Technical Report M22

SIDE CHANNEL STUDY OF THE MIDDLE MISSISSIPPI RIVER AT MORO CHUTE RIVER MILES 122.6 TO 120.2

GEOMORPHIC AND POTAMOLOGIC INVESTIGATION

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INTRODUCTION

Through the Avoid and Minimize Program (A&M), the U.S. Army Corps of Engineers, St. Louis District initiated a side channel study of the Middle Mississippi River at Moro Chute, between Miles 122.6 and 120.2. The purpose of the study was to evaluate the characteristics of Moro Chute and determine the factors responsible for its connectivity with the main channel. It was believed by some members of the A&M team that flow in this particular channel occurs over a longer duration than any other side channel within the Middle Mississippi River.

The study was conducted between August 2001 and October 2001 by Ms. Dawn M. Lamm, Hydraulic Engineer, under direct supervision of Mr. David C. Gordon, Hydraulic Engineer, and Mr. Robert D. Davinroy, District Potamologist. Personnel involved with data collection and computation included, Mr. Edward Riiff, Mr. Aron Rhoads, Mr. Peter Russell, and Mr. Jasen Brown from the Hydrologic and Hydraulics Branch. Other Hydrologic and Hydraulics Branch personnel involved included Mr. Claude Strauser, Mr. Dave Busse, Mr. Leonard Hopkins, and Mr. Stephen Redington. Additional assistance was provided by Mr. T. Miller, Mr. Brian Johnson, and Mr. Eric Laux from the Environmental Branch of the Planning, Programs, and Project Management Division. Detailed hydrographic surveys were provided by the St. Louis District's crew aboard the M/V Simpson. Post processing of the survey data was provided by Mr. Alan Berman of the Geospatial Engineering Branch.

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BACKGROUND

This report details a geomorphic and potamologic investigation of Moro Chute, a side channel located on the Middle Mississippi River.

1. Study Reach

Moro Chute is located on the Middle Mississippi River between Miles 122.6 L and 120.2 L, approximately 2.5 miles upstream of the mouth of the Kaskaskia River, in Randolph County, Illinois. The reach is just east of Ste. Genevieve, Missouri. Plate 1 is a location and vicinity map of the study reach. Plate 2 is a 1998 aerial photograph depicting the main river channel, Moro Chute and the characteristics of the study reach.

As shown on the aerial photograph, the side channel contains two major islands and has two entrance points. The primary entrance to the side channel is much narrower and deeper than the secondary entrance. The secondary side channel entrance is located downstream of the primary entrance and is situated between the two islands. Although the width of this channel is much greater than the primary channel, the elevations of the bed are also much higher. The remainder of the side channel downstream of the confluence is defined as the main side channel. It is the portion of the side channel located between the confluence of the two entrance channels and the exit of the side channel. A description of each channel reach follows.

Primary Side Channel

The primary entrance channel begins along the downstream side of Dike 122.6 L and is eventually positioned between the Illinois bankline and the smaller upstream island. It is believed that the plunge pool created by Dike 122.6 L forms the inlet to this channel. This inlet plunge pool is about 1000 feet long and is parallel to the

dike. A badly deteriorated wooden pile extension of this dike extends longitudinally from the middle of the dike and crosses the primary inlet at a low elevation. The channel is then located between the Illinois bankline and the smaller island for approximately 4500 feet to its confluence with the secondary side channel at the downstream tip of the smaller island. The width of the side channel through this area ranges between 200 and 300 feet.

Most of the primary channel contains near vertical, erosional banklines along both the left descending bank (LDB) and the right descending bank (RDB). A 100-degree bend is located in the primary side channel, approximately 2,000 feet from the mouth of the chute near the main channel. The LDB in this area is slightly steeper, and a point bar is located off of the RDB. Just upstream of this bend, another smaller and shorter channel cuts through the smaller island. This channel is extremely narrow with high bed elevations. The width is less than 100 feet wide, and extends a distance of 1000 feet through the corner of the island. The banklines are heavily vegetated and the channel is littered with drift.

Remnant pile Dike 122.0 L is located within the primary side channel just downstream of the outlet of the small channel. This structure is extremely deteriorated and sits at a low elevation. The segment of the channel downstream of the bend is relatively straight. The thalweg gradually meanders from the RDB to the LDB.

Secondary Side Channel

The secondary side channel is approximately 3200 feet long, beginning near the main river channel to its confluence with the primary side channel at the downstream tip of the smaller island. The channel entrance is approximately 2200-feet wide at its mouth and reduces to 1200-feet wide at its confluence with the primary channel.

The higher bed elevations within this wider entrance channel only allow flows through this reach at high stages. However, a scour area in the middle of the bar usually isolates a large pocket of water after water elevations drop and flow ceases through this channel. This lower elevation area begins along the LDB of the smaller island and extends across the channel and downstream to the RDB of the larger island.

Main Side Channel

The main side channel, excluding the plunge pools downstream of Dike 121.1 L, has an average channel width between 700 and 850 feet. The channel at the plunge pools is estimated to be 1100 feet wide. The configuration of the upstream segment of the main channel is described as a long, gradual 45-degree bend. The thalweg through this area is located mainly along the LDB with a large depositional area along the RDB of the larger island.

At the confluence of the primary and secondary channels, a depositional area extends into the main channel and encroaches upon the channel thalweg. Just downstream of this area, remnant pile Dike 121.8 L crosses this side channel from the LDB and continues into the higher elevations of the secondary channel. This pile dike is also significantly deteriorated and contains a low crown elevation. Pile Dike 121.6 L is located 1000 feet downstream of Pile Dike 121.8 L. This pile dike may have been flanked along the LDB sometime during or shortly after the 1993 flood. The remainder of the dike crosses the side channel into a sandbar along the RDB. The apex of the bend is located just downstream of this dike and within an area of scour. The LDB downstream of this area is heavily revetted to a point near Dike 121.1 L.

Dike 121.1 L is located 2500 feet downstream of Pile Dike 121.8 L and at the downstream end of the long bend. The configuration of Dike 121.1 L consists of two downstream angled dikes extending from each bankline and connected at mid-

channel. A small notch or low area in the dike is located to the right of the intersection point of the two angled dikes. A remnant pile dike exists along the alignment of the rock structure from the LDB of the chute to the center intersection point. The pile structure then continues across the channel at the same angle and ends within the RDB of the larger island.

The banklines immediately downstream of Dike 121.1 L are rounded out. Most likely these banks have experienced severe scouring and migration due to the downstream angled configuration of the structure. The banks are relatively stable at this time because of rock revetment along the LDB and thick vegetation along the RDB. The width of the channel just downstream of the dike is 1100 feet while the widths upstream and downstream of this area are only 700 to 800 feet.

Downstream of Dike 121.1 L, the channel is divided with a middle bar and a thalweg along both banklines. Remnant Pile Dike 120.7 L is located is this reach but at a low elevation and is in a deteriorated state. The RDB is slightly steeper than the LDB through the area. However, an overbank scouring zone is situated on top of the LDB in the floodplain where vegetation is limited. The divided channels merge back together at a point near Dike 120.2 L. This downstream angled structure is the last within Moro Chute. It extends from the LDB within the chute into the main river channel. A plunge pool is located immediately downstream of the structure.

2. Study Purpose and Goals

It is believed that Moro Chute is one of the last side channels on the Middle Mississippi River to maintain its connectivity to the main channel as water levels drop. A side channel has connectivity with the river if sufficient depths are maintained for the passage of fish, preferably at the side channel exit. Sufficient depth is between 12 and 18 inches. This study will discuss the physical aspects of Moro Chute and the relative importance of those aspects in maintaining connectivity with the main channel at lower stages. Once these aspects are understood, this

knowledge may be applied to other side channels on the river to possibly increase the percentage of time connectivity is maintained to the main channel.

Physical aspects such as the planform, bathymetry, number of bends, cross-sectional depth and width, condition and type of banks, bed sediment composition, and velocity of flow were examined in this study. Historical aerial photographs and hydrographic surveys were analyzed to quantify changes within the study area over time. However, it should be noted that each piece of data collected from a dynamic river environment represents only a single point in time. For example, if a recent high water event occurred before the hydrographic survey/aerial photograph was taken, the bathymetry of the side channel may have been affected by the event. These events can dramatically transform the dimensions of a channel temporarily or permanently. Therefore, the uncertainties involving historic photography and hydrographic surveys were combined with the knowledge of stream dynamics to determine the general trends in the study area.

3. Historical Planform and Bathymetry

The study area has experienced minimal structural modifications in the past 36 years. Remnants of Pile Dikes 122.6L, 122.0L, 121.8L, 121.6L, 121.1L and 120.7L, built in the 1930's, still exist in portions of the river today. The only known modifications in this reach were the reconstruction of Dikes 122.6 L, 121.1 L, and 120.2 L, which were completed in the 1960's. Revetment works on threatened banklines were completed in the 1980's and 1990's. Additional dikes have not been constructed within the side channel nor has there been any significant levee construction performed adjacent to the side channel.

The following observations were made from aerial photographs and hydrographic surveys collected from 1928 through 2001. All stage data was obtained from the Chester, Illinois gage at Mile 109.9.

1928

The earliest aerial photograph obtained was from 1928, shown on Plate 3. This photo delineates pile dike locations within the main channel and the future side channel location. Two of the pile dikes shown in the photograph are located in the present day side channel. Dike 122.6 L was rebuilt with stone in 1960, and Pile Dike 122.0 L still exists in a badly deteriorated state. A large middle bar had formed in the river channel where the present day navigation channel is located. The photograph also shows the position of the LDB in 1930, two years after the photo was taken. The white line shown on the photo indicated that major bankline erosion occurred within a two year time period. This was most likely caused by the lack of vegetation due to farming practices along this bank. However, the alignment of the present day bankline remains very similar to the alignment and location of the LDB in 1930.

1932

The 1932 aerial photograph on Plate 4 displays pile dikes, either existing or proposed, and a dominant middle bar. Although larger, the location of this middle bar was approximately the same as in 1928. The locations of the pile dikes were enhanced with dark lines drawn on the photograph. Pile Dikes 123.4L, 123.0L, 122.6L, and 122.0L appeared to be slightly longer. Downstream of these structures, the photograph shows the newly constructed pile dikes (121.8L, 121.6L, 121.1L and 120.7L) located along the LDB. These dikes were proposed to reduce bankline erosion and develop a more manageable contraction width. The older pile dikes along the RDB (122.6 R, 122.3 R, 121.8 R and 121.4 R) developed significant deposition between the structures as well as upstream and downstream of the dike field. The alignment and configuration of the channel located along the RDB did not appear completely natural. It may be possible that the dredges shown in the photo artificially maintained much of this channel.

1935

The 1935 photograph on Plate 5 shows most of the pile structures depicted in the previous photos. However, a new structure was placed at Mile 120.2L and the lengths of some of the pile dikes along the RDB (122.6R, 122.3R, 121.8R, and 121.4R) appeared to have been reduced intentionally or by erosion. The remaining portions of the RDB dikes were fully entrenched into a newly formed bankline due to significant deposition between the structures. These dikes and sediment deposits moved the RDB into the river a distance of approximately 1000 feet. The large middle bar had lengthened, widened and shifted towards the LDB. A dominant main channel was located along the RDB while a much smaller side channel was located along the LDB. The shifted position of the middle bar indicated that it had transformed into a side bar. Seven pile structures (Dikes 122.6 L, 122.0 L 121.8 L, 121.6 L, 121.1 L, 120.7 L, and 120.2 L) were located along the LDB in the side channel and adjacent to the large side bar. Most of the deposition occurred off the ends of the structures near the side bar. Flow appeared to have been maintained along the LDB where the dikes were tied into the bankline. Smaller isolated sandbars developed upstream of the side channel between Dikes 123.9 L, 123.6 L, 123.4 L, and 123.0 L. The configuration of the main channel, large side bar, and secondary channel in this photo suggested the initial formation of Moro Chute.

The analysis of the photographs from 1928, 1932 and 1935 indicated major changes in the planform of the river. An immense amount of erosion and deposition appeared to have occurred within a short 7-year time period. The photographs also showed limited vegetation along most of the banklines in this reach. These characteristics were indicative of the entire Middle Mississippi River during this time period and were not limited to this reach. Extensive bankline erosion was taking place, which was unnaturally widening the river channel and causing an increase in sediment load. The additional sediment load formed numerous middle bars and accelerated deposition within dike fields. Many of these dike fields were responsible for significantly reducing the bankline erosion and limiting the amount of additional sediment that entered the river system.

1956

The 1956 hydrographic survey, depicted on Plate 6, shows the earliest bathymetry available after the initial development of the side channel. The survey indicated that the bathymetric trends in the main river channel were similar to the present day trends. The main channel thalweg upstream of Moro Chute was located along the LDB dikes between Miles 125.5 and 123.0. A crossing to the RDB was located between Miles 123.0 and 122.4. The thalweg remained along the RDB throughout the bend and the rest of the study reach with depths over –20 feet LWRP. Navigable depths below –10 feet LWRP were maintained throughout the reach in the main channel. Unfortunately this survey did not extend into the side channel. However, it did show pile dike locations and indicated areas of woody vegetation on the side bar, which was developing into an island. Most of the vegetation was developing on the downstream half of the present island location. The pile dikes along the RDB were still fully entrenched into the bankline and did not extend into the river channel. Additional length and trails were added to pile dikes 123.0 L, 122.6 L, and 120.7 L. An additional pile dike with a trail was placed along the LDB at Mile 123.2 L. New pile dikes were positioned in the river channel, along the edge of the large side bar and the developing island at Miles 122.1 L, 121.5 L, 121.2 L, and 121.0 L. The survey also shows that a wooden mattress was laid just upstream and downstream of Dike 122.6 L. A portion of the mattress located downstream of the pile dike seemed to correspond to the present location of the smaller island within the upstream segment of the chute.

1965

An aerial photo from 1965 (Plate 7) shows that Pile Dikes 123.0 L, 122.6 L, 121.0 L, and 120.2 L had been reconstructed with stone except for the trails. A large vegetated island with a well established side channel was observed in this photo. Additional islands and an expanded bankline had also developed upstream of the side channel complex. The photograph indicated multiple inlets to the side channel. Numerous narrow secondary inlets that connect into the main side channel complex

were located upstream of Dike 122.6 L. A wider inlet was located along the downstream side of Dike 122.6 L, similar in alignment to that of the current primary inlet. The outline of the smaller upstream island was slightly defined in the photo by sparse vegetation. The larger, secondary inlet was located upstream of the main island through the area where the present sandbar is currently located. The water level in this photograph was + 7.18 feet LWRP according to the Chester, Illinois gage.

1968 / 1971

The 1971 hydrographic survey with a 1968 aerial photograph background is shown on Plate 8. In 1965, Pile Dike 121.1 L was reconfigured and constructed with stone. The dike was originally constructed at a downstream angle and extended from the LDB to the RDB. The new configuration consisted of two downstream angled dikes extending from each bankline and connected at mid-channel. The aerial photograph indicated that this dike configuration initiated significant bank erosion directly downstream from the dike. The survey showed bathymetric trends similar to those shown on the 1956 hydrographic survey. However, the 1971 survey indicated higher bed elevations in the main channel. This was especially evident in the crossing between Miles 123.0 and 122.0.

1976 / 1977

The 1977 hydrographic survey with a 1976 aerial photograph background is shown on Plate 9. The Chester gage reading at the time of the 1976 photograph was +3.48 Feet LWRP. An additional 1976 aerial photograph with a 1977 aerial photo insert is shown on Plate 10. The Chester gage reading at the time of the 1976 aerial photograph was –0.32 feet LWRP and +10.98 feet LWRP at the time of the 1977 photograph. At the river stages shown in the 1976 photographs, the main channel was not connected with the side channel at the upstream end. However, the downstream end of the channel seemed to have maintained a slight degree of connectivity. The photographs indicate well-defined islands as well as banklines

with significant amounts of woody vegetation. The alignment is similar to that of present day conditions. The photo also showed that the numerous narrow inlets that were previously located upstream of Dike 122.6 L had been filled with sediment and were becoming vegetated. Both aerial photographs on Plate 10 displayed a temporary haul road that had been constructed from Dike 122.6 L near the bankline, across the primary inlet, to the smaller upstream island. The water level in the 1976 photograph indicated that the bed upstream of this haul road appeared to have aggraded while the bed downstream appeared unchanged. The 1977 view of this area indicated that a portion of the flow into the side channel was possibly diverted down the larger channel due to the presence of the road across the smaller channel. Other observations included additional bank migration along both banklines downstream of Dike 121.1 L. The crossing in the navigation channel between Miles 123.0 and 122.0 indicated sufficient depths for navigation.

1983 / 1987

The 1987 hydrographic survey with a 1983 aerial photograph background is shown on Plate 11. The Chester gage reading at the time of the 1983 photograph was +4.92 feet LWRP. This survey shows the first known bathymetric data collected within the side channel. The deepest portion of the side channel was located in the scour holes downstream of Dike 121.1 L. However, additional deep areas were located along the LDB between Dikes 121.8 L and 121.1 L. The remainder of the chute downstream of Dike 121.1 L contained higher bed elevations compared to those found upstream of the dike. Shallow depths were also recorded between the two islands in the side channel complex. Connectivity between the main channel and side channel was not shown. As observed in past hydrographic surveys, a shallow crossing existed in the main channel between Miles 123.0 and 122.0.

1988

Plate 12 displays an aerial photograph taken during low water in 1988. The Chester, IL gage reading at the time of this photo was –0.62 feet LWRP. The photo indicated

that the side channel was narrowly connected to the main channel. The upstream and downstream openings were extremely narrow. Additional areas between Dikes 122.0 L and 121.6 L also had high bed elevations that did not allow flow at this stage. The photograph showed no indications of the haul road that once existed across the primary inlet to the smaller upstream island. However, higher bed elevations were still observed upstream of the previous haul road crossing. The downstream angle of Pile Dike 121.6 L seemed to have initiated significant bankline erosion along the LDB just downstream of the structure. Additional bankline erosion was observed downstream of Dike 121.1L. A possible split channel was forming further downstream of Dike 121.1 L near the end of the side channel.

1993

An aerial photo of Moro Chute during the 1993 flood is shown on Plate 13. The Chester, IL gage reading at the time of this photo was +48.28 feet LWRP. The outlines of three islands are distinctly observed in the photograph. Significant overbank flows may have entered the floodplain along the LDB in the downstream portion of the chute. This area had a minimal amount of vegetation along the bankline. The levee along the RDB of the Mississippi River was breached near Mile 120.0.

1998 / 2000

Plates 14 and 15 depict aerial photographs taken in 1998 and 2000 respectively. The Chester gage reading at the time of the 1998 aerial photograph was +7.06 feet LWRP and +4.77 feet LWRP at the time of the 2000 photograph. The photographs showed insignificant differences in the configuration of the side channel complex. Minimal connectivity was observed at both ends of the chute at the given stages. The shallowest and narrowest areas appeared to be at the chute openings and in the vicinity of Dike 121.8 L. Dike 121.6 L had been flanked along the LDB due to significant bankline scouring that had occurred downstream of the structure. A clear inflection point was formed in the bankline near the dike and localized widening

occurred. The photographs also revealed that most of the bankline between Dikes 121.6 L and 121.1 L was devoid of vegetation. A distinct split channel with a middle bar was located downstream of Dike 121.1 L. Obvious erosional scars in the floodplain caused by overbank flows were located along the LDB downstream of Dike 121.1 L.

4. Recent Physical Analysis

Comprehensive hydrographic sweep surveys from 1999 and 2001 are shown on Plates 16 and 17, respectively. These surveys were utilized to investigate the present day bathymetry within the side channel. Plate 18 illustrates an isopach or bathymetric elevation comparison that occurred in the time period between those surveys. The various colors on the map represented either aggradation or degradation of the riverbed during that period of time. The warm colors (yellows, oranges, and reds) represented aggradation. The cool colors (shades of blue) represented degradation. Gray represented areas that contained elevation changes between +2 and –2 feet, which were considered normal fluctuations in the riverbed and were not representative of long-term trends.

The prominent green color codes in the sweep surveys indicated that the majority of elevations throughout the side channel were above 0 feet LWRP. Depths between 0 and –10 feet LWRP were reached in the area along the LDB between Dikes 121.6 L and 121.1 L. The deepest portion of the side channel was located in the plunge pools immediately downstream of Dike 121.1 L, where depths reached –30 feet LWRP. Both surveys showed a split channel with a middlebar situated downstream of these plunge pools near the end of the side channel. This middlebar contained elevations that approach +15 feet LWRP. The 2001 survey revealed a more distinct split channel at the end of the chute, with greater depths in both channels and a narrower middle bar. This survey also showed that the depths at the entrance to the side channel were greater than those shown in the 1999 survey. The bed elevations in the secondary entrance channel between the two islands were generally above

+15 feet LWRP. However, a narrow low flow channel existed in this area and crossed from the upstream island to the downstream island.

From the isopach, it was determined that most areas in the side channel experienced minimal changes in bed elevations between 1999 and 2001. However, three areas in the study reach had experienced notable aggradation and four areas had experienced notable degradation. Significant degradation occurred in two areas, both downstream of a rock dike.

Localized scour depths in the plunge pool directly downstream of Dike 122.6 L increased by approximately 16 feet. This was especially evident between the dike and the upstream island. Minor depth increases were realized throughout the remainder of the primary channel. However, a small, localized area of aggradation was located just downstream of the 100-degree bend in this channel. This area can possibly be attributed to the presence of drift that may have encouraged deposition.

Minor increases in depth were noticed in the secondary side channel entrance. In the main side channel, the thalweg along the LDB between Dikes 121.6 L and 121.1L experienced aggradation of approximately 10 feet. The majority of areas in the plunge pools downstream of Dike 121.1 L increased in depth by at least 14 feet. However, the area along the RDB just downstream of the plunge pool decreased in depth upwards of 14 feet. This area, which was an extension of the plunge pools shown in the 1999 sweep survey, had filled in as indicated by the 2001 sweep survey. Further degradation was realized within the split channels near the downstream end of the chute.

These detailed surveys also allowed the calculation of the minimum water level needed to maintain continuous flow through the side channel. On the date of the 2001 survey, it was determined that Moro Chute maintained connectivity with the main channel at all water surface elevations greater than +11.25 feet LWRP as shown on Plate 19. Blue represented those areas that maintained channel depth, or

had flowing water at this elevation. Tan represented those areas that had higher bed elevations and would be out of the water at this elevation. At this stage the chute entrance maintained a minimal depth of flow, and was the deciding factor of the minimum water elevation needed to maintain flow. However, the lower end of the chute maintained depths of approximately 2 feet. When compared to historic gage data, this chute would retain continuous flow to the main channel at an average of 48.52 percent of the year, using the present day bed configurations.

5. Comparison to Other Side Channels

The bathymetry of two other chutes were studied and then compared to Moro Chute. Sweep surveys from 1999 of Osborn and Liberty Chutes are shown on Plates 20 and 21, respectively. Using this data, water surface elevation profiles were calculated on these additional side channels for comparison purposes.

Osborne Chute

Osborn Chute is located along the LDB between Miles 146.4 and 144.0. This side channel has multiple dike and closure structures located at the side channel entrance. It also contained 6 additional dikes; both new stone structures and deteriorated pile structures. The sweep survey indicated that the majority of the channel had maintained bed elevations above 0 foot LWRP. Areas of scour were located upstream and downstream of Dike 145.9 L and downstream of Dikes 145.3 L, 144.7 L, and 144.3 L. The minimum water level needed to maintain continuous flow through this side channel on the date of the 1999 survey was calculated at elevations greater than +12.5 feet LWRP. At this stage the exit of the chute contained minimal depths, apparently due to the height of Dike 144.3 L. When compared to historic gage data, this chute would retain full connectivity to the main channel an average of 42.68 percent of the year with the current bed elevations. However, this percentage may increase slightly if Dike 144.3 L were to be either lowered or notched.

Liberty Chute

Liberty Chute is located along the LDB between Miles 103.1 and 100.1. This side channel contained 6 dikes/closure structures. The chute had two distinct exits into the river, located at Miles 101.0 and 100.1. The sweep survey indicated that large portions of the chute maintained depths below 0 feet LWRP. The channel entrance, downstream of the plunge pool formed by Dike 101.1L as well as within the two channel exits had bed elevations greater than 0 feet LWRP across the entire channel width. The first outlet at Mile 101.0 had bed elevations of +15 feet LWRP and greater. The side channel contained fluctuating bed elevations from –4 to +8 feet LWRP at the Mile 101.0 exit to the second channel exit at Mile 100.1. The minimum water level needed to maintain continuous flow through this side channel on the date of the 1999 survey was calculated at water surface elevations greater than +10.0 feet LWRP. At this stage the elevation of the water surface was greater than Dike 101.0 L, which seemed to be the determining structure for connectivity. When compared to historic gage data, this chute would retain full connectivity to the main channel an average of 54.44 percent of the year with the current bed elevations. However, this percentage may increase significantly if Dike 101.1 L was either lowered or notched.

6. Field Observations

Personnel from the Applied River Engineering Center inspected the study reach by helicopter on three occasions and visited the side channel once by shallow draft boat. These four reconnaissance missions allowed the site to be photographed and studied at four different water surface elevations. Each site visit is described below with the water surface elevations on each date referenced to LWRP at the Chester, Illinois gage. At these elevations, flows were only maintained within the narrower and deeper primary side channel entrance. The secondary entrance remained dry. Photographs taken at these various stages are shown on Plates 22 through 29.

+11.48 feet LWRP (August 8, 2001)

The site was visited by boat to record various field observations and measurements. At this stage, the side channel maintained continuous flow to the main channel and depths were sufficient to travel the length of the chute by a shallow draft boat. The data collected at the site included sediment samples, velocity profiles and general information about the side channel. The following is a description of each:

General observations indicated that bed elevations within the secondary channel were equal to or greater than the height of Dike 122.6 L (Plate 26, Top Photo). The primary inlet channel located parallel to Dike 122.6 L contained numerous shallow areas, mostly near the upstream end of the smaller island (Plate 22, Bottom Photo). A large point bar was located along the RDB within the bend of this channel (Plate 24, (Top Photo). A 400-foot segment of the LDB in the bend was unvegetated and was actively eroding (Plate 24). Downstream of the bend within the primary channel, debris along the LDB constricted the width of the channel and induced some deposition (Plate 24, Top Photo). A shallow area was located at the confluence of the primary and secondary channels just upstream of Dike 121.8 L (Plates 25 and 26). Greater depths were experienced downstream of Dike 121.8 L, along the LDB in the thalweg of the main side channel. The plunge pools directly downstream of Dike 121.1 L exhibited depths between 12 and 30 feet (Plate 27, Bottom Photo). Woody debris had been deposited in the plunge pools, either from high flow events or previous bank failures.

Downstream of Dike 121.1 L, the channel was divided with a large middle bar that was approximately 3 to 5 feet above the water surface (Plates 28 and 29). Pile Dike 120.7 was not visible at the time of this site visit. The left side of this split channel was located near the LDB until Dike 120.2 L, where it was positioned along the upstream side of the structure. The upstream portion of this channel had a depth of 5 feet while the middle and lower reaches had an average depth of 1.5 feet. The right side of the split channel was located along the steep RDB. The upstream portion of this channel had a depth of 8 feet while the middle reach averaged 2 feet

deep and the lower segment was 3 to 5 feet deep. The two divided channels converged near the end of Dike 120.2 L in the main navigation channel.

Sediment samples were obtained using a clamshell bucket during the site visit. The samples collected throughout the channel were consistent. The channel thalweg consisted of compacted course to fine sands. Sandy silts and silty clays were commonly found downstream of structures and obstacles in the channel. Very little gravel was found in the sediment samples. Plate 30 shows the sediment types at each location and Plates 31 and 32 are diagrams of sediment sample locations.

Velocity data was collected using time-averaged floats. Velocities were within expected values, between 0 and 2 feet per second, throughout the chute. The values were greater in the upstream reaches of the chute where the channel was narrower and water levels were deeper. In the lower portion of the chute, where the channel was wider and shallower, the values were lower. Plate 33 shows the velocity values recorded and Plate 34 is a diagram of collection locations.

+9.08 feet LWRP (November 6, 2001)

This helicopter reconnaissance revealed that at this water surface elevation, the chute maintained its connectivity to the main channel at the entrance and exit to the side channel as shown on Plates 23 (Bottom) and 29. However, the left side of the split channel at the exit of the chute did not maintain connectivity and was closed off just upstream of Dike 120.2 L. Previously discussed shallow areas within the interior of the side channel allowed flows to pass on this day at this elevation (Plates 26, Bottom and 27, Top).

+7.86 feet LWRP (April 5, 2000)

Photographs were taken only of the side channel entrance and exit on this helicopter flight. At this water surface elevation, the side channel maintained full connectivity with the river at both the entrance and exit (Plates 23, Top and 28, Bottom). The

photograph on Plate 28 indicates that both sides of the split channel at the end of the chute were experiencing flow at this stage.

+5.05 feet LWRP (August 16, 2001)

One week after the site visit by boat, personnel on a helicopter reconnaissance observed Moro Chute at low water conditions. At this stage, connectivity to the main channel was not maintained at the entrance to the chute as shown on Plate 22. Furthermore, the area from the downstream tip of the smaller island to Dike 121.8 L experienced minimal depths as shown on Plate 25. At the side channel exit, the left side of the split channel was completely emergent while the right side appeared to have very little depth (Plate 28, Top Photo).

CONCLUSIONS

1. Connectivity Factors in Moro Chute

Many factors contribute to Moro Chute's ability to maintain full connectivity to the main river channel at lower stages. These factors have influenced the development of the side channel configuration. Factors beyond man's control that contribute greatly to the development of the planform and bed configuration of any side channel include; channel alignment, hydrographic events, and vegetation viability on exposed areas. Man induced factors that have historically contributed to the development of these side channels included the construction and alteration of river training structures, dredging, stabilization of banklines, and protection of buffer areas that assist in the maintenance of banklines. The analysis of historical data has shown that a combination of all these factors was involved in the development of this side channel throughout the 20th century.

River Training Structures

The river was excessively widening from the early 1800's to the early 1900's as a result of deforestation and increased sedimentation. To abate associated accelerated erosion of the banks, pile dikes were constructed in the river in the late 1920's and early 1930's. Many of these structures contributed to the development of the majority of the side channels that exist in the modern day river. In the 1960's, a number of the pile structures were covered with stone and altered to enhance their effectiveness.

The mouth of the side channel is located along the downstream side of Dike 122.6 L shown on Plates 22 and 23. This is the uppermost structure in the side channel and was constructed with stone over an existing pile structure in June 1960, at a downstream angle with a crown elevation of 363.5 feet, or +14 feet LWRP. The dike was also extended beyond the footprint of the pile dike with an additional length angled slightly upstream. This dike has played a crucial role in maintaining the side

channel's connectivity to the river. During high water events, Dike 122.6 L would be overtopped, which produced a plunge pool directly downstream of the structure. The scouring action created depths of 6 to 10 feet at the primary side channel inlet. Additional scouring off the end of the dike also assisted in maintaining a sufficient entrance depth. The downstream angle of the structure also directs flow through the secondary entrance channel during high water events.

The height of the structure is responsible for negating significant sources of bed load in the main river channel from entering the primary side channel. Plate 23 showed a large sandbar and a significant depositional area just upstream of the dike while the primary side channel inlet just downstream of the dike still contained water at these stages. This indicated that this dike may collect a majority of the bed load entering the side channel complex.

The heavily forested, riparian area upstream of Dike 122.6 L was created by deposition near the bankline between the original pile structures 123.0 L and 122.6 L. It is believed that this riparian area shielded the primary side channel, which is located in its shadow, from deposition during flood events.

The next significant control structure in the chute was Dike 121.1 L, shown on Plate 35. This rock structure was constructed in October 1965 to an elevation of 361.7 feet, or +13 feet LWRP, partially along the alignment of an existing pile dike. The unusual design of the structure has had both positive and negative effects on the channel. Water flowing over the downstream angled structures was responsible for producing the deepest scour areas in the side channel. However, this design also directed flow into the downstream bankline, instead of the center of the channel, encouraging bankline scouring. This also meant that flows were divided towards both banklines, which created two shallow split channels in the downstream segment of the chute.

The last substantial structure in the side channel is the Dike 120.2 L (Plate 36), which also borders the main river channel. Dike 120.2 L was constructed in July 1962 along an existing pile structure at an elevation of 360.0 feet, or +12 feet LWRP. The structure created a scour hole off the end of the dike and a plunge pool on the downstream side. It forces the divided channels to converge at the exit of the chute.

Other remnant pile structures are still present throughout the channel, but are in a badly deteriorated state. During low water, the structures create minor obstructions in the channel. During high water events it is not believed that these structures presented a significant obstruction. However, portions of these structures may encourage deposition and could be responsible in some instances for the height of the bed and the overall gradient of the side channel.

Main Channel Dredging

The thalweg of the main channel has historically been located along the LDB upstream of Moro Chute and along the RDB adjacent to the location of this side channel. Over the last 10 years, portions of the main channel have been dredged several times. Disposal materials have been placed along the LDB in the dike field along the larger island's banklines. This practice has not directly affected the functionality of Moro Chute. There has been no dredging, for environmental reasons or otherwise, performed in the actual side channel. However, the 1932 aerial photograph on Plate 4 indicates that dredging combined with river training structures may have played a role in the present position of the main navigation channel.

Bank Stabilization

Bank stabilization was performed within the side channel in many locations, mostly along the LDB in the lower third of the side channel. Rock and other material was often placed on the banklines to protect private property. The alignment of the LDB in the downstream reaches of Moro Chute have not changed significantly since these stabilization measures were first implemented in the 1930's. The latest

stabilization measures have reduced the sediment load entering the channel from the banklines and prevented unwanted migration of the side channel borders.

Vegetated Buffers

A vegetated buffer along a waterway is a natural means to hold and protect shorelines and collect sediment in the overbank areas. In Moro Chute, the islands are heavily vegetated and are experiencing minimal erosion. However, significant portions of the LDB in the chute are bordered by farm fields, without a vegetated buffer in many locations, and have had obvious bankline erosion problems. Many problem areas have been reveted while other unprotected areas still exist. Plates 24 and 37 displayed some of the eroding vertical banklines present in Moro Chute. These banklines are actively sloughing into the channel, increasing sediment loads, widening the channel, and threatening private property.

2. Prognosis

Previously, Moro Chute was thought to be the last side channel on the Upper Mississippi River to lose its connectivity to the main river channel. As discussed earlier, it does retain connectivity longer then the majority of side channels on the Upper Mississippi River but it is not the last. However, if the side channel were to experience significant bank erosion and lateral migration, the status as “one of the last” could be in jeopardy. Fortunately, as was previously discussed, it does not appear that the connectivity of Moro Chute is in jeopardy, and measures could be taken that would draw out the length of time Moro Chute remained connected to the Mississippi River.

Bank Erosion

The area with the most critical erosion problem was the 100-degree bend in the primary side channel. The LDB borders farmland, is actively migrating, and lacked any vegetative buffer. As this bankline undermined and sloughed into the channel, it

decreased depths in the channel and elongated the bend in the chute, creating a more tortuous bend. The higher radius the bend becomes, the flatter the water surface slope it creates. A flatter slope would decrease velocities, encourage deposition, and increase the height of the bed in the channel. The bank erosion generated by a migrating channel enables additional sediments to enter the bed load of the side channel. Other minor areas were also experiencing limited bank erosion.

Aggradational / Degradational Trends

The bed elevation differences between the 1999 and 2001 hydrographic surveys on Plate 18 showed localized areas in the side channel that experienced aggradation and degradation within this two year time period. Significant aggradational areas included a small area of drift in the primary side channel, the deep thalweg along the LDB in the main channel, and a portion of the scour hole formed by Dike 121.1 L. Significant degradational areas included the primary side channel near Dike 122.6 L, in the scour hole formed by Dike 121.1 L, and within the divided channel at the lower end of the main side channel.

However, the analysis of photographs collected at different water levels during reconnaissance missions in 2000 and 2001 indicated slight aggradation in the divided channel at the end of the side channel. The contradiction between the data suggested a natural fluctuation in the bed of the side channel within this divided segment. This kind of bed response is to be expected wherever a split channel exists. Further scrutiny of historical aerial photography showed that this divided channel has constantly shifted and changed depths. The study also indicated that there has not been a long-term trend towards either aggradation or degradation in the primary or main side channel segments. Fluctuation in bed elevations and water depths throughout the side channel are considered natural.

Depositional Locations

There are a few locations throughout the chute that remain relatively shallow compared to other reaches in the channel. The primary side channel inlet just downstream of Dike 122.6 L was the first area to lose connectivity with the main river channel. This area is evident in the photography on Plates 15 and 22, taken during low water when the side channel lost connectivity to the river.

Another area that caused the side channel to lose connectivity was located at the confluence of the primary and secondary channels, just downstream of the smaller island (Plates 25 and 26). The higher bed elevations in the secondary channel appeared to force or spill sediment into the deeper primary side channel. This forced the channel thalweg to cross abruptly towards the LDB, which therefore narrows and shallows the chute. This trend had been seen repeatedly throughout several years of photography.

The final shallow segment of the side channel was located in the divided channels at the end of the chute, upstream of Dike 120.2 L (Plates 28 and 29). The split channel at this location has formed a large middlebar. Due to flows being divided, velocities are slower and both channels have shallow areas that lose their connectivity to the river during low water.

3. Recommendations

Various improvements could be implemented in Moro Chute to increase the length of time that the chute maintains its connectivity to the main river channel. Bank stabilization, rock structures, and a minimal amount of initial dredging would assist this side channel in maintaining connectivity at lower river stages.

The first recommendation is the revetment of threatened banklines within the side channel. The most critical location is in the primary side channel at the first bend just downstream from the channel inlet. The bankline along this bend is nearly vertical, due to the configuration of the channel and lack of vegetation. This bankline

would need to be graded and revetted to discontinue the channel migration and decrease sediment loads introduced into the side channel.

The second recommendation would be the placement of rock structures in the form of hard points and dikes. These structures should be constructed to assist in scouring the three shallow areas within Moro Chute where connectivity to the river is minimal. The first area would be in the primary inlet, just downstream of where Dike 122.6 L ties into the upstream bankline. The second would be located just downstream of the upper island at the confluence of the primary and secondary side channels. Alternating hardpoints would assist the channel in maintaining adequate depth for connectivity at this location. However, a longitudinal rock dike extending downstream from the island tip would prevent sediment from the secondary entrance channel from spilling across the channel thalweg. The third structure location would be just upstream of the split channel at the end of the chute. A dike structure placed along the LDB at this location would restrict channel flow to the right side of the chute and eliminate the split channel conditions that currently exist. By directing all the flow down one side, velocities would be increased which would then increase depth in the channel.

A third recommendation is that initial dredge work be performed in the previously mentioned shallow areas. Depositional areas would eventually be deepened by scouring from the recommended structures. However, for the structures to perform adequately, the channel may have to experience multiple high water events. Initially dredging the area would accelerate the scouring process as well as increase the duration of side channel connectivity.

FOR MORE INFORMATION

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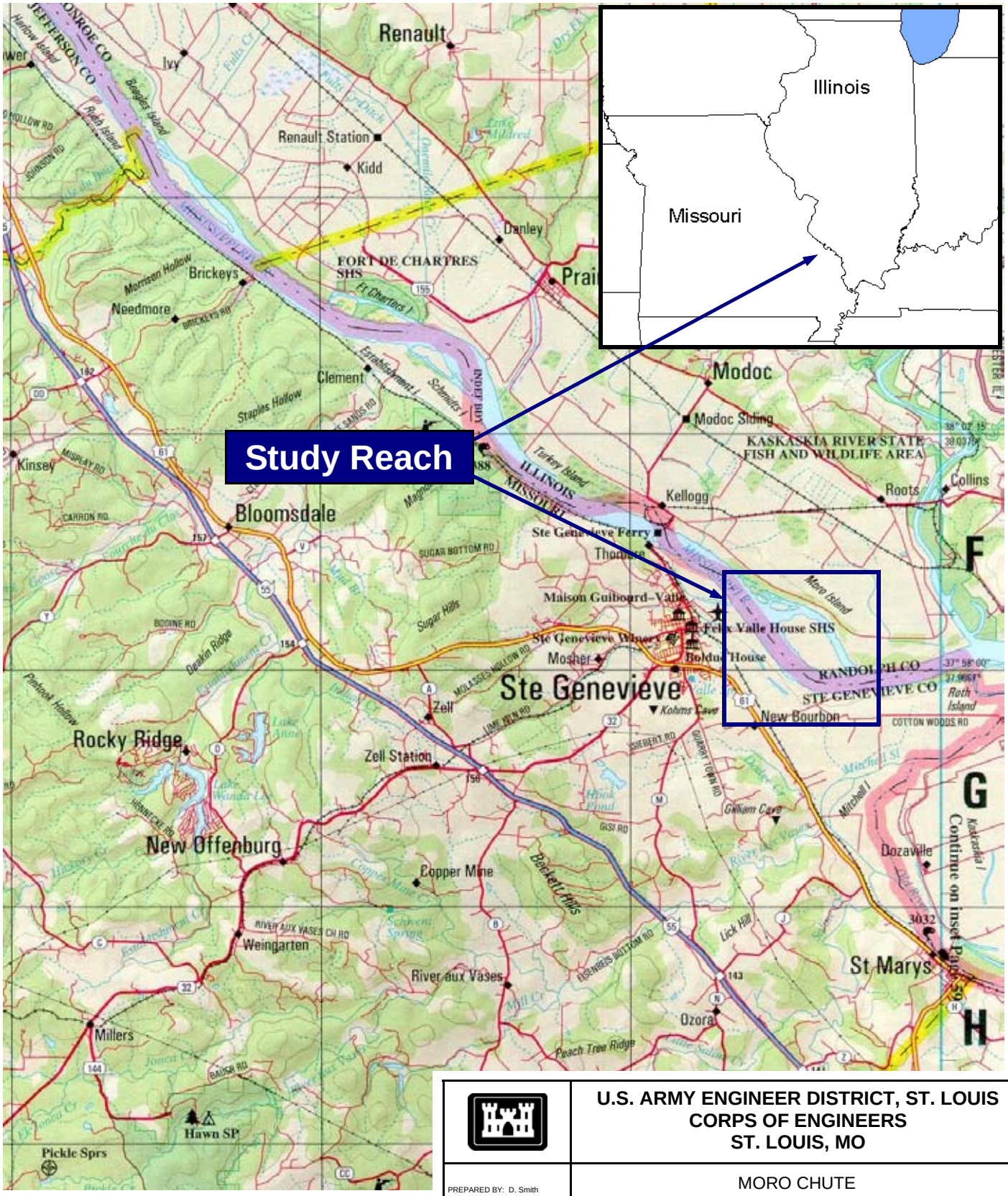
http://www.mvs.usace.army.mil/engr/river/river.htm

APPENDIX OF PLATES

Plate #'s 1 through 37 follow:

1. Location and Vicinity Map of the Study Reach
2. Characteristics of the Study Reach
3. 1928 Aerial Photograph
4. 1932 Aerial Photograph
5. 1935 Aerial Photograph
6. 1956 Hydrographic Survey
7. 1965 Aerial Photograph
8. 1971 Hydrographic Survey and 1968 Aerial Photograph
9. 1977 Hydrographic Survey and 1976 Aerial Photograph
10. 1976 Aerial Photograph with 1977 Insert
11. 1987 Hydrographic Survey and 1983 Aerial Photograph
12. 1988 Aerial Photograph
13. 1993 Aerial Photograph
14. 1998 Aerial Photograph
15. 2000 Aerial Photograph
16. Moro Chute - 1999 Sweep Survey
17. Moro Chute - 2001 Sweep Survey
18. 1999 / 2001 Isopach
19. 2001 Water Surface Elevation Profile
20. Osborn Chute – 1999 Sweep Survey
21. Liberty Chute – 1999 Sweep Survey
22. August 2001 Photographs of the Primary Side Channel Entrance
23. April 2000 and November 2001 Photographs of the Primary Side Channel Entrance
24. Vertical Bankline Along LDB of First Bend
25. August 2001 Photographs of the Secondary Side Channel Entrance
26. April 2000 and November 2001 Photographs of the Secondary Side Channel Entrance

27. November and August 2001 Photographs of the Dikes 121.6 L and 121.1 L
28. August 2001 and April 2000 Photographs of the Side Channel Exit
29. November 2001 Photographs of the Side Channel Exit
30. Sediment Sample Spreadsheet
31. Sediment Sample Locations – Boat 1
32. Sediment Sample Locations – Boat 2
33. Velocity Values Spreadsheet
34. Velocity Measurements
35. Dike 121.1 L
36. Dike 120.2 L and Side Channel Exit
37. Vertical Bankline Downstream of Dike 121.8 L



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CHECKED BY: R. Davinroy

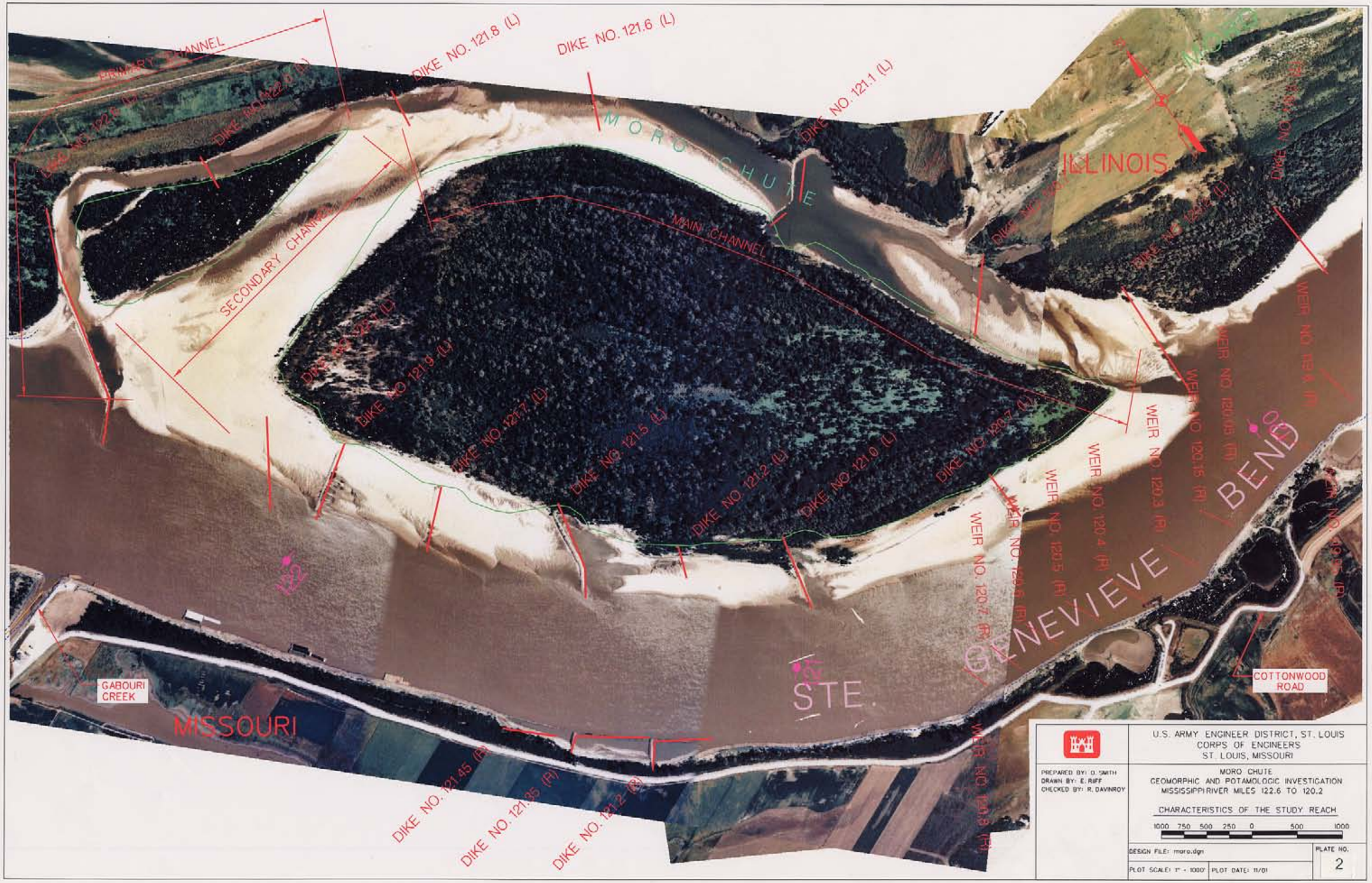
MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2

LOCATION AND VICINITY MAP OF THE STUDY REACH

Design File: moro vicinity.pub

Plot Date: 11/01

PLATE NO.
1



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CHARACTERISTICS OF THE STUDY REACH

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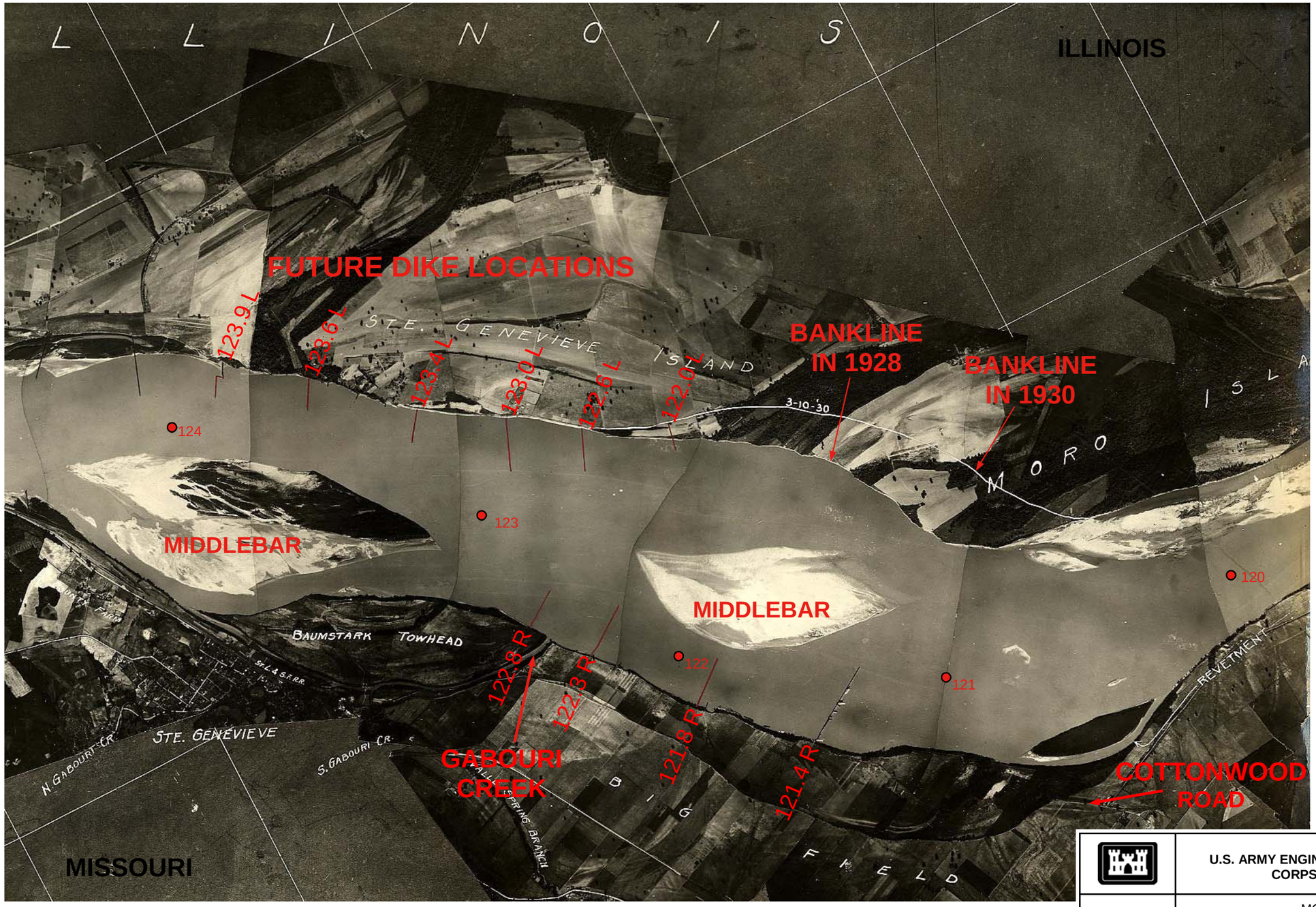
DESIGN FILE: moro.dgn
PLOT SCALE: 1" = 1000'
PLOT DATE: 11/01
PLATE NO. 2



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1928 AERIAL PHOTOGRAPH

File Name: 1928aerial.pub | Plot Date: 11/01 | PLATE NO. 3

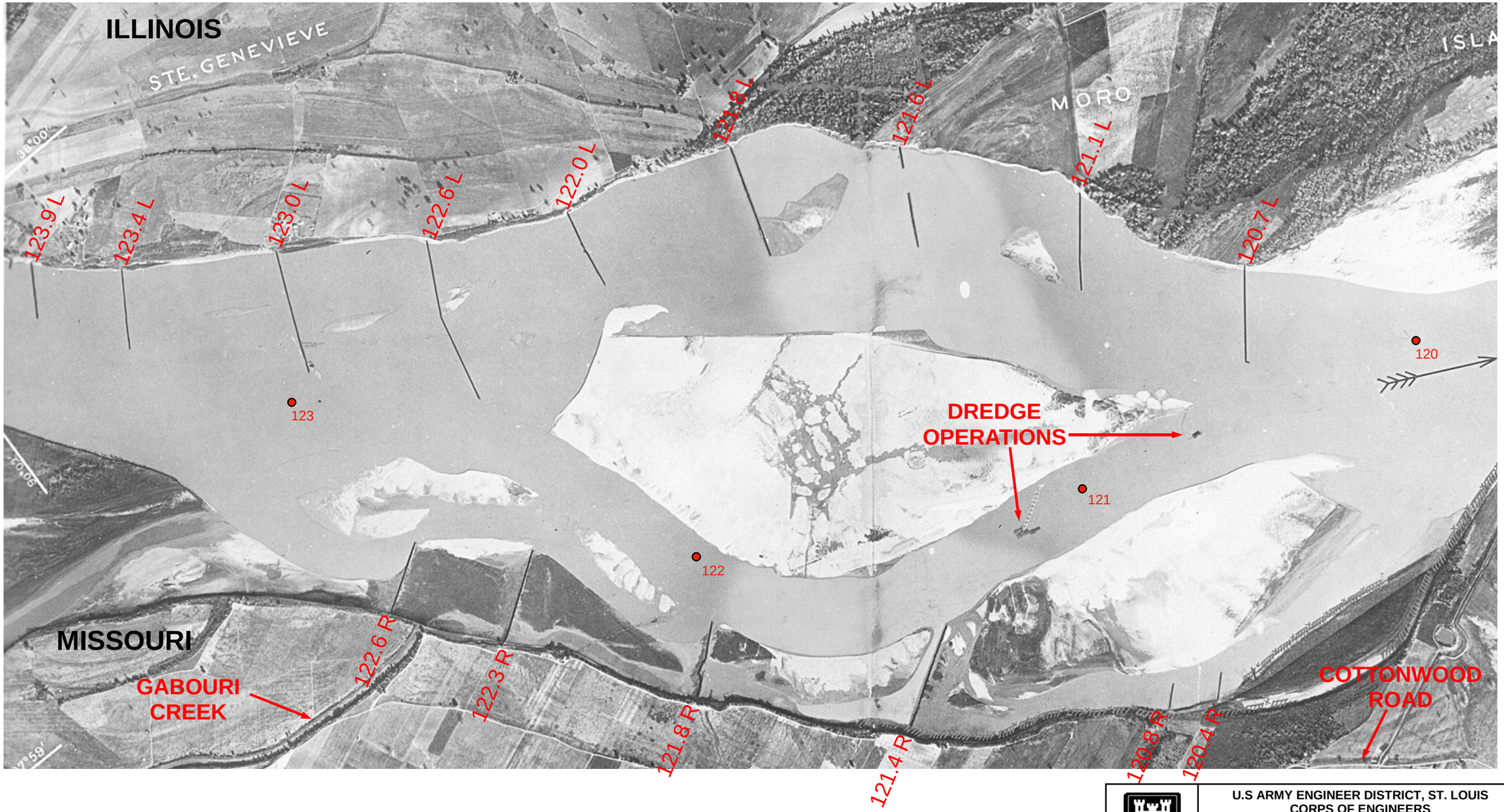

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PHOTO TAKEN ON 11/08/1932 AT +3.58 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

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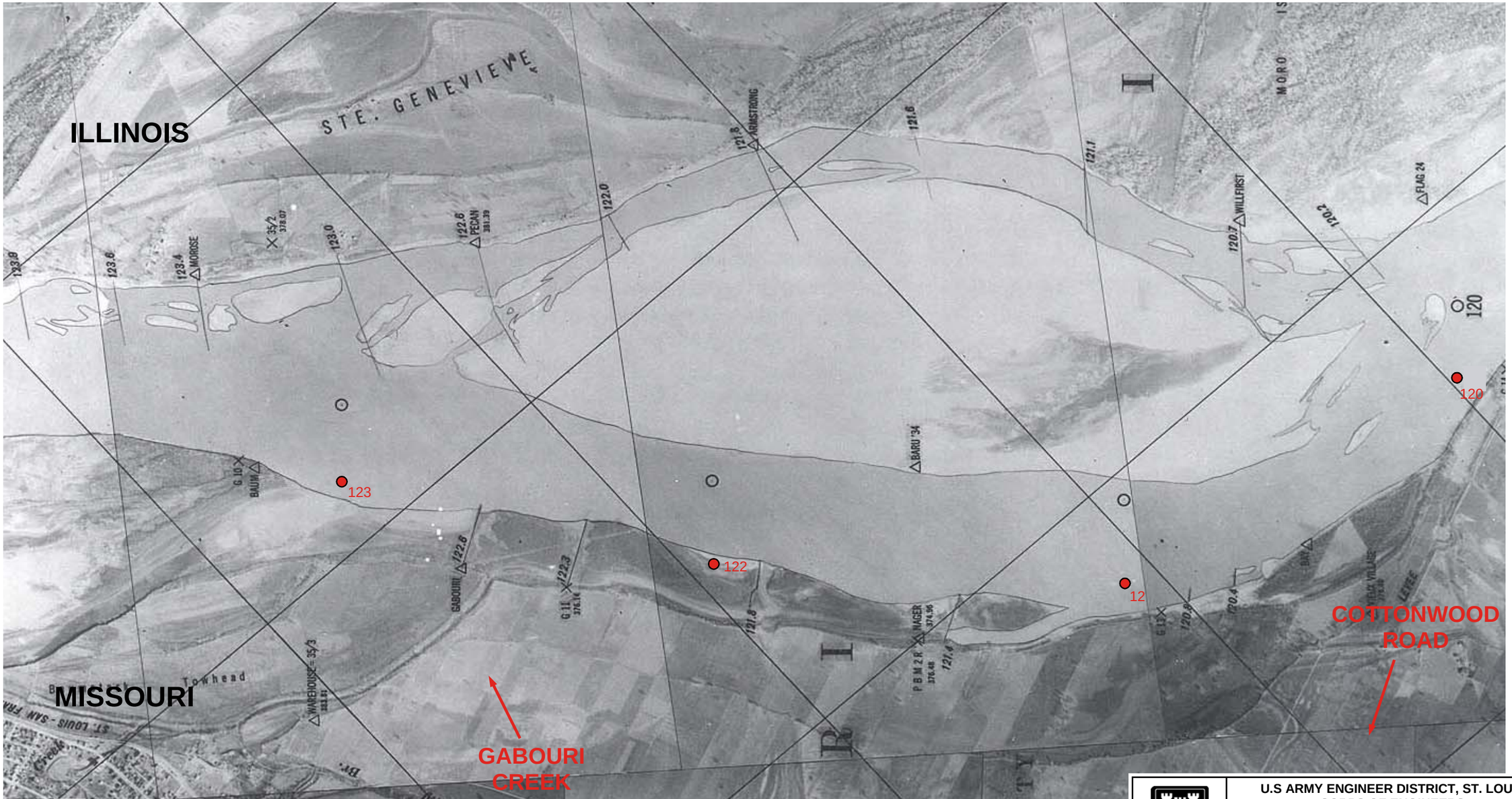
MISSISSIPPI RIVER MILES 122.6 AND 120.2

1932 AERIAL PHOTOGRAPH

PLATE NO. 4

Filename: 1932aerial.pub
Plot Date: 11/01



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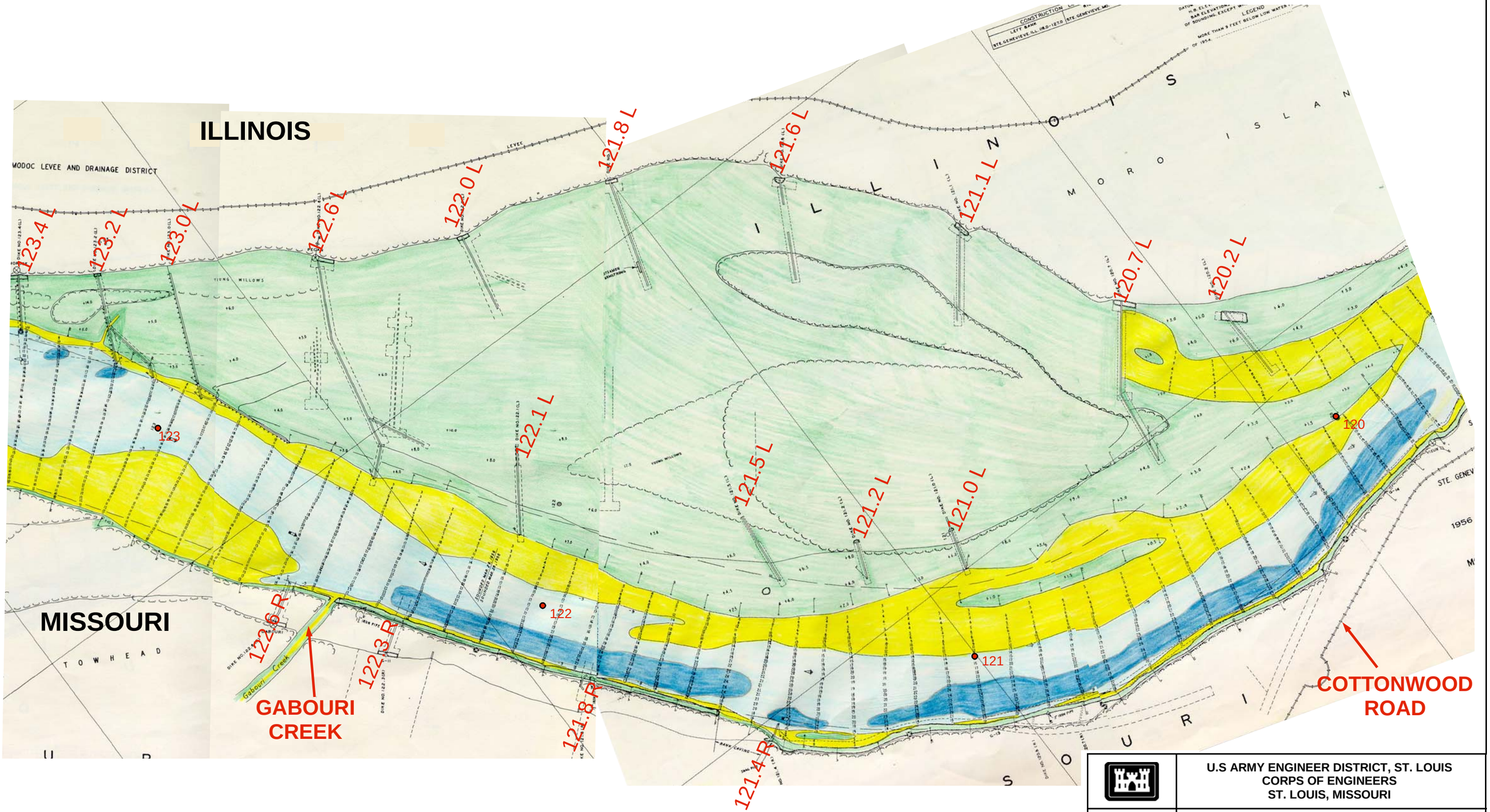
	FILENAME:1935aeril.pub | PLOT DATE: 11/01 | PLATE NO. 5



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MISSISSIPPI RIVER MILES 122.6 TO 120.2

1956 HYDROGRAPHIC SURVEY

Filename: 1956hydro.pub | Plot Date: 11/01

PLATE NO. **6**

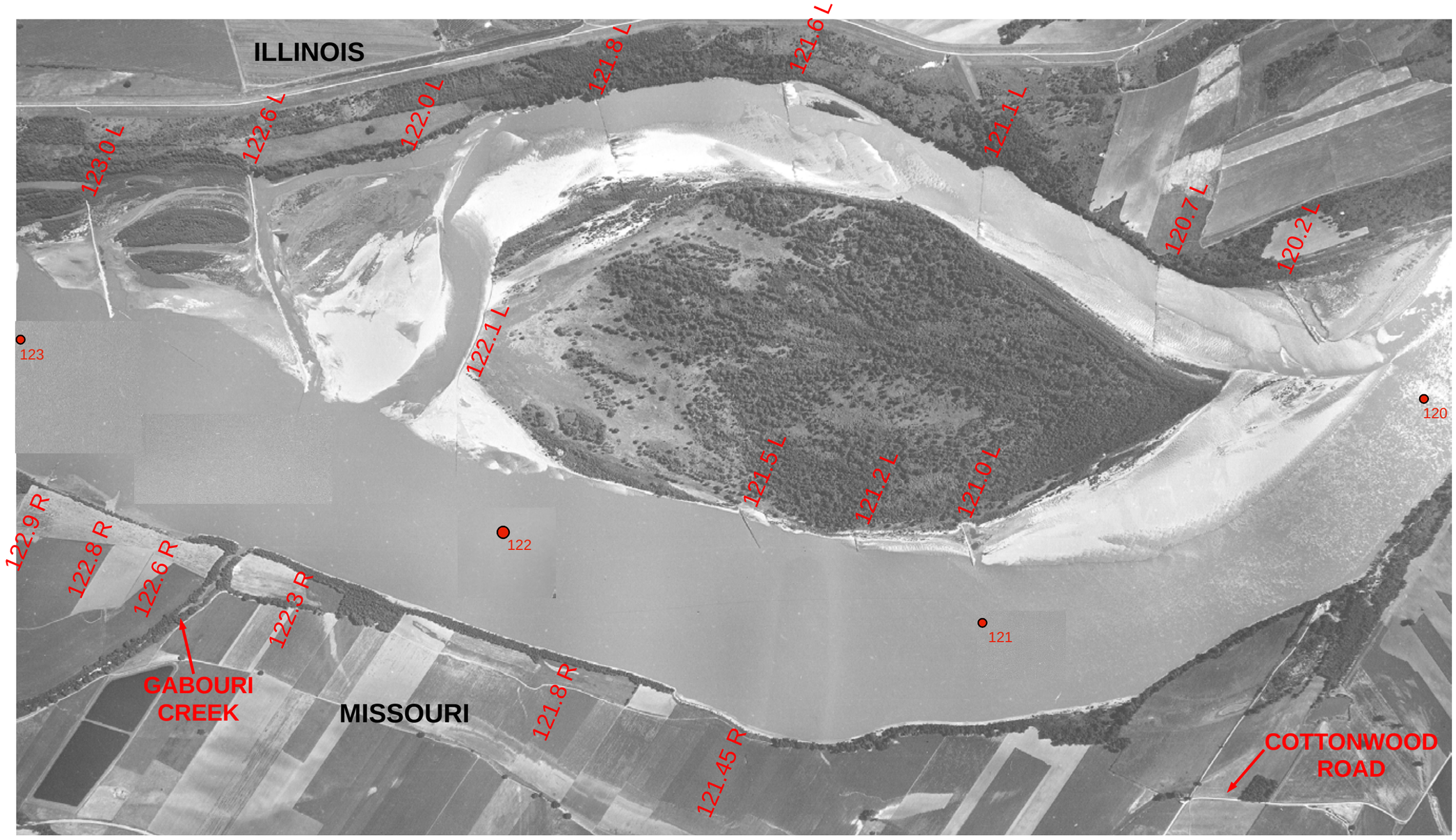

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PHOTO TAKEN ON 8/3/1965 AT +7.18 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

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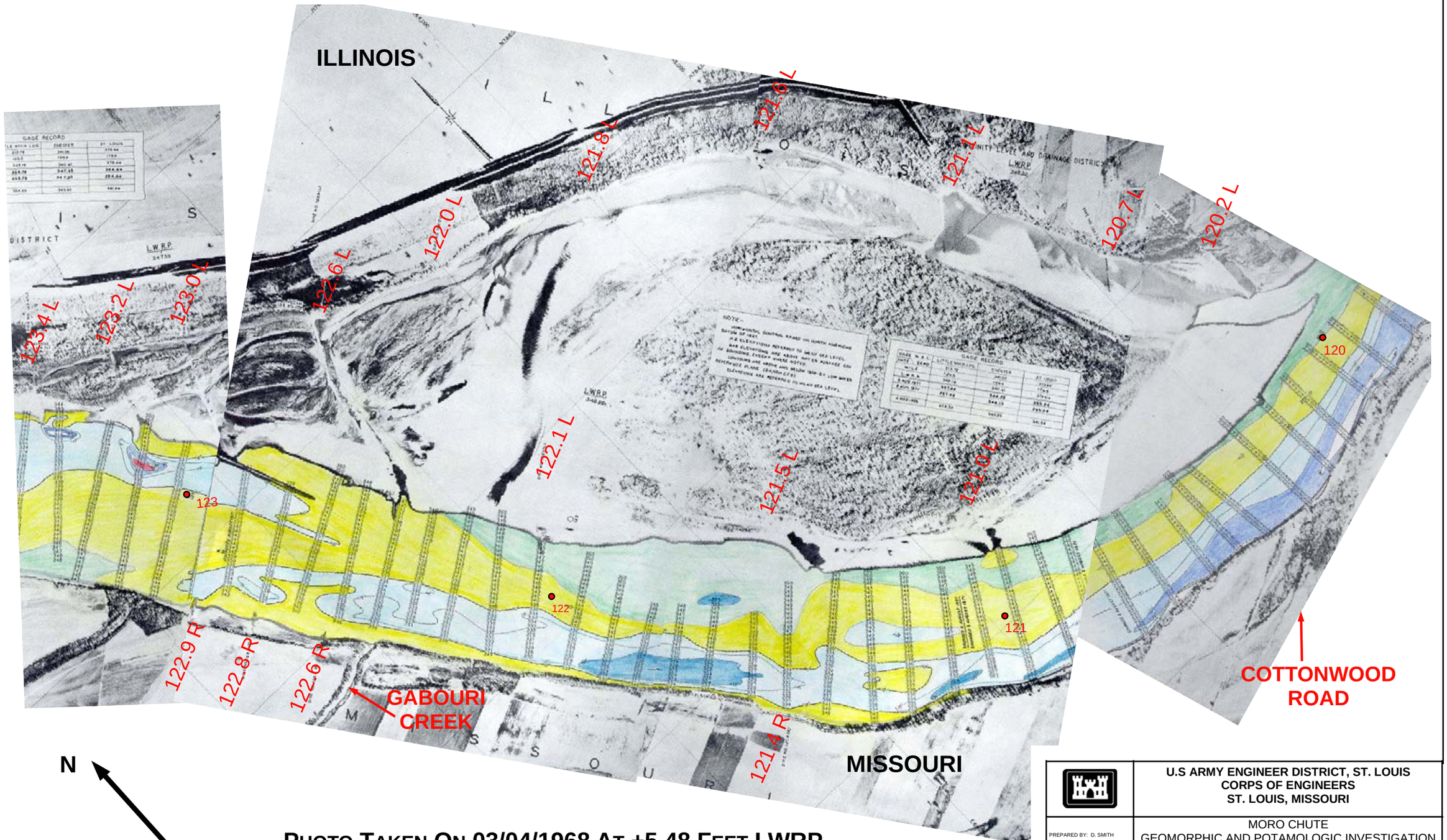

PHOTO TAKEN ON 03/04/1968 AT +5.48 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

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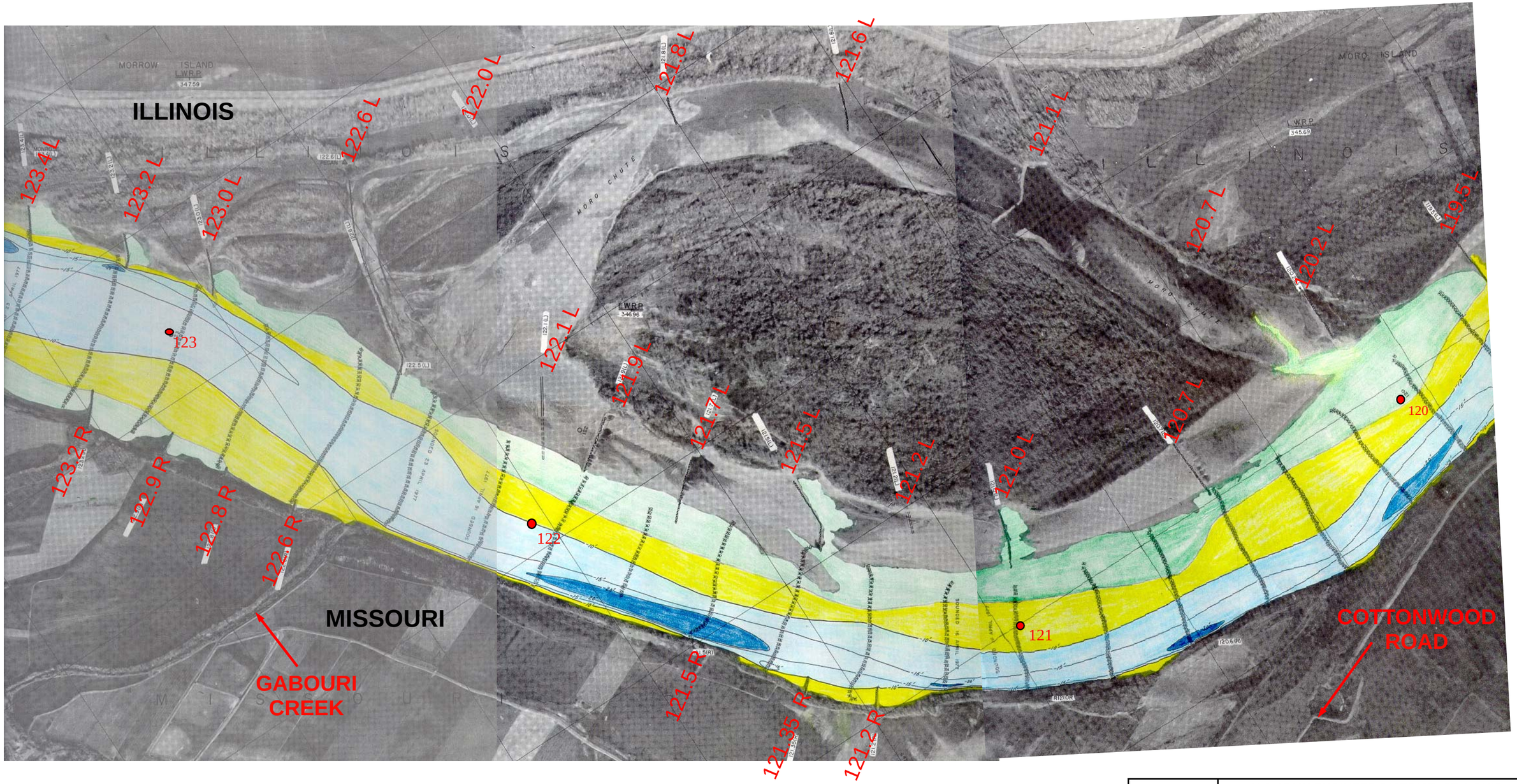

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PHOTO TAKEN ON 1/22/1976 AT +3.48 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

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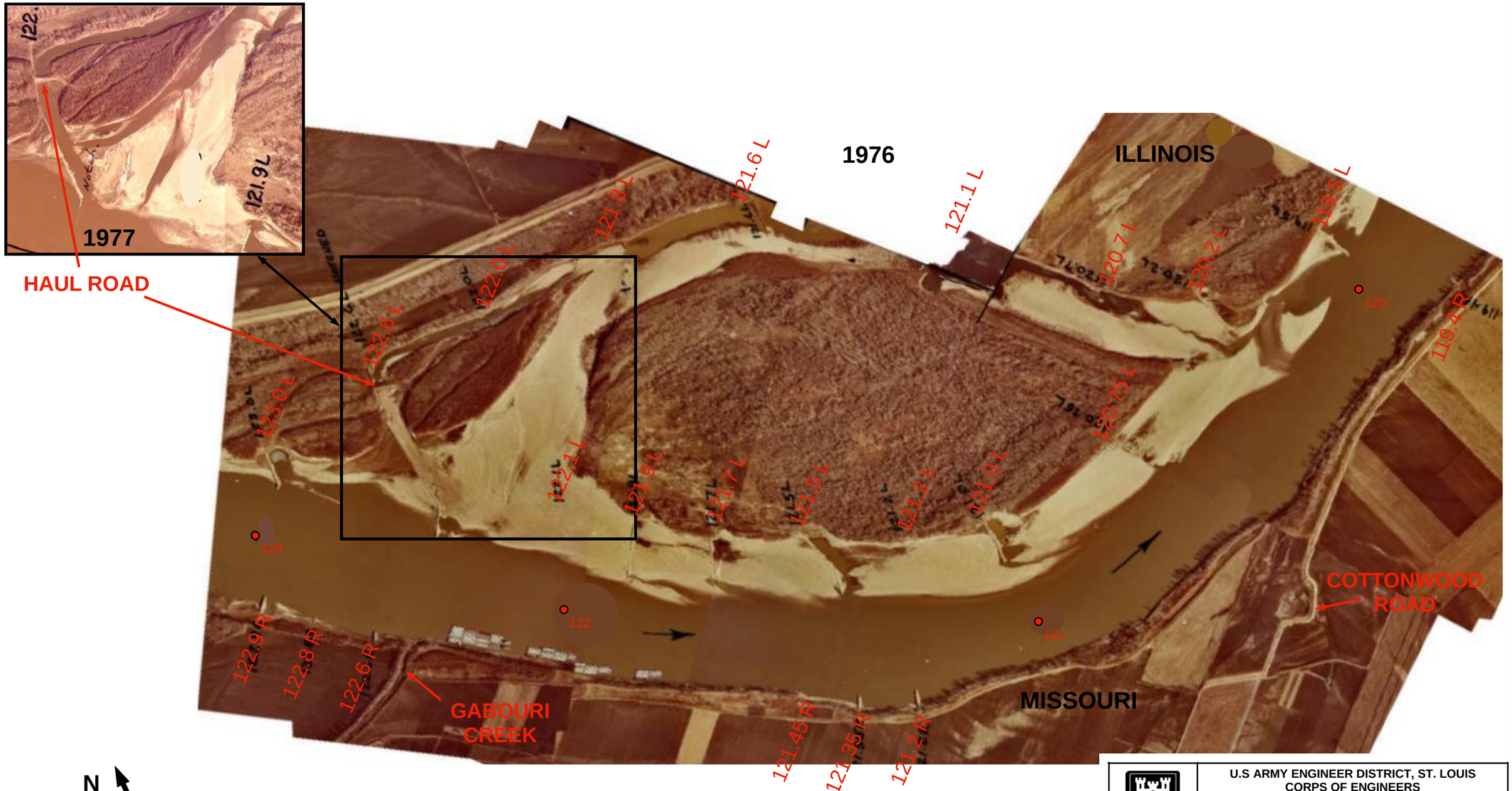
	Filename: 1977hydro.pub — Plot Date: 11/01 — PLATE NO. 9



1976 PHOTO TAKEN ON 12/17/1976 AT –0.32 FEET LWRP
1977 PHOTO TAKEN ON 12/23/1977 AT +10.98 FEET LWRP
ACCORDING TO THE CHESTER, ILLINOIS GAGE

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	FILENAME:1976aerial.pub PLOT DATE:11/01 PLATE NO. 10

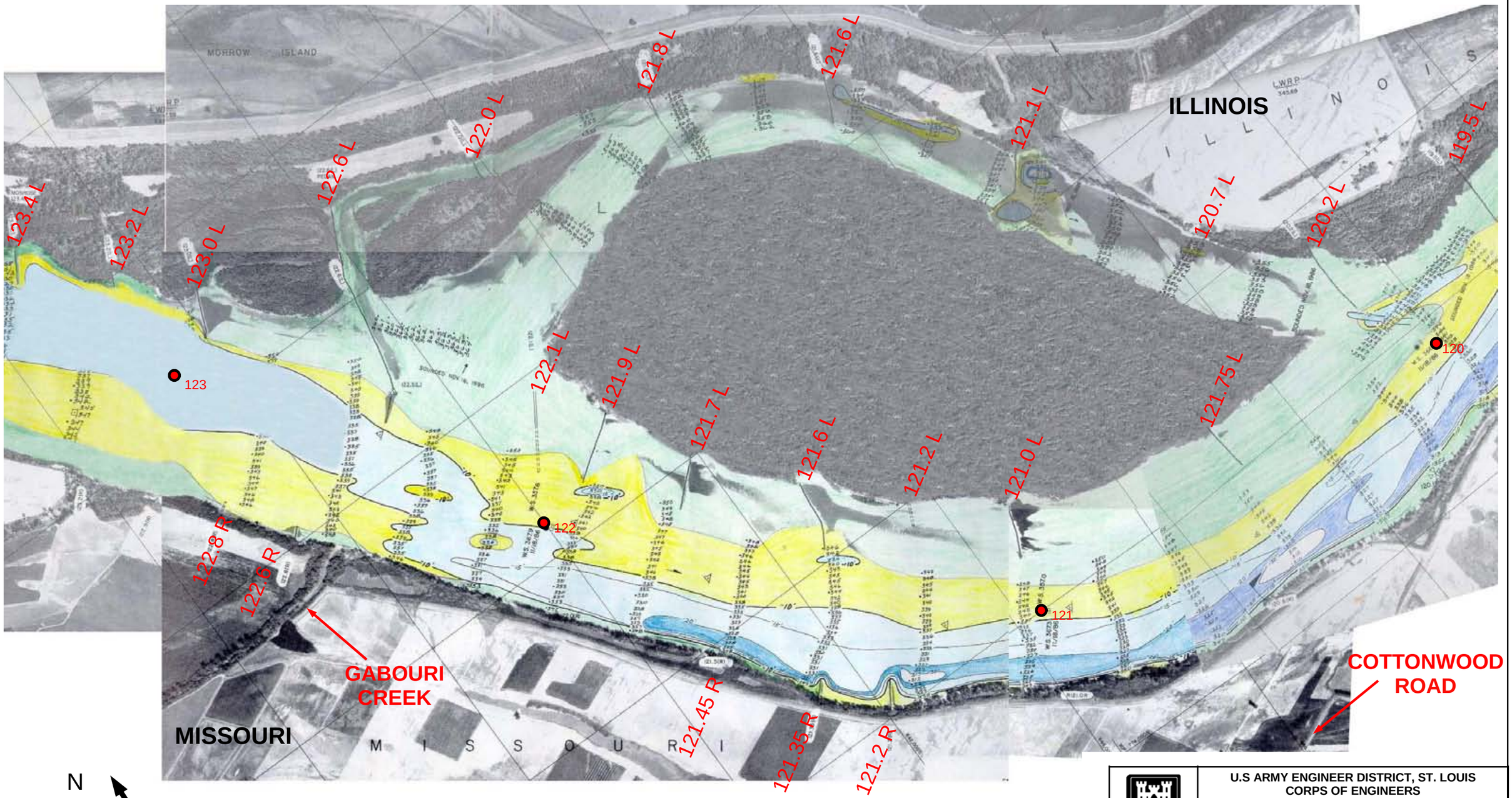

PHOTO TAKEN ON 9/16/1983AT +4.92 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

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MISSISSIPPI RIVER MILES 122.6 TO 120.2

1987 HYDROGRAPHIC SURVEY AND
1983 AERIAL PHOTOGRAPH

FILE NAME:1987hydro.pub | PLOT DATE: 11/01

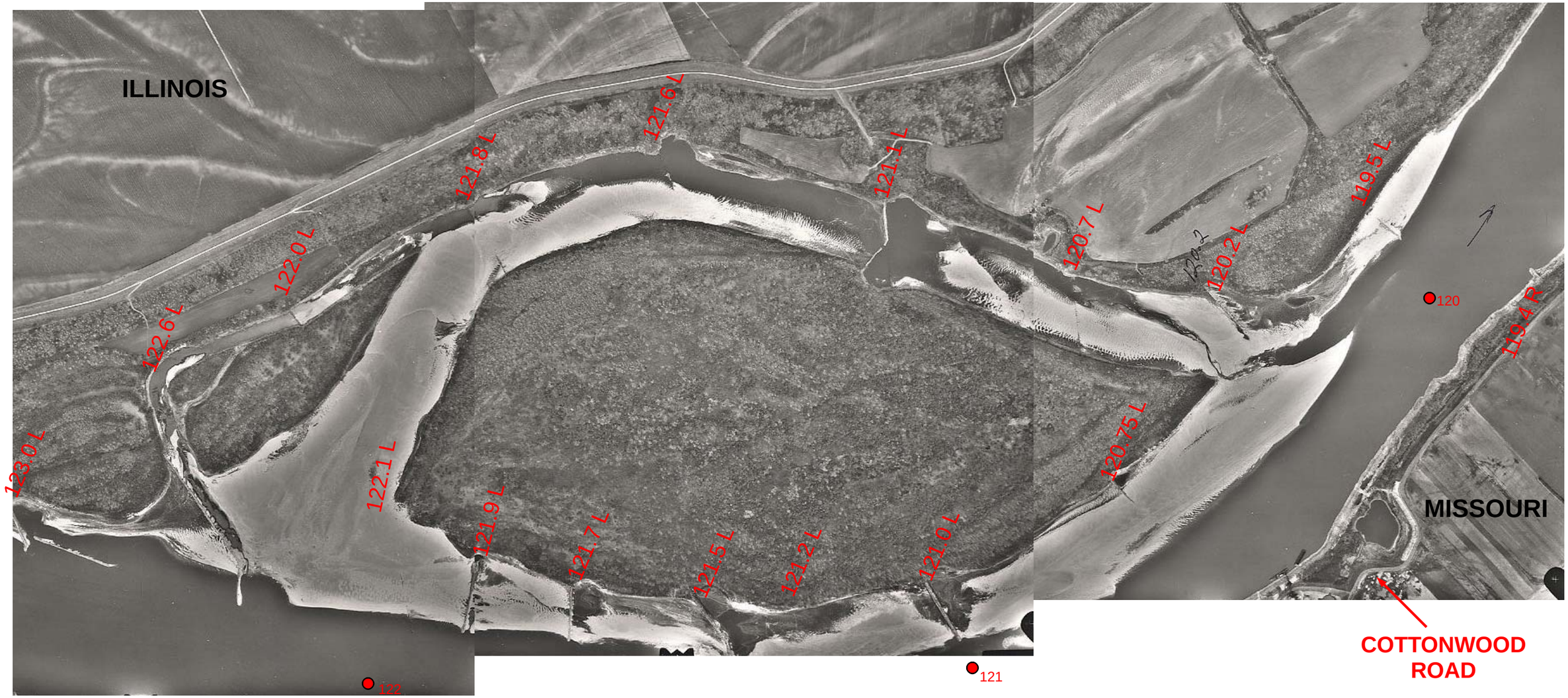

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PHOTO TAKEN ON 12/16/1988 AT –0.62 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

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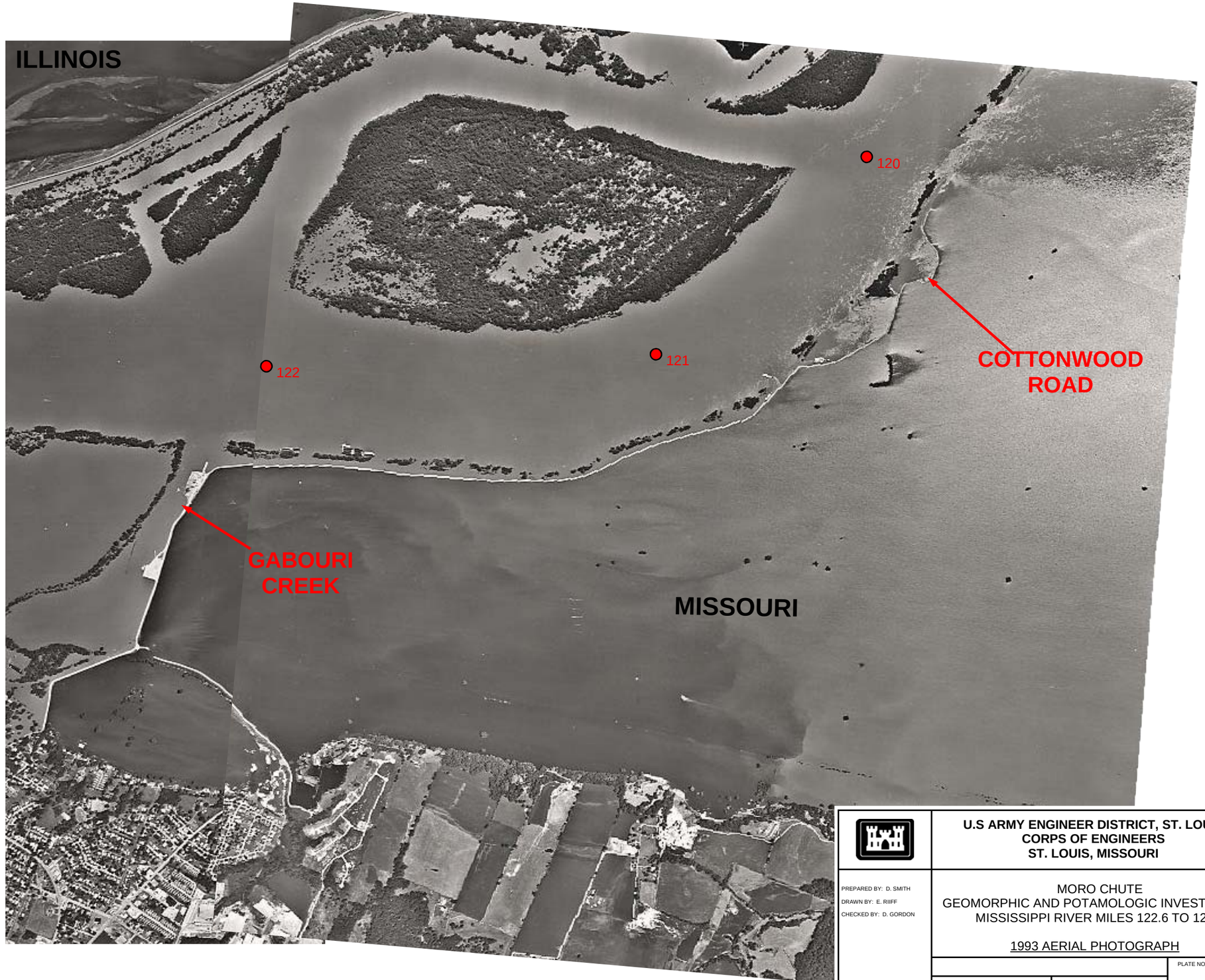

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MISSISSIPPI RIVER MILES 122.6 TO 120.2

1993 AERIAL PHOTOGRAPH

Filename:1993aerial.pub | Plot Date: 11/01

PLATE NO.

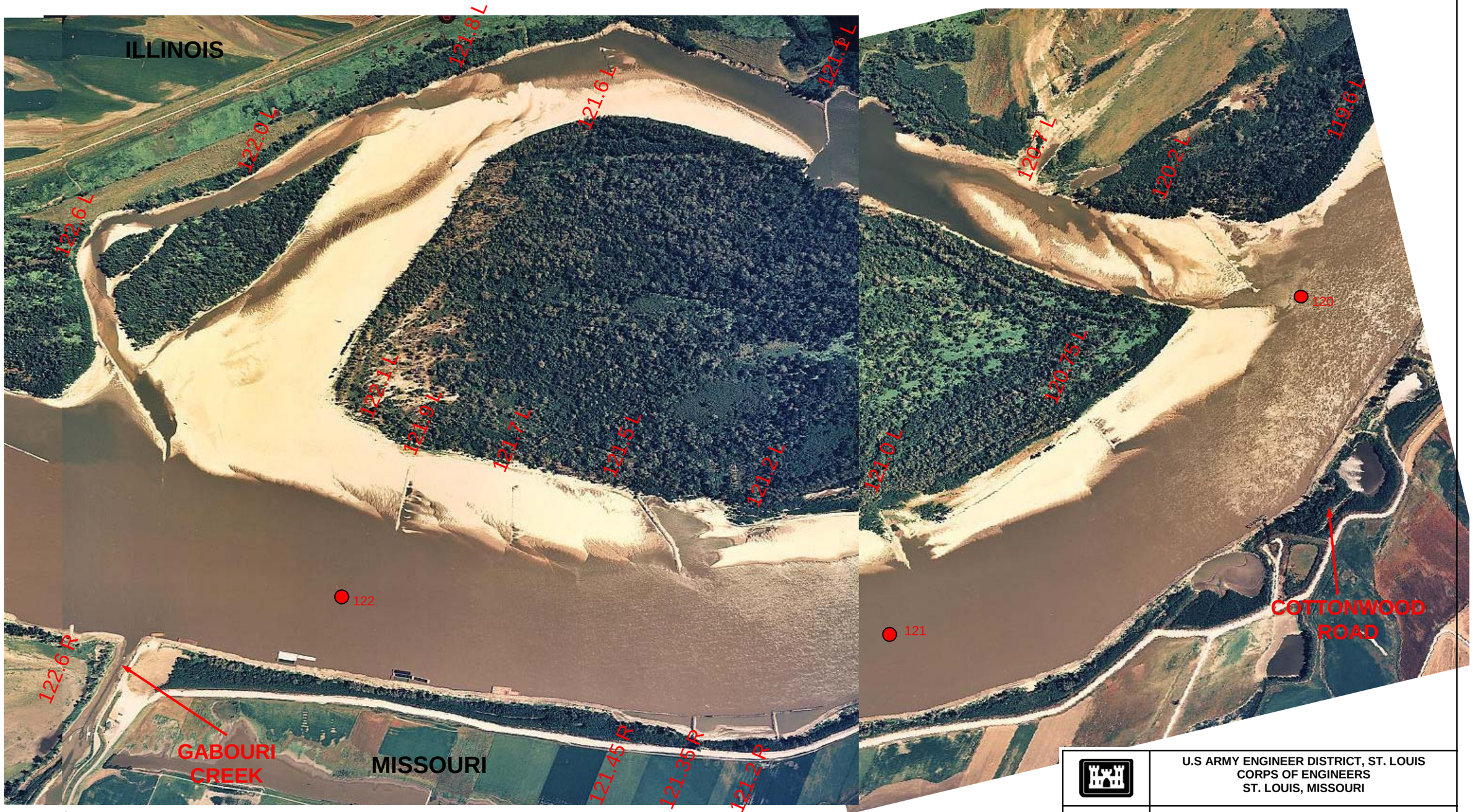

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PHOTO TAKEN ON 9/10/1998 AT +7.06 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

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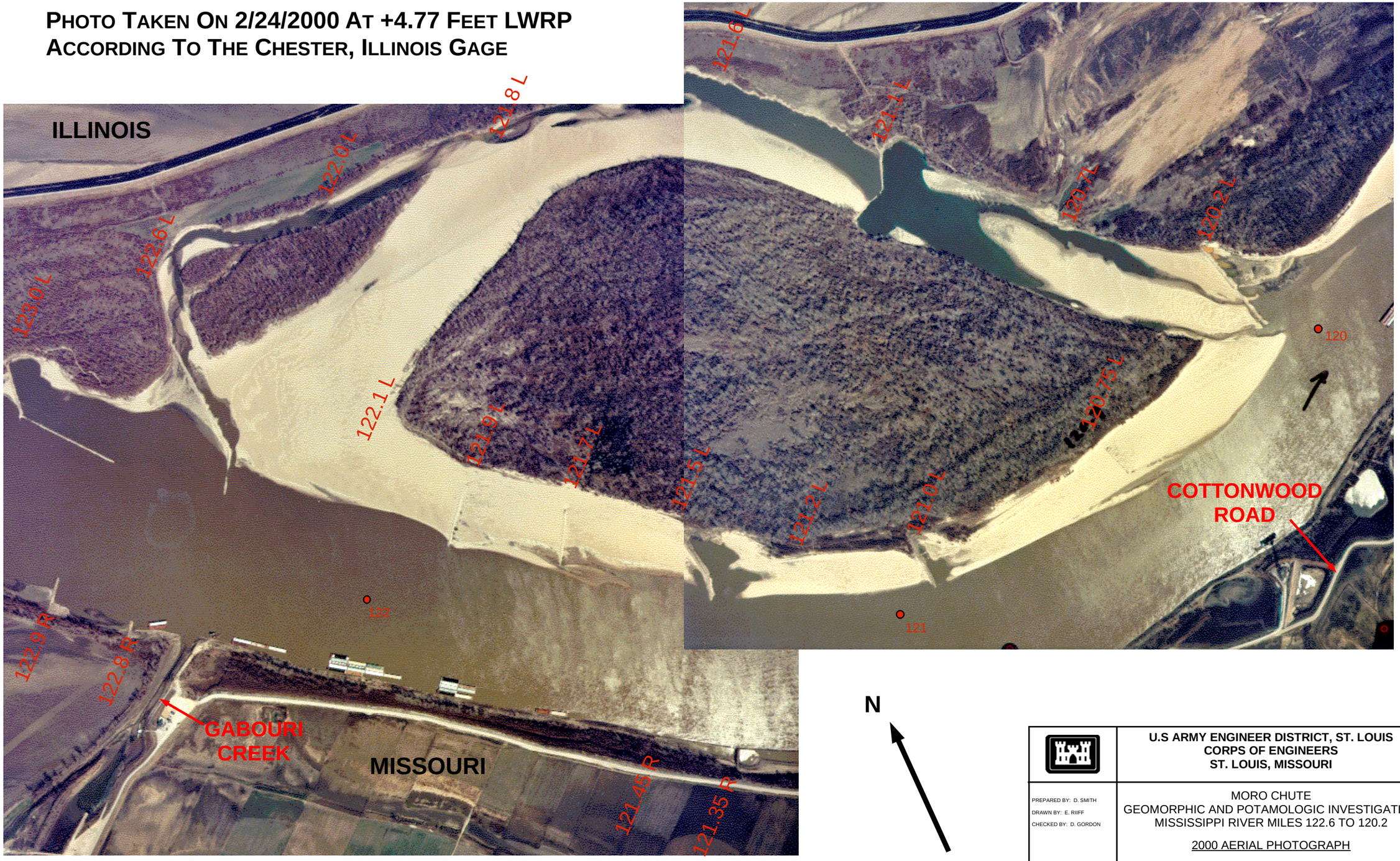
	Filename: 1998aerial.pub | Plot Date: 11/01 | PLATE NO.

PHOTO TAKEN ON 2/24/2000 AT +4.77 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE



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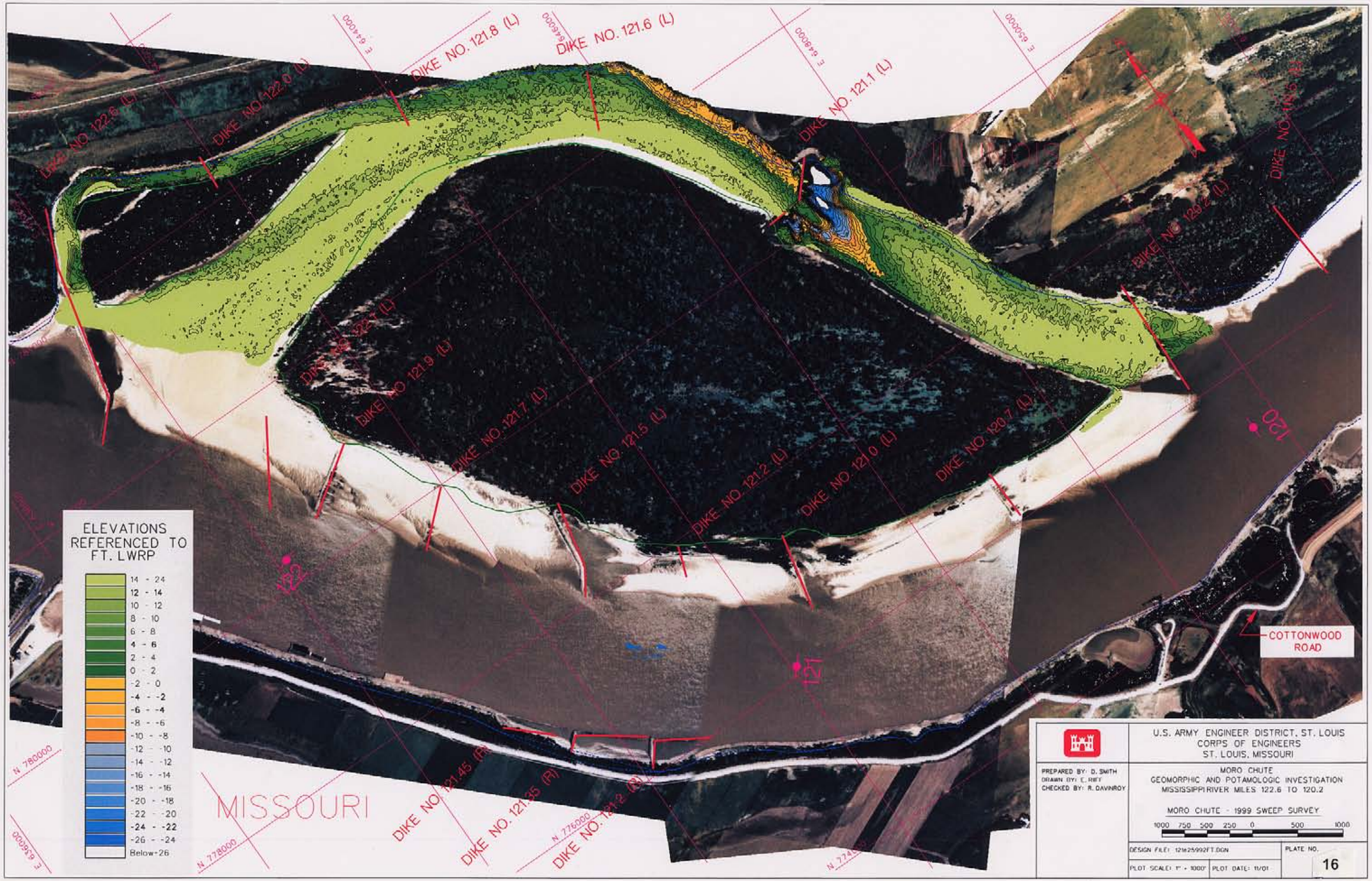
	FILE NAME:2000aerial.pub | PLOT DATE: 11/01 | PLATE NO. 15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DIKE NO. 120.7 (L)
DIKE NO. 121.45 (R)
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E 650000
N 780000
N 778000
N 776000
N 774000
122
120
CV
MISSOURI
COTTONWOOD ROAD
ELEVATIONS REFERENCED TO FT. LWRP
14 - 24
12 - 14
10 - 12
8 - 10
6 - 8
4 - 6
2 - 4
0 - 2
-2 - 0
-4 - -2
-6 - -4
-8 - -6
-10 - -8
-12 - -10
-14 - -12
-16 - -14
-18 - -16
-20 - -18
-22 - -20
-24 - -22
-26 - -24
Below -26
U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
PREPARED BY: D. SMITH
DRAWN BY: C. RIET
CHECKED BY: R. DAVINROY
MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2
MORO CHUTE - 1999 SWEEP SURVEY
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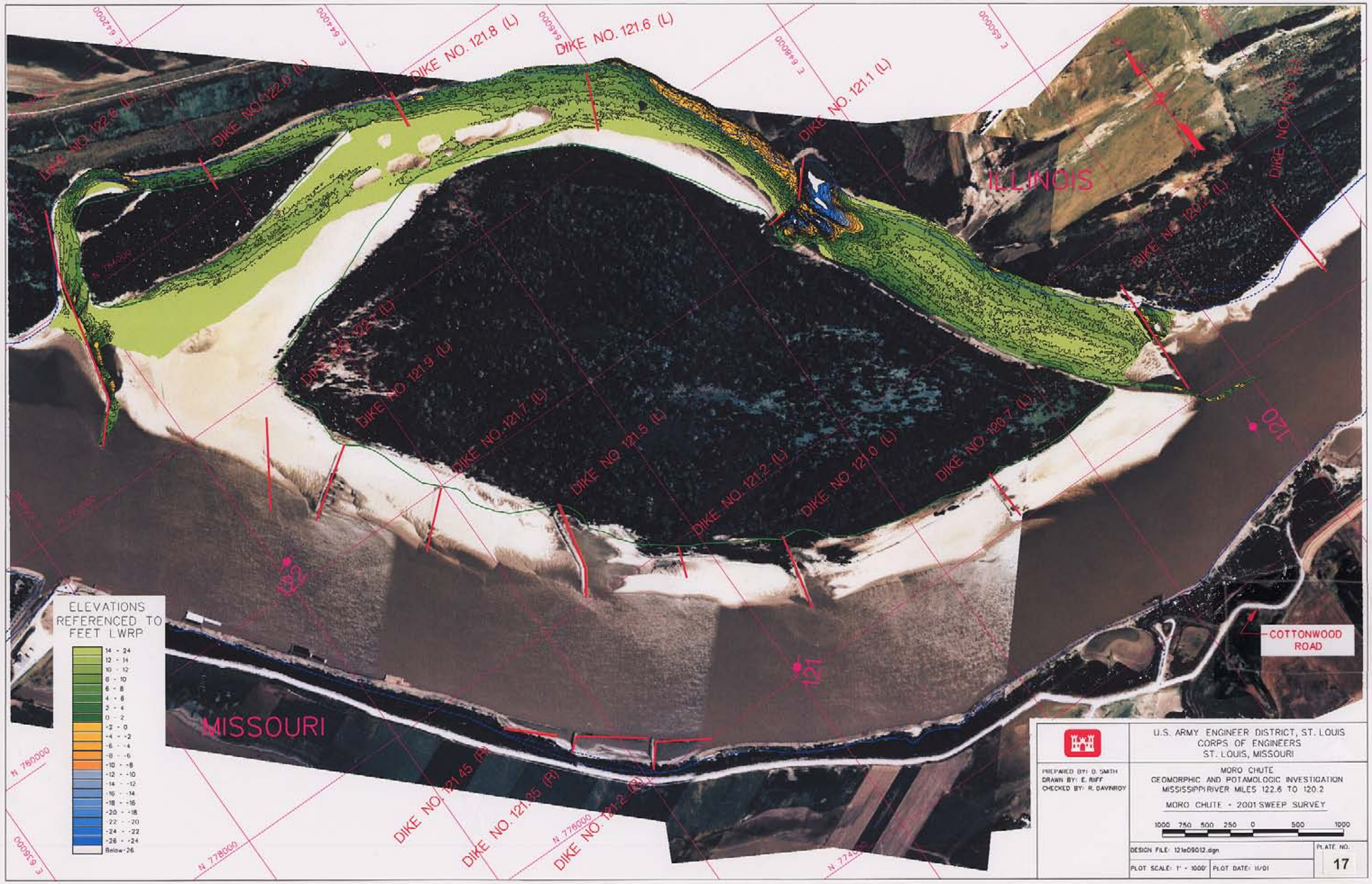
DESIGN FILE: 121to25992FT.DGN
PLATE NO.
16
PLOT SCALE: 1" = 1000'
PLOT DATE: 11/01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DIKE NO. 122.0 (L)
DIKE NO. 121.8 (L)
DIKE NO. 121.6 (L)
DIKE NO. 121.1 (L)
DIKE NO. 120.2 (L)
DIKE NO. 120.0 (L)
DIKE NO. 121.9 (L)
DIKE NO. 121.7 (L)
DIKE NO. 121.5 (L)
DIKE NO. 121.2 (L)
DIKE NO. 121.0 (L)
DIKE NO. 120.7 (L)
DIKE NO. 121.45 (R)
DIKE NO. 121.35 (R)
DIKE NO. 121.2 (R)
ILLINOIS
MISSOURI
COTTONWOOD ROAD
122
121
120
ELEVATIONS REFERENCED TO FEET LWRP
14 - 24
12 - 14
10 - 12
8 - 10
6 - 8
4 - 6
2 - 4
0 - 2
-2 - 0
-4 - -2
-6 - -4
-8 - -6
-10 - -8
-12 - -10
-14 - -12
-16 - -14
-18 - -16
-20 - -18
-22 - -20
-24 - -22
-26 - -24
Below -26
N 780000
N 778000
N 776000
E 642000
E 644000
E 646000
E 648000
E 650000
E 652000
U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
PREPARED BY: D. SMITH
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY
MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2
MORO CHUTE - 2001 SWEEP SURVEY
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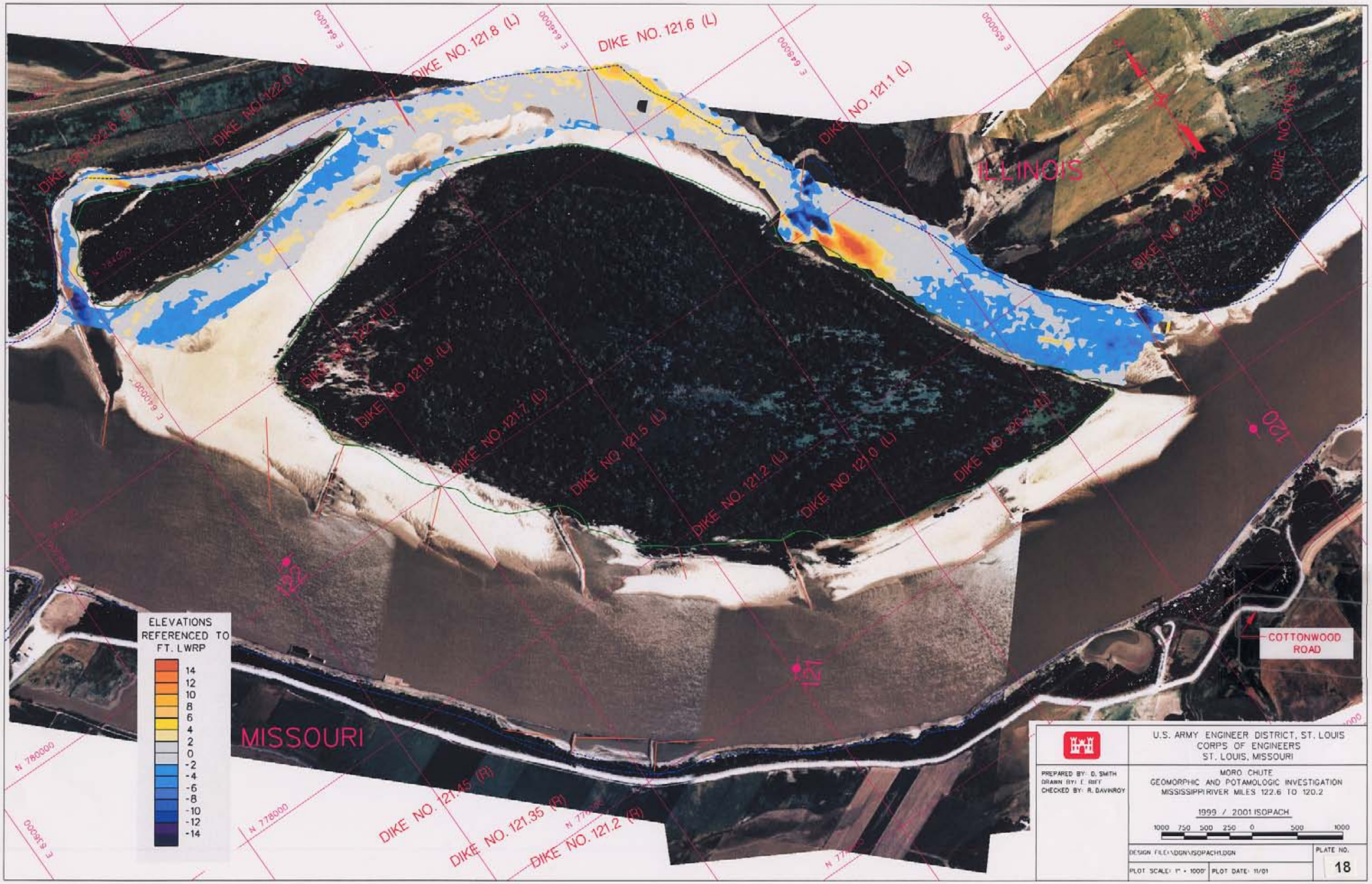
PLOT SCALE: 1" = 1000'
PLOT DATE: 11/01
PLATE NO.
17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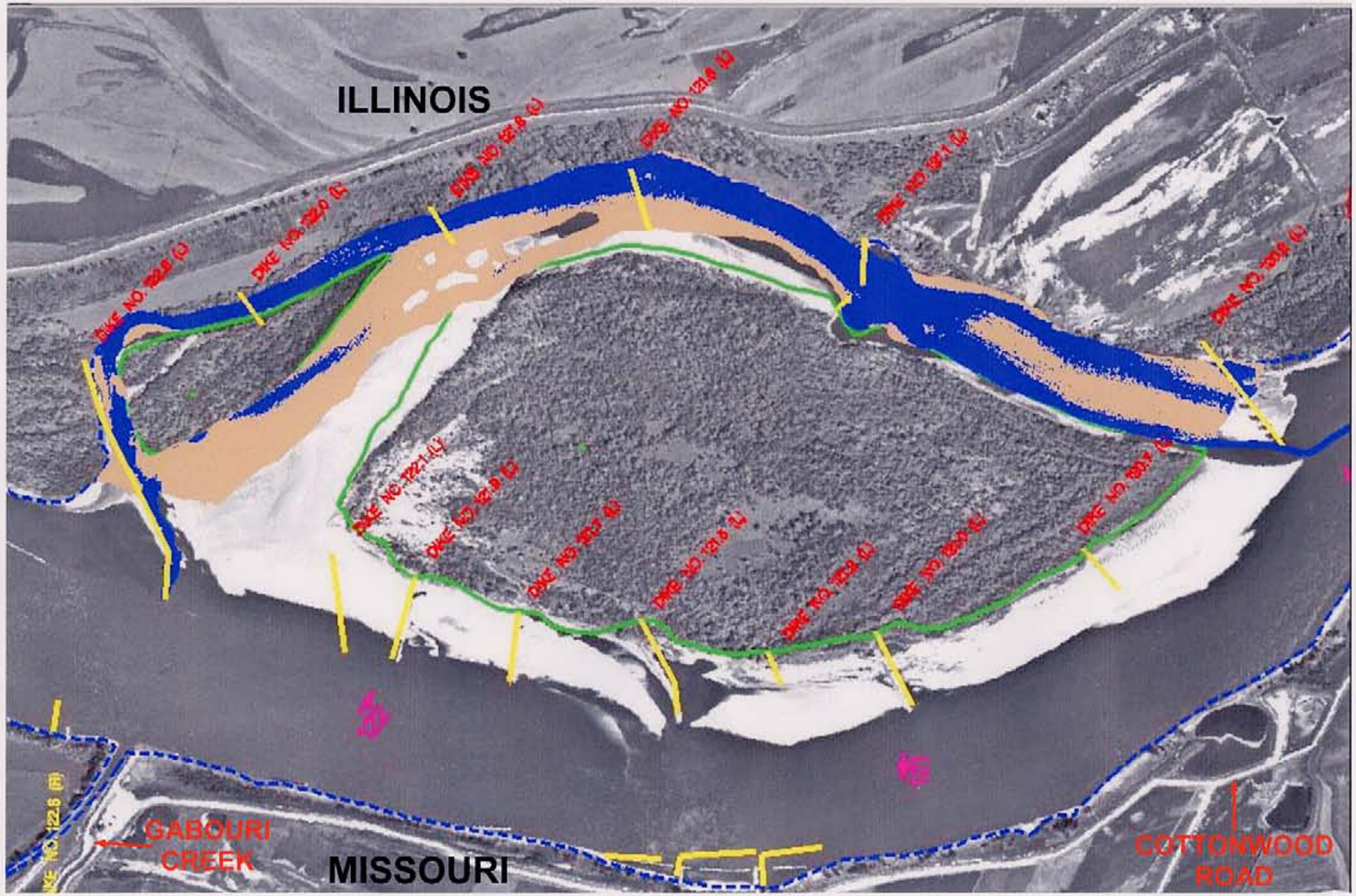
DIKE NO. 121.6 (L)
DIKE NO. 121.1 (L)
DIKE NO. 122.0 (L)
DIKE NO. 121.9 (L)
DIKE NO. 121.7 (L)
DIKE NO. 121.5 (L)
DIKE NO. 121.2 (L)
DIKE NO. 121.0 (L)
DIKE NO. 121.45 (R)
DIKE NO. 121.35 (R)
DIKE NO. 121.2 (R)
ILLINOIS
MISSOURI
COTTONWOOD ROAD
ELEVATIONS REFERENCED TO FT. LWRP
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
N 780000
N 778000
E 644000
E 646000
E 648000
E 650000
U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
PREPARED BY: D. SMITH
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY
MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2
1999 / 2001 ISOPACH
1000 750 500 250 0 500 1000
DESIGN FILE: \DGN\ISOPACH1.DGN
PLATE NO.
18
PLOT SCALE: 1" = 1000'
PLOT DATE: 11/01



Water Surface at +11.25 feet LWRP

Below +11.25 feet LWRP

Above +11.25 feet LWRP

U.S ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

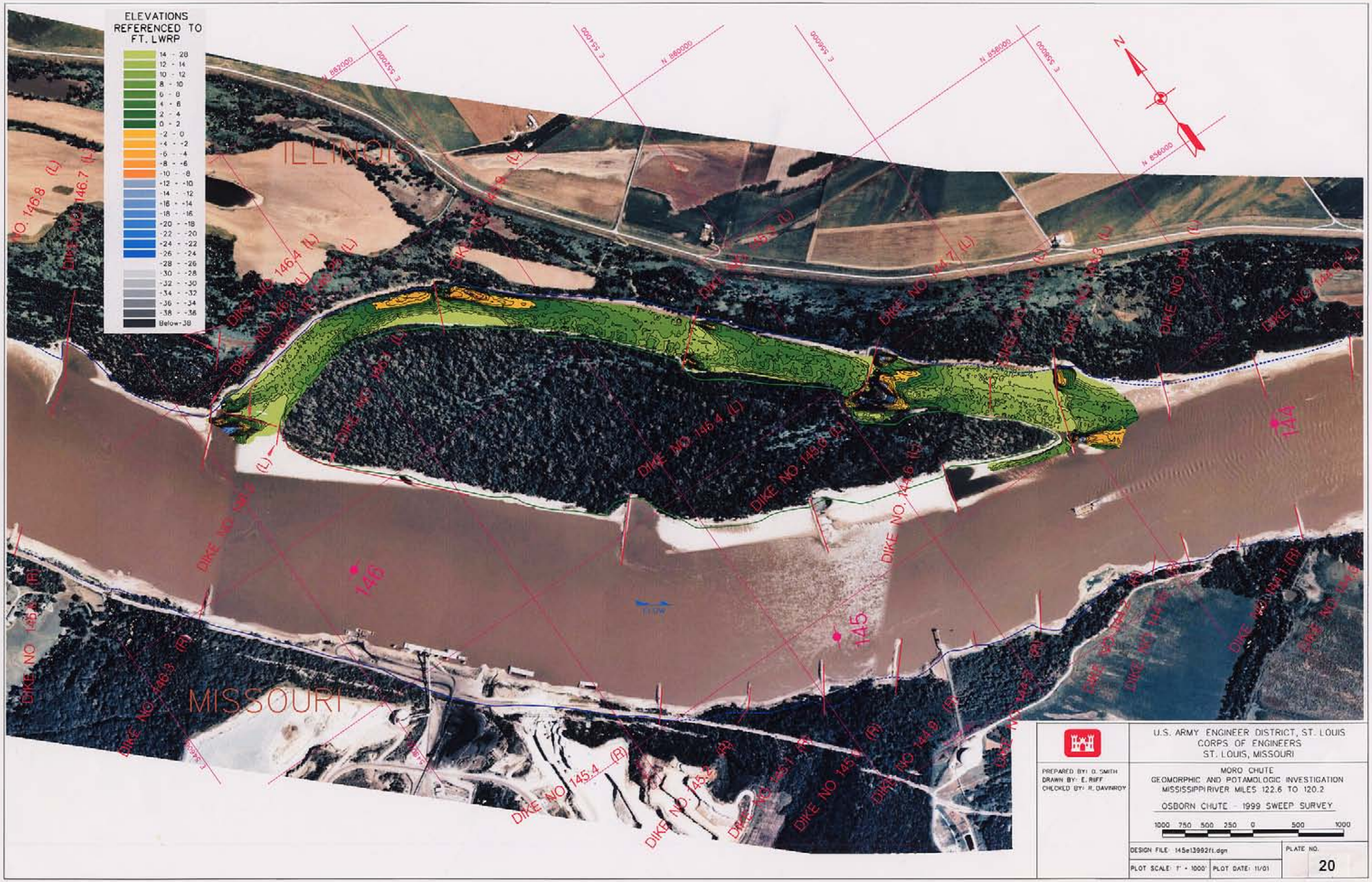
PREPARED BY: D. SMITH
DRAWN BY: E. RIFF
CHECKED BY: D. GORDON

MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2

2001 WATER SURFACE ELEVATION PROFILE

FILE NAME: WSELMORO99.PUB | PLOT DATE: 11/01

PLATE NO. 19



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: D. SMITH
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2

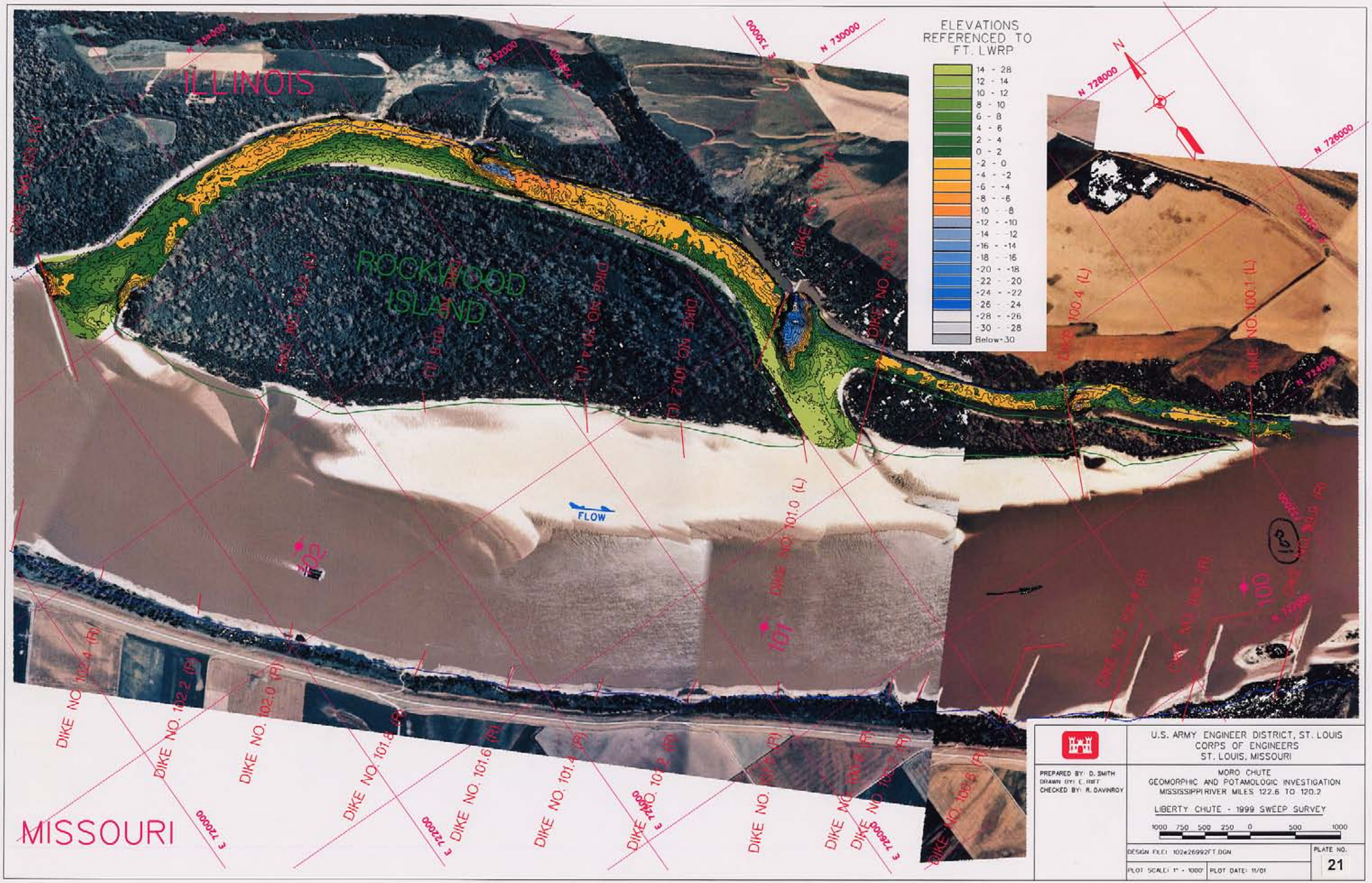
OSBORN CHUTE - 1999 SWEEP SURVEY

1000 750 500 250 0 500 1000

DESIGN FILE: 145e13992fi.dgn

PLOT SCALE: 1" = 1000' PLOT DATE: 11/01

PLATE NO. 20



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: D. SMITH
DRAWN BY: C. RIFF
CHECKED BY: R. DAVINROY

MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2

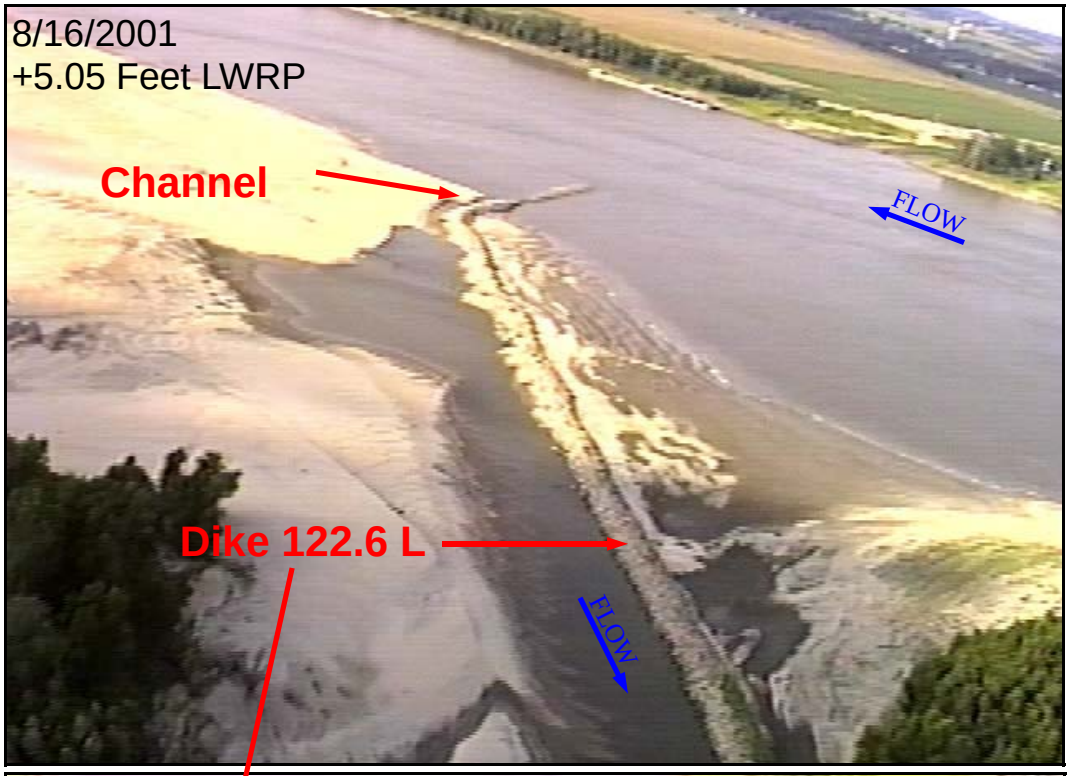
LIBERTY CHUTE - 1999 SWEEP SURVEY

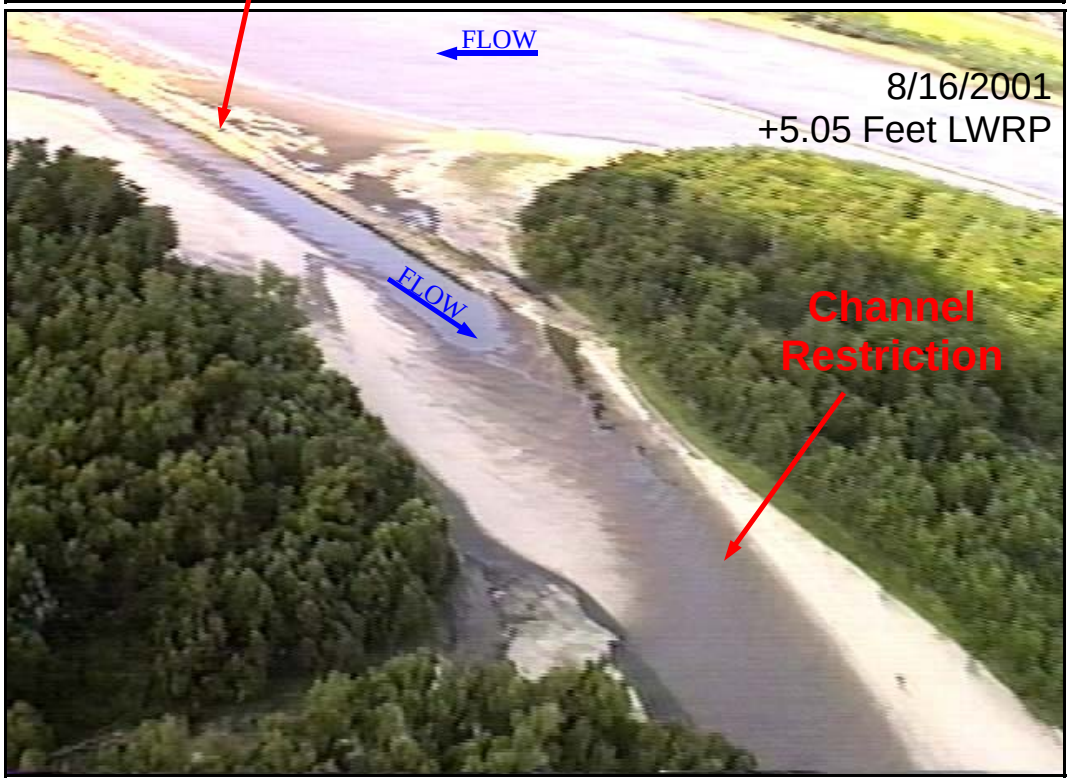
1000 750 500 250 0 500 1000

DESIGN FILE: 102e26992FT.DGN

PLOT SCALE: 1" = 1000' | PLOT DATE: 11/01

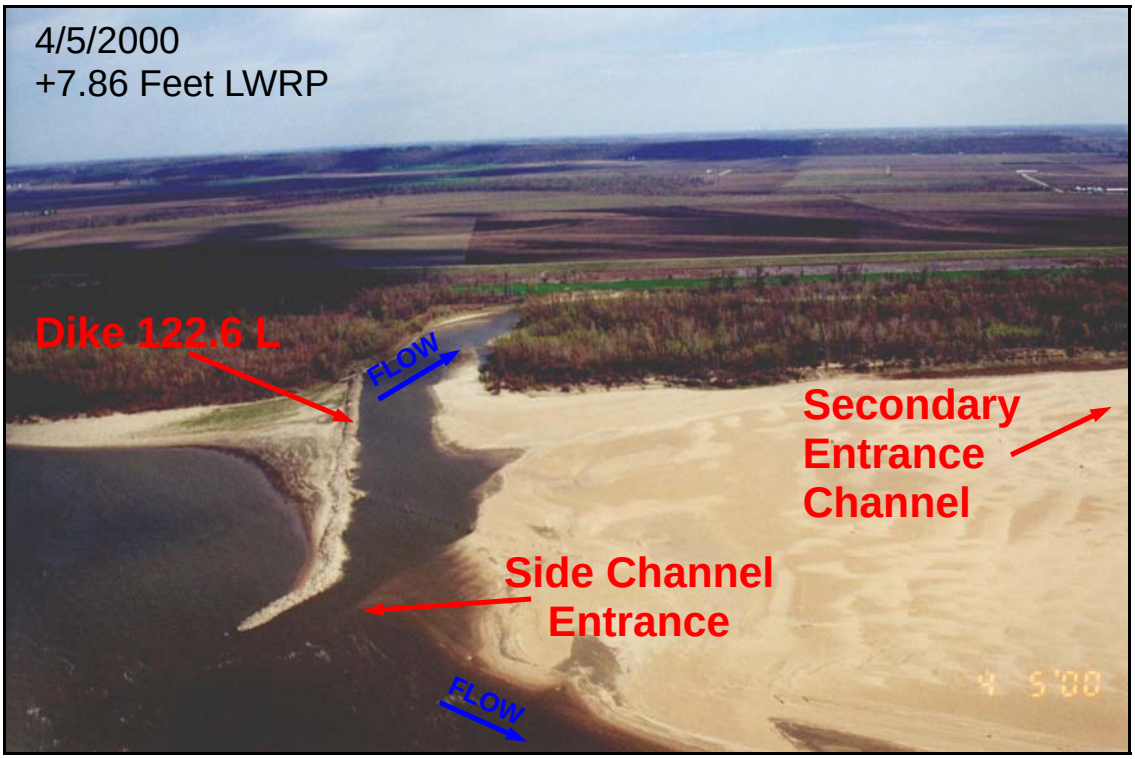
PLATE NO. 21

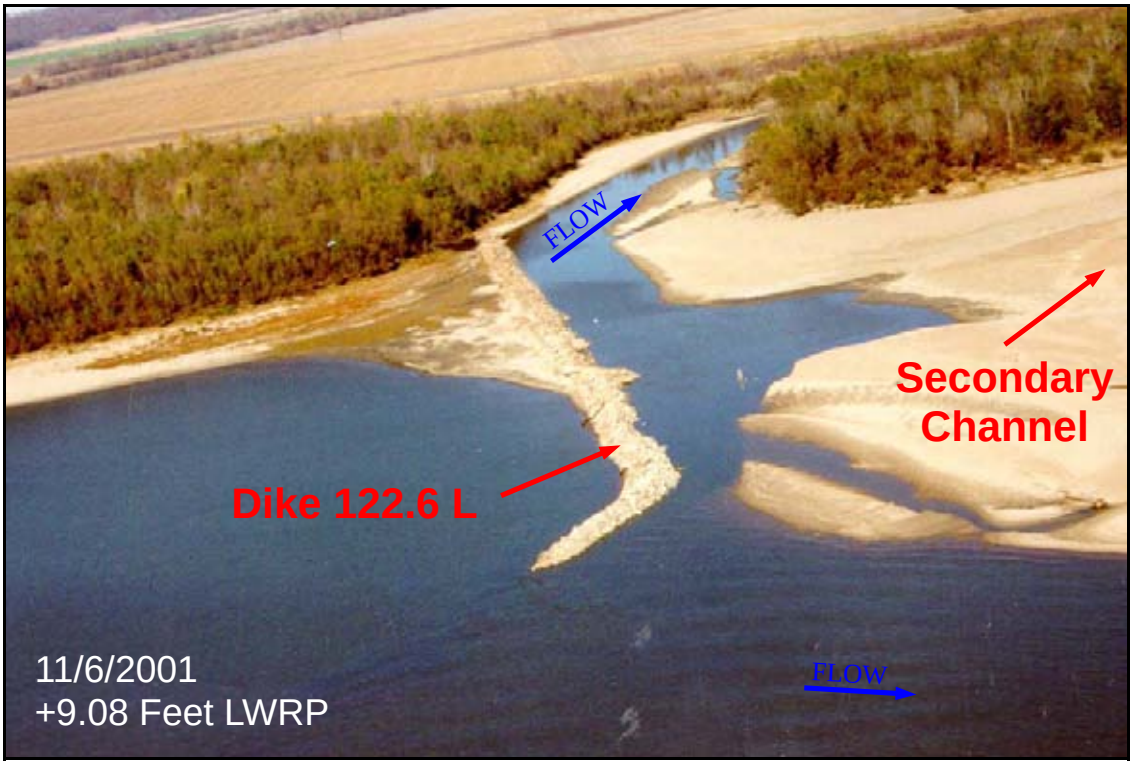




BOTH PHOTOS TAKEN ON 8/16/2001 AT +5.05 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS **CORPS OF ENGINEERS** **ST. LOUIS, MISSOURI**
PREPARED BY: D. Smith CHECKED BY: R. Davinroy	MORO CHUTE GEOMORPHIC AND POTAMOLOGIC INVESTIGATION MISSISSIPPI RIVER MILES 122.6 TO 120.2 AUGUST 2001 PHOTOGRAPHS OF THE PRIMARY SIDE CHANNEL ENTRANCE
	FILENAME:0801entrance.pub | PLOT DATE: 11/01 | PLATE NO. **22**

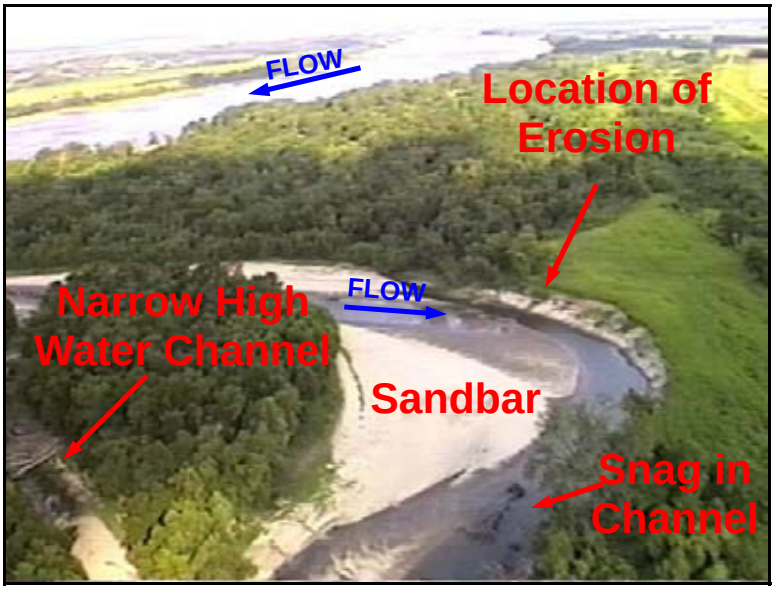




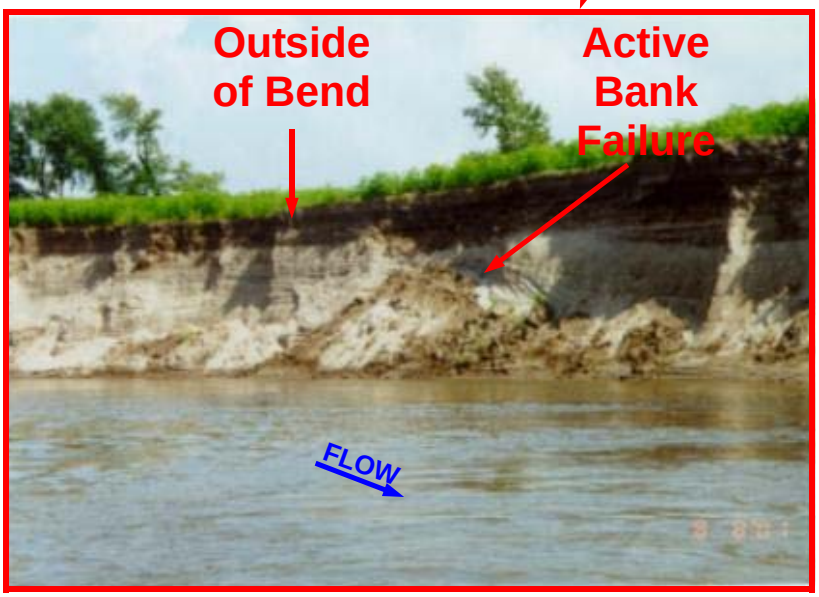
TOP PHOTO TAKEN ON 4/5/2000 AT +7.86 FEET LWRP AND BOTTOM PHOTO TAKEN ON 11/6/2001 AT +9.08 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS **CORPS OF ENGINEERS** **ST. LOUIS, MISSOURI**
PREPARED BY: D. Smith CHECKED BY: R. Davinroy	MORO CHUTE GEOMORPHIC AND POTAMOLOGIC INVESTIGATION MISSISSIPPI RIVER MILES 122.6 TO 120.2 APRIL 2000 AND NOVEMBER 2001 PHOTOGRAPHS OF THE PRIMARY SIDE CHANNEL ENTRANCE
	File Name: chute.pub Plot Date: 11/01 — PLATE NO. 23

8/16/2001
+5.05 Feet LWRP

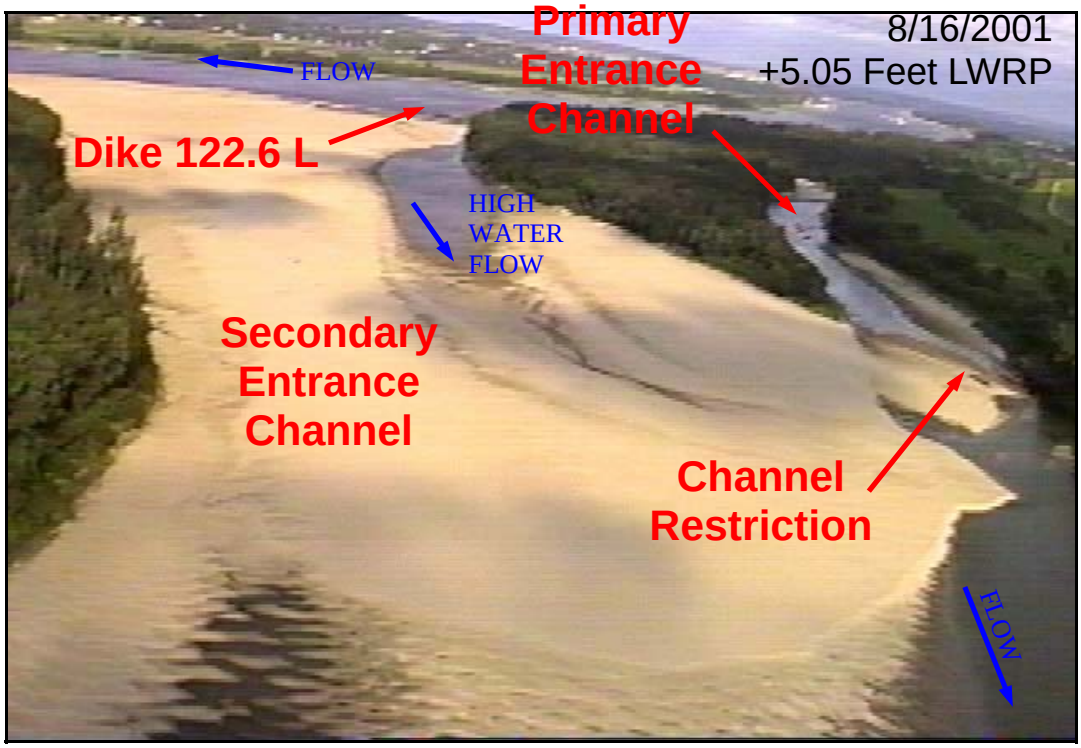


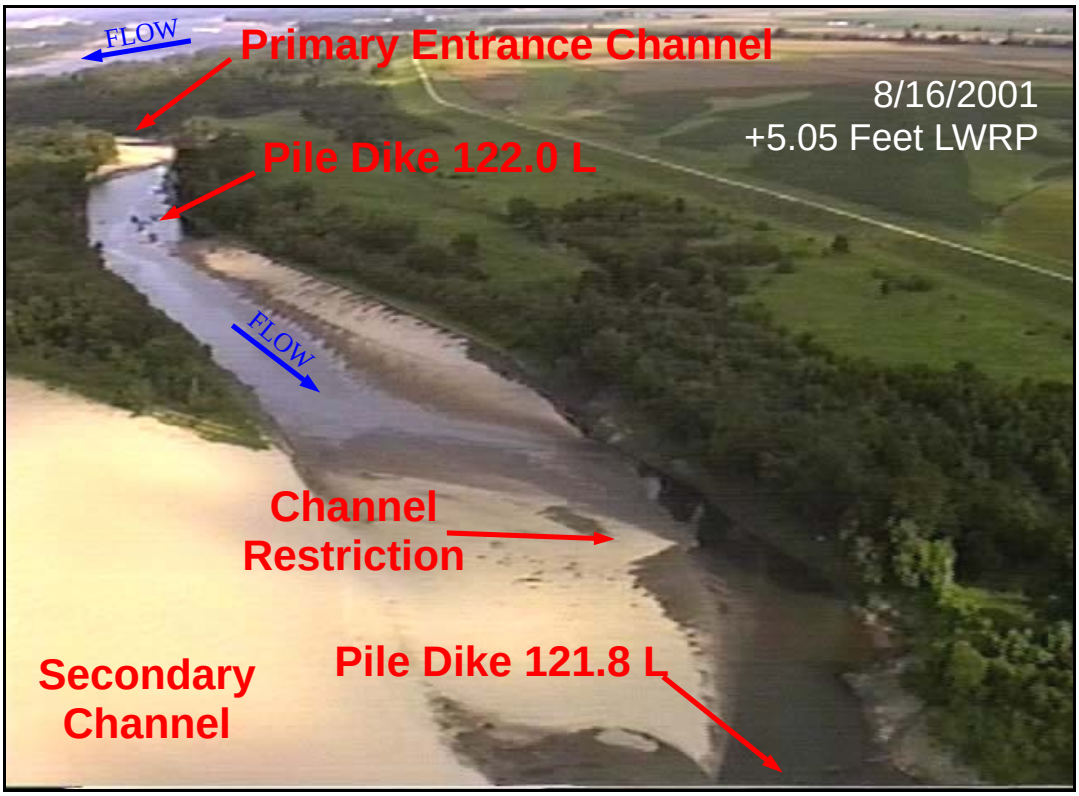
8/8/2001
+11.48 Feet LWRP



TOP PHOTO TAKEN ON 8/16/2001 AT +5.05 FEET LWRPAND BOTTOM TWO PHOTOS TAKEN ON 8/8/2001 AT +11.48 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

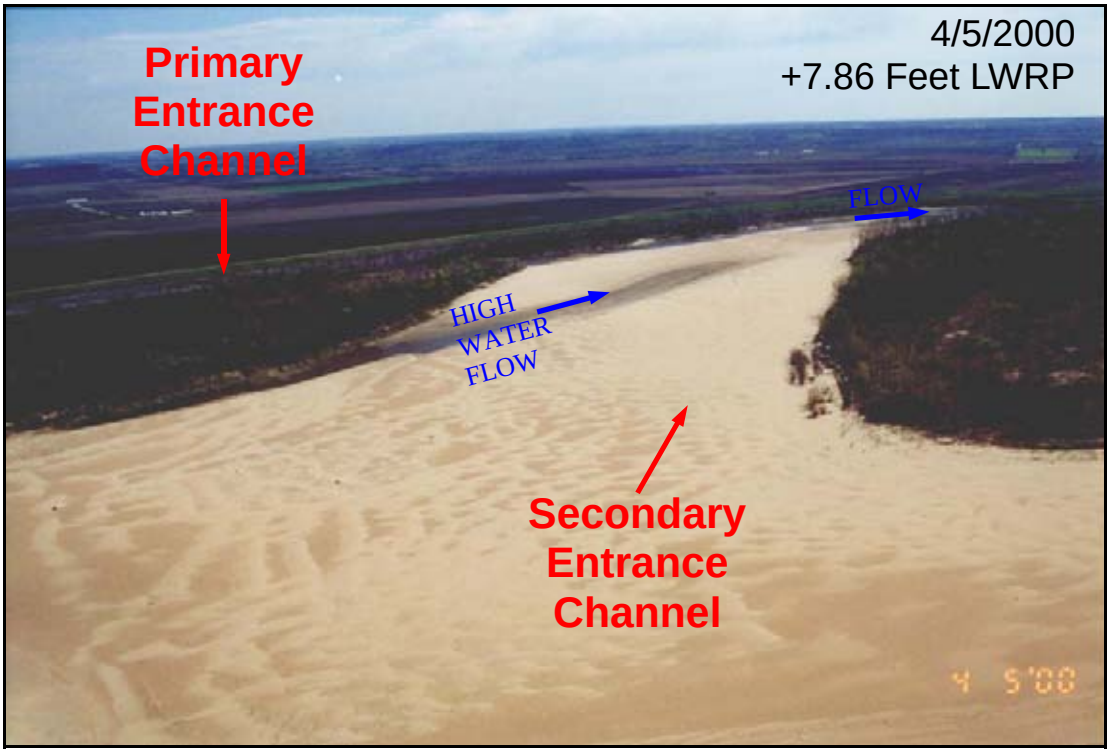
	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS ST. LOUIS, MISSOURI
PREPARED BY: D. Smith CHECKED BY: R. Davinroy	MORO CHUTE GEOMORPHIC AND POTAMOLOGIC INVESTIGATION MISSISSIPPI RIVER MILES 122.6 TO 120.2 VERTICAL BANKLINE ALONG LDB OF FIRST BEND
	File Name:banklines.pub Plot Date: 11/01 — PLATE NO. 24

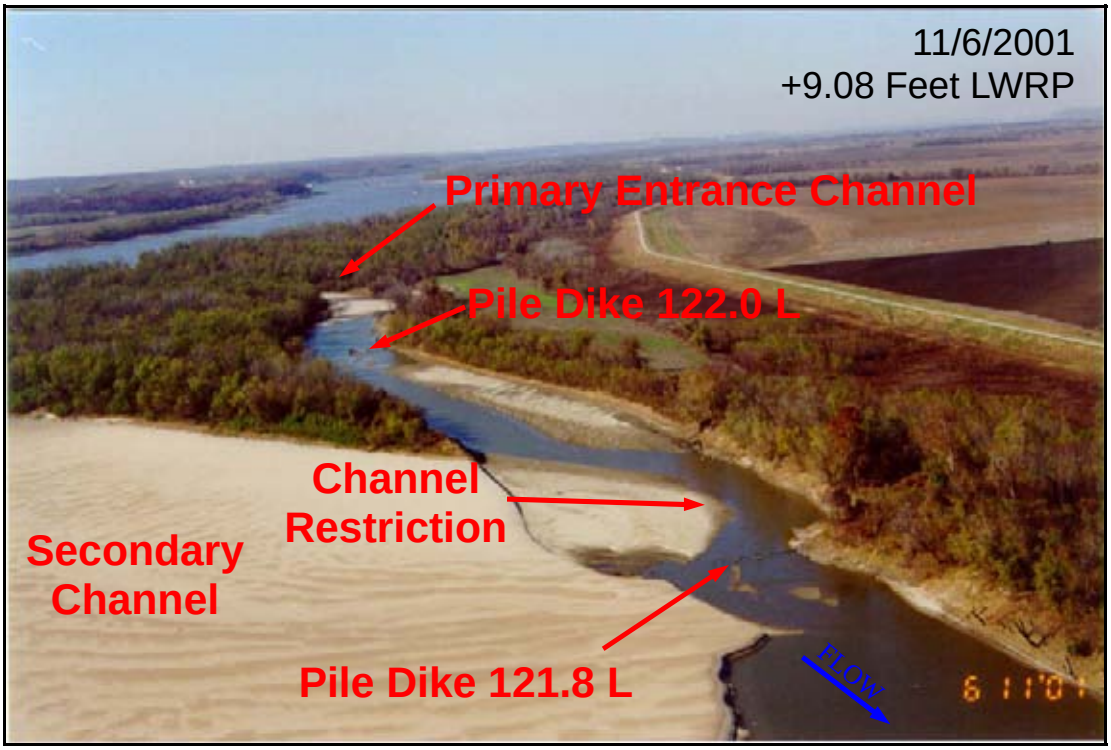




BOTH PHOTOS TAKEN ON 8/16/2001 AT +5.05 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

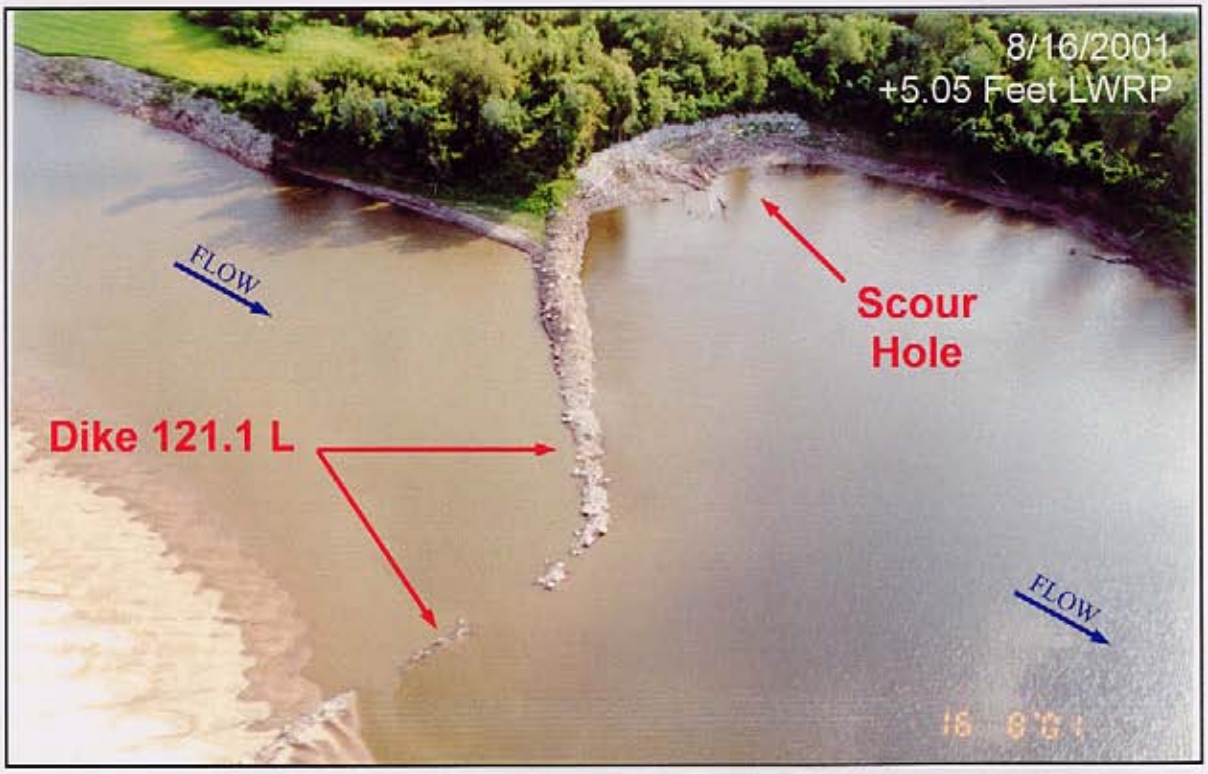
	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS ST. LOUIS, MISSOURI
PREPARED BY: D. Smith CHECKED BY: R. Davinroy	MORO CHUTE GEOMORPHIC AND POTAMOLOGIC INVESTIGATION MISSISSIPPI RIVER MILES 122.6 TO 120.2 AUGUST 2001 PHOTOGRAPHS OF THE SECONDARY SIDE CHANNEL ENTRANCE
	Filename: 2nd channel.pub | Plot Date: 11/01 | PLATE NO. 25





TOP PHOTO TAKEN ON 4/5/2000 AT +7.86 FEET LWRPAND BOTTOM PHOTO TAKEN ON 11/6/2001 AT +9.08 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS ST. LOUIS, MISSOURI
PREPARED BY: D. Smith CHECKED BY: R. Davinroy	MORO CHUTE GEOMORPHIC AND POTAMOLOGIC INVESTIGATION MISSISSIPPI RIVER MILES 122.6 TO 120.2 APRIL 2000 AND NOVEMBER 2001 PHOTOGRAPHS OF THE SECONDARY SIDE CHANNEL ENTRANCE
	Filename: Crossover.pub Plot Date: 11/01 — PLATE NO. 26



TOP PHOTO TAKEN ON 11/6/2001 AT +9.08 FEET LWRP AND BOTTOM PHOTO TAKEN ON 8/16/2001 AT +5.05 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

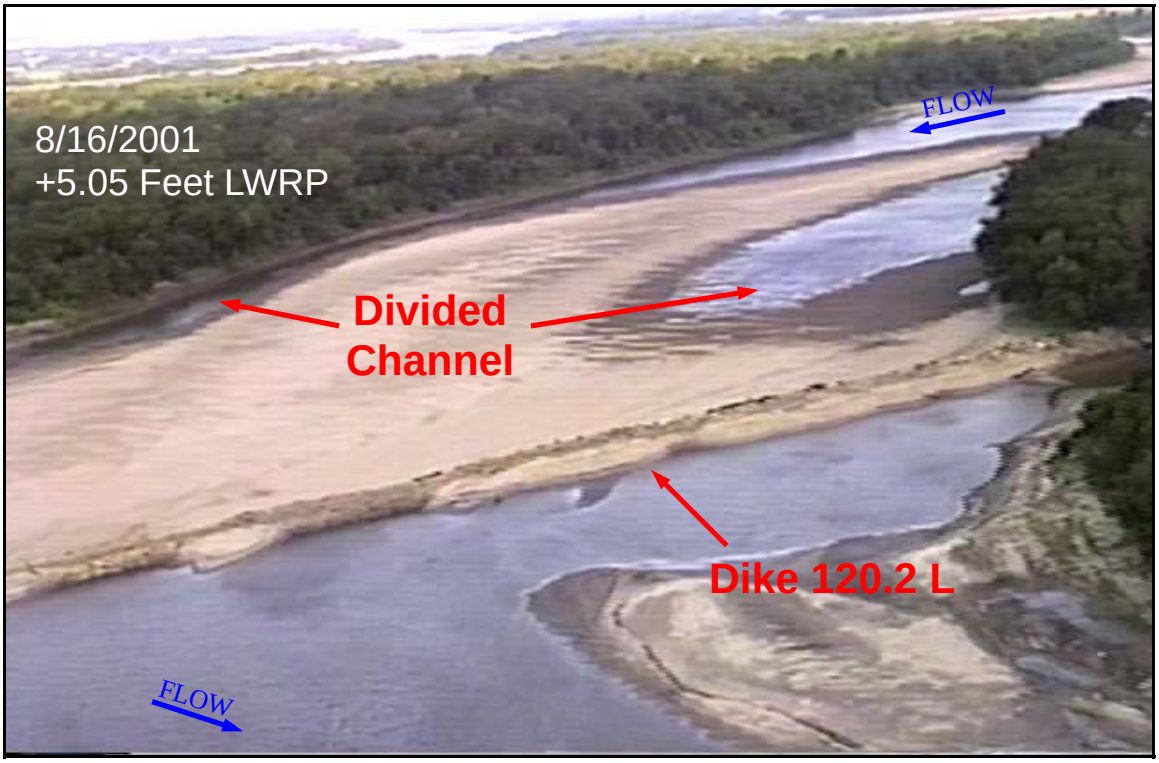
PREPARED BY: D. Smith
CHECKED BY: R. Davinney

MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2

NOVEMBER AND AUGUST 2001 PHOTOGRAPHS OF THE DIKES 121.6 L AND 121.1 L

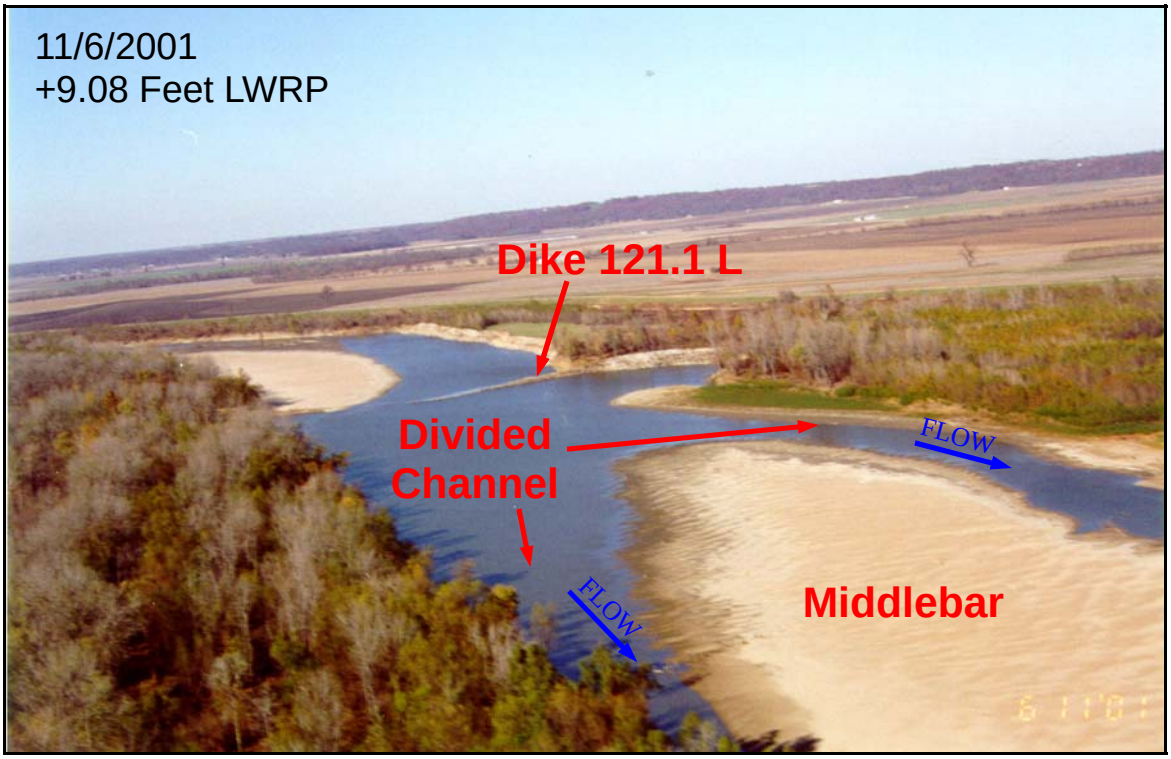
Filename: Crossover.pub | Plot Date: 11/01

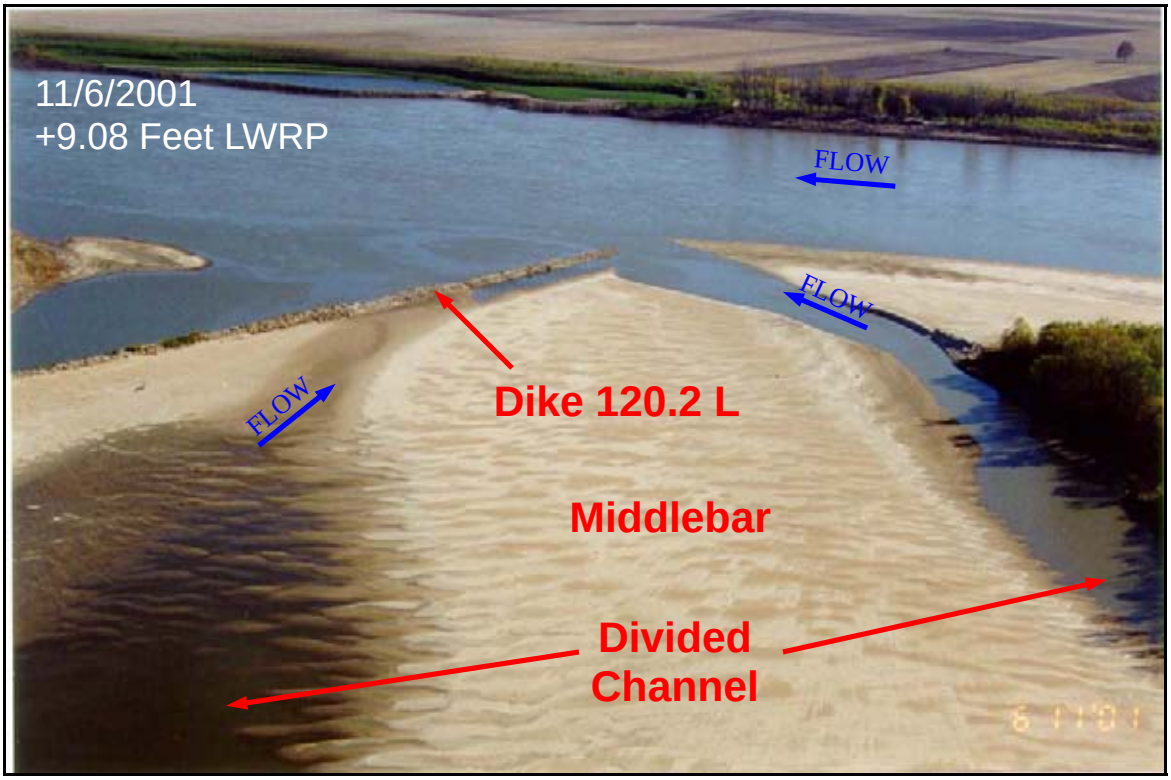
PLATE NO. 27



TOP PHOTO TAKEN ON 8/16/2001 AT +5.05 FEET LWRP AND BOTTOM PHOTO TAKEN ON 4/5/2000 AT +7.86 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS **CORPS OF ENGINEERS** **ST. LOUIS, MISSOURI**
PREPARED BY: D. Smith CHECKED BY: R. Davinroy	MORO CHUTE GEOMORPHIC AND POTAMOLOGIC INVESTIGATION MISSISSIPPI RIVER MILES 122.6 TO 120.2 AUGUST 2001 AND APRIL 2000 PHOTOGRAPHS OF THE SIDE CHANNEL EXIT
	FILENAME:1101 entr exit.pub | PLOT DATE: 11/01 | PLATE NO. 28





BOTH PHOTOS TAKEN ON 11/6/2001 AT +9.08 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: D. Smith
CHECKED BY: R. Davinroy

MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2

NOVEMBER 2001 PHOTOGRAPHS
OF THE SIDE CHANNEL EXIT

Filename:div channel.pub | Plot Date: 11/01

PLATE NO.
29

Boat 1

Waypoint	Depth (ft)	Elev.	Latitude*	Longitude*	Sediment Type	Notes
1	14	363	37.965	-89.982	Course Sand	
2	1.5	368	37.966	-89.982	Medium Sand	
4	4	391	37.968	-89.984	Course Sand	
5	5	371	37.970	-89.986	Sandy Silt	
7	5	370	39.972	-89.987	Fine Sand/Silt	
8	10	358	37.974	-89.988	Medium Sand	
9	33	362	37.975	-89.989	Silt	
10	20	349	37.975	-89.990	Course Sand	Below Dike 120.2L near notch opening
12	17	348	37.977	-89.990	Silt	
13	20	355	37.978	-89.990	Silt	
14	15	354	37.980	-89.991	Fine Sand	
15	10	347	37.982	-89.993	Fine Sand	Compacted
16	0	361	37.982	-89.993	Silty Clay	Bar behind pile dike
18	6	356	37.983	-89.995	Fine Sand	
19	3	357	37.985	-89.998	Fine Sand	
20	4	358	37.985	-89.998	Fine Sand	Compacted
21	9	345	37.985	-89.999	Fine Sand	Compacted
23	3	351	37.987	-90.008		Flanked pile structure
24	0	363	37.988	-90.011	Medium Sand	Tip of Bar
25	0	354	37.988	-90.013	Medium Sand	Northern tip of island
26	2	324	37.988	-90.011	Fine Sand	
27	1.5	343	37.988	-90.011	Fine Sand	Shallowest point of channel
28	3	344	37.988	-90.011	Fine Sand	
29	2	343	37.988	-90.011	Fine Sand	Brush pile in stream
30	2.2	344	37.987	-90.014	Medium Sand	
32	5	343	37.987	-90.015	Fine Sand	
33	2	350	37.983	-90.016	Course Sand	
34	4	351	37.985	-90.016	Silt	Upstream of dike 122.6, nearest shore
35	6	343	37.985	-90.016	Silt w/ Fine Sand	
36	7.3	347	37.984	-90.016	Medium Sand	Upstream of tip of dike 122.6
37	0	351	37.981	-90.015	Med/Course Sand	On sand bar at upstream end of Island

Boat 2

Waypoint	Depth (ft)	Elev.	Latitude*	Longitude*	Sediment Type	Notes
3	13	386	37.965	-89.983	Sand	
4	13	375	37.965	-89.983	Sand	
5	2	377	37.965	-89.984	Sand	
6	3	363	37.966	-89.985	Sand	
7	5	373	37.966	-89.985	Sand	
8	7	376	37.967	-89.986	Sand	
9	4	386	37.969	-89.987	Sand	
10	12	372	37.975	-89.990	Sand	
11	3	363	37.976	-89.990	Sand	
12	6	361	37.976	-89.990	Silty Sand	
13	7	357	37.978	-89.991	Silty Sand	
14	5	356	37.980	-89.992	Silty Sand	
15	4	357	37.983	-89.994	clay/silt and sand	Brush pile in stream
16	4	347	37.983	-89.995	Silty Sand	
17	7	354	37.983	-89.995	Sand	
18	0	369	37.985	-90.000	Sand	Mouth of Side Channel
19	10	365	37.987	-90.009	Sand	
20	5	347	37.983	-90.016	Sand	

* COORDINATES ARE ACCURATE TO WITHIN +/- 20 FEET

U.S ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: D. SMITH

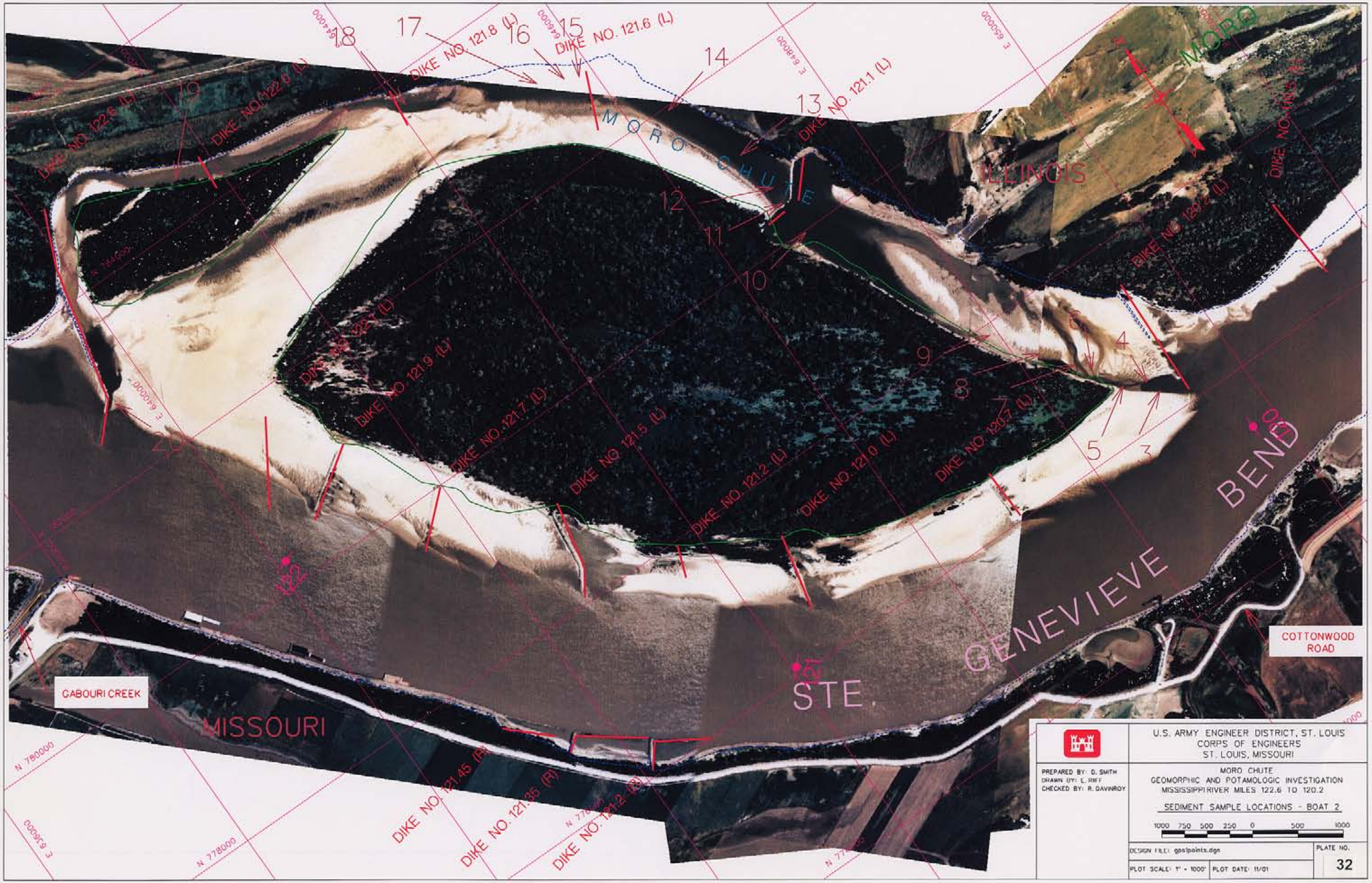
CHECKED BY: D. GORDON

MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2

SEDIMENT SAMPLE SPREADSHEET

FILE NAME:Sed Spread.pub | PLOT DATE: 11/01

PLATE NO. 30



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: D. SMITH
DRAWN BY: L. RIFF
CHECKED BY: R. DAVINROY

MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2

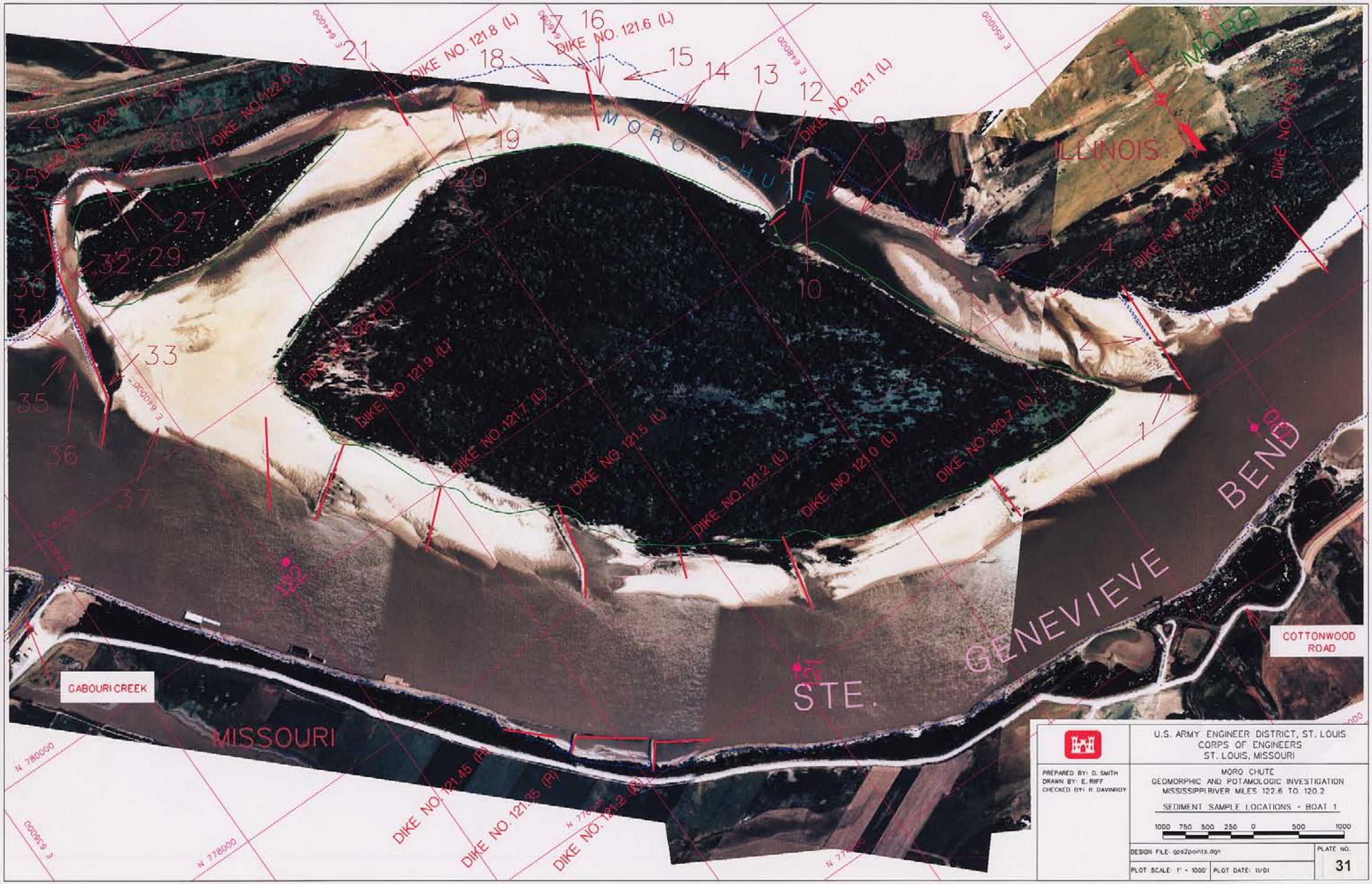
SEDIMENT SAMPLE LOCATIONS - BOAT 2

1000 750 500 250 0 500 1000

DESIGN FILE: gpslpoints.dgn

PLOT SCALE: 1" = 1000' | PLOT DATE: 11/01

PLATE NO. 32


MORO CHUTE
ILLINOIS
MORO
BEND
GENEVIEVE
STE.
MISSOURI
GABOURI CREEK
COTTONWOOD ROAD
DIKE NO. 121.8 (L)
DIKE NO. 121.6 (L)
DIKE NO. 121.1 (L)
DIKE NO. 122.6 (L)
DIKE NO. 122.0 (L)
DIKE NO. 121.9 (L)
DIKE NO. 121.7 (L)
DIKE NO. 121.5 (L)
DIKE NO. 121.2 (L)
DIKE NO. 121.0 (L)
DIKE NO. 120.7 (L)
DIKE NO. 121.45 (R)
DIKE NO. 121.35 (R)
DIKE NO. 121.2 (R)
N 780000
N 778000
E 644000
E 646000
E 650000
U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI
PREPARED BY: D. SMITH
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY
MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2
SEDIMENT SAMPLE LOCATIONS - BOAT 1
1000 750 500 250 0 500 1000
DESIGN FILE: gps2points.dgn
PLOT SCALE: 1" = 1000'
PLOT DATE: 11/01
PLATE NO.
31

Float #	Depth (ft)	Way-point	Elev.	Latitude*	Longitude*	Float 1 (s)	Float 2 (s)	Float 3 (s)	Avg. Time (s)	Velocity (ft/sec)
1	3	38	377	37.983	-90.016	25.84	24.19	25.56	25.197	1.984
2	4	39	370	37.987	-90.015	23.59	23.28	22.63	23.167	2.158
3	3	40	384	37.988	-90.010	34.00	32.00	31.19	32.397	1.543
4	4	41	369	37.986	-90.006	48.54	57.72	55.09	53.783	0.930
5	10	42	347	37.985	-90.000	25.66	32.84	28.78	29.093	1.719
6	3	45	351	37.978	-89.990	01:53.2	01:29.6	01:29.0	01:37.3	0.513
7	3	46	358	37.978	-89.990	02:04.9	01:46.0	02:01.0	01:57.3	0.426
8	12	47	337	37.975	-89.990	36.60	47.13	38.63	40.787	1.226
9	30	48	329	37.976	-89.989	After 2 minutes, little to no velocity observed				0.000
10	3	49	354	37.973	-89.987	01:35.9	01:32.0	01:33.9	01:33.9	0.532
11	4	50	343	37.970	-89.986	02:31.4	02:24.2	02:51.0	02:35.5	0.322
12	5	51	354	37.972	-89.988	02:23.2	03:48.6	02:53.9	03:01.9	0.275
13	2	52	355	37.969	-89.987	34.47	30.09	35.88	33.480	1.493
14	2	54	369	37.964	-89.983	22.62	22.21	25.34	23.390	2.138

Float #	Location Notes
1	Downstream side of Dike 122.6 L
2	Adjacent to the entrance for the high water channel through upper island
3	Next to snag in the channel, upstream from the outlet of high water channel
4	Near Pile Dike 121.8 L
5	Halfway between Pile Dikes 121.8 L and 121.6 L
6	Slightly upstream of Pile Dike 121.6 L
7	Halfway between Pile Dike 121.6 L and Dike 121.1 L
8	Right Bank scour below Dike 121.1 L, Downstream of remnent of Pile Dike 121.1 L
9	Left Bank scour below Dike 121.1 L
10	Adjacent and left of upstream tip of middlebar near the end of the side channel
11	Midway down left side of split channel
12	Adjacent and right of upstream tip of middlebar near the end of the side channel
13	Midway down right side of split channel
14	End of chute at junction with Mississippi River

* COORDINATES ARE ACCURATE TO WITHIN +/- 20 FEET

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: D. Smith
CHECKED BY: R. Davinroy

MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2

VELOCITY VALUES SPREADSHEET

File Name: vel spread.pub | Plot Date: 11/01

PLATE NO. 33

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: D. SMITH
DRAWN BY: E. RIFF
CHECKED BY: R. DAVINROY

MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2

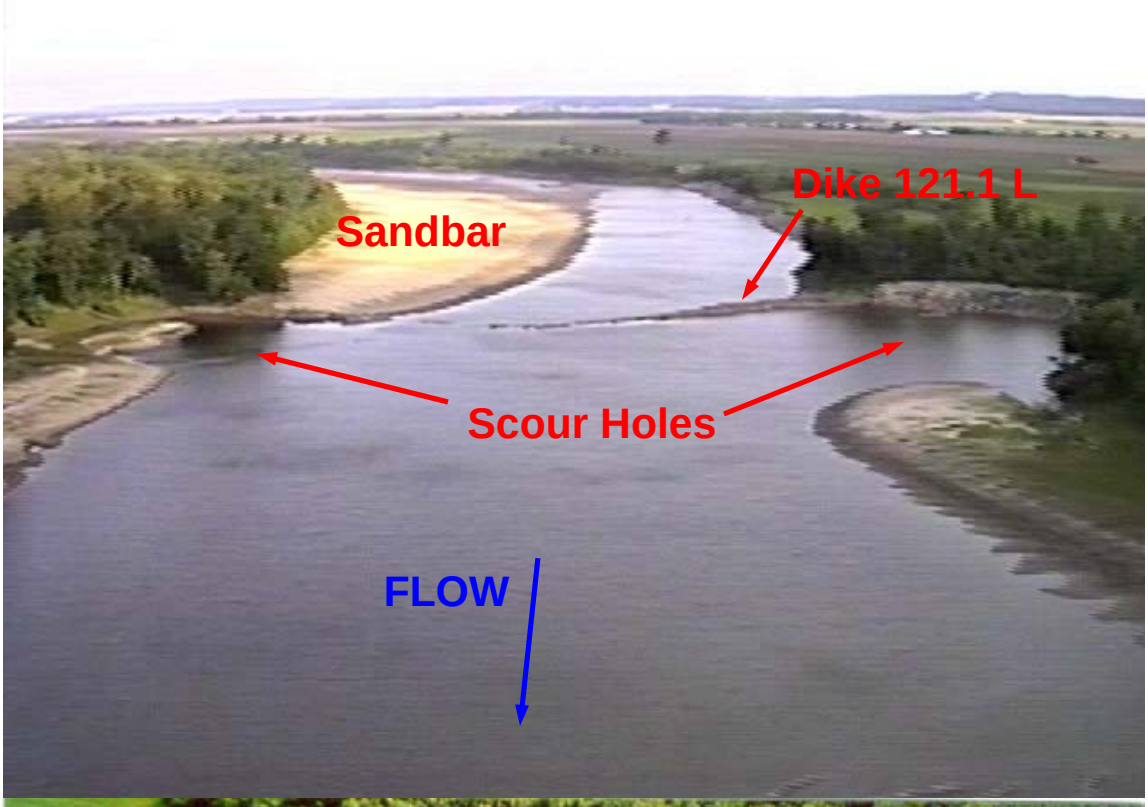
VELOCITY MEASUREMENTS

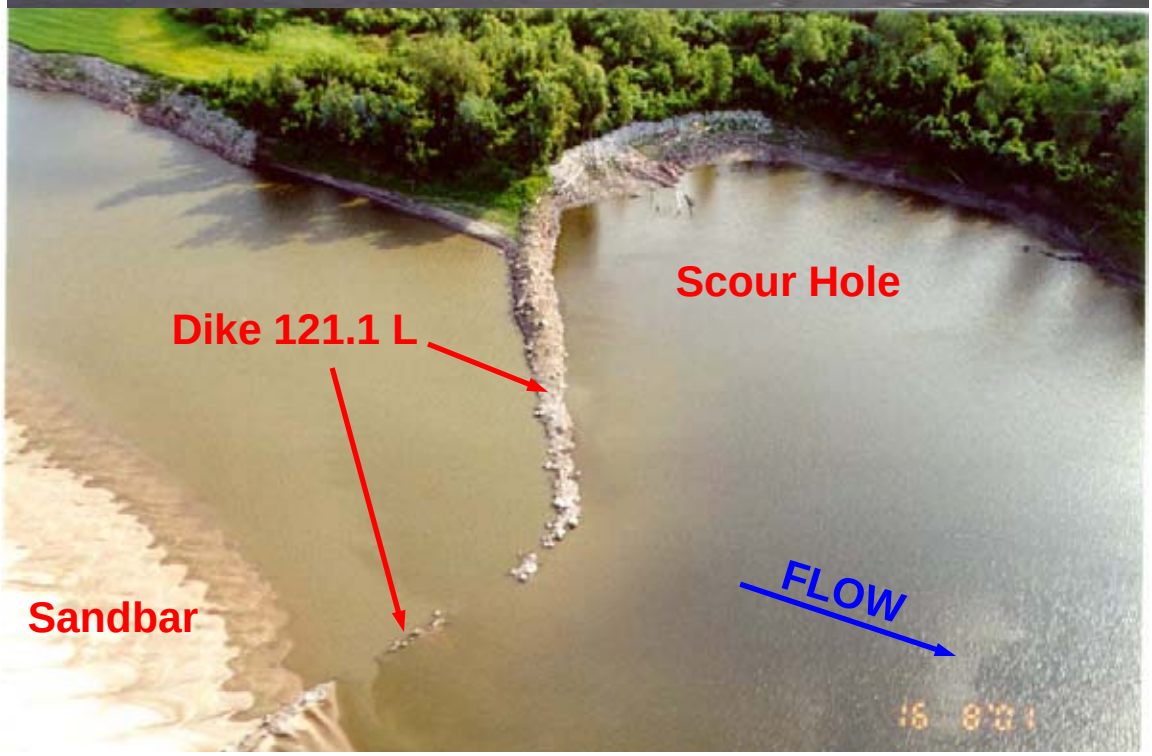
1000 750 500 250 0 500 1000

DESIGN FILE: velocities.dgn

PLOT SCALE: 1" = 1000' | PLOT DATE: 11/01

PLATE NO. 34





PHOTOS TAKEN ON 8/16/2001 AT +5.05 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS **CORPS OF ENGINEERS** **ST. LOUIS, MISSOURI**
PREPARED BY: D. Smith CHECKED BY: R. Davinroy	MORO CHUTE GEOMORPHIC AND POTAMOLOGIC INVESTIGATION MISSISSIPPI RIVER MILES 122.6 TO 120.2 DIKE 121.1 L
	Filename:Dike 121.1L.pub Plot Date: 11/2001 PLATE NO. 35

TOP PHOTO TAKEN AT +9.08 FEET LWRP AND BOTTOM PHOTO TAKEN AT +5.05 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

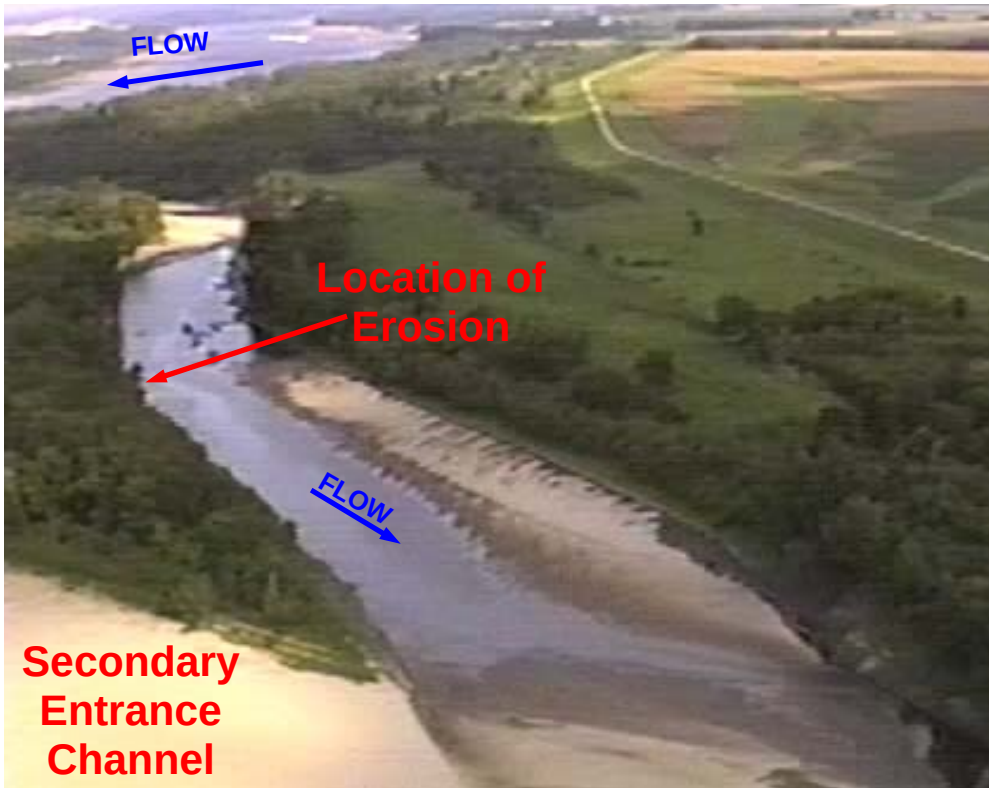
PREPARED BY: D. Smith
CHECKED BY: R. Davinroy

MORO CHUTE
GEOMORPHIC AND POTAMOLOGIC INVESTIGATION
MISSISSIPPI RIVER MILES 122.6 TO 120.2

DIKE 120.2 L AND SIDE CHANNEL EXIT

Filename: Dike 120.2 L.pub | Plot Date: 11/01

PLATE NO. 36



TOP PHOTO TAKEN AT +5.05 FEET LWRP AND BOTTOM PHOTO TAKEN AT +11.48 FEET LWRP ACCORDING TO THE CHESTER, ILLINOIS GAGE

	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS ST. LOUIS, MISSOURI
PREPARED BY: D. Smith CHECKED BY: R. Davinroy	MORO CHUTE GEOMORPHIC AND POTAMOLOGIC INVESTIGATION MISSISSIPPI RIVER MILES 122.6 TO 120.2 VERTICAL BANKLINE DOWNSTREAM OF DIKE 121.8 L
	File Name:banklines.pub Plot Date: 11/01 — PLATE NO. 37