the older intermediate terrace, swales have been filled with late Holocene vertical accretion deposits.

Furthermore, in Pool 21, ridge and swale topography is evident on Mississippi River islands. Radiometric dating has shown that one island (Long Island) developed after about 3500 yr B.P. Island development was rapid based upon the radiocarbon chronology. To summarize, regional evidence suggests that ridge and swale topography occurs in reaches where bedrock control and/or valley constriction exists. In addition, these landforms are probably indicative of late Holocene age.

Mixed Lateral and Vertical Accretion Deposits

These mixed deposits occupy a large portion of Pool 7 and are produced by lateral migration of minor channels that are subsequently capped by fine grained vertical accretion deposits. The thickness of the vertical accretion deposit will vary considerably and will depend on the location within the pool and proximity toward areas frequently flooded. Areas further away from long term inundation and high concentrations from flood discharge will have a thin veneer of vertical accretion deposits. Consequently, the thickness of vertical accretion capping the lateral accretion deposits in the areas mapped will vary throughout the pool.

The mixed lateral and vertical accretion deposits lie below the Mississippi river terrace surfaces. Some of these areas are inundated along the southern pool margin in Lake Onalaska while the northern end of the pool has exposed areas. The deposit is interpreted to be late Holocene in age and has developed through lateral channel migration of minor main valley and Black River channels.

Relatively few islands are observed in the pool. They have been mapped as mixed deposits or vertical accretion. Based upon other work by Church (1984) in Pool 10 and Anderson (report in progress) in Pool 21, the islands originated as bar deposits. As vegetation became established, lateral and vertical development of the island occurred. Some of the smaller islands are probably late pre-historic or historic in age, while larger islands such as Dresbach and Richmond are considerably older. A radiocarbon date from an island interior in Pool 21 showed a basal date of 3,200 yr B.P. Hence, Dresbach and Richmond islands could be several hundred to a few thousand years old.

Vertical Accretion Deposits

Vertical accretion deposits were mapped for areas expected to have thick, fine grained deposits. These thick deposits are expected to be found in depressions located in the Pool. Many of these areas are former lakes and meander cut-offs which have been abandoned and subsequently filled. Prominent swales located between the few lateral accretion ridges are also mapped as these deposits. These depression areas are expected to contain considerable thickness of fine grained Holocene and post settlement alluvium. The borehole cross-section shows minor ridge and swale topography (note vertical exaggeration). The general tendency in the borehole data (Figure 5) shows that the swales have a thick unit of fine grained sediment. The evidence suggests that preferential deposition has occurred in the swales.

Recent Channel Bar Deposits and Dredge Spoil

The recent deposits have formed adjacent to the main channel, along island margins, and along downstream island reaches. In some cases they are in response to wing dam construction which occurred during the 1800's. The recent deposits are also in response to accelerated valley alluviation from Pool impoundment.

Many of the islands have been affected by deposition of dredge spoil deposits. The bedload spoil material has been deposited on the major islands in the main channel. The spoil results from dredging operations in order to maintain the nine foot navigation pool.

LOCK AND DAM #7 BOREHOLE DATA INTERPRETATION

Prior to construction of Lock and Dam No. 7 a series of boreholes were drilled along the proposed corridor from the Minnesota side to French Island. Lock and dam borings were taken in the Mississippi Valley from October 1933 through October 1935 by the

St. Paul District Corps of Engineers. The deepest of borings extended to an elevation of 574 feet. The boring observations show at least 50 feet of presumably Holocene fine sand existing in Pool 7. Overall, this alluvium appears to be finer compared to the coarser deposits found in the Mississippi terraces. It is unknown how deep this alluvium extends in the Valley.

A sample of these borehole descriptions have been plotted along the cross-section and shown in Figure 5. A total of 32 boreholes have been plotted on this cross-section. The borehole data include a number of limitations. First, discrete textural intervals are poorly represented. In some cases, boreholes descriptions just included a single word, for example, "sand". While in other cases, descriptions included medium, dark, gray sand, very fine, gray sand. As a result, sediment descriptions over the two year sampling period lacked consistency.

The boreholes chosen were those which most closely approximated a transect across the valley. The transect tends to follow the section line in Campbell Township between Sections 11 and 12, and to the south Sections 13 and 14. Occasionally, two sets of borings were taken near the same location. For example, additional borings occurred where a proposed concrete spillway was to be located. Different descriptions exist for the approximate same location along this transect. Furthermore, Drill Hole 25 and 38 indicate only sand throughout the entire profile without any further differentiation of particle size. Thus, the descriptions required liberal interpretation.

Drill Hole 38 showed an apparent organic enriched, loamy clay from 598 to 602 feet. The organic enriched unit is buried by about 40 feet of sediment. In Drill Hole 107 a very dark gray, fine sand was recovered from 592 to 601 feet. Although not plotted, Drill Hole 108 adjacent to Number 107 shows a fine sand that contains wood f 606 to 618 feet. These cores indicate a potential for radiometric dating which would provide key information surrounding the late glacial and Holocene Mississippi River Valley development.

Interesting to note that along the borings at Lock and Dam No. 7, Boring No. 38 shows apparent organic enriched layer of coarse gravelly sand and loamy clay from 598 to 602 feet. If this description is correct, and if indeed the loamy clay is organic enriched implied by the black color, an important radiocarbon date could be obtained from this location.

A second boring, Boring No. 102, indicates that between 601 and 610 feet, wood is encountered in a fine brown sandy matrix. Further investigation of this location could also bring key radiocarbon dates, which would be important in determining the fluvial history during the late Wisconsinan and early Holocene.

The valley cross-section shows that a natural levy has been constructed along the Mississippi River east channel margin. This is particularly evident from Drill Hole No. 38 to Drill Hole S102. Elevation of this surface descends in an eastward direction from a mean elevation of about 638 feet to about 632 feet near the margin of French Island.

The subsurface sediment indicates a general fining upward sequence. The basal unit ranges from medium coarse sand to fine sand and grades upward to a fine sand to clay deposit near the top of the sequence. The drill holes indicate that very little coarse grain sediment was encountered in this portion of the valley, although they are expected to occur deeper in the valley fill. The drill cores show coarser grained deposits probably associated with channel lag closer to the main Mississippi River channel. Furthermore, the drill hole data suggests that the Mississippi River has probably been in its present position as floodplain aggradation progressed during most of the Holocene. With only one exception, the coarser sand deposits with some gravel are not seen further to the east from the natural levy toward French Island. This indicates that lateral erosion has been somewhat limited and tends to support Holocene floodplain aggradation and relative channel stability.

Along the western margin of the valley the river abuts the valley wall. Poorly sorted colluvial sediments are seen in the drill hole cores. Drill Holes 9 and 28 show sandy clay gravel which characterizes the valley wall mass wasted deposits.

GEOMORPHOLOGICAL FIELD INVESTIGATIONS AND INTERPRETATIONS

Dakota Creek Terrace:

A total of four silt probe cores were taken on this late Woodfordian surface. The profile shows a surface Ap horizon. Below the plowed horizon is an eluvial (E) horizon indicative of forest soils and indiginous to the region. Underlying the E horizon is a Bt horizon. In most of the four cores taken, the solum extends to a depth of about 1.3 meters. The solum is developed in what is interpreted as reworked silty alluvium from tributary drainage.

Alluvial flood laminae extend below the solum to depths exceeding 320 cm. The laminae vary in texture from silty-fine sand to coarse-medium sand. Two of the profiles show leached red silt and clay. These lamina were approximately 3 to 6 mm thick and were interbedded with medium sand, brown silt and gray silt.

Some of these units of flood deposits were calcareous while others were leached. The calcareous sediment in some cases, is secondary carbonate. Secondary carbonate was observed between a unit of medium sand and underlying red silt. Although in other cases, the deposits represent unleached reworked loess.

Two of the four silt probe cores were extended to depths exceeding 3 meters. The flood lamina seen below about 1.5 meters is interpreted to represent deposits from two different sources. The coarse textured leached deposits are interpreted to be main valley alluvium deposited during valley aggradation as pulses of flood discharge penetrated up the tributary valley. The gray silt, red clay, and red silt is also interpreted as Savanna terrace development and have a main valley origin. The brown silt, which is calcareous, is interpreted as reworked alluvium mobilized from the tributary and deposited on the floodplain as flood waters receded, and main valley entrenchment ensued.

<u>Mississippi Terraces Along the East Valley Margin</u>:

Mississippi River terraces were investigated along the east margin of the Pool. The areas studied were Amsterdam Prairie, Rosebud Island, Halfway Creek, and Brice Prairie. The differences in elevations of these surfaces indicate that these terraces are probably late glacial relicts associated with the final stages of main valley downcutting and scour. The channel cut between Brice and Amsterdam Prairies is interpreted as an abandoned main river channel that was occupied during these episodes of downcutting. The erosional episodes are indicated by the coarse lag observed at Rosebud Island. Elevation of this island is approximately 647 feet and the coarse textured sand, granules, and pebbles were observed in the solum. Observation from the silt probe cores at Rosebud Island indicate that scour of the floodplain occurred prior to further downcutting.

Rosebud Island is an erosional remnant related to the final stages of downcutting and fluvial scour prior to Holocene valley alluviation. At several locations attempts were made to penetrate the coarse lag found on the surface. Finally one core penetrated below 50 cm and continued to greater than 2 meters. The solum is developed in coarse sand with granules and below 65 cm, a coarse erosional lag with pebbles is encountered. At 200 cm, the lag was penetrated and much better sorted coarse sand was observed to a depth of 275 cm. Finally, another coarse lag was encountered at 275 cm, where core refusal occurred.

The east side of the valley shows a late glacial erosional history which occurred as high magnitude, sediment free discharge scoured late Woodfordian deposits. The lowest surface at Rosebud Island was scoured repeatedly and shows the coarsest deposits. Further entrenchment apparently occurred based upon the borehole sedimentological data, followed by valley alluviation.
At least four major late glacial erosional episodes occurred in this reach of the Mississippi River Valley. These episodes are

indicated by 4 terrace elevations located in the valley. The highest surface is Amsterdam Prairie with an elevation of 700-720 feet. Below this surface lies the second which is Brice Prairie, the Caledonia terrace, and the western margin of Amsterdam Prairie. This surface occurs at about 680 feet.

Below the 680-foot surface, is one at about 655-660 feet, and is observed at Red Oak Ridge Island, the S.E. margin of Brice Prairie, and French island. The lowest late glacial surface is Rosebud and Bell Islands. This surface is from about 645-650 feet.

The boring log at the Pool 7 dam site shows that the fill between French Island and the present major channel is comparatively fine-grained (Figure 5). The deepest boreholes in this portion of the valley penetrated to a depth of 590 feet. These deposits which are finer than the terrace deposits are interpreted to be Holocene alluvial fill.

The lack of fine grained alluvium on these high late glacial terraces indicates that these surfaces developed under different hydrologic conditions. The relatively fine grained alluvium found in the Halfway Creek fan overlies much coarser sand and granules associated with late glacial erosion.

Wisconsinan terraces along the east margin have been exposed to repeated eolian erosion during the Holocene. Orientation of the dunes and depressions is in a generally northwest-southeast trending position. Orientation is parallel to the valley axis and supports the ascertion that considerable eolian reworking has occurred on these terraces.

Two silt probe cores were taken on Amsterdam Prairie, one from a dune, the other from a blowout. The core from the dune showed that fine sand and coarse silt occurs in the solum and the fine sand continues to a depth of about 2.9 meters; below 2.9 meters coarsening to medium sand occurs. The upper unit of fine sand and silt is interpreted as reworked eolian, whereas below 2.9 meters the medium sand is interpreted as terrace sediment. The upper unit shows Beta B textural lamellae development which indicates that the lamellae have probably developed for at least a few thousand years (Berg, 1984). In this case, the reworked eolian material is interpreted to be the upper 2.9 meter unit, whereas below this the terrace deposit is observed.

Within 100 meters of this site was a blowout. The solum is developed in the top 52 cm and showed a clayey silt sand. Below 52 cm was a lag of granules and coarse sand, and by 96 cm small pebbles were observed in the deposit. Sorting between the dune and the blowout surfaces was distinctly different. At the dune, sediment was well sorted in contrast to the blowout where considerably less sorting exists.

It is virtually unknown as to what extent surficial instability occurred on these late glacial surfaces. They show textural lamellae which indicates stability in the lower solum for at least the last few thousand years, but it is virtually unknown if the upper meter has been totally reworked during the late Holocene. The evidence to date is inconclusive. In one instance at Red Oak Ridge Island, (Overstreet, 1985) excavation units observed showed repeated deflation occurring during the late Holocene. Similarly, at the Osceola terrace episodes of deflation occurred at the site (Overstreet, 1984).

Boszhardt (1984) has shown that at some locations late Holocene stability has occurred on these high terraces. Site 47LC189 shows that cultural materials found within the B-horizon may have original context. The profile described by E.A. Bettis recognized that the B-horizon contained an in situ Late Woodland cultural horizon.

R/STPAUL7/AB8

CHAPTER 4

ARCHAEOLOGICAL POTENTIAL OF GEOMORPHIC UNIT

Geomorphological investigations can be used to assess archaeological potential and predict site condition and relative age of deposits. Such investigations can be an important component when addressing archaeological problems and site integrity in the upper Mississippi Valley. Throughout the 1980s, numerous recent studies have been conducted in the upper Mississippi Valley and have shown that archaeology and geomorphology can be used effectively to analyze landscape evolution and cultural prehistory (Overstreet, 1984, 1985, Anderson and Overstreet, 1986, Benn and Bettis, 1985). The application of geomorphological concepts to archaeological site investigation helps determine archaeological site context and potential.

The upper Mississippi River Valley has received much attention by archaeologists throughout this century. This is especially true in the LaCrosse area where several investigators have recovered archaeological data from numerous sites. For example, so many sites have been recorded that the Onalaska Township has the highest density of archaeological sites within the state (Penman, 1984). Many of the investigations have been conducted by the

Mississippi Valley Archaeology Center, with other investigations conducted by GLARC, and the Wisconsin Department of Transportation.

An incredible amount of archaeological data has been collected and precludes discussion in this text. Readers are directed to investigate the publications produced by Penman (1984), Gallagher, et al., (1982), and Overstreet, et al., (1985). These authors discuss in detail the cultural prehistory of the upper Mississippi Valley specific to the Pool 7 area and LaCrosse County.

An important observation has occurred throughout the last few years regarding archaeological site distribution in the upper Mississippi Valley. One important aspect of this is that a bias exists regarding archaeological site distribution. Often, archaeological sites are found in erosional context. Anderson and Overstreet (1986) and Rogers et al. (1987), have shown that archaeological site distribution in specific areas of the Iowa and Des Moines River Valleys are in erosional contexts Considerable effort has been applied during the evaluation of these erosional sites. However, buried archaeological context by historical and Holocene deposits have frequently not been recognized.

Furthermore, although archaeological site distribution is often biased by erosional surface contexts, subsurface intact and preserved lower A horizons and paleosols often exists. Recent studies conducted by Rogers et al. (1987) have shown that below the disturbed surface context the lower A horizon remains intact and provides cultural context in deep prairie Mollisols. Therefore, although surface erosion on Mississippi terraces in Pool 7 is of concern, subsurface integrity produced by late Holocene landscape stability should be recognized. It is also important to note that surface instability on the easily deflated Mississippi terraces probably occurred episodically throughout the Holocene. Surfaces stabilized spatially at different times throughout the late Holocene. Thus, each site found on these high Mississippi terraces should be considered in a geomorphic context as having a high probability for Holocene eolian reworking during the middle and into the late Holocene, but that stability at each individual site occurred at different times and at different locations throughout the late Holocene.

ARCHAEOLOGICAL POTENTIAL OF THE GEOMORPHIC MAP UNITS

Main Valley Deposits

Mixed Lateral and Vertical Accretion Deposits

The potential of these deposits are for the most part uncertain. This is because lateral reworking from the Black and minor channels has probably occurred during the late Holocene affecting the cultural context. PSA deposits are expected to cap these sediments with a thick deposit.

Provided lateral reworking has not affected an archaeological deposit, site burial by both Holocene and historical deposits is likely to occur. Areas along the northern end of the pool, particularly in Caledonia where the mixed deposits abut the Caledonia terrace, provide potential for deeply buried archaeological deposits. In contrast, the Van Loon State Public Hunting Grounds have mixed deposits that have probably been reworked during the late Holocene by feeder streams associated with the Black River alluvial fan.

Vertical Accretion Deposits

The areas mapped as vertical accretion deposits probably contain significant portion of the Holocene record. It is unknown if these areas were amenable to cultural occupation during the Holocene. Assuming that early Holocene Mississippi River incision occurred, the lowered base would exhume stratigraphically lower surfaces in the Pool currently mapped as vertical accretion. If the mid-Holocene drought was severe to the point of significant reduction of upland water resources, perhaps these areas were dry and hospitable surfaces. If these surfaces were amenable to cultural occupation during the mid-Holocene a high potential for cultural deposits buried deeply by late Holocene and historic sediments exists.

Lateral Accretion Ridges

Very few lateral accretion ridges exist in this valley. Their distribution is such that they are mostly located adjacent to the main Mississippi River channel. The ridges are interpreted as being relatively young and have developed perhaps during the last few thousand or less years. Historically, they have been capped by PSA deposits and thus have potential for buried late Holocene or Woodland deposits.

Recent Channel Bar Deposits and Dredge Spoil

These deposits are located adjacent to the main channel margin and main channel islands. These deposits have little if any archaeological potential. The only potential associated with the spoil is where they bury older Holocene surfaces. For example, considerable dredge spoil covers Dresbach Island, and are suspected to cover tributary alluvial fans which enter the main channel area.

Mississippi River and Tributary Channel, Lakes, and Abandons

These valley features have no archaeological potential. However, along the margins of the lakes, some potential exists. This is especially true of Third and Round Lake which are located in the upper end of the pool. The lakes located in the lower end of the pool are now currently inundated by Lake Onalaska.

Valley Margin Deposits, Tributary, and Mississippi River Terraces

Mississippi Terrace

Mississippi terraces have a high potential for archaeological deposits primarily because they span the Holocene record. The surfaces have been affected by eolian activity during the Holocene. As a result of this deflation, archaeological deposits recovered on these surfaces will have a site specific component and should be addressed individually regarding geomorphic and archaeological contexts. As previously mentioned individual site characteristics and the impact of Holocene climates and cultural utilization will determine when late Holocene stability occurred at a specific location. It is anticipated that surface erosion as a result of agricultural land use, has affected these terraces. But similar to other locations in the upper Mississippi Valley in high, dry terrace surfaces where thick Mollisols exist, preserved lower A horizons often occur. This should be taken into consideration when evaluating cultural materials on these surfaces.

Tributary Terrace

Most of these terraces are located along the west valley margin of the pool. The terraces are in association with main valley aggradation which occurred during the late glacial period. Due to their orientation in the valley, they have been protected from eolian activity and drought. Recent agricultural erosion has affected the surface horizon although dunes and blowouts are not observed on this surface. Their potential for buried archaeological deposits is unknown, however, due to the age of the deposit Paleo deposits could be buried. Since these surfaces were stable for the last 10,000 years, the archaeological potential in the solum is high. Below the agriculturally affected A horizon, cultural context should be preserved.

Tributary Floodplain

Tributary floodplains include Holocene surfaces within the tributary valley margin. The surfaces have a high archaeological potential and in some cases may be buried by historical alluvium. The potential for buried archaeological context is especially high where they abut the tributary valley margin and have been covered by a mantle of hillslope deposits. Closer to the tributary channels historical alluvium is expected to cap the pre-settlement surface with a thick deposit.

Valley Wall

The valley wall is located on steep sideslopes and has a low archaeological potential. The only potential contained in this mapping unit would be where rock shelters and caves exist in the dolomite and sandstone. The steep bluffs and valley sideslopes for the most part would be inhospitable for cultural occupation.

Alluvial Fan - Colluvial Slopes

At the base of valley walls, these deposits exist and contain a high potential for buried cultural deposits. The deposits may bury Archaic and older encampments. Hillslope erosion occurred throughout much of the Holocene, and slopes were probably not stable until very late.

The broader alluvial fans that occur at Halfway Creek and the Black River have a high archaeological potential. A weak organic enriched horizon was identified deeply buried in the Halfway Creek fan. It is expected that these deposits contain an alluvial sequence that transcends throughout much of the Holocene.

Dunes - Blowouts

The archaeological potential at dune and blowout locations is for the most part unknown. This is because eolian activity and surface reworking of Mississippi River terrace sediments probably occurred throughout much of the Holocene. It is unknown when the sites became stable. Site burial on the backside or downwind side of dunes is likely.

RP/STPAUL7/AB9

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Events during the late glacial and Holocene produced a mosaic, of different aged landforms in Pool 7. Some of the surfaces have been stable throughout the Holocene while others have been affected by eolian reworking and more recent historical alluvial deposition. As a result, archaeological potential on these surfaces varies considerably within the Pool. At least four major late glacial erosional events occurred in this reach of the upper Mississippi Valley.

Four late glacial/early Holocene surfaces are observed in Pool 7. Abandonment of the Mississippi River main channel located between Brice and Amsterdam Prairie presumably occurred during these episodes of valley entrenchment. Entrenchment progressed an additional 50-feet below the present surface. Since early Holocene entrenchment, valley alluviation and major alluvial fan development has occurred in the valley. Valley alluviation probably began at the end of early Holocene and has been continuing to the present. During the mid and into the late Holocene, eolian reworking has affected the four late glacial surfaces. Numerous dunes and blowouts are observed at these locations. A slightly finer textured and stratigraphically higher Amsterdam Prairie has the highest density of these eolian surfaces, whereas, stratigraphically lower fluvial erosional surfaces contain coarser Woodfordian deposits. Dune and blowout activity on these surfaces is apparent but to a somewhat lesser degree. As the late Holocene climate changed due to increased precipitation, it is anticipated that water tables recovered and stability occurred on these sandy surfaces. Throughout the late Holocene incidents of local instability probably occurred in response to local site characteristics, Holocene climates and anthropogenic pressure.

It is expected that a biased distribution of archaeological sites exist in Pool 7. Many sites could be buried by Holocene deposits in the main valley. This is especially true if valley entrenchment occurred during the early Holocene making surfaces in the main valley more hospitable to cultural encampment. As valley alluviation progressed during the late and mid-Holocene, the early deposits have a high potential to be deeply buried. A high potential for burial exists in the Caledonia/Holland area where lateral reworking of minor channels and feeder alluvial fan streams has not occurred. Furthermore, inundation by Lake Onalaska is not observed in the northern end of the pool. The upper end of the Pool remains the least affected by Lock and Dam impoundment. This was particularly the case in Pool 11 (Overstreet, 1985). Terrace outliers such as Red Oak Ridge Island indicate that lateral reworking by the Mississippi River has been modest.

From the borehole data and field investigations, major textural differences occur between Holocene and late glacial deposits. The borehole data shows that fine sand and clay occur in the drill holes between French Island and the main Mississippi River channel (Figure 5). These relatively finer deposits are interpreted to represent Holocene deposition. In contrast, coarser deposits of coarse sand, granules, and pebbles, which occur on Rosebud and Red Oak Ridge Island are interpreted as late glacial. Provided this interpretation is correct, Mississippi River migration has been minimal during the Holocene.

RECOMMENDATIONS

Additional work at Pool 7 should include a comprehensive assessment of the depth and distribution of Post Settlement Alluvium (PSA) located within the management area. Predicting the depth and distribution of this deposit is important for cultural resource managers, particularly in areas where buried cultural deposits could be disturbed by dredging or other land use activities. Additionally, archaeological sampling strategies should be developed based upon local depths of PSA deposits. An overlay map should be constructed to predict the distribution and depth of PSA. Proposed mapping unit PSA depths should be <10 cm., 10-50 cm., 50>cm. Field investigations should be used to verify the accuracy of the mapped deposits.

Further investigations should include a Holocene stratigraphic study of the exposed land and islands along the upper end of the Pool. These are surfaces that represent considerable valley alluviation during the Holocene and likely have a high potential for buried soils and/or archaeological context. The study should include soil/sediment sampling and associated particle size and organic carbon analysis. Radiometric dating of organic enriched sediments should also be performed in order to accurately determine the landscape chronology. The stratigraphic study should be in the form of a surveyed transect in order to develop a detailed cross-section across the Holocene surfaces.

Valley margin deposits usually contain buried soils and consequently have a high potential for buried archaeological sites. These deposits, such as alluvial fans and colluvial slopes, should be tested through the use of particle size, organic carbon and radiometric analysis.

Particular problem areas are hillslope deposits overlying Amsterdam prairie. Considerable informal debate has occurred regarding the late Woodfordian/early Holocene Mississippi River evolution.

Some investigators contend that the upper Mississippi River has been reworked during the Holocene, and that the Mississippi terraces are not associated with the final episodes of catastrophic glacial lake discharges. This is an alternative interpretation which should be considered. The questions raised could be answered by dating the terraces where they are buried by hillslope deposits. The east valley margin should be examined in order to resolve the questions surrounding early Holocene floodplain evolution.

RP/STPAUL7/AC1

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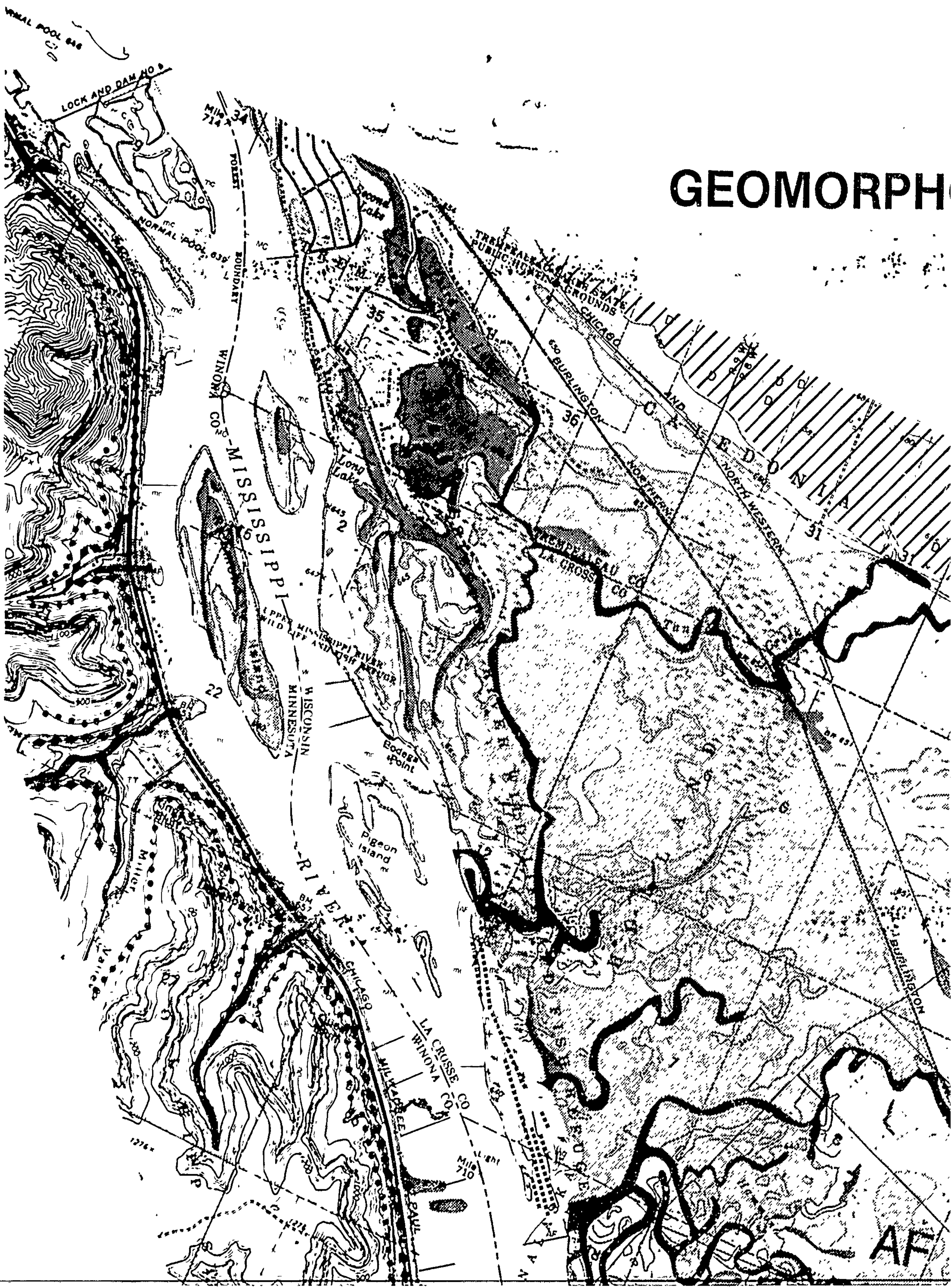
RP/STPAUL7/AB4

GEOMORPH



LOCK AND DAM NO 8
NORMAL POOL 639
Mile 714
FOREST BOUNDARY
Second Lake
TREMPEALEAU STATE PUBLIC HUNTING GROUNDS
CHICAGO BURLINGTON AND NORTHERN
CHICAGO AND NORTH WESTERN
CALEDONIA
WINONA CO
MISSISSIPPI
Long Lake
TREMPEALEAU CO
LA CROSSE CO
UPPER MISSISSIPPI RIVER WILD LIFE AND FISH REFUGE
WISCONSIN
MINNESOTA
Bodega Point
Pigeon Island
RIVER
LA CROSSE CO
WINONA CO
CHICAGO
MILWAUKEE
ST PAUL
Mile 710
BURLINGTON
AF

Bodega Point
Pigeon Island
RIVER
CHICAGO
MILWAUKEE
ST. PAUL
AND
PACIFIC
LA CROSSE CO
WINONA CO
Light
Mile 710
AF
BURLINGTON
Bullet
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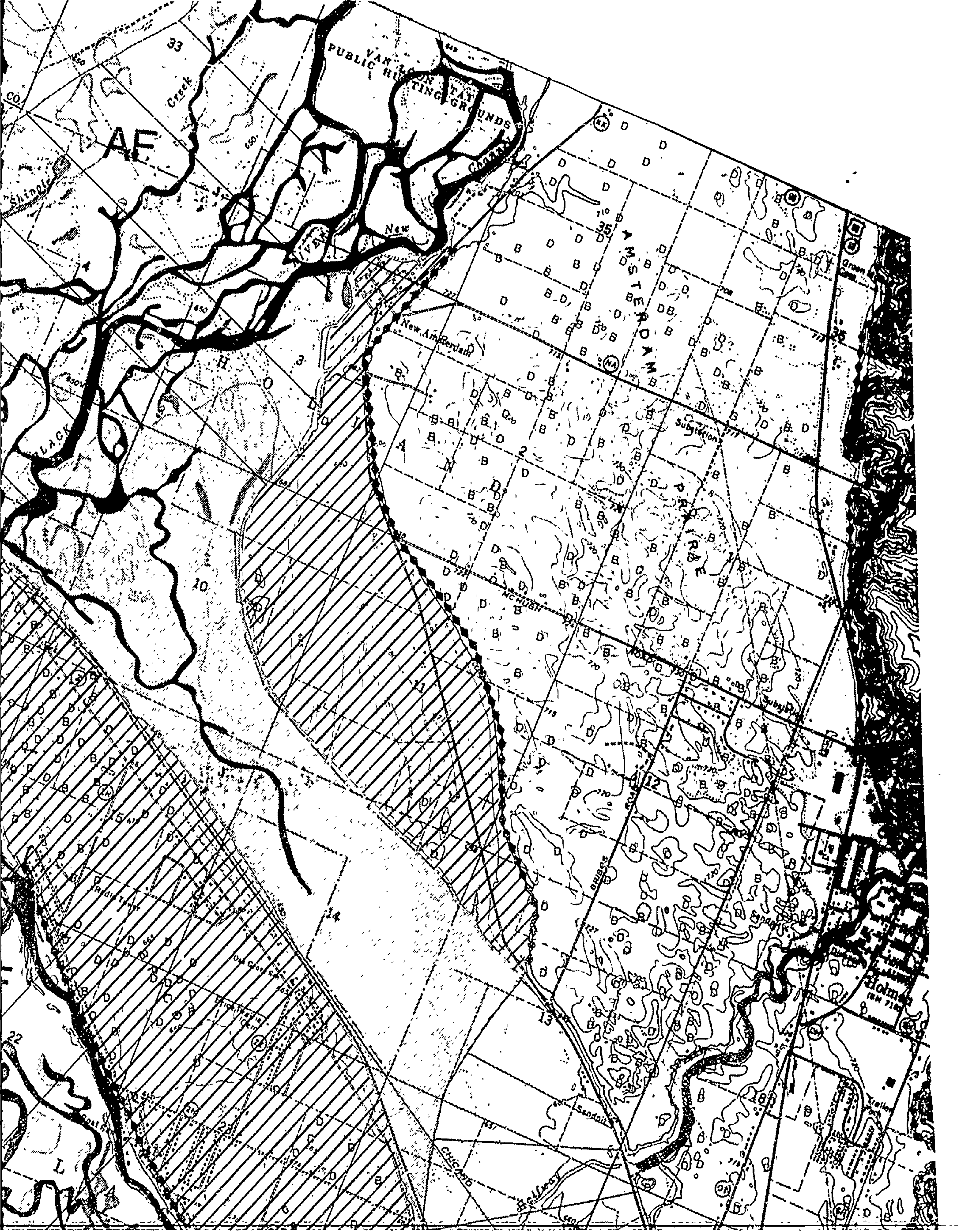
Dakota
(BM 691)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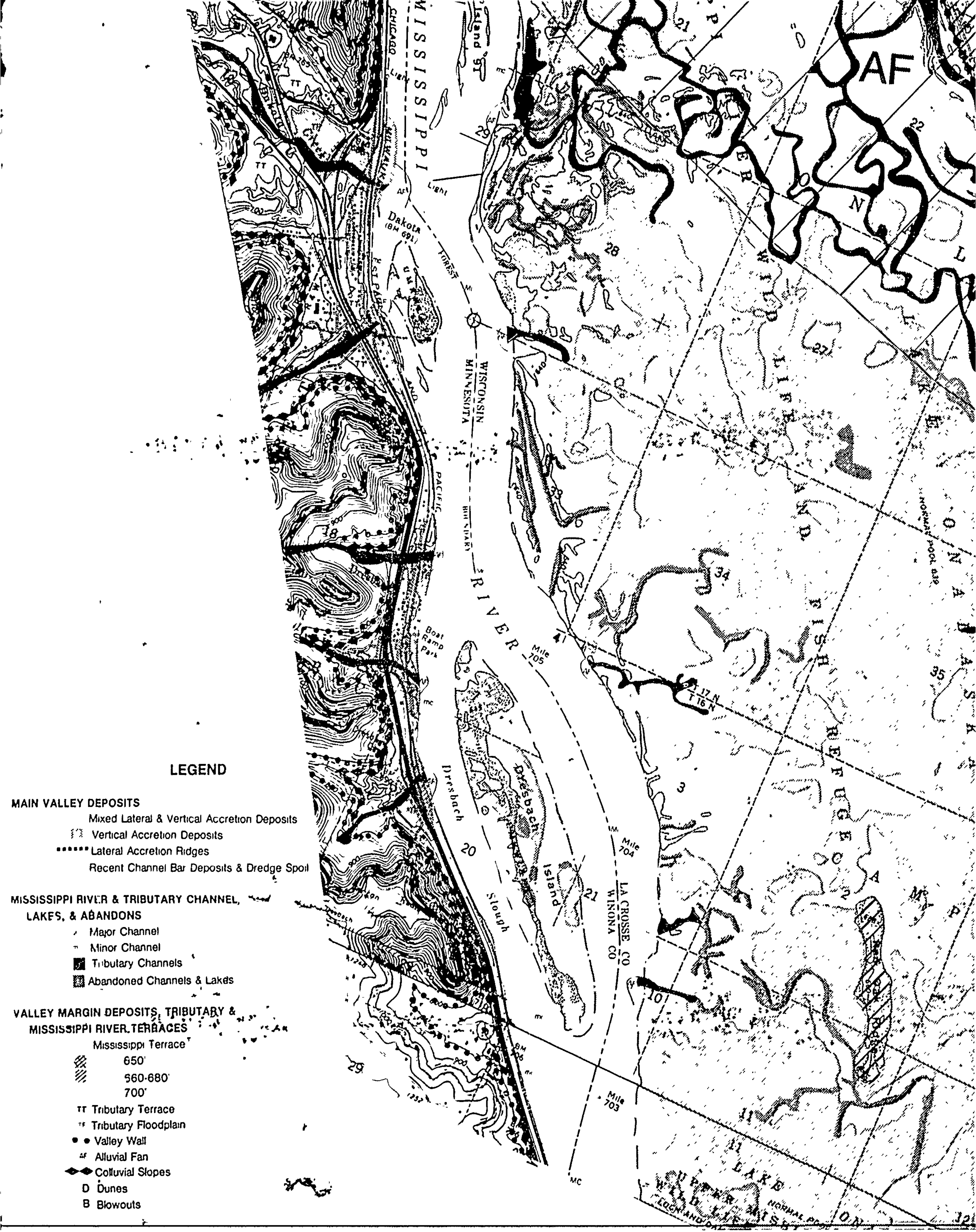
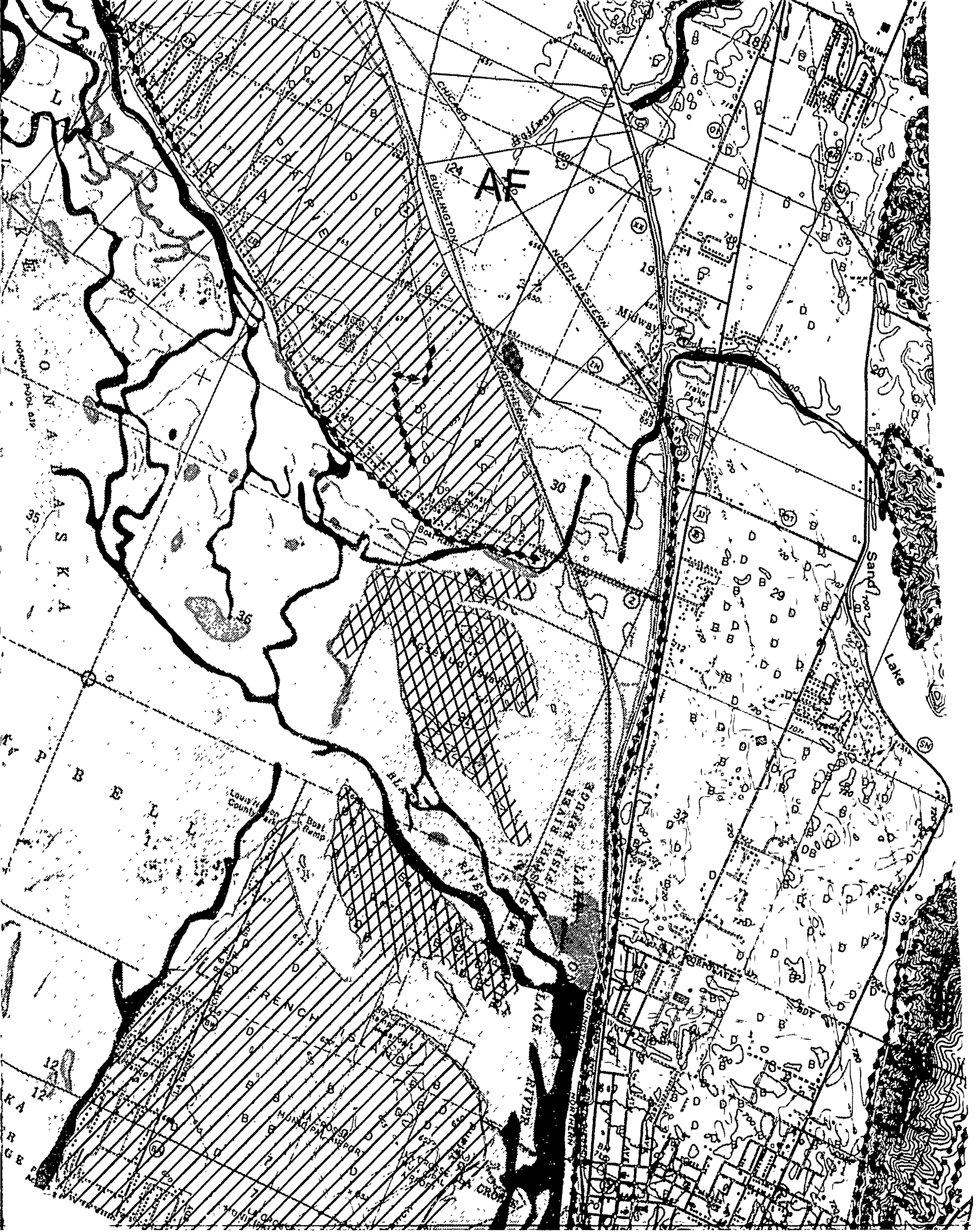

LEGEND
MAIN VALLEY DEPOSITS
Mixed Lateral & Vertical Accretion Deposits
Vertical Accretion Deposits
Lateral Accretion Ridges
Recent Channel Bar Deposits & Dredge Spoil
MISSISSIPPI RIVER & TRIBUTARY CHANNEL, LAKES, & ABANDONS
Major Channel
Minor Channel
Tributary Channels
Abandoned Channels & Lakes
VALLEY MARGIN DEPOSITS, TRIBUTARY & MISSISSIPPI RIVER TERRACES
Mississippi Terrace
650'
560-680'
700'
TT Tributary Terrace
TF Tributary Floodplain
Valley Wall
AF Alluvial Fan
Colluvial Slopes
D Dunes
B Blowouts
MISSISSIPPI
RIVER
Dakota
WISCONSIN
MINNESOTA
BOUNDARY
Boat Ramp Park
Dresbach
Dresbach Island
Dresbach Slough
Mile 705
Mile 704
Mile 703
LA CROSSE CO
WINONA CO
T 17 N
T 16 N
AF
UPPER MISSISSIPPI RIVER WILD LIFE AND FISH REFUGE
LAKE ONALASKA
NORMAL POOL 639
CHICAGO MILWAUKEE ST PAUL AND PACIFIC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RIVER
FISH REFUGE
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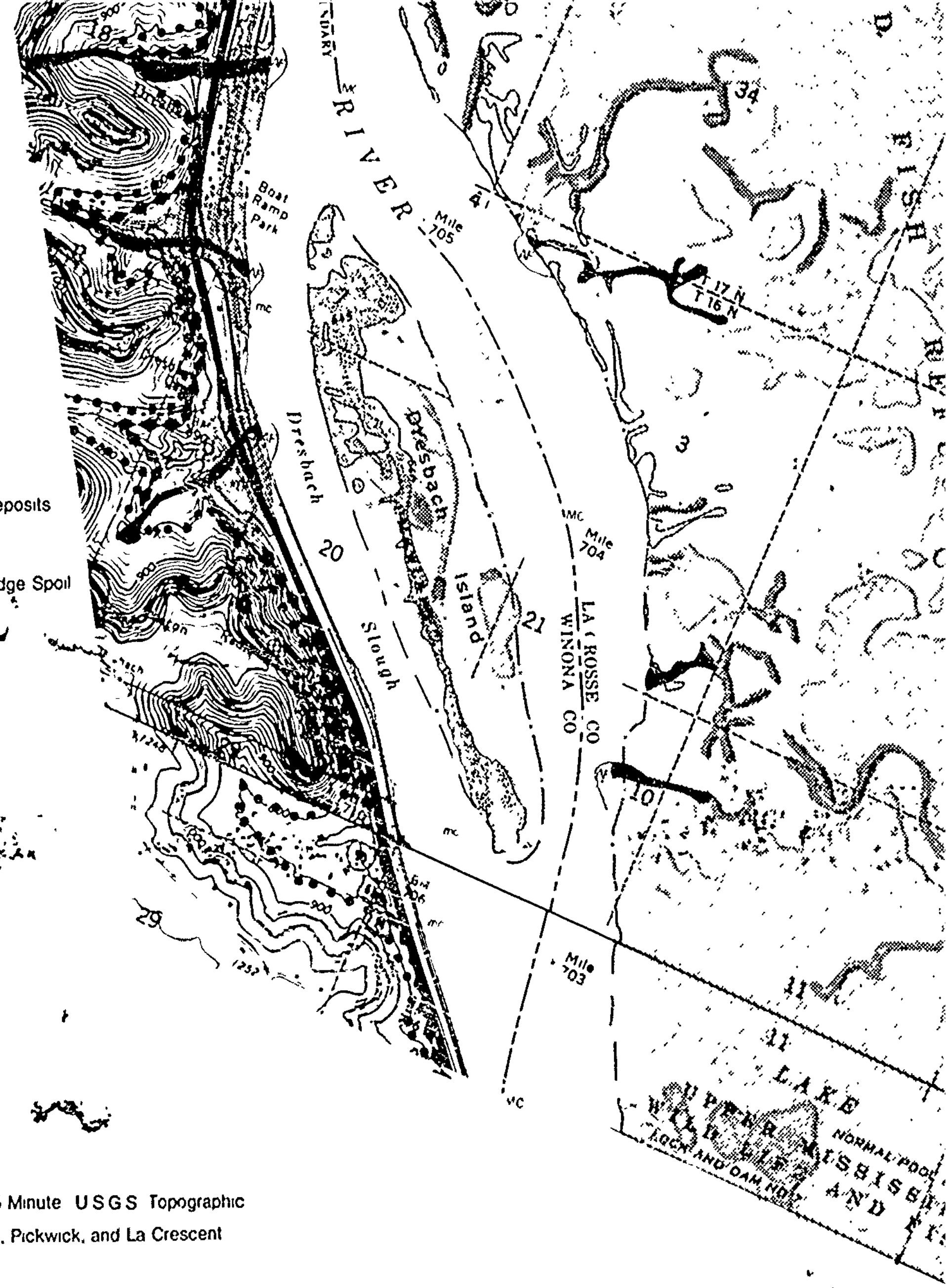
MUNICIPAL AIRPORT



LEGEND

MAIN VALLEY DEPOSITS

Mixed Lateral & Vertical Accretion Deposits

Vertical Accretion Deposits

Lateral Accretion Ridges

Recent Channel Bar Deposits & Dredge Spoil

MISSISSIPPI RIVER & TRIBUTARY CHANNEL, LAKES, & ABANDONS

MC Major Channel

Minor Channel

Tributary Channels

Abandoned Channels & Lakes

VALLEY MARGIN DEPOSITS, TRIBUTARY & MISSISSIPPI RIVER TERRACES

Mississippi Terrace

650'

560-680'

700'

TT Tributary Terrace

TF Tributary Floodplain

Valley Wall

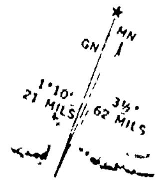
AF Alluvial Fan

Colluvial Slopes

D Dunes

B Blowouts

SOURCE Base Map Composite From 7 5 Minute U S G S Topographic Quadrangle Holmen, Onalaska, Pickwick, and La Crescent



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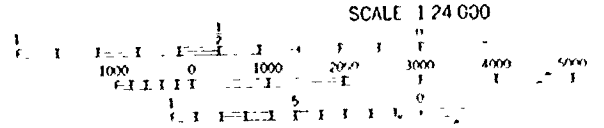
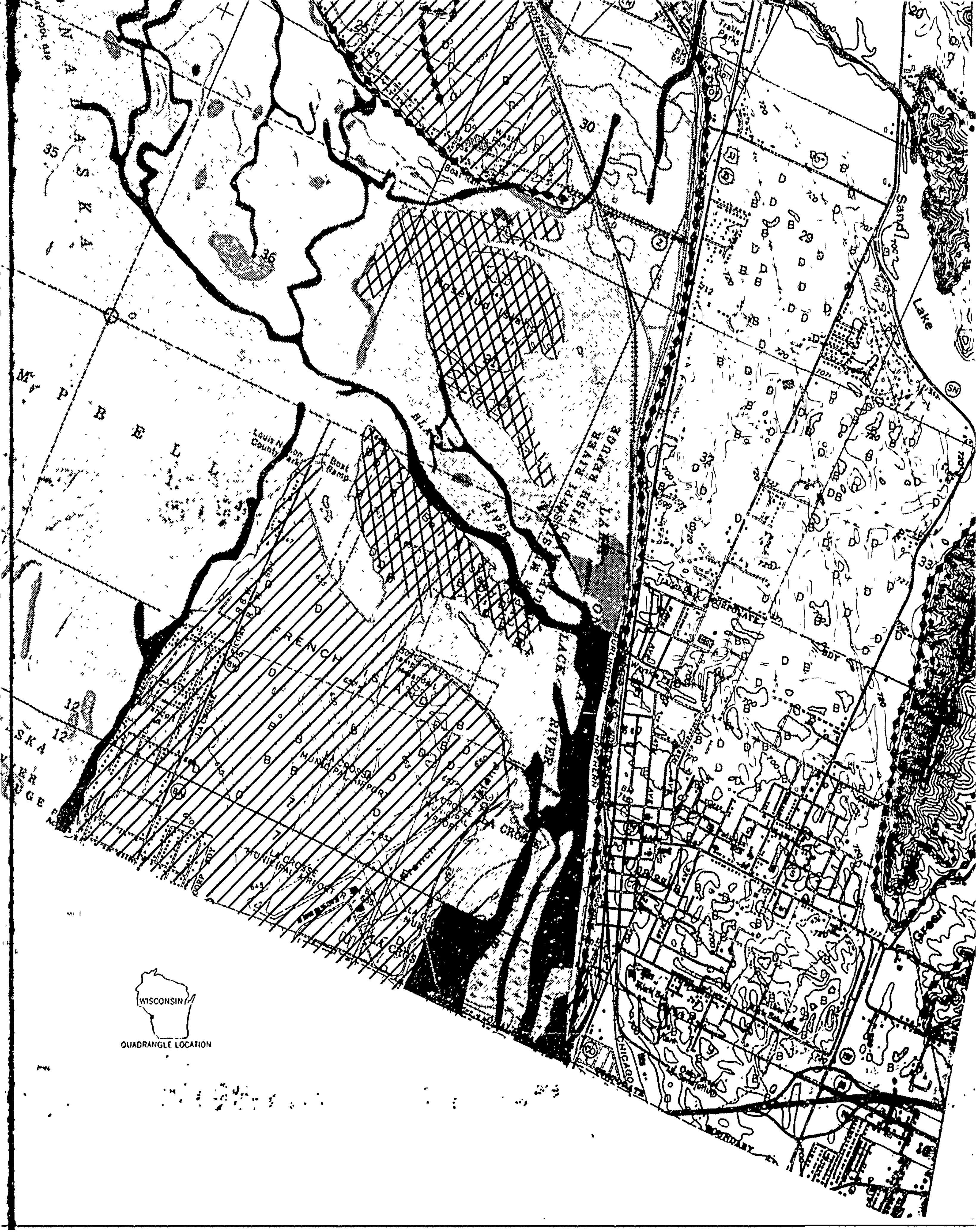
SCALE 1 24 000



CONTOUR INTERVAL 20 FEET
DOTTED LINES REPRESENT 5 FOOT CONTOURS
NATIONAL GEODETIC VERTICAL DATUM OF 1929



WISCONSIN
QUADRANGLE LOCATION
Sand
Lake
Trailer Parks
Boat Ramp
RIVER
FISH REFUGE
BURLINGTON
NORTHERN
CHICAGO
LA CROSSE
MUNICIPAL AIRPORT
CORPORATE
BDY
BOUNDARY